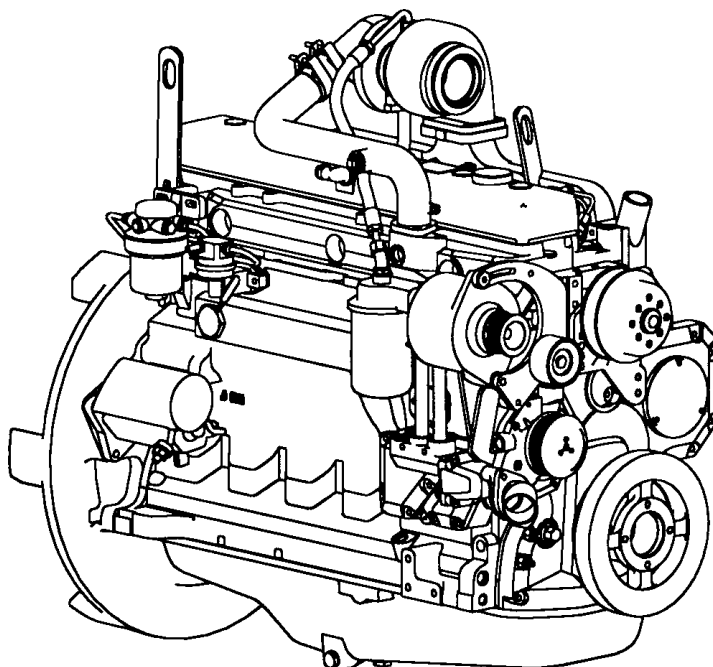


**ARMY TM 9-2815-259-24  
AIR FORCE TO 38G1-125-2  
MARINE CORPS 09249A/09246A-24**

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**TECHNICAL MANUAL**

**UNIT, DIRECT SUPPORT AND GENERAL SUPPORT  
MAINTENANCE MANUAL  
DIESEL ENGINE  
MODEL 4045TF151  
4 CYLINDER 4.5 LITER  
(NSN: 2815-01-462-2289) (EIC: N/A)**



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**DEPARTMENTS OF THE ARMY AND THE AIR FORCE  
AND HEADQUARTERS, MARINE CORPS**

**1 NOVEMBER 2000  
PCN: 182 092494 00**



**WARNING**

Where applicable, prior to performing engine maintenance, ensure batteries are disconnected to prevent serious injury or death.

**WARNING**

Batteries give off a flammable gas. Do not smoke or use open flame when performing maintenance. Failure to comply can cause injury to personnel and equipment due to flame and possible explosion.

**WARNING**

Engine coolant is very hot and under pressure after engine has been operating. Allow engine to cool before you slowly loosen filler cap and relieve pressure from cooling system. Failure to comply could result in severe personal injury.

**WARNING**

Escaping diesel or JP fuel under pressure can have sufficient force to penetrate the skin, causing serious injury. Always direct fuel injection nozzle tip away from personnel and place a clear, protective shield around spray zone. Before disconnecting fuel lines, be sure to relieve pressure. Before applying pressure to the system, be sure all connections are tight and lines, pipes, and hoses are not damaged. Keep hands and body away from pinholes and nozzles which eject fuel under pressure. Use a piece of cardboard or wood, rather than hands, to search for suspected leaks.

**WARNING**

If diesel or JP fuel is injected into the skin, seek medical attention immediately. Failure to comply can result in serious injury.

**WARNING**

Diesel and JP fuels are flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.

**WARNING**

Fuels used in the generator set are flammable. Do not smoke or use open flames when performing maintenance. Failure to comply can result in flame and possible explosion and can cause injury or death to personnel and damage the generator set.

**WARNING**

Exhaust system is very hot after operating engine. After operating engine, allow exhaust system to cool before removal. Failure to comply could result in personal injury.

**WARNING**

Cleaning solvent is flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection are required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.

**WARNING**

Compressed air used for cleaning can create airborne particles that may enter the eyes. Never exceed 30 psi (207 kPa) of pressure. Eye protection required. Failure to comply could result in serious eye damage or blindness.

**WARNING**

Care should be exercised when using steam for cleaning. Steam is extremely hot. Skin and eye protection are required. Avoid steam contact with skin.

**WARNING**

Operating the generator set with any access door open exposes personnel to high noise levels. Hearing protection must be worn when operating or working near the generator set with any access door open. Failure to comply can cause hearing damage or loss.

**WARNING**

Block cylinder head with a solid block of wood at each end of cylinder head while using spring compressor. Failure to comply could result in serious personal injury.

**WARNING**

Do not stand in front of valve spring while compressing valve springs. Failure to comply could result in serious personal injury.

**WARNING**

When using bench grinder, eye protection must be worn to prevent particles from entering eyes. Failure to comply could result in serious eye damage or blindness.

**WARNING**

Flywheel is heavy. Provide adequate lifting device to support weight. Failure to comply could result in serious personal injury.

**WARNING**

Wear protective gloves to help prevent burns from handling hot ring gear.

**WARNING**

Crankshaft is very heavy, do not attempt to remove crankshaft by hand. Use proper lifting equipment.

**WARNING**

Oil fumes or oil can ignite above 380°F (193°C). Use a temperature device and do not exceed 360°F (182°C). Do not allow a flame or heating element to be in direct contact with oil. Heat oil in a well ventilated area. Plan a safe handling procedure to avoid burns. Wear protective clothing, gloves, apron, etc.

**WARNING**

The engine repair stand should be used only by qualified service technicians who are familiar with this equipment. Failure to comply could result in serious personal injury and/or equipment damage.

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**WARNING**

To prevent possible personal injury and/or equipment damage, alloy steel SAE Grade 8 or higher socket head cap screws must be used when installing engine adapters on engine rotating repair stand. Use Thread Lock and Sealer (Loctite 242) or equivalent on cap screws when installing lift straps on the engine. Tighten cap screws to 125 ft-lb (170 Nm).

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**WARNING**

To prevent possible personal injury and/or equipment damage, be sure tapped hole on the engine rotating repair stand's adapters and mounting hub are clean and not damaged and that a thread length engagement equal to 1-1.2 screw diameter minimum is available.

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**WARNING**

To prevent possible personal injury and/or equipment damage, use an engine repair stand (NSN 4910-00-529-8387) with a capacity of (2000 lbs.) or larger.

To avoid structural or personal injury, do not exceed the maximum capacity rating or 2000 lbs. (4408 kg.). Maximum capacity is determined with the center of the engine located no more than 13 inches (330 mm) from the mounting hub surface of the engine stand.

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**WARNING**

To prevent possible personal injury and or equipment damage due to unsafe off-balance load condition, the center of balance of engine must be located within 2 inches (51 mm) of the engine stand rotating shaft. Engine center of balance is generally located a few millimeters above the crankshaft.

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**WARNING**

To prevent possible personal injury due to engine slippage, recheck to make sure engine is solidly mounted before releasing support from engine lifting device.

**WARNING**

When using the engine rotating repair stand, never permit any part of the body to be positioned under a load being lifted or suspended. Accidental slippage may result in personal injury.

**WARNING**

The lifting jack of the engine rotating repair stand is to be used when it is necessary to lift the engine for rotation. When working on the engine, the jack should be at its lowest position to keep the center of gravity low and the possibility of tipping low. Failure to comply could result in personal injury and/or equipment damage.

**WARNING**

When adding coolant to the system, use the appropriate cooling solution. Failure to comply could result in damage to the engine and injury to personnel.

**WARNING**

To prevent possible personal injury and/or equipment damage due to sudden engine movement, unscrew the release valve knob slowly when lowering the engine on the engine rotating repair stand.





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Page No.	* Change No.	Page No.	* Change No.	Page No.	* Change No.
Title.....	0	4-1—4-98 .....	0	G-1—G-3 .....	0
Title blank.....	0	5-1—5-118 .....	0	G-4 blank .....	0
A .....	0	A-1—A-2.....	0	H-1—H-2 .....	0
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i - ix.....	0	C-1—C-3 .....	0		
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1-1—1-8.....	0	D-1.....	0		
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DEPARTMENTS OF THE ARMY  
AND THE AIR FORCE  
AND HEADQUARTERS, MARINE CORPS

Washington, DC, 1 November 2000

**UNIT, DIRECT SUPPORT AND GENERAL SUPPORT  
MAINTENANCE MANUAL  
FOR  
DIESEL ENGINE, MODEL 4045TF151  
4 CYLINDER, 4.5 LITER**

**(NSN: 2815-01-462-2289) (EIC: N/A)**

**REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS**

You can help improve this manual. If you find any mistakes, or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms) or DA Form 2028-2 located in back of this manual directly to: Commander, US Army Communications-Electronics Command and Fort Monmouth, ATTN: AMSEL-LC-LEO-D-CS-CFO, Fort Monmouth, New Jersey 07703-5006. The fax number is 732-532-1413, DSN 992-1413. You may also e-mail your recommendations to AMSEL-LC-LEO-PUBS-CHG@mail1.monmouth.army.mil.

For Air Force, submit AFTO Form 22 (Technical Order System Publication Improvement Report and Reply) in accordance with paragraph 6-5, Section VI, TO 00-5-1. Forward direct to prime ALC/MST.

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## TABLE OF CONTENTS

Chapter/Section		Page
	HOW TO USE THIS MANUAL.....	ix
CHAPTER 1	INTRODUCTION .....	1-1
Section I.	GENERAL INFORMATION .....	1-1
Section II.	EQUIPMENT DESCRIPTION AND DATA.....	1-2
Section III	PREPARATION FOR USE.....	1-8
CHAPTER 2	OPERATING INSTRUCTIONS.....	2-1
Section I.	PRINCIPLES OF OPERATION .....	2-1
Section II.	OPERATING INSTRUCTIONS.....	2-2
Section III.	SPECIAL INSTRUCTIONS .....	2-2
CHAPTER 3	UNIT MAINTENANCE INSTRUCTIONS.....	3-1
Section I.	LUBRICATION INSTRUCTIONS.....	3-1
Section II.	REPAIR PARTS; TOOLS; SPECIAL TOOLS; TEST, MEASUREMENT AND DIAGNOSTIC (TMDE); AND SUPPORT EQUIPMENT .....	3-1
Section III.	PREVENTIVE MAINTENANCE CHECKS AND SERVICES (PMCS).....	3-1
Section IV	TROUBLESHOOTING .....	3-3
Section V.	MAINTENANCE PROCEDURES .....	3-15
CHAPTER 4	DIRECT SUPPORT MAINTENANCE INSTRUCTIONS.....	4-1
Section I.	TROUBLESHOOTING .....	4-1
Section II.	MAINTENANCE PROCEDURES .....	4-14
CHAPTER 5	GENERAL SUPPORT MAINTENANCE INSTRUCTIONS.....	5-1
Section I.	TROUBLESHOOTING .....	5-1
Section II.	MAINTENANCE PROCEDURES.....	5-1
Appendix A	References.....	A-1
Appendix B	Maintenance Allocation Chart (MAC).....	B-1
Appendix C	Components of End Item and Basic Issue Items List.....	C-1
Appendix D	Additional Authorization List .....	D-1
Appendix E	Expendable and Durable Items List .....	E-1
Appendix F	Illustrated List of Manufactured Items.....	F-1
Appendix G	Torque Limits .....	G-1
Appendix H	Mandatory Replacement Parts .....	H-1
Alphabetical Index	.....	Index-1

## LIST OF ILLUSTRATIONS

Figure		Page
Figure 1-1.	Engine Components .....	1-4
Figure 1-2.	Option Code Label.....	1-5
Figure 3-1.	Thermostat and Water Manifold/Thermostat Cover .....	3-19
Figure 3-2.	Thermostat Installation .....	3-21
Figure 3-3.	Water Pump Assembly .....	3-22
Figure 3-4.	Battery Charging Alternator and Mounting .....	3-24
Figure 3-5.	Starter Solenoid Test Circuit .....	3-25
Figure 3-6.	Starter Assembly.....	3-27
Figure 3-7.	Intake Manifold .....	3-28
Figure 3-8.	Exhaust Manifold.....	3-29
Figure 3-9.	Oil Filter Assembly.....	3-30
Figure 3-10.	Oil Cooler Assembly .....	3-32
Figure 3-11.	Oil Fill Tube Assembly.....	3-33
Figure 3-12.	Oil Dipstick Tube Assembly.....	3-34
Figure 3-13.	Oil Dipstick Tube Installation.....	3-35
Figure 3-14.	Oil Pan .....	3-36
Figure 3-15.	Fuel Filter Assembly.....	3-38
Figure 3-16.	Fuel Supply Pump.....	3-39
Figure 3-17.	Fuel Injection Assembly .....	3-41
Figure 4-1.	Battery Charging Alternator Test Circuit.....	4-14
Figure 4-2.	Battery Charging Alternator Assembly.....	4-16
Figure 4-3.	Stator and Rear Housing Separation .....	4-17
Figure 4-4.	Testing Brush Assembly .....	4-17
Figure 4-5.	Testing Exciting Diodes .....	4-18
Figure 4-6.	Testing Positive/Negative Diodes.....	4-18
Figure 4-7.	Testing Stator Windings .....	4-19
Figure 4-8.	Testing Rotor .....	4-20
Figure 4-9.	Starter Bench Test Setup .....	4-22
Figure 4-10.	Starter Assembly.....	4-23
Figure 4-11.	Disconnecting Lead Wire (Typical).....	4-24
Figure 4-12.	Removing Through Bolts (Typical).....	4-24
Figure 4-13.	Removing Starter End Frame and Yoke Assembly (Typical).....	4-25
Figure 4-14.	Removing Brushes.....	4-25
Figure 4-15.	Removing Armature.....	4-26
Figure 4-16.	Removing Housing (Typical) .....	4-26
Figure 4-17.	Removing Overrunning Clutch (Typical) .....	4-27
Figure 4-18.	Removing Steel Ball .....	4-27
Figure 4-19.	Removing Pinion, Retainer, and Rollers (Typical).....	4-28
Figure 4-20.	Removing Washer and Spring .....	4-28
Figure 4-21.	Checking Commutator Run-Out .....	4-29
Figure 4-22.	Measuring Commutator OD .....	4-29
Figure 4-23.	Measuring Segment Mica Depth.....	4-30
Figure 4-24.	Inspecting and Replacing Bearings.....	4-30
Figure 4-25.	Measuring Brush Length.....	4-31

LIST OF ILLUSTRATIONS (CONTINUED)

Figure		Page
Figure 4-26.	Checking Overrunning Clutch.....	4-31
Figure 4-27.	Growler Test .....	4-32
Figure 4-28.	Testing for Grounded Windings.....	4-32
Figure 4-29.	Checking for Open Circuit Windings.....	4-33
Figure 4-30.	Checking Brush Holder Assembly .....	4-33
Figure 4-31.	Checking Field Coils.....	4-34
Figure 4-32.	Checking for Open Field Coil .....	4-34
Figure 4-33.	Installing Brushes.....	4-35
Figure 4-34.	Installing Cover On Yoke .....	4-36
Figure 4-35.	Installing Yoke.....	4-36
Figure 4-36.	Turbocharger.....	4-39
Figure 4-37.	Turbocharger Inspection Points .....	4-40
Figure 4-38.	Inspecting Turbocharger Bearings .....	4-43
Figure 4-39.	Oil Pressure Regulating Valve Assembly .....	4-47
Figure 4-40.	Pick-Up Tube Assembly .....	4-49
Figure 4-41.	Separating Gear and Shaft.....	4-52
Figure 4-42.	Check Timing Marks .....	4-53
Figure 4-43.	Fuel Injection Pump Pressure Outlet Ports .....	4-55
Figure 4-44.	Fuel Injection Nozzle Assembly .....	4-59
Figure 4-45.	Rocker Arm Cover.....	4-65
Figure 4-46.	Engine Timing Hole Location.....	4-66
Figure 4-47.	Rocker Arm Location.....	4-67
Figure 4-48.	Rocker Arm Assembly .....	4-70
Figure 4-49.	Cylinder Head Assembly .....	4-75
Figure 4-50.	Fuel Transfer Pump Push Rod Location .....	4-76
Figure 4-51.	Valve Recess Measurement .....	4-76
Figure 4-52.	Cylinder Head Capscrew Torque Sequence.....	4-79
Figure 4-53.	Flywheel Flatness.....	4-82
Figure 4-54.	Flywheel Removal .....	4-82
Figure 4-55.	Flywheel Housing Cutouts .....	4-83
Figure 4-56.	Flywheel Ring Gear .....	4-83
Figure 4-57.	Removal of Rear Crankshaft Oil Seal .....	4-84
Figure 4-58.	Rear Camshaft Oil Seal Installation.....	4-86
Figure 4-59.	Flywheel and Housing Assembly .....	4-88
Figure 4-60.	Gasket Application to Cylinder Block .....	4-89
Figure 4-61.	Crankshaft Pulley .....	4-90
Figure 4-62.	Fan Drive Assembly.....	4-91
Figure 4-63.	Timing Gear Cover .....	4-93
Figure 4-64.	Engine Lifting .....	4-97
Figure 5-1.	Fuel Injection Pump.....	5-6
Figure 5-2.	Clip Removal .....	5-9
Figure 5-3.	Droop Control Locking Cap Removal .....	5-9

# LIST OF ILLUSTRATIONS (CONTINUED)

Figure		Page
Figure 5-4.	Control Rod Assembly and Governor Spring Removal .....	5-10
Figure 5-5.	Cam Advance Pin Removal .....	5-11
Figure 5-6.	Reed Valve Removal. ....	5-11
Figure 5-7.	Linkage Hook Disconnection .....	5-12
Figure 5-8.	Hydraulic Head Assembly Removal. ....	5-12
Figure 5-9.	Governor Arm and Linkage Hook Removal .....	5-13
Figure 5-10.	Drive Shaft Bearing and Seal Removal (Shown Removed) .....	5-14
Figure 5-11.	Transfer Pump End Cap Seal Removal (Typical). ....	5-14
Figure 5-12.	Cam Ring Removal .....	5-15
Figure 5-13.	Pumping Plunger Removal .....	5-15
Figure 5-14.	Delivery Valve Removal.....	5-16
Figure 5-15.	Retaining Clip Removal.....	5-16
Figure 5-16.	Fuel Injection Housing .....	5-17
Figure 5-17.	Drive Shaft.....	5-18
Figure 5-18.	Cam Ring.....	5-19
Figure 5-19.	Hydraulic Head Assembly (Typical) .....	5-20
Figure 5-20.	Distributor Rotor Assembly (Typical) .....	5-20
Figure 5-21.	Shoes and Rollers .....	5-21
Figure 5-22.	Leaf Springs.....	5-21
Figure 5-23.	Transfer Pump Blades .....	5-22
Figure 5-24.	Transfer Pump Liner.....	5-23
Figure 5-25.	Transfer Pump Regulating Piston and Adjusting Screw .....	5-23
Figure 5-26.	Transfer Pump Regulator Assembly .....	5-24
Figure 5-27.	Metering Valve and Arm Assembly.....	5-25
Figure 5-28.	Delivery Valve.....	5-25
Figure 5-29.	Fuel Side Seal Installation .....	5-26
Figure 5-30.	Oil Side Seal Installation .....	5-27
Figure 5-31.	Drive Shaft Bearing Installation .....	5-27
Figure 5-32.	Seal Protection Tube.....	5-28
Figure 5-33.	Thrust Bearing and Thrust Washer .....	5-28
Figure 5-34.	Spring Washer and Retaining Ring .....	5-29
Figure 5-35.	Timing Mark Locator .....	5-29
Figure 5-36.	Weight Retaining Assembly .....	5-30
Figure 5-37.	Tightening Delivery Valve Stop Screw .....	5-30
Figure 5-38.	Pumping Plunger Installation.....	5-31
Figure 5-39.	Installing Rollers and Shoes (Typical).....	5-31
Figure 5-40.	Measuring Roller to Roller Dimension.....	5-32
Figure 5-41.	Transfer Pump Liner Installation (Typical) .....	5-33
Figure 5-42.	Transfer Pump Blade Installation (Typical) .....	5-33
Figure 5-43.	Regulator Assembly Installation (Typical) .....	5-34
Figure 5-44.	Governor Weight Installation (Typical).....	5-35

LIST OF ILLUSTRATIONS (CONTINUED)

Figure		Page
Figure 5-45.	Thrust Washer Installation (Typical) .....	5-35
Figure 5-46.	Thrust Sleeve Installation (Typical).....	5-36
Figure 5-47.	Head and Rotor Assembly Installation (Typical).....	5-36
Figure 5-48.	Control Spring Installation.....	5-37
Figure 5-49.	Control Rod Installation.....	5-38
Figure 5-50.	Droop Control Locking Cap Installation.....	5-38
Figure 5-51.	Damper Barrel and Piston.....	5-39
Figure 5-52.	Throttle Installation.....	5-39
Figure 5-53.	Setting Governor Linkage Gap .....	5-40
Figure 5-54.	Reed Valve Assembly .....	5-41
Figure 5-55.	Piston and Piston Ring Seal .....	5-41
Figure 5-56.	Piston Ring.....	5-42
Figure 5-57.	Piston Ring Compressor.....	5-42
Figure 5-58.	Piston in Power Side Piston Hole .....	5-43
Figure 5-59.	Power Side Piston Hole Plug Installation .....	5-43
Figure 5-60.	Aligning Pin Hole in Piston .....	5-44
Figure 5-61.	Camshaft and Balancer Shafts.....	5-47
Figure 5-62.	Measuring Camshaft Lobe Height .....	5-50
Figure 5-63.	Idler Gears .....	5-55
Figure 5-64.	Spring Pin Protrusion.....	5-56
Figure 5-65.	Front Plate.....	5-57
Figure 5-66.	Front Plate Sealant Application .....	5-59
Figure 5-67.	Crankshaft and Main Bearings.....	5-61
Figure 5-68.	Critical Areas of Crankshaft Load Stress .....	5-63
Figure 5-69.	Measuring Main Thrust Journal and Thrust Bearing Width.....	5-65
Figure 5-70.	Fastening Cylinder Liners .....	5-71
Figure 5-71.	Removing Carbon From Cylinder Liners .....	5-71
Figure 5-72.	Pistons, Connecting Rods and Cylinder Liners .....	5-74
Figure 5-73.	Piston Inspection (Defects Exaggerated) .....	5-75
Figure 5-74.	Checking Piston Keystone Ring Groove Wear .....	5-75
Figure 5-75.	Measuring Piston Ring Groove Clearance .....	5-76
Figure 5-76.	Measuring Piston Skirt.....	5-76
Figure 5-77.	Measuring Rod Center-to-Center Bores .....	5-80
Figure 5-78.	Inspecting Cylinder Liner Pitting .....	5-86
Figure 5-79.	Inspecting Piston Cooling Orifice .....	5-95
Figure 5-80.	Oil Gallery Plugs.....	5-96
Figure 5-81.	Inspecting Cylinder Block.....	5-97
Figure 5-82.	Measuring Main Bearing Bore.....	5-98
Figure 5-83.	Measuring Cam Follower Bore Diameter .....	5-99
Figure 5-84.	Measuring Camshaft Bore Diameter .....	5-99
Figure 5-85.	Measuring Cylinder Block Top Deck Flatness .....	5-100
Figure 5-86.	Oil Pump Assembly .....	5-103



LIST OF ILLUSTRATIONS (CONTINUED)

Figure		Page
Figure 5-87.	Oil Pump Axial Clearance .....	5-104
Figure 5-88.	Oil Pump Radial Clearance Measurement .....	5-105
Figure 5-89.	Oil Bypass Valve. ....	5-107
Figure 5-90.	Valve Face Angle .....	5-110
Figure 5-91.	Measuring Cylinder Head Thickness .....	5-112
Figure 5-92.	Valve Seat Removal Chisel .....	5-115
Figure 5-93.	Removal of Valve Seat Insert .....	5-115
Figure 5-94.	Valve Seat Bore in Cylinder Head .....	5-116
Figure 5-95.	Valve Installation.....	5-117

# LIST OF TABLES

Table		Page
Table 1-1.	Table of Specifications .....	1-5
Table 1-2.	Engine Option Codes - 6 Cylinder, 6.8 Liter .....	1-6
Table 3-1.	Preventive Maintenance Checks and Services (PMCS) .....	3-2
Table 3-2.	Unit Troubleshooting .....	3-4
Table 4-1.	Direct Support Troubleshooting.....	4-2
Table 4-2.	Valve Clearance Specification (Rocker Arm-To-Valve Tip).....	4-68
Table 4-3.	Valve Lift Specifications at 0.00 in. (mm) Valve Clearance.....	4-69
Table 4-4.	Valve Recess Specifications .....	4-77
Table 4-5.	Cylinder Block Top Deck Specifications.....	4-78
Table 4-6.	Flywheel Face Flatness Specifications .....	4-82
Table 5-1.	Procedural Index for General Support Maintenance .....	5-1
Table 5-2.	Fuel Injection Pump Checks .....	5-5
Table 5-3.	Camshaft Lobe Height Specifications .....	5-50
Table 5-4.	Camshaft and Timing Gear Train Specifications .....	5-53
Table 5-5.	Crankshaft and Main Bearings Specifications .....	5-64
Table 5-6.	Connecting Rod Journal and Bearing Specifications .....	5-77
Table 5-7.	Connecting Rod Bore (Without Bearing Inserts) Specifications.....	5-78
Table 5-8.	Connecting Rod Piston Pin Bushing Specifications.....	5-79
Table 5-9.	Cylinder Liner Height Specifications.....	5-83
Table 5-10.	Cylinder Liner Thickness Specifications.....	5-87
Table 5-11.	Piston and Cylinder Liner Specifications .....	5-87
Table 5-12.	Valve Seat Bore Insert Specifications .....	5-117

## HOW TO USE THIS MANUAL

In this manual (TM 9-2815-259-24) paragraphs are underlined and sections and chapters appear in capital letters. The location of additional material that must be referenced is clearly marked. Illustrations in this text are located as close as possible to their references.

Chapter 1 - INTRODUCTION. This section contains general information, equipment description and data, and principles of operation for the engine.

Chapter 2 - OPERATING INSTRUCTIONS. This section contains functional descriptions of the engine systems and how they are connected to the end item. For operation, refer to end item operator's manual.

Chapter 3 - UNIT MAINTENANCE INSTRUCTIONS. This section contains troubleshooting procedures used to recognize and correct engine malfunctions at the unit level, and all maintenance procedures authorized to be performed on the engine the unit level.

Chapter 4 - DIRECT SUPPORT MAINTENANCE INSTRUCTIONS. This section contains direct support level troubleshooting procedures used to recognize and correct engine malfunctions at the direct support level, and all maintenance procedures authorized to be performed on the engine at the direct support level.

Chapter 5 - GENERAL SUPPORT MAINTENANCE INSTRUCTIONS. This section contains general support maintenance instructions which are limited to the disassembly, cleaning, inspection and assembly of components after troubleshooting has already been accomplished.

## APPENDICES.

Appendix A lists all forms, field manuals, technical manuals and miscellaneous publications referenced in this manual and should be used in conjunction with this manual.

Appendix B is the Maintenance Allocation Chart (MAC) which designates all maintenance and repair functions authorized to be performed at the different maintenance levels.

Appendix C lists the Components of End Item (COEI) and Basic Issue Items (BII) lists.

Appendix D. Refer to End Item Maintenance Manual Appendix D for lists of items authorized for use with the generator set, but not issued with it or supported by generator set engineering drawings.

Appendix E lists expendable supplies and materials required to operate and maintain the generator set. These items are authorized by CTA 50-970, Expendable Items (except medical, Class V, repair parts, and heraldic items).

Appendix F includes complete instructions for fabricating or assembling parts as required for the engine.

Appendix G provides torque limits for fasteners used in maintenance of the engine.

Appendix H lists parts that must be replaced if removed during maintenance.



## CHAPTER 1 INTRODUCTION

### Section I. GENERAL INFORMATION

#### 1.1. SCOPE.

- a. Type of Manual. This manual contains unit, direct support, and general support maintenance instructions for the Model TO4045TF151 Diesel Engine, hereafter referred to as engine. Also included are descriptions of major systems/components and their functions in relation to other systems/components.
- b. Purpose of Equipment. The engine provides a driving force for generators or other equipment requiring this size (HP rating) and compatibility.

#### 1.2. MAINTENANCE FORMS, RECORDS, AND REPORTS.

- a. Reports of Maintenance and Unsatisfactory Equipment. Department of the Army forms and procedures used for equipment maintenance will be those prescribed by DA Pam 738-750, Army Maintenance Management System (TAMMS). Air Force personnel will use AFR 66-1, Air Force Maintenance Management Policy, for maintenance reporting and TO-OO-35D54 for unsatisfactory equipment reporting.
- b. Reporting of Item and Packaging Discrepancies. Fill out and forward SF 364 (Report of Discrepancy (ROD)) as prescribed in AR 735-11-2/DLAR 414-55/SECNAVINST 4355.18/AFR 400-54/MCO 4430.3J.
- c. Transportation Discrepancy Report (TDR) (SF 361). Fill out and forward Transportation Discrepancy Report (TDR) (SF361) as prescribed in AR 55-38/NAVSUPINST 4610.33C/AFR 75-18/MCO P4610.19D/DLAR 4500.15.

#### 1.3. REPORTING EQUIPMENT IMPROVEMENT RECOMMENDATIONS (EIR).

Army - If your equipment needs improvement, let us know. Send us an EIR. You, the user, are the only one who can tell us what you don't like about your equipment. Let us know why you don't like the design or performance. Put it on a SF 368 (Product Quality Deficiency Report). Mail it to us at the address below. We'll send you a reply. The fax number is 908-532-1413, DSN 992-1413. You may also e-mail your recommendations to AMSEL-LC-LEO-PUBS-CHG@cecom3.monmouth.army.mil.

Commander  
U.S. Army Communications and Electronics Command (CECOM)  
ATTN: AMSEL-LC-LEO-D-CS-CFO  
Fort Monmouth, New Jersey 07703-5008

(AF) USAF Deficiency Reporting and Investigating System, TO 00-35D-54, Appendix A procedures will be used for electronic submission. Submit mailed forms to:

SMALC/LHCABD  
5029 Dudley Boulevard  
McClellan AFB, CA 95652-1095

**ARMY TM 9-2815-259-24**  
**AIR FORCE TO 38G1-125-2**  
**MARINE CORPS 09249A/09246A-24**

(MC) Quality Deficiency Reports (QDR) shall be submitted on SF 368 in accordance with MCO 4855.10. Submissions may also be made using NAVMC Form 10772. Submit directly to:

Commander  
Marine Corps Logistics Bases  
(Code 856)  
Albany, GA 31704-5000

A reply will be furnished to you.

1.4. DESTRUCTION OF ARMY MATERIAL TO PREVENT ENEMY USE.

Refer to TM 750-244-3 for procedures to destroy equipment to prevent enemy use.

1.5. CORROSION PREVENTION AND CONTROL.

Refer to Corrosion and Corrosion Prevention: Metals, MIL-HDBK-729.

1.6. PREPARATION FOR STORAGE OR SHIPMENT.

Refer to TB 740-97-2 for procedures to place the equipment into storage.

1.7. WARRANTY.

The engine is warranted for a specific period of time. Refer to Warranty Technical Bulletin for the end item. The warranty begins from the date stamped on the data plate. Report all defects in material or workmanship to your supervisor, who will take appropriate action.

**Section II. EQUIPMENT DESCRIPTION AND DATA**

1.8. GENERAL.

The diesel engine (Figure 1-1) is four cylinder, four cycle, fuel injected, turbocharged, and liquid cooled. The firing order is 1-3-4-2. The number one cylinder is toward the fan end of the engine. The serial number is found on top of valve cover. Rotation of engine is counterclockwise as viewed from rear of engine facing forward.

**NOTE**

All locations referenced herein are given from rear of engine facing forward.

1.9. DETAILED DESCRIPTION.

- a. Turbocharger. A turbocharger, operated by exhaust gases, compresses intake air and routes it to the combustion chamber.
- b. Camshaft. The camshaft is driven by an intermediate gear in the timing gear train which meshes with the crankshaft gear. Camshaft rotates in honed machined bores in cylinder block; no bushings are used. The camshaft lobes determine the time and rate of opening of each valve and actuates the fuel supply pump.

- c. Intake and Exhaust Valves. Intake and exhaust valves are operated by cam followers, push rods, and rocker arm assembly. Valve seat inserts in cylinder head are used for intake and exhaust valves.
- d. Crankshaft. The crankshaft is a one-piece, heat treated, steel forging which operates in replaceable two-piece main bearings. The rear thrust bearing has a flange on each side to support crankshaft thrust and to limit end play.
- e. Cylinder Liners and Pistons. Cylinder liners are "wet" (surrounded by coolant) and are individually replaceable. O-rings are used to seal the connection between cylinder block and liners. Pistons are made of cast high-grade aluminum alloy with internal ribbing. The skirt is cam ground to allow for expansion when heated during operation. The piston crown has a cut-out swivel cup with a truncated cone in the center. Two compression rings and one oil control ring are used. The top compression ring is a keystone type ring. All piston rings are located above the piston pin. The hardened piston pins are fully-floating and held in position by means of retainer rings. Spray jets (piston cooling orifices) in cylinder block direct pressurized oil to lubricate piston pins and cool pistons. Connecting rods are forged steel and have replaceable bushing and bearing inserts.
- f. Cooling System. The cooling system consists of a radiator, water pump, cooling fan, thermostat, and connecting hoses. The fan and water pump are both belt driven from the crankshaft pulley. The thermostats control engine temperature and are installed in top of engine. The function of the cooling system is to maintain a specific operating temperature of 180 to 220°F (82 to 104°C) for the engine.
- g. Lubrication System. The lubrication system consists of oil pan (sump), a gear type pump, full flow spin-on oil filter with built-in bypass valve, oil cooler with built-in bypass valve, pressure regulating valve, bypass valve, and the internal passages.
- h. Fuel System. The function of the fuel system is to inject a metered quantity of clean atomized fuel into the engine cylinders at a precise time near the end of the compression stroke of each piston. The fuel system consists of the fuel tank, fuel filter/water separator, fuel supply pump, fuel injection pump, and the fuel injectors. The fuel tank is not mounted on the engine. The fuel supply pump is mounted to the block and is driven by the camshaft. The fuel injection pump is mounted on the front plate and is driven by an intermediate gear in the timing gear train meshing with crankshaft gear.
- i. Electrical System. The electrical system is 28VDC operation and consists of a battery charging alternator, starter, externally mounted batteries, and other items as required. The battery charging alternator is mounted on front of engine and is belt driven. When engine is operating, the battery charging alternator supplies 28VDC to recharge the batteries and maintain them at a full state of charge. The starter is mounted on the flywheel housing, and when energized, engages the ring gear of the flywheel to rotate the engine.

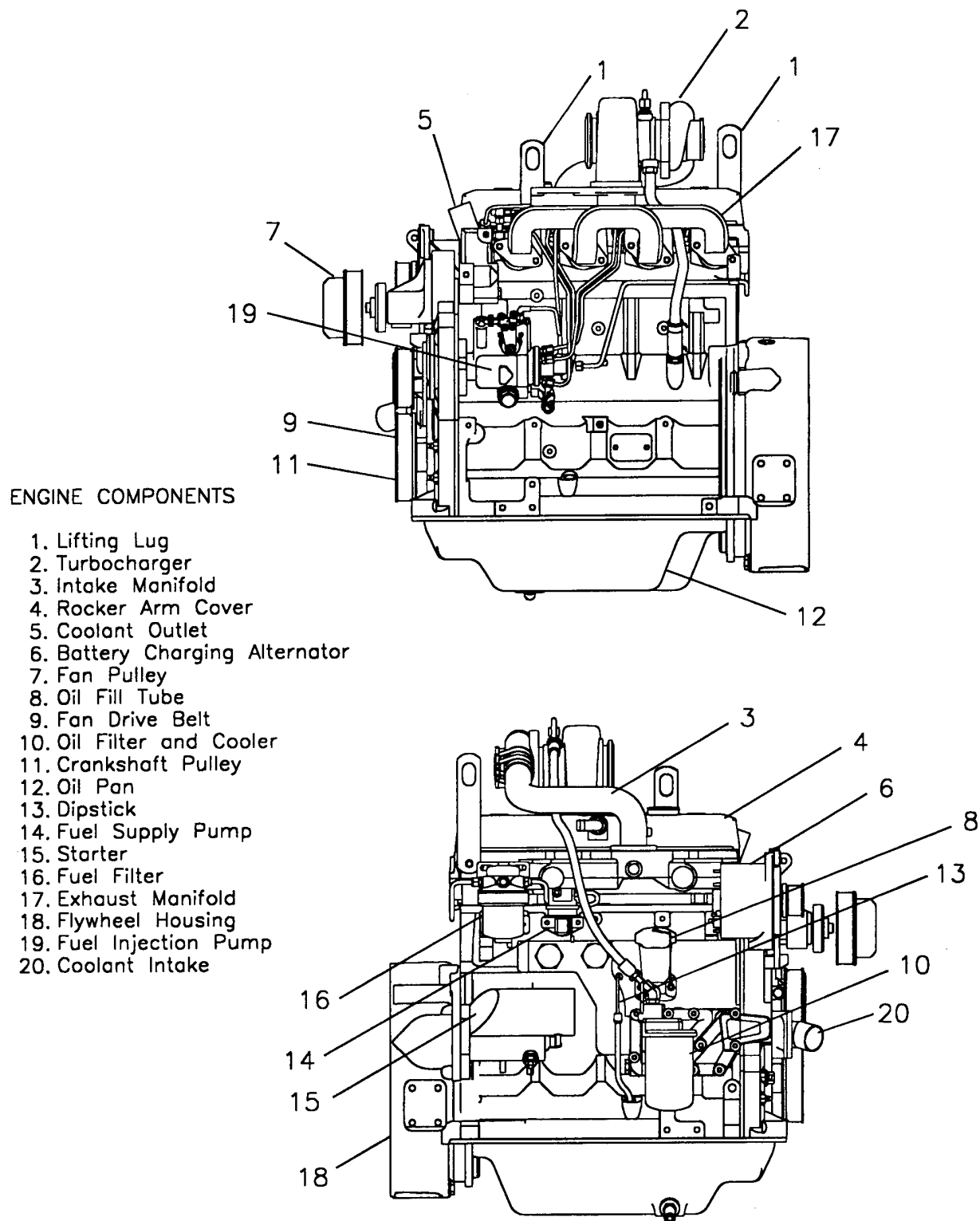


FIGURE 1-1. ENGINE COMPONENTS



#### 1.10. EQUIPMENT DATA.

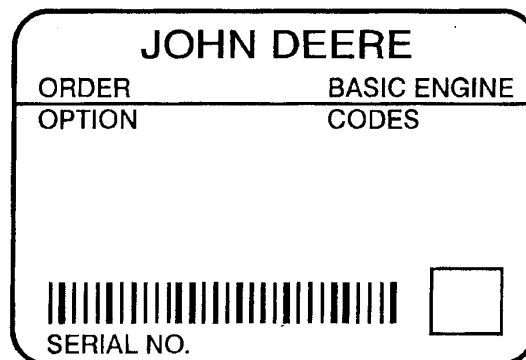
Leading Particulars. For a list of Leading Particulars, refer to TABLE 1-1.

**TABLE 1-1. TABLE OF SPECIFICATIONS**

Model .....	John Deere TO4045TF150
Type .....	EPA compliant four cylinder, four cycle, turbocharged diesel
Bore .....	4.19 in. (106 mm)
Stroke .....	5.00 (127.0 mm)
Displacement .....	276 cu in. (4.5 liters)
Compression Ratio .....	17.0:1
Firing Order .....	1-3-4-2
Width .....	23.5 in. (598 mm)
Height .....	38.6 in. (980 mm)
Length .....	33.9 in. (861 mm)
Weight .....	872 lbs (396 kg)
Injection Pump/Governor .....	Stanadyne Model DB4
Injection Starting Pressure	
New .....	3,660 psi (25,200 kPa) min
Used .....	3,330 psi (22,950 kPa) min
Cylinder Compression Pressure .....	350 psi (2400 kPa) min
Lubrication System Capacity .....	14.0 qts (13 liters)
Coolant System capacity (engine only) .....	15.5 qts. (14.7 liters)
Alternator .....	Bosch 28 volt DC - 45 amp
Starter .....	Nippon-Denso 24 volt DC - 4.5 kw

#### 1.11 DATA PLATES.

Refer to Table 1-2 for the engine option codes. The engine option codes data plate is affixed to the top of the rocker arm cover (4, Figure 1-1). These codes indicate which of the engine options were installed on your engine at the factory. These codes are important when parts and service are required. The engine option code includes an engine base code (1, Figure 1-2) which identifies the basic engine installed. The engine option code consists of a four-digit number. The first two digits of each code identify a specific group, such as alternators. The last two digits of each code identify one specific option provided on your engine, such as 12-volt, 55-amp alternator. If an engine is ordered without a particular component, the last two digits of that functional group option code will be 99, 00, or XX.



**FIGURE 1-2. OPTION CODE LABEL**

ARMY TM 9-2815-259-24  
AIR FORCE TO 38G1-125-2  
MARINE CORPS 09249A/09246A-24

TABLE 1-2. ENGINE OPTIONS CODES - 4 CYLINDER, 4.5 LITER		
ENGINE BASE CODE: 2116F		
OPTION CODES	DESCRIPTION	REMARKS
1103	Rocker Arm Cover	
1214	Oil Filler Neck	
1302	Crankshaft Pulley	
1404	Flywheel Housing	
1503	Flywheel	
1677	Fuel Injection Pump	
1701	Air Inlet	
1936	Oil Pan	
2002	Water Pump	
2112	Thermostat Cover	
2201	Thermostat	
2301	Fan Drive	
2485	Fan Belt	
2599	Fan	Not installed on engine at factory.
2699	Engine Coolant Heater	Not installed on engine at factory.
2803	Exhaust Manifold	
2999	Ventilator System	Not installed on engine at factory.
3044	Starting Motor	
3110	Alternator	
3516	Fuel Filter	
3601	Front Plate	
3702	Fuel Transfer Pump	
3999	Thermostat Housing	Not installed on engine at factory.
4020	Oil Dipstick	
4199	Belt Driven Front Auxiliary Drive	Not installed on engine at factory.
4399	Starting Aid	Not installed on engine at factory.
4401	Timing Gear Cover with Gears	
4502	Balancer Shaft	
4601	Cylinder Block With Liners and Camshaft	
4701	Crankshaft and Bearings	
TABLE 1-2. ENGINE OPTIONS CODES - 4 CYLINDER, 4.5 LITER – CONT.		

**ARMY TM 9-2815-259-24**  
**AIR FORCE TO 38G1-125-2**  
**MARINE CORPS 09249A/09246A-24**

ENGINE BASE CODE: 2116F		
OPTION CODES	DESCRIPTION	REMARKS
4803	Connecting Rods and Pistons	
4901	Valve Actuating Mechanisms	
5002	Oil Pump	
5102	Cylinder Head With Valves	
5501	Shipping Stand	
5602	Paint Option	
5707	Water Pump Inlet	
5904	Oil Cooler	
6099	Add-on Auxiliary Drive Pulley	Not installed on engine at factory.
6212	Alternator Mounting	
6499	Exhaust Elbow	Not installed on engine at factory.
6524	Turbocharger	
6699	Temperature Switch	Not installed on engine at factory.
6799	Electronic Tachometer Sensor	Not installed on engine at factory.
6901	Engine Serial Number Plate	
7499	Air Conditioner Compressor Mounting	Not installed on engine at factory.
7699	Oil Pressure Switch	Not installed on engine at factory.
8604	Fan Pulley	
8799	Automatic Belt Tensioner	Not installed on engine at factory.
8803	Oil Filter	

### **Section III. PREPARATION FOR USE**

#### **1.12. INSPECTING AND SERVICING ENGINE.**

This section provides information and guidance for inspecting, servicing, and installing the engine. For additional information, refer to end item maintenance manual.

a. Inspection.

Check that all packing materials have been removed.

Check engine identification plate for positive identification.

Inspect engine exterior for shipping damage.

Check fan drive belt for proper tension. Refer to end item maintenance manual.

Inspect engine for loose or missing mounting hardware, or damaged or missing parts.

b. Service.

Except for servicing the lubrication system, all other servicing must be accomplished after engine is mounted in the end item. Refer to the end item maintenance manual.

## CHAPTER 2 OPERATING INSTRUCTIONS

### Section I. PRINCIPLES OF OPERATION

#### 2.1. INTRODUCTION.

This section contains functional descriptions of the engine systems and how they are connected to the end item.

#### 2.2. COOLING SYSTEM.

The cooling system consists of a radiator, hoses, a thermostat, a belt driven fan, a water pump, and cooling jackets within the engine. The water pump forces coolant through passages (coolant jackets) in the engine block and oil cooler where coolant absorbs heat from the engine. When the coolant temperature is below operating temperature, the thermostat is closed and coolant is bypassed to the water pump inlet. As coolant temperature increases to 180E F (82E C), the thermostat fully opens, shutting off all bypass flow and providing full flow through the radiator. Air forced through the fins of the radiator by the fan cools the coolant pumped through the radiator. Items are added to the engine to monitor coolant temperature and to warn if temperature exceeds a predetermined value.

#### 2.3. LUBRICATION SYSTEM.

The pressure lubrication system consists of a positive displacement gear-driven pump, filter strainer in the suction pipe, full flow oil filter, oil cooler, oil pressure regulating valve, and oil bypass valve. Additionally, the oil cooler and oil filter have their own bypass valve. The pump draws lubrication oil from the crankcase through a strainer and a suction line. The oil is then pumped through an oil line to the oil cooler, oil filter, and through the main oil gallery of the cylinder block. From the oil gallery, oil is forwarded under pressure to the main bearings and spray jets to cool the pistons. Drilled cross passages in the crankshaft distribute oil from the main bearings to connecting rod bearings and camshaft bearings. A drilled passage from the rear camshaft bearing through the cylinder block and cylinder head supplies lubricating oil to the rocker arm shaft. A turbocharger oil supply line provides lubricating oil to the shaft of the turbocharger. Items are added to monitor oil pressure and to warn the operator or stop the engine if pressure drops to a dangerously low value.

#### 2.4. FUEL SYSTEM.

The fuel system consists of an external fuel tank, fuel supply pump, fuel filter, fuel injection pump, fuel injectors, and piping. The fuel supply pump draws fuel from the tank and pressurizes it. This pressure permits the fuel to flow through the fuel filter and charge the transfer pump of the fuel injection pump. With the fuel injection pump charged with fuel by the fuel supply pump, the fuel injection pump plungers pressurize the fuel to approximately 3,660 psi (25,200 kPa). Delivery (pressure) lines are used to route this high pressure fuel to the fuel injection nozzles. Fuel enters the injection nozzle at a pressure which easily overcomes the pressure required to open the nozzle valve. When the nozzle valve opens, fuel is forced out through the orifices in the nozzle tip and atomizes as it enters the combustion chamber. The fuel that is not used by the injectors and injection pump is returned to the fuel tank via an excess fuel return line.

## **2.5. ELECTRICAL SYSTEM.**

The electrical system consists of external mounted batteries, starter, battery charging alternator, and related relays and switches for control of the system. Battery power supplied to the starter during the start cycle energizes the starter which engages the ring gear of the flywheel causing the engine to turn over. When engine start is complete, the starter is deenergized and disengages from the flywheel. The battery charging alternator is belt driven. It is a 45 ampere, 28 VDC alternator that when operating supplies voltage to recharge the batteries and maintain them at a full state of charge.

## **Section II. OPERATING INSTRUCTIONS**

(Refer to end item operator's manual.)

## **Section III. SPECIAL INSTRUCTIONS.**

**2.6. NUCLEAR, BIOLOGICAL, CHEMICAL (NBC) DECONTAMINATION PROCEDURES.** The engine is capable of being operated by personnel wearing nuclear, biological, or chemical (NBC) protective clothing without special tools or support equipment. Refer to FM 3-5, NBC Decontamination for information on decontamination procedures. Specific procedures for the engine are the following:

- a. Rubber tubing and belts, coverings for electrical conduits, gaskets, and bushings will absorb and retain chemical agents. Replacement of these items is the recommended method of decontamination.
- b. Lubricants, fuel, and coolant may be present on the external surfaces of the generator set or components due to leaks or normal operation. These fluids will absorb NBC agents. The preferred method of decontamination is removal of these fluids using conventional decontamination methods in accordance with FM 3-5.
- c. The primary area that will entrap contaminants on the engine, making efficient decontamination extremely difficult, include the area around the external fuel drain. Replacement of this item, if available, is the recommended method of decontamination. Conventional decontamination methods should be used on this area, while stressing the importance of thoroughness and the probability of some degree of continuing contact and vapor hazard.
- d. In an NBC contaminated environment, all access doors on the end item unit should be closed to reduce the effects of contamination.
- e. The use of overhead shelters or chemical protective covers is recommended as an additional means of protection against contamination in accordance with FM 3-5. When using covers, care should be taken to provide adequate space for air flow and exhaust.
- f. For additional NBC information refer to FM 3-3, FM 3-4 and FM 3-5. Other services use applicable publications for NBC.

## CHAPTER 3 UNIT MAINTENANCE INSTRUCTIONS

### Section I. LUBRICATION INSTRUCTIONS

#### 3.1. LUBRICATION INSTRUCTIONS.

Refer to TM 9-6115-671-14 for special lubrication instructions. Refer to unit level Preventive Maintenance Checks and Services (PMCS) Table 3-1 for lubrication intervals.

### Section II. REPAIR PARTS; TOOLS; SPECIAL TOOLS; TEST, MEASUREMENT AND DIAGNOSTIC (TMDE); AND SUPPORT EQUIPMENT

#### 3.2. MAINTENANCE REPAIR PARTS.

Repair parts and equipment are listed and illustrated in the Repair Parts and Special Tools List (RPSTL) manual TM 9-2815-259-24P.

#### 3.3. TOOLS AND EQUIPMENT.

There are no special tools or support equipment required to perform unit level of maintenance on the engine. A list of recommended tools and support equipment required to maintain the engine is contained in Appendix B, SECTION III.

#### 3.4. FABRICATION OF TOOLS AND EQUIPMENT.

There are no fabricated tools/equipment required to perform unit level of maintenance on the engine. For fabrication of tools and equipment for maintenance of the engine, refer to Appendix F -Illustrated List of Manufactured Items.

### Section III. PREVENTIVE MAINTENANCE CHECKS AND SERVICES (PMCS)

#### 3.5. PMCS PROCEDURES.

- a. General. To ensure that engine is ready for operation at all times, it must be inspected so defects can be discovered and corrected before they result in serious damage or failure. Perform Generator Set PMCS prior to or in conjunction with performance of engine PMCS. For engine PMCS, refer to Table 3-1.
- b. Purpose of PMCS Table. Your Preventive Maintenance Checks and Services table lists the inspections and care of your equipment required to keep it in good operating condition.
- c. Purpose of Service Intervals. The interval column of your PMCS table tells you when to do a certain check or service.
- d. Procedures Column. The procedures column of your PMCS table tells you how to do the required checks and services. Carefully follow these instructions.
- e. The "Equipment Is Not Ready / Available IF" column. This column tells you when and why the engine cannot be used.

**NOTE**

The terms ready / available and mission capable refer to the same status: Engine is on hand and is able to perform its combat missions (see DA Pam 738-750).

f. Reporting and Correcting Deficiencies. If your engine does not perform as required, refer to Troubleshooting section for possible problems. Report any malfunctions or failures on DA form 2404, or refer to DA Pam 738-750.

**TABLE 3-1. Preventive Maintenance Checks and Services (PMCS)**

M - Monthly Q - Quarterly S - Semi-annually A - Annually B - Bi-annually H - Hours

Item No.	Interval						Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary	Equipment is Not Ready/ Available If:
	M	Q	S	A	B	H			
<p style="text-align: center;"><b><u>CAUTION</u></b></p> <p>Engine oil and filter must be changed at a hard time interval of 100 hours on initial break-in. Failure to change the oil and filter may void the warranty.</p>									
1			M			300	Oil Filter	Refer to paragraph 3.11.2.  <b>NOTE</b>  <b>Oil filter change interval is a hard time replacement to be used when AOAP lab is not available.</b>	
2					M	1500	Engine Compression	Check engine compression. Refer to paragraph 3.7.1.	Engine compression is low.
3					M	1500	Engine Oil Pressure	Check engine oil pressure. Refer to TM 9-6115-671-14.	Engine oil pressure not as specified
<p style="text-align: center;"><b>NOTE</b></p> <p style="text-align: center;"><b>The following PMCS items are Direct Support maintenance tasks.</b></p>									
4					M	1500	Engine Valves	Adjust engine valves at Direct Support maintenance level. See paragraph 4.7.2.	
5					M	1500	Engine Fuel Injection Nozzles	Remove, clean, and test fuel injection nozzles at Direct Support maintenance level. See paragraph 4.6.2.	



## Section IV. TROUBLESHOOTING

### 3.6. UNIT TROUBLESHOOTING PROCEDURES.

#### 3.6.1 Purpose of Troubleshooting Flowchart.

This section contains troubleshooting information for locating and correcting operating troubles which may develop in the engine. Each malfunction for an individual component, unit, or system is followed by a list of tests or inspections which will help you to determine probable causes and corrective action to take. You should perform tests/inspections and corrective actions in order listed.

Table 3-2 Unit Troubleshooting, cannot list all malfunctions that can occur, nor all tests or inspections and corrective actions. If a malfunction is not listed or cannot be corrected by listed corrective actions, notify your supervisor.

#### NOTE

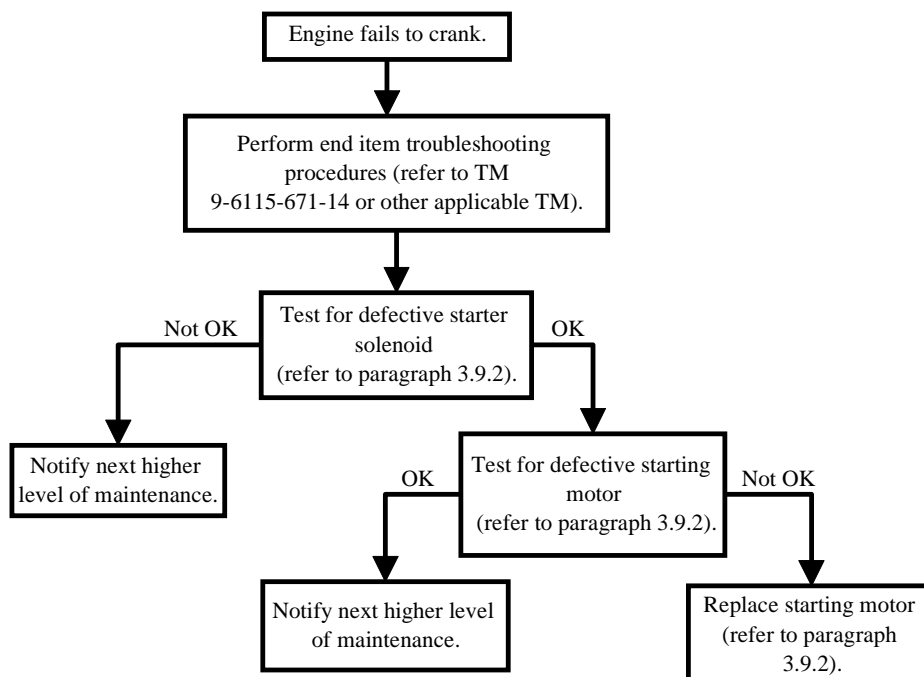
**Before you use Table 3-2, be sure you have performed your PMCS. Prior to performing troubleshooting procedures within this manual, perform troubleshooting procedures in TM 9-6115-671-14 or other applicable TM.**

#### SYMPTOM INDEX

Malfunction	Page
Engine Fails to Crank .....	3-4
Starter Operates But Engine Does Not Turn Over.....	3-4
Engine Cranks But Fails to Start.....	3-5
Engine Misfires Or Runs Erratically Or Stalls Frequently.....	3-6
Engine Does Not Develop Full Power.....	3-7
Engine Overheating .....	3-8
Excessive Oil Consumption .....	3-9
Low Oil Pressure .....	3-10
Excessive Fuel Consumption.....	3-11
Black or Gray Exhaust Smoke.....	3-12
Blue or White Exhaust Smoke.....	3-12
Engine Knocks.....	3-13
Engine Makes Abnormal Noise .....	3-13
Engine Makes a Gas Leaking Noise .....	3-14

TABLE 3-2. UNIT TROUBLESHOOTING  
 (Sheet 1 of 11)

### ENGINE FAILS TO CRANK



### STARTER OPERATES BUT ENGINE DOES NOT TURN OVER.

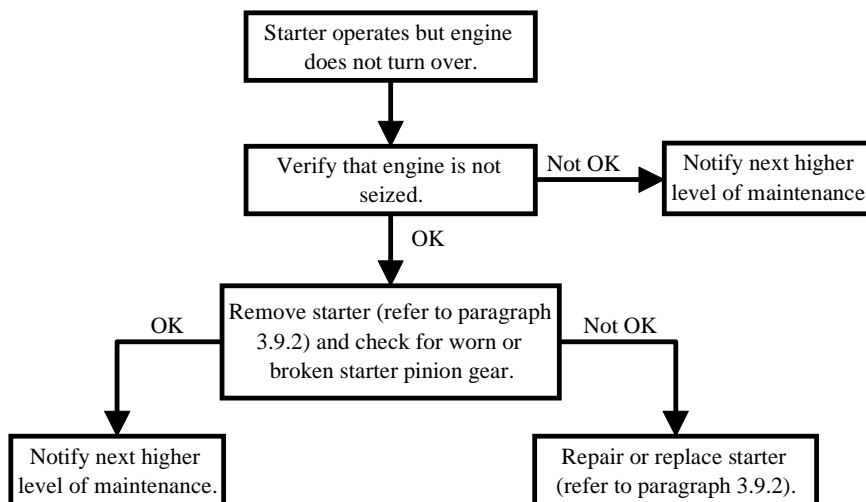


TABLE 3-2. UNIT TROUBLESHOOTING  
 (Sheet 2 of 11)

## ENGINE CRANKS BUT FAILS TO START

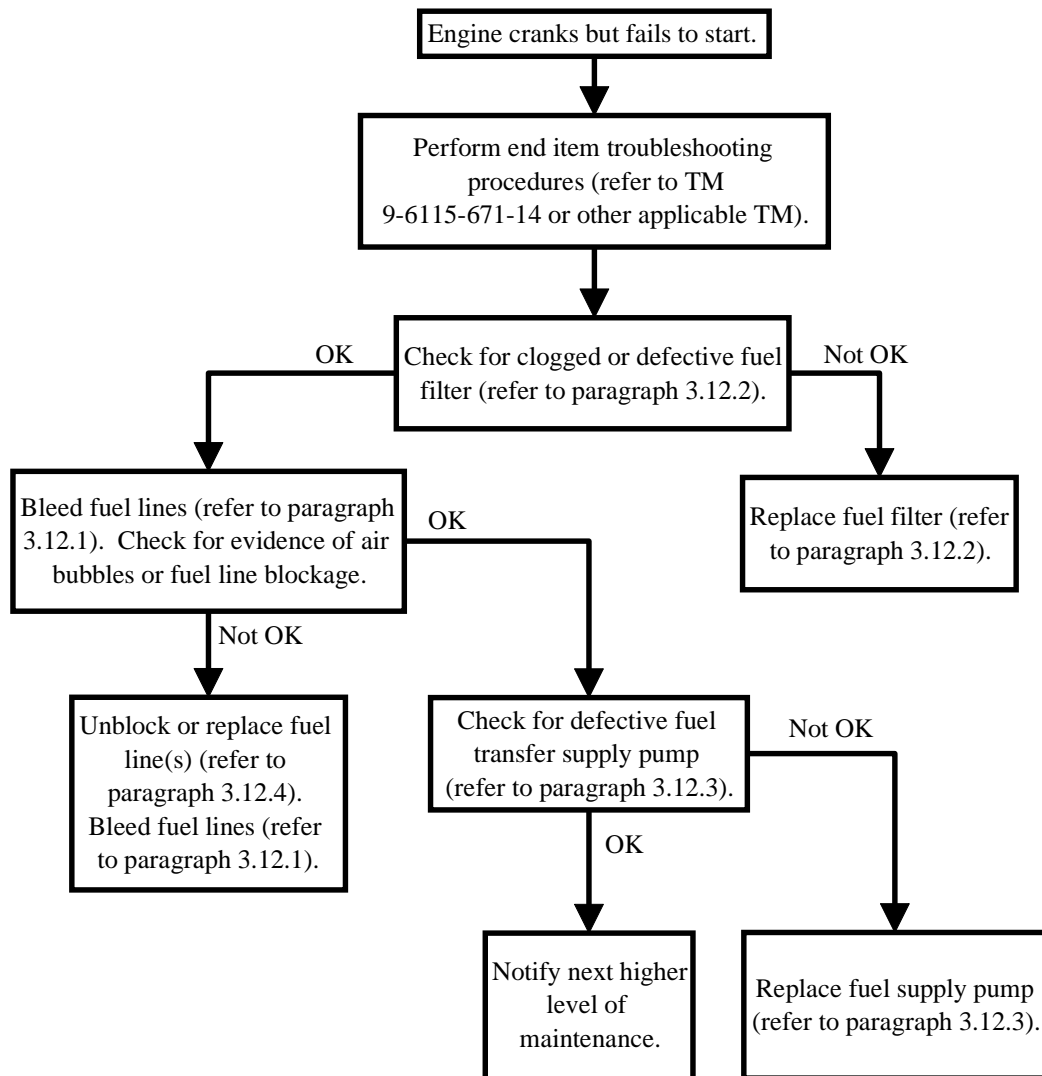


TABLE 3-2. UNIT TROUBLESHOOTING  
 (Sheet 3 of 11)

## ENGINE MISFIRES OR RUNS ERRATICALLY OR STALLS FREQUENTLY

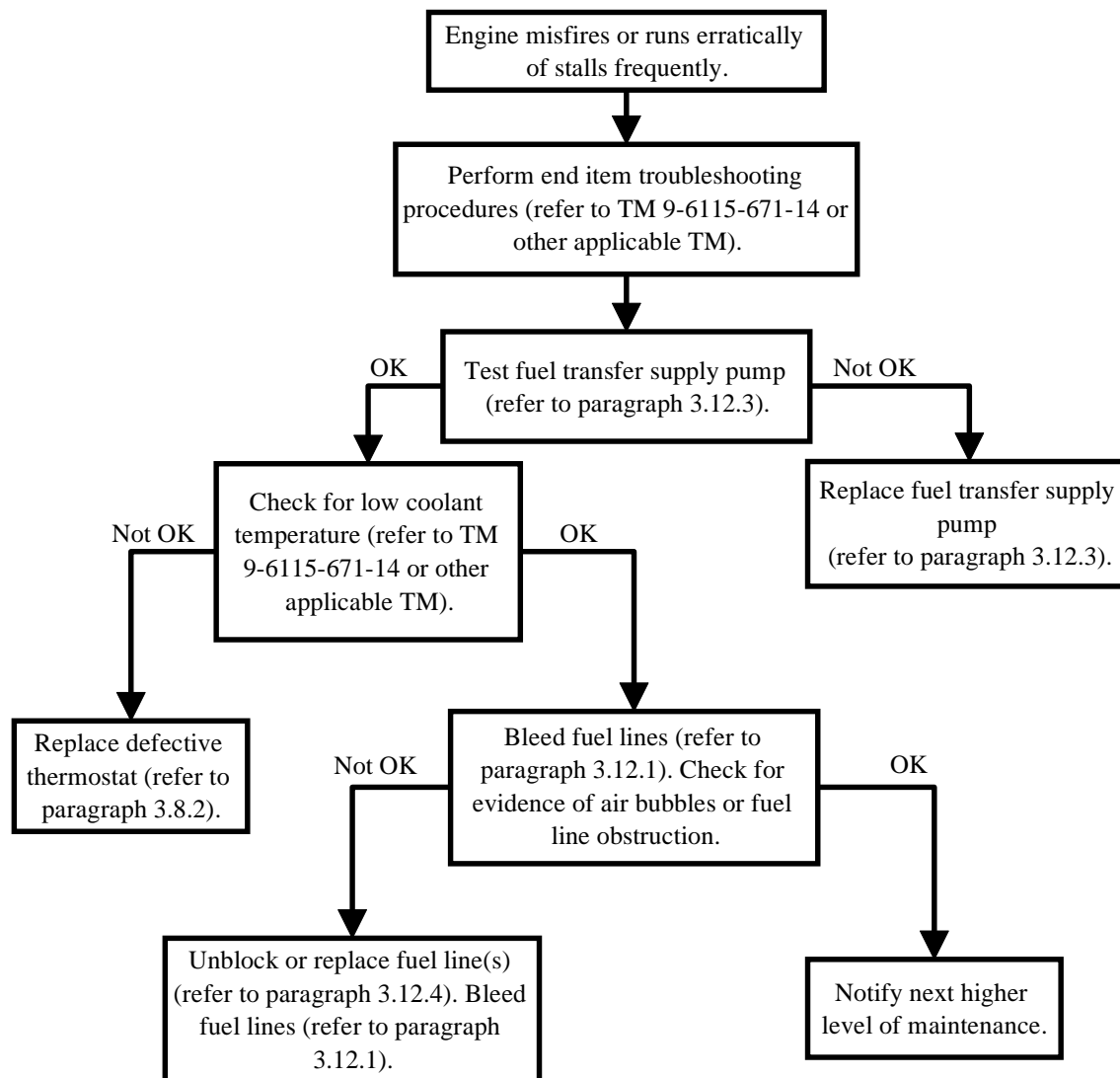


TABLE 3-2. UNIT TROUBLESHOOTING  
(Sheet 4 of 11)

### ENGINE DOES NOT DEVELOP FULL POWER

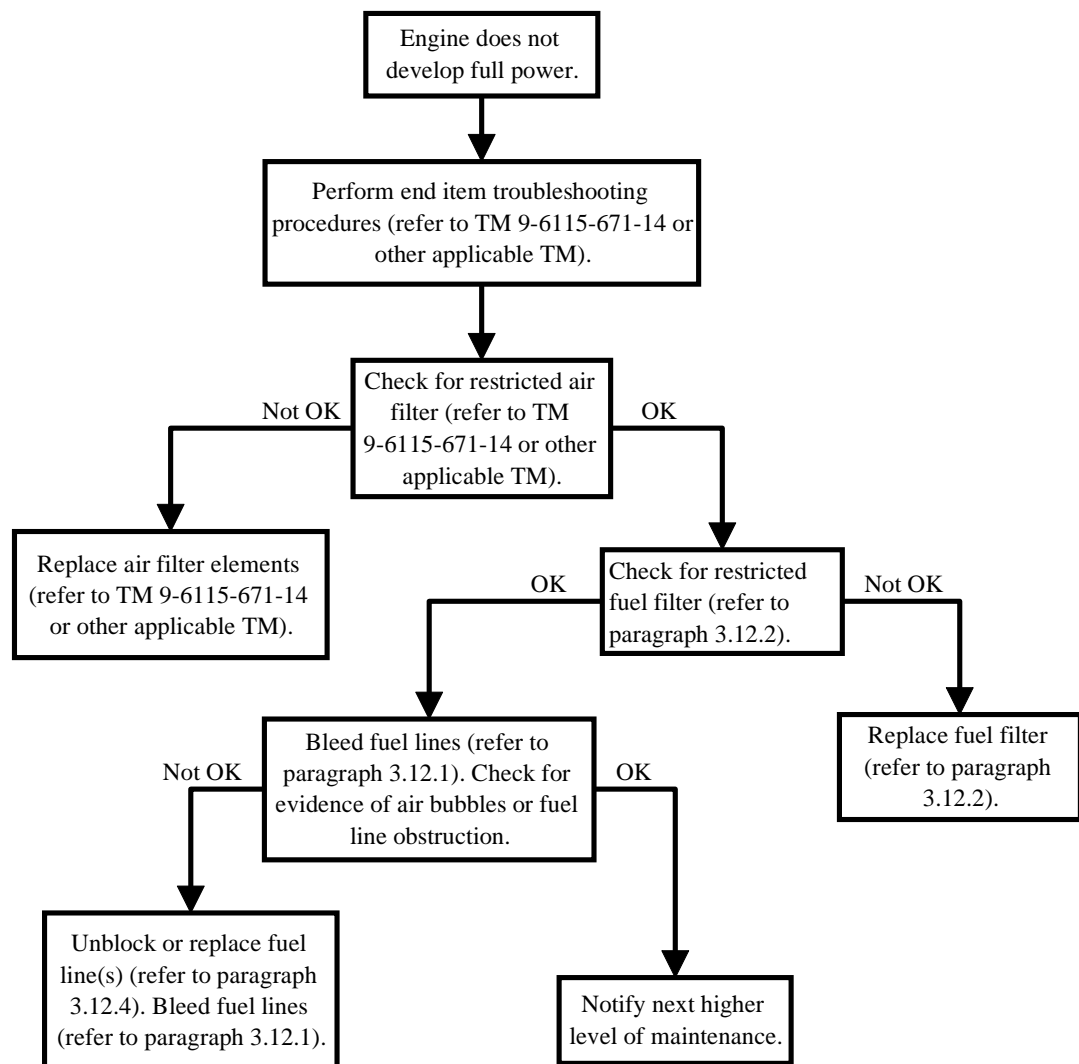


TABLE 3-2. UNIT TROUBLESHOOTING  
(Sheet 5 of 11)

## ENGINE OVERHEATING

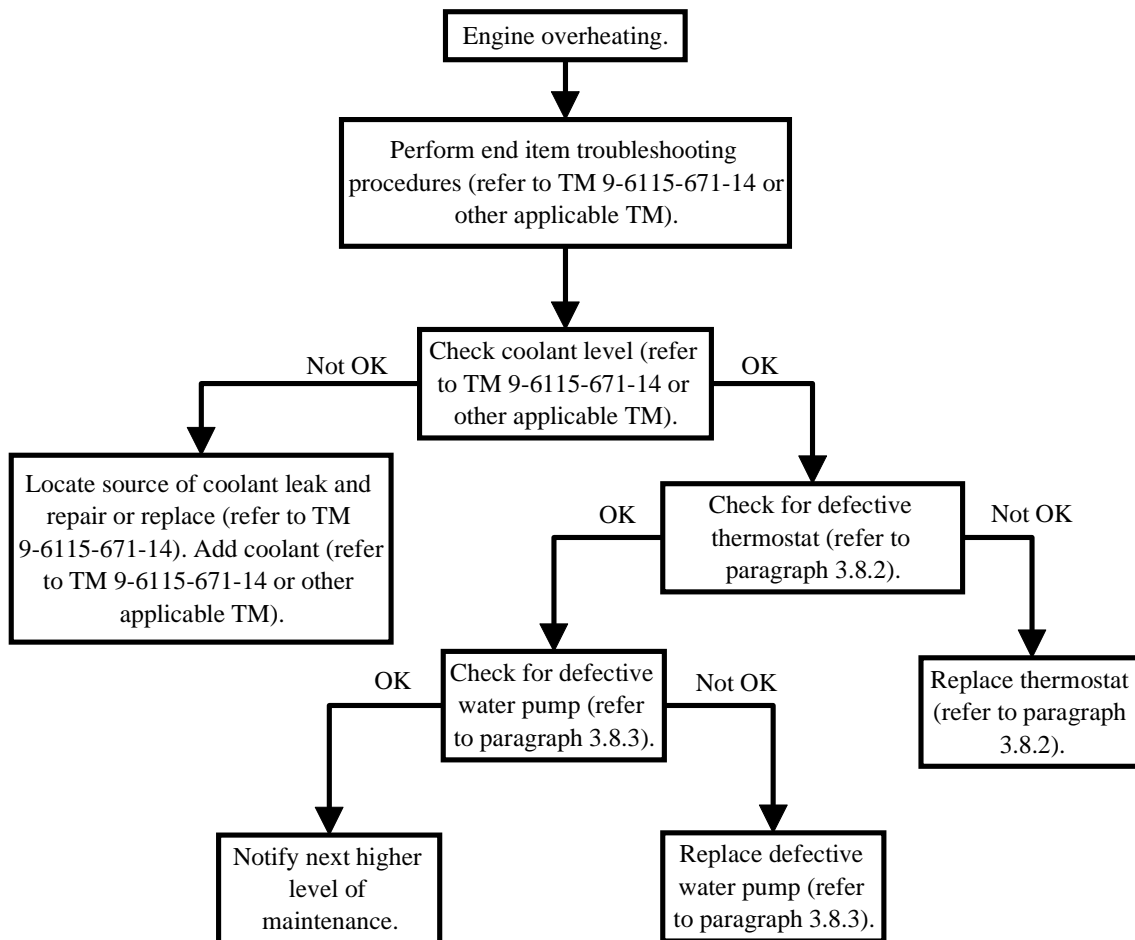


TABLE 3-2. UNIT TROUBLESHOOTING  
(Sheet 6 of 11)

## EXCESSIVE OIL CONSUMPTION

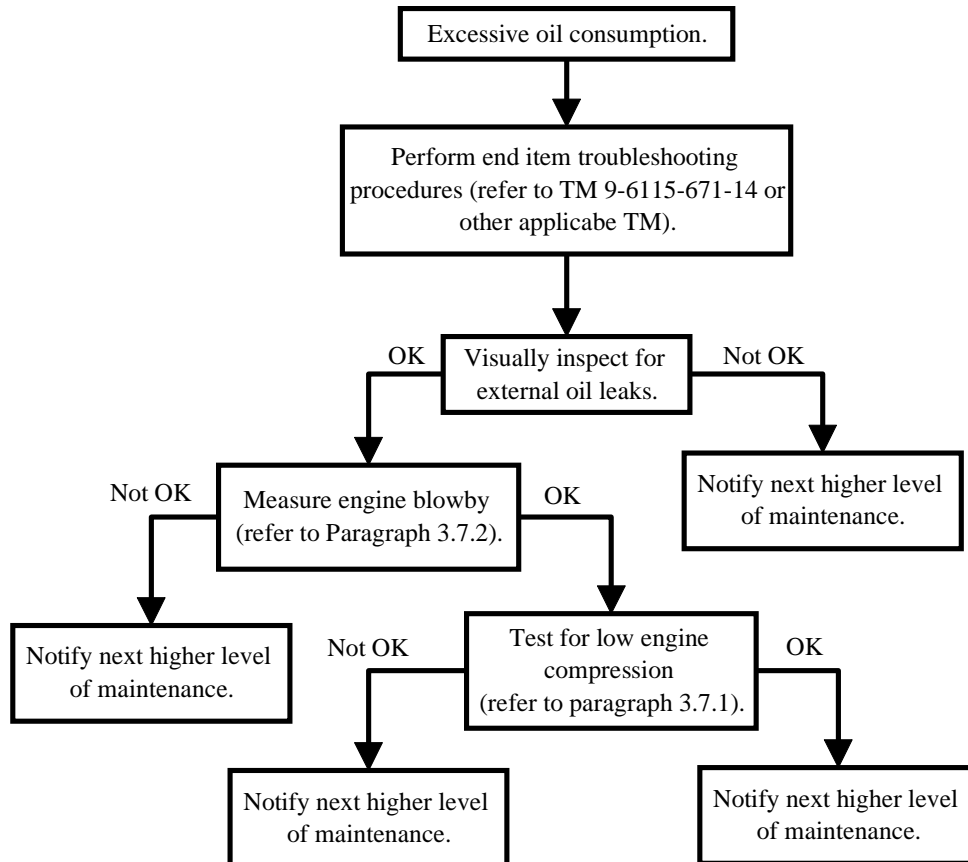


TABLE 3-2. UNIT TROUBLESHOOTING  
(Sheet 7 of 11)

### LOW OIL PRESSURE

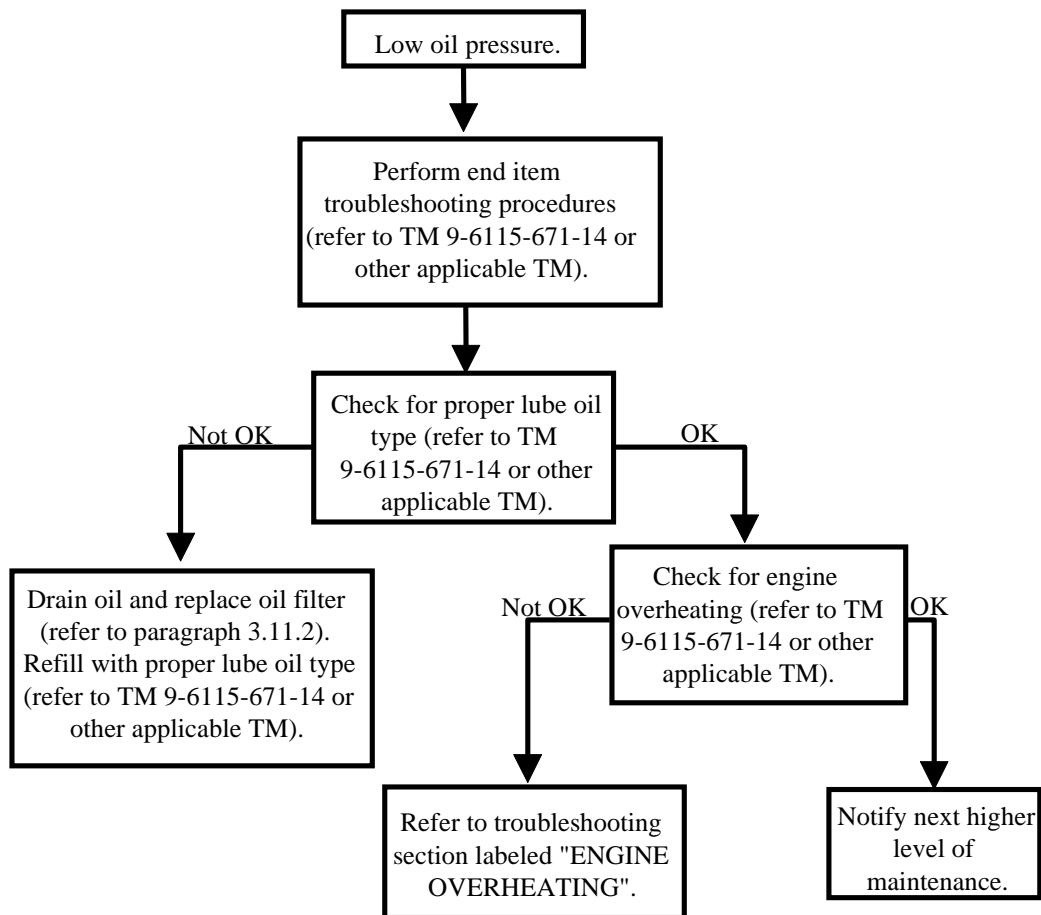




TABLE 3-2. UNIT TROUBLESHOOTING  
(Sheet 8 of 11)

## EXCESSIVE FUEL CONSUMPTION

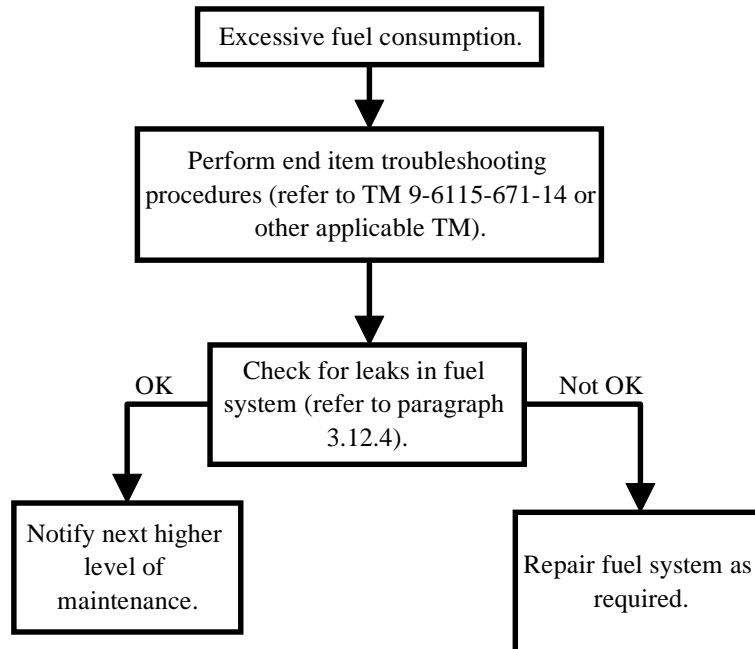
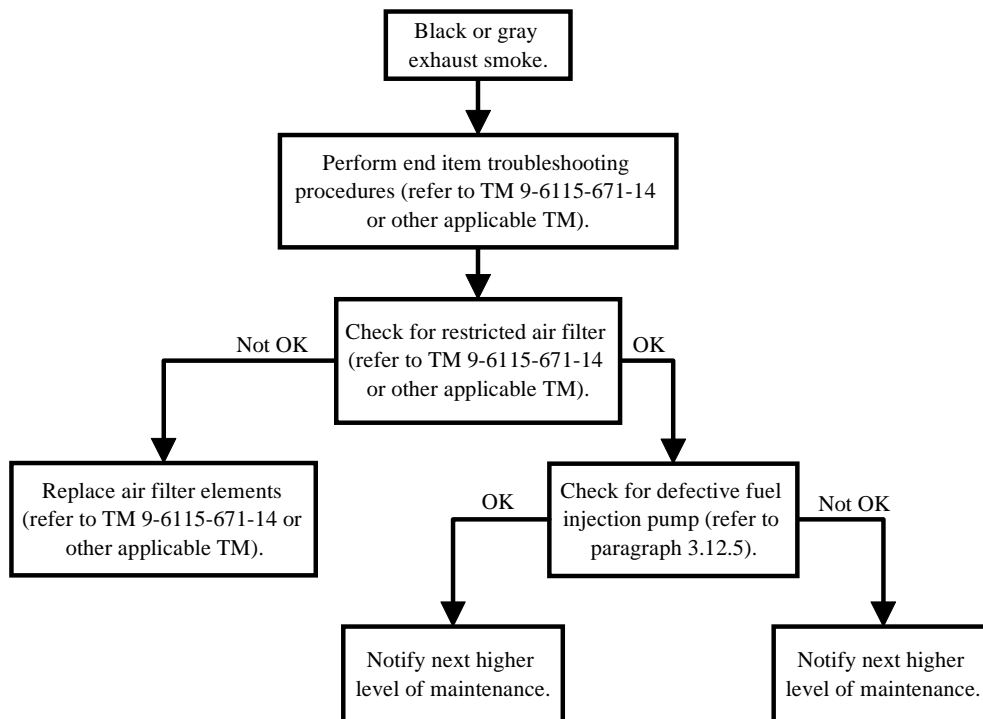


TABLE 3-2. UNIT TROUBLESHOOTING  
(Sheet 9 of 11)

### BLACK OR GRAY EXHAUST SMOKE



### BLUE OR WHITE EXHAUST SMOKE

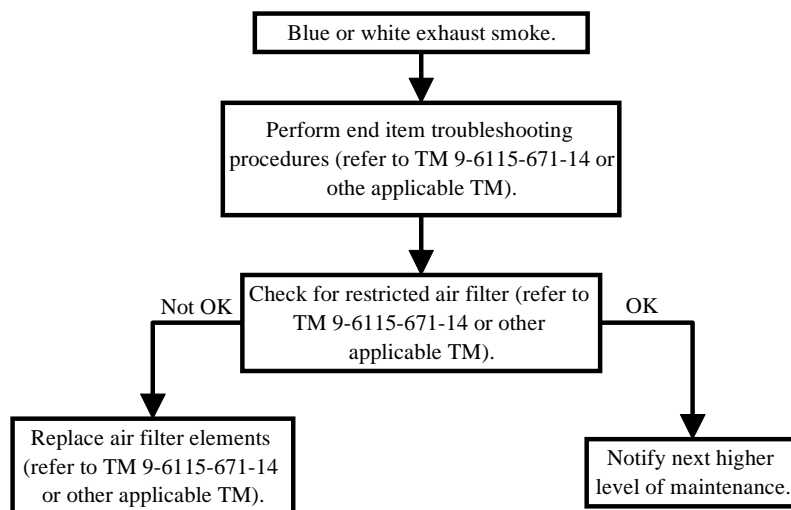
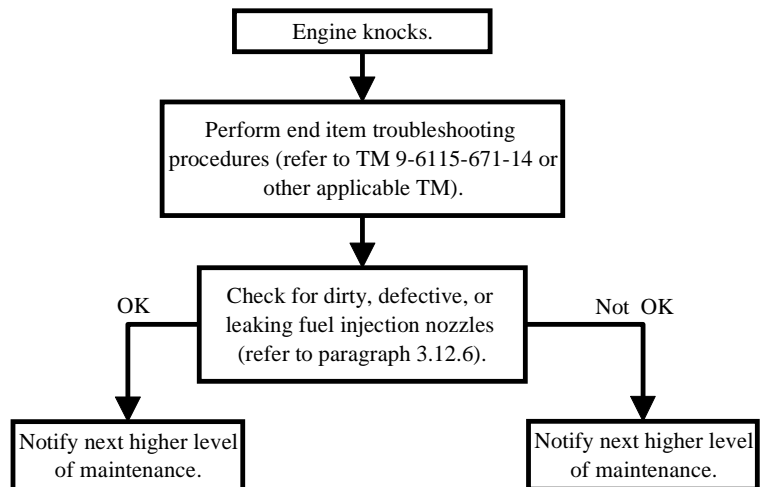


TABLE 3-2. UNIT TROUBLESHOOTING  
(Sheet 10 of 11)

### ENGINE KNOCKS



### ABNORMAL ENGINE NOISE

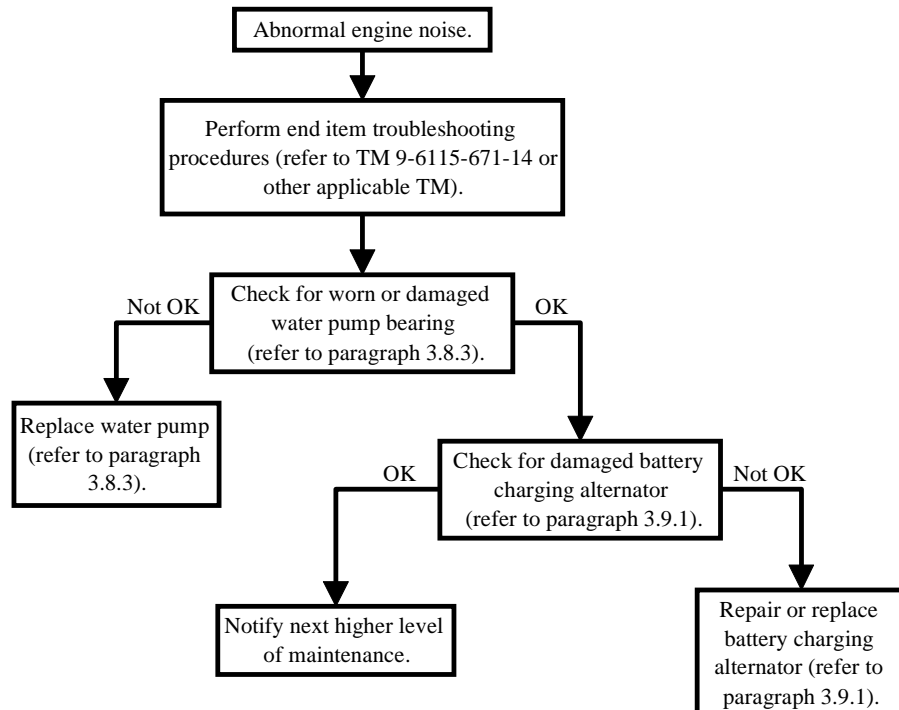
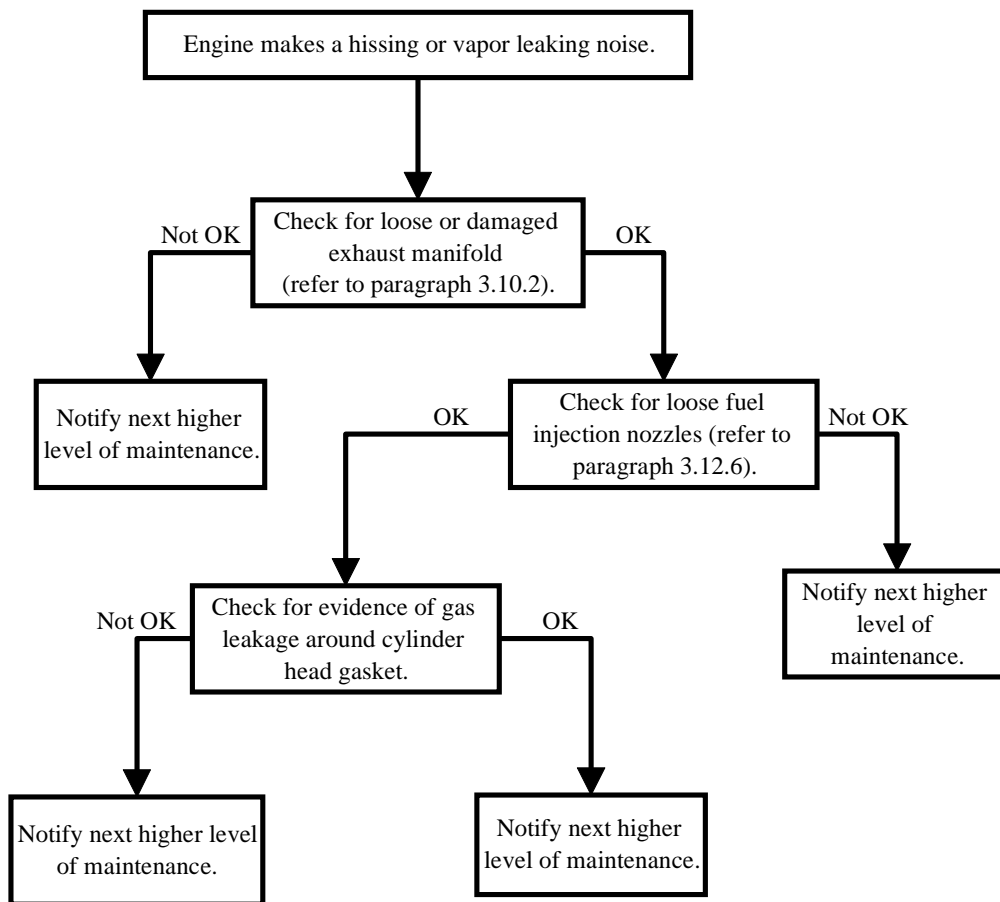


TABLE 3-2. UNIT TROUBLESHOOTING  
(Sheet 11 of 11)

**ENGINE MAKES A HISSING OR  
VAPOR LEAKING NOISE**



## Section V. MAINTENANCE PROCEDURES

### 3.7. GENERAL.

This section provides general maintenance not found in other sections of Chapter 3.

#### WARNING

**Where applicable, prior to performing engine maintenance, ensure batteries are disconnected to prevent serious injury or death.**

#### WARNING

**Service tools are designed to aid disassembly and assembly procedures. Service tools must be used to prevent possible damage to components. Some operations can cause personal injury if carried out without use of relevant tools.**

#### NOTE

**Refer to TM 9-6115-671-14 for removal of any components necessary to gain access to engine.**

- a. All bolts or nuts securing cylinder heads, covers, and doors must be tightened in proper sequence.
- b. When assembling an engine, always replace nuts, bolts, and lockwashers that have been removed from high stress locations such as from connecting rods and cylinder heads.
- c. When assembling an engine always apply a small quantity of new engine lubricating oil (MIL-L-2104) to all moving parts.
- d. After any maintenance work on engine has been completed lubricating oil and fuel levels must be checked and all safety guards installed before operating.
- e. When a new fan drive belt has been installed, check belt tension after first 20 hours of operation.
- f. Wear protective overalls, and keep items of loose clothing clear of all hot and moving parts. Use protective barrier cream when necessary.
- g. Clean components and surrounding area before removing or disassembling. All dirt and debris must be excluded from fuel injection equipment while it is being serviced.
- h. Some parts are cemented with gasket compound. Before assembly, remove all traces of old gasket and compound. All gaskets and gasket compound must be excluded from tapped holes unless otherwise specified.
- i. All oil seals removed from their original position must be replaced. Seals must be installed square in housing and all lip seals must be installed with lip facing lubricant to be retained. Use service tool to install oil seals. Care must be taken to prevent damaging new seal when it passes over shafts.
- j. Replace all nuts, bolts, capscrews, and studs with damaged threads. Do not use tap or die to repair damaged threads which may impair the strength and/or closeness of the threads.

- k. Do not allow grease or oil to enter a blind threaded hole. Hydraulic action present when bolt or stud is tightened could split or stress housing.
- l. Bolts or nuts must be loosened one quarter turn and then tightened to specified value to check or re-torque.
- m. Steel ISO metric bolt and nuts can be identified by the letter M either on head or on one hexagon flat. The strength grade will also be marked on top or on one flat.
- n. Nuts with identification marks on face will reduce frictional area of surface. Nuts with identification marks on one face must be installed with unmarked face towards component.
- o. Cover or cap all openings to prevent entry of foreign material when removing or disconnecting fuel lines, lubrication lines, or coolant hoses. Remove covers and caps upon installation.

3.7.1. TEST ENGINE COMPRESSION PRESSURE.

**NOTE**

**Before beginning test, ensure that batteries are fully charged and injection nozzle area is thoroughly cleaned.**

- a. Run engine to bring up to normal operating temperature. (From a cold start, operate engine 10 to 15 minutes then shut off engine).
- b. Shut off fuel supply and remove fuel injection nozzles, refer to paragraph 4.6.2.
- c. Install adapter (JT01679) with O-ring in injection nozzle bore. Use holding clamp (JT02017) to hold adapter in position. Install hold down screw in clamp and tighten screw to 27 lb-ft (37 Nm). Attach test gage (JT01682) to adapter. Refer to Appendix B, Section III.
- d. Refer to TM 9-6115-671-14, and using DEAD CRANK switch, (or other applicable device), turn crankshaft for 10 to 15 seconds with starter (150 rpm minimum cranking speed). Record pressure reading.
- e. Compare readings from all cylinders.
- f. Compression pressure must be 350 psi (2400 kPa) minimum. The difference between the highest and lowest cylinder must be less than 50 psi (340 KPa).
- g. If pressure is much lower than shown, remove gage and apply oil to ring area of piston through injection nozzle bore. Do not use too much oil. Do not get oil on the valves.
- h. Test compression again. If pressure is still low, it is possible that valves are worn or sticking, or o-rings are worn or stuck.

3.7.2. MEASURE ENGINE BLOW-BY.

- a. Place a hose with a standard gas gage in end of crankcase vent tube.
- b. Run engine at rated speed and load (engine at operating temperature and run-in, with at least 100 operating hours).

- c. Measure blow-by over a period of 5 minutes. Multiply figure obtained by 12 (hourly rate). Maximum allowable blow-by is 600 cu ft/h (17 m<sup>3</sup>/h).
- d. If blow-by is lower, there probably is no undue wear between piston rings and liners. If blow-by is higher, there could be excessive wear between piston rings and liners, resulting in loss of engine power.

3.7.3 INTAKE MANIFOLD PRESSURE CHECK.

- a. Remove plug (6, Figure 3-7) from intake manifold and connect suitable gage to intake manifold.
- b. Run engine to bring up to normal operating temperature. (From a cold start, operate engine 10 to 15 minutes).

**NOTE**

**Engine speed and load should be stabilized before taking readings on gage. Be sure that gage works properly.**

**NOTE**

**Pressure checks are only a guide to determine if there is an engine problem (valve leakage, defective nozzles, etc.). Low readings are not a valid reason for increasing injection pump fuel delivery. Pump adjustment should be within specification.**

- c. Observe pressure reading on gage. Reading should be at least 9 psi (60 KPa)/0.6 bar) when engine is developing rated power at full load rated speed. Shut down engine.
- d. If boost pressure is too high, remove and test fuel injection pump for high fuel delivery.
- e. If boost pressure is too low, check for the following:
  - (1) Restricted air filter elements. Refer to TM 9-6115-671-14.
  - (2) Restricted fuel filter elements. Refer to TM 9-6115-671-14.
  - (3) Incorrect injection pump timing. Refer to paragraph 5.3.1.
  - (4) Exhaust manifold leaks. Refer to paragraph 3.10.2.
  - (5) Intake manifold leaks. Refer to paragraph 3.10.1.
  - (6) Faulty fuel transfer pump. Refer to paragraph 3.12.3.
  - (7) Low compression pressure. Refer to paragraph 3.7.1.
  - (8) Faulty fuel injection nozzles. Notify next higher level of maintenance, refer to paragraph 4.6.2.
  - (9) Carbon build-up in turbocharger. Notify next higher level of maintenance, refer to paragraph 4.4.1.
  - (10) Turbocharger compressor or turbine wheel rubbing housing. Notify next higher level of maintenance, refer to paragraph 4.4.1.

(11) Low fuel injection pump fuel delivery. Notify general support maintenance, refer to paragraph 5.4.12.

(12) Restricted exhaust. Refer to TM 9-6115-671-14.

f. Remove test gage and install plug (6, Figure 3-7) in intake manifold.

3.8. COOLING SYSTEM MAINTENANCE.

3.8.1. GENERAL.

This section provides maintenance for cooling system components. Components of cooling system not mentioned in this section can be found in the TM 9-6115-671-14.

**WARNING**

**Engine coolant is very hot and under pressure after engine has been operating. Allow engine to cool before you slowly loosen filler cap and relieve pressure from cooling system. Failure to comply could result in severe personal injury.**

3.8.2. THERMOSTAT AND WATER MANIFOLD/THERMOSTAT COVER.

a. Removal.

**WARNING**

**Engine coolant is very hot and under pressure after engine has been operating. Allow engine to cool before you slowly loosen filler cap and relieve pressure from cooling system. Failure to comply could result in severe personal injury.**

(1) Drain coolant system if not already drained, refer to TM 9-6115-671-14.

**NOTE**

**Remove fan guards if needed.**

(2) Disconnect coolant outlet hose from water manifold/thermostat cover (8, Figure 3-1), refer to TM 9-6115-671-14.

(3) Remove capscrews (1, Figure 3-1) and move clamp (3) clear of cylinder head and alternator bracket.

(4) Disconnect water pump tube (4) and remove seal (5). Seal can be accessed by removing water temperature sender (refer to TM 9-6115-671-14). Discard seal.

(5) Remove capscrews (6 and 7), from water manifold / thermostat cover (8), thermostat (9), and gasket (10). Discard gasket.

(6) Disconnect plug (11).

(7) Cover all openings to prevent entry of foreign material.



b. Inspection.

- (1) Remove thermostat (9, Figure 3-1), refer to step a.
- (2) Inspect thermostat (9) for excessive wear or damage.
- (3) Inspect water manifold / thermostat cover (8) for cracks, corrosion, or other damage.
- (4) Inspect water temperature sender (15) if installed.

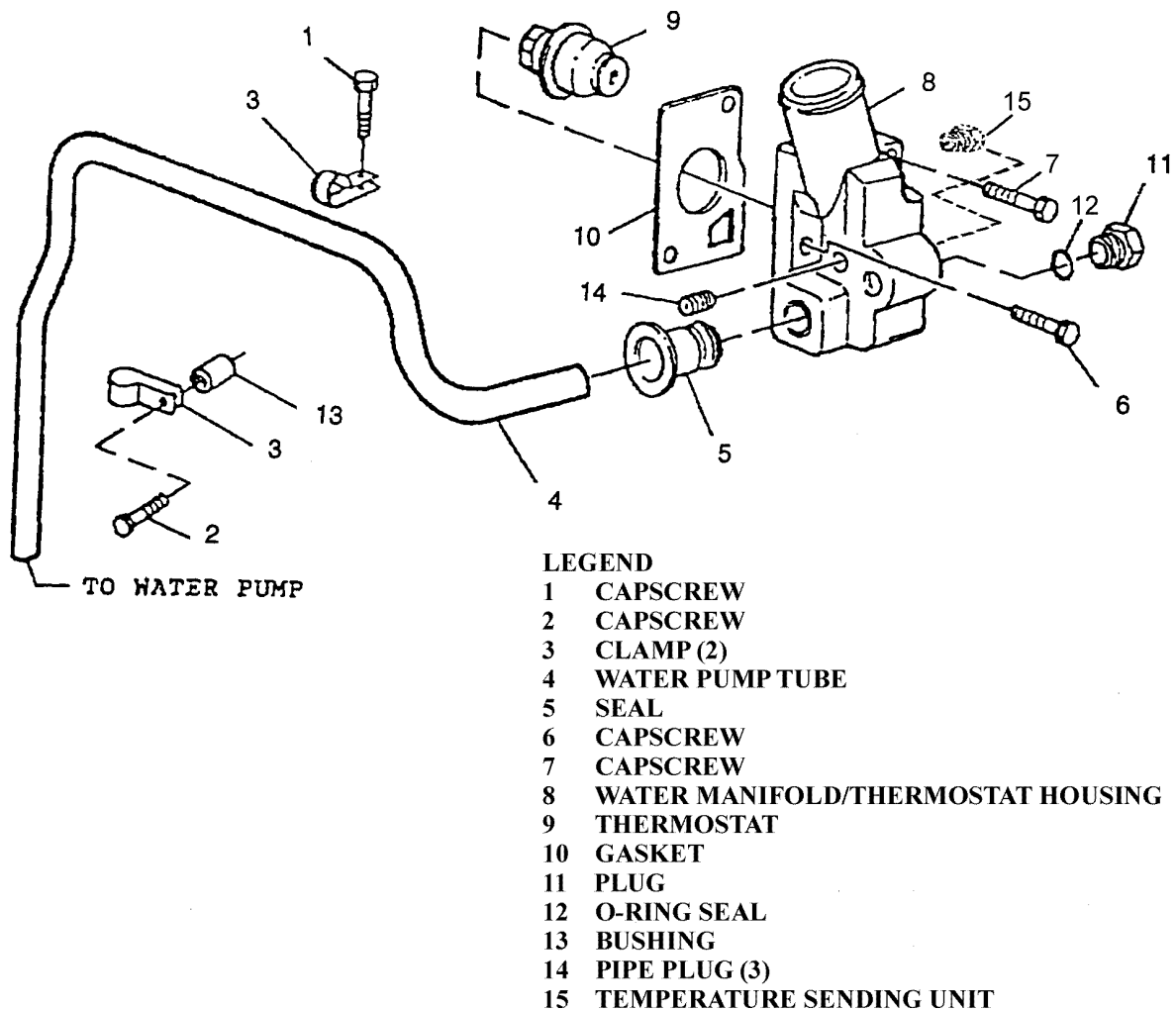


FIGURE 3-1. THERMOSTAT AND WATER MANIFOLD/THERMOSTAT COVER.

c. Replacement.

**NOTE**

**Replace thermostat if suspected of being defective.**

- (1) Remove thermostat and water manifold/thermostat cover, refer to step a.
- (1) Inspect thermostat and water manifold/thermostat cover, refer to step b. Replace parts found defective.
- (2) Position new O-ring seal (12, Figure 3-1) on water manifold / thermostat cover and install plug (11).
- (3) Install thermostat (9), refer to step d.

d. Installation.

- (1) Remove all covering installed during step a (6).
- (2) Ensure all old gasket material is removed from gasket surfaces.
- (3) Lubricate seal (5) with multi-purpose grease. Install seal.
- (4) Install guide studs (1, Figure 3-2) if needed, in place of capscrews (6 and 7, Figure 3-1) and position gasket (10, Figure 3-1) on cylinder head.
- (5) Connect water temperature sending unit (15).
- (6) Position thermostat (9, Figure 3-1) and water manifold / thermostat cover (8) on cylinder head using a screwdriver (2, Figure 3-2) to hold thermostat in place, refer to Figure 3-2.

**NOTE**

**Remove one guide stud, if used, and install one capscrew before removing second guide stud.**

- (7) Remove guide studs, if used, and install capscrews (6 and 7, Figure 3-1). Torque capscrews evenly to 52 lb-ft (70 Nm).
- (8) Install water pump tube (4).
- (9) Position clamps (3) on cylinder head and alternator bracket and install capscrews (1 and 2).
- (10) Connect coolant outlet hose, refer to TM 9-6115-671-14.

**NOTE**

**Air must be expelled from system when refilled with coolant. Loosen plug in thermostat housing to allow air to escape when filling system. Retighten plug when all air has been expelled.**

- (11) Service coolant system, refer to TM 9-6115-671-14.

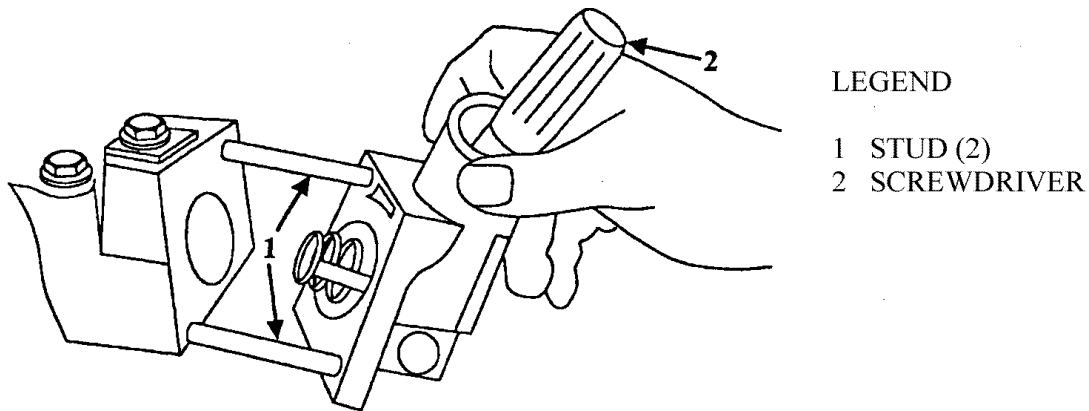


FIGURE 3-2. THERMOSTAT INSTALLATION.

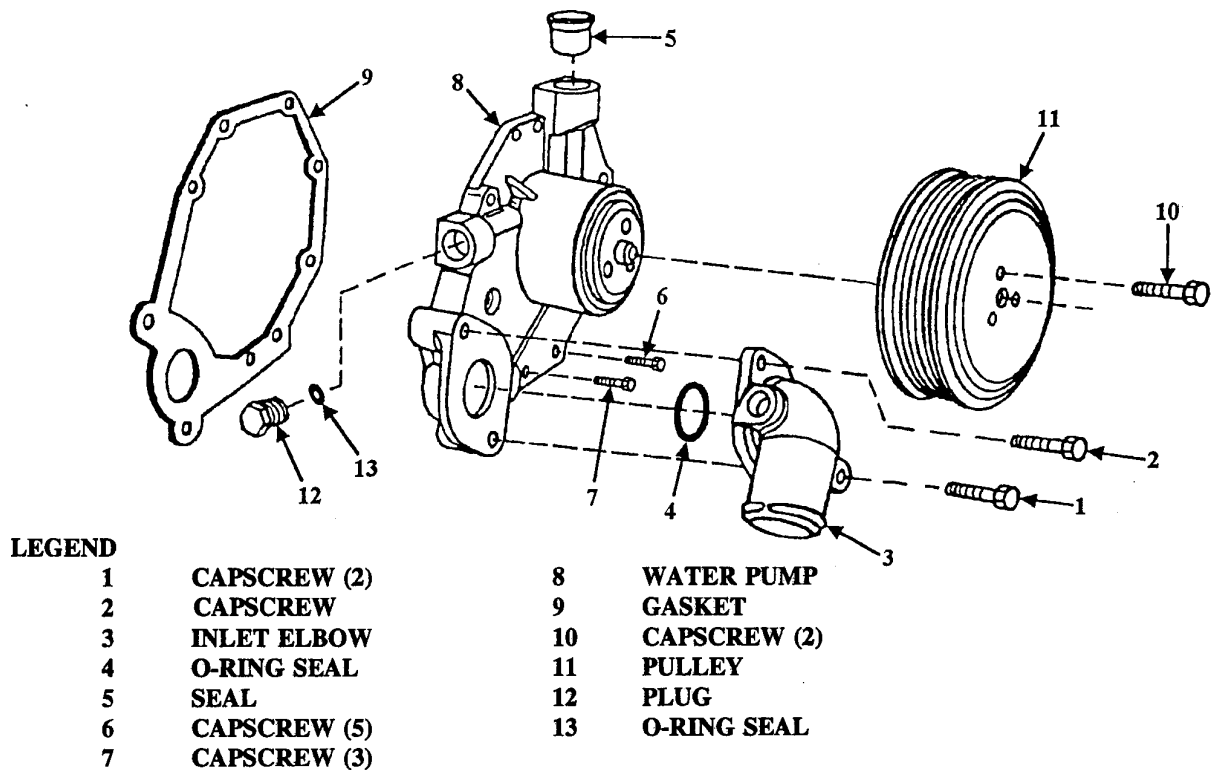
### 3.8.3. WATER PUMP.

#### a. Removal.

#### WARNING

**Engine coolant is very hot and under pressure after engine has been operating. Allow engine to cool before you slowly loosen filler cap and relieve pressure from cooling system. Failure to comply could result in severe personal injury.**

- (1) Drain coolant system if not already drained. Refer to TM 9-6115-671-14.
- (2) Remove fan shroud, fan, and fan belt, refer to TM 9-6115-671-14.
- (3) Disconnect lower inlet coolant hose from inlet elbow (3, Figure 3-3), refer to TM 9-6115-671-14.
- (4) Remove capscrews (1 and 2), inlet elbow (3), and O-ring seal (4). Discard O-ring seal.
- (5) Remove capscrews (1 and 2, Figure 3-1) and move clamps (3) clear of cylinder head and alternator bracket.
- (6) Disconnect water pump tube (4, Figure 3-1) from water pump (8, Figure 3-3).
- (7) Remove and discard seal (5, Figure 3-3).
- (8) Remove capscrews (10) and pulley (11)
- (9) Remove short capscrews (6), long capscrews (7), water pump (8), and gasket (9). Discard gasket.
- (10) Remove plug (12) and O-ring seal (13). Discard O-ring seal.
- (11) Cover all openings to prevent entry of foreign material.



**FIGURE 3-3. WATER PUMP ASSEMBLY.**

**b. Inspection.**

- (1) Remove water pump (8, Figure 3-3), refer to step a.
- (2) Inspect water pump (8) rotation for abnormal noise, binding, or other abnormal conditions.
- (3) Inspect water pump (8) housing for cracks, corrosion, or any other damage.

**c. Replacement.**

- (1) Remove water pump (8, Figure 3-3), refer to step a.
- (2) Inspect water pump (8), refer to step b. Replace water pump if inspection reveals cracks, corrosion, or any other damage. For installation of water pump (8), refer to step d.

**d. Installation.**

- (1) Remove all covering installed during step a (11).
- (2) Ensure all old gasket material is removed from gasket surfaces.
- (3) Position new O-ring seal (13, Figure 3-3) on water pump (8). Install plug.
- (4) Lubricate new seal (5) with multi-purpose grease. Install seal and water pump tube (4, Figure 3-1).

- (5) Position new gasket (9) and water pump (8) on timing gear cover. Install short capscrews (6), and long capscrews (7), and torque evenly to 12 lb-ft (16 Nm).
- (6) Position pulley (11) on water pump (8). Install capscrews (10) and torque evenly to 12 lb-ft (16 Nm).
- (7) Position new O-ring seal (4, Figure 3-3) and inlet elbow (3) on water pump (8). Install capscrews (1 and 2) and torque evenly to 26 lb-ft (35 Nm).
- (8) Install capscrews (1 and 2, figure 3-1) clamps (3), water pump tube (4) and new seal (5).
- (9) Connect coolant inlet hose, refer to TM 9-6115-671-14.
- (10) Install fan shroud, fan, and fan belt, refer to TM 9-6115-671-14.

**NOTE**

**Air must be expelled from system when refilled with coolant. Loosen plug in thermostat housing to allow air to escape when filling system. Retighten plug when all air has been expelled.**

- (11) Service coolant system, refer to TM 9-6115-671-14.

3.9. ELECTRICAL SYSTEM MAINTENANCE.

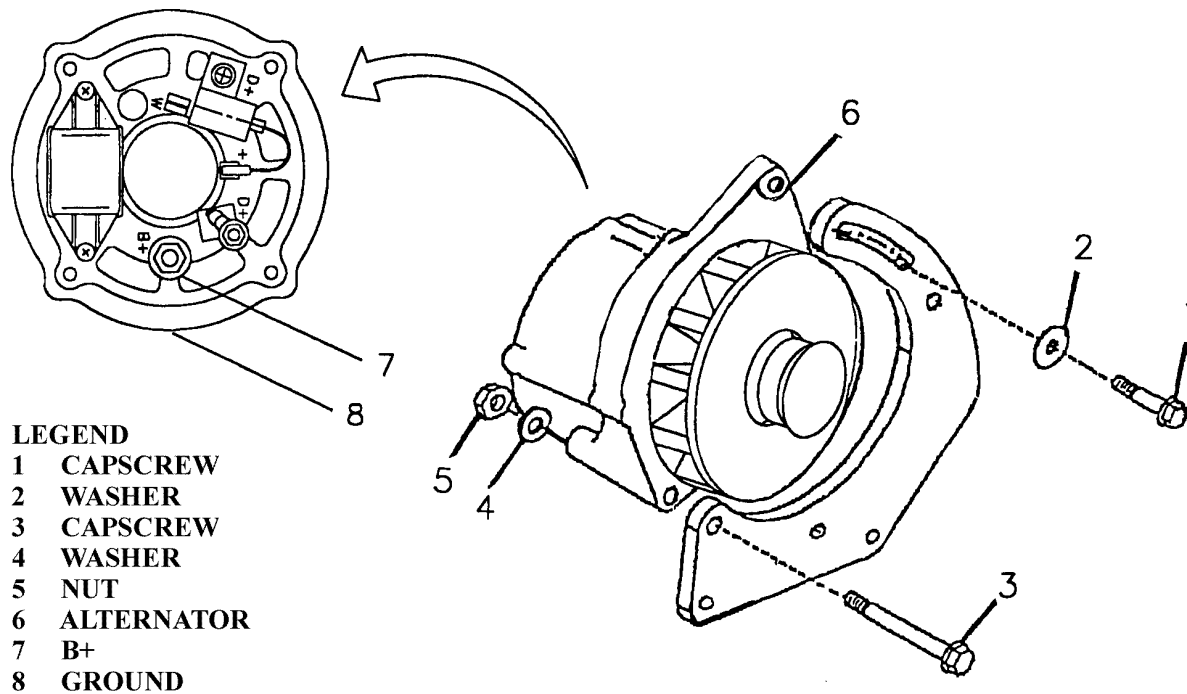
3.9.1. BATTERY CHARGING ALTERNATOR.

a. Test, Battery charging alternator (installed).

- (1) Check for battery voltage at alternator, between terminals B+ (7, Figure 3-4) and ground (8). Note voltage. Voltage should be between 0 and 24 VDC. Minimum required voltage for start up is 18 VDC.
- (2) Start and operate generator. Refer to TM 9-6115-671-14. Recheck voltage on alternator terminal B+ and ground (8) for 28 +/- 2 VDC.

b. Removal.

- (1) Tag and disconnect electrical leads from battery charging alternator.
- (2) Remove fan belt, refer to TM 9-6115-671-14.
- (3) Remove capscrew (1, Figure 3-4) and washer (2).
- (4) Support weight of battery charging alternator and remove capscrew (3), washer (4), nut (5) and alternator (6). Remove alternator (6).



**FIGURE 3-4. BATTERY CHARGING ALTERNATOR MOUNTING.**

c. Inspection.

- (1) Inspect rear housing for cracked or broken casting, stripped threads and severe wear of the bearing bore.
- (2) Inspect fan for cracked or broken fins and for worn mounting hole.
- (3) Inspect front housing for cracked or broken casting, stripped threads and bore of mounting foot for elongation.
- (4) Inspect other components for damage such as broken terminals or insulation, discoloration, stripped threads and other obvious damage.

d. Replacement.

- (1) Test battery charging alternator (6, Figure 3-4), refer to paragraph 3.9.1.a.
- (2) Remove battery charging alternator (6) from engine, refer to paragraph 3.9.1.b.
- (3) Inspect battery charging alternator (6), refer to paragraph 3.9.1.c. Replace if inspection reveals defective. For installation of battery charging alternator, refer to paragraph 3.9.1.e.
- (4) Send removed alternator to next higher maintenance level for repair.

e. Installation.

- (1) Position battery charging alternator (6, Figure 3-4) on mounting bracket and install capscrew (3), washer (4) and nut (5).
- (2) Install washer (2) and capscrew (1).
- (3) Connect electrical leads to battery charging alternator (6) as tagged during removal. Refer to paragraph a.
- (4) Install fan belts on battery charging alternator (6), refer to TM 9-6115-671-14.

3.9.2. STARTER.

a. Test (Installed on Generator).

- (1) Make sure batteries are fully charged and that all battery and starter cables are serviceable and properly installed.
- (2) Set multimeter for DC volts and connect as shown in Figure 3-5, Test A. If voltage is indicated solenoid is defective.
- (3) Momentarily connect a jumper as shown in Figure 3-5, Test B. Multimeter should indicate battery voltage and starter should crank the engine. If multimeter does not read battery voltage, the solenoid is defective and must be replaced. If multimeter indicates battery voltage, but starter does not operate, starter is defective and must be replaced.

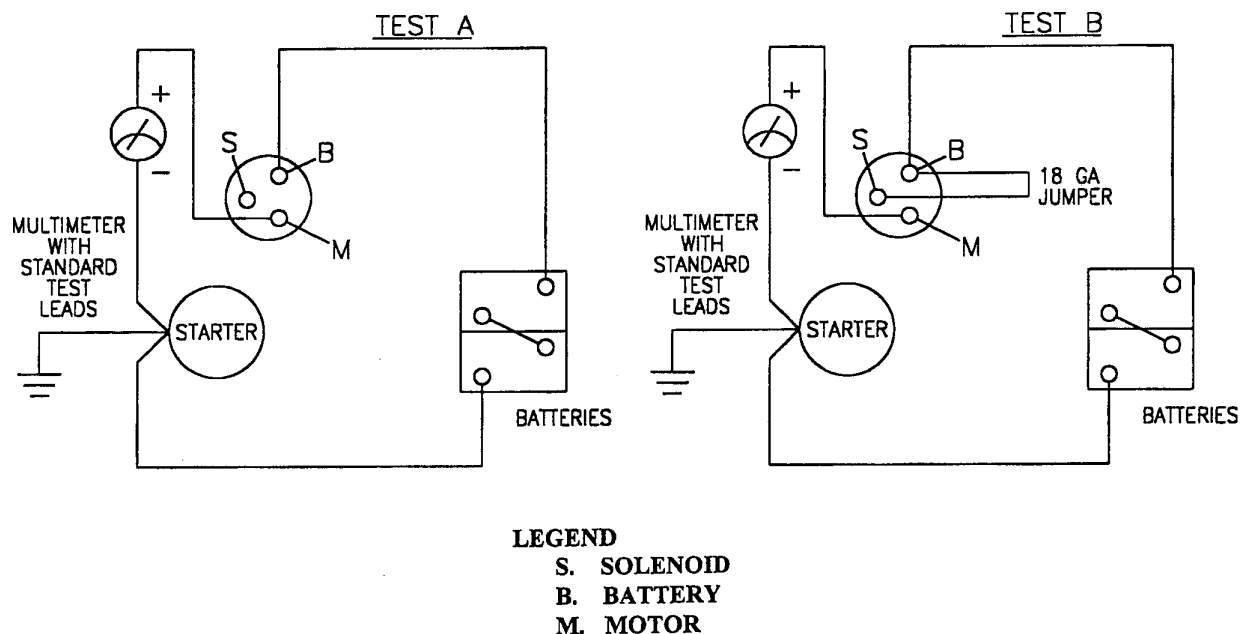


FIGURE 3-5. STARTER SOLENOID TEST CIRCUIT.

b. Removal.

- (1) Ensure generator set negative battery terminal connection is disconnected from battery.
- (2) Tag and disconnect electrical leads from starter.
- (3) Support weight of starter and remove two screws (1, Figure 3-6), lockwashers (2) and washers (3) securing starter to flywheel housing. Remove starter.
- (4) Cover opening in flywheel housing.

c. Inspection.

- (1) Inspect housing for cracked or broken casting and stripped threads or missing insulation.
- (2) Inspect pinion (19, Figure 3-6) for chipped or worn teeth.

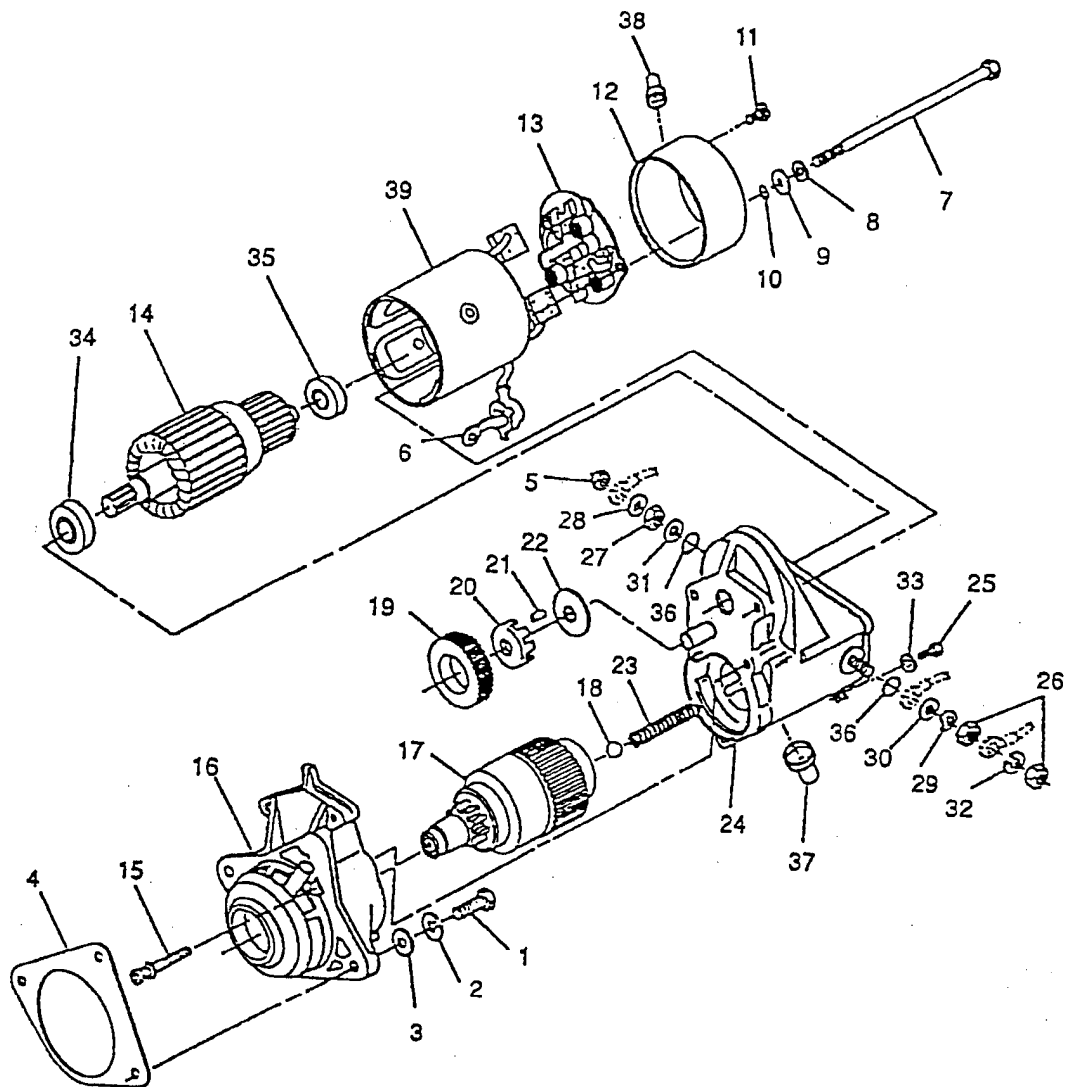
d. Replacement.

- (1) Test starter installed on generator, refer to paragraph 3.9.2.a.
- (2) Remove starter, refer to paragraph 3.9.2.b.
- (3) Inspect starter, refer to paragraph 3.9.2.c. Replace starter if solenoid or starter is found defective during test in step a. Starter must also be replaced if inspection reveals faulty components. For installation of starter, refer to paragraph 3.9.2.e.
- (4) Send removed starter to next higher maintenance level for repair.

e. Installation.

- (1) Remove cover in opening of flywheel housing.
- (2) Place gasket (4, Figure 3-6), and starter on flywheel housing and secure with two screws (1), new lockwashers (2) and washers (3). Tighten screws to 30 - 35 lb-ft (41 - 47 Nm).
- (3) Connect electrical leads to starter as tagged during removal.
- (4) Reconnect negative battery terminal.





**LEGEND**

1	SCREW	14	ARMATURE	27	NUT
2	LOCKWASHER	15	SCREW	28	WASHER
3	WASHER	16	HOUSING	29	WASHER
4	GASKET	17	OVERRUNNING CLUTCH	30	WASHER
5	NUT	18	STEEL BALL	31	WASHER
6	YOKE ASSY LEAD WIRE	19	STARTER PINION	32	LOCK WASHER
7	THROUGH BOLTS	20	RETAINER	33	LOCK WASHER
8	LOCKWASHER	21	ROLLER (5)	34	BEARING
9	WASHER	22	WASHER	35	BEARING
10	PACKING	23	SPRING	36	WASHER
11	SCREW	24	MAGNETIC SWITCH ASSY	37	RUBBER PLUG
12	END FRAME	25	SCREW	38	RUBBER PLUG
13	BRUSH HOLDER ASSY	26	NUT	39	YOKE ASSY

FIGURE 3-6. STARTER ASSEMBLY

3.10. INTAKE AND EXHAUST SYSTEM MAINTENANCE.

**WARNING**

Exhaust system is very hot after operating engine. After operating engine, allow exhaust system to cool before removal. Failure to comply could result in personal injury.

3.10.1. INTAKE MANIFOLD.

a. Inspection.

Inspect intake manifold (4, Figure 3-7) for serviceability. Notify next higher maintenance level if cracked or otherwise damaged.

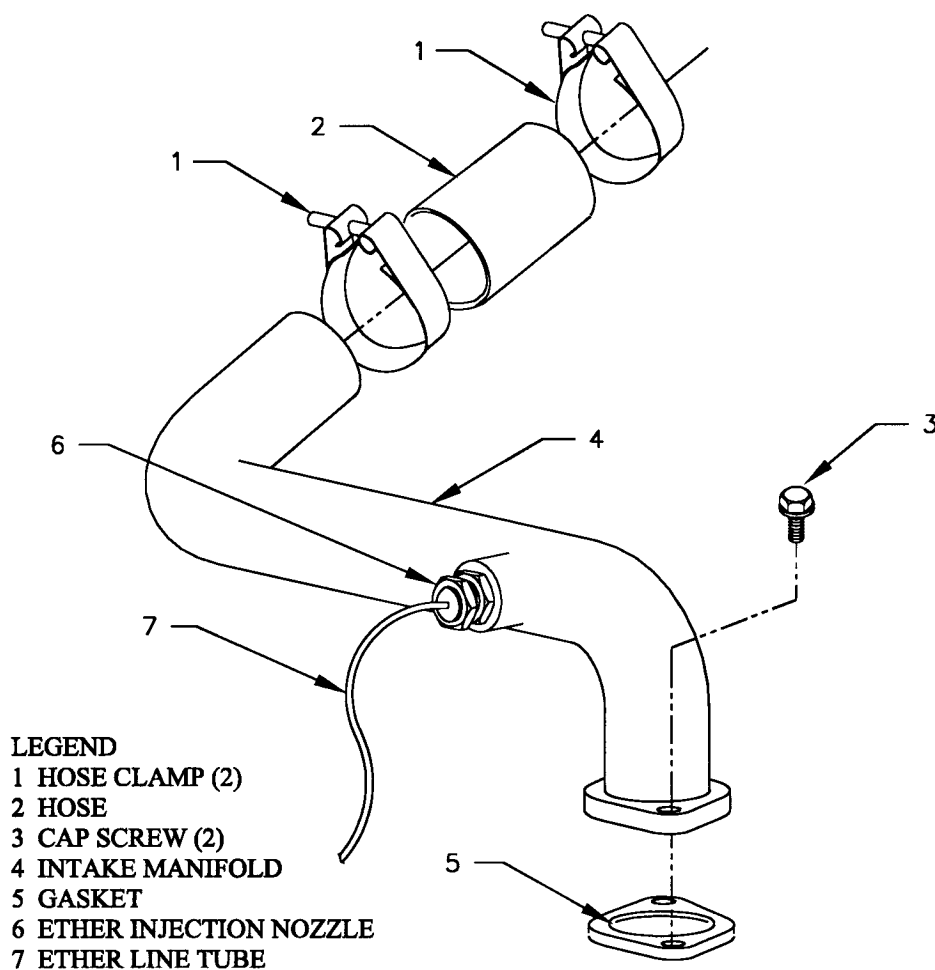
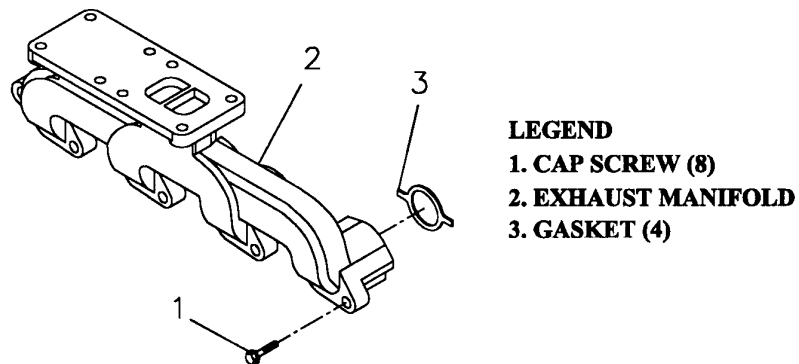


FIGURE 3-7. INTAKE MANIFOLD.

3.10.2. EXHAUST MANIFOLD.

a. Inspection.

Inspect exhaust manifold (2, Figure 3-8) for serviceability. Notify next higher maintenance level if cracked or otherwise damaged.



**FIGURE 3-8. EXHAUST MANIFOLD.**

3.11. LUBRICATION SYSTEM MAINTENANCE.

3.11.1. GENERAL.

This section provides maintenance for lubrication system components.

3.11.2. OIL FILTER ASSEMBLY.

a. Removal.

- (1) Drain engine lubrication system, refer to TM 9-6115-671-14.
- (2) Remove oil filter (1, Figure 3-9).
- (3) Disconnect turbocharger oil inlet line from fitting (2). Remove fitting.
- (4) Remove capscrews (3 and 4). Gently remove oil filter head (5). Remove and discard gasket (6).
- (5) Cover all openings to prevent entry of foreign material.

b. Inspection.

- (1) Remove oil filter assembly, refer to step a.
- (2) Inspect oil filter head (5, Figure 3-9) for cracks or other damage. Replace parts as needed.

- (3) Install oil filter assembly, refer to step d.
- (4) Service engine lubrication system, refer to TM 9-6115-671-14.

c. Replacement.

- (1) Remove oil filter assembly, refer to step a.
- (2) Inspect oil filter assembly, refer to step b. Replace oil filter head (5, Figure 3-9) if inspection reveals cracks, corrosion, or any other damage. For installation of oil filter assembly, refer to step d.
- (3) For servicing of engine lubrication system, refer to TM 9-6115-671-14.

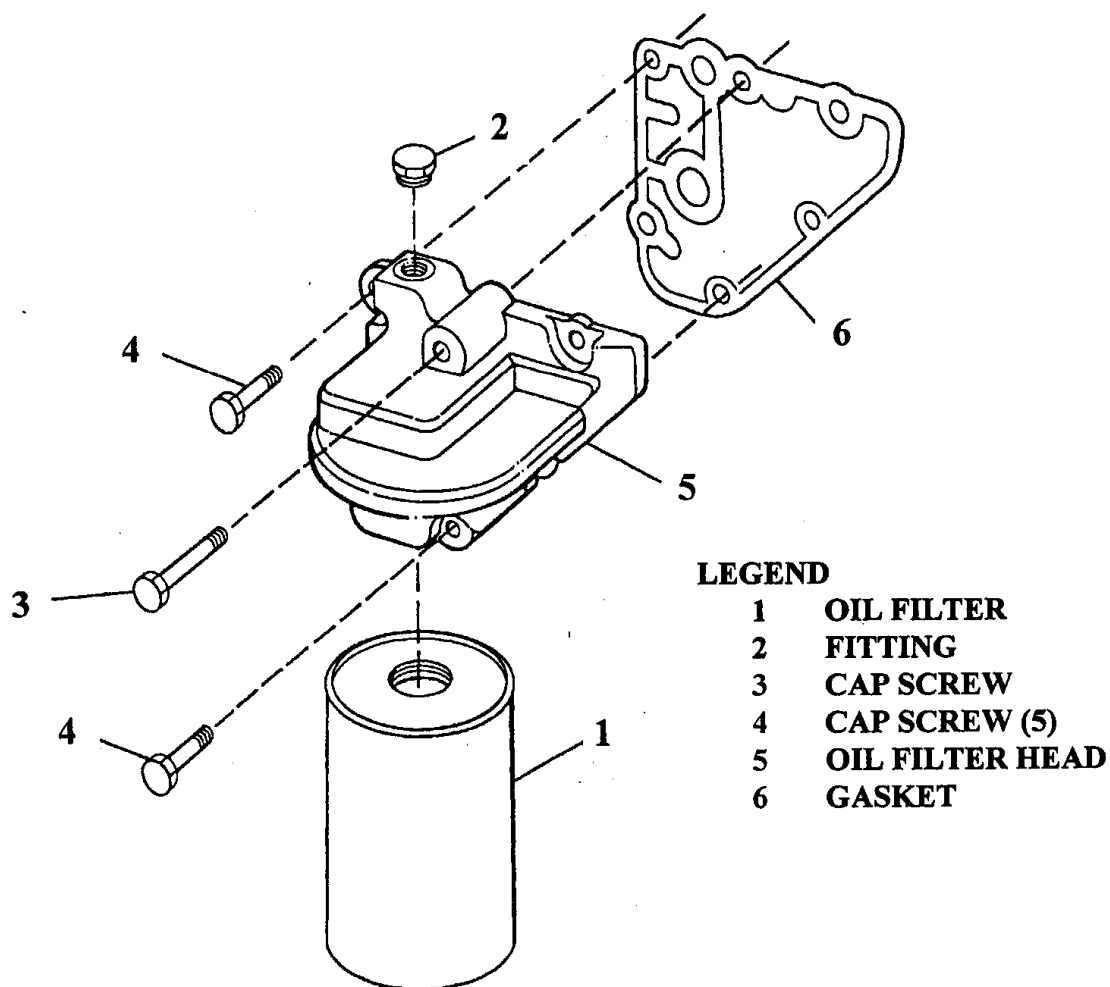


FIGURE 3-9. OIL FILTER ASSEMBLY.

d. Installation.

- (1) Remove all covers installed during step a.
- (2) Ensure all old gasket material is removed from gasket surfaces.
- (3) Position gasket (6) and oil filter head (5) together into proper position on cylinder block and oil cooler housing. Install capscrews (3 and 4) and torque to 26 lb-ft (35.9 Nm).
- (4) Install fitting (2). Connect turbocharger oil inlet line to fitting (2).
- (5) Install oil filter (1).
- (6) Service engine lubrication system, refer to TM 9-6115-671-14.

3.11.3. OIL COOLER.

a. Removal.

**WARNING**

**Engine coolant is very hot and under pressure after engine has been operating. Allow engine to cool before you slowly loosen filler cap and relieve pressure from cooling system. Failure to comply could result in severe personal injury.**

- (1) Allow engine to cool and drain coolant system, refer to TM 9-6115-671-14.
- (2) Remove oil filter assembly, refer to paragraph 3.11.2, step a.
- (3) Remove drain plug (1, Figure 3-10) and plug (2).
- (4) Remove capscrews (3 and 4), adapter (5), gasket (6) and O-ring seal (7). Discard gasket and O-ring seal.
- (5) Remove oil cooler housing (8) and gasket (9). Discard gasket.
- (6) Remove capscrews (10) and oil cooler (11).
- (7) Remove O-ring seals (12) and discard.
- (8) Cover all openings to prevent entry of foreign material.

b. Inspection.

- (1) Remove oil cooler (11, Figure 3-10), refer to step a.
- (2) Inspect oil cooler (11) for physical damage, plugging, or leakage which may allow mixing of oil and coolant.
- (3) Back flush oil cooler (11) to clean all debris from core.

- (4) Pressure test oil cooler (11) in liquid with compressed air if mixing of oil and coolant is suspected. Oil cooler should show no leakage when 20-25 psi (140-170 kPa) of air pressure is applied for a minimum of 30 seconds. If leakage exists, oil cooler must be replaced.
- (5) Inspect oil cooler housing (8) and adapter (5) for physical damage, plugging, or leakage. Replace parts as needed.

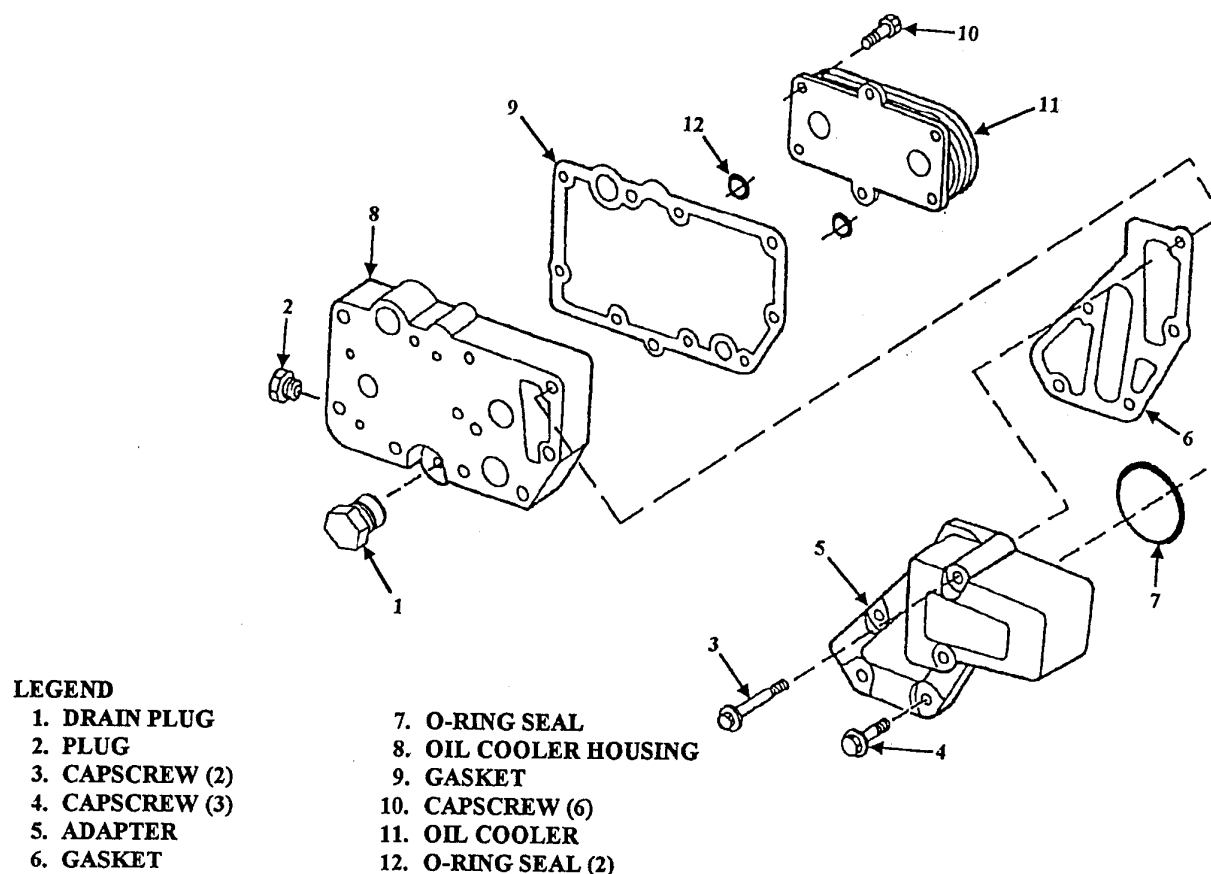


FIGURE 3-10. OIL COOLER ASSEMBLY.

c. Replacement.

- (1) Remove oil cooler (11, Figure 3-10), refer to step a.
- (2) Inspect oil cooler assembly, refer to step b. Replace components if physically damaged or leaks are detected during inspection.
- (3) Install oil cooler (11), refer to step d.

d. Installation.

- (1) Remove all covering installed during step a (8).

- (2) Ensure all old gasket material is removed from gasket surfaces.
- (3) Install plug (2) and drain plug (1) and torque evenly to 26 lb-ft (35 Nm).
- (4) Position O-ring seals (12, Figure 3-10) on oil cooler (11) and lubricate with clean engine oil.
- (5) Apply Thread Lock and Sealer (LOCTITE 242) to capscrews (10).
- (6) Position oil cooler (11) in oil cooler housing (8). Install capscrews (10) and torque evenly to 9 lb-ft (12 Nm).
- (7) Position O-ring seal (7) in adapter (5).
- (8) Position gasket (9), oil cooler housing (8), gasket (6) and adapter (5) on engine block. Install capscrews (3 and 4) and torque evenly to 26 lb-ft (35 Nm).
- (9) Install oil filter assembly, refer to paragraph 3.11.2, step c.

#### 3.11.4. OIL FILL TUBE.

##### a. Removal.

- (1) Remove oil fill cap (1, Figure 3-11), capscrews (2), oil fill tube (3) and gasket (4). Discard gasket.
- (2) Cover all openings to prevent entry of foreign material.

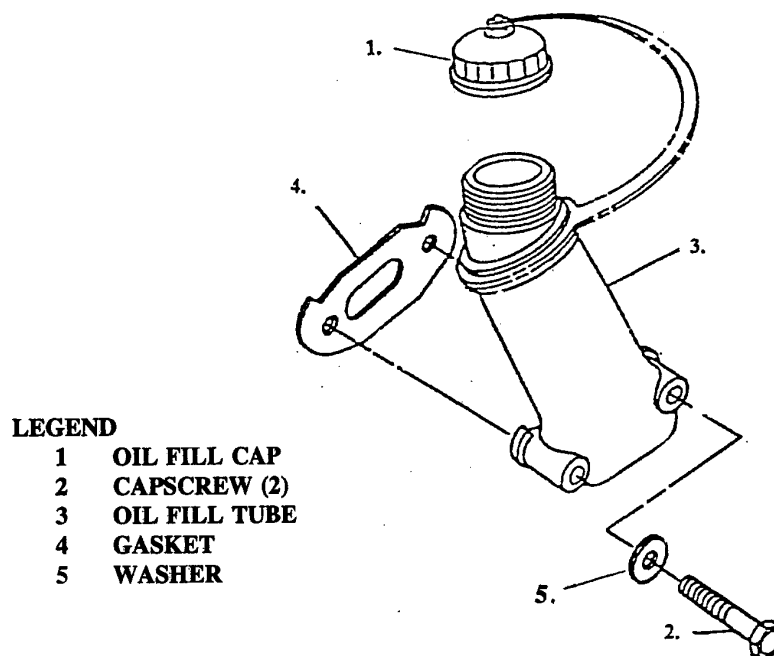


FIGURE 3-11. OIL FILL TUBE ASSEMBLY.

b. Inspection.

Inspect oil fill tube (3, Figure 3-11) and oil fill cap (1) for cracks or other damage.

c. Replacement.

- (1) Remove oil fill tube, refer to step a.
- (2) Inspect oil fill tube (3, Figure 3-11) and cap (1), refer to step b. Replace oil fill tube or oil fill cap if found defective. For installation, refer to step d.

d. Installation.

- (1) Remove all covering installed during step a (2).
- (2) Ensure all old gasket material is removed from gasket surfaces.
- (3) Apply Thread Lock and Sealer (LOCTITE 242) to threads of capscrews (2).
- (4) Position gasket (4) and oil fill tube (3) on engine block. Install capscrews (2) and torque evenly to 26 lb-ft (35 Nm).
- (5) Install oil fill cap (1)

3.11.5. OIL DIPSTICK TUBE.

a. Inspection.

Visually inspect oil dipstick (1, Figure 3-12) and oil dipstick tube (2) for cracks, dents, or other damage. Remove and replace if found defective.

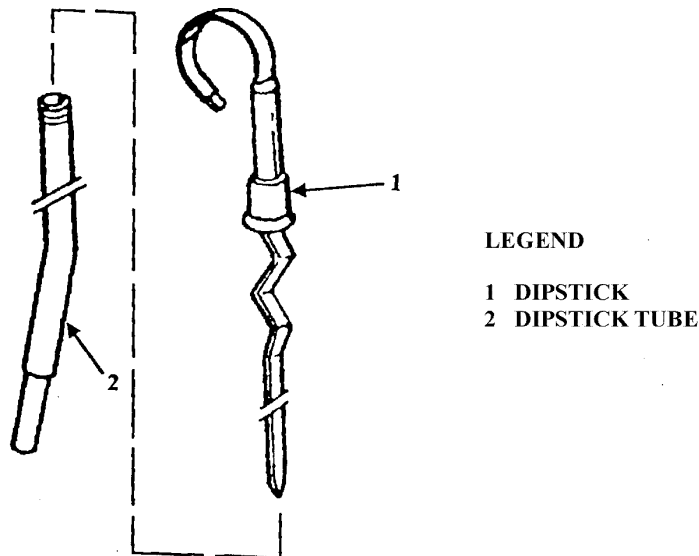


FIGURE 3-12. OIL DIPSTICK TUBE ASSEMBLY.



b. Removal.

- (1) Remove oil dipstick (1, Figure 3-12).

**NOTE**

**Note position of dipstick tube to ensure proper position during installation.**

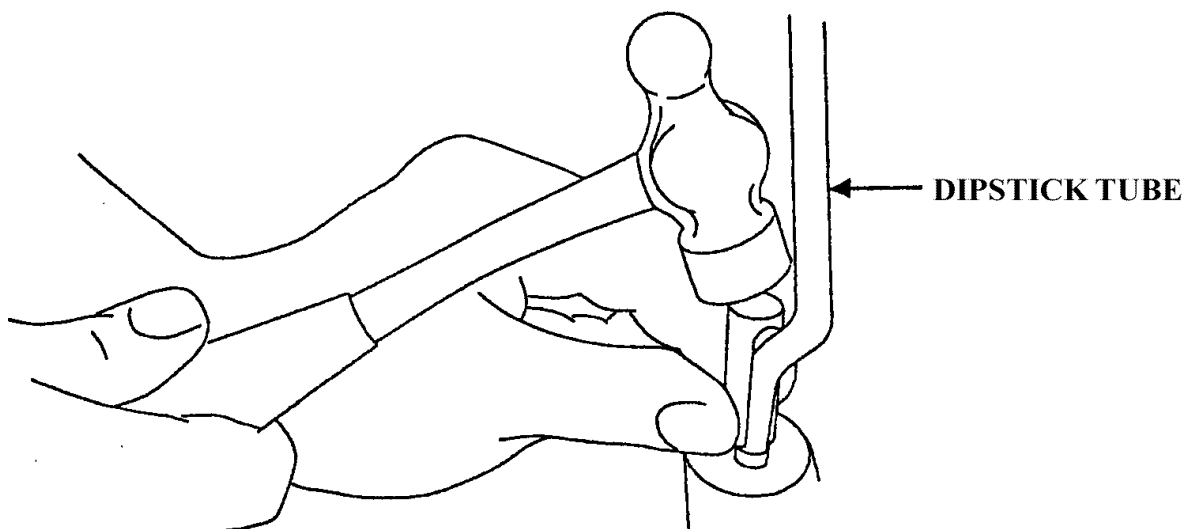
- (2) Remove dipstick tube (2).
- (3) Cover all openings to prevent entry of foreign material.

c. Replacement.

- (1) Inspect oil dipstick (1, Figure 3-12) and oil dipstick tube (2), refer to step a.
- (2) Remove oil dipstick (1) and oil dipstick tube (2), refer to step b. Replace if damaged. For installation, refer to step d.

d. Installation.

- (1) Remove all covering installed during step b (3).
- (2) Coat end of dipstick tube (2, Figure 3-12) with Retaining Compound (LOCTITE 680).
- (3) Install dipstick tube until dipstick tube shoulder bottoms against engine block.
- (4) Install dipstick.



**FIGURE 3-13. OIL DIPSTICK TUBE INSTALLATION.**

3.11.6. OIL PAN.

a. Inspection.

- (1) Inspect oil pan (2, Figure 3-14) for cracks, dents, or other damage. Notify next higher maintenance level if oil pan is cracked, dented, or damaged.
- (2) Inspect gasket (1) for signs of leakage. Notify next higher maintenance level if oil pan gasket shows signs of leakage.
- (3) Inspect plugs (5) and hole for damaged threads or signs of leakage. Notify next higher maintenance level if oil plugs (5) or hole shows signs of leakage.

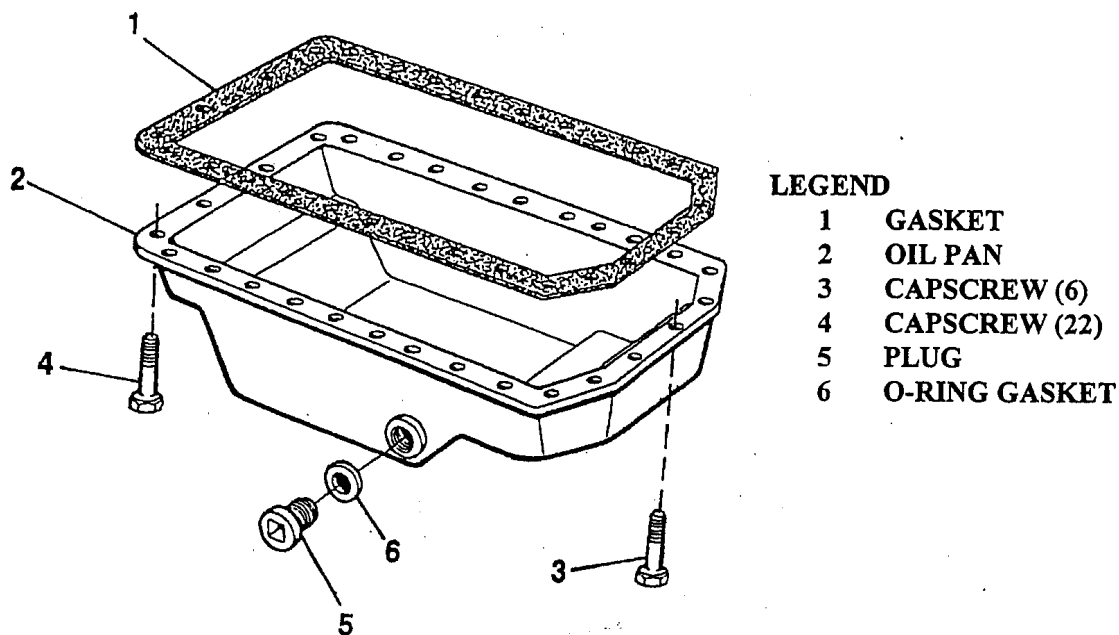


FIGURE 3-14. OIL PAN.

3.12. FUEL SYSTEM MAINTENANCE.

**WARNING**

Escaping diesel or JP fuel under pressure can have sufficient force to penetrate the skin, causing serious injury or death. Before disconnecting fuel lines, be sure to relieve pressure. Before applying pressure to the system, be sure all connections are tight and lines, pipes, and hoses are not damaged. Keep hands and body away from pinholes and nozzles which eject fuel under pressure. Use a piece of cardboard or wood, rather than hands, to search for suspected leaks.

**WARNING**

**If diesel or JP fuel is injected into skin, seek medical attention immediately. Failure to comply can result in serious injury.**

3.12.1. **BLEEDING FUEL SYSTEM.**

a. **General.**

Any time fuel system has been opened up for service (lines disconnected or filter removed), it will be necessary to bleed air from system. The fuel system can be bled at one of several locations.

**NOTE**

**The top panel may have to be removed to access fuel lines.**

b. **Bleed at Fuel Filter.**

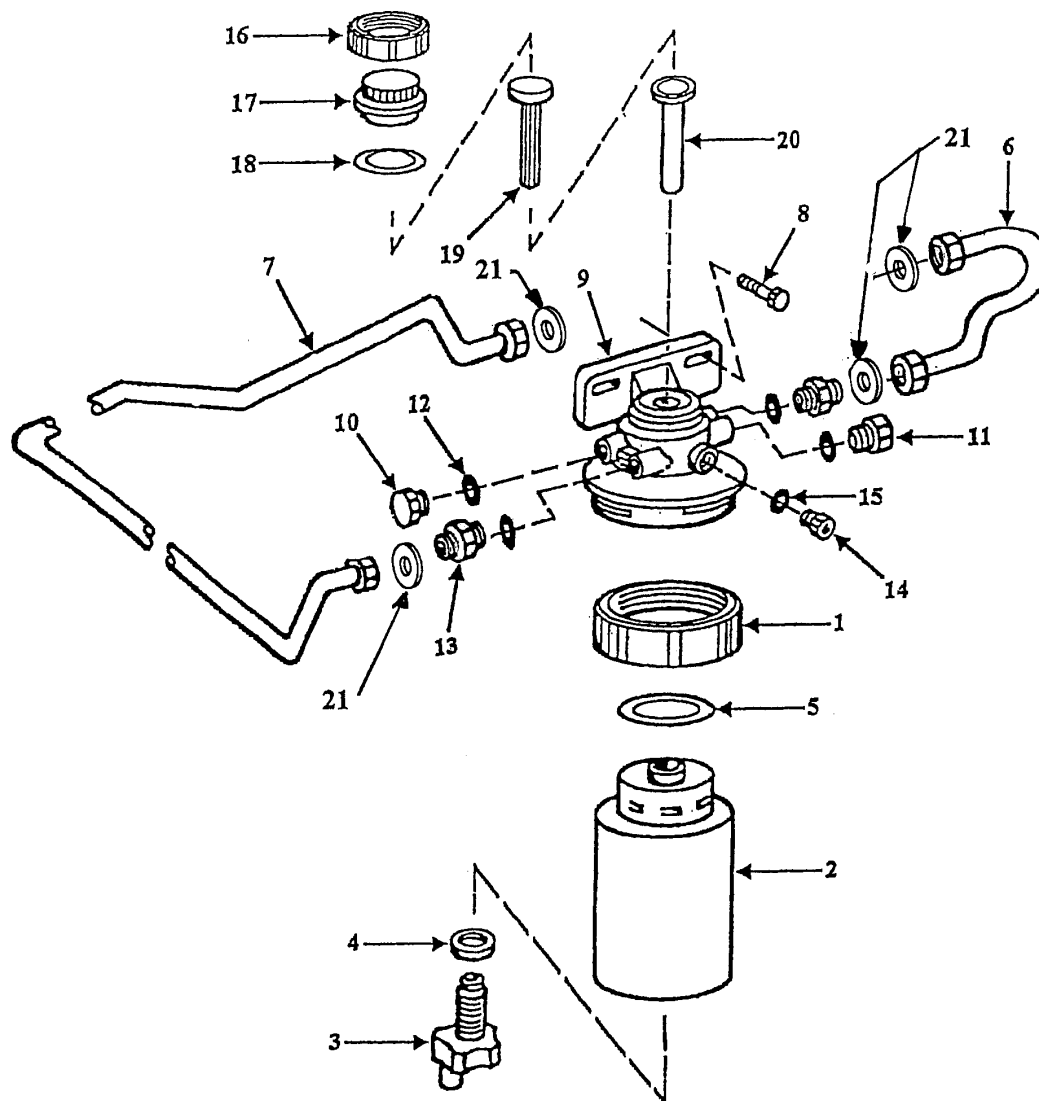
**WARNING**

**Diesel and JP fuels are flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.**

**NOTE**

**Catch fuel in suitable container.**

- (1) Open air bleed vent screw (14, Figure 3-15) two full turns.
- (2) Pump primer lever (6, Figure 3-16) on fuel supply pump until a noticeable amount of fuel and air comes out of air bleed vent screw (14, Figure 3-15) opening. Continue pumping primer lever and close air bleed vent screw when fuel starts to flow out air bleed vent screw opening and is free of air bubbles.
- (3) Pump primer lever (6, Figure 3-16) several times until resistance is felt. Continue pumping primer lever and open air bleed vent screw (14, Figure 3-15) again momentarily.
- (4) Close air bleed vent screw (14, Figure 3-15) and pump primer lever (6, Figure 3-16) several times until resistance is felt again. Push primer lever downward and release.



**LEGEND**

- |                       |                            |                          |
|-----------------------|----------------------------|--------------------------|
| 1 RETAINING RING      | 8 CAP SCREW (2)            | 15 O-RING SEAL           |
| 2 FUEL FILTER ELEMENT | 9 FUEL FILTER BASE         | 16 RETAINING CAP         |
| 3 DRAIN PLUG          | 10 PLUG                    | 17 CAP                   |
| 4 O-RING SEAL         | 11 PLUG                    | 18 O-RING SEAL           |
| 5 SEAL PLUG           | 12 O-RING SEAL (4)         | 19 PLUNGER               |
| 6 FUEL LINE           | 13 CONNECTOR (2)           | 20 PLUNGER               |
| 7 FUEL LINE           | 14 AIR BLEED VENT<br>SCREW | HOUSING                  |
|                       |                            | 21 SEALING<br>WASHER (4) |

**FIGURE 3-15. FUEL FILTER ASSEMBLY.**

c. Bleed at Fuel Injection Pump.

**WARNING**

Diesel and JP fuels are flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.

**CAUTION**

Fuel lines are fragile and can become twisted and damaged during maintenance. Always use one wrench to hold one fitting stationary while the other fitting is loosened or tightened. Failure to comply can cause damage to equipment.

**NOTE**

Catch fuel in suitable container.

- (1) Loosen fuel return line (3, Figure 3-17) at fuel injection pump.
- (2) Pump primer lever (6, Figure 3-16) on fuel supply pump until fuel flow is free from air bubbles.

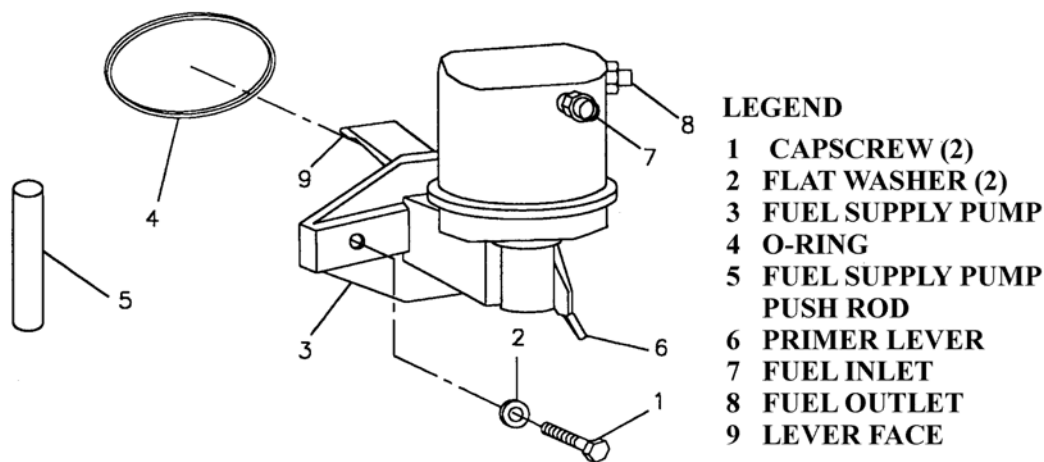


FIGURE 3-16. FUEL SUPPLY PUMP.

**CAUTION**

Fuel lines are fragile and can become twisted and damaged during maintenance. Always use one wrench to hold one fitting stationary while the other fitting is loosened or tightened. Failure to comply can cause damage to equipment.

- (3) Tighten fuel return line to 12 lb-ft (16 Nm).

- d. Bleed at Fuel Injection Nozzles.

**WARNING**

Exhaust system is very hot after operating engine. After operating engine, allow exhaust system to cool before removal. Failure to comply could result in personal injury.

**WARNING**

Diesel and JP fuels are flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.

**CAUTION**

Fuel lines are fragile and can become twisted and damaged during maintenance. Always use one wrench to hold one fitting stationary while the other fitting is loosened or tightened. Failure to comply can cause damage to equipment.

- (1) Loosen connections at all of the fuel injection nozzles.

**WARNING**

Escaping diesel or JP fuel under pressure can have sufficient force to penetrate skin. Place a clear, protective shield around spray zone. Failure to comply could result in serious injury or death.

**CAUTION**

Damage to fuel injection pump, battery, or starter motor can occur if starter motor is used excessively to eliminate air from the fuel system. Allow at least two minutes for cooling and battery recovery before operating again.

- (2) Using an assistant, operate starter motor (but do not start engine), refer to TM 9-6115-671-14, and observe connections until fuel, free from air, comes from high-pressure connections.

**CAUTION**

Fuel lines are fragile and can become twisted and damaged during maintenance. Always use one wrench to hold one fitting stationary while the other fitting is loosened or tightened. Failure to comply can cause damage to equipment.

- (3) Tighten connections to 20 lb-ft (27 Nm).



**WARNING**

**Diesel and JP fuels are flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.**

- (4) Thoroughly clean engine and surrounding area to remove spilled diesel fuel.

3.12.2. **FUEL FILTER.**

- a. **Remove Fuel Filter Element**

**CAUTION**

**Dirt in the fuel system can damage components or cause poor engine performance. Always thoroughly clean the area around connection before disconnecting. Always cover all openings after disconnecting. Failure to comply can cause damage to components or poor engine performance.**

- (1) Thoroughly clean outside surface of the fuel filter and surrounding area.

**WARNING**

**Diesel and JP fuels are flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.**

**NOTE**

**Catch fuel in suitable container. Dispose of fuel in accordance with local ordinances.**

- (2) Loosen drain plug (3, Figure 3-15) and allow water and fuel to drain into suitable container.

**NOTE**

**Lift up on retaining ring while rotating to ease removal.**

- (3) Firmly grasp retaining ring (1) and rotate retaining ring counterclockwise 3 turn. Remove retaining ring and fuel filter element (2).



b. Service.

- (1) Remove drain plug (3, Figure 3-15) and O-ring seal (4). Discard fuel filter element and O-ring seal in a safe place in accordance with local regulations.
- (2) Inspect fuel filter base (9) for cleanliness. Clean as required.
- (3) Thoroughly inspect seal ring (5) for cracks and other damage. Replace as needed.

c. Installation

- (1) Position O-ring seal (4, Figure 3-15) on drain plug (3) and install drain plug (3) on new fuel filter element (2).

**NOTE**

**Fuel filter element must be indexed properly and key on fuel filter element must be oriented in slot of fuel filter base for correct installation.**

- (2) Position new fuel filter element (2) on fuel filter base (9) using a slight rocking motion. Insure that fuel filter element is properly indexed on fuel filter base.
- (3) Position retaining ring (1) on fuel filter base (9) and tighten about 1/3 turn until retaining ring "snaps" into detent. Do not overtighten retaining ring.
- (4) Bleed fuel system, refer to paragraph 3.12.1.

3.12.3. FUEL TRANSFER SUPPLY PUMP.

a. Test, on Engine.

**CAUTION**

**Dirt in the fuel system can damage components or cause poor engine performance. Always thoroughly clean the area around connection before disconnecting. Always cover all openings after disconnecting. Failure to comply can cause damage to components or poor engine performance.**

- (1) Thoroughly clean outside surface of fuel filter and surrounding area.

**WARNING**

**Diesel and JP fuels are flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.**

**WARNING**

Escaping diesel or JP fuel under pressure can have sufficient force to penetrate skin. Before removing plug, be sure to relieve pressure. Failure to comply could result in serious injury or death.

**NOTE**

Catch fuel in suitable container. Dispose of fuel in accordance with local ordinances.

- (2) Slowly loosen plug (11, Figure 3-15) and allow fuel pressure to dissipate. Remove plug (11) from fuel filter and install fuel pressure gage.

**WARNING**

Operating the generator set with any access door open exposes personnel to high noise levels. Hearing protection must be worn when operating or working near the generator set with any access door open. Failure to comply can cause hearing damage or loss.

- (3) Start engine, refer to TM 9-6115-671-14. Fuel supply pump should maintain positive minimum pressure of 2-4 psi (15-30 kPa).
  - (a) If pressure is low, replace filter element, refer to paragraph 3.12.2, and test pressure again.
  - (b) If pressure is still low, bench test fuel supply pump, refer to step d.
- (4) Remove fuel pressure gage and install plug (11).
- (5) Bleed fuel system, refer to paragraph 3.12.1.

b. Removal.

**CAUTION**

Dirt in the fuel system can damage components or cause poor engine performance. Always thoroughly clean the area around connection before disconnecting. Always cover all openings after disconnecting. Failure to comply can cause damage to components or poor engine performance.

- (1) Thoroughly clean outside surface of fuel supply pump and surrounding area.

**WARNING**

Diesel and JP fuels are flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.

**WARNING**

Escaping diesel or JP fuel under pressure can have sufficient force to penetrate skin. Before disconnecting lines, be sure to relieve pressure. Failure to comply could result in serious injury or death.

**CAUTION**

Fuel lines are fragile and can become twisted and damaged during maintenance. Always use one wrench to hold one fitting stationary while the other fitting is loosened or tightened. Failure to comply can cause damage to equipment.

**NOTE**

**Catch fuel in suitable container.**

- (2) Disconnect fuel supply line, connected to fuel inlet (7, Figure 3-16). Slowly loosen fuel line (6, Figure 3-15) and allow fuel pressure to dissipate. Remove fuel line.
  - (3) Remove capscrews (1, Figure 3-16), flat washers (2), fuel supply pump (3) and o-ring (4). Discard o-ring.
  - (4) Inspect all removed sealing washers and fittings. If damaged, replace.
  - (5) Cover all openings to prevent entry of foreign material.
- c. Inspection.
- (1) Remove fuel supply pump, refer to step b.
  - (2) Inspect fuel supply pump (3, Figure 3-16) lever face (9) for wear. Replace fuel supply pump if lever face is worn flat or concave.
- d. Test, bench.
- (1) Remove fuel supply pump, refer to step b.
  - (2) Perform vacuum/pressure test as follows:
    - (a) Install vacuum/pressure gage to fuel inlet (7, Figure 3-16).
    - (b) Move primer lever (6) all the way downward. Release lever and at the same time observe gage.
      - 1 Gauge needle should read the same value each time primer lever is moved all the way downward and released. Gauge needle should then slowly return to "0" each time. Repeat several times.

- 2 If gauge needle reads different values on different attempts, does not move at all, or rapidly returns to “0”, fuel supply pump is defective and must be replaced.
  - (c) Remove vacuum/pressure gage from fuel inlet (7) and install vacuum/pressure gage on fuel outlet (8).
  - (d) Move primer lever (6) all the way upward. Release lever and at the same time observe gage.
    - 1 Gauge needle should initially read 4-6 psi (28-41 kPa) , then quickly return to “0”. This indicates that the outlet valve and diaphragm are in good condition, supply pump is operating properly and should be reinstalled on engine.
    - 2 If gauge needle does initially read same value as indicated above and then returns immediately back to “0” fuel supply pump is defective and must be replaced.
  - (e) Remove vacuum/pressure gauge from fuel outlet (8).
- (3) Perform leakage test as follows:
  - (a) Install a plug on fuel outlet (8, Figure 3-16).
  - (b) Install regulated pressure air line on fuel inlet (7, Figure 3-15) and apply 20 psi (140 kPa) pressure.

**WARNING**

**Diesel and JP fuels are flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.**

- (c) Submerge pump in clean diesel fuel and look for air bubbles. Replace fuel supply pump if air bubbles are present.
      - (d) Remove plug and regulated pressure air line.
- e. Replacement.
  - (1) Remove fuel supply pump, refer to step b.
  - (2) Inspect fuel supply pump, refer to step c. Replace fuel supply pump if lever face is worn flat or concave.
  - (3) Perform bench test, refer to step d. Replace if fuel supply pump fails bench test.
  - (4) For installation of fuel supply pump, refer to step f.

f. Installation.

- (1) Remove all covering installed during step b (4).
- (2) Ensure all old gasket material is removed from gasket surfaces.
- (3) Apply Thread Lock and Sealer (LOCTITE 242) to threads of capscrews (1, Figure 3-16).

**NOTE**

**Pump lever must be positioned above fuel supply pump push rod before fuel supply pump can be installed.**

- (4) Position o-ring (4) and fuel supply pump (3) on engine block. Install flat washers (2) and capscrews (1). Torque capscrews evenly to 22 lb-ft (30 Nm).

**CAUTION**

**Thread sealant can cause damage to fuel system. Do not allow sealant to get into fuel system. Failure to comply could result in damage to fuel system.**

- (5) Apply Thread Lock and Sealer (LOCTITE 242) to threads of fuel inlet (7) and fuel outlet (8).

**CAUTION**

**Fuel lines are fragile and can become twisted and damaged during maintenance. Always use one wrench to hold one fitting stationary while the other fitting is loosened or tightened. Failure to comply can cause damage to equipment.**

- (6) Install fuel line (6). Reconnect fuel supply line to fuel inlet (7, Figure 3-16). Torque fuel lines to 22 lb-ft (30 Nm).
- (7) Bleed fuel system, refer to paragraph 3.12.1.

3.12.4. FUEL LINES.

a. Removal.

**CAUTION**

**Fuel injection pump gets very hot during operation. Never steam clean or pour water on fuel injection pump while fuel injection pump is running or warm. Failure to comply could cause seizure of internal rotating parts.**

**CAUTION**

**Dirt in the fuel system can damage components or cause poor engine performance. Always thoroughly clean the area around connection before disconnecting. Always cover all openings after disconnecting. Failure to comply can cause damage to components or poor engine performance.**

- (1) Thoroughly clean outside surfaces of fuel lines and surrounding area.
- (2) Remove capscrews (6, Figure 3-17) and loop clamps (5).
- (3) Remove capscrews (16) and loop clamp (15).

#### **WARNING**

**Diesel and JP fuels are flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.**

#### **CAUTION**

**Fuel lines are fragile and can become twisted and damaged during maintenance. Always use one wrench to hold one fitting stationary while the other fitting is loosened or tightened. Failure to comply can cause damage to equipment.**

#### **NOTES**

**Catch fuel in suitable container. Dispose of fuel in accordance with local ordinances.**

**Disconnect all fuel delivery (pressure) lines from injection pump using a suitable 17 mm deep-well crow'sfoot socket.**

- (4) Disconnect coupling nut (29, Figure 3-17), remove clamp (13) and remove supply line from fuel filter, refer to paragraph 3.12.2.
  - (5) Disconnect coupling nut (30) on return tube (3).
  - (6) Disconnect coupling nuts (2) securing tubes (4) to injectors. Remove tubes, coupling nuts and return fuel line.
  - (7) Tag and disconnect fuel injection lines (7, 8, 9, and 10) from fuel injectors and fuel injection pump.
  - (8) Cover all openings to prevent entry of foreign material.
- b. **Inspection.**
- (1) Remove fuel lines, refer to step a.
  - (2) Inspect all fuel lines and seals for wear, kinks, or fitting damage. Replace as necessary.
  - (3) Ensure all connections are open. Replace as necessary.
  - (4) Inspect all removed o-rings, sealing washers, and fittings. If damaged, replace.

c. Replacement.

- (1) Remove fuel lines, refer to step a.
- (2) Inspect fuel lines and seals, refer to step b. Replace if worn, kinked, or fitting damage is present.
- (3) Install fuel lines, refer to step d.

d. Installation.

- (1) Remove all covering installed during step a (8).

**CAUTION**

**Fuel lines are fragile and can become twisted and damaged during maintenance. Always use one wrench to hold one fitting stationary while the other fitting is loosened or tightened. Failure to comply can cause damage to equipment.**

- (2) Connect fuel injection lines (7, 8, 9 and 10 , Figure 3-17) to fuel injectors and fuel injection pump as tagged during removal. Torque fuel injection lines to 20 lb-ft (27 Nm).
- (3) Position coupling nuts (2) on tubes.
- (4) Position tubes (4) on fuel injectors and secure with coupling nuts (2). Torque coupling nuts to 20 lb-ft (27 Nm).
- (5) Position coupling nut (30) on return tube and connect to fuel injection pump (22).
- (6) Position coupling nut (29) on fuel supply line.
- (7) Connect supply line to fuel filter and install clamp (13).
- (8) Position loop clamps (5 and 15) on fuel injection lines (7, 8, 9 and 10) and secure with capscrews (6 and 16).
- (9) Bleed fuel system, refer to paragraph 3.12.1.

3.12.5. FUEL INJECTION PUMP.

Inspection.

Inspect fuel injection pump for cracks, leaks, or obvious signs of damage. Notify next higher maintenance level if cracked, leaking, or otherwise damaged.

3.12.6. FUEL INJECTION NOZZLE ASSEMBLY.

Inspection.

Inspect fuel injection nozzle assembly for cracks, leaks, or obvious signs of damage. Notify next higher maintenance level if cracked, leaking, or otherwise damaged.





## CHAPTER 4

### DIRECT SUPPORT MAINTENANCE INSTRUCTIONS

#### Section I. TROUBLESHOOTING

##### 4.1. DIRECT SUPPORT TROUBLESHOOTING PROCEDURES.

###### Purpose of Troubleshooting Flowchart.

This section contains troubleshooting information for locating and correcting operating troubles which may develop in the engine. Each malfunction for an individual component, unit, or system is followed by a list of tests or inspections which will help you to determine probable causes and corrective action to take. You should perform tests/inspections and corrective actions in order listed.

Table 4-1 cannot list all malfunctions that can occur, nor all tests or inspections and corrective actions. If a malfunction is not listed or cannot be corrected by listed corrective actions, notify your supervisor.

#### NOTE

**Before you use Table 4-1, be sure you have performed your PMCS. Prior to performing troubleshooting procedures within this manual, perform troubleshooting procedures per TM 9-6115-671-14.**

#### SYMPTOM INDEX

Malfunction	Page
Engine Fails to Crank .....	4-2
Starter Operates But Engine Does Not Turn Over.....	4-3
Engine Cranks But Fails to Start.....	4-4
Engine Misfires Or Runs Erratically Or Stalls Frequently.....	4-5
Engine Does Not Develop Full Power.....	4-6
Engine Overheating .....	4-7
Excessive Oil Consumption .....	4-7
Low Oil Pressure .....	4-8
Excessive Fuel Consumption.....	4-9
Black or Gray Exhaust Smoke.....	4-10
Blue or White Exhaust Smoke.....	4-11
Engine Knocks.....	4-12
Engine Makes Abnormal Noise .....	4-13

TABLE 4-1. DIRECT SUPPORT TROUBLESHOOTING  
(Sheet 1 of 12)

## ENGINE FAILS TO CRANK

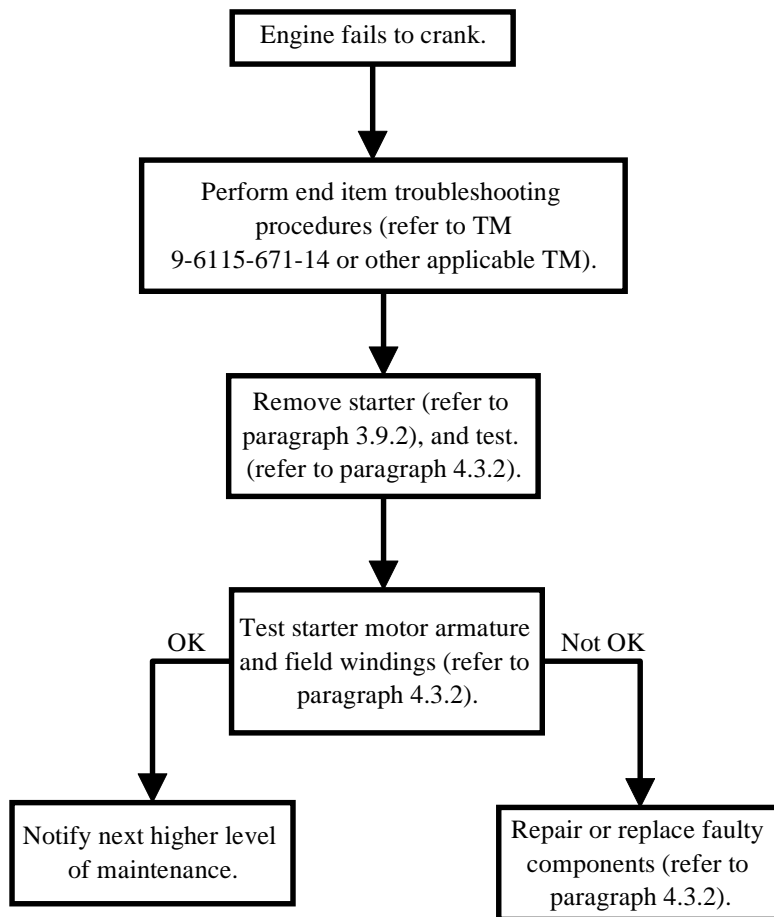


TABLE 4-1. DIRECT SUPPORT TROUBLESHOOTING  
(Sheet 2 of 12)

**STARTER OPERATES BUT ENGINE  
DOES NOT TURN OVER.**

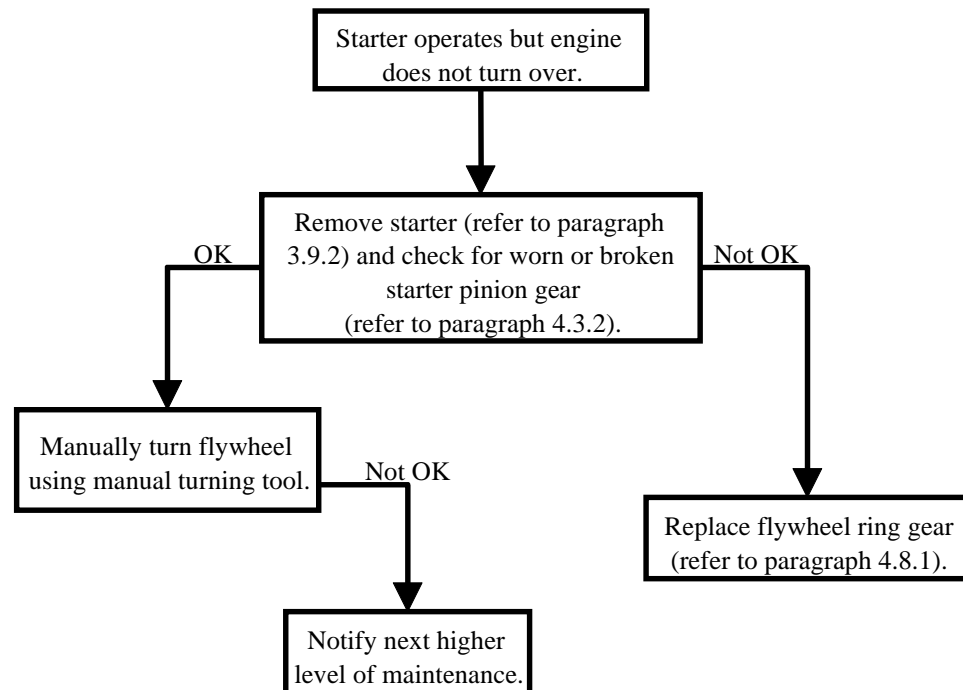


TABLE 4-1. DIRECT SUPPORT TROUBLESHOOTING  
(Sheet 3 of 12)

### ENGINE CRANKS BUT FAILS TO START

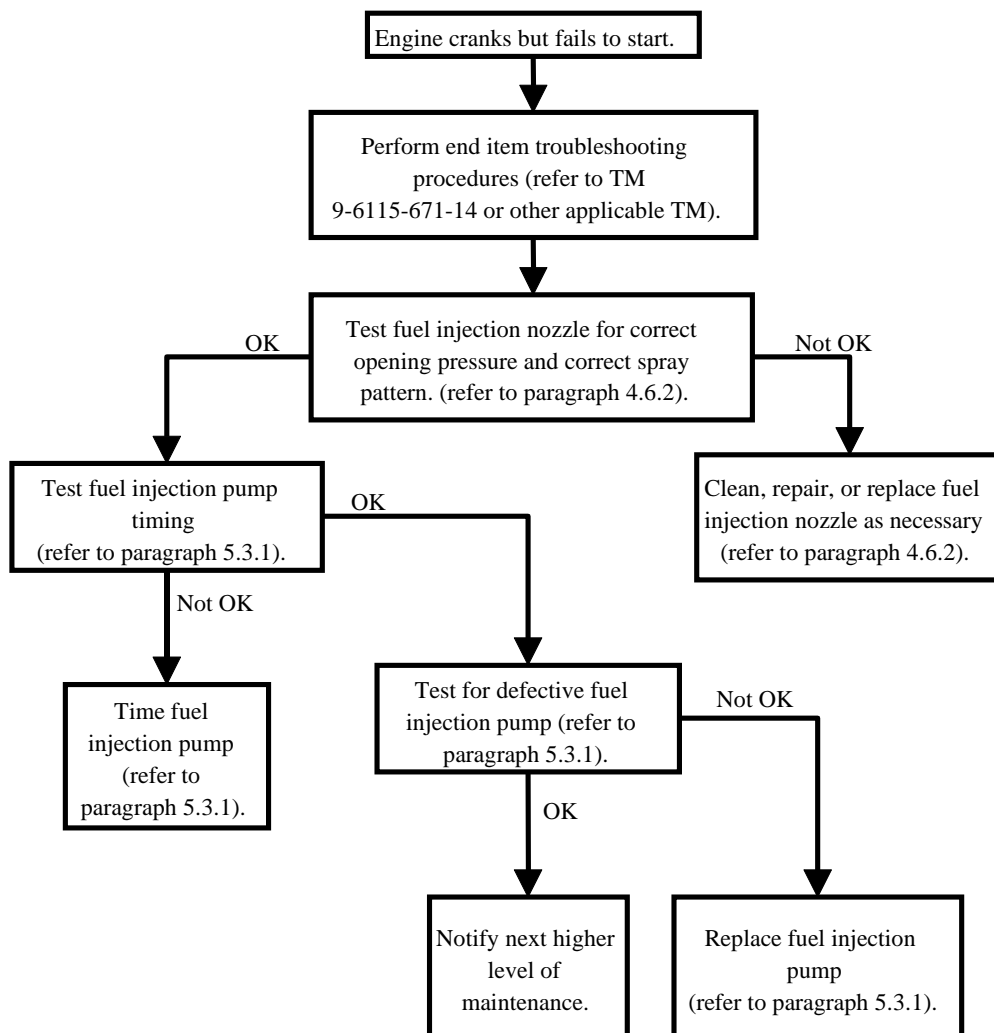


TABLE 4-1. DIRECT SUPPORT TROUBLESHOOTING  
 (Sheet 4 of 12)

**ENGINE MISFIRES OR RUNS ERRATICALLY OR  
 STALLS FREQUENTLY**

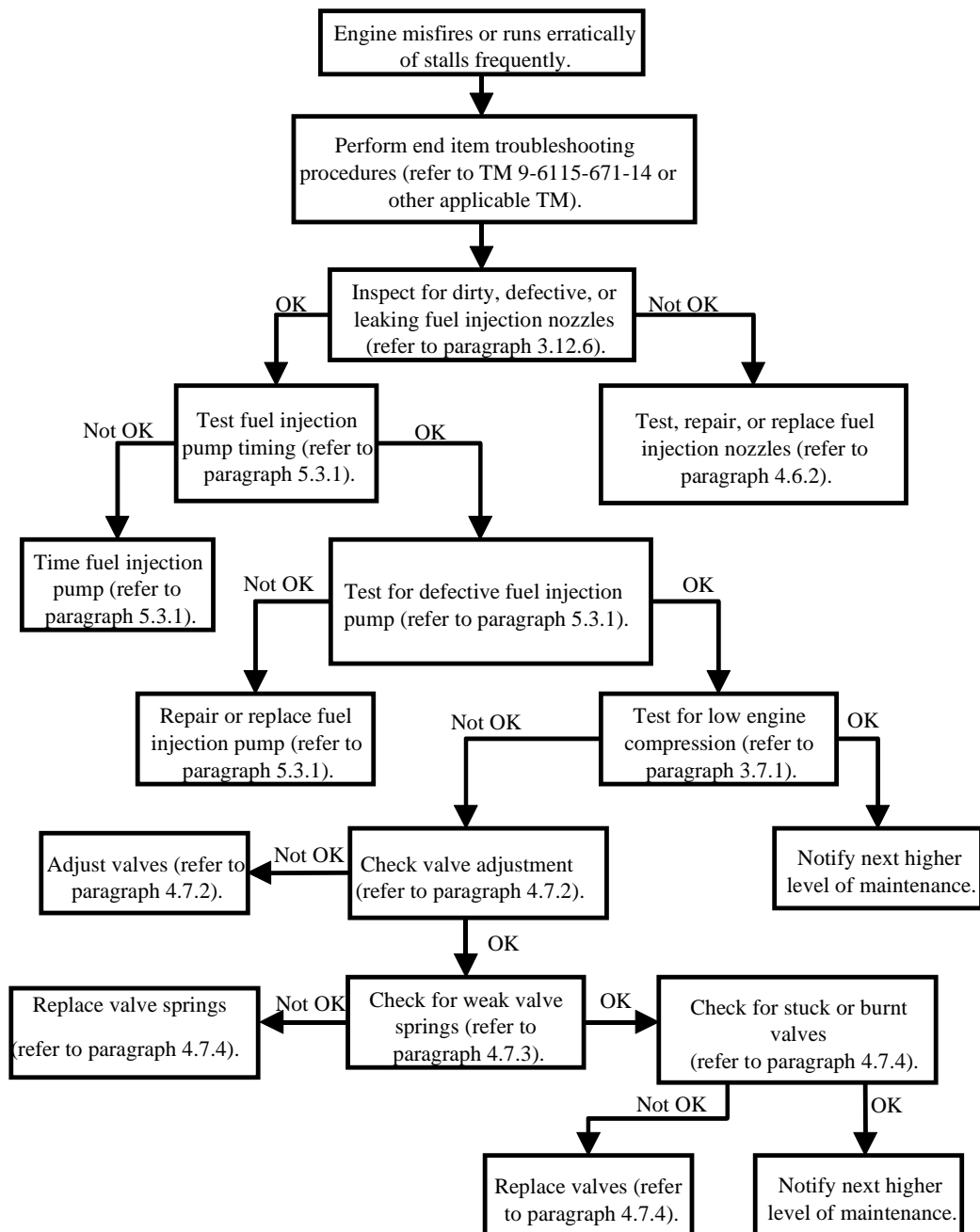


TABLE 4-1. DIRECT SUPPORT TROUBLESHOOTING  
 (Sheet 5 of 12)

**ENGINE DOES NOT DEVELOP FULL POWER**

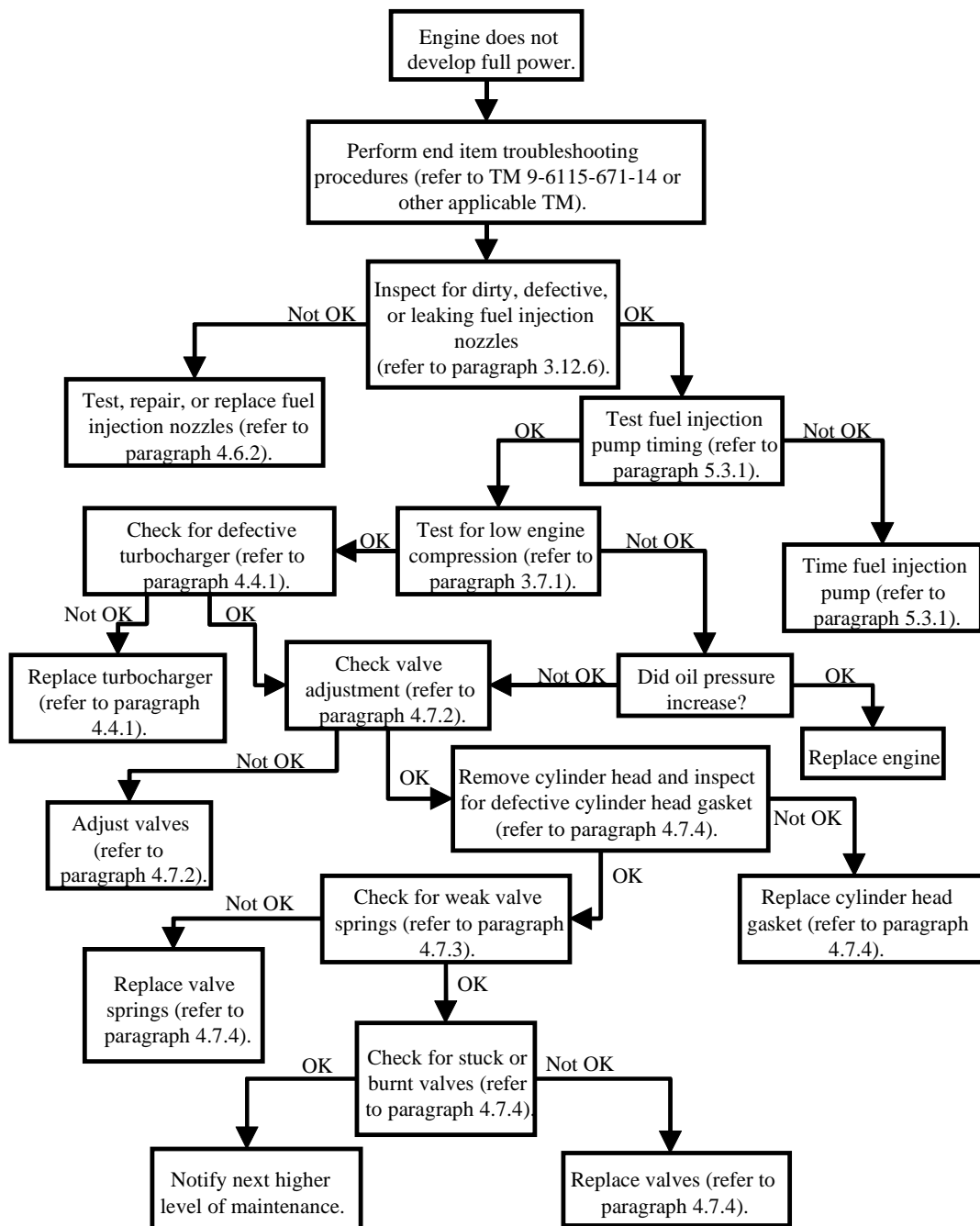
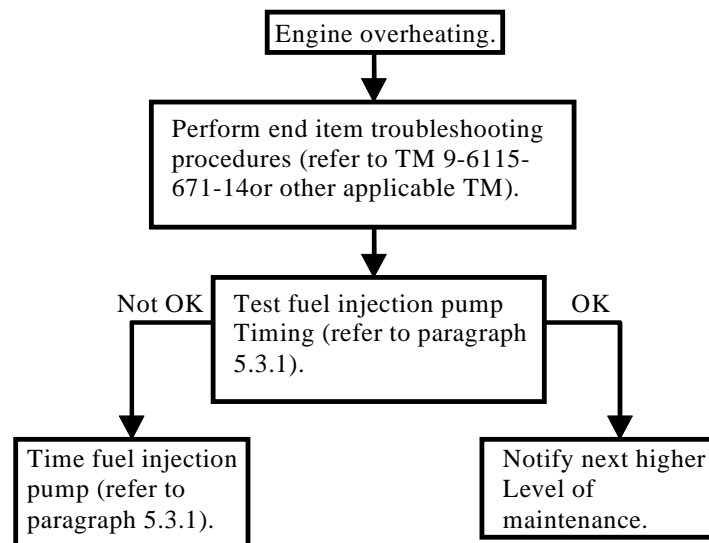


TABLE 4-1. DIRECT SUPPORT TROUBLESHOOTING  
(Sheet 6 of 12)

### ENGINE OVERHEATING



### EXCESSIVE OIL CONSUMPTION

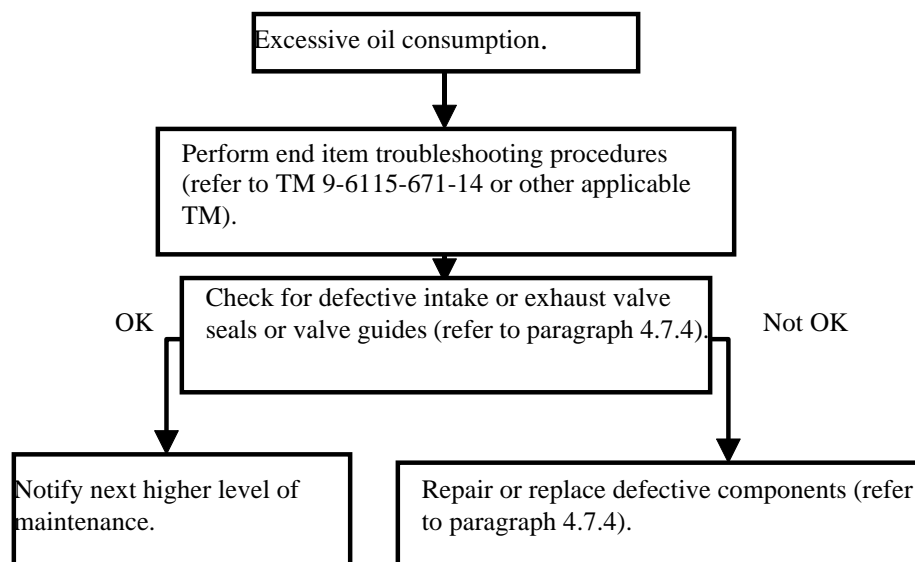


TABLE 4-1. DIRECT SUPPORT TROUBLESHOOTING  
 (Sheet 7 of 12)

### LOW OIL PRESSURE

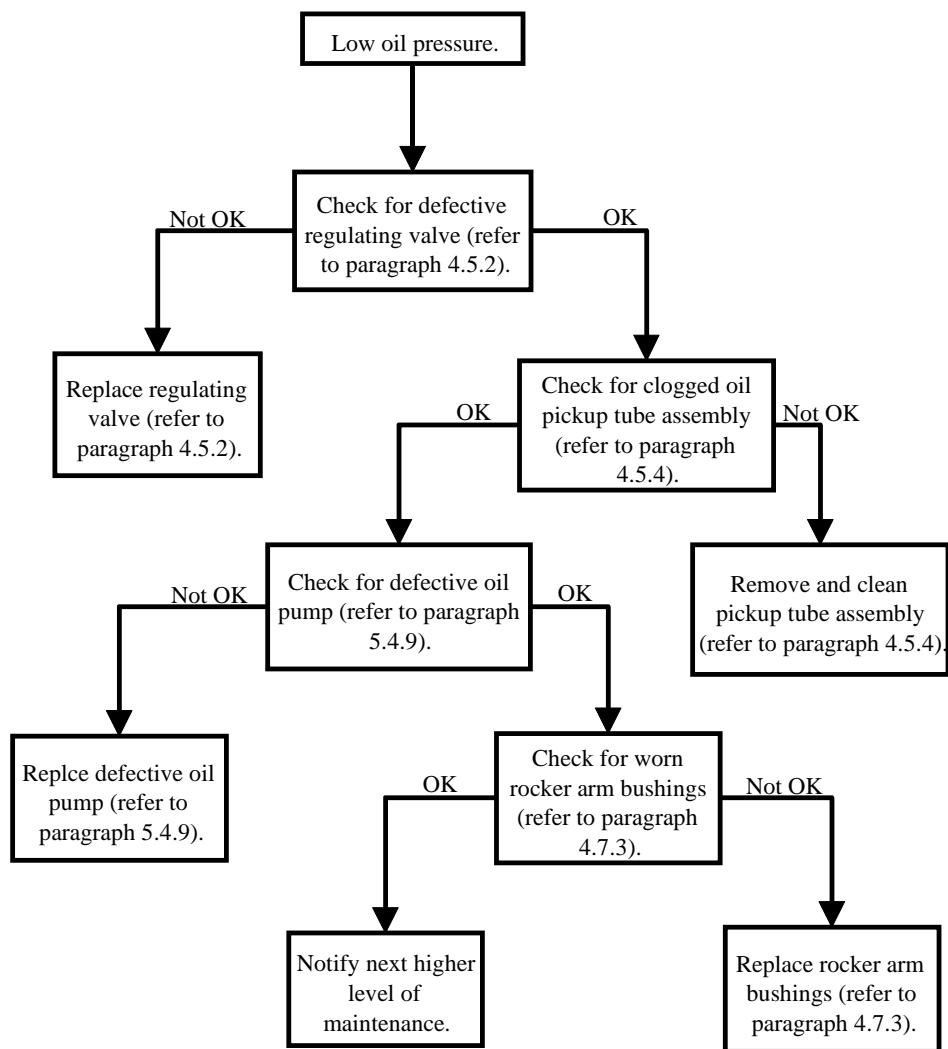




TABLE 4-1. DIRECT SUPPORT TROUBLESHOOTING  
 (Sheet 8 of 12)

### EXCESSIVE FUEL CONSUMPTION

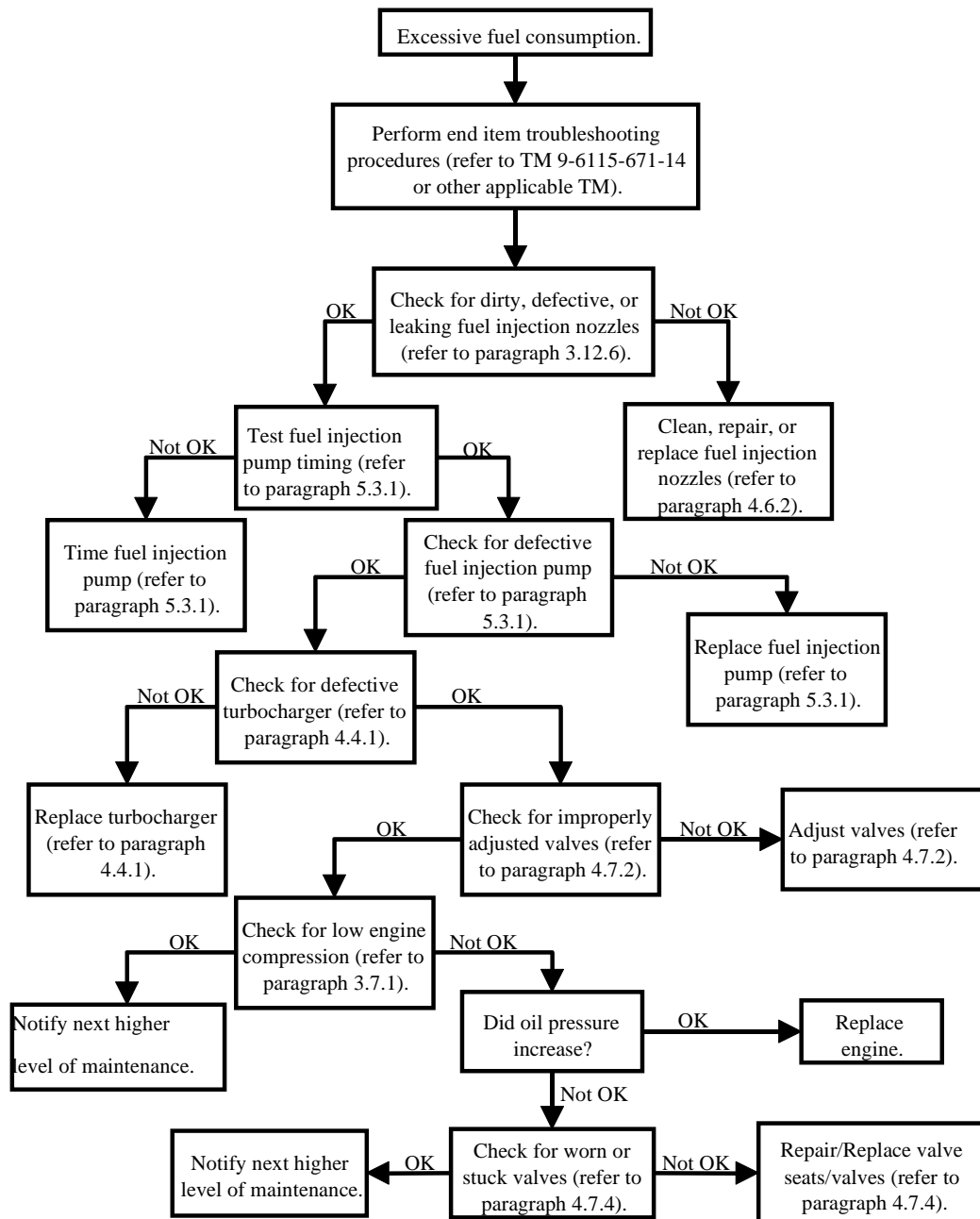


TABLE 4-1. DIRECT SUPPORT TROUBLESHOOTING  
 (Sheet 9 of 12)

### BLACK OR GRAY EXHAUST SMOKE

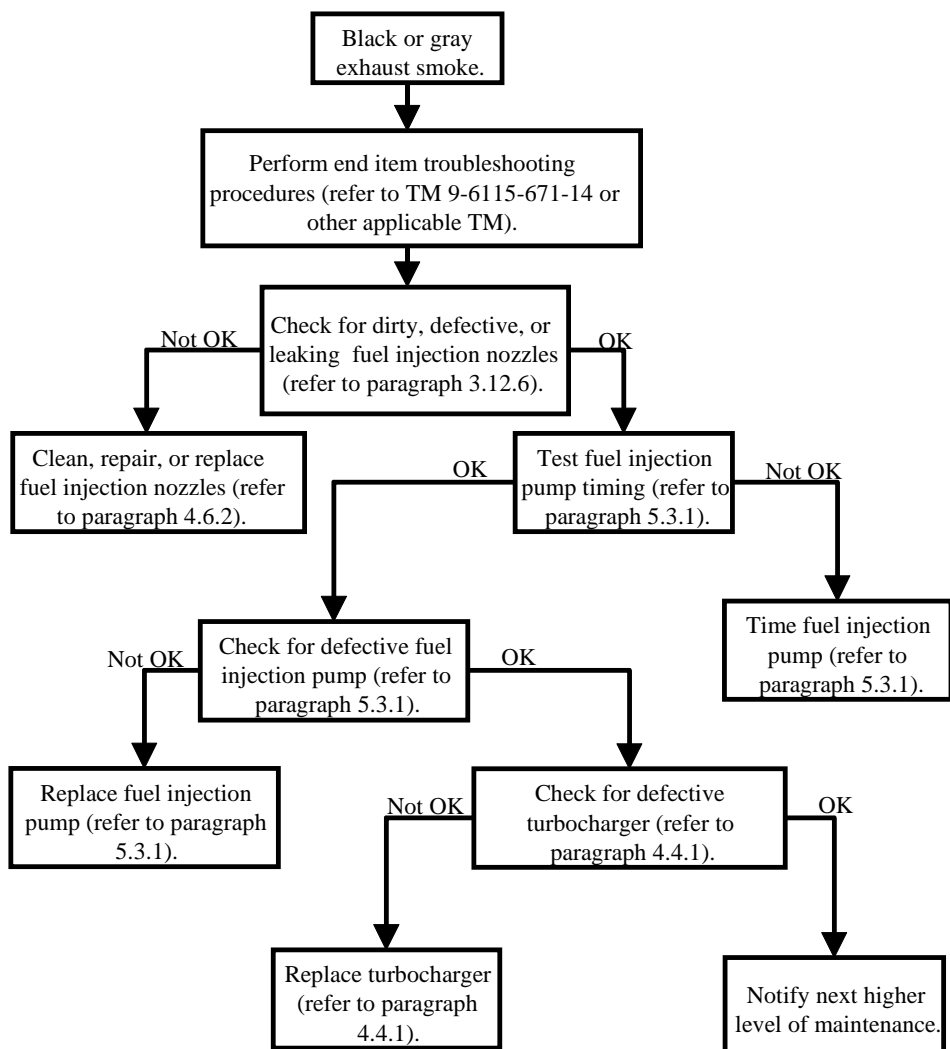


TABLE 4-1. DIRECT SUPPORT TROUBLESHOOTING  
(Sheet 10 of 12)

### BLUE OR WHITE EXHAUST SMOKE

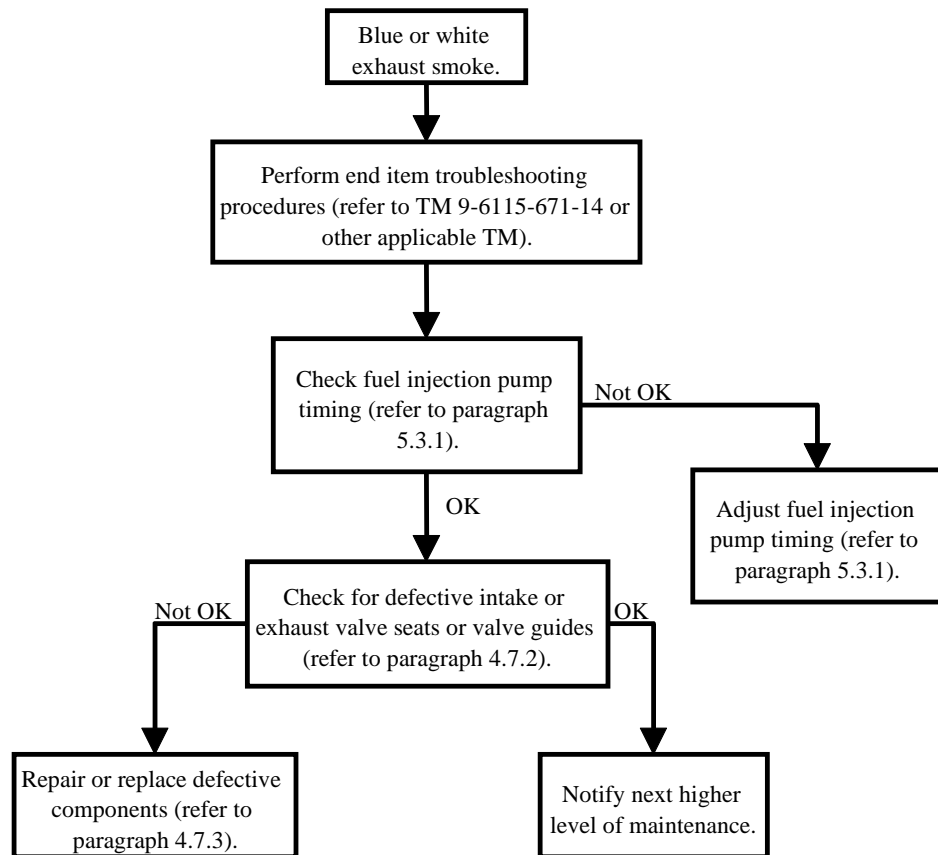


TABLE 4-1. DIRECT SUPPORT TROUBLESHOOTING  
 (Sheet 11 of 12)

## ENGINE KNOCKS

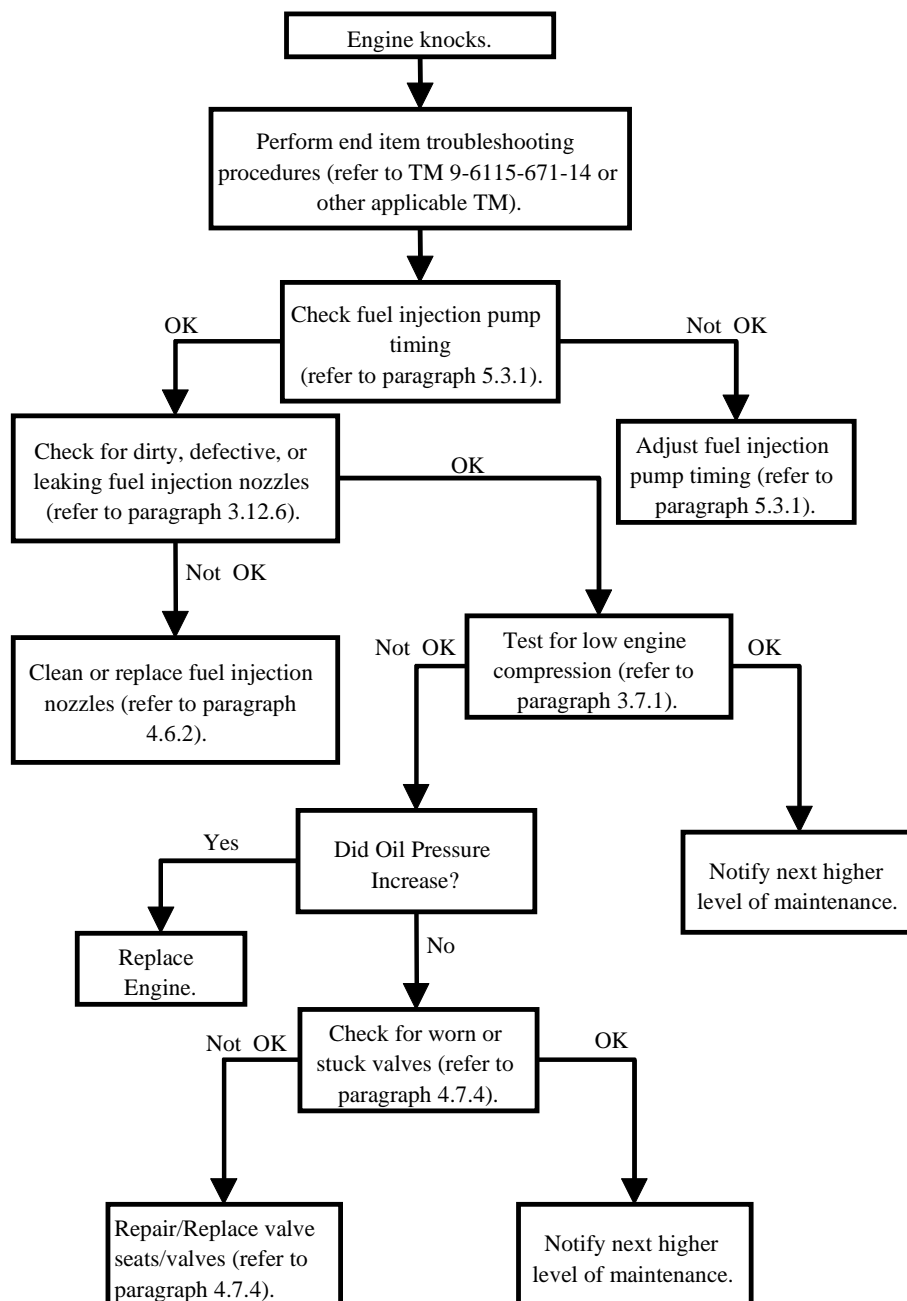
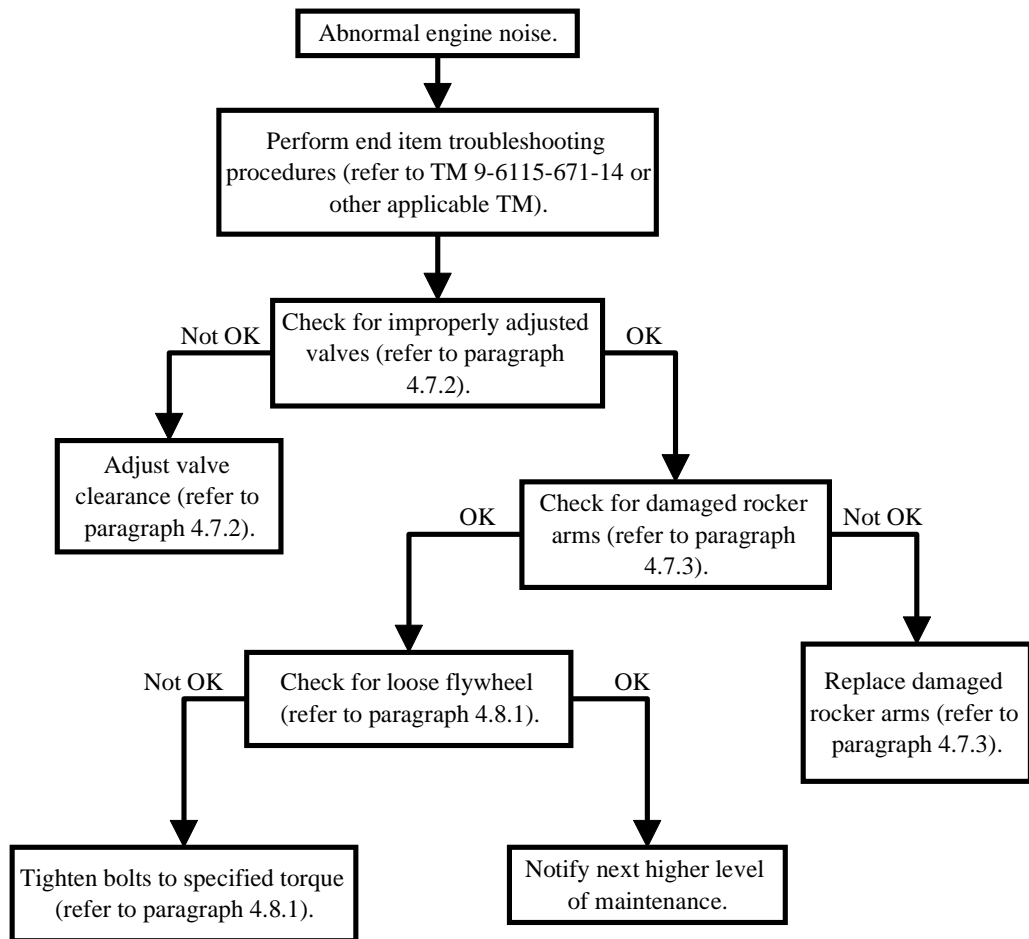


TABLE 4-1. DIRECT SUPPORT TROUBLESHOOTING  
(Sheet 12 of 12)

### ABNORMAL ENGINE NOISE



## Section II. MAINTENANCE PROCEDURES

### 4.2. GENERAL.

This section contains direct support maintenance procedures. Deficiencies noted during inspection which are beyond the scope of direct support level maintenance shall be reported to the next higher level of maintenance.

### 4.3. ELECTRICAL SYSTEM MAINTENANCE.

#### 4.3.1. BATTERY CHARGING ALTERNATOR.

##### a. Test.

- (1) Remove battery charging alternator, refer to paragraph 3.9.1.
- (2) Mount battery charging alternator on test fixture capable of providing 5000 alternator rpm.

### CAUTION

**Make sure connections are tight to avoid possible damage to instruments, battery charging alternator, or wiring due to short circuits.**

- (3) Set up circuit as shown in Figure 4-1.

### NOTE

**Carbon pile and ammeter must be capable of handling the alternator rated output.**

- (4) Starting with the carbon pile off, slowly increase load while observing ammeter and maintaining 5000 rpm. Increase load until an output voltage of 27.0 to 29.0 VDC is achieved. Record the output current at this point. Acceptable current is 38 amperes at 70 to 80°F (21.1 to 26.7°C).

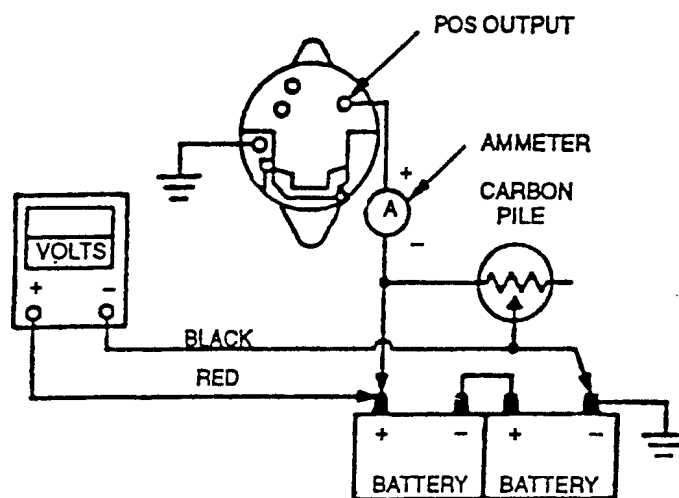


FIGURE 4-1. BATTERY CHARGING ALTERNATOR TEST CIRCUIT

b. Repair.

**NOTE**

**The following procedure is provided for repairing the battery charging alternator. Remove battery charging alternator (refer to paragraph 3.9.1.) and place on a suitable workbench.**

- (1) Remove terminal parts set (12, Figure 4-2) from slip ring end housing and through bolts (10) from drive end housing (1).
- (2) Remove two attaching bolts (16) from regulator assembly (8).
- (3) Remove attaching bolt from suppression capacitor (11).

**NOTE**

**When removing regulator assembly (8), exercise caution not to damage service brush set (13)**

- (4) Remove regulator assembly (8) and suppression capacitor (11) from slip ring end housing (5).

**CAUTION**

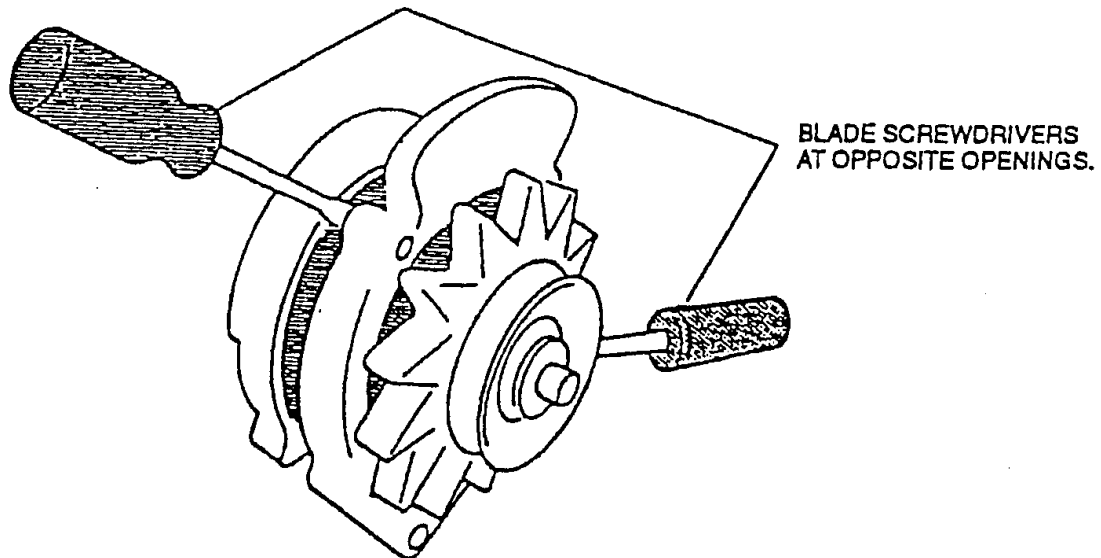
**Do not insert screwdriver blades deeper than 1/16 inch (1.587 mm) to avoid damaging stator winding.**

- (5) Match mark front and rear housing. Insert two flat tip screwdrivers in opposite openings between stator (9) and slip ring end housing (5), refer to Figure 4-3.
- (6) Pry units apart and remove slip ring end housing (5) and stator (9) from drive end housing (1).
- (7) Tag and remove stator (9) leads from rectifier (6).
- (8) Remove bolts (16) and rectifier (6) from slip ring end housing (5).
- (9) If not previously done, remove pulley and fan from rotor assembly (3, Figure 4-2) shaft.
- (10) Using arbor press, remove rotor assembly (3) from drive end housing (1).
- (11) Remove bearing retaining screws and press bearing (2) from drive end housing (1).
- (12) Remove bearing (4) from rotor assembly (3).
- (13) Check or replace brush assembly as follows;
  - (a) Refer to Figure 4-4 and check measurement "A". If dimension "A" is less than 0.2 in. (5mm), replace the brush assembly. When the new brush assembly is installed the new dimension "A" should not exceed 0.4 in. (10mm).
  - (b) Always replace the bearing (4) when replacing the brush assembly.

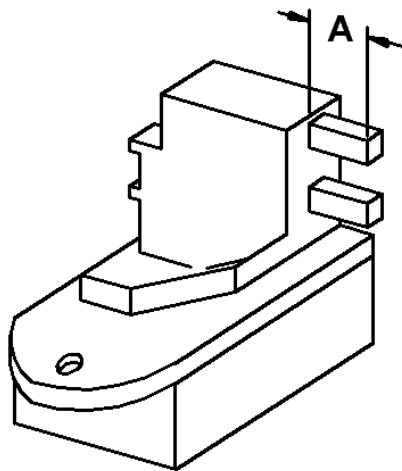


- FIGURE 4-2. BATTERY CHARGING ALTERNATOR ASSEMBLY**





**FIGURE 4-3. STATOR AND REAR HOUSING SEPARATION.**



**FIGURE 4-4. TESTING BRUSH ASSEMBLY**

(14) Check or replace exciting diodes as follows:

- (a) Set multimeter for ohms and check exciting diodes (refer to Figure 4-5) by noting multimeter indications between each of the diode leads (A) and the D+ stud (B). Reverse multimeter leads, repeat checks and note indications.
- (b) If readings are the same in both directions for any diode, replace exciting diodes assembly. A good diode will show a high indication in one direction and a low indication in the other.

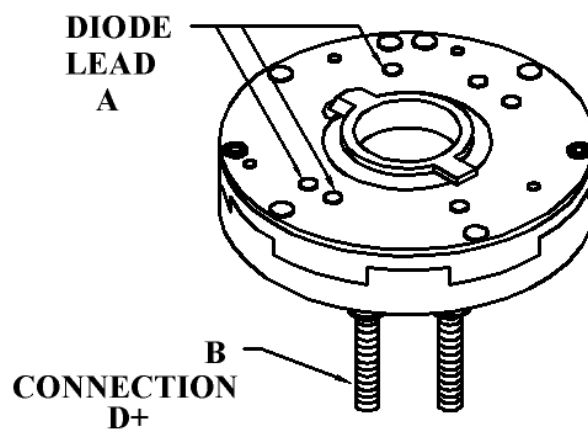


FIGURE 4-5. TESTING EXCITING DIODES

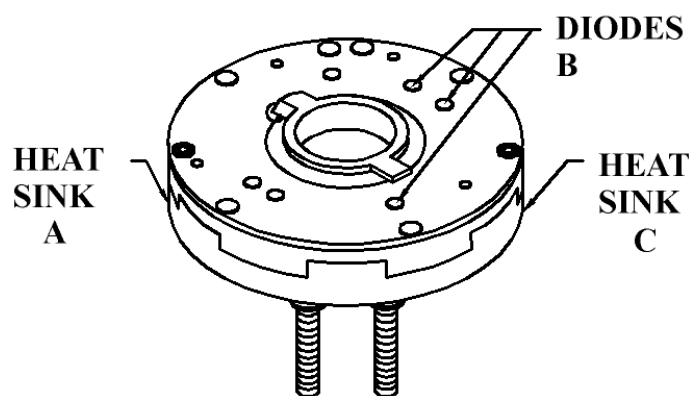


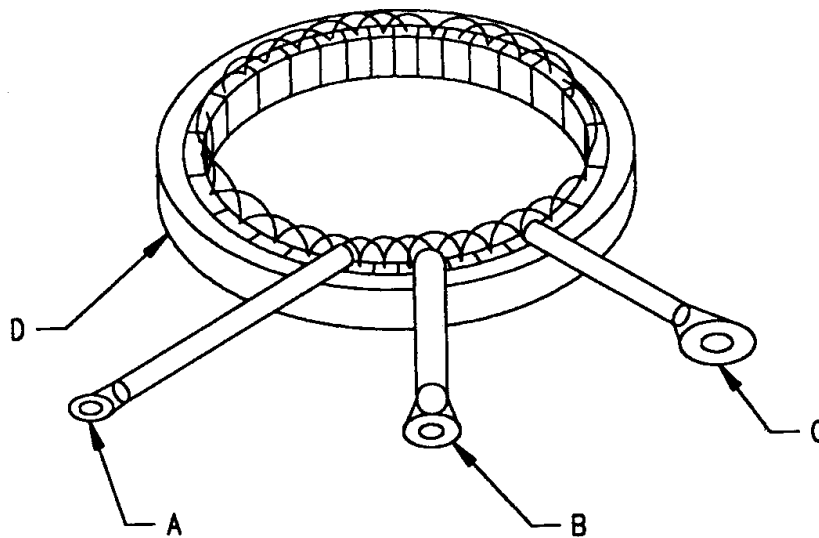
FIGURE 4-6. TESTING POSITIVE/NEGATIVE DIODES

(15) Check or replace positive diodes as follows:

- (a) Set multimeter for ohms and connect positive test probe of ohmmeter to positive heat sink (A) and negative test probe to leads (B) of diodes (refer to Figure 4-6). Meter must show continuity. Reverse leads, repeat check and note indications.
- (b) Replace entire rectifier bridge assembly if readings are the same in both directions for any diode. A good diode will have a high indication in one direction and a low indication in the other.

(16) Check or replace negative diodes as follows:

- (a) Set multimeter for ohms and connect positive test probe of ohmmeter to positive heat sink (C) and negative test probe to leads (B) of diodes (refer to Figure 4-6). Meter must show continuity. Reverse leads, repeat check and note indications.
- (b) Replace entire rectifier bridge assembly if readings are the same in both directions for any diode. A good diode will have a high indication in one direction and a low indication in the other.



**FIGURE 4-7. TESTING STATOR WINDINGS**

(17) Check or replace stator as follows:

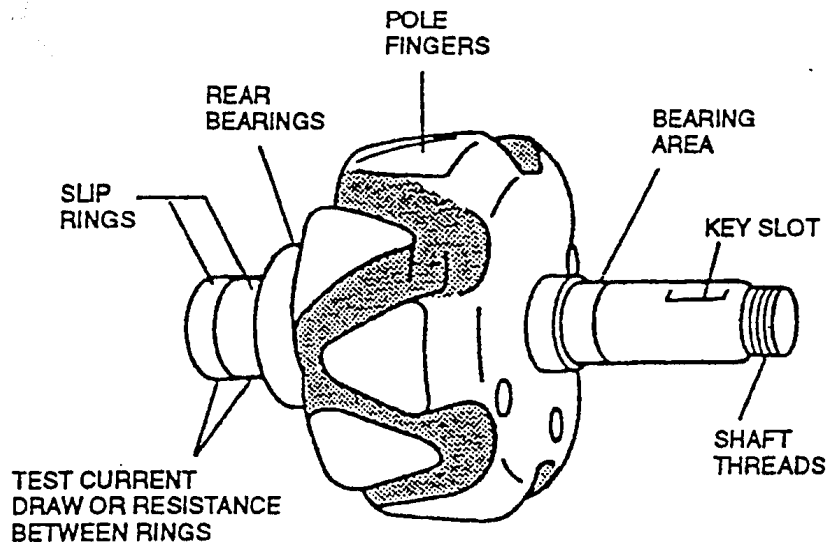
- (a) Set multimeter for ohms and check stator (refer to Figure 4-7) for open circuits between point D (lamination) and each terminal A, B, and C.
- (b) If continuity is noted between lamination and any terminal, stator is defective and must be replaced.
- (c) Set multimeter for ohms and check stator windings (refer to Figure 4-7) for continuity

between terminals A-B, A-C, and B-C.

(d) If open, replace stator.

(18) Check/replace rotor assembly.

- (a) Set multimeter for ohms, clean sliprings with solvent, and check rotor assembly (refer to Figure 4-8) for 9.0 to 14.0 ohms indication between slip rings.
- (b) Check that open circuits are indicated between pole fingers and each slip ring.
- (c) Replace entire rotor assembly if indications are other than stated in (a) and (b) above.



**FIGURE 4-8. TESTING ROTOR**

c. Assembly.

- (1) Install bearing (4, Figure 4-2) on rotor assembly (3).
- (2) Install bearing plate, bearing (2) and drive end housing (1) on rotor assembly (3).
- (3) Install bearing plate bolts (16), through front of drive end housing (1); alternately tighten bolts which pull bearing (2) into drive end housing (1).
- (4) Install splash shield (7) on to service slip ring end of rotor assembly (3).
- (5) Connect tagged stator (9) leads to rectifier (6).
- (6) Install bolts (16) and rectifier (6) on slip ring end housing (5).
- (7) Align drive end housing (1) with slip ring end housing (5) and tap into position using soft face mallet.

**NOTE**

**When installing regulator assembly (8) exercise caution not to damage service brush set (13).**

- (8) Install regulator assembly (8) and suppression capacitor (11) on slip ring end housing (5). Connect lead to positive terminal.
- (9) Install terminal part set (12) to slipring end housing (5) and through bolts (10) to drive end housing (1).
- (10) Install pulley and fan to rotor assembly (3) shaft.

4.3.2. STARTER.

a. Test.

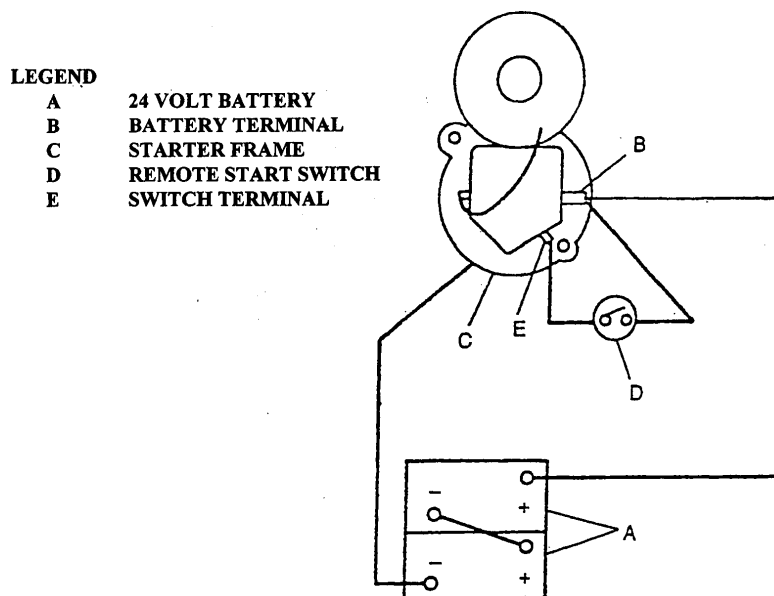
- (1) Remove starter, refer to paragraph 3.9.2.
- (2) Turn overrunning clutch drive (17, Figure 4-10) clockwise by hand. Pinion should turn freely.
- (3) Turn pinion counterclockwise. A definite resistance should be felt. If clutch assembly is defective, disassemble the starter clutch.
- (4) If armature turns freely and the clutch is not defective, test the starter under no-load conditions.

**CAUTION**

**Never operate starter longer than 30 seconds. Allow at least two minutes for cooling and battery recovery before operating again. Overheating, caused by excessive operation, will seriously damage starter.**

- (5) Connect a 24 VDC source (A) to starter battery terminal (B) and starter frame (C) as shown. Use heavy duty cables, refer to Figure 4-9.
- (6) Connect a remote start switch (D) between switch terminal (E) and battery terminal (B).
- (7) When switch is activated, starter should engage and run.

- (8) If solenoid only chatters, hold-in winding is open-circuited. If nothing happens, either pull-in winding is open-circuited or mechanical parts are sticking. To check for sticking, remove starter motor, then solenoid end cover and push plunger by hand.

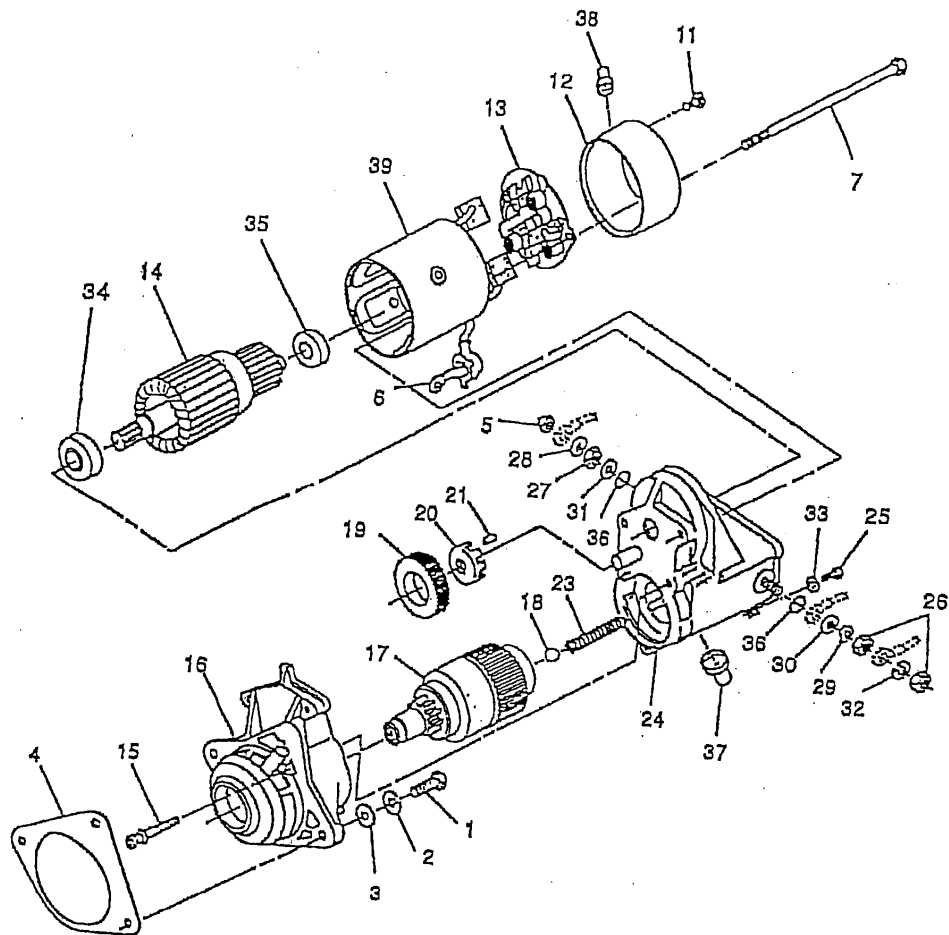


**FIGURE 4-9. STARTER BENCH TEST SETUP**

**NOTE**

**The solenoid cannot be repaired.**

- (9) If solenoid engages properly, but starter does not run, check main contact points, bearings, brushes, reduction gears, armature and field windings. Refer to step (13).



**LEGEND**

1	SCREW	14	ARMATURE	27	NUT
2	LOCKWASHER	15	SCREW	28	WASHER
3	WASHER	16	HOUSING	29	WASHER
4	GASKET	17	OVERRUNNING CLUTCH	30	WASHER
5	NUT	18	STEEL BALL	31	WASHER
6	YOKE ASSY LEAD WIRE	19	STARTER PINION	32	LOCK WASHER
7	THROUGH BOLTS	20	RETAINER	33	LOCK WASHER
8	NOT USED	21	ROLLER (5)	34	BEARING
9	NOT USED	22	NOT USED	35	BEARING
10	NOT USED	23	SPRING	36	WASHER
11	SCREW	24	MAGNETIC SWITCH ASSY	37	RUBBER PLUG
12	END FRAME	25	SCREW	38	RUBBER PLUG
13	BRUSH HOLDER ASSY	26	NUT	39	YOKE ASSY

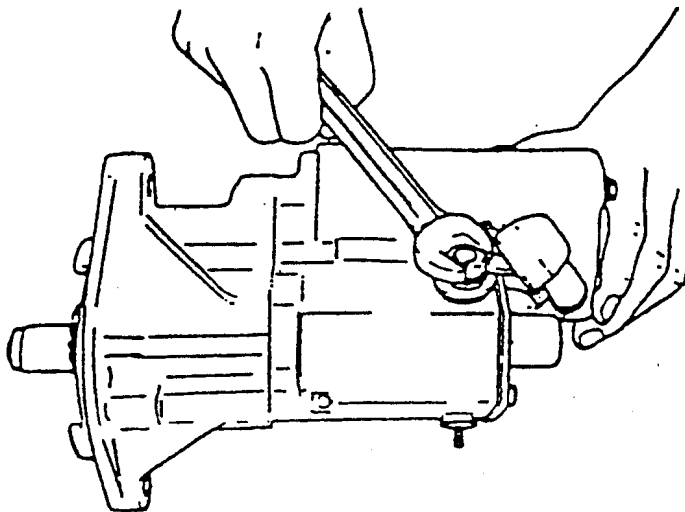
**FIGURE 4-10. STARTER ASSEMBLY**

b. Repair.

**NOTE**

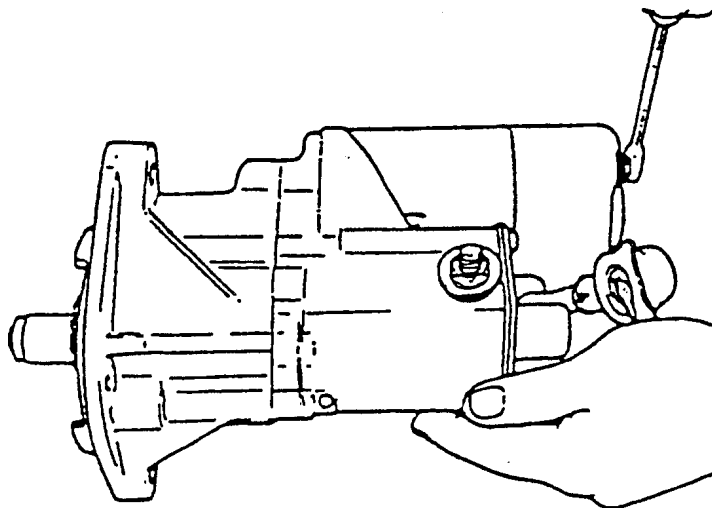
**The following procedure is provided for repairing the starter. Remove starter (refer to paragraph 3.9.2.) and place on a suitable workbench.**

- (1) Remove nut (5, Figure 4-10) and washer (28).
- (2) Disconnect yoke assembly lead wire (6) at magnetic switch assembly (24). Refer to Figure 4-11 for detailed view.



**FIGURE 4-11. DISCONNECTING LEAD WIRE (TYPICAL)**

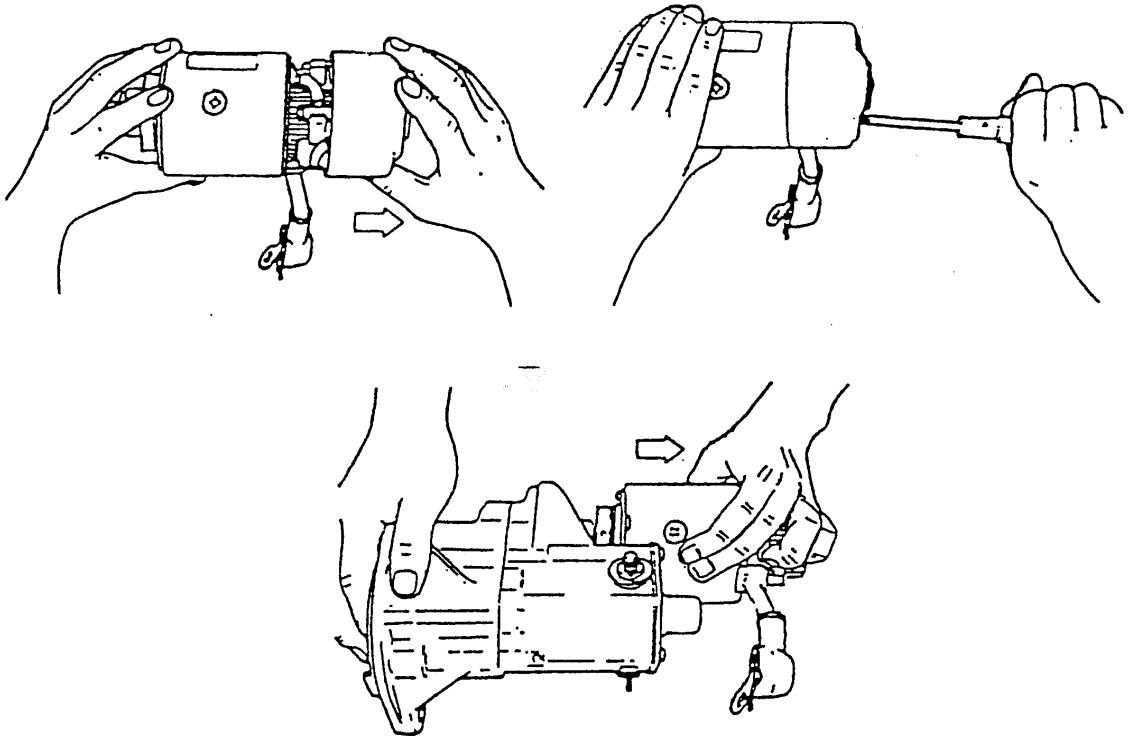
- (3) Remove two through bolts (7, Figure 4-10). Refer to Figure 4-12 for detailed view.



**FIGURE 4-12. REMOVING THROUGH BOLTS (TYPICAL)**

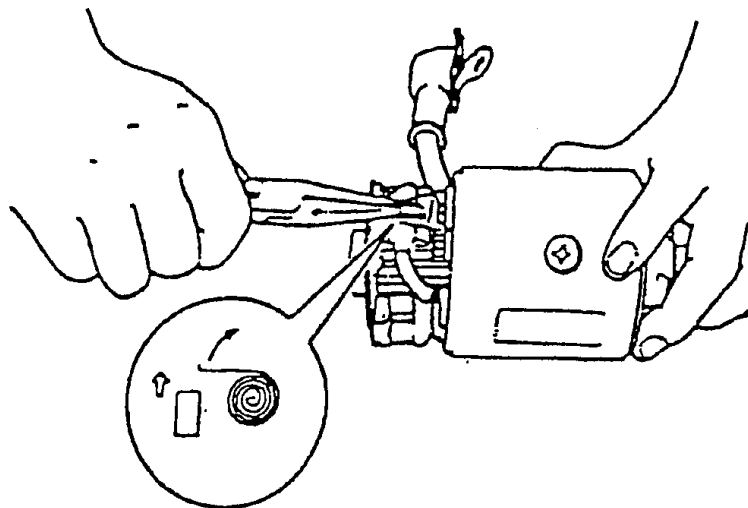


- (4) Remove two screws (11, Figure 4-10) and starter end frame (12). Remove yoke assembly (39). Refer to Figure 4-13 for detailed view.



**FIGURE 4-13. REMOVING STARTER END FRAME AND YOKE ASSEMBLY (TYPICAL)**

- (5) Lift brush springs and remove brushes from brush holder (13). Remove brush holder assembly (13), refer to Figure 3-16. Refer to Figure 4-14 for detailed view.



**FIGURE 4-14. REMOVING BRUSHES**

- (6) Remove armature (14, Figure 3-15) from magnetic switch assembly (24). Refer to Figure 4-15 for detailed view.

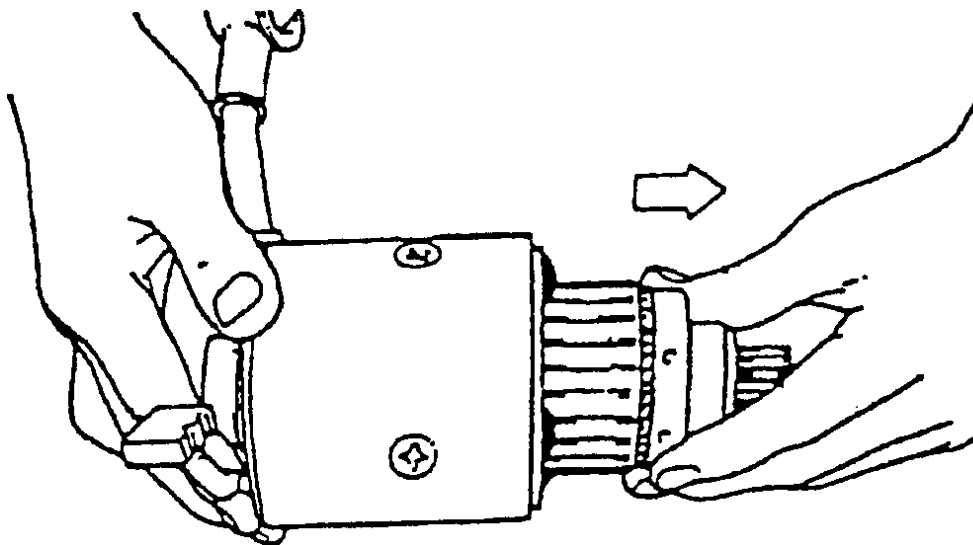


FIGURE 4-15. REMOVING ARMATURE

- (7) Remove three screws (15, Figure 4-10) from housing (16). Remove housing (16) from magnetic switch assembly (24). Refer to Figure 4-16 for detailed view.

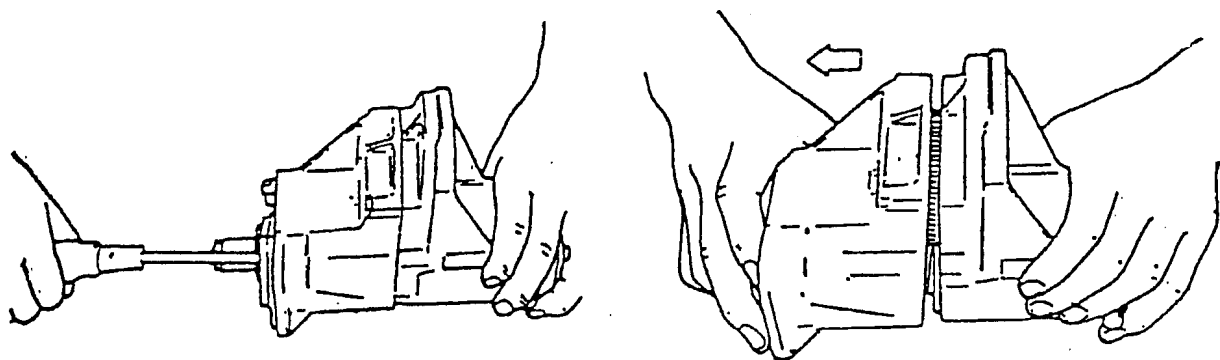
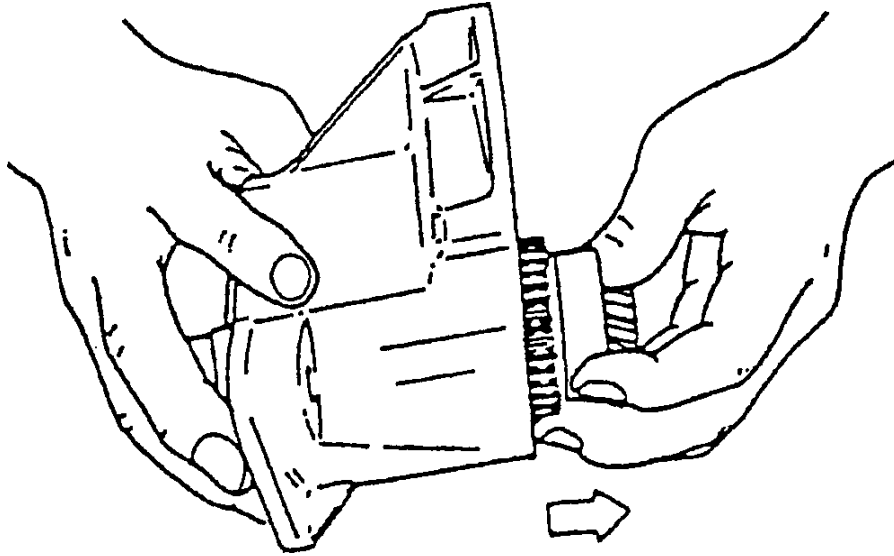


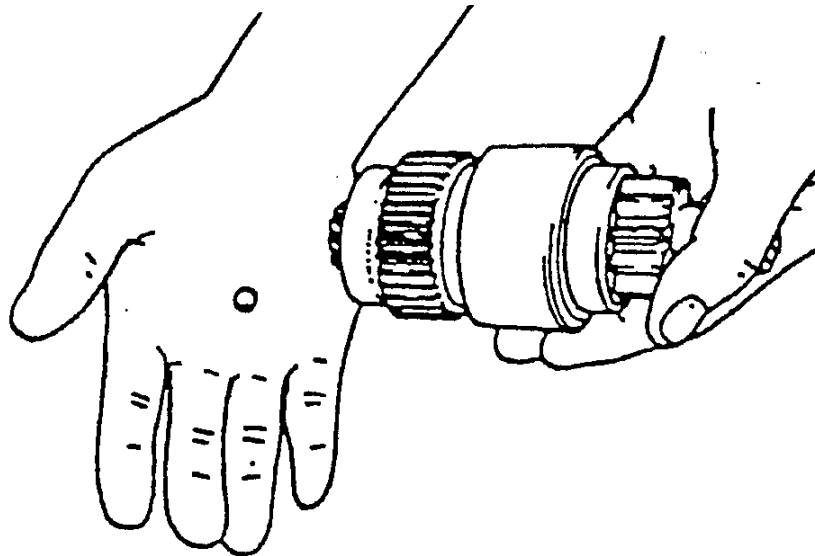
FIGURE 4-16. REMOVING HOUSING (TYPICAL)

- (8) Remove overrunning clutch (17, Figure 4-10) from magnetic switch assembly (24). Refer to Figure 4-17 for detailed view.



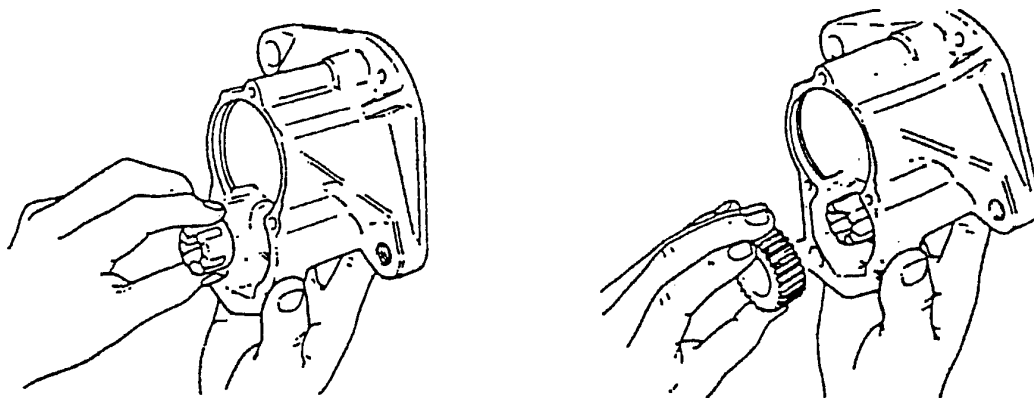
**FIGURE 4-17. REMOVING OVERRUNNING CLUTCH (TYPICAL)**

- (9) Remove steel ball (18, Figure 4-10) from overrunning clutch (17). Refer to Figure 4-18 for detailed view.



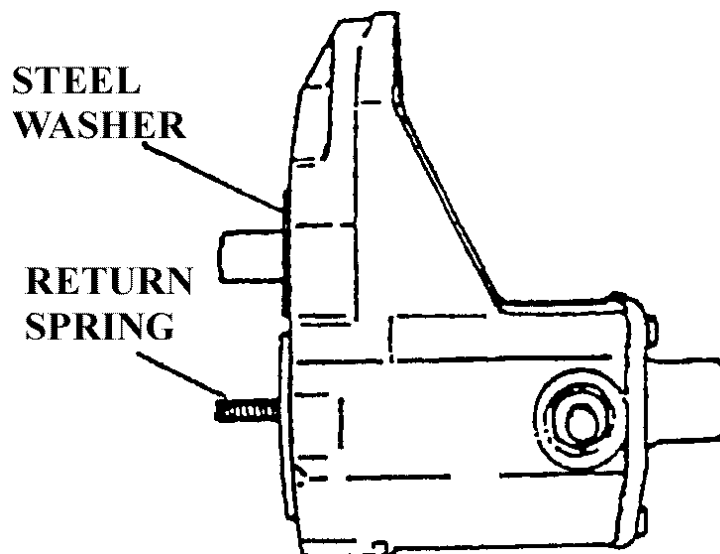
**FIGURE 4-18. REMOVING STEEL BALL**

- (10) Remove starter pinion (19, Figure 4-10), retainer (20), and five rollers (21) from housing (16). Refer to Figure 4-19 for detailed view.



**FIGURE 4-19. REMOVING PINION, RETAINER, AND ROLLERS (TYPICAL)**

- (11) Remove spring (23, Figure 4-10) from magnetic switch assembly (24). Refer to Figure 4-20 for detailed view.

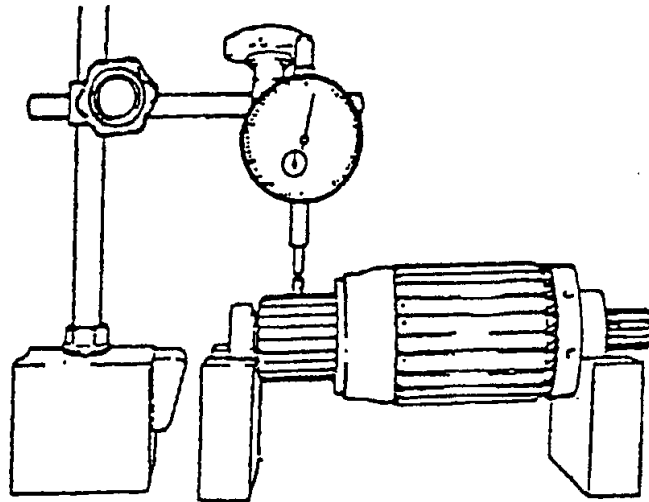


**FIGURE 4-20. REMOVING WASHER AND SPRING**

- (12) If necessary, remove screw (25, Figure 4-10), nuts (26 and 27), washers (28 through 30), and lockwashers (31 and 32) from terminal studs on magnetic switch assembly (24).

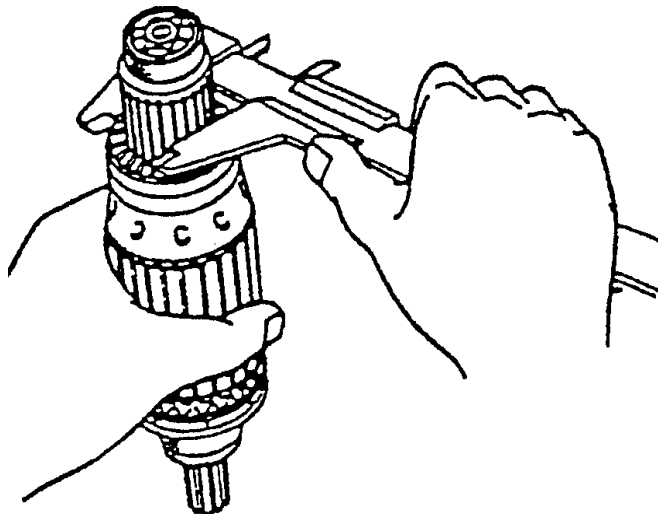
(13) Check and replace starter components.

(a) Check armature commutator run-out as follows (Refer to Figure 4-21):



**FIGURE 4-21. CHECKING COMMUTATOR RUN-OUT**

- (1) Place armature bearings on V-blocks.
  - (2) Zero dial indicator on commutator.
  - (3) Rotate armature and record run-out. Standard is 0.0008 inch (0.02 mm), with a limit of 0.00197 inch (0.5 mm).
- (b) Using a micrometer, measure outer diameter of commutator. If measurement is less than 1.38 inches (35 mm), replace armature. Refer to Figure 4-22.



**FIGURE 4-22. MEASURING COMMUTATOR OD**

- (c) Measure commutator segment mica depth as shown in Figure 4-23. If depth is less than 0.0079 inch (0.2 mm), undercut the mica.

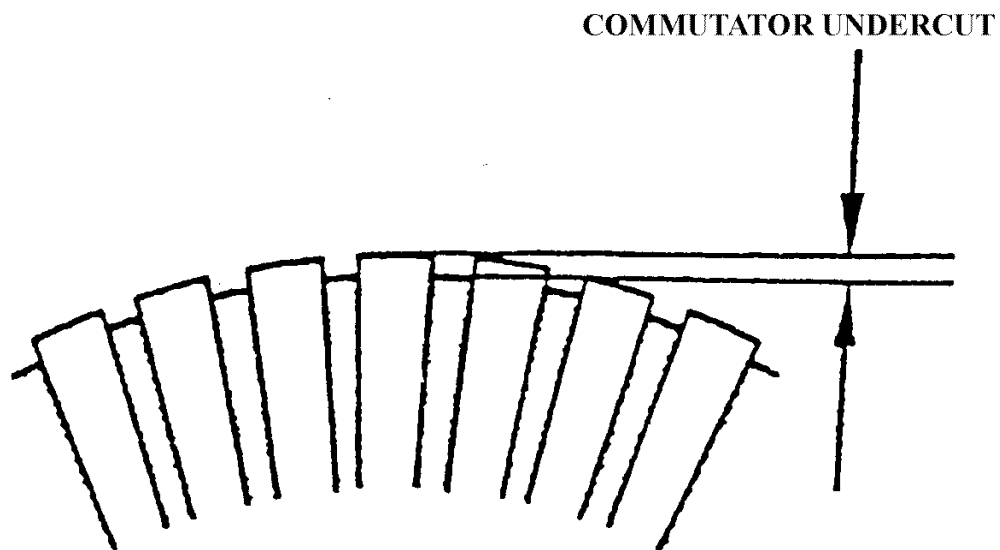


FIGURE 4-23. MEASURING SEGMENT MICA DEPTH

- (d) Check commutator surface for burn spots. This usually indicates an open circuit. Remove these spots using #400 abrasive paper. (Refer to Appendix E).
- (e) Inspect bearings (34 and 35, Figure 4-10) for wear and damage. If damaged or worn, replace bearings using a press. Refer to Figure 4-24 for detailed view.

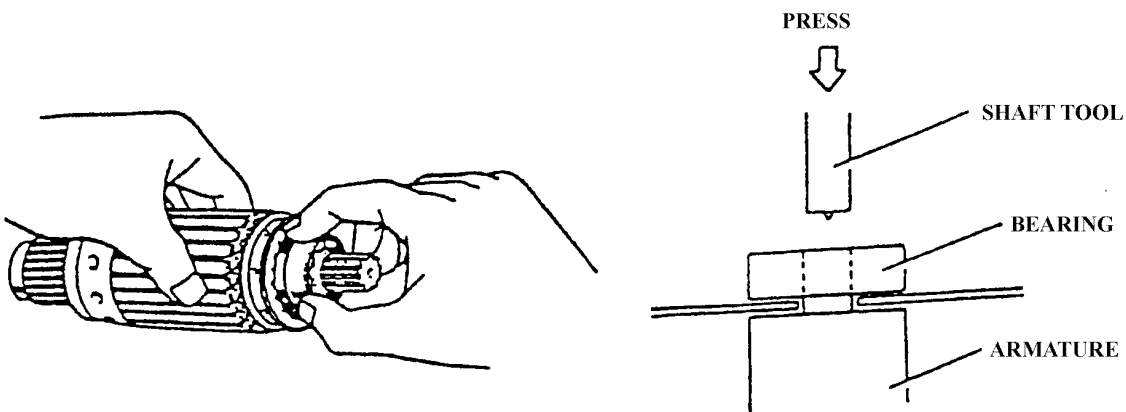
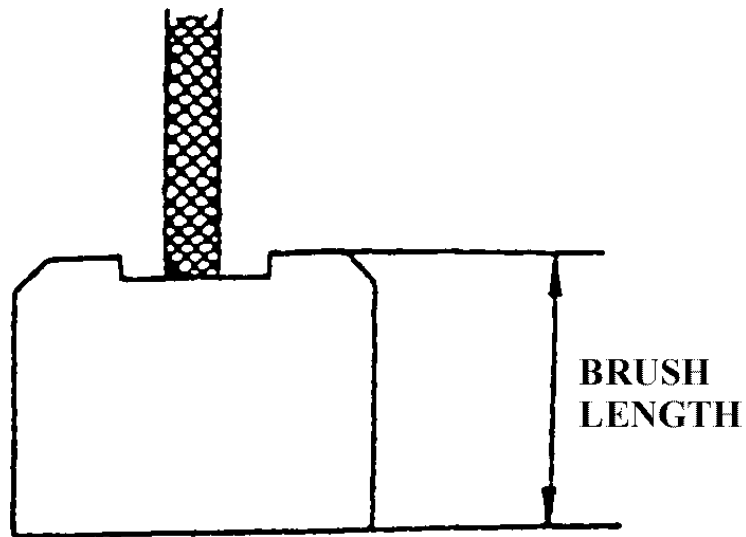


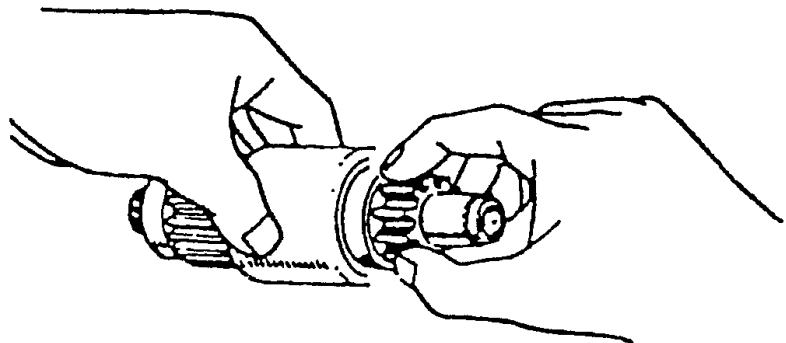
FIGURE 4-24. INSPECTING AND REPLACING BEARINGS

- (f) Check field windings of yoke for wear or damage. Check all connections for clean and tight solder joints.
- (g) Measure brush length, refer to Figure 4-25. If less than 0.51 inch (13 mm), replace brush holder and/or yoke assembly.



**FIGURE 4-25. MEASURING BRUSH LENGTH**

- (h) Check brush springs for damage or corrosion. If damaged or corroded, replace brush holder.
- (i) Check that all overrunning clutch rotates freely in direction of starter rotation and that it will be locked when trying to rotate in opposite direction. Refer to Figure 4-26 for detailed view.



**FIGURE 4-26. CHECKING OVERRUNNING CLUTCH**

- (j) Using a growler tester, place armature on it and hold a hacksaw blade against armature core while slowly rotating armature, refer to Figure 4-27. A short circuited armature causes blade to vibrate and be attracted to core. An armature which is short circuited must be replaced.

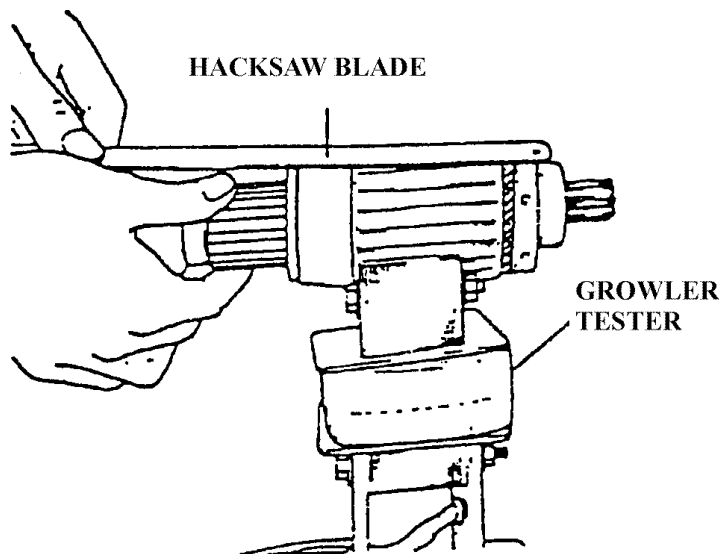


FIGURE 4-27. GROWLER TEST

- (k) Set multimeter for ohms and touch one probe to a commutator segment and other one to armature core, refer to Figure 4-28. There should be no continuity, armature is grounded. Replace armature if grounded.

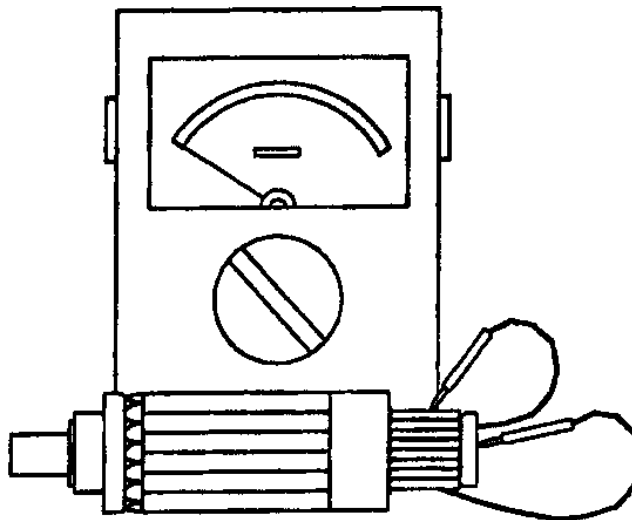


FIGURE 4-28. TESTING FOR GROUNDED WINDINGS



- (l) Set multimeter for ohms and touch probes to two segments, refer to Figure 4-29. There should be continuity at any point. If there is no continuity, winding is open circuited. Replace the armature if open circuited.

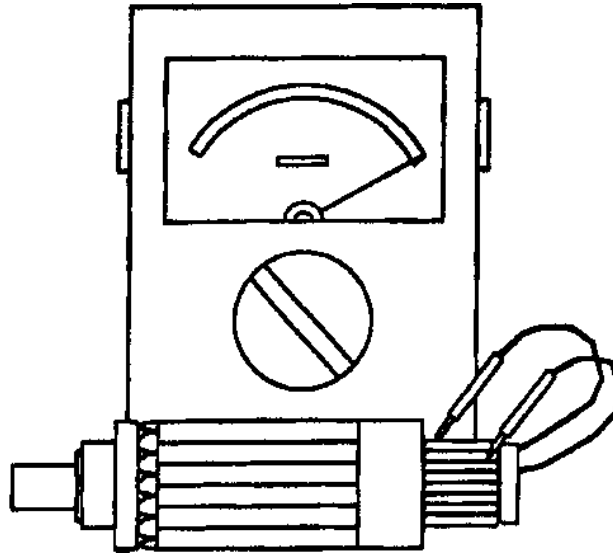


FIGURE 4-29. CHECKING FOR OPEN CIRCUIT WINDINGS

- (m) Set multimeter for ohms and touch one probe to positive brush holder and other one to the holder plate, refer to Figure 4-30. There should be no continuity. If there is continuity, replace brush holder.

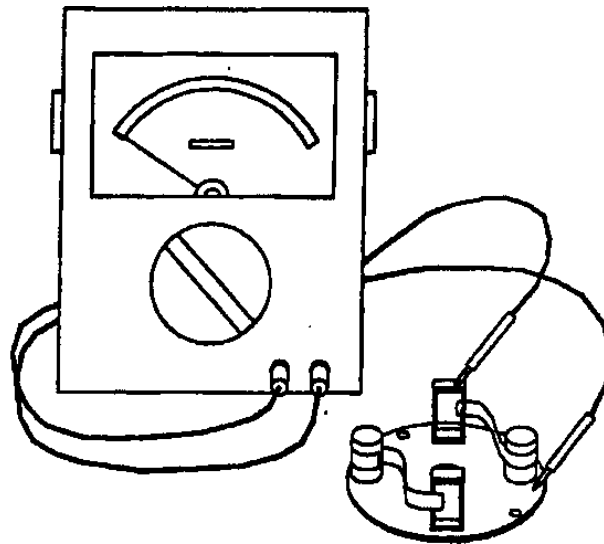
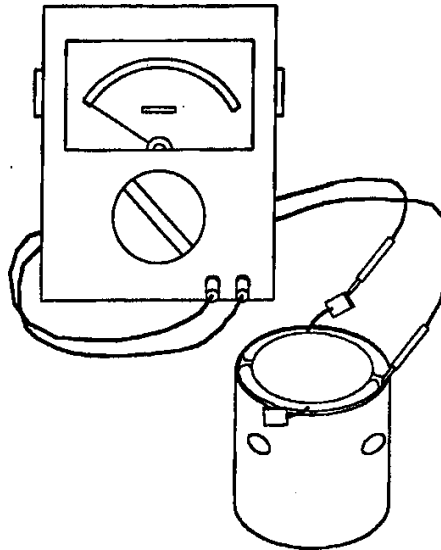


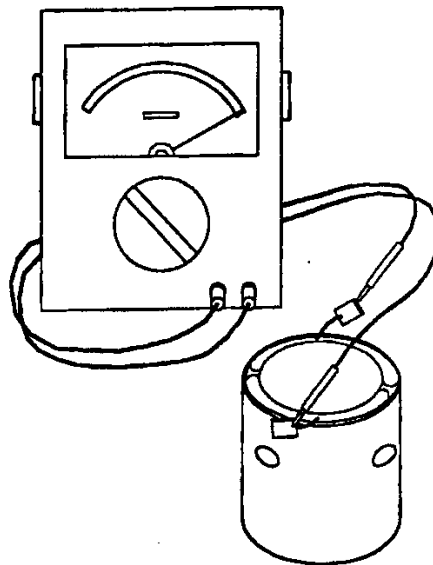
FIGURE 4-30. CHECKING BRUSH HOLDER ASSEMBLY

- (n) Using a multimeter, touch one probe to field winding end of brush and other one to bare surface of yoke body, refer to Figure 4-31. There should be no continuity. If there is continuity, field windings are grounded. Replace the yoke assembly.



**FIGURE 4-31. CHECKING FIELD COILS**

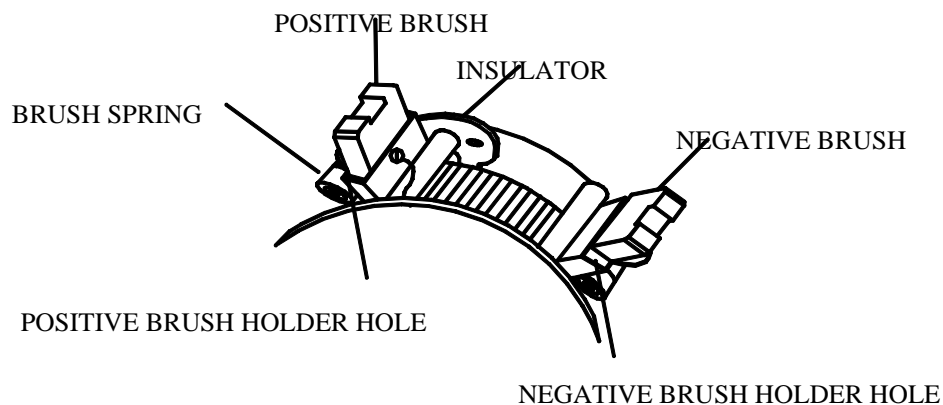
- (o) Using a multimeter, touch one probe to lead wire and other one to brush, refer to Figure 4-32. There should be continuity. If there is no continuity, field windings are open circuited. Replace the yoke assembly.



**FIGURE 4-32. CHECKING FOR OPEN FIELD COIL**

c. Assembly.

- (1) If removed, install nuts (26 and 27, Figure 4-10), washers (28 through 30), lockwashers (31 and 32), and screw (25).
- (2) Apply general purpose grease (630AA) to retainer (20), rollers (21), overrunning clutch (17), steel ball (18), spring (23), and bearings (34 and 35).
- (3) Install spring (23, Figure 4-10) in magnetic switch assembly (24).
- (4) Install five rollers (21), retainer (20), and starter pinion (19) in housing (16).
- (5) Place steel ball (18) in overrunning clutch (17) and install both in housing (16).
- (6) Position assembled housing (16) on magnetic switch assembly (24) and secure with three screws (15). Tighten screws 5.1 to 8.7 lb-ft (6.9 to 11.8 Nm).
- (7) Install armature (14) in yoke (39).
- (8) Position brush holder (13) over armature (14) commutator. Lift springs and install brushes, refer to Figure 4-33. Ensure negative brushes (connected to brush holder) are installed in negative holes (not insulated) and positive brushes (connected to yoke) are installed in positive holes (separated from plate with insulator). Ensure positive brush leads are not grounded.



**FIGURE 4-33. INSTALLING BRUSHES**

- (9) Position end frame cover (12, Figure 4-10) on yoke (39) engaging tab on cover with lead wire grommet, refer to Figure 4-34. Secure with two screws (11). Tighten screws 1.95 to 3.40 lb-ft (2.6 to 4.6 Nm).

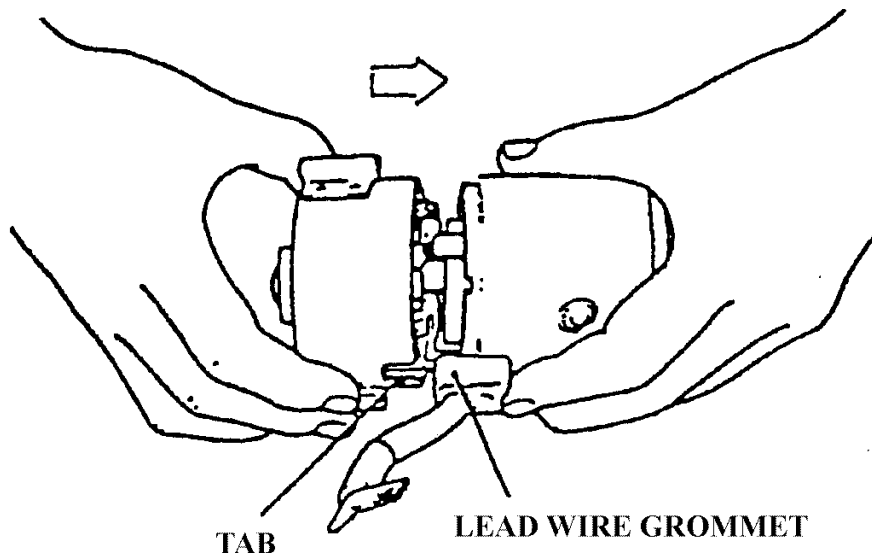


FIGURE 4-34. INSTALLING COVER ON YOKE

- (10) Position yoke assembly (39, Figure 4-10) on magnetic switch assembly (24) engaging tab on yoke assembly with notch in magnetic switch, refer to Figure 4-35. Secure with two through bolts (7, Figure 4-10). Tighten through bolts 5.1 to 8.7 lb-ft (6.9 to 11.8 Nm).

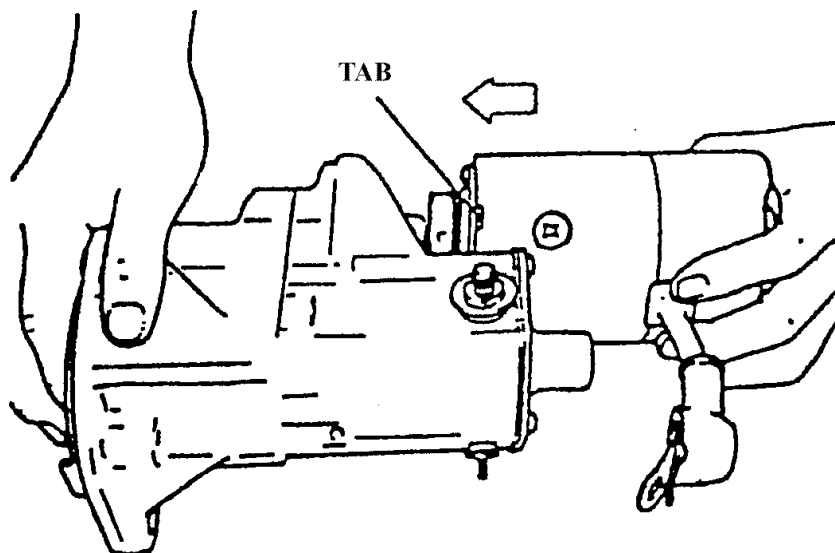


FIGURE 4-35. INSTALLING YOKE

- (11) Connect yoke assembly lead wire (6) to terminal on magnetic switch assembly with washer(s) and nut (4). Tighten nut to 18.1 to 26.0 lb-ft (24.5 to 35.3 Nm). Ensure rubber boot (36) is installed securely.

#### 4.4. INTAKE AND EXHAUST SYSTEM MAINTENANCE.

##### 4.4.1. TURBOCHARGER.

###### **NOTE**

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

- a. Removal.

###### **WARNING**

**Exhaust system is very hot after operating engine. After operating engine, allow exhaust system to cool before removal. Failure to comply could result in personal injury.**

###### **CAUTION**

**When cleaning turbocharger, do not spray directly into compressor cover or turbine housing. Failure to comply could result in damage to the turbocharger.**

###### **NOTE**

**If turbocharger inspection is required, do not clean exterior prior to removal. Cleaning exterior may wash away evidence of a potential failure mode.**

- (1) Thoroughly clean exterior of turbocharger and surrounding area to prevent entry of dirt into air intake system during removal.
- (2) Remove air intake line and exhaust line from turbocharger (12, Figure 4-36), refer to TM 9-6115-671-14.
- (3) Loosen clamps securing air intake manifold hose to turbocharger, refer to paragraph 4.4.2.

###### **CAUTION**

**Oil inlet line is fragile and can become twisted and damaged during maintenance. Always use one wrench to hold one fitting stationary while the other fitting is loosened or tightened. Failure to comply can cause damage to equipment.**

- (4) Disconnect oil inlet line (3, Figure 4-36) from fitting (6) on top of turbocharger (12).

- (5) Remove capscrews (4) and disconnect oil return pipe (5). Remove line (5) and gasket (9); discard gasket (9).
- (6) Remove four mounting capscrews (10) securing turbocharger (12) to exhaust manifold. Remove turbocharger (12) and stainless steel gasket (13); discard gasket (13).
- (7) Cover all openings to prevent entry of foreign material.

b. Inspection.

The following inspection procedure is recommended for systematic failure analysis of a suspected turbocharger failure. This procedure will help to identify when a turbocharger has failed, and why it has failed so the primary cause of failure can be corrected. Proper diagnosis of a “non-failed” turbocharger is important for two reasons. First, identification of a “non-failed” turbocharger will lead to further investigation and repair of the cause of a performance complaint. Second, proper diagnosis eliminates unnecessary expense incurred when a “non-failed” turbocharger is replaced.

- (1) Remove turbocharger, refer to step a.
- (2) Inspect compressor housing inlet and compressor wheel.
  - (a) Check compressor inlet and compressor wheel for foreign object damage. If foreign object damage is found, locate and correct source of foreign object damage.

**NOTE**

**Score marks can be difficult to see. Provide adequate lighting to insure that damage is not overlooked.**

- (b) Check compressor inlet for wheel rub on the housing. Check for score marks on housing and check tips of compressor wheel blades for damage.
- (3) Inspect housing outlet. The outlet should be clean and free of dirt and oil.
- (4) Inspect turbine housing inlet.
  - (a) Check turbine housing inlet ports for oil in housing and excessive carbon deposit. Oil or excessive carbon deposits in the inlet port indicates an engine problem is likely.
  - (b) Check turbine housing inlet ports for erosion of center walls. Center wall erosion (cracking or missing pieces) indicates excessive exhaust temperature.

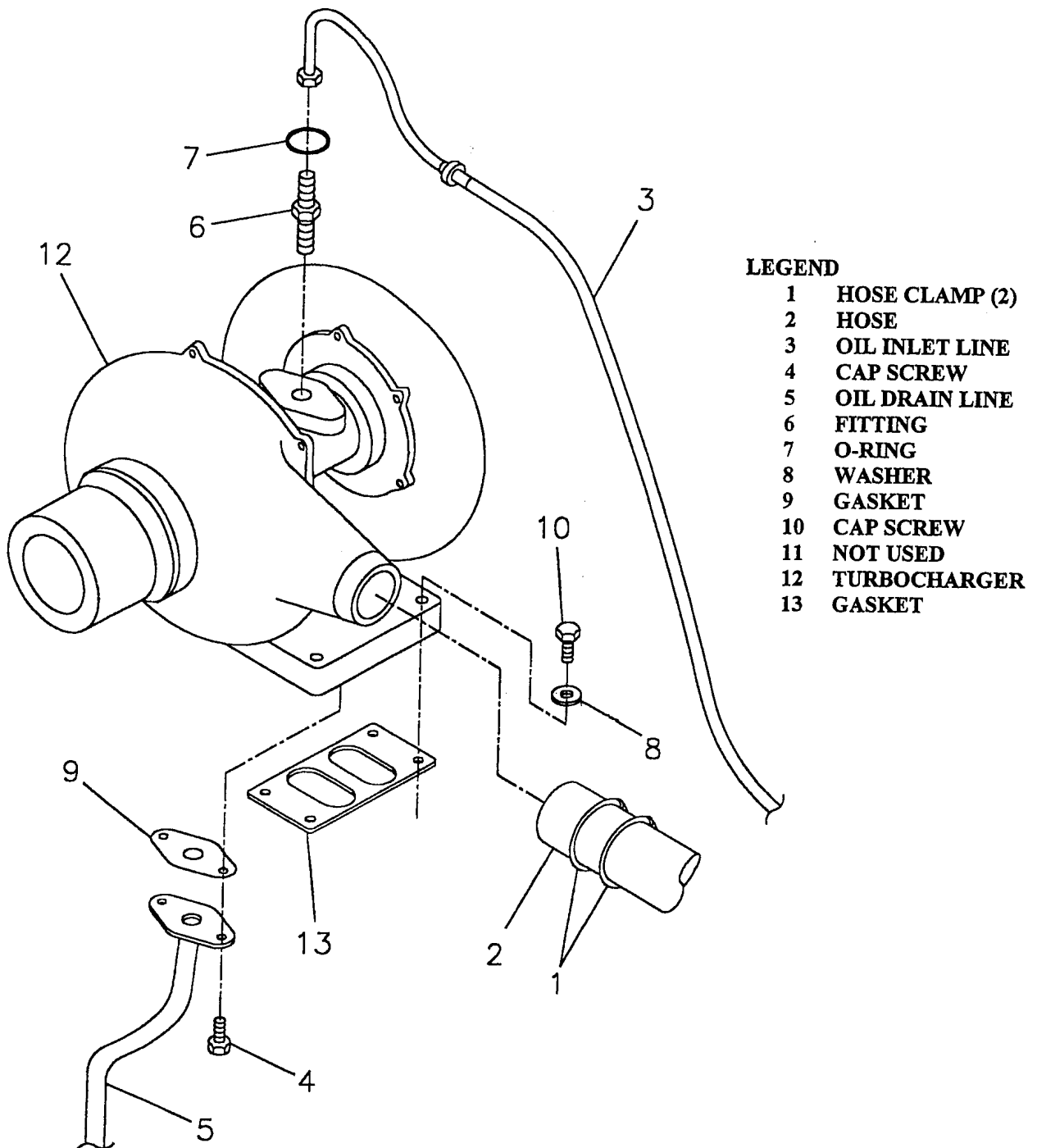


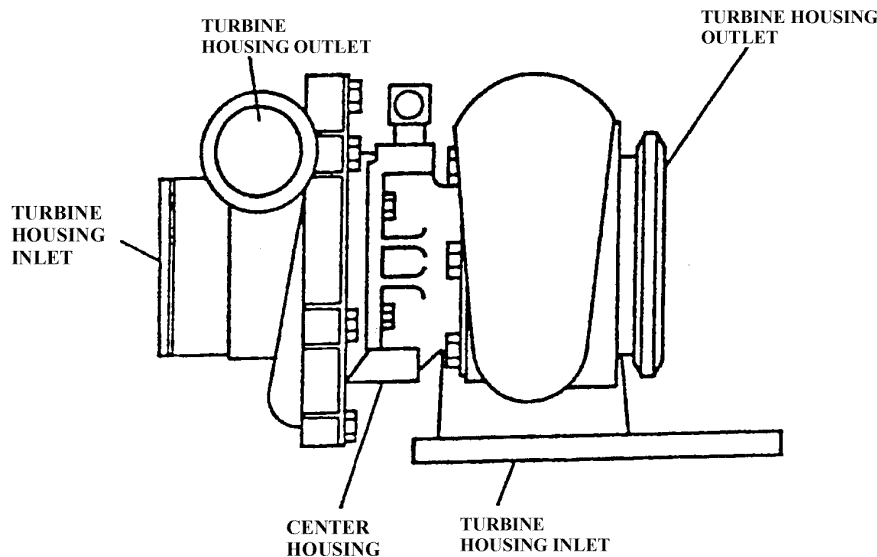
FIGURE 4-36. TURBOCHARGER

- (5) Inspect turbine housing outlet and turbine wheel.

**NOTE**

**Foreign object damage can be difficult to see. Provide adequate lighting to insure that damage is not overlooked.**

- (a) Check blades inside turbine housing outlet Figure 4-37 for foreign object damage. Foreign object damage indicates an engine problem is likely.



**FIGURE 4-37. TURBOCHARGER INSPECTION POINTS**

- (b) Inspect wheel blades and housing for evidence of wheel rub. Wheel rub can bend the tips of wheel blades and cause wear or damage to the housing.

**NOTE**

**Note location and source of any oil leaks found.**

- (6) Inspect outside of center housing, connections to the compressor, and turbine housing for oil.  
(7) Inspect internal center housing.

**NOTE**

**Foreign object damage can be difficult to see. Provide adequate lighting to insure that damage is not overlooked.**

- (a) Look through oil return hole Figure 4-38 to check condition of shaft and bearings. There should not be excess carbon deposits on shaft or in housing.



- (b) Check for excessive “blueing” or “coking” of oil along the complete length of shaft. Excessive “blueing” or “coking” along the complete length of shaft indicates either a possible lack of lubrication caused by engine failure or improper operation, such as hot shutdowns.
- (8) Perform turbocharger bench inspection.
  - (a) Mount turbocharger in vise.
  - (b) Check shaft rotation and clearance by rotating shaft with both hands. Shaft should turn freely, however, there may be a slight amount of drag.

**NOTE**

**There will be some “play” because the bearings inside center housing are free floating.**

- (c) Pull up on compressor end of shaft and press down on turbine end while rotating shaft. The compressor wheel and turbine should not contact the housing at any point.
  - (d) Check shaft end play by moving shaft back and forth while rotating. There will be some end play, but the wheels should not contact the housings.
- c. Replacement.
- (1) Remove turbocharger, refer to step a.
  - (2) Perform inspection procedures, refer to step b. If turbocharger fails any inspection portion, the unit is defective and must be replaced. If turbocharger passes inspection, continue with step c (3) listed below.
  - (3) Test turbocharger per step d. Replace turbocharger if unit fails any portion of the tests. If turbocharger passes tests, install per step e.
- d. Test.
- (1) Inspect turbocharger, refer to step b.
  - (2) Prelube turbocharger center housing bearings, refer to step e (3).
  - (3) Perform radial bearing clearance test as follows:
    - (a) Fasten a plunger-type dial indicator to turbocharger mounting base. Assemble an extension adapter and 2.0 in. (51 mm) indicator extension rod onto dial indicator.
    - (b) Grasp rotating shaft at both ends and move shaft toward indicator then away from indicator. Use care to move shaft in same direction as dial indicator tip travels and apply equal pressure at both ends of shaft. Refer to Figure 4-38.

- (c) Observe and record total indicator reading. Bearing clearance should be 0.003 - 0.007 in. (0.08 - 0.18 mm). Replace turbocharger, refer to step d, if bearing clearance is out of specifications.
  - (4) Perform axial bearing end play test as follows:
    - (a) Mount base dial indicator so that indicator tip rests on end of shaft. Preload indicator tip and zero dial on indicator. Refer to Figure 4-38.
    - (b) Move shaft back and forth by hand. Refer to Figure 4-38.
    - (c) Observe and record total indicator reading. Bearing end play should be 0.001 - 0.004 in. (0.025 - 0.102 mm). Replace turbocharger, refer to step d, if bearing end play is out of specifications.
  - (5) Install turbocharger, refer to step e.
- e. Install.

**CAUTION**

**If turbocharger failed because of foreign material entering the air intake system, be sure to examine the system and clean as required to prevent a repeat failure.**

**CAUTION**

**Do not spin the rotor assembly with compressed air. Damage to the bearings can occur when using compressed air.**

- (1) Remove all covering installed during step a (7).
- (2) Ensure all old gasket material is removed from gasket surfaces.
- (3) Prelube turbocharger: Fill center housing of turbocharger (12, Figure 4-36) with new engine lubricating oil through oil drain hole. Turn rotating assembly of turbocharger by hand to lubricate bearings.
- (4) Position gasket (13) and turbocharger (12) on exhaust manifold. Install capscrews (10) and tighten to 52 lb-ft (70 Nm).
- (5) Position gasket (9) and oil return pipe (5) on turbocharger (12). Install capscrews (4 and torque to 26 lb-ft (35 Nm).

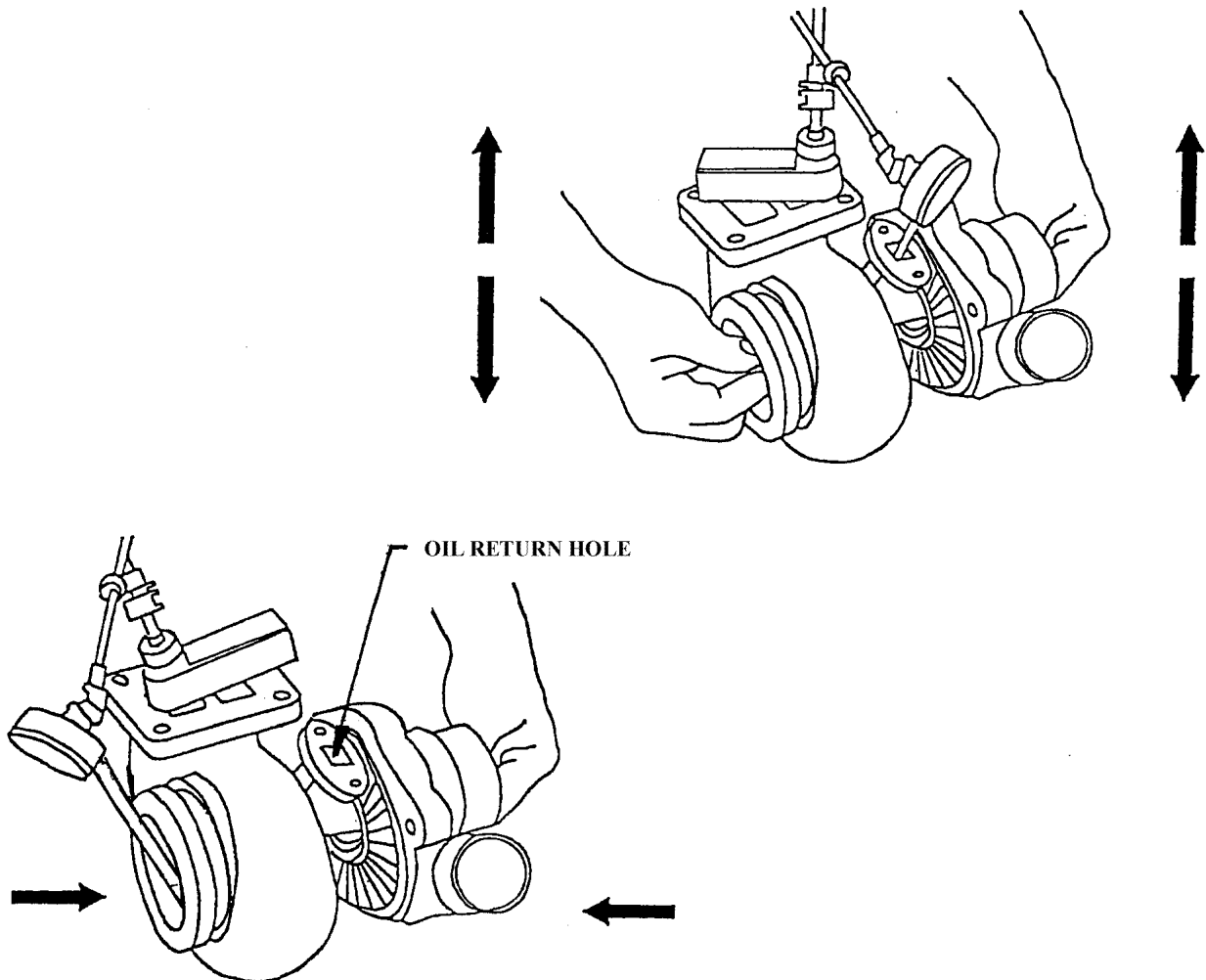


FIGURE 4-38. INSPECTING TURBOCHARGER BEARINGS

**CAUTION**

Oil inlet line is fragile and can become twisted and damaged during maintenance. Always use one wrench to hold one fitting stationary while the other fitting is loosened or tightened. Failure to comply can cause damage to equipment.

- (6) Connect oil inlet line (3) to turbocharger (12) and torque to 20 lb-ft (27 Nm).
- (7) Position hose (2) and hose clamps (1) on turbocharger (12) and intake manifold. Tighten hose clamps.
- (8) Connect air intake line and exhaust line to turbocharger, refer to TM 9-6115-671-14.
- (9) Place throttle system so engine cannot start, refer to TM 9-6115-671-14.

**CAUTION**

**Excessive cranking on the engine using the starter can damage the starter. Do not crank engine longer than 30 seconds at a time, with a two minute break in between cranking attempts. Failure to comply could damage the starter.**

- (10) Crank engine (without starting) using starter until oil pressure is within normal range.

4.4.2. **INTAKE MANIFOLD.**

**NOTE**

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

a. **Removal.**

- (1) Thoroughly clean outside surface of intake manifold and surrounding area.
- (2) Remove crankcase breather assembly. Refer to TM 9-6115-671-14.
- (3) Loosen hose clamps (1, Figure 3-7) and slide hose (2) down intake manifold (4), clear of turbocharger.
- (4) Remove capscrews (3), intake manifold (4), and gasket (5). Discard gasket.
- (5) Remove hose (2) and hose clamps (1)
- (6) Cover all openings to prevent entry of foreign material.

b. **Inspection.**

- (1) Remove intake manifold, refer to step a.
- (2) Inspect intake manifold (4, Figure 3-7) for cracks or damage. Inspect machined mounting surface for burrs or other defects which might prevent gasket (5) from sealing properly. Replace as needed.

c. **Replacement.**

- (1) Remove intake manifold, refer to step a.
- (2) Inspect intake manifold, refer to step b. Replace intake manifold if damaged.
- (3) For installation of intake manifold, refer to step d.

d. Installation.

- (1) Remove all covering installed during step a (5).
- (2) Ensure all old gasket material is removed from gasket surfaces.
- (3) Position hose clamps (1, Figure 3-7) and hose (2) on intake manifold (4).
- (4) Position new gasket (5) and intake manifold (4) on cylinder head. Install capscrews (3) and torque to 52 lb-ft (70 Nm).
- (5) Position hose (2) and hose clamps (1) on turbocharger and intake manifold (4). Tighten hose clamps.
- (6) Install crankcase breather assembly. Refer to TM 9-6115-671-14.

4.4.3. EXHAUST MANIFOLD.

**NOTE**

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

a. Removal.

- (1) Remove turbocharger, refer to paragraph 4.4.1.

**NOTE**

**Use guide studs to ease removal.**

- (2) Remove capscrews (1, Figure 3-8), exhaust manifold (2), and gaskets (3). Discard gaskets.
- (3) Remove all residue and gasket material from gasket surfaces.
- (4) Thoroughly clean passages in exhaust manifold (2).
- (5) Cover all openings to prevent entry of foreign material.

b. Inspection.

- (1) Remove exhaust manifold, refer to step a.
- (2) Inspect exhaust manifold for cracks or damage. Inspect machined mounting surfaces for burrs or other defects which might prevent gaskets from sealing properly. Replace as needed.

c. Replacement.

- (1) Remove exhaust manifold, refer to step a.
- (2) Inspect exhaust manifold, refer to step b. Replace exhaust manifold if damaged.
- (3) For installation of exhaust manifold, refer to step d.

d. Installation.

- (1) Remove all covering installed during step a (5).
- (2) Ensure all old gasket material is removed from gasket surfaces.
- (3) Position gaskets (3, Figure 3-8) on exhaust manifold (2).
- (4) Using guide studs, position exhaust manifold (2) on cylinder head.
- (5) Apply antiseize compound (Refer to Appendix E) to capscrews (1).

**NOTE**

**Tighten capscrews on No. 3 and No. 4 cylinders first.**

- (6) Install capscrews (1) and torque evenly to 52 lb-ft (70 Nm).
- (7) Install turbocharger, refer to paragraph 4.4.1.

4.5. LUBRICATION SYSTEM MAINTENANCE

4.5.1. GENERAL.

This section provides maintenance for lubrication system components.

4.5.2. OIL PRESSURE REGULATING VALVE ASSEMBLY.

**NOTE**

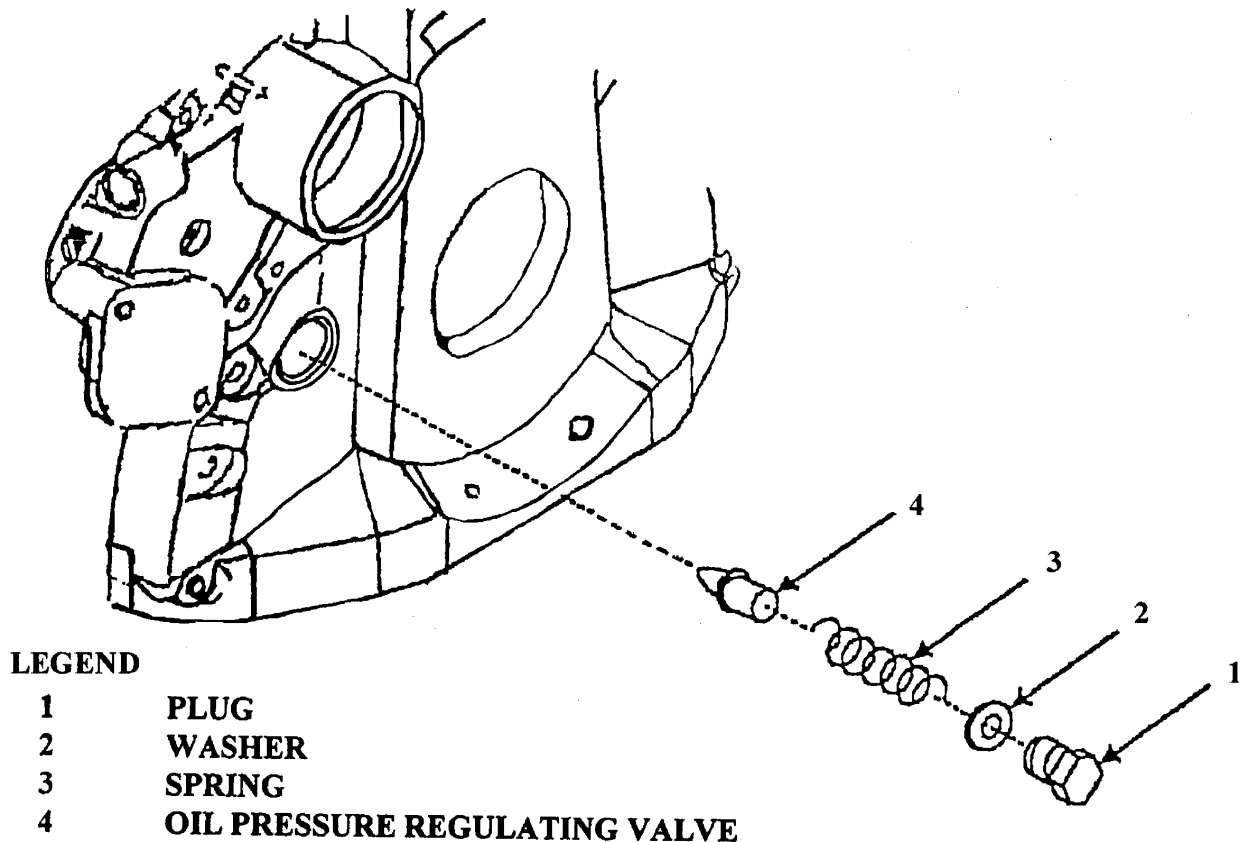
**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

a. Removal.

- (1) Remove fan belt, refer to TM 9-6115-671-14.
- (2) Remove plug (1, Figure 4-39) and washer (2) from timing gear cover.
- (3) Remove spring (3) and oil pressure regulating valve (4).
- (4) Cover all openings to prevent entry of foreign material.

b. Inspection.

- (1) Remove oil pressure regulating valve assembly, refer to step a.
- (2) Inspect cone of oil pressure regulating valve (4, Figure 4-39) for excessive wear or damaged sealing face. If oil pressure regulating valve shows excessive wear or damaged sealing face, replace both valve (4) and valve seat (5). Refer to next higher level of maintenance.



**FIGURE 4-39. OIL PRESSURE REGULATING VALVE ASSEMBLY**

- (3) Inspect spring (3) using the following steps. Replace per step c., if defective.
  - (a) Measure free length of spring (3). Free length of spring should be 4.55 in. (115.5 mm).
  - (b) Using a spring tester (DO1168AA or equivalent), apply force to spring (3) until spring is compressed to a length of 1.68 in. (42.5 mm). Spring tension should be 9.1-11.1 lbs. (45 N).

c. Replacement.

- (1) Remove oil pressure regulating valve assembly, refer to step a.
- (2) Replace spring (3) if found defective.
- (3) For installation of oil pressure regulating valve assembly, refer to step d.

d. Installation.

- (1) Remove all covering installed during step a (4).
- (2) Position oil pressure regulating valve (4, Figure 4-39) and spring (3) inside valve seat (5). Position washer (2) on plug (1). Install plug and torque to 70 lb-ft (95 Nm).

4.5.3. OIL PAN.

**NOTE**

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

a. Removal.

- (1) Drain engine lubrication system, refer to TM 9-6115-671-14.
- (2) If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand. Refer to paragraph 4.10.
- (3) If necessary, remove oil dipstick assembly, refer to paragraph 3.11.5.
- (4) Remove plugs/fittings (5, Figure 3-14) and O-ring gasket (6).
- (5) Support oil pan (2) and remove capscrews (3 and 4), oil pan, and gasket (1). Discard gasket.
- (6) Cover all openings to prevent entry of foreign material.

b. Inspection.

- (1) Remove oil pan (2, Figure 3-14), refer to step a.
- (2) Inspect oil pan (2) for cracks, dents, or other signs of damage. Replace per step c., as necessary.
- (3) Inspect plugs/fittings (5) and hole for damaged threads or signs of leakage. Repair or replace as necessary.
- (4) Inspect oil pump pickup tube assembly (refer to paragraph 4.5.4) for clogging or damage.
- (5) Install oil pan (2), refer to step d.



c. Replacement.

- (1) Remove oil pan (2, Figure 3-14), refer to step a.
- (2) Inspect oil pan (2), refer to step b. Replace oil pan if cracks, dents, or other signs of damage are found during inspection. Refer to step d. for installation.

d. Installation.

- (1) Remove all covering installed during step a (6).
- (2) Ensure all old gasket material is removed from gasket surfaces.
- (3) Apply Flexible Form-In-Place Gasket on oil pan rail where flywheel housing, front plate, and timing gear cover attach to cylinder block.
- (4) Position gasket (1, Figure 3-14) and oil pan (2) on cylinder block. Install screws (3 and 4) and torque to 26 lb-ft (35 Nm).
- (5) If engine was removed from vehicle or machinery, install engine, refer to TM 9-6115-671-14.
- (6) Install aluminum or copper washers on drain plugs (5) with raised center against plug. Install plugs in oil pan and torque to 35 lb-ft (47 Nm). Install fittings as required.
- (7) Service engine lubrication system, refer to TM 9-6115-671-14.

4.5.4 PICK-UP TUBE ASSEMBLY

a. Inspection.

Inspect pick-up tube assembly for clogging or damage. Refer to Figure 4-40.

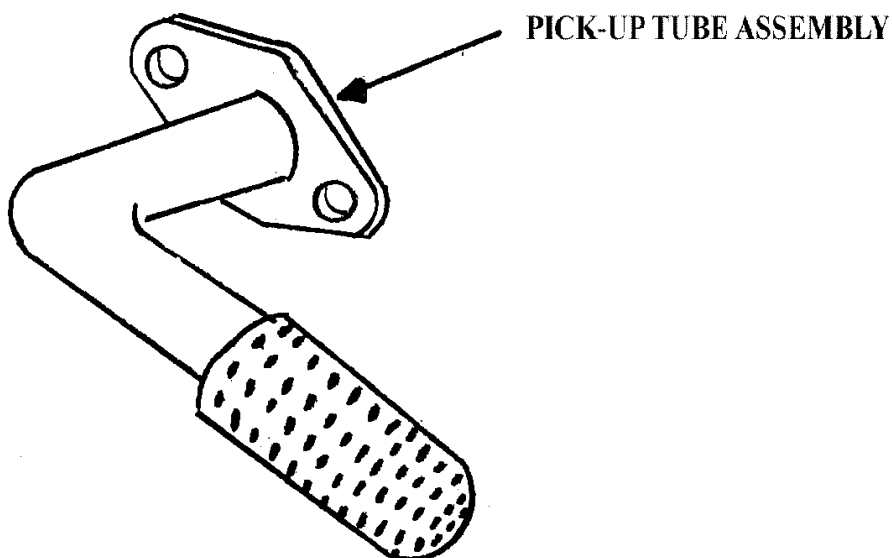


FIGURE 4-40 PICK-UP TUBE ASSEMBLY

4.6. FUEL SYSTEM MAINTENANCE

**WARNING**

Escaping diesel or JP fuel under pressure can have sufficient force to penetrate the skin, causing serious injury or death. Before disconnecting fuel lines, be sure to relieve pressure. Before applying pressure to the system, be sure all connections are tight and lines, pipes, and hoses are not damaged. Keep hands and body away from pinholes and nozzles which eject fuel under pressure. Use a piece of cardboard or wood, rather than hands, to search for suspected leaks.

**WARNING**

If diesel or JP fuel is injected into skin, seek medical attention immediately. Failure to comply can result in serious injury.

4.6.1. FUEL INJECTION PUMP.

**NOTE**

The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.

**NOTE**

If working on fuel injection pump on TQG, refer to TM 9-6115-671-14 for removal and installation procedure for electrical actuator.

a. Removal.

- (1) Disconnect negative cable from batteries.

**WARNING**

Cleaning solvent is flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection are required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.

**WARNING**

Care should be exercised when using steam for cleaning. Steam is extremely hot. Skin and eye protection are required. Avoid contact with steam.

**CAUTION**

**Fuel injection pump gets very hot during operation. Never steam clean or pour water on fuel injection pump while fuel injection pump is running or warm. Failure to comply could cause seizure of internal rotating parts.**

**CAUTION**

**Dirt in the fuel system can damage components or cause poor engine performance. Always thoroughly clean the area around connection before disconnecting. Always cover all openings after disconnecting. Failure to comply can cause damage to components or poor engine performance.**

- (2) Thoroughly clean outside surface of fuel injection pump, fuel lines, and surrounding area with cleaning solvent or steam cleaner.
- (3) Disconnect electrical connector mounted on top of pump which leads to governor.

**WARNING**

**Diesel or JP fuel is flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection are required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.**

**CAUTION**

**Fuel lines are fragile and can become twisted and damaged during maintenance. Always use one wrench to hold one fitting stationary while the other fitting is loosened or tightened. Failure to comply can cause damage to equipment.**

**NOTES**

**Catch fuel in suitable container.**

**Disconnect all fuel delivery (pressure) lines from injection pump using a suitable 17 mm deep-well crowsfoot socket.**

- (4) Disconnect throttle cable from throttle arm (26).
- (5) Disconnect fuel return line (3, Figure 3-17), fuel supply line (27), and fuel injection lines (7, 8, 9 and 10).
- (6) Remove capscrews (9, Figure 4-63), gear cover (8), and O-ring (7). Discard O-ring.

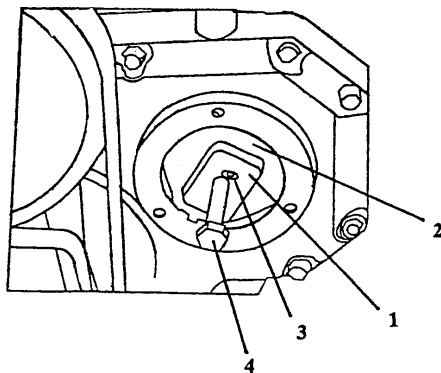
**CAUTION**

Washer is small and easy to drop. Do not allow washer to fall inside timing gear cover. Failure to comply can cause damage to equipment when engine is started.

- (7) Remove retaining nut (25, Figure 3-17) and washer (24) from end of pump shaft.
- (8) Remove nut (19), washer (33), and lockwasher (34) from injection pump.
- (9) Attach Drive Gear Puller (1, Figure 4-41) to injection pump drive gear (2). Evenly tighten screws (3) and snugly tighten center forcing screw (4) against end of pump shaft.
- (10) Tighten center forcing screw (4, Figure 4-41) until pump drive gear (2) is free from tapered shaft. Remove from drive gear.

**LEGEND**

- |          |                                  |
|----------|----------------------------------|
| <b>1</b> | <b>DRIVE GEAR PULLER</b>         |
| <b>2</b> | <b>INJECTION PUMP DRIVE GEAR</b> |
| <b>3</b> | <b>SCREW (2)</b>                 |
| <b>4</b> | <b>CENTER FORCING SCREW</b>      |

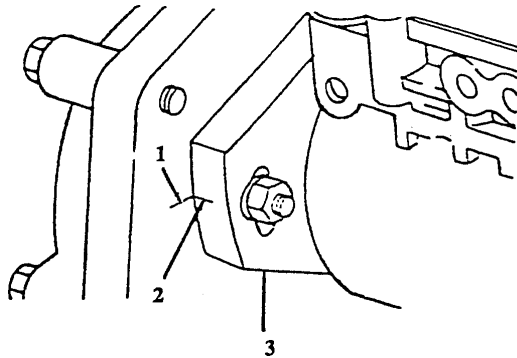


**FIGURE 4-41. SEPARATING GEAR AND SHAFT**

- (11) Check timing marks on back side of front plate (1, Figure 4-42) and injection pump flange (2).  
If timing marks are not aligned, or not clearly visible, scribe a visible reference mark in line with mark on pump flange.

**LEGEND**

- 1 FRONT PLATE TIMING MARK**  
**2 INJECTION PUMP FLANGE TIMING MARK**  
**3 INJECTION PUMP MOUNTING FLANGE NUT**



**FIGURE 4-42. CHECK TIMING MARKS**

- (12) Remove fuel injection pump (22, Figure 3-17), and sealing ring (28). Discard sealing ring.  
(13) Cover all openings to prevent entry of foreign material.

**b. Inspection.**

- (1) Inspect all fuel lines for wear, kinks or fitting damage. Repair as necessary.

**NOTE**

**Use a good light source to thoroughly inspect gear inner diameter and shaft outer diameter.**

- (2) Inspect injection pump drive gear inner diameter full 360° for metal transfer as a result of slippage on shaft  
(3) Inspect injection pump drive shaft outer diameter full 360° for presence of metal transfer from gear slippage. Also, check index pin in shaft for damage, indicating gear slippage.

**c. Replacement.**

- (1) Remove fuel injection pump, refer to step a.  
(2) Perform inspection, refer to step b. Replace fuel injection pump if damaged.  
(3) For fuel injection pump installation, refer to step e.

d. Installation.

- (1) Remove all covering installed during step a (11).
- (2) Lubricate sealing ring (28, Figure 3-17) with clean engine oil. Install sealing ring into groove on front face of fuel injection pump mounting flange.

**CAUTION**

**Index pin is easily damaged if fuel injection pump is installed improperly. Insure that fuel injection pump shaft is properly aligned with pump drive gear. Pump drive gear should not move when initially installing shaft key into pump drive gear key slot. Failure to comply could result in damage to equipment.**

- (3) Align shaft key (21) on fuel injection pump shaft with pump drive gear key slot. Loosely position fuel injection pump on mounting studs while inserting pump shaft into drive gear.
- (4) Check pump shaft and index pin for proper alignment with pump drive gear key slot.

**CAUTION**

**Index key is easily damaged if fuel injection pump is installed improperly. DO NOT tighten nuts more than three full turns on mounting studs. Failure to comply could result in damage to equipment.**

- (5) Position flat washers (33) and lock washers (34) on mounting studs. Position nuts on mounting studs and tighten only three turns.

**CAUTION**

**Index key is easily damaged if fuel injection pump is installed improperly. DO not use tightening force of nuts (25) to pull pump shaft into drive gear.**

- (6) Position fuel injection pump mounting flange flush to engine front plate. Tighten mounting stud nuts (19) finger tight.
- (7) Push pump drive gear firmly onto fuel injection pump shaft taper. Install washer and retaining nut. Torque nut to 150 lb-ft (203 Nm).
- (8) Position O-ring (7, Figure 4-63) and access cover plate (8) on front plate. Apply Thread Lock and Sealer (LOCTITE 242) to cap screw (9) threads. Install cap screws and torque to 17 lb-in (2 Nm).
- (9) Align timing mark on fuel injection pump flange with timing mark on front plate. Torque nuts (3, Figure 4-42) to 20 lb-ft (27 Nm).
- (10) Connect fuel injection pump pressure lines. Begin at outlet port for cylinder 1 (1, Figure 4-43) and continue around in counterclockwise direction, attaching lines in same order as engine firing (1-3-4-2). Refer to Figure 4-43 for a detailed view.

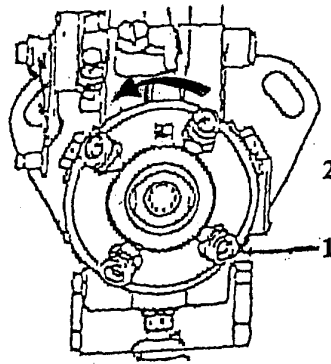
**CAUTION**

Fuel lines are fragile and can become twisted and damaged during maintenance. Always use one wrench to hold one fitting stationary while the other fitting is loosened or tightened. Failure to comply can cause damage to equipment.

- (11) Torque fuel injection pump pressure lines to 20 lb-ft (27 Nm).
- (12) Connect fuel supply line and torque to 22 lb-ft (30 Nm).

**LEGEND**

- 1 CYLINDER NO.1 OUTLET PORT
- 2 ENGINE SIDE



**FIGURE 4-43. FUEL INJECTION PUMP PRESSURE OUTLET PORTS**

- (13) Connect fuel return line and torque to 12 lb-ft (16 Nm).
- (14) Connect electrical connector mounted on top of pump which leads to governor.
- (15) Connect negative cable to batteries, refer to TM 9-6115-671-14.

**WARNING**

Operating the generator set with any access door open exposes personnel to high noise levels. Hearing protection must be worn when operating or working near the generator set with any access door open. Failure to comply can cause hearing damage or loss.

- (16) Bleed fuel system, refer to paragraph 3.12.1.
- (17) Start engine, refer to TM 9-6115-671-14, run for several minutes and check entire fuel system for leaks. Shut down engine.

4.6.2. FUEL INJECTION NOZZLE ASSEMBLY.

**NOTE**

The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.

a. Removal.

**WARNING**

Compressed air used for cleaning can create airborne particles that may enter the eyes. Pressure will not exceed 30 psi (207 kPa). Eye protection required.

**CAUTION**

Before removal, carefully remove all dirt from cylinder head around fuel injection nozzles. Clean with compressed air to prevent dirt from entering cylinders or valve seats. Plug bore in cylinder head after each fuel injection nozzle has been removed. Cap fuel line openings as soon as they are disconnected.

**CAUTION**

Immediately fit protective caps over nozzle tips and line connections to avoid handling damage.

- (1) If removing only one fuel injection nozzle, loosen coupling nuts (2, Figure 3-17) and remove leak off line on each side of fuel injection nozzle.

**CAUTION**

Fuel lines are fragile and can become twisted and damaged during maintenance. Always use one wrench to hold one fitting stationary while the other fitting is loosened or tightened. Failure to comply can cause damage to equipment.

- (2) If removing all fuel injection nozzles, remove fuel leak-off line assembly, refer to paragraph 3.12.4.
- (3) Loosen coupling nut (2, Figure 3-17) and remove leak-off T-fitting (2, Figure 4-44) from each fuel injection nozzle (6) to be removed. Remove and discard washer (3).
- (4) Disconnect fuel injection line from nozzle. Cap openings.
- (5) Remove capscrew (5).



**CAUTION**

**Improper removal can damage fuel injection nozzle beyond repair. Do not use screwdrivers, pry bars, or similar tools to remove fuel injection nozzle. Failure to comply can cause damage to equipment.**

- (6) Pull fuel injection nozzle out of cylinder head using Injection Nozzle Puller Set or Adapter and slide handle from Puller Set (JDE38 or JDE38A).
- (7) Remove washer (8, Figure 4-44) using razor blade or sharp knife. Discard washer.
- (8) Remove upper packing and discard.
- (9) Cover all openings to prevent entry of foreign material.

b. **Test.**

- (1) Remove fuel injection nozzle, refer to step a.

**WARNING**

**Compressed air used for cleaning can create airborne particles that may enter the eyes. Pressure will not exceed 30 psi (207 kPa). Eye protection required.**

- (2) Prior to testing, clean the nozzles using the following procedures;
  - (a) Clean fuel injection nozzle bore with (JDE39) nozzle bore cleaning tool or equivalent. Blow debris from bore with compressed air and plug bore to prevent entry of foreign material.

**WARNING**

**Cleaning solvent is flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection are required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.**

- (b) Place fuel injection nozzle in solvent or clean diesel fuel and soak for several minutes.

**CAUTION**

**Do not scrape or disturb teflon coating on fuel injection nozzle body above washer groove. Do not use a steel wire brush, scraper, or motor-driven brush to clean nozzle body. Failure to comply could result in damage to fuel injection nozzle.**

**NOTE**

**Teflon coating will become discolored during normal operation, but this is not harmful.**

- (c) After soaking, clean fuel injection nozzle tip with brass wire brush (ROS16488) or equivalent.

**NOTE**

**Insure that nozzle tester is in good condition and that gauge works properly. Service nozzle tester as recommended in operating instructions provided with tester.**

- (3) Connect fuel injection nozzle (6, Figure 4-44) to nozzle tester.

**WARNING**

**Fuel from spray orifices can penetrate clothing and skin and cause serious personal injury. Always direct fuel injection nozzle tip away from personnel. Always enclose fuel injection nozzle in a transparent cover. Failure to comply could result in serious personal injury.**

**WARNING**

**If diesel or JP fuel is injected into skin, seek medical attention immediately. Failure to comply can result in serious injury.**

- (4) Position tip of nozzle below top of beaker and back out 30 degrees from vertical. Leave connections slightly loose.
- (5) Pump handle several strokes to flush air from lines and fittings and to determine pumping rate required for proper atomization. Tighten all connections securely after all air has been expelled from nozzle and line.
- (6) Perform opening pressure test as indicated below:

**WARNING**

**Fluid escaping from a very small hole can be almost invisible. Before applying pressure to nozzle tester, be sure that all connections are tight, and that fittings are not damaged. Use a piece of cardboard or wood to search for suspected leaks. Do not use hands to search for suspected leaks. Failure to comply could result in serious personal injury.**

- (a) Actuate nozzle tester rapidly several times to allow valve to seat rapidly.
- (b) Open gauge valve and raise pressure to a point where gage needle falls rapidly. This is the nozzle opening pressure. Record nozzle opening pressure.
- (c) Opening pressure should be at least 3,330 psi (22,950 kPa) for a used fuel injection nozzle and 3,660 psi (25,200 kPa) for a new fuel injection nozzle. Replace fuel injection nozzle if nozzle opening pressure is not within specified range.

- (d) Opening pressure of all fuel injector nozzles on engine should be within 100 psi (700 kPa) of each other. Replace any fuel injection nozzle that is not within specified limit.
- (7) Perform chatter test as indicated below:

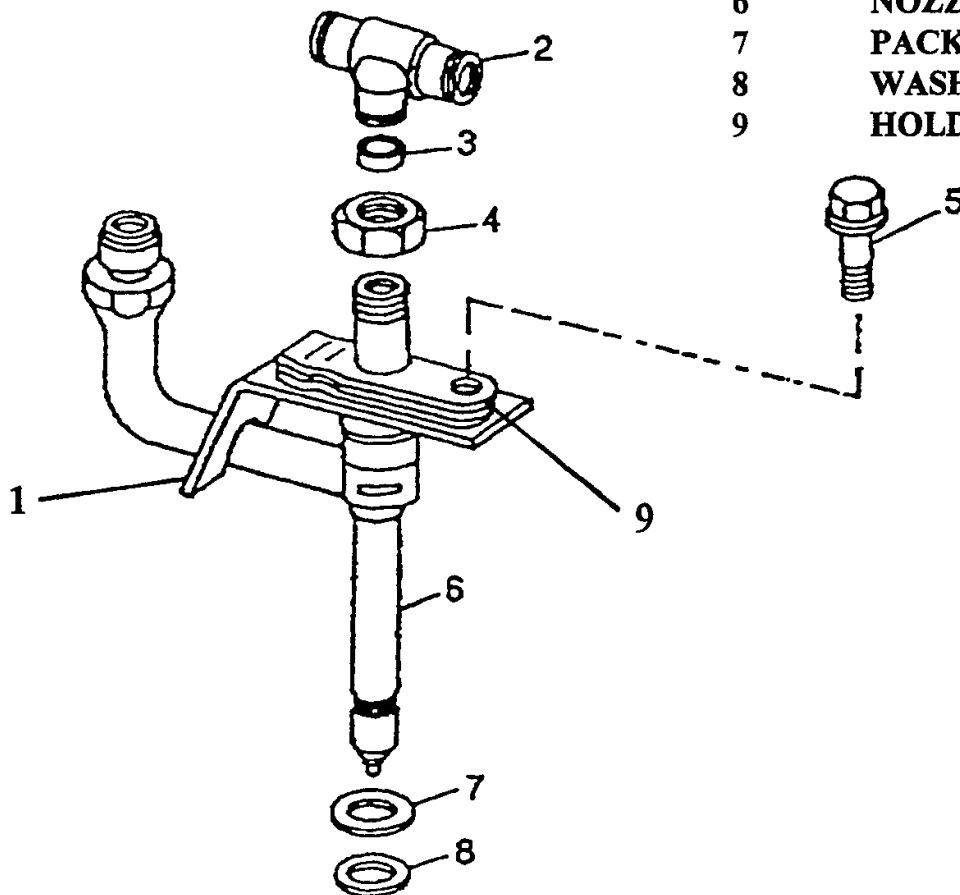
**NOTE**

**Until chattering range is reached, fuel will emerge in non-atomized streams.**

- (a) Operate nozzle tester at a pumping rate that will cause fuel injection nozzle to chatter.

**LEGEND**

- |   |                 |
|---|-----------------|
| 1 | INDEX CLAMP     |
| 2 | TEE FITTING     |
| 3 | WASHER          |
| 4 | TUBE NUT        |
| 5 | SCREW           |
| 6 | NOZZLE          |
| 7 | PACKING         |
| 8 | WASHER          |
| 9 | HOLDDOWN CLAMPS |



**FIGURE 4-44. FUEL INJECTION NOZZLE ASSEMBLY**

- (b) Fuel injection nozzle should chatter softly, and spray pattern should be broad and finely atomized. Replace fuel injection nozzle if it fails to chatter.
  - (c) Using pumping rate for proper atomization, operate tester for ten strokes. Fuel injection nozzle must atomize on at least eight of the ten strokes without consecutive misses. If nozzle fails to meet requirement, repeat procedure. Replace fuel injection nozzle if it fails on second test.
- (8) Perform spray pattern test as indicated below:
- (a) Operate nozzle tester at a pumping rate that will cause fuel injection nozzle to chatter.
  - (b) Observe spray pattern of three orifices and check for plugged orifices. Replace fuel injection nozzle if spray pattern angle is incorrect or if spray pattern is streaky instead of finely atomized.
- (9) Perform leakage test as indicated below:
- (a) Position fuel injection nozzle on nozzle tester with nozzle tip down.
  - (b) Operate pump handle rapidly to firmly seat valve. Wipe nozzle tip dry with a clean, lint free cloth.
  - (c) Slowly raise pressure on test gauge to 400-500 psi (2800-3500 kPa) below opening pressure measured in step 5.
  - (d) Watch for accumulation of fuel around all three fuel injection nozzle tip orifices. Replace fuel injection nozzle if fuel drips from fuel injection nozzle within 5 seconds.
- (10) Perform valve stem and guide wear test as indicated below:

**WARNING**

**Fuel from spray orifices can penetrate clothing and skin and cause serious personal injury. Always direct fuel injection nozzle tip away from personnel. Always enclose fuel injection nozzle in a transparent cover. Failure to comply could result in serious personal injury.**

- (a) Position fuel injection nozzle with tip slightly above horizontal plane.
- (b) Slowly raise pressure on test gauge to 1500 psi (10300 kPa).

**NOTE**

**Leakage rate based on use of No. 2 diesel fuel or an equivalent viscosity of test oil at 65 to 75° F (18 to 24° C).**

- (c) Check for leakage from return end of fuel injection nozzle. After one drop, leakage should be 3-10 drops in 30 seconds. Replace fuel injection nozzle if not within specified range.

c. Replacement.

- (1) Remove fuel injection nozzle assembly, refer to step a.
- (2) Test fuel injection nozzle assembly, refer to step b. Replace any nozzle that does not perform within specifications.
- (3) For installation of fuel injection nozzle, refer to step d.

d. Installation.

- (1) Remove plug installed during step a. from nozzle bore in cylinder head and blow out bore with compressed air.

**NOTE**

**Dirt or damage on the sealing surface of cylinder head (where fuel injection nozzle seal washer will be resting) can result in poor engine performance. Make sure that sealing surface of cylinder head is smooth and free from damage and dirt. Damage or dirt could prevent proper sealing or cause distortion to nozzle when attaching bolt is tightened.**

- (2) Thoroughly clean sealing surface of cylinder head, where washer (8, Figure 4-44) will be resting, and insure that sealing surface is free of damage. Repair or replace as required.
- (3) Position new upper sealing washer (8) and packing (7) on fuel injection nozzle (6).
- (4) Install fuel injection nozzle (6) in cylinder head using a slight twisting motion as fuel injection nozzle is seated in bore. Insure that fuel injection nozzle is installed in the proper orientation.
- (5) Align index clamp (1) and hold-down clamps (9) and install capscrew (5, Figure 4-44) finger tight.
- (6) Remove caps and connect fuel pressure line to fuel injection nozzle (6). Torque connection to 20 lb-ft (27 Nm).
- (7) Tighten capscrew (5) to 30 lb-ft (40 Nm).
- (8) Position washer (3), leak-off T-fitting (2) and tube nut (4) on fuel injection nozzle (6).
- (9) Install leak-off line assembly, refer to paragraph 3.12.4.
- (10) Torque coupling nut (2, Figure 3-17) to 20 lb-ft (27 Nm).
- (11) Bleed air from fuel injection system, refer to paragraph 3.12.1.

4.6.3. FUEL FILTER BASE.

a. Removal.

- (1) Remove fuel filter element, refer to paragraph 3.12.2.

**CAUTION**

**Fuel lines are fragile and can become twisted and damaged during maintenance. Always use one wrench to hold one fitting stationary while the other fitting is loosened or tightened. Failure to comply can cause damage to equipment.**

- (2) Remove fuel line (6, Figure 3-15) and disconnect fuel line (7).
- (3) Remove capscrews (8) and fuel filter base (9).
- (4) Cover all openings to prevent entry of foreign material.

b. Repair.

**NOTE**

**Repair of this item is limited to the replacement of the O-rings only.**

- (1) Remove plugs (10 and 11, Figure 3-15) and O-ring seals (12). Discard O-ring seals.
- (2) Remove connectors (13) and O-ring seals (12). Discard O-ring seals.
- (3) Remove air bleed vent screw (14) and O-ring seal (15).
- (4) Remove retaining ring (16), cap (17), O-ring seal (18), plunger (19) and plunger housing (20). Discard O-ring seal.
- (5) Inspect fuel filter base (9, Figure 3-15) for cracks or other damage. Replace if necessary.
- (6) Position plunger housing (20, Figure 3-15), plunger (19), O-ring seal (18) and cap (17) in fuel filter base (9). Install retaining ring (16) hand tight.
- (7) Position O-ring seal (15) on air bleed vent screw (14) and install air bleed vent screw hand tight.
- (8) Position O-ring seals (12) on connectors (13) and install connectors.
- (9) Position O-ring seals (12) on plugs (10 and 11) and install plugs.

c. Installation.

- (1) Remove all covering installed during step a (4).
- (2) Position fuel filter base (9, Figure 3-15) on cylinder head. Install capscrews (8) and torque evenly to 26 lb-ft (35 Nm).

**CAUTION**

**Thread sealant can cause damage to fuel system. Do not allow sealant to get into fuel system. Failure to comply could result in damage to fuel system.**

- (3) Apply Thread Lock and Sealer (LOCTITE 242) to threads of fuel lines (6 and 7).

**CAUTION**

**Fuel lines are fragile and can become twisted and damaged during maintenance. Always use one wrench to hold one fitting stationary while the other fitting is loosened or tightened. Failure to comply can cause damage to equipment.**

- (4) Connect fuel line (7) and install fuel line (6).
- (5) Install fuel filter element, refer to paragraph 3.12.2.
- (6) Bleed fuel system, refer to paragraph 3.12.1.

4.7. **CYLINDER HEAD ASSEMBLY MAINTENANCE**

4.7.1. **ROCKER ARM COVER.**

**NOTE**

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

a. **Removal.**

- (1) Remove plugs (2 and 6, Figure 4-45), nuts (3), O-ring seals (4), rocker arm cover (7) and gasket (5). Discard O-ring seals and gasket.
- (2) Cover all openings to prevent entry of foreign material.

b. **Replacement.**

Remove rocker arm cover, refer to step a. Replace cover if bent or damaged. For installation, refer to step c.

c. Installation.

- (1) Remove all covering installed during step a (2).

**CAUTION**

**Do not use any cutting tool to remove gasket material from rocker arm cover. Failure to comply could result in damage to rocker arm cover.**

- (2) Insure all gasket material is removed from sealing surfaces.

**NOTE**

**Do not use sealant on gasket**

- (3) Position new gasket (5, Figure 4-45) on rocker arm cover (7).

**CAUTION**

**Do not overtighten nuts. Failure to comply could result in damage to gasket and loss of lubrication oil.**

- (4) Position rocker arm cover (7) on cylinder head. Install O-ring seals (4) and nuts (3). Torque nuts to 26 lb-ft (35 Nm), starting at center of rocker arm cover and alternating sides until reaching ends.
- (5) Install plugs (2) and (6).

4.7.2. INTAKE AND EXHAUST VALVE CHECKS AND ADJUSTMENTS.

**NOTE**

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

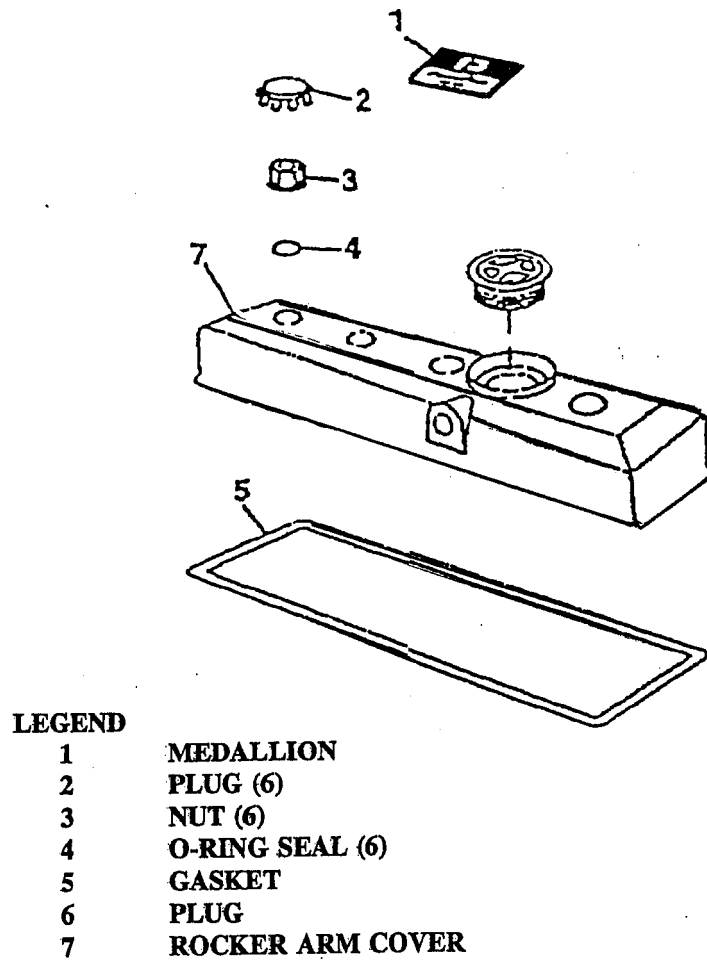
a. Adjust.

**NOTE**

**Setting engine with No. 1 Piston at TDC Compression stroke is required in many different maintenance steps and is not a stand alone maintenance procedure.**

- (1) Set Engine with No. 1 Piston at TDC (Top Dead Center) Compression Stroke.





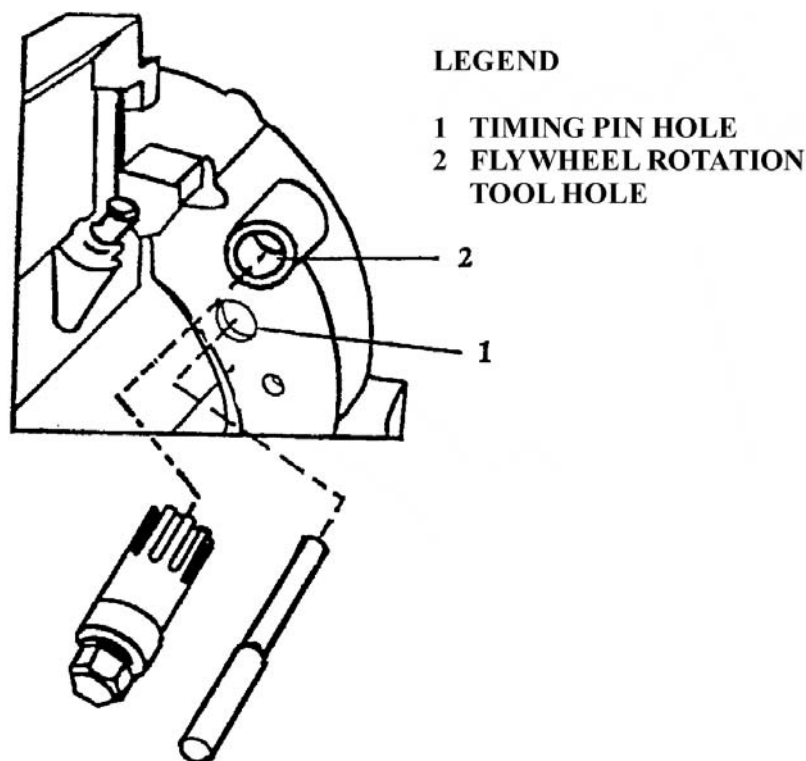
**FIGURE 4-45. ROCKER ARM COVER.**

- (a) Remove rocker arm cover, refer to paragraph 4.7.1.
- (b) Remove cover plate from timing hole (1, Figure 4-46).
- (c) Position timing pin (JDE81-4) in timing hole (2).
- (d) Position flywheel rotation tool (JDG820) in hole (2) and insure that tool meshes with flywheel gear.

**NOTE**

**Rotate engine flywheel clockwise when viewed from the front of the engine.**

- (e) Apply light pressure to tip of timing pin and rotate flywheel rotation tool counterclockwise until timing pin slides into hole in flywheel and prevents flywheel from turning.



**FIGURE 4-46. ENGINE TIMING HOLE LOCATION**

- (f) Check rocker arms on Number 1 cylinder, refer to Figure 4-47. If both rocker arms are loose, the engine is set with No. 1 Piston at TDC. If both rocker arms are not loose, engine is one full revolution (360°) away from TDC, rotate engine slightly and repeat steps c and d.
- (2) Set Engine with No. 4 Piston at TDC Compression Stroke.

**NOTE**

**Setting engine with No. 4 Piston at TDC Compression stroke is required in many different maintenance steps and is not a stand alone maintenance procedure.**

- (a) Remove rocker arm cover, refer to paragraph 4.7.1.
- (b) Remove cover plate from timing hole (1, Figure 4-46).
- (c) Position timing pin (JDE81-4) in timing hole (1, Figure 4-46).
- (d) Position flywheel rotation tool (JDG820) in hole (2) and insure that tool meshes with flywheel gear.

**NOTE**

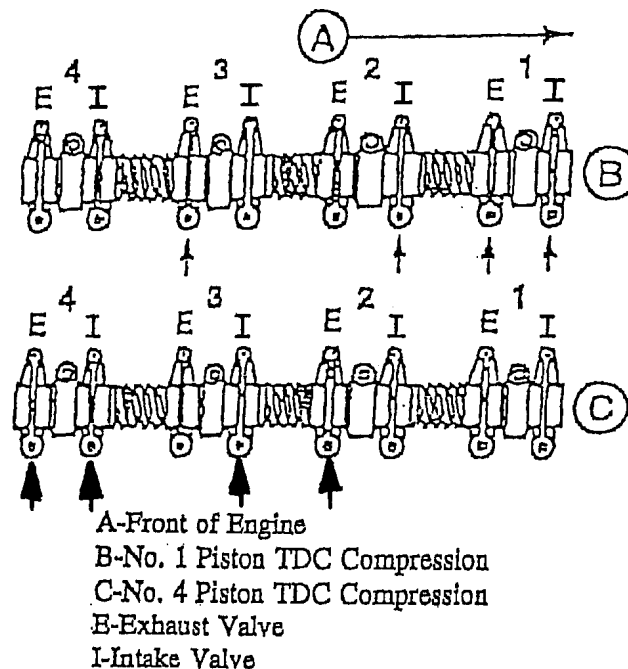
**Rotate engine flywheel clockwise when viewed from the front of the engine.**

- (e) Apply light pressure to tip of timing pin and rotate flywheel rotation tool counterclockwise until timing pin slides into hole in flywheel and prevents flywheel from turning.
  - (f) Check rocker arms on Number 4 cylinder, refer to Figure 4-47. If both rocker arms are loose, the engine is set with No. 4 Piston at TDC. If both rocker arms are not loose, engine is one full revolution (360°) away from TDC, rotate engine slightly and repeat steps 4 and 5.
- b. Test Valve Clearance.
- (1) Check and Adjust Valve Clearance.

**NOTE**

**Valve clearance MUST BE checked and adjusted with engine COLD.**

- (a) Remove rocker arm cover, refer to paragraph 4.7.1.
- (b) Visually inspect contact surfaces of valve tips and rocker arm wear pads. Check all parts for excessive wear. Replace all parts that show visible damage.



**FIGURE 4-47. ROCKER ARM LOCATION**

**NOTE**

**Firing order is 1-3-4-2.**

- (2) Set engine with No. 1 cylinder at TDC compression stroke.
- (3) Check valve clearance on No. 1 and 3 exhaust valves and No. 1 and 2 intake valves per specifications in Table 4-2. Thoroughly inspect rocker arms for damaged parts if valve clearance exceeds specifications, thoroughly inspect rocker arms for damaged parts. If required, adjust per step 4.
- (4) Loosen jam nut (8, Figure 4-48) and adjust valve clearance on No. 1 and 3 exhaust valves and No. 1 and 2 intake valves to specifications given in Table 4-2. Torque jam nut to 20 lb-ft (27 Nm). Verify valve clearance and adjust again if necessary.

<b>Table 4-2. Valve Clearance Specification (Rocker Arm-To-Valve Tip)</b>	
Item	Specification
Intake Valves	0.014 in. (0.35 mm)
Exhaust Valves	0.018 in. (0.045 mm)

- (5) Set engine with No. 4 cylinder at TDC compression stroke.
  - (6) Check valve clearance on No. 2 and 4 exhaust valves and No. 3 and 4 intake valves per specifications in Table 4-2. If valve clearance exceeds specifications, thoroughly inspect rocker arms for damaged parts. If required, adjust per step 7.
  - (7) Loosen jam nut (8, Figure 4-48) and adjust valve clearance on No. 2 and 4 exhaust valves and No. 3 and 4 intake valves to specifications given in Table 4-2. Torque jam nut to 20 lb-ft (27 Nm). Verify valve clearance and adjust again if necessary.
  - (8) Install rocker arm cover, refer to paragraph 4.7.1.
- c. Test Valve Lift.
- (1) Remove rocker arm cover, refer to paragraph 4.7.1.
  - (2) Visually inspect contact surfaces of valve tips and rocker arm wear pads. Check all parts for excessive wear. Replace all parts that show visible damage.
  - (3) Set engine with No. 1 piston at TDC compression stroke, refer to step a.
  - (4) Loosen jam nut (8, Figure 4-48) and adjust valve clearance on No. 1 and 3 exhaust valves and No. 1 and 2 intake valves to 0.00 in. (mm). Torque jam nut to 20 lb-ft (27 Nm).
  - (5) Position dial indicator tip on top of No. 1 exhaust valve spring cap.
  - (6) Preload dial indicator tip and set dial at 0.00 in. (mm).

- (7) Remove timing pin from flywheel and manually rotate engine one full revolution (360°) in running direction (clockwise when viewed from front of engine) using (JDG820) flywheel turning tool.
- (8) Observe dial indicator reading as valve is moved to full open. Record maximum reading and compare with specifications given in Table 4-3.
- (9) Repeat steps 5 through 8 for remaining valves.
- (10) Set engine with No. 4 piston at TDC compression stroke, refer to step a.
- (11) Loosen jam nut (8) and adjust valve clearance on No. 2 and 4 exhaust valves and No. 3 and 4 intake valves to 0.00 in. (mm). Torque jam nut to 20 lb-ft (27 Nm).
- (12) Position dial indicator tip on top of No. 2 exhaust valve spring cap.
- (13) Preload dial indicator tip and set dial at 0.00 in. (mm).
- (14) Remove timing pin from flywheel and manually rotate engine one full revolution (360°) in running direction (clockwise when viewed from front of engine) using (JDG820) flywheel turning tool.
- (15) Observe dial indicator reading as valve is moved to full open. Record maximum reading and compare with specifications given in Table 4-3.
- (16) Repeat steps 12 through 15 for remaining valves.
- (17) If valve lift on all valves is within specifications given in Table 4-3, check and adjust valve clearance, refer to paragraph b.
- (18) If valve lift on one or more valves is not within specifications given in Table 4-3, notify next higher maintenance level to remove and inspect entire valve train and camshaft.

<b>Table 4-3. Valve Lift Specification at 0.00 in. (mm) Valve Clearance</b>	
Item	Specification
Intake Valves	0.455 - 0.487 in. (11.56 - 12.37 mm)
Exhaust Valves	0.444 - 0.477 in. (11.28 - 12.12 mm)

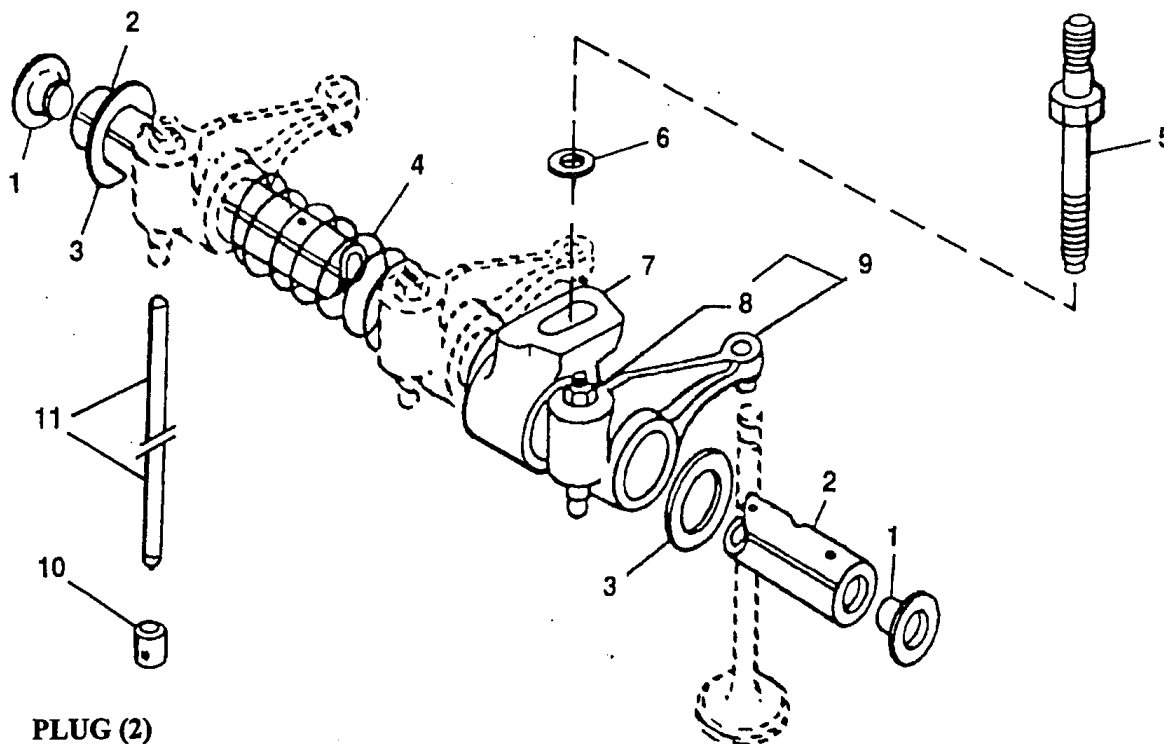
4.7.3. ROCKER ARM ASSEMBLY.

NOTE

The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.

a. Removal.

- (1) Remove rocker arm cover, refer to paragraph 4.7.1.



**LEGEND**

- |    |                  |
|----|------------------|
| 1  | PLUG (2)         |
| 2  | ROCKER ARM SHAFT |
| 3  | WASHER (2)       |
| 4  | SPRING           |
| 5  | STUD             |
| 6  | WASHER (4)       |
| 7  | SUPPORT          |
| 8  | NUT              |
| 9  | ROCKER ARM       |
| 10 | FOLLOWER         |
| 11 | PUSH ROD         |

FIGURE 4-48. ROCKER ARM ASSEMBLY.

**CAUTION**

**Support studs must be loosened sequentially, a little at a time, to prevent warping of shaft.**

- (2) Remove support studs (5, Figure 4-48), washers (6) and remainder of rocker arm assembly.
- (3) Remove push rods (11) and tag push rods as to their location.
- (4) Cover all openings to prevent entry of foreign material.

b. **Adjust.**

For valve adjustment, refer to paragraph 4.7.2.

c. **Repair.**

- (1) Remove rocker arm assembly (refer to step a.) and place on a suitable workbench.

**NOTE**

**Note locations and tag parts as they are removed.**

- (2) Remove end plugs (1, Figure 4-48), washers (3), rocker arms (9), supports (7) and springs (4) from rocker arm shaft (2). Discard end plugs.

**WARNING**

**Cleaning solvent is flammable and toxic to eyes, skin, and respiratory tract. Skin/eye protection required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.**

**WARNING**

**Compressed air used for cleaning can create airborne particles that may enter the eyes. Never exceed 30 psi (207 kPa) of pressure. Eye protection required. Failure to comply could result in serious eye damage or blindness.**

- (3) Thoroughly clean all rocker arm assembly components and push rods (11, Figure 4-48) with dry cleaning solvent (P-D-680). Dry with compressed air.
- (4) Inspect parts for cracks or obvious signs of damage. Replace as necessary.
- (5) Measure springs (4) with spring tester (DO1168AA) by applying force to spring until spring is compressed to a length of 1.81 in. (46 mm). Spring tension should be 4 - 6 lbs. (18 - 27 N). Replace any spring not within specifications.

- (6) Inspect rocker arm shaft (2) for severe scratching, scoring, or excessive wear at points of rocker arm contact. Roll rocker arm shaft on a flat surface to check for bends or distortion. Replace as necessary.
- (7) Measure outer diameter of rocker arm shaft (2) with outer diameter micrometer. Rocker arm shaft outer diameter should be 0.787 - 0.788 in. (19.99 - 20.02 mm). Replace rocker arm shaft if not within specifications.
- (8) Measure inner diameter of supports (7) with inner diameter micrometer. Support inner diameter should be 0.794 in. (20.17 mm) maximum. Replace any support not within specifications.
- (9) Inspect adjusting screw on rocker arm (9) and jam nut (8) for damage. Visually inspect rocker arm for hairline cracks. Replace as necessary.
- (10) Inspect for cups or concave wear on ends of rocker arms (9) where rocker arms contact valve tips. If wear exists, replace rocker arm.
- (11) Measure inner diameter of rocker arm (9) bore with inner diameter micrometer. Rocker arm bore inner diameter should be 0.790 - 0.792 in. (20.07 - 20.12 mm). Replace any rocker arm not within specifications.
- (12) Inspect push rods (11) for wear, damage, or physical distortion. Roll push rods on a flat surface to check for bends or distortion. Replace as necessary.
- (13) For assembly, lubricate outer diameter of rocker arm shaft (2, Figure 4-48), bores of rocker arms (9) and supports (7) with clean engine lubricating oil (MIL-L-2104).

**CAUTION**

**Oil supply hole on rocker arm shaft must be toward flywheel end of engine.  
Failure to comply could result in damage to engine.**

**NOTE**

**Assemble parts in same locations from which they were removed.**

- (14) Position rocker arms (9), supports (7), springs (4) and washers (3) on rocker arm shaft (2). Install new end plugs (1). End plugs must be firmly seated against end of shaft.
- d. Replacement.
- (1) Remove rocker arm assembly, refer to step a.
  - (2) Perform repair procedures, refer to step c. Replace any components that are not within specifications.
  - (3) For installation, refer to step e.



e. Installation.

- (1) Remove all covering installed during step a (4).
- (2) Install push rods (1, Figure 4-48) in same locations from which they were removed.
- (3) Position rocker arm assembly on engine.
- (4) Lubricate all rocker arms (9) with MIL-L-2104 engine lubricating oil. Insure that rocker arms move freely.
- (5) Position supports (7) and washers (6) on cylinder head. Install support studs and torque evenly, a little at a time, to 59 lb-ft (80 Nm).
- (6) Adjust valve clearance. Refer to paragraph 4.7.2.

4.7.4. CYLINDER HEAD.

**NOTE**

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

a. Removal.

- (1) Disconnect negative cable from battery, refer to TM 9-6115-671-14.
- (2) Drain engine coolant system, refer to TM 9-6115-671-14.
- (3) Remove air intake and exhaust system, refer to TM 9-6115-671-14.
- (4) Remove turbocharger, refer to paragraph 4.4.1
- (5) Remove intake manifold, refer to paragraph 4.4.2.
- (6) Remove exhaust manifold, refer to paragraph 4.4.3.
- (7) Remove thermostat housing and thermostat housing to water pump tube, refer to paragraph 3.8.2.
- (8) Remove fuel filter, refer to paragraph 3.12.2.
- (9) Remove fuel transfer lines, refer to paragraph 3.12.3.
- (10) Remove fuel injection lines, refer to paragraph 3.12.4.
- (11) Remove fuel injection nozzles, refer to paragraph 4.6.2.
- (12) Remove rocker arm cover, refer to paragraph 4.7.1.

- (13) Remove rocker arm assembly and push rods, refer to paragraph 4.7.3.
- (14) If a blown head gasket (12, Figure 4-49) is suspected, check and record torque on each capscrew (1) on cylinder head (14) before removing as follows:
  - (a) Make a reference mark (in-line) on head of capscrew (1) (or socket) and cylinder head surface.
  - (b) Loosen capscrew at least 1/2 turn, then retighten capscrew (using a torque wrench) until reference marks align and record torque.
  - (c) If capscrews are not tightened to 110 lb-ft (150Nm), retorque to 110 lb-ft (150Nm) per step g. and retest engine.
- (15) Remove all cylinder head capscrews (1).

**CAUTION**

**Do not use screwdrivers or pry bars between cylinder block and cylinder head to loosen cylinder head gasket seal. Screwdrivers or pry bars can damage cylinder head and cylinder block gasket surfaces.**

**CAUTION**

**Do not rotate crankshaft with cylinder head removed unless cylinder liners are secured with cap screws and large flat washers, refer to paragraph 5.4.5.**

- (16) Using adequate lifting device, lift cylinder head (14) from cylinder block. If cylinder head sticks, use a soft hammer to tap cylinder head.
- (17) Remove cylinder head gasket (12). Inspect cylinder head gasket for possible oil, coolant, or combustion chamber leaks. Discard cylinder head gasket.

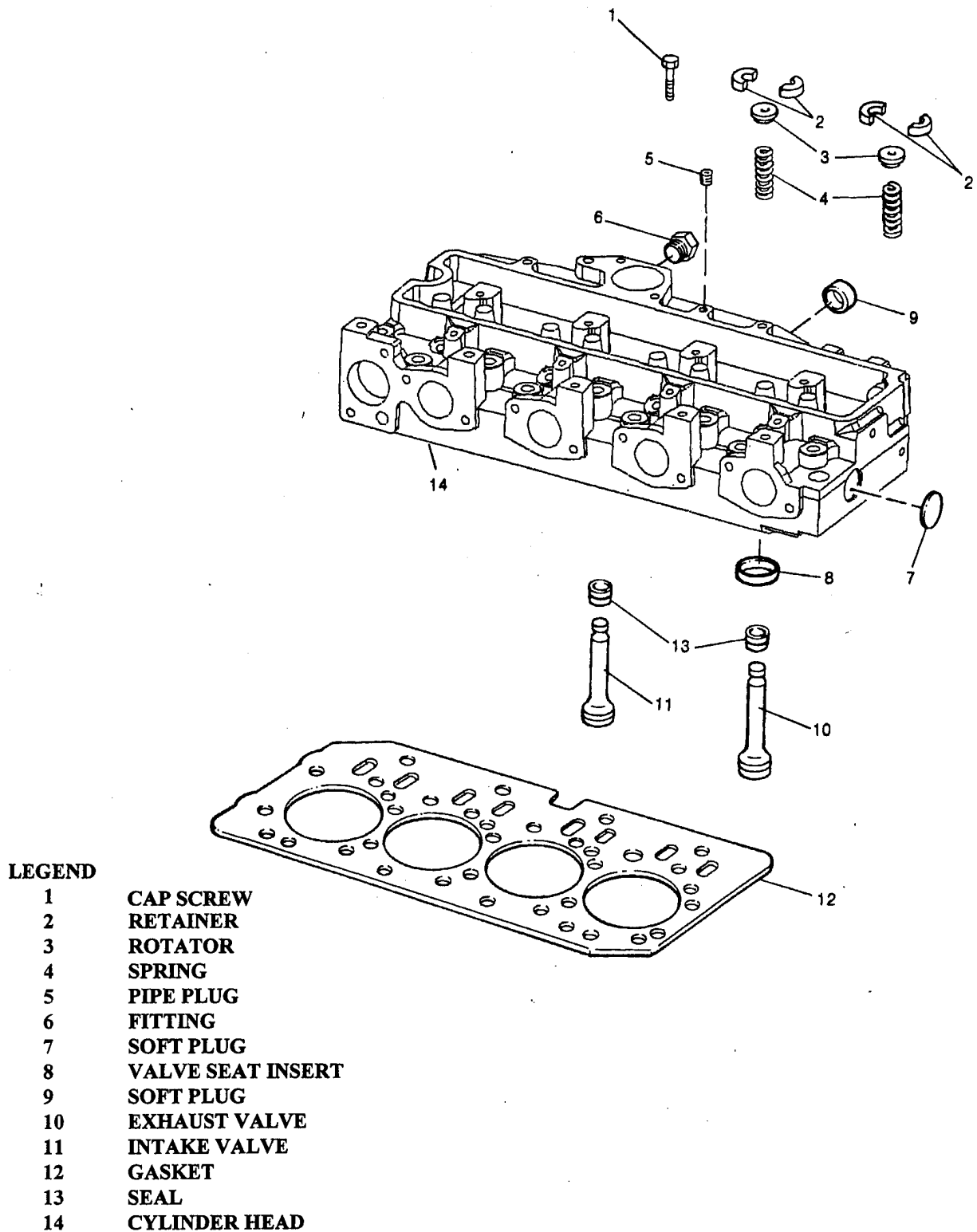
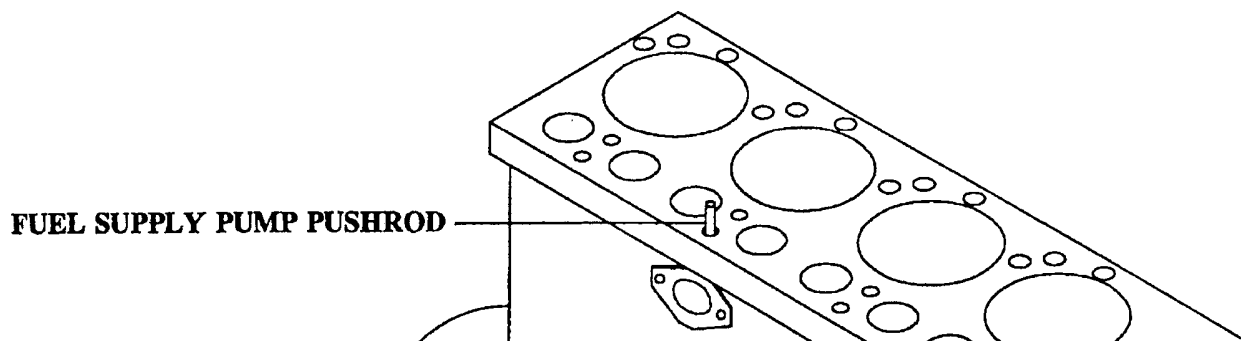


FIGURE 4-49. CYLINDER HEAD ASSEMBLY.

- (18) Remove fuel supply pump push rod. Label end for reassembly in same orientation. Refer to Figure 4-50.



**FIGURE 4-50. FUEL TRANSFER PUMP PUSH ROD LOCATION**

- (19) Cover all openings to prevent entry of foreign material.

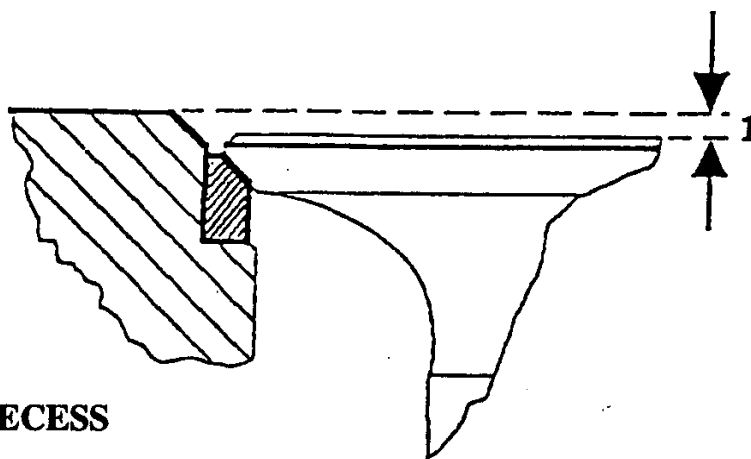
b. Inspection.

- (1) Measure and record valve recess (Figure 4-51) for all valves using a depth micrometer or magnetic base dial indicator. Measurements must be made a maximum of 0.12 in. (3.0 mm) from edge of valve head.

**LEGEND**

**1**

**VALVE RECESS**



**FIGURE 4-51. VALVE RECESS MEASUREMENT**

- (2) Compare valve recess measurements for all valves to specifications given in Table 4-4. Install new valves, inserts, or grind existing valves and inserts, as necessary, to obtain proper valve recess.

Table 4-4. Valve Recess Specifications	
Item	Specification
Intake Valves (new or rebuilt)	0.024 - 0.044 in. (0.61 - 1.11 mm)
Intake Valves (worn)	0.024 - 0.064 in. (0.61 - 1.63 mm)
Exhaust Valves (new or rebuilt)	0.048 - 0.068 in. (1.22 - 1.72 mm)
Exhaust Valves (worn)	0.048 - 0.089 in. (1.22 - 2.26 mm)

- (3) If valve recess is not within specifications, install new valves or valve seat inserts, or grind existing valves and valve seat inserts, to obtain proper valve recess.

c. Testing Prior to Installation.

- (1) Clean and inspect cylinder head cap screws as follows:

**WARNING**

**Cleaning solvent is flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection are required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.**

**WARNING**

**Compressed air used for cleaning can create airborne particles that may enter the eyes. Never exceed 30 psi (207 kPa) of pressure. Eye protection required. Failure to comply could result in serious eye damage or blindness.**

- (a) Clean entire length of cap screws. Use wire brush and solvent to remove rust and scale. Dry cap screws with compressed air.
  - (b) Inspect cap screws for corrosion damage and overall condition of threads. Cap screws with corrosion or other imperfections must be replaced.
- (2) Clean and inspect top deck of cylinder block as follows:
- (a) Remove gasket material, rust, carbon, and other foreign material from top deck of cylinder block. Gasket surface must be clean.
  - (b) Clean threaded holes in cylinder block using 2-13 UNC-2A tap about 3.0 in. (76 mm) long. Use compressed air to remove debris and fluids from cap screw holes. Replace block if there is evidence of damage.

- (c) Use compressed air to remove all loose foreign material from cylinders and top deck of cylinder block.
  - (d) Remove camshaft followers from cylinder block and wash in solvent. Lubricate with clean engine oil and install in same bore.
  - (e) Measure cylinder block top deck flatness using precision straightedge (DO5012ST) and feeler gauge. Compare measurements with specifications given in Table 4-5. If flatness is not within specifications notify next higher maintenance level.
- (3) Inspect fuel supply pump push rod and bore as follows:
- (a) Measure outer diameter of fuel transfer pump push rod with outer diameter micrometer. Fuel supply pump push rod outer diameter should be 0.3894 - 0.3904 in. (9.891 - 9.917 mm). Replace fuel supply pump push rod if not within specifications.
  - (b) Check crown on fuel supply pump push rod ends. If crown is flat or concave, replace fuel supply pump push rod and notify next higher maintenance level to check camshaft lobe for wear.
  - (c) Measure inner diameter of fuel supply pump push rod bore with inner diameter micrometer. Fuel supply pump push rod bore should be 0.3937 - 0.3957 in. (9.891 - 9.917 mm). Repair or replace block as necessary.

Table 4-5. Cylinder Block Top Deck Specifications	
Item	Specification
Maximum Acceptable Out-of-Flat:	
Entire Length or Width	0.003 in. (0.025 mm)
Any 5.90 in. (150 mm) Length	0.001 in. (0.025 mm)

d. Installation.

- (1) Remove all covering installed during step a (19).
- (2) Ensure all old gasket material is removed from gasket surfaces.
- (3) Lubricate fuel supply pump push rod with clean engine oil and install in same orientation as removed from in step a.
- (4) Install two guide studs in cylinder block at locating holes 16 and 17 shown in Figure 4-52.

**CAUTION**

**Thoroughly inspect new cylinder head gasket for possible manufacturing imperfections. Do not install any gasket that does not pass inspection. Failure to comply could result in cylinder head gasket failure.**

- (5) Position new cylinder head gasket on cylinder block. Do not use sealant; install dry.

**CAUTION**

**O-Ring seals in head gasket can be damaged if head is repositioned while resting on engine block. Always use guide studs to position cylinder head on block. Failure to comply could result in cylinder head gasket failure.**

- (6) Using adequate lifting device, position cylinder head over guide studs and carefully lower cylinder head onto cylinder block.

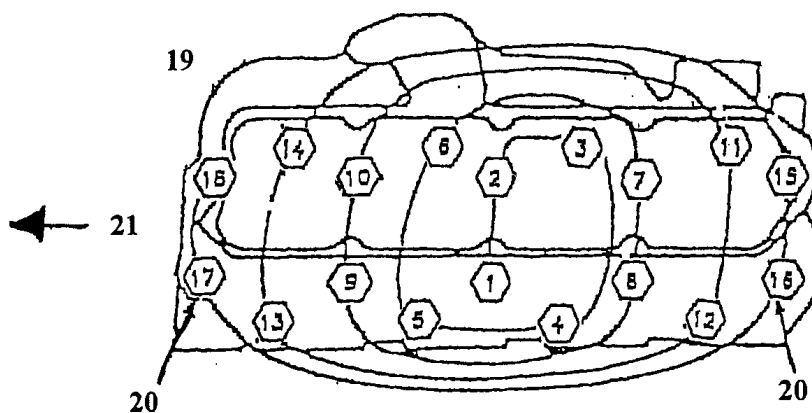
**NOTE**

**Prior to installing capscrews in cylinder block, dip entire capscrew in clean engine oil. Remove excess oil from capscrew.**

- (7) Install several capscrews (1, Figure 4-49) finger tight. Remove guide studs. Install remaining capscrews finger tight.
- (8) Tighten all capscrews (1) in sequence shown in Figure 4-52, beginning with No. 1, to 75 lb-ft (100 Nm).
- (9) Using the same sequence repeat step 8, this time tightening all capscrews (1) to 110 lb-ft (150 Nm).

**LEGEND**

- 19 4 CYLINDER ENGINE**  
**20 LOCATING HOLES (GUIDE STUD LOCATIONS)**  
**21 ARROW TOWARD FRONT OF ENGINE**



**FIGURE 4-52. CYLINDER HEAD CAPSCREW TORQUE SEQUENCE**

- (10) Wait 5 minutes, then verify 110 lb-ft (150 Nm) torque on all capscrews (1, Figure 4-52). Tighten capscrews as required.
- (11) Repeat step 9, this time tightening all capscrews (1) an additional 1/6 turn, as described below:
  - (a) Make a mark on socket and make a second mark 1/6 turn (one wrench flat) counterclockwise of first mark, when viewed from top of socket.
  - (b) Place socket on capscrew and make a mark on cylinder head adjacent with first mark on socket.
  - (c) Tighten capscrew until second mark aligns with mark on cylinder head.
- (12) Install push rods and rocker arm assembly, refer to paragraph 4.7.3.
- (13) Adjust valve clearance, refer to paragraph 4.7.2.
- (14) Install valve cover, refer to paragraph 4.7.1.
- (15) Install fuel injection nozzles, refer to paragraph 4.6.2.
- (16) Install fuel injection lines, refer to paragraph 3.12.4.
- (17) Install fuel filter, refer to paragraph 3.12.2.
- (18) Install thermostat housing and thermostat housing to water pump tube, refer to paragraph 3.8.2.
- (19) Install exhaust manifold, refer to paragraph 4.4.3.
- (20) Install intake manifold, refer to paragraph 4.4.2.
- (21) Install turbocharger, refer to paragraph 4.4.1.
- (22) Install air intake and exhaust system, refer to TM 9-6115-671-14.
- (23) Connect negative cable to battery, refer to TM 9-6115-671-14.
- (24) Service lubrication and coolant systems, refer to TM 9-6115-671-14.
- (25) Start engine, refer to TM 9-6115-671-14.
- (26) Run engine at no load for one minute. Shut down engine and check for fuel, coolant and oil leaks. Correct as required.
- (27) Start engine, refer to TM 9-6115-671-14.
- (28) Run engine at load for 10 minutes. Shut down engine and allow to cool.
- (29) Recheck valve clearances and adjust, as necessary, refer to paragraph 4.7.2.



#### 4.8. FLYWHEEL AND HOUSING ASSEMBLY MAINTENANCE

##### 4.8.1. FLYWHEEL.

###### **NOTE**

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

###### a. Inspection.

###### **WARNING**

**Cleaning solvent is flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection are required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.**

###### **WARNING**

**Compressed air used for cleaning can create airborne particles that may enter the eyes. Never exceed 30 psi (207 kPa) of pressure. Eye protection required. Failure to comply could result in serious eye damage or blindness.**

- (1) Thoroughly clean flywheel with solvent and dry with compressed air.
- (2) Inspect flywheel for rust, corrosion, cracks, or other forms of damage. Clean or replace as required.
- (3) Inspect ring gear (2, Figure 4-56) for worn or broken teeth. Replace ring gear if damaged, refer to 4.8.1.c.
- (4) Check flywheel face flatness as follows:

###### **CAUTION**

**Do not allow dial indicator to contact driving ring mounting holes. Failure to comply could result in damage to dial indicator.**

- (a) Attach magnetic base of dial indicator to flywheel housing (Figure 4-53). Position dial indicator against driving ring mounting surface on flywheel.
- (b) Rotate flywheel by turning crankshaft. Read total indicator movement and compare with specifications given in Table 4-6. Replace as required.

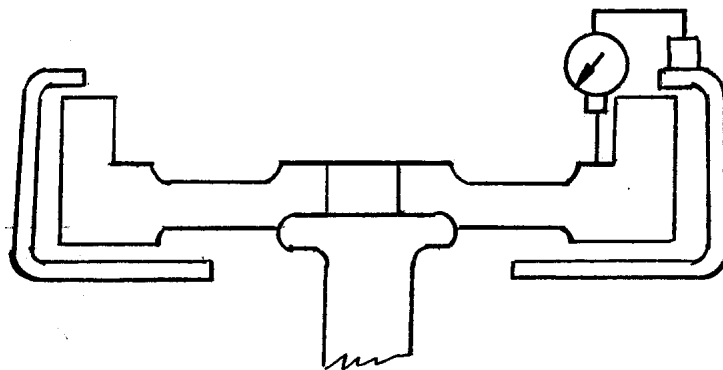


FIGURE 4-53 FLYWHEEL FLATNESS

Table 4-6. Flywheel Face Flatness Specifications	
Item	Specification
Maximum variation	0.009 in. (0.23 mm)
Maximum variation per 1.0 in. (25 mm) of travel	0.0005 in. (0.013 mm)

b. Removal.

**WARNING**

**Flywheel is heavy. Provide adequate lifting device to support weight. Failure to comply could result in serious personal injury.**

- (1) Remove bolts (Figure 4-54).

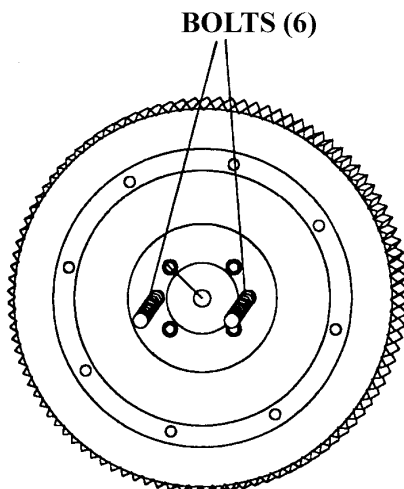
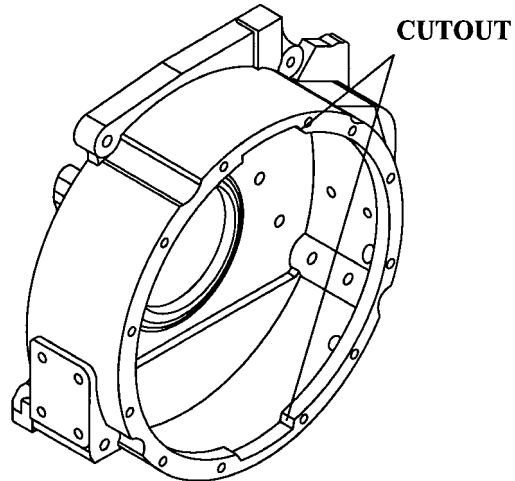


FIGURE 4-54. FLYWHEEL REMOVAL

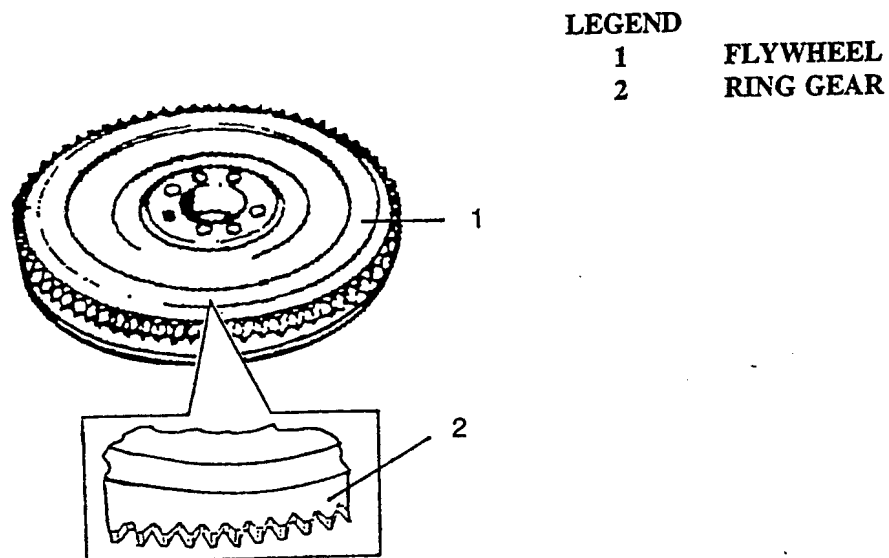
- (2) Remove flywheel by pivoting flywheel through cutouts in the top and bottom of the flywheel housing (Figure 4-55).



**FIGURE 4-55 FLYWHEEL HOUSING CUTOUTS**

c. Replacement.

- (1) Before removal, perform 4.8.1.a inspection of flywheel and ring gear while mounted to engine. Replace flywheel if damaged. If only ring gear is damaged, repair per step d.
- (2) For installation of flywheel, refer to step e.



**FIGURE 4-56 FLYWHEEL RING GEAR**

d. Installation.

**WARNING**

**Flywheel is heavy. Provide adequate lifting device to support weight. Failure to comply could result in serious personal injury.**

- (1) Pivot flywheel and install into flywheel housing through cutouts in top and bottom of flywheel housing. Place flywheel on studs and slide into position against crankshaft.
- (2) Apply Thread Lock (Appendix E) to threads of all flywheel mounting bolts (Figure 4-54). Install bolts finger tight. Torque all bolts to 102 lb-ft (138 Nm).

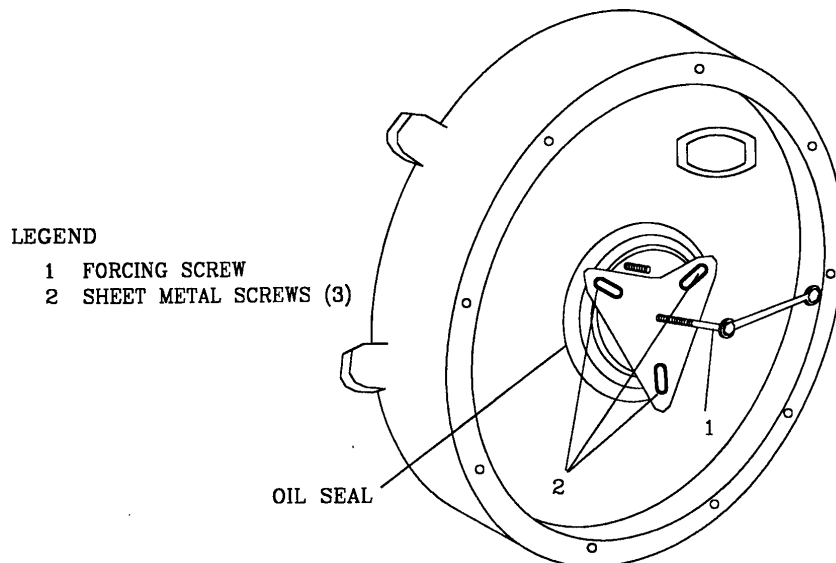
4.8.2. REAR CRANKSHAFT OIL SEAL/WEAR SLEEVE ASSEMBLY.

**NOTE**

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

a. Removal.

- (1) Remove flywheel, refer to paragraph 4.8.1.b.
- (2) Adjust forcing screw (1, Figure 4-57) on Seal and Wear Sleeve Remover and position screw so screw centers tool on crankshaft flange.



**FIGURE 4-57. REMOVAL OF REAR CRANKSHAFT OIL SEAL**

**CAUTION**

**Do not remove seal and wear sleeve assembly from plastic bag until immediately before installing. Failure to comply could result in dirt contamination and premature seal failure.**

- (3) Use slots in Seal and Wear Sleeve Remover as a template and mark three locations on seal casing where screws should be installed for removal purposes. Remove tool from crankshaft flange.

**NOTE**

**Holes must be drilled at outer edge of seal case so screws will pull seal against wear ring and allow both pieces to be removed.**

- (4) Drill a 5/32 in. hole through wear sleeve lip and seal casing at all three marked locations.
  - (5) Position Seal and Wear Sleeve Remover on end of crankshaft.
  - (6) Install three 2 in. sheet metal screws (2, Figure 4-57) with washers into slots of removal tool and thread screws into holes in seal casing. Evenly tighten screws until plate is flush with rear face of crankshaft.
  - (7) Tighten forcing screw until seal and wear sleeve assembly is removed from engine.
  - (8) Discard seal and wear sleeve assembly.
  - (9) Cover all openings to prevent entry of foreign material.
- b. Inspection.

**WARNING**

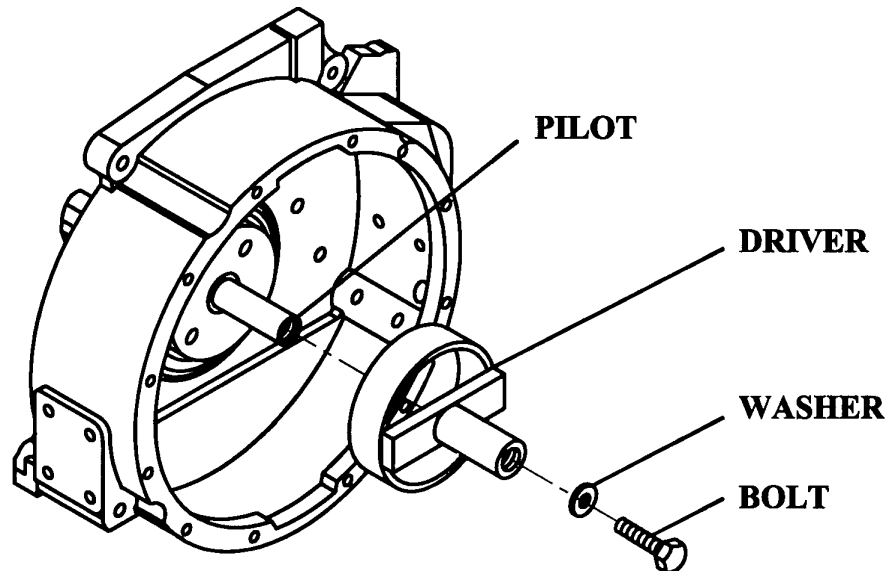
**Cleaning solvent is flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection are required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.**

- (1) Thoroughly clean outer diameter of crankshaft flange and inner diameter of flywheel housing with cleaning solvent. Refer to paragraph 4.8.3.d.
  - (2) Inspect wear ring surface and bore in flywheel housing for nicks or burrs. Remove nicks or burrs with polishing cloth, as required.
  - (3) Inspect flywheel seal base, refer to paragraph 4.8.3.d(7).
- c. Replacement.

The rear crankshaft oil seal must be replaced if any liquid is present during visual inspection. Refer to 4.8.2.a for removal and 4.8.2.d for installation.

d. Installation.

- (1) Remove all covering installed during 4.8.2.a (9).
- (2) Clean outer diameter of crankshaft flange and inner diameter of wear sleeve with cleaning solvent (Appendix E). Apply light coating of retaining compound (Appendix E) completely around leading edge of crankshaft flange. Wipe away sealant that may have gotten on flywheel housing seal bore.
- (3) Install Pilot on end of crankshaft using two socket head capscrews (Figure 4-58). Tighten both capscrews until capscrews touch base of pilot. Loosen capscrews 2 turn.
- (4) Install driver over pilot until driver cross plate bottoms on pilot (Figure 4-58). If necessary, lift up on pilot to install driver to full depth over pilot and crankshaft flange.
- (5) Tighten pilot socket head capscrews securely. Remove driver from pilot.



**FIGURE 4-58 REAR CRANKSHAFT OIL SEAL INSTALLATION**

**CAUTION**

**Oil seal and wear sleeve are assembled. Do not separate. Failure to comply could result in damage to seal and loss of engine oil.**

- (6) Carefully inspect new oil seal and wear sleeve assembly. Discard and replace if seal is scratched or gouged, or if any liquid is present.
- (7) Carefully slide oil seal and wear sleeve over pilot and crankshaft flange with open side of seal toward engine.

- (8) Attach Driver and thrust washer to guide plate with capscrew. Tighten capscrew until driver bottoms on pilot.
- (9) Remove seal driver and pilot plate. Check that seal and wear sleeve assembly is properly positioned on crankshaft flange and installed evenly in flywheel housing bore.
- (10) Install flywheel, refer to paragraph 4.8.1.d.

#### 4.8.3. FLYWHEEL HOUSING.

##### NOTE

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

##### a. Removal.

- (1) Remove starter, refer to paragraph 4.3.2.
- (2) Remove flywheel, refer to paragraph 4.8.1.
- (3) Remove crankshaft rear oil seal and wear sleeve, refer to paragraph 4.8.2.

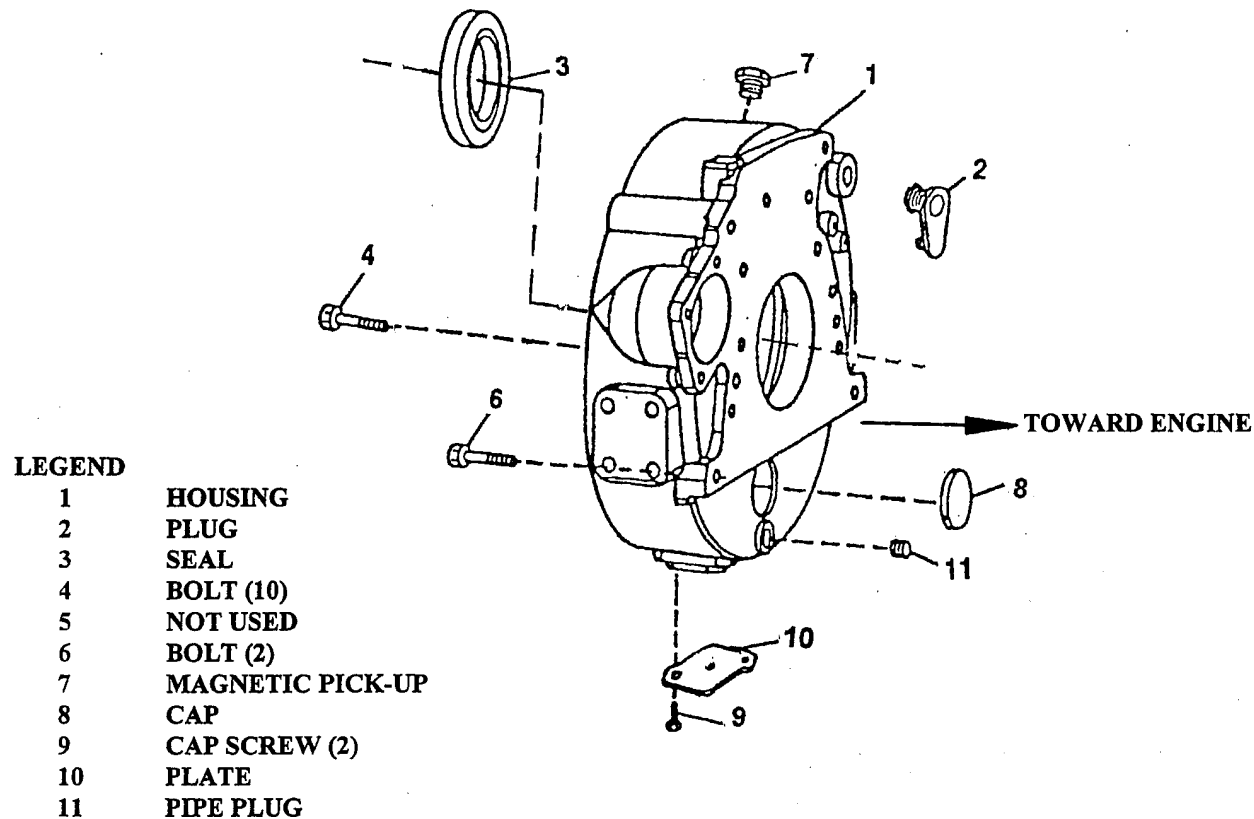
##### WARNING

**Flywheel housing is heavy. Provide adequate lifting device to support weight. Failure to comply could result in serious personal injury.**

- (4) Remove bolts (4, Figure 4-59), bolts (6) and flywheel housing (1).
- (5) Cover all openings to prevent entry of foreign material.

##### b. Inspection.

- (1) Remove flywheel housing, refer to 4.8.3.a.
- (2) Thoroughly clean flywheel housing gasket surface using brass scraper.
- (3) Inspect flywheel housing for cracks, corrosion, or other forms of damage. Repair or replace as required.
- (4) Install flywheel housing, refer to 4.8.3.d.



**FIGURE 4-59. FLYWHEEL AND HOUSING ASSEMBLY**

c. Replacement.

- (1) Remove flywheel housing, refer to 4.8.3.a.
- (2) Inspect flywheel housing, refer to 4.8.3.b. Replace if damaged.
- (3) Install flywheel housing, refer to 4.8.3.d.

d. Installation.

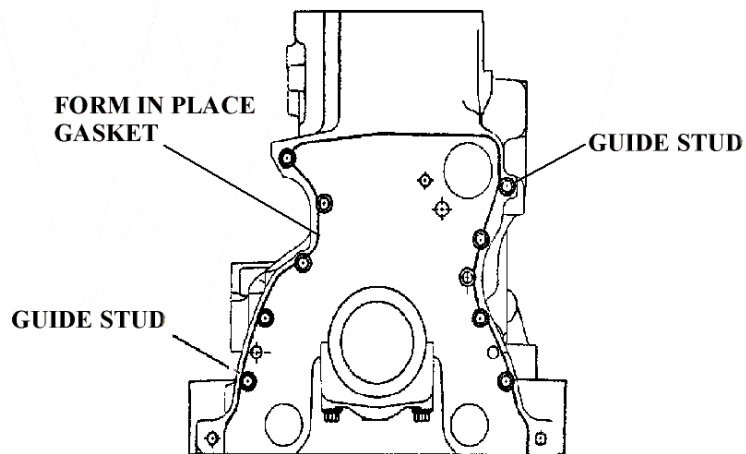
- (1) Remove all covering installed during 4.8.3.a(5).
- (2) Insure all gasket material is removed from sealing surfaces.
- (3) Apply Flexible Form-In-Place Gasket (Appendix E) in a continuous 0.06 - 0.08 in. (1.5 - 2 mm) thick bead (A) to cylinder block as shown in Figure 4-60. Ensure that sealant bead is located in center of mating surfaces and completely encircle bolt holes.
- (4) Install two guide studs in bolt holes (Figure 4-60).



**WARNING**

**Flywheel housing is heavy. Provide adequate lifting device to support weight. Failure to comply could result in serious personal injury.**

- (5) Using guide studs, position flywheel housing on cylinder block and install bolts finger tight.



**FIGURE 4-60. GASKET APPLICATION TO CYLINDER BLOCK**

- (6) Remove guide studs and install remaining bolts finger tight. Torque all attaching bolts, using a cross pattern, to 92 lb-ft (125 Nm).
- (7) Check flywheel housing seal bore run out as follows:
- (a) Attach magnetic base of dial indicator to flywheel end of crankshaft.
  - (b) Position dial indicator against inner diameter of seal bore in flywheel housing and zero dial indicator.
  - (c) Turn crankshaft 360 degrees from front of engine while observing dial indicator. Maximum permissible run out of flywheel housing seal bore is 0.006 in. (0.0152 mm). Replace flywheel housing if run out exceeds specification.
- (8) Install rear crankshaft oil seal/wear sleeve assembly, refer to paragraph 4.8.2.
- (9) Install flywheel, refer to paragraph 4.8.1.

4.9. CRANKSHAFT PULLEY AND TIMING GEAR COVER ASSEMBLY MAINTENANCE

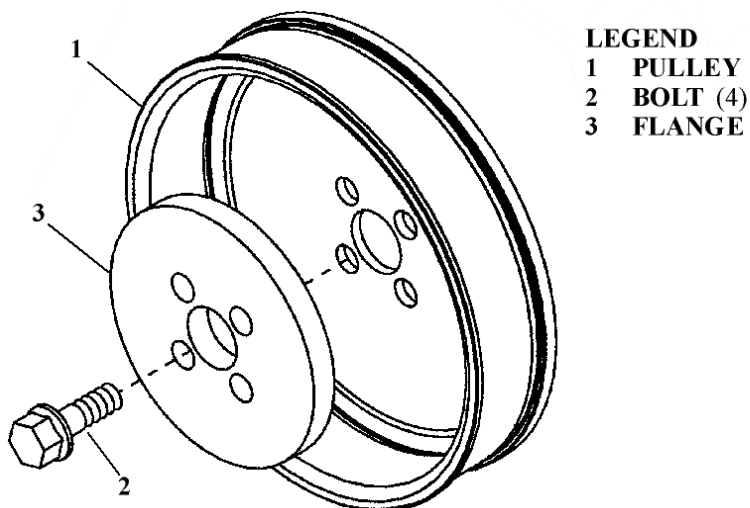
4.9.1. CRANKSHAFT PULLEY.

**NOTE**

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

a. Removal.

- (1) Remove fan drive belt, refer to TM 9-6115-671-14.
- (2) Remove bolts (2, Figure 4-61), flange (3), and crankshaft pulley (1).



**FIGURE 4-61. CRANKSHAFT PULLEY**

b. Inspection.

- (1) Remove crankshaft pulley (1), refer to 4.9.1.a.
- (2) Inspect crankshaft pulley (1) for cracks and wear. Replace as necessary.
- (3) Install crankshaft pulley, refer to 4.9.1.d.

c. Replacement.

- (1) Remove crankshaft pulley (1), refer to 4.9.1.a.
- (2) Inspect crankshaft pulley (1) refer to 4.9.1.b. Replace if defective.
- (3) Install crankshaft pulley, refer to 4.9.1.d.

d. Installation.

- (1) Position crankshaft pulley (1, Figure 4-61), and flange (3) on crankshaft and secure with bolts (2). Torque bolts to 59 lb-ft (80 Nm).
- (2) Install fan drive belt, reference TM 9-6115-671-14.

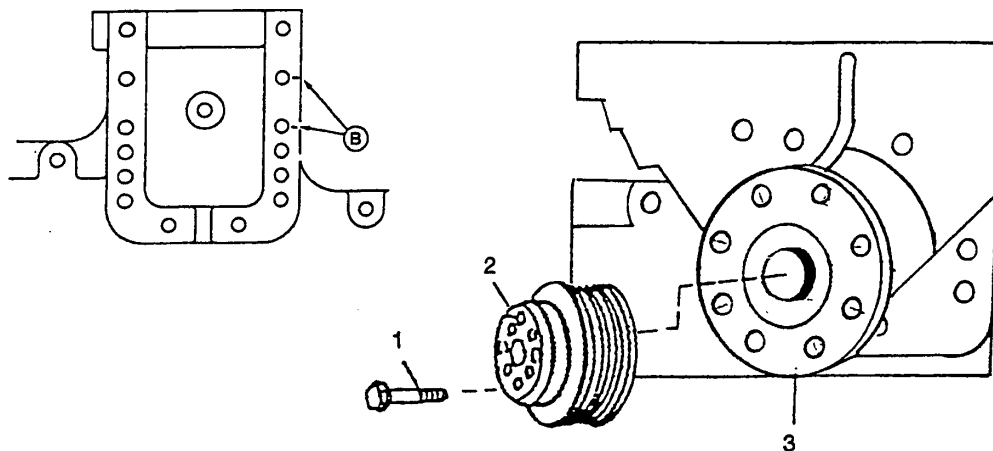
4.9.2. TIMING GEAR COVER.

**NOTE**

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

a. Removal.

- (1) Drain lubrication system, refer to TM 9-6115-671-14.
- (2) Remove fan drive belt and fan, refer to TM 9-6115-671-14.
- (3) Remove alternator and alternator mounting bracket, refer to paragraph 3.9.1.
- (4) Remove water pump if needed, refer to paragraph 3.8.3.
- (5) Remove fan pulley and fan drive assembly as follows;
  - (a) Remove bolts (1, Figure 4-62) and (2) fan pulley.



**LEGEND**

- |   |                            |
|---|----------------------------|
| 1 | BOLT                       |
| 2 | FAN PULLEY                 |
| 3 | HUB AND FAN DRIVE ASSEMBLY |

**FIGURE 4-62. FAN DRIVE ASSEMBLY**

- (b) Mark bolt positions (B) on timing gear cover before removal to assure that fan pulley is installed in same position as removed and assure proper belt tension.
  - (6) Remove hub and fan drive (3).
  - (7) Remove crankshaft pulley, refer to paragraph 4.9.1.
  - (8) Remove water pump tube from water manifold cover, refer to paragraph 3.8.2.
  - (9) Remove oil pan, refer to paragraph 4.5.3.
  - (10) Remove oil pressure regulating valve plug, refer to paragraph 4.5.2.
  - (11) Remove bolts (5, 6, 10, and 17, Figure 4-63), stud nuts (16), timing gear cover, and gasket. Discard gasket.
  - (12) Cover all openings to prevent entry of foreign material.
- b. Inspection.
- (1) Remove timing gear cover, refer to 4.9.2.a.
  - (2) Remove oil seal (11, Figure 4-63).

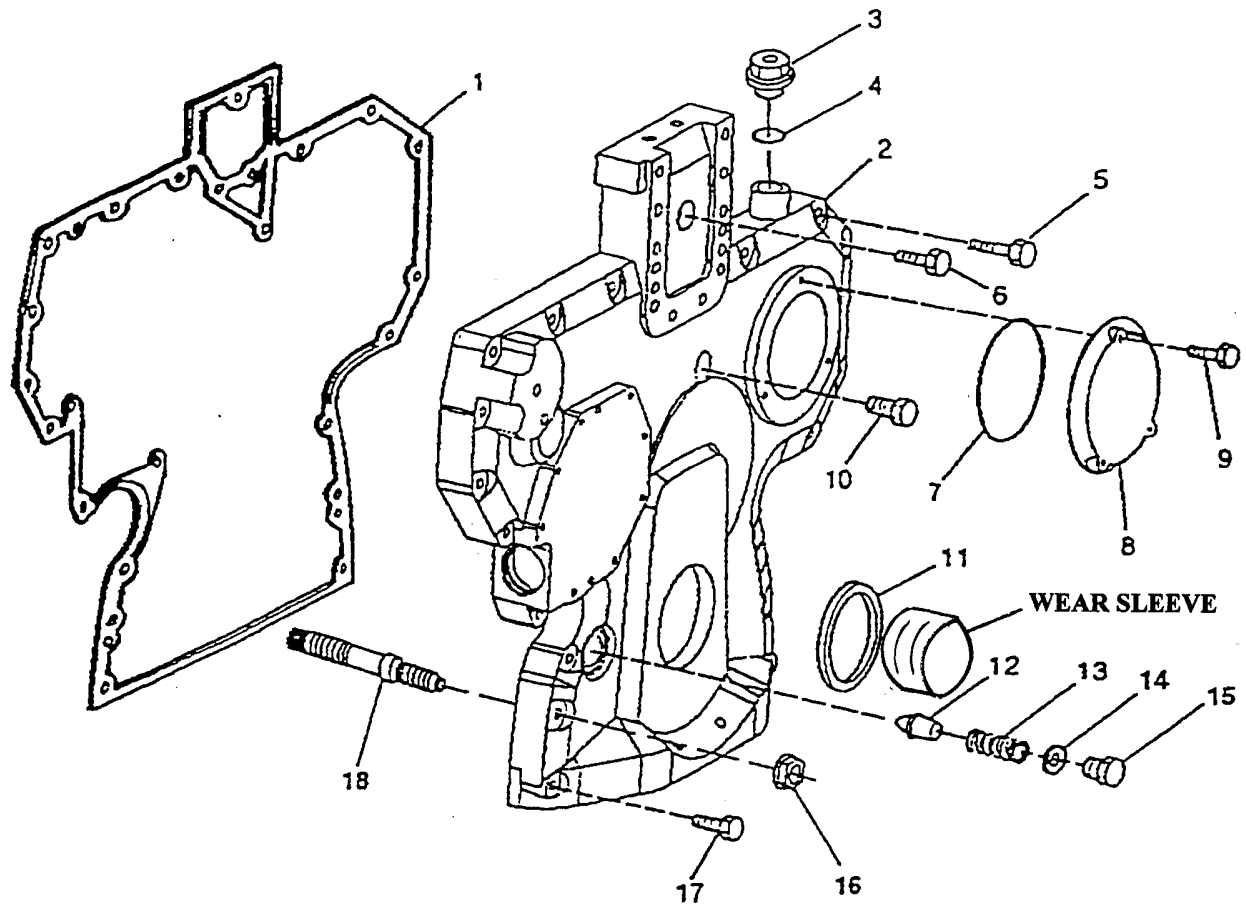
**WARNING**

**Cleaning solvent is flammable and toxic to eyes, skin, and respiratory tract. Skin/eye protection required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.**

**WARNING**

**Compressed air used for cleaning can create airborne particles that may enter the eyes. Never exceed 30 psi (207 kPa) of pressure. Eye protection required. Failure to comply could result in serious eye damage or blindness.**

- (3) Thoroughly clean timing gear cover in solvent. Dry with compressed air.
- (4) Inspect timing gear cover for cracks or other damage. Replace as required.
- (5) Inspect front crankshaft oil seal bore for nicks. Repair or replace as required.
- (6) Install timing gear cover, refer to 4.9.2.d.



**LEGEND**

1	GASKET	10	BOLT
2	COVER	11	SEAL KIT
3	PLUG	12	VALVE
4	O-RING	13	SPRING
5	BOLT (6)	14	WASHER
6	BOLT	15	FITTING PLUG
7	O-RING	16	NUT
8	COVER	17	BOLT (2)
9	SCREW	18	STUD

**FIGURE 4-63. TIMING GEAR COVER**

c. Replacement.

- (1) Remove timing gear cover, refer to 4.9.2.a.
- (2) Inspect timing gear cover, refer to 4.9.2.b. Replace if damaged.
- (3) For installation, refer to 4.9.2.d.

d. Installation.

- (1) Remove all covering installed during 4.9.2.a (11).
- (2) Insure all gasket material is removed from sealing surfaces.
- (3) Position gasket (1, Figure 4-63) and timing gear cover (2) on front plate and install bolts (5, 6, 10, and 17) and stud nuts (16). Torque bolts and stud nuts to 26 lb-ft (35 Nm).
- (4) Install oil pressure regulating valve assembly, refer to paragraph 4.5.2.
- (5) Install adjustable fan drive assembly and fan pulley, as follows
  - (a) Install fan pulley (2, Figure 4-61). Install bolts (1). Ensure bolts are installed in positions as marked in paragraph 4.9.2 (a) step 5. to assure proper belt tension.
  - (b) Install belt, refer to TM 9-6115-671-14.
- (6) Install water pump, if removed, refer to paragraph 3.8.3.
- (7) Install water pump tube to water manifold cover, refer to paragraph 3.8.2.
- (8) Install oil pan, refer to paragraph 4.5.3.
- (9) Install crankshaft front wear sleeve as follows:
  - (a) Coat inner diameter of new wear sleeve with LOCTITE 680 Retaining Compound.
  - (b) Position wear sleeve on nose of crankshaft with flange of crankshaft front wear sleeve toward crankshaft.
  - (c) Position (JDG954-1) installation tool over crankshaft front wear sleeve. Install crankshaft front wear sleeve until tool bottoms against nose of crankshaft, using a dead blow hammer.
  - (d) Clean any sealant from outer diameter of crankshaft flange and wear sleeve.
- (10) Install crankshaft front oil seal as follows:
  - (a) Inspect and clean seal bore in timing gear cover. Check for nicks or burrs. Use medium grit emery cloth to smooth rough areas.
  - (b) Clean outer diameter of crankshaft and wear sleeve with solvent (Appendix E) or ignition cleaner and allow to dry.

- (c) Slide adapter on nose of crankshaft and install bolts.

**CAUTION**

**Do not allow oil to contact coating on outer diameter of crankshaft front oil seal. Failure to comply could result in damage to crankshaft front oil seal and oil leakage.**

**NOTE**

**Position spring loaded side of crankshaft front oil seal into timing gear cover first.**

- (d) Apply light coat of clean engine oil to flange of crankshaft front oil seal and position crankshaft front oil seal on crankshaft flange.
  - (e) Place installer over adapter. Tighten screw until driver bottoms against nose on crankshaft.
- (11) Install crankshaft pulley, refer to paragraph 4.9.1.
  - (12) Install alternator mounting bracket and alternator, refer to paragraph 3.9.1.
  - (13) Install fan and fan drive belt, refer to TM 9-6115-671-14.
  - (14) Service lubrication system, refer to TM 9-6115-671-14.

4.10. **VEHICLE ENGINE STAND**

**NOTE**

**The 2000 lb (908 kg) Vehicle Engine Stand (NSN 4910-01-016-1835) is referenced in this manual. When any other repair stand is used, consult the manufacturer's instructions for mounting the engine.**

**WARNING**

**The vehicle engine stand should be used only by qualified service technicians familiar with this equipment. Failure to comply could result in personal injury and/or equipment damage.**

**WARNING**

**Use alloy steel SAE Grade 8 or higher socket head cap screws when installing engine adapters on vehicle engine stand. Use Thread Lock and Sealer (Loctite 242) or equivalent on cap screws when installing lift straps on the engine. Tighten cap screws to 125 lb-ft (170 Nm). Failure to comply could result in personal and/or equipment damage.**

**WARNING**

Be sure that tapped hole on the vehicle repair stand's adapter and mounting hub are clean and not damaged. Ensure that thread engagement is within 1-1.2 times the screw diameter minimum to properly secure the engine. Failure to comply could result in personal injury and/or equipment damage.

**WARNING**

To avoid structural or personal injury, do not exceed the maximum capacity rating or 2000 lbs. (908 kg.). Maximum capacity is determined with the center of the engine located no more than 13 inches (330 mm) from the mounting hub surface of the engine stand.

**WARNING**

Be sure that the center of the engine must be located within 2 inches (51 mm) of the engine stand rotating shaft to prevent unsafe off-balance load condition. Failure to comply could result in personal injury and/or equipment damage.

**WARNING**

Recheck to make sure engine is solidly mounted before releasing support from engine lifting device. Failure to comply could result in personal injury and/or equipment damage.

**WARNING**

Never permit any part of the body to be positioned under a load being lifted or suspended. Failure to comply could result in personal injury.

**WARNING**

The lifting jack is to be used when it is necessary to lift the engine for rotation. When working on the engine, the jack should be at its lowest position to keep the center of gravity low and the possibility of tipping low.

**WARNING**

Unscrew the release valve slowly when lowering the engine on vehicle engine stand to prevent sudden engine movement. Do not unscrew release valve knob more than two turns from its closed position. Failure to comply could result in personal injury and/or equipment damage.



**CAUTION**

Use extreme caution when lifting and NEVER permit any part of the body to be positioned under an engine being lifted or suspended.

**CAUTION**

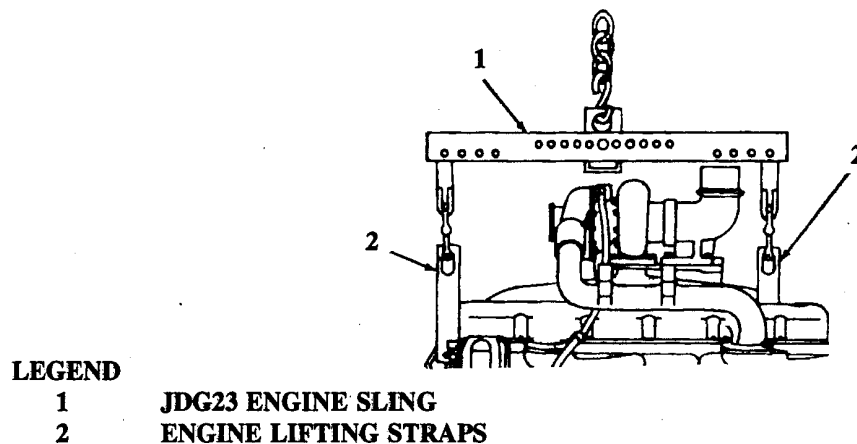
Lift engine with longitudinal loading on lift sling and lifting brackets only. Angular loading greatly reduces lifting capacity of sling and brackets.

- a. Lift engine using the following steps;
- (1) Attach Engine Lifting Sling to engine lifting straps and overhead hoist on floor crane.

**NOTE**

Use of an engine lifting sling as shown in Figure 4-64 is the only APPROVED method of lifting an engine.

- (2) Carefully lift engine to desired location.



**FIGURE 4-64 ENGINE LIFTING**

**CAUTION**

When servicing turbocharged engines on a rollover stand, disconnect turbocharger oil inlet line from the oil filter housing or turbocharger before rolling engine over. Failure to do so may cause a hydraulic lock upon starting engine. Hydraulic lock may cause possible engine failure.

**NOTE**

Hydraulic lock is the event that occurs when trapped oil in the oil filter housing drains through the turbocharger, to the exhaust and intake manifolds, and into the cylinder head. After starting the engine, the trapped oil in the manifold and head is released into the cylinder(s) filling them with oil causing hydraulic lock and possible engine failure.

- b. Disconnect turbocharger oil inlet line as follows;
  - (1) Drain all engine oil and coolant, if not previously done.
  - (2) Disconnect turbocharger oil inlet line, refer to paragraph 4.4.1.

**CAUTION**

**NEVER remove the overhead lifting equipment until the engine is secure mounted onto the repair stand and all mounting hardware is tightened to specific torque. Always release the overhead lifting equipment slowly.**

- c. Mount engine on vehicle engine stand using the following steps;
  - (1) If not done previously, remove turbocharger. Refer to paragraph 4.4.1. Ensure oil and coolant are drained as stated in 4.10.b. above.
  - (2) Mount engine on vehicle engine stand.

CHAPTER 5  
GENERAL SUPPORT MAINTENANCE INSTRUCTIONS

Section I. TROUBLESHOOTING

5.1. GENERAL SUPPORT TROUBLESHOOTING PROCEDURES.

This section does not contain any troubleshooting information for locating and correcting operating engine troubles at the general support level. General support is limited to the disassembly, cleaning, inspection and assembly of components after troubleshooting has already been accomplished. Refer to Table 5-1 for maintenance procedures covered in this chapter. For troubleshooting, refer to Table 3-1 for troubleshooting at the unit level and Table 4-1 for troubleshooting at the direct support level.

NOTE

**Before using troubleshooting Tables 3-1 and 4-1, be sure you have performed your PMCS. Prior to performing troubleshooting procedures within this manual, perform previous maintenance level troubleshooting procedures and TM 9-6115-671-14 troubleshooting procedures.**

Table 5-1. Procedural Index for General Support Maintenance

Subject	Paragraph
Fuel Injection Pump .....	5.3.1.
Camshaft Assembly .....	5.4.1.
Idle Gears and Idle Gear Shafts .....	5.4.2.
Front Plate .....	5.4.3.
Crankshaft and Main Bearings .....	5.4.4.
Pistons and Connecting Rods .....	5.4.5.
Cylinder Liners .....	5.4.6.
Balancer Shaft Assembly .....	5.4.7.
Cylinder Block .....	5.4.8.
Oil Pump Assembly .....	5.4.9
Oil Bypass Valve Assembly .....	5.4.10
Cylinder Head.....	5.4.11
Oil Pressure Regulating Valve Assembly Valve Seat.....	5.4.12

Section II. MAINTENANCE PROCEDURES

5.2. GENERAL.

This section contains general support maintenance procedures. Topics covered at this level include disassembly, cleaning, inspection and assembly of components.

5.3. FUEL SYSTEM MAINTENANCE

5.3.1. FUEL INJECTION PUMP

**NOTE**

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

**NOTE**

**If working on fuel injection pump on TQG, refer to TM 9-6115-671-14 for removal and installation procedure for electrical actuator.**

a. Test

**NOTE**

**Test bench coupling should be of self aligning, zero backlash type.**

- (1) Remove injection pump, refer to paragraph 4.6.1.a.
- (2) Install injection pump on a motorized test bench meeting ISO Standard 4008.
- (3) Ensure rotation of drive shaft on test stand is clockwise.

**CAUTION**

**If incorrect connector is used on the transfer pump inlet, damage to internal threads will occur.**

- (4) Install transfer pump inlet connector from the transfer pressure adjusting tool kit.
- (5) Install transfer pressure gage connector.
- (6) Install a shutoff valve to isolate gage when not in use.
- (7) Remove timing line cover and install advanced indicator.
- (8) Energize electric shutoff device with 24 VDC at lowest speed.
- (9) Move pump throttle lever to full load position.
- (10) Pressurize transfer pump inlet to  $5.0 \pm 0.5$  psi ( $34 \pm 3$  kPa).

**NOTE**

**When transfer pump is primed, allow fuel to bleed for several seconds from loosened injection line nuts at nozzles.**

- (11) With pump operating at 300 rpm, bleed injector lines.
- (12) After bleeding, tighten nuts securely.

**WARNING**

**Compressed air used for cleaning can create airborne particles that may enter the eyes. Pressure will not exceed 30 psig (207 kPa). Eye protection required.**

**CAUTION**

**Under no circumstances should 130 psi (896.4 kPa) transfer pump pressure be exceeded, to prevent damage to the pump.**

**NOTE**

**Table 5-2 lists fuel delivery in cubic millimeters/stroke. Some test benches measure fuel flows in cubic centimeters (milliliters). To convert from mm<sup>3</sup>/stroke to CC's, use the following formula:**

$$\text{CC's} = (\text{mm}^3/\text{stroke} \times \text{No. of strokes})/1000$$

**NOTE**

**All rpm readings are at pump speed.**

- (13) Operate pump at 1000 pump rpm wide open throttle (WOT) for ten minutes or until temperature reaches 110°F to 115°F (43.3°C to 46.1°C). Completely dry pump off using compressed air. Observe for leaks and correct as necessary.

**CAUTION**

**Never back out low idle screw or disengagement of throttle lever from guide bushing could result.**

- (14) Back out high idle screw.
- (15) Close valve in fuel supply line. With pump running 400 pump rpm, the transfer pump must be capable of creating a vacuum of at least 18 inches (45.7 cm) of mercury. If it does not, check for air leaks between pump inlet and shutoff valve or deficiency in transfer pump.
- (16) Fill graduates to bleed air from test stand and to lubricate graduates.

- (17) While operating pump at 1750 rpm wide open throttle (WOT), perform the following:

**NOTE**

**Pressure should be 89 to 91 psi (614 to 628 kPa)**

- (a) Observe transfer pump pressure. To adjust pressure, remove lines to transfer pump inlet connector and use a 5/32 inch hex key wrench to adjust pressure regulating spring plug. Clockwise adjustment increases pressure. Do not over-adjust.

**NOTE**

**Transfer pump pressure gage must be isolated by shutoff valve at injection pump when checking fuel delivery and advance movement.**

**NOTE**

**Oil return flow reading should be 400 to 700 cc/min.**

- (b) Check return oil flow.
- (c) Recheck transfer pump pressure. Adjust as necessary.
- (d) Check housing pressure for 8.5 to 13.5 psi (59-93 kPa).
- (18) While operating at 2000 rpm WOT, set advance trimmer screw for 0 degrees.
- (19) While operating at 1750 rpm WOT, set roller-to-roller fuel delivery to 106.5 to 107.5 mm<sup>3</sup>/stroke.
- (20) Turn speed droop adjusting cap clockwise six full turns.
- (21) While operating at 1750 rpm WOT, set light load advance adjusting screw for 6.0 degrees.
- (22) While operating at 300 rpm, with supply pump on unscrew advance cap four full turns and allow fuel to bleed for 30 seconds. Retorque cap to 455-505 lb-in (51 – 57 Nm).
- (23) Adjust speed droop to minimum droop position counterclockwise. Turn speed droop cap in two full turns clockwise.
- (24) While operating at 2290 rpm WOT, adjust high idle screw to obtain maximum 5 mm<sup>3</sup>/stroke.
- (25) Perform the checks at pump rpm specified in Table 5-2.
- (26) Install injection pump, refer to paragraph 4.6.1.d.

Table 5-2. Fuel Injection Pump Checks				
NOTE				
Throttle position is at full load, wide open position (WOT).				
PUMP RPM	THROTTLE POSITION	mm <sup>3</sup> /STROKE	ADVANCE	PRESS
150	WOT	43 Min.	----	◆◆10 Min.
400	WOT ◆	4 Max.	----	----
1750	WOT	106.5-107.5	0°	◆◆◆89-91
1750	ADJ	26-34	5.5°- 6.5°	----
1750	WOT ◆	4 Max.	----	----
2000	WOT	----	0°-0.3°	----
2290	WOT	5 Max.	8.0°- 9.0°	----
Legend:           ◆       Electric Shut Off (ESO) Deenergized ◆◆       (69 kPa) ◆◆◆      (614-628 kPa)				

**NOTE**

**A generic (DB Series) fuel injection pump is illustrated Figures 5-1 thru 5-16.**

**b. Disassembly.**

- (1) Remove fuel injection pump, refer to paragraph 4.6.1.
- (2) Remove governor actuator from top of fuel injection pump (1, Figure 5-1), refer to TM 9-6115-671-14.
- (3) Remove flange seal (2, Figure 5-1) and discard.
- (4) Clamp pump holding fixture in vise and mount fuel injection pump on pump holding fixture. Refer to Appendix F, Figure F1.

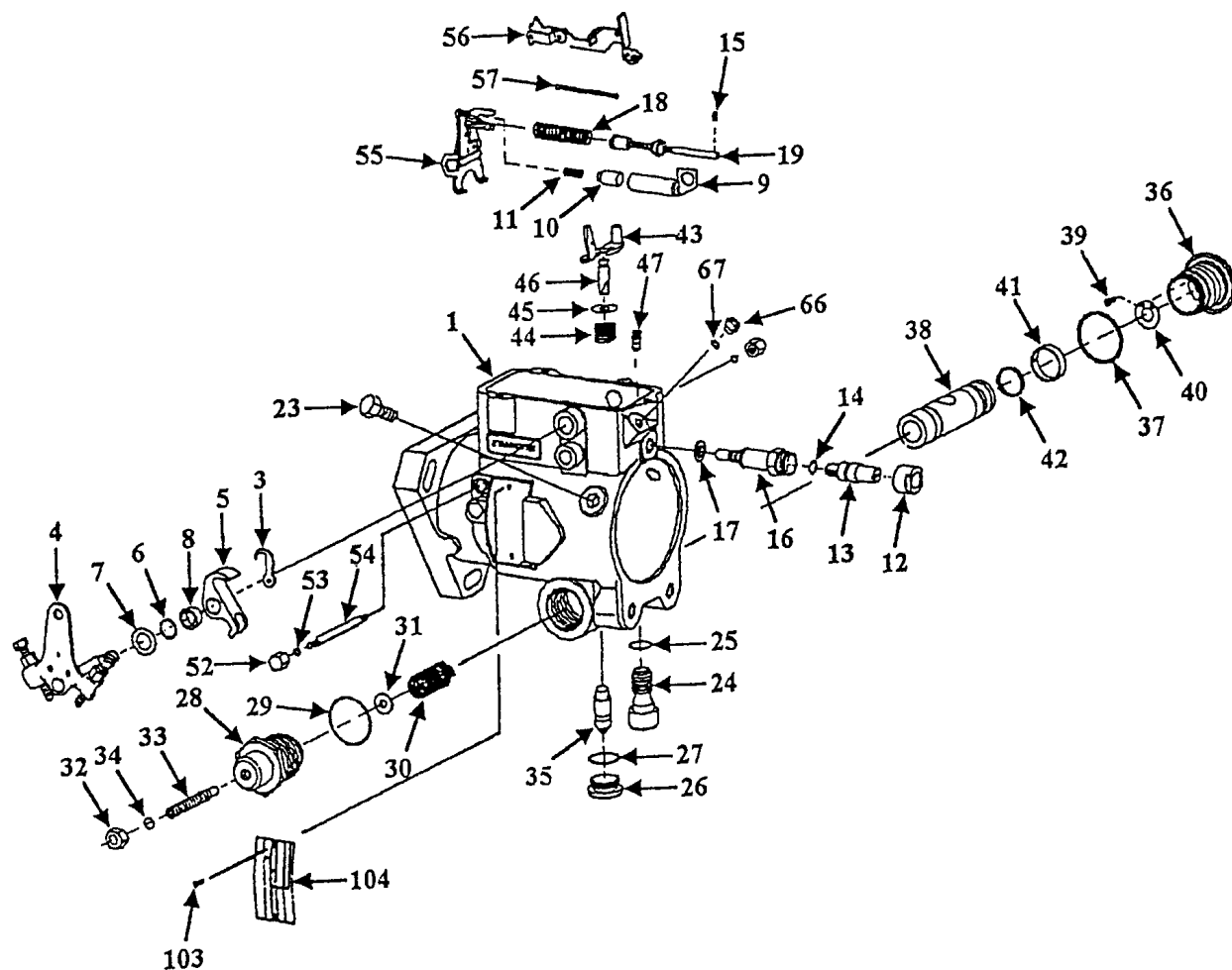


FIGURE 5-1. FUEL INJECTION PUMP (TYPICAL) (PAGE 1 OF 3)



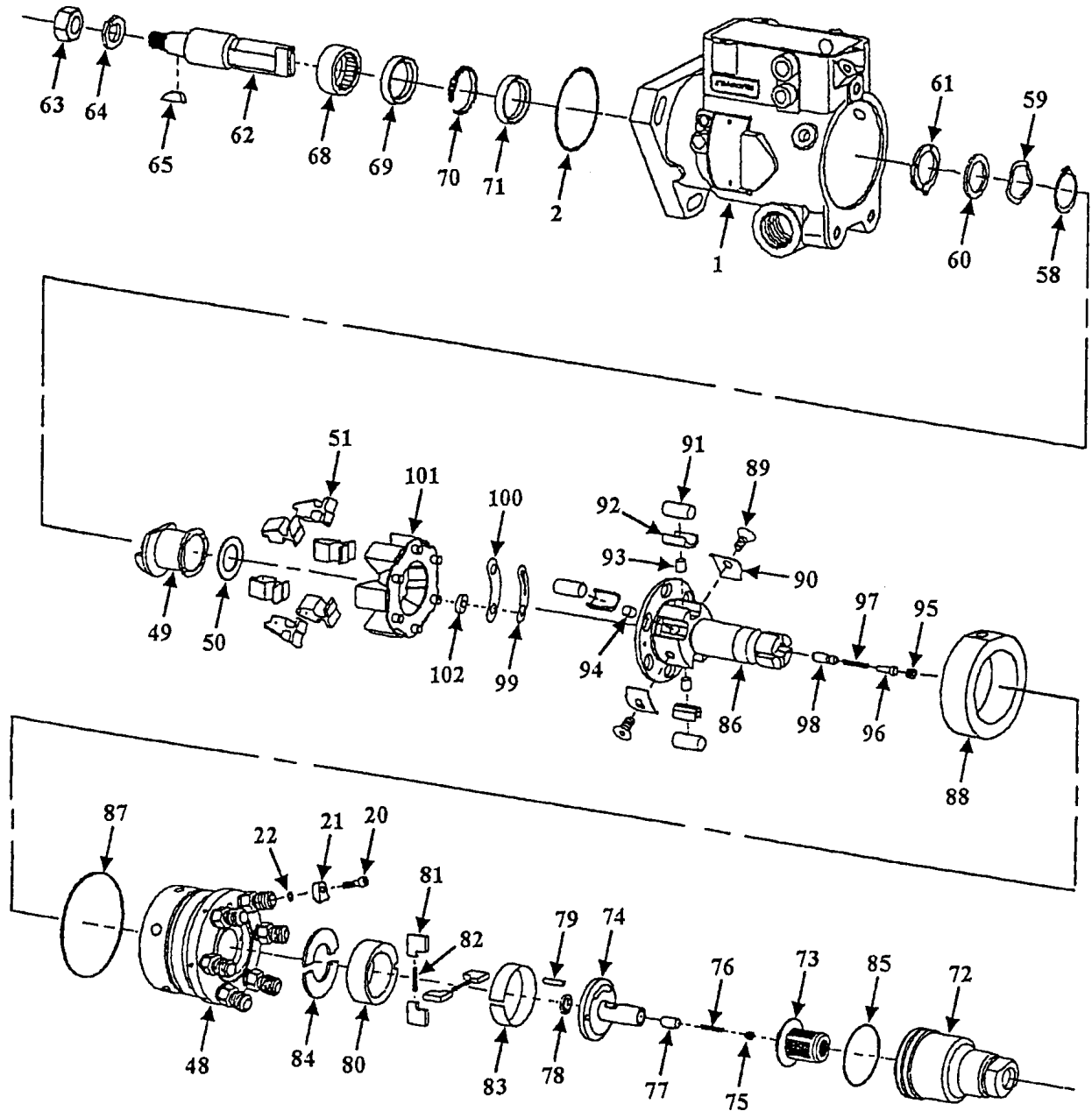


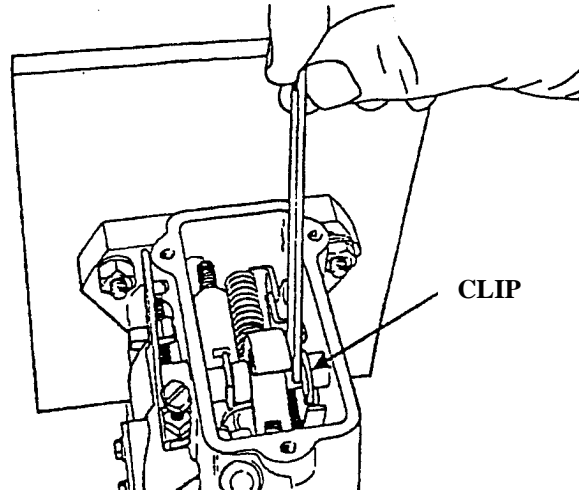
FIGURE 5-1. FUEL INJECTION PUMP (TYPICAL) (PAGE 2 OF 3)

LEGEND

1	HOUSING ASSY	36	PLUG, PISTON HOLE	71	LIP SEAL, D.S., FUEL SIDE
2	SEAL, FLANGE	37	SEAL, O-RING	72	CAP, TRANSFER PUMP END
3	CLIP, HOOK	38	PISTON, ADVANCE	73	FILTER, INLET
4	SHAFT ASSY, THROTTLE	39	SCREW, REED VALVE	74	REGULATOR ASSY, TRANSFER PUMP
5	LEVER, THROTTLE FORK	40	VALVE, REED	75	SCREW, ADJUSTING
6	SEAL, O-RING	41	RING, ADVANCE PISTON	76	SPRING, REGULATING
7	WASHER, SPACER	42	SEAL, PISTON RING	77	PISTON, REGULATOR
8	SPACER	43	ARM ASSY, METERING VALVE	78	SEAL, REGULATOR SLEEVE
9	BARREL ASSY, DAMPER	44	SPRING, METERING VALVE	79	ROLLPIN, REGULATOR ASSY
10	PISTON ASSY, DAMPER	45	SHIM, METERING VALVE SPRING	80	LINER, TRANSFER PUMP
11	SPRING, DAMPER	46	VALVE, METERING	81	BLADE, TRANSFER PUMP
12	CAP, CONTROL LOCKING	47	SCREW ASSY, VENT	82	SPRING, TRANSFER PUMP BLADE
13	CAP ASSY, ADJUSTING	48	HEAD ASSY, HYDRAULIC	83	RING, LINER LOCATING
14	SEAL, O-RING	49	SLEEVE, THRUST	84	RETAINER, ROTOR
15	PIN, CONTROL SPRING	50	WASHER, THRUST	85	SEAL, O-RING
16	GUIDE, CONTROL ROD	51	WEIGHT, GOVERNOR	86	ROTOR ASSY
17	WASHER, SEALING	52	NUT, PIVOT SHAFT	87	SEAL, O-RING
18	SPRING, GOVERNOR CONTROL	53	SEAL, O-RING	88	CAM RING
19	ROD ASSY, CONTROL	54	SHAFT, PIVOT	89	SCREW, LEAF SPRING
20	SCREW, LOCKING PLATE	55	ARM, GOVERNOR	90	SPRING, LEAF
21	PLATE, LOCKING	56	HOOK, GOVERNOR LINKAGE	91	ROLLER, CAM
22	SEAL, O-RING	57	SPRING, GOVERNOR LINKAGE	92	SHOE, CAM ROLLER
23	SCREW, HEAD LOCKING	58	RING, RETAINING	93	PLUNGER, LONG
24	SCREW, HEAD LOCATING	59	WASHER, SPRING	94	PLUNGER, SHORT
25	SEAL, O-RING	60	WASHER, THRUST	95	SCREW, RETAINING
26	PLUG, ADVANCE SCREW HOLE	61	BEARING, THRUST	96	STOP, DELIVERY VALVE
27	SEAL, O-RING	62	DRIVE SHAFT	97	SPRING, DELIVERY VALVE
28	PLUG, PISTON HOLE	63	NUT, DRIVE SHAFT	98	VALVE, DELIVERY
29	SEAL, O-RING	64	LOCKWASHER, DRIVE SHAFT	99	CLIP, RETAINING
30	SPRING, ADVANCE	65	KEY, WOODRUFF	100	RETAINER, CUSHION
31	GUIDE, ADVANCE ADJ SPRING	66	SCREW, LOCK	101	RETAINER, WEIGHT
32	NUT, LOCK	67	SEAL, O-RING	102	CUSHION, WEIGHT RETAINER
33	SCREW, TRIMMER	68	BEARING, NEEDLE	103	SCREW, NAMEPLATE
34	SEAL, O-RING	69	LIP SEAL, D.S., LUBE OIL SIDE	104	NAMEPLATE
35	PIN, CAM ADVANCE	70	SPACER, LIP SEAL		

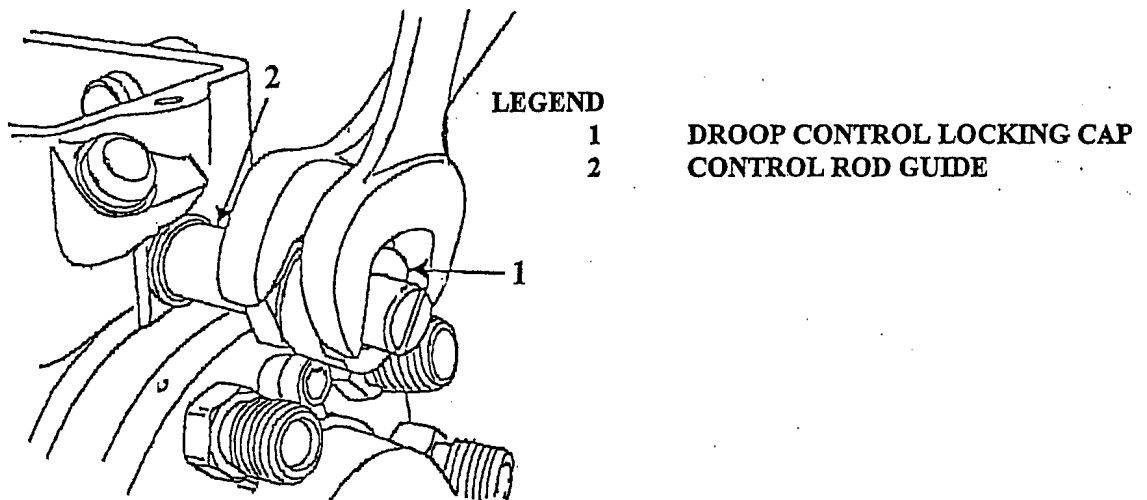
FIGURE 5-1. FUEL INJECTION PUMP (TYPICAL) (PAGE 3 OF 3)

- (5) Disconnect hook clip (3, Figure 5-1) using tool (20992), refer to Figure 5-2.



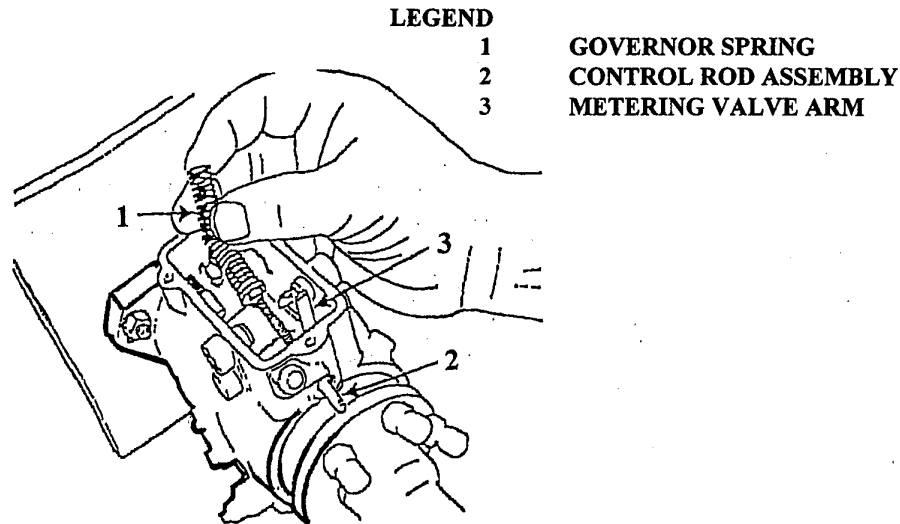
**FIGURE 5-2. CLIP REMOVAL.**

- (6) Remove throttle shaft assembly (4), throttle lever fork (5), O-ring seal (6) spacer washer (7), and spacer (8). Discard O-ring seal and spacer washer.
- (7) Remove damper barrel (9), damper piston (10), and damper spring (11).
- (8) Remove droop control locking cap (12) using one wrench to hold control rod guide (16) while another wrench is used to loosen droop control locking cap, refer to Figure 5-3.



**FIGURE 5-3. DROOP CONTROL LOCKING CAP REMOVAL.**

- (9) Remove adjusting cap assembly (13, Figure 5-1) by twisting and pulling. Remove O-ring seal (14) and spring pin (15). Discard O-ring seal.
- (10) Remove control rod guide (16) and seal washer (17). Discard seal washer.
- (11) Disengage governor spring (18) from governor arm (55), refer to Figure 5-4. Depress metering valve arm (43) and remove control rod assembly (19) and governor spring.



**FIGURE 5-4. CONTROL ROD ASSEMBLY AND GOVERNOR SPRING REMOVAL.**

- (12) Remove screw (20), locking plate (21), and O-ring seal (22). Discard O-ring seal.
- (13) Loosen but do not remove transfer pump end cap (72) using wrench (20548).
- (14) Remove head locking screws (23).
- (15) Invert fuel injection pump housing (1) in vise and remove head locating screw (24) and O-ring seal (25). Discard O-ring seal.
- (16) Remove cam advance pin hole plug (26) and O-ring seal (27).
- (17) Loosen locknut (32). Remove spring side piston hole plug (28) using wrench (14490).
- (18) Remove O-ring seal (29), spring (30), spring seat (31), locknut (32), trimmer screw (33), and O-ring seal (34). Discard O-ring seals.
- (19) Remove cam advance pin (35) using needle nose pliers, refer to Figure 5-5.
- (20) Remove power side piston hole plug (36), O-ring seal (37), and advance piston (38).

- (21) Remove screws (39) and reed valve (40) from power side piston hole plug (36), refer to Figure 5-6.

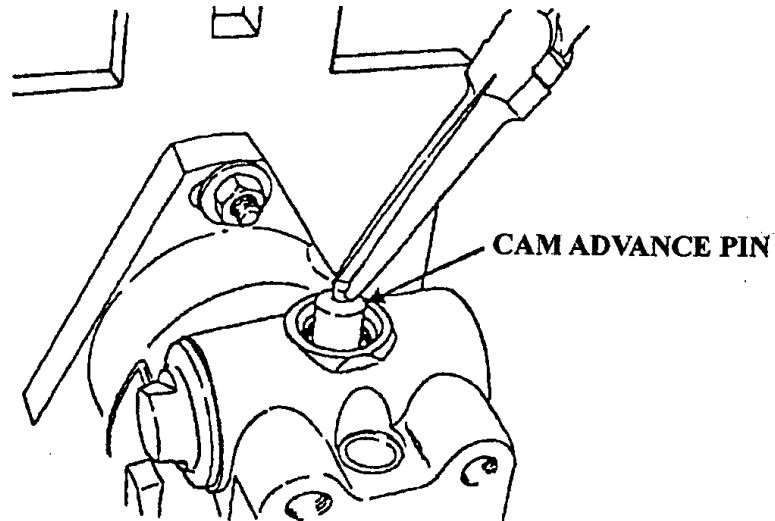


FIGURE 5-5. CAM ADVANCE PIN REMOVAL.

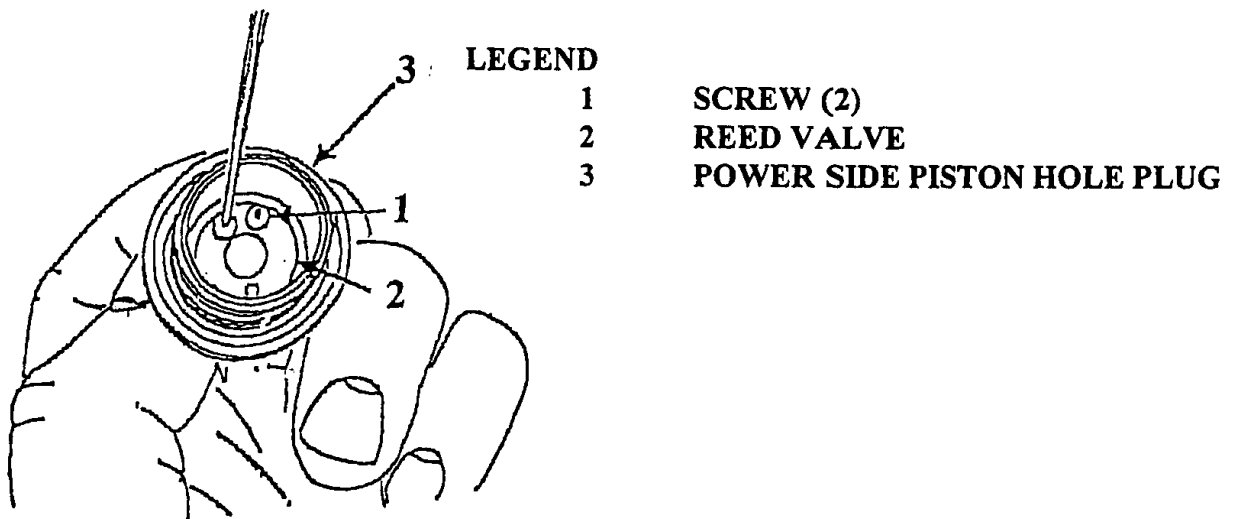


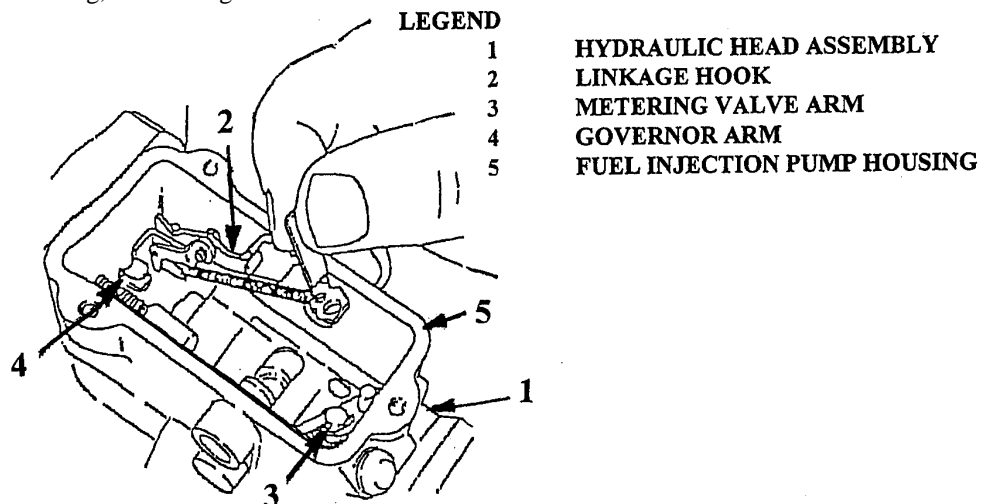
FIGURE 5-6. REED VALVE REMOVAL.

**CAUTION**

Piston ring is fragile and easily damaged. Do not over expand piston ring during removal. Failure to comply could result in damage to piston ring.

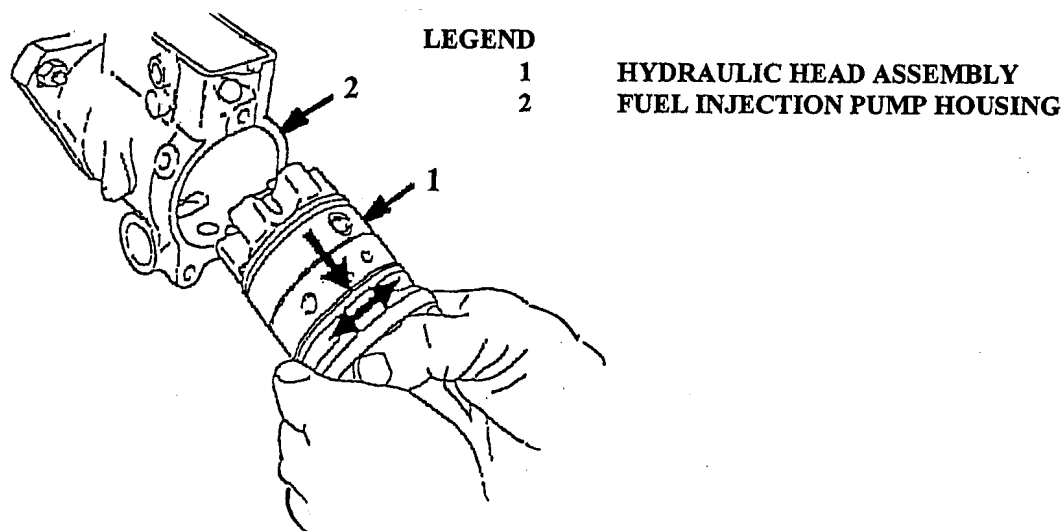
- (22) Remove piston ring (41, Figure 5-1) using snap ring pliers (13337). Remove and discard seal (42).

- (23) Invert fuel injection pump in vise. Rotate hydraulic head assembly (48) counterclockwise in fuel injection pump housing (1) and lift linkage hook (56) off metering valve arm (43). Disconnect linkage hook from governor arm (55) and hang linkage hook over side of fuel injection pump housing, refer to Figure 5-7.



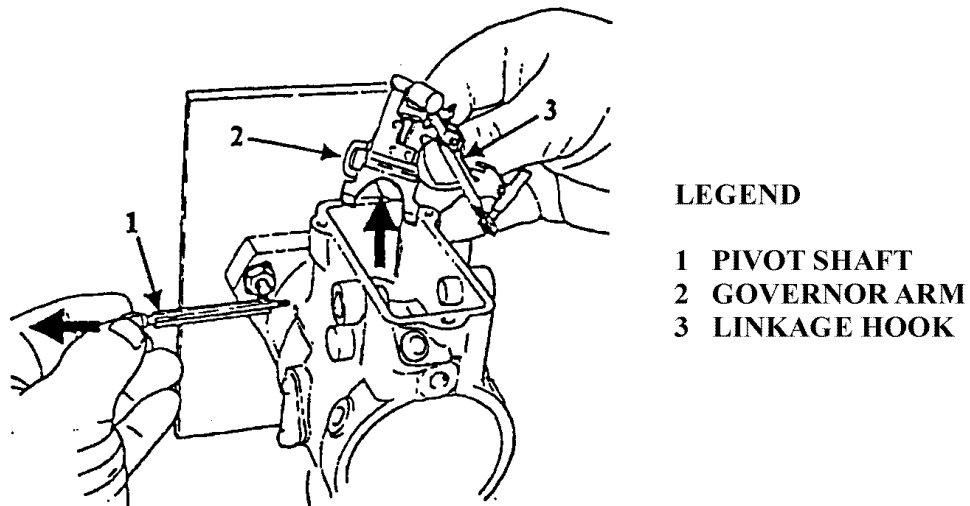
**FIGURE 5-7. LINKAGE HOOK DISCONNECTION.**

- (24) Remove metering valve arm (43), spring (44), shim (45), and metering valve (46).
- (25) Remove vent screw assembly (47).
- (26) Remove hydraulic head assembly (48) by tilting fuel injection pump housing (1) downward and twisting and pulling on hydraulic head assembly, refer to Figure 5-8.



**FIGURE 5-8. HYDRAULIC HEAD ASSEMBLY REMOVAL.**

- (27) Remove thrust sleeve (49, Figure 5-1), thrust washer (50), and governor weights (51).
- (28) Remove pivot shaft nut (52) and O-ring seal (53) from one side of pivot shaft (54).
- (29) Remove pivot shaft (54), governor arm (55), and linkage hook (56), refer to Figure 5-9.



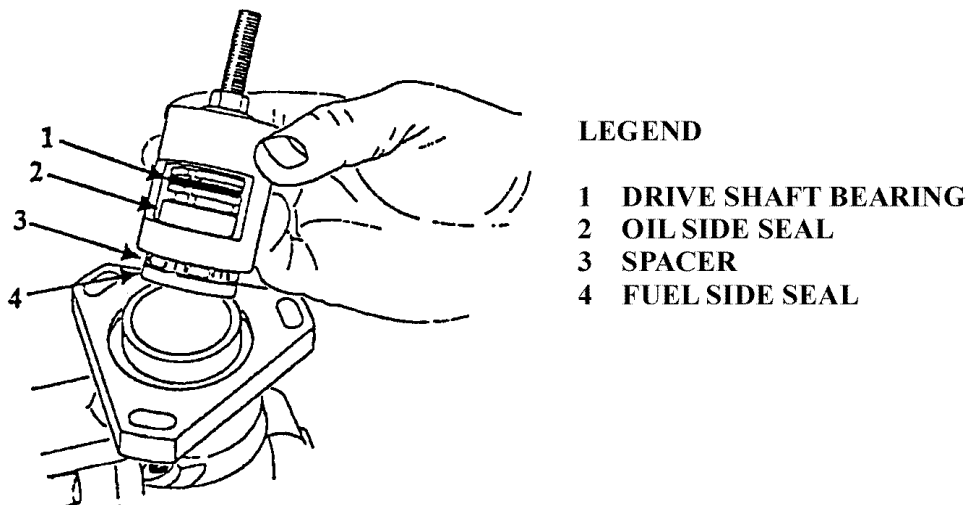
**FIGURE 5-9. GOVERNOR ARM AND LINKAGE HOOK REMOVAL**

- (30) Remove retaining ring (58, Figure 5-1) using snap ring pliers (20044). Remove thrust spring (59) and thrust washer (60). Remove thrust bearing (61) using snap ring pliers (20043).

**CAUTION**

**Drive shaft is easily damaged. Handle drive shaft with care. Failure to comply could result in damage to fuel injection pump.**

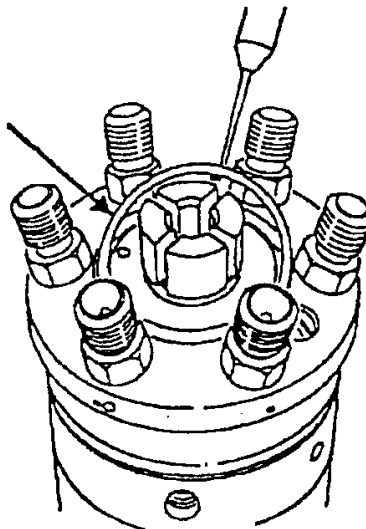
- (31) Remove drive shaft (62), drive shaft nut (63), lock washer (64), and Woodruff key (65).
- (32) Remove screw (66) and gasket (67). Discard gasket.
- (33) Position fuel injection pump housing (1) with flange facing upwards. Remove drive shaft bearing (68), oil side seal (69), spacer (70) and fuel side seal (71) using Bearing and Seal Puller (28311), refer to Figure 5-10. Discard drive shaft bearing, oil side seal, and fuel side seal.
- (34) Remove transfer pump end cap (72, Figure 5-1), inlet filter screen (73), and transfer pump regulator assembly (74).
- (35) Remove adjusting screw (75), regulating spring (76), regulator piston (77), sleeve seal (78), and regulator assembly roll pin (79). Discard sleeve seal.
- (36) Remove transfer pump liner (80), transfer pump blades (81), and transfer pump blade springs (82).
- (37) Remove liner locating ring (83) and rotor retainers (84).



**FIGURE 5-10. DRIVE SHAFT BEARING AND SEAL REMOVAL (SHOWN REMOVED).**

(38) Remove transfer pump end cap seal (85), refer to Figure 5-11.

**TRANSFER PUMP END CAP SEAL**



**FIGURE 5-11. TRANSFER PUMP END CAP SEAL REMOVAL (TYPICAL)**

(39) Remove rotor assembly (86, Figure 5-1).

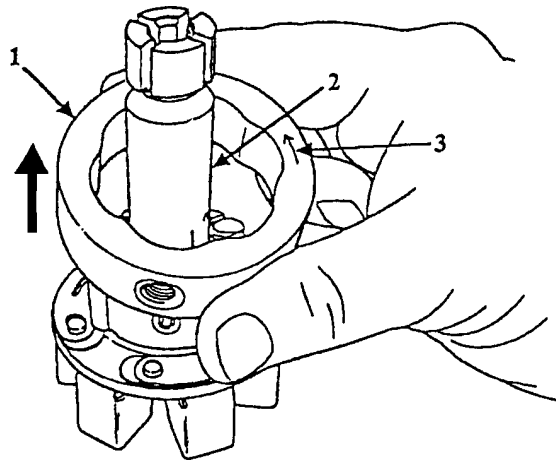
(40) Remove and discard O-ring seal (87).



**NOTE**

**Note direction (clockwise or counterclockwise) of directional arrow to insure proper installation.**

- (41) Remove cam ring (88), refer to Figure 5-12.



**LEGEND**

- 1 CAM RING  
2 ROTOR ASSEMBLY  
3 DIRECTIONAL ARROW

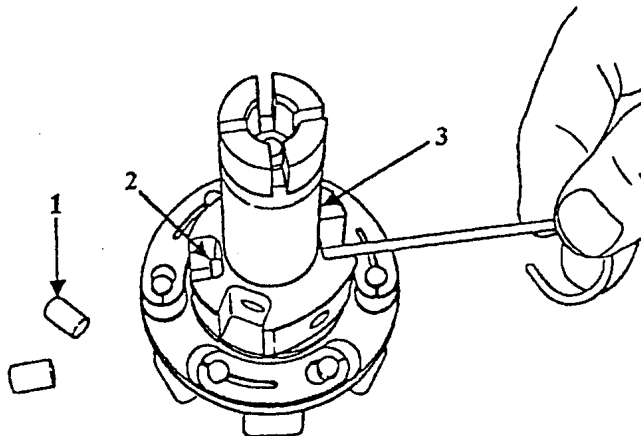
**FIGURE 5-12. CAM RING REMOVAL.**

- (42) Remove adjusting screws (89, Figure 5-1), leaf springs (90), cam rollers (91), and cam roller shoes (92).

**NOTE**

**Note location of short and long pumping plungers to insure proper installation.**

- (43) Remove long pumping plungers (93) and short pumping plungers (94) using Brass Hook (13301), refer to Figure 5-13.

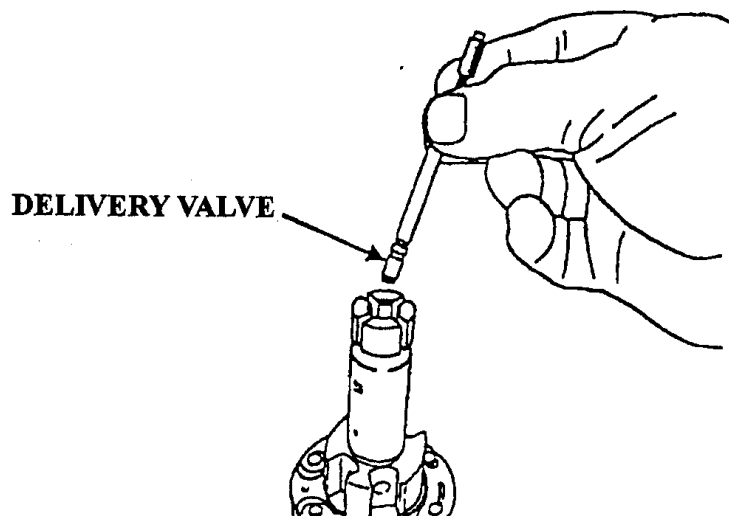


**LEGEND**

- 1 SHORT PUMPING PLUNGER (2)  
2 LONG PUMPING PLUNGER (2)  
3 ROTOR

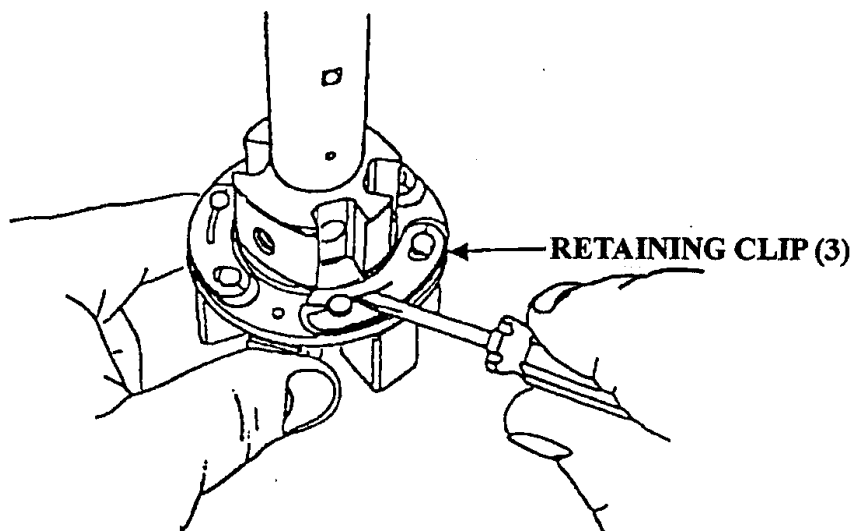
**FIGURE 5-13. PUMPING PLUNGER REMOVAL.**

- (44) Position rotor (86, Figure 5-1) in (16313) fixture and clamp in vise. Remove retaining screw (95), delivery valve stop (96), and spring (97). Discard delivery valve stop.
- (45) Remove delivery valve (98) using delivery valve extractor (26081), refer to Figure 5-14.



**FIGURE 5-14. DELIVERY VALVE REMOVAL.**

- (46) Remove retaining clips (99, Figure 5-1) by prying with small screwdriver, refer to Figure 5-15. Discard retaining clips.



**FIGURE 5-15. RETAINING CLIP REMOVAL.**

- (47) Remove retainer cushions (100, Figure 5-1), weight retainer (101), and weight retainer cushions (102).
- (48) If necessary, remove screws (103) and nameplate (104).
- (49) Remove and discard all seals.

**WARNING**

Cleaning solvent is flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection are required. Avoid repeated/prolonged contact. Good general ventilation is normally adequate.

**WARNING**

Compressed air used for cleaning can create airborne particles that can enter the eyes. Pressure must not exceed 30 psig (207 kPa). Eye protection required.

- (50) Thoroughly clean all parts in solvent. Dry all parts with compressed air. Dip all parts in clean calibrating fluid.

c. Repair.

- (1) Disassemble fuel injection pump, refer to 5.3.1.a.
- (2) Inspect each component for excessive wear, scoring, corrosion, distortion, cracks, or breakage. Replace all damaged or excessively worn parts.
- (3) Inspect fuel injection housing (Figure 5-16) as follows:

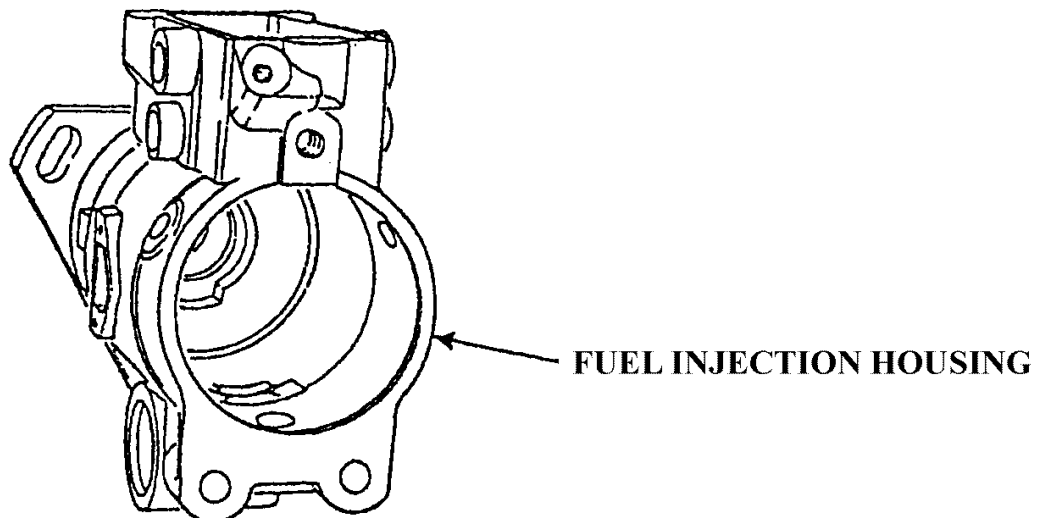


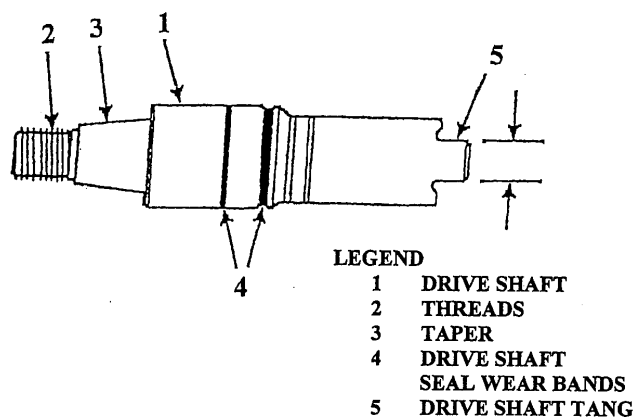
FIGURE 5-16. FUEL INJECTION HOUSING.

- (a) Inspect fuel injection housing for cracks or signs of damage.
- (b) Inspect threaded holes for damage.
- (c) Inspect inside of fuel injection housing where hydraulic head seal contacts fuel injection pump. Inspect thrust bearing counterbore and area where cam ring rides.
- (d) Replace fuel injection housing as required.

**CAUTION**

**Drive shaft is fragile and easily damaged. Handle drive shaft with care.**

- (4) Inspect drive shaft (1, Figure 5-17) as follows:



**FIGURE 5-17. DRIVE SHAFT.**

**NOTE**

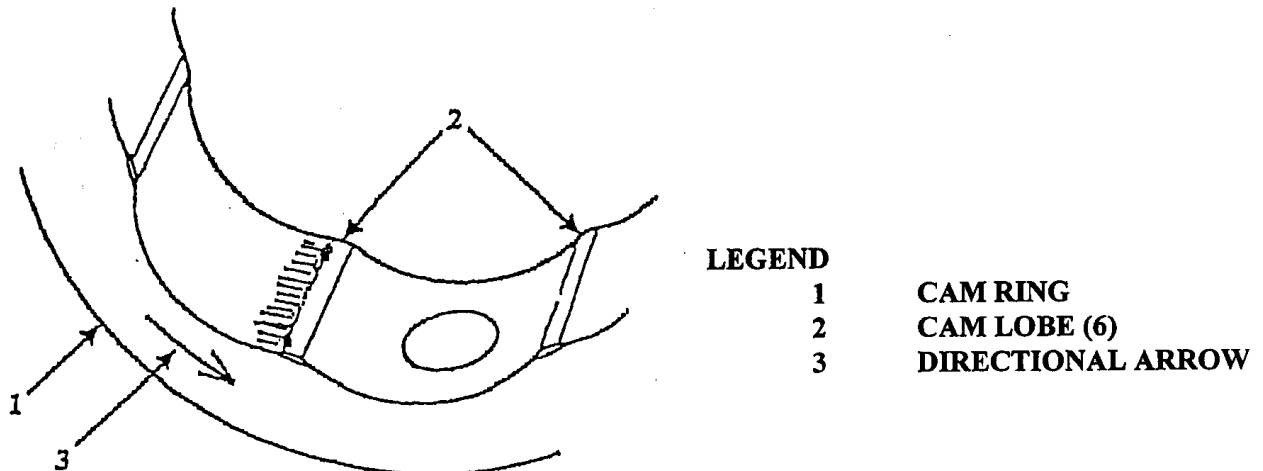
**Drive shaft seal wear bands are normal and should not be reason for drive shaft replacement.**

- (a) Inspect threads (2, Figure 5-17) and taper (3) for damage.
- (b) Inspect drive shaft (1) where drive shaft seals ride for nicks or scratches.
- (c) Measure drive shaft tang (5) width using outer diameter micrometer. Drive shaft tang width should be 0.430 in. (10.92 mm) minimum. If drive shaft tang width is less than specifications, replace drive shaft.
- (d) Replace drive shaft as required.

- (5) Inspect cam ring (1, Figure 5-18). Carefully inspect cam lobes and edges of all flat surfaces. If there is evidence of spalling or flaking out, replace with a new cam.

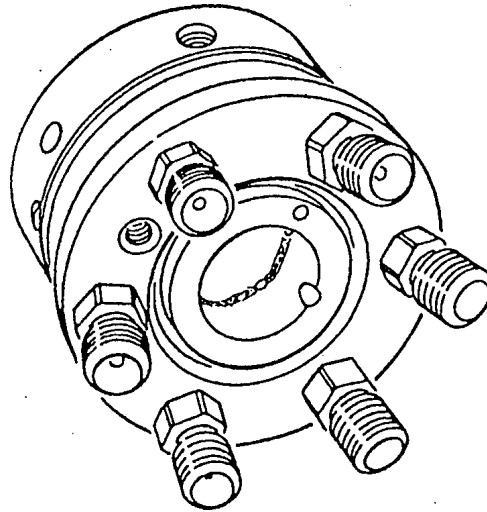
**NOTE**

Only working portions of lobes on inside diameter are ground, so any tool marks between lobes should not be considered as damage. The mottled appearance of cam is from heat treatment rather than from operation.



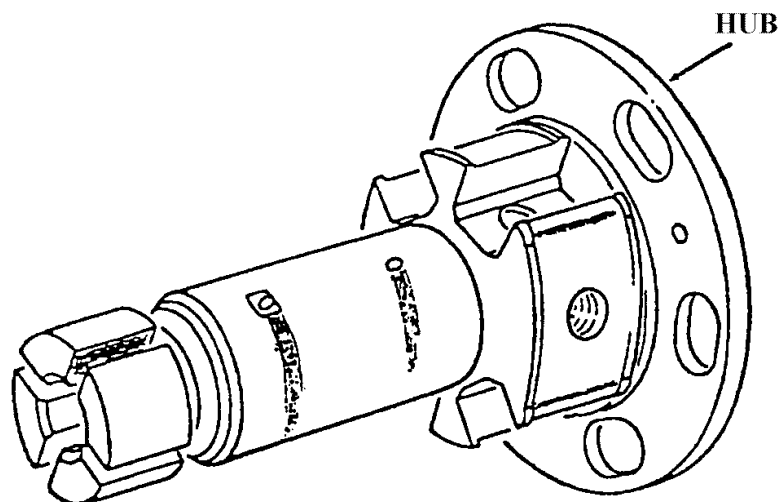
**FIGURE 5-18. CAM RING.**

- (6) Examine the Hydraulic Head Assembly. Refer to Figure 5-19.
- (a) Examine the metering valve bore and the threaded holes for damage.
  - (b) Examine the rotor bore for wear band in line with the charging ports and/or the discharge ports which could indicate that dirty fuel was used.
  - (c) Inspect the discharge fittings for damage to the area where the injection lines seat or to the threads.
  - (d) Check the threaded hydraulic head plugs to ensure they are tight.
  - (e) Replace the Hydraulic Head Assembly if found defective.



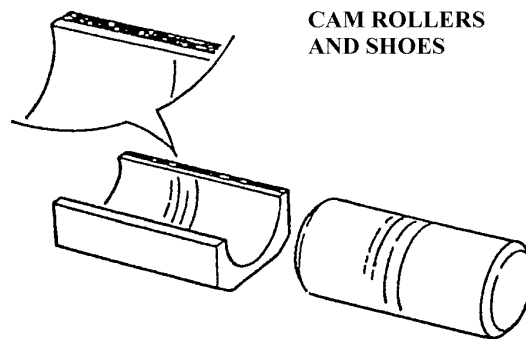
**FIGURE 5-19. HYDRAULIC HEAD ASSEMBLY (TYPICAL)**

- (7) Examine the Distributor Rotor Assembly. Refer to Figure 5-20.
- (a) Examine the working areas of the distributor rotor including the transfer pump blade slots, the discharge and charging ports, the plunger bores, the leaf spring contact area and the drive slot. Check for wear, erosion or damage.
  - (b) Examine the flat delivery valve seat in the rotor bore for chipping, erosion or damage.
  - (c) Ensure the governor weight retainer is secure on the rotor. If hub is loose, head and rotor assembly must be replaced.
  - (d) Replace the Distribution Rotor Assembly if found defective.



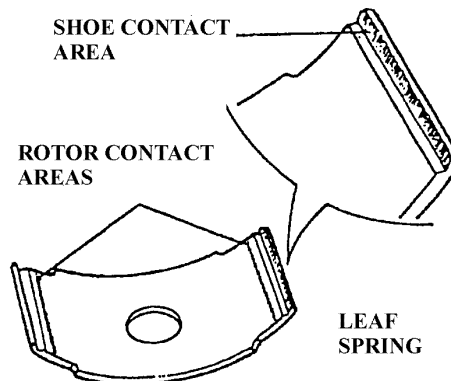
**FIGURE 5-20. DISTRIBUTOR ROTOR ASSEMBLY (TYPICAL)**

- (8) Examine the Shoes and Rollers. Refer to Figure 5-21.
- (a) Inspect the edge of the shoe that has been in contact with the leaf spring for excessive wear or damage. Shoes with sides of equal height may be reversed in the shoe slot to expose the unused surface to the leaf spring.
  - (b) Inspect the inside of the shoe where the roller rides and the outside diameter of the roller for scoring.
  - (c) Ensure the rollers are a close fit in the shoes.
  - (d) Replace the Shoes and Rollers if found defective.



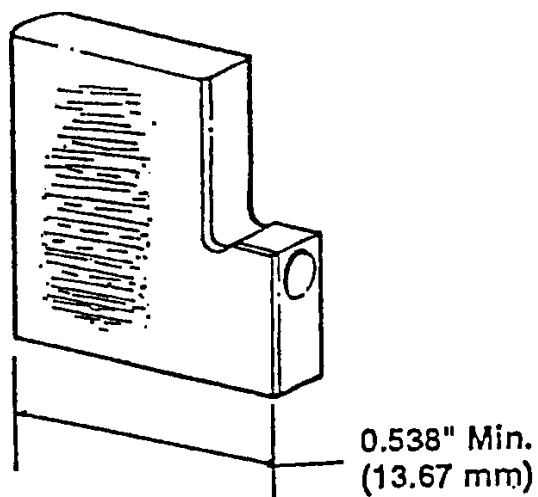
**FIGURE 5-21. SHOES AND ROLLERS.**

- (9) Examine the Leaf Springs. Refer to Figure 5-22.
- (a) Examine the surface of the leaf spring which contacts the cam roller shoes.
  - (b) Inspect the area on the underside of the leaf spring which contacts the rotor. Replace the leaf spring if there is evidence of pitting or excessive fretting.
  - (c) Replace the Leaf Springs if found defective



**FIGURE 5-22. LEAF SPRINGS.**

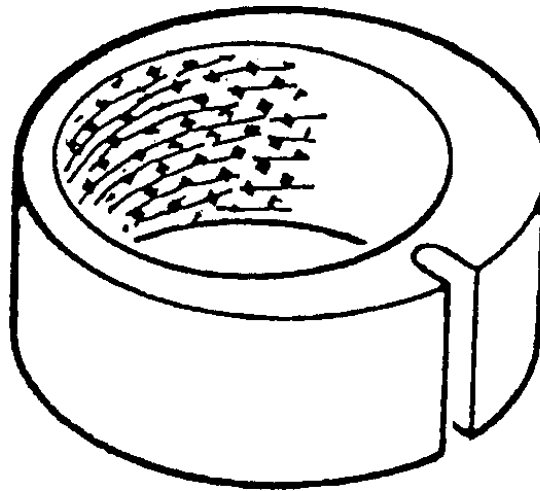
- (10) Examine the Transfer Pump Blades. Refer to Figure 5-23.
- (a) Inspect for excessive wear and scoring of the edge of the blade which rides on the inside of the transfer pump liner. A minimum allowable thickness is provided in Figure 5-23.
  - (b) Examine the sides of the blades for wear from contact with the blade slots.
  - (c) Replace the Transfer Pump Blades if found defective.



**FIGURE 5-23. TRANSFER PUMP BLADES.**

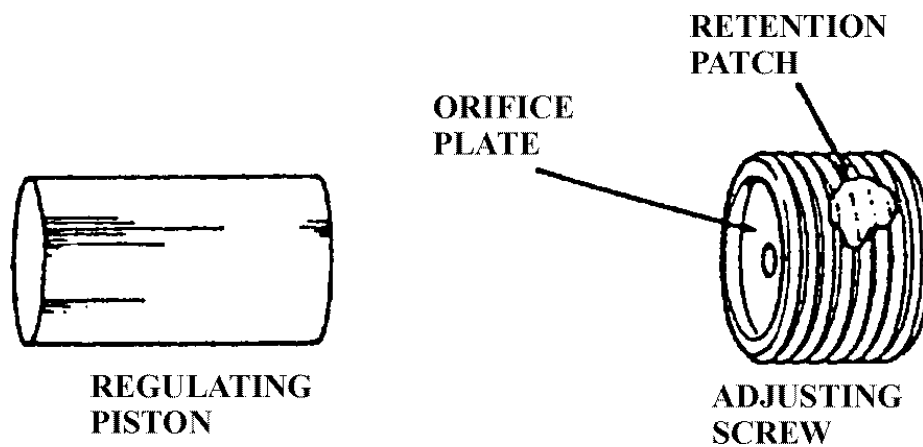
- (11) Examine the Transfer Pump Liner. Refer to Figure 5-24.
- (a) Examine the inside diameter of the liner for scoring or excessive wear.
  - (b) Replace transfer Pump Liner if scored or wear is excessive.





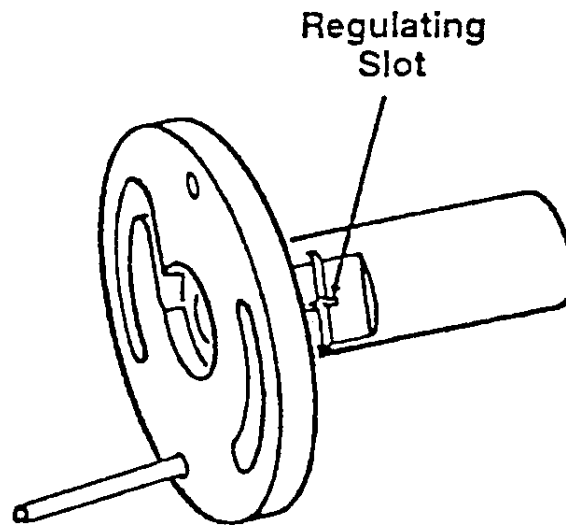
**FIGURE 5-24. TRANSFER PUMP LINER.**

- (12) Examine the Transfer Pump Regulating Piston and Adjusting Screw. refer to Figure 5-25.
- (a) Inspect the adjusting screw to ensure the orifice is not plugged and the orifice plate is secure to the screw.
  - (b) Replace the screw if the retention patch does not offer enough resistance to turning when the screw is threaded in and out of the regulator.
  - (c) Inspect the regulating piston. Replace if excessive scoring or wear is present.
  - (d) Replace the Transfer Pump Regulating Piston and Adjusting Screw if found defective.



**FIGURE 5-25. TRANSFER PUMP REGULATING PISTON AND ADJUSTING SCREW.**

- (13) Examine the Transfer Pump Regulator Assembly. Refer to Figure 5-26.
- (a) Examine the face of the regulator where the transfer pump blades ride. The face may be lapped with fine grit lapping compound if light wear is present.
  - (b) Examine the regulating piston bore and transfer pressure regulating slot for wear or damage. Replace the regulator locating pin if bent or broken.
  - (c) Replace the Transfer Pump Regulator Assembly if found defective.



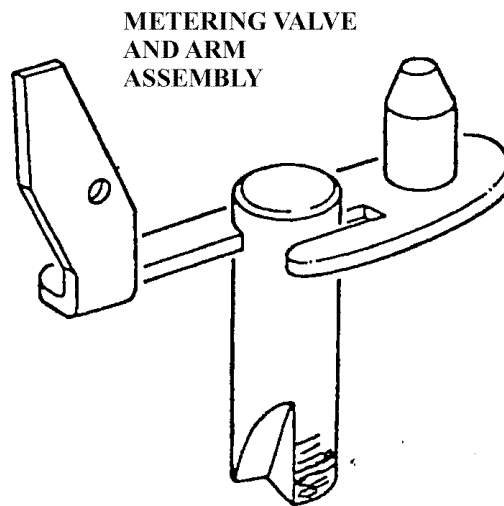
**FIGURE 5-26. TRANSFER PUMP REGULATOR ASSEMBLY.**

- (14) Examine the Metering Valve and Arm Assembly. Refer to Figure 5-27.
- (a) Inspect the metering valve arm to be sure the pin on which the linkage hook rides is tightly mounted to the arm.

**NOTE**

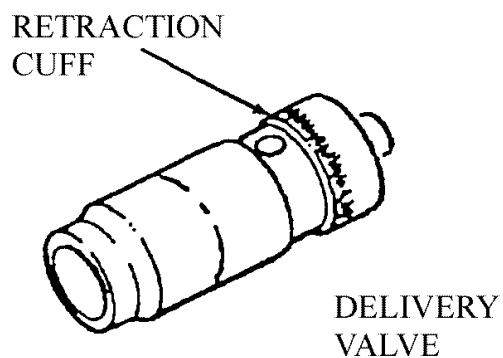
**The appearance of the valve is not the best criteria for determining if a valve should require replacement. The pump's ability to pass the test specifications, along with shut-off requirements should be the best guide as to whether the valve is replaced or not.**

- (b) Check the valve to ensure it is securely attached to the arm. Examine the valve for excessive scoring.
- (c) Replace the Metering Valve and Arm Assembly if found defective.



**FIGURE 5-27. METERING VALVE AND ARM ASSEMBLY.**

- (15) Examine the Delivery Valve. Refer to Figure 5-28.
- (a) Inspect the cuff of the delivery valve for excessive scratching or scoring.
  - (b) Examine for a wear band around the center of the valve, which if excessive, is criteria for replacement of the valve.
  - (c) Check the valve for correct retraction value 0.59 in. (15mm).
  - (d) Replace the Delivery Valve if found defective.



**FIGURE 5-28. DELIVERY VALVE.**

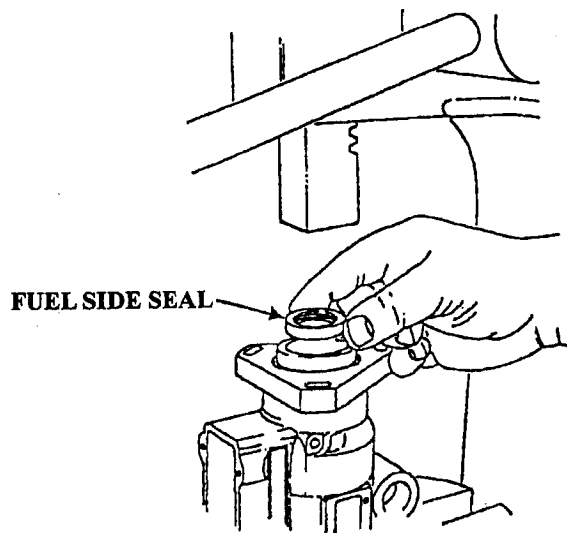
d. Assembly.

- (1) Install nameplate (104, Figure 5-1) and screws (103).
- (2) Position fuel injection pump housing (1), flange facing up, on arbor press. Ensure fuel injection pump housing is resting flatly.

**CAUTION**

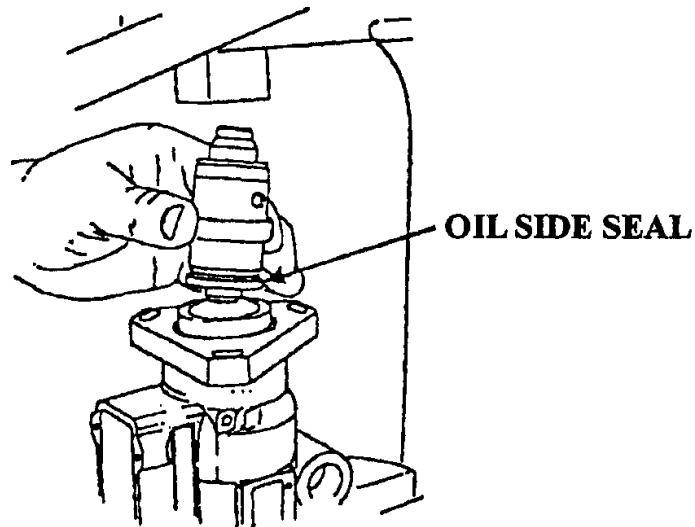
**Lubricants can cause damage to fuel side seal. Do not use any lubricants on fuel side seal when installing. Failure to comply could result in damage to fuel side seal.**

- (3) Position fuel side seal (Figure 5-29) into fuel injection pump housing (1, Figure 5-1) bore with seal lip facing downwards. Position seal installation tool into fuel injection pump housing bore. Press fuel side seal in using arbor press until seal installation tool bottoms.



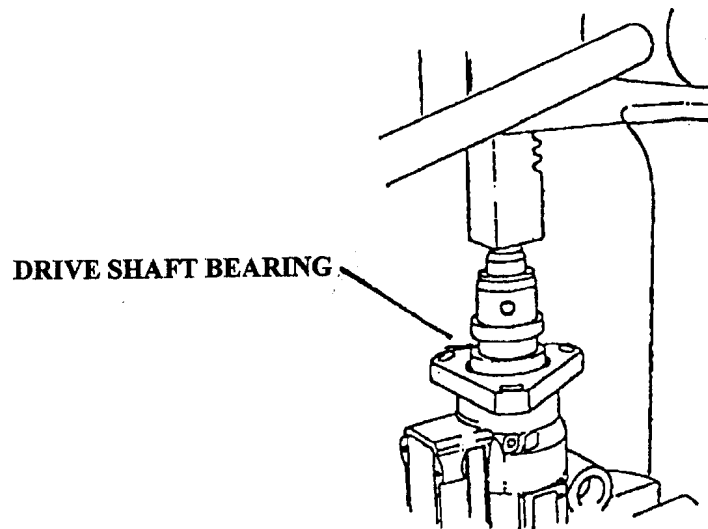
**FIGURE 5-29. FUEL SIDE SEAL INSTALLATION**

- (4) Install spacer (70, Figure 5-1).
- (5) Apply light coating of Lubriplate grease (30465) to seal bore inside fuel injection pump housing (1). Install oil side seal (Figure 5-30) in fuel injection pump housing with seal lip facing outward using installation tool and arbor press.



**FIGURE 5-30. OIL SIDE SEAL INSTALLATION**

- (6) Install drive shaft bearing (Figure 5-31) with part number facing outward using installation tool (28316A) and arbor press. Check drive shaft bearing rollers for freedom of movement.



**FIGURE 5-31. DRIVE SHAFT BEARING INSTALLATION**

- (7) Position seal protection tube (included in seal and bearing kit) over drive shaft (Figure 5-32). Lubricate seal protection tube and drive shaft with clean calibrating fluid.

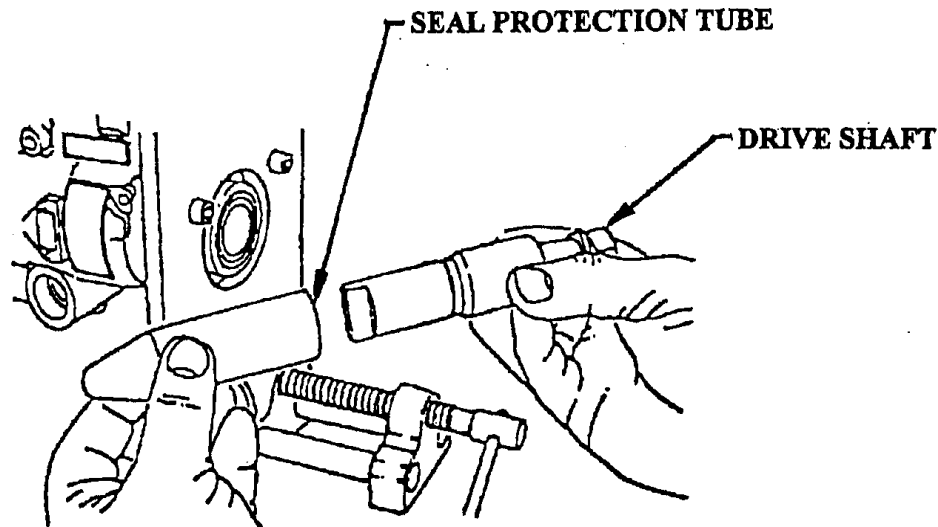


FIGURE 5-32. SEAL PROTECTION TUBE

- (8) Insert seal protection tool and drive shaft (1, Figure 32) into fuel injection pump housing from flange end of fuel injection pump housing. Position shoulder of drive shaft flush with drive shaft bearing (1, Figure 5-31). Hold shoulder of drive shaft flush with face of drive shaft bearing and remove seal protection tube from inside of fuel injection pump housing.
- (9) Install thrust bearing (1, Figure 5-33) using snap ring pliers (20043). Install thrust washer (2).

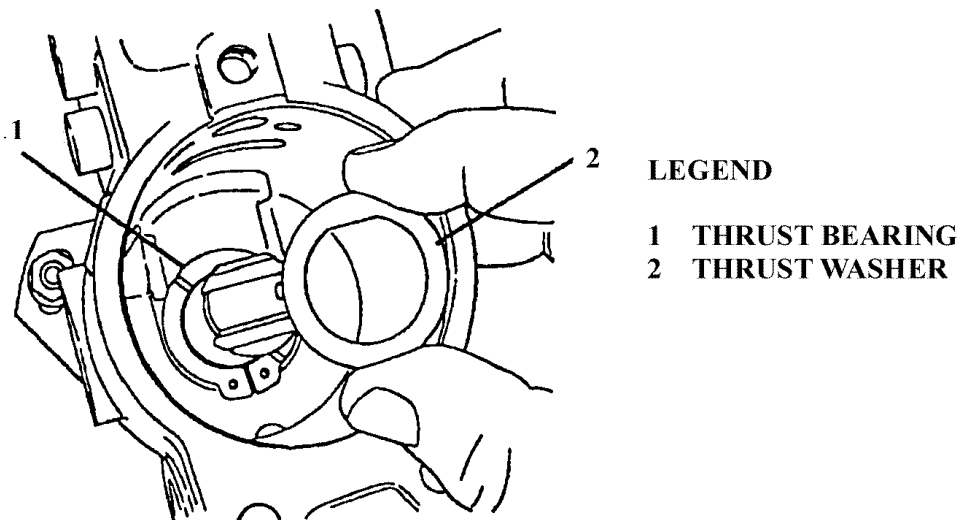


FIGURE 5-33. THRUST BEARING AND THRUST WASHER

- (10) Install thrust spring (1, Figure 5-34) on top of thrust washer (2, Figure 5-33). Install retaining ring (2, Figure 5-34) using snap ring pliers (20044).

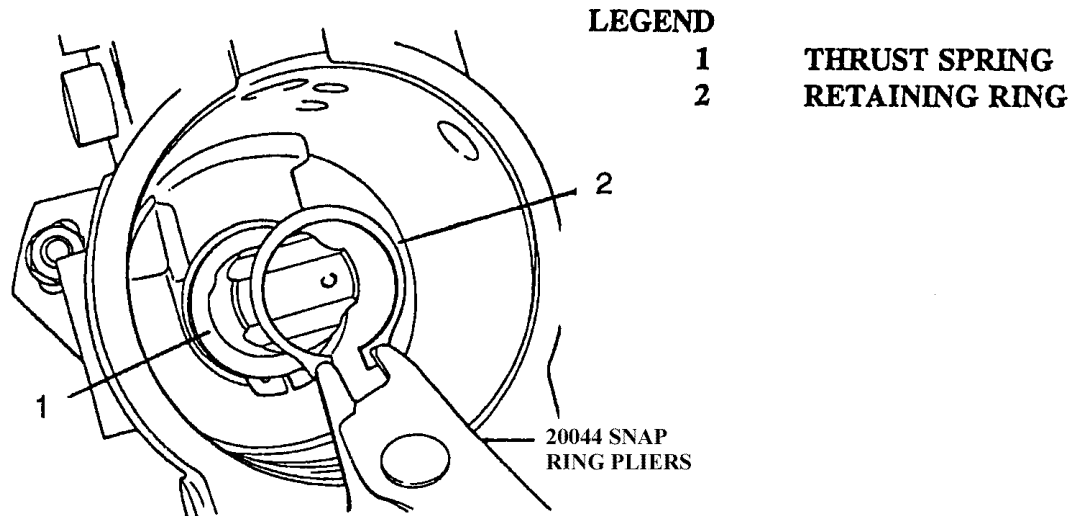


FIGURE 5-34. SPRING WASHER AND RETAINING RING

- (11) Place new timing mark on hub as follows:
- (a) Place the rotor assembly onto the timing locator (20395) with drill point in rotor drive tang aligned with tool pointer. Refer to Figure 5-35.

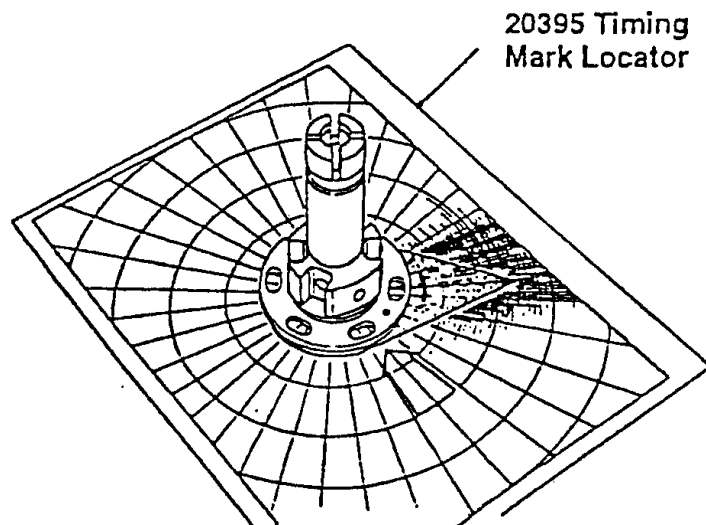
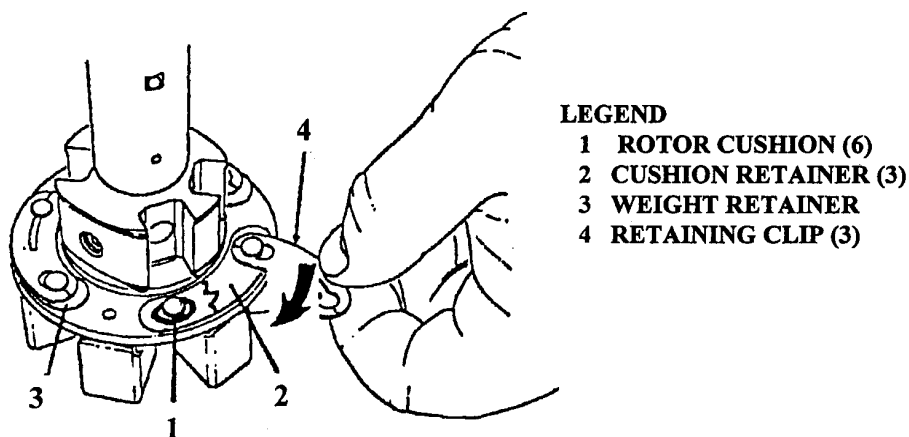


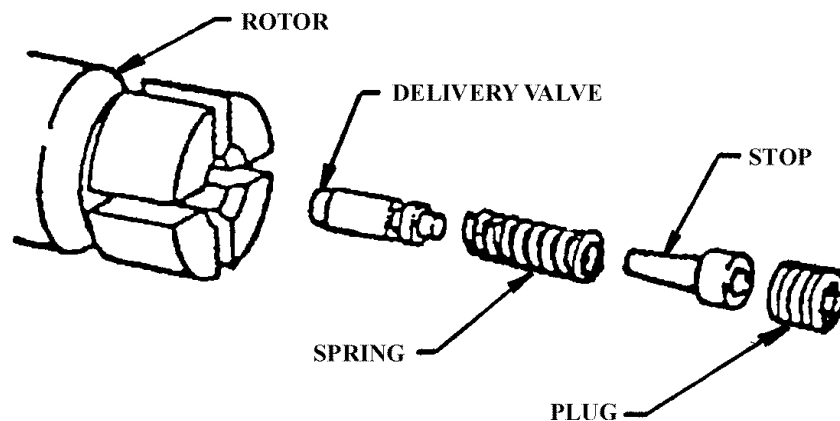
FIGURE 5-35. TIMING MARK LOCATOR

- (b) Rotate the pointer and rotor in the direction of rotation indicated on the pointer (counterclockwise) until pointer is aligned with specified number of degrees on upper or outer scale. Mark on hub should line up with zero on locator (where "place timing line here" arrow point is located). If line is not correct, use abrasive stone to remove incorrect mark from hub. Place a mark at the correct angle first using a pencil and then with electric marking pencil.
- (c) Timing mark is now in correct position.
- (12) Position rotor cushions (1, Figure 5-36) and cushion retainers (2) on weight retainer (3).
- (13) Install retaining clips (4).



**FIGURE 5-36. WEIGHT RETAINING ASSEMBLY.**

- (14) Install delivery valve (98, Figure 5-1) using delivery valve extractor (26081).
- (15) Install spring (97), delivery valve stop (96), and screw (95) in rotor (86). Position rotor in fixture (16313) and secure fixture in vise. Torque screw (95) to 120 to 125 lb-ft (13.6 to 14.1 Nm). Refer to Figure 5-37.



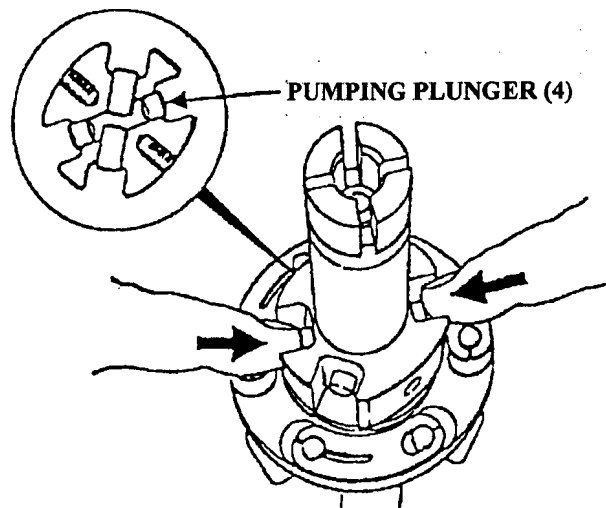
**FIGURE 5-37. TIGHTENING DELIVERY VALVE STOP SCREW**



**NOTE**

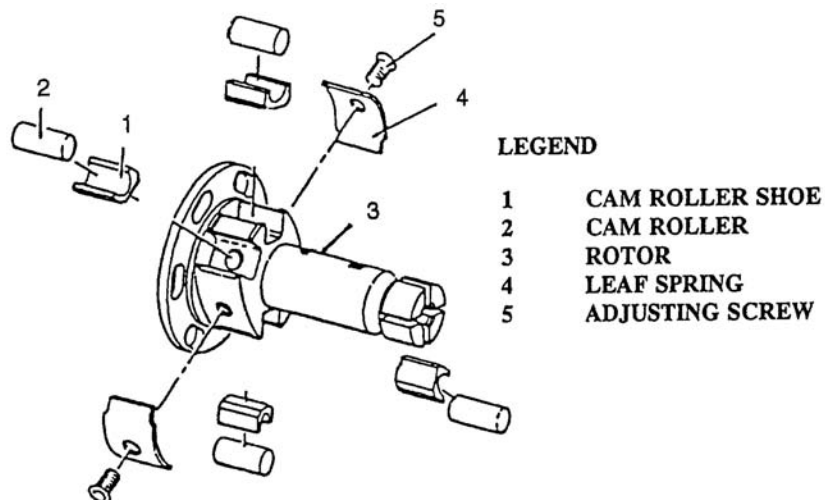
**Orientation of pumping plungers is important. Ensure that long and short pumping plungers are installed in correct orientation.**

- (16) Remove rotor (86, Figure 5-1) from fixture (16313). Install pumping plungers (Figure 5-38), refer to Figure 5-38 for correct orientation.



**FIGURE 5-38. PUMPING PLUNGER INSTALLATION.**

- (17) Install cam roller shoes (1, Figure 5-39) and cam rollers (2) on rotor (3).
- (18) Install leaf springs (4) and adjusting screws (5). Bottom screws, then back out one full revolution.



**FIGURE 5-39. INSTALLING ROLLERS AND SHOES (TYPICAL)**

(19) Measure the roller to roller dimension (Figure 5-40) by performing the following:

- (a) Secure roller-to-roller setting fixture (19969) in vise and insert rotor assembly. Connect dry, clean, filtered, compressed air source regulated to 40-100 p.s.i. (4.5-11.3 kPa) to force plungers outward until shoes contact leaf spring.
- (b) Using a 1-2 inch micrometer, measure the distance between the outer surfaces of each pair of opposed rollers. Compare the dimensions to the roller-to-roller dimension called for on the individual specification. Turn leaf spring adjusting screws clockwise to increase or counterclockwise to decrease the dimension. The two dimensions must be within 0.0003 inches (0.076 mm) of each other and the average of both roller-to-roller dimensions must be within 0.0015 of the specified dimension.

Example: Specified roller-to-roller dimension = 1.960 inches (49.78 mm). One pair of rollers measures 1.961 inches (49.81 mm) while the other measures 1.958 inches (49.73 mm). The 2 dimensions are within .003 inches of each other and the average of the 2 dimensions (1.9595 inches) is within 0.0015 inches of the specified roller-to-roller. Since each leaf spring controls one shoe and roller of each set it may be necessary to interchange shoes between slots or use optical size shoes (as indicated on the specification) in order to achieve the proper roller-to-roller dimension and concentricity.

- (c) After the roller-to-roller dimensions are achieved, the roller concentricity must be checked. Proper concentricity is needed to ensure that all rollers strike the cam lobes at the same time during pump operation.
- (d) Rotate the rotor until one roller is aligned with in dial indicator plunger on fixture 19969. Slide the indicator inward until plunger depresses at least 0.010 inches (0.254 mm). "Zero" indicator by loosening thumbscrew and rotating dial. Recheck "zero" by rotating rotor to be sure indicator plunger is on high point of cam roller.
- (e) Rotate rotor and observe dial indicator reading for each of the other rollers. Roller concentricity must be within 0.004 inches (0.1 mm). If not within specification, concentricity can be achieved through interchanging of shoes or leaf spring positions.

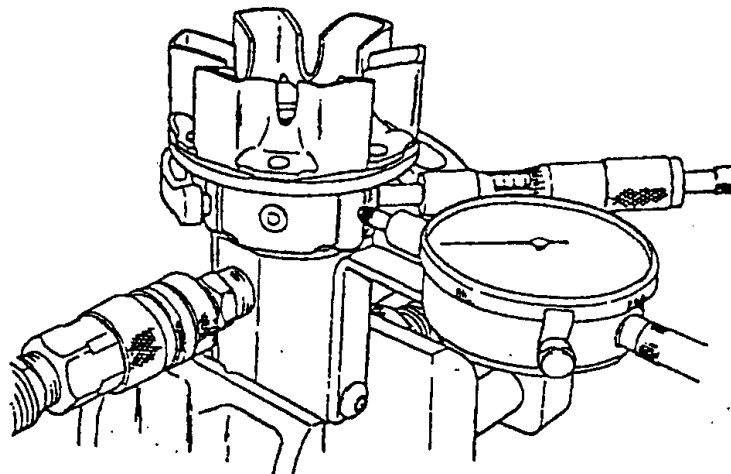
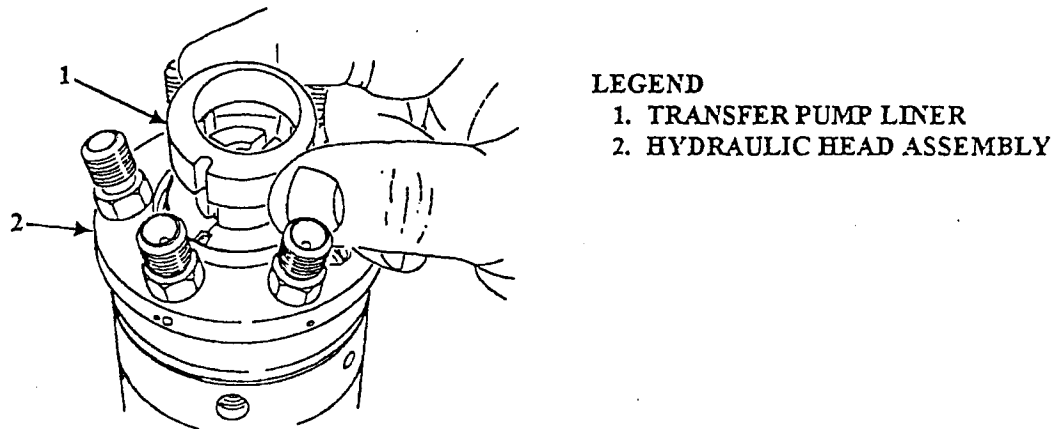
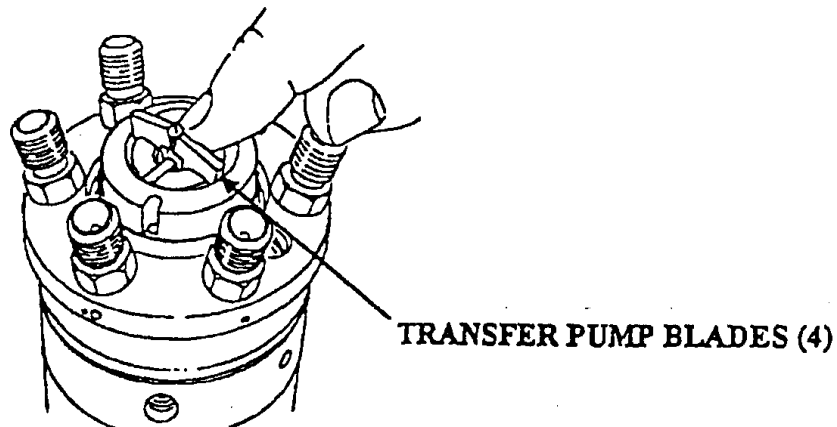


FIGURE 5-40. MEASURING ROLLER TO ROLLER DIMENSION

- (20) Install seal (87, Figure 5-1) into groove on hydraulic head (48).
- (21) Position cam ring (88) on rotor assembly (86) with directional arrow facing counterclockwise when viewed from above.
- (22) Carefully slide hydraulic head assembly (87) over rotor.
- (23) Install transfer pump end cap seal (85). Insure that transfer pump end cap seal is pushed completely down into groove.
- (24) Install rotor retainers (84). Align cutouts in rotor retainers with hole in hydraulic head.
- (25) Install liner locating ring (83) with opening in liner locating ring 90° (1/4 revolution) from rotor retainer (84) ends.
- (26) Install transfer pump liner (1, Figure 5-41) with notch aligned with hole in hydraulic head assembly (2).
- (27) Install transfer pump blades (Figure 5-42) and springs one pair at a time.



**FIGURE 5-41. TRANSFER PUMP LINER INSTALLATION (TYPICAL)**



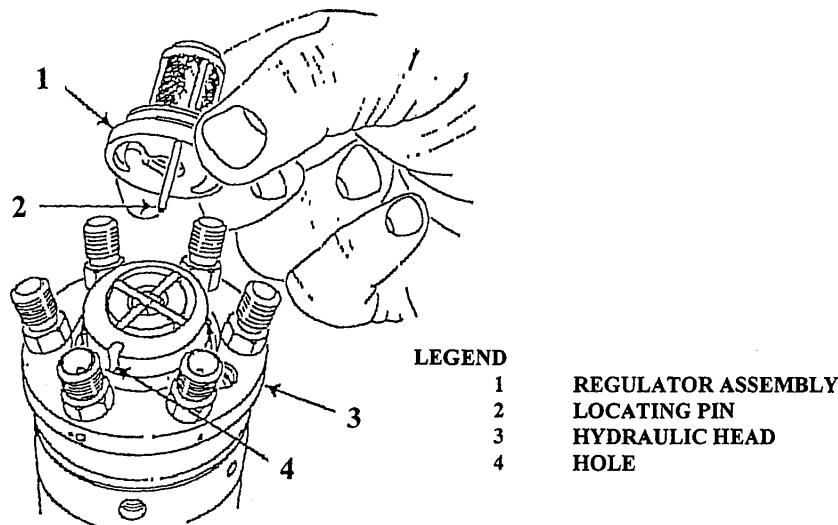
**FIGURE 5-42. TRANSFER PUMP BLADE INSTALLATION (TYPICAL).**

- (28) Install sleeve seal (78, Figure 5-1) into groove in transfer pump regulator assembly (74). Ensure that sleeve seal is seated completely.
- (29) Position piston (77) in transfer pump regulating assembly (74) with open end of piston facing outward.

**NOTE**

**Adjusting screw is fragile. Do not exert excessive downward force on hex wrench while installing adjusting screw. Failure to comply could result in damage to adjusting screw.**

- (30) Install spring and adjusting screw (76, 75) into transfer pump regulating assembly (74). Tighten adjusting screw until adjusting screw is 1-2 threads below flush with end of sleeve of transfer pump regulator housing.
- (31) Install inlet filter screen (73) on transfer pump regulator assembly (74).
- (32) Install regulator assembly (1, Figure 5-43) on hydraulic head (3) by aligning locating pin (2) with hole (4).



**FIGURE 5-43. REGULATOR ASSEMBLY INSTALLATION (TYPICAL).**

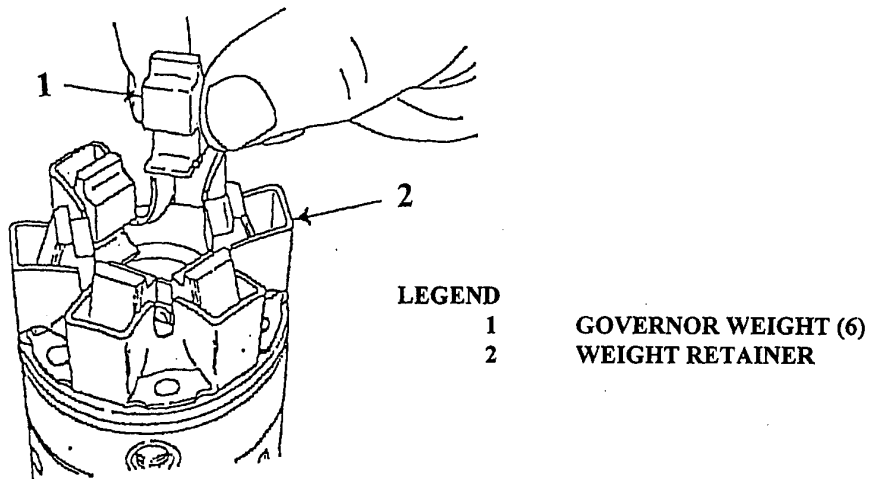
- (33) Apply thin coating of grease (Appendix E) to beveled surface on inside of transfer pump end cap (72, Figure 5-1) and to threads of transfer pump end cap.
- (34) Position transfer pump end cap (72) on hydraulic head assembly. Rotate transfer pump end cap counterclockwise until “click” is heard, then rotate transfer pump end cap clockwise until hand tight.
- (35) Position governor arm (55) in fuel injection pump housing with linkage hook (56) hanging over side of fuel injection pump housing.

- (36) Orient pivot shaft (54) with knife edge facing transfer pump end of fuel injection pump housing. Carefully install pivot shaft (54) into fuel injection pump housing and through openings in governor arm (55).
- (37) Position O-ring seals (53) on pivot shaft (54) and install pivot shaft nuts (52) finger tight.

**NOTE**

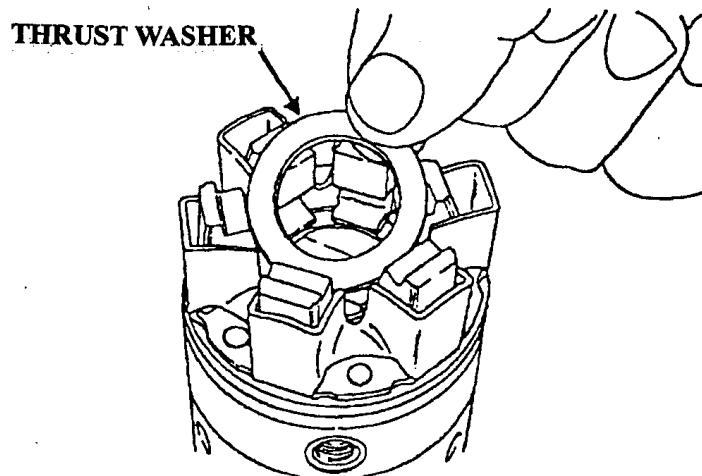
**Finish torque sequence with shaft nut on linkage hook side of pump.**

- (38) Torque each pivot shaft nut (52) alternately to 20 to 25 lb-in (2.3 to 2.8 Nm).
- (39) Invert head and rotor assembly and install governor weights (1, Figure 5-44) into weight retainer (2) with rounded “heels” of governor weights in corners of weight retainer sockets.



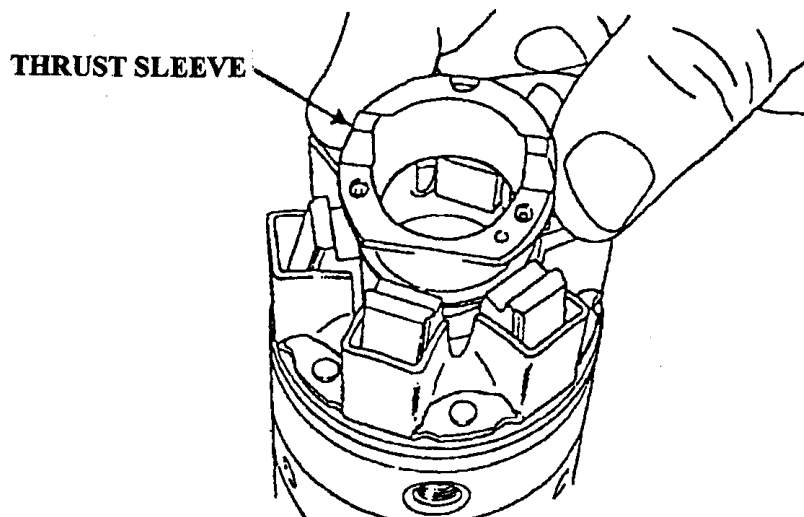
**FIGURE 5-44. GOVERNOR WEIGHT INSTALLATION (TYPICAL).**

- (40) Install thrust washer (Figure 5-45) so that thrust washer is resting on top of governor weight (1, Figure 5-44) “toes”.



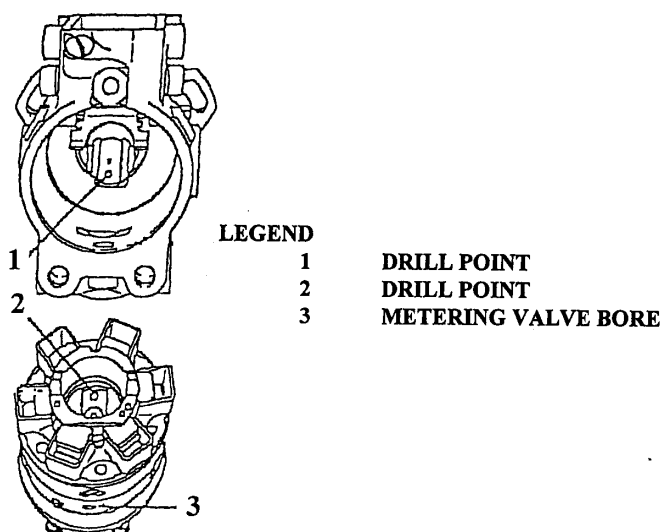
**FIGURE 5-45. THRUST WASHER INSTALLATION (TYPICAL).**

- (41) Install thrust sleeve (Figure 5-46).



**FIGURE 5-46. THRUST SLEEVE INSTALLATION (TYPICAL).**

- (42) Install fuel injection pump housing on mounting plate (Refer to Appendix F, Figure F1) and secure in vice with hydraulic head bore tilted downward approximately 30-45 degrees.
- (43) Rotate drive shaft until drill point (1, Figure 5-47) on end is in 6 o'clock position. Apply light coating of lubricant (22204) to hydraulic head seal (87, Figure 5-1) and to entrance to fuel injection pump housing.



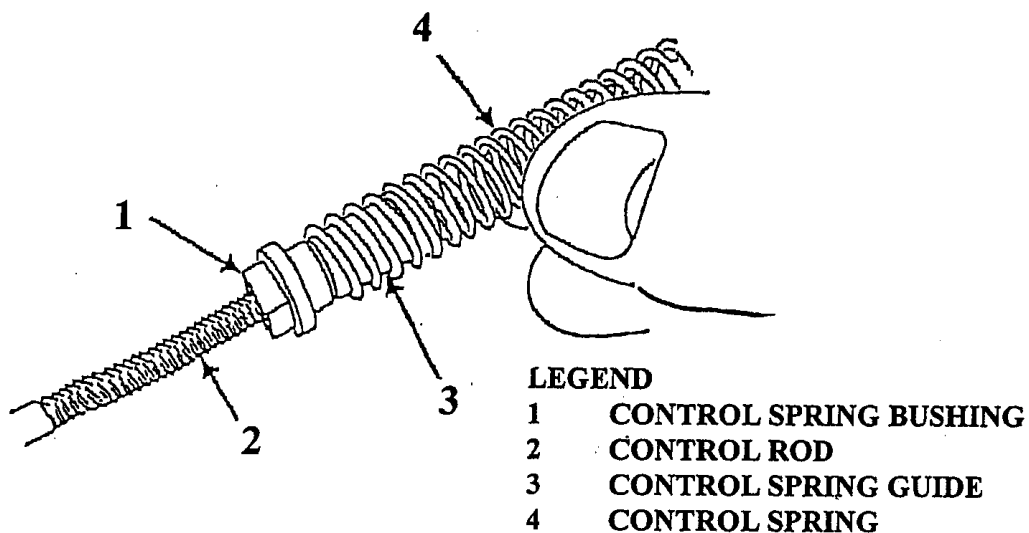
**FIGURE 5-47. HEAD AND ROTOR ASSEMBLY INSTALLATION (TYPICAL).**

- (44) Align drill point (2, Figure 5-47) in rotor with head locating screw bore at bottom of head. Align cam pin hole in cam ring (88, Figure 5-1) with head locating screw bore in hydraulic head.
- (45) Orient governor thrust sleeve (1, Figure 5-46) so that governor arm groove is in horizontal position.
- (46) Carefully slide head and rotor assembly into fuel injection pump housing with metering valve bore (3) at the 12 o'clock position (straight up). When hydraulic head seal contacts fuel injection pump housing, push head and rotor assembly in with slight twisting motion until head locking screw bore in head and rotor assembly aligns with head locating screw bore in fuel injection pump housing.
- (47) Install vent wire assembly (47, Figure 5-1) into hydraulic head until it bottoms. Insure that vent wire assembly does not protrude above surface of hydraulic head.
- (48) Install shim (45), spring (44), and metering valve arm (43).

**NOTE**

**Rotate hydraulic head slightly counterclockwise to aid in installing linkage hook onto pin on metering valve arm.**

- (49) Engage linkage hook (56) to cutout in governor arm (43) and fit linkage hook onto pin on metering valve arm (41).
- (50) Install head locking screws (23) finger tight.
- (51) Thread control spring bushing (1, Figure 5-48) onto control rod (2) until control spring bushing contacts control spring guide (3). Thread control spring (4) five full turns onto control spring guide.

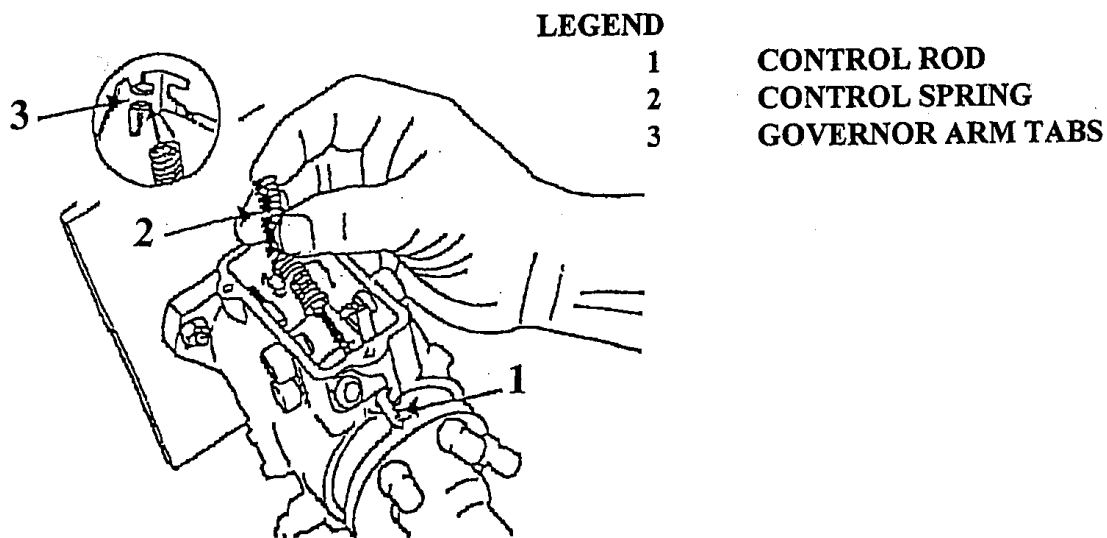


**FIGURE 5-48. CONTROL SPRING INSTALLATION.**

**NOTE**

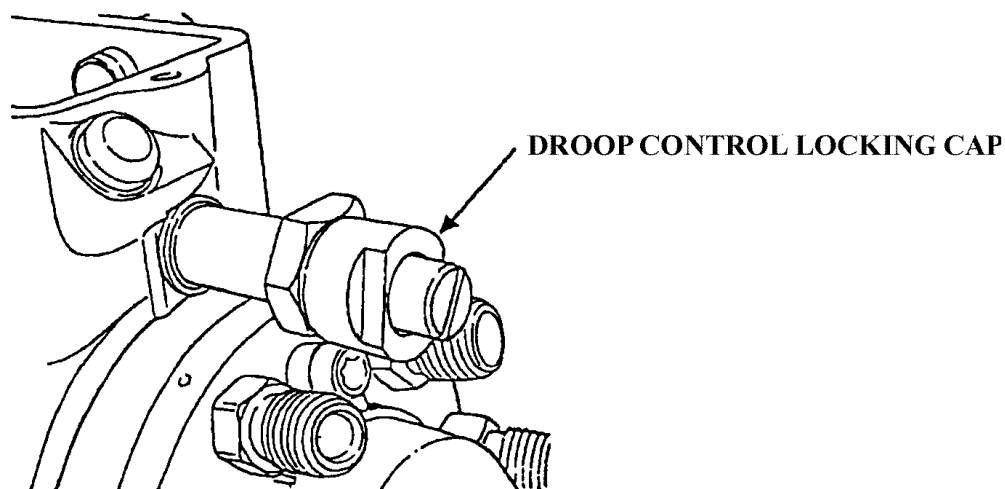
**Ensure that cross loop on end of control spring is installed between tabs on governor arm.**

- (52) Depress metering valve arm (43, Figure 5-1) and install control rod (1, Figure 5-49). Install control spring (2) over governor arm tabs (3).



**FIGURE 5-49. CONTROL ROD INSTALLATION.**

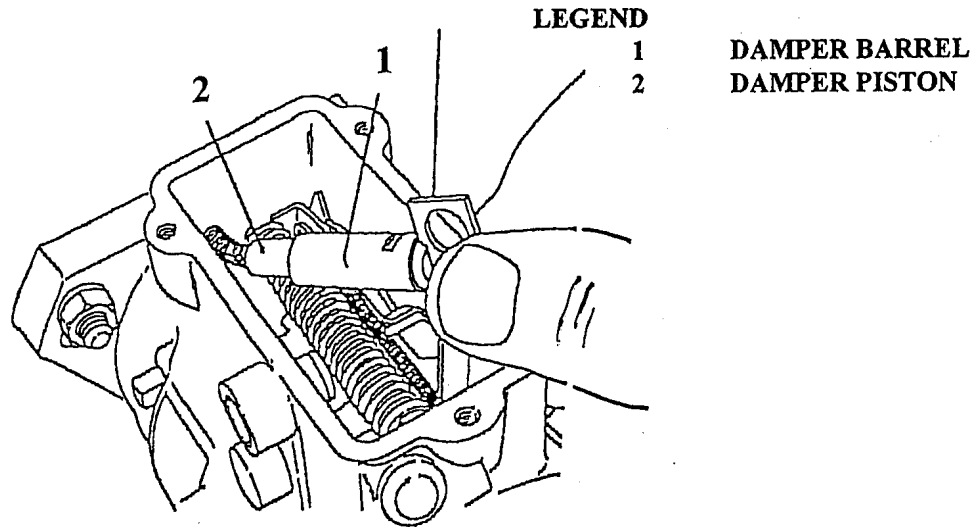
- (53) Depress metering valve arm (43, Figure 5-1) and install seal washer (17) and control rod guide (16). Torque control rod guide to 70 to 80 lb-in (8 to 9 Nm).
- (54) Install spring pin (15), O-ring (14), and slotted adjusting cap assembly (13).
- (55) Install droop control locking cap (Figure 5-50).



**FIGURE 5-50. DROOP CONTROL LOCKING CAP INSTALLATION.**

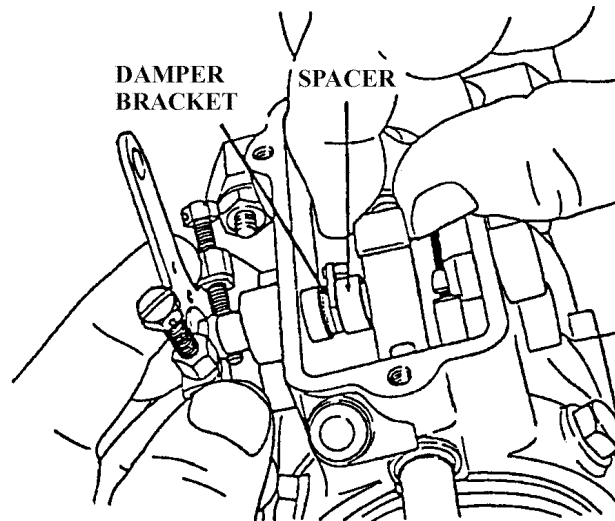


- (56) Install damper piston (2, Figure 5-51) and damper barrel (1).



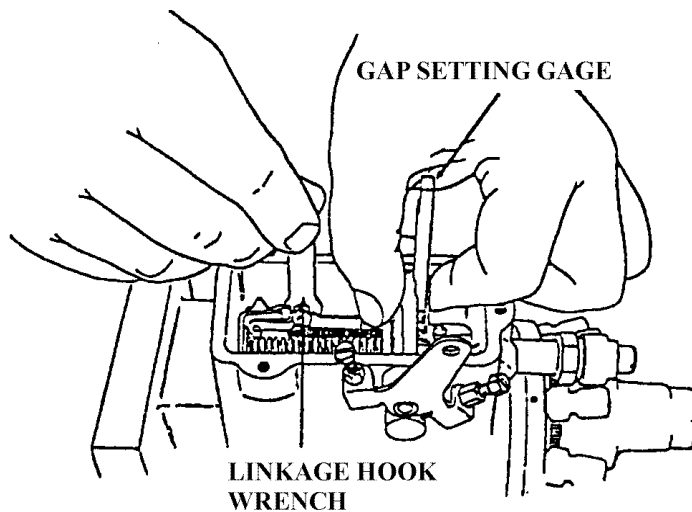
**FIGURE 5-51. DAMPER BARREL AND PISTON**

- (57) Install new spacer washer (7, Figure 5-1). Install O-ring (6) to throttle using seal protection tube (18338).
- (58) Install throttle shaft on right side of pump. Slide throttle shaft assembly into housing, lever pointing upwards through damper barrel bracket. Position throttle shaft lever in pump with fork straddling control rod and resting on flats of control spring bushing. Insert shaft through lever. Refer to figure 5-52.



**FIGURE 5-52. THROTTLE INSTALLATION**

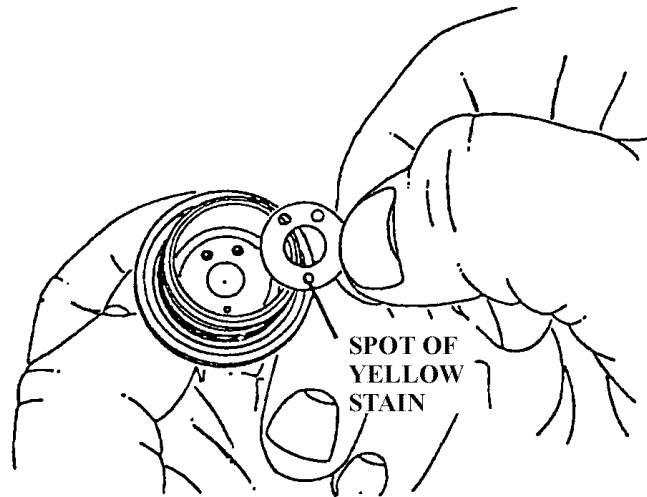
- (59) Ensure the governor linkage gap is properly set up prior to calibration by performing the following:
- (a) Partially loosen the adjusting screw with (13379) wrench until the parts can move in relationship to one another but with some resistance.
  - (b) Expand the linkage to the maximum gap. Refer to Figure 5-53. Insert thickness gap setting gage between the throttle shaft and the upright on the linkage hook. Refer to Stanadyne Service Bulletin 95.
  - (c) While holding the throttle lever in the wide open throttle position, close the gap to the thickness of the gage, press the linkage hook upright flush against the gage and tighten the linkage hook locking screw.
  - (d) Rotate the drive shaft 1/2 turn and recheck the gap to ensure it is within the specified tolerance.



**FIGURE 5-53. SETTING GOVERNOR LINKAGE GAP**

- (60) Invert pump in vise. Install new seal to head locating screw and install head locating screw to pump finger tight.

- (61) Assemble reed valve to power side piston hole plug with concave side (spot of yellow stain). Refer to Figure 5-54.



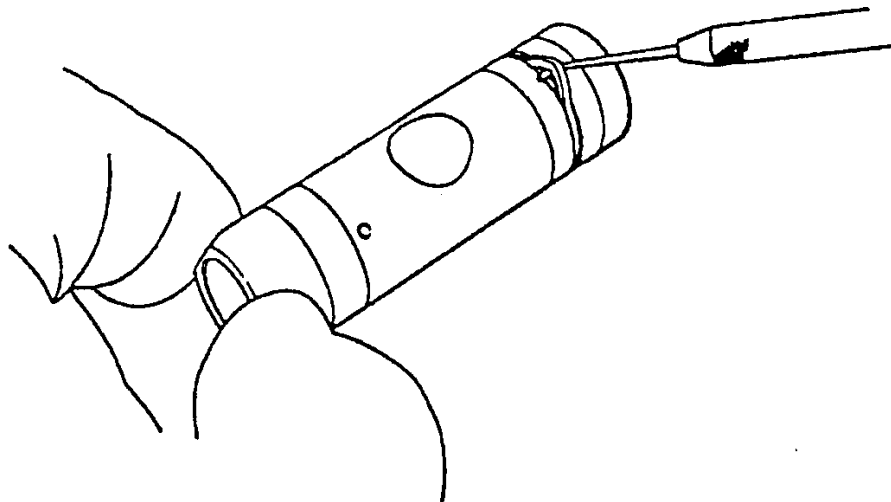
**FIGURE 5-54. REED VALVE ASSEMBLY**

- (62) Install reed valve retaining screws.

**NOTE**

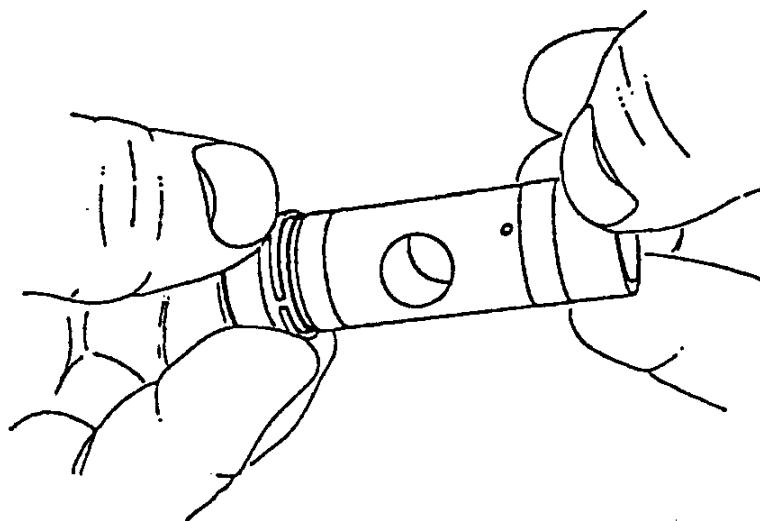
**A dental pick or similar tool can be slipped under seal and rotated around circumference of piston to untwist this seal.**

- (63) Install new advance piston ring seal (square cross section) to piston making sure that seal is not twisted in groove. Refer to Figure 5-55.



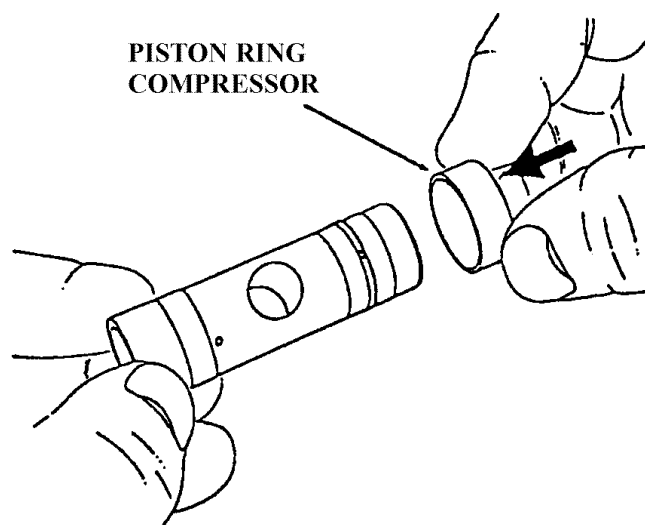
**FIGURE 5-55. PISTON AND PISTON RING SEAL**

- (64) Slide piston ring into its groove on piston exercising caution not to over expand ring. Refer to Figure 5-56.



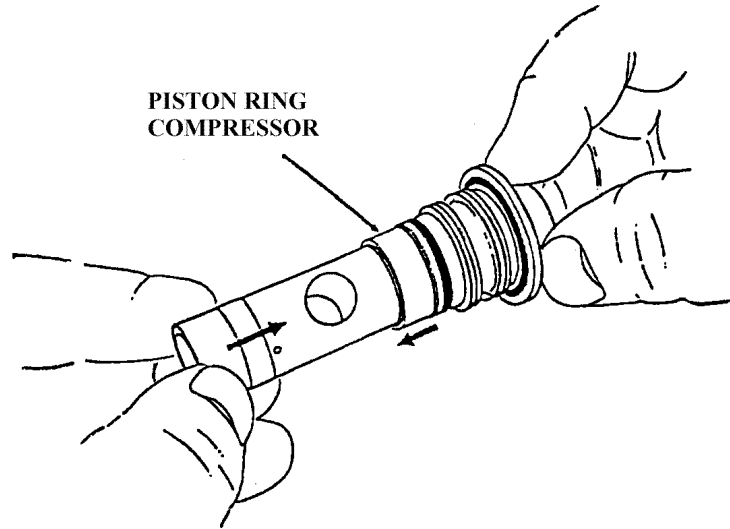
**FIGURE 5-56. PISTON RING**

- (65) Slide piston ring compressor tool, over end of piston, chamfered side facing piston ring. Refer to Figure 5-57.



**FIGURE 5-57. PISTON RING COMPRESSOR**

- (66) Install piston into power side piston hole plug and remove tool. Refer to Figure 5-58.

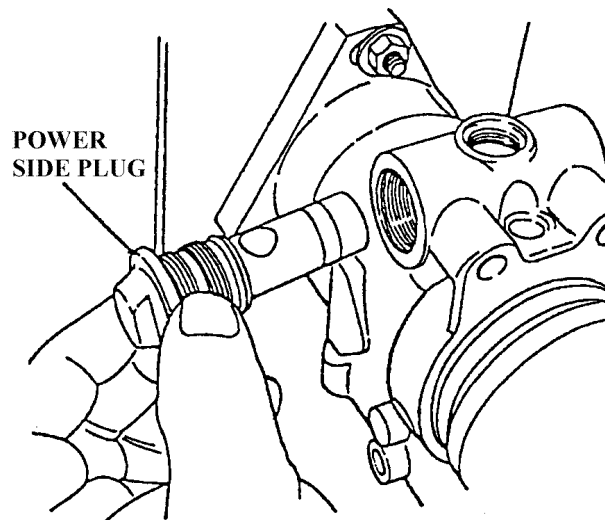


**FIGURE 5-58. PISTON IN POWER SIDE PISTON HOLE**

**NOTE**

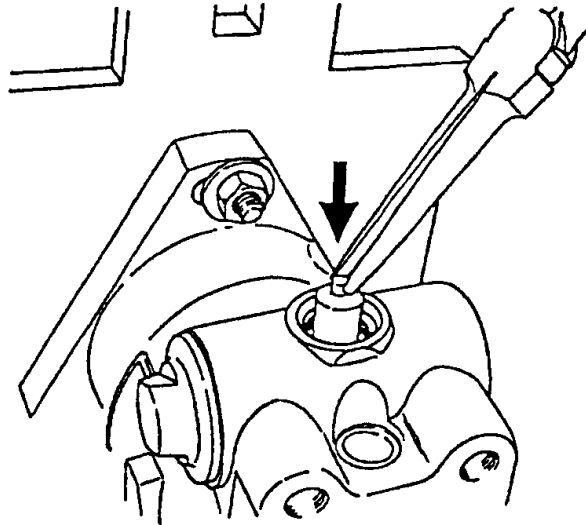
For clockwise rotation pumps, power side plug is marked on side of housing with "C". For counterclockwise rotation pumps, power side plug is marked on side of housing with "CC".

- (67) Install two new O-ring seals to power side piston hole plug and install assembly to advance bore. Refer to figure 5-59.



**FIGURE 5-59. POWER SIDE PISTON HOLE PLUG INSTALLATION**

- (68) Align pin hole in piston with hole in cam ring and install cam pin. Refer to Figure 5-60.



**FIGURE 5-60. ALIGNING PIN HOLE IN PISTON**

- (69) Install two new O-ring seals (29, Figure 5-1) to the spring side piston hole plug. Assemble the trimmer screw (33), a new O-ring seal (34) and the locknut (32)(chamfered side facing seal) to spring side plug (28).
- (70) Assemble the advance spring guide (31) and the advance spring(s) (30) to the trimmer screw (33).
- (71) Install spring side plug assembly (28) to housing (1) and tighten to 455 to 505 lb-in (51.5 to 57.2 Nm).
- (72) Use wrench to tighten the power side plug to 455 to 505 lb-in (51.5 to 57.2 Nm).
- (73) Install new seal (25) to cam pin hole plug (24) and install plug (24). Tighten to 75 to 100 lb-in (8.5 to 11.3 Nm).
- (74) Tighten head locating screw (24) to 180 to 220 lb-in (20.0 to 25.0 Nm).
- (75) Invert pump and holding fixture in vise and tighten the two head locking screws (23) to 180 to 220 lb-in (20.0 to 25.0 Nm).
- (76) Using end cap wrench, tighten the transfer pump end cap (72) to 360 to 440 lb-in (41.0 to 50.0 Nm).
- (77) Assemble the transfer pump end cap locking plate (21) and the new seal (22) to screw (20) and install locking plate assembly to hydraulic head (48). Tighten screw to 70 to 80 lb-in (7.9 to 9.0 Nm).
- (78) If pump is not equipped with a torque screw, install torque screw hole plug and new seal and tighten to 75 to 100 lb-in (8.5 to 11.3 Nm).

#### 5.4. SHORT BLOCK ASSEMBLY

##### 5.4.1. CAMSHAFT ASSEMBLY

#### NOTE

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

##### a. Inspection Prior to Camshaft Removal

- (1) Remove timing gear cover, refer to paragraph 4.9.2.
- (2) Inspect camshaft gear for chipped, broken, or missing teeth. If camshaft gear has chipped, broken, or missing teeth, camshaft must be removed and the camshaft gear replaced. Refer to refer to 5.4.1.c.

##### b. End Play Test

- (1) If not already performed, remove timing gear cover. Refer to paragraph 4.9.2.
- (2) Attach magnetic base of dial indicator to front plate.
- (3) Position dial indicator against end of camshaft and zero dial indicator.
- (4) Measure camshaft end play. Camshaft end play should be 0.003 - 0.009 in. (0.08 - 0.23 mm). If camshaft end play exceeds specifications camshaft must be removed from engine and inspected, refer to step c.
- (5) Remove camshaft, refer to step c, or install timing gear cover, refer to paragraph 4.9.2,

##### c. Removal

- (1) If not done previously, remove engine. Refer to TM 9-6115-671-14. Install engine on rotating repair stand, refer to paragraph 4.10.
- (2) If not done previously, drain engine oil and coolant, refer to TM 9-6115-671-14.
- (3) Remove rocker arm cover, refer to paragraph 4.7.1.
- (4) Measure valve lift for excessive wear, refer to paragraph 4.7.2. If valve lift shows excessive wear, cylinder head must be removed for inspection of cylinder block, cylinder head, and camshaft followers, refer to paragraph 4.7.4.
- (5) Lock engine at No. 1 TDC compression, refer to paragraph 4.7.2.
- (6) Remove rocker arm assembly and push rods, refer to paragraph 4.7.3.

- (7) Inspect push rods. If push rods are bent or show excessive scuffing, cylinder head must be removed for inspection of cylinder block, cylinder head, and camshaft followers, refer to paragraph 4.7.4.
- (8) Remove timing gear cover, refer to paragraph 4.9.2.
- (9) Remove fuel supply pump, refer to paragraph 3.12.3.
- (10) Rotate engine gear train using Flywheel Turning Tool (JDG820) until bolts (6, Figure 5-61) behind camshaft gear (4) can be removed. Remove bolts.
- (11) Mark camshaft gear teeth and idler gear teeth with timing marks using white paint to insure proper positioning of camshaft during installation.

**NOTE**

**If camshaft is going to be replaced with new camshaft, cylinder head must be removed and camshaft followers must be replaced.**

- (12) Remove cylinder head, if necessary, refer to paragraph 4.7.4.
- (13) If cylinder head has been removed, tag and remove camshaft followers and fuel supply pump activator pin.

**NOTE**

**Engine must remain in a position where camshaft followers rest against cylinder head and do not fall into engine crankcase. If camshaft followers fall into crankcase, cylinder head removal is required.**

- (14) If cylinder head has not been removed, revolve engine on rotating repair stand until camshaft followers (2, Figure 5-61) and fuel supply pump activator pin falls away from camshaft lobes.

**CAUTION**

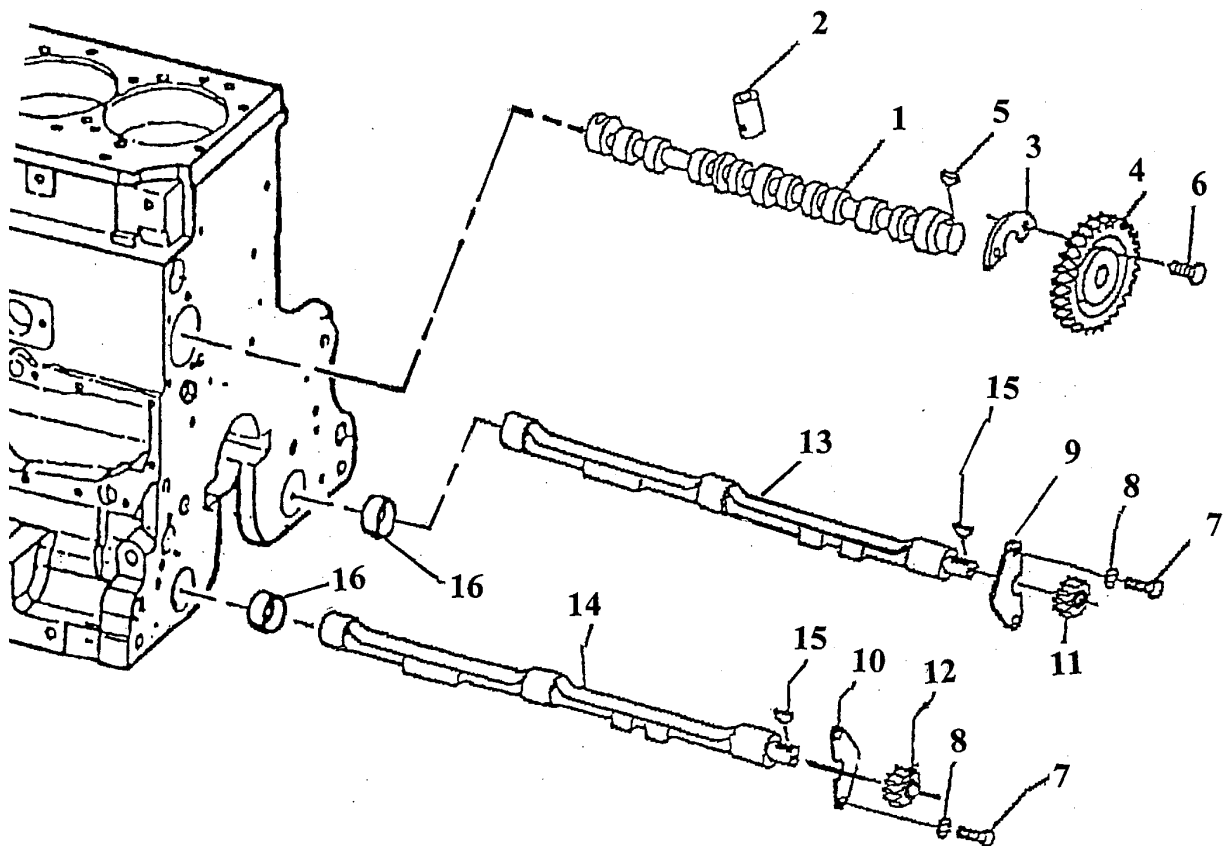
**Do not allow camshaft lobes to drag in bushing or honed bores. Failure to comply could result in damage to camshaft, camshaft bushing, or camshaft honed bores.**

**NOTE**

**Rotate camshaft carefully to aid in removal.**

- (15) Pull camshaft (1) straight up, out of cylinder block.
- (16) Remove thrust plate (3, Figure 5-61) from camshaft.





**LEGEND**

1	CAMSHAFT	9	THRUST PLATE
2	CAMSHAFT FOLLOWER	10	THRUST PLATE
3	THRUST PLATE	11	GEAR
4	CAMSHAFT GEAR	12	GEAR
5	WOODRUFF KEY	13	BALANCER SHAFT (LEFT)
6	CAPSCREW	14	BALANCER SHAFT (RIGHT)
7	CAPSCREW	15	SHAFT KEY
8	LOCKWASHER	16	BUSHING

**FIGURE 5-61. CAMSHAFT AND BALANCER SHAFTS**

**CAUTION**

Camshaft must be replaced if dropped or damaged. Do not allow camshaft to strike floor when removing camshaft gear.

**NOTE**

Camshaft gear must be removed if camshaft or camshaft gear is to be replaced.

- (17) If necessary, remove camshaft gear using press. Transfer painted timing mark from old camshaft gear to new camshaft gear.

- (18) Cover all openings to prevent entry of foreign material.

d. Test.

- (1) Remove camshaft, refer to step b.

**WARNING**

**Cleaning solvent is flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection are required. Avoid repeated/prolonged contact. Good general ventilation is normally adequate.**

**WARNING**

**Compressed air used for cleaning can create airborne particles that can enter the eyes. Pressure must not exceed 30 psig (207 kPa). Eye protection required.**

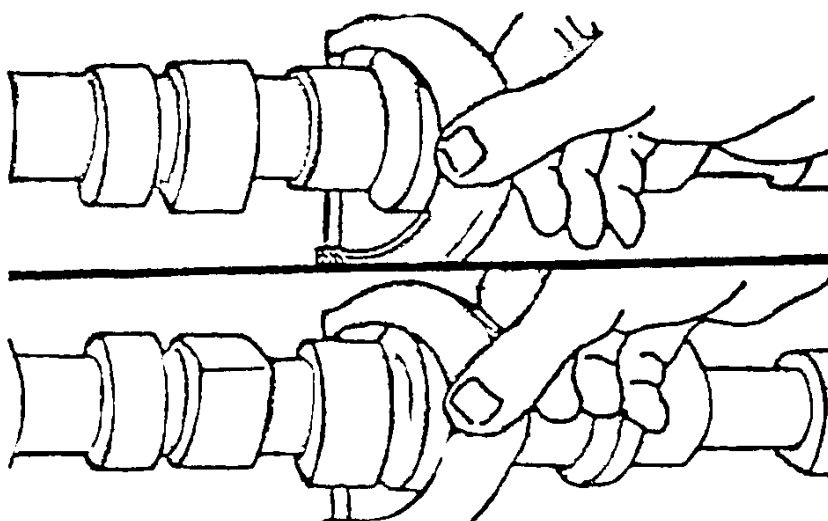
- (2) Clean camshaft in solvent. Dry camshaft with compressed air.
- (3) Inspect all camshaft lobes and journals for wear, damage, or pitting. Replace camshaft and camshaft followers if wear or damage is found.
- (4) Measure camshaft bushing inner diameter and camshaft journal outer diameter as follows:
- (a) Measure and record camshaft journal outer diameter for each camshaft journal. Camshaft journal outer diameter should be 2.1997 - 2.2007 in. (55.872 - 55.898 mm). Replace camshaft and camshaft followers if any camshaft journal outer diameter is out of specifications.
  - (b) Measure and record front camshaft bushing inner diameter. Front camshaft bushing inner diameter should be 2.2031 - 2.2042 in. (55.961 - 55.987 mm). Replace front camshaft bushing as follows if measurement is not within specification.
    - 1 Remove countersunk TORX® cap screw and install M8 X 1.25 tapered bottom leg from Camshaft Bushing Service Kit into hole that has chamfered screw and star washer.
    - 2 Install M8 X 1.25 flat bottom legs and Removing/Installing Plate to cylinder block so plate is parallel with front plate and centered over camshaft bore. Tighten legs and hex nuts securely.
    - 3 Insert Bushing Remover into camshaft bore so puller pilots in bushing inner diameter and Bushing Installer Screw extends through plate.

**CAUTION**

**Cylinder block bore is easily damaged. Cylinder block must be replaced if cylinder block bore is damaged. Insure that puller is properly piloted before pulling bushing. Failure to comply could result in damage to cylinder block.**

- 4 Install thrust washer and hex nut. Tighten hex nut until bushing is free of block bore. Remove puller and discard bushing.
  - 5 Clean and inspect bore in cylinder block. Cylinder block must be replaced if cylinder block bore is damaged, refer to paragraph 5.4.8.
  - 6 Measure camshaft bore inner diameter with bushing removed. Camshaft bore inner diameter with bushing removed should be 2.3607 - 2.3617 in. (59.961 - 59.987 mm). Replace cylinder block if camshaft bore inner diameter is out of specification, refer to Paragraph 5.4.8.
  - 7 Mark orientation of oil supply hole on front face of engine block and on bushing using permanent marker.
  - 8 Apply High Temperature Grease (Appendix E) to inner diameter and outer diameter of new bushing and to inner diameter of bushing bore. Slide bushing onto Bushing Installer so notched end of bushing will be toward front end of engine when installed.
  - 9 Thread Bushing Installer Screw into Removing/Installing Plate. Insure that bushing is started, square in bore, and oil hole is aligned.
  - 10 Tighten forcing screw until flange of bushing driver bottoms against face of block.
  - 11 Remove bushing tool from cylinder block.
  - 12 Check oil supply hole for correct alignment. If oil supply holes are not aligned, remove and discard bushing and install new bushing.
- (c) Measure and record camshaft bore inner diameter for each remaining camshaft bore. Camshaft bore inner diameter should be 2.3607 - 2.3617 in. (59.961 - 59.987 mm). Replace cylinder block if any camshaft bore inner diameter measurement is out of specification.
- (d) Calculate and record front camshaft journal-to-front camshaft bushing oil clearance by subtracting front camshaft journal outer diameter from front camshaft bushing inner diameter. Front camshaft journal-to-front camshaft bushing oil clearance should be 0.0025 - 0.0045 in. (0.063 - 0.115 mm). Replace front camshaft bushing, refer to step c., or camshaft, refer to paragraph 5.4.1, as required if front camshaft journal-to-front camshaft bushing oil clearance is out of specification.

- (e) Calculate and record camshaft journal-to-camshaft bore oil clearance for each camshaft journal by subtracting camshaft journal outer diameter from camshaft bore inner diameter. Camshaft journal-to-camshaft bore oil clearance should be 0.0035 - 0.0055 in. (0.088 - 0.140 mm). Replace camshaft or cylinder block as required if camshaft journal-to-front camshaft bushing oil clearance is out of specification.
- (5) Measure camshaft lobe height as follows:
  - (a) Measure and record height at widest point on camshaft lobe and height at narrowest point on camshaft lobe using micrometer. Refer to Figure 5-62.



**FIGURE 5-62. MEASURING CAMSHAFT LOBE HEIGHT**

- (b) Calculate and record camshaft lobe height by subtracting height at narrowest point on camshaft lobe from height at widest point on camshaft lobe.
- (c) Record camshaft lobe height and compare with specifications given in Table 5-3.

<b>Table 5-3. Camshaft Lobe Height Specifications.</b>	
Camshaft Lobe Height = Widest lobe point measurement - Narrowest lobe point measurement	
Intake Valve Camshaft Lobe Height	0.273 - 0.292 in. (6.93 - 7.42 mm)
Exhaust Valve Camshaft Lobe Height	0.266 - 0.286 in. (6.76 - 7.26 mm)

- (d) Repeat steps a and b for all camshaft lobes. Replace camshaft and camshaft followers if any camshaft lobes are not within specifications.

- (e) Measure fuel supply pump camshaft lobe diameter using micrometer. Fuel supply pump camshaft lobe diameter should be 1.680 - 1.690 in. (42.67 - 42.93 mm). Replace camshaft and camshaft followers if fuel supply pump camshaft lobe diameter is not within specification.
  - (6) Position camshaft thrust plate on camshaft and check clearance using a feeler gage. Camshaft thrust plate clearance should be 0.003 - 0.009 in. (0.08 - 0.23 mm). Replace camshaft thrust plate, camshaft, or both if clearance is not within specification.
  - (7) Install camshaft, refer to step f.
- e. Replacement.
  - (1) Remove camshaft, refer to step c.
  - (2) Perform test procedures, refer to step d. Replace camshaft if it fails any portion of test.
  - (3) Install camshaft, refer to step f.
- f. Installation.
  - (1) Remove all covering installed during step c (18).
  - (2) Ensure that engine is locked with No. 1 piston at TDC compression stroke using Timing Pin (JDE81-4).
  - (3) If camshaft is being replaced, remove cylinder head and replace camshaft followers, refer to paragraph 4.7.4.
  - (4) If necessary, install camshaft gear on camshaft as follows:
    - (a) Support camshaft (1, Figure 5-61) under first bearing journal in hydraulic press.
    - (b) Apply High Temperature Grease (Appendix E) to camshaft nose and camshaft gear inner diameter.
    - (c) Install woodruff key (5) in camshaft nose.
    - (d) Position camshaft gear on camshaft nose with timing mark away from camshaft. Carefully press camshaft gear onto camshaft using a Tubular Driver until camshaft gear bottoms against camshaft shoulder.
  - (5) Lubricate camshaft bearing journals and camshaft lobes with High Temperature Grease (Appendix E).
  - (6) Position thrust plate (3) on camshaft (1).

**CAUTION**

**Do not allow camshaft lobes to drag in bushing or honed bores. Failure to comply could result in damage to camshaft, camshaft bushing, or camshaft honed bores.**

- (7) Carefully position camshaft and thrust plate in cylinder block. Rotate camshaft during installation to avoid obstruction in any bore. Install thrust plate capscrews (6, Figure 5-61) and tighten to 26 lb-ft (35 Nm).
- (8) Remove upper idler gear if not removed. Refer to paragraph 5.4.2.
- (9) Time the camshaft as follows:
  - (a) With timing tool (JD254A) resting on nose of crankshaft and center of camshaft, turn camshaft until timing mark on camshaft gear aligns with timing tool.
  - (b) Check injection pump gear timing with timing tool (JD254A) resting on nose of crankshaft and center of injection pump shaft. Timing mark (SD4 for 4 cylinder) on injection pump drive gear must align with timing tool.
- (10) If removed, reinstall upper idler gear. Refer to paragraph 5.4.2.
- (11) Install fuel supply pump, refer to paragraph 3.12.3.
- (12) If cylinder head has been removed, install camshaft followers, fuel supply pump activator pin, and cylinder head, refer to paragraph 4.7.4.
- (13) Install push rods and rocker arm assembly, refer to paragraph 4.7.3.
- (14) Adjust valve clearance, refer to paragraph 4.7.2.
- (15) Install rocker arm cover, refer to paragraph 4.7.1.
- (16) Install timing gear cover, refer to paragraph 4.9.2.
- (17) Service lubrication system and coolant system, refer to TM 9-6115-671-14.
- (18) Install engine, refer to TM 9-6115-671-14.

5.4.2. IDLER GEARS AND IDLER GEAR SHAFTS.

**NOTE**

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

a. Idler Gear End Play and Backlash Test.

- (1) Remove timing gear cover, refer to paragraph 4.9.2.
- (2) Remove oil pan, refer to paragraph 4.5.3.
- (3) Measure idler gear end play as follows:
  - (a) Using dial caliper, check end play of upper and lower idler gears. Refer to Table 5-4 for specifications.
  - (b) Observe specifications for new end play and maximum acceptable end play.
- (4) Measure idler timing gear backlash as follows:
  - (a) Using a dial indicator, measure backlash between timing gears. Refer to Table 5-4 for specifications.
    - (1) Measure upper idler gear-to-camshaft gear. Refer to Table 5-4.
    - (2) Measure upper idler gear-to-injection pump gear. Refer to Table 5-4.
    - (3) Measure upper idler-to-crankshaft gear. Refer to Table 5-4.
    - (4) Measure lower idler gear-to-crankshaft. Refer to Table 5-4.
    - (5) Measure lower idler gear-to-oil pump gear. Refer to Table 5-4.
  - (b) If backlash is not within specification, install new timing gears.

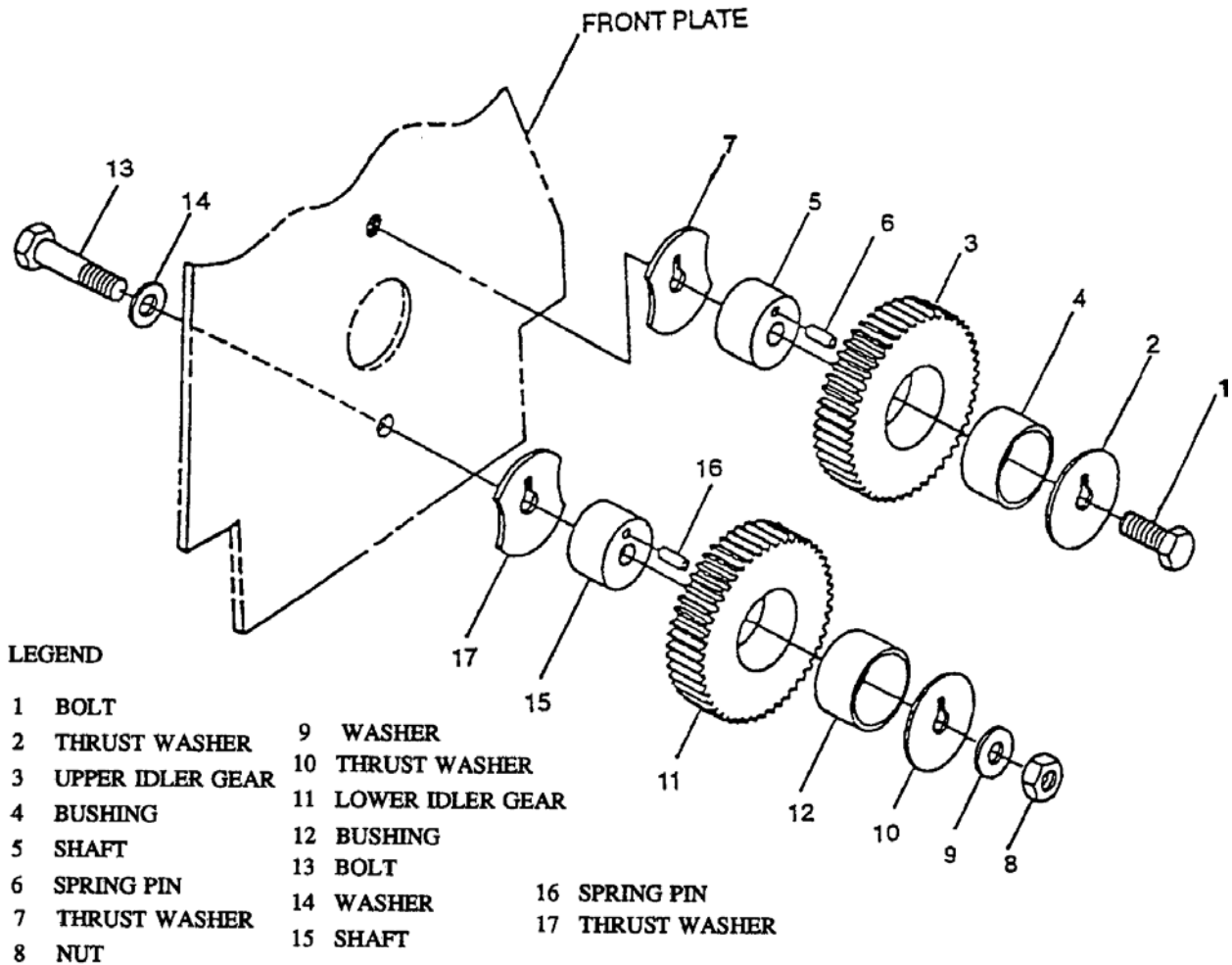
<b>Table 5-4. Camshaft and Timing Gear Train Specifications</b>	
Item	Specification
Upper Idler Shaft OD	2.7463 - 2.7471 in. (69.757 - 69.777 mm)
Upper Idler Gear Bushing ID	2.7481 - 2.7493 in. (69.802 - 69.832 mm)
Lower Idler Shaft OD	1.7495 - 1.7505 in. (44.437 - 44.463 mm)
Lower Idler Gear Bushing ID	1.7515 - 1.7535 in. (44.489 - 44.539 mm)
Upper and Lower Idler Gear End Play	0.0037 - 0.0057 in. (0.095 - 0.145 mm)

Table 5-4. Camshaft and Timing Gear Train Specifications – CONT.	
Balancer Shaft Bearing Journal Diameter	1.5801 – 1.5811 in. (40.135 – 40.161 mm)
Balancer Shaft Bushing ID	1.5818 – 1.5841 in. (40.177 – 40.237 mm)
Bushing-to Journal Clearance	0.0006 – 0.0040 in. (0.016 – 0.102 mm)
Cylinder Block Bore diameter for Balancer Shaft Bushing (Standard)	1.7032 – 1.7042 in. (43.262 – 43.288 mm)
Balancer Shaft Thrust Plate Thickness	0.117 – 0.119 in. (2.97 – 3.02 mm)
Balancer Shaft End Play	0.002 – 0.010 in. (0.05 – 0.26 mm)
Oil Clearance:	
Upper Idler Gear Bushing-to-Shaft	0.0030 - 0.0049 in. (0.075 - 0.125 mm)
Lower Idler Gear Bushing-to-Shaft	0.0010 - 0.0040 in. (0.026 - 0.102 mm)
Timing Gear Backlash:	
Upper Idler Gear-to-Camshaft Gear	0.0030 - 0.0162 in. (0.077 - 0.412 mm)
Upper Idler Gear-to-Injection Pump Gear	0.0030 - 0.0162 in. (0.077 - 0.412 mm)
Upper Idler Gear-to-Crankshaft Gear	0.0025 - 0.0127 in. (0.065 - 0.322 mm)
Lower Idler Gear-to-Crankshaft Gear	0.0026 - 0.0132 in. (0.067 - 0.336 mm)
Lower Idler Gear-to-Oil Pump Gear	0.0032 - 0.0135 in. (0.081 - 0.342 mm)
Lower Idler Gear-to-Balancer Shaft Gear	0.0028 – 0.0141 in. (0.071 – 0.359 mm)
Oil Pump-to-Balancer Shaft Gear	0.0025 – 0.0141 in. (0.065 – 0.358 mm)

b. Removal.

- (1) Remove timing gear cover, refer to paragraph 4.9.2.
- (2) Remove oil pan, refer to paragraph 4.5.3.
- (3) Remove bolt (1, Figure 5-63) and thrust washer (2) securing upper idler gear (3) to shaft (5); remove idler gear (3).
- (4) Remove nut (8), washer (9), and thrust washer (10) securing lower idler gear (11); remove idler gear (11).
- (5) If necessary, use an arbor press and remove bushings (4 and 12) from gears (3 and 11).
- (6) Remove bolt (13) and washer (14) from lower idler gear shaft (15).
- (7) Remove lower idler gear shaft (15) from front plate using a pry bar. Remove thrust washer (17).
- (8) Remove upper idler gear shaft (5) from front plate using a pry bar. Remove thrust washer (7).
- (9) Remove spring pins (6 and 16) from shafts.





**FIGURE 5-63. IDLER GEARS**

c. Test.

- (1) Measure upper and lower sleeve bushing (4 and 12, Figure 5-63) inner diameter. Refer to Table 5-4 for specifications.
- (2) Measure upper and lower shaft (5 and 15) outer diameter. Refer to Table 5-4 for specifications.
- (3) Oil clearance is required between upper and lower bushing to shaft. Refer to Table 5-4 for specifications. If oil clearance exceeds limit, replace worn parts.
- (4) If necessary, replace worn idler gears (3 and 11 Figure 5-63), shaft (5 and 15) or bushing (4 and 12).
- (5) If sleeve bushings (4 and 12) were removed, use an arbor press, driver and handle to install sleeve bushing (4) in idler gear (3) and sleeve bushing (12) in idler gear (11).

d. Installation.

- (1) Install spring pins (6 and 16, Figure 5-63) with end pin protruding as shown in Figure 5-64.
- (2) Install upper thrust washer (7, Figure 5-63) and idler gear shaft (5) with spring pin (6) in notch. Drive shaft into front plate until thrust washer (7) is fully seated with oil hole facing up. Tighten capscrew (1) in engine block to 59 lb-ft (80 Nm).
- (3) Install lower thrust washer (17) and idler gear shaft (15) with spring pin (16) in notch. Drive shaft into front plate until thrust washer (17) is fully seated with oil hole facing up. Install capscrew (13) and washer (14) through rear of front plate and tighten to 59 lb-ft (80 Nm).
- (4) If sleeve bushings (4 and 12) were removed, use an arbor press driver and handle to install sleeve bushing (4) in idler gear (3) and sleeve bushing (12) in idler gear (11).
- (5) Install lower idler gear (11), thrust washer (10), washer (9) and nut (8).
- (6) Time camshaft and install upper idler gear (3), thrust washer (2) and capscrew (1). Refer to paragraph 5.4.1.
- (7) Install oil pan, refer to paragraph 4.5.3.
- (8) Install timing gear cover, refer to paragraph 4.9.2.

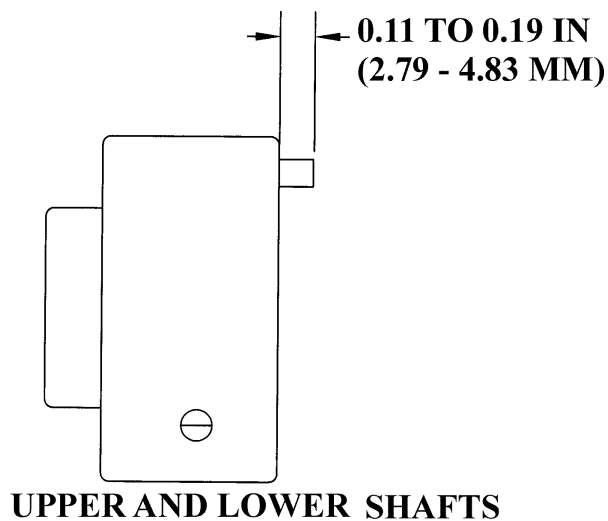


FIGURE 5-64. SPRING PIN PROTRUSION

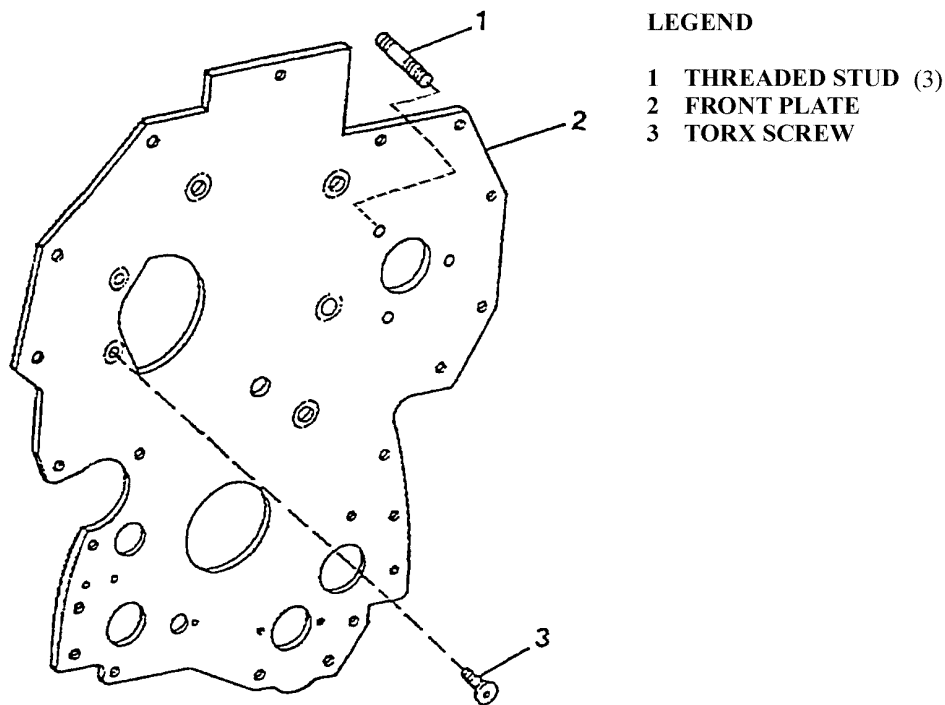
5.4.3. FRONT PLATE.

**NOTE**

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

a. Removal.

- (1) Remove timing gear cover, refer to paragraph 4.9.2.
- (2) Remove camshaft, refer to paragraph 5.4.1.
- (3) Remove fuel injection pump and drive gear, refer to paragraph 4.6.1.
- (4) Remove oil pump and drive gear, refer to paragraph 5.4.9.
- (5) Remove idler gears, refer to paragraph 5.4.2.
- (6) Remove six TORX® screws (3, Figure 5-65) securing front plate (2); remove front plate (2).
- (7) Remove threaded studs (1).
- (8) Remove oil bypass valve, refer to paragraph 5.4.10.



**FIGURE 5-65. FRONT PLATE**

b. Inspection.

**WARNING**

**Compressed air used for cleaning can create airborne particles that can enter the eyes. Pressure must not exceed 30 psi (207 kPa). Eye protection required.**

- (1) Remove all old sealant material from front plate and engine block.
- (2) Clean plate with soapy water and compressed air. Wipe front face of engine block with a cleaning cloth. Ensure sealant surface on engine block is clean.
- (3) Inspect front plate for wear or damage. Replace if necessary.

c. Installation.

**NOTE**

**Apply thread lock (LOCTITE 242) to threads of studs (1, Figure 5-66) before installing front plate.**

**CAUTION**

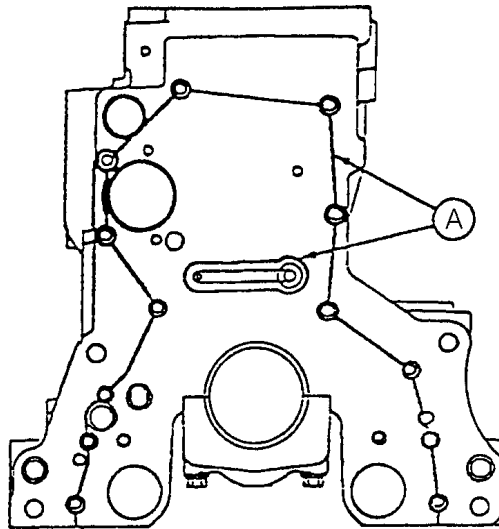
**Replacement front plates are supplied without injection pump timing mark. It is extremely important that timing mark be accurately transferred from original front plate to replacement plate in the exact location for correct injection pump timing.**

- (1) Transfer injection pump timing pump mark from original front plate onto replacement plate, as follows:
  - (a) Position locally manufactured template (Figure F2, Appendix F) on front plate and secure with three 3/8-16 capscrews.
  - (b) Transfer injection pump timing mark from previous front plate onto template using a fine tip marker and straightedge. Remove template from front plate being replaced.
  - (c) Attach template (with timing mark) to new front plate and tighten capscrews securely.
  - (d) Transfer timing mark from the template to the new front plate using a scribe. Scribe deep enough so mark becomes a permanent reference.
  - (e) Remove template from front plate.
- (2) Install oil bypass valve (1, Figure 5-89) and spring (2) in engine block bore.
- (3) Apply Flexible Form-In-Place Gasket in a continuous 1.5 to 2.0 mm bead (A) to cylinder block. Refer to Figure 5-66.
- (4) Locate bead in the center of the mating surfaces and completely encircle bolt and bolt holes.

**CAUTION**

**For flexible gasket to seal properly, tighten screws to specified torque using a cross pattern within 10 minutes after parts are assembled.**

- (5) Install front plate (2, Figure 5-65).
- (6) Secure front plate (2) with six TORX® screws (3). Tighten screws to 18 lb-ft (25 (Nm)).
- (7) Install threaded studs (1). Tighten studs to 26 lb-ft (35 (Nm)).
- (8) Install idler gears, refer to paragraph 5.4.2.
- (9) Install oil pump and drive gear, refer to paragraph 5.4.9.
- (10) Install fuel injection pump and drive gear, refer to paragraph 4.6.1.
- (11) Install camshaft, refer to paragraph 5.4.1.
- (12) Install timing gear cover, refer to paragraph 4.9.2.



**FIGURE 5-66. FRONT PLATE SEALANT APPLICATION**

#### 5.4.4 CRANKSHAFT AND MAIN BEARINGS.

##### NOTE

**Before removing crankshaft, check crankshaft end play, refer to paragraph 5.4.4 b.**

a. Removal.

- (1) Remove oil pan, refer to paragraph 4.5.3.
- (2) Remove oil pump, refer to paragraph 5.4.9.
- (3) Remove rocker arm assembly, pushrods, and cam followers, refer to paragraph 4.7.3.
- (4) Remove front plate, refer to paragraph 5.4.3.
- (5) Remove flywheel housing, refer to paragraph 4.8.3.

##### NOTE

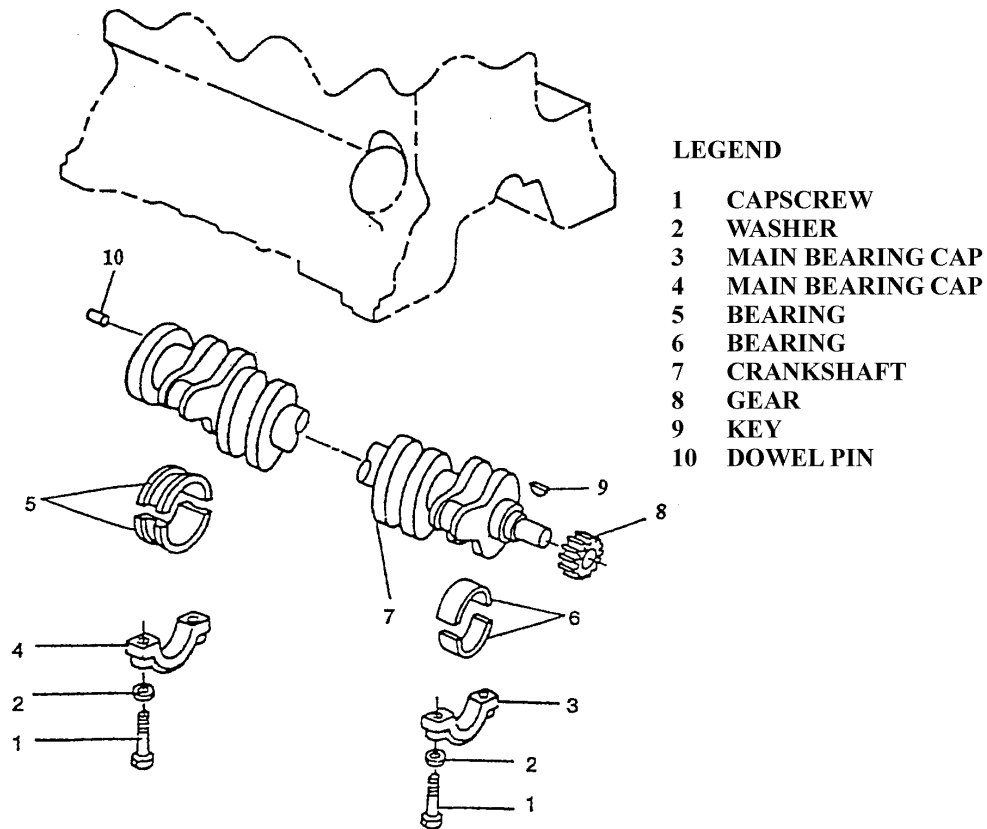
**Leave front and rear main bearing caps installed until all of connecting rod caps have been removed. Push pistons and rods away from crankshaft.**

- (6) Remove connecting rod bearing caps, refer to paragraph 5.4.5.
- (7) Check main bearing caps (3 and 4, Figure 5-67) for arrows (cast in bearing cap) and numbers stamped on cap and oil pan rail. Arrow points toward camshaft side of engine. If there are no numbers, stamp corresponding numbers on cap and oil pan rail. This will assure correct placement location of main bearing caps during reassembly.
- (8) Remove capscrews (1) and washers (2) securing main bearing caps (3 and 4); remove main bearing caps.

##### NOTE

**Visually inspect condition of bearing inserts (5 and 6) as main bearing caps are removed. Keep caps and inserts together and in correct order.**

- (9) Check bearing (5 and 6) clearances as follows:
  - (a) Place a strip of bearing gage (PLASTIGAGE) in the center of the main bearing cap about three fourths of width of bearing.
  - (b) Use oil on bearing gage to prevent smearing.
  - (c) Install cap and tighten capscrews (1) to 100 lb-ft (135 Nm).
  - (d) Remove cap and compare width of bearing gage with scale provided, to determine clearance. Maximum permissible clearance is 0.0043 inch (0.109 mm).



**FIGURE 5-67. CRANKSHAFT AND MAIN BEARINGS**

**WARNING**

Crankshaft is very heavy, do not attempt to remove crankshaft by hand.  
Use proper lifting equipment.

**NOTE**

Use of bearing gage will determine wear, but will not determine condition of  
either bearing or journal.

- (10) Attach a nylon sling (or other suitable lifting sling) to journals of crankshaft (7).

**NOTE**

An alternate method of attaching sling is to install a capscrew on both ends  
of crankshaft and attach sling to screws.

- (11) Using proper lifting equipment, carefully raise crankshaft out of engine block.  
(12) Place crankshaft (7) on a clean flat surface and support journals with wooden blocks.

- (13) If bearings (5 and 6) are to be replaced, remove inserts from engine block. Otherwise, leave bearing inserts in block until assembled inner diameter has been measured.
- (14) Using an arbor press and gear puller, pull gear (8) from crankshaft (7). Remove key (9) from crankshaft.

b. Crankshaft End Play Test.

**WARNING**

**Cleaning solvent is flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection are required. Avoid repeated/prolonged contact. Good general ventilation is normally adequate.**

**WARNING**

**Compressed air used for cleaning can create airborne particles that may enter the eyes. Pressure will not exceed 30 psig (207 kPa). Eye protection required.**

- (1) Inspect gear (8, Figure 5-67) for wear or damage.
- (2) Check crankshaft end play as follows:

**NOTE**

**It is recommended that crankshaft end play be measured prior to removing crankshaft to determine condition of thrust bearings. Crankshaft end play may also be checked at front end of crankshaft.**

- (a) Position dial indicator on face of flywheel.
- (b) Push crankshaft as far to rear of engine as possible.
- (c) Zero dial indicator.

**CAUTION**

**Do not apply too much pressure with bar, as this could damage bearings.**

- (d) Using a bar, gently pry crankshaft as far forward as possible.

**NOTE**

**New thrust bearings will usually restore proper end play. If end play is not within specification on two piece flanged thrust bearings, install a two piece thrust bearing (without flange) and oversized thrust washers.**

- (e) End play for new two piece thrust bearing, refer to Table 5-5 for values.



c. Inspection.

- (1) Inspect crankshaft per the following procedures:
  - (a) Clean crankshaft using solvent and compressed air.
  - (b) Inspect oil passages to make sure they are open. Use compressed air and a small piece of wire.
  - (c) Inspect crankshaft for any signs of load stress, cracks, scoring, or scratches on journals. (An inspection must be made if the crankshaft damper was found to be damaged or defective.) Figure 5-68 shows critical areas of load stress in a crankshaft.

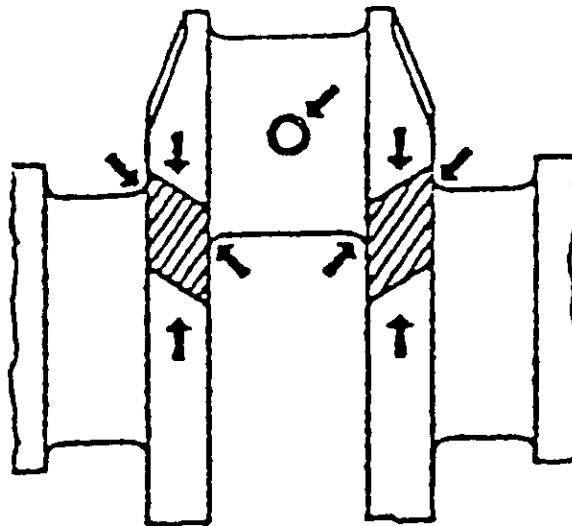


FIGURE 5-68. CRITICAL AREAS OF CRANKSHAFT LOAD STRESS

NOTE

When inspecting crankshaft for cracks, a method (such as the Fluorescent Magnetic Particle Method) must be used that is capable of detecting minute cracks that are not visible to the eye. This method magnetizes the crank, employing magnetic particles which are fluorescent and glow under black light. Replace crankshaft if cracks are found. The crankshaft must be demagnetized after the test.

- (d) Check each journal for evidence of excessive overheating or discoloration. If either condition exists, replace crankshaft since heat treatment has probably been destroyed.

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**AIR FORCE TO 38G1-125-2**  
**MARINE CORPS 09249A/09246A-24**

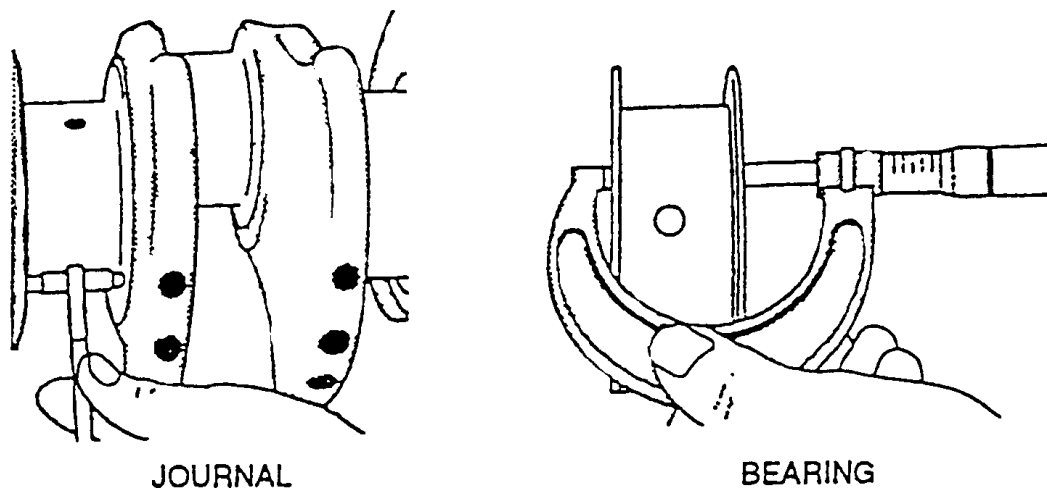
- (2) Measure assembled inner diameter of bearings and outer diameter of crankshaft journals as follows:
- (a) With crankshaft out of engine block, install main bearing inserts and caps (be sure inserts are installed correctly).
  - (b) Tighten main bearing capscrews. Refer to Table 5-5 for values.
  - (c) Measure inner diameter of all bearings with an inside micrometer. Refer to Table 5-5 for values.
  - (d) Measure outer diameter of all respective main bearing journals at several points around journal. Refer to Table 5-5 for values.

<b>Table 5-5. Crankshaft and Main Bearings Specifications.</b>	
Item	Specification
Crankshaft End Play (Thrust Bearing Clearance) Engine With Two-piece Thrust Bearing	0.002- 0.010 in. (0.05 - 0.25 mm)
Main Bearing Journal OD	3.1229 - 3.1240 in. (79.324 - 79.350 mm)
Main Bearing Assembled ID	3.1256 - 3.1273 in. (79.391 - 79.433 mm)
Main Bearing-to-Journal Clearance	0.0016 - 0.0043 in. (0.041 - 0.109 mm)
Main Bearing-to-Journal Width	1.5335 - 1.5365 in. (38.952 - 39.028 mm)
Thrust Bearing Overall Width	1.527 - 1.530 in. (38.79 - 38.87 mm)
Maximum Main or Rod Journal Taper	0.0004 in. (0.010 mm)
Maximum Main or Rod Journal Out-of-Roundness	0.0002 in. (0.005 mm)
Undersize Main or Rod Bearing Available	(0.25 mm) (0.010 in.)
Main Bearing Bore Specifications:	
ID Without Bearing Inserts	3.3250 - 3.3260 in. (84.455 - 84.481 mm)
Bore Centerline-to-Top Deck of Block	13.3029 - 13.3059 in. (337.896 - 337.972 mm)
Torque Values:	
Main Bearing Cap Screw	100 lb-ft (135 Nm)
Piston Cooling Orifices	8 lb-ft (11 Nm)

**NOTE**

**If engine has previously had a major overhaul and undersized bearing inserts were used, above listed inner diameter and outer diameter dimensions may not be the same as those recorded. However, oil clearance should be within specifications. Oil clearance is 0.0016-0.0043 inch (0.041 to 0.109 mm).**

- (e) Use crankshaft journal outer diameter measurements to determine if journal is out-of-round or tapered. Refer to Table 5-5 for journal out-of roundness wear limit and journal taper-per-inch of journal length wear limit.
  - (f) If journals are tapered, out-of-round, scored, or damaged, crankshaft should be ground. Refer to paragraph (e). Proper undersize bearings should be installed after grinding.
- (3) Measure main thrust journal width and thrust bearing width, refer to Figure 5-69, as follows:
- (a) Measure width of main thrust journal with an inside micrometer.
  - (b) Refer to Table 5-5 for new main thrust journal width.
  - (c) If width is not within specification, recondition crankshaft and install an oversize thrust washer set. If width is correct, measure main thrust bearing width.



**FIGURE 5-69. MEASURING MAIN THRUST JOURNAL AND THRUST BEARING WIDTH**

- (d) Measure width of thrust bearing using an outside micrometer.
- (e) Refer to Table 5-5 for new main thrust bearing width.

- (f) Refer to Table 5-5 for bearing-to-journal clearance.
- (4) Measure assembled inner diameter of main bearing caps as follows:
  - (a) Remove bearing inserts from caps and engine block. Keep inserts in correct order if they are to be reused.
  - (b) Clean caps in solvent and dry with compressed air.
  - (c) Inspect caps for serviceability. Small burrs or nicks on flat surfaces may be removed with a file. Use a medium-grit polishing cloth to dress up curved bearing surfaces.
  - (d) Install bearing caps in engine block. Refer to Table 5-5 for values.
  - (e) Measure inner diameter of bore without bearings. Refer to Table 5-5 for main bearing bore inner diameter without bearings.
  - (f) If bearing caps are damaged or bore is not within specification, replace cap and bore to specification.

**CAUTION**

**Main bearing cap line boring should be done only by experienced personnel on equipment capable of maintaining the bore specifications. Refer to Table 5-5 for dimension from centerline of bore-to-top of deck of engine block.**

**NOTE**

**Replacement bearing caps are supplied with bearing bore unfinished.**

- (5) Inspect piston cooling orifices as follows:
  - (a) Inspect each cooling orifice to make sure it is not plugged or damaged.
  - (b) Use a soft wire and compressed air to clean orifice. Replace, if condition is questionable.

**CAUTION**

**A piston cooling orifice failure could cause damage to pistons, piston pins, rod pin bushings, and liners. If a piston cooling orifice is left out of block during assembly, low or no oil pressure will result.**

- (c) Install all the orifices and tighten to values in Table 5-5.

d. Repair.

**NOTE**

If crankshaft is to be reground, use following recommended guidelines.

**CAUTION**

Crankshaft grinding should be done only by experienced personnel on equipment capable of maintaining crankshaft size and finish specifications.

**CAUTION**

If undersize bearings are used, check bearing clearance after bearing caps have been tightened to specified torque. If undersize bearings are too tight and clearance is not within specifications, journals and bearing will be wiped clean of all oil. This would result in premature wear of parts.

**CAUTION**

When grinding crankshaft, also grind fillet radii to specifications. This is necessary to prevent stress risers in fillet areas during grinding.

**NOTE**

Refer to Table 5-5 for undersize main and connecting rod bearings.

**NOTE**

To maintain the correct end play, the two piece main bearing with three piece thrust washer set can be used to replace the two piece flanged main bearings if desired.

- (1) Compare crankshaft journal measurements taken during inspection and determine size which journals are to be reground.
- (2) If one or more main or connecting rod journals requires grinding, then grind all of main journals or all of connecting rod journals to same required size. Grind clockwise (opposite engine rotation).
- (3) All journal fillets radii must be free of any sharp grind marks or scratches. Fillet must blend smoothly into journal and crank cheek. Radius may be checked with a fillet gage.
- (4) Care must be taken to avoid localized heating which often produces grinding cracks. Use coolant generously to cool crankshaft while grinding. Do not crowd grinding wheel into work.
- (5) Polish or lap (counterclockwise) ground surfaces to specified finish. Reground journals will be subject to excessive wear unless polished smooth.

**NOTE**

**When thrust surfaces are reground and an oversize washer is used, crankshaft end play specification must be maintained.**

- (6) If thrust surfaces of crankshaft are worn or grooved excessively, they must be reground and polished. Care must be taken to maintain specified radius between each thrust surface and bearing journal. An oversize thrust washer set is available.
- (7) Stone edge of all oil holes in journal surfaces smooth to provide a radius of approximately 0.060 inch (1.50 mm).
- (8) After grinding has been completed, inspect crankshaft by fluorescent magnetic particle method, or other similar method to determine if cracks have originated due to grinding operation.
- (9) Demagnetize crankshaft.

**WARNING**

**Cleaning solvent is flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection are required. Avoid repeated/ prolonged contact. Good general ventilation is normally adequate.**

**WARNING**

**Compressed air used for cleaning can create airborne particles that may enter the eyes. Pressure will not exceed 30 psig (207 kPa). Eye protection required.**

- (10) Thoroughly clean crankshaft and oil passages with solvent. Dry with compressed air.

d. Installation.

- (1) Install gear (8, Figure 5-67) on crankshaft as follows:

**WARNING**

**Oil fumes or oil can ignite above 380°F (193°C). Use a thermometer and do not exceed 360°F (182°C). Do not allow a flame or heating element to be in direct contact with oil. Heat oil in a well ventilated area. Plan a safe handling procedure to avoid burns. Wear protective clothing, gloves, apron, etc..**

- (a) Heat gear (8), in oil, to 300°F (148°C).
- (b) Install Adapter on nose of crankshaft (7). Tighten capscrews securely.

**NOTE**

**When installing gear, do not gouge or nick crankshaft flange or wear sleeve.**

- (c) Place gear on crankshaft flange. Be sure woodruff key (9) is properly aligned with keyway in gear (8).
  - (d) Install Installer over adapter.
  - (e) Tighten nut clockwise until gear firmly seats against crankshaft flange. Allow gear to cool before removing installer.
- (2) Install main bearing (6) inserts. Make sure that tang on inserts is engaged with slot in engine block and main bearing caps. Also make sure that oil holes line up with oil passages in block.

**CAUTION**

**If new thrust bearing inserts or thrust bearing washers are installed, they must be installed as a set.**

- (3) Install main thrust bearing (5) in rear web of engine block.
- (4) Apply a liberal coating of clean engine lubricating oil to bearing surfaces and crankshaft journals.
- (5) Using proper lifting equipment, lower crankshaft (7) onto main bearings.
- (6) Dip entire bearing capscrews (1) in clean engine lubricating oil (MIL-L-2104) and position them in the main bearing caps. Apply a liberal amount of oil to bearing inserts in caps.

**NOTE**

**Make sure bearing caps are installed on the bearing bosses from which they were removed. The numbers stamped on the caps should be on the same side as the numbers on the block. If there is an arrow on cap, arrow must point toward camshaft side of block.**

- (7) Install each bearing cap (3 and 4), bearings (5 and 6), and capscrews (1) with washers (2) with the recesses and tags aligned in matching order. Make sure bearing tabs also match up before tightening capscrews.

**CAUTION**

**Do not use pneumatic wrench to install main bearing capscrews, as damage may occur to the threads.**

- (8) Before tightening capscrews on main bearing caps, align upper and lower thrust washers or flanges on main thrust bearings (5). Using a soft-face hammer, tap crankshaft to the rear and then to the front to line up thrust bearing surfaces.
- (9) Tighten all capscrews to values in Table 5-5.

- (10) Turn crankshaft (7) by hand. If it does not turn easily, disassemble parts and determine the cause.

**CAUTION**

**Using pneumatic wrenches to install capscrews may cause damage to the threads. Never reuse connecting rod capscrews.**

- (11) Install connecting rod caps and bearings. Use new capscrews and tighten to specification. Refer to paragraph 5.4.5.
- (12) Check crankshaft for specified end play, refer to paragraph 5.4.2.
- (13) Install flywheel housing, refer to paragraph 4.8.3.
- (14) Install front plate, refer to paragraph 5.4.3.
- (15) Install rocker arm assembly, pushrods, and cam followers, refer to paragraph 4.7.3.
- (16) Install oil pump, refer to paragraph 5.4.9.
- (17) Install oil pan, refer to paragraph 4.5.3.

5.4.5. **PISTONS AND CONNECTING RODS.**

**NOTE**

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

a. **Removal.**

The following procedure is provided for removal of the pistons and connecting rods.

- (1) Drain coolant and lubrication system, refer to TM 9-6115-671-14.
- (2) Remove cylinder head, refer to paragraph 4.7.4.
- (3) Remove camshaft followers, refer to paragraph 5.4.1. Ensure that camshaft followers are kept in order for reassembly into the same position.

**WARNING**

**Compressed air used for cleaning can create airborne particles that can enter the eyes. Pressure must not exceed 30 psig (207 kPa). Eye protection required.**

- (4) Thoroughly clean all gasket surfaces. Remove all old gasket material, corrosion, carbon, and other foreign material from top deck. Use compressed air to remove loose material.



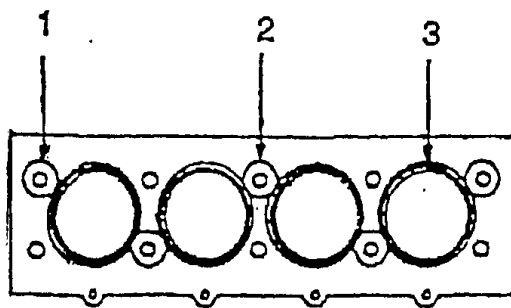
**CAUTION**

Cap screws and washers must be tightened to correct specification to achieve an accurate reading when checking liner standout (height above block), as detailed later in this paragraph.

- (5) Use short capscrews (1, Figure 5-70) and 1/8 in. (3 mm) thick washers (2) to bolt down cylinder liners (3). Fasten each liner in two locations. Tighten capscrews to 50 lb-ft (68 Nm).

**LEGEND**

- 1 SHORT CAPSCREWS  
2 WASHERS  
3 CYLINDER LINERS

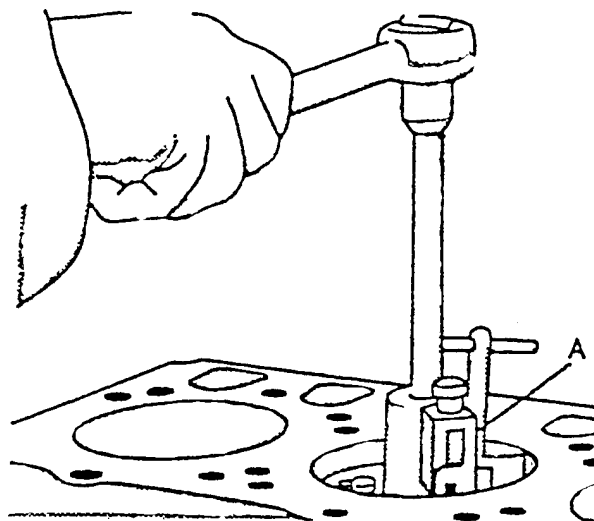


**FIGURE 5-70. FASTENING CYLINDER LINERS.**

**NOTE**

Do not rotate crankshaft with cylinder head removed unless liners are fastened down.

- (6) Remove carbon from liner bore using scraper or ridge reamer, refer to Figure 5-71. Rotate crankshaft as required to allow clearance for scraper or ridge reamer. Use compressed air to remove loose material.



**FIGURE 5-71. REMOVING CARBON FROM CYLINDER LINER.**

- (7) Remove oil pan, refer to paragraph 4.5.3.
- (8) Remove oil pump and outlet tube, refer to paragraph 5.4.9.
- (9) Mark rods (5, Figure 5-72), pistons (4), and rod caps (2) to insure correct assembly in same location.

**CAUTION**

**Insure that bearings are kept with same rod caps and rods from which they are removed. Failure to comply could result in excessive engine wear.**

- (10) Remove capscrews (1), rod cap (2) and rod cap bearing (3).

**NOTE**

**Use PLASTIGAGE as directed by the manufacturer. PLASTIGAGE will determine bearing-to-journal oil clearance, but will not indicate the condition of either surface.**

- (11) Measure rod bearing (6) to crankshaft oil clearance using PLASTIGAGE before removing piston (4) and rod (5). Record measurements. Refer to paragraph 5.4.5.b.2(h).

**CAUTION**

**Hold on to piston to prevent piston from dropping. Piston will drop once piston rings have cleared cylinder liner. Failure to comply could result in damage to piston or rod.**

**CAUTION**

**Do not allow rod to hit cylinder liner bore when removing piston and rod assembly. Failure to comply could result in damage to cylinder liner.**

- (12) Gently tap bottom of piston (4) until piston is clear of cylinder block. Remove piston (4) and rod (5) assembly. Remove rod bearing (6).
- (13) Repeat steps 9-12 for all cylinders.
- (14) Cover all openings to prevent entry of foreign material.

b. Repair.

The following procedure is provided for repairing the pistons and connecting rods. Remove pistons and connecting rods (refer to paragraph step a. above) and place on a suitable workbench. Disassemble per the following steps:

- (1) Disassemble the pistons per the following steps:
  - (a) Remove piston (4, Figure 5-72), refer to step a.
  - (b) Remove piston rings (7) using Piston Ring Expander.
  - (c) Remove snap rings (8) using snap ring pliers. Discard snap rings.
  - (d) Remove piston pin (9) and rod (5).
- (2) Test the pistons and connecting rods per the following steps:
  - (a) Clean piston ring grooves using piston ring groove cleaning tool.

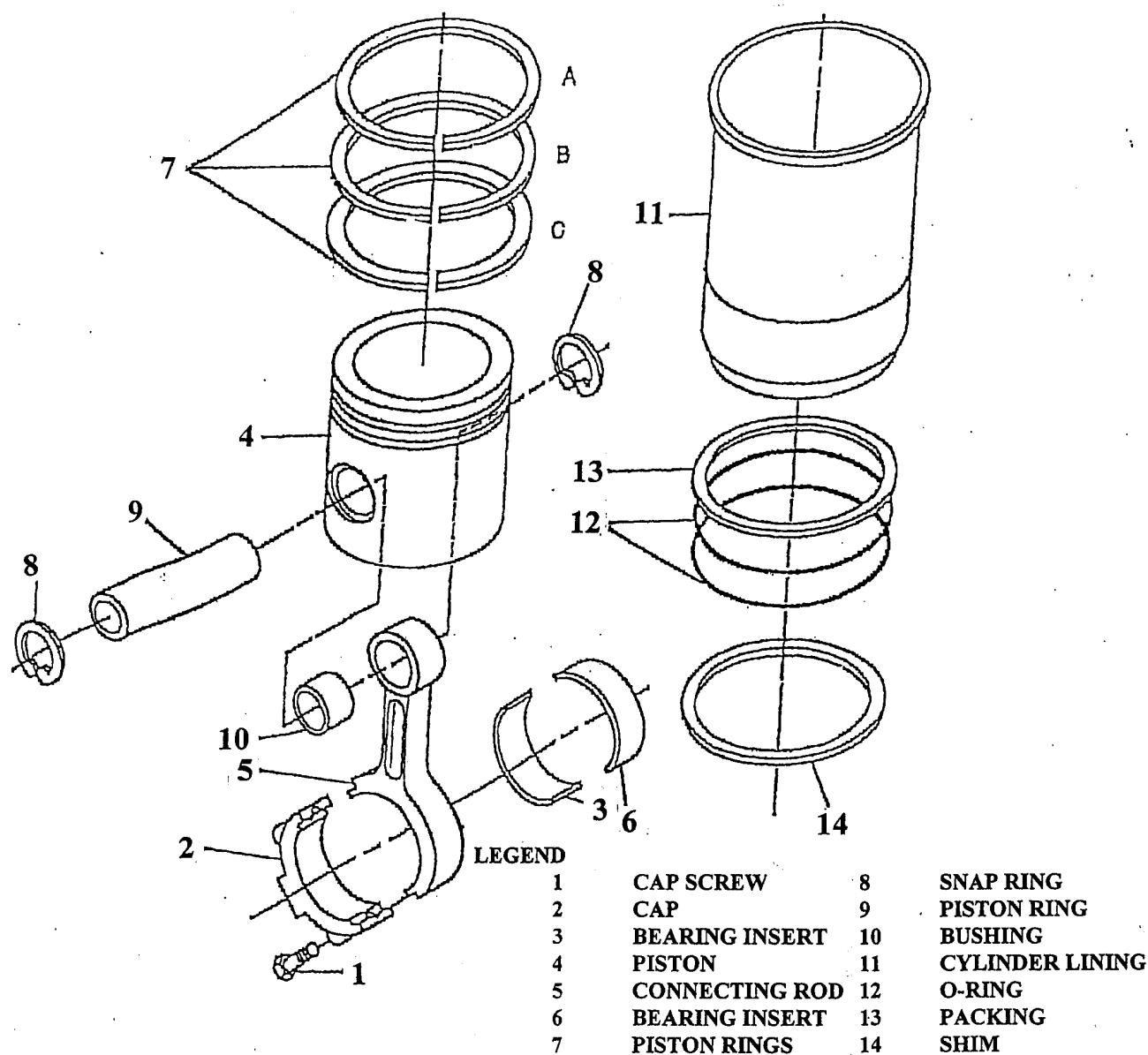
**WARNING**

**Compressed air used for cleaning can create airborne particles that can enter the eyes. Pressure must not exceed 30 psi (207 kPa). Eye protection required.**

**CAUTION**

**When washing pistons, always use a stiff bristle brush, not a wire brush, to loosen carbon residue. Failure to comply could result in damage to pistons.**

- (b) Clean pistons (4, Figure 5-72) with hot water and liquid detergent. Soak pistons in a solution of 50 percent liquid household detergent and 50 percent hot water for 30 to 60 minutes. Use stiff bristle brush to loosen carbon residue. Dry with compressed air.
- (c) Carefully inspect pistons (4) under magnification. Check for the following: signs of fatigue, fine cracks in piston head (1, Figure 5-73), bent or broken ring lands (2), cracks in skirt (3) at inner and outer ends of piston pin bore, and excessive piston skirt wear. (Original machining marks must be visible.). If any imperfections are found, replace piston (4) and cylinder liner (11, Figure 5-72), refer to paragraph 5.4.6, as a set.



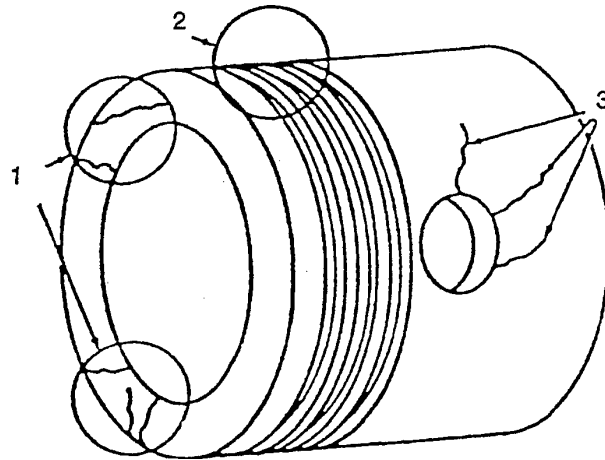
**FIGURE 5-72. PISTONS, CONNECTING RODS, AND CYLINDER LINERS.**

(d) Check piston ring groove wear as follows:

1. Check wear of keystone ring groove (top groove) using Ring Groove Wear Gauge (JDE62). Check groove at several locations around circumference of piston. Gauge shoulders should not contact ring land. Clearance (1, Figure 5-74) between shoulders of Ring Groove Wear Gauge (2) and ring land indicate ring groove is good. If ring groove is worn, replace piston (4, Figure 5-72) and cylinder liner (11), refer to paragraph 5.4.6, as a set.

**LEGEND**

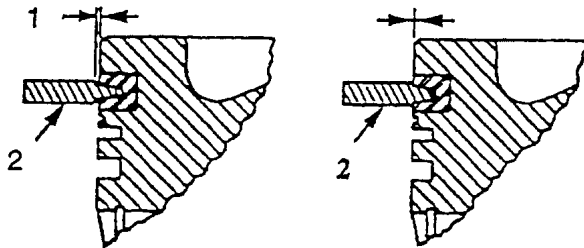
- 1 PISTON HEAD (CRACKS)
- 2 RING LANDS (BENT)
- 3 SKIRT (CRACKS)



**FIGURE 5-73. PISTON INSPECTION (DEFECTS EXAGGERATED)**

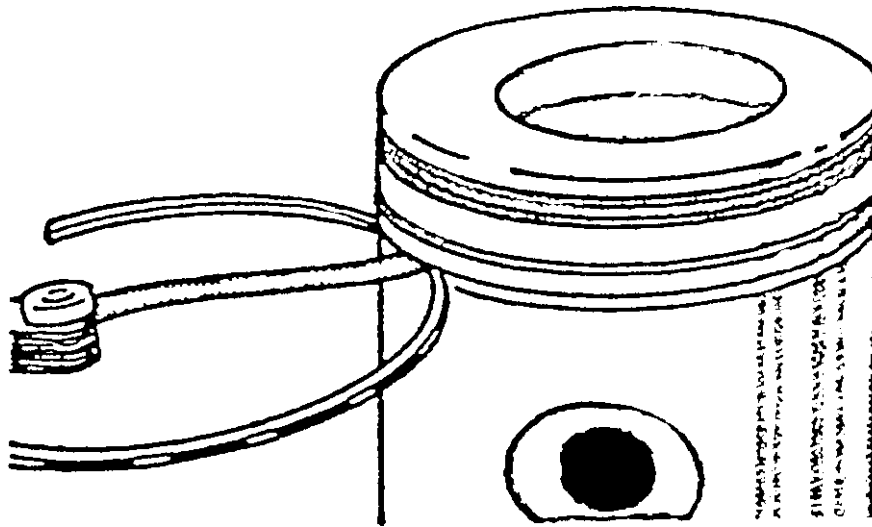
**LEGEND**

- 1 CLEARANCE
- 2 RING GROOVE WEAR GAUGE



**FIGURE 5-74. CHECKING PISTON KEYSTONE RING GROOVE WEAR.**

- 2 Check second and third piston grooves using new piston ring (7, Figure 5-72) and feeler gauge, refer to Figure 5-75. Check clearance at several points. Ring groove clearance should not exceed 0.008 in. (0.20 mm). If clearance exceeds specification, replace piston (4, Figure 5-72) and cylinder liner (11), refer to paragraph 5.4.6, as a set.

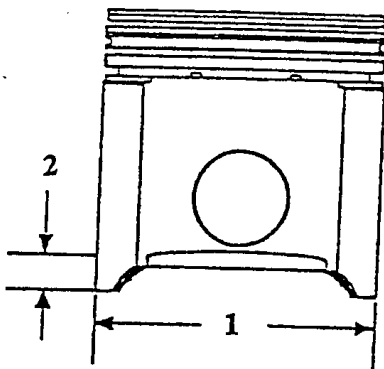


**FIGURE 5-75. MEASURING PISTON RING GROOVE CLEARANCE.**

- (e) Measure piston pin bore inner diameter. Piston pin bore inner diameter should be 1.6254 - 1.6258 in. (41.285 - 41.295 mm). If piston pin bore inner diameter exceeds specifications, replace piston and cylinder liner, refer to paragraph 5.4.6, as a set.
- (f) Measure and record piston skirt diameter (1, Figure 5-76) 90 degrees off piston pin bore and 1.1 in. (28 mm) from bottom of piston (2). Piston skirt diameter should be 4.188 - 4.189 in. (106.38 - 106.40 mm). If piston skirt diameter exceeds specifications, replace piston and cylinder liner, refer to paragraph 5.4.6, as a set.

**LEGEND**

- 1 PISTON SKIRT DIAMETER
- 2 BOTTOM OF PISTON TO PISTON PIN BORE



**FIGURE 5-76. MEASURING PISTON SKIRT**

(g) Inspect piston pin as follows:

**CAUTION**

**Piston pin has a highly polished surface. Do not attempt to polish or refinish piston pin. Failure to comply could result in excessive piston wear.**

- 1 Visually inspect piston pin for wear or damage. Replace piston pin if worn or damage is observed.
- 2 Measure piston pin outer diameter using outer diameter micrometer. Piston pin outer diameter should be 1.6243 - 1.6252 in. (41.257 - 41.280 mm). Replace piston pin if measurement is out of specifications.
- 3 Dip piston pin in clean engine oil.
- 4 Install piston pin through piston. Piston pin should pass through piston using only light thumb pressure.
- 5 Insert piston pin from both sides. If piston pin enters freely, but binds in the center, replace piston and cylinder liner, refer to paragraph 5.4.6, as a set.
- 6 Insert piston pin to check for bore alignment. If piston pin “clicks” or needs to be forced into bore on opposite side, replace piston and cylinder liner, refer to paragraph 5.4.6, as a matched set.

(h) Inspect connecting rod as follows:

- 1 Inspect rod bearings for damage. Replace rod bearings if damage is observed.
- 2 Measure and record crankshaft (7, Figure 5-67) journal outer diameter at several points. Compare crankshaft journal outer diameter with specifications given in Table 5-6. Replace crankshaft (7) if out of specifications.

<b>Table 5-6. Connecting Rod Journal and Bearing Specifications.</b>	
Item	Specification
Crankshaft Journal OD	3.0629 - 3.0640 in. (77.800 - 77.826 mm)
Assembled Rod Bearing ID	3.0659 - 3.0679 in. (77.876 - 77.927 mm)
Rod Bearing-to-Journal Oil Clearance (new parts)	0.0020 - 0.0050 in. (0.050 - 0.127 mm)
Rod Bearing-to-Journal Oil Clearance (used parts)	0.0020 - 0.0600 in. (0.050 - 0.152 mm)

- 3 Assemble connecting rod (5, Figure 5-72), cap (2), and bearings (3 and 6) using old capscrews (1). Torque capscrews to 50 lb-ft (68 Nm). Tighten capscrews an additional 90 degrees (1/4 turn).

- 4 Measure and record assembled rod bearing inner diameter. Compare assembled rod bearing inner diameter with specifications given in Table 5-6. Replace bearings (3 and 6) if out of specifications.
- 5 Subtract crankshaft journal outer diameter from rod bearing inner diameter to determine oil clearance. Compare oil clearance calculations with specifications given in Table 5-6. Replace bearings (3 and 6), connecting rod (5) or crankshaft (7, Figure 5-67) as required if out of specifications.
- 6 Remove capscrews (1, Figure 5-72), cap (2), and bearings (3 and 6).
- 7 Inspect connecting rod (5) and cap (2) for wear or damage, such as chips or cracks in the joint area. Inspect in and around capscrew (1) holes in cap. Replace connecting rod and cap if any imperfections are found.

#### NOTE

#### Assemble rod and cap without bearings installed.

- 8 Assemble connecting rod (5) and cap (2) using old capscrews (1). Torque capscrews to 43 lb-ft (58 Nm). Tighten capscrews an additional 90 degrees (1/4 turn).
- 9 Measure and record assembled connecting rod bore inner diameter at center of bore as follows:
  - a At right angle to connecting rod-to-cap joint.
  - b At 45 degrees left of measurement step a.
  - c At 45 degrees right of measurement step a.
- (i) Compare connecting rod bore inner diameter with specifications given in Table 5-7. Replace connecting rod (5) and cap (2) if out of specifications.

<b>Table 5-7. Connecting Rod Bore (Without Bearing Inserts) Specifications.</b>	
Item	Specification
Rod Bore ID	3.2550 - 3.2560 in. (82.677 - 82.703 mm)
Maximum Permissible Bore Out-of-Round	0.0015 in. (0.038 mm)

- (j) Subtract smallest rod bore inner diameter measurement from largest rod bore inner diameter measurement. This is the maximum bore out-of-round measurement. Replace connecting rod (5) and cap (2) if maximum bore out-of-round measurement exceeds specifications given in Table 5-7.
- (k) Measure connecting rod (5) piston pin bushing (10) inner diameter and compare with specifications given in Table 5-8. Replace connecting rod piston pin bushing if out of specifications, refer to step m.



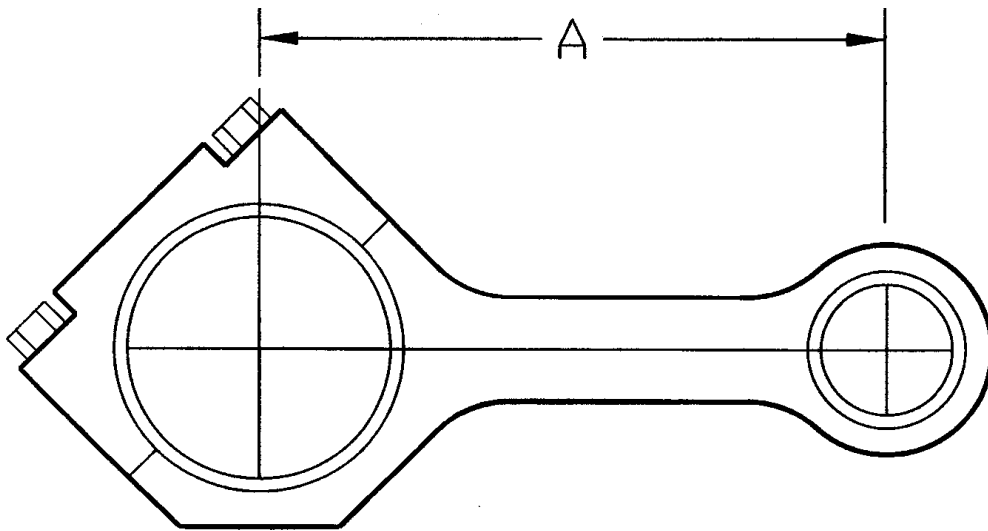
Table 5-8. Connecting Rod Piston Pin Bushing Specifications.	
Item	Specification
Connecting Rod Piston Pin Bushing ID	1.6260 - 1.6290 in. (41.300 - 41.376 mm)
Piston Pin-to-Bushing Oil Clearance	0.0007 - 0.0040 in. (0.020 - 0.102 mm)

- (l) If necessary, replace connecting rod piston pin bushing in straight pin-end rod as follows:

**CAUTION**

**Oil holes must be aligned. If holes are not aligned, remove and discard bushing. Install a new bushing. DO NOT attempt to reuse the bushing. Install bushing in rod.**

- 1 Use driver for 1.6 in. (41 mm) pin to install bushing.
  - 2 Press bushing into rod bore until edge of bushing is flush or just slightly below machined surface on face of rod.
  - 3 Remove rod from press.
  - 4 inner diameter of bushing must be precision bored to proper size. Pin-to-Bushing oil clearance should be 0.0007 - 0.0022 in. (0.020 - 0.056 mm) and wear limit should be 0.0040 in. (0.102 mm).
- (m) Calculate piston pin-to-bushing oil clearance by subtracting piston pin (9) outer diameter from connecting rod piston pin bushing (10) inner diameter. Compare piston pin-to-bushing oil clearance with specifications given in Table 5-8. Replace connecting rod piston pin bushing, refer to step l, or piston pin if out of specifications.
- (n) Insert piston pin (9) from either side of connecting rod piston pin bushing (10). Replace connecting rod piston pin bushing, refer to step l, if piston pin is free on one end but tight on the other, or if piston pin enters freely from both sides, but is tight in the center.
- (o) Measure rod center-to-center bore as follows;
- 1 Measure rod center-to-center bores (with bushings removed). Bearing bore-to-pin bushing (center-to-center) length A should be 7.990 - 7.994 in. (202.95 - 203.05 mm). Refer to Figure 5-77.
  - 2 Replace rod if not within specifications.



**FIGURE 5-77. MEASURING ROD CENTER-TO-CENTER BORES**

- (3) Assemble the pistons and connecting rods per the following steps:

**NOTE**

**If new piston and liner assembly is to be installed, leave piston inside liner. Push piston out of liner bottom only far enough to install piston pin.**

- (a) Lubricate piston pin (9, Figure 5-72), connecting rod piston pin bushing (10), and piston pin bore in piston (4) with clean engine oil.

**CAUTION**

**Install pistons on same connecting rods as pistons were removed from. Use new piston pin snap rings. Failure to comply could result in excessive engine wear or engine failure.**

- (b) Assemble piston (4) and matching connecting rod. Insure that the word "FRONT" on side of piston and side of connecting rod are facing same direction..
- (c) Insert piston pin into piston pin bore in piston and through connecting rod piston pin bushing.
- (d) Install new snap rings (8) with sharp edge of ring facing away from piston pin. Insure that snap rings are seated in grooves of piston pin bore.

**CAUTION**

**Do not over expand piston rings. Piston rings can be damaged if expanded too far. Expand piston rings only as far as necessary to install rings on piston. Failure to comply could result in engine failure.**

**NOTE**

**Piston rings come pre-installed in new piston and liner assemblies. Leave piston inside liner.**

- (e) Install piston rings as follows:
- 1 Install oil ring expander in bottom ring groove of piston (4) using piston ring expander (JD135). Position end gap of oil ring expander toward either side of piston pin.
  - 2 Install oil control ring (7c.) in bottom ring groove over ring oil ring expander. Position end gap of oil control ring on opposite side of piston from oil ring expander gap.
  - 3 Identify top side of compression rings (7a. and 7b.). Top side of rectangular and keystone compression rings are identified by depression marks on top side of two rings.
  - 4 Install rectangular compression ring (7b.) in center ring groove of piston (4) with depression marks facing top of piston.
  - 5 Position gap in rectangular compression ring (7b.) on opposite side of piston from gap in oil control ring (7c.).
  - 6 Install keystone compression ring (7a.) in top ring groove of piston (4) with depression marks facing top of piston.
  - 7 Position gap in keystone compression ring (7a.) on opposite side of piston from gap in rectangular compression ring.
- (f) Measure piston protrusion as follows:
- 1 Press down on top of piston (4) to remove oil clearances before measuring piston protrusion.
  - 2 Position gauge on cylinder block. Zero dial indicator against cylinder block.
  - 3 Position gauge across piston. While pressing gauge downward, rotate crankshaft until piston is at Top Dead Center (TDC) position.
  - 4 Measure piston height at several positions around piston. Piston Protrusion (above cylinder block deck) should be 0.003 - 0.012 in. (0.08 - 0.30 mm).

- (g) If piston protrusion is out of specifications, check dimensions of piston, cylinder block, crankshaft, and bearings to determine the cause.

c. Installation.

- (1) Assemble piston assembly, refer to paragraph d.
- (2) Remove all covering installed during step a (14).
- (3) Coat piston (4, Figure 5-72), piston liner (11), and Piston Ring Compressor with clean engine oil.
- (4) Carefully position piston and connecting rod assembly inside Piston Ring Compressor.
- (5) Carefully place Piston Ring Compressor with piston and connecting rod over piston liner so the word "FRONT" on side of rod and on side of piston faces toward front of engine. Push piston into piston liner.
- (6) Position bearing insert (6) in connecting rod (5) from bottom of cylinder block. Insure that tang of bearing insert is firmly seated in groove of connecting rod.
- (7) Apply clean engine oil to bearing insert (6) and crankshaft journal. Carefully pull connecting rod (5) and bearing insert against crankshaft journal.
- (8) Install bearing insert (3) in cap (2). Insure that tang of bearing insert is firmly seated in groove of cap.
- (9) Apply clean engine oil to bearing insert (3). Install cap (2) on connecting rod (5) with tangs to same side.

**CAUTION**

**Always use new capscrews for final assembly of connecting rod and cap. If capscrews have been tightened before, do not reuse for final assembly. Failure to comply could result in engine failure.**

- (10) Dip new capscrews (1) in clean engine oil. Install capscrews and torque evenly to 43 lb-ft (58 Nm). Tighten capscrews an additional 90 degrees (1/4 turn).
- (11) Rotate crankshaft several revolutions to insure that engine rotates without excessive tightness.
- (12) Measure piston protrusion, refer to paragraph 5.4.5.b(3)(f) and (g).
- (13) Check liners for deep scratches caused by improperly installed or broken piston ring.
- (14) Check side clearance of connecting rods. Connecting rods must have slight side-to-side movement.
- (15) Install oil pump and outlet tube, refer to paragraph 5.4.9.
- (16) Install oil pan, refer to paragraph 4.5.3.
- (17) Remove capscrews (1, Figure 5-70) and washers (2) that hold down cylinder liners (3).

- (18) Insure that all gasket surfaces are clean and free of foreign material.
- (19) Install camshaft followers, refer to paragraph 5.4.1.
- (20) Install cylinder head, refer to paragraph 4.7.4.
- (21) Service coolant and lubrication system, refer to TM 9-6115-671-14.

5.4.6. CYLINDER LINERS.

**NOTE**

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

a. Testing Cylinder Liner Height Prior to Removal.

- (1) Remove piston, refer to paragraph 5.4.5.
- (2) Check height of each cylinder liner using Dial Indicator. Check height of each cylinder liner at 1, 5, 7, and 11 o'clock positions as viewed from rear of engine. Record all measurements.
- (3) Compare measurements with specifications given in Table 5-9. Replace any cylinder liner that is out of specifications, refer to step b.

<b>Table 5-9. Cylinder Liner Height Specifications.</b>	
Item	Specification
Cylinder Liner Height Above Block	0.001 - 0.004 in. (0.030 - 0.100 mm)
Maximum permissible difference between readings within one cylinder or between adjacent cylinders	0.002 in. (0.05 mm)

b. Removal.

- (1) Remove piston, refer to paragraph 5.4.5.
- (2) Remove capscrews (1, Figure 5-70) and washers (2) securing cylinder liners (3) to cylinder block.

**CAUTION**

**Stamp cylinder liner on fire dam only. Do not stamp cylinder liner on flange. Failure to comply could result in engine damage.**

**CAUTION**

**Stamp piston on side of piston, away from machined surface that contacts cylinder liner. Do not stamp top of piston. Failure to comply could result in engine damage.**

- (3) Number cylinder liners and pistons. Stamp front of cylinder liner to assure correct assembly position.

**CAUTION**

**Keep matched pistons and liners together. Liners must be reinstalled in same cylinder bore. Failure to comply could result in excessive engine wear.**

- (4) Remove cylinder liner (11, Figure 5-72) using Puller.
- (5) Remove O-rings (12) from cylinder block.
- (6) Remove packing (13) from cylinder liner (11).
- (7) Cover all openings to prevent entry of foreign material.

c. Inspection.

- (1) Perform testing of cylinder liner height prior to removal, refer to step a. If out of specifications, continue inspection by performing step c (2).
- (2) Remove cylinder liner, refer to step b (4).
- (3) Clean cylinder liner (11, Figure 5-72) as follows:
  - (a) Clean cylinder liner using stiff bristle brush. Remove all debris, rust, and scale from outer diameter of cylinder liners, under cylinder liner flange, and in O-ring packing areas.
  - (b) Visually inspect cylinder liner (11) to insure that there are no nicks or burrs in areas where packings will seat. Replace cylinder liner if nicks or burrs are observed.

**CAUTION**

**Solvents will not remove all abrasives from liner walls. Do not use gasoline, kerosene, or commercial solvents to clean liners. Failure to comply could result in engine damage.**

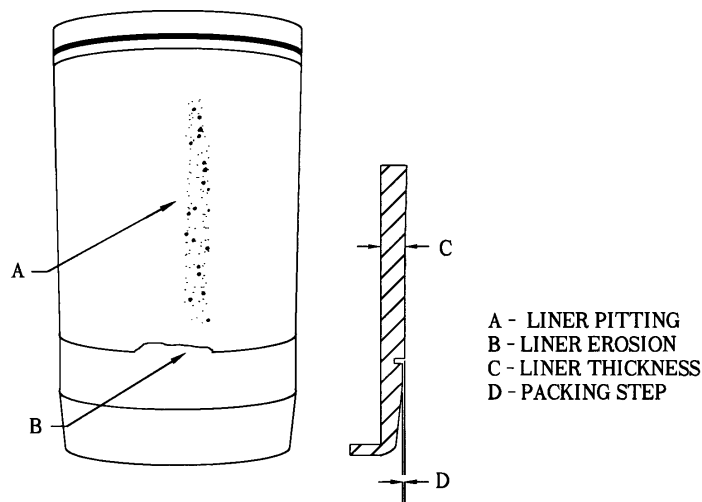
- (c) Thoroughly clean cylinder liner (11) inner diameter using a solution of 50 percent hot water and 50 percent liquid detergent.

- (d) Thoroughly rinse cylinder liner with water and wipe dry with clean rag.
  - (e) Swab out cylinder liner (11) as often as necessary with clean SAE 10W oil. Clean cylinder liner until a clean, white rag shows no discoloration when rubbed against inner diameter of cylinder liner.
- (4) Clean cylinder liner O-ring bore inside cylinder block using O-ring bore cleaning brush IAW instructions supplied with O-ring bore cleaning brush.
- (5) Visually inspect cylinder liner (11) as follows:
- (a) Inspect cylinder liner outer diameter (11) for pitting and erosion as follows:

**CAUTION**

**If liner pitting has occurred, check condition of coolant.**

- 1 Refer to Figure 5-78. Inspect exterior length of liner for pitting (A). Check packing step for erosion (B). If pitting or erosion is observed, measure depth of pits with a fine wire or needle. Replace piston liner if depth of any pit is one-half or more of liner thickness (C) or depth of erosion is one-half or more of the packing step (D).
  - 2 Refer to Table 5-10 for cylinder liner specifications.
- (b) Measure cylinder liner thickness at several points. Refer to Table 5-10 for specifications. Replace piston and cylinder liner if out of specifications.
  - (c) Measure packing step dimension at several points. Refer to Table 5-10 for specifications.
  - (d) Inspect cylinder liner inner diameter for crosshatch honing pattern. Replace piston and cylinder liner if crosshatch honing pattern is not visible immediately below top ring turn-around area.
  - (e) Inspect cylinder liner inner diameter for pitting or deep vertical scratches that can be detected by the fingernail. Replace piston and liner if pitting or deep vertical scratches are detected.
  - (f) Carefully examine cylinder liner under magnification for signs of fatigue such as fine cracks in the flange area and cracks in the ring travel area. Replace piston and cylinder liner if signs of fatigue are observed.



**FIGURE 5-78. INSPECTING CYLINDER LINER PITTING**

- (g) Inspect cylinder block for cracks or erosion in the o-ring packing areas. Replace cylinder block, refer to paragraph 5.4.8, if cracks or erosion are observed.
- (h) Calculate piston-to-liner clearance as shown below. Replace piston and cylinder liner if any clearances exceed specifications.
  - 1 Position piston (4, Figure 5-72) without rings in matched cylinder liner with piston front and cylinder liner front aligned. Move piston down until bottom edge of piston skirt is 1.00 in. (25.4 mm) from bottom of cylinder liner.
  - 2 Use feeler gauge to measure piston skirt-to-cylinder liner clearance 90 degrees (1/4 turn) away from piston pin bore. Record measured clearance. Compare piston skirt-to-cylinder liner clearance with specifications given in Table 5-11.
  - 3 Turn piston 90 degrees (1/4 turn) in liner. Measure piston skirt-to-cylinder liner clearance 90 degrees (1/4 turn) away from piston pin bore. Record measured clearance.
  - 4 Remove piston from cylinder liner, turn piston upside down, and position piston upside down in cylinder liner with piston "front" and cylinder liner "front" aligned.
  - 5 Position piston so bottom edge of piston skirt is 1.00 in. (25.4 mm) below top of liner.



- 6 Measure piston skirt-to-cylinder liner clearance 90 degrees (1/4 turn) away from piston pin bore. Record measured clearance. Compare piston skirt-to-cylinder liner clearance with specifications given in Table 5-11.
  - 7 Turn piston 90 degrees (1/4 turn) in liner. Measure piston skirt-to-cylinder liner clearance 90 degrees (1/4 turn) away from piston pin bore. Record measured clearance. Compare piston skirt-to-cylinder liner clearance with specifications given in Table 5-11.
  - 8 The difference between clearances in steps 3 and 4 is the amount cylinder liner is out-of-round at bottom of cylinder liner. Compare cylinder liner out-of-round with specifications given in Table 5-11.
  - 9 The difference between clearances in steps 6 and 7 is the amount cylinder liner is out-of-round at bottom of cylinder liner. Compare cylinder liner out-of-round with specifications given in Table 5-11.
  - 10 The difference between clearances in steps 2 and 6 is the amount cylinder liner is tapered. Compare cylinder liner taper with specifications given in Table 5-11.
- (i) Measure cylinder liner flange thickness. Cylinder liner flange thickness should be 0.2371 - 0.2385 in. (6.022 - 6.058 mm). Replace piston and cylinder liner if cylinder liner flange thickness exceeds specifications.

<b>Table 5-10. Cylinder Liner Thickness Specifications.</b>	
Item	Specification
Cylinder Liner Thickness	0.2313 - 0.2510 in. (5.875 - 6.375 mm)
Packing Step Dimension	0.07947 - 0.09002 in. (2.0185 - 2.2865 mm)

<b>Table 5-11. Piston and Cylinder Liner Specifications (Continued).</b>	
Item	Specification
Piston-to-Liner Clearance (Measured at Bottom of Piston Skirt) for Turbocharged Engines	0.003 - 0.006 in. (0.08 - 0.15 mm)
Maximum Permissible Cylinder Out-of-Round	0.002 in. (0.05 mm)
Maximum Permissible Cylinder Taper	0.002 in. (0.05 mm)
Liner Height Above Block	0.001 - 0.004 in.(0.030 - 0.100 mm)

Table 5-11. Piston and Cylinder Liner Specifications (Continued).	
Item	Specification
Maximum Permissible height differences a Nearest Point of Two Adjacent Liners or Within A Single Liner	0.002 in. (0.05 mm)
Main Bearing bore in Cylinder Block	3.3250 - 3.3260 in. (84.455 - 84.481 mm)
Camshaft Follower Bore ID in Block	1.248 - 1.250 in. (31.70 - 31.75 mm)
Camshaft Follower	1.245 - 1.246 in. (31.61 - 31.64 mm)
Camshaft Follower-to-Bore Clearance	0.002 - 0.005 in. (0.06 - 0.13 mm)
<p style="text-align: center;"><b>NOTE</b></p> <p style="text-align: center;"><b>Front cam bore in block has a replaceable bushing; remaining machined bores do not have bushings.</b></p>	
Camshaft Bore ID: Front (No. 1) in Block (without bushing)	2.3607 - 2.3617 in. (59.961 - 59.987 mm)
Front (No. 1) in Block (with bushing)	2.2031 - 2.2042 in. (55.961 - 55.987 mm)
All except No. 1	2.2042 - 2.2052 in. (55.986 - 56.012 mm)

- (j) Measure cylinder liner height above cylinder block as follows:
1. Ensure that cylinder liner bore in cylinder block and top deck of cylinder block are clean.
  2. Install cylinder liner in cylinder liner bore without O-rings and packing.
  3. Insure that cylinder liner rotates smoothly by hand. If cylinder liner does not rotate smoothly by hand, remove cylinder liner and polish cylinder liner bore with emery cloth or Brush. Use shop towel or other suitable means to collect debris when polishing cylinder liner bore.
  4. Position cylinder liner with liner mark towards front of engine. Secure with capscrews and washers, refer to paragraph 5.4.5. Torque capscrews to 50 lb-ft (68 Nm).
  5. Using Piston and Liner Height Gauge and Dial Indicator, measure cylinder liner height above cylinder block at 1, 5, 7, and 11 o'clock positions as viewed from back of engine. Record measurement. Compare cylinder liner height above cylinder block with specifications given in Table 5-11.
  6. If cylinder liner height above cylinder block is above specification, check cylinder block for burrs. Repair or replace as required.

**CAUTION**

**Only one liner shim may be installed under each cylinder liner flange.**

- 7 If cylinder liner height is below specifications given in Table 5-11, install liner shim or replace as required.
- 8 Two shim sizes are available, 0.002 in.(0.05mm) and 0.004 in. (0.10 mm).

d. Repair.

- (1) Deglaze cylinder liner using Flexible Cylinder Hone and honing oil.
- (2) Use Flexible Cylinder Hone (D17004BR) in accordance with instructions supplied with hone to obtain a 45 degree cross-hatch pattern.
- (3) Thoroughly clean cylinder liner after deglazing, refer to step c. above.

e. Installation.

**CAUTION**

**Install cylinder liners into same cylinder block bore as removed. DO NOT scuff the liner packing across the upper counterbore.**

- (1) Remove all covering installed during step b (7).

**CAUTION**

**If liner outer diameter is pitted or eroded, but still within acceptable service limits, rotate liner 90 degrees from its removed position. Pitted sections of the liner should be facing the front or rear of the engine.**

- (2) Install liner in block bore with mark toward front of engine, unless outer diameter is pitted or eroded.

**CAUTION**

**If you suspect a packing may have sheared or displaced during liner installation, remove and examine the liner and packing assembly. If no damage is found, check packings for proper position. Resoap packings, and reinstall liner assembly.**

- (3) A resistance will be felt when the cylinder liner is aligned in pilot bore. Finish seating liners using clean, hardwood block and mallet. Gently tap hardwood block over top of cylinder liner with mallet.

**NOTE**

**Cylinder liner will protrude over top of cylinder block more than normal due to uncompressed packings and O-rings.**

- (4) Hold liners in place with large flat washers and capscrews. Turn capscrews snug but do not tighten.
- (5) Clean cylinder liner bores with waterless hand cleaner after installation. Wipe dry with clean towels.
- (6) Apply clean engine oil to liner bores immediately to prevent corrosion.

**5.4.7. BALANCER SHAFT ASSEMBLY**

a. Inspection Prior to Removal.

- (1) Remove timing gear cover, refer to paragraph 4.9.2.
- (2) Use a dial indicator and measure balancer shaft end play. New balancer shaft end play is 0.002 to 0.010 inch (0.05 to 0.26 mm).

**NOTE**

**If end play of balancer shaft exceeds specifications, then check thickness of thrust plate as this determines end play. Refer to paragraph c.**

- (3) Measure balancer timing gear backlash, as follows:
  - (a) Using a dial indicator, measure backlash between timing gears. Specifications are given for new parts (refer to Table 5-4).
    - (1) Measure upper balancer shaft gear-to-oil pump gear. Refer to Table 5-4.
    - (2) Measure lower idler gear-to-lower balancer shaft gear. Refer to Table 5-4.
  - (b) If backlash is not within specifications, install new timing gears.

b. Removal.

- (1) Remove timing gear cover, refer to paragraph 4.9.2.
- (2) Remove lower idler gear, refer to paragraph 5.4.2.
- (3) Remove oil pump gear, refer to paragraph 5.4.9.
- (4) Measure balancer shaft end play, refer to paragraph a.
- (5) Remove two capscrews (7, Figure 5-61) and lockwashers (8) securing each thrust plate (9 and 10); remove thrust plates (9 and 10). Discard lockwashers.

**CAUTION**

**During removal, identify left and right balancer shafts (13 and 14) for correct reassembly. Journals are lapped for one direction of rotation and interchanging shaft locations could cause premature wear of shafts and bushings.**

- (6) Remove balancer shafts (13 and 14).
- (7) If necessary, remove gear (11 or 12) from balancer shaft (13 or 14) using an arbor press and gear puller. Remove key (15) from shaft.
- (8) If necessary, use balancer shaft bushing driver and drive bushings (16) out of engine block.

c. **Test.**

- (1) With bushings (16, Figure 5-61) removed, check for cracked or broken block bosses.
- (2) Inspect for broken, cracked, or excessively worn gears (11 and 12).
- (3) Check thrust plates (9 and 10) for scoring or other excessive wear. New thrust plate thickness is 0.117 thickness to 0.119 inch (2.97 to 3.02 mm). Refer to Table 5-4.
- (4) Inspect bushings (16) in engine block for wear or damage.
- (5) Measure balancer shaft bushing (16) inner diameter. New standard bushing diameter is 1.5818-1.5841 inches (40.177-40.237 mm). Refer to Table 5-4.
- (6) Measure balancer shaft journal diameter. New part diameter is 1.5801-1.5811 inches (40.135-40.161 mm). Refer to Table 5-4.
- (7) Subtract journal diameter from bushing diameter. New part oil clearance is 0.0006-0.0040 (0.0016-0.102 mm). Maximum allowable oil clearance is 0.006 inch (0.15 mm). Refer to Table 5-4.
- (8) Install new bushings (16) and/or a new balancer shaft (13 or 14) if oil clearance is not within specification.

d. **Replacement.**

- (1) Inspect balancer shaft prior to removal, refer to step a.
- (2) Remove balancer shaft assembly, refer to step b.
- (3) Perform test procedures on balancer shaft, refer to step c. Replace balancer shaft if it is not within specification.
- (4) Install balancer shaft, refer to step e.

e. Installation.

**CAUTION**

**Make sure oil hole in bushing (16, Figure 5-61) is aligned with oil passage in block for proper bushing and journal lubrication.**

- (1) If removed, use balancer shaft bushing driver (JD249) to drive new bushings (16, Figure 5-61) into engine block.

**NOTE**

**Adequate bushing-to-balancer shaft clearance exists, if shaft can be rotated by hand with a slight-to-moderate drag. It is not necessary to hone bushing to obtain specified oil clearance. Excessive clearance can result in shaft seizure.**

- (2) If gear (11 or 12) was removed, install as follows:
  - (a) Install key (15) in slot on shaft.
  - (b) Position balancer shaft (13 or 14) in balancer shaft holding tool.
  - (c) Install thrust plate (9 or 10) and gear (11 and 12) on balancer shaft. Be sure timing mark on gear faces away from balancer shaft.
  - (d) Press gear onto shaft with a tube-type driver and arbor press. Press gear until a clearance of 0.002 to 0.008 inch (0.005 and 0.20 mm) exists between thrust plate and gear/shoulder.
- (3) Make sure engine is at TDC (refer to paragraph 4.7.2) (No. 1 piston on compression stroke), with timing pin engage in flywheel.
- (4) Apply a liberal amount of clean engine lubricating oil, MIL-L-2104, to bushings (16) in engine block and to balancer shaft (13 and 14) journals.

**CAUTION**

**Do not intermix shafts (13 and 14) or gears (11 and 12) in location from which they were removed. Shafts are lapped for one direction of rotation, and exchanging locations could cause premature wear of shafts and bushings. If doubt exists as to which shaft is left- or right-hand, always replace the balancer shaft bushings (16).**

- (5) Install balancer shafts (13 and 14) and thrust plates (9 and 10).
- (6) Secure each thrust plate (9 and 10) with two capscrews (7) and new lockwashers (8). Tighten capscrews to 26 lb-ft (35 Nm).

- (7) Time balancer shaft as follows:
  - (a) Turn right (camshaft side) balancer shaft (14) so timing mark is under. Timing mark on both balancer shaft gears (11 and 12) must align with centerline of crankshaft when correctly timed.
  - (b) Install lower idler gear, and without turning balancer shaft, secure gear. Spring pin must enter hole in washer when it is installed.
  - (c) Install thrust washer over lower idler gear and shaft. Install capscrew through idler shaft into threaded leg of oil pump housing, and finger-tighten only.
  - (d) Turn left (injection pump side) balancer shaft (13) so timing mark is under timing tool (JD254).
  - (e) Install oil pump gear. Finger-tighten gear retaining nut.
  - (f) Recheck gear timing for both balancer shafts (13 and 14).
  - (g) Torque oil pump drive gear retaining nut to 37 lb-ft (50 Nm). Stake nut to shaft in three places.
  - (h) Torque lower idler gear capscrew to 59 lb-ft (80 Nm).
- (8) Install timing gear cover. Refer to paragraph 4.9.2.

#### 5.4.8. CYLINDER BLOCK.

##### NOTE

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

- a. Disassembly.
  - (1) If not already performed, mount engine on rotating repair stand. Refer to paragraph 4.10.
  - (2) Drain coolant and oil. Refer to TM 9-6115-671-14.
  - (3) Remove fan belts. Refer to TM 9-6115-671-14.
  - (4) Remove alternator, refer to paragraph 3.9.1.
  - (5) Remove turbocharger, refer to paragraph 4.4.1.
  - (6) Remove exhaust manifold, refer to paragraph 4.4.3.

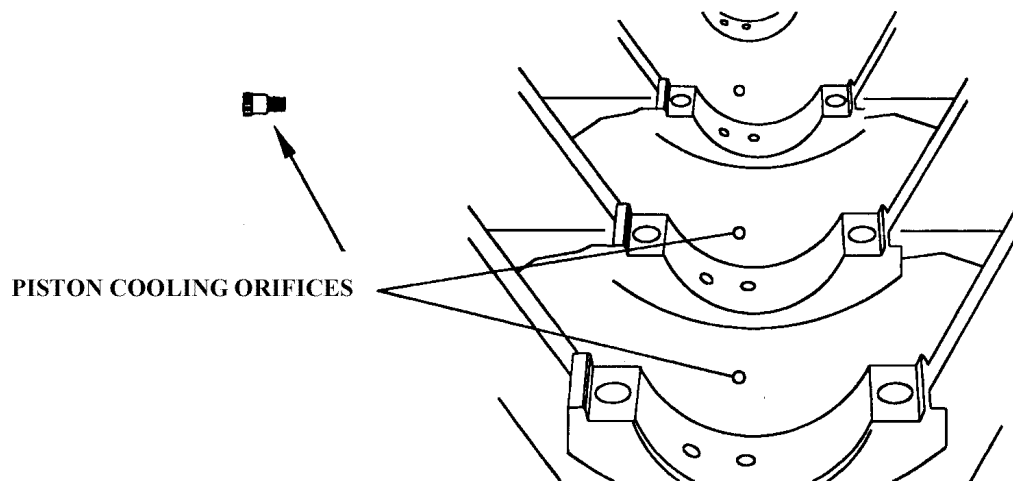
- (7) Remove rocker arm cover, refer to paragraph 4.7.1. If option code label is located on rocker arm cover, be careful not to damage label.
- (8) Remove water manifold and thermostat housing, refer to paragraph 3.8.2.
- (9) Remove oil cooler piping, refer to paragraph 3.11.3.
- (10) Remove water pump, refer to paragraph 3.8.3.
- (11) Remove dipstick, refer to paragraph 3.11.5.
- (12) Remove oil filter and oil cooler, refer to paragraph 3.11.3.
- (13) Remove oil pressure regulating valve assembly, refer to paragraph 4.5.2.
- (14) Remove fuel filter, refer to paragraph 3.12.2.
- (15) Remove fuel supply pump, refer to paragraph 3.12.3.
- (16) Remove fuel line, refer to paragraph 3.12.4.
- (17) Remove injection lines, refer to paragraph 3.12.4.
- (18) Remove injection pump, refer to paragraph 4.6.1.
- (19) Remove injection nozzles, refer to paragraph 4.6.2.
- (20) Remove starter, refer to paragraph 3.9.2.
- (21) Remove rocker arm assembly and push rods, refer to paragraph 4.7.3. Keep push rods in order.
- (22) Remove cylinder head, refer to paragraph 4.7.4.
- (23) Remove cam followers, refer to paragraph 4.7.4.
- (24) Remove flywheel, refer to paragraph 4.8.1.
- (25) Remove flywheel housing, refer to paragraph 4.8.3.
- (26) Remove oil pan, refer to paragraph 4.5.3.
- (27) Remove crankshaft pulley, refer to paragraph 4.9.1.
- (28) Remove timing gear cover, refer to paragraph 4.9.2.
- (29) Remove oil pump drive gear, outlet tube and pump body, refer to paragraph 4.5.4. and 5.4.9.
- (30) Remove timing gears and camshaft, refer to paragraph 5.4.1.
- (31) Remove engine front plate, refer to paragraph 5.4.3.



- (32) Remove oil bypass valve, refer to paragraph 5.4.10.
- (33) Remove pistons and rods, refer to paragraph 5.4.5. Stamp cylinder number on connecting rods.
- (34) Remove crankshaft and main bearings, refer to paragraph 5.4.4.
- (35) Remove cylinder liners, refer to paragraph 5.4.6. Mark each one with cylinder number.
- (36) Remove camshaft bushing, refer to paragraph 5.4.1.

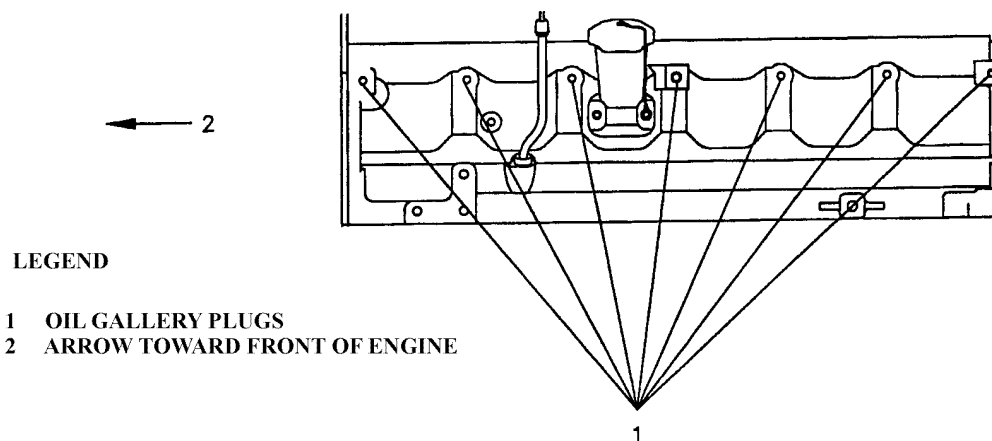
b. Repair.

- (1) Clean cylinder block using the following procedures:
  - (a) Remove engine and perform steps listed in paragraph a. to expose cylinder block.
  - (b) Remove piston cooling orifices (1), Figure 5-79.



**FIGURE 5-79. INSPECTING PISTON COOLING ORIFICE**

- (c) Remove oil gallery plugs (1), Figure 5-80 using Oil Gallery Plug Tool.
- (d) Remove soft plugs (7,9), Figure 4-51.
- (e) Clean upper and lower liner bores with nylon brush.



**FIGURE 5-80. OIL GALLERY PLUGS**

**WARNING**

Cleaning solvent is flammable and toxic to eyes, skin and respiratory tract. Skin and eye protection are required. Avoid repeated/prolonged contact. Good general ventilation is normally adequate.

**WARNING**

Compressed air used for cleaning can create airborne particles that can enter the eyes. Pressure will not exceed 30 psig (207 kPa). Eye protection required.

**CAUTION**

If engine block is cleaned in a hot tank, be sure to remove any aluminum parts (such as nameplates). Aluminum parts can be damaged or destroyed by hot tank solutions.

- (e) Thoroughly clean engine block using solvent or pressure steam. If necessary, place engine block in "hot tank" for total cleaning. Before dipping, ensure any aluminum parts such as the engine serial number plate has been removed.
- (2) After thorough cleaning, inspect and clean cylinder block as follows:

**NOTE**

All components (including piston cooling orifices, soft plugs and oil gallery plugs) must be removed from the cylinder block for inspection and cleaning.

- (a) Inspect each piston orifice (1, Figure 5-79) to make sure it is not plugged or damaged. Cooling orifices deliver approximately 0.4 gallon per min (1.50 liters/min) oil flow.
- (b) Use soft wire brush and compressed air to clean orifice. Replace if condition is questionable.

**CAUTION**

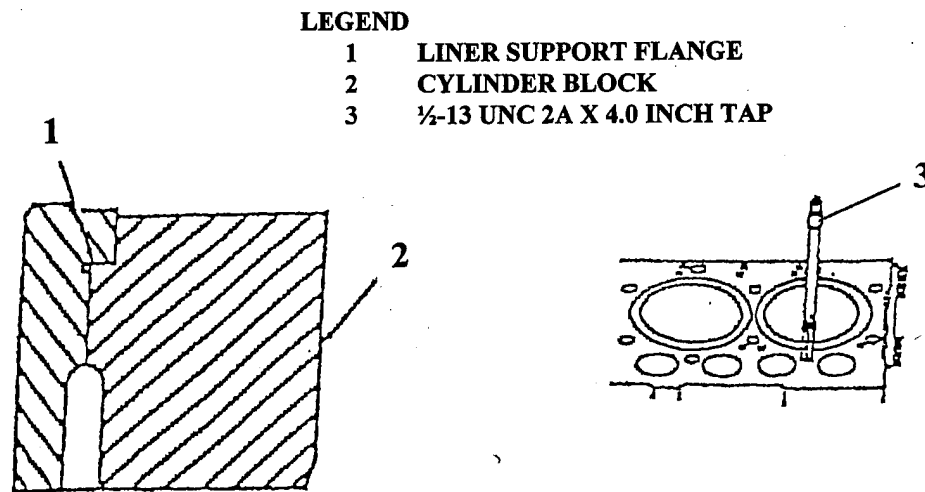
**A piston cooling orifice failure could cause damage to piston, piston pins, rod pin bushings, and liners. If a piston cooling orifice is left out of assembly, low or no oil pressure will result.**

- (c) Inspect all passages and crevices to ensure they are cleared of sludge and grease.
- (d) Inspect all coolant passages to ensure they are cleared of any lime deposits and scale.

**CAUTION**

**Do not file liner support flange excessively. Excess filing can damage liner support flange and may result in an improper fit. Thoroughly clean all filings from cylinder block (2, Figure 5-81). Failure to comply may result in engine damage.**

- (e) Be sure liner support flange (1, Figure 5-81) is free of any burrs. If burrs are present, use a small half-moon file and lightly file (in a circular motion) burr off at approximately 60 degree angle. Do not let file hit top of cylinder block while filing.



**FIGURE 5-81. INSPECTING CYLINDER BLOCK**

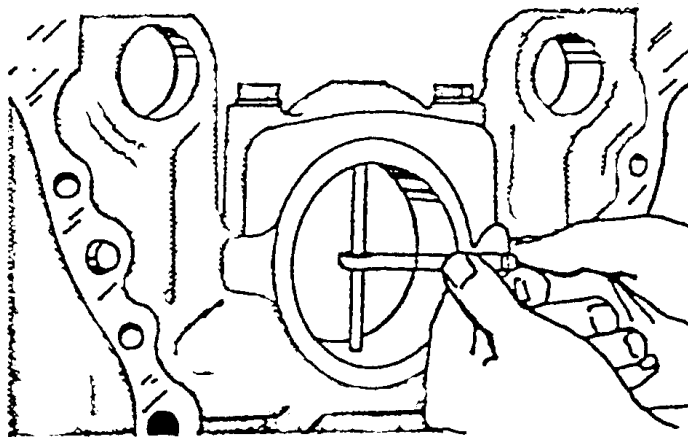
- (f) Carefully inspect cylinder block for cracks or damage. Replace block if there is evidence of physical damage.

- (g) When determined that cylinder block is serviceable, clean out threads for cylinder head capscrews in top deck of cylinder block using 1/2-13 UNC-2A x 4.00 inches (101.6 mm) long tap (3). Use compressed air to remove any debris or fluid which may be present in the tapped holes after cleaning.
- (h) Inspect O-ring bore. If required, clean O-ring bore using O-ring bore cleaning brush as follows:
  - 1 Chuck bore cleaning brush in 1/2 inch drill motor. Rotate brush and move in an up and down motion in O-ring bore.
  - 2 Thoroughly clean all lime deposits from O-ring bore.
- (3) Test the cylinder block to confirm that it is within specifications. Perform testing using the following steps:

**NOTE**

**The cylinder block measurements must be made with the main bearing caps installed.**

- (a) Before assembly of main bearing caps, identify markings and ensure caps are reinstalled in their original position. Refer to paragraph 5.4.4. Install main bearing caps (without bearings) in cylinder block and tighten to 100 lb-ft (135 Nm).
- (b) Measure main bearing bore diameter, refer to Figure 5-82. Refer to Table 5-11 for specifications.
- (c) Measure engine block main thrust bearing width. Refer to Table 5-5 for specifications.
- (d) If bearing caps are damaged, or bore is not within specifications, replace cylinder block.

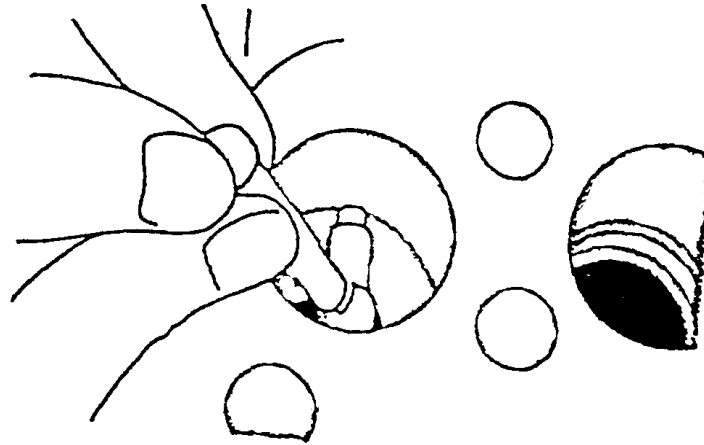


**FIGURE 5-82. MEASURING MAIN BEARING BORE**

**NOTE**

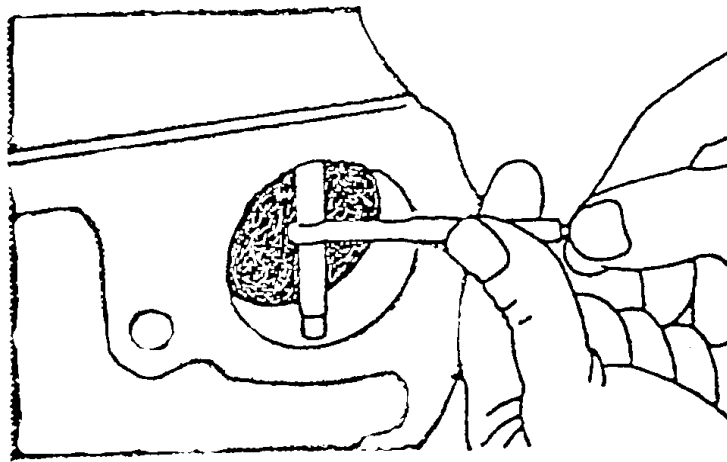
**Replacement bearing caps are supplied with bearing bore unfinished.**

- (e) Measure cam follower bore diameter, refer to Figure 5-83. Refer to Table 5-11 for values of the following; camshaft follower bore inner diameter in block, camshaft follower outer diameter (new) and camshaft follower-to-bore clearance.



**FIGURE 5-83. MEASURING CAM FOLLOWER BORE DIAMETER**

- (f) Measure camshaft bore diameter, refer to Figure 5-84. Refer to Table 5-11 for specifications of the following; camshaft bore inner diameter front No. 1, in block without bushing, front No. 1 in block with bushing and all except No. 1.



**FIGURE 5-84. MEASURING CAMSHAFT BORE DIAMETER**

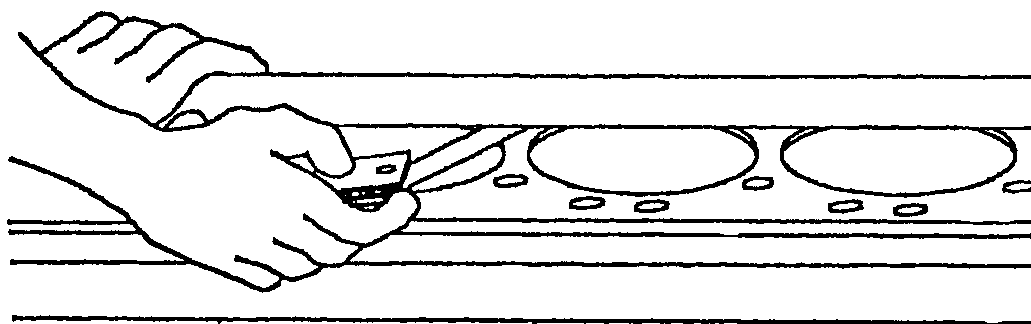
**CAUTION**

When cylinder block is machined (top deck or crankshaft bearing bores), the dimension from centerline of crankshaft bearing bore to top deck will be changed. Ensure that this dimension is not less than 13.302 inches (337.89 mm). Otherwise, piston may contact cylinder head.

**CAUTION**

**If cylinder block top deck is resurfaced, also measure depth of liner counterbores. Bore depth must be within 0.234 to 0.236 inch (5.95 to 5.99 mm).**

- (g) Measure cylinder block top deck flatness using precision straightedge, refer to Figure 5-85. New flatness is 0.003 inch (0.08 mm). If flatness is not as specified, resurface engine block.



**FIGURE 5-85. MEASURING CYLINDER BLOCK TOP DECK FLATNESS**

- (4) Install plugs and piston cooling orifices in engine block.
  - (a) Install all plugs and serial number plate in cylinder block (if removed).
  - (b) Install piston cooling orifices; tighten to 8 lb-ft (11 Nm).

c. Reassembly.

- (1) Install cylinder liners without O-rings. Measure liner height, refer to paragraph 5.4.6.
- (2) Install new liners with O-rings, refer to paragraph 5.4.6.
- (3) Install main bearings and crankshaft, refer to paragraph 5.4.4. PLASTIGAGE bearings.
- (4) Install flywheel housing, refer to paragraph 4.8.3.
- (5) Install rear oil seal, refer to paragraph 4.8.2
- (6) Install flywheel, refer to paragraph 4.8.1.
- (7) Install pistons and rods, refer to paragraph 5.4.5. Measure piston protrusion.
- (8) Install oil by-pass valve, refer to paragraph 5.4.10.
- (9) Install front plate, refer to paragraph 5.4.3.
- (10) Install oil outlet tube, O-ring in block, and oil pump, refer to paragraph 4.5.4. and 5.4.9.
- (11) Install injection pump, refer to paragraph 4.6.1.

- (12) Install camshaft bushing and timing gears, refer to paragraph 5.4.1.
- (13) Time all gears with No. 1 cylinder at TDC compression stroke, refer to paragraph 5.4.1.
- (14) Install timing gear cover and install new front seal, refer to paragraph 4.9.2.
- (15) Install oil pan, refer to paragraph 4.5.3.
- (16) Install oil pressure regulating valve, refer to paragraph 4.5.2.
- (17) Install cam followers in same order as removed, refer to paragraph 4.7.4.
- (18) Install cylinder head gasket, refer to paragraph 4.7.4.
- (19) Install cylinder head, push rods, and rocker arm assembly, refer to paragraph 4.7.3.
- (20) Install starting motor, refer to paragraph 3.9.2.
- (21) Install injection nozzles (with new seals), refer to paragraph 4.6.2.
- (22) Install injection lines, refer to paragraph 4.6.1. and 3.12.4.
- (23) Install fuel filter, refer to paragraph 3.12.2.
- (24) Install fuel supply pump, refer to paragraph 3.12.3
- (25) Install fuel lines, refer to paragraph 3.12.4.
- (26) Install oil cooler, refer to paragraph 3.11.3.
- (27) Install new oil filter, and dipstick, refer to paragraph 3.11.5.
- (28) Install water manifold or thermostat housing and thermostats, refer to paragraph 3.8.2.
- (29) Install exhaust manifold, refer to paragraph 4.4.3.
- (30) Install turbocharger, refer to paragraph 4.4.1. Prelube the turbocharger, refer to paragraph 4.4.1.
- (31) Install water pump, refer to paragraph 3.8.3.
- (32) Install hoses, refer to TM 9-6115-671-14.
- (33) Install crankshaft pulley, refer to paragraph 4.9.1.
- (34) Install alternator, refer to paragraph 3.9.1.
- (35) Install belt tensioner, fan and fan belts, refer to TM 9-6115-671-14.
- (36) Adjust valves, refer to paragraph 4.7.2.
- (37) Install rocker arm cover, refer to paragraph 4.7.1.

- (38) Install vent tube, refer to TM 9-6115-671-14.
- (39) Fill engine with clean oil and proper coolant, refer to TM 9-6115-671-14.
- (40) Perform engine break-in and standard performance checks, refer to TM 9-6115-671-14.

#### 5.4.9 OIL PUMP ASSEMBLY.

##### **NOTE**

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

##### a. Removal.

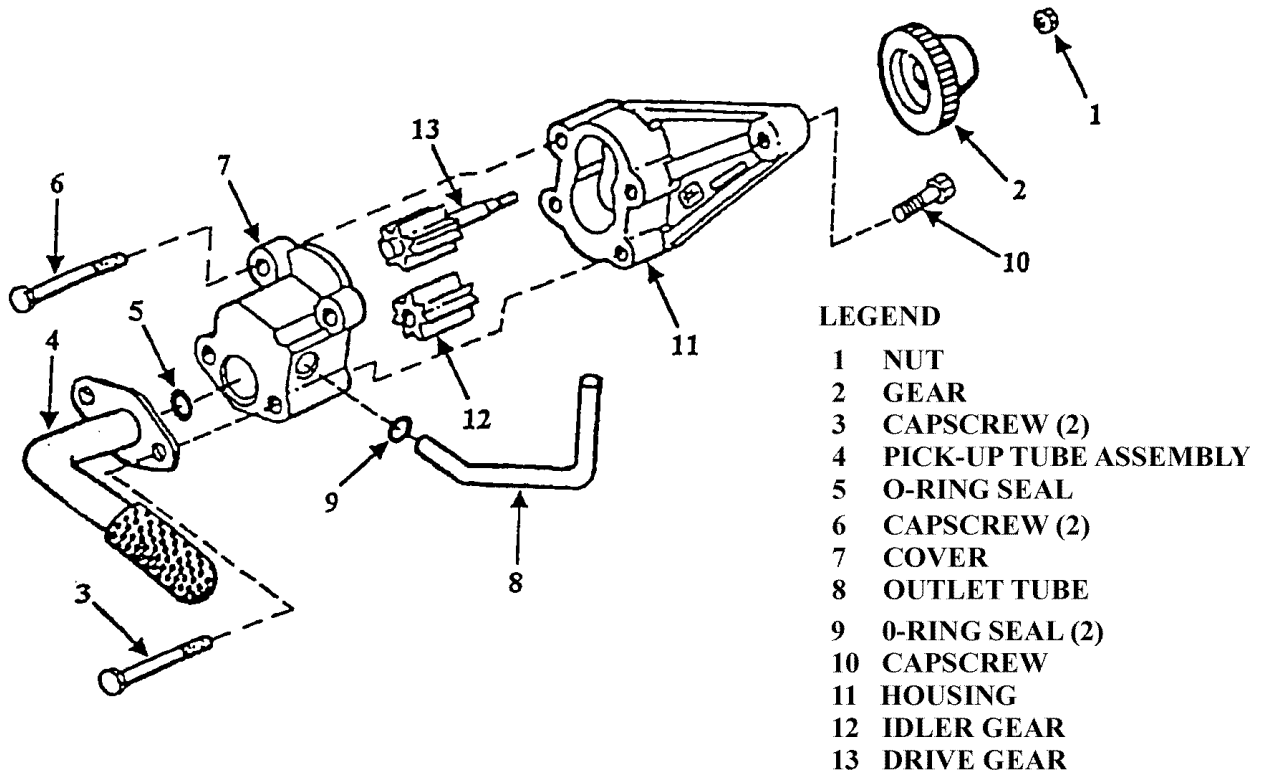
- (1) Drain engine lubrication system, refer to TM 9-6115-671-14.

##### **CAUTION**

**Oil inlet line is fragile and can become twisted and damaged during maintenance. Always use one wrench to hold one fitting stationary while the other fitting is loosened or tightened. Failure to comply can cause damage to equipment.**

- (2) Disconnect turbocharger oil inlet line (3, Figure 4-36) at turbocharger.
- (3) Remove oil pan, refer to paragraph 4.5.3.
- (4) Loosen nut (1, Figure 5-86) several turns until nut covers end of shaft. Using two small pry bars, apply force between front plate and gear (2) on two sides of gear. If gear does not loosen, loosen capscrews (3, 6, and 10) and strike nut with a small lead hammer while applying force to gear until gear loosens. Remove nut and gear. Discard nut.
- (5) Remove capscrews (3), pick-up tube assembly (4) and O-ring seal (5). Discard O-ring seal.
- (6) Remove capscrews (6), cover (7), outlet tube (8), and O-ring seals (9). Discard O-ring seals.
- (7) Remove capscREW (10) and housing (11).
- (8) Cover all openings to prevent entry of foreign material.





**FIGURE 5-86. OIL PUMP ASSEMBLY**

b. Inspection.

- (1) Remove oil pump assembly, refer to step a.
- (2) Remove idler gear (12, Figure 5-86) and drive gear (13) from oil pump housing.

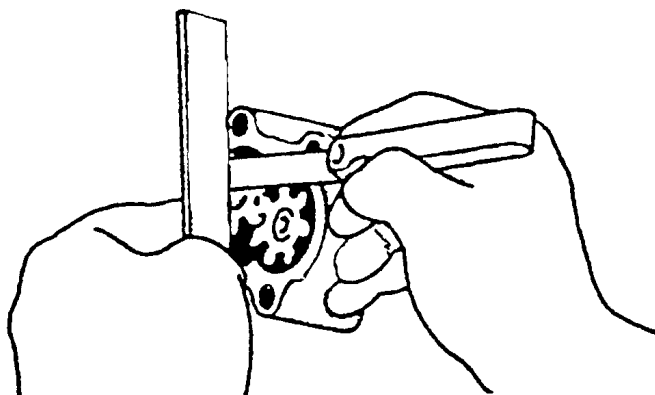
**WARNING**

Cleaning solvent is flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection are required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.

**WARNING**

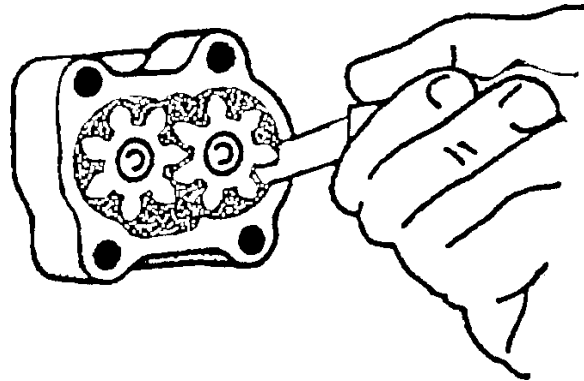
**Compressed air used for cleaning can create airborne particles that may enter the eyes. Never exceed 30 psi (207 kPa) of pressure. Eye protection required. Failure to comply could result in serious eye damage or blindness.**

- (3) Clean oil pump parts in cleaning solvent. Dry with compressed air.
- (4) Inspect oil pump components for excessive wear. Replace parts or oil pump assembly as necessary.
- (5) Inspect outlet tube (8) and pick-up tube assembly (4) for cracks or defects. Replace parts as necessary.
- (6) Install idler gear (12) and drive gear (13).
- (7) Using straight edge and feeler gage, check axial clearance between idler gear (12) and housing (11, Figure 5-86), refer to Figure 5-87. Replace oil pump if clearance is not 0.0018 - 0.0065 in. (0.045 - 0.165 mm).



**FIGURE 5-87. OIL PUMP AXIAL CLEARANCE**

- (8) Using straight edge and feeler gage, check axial clearance between drive gear (13) and housing (11), refer to Figure 5-87. Replace oil pump if clearance is not 0.0018 - 0.0065 in. (0.045 - 0.165 mm).
- (9) Using feeler gage, check radial clearance between idler gear (12) and housing (11), refer to Figure 5-86. Replace oil pump if clearance is not 0.005 - 0.008 in. (0.131 - 0.211 mm).
- (10) Using feeler gage, check radial clearance between drive gear (13) and housing (11), refer to Figure 5-88. Replace oil pump if clearance is not 0.005 - 0.008 in. (0.131 - 0.211 mm).
- (11) Remove idler gear (12, Figure 5-86).



**FIGURE 5-88. OIL PUMP RADIAL CLEARANCE MEASUREMENT.**

- (12) Using inner diameter micrometer, measure idler gear (12) inner diameter. Replace oil pump if idler gear inner diameter is not 0.4864 - 0.4867 in. (12.355 - 12.363 mm).
  - (13) Using outer diameter micrometer, measure idler gear (12) thickness. Replace oil pump if idler gear thickness is not 1.4163 - 1.4183 in. (35.975 - 36.025 mm)
  - (14) Using outer diameter micrometer, measure outer diameter of shaft inside housing (11). Replace oil pump if shaft outer diameter is not 0.4849 - 0.4855 in. (12.316 - 12.332 mm).
  - (15) Remove drive gear (13).
  - (16) Using outer diameter micrometer, measure drive gear (13) shaft outer diameter. Replace oil pump if drive gear shaft outer diameter is not 0.6306 - 0.6314 in. (16.017 - 16.037 mm).
  - (17) Using outer diameter micrometer, measure drive gear (13) thickness. Replace oil pump if drive gear thickness is not 1.4163 - 1.4183 in. (35.975 - 36.025 mm)
  - (18) Using inner diameter micrometer, measure bushing inner diameter inside housing (11). Replace oil pump if bushing inner diameter is not 0.6320 - 0.6339 in. (16.052 - 16.102 mm).
  - (19) Inspect cover (7) and housing (11) for evidence of gear rub. Light contact is acceptable. Replace oil pump if parts are heavily worn.
  - (20) Install idler gear (12) and drive gear (13).
  - (21) Install oil pump assembly, refer to step d.
- c. Replacement.
- (1) Remove oil pump assembly, refer to step a.
  - (2) Inspect oil pump assembly, refer to step b. Replace oil pump components found defective during inspection. Replace entire oil pump if components are not within specifications. Refer to step d for installation.

d. Installation.

- (1) Remove all covering installed during step a (8).
- (2) Position housing (11, Figure 5-86) on front plate. Install capscrew (10) finger tight.
- (3) Position O-ring seal (9) and outlet tube (8) in cylinder block.
- (4) Position O-ring seal (9) in cover (7). Position cover on housing (11) and outlet tube (8). Install capscrews (6) finger tight.
- (5) Position O-ring seal (5) and pick-up tube assembly (4) on cover (7). Install capscrews (3) finger tight.
- (6) Torque capscrews (3, and 6) evenly in cross pattern to 26 lb-ft (35 Nm).
- (7) Torque capscrew (10) to 59 lb-ft (80 Nm).
- (8) Position gear (2) on shaft. Install new nut (1) and torque to 37 lb-ft (50 Nm).
- (9) Stake nut (1) to shaft by applying three center punch marks near inner diameter of nut.

5.4.10 OIL BYPASS VALVE ASSEMBLY.

**NOTE**

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

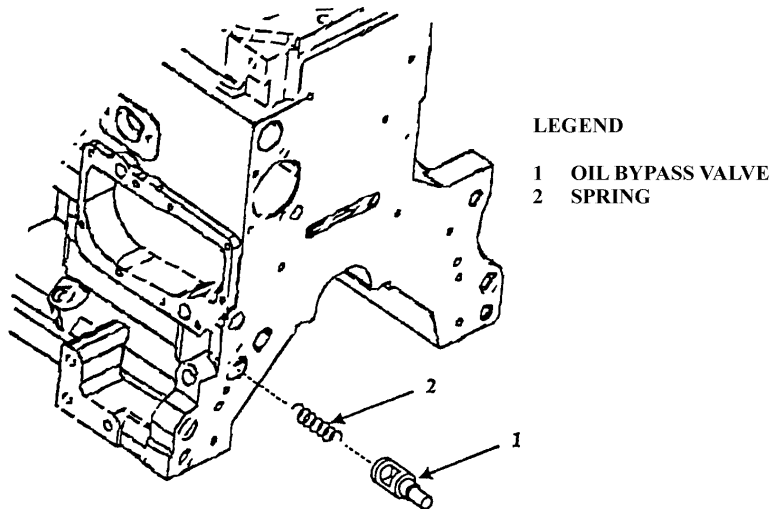
a. Removal.

- (1) Remove front plate, refer to paragraph 5.4.3.
- (2) Remove oil bypass valve (1, Figure 5-89) and spring (2).
- (3) Cover all openings to prevent entry of foreign material.

b. Inspection.

- (1) Remove oil bypass valve assembly, refer to step a.

- 2) Inspect oil bypass valve (1, Figure 5-89) for damage. Replace parts as necessary.



**FIGURE 5-89. OIL BYPASS VALVE.**

- (3) Inspect spring (2) as follows:
  - (a) Inspect spring (2) for damage.
  - (b) Using a ruler, check free length of spring (2). Free length of spring should be 2.00 in. (51 mm). Replace spring if out of specifications.
  - (c) Using a spring tester, apply force to spring (2, Figure 5-89) until spring is compressed to a length of 1.14 in. (29 mm). Spring tension should be 20 lbs. (87.8 N). Replace spring if out of specifications.

c. Replacement.

- (1) Remove oil bypass assembly, refer to step a.
- (2) Inspect oil bypass assembly, refer to step b. Replace oil bypass valve (1, Figure 5-89) or spring (2), if found defective.
- (3) Install oil bypass valve assembly, refer to step d.

d. Installation.

- (1) Remove all covering installed during step a (3).
- (2) Position spring (2, Figure 5-89) and oil bypass valve (1) in cylinder block.
- (3) Install front plate, refer to paragraph 5.4.3.

5.4.11. CYLINDER HEAD.

**NOTE**

**The following procedures require complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

a. Disassembly.

- (1) Remove cylinder head, refer to paragraph 4.7.4.a.

**WARNING**

**Block cylinder head with a solid block of wood at each end of cylinder head while using spring compressor. Failure to comply could result in serious personal injury.**

**WARNING**

**Do not stand in front of valve spring while compressing valve springs. Failure to comply could result in serious personal injury.**

**NOTE**

**Identify all parts for correct assembly. Use a valve board or other suitable means of keeping valves in order.**

- (2) Using valve spring compressor, compress valve spring (4, Figure 4-52) and remove valve spring retainers (2).
- (3) Release valve spring (4) tension and remove valve rotator (3) and valve spring (4).
- (4) Remove valve (10, 11) from cylinder head.
- (5) Remove valve stem seal (13) from valve guide tower.

b. Repair.

**NOTE**

**The following procedure is provided for repairing the cylinder head. Remove cylinder head (refer to paragraph 4.7.4. step a.) and place on a suitable workbench.**

- (1) Inspect valve springs as follows:
  - (a) Inspect valve springs for alignment, wear, and damage. Replace all defective valve springs.

- (b) Put valve springs on flat surface to insure that valve springs are square and parallel. Replace all defective valve springs.
- (c) Measure valve spring free length. Free length of valve spring should be 2.125 in. (54.4 mm). Replace valve spring if not within specifications.
- (d) Test valve spring tension with spring compression tester (DO1168AA). Replace valve spring if not within specifications.
  - 1 At 1.81 in. (46.0 mm) height, valve spring tension should be 54 - 62 lb-force (240 - 280 N).
  - 2 At 1.36 in. (34.5 mm) height, valve spring tension should be 133 - 153 lb-force (590 - 680 N).
- (2) Inspect valve rotators to insure that valve rotators turn freely in both directions. Replace if defective.
- (3) Clean, inspect, and measure valves as follows:

**WARNING**

**When using bench grinder, eye protection must be worn to prevent particles from entering eyes. Failure to comply could result in serious eye damage or blindness.**

**CAUTION**

**Do not use wire wheel on plated portion of valve stem. Failure to comply could result in damage to valve and valve guide.**

- (a) Remove all carbon from valve head, face, and unplated portion of valve stem using a soft wire wheel on a bench grinder.
- (b) Polish valve stem with steel wool or crocus cloth to remove any scratch marks left by wire brush.
- (c) Clean and inspect valves, valve stems, valve stem tips, and retainer lock groove for cracks, wear, or evidence of physical damage. Replace valves that are worn or damaged.
- (d) Measure valve stem outer diameter with outer diameter micrometer. Record measurements and compare with valve guide inner diameter, refer to step 4 (i). Replace valves not within specifications.

**NOTE**

**Intake valve has a larger head outer diameter and is also identified with a dimple on valve head.**

- 1 Intake valve outer diameter should be 0.3096 - 0.3104 in. (7.864 - 7.884 mm).

2 Exhaust valve outer diameter should be 0.3090 - 0.3100 in. (7.848 - 7.874 mm).

- (e) Use valve inspection center (D-05058ST) to determine if valves are out of round, bent or warped. Maximum valve face runout is 0.0015 in. (0.038 mm). Replace valves not within specifications.

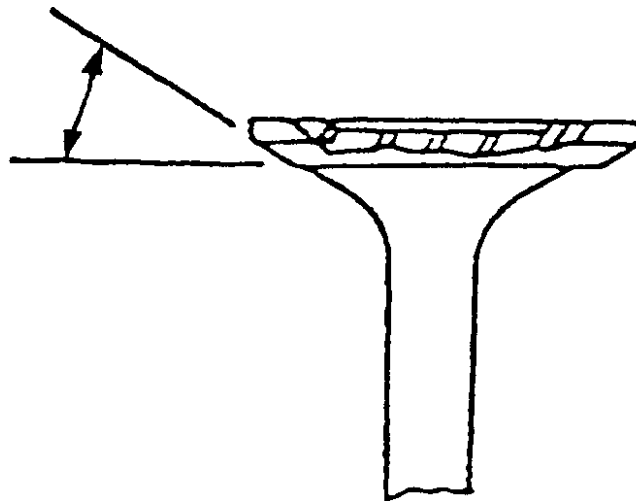
**CAUTION**

**Do not nick valve head-to-stem radius while grinding valves. A nick could cause valve to break. Break all sharp edges after grinding valve. Failure to comply could result in damage to engine.**

- (f) Reface valve to  $29.25^\circ \pm 0.25^\circ$  using valve refacing station, refer to Figure 5-90.

(4) Clean, inspect, and measure cylinder head as follows:

- (a) Inspect combustion face for evidence of physical damage, oil or coolant leakage, or gasket failure. Repair or replace cylinder head if there is evidence of physical damage; such as cracking, abrasion, distortion, or valve seat "torching". Inspect all cylinder head passages for restrictions.



**FIGURE 5-90. VALVE FACE ANGLE**

- (b) Remove all plugs from cylinder head.
- (c) Scrape gasket material, oil, carbon, and rust from cylinder head. Use a powered wire brush to clean sealing surfaces.



**WARNING**

**Cleaning solvent is flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection are required. Avoid repeated/prolonged contact. Provide adequate ventilation. Failure to comply could result in serious injury or death.**

**WARNING**

**Compressed air used for cleaning can create airborne particles that may enter the eyes. Never exceed 30 psi (207 kPa) of pressure. Eye protection required. Failure to comply could result in serious eye damage or blindness.**

- (d) Clean cylinder head in chemical hot tank if available, or with solvent and brush if hot tank is not available. Dry cylinder head with compressed air and blow out all passages.
- (e) Check cylinder head flatness as follows:
  - 1 Check cylinder head flatness with precision straightedge and feeler gage. Check lengthwise, crosswise, and diagonally in several places.
  - 2 Maximum acceptable out of flat measurements are 0.003 in. (0.08 mm) for entire length or width of cylinder head and 0.001 in. (0.03 mm) for every 5.90 in. (150 mm).
  - 3 If any measurement exceeds specifications, cylinder head must be resurfaced or replaced. To determine if cylinder head can be resurfaced, refer to step 4 (f). (Measure cylinder head thickness).
- (f) Measure cylinder head thickness from valve cover gasket rail-to-combustion face using outer diameter micrometer. Minimum acceptable cylinder head thickness is 4.104 in. (104.24 mm). Replace cylinder head if out of specifications. Refer to Figure 5-91.

**NOTE**

**Resurfacing cylinder head is only necessary if cylinder head fails cylinder head flatness test, refer to step 4 (e).**

- (g) Resurface cylinder head as follows:
  - 1 Resurface cylinder head if cylinder head thickness is less than the minimum acceptable thickness of 4.104 in. (104.24 mm). Remove only what is necessary to restore flatness.
  - 2 Combustion face surface finish (surface grind only) should be 31 - 125 micro-in. (0.7 - 3.2 micrometers). Maximum wave depth is 0.0005 in. (0.012 mm).

- 3 Recheck cylinder head flatness, refer to step 4 (e).
- 4 Recheck cylinder head thickness, refer to step 4 (f).
- 5 Recheck valve recess in cylinder head, refer to paragraph 4.7.4.b.

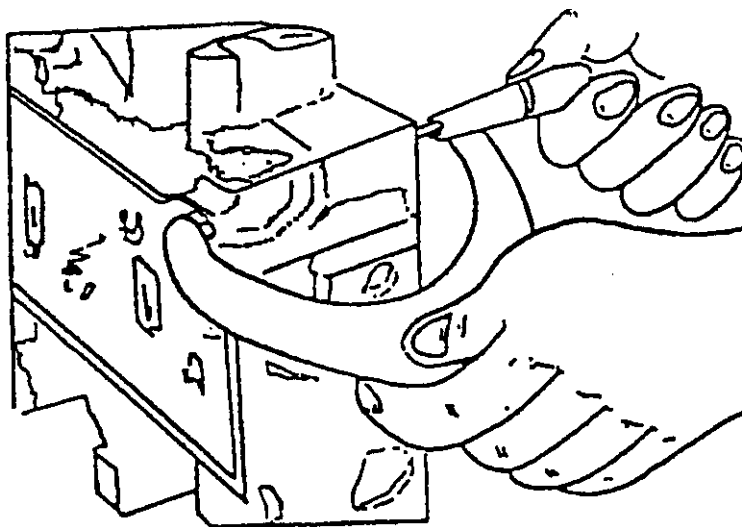


FIGURE 5-91. MEASURING CYLINDER HEAD THICKNESS

**WARNING**

Compressed air used for cleaning can create airborne particles that may enter the eyes. Never exceed 30 psi (207 kPa) of pressure. Eye protection required. Failure to comply could result in serious eye damage or blindness.

- (h) Clean injection nozzle bores with nozzle bore cleaning tool. Blow debris from bore with compressed air.
- (i) Clean and measure valve guides as follows:
  - 1 Clean valve guides with plastic brush and a few drops of light oil or kerosene.
  - 2 Measure valve guide inner diameter using telescopic gauge and record measurements.
  - 3 Calculate valve guide-to-stem oil clearance by subtracting valve stem outer diameter from valve guide inner diameter. Valve guide-to-stem oil clearance should be 0.002 - 0.006 in. (0.05 - 0.15 mm).
  - 4 If valve guide-to-stem oil clearance is out of specifications, knurl, thread, and ream valve guides, refer to step 4 (j).

**NOTE**

**Valve guides only need to be knurled, threaded, and reamed if valve guide-to-stem oil clearance in Step 4(i) (above) is out of specifications.**

- (j) Knurl, thread, and ream valve guides as follows:
- 1 Knurl valve guides using valve guide knurler kit. Use kit exactly as directed by kit manufacturer.
  - 2 Thread valve guides for entire length of bore using 5/16-24NF modified internal thread tap with a major outer diameter of 0.3170 - 0.3199 in. (8.052 - 8.128 mm).
  - 3 Hand ream valve guide to finished size to provide valve guide-to-stem oil clearance of 0.002 - 0.004 in. (0.05 - 0.10 mm). Valves are available with 0.015 in. (0.38 mm) and 0.030 in. (0.76 mm) oversize stems.
- (k) Clean and inspect valve seats as follows:
- 1 Clean valve seats using electric hand drill with end brush. Remove all carbon from valve seats.
  - 2 Check valve seats for cracks, pits, or excessive wear. Replace valve seats as required, refer to Step 7 (m).
  - 3 Check entire combustion face for rust, scoring, pitting, or cracks.

**NOTE**

**Always keep valve guides and work area clean when grinding valve seats.**

- (l) Grind valve seats using the following steps:
- 1 Select a 0.3125 in. (7.9 mm) pilot that will extend approximately 2.754 in. (6.9 mm) above valve seat. Wipe pilot stem with oily cloth and insert into valve stem guide.
  - 2 Select an appropriate 30° angle grinding stone which is in good condition and install grinding stone on arbor.
  - 3 Carefully lower grinding stone and arbor on to pilot until grinding stone almost contacts valve seat.

**CAUTION**

**Support weight of grinder to avoid excessive pressure on grinding stone. Failure to comply could result in damage to valve seat.**

**CAUTION**

**Do not grind valve seat too long. Only a few seconds are required to recondition the average valve seat. Avoid tendency to grind off too much. Do not apply excessive pressure. Failure to comply could result in damage to valve seat.**

- 4 While applying light pressure, carefully grind valve seat with grinding stone.
- 5 Remove arbor, grinding stone, and pilot from valve seat.

**CAUTION**

**If valve seat width is too narrow, valve may burn or erode. Use care when narrowing valve seat width.**

- 6 Check valve seat width with vernier caliper. Valve seat width should be 0.059 - 0.079 in. (1.50 - 2.00 mm). If valve seat is too wide, reduce width by repeating steps 1 through 5 using a 45° grinding stone.
- 7 Position new or refaced valve in cylinder head and check contact between valve seat and valve face using blue bearing dye. If necessary, lap valve onto valve seat using a lapping tool and lapping compound. Replace valves and valve inserts as necessary.
- 8 Check valve recess in cylinder head, refer to step 4.7.4.(b).

**NOTE**

**It is not necessary to replace valve seat inserts if valve seats were successfully ground.**

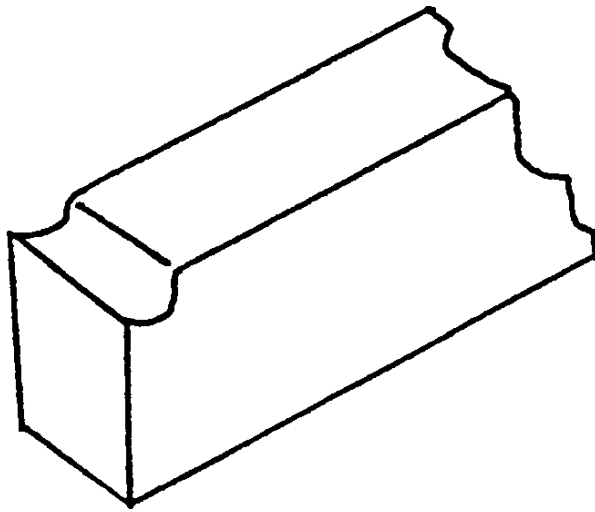
- (m) Replace valve seat inserts as follows:

**CAUTION**

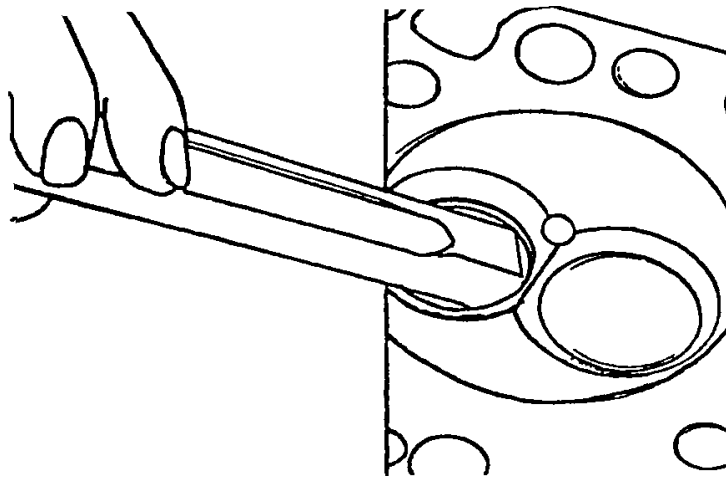
**Do not use oxygen-acetylene torch to remove valve seat inserts. Oxygen-acetylene torch will alter the hardness of cylinder head and could cause damage to engine.**

- 1 Raise a burr on bottom of valve seat insert.
- 2 Protect surface of cylinder head with cardboard or cloth.

- 3 Position chisel with special ground end (Figure 5-92) in burr on valve seat insert. Tap handle of chisel with hammer until valve seat insert comes loose. Remove and discard valve seat insert. Refer to Figure 5-93 for detailed view.



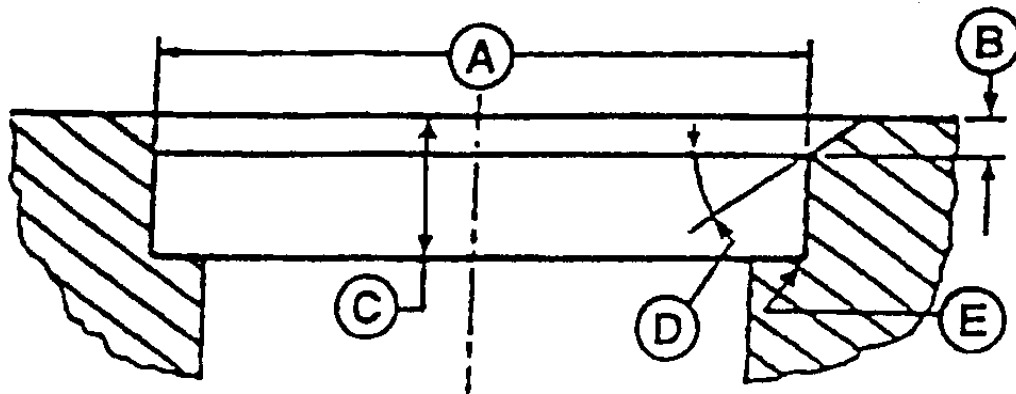
**FIGURE 5-92. VALVE SEAT REMOVAL CHISEL**



**FIGURE 5-93. REMOVAL OF VALVE SEAT INSERT**

- 4 Thoroughly clean area around valve seat bore and inspect for damage or cracks. Replace cylinder head as necessary.

- 5 Measure intake and exhaust valve seat bore in cylinder head, refer to Figure 5-94 for measurement locations. If bore dimensions are not within specifications shown in Table 5-12, machine cylinder head to specifications or replace cylinder head.



**FIGURE 5-94. MEASURE VALVE SEAT BORE IN CYLINDER HEAD**

- 6 Install valve seat inserts in cylinder head using pilot driver and valve seat insert installing adapter. Use one end of valve seat insert installing adapter to install intake valve seat inserts, the other end is used to install exhaust valve seat inserts.
- 7 Grind valve seats as required to maintain correct valve recess and valve face-to-seat seal, refer to step 4 (1).

c. Assembly.

- (1) Lubricate stems of valves (10 and 11, Figure 4-52) and valve guides with clean engine oil.

**NOTE**

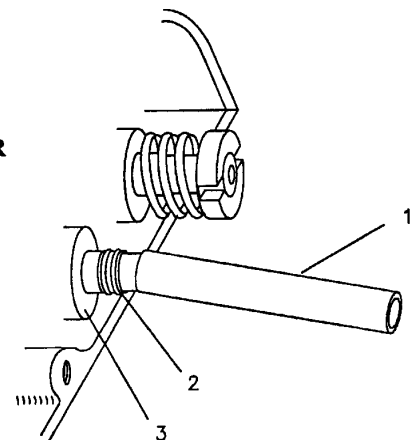
**If valves are reused, install valves in same location from which removed.**

- (2) Insert valves (10 and 11) in cylinder head.
- (3) Use valve stem seal installer to slide valve stem seals (13) over stems of valves (10 and 11) and onto valve guide tower (3, Figure 5-95).
- (4) Position valve springs (4, Figure 4-52) and rotators (3) on cylinder head.
- (5) Compress valve springs (4, Figure 4-52) using valve spring compressor (JDE138) and install retainers on stems of valves (10 and 11).
- (6) Strike end of each valve three or four times using soft, non-metallic mallet to insure proper positioning of retainer locks.

Table 5-12. Valve Seat Insert Bore Specifications	
Item	Specification
Exhaust	
A	1.6924 - 1.6934 in. (42.987 - 43.013 mm)
B	0.150 in. (3.82 mm) Reference
C	0.3912 - 0.3962 in. (9.936 - 10.064 mm)
D	38 - 42°
E	Maximum Radius 0.019 in. (0.5 mm)
Maximum surface finish bore "A"	0.000062 in. (0.00158 mm)
Intake	
A	1.8545 - 1.8555 in. (47.104 - 47.130 mm)
B	0.136 in. (3.45 mm) Reference
C	0.3912 - 0.3962 in. (9.936 - 10.064 mm)
D	38 - 42°
E	Maximum Radius 0.019 in. (0.5 mm)
Maximum surface finish bore "A"	0.000062 in. (0.00158 mm)
Replacement Valve Seat Insert OD:	
Exhaust	1.8565 - 1.8575 in. (47.155 - 47.181 mm)
Intake	1.6944 - 1.6954 in. (43.038 - 43.064 mm)

**LEGEND**

- 1 VALVE STEM SEAL INSTALLER**
- 2 VALVE STEM SEAL**
- 3 VALVE GUIDE TOWER**



**FIGURE 5-95. VALVE INSTALLATION**

- (7) Recheck valve recess, refer to paragraph 4.7.4.(b).
- (8) Test cylinder head prior to installation, refer to paragraph 4.7.4.c.
- (9) Install cylinder head, refer to paragraph 4.7.4.d.

5.4.12. OIL PRESSURE REGULATING VALVE ASSEMBLY VALVE SEAT.

**NOTE**

**The following procedure requires complete access to the engine. If necessary, remove engine from generator set, refer to TM 9-6115-671-14. Mount engine on repair stand (NSN 4910-01-016-1835 or equal) as outlined in paragraph 4.10.**

a. Replacement.

Inspect oil pressure regulating valve assembly, refer to paragraph 4.5.2.b. Replace oil pressure regulating valve (4, Figure 4-39) and valve seat (5) if cone of valve is found defective. Refer to the following steps for removal and replacement of valve seat (5);

- (1) Remove oil pressure regulating valve, refer to paragraph 4.5.2.a.
- (2) Remove valve seat (5) using collet (JT01727) and slide hammer (JT01718). Discard valve seat.

**CAUTION**

**Valve seat bore is easily damaged. Do not drive against raised inner rim of valve seat. Failure to comply could result in damage to cylinder block.**

- (3) Install new valve seat (5) using oil pressure relief valve bushing driver (JD248A) and handle (JDG536). Drive valve seat into cylinder block until valve seat bottoms in bore.
- (4) Install oil pressure regulating valve, refer to paragraph 4.5.2.d.



## APPENDIX A

### REFERENCES

#### A-1 SCOPE.

This appendix lists all forms, field manuals, technical manuals and miscellaneous publications referenced in this manual.

#### A-2 FORMS.

Air Force Reporting Errors Form .....	AFTO Form 22
Marine Corps Reporting of Errors Form .....	NAVMC Form 10772
Product Quality Deficiency Report.....	SF 368
Recommended Changes to DA Publications .....	DA Form 2028-2
Recommended Changes to Publications and Blank Forms .....	DA Form 2028
Report of Discrepancy (ROD) .....	SF 364
Reporting of Item and Packaging Discrepancies .....	AR 735-11-2
Reporting of Transportation Discrepancies in Shipment.....	AR 55-38
Transportation Discrepancy Report .....	SF 361
Equipment Control Records.....	DA Form 2408-9

#### A-3 FIELD MANUALS.

First Aid for Soldiers.....	FM 21-11
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#### A-4 TECHNICAL MANUALS.

Destruction of Material .....	TM 750-244-3
Repair Parts and Special Tools List	
Engine, Diesel Model 4045T (4 Cylinder):	
Army.....	TM9-2815-259-24P
Air Force .....	TO 38G1-125-2
Marine Corps.....	TM 09249A/09246A-24
Operator, Unit, Direct Support and General Support Maintenance Manual:	
Army.....	TM9-6115-671-14
Air Force .....	TO 35C2-3-446-32
Marine Corps.....	TM 09249A/09246A-14

#### A-5 MISCELLANEOUS PUBLICATIONS.

Maintenance Management Policy .....	AFR 66-1
Preservation of USAMECOM Mechanical Equipment for Shipment and Storage .....	TB 740-97-2
Stanadyne Service Bulletin .....	99689 (8-95)
	for Model DB4
Suggestion Program .....	AFR 900-4
The Army Maintenance Management System (TAMMS) .....	DA PAM 738-750
USAF Material Deficiency Reporting .....	TO-00-35D54
John Deere Organization and Maintenance Manual.....	OMRG25204
	(20 May 96)

**ARMY TM 9-2815-259-24**  
**AIR FORCE TO 38G1-125-2**  
**MARINE CORPS TM 09249A/09246A-24**

John Deere Component Technical Manual.....CTM 104 (01 June 96)  
John Deere Parts Catalog (6 Cylinder, 6.8L).....PC2522 (Oct 96)

## MAINTENANCE ALLOCATION CHART

### Section I. INTRODUCTION

#### B.1 The Army Maintenance System MAC:

- a. This introduction (section I) provides a general explanation of all maintenance and repair functions authorized at various maintenance levels under the standard Army Maintenance System concept.
- b. The Maintenance Allocation Chart (MAC) in section II designates overall authority and responsibility for the performance of maintenance functions on the identified end item or component. The application of the maintenance functions to the end item or component will be consistent with the capacities and capabilities of the designated maintenance levels, which are shown in the MAC in column (4) as:
  - Unit - includes two subcolumns, C (operator/crew) and O (unit) maintenance.
  - Direct Support - includes an F subcolumn.
  - General Support - includes an H subcolumn.
  - Depot - includes a D subcolumn.
- c. Section III lists the tools and test equipment (both special tools and common tool sets) required for each maintenance function as referenced from section II.
- d. Section IV contains supplemental instructions and explanatory notes for a particular maintenance function.

#### B.2 Maintenance Functions. Maintenance Functions are limited to and defined as follows:

- a. Inspect. To determine the serviceability of an item by comparing its physical, mechanical, and/or electrical characteristics with established standards through examination (i.e., by sight, sound, or feel).
- b. Test. To verify serviceability by measuring the mechanical or electrical characteristics of an item and comparing those characteristics with prescribed standards.
- c. Service. Operations required periodically to keep an item in proper operating condition, i.e.; to clean (includes decontamination, when required), to preserve, to drain, to paint, or to replenish fuel, lubricants, chemical fluids, or gases.
- d. Adjust. To maintain or regulate, within prescribed limits, by bringing into proper position, or by setting the operating characteristics to specified parameters.
- e. Align. To adjust specified variable elements of an item to bring about optimum or desired performance.
- f. Calibrate. To determine and cause corrections to be made or to be adjusted on instruments or test, measuring, and diagnostic equipment used in precision measurement. Consists of comparisons of two instruments, one of which is a certified standard of known accuracy, to detect and adjust any discrepancy in the accuracy of the instrument being compared.

MAINTENANCE ALLOCATION CHART (Continued)

- g. Remove/Install. To remove and install the same item when required to perform service or other maintenance functions. Install may be the act of emplacing, seating, or fixing into position a spare, repair part, or module (component or assembly) in a manner to allow the proper functioning of an equipment or system.
- h. Replace. To remove an unserviceable item and install a serviceable counterpart in its place. Replace is authorized by the MAC and assigned maintenance level is shown as the 3rd position code of the SMR code.
- i. Repair. The application of maintenance services<sup>1</sup> including fault location/troubleshooting<sup>2</sup>, removal/installation, and disassembly/assembly<sup>3</sup> procedures, and maintenance actions<sup>4</sup> to identify troubles and restore serviceability to an item by correcting specific damage, fault, malfunction, or failure in a part, subassembly, module (component or assembly), end item, or system.
- j. Overhaul. That maintenance effort (service/action) prescribed to restore an item to a completely serviceable/ operational condition as required by maintenance standards in appropriate technical publications (i.e., DMWR). Overhaul is normally the highest degree of maintenance performed by the Army. Overhaul does not normally return an item to like new condition.
- k. Rebuild. Consists of those services/actions necessary for the restoration of unserviceable equipment to a like new condition in accordance with original manufacturing standards. Rebuild is the highest degree of materiel maintenance applied to Army equipment. The rebuild operation includes the act of returning to zero those age measurements (e.g. hours/ miles) considered in classifying Army equipment/components.

**B.3 Explanation of Columns in the MAC, Section II.**

- a. Column 1, Group Number. Column 1 lists functional group code numbers, the purpose of which is to identify maintenance significant components, assemblies, subassemblies, and modules with the next higher assembly.
- b. Column 2, Component/Assembly. Column 2 contains the item names of components, assemblies, subassemblies, and modules for which maintenance is authorized.
- c. Column 3, Maintenance Function. Column 3 lists the functions to be performed on the item listed in column 2. (For detailed explanation of these functions, see paragraph B.2).
- d. Column 4, Maintenance Level. Column 4 specifies each level of maintenance authorized to perform each function listed in Column 3, by indicating work time required (expressed as man-hours in whole hours or decimals) in the appropriate subcolumn.. This work-time figure represents the active time required to perform that maintenance function at the indicated level of maintenance. If the number or complexity of the tasks within the listed maintenance function vary at different maintenance levels, appropriate work time figure will be shown for each level. The work-time figure represents the average time required to restore an item (assembly, subassembly, component, module, end item, or system) to a serviceable condition under typical field operating conditions. This time includes preparation time (condition/follow-on tasks) (including any necessary disassembly / assembly time), troubleshooting / fault location time, and quality assurance time in addition to the time required to perform the specific

**MAINTENANCE ALLOCATION CHART (Continued)**

- d. (Cont) tasks identified for the maintenance functions authorized in the MAC. The symbol designations for the various maintenance levels are as follows:
- |   |                              |
|---|------------------------------|
| C | Operator or crew maintenance |
| O | Unit maintenance             |
| F | Direct support maintenance   |
| H | General support maintenance  |
| D | Depot maintenance            |
- e. Column 5, Tools and Test Equipment reference code. Column 5 specifies, by code, those common tool sets (not individual tools), common TMDE, and special tools, special TMDE, and support equipment required to perform the designated function. Codes are keyed to tools and test equipment in section III.
- f. Column 6, Remarks. When applicable, this column contains a letter code, in alphabetic order, which shall be keyed to the remarks contained in section IV.

**B.4 Explanation of columns in Tool and Test Equipment Requirements, Section III.**

- a. Column 1, Reference Code. The tool and test equipment reference code correlates with a code used in the MAC, Section II, Column 5.
- b. Column 2, Maintenance Level. The lowest level of maintenance authorized to use the tool or test equipment.
- c. Column 3, Nomenclature. Name or identification of the tool or test equipment.
- d. Column 4, National Stock Number. The National Stock Number of the tool or test equipment.
- e. Column 5, Tool Number. The manufacturer's part number, model number, or type number.

**B.5 Explanation of Columns in Remarks, Section IV**

- a. Column 1, Remarks Code. The code recorded in column 6, section II.
- b. Column 2, Remarks. This column along with the related codes should be used to clarify maintenance and inspection functions by different MOSs involved in maintaining some components.



SECTION II. MAINTENANCE ALLOCATION CHART FOR DIESEL ENGINE MODEL 4045TF151									
(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
Number	Component/Assembly	Function	Unit		Direct Support	General	Depot	Ref Code	Code
			C	O	F	H	D		
00	ENGINE ASSEMBLY 30KW	INSPECT		2.1	1.7	1.3			
		TEST		1.5	7.3	3.3		2,3,5,6,7,8	
		SERVICE		.4					
		ADJUST			2.8			1,3,4,6	
		R/I		7.4	55.1	48.0		1,2,3,4,5,6	
		REPLACE		7.4	55.1	48.0		1,2,3,4,5,6	A
		REPAIR			17.2	39.5		1,2,3,4,5,6,8,41	
01	COOLING SYSTEM	INSPECT		.8					
		R/I		1.5				1,5	
		REPLACE		1.5				1,5	A
0101	Thermostat and Water Manifold/Thermostat Cover.	INSPECT		1.1					
		R/I		1.0				1,5	
		REPLACE		1.0				1,5	A
0102	Water Pump.	INSPECT		.1					
		R/I		1.5				1,5	
		REPLACE		1.0				1,5	A
02	ELECTRICAL SYSTEM	INSPECT		.2					
		TEST		1.0	2.0			2,6,7,8	
		R/I		1.5				5	
		REPLACE		1.5				5	A
		REPAIR			4.0			4,6,8	

**SECTION II. MAINTENANCE ALLOCATION CHART FOR  
 DIESEL ENGINE MODEL 4045TF151 – CONT.**

(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
Number	Component/Assembly	Function	Unit		Direct Support	General	Depot	Ref Code	Code
			C	O	F	H	D		
0201	Battery Charging Alternator.	INSPECT		.1					
		TEST		.3	1.0			2,7	
		R/I		1.0				5	
		REPLACE		1.0				5	A
		REPAIR			2.0			4,8	
0202	Starter.	INSPECT		.1					
		TEST		.5	1.0			6,7,8	
		R/I		.5				5	
		REPLACE		.5				5	A
		REPAIR			2.0			6,8	
03	INTAKE AND EXHAUST SYSTEM	INSPECT		.2	.3				
		TEST			1.0			2,6	
		R/I			7.0			4	
		REPLACE			7.0			4	A
0301	Turbocharger	INSPECT			.1				
		TEST			1.0			2,6	
		R/I			2.0			4	
		REPLACE			2.0			4	A
0302	Intake Manifold.	INSPECT		.1	.1				
		R/I			2.0			4	
		REPLACE			2.0			4	A
0303	Exhaust Manifold.	INSPECT		.1	.1				
		R/I			3.0			4	
		REPLACE			3.0			4	A



SECTION II. MAINTENANCE ALLOCATION CHART FOR DIESEL ENGINE MODEL 4045TF151 – CONT.									
(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
Number	Component/Assembly	Function	Unit		Direct Support	General	Depot	Ref Code	Code
			C	O	F	H	D		
04	LUBRICATION SYSTEM	INSPECT		.5	.4				
		R/I		1.7	15.5			1,4,5,6	
		REPLACE		1.7	15.5			1,4,5,6	A
0401	Oil Filter Assembly.	INSPECT		.1					
		R/I		.3				5	
		REPLACE		.3				5	A
0402	Oil Cooler.	INSPECT		.1					
		R/I		1.0				1,5	
		REPLACE		1.0				1,5	A
0403	Oil Pressure Regulating Valve Assembly.	INSPECT			.1				
		R/I			1.0			4	
		REPLACE			1.0			4	A
0405	Oil Pump Assembly.	INSPECT				.1			
		R/I				8.5		6	
		REPLACE				8.5		6	A
0406	Oil Bypass Valve Assembly.	INSPECT				.1			
		R/I				10.0		6	
		REPLACE				10.0		6	A
0407	Oil Fill Tube.	INSPECT		.1					
		R/I		.2				5	
		REPLACE		.2				5	A
0408	Oil Dipstick Tube.	INSPECT		.1					
		R/I		.2				1,5	
		REPLACE		.2				1,5	A

**SECTION II. MAINTENANCE ALLOCATION CHART FOR  
 DIESEL ENGINE MODEL 4045TF151 – CONT.**

(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
Number	Component/Assembly	Function	Unit		Direct Support	General	Depot	Ref Code	Code
			C	O	F	H	D		
0409	Oil Pan.	INSPECT		.1	.1				
		R/I			8.0			4	
		REPLACE			8.0			4	A
05	FUEL SYSTEM	INSPECT		.4	.1				
		SERVICE		.4				5	
		TEST		.5	2.0			2,5,6	
		R/I		2.7	4.7			1,2,5,6	
		REPLACE		2.7	4.7			1,2,5,6	A
0501	Fuel Filter.	REPAIR			.2	4.5		2,6,41	
		SERVICE		.4				5	
		R/I		.2	.2			5	
		REPLACE		.2	.2			5	A
		REPAIR			.2			5	
0502	Fuel Transfer Supply Pump.	INSPECT		.1					
		TEST		.5				5	
		R/I		1.0				1,5	
		REPLACE		1.0				1,5	A
0503	Fuel Lines.	INSPECT		.1					
		R/I		1.5				5	
		REPLACE		1.5				5	A
0504	Fuel Injection Pump.	INSPECT		.1	.1				
		TEST				1.0		2,6	
		R/I			2.0			6	
		REPLACE			2.0			6	A
		REPAIR				16.0		2,6,41	

SECTION II. MAINTENANCE ALLOCATION CHART FOR DIESEL ENGINE MODEL 4045TF151 – CONT.									
(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
Number	Component/Assembly	Function	Unit		Direct Support	General	Depot	Ref Code	Code
			C	O	F	H	D		
0505	Fuel Injection Nozzle Assembly.	INSPECT		.1					
		TEST			1.0			2,6	
		R/I			1.5			2,6	
		REPLACE			1.5			2,6	A
06	CYLINDER HEAD ASSEMBLY	ADJUST			2.8			3,4,6	
		TEST			2.3			3,6	
		R/I			7.4			3,4,5,6	
		REPLACE			7.4			3,4,5,6	A
		REPAIR				7.0		3,4,6	
0601	Rocker Arm Cover.	R/I			.4			5	
		REPLACE			.4			5	A
0602	Intake and Exhaust Valves	TEST			.8			3,6	
		ADJUST			2.0			3,6	
0603	Rocker Arm Assembly	R/I			2.5			4	
		REPLACE			2.5			4	A
		ADJUST			.8			3,4	
		REPAIR			2.5			4	
0604	Cylinder Head.	TEST			1.5			3,6	
		R/I			4.5			3,6	
		REPLACE			4.5			3,6	A
		REPAIR				4.5		3,6	

SECTION II. MAINTENANCE ALLOCATION CHART FOR DIESEL ENGINE MODEL 4045TF151 – CONT.									
(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
Number	Component/Assembly	Function	Unit		Direct Support	General	Depot	Ref Code	Code
			C	O	F	H	D		
07	FLYWHEEL AND HOUSING ASSEMBLY	INSPECT			.7				
		R/I			17.5			3,6	
		REPLACE			17.5			3,6	A
		REPAIR			6.0			3,6	
0701	Flywheel.	INSPECT			.1				
		R/I			9.0			3,6	
		REPLACE			9.0			3,6	A
0702	Rear Crankshaft Oil Seal/Wear Sleeve Assembly.	INSPECT			.1				
		R/I			10.0			3,6	
		REPLACE			10.0			3,6	A
0703	Flywheel Housing.	INSPECT			.5				
		R/I			10.0			3,6	
		REPLACE			10.0			3,6	A
08	Crankshaft Pulley.	INSPECT			.1				
		R/I			1.0			6	
		REPLACE			1.0			6	A
09	Timing Gear Cover.	INSPECT			.1				
		R/I			10.0			3,6	
		REPLACE			10.0			3,6	A

SECTION II. MAINTENANCE ALLOCATION CHART FOR DIESEL ENGINE MODEL 4045TF151 – CONT.									
(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
Number	Component/Assembly	Function	Unit		Direct Support	General	Depot	Ref Code	Code
			C	O	F	H	D		
10	SHORT BLOCK ASSEMBLY	INSPECT				1.3			
		TEST				3.3		2,3,6	
		R/I				48.0		2,3,6	
		REPLACE				48.0		2,3,6	A
		REPAIR				35.0		2,3,6	
1001	Camshaft Assembly.	INSPECT				.2			
		TEST				.5		3,6	
		R/I				9.0		3,6	
		REPLACE				9.0		3,6	A
1002	Idler Gears and Idler Gear Shafts.	TEST				.5		2,3,6	
		R/I				10.0		3,6	
1003	Front Plate.	INSPECT				.3			
		R/I				9.5		2,3,6	
1004	Crankshaft and Main Bearings.	INSPECT				.4			
		TEST				1.0		2,3,6	
		R/I				16.0		3,6	
		REPAIR				10.0		2,3,6	
1005	Pistons and Connecting Rods.	R/I				15.0		3,6	
		REPAIR				6.0		3,6	
1006	Cylinder Liner.	INSPECT				.2			
		TEST				.8		6	
		R/I				15.0		6	
		REPAIR				4.0		2,3,6	

SECTION II. MAINTENANCE ALLOCATION CHART FOR DIESEL ENGINE MODEL 4045TF151 – CONT.									
(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
Number	Component/Assembly	Function	Unit		Direct Support	General	Depot	Ref Code	Code
			C	O	F	H	D		
1007	Balancer Shaft Assembly	INSPECT				.2			
		TEST				.5		6	
		R/I				10.0		3,6	
		REPLACE				10.0		3,6	A
1008	Cylinder Block	REPAIR				15.0		3,6	

Section III. TOOL AND TEST EQUIPMENT REQUIREMENTS FOR DIESEL ENGINE MODEL 4045TF151				
TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE LEVEL	NOMENCLATURE	NATIONAL STOCK NUMBER	TOOL NUMBER
1	O	SHOP EQUIPMENT, AUTOMOTIVE MAINT AND REPAIR., ORGANIZATIONAL MAINTENANCE COMMON NO. 1, LESS POWER	4910-00-754-0654	SC 4910-95-A74 (10 Sept. 1994)
2	F	SHOP EQUIPMENT, FUEL AND ELECTRICAL SYSTEM ENGINE FIELD MAINTENANCE, BASIC, LESS POWER	4910-00-754-0714	SC 4910-95-CL-B20 (01 June 1987)
3	F	SHOP EQUIPMENT, AUTOMOTIVE, MAINTENANCE AND REPAIR, FIELD MAINTENANCE, SUPPLEMENTAL SET NO. 2, LESS POWER	4910-00-754-0707	SC 4910-95-A63 (01 December 1987)
4	F	SHOP EQUIPMENT, AUTOMOTIVE MAINTENANCE AND REPAIR: FIELD MAINTENANCE , BASIC, LESS POWER	4910-00-754-0705	SC 4910-95-A31 (30 June 1990)
5	O	TOOL KIT, GENERAL MECHANIC S: AUTOMOTIVE	5180-00-177-7033	SC 5180-90-N26 (30 October 1986)
6	F	SHOP EQUIPMENT, AUTOMOTIVE MAINTENANCE AND REPAIR: FIELD MAINTENANCE, WHEELED VEHICLES, POST, CAMP, AND STATION SET A	4910-00-348-7696	SC 4910-95-A02 (1 October 1989)
7	O	MULTIMETER	6625-01-312-2930	FLUKE Model 87
8	F	SHOP EQUIPMENT, ELECTRICAL REPAIR, SEMITRAILER MOUNTED	4940-00-294-9517	SC 4940-95-CL-B05
9	F	OIL PRESSURE RELIEF VALVE BUSHING DRIVER	5120-01-393-3638	JOHN DEERE JD248A

Section III. TOOL AND TEST EQUIPMENT REQUIREMENTS FOR DIESEL ENGINE MODEL 4045TF151 – CONT.				
TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE LEVEL	NOMENCLATURE	NATIONAL STOCK NUMBER	TOOL NUMBER
10	F	HANDLE, BUSHING DRIVER	5120-01-391-2093	JOHN DEERE JDG536
11	F	FLYWHEEL TURNING TOOL	(NONE)	JOHN DEERE JDG820
12	F	TIMING PIN	5135-01-321-6068	JOHN DEERE JDE81-4
13	F	INJECTION PUMP TIMING GEAR PULLER	5120-01-393-9501	JOHN DEERE JDG670A
14	F	VALVE GUIDE KNURLER KIT	(NONE)	JOHN DEERE JTO5949
15	F	VALVE SEAT PILOT DRIVER	5120-01-393-1254	JOHN DEERE JDG676
16	F	VALVE SEAT INSERT INSTALLING ADAPTER	5120-01-393-3892	JOHN DEERE JDG675
17	F	VALVE STEM SEAL INSTALLER	(NONE)	JOHN DEERE JDG678
18	H	PISTON AND CYLINDER LINER HEIGHT GAUGE	5210-01-351-5114	JOHN DEERE JDG451
19	F	SEAL AND WEAR SLEEVE REMOVER	(NONE)	JOHN DEERE JDG698A
20	F	SEAL AND WEAR SLEEVE INSTALLER SET	5120-01-384-4147	JOHN DEERE JT30040
21	F	CAMSHAFT GEAR AND FRONT OIL SEAL INSTALLER SET	(NONE)	JOHN DEERE JDG954
22	H	CAMSHAFT BUSHING SERVICE SET	(NONE)	JOHN DEERE JDG739B
23	H	IDLER GEAR BUSHING DRIVER	5120-01-394-5256	JOHN DEERE JD252
24	H	IDLER GEAR BUSHING DRIVER HANDLE	5120-00-034-0881	JOHN DEERE 10914188
25	H	GEAR TIMING TOOL	5120-01-353-1121	JOHN DEERE JD254A



**Section III. TOOL AND TEST EQUIPMENT REQUIREMENTS FOR  
DIESEL ENGINE MODEL 4045TF151 – CONT.**

TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE LEVEL	NOMENCLATURE	NATIONAL STOCK NUMBER	TOOL NUMBER
26	H	OIL GALLERY PLUG TOOL	(NONE)	JOHN DEERE JDG782
27	H	RING GROOVE WEAR GAUGE	(NONE)	JOHN DEERE JDE62
28	H	PISTON PIN BUSHING REMOVER AND INSTALLER (SMALL)	(NONE)	JOHN DEERE JDE88
29	H	CYLINDER LINER PULLER	5120-01-346-0983	JOHN DEERE D01073AA
30	O	ADAPTER	4910-01-394-6187	JOHN DEERE JT01679
31	O	HOLDING CLAMP	4910-01-395-3445	JOHN DEERE JT02017
32	O	TEST GAUGE	6620-01-382-7334	JOHN DEERE JT01682
33	O	SLIDE HAMMER	(NONE)	JOHN DEERE D01299AA
34	O	DIPSTICK DRIVER	(NONE)	JOHN DEERE JDG965
35	F	COLLET	(NONE)	JOHN DEERE JT01727
36	F	SLIDE HAMMER	(NONE)	JOHN DEERE JT01718
37	H	PISTON RING COMPRESSOR	5120-01-351-3471	JOHN DEERE JDE84
38	F	VALVE INSPECTION CENTER	(NONE)	JOHN DEERE D-05058ST
39	F	NOZZLE BORE CLEANING TOOL	(NONE)	JOHN DEERE JDE39
40	F	BALANCER SHAFT BUSHING DRIVER	5120-01-393-3636	JOHN DEERE JD249
41	F	BALANCER SHAFT BUSHING ADAPTER	(NONE)	JOHN DEERE JD963

ARMY TM 9-2815-259-24  
 AIR FORCE TO 38G1-125-2  
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Section III. TOOL AND TEST EQUIPMENT REQUIREMENTS FOR DIESEL ENGINE MODEL 4045TF151 – CONT.				
TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE LEVEL	NOMENCLATURE	NATIONAL STOCK NUMBER	TOOL NUMBER
42	F	BALANCER SHAFT HOLDING TOOL	5120-01-393-3890	JOHN DEERE JD247
43	F	TRANSFER PUMP PRESSURE ADJUSTER	(NONE)	STANADYNE 26079
44	F	STANADYNE SEVICE TOOL KIT	(NONE)	STANADYNE 18951
45	H	ARBOR PRESS DRIVER	(NONE)	JOHN DEERE JD252
46	H	ARBOR PRESS DRIVER HANDLE	(NONE)	JOHN DEERE JD6537

**Section III. TOOLS CONTAINED IN STANADYNE SERVICE  
TOOL KIT 18951 (Continued)**

TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE LEVEL	NOMENCLATURE	NATIONAL STOCK NUMBER	TOOL NUMBER
1	H	VALVE EXTRACTER	(NONE)	26081
2	H	DIMENSION SETTING FIXTURE	5120-00-200-4526	19969
3	H	GAGE, LINKAGE KIT	(NONE)	23093
4	H	WRENCH, END CAP	5120-01-207-5563	20548
	H	TIMING LINE INDICATOR	5120-01-394-2315	20395
6	H	SHUTOFF CAM REMOVER	(NONE)	20992
7	H	ADVANCE PLUG WRENCH	(NONE)	14490
8	H	SMALL SNAP RING PLIERS	(NONE)	13337
9	H	SNAP RING PLIERS-SQUEEZE TO CLOSE	(NONE)	20043
10	H	SNAP RING PLIERS-SQUEEZE TO OPEN	(NONE)	20044
11	H	BRASS HOOK	(NONE)	13301
12	H	ROTOR SUPPORT TOOL	(NONE)	16313
13	H	LINKAGE HOOK WRENCH	(NONE)	13379
14	H	ADVANCE PISTON RING COMPRESSOR	(NONE)	16199
15	H	ADVANCE PLUG SOCKET	(NONE)	27760
16	H	ADVANCE PLUG SOCKET	(NONE)	27761
17	F	TRANSFER PUMP PRESSURE TAP	4910-01-395-4246	21900
18	F	ADVANCE INDICATOR	5120-01-249-0368	23745
19	F	NOZZLE CLEANING KIT	5180-01-351-3467	16494
20	H	BEARING AND SEAL REMOVER	5120-01-351-3953	28311
21	H	BEARING AND SEAL INSTALLATION TOOL	5120-01-351-3955	28316
22	H	ROTOR SUPPORT TOOL	(NONE)	16313
23	H	SEAL PROTECTION TUBE	(NONE)	18338

Section IV. REMARKS FOR DIESEL ENGINE MODEL 4045TF151	
REMARKS CODE	REMARKS
A	Replace function identical to removal/install function

## APPENDIX C

### COMPONENTS OF END ITEM (COEI) AND BASIC ISSUE ITEMS (BII) LIST

#### SECTION I. INTRODUCTION

##### C-1 SCOPE.

This appendix lists components of the end item and basic issue items for the generator set to help inventory the items for safe and efficient operation of the equipment.

##### C-2 GENERAL.

The Components of End Item (COEI) and Basic Issue Items (BII) lists are divided into the following sections:

- a. Section II, Components of End Item. This listing is for information purposes only, and is not authority to requisition replacements. These items are part of the generator set. As part of the end item, these items must be with the end item whenever it is issued or transferred between property accounts. Items of COEI are removed and separately packaged for transportation or shipment only when necessary. Illustrations are furnished to help you find and identify the items.
- b. Section III. Basic Issue Items. These essential items are required to place the generator set in operation, operate it, and to do emergency repairs. Although shipped separately packaged, BII must be with the generator set during operation and when it is transferred between property accounts. This list is your authority to request/requisition them for replacement based on authorization of the end item by the TOE/MTOE. Illustrations are furnished to help you find and identify the items.

##### C-3 EXPLANATION OF COLUMNS.

The following provides an explanation of columns found in the tabular listing:

- a. Column (1), Illus Number, gives the identifying number of the item illustrated.
- b. Column (2), National Stock Number, identifies the stock number of the item to be used for requisitioning purposes.
- c. Column (3), Description and Usable On Code, identifies the Federal item name (in all capital letters) followed by a minimal description when needed. The last line below the description is the Commercial and Government Entity Code (CAGEC) in parentheses and the part number.
- d. Column (4), U/I (unit of issue), indicates how the item is issued for the National Stock Number shown in column (2).
- e. Column (5), Qty Rqd, indicates the quantity required.

ARMY TM 9-2815-259-24  
AIR FORCE TO 38G1-125-2  
MARINE CORPS TM 09249A/09246A-24

## SECTION II. COMPONENTS OF END ITEM

NONE

## SECTION III. BASIC ISSUE ITEMS

(1) Illus Number	(2) National Stock Number	(3) Description Cage and Part Number Usable On Code	(4) U/I	(5) Qty Reqd
1		TECHNICAL MANUAL TM 9-2815-259-24	EA	1
2		WARRANTY TECHNICAL BULLETIN TO BE ASSIGNED	EA	1

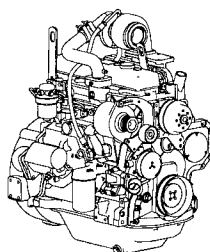
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**TECHNICAL MANUAL**

**UNIT, DIRECT SUPPORT AND GENERAL SUPPORT  
MAINTENANCE MANUAL  
DIESEL ENGINE  
MODEL 4045TF151  
4 CYLINDER 4.5 LITER  
NSN: 2815-01-462-2289**



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**DEPARTMENTS OF THE ARMY, THE AIR FORCE,  
AND THE MARINE CORPS**

**10 FEBRUARY 2000**

**1. TECHNICAL MANUAL**

**ARMY TB X-XXXX-XXX-XX**

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**DEPARTMENT OF THE ARMY TECHNICAL BULLETIN**

---

**WARRANTY PROGRAM  
FOR  
GENERATOR SET, TACTICAL QUIET**

---

**Headquarters, Department of the Army, Washington, D.C.**

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**REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS**

You can help improve this manual. If you find a mistake or if you know a way to improve the procedures, please let us know.

(A) - ARMY: Mail your letter or DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA-Form 2028-2 located in the back of this manual directly to Commander, U.S. Army Communications - Electronics Command, ATTN: AMSEL-LC-OCS-P-SN, Ft. Monmouth, NJ 07703-5006. You may also submit your recommended changes by E-mail directly to <widmaec@dolm6.monmouth.army.mil>. Instructions for sending an electronic 2028 may be found at the back of this manual immediately preceding the hard copy 2028.

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A reply will be furnished directly to you.

---

**2. WARRANTY TECHNICAL BULLETIN**

**C-3/C-4 BLANK**





**ARMY TM 9-2815-259-24  
AIR FORCE TO 38G1-125-2  
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**APPENDIX D**

**ADDITIONAL AUTHORIZATION LIST (AAL)**

**REFER TO TM 9-6115-671-14 APPENDIX D**



## APPENDIX E

### EXPENDABLE AND DURABLE ITEMS LIST

#### SECTION I. INTRODUCTION

##### E-1 SCOPE.

This appendix lists expendable supplies and materials required to operate and maintain the generator set. These items are authorized by CTA 50-970, Expendable Items (except medical, Class V, repair parts, and heraldic items).

##### E-2 EXPLANATION OF COLUMNS.

- a. Column (1) - Item Number. Number assigned to an entry in the listing for reference within the technical manual to identify the material, i.e. "Use of cleaning compound (Item 5, Appendix E)."
- b. Column (2) - Level. Identifies the lowest level of maintenance requiring the listed item.
- c. Column (3) - National Stock Number (NSN). Standardized number assigned to an item for the purpose of requisition.
- d. Column (4) - Description. Federal item name and, if required, description of the item. The last line for each applicable item indicates the Commercial and Government (CAGE) code in parenthesis followed by the part number.
- e. Column (5) - Unit of Measure (U/M). Measure used in performing actual maintenance function. Measure is expressed by a two character alphabetical abbreviation (i.e., ea, in, pr). If the unit of measure differs from the unit of issue, requisition the lowest unit that will satisfy requirements.

#### SECTION II. EXPENDABLE AND DURABLE ITEMS LIST

(1) Item Number	(2) Level	(3) National Stock Number	(4) Description	(5) U/M
1	O, F	8400-00-390-7959	Adhesive, Seal, EC847	QT
2	O, F	6850-00-181-7929	Antifreeze, MIL-A-46153, 1 Gal. Can	GL
3	O, F	6850-00-181-7933	Antifreeze, MIL-A-46153, 5 Gal. Can	GL
4	O, F	6850-00-181-7940	Antifreeze, MIL-S-46153, 55 Gal. Can	GL
5	O, F	6850-00-174-1806	Antifreeze, MIL-A-11755, 1 Gal. Can	GL
6	O, F	8030-01-234-2792	Antiseize Compound, CP-8, 8 Oz. Can	OZ
7	O	2910-00-646-9727	Cartridge, Engine, Ether, MS39254	EA

**ARMY TM 9-2815-259-24**  
**AIR FORCE TO 38G1-125-2**  
**MARINE CORPS TM 09249A/09246A-24**

EXPENDABLE DURABLE ITEMS LIST – CONT.

8	O, F	7920-01-338-3329	Cloth, Cleaning, TX-1250	EA
9	F	8030-00-056-8673	Compound, Thermo, Pentrox A	OZ
10	O, F	9150-00-663-1770	Grease, General Purpose, 630AA, 6 Lb. Can	LB
11	O, F	6850-01-160-3868	Inhibitor, Corrosion, MIL-A-53009	QT
12	O, F	9150-00-152-4117	Lubricating Oil, Engine, MIL-L-2104, 15/40W	QT
13	O, F	9150-00-189-6727	Lubricating Oil, Engine, BRAYC0421C, 10W	QT
14	O, F	9150-00-186-6681	Lubricating Oil, Engine, ALIEDC030, 30W	QT
15	O, F	9150-00-402-2372	Lubricating Oil, Engine, MIL-L-46167, OEA	QT
16	O, F	5330-00-543-3600	Paper, Abrasive, ALOXGRIT 80	SH
17	O, F	8030-01-408-9944	Seal, Edge, PES-821-B	QT
18	O, F	8040-00-843-0802	Sealant, RTV108	OZ
19	O, F	6850-00-264-9038	Solvent, Dry Cleaning, P-D-680, 5 Gal. Can	GL
20	O, F	8030-00-849-0071	Sealing Compound, FORM GASKET 2	TU
21	O, F	8040-01-359-8441	Sealing Compound, MIL-S-22473, Grade HW	OZ
22	F		Sealant, Locktite 242	OZ
23	F		Sealant, Locktite 680	OZ
24	F		Form-in-Place Gasket, Locktite 515, TY6304	OZ
25	F		Grease, 30465	LB
26	F		Lubricant, 22204	OZ
27	F		Grease, Hi-Temp, TY6333	LB

APPENDIX F  
ILLUSTRATED LIST OF MANUFACTURED ITEMS

F.1 INTRODUCTION.

This appendix includes complete instructions for fabricating or assembling parts as required for the engine.

NOTE  
All dimensions are expressed in inches. Refer to Table F-1 for metric conversion.

Figure Number		
Page		
F-1	Fuel Injection Pump Holding Fixture.....	F-2
F-2	Fuel Injection Pump Timing Mark Template.....	F-3

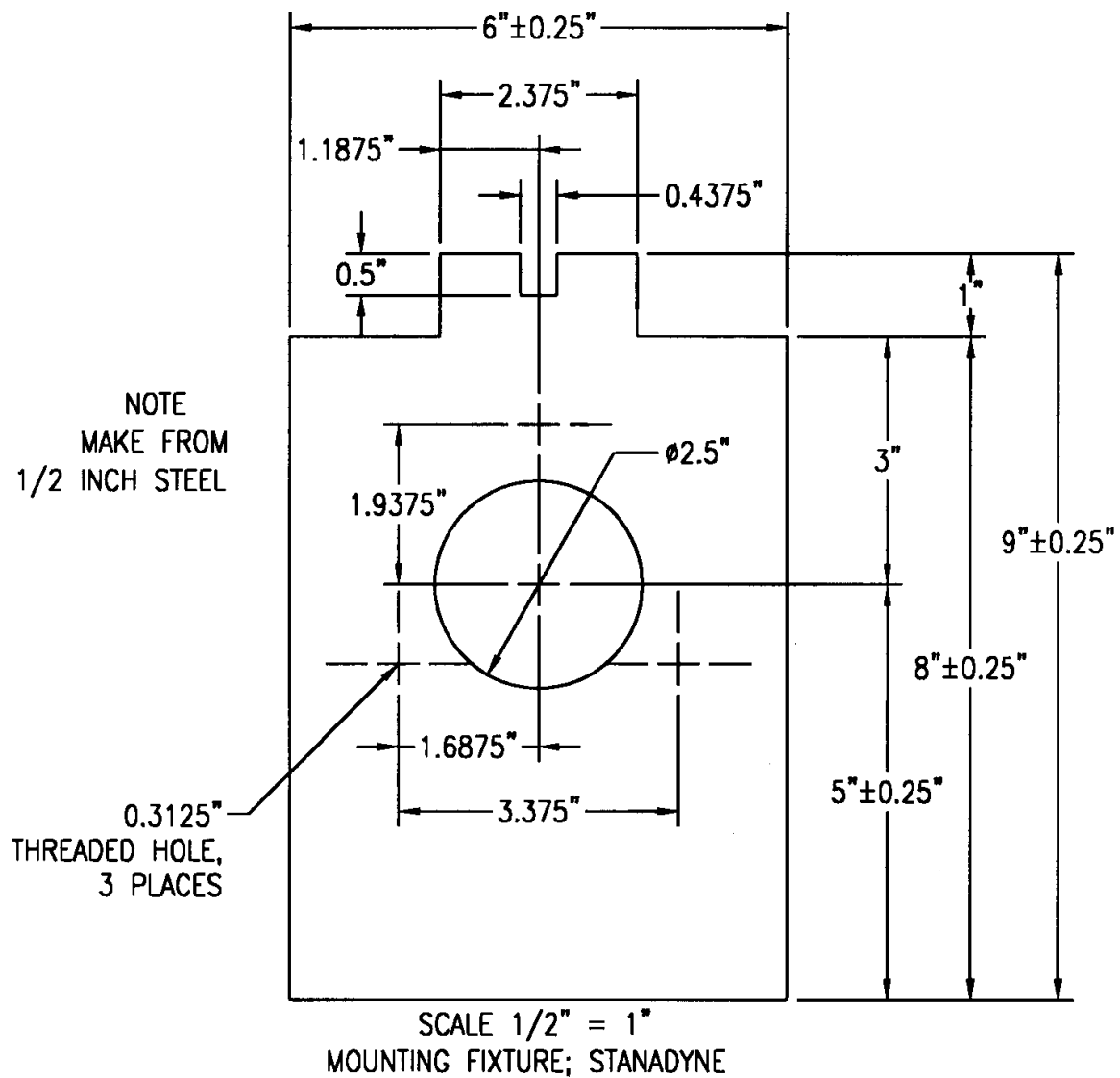


FIGURE F-1, FUEL INJECTION PUMP HOLDING FIXTURE

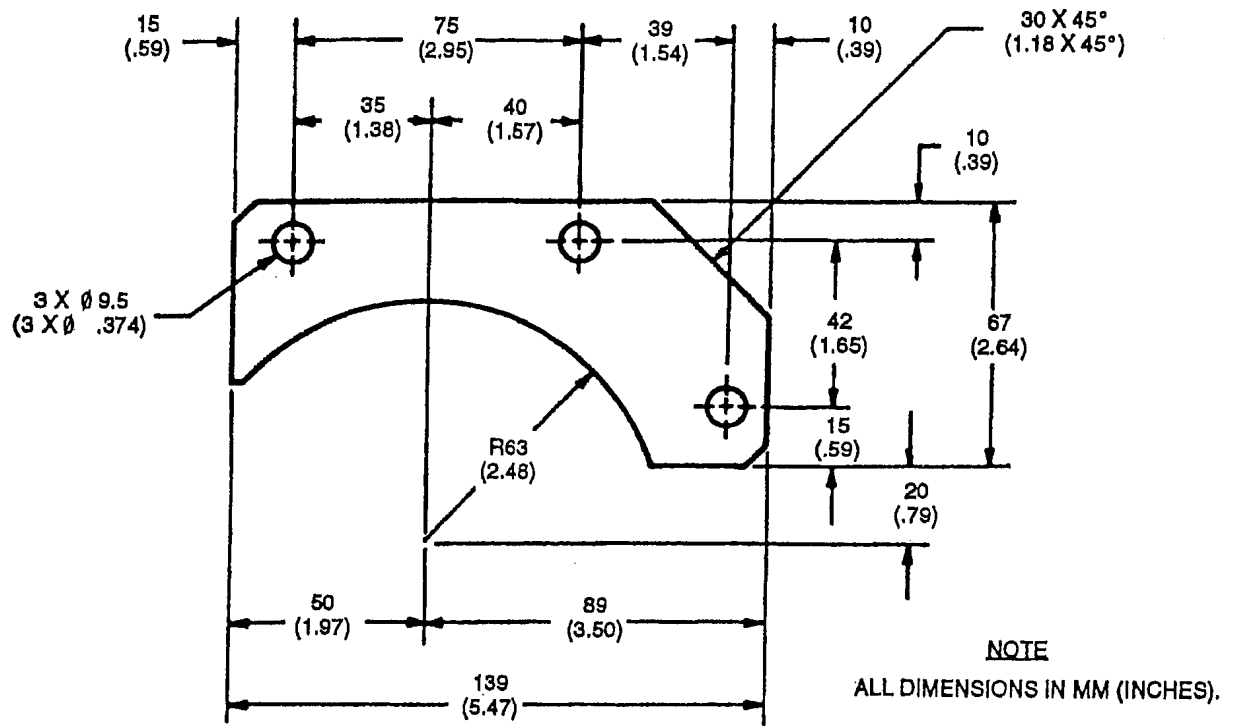


FIGURE F-2, FUEL INJECTION PUMP TIMING MARK TEMPLATE

**TABLE F-1. METRIC CONVERSION**

**Part I. Fractional Equivalent**

<b>Fractional Inches</b>	<b>Decimal Inches</b>	<b>mm</b>
1/16	.0625	1.587
1/8	.1250	3.175
3/16	.1875	4.762
1/4	.2500	6.350
5/16	.3125	7.937
3/8	.3750	9.525
7/16	.4375	11.112
1/2	.5000	12.700
9/16	.5625	14.287
5/8	.6250	15.875
11/16	.6875	17.462
3/4	.7500	19.050
13/16	.8125	20.637
7/8	.8750	22.225
15/16	.9375	23.812
1	1	25.400

**Part II. Inches to Centimeters**

<b>Inches</b>	<b>cm</b>
1	2.540
2	5.080
3	7.620
4	10.160
5	12.700
6	15.240
7	17.780
8	20.320
9	22.860
10	25.400
20	50.800
30	76.200
40	101.600
50	127.000
60	152.400
70	177.800
80	203.200
90	228.600
100	254.000



## APPENDIX G TORQUE LIMITS

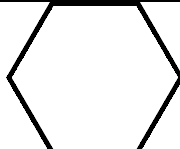
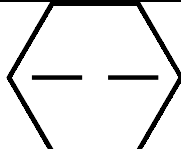
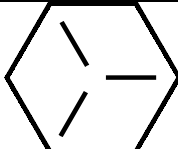
### SECTION I. INTRODUCTION

#### G.1 SCOPE.

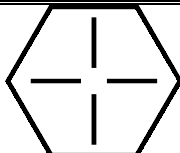
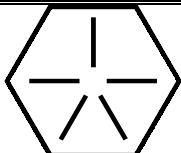
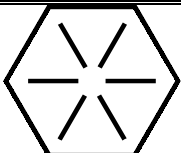
Section II lists torque ratings for fasteners used on the engine. When specific torque values called out in the maintenance procedures, they supersede the values in this appendix. Table G-1 lists torque limits for standard fasteners installed dry. Table G-2 provides formulas for converting the dry torque values to wet. Table G-3 lists torque limits for metric fasteners installed dry.

### SECTION II. TORQUE LIMITS

**TABLE G-1. TORQUE LIMITS FOR DRY FASTENERS**

								
SIZE			TORQUE					
			SAE GRADE 0-1-2		SAE GRADE 3		SAE GRADE 5	
Diameter in Inches	Threads Per Inch	Millimeters	Foot Pounds	Newton Meters	Foot Pounds	Newton Meters	Foot Pounds	Newton Meters
1/4	20	6.350	6	8	9	12	10	14
1/4	28	6.350	7	9	10	13	11	15
5/16	18	7.937	12	16	17	23	19	26
5/16	24	7.937	13	18	18	25	21	28
3/8	16	9.525	20	27	30	40	33	45
3/8	24	9.525	22	30	33	44	36	49
7/16	14	11.112	32	43	47	64	54	73
7/16	20	11.112	35	47	51	69	59	80
1/2	13	12.700	47	64	69	93	78	106
1/2	20	12.700	51	69	75	102	85	115
9/16	12	14.287	69	94	103	140	114	155
9/16	18	14.287	75	102	112	152	124	168
5/8	11	15.875	96	130	145	197	154	209
5/8	28	15.875	105	142	158	214	168	228
3/4	10	19.050	155	210	234	317	257	348
3/4	26	19.050	169	229	255	346	280	380
7/8	9	22.225	206	279	372	504	382	518
7/8	24	22.225	225	304	405	550	416	565
1	8	25.400	310	420	551	747	587	796
1	14	25.400	338	458	601	814	640	867

**TABLE G-1. TORQUE LIMITS FOR DRY FASTENERS (continued)**

								
SIZE			TORQUE					
			SAE GRADE 6		SAE GRADE 7		SAE GRADE 8	
Diameter in Inches	Threads Per Inch	Millimeters	Foot Pounds	Newton Meters	Foot Pounds	Newton Meters	Foot Pounds	Newton Meters
1/4	20	6.350	13	17	13	18	14	19
1/4	28	6.350	14	18	14	19	15	21
5/16	18	7.937	24	33	25	34	29	39
5/16	24	7.937	26	35	27	37	32	43
3/8	16	9.525	43	58	44	60	47	64
3/8	24	9.525	47	64	48	65	51	69
7/16	14	11.112	69	94	71	96	78	106
7/16	20	11.112	75	102	77	105	85	115
1/2	13	12.700	106	144	110	149	119	161
1/2	20	12.700	116	157	120	163	130	176
9/16	12	14.287	150	203	154	209	169	229
9/16	18	14.287	164	222	168	228	184	250
5/8	11	15.875	209	283	215	291	230	312
5/8	28	15.875	228	309	234	318	251	340
3/4	10	19.050	350	475	360	488	380	515
3/4	26	19.050	382	517	392	532	414	562
7/8	9	22.225	550	746	570	773	600	813
7/8	24	22.225	600	813	621	842	654	887
1	8	25.400	825	1119	840	1139	900	1220
1	14	25.400	899	1219	916	1241	981	1330

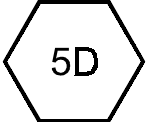



See Table G-2 for the effect of lubrication on torque.

**TABLE G-2. EFFECT OF LUBRICATION ON TORQUE**

Lubricant	TORQUE RATING IN FOOT-POUNDS	
	5/16-18 Thread/Inch	1/2-13 Thread/Inch
NO LUBE, Steel	29	121
Plated and cleaned	19 (66%)	90 (26%)
SAE 20 Oil	18 (38%)	87 (28%)
SAE 40 Oil	17 (41%)	83 (31%)
Plated and SAE 30	16 (45%)	79 (35%)
White Grease	16 (45%)	79 (35%)
White Moly Film	14 (52%)	66 (45%)
Graphite and Oil	13 (55%)	62 (49%)

Use the above lubrication percentages to calculate the approximate decrease in torque rating for other bolt sizes.

**TABLE G-3. TORQUE LIMITS FOR DRY FASTENERS (METRIC)**

						
			Standard 5D	Standard 8G	Standard 10K	Standard 12K
Diameter in Millimeters	Coarse Thread Pitch	Inches	Ft-lb    Nm	Ft-lb    Nm	Ft-lb    Nm	Ft-lb    Nm
6	1.00	0.2362	5      7	6      8	8      11	10     14
8	1.00	0.3150	10     14	16     22	22     30	27     37
10	1.25	0.3937	19     26	31     42	40     54	49     66
12	1.25	0.4624	34     46	54     73	70     95	86     117
14	1.25	0.5512	55     75	89     121	117    159	137    186
16	2.00	0.6299	83     113	132    179	175    237	208    282
18	2.00	0.7087	111    150	182    247	236    320	283    384
22	2.50	0.8771	182    247	284    385	394    534	464    629
24	3.00	0.9449	261    354	419    568	570    773	689    934

To determine torque rating for a fine thread bolt, increase the above coarse thread ratings by 9%. See Table G-2 for the effect of lubrication on torque.



## APPENDIX H MANDATORY REPLACEMENT PARTS

### SECTION I. INTRODUCTION

H.1 SCOPE. Section II of this appendix list parts that must be replaced if removed during maintenance.

### SECTION II. MANDATORY REPLACEMENT PARTS

TABLE H-1. MANDATORY REPLACEMENT PARTS

PART NO.	PART NAME	QTY.	REMARKS
R123501	GASKET	1	ENGINE OIL COOLER
R123572	GASKET	1	TURBOCHARGER
R123352	GASKET	1	ENGINE OIL PAN
R123525	GASKET	1	OIL FILTER HEAD
R123502	GASKET	1	ENGINE OIL COOLER
R123542	GASKET	1	ROCKER ARM COVER
R81275	GASKET	1	AIR INLET
R90658	GASKET	4	EXHAUST MANIFOLD
R123421	GASKET	1	TIMING GEAR COVER
R136516	GASKET	1	(SUB FOR R123421 AND R134534) TIMING GEAR COVER
R116515	GASKET	1	CYLINDER HEAD
R135896	GASKET	1	(SUB FOR R121416) THERMOSTAT
R136495	GASKET	2	(SUB FOR R116297) ENGINE OIL FILLER NECK
R123417	GASKET	1	WATER PUMP
R27149	O-RING	1	FLYWHEEL HOUSING
T122075	O-RING	2	ENGINE OIL COOLER
U13639	O-RING	2	CYLINDER BLOCK
R26375	O-RING	2	THERMOSTAT
R121424	O-RING	1	TIMING GEAR COVER
R75892	O-RING	1	CYLINDER BLOCK
R89944	O-RING	1	WATER PUMP
R10093	O-RING	1	DIPSTICK

ARMY TM 9-2815-259-24  
 AIR FORCE TO 38G1-125-2  
 MARINE CORPS TM 09249A/09246A-24

TABLE H-1. MANDATORY REPLACEMENT PARTS – CONT.			
PART NO.	PART NAME	QTY.	REMARKS
AR65507	O-RING KIT	4	CYLINDER LINER
R63548	O-RING	2	TURBOCHARGER
R61871	O-RING	1	OIL PUMP
R123575	O-RING	4	ROCKER ARM COVER
R61105	O-RING	2	ENGINE OIL COOLER
51M7040	O-RING	1	FUEL INJECTION PUMP SUPPLY
51M7043	O-RING	1	OIL PAN
R97185	O-RING	1	OIL PUMP
51M7044	O-RING	1	17.300 X 2.200 MM TIMING GEAR COVER
RE59754	OIL FILTER	1	
RE66271	PISTON RING KIT	4	PISTON RINGS
RE50752	SEAL KIT	1	FUEL FILTER
R26125	SPRING	8	CYLINDER HEAD
R111137	SPRING	1	CYLINDER BLOCK
T20314	SPRING	3	ROCKER ARM SHAFT
RE64354	THERMOSTAT	1	82° C (180°F)
R131206	THRUST WASHER	1	CRANKSHAFT
R131283	THRUST WASHER	1	CRANKSHAFT

INDEX

**A**

Aligning Pin Hole in Piston, Figure 5-60 .....	5-44
--	------

**B**

Balancer Shaft Assembly .....	5-90
Inspection Prior to Removal .....	5-90
Installation .....	5-92
Removal .....	5-90
Test .....	5-91
Replacement .....	5-91
Battery Charging Alternator .....	3-23, 4-14
Assembly .....	4-20
Assembly, Figure 4-2 .....	4-16
Mounting, Figure 3-4 .....	3-24
Inspection .....	3-24
Installation .....	3-25
Repair .....	4-15
Removal .....	3-23
Replacement .....	3-24
Test .....	4-14
Test (Battery Charging Alternator Installed) .....	3-23
Test Circuit, Figure 4-1 .....	4-14
Bleeding Fuel System .....	3-37
General .....	3-37
at Fuel Filter .....	3-37
at Fuel Injection Nozzles .....	3-40
at Fuel Injection Pump .....	3-39

**C**

Cam Advance Pin Removal, Figure 5-5 .....	5-11
Cam Rollers And Shoes, Figure 5-21 .....	5-21
Cam Ring Removal, Figure 5-12 .....	5-15
Figure 5-18 .....	5-19
Camshaft Lobe Height Specifications, Table 5-3 .....	5-50
Camshaft And Timing Gear Train Specifications, Table 5-4 .....	5-53
Camshaft and Balancer Shafts, Figure 5-61 .....	5-47

# INDEX (Continued)

## C (Continued)

Camshaft Assembly .....	5-45
End Play Test.....	5-45
Inspection Prior to Camshaft Removal .....	5-45
Installation .....	5-51
Removal .....	5-45
Replacement.....	5-51
Test .....	5-48
Checking	
Timing Marks, Figure 4-42 .....	4-53
Brush Holder Assembly, Figure 4-30 .....	4-33
Commutator Run-Out, Figure 4-21 .....	4-29
Field Coils, Figure 4-31 .....	4-34
For Open Field Coil, Figure 4-32 .....	4-34
For Open Circuit Windings, Figure 4-29 .....	4-33
Overrunning Clutch, Figure 4-26 .....	4-31
Piston Ring Groove Clearance, Figure 5-75 .....	5-76
Piston Keystone Ring Groove Wear, Figure 5-74.....	5-75
Clip Removal, Figure 5-2.....	5-9
Connecting Rod Bore (Without Bearing Inserts) Specifications, Table 5-7 .....	5-78
Piston Pin Bushing Specifications, Table 5-8 .....	5-79
Journal And Bearing Specifications, Table 5-6 .....	5-77
Assembly And Governor Spring Removal, Figure 5-4 .....	5-10
Control Rod Installation, Figure 5-49 .....	5-38
Control Spring Installation, Figure 5-48 .....	5-37
Cooling System.....	2-1
General.....	3-18
Maintenance.....	3-18
Corrosion Prevention And Control .....	1-2
Crankshaft And Main Bearings.....	5-60
Figure 5-67.....	5-61
Installation .....	5-68
Inspection.....	5-63
Removal .....	5-60
Repair.....	5-67
Specifications, Table 5-5 .....	5-64



INDEX (Continued)

C (Continued)

Crankshaft End Play Test .....	5-62
Crankshaft Pulley.....	4-90
Figure 4-61 .....	4-90
Inspection .....	4-90
Installation .....	4-91
Removal.....	4-90
Replacement .....	4-90
Crankshaft Pulley And Timing Gear Assembly Maintenance .....	4-90
Critical Areas of Crankshaft Load Stress, Figure 5-68 .....	5-63
Cylinder Block .....	5-93
Disassembly .....	5-93
Reassembly .....	5-96
Repair .....	5-95
Top Deck Specifications, Table 4-5 .....	4-78
Cylinder Head.....	4-73, 5-108
Assembly .....	5-116
Assembly, Figure 4-49.....	4-75
Assembly Maintenance .....	4-63
Capscrew Torque Sequence, Figure 4-52 .....	4-79
Disassembly .....	5-108
Inspection .....	4-76
Installation .....	4-78
Repair .....	5-108
Removal.....	4-73
Testing Prior to Installation .....	4-77
Cylinder Liners .....	5-83
And Piston Specifications, Table 5-11 .....	5-87
Height Specifications, Table 5-9 .....	5-83
Inspection .....	5-84
Installation .....	5-89
Removal.....	5-83
Repair .....	5-89
Testing Cylinder Liner Height Prior to Removal.....	5-83
Thickness Specifications, Table 5-10 .....	5-87

INDEX (Continued)

**D**

Damper Barrel and Piston, Figure 5-51 .....	5-39
Data Plates .....	1-5
Delivery Valve, Figure 5-28 .....	5-25
Removal, Figure 5-14 .....	5-16
Destruction of Army Material to Prevent Enemy Use.....	1-2
Direct Support Troubleshooting, Table 4-1 .....	4-2
Direct Support Troubleshooting Procedures.....	4-1
Disconnecting Lead Wire (Typical), Figure 4-11 .....	4-24
Drive Shaft Bearing and Seal Removal (Shown Removed), Figure 5-10 .....	5-14
Figure 5-17.....	5-18
Bearing Installation, Figure 5-31 .....	5-27
Droop Control Locking Cap Installation, Figure 5-50 .....	5-38
Removal, Figure 5-3 .....	5-9

**E**

Electrical System .....	2-2
Electrical System Maintenance .....	3-23, 4-14
Engine Components, Figure 1-1 .....	1-4
Engine Description, General .....	1-2
Lubrication System .....	1-3
Camshaft .....	1-2
Cooling System.....	1-3
Crankshaft.....	1-3
Cylinder Liners and Pistons .....	1-3
Detailed.....	1-2
Electrical System .....	1-3
Fuel System.....	1-3
Intake and Exhaust Valves.....	1-3
Turbocharger .....	1-2
Engine, Inspection .....	1-8
Lifting, Figure 4-64.....	4-97
Option Codes - 6 Cylinder, 6.8 Liter, Table 1-2 .....	1-6
Timing Hole Location, Figure 4-46 .....	4-66
Service .....	1-8
Equipment Data, Leading Particulars .....	1-5

INDEX (Continued)

E (Continued)

Exhaust Manifold .....	3-29, 4-45
Figure 3-8 .....	3-29
Inspection .....	3-29, 4-45
Installation .....	4-46
Removal.....	4-45
Replacement .....	4-46

F

Fabrication of Tools and Equipment .....	3-1
Fan Drive Assembly, Figure 4-62.....	4-91
Fastening Cylinder Liners, Figure 5-70 .....	5-71
Flywheel .....	4-81
Flatness, Figure 4-53 .....	4-82
Flatness Specifications, Table 4-6 .....	4-82
Inspection .....	4-81
Installation .....	4-84
Removal.....	4-82
Removal, Figure 4-54 .....	4-82
Replacement .....	4-83
and Housing Assembly, Figure 4-59.....	4-88
and Housing Assembly Maintenance.....	4-81
Flywheel Housing .....	4-87
Cutouts, Figure 4-55 .....	4-83
Inspection .....	4-87
Removal.....	4-87
Replacement .....	4-88
Installation .....	4-88
Flywheel Ring Gear, Figure 4-56 .....	4-83
Front Plate .....	5-57
Figure 5-65 .....	5-57
Inspection .....	5-58
Installation .....	5-58
Removal.....	5-57
Sealant Application, Figure 5-66.....	5-59

# INDEX (Continued)

## F (Continued)

Fuel Filter.....	3-42
Assembly, Figure 3-15 .....	3-38
Installation .....	3-43
Remove Fuel Filter Element .....	3-42
Service .....	3-43
 Fuel Filter Base.....	4-62
Installation .....	4-62
Removal .....	4-62
Repair.....	4-62
 Fuel Injection Assembly, Figure 3-17 .....	3-41
Fuel Injection Housing Assembly, Figure 5-16 .....	5-17
Fuel Injection Nozzle Assembly .....	4-56
Figure 4-44.....	4-59
Inspection.....	3-49
Installation .....	4-61
Removal .....	4-56
Replacement.....	4-61
Test .....	4-57
 Fuel Injection Pump.....	4-50, 5-2
Assembly .....	5-26
Checks, Table 5-2 .....	5-5
Disassembly .....	5-5
Figure 5-1.....	5-6
Inspection.....	3-49, 4-53
Installation .....	4-54
Pressure Outlet Ports, Figure 4-43 .....	4-55
Removal .....	4-50
Repair.....	5-17
Replacement.....	4-53
Test .....	5-2
 Fuel Lines .....	3-47
Inspection.....	3-48
Installation .....	3-49
Removal .....	3-47
Replacement.....	3-49

INDEX (Continued)

**F (Continued)**

Fuel Side Seal Installation, Figure 5-29.....	5-26
Fuel Supply Pump, Figure 3-16.....	3-39
Fuel System .....	2-1
Maintenance .....	4-50, 5-2
Fuel Transfer Supply Pump.....	3-43
Bench Test.....	3-45
Inspection .....	3-45
Installation .....	3-47
Replacement .....	3-46
Removal.....	3-44
Test On Engine .....	3-43
Fuel Transfer Pump Push Rod Location, Figure 4-50 .....	4-76

**G**

Gasket Application to Cylinder Block, Figure 4-60 .....	4-89
General .....	4-13
Maintenance .....	3-15
General Support Troubleshooting Procedures.....	5-1
Governor Arm and Linkage Hook Removal, Figure 5-9 .....	5-13
Governor Weight Installation, Figure 5-44.....	5-35
Growler Test, Figure 4-27 .....	4-32

**H**

Head and Rotor Assembly Installation, Figure 5-47.....	5-36
Hydraulic Head Assembly, Figure 5-19 .....	5-20
Removal, Figure 5-8.....	5-12

# INDEX (Continued)

## I

Idler Gears and Idler Gear Shafts.....	5-53
Figure 5-63.....	5-55
End Play and Backlash Test.....	5-53
Installation .....	5-56
Removal .....	5-54
Test .....	5-55
Inspecting	
Cylinder Block, Figure 5-81 .....	5-97
Cylinder Liner Pitting, Figure 5-78.....	5-86
Piston Cooling Orifice, Figure 5-79.....	5-95
and Replacing Bearings, Figure 4-24.....	4-30
and Servicing Engine .....	1-8
Turbocharger Bearings, Figure 4-38.....	4-43
Installing	
Brushes, Figure 4-33 .....	4-35
Cover On Yoke, Figure 4-34 .....	4-36
Rollers and Shoes (Typical), Figure 5-39 .....	5-31
Yoke, Figure 4-35 .....	4-36
Intake and Exhaust System Maintenance .....	3-28, 4-37
Adjust.....	4-64
Test Valve Lift.....	4-68
Test Valve Clearance .....	4-67
Intake Manifold.....	3-28, 4-44
Figure 3-7.....	3-28
Inspection.....	3-28, 4-44
Installation .....	4-45
Pressure Check.....	3-17
Removal.....	4-44
Replacement.....	4-44
Introduction.....	2-1

## INDEX (Continued)

### L

Leaf Springs, Figure 5-22 .....	5-21
Linkage Hook Disconnection, Figure 5-7 .....	5-12
Lubrication Instructions .....	3-1
Lubrication System .....	2-1
Maintenance .....	3-29, 4-46

### M

Maintenance Repair Parts .....	3-1
Measuring	
Engine Blow-by .....	3-16
Brush Length, Figure 4-25 .....	4-31
Cam Follower Bore Diameter, Figure 5-83 .....	5-99
Camshaft Bore Diameter, Figure 5-84 .....	5-99
Camshaft Lobe Height, Figure 5-62 .....	5-50
Commutator OD, Figure 4-22 .....	4-29
Cylinder Block Top Deck Flatness, Figure 5-85 .....	5-100
Cylinder Head Thickness, Figure 5-91 .....	5-112
Main Bearing Bore, Figure 5-82 .....	5-98
Main Thrust Journal and Thrust Bearing Width, Figure 5-69 .....	5-65
Piston Skirt, Figure 5-76 .....	5-76
Rod Center-to-Center Bores, Figure 5-77 .....	5-80
Roller to Roller Dimension, Figure 5-40 .....	5-32
Segment Mica Depth, Figure 4-23 .....	4-30
Metering Valve and Arm Assembly, Figure 5-27 .....	5-25

### N

Nuclear, Biological, Chemical (NBC) Decontamination Procedures .....	2-2
--	-----

### O

Oil Bypass Valve Assembly .....	5-106
Figure 5-89 .....	5-107
Inspection .....	5-106
Installation .....	5-107
Removal .....	5-106
Replacement .....	5-107

INDEX (Continued)

O (Continued)

Oil Cooler .....	3-31
Assembly, Figure 3-10 .....	3-32
Inspection.....	3-31
Installation .....	3-32
Removal .....	3-31
Replacement.....	3-32
Oil Dipstick Tube .....	3-34
Inspection.....	3-34
Installation .....	3-35
Installation, Figure 3-13.....	3-35
Removal .....	3-35
Replacement.....	3-35
Assembly, Figure 3-12 .....	3-34
Oil Fill Tube .....	3-33
Assembly, Figure 3-11 .....	3-33
Inspection.....	3-34
Installation .....	3-34
Removal .....	3-33
Replacement.....	3-34
Oil Filter Assembly.....	3-29
Figure 3-9.....	3-30
Inspection.....	3-29
Installation .....	3-31
Replacement.....	3-30
Removal .....	3-29
Oil Gallery Plugs, Figure 5-80.....	5-96
Oil Pan .....	4-48
Figure 3-14.....	3-36
Inspection.....	3-36, 4-48
Installation .....	4-49
Removal .....	4-48
Replacement.....	4-49



# INDEX (Continued)

## O (Continued)

Oil Pressure Regulating Valve Assembly .....	4-46
Figure 4-39 .....	4-47
Inspection .....	4-47
Installation .....	4-48
Removal.....	4-46
Replacement .....	4-48
Valve Seat Replacement .....	5-118
Oil Pump Assembly .....	5-102
Figure 5-86 .....	5-103
Axial Clearance Measurement, Figure 5-87 .....	5-104
Installation .....	5-106
Inspection .....	5-103
Radial Clearance Measurement, Figure 5-88.....	5-105
Removal.....	5-102
Replacement .....	5-105
Oil Side Seal Installation, Figure 5-30.....	5-27
Option Code Label, Figure 1-2.....	1-5

## P

Pick-Up Tube Assembly .....	4-49
Figure 4-40 .....	4-49
Inspection .....	4-49
Piston Inspection, Figure 5-73 .....	5-75
Piston and Piston Ring Seal, Figure 5-55 .....	5-41
Piston in Power Side Piston Hole, Figure 5-58.....	5-43
Piston Ring Compressor, Figure 5-57.....	5-42
Figure 5-56 .....	5-42
Pistons and Connecting Rods .....	5-70
Installation .....	5-82
Removal.....	5-70
Repair .....	5-73
and Cylinder Liners, Figure 5-72.....	5-74
PMCS Procedures.....	3-1
Power Side Piston Hole Plug Installation, Figure 5-59 .....	5-43

# INDEX (Continued)

## P (Continued)

Preparation for Storage or Shipment.....	1-2
Preventive Maintenance Checks and Services (PMCS), Table 3-1.....	3-2
Procedural Index, General Support Maintenance .....	5-1
Pumping Plunger Installation, Figure 5-38 .....	5-31
Removal, Figure 5-13 .....	5-15
Purpose	
of Troubleshooting Flowchart.....	3-3, 4-1
of Equipment.....	1-1

## R

Rear Crankshaft Oil Seal/Wear Sleeve Assembly.....	4-84
Removal of Rear Crankshaft Oil Seal, Figure 4-57 .....	4-84
Removal .....	4-84
Replacement.....	4-85
Installation .....	4-86
Installation, Figure 4-58.....	4-86
Inspection.....	4-85
Reed Valve Assembly, Figure 5-54 .....	5-41
Removal, Figure 5-6 .....	5-11
Regulator Assembly Installation, Figure 5-43.....	5-34
Removing	
Armature, Figure 4-15 .....	4-26
Brushes, Figure 4-14.....	4-25
Carbon From Cylinder Liners, Figure 5-71.....	5-71
Overrunning Clutch (Typical), Figure 4-17 .....	4-27
Pinion, Retainer, and Rollers (Typical), Figure 4-19.....	4-28
Housing (Typical), Figure 4-16 .....	4-26
Rear Crankshaft Oil Seal, Figure 4-57 .....	4-84
Starter End Frame and Yoke Assembly, (Typical), Figure 4-13.....	4-25
Steel Ball, Figure 4-18 .....	4-27
Through Bolts (Typical), Figure 4-12.....	4-24
Valve Seat Insert, Figure 5-93 .....	5-115
Washer and Spring, Figure 4-20 .....	4-28

INDEX (Continued)

**R** (Continued)

Reporting

Equipment Improvement Recommendations (EIR) .....	1-1
Item and Packaging Discrepancies .....	1-1
Equipment Improvement Recommendations (EIR), Army .....	1-1
Equipment Improvement Recommendations (EIR), Air Force .....	1-1
Equipment Improvement Recommendations (EIR), Marine Corps .....	1-2
Reports of Maintenance and Unsatisfactory Equipment .....	1-1
Retaining Clip Removal, Figure 5-15 .....	5-16
Rocker Arm Assembly .....	4-70
Figure 4-48 .....	4-70
Adjust .....	4-71
Installation .....	4-73
Removal .....	4-70
Repair .....	4-71
Replacement .....	4-72
Rocker Arm Cover .....	4-63
Figure 4-45 .....	4-65
Installation .....	4-64
Removal .....	4-63
Replacement .....	4-63
Rocker Arm Location, Figure 4-47 .....	4-67
Rotor Assembly, Figure 5-20 .....	5-20

**S**

Seal Protection Tube, Figure 5-32 .....	5-28
Separating Gear and Shaft, Figure 4-41 .....	4-52
Setting Governor Linkage Gap, Figure 5-53 .....	5-40
Short Block Assembly .....	5-45
Spring Pin Protrusion, Figure 5-64 .....	5-56
Spring Washer and Retaining Ring, Figure 5-34 .....	5-29
Stand, Vehicle Engine .....	4-95

# INDEX (Continued)

## S (Continued)

Starter.....	3-25, 4-21
Assembly .....	4-21, 4-35
Assembly, Figure 3-6.....	3-27
Bench Test Setup, Figure 4-9.....	4-22
Inspection.....	3-26
Installation .....	3-26
Removal .....	3-26
Repair.....	4-24
Replacement.....	3-26
Test .....	4-21
Test (Installed on Generator) .....	3-25
Solenoid Test Circuit, Figure 3-5.....	3-25
Stator and Rear Housing Separation, Figure 4-3.....	4-17

## T

Table of Specifications, Table 1-1 .....	1-5
Testing	
Cylinder Liner Height Prior to Cylinder Liner Removal.....	5-79
Engine Compression Pressure.....	3-16
For Grounded Windings, Figure 4-28.....	4-32
Brush Assembly, Figure 4-4 .....	4-17
Exciting Diodes, Figure 4-5 .....	4-18
Positive/Negative Diodes, Figure 4-6 .....	4-18
Rotor, Figure 4-8 .....	4-20
Stator Windings, Figure 4-7.....	4-19
Thermostat and Water Manifold/Thermostat Cover .....	3-18
Figure 3-1.....	3-19
Inspection.....	3-19
Installation .....	3-20
Installation, Figure 3-2.....	3-21
Removal .....	3-18
Replacement.....	3-20
Throttle Installation, Figure 5-52 .....	5-39
Thrust Bearing and Thrust Washer, Figure 5-33.....	5-28
Sleeve Installation, Figure 5-46 .....	5-36

## INDEX (Continued)

### T (Continued)

Thrust Washer Installation, Figure 5-45 .....	5-35
Tightening Delivery Valve Stop Screw, Figure 5-37.....	5-30
Timing Gear	
Cover .....	4-91
Cover, Figure 4-63.....	4-93
Cover, Inspection.....	4-92
Cover, Installation .....	4-94
Cover, Removal.....	4-91
Cover, Replacement.....	4-94
Timing Mark Locator, Figure 5-35 .....	5-29
Tools and Equipment.....	3-1
Transfer Pump	
Blades, Figure 5-23 .....	5-22
Blade Installation, Figure 5-42 .....	5-33
End Cap Seal Removal, Figure 5-11 .....	5-14
Liner, Figure 5-24.....	5-23
Liner Installation, Figure 5-41 .....	5-33
Regulator Assembly, Figure 5-26 .....	5-24
Regulating Piston and Adjusting Screw, Figure 5-25 .....	5-23
Transportation Discrepancy Report (TDR) (SF 361) .....	1-1
Turbocharger .....	4-37
Figure 4-36 .....	4-39
Inspection .....	4-38
Inspection Points, Figure 4-37.....	4-40
Inspecting Turbocharger Bearings, Figure 4-38 .....	4-43
Install.....	4-42
Removal.....	4-37
Replacement .....	4-41
Test.....	4-41
Type of Manual .....	1-1

### U

Unit Troubleshooting Procedures .....	3-3
Unit Troubleshooting, Table 3-2 .....	3-4

# INDEX (Continued)

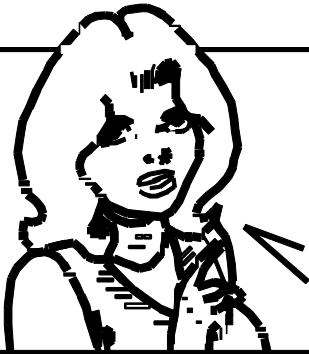
## V

### Valve

Clearance Specification (Rocker Arm-To-Valve Tip), Table 4-2.....	4-68
Face Angle, Figure 5-90 .....	5-110
Guide Installation, Figure 5-95 .....	5-117
Lift Specifications at 0.00 in. (mm) Valve Clearance, Table 4-3.....	4-69
Recess Measurement, Figure 4-51 .....	4-76
Recess Specifications, Table 4-4 .....	4-77
Seat Bore in Cylinder Head Measurement, Figure 5-94 .....	5-116
Seat Bore Insert Specifications, Table 5-12.....	5-117
Seat Removal Chisel, Figure 5-92 .....	5-115

## W

Warranty .....	1-2
Water Pump .....	3-21
Assembly, Figure 3-3 .....	3-22
Inspection.....	3-22
Installation .....	3-22
Removal .....	3-21
Replacement.....	3-22
Weight Retaining Assembly, Figure 5-36 .....	5-30

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2-25

2-28

Recommend that the installation antenna alignment  
procedure be changed throughout to specify a 20 IFF  
antenna lag rather than 10.

REASON: Experience has shown that with only a 10 lag,  
the antenna servo system is too sensitive to wind gusting in  
excess of 25 knots, and has a tendency to rapidly accelerate  
and decelerate as it hunts, causing strain to the drive train.  
Hunting is minimized by adjusting the lag to 20 without  
degradation of operation.

3-10

3-3

3-1

Item 5, Functional column. Change • 2 dB" to • 3 dB".

REASON: The adjustment procedure for the TRANS POWER  
FAULT indicator calls for a 3 dB (500 watts) adjustment to light  
the TRANS POWER FAULT indicator.

5-6

5-8

Add new step f.1 to read, • Replace cover plate removed in  
step f.1, above."

REASON: To replace the cover plate.

FO-3

Zone C 3. On J1-2, change • +24 VDC" to • +5 VDC".

REASON: This is the output line of the 5 VDC power supply.  
+24 VDC is the input voltage.

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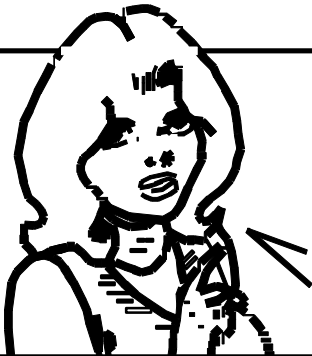
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