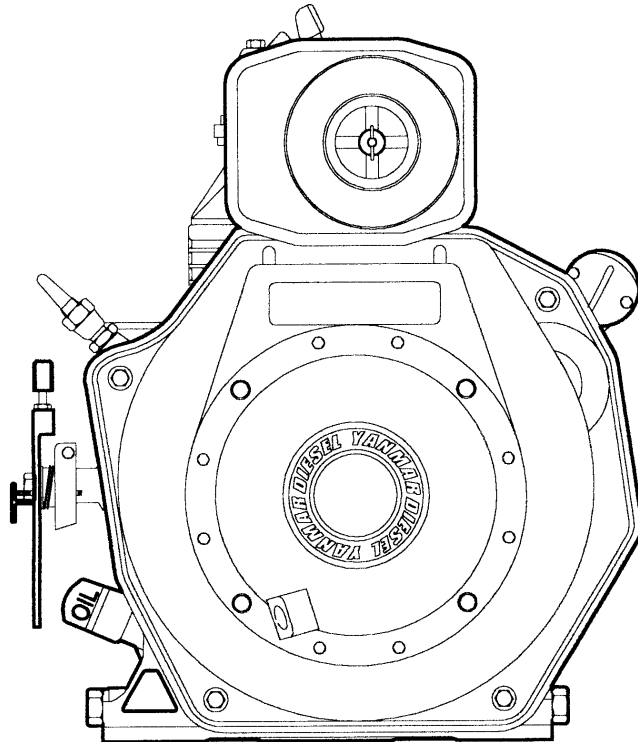


**ARMY TM 9-2815-257-24
AIR FORCE TO 38G1-128-2
MARINE CORPS TM 10155A/2815-24/3**

**UNIT, DIRECT SUPPORT, AND GENERAL SUPPORT
MAINTENANCE MANUAL**



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**DIESEL ENGINE ASSEMBLY
MODEL L70AE-DEGFR
(NSN: 2815-01-465-5993) (EIC: N/A)**

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WARNING SUMMARY

The following safety precautions are for personnel to understand and apply during many phases of maintenance. Disregard of these warnings and precautionary information can result in serious injury or death.

Warning statements have been strategically placed throughout this manual prior to the maintenance procedures considered essential to the protection of personnel. Prior to starting any task, the warning included in the text for that task must be reviewed and understood.

This manual describes physical and chemical processes which may require the use of chemicals, solvents, paints, or other commercially available material. The user of this manual should obtain the material safety data sheets (Occupational Safety and Health Act (OSHA) Form 20 or equivalent) from the manufacturer or suppliers of materials to be used. The user must be completely familiar with the manufacturer/supplier information and adhere to the procedures, recommendations, warnings, and cautions of the manufacturer/supplier for the safe use, handling, storage, and disposal of these materials.

FOR ARTIFICIAL RESPIRATION, REFER TO FM 21-11.

WARNING

Cleaning solvents are flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protections are required when working in contact with cleaning solvents. Avoid prolonged or repeated contact. Work in well ventilated area only. Keep away from heat, sparks, and open flame. Do not smoke while using cleaning solvent. Failure to observe this warning can result in injury or death to personnel.

WARNING

Valve springs are under high pressure. Use caution and remove spring retainers slowly. Failure to observe this warning can cause serious injury to personnel.

WARNING

Use extreme caution when handling hot components. Wear protective gloves. Failure to observe this warning can result in injury to personnel.

WARNING

REMOVE ALL JEWELRY BEFORE WORKING ON THE EQUIPMENT

Metal jewelry can conduct electricity. Remove metal jewelry before working on electrical system or components. Failure to observe this warning can result in severe personal injury from electric shock.

WARNING

Jewelry and other loose and dangling articles and clothing can be caught in moving parts. Remove jewelry and loose and dangling articles and clothing before working on the engine. Failure to observe this warning can result in injury to personnel.

WARNING

The engine is heavy. Provide adequate lifting device to support the weight. Use lifting ring for lifting purpose and use caution when lifting or moving the engine assembly. Failure to observe this warning can result in injury to personnel and/or damage to equipment.

WARNING

With any access door open, the noise level of the generator set when operating could cause hearing damage. Hearing protection must be worn when working near the generator set while running.

**UNIT, DIRECT SUPPORT, AND GENERAL SUPPORT
MAINTENANCE MANUAL**

FOR

**DIESEL ENGINE ASSEMBLY
MODEL L70AE-DEGFR
(NSN: 2815-01-465-5993) (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 Form) or DA Form 2028-2 located in the back of this manual directly to: Commander, US Army Communications and Electronics Command (CECOM), ATTN: AMSEL-LC-LEO-D-CS-CFO, Fort Monmouth, NJ 07703-5000. The FAX number is 732-532-1413, DSN 992-1413. You can also E-mail your recommendations to AMSEL-LC-LEO-PUBS-CHG@cecom3.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.

For Marine Corps units, submit NAVMC 10772 (Recommended Changes to Technical Publications) to: Commanding General, Marine Corps Logistics Base, Life Cycle Management Center, ATTN Code 826, 814 Radford Blvd., Suite 20320, Albany, Georgia 31704-0320. You can submit and electronic form over the web by going to: als.usmc.mil and selecting NAVMC Tracking Program.

A reply will be furnished directly to you.

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How to Use This Manual

1. DESCRIPTION OF THE MANUAL.

a. **Chapter Organization.** This manual has five chapters covering: introductory information, principles of operation, unit maintenance instructions, direct support maintenance instructions, and general support maintenance instructions. Each chapter is divided into sections. These sections contain the cleaning, inspection, troubleshooting, and repair tasks appropriate for the specific maintenance level. Each chapter contains a table of contents containing the tasks within that chapter. See the overall Table of Contents (page i) for the chapters and sections of this manual.

b. **Paragraph and Task Numbering.** All paragraphs and maintenance tasks are numbered. This helps you find what you need when you need it. Use the Table of Contents (page i) or alphabetical index (at the back of the manual) to find the paragraph or task you need.

c. **Appendices.** The appendices in this manual contain both general maintenance information and specific data for this engine. They list reference manuals and materials, components of the engine assembly, additional authorization list items, expendable supplies and materials, torque limits, and mandatory replacement parts. Refer to the Table of Contents (page i) for a complete list of the appendices used in this manual.

2. HOW TO FIX AN ENGINE MALFUNCTION.

a. **Determining the Cause.** Figuring out the cause of the malfunction, or troubleshooting, is the first step in fixing the engine assembly and returning it to operation. Follow these steps to determine the root of your problem:

- (1) Turn to the Table of Contents section in this manual (page i).
- (2) Locate "Troubleshooting" for your maintenance level and turn to the page indicated.
- (3) In the Troubleshooting section, find the troubleshooting symptom for the component affected by the malfunction. Refer to the Symptom Index for help.

NOTE

If the specific symptom is not addressed, the maintenance required is most likely more detailed than authorized for your level. Notify personnel at a higher maintenance level.

- (4) Begin troubleshooting. Carefully work your way down through the troubleshooting table to try and determine what the problem is.
- (5) Once the trouble has been determined, go to the maintenance task called out. Remedy the malfunction, test the engine, and return it to service.

b. **Preparing for a Task.**

NOTE

You must familiarize yourself with the entire maintenance procedure before starting any maintenance task. Ensure all parts, materials, and tools are handy. Read through all steps before beginning.

- (1) PAY ATTENTION TO WARNINGS, CAUTIONS, AND NOTES.
- (2) Maintenance tasks are arranged in a logical disassembly/assembly sequence and address only the component or assembly to be replaced. Locator illustrations are included for removal and installation. These illustrations show you the area of the generator set to be worked on.
- (3) All mandatory replacement parts are listed, including gaskets, packings, cotter pins, and lockwashers. They are listed by the Repair Parts and Special Tools List (RPSTL) name. Expendable supplies and support materials are listed, including solvents, rags, grease, and safety wire.
- (4) Tools, tool kits or shop sets needed to do the task are listed. If tools from a repairman's kit are needed, the kit is listed. Tools that are not in a kit or set are listed by name, type, and size. Special tools and test equipment are listed by part number.
- (5) Related TM's needed to accomplish the task are listed. The steps tell when these TM's are needed.
- (6) Read the entire task carefully before starting. **DO NOT START A TASK UNTIL:**

You know what replacement parts, tools, and supplies are needed

You have the things you need

You understand what to do

c. **How To Do The Task.** Before starting, read the entire task. Familiarize yourself with the entire procedure before you begin the task. The following are considered standard maintenance practices. Instructions about these practices will not normally be included in the task steps. Task steps will tell you when standard maintenance practices do not apply. As you read, remember the following:

- (1) Electrical wiring must be tagged before it is disconnected.
- (2) Used packings, retainers, gaskets, cotter pins, lockwashers, and safety wire shall be discarded. Do not reuse. New parts shall be installed.
- (3) Packings shall be coated with lubricant before installation in accordance with task instructions.

- (4) Disassembly procedures list all steps required to support total authorized repair of a component. You may not need to disassemble a part as far as described in the task. Follow the steps to disassemble as far as required to replace worn or damaged parts.
- (5) Before components or the disassembled parts of a component are inspected, they must be cleaned as required.
- (6) Components and mating surface areas must be inspected for serviceable condition before installation.
- (7) When a nut is tightened or loosened on a bolt, the bolt head must be held with a wrench.
- (8) A special torque will be cited when the words TORQUE TO are used in the task. Standard torques are used at all other times. Refer to Torque Limits, Appendix G, for information.
- (9) When tightening hardware, observe compliance with the drag torque as required. To determine drag torque, thread nut onto bolt until at least two threads protrude. The nut must not contact the mating part. The torque required to begin turning the nut is the drag torque.
- (10) When a cotter pin is required, cotter pin holes will be aligned within the allowable torque range.
- (11) After maintenance, inspect for foreign objects.

NOTE

Remember, this manual is divided by maintenance level (unit, direct support and general support). If you cannot find an engine malfunction in the troubleshooting section for your maintenance level, or cannot find the appropriate corrective actions in the maintenance section, notify personnel at a higher maintenance level.

3. REPAIR PARTS AND SPECIAL TOOLS LIST.

Refer to TM 9-2815-257-24P for the Engine Assembly Repair Parts and Special Tools List (RPSTL). The RPSTL contains exploded view illustrations and parts lists keyed to the illustrations. It lists part number, part name, and quantity used in each application. Use the RPSTL to identify and order replacement parts.

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Section I. GENERAL INFORMATION

1-1. SCOPE.

This manual provides instructions on troubleshooting and maintenance of the Diesel Engine Assembly, Model Number L70AE-DEGFR, NSN 2815-01-465-5993, manufactured by Yanmar Diesel Engine Company, Ltd. Information is provided on principles of operation, preventive maintenance checks and services, lubrication, troubleshooting, and maintenance. Refer to Figure 1-1 for full view illustrations of the Diesel Engine Assembly.

1-2. CONSOLIDATED INDEX OF ARMY PUBLICATIONS AND FORMS.

Refer to the latest issue of DA Pam 25-30 to determine whether there are new additions, changes, or additional publications pertaining to the equipment.

1-3. 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, The Army Maintenance Management System (TAMMS). Air Force personnel will use AFR 66-1 for maintenance reporting and TO 00-35D54 for unsatisfactory equipment reporting. Marine Corps personnel refer to the on-line MCPDS Index of Technical Publications. Refer to TM 4700-15/1 for disposition of forms and records required for Marine Corps equipment.

b. **Reporting of Item and Packaging Discrepancies.** Fill out and forward SF 364 (Report of Discrepancy (ROD)) as prescribed in AR 735-11-2, AFR 400-54, or MCO 4430.3J.

c. **Transportation Discrepancy Report (TDR) (SF 361).** Fill out and forward Transportation Discrepancy Report (TDR) (SF 361) as prescribed in AR 55-38, AFR 75-18, or MCO P4610.19D.

1-4. CORROSION PREVENTION AND CONTROL (CPC).

a. Corrosion Prevention and Control (CPC) of Army materiel is a continuing concern. It is important that any corrosion problems with the engine assembly be reported so that the problem can be corrected and improvements can be made to prevent the problem in future engine assemblies.

b. While corrosion is typically associated with rusting of metals, it can also include deterioration of other materials, such as rubber or plastic. Unusual cracking, softening, swelling, or breaking of these materials may be a corrosion problem.

c. If a corrosion problem is identified, it can be reported using Standard Form 368, Product Quality Deficiency Report. Use of keywords such as "corrosion", "rust", "deterioration", or "cracking" will ensure that the information is identified as a CPC problem.

d. Submit Form 368 to address specified in DA Pam 738-750. Air Force personnel will use TO 25-1-3.

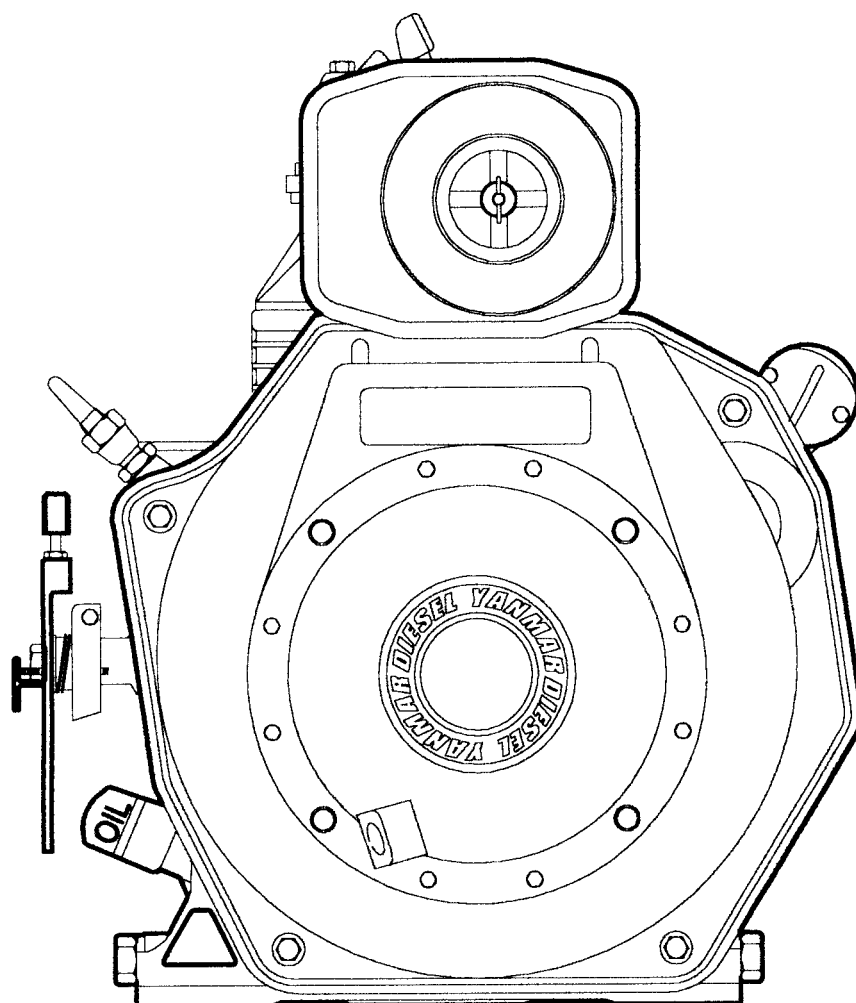


Figure 1-1. Diesel Engine Assembly

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1-5. DESTRUCTION OF MATERIEL TO PREVENT ENEMY USE.

For destruction of Army materiel to prevent enemy use, refer to TM 750-244-3. Air Force personnel will refer to Service Directive to obtain procedure for destruction of materiel to prevent enemy use. Marine Corps personnel will destroy by weapons fire, smashing, disassembling, burning, or any other means to render the equipment useless to the enemy.

1-6. REPORTING EQUIPMENT IMPROVEMENT RECOMMENDATIONS (EIR's).

a. **Army.** If your engine assembly needs improvement, let us know. Send us an EIR. You are the only one who can tell us what you do not like about your equipment. Put it on a SF 368 (Product Quality Deficiency Report). Mail it to: Commander, US Army Communications and Electronics Command (CECOM), ATTN: AMSEL-LC-LEO-D-CS-CFO, Fort Monmouth, NJ 07703-5000. We will send you a reply.

b. **Air Force.** Air Force personnel are encouraged to submit EIR's in accordance with AFR 900-4.

c. **Marine Corps.** QDR shall be reported on SF 368 in accordance with MCO P4855.10, Product Quality Deficiency Report Manual. Submit to: Commander, Marine Corps Logistics Base, Life Cycle Management Center, ATTN Product Support Section 822, 814 Radford Blvd., Suite 20320, Albany, Georgia 31704-0320, or email to mbmatcompqdrs @ matcom.usmc.mil.

1-7. WARRANTY INFORMATION.

Refer to Appendix I for information on engine manufacturer's component warranties and conditions.

1-8. NOMENCLATURE CROSS-REFERENCE LIST.

Shortened nomenclature is used in this manual to make procedures easier for you to read. A cross-reference between the shortened nomenclature and the official nomenclature is shown in Table 1-1.

Table 1-1. Nomenclature Cross-Reference

Common Name	Official Nomenclature
Engine	Diesel Engine Assembly, Model L70AE-DEGFR

1-9. LIST OF ABBREVIATIONS.

All abbreviations used in this manual are found in MIL-STD-12.

1-10. ADMINISTRATIVE STORAGE.

Administrative storage or equipment issued to and used by Army activities will have Preventive Maintenance Checks and Services (PMCS) performed before storing. When removing the equipment from administrative storage, the PMCS checks should be performed to assure operational readiness.

Section II. EQUIPMENT DESCRIPTION

1-11. EQUIPMENT CHARACTERISTICS, CAPABILITIES, AND FEATURES.

a. Characteristics

- Single cylinder, direct injection, four-stroke cycle diesel engine
- Air cooled via flywheel fan
- Self-contained lubricating oil and fuel systems
- Engine crankcase acts as oil sump, no separate oil pan
- Equipped with a 24 VDC starter motor
- Rope pull recoil starter system allows for manual start

b. Capabilities and Features

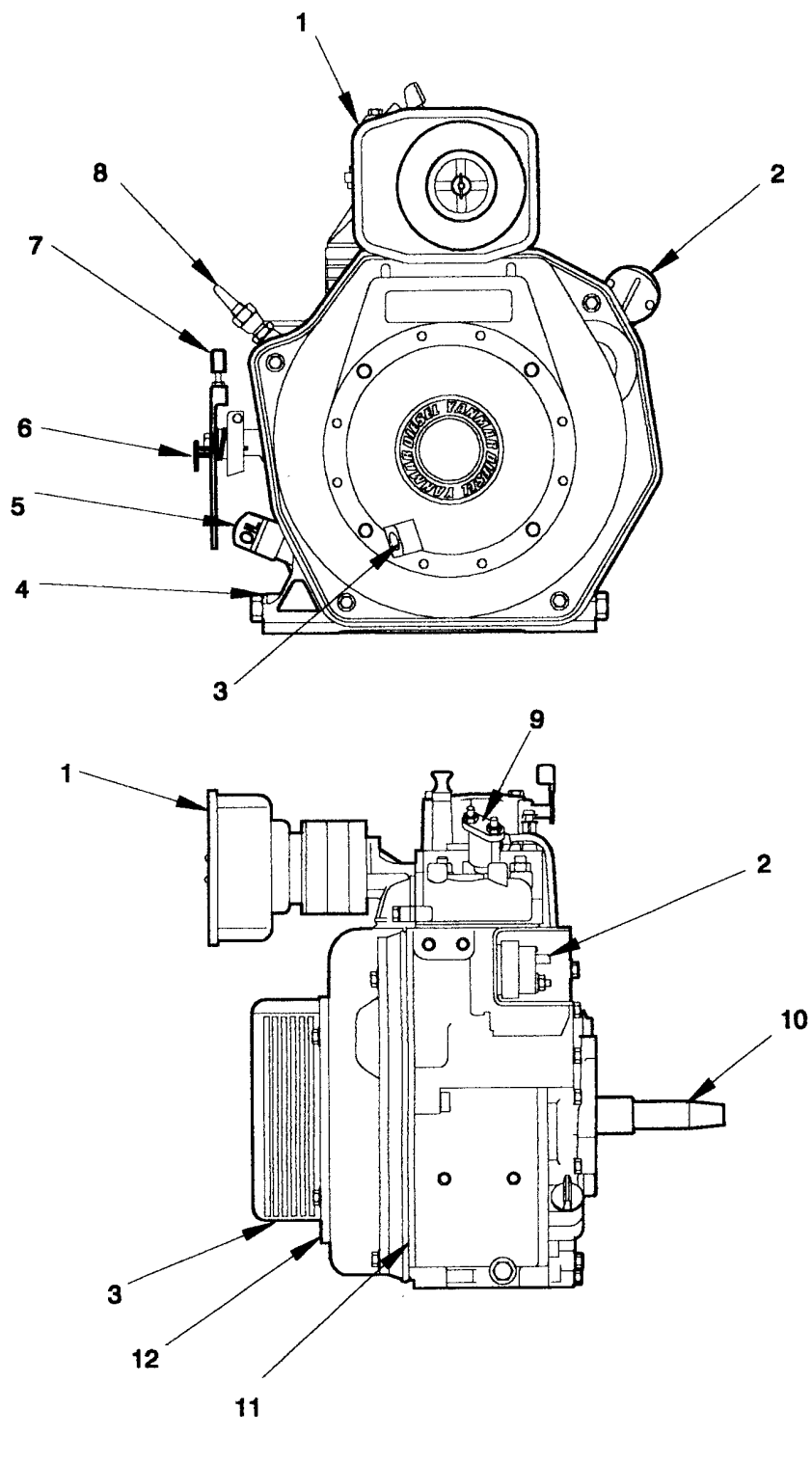
- 3000 to 3600 RPM operating speed
- Rated engine horsepower of 6.7 HP at 3600 RPM
- Mechanical governor set for 3750 RPM maximum
- Weight: 86 pounds (39 kilograms)
- Dimensions: 15.08 x 16.58 x 17.72 inches (38.3 x 42.1 x 45.0 centimeters)

1-12. LOCATION AND DESCRIPTION OF MAJOR COMPONENTS (Figure 1-2).

a. The Diesel Engine Assembly, Model L70AE-DEGFR, NSN 2815-01-465-5993, hereafter referred to as the engine, is a single cylinder, air cooled, direct injection, four-stroke cycle, diesel engine. The engine is designed to operate between 3000 and 3600 RPM, with an output of 6.7 horsepower at 3600 RPM.

b. The engine has self-contained oil lubrication and fuel systems. It is equipped with an air filter and housing (1, Figure 1-2), 24VDC starter motor (2), engine oil filter (4), oil fill cap and gauge (5), fuel injection pump (8), and fuel injector (9). A recoil starter system (3) permits manual start of the engine without a battery. All components are housed in or attached to an engine block (11).

c. A mechanical governor (6) mounted on the left side of the engine is set for 3750 RPM, maximum. In generator set applications, an electrical actuator connected to the governor lever (7) controls the governor and allows for variable speed operation.



1. Air Filter and Housing
2. 24VDC Starter Motor
3. Recoil Start System
4. Engine Oil Filter
5. Oil Fill Cap and Gauge
6. Mechanical Governor
7. Governor Lever
8. Fuel Injection Pump
9. Fuel Injector
10. Crankshaft
11. Engine Block
12. Flywheel Housing

Figure 1-2. Location of Engine Assembly Components

d. Engine cooling is provided by a flywheel fan (12) connected to the crankshaft (10). The fan forces air over the cylinder fins and engine components. The fan is completely guarded by a cover to prevent inadvertent contact during operation.

1-13. EQUIPMENT DATA.

Refer to Table 1-2, Equipment Data, for a summary of specific capabilities, limitations, and critical data for maintenance of the engine assembly.

Table 1-2. Equipment Data

WEIGHTS AND DIMENSIONS

Weight	86.0 pounds (39.0 kilograms)
Length	15.08 inches (38.3 centimeters)
Width	16.58 inches (42.1 centimeters)
Height	17.72 inches (45.0 centimeters)

GENERAL SPECIFICATIONS

Horsepower	6.7 horsepower (at 3600 rpm)
Operating RPM	3000 to 3600 RPM
Engine cooling system	Forced air cooling
Oil requirements:	
MIL-L-46167, OEA	-25°F to +40°F (-31°C to +5°C)
MIL-L-2104, OE/HDO-15/40	+5°F to +120°F (-15°C to +49°C)
MIL-L-2104, OE/HDO-10	-15°F to +40°F (-26°C to +5°C)
MIL-L-2104, OE/HDO-30	+15°F to +90°F (-9°C to +32°C)
MIL-L-2104, OE/HDO-40	+30°F to +120°F (-1°C to +49°C)
Oil capacity:	
Engine	1.2 quarts (1.1 liters)
Oil consumption rate (at rated load)	0.04 ounces (1.18 milliliters) per hour
Compression ratio	19.5
Bore x stroke	3.07 x 2.44 inches (78 x 62 millimeters)
Cylinder	One
Displacement	18.1 in ³ (296 cm ³)

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CHAPTER 2
OPERATING INSTRUCTIONS

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Section I. PRINCIPLES OF OPERATION

2-1. PRINCIPLES OF OPERATION.

The theory behind the operation of the engine assembly is described in the following paragraphs. The information contained herein will assist unit, direct support, and general support maintenance personnel in understanding how the engine functions. This knowledge will assist in isolating components which have failed.

2-2. ENGINE STARTING SYSTEM. (Figure 2-1)

a. Normal engine start-up is controlled by the engine starter motor (Figure 2-1). A recoil starter (5, Figure 2-2) allows the operator to manually crank the engine should the starter motor fail.

b. The starter motor consists of three major components: a solenoid (1, Figure 2-1), continuous current motor, and pinion (10). An armature (11), brushes (17), and field coil (18) create the magnetic force required to operate the solenoid plunger. Brush holders (16) keep the brushes in their proper position. A gear case (7), yoke (12), rear cover (13), and dust covers (2, 3, 14) protect the internal components of the starter motor. A gear case bearing (9) and rear cover bearing (15) ensure smooth operation.

c. During operation, the solenoid (1) moves a spring loaded shift lever (5) to engage and disengage the pinion (10). The pinion (10) transfers driving power from the motor to a ring gear. An over-running clutch (6) is used to prevent damage should the engine run too fast.

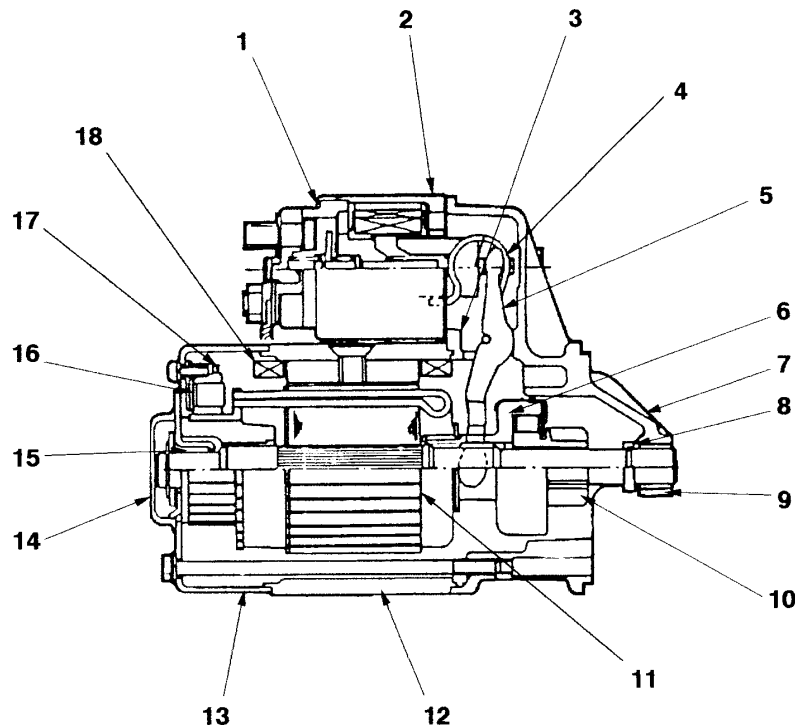
d. When the solenoid (1) is energized, magnetic force pulls the solenoid plunger in. As the plunger is pulled in, the torsion spring (4) on the shift lever (5) moves the lever. The lever pushes the pinion (10) away from the pinion stopper (8) and out to engage the engine flywheel. When the solenoid plunger is all the way in, the main contacts close, providing battery power to the motor.

e. The starter motor will operate until the solenoid (1) is de-energized. Once de-energized, the solenoid's magnetic force is removed and the solenoid plunger slides out, opening the main contacts and removing power from the motor. The shift lever (5) retracts, disengaging the pinion (10) from the engine flywheel ring gear.

2-3. ENGINE COMBUSTION CYCLE. (Figure 2-2)

a. **Combustion Cycle.** The diesel engine combustion cycle can be divided in four separate strokes; compression stroke, power stroke, exhaust stroke, and intake stroke. Thus the term "four-stroke engine" is applied to this type of engine.

b. **Compression Stroke.** During the engine compression stroke, the engine starter motor cranks the engine flywheel (4, Figure 2-2). The crankshaft (6) turns, forcing the piston (8) to rise to its highest point in the cylinder. The upward movement of the piston compresses air trapped inside the combustion chamber, causing temperature to rise in the chamber. A fine mist of fuel is sprayed into the combustion chamber by the engine's fuel injector just before the piston reaches its high point. The compressed air and fuel mist mixture combusts in the chamber.



- | | | |
|------------------------|----------------------|------------------------|
| 1. Solenoid | 7. Gear Case | 13. Rear Cover |
| 2. Dust Cover | 8. Pinion Stopper | 14. Dust Cover |
| 3. Dust Cover | 9. Gear Case Bearing | 15. Rear Cover Bearing |
| 4. Torsion Spring | 10. Pinion | 16. Brush Holder |
| 5. Shift Lever | 11. Armature | 17. Brush |
| 6. Over-Running Clutch | 12. Yoke | 18. Field Coil |

Figure 2-1. Engine Starter Motor (Side View)

c. **Power Stroke.** The combustion of the air and fuel mixture forces the piston (8) downward, causing the piston connecting rod to turn the crankshaft (6). The crankshaft is coupled to the end item and drives the end item as designed.

d. **Exhaust Stroke.** As the crankshaft (6) turns, it pushes up on the connecting rod, forcing the piston (8) to rise to its high point again. Once the piston begins to rise, the exhaust valve (9) opens. Exhaust gases (a result of the air / fuel combustion) are forced out of the cylinder through the exhaust valve. The valve closes just before the piston reaches its high point.

e. **Intake Stroke.** As the piston (8) moves downward again, the inlet valve (10) opens. Air is drawn through the open valve and into the cylinder. The inlet valve closes just before the piston reaches the end of its stroke (low point in the cylinder). The piston moves upward once more to repeat the combustion cycle.

A decompression lever (1) installed in the rocker arm cover is utilized during manual start operations. A breather (2) regulates the amount of pressure built up on the chamber and opens to release pressure as required. An air cleaner (3) ensure that air entering the combustion chamber is free of particles that could cause damage to engine components.

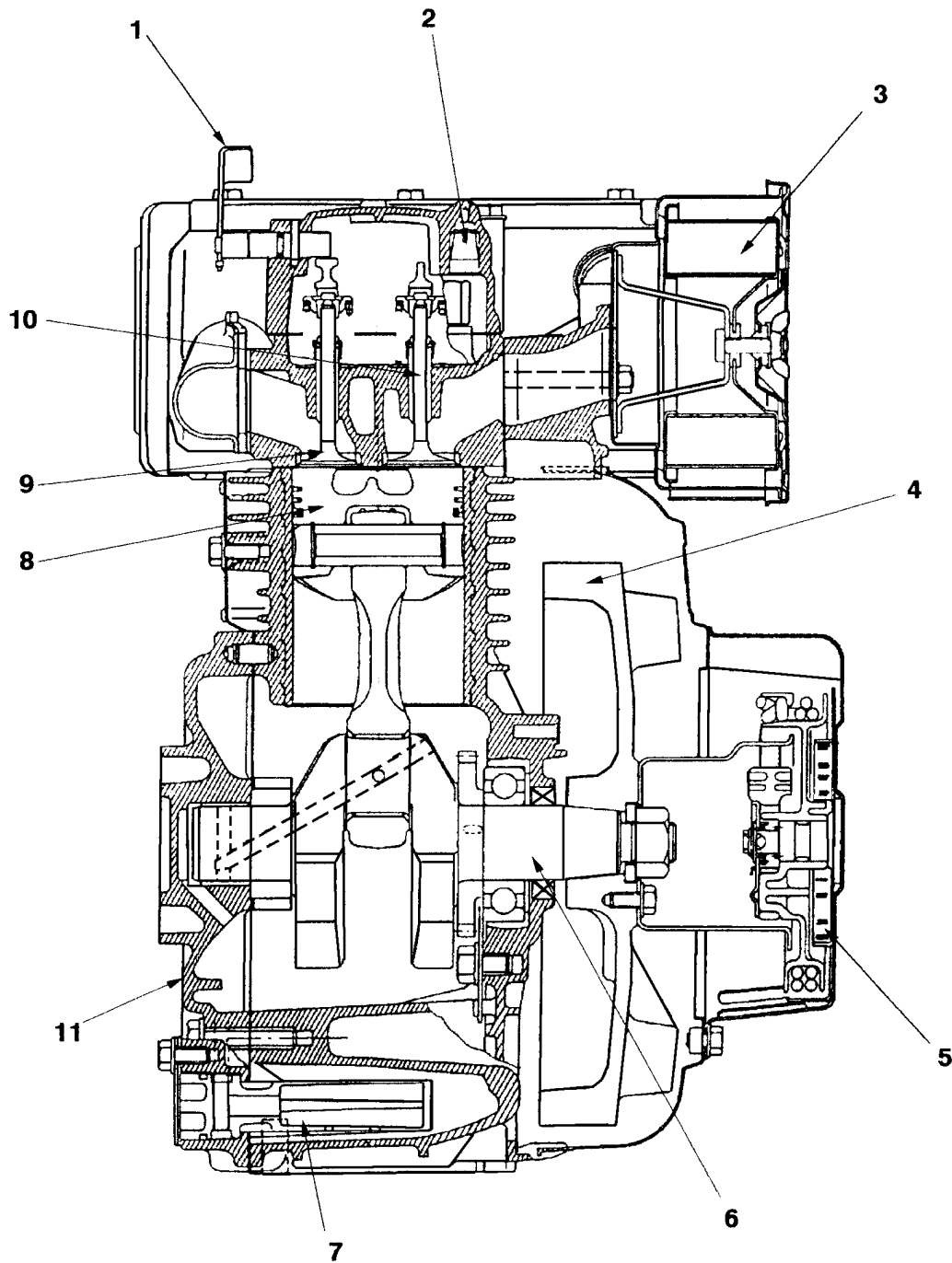
2-4. ENGINE LUBRICATION. (Figure 2-2)

a. Engine lubrication is controlled by a crankshaft driven oil pump (11, Figure 2-2). The oil pump is housed in the engine crankcase and supplies all oil to lubricate and cool high friction internal components. The crankcase acts as the oil sump, since a separate oil pan does not exist. The oil pump draws oil from the oil sump through an oil filter (7). After the oil passes through the filter, it is carried through oil passages to lubricate the crankshaft and camshaft bearings.

b. Oil level in the crankcase is measured using a gauge attached to the oil fill cap. Markings on the gauge indicate the amount of oil in the engine. An engine drain plug allows the engine oil to be drained to a pan during servicing.

Section II. OPERATING INSTRUCTIONS

Diesel engine assembly operating instructions are not provided in this manual. Refer to the end item Operator's Manual for detailed operating instructions.



BOTTOM OF ENGINE

- | | | |
|------------------------|-------------------|------------------|
| 1. Decompression Lever | 5. Recoil Starter | 9. Exhaust Valve |
| 2. Breather | 6. Crankshaft | 10. Inlet Valve |
| 3. Air Cleaner | 7. Oil Filter | 11. Oil Pump |
| 4. Flywheel | 8. Piston | |

Figure 2-2. Engine Components (Side View)

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CHAPTER 3

UNIT MAINTENANCE INSTRUCTIONS

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Section I. LUBRICATION INSTRUCTIONS

3-1. LUBRICATION INSTRUCTIONS.

Lubrication instructions for the engine assembly are contained in Paragraph 3-6, Engine Oil Servicing. Lubrication intervals (on-condition or hard time) are based on normal operation. Lube more during constant use, and less during inactive periods. Use correct grade of lubricant for seasonal temperature expected.

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

3-2. COMMON TOOLS AND EQUIPMENT.

- a. For authorized common tools and equipment, refer to the Modified Table of Organization and Equipment (MTOE), CTA 50-970, or CTA 8-100, as applicable to your unit.
- b. Tool Kit, General Mechanics; Automotive, Supply Catalog SC5180-90-CL-N26, is the primary supply source for tools used in maintenance of the engine assembly.

3-3. SPECIAL TOOLS, TMDE, AND SUPPORT EQUIPMENT.

Refer to TM 9-2815-257-24P, Diesel Engine Assembly Repair Parts and Special Tools List, for complete data on special tools and equipment required for engine assembly maintenance. Refer to the Maintenance Allocation Chart (MAC), Appendix B, for special tools and equipment used at the unit maintenance level.

3-4. REPAIR PARTS.

- a. Refer to Appendix H for a list of Mandatory Replacement Parts required for unit level maintenance of the engine assembly.
- b. Repair parts are listed and illustrated in TM 9-2815-257-24P, Diesel Engine Assembly Repair Parts and Special Tools List.

Section III. SERVICE UPON RECEIPT OF EQUIPMENT

3-5. GENERAL.

WARNING

The engine is heavy. Provide adequate lifting device to support the weight. Use lifting ring for lifting purpose and use caution when lifting or moving the engine assembly. Failure to observe this warning can result in injury to personnel and/or damage to equipment.

- a. Using a lifting device capable of lifting 100 pounds, remove the engine assembly from its shipping container. Place on a suitable work surface.
- b. Remove packing material from engine assembly.
- c. Inspect the engine assembly for damage incurred during shipping. If the equipment has been damaged, report the damage on the appropriate form as required.
- d. Check the engine assembly against the packing slip to ensure that the shipment is complete. Report all discrepancies in accordance with the instructions of DA PAM 738-750.
- e. Check all tags and forms accompanying the engine assembly for special instructions. Do not remove any forms or tags until the unit is installed and ready for operation. When the unit is installed, remove forms and tags and forward to Quality Control (QC) section office.
- f. If required, drain preservative oil from engine as follows:
 - (1) Place oil catch pan under end oil drain plug (1, Figure 3-1).
 - (2) Remove engine oil fill cap (2) to vent engine crankcase while draining.
 - (3) Remove oil drain plug (1) and drain preservative oil from crankcase.
 - (4) Once preservative oil is drained, install drain plug (1) and remove oil catch pan. Dispose of oil in accordance with local ordinance.
- g. Fill engine crankcase with oil in accordance with the procedures in Paragraph 3-6.

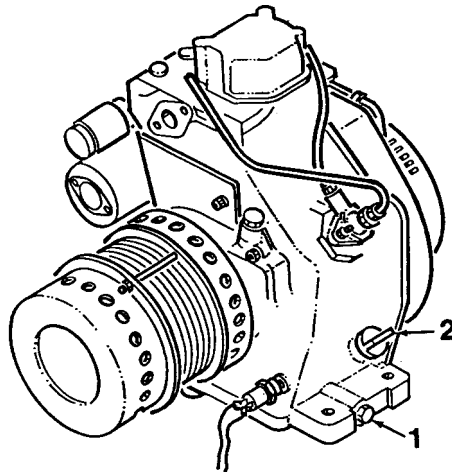
3-6. ENGINE OIL SERVICING.

- a. Remove engine oil fill cap (2, Figure 3-1).

CAUTION

Do not overfill crankcase. Damage to engine will result.

- b. Inspect and clean oil filter (Para. 3-18).
- c. Fill engine with required oil until oil level reaches threaded opening of oil fill cap (2) (up to 1.2 quarts (1.1 liters)). Refer to Table 1-2, Equipment Data, for recommended oils.
- d. Install oil fill cap (2).



1. Oil Drain Plug
2. Oil Fill Cap

Figure 3-1. Engine Oil Servicing

Section IV. UNIT PREVENTIVE MAINTENANCE CHECKS AND SERVICES (PMCS)

3-7. GENERAL.

Unit Preventive Maintenance Checks and Services (PMCS) means systematic caring, inspecting, and servicing of equipment to keep it in good condition and to prevent breakdowns. This section lists PMCS required for the engine assembly and authorized for the unit maintenance level.

- a. Be sure to perform your PMCS in the same order, so it gets to be a habit. Once you have had some practice, you will quickly spot anything wrong.
- b. Pay attention to WARNINGS, CAUTIONS, and NOTES.
- c. Perform PMCS tasks at the intervals noted in Table 3-1. Do not skip PMCS intervals.
- d. Use DA Form 2404 (Equipment Inspection and Maintenance Worksheet) to record any faults you discover, unless you can fix them. You DO NOT need to record faults that you fix.

3-8. PMCS PROCEDURES.

Your Preventive Maintenance Checks and Services, Table 3-1, lists inspections and care required to keep your engine assembly in good operating condition.

- a. **Item No. Column.** The Item No. column in Table 3-1 lists each check / service in chronological order.
- b. **Interval Column.** The Interval column tells you when to do a certain check or service. Intervals are based on operating hours, unless otherwise noted.
- c. **Location Column.** The Location: Item to Check / Service column directs maintenance personnel to the general area on the engine where the check or service is to be performed.
- d. **Procedure Column.** The Procedure column of Table 3-1 tells you how to do required checks and services. Tolerances, adjustment limits, and instrument readings are included as applicable. When replacement or repair of a component is required, the procedures column will direct you to the appropriate task.

NOTE

Terms “ready/available” and “mission capable” refer to same status: Equipment is on hand and ready to perform its combat missions. (See DA Pam 738-750).

- e. **Not Fully Mission Capable If Column.** The Not Fully Mission Capable If column in Table 3-1 tells you when your engine assembly is non-mission capable and why the engine assembly cannot be used.
- f. If the engine assembly does not perform as required, perform unit level troubleshooting, Section V.

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g. If anything looks wrong and you cannot fix it, write it on your DA Form 2404. IMMEDIATELY report it to your supervisor.

h. When you perform PMCS you will always need a rag (Item 8, App. E). One rag is required, but more are recommended. Following are checks that are common to the entire engine assembly:

- (1) Keep It Clean. Dirt, grease, oil, and debris only get in the way and may cover up a serious problem. Clean as you work and as needed. Use dry cleaning solvent on all metal surfaces. Use soap and water when you clean rubber or plastic material.
- (2) Rust and Corrosion. Check engine assembly components for rust and corrosion. If any bare metal or corrosion exists, clean, and apply a thin coat of oil (Item 6, App. E). Report it to your supervisor.
- (3) Bolts, Nuts, and Screws. Check them for obvious looseness, missing, bent, or broken condition. You cannot check them all with a tool, but look for chipped paint, bare metal, or rust around bolt heads. If you find a bolt, nut, or screw that is loose, tighten it.
- (4) Welds. Look for loose or chipped paint, rust, or gaps where parts are welded together. If you find a bad weld, report it to your supervisor.
- (5) Electric Wires and Connectors. Look for cracked, frayed, or broken insulation, bare wires, and loose or broken connectors. Tighten loose connectors. Report any damaged wires to your supervisor.
- (6) Hoses and Fluid Lines. Look for wear, damage, and leaks, and make sure clamps and fittings are tight. Wet spots show leaks, but a stain around a fitting or connector can also mean a leak. If a leak comes from a loose fitting or connector, tighten it. If something is broken or worn out, replace it.

3-9. CLEANING AGENTS.

WARNING

Cleaning solvents are flammable and toxic to eye, skin, and respiratory tract. Skin and eye protections are required when working in contact with cleaning solvents. Avoid repeated or prolonged contact. Work in well ventilated area only. Keep away from heat, sparks, and open flame. Do not smoke while using cleaning solvent. Failure to observe this warning can result in injury or death to personnel.

CAUTION

When cleaning, engine must be COLD (same temperature as outside air). DO NOT point water stream directly at any electrical connection. DO NOT use high pressure water supply system. Damage to engine, electrical system, and other components may result.

NOTE

Only use those authorized cleaning solvents or agents listed in Appendix E, Expendable and Durable Items List.

- a. When using water to clean the engine assembly, always cover all air ducts and exhaust ports using waterproof material to prevent damage to components. Cover all electrical components and connections. Use water pressure and volume similar to a standard household water supply (50 PSI maximum, 3 gallons per minute).
- b. After cleaning, allow engine assembly to air dry. Do not use compressed air to dry. Do not run engine to decrease drying time.
- c. Remove all component covers after cleaning.

CAUTION

Keep cleaning solvents, gasoline, and lubricants away from rubber or soft plastic parts. Solvents will deteriorate these materials.

- d. When cleaning grease build-up or rusty places, use cleaning solvent (Item 7, App. E), then apply a thin coat of light oil (Item 6, App. E) to affected area.

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Table 3-1. Unit Level Preventive Maintenance Checks and Services for Engine Assembly

Item No.	Interval	Location: Item to Check/ Service	Procedure	Not Fully Mission Capable If:
1	100 hours	Lubricating oil system	<p>NOTE: First oil service occurs after 25 hours of operation. 100 hour intervals thereafter.</p> <p>Service engine lubricating oil (Para. 3-6).</p>	Engine oil has not been changed.
2	100 hours	Oil filter	Remove and clean engine oil filter (Para. 3-18). Replace as required.	Oil filter is clogged, dirty, or damaged.
3	500 hours	Air filter	Remove and replace air filter (Para. 3-16).	Air filter is dirty or damaged.
4	500 hours	Fuel injection pump	<p>a. Inspect fuel injection pump for damage and evidence of leakage.</p> <p>b. Check area around pump sealing gasket for leaks. Remove and replace gasket as required (refer to Direct Support Maintenance).</p>	Fuel leak of any kind is present.
5	500 hours	Valve clearance	Adjust valve clearance (Para. 3-15).	Valves are not properly adjusted, causing improper engine operation.
6	1000 hours	Fuel injector nozzle	Remove and replace fuel injector nozzle (Para. 3-14).	Fuel injector nozzle has not been replaced.

Section V. UNIT LEVEL TROUBLESHOOTING PROCEDURES

3-10. GENERAL.

This section contains unit level troubleshooting and tests for the engine assembly. Each malfunction or trouble symptom is addressed and is followed by a series of inspections or tests necessary to determine the probable cause and corrective action.

3-11. TROUBLESHOOTING.

a. This chapter does not list all possible malfunctions that may occur, all tests or inspections that may be performed, or all corrective actions for each malfunction. Only those checks and tests authorized for the unit level are covered. If a malfunction is not listed, or is not remedied by corrective actions, notify personnel at a higher maintenance level.

b. Prior to using troubleshooting table, be sure you have performed all normal operational checks.

c. These troubleshooting procedures assume that electrical wires are undamaged and wiring harnesses are operable. Conduct continuity checks on suspect wiring / harnesses as required prior to performing troubleshooting procedures in Table 3-3.

d. Refer to Table 3-2, Malfunction Index, for determining applicable troubleshooting procedure located in Table 3-3.

Table 3-2. Malfunction Index

Trouble	Procedure
Engine will not crank	1
Engine will not start	2
Engine starts and stops	3
Engine output drops	4
Engine runs rough	5
Low compression pressure	6
Engine emits white smoke	7
Engine emits black smoke	8

Table 3-2. Unit Level Troubleshooting

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1. ENGINE WILL NOT CRANK		
	Damaged or defective starter motor.	Remove and replace starter motor (Para. 3-19).
2. ENGINE WILL NOT START		
	a. Check for improper valve / rocker arm clearance.	Adjust valve clearance (Para. 3-15).
	b. Check for kinked, blocked, or clogged fuel line.	Adjust fuel line and/or clear line of blockage.
	c. Check for clogged, sticking, or worn fuel injector nozzle.	Remove and replace fuel injector (Para. 3-14).
	d. Refer trouble to direct support maintenance level.	
3. ENGINE STARTS AND STOPS		
	a. Check for damaged air heater or air heater electrical leads.	Remove and replace air heaters (Para. 3-16).
	b. Check for kinked or clogged fuel line.	Adjust fuel line and/or clear line of blockage.
	c. Check for clogged, sticking, or worn fuel injector nozzle.	Remove and replace fuel injector (Para. 3-14).
	d. Refer trouble to direct support maintenance level.	

Table 3-2. Unit Level Troubleshooting (continued)

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
4. ENGINE OUTPUT DROPS		
a.	Check for clogged or dirty air cleaner.	Remove and replace air cleaner element (Para. 3-16).
b.	Check for improper valve / rocker arm clearance.	Adjust valve clearance (Para. 3-15).
c.	Check for clogged, sticking, or worn fuel injector nozzle.	Remove and replace fuel injector (Para. 3-14).
5. ENGINE RUNS ROUGH		
a.	Check for clogged, sticking, or worn fuel injector nozzle.	Remove and replace fuel injector (Para. 3-14).
b.	Refer trouble to direct support maintenance level.	
6. LOW COMPRESSION PRESSURE		
a.	Check for improper valve / rocker arm clearance.	Adjust valve clearance (Para. 3-15).
b.	Check for leaks around fuel injector.	Tighten injector nuts to 7 to 9 ft-lbs. (100 to 120 kg-cm) (Para. 3-14).
c.	Refer trouble to direct support maintenance level.	
7. ENGINE EMITS WHITE SMOKE		
a.	Check to see if engine oil level is too high. Check for contaminants in the oil system	Drain and service engine oil (Para. 3-5).
b.	Check for improper valve / rocker arm clearance.	Adjust valve clearance (Para. 3-15).
c.	Refer trouble to direct support maintenance level.	

Table 3-2. Unit Level Troubleshooting (continued)

MALFUNCTION	
TEST OR INSPECTION	
CORRECTIVE ACTION	
8. ENGINE EMITS BLACK SMOKE	
a. Check for clogged or dirty air filter.	Remove and replace air filter (Para. 3-16).
b. Check for clogged, sticking, or worn fuel injector nozzle.	Remove and replace fuel injector (Para. 3-14).
c. Refer trouble to direct support maintenance level.	

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Section VI. UNIT MAINTENANCE PROCEDURES

3-12. RECOIL STARTER ASSEMBLY MAINTENANCE

This task covers removal, cleaning, inspection, and installation.

INITIAL SETUP

Tools:

Tool Kit, General Mechanic's Automotive
(Item 2, App. B, Sect. III)

Equipment Condition:

None

Parts/Materials:

Solvent, Dry Cleaning (Item 7, App. E)
Rag, Cleaning (Item 8, App. E)

A. REMOVAL.

1. Remove recoil starter assembly (1, Figure 3-2) from flywheel housing (2) by removing four screws (3).
2. Remove plunger (5) from cylinder block by removing three screws (6).

B. CLEANING.

WARNING

Cleaning solvents are flammable and toxic to eye, skin, and respiratory tract. Skin and eye protections are required when working in contact with cleaning solvents. Avoid repeated or prolonged contact. Work in well ventilated area only. Keep away from heat, sparks, and open flame. Do not smoke while using cleaning solvent. Failure to observe this warning can result in injury or death to personnel.

Clean components with cleaning solvent and a clean rag. Allow to air dry.

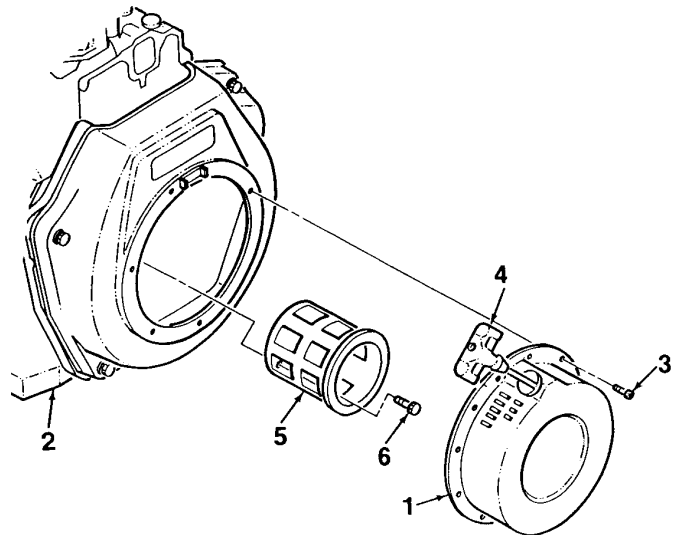


Figure 3-2. Recoil Starter Removal

3-12. RECOIL STARTER ASSEMBLY MAINTENANCE - cont.

C. INSPECTION.

1. Inspect recoil starter assembly (1, Figure 3-2) and plunger (5) for cracks, deformation, or obvious damage. Replace case if damaged.
2. Inspect starter rope for cuts, tears, or frayed strands. Ensure tee handle (4) is securely attached. Replace starter assembly if any component is damaged.

D. INSTALLATION.

1. Install plunger (5, Figure 3-2) into cylinder block using three screws (6).
2. Mate recoil starter assembly (1) to flywheel housing (2) and secure using four screws (3).

3-13. FLYWHEEL HOUSING AND COVER MAINTENANCE

This task covers removal, cleaning, inspection, and installation.

INITIAL SETUP

Tools:

Tool Kit, General Mechanic's Automotive
(Item 2, App. B, Sect. III)

Equipment Condition:

Recoil starter assembly removed
(Para. 3-12)

Parts/Materials:

Solvent, Dry Cleaning (Item 7, App. E)
Rag, Cleaning (Item 8, App. E)

A. REMOVAL.

1. Remove flywheel housing (1, Figure 3-3) from cylinder block (5) by removing four screws (2) and washers (3). Remove seal (4).
2. Remove the cylinder head fin cover (6) by removing screw (7), grommet (8), and collar (9). Remove seal (10).

B. CLEANING.

WARNING

Cleaning solvents are flammable and toxic to eye, skin, and respiratory tract. Skin and eye protections are required when working in contact with cleaning solvents. Avoid repeated or prolonged contact. Work in well ventilated area only. Keep away from heat, sparks, and open flame. Do not smoke while using cleaning solvent. Failure to observe this warning can result in injury or death to personnel.

Clean components with cleaning solvent and a clean rag. Allow to air dry.

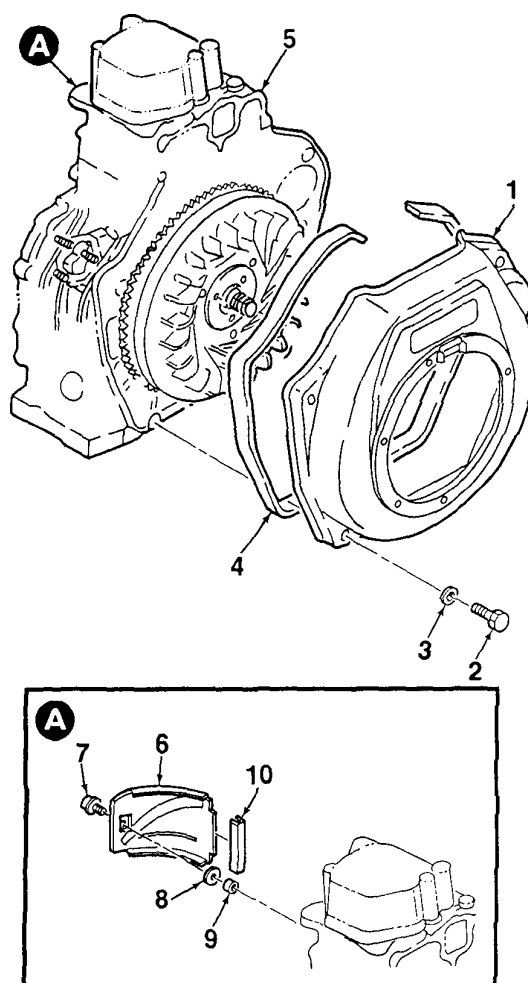


Figure 3-3. Flywheel Housing Removal

3-13. FLYWHEEL HOUSING AND COVER MAINTENANCE - cont.

C. INSPECTION.

1. Inspect flywheel housing (1, Figure 3-3) and cylinder fin cover (6) for cracks, deformation, or obvious damage. Replace if damaged.
2. Inspect seals (4, 10) for cracks, cuts, damage, or deterioration. Replace if damaged in any way.

D. INSTALLATION.

1. Install seal (10, Figure 3-3) onto cylinder head fin cover (6). Install cover using screw (7), grommet (8), and collar (9).
2. Install seal (4) onto flywheel housing (1).
3. Mate flywheel housing (1) to cylinder block (5). Secure using four screws (2) and washers (3).

3-14. FUEL INJECTOR MAINTENANCE

This task covers removal, inspection, and installation.

INITIAL SETUP

Tools:

Tool Kit, General Mechanic's Automotive
(Item 2, App. B, Sect. III)
Bolt, M8 or M9 x 100mm, minimum length

Equipment Condition:

Engine cool

A. REMOVAL.

1. Disconnect fuel supply line from fuel injector (3, Figure 3-4). Disconnect fuel return hose (2) by loosening clamp (1).
2. Remove two nuts (4) and nozzle retainer (5) from studs (8).

CAUTION

When removing fuel injector, wrap it in a clean cloth to protect injector nozzle. Do not place nozzle tip directly onto a hard surface, as damage will result.

3. Carefully remove fuel injector (3) from injection port in cylinder head.
4. Remove injector spacer (6) and gasket (7). Thread M8 or M9 bolt into nozzle gasket. Pull out bolt to remove gasket. Discard gasket.

B. INSPECTION.

1. Inspect fuel injector (3, Figure 3-4) for obvious damage. Check for clogged or dirty injector nozzle. Replace injector if nozzle is damaged.
2. Inspect return fuel hose (2) for cuts, tears, kinks, or crimping. Replace hose if damaged.

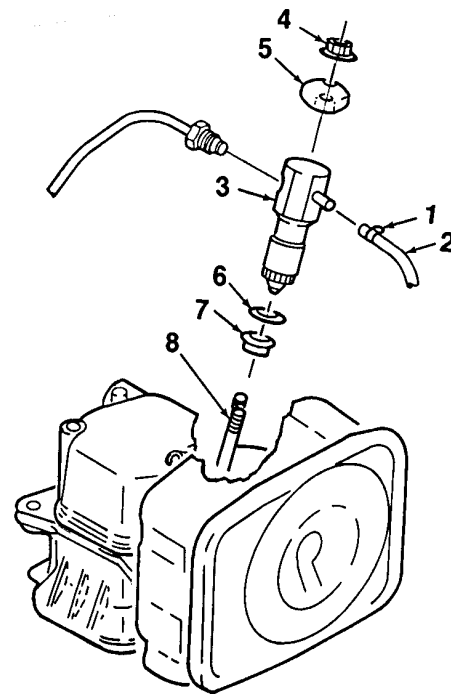


Figure 3-4. Fuel Injector Removal

3-14. FUEL INJECTOR MAINTENANCE - cont.

C. INSTALLATION.

1. Install new gasket (7, Figure 3-4) into cylinder head injector port. Ensure proper seating. Install fuel spacer (6).

CAUTION

When installing fuel injector, use care to prevent damage to injector nozzle.

2. Carefully position and insert fuel injector (3) into cylinder head. Ensure fuel pipe fitting is facing the correct direction.
3. Install nozzle retainer (5) onto studs (8). Install nuts (4) and torque to 7 to 9 ft-lbs (100 to 120 kg-cm).
4. Connect fuel return hose (2) to fuel injector (3) and tighten clamp (1). Connect fuel supply line.

3-15. ROCKER ARM ASSEMBLY MAINTENANCE

This task covers head cover removal, rocker arm / valve clearance adjustment, and head cover installation.

INITIAL SETUP

Tools:

Tool Kit, General Mechanic's Automotive
(Item 2, App. B, Sect. III)

Equipment Condition:

Engine cool

A. HEAD COVER REMOVAL.

Remove head cover (1, Figure 3-5) from cylinder head (2) by removing bolts (3). Remove cover gasket (4) only if replacement is required.

B. VALVE CLEARANCE ADJUSTMENT.

1. Remove flywheel housing and recoil starter as an assembly (Para. 3-13).
2. Rotate flywheel in the clockwise direction until T mark on flywheel match V mark on cylinder body fin. This is the top dead center (TDC) position. Intake and exhaust valves will be in closed position.
3. Using a feeler gauge, check rocker arm to valve clearance (Figure 3-6). Clearance shall be 0.0039 to 0.0059 inch (0.10 to 0.15 mm). Drag on feeler gauge when passing through gap shall be minimal.
4. If adjustment is required, loosen lock nut and rotate adjusting screw clockwise / counter-clockwise to expand / reduce gap. Tighten lock nut and recheck clearance.
5. Repeat steps 3 and 4 until proper clearance is attained.

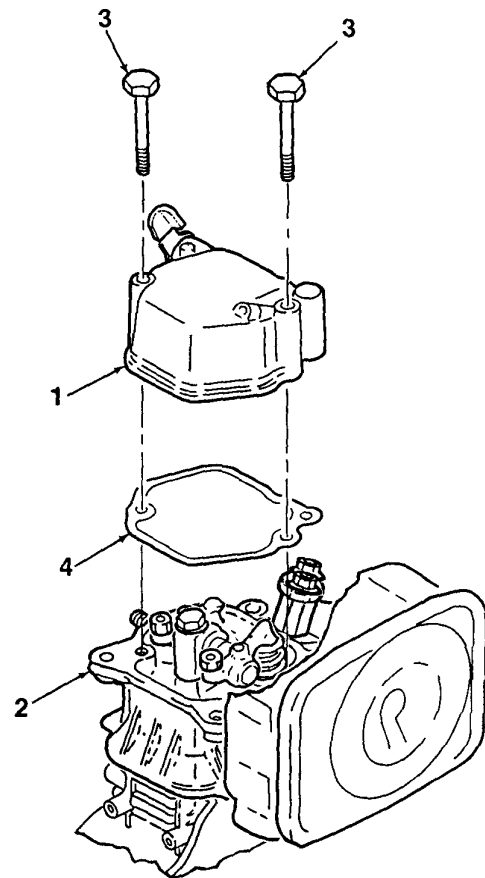


Figure 3-5. Head Cover Removal

3-15. ROCKER ARM ASSEMBLY MAINTENANCE - cont.

C. HEAD COVER INSTALLATION.

Install head cover (1) onto cylinder head (2) using bolts (3).

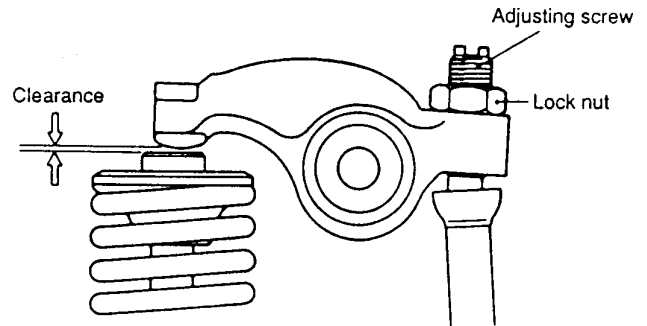


Figure 3-6. Valve Clearance Adjustment

3-16. AIR CLEANER ASSEMBLY MAINTENANCE

This task covers removal, cleaning, inspection, and installation.

INITIAL SETUP

Tools:

Tool Kit, General Mechanic's Automotive
(Item 2, App. B, Sect. III)

Equipment Condition:

Engine cool

Parts/Materials:

Solvent, Dry Cleaning (Item 7, App. E)
Rag, Cleaning (Item 8, App. E)

A. REMOVAL.

1. Remove cover (1, Figure 3-7) from air filter housing (2) by removing wing nut (3) and washer (4).
2. Remove air filter element (5) from housing (2). Remove housing from adapter (6) by removing three screws (7).
3. If replacement of air heaters (8) is required, disconnect electrical wire leads from heaters by removing two nuts (9) and washers (10). Reinstall nuts and washers to prevent loss.
4. Remove adapter (6), air heaters (8), and gaskets (11) from adapter (12) by removing four screws (13) and washers (14).
5. Remove adapter (12) from air intake duct (15) by removing three nuts (16). Remove gasket (17). Remove studs (18) from duct only if replacement is required.
6. Remove air intake duct (15) from cylinder head by removing two screws (19). Remove gasket (20).

B. CLEANING.

WARNING

Cleaning solvents are flammable and toxic to eye, skin, and respiratory tract. Skin and eye protections are required when working in contact with cleaning solvents. Avoid repeated or prolonged contact. Work in well ventilated area only. Keep away from heat, sparks, and open flame. Do not smoke while using cleaning solvent. Failure to observe this warning can result in injury or death to personnel.

3-16. AIR CLEANER ASSEMBLY MAINTENANCE - cont.

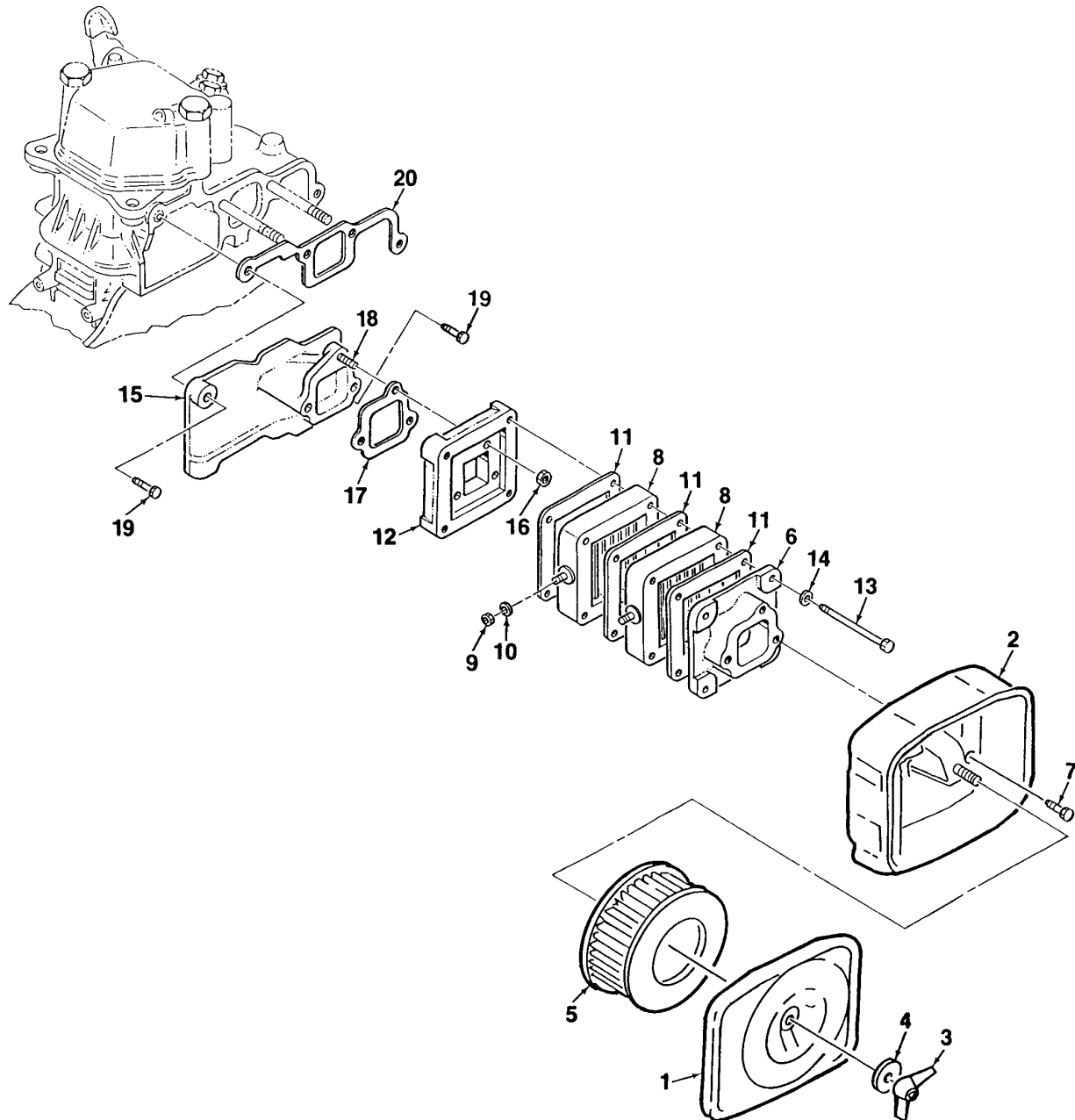


Figure 3-7. Air Cleaner Removal

3-16. AIR CLEANER ASSEMBLY MAINTENANCE - cont.

1. Do not clean air filter element. Do not tap or hit to remove dirt. If element is clogged or dirty, replace it.
2. Clean electrical connection studs on air heaters with a stiff wire brush.
3. Clean remaining components with cleaning solvent and a clean rag. Allow to air dry.

C. INSPECTION.

1. Inspect cover (1, Figure 3-8), housing (2), adapters (6, 12), and air intake duct (15) for cracks, dents, or corrosion. Replace component if damaged to the extent that it will effect proper operation of the air filtering system.
2. Inspect air heaters (8) for obvious damage. Replace if damaged is suspected.
3. Inspect gaskets (11, 17, 20) for cuts, tears, or deformation. Replace if damaged or deformed.

D. INSTALLATION.

1. If removed, install air intake duct (15, Figure 3-8) and gasket (20) using two screws (19). Install studs (18).
2. Install adapter (12) and gasket (17) using three nuts (16).
3. Install adapter (6), air heaters (8) and gaskets (11) using four screws (13) and washers (14). Connect electrical wire leads to heaters using nuts (9) and washers (10).
4. Install filter housing (2) using three screws (7). Install filter element (5) into housing.
5. Install cover (1) onto housing (2) and secure using wing nut (3) and washer (4).

3-16. AIR CLEANER ASSEMBLY MAINTENANCE - cont.

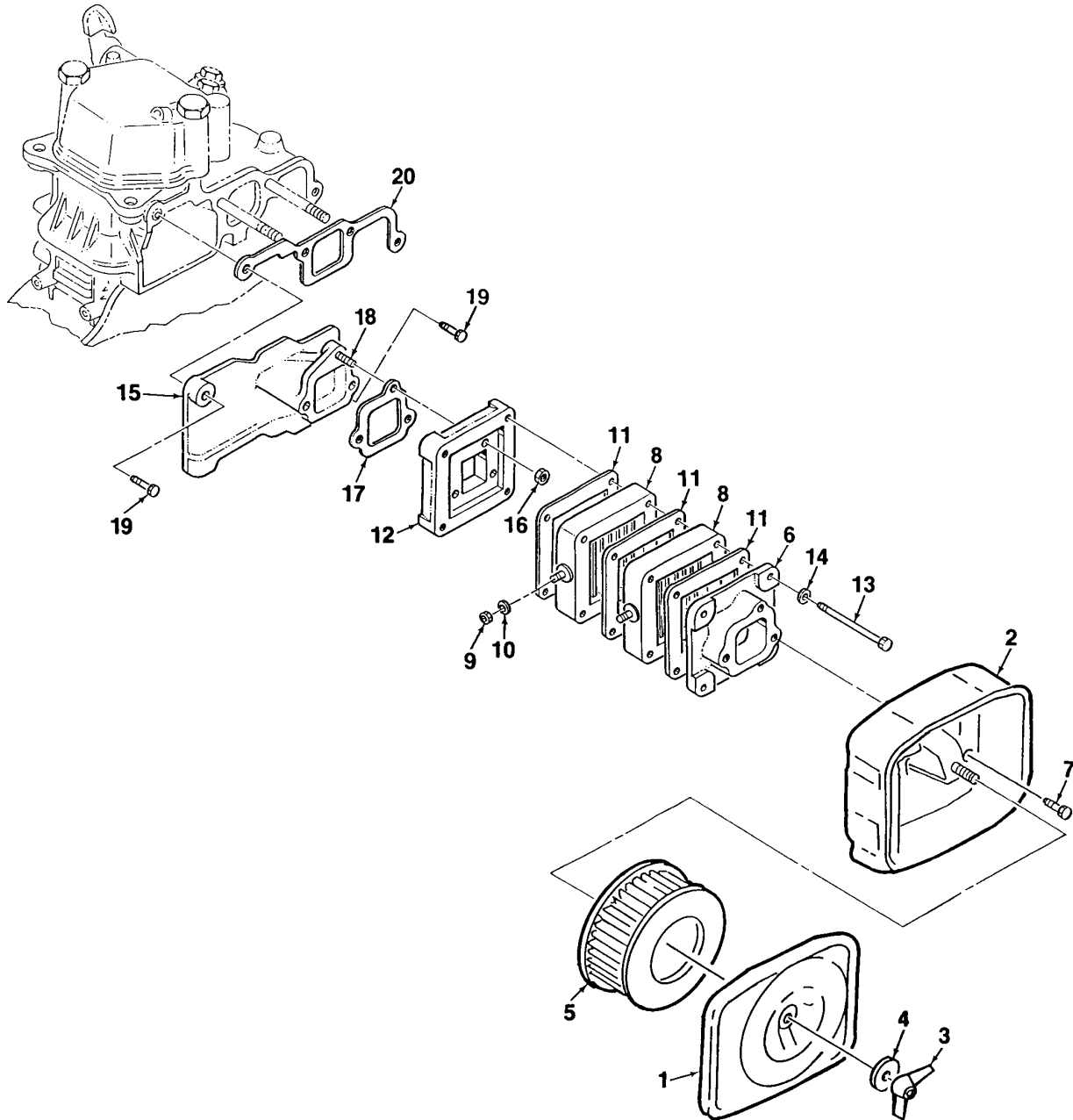


Figure 3-8. Air Cleaner Installation

3-17. OIL FILL CAP MAINTENANCE

This task covers removal, inspection, and installation.

INITIAL SETUP

Tools:

Tool Kit, General Mechanic's Automotive
(Item 2, App. B, Sect. III)

Equipment Condition:

Engine cool

Parts/Materials:

Oil, Engine Lubricating (Item 1-5, App. E)
Rag, Cleaning (Item 8, App. E)

A. REMOVAL.

Remove engine oil fill cap (1, Figure 3-9) from engine block (2). Remove O-ring (3).

B. INSPECTION.

1. Inspect oil fill cap (1, Figure 3-9) for obvious damage. Check oil level gauge (4) for security of attachment to cap. Inspect for corrosion.
2. Inspect O-ring (3) for cuts, tears, or permanent set. Replace O-ring if it will not allow a proper seal.
3. Inspect area around oil fill port for evidence of leakage. Clean area of dirt and accumulated grime using a clean rag.

C. INSTALLATION.

1. Apply a light coat of lubricating oil to O-ring (3, Figure 3-9) and install into oil fill port.
2. Insert engine oil fill cap (1) into engine block (2).

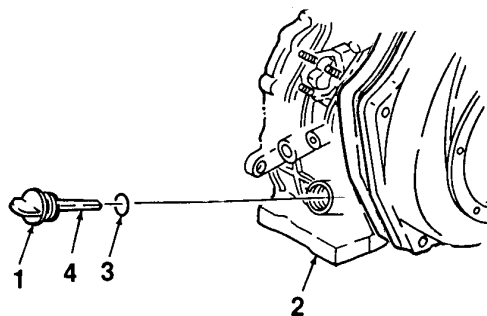


Figure 3-9. Oil Fill Cap

3-18. OIL FILTER MAINTENANCE

This task covers removal, inspection, and installation.

INITIAL SETUP

Tools:

Tool Kit, General Mechanic's Automotive
(Item 2, App. B, Sect. III)

Equipment Condition:

Engine oil drained (Para. 3-5)

Parts/Materials:

Oil, Engine Lubricating (Item 1-5, App. E)
Rag, Cleaning (Item 8, App. E)

A. REMOVAL.

Remove oil filter (1, Figure 3-10) from crankcase cover (2) by removing bolt (3). Remove and discard O-ring (4).

B. INSPECTION.

1. Inspect oil filter (1, Figure 3-10) for obvious damage. Check filter's mesh material for damage. Clean out clogging dirt and residue. Replace as required.
2. Inspect area around oil filter port for evidence of leakage. Clean area of dirt and accumulated grime using a clean rag.

C. INSTALLATION.

1. Apply a light coat of lubricating oil to new O-ring (4, Figure 3-10) and install O-ring onto oil filter (1).
2. Slide oil filter (1) into crankcase cover (2) and secure using bolt (3).

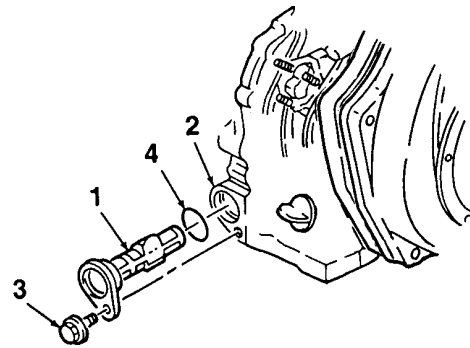


Figure 3-10. Oil Filter

3-19. STARTER MOTOR MAINTENANCE

This task covers removal, cleaning, inspection, and installation.

INITIAL SETUP

Tools:

Tool Kit, Master Mechanic (Item 3, App. B, Sect. III)

Equipment Condition:

None

Parts/Materials:

Solvent, Dry Cleaning (Item 7, App. E)

Rag, Cleaning (Item 8, App. E)

A. REMOVAL.

NOTE

Wiring shown in Figure 3-11 is for a typical connection configuration. Connections will vary with application.

1. Tag and disconnect electrical wires (1, 2, Figure 3-11) from connection stud (3) by removing nut (4) and washer (5). Reinstall nut and washer to prevent loss.
2. Tag and disconnect electrical wire (6) from starter solenoid lug.
3. Remove starter motor (7) from cylinder block by removing two screws (8).

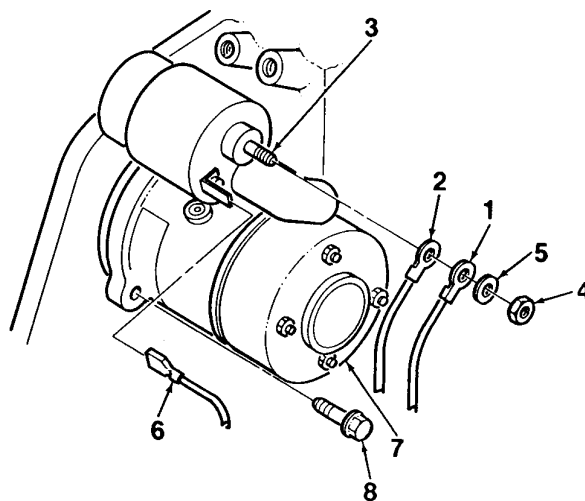


Figure 3-11. Starter Motor Removal

3-19. STARTER MOTOR MAINTENANCE - cont.

B. CLEANING.

WARNING

Cleaning solvents are flammable and toxic to eye, skin, and respiratory tract. Skin and eye protections are required when working in contact with cleaning solvents. Avoid repeated or prolonged contact. Work in well ventilated area only. Keep away from heat, sparks, and open flame. Do not smoke while using cleaning solvent. Failure to observe this warning can result in injury or death to personnel.

Clean starter motor with cleaning solvent and a clean rag. Allow to air dry.

C. INSPECTION.

1. Inspect starter motor body for deformation, dents, cracks, deformation, or obvious damage. Replace starter motor if damaged.
2. Inspect solenoid for evidence of electrical short. Inspect electrical connection studs for corrosive damage. Replace starter motor if any damage is suspected.

D. INSTALLATION.

1. Install starter motor (7, Figure 3-11) into cylinder block. Secure using two screws (8).
2. Connect electrical wire (6) to start solenoid lug.
3. Connect electrical wires (1, 2) to connection stud (3) using nut (4) and washer (5).

Section VII. PREPARATION FOR SHIPMENT AND STORAGE

3-20. GENERAL.

This section provides instructions for short term and immediate storage, or shipment, of the engine assembly.

3-21. ADMINISTRATIVE STORAGE.

Administrative storage shall be in accordance with AR 750-1.

3-22. SHORT TERM STORAGE (30 days or less).

- a. Check engine oil level and service as required.
- b. Cap all disconnected fuel lines.
- c. Conduct a general inspection of the engine assembly to ensure all components are present and securely fastened.
- d. Store the engine on a level surface in an area protected from the elements. Cover as required depending upon weather conditions.

3-23. INTERMEDIATE TERM STORAGE (more than 30 days)

- a. Start the engine and allow it to operate for 3 minutes. Shut down engine.
- b. Drain engine oil while engine is still warm in accordance with Paragraph 3-5.
- c. Fill engine crankcase with fresh oil in accordance with Paragraph 3-6.
- d. Remove head cover (Para. 3-15). Add 2 cubic centimeters (cc) of engine oil to the cylinder head, then reinstall head cover.
- e. Locate decompression lever on head cover. Push decompression lever down and hold in position while you pull the recoil starter handle 3 times. Do not pull hard enough to start engine.
- f. Pull decompression lever up. Slowly pull the recoil starter handle until it feels tight. This closes the intake and exhaust valves in compression position and helps prevent rust from forming.
- g. Conduct a general inspection of the engine assembly to ensure all components are present and securely fastened.
- h. Store the engine on a level surface in an area protected from the elements. Cover as required depending upon weather conditions.

3-24. SHIPMENT.

- a. Prepare engine for short or intermediate term storage, as applicable.
- b. Attach all forms, tags, and records to engine assembly.
- c. Mark for shipment in accordance with MIL-STD-129.

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CHAPTER 4

DIRECT SUPPORT MAINTENANCE INSTRUCTIONS

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

4-1. COMMON TOOLS AND EQUIPMENT.

- a. For authorized common tools and equipment, refer to the Modified Table of Organization and Equipment (MTOE), CTA 50-970, or CTA 8-100, as applicable to your unit.
- b. Tool Kit, Master Mechanics, Supply Catalog SC5180-90-CL-N05, is the primary supply source for tools used in direct support maintenance of the engine assembly.

4-2. SPECIAL TOOLS, TMDE, AND SUPPORT EQUIPMENT.

Refer to TM 9-2815-257-24P, Diesel Engine Assembly Set Repair Parts and Special Tools List, for complete data on special tools and equipment required for engine assembly maintenance. Refer to the Maintenance Allocation Chart (MAC), Appendix B, Section III, for special tools and equipment used at the direct support maintenance level.

4-3. REPAIR PARTS.

- a. Refer to Appendix H for a list of Mandatory Replacement Parts required for direct support level maintenance of the engine assembly.
- b. Repair parts are listed and illustrated in TM 9-2815-257-24P, Diesel Engine Assembly Repair Parts and Special Tools List.

Section II. SERVICE UPON RECEIPT OF EQUIPMENT

4-4. GENERAL.

WARNING

The engine is heavy. Provide adequate lifting device to support the weight. Use lifting ring for lifting purpose and use caution when lifting or moving the engine assembly. Failure to observe this warning can result in injury to personnel and/or damage to equipment.

- a. Using a lifting device capable of lifting 100 pounds, remove the engine assembly from its shipping container. Place on a suitable work surface.
- b. Remove packing material from engine assembly.
- c. Inspect the engine assembly for damage incurred during shipping. If the equipment has been damaged, report the damage on the appropriate form as required.
- d. Check the engine assembly against the packing slip to ensure that the shipment is complete. Report all discrepancies in accordance with the instructions of DA PAM 738-750.
- e. Check all tags and forms accompanying the engine assembly for special instructions. Do not remove any forms or tags until the unit is installed and ready for operation. When the unit is installed, remove forms and tags and forward to Quality Control (QC) section office.
- f. If required, drain preservative oil from engine in accordance with Paragraph 3-5.
- g. Fill engine crankcase with oil in accordance with Paragraph 3-6.

Section III. DIRECT SUPPORT LEVEL TROUBLESHOOTING PROCEDURES

4-5. GENERAL.

This section contains direct support level troubleshooting and tests for the engine assembly. Each malfunction or trouble symptom is addressed and is followed by a series of inspections or tests necessary to determine the probable cause and corrective action.

4-6. TROUBLESHOOTING.

a. This chapter does not list all possible malfunctions that may occur, all tests or inspections that may be performed, or all corrective actions for each malfunction. Only those checks and tests authorized for the direct support level are covered. If a malfunction is not listed, or is not remedied by corrective actions, notify personnel at a higher maintenance level.

b. Prior to using troubleshooting table, be sure you have performed all normal operational checks.

c. These troubleshooting procedures assume that electrical wires are undamaged and wiring harnesses are operable. Conduct continuity checks on suspect wiring / harnesses as required prior to performing troubleshooting procedures in Table 4-2.

d. Refer to Table 4-1, Malfunction Index, for determining applicable troubleshooting procedure located in Table 4-2.

Table 4-1. Malfunction Index

Trouble	Procedure
Engine will not start	1
Engine starts and stops	2
Engine speed fluctuates (races or uneven speed)	3
Engine output drops	4
Engine runs rough	5
Engine emits white smoke	6
Engine emits black smoke	7

Table 4-2. Direct Support Level Troubleshooting

MALFUNCTION	
TEST OR INSPECTION	CORRECTIVE ACTION
1. ENGINE WILL NOT START	
a. Check for proper thickness of fuel injection pump shim (Para. 4-11). Adjust shim thickness / injection timing (Para. 4-11).	
b. Damaged or defective fuel injection pump. Remove and replace fuel injection pump (Para. 4-11).	
c. Refer trouble to general support maintenance level.	
2. ENGINE STARTS AND STOPS	
a. Check for damaged governor control component (Para. 4-7). Remove and replace damaged control component (Para. 4-7).	
b. Damaged or defective fuel injection pump. Remove and replace fuel injection pump (Para. 4-11).	
c. Refer trouble to general support maintenance level.	
3. ENGINE SPEED FLUCTUATES (RACES OR UNEVEN SPEED)	
a. Check governor control for proper position of regulator spring (Para. 4-7). Adjust governor lever (Para. 4-7).	
b. Damaged or defective governor control component (Para. 4-7). Remove and replace damaged control component (Para. 4-7).	
4. ENGINE OUTPUT DROPS	
a. Damaged or defective fuel injection pump. Remove and replace fuel injection pump (Para. 4-11).	
b. Refer trouble to general support maintenance level.	

Table 4-2. Direct Support Level Troubleshooting (continued)

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
5. ENGINE RUNS ROUGH		
a.	Check governor control for proper position of regulator spring (Para. 4-7). Adjust governor lever (Para. 4-7).	
b.	Check for proper thickness of fuel injection pump shim (Para. 4-11). Adjust shim thickness / injection timing (Para. 4-11).	
c.	Damaged or defective fuel injection pump. Remove and replace fuel injection pump (Para. 4-11).	
d.	Refer trouble to general support maintenance level.	
6. ENGINE EMITS WHITE SMOKE		
a.	Check injection timing (too slow) (Para. 4-11). Adjust fuel injection pump timing by removing shims (Para. 4-11).	
b.	Refer trouble to general support maintenance level.	
7. ENGINE EMITS BLACK SMOKE		
a.	Check injection timing (too slow) (Para. 4-11). Adjust fuel injection pump timing by removing shims (Para. 4-11).	
b.	Refer trouble to general support maintenance level.	

Section IV. DIRECT SUPPORT MAINTENANCE PROCEDURES

4-7. GOVERNOR CONTROL MAINTENANCE

This task covers removal, cleaning, inspection, and installation.

INITIAL SETUP

Tools:

Tool Kit, Master Mechanic (Item 3, App. B, Sect. III)

Equipment Condition:

None

Parts/Materials:

Solvent, Dry Cleaning (Item 7, App. E)

Rag, Cleaning (Item 8, App. E)

A. REMOVAL.

CAUTION

Governor lever (7) and torque spring are factory preset. Do not adjust locking nut or cut lockwire.

1. Remove adjusting screw (1, Figure 4-1) and washer (2) from regulator bracket assembly (3).
2. Disconnect springs (4, 5) from governor lever (7) and manual control handle (6).
3. Release regulator bracket assembly (3) from cylinder block by removing screw (8).
4. Remove screw (9), knob (10), and nut (11). Remove screw (13) and spring (12).

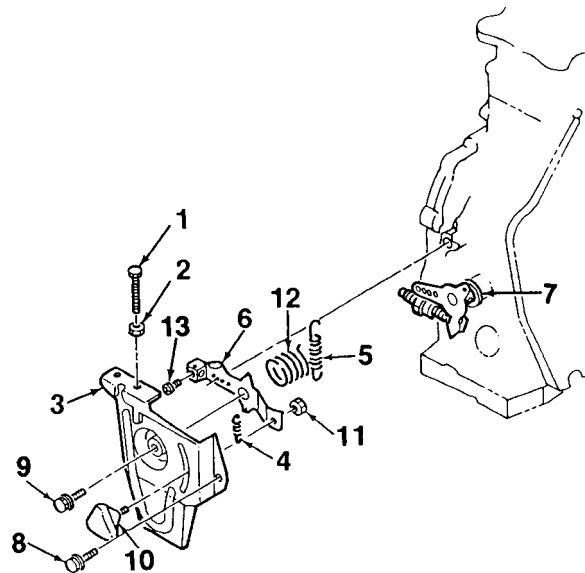


Figure 4-1. Governor Control Removal

4-7. GOVERNOR CONTROL MAINTENANCE - cont.

B. CLEANING.

WARNING

Cleaning solvents are flammable and toxic to eye, skin, and respiratory tract. Skin and eye protections are required when working in contact with cleaning solvents. Avoid repeated or prolonged contact. Work in well ventilated area only. Keep away from heat, sparks, and open flame. Do not smoke while using cleaning solvent. Failure to observe this warning can result in injury or death to personnel.

Clean components with cleaning solvent and a clean rag. Allow to air dry.

C. INSPECTION.

Inspect governor control components for damage. Replace any part that is damaged in any way.

D. INSTALLATION.

1. Install screw (13, Figure 4-2) onto manual control handle (6). Mate handle to regulator bracket assembly (3) and install screw (9), knob (10), nut (11), and spring (12).
2. Mate regulator bracket assembly (3) to cylinder block and install screw (8). Connect springs (4, 5) to handle (6) and lever (7).
3. Install screw (1) and washer (2).

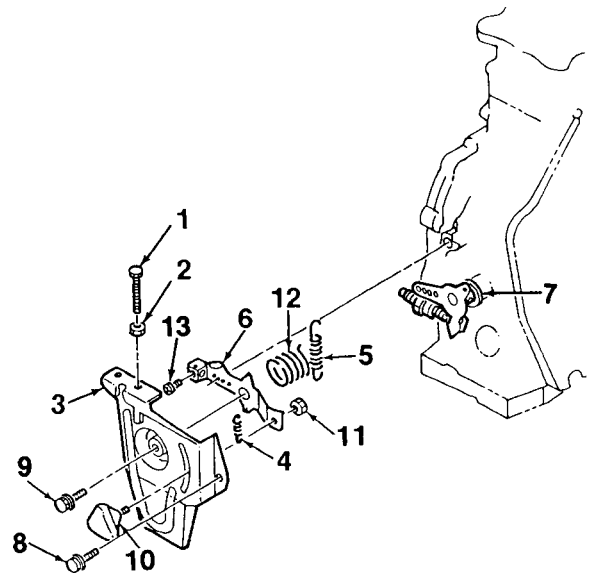


Figure 4-2. Governor Control Installation

4-8. CYLINDER BLOCK MAINTENANCE

This task covers removal, cleaning, inspection, and installation of the crankcase cover.

INITIAL SETUP

Tools:

Tool Kit, Master Mechanic (Item 3, App. B, Sect. III)

Equipment Condition:

Engine oil drained (Para. 3-5)

Parts/Materials:

Oil, Lubricating (Item 1-5, App. E)

Solvent, Dry Cleaning (Item 7, App. E)

Rag, Cleaning (Item 8, App. E)

Grease, Automotive (Item 9, App. E)

A. REMOVAL.

CAUTION

When removing crankcase cover, be careful not to damage oil seal.

1. Note attachment location of engine lifting cable (4, Figure 4-3). Release crankcase cover (1) and lifting cable from cylinder block by removing fifteen screws (2). Carefully pry crankcase cover from cylinder block.
2. Remove cover gasket (3). Discard gasket if damaged or deformed. Remove pipe (5), two guide pins (6), and threaded plug (7) only if replacement is required.

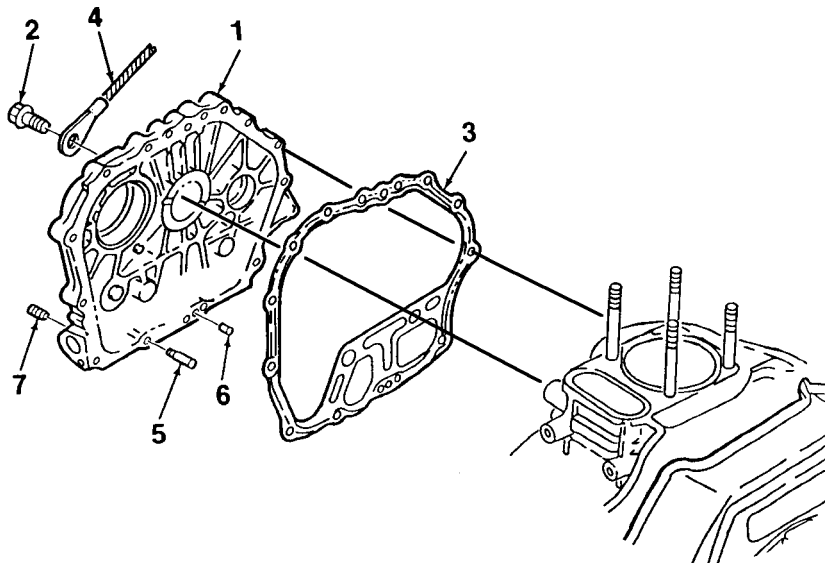


Figure 4-3. Crankcase Cover Removal

4-8. CYLINDER BLOCK MAINTENANCE - cont.

B. CLEANING.

WARNING

Cleaning solvents are flammable and toxic to eye, skin, and respiratory tract. Skin and eye protections are required when working in contact with cleaning solvents. Avoid repeated or prolonged contact. Work in well ventilated area only. Keep away from heat, sparks, and open flame. Do not smoke while using cleaning solvent. Failure to observe this warning can result in injury or death to personnel.

1. Clean crankcase cover with cleaning solvent and a clean rag. Allow to air dry.
2. Remove any old gasket material or grease from crankcase cover and engine crankcase mating surfaces.

C. INSPECTION.

1. Inspect crankcase cover (1, Figure 4-4) for cracks, deformation, or obvious damage. Inspect cover mating surfaces for scratches, burrs, or blemishes. Replace cover if damaged.
2. Inspect cover gasket (3) for damage or deformation. Replace if damaged in any way.

D. INSTALLATION.

1. If removed, install threaded plug (7, Figure 4-4), pipe (5), and two guide pins (6) into crankcase cover (1).
2. Apply grease to lips of crankshaft oil seal (housed in crankcase cover (1)).
3. Apply oil to crankshaft and camshaft. Make sure that oil pump drive gears are properly engaged.
4. Mate cover gasket (3) to cylinder block.
5. Mate crankcase cover (1) to cylinder block and secure using fifteen screws (2). Make sure to attach lifting cable (4) at position noted during removal. Tighten screws in criss-cross sequence as shown in Figure 4-5. Torque all screws to 14.5 to 16.6 ft-lbs. (200 to 230 kg-cm).
6. Service engine oil (Para. 3-6).

4-8. CYLINDER BLOCK MAINTENANCE - cont.

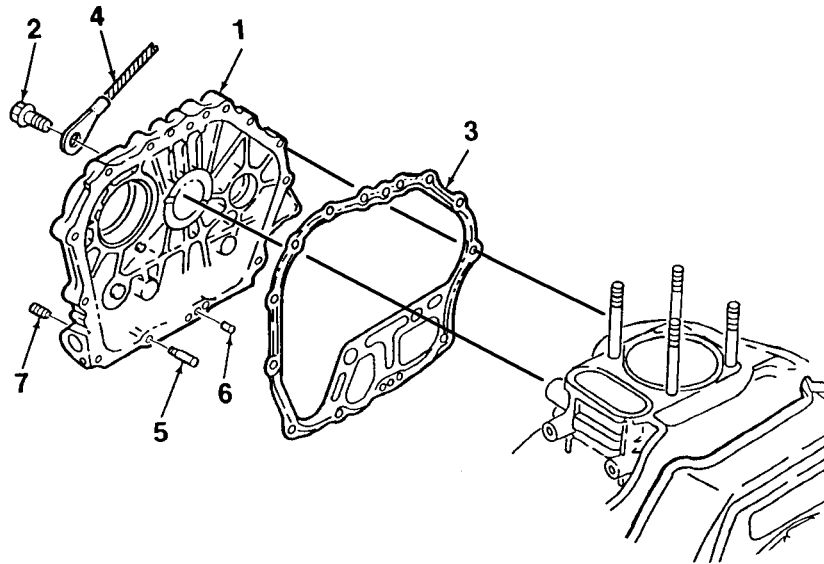


Figure 4-4. Crankcase Cover Installation

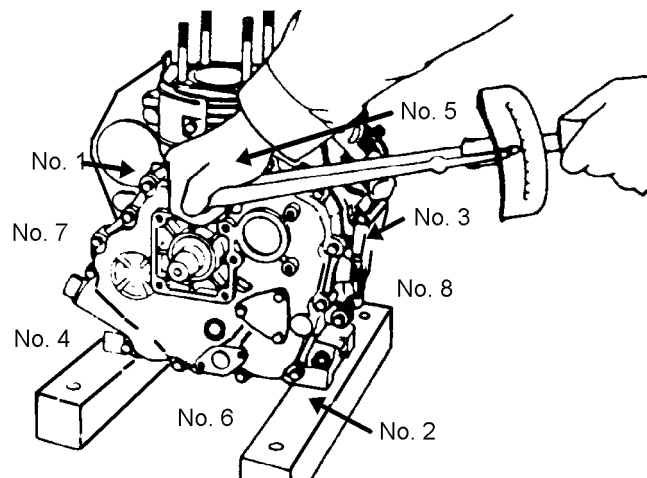


Figure 4-5. Crankcase Cover Bolt Tightening Sequence

4-9. ROCKER ARM ASSEMBLY MAINTENANCE

This task covers removal, cleaning, inspection, and installation.

INITIAL SETUP

Tools:

Tool Kit, Master Mechanic (Item 3, App. B, Sect. III)

Equipment Condition:

Rocker cover removed (Para. 3-15)

Parts/Materials:

Solvent, Dry Cleaning (Item 7, App. E)

Rag, Cleaning (Item 8, App. E)

A. REMOVAL.

1. Remove rocker arm support (1, Figure 4-6) from cylinder head (8) by removing screw (2). Place assembled support and rocker arms on a clean work surface for further disassembly.
2. Remove rocker arms (3, 4) from rocker arm support (1). Remove lock nuts (5), adjusting screws (6), and valve cap (7).

B. CLEANING.

WARNING

Cleaning solvents are flammable and toxic to eye, skin, and respiratory tract. Skin and eye protections are required when working in contact with cleaning solvents. Avoid repeated or prolonged contact. Work in well ventilated area only. Keep away from heat, sparks, and open flame. Do not smoke while using cleaning solvent. Failure to observe this warning can result in injury or death to personnel.

Clean rocker arm components with cleaning solvent and a clean rag. Allow to air dry.

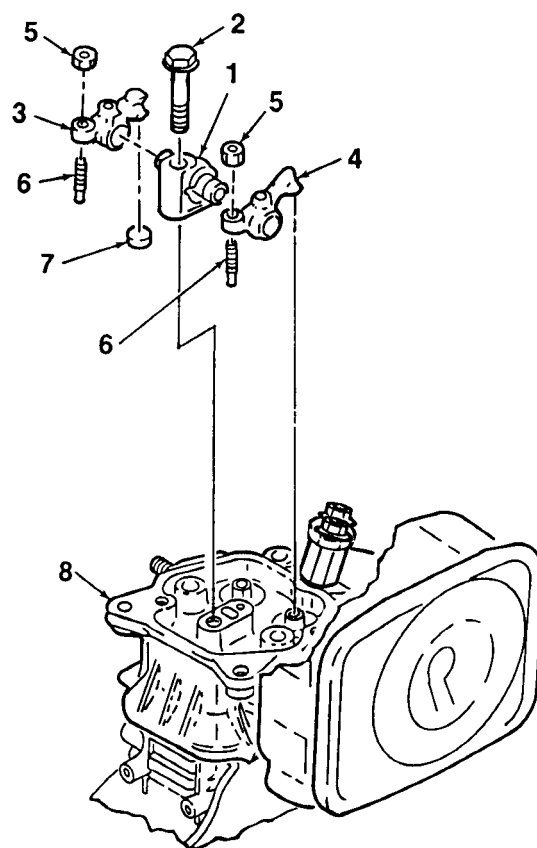


Figure 4-6. Rocker Arm Assembly Removal

4-9. ROCKER ARM ASSEMBLY MAINTENANCE - cont.

C. INSPECTION.

1. Measure the outside diameter (OD) of the rocker arm support shaft (Figure 4-7). OD must be 0.4685 inch (11.90 mm), minimum. Replace support (1, Figure 4-6) if out of limits.
2. Measure the internal diameter (ID) of the rocker arms (Figure 4-8). ID must be 0.4764 in (12.10 mm), maximum. Replace rocker arm (3, 4, Figure 4-6) if out of limits.

D. INSTALLATION.

1. Install lock nuts (5, Figure 4-6) and adjusting screws (6) onto rocker arms (3, 4). Install valve cap (7). Install rocker arms onto rocker arm support (1).
2. Install rocker arm support (1) onto cylinder head (8) using screw (2). Torque screw to 14.5 to 16.5 ft-lbs. (200 to 230 kg-cm).
3. Adjust valve clearance (Para. 3-15).

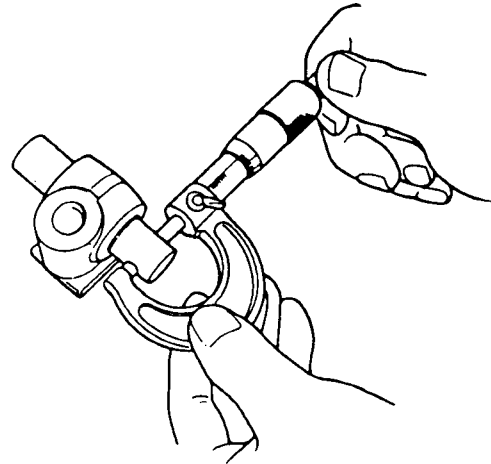


Figure 4-7. Rocker Arm Support Shaft OD

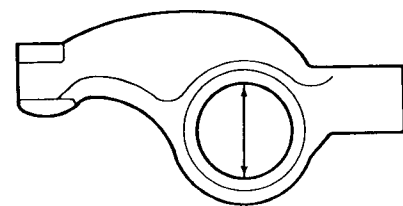


Figure 4-8. Rocker Arm ID

4-10. OIL PUMP MAINTENANCE

This task covers removal, cleaning, inspection, and installation.

INITIAL SETUP

Tools:

Tool Kit, Master Mechanic (Item 3, App. B, Sect. III)

Equipment Condition:

Engine oil drained (Para. 3-5)

Parts/Materials:

Oil, Lubricating (Item 1-5, App. E)

Solvent, Dry Cleaning (Item 7, App. E)

Rag, Cleaning (Item 8, App. E)

Grease, Automotive (Item 9, App. E)

A. REMOVAL.

CAUTION

When removing crankcase cover, be careful not to damage oil seal.

1. Release crankcase cover (1, Figure 4-9) from cylinder block by removing fifteen screws (2). Carefully separate crankcase cover from engine crankcase.
2. Remove cover gasket (3). Discard if damaged or deformed.
3. Remove oil pump cover (4) from crankcase cover (1) by removing three screws (5). Remove and discard O-ring (6).
4. Remove parallel pin (7) and slide oil pump (9) out of crankcase cover (1). Remove outer rotor (8). Remove and discard governor assembly (11) and pin (10).

B. CLEANING.

WARNING

Cleaning solvents are flammable and toxic to eye, skin, and respiratory tract. Skin and eye protections are required when working in contact with cleaning solvents. Avoid repeated or prolonged contact. Work in well ventilated area only. Keep away from heat, sparks, and open flame. Do not smoke while using cleaning solvent. Failure to observe this warning can result in injury or death to personnel.

1. Clean components with cleaning solvent and a clean rag. Allow to air dry.
2. Remove any old gasket material or grease from crankcase cover and engine crankcase mating surfaces.

4-10. OIL PUMP MAINTENANCE - cont.

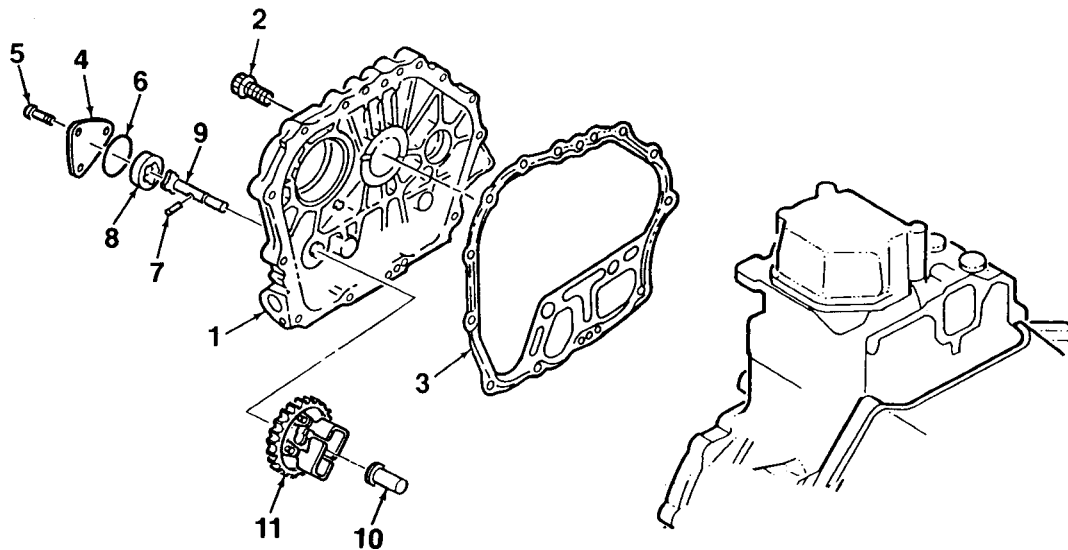


Figure 4-9. Oil Pump Removal

C. INSPECTION.

1. Inspect crankcase cover (1, Figure 4-9) for cracks, deformation, or obvious damage. Inspect mating surfaces for scratches, burrs, or blemishes. Replace cover if damaged.
2. Inspect cover gasket (3) for damage or deformation. Replace if damaged in any way.
3. Inspect outer rotor (8) and inner rotor portion of oil pump (9) for signs of excessive or uneven wear. Fit inner rotor into outer rotor and measure gap at various points. Gap between inner and outer rotors must not exceed 0.0098 inch (0.25 mm). Replace outer rotor (8) and oil pump (9) as an assembly if excessively worn, damaged, or out of limits.
4. Measure the outside diameter (OD) of outer rotor (8). OD must be 1.1378 inches (28.90 mm), minimum. Replace outer rotor (8) and oil pump (9) as an assembly if out of limits.
5. Measure the internal diameter (ID) of outer rotor port in crankcase cover (1). ID must not exceed 1.1488 inches (29.18 mm). Replace crankcase cover (1) if out of limits.

4-10. OIL PUMP MAINTENANCE - cont.

D. INSTALLATION.

1. Insert oil pump (9, Figure 4-10) into crankcase cover (1) and install parallel pin (7). Coat oil pump rotor with oil, and install outer rotor (8).
2. Coat new O-ring (6) with oil and install into crankcase cover (1). Install oil pump cover (4) using three screws (5).
3. Install new governor assembly (11) and pin (10).
4. Apply grease to lips of crankshaft oil seal (installed in crankcase cover (1)).
5. Apply oil to crankshaft and camshaft. Make sure that oil pump drive gears are properly engaged.
6. Mate cover gasket (3) to cylinder block.
7. Mate crankcase cover (1) to cylinder block and secure using fifteen screws (2). Tighten screws in criss-cross sequence as shown in Figure 4-5. Torque all screws to 14.5 to 16.6 ft-lbs. (200 to 230 kg-cm).
8. Service engine oil (Para. 3-6).

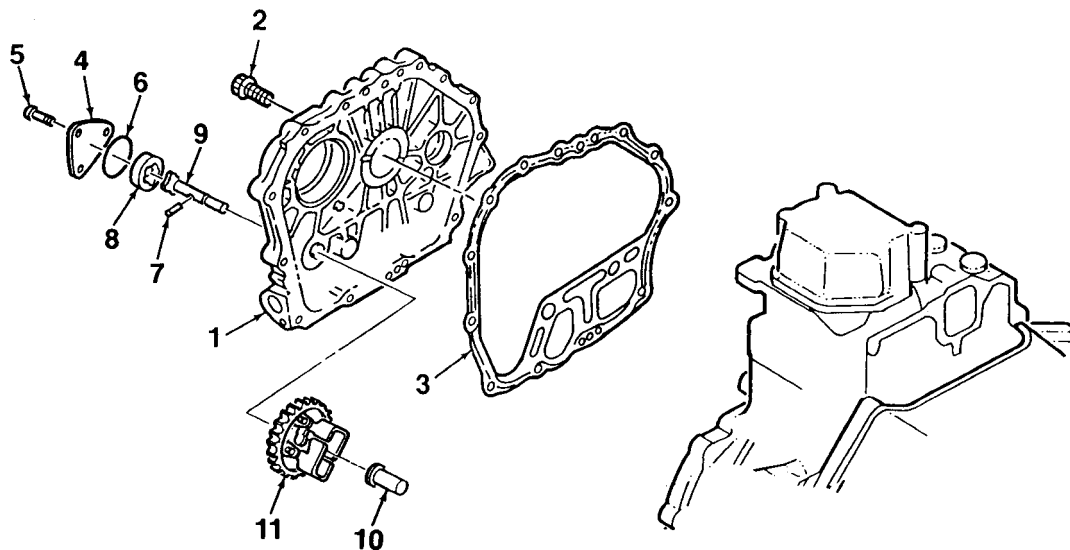


Figure 4-10. Oil Pump Installation

4-11. FUEL INJECTION PUMP MAINTENANCE

This task covers removal, cleaning, inspection, installation., and adjustment

INITIAL SETUP

Tools:

Tool Kit, Master Mechanic (Item 3, App. B, Sect. III)

Equipment Condition:

None

Parts/Materials:

Solvent, Dry Cleaning (Item 7, App. E)

Rag, Cleaning (Item 8, App. E)

Shims, Timing (Item 7, Figure 4-11), as required

A. REMOVAL.

1. Disconnect fuel pipe (1, Figure 4-11) from fuelinjection pump (2).
2. Remove nut (4), inspection cover (5), and gasket (6) from lower pump stud (8).
3. Remove fuel injection pump (2) from pump studs (8) by removing two nuts (3). Remove shim(s) (7). Note number of shims utilized.
4. Remove fuel tappet (9) from engine crankcase.

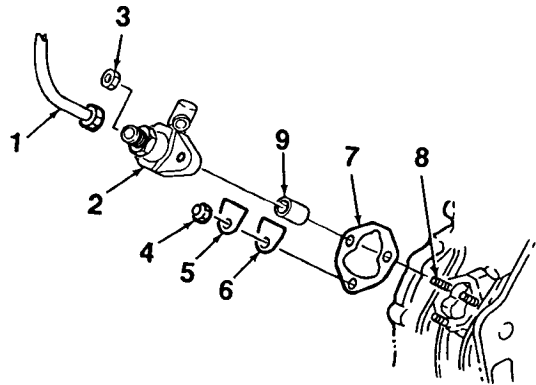


Figure 4-11. Fuel Injection Pump Removal

4-12. FUEL INJECTION PUMP MAINTENANCE - cont.

B. CLEANING.

WARNING

Cleaning solvents are flammable and toxic to eye, skin, and respiratory tract. Skin and eye protections are required when working in contact with cleaning solvents. Avoid repeated or prolonged contact. Work in well ventilated area only. Keep away from heat, sparks, and open flame. Do not smoke while using cleaning solvent. Failure to observe this warning can result in injury or death to personnel.

Clean components with cleaning solvent and a clean rag. Allow to air dry.

C. INSPECTION.

1. Inspect fuel pipe (1, Figure 4-12) for cracks, kinks, and leaks. Inspect injection pump (2) for crossed, stripped, or damaged threads. Replace if damaged.
2. Inspect fuel tappet (9) for scores, pitting, or wear. Replace if damaged or worn.

D. INSTALLATION.

1. Install fuel tappet (9, Figure 4-12) into engine crankcase.
2. Install shim(s) (7) onto injection pump studs (8). Install gasket (6), cover (5), and nut (4).
3. Install injection pump (2) onto studs (8), aligning tooth on control lever with slot on governor lever (see Figure 4-12). Governor lever must be set so slot is in the center of opening in housing. Install nuts (3) and tighten to 7.2 to 8.7 ft-lbs. (100 to 120 kg-cm).

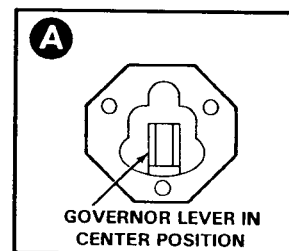
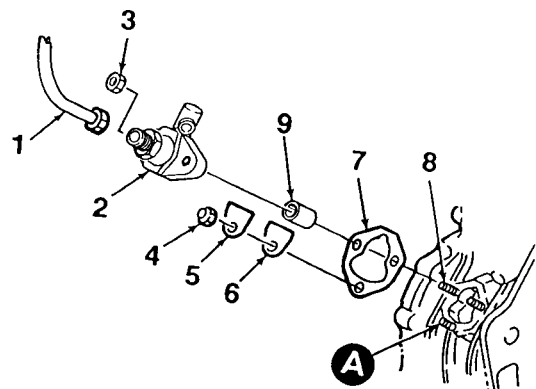


Figure 4-12. Fuel Injection Pump Installation

4-11. FUEL INJECTION PUMP MAINTENANCE - cont.

4. Adjust fuel injection timing in accordance with step E before connecting fuel pipe (1) to injection pump (2).

E. FUEL INJECTION TIMING ADJUSTMENT.

1. Remove flywheel housing (Para. 3-13). Disconnect fuel pipe (1, Figure 4-12) from injection pump (2).
2. Set governor speed control handle to RUN position.
3. Rotate flywheel one revolution in the clockwise direction until T position mark on flywheel matches V mark off line on cylinder body fin (see Figure 4-13). This is the top dead center (TDC) position. There should be some fuel coming out of the fuel injection pump. If fuel is not present, rotate the flywheel another revolution clockwise.
4. Turn flywheel counter-clockwise about 30 degrees from T position mark.
5. Slowly turn flywheel clockwise until fuel flows from injection pump, then stop rotation.
6. Use timing marks on flywheel to determine flywheel position. Marks are 5 degrees apart. Flywheel should be 16 to 18 degrees before TDC position. Therefore, the V mark off line should be aligned between the third and fourth flywheel timing marks before the TDC position mark.
7. Repeat steps 4 through 6 two or three times to make sure reading is accurate. Fuel injection should begin when flywheel is rotated 16 to 18 degrees from TDC position mark.

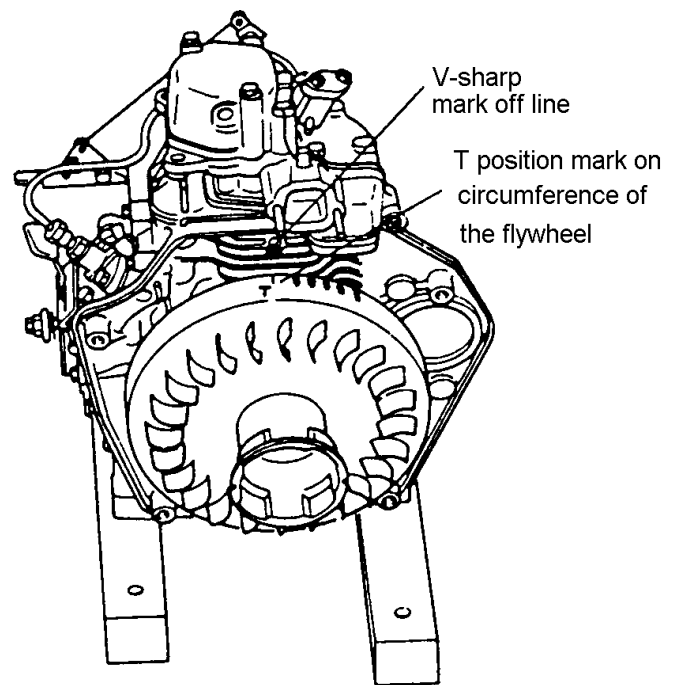


Figure 4-13. Fuel Injection Timing

4-11. FUEL INJECTION PUMP MAINTENANCE - cont.

8. Injection timing can be adjusted by adding or removing injection pump shims (7, Figure 4-14). If fuel is injected before a 16 degree rotation, add shims. If fuel is not injected until after a 18 degree rotation, subtract shims. Each 0.1 mm (0.0039 inch) shim changes timing by 1 degree.
9. Add or subtract shims (7) as required and retest to ensure proper timing. Install fuel pipe (1) onto injection pump (2). Install flywheel housing (Para. 3-13).

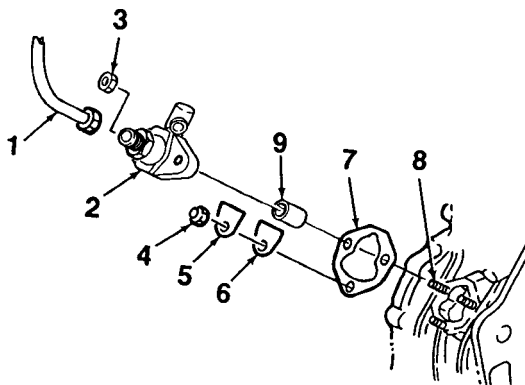


Figure 4-14. Timing Adjustment

CHAPTER 5

GENERAL SUPPORT MAINTENANCE INSTRUCTIONS

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

5-1. COMMON TOOLS AND EQUIPMENT.

- a. For authorized common tools and equipment, refer to the Modified Table of Organization and Equipment (MTOE), CTA 50-970, or CTA 8-100, as applicable to your unit.
- b. Tool Kit, Master Mechanics, Supply Catalog SC5180-90-CL-N05, is the primary supply source for tools used in general support maintenance of the engine assembly.

5-2. SPECIAL TOOLS, TMDE, AND SUPPORT EQUIPMENT.

Refer to TM 9-2815-257-24P, Diesel Engine Assembly Set Repair Parts and Special Tools List, for complete data on special tools and equipment required for engine assembly maintenance. Refer to the Maintenance Allocation Chart (MAC), Appendix B, Section III, for special tools and equipment used at the general support maintenance level.

5-3. REPAIR PARTS.

- a. Refer to Appendix H for a list of Mandatory Replacement Parts required for general support level maintenance of the engine assembly.
- b. Repair parts are listed and illustrated in TM 9-2815-257-24P, Diesel Engine Assembly Repair Parts and Special Tools List.

Section II. SERVICE UPON RECEIPT OF EQUIPMENT

5-4. GENERAL.

WARNING

The engine is heavy. Provide adequate lifting device to support the weight. Use lifting ring for lifting purpose and use caution when lifting or moving the engine assembly. Failure to observe this warning can result in injury to personnel and/or damage to equipment.

- a. Using a lifting device capable of lifting 100 pounds, remove the engine assembly from its shipping container. Place on a suitable work surface.
- b. Remove packing material from engine assembly.
- c. Inspect the engine assembly for damage incurred during shipping. If the equipment has been damaged, report the damage on the appropriate form as required.
- d. Check the engine assembly against the packing slip to ensure that the shipment is complete. Report all discrepancies in accordance with the instructions of DA PAM 738-750.
- e. Check all tags and forms accompanying the engine assembly for special instructions. Do not remove any forms or tags until the unit is installed and ready for operation. When the unit is installed, remove forms and tags and forward to Quality Control (QC) section office.
- f. If required, drain preservative oil from engine in accordance with Paragraph 3-5.
- g. Fill engine crankcase with oil in accordance with Paragraph 3-6.

**Section III. GENERAL SUPPORT LEVEL TROUBLESHOOTING
PROCEDURES**

5-5. GENERAL.

This section contains general support level troubleshooting and tests for the engine assembly. Each malfunction or trouble symptom is addressed and is followed by a series of inspections or tests necessary to determine the probable cause and corrective action.

5-6. TROUBLESHOOTING.

- a. This chapter does not list all possible malfunctions that may occur, all tests or inspections that may be performed, or all corrective actions for each malfunction. Only those checks and tests authorized for the direct support level are covered. If a malfunction is not listed, or is not remedied by corrective actions, notify personnel at a higher maintenance level.
- b. Prior to using troubleshooting table, be sure you have performed all normal operational checks.
- c. These troubleshooting procedures assume that electrical wires are undamaged and wiring harnesses are operable. Conduct continuity checks on suspect wiring / harnesses as required prior to performing troubleshooting procedures in Table 5-2.
- d. Refer to Table 5-1, Malfunction Index, for determining applicable troubleshooting procedure located in Table 5-2.

Table 5-1. Malfunction Index

Trouble	Procedure
Engine will not start	1
Engine starts and stops	2
Engine output drops	3
Engine runs rough	4
Low compression pressure	5
Engine emits white smoke	6
Engine emits black smoke	7

Table 5-2. General Support Level Troubleshooting

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1. ENGINE WILL NOT START		
	a. Check for defective injection pump delivery valve (Para. 5-12).	Remove and replace pump delivery valve (Para. 5-12).
2. ENGINE STARTS AND STOPS		
	a. Check for defective injection pump delivery valve (Para. 5-12).	Remove and replace pump delivery valve (Para. 5-12).
	b. Possible crankshaft bearing seizure. Grasp flywheel and attempt to manually rotate engine in clockwise direction to check for seizure.	Remove and replace crankshaft bearing (Para. 5-7).
	c. Possible piston liner seizure. Grasp flywheel and attempt to manually rotate engine in clockwise direction to check for seizure.	Remove and replace piston components (Para. 5-10).
3. ENGINE OUTPUT DROPS		
	a. Check for defective injection pump delivery valve (Para. 5-12).	Remove and replace pump delivery valve (Para. 5-12).
	b. Check for carbon deposits in the combustion chamber (Para. 5-10).	Clean carbon from combustion chamber (Para. 5-10).
	c. Possible piston seizure or wear. Inspect pistons (Para. 5-10).	Remove and replace damaged or worn piston components (Para. 5-10).
4. ENGINE RUNS ROUGH		
	a. Check flywheel nut for proper tightness.	Tighten flywheel nut to 86 to 94 ft-lbs (1200 to 1300 kg-cm).

Table 5-2. General Support Level Troubleshooting (continued)

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
5. LOW COMPRESSION PRESSURE		
	a. Check for leak at inlet and exhaust valves indicating worn valve seat or guide (Para. 5-11).	Remove and replace inlet / exhaust valve components as required (Para. 5-11).
	b. Check for loose cylinder head nuts causing leak at cylinder head gasket.	Tighten cylinder head nuts in an even pattern to 30 to 33 ft-lbs (420 to 460 kg-cm).
	c. Check for broken or damaged cylinder head gasket (Para. 5-11).	Remove and replace cylinder head gasket (Para. 5-11).
6. ENGINE EMITS WHITE SMOKE		
	a. Possible worn or broken piston ring, worn piston. Inspect piston assembly (Para. 5-10).	Remove and replace damaged piston assembly components (Para. 5-10).
	b. Check for defective valve stem seal (Para. 5-11).	Remove and replace valve stem seal (Para. 5-11).
7. ENGINE EMITS BLACK SMOKE		
	a. Possible piston / cylinder liner seizure. Inspect for seized components (Para. 5-10).	Remove and replace damaged piston assembly components (Para. 5-10).

Section IV. GENERAL SUPPORT MAINTENANCE PROCEDURES

5-7. CRANKSHAFT ASSEMBLY MAINTENANCE

This task covers removal, cleaning, inspection, and installation.

INITIAL SETUP

Tools:

Tool Kit, Master Mechanic (Item 3, App. B, Sect. III)
Handle, Flywheel Locking (Item 5, App. B, Sect. III)
Remover, Flywheel (Item 6, App. B, Sect. III)

Equipment Condition:

Balancer shaft removed (Para. 5-8)
Camshaft removed (Para. 5-9)
Connecting rod removed (Para. 5-10)

Parts/Materials:

Oil, Lubricating (Item 1-5, App. E)
Solvent, Dry Cleaning (Item 7, App. E)
Rag, Cleaning (Item 8, App. E)
Grease, Automotive (Item 9, App. E)

5-7. CRANKSHAFT ASSEMBLY MAINTENANCE - cont.

A. REMOVAL.

1. Remove flywheel housing (1, Figure 5-1) from cylinder block (7) by removing four screws (2), washers (3), collars (4), and spacers (5). Remove seal (6).
2. Using flywheel locking handle, hold flywheel (10) in place and remove nut (8) and washer (9).
3. Carefully remove flywheel (10) from crankshaft using flywheel remover. Use care to prevent damage to flywheel fins.
4. Remove key (11, Figure 5-1). Remove bearing holder (10, Figure 5-2) and screw (11).
5. Carefully remove assembled crankshaft (5) from cylinder block, taking care not to damage oil seal (3). Remove key (9).
6. Remove bolt (1) and washer (2). Remove oil seal (3) and bearing (4) only if replacement is required.

NOTE

Bearing (6, Figure 5-2) and gears (7, 8) are supplied with crankshaft (5) as a matched set. Do not remove from crankshaft.

B. CLEANING.

WARNING

Cleaning solvents are flammable and toxic to eye, skin, and respiratory tract. Skin and eye protections are required when working in contact with cleaning solvents. Avoid repeated or prolonged contact. Work in well ventilated area only. Keep away from heat, sparks, and open flame. Do not smoke while using cleaning solvent. Failure to observe this warning can result in injury or death to personnel.

Clean components with cleaning solvent and a clean rag. Allow to air dry.

5-7. CRANKSHAFT ASSEMBLY MAINTENANCE - cont.

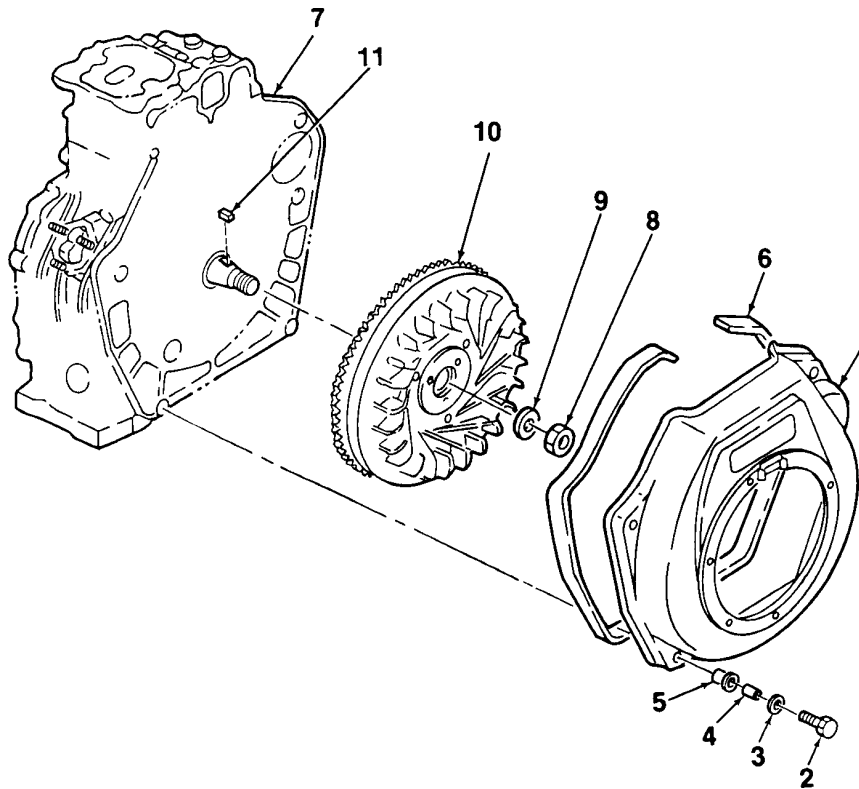


Figure 5-1. Flywheel Removal

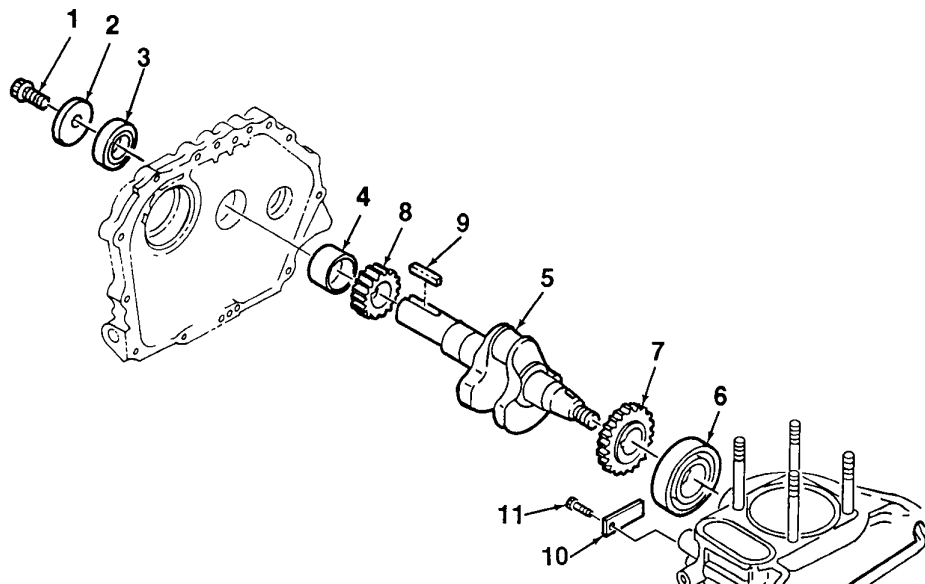


Figure 5-2. Crankshaft Assembly Removal

5-7. CRANKSHAFT ASSEMBLY MAINTENANCE - cont.

C. INSPECTION.

1. Inspect flywheel (10, Figure 5-1) for cracks, deformation, or obvious damage. Inspect for broken, chipped, or cracked flywheel fins. Replace flywheel if damaged.
2. Inspect flywheel housing seal (6) for deterioration or permanent set. Replace if damaged or deformed.
3. Inspect crankshaft (5, Figure 5-5) for cracks, deformation, or obvious damage. Replace crankshaft if cracked or damaged.
4. Inspect gears (7, 8) for broken, chipped, or worn teeth. Replace gears and crankshaft (5) as an assembly if a gear is damaged or worn.
5. Measure the outside diameter (OD) of crankshaft crank pin (Figure 5-3). OD must be 1.4134 inches (35.90 mm), minimum. Replace crankshaft assembly if out of limits.
6. Measure the OD of crankshaft where crankshaft mates to crankcase cover plain bearing (Figure 5-3). OD must be 1.3744 inches (34.91 mm), minimum. Replace crankshaft assembly if out of limits.
7. Measure the OD of crankshaft where it mates to flywheel side ball bearing (Figure 5-3). OD must be 1.3782 inches (35.01 mm), minimum. Replace crankshaft assembly if out of limits.
8. Bearing (6, Figure 5-5) is press fit onto crankshaft (5). Check bearing for looseness. Replace crankshaft assembly if bearing is loose.
9. Inspect bearing (4) for discoloration, separation, or any other obvious damage. Remove and replace bearing if damaged in any way.

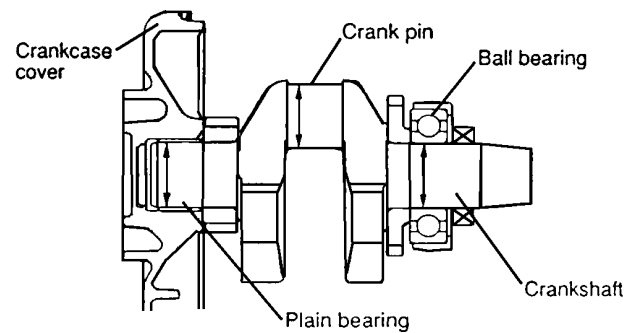


Figure 5-3. Crankshaft Inspection

5-7. CRANKSHAFT ASSEMBLY MAINTENANCE - cont.

D. INSTALLATION.

1. If installing a new bearing (4, Figure 5-5), mount bearing so that oil groove in bearing faces up (see Figure 5-4). Press fit bearing so that sinkage between face of bearing and face of crankcase cover is 0.0394 inch (1.0 mm).
2. Install a new oil seal (3, Figure 5-5). Apply grease to oil seal and press into crankcase cover. Install bolt (1) and washer (2).
3. Apply grease to lips of oil seal (3). Apply a light coat of oil to crankshaft (5) journal and pin.
4. Install key (9) into crankshaft (5). Carefully insert assembled crankshaft into cylinder block. Make sure that crankshaft is inserted as far as it will go.
5. Install bearing holder (10) using screw (11).

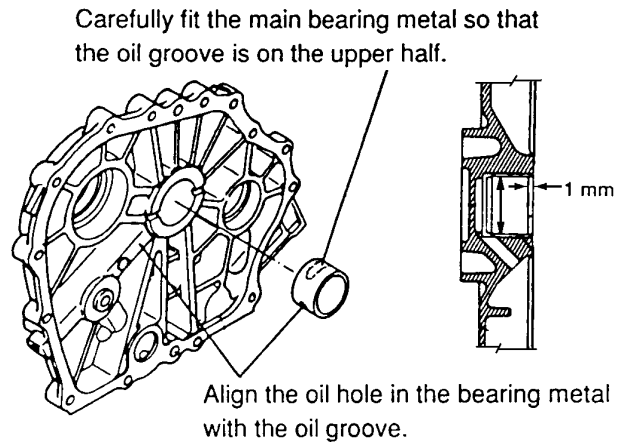


Figure 5-4. Bearing Installation

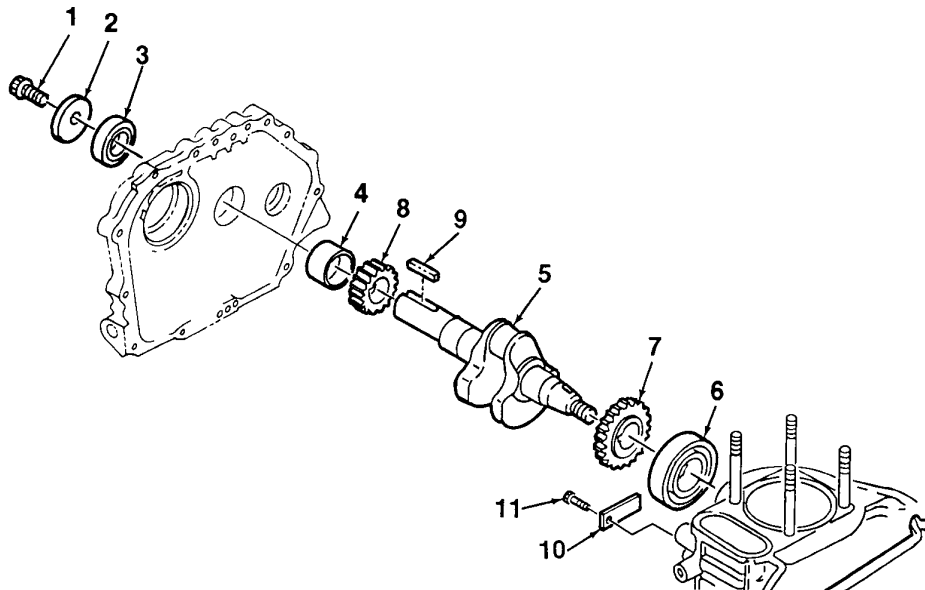


Figure 5-5. Crankshaft Assembly Installation

5-7. CRANKSHAFT ASSEMBLY MAINTENANCE - cont.

6. Install key (11, Figure 5-6). Mate flywheel (10) to crankshaft, taking care not to damage crankshaft threads. Install washer (9) and nut (8). Lock flywheel in place using locking handle and tighten nut to 87 to 94 ft-lbs. (1200 to 1300 kg-cm).
 7. Install seal (6) onto flywheel housing (1).
 8. Mate flywheel housing (1) to cylinder block (7). Secure using four spacers (5), collars (4), washers (3), and screws (2).
 9. Install connecting rod (Para. 5-10).
 10. Install balancer shaft (Para. 5-8).
 11. Install camshaft (Para. 5-9).
-

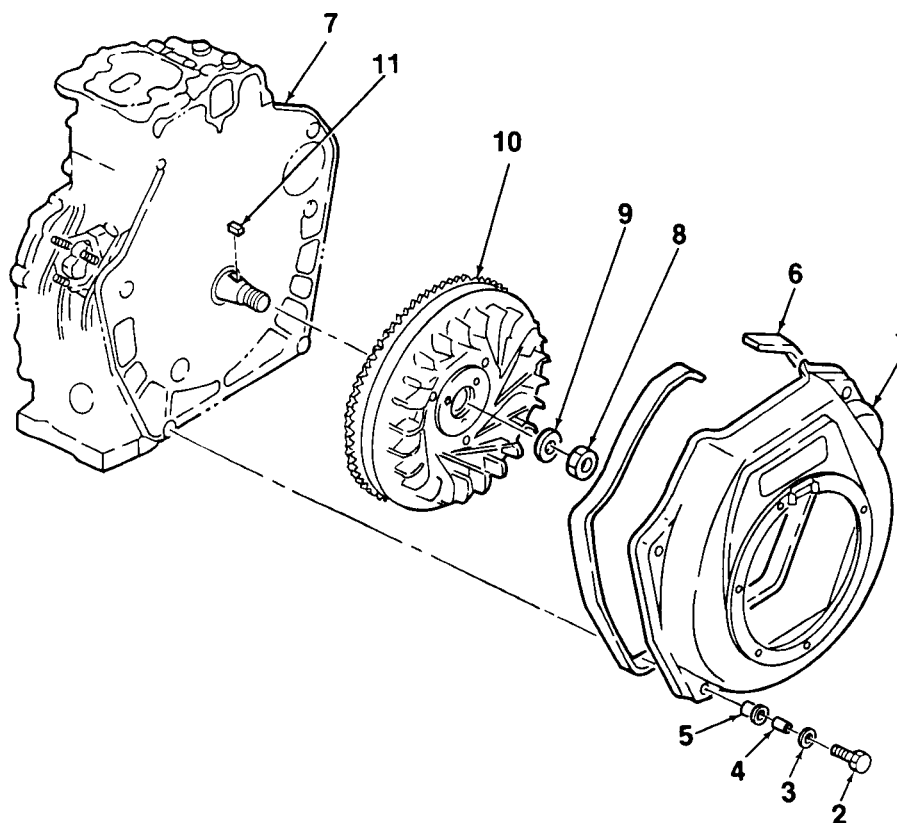


Figure 5-6. Flywheel Installation

5-8. BALANCER SHAFT ASSEMBLY MAINTENANCE

This task covers removal, cleaning, inspection, and installation.

INITIAL SETUP

Tools:

Tool Kit, Master Mechanic (Item 3, App. B, Sect. III)

Equipment Condition:

Engine oil drained (Para. 3-5)

Parts/Materials:

Oil, Lubricating (Item 1-5, App. E)

Solvent, Dry Cleaning (Item 7, App. E)

Rag, Cleaning (Item 8, App. E)

Grease, Automotive (Item 9, App. E)

5-8. BALANCER SHAFT ASSEMBLY MAINTENANCE - cont.

A. REMOVAL.

CAUTION

When removing crankcase cover, be careful not to damage oil seal.

1. Release crankcase cover (1, Figure 5-7) from cylinder block (8) by removing fifteen screw (2). Carefully pry crankcase cover from engine crankcase.
2. Remove cover gasket (3). Discard if damaged or deformed.
3. Carefully remove assembled balancer shaft (5) and gear (7) from cylinder block (8).
4. Remove bearing (4) from crankcase cover (1) and bearing (6) from cylinder block (8) only if replacement is required.

B. CLEANING.

WARNING

Cleaning solvents are flammable and toxic to eye, skin, and respiratory tract. Skin and eye protections are required when working in contact with cleaning solvents. Avoid repeated or prolonged contact. Work in well ventilated area only. Keep away from heat, sparks, and open flame. Do not smoke while using cleaning solvent. Failure to observe this warning can result in injury or death to personnel.

1. Clean components with cleaning solvent and a clean rag. Allow to air dry.
2. Remove any old gasket material or grease from crankcase cover and engine crankcase mating surfaces.

C. INSPECTION.

1. Inspect crankcase cover (1, Figure 5-7) for cracks, deformation, or obvious damage. Inspect mating surfaces for scratches, burrs, or blemishes. Replace cover if damaged.
2. Inspect cover gasket (3) for damage or deformation. Replace if damaged in any way.
3. Inspect gear (7) for broken, chipped, or worn teeth. Replace gear and camshaft (5) as an assembly if gear is damaged or worn.
4. Inspect balancer shaft for signs of unusual or uneven wear. Check for obvious damage. Replace if any damage or excessive wear is suspected.

5-8. BALANCER SHAFT ASSEMBLY MAINTENANCE - cont.

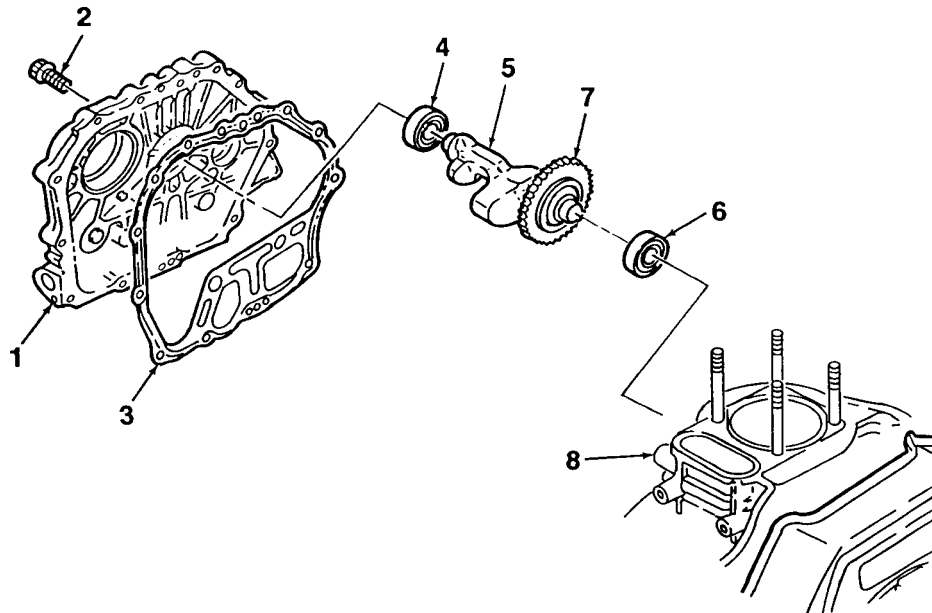


Figure 5-7. Balancer Shaft Assembly Removal

D. INSTALLATION.

1. If removed, install bearings (4, 6, Figure 5-7).
2. Carefully insert assembled balancer shaft (5) and gear (7) into cylinder block (8). Align match-marks on balancer gear and crankshaft gear, then press balancer shaft (5) into bearing (6).
3. Apply grease to lips of crankshaft oil seal (located in crankcase cover (1)).
4. Apply oil to crankshaft and camshaft. Make sure that oil pump drive gears are properly engaged.
5. Mate cover gasket (3) to cylinder block (8).
6. Mate crankcase cover (1) to cylinder block (8) and secure using fifteen screws (2). Tighten screws in criss-cross sequence as shown in Figure 5-8. Torque all screws to 14.5 to 16.6 ft-lbs. (200 to 230 kg-cm).
7. Service engine oil (Para. 3-6).

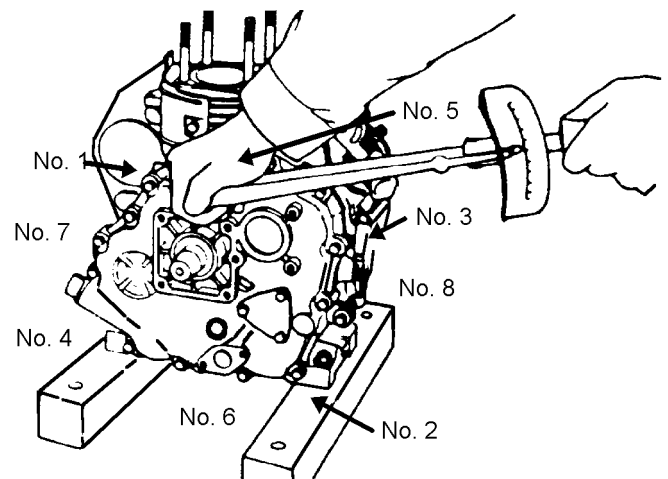


Figure 5-8. Crankcase Cover Bolt Tightening Sequence

5-9. CAMSHAFT ASSEMBLY MAINTENANCE

This task covers removal, cleaning, inspection, and installation.

INITIAL SETUP

Tools:

Tool Kit, Master Mechanic (Item 3, App. B, Sect. III)

Equipment Condition:

Engine oil drained (Para. 3-5)

Fuel injection pump removed (Para. 4-12)

Parts/Materials:

Oil, Lubricating (Item 1-5, App. E)

Solvent, Dry Cleaning (Item 7, App. E)

Rag, Cleaning (Item 8, App. E)

Grease, Automotive (Item 9, App. E)

A. REMOVAL.

CAUTION

When removing crankcase cover, be careful not to damage oil seal.

1. Release crankcase cover (1, Figure 5-9) from cylinder block by removing fifteen screws (2). Carefully pry crankcase cover from engine crankcase.
2. Remove cover gasket (3). Discard if damaged or deformed.

NOTE

Exhaust and intake tappets (6, 7) may fall down when pulling out camshaft assembly. Keep tappets separate to avoid confusion.

3. Carefully remove assembled camshaft components from cylinder block. Remove exhaust and intake tappets (6, 7) and push rods (8, 9).
4. Remove bearing (4) from crankcase cover (1) only if replacement is required.

5-9. CAMSHAFT ASSEMBLY MAINTENANCE - cont.

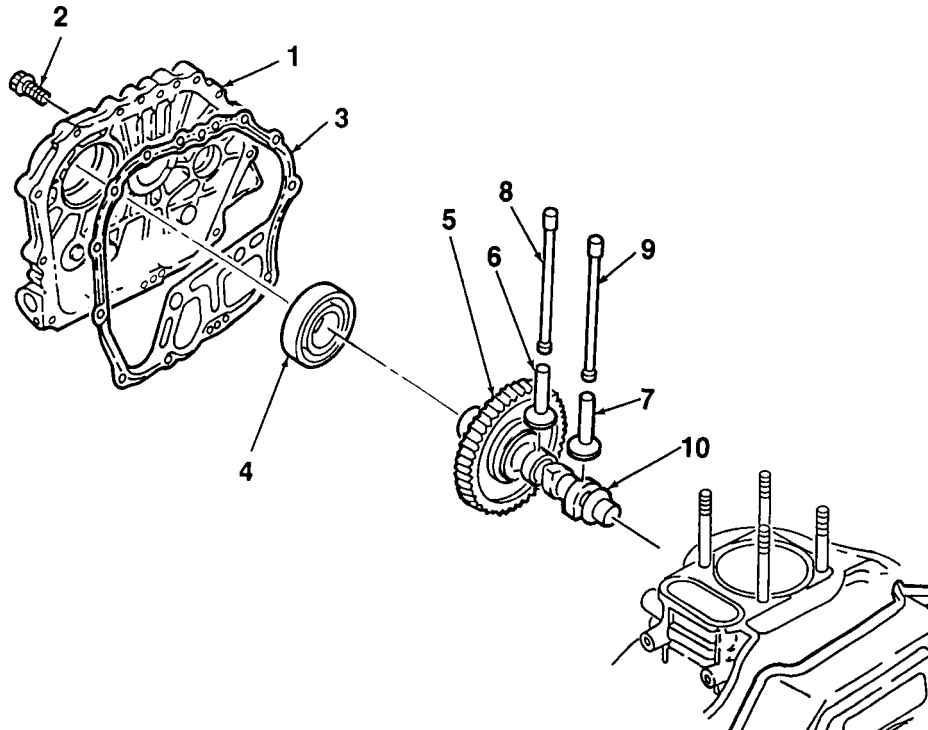


Figure 5-9. Camshaft Assembly Removal

B. CLEANING.

WARNING

Cleaning solvents are flammable and toxic to eye, skin, and respiratory tract. Skin and eye protections are required when working in contact with cleaning solvents. Avoid repeated or prolonged contact. Work in well ventilated area only. Keep away from heat, sparks, and open flame. Do not smoke while using cleaning solvent. Failure to observe this warning can result in injury or death to personnel.

1. Clean components with cleaning solvent and a clean rag. Allow to air dry.
2. Remove any old gasket material or grease from crankcase cover and engine crankcase mating surfaces.

C. INSPECTION.

1. Inspect crankcase cover (1, Figure 5-9) for cracks, deformation, or obvious damage. Inspect mating surfaces for scratches, burrs, or blemishes. Replace cover if damaged.
2. Inspect cover gasket (3) for damage or deformation. Replace if damaged in any way.

5-9. CAMSHAFT ASSEMBLY MAINTENANCE - cont.

3. Inspect gear (5, Figure 5-10) for broken, chipped, or worn teeth. Replace gear and camshaft (10) as an assembly if gear is damaged or worn.
4. Inspect outer surfaces of tappets (6, 7) for wear or damage. Check condition of tappet contact point. Measure the outside diameter (OD) of tappet stems. OD must be 0.2705 inch (6.87 mm), minimum. Replace tappet if damaged, worn, or out of limits.
5. Measure the OD of camshaft (10) where it mates to crankcase cover bearing (4). OD must be 1.1772 inches (29.90 mm), minimum. Replace camshaft (10) and gear (5) if out of limits.
6. Measure the OD of camshaft (10) on opposite end (where it mates to cylinder block needle bearing). OD must be 0.5874 inch (14.92 mm), minimum. Replace camshaft (10) and gear (5) if out of limits.
7. Measure the internal diameter (ID) of bearing (4). ID must be 1.1808 inches (29.993 mm), maximum. Replace bearing if out of limits.

D. INSTALLATION.

1. Insert tappets (8, 9, Figure 5-10) into cylinder block. Install push rod tappets (6, 7).
2. Carefully insert assembled camshaft (10) and gear (5) into cylinder block. Align match-marks on camshaft gear with those on crankshaft gear, then press camshaft (10) into crankcase needle bearing.
3. Apply grease to lips of crankshaft oil seal (located in crankcase cover (1)).
4. Apply oil to crankshaft and camshaft. Make sure that oil pump drive gears are properly engaged.
5. Mate cover gasket (3) to cylinder block.
6. Mate crankcase cover (1) to cylinder block and secure using fifteen screws (2). Tighten screws in criss-cross sequence as shown in Figure 5-11. Torque all screws to 14.5 to 16.6 ft-lbs. (200 to 230 kg-cm).
7. Install fuel injection pump (Para. 4-12).
8. Service engine oil (Para. 3-6).

5-9. CAMSHAFT ASSEMBLY MAINTENANCE - cont.

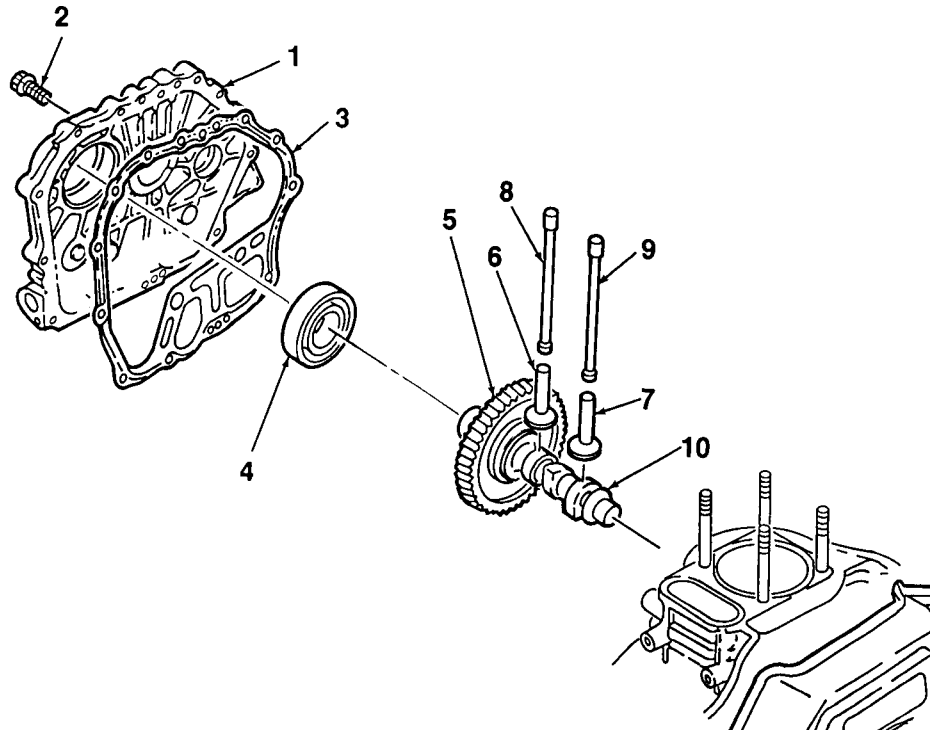


Figure 5-10. Camshaft Assembly Installation

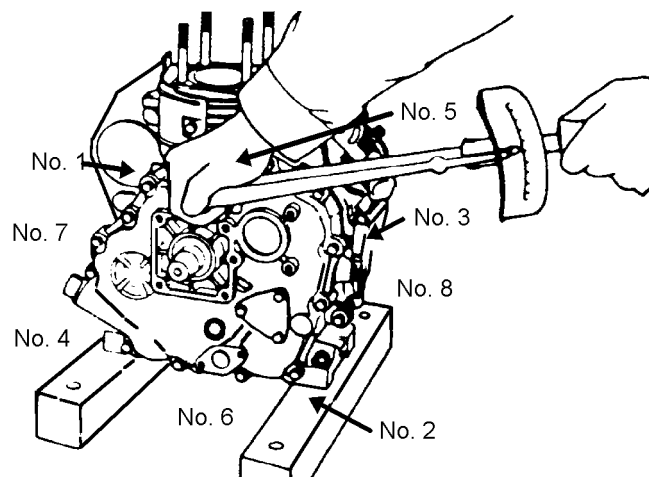


Figure 5-11. Crankcase Cover Bolt Tightening Sequence

5-10. PISTON AND CONNECTING ROD MAINTENANCE

This task covers removal, cleaning, inspection, and installation.

INITIAL SETUP

Tools:

Tool Kit, Master Mechanic (Item 3, App. B, Sect. III)

Equipment Condition:

Cylinder head removed (Para. 5-11)

Camshaft removed (Para. 5-9)

Balancer shaft removed (Para. 5-8)

Parts/Materials:

Solvent, Dry Cleaning (Item 7, App. E)

Rag, Cleaning (Item 8, App. E)

A. REMOVAL.

1. Remove connecting rod nuts (1, Figure 5-12) and washers (2) from rod bolts (3, 4).
2. Remove connecting rod cap (5) and lower bearing half (6) from crankshaft journal. Remove pins (7) only if replacement is required.
3. Rotate crankshaft to the top of its stroke so that piston (8) rises out of cylinder block. Remove assembled piston (8) and connecting rod (9) from crankcase. Remove upper bearing half (10).

WARNING

Use extreme caution when handling hot components. Wear protective gloves. Failure to observe this warning can result in injury to personnel.

4. Remove two circlips (11) from piston pin (12). Discard circlips. To remove piston pin from piston (8), heat components to 158 to 176° F (70 to 80° C). Drive pin from piston and connecting rod (9).
5. Remove piston rings (13) from piston (8). Discard rings.
6. Remove rod bolts (3, 4) from connecting rod (9).

5-10. PISTON AND CONNECTING ROD MAINTENANCE - cont.

B. CLEANING.

WARNING

Cleaning solvents are flammable and toxic to eye, skin, and respiratory tract. Skin and eye protections are required when working in contact with cleaning solvents. Avoid repeated or prolonged contact. Work in well ventilated area only. Keep away from heat, sparks, and open flame. Do not smoke while using cleaning solvent. Failure to observe this warning can result in injury or death to personnel.

1. Clean all components with cleaning solvent and a clean rag. Allow to air dry.
2. Remove carbon deposits from ring grooves of piston (8, Figure 5-12) by scraping with discarded ring. Rinse with cleaning solvent and allow to air dry.
3. Remove carbon deposits from top of piston (8). Use care to prevent scratching of surface.

C. INSPECTION.

1. Inspect piston (8, Figure 5-12) and connecting rod (9) for cracks, deformation, or obvious damage. Inspect for uneven or excessive wear. Replace component if any damage is suspected.

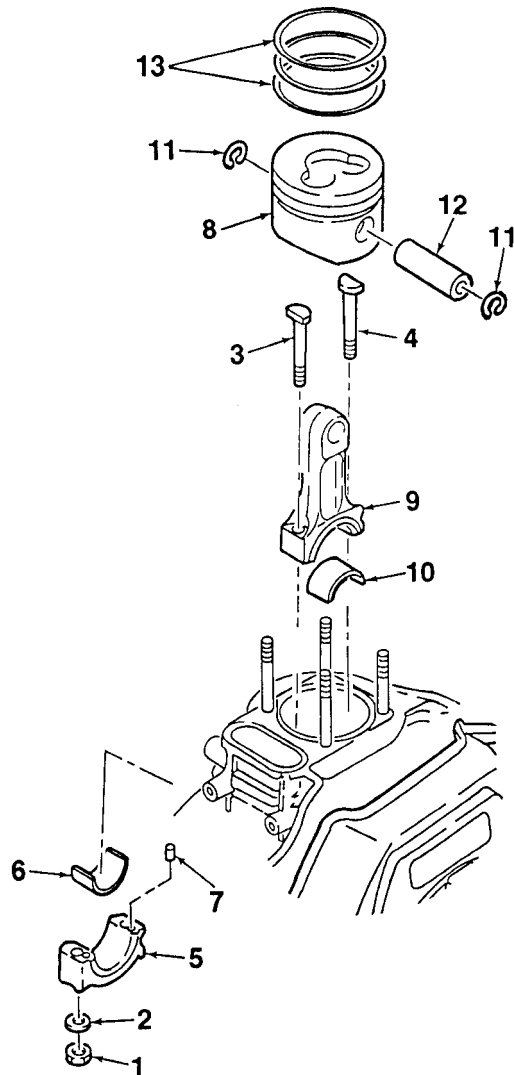


Figure 5-12. Piston and Connecting Rod Removal

5-10. PISTON AND CONNECTING ROD MAINTENANCE - cont.

2. Measure the outside diameter (OD) of piston, approximately 1/2 inch from the bottom (Figure 5-13). OD must be 3.0591 inches (77.70 mm), minimum. Replace piston if out of limits.
3. Measure the internal diameter (ID) of the piston pin hole in piston. ID must be 0.8295 inch (21.07 mm), maximum. Replace piston if out of limits.
4. Measure the OD of piston pin (12, Figure 5-15) along the length of the pin. OD must be 0.8232 inch (20.91 mm), minimum. Replace piston pin if out of limits.
5. Using new piston ring set, measure the clearance between piston rings and piston grooves (Figure 5-14). Side clearance must be 0.0059 inch (0.15 mm), maximum. If clearance exceeds limit, replace piston.

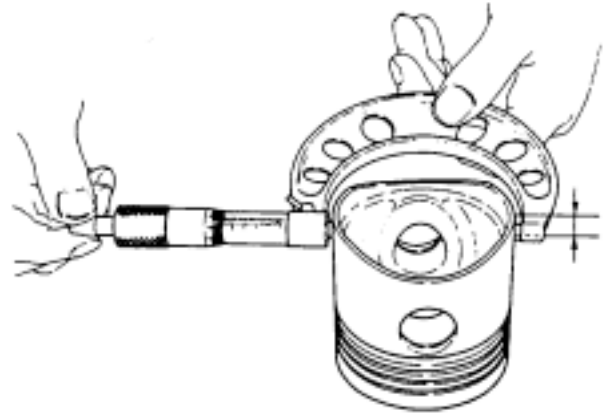


Figure 5-13. Piston Inspection

D. INSTALLATION.

1. Install new ring set into piston ring grooves. Mount rings with end gaps staggered 120° apart (see Figure 5-16). Make sure that rings move smoothly in grooves.

WARNING

Use extreme caution when handling hot components. Wear protective gloves. Failure to observe this warning can result in injury to personnel.

2. To install piston pin (12, Figure 5-15) into piston (8) and connecting rod (9), heat components to 158 to 176° F (70 to 80° C). Match marks on piston and connecting rod and install connecting rod into piston. Install piston pin (12) and allow components to cool.

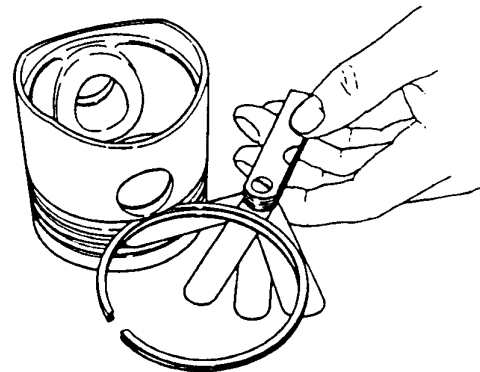
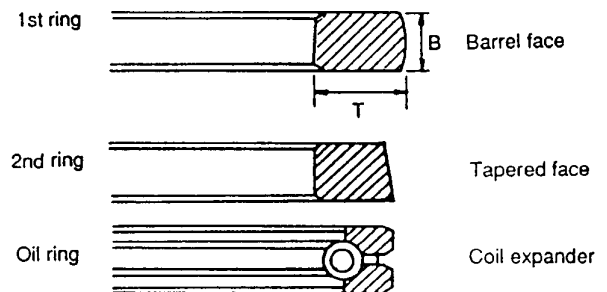


Figure 5-14. Piston Ring Groove Clearance

5-10. PISTON AND CONNECTING ROD MAINTENANCE - cont.

3. Install new circlips (11) onto piston pin (12). Insert rod bolts (3, 4) into connecting rod (9).
4. Apply oil to the outer surface of piston (8), the inner surface of the piston sleeve, and crankshaft crank pin. Carefully install upper bearing half (10), piston (8), and connecting rod (9) into cylinder block. Piston top mark must face crankcase cover side of cylinder block.
5. Install pins (7) into connecting rod cap (5).
6. Install lower bearing half (6). Mate connecting rod cap (5) to connecting rod (9), ensuring match marks are aligned. Install nuts (1) and washers (2). Tighten nuts to 13.0 to 15.2 ft-lbs. (180 to 210 kg-cm).
7. Install balancer shaft (Para. 5-8).
8. Install camshaft (Para. 5-9).
9. Install cylinder head (Para. 5-11).

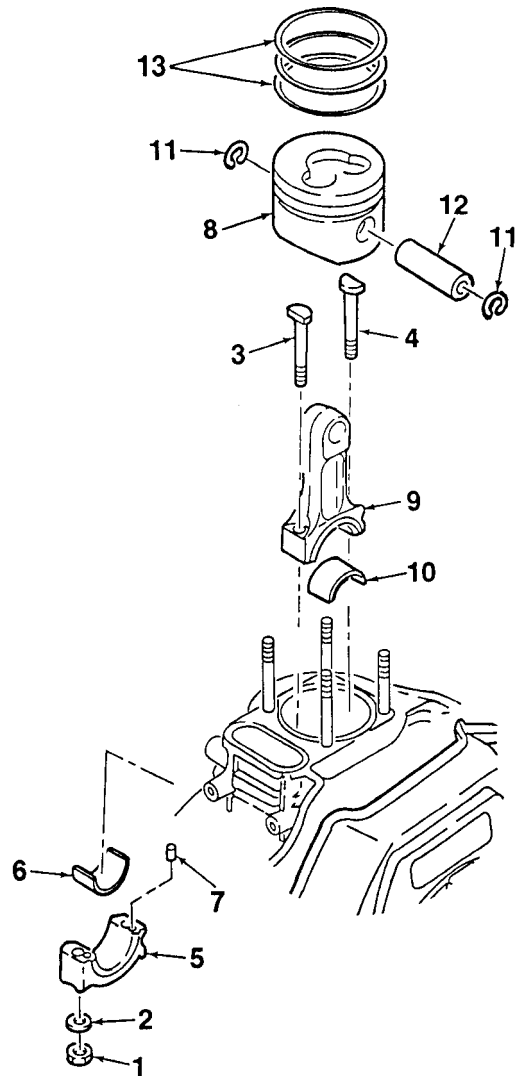


Figure 5-15. Piston and Connecting Rod Installation

5-10. PISTON AND CONNECTING ROD MAINTENANCE - cont.

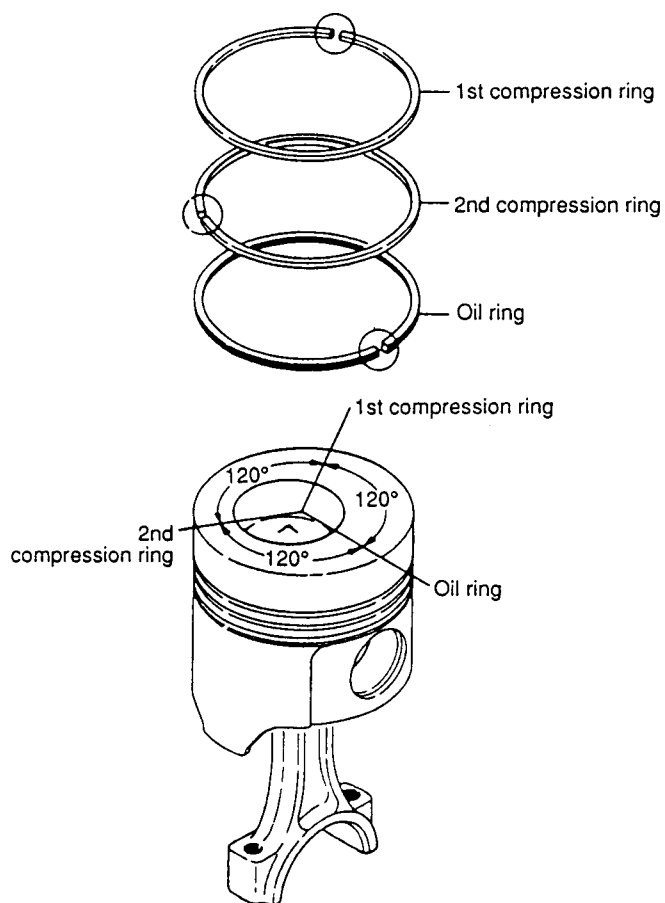


Figure 5-16. Piston Ring Set Installation

5-11. CYLINDER HEAD MAINTENANCE

This task covers removal, cleaning, inspection, and installation.

INITIAL SETUP

Tools:

Tool Kit, Master Mechanic (Item 3, App. B, Sect. III)

Parts/Materials:

Solvent, Dry Cleaning (Item 7, App. E)

Oil, Lubricating (Item 1-5, App. E)

Rag, Cleaning (Item 8, App. E)

Equipment Condition:

Air cleaner removed (Para. 3-16)

Fuel injector removed (Para. 3-14)

Rocker arm assembly removed (Para. 4-10)

5-11. CYLINDER HEAD MAINTENANCE - cont.

A. REMOVAL.

1. Release cylinder head (1, Figure 5-17) from studs (6) by removing nuts (2, 3) and washers (4, 5). Carefully remove cylinder head from studs and place on a clean work surface.
2. Remove and discard O-ring (7) and cylinder head gasket (8).
3. Slide exhaust valve (16) and inlet valve (15) out of cylinder head (1).
4. Remove valve cap (9) and cotter assembly (10) from inlet valve (15).

WARNING

Valve springs are under high pressure. Use caution and remove spring retainers slowly. Failure to observe this warning can cause serious injury to personnel.

5. Compress spring (12) using compression tool and carefully remove spring retainer (11). Slowly release hold on compression tool to release spring tension. Remove spring.
6. Remove valve stem seal (13) and washer (14) from inlet valve.
7. Repeat steps 4 through 6 for exhaust valve (16).
8. Remove air intake pipe studs (17) from cylinder head (1) only if replacement is required.

B. CLEANING.

WARNING

Cleaning solvents are flammable and toxic to eye, skin, and respiratory tract. Skin and eye protections are required when working in contact with cleaning solvents. Avoid repeated or prolonged contact. Work in well ventilated area only. Keep away from heat, sparks, and open flame. Do not smoke while using cleaning solvent. Failure to observe this warning can result in injury or death to personnel.

1. Clean cylinder head components with cleaning solvent and a clean rag. Allow to air dry.
2. Remove carbon deposits from cylinder head (1, Figure 5-17) and valves (15, 16) using a wire brush. Use care to prevent damage to surfaces.
3. Remove all old gasket material from crankcase and cylinder head mating surfaces.

5-11. CYLINDER HEAD MAINTENANCE - cont.

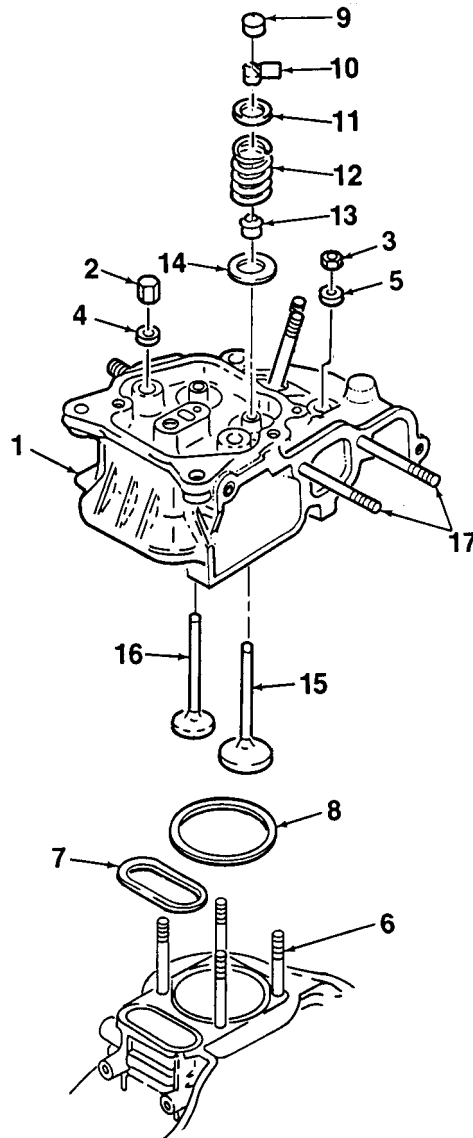


Figure 5-17. Cylinder Head Removal

5-11. CYLINDER HEAD MAINTENANCE - cont.

C. INSPECTION.

1. Inspect cylinder head (1, Figure 5-17) for cracks, on, and deformation. Replace cylinder head if damaged or deformed in any manner
2. Inspect stems of valves (15, 16) for wear or distortion. Measure the outside diameter (OD) of the stems (Figure 5-18). OD shall be 0.2323 inch (5.90 mm), minimum. Replace valve if stem is out of limits.
3. Measure the internal diameter (ID) of the valve guides (installed in cylinder head). ID shall be 0.2394 inch (6.08 mm), maximum. Replace cylinder head (1, Figure 5-17) if valve guide ID is out of limits.
4. Inspect valve springs (12) for cracks, broken sections, or deformation. Replace spring if damaged or deformed in any way.
5. Measure free length (non-compressed) of valve springs (Figure 5-19). Length must be 1.240 inch (31.5 mm), minimum. Replace valve spring if less than required length.
6. Insert valves (15, 16, Figure 5-17) into cylinder head (1). Measure valve sinkage (Figure 5-20). Sinkage shall be 0.043 inch (1.1 mm), maximum. If sinkage exceeds limit, discard valves.

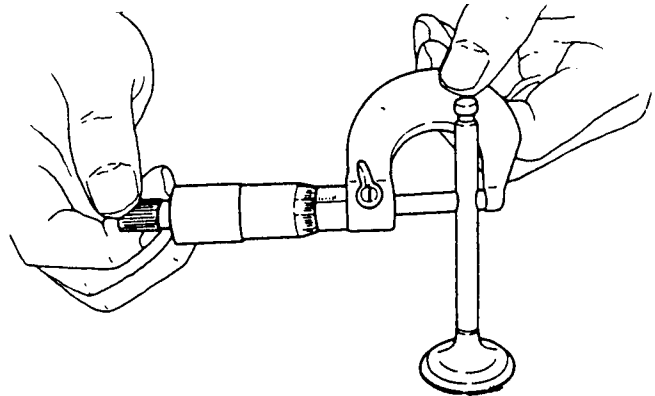


Figure 5-18. Valve Stem OD

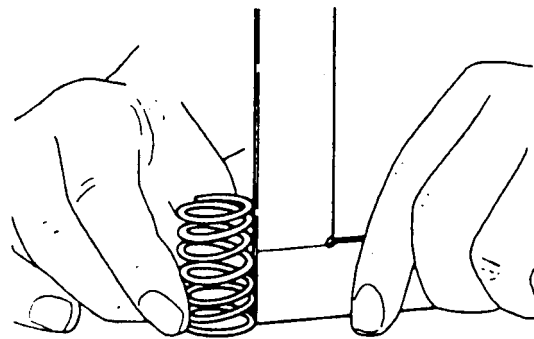


Figure 5-19. Valve Spring Length

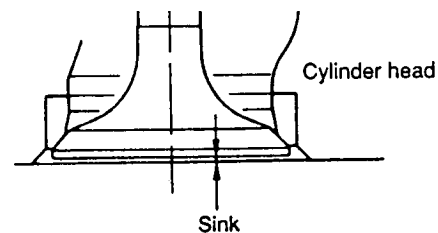


Figure 5-20. Valve Sinkage

5-11. CYLINDER HEAD MAINTENANCE - cont.

D. INSTALLATION.

1. Install air intake pipe studs (17, Figure 5-21) into cylinder head (1).
2. Lubricate the stems of exhaust valve (16) and inlet valve (15) with a light coat of lubricating oil. Slide valves into cylinder head (1).
3. Install valve stem seal (13) and washer (14) onto inlet valve (15).
4. Install and compress valve spring (12) using compression tool. Carefully install spring retainer (11). Slowly release hold on compression tool to release spring tension.
5. Install cotter assembly (10) and valve cap (9).
6. Repeat steps 3 through 5 for exhaust valve (16).
7. Mate new O-ring (7) and cylinder head gasket (8) to crankcase.
8. Carefully slide cylinder head (1) over studs (6) and mate to crankcase.
9. Install nuts (2, 3) and washers (4, 5). Torque nuts in a criss-cross pattern to 30.5 to 33 ft-lbs. (420 to 460 kg-cm). Tighten a second time to ensure a snug fit of cylinder head to crankcase.
10. Install air cleaner (Para. 3-16).
11. Install fuel injector (Para. 3-14).
12. Install rocker arm assembly (Para. 4-10)

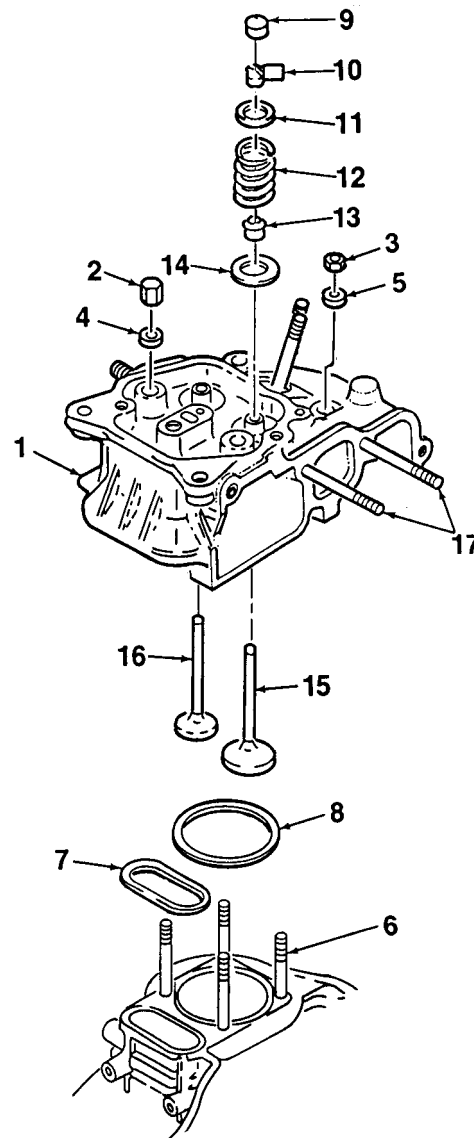


Figure 5-21. Cylinder Head Installation

5-12. FUEL INJECTION PUMP MAINTENANCE

This task covers disassembly, cleaning, inspection, and assembly

INITIAL SETUP

Tools:

Tool Kit, Master Mechanic (Item 3, App. B, Sect. III)

Equipment Condition:

Fuel injection pump removed (Para. 4-12)

Parts/Materials:

Solvent, Dry Cleaning (Item 7, App. E)

Rag, Cleaning (Item 8, App. E)

A. DISASSEMBLY.

1. Remove valve holder (1, Figure 5-22) from body (2). Remove delivery spring (3).
2. Remove delivery valve (4) and gaskets (5, 6) from body (2). Discard gaskets.
3. Disengage spring seat (7) from control lever (8). Remove spring (9), pin (15), spring seat (10), and control lever (8) from body (2).
4. Remove snap ring (11). Remove plate (12), gasket (13), and plunger (14) from body (2). Discard gasket.

B. CLEANING.

WARNING

Cleaning solvents are flammable and toxic to eye, skin, and respiratory tract. Skin and eye protections are required when working in contact with cleaning solvents. Avoid repeated or prolonged contact. Work in well ventilated area only. Keep away from heat, sparks, and open flame. Do not smoke while using cleaning solvent. Failure to observe this warning can result in injury or death to personnel.

Clean components with cleaning solvent and a clean rag. Allow to air dry.

5-12. FUEL INJECTION PUMP MAINTENANCE - cont.

C. INSPECTION.

1. Inspect delivery valve (4, Figure 5-22) and plunger (14) for scores, pitting, or wear. Replace if damaged or worn.
2. Inspect springs (3, 9) for damage or deformation. Replace if damaged or deformed in any way.

D. ASSEMBLY.

1. Insert plunger (14, Figure 5-22) into body (2). Secure using snap ring (11).
2. Install new gasket (13) and plate (12) onto body (2). Install control lever (8) with tab on lever mating to hole on plate (12).
3. Install spring seat (10) and pin (15). Install spring (9) and spring seat (7).
4. Install new gaskets (5, 6) onto delivery valve (4). Insert spring (3) and delivery valve into valve holder (1).
5. Install valve holder (1) into body (2). Tighten holder to 22 to 25 ft-lbs. (300 to 350 kg-cm).
6. Install fuel injection pump (Para. 4-12).

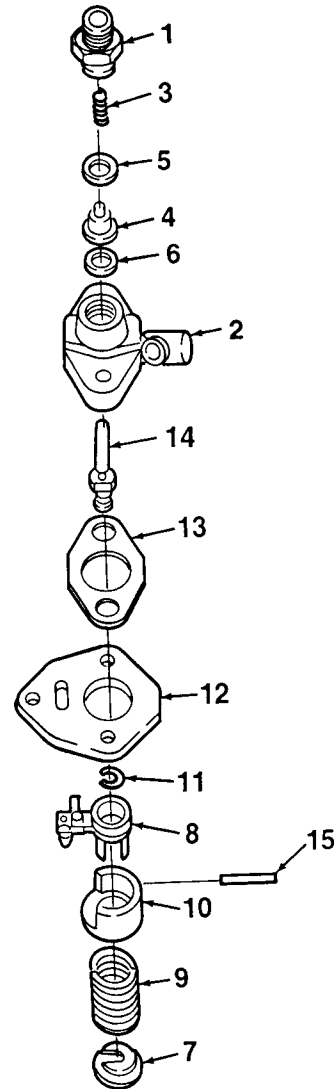


Figure 5-22. Fuel Injection Pump Removal

5-13. GOVERNOR MAINTENANCE

This task covers removal, cleaning, inspection, and installation.

INITIAL SETUP

Tools:

Tool Kit, Master Mechanic (Item 3, App. B, Sect. III)

Parts/Materials:

Solvent, Dry Cleaning (Item 7, App. E)

Rag, Cleaning (Item 8, App. E)

Equipment Condition:

Governor control removed (Para. 4-7)

Camshaft assembly removed (Para. 5-9)

A. REMOVAL.

1. Reach into cylinder block and disengage governor (7, Figure 5-23) from governor lever assembly (3). Remove governor lever assembly from lever (1) by removing pin (2).
2. Remove washer (4), bearing (5), and bush (6).

B. CLEANING.

WARNING

Cleaning solvents are flammable and toxic to eye, skin, and respiratory tract. Skin and eye protections are required when working in contact with cleaning solvents. Avoid repeated or prolonged contact. Work in well ventilated area only. Keep away from heat, sparks, and open flame. Do not smoke while using cleaning solvent. Failure to observe this warning can result in injury or death to personnel.

Clean components with cleaning solvent and a clean rag. Allow to air dry.

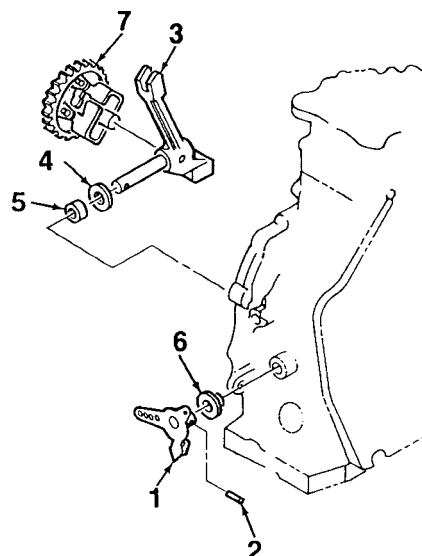


Figure 5-23. Governor Removal

5-13. GOVERNOR MAINTENANCE - cont.

C. INSPECTION.

Inspect governor components for damage. Replace any part that is damaged in any way.

D. INSTALLATION.

1. Install governor lever assembly (3, Figure 5-23), washer (4), and bearing (5) into cylinder block. Engage governor (7).
2. Install bush (6). Mate lever (1) onto governor lever assembly (3) and secure using pin (2).
3. Install camshaft assembly (Para. 5-9).
4. Install governor control (Para. 4-7).

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APPENDIX A

REFERENCES

A-1. Scope.

This appendix lists all forms, field manuals, and technical manuals referenced in this manual or used in conjunction with the engine assembly.

Forms

Recommended Changes to Publications	DA Form 2028
Recommended Changes to Equipment	
Technical Manuals	DA Form 2028-2
Equipment Inspection and Maintenance Worksheet	DA Form 2404
Product Quality Deficiency Report	DA Form 368
Transportation and Travel Record of Transportation Discrepancies	MCO P4610.19
Report of Item and Packaging Discrepancies	MCO 4430.0
Quality Deficiency Reports	MCO 4855.10
Recommended Changes to Technical Publications	NAVMC 10772

Field Manuals

First Aid for Soldiers	FM 21-11
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Painting Requirements

Color, Marking, and Preparation of Equipment	
for Shipment	AR 740-1
Color and Marking of Army Material	AR 746-5

Technical Bulletins

Noise and Conservation of Hearing	TB MED 251
Hand Portable Fire Extinguishers Approved	
for Army Use	TB 5-4200-200-10
Specification List of Standard Liquid Fuels,	
Lubricants, Preservatives, and Related	
Products Authorized for Use by US Army	TB 703-1

Technical Manuals

The Army Maintenance Management System (TAMMS)	DA PAM 738-750
Ground Equipment Record Procedures	TM 4700-15/1
Administrative Storage of Equipment	TM 740-90-1
Procedures for Destruction of Equipment to Prevent Enemy Use	TM 750-244-3
Unit, Direct Support, and General Support Repair Parts and	
Special Tools List (RPSTL), Engine Assembly	TM 9-2815-257-24P
Corrosion Prevention, Painting and Marking of USAF Support	TO 35-1-3
Equipment (SE)	
Processing and Inspection of Support Equipment for Storage and Shipment	TO 35-1-4

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APPENDIX B

MAINTENANCE ALLOCATION CHART (MAC)

Section I. INTRODUCTION

B-1. General.

a. This section provides a general explanation of all maintenance and repair functions authorized at various maintenance categories.

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 (e.g., by sight, sound, or feel).

b. **Test.** To verify serviceability by measuring the mechanical, pneumatic, hydraulic, 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; e.g., to clean (includes decontaminate, 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.

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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.

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(1) including fault location/troubleshooting(2), removal/installation, and disassembly/assembly(3) procedures, and maintenance actions(4) to identify troubles and restore serviceability to an item by correcting specific damage, fault, malfunction, or failure in a parts, 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.

(1) Services - Inspect, test, service, adjust, align, calibrate, and/or replace.

(2) Fault location/troubleshooting - The process of investigating and detecting the cause of equipment malfunctioning; the act of isolating a fault within a system or unit under test (UUT).

(3) Disassembly/assembly - The step-by-step breakdown (taking apart) of a spare/functional group coded item to the level of its least component, that is assigned an SMR code for the level of maintenance under consideration (i.e., identified as maintenance significant).

(4) Actions - Welding, grinding, riveting, straightening, facing, machining, and/or resurfacing.

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 figures are 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 (including any necessary disassembly/assembly time), troubleshooting/fault location time, and quality assurance time in addition to the time required to perform the specific tasks identified for the maintenance functions authorized in the maintenance allocation chart. the symbol designations for the various maintenance levels are as follows:

- C Operator or crew maintenance
- O Unit maintenance
- F Direct support maintenance
- L Specialized Repair Activity (SRA)(5)
- H General support maintenance
- D Depot maintenance

e. **Column 5, Tools and Test Equipment Reference Code.** Column 5 specifies the common tool sets (not individual tools), common TMDE, special tools, special TMDE, and special 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 alphabetical order, which is 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.

(5) This maintenance level is not included in Section II, Column 4 of the MAC. Functions to this level of maintenance are identified by a work-time figure in the "H" column in Section II, Column 4, and an associated reference code is used in the Remarks column. This code is keyed to Section IV, remarks, and the SRA complete repair application is explained there.

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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 lists information pertinent to the maintenance function being performed as indicated in the MAC, Section II.

Section II. MAINTENANCE ALLOCATION CHART FOR DIESEL ENGINE

(1) Group Number	(2) Component/Assembly	(3) Maintenance Function	(4) Maintenance Level					(5) Tools and Equipment Ref Code	(6) Remarks Code
			Oper	Unit	Direct Support F	General Support H	Depot D		
00	ENGINE, DIESEL	INSPECT SERVICE TEST REM/INST REPAIR	0.1	0.1 0.2 0.2 1.2	0.5 3.0 1.0	2.0		1, 2 1 - 4 1 - 6	A A, D B
01	CYLINDER BLOCK	INSPECT REPAIR	0.1	0.1 0.3	1.0	2.5		1 - 6	A E
0101	CRANKSHAFT	INSPECT REM/INST REPAIR				0.5 2.0 0.5		3, 4 3 - 6 3, 4	E
0102	BALANCER SHAFT ASSY	INSPECT REM/INST REPAIR				0.4 1.5 1.0		3, 4 3, 4 3, 4	E
0103	CAMSHAFT ASSY	INSPECT REM/INST REPAIR				0.4 1.5 1.0		3, 4 3, 4 3, 4	E
0104	PISTON AND CONNECTING ROD	INSPECT SERVICE REM/INST REPAIR				0.5 1.5 1.5 0.5		3, 4 3, 4 3, 4 3, 4	A E
0105	CYLINDER HEAD	INSPECT REM/INST REPAIR		0.1 0.8	1.0 1.3	1.5 1.5		1, 2 3, 4	E
010501	ROCKER ARM ASSY	INSPECT ADJUST REM/INST REPAIR		0.5	0.4 1.0 1.3			3, 4 1, 2 3, 4 3, 4	A E
02	AIR CLEANER ASSY	INSPECT SERVICE REM/INST REPAIR	0.1 0.1	0.1 0.3 0.5 0.5				1, 2 1, 2	A A, C E

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(1) Group Number	(2) Component/Assembly	(3) Maintenance Function	(4) Maintenance Level					(5) Tools and Equipment Ref Code	(6) Remarks Code
			Oper	Unit	Direct Support F	General Support H	Depot D		
03	OIL PUMP AND FILTER	INSPECT REM/INST REPAIR		0.4	0.4 1.5 1.5			3, 4 3, 4 3, 4	A E
04	INJECTION PUMP ASSY	INSPECT ADJUST REM/INST REPAIR	0.1		0.2 0.5 0.8	1.0		3, 4 3, 4 3, 4	A E

Section III. TOOLS AND TEST EQUIPMENT FOR ENGINE ASSEMBLY

Tool or Test Equipment Ref Code	Maintenance Level	Nomenclature	National Stock Number	Tool Number
1	O	SHOP EQUIPMENT, AUTOMOTIVE MAINTENANCE AND REPAIR	4910-00-754-0654	SC4910-95-CL-A74
2	O	TOOL KIT, GENERAL MECHANIC'S AUTOMOTIVE	5180-00-177-7033	SC5180-90-CL-N26
3	F, H	TOOL KIT, MASTER MECHANIC'S	5180-00-699-5273	SC5180-90-CL-N05
4	F, H	SHOP EQUIPMENT, AUTOMOTIVE MAINTENANCE AND REPAIR, FIELD BASIC, LESS POWER	4910-00-754-0705	SC4910-95-CL-A31
5	H	HANDLE, FLYWHEEL LOCKING	5120-01-415-8266	114250-92101
6	H	REMOVER, FLYWHEEL	5120-01-416-0424	114250-92130

Section IV. REMARKS FOR ENGINE ASSEMBLY

Remarks Code	Remarks
A	PREVENTIVE MAINTENANCE CHECKS AND SERVICES (PMCS)
B	REFER TO TM 9-6115-639-13 FOR REMOVAL AND REPLACEMENT OF ENGINE
C	SERVICE CONSISTS OF AIR FILTER CHANGE
D	SERVICE IN ACCORDANCE WITH LUBRICATION INSTRUCTIONS, PARAGRAPH 3-6
E	REPAIR IS LIMITED TO REPLACEMENT OF DAMAGED PARTS

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APPENDIX C

COMPONENTS OF END ITEM (COEI) AND BASIC ISSUE ITEMS (BII) LISTS

Section I. INTRODUCTION

C-1. Scope.

This appendix list components of end item and basic issue items for the engine assembly to help you 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 engine assembly. 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 engine assembly in operation, operate it, and to do emergency repairs. Although shipped separately packaged, BII must be with the engine assembly 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.

- a. **Column 1, Illus Number,** gives you the 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 minimum 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 Reqd,** indicates the quantity required.

Section II. COMPONENTS OF END ITEM

(1) Illus Number	(2) National Stock Number	(3) Description CAGEC and Part Number	(4) U/M	(5) Qty Reqd
		NOT APPLICABLE		

Section III. BASIC ISSUE ITEMS

(1) Illus Number	(2) National Stock Number	(3) Description CAGEC and Part Number	(4) U/M	(5) Qty Reqd
1	N/A	TECHNICAL MANUAL, TM 9-2815-257-24	EA	1
2	N/A	REPAIR PARTS AND SPECIAL TOOLS MANUAL, TM 9-2815-257-24P	EA	1

APPENDIX D

ADDITIONAL AUTHORIZATION LIST (AAL) ITEMS

Section I. INTRODUCTION

D-1. Scope.

This appendix lists additional items that you are authorized for the support of the engine assembly.

D-2. General.

This list identifies items that do not accompany the engine assembly and that do not have to be turned in with it. These items are all authorized by CTA, MTOE, TDA, or JTA.

D-3. Explanation of Listing.

National Stock Numbers, descriptions, and quantities are provided to help identify and request the additional items required to support the engine assembly. These items are listed in alphabetical sequence by item name under the type of document (ie, CTA, MTOE, TDA, or JTA) which authorizes the item(s).

Section II. ADDITIONAL AUTHORIZATION LIST

(1) National Stock Number	(2) Description CAGEC and Part Number	Usable On Code	(3) U/I	(4) Qty Reqd
	NOT APPLICABLE			

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APPENDIX E

EXPENDABLE AND DURABLE ITEMS LIST

Section I. INTRODUCTION

E-1. Scope.

This appendix lists expendable and durable items that you will need to operate and maintain the engine assembly. This listing is for information only and is not authority to requisition the listed items. These items are authorized to you by CTA 50-790, Expendable/Durable Items (except medical, class V repair parts, and heraldic items), or CTA 8-100, Army Medical Department Expendable/Durable Items.

E-2. Explanation of Columns.

- a. **Column 1, Item Number.** This number is assigned to the entry in the listing and is referenced in the narrative instructions to identify the item (e.g., Cleaning Compound (Item 5, App. E)).
- b. **Column 2, Level.** This column identifies the lowest level of maintenance that requires the item.
- c. **Column 3, National Stock Number.** This is the national stock number assigned to the item which you can use to requisition it.
- d. **Column 4, Item Name, Description, CAGEC, Part Number.** This provides the other information you need to identify the item.
- e. **Column 5, UM.** This code shows the physical measurement or count of an item, such as gallon, dozen, pound, or gross.

Section II. EXPENDABLE/DURABLE SUPPLIES AND REQUIREMENTS LIST

(1) Item Number	(2) Level	(3) National Stock Number	(4) Item Name, Description CAGEC, Part Number	(5) U/M
1	O, F, H	9150-00-402-2372	OIL, ENGINE, MIL-L-46167, OEA	QT
2	O, F, H	9150-00-491-7197	OIL, ENGINE, MIL-L-2104, OE/HDO-15/40	QT
3	O, F, H	9150-00-189-6727	OIL, ENGINE, MIL-L-2104, OE/HDO-10	QT
4	O, F, H	9150-01-092-3205	OIL, ENGINE, MIL-L-2104, OE/HDO-30	QT
5	O, F, H	9150-01-433-7970	OIL, ENGINE, MIL-L-2104, OE/HDO-40	QT
6	O, F, H	6850-01-160-3868	OIL, CORROSION INHIBITOR	QT
7	O, F, H	6850-00-264-9038	SOLVENT, CLEANING, DRY (81349) P/N PD-680, TYPE II OR III	CN
8	O, F, H	7920-01-338-3329	CLOTH, CLEANING	BG
9	O, F, H	9150-00-663-1770	GREASE, GENERAL PURPOSE, 630AA	OZ

APPENDIX F

ILLUSTRATED LIST OF MANUFACTURED ITEMS

NOT APPLICABLE

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APPENDIX G

TORQUE LIMITS

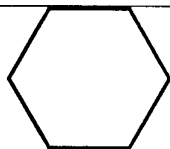
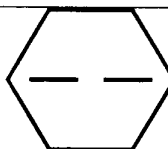
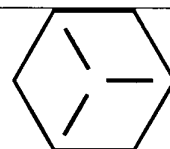
Section I. INTRODUCTION

G-1. Scope.

This appendix lists torque ratings for fasteners used on the engine assembly. When torque values are called out in the maintenance procedures, those torques supersede the torques specified 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 standard 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

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Table G-1. Torque Limits for Dry Fasteners - cont.

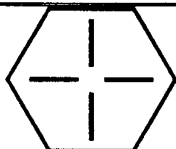
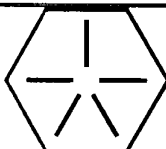
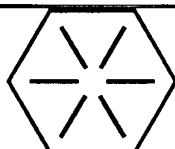
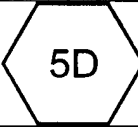
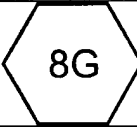
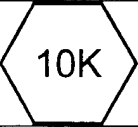
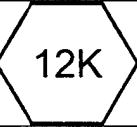
								
SIZE			TORQUE					
			SAE GRADE 6		SAE GRADE 7		SAE GRADE 8	
Diameter in Inches	Threads Per Inch	Millimeters	Foot Pounds	Newton Meters	Foot Pounds	Newton Meters	Foot Pounds	Newton Meters
1/4	20	6.350	13	17	13	18	14	19
1/4	28	6.350	14	18	14	19	15	21
5/16	18	7.937	24	33	25	34	29	39
5/16	24	7.937	26	35	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

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%)

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

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APPENDIX H

MANDATORY REPLACEMENT PARTS

Section I. INTRODUCTION

H-1. Scope.

This appendix lists all mandatory replacement parts referenced in the maintenance procedures in this manual. These are items that must be replaced during maintenance whether they have failed or not. This includes items based on usage intervals such as time, operating hours, etc.

Section II. MANDATORY REPLACEMENT PARTS

(1) Item No.	(2) Part Number	(3) National Stock Number	(4) Nomenclature	(5) Qty
1	114250-11460	5330-01-326-8021	GASKET	1
2	24341-000224	5331-01-326-8017	O-RING	1
3	103338-32570	5331-01-324-8279	O-RING	1
4	714870-22500		RING SET, PISTON	1
5	714870-22550		RING SET, PISTON	1
6	714870-22540		RING SET, PISTON	1
7	114870-01340		GASKET	1
8	114350-01380	5331-01-446-0712	O-RING	1
9	114550-51350	5330-01-328-4169	GASKET	2
10	105546-51020	5330-01-323-1551	GASKET	1

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APPENDIX I

WARRANTY INFORMATION

Section I. INTRODUCTION

I-1. Scope.

a. This appendix provides information on manufacturer's warranties for engine assembly components. The warranty period begins on the date of end item shipment to the government, as defined by the warranty date on the end item data plate, unless otherwise noted in Table I-1.

b. Warranty service may be obtained with two methods. 1) Warranty service can be obtained by contacting the actual warranted component manufacturer listed in column 1. Each manufacturer will provide instructions on filing a claim. 2) Fill out a warranty claim per DA PAM 738-750. The preferred warranty claim form is the SF368, Product Quality Deficiency Report. The DA Form 2407, Maintenance Request, is also acceptable.

c. Troubleshooting should be performed to the level of warranted component, but no further. Troubleshooting to the failed part inside warranted components may invalidate the warranty.

d. If you have difficulty with or questions about the warranty process, contact your local CECOM LAR or the CECOM Generator Branch, DSN 992-1313, (732) 532-1313.

Section II. WARRANTY INFORMATION

Table I-1. Manufacturer's Warranties

(1) Manufacturer	(2) Component Under Warranty	(3) Warranty Period
Yanmar Diesel America Corp Mack Boring and Parts Company 2365 Route 22 West Union, NJ 07083 Phone: 908-964-0700 Fax: 908-964-8475 E-mail: sales@mackboring.com CAGE: S4163	Diesel Engine Assembly Model L70AE-DEGFR NSN 2815-01-465-5993	1 Year

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Radar Set AN/PRC-

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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 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 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 e.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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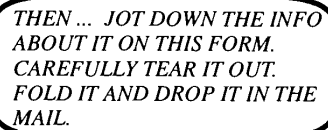
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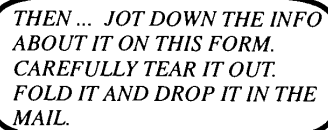
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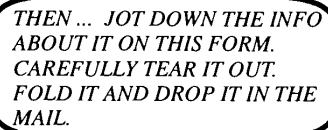
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