TECHNICAL MANUAL

UNIT, INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT MAINTENANCE INSTRUCTIONS

SHIP'S SERVICE GENERATOR

FOR LANDING CRAFT UTILITY (LCU)

NSN 1905-01-154-1191

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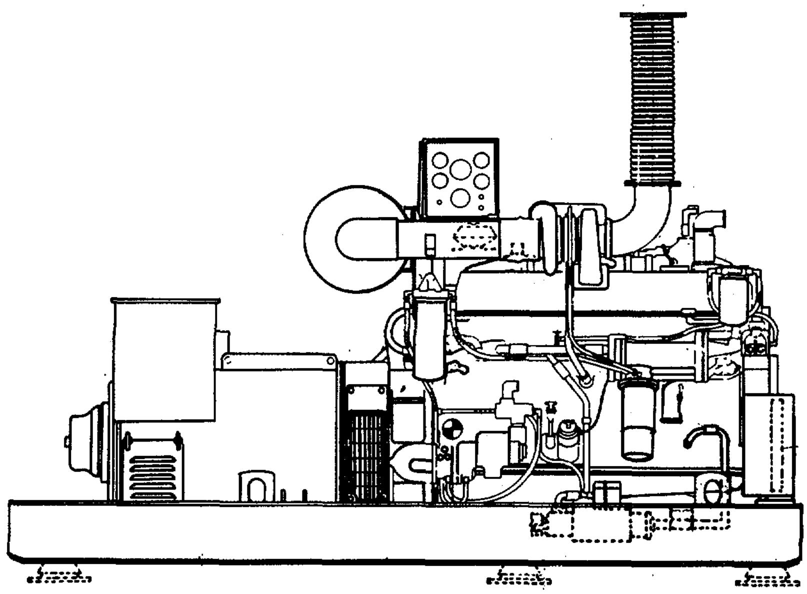

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NO. 5

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SHIP'S SERVICE GENERATOR
for
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MAINTENANCE INSTRUCTIONS

SHIP'S SERVICE GENERATOR
for
LANDING CRAFT UTILLITY (LCU)
NSN 1905-01-154-1191

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3-49 and 3-50	3-49 and 3-50
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4-99 and 4-100	4-99 and 4-100
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WARNING

MODIFICATION HAZARD

Unauthorized modifications, alterations or installations of or to this equipment are prohibited and are in violation of AR 750-10. Any such unauthorized modifications, alterations or installations could result in death, injury or damage to the equipment.

HIGH PRESSURE
HYDRAULIC SYSTEM HAZARDS

Hydraulic systems can cause serious injuries if high pressure lines or equipment fail.

Never work on hydraulic systems or equipment unless there is another person nearby who is familiar with the operation and hazards of the equipment, and who can give first aid. A second person should stand by controls to turn off hydraulic pumps in an emergency. When the technicians are aided by the operators, the operators must be warned about dangerous areas.

MOVING MACHINERY HAZARDS

Be very careful when operating or working near moving machinery.

Running engines, rotating shafts, and other moving machinery parts could cause personal injury or death.

ELECTRICAL HAZARDS

Whenever possible, the power supply to the equipment must be shut off before beginning work on the equipment. Do not be misled by the term "low voltage." Potentials as low as 50 volts may cause death under adverse conditions.

Be careful not to contact 115-Vac input connections when installing or operating this equipment.

Whenever the nature of the operation permits, keep one hand away from the equipment to reduce the hazard of current flowing through the body.

For Artificial Respiration, refer to FM 21-11.

TECHNICAL MANUAL

NO. 55-1905-223-24-3

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., 17 January 1989

UNIT, INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT MAINTENANCE INSTRUCTIONS SHIP'S SERVICE GENERATOR FOR LANDING CRAFT UTILITY (LCU) NSN 1905-01-154-1191

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 these procedures, please let us know. Mail your letter or DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2 located in the back of this manual directly to: Commander, US Army Aviation and Troop Command, ATTN: AMSAT-I-MP, 4300 Goodfellow Blvd., St. Louis, MO 63120-1798. A reply will be furnished directly to you.

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CHAPTER 1
INTRODUCTION

SECTION I. GENERAL INFORMATION

1-1. Scope. The scope of this manual is as follows:

a. Type of Manual. Unit, intermediate direct support, and intermediate general support maintenance manual.

b. Model Number and Equipment Name. NTA 855-GC Ship's Service Generator Set.

c. Purpose of Equipment. Used to supply primary electric power for vessel services, under normal operation.

1-2. Maintenance Forms, Records, and Reports. Department of the Army forms and procedures used for equipment maintenance are those prescribed by DA Pam 738-750, the Army Maintenance Management System.

1-3. Destruction of Army Materiel. Refer to TM 750-244-3 for instructions covering the destruction of Army materiel to prevent enemy use.

1-4. Reporting Equipment Improvement Recommendations(EIR). If your equipment needs improvement, let us know. Send us an EIR. You, the user, are the only one who can tell us what you don't like about your equipment. Let us know why you don't like the design. Put it on an SF 368 (Quality Deficiency Report). Mail it to: Commander, U.S. Army Aviation and Troop Support Command; ATTN: AMSAT-I-MDO; 4300 Goodfellow Blvd.; St. Louis, Missouri 63120-1798. We'll send you a reply.

1-5. Preparation for Storage or Shipment. Administrative storage of equipment issued to and used by Army activities will have preventive maintenance performed in accordance with the Preventive Maintenance Checks and Services (PMCS) charts before storing. When removing the equipment from administrative storage, the PMCS should be performed to assure operational readiness. Repacking of equipment for shipment or short term storage is covered in paragraph 2-44.

SECTION II. EQUIPMENT DESCRIPTION AND DATA

1-6. General Description. The ship's service generator sets are made up of a 300 hp engine and a 250 kW power unit. Elements of the generator sets include the following: the air induction system, lubrication system, cooling system, exhaust system (air piping and water cooled manifold), fuel system, fuel check valves, and the electrical system. An electric starting motor supports one generator set, while an air starter is provided for the second.

1-7. Characteristics, Capabilities, and Features. A very broad view of the ship's service generator set is as follows:

a. Characteristics.

(1) Characteristics. The NTA 855-GC is a 300 HP, in-line, 6 cylinder, water cooled diesel engine designed for marine use.

(2) Capabilities and Features.

(a) Prime mover for ship's service generator.

(b) Cooling system designed for keel cooling.

(c) Equipped with remote and local control stations.

(d) Aftercooled intake manifold.

b. Generator.

(1) Characteristics. Each ship's service generator is a 250 kilowatt, 240 volt, 60 Hertz, 3 phase mechanically (engine) driven power unit.

(2) Capabilities and Features.

(a) Brushless exciter.

(b) Continuous use.

(c) Remote, automatic synchronization controls.

(d) Provides the ship's primary electrical power.

(e) Self-ventilating cooling.

1-8. Location and Description of Major Components. Figure 1-1 shows views of each side of the generator set with the locations of major components indicated. Refer to Figure 1-1 and the reference number key for the description of these components.

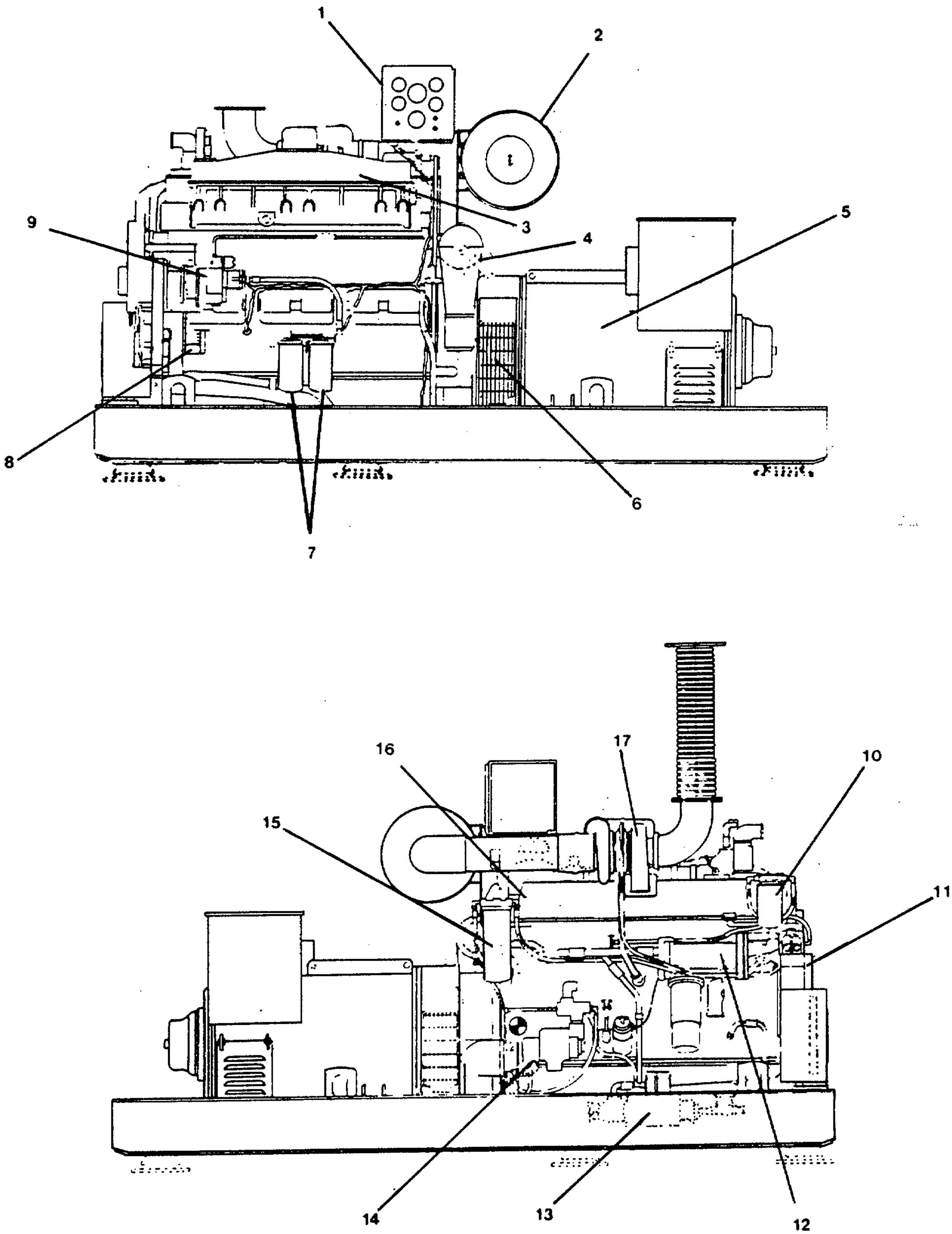

FIGURE 1-1. Location of Major Components.

a. Instrument Panel (1). An electrical panel on top of the engine that contains the local display of operational gauges and the switches for local control of the engine.

b. Air Cleaner Assembly (2). The filter canister and cover assembly, located on the top, front end of the engine.

c. Aftercooler (Intake Manifold) (3). The intake air cooling and distribution tank, and piping (assembly), on the right side of the engine.

d. Rotary Sump Pump (4). The manually operated oil pump, located on the front, right side of the engine.

e. Generator Assembly (5). The electric power producing assembly, connected to the flywheel housing on the front of the engine.

f. Flywheel Housing (6). The housing, located between the engine and the generator assembly containing the engine flywheel.

g. Fuel Filters (7). Two spin-on type filters, located together on the lower right side of the engine.

h. Lube Oil Pump (8). A gear driven pump, located on the right, rear corner of the engine.

i. Fuel Pump (9). A PT (type G) pump and throttle assembly with a 24-volt shutoff valve and electric governor actuator located on the right, rear end of the engine.

j. Water Filter (10). A spin-on filter containing diesel coolant additive (DCA), located on the left side near the rear end of the engine.

k. Fresh Water Pump (11). The belt driven pump, located on rear end of the engine.

l. Lube Oil Filter/Cooler (12). The spin-on filter and cooling core assembly, located on the left side-near the rear-of the engine.

m. Coolant Heater (13). The engine jacket water heater, located at the bottom of the engine on the left side. It is mounted to the subbase frame.

n. Starter (14). The electrical (starboard engine) or air (port engine) controlled starter motor, located on the left, front corner of the engine.

o. Bypass Oil Filter (15). A spin-on filter, located on the left, front corner near the top of the engine.

p. Exhaust Manifold (16). The water cooled exhaust air assembly, on the left side of the engine. The turbocharger is mounted on this manifold.

q. Turbocharger (17). A turbine wheel unit, mounted on the exhaust manifold on the left side of the engine.

1-9. Difference Between Models. The only difference in the two ship's service generator sets (NTA 855-GC) is in the engine starting motors.

a. Starboard Engine. The generator engine on the starboard (right) side of the vessel is equipped with an electric starter motor and solenoid.

b. Port Engine. The generator engine on the port (left) side of the vessel is equipped with an air starter.

1-10. Engine Identification Data. For model identification of an engine, check the data or serial number plate. The following example shows how the engines are identified.

NTA 855-GC

N = Model Identification (In-Line)
T = Turbocharged
A = Aftercooled
855 = Cubic Inch Displacement
GC = Generator/Continuous

a. Engine Dataplate. The engine dataplate shows specific information about your engine. The engine serial number and the Control Parts List (CPL) provide information for ordering parts and service needs (Figure 1-2).

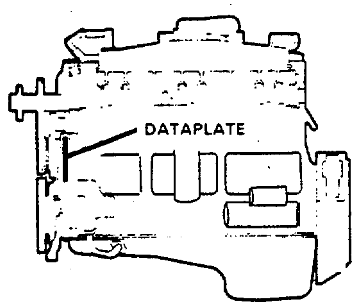

FIGURE 1-2. Engine Dataplate Location.

b. Serial Number and Control Parts List. Always record the serial number (1) of the engine, the CPL (Control Parts List) number (2), and the engine model number (3) on all orders for parts. This information is important for fuel pump calibration and correct identification of parts (Figure 1-3).

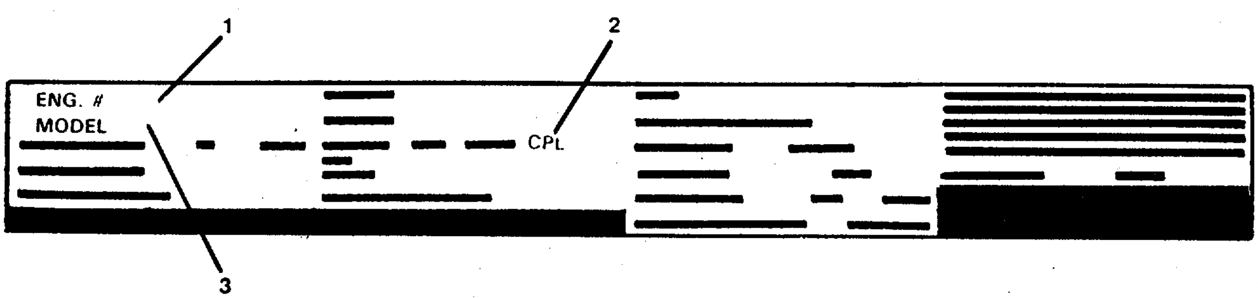

FIGURE 1-3. Dataplate Information to Record.

c. Fuel Pump Dataplate (Nameplate). The fuel pump dataplate is located on the top of the fuel pump. It provides information for fuel pump calibration (Figure 1-4).

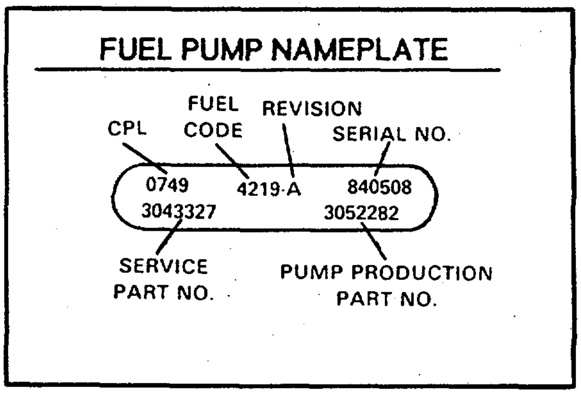

FIGURE 1-4. Fuel Pump Dataplate.

d. Generator Dataplate. The generator dataplate is located on the generator housing. Figure 1-5 shows a typical dataplate.

KW	**KVA**	**PF 0.8**	**PHASE**
RPM	**HZ**	**DUTY CONTINUOUS**	
VOLTAGE			
AMP			
VOLTAGE			
AMP			
OVERLOAD	**% FOR HRS.**	**CLASS OF INSULATION F**	
FIELD AMP		**FIELD VOLTAGE**	
PART NO.		**FRAME**	
MODEL NO.		**SERIAL NO.**	
VOLTAGE REGULATOR MODEL NO.			
LR 2025	**BS 2613 1957**		**NEMA MG1**

PART NO. ________________

MODEL NO. ________________

SERIAL NO. ________________

FIGURE 1-5. Generator Dataplate.

1-11. Equipment Data. Characteristics and reference data are provided in Table 1-1. Also see the equipment data given in the operator's manual, TM 55-1905-223-10.

Table 1-1. Equipment Data

Characteristics	Reference Data
GENERAL ENGINE DATA	
Horsepower	300 hp
Engine speed @ maximum output	1800 rpm
Bore and stroke	5.5 in (140 mm) x 6.0 in (152 mm)
Displacement	855 in^3 (14.0 litres)
Firing order	1-5-3-6-2-4
Compression ratio	13.5:1 to 17.2:1
Engine Weight (without generator and subbase):	
Dry weight	2690 lb (1221 kg)
Wet weight	2810 lb (1276 kg)
Engine dimensions overall (without generator):	
Length	71.6 in (1819 mm)
Width	36.1 in (917 mm)
Height	65.0 in (1651 mm)
Overall dimensions (including generator and subbase):	
Length	115.3 in (2928 mm)
Width	36.8 in (935 mm)
Height	65.0 in (1651 mm)
Overall weights (including generator and subbase):	
Dry weight	5760 lbs (2613 kg)
Wet weight	5876 lbs (2665 kg)
AIR INDUCTION SYSTEM	
Maximum allowable turbocharged intake restriction	25 in H2O (64 cm H_20)
LUBRICATION SYSTEM	
Oil pressure at idle (minimum allowable)	10 psi (70 kPa) minimum
At no load speed	35-45 psi (240-310 kPa)
At full load speed	50 psi (350 kPa) minimum
Oil capacity of engine:	
Bypass filter	0.75 U.S. gal (2.8 litres)
Full flow filter	0.93 U.S. gal (3.5 litres)
Oil pan capacity (high-low)	9 to 7 U.S. gal (26-21 litres)
Total system cap. (including filters)	11 U.S. gal

Table 1-1. Equipment Data - CONT

Characteristics	Reference Data
COOLING SYSTEM	
Coolant capacity (engine only)	22 U.S. quarts (21 litres)
Standard modulating thermostat range	180-200ºF (82-93ºC)
Maximum coolant cylinder block pressure (pressure cap removed)	40 psi (275 kPa)
Maximum allowable top tank temperature	212ºF (100ºC)
Minimum recommended top tank temperature	158ºF (70ºC)
Minimum recommended pressure cap (on remote tank)	7 psi (50 kPa)
EXHAUST SYSTEM	
Maximum allowable back pressure imposed by piping and silencer	3 in Hg (75 mm Hg)
Exhaust pipe size (normally acceptable inside diameter)	5 in (127 mm)
FUEL SYSTEM	
Engine idle speed	650 to 750 rpm
Maximum allowable restriction to pump:	
With clean filter	4 in Hg (100 mm Hg)
With dirty filter	8 in Hg (200 mm Hg)
Maximum allowable fuel return line restriction	2.5 in Hg (63 mm Hg)
With check valves and/or overhead tanks	6.5 in Hg (165 mm Hg)
Fuel check valve between fuel filter and fuel pump: minimum opening pressure	0.3 psi (2.1 kPa)
Fuel check valve between fuel pump and cylinder head: opening pressure	3 to 8 psi (21 to 55 kPa)
Fuel check valve in fuel drain line: opening pressure	.25 to .50 psi (13 to 25 mm Hg)
Derate engine fuel rate for hot weather	1% per 10º above 100ºF (2% per 11ºC above 38ºC)
Coil resistance shutoff valve solenoid: 24 volts (dc)	28-32 ohms

Table 1-1. Equipment Data - CONT

Characteristics	Reference Data
ELECTRICAL SYSTEM	
Generator Assembly (Manufacturer-Newage):	
Rated at	250 kW, 240 volts, 3 phase, 60 Hz
rpm	1800
Power factor	0.8
Continuous at	122F (50C) ambient air temperature
Weight of generator only	1909 lbs (866 kg)
Manual voltage regular:	
Connections required to the generator	Exciter windings (X and XX) Permanent magnet windings (P2, P3, and P4)
Connections required to the automatic voltage regulator	Exciter output (X and XX) Permanent magnet supply (P2, P3, and P4)
Starter motor, electric (STBD engine only):	
Maximum allowable resistance of starting circuit with 24-volt starter	0.002 ohms
STARTING AIR SYSTEM	
Minimum operating pressure	60 psig
Maximum operating pressure	150 psig

1-12. Safety, Care, and Handling. Safety precautions must be observed at all times while performing maintenance. General WARNINGS and first-aid data appear in the front of this manual. Review all safety information before starting any task. Carefully read through an entire maintenance procedure before performing any maintenance function. Make sure the task can be done safely. All WARNINGS, CAUTIONS, and NOTES are of great importance to your safety and the safety of the equipment.

SECTION III. PRINCIPLES OF OPERATION

Overview. The principles of operation section will give you overall descriptions of how the ship's service diesel generator set works. Keep in mind that proper engine operation depends on two things: (1) compression for ignition, and (2) that fuel can be measured and injected into cylinders in the proper quantity at the proper time.

1-13. Diesel Engine Operation. Diesel engines are different from spark-ignited engines in a number of ways. Compression ratios are higher and the charge taken into combustion chambers during the intake stroke consists of air only, with no fuel mixture. Injectors receive low pressure fuel from the fuel pump and deliver it into individual combustion chambers at the proper time, in equal quantity, and in an atomized condition for burning. Ignition of fuel is caused by heat of compressed air in the combustion chamber.

a. Diesel Engine Cycles. It is easier to understand the function of engine parts if you know what happens in the combustion chamber during each of the four piston strokes of the cycle. The four strokes and order in which they occur are: intake stroke, compression stroke, power stroke, and exhaust stroke (Figure 1-6). In order for the four strokes to function properly, valves and injectors must act in direct relation to each of the four strokes of the piston. The intake valves, exhaust valves, and injectors are camshaft actuated, linked by tappets or cam followers, push rods, rocker levers and valve crossheads. The camshaft is driven by the crankshaft gear, and that means rotation of the crankshaft directs the action of the camshaft, which controls the opening and closing sequence of the valves and the injection timing (fuel delivery).

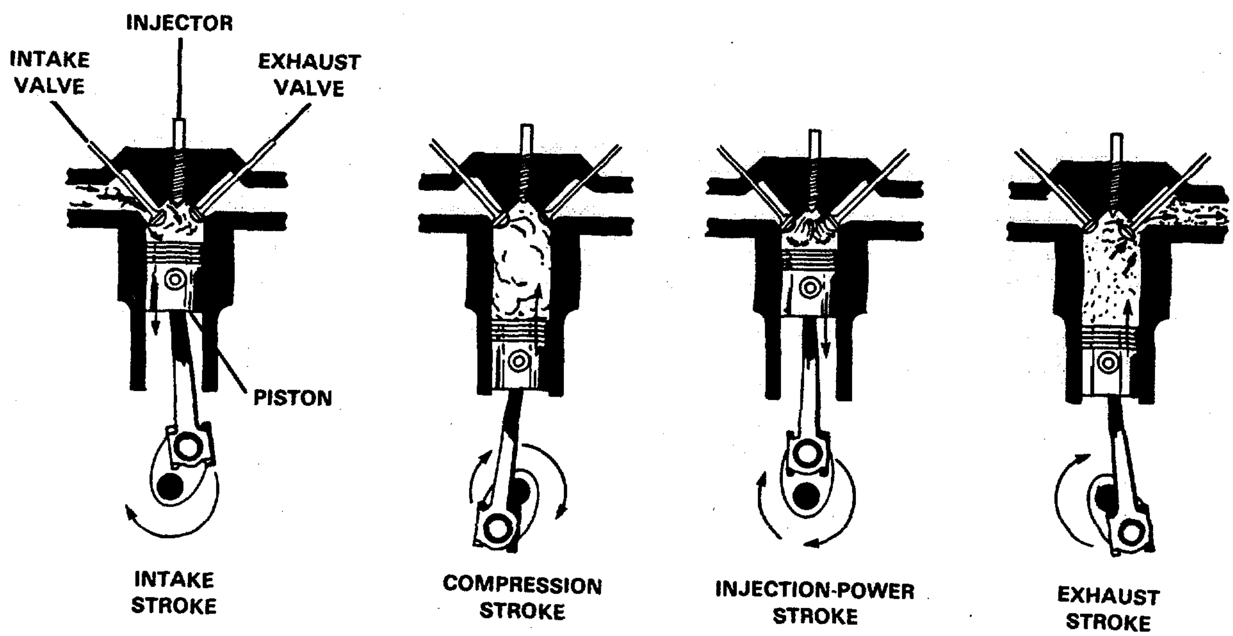

FIGURE 1-6. Diesel Engine Cycles.

(1) Intake Stroke. During intake stroke, the piston travels downward, intake valves are open, and exhaust valve are closed. The downward travel of the piston allows air from the atmosphere to enter the cylinder. On turbocharged engines the intake manifold is pressurized as the turbocharger forces more air into the cylinder through the intake manifold. The intake charge consists of air only, with no fuel mixture.

(2) Compression Stroke. At the end of the intake stroke, intake valves close and piston starts upward on compression stroke. The exhaust valves remain closed. At end of compression stroke, air in combustion chamber has been forced by the piston to occupy a smaller space than it occupied at the beginning of stroke. Thus, compression ratio is the direct proportion in the amount of air in the combustion chamber before and after being compressed. Compressing air into a small space causes temperature of that air to rise to a point high enough for ignition of fuel. During last part of compression stroke and early part of power stroke, a small metered charge of fuel is injected into the combustion chamber. Almost immediately after fuel charge is injected into combustion chamber, fuel is ignited by the existing hot compressed air.

(3) Power Stroke. During the beginning of the power stroke, the piston is pushed downward by the burning and expanding gases. Both intake and exhaust valves are closed. As more fuel is added and burns, gases get hotter and expand more to further force piston downward. Thus adds driving force to crankshaft rotation.

(4) Exhaust Stroke. During exhaust stroke, intake valves are closed, exhaust valves are open, and piston is on the upstroke. Upward travel of the piston forces burned gases out of the combustion chamber through open exhaust valve ports and into the exhaust manifold.

b. <u>Fuel System</u>. The "Pressure Time" (PT) Fuel System used on this engine consists of the fuel pump, supply lines, drain lines, fuel passages, and injectors.

(1) Fuel Pump. The fuel pump is coupled to the fuel pump drive which is driven from the engine gear train. Fuel pump main shaft in turn drives the gear pump.

(a) Gear Pump and Pulsation Damper. The gear pump is driven by the pump main shaft and contains a single set of gears to pick up and deliver fuel throughout the fuel system. Inlet is at the rear of the gear pump. A pulsation damper mounted to the gear pump contains a steel diaphragm which absorbs pulsations and smooths fuel flow through the fuel system. From gear pump, fuel flows through the filter screen.

(b) Electric Fuel Control (EFC) Governor/Actuator. The EFC governor contains a magnetic pickup, a remote automatic governor control, and an actuator. The magnetic pickup senses the flywheel rotation and sends an electrical signal to the remote governor control. The governor control compares the electrical signal, or pulse, from the magnetic pickup with a preset reference point. The control then changes the current going to the actuator on the fuel pump. When the control current changes, the actuator shaft turns. When the shaft turns, the engine speed changes.

(c) Magnetic Pickup. The magnetic pickup is an electromagnetic device that is mounted in the flywheel housing. When the flywheel gear teeth pass the pickup, an alternating current (ac) voltage is induced, one cycle for each gear tooth. The pickup then sends the electrical signal to the remote governor control.

(d) Governor Control and Overspeed Switch. The governor control is an all electric solid-state module that compares the pulses from the magnetic pickup, which are directly proportional to the engine speed, with the speed control reference set point. A current output is supplied to the actuator on the fuel pump that controls the fuel flow to the engine. The overspeed switch will shut down the generator set when maximum rated rpm is exceeded.

(e) Shut Down Valve. An electric solenoid operated shutdown valve with manual override is used on the fuel pump.

(2) PT Injectors. The injector provides a means of introducing fuel into each combustion chamber. It combines the acts of metering, timing and injection.

(3) Fuel Lines and Connections. Fuel is supplied through lines to the cylinder heads. A common drain line returns fuel not injected to the supply tank. Fuel connectors are used between the inline engine cylinder heads to bridge the gap between each supply and drain passage.

c. Lubricating System. The diesel engine is pressure lubricated. Pressure is supplied by a gear-type oil pump located on the side of the engine.

(1) System Operation. Oil is drawn into the pump through an external oil line connected to the oil pan sump. A screen in the sump filters the oil. Oil is drawn from the pan by the pump, out through a full-flow filter and circulates back into the block.

(2) Lubricating Oil Flow. Oil flows from the pump to the filter/cooler, then flows to an oil header through internal drillings in the gear case. The oil header, drilled full length of block, delivers oil to moving parts within the engine. Oil pipes carry oil from the camshaft to upper rocker housings. Drillings through the block, crankshaft, connecting rods, and rocker levers complete the oil circulating passages.

d. Cooling System. The primary function of the cooling system is to remove the heat created by the engine and its support components. The excess heat energy that is not removed by the cooling system is carried away by exhaust gases and radiated into the atmosphere.

(1) Coolant Flow Path. Water (coolant) is circulated by a centrifugal water pump mounted on front of the engine. The water pump is belt driven. Water circulates around wet-type cylinder liners, through the cylinder heads, and around the injector sleeves. Injector sleeves, in which the injectors are mounted, are designed for fast dissipation of heat. The engine has a thermostat to control engine operating temperature. Figure 1-7 shows the coolant flow path through the engine.

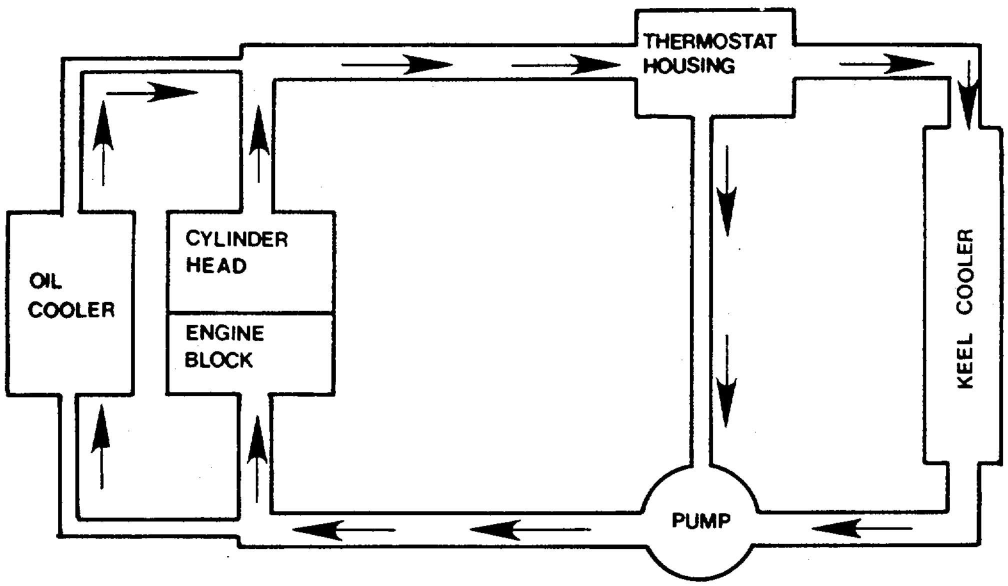

FIGURE 1-7. Coolant Flow Path.

(2) Water Filter. A water filter (corrosion inhibitor) bypasses a small amount of coolant from the system through a filtering and treating element which must be replaced periodically. The filter protects the cooling system from abrasive materials and debris.

(3) Cooling System Venting. The cooling system must be designed to allow air to escape while filling the cooling system. During engine operation, coolant will continuously flow through the engine vent line to remove air.

(4) Coolant Cooling. The engine coolant is cooled in a remote keel cooler. Sea water is circulated through the cooler, around a tube bundle that has the engine coolant passing through, and back to the engine. Heat contained in the coolant is dissipated by the keel cooler.

(5) Coolant. Use ethylene glycol antifreeze year-round to provide freeze point and boil-over protection and always use good quality soft water in the cooling system. Refer to Army Technical Bulletin TB 55-1900-207-24, Treatment of Cooling Water, for antifreeze and additive requirements.

(a) Antifreeze. A mixture of 50 percent water and 50 percent antifreeze is sufficient for freeze protection to -34° F (-37°C) and is used in the NTA 855-GC cooling system.

(b) Sealing Additives. Sealing additives are not used in the cooling system. They will build up in the low flow areas and clog the cooling system.

(6) Coolant Heating. The engine is equipped with a coolant heater that operates on the principle of thermosiphon when the engine is shut down. An oil pressure switch automatically turns the heater ON and OFF. The heater comes on when the engine is shut down. Heated coolant expands and forces a flow check valve on the water inlet closed. The heated coolant is forced up the outlet to the top of the engine. When the pressure drops in the tank, cold coolant enters the tank and the cycle is repeated. A flow-through thermostat, installed in the inlet line of the engine heater, measures the coolant at its coldest point and keeps the coolant within a preset temperature range.

e. Air System. The diesel engine requires several hundred cubic feet of air for every gallon of fuel that it burns. For the engine to operate efficiently, it must breathe freely. Intake and exhaust systems must not be restricted. The intake air is always routed through an air cleaner. The cleaner is mounted on the engine. Air is routed from the air cleaner directly to the turbocharger intake air manifold (aftercooler).

(1) Aftercooler. An aftercooler is a device in the engine intake system designed to reduce intake air temperature and/or preheat intake air temperature. The aftercooler consists of a housing, used as a portion of the engine intake air manifold, with an internal core. The core is made of tubes through which coolant circulates. Air is cooled or heated by passing over the core before going into the engine combustion chambers. Improved combustion results from the better control of intake air temperature, cooling or warming as applied by the aftercooler.

(2) Turbocharger. The turbocharger forces additional air into combustion chambers so the engine can burn more fuel and develop more horsepower than if it were naturally aspirated. The turbocharger consists of a turbine wheel and a centrifugal blower, or compressor wheel, separately encased but mounted on and rotating with a common shaft. The power to drive turbine wheel - which in turn drives the compressor - is obtained from energy of the engine exhaust gases. Rotating speed of the turbine changes as the energy level of the gas changes; therefore, the engine is supplied with enough air to burn fuel for its load requirements. The turbocharger is lubricated and cooled by engine lubricating oil.

f. Electrical System. The electrical power to the engine is a 24 volt circuit coming from the batteries to a magnetic switch, instrument panel, and starter motor and solenoid. Operational gauges and switches for local control of the engine are mounted on the instrument panel on top of the engine. The engine crankshaft drives a 250 kW generator which produces the ship's ac power. Each generator is equipped with automatic paralleling controls and an automatic voltage regulator.

(1) Generator. Transforms the mechanical energy from the engine into electrical energy.

(a) When two or more generators furnish power to a common load, they are said to be operating in parallel (maintaining equal voltage). The NTA 855-GC is equipped with automatic paralleling controls. These controls are located remote from the generator units. For operating instructions, refer to TM 55-1905-223-10.

(b) The automatic voltage regulator (AVR) controls the generator voltage by controlling the electrical current supplied to the exciter field. An internal motor-driven rheostat sets the required voltage. An external exciter field circuit breaker monitors the field current output to the regulator. The breaker will trip if the current level becomes excessive and extended. The AVR is located on the generator terminal box.

(c) The manual voltage regulator is an electronic control unit designed for use in conjunction with the ac generators. It provides linear manual control of the excitation field current independent of load, output voltage, or speed fluctuations. The unit is interlinked with the permanent magnet generator, the machine exciter field, and an automatic voltage regulator, to provide three operating conditions, depending upon the position of the selector toggle switch. The manual regulator is located on the control panel, remote from the generator.

1 MANUAL. The generator exciter current is under the control of the excitation control knob and is independent of machine voltage, load current, or shaft speed.

WARNING

Be careful when adjusting the generator loading. Do not produce a dangerous over-voltage condition.

2 OFF. The generator runs unexcited.

3 AUTO. The generator is under the complete control of the automatic voltage regulator.

WARNING

With the switch in the OFF position, neither the automatic voltage regulator nor the generator is completely electrically isolated.

(2) Electric Fuel Control Governor. For the technical operation of the governor and magnetic pickup, refer to paragraph b, Fuel System.

NOTE

For maintenance procedures on remote mounted components, refer to TM 55-1905-223-24-18.

CHAPTER 2

UNIT MAINTENANCE INSTRUCTIONS

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

2-1. Common Tools and Equipment. For authorized common tools and equipment refer to the Modified Table of Organization and Equipment (MTOE) applicable to your organization.

2-2. Special Tools, TMDE, and Support Equipment. Special tools; test, measurement, and diagnostic equipment; and support equipment requirements are listed and illustrated in the Repair Parts and Special Tools List (RPSTL), TM 55-1905-223-24P. These items are also listed in the Maintenance Allocation Chart (MAC), Appendix B of this manual.

2-3. Repair Parts. Repair parts are listed and illustrated in the Repair Parts and Special Tools List (RPSTL), TM 55-1905-223-24P.

SECTION II. SERVICE UPON RECEIPT

2-4. Checking Unpacked Equipment.

a. Inspect the equipment for damage incurred during shipment. If the equipment has been damaged, report the damage in accordance with the instructions of DA Pam 738-750.

b. Check the equipment against the packing slip to see if the shipment is complete. Report all discrepancies in accordance with the instructions of DA Pam 738-750.

c. Check to see whether the equipment has been modified.

2-5. Deprocessing Unpacked Equipment.

a. Remove protective caps, plugs, inserts, wrappings and tape when inspection/inventory is completed. Inspect piping openings for damage. Wipe off dirt, grease, or protective films at time of installation.

b. Remove chocks from resilient mounted components.

2-6. Engine Break-in. The way a new engine is operated during the first 100 hours of service will have an important effect on the life of the engine and its parts. Even though all engines are run on a dynamometer for several hours before they leave the factory, an additional period of careful operation is required.

a. Engine Speeds. Avoid operation for long periods at engine idle speeds, or at maximum horsepower levels in excess of 5 minutes.

b. Engine Instruments. Develop the habit of watching engine instruments closely during operation and reduce speed if oil temperature reaches 250°F (121°C) or coolant temperature exceeds 190°F (88°C).

c. Oil Level. Check oil level every 10 hours during break-in period.

2-7. Preliminary Servicing and Adjustment. Follow these procedures when starting a new or rebuilt engine for the first time.

a. **Priming the Engine**. Prime the fuel and lubricating oil systems before attempting to start the engine.

(1) Fill fuel filter with clean, No. 2 diesel fuel oil.

(2) Remove suction line from fuel pump (paragraph 2-40) and prelubricate gear pump with 2 to 3 oz (50 to 60 cc) of clean lubricating oil, Item 2, Appendix C. Reconnect the suction line.

(3) Check Fuel Tanks. There must be an adequate supply of clean, No. 2 diesel fuel in the tanks.

(4) If injector and valve or other adjustments have been disturbed by any maintenance work, check to be sure they have been properly adjusted before starting the engine.

CAUTION

Remove oil inlet line from the turbocharger (paragraph 2-30) and prelubricate bearing with 2 to 3 oz (50 to 60 cc) of clean lubricating oil, Item 2, Appendix C. Reconnect oil supply line.

(5) Fill crankcase until oil appears on dipstick.

CAUTION

Do not prime engine lubricating system from bypass filter.

(6) Remove plug from lubricating oil filter head and use this opening as the oil priming point.

(7) Connect a hand or motor-driven priming pump hose from source of clean lubricating oil to priming point.

(8) Prime until a 30 psi (207 kPa) pressure is obtained. Crank engine at least 15 seconds (with fuel shutoff valve closed or disconnected to prevent starting), while maintaining external oil pressure at a minimum of 15 psi (103 kPa). Remove priming hose and replace plug removed in step (6).

b. Oil Dipstick Gauge. All marine engines are shipped with unmarked lubricating oil dipstick gauges. The reason for this is the engine mounting angle is determined at installation; and even though a given amount of oil is required, the dipstick must be marked so the oil level is correct at the engine mounting angle. Should it be necessary to mark a new dipstick, use the following procedure.

CAUTION

Any oil left in oil pan will cause error in marking; the oil sometimes accumulates as the oil drains from upper portions and oil passages within the engine.

(1) Remove the oil pan drain plug or use suction pump to be sure all oil is drained. Replace plug or close sump pump valve.

(2) A tag is attached to new engines indicating high and low capacities of the oil pan. The capacity of the NTA 855 GC engine is 7 gallons (low) to 11 gallons (high).

(3) Fill engine with amount of oil listed as low-level oil pan capacity.

(4) Allow 5 minutes or more for oil to drain to the oil pan. If engine and/or oil temperature is below 40°F (4°C), a longer period may be required for full drain.

(5) Insert dipstick into gauge tube until fully seated; hold for 5 to 10 seconds, then withdraw slowly.

(6) Mark oil level indicated on dipstick with an electric etch. Depth of mark must not exceed 0.010 inch (0.24 mm). Etch "L" above mark.

(7) Add enough additional oil to fill engine to listed high-level capacity.

(8) Repeat Steps 4, 5, and 6. Etch letter "H" directly above the second or high level mark.

NOTE

The above procedure determines dipstick gauge marking for oil pan capacity only. Do not confuse with complete oil capacity, which also includes drilled passages, lines, and filters.

c. Air Connectors. Check air connections for loose clamps or connections, cracks, punctures, or tears in hoses or tubings, collapsing hoses, or other damage. Tighten clamps or replace parts as necessary to ensure an airtight air intake system.

NOTE

The expansion tank is remotely located from the engine.

d. Engine Coolant. Remove expansion tank cap and check engine coolant supply. Add coolant and check water filter. Check for evidence of coolant leakage around tubings, hose connections, etc., and correct as necessary. Inspect water pump for leakage.

WARNING

Fuel spills or leaks create a fire hazard.

e. Fuel Connections. Visually check for any sign of leakage at fuel connections and tighten as necessary.

2-8. Starting the Engine. Starting the engine requires that clean air and fuel be supplied to the combustion chamber in proper quantities at the correct time.

CAUTION

Protect the engine and engine components during startup by idling until normal idle oil pressure is obtained.

a. Starting Procedure.

(1) Open water inlet and outlet valves.

(2) Set idle run switch for idle speed.

(3) Set the generator in a "NO LOAD" operation.

CAUTION

To prevent permanent cracking motor damage, do not crank engine for more than 30 seconds continuously. If engine does not start within first 30 seconds, wait 1 to 2 minutes before cranking.

(4) Set the instrument panel toggle switch to "START" and press starter button (Figure 2-1).

(5) Run engine for 5 minutes and turn engine off.

(6) Wait 5 minutes and check oil level. Add as required.

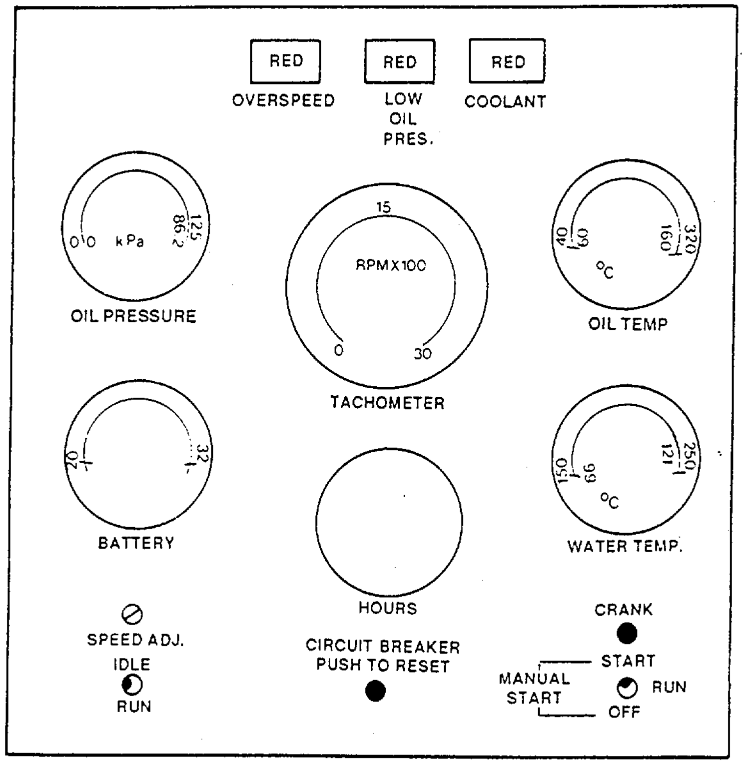

FIGURE 2-1. Instrument Panel Arrangement.

CAUTION

Never operate the engine with oil level below the low level mark (L), or above the high level mark (H) on the oil dipstick gauge.

b. External Leaks. Check for evidence of external oil leakage. Secure capscrews, fittings and connections, and replace gaskets and O-rings as necessary to correct. Check oil dipstick and filler tube caps; see that they are secure.

2-9. Engine Run-In. After each run-in step has been completed, carefully inspect the engine for fuel, oil, water, air, or exhaust leaks and correct as necessary.

a. Engine Dynamometer Run-In Schedule.

(1) 1200 rpm and 25% of rated load until water temperature reaches 160°F (71°C).

(2) 1200 rpm and 40% of rated load for 2 minutes.

(3) 1600 rpm and 65% of rated load for 5 minutes.

(4) Nominal torque peak rpm (100 below torque peak rpm) and full load for 4 minutes.

(5) Rated speed and full load for 4 minutes.

CAUTION

Do not stop the engine immediately after the last run-in step is completed. Serious engine damage can result.

b. Checks During Run-In. During engine run-in, make the following checks frequently.

(1) Oil Pressure. Pressure must not change while the engine is operating at a given rpm.

(a) Oil pressure should be 15 psi at idle speed.

(b) Oil pressure should be 50-70 psi at rated speed.

(c) Check the oil temperature. If the oil temperature rises above 225°F (107°C), stop the engine, locate the problem, and make the necessary corrections. Refer to Table 2-2.

NOTE

Check the oil pressure when the temperature of the oil in the oil pan is at 200 to 225°F (93 to 107°C).

(2) Engine Coolant. Temperature of engine coolant must be between 160°F (71°C) and 200°F (93°C) during engine operation.

2-10. **Governor Speed Check and Adjustment**. Before applying a "LOAD" to the generator, check the governed speed of the engine (2) and adjust as required.

a. Idle Speed.

(1) Place the Idle-Run Switch on the engine instrument panel in the "Idle" position (Figure 2-1).

(2) Start the engine.

(3) Check the idle speed on the tachometer. It should reach 600 to 650 rpm.

NOTE

Adjust the idle speed potentiometer as necessary by turning the adjusting screw on the instrument panel (Figure 2-1) and monitor the engine tachometer to correct engine idle speed.

b. Run Speed.

(1) Move the Idle-Run Switch to the "Run" position.

(2) Check the NO-LOAD governed speed. It should be 60 Hz/1800 rpm.

(3) If required, adjust the run speed potentiometer until the NO LOAD speed is correct.

2-11. Generator Startup. When a new generator is installed or operated for the first time, the following inspection must be performed.

a. Pre-Startup Inspection.

(1) Make sure that adequate ventilation exists and that the generator is free of dirt, debris, and other foreign materials.

WARNING

Before attempting any work on the generator, exciter regulator or the control panel, make sure the generator is removed from the line. Make sure the engine is shut off and that the automatic starting circuits on engines are disabled to avoid injury to personnel. Make sure that you read the warning page at the front of this manual.

(2) Visually check all wiring connections in the terminal (conduit) box (Figure 2-2).

(a) Check for loose or disconnected leads. Secure as required.

(b) Make sure that leads are not touching together or against other parts of the terminal box.

(3) Check all wiring connections on the voltage regulator for loose connections. Secure as required.

- If a generator has been in storage for over 6 months or has been exposed to high humidity or temperature changes that could cause condensation, check the insulation resistance before putting the unit into service. (Chapter 4 for Procedures).

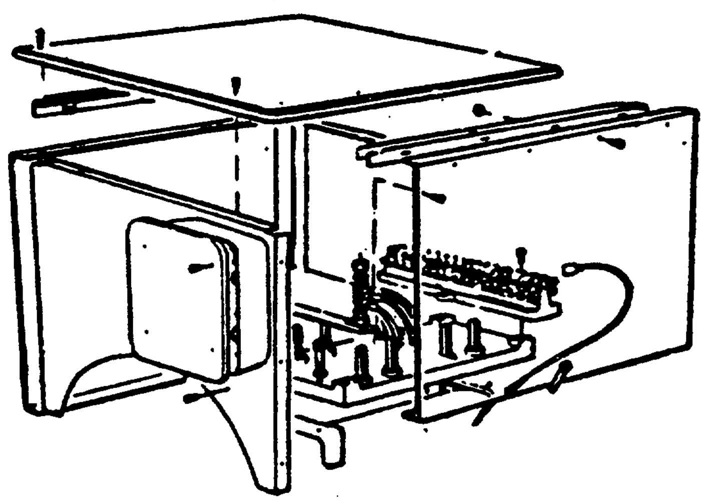

FIGURE 2-2. Generator Terminal Box

b. Run Inspection.

(1) Restore electrical power.

(2) Start the engine with the generator in a NO LOAD mode (TM 55-1905-223-10). Bring it to governed speed.

(3) Check for excessive vibrations. If vibrations are noticed, stop the engine and locate the problem. Correct as necessary.

(4) Listen for any unusual noises that may indicate an internal problem. Correct as required.

(5) Visually check the generator voltmeter to see that the NO LOAD voltage is stable (holding steady at approximately 250 volts).

(6) Apply an actual LOAD to the generator and check for voltage fluctuations or dips. Correct as required. Refer to Table 2-2 for troubleshooting symptoms.

SECTION III. UNIT PREVENTIVE MAINTENANCE CHECKS AND SERVICES (PMCS)

2-12. **Explanation of PMCS Table**. PMCS is designed to keep the equipment in good working condition. This is accomplished by performing certain test, inspections, and services. Table 2-1 lists items to be serviced and the procedures needed to accomplish the PMCS. The "Interval" column tells you when to perform a check or service. If needed, PMCS may be performed more frequently than the indicated interval. The "Procedures" column tells you how to perform the required checks and services. If your equipment does not perform as required, see Table 2-2, Troubleshooting. Report any malfunctions or failures on DA Form 2404. In the Item Number column on DA Form 2404, record the appropriate Item Number from the PMCS table.

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Table 2-1. Preventive Maintenance Checks and Services

D-Daily M-Monthly Q-Quarterly A-Annually B-Biennially E-Every 1600 Operating Hours

Item No.	Interval D	M	Q	A	B	E	Items To Be Inspected/Serviced	Procedures
								WARNING Before attempting any maintenance task on the generator set, make sure the generator is removed from the line. Make sure the engine is shut off and that the automatic starting circuits on engines are disabled to avoid injury to personnel. Make sure that you read the warning page at the front of this manual.
1	•						Water Pump Belt	Visually inspect the engine. Look for glazed, loose, frayed, cracked, or misaligned belts. Secure, align, or replace belt as necessary (paragraph 2-33). If the water pump belt and pulley can not be aligned, replace the water pump (paragraph 2-33).
2	•						Hoses (on all components)	CAUTION Do not bend or deform the hoses during inspection. This can cause hoses to crack. Visually inspect all hoses for cracks or cuts and check for any signs of ballooning or collapsing. Replace as necessary. Check for loose fittings and clamps, and signs of leakage. Secure as necessary.

Table 2-1. Preventive Maintenance Checks and Services

D-Daily M-Monthly Q-Quarterly A-Annually B-Biennially E-Every 1600 Operating Hours

Item No.	Interval D	M	Q	A	B	E	Items To Be Inspected/Serviced	Procedures
3	•						Batteries (remote from generator sets)	Remove the cell caps and check the electrolyte level in each cell. Add distilled water as required to bring the level to the split ring in each cell. Use a hydrometer to measure the specific gravity of each cell. If any or all cells measure below 1.200, the battery must be charged. After charging, replace battery if any cell measures below 1.150.
4	•						Oil Level	NOTE Allow time for the oil to settle in the pan after engine shutdown. Check the engine oil level. The level should be at, or near, the "H" (high) mark on the dipstick. Add oil as necessary. Refer to LO 55-1905-223-12 for oil specification.
5	•						Coolant Level	WARNING Check the coolant level only when the engine is stopped. Wait until the temperature is below 120º (50ºC) before removing the pressure cap, or personal injury could result from hot coolant spray. Check the coolant level. It should be at the 3/4 mark on the expansion tank sight glass. Add coolant as necessary. Refer to TB 55-1900-207-24 for antifreeze and other additive requirements on make-up coolant.

Table 2-1. Preventive Maintenance Checks and Services

D-Daily M-Monthly Q-Quarterly A-Annually B-Biennially E-Every 1600 Operating Hours

Item No.	Interval D	M	Q	A	B	E	Items To Be Inspected/Serviced	Procedures
6	•						Intake Air System	Check all air connections for loose clamps or connections, and tighten as required. Check all hoses and tubing for cracks, punctures and tears, and replace as required. Check for collapsing hoses or tubing and other damage, and replace as required. Check filter warning indicator for intake air restriction. The intake filter warning indicator will change from green to red, indicating an intake air restriction. Replace air cleaner element if required (para. 2-29).
7	•						Throttle (Actuator)	Check for binding, loose fittings, and capscrews that affect the smooth operation of the throttle throughout its range. Secure capscrews, starting at bottom, in 1/8 turn increments to 50 in-lb(5.6 N M). Check for corrosion and clean as required.
8	•						Exhaust System	Check for exhaust leaks and correct as required (Table 2-2, Item 14).
9	•						Generator	Make sure that air intakes and vents on the generator housing are free from dirt, debris, and other foreign materials.
10	•						Engine (General)	Visually check for air, water, fuel or oil leaks. Secure any loose connections, fittings, filter elements or capscrews.

Table 2-1. Preventive Maintenance Checks and Services

D-Daily M-Monthly Q-Quarterly A-Annually B-Biennially E-Every 1600 Operating Hours

Item No.	D	M	Q	A	B	E	Items To Be Inspected/Serviced	Procedures
10 CONT	•						Engine (General)-continued	Replace gaskets and damaged components as neces sary. Visually inspect the front of the instrument panel for broken gauges, lenses or damage to the panel face or cabinet. WARNING Turn off and tag all electrical power to the instrument panel and automatic starting circuits. Failure to do may result in personal injury. Open the instrument panel assembly by removing the two screws one each in top corners of the panel. Swing the panel front down to expose the terminal board and the back of the instruments and wiring connections. Visually check all wiring and connections for loose or broken connections. Secure or repair wiring as necessary.
11		•					Generator (exterior)	WARNING Before attempting any maintenance task on the generator set, make sure the generator is removed from the line. Make sure the engine is shut off and the automatic starting circuits on engines are disabled to avoid injury to personnel.

Table 2-1. Preventive Maintenance Checks and Services

D-Daily M-Monthly Q-Quarterly A-Annually B-Biennially E-Every 1600 Operating Hours

Item No.	Interval D	M	Q	A	B	E	Items To Be Inspected/Serviced	Procedures
11 CONT							General (exterior)- continued	Clean the exterior of the generator housing and terminal box. Use a rag or soft nonmetallic brush (Items 4 and 5, Appendix C) or vacuum cleaner.
12		•					Voltage Regulator	Clean dust from electrical terminals and casing on voltage regulator. Use a soft bristle nonmetal lic brush or vacuum cleaner. Secure all leads to regulator after cleaning.
13		• *					Fuel Filters	Remove the fuel filters by turning them counter clockwise with a filter wrench. Clean the filter head gasket surface with a lint free cloth. Apply a light film of clean engine oil to the gasket surface on the filter. Fill the new filters with clean fuel. Install the new filters on the filter head. a. Hand tighten the filter until it con- tacts the filter head surface. b. Hand tighten an additional one-half to three- quarter turn.
14			•				Generator Terminal Box	Clean dust from electrical terminals and blocks inside of the terminal box. Use a soft bristle nonmetallic brush and/or vacuum cleaner. Secure all leads to terminal blocks after cleaning.

* or every 250 operating hours

Table 2-1. Preventive Maintenance Checks and Services

D-Daily M-Monthly Q-Quarterly A-Annually B-Biennially E-Every 1600 Operating Hours

Item No.	D	M	Q	A	B	E	Items To Be Inspected/Serviced	Procedures
14			•				Generator Terminal Box continued	Check and make sure that no leads are touching together or grounded against the framework after cleaning.
15			• **				Engine Oil	Remove the engine oil: a. Run the engine until it reaches operating temperature and then shut it off. b. Allow time for the oil to settle in the pan. c. Drain the oil. (1) Open the suction valve in the sump pump line into the oil pan. (2) Manually pump the old oil into the waste oil tank. (3) Close the sump pump valve. NOTE Replace the full-flow and bypass oil filters before adding clean oil Refer to Item 16. Add clean oil until the level is at the "H" (high) mark on the dipstick. Refer to LO 55-1905-223-12 for oil specifications. Operate the engine and check for oil leaks. Correct as necessary.
16			• *				Oil Filters (Full-Flow and Bypass)	Change the full-flow and bypass filters. a. Remove the full-flow and bypass filters.

* or every 250 operating hours
** or as determined by the Army Oil Analysis Program (AOAP)

Table 2-1. Preventive Maintenance Checks and Services

D-Daily M-Monthly Q-Quarterly A-Annually B-Biennially E-Every 1600 Operating Hours

Item No.	D	M	Q	A	B	E	Items To Be Inspected/Serviced	Procedures
16 CONT			• *				Oil Filters (Full-Flow and Bypass)-continued	b. Clean the filter heads with a lint-free cloth. c. Apply a light film of clean engine oil to the gasket surface of the filters. d. Fill the filters with clean oil. e. Install the new filters onto their filter heads. (1) Hand tighten the filter until it contacts the filter head surface. (2) Hand tighten an additional one-half to three-quarter turn. f. Operate the engine and check for leaks. NOTE The old filter should be cut open with a filter cutter and inspected. Inspect the element for metal particles. If metal particles are found in the element, direct support maintenance is required.
17			•				Air Filter	Replace air intake filter (para. 2-29).
18			•				Crank/Breather/Tube	Clean crankcase breather and tube. Refer to paragraph 2-39.
19			•				Coolant Filter (Corrosion Resistor)	Replace fluid filter. Refer to paragraph 2-27. (Use DCA test and replacement procedures. Refer to paragraph 2-36.)

* or every 250 operating hours or as determined by the Army Oil Analysis Program (AOAP)

Table 2-1. Preventive Maintenance Checks and Services

D-Daily M-Monthly Q-Quarterly A-Annually B-Biennially E-Every 1600 Operating Hours

Item No.	Interval D	M	Q	A	B	E	Items To Be Inspected/Serviced	Procedures
20				•			Magnetic Pickup	Remove the magnetic pickup from the flywheel hous ing and clean with a soft cloth and low pressure air. Pickup is located on the upper left of the flywheel housing.
21				•			Engine (Exterior)	CAUTION Be sure that all access covers, filters, oil dipstick and filler caps are in place before cleaning engine. NOTE Protect surrounding areas with tarpaulins, plastic sheeting, or similar material before cleaning the engine. Clean the engine exterior. Be sure to clean areas hidden by external components. The engine may be wiped down with solvent (Item 6, Appendix C) and dried thoroughly.
22				•			Engine Mounts	Check the tightness of mounting capscrews. Replace any missing nuts, bolts, and washers. Tighten to 135 ft-lb (190 N m).
23				•			Crankshaft	Check the crankshaft and clearance. Refer to paragraph 3-26.
24				•			Cooling System	Check for rust and scale formation in the system. If rust or scale is found, the system must be

Table 2-1. Preventive Maintenance Checks and Services

D-Daily M-Monthly Q-Quarterly A-Annually B-Biennially E-Every 1600 Operating Hours

Item No.	D	M	Q	A	B	E	Items To Be Inspected/Serviced	Procedures
24 CONT				•			Cooling System-continued	cleaned and flushed. Refer to TB-55-1900-207-24. Drain the engine block by opening the drain valve (petcock) located just above the starting motor. Remove the thermostat housing in accordance with para. 2-28. Check for rust and scale on thermostat housing components. Refer to para. 2-28 for cleaning, repair, and replacement procedures. NOTE Install a new pre-charge (DCA) type filter element before filling the system. Refer to Item 19 of this table. Fill the system. Refer to TB 55-1900-207-24.
25				•			Safety Controls	NOTE Engine safety controls should be hooked up to a horn or other warning device. Check the High Water Temperature Control. a. Remove the sensing unit and check the opening or the circuit against a thermometer immersed in water.

Table 2-1. Preventive Maintenance Checks and Services

D-Daily M-Monthly Q-Quarterly A-Annually B-Biennially E-Every 1600 Operating Hours

Item No.	D	M	Q	A	B	E	Items To Be Inspected/Serviced	Procedures
25 CONT								b. Heat the water to activate the temperature control. The horn or warning device should sound at, or near, 200°F (93°C). c. Replace sensing unit if necessary. Check the lubricating oil pressure sending device.. a. Check for oil leakage from the sender. Replace if required. b. Check for broken or disconnected wire. Repair as required. c. With the wire disconnected from the sender, check resistance from the terminal post to equipment ground (metal chassis). If the reading is not between 227 to 257 ohms, replace.
26					•		Injectors	Replace injectors (paragraph 2-40).
27					•		Fuel Pump	Replace the fuel pump (paragraph 2-37).
28					•		Water Pump	Replace the water pump (paragraph 2-33).
29					•		Turbocharger Bearing	Check the bearing radial and axial clearances. a. Remove the shield and piping from the turbocharger (paragraph 2-30). b. Measure the axial (end-to-end) clearance of the shaft with a dial indicator. Clearance should be no greater than 0.018 inch (0.46 mm).

Table 2-1. Preventive Maintenance Checks and Services

D-Daily M-Monthly Q-Quarterly A-Annually B-Biennially E-Every 1600 Operating Hours

Item No.	Interval D	M	Q	A	B	E	Items To Be Inspected/Serviced	Procedures
29 CONT								c. Use a wire feeler gauge and measure the radial (side-to-side) clearance. Hold the shaft toward the feeler gauge to check. The clearance should be no greater than 0.033 inch (0.84 mm). d. Replace the turbocharger if either measurement exceeds specifications above (paragraph 2-30).
30					•		Vibration Damper	Visually check the damper for dents, wobble, and other damage or deformation. Replace if required. Refer to paragraph 3-26.
31						•	Fuel Pump	Clean or replace the fluid filter element. Refer to paragraph 3-16.
32					•		Valves and Injectors	Adjust valves and injectors every 1500 hrs. or annually which ever occurs first. Refer to page 2-115, para. (5)-g.

SECTION IV. UNIT MAINTENANCE TROUBLESHOOTING

2-13. **General Engine Noise Diagnostic Procedures**. When diagnosing engine noise problems, make sure that noises caused by accessories, such as the air compressor and power takeoff, are not mistaken for engine noises. Remove the accessory drive belts to eliminate noise caused by these units. Noise will also travel to other metal parts not involved in the problem. The use of a stethoscope can help locate an engine noise.

2-14. **Frequency of Engine Noise**. Engine noises heard at the crankshaft speed (engine rpm) are noises related to the crankshaft, rods, pistons, and piston pins. Noises heard at the camshaft speed (one-half of the engine rpm) are related to the valve train. A hand-held digital tachometer can help to determine if the noise is related to components operating at the crankshaft or camshaft speed.

2-15. **Isolating Engine Noise**. Engine noise can sometimes be isolated by holding down the injector plungers one at a time (refer to paragraph 2-40). If the volume of the noise decreases or the noise disappears, it is related to that particular engine cylinder.

2-16. **Accessory Noise.** Engine driven components and accessories, such as gear-driven fan clutches, hydraulic pumps, belt-driven alternators, and turbochargers can contribute to engine noise. Use the following information as a guide to diagnosing engine noise.

2-17. **Main Bearing Noise (refer to Table 2-2, Item No. 34).** The noise caused by a loose main bearing is a loud, dull knock heard when the engine is pulling a load. If all main bearings are loose, a loud clatter will be heard. The knock is heard regularly every other revolution. The noise is the loudest when the engine is "lugging" or under heavy load. The knock is duller than a connecting rod noise. Low oil pressure can also accompany this condition. If the bearing is not loose enough to produce a knock by itself, the bearing can knock if the oil is too thin or if there is no oil at the bearing.

a. An irregular noise can indicate worn crankshaft thrust bearings.

b. An intermittent sharp knock indicates excessive crankshaft end clearance. Repeated clutch disengagements can cause a change in the noise.

2-18. **Connecting Rod Bearing Noise (refer to Table 2-2, Item No. 35).** Connecting rods with excessive clearance knock at all engine speeds and under both idle and load conditions. When the bearings begin to become loose, the noise can be confused with piston slap or loose piston pins. The noise increases in volume with engine speed. Low oil pressure can also accompany this condition.

2-19. **Piston Noise (refer to Table 2-2, Item No. 36).** It is difficult to tell the difference between piston pin, connecting rod, and piston noise. A loose piston pin causes a loud double knock which is usually heard when the engine is idling. When the injector to this cylinder is held down, a noticeable change will be heard in the sound of the knocking noise. However, on some engines, the knock becomes more noticeable when the engine is operated at a steady speed.

2-20. **White Smoke-General Information**. White smoke is the result of incomplete combustion and is generally associated with engine startup at low ambient temperatures. This condition is more predominant on high horsepower fixed injection timing engines because the fuel and combustion systems are optimized for maximum performance and for reliability and durability under high load operating conditions.

a. Starting at Low Ambient Temperatures. These engines can have two or three cylinders that misfire or have incomplete combustion when the engine is started at low ambient temperatures. The fuel that is injected into the cylinders that are misfiring is exhausted into the atmosphere as unburned hydrocarbons which cool, condense, and appear as white smoke. As the cylinder temperature and subsequently the coolant temperature rise, the misfiring cylinders begin to sustain combustion which decreases the hydrocarbon level in the exhaust, resulting in less white smoke being produced.

b. Level of White Smoke. Since white smoke is a normal characteristic of high horsepower, heavy-duty diesel engines during startup at low ambient temperatures, it is extremely important to determine if the level of white smoke is significantly higher than normal for a particular engine model before making any attempt to correct a complaint. This can be accomplished by comparing the level of white smoke from one unit to another which has the same chasses configuration and engine model. If a significant difference in the level of white smoke between the two units is noted under the same operating conditions, refer to Table 2-2, Item 33, "Excessive White Smoke in Idle," for corrective action.

2-21. **Generator Troubleshooting-General Information**. Troubleshooting generators can start with finding out as much of the past history of the unit as possible. Record the generator model number, part number, serial number, voltage and Kw ratings. Were there any past failures and how many hours are on the unit? Question the operator about the types of loads encountered and ask what was observed when the failure was detected. Were there any peculiar noises or odors? Use a systematic approach to isolate the problem.

2-22. **Troubleshooting Index and Table**. Both a symptom index and a troubleshooting table are provided. The symptom index will help you locate the information you need for troubleshooting.

SYMPTOM INDEX

	Troubleshooting Procedure (Table 2-2)
AIR STARTER	
Air constant to starter	44
Does not run-no air	45
Keeps going after control valve shutoff	48
Reduced output power	46
Starter runs-engine won't crank	46
COOLANT	
Coolant in lube oil	12
Loss from leakage	4
Loss from overflow	3
Loss-internal	5
Oil in coolant	9
Temperature above normal	1
Temperature below normal	2
ENGINE	
Crankcase gases excessive	30
Cranks too fast	47
Cranks, won't start	17
Exhaust smoke excessive under load	25
Fuel consumption excessive	37
Hard to start or won't start	18
Keeps going after control valve shutoff	48
Low power	24
Noise excessive	32
Operates at high idle, speed	39
Operates below idle speed	38
Poor deceleration	27
Rough idle	21
Runs rough or misfires	20
Starts, won't keep running	19
Surge at high idle	28
Surge at low idle	22
Vibration excessive	31
White smoke excessive in idle	33
Won't crank or cranks slowly	29
Won't reach rated speed	23
Won't shut off	26

SYMPTOM INDEX-CONT

	Troubleshooting Procedure (Table 2-2)
GENERATOR	
No voltage output	40
Voltage fluctuates	43
Voltage too high	42
Voltage too low	41
LUBE OIL	
Coolant in lube oil	12
Fuel in lube oil	13
High pressure	7
Low pressure	6
Consumption excessive	10
Oil in coolant	9
Sludge in crankcase	11
Temperature above normal	8
NOISE	
Connecting rod bearing	35
Engine noise excessive	32
Main bearing	34
Piston	36
TURBOCHARGER	
Leaks oil or fuel	16
Low power or excessive smoke	15
Noise	14

Table 2-2 lists the common fault conditions that may be found during operation or maintenance of the equipment. Look for causes and do corrective actions in the order listed. This manual cannot list every symptom that may show up, and it cannot list all of the possible causes and corrective actions. If a symptom is not listed, or if it keeps up after you have performed the corrective actions, notify your supervisor.

TABLE 2-2. TROUBLESHOOTING

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

1. Coolant temperature above normal.

WARNING

Make sure engine is cooled to below 120°F (50°C) to avoid burn injury.

STEP 1. Check if coolant level is low.
Add coolant as required. Refer to PMCS Item 5.

STEP 2. Check function of shutoff valves on either side of the water filter.
Make sure they are completely open, counterclockwise, (para. 2-27).

STEP 3. Check for collapsed or restricted hoses (refer to PMCS Table 2-1, Item 2).
Replace hoses as needed (paras. 2-27 and 2-28).

STEP 4. Check if water pump belt is loose.
Check belt tension and tighten if necessary (para. 2-33).

STEP 5. Check if oil level is incorrect.
Add or drain engine oil. Refer to PMCS Table 2-1, Items 4 and 15.

STEP 6. Check if pressure cap on remove expansion tank is incorrect or malfunctioning.
Check the gasket on expansion tank fill cap (TM 55-1905-223-24-18).

STEP 7. Check if temperature gauge is malfunctioning.
a. Test the gauge as follows:
(1) Check for a blown fuse.
(2) Check the wiring from the gauge to the sending unit for a broken connection.
(3) Check the temperature sending unit in the front upper water manifold.
(4) Use a temperature gauge of known accuracy to check system.
(5) Replace faulty gauge (para. 2-26).

TABLE 2-2. TROUBLESHOOTING-CONT.

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

STEP 8. Check for combustion gases in the cooling system.

a. Remove pressure cap located on the remote mounted expansion tank.
b. Install a pressure cap which has had the spring and relief valve removed to allow free flow fromthe overflow tube.
c. Attach a hose to the overflow connection.
d. Put the hose end into a container of water.
e. Operate the engine until water temperature reaches 180°F (80°C).
f. Check for bubbles coming from the end of the hose submerged in water.
g. A continuous flow of air bubbles indicates the following:
   (1) After cooler core leaks.
   (2) Cylinder liner protrusion incorrect.
   (3) Cracked cylinder liner.
   (4) Cylinder head or gasket leakage.
h. If no bubbles are present, do the following:
   (1) Remove the test equipment.
   (2) Check coolant level and fill if necessary.
   (3) Install the expansion tank pressure cap.
   (4) Operate the engine until it reaches a temperature of 180°F (80°C) and check for coolant leaks.

STEP 9. Check for overconcentration of antifreeze and/or supplemental coolant additives.

Check concentration (TB 55-1900-207-24).

STEP 10. Check if thermostat is incorrect or malfunctioning.

a. Remove the upper radiator hose from the thermostat housing.
b. Install a hose of the same size on the thermostat housing outlet long enough to reach a remote dry container used to collect coolant.
c. Install and tighten a hose clamp on the housing outlet.
d. Install the end of the hose in a dry container.
e. Operate the engine at rated RPM for one (1) minute.
f. Shut the engine off, and measure the amount of coolant collected in the container.
g. The amount of coolant collected must not be more than 3.3 fluid ounces (100 cc).
h. If more than 3.3 fluid ounces (100 cc) of coolant is collected, the thermostat seal is leaking.
i. Remove the thermostat (para. 2-28) and inspect as follows:
   (1) Visually inspect the thermostat for damage.
   (2) Suspend the thermostat and a 212°F (100°C) thermometer in a container of water. Do not allow the thermostat or the thermometer to touch the sides of the container.
   (3) Heat the water.

TABLE 2-2. TROUBLESHOOTING-CONT.

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

NOTE

- Write down the temperatures at which the thermostat begins to open and when it is fully open.
- The nominal operating temperature is stamped on the thermostat.
- The thermostat must begin to open within 2°F (1°C) of nominal temperature.
- The thermostat must be fully open to at least 0.375-inch (9.5 mm) within 22° F (12°C) of nominal temperature.

(4) Replace the thermostat if it does not operate as described.
(5) Visually inspect the thermostat seal for cracks, corrosion, or other damage. Replace if necessary (para. 2-28).

STEP 11. Check if water pump is malfunctioning.
Replace the water pump (para. 2-33).

STEP 12. Check for obstructed or damaged aftercooler.
Replace aftercooler (para. 2-41).

2. Coolant temperature below normal.

STEP 1. Check if thermostat is incorrect or malfunctioning.
Refer to Malfunction 1, Step 10.

STEP 2. Check if temperature gauge is malfunctioning.
Refer to Malfunction 1, Step 7.

3. Loss of engine coolant (overflow).

STEP 1. Check if cooling system is overfilled.
Drain coolant to proper level (TM 55-1905-223-10).

STEP 2. Check for dirt, scale, or sludge in the cooling system.
Clean cooling system. Refer to TB 55-1900-207-24.

STEP 3. Check for frozen coolant due to incorrect antifreeze concentration.
Check coolant antifreeze concentration. Refer to TB 55-1900-207-24.

STEP 4. Check if engine is overheating.
Refer to Malfunction 1 of this table.

TABLE 2-2. TROUBLESHOOTING-CONT

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

STEP 5. Check for defective cylinder head, head gasket, cylinder block, or liner as follows:

a. Drain the engine lubricating oil. Refer to TM 55-1905-223-10.
b. Remove the lubricating oil pan (para. 3-21).
c. Use 20 psi (140 kPa) air pressure to pressurize the engine cooling system.

NOTE

Apply the air pressure 15 minutes before inspecting the cylinder liner, the crevice seal, or the cylinder block for coolant leaks.

d. Inspect the inside and the outside diameters of the cylinder liners and also the area of the cylinder block around the crevice seals and the push tube cavity for coolant leaks.
e. If a leak is found, remove the pressure test equipment. Remove the cylinder head and gasket (para. 2-43) and inspect for coolant leaks.
f. Replace the cylinder head or gasket as required (para. 2-43).
g. Remove and inspect the cylinder liner(s) for cracks, porosity, or creviœ seal damage.
h. Remove and inspect the cylinder block (2) for cracks or porosity in the crevice seal area. Refer to (para. 4-17) for cylinder liner removal/replacement.
i. Install a new gasket and the lubricating oil pan (para. 3-21).
j. Fill the engine with clean lubricating oil. Refer to LO 55-1905-223-12.

NOTE

Make sure the oil drain plug is tight.

k. Operate the engine until it reaches a temperature of 180°F (80°C), and check for coolant or lubricating oil leaks.

4. Loss of engine coolant (external leakage).

WARNING

Before removing pressure cap, engine must be cooled to below 120ºF (50ºC) to avoid burn injury.

TABLE 2-2. TROUBLESHOOTING-CONT.

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

STEP 1. Check if pressure cap on remote expansion tank is incorrect or malfunctioning.
Check the gasket on the remote mounted expansion tank fill cap (TM 55-1905-223-24-18).

STEP 2. Check all hose clamps for security.
Inspect hose clamps. Tighten to 40 in-lb.

STEP 3. Check all hoses for leaks.
Inspect all coolant hoses. Correct leaks as necessary.

STEP 4. Check if coolant expansion plugs, pipe plugs, or fitting are leaking.
Inspect coolant plugs and fittings. Tighten or replace if necessary.

STEP 5. Check if gaskets are leaking or installed incorrectly.
Inspect gasket sealing surfaces, and install new gaskets as required.

STEP 6. Check if lubricating oil cooler/filter is leaking.
a. Inspect lubricating oil cooler (para. 2-34).
b. Replace oil cooler/filter (para. 2-34).

STEP 7. Check if water pump seal is leaking.
Replace the water pump (para. 2-33).

STEP 8. Check if aftercooler is leaking as follows:
a. Disconnect the coolant supply and the return hoses from the aftercooler.
b. Plug the hoses after removing them from the aftercooler.

NOTE

The engine must be operated at rated speed and full load to detect air in the cooling system due to a defective aftercooler core.

c. Repeat the test for air in the cooling system as previously described. If no air is found in the cooling system with the aftercooler isolated, install a new aftercooler (para. 2-41).

STEP 9. Check for leaking coolant draincocks.
Check, tighten or replace if necessary.

5. Loss of engine coolant-internal.

STEP 1. Check for leaking cylinder head or gasket.
Refer to Malfunction 3, Step 5.

Table 2-2. Troubleshooting-CONT

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

STEP 2. Check if lubricating oil cooler is leaking.
Replace oil cooler assembly (para. 2-34).

STEP 3. Check if aftercooler is leaking.
Refer to Malfunction 4, Step 8.

STEP 4. Check for leaking cylinder head, gasket, liner or block.
Refer to Malfunction 3, Step 5.

STEP 5. Check for combustion gases in cooling system.
Refer to Malfunction 1, Step 8.

STEP 6. Check for incorrectly seated injector sleeves.
Test for combustion gases in cooling system. Refer to Malfunction 1, Step 8.

6. Low lubricating oil pressure.

STEP 1. Check if oil level is incorrect.
a. Add or drain engine oil to proper level.
b. Check for oil leaks as follows:
(1) Use a steam cleaner or a high pressure washer to clean the engine.
(2) Check the engine crankcase breather element, hose, and tube for restriction.
(3) Check for a loose or missing oil dipstick tube, dipstick, or oil filler cap.
(4) Operate the engine until the water temperature reaches 180°F (80°C). Inspect the exterior of the engine for leaking gaskets, seals, O-rings, pipe plugs, or fittings.

NOTE

Before replacing any gaskets, check the capscrews to make sure they are tightened to the correct torque values.

STEP 2. Check if oil pressure gauge is malfunctioning as follows:
a. Check the following for defects:
(1) Electrical wiring broken.
(2) Sending unit malfunction (refer to step b. below).
(3) Plumbing loose or broken.
b. Use a master gauge of known accuracy to verify the reading of the suspect gauge.
c. Connect the line from the master gauge to the main oil gallery on the fuel pump side of the engine.
d. Replace the sending unit if it is defective.
e. Replace pressure gauge if defective (para. 2-26).

Table 2-2. Troubleshooting-CONT

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

STEP 3. Check for oil diluted with fuel.
Refer to Malfunction 13.

STEP 4. Check for incorrect oil specifications.
Check oil specification (LO 55-1905-223-12).
Change oil (PMCS, Table 2-1, Item 15).

STEP 5. Check if oil temperature is above normal 250° F (120° C).
Refer to Malfunction 8.

7. High lubricating oil pressure.

STEP 1. Check if oil pressure gauge is malfunctioning.
Refer to Malfunction 6, Step 2.

STEP 2. Check for incorrect oil specifications.
Check oil specifications (L0 55-1905-223-12).
Change oil (PMCS Table 2-1, Item 15).

STEP 3. Check for defective oil filter/cooler.
Replace oil filter/cooler (para. 2-34).

8. Lubricating oil temperature above normal.

STEP 1. Check for incorrect oil level.
Add or drain engine oil as required.

STEP 2. Check for high engine temperature (above 212°F) (100°C).
a. Check coolant level and thermostat operation. Refer to malfunction 1, Step 10.
b. Check for damaged coolant hoses and tubing. Replace as necessary.
c. Check for loose water pump belt and tighten as required (para. 2-33).
d. Check water pump operation. Replace as required (para. 2-33).

STEP 3. Check if oil temperature gauge is malfunctioning as follows:
a. Drain the oil from the oil pan (TM 55-1905-223-10).
b. Remove the pipe plug on either side of the oil pan. Install the oil temperature gauge sending unit.
c. Fill the oil pan with clean oil. Refer to PMCS Table 2-1, Item 15.
d. Check the following for defects:
(1) Electrical wiring broken.
(2) Sending unit malfunction (refer to step e. below).
e. Use a master gauge of known accuracy to verify the reading of the suspect gauge.
f. Replace the sending unit or the gauge if it is defective (para. 2-26).

Table 2-2. Troubleshooting-CONT

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

g. Drain the oil from the oil pan, and remove the test gauge.
h. Fill the oil pan with clean oil. Refer to PMCS Table 2-1, Item 15.

STEP 4. Check for malfunctioning oil cooler bypass valve as follows:
a. Remove the two capscrews and the bypass valve. Discard the O-ring.
b. Visually inspect the valve for damage.

CAUTION

The flash point of new lubricating oil is approximately 430°F (220°C). Do not allow oil temperature in the container to exceed 300°F (150°C). Do not allow water droplets to enter the container of hot oil. Water droplets will cause a violent reaction which can cause personal injury.

c. Suspend the valve and a 240°F (115°C) thermometer in a container of new lubricating oil. Do not allow the valve or the thermometer to touch the sides of the container.
d. Heat the lubricating oil.

NOTE

Write down the temperature at which the valve is fully extended. The valve must be fully extended to at least 2.770 inches (70.36 mm) when the temperature reaches 234°F (112°C).

e. Replace the valve if it does not operate as follows:

CAUTION

Do not install the O-ring on the control valve and then try to pull the control valve into position with the capscrews. The sharp corners of the counterbore will cut the O-ring.

(1) Lubricate the O-ring with vegetable oil, and install it in the oil cooler support.
(2) Install the valve in the oil cooler support, and push it in position. Tighten the capscrews to 30 ft-lb (40 N•m) torque.
(3) Operate the engine until the water temperature reaches 180°F (80°C) and check for oil leaks.

9. Lubricating oil in the coolant.

STEP 1. Check if lubricating oil cooler is malfunctioning.
Repair or replace oil cooler (para. 2-34).

Table 2-2. Troubleshooting-Cont

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

10. Excessive lubricating oil consumption.

STEP 1. Check for external oil leaks.
Tighten capscrews, pipe plugs, and fittings.

STEP 2. Check if blowby restriction is causing external oil leaks.
Replace crankcase breather and tube (para. 2-43).

STEP 3. Check for incorrect oil specifications.
Check oil specifications (L0 55-1905-223-10).
Change oil (PMCS Table 2-1, Item 15).

STEP 4. Check if oil is contaminated with fuel.
Refer to "Fuel in the Lubricating Oil," Table 2-2, Item 13.

STEP 5. Check for high oil temperature (above 250°F) (120°C).
Check engine oil and coolant levels.

STEP 6. Check if turbocharger seal is malfunctioning.
Replace turbocharger (para. 2-30).

11. Excessive oil sludge in crankcase.

STEP 1. Check for incorrect lubricating oil specifications.
Check lubricating oil specifications. (Refer to LO 55-1905-223-12.)

STEP 2. Check for dirty oil filter(s).
Replace oil filter(s). Refer to PMCS Table 2-1, Item 16.

STEP 3. Check if engine coolant temperature is too low (below 140°F) (60°C).
Check coolant thermostat operation (para. 2-28).

STEP 4. Check if internal coolant is leaking.
a. Pressure test the cooling system as follows:

WARNING

Wait until engine temperature is below 120°F (50°C) before removing the coolant system pressure cap. Failure to do so can cause personal injury from heated coolant spray.

(1) Check the coolant level and fill if necessary.
(2) If the surge tank is equipped with a pressure relief valve, install a plug in the overflow tube.

Table 2-2. Troubleshooting-Cont

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

CAUTION

Do not apply more than 20 psi (140 kPa) air pressure to the cooling system. The water pump seal may be damaged.

(3) Install the pressure tester on the surge tank and apply 20 psi (140 kPa) maximum air pressure.
(4) Install the coolant system pressure cap.
(5) Inspect for coolant leaks and repair if necessary.
(6) Remove the pressure test equipment and the plug from the pressure relief valve overflow tube.

12. Coolant in the lubricating oil.

WARNING

Make sure engine is cooled to below 120°F (50°C) to avoid burn injury.

STEP 1. Check cylinder liner, crevice seal, or cylinder block for leaks.
a. Drain the engine lubricating oil (PMCS Table 2-1, Item 15).
b. Remove the lubricating oil pan (para. 3-21).

CAUTION

Do not apply more than 20 psi (140 kPa) air pressure to the cooling system. The water pump seal may be damaged.

c. Use 20 psi (140 kPa) air pressure to pressurize the engine cooling system.

NOTE

Apply the air pressure 15 minutes before inspecting the cylinder liner, the crevice seal, or the cylinder block for coolant leaks. Make sure the system is holding air pressure before beginning the inspection.

d. Inspect the inside and the outside diameters of the cylinder liners and also the area of the cylinder block around the crevice seals and the push tubecavity for coolant leaks.
e. If a leak is found, remove the pressure test equipment. Remove the cylinder head gasket (para. 2-43) and inspect for coolant leaks.
f. Remove and inspect the cylinder liner(s) for cracks, porosity, or crevice seal damage (para. 4-17).

Table 2-2. Troubleshooting-Cont

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

g. Visually inspect the cylinder block for cracks or porosity, or crevice seal area.
h. Install a new gasket and the lubricating oil pan (para. 3-21).
i. Fill the engine with clean lubricating oil (L0 55-1905-223-12).

NOTE

Make sure the oil drain plug is tight.

j. Operate the engine until it reaches a temperature of 180°F (80°C), and check for coolant or lubricating oil leaks.

STEP 2. Check if lubricating oil cooler is malfunctioning. Repair or replace oil cooler (para. 2-34).

13. Fuel in the lubricating oil.

STEP 1. Check for low oil and coolant temperature caused by long periods of engine idling as follows:
a. Turn engine OFF (TM 55-1905-223-10) rather than idling for long periods. If long idle necessary, temporarily increase idle speed.
b. With engine running, use a tachometer to check the idle speed. It should be between 650 and 725 rpm.
c. Stop the engine (TM 55-1905-223-10).
d. Remove the cover plug for the idle speed adjusting screw (para. 2-33).
e. Operate the engine at high idle for 30 seconds.
f. Adjust the idle speed with the adjusting screw.
g. Install the cover plug to the adjusting screw.

STEP 2. Check if top injector O-ring is damaged.
Check the injectors. Replace if necessary (para. 2-40).

STEP 3. Check injector plunger.
Replace the injector or plunger (para. 2-40).

STEP 4. Check if injector adapter wall is damaged behind balance orifice.
Replace the injectors (para. 2-40).

STEP 5. Check for damaged fuel pump main shaft seals.
Replace the fuel pump (para. 2-37).

STEP 6. Check for a defective cylinder head.
Refer to Malfunction 3, Step 5.

Table 2-2. Troubleshooting-Cont

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

14. Turbocharger noise.

STEP 1. Check for incorrect turbocharger installed.
Install correct equipment (para. 2-30). Refer to TM 55-1905-223-24P.

STEP 2. Check for intake or exhaust air leaks.
Secure or repair loose or damaged piping (para. 2-30).

STEP 3. Check for excessive intake air restriction as follows:
a. Install a vacuum gauge or water manometer in the intake air piping.

NOTE

The gauge adapter must be installed at a 90-degree angle to the air flow in a straight section of pipe, one pipe diameter or 4 inches before the turbocharger.

b. Operate the engine at full throttle and rated rpm with maximum load.
c. Record the reading on the gauge or manometer.

NOTE

Restriction must not exceed 25.0 inches H_20 (635 cm H_20).

d. If the restriction exceeds specifications, do the following:
(1) Replace or clean the air filter element (para. 2-29).
(2) Visually inspect the intake air piping for damage.
e. Remove the test equipment.

STEP 4. Check for excessive exhaust restriction as follows:
a. Install a mercury manometer in the exhaust piping.

NOTE

The gauge adapter must be installed near the turbocharger or exhaust manifold in a straight section of pipe.

b. Operate the engine at rated rpm and load, and record the manometer reading.

NOTE

Exhaust pressure must not exceed 3.0 inches (Hg) (7.5 cm Hg).

c. If exhaust pressure exceeds the specifications, visually inspect the exhaust piping for damage.

Table 2-2. Troubleshooting-Cont

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

d. Remove the test equipment.

STEP 5. Check for defective turbocharger compressor impeller or turbine wheel as follows:
a. Remove the intake and exhaust pipes from the turbocharger (para. 2-30).
b. Visually inspect the turbocharger compressor impeller blades for damage.
c. If damage is found, replace turbocharger (para. 2-30).

STEP 6. Check for turbocharger bearings damage.
a. Refer to PMCS Table 2-1, Item 27.
b. Replace turbocharger (para. 2-30).

15. Low power or excessive smoke (low turbocharger boost pressure).

STEP 1. Check for engine overload.
Reduce engine load.

STEP 2. Check for incorrect turbocharger installed.
Install correct equipment (para. 2-26). Refer to TM 55-1905-223-24P.

STEP 3. Check for dirty air filter element.
Replace or clean air filter element (para. 2-29).

STEP 4. Check for intake or exhaust air leaks.
Secure loose or replace damaged piping.

STEP 5. Check for excessive exhaust restriction.
Refer to Malfunction 14, Step 4.

STEP 6. Check for intake air restriction.
Refer to Malfunction 14, Step 3.

STEP 7. Check for defective turbocharger bearings.
a. Refer to PMCS Table 2-1, Item 27.
b. Replace turbocharger (para. 2-30).

STEP 8. Check for malfunction in fuel system.
Refer to Malfunction 25.

16. Turbocharger leaks engine oil or fuel.

STEP 1. Check for defective turbocharger turbine seal.
a. Check turbocharger for oil leaks.
b. Replace turbocharger (para. 2-30).

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

STEP 2. Check for excessive engine crankcase gases (blowby).

NOTE

Excessive blowby indicates a turbocharger or internal engine malfunction. Do not run engine for more than 10 minutes.

a. Install a plug in the crankcase breather vent (para. 2-34).
b. Remove the oil filler cap and replace it with a blowby checking tool (P/N 3375150).
c. Connect a pressure manometer to blowby checking tool.
d. Run engine at rated speed (TM 55-1905-223-10). Pressure manometer reading should be no more than 18.0 in. H_20 (45.7 cm H_20).

NOTE

Reading should be no more than 12.0 in. H_20 (30.5 cm H_20) on engines with less than 3600 operating hours.

e. Check for incorrect oil pressure and any fuel, oil, water, or air leaks.
f. Replace turbocharger (para. 2-26).

17. Engine cranks but will not start (no smoke from exhaust).

STEP 1. Check to see if fuel shutoff valve is closed or defective.
a. Use manual override.
b. Check solenoid valve and clean terminals as follows:
(1) Make sure all of the wire connection nuts are tight, whether a wire is attached or not.
(2) Use a wire brush to clean the corroded solenoid terminals.
(3) Make sure the shutoff valve solenoid is receiving the correct voltage.

NOTE

The solenoid voltage and a part number are cast into the terminal connection end of the solenoid.

(4) Check the voltage (24 Vdc) to the solenoid with a volt-ohm meter.

NOTE

Make sure the coil wires are not connected before checking the solenoid resistance.

Table 2-2. Troubleshooting-Cont

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

(5) Check the solenoid resistance with a volt-ohm meter.
(6) The solenoid resistance at 24 Vdc should be 28-32 Ohms.
(7) If resistance is not 28-32 Ohms replace solenoid.

STEP 2. Check for no fuel to injectors.
a. Loosen fuel line between fuel pump and cylinder head while cranking engine. Check for fuel.
b. Check fuel pump for fuel. Replace pump if required (para. 2-37).

STEP 3. Check if fuel connections on suction side of fuel pump are loose.
Tighten all fuel filter fittings and connections from fuel tank to fuel pump.

STEP 4. Check if fuel filter is plugged or suction line is restricted.
a. Replace fuel filter (para. 2-31).
b. Inspect for fuel hose restriction.
(1) Remove fuel supply hose to fuel pump and install a vacuum gauge between the pump and supply line.
(2) Hold gauge at the same level as the fuel inlet line.
(3) Run the engine and observe the reading.
(4) Maximum reading should be 4 in. Hg (10.2 cm Hg).
c. Remove gauge and connect supply line.
d. If restriction is above maximum, check fuel supply lines and clear.

STEP 5. Check for fuel in pump as follows:

NOTE

- Loosen the fuel line at the shutoff valve while the engine is cranking. If fuel does not come out of the connection, the pump must be primed.
- If fuel pump is dirty, clean the outside of the pump.

a. Remove the priming plug from the top of the housing.
b. Fill the housing with clean fuel oil.
c. Tighten the plug to 20 ft-lb (30 N•m) torque.
d. If the priming plug is hard to remove, remove the fuel supply hose to the gear pump.
e. Fill the gear pump with clean engine lubricating oil.
f. If fuel does not come out of the connection now, replace the pump (para. 2-37).
g. Install the supply hose to the gear pump.

Table 2-2. Troubleshooting-Cont

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

STEP 6. Check for fuel pump not turning.
a. Check tachometer shaft for rotation while cranking.
b. If tachometer shaft is not turning, remove the fuel pump and check to see if the accessory drive shaft is turning (para. 2-37).
c. If turning, replace fuel pump (para. 2-37).
d. If not turning, refer to direct support maintenance for corrective action.

STEP 7. Check for excessive intake air restriction.
Refer to Malfunction 14, Step 3.

STEP 8. Check for excessive exhaust restriction.
Refer to Malfunction 14, Step 4.

18. Engine hard to start or will not start (exhaust smoke present).

STEP 1. Check for low engine cranking speed (below 150 rpm).
Check engine cranking rpm.

STEP 2. Check coolant heater (para. 2-36).
Repair coolant heater (para. 2-36).

STEP 3. Check to see if fuel filter plugged.
Replace fuel filter (para. 2-31).

STEP 4. Check for air in the fuel system.
a. Tighten all fuel line connections.
b. Tighten fuel filters.
c. Check for air leaks at fuel pump:
(1) Run the engine.
(2) Loosen the fuel outlet line at the shutoff valve.
(3) If air bubbles continue after initial release of air, replace the fuel pump (para. 2-37).

STEP 5. Check to see if fuel suction line is restricted.
Inspect fuel lines for restriction or damage. Correct as required. Refer to Malfunction 17, Step 4.

STEP 6. Check air intake system for restriction.
Refer to Malfunction 14, Step 3.

STEP 7. Check for contaminated fuel.
If contaminated drain, clean, and replace.

Table 2-2. Troubleshooting-Cont

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

19. Engine starts but will not keep running.

STEP 1. Check for air in the fuel system.
Refer to Malfunction 18, Step 5.

STEP 2. Check if fuel filter is plugged or fuel waxing due to cold weather.
Replace fuel filter (para. 2-31).

STEP 3. Check for idle speed too low (para. 2-10).
Adjust idle speed (refer to para. 2-10).

STEP 4. Check if fuel suction line is restricted.
Inspect fuel lines. Refer to Malfunction 17, Step 4.

STEP 5. Check if fuel is contaminated.
Check, drain, clean and replace.

STEP 6. Check if intake or exhaust system is restricted.
a. Check intake and exhaust restriction. (Refer to para. 2-29 and Item No. 14 of this table).
b. Check for correct injector timing (para. 2-39).

STEP 7. Check plugged injector cup spray holes.
Remove injectors and clean (para. 2-40).

20. Warm engine runs rough or misfires in operating range.

STEP 1. Check for air in fuel.
Refer to Malfunction 18, Step 5.

STEP 2. Check to see if fuel is contaminated.
If contaminated drain, clean and replace fuel.

STEP 3. Check for defective injectors as follows:
a. Remove the poppet covers (para. 2-39).
b. Operate the engine until it is up to 160°F (70°C).
c. Install Rocker Lever Actuator, P/N ST-1193 on an injector rocker lever.
d. Hold the injector plunger down while the engine is running at low idle. This will stop the fuel flow to that injector.
e. If the engine rpm decreases when an injector plunger is held down, the injector is good.
f. If the engine rpm does not decrease, replace the defective injector (para. 2-34).

STEP 4. Check injection timing.
Adjust timing (para. 2-40).

Table 2-2. Troubleshooting-Cont

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

STEP 5. Check valve timing.
Adjust timing (para. 2-40).

21. Rough idle.

STEP 1. Check if engine idle speed is low.
Check and adjust low idle speed (para. 2-10).

STEP 2. Check for air in fuel.
Refer to Malfunction 18, Step 5.

STEP 3. Check for defective injector.
Refer to Malfunction 20, Step 3.

STEP 4. Check for defective fuel pump.
Refer to Malfunction 17, Steps 5 and 8.

STEP 5. Check for defective engine mounts.
Check engine mounts and capscrews for cracks or other defects. Replace as necessary. Secure capscrews to 135 ft-lb.

STEP 6. Check injector timing/adjustment valves worn or damaged, etc.
Adjust or repair as required.

22. Engine surges at low idle.

STEP 1. Check for air in fuel system.
Refer to Malfunction 18, Step 5.

STEP 2. Check if engine idle speed is too low.
Refer to Malfunction 13, Step 1.

STEP 3. Check for fuel return restriction.
a. Disconnect fuel return line and install a vacuum gauge between the line and the fuel pump return fitting.
(1) Use hose adapters to connect gauge.
(2) Maximum reading should be 6.5 in. Hg (16.5 cm Hg) with check valves.
b. If restriction is above maximum, check lines or tank vents for obstructions.

23. Engine will not reach rated speed when under a load.

STEP 1. Check for clogged fuel filters.
Replace filters (PMCS Item 13).

Table 2-2. Troubleshooting-Cont

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

STEP 2. Check if tachometer has a malfunction.
Check against a known good tachometer (para. 2-26).

STEP 3. Check if fuel suction line is restricted.
Refer to Malfunction 17, Step 4.

STEP 4. Check for defective fuel pump.
Refer to Malfunction 17, Steps 5 and 8.

24. Low power.

STEP 1. Check if fuel suction line or fuel filter is restricted.
Refer to Malfunction 17, Step 4.

STEP 2. Check if lubricating oil level is too high.
Drain oil to proper level.

STEP 3. Check if intake or exhaust system is restricted.
Refer to Malfunction 14, Step 3 for intake, Step 4 for exhaust.

STEP 4. Check if return line is restricted or fuel tank vents are plugged.
Refer to Malfunction 22, Step 3.

STEP 5. Check for poor fuel quality.
Check, drain, clean and replace fuel.

STEP 6. Check for air or exhaust leaks between turbocharger and engine.
Refer to Malfunction 14, Step 2.

STEP 7. Check to see if fuel rate low, fuel pressure low, and turbocharger pressure low as follows:
a. Stop engine.
b. Remove plug from spring pack cover.
c. Install fuel pump idle adjusting tool, P/N 3375981, in the plug hole.
d. Operate engine for 30 seconds at high idle to remove air from fuel system.
e. Ensure that engine temperature is at or above 1600F (700C).
f. Adjust idle speed between 650 and 725 rpm.
g. Remove fuel pump adjusting tool and -install plug.
h. Operate engine until rpm is constant and all air is out of fuel system.
i. Recheck idle speed.

STEP 8. Fuel rate high, fuel pressure high, and turbocharger pressure high.
a. Lower fuel rate.
b. Refer to Malfunction 24, Step 10.

Table 2-2. Troubleshooting-Cont

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

STEP 9. Check to see if fuel rate correct, fuel pressure high, and turbocharger pressure correct.
a. Check for defective injector.
b. Refer to Malfunction 21, Step 3.

STEP 10. Check to see if fuel rate low, fuel pressure high, and turbocharger pressure correct or low.
a. Check for defective injector.
b. Refer to Malfunction 21, Step 3.

STEP 11. Check to see if fuel rate low, fuel pressure correct, and turbocharger pressure high.
Replace turbocharger (para. 2-30).

STEP 12. Check to see if fuel rate low, fuel pressure correct and turbocharger pressure low.
a. Check for defective injector.
b. Refer to Malfunction 21, Step 3.

STEP 13. Check to see if fuel rate correct, fuel pressure correct, and turbocharger pressure low.
a. Check intake air restrictions (refer to Malfunction 14, Step 3).
b. Replace turbocharger (para. 2-30).

STEP 14. Check to see if fuel rate correct, fuel pressure high, and turbocharger pressure correct.
Check for restrictions in fuel pressure lines.

STEP 15. Check to see if injectors are seated.
Secure holddown capscrews (para. 2-40).

STEP 16. Check to see if injectors are carboned.
Replace injectors (para. 2-40).

STEP 17. Check to see if injectors(s) are stuck.
Make sure rocker lever, injector link action is correct (para. 2-40).

STEP 18. Check for defective fuel pump.
Refer to Malfunction 17, Steps 5 and 8.

STEP 19. Check for misadjusted valves or injector.
Adjust valves and injectors (para. 2-39).

25. Exhaust smoke excessive under load.

STEP 1. Check for overloaded engine.
Reduce load.

Table 2-2. Troubleshooting-Cont

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

STEP 2. Check if intake air system is restricted.
Check intake air restriction (para. 2-29).

STEP 3. Check for intake air leaks between turbocharger and cylinder head.
Check for air leaks (paras. 2-29, 2-30 and 2-43).

STEP 4. Check if turbocharger wheel is rubbing.
Replace turbocharger (para. 2-30).

STEP 5. Check for loose injector.
Tighten or replace injector (para. 2-40).

STEP 6. Check for fuel return line restriction.
Refer to Malfunction 22, Step 3.

STEP 7. Check if engine is receiving too much fuel.
Replace fuel pump (para. 2-37).

STEP 8. Check if turbocharger turbine seal is leaking.
Replace turbocharger (para. 2-30).

STEP 9. Check for damaged injector cups.
a. Hold down injector at idle.
b. Observe change in smoke level.
c. Replace injector (para. 2-40).

26. Engine will not shut off.

NOTE

Shut off engine by turning fuel pump shutoff valve counterclockwise.

STEP 1. Check if fuel pump manual override is open.
Check to make sure manual override shutoff screw is turned fully counterclockwise.

STEP 2. Check if fuel pump shutdown valve disk is stuck.
Replace fuel shutdown valve (para. 3-19).

STEP 3. Check for defective turbocharger seals.
Replace turbocharger (para. 2-30).

STEP 4. Check if fuel return line is restricted.
Check lines for head to tank. (Refer to Item No. 22 of this table.)

Table 2-2. Troubleshooting-Cont

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

STEP 5. Check if engine is running on fumes drawn into air intake.
Locate and isolate the source of fumes.

STEP 6. Check if injector check balls are not seating or missing.
Replace injector (para. 2-40).

27. Poor deceleration.

STEP 1. Governor actuator not operating properly.
Replace governor actuator (para. 2-37).

STEP 2. Check if fuel return lines are restricted.
Check for loops, restricted fittings.

STEP 3. Check for excessive fuel leakage at throttle.
Replace fuel pump (para. 2-37).

STEP 4. Check throttle linkage adjustment.
Correct adjustment.

STEP 5. Check if injector check ball is not seating or missing.
Replace injector(s), (para. 2-40).

28. Engine surges at high idle.

STEP 1. Check for air leak in fuel lines or in fuel pump.
Check for air in fuel, tighten fuel connections, tighten filter. Replace pump as required (para. 2-37).

29. Engine will not crank or cranks slowly.

STEP 1. Check if starter connections are broken, loose, or corroded (on electric starter motor).
Check starter connection. Clean, tighten or replace wiring as required (para. 2-25).

STEP 2. Check if starting current is low (for electric starter motor) on remote battery supply.
Check electrolyte level and specific gravity. (Refer to TM 55-1905-223-24-18.)

STEP 3. Check if starting circuit component is malfunctioning (electric or air starter).
Check starting circuit components (paras. 2-24 (air) and 2-25 (electric)) Replace starter motor as required.

Table 2-2. Troubleshooting-Cont

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

STEP 4 Check for external or internal conditions affecting engine crankshaft rotation.
Check engine for ease of crankshaft rotation. Locate problem and correct as required.

30. Excessive crankcase gases (blowby).

STEP 1. Check for restricted crankcase breather vent tube.
Check breather tube restriction (para. 2-39).

STEP 2. Check for leaking turbocharger seals.
Replace turbocharger (para. 2-30).

31. Excessive engine vibration.

STEP 1. Check for loose generator coupling.
Check driveline components and couplings.

STEP 2. Check for loose mountings.
Replace any broken or missing bolts, washers and nuts. Tighten capscrews to 135 ft-lb.

32. Excessive engine noise.

STEP 1. Check for accessory noise.
Make sure that engine accessories are not the cause of the noise first.
Check all accessories and brackets for tightness.

33. Excessive white smoke in idle.

STEP 1. Check if engine coolant heater is not operating.
Check electrical source and wiring to heater. Replace heater as required (para. 2-36).

STEP 2. Check for low coolant temperature.
Incorrect or malfunctioning thermostat.

STEP 3. Check for poor fuel quality.
Check, clean, drain and replace.

STEP 4. Check for raw fuel in intake manifold.
Check intake manifold for fuel. Repair or replace as necessary (para. 2-42).

STEP 5. Check for damaged injector cups.
Replace injector (para. 2-40).

Table 2-2. Troubleshooting-Cont

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

STEP 6. Check if valves or injectors are adjusted wrong.
Check valve and injector settings.

STEP 7. Check if injection timing set wrong.
Check injection timing.

34. Main bearing noise.

STEP 1. Check for insufficient oil or low oil pressure.
Correct oil level.

STEP 2. Check for thin or diluted lube oil.
Change oil (PMCS Item 15).

35. Connecting rod bearing noise.

STEP 1. Check for insufficient oil supply or low oil pressure.
Correct oil level.

36. Piston noise.

STEP 1. Check for contaminated or poor quality fuel.
Check, clean, drain and replace.

37. Excessive fuel consumption.

STEP 1. Check for restricted air intake.
Check intake air restriction (para. 2-29). Replace air cleaner element as required.

STEP 2 Check for exhaust restriction. If necessary, refer to Malfunction 14, Step 4.
a. Remove exhaust restriction.
b. Repair faulty or damaged piping as necessary.

STEP 3. Check for fuel line restriction.
Check the fuel supply line with a vacuum gauge. Refer to Malfunction 25, Step 6.

STEP 4. Check for external or internal leaks.
a. Check all lines and fittings for external leaks. Repair as necessary.
b. Check cooling system and lubricating oil system for signs of fuel dilution. (Refer to Items No. 5 and No. 13, respectively, in this table.)

STEP 5. Check for faulty or damaged injectors.
Clean or replace injectors as required (para. 2-40)

Table 2-2. Troubleshooting-Cont

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

STEP 6. Check for poor quality fuel.
Check, clean, drain and replace.

38. Engine operates below idle speed in idle.

STEP 1. Check if "Idle" is not adjusted correctly.
Adjust idle.

STEP 2. Check if throttle is not opening. Check for defective actuator.
Replace fuel pump (para. 2-37).

39. Engine operates at high idle in idle.

STEP 1. Check if no voltage is going to the governor control.
Check wiring connections on the governor control. Check for voltage to the control (para. 2-26).

STEP 2. Check if magnetic pickup voltage is below 1.5 Vac when operating engine.
Check for loose terminals at the governor control (para. 2-26).

STEP 3. Check for EFC or governor control failure.
Replace EFC or governor control (para. 2-26).

40. No voltage output from generator.

STEP 1. Check for broken or loose leads.
Check generator connections for burned or loose control and exciter leads.
Secure leads.

41. Generator voltage too low.

STEP 1. Check for defective panel voltmeter.
Replace the voltmeter (para. 2-26).

STEP 2. Check for low RPM.
Adjust "Idle" and "Run" potentiometer (para. 2-10).

STEP 3. Check if fuel line is restricted.
Refer to Malfunction 17, Step 4.

STEP 4. Check for defective voltage regulator.
a. Operate engine at rated speed.
b. Turn voltage adjust rheostat on the AVR from maximum to minimum volts. (AVR is operating if the generator output voltage changes.)
c. Replace regulator (para. 2-23), as necessary.

Table 2-2. Troubleshooting-Cont

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

42. Generator voltage too high.

STEP 1. Check for fluctuating or improper reading from panel voltmeter.
Replace voltmeter (para. 2-26).

STEP 2. Check for defective voltage regulator.
Refer to Malfunction 41, Step 4.

43. Generator voltage fluctuates.

STEP 1. Check if governor rpm is unstable.
Adjust idle.

STEP 2. Check for defective actuator or fuel pump.
Replace actuator or fuel pump (para. 2-37).

STEP 3. Check if intermittent opens or grounds in control wiring or leads.
Check all control wiring and connections for tightness and damage.

STEP 4. Check for defective automatic voltage regulator.
Refer to Malfunction 41, Step 4.

44. Air constantly flows to the air starter.

STEP 1. Check if relay valve is improperly installed, missing or stuck.
Check installation (para. 2-24).

45. Air starter does not run-no air flow.

STEP 1. Check for water leaking from vent port in air starter.
Replace air starter (para. 2-24).

STEP 2. Check for starter running but not turning engine.
Replace air starter (para. 2-24).

46. Reduced air starter output power or starter runs, pinion engages but does not crank engine.

STEP 1. Check for insufficient air inlet pressure.
Increase pressure in 10 psig increments.

STEP 2. Check for broken bendix drive.
Replace air starter (para. 2-24).

Table 2-2. Troubleshooting-Cont

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

47. Engine cranks too quickly causing automatic trip valve to trip before engine starts.

STEP 1. Check if air inlet pressure is too high.
Reduce inlet pressure in 10 psig increments until successful engine start.

48. Air starter continues to operate after control valve shutoff.

STEP 1. Check if relay valve is sticking.
Replace relay valve (para. 2-24).

SECTION V. UNIT MAINTENANCE PROCEDURES

MAINTENANCE OF SHIP'S SERVICE GENERATOR SETS, ELECTRIC AND AIR START

2-23. Repair Generator Assembly. (Figure 2-3)

This task covers: Repair

INITIAL SETUP

Tools

Tool kit, general mechanic's rail and marine diesel engines, 5180-00-629-9783
Tool kit, electrician, 5180-00-391-1087

Materials/Parts

Automatic voltage regulator P/N E000-23020

Equipment Condition

Electrical power to generator assembly turned OFF and tagged. TM 55-1905-223-10.

REPAIR

Repair of the generator assembly consists of replacing the automatic voltage regulator.

WARNING

Turn OFF and tag all electrical power to the generator assembly and engine. Failure to do so may result in personal injury.

a. Remove four machine screws (1) from access cover (2) on the generator.

b. Remove three screw pillars (4) and remove the automatic voltage regulator (3) enough to gain access to wiring.

c. Tag and remove all electrical leads attached to the automatic voltage regulator (3).

d. Connect electrical leads to the automatic voltage regulator (3). Remove tags.

e. Position the new automatic voltage regulator (3) in the terminal box (5) and install the screw pillars (4).

f. Place the cover (2) on the terminal box and install four machine screws (1) and secure.

g. Remove tags, restore electrical power, and check for proper operation.

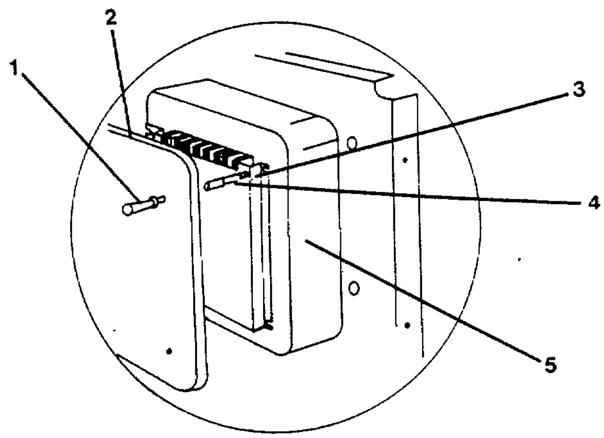


FIGURE 2-3. Voltage Regulator Panel.

2-24. Replace Engine Air Starter. (Figure 2-4)

This task covers: a. Removal b. Replacement

INITIAL SETUP

Tools

Tool kit, general mechanic's rail and marine diesel engines, 5180-00-629-9783
Torque wrench kit P/N 3377216

Materials/Parts

Anti-seize compound, pipe thread, Item 9, Appendix C
Air starter P/N 42 KG 312-08-601

Equipment Condition

Engine shut down and cooled below 120°F (50°C). TM 55-1905-223-10.
Air supply secured (port). TM 55-1905-223-10.
Battery banks disconnected (starboard). TM 55-1905-223-10.

REMOVAL

WARNING

Ensure that all external high pressure air supply valves are closed before attempting any maintenance or repair function to starter. Failure to do so could result in personal injury.

a. Close external air supply valves to the starter, tag, and disconnect the air supply fitting (3).

b. Disconnect the air exhaust screen guard fitting (9).

c. Disconnect the air inlet (6), air outlet (7), and vent port (8) lines.

d. Disconnect the relay valve input signal port connection (1) and supply port connection (4).

e. Remove the four capscrews (5) and remove the starter from the engine.

f. To remove the relay valve (2) from the starter, disconnect at bushing (11) and nipple (10).

g. Remove spacers or shims (if used) and place them where they will not be damaged.

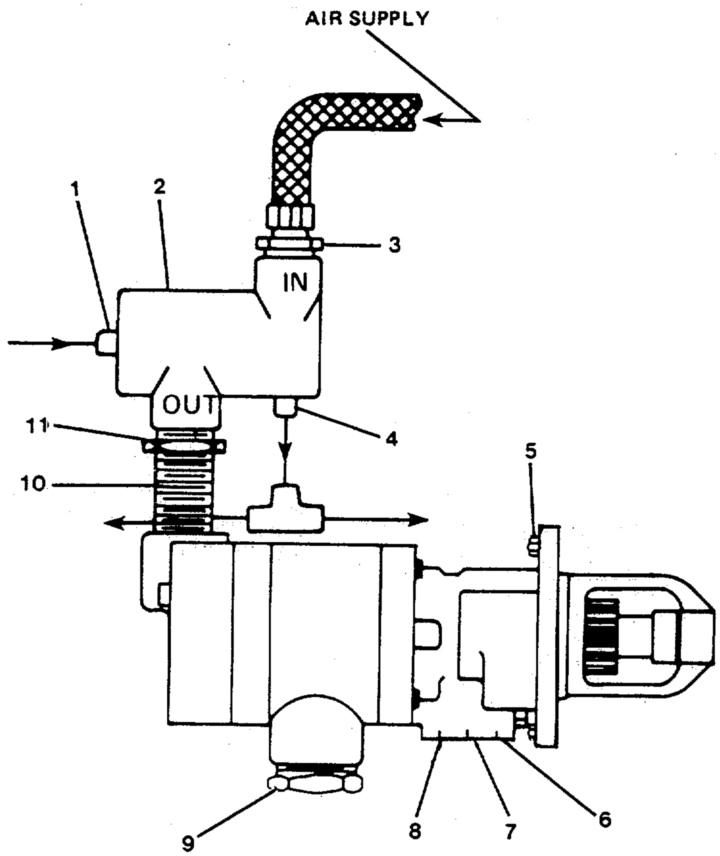


FIGURE 2-4. Engine Air Starter.

CAUTION

If spacers or shims are used between the starter mounting flange and the flywheel housing, mark their position, and save. Use the same spacers or shims, placed in marked positions, when installing a new or rebuilt starter.

REPLACEMENT

NOTE

Ensure mounting surfaces are clean before installing starter.

a. Replace all spacers or shims that were removed with the starter. Place them in their original position.

b. Position the starter on the flywheel housing. Ensure the bendix gear teeth engage the flywheel gear.

c. Install the capscrews (5). Tighten alternately to specified values as follows:

NOTE

Capscrews are alternately torqued to the specification in item (1); then item (2); then item (3); and finally item (4).

(1) Tighten to 25 ft-lb (34 N•m) torque.

(2) Tighten to 50 ft-lb (68 N•m) torque.

(3) Tighten to 75 ft-lb (102 N•m) torque.

(4) Tighten to 100 ft-lb (136 N•m) torque.

d. Connect the relay valve (2) with bushing (11) and nipple (10).

e. Connect the air inlet (6), air outlet (7), and vent port (8) lines to the starter. Tighten to 35 in-lb (4 N•m) torque.

f. Connect the exhaust screen guard fitting (9). Tighten to 65 ft-lb (88 N•m) torque.

g. Connect the air supply fitting (3). Tighten to 65 ft-lb (88 N•m) torque.

h. Connect the relay valve input signal port fitting (1) and supply port fitting (4). Tighten fittings to 35 in-lb (4 N•m) torque.

i. Remove tag and open the external air supply valve to the starter.

j. Remove tag and turn on electrical power.

k. Start the engine to ensure proper operation of the starter (TM 55-1905-223-10). If a starting problem exists, refer to Table 2-2, Troubleshooting Symptoms.

2-25. Replace/Repair Electric Starting Motor/Magnetic Switch Group. (Figure 2-5).

This task covers: a. Removal, b. Repair, c. Replacement.

INITIAL SETUP

Tools

Tool kit, general mechanic's rail and marine diesel engines, 5180-00-629-9783
Torque wrench kit P/N 3377216

Materials/Parts

Electrical starter P/N 3021036
Magnetic switch P/N 3050692

Equipment Condition

Engine shut down and cooled below 120°F (50°C). TM 55-1905-223-10.
Battery banks disconnected (starboard).

REMOVAL

a. Tag and remove all electrical connections from the engine electrical starter (1).

b. Remove and tag all electrical connections from the magnetic switch (5).

c. Remove the three capscrews (9) from the electrical starter (1). Remove the starter, spacers (or shims) if used, and magnetic switch (5).

CAUTION

If spacers or shims are used between the starter motor and the flywheel housing, mark their position, and save. Use the same spacers or shims, placed in marked positions, when installing a new or rebuilt starter.

d. When replacing only the magnetic switch, remove four hexagon nuts (2), four lockwashers (3), and four flat washers (4). Remove the switch (5), four flat washers (6), and two vibration isolators (7) from the magnetic switch bracket (8).

REPAIR

Repair of the electric starting motor/magnetic switch group consists of replacing the magnetic switch and engine electrical starter.

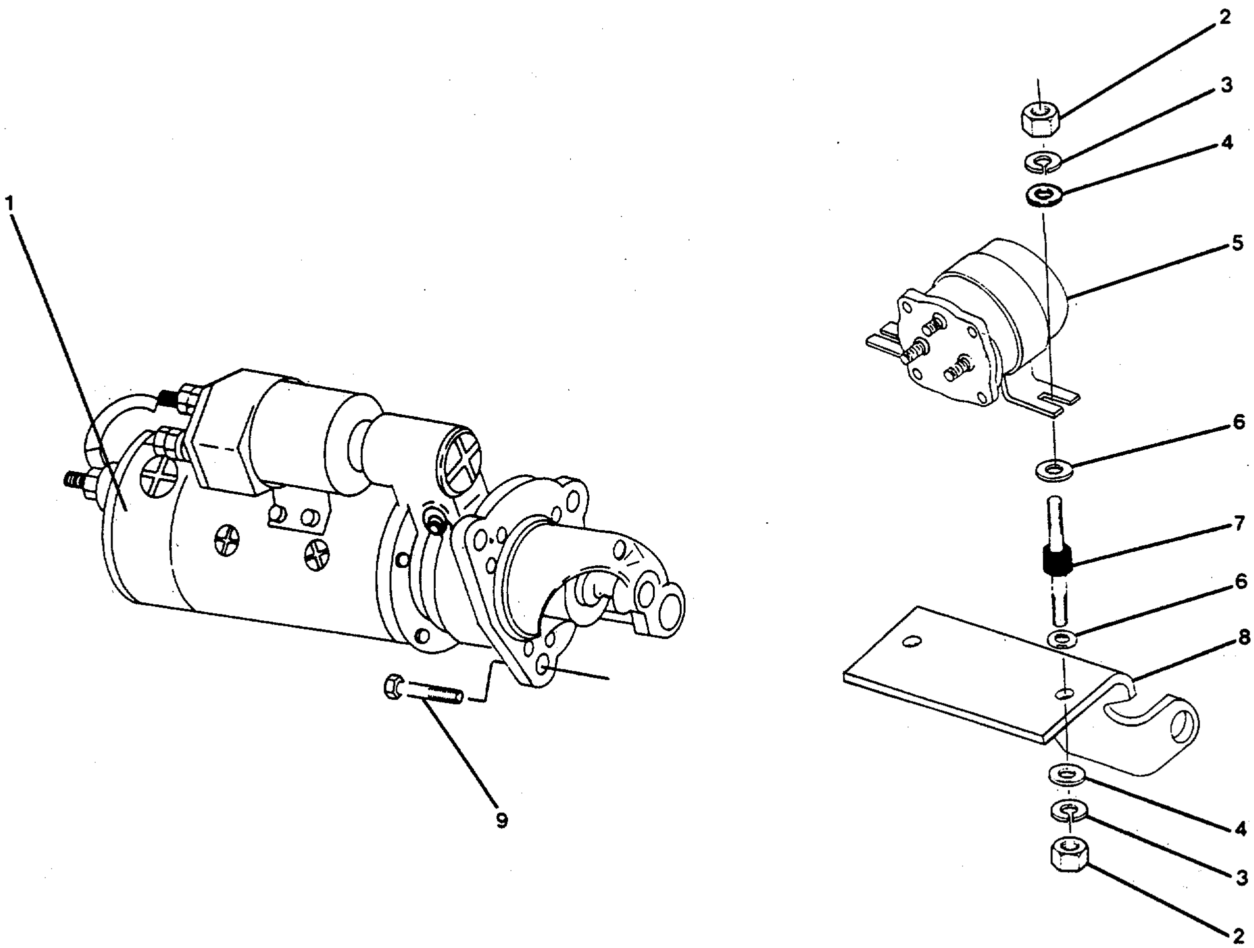


FIGURE 2-5. Electric Starting Motor/Magnetic Switch.

REPLACEMENT

CAUTION

Use the original spacers (or shims) removed with the starter if they were not damaged. If new spacers (or shims) are used, ensure they are of the same thickness as the originals.

a. Install the starter (1) and bracket (8) with the capscrews (9).

b. Tighten the capscrews to 130 ft-lb torque.

c. Connect, and secure the electrical connections to the starter assembly (1). Remove tags.

d. Install the magnetic switch with isolators (7), flat washers (6, 4), lockwashers (3) and nuts (2). Connect the electrical leads to the magnetic switch (5). Remove tags.

e. Reconnect batteries and start engine. TM 55-1905-223-10.

2-26. Replace/Repair Instrument Panel Assembly. (Figure 2-6)

This task covers:
a. Removal, b. Repair, c. Replacement.

INITIAL SETUP:

Tools

Tool kit, general mechanic's rail and marine diesel engines, 5180-00-629-9783

Materials/Parts

Instrument panel assembly P/N 3037741
Dial indicating gauge pressure P/N 3015232
Voltmeter P/N 3015235
Meter time totalizing P/N 3035766
Capillary tube and bulb thermometer P/N 3015234
Oil temperature gauge P/N 3015233
Electrical tachometer P/N 3031734
Lens cap P/N 3018796
Incandescent lamp P/N 3018799
Toggle switch P/N 113527
Toggle switch P/N MS 35058-22
Push switch P/N 3035150
Circuit breaker P/N 3034953
Variable nonwirewound resistor P/N 3015105
Terminal board P/N 3053065
Overspeed switch P/N 3036453
Governor control P/N 3044195
Tranducers P/N 3015237, 3015238

Equipment Condition

Electrical power to generator assembly turned OFF and tagged. TM 55-1905-223-10.

NOTE

Repair of individual components within the instrument panel assembly may be accomplished without the removal of the entire assembly. Refer to the REPAIR task in this paragraph.

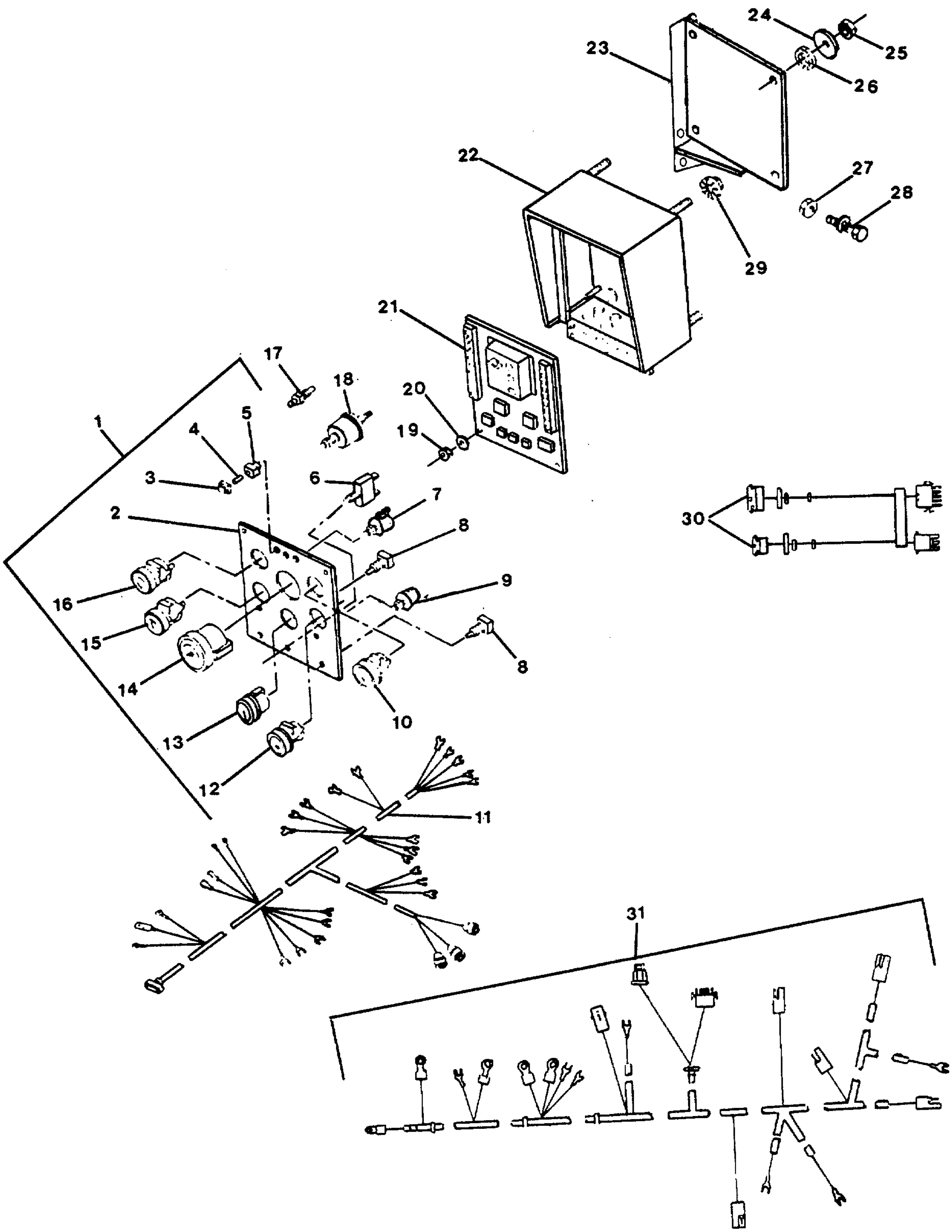


FIGURE 2-6. Instrument Panel Assembly.

REMOVAL

WARNING

Turn off and tag all electrical power to the instrument panel and automatic starting circuits. Failure to do so may result in personal injury.

a. Open the instrument panel (2) by removing the two screws one each in top corner of the panel, and swing the panel (2) front down to open.

b. Tag and disconnect and withdraw unharnessed wires through the bottom of the instrument cabinet (22).

c. Unplug wiring harnesses (11, 31) and electrical power cable assembly (30) from the bottom of the instrument cabinet (22).

d. Remove the four hexagon nuts (25), four flat washers (24), and four resilient mounts (26) from the instrument bracket (23) and remove the cabinet (22) and four resilient mounts (29) from the bracket (23).

e. Remove four assembled washer screws (28) and four hexagon nuts (27) to remove the bracket (23) if required.

REPAIR

a Repair Instrument Panel. Repair to the instrument panel assembly will be the replacement of defective gauges, switches, meters, circuit breaker, lights and other instrument panel components, or the replacement of the assembly.

(1) Tag and remove the electrical wiring from the defective gauge, switch, circuit breaker, meter, resistor, or light assembly.

(2) Remove the mounting hardware that holds the gauge, switch, circuit breaker, meter, resistor, or light to the panel (2). Remove the defective part and discard.

(3) Position the new part in the panel (2) and install the mounting hardware that holds it to the panel (2).

(4) Connect the electrical wiring to the appropriate gauge, switch, circuit breaker, meter, resistor, or light. Remove tags. Tighten the connections.

b Repair Terminal Board. Repair to the terminal board (21, Figure 2-6) is replacement of overspeed switch (1, Figure 2-7) and governor control (2, Figure 2-7) or replacement of the terminal board (3).

(1) Replace overspeed switch (1, Figure 2-7) as follows:

(a) Disconnect and tag the wiring connections from terminal strip.

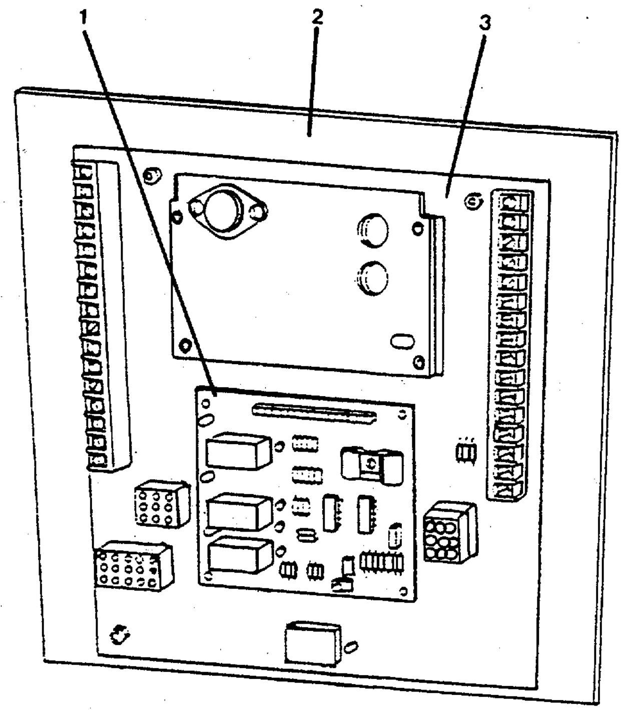


FIGURE 2-7. Terminal Board.

(b) Remove the four machine screws and four lockwashers securing the overspeed switch (1) to the terminal board (3).

(c) Remove the overspeed switch (1) from the terminal board (3).

(d) Position the new overspeed switch (1) on the terminal board (3) and install four screws and lockwashers.

(e) Connect wiring connections to terminal strip. Remove tags.

(2) Replace the governor control (2, Figure 2-7) as follows:

(a) Disconnect and tag all wiring connections to the governor control (2).

(b) Remove the four machine screws and four lockwashers securing the governor control (2) to the terminal board (3).

(c) Remove the governor control (2) from the terminal board (3).

(d) Position the new governor control (2) on the terminal board (3) and install four screws and lockwashers.

(e) Connect all wiring connections on the governor control (2). Remove tags.

(3) Replace the terminal board (21, Figure 2-6) as follows:

(a) Tag and disconnect wires from terminal strips.

(b) Unplug wiring harnesses.

(c) Remove four self-locking nuts (19) and flat washers (20) securing the terminal board to the instrument cabinet (22) and remove the terminalboard.

(d) Position the new terminal board (21, Figure 2-6) in the instrument cabinet (22) and install self-locking nuts (19) and flat washers (20). Secure self-locking nuts (19).

(e) Plug in wiring harnesses to their proper locations on the terminal board (21). Connect all wiring and secure. Remove tags.

REPLACEMENT

a. Install the instrument bracket (23) with screws (27) and nuts (28), if removed.

b. Position the instrument cabinet (22) with mounts (29) to the bracket (22) and install resilient mounts (26), flat washers (24), and nuts (25). Tighten the nuts.

c. Run unharnessed wiring through their proper conduits in the bottom of the instrument cabinet (22) and reconnect. Plug wiring harnesses (11, 31) and electrical power cable assembly (30) to their proper locations on the bottom of the cabinet (22) and tighten. Remove tags.

d. Close the front panel (2) by swinging it upward and tighten the screws in top corners.

2-27. Replace/Repair Water Filter Assembly. (Figure 2-8)

This task covers: a. Inspection, b. Removal, c. Repair, d. Replacement.

INITIAL SETUP

Tools

Tool kit, general mechanic's rail
and marine diesel engines,
5180-00-629-9783
Strap wrench P/N 3376807
Torque wrench kit P/N 3377216
DCA test kit P/N 3300846S

Materials/Parts

Lubricating oil, Item 2, Appendix C
Filter assembly P/N 3827107
Fluid filter P/N 3318319
Paper towel, lint-free,
Item 43, Appendix C
Pipe thread teflon lubricant,
Item 11, Appendix C
Nonmetallic hoses P/N 179918 and 179930

Equipment Condition

Engine shut down and cooled below
120°F (50°C). TM 55-1905-223-10.
Electrical power to engine turned OFF
and tagged. TM 55-1905-223-10.

INSPECTION

WARNING

Ensure engine coolant temperature is below 120°F (50°C) before removing filters or replacing parts and fittings.

a. Visually inspect the fluid filter (11) and fluid filter head assembly (5) for signs of leakage and corrosion.

b. If the filter (11) is leaking around the gasket sealing surface, perform the following:

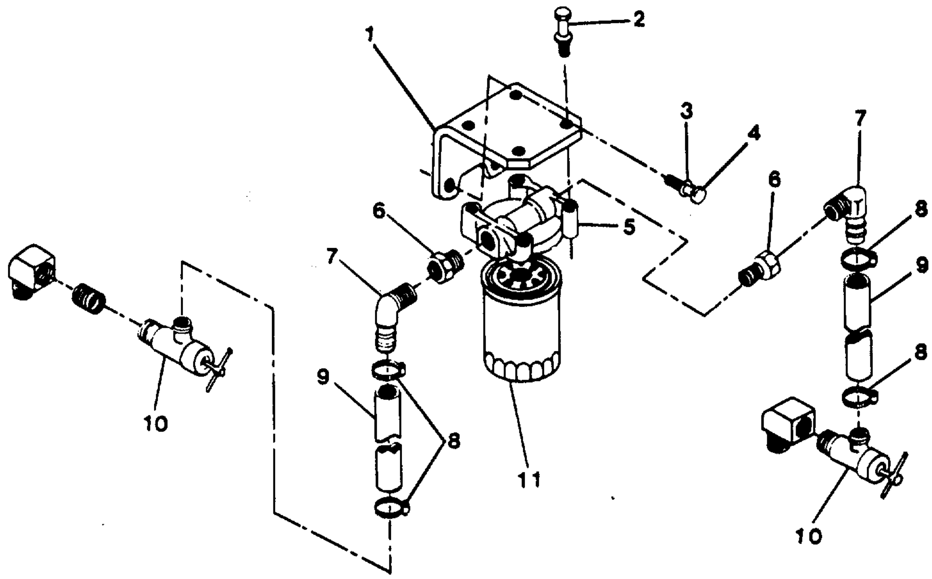


FIGURE 2-8. Water Filter Assembly.

WARNING

Ensure engine coolant temperature is below 120°F (50°C) before removing the coolant system radiator or fill cap. Failure to do so may cause personal injury from heated coolant spray.

(1) Remove the radiator or fill cap on the remote mounted expansion tank (TM 55-1905-223-24-18).

(2) Close the water inlet and outlet angle valves (10, Figure 2-8) on each side of thewater filter head assembly (5).

(3) Remove the fluid filter (11) with a filter wrench.

(4) Clean the gasket sealing surfaces of the filter (11) and head (5) with a lint-free paper towel.

(5) Position filter (11) onto head (5) and hand tighten filter (11) until the sealing gasket touches head (5), then hand-tighten an additional 1/2 to 3/4 turn.

(6) Install the radiator or fill cap on expansion tank (TM 55-1905-223-24-18).

(7) Open angle valves (10).

(8) If leakage is still present, replace filter (11), and recheck.

(9) If the new filter element (11) still leaks, replace the fluid filter head assembly (5). Refer to removal and replace steps.

c. Check connection fittings for signs of leaks.

d. Check nonmetallic hoses (9) for signs of cracks or damage. Replace as required.

e. Tighten hose clamps (8) to 35-40 in-lb.

f. Check fittings (6, 7) for signs of corrosion.

NOTE

For coolant inspection procedures, refer to TB 55-1900-207-24. Refer to Item 19, PMCS, for DCA test procedures.

REMOVAL

WARNING

Ensure engine coolant temperature is below 120°F (50°C) before removing the coolant system radiator or fill cap.

a. Remove the radiator or fill cap on the remote mounted expansion tank (TM 55-1905-223-24-18) to release pressure.

b. Close the water inlet and outlet angle valves (10, Figure 2-8).

c. Remove fluid filter (11) with a filter wrench. Discard filter.

d. Loosen hose clamps (8) and remove nonmetallic hoses (9).

e. Remove the four assembled washer screws (2) that hold the fluid filter head (5) to the angle bracket (1).

f. Remove the filter head (5).

REPAIR

Repair to the water filter is by replacing parts or the assembly. Refer to the Removal and Replacement steps.

REPLACEMENT

a. Install the filter head (5) with washer screws (2) to the bracket (1). Tighten the screws to 30 to 35 ft-lb 40.6 to 47.4 N•m) torque.

b. Install hoses (9) to the filter head elbows (7) and valves (10) with the hose clamps (8). Tighten clamps (8) to 35-40 in-lb (3.9 to 4.5 N•m) torque.

c. Apply a light coat of lubricating oil to the sealing gasket of a new fluid filter (11).

CAUTION

Do not use a wrench to tighten the filter. Overtightening can damage the threads and the seal.

d. Install a new filter (11) onto head (5). Hand tighten the filter (11) until the sealing gasket touches the head (5). Then tighten an additional 1/2 to 3/4 turn.

e. Open the water inlet and outlet angle valves (10) on each side of the filter assembly and check for leaks. Correct as required.

f. Install the radiator or fill cap (if any coolant is required, refer to PMCS, Item 24).

2-28. Replace/Repair Thermostat Housing Group. (Figure 2.-9)

This task covers:
a. Removal, b. Repair, c. Replacement.

INITIAL SETUP

Tools

Tool kit, general mechanic's rail
and marine diesel engines,
5180-00-629-9783
Mandrel, thermostat seal P/N ST-1225
Mandrel, thermostat seal P/N ST-1226
Torque wrench kit P/N 3377216

Materials/Parts

Nonmetallic hose P/N 102522
Gaskets P/N 208128, P/N 3009457
Water outlet gasket P/N 3019158
Flow control thermostat P/N 201737
Thermostat seal P/N 186780
Preformed packing P/N 43463-A
Coolant, Item 8, Appendix C
Metal cleaning solvent, Item 6,
Appendix C
Wiping rag, Item 4, Appendix C

Equipment Condition

Engine shut down and cooled below
120°F (50°C). TM 55-1905-223-10.
Cooling system drained (Table 2-1,
Item 24).
Air supply secured (port).
Battery banks disconnected (starboard).
TM 55-1905-223-10.

REMOVAL

WARNING

Ensure engine water temperature is below 120°F (50°C) before removing the cooling system radiator or fill cap. Failure to do so may cause personal injury from the hot coolant spray.

a. Remove fill cap on external expansion tank to relieve cooling system pressure.

b. Drain engine cooling system. Refer to Table 2-1, Item 24.

c. Remove pipe plugs (19) to drain housing (12) and thermostat support (4).

d. Loosen hose clamp (23) and disconnect hose (22) from outlet connection (1).

e. Loosen hose clamps (18) and disconnect nonmetallic hose (13) from housing (12).

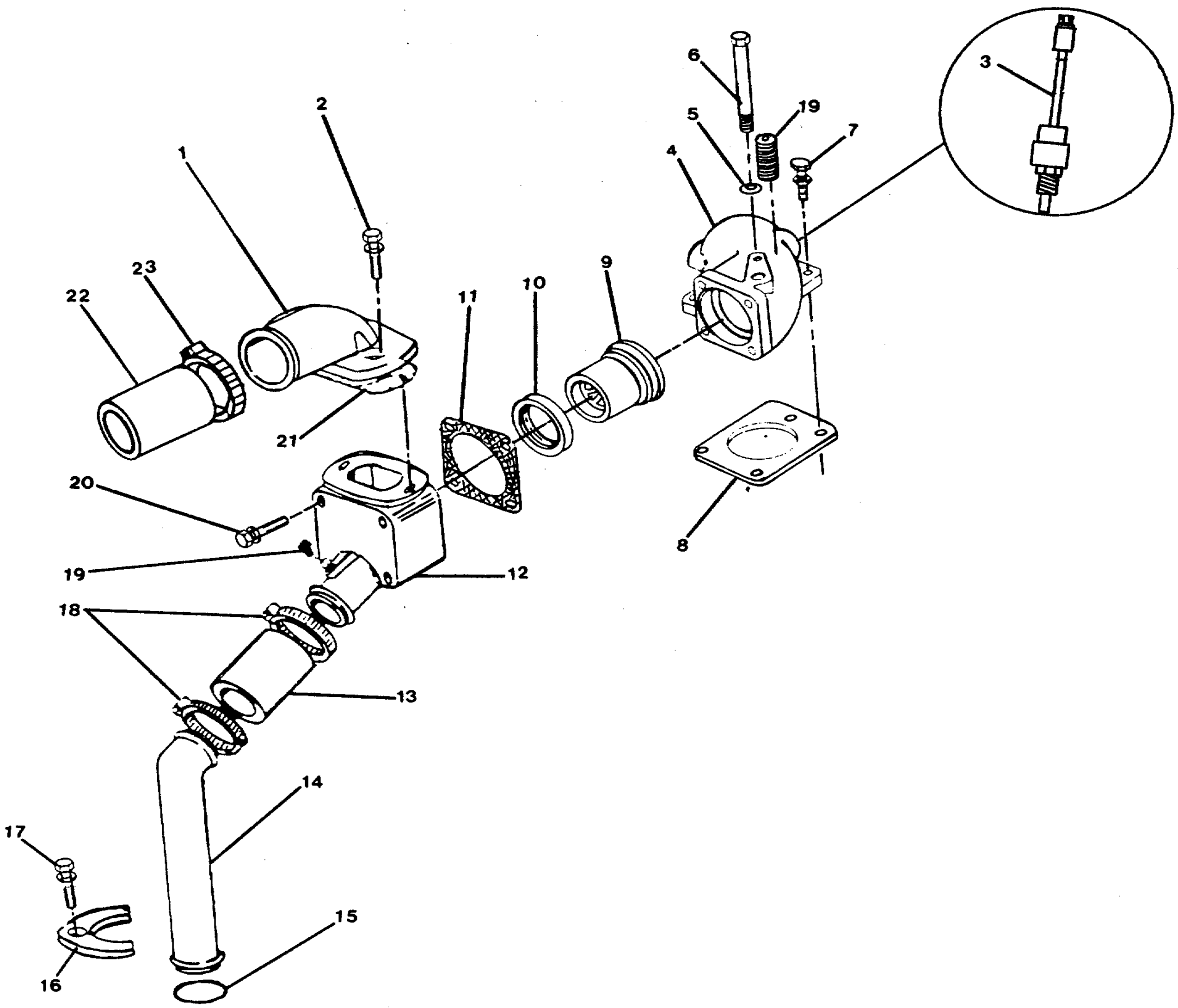


FIGURE 2-9. Thermostat Housing Group.

f. Remove machine bolts (17) and rim clenching clamps (16) and remove bent metallic tube (14) with nonmetallic hose (13) and clamps (18).

g. Remove preformed packing (15). Discard packing.

h. Remove four assembled washer screws (20) and remove housing (12) with gasket (11), thermostat seal (10), and flow control thermostat (9) from thermostat support.

i. Tag and disconnect electrical wiring from engine temperature switch (3) and remove engine temperature switch (3) from thermostat support (4).

j. Remove two hexagon cap screws (6), lockwashers (5) and two machine screws (7) from thermostat support (4).

k. Remove thermostat support (4) and gasket (8). Discard gasket.

REPAIR

Repair of the thermostat housing group consists of replacing gaskets (8,12, and 21), preformed packing (15), thermostat seal (10), flow control thermostat (9), and nonmetallic hose (13).

a. Remove gasket (11) from housing (12). Discard gasket.

b. Remove flow control thermostat (9) from housing (12).

c. Check thermostat seal (10) for cracks or corrosion. Replace if cracked or corroded.

CAUTION

When removing thermostat seal (10), be careful not to sear housing (12).

(1) Using a punch and hammer, remove thermostat seal (10) from housing (12).

(2) Using solvent, clean housing and check for cracks, pitting or corrosion. Replace if cracked, pitted, or corroded.

CAUTION

When installing new thermostat seal (10), the flat side of the seal must be toward the mandrel for correct installation, so as not to cause damage to the engine.

d Using thermostat seal mandrel and hammer, install new thermostat seal (10) in housing (12).

e. Using solvent, clean thermostat support (4).

(1) Check thermostat support (4) for cracks or pitting.

(2) If cracked or pitted, replace.

f. Remove two machine screws (2) securing water outlet connection (1) to the housing (12) and remove gasket (21). Discard gasket.

g. Using solvent, clean water outlet connection (1) and housing support (12) gasket surfaces.

(1) Check water outlet connection (1) for cracks or pitting.

(2) Replace water outlet connection (1), if pitted or cracked.

REPLACEMENT

a. Install new gasket (21) on water outlet connection (1) and position on housing (12).

b. Install two machine screws (2) and tighten to 35 ft-lb (47.4 N•m) torque.

c. Install new gasket (8) on thermostat support (4).

d. Position thermostat support (4) and gasket (8) and secure with two machine screws (7), lockwashers (5), and hexagon capscrews (6). Tighten screws to 35 ft-lb (48 N•m) torque.

e. Install engine temperature switch (3) in thermostat support (4) and connect electrical wiring to switch. Remove tags.

f. Install new flow control thermostat (9) in housing (12).

g. Install new gasket (11) on housing (12).

h. Position housing (12) on thermostat support (4) and secure with four assembled washer screws (2). Tighten screws (20) to 35 ft-lb (48•N-m) torque.

i. Install new preformed packing (15) and bent metallic tube (14) with new nonmetallic hose (13) and hose clamps (18). Tighten hose to 40 in-lb (4.5 N•m) torque.

j. Position rim clenching clamps (16) and secure with machine bolts (17). Tighten machine bolts to 35 ft-lb (48 N-m) torque.

k. Connect nonmetallic hose (22) to water outlet connection (1) and secure with hose clamp (22). Tighten hose clamp to 40 in-lb (4.5 Nom) torque.

l. Install pipe plugs (19) and secure.

m. Fill engine cooling system. Refer to Table 2-1, Item 24.

n. Replace fill cap on external expansion tank and secure.

2-29. Replace/Repair Air Cleaner Group. (Figure 2-10)

This task covers:
a. Removal, b. Repair, c. Replacement.

INITIAL SETUP

Tools

Tool kit, general mechanic's rail
and marine diesel engines,
5180-00-629-9783

Materials/Parts

Preformed hose P/N 3030790
Metallic tube P/N 3000302
Filter warning indicator P/N 178957
Intake air cleaner filter element
P/N 3022209

Equipment Condition

Engine shut down and cooled below
120°F (50°C). TM 55-1905-223-10.

REMOVAL

a. Wipe dirt from cap (5) and upper portion of intake air cleaner (3).

b. Remove wingnut (6) and cap (5).

c. Remove intake air cleaner filter element (4).

d. Check intake air cleaner filter element for accumulation of debris. Clean with compressed air or replace as required.

e. Install clean or new intake air cleaner filter element (4) into intake air cleaner (3) housing. Ensure proper seating of element.

f. Install cap (5) and secure with wing nut (6).

g. Remove intake air filter warning indicator (14). Check indicator for cracks, dents, or restricted opening. Replace if cracked, dented, or restricted.

h. Install intake air filter warning indicator (14).

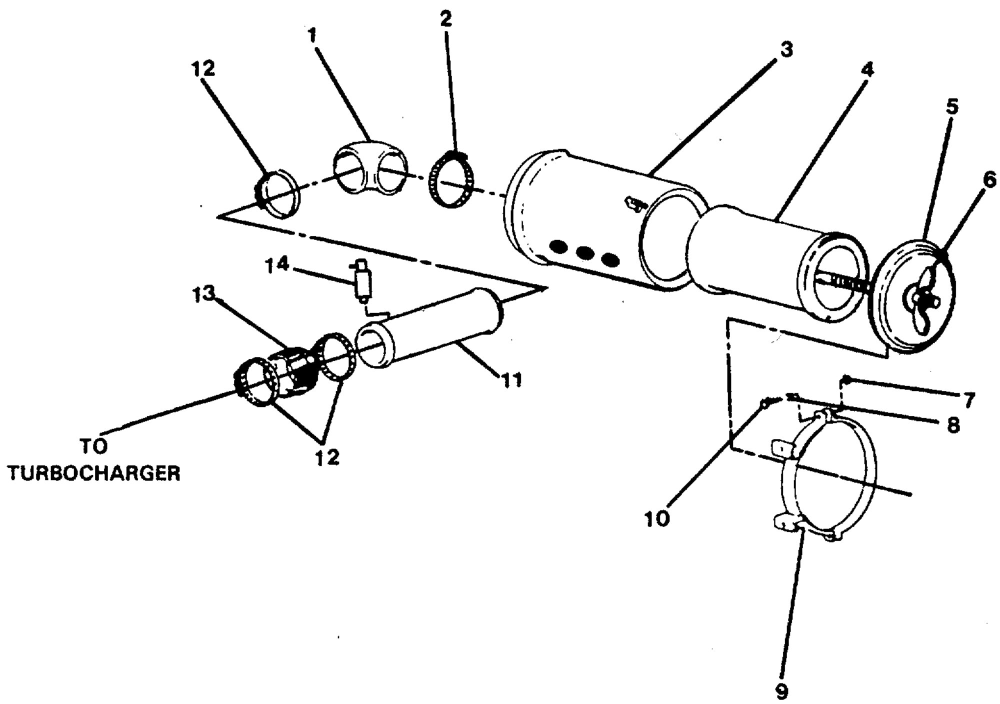


FIGURE 2-10. Air Cleaner Group.

REPAIR

Repair of the air cleaner group is by replacement of parts listed in materials/parts.

a. Loosen hose clamp (12) securing preformed hose (13) to turbocharger.

b. Remove hexagon capscrews (10), lockwashers (8), and plain hexagon nuts (7) from retaining straps (9) and remove air cleaner group from engine.

c. Remove hose clamps (12) securing preformed hose (13) to metallic tube (11).

d. Remove hose clamp (12) securing metallic tube (11) to nonmetallic elbow (1).

e. Remove wing nut (6) and cap (5) from intake air cleaner (3).

f. Remove intake air cleaner filter element (4) from intake air cleaner (3).

REPLACEMENT

a. Install new or clean intake air cleaner filter element (4). Ensure proper seating of element.

b. Install cap (5) and secure with wing nut.

c. Install replacement metallic tube (11) to nonmetallic elbow (1) and secure with hose clamp (12).

d. Install replacement preformed hose (13) to metallic tube (11) and secure with hose clamp (12).

e. Position air cleaner group on engine mounting straps (9) and secure with plain hexagon nuts (7), lockwashers (8), and hexagon capscrews (10).

f. Connect preformed hose (13) to turbocharger and secure with hose clamp (12).

g. Startup engine. Refer to TM 55-1905-223-10.

h. Observe intake air filter warning indicator for green indication.

2-30. Replace/Repair Turbocharger and Exhaust Group. (Figure 2-11)

This task covers:
a. Removal, b. Repair, c. Replacement.

INITIAL SETUP

Tools

Tool kit, general mechanic's rail and marine diesel engines, 5180-00-629-9783
Torque wrench kit P/N 3377216

Materials/Parts

Anti-seize, pipe thread compound Item 9, Appendix C
Non-aircraft turbosupercharger P/N 3801941
Exhaust outlet connection gasket P/N 190849
Gasket P/N 106322
Turbocharger heat cover P/N 3002138
Nonmetallic hose P/N 3035174
Nonmetallic hose assembly P/N 209959
Exhaust flexible connection P/N 203555
Bent metallic tube P/N 3022867

Equipment Condition

Engine shut down and cooled below 120°F (50°C). TM 55-1905-223-10.
Air supply secured (port).
Battery banks disconnected (starboard).
Air cleaner group removed (paragraph 2-29).

REMOVAL

a. Remove two capscrews (18) from the nut and bolt locking plate (19) and remove the turbocharger heat cover (17).

b. Remove the intake air piping from the turbocharger inlet at point (21, Figure 2-11). See paragraph 2-29.

c. Loosen the clamp on the air crossover connection at point (22, Figure 2-11) on the turbocharger.

d. Disconnect the exhaust outlet connection (7) at V-band clamp (8).

e. Disconnect hose clamps (14) and remove nonmetallic hose (15) from bent metallic tube (13) and pipe-to-hose elbow (16).

f. Disconnect nonmetallic hose assembly (3) at exhaust manifold adapter (2). Remove nonmetallic hose assembly (3) from pipe-to-tube elbow (4).

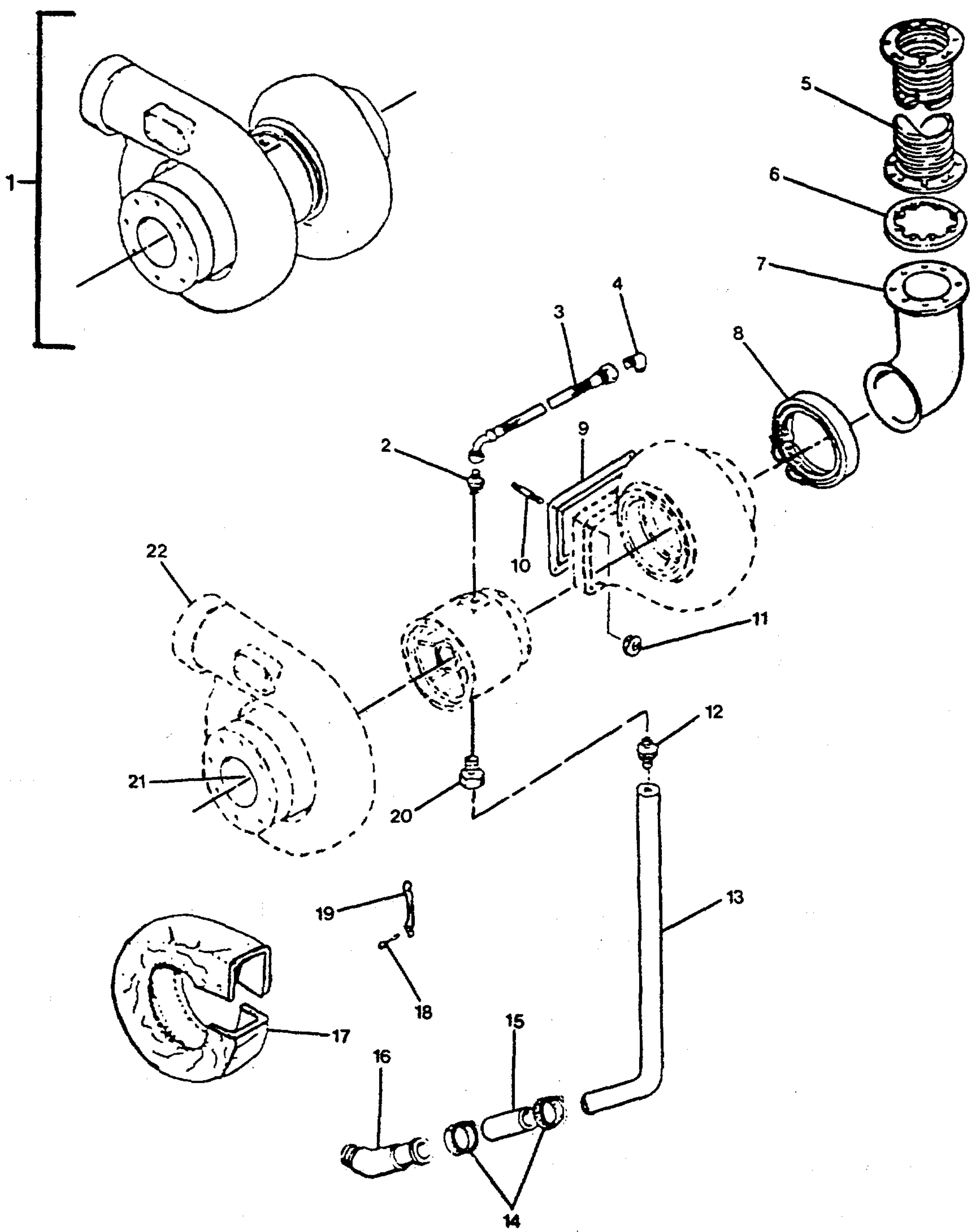


FIGURE 2-11. Turbocharger and Exhaust Group.

g. Remove mounting clamps and hardware from bent metallic tube (13). Remove bent metallic tube (13) from pipe reducer (20) at pipe-to-tube adapter (12).

h. Remove four sleeve nuts (11) from plain studs (10).

i. Remove non-aircraft turbosupercharger (1) and exhaust outlet connection gasket (9). Discard gasket (9).

j. Disconnect the exhaust flexible connection (5) from exhaust outlet connection (7) and remove the gasket (6). Discard gasket (6).

REPAIR

Repair of the turbocharger and exhaust group is by replacing parts listed in materials/parts.

REPLACEMENT

NOTE

Ensure gasket surfaces are clean before installing gasket.

a. Install a new gasket (6) and connect the flexible connection (5) to the exhaust outlet connection (7).

b. Position new exhaust outlet connection gasket (9) and non-aircraft turbosupercharger (1) on the studs (10). Ensure the gasket sealing surfaces are clean and that the raised bead on the gasket is towards the turbocharger.

c. Apply anti-seize pipe thread compound to the stud threads (10) and install nuts (11). Tighten nuts (11) to 20-25 ft-lb (27.1-33.8 N•m) torque.

d. Install bent metallic tube (13) to the pipe reducer (20) on the turbocharger with the adapter (12). Connect hose (15) with clamps (14) to tube (13) and elbow (16). Tighten clamps (14). Install clamps with hardware to tube (13).

e. Connect the hose (3) to elbow (4). Connect the hose (3) to the adapter (2).

f. Connect the outlet connection (7) to the turbocharger (1) with V-band clamp (8).

g. Connect the air crossover connection from the intake manifold to point (22) on the turbocharger (1).

h. Connect the intake air piping to the turbocharger at point (21). See paragraph 2-29.

i. Install the heat cover (17, Figure 2-11) on the turbocharger (1) with capscrews (18) and locking plate (19).

j. Remove tags, turn on electrical power, start the engine (TM 55-1905-223-10), and check for leaks. Correct as required.

2-31. Replace/Repair Fuel Filter Group. (Figure 2-12)

This task covers:
a. Removal, b. Repair, c. Replacement

INITIAL SETUP:

Tools

Tool kit, general mechanic's rail
and marine diesel engines,
5180-00-629-9783
Strap wrench P/N 3376807
Torque wrench P/N 3377216

Materials/Parts

Lubricating oil, Item 2, Appendix C
Teflon pipe thread lubricant,
Item 11, Appendix C
Fuel cartridge P/N 3315847
Nonmetallic hose assembly
P/N AM1002200SS
Container to catch fuel run-off
when removing filters.

Equipment Condition

Engine shut down and cooled below
120°F (50°C). TM 55-1905-223-10.
Fuel supply valve closed and tagged.
Air supply secured (port).
Battery banks disconnected (starboard).

REMOVAL

a. Close fuel supply valve to the fuel filter assembly. TM 55-1905-223-10.

NOTE

Place a container under the filters when removing them to catch fuel run-off.

b. Remove the two fuel cartridges (7), using a strap wrench, and turning counterclockwise. Discard the cartridges (7).

c. Disconnect nonmetallic hose assembly (8) at elbow (9) and nonmetallic hose assembly (5) at elbow (6).

d. Disconnect nonmetallic hose assemblies (8 and 5) at fuel supply and outlet fittings (4).

e. Remove four assembled washer screws (1) to remove the fluid filter head (3) from the angle bracket (2).

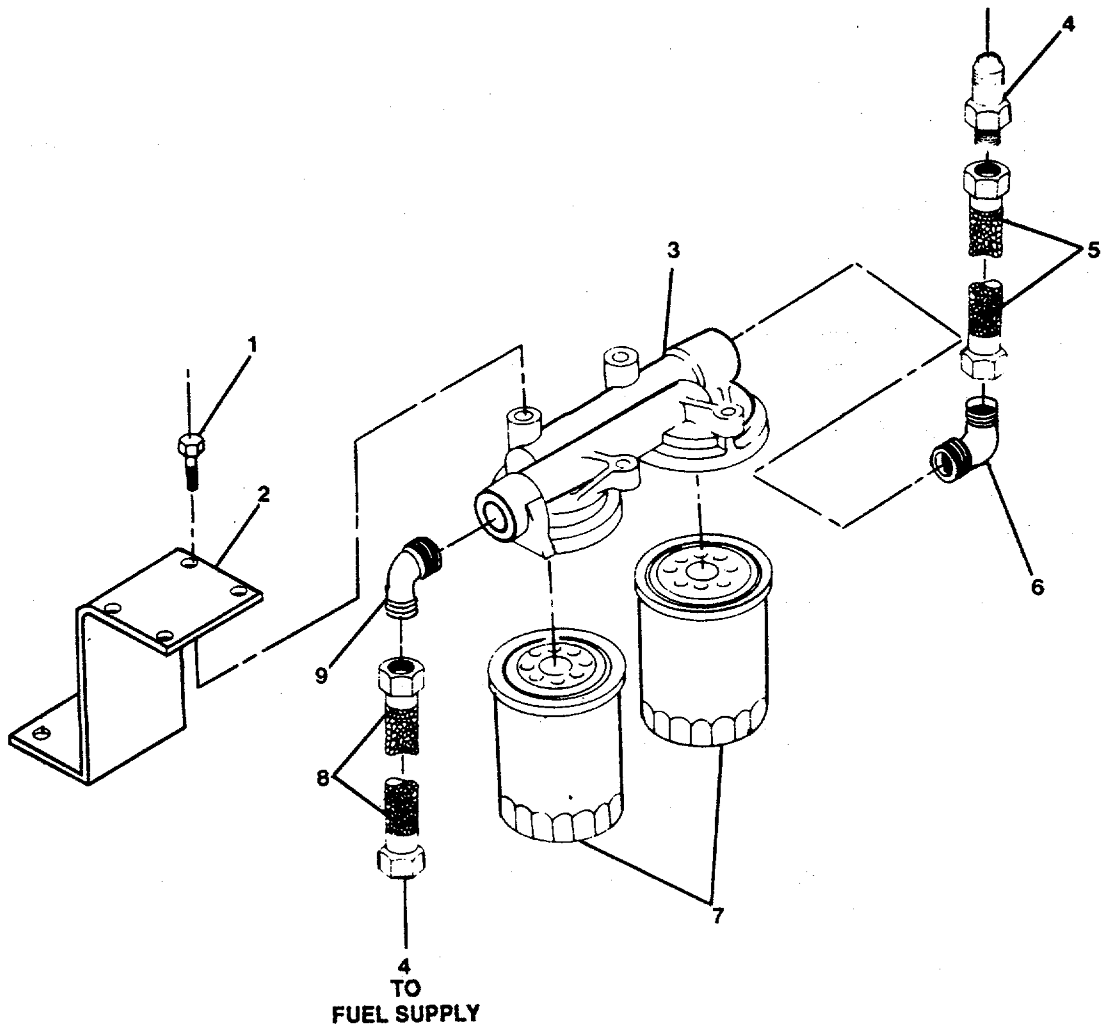


FIGURE 2-12. <u>Fuel Filter Group</u>.

REPAIR

Repair of the fuel filter group is by replacement of parts. Refer to Removal and Replacement steps of this procedure.

REPLACEMENT

a. Mount the fluid filter head (3) to the bracket with assembled washer screws (1). Tighten screws to 30 to 35 ft-lb (40.6 to 47.4 N•m) torque.

b. Apply teflon pipe thread lubricant to threads exposed on elbows (6 and 9). Connect nonmetallic hose assemblies (8 and 5) to elbows (6 and 9).

c. Connect nonmetallic hose assembly (8) to fuel supply (4).

d. Connect nonmetallic hose assembly (5) to outlet fitting (4) on fuel pump.

e. Install two new fuel cartridges (7) to the head (3) as follows:

(1) Apply a light coat of lubricating oil to the gaskets on the cartridges (7).

NOTE

Do not use a strap wrench to install filter cartridge.

(2) Install the cartridge (7) by hand, turning clockwise, until the gasket on the cartridge (7) contacts the gasket surface on the head (3). Then tighten another 1/2 to 3/4 turn. Repeat sequence for other cartridge.

f. Open the fuel supply valve (TM 55-1905-223-10), remove tags, and run engine to check for leaks. Correct as required.

2-32. Replace/Repair Sump Pump Group. (Figure 2-13)

This task covers:

a. Removal, b. Repair, c. Replacement

INITIAL SETUP:

Tools

Tool kit, general mechanic's rail and marine diesel engines, 5180-00-629-9783

Equipment Condition

Engine shut down and cooled below 120°F (50°C). TM 55-1905-223-10.
Air supply secured (port).
Battery banks disconnected (starboard).

Materials/Parts

Lubricant, teflon, pipe thread, Item 11, Appendix C
Rotary pump P/N 123822
Nonmetallic hose assembly P/N AM1005400SS
Shutoff valve P/N 3200802

REMOVAL

a. Disconnect the loop clamp (12) and-hardware from around nonmetallic hose assembly (14).

b. Disconnect nonmetallic hose assembly (14) from elbows (13, 15). Remove elbow (13) and shutoff valve (11).

c. Disconnect the outlet pipe at point (5) on top of the pump (6). Remove the pipe elbow (9), pipe nipples (8, 10) and pipe bushing (7) from the bottom of the pump (6).

d. Remove the three capscrews (2), lockwashers (3), and flat washers (4), and remove the pump (6) from the angle bracket (1).

e. If the pipe-to-hose elbow (15) and the pipe bushing (16) are to be replaced, remove them from the engine.

REPAIR

Repair of the sump pump group consists of replacing rotary pump, nonmetallic hose assembly and shutoff valve.

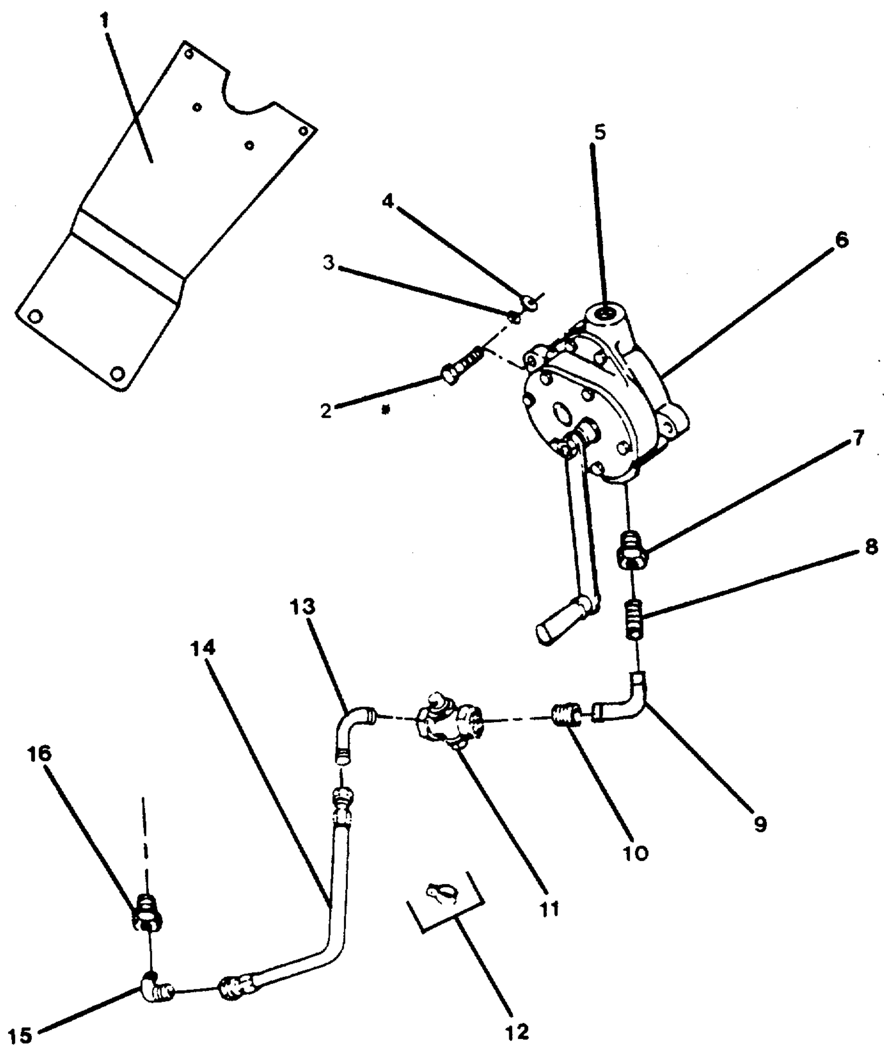


FIGURE 2-13. Sump Pump Group.

REPLACEMENT

NOTE

Apply teflon pipe thread lubricant to threaded fittings.

a. If the elbow (15) and reducer (16) were removed, apply a thin coating of teflon pipe thread lubricant to the threads, and replace them on the engine.

b. Mount the pump (6) to bracket (1) with the capscrews (2) and washers (3, 4). Apply a thin coating of teflon pipe thread lubricant to the threads and install the pipe bushing (7) pipe nipples (8, 10) and elbow (9) to the bottom of the pump (6).

c. Install the shutoff valve (11) and elbow (13) and connect the hose (14) to elbows (13 and 15) and tighten.

d. Connect the clamp (12) to hose (14). Tighten hardware.

e. Connect the outlet pipe to the top of the pump at point (5).

f. Operate the sump pump (TM 55-1905-223-10) and check for leaks. Tighten fitting as required.

g. Return the generator to service. TM 55-1905-223-10.

2-33. Replace/Repair Water Pump and Idler Group.

This task covers:
a. Inspection b. Adjustment c. Removal d. Repair e. Replacement

INITIAL SETUP

Tools

Tool kit, general mechanic's rail and marine diesel engines, 5180-00-629-9783
Torque wrench kit P/N 3377216
Belt tension gauge P/N ST-1293

Materials/Parts

Cooling system engine pump P/N 3801708
V-belt P/N 217638
Gasket P/N 3024960
Water pump gasket P/N 3002385
Bearing retaining ring P/N S-16255
Annular ball bearing P/N 115519 (8 ea.)
Ring spacer P/N 3050395
Centrifugal pump impeller P/N 3000888
Packing with retainer P/N 3033677
Spacer P/N 196844
Preformed packing P/N 43463-A
Belt-chain tension adjusting device P/N 3050398
Rags, Item 4, Appendix C

Equipment Condition

Engine shut down and cooled below 120°F (50°C). TM 55-1905-223-10.
Cooling system drained (Table 2-1, Item 24).
Air supply secured (port).
Battery banks disconnected (starboard). TM 55-1905-223-10

INSPECTION

a. Remove the water pump belt guard (21, Figure 2-14). Refer to Removal step in this procedure.

b. Remove the water pump V-belt (25). Refer to Removal step in this procedure.

c. Turn the groove pulley (18) by hand to check ease of rotation. If the pulley (18) does not turn easily, replace the belt tension adjusting device (20).

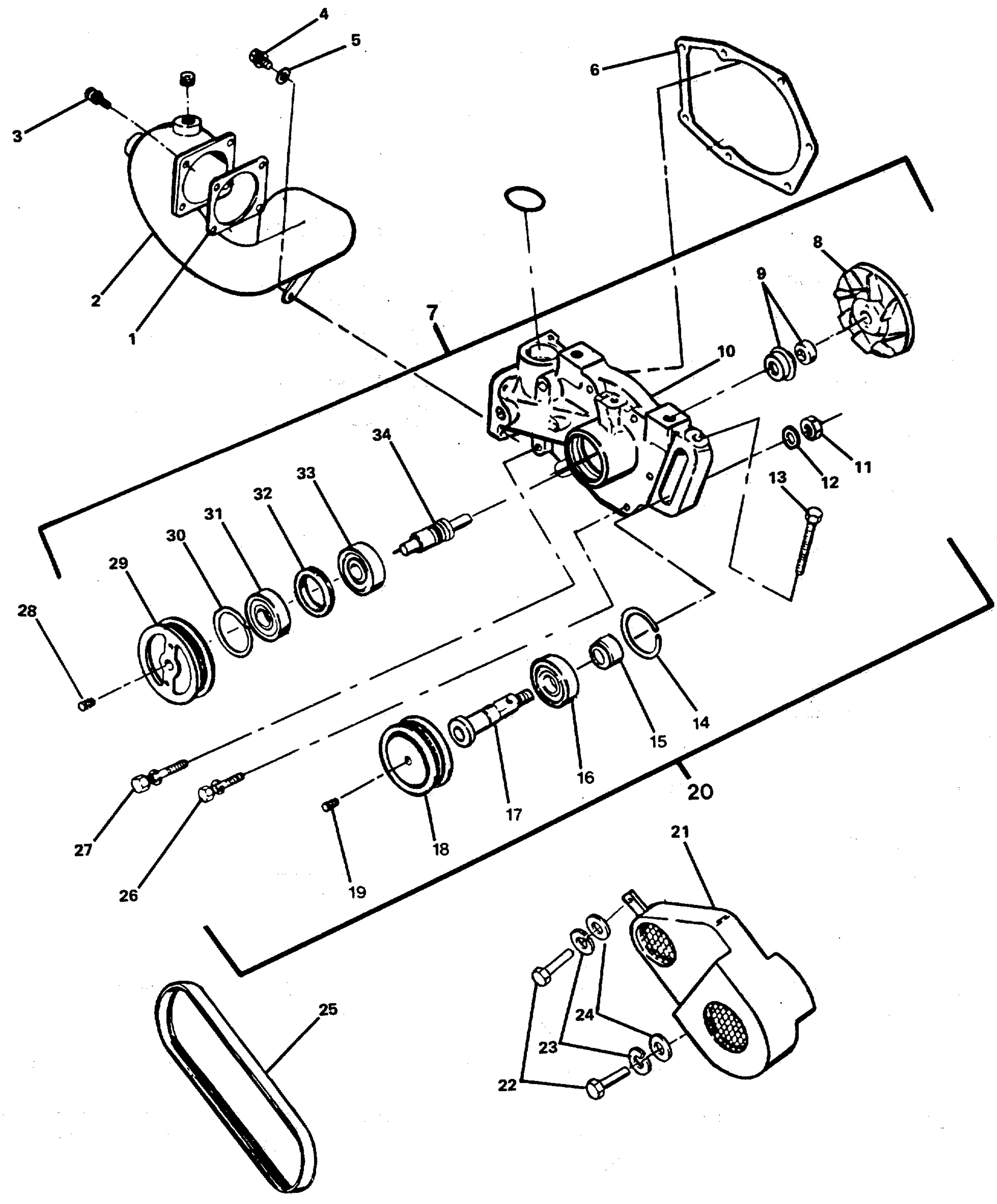


FIGURE 2-14. Water Pump and Idler Group.

d. Visually inspect the water pump pulley (28) and pulley (18) for cracked, chipped, or broken pulley grooves. Replace if damaged.

e. Visually inspect pulleys (18, 28) and V-belt (25) alignment. Misalignment between pulleys (18, 28) shall not exceed 1/16 inch per foot (0.5 mm per cm) of distance between the pulley centers. Replace the water pump (7) or the device (20) if they are not in alignment.

ADJUSTMENT

a. Remove the water pump belt guard (21, Figure 2-14). Refer to Removal step in this procedure.

b. Loosen the idler shaft nut (3, Figure 2-15).

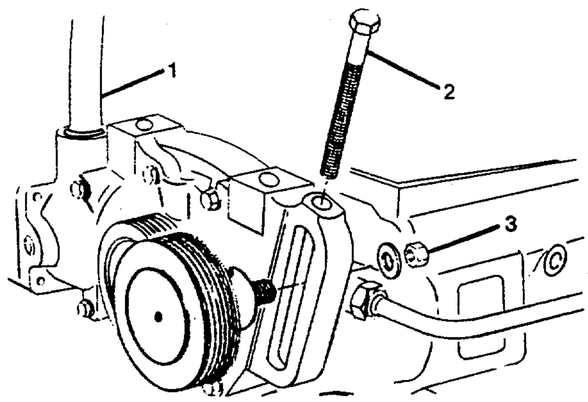


FIGURE 2-15. Water Pump Belt Adjustment.

c. Turn the capscrew (2) counterclockwise to release tension on the belt.

NOTE

Belt tension can increase when the nut (3) is tightened. Do not adjust belt tension to full value with the capscrew (2).

d. Turn the capscrew (2) to adjust the belt tension.

e. Use belt tension gauge to measure belt tension as follows:

(1) 150 to 160 ft-lb (200 to 220 N•m) for new belt.

(2) 70 to 120 ft-lb (45 to 165 N•m) for used belt.

f. When the belt is tight, tighten the idler shaft nut (3) to 50 ft-lb (67.7 N•m) torque.

g. Loosen the capscrew (2) 1/2 turn to prevent V-belt breakage during operation.

h. Install the water pump belt guard (21, Figure 2-14). Refer to Replacement step in this procedure.

REMOVAL

a. Drain coolant. Refer to Table 2-1, Item 24.

b. Remove the two capscrews (22, Figure 2-14), lockwashers (23) and flat washers (24) and remove the water pump belt guard (21).

c. Loosen the idler shaft nut (11).

d. Turn the capscrew (13) counterclockwise to release tension and remove the water pump V-belt (25). Remove the nut (11) and washer (12) to remove the adjusting device (20). Remove the capscrew (13) from the water pump body (10).

e. Remove the rim-clenching clamp (16, Figure 2-9) and disconnect the tube connection (1, Figure 2-15). Refer to paragraph 2-28.

f. Remove the four machine screws (3, Figure 2-14) and the assembled washer screw and flat washer (4, 5) and remove the engine water outlet (2). Discard the gasket (1).

g. Remove the six capscrews (26 and 27) from the water pump body (10).

NOTE

The water pump must be removed carefully to prevent damage to the impeller (8).

h. Remove the water pump body (10) from the engine.

i. Remove gasket (6). Discard the gasket.

REPAIR

Repair of the water pump and idler group consists of replacement of parts listed in Materials/Parts.

a. Disassemble and replace adjusting device (20, Figure 2-14) parts as follows:

(1) Remove the machine thread plug (19) and remove the groove pulley (18).

(2) Remove the retainer ring (14), the spacer ring (15), and annular ball bearing (16) from the idler shaft (17).

b. Clean all adjusting device (20) parts to be reused before assembly.

c. Assemble the adjusting device (20) parts as follows:

(1) Install the bearing (16), the spacer (15) and the retaining ring (14) on to the idler shaft (17).

(2) Install the groove pulley (18) and plug (19).

d. Disassemble and replace the engine pump cooling system (7) components as follows:

(1) Remove the machine thread plug (28) and the water pump pulley (29).

(2) Remove the retaining ring (30), the annular ball bearing (31), the spacer (32), and the annular ball bearing (33) from the shouldered shaft (34).

(3) Remove the impeller (8), packing with retainer (9), and shaft (33) from the body (10). Remove the impeller (8), retainer (9), and packing (9) from the shaft (34). Discard packing.

e. Clean all parts to be reused before assembly.

f. Assemble the shaft (34) components as follows:

(1) Install on the shaft (34), new packing with retainer (9) and the impeller (8). Install into the body (10).

(2) Install bearing (33), spacer (32), and bearing (31) onto the shaft (34). Install the retaining ring (30).

(3) Install the pulley (29) onto the shaft (34) and secure with plug (28).

REPLACEMENT

a. Ensure gasket surfaces are clean on the body (10, Figure 2-14) and engine.

b. Use new gasket (6) and install the water pump (7) to the engine with capscrews (26, 27). Use new gasket (1) and connect the engine water outlet (2) to the body (10) with screws (3). Do not tighten screws until all have been installed.

c. Tighten the capscrews (26, 27) in the sequence shown in Figure 2-16 to the following values.

(1) Tighten to 10 ft-lb (13.5 N•m) torque.

(2) Tighten to 20 ft-lb (27.1 N•m) torque.

(3) Tighten to 35 ft-lb (47.4 N•m) torque.

d. Install washer (5, Figure 2-14) and screw (4).

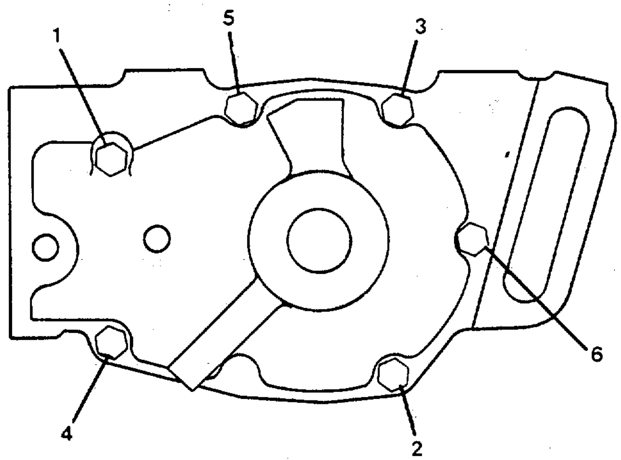


FIGURE 2-16. Water Pump Torque Sequence.

e. Tighten the capscrews (3) and the screw (4) to the 35 ft-lb (47.4 N•m) torque.

f. Install the preform packing and transfer tube to the top of the body (10) with the rim-clenching clamp (paragraph 2-28).

g. Install the adjusting device (20) in the adjustment slot in the water pump body (10) and install lockwasher (12) and nut (11). Do not tighten the nut until the V-belt (25) has been installed.

h. Install the capscrew (13) into the body (10). Turn the capscrew only a few turns.

i. Install a new V-belt (25) and adjust. Refer to the Adjustment steps in this procedure.

j. Install the belt guard (21) with capscrews (22), lockwashers (23) and flat washers (24).

k. Fill the cooling system. Refer to Table 2-1, Item 24.

i. Remove tags, turn on electrical power, run the engine (TM 55-1905-223-10), and check for leaks. Correct as required.

2-34. Replace/Repair Lubricating Oil Cooler/Filter Group. (Figure 2-17)

This task covers:
a. Removal, b. Repair, c. Replacement

INITIAL SETUP:

Tools

Tool kit, general mechanic's rail
and marine diesel engines,
5180-00-629-9783
Filter wrench P/N 3375049
Filter cutter P/N 3376579
Torque wrench kit P/N 3377216

Materials/Parts

Lint-free paper towel, Item 43,
Appendix C
Lubricating oil, Item 2, Appendix C
Preformed hose P/N 3031560
Oil cooler gasket P/N 3008017
Fluid filter element P/N 3313279
Preformed packing P/N 3302630
Gasket P/N 3308958
Coolant, Item 8, Appendix C

Equipment Condition

Engine shut down and cooled below
120°F (50°C). TM 55-1905-223-10.
Cooling system drained (Table 2-1,
Item 24.)
Air supply secured (port).
Battery banks disconnected (starboard).

REMOVAL

a. Disconnect the coolant heater hose clamp connection at point (18).

b. Loosen the hose clamps (19) on the preformed hose (20) and the water transfer tube (17). Remove the transfer tube (17), and preformed hose (20).

c. Using filter wrench, remove the fluid filter element (12).

NOTE

The old filter should be cut open with a filter cutter and inspected. Inspect the element for metal particles. If metal particles are found in the element, direct support maintenance is required.

d. Remove the capscrew (1) and flat washer (2) that holds the angle bracket (3) and the oil cooler housing (4) to the cylinder block.

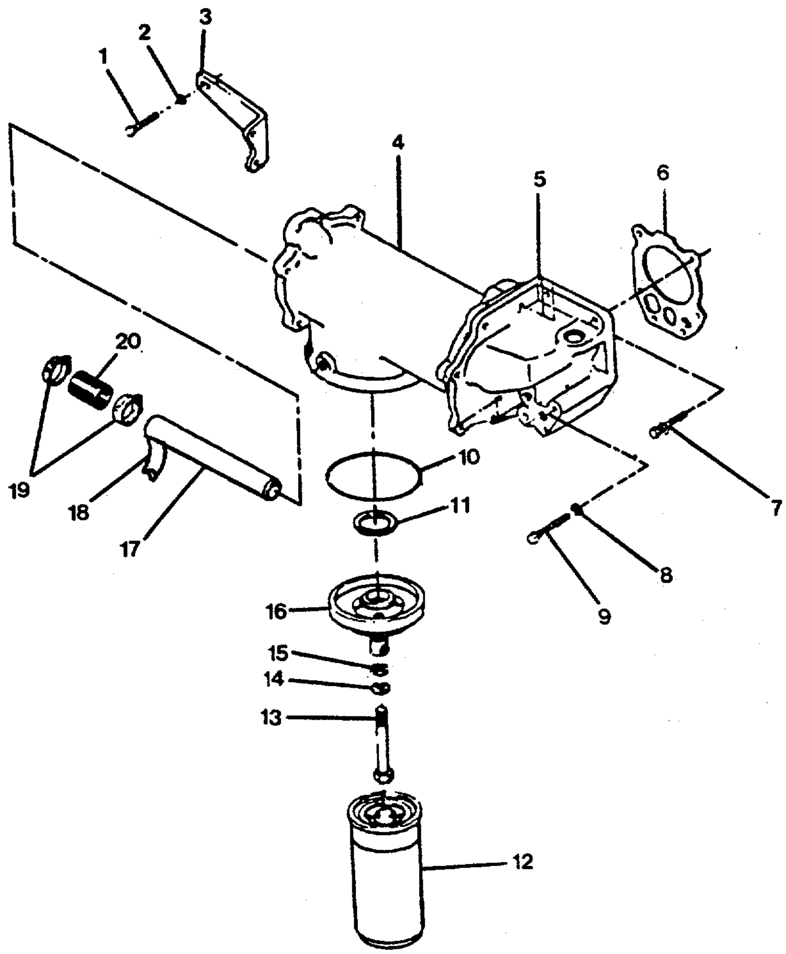


FIGURE 2-17. Lubricating Oil Cooler/Filter Group.

e. Remove the two machine screws (7) and the two hexagon capscrews (9) and lockwashers (8) that holds the oil cooler support (5) and the oil cooler housing (4) to the cylinder block.

f. Remove oil cooler housing (4), oil cooler support (5) and gasket (6). Discard gasket.

g. Remove assembled washer screws (13), lockwasher (14), and flat washer (15) to remove the fluid filter head (16) and preformed packing (10) and gasket (11). Discard packing and gasket.

REPAIR

Repair of the Lubricating Oil Cooler/Filter Group is by replacement of parts listed in Materials/Parts.

REPLACEMENT

a. Install a new oil cooler support gasket (6).

b. Position the oil cooler housing (4) and oil cooler support (5)on the cylinder block.

c. Install machine screws (7), capscrews (9) and lockwashers (8). Tighten the capscrews to 30 to 35 ft-lb (41 to 47 N•m) torque.

d. Install capscrew (1) and washer (2) in the angle bracket (3). Tighten the capscrew to 30 to 35 ft-lb (41 to 47 N•m) torque.

e. Install the water transfer tube (17) into the rear of the oil cooler housing (4). Install preformed hose (20) and hose clamps (19).

f. Install the fluid filter head (16), using new preformed packing (10) and gasket (11), with flat washer (15), lockwasher (14), and assembled washer screw (13).

NOTE

Fill the fuel filter element with clean lube oil before installing.

g. Apply a coat of clean oil to the sealing gasket of the fluid filter element (12). Install the fluid filter element (12) and hand tighten until gasket touches sealing surface, and hand tighten an additional 1/2 to 3/4 turn.

h. Connect the coolant heater hose with clamp to the transfer tube (17) at point (18).

NOTE

Ensure there is a minimum of 0.250 inch (6.3 mm) clearance between the filter and the oil pan flange of the cylinder block.

i. Fill the cooling system.

j. Remove tags, turn ON electrical power, start the engine (TM 55-1905-223-10),and check for leaks. Correct as required.

2-35. Replace/Repair Lube Oil Bypass Filter Group. (Figure 2-18)

This task covers:
a. Removal, b. Repair, c. Replacement

INITIAL SETUP:

Tools

Tool kit, general mechanic's rail marine diesel engines, 5180-00-629-9783
Filter wrench P/N 3375049
Filter cutter P/N 3376579

Materials/Parts

Lubricating oil, Item 2, Appendix C
Fluid filter element P/N 3313289
Nonmetallic hose assembly P/N AS0603200SS
Nonmetallic hose assembly P/N AS0603600SS
Filter head P/N 3304173

Equipment Condition

Engine shut down and cooled below and 120°F (50°C). TM 55-1905-223-10.
Air supply secured (port).
Battery banks disconnected (starboard).

REMOVAL

a. Remove hexagon head capscrew (10) and loop clamp (9) from nonmetallic hose (11).

b. Remove hexagon head capscrew (16), lockwasher (17), flat washer (18) and remove loop clamp (19) from nonmetallic hose assembly (15).

c. Disconnect each nonmetallic hose assembly (11, 15) from the inlet and outlet oil lines.

d. Using filter wrench, remove the fluid filter element (14) by turning it counterclockwise.

NOTE

The old filter should be cut open with a filter cutter and inspected. Inspect the element for metal particles. If metal particles are found in the element, direct support maintenance is required.

e. Remove three hexagon capscrews (8), lockwashers (6), flat washers (7), plain hexagon nuts (5) and remove the fluid filter head (13) from the angle bracket (3)

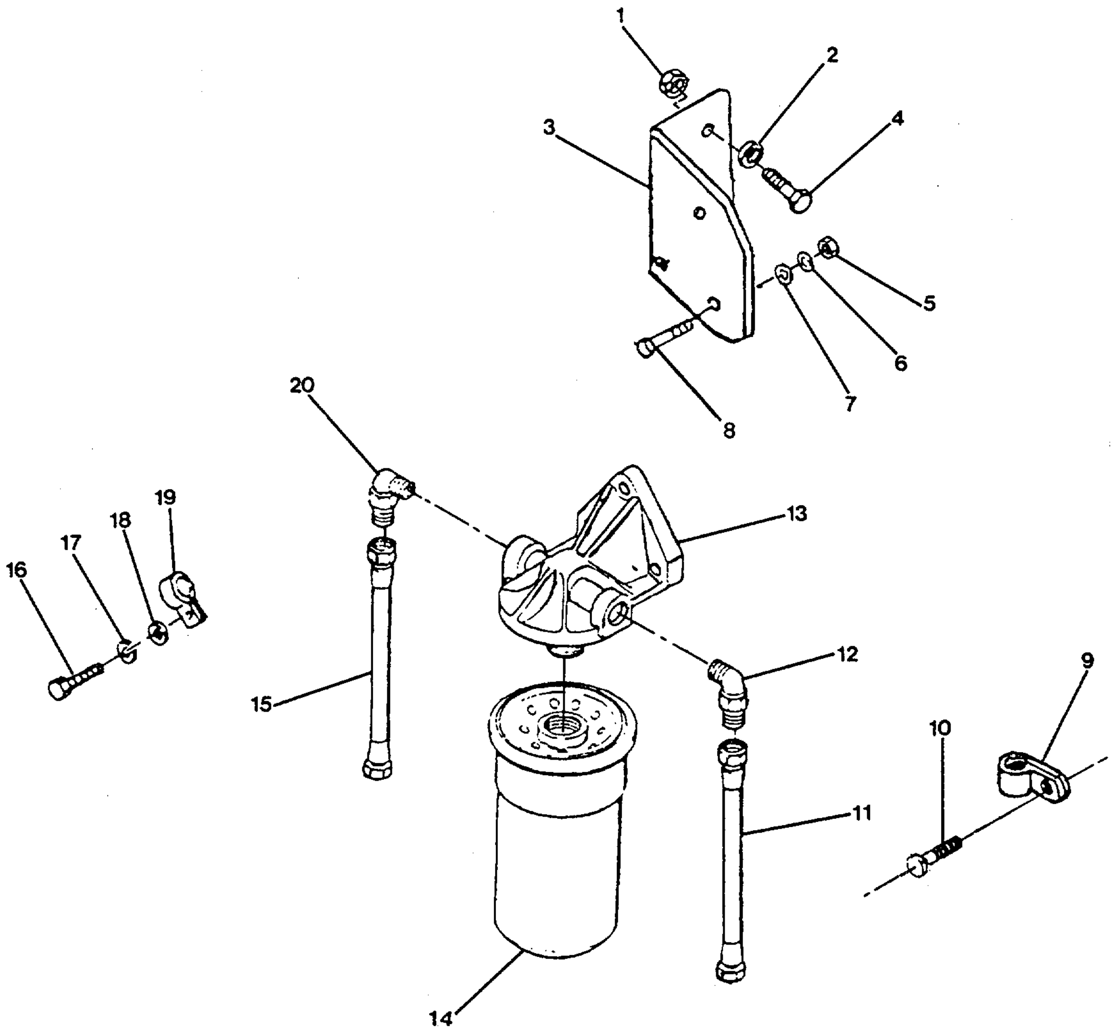


FIGURE 2-18. Lube Oil Bypass Filter Group.

REPAIR

Repair to the lube oil bypass filter group is by replacement of parts listed in Materials/Parts.

REPLACEMENT

a. Position fluid filter head (13) on the angle bracket (3) and install three hexagon capscrews (8), flat washers (7), lockwashers (6), and plain hexagon nuts (5).

b. Apply a light coat of engine oil to the gasket surface of the filter (14) and install the new filter by turning clockwise, by hand. Turn the filter (14) until the gasket surface on the filter (14) contacts the head (13) surface. Tighten another 1/2 to 3/4 turn.

c. Connect nonmetallic hose assemblies (11, 15) to inlet and outlet oil lines.

d. Install loop clamp (9) and secure with hexagon headcapscrew (10).

e. Install loop clamp (19) and secure with hexagon head capscrew (16), lockwasher (17), and flat washer (18).

f. Return generator to service. TM 55-1905-223-10.

g. Check for leaks.

2-36. Replace/Repair Coolant Heater Group.

This task covers:
a. Removal, b. Repair, c. Replacement

INITIAL SETUP:

Tools

Tool kit, general mechanic's rail
and marine diesel engines,
5180-00-629-9783
DCA test kit P/N 3300846S

Equipment Condition

Engine shut down and cooled below
120°F (50°C). TM 55-1905-223-10.
Cooling system drained (Table 2-1,
Item 24).
Air supply secured (port).
Battery banks disconnected (starboard).

Materials/Parts

Coolant, Item 8, Appendix C
Coolant engine heater P/N 212024
Preformed hoses P/N 3000270
Nonmetallic hose assembly P/N AS0403000SS
Nonmetallic hoses P/N 155789
Pressure switch P/N 196074

REMOVAL

WARNING

Turn OFF and tag the electrical power switch to the engine coolant heater.

a. Loosen hose clamps (15 and 17, Figure 2-19) and disconnect nonmetallic hoses (18 and 23) from straight pipe-to-hose adapter (19) and engine.

b. Remove nonmetallic hoses (18 and 23) and heater tube (16).

c. Loosen hose clamps (2) and disconnect preformed hose (32) from water transfer tube (1).

d. Loosen hose clamps (30) and disconnect preformed hose (31) from pipe-to-tube elbow (29).

e. Remove preformed hoses (31 and 32) with bent metallic tube (3).

f. Remove hexagon capscrew (5), lockwasher (4), and remove loop clamp (14) from nonmetallic hose assembly (6).

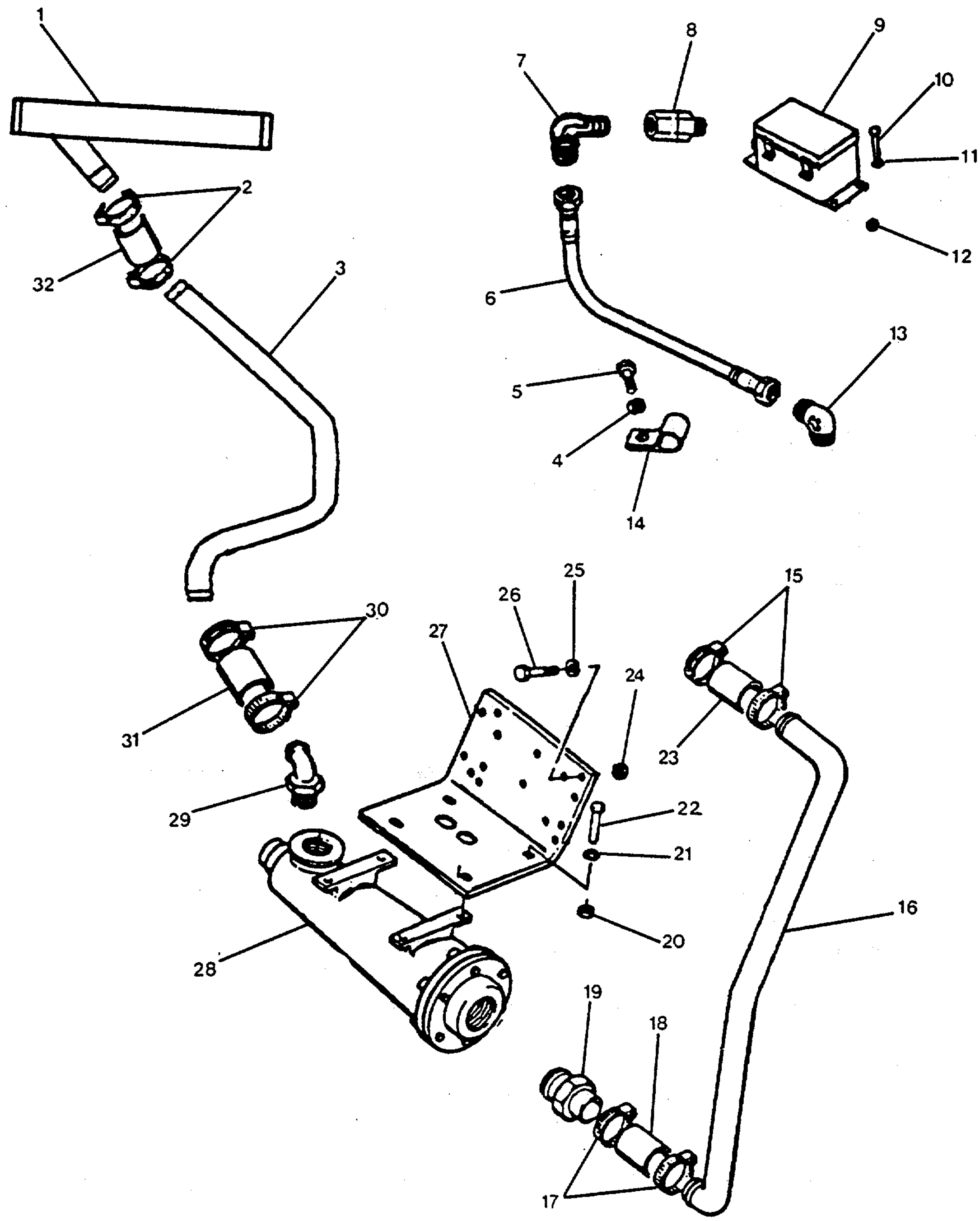


FIGURE 2-19. Coolant Heater Group.

g. Disconnect nonmetallic hose assembly (6), pipe-to-tube elbow (7), and tube-to-hose elbow (13) and remove.

h. Remove straight pipe-to-hose adapter (8) from pressure switch (9).

NOTE

The electrical boxes and cabling are removed with the engine coolant heater (28). Figure 2-20 shows location of electrical boxes for reference only.

i. Tag and disconnect electrical wiring from pressure switch (9).

j. Remove hexagon head capscrews (10), lockwashers (11), and plain hexagon nuts (12) securing pressure switch (9) to angle bracket (27).

k. Remove pressure switch (9).

l. Remove four hexagon head capscrews (22), lockwashers (21), and plain hexagon nuts (20) securing engine coolant heater (28) to angle bracket (27).

m. Remove engine coolant heater (28).

n. Remove pipe-to-hose elbow (29) and straight pipe-to-hose adapter (19) from engine coolant heater (28).

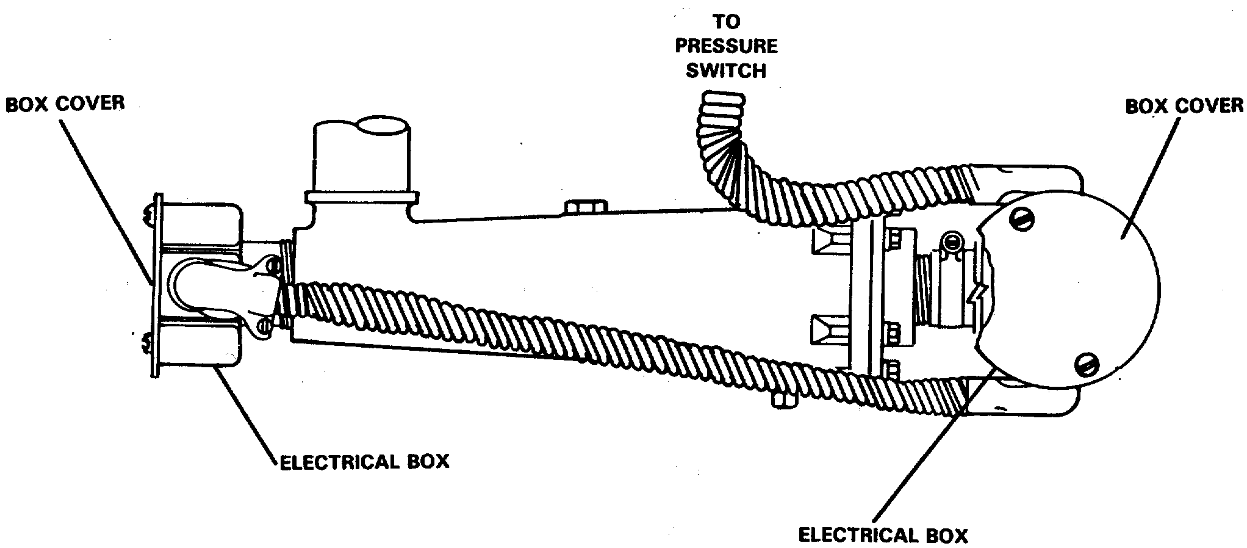


Figure 2-20. Location of Electrical Boxes.

REPAIR

Repair of the coolant heater group consists of replacing preformed hoses (31 and 32), nonmetallic hoses (18 and 23), nonmetallic hose assembly (6), pressure switch (9), and engine coolant heater (28).

REPLACEMENT

a. Install straight pipe-to-hose adapter (19) and pipe-to-hose elbow (29) on engine coolant heater (28).

b. Position engine coolant heater (28) on angle bracket (27) and secure with four plain hexagon nuts (20), lockwashers (21), and hexagon head capscrews (22).

c. Install pressure switch (9) on angle bracket (27) and secure with plain hexagon nuts (12), lockwashers (11), and hexagon head capscrews (10).

d. Connect electrical wiring to pressure switch (9). Remove tags.

e. Install straight pipe-to-hose adapter (8) on pressure switch (9).

f. Install pipe-to-tube elbow (7) and tube-to-hose elbow (13).

g. Connect nonmetallic hose assembly (6) to pipe-to-tube elbow (7) and tube-to-hose elbow (13).

h. Install loop clamp (14) and secure with lockwasher (4) and hexagon capscrew (5).

i. Install preformed hoses (31 and 32) on bent metallic tube (3) with hose clamps (2 and 30).

j. Connect preformed hose (31) to pipe-to-tube elbow (29) and secure with hose clamp (30).

k. Install nonmetallic hoses (18 and 23) on heater tube (16) and secure with hose clamps (15 and 17).

l. Install nonmetallic hose (18) on straight pipe-to-hose adapter (19) and secure with hose clamp (17).

m. Install nonmetallic hose (23) on engine and secure with hose clamp (15).

NOTE

- Refill the engine with coolant with bent metallic tube (3) disconnected until heater tube (16) is full of coolant. This will eliminate airlocks in the heater and hoses.

- If coolant is added between drain intervals, additional coolant additive (DCA or equivalent) could be required.

n. Before adding coolant the coolant additive concentration must be checked using the DCA test kit and TB 55-1900-207-24.

o. Add coolant as required using a minimum concentration of one DCA unit for each U.S. gallon (3.8 litre) of cooling system capacity.

NOTE

One DCA unit equals 1.5 dry ounces (42 grams) or 4.0 fluid ounces (118 millilitres).

CAUTION

Do not use more than two DCA units per U.S. gallon (3.8 litre) as over concentration will cause sludge in cooling system.

p. Connect preformed hose (32) to water transfer tube (1) and secure with hose clamp (2).

q. Continue filling cooling system.

r. Remove tags and return generator to service. TM 55-1905-223-10.

s. Start the engine. TM 55-1905-223-10.

t. Check the engine for leaks. Correct as required.

2-37. REPLACE PUMP, FUEL, METERING AND DISTRIBUTING ASSEMBLY . (Figure 2-21)

This task covers:
a. Removal, b. Replacementd.

INITIAL SETUP:

Tools

Tool kit, general mechanic's rail
and marine diesel engines,
5180-00-629-9783
Torque wrench kit P/N 3377216

Materials/Parts

Fuel metering and distribution pump
assembly P/N 3052770-9867

Equipment Condition

Engine shut down and cooled below
120ºF (50ºC). TM 55-1905-223-10.
Fuel supply closed and tagged at the
fuel filter outlet valve.
TM 55-1905-223-10.
Air supply secured (port).
Battery banks disconnected (starboard).
TM 55-1905-223-10.

REMOVAL

a. Clean the fuel pump and surrounding area before removing it from the engine.

b. Disconnect the 24 Vdc emergency switchboard buss battery cables. TM 55-1905-223-10.

c. Tag and remove wires to the solenoid shutoff valve (4).

d. Tag and remove wires from the electric governor actuator (1).

e. Disconnect the following:

(1) Gear pump suction line (6).

(2) Tachometer cable (13).

(3) Fuel return line (14).

(4) Air supply hose (2).

(5) Fuel supply line to the injectors (3).

(6) Gear pump cooling drain (5).

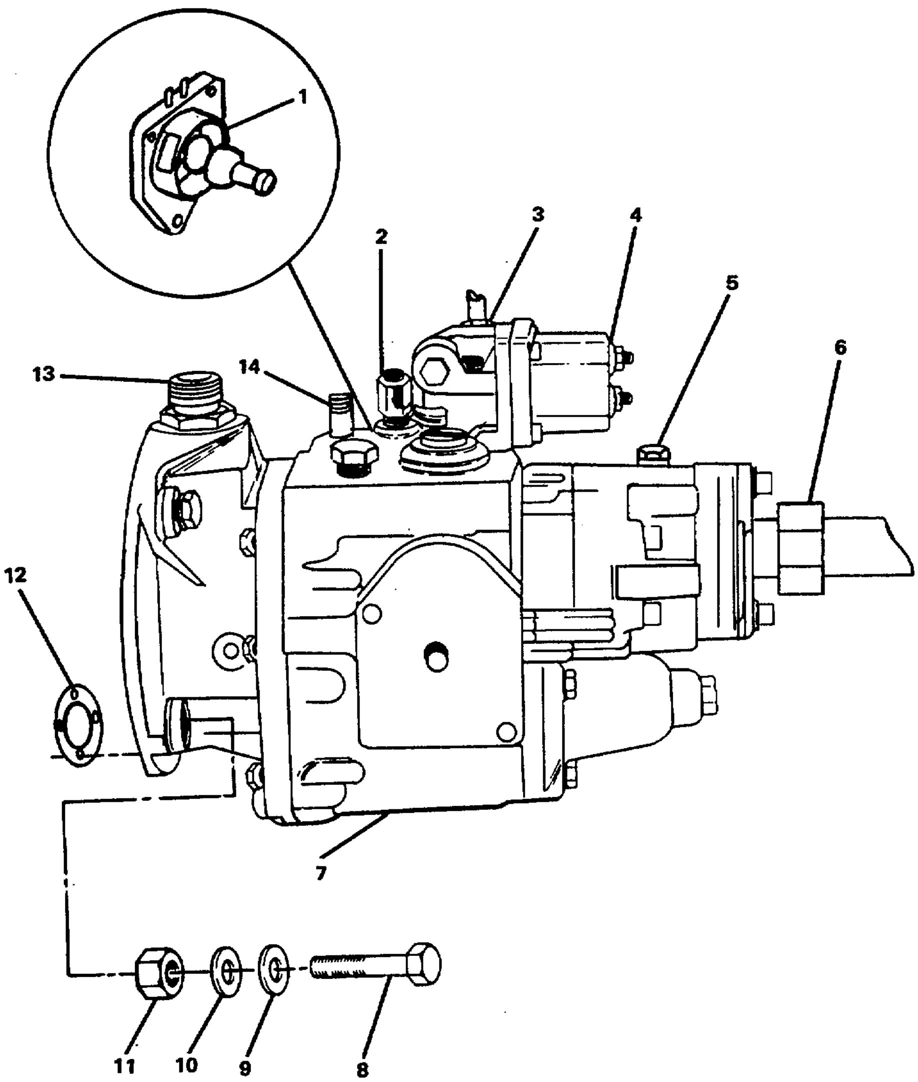


FIGURE 2-21. Pump, Fuel, Metering and Distributing Assembly.

f. Remove four hexagon capscrews (8), lockwashers (9), flat washers (10), plain hexagon nuts (11) and remove the pump assembly (7) and gasket (12). Discard gasket.

REPLACEMENT

a. Install a new gasket (12) on pump assembly (7). Ensure gasket surfaces are clean.

b. Position pump assembly (7) and secure with four plain hexagon nuts (11), flat washers (10), lockwashers (9), and hexagon capscrews (8). Tighten capscrews to 35 ft-lb (47.4 N-m) torque.

c. Connect the following:

(1) Gear pump suction line (6) (fuel inlet connection).

(2) Tachometer cable (13).

(3) Fuel return line (14).

(4) Air supply hose (2).

(5) Fuel supply to the engine (3) (fuel outlet connection).

(6) Gear pump cooling drain (5).

d. Connect shutoff valve (4) electrical wires and remove tags.

e. Connect the governor actuator (1) wires and remove tags.

f. Connect the 24 Vdc emergency switchboard buss battery cables. TM 55-1905-223-10.

g. Remove tags and turn on electrical power to the engine. TM 55-1905-223-10.

h. Open all valves that were closed and tagged. Remove tags.

i. Start the engine (TM 55-1905-223-10) and check for leaks.

2-38. REPLACE/REPAIR FUEL TUBING GROUP. (FIGURE 2-22)

This task covers:
a. Removal **b. Repair** **c. Replacement**

INITIAL SETUP

Tools

Tool kit, general mechanic's rail and marine diesel engines, 5180-00-629-9783

Materials/Parts

Check valve P/N 178079
Check valve P/N 3028325
Ring spacer P/N 65434

Equipment Conditions

Engine shut down and cooled below 120ºF (50ºC). TM 55-1905-223-10.
Fuel supply closed and tagged. TM 55-1905-223-10.
Air supply secured (port).
Battery banks disconnected (starboard). TM 55-1905-223-10.

REMOVAL

a. Disconnect metallic tube (21) and machine thread plug (22) from fuel pump.

b. Disconnect and remove metallic tube (21) and pipe union (17) from check valve (18).

c. Disconnect bent metallic tube (8) from pipe tee (7).

d. Disconnect and remove bent metallic tube (8) and pipe union (20) from check valve (18).

e. Disconnect bent metallic tube (5) from pipe-to-tube elbow (6).

f. Disconnect and remove bent metallic tube (5) from pipe-to-tube elbow (23).

g. Remove pipe-to-tube elbow (23) and pipe reducer (24) from check valve (25).

h. Disconnect and remove pipe-to-tube elbow (2) from check valve (25).

i. Remove hexagon capscrew (1), lockwasher (27), flat washer (26) and remove check valve (25) and loop clamp (3) from angle bracket (4).

j. Remove check valve (25) from loop clamp (3).

k. Remove machine bolt (15), flat washer (16), lockwasher (9), plain hexagon nut (10), and remove check valve (18) and loop clamp (19) from angle bracket (12).

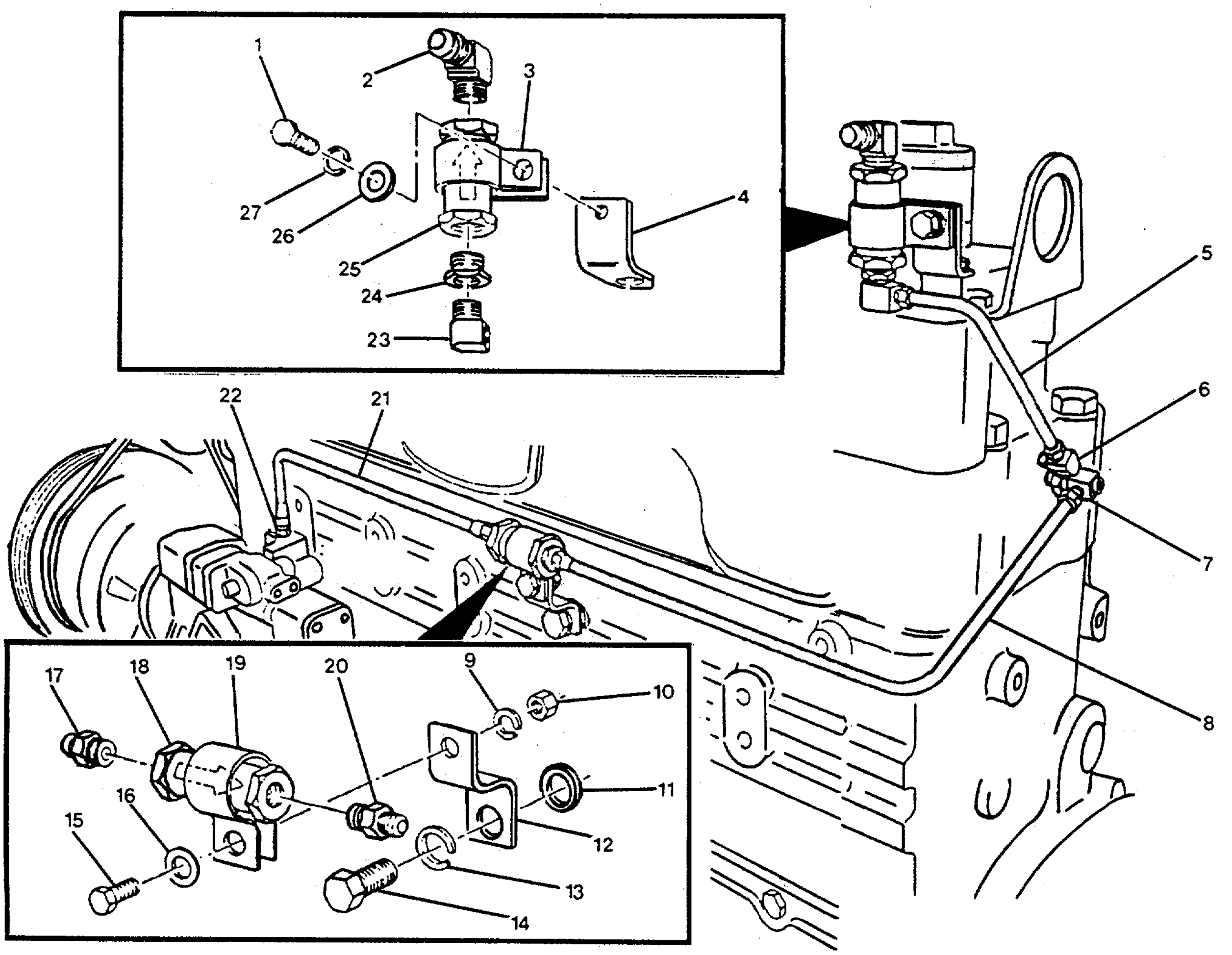


FIGURE 2-22. Fuel Line Check Valves.

l. Remove check valve (18) from loop clamp (19).

m. Remove hexagon capscrew (14), lockwasher (13), and remove angle bracket (12) and ring spacer (11).

REPAIR

Repair of the fuel tubing group consists of replacing check valves (18 and 25) and ring spacer (11).

REPLACEMENT

a. Install new ring spacer (11), angle bracket (12) and secure with lockwasher (13) and hexagon capscrew (14).

b. Install check valve (18) and loop clamp (19) and secure to angle bracket (12) with plain hexagon nut (10), lockwasher (9), flat washer (16), and machine bolt (15).

c. Install check valve (25) and loop clamp (3) and secure to angle bracket (4) with flat washer (26), lockwasher (27), and hexagon capscrew (1).

d. Install pipe-to-tube elbows (2 and 23) and pipe reducer (24) on check valve (25).

e. Install and connect bent metallic tube (5) to pipe-to-tube elbow (23).

f. Connect bent metallic tube (5) to pipe-to-tube elbow (6).

g. Install and connect bent metallic tube (8) and pipe union (20) to check valve (18).

h. Connect bent metallic tube (8) to pipe tee (7).

i. Install and connect metallic tube (21) and pipe union (17) to check valve (18).

j. Connect metallic tube (21) and machine thread plug (22) onfuel pump.

k. Open fuel supply valve and remove tag. TM 55-1905-223-10.

l. Remove tags from electrical power. TM 55-1905-223-10.

2-39. REPLACE/REPAIR ROCKER LEVER HOUSING COVER GROUP.

This task covers:
a. Removal, b. Disassembly, c. Repair, d. Assembly, e. Replacement

INITIAL SETUP

Tools

Tool kit, general mechanic's rail and marine diesel engines 5180-00-629-9783
Injector adjustment kit P/N 3375842
Torque wrench kit P/N 3377216
Rocker lever actuator P/N 3375790
Dial indicator gauge P/N 3376050
Dial indicator attachment P/N ST-1325

Materials/Parts

Cleaning solvent, Item 6, Appendix C
Rocker lever housing P/N 3044788
Engine poppet cover gaskets P/N 3054841
Rocker lever housing gaskets P/N 3017750
Cylinder head mounting guide studs, Item 46, Appendix C
Engine, rocker arm P/N BM-95161
Engine, rocker arm P/N BM-95162
Injector rocker lever P/N AR-2308
Vegetable oil, Item 44, Appendix C
Nonmetallic hose P/N 64775

Equipment Condition

Engine shut down and cooled below 120ºF (50ºC). TM 55-1905-223-10.
Instrument panel removed (paragraph 2-26).
Intake air crossover pipe removed (paragraph 2-29).
Upper fuel line check valve removed (paragraph 2-38).
Air supply secured (port).
Battery banks disconnected (starboard). TM 55-1905-223-10.

REMOVAL

a. Remove the crankcase breather and tube as follows:

(1) Loosen the hose clamps (2, Figure 2-23) on nonmetallic hose (3) and remove bent metallic tube (1) and hose (3).

(2) Pull the breather (4) from the engine poppet valve rocker arm cover (6).

b. Remove five assembled washer screws (5) from engine poppet valve rocker arm covers (6, 7, 8).

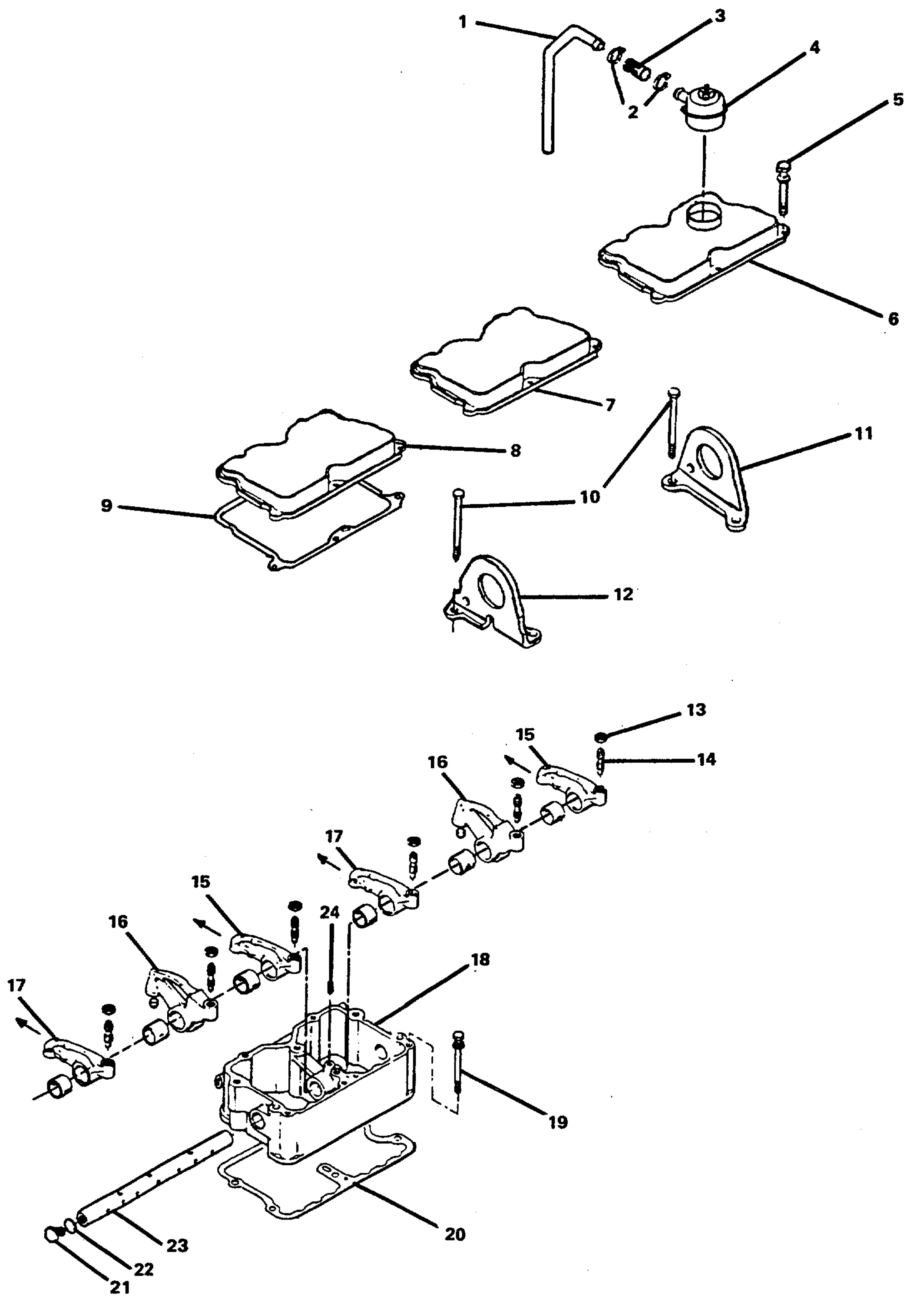


FIGURE 2-23. <u>Rocker Lever Housing Group</u>.

c. Remove the three covers (6, 7, 8) and valve cover gaskets (9). Discard gaskets.

d. Remove two hexagon head capscrews (10) in each engine lifting bracket (11, 12).

e. Remove the two engine lifting brackets (11, 12).

f. Remove the rocker lever housing (18) as follows:

(1) Loosen the six plain hexagon nuts (13).

(2) Turn each of the six setscrews (14) counterclockwise two full turns.

NOTE

To prevent increased wear, mark each rocker lever housing (18) as it is removed, and install each housing in its original location.

(3) Remove the six assembled washer screws (19) from the rocker lever housing (18).

(4) Remove the rocker lever housing (18).

(5) Remove rocker lever housing gasket (20). Discard gasket.

DISASSEMBLY

a. Remove the setscrew (24) from the housing (18).

b. Lightly tap the end of the straight shaft (23) with a drift punch and hammer and remove the shaft (23) with the engine poppet valve rocker arms (15, 17) and injector rocker levers (16) from the housing (18).

c. Remove the plain hexagon nuts (13) and the setscrews (14) from the engine poppet valve rocker arms (15, 17) and injector rocker levers (16).

NOTE

To prevent increased wear, mark each rocker arm (15, 17) and rocker lever (16) as it is removed, and install each in its original location.

d. Remove engine poppet valve rocker arms (15, 17) and injector rocker levers (16) from straight shaft (23).

NOTE

Machine thread plugs must be removed with an allen wrench.

e. Remove machine thread plugs (21) from each end of straight shaft (23).

f. Remove preformed packing (22) from each end of straight shaft (23). Save the packings.

REPAIR

a. Clean all parts with solvent or steam before instalation.

WARNING

High pressure compressed air tanks, piping systems, and air operated equipment has a potential for serious injury to eyes and exposed areas of skin due to escaping air pressure.

b. Dry all parts with compressed air.

NOTE

Visually inspect all parts and housing for cracks, burrs, or damage. Replace, if necessary, rocker lever housing (18), poppet cover gaskets (9) rocker lever housing gaskets (20), engine poppet valve rocker arms (15, 17), injector rocker levers (16), and nonmetallic hose (3).

ASSEMBLY

a. Install the setscrew (14) and plain hexagon nut (13) in each engine poppet valve rocker arm (15, 17) and injector rocker lever (16). Do not tighten the nuts (13).

b. Install machine thread plugs (21) in the straight shaft (23).

NOTE

Hold one machine thread plug with an allen wrench while tightening the other plug to 70 ft-lb (94.9 N.m) torque. Repeat so both plugs are tightened to 70 ft-lb (94.9 N.m) torque.

CAUTION

The setscrew hole (4, Figure 2-24) must be to the top and the seven oil passage holes (5) toward the flat side of the housing for correct assembly.

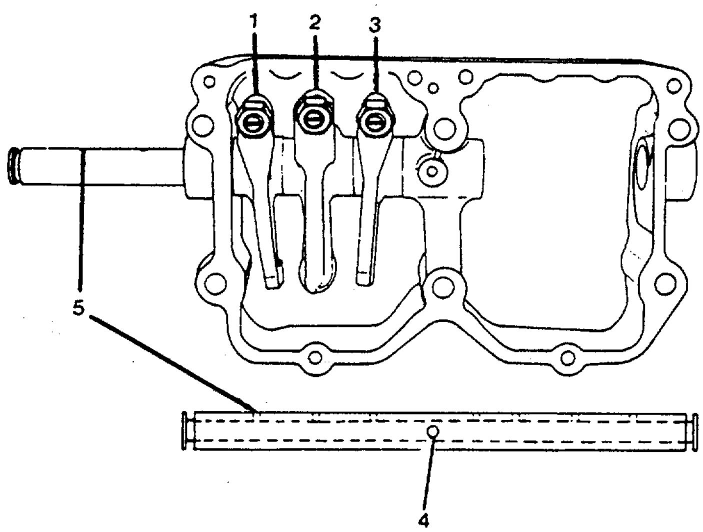


FIGURE 2-24. Set Screw and Oil Passage Holes.

c. Install, in their original location, the exhaust rocker arm (1), injector rocker lever (2), and intake rocker arm (3) as the shaft is pushed through the rocker lever housing (18, Figure 2-23).

d. Install, in their original position, the intake rocker arm (1, Figure 2-25), injector rocker lever (2), and exhaust rocker arm (3) as the shaft continues through the rocker lever housing (18, Figure 2-23).

e. Install the preformed packing (22) as follows:

   (1) Push the straight shaft (23) until 0.50 inch (12.7 mm) extends from the rocker lever housing (18).

   (2) Lubricate the packing (22) with vegetable oil.

   (3) Install the lubricated packing.

   (4) Push the straight shaft (23) until the other end extends 0.50 inch (12.7 mm) from the rocker lever housing (18).

   (5) Install the lubricated packing.

f. Align the straight shaft (23) and the rocker lever housing setscrew holes. See (4) and (5) Figure 2-24.

g. Install the setscrew (24, Figure 2-23).

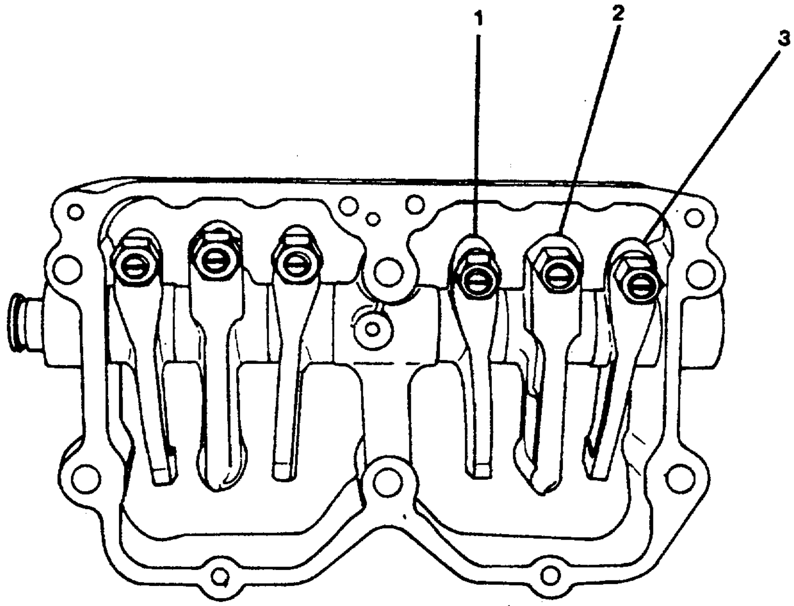


FIGURE 2-25. Installing the Arms and Levers on Shaft.

REPLACEMENT

NOTE

Be sure that the covers, housing, and cylinder head surfaces are clean before installing gaskets (9 and 20).

a. Install new rocker lever housing gaskets (2, Figure 2-26) on the cylinder heads.

b. Install two rocker lever guide studs (1) in each cylinder head.

NOTE

Return each housing to its original position on the engine.

c. Install each rocker lever housing (18, Figure 2-23).

CAUTION

If the adjusting screws protrude beyond the maximum of 1.259 inches from the top surface of the lever and the ball end of the adjusting screws, the push rods can be damaged when the housing capscrews are tightened.

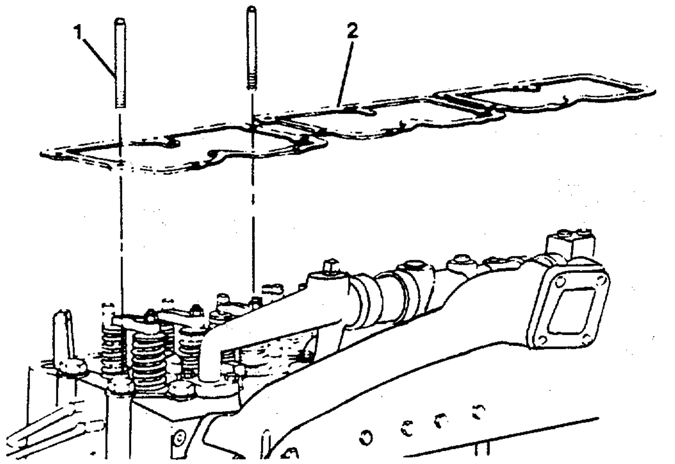


FIGURE 2-26. Rocker Housing Gaskets and Guide Studs.

d. Loosen the rocker lever setscrews so there is a maximum of 1.259 inches (32 mm) from the top surface of the lever and the ball end of the adjusting screw (Figure 2-27).

e. Hold the rocker levers in position.

(1) Install the ball end of the setscrews (14, Figure 2-23) in the push rod sockets.

(2) Remove the guide studs (1, Figure 2-26).

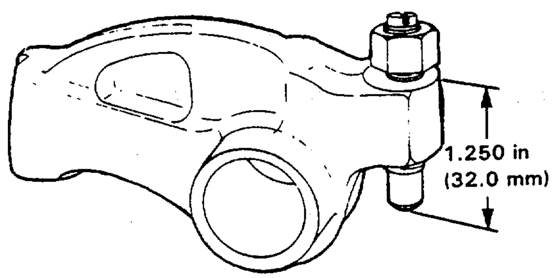


FIGURE 2-27. Rocker Lever Adjusting Screw.

(3) Install the assembled washer screws (19, Figure 2-23).

NOTE

The longer capscrews are used to secure the engine lifting brackets.

(4) Install the engine lifting brackets (11, 12) with hexagon head capscrews (10).

(5) Tighten the housing and bracket capscrews (10 and 19) to 60 ft-lb (81.3 N-m) torque. Use the sequence shown in Figure 2-28 when tightening the housing capscrews assembled washer screws.

f. Repeat steps k through m for the two remaining rocker lever housings (18, Figure 2-23).

g. Adjust crossheads, valves, and injectors as follows:

NOTE

The crossheads, valves, and injectors must be adjusted at the same time. Use the following procedure for adjusting.

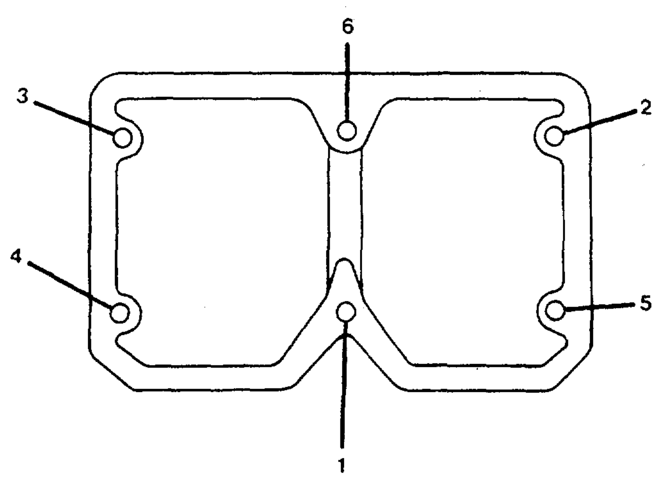


FIGURE 2-28. Rocker Housing Torque Sequence.

NOTE

- After any repair where the injector setting is disturbed, all of the valves and injectors must be set. Once the adjustment procedure has been completed, continue through the crankshaft rotation and check (adjust if necessary) the injector adjustment on cylinders No. 2, No. 3, and No. 6. This takes care of any camshaft and rocker lever shaft deflection which may have occurred during the initial adjustment.

- All overhead (crosshead, valve, and injector) adjustments must be made when the engine is cold (coolant temperature at 140°F (60°C) or below).

(1) With the rocker lever covers removed and rocker housing capscrews tightened to 60 ft-lb torque, alternately tighten the injector holddown clamp capscrews to 156 in-lb torque. Refer to paragraph 2-40.

(2) General Adjustment information:

(a) The valve set marks are located on the accessory drive pulley. The marks align with a pointer on the gear cover.

(b) Use the accessory drive shaft to rotate the crankshaft. See Figure 2-29.

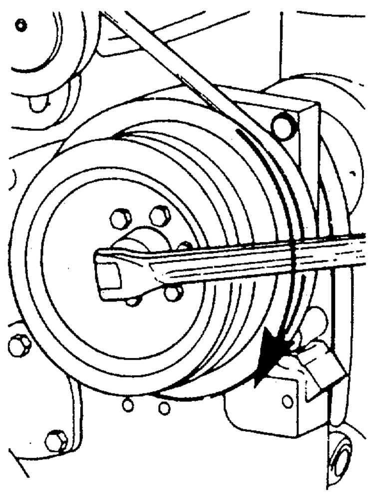


FIGURE 2-29. Rotating Accessory Drive.

(c) The crankshaft rotation is clockwise when viewed from the front of the engine.

(d) The cylinders are numbered from the front gear cover end of the engine.

(e) The engine firing order is 1-5-3-6-2-4.

(f) Each cylinder has three rocker levers. The rocker lever nearest to the center of the housing is the intake lever (3, Figure 2-30), the exhaust lever is (1), and the injector lever is (2).

(g) The valves and the injectors on the same cylinder are not adjusted at the same index mark on the accessory drive pulley (see Table 2-3).

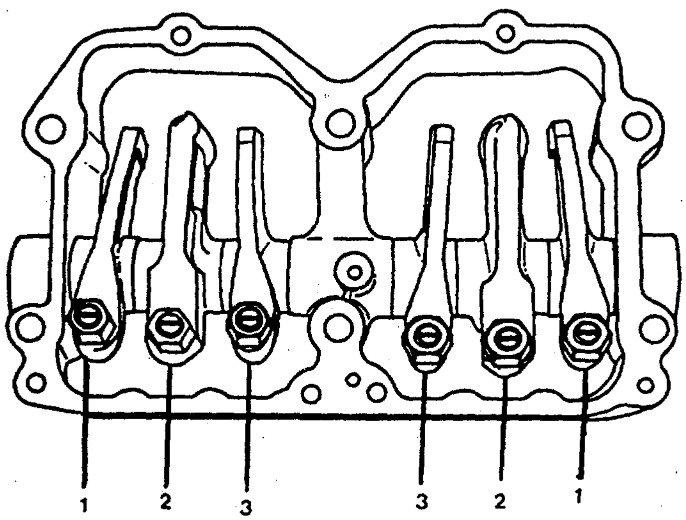


FIGURE 2-30. Identifying Rocker Levers.

Table 2-3. Injector and Valve Adjustment Sequence

Bar Engine in Direction of Rotation	Pulley Position	Set Cylinder Injector	Valve
Start	A	3	5
Advance to	B	6	3
Advance to	C	2	6
Advance to	A	4	2
Advance to	B	1	4
Firing Order: 1-5-3-6-2-4	C	5	1

(h) One pair of valves and one injector are adjusted at each pulley index mark before rotating the accessory drive to the next index mark.

(i) Two crankshaft revolutions are required to adjust all the valves and the injectors.

(3) Injector Adjustment, Dial Indicator Method (Nonstop Injector Only).

(a) Rotate the accessory drive clockwise until the "A" valve set mark on the accessory drive pulley is aligned with the point on the gear cover (Figure 2-31).

(b) Check the valve rocker levers on cylinder No. 5 to see if both valves are closed.

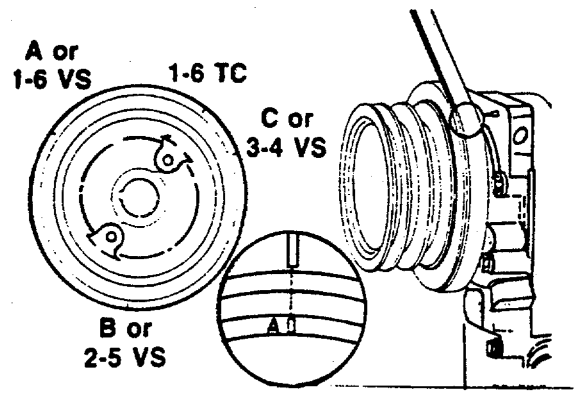


FIGURE 2-31. Aligning Pulley and Gear Pointer.

NOTE

Both valves are closed when both rocker levers are loose and can be moved from side to side. If both valves are not closed, rotate the accessory drive one complete revolution; align the "A" mark with the pointer again.

CAUTION

To prevent damage to the indicator or to avoid getting an incorrect reading, install the dial indicator extension so that it clears the rocker lever. See Figure 2-32.

(c) Install the dial indicator (6, Figure 2-32) and the support (4) from the Injector Adjustment Kit so that the stem (5) of the dial indicator is on top of the injector plunger flange on cylinder No. 3.

(d) Securely tighten the thumbscrew (1) and the holddown screw (2) in place.

(e) Loosen the thumbscrew (3) and lower the indicator against the injector plungerflange until the stem (5) is fully compressed.

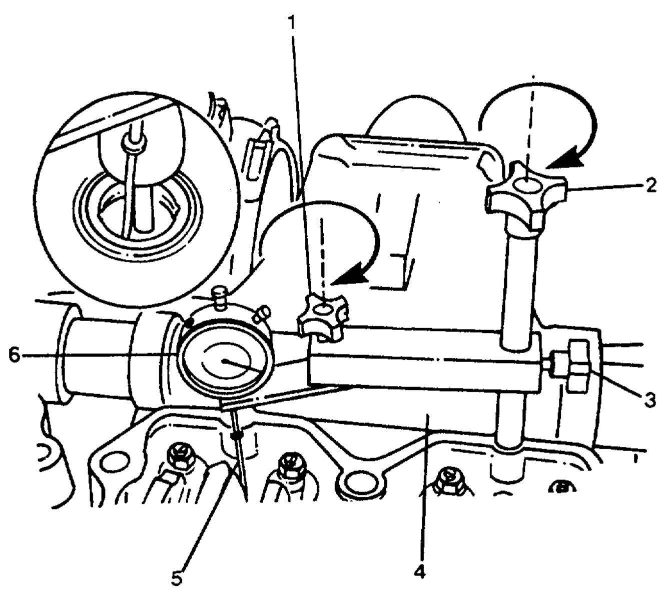


FIGURE 2-32. Installing Dial Indicator and Support.

(f) Raise the indicator (6) approximately 0.025 inch (0.653 mm), and tighten the thumbscrew (3) to hold the indicator in position.

WARNING

The injector plunger is under spring tension. Do not allow the tool to slip. Personal injury can result.

(g) Use the rocker lever actuator (1, Figure 2-33) to depress the injector plunger three or four times to make sure all the oil and fuel have been removed from the injector assembly. Allow the lever to return slowly to prevent damage to the dial indicator.

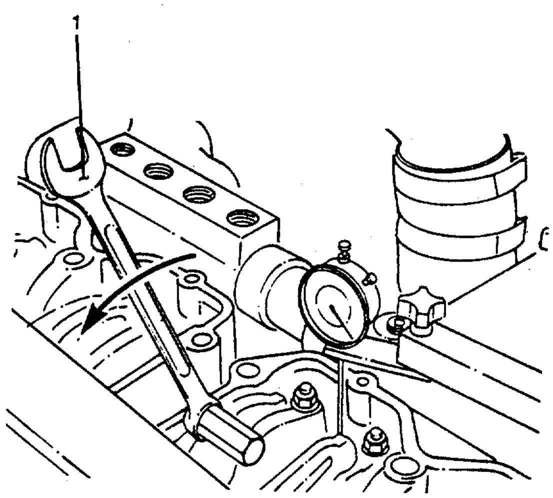


FIGURE 2-33. Rocker Lever Actuator.

(h) Actuate the lever again, and set the dial indicator at "0" (zero) while holding the injector plunger to the bottom of its travel.

(i) Slowly release the actuator and check the indicator travel.

(j) The indicator travel should be between 0.226 inch and 0.230 inch. If not within those limits, go to step (k).

(k) Loosen the lock nut on the injector adjusting screw.

(l) Turn the adjusting screw clockwise or counterclockwise to adjust the injector plunger to 0.228 inch.

(m) Hold the adjusting screw in this position. See Figure 2-34. The adjusting screw must not turn when the lock nut is tightened. Tighten the lock nut to the following value:

With adaptor	- 35 ft-lb (45 N•m) torque.
Without adaptor	- 45 ft-lb (60 N•m) torque.

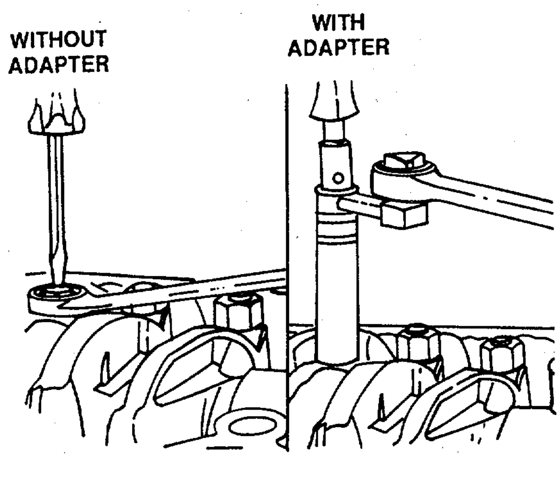


FIGURE 2-34. Torque Methods.

WARNING

The injector plunger is under spring tension. Do not allow the tool to slip. Personal injury can result.

(n) Actuate the injector rocker lever several times. Allow the lever to return slowly to prevent damage to the dial indicator. Hold the injector plunger to the bottom of its travel, and confirm the "0" (zero) reading on the dial indicator.

(o) Allow the injector rocker lever to return slowly. Check the reading on the dial indicator. Repeat the adjustment process if the reading is not within specifications.

(p) Adjust the crossheads and the valves on cylinder No. 5 before rotating the accessory drive to the next valve set mark. Refer to Crosshead Adjustment and Valve Adjustment in this procedure.

(q) After adjusting the crossheads and the valves on cylinder No. 5, rotate the accessory drive; align the next valve set mark on the accessory drive pulley with the pointer on the gear cover.

(r) Adjust the appropriate injector, the crossheads, and the valves. Follow Table 2-3, Valve and Injector Adjustment Sequence Chart.

(s) Repeat the process to adjust all the injectors, the crossheads, and the valves correctly.

(4) Injector Preload Adjustment Procedures (Top-stop Injectors Only).

CAUTION

Top-stop injector plunger travel can only be adjusted when the injectors are removed from the engine. Use the injector adjusting tool to set the injectors.

(a) The top-stop injector preload setting is made at the same injector adjustment position on the accessory drive pulley which is used for the dial indicator method.

(b) Rotate the accessory drive clockwise until the "A" valve set mark on the accessory drive pulley is aligned with the pointer (Figure 2-31).

(c) Loosen the lock nut on the injector adjusting screw (Figure 2-35) on cylinder No. 3. Tighten the adjusting screw until all the clearance is removed from the injector train.

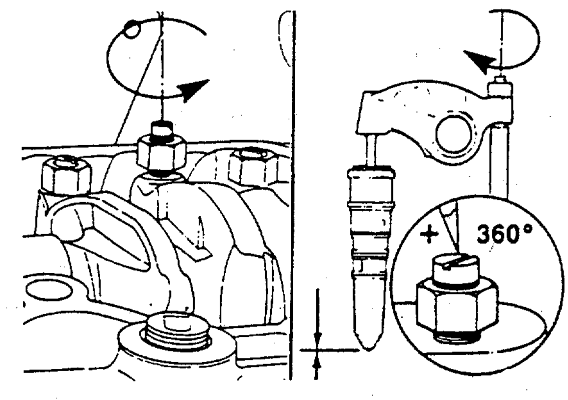


FIGURE 2-35. Injector Adjusting Screw.

(d) Tighten the adjusting screw one additional turn to correctly seat the link.

(e) Loosen the injector adjusting screw until the injector spring retainer washer touches the top-stop screw (Figure 2-36).

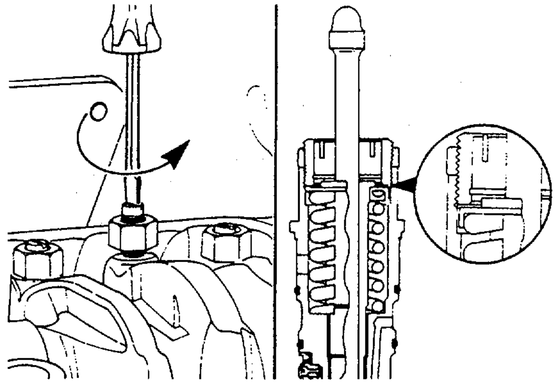


FIGURE 2-36. Loosening Injector Adjusting Screw.

CAUTION

An overtightened setting on the injector adjusting screw will produce increased stress on the injector train and the camshaft injector lobe which can result in engine damage.

(f) Tighten the adjusting screw to 5 to 6 in-lb (0.56 to 0.68 N.m) torque.

(g) Hold the adjusting screw in position. The adjusting screw must not turn when the lock nut is tightened. Tighten lock nut to the following value:

With adapter	- 35 ft-lb (47 N•m) torque.
Without adapter	- 45 ft-lb (61 N•m) torque.

(h) Adjust the crossheads and the valves on cylinder No. 5 before rotating the accessory drive to the next valve set mark. Refer to Crosshead Adjustment and Valve Adjustment in this procedure.

(i) After adjusting the crossheads and the valves on cylinder No. 5, rotate the accessory drive and align the next valve set mark on the accessory drive pulley with the pointer on the gear cover.

(j) Adjust the appropriate injector, the crossheads, and the valves following the Injector and Valve Adjustment Sequence Chart (Table 2-4).

(k) Repeat the process to adjust all injectors, crossheads, and valves correctly.

(5) Crosshead Adjustment.

NOTE

Crosshead adjustment must always be made before attempting to adjust the valves.

(a) With the "A" valve set mark aligned with the pointer on the gear cover (Figure 2-31) and both valves closed on cylinder No. 5, loosen the crosshead adjusting screw lock nuts on the intake and the exhaust valve crossheads for cylinder No. 5.

NOTE

The same procedure is used to adjust the intake and exhaust crossheads.

(b) Turn the adjusting screw out at least one turn.

(c) Hold the crosshead down against its mating valve stems.

(d) Turn the adjusting screw in until it touches the top of the valve stem, but does not raise the crosshead.

(e) Hold the adjusting screw in this position. The adjusting screw must not turn when the lock nut is tightened to its torque value (Figure 2-34). Tighten the lock nut to the following value:

With adaptor	- 25 ft-lb (35 N•m) torque.
Without adaptor	- 30 ft-lb (40 N•m) torque.

(f) Adjust the intake and the exhaust valves on No. 5 cylinder before rotating accessory drive to the next valve set mark. Refer to Valve Adjustment item (6), in this procedure.

(6) Valve Adjustment.

(a) With the "A" valve set mark aligned with the pointer on the gear cover (Figure 2-31) and both valves closed on cylinder No. 5, loosen the lock nuts on the intake and the exhaust valve adjusting screws.

(b) Select a feeler gauge for the correct valve lash specification.

Valve Lash Specification

Intake	Exhaust
(0.028 mm)	(0.058 mm)
0.011-inch	0.023-inch

(c) Insert the feeler gauge between the top of the crosshead and the rocker lever pad (Figure 2-37).

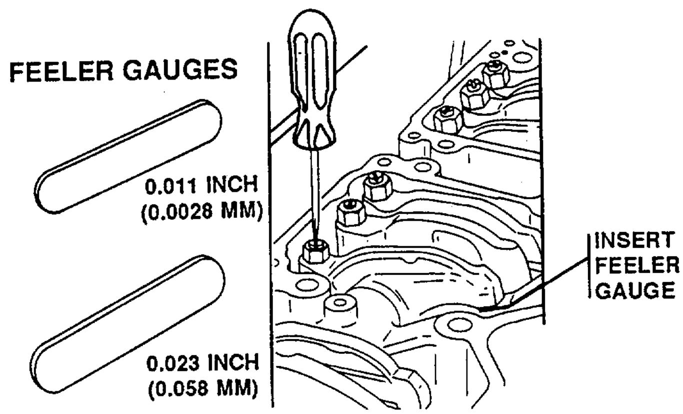


FIGURE 2-37. Checking Valve Lash (Feeler Method).

NOTE

Two different methods for establishing valve lash clearance are described. Either method can be used; however, the torque wrench method has proved to be the most consistent. It eliminates the need to feel the drag on the feeler gauge.

Torque Wrench Method: Use an Inch-pound Torque Wrench (normally used to set preload on top-stop injectors), and tighten the adjusting screw (1, Figure 2-38) to 6 in.-lb torque (0.68 N-m) torque.

Feel Method: Tighten the adjusting screw (2, Figure 2-38) until a slight drag is felt on the feeler gauge.

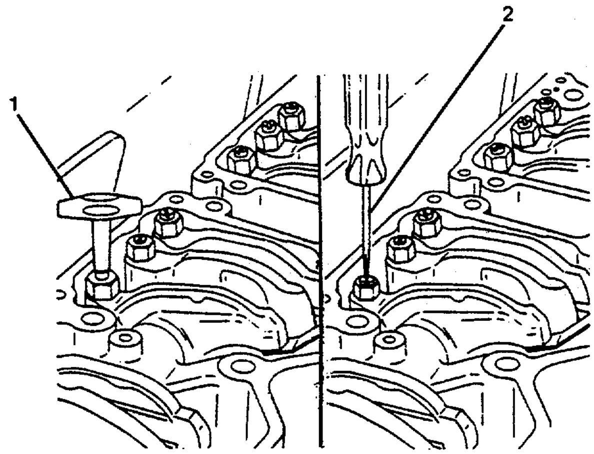


FIGURE 2-38. Tightening Adjusting Screw.

(d) Hold the adjusting screw in this position. The adjusting screw must not turn when the lock nut is tightened (refer to Figure 2-36). Tighten the lock nut to the following value:

With adapter	- 35 ft-lb (45 N•m) torque.
Without adapter	- 45 ft-lb (60 N•m) torque.

(e) After tightening the lock nut to the correct torque valve, ensure the feeler gauge will slide backward and forward between the crosshead and the rocker lever with only a slight drag.

(f) If using the feel method, attempt to insert a feeler gauge that is 0.001 inch (0.03 mm) thicker between the crosshead and the rocker lever pad. The valve lash is not correct when a thicker feeler gauge will fit.

(g) After adjusting the injector on cylinder No. 3 and the crossheads and the valves on cylinder No. 5, rotate the accessory drive and align the next valve set mark with the pointer.

(h) Adjust the appropriate injector, the crossheads, and the valves following the Injector and Valve Adjustment Sequence Chart, Table 2-3.

(i) Repeat the process to adjust all injectors, crossheads, and valves correctly.

h. Install a new valve cover gasket (9, Figure 2-23) on each rocker lever housing (18).

NOTE

Stamped steel valve covers are designed and manufactured with 0.030 inch (0.75 mm) bow located in the shaded areas as shown in Figure 2-39 to provide better sealing qualities. This built-in bow on the valve covers must not be mistaken for warpage. Also, do not attempt to increase or remove the bow from the sealing surface.

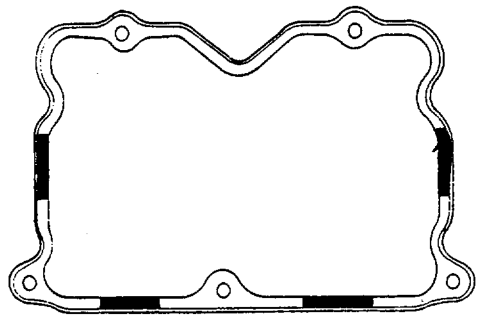


FIGURE 2-39. Cover Manufactured Bow Areas.

i. Install the covers (6, 7, 8) on the rocker lever housings (18).

j. Install the five assembled washer screws (5) in each cover.

k. Tighten the assembled washer screws in each cover in the sequence shown to 15 ft-lb (20.3 N•m) torque (Figure 2-40).

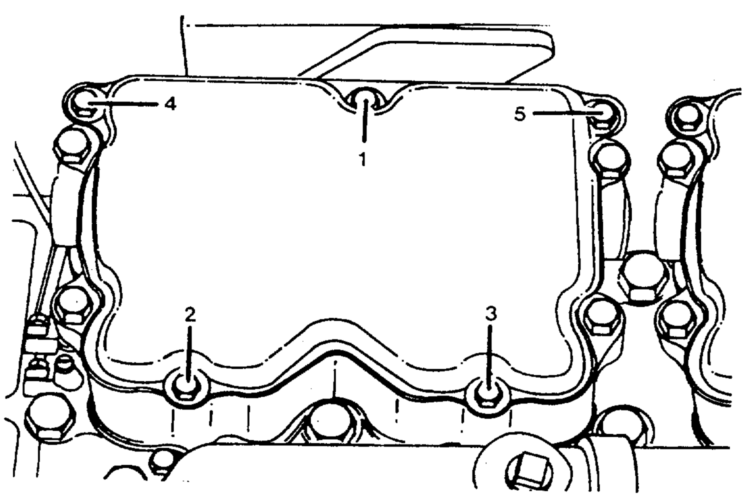


FIGURE 2-40. Rocker Arm Cover Torque Sequence.

l. Insert the crankcase breather (4, Figure 2-41) in the cover (5).

m. Install the bent metallic tube (1) on the breather (4) with preformed hose (2) and clamps (3). Tighten clamps (3).

n. Install the upper fuel line check valve (paragraph 2-40).

o. Install the intake air crossover pipe (paragraph 2-43).

p. Install the instrument panel (paragraph 2-26).

q. Prepare engine for run operation. Remove tags.

r. Start the engine and check for proper operation. (TM 55-1905-223-10).

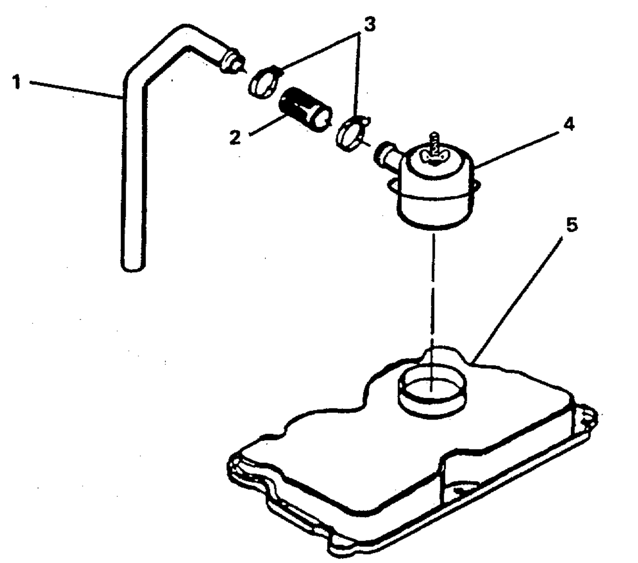


FIGURE 2-41. Crankcase Breather and Tube.

2-40. Inspect/Replace/Repair Injector Group

This task covers: a. Inspection, b. Removal, c. Repair, d. Replacement.

INITIAL SETUP

Tools

Tool kit, general mechanic's rail
and marine diesel engines,
5180-00-629-9783
Injector adjustment kit
P/N 3375842
Injector puller P/N 3376000
Torque wrench kit P/N 3377216
Rocker lever actuator P/N 3375790

Materials/Parts

Fuel injection nozzle P/N 3054219
Detent plunger P/N 191916
Lockwasher P/N 180626
Lubricating oil, Item 2, Appendix C

Equipment Condition

Rocker lever housing cover removed
(paragraph 2-39).
Electrical power to generator assembly
Air supply secured (port).
Battery banks disconnected (starboard).
TM 55-1905-223-10.

INSPECTION

a. Injector Check. If the engine is misfiring and a bad injector is suspected, use this procedure to locate the bad injector.

(1) Remove the engine poppet valve rocker assembly cover (paragraph 2-39).

(2) Check the injector clamp (2, Figure 2-42) for tightness. Tighten hexagon head capscrews (1) (see Replacement Procedure Step e).

(3) Run the engine until it warms up to 1600F (700C).

(4) Install a rocker lever actuator on an injector rocker lever as shown in Figure 2-43.

(5) Hold the injector plunger down while the engine is running as low idle.

(6) If the engine RPM decreases when an injector plunger is held down, the injector is good.

(7) If the engine RPM does not decrease, replace the injector. Refer to the Removal and Replacement steps of this procedure.

b. Install the rocker assembly cover (paragraph 2-39).

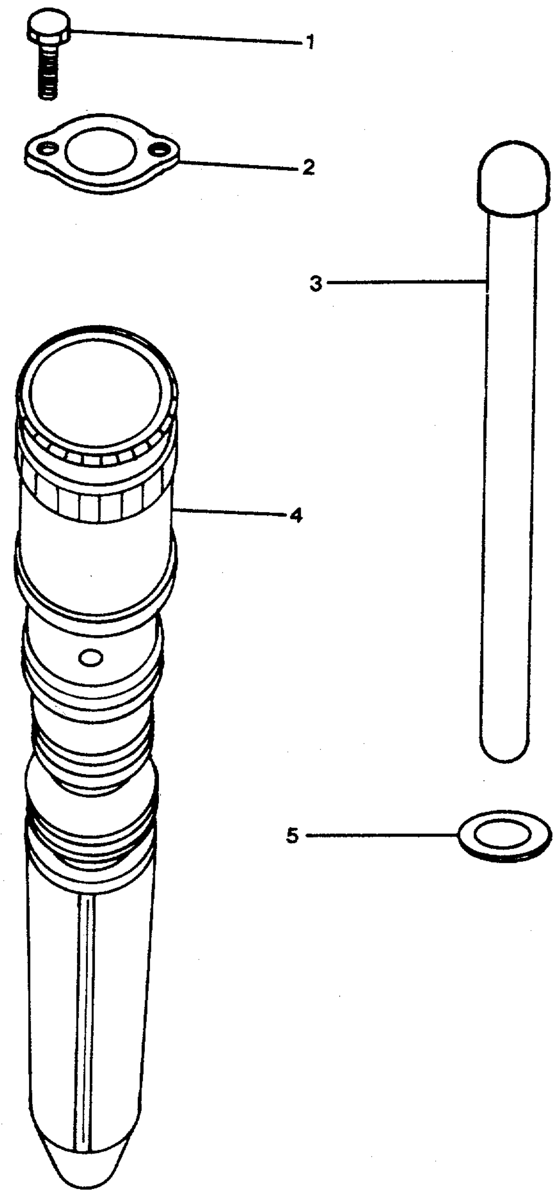


FIGURE 2-42. Injector Group.

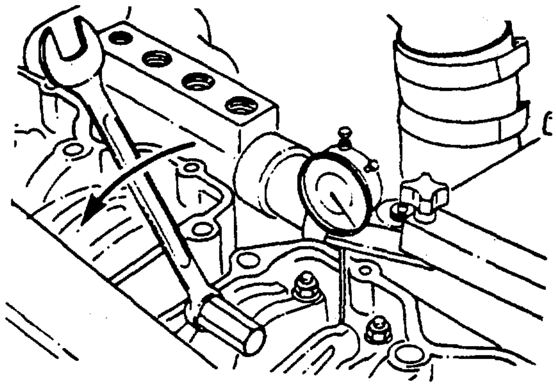


FIGURE 2-43. *Using Rocker Lever Actuator.*

REMOVAL

a. Loosen the nut (1, Figure 2-44) on each injector lever.

b. Turn out the setscrew (2) on each injector rocker lever.

c. Move the injector push rod to the side.

d. Rotate the rocker lever up on each cylinder.

e. Remove the detent plunger (3) and lockwasher.

f. Remove the two clamp capscrews (4) and the injector clamp (5).

g. Remove the injector (1, Figure 2-45) with the injector puller (2).

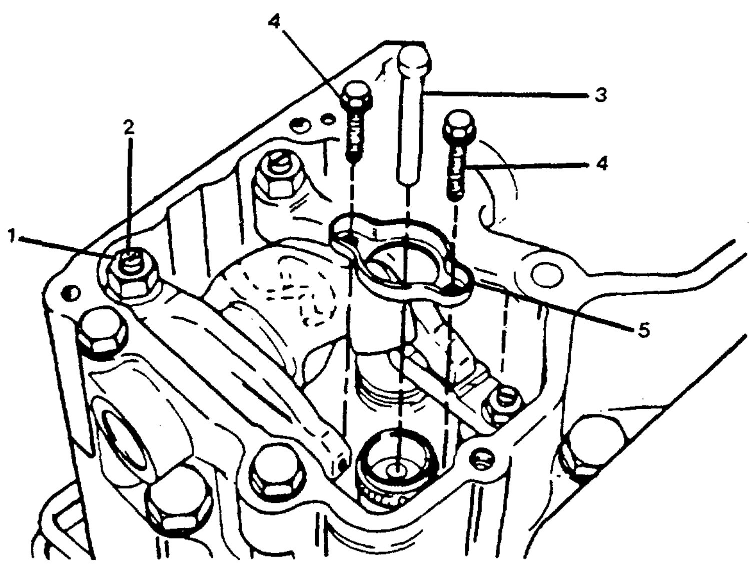


FIGURE 2-44. *Removing Injector.*

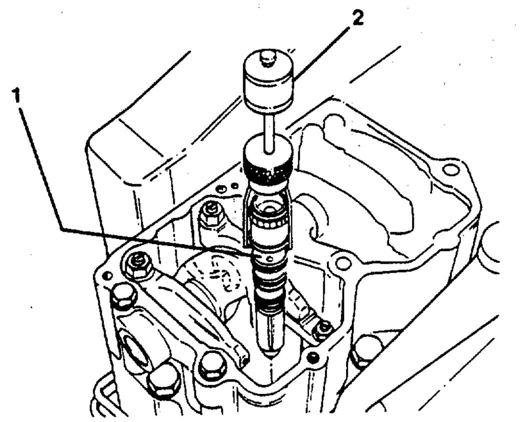


FIGURE 2-45. Using Injector Puller.

REPAIR

a. Replace faulty injector and perform replacement procedures.

REPLACEMENT

NOTE

Lubricate injector preformed packing with lubricating oil before installation.

a. Install the injector (4, Figure 2-42) in the cylinder head injector bore.

b. Use a clean hammer handle to seat injector into the bore.

CAUTION

Place the hammer handle on the body of the injector (4) not the plunger or link.

c. Apply pressure to the body of the injector (4) to seat the injector in the bore. A "snap" will be heard and felt as the injector is seated.

d. Install the holddown clamp (5, Figure 2-44) and capscrews (4) over the injector body.

e. Tighten the capscrews alternately and evenly, 50 in-lb (6.0 N•m) torque at a time, to final tightening of 144 to 168 in-lb (16.0 N•m) torque.

f. Install the injector plunger (3, Figure 2-42) and washer (5) in the injector (4).

g. Align the push rod with the injector rocker lever.

h. Turn the adjusting screw (2, Figure 2-44) for the injector rocker lever in until it is properly seated in the push rod socket.

i. Adjust all crossheads, valves, and injectors (paragraph 2-39).

j. Install the rocker lever cover (paragraph 2-39).

2-41. Replace/Repair Aftercooler Group.

This task covers: **a. Removal,** **b. Disassembly,** **c. Repair,** **d. Assembly,** **e. Replacement.**

INITIAL SETUP

Tools

Tool kit, general mechanic's rail and marine diesel engines, 5180-00-629-9783
Torque wrench kit P/N 3377216

Materials/Parts

Coolant, Item 8, Appendix C
Aftercooler mounting guide studs Item 47, Appendix C
Cleaning solvent, Item 6, Appendix C
Gaskets P/Ns 216487/215044/70089-1/3032348/216486/3008591/S-684
Aftercooler core P/N 3028997
Preformed hose P/N 202994
Nonmetallic hose P/Ns 3025874/3041968
Preformed packing P/N 195952
Lubricating oil, Item 2, Appendix C

Equipment Condition

Engine shut down and cooled below 120°F (50° C). TM 55-1905-223-10.
Cooling system drained (Table 2-1, Item 24).
Air supply secured (port).
Battery banks disconnected (starboard). Refer to TM 55-1905-223-10.

REMOVAL

a. Remove the air crossover piping from the turbocharger and the aftercooler as follows:

(1) Loosen hose clamps (1, Figure 2-46) and remove preformed hose (2) from air crossover connection (3).

(2) Remove four capscrews (4) and four flat washers (5) and remove air crossover connection (3) and gasket (6) from the aftercooler. Discard the gasket.

b. Loosen two hose clamps (12) on nonmetallic hose (19) and disconnect the bentmetallic tube (18) from the water inlet connection (10).

c. Loosen two hose clamps (12) and disconnect nonmetallic hose (13) from the elbow to hose flanged water outlet connection (39).

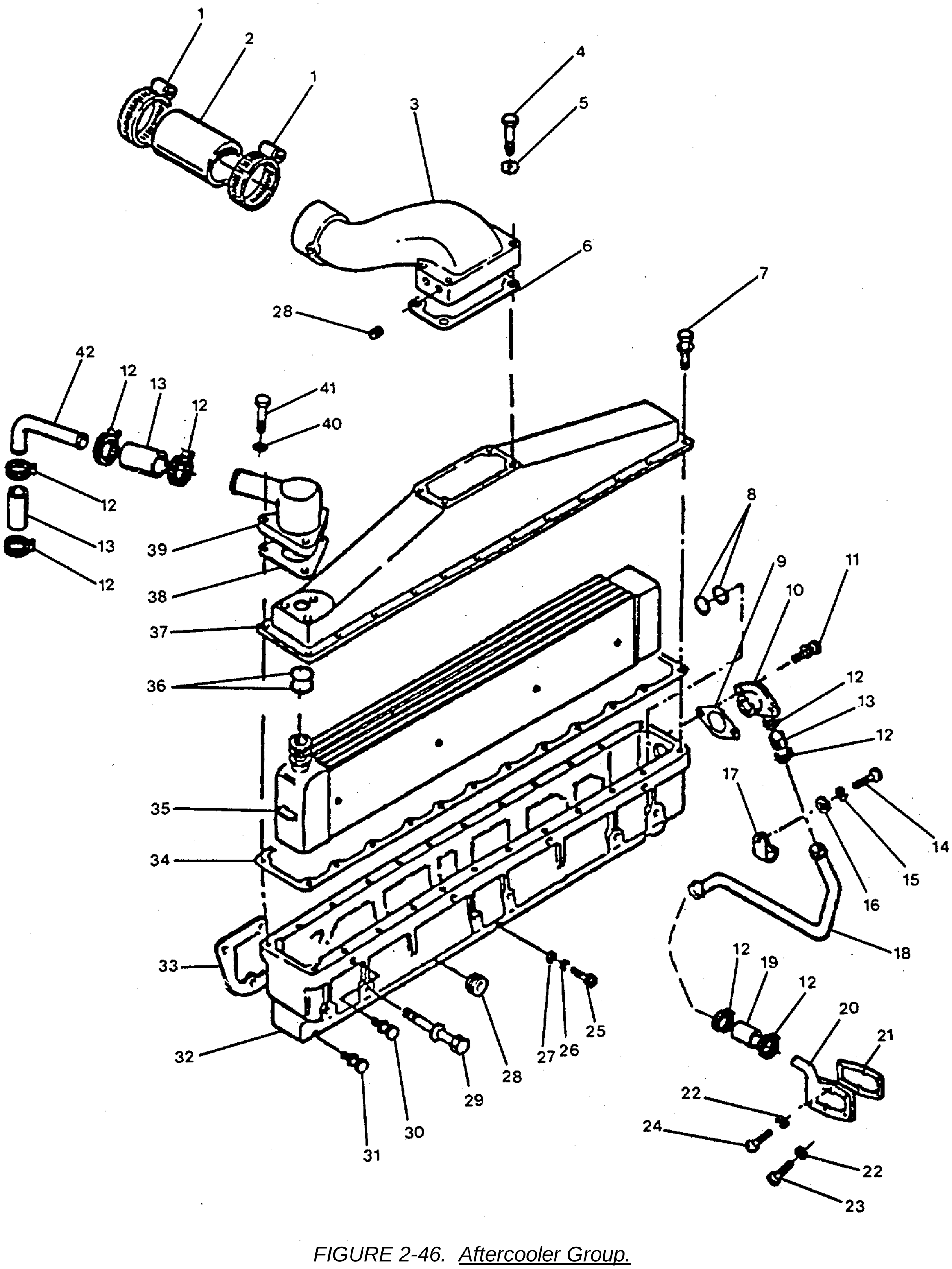


FIGURE 2-46. Aftercooler Group.

NOTE

Two threaded guide studs are required to support the aftercooler assembly during removal.

d. Remove two assembled washer screws (31) at each end of the air intake manifold housing (32). Install a guide stud in each mounting hole.

e. Remove remaining seven assembled washer screws (31).

WARNING

Because this assembly weighs more than 50 lbs (23 kg), two soldiers will be required to lift the aftercooler assembly to avoid personal injury.

f. Remove the aftercooler from the engine.

DISASSEMBLY

a. Remove the three gaskets (33). Discard gaskets.

b. Remove two assembled washer screws (11, Figure 2-46) and remove the water inlet connection (10) and gasket (9). Discard the gasket.

c. Remove three machine bolts (41) and gaskets (40) and remove the flanged elbow to hose outlet connection (39) and gasket (38). Discard gasket.

d. Remove the 24 assembled capscrews and washers (7) which secure the aftercooler cover (37) to the air intake manifold housing (32).

e. Remove eight assembled washer screws (30) which secure the housing (32) to the aftercooler core (35).

f. Remove core (35) from the housing.

g. Remove gasket (34) and preformed packings (8 and 36).

REPAIR

a. Visually inspect the tubes (18 and 42), hoses (2 and 19) for signs of deterioration or damage. Replace tubes or hoses as required.

b. Inspect the water connections (10, 20 and 39) for signs of damage. Replace as required using new gaskets.

c. Clean the core (35) with an approved solvent and visually inspect for signs of damage. Replace as required.

d. Visually inspect all capscrews and bolts for corrosion or thread damage. Replace as required.

e. Clean and inspect the cover (37) and housing (32) for signs of cracks and other damage. Replace if damaged or cracked.

f. Visually inspect the crossover connection (3) and clamps (1 and 2) for signs of cracks or other damage. Replace parts as necessary.

ASSEMBLY

a. Lubricate the four new preformed packings (8, 36) with clean lubricating oil.

b. Install the packings on the inlet and the outlet fittings of the core (35).

NOTE

The core is precision fit in the housing. Install the core carefully to prevent damage to it.

c. Install the core (35) in the housing (32).

d. Install eight assembled washer screws (35) holding the core to the housing (32).

e. Tighten screws in the sequence shown in Figure 2-47 to the following values:

NOTE

All screws are torqued to the specification in item (1); then item (2).

(1) Tighten all screws to 15 ft-lb (20 N•m) torque.

(2) Tighten all screws to 25 ft-lb (35 N•m) torque.

f. Install a new gasket (34, Figure 2-46) and the waterinlet connection (10) on the housing (32). Use fingers to tighten the assembled washer screws (11).

g. Install a new gasket (35) and the aftercooler cover (37) to the housing (32). Use fingers to tighten the capscrews (7).

h. Install a new gasket (38) and the water outlet connection (39). Use fingers to tighten the machine bolts (41).

i. Tighten the water inlet mounting capscrews (11) to 30 ft-lb (40 N•m) torque.

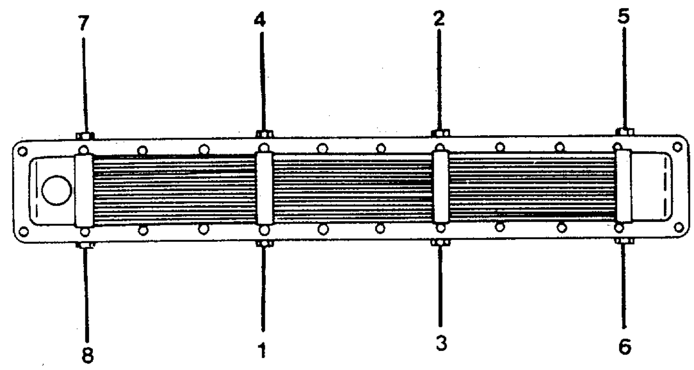


FIGURE 2-47. *Housing to Core Capscrew Torque Sequence.*

j. Follow the sequence shown in Figure 2-48 and tighten the 24 capscrews (7), which fasten the cover (37, Figure 2-46) to the housing (32), to 25 ft-lb (35 N•m) torque.

k. Tighten the water outlet bolts (41) to 20 ft-lb (30 N•m) torque.

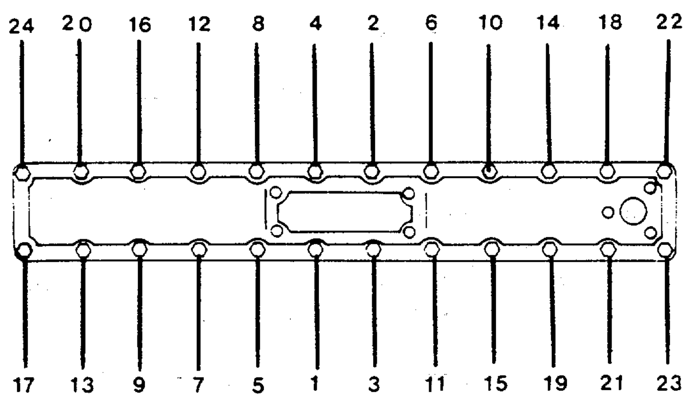


FIGURE 2-48. *Cover Torque Sequence.*

REPLACEMENT

a. Install two threaded-guide studs in the cylinder heads to aid in mounting the aftercooler.

WARNING

Because this assembly weighs more than 50 lbs (23 kg), two soldiers will be required to lift the aftercooler assembly to avoid personal injury.

NOTE

Ensure gasket sealing surfaces are clean before installing the aftercooler.

b. Install three new gaskets (33, Figure 2-46), and install the aftercooler assembly on the guide studs.

c. Install six assembled washer screws (31).

d. Remove the guide studs, and install two remaining assembled washer screws (31).

e. Tighten the assembled washer screws (31) in the sequence shown in Figure 2-49 to 25 ft-lb (35 Nm) torque.

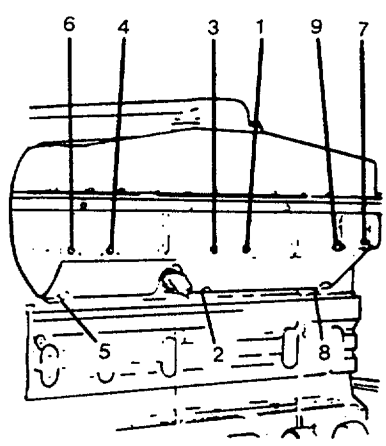


FIGURE 2-49. Aftercooler Mounting Torque Sequence.

f. Install the hoses (13, 14, Figure 2-46) on the coolant inlet and the outlet connections (10, 20) and replace hose clamps (12).

g. Tighten all hose clamps to 40 in-lb (5 N•m) torque.

h. Install new air crossover connection gasket (6), connection (3), hose (2), and clamps (1). Tighten the clamps to 70 in-lb (8 N•m) torque.

i. Fill the cooling system (Table 2-1, item 24).

j. Remove tags and turn on electrical power. TM 55-1905-223-10.

k. Start the engine (TM 55-1905-223-10) and check for leaks. Correct leaks as required.

2-42. Replace/Repair Exhaust Manifold Group.

This task covers: a. Removal, b. Repair, c. Replacement

INITIAL SETUP

Tools

Tool kit, general mechanic's rail
and marine diesel engines,
5180-00-629-9783
Lifting sling P/N 3375958
Lifting fixture P/N 3822512
Torque wrench kit P/N 3377216

Materials/Parts

Emery cloth, Item 12, Appendix C
Lubriplate, Item 28, Appendix C
Gaskets P/N 3020943 and 3029032
Preformed packing P/N 212161/178937
Exhaust manifold mounting guide studs,
Item 48, Appendix C
Anti-seize, pipe thread compound
Item 9, Appendix C

Equipment Condition

Cooling System drained (Table 2-1,
Item 24).
Turbocharger removed (paragraph 2-30).
Air crossover piping to aftercooler
removed (paragraph 2-41).
Water filter removed (paragraph 2-27).
Thermostat housing removed
(paragraph 2-28).
Lube oil bypass filter removed
(paragraph 2-35).
Air supply secured (port).
Battery banks disconnected (starboard).

REMOVAL

a. Remove the drain cock (1, Figure 2-50) from the exhaust manifold (3).

WARNING

Because this assembly weights more than 50 lb (23 kg), two soldiers will be required to lift the exhaust manifold assembly to avoid personal injury.

b. Loosen and remove two hexagon head capscrews (6), lockwashers (7), and flat washers (8) and remove the water transfer connection (9) and preformed packing (5) and gasket (10). Discard preformed packing and gasket.

c. Remove two end hexagon head cap screws (11) and lockwashers (12) on the exhaust manifold (3), and install two exhaust manifold threaded guide studs.

d. Remove the remaining ten hexagon head capscrews (11) and lockwashers (12), the exhaust manifold (3), and the three exhaust manifold gaskets (4) and preformed packing (2). Discard gaskets and packing.

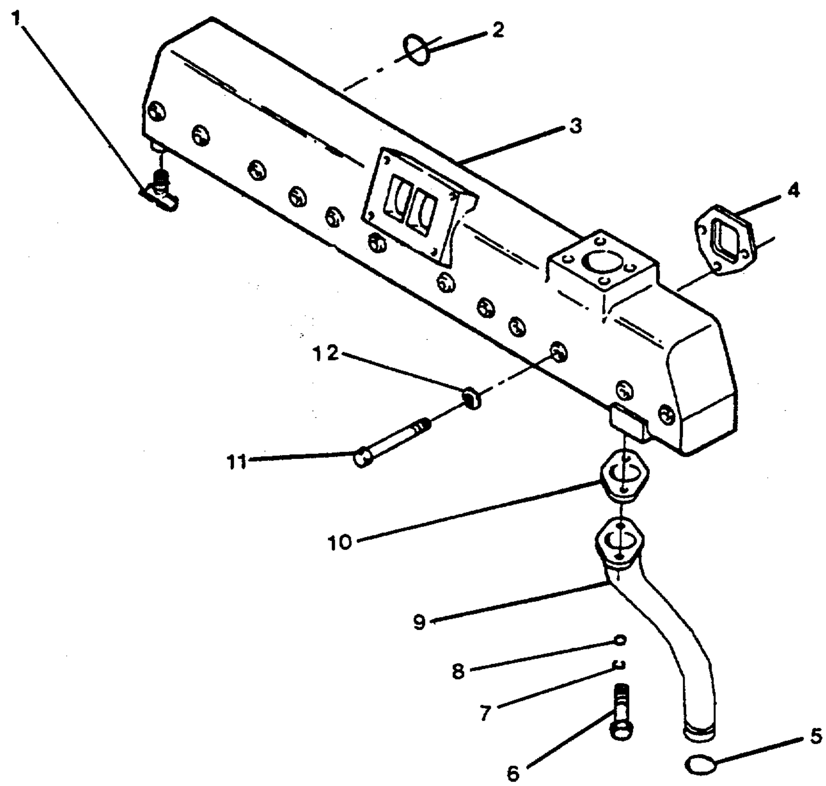


FIGURE 2-50. Exhaust Manifold Group.

REPAIR

Repair consists of replacing gaskets, tubes, or connections.

a. Use a 240 grit emery cloth to remove carbon deposits from the sealing surfaces.

b. Clean the exhaust manifold (3).

c. Visually inspect the water transfer tube and connection (9). Replace as required.

d. Visually inspect for cracks or damage to the exhaust manifold (3).

e. Install new gaskets (4) and preformed packing (2) during ASSEMBLY.

REPLACEMENT

a. Install two threaded exhaust manifold guide studs to aid in mounting the manifold.

CAUTION

Side of gasket marked "out" must be away from the cylinder heads.

NOTE

To aid in future hexagon head cap screw removal, apply film of high temperature anti-seize compound to the hexagon head cap screw threads.

b. Install the exhaust manifold (3, Figure 2-50) with three new gaskets (4), new packing (2) and ten hexagon head capscrews (11) and lockwashers (12).

c. Remove the guide studs, and install the two remaining hexagon head capscrews (11) and lockwashers (12).

d. Tighten the hexagon head capscrews (11) in the sequence shown (Figure 2-51)ɑt the following values:

(1) Tighten to 35 ft-lb (47.4 N•m) torque.

(2) Tighten to 60 ft-lb (81.3 N•m) torque.

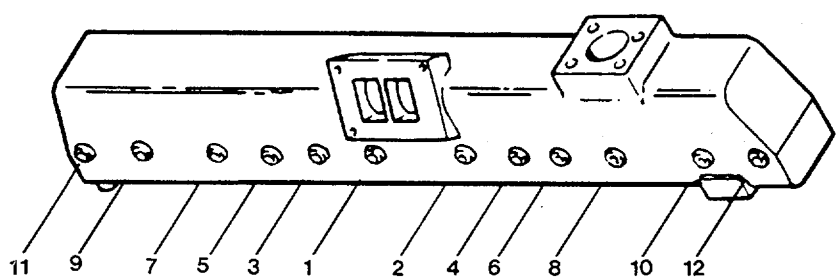


FIGURE 2-51. Exhaust manifold Torque Sequence

e. Install the water connection (9, Figure 2-50) tube, with a new gasket (10), and packing (5). Install hexhead capscrews (6) and lockwashers (7) and flat washers (8).

f. Install a new turbocharger mounting gasket and the turbocharger (paragraph 2-30).

g. Install the lube oil bypass filter (paragraph 2-35).

h. Install the thermostat housing (paragraph 2-28).

i. Install the water filter (paragraph 2-27).

j. Install the air crossover pipe to the aftercooler (paragraph 2-41).

k. Fill the cooling system (Table 2-1, item 24).

l. Remove tags and turn on electrical power, start engine. TM 55-1905-223-10.

m. Check for leaks and proper engine operation.

2-43. Replace/Repair Cylinder Head Group.

This task covers:
a. Removal b. Repair c. Replacement d. Installation e. Inspection

INITIAL SETUP

Tools

Tool kit, general mechanic's rail and marine diesel engines, 5180-00-629-9783
Injector puller P/N 3376000
Torque wrench kit P/N 3377216
Lifting fixture P/N 3822512
Lifting sling P/N 3375958
Injector adjustment kit P/N 3375842
T-handles

Materials/Parts

Guide studs, Item 46, Appendix C
Diesel engine cylinder head P/N 3041993
Wood blocks (for laying the cylinder heads on when they are removed)
Cylinder head gaskets P/N 3047402
Coolant, Item 8, Appendix C
Lubricating oil, Item 2, Appendix C
Crosshead assembly valve P/N 3030038
Setscrew P/N 4147389
Plain hexagon nut P/N 4203131

Equipment Condition

Engine shut down and cooled below 120°F (50°C). TM 55-1905-223-10.
Cooling system drained (Table 2-1, Item 24).
Aftercooler removed (paragraph 2-41).
Exhaust manifold removed (paragraph 2-42).
Turbocharger removed (paragraph 2-30).
Rocker lever housing removed (paragraph 2-39).
Injector group removed (paragraph 2-40).
Air supply secured (port).
Battery banks disconnected (starboard). TM 55-1905-223-10.
Fuel crossovers removed (paragraph 2-38).

REMOVAL

a. Remove the push rods as follows:

(1) Some push rods (1, Figure 2-52) are under compression due to the valves being open. Rotate the crankshaft with the accessory drive pulley (2) to relieve the spring tension.

(2) To prevent increased wear, mark each push rod (1) asit is removed to identify its location in the engine.

(3) Lift the push rods (1) from the cylinder head (3). Store push rods where they will not be damaged.

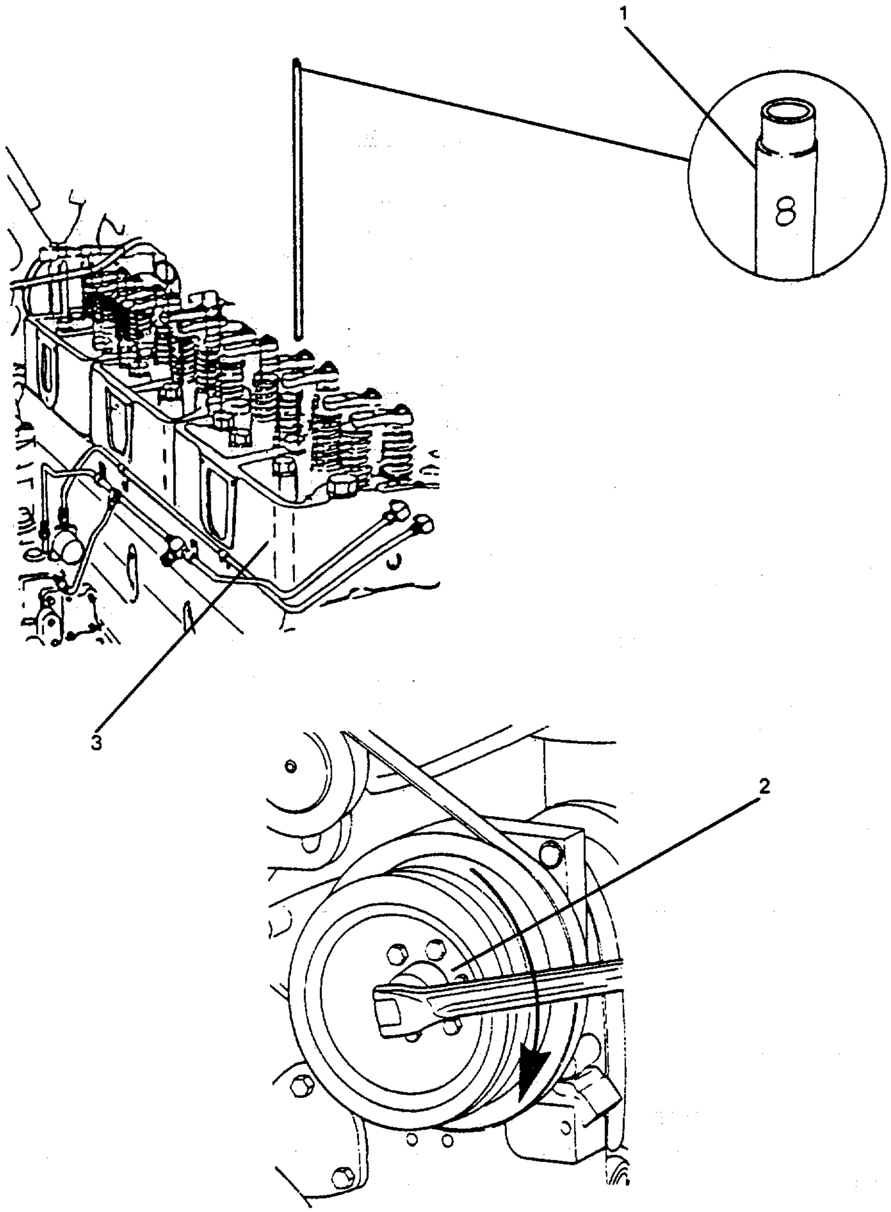


FIGURE 2-52. Push Rod Replacement.

b. Remove valve crossheads (3, Figure 2-53) from the cylinder head (7) as follows:

(1) Remove twelve valve crosshead plain hexagon nuts (2) and setscrews (1).

(2) Remove all valve crossheads (3).

c. Remove assembled washer screws (10), preformed packings.(8), and fuel crossover connections (9). Discard packings (8).

d. Remove twelve hexagon capscrews (4) and flat washers (5) from each cylinder head (7).

WARNING

Because the cylinder weighs more than 50 lb (23 kg), two people or a hoist will be required to lift the cylinder heads to avoid personal injury.

CAUTION

To prevent damage to the head gasket surface, put the cylinder heads on wooden blocks when they are removed.

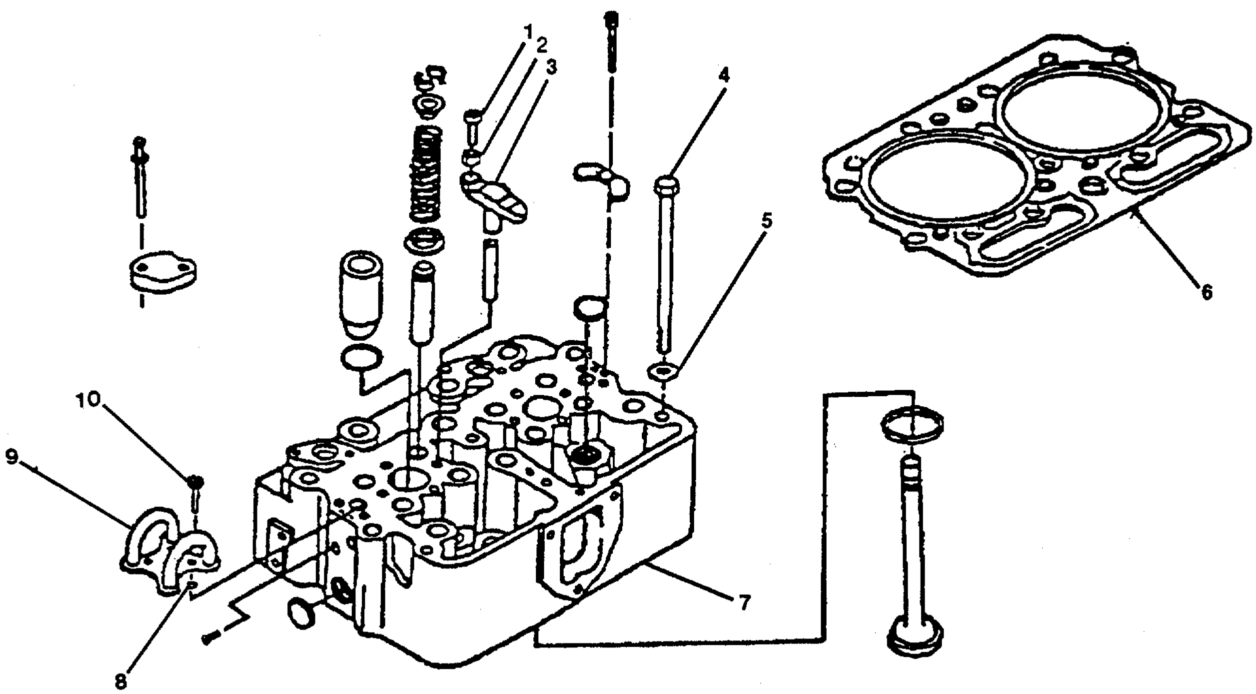


FIGURE 2-53. Cylinder Head Group.

NOTE

To prevent increased wear, mark each cylinder head as it is removed to identify its location on the engine.

e. Using the lifting fixture (hoist) and lifting sling or T-handles, lift each cylinder head (7) from the block. Remove each cylinder head gasket (6). Discard each gasket.

REPAIR

Repair of the cylinder head group is by replacement of the cylinder head (7, Figure 2-53) and cylinder head gasket (6).

REPLACEMENT

NOTE

- Be sure that the side of the gasket marked "TOP" is up (Figure 2-54).
- Two types of head gaskets can be used. One type has red silicone sealing beads. This gasket does not require any additional parts. The other type does not have the red silicone sealing beads and you must install water grommets into the gasket.

a. Install a new cylinder head gasket (2, Figure 2-54) on the dowel pins (1) in each cylinder block.

b. Install two threaded guide studs (4) in each block for each cylinder head (3).

WARNING

Because the cylinder weighs more than 50 lb (23 kg), two people or a hoist will be required to lift the cylinder heads to avoid personal injury.

c. Install each cylinder head (3) over the guide studs (4) using T-handles.

d. Remove the guide studs (4).

e. Use clean engine oil to lubricate the cylinder head capscrews (4, Figure 2-53) and both sides of the flat washer (5).

f. Allow the excess oil to drain from the threads.

g. Install capscrews (4) and flat washers (5) in each cylinder head.

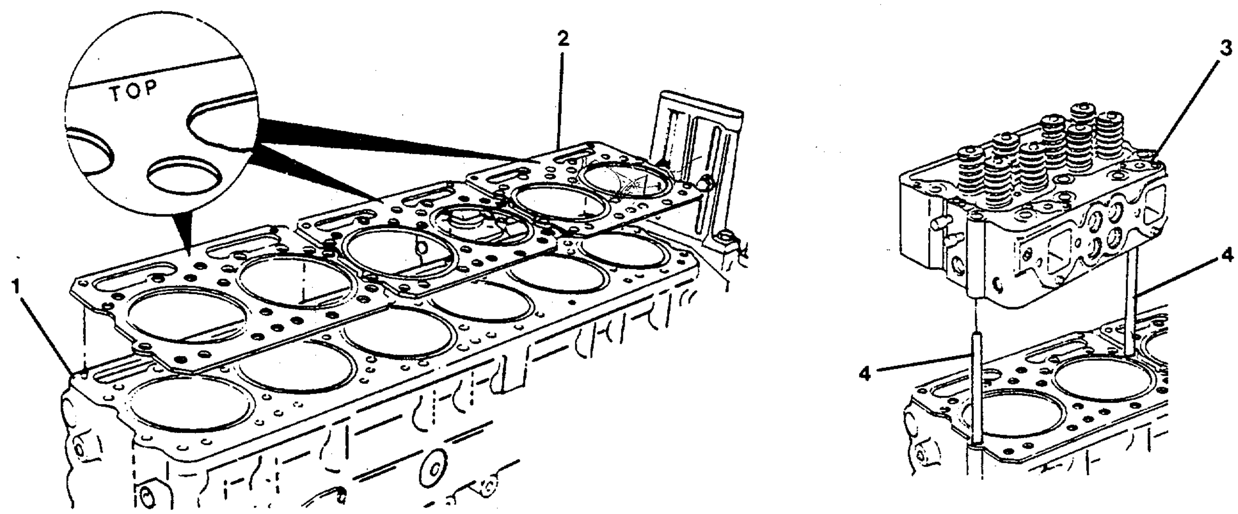


FIGURE 2-54. Positioning Head Gaskets.

h. Complete the following steps to tighten the capscrews on each cylinder head to the specified values in sequence shown in Figure 2-55.

NOTE

All capscrews are torqued to the specification in item 1; then item 2; and then item 3.

(1) Tighten to 25 ft-lb (34 N•m) torque.

(2) Tighten to 100 ft-lb (136 N•m) torque.

(3) Tighten to 285 ft-lb (387 N•m) torque.

i. Install fuel crossover connections (9, Figure 2-52) with preformed packing (8) and secure with assembled washer screws (10).

j. Install the injectors (paragraph 2-42).

k. Install the valve crossheads (3, Figure 2-53) as follows:

(1) Lubricate with clean engine oil.

(2) Install the crossheads (3) with the adjusting screw (1)toward the exhaust manifold side of the engine.

(3) Loosen the adjusting screw lock nut (2). Loosen the adjusting screw one full turn.

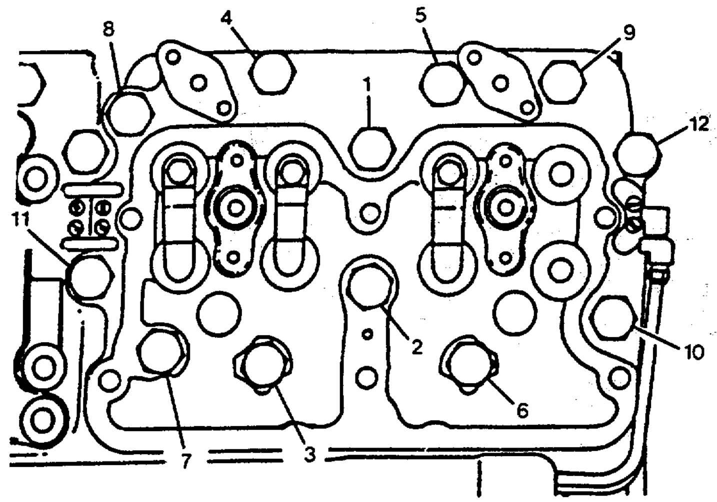


FIGURE 2-55. Cylinder Head Torque Sequence.

(4) Use light finger pressure to hold the crosshead (3) in position, and tighten the adjusting screw (1) until it touches the top of the valve stem.

NOTE

When a torque wrench adapter is used, tighten the lock nut (2) to 25 ft-lb (33.8 N•m) torque. If torque wrench adapter is not used, tighten to 30 ft-lb (41 N•m) torque.

(5) Measure the clearance (1 and 2, Figure 2-56) between the crosshead and the valve spring retainer. The clearance must be a minimum of 0.025 inch (0.65 mm).

NOTE

The injector push rods are larger in diameter than the valve push rods.

l. Install the push rods in the cylinder head as follows:

(1) Use clean engine oil to lubricate the ball end of the push rods(1, Figure 2-52).

(2) Install the push rods in the corresponding numbered location.

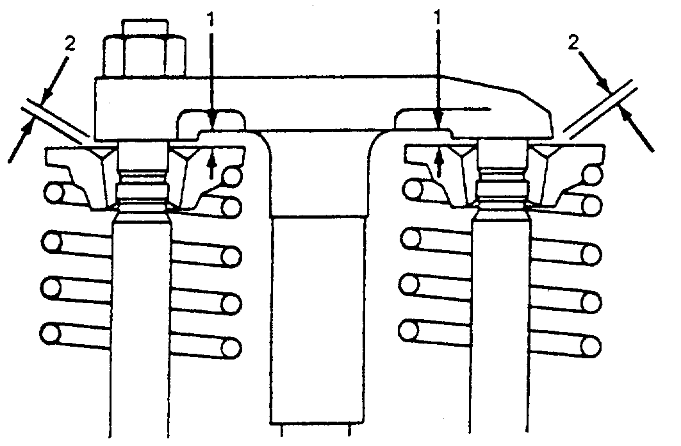


FIGURE 2-56. Crosshead Clearance.

NOTE

The crankshaft must be rotated clockwise to the accessory drive pulley (2, Figure 2-52) to install all the push rods.

(3) Install the injector push rods in the corresponding numbered location.

(4) Install the valve push rods in the corresponding numbered location.

m Install the rocker lever housings (paragraph 2-39).

n. Adjust the valves and the injectors (paragraph 2-39).

o. Install the aftercooler (paragraph 2-41).

p. Install the exhaust manifold (paragraph 2-42).

q. Install the injectors (paragraph 2-40).

r. Install the turbocharger (paragraph 2-30).

s. Install the rocker housing covers (paragraph 2-39).

t. Install the air crossover connection pipe (paragraph 2-41).

u. Fill the cooling system (Table 2-1, Item 24).

v. Prepare engine for operation, remove all tags, and turn on electrical power. TM 55-1905-223-10.

w. Start engine and run until it reaches a temperature of 1800F (820C) and check for leaks. TM 55-1905-223-10.

SECTION VI. PREPARATION FOR STORAGE, RESHIPMENT, AND RETURN TO SERVICE

2-44. General. If the generator set will be out of service for an extended period of time (3 weeks or longer), or reshipped to another location, certain actions must be taken to protect the engine against the corrosive effects of the elements. All surfaces of an engine will rust or corrode if they are not protected. The actions in this procedure must be taken before placing the set in storage or before reshipment to another location. Also see TB 740-97-4, Preservation of Vessels for Storage.

a. Temporary Storage. If an engine remains out of service for 3 weeks to 6 months, take steps to prevent rust. The following procedures are required to prevent damage to engine in temporary storage.

(1) The engine must be started and the speed gradually increased to 1200 rpm with no load. Operate the engine until the water temperature is at least 160°F (71°C).

(2) Disconnect both fuel lines at the fuel supply tank. Fill two portable containers, one with diesel fuel and a second with preservative oil (U.S. Military Specification MIL-L-644, Type P-9).

(3) Start the engine with the fuel inlet line pulling fuel from the can with the diesel fuel. Let the drain line flow into the container with the diesel fuel. After the engine is started and is running at idle, move the fuel line to the container with the preservative oil. Operate the engine 5 to 10 minutes on the preservative oil. Stop the engine and reconnect the fuel lines to the supply tank.

(4) The oil sump, fuel filters, and fuel tank must be drained and the drain plugs installed.

(5) Remove the intake hose from between the air cleaner and the intake manifolds.

(6) Disconnect the electrical wiring to the engine and generator assembly. Turn the shutoff valve on the fuel pump counterclockwise so that the engine will not start. Rotate the crankshaft of the engine while applying a spray of 10W oil into the intake manifold of the engine.

(7) Put tape over all the intake manifold (aftercooler) openings to keep out dirt and moisture.

(8) Put tape over all the engine openings, including the coolant inlets, cylinder block, oil breather and crankcase. Cover all openings in the generator assembly.

(9) Drain the coolant from the cooling system, unless it is a permanent antifreeze with a rust inhibitor added.

(10) Put the generator set in a place protected from the weather where the air is dry and the temperature is even.

(11) Rotate the engine crankshaft two or three revolutions every 3 weeks.

b. Long Term Storage. When the generator set is to be stored for 6 months or more, the following procedures must be performed.

(1) The engine must be started and the speed gradually increased to 1200 RPM with no load. Operate the engine until the water temperature reaches 160°F (71°C). Stop the engine and drain the old oil.

(2) Fill the crankcase to the full mark on the dipstick with preservative oil, U.S. Military Specification MIL-L-21260, Type P-10, Grade 2, SAE 30.

(3) Disconnect both fuel lines at the fuel supply tank. Fill two portable containers, one with diesel fuel and the second with preservative oil U.S. Military Specification MIL-L-644, Type P-9.

(4) Start the engine with the fuel inlet line pulling fuel from the can with the diesel fuel. The injector drain line can flow into the container with the diesel fuel. After the engine is started and is running at idle, move the fuel inlet line to the container with the preservative oil. Stop the engine and reconnect the fuel lines to the supply tank.

(5) The fuel tank must be drained and the drain plug installed. Make a cover for the filler vent with tape.

(6) Drain all the pumps, compressors, coolers, filters, and the crankcase. Replace all the plugs after draining.

(7) Remove the intake and exhaust manifolds. Apply the preservative oil in a spray into the intake and exhaust parts of the engine. Install the intake and exhaust manifolds.

(8) Inspect the coolant in the cooling system. If the coolant contains rust, drain and flush the system. Then fill it with a rust preventing compound. Drain the system while it is hot and then replace the plug. Use an oil that has rust inhibitors which will mix with the water. Flush the cooling system before returning it to service.

(9) Make sure that all outside surfaces of the engine are painted. If painting is necessary, refer to step c. of this procedure.

(10) Remove the valve covers and apply preservative oil to the rocker levers, valve stems, springs, guides, crossheads and push rods. Install the covers.

(11) All engine openings must have a cover of heavy paper and tape.

(12) Put a tag on the engine to show the following:

(a) The engine has been prepared for storage.

(b) The coolant has been removed.

(c) The crankshaft must not be rotated.

(d) The date the engine or set was prepared for storage.

(e) The compound used for storage must be removed before running the engine.

(13) Put the engine in a place protected from the weather and where the air is dry and the temperature is even.

NOTE

After the engine has been in storage for 24 months, flush it with solvent and repeat the preparation for storage.

c. Painting the Generator Set.

(1) Make sure that all engine surfaces are clean and dry before painting them.

(2) Put tape over all openings that must not be painted. Cover all openings in the generator assembly. Extreme care should be taken to avoid paint getting into the electrical windings, terminal box, and voltage regulator.

(3) Put tape over all belts or remove them.

(4) Protect the fuel pump dataplate, engine dateplate and other dataplates on the generator set from paint.

(5) Exposed threads, wire terminals, and hose fittings must be protected with tape. Pipe openings, fuel pump drain, fuel manifold drain, and oil cooler openings must have a cap installed.

(6) If the generator assembly is removed from the engine, protect the surface of the flywheel with a rust preventing compound if the engine is not going into immediate service.

(7) Apply a coat of primer to the outside surfaces of the generator set.

(8) Apply enamel paint to the outside surfaces after the primer is dry.

2-45. Preparing the Generator Set For Service From Storage. When an engine or generator set is removed from storage and put into service, the operations listed below must be completed.

a. Cleaning the Generator Set.

(1) Remove all dirt from the outside of the generator set.

(2) Remove all the paper covers and tape.

(3) Use solvent to remove rust preventing compound from the surfaces of the engine.

(4) Fill the crankcase with clean oil.

(5) Flush and fill the cooling system.

b. Inspecting the Generator Set.

(1) Engines in storage 6 months or less must have the adjustment of the injectors, valves, and the belts checked. Also check the oil filters, air filters, connections, and the torque of the cylinder head capscrews.

(2) When an engine has been in storage for 6 months or more, the following inspection procedure must be followed:

(a) Flush the fuel system with fuel oil until the fuel system is clean.

(b) Remove the plug from the oil filter head and run hot, light mineral oil through the oil passages. Rotate the engine three or four times during the flushing operation.

(c) Remove all screens and make sure they are clean before the engine is started.

(3) If a generator has been in storage for over 6 months, or has been exposed to high humidity or temperature changes that could cause condensation, the insulation resistance should be checked before putting the unit into service.

(a) Check all internal wiring connections for tightness.

(b) Check the resistance of the main stator windings (paragraph 3-12).

(c) If the resistance reading is not satisfactory, dry the generator windings.

1 Direct the warm air from one or two fan heaters into the openings at either end of the generator.

2 Make sure the air flows over the windings through the generator.

3 Do not exceed 176°F (80°C) air temperature when drying the generator.

(d) After 2 hours of drying, measure the main stator resistance again. If resistance is satisfactory, put the unit into service. If the resistance is still too low, repeat the drying procedure.

c. Precautions Before Starting.

(1) Too much oil in the combustion chamber can cause a hydraulic lock. Damage to the engine will occur if it is started before the oil is removed.

(2) When returning an engine to service from storage, make sure all foreign matter is removed from the screens and strainers.

(3) Apply oil under pressure to the lubricating system before starting the engine.

(4) The engine is now ready to start.

d. Starting the Engine.

(1) After inspecting the engine and parts, make sure all the preservative oil has been flushed away. For pre-servicing refer to paragraph 2-7.

(2) Start the engine and conduct run-in inspection. Refer to paragraphs 2-8 and 2-9.

(3) Adjust the governor speed. Refer to-paragraph 2-10.

(4) Conduct generator pre-service, startup, and run check. Refer to paragraph 2-11.

CHAPTER 3

INTERMEDIATE DIRECT SUPPORT MAINTENANCE INSTRUCTIONS

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

3-1. Common Tools and Equipment. For authorized common tools and equipment refer to the Modified Table of Organization and Equipment (MTOE) applicable to your organization.

3-2. Special Tools, TMDE, and Support Equipment. Special tools; test, measurement, and diagnostic equipment; and support equipment requirements are listed and illustrated in the Repair Parts and Special Tools List (RPSTL), TM 55-1905-223-24P. These items are also listed in the Maintenance Allocation Chart (MAC), Appendix B of this manual.

3-3. Repair Parts. Repair parts are listed and illustrated in the Repair Parts and Special Tools List (RPSTL), TM 55-1905-223-24P.

SECTION II. SERVICE UPON RECEIPT

3-4. Checking and Deprocessing Unpacked Equipment.

a. Inspect the equipment for damage incurred during shipment. If the equipment has been damaged, report the damage in accordance with the instructions of DA Pam 738-750.

b. Check the equipment against the packing slip to see if the shipment is complete. Report all discrepancies in accordance with the instructions of DA Pam 738-750.

c. Check to see whether the equipment has been modified.

d. Remove protective caps, plugs, inserts, wrappings, and tape when inspection/inventory is completed. Inspect piping openings for damage. Wipe off dirt, grease or protective films at time of installation.

e. Remove chocks from resilient mounted components.

3-5. Initial Setup Procedure. Includes operational checks and inspections that are not performed for a routine startup. Direct support maintenance personnel will perform initial setup in accordance with the operator's manual, TM 55-1905-223-10.

3-6. Normal Startup. Refer to the operator's manual, TM 55-1905-223-10.

3-7. Shutdown Procedure (Usual or Unusual). Refer to the operator's manual, TM 55- 1905-223-10.

SECTION III. INTERMEDIATE DIRECT SUPPORT PREVENTIVE MAINTENANCE CHECKS AND SERVICES (PMCS)

3-8. PMCS. There is no PMCS at the direct support level. See Chapter 2, Section III.

SECTION IV. INTERMEDIATE DIRECT SUPPORT TROUBLESHOOTING

3-9. General Engine Noise Diagnostic Procedures. When diagnosing engine noise problems, make sure that noises caused by accessories, such as the air compressor and power take-off, are not mistaken for engine noises. Remove the accessory drive belts to eliminate noise caused by these units. Noise will also travel to other metal parts not involved in the problem. The use of a stethoscope can help locate an engine noise. For further information concerning engine noise, refer to paragraph 2-13.

3-10. White Smoke - General Information. White smoke is the result of incomplete combustion and is generally associated with engine start-up at low ambient temperatures. This condition is more predominant on high horsepower fixed injection timing engines because the fuel and combustion systems are optimized for maximum performance and for reliability and durability under high load operating conditions. For further information concerning white smoke, refer to paragraph 2-14.

3-11. Troubleshooting. Both a symptom index and a troubleshooting table are provided. The symptom index will help you locate the information you need for troubleshooting.

SYMPTOM INDEX

	Troubleshooting Procedure (Table 3-1)
COOLANT	
Temperature above normal	1
In the lube oil	6
Loss (internal)	2
ENGINE	
Excessive white smoke (idle)	16
Starts but will not keep running	9
Crankcase gases excessive	13
Cranks, won't start	8
Runs rough (warm)	10
Vibration excessive	14
Rough idle	11
Exhaust smoke excessive (under load)	12
Surges under load	23
Surges at high idle	24
GENERATOR	
No voltage output	21
Voltage fluctuating	22
Voltage not satisfactory	20
LUBE OIL	
Consumption excessive	7
In coolant	3
Pressure high	5
Pressure low	4
NOISE	
Connecting rod bearing	18
Main bearing	17
Piston	19
Engine noise excessive	15

Table 3-1 lists the common fault conditions that may be found during operation or maintenance of the equipment. Look for causes and do corrective actions in the order listed. This manual cannot list every symptom that may show up, and it cannot list all of the possible causes and corrective actions. If a symptom is not listed, or if it keeps up after you have performed the corrective actions, notify your supervisor.

Table 3-1. Troubleshooting

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

1. Coolant temperature above normal.

   STEP 1. Check for obstructed or damaged oil cooler.

   Clean and inspect oil cooler (para. 3-15).

2. Loss of engine coolant (internal leakage).

   STEP 1. Check for leaking lubricating oil cooler.

   Inspect cooler element (para. 3-15).

3. Lubricating oil in coolant.

   STEP 1. Check for malfunctioning oil cooler.

   Inspect oil cooler (para. 3-15).

4. Low lubricating oil pressure.

   STEP 1. Check to see if main oil pressure regulator is indicating low pressure on the lube oil cooler/filter.

   Clean or replace pressure regulator (para. 3-15).

   STEP 2. Check to see if lubricating oil pump signal orifice is restricted or plugged.

   Clean signal line orifice (para. 3-22).

   STEP 3. Check for broken oil transfer to suction tube.

   Remove and inspect oil pan, tubes, and fittings (para. 3-21).

   STEP 4. Check for lubricating oil pump malfunction.

   Repair or replace pump as required (para. 3-22).

5. High lubricating oil pressure.

   STEP 1. Check to see if main oil pressure regulator is malfunctioning on the lube oil cooler/filter.

   Clean or replace pressure regulator (para. 3-15).

6. Coolant in the lubricating oil.

   STEP 1. Check for malfunctioning oil cooler.

   Inspect oil cooler (para. 3-15).

7. Excessive lubricating oil consumption.

   STEP 1. Check to see if piston rings are worn, broken, or not properly seated.

   a. Refer to engine blowby checks in Table 2-2, Malfunction 16, Step 2.

Table 3-1. Troubleshooting-CONT

MALFUNCTIO N
TEST OR INSPECTION
CORRECTIVE ACTION

b. Replace piston and ring assembly (para. 3-24).

STEP 2. Check for worn piston ring grooves.
Refer to Step 1 corrective action.

8. Engine cranks but will not start (no smoke from exhaust).

STEP 1 Check if shutdown valve is closed or defective.
Replace shutdown valve (para. 3-16).

STEP 2. Check for no fuel through governor actuator.
Replace fuel pump actuator (para. 3-16).

STEP 3. Check for broken camshaft.
Replace camshaft (para. 3-23).

9. Engine starts but will not keep running.

STEP 1. Check injection timing (para. 3-18).

10. Warm engine runs rough or misfires in operating range.

STEP 1. Check for damaged camshaft.
Replace camshaft (para. 3-23.)

STEP 2. Check injection timing.
Adjust timing (para. 3-18).

STEP 3. Check valve timing.
Adjust timing (para. 2-40).

11. Rough idle.

STEP 1. Check injection timing.
Adjust timing (para. 3-18).

STEP 2. Check valve timing.
Adjust timing (para. 2-40).

smoke excessive under load (blue smoke).

Check to see if piston rings are not sealing.
to Malfunction 7, Step 1 corrective action.

Table 3-1. Troubleshooting-CONT

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

13. Excessive crankcase gases (blowby).

STEP 1. Check to see if piston rings are broken or worn.
Refer to Malfunction 7, Step 1 corrective action.

14. Excessive engine vibration.

STEP 1. Check for loose or damaged vibration dampener.
Inspect vibration dampener (para. 3-26).

STEP 2. Check for loose or damaged flywheel.
Repair flywheel (para. 3-25).

15. Excessive engine noise.

STEP 1. Check for damaged push rod or cam follower.
Replace push rods or cam followers as required (para. 3-18).

STEP 2. Check for excessive gear train backlash or damaged gear teeth.
Replace camshaft as required (para. 3-23).

16. Excessive white smoke at idle.

STEP 1. Injection timing set wrong.
Check injection timing (para. 3-18).

17. Main bearing noise.

STEP 1. Check for loose flywheel.
Check flywheel mounting capscrews. Replace flywheel if required (para.3-25).

18. Connecting rod bearing noise.

STEP 1. Check to see if connecting rod capscrews are loose or not tightened correctly.
Inspect the connecting rod capscrews (para. 3-24).

STEP 2. Check to see if connecting rod bearings are damaged, worn, not assembled correctly, or if wrong bearings installed.
Replace connecting rod bearings (para. 3-24).

STEP 3. Check to see if connecting rods are bent or are out of alignment.
Replace connecting rod assembly (para. 3-24).

STEP 4. Check for damaged or out of round crankshaft journals.
Replace crankshaft (para. 4-16).

Table 3-1. Troubleshooting-CONT

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

19. Piston noise.

STEP 1. Check to see if pin or bushing is loose, worn, or not installed correctly.
Replace piston and ring assembly (para. 3-24).

STEP 2. Check for cracked or broken piston.
Replace piston and ring assembly (para. 3-24).

STEP 3. Check to see if connecting rod(s) are bent or out of alignment.
Replace connecting rods(s) (para. 3-24).

STEP 4. Check to see if piston rings are worn or are out of alignment.
Replace connecting rod and piston assembly (para. 3-24).

STEP 5. Check for worn or broken piston rings.
Replace piston and ring assembly (para. 3-24).

STEP 6. Check to see if liners are worn or out-of-round.
Replace cylinder block (para. 3-27).

20. Generator voltage unsatisfactory (voltage regulator operating properly).

STEP 1. Check for defective generator or exciter.
Test generator (para. 3-13).

21. No voltage output from generator.

STEP 1. Check for open or shorted exciter leads or windings.
Test generator (para. 3-13).

22. Generator voltage fluctuates, even though voltage regulator and accessories are operating properly.

STEP 1. Check for intermittent fault within the generator windings.
Test generator (para. 3-13).

23. Engine surges under load at rated speed, throttle wide open.

STEP 1. Check fuel pump for incorrect assembly or adjustment.
Replace fuel pump (para. 2-37).

24. Engine surges at high idle.

STEP 1. Check fuel pump for incorrect assembly or adjustment.
Replace fuel pump (para. 2-37).

Section V. INTERMEDIATE DIRECT SUPPORT MAINTENANCE PROCEDURES

MAINTENANCE OF SHIP'S SERVICE GENERATOR SETS, ELECTRIC AND AIR START

3-12. Replace/Repair Ship's Service Generator Sets, Electric and Air Start.

This task covers: a. Removal, b. Repair, c. Replacement.

INITIAL SETUP

Tools

Tool kit, general mechanic's
rail and marine diesel engines,
5180-00-629-9783
Tool kit, electrician's
5180-00-391-1087
Lifting fixture P/N 3822512
Lifting sling P/N 3375958
Torque wrench kit P/N 3377216

Materials/Parts

New generator set and subbase
P/N S.O. 56419 (electric start) or
P/N S.O. 56420 (air start)
Lubricating oil, Item 2, Appendix C
Antifreeze coolant, Item 8, Appendix C

Equipment Condition

Engine cooled below 120°F (50°C).
Cooling system drained (Table 2-1, Item 24).
Lube oil drained (Table 2-1, Item 15).
Air supply secured (port).
Battery bank disconnected (stbd) TM 55-1905-223-10.

REMOVAL

WARNING

Ensure that all local and automatic starting circuits are disabled to avoid injury to personnel.

a. Turn all starting circuits to the generator assembly OFF and tag. Close start air valves on air start engine and tag.

b. Disconnect all external wiring and cables to generator assembly and tag. Refer to paragraph 3-13.

(1) Remove the terminal box cover on generator. Disconnect cable connectors in the cover as necessary for access into terminal box.

CAUTION

Ensure that all wiring and cables are tagged with their locations recorded as they are removed from the generator terminal box.

(2) Disconnect and tag all external cables from inside the terminal box.

(3) Remove the disconnected cables and their conduits from the generator terminal box. Ensure that you record the location where each cable and conduit is removed from the terminal box. Each cable must be returned to the same location on replacement generator set when it is installed.

(4) Tag and disconnect all control wiring attached to the voltage regulator.

c. Disconnect hoses, lines, and electrical wiring to the engine assembly as follows:

NOTE

Tag all hoses, lines, and electrical wiring connections as they are removed. This will identify their locations on installation of replacement engine.

(1) Close the following external valves:

(a) Fuel supply line valve.

(b) Fuel drain line valve.

(c) Clean oil supply line valve.

(d) Dirty oil drain line valve.

NOTE

Coolant supply, drain, and vent line valves should have been closed when draining the cooling system.

(2) Disconnect starter motor.

(a) Disconnect the external wiring and cables on electrical starting motor/magnetic switch group (paragraph 2-25).

(b) Disconnect air supply lines to engine air starter (paragraph 2-24).

(3) Disconnect and tag all external electrical wiring to the instrument panel, fuel pump governor control.

(4) Remove the inlet connection to the fuel filter group (paragraph 2-31) and drain excess fuel from the engine.

WARNING

Ensure that all power is OFF and tagged to the coolant heater group.

(5) Remove and tag external electrical wiring to the coolant heater group (paragraph 2-36).

NOTE

Cover all engine openings to prevent dirt and debris from entering.

(6) Disconnect and tag the turbocharger and exhaust group air piping (paragraph 2-30).

(7) Disconnect and tag the following lines from the engine:

(a) Fuel supply and tank return lines.

(b) Clean oil supply line.

(c) Dirty oil drain line at sump pump.

(d) Coolant supply, drain, and remote expansion tank vent lines.

d. Attach the lifting fixture (hoist) to the four lifting pad eyes (1, Figure 3-1) provided on the generator subbase (two on each side).

e. Remove the subbase mounting nuts at the six resilient mount (2) locations (three on each side).

WARNING

Personnel stand clear during hoisting operation.

f. Lift the set slowly, ensuring that the lifting device is holding properly.

g. Remove the generator and subbase.

NOTE

It may be necessary to move, or remove, other external components or fixtures to provide necessary clearance for removing the set.

h. Remove the two bolts in each mount (2, Figure 3-2) and remove the six rubber cushioned mounts.

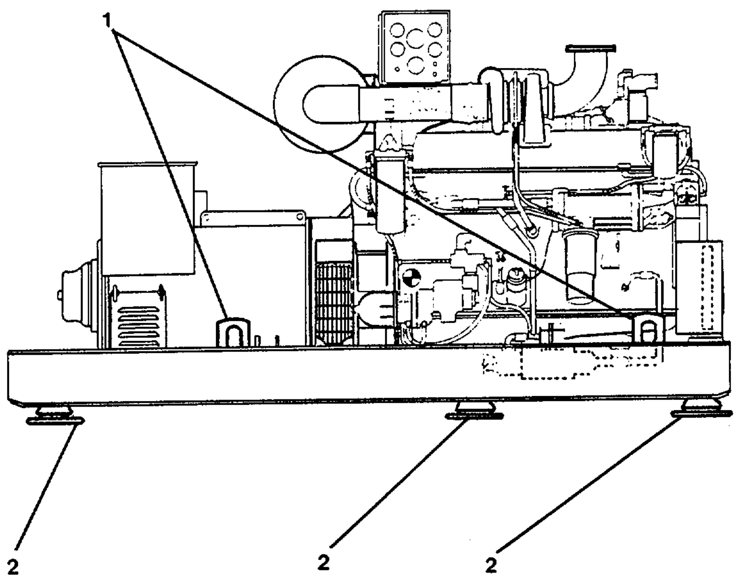


FIGURE 3-1. Lifting Eyes and Mounts.

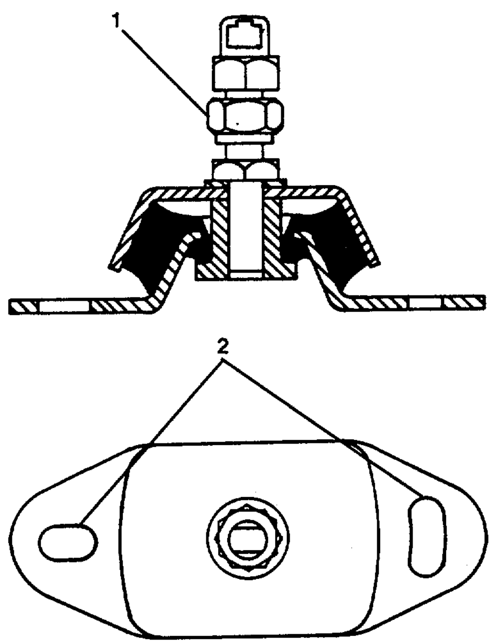


FIGURE 3-2. Resilient Mount.

REPAIR

Repair of the components in the ship's service generator set is covered in paragraphs 3-13 through 3-28 of these procedures.

REPLACEMENT

a. Install new resilient mounts:

(1) Insert two mounting bolts in each mount (2, Figure 3-2).

(2) Do not tighten bolts completely at this point.

NOTE

- The bolt holes in the mounts are elongated slightly to allow for minor adjustment when aligning the generator set on the mounts.

- Ensure the nuts (1, Figure 3-2) are removed from each mount before hoisting generator set into place.

b. Hoist replacement generator set into place over the rubber cushioned mounts. Lower the seat slowly, while at the same time, aligning the bolt stud in each mount with the subbase mounting holes. Tap the mount slightly in the required direction to align.

c. Lower the generator subbase onto the mounts. Install the nut on each of the six mounting bolt studs.

d. Tighten the resilient bolts to 120 ft-lb (160 N•m) torque.

e. Tighten the center bolt/nut in each resilient mount to 120 ft-lb (160 N•m) torque.

f. Remove the lifting fixture.

NOTE

Uncover each engine opening prior to connecting the line, hose, or pipe.

g. Connect the following lines to the engine:

(1) Coolant supply, drain, and remote expansion tank vent lines.

(2) Dirty oil drain line to the sump pump.

(3) Clean oil supply line.

(4) Fuel supply and tank return lines.

(5) Remove all tags.

h. Connect the exhaust group air piping (paragraph 2-30).

i. Connect the electrical wiring to the coolant heater group (paragraph 2-36). Remove tags.

j. Ensure the following filters are secure:

(1) Fuel filters

(2) Full flow and bypass oil filters

(3) Water filter

k. Connect all external wiring that was removed from the instrument panel, governor control, and emote sending units. Ensure that all connections are returned to the same locations from which they were removed on the old engine. Remove tags.

l. Remove the cover from generator terminal box.

m Refer to tags and notes made during the removal process and connect all cables and conduits to, and through, the same locations on the generator terminal box that they were removed from on the old generator set. Remove tags.

CAUTION

Ensure all leads are connected to their proper terminals to avoid electrical component damage.

The center neutral or ground terminal is not to be used. If the new generator comes equipped with a grounding strap, remove the strap.

n. Refer to tags and notes made on removal and connect all leads to their proper terminals within the terminal box. Remove tags. Replace the cover on the terminal box.

o. Remove the cover on the voltage regulator and return all external leads to the voltage regulator to their proper terminals. Remove tags.

p. Install the voltage regulator and terminal box covers.

q. Connect the starter motor:

(1) Connect wiring and cables to electric starting motor/magnetic switch group (paragraph 2-25). Remove tags.

(2) Connect air supply line to engine air starter (paragraph 2-24).

r. Open the following external valves to the engine:

(1) Fuel supply line valve.

(2) Fuel tank return line valve.

(3) Coolant supply, drain, and remote expansion tank vent line valves.

(4) Remove all tags.

s. Fill the lubricating oil system (Table 2-1, Item 15).

t. Fill the cooling system.

NOTE

Replace any external components or fixtures that were moved, or removed, when removing the old generator set.

u. Perform break-in, pre-servicing, start-up, run-checks, and generator inspection in accordance with paragraphs 2-6 through 2-11.

3-13. Replace/Repair Generator Assembly.

This task covers: **a. Test,** **b. Repair,** **c. Removal** **d. Replacement**

INITIAL SETUP

Tools

Tool kit, general mechanic's
rail and marine diesel engines,
5180-00-629-9783
Tool kit, electrician's,
5180-00-391-1087
Lifting fixture P/N 3822512
Lifting sling P/N 3375958
Multimeter, 6625-01-139-2512

Materials/Parts

Silicone heat sink compound,
Item 14, Appendix C
Semiconductor P/N 364-10840
Semiconductor P/N 364-10850

Equipment Conditions

Engine cooled below 120°F (50°C).
Air supply secured (port).
Battery bank disconnected (stbd).

TEST

NOTE

For check/test purposes the generator is divided into two areas: the windings and rectifier assembly (1, Figure 3-3) and the electronic system and its wiring (2).

a. Windings and rectifier assembly.

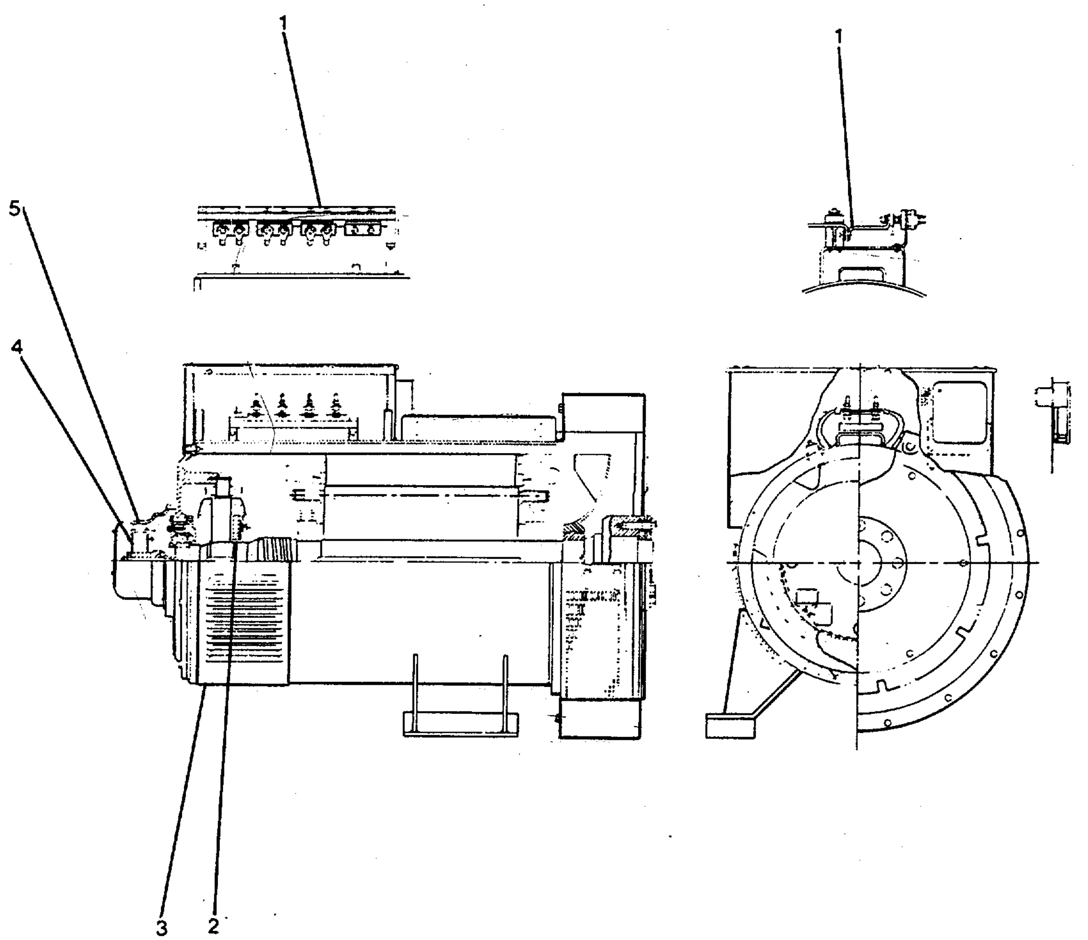


FIGURE 3-3. Generator Assembly.

NOTE

The generator is separately excited by a 12 volt dc battery supply to give an indication of the condition of the windings and main rectifier assembly. Refer to figures 3-4 and 3-5 for terminal locations and method of separately exciting the generator.

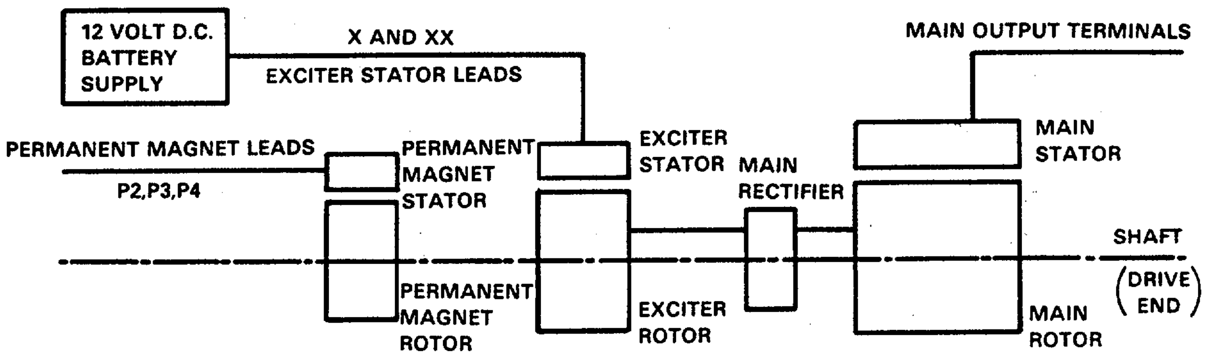


FIGURE 3-4. Separately Exciting the Generator.

NOTE

A 12 volt dc battery supply is sufficient to obtain the full output voltage within ±10 percent, at no load and rated speed.

(1) Use a 12 volt dc supply to separately excite the generator as follows (see Figure 3-5 for voltage regulator terminals):

(a) Remove and tag the exciter stator leads marked X and XX from the automatic voltage regulator.

(b) Measure the resistance between lead Xand lead XX. Resistance should be 26.6 to 30.8 ohms.

(c) Remove and tag the remaining push on leads from the automatic voltage regulator.

(d) Connect the 12 volt dc battery positive lead to the X lead and the negative lead to the XX lead going to the manual voltage regulator.

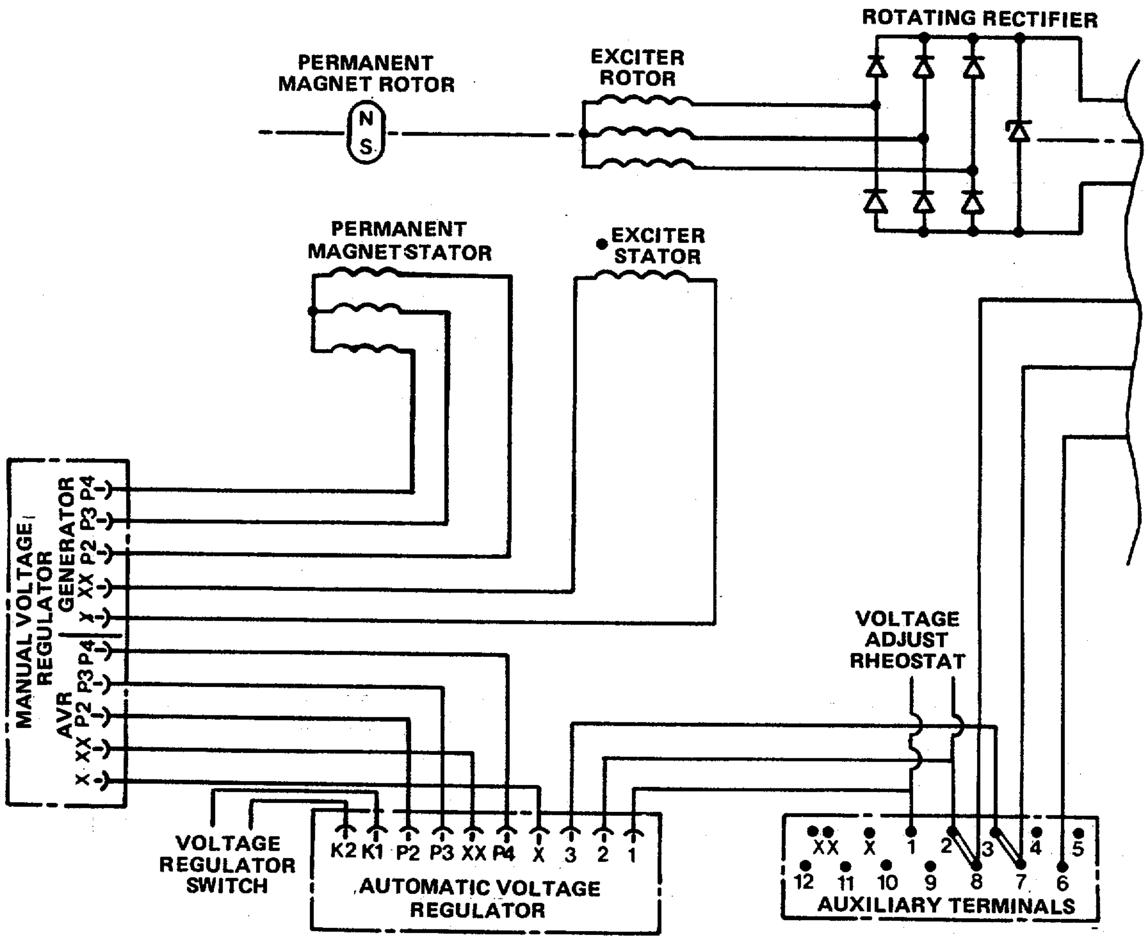


FIGURE 3-5. Voltage Regulator Connections and Wiring.

WARNING

Disconnect main line circuit breaker to generator, if applicable, and tag.

(e) Start ship's service generator set and bring it to rated speed (1800 rpm). TM 55-1905-223-10.

NOTE

It is essential that the speed is correct when checking the output voltage.

(2) Using a multimeter, measure the dc voltage at leads X and XX. The voltage must read between 12.0 to 13.2 volts.

(3) Using a multimeter, check the output from the main stator terminals on the main terminal board (1, Figure 3-3).

(a) If the voltage is balanced and within 1 percent of nominal, the main windings and rectifier semiconductors are good and require no further test.

(b) If an unbalance is shown on any phase of more than 1 percent, this indicates that a fault exists in the main stator windings. Check the main excitation windings (step (5) of this procedure).

NOTE

The balance check should be made again with all external wiring connections removed to eliminate the possibility of external shorts.

(c) If the voltage is balanced but reading low when separately excited, this indicates that a fault exists in either the rectifier assembly or one of the excitation windings. Check the rectifier semiconductors, step (4), and excitation windings, step (5) of this procedure.

NOTE

Ensure the separate battery supply is between 12.0 and 13.2 volts and the speed is 1800 rpm.

(d) Shut down generator and turn electrical power OFF and tag (TM 55-1905-223-10). Remove the separate 12 volt battery and reconnect all leads to the voltage regulator and external connections that were removed for test purposes.

(4) With the generator set shut down and cool, and electrical power OFF, check the rectifier semiconductors. The rectifier assembly (Figure 3-6) is split into two plates, positive and negative, and the main rotor is connected across these plates. The positive plate has three positive semiconductors, and the negative plate has three negative semiconductors.

CAUTION

Ensure that the correct polarity of the semiconductors is fitted to each respective plate.

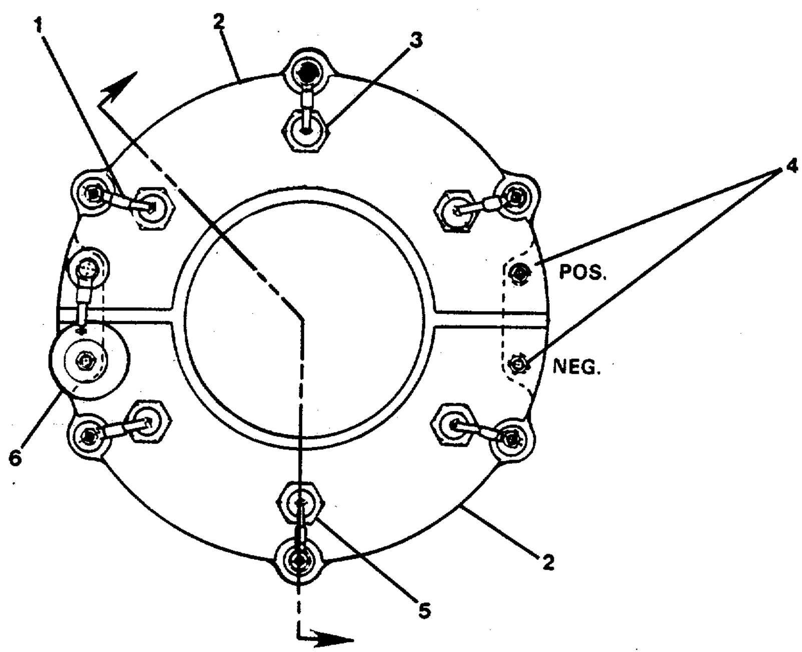


FIGURE 3-6. Rectifier Assembly.

(a) Check the tightness of the semiconductors to ensure good mechanical and electrical connection. Tighten the semiconductors to 36-42 in-lb (4.06-4.74 N•m) torque.

(b) Disconnect the flexible lead to each semiconductor (1, Figure 3-6) and check the forward and reverse resistance. Use a multimeter on the 10,000 ohms scale and check the semiconductor resistance.

1 A good semiconductor will give a high resistance (infinity) in the reverse direction, and a low resistance in the forward direction.

2 An open semiconductor will give a high resistance reading in both directions, and a low resistance reading in both directions for a shorted one.

(c) Check the varistor (6, Figure 3-6) surge suppressor using a multimeter. The varistor is connected across the two rectifier plates to prevent reverse voltages from damaging the semiconductors.

1 A good varistor will show a high resistance (virtually infinity) reading in both directions.

NOTE

A defective varistor will be burnt, missing, or have the lead wire burnt off.

2 A defective varistor will show a full-deflection (short-circuit) reading in both directions.

(d) Replace defective semiconductors and varistor as necessary (see Disassembly and Assembly steps of this procedure).

(5) With the generator shut down, and electrical power OFF to the machine, check the main excitation windings.

(a) Check the exciter stator resistance. Remove leads X and XX from the manual voltage regulator. Using a multimeter measure the resistance between leads X and XX. Refer to Table 3-2 for the correct winding resistance (reading).

Table 3-2. Winding Resistance (Ohms)

Exciter Stator	Exciter Rotor	Main Stator (per phase)	Main Rotor
21.0	0 (0.17)	0 (0.009 to 0.011)	1.20

(b) Check the exciter rotor resistance. The exciter rotor is connected to the six studs on the rectifier assembly where the six semiconductor leads are connected (3, 5, Figure 3-6). All six rotor leads must be disconnected and resistance measured between the forward and reverse leads to the rotor. Refer to Table 3-2.

NOTE

A normal exciter rotor resistance reading is not distinguishable as it is less than one ohm, but an abnormal resistance reading is detectable.

(c) Check the main rotor resistance. The main rotor winding is connected across the two plates on the rectifier assembly (4, Figure 3-6). Disconnect the two leads and measure the resistance between the leads. Refer to Table 3-2.

(6) Check the automatic voltage regulator sensing supply from the main stator.

(a) Separately excite the generator as described in step (1) of this procedure.

(b) Ensure the output voltage is correct on the main terminals.

(c) Check the voltage on leads 2 and 3 which were disconnected and tagged from the automatic voltage regulator in step (1) of this procedure. The voltage should be between 10 and 16 volts dc.

(d) Remove the separately excited supply battery and connect all leads that were removed from the voltage regulator terminals. Remove tags.

(7) Test the permanent magnet exciter. The permanent magnet exciter (4, 5, Figure 3-3) is on the non-drive end of the generator and is isolated from all other windings. It is the main power supply to the voltage regulator and must be tested independent of the other windings.

(a) Disconnect and tag the permanent magnet exciter leads from terminals P2, P3, and P4 on the automatic voltage regulator.

(b) Run the generator up to full speed.

(c) Using a multimeter, check the output voltage across leads P2, P3, and P4. The voltage between P2 and P3, P2 and P4, and P3 and P4 should be balanced with a minimum of 150 volts at 1500 rpm (180 volts at 1800 rpm).

NOTE

The permanent magnet exciter will produce an output voltage completely independent from the rest of the generator. It has no effect on the separate excitation tests carried out in previous text.

(d) Shut down the generator and connect the push-on leads to terminals P2, P3, and P4 on the voltage regulator. Remove tags.

NOTE

When the generator is being controlled by the voltage regulator, a fault in the permanent magnet exciter could result in voltage drift or a loss of voltage completely.

b. Electronic Control System.

NOTE

Should all windings tests prove successful, faults can normally be assumed to be within the voltage control system and/or its respective wiring.

(1) Check for broken, loose, or corroded connections on the voltage regulator. Correct as required.

(2) Check the wiring between auxiliary terminals and the voltage regulator for breaks, burns, loose terminals, or other damage. Correct as required.

(3) To check for a defective automatic voltage regulator, perform the following procedure.

(a) Operate engine at rated speed.

(b) Turn voltage adjust rheostat on the automatic voltage regulator from maximum to minimum volts.

(c) If the generator output voltage changes, the automatic voltage regulator is operating properly.

REPAIR

Repair of the generator assembly is limited to replacement of defective semiconductors.

a. Removal of semiconductors.

WARNING

Before attempting any work on the generator, ensure engine is shut down and automatic starting circuits are disabled to avoid injury to personnel. Read the WARNING section at the front of this manual before performing any maintenance function.

(1) Turn off and tag all starting circuits to the generator set.

(2) Remove the non-drive end covers (3, Figure 3-3) for access to the rectifier assembly (2)

(3) Disconnect the terminal leads on positive semiconductors (3, Figure 3-6) and/or negative semiconductors (5) as appropriate.

(4) Remove faulty semiconductors.

b. Replacement of semiconductors.

CAUTION

Heat sink compound must not be applied to the semiconductor stud threads.

NOTE

All semiconductors in the rectifier assembly must be from the same manufacturer.

(1) Apply a small amount of silicone heat sink compound to the underside of each semiconductor. Ensure no compound gets on the threads.

(2) Install the new semiconductor (3, 5, Figure 3-6) and tighten to 36-42 in-lb (4-4.8 N-m) torque. Connect the terminal leads and remove tags.

(3) Replace the non-drive end covers (3, Figure 3-3).

REMOVAL

a. Turn all starting circuits to the generator set OFF. Close start air valves on air start engine.

b. Remove the screws (1, Figure 3-7) and remove the terminal box cover (2).

CAUTION

It is extremely important to ensure that all wiring and cables are tagged with locations recorded as they are removed from the terminal block (3, Figure 3-7).

c. Tag and disconnect all external cables attached to the block (3).

d. Remove the disconnect cables and their conduits from the generator terminal box. Ensure that you record the location where each cable and conduit is removed from the terminal box. Each cable must be returned to the same location on the new generator assembly when it is installed.

e. Tag and disconnect all external control wiring coming to the voltage regulator (4).

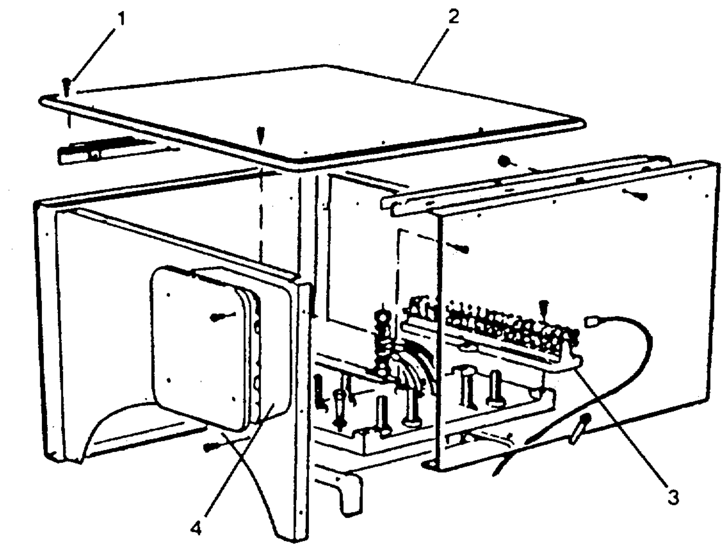


FIGURE 3-7. Generator Terminal Box.

f. Remove screws (4, Figure 3-8) and weather screens (5) from each side of the housing (6).

g. Attach a suitable hoist to the generator lifting bracket (10).

h. Remove the mounting bolts (2) securing the generator to the subbase.

i. Remove the capscrews (8) securing flex discs (7) to the flywheel of the engine.

j. Remove the capscrews (3) securing the generator to the housing (6).

k. Lift the generator slightly and move it slowly away from the engine flywheel. Be very careful.

l. Remove the generator assembly.

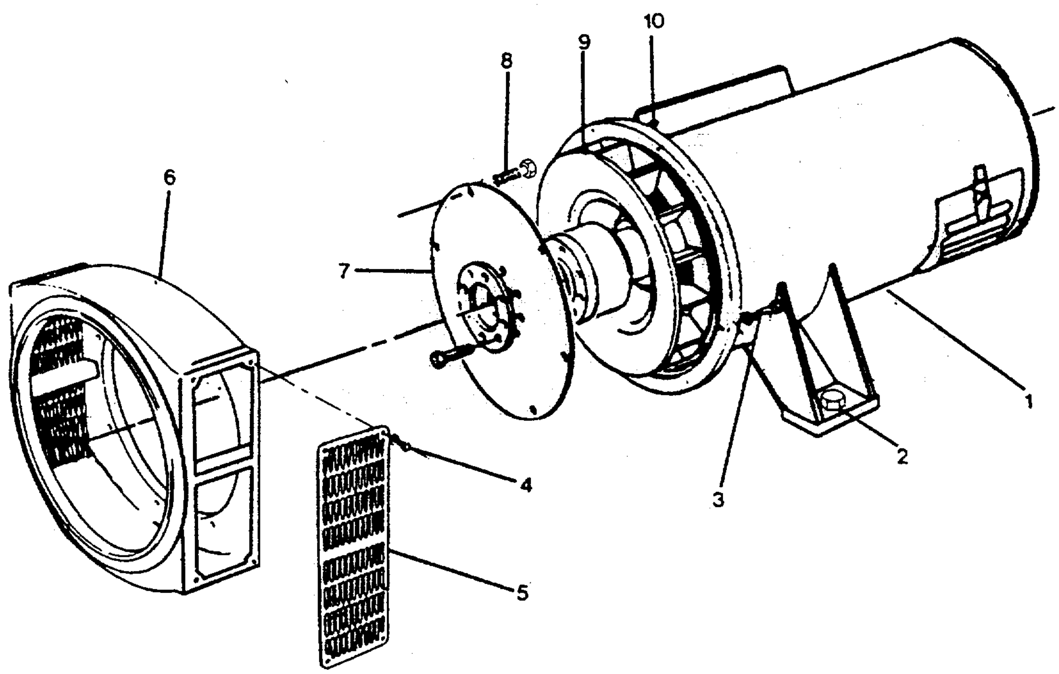


FIGURE 3-8. *Generator Coupling and Housing.*

REPLACEMENT

CAUTION

Do not use the generator cooling fan for lifting or rotating the rotor assembly. Do not force the alignment of the generator. Move the generator assembly slowly from side to side or up and down as necessary.

a. Loosen the capscrews which mount the generator supporting crossmember(s) to the subbase side rails.

b. Install two guide studs into the flywheel and two in the flywheel housing.

c. Lift the generator into a position so that the mounting holes in the drive discs and the generator housing adapter slide over the guide studs. Make sure that the generator and housing are correctly piloted to the flywheel and flywheel housing.

NOTE

One of the rotor poles should be at the bottom centerline position when installing the generator.

d. Pilot the generator into the flywheel and flywheel housing.

e. Install the capscrews (8, Figure 3-8) with hardened washers through the discs into the flywheel. Do not use lockwashers. Do not tighten capscrews.

f. Install capscrews (3, Figure 3-8) with lockwashers through the generator housing adapter into the flywheel housing. Do not tighten.

g. Remove the guide studs and install the remaining capscrews.

h. Tighten the eight housing capscrews (3, Figure 3-8) to 50 ft-lb (65 N•m) torque. Tighten in the sequence shown in Figure 3-9.

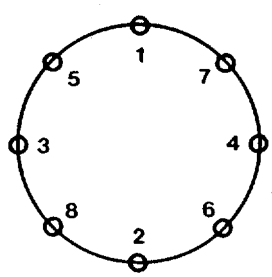


FIGURE 3-9. Generator Housing Torque Sequence.

i. Tighten the six flywheel coupling capscrews (8, Figure 3-8) to 352 ft-lb (476 N•m). Tighten in the sequence shown in Figure 3-10.

j. Align the generator feet on the subbase crossmember.

k. Slowly remove the hoist tension on the generator.

CAUTION

Alignment of the generator is critical. If necessary, shims should be placed under the generator to aid in alignment.

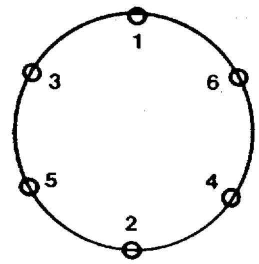


FIGURE 3-10. Coupling Torque Sequence.

l. If a gap remains between the generator feet and the subbase crossmember after relieving all tension on the hoist, add shims as necessary to close the gap.

m. Remove the hoist from the generator.

n. Install the mounting bolts in the generator feet to fasten it to the crossmember.

o. Tighten the mounting bolts in the generator feet.

p. Tighten the mounting bolts in the generator feet.

q. Check the air gap between the exciter rotor and the exciter stator as follows:

NOTE

Access the rotor through the housing openings.

(1) Insert a .010 inch (.254 mm) feeler gauge between the exciter rotor and the exciter stator.

(2) Run the feeler gauge around the rotor.

(3) Gap must be at least .010 inch (.254 mm) al the way around the rotor.

(4) If the gap is less than .010 inch on any side, the generator must be realigned.

r. Install the weather screens (5, Figure 3-8) to each side of the housing (6) with screws (4).

s. With the terminal box cover removed, run all cables, wiring, and conduits to, and through, the same locations on the generator terminal box that they were removed from on the old generator assembly. Refer to tags and notes that were make on the removal process.

CAUTION

Ensure all leads are connected to their proper terminals to avoid electrical component damage.

t. Refer to tags and notes made on removal and connect all leads to their proper terminals within the terminal box. Remove tags.

u. Return all external leads to the voltage regulator to their proper terminals. Remove tags.

v. Install the voltage regulator and terminal box covers.

w. Restore power, start engine and run the machine up to speed and check for excessive vibration and proper operation. Correct as necessary. Refer to paragraphs 2-8 through 2-11.

3-13A. Repair Diesel Engine, Air and Electrical Start.

This task covers: a. Removal, b. Repair, c. Replacement.

INITIAL SETUP

Tools

Tool kit, mechanic's rail and
marine diesel engines,
5180-00-629-9783
Lifting fixture P/N 3822512
Lifting sling P/N 3375958

Materials/Parts

Diesel engine P/N NTA-855E
for electric start or
P/N NTA-855A for air start

Equipment Condition

Generator removed, (paragraph 3-13).
Cooling system drained (Table 2-1,
Item 24).
Lube oil drained (Table 2-1, Item 15).
Battery bank disconnected (starboard).
Air system secured (port),
TM 55-1905-223-10.

REMOVAL

NOTE

Place a tag on all hoses, lines, linkage, and electrical wiring connections as they are removed. This will identify their locations on installation of new engine.

a. Close the following external valves:

(1) Fuel supply.

(2) Fuel drain.

(3) Air supply (port engine).

(4) Clean oil supply.

(5) Dirty oil drain.

NOTE

Coolant supply, drain, and vent line valves should have been closed when draining the cooling system.

b. Disconnect starter motor.

(1) Disconnect the external wiring and cables on electrical starter motor, starboard engine (paragraph 2-25).

(2) Disconnect air supply lines to air starter motor, port engine (paragraph 2-24).

c. Disconnect all external electrical wiring to the instrument panel, fuel pump, and remote sending units.

NOTE

Cover all engine openings as they are disconnected to keep dirt and debris from entering.

d. Remove the inlet connection to the fuel filter assembly and drain excess fuel from the engine (paragraph 2-33).

e. Disconnect the coolant heater (paragraph 2-42).

(1) Disconnect the water inlet and outlet tubes to the engine.

(2) Disconnect the oil line to the pressure switch from the engine.

NOTE

The coolant heater is mounted separately to the engine subbase. If the heater is to be replaced along with the engine assembly continue with steps (3) and (4).

WARNING

Ensure that all power is off to the heater assembly.

(3) Remove electrical wiring to the coolant heater.

(4) Remove the mounting bolts from the subbase and remove the heater assembly.

f. Disconnect the exhaust air piping.

g. Disconnect the following lines from the engine:

(1) Fuel supply and tank return lines.

(2) Clean oil supply line.

(3) Dirty oil drain line at sump pump.

(4) Coolant supply, drain, and remote expansion tank vent lines.

WARNING

Ensure the engine is properly attached to, and supported by, the lifting fixture before removing engine mounting capscrews.

h. Attach the lifting fixture to the two lifting brackets on top of the engine (paragraph 2-45).

i. Remove the capscrews holding the front and rear engine mounts to the frame support (subbase).

WARNING

Soldiers stand clear during hoisting operation.

j. Lift the engine slowly, ensuring that the lifting device is holding properly.

k. Remove the engine assembly.

NOTE

It may be necessary to move, or remove, other external components or fixtures to provide necessary clearance for removing the engine.

REPAIR

Repair of the diesel engine is accomplished through maintenance procedures in paragraph 3-15 through 3-48.

REPLACEMENT

a. Use the lifting fixture and sling to hoist replacement engine into place on the frame support and install the mounting capscrews.

b. Torque capscrews to 135 ft-lb (190 N•m).

c. Remove the lifting fixture.

d. Connect the following lines to the engine:

(1) Coolant supply, drain, and remote expansion tank vent lines.

(2) Dirty oil drain line at sump pump.

(3) Oil supply line.

(4) Fuel supply and tank return.

e. Connect the exhaust piping.

f. Install the coolant heater, if removed.

g. Connect oil pressure sensor switch supply line.

h. Connect water inlet and outlet tubes.

i. Connect the coolant heater (paragraph 2-42).

j. Install inlet connection on the fuel filter assembly (paragraph 2-33).

k. Connect all external electrical wiring to the instrument panel, fuel pump, and remote sending units.

1. Connect air supply lines to air starter, port engine (paragraph 2-24).

m. Connect electrical wiring and cables to electric starter, starboard engine (paragraph 2-25).

n. Close the following valves:

(1) Fuel drain.

(2) Oil drain.

(3) Coolant drain.

o. Open the following external valves:

(1) Coolant supply.

(2) Coolant vent.

(3) Oil supply.

(4) Air supply (port engine).

(5) Fuel supply.

p. Install generator (paragraph 3-13).

NOTE

Replace any external components or fixtures that were moved, or removed, to facilitate removing the old engine assembly.

q. Perform break-in, pre-servicing, start-up, run-checks, and generator inspection in accordance with paragraphs 2-6 through 2-11.

3-14. Repair Engine Air Starter.

This task covers: a. Repair.

INITIAL SETUP

Tools

Tool kit, general mechanic's rail and marine diesel engines, 5180-00-629-9783

Materials/Parts

Engine air starter P/N 42KG312-08-601
Drive bendix P/N 22148
Bearing P/N 91380
Preformed packing P/N 90001-046
Lip seal P/N 22376
Preformed packing P/N 90001-016
Rod plunger P/N 21927
Reset spring, plunger P/N 90408-08
Preformed packing P/N 90002-010
Ball bearing, annular P/N 91394
Spring, lever arm P/N 90408-09
Spring, hammer reset P/N 90408-07
Bearing, planet gear P/N 91389
Gear, internal P/N 21985
Spacer, ring P/N 93065
Spring, bearing preload P/N 90424
Ring, retaining P/N 92001-15
Bearing P/N 91281

Equipment Condition

Starter removed (paragraph 2-24).

NOTE

The engine air starter is a candidate for direct exchange with the vendor.

REPAIR

a. Visually inspect the engine air starter for obvious damage.

b. Replace engine air starter if required.

3-15. Repair Lubricating Oil Cooler/Filter Group.

This task covers: a. Disassembly, b. Repair c. Assembly.

INITIAL SETUP

Tools

Tool kit, general mechanic's
rail and marine diesel engines,
5180-00-629-9783
Valve spring compressor tester,
4910-01-142-4929
Mandrel, "O" ring ST-1218
Tube bundle tester P/N 3375253
Torque wrench kit P/N 3377216

Materials/Parts

Metal cleaning solvent, Item 6, Appendix C
Alkaline solution, Item 17, Appendix C
Muriatic acid, Item 18, Appendix C
Oxalic acid, Item 19, Appendix C
Pyridene, Item 20, Appendix C
A 5% sodium carbonate and water solution,
Item 21, Appendix C
Packing P/N 3007713
Lube oil circle cover gaskets
P/N 218245 and P/N 3010030
Lubricating oil, Item 2, Appendix C
Valve disk P/N 3018673
Helical compression spring P/N 202128
Retaining rings P/N 3006745
Helical compression spring P/N 68274
Regulator plunger P/N 127558
Filter element P/N 3021581

Equipment Condition

Filter/cooler group removed (paragraph 2-34).
Filter removed from the assembly.

DISASSEMBLY

NOTE

The Full Flow Cooling (FFC) engine has an oil pressure regulator that is part of the oil cooler and is located in the front support of the cooler (Figure 3-11). The regulator controls the oil pressure before the oil flows through the oil filter.

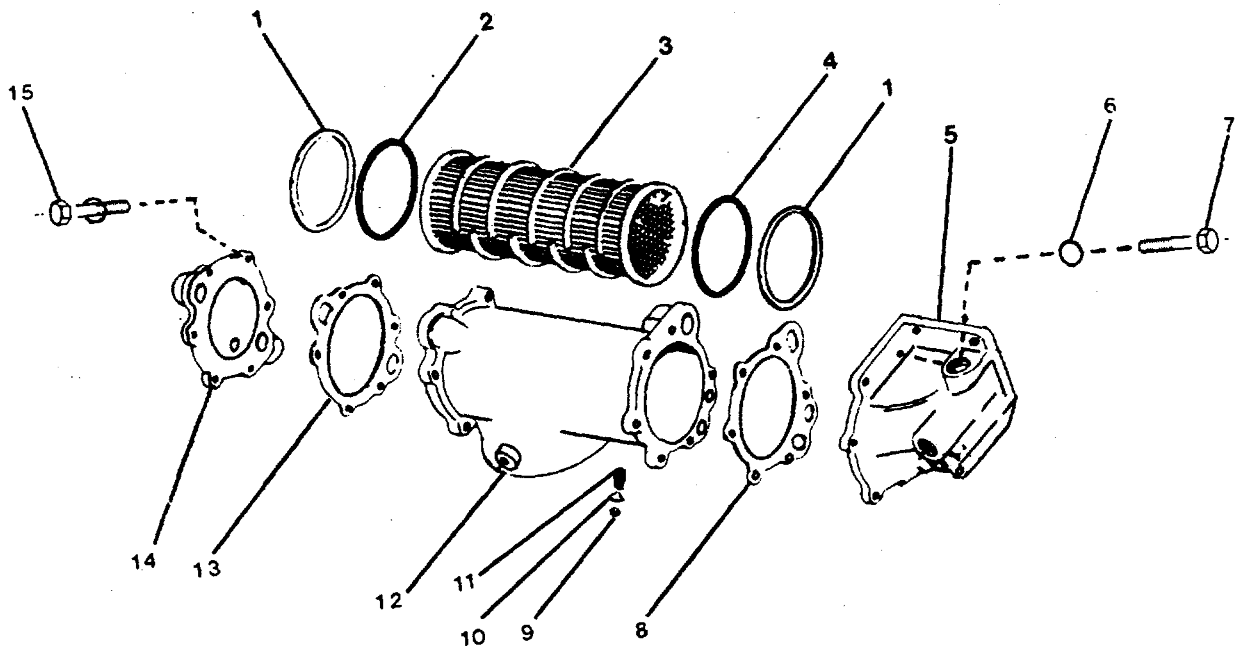


FIGURE 3-11. Oil Cooler/Filter - Filter Element Removed.

WARNING

Carefully remove the capscrew. The pressure regulator spring is under compression.

a. Remove the regulator machine thread plug (5, Figure 3-12), spacer ring (4), and helical compression spring. (3).

b. Remove the regulator plunger (2) from the cooler support (1).

c. Remove the cooler support (5, Figure 3-11) and cover (14) from the housing (12) by removing lockwashers (6), hexagon head capscrews (7) and assembled washer screws (15).

d. Remove the lube oil circle cover gaskets (8, 13) and retaining rings (1). Discard the gaskets.

e. Remove and discard the preformed packings (2, 4). Be careful not to damage the fluid filterelement (3) when removing packing.

f. Remove the element (3) cooler core from the housing (12). Remove retainer plug (9), valve disk (10), and helical compression spring (11) from the housing (12).

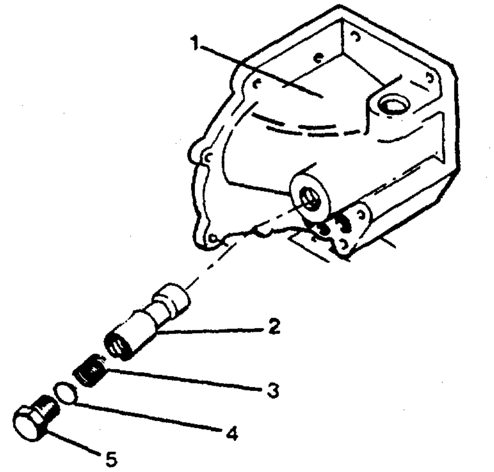


FIGURE 3-12. Oil Cooler Pressure Regulator.

REPAIR

a. Check the regulator plunger, (2, Figure 3-12).

(1) Inspect the plunger (2) for scratches or other damage.

(2) If scratch is deep enough to be felt with a fingernail, replace the plunger.

(3) Inspect helical compression spring (3) for damaged or broken coils. Replace if damaged.

(4) Use a valve spring compressor to compress the helical compression spring (3) to 1.820 inches (46.23 mm). The force required must be between 22 and 26 pounds. Replace if necessary.

b. Clean and inspect the cooler element (fluid transmission center) (3, Figure 3-11) as follows:

WARNING

The fumes from the cleaning solution are dangerous. Use the solution in open air or in a room that has proper ventilation. Wear safety glasses and gloves.

(1) Put the element (3) into a container of an approved cleaning solvent. Keep the element in the solution for several minutes. Flush the solution around and through the tubes in the element.

(2) Flush the tubes in the element with a solution of alkaline. After cleaning, flush several times with hot water.

WARNING

The fumes from the solution are dangerous. Use the solution in open air or in a room that has proper ventilation. Wear safety glasses and gloves.

(3) Put the element into a container of solution made up of the following: 1 part muriatic acid, 9 parts water, 1 pound (0.5 kg) oxalic acid, and 0.01 gallon (0.038 L) of pyridene added to each 5 gallons (18.9 L) of muriatic acid.

(4) Remove the element when there are no foam or bubbles in the solution. The foam and bubbles normally stop in 30 to 60 seconds.

(5) Put the element into a container that has a 5 percent solution of sodium carbonate. Remove the element when there are no bubbles coming from the solution.

(6) Flush the element with clean, warm water.

(7) Visually inspect the element for damage. Replace if damaged.

c. Clean the housing (12), support (5), and cover (14) with cleaning solvent.

d. Inspect the following:

(1) Check the cooler housing (12), support (5) and cover (14) for cracks, damage and corrosion (Figure 3-11). Replace damaged parts.

(2) Check the cooler element for damage and leaks. Use the Part No. 3375253 Tube Bundle Tester (Figure 3-13) to check for leaks. Follow these instructions:

(a) Install the end plates to each end of the element.

(b) Put the sliding plate of the fixture so that the fixture will fit over the element and end plates, Figure 3-13, left.

(c) Put the element into the fixture. Place the fixture so that the air connection fitting goes through the notch in the fixture plate. Install locking clips into the bars of the fixture, Figure 3-13, right.

(d) Connect an air supply line that has a quick-disconnect fitting to the air connection fitting.

(e) Use an air pressure regulator and a three-way air discharge valve to control the air pressure.

(f) Apply 60 psi (414 kpa) of air pressure to the element.

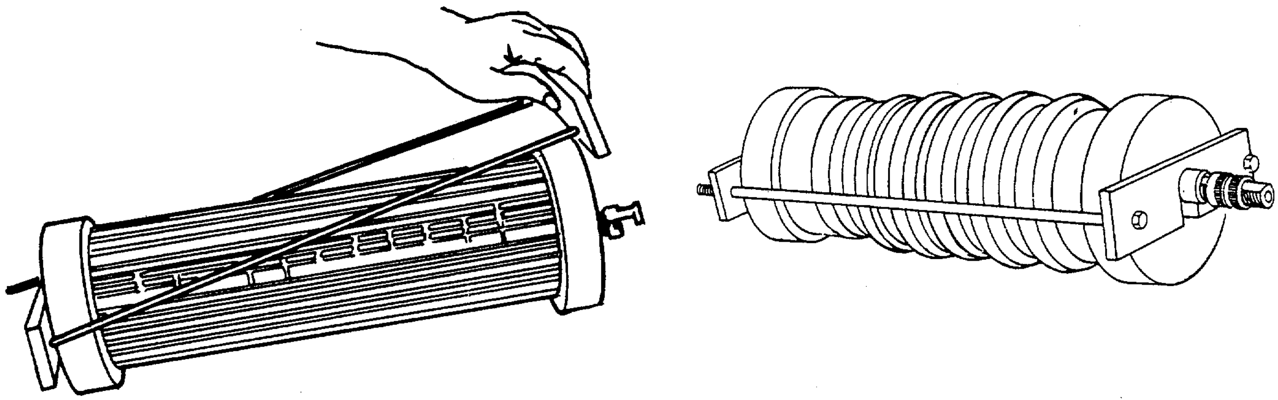


FIGURE 3-13. Tube Bundle Tester.

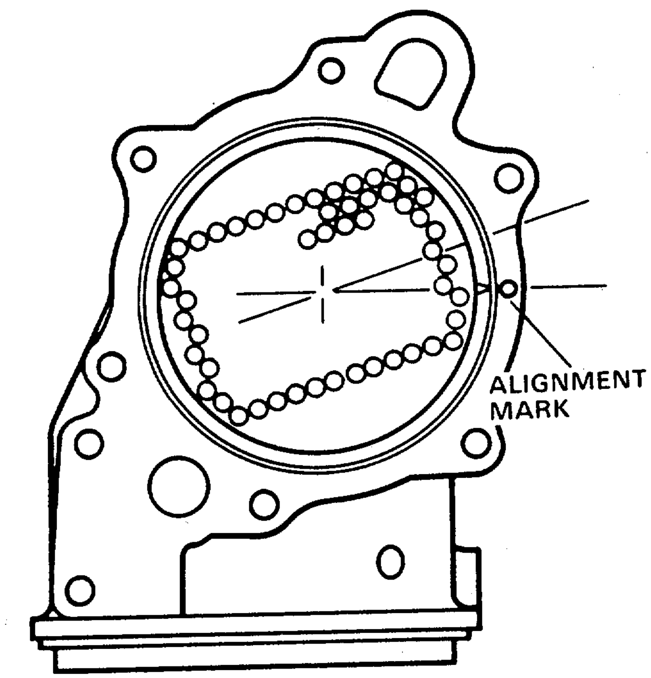


FIGURE 3-14. Aligning Index Marks.

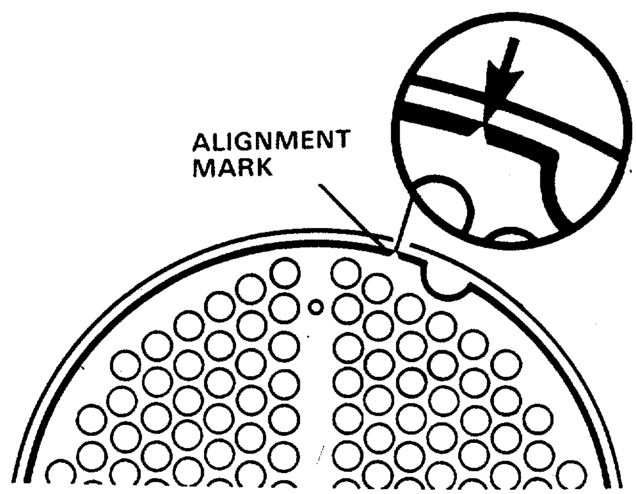


FIGURE 3-15. Notch Type Index Marks.

(g) Put the element and tool assembly into a container of water. Make sure the water completely covers the element. Check the element for air leaks. Replace the element if bubbles are observed.

(h) Remove the element and tool assembly from the container.

(i) Use the air discharge valve to release the air pressure from the element.

(j) Remove the tube bundle tester from the element.

ASSEMBLY

CAUTION

Never use a cooler element from an engine that had a failure. When an engine has a failure, metal particles enter the oil cooler. These particles cannot be completely removed from the element and can cause damage to the engine.

a. Place element (3, Figure 3-11) into the housing (12). Place the housing (12) with the element on a flat workbench.

b. Align the index mark on the element with the index mark on the housing (Figure 3-14 or 15).

NOTE

Some of the elements have two index marks. They can Wave an "O" on the tube end plate.(Figure 3-13) or notch cut/into the inside diameter of the rim (Figure 3-14). Use the notch to align the element in the housing.

c. Install the valve disk (10, Figure 3-11) and helical compression spring (11) and secure with retainer plug (9).

d. Apply a coat of clean lubricating oil to a new preformed packing (2, Figure 3-11). Place packing between the element (3) and the housing (12). -Ensure that the packing does not protrude over the element and housing.

NOTE

The packing must be installed in less than 1 hour after the oil is applied.

e. Push the packing (2) into the housing. Using "O" ring mandrel. Tap mandrel with a plastic hammer until it is against the element and housing.

f. Install the retaining ring (1). Ensure that the part number on the ring faces out.

g. Install a new gasket (13) and the cover (14) to the housing (12). Tighten the assembled washer screws (15) to 30 to 35 ft-lb (40.6 to 47.4 N•m) torque.

h. Slide the housing to the edge of the workbench until you can hold the element in position with your hand. Ensure that the element does not move in the housing. Place the housing with the cover end down onto the workbench.

i. Repeat steps (d), (e), and (f) to install the packing (4, Figure 3-1l) and retaining ring (1).

j. Install a new gasket (8) and the support (5) to the housing (12). Tighten the hexagon capscrews (7) and lockwashers (6) to 30 to 35 ft-lb (40.6 to 47.4 N•m) torque.

k. Install any pipe plugs that were removed.

l. Tighten the 1/4 inch pipe plug to 25 ft-lb (33.8 N•m) torque.

m. Tighten the 1/8 inch pipe plug to 7 ft-lb (9.4 N•m) torque.

n. Install the plunger (2, Figure 3-12), compression spring (3), spacer (4), and machine thread plug (5) into the support housing (1) and tighten the plug to 20 ft-lb (25 N•m) torque.

o. Mount the cooler/filter group on the engine (paragraph 2-24) and install a new filter.

3-16. Repair Fuel Metering and Distributing Pump Assembly.

This task covers: a. Disassembly, b. Repair, c. Assembly.

INITIAL SETUP

Tools

Tool kit, general mechanic's
rail and marine diesel engines,
5180-00-629-9783
Multimeter 6625-01-139-2512
Torque wrench kit P/N 3377216

Materials/Parts

Gasket P/N 151900
Fluid pressure dampener P/N BM-76340
Fuel pump gear assembly P/N 3034209
Shutoff valve assembly P/N 3018453
Electric governor actuator P/N 3044189
Preformed packing P/N 190876, 129888
Packing P/N 3048182
Fluid filter element P/N 146483
Disc, valve P/N 196057
Solenoid P/N 3054609
Petroleum jelly, Item 23, Appendix C
Emery cloth, 240 grit, Item 12, Appendix C
Metal cleaning solvent, Item 6,
Appendix C

Equipment Condition

Fuel pump removed (paragraph 2-37).

DISASSEMBLY

NOTE

Disassembly in this procedure consists of removing the fluid pressure dampener, gear pump assembly, shutoff valve assembly, electric governor actuator, and fluid filter element from the fuel pump body.

a. Remove the fuel shutoff valve (2, Figure 3-16).

(1) Remove the two hexagon capscrews lockwashers and flat washers (2, Figure 3-17), securing the shutoff valve to the fuel pump (6).

(2) Remove the shutoff valve body and preformed packing (5) from the fuel pump. Discard preformed packing.

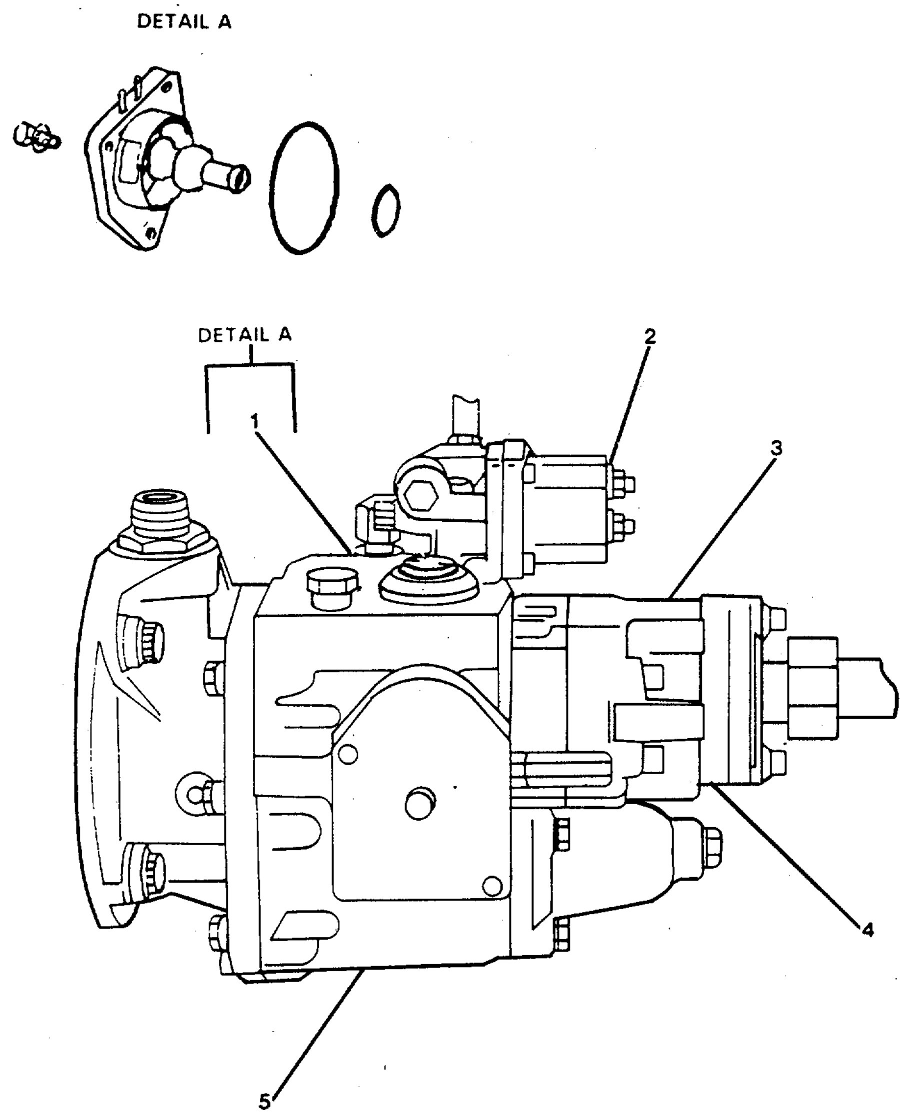


FIGURE 3-16. Fuel Pump.

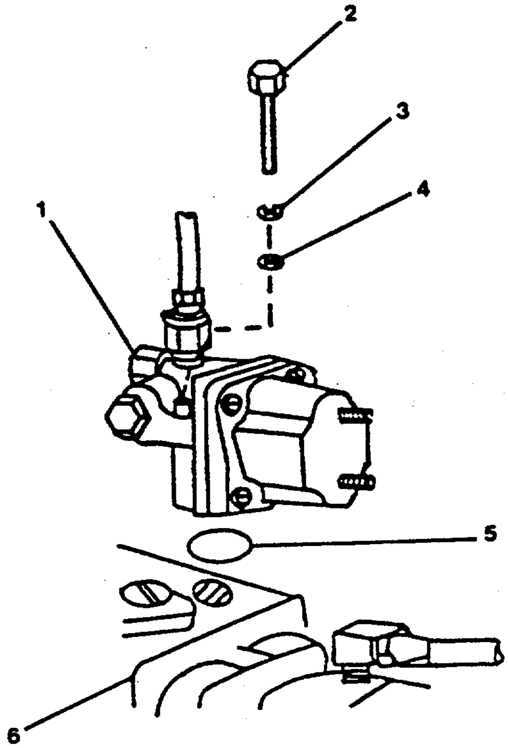


FIGURE 3-17. *Shutoff Valve Assembly.*

b. Remove the fluid pressure dampener (4, Figure 3-16).

(1) Remove two capscrews, lockwashers (1, Figure 3-18) and two capscrews and lockwashers and flat washers (5).

(2) Remove the cover access (4), preformed packing, solid plain disk, and spacer ring (3), and the fuel pump dampener housing (2).

(3) Remove packing (6) from the back of housing (2).

c. Remove the fuel pump gear assembly (3, Figure 3-16).

NOTE

If only the pump gear assembly is to be replaced on the fuel pump, the dampener must be removed first (step (b) of this procedure).

(1) Remove the two machine bolts, lockwashers and flat washers (3, Figure 3-19).

(2) Remove the pump gear assembly.

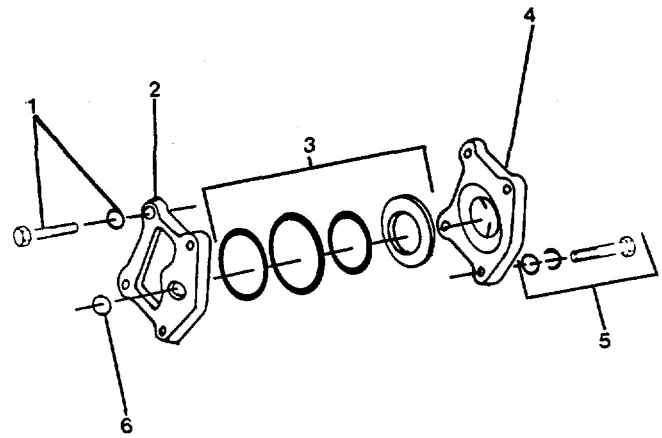


FIGURE 3-18. Fuel Pump Fluid Pressure Dampener.

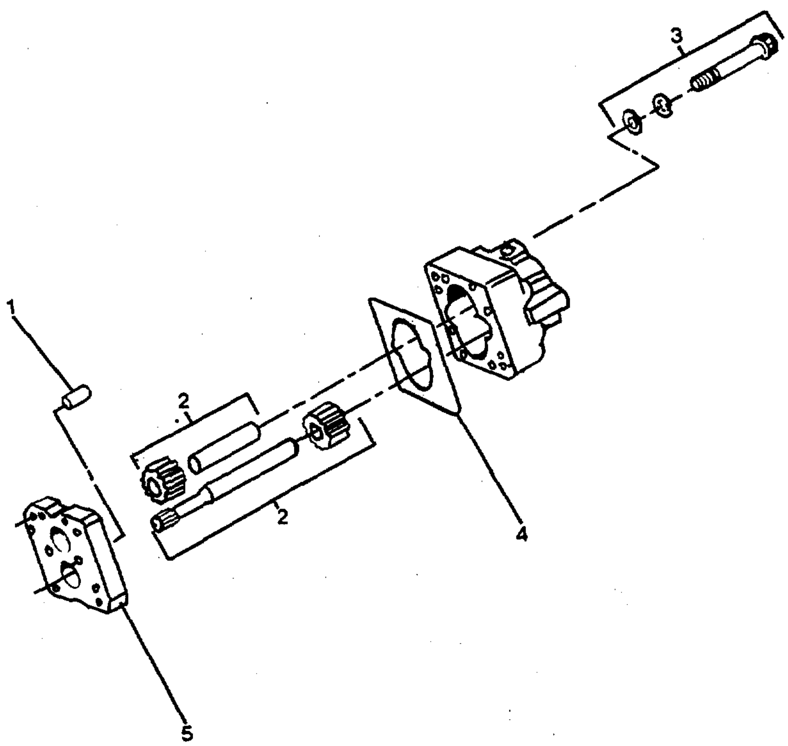


FIGURE 3-19. Fuel Pump Gear Assembly.

d. Remove the electric governor actuator (1, Figure 3-16).

(1) Remove the three capscrews (1, Figure 3-20).

(2) Pull the actuator (2) from the fuel pump (9) body while twisting slowly in a clockwise direction.

(3) Remove the preformed packing (3, 4).

(4) Remove the machine thread plug (5) and remove the seal (6), helical compression spring (7), and fluid filter element (8) from the top of the fuel pump body (9).

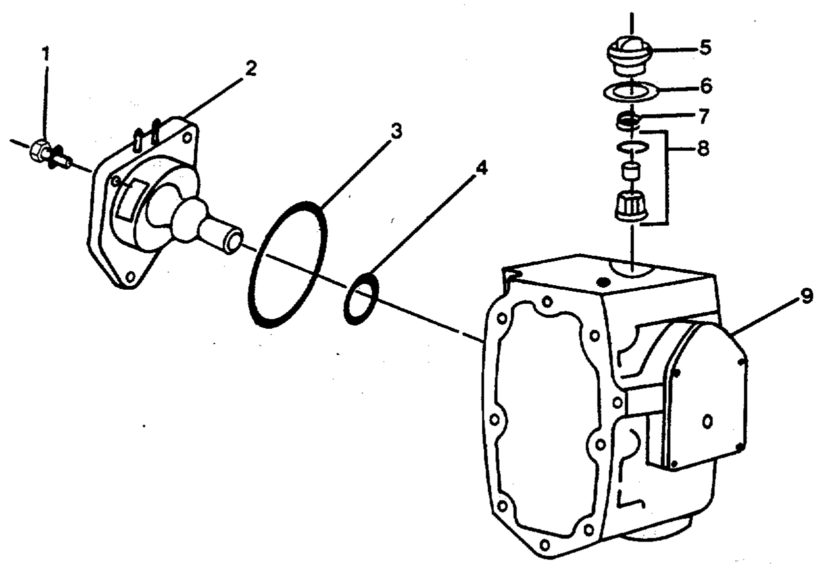


FIGURE 3-20. Fuel Pump Electric Governor Actuator and Fluid Filter Element Assembly.

REPAIR

a. Check the shutoff valve assembly (Figure 3-17).

(1) Check the coil assembly with an ohmmeter. Replace the shutoff valve assembly if the resistance reading is not between 28 and 32 ohms.

(2) Operate the manual control knob (1, Figure 3-17) and check for proper operation. With the control knob rotated fully counterclockwise, the fuel passage through the valve should be closed (with no electricity being applied to the coil). With the knob rotated fully clockwise, the fuel passage should be open.

(3) Visually check for dirt, corrosion, or. damage. Replace the shutoff valve assemblyif any damage is found.

(4) Replace the shutoff valve assembly (Figure 3-17) as required.

b. Inspect the fluid pressure dampener (Figure 3-18).

(1) Visually check the body and plate for signs of damage.

(2) Replace the fluid pressure dampener if damaged.

c. Inspect the fuel pump gear (Figure 3-19).

(1) Visually inspect the shafts and spur gears (2). Replace the pump gear assembly if excessive wear, or burrs, cracks, or broken gear teeth are found.

(2) Check the installed depth of the regulating fluid pressure valve (1) in the cover (5) face. The valve must be even to 0.015 inch (0.38 mm) below the cover face. Seat the pressure valve as required.

d. Inspect the fluid filter element assembly (8, Figure 3-20).

NOTE

The filter element contains a magnet to hold any steel particles that may have entered the fuel pump.

(1) Clean the metal parts of the fluid filter element (8) in solvent.

(2) After cleaning, visually inspect for metal particles in the mesh. Replace screen as necessary.

(3) Clean the machine thread plug(s) (5) and helical compression spring (7) in fuel oil and inspect for signs of damage. Replace parts as necessary.

e. Check the governor actuator (2, Figure 3-20):

(1) Visually check for signs of damage and replace actuator as necessary.

(2) Discard old preformed packing (3, 4).

f. Check the fuel pump body for signs of damage. If damaged, replace the fuel pump assembly.

ASSEMBLY

CAUTION

Handle aluminum parts with care to avoid damage.

Do not use a lockwasher next to aluminum. Always use a flat washer between the lockwasher and the aluminum part.

a. Install the fluid filter element assembly (8, Figure 3-20) into the top of the pump body. The hole in the screen goes down.

(1) Install the threaded plug (5) and tighten to 10 ft-lb (13.5 N.m) torque.

b. Install the fuel pump gear assembly (Figure 3-19) and pressure dampener (Figure 3-18).

(1) Use a new gasket (4, Figure 3-19) and install the pump gear assembly to the pump body (5, Figure 3-16).

NOTE

Align the notches on the top corner of the plate and cover.

(2) Ensure the gasket (4, Figure 3-19) is positioned properly and that the housing (body) fuel holes align with the holes in the pump gear assembly.

(3) Install capscrews, lockwashers, and flat washers (3, Figure 3-19) and tighten to 12 ft-lb (16.5 N-m) torque. Turn the drive shaft to ensure the gear pump rotates freely. If gears do not rotate freely, disassemble gear pump and correct as required.

(4) Use new preformed packing (6, Figure 3-18) and install the dampener to the gear pump. Tighten mounting capscrews (1, 5) to 12 ft-lb (16.5 N.m) torque.

c. Use petroleum jelly to hold new preformed packing (5, Figure 3-17) to the bottom of the shutoff valve. Install the shutoff valve on the pump body. Tighten the capscrews (2) to 10 ft-lb (13.5 N-m) torque.

d. Install the fuel pump electric governor actuator (2, Figure 3-20) in the pump body.

CAUTION

Do not use any gasket adhesive or sealant on the governor actuator preformed packing.

(1) Install the preformed packing (3, 4, Figure 3-20) on the actuator. Check that all mounting holes are aligned.

(2) Lubricate the governor actuator preformed packing with clean engine oil and insert the actuator in the cavity of the fuel pump body. The actuator flange will stop approximately 3/8 inch from the pump body.

(3) Using palm of the hand, firmly push and rotate the actuator approximately 30 degrees clockwise until the actuator flange contacts the fuel pump body.

(4) Rotate the actuator counterclockwise until the mounting holes are aligned.

(5) Install the capscrews (1, Figure 3-20). These capscrews have captive spring washers and do not require lockwashers. Tighten the capscrews until they are finger tight.

(6) Tighten the actuator capscrews as follows:

(a) Starting with the bottom capscrew, tighten each capscrew 1/8 of a turn until it is seated.

(b) Tighten the capscrews in a clockwise sequence to 25 in-lb (2.8 N.m) torque.

(c) Tighten in sequence to 50 in-lb (5.6 N-m) torque.

(d) Now, loosen all three capscrews completely.

(e) Tighten the capscrews again using the same procedure described above. This procedure should keep the actuator from binding.

CAUTION

This test will only verify that the actuator will go from the full open to the full closed position. A slight binding of-the actuator shaft can cause a governor stability problem. This test may not detect a slight binding.

(7) A final check is to apply and remove battery voltage across the two actuator terminals. You should hear the actuator as it opens and closes. If the actuator sounds as if it is not operating, or is operating too slowly, loosen all capscrews and tighten them again as described in step (6) of this procedure.

e. Install the fuel pump on the engine (paragraph 2-37).

3-17. Repair Rocker Lever Housing/Cover Group.

This task covers: a. Repair

INITIAL SETUP

Tools

Tool kit, general mechanic's
rail and marine diesel engines,
5180-00-629-9783
Injector adjustment kit
P/N 3375842
Torque wrench kit P/N 3377216
Magnaglo tester P/N H260
Machinists Measuring Set
5280-00-278-9919

Materials/Parts

Emery cloth, 240 grit, Item 12,
Appendix C
Metal cleaning solvent, Item 6,
Appendix C
Engine poppet rocker arm (lever)
P/N BM-95161 and P/N BM-95162
Rocker lever, injector P/N AR-2308
Plain hexagon nut P/N MS-51968-14
Setscrews P/N 168306
Rocker lever housing P/N 3044788
Bottle brush, Item 24, Appendix C
Bluing compound, Item 25, Appendix C

Equipment Conditions

Rocker lever housing/cover group
removed and disassembled
(paragraph 2-39).

REPAIR

a. Clean the engine poppet rocker arms, injector rocker levers, and housing with cleaning solvent and inspect as follows:

NOTE

- Make sure the breather vent hole is free of dirt or other deposits.
- Make sure the to clean the shaft bore. Use a bottle brush.

(1) Visually inspect the housing for cracks or damage, and replace if necessary.

(2) Visually inspect the assembled washer screw holes in the housing for damaged threads.

(3) Visually inspect the straight shaft bore. Remove any burrs or sharp edges with emery cloth.

(4) Measure the straight shaft bore in the housing. If the inside diameter exceeds 1.1246 in. (28.565 mm), replace the housing.

b. Clean the shafts and inspect as follows:

(1) Use solvent to clean the shaft.

(2) Dry with compressed air.

(3) Visually inspect the shaft for cracks or damage.

(4) Visually inspect the thread condition of the shaft internal threads.

(5) Measure outside diameter in the center and each end of the shaft. The measurement should be between 1.122 inch (28.50 mm) and 1.124 inch (28.55 mm).

(6) Replace the shaft as necessary.

c. Clean the engine poppet valve rocker arms and injector rocker levers wth solvent and inspect as follows:

(1) Use magnetic inspection to check the rocker arms and rocker levers for cracks. Use coil magnetization with amperage at 300 to 500 with residual Magnaglo. Special attention should be given to the areas indicated in Figure 3-21.

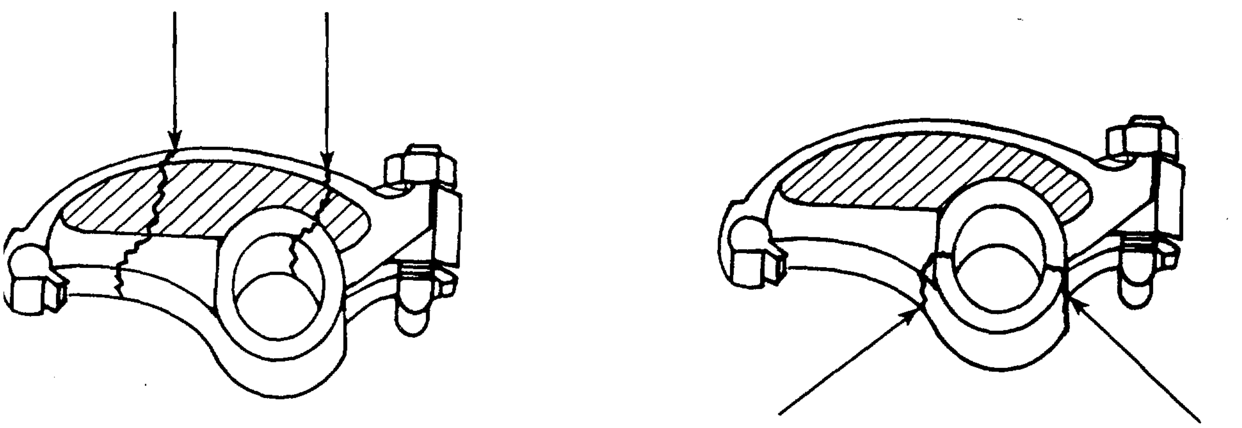


FIGURE 3-21. *Crack Inspection Areas.*

(2) Inspect the ball end of rocker adjusting set screw for scratches and wear. Use a 0.25 in. (6.35 mm) radius gauge to check the ball end of the adjusting screw.

(3) Replace the adjusting set screw if the ball end is out-of-round or flat at the bottom.

(4) Check the thread condition on all rocker adjusting set screws.

(5) Check carefully for thread distortion at the assembly position of the locknut. Screws must move freely through the rockers.

(6) Inspect the sockets on the end of each rocker for damage as follows:

(a) Apply a bluing compound with a 0.500 inch (12.70 mm) diameter gauge or a new injector link.

(b) The blue patter must coat at least 80% of the socket surface.

(c) Replace the rocker levers as necessary.

(7) Inspect the rocker lever bushings for damage.

(8) Measure the inside diameter of the rocker lever bushing. The measurement must not exceed 1.1286 inches (28.664 mm). If these limits are exceeded, replace the rocker lever assembly.

d. Install the rocker arms and rocker levers and shaft in the housing (paragraph 2-39).

e. Install the rocker lever housing on the engine (paragraph 2-39).

3-18. Replace/Repair Cam Follower Housing Group.

This task covers: a. Removal, b. Repair, c. Replacement

INITIAL SETUP

Tools

Tool kit, general mechanic's
rail and marine diesel engines,
5180-00-629-9783
Injection timing tool
P/N 3375522
Torque wrench kit P/N 3377216

Materials/Parts

Cam follower housing P/N 3036939
Cam follower gaskets (P/N will
vary according to thickness
required for timing. Refer
to TM 55-1905-223-24P.)
Internal push rod P/N 3046420
Injector push rod P/N 3046430

Equipment Conditions

Fuel pump removed (paragraph 2-37).
Rocker lever housing removed,
(paragraph 2-39).
Accessory drive assembly removed,
(paragraph 3-19).

REMOVAL

a. Remove the cam follower housings as follows:

(1) Remove six hexagon capscrews (5, Figure 3-22) from each cam follower housing (6).,

NOTE

To prevent increased wear, mark the cam follower housing assemblies as they are removed to identify their original location on the block (if they are to be reused).

(2) Remove housings (6) and their gaskets (4).

(3) Remove the push rods (1) from the cam follower sockets (2) in the cam followers (3).

b. Measure and record the thickness of the gaskets (4) used between each housing and block.

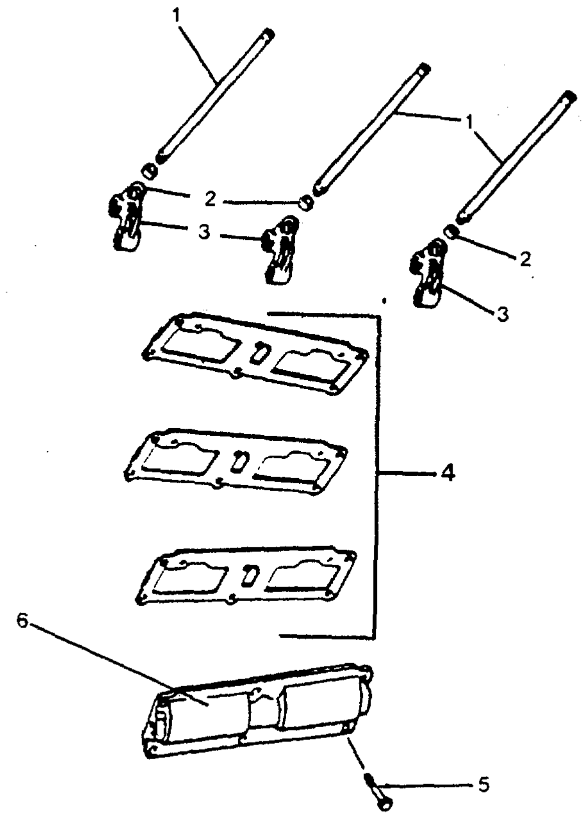


FIGURE 3-22. Cam Follower Housing Group.

NOTE

The thickness of the gaskets controls the injection timing.

c. Discard the gaskets.

REPAIR

Repair of the cam follower housing consists of replacement of cam follower housing (6) and gaskets (4).

REPLACEMENT

CAUTION

Ensure gasket sealing surfaces are clean.

a. Install the new cam follower gaskets (4) to the block as follows:

(1) At least one gasket (4) is required for each cover (6).

(2) The gasket (4) must be installed against the block with the sealing bead toward the cover (6).

(3) Measure the gasket thickness. The new gaskets must be the same thickness as the gaskets which were removed.

(4) Install the gaskets (4) over the dowel pins in the block.

b. Install the cam follower housings on the dowel pins in the block as follows:

(1) Install the push rods (1) in the cam follower socket (2) and position cover (6).

(2) Install six capscrews (5) in each cam follower housing (6).

(3) Tighten the capscrews in the sequence shown in Figure 3-23 to the following values.

NOTE

All capscrews are tightened to the specification in step (a); then step (b).

(a) Tighten to 15 ft-lb (20 N•m) torque.

(b) Tighten to 35 ft-lb (45 N•m) torque.

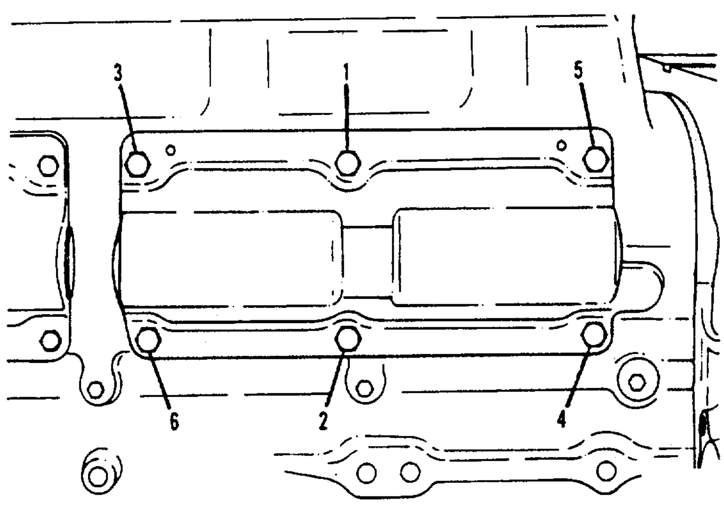


FIGURE 3-23. Cam Follower Housing Torque Sequence.

c. Check the injection timing as follows:

(1) Injection Timing General Information. The injection timing is the relative measurement of the distance remaining between the injector plunger and the injector cup when the piston is 0.2032 inch (5.161 mm), or 19 degrees Before Top Dead Center (BTDC) on the compression stroke (Figure 3-24). Injector timing is expressed by the amount of push tube travel remaining.

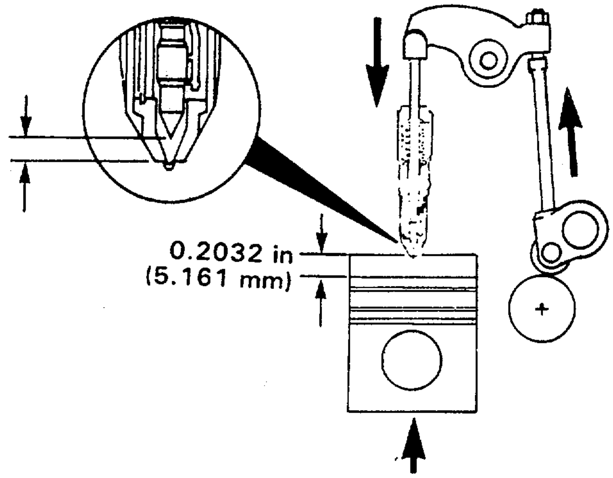


FIGURE 3-24. Injection Timing.

(a) Injection Timing Code. The injection timing code appears on the engine data plate. Codes are alphabetic letters that relate to a numerical specification.

(b) Advanced and Retarded Timing. Advanced timing (1, Figure 3-25) means the fuel is injected earlier into the cylinder during the compression stroke. Retarded timing (2) means the fuel injection occurs closer to TDC in the cylinder.

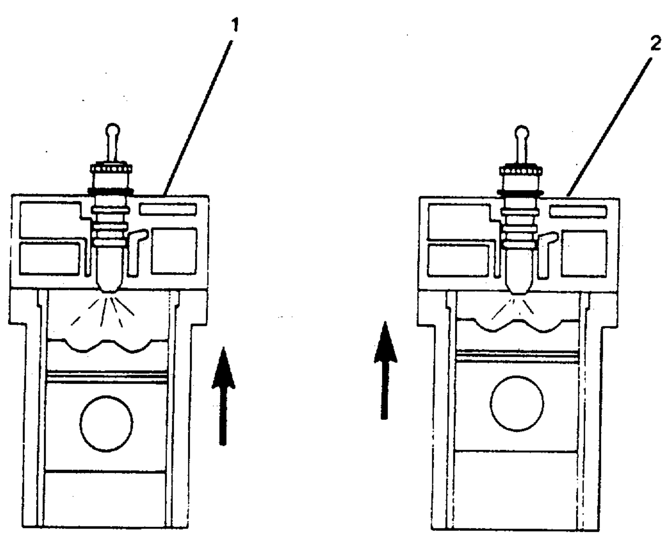


FIGURE 3-25. Advanced and Retarded Timing.

(c) Injection Timing Changes. Injection timing changes are accomplished by Advancing (1) or Retarding (2) the cam follower action in relation to the piston position (Figure 3-26). This is accomplished by changing the orientation of the camshaft lobe to the cam follower using different cam follower gasket thicknesses or offset camshaft gear keys.

NOTE

Gear train timing (index mark alignment) always remains the same.

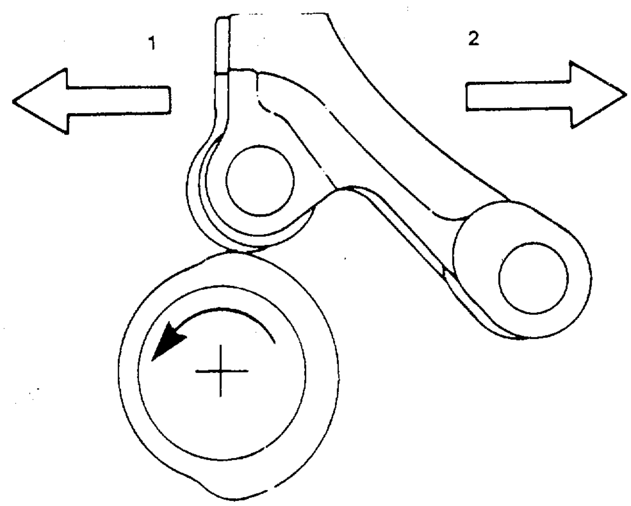


FIGURE 3-26. Cam Follower Action.

(d) Injection Timing Check. The injection timing check is a measurement which determines the injector push rod travel in relation to the piston travel. Due to normal parts tolerances, it is necessary to check one cylinder for each cam follower housing.

(2) Measuring Injector Timing.

(a) Remove the rocker housing covers (paragraph 2-39).

NOTE

It is not necessary to remove all of the injectors; however, engine rotation will be easier with all of the injectors removed.

(b) Remove the injectors from cylinders No. 1, No. 3, and No. 5. (paragraph 2-42).

NOTE

Injector timing tool can be installed without removing the rocker levers.

CAUTION

Pivot the dial indicator stems away from their respective plunger rods before installing the timing fixture to prevent damage to the indicators.

(c) Install the support bracket (2, Figure 3-27) for the push rod adapter (4) into the slot nearest the clamp handle (1).

(d) Install the piston plunger rod (5) into the injector sleeve of the No. 1 cylinder.

(e) To fasten the timing tool to the cylinder head, install the threaded adapter screws through the mounting foot (6) and into the holes for the injector holddown plate.

NOTE

To prevent damage to the adapter screws, tighten just enough to hold the timing tool rigid.

(f) Use the tightening rod (3) to tighten the adapter screws.

(g) Loosen the clamp handle (1) and align the push rod adapter (4) with the injector push rod. Tighten the clamp handle.

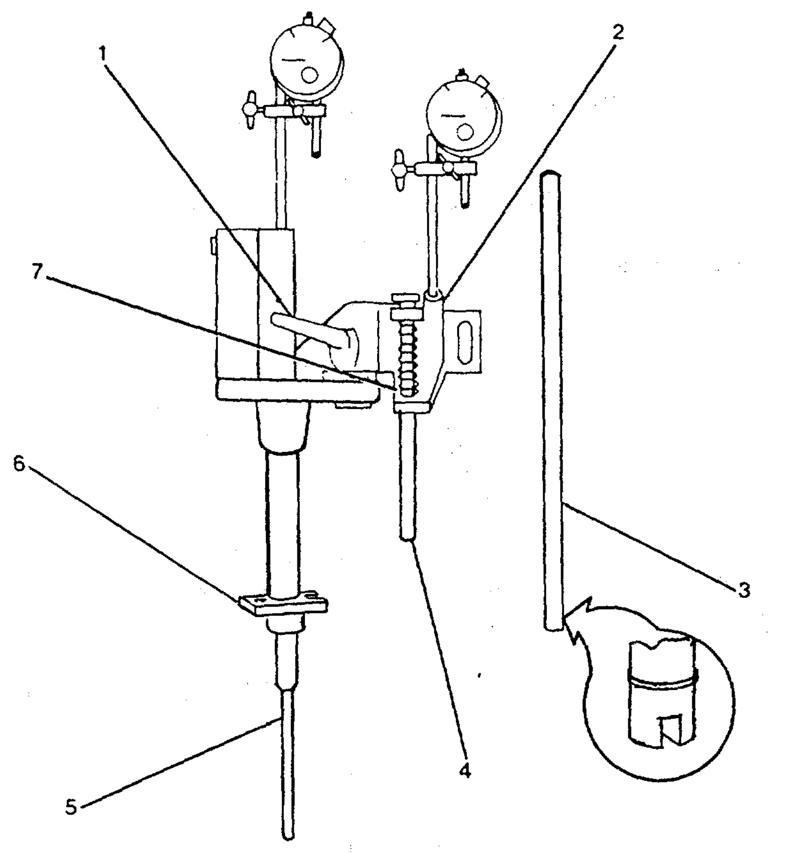


FIGURE 3-27. Injection Timing Tool.

(h) Loosen the support bracket (2).

(i) Slide the bracket down until the push rod adapter (4) engages the push rod. Then, compress the tension spring (7) for the adapter approximately 0.50 inch (12.7 mm).

(j) Tighten the support bracket. Ensure the support bracket is aligned with the vertical line on the clamp handle bracket, and the push rod is aligned vertically with the plunger rod.

(k) Rotate the crankshaft in the direction of engine rotation to the Top Dead Center (TDC) position (1, Figure 3-28) of the compression stroke for the No. 1 cylinder.

(1) Loosen the thumbscrew for the piston travel gauge. Move the gauge so that the stem of the gauge is in the center of the piston plunger rod.

(m) Lower the gauge against the piston plunger rod until the stem is fully compressed, then raise the gauge approximately 0.025 inch (0.63 mm).

(n) Tighten the thumbscrew to hold the gauge in position.

(o) Rotate the crankshaft 2 or 3 degrees clockwise and counterclockwise to make sure the piston is at TDC on compression stroke.

(p) Loosen the setscrew for the gauge dial and turn the dial so that the indicator is at zero. Tighten the setscrew.

NOTE

Each gauge for the timing tool has a total travel of 1.0 inch. One revolution of the indicator needle equals 0.1 inch travel of the indicator stem. When the stem of the gauge is compressed, the indicator turns clockwise and the revolution counter turns counterclockwise. Be sure to note the reading on the revolution counter at TDC. This will help you find 0.2032 inch Before Top Dead Center (BTDC).

(q) Rotate the crankshaft in the direction of engine rotation to 90 degrees After Top Dead Center (ATDC) (3, Figure 3-28).

NOTE

The piston rod travel gauge will be at the "NH/NT 90-degree" mark on the timing tool.

(r) Loosen the thumbscrew for the push rod travel gauge.

(s) Move the gauge so that the stem of the gauge is in the center of the push rod adapter.

(t) Lower the gauge against the adapter until the stem is fully compressed. Then raise the gauge approximately 0.025 inch (0.63 mm).

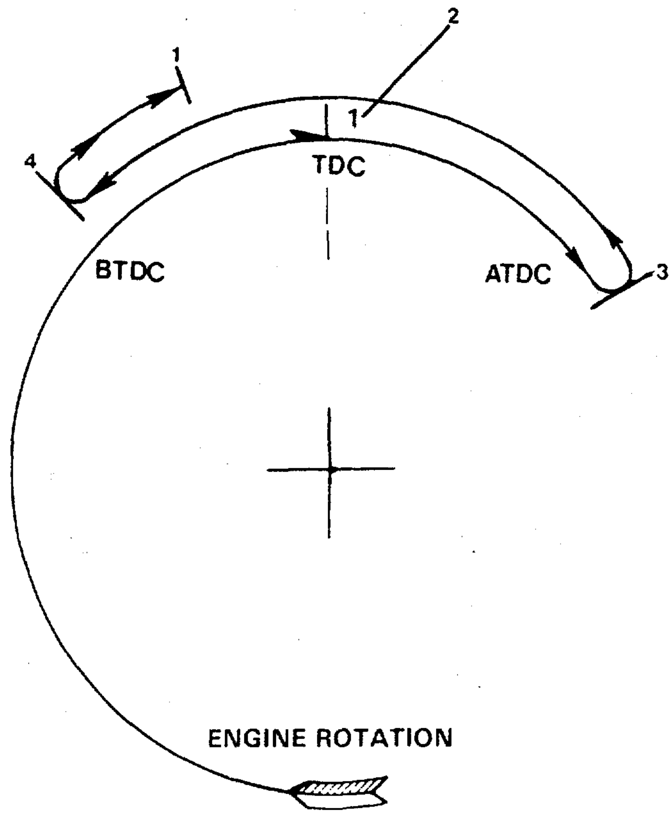


FIGURE 3-28. Timing Tool Travel.

(u) Tighten the thumbscrew to hold the gauge in position.

(v) Loosen the setscrew for the gauge dial, turn the dial so that the indicator is zero and tighten the setscrew.

NOTE

Always rotate the crankshaft slowly. Watch the piston travel indicator as you rotate the crankshaft.

(w) Rotate the crankshaft in the opposite direction of engine rotation (counterclockwise), through TDC to 45 ° before TDC.

NOTE

This step is necessary to remove the gear train lash and to provide more accurate indicator readings.

(x) Rotate the crankshaft slowly in the direction of engine rotation (clockwise) until a reading of 0.2032 inch (5.161 mm) BTDC is reached on the piston travel gauge.

(y) If the crankshaft is rotated beyond 0.2032 inch (5.161 mm) position, the crankshaft must be rotated counterclockwise back to 45° BTDC. Repeat / step (x).

NOTE

- The engine must be on the compression stroke. When the crankshaft is rotated to TDC on the compression stroke, the indicator on both gauges will move in the same direction. If they do not, rotate the crankshaft one complete revolution and repeat steps (q) through (v) of this procedure.

- The push rod travel gauge is read in a counterclockwise direction from "0" (zero). The total amount of travel represents the injection timing code.

(z) Read the push rod travel gauge. The push rod travel must be within the limits given in Table 3-3.

NOTE

To verify the correct injection timing for engine, check the injection timing code on the engine dataplate.

NOTE

To verify the correct injection timing for engine, check the injection timing code on the engine dataplate.

(3) Correcting Injector Timing.

(a) Do not change the cam follower gaskets to correct the injection timing until you check the following items:

1 Timing tool is correctly installed.
2 Gauges are correctly adjusted.
3 Crankshaft has been rotated in the correct direction.
4 Capscrews for the cam follower housing are tightened to 30 to 35 ft-lb (40.6 to 47.4 N•m) torque.

(b) If the reading on the push rod travel gauge is not within limits given in Table 3-3, increase or decrease the thickness of the cam follower housing gaskets, Table 3-4, as follows:

1 If the indicator reading is higher than the specification, the timing is retarded. Increase the gasket thickness to advance the injection timing (right hand rotation engine).

Table 3-3. Injection Timing Codes and Push Rod Travel

Timing (1) Code	Push Rod Travel (2) (Inches) Fast	Slow
A	-0.0395	-0.0435
C	-0.0315	-0.0355
D	-0.034	-0.038
E	-0.028	-0.030
Z	-0.024	-0.028
AA	-0.030	-0.032
AC	-0.027	-0.029
AF	-0.044	-0.046
AH	-0.034	-0.036
AK	-0.040	-0.042
AN	-0.045	-0.047
AQ	-0.041	-0.043
AS	-0.035	-0.037
AU	-0.048	-0.050
AV	-0.049	-0.051
AW	-0.059	-0.061
AX	-0.054	-0.056
AY	-0.039	-0.041
AZ	-0.058	-0.060
BA	-0.027	-0.029
BC	-0.023	-0.025
BH	-0.051	-0.053
BM	-0.052	-0.054
BS	-0.071	-0.073
BT	-0.080	-0.082
BU	-0.064	-0.066
BV	-0.061	-0.063
BW	-0.066	-0.068
BY	-0.069	-0.071
CD	-0.073	-0.075
CE	-0.025	-0.027
CF	-0.037	-0.039
CH	-0.051	-0.053
CO	-0.0625	-0.0645

2 If the indicator reading is lower than specification, the timing is advanced. Decrease the gasket thickness to retard the injection timing (right hand rotation engine).

NOTE

Table 3-4 lists the different cam follower housing gaskets, the gasket thickness, and approximate change in push rod travel at 19º BTDC 0.2032 inch (5.161 mm) piston travel.

Table 3-4. Change in Push Rod Travel Due to Gasket Thickness

Gasket Thickness inch (mm)	Change In Push Rod Travel At 19º BTDC inch (mm)
0.006 to 0.008 (0.15 to 0.20)	0.0015 to 0.002 (0.04 to 0.05)
0.014 to 0.020 (0.36 to 0.51)	0.0035 to 0.005 (0.09 to 0.13)
0.020 to 0.24 (0.51 to 0.61)	0.005 to 0.006 (0.13 to 0.15)
0.027 to 0.033 (0.69 to 0.84)	0.007 to 0.008 (0.18 to 0.20)

NOTE

Gaskets are available in the following thicknesses.

Each 0.18 mm (0.007-inch) of gasket thickness affects injection timing by approximately 0.05 mm (0.002-inch) indicator travel.

Gaskets are available in the following nominal thicknesses:

a. 0.18 mm (0.007 inch).
b. 0.43 mm (0.017 inch).
c. 0.43 mm (0.017 inch) (Print-O-Seal*).
d. 0.56 mm (0.022 inch).
e. 0.76 mm (0.030 inch).

*One Print-O-Seal gasket must be used for each cam follower housing.

(c) The gasket (1, Figure 3-29) must be against the cylinder block with the sealing bead toward the cam follower housing. The minimum amount of gasket stack-up thickness which may be used is 0.017 inch (0.43 mm). The maximum gasket stack-up thickness allowed is 0.080 inch (2.03 mm).

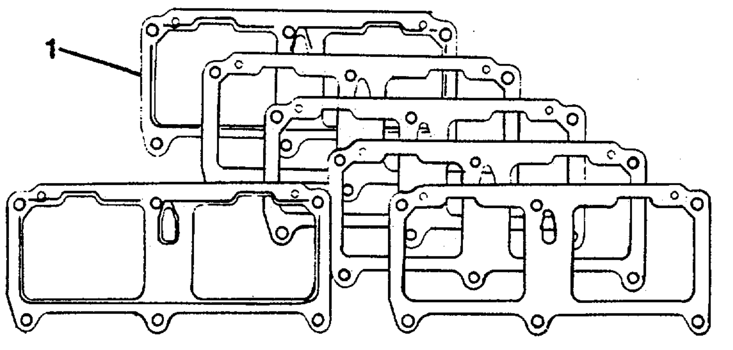


FIGURE 3-29. Gasket Stack-Up Thickness.

(d) If you can not correct the injection timing by increasing or decreasing the thickness of the cam follower housing gaskets, an offset camshaft key must be installed (paragraph 4-13).

(e) After completing the injection timing check on cylinder No. 1, check the injection timing on cylinders No. 3 and 5. Remove test equipment.

d. Install the injectors (paragraph 2-40).

e. Install the accessory drive assembly (paragraph 3-19).

f. Install the fuel pump (paragraph 2-37).

g. Install the push rods.

h. Install the rocker lever housings (paragraph 2-39).

i. Adjust the valves and injectors (paragraph 2-39).

j. Install the rocker housing covers (paragraph 2-39).

k. Remove tags, run the engine, and check for leaks and engine operation.

3-19. REPLACE/REPAIR ACCESSORY DRIVE AND PULLEY GROUP.

This task covers:
a. Removal, b. Disassembly, c. Repair, d. Assembly, e. Replacement.

INITIAL SETUP:

Tools

Tool kit, general mechanic's
rail and marine diesel engines,
5180-00-629-9783
Torque wrench kit P/N 3377216
Pulley installation tool
P/N 3376326
Coupling puller P/N ST-1249
Standard gear puller P/N ST-647
Arbor press 4920-00-373-9376
Machinists Measuring Set
5280-00-278-9919

Materials/Parts

Metal cleaning solvent,
Item 6, Appendix C
Lubricating oil, Item 2, Appendix C
Crocus cloth, Item 26, Appendix C
Lubriplate, Item 28, Appendix C
Gasket, accessory support drive
P/N 200809
Transmission power take-off P/N 3005131
Wiping rag, Item 4, Appendix C
Pipe thread anti-seize compound
Item 9, Appendix C
Pulley pump sleeve P/N 190397
Accessory gasket P/N 200809
Rubber strip P/N 3008947
Helical gear P/N 142689
Pulley drive coupling P/N 3000175
Thrust washer bearings P/N 3026556
and P/N 3026557
Straight headless pin P/N 3034438
Shaft P/N 3000171
Constant speed mechanical drive
P/N AR-45728
Sleeve bearing P/N 116391

Equipment Conditions

Engine cooled below 120ºF(50ºC). Air
supply secured (port).
Battery banks disconnected (starboard).
TM 55-1905-223-10.
Water pump belt removed (paragraph
2-33).
Fuel pump removed (paragraph 2-37).

REMOVAL

CAUTION

The timing marks on the accessory drive gear and the camshaft gear must be aligned so that the valve and injector set marks on the accessory drive pulley show the correct adjustment position.

a. Rotate the crankshaft until the "A" mark on the accessory drive is aligned with the pointer on the gear cover (Figure 3-30).

CAUTION

The gear cover will be damaged if the puller capscrews extend beyond the rear face of the accessory drive pulley.

b. Remove the self-locking hexagon nut (12, Figure 3-31) and flat washer (11).

c. Remove the pulley (14, Figure 3-31), rubber strip (13) with standard gear puller.

d. Remove the inspection hole pipe plug (Figure 3-32) in the gear cover.

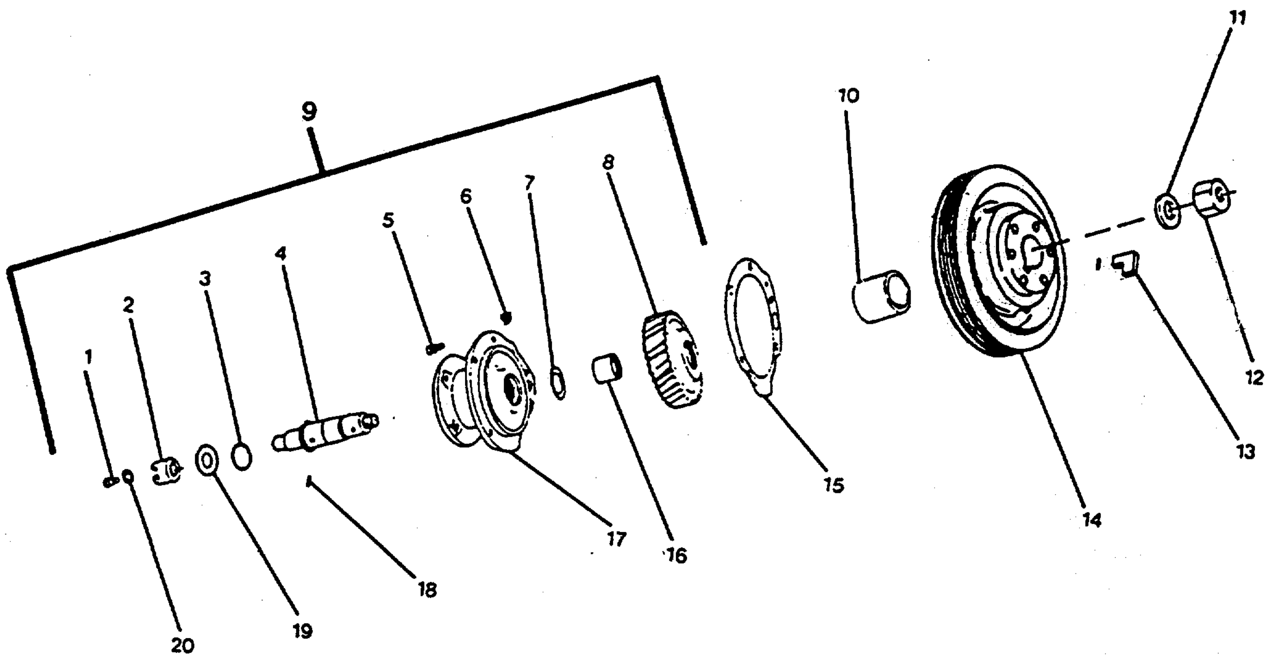


FIGURE 3-30. Alignment Pointer.

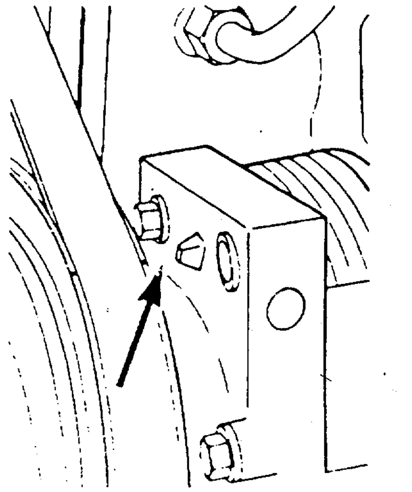


FIGURE 3-31. Accessory Drive and Pulley.

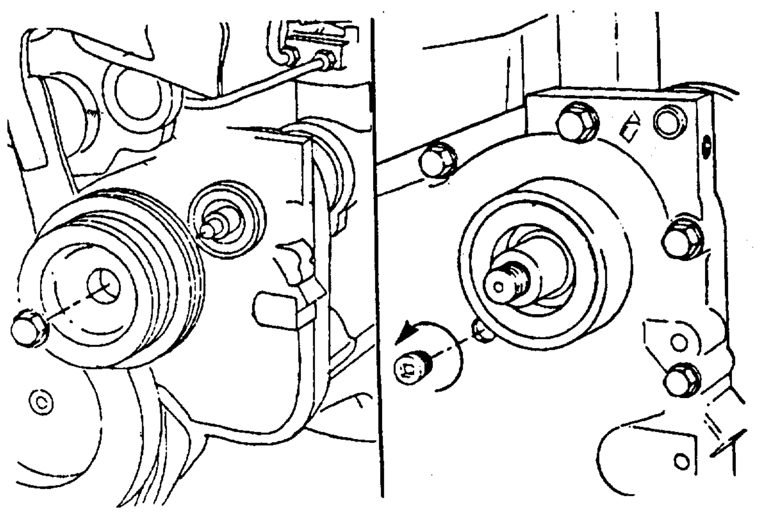


FIGURE 3-32. Inspection Hole Plug.

e. Ensure timing marks on the camshaft gear and accessory drive gear are aligned. (Figure 3-33).

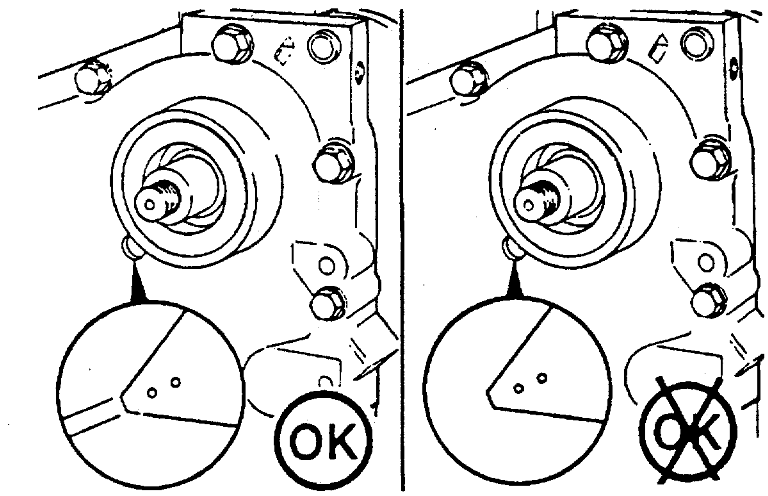


FIGURE 3-33. Gear Alignment.

NOTE

If only the timing mark on the accessory drive gear is visible through the inspection hole, rotate the crankshaft one complete revolution in the direction of rotation to align the timing marks on the camshaft gear and the accessory drive gear.

CAUTION

If the accessory drive dowel pin has been incorrectly installed, the dowel pin must be removed before attempting to remove the accessory drive to prevent damage to the accessory drive bushing (Figure 3-34).

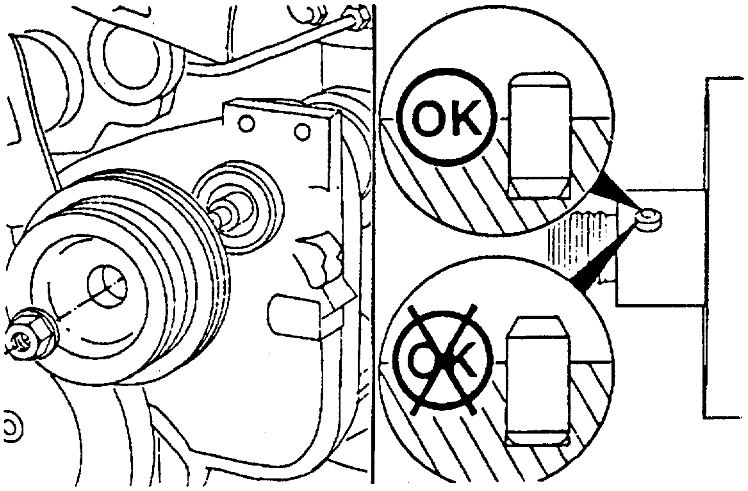


FIGURE 3-34. <u>Accessory Drive Dowel Pin</u>.

f. Remove five assembled screws and flat washers (2, Figure 3-35) from accessory drive assembly (3).

g. Use a rubber hammer to loosen the drive. Remove drive assembly (3) and gasket (1). Discard gasket.

h. Remove all of the old gasket material from sealing surface.

i. Remove gear cover accessory drive seal (paragraph 3-20).

DISASSEMBLY

a. Disassemble the power take-off transmission parts from the shaft (4, Figure 3-31) as follows:

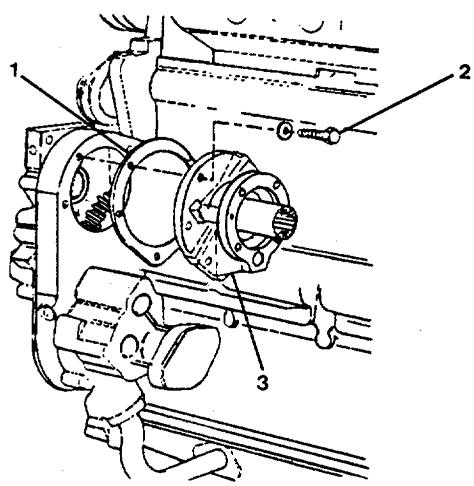


FIGURE 3-35. <u>Removing Accessory Drive</u>.

(1) Remove the capscrew (1) and washer (20) from the shaft (4).

(2) Install the capscrew (1) onto the shaft (4) after washer (20) has been removed.

(3) Remove the coupling (2) using coupling puller.

(4) Remove washer (19).

(5) Remove thrust washers (3 and 7).

(6) Remove the shaft (4) and gear (8) from the housing (17).

(7) Remove the gear (8) from the shaft (4) as follows:

(a) Remove the headless pin (18) from the shaft (4).

(b) Put the housing side of the gear (8) onto a support and use a press to push the shaft (4) from the gear (8).

b. Disassemble pulley (14, Figure 3-31) as follows:

CAUTION

The jaws of the vise must have copper plates to prevent damage to the pulley.

(1) Put the flat pulley (14) in a vise.

(2) Grind a 0.062 inch (1.57 mm) radius on the cutting edge of a 0.75 inch (19.05 mm) chisel.

(3) Put the chisel against the wear sleeve. Use a hammer to strike the chisel at four points on the outside diameter of the wear sleeve to relieve the press fit (Figure 3-36).

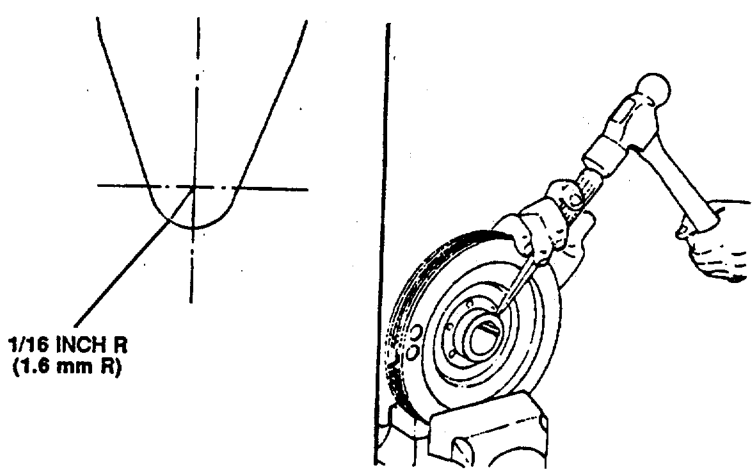


FIGURE 3-36. Relieving Press Fit on Wear Sleeve.

(4) After the press fit has been relieved, remove the sleeve (10, Figure 3-31) by hand.

REPAIR

a. Clean and inspect pulley:

(1) Visually inspect the pulley for cracks, wear in the belt grooves, or other damage.

NOTE

A new belt, when pushed down into the groove, must protrude 1/16 to 1/8 inch (0.06 to 0.13 mm) above the outside diameter of the pulley. The belt must not touch the bottom of the groove.

(2) Replace the pulley if damage or wear is found.

(3) If the oil seal wear surface on the accessory drive pulley wear sleeve is mutilated or has a groove worn deep enough that it can be felt with a fingernail, the wear sleeve must be replaced.

(4) Inspect the oil seal wear area of the accessory drive pulley for minor nicks, scratches, or sharp edges.

(5) Use a 240 grit emery cloth dipped in clean lubricating oil to remove any minor defects.

(6) Use a crocus cloth for a final polishing operation and to remove any remaining deposits on the oil seal wear area.

(7) Clean the oil seal wear area with a clean cloth.

b. Clean and inspect accessory drive:

(1) Clean all parts with cleaning solvent.

(2) Dry with compressed air.

(3) Check the bushing (16, Figure 3-31) in the drive housing.

(4) If the bushing is worn larger than 1.321 inch, remove and discard bushing.

(5) Check the shaft (4) for wear distortion or damage.

(6) The outside diameter of the shaft must not be worn less than 1.310 inch (33.27 mm).

ASSEMBLY

a. Assemble the power take-off transmission parts onto the shaft (4, Figure 3-31).

(1) Install the headless pin (18) into the shaft (4).

(2) Install the gear (8) onto the shaft (4) as follows:

(a) Use a press to push the gear onto the shaft.

(b) Push the gear onto the shaft until the gear is against the shoulder on the shaft.

(3) Apply a coat of lubricating oil to the thrust washer (7) and bushing (16) in the housing.

<u>CAUTION</u>

On accessory drive units the grooved side of the washer is installed away from housing. The steel backing against the cast iron housing will keep the thrust washers from turning. Incorrect installation of these washers will result in excessive wear and increased end play, which causes early failure of the accessory drive assembly.

(4) Place the thrust washer (7) in position.

(5) Install the gear (8) and shaft (4) through the thrust washer (7) and into the bushing in the housing.

(6) Turn the assembly over so that the gear on the shaft is down.

(7) Make sure that thrust washer (7) stays in position.

(8) Apply a coat of lubricating oil to the rear thrust washer (3). Install the thrust washer.

(9) Install washer (19).

(10) Install the coupling (2). Use a press to push the coupling onto the shaft.

NOTE

Do not damage the threads on the shaft.

(11) Install the washer (20) and capscrew (1).

(12) Tighten the capscrew to 30 to 35 ft-lb (41 to 47 N·m) torque.

b. Assemble pulley (14, Figure 3-31).

(1) Support the pulley (14) in an arbor press.

(2) Place the wear sleeve (10) on the pulley seal wear surface with the chamfer on the outside diameter of the wear sleeve (10) facing up (away from the pulley).

(3) Place a flat steel plate on top of the wear sleeve (10).

(4) Press the wear sleeve (10) on the pulley (14) until the steel plate contacts the pulley.

(5) Inspect the wear sleeve (10) for obvious damage during assembly.

REPLACEMENT

CAUTION

If the crankshaft was rotated after the accessory drive was removed, rotate the crankshaft until the timing mark on the camshaft gear is visible in the inspection hole before installing the accessory drive assembly. See Figure 3-33.

NOTE

Ensure mounting surfaces are clean of dirt and debris before installing the accessory drive.

a. Install a new gasket (15, Figure 3-31) on the accessory drive assembly.

CAUTION

Ensure the dowel pin has been inserted correctly before installing the accessory drive. See Figure 3-34.

b. Put the accessory drive shaft dowel pin at approximately the 11:30 o'clock position when facing the shaft from the pulley end.

c. Install the accessory drive assembly in the gear housing accessory drive mounting hole.

d. Check the alignment of the camshaft gear and the accessory drive gear timing marks through the inspection hole in the gear cover (Figure 3-33).

NOTE

The accessory drive shaft dowel pin will be at the 12:00 o'clock position after the accessory drive is installed.

e. Install and tighten the accessory drive washer screws (5, Figure 3-31) to 45 ft-lb (61.0 N·m) torque.

f. Apply anti-seize thread compound to the 3/8-inch inspection hole pipe plug (Figure 3-32).

g. Install and tighten the plug to 20 ft-lb (30 N·m) torque.

h. Install a new accessory drive seal in the gear cover (paragraph 3-20):

CAUTION

Do not use any kind of lubricant to install the seal. The oil seal must be installed with the lip of the seal and the seal wear area of the accessory drive pulley clean and dry. Use of lubricant will result in oil leakage at the seal.

(1) Install the oil seal with the closed or part number side facing outward from the gear cover.

(2) Install the oil seal over the accessory drive pulley shaft.

(3) Push the seal into the gear cover seal bore until the seal is seated.

i. Install the accessory drive flat pulley assembly:

(1) Apply a film of Lubriplate or its equivalent to the accessory drive shaft.

(2) Align the keyway in the pulley with the dowel pin in the shaft.

(3) Use your hand to partially push the pulley on the shaft.

(4) Using pulley installation tool, press the pulley onto the shaft until it fits against the accessory drive gear.

(5) Install the keyway rubber strip (13, Figure 3-31) in the pulley keyway with one end of the seal pointing toward the center line of the shaft.

(6) Install the washer (11, Figure 3-31) and the nut (12) on the accessory drive shaft. Tighten the nut to 30 ft-lb (40.6 N·M) torque.

j. Install the fuel pump (paragraph 2-37).

k. Install the water pump belt (paragraph 2-33).

l. Connect battery banks (starboard), operate air system (port), refer to TM 55-1905-223-10.

m. Run the engine and check for leaks.

3-20. REPLACE/REPAIR GEAR COVER AND SUPPORT GROUP.

This task covers:
a. Removal, b. Repair, c. Replacement.

INITIAL SETUP:

Tools

Tool kit, general mechanic's
rail and marine diesel engines,
5186-00-629-9783
Lifting sling P/N 3375958
Dial indicator, 5210-00-277-8840
Lifting fixture P/N 3822512
Torque wrench kit P/N 3377216
Oil seal puller/installer
P/N ST-1259
Fuel pump drive oil seal mandrel
P/N ST-1173
Machinist Measuring Set
5280-00-278-9919

Materials/Parts

Lubriplate, Item 28, Appendix C
Lubricating oil, Item 2, Appendix C
Metal cleaning solvent, Item 6,
Appendix C
Gasket P/N 3021704
Seals P/N 3020183 and P/N 3020185
Gear cover P/N 3052534
Preformed packing P/N 215705
Thrust shim P/N AR-1176
Sleeve bearing P/N 132770
Vegetable oil, Item 44, Appendix C
Gear cover mounting guide pins, Item
51, Appendix C

Equipment Conditions

Engine cooled below 120ºF (50ºC).
Air supply secured (port).
Battery banks disconnected (starboard)
TM 55-1905-223-10.
Oil drained (PMCS Table 2-1, Item 15).
Vibration damper assembly removed,
(paragraph 3-26).
Water pump belt removed (paragraph
2-33).
Accessory drive pulley removed
(paragraph 3-19).

REMOVAL

WARNING

A lifting fixture must be used to support the engine when removing the gear housing assembly. It must be firmly in place before removing the mounting capscrews.

CAUTION

If the accessory drive dowel pin has been incorrectly installed, the dowel pin must be removed before attempting to remove the gear cover to prevent damage to the accessory drive bushing (Figure 3-37).

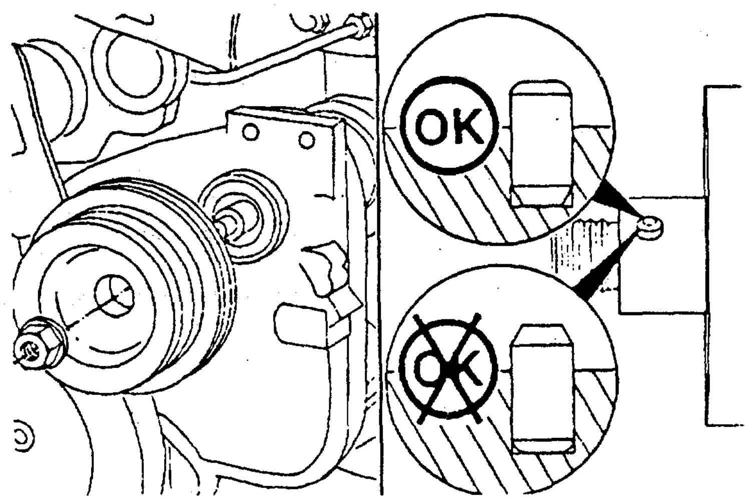


FIGURE 3-37. Dowel Pin Installation.

a. Remove the camshaft support and the thrust bearing:

(1) Remove the three assembled washer screws (15) from the camshaft thrust support (14) (Figure 3-38).

(2) Use a rubber or plastic hammer to rotate the bearing support approximately 60 degrees (Figure 3-39).

(3) Remove the support (14, Figure 3-38) from the gear cover (10).

(4) Remove the packing (17) and the thrust shims (16) from the support (14). Do not discard the shims.

b. Remove the four hexagon capscrews (1, Figure 3-40) that hold the oil pan to the gear cover.

c. Loosen all remaining oil pan capscrews four to five turns.

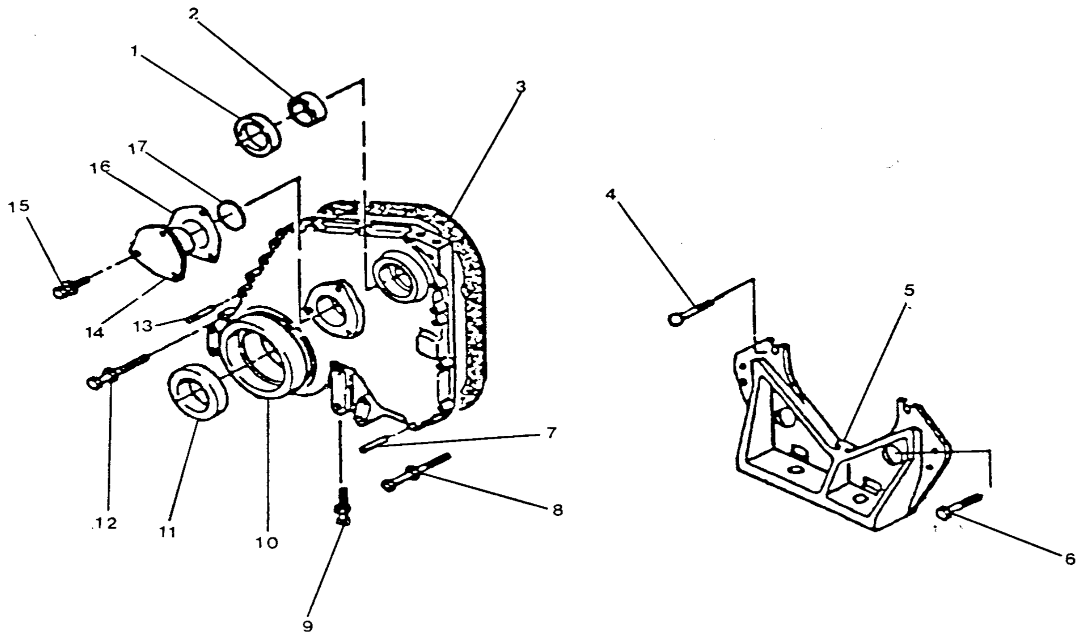


FIGURE 3-38. Gear Cover and Support Group.

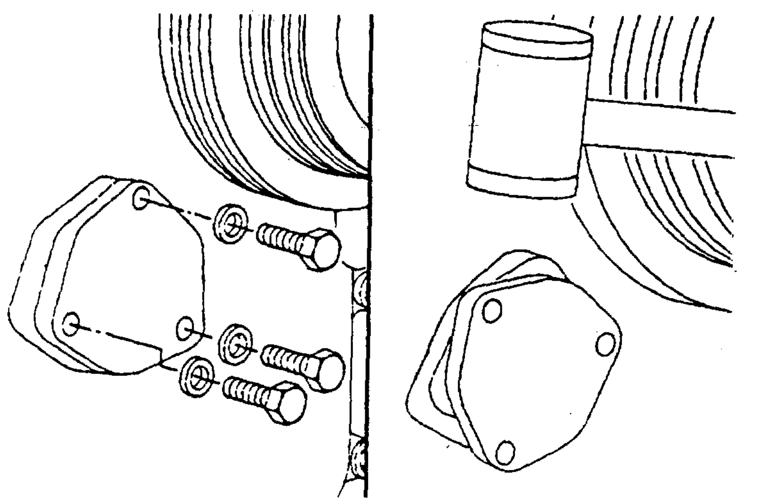


FIGURE 3-39. Camshaft Bearing Support.

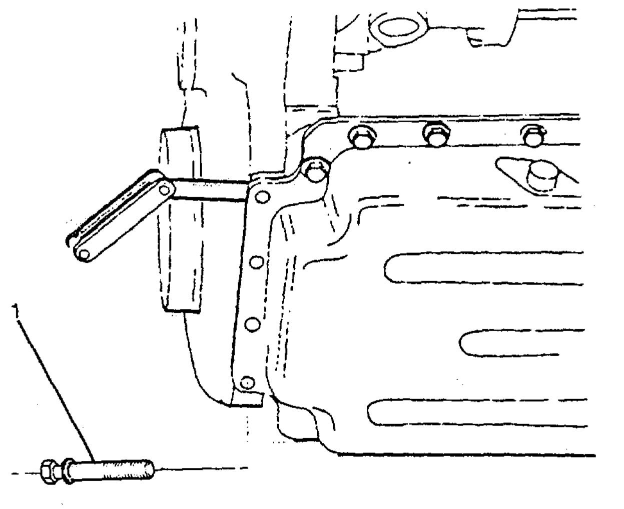


FIGURE 3-40. Releasing Oil Pan Gasket.

WARNING

A hoist must be solidly supporting the engine before removing the machine bolts and hexagon capscrews from engine mounting bracket (Figure 3-38).

d. Loosen the screws (4, 6) which hold the engine mounting bracket (5) to the cross-member of the equipment. Ensure the hoist is firmly supporting the engine. Apply only the lift required to remove the engine supports.

e. Remove the eight capscrews (4, 6) from the engine mount bracket (5) and remove the bracket.

CAUTION

Use extreme care when releasing the oil pan gasket from the gear cover to prevent damage to the gasket. If the gasket is damaged, the oil pin must be removed and the gasket replaced. Refer to paragraph 3-21.

f. Insert a feeler gauge or a shim stock between the gear cover and the oil pan gasket. Move the feeler gauge or the shim stock back and forth to release the gasket from the gear cover (Figure 3-40).

g. Remove one assembled washer screw (8, 12, Figure 3-38) on each side of the gear cover (10), and install the 7/16-20 x 4 inch straight headless pins (7, 13) in each location to support the cover (10) during removal (Figure 3-41).

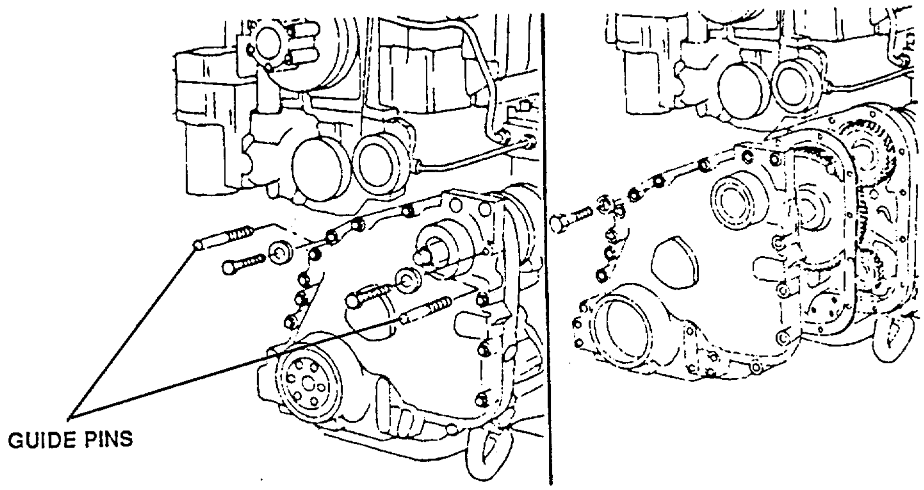


FIGURE 3-41. Removing Gear Cover.

h. Remove assembled washer screws (9, Figure 3-38) and the remaining gear cover (10) screws (8, 12). Remove the gear cover (10). The pins (7, 13) will remain in the block until installation.

i. Remove the plain encased seal (11) and accessory drive seal (1) from the cover (10).

j. Remove the gasket (3). Discard gasket.

REPAIR

a. Clean and inspect gear cover.

(1) Clean the gear cover and cylinder block gasket surfaces.

(2) Clean gear cover with solvent.

(3) Visually inspect the gear cover for cracks or damage. Replace cover if damaged.

(4) Use a clean cloth to clean the crankshaft seal bore.

b. Clean the inspect camshaft bearing support.

(1) Clean the bearing support and shims with solvent.

(2) Visually inspect the bearing support for cracks or damage on the thrust surface. Replace bearing support if damaged.

c. Clean and inspect engine mount bracket.

(1) Clean the engine mount bracket with solvent.

(2) Dry with compressed air.

(3) Visually inspect the engine mount bracket for cracks or damage.

(4) Visually inspect the capscrew threads for damage.

(5) If any damage is found, replace engine mount bracket.

REPLACEMENT

NOTE

- Ensure the gasket surfaces on the gear cover and cylinder block are clean before installing the gear cover assembly.
- Use a film of Lubriplate or equivalent to hold the gear cover gasket in place, if necessary.

a. Install the gasket (3, Figure 3-38) over the guide pins (7, 13).

b. Install the gear cover (10) and screws (8, 9, 12). Tighten the screws to 50 ft-lb (67.7 N·M) torque.

(1) Remove pins (7, 13) and install the remaining two screws. Tighten the screws to 50 ft-lb (67.7 N·M) torque.

c. Cut the ends of the gasket off even with the oil pin mounting flange.

d. Mount a dial indicator on the front face of the crankshaft. Put the indicator plunger against the oil seal bore, and set the dial indicator at "0" (zero).

e. Rotate the crankshaft one complete revolution while monitoring the indicator. The total indicator reading must not exceed 0.010-inch (0.25 mm).

f. If the total indicator reading exceeds 0.010-inch (0.25 mm), remove the gear cover. Check the cover and the housing for nicks or burrs.

g. Clean the gear cover and the housing surfaces thoroughly with solvent.

h. Repeat the gear cover replacement procedure, and check the total indicator reading again.

i. Lower the engine with the lifting fixture onto the engine mounting bracket (5). Install the bracket (5) and the eight capscrews (4, 6). Tighten the screws (4, 6) to 50 ft-lb (67.7 N·M) torque.

j. Install the camshaft bearing support (14, Figure 3-38) as follows:

(1) Place the bearing support in the bore of the gear cover. Do not install the packing (17) on the support at this time.

(2) Push the support against the camshaft so the camshaft gear rests against the camshaft thrust washer.

(3) Hold the support against the camshaft, and use a feeler gauge to measure the space between the gear cover flange and the support bearing (Figure 3-42).

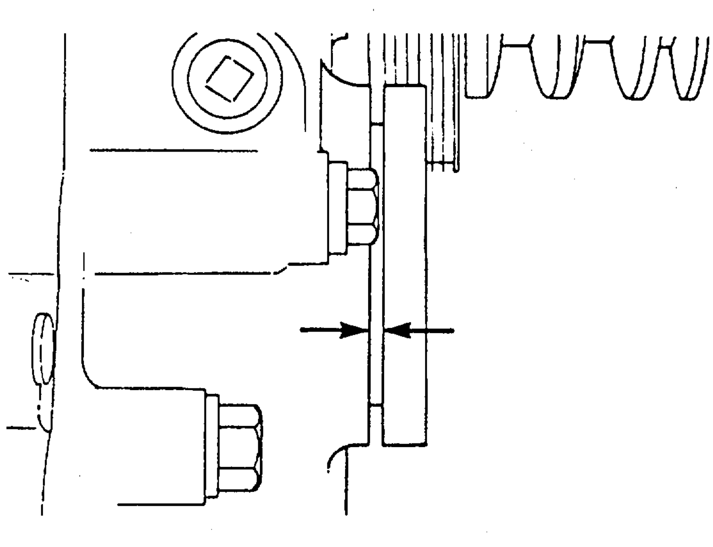


FIGURE 3-42. Support Bearing Clearance.

(4) The clearance between the bearing support and the camshaft gear must be 0.008 to 0.013 inch (0.20 mm to 0.33 mm). After measuring the space between the bearing support and the gear cover flange, add an additional 0.008 to 0.013 inch (0.20 mm to 0.33 mm) to that number to determine the thickness of the shims required. Example: Space of 0.060 inch (11.52 mm), measured with a feeler gauge, plus 0.010 inch (0.25 mm) for clearance would require 0.070 inch (1.77 mm) shims.

(5) Use a micrometer to measure the shims removed from the support at the time of disassembly. Add or remove shims as required to obtain the correct clearance between the bearing support and the camshaft gear. Shims are available in the following thickness:

Shim Thickness mm	in
0.05	0.002
0.13	0.005
0.25	0.010
0.63	0.025

(6) Remove the support and install the required number of shims and a new packing (17, Figure 3-38) on the camshaft bearing support (14).

CAUTION

Do not use lubricating oil on the packing. The packing will increase in size when in contact with lubricating oil. Use vegetable oil.

(7) Lubricate the packing (17, Figure 3-38) with oil and install the camshaft bearing support (14) in the gear cover with the screws (15).

(8) Tighten the screws to 20 ft-lb (25 N·M) torque.

f. Install the plain encased seal (11), as follows:

CAUTION

The oil seal must be installed with the lip of the seal and crankshaft clean and dry. Do not use any kind of lubricant. The use of lubricant will result in oil leakage at the seal.

NOTE

Plain encased oil seals for service replacement have an assembly tool which protects the seal lip during shipment and installation.

(1) Use hand pressure to push the oil seal from the assembly tool onto the crankshaft as far as possible. Remove the assembly tool.

(2) Install P/N ST-1259-1 Top Plate (from P/N ST-1259 Oil Seal Puller/Installer) on the crankshaft, and use three vibration damper mounting capscrews and flat washers.

(3) Tighten the three capscrews alternately in 1/2-turn increments until top plate seats against the crankshaft nose.

g. Install the crankshaft pulley and the vibration damper (paragraph 3-26).

h. Install the accessory drive seal (1, Figure 3-38) as follows:

(1) Install the oil seal on P/N ST-1173 Fuel Pump Drive Oil Seal Mandrel with the part number side facing the driver.

CAUTION

Do not use any kind of lubricant to install the seal. The oil seal must be installed with the lip of the seal and the seal wear area of the accessory drive pulley clean and dry. Use of lubricant will result in oil leakage at the seal.

(2) Put fuel pump drive oil seal mandrel over the accessory drive shaft.

(3) Align the keyway in the driver with the groove pin in the accessory drive shaft.

(4) Push the seal into the seal bore until the seal casing fits against the ledge.

i. Install the dowel pin (if removed) in the accessory drive shaft (Figure 3-37).

j. Install the accessory drive pulley (paragraph 3-19).

k. Install the water pump belt (paragraph 2-33).

1. Install the four capscrews that hold the oil pan to the gear cover (1 through 4, Figure 3-43).

m. Tighten two 7/16 inch oil pan mounting capscrews (11 and 25) one on each side of the oil pan, halfway between the front and the rear of the oil pan, to 15 ft-lb (20 N·M) torque.

n. Tighten the four 5/16 inch capscrews in the rear of the oil pan to 20 ft-lb (25 N·M) torque in the sequence shown in Figure 3-43.

o. Tighten the 32 7/16 inch capscrews to 50 ft-lb (70 N·M) torque in the sequence shown in Figue 3-43.

p. Fill the lubricating oil system (PMCS Table 2-1, Item 15).

q. Connect battery banks (starboard), operate air system (port), refer to TM 55-1905-223-10.

r. Run the engine until it reaches a temperature of 180°F (80ºC) and check for leaks.

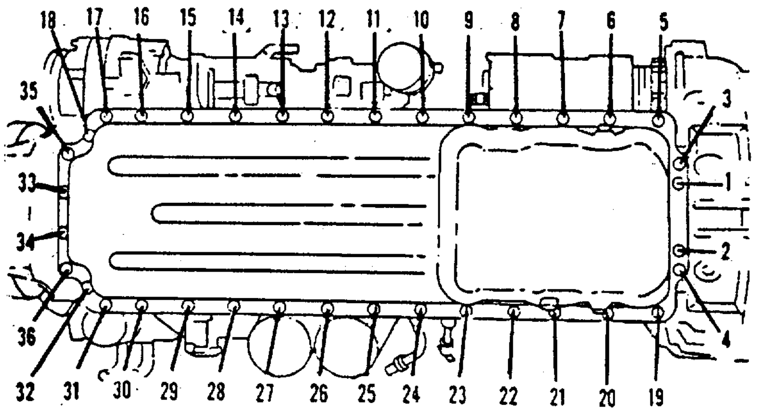


FIGURE 3-43. Oil Pan Torque Sequence.

3-21. REPLACE/REPAIR OIL PAN GROUP.

This task covers:

a. Removal **b. Repair** **c. Replacement**

INITIAL SETUP:

Tools

Tool kit, general mechanic's
rail and marine diesel engines,
5180-00-629-9783
Torque wrench kit P/N 3377216

Materials/Parts

Gasket P/N 57551
Nonmetallic hose assembly P/N 3017963
Sediment strainer element P/N 20622
Oil pan P/N 193631
Metal cleaning solvent, Item 6, Appendix C
Hand hole gasket P/N 65274
Lube oil pump gasket P/N 157551
Gasket P/N 3032861
Shutoff valve P/N 3023067
Lubricating oil, Item 2, Appendix C
Contact adhesive

Equipment Condition

Engine cooled below 120ºF (50ºC).
Air supply secured (port).
Battery banks disconnected (starboard).
TM 55-1905-223-10.
Lubricating oil drained (PMCS Table 2-1, Item 15).

REMOVAL

a. Remove the liquid level gauge rod-cap (18, Figure 3-44) from the dipstick tube (17). Remove the filler opening cap (16).

b. Remove the loop clamp (9) from the nonmetallic hose assembly (8).

c. Remove the four machine screws and flat washers (13) from the access cover (14) and remove the tube (17), access cover (14), and handhold gasket (15) from the cylinder block. Discard gasket.

d. Disconnect the nonmetallic hose assembly (8) from the oil pan (4) connection and lubrication pump connection. Remove the nonmetallic hose assembly (8).

e. Remove the two assembled washer screws (7) from the flange-to-tube elbow (6) and remove the elbow (6) and the gasket (5) from the oil pan (4). Discard the gasket.

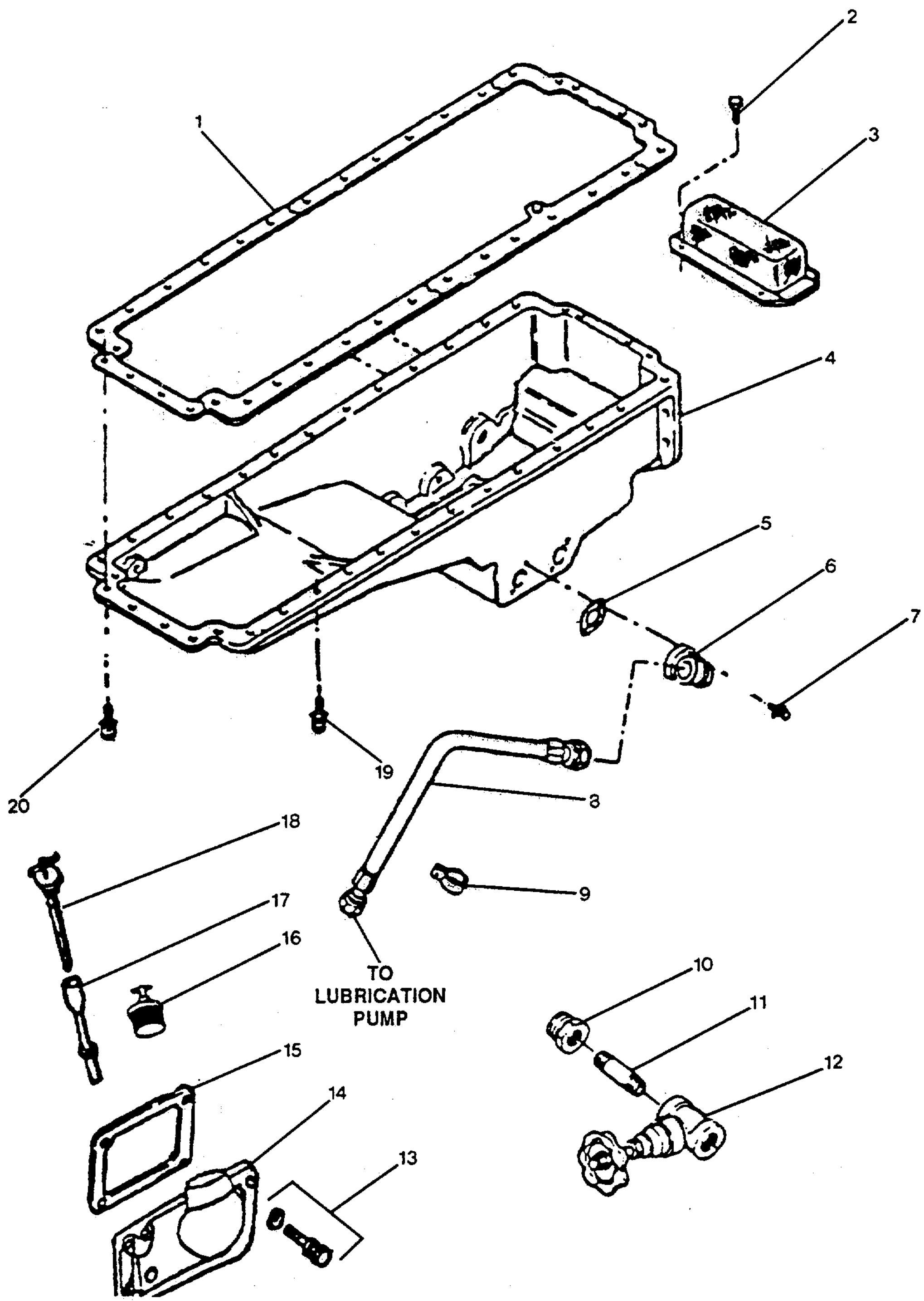


FIGURE 3-44. Oil Pan Group.

f. Disconnect the sump pump from the shutoff valve (12). Remove the machine thread plug (10), the pipe nipple (11) and shutoff valve (12).

g. Remove the 32 capscrews (19, 20) that hold the oil pan in place.

h. Remove the oil pan (4) gasket (1). Discard gasket.

i. Remove the two thread forming tapping screws (2) and remove sediment strainer element (3).

REPAIR

a. Clean the nonmetallic hose assembly (8, Figure 3-44) and the mounting flanges. Clean the sediment strainer element (3). Inspect the nonmetallic hose assembly (8) and element (3) for damage. Replace as required.

b. Clean the mounting capscrews.

c. Visually inspect the hose and the flanges for cracks, corrosion, or other damage. Replace if damaged.

d. Visually inspect access cover (14), dipstick tube (17), and rod-cap (16) for damage. Replace if damaged.

e. Visually inspect the pan (4) for signs of cracks or other damage. Replace the oil pan (4) if damaged.

REPLACEMENT

a. Install the sediment strainer element (3) in the oil pan (4) with thread forming tapping screws (2).

NOTE

Ensure the gasket surfaces are clean before installing oil pan.

b. Install two guide studs into the oil pan flange of the cylinder block.

NOTE

Use a contact adhesive to attach the new gasket to the oil pan. The silicon printed side of the gasket must be towards the oil pan.

c. Install new gasket (1) and position oil pan (4) on the engine block. Install the capscrews (19, 20, Figure 3-44) finger tight.

d. To prevent damage to the oil pan or flywheel housing, use following sequence to tighten capscrews.

(1) Install and tighten the middle capscrew in each buttress on the flywheel housing (Figure 3-45).

(2) Tighten two capscrews on each side of the oil pan flange. Tighten the capscrews that are located halfway between the front and the rear of the oil pan (Figure 3-46).

(3) Remove the capscrews that were installed in step d.(1) of this procedure. This is necessary to provide the clearance to perform the following step.

(4) Install and tighten capscrews to hold the rear corners of the oil pan to the cylinder block.

(5) Remove the guide studs and install all oil pan capscrews.

(6) Tighten the capscrews that hold the oil pan to the cylinder block and front cover to 35 to 40 ft-lb (47 to 54 N·M) torque.

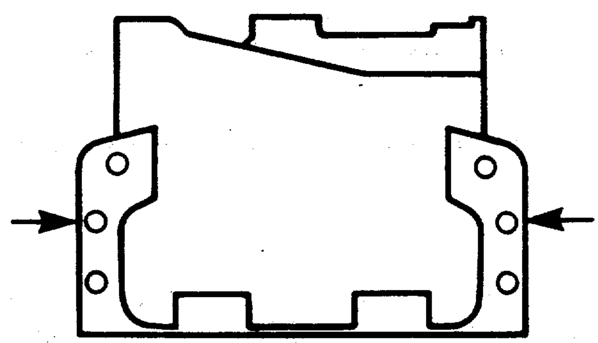


FIGURE 3-45. Flywheel Housing Buttresses.

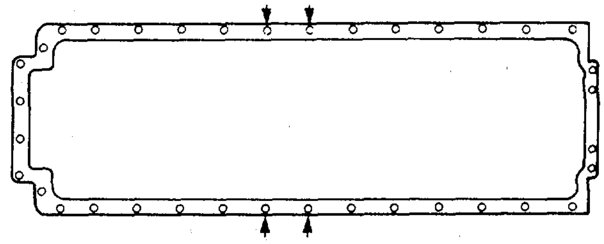


FIGURE 3-46. Middle Oil Pan Capscrews.

(7) Tighten the capscrews that hold the oil pan buttress to the flywheel housing buttress to 70 to 80 ft-lb (95 to 108 N·M) torque.

(8) Tighten the capscrews that hold the oil pan to the rear cover plate to 15 to 20 ft-lb (20 to 27 N·M) torque.

e. Install the nonmetallic hose assembly (8) and flange to tube elbow (6) as follows:

(1) Apply clean lubricating oil to the hose nuts and sleeves. Install the oil pan flange (6) onto the hose nut but do not tighten.

(2) Install the oil pan flange (6) and a new gasket (5) with capscrews (7) onto the oil pan. Do not tighten the capscrews.

(3) Push the hose connector into the oil pump adapter until it is against the bottom of the adapter. Hand tighten the nut. Then tighten the nut an additional 1 to 1-1/4 turn.

(4) Hand tighten the hose nut on the oil pan flange (6). Tighten the capscrews (16) that hold the flange to the oil pan to 30 to 35 ft-lb (41 to 47 N·M) torque. Tighten the hose nut until it is against the stop on the suction flange.

f. Install thread machine plug (10), pipe plug (11), and valve (12) into the oil pan and connect the sump pump line.

g. Install the access cover (14) and a new hand hole gasket (15) with the screws and flat washers (13). Tighten the screws (15) to 30 to 35 ft-lb (40 to 47 N·M) torque.

h. Place gauge rod-cap (18) into the tube (17). Turn T-handle on rod-cap (18) and on filler cap (16), clockwise to secure.

i. Install the loop clamp (9) to the nonmetallic hose assembly (8).

j. Fill the engine with clean oil (PMCS Table 2-1, Item 15).

k. Connect battery banks (starboard), operate air system (port), refer to TM 55-1905-223-10.

l. Remove tags,- turn on electrical power, and operate the engine until the water temperature reaches 180ºF (80ºC), and check for oil leaks.

3-22. REPLACE/REPAIR ENGINE LUBRICATING OIL PUMP ASSEMBLY.

This task covers:
a. Removal, b. Disassembly, c. Repair, Assembly, e. Replacement.

INITIAL SETUP:

Tools

Tool kit, general mechanic's
rail and marine diesel engines,
5180-00-629-9783
Combination wrench set,
metric 10mm to 24mm,
5120-01-046-4979
Torque wrench kit P/N 3377216
Depth vernier P/N ST-537
Gear puller P/N 3375082
Gear puller P/N 3375083
Dowel puller P/N ST-1134
Bushing mandrel P/N ST-1158
Lubricating oil pump boring tool
P/N 3375206
Gear spacer mandrel ST-1157

Materials/Parts

Lubricating oil pump P/N AR9834
Sleeve bearing P/N 69521
Gasket P/N 203145, 3031434
Sleeve bushing P/N 68365
Helical compression spring P/N 211939
Pressure regulator plunger P/N 109333
Lubricating oil, Item 2, Appendix C

Equipment Condition

Engine shut down (TM 55-1905-223-10)
and cooled to below 120°F (50°C).
Air supply secured (port).
Battery banks disconnected (starboard).
Oil pan removed (paragraph 3-21).

REMOVAL

a. Disconnect oil lines to the inlet and outlet of the oil pump.

b. Remove capscrews (19, Figure 3-47), machine bolts (20) and lockwashers (18), securing oil pump to the cylinder block.

CAUTION

Do not pry on oil pump mounting flange when removing oil pump. This will cause damage to the oil pump.

c. Remove the oil pump and gasket from the gear case. Discard gasket (32).

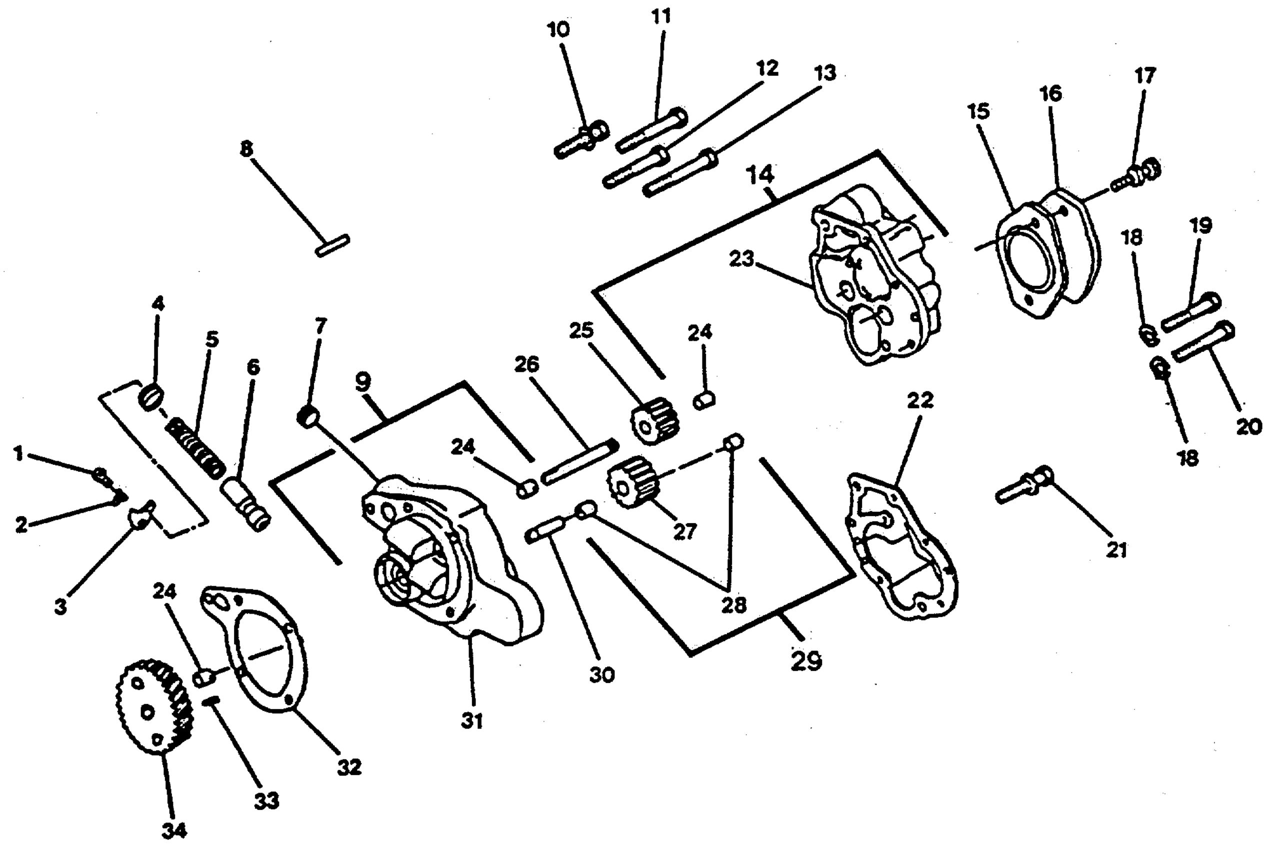


FIGURE 3-47. Lubricating Oil Pump Group.

CAUTION

Do not allow dirt or gasket material to enter oil passages on the pump. Bearing damage will result.

d. Remove two assembled washer machine screws (17) and remove access cover (16) and gasket (15). Discard gasket.

e. Using solvent, clean pump and cylinder block gasket surfaces, dry with compressed air.

f. Inspect gears (25, 27 and 34) for freedom of rotation.

g. Inspect gears (25, 27 and 34) for cracked or broken teeth. Replace in REPAIR procedure if cracked or broken teeth are observed.

h. Inspect bushings (28 and 24) for excessive wear or discoloration due to overheating or seizure to the shafts. Replace if necessary in REPAIR procedure.

i. Use depth verniers to measure drive shaft (30) end clearance (Figure 3-48) in two locations 90° part. Drive shaft end clearance should be as follows:

Minimum - 0.002 inch (0.05 mm)
Maximum - 0.005 inch (0.13 mm)

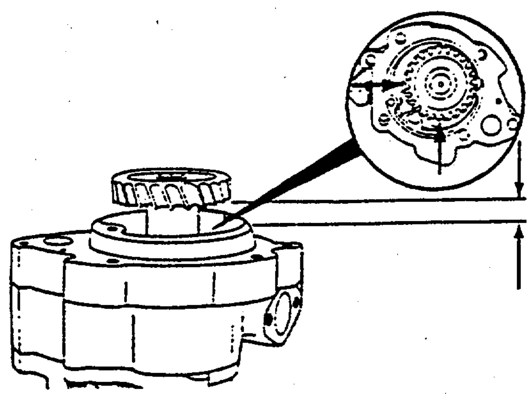


FIGURE 3-48. Drive Shaft End Clearance.

DISASSEMBLY

a. Remove assembled washer capscrews(21, Figure 3-47) securing cover (23) to pump body (31). Tap cover (23) lightly with rubber hammer to help remove cover (23) from dowels (8) in the body (31). Remove cover.

b. Remove the idler gear (25) from shaft (26).

c. Using gear puller P/N 3375082 to remove drive gear P/N 143190 or gear puller P/N 3375083 to remove drive gear P/N 125988, remove drive gear (27) from drive shaft (30) and drive gear (34).

NOTE

Some double lubricating oil pumps have a scavenger pump body that must be removed after the drive shaft is pushed through the driven gear. After removing scavenger pump body, repeat steps b. and c.

d. If the oil pump has a tube for piston cooling and the tube is damaged, push the tube from the inside part of pump body to remove.

e. Push idler shaft (26) from pump body (31).

WARNING

Carefully remove the capscrew. The pressure regulator spring is under compression.

f. Remove capscrew (1), lock plate (2), clamp (3), vent plug (4), helical compression spring (5) and pressure regulator plunger (6). Ensure plunger (6) moves freely in the bore.

REPAIR

a. Check idler shaft (22) for damage. Replace if damaged.

b. Check dowel pins (8) in the pump body (31) for damage. Use dowel puller P/N ST-1134 to remove damaged pins.

c. Check drive shaft (30) for damage.

d. Check all gears (25, 27 and 34) for worn or broken teeth. Replace with new ones if damaged.

e. Check pump body (31) for cracks, worn bushing threads or scratched gasket surfaces.

f. Use bushing mandrel, P/N ST-1158, and push bushings (24, 28) from pump body (31), cover (23) and gears (25, 27 and 34).

g. Use bushing mandrel, P/N ST-1158, to push new bushings (24, 28) into body (31), cover (23) or gears (25, 27 and 34). Bushings must be even with or 0.020 inch (0.51 mm) below surface of body (31), cover (23) or gears (25, 27 and 34).

h. Use lubricating oil pump boring tool to cut the bore in the new bushings in the pump body (31).

i. Cut the bore in new bushings:

(1) Install the guide bushing (1, Figure 3-49) into the gear pocket. Tighten the capscrew (2) against the side of the gear pocket to hold the guide bushing in position.

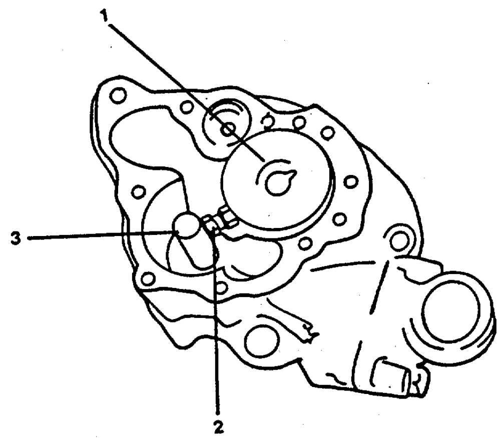


FIGURE 3-49. Install the Guide Bushing into the Gear Pocket.

(2) Install the dial indicator (3) into the setting block. Put the setting block on the setting standard with the indicator tip on the diameter size of the bore to be cut. See Table 3-5. Adjust the dial indicator.

Table 3-5. Shaft and Bushing Measurements

	Worn Limit	New Minimum	New Maximum
Bushing Inside Diameter	0.6185 in (15.710 mm)	0.6165 in (15.659 mm)	0.6175 in (15.684 mm)
Idler and Drive Shaft Outside Diameter	0.6145 in (15.608 mm)	0.615 in (15.62 mm)	0.6155 in (15.634 mm)

(3) Install the tool bit into the boring bar. Do not completely tighten the setscrew. Install the tool bit adjusting knob into the boring bar. Hold the setting block and indicator against the boring bar so the indicator tip will be over the tool bit. Turn the adjusting knob clockwise to push the tool bit against the indicator tip. Adjust the tool bit until the indicator has the same reading as when adjusted on the setting standard. After the tool bit is correctly adjusted, tighten the setscrew and remove the adjusting knob.

(4) Install the boring tool (1, Figure 3-50) into the guide bushing. The tool bit must go through the slot in the guide bushing. Do not hit the tool bit against the bushing.

(5) Adjust the travel of the boring bar so the tool bit will go through the guide bushing but not touch the bushing in the pump body.

(6) Fasten the boring tool to the pump body with capscrews (2). Rotate the shaft to make sure it will turn freely.

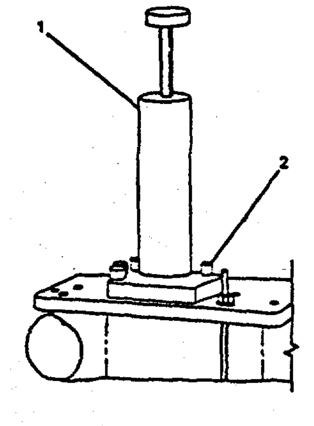


FIGURE 3-50. Install the Boring Tool.

(7) Move the feed control lever to the "on" position. This will prevent the drive shaft from moving down. Put the pump and boring tool in a vertical position. Make sure the boring tool can cut completely through the bushing.

(8) Install the drive adapter into a heavy duty 3/8 inch electric drill. Engage the adapter with the drive shaft of the boring tool.

(9) Start the drill and cut the bore in the bushings. Make sure you cut the bore in both bushings. Do not push down on the drill. The feed mechanism in the boring tool will move the boring bar.

(10) Stop the drill. Move the feed control lever to the "off" position. Pull up on the drive shaft to remove the tool bit from the bore.

(11) Remove the boring tool from the pump body. Make sure the tool bit moves through the slot in the guide bushing. Do not hit the tool bit against the guide bushing.

(12) Remove the guide bushing. Clean the metal particles from the pump body.

(13) Measure the bore in the bushings.

j. Cut the bore in the bushings that are in the cover.

(1) Repeat step i. (1) through (3) for the bushings in the body.

(2) Install the pump cover to the body.

(3) Put the pump on a workbench with the cover down.

(4) Install the boring tool to the pump body. Use the long capscrews and nuts to fasten the tool to the body.

(5) Install the boring bar through the guide bushing. Do not damage the tool bit.

(6) With the feed control lever in the "off" position, move the drive shaft down until the tool bit touches the bushing in the cover.

(7) Hold a new bushing and a 1/16 inch (1.59 mm) feeler gauge against the drive shaft, at the top of the boring tool body. Move the stop collar down against the feeler gauge. Tighten the set screw in the stop collar. Move the feed lever to the "on" position and remove the feeler gauge and bushing.

(8) Start the drill and cut the bore in the bushing.

(9) Stop the drill when the stop collar on the drive shaft is against the body of the boring tool.

(10) Move the feed control lever to the "off" position.

(11) Pull the drive shaft up to remove the tool bit from the bushing. Move the lever to the "on" position.

(12) Remove the boring tool from the pump body. Do not damage the tool bit.

(13) Remove the cover from the body.

(14) Remove the guide bushing. Clean all metal particles from the body and cover.

(15) Measure the inside diameter of the bushing.

ASSEMBLY (Refer to Figure 3-47).

a. Apply a coat of lubricating oil to the large outside diameter of the idler shaft (26).

b. Install the large outside diameter of the shaft (26), from the gear pocket side of the body (31), into the bore in the pump body.

c. Use gear and spacer mandrel and an arbor press to push the shaft (26) into the bore.

d. Apply a coat of lubricating oil to the inside diameter of the driven gear (27). Install the gear (27) onto the drive shaft (30). Use an arbor press to push the gear (27) onto the shaft (30). See Table 3-6 and Figure 3-51 to find the correct amount of protrusion the drive shaft must have after the gear is installed.

e. Install the drive shaft (30) from the gear pocket side of the pump body, into the bore in the pump body (31). Apply a coat of lubricating oil to the inside diameter of the drive gear(s) (34). Put the gear (34) on the shaft (30) on the side of the body opposite to the gear pockets; use an arbor press to push the gear (34) onto the shaft (30). There must not be more than 0.012 inch (0.030 mm) clearance between the gear (34) and the body (31).

f. Apply lubricating oil to the inside diameter of the idler gear (25). Install the idler gear onto the idler shaft (26).

Table 3-6. Oil Pump Shaft Limits - Inch (mm)

	Minimum	Maximum
Oil Pump Drive Shaft Protrusion 1	0.855 (21.72)	0.875 (22.22)
Idler Shaft	0.720 (18.29)	0.740 (18.80)
Protrusion 2	0.0002 (0.05)	0.0005 (0.13)

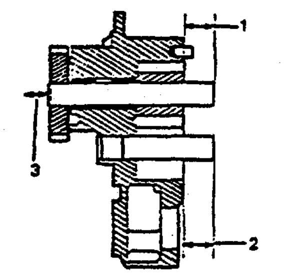


FIGURE 3-51. Limits.

g. Apply clean lubricating oil to the gears, bushings, and shafts.

h. Install plunger (6), spring (5), plug (4), cap (3), washer (2), and capscrew (1) into the pump body (31). Tighten the capscrew (1) to 30 to 35 ft-lb (41 to 47 N.m) torque.

i. Install the cover (16) with capscrew (17) and gasket (15) to the pump cover (14). Install cover (14) with capscrews (21). Hit the cover lightly with a rubber hammer to push the cover onto the dowels. Install the capscrews (17) and lockwashers so that the cover is held to the body. Tighten the capscrews to 30- 35 ft-lb (41 to 47 N•m) torque. Turn the gears to make sure they move freely in the pump.

REPLACEMENT

a. Install new gasket (32, Figure 3-51) onto the mounting flange of the oil pump,

b. Position the pump onto the mounting hole in the, cylinder block. Make sure that the gear teeth of the pump align with the camshaft gear teeth.

c. Install the capscrews (19, 20) and lockwashers (18) to fasten the pump to the cylinder block. Tighten the capscrews to 35 to 45 ft-lb (47 to 61 N•m) torque.

d. Connect the oil inlet and outlet lines to the pump.

e. Connect battery banks (starboard), operate air system (port), refer to TM 55-1905-223-10.

f. Operate the engine until it reaches a temperature of 180°F (80°C) and check for leaks and for proper oil pressure at operating temperature.

3-23. Replace Camshaft and Gear Group.

This task covers:
a. Removal **b. Replacement**

INITIAL SETUP

Tools

Tool kit, mechanic's, general
5180-00-629-9783
Installation pilots P/N 3375268
Dial indicator, 5210-00-277-8840

Materials/Parts

Lubriplate, Item 28, Appendix C
Rubber bands, Item 29, Appendix C
Camshaft P/N 3049024
Lubricating oil, Item 2, Appendix C

Equipment Condition

Engine shut down and cooled to below 120°F (50°C).
Air supply secured (port).
Battery banks disconnected (starboard).
Crankshaft pulley and vibration dampener removed (paragraph 3-26).
Accessory drive pulley removed (paragraph 3-19).
Gear cover removed (paragraph 3-20).
Cam follower housing removed (paragraph 3-18).

REMOVAL

a. Install four camshaft pilots over the outer base circle of the valve lobes between the camshaft journals (Figure 3-52).

b. Use a rubber band to hold the installation pilots in place. The rubber band must straddle the valve lobe (Figure 3-52).

c. Use one hand to slowly rotate and pull the camshaft from the cylinder block and the other hand to balance the camshaft as it is removed.

d. Remove the camshaft thrust bearing (2, Figure 3-53) from the camshaft (6).

NOTE

Measure the camshaft thrust bearing. If worn thinner than 0.083 inch (2.11 mm) notify your supervisor.

REPLACEMENT

a. Apply a film of Lubriplate 105 or its equivalent to both sides of the camshaft thrust bearing (2, Figure 3-53).

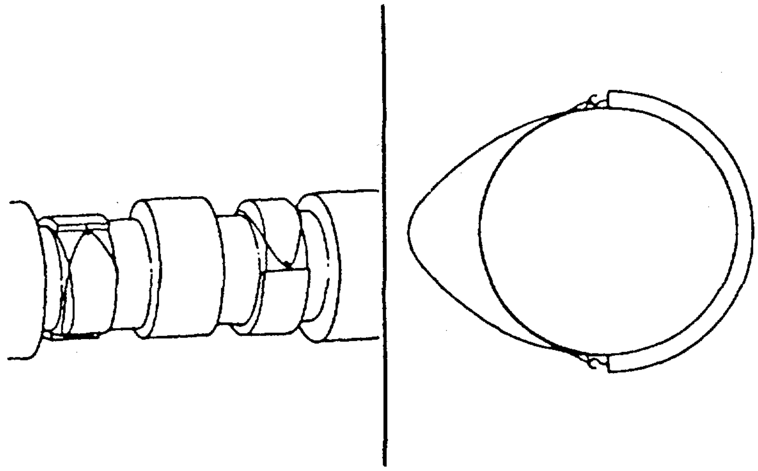


FIGURE 3-52. Camshaft Installation Pilots.

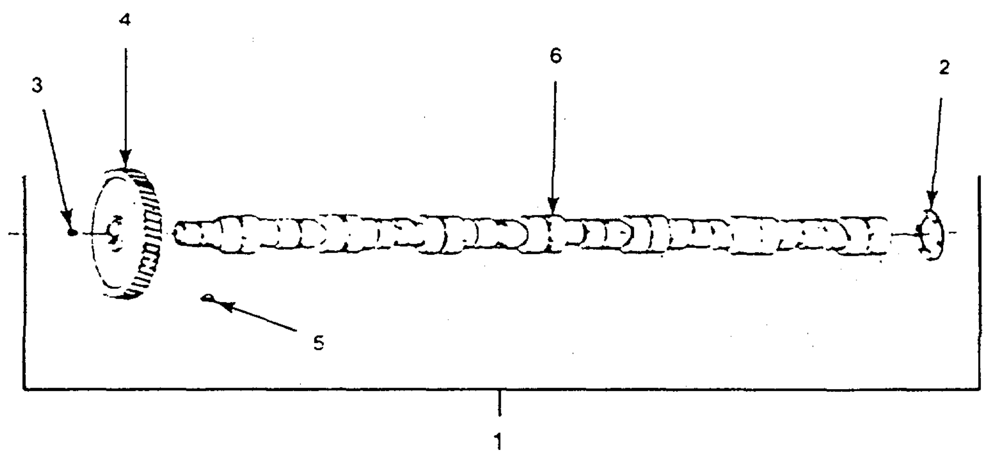


FIGURE 3-53. Camshaft and Gear Group.

CAUTION

The oil grooves on the thrust bearing must be toward the camshaft gear to prevent bearing failure.

b. Install the thrust bearing on the camshaft.

c. Install four camshaft pilots over the outer base circle of the valve lobes between the camshaft journals (Figure 3-52).

d. Use a rubber band to. hold the installation pilots in place. The rubber band must straddle the valve lobes (Figure 3-52).

e. Apply a film of Lubriplate 105 or its equivalent to the camshaft journals and the camshaft bushings in the block.

f. Rotate the camshaft slowly as it is being installed in the cylinder block.

g. Align the "0" mark on the camshaft gear with the "0" mark on the crankshaft gear (Figure 3-54).

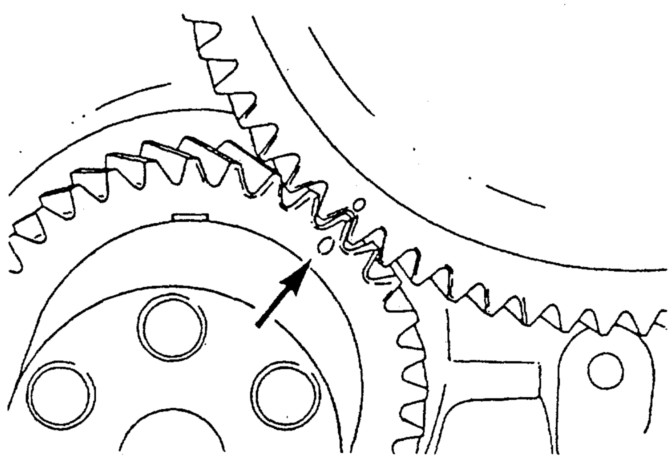


FIGURE 3-54. Gear Alignment.

h. After aligning the "0" marks, push the camshaft in the bore until the thrust bearing fits against the cylinder block.

CAUTION

Do not allow the rubber bands to fall into the camshaft cavity of the cylinder block when removing the installation pilots.

i. Remove the camshaft installation pilots.

j. Use a dial indicator to check the backlash between the camshaft gear and the crankshaft gear.

(1) Put the tip of the dial indicator against a tooth on the camshaft gear (Figure 3-55).

(2) Turn the camshaft gear by hand as far as it will freely move, and set the dial indicator at "0" (zero).

(3) Turn the camshaft gear by hand in the opposite direction as far as it will freely move, and read the dial indicator. Backlash between the camshaft and the crankshaft gears should be between 0.002 inch (0.05 mm) and 0.20 inch (0.50 mm).

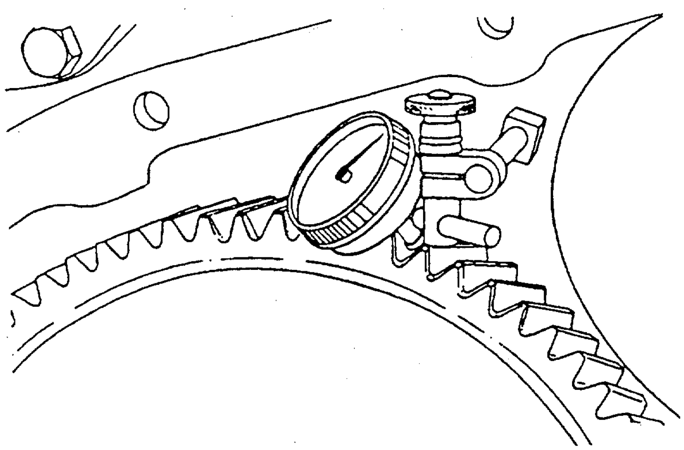


FIGURE 3-55. Camshaft Gear Backlash Measurement.

k. Install the gear cover (paragraph 3-20).

l. Lubricate the valve and the injector lobes with engine lubricating oil, and install the cam follower housing (paragraph 3-18).

m. Install the crankshaft pulley and the vibration dampener assembly (paragraph 3-26).

n. Install the accessory drive pulley (paragraph 3-19).

o. Connect battery banks (starboard), operate air system (port), refer to TM 55-1905-223-10.

p. Operate the engine until it reaches a temperature of 180°F (80°C), and check for coolant or lubricating oil leaks.

3-24. Replace Connecting Rod and Piston Group.

This task covers:

a. Removal **b. Replacement**

INITIAL SETUP

Tools

Tool kit, general mechanic's
rail and marine diesel engines,
5180-00-629-9783
Connecting rod guide pins
P/N 3375601
Piston ring compressor
P/N 3822736

Materials/Parts

Lubriplate, Item 28, Appendix C
Lubricating oil, Item 2, Appendix C,
Piston connecting rod P/N 3013930
Piston P/N 3801876

Equipment Condition

Engine cooled below 120°F (50°C).
Air supply secured (port).
Battery banks disconnected (starboard).
TM 55-1905-223-10.
Oil pan removed (paragraph 3-21).
Cylinder heads removed (paragraph
2-43).

REMOVAL

a. Rotate the crankshaft to position two of the connecting rods at Bottom Dead Center (BDC) (Figure 3-56).

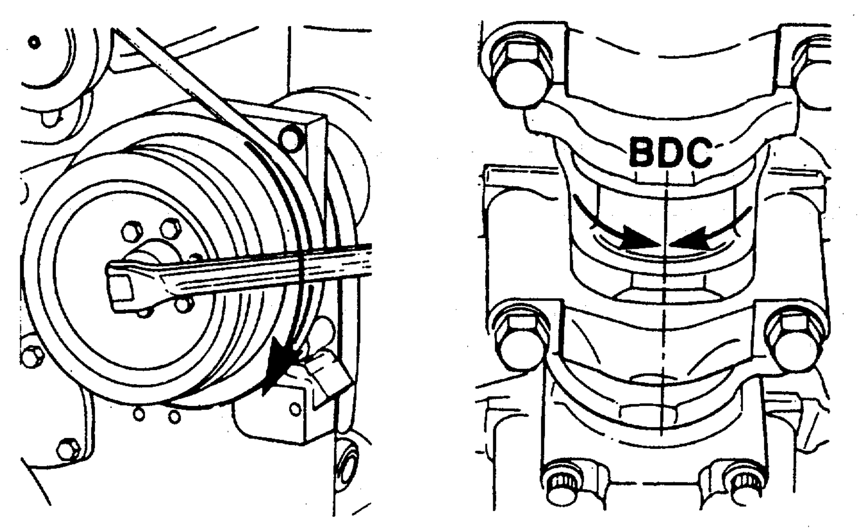


FIGURE 3-56. Rotating Crankshaft.

b. Loosen the connecting rod machine bolts (5, Figure 3-57).

NOTE

Do not remove the machine bolts from the rods.

c. Use a rubber hammer to hit the connecting rod bolts (5, Figure 3-57) to loosen the cap (6) from the piston pin (4) in the connecting rod (1).

d. Ensure connecting rod and the cap have matching numbers stamped on them and that they are in the correct cylinder location.

e. Remove the connecting rod bolts (5).

f. Remove the lower rod cap (6) and lower rod bearings (3). Mark the cylinder number and the letter "L" in the flat surface of the bearing tang.

g. Remove the upper rod bearings (2). Mark the cylinder number and the letter "U" in the flat surface of the bearing tang.

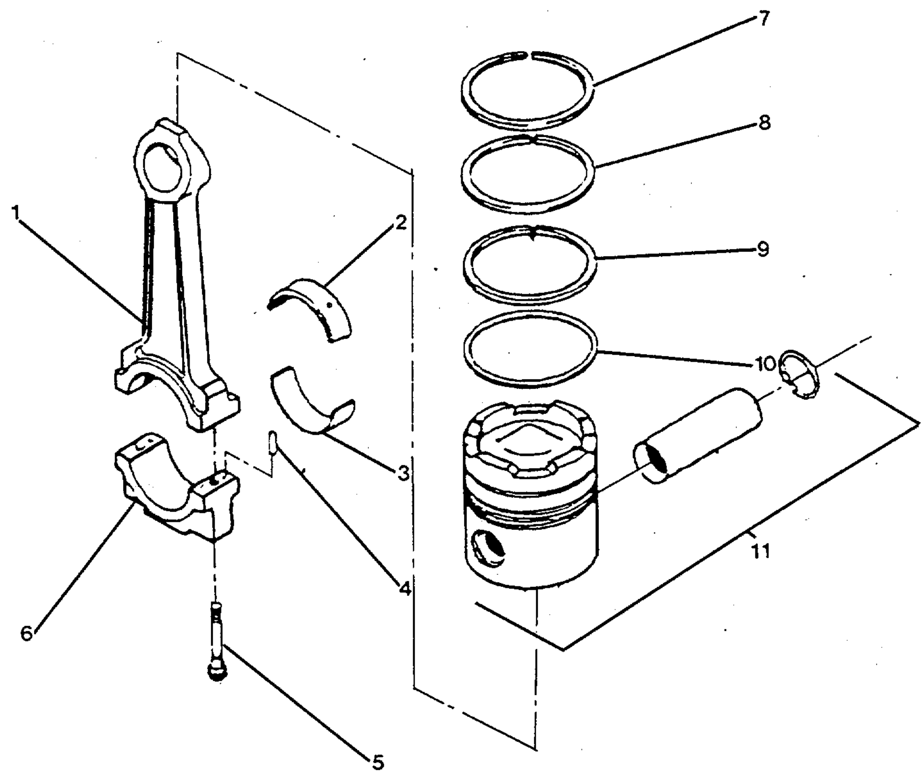


FIGURE 3-57. <u>Connecting Rod and Piston Group</u>.

h. Install two connecting rod guide pins in the bolt holes.

i. Push the rod away from the crankshaft.

NOTE

Push the rod until the piston rings are outside of the top of the cylinder liner.

j. Remove the piston and rod group (11).

NOTE

- For further information on the piston rings, refer to general support level maintenance (para. 4-14) for corrective action.
- To prevent increased wear, the piston and connecting rod assemblies must be installed in the same cylinder number from which they were removed. If the piston was not previously marked, mark the cylinder number on the top of each piston on the camshaft side as the assembly is removed.
- The pistons must have the cylinder numbers stamped on the piston top toward the camshaft side of the engine.

k. Place the rod and piston assemblies in a container of engine oil to protect them from damage.

NOTE

The cylinder number is stamped on the rod and the cap. When the rods and the caps are installed in the engine, the numbers on the rods and the caps must match and be installed on the same side of the engine.

REPLACEMENT

a. Install the upper bearing shell (2, Figure 3-57) in the connecting rod (1). If used bearing shells are to be installed, each bearing shell must be installed in its original location.

NOTE

The tang of the bearing shell must be in the slot of the rod. Make sure the oil hole in the shell is aligned with the oil hole in the connecting rod.

b. Use clean Lubriplate or its equivalent to lubricate the bearing shell.

c. Apply a heavy film of clean engine oil to the cylinder liner.

d. Put the piston and the ring assembly in a container of clean engine oil.

e. Remove the piston and the ring assembly from the container of engine oil. Allow the excess oil to drain from the piston.

NOTE

The ring gap of each ring must not be aligned with the piston pin or with any other ring.

f. Position the ring gaps as shown in Figure 3-58 .

(1) (Top) Ring - A

(2) Second Ring - B

(3) Third Ring - C

(4) (Bottom) Oil Ring - D

(5) Piston Pin - E

g. Install the connecting rod guide pins (Figure 3-59).

h. Use piston ring compressor to compress the rings (Figure 3-59).

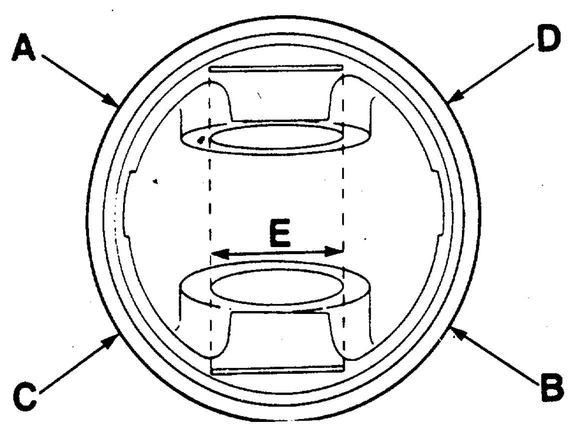


FIGURE 3-58. Ring Gap Positions.

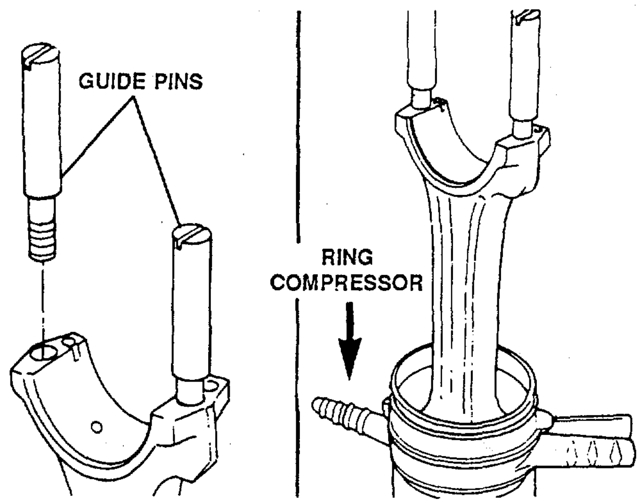


FIGURE 3-59. Guide Pins and Ring Compressor.

NOTE

Use the accessory drive pulley to rotate the crankshaft.

i. Rotate the crankshaft to position the journal for the connecting rod Bottom Dead Center (BDC).

CAUTION

- To avoid piston damage, do not use a metal object to push the piston in the liner.
- Do not use a hammer or equivalent to install the piston in the cylinder liner. The piston rings can be damaged.

NOTE

The tang of the connecting rod must be toward the camshaft side of the cylinder block.

j. Install the connecting rod in the cylinder liner, and push the piston down. If the piston does not move freely, remove the piston. Inspect for broken or damaged rings (7 through 10, Figure 3-57). Replace damaged rings.

k. Use the guide pins to pull the connecting rod against the crankshaft.

l. Remove the guide pins.

CAUTION

The rod cap number must match the number on the connecting rod and must be installed with the numbers aligned to prevent damage to the connecting rods and the crankshaft. The slot in the cap and the rod must be toward the camshaft side of the cylinder block.

NOTE

The tang of the bearing must be in the slot of the cap. The connecting rod caps and shells do not have oil holes.

m. Install the lower rod bearing (3) in the connecting rod cap (6).

n. Lubricate the bearing shell with Lubriplate or equivalent. Lubricate the connecting rod bolt threads and the washer face with engine lubricating oil.

CAUTION

The connecting rod cap and rod numbers must match (Figure 3-60).

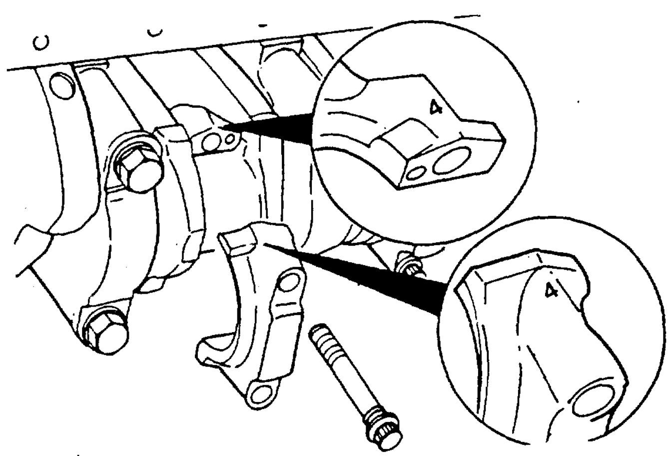


FIGURE 3-60. Matching Caps and Rods.

o. Install the lower connecting rod caps (6, Figure 3-57) and bolts (5) to connecting rod (1).

p. Tighten the rod bolts in alternating sequence to the following values:

NOTE

All bolts are tightened to the specification in item (1); then item (2).

(1) Tighten to 75 ft-lb (100 N•m) torque.

(2) Tighten to 170 ft-lb (230 N•m) torque.

q. Measure the connecting rod side clearance. The side clearance must be between 0.0045 inch (0.114 mm) and 0.13 inch (3.30 mm).

NOTE

The connecting rod must move freely from side to side on the crankshaft journal. If the rod does not move freely, remove the rod cap and ensure the bearing shells are the correct size. Check for dirt or damage on the crankshaft and the bearing shells.

r. Install the oil pan (paragraph 3-21).

s. Install the cylinder heads (paragraph 2-43).

CAUTION

The lubricating oil system must be primed before operating the engine after any internal engine repairs to avoid internal component damage. Do not prime the system from the bypass filter; the filter will be damaged.

t. Remove the pipe plug from the lubricating oil pump cover.

u. Install the priming pump oil supply hose. Use clean engine lubricating oil out of a bucket or a container. Supply oil to the crossover oil passage.

v. Allow the oil to flow until the oil pressure gauge indicates a maximum pressure of 30 psi (210 kPa) to prime the lubricating oil system. Remove the priming pump hose and replace the pipe plug.

w. Fill the oil pan (PMCS Table 2-1, Item 12).

x. Connect battery banks (starboard), operate air system (port), refer to TM 55-1905-223-10.

y. Run the engine until it reaches a temperature of 180°F (80°C) and check for proper oil pressure and leaks.

3-25. Replace/Repair Flywheel and Flywheel Housing Group.

This task covers:

a. Removal **b. Repair** **c. Replacement**

INITIAL SETUP

Tools

Tool kit, general mechanic's
rail and marine diesel engines,
5180-00-629-9783
Torque wrench kit P/N 3377216
Multimeter 6625-01-139-2512
Combination wrench set,
5120-01-046-4979
Lifting fixture P/N 3822512
Lifting sling P/N 3375958
Crack detection kit P/N 3375432
Dial indicator gauge P/N 3376050
Dial indicator attachment
P/N ST-1325
Dowel puller P/N ST-1134
Crankshaft oil seal driver
P/N ST-997

Materials/Parts

Wire brush, Item 42, Appendix C
Lubricating oil, Item 2, Appendix C
Marking chalk, white,
Item 30, Appendix C
Crocus cloth, fine, Item 26, Appendix C
Engine flywheel assembly
P/N 3023510
Rear crankshaft seal P/N 3006737
Gaskets P/N 3021735 and P/N 40662-A
T-handle studs
Metal cleaning solvent,
Item 6, Appendix C
Flywheel mounting guide studs, Item 49,
Appendix C

Equipment Condition

Engine shut down and cooled below 120°F
(50°C) TM 55-1905-223-10.
Air supply secured (port).
Battery banks disconnected (starboard).
Generator assembly removed (paragraph
3-13).
Air starter removed, port engine
(paragraph 2-24).
Electric starter removed, starboard
engine (paragraph 2-25).

REMOVAL

a. Remove the flywheel assembly as follows:

NOTE

Hold the flywheel to prevent rotation.

(1) Install two 1/2-13 x 1-1/2 puller capscrews (2, Figure 3-61) which have a minimum of 1-1/4 inch threaded area.

(2) Remove two hexagon capscrews (4) and install two 5/8-18 x 6 inch guide studs (3).

(3) Determine capscrew thread size and install two T-handles (1) in the flywheel.

(4) Remove the remaining four flywheel capscrews (11, Figure 3-62) and flatwashers (10).

(5) Tighten the puller capscrews (2, Figure 3-61) in alternating sequenceto loosen the flywheel.

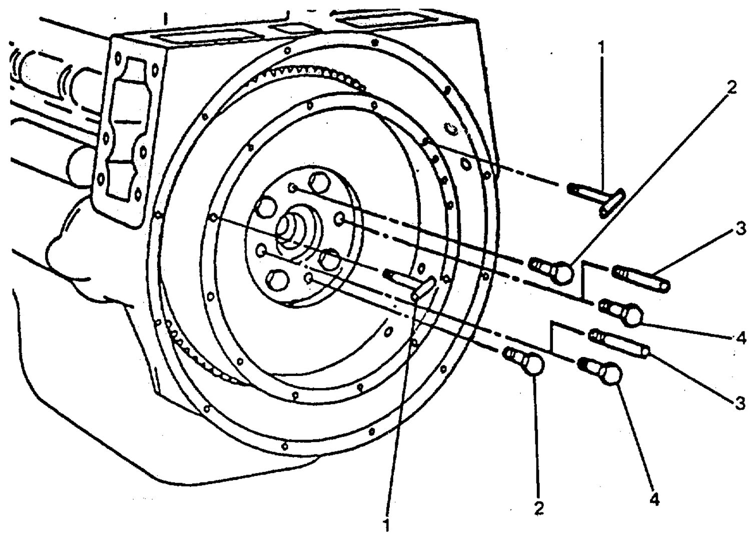


FIGURE 3-61. Guide Studs and T-Handles.

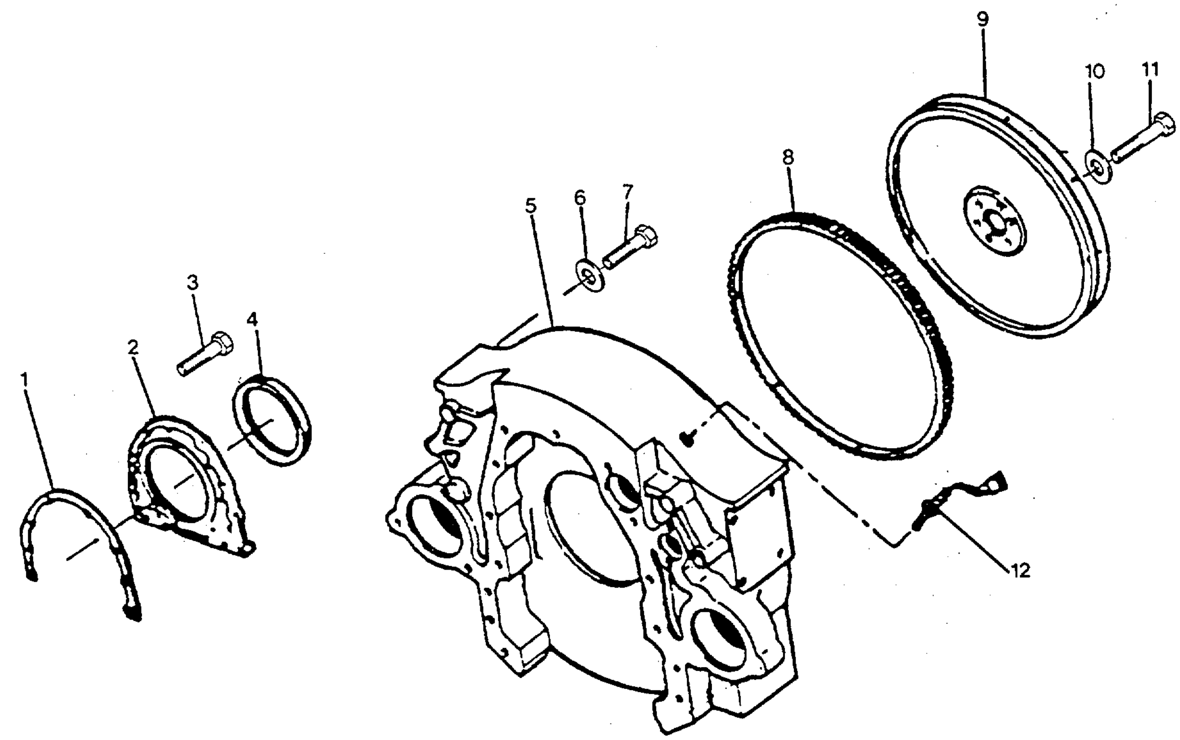


FIGURE 3-62. Flywheel and Flywheel Housing Group.

WARNING

Because the flywheel weighs more than 50 lb (23 kg), two soldiers or a hoist will be required to lift the flywheel to avoid personal injury.

(6) Remove the flywheel (9, Figure 3-62). Spur gear (8) will remain on the flywheel.

b. Remove the flywheel housing (5) as follows:

(1) Before removing the housing, unplug the electrical connection of the magnetic pickup (12), loosen the locknut and unscrew the magnetic pickup (12) from the housing (5).

(2) Loosen the oil pan mounting capscrews four to five turns.

(3) Remove the four oil pan mounting capscrews (1, Figure 3-64) that secure the oil pan to the rear cover.

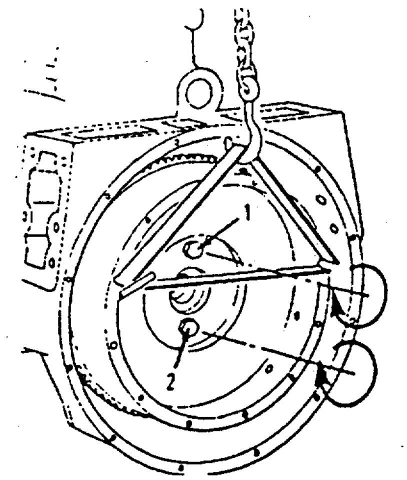


FIGURE 3-63. Removing Flywheel.

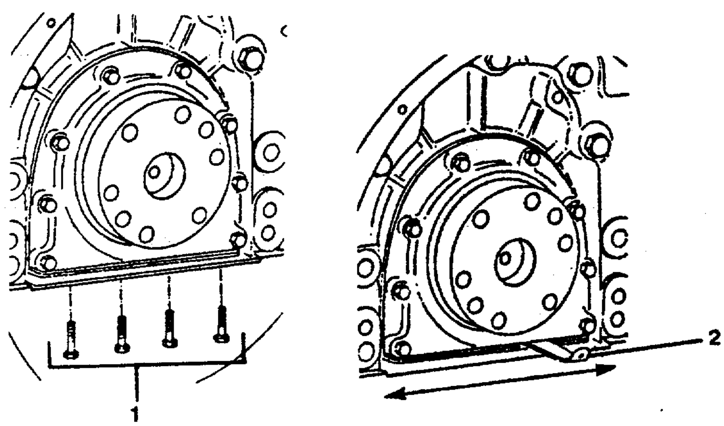


FIGURE 3-64. Rear Cover.

CAUTION

Use extreme care when releasing the oil pan gasket from the rear cover to prevent damage to the gasket. If the gasket is damaged, the oil pan must be removed and the gasket replaced (paragraph 3-21).

(4) Insert a feeler gauge (2, Figure 3-64) between the rear cover and theoil pan gasket. Move the feeler gauge or the shim stock back and forth to release the gasket from the rear cover.

(5) Remove the capscrews from the rear cover, and remove the cover from the crankshaft flange (Figure 3-65).

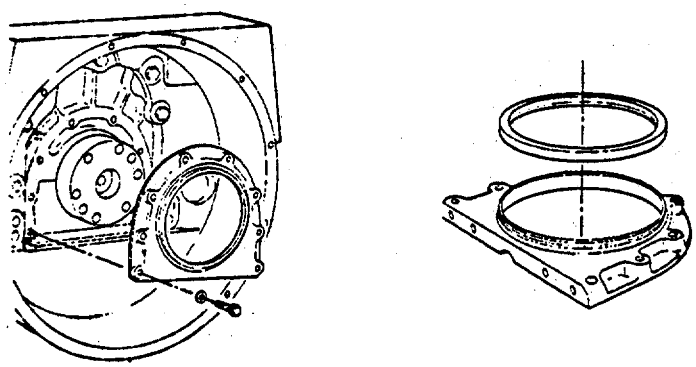


FIGURE 3-65. Crankshaft Flange Cover.

(6) Remove the crankshaft seal from the rear cover (Figure 3-65).

(7) Use the lifting fixture to support the rear of the engine.

(8) Remove the capscrews (1, Figure 3-66) and both rear engine mounts (2).

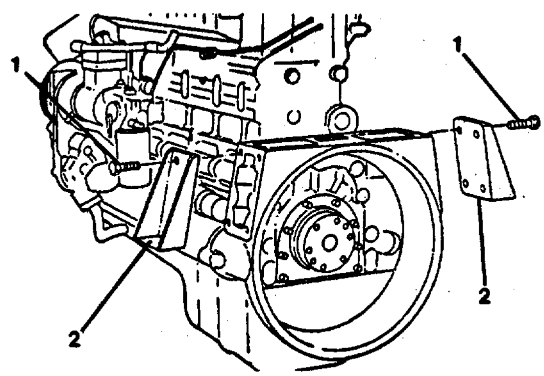


FIGURE 3-66. Removing Mounts.

(9) Remove capscrews (1, Figure 3-67) and install two 5/8-18 x 4 inch guide studs (2).

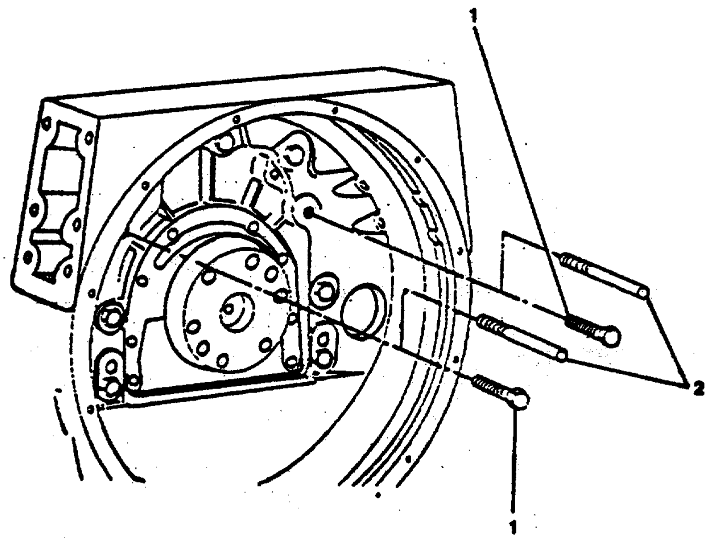


FIGURE 3-67. Flywheel Housing Guide Studs.

(10) Remove the remaining capscrews.

(11) Use a rubber hammer to loosen the housing from the dowels in the cylinder block.

(12) Remove the flywheel housing.

REPAIR

a. Clean and inspect the flywheel as follows:

(1) Use a wire brush to clean the crankshaft pilot bore.

(2) Clean the flywheel with solvent, and dry with compressed air.

(3) Visually inspect for nicks or burrs.

(4) Use a fine crocus cloth to remove small nicks and burrs.

WARNING

Do not use a cracked or resurfaced flywheel. It can break, causing serious personal injury or property damage.

(5) Use crack detection kit to check for cracks in the flywheel. Follow the instructions provided with the kit.

(6) If cracks are found, replace flywheel assembly.

(7) Inspect the flywheel ring gear teeth for cracks and chips.

NOTE

If the ring gear teeth are cracked or broken, the flywheel assembly must be replaced.

b. Clean and inspect flywheel housing as follows:

(1) Use solvent to clean the housing.

(2) Dry with compressed air.

(3) Visually inspect all surfaces for nicks, burrs, or cracks.

(4) Use a fine crocus cloth to remove small nicks and burrs.

(5) Inspect all threaded capscrew holes for damage.

(6) Replace the housing if threads or housing are damaged.

REPLACEMENT

a. Install the flywheel housing (5, Figure 3-62).

CAUTION

If a new flywheel housing is being installed, the dowels must be removed from the cylinder block prior to installing the housing to prevent damage to the housing. The housing must be doweled with an oversize dowel after it has been aligned. Refer to paragraph 4-15.

(1) Install two 5/8-18 x 4 inch guide studs (Figure 3-68) in the cylinder block to help support and align the housing during installation.

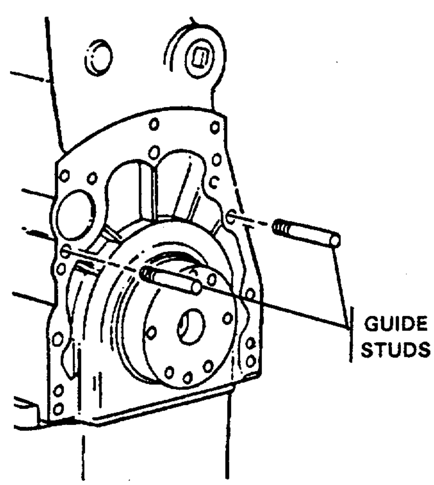


FIGURE 3-68. Housing Alignment Guide Studs.

(2) Install the flywheel housing over the guide studs.

(3) Install the capscrews, and tighten to 150 ft-lb (205 N•m) torque in the sequence shown in Figure 3-69 .

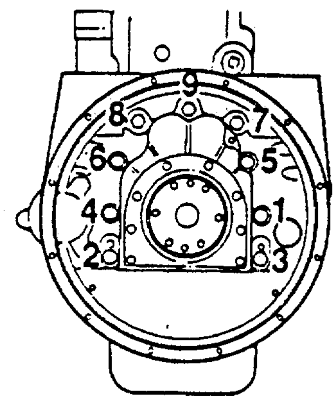


FIGURE 3-69. Flywheel Housing Torque Sequence.

(4) Measure the flywheel housing bore alignment as follows:

CAUTION

The flywheel housing bore and the surface must be in alignment with the crankshaft to prevent possible damage to the engine or generator.

(a) Use chalk to mark the housing at the 12 o'clock, 3 o'clock, 6 o'clock, and 9 o'clock positions.

(b) Use dial indicator gauge and the dial gauge attachment to measure the bore alignment. Attach the dial indicator to the crankshaft as shown in Figure 3-70 .

NOTE

The indicator arm must be rigid for an accurate reading. It must not sag.

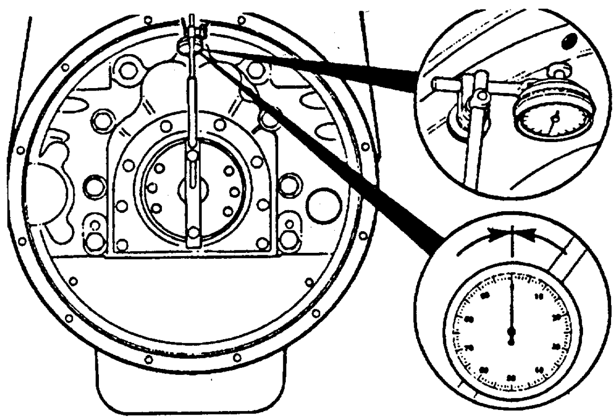


FIGURE 3-70. Measure Bore Alignment.

(c) Put the indicator at the 12 o'clock position. Adjust the dial indicator until the needle points to "0" (zero).

(d) Use the accessory drive shaft to rotate the crankshaft in a clockwise direction (Figure 3-71) .

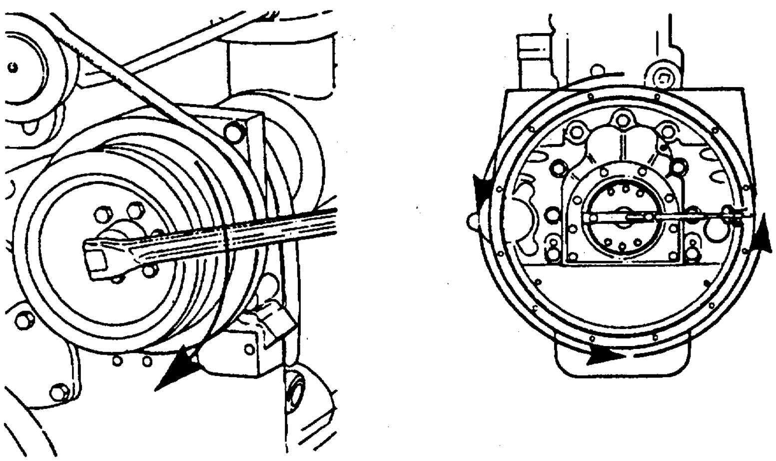


FIGURE 3-71. Rotating Crankshaft.

(e) Record the indicator reading at three different points: 3 o'clock, 6 o'clock, and 9 o'clock.

(f) Continue rotating the crankshaft until the dial indicator is at the 12 o'clock position.

(g) Check the dial indicator to ensure the needle still points to "0" (zero).

NOTE

If the dial indicator is not pointing to "0" (zero), check the tightness of the indicator arm and repeat steps (a) through (g) above.

(h) Determine the Total Indicator Reading (TIR) as follows:

	mm	in
Example:		
12 o'clock	(0.00)	0.00
3 o'clock	(+ 0.08)	+ 0.003
6 o'clock	(- 0.05)	- 0.002
9 o'clock	(+ 0.08)	+ 0.003
Equals TIR	(0.13)	0.005

(i) The maximum allowable TIR depends on the diameter of the housing bore (Figure 3-72).

(j) Refer to Table 3-7 for allowable TIR.

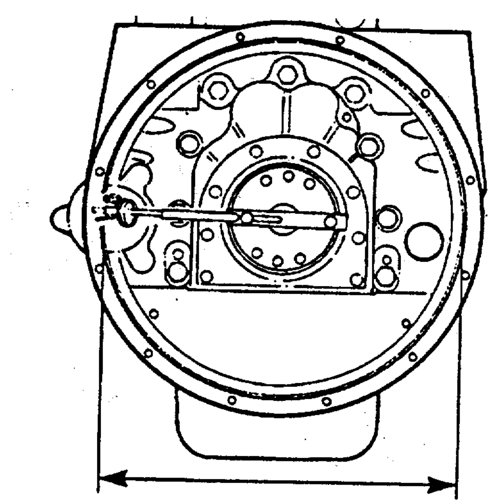


FIGURE 3-72. Housing Bore Diameter

Table 3-7. Allowable Total Indicator Reading (TIR) Flywheel Housing Bore and Face

SAE No.	Bore Diameter (mm)	Bore Diameter in	Bore Location Tolerance (mm)	Bore Location Tolerance in
00	(787.40 to 787.64)	31.000 to 31.010	(0.30)	0.012 TIR
0	(647.70 to 647.95)	25.500 to 25.510	(0.25)	0.010 TIR
1/2	(584.00 to 584.20)	23.000 to 23.008	(0.25)	0.010 TIR
1	(534.27 to 534.40)	20.125 to 20.130	(0.20)	0.008 TIR
2	(447.68 to 447.80)	17.625 to 17.630	(0.20)	0.008 TIR
3	(409.58 to 409.70)	16.125 to 16.130	(0.20)	0.008 TIR

(k) If the bore alignment does not meet the specification, loosen the housing capscrews. Tighten the capscrews again, and measure the bore alignment again.

(l) If the alignment is not within specifications and the bore is round, the housing can be shifted. Refer to paragraph 4-15.

(m) If the alignment is not within specifications and the bore is not round, the housing must be replaced.

(5) Measure the flywheel housing face alignment as follows:

(a) Install the dial indicator as shown in Figure 3-73 .

CAUTION

The tip of the gauge must not enter the capscrew holes or the gauge will be damaged.

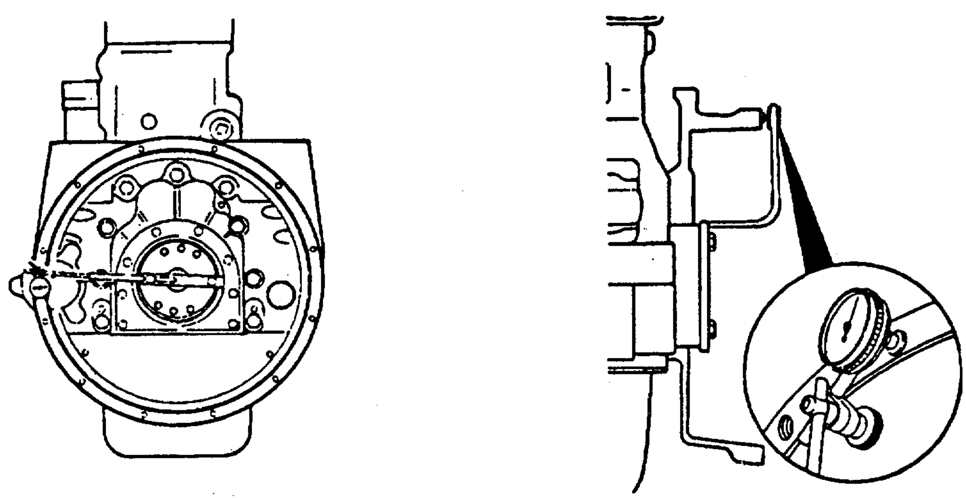


FIGURE 3-73. Dial Indicator.

(b) Put the tip of the dial indicator gauge against the flywheel housing surface.

(c) Use the accessory drive to rotate the crankshaft until the dial indicator is at the 12 o'clock position.

(d) Push the crankshaft toward the front of the engine. Adjust the dial on the indicator until the needle points to "0" (zero).

NOTE

The crankshaft must be pushed toward the front of the engine to remove the crankshaft end clearance each time a point is measured.

(e) Use the accessory drive to rotate the crankshaft in the clockwise direction.

(f) Record the indicator reading at three different points: 3 o'clock, 6 o'clock, and 9 o'clock.

(g) Continue rotating the crankshaft until the dial indicator is at the 12 o'clock position.

(h) Check the dial indicator to ensure the needle still points to "0" (zero).

(i) Determine the Total Indicator Reading (TIR) as follows:

	mm	in
Example:		
12 o'clock	(0.00)	0.00
3 o'clock	(+ 0.08)	+ 0.003
6 o'clock	(- 0.05)	- 0.002
9 o'clock	(+ 0.08)	+ 0.003
Equals TIR	(0.11)	0.004

(j) The maximum allowable TIR depends on the diameter of the housing bore. Refer to Table 3-7.

(k) If the alignment is not within specifications, remove the housing. Check for nicks, burrs, or foreign material between the block and the housing.

(l) Check the alignment again. If the alignment is not within specifications, the block or the housing is not machined correctly.

(6) Install the two rear engine mounts (see Figure 3-66). Tighten the capscrews to 158 ft-lb (214 N•m) torque.

(7) Remove the lifting fixture used to support the engine.

b. Install crankshaft seal (4, Figure 3-62), rear cover gasket (1) and rear cover (2).

(1) Clean the gasket surface of the cylinder block and the rear cover (2).

(2) Use a crocus cloth to remove any rust or other deposits from the crankshaft flange.

(3) Use a clean cloth to clean the crankshaft flange.

(4) Install a new gasket (1) on the cylinder block.

(5) Install the rear cover (2) and the capscrews (3). Tighten the capscrews just enough to hold the rear cover in position.

(6) Remove the pins from the crankshaft oil seal driver, and use the driver to align the rear cover with the crankshaft (Figure 3-74).

(7) Install the seal driver on the crankshaft flange and in the bore of the rear cover (Figure 3-74).

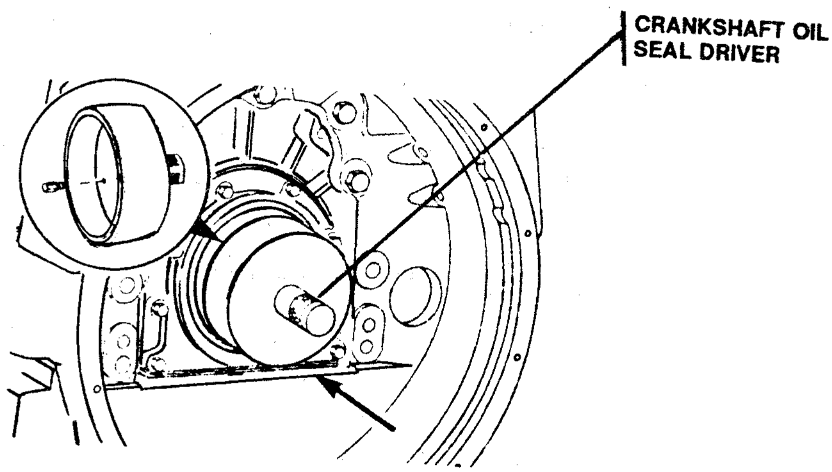


FIGURE 3-74. Seal Driver.

(8) Tighten the rear cover capscrews to 35 ft-lb (45 N•m) torque, and remove the crankshaft oil seal driver (Figure 3-75).

(9) Use a feeler gauge to ensure the rear cover is within 0.004 inch (0.10 mm) of being parallel with the oil pan flange of the cylinder block (Figure 3-75).

(10) Trim the excess gasket material from the ends of the rear cover gasket (1, Figure 3-62) so the gasket is even or does not extend more than 0.010 inch (0.25 mm) beyond the pan flange.

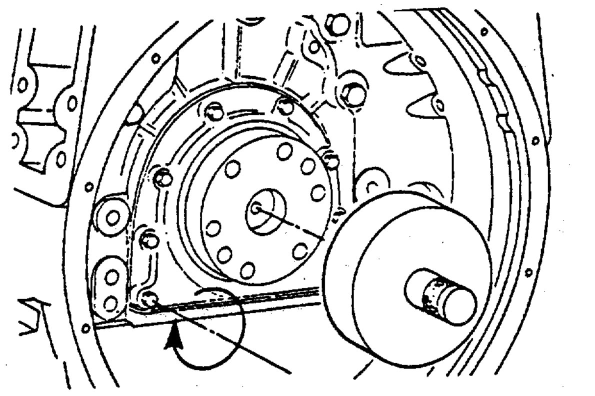


FIGURE 3-75. *Checking Rear Cover and Oil Pan Flange.*

(11) Use the installation sleeve provided with the seal to install the seal on the crankshaft (Figure 3-76).

NOTE

Do not use any lubricant to install the seal. The oil seal must be installed with the lip of the seal and the crankshaft clean and dry.

(12) Push the oil seal over the installation sleeve onto the crankshaft and remove the sleeve (Figure 3-76).

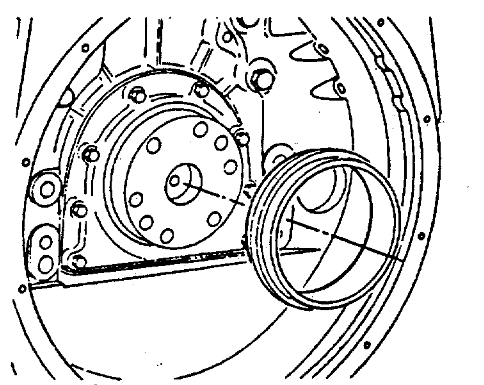


FIGURE 3-76. *Installation Sleeve.*

(13) Install the pins in the crankshaft oil seal drive (Figure 3-77).

(14) Use the crankshaft oil seal driver to install the oil seal in the rear cover (Figure 3-77).

(15) Install the four capscrews that hold the oil pan to the rear cover. See Figure 3-64.

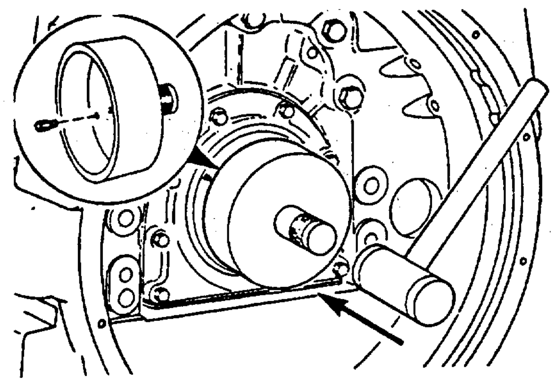


FIGURE 3-77. Installing Seal With Driver.

(16) Tighten one of the 7/16-inch oil pan mounting capscrews on each side of the oil pan, halfway between the front and the rear of the oil pan, to 15 ft-lb (20 N•m) torque.

(17) Tighten the four 5/16-inch capscrews in the rear of the oil pan to 20 ft-lb (25 N•m) torque in the sequence shown in (Figure 3-78).

(18) Tighten the thirty-two (32) 7/16-inch capscrews to 50 ft-lb (70 N•m) torque in the sequence shown in (Figure 3-78).

c. Install the flywheel assembly as follows:

NOTE

The pilot bearing must be installed flush with the pilot bore surface. Refer to paragraph 4-15 for proper installation.

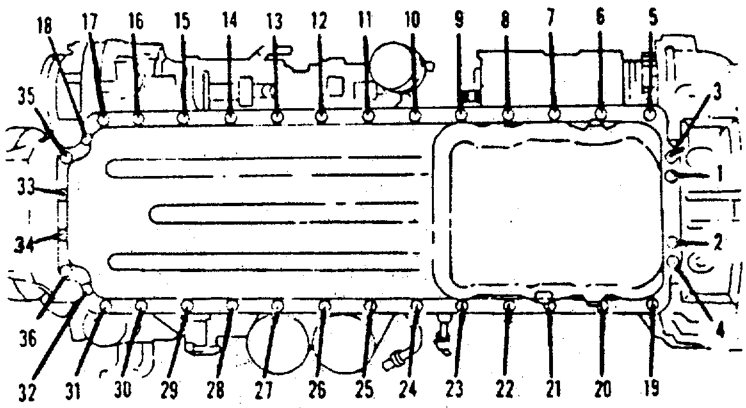


FIGURE 3-78. Oil Pan Torque Sequence.

(1) Install two 5/8-18 x 6 inch guide studs in the crankshaft flange (3, Figure 3-61).

(2) Install two T-handles (1) in the flywheel.

WARNING

Because the flywheel weighs more than 50 lb (23 kg), two soldiers or a hoist will be required to lift the flywheel to avoid personal injury.

(3) Install the flywheel assembly (9, Figure 3-62) on the guide studs.

(4) Lubricate the threads of the capscrews (11) and the surface of the flat washers (10) with lubricating oil.

(5) Install the four capscrews (11) and washers (10).

(6) Remove the T-handles (1, Figure 3-61) and the guide studs (3).

(7) Install the remaining two capscrews in the holes from which the guide studs were removed.

(8) Tighten the capscrews in a star pattern to 200 ft-lb (270 N•m) torque.

d. Measure the flywheel bore runout as follows:

NOTE

Use a dial indicator gauge (Figure 3-79) or its equivalent and a gauge attachment to check the flywheel bore and surface runout.

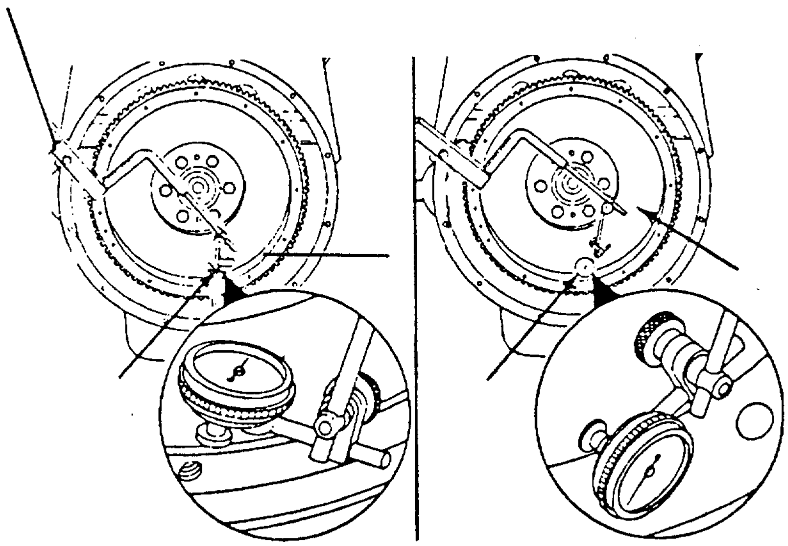


FIGURE 3-79. Measuring Flywheel Runout.

(1) Install the gauge attachment to the flywheel housing.

(2) Install the gauge on the attachment.

(3) Install the contact tip of the indicator against the inside diameter of the flywheel bore, and set the dial indicator at "O" (zero).

(4) Use the accessory drive shaft to rotate the crankshaft one complete revolution.

NOTE

The Total Indicator Reading (TIR) must not exceed 0.0050 inch (0.127 mm).

(5) If the TIR is greater than the specification, perform the following:

(a) Remove the flywheel.

(b) Inspect the flywheel mounting surface for dirt or damage.

(c) Inspect the crankshaft for dirt or damage.

(d) Install the flywheel, and inspect the bore runout again.

(e) Replace the flywheel if the runout does not meet specifications.

e. Measure the flywheel face runout (Figure 3-80) as follows:

(1) Install the contact tip of the indicator against the flywheel face, as close to the outside diameter as possible.

(2) Push the flywheel forward to remove the crankshaft end clearance. Adjust the dial on the indicator until the needle points to "O" (zero).

(3) Use the accessory drive shaft to rotate the crankshaft one complete revolution. Measure the flywheel runout at four equal points on the flywheel.

NOTE

The flywheel must be pushed toward the front of the engine to remove the crankshaft end clearance each time a point is measured.

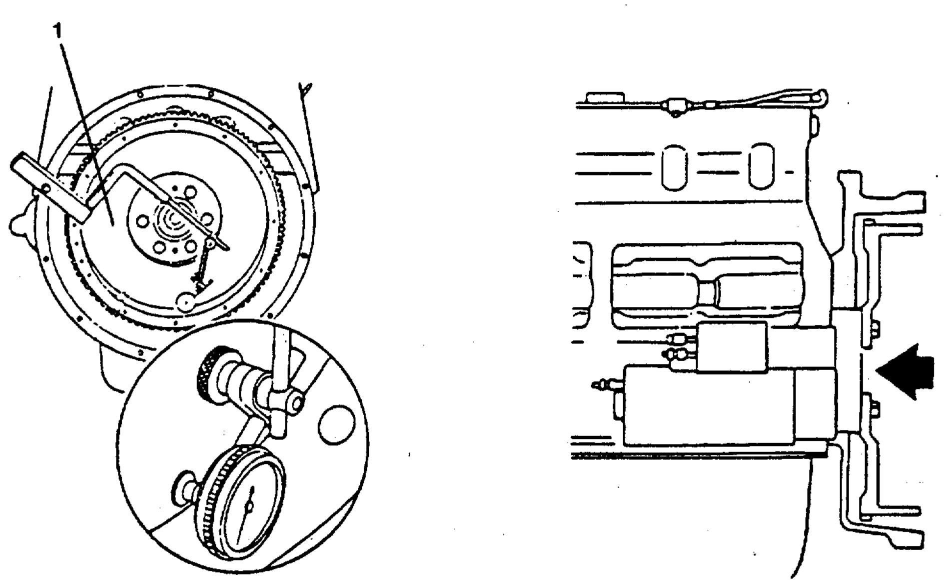


FIGURE 3-80. Checking Flywheel Face

(4) The Total Indicator Reading (TIR) of the flywheel face must not exceed the following specifications:

Flywheel Radius (A)		Maximum TIR of Flywheel Face	
in	mm	in	mm
203	8	0.203	0.008
254	10	0.254	0.010
305	12	0.305	0.012
356	14	0.356	0.014
406	16	0.406	0.016

(5) If the flywheel face runout is not within specifications, remove the flywheel. Check for nicks, burrs, or foreign material between the flywheel mounting surface and the crankshaft flange.

(a) Clean or replace as necessary.

(b) Measure the face runout again.

f. Install the magnetic pickup (12, Figure 3-62) in the flywheel housing as follows:

NOTE

The magnetic pickup hole is perpendicular to the flywheel gear teeth.

(1) Ensure a gear tooth is centered in the pickup hole. If necessary, rotate the flywheel to center a tooth in the hole.

(2) Screw the magnetic pickup all of the way down until it contacts the flywheel gear tooth. The pickup will screw in very easily; do not use excessive pressure to install the pickup.

NOTE

If the pickup does not screw in with finger pressure, check the hole and the pickup threads. Tap the hole if required.

(3) Back the pickup out 1/2 to 3/4 of a turn.

(4) Tighten the locknut down on the flywheel housing.

(5) Plug the electrical connection into the magnetic pickup.

g. Install the starter motor (paragraph 2-24 or 2-25).

h. Fill the engine with lubricating oil (PMCS Table 2-1, Item 12).

i. Install the generator assembly (paragraph 3-12).

j. Connect battery banks (starboard), operate air supply (port), refer to TM 55-1905-223-10.

k. Operate the engine until it reaches a temperature of 180ºF (80ºC) and check for leaks.

l. With the engine running, use a multimeter to check the magnetic pickup voltage at the governor control inside the instrument panel (paragraph 2-26). If voltage is less than 1.5 volts ac, loosen the locknut on the magnetic pickup (12, Figure 3-62) and screw it in clockwise 1/8 to 1/4 turn.

3-26. REPAIR CRANKSHAFT GROUP.

This task covers:

REPAIR

INITIAL SETUP:

Tools

Tool kit, general mechanic's
rail and marine diesel engines,
5180-00-629-9783
Dial indicator gauge P/N 3376050

Materials/Parts

Lubricating oil, Item 2, Appendix C
Fluid pressure dampener P/N 217323
Crankshaft end guide studs, Item 53,
Appendix C

Equipment Condition

Engine cooled below 120° F (50 º C).
Air supply secured (port).
Battery banks disconnected (starboard).
TM 55-1905-223-10.

REPAIR

a. Remove the dampener belt guard.

b. Check the vibration dampener for eccentricity and wobble as follows:

(1) Install the dial indicator on the gear cover as shown in Figure 3-81.

(2) Rotate the crankshaft and record the indicator movement.

(3) Replace the vibration dampener if the eccentricity exceeds 0.0004 inch (0.10 mm) per 1.0 inch (25.4 mm) of the dampener diameter.

(4) Install the dial indicator as shown in Figure 3-82 to measure wobble.

(5) Push the crankshaft to the front or rear.

(6) Rotate the crankshaft 360 degrees, maintaining the position of the crankshaft (either toward the front or the rear) in relation to the block.

(7) Record the total indicator motion.

(8) Replace the dampener if wobble exceeds 0.007 inch (0.18 mm) per 1.0 inch (25.4 mm) of radius.

c. Remove one of the capscrews and recessed washers (1, Figure 3-83) that hold the vibration dampener and the pulley to the crankshaft and install a guide stud (2) in the hole.

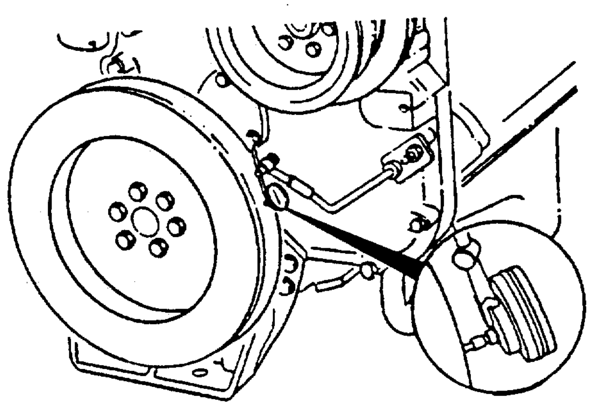


FIGURE 3-81. Measuring Dampener Eccentricity.

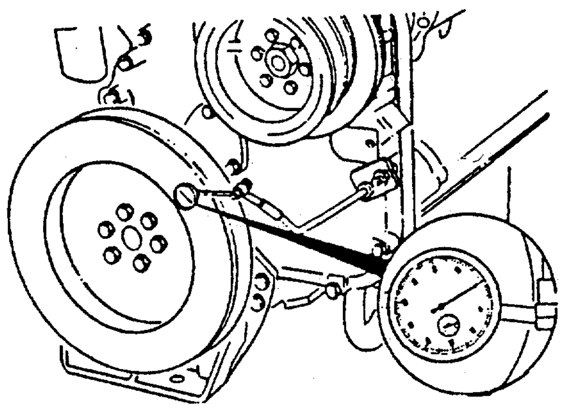


FIGURE 3-82. Measuring Dampener Wobble.

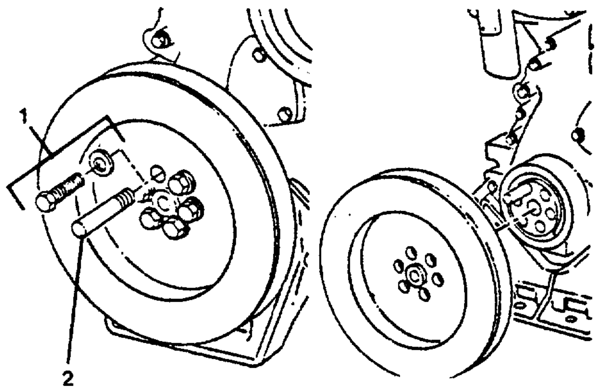


FIGURE 3-83. Dampener and Pulley Removal.

CAUTION

Do not use a hammer or screwdriver to remove dampener. These tools may damage the dampener.

d. Remove the remaining five capscrews and washers, the dampener, and the pulley.

e. Inspect the dampener as follows:

(1) Apply a spray of Spotcheck Developer, Type SKD-NF, or equivalent on the dampener. Put the dampener in an oven heated to 200 ° F (93 ° C). Let the dampener reach the temperature inside the oven, and then remove it.

(2) Inspect the dampener for oil leaks. Discard the dampener if any leaks are seen.

(3) Remove the paint from four areas on each side of the dampener. Use these areas to take measurements of the thickness of the dampener.

CAUTION

Do not use coarse emery cloth or a sharp tool to remove the paint. Use cleaning solvent and 240 grit emery cloth.

(4) Use a micrometer to measure the thickness at each of the four areas. Measure approximately 0.125 inch (3.18 mm) from the outside diameter of the dampener.

(5) Replace the dampener if the difference in the measurements between any two of the four areas is more than 0.010 inch (0.25 mm).

f. Install the dampener and pulley as follows:

(1) Install two guide studs in the crankshaft nose.

(2) Install the pulley and the dampener on the guide studs.

NOTE

Ensure the mounting surfaces of the crankshaft nose, the vibration dampener, and the pulley are clean, dry, and free of burrs.

(3) Lubricate the capscrew threads and the face of the washers with clean engine oil.

(4) Install four of the six capscrews.

(5) Remove the guide studs and install the remaining two capscrews and washers.

(6) Tighten the capscrews to 190 ft-lb (260 N•m) torque.

g. Repeat check for eccentricity and wobble in accordance with step b.

h. After eccentricity and wobble check have been satisfactorily accomplished, leave the dial indicator mounted as shown in Figure 3-81.

i. Check crankshaft end clearance.

(1) Use a pry bar to move the crankshaft forward and backward while observing the dial indicator gauge.

(2) End clearance must not exceed 0.022 inch (0.56 mm) with the engine mounted and generator attached. If the measurement exceeds this figure, notify your supervisor. Installation of new thrust washers is required by general support maintenance personnel.

j. Install the dampener belt guard.

k. Connect battery banks (starboard), operate air system (port), refer to TM 55-1905-223-10.

3-27. REPAIR CYLINDER BLOCK GROUP.

This task covers:
a. Disassembly **b. Repair** **c. Assembly**

INITIAL SETUP:

Tools

Tool kit, general mechanic's rail and marine diesel engines, 5180-00-629-9783
Lifting fixture P/N 3822512
Lifting sling P/N 3375958

Materials/Parts

Block assembly P/N 3801592

Equipment Conditions

Engine cooled below 120° F (50 ° C).
Air supply secured (port).
Battery banks disconnected (starboard). TM 55-1905-223-10.
Generator removed (paragraph 3-13).
Starter assembly removed (paragraph 2-24 or 2-25).
Coolant heater removed (paragraph 2-36).
Instrument panel and wiring removed (paragraph 2-26).
Sump pump removed (paragraph 2-32).
Air cleaner group removed (paragraph 2-29).
Fuel filters removed (paragraph 2-31).
Lube oil by pass filter removed (paragraph 2-35).
Lube oil cooler/filter removed (paragraph 2-34).
Water pump and idler group removed (paragraph 2-33).
Cylinder heads removed (paragraph 2-43).
Aftercooler removed (paragraph 2-41).
Exhaust manifold removed (paragraph 2-42).
Oil pan group removed (paragraph 3-21).
Lube oil pump removed (paragraph 3-22).
Accessory drive and pulley removed (paragraph 3-19).
Gear cover group removed (paragraph 3-20).
Flywheel and housing removed (paragraph 3-25).

DISASSEMBLY

a. Unless otherwise directed, perform the following disassembly actions:

(1) Cam follower housings (paragraph 3-18).

(2) Camshaft and gear group (paragraph 3-23).

(3) Connecting rod and piston group (paragraph 3-24).

b. Through the process of removing the assemblies and components listed in the Equipment Conditions and in Step a. above, the diesel engine block assembly should now be free from its mounts and supported by the lifting fixture. Hoist and remove the block assembly.

REPAIR

Repair of the cylinder block group consists of replacing the diesel engine block.

ASSEMBLY

a. Install the following:

(1) Connecting rod and piston group (paragraph 3-24).

(2) Camshaft and gear group (paragraph 3-23).

(3) Cam follower housings (paragraph 3-18).

b. Using the lifting fixture, hoist the block assembly into place.

c. Install the following assemblies:

(1) Flywheel and housing (paragraph 3-25).

(2) Gear cover (paragraph 3-20).

(3) Accessory drive and pulley (paragraph 3-19).

(4) Lube oil pump (paragraph 3-22).

(5) Oil pan group (paragraph 3-21).

(6) Cylinder heads (paragraph 2-43).

(7) Exhaust manifold (paragraph 2-42).

(8) Aftercooler (paragraph 2-41).

(9) Water pump and idler (paragraph 2-33).

(10) Lube oil cooler/filter (paragraph 2-34).

(11) Lube oil bypass filter (paragraph 2-35).

(12) Fuel filters (paragraph 2-31).

(13) Air cleaner group (paragraph 2-29).

(14) Sump pump (paragraph 2-32).

(15) Instrument panel and wiring (paragraph 2-26).

(16) Coolant heater (paragraph 2-36).

(17) Starter assembly (paragraph 2-24 or 2-25).

d. Install the generator assembly (paragraph 3-13).

e. Connect battery banks (starboard), operate air supply (port), refer to TM 55-1905-223-10.

f. Operate the engine until it reaches a temperature of 180ºF (80ºC) and check for proper oil pressure and leaks.

-

3-28. REMOVE/REPAIR SUBBASE GROUP.

This task covers:

a. Removal **b. Repair** **c. Replacement**

INITIAL SETUP:

Tools

Tool kit, general mechanic's rail and marine diesel engines, 5180-00-629-9783
Lifting fixture P/N 3822512
Lifting sling P/N 3375958

Materials/Parts

Resilient mounts P/N 3056517

Equipment Condition

Generator removed (paragraph 3-13).
Engine removed (paragraph 3-13A).

REMOVAL

a. Attach the lifting fixture to the four lifting pad eyes (2, Figure 3-84).

b. Remove the nuts (6) and lift the subbase (3) clear of the resilient mounts (7). Remove the mounts.

c. Remove lifting fixture.

d. Remove four hexagon capscrews (5), lockwashers (4), and plain hexagon nuts (1) to remove each lifting pad eye (2).

REPAIR

Repair to the subbase is by replacement of resilient mounts. Refer to the Removal and Replacement steps of this procedure.

NOTE

The subbase is mounted to the six resilient mounts (7, Figure 3-84).

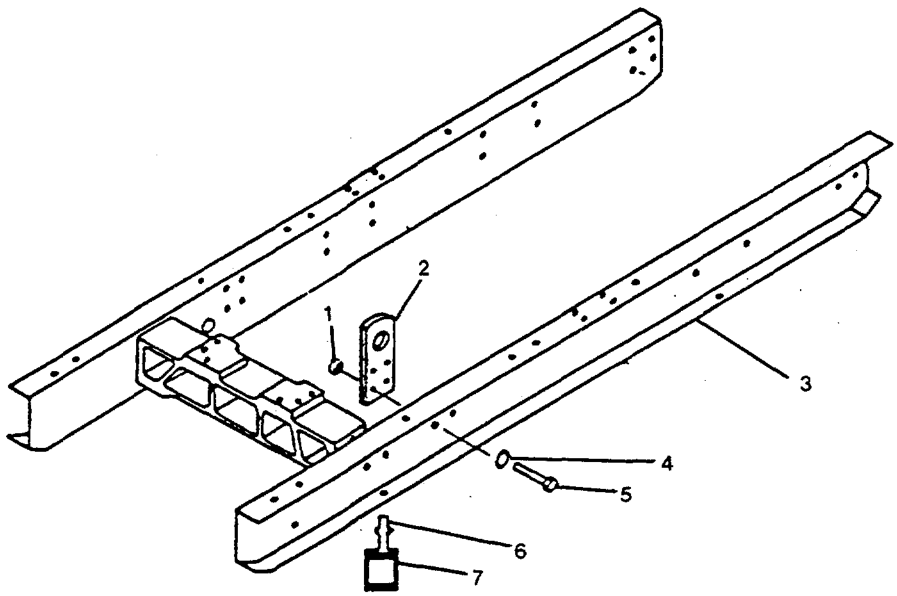


FIGURE 3-84. Subbase Group.

REPLACEMENT

a. Install new resilient mounts (7). Refer to paragraph 3-12.

b. Install the lifting padeyes (2, Figure 3-84) with capscrews (5), lockwashers (4), and nuts (1)-to the subbase (3).

c. Attach the lifting fixture to each lifting pad eye (2) and lower the subbase (3) onto the six resilient mounts (7).

NOTE

Adjust the mounts as described in paragraph 3-12 while positioning the subbase.

d. Install the nut on each of the six isolator mount studs.

(1) Install the resilient mount bolts (paragraph 3-12).

(2) Tighten the center bolt/nut on each resilient mount (7) to 120 ft-lb (160 N•m) torque.

e. Remove the lifting fixture.

f. Install the engine (paragraph 3-13A).

g. Install the generator assembly (paragraph 3-13).

SECTION VI. PREPARATION FOR STORAGE OR SHIPMENT

Refer to Chapter 2, Section VI.

CHAPTER 4

INTERMEDIATE GENERAL SUPPORT MAINTENANCE INSTRUCTIONS

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

4-1. Common Tools and Equipment. For authorized common tools and equipment, refer to the Modified Table of Organization and Equipment (MTOE) applicable to your organization.

4-2. Special Tools, TMDE, and Support Equipment. Special tools; test, measurement, and diagnostic equipment; and support equipment requirements are listed and illustrated in the Repair Parts and Special Tools List (RPSTL), TM 55-1905-223-24P. These items are also listed in the Maintenance Allocation Chart (MAC), Appendix B of this manual.

4-3. Repair Parts. Repair parts are listed and illustrated in the Repair Parts and Special Tools List (RPSTL), TM 55-1905-223-24P.

SECTION II. SERVICE UPON RECEIPT

4-4. Checking Unpacked Equipment.

a. Inspect the equipment for damage incurred during shipment. If the equipment has been damaged, report the damage in accordance with the instructions of DA Pam 738-750.

b. Check the equipment against the packing slip to see if the shipment is complete. Report all discrepancies in accordance with the instruction of DA Pam 738-750.

c. Check to see whether the equipment has been modified.

d. Remove protective caps, plugs, inserts, wrappings, and tape when inspection/inventory is completed. Inspect piping openings for damage. Wipe off dirt, grease, or protective films at time of installation.

e. Remove chocks from resilient mounted components.

4-5. Initial Setup Procedure. Includes operational checks and inspections that are not performed for a routine startup. Direct support maintenance personnel will perform initial setup in accordance with the operator's manual, TM 55-1905-223-10. Also refer to Chapter 2, Section II.

4-6. Normal Startup. Refer to the operator's manual, TM 55-1905-223-10.

4-7. Shutdown Procedure (Usual or Unusual). Refer to the operator's manual, TM 55-1905-223-10.

SECTION III. INTERMEDIATE GENERAL SUPPORT PREVENTIVE MAINTENANCE CHECKS AND SERVICES (PMCS)

4-8. PMCS. There is no PMCS at the general support level. See Chapter 2, Section IV.

SECTION IV. INTERMEDIATE GENERAL SUPPORT TROUBLESHOOTING

4-9. Troubleshooting. There is no troubleshooting at the general support level. See Chapter 2, Section IV and Chapter 3, Section IV.

SECTION V. INTERMEDIATE GENERAL SUPPORT MAINTENANCE PROCEDURES

MAINTENANCE OF THE SHIP'S SERVICE GENERATOR SET, ELECTRIC AND AIR START

4-10. Repair Generator Assembly.

This task covers:

a. Disassembly **b. Repair** **c. Assembly**

INITIAL SETUP:

Tools

Tool kit, general mechanic's rail
and marine diesel engines,
5180-00-629-9783
Tool kit, electrician's,
5180-00-391-1087
Lifting fixture P/N 3822512
Lifting sling P/N 3375958
Mechanical puller,
5120-00-595-9304
Hydraulic press P/N 2009-15
Multimeter, 6625-01-139-2512
Megger P/N 3376304

Materials/Parts

Vacuum cleaner, Item 54, Appendix C
Lithium based grease,
Item 32, Appendix C
Petroleum distillate solvent
Item 31, Appendix C
Exciter rotor P/N 458-22800
Rectifier assembly P/N 362-12800
Varistor lead assembly P/N 450-11760
Rotor P/N 414ER03S27R12A
Stator frame assembly P/N 414Ell5F1503A
Generator end bracket guide studs,
Item 55, Appendix C
Generator drive coupling, guide stud,
Item 56, Appendix C

Equipment Condition

Generator removed (para. 3-13).
Air supply secured (port).
Battery banks disconnected (stbd).
TM 55-1905-223-10.

DISASSEMBLY

a. Remove the permanent magnet stator and rotor (exciter).

NOTE

The angular position of the permanent magnet exciter is set during the final electrical test prior to dispatch, and a mark indicating the correct position is made on the stator housing and the non-drive end bracket at approximately the 12 o'clock position. It is essential that the stator is returned to exactly the same position when refitting this unit; therefore, before dismantling, this mark must be as clear as possible.

(1) Mark the position of the stator mount and remove the three stator hex head capscrews to remove stator cover (Figure 4-1a).

(2) Disconnect the plug inside the permanent magnet exciter access cover. This plug connects the stator to the leads going into the generator rear end bracket (Figure 4-1b).

(3) Remove the four capscrews and clamps retaining the stator mount to the end bracket (Figure 4-1c).

CAUTION

The magnetic rotor will attract the stator core. Care must be taken to avoid a contact which may damage the windings when removing the stator housing.

(4) Pull the permanent magnet exciter stator housing out of the recess in the end bracket. It may be necessary to tap the housing to loosen it. Some pulling force may also be required (Figure 4-1d).

(5) Remove the machine bolt and lockwasher from the main rotor shaft and firmly pull the complete rotor assembly from the shaft (Figure 4-1e and 1f).

(6) Wrap the magnetic rotor in a protective cover to keep it clean and prevent metallic particles from collecting on the magnets.

CAUTION

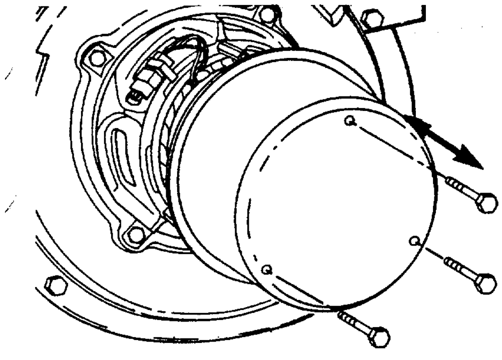
The magnetic properties will be destroyed if the rotor assembly is disassembled.

b. Remove the main rotor assembly.

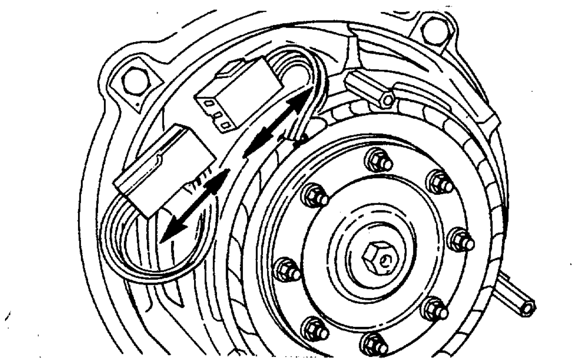
NOTE

The main rotor assembly is removed from the drive end of the generator. A minimum free area, the length of the generator is required to remove the rotor.

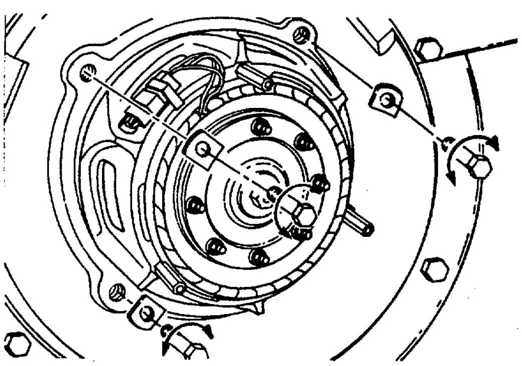
(1) Tag and disconnect exciter leads X and XX as well as P2, P3 and P4 from the terminal block. Bring the leads back into the non-drive end bracket.



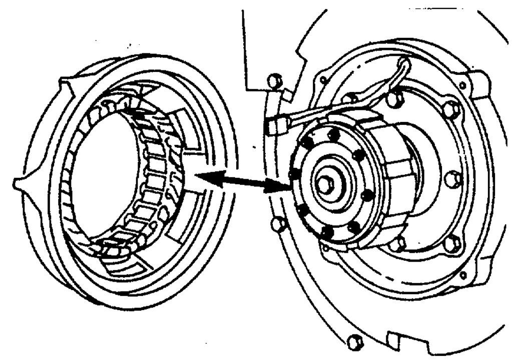
4-1a



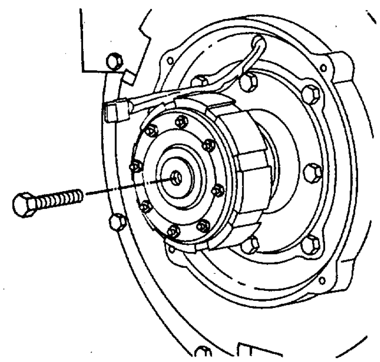
4-1b



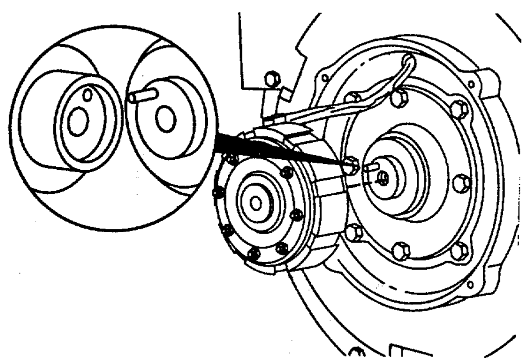
4-1c



4-1d



4-1e



4-1f

FIGURE 4-1. Exciter Removal/Installation.

(2) Remove the four outer capscrews holding the end bearing cap in the end bracket (Figure 4-2a).

NOTE

Do not remove the inner four capscrews unless the bearing is to be replaced.

CAUTION

The main exciter stator is attached to the end bracket and comes out when the end bracket is removed. Use extreme care not to damage the main exciter as the end bracket is removed.

(3) Remove the eight hexhead capscrews holding the end bracket to the frame (Figure 4-2b)

(4) Insert 2 capscrews in the jacking holes (Figure 4-2b) to provide for "jacking" purposes on the end bracket center line. Screw bolts in until end bracket is clear of locating recess.

NOTE

Tap the end bracket lightly while turning the jacking screws in. Make sure the bearing cartridge is not stuck in the end bracket.

CAUTION

Do not pry on the fan ring between the fan blades. The fan blades can be easily bent or broken. The entire generator rotor must be disassembled (normally at the factory) to replace a generator fan.

(5) Move the rotor out from the stator by prying on the fan ring at a fan blade (Figure 4-2c).

(6) Rotate the rotor while pulling it from the stator assembly. Pull the rotor out until the main rotor poles are exposed (Figure 4-2d).

CAUTION

As the rotor is fully withdrawn from the stator core, THE FULL WEIGHT OF THE ROTOR MUST BE SUPPORTED-BY THE HOIST. If the rotor core is allowed to drop more than a few millimeters at this point, it will make contact with the stator windings, and may damage them. Do not use any force on the generator fan during lifting or rotating the assembly.

NOTE

This operation will be easier with a second person supporting and guiding the non-drive end of the shaft

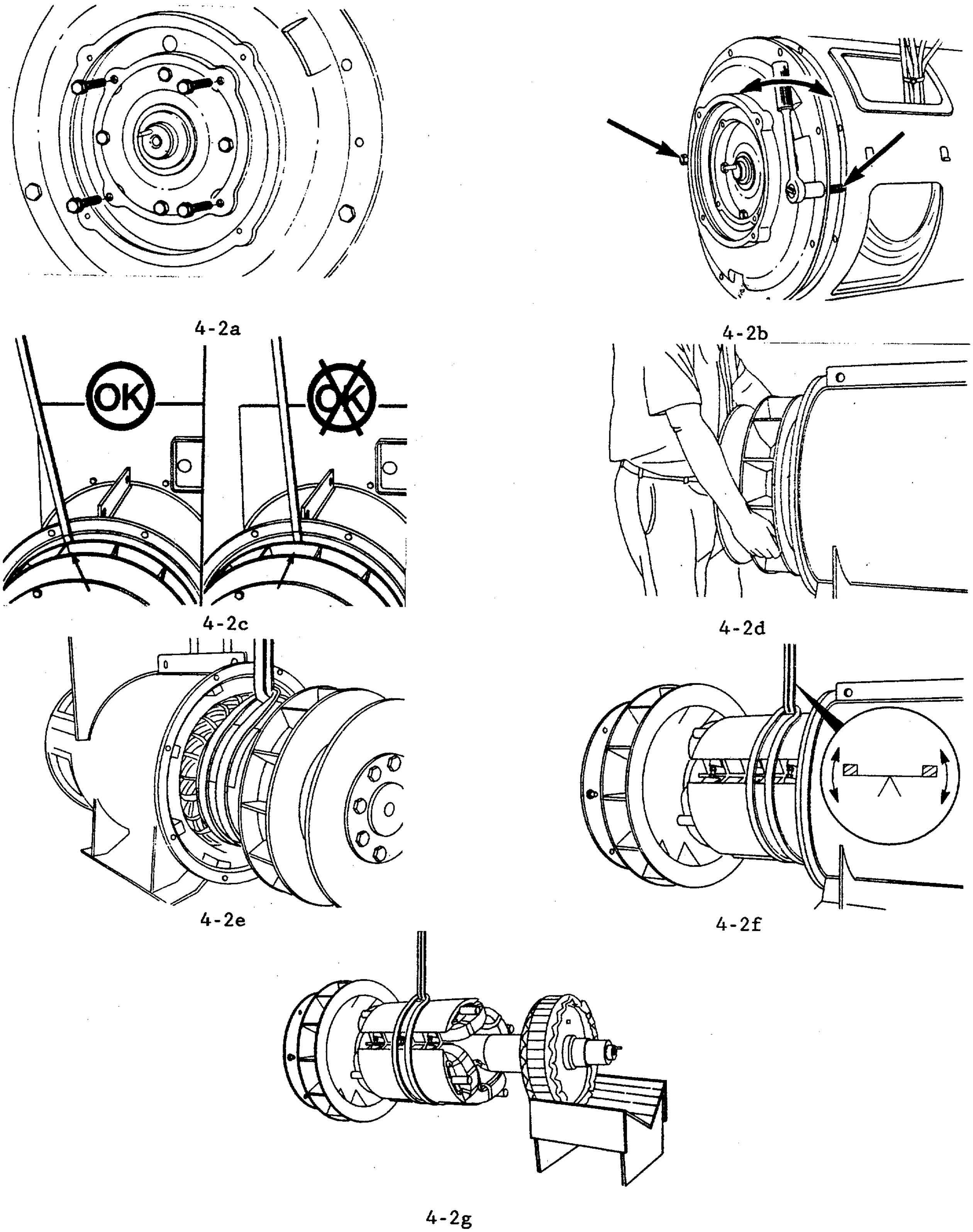


FIGURE 4-2. <u>Main Rotor Removal/Installation</u>.

(7) Support the rotor drive end with a sling around the main generator rotor poles.

(8) Continue to pull and rotate the assembly as it is removed from the stator.

(9) Move the sling closer to the center balance point of rotor as it is removed (Figure 4-2f).

NOTE

The best location for the sling is where only a slight downward force on the fan is required to balance the assembly.

(10) Set the rotor in a formed support as shown or leave it supported by the hoist to avoid damage to the main exciter rotor windings (Figure 4-2g).

c. Remove the generator bearing. Removal of the bearing can be carried out after removal of the main rotor assembly or by removing the end bracket only as described in step b. of this procedure.

NOTE

The bearing is enclosed in a pre-packed cartridge housing and must not be dismantled unless necessary, for replacement of the bearing.

(1) Remove the four capscrews securing the bearing cartridge cap (Figure 4-3a).

(2) Remove the bearing cap (Figure 4-3b).

(3) Remove the clip from the generator shaft (Figure 4-3c).

<u>CAUTION</u>

Use two or more flat washers or a spacer between the puller and the end of the shaft to avoid damaging the threads in the end of the shaft.

(4) Remove the bearing cartridge with a puller (Figure 4-3d).

(5) Press the old bearing from the bearing cartridge. Use solvent to clean the old grease from the bearing cartridge and end cap (Figure 4-3e).

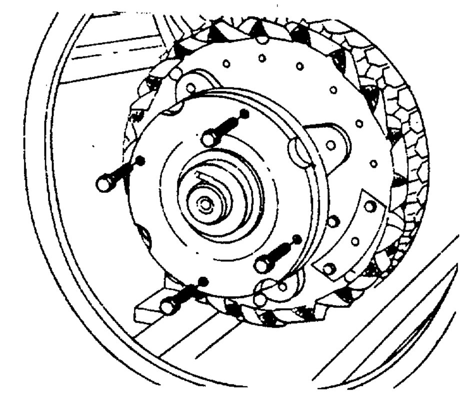
NOTE

The outer race of the bearing is a light press fit in the bearing cartridge.

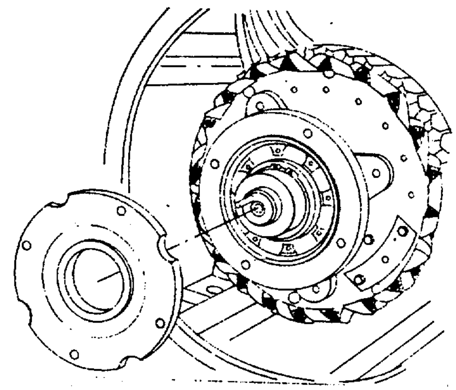
d. Remove the rectifier assembly.

NOTE

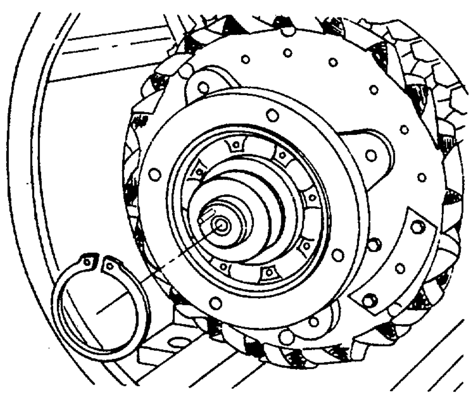
The rectifier assembly is attached to the drive side of the main exciter rotor.



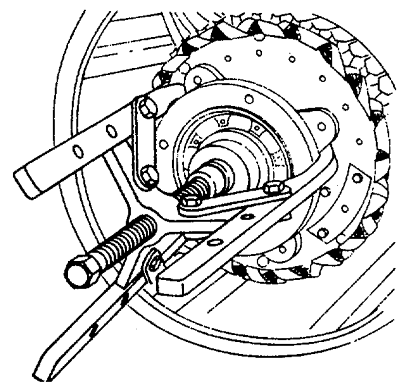
4-3a



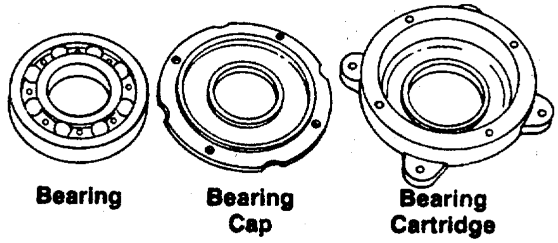
4-3b



4-3c



4-3d



4-3e

FIGURE 4-3. Bearing Removal.

(1) Tag and disconnect the wiring to the rectifier assembly (Figure 4-4).

(2) Remove the diodes (2, 4) from the rectifier assembly (1). Refer to paragraph 3-13.

(3) Disconnect the lead and remove the varistor lead assembly (5).

(4) Remove the nut and washers at points (3) from the positive and negative plates. Remove the plates from the molded base (6).

REPAIR

Repair to the internal generator assembly consists of cleaning, inspecting, and replacing the defective parts or assemblies that were removed in the disassembly step of this procedure. Replacement of a faulty varistor is also included in this section.

a. Clean internal parts and windings.

CAUTION

Do not use wire brushes for cleaning.

(1) Dust and dirt may be removed by brushing with bristle brushes, followed by vacuum cleaning. Vacuum cleaning is an effective and desirable method of removing dry and loose dirt since it does not scatter the dirt.

EXCITER ROTOR CORE

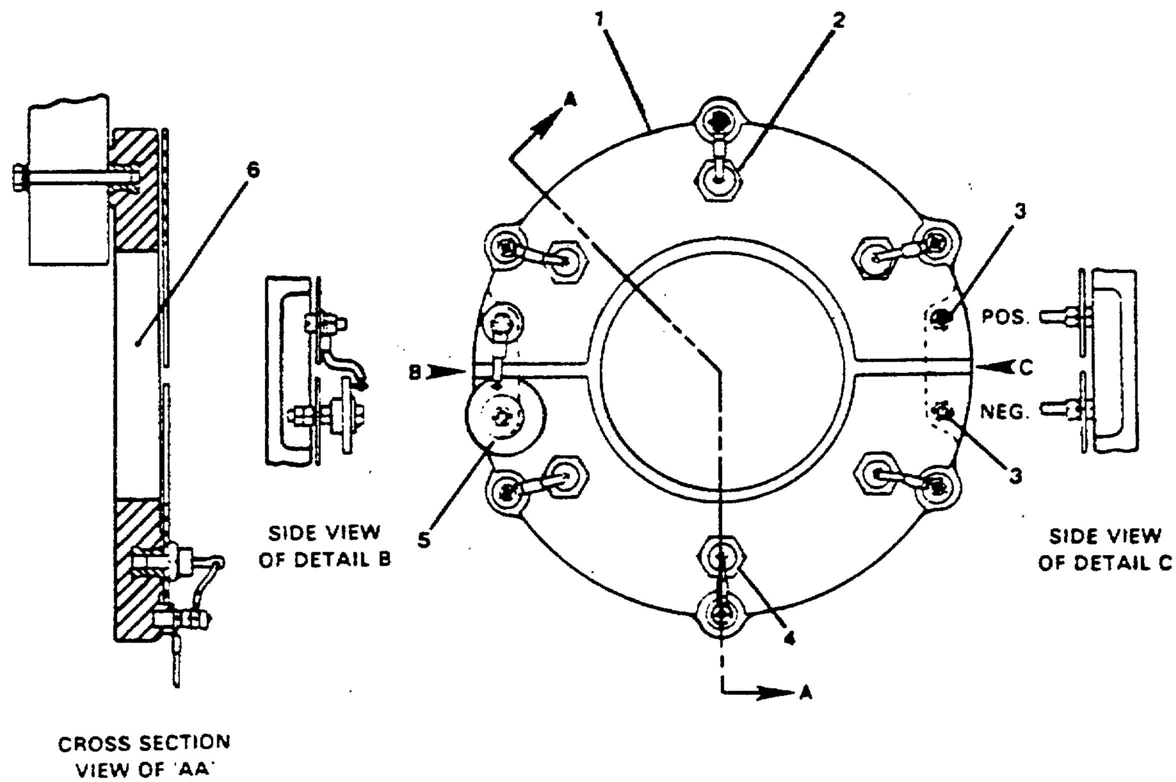


FIGURE 4-4. Rectifier Assembly

(2) Cleaning with a dry cloth is satisfactory when the components are small, the surfaces to be cleaned are accessible, and only dry dirt is to be removed.

WARNING

High pressure compressed air tanks, piping systems, and air operated devices possess potential for serious injury to eyes and exposed areas of skin due to escaping air pressure.

(3) Blowing out dirt with compressed air is usually effective, particularly when the dirt has collected in places which cannot be reached with a cloth. Use clean dry air at 30 psi (206 kPa).

WARNING

Adequate ventilation must be available to avoid fire, explosion, and health hazards where solvents are used. Avoid breathing solvent vapors.

CAUTION

Prevent getting solvent on insulating varnishes or deterioration of varnish will occur.

(4) If accumulated soil contains oil or grease, an approved petroleum distillate solvent is usually required to remove it.

b. Inspect the exciter stator and rotor.

(1) Check for loose, frayed, or burned windings.

(2) Visually check for score marks in the bore of the stator caused by rubbing of the stator against the rotor.

(3) Check the mating surfaces of the rotor for burrs.

(4) Check for score marks on the outside of the rotor caused by rubbing.

(5) Replace the exciter stator and rotor if any of the above damage is found.

c. Inspect the generator main rotor assembly.

(1) Check for loose, frayed, or burned windings.

(2) If damaged, replace the main rotor.

d. Inspect the generator main stator.

(1) Check for loose, frayed, or burned windings.

(2) Inspect the mating surfaces of the stator/frame for cracks and burrs.

(3) If any damage is found, replace the main stator/frame or the generator assembly.

e. Inspect the generator fan at the drive end of the main rotor assembly.

CAUTION

The entire rotor assembly must be balanced when a new fan is installed. For this reason, install a new rotor assembly if the fan is damaged.

(1) Check the fan for cracks, broken blades, or distortion.

(2) If the fan is damaged, replace the main rotor with a new balanced rotor assembly.

f. If the generator bearing has been removed for any reason, always install a new bearing.

g. Varistor replacement. The varistor may be replaced without removing the generator assembly. Use the following procedure:

(1) Shut down the generator and turn off and tag all starting circuits.

(2) Remove the end covers (3, Figure 3-3) for access to the rectifier assembly.

(3) Disconnect the terminal lead and remove the varistor (5, Figure 4-4).

(4) Install the new varistor and tighten nut to 36-42 in-lb (4.8 N•m) torque. Connect the terminal lead.

h. Insulation resistance measurements.

NOTE

- If a generator has been in storage for over 6 months or has been exposed to high humidity or temperature changes that could cause condensation, check the insulation resistance before putting the unit into service.

- The insulation resistance of the main stator winding is the most important value. The insulation resistance of the main stator and the permanent magnet stator are easy to measure.

NOTE

The insulation resistance of the main exciter rotor and main rotor are more difficult to measure and are less significant. It is recommended that these resistances can be checked only when diagnosing a problem.

(1) Remove the AVR from the AVR box by removing the four cover captive screws, the cover, the four threaded pillars, and then the AVR.

(2) Disconnect all of the external leads from the AVR and separate the leads so terminals do not touch each another or AVR box.

(3) Remove both sides of the terminal box.

(4) Remove the E0 and E2 leads from the overvoltage module. Separate the leads so they do not touch anything.

(5) Remove the two leads from the voltage adjust rheostat. Separate the leads so they do not touch anything.

(6) Remove the leads that connect the generator windings to the generator frame.

(7) Open the generator main line circuit breaker (if there is one).

(8) Disconnect any instrumentation and controls (voltmeter, wattmeter, load sensing governor, synchronizer, etc.) as well as any capacitors that may be connected to the main leads (U or U6, V or V6, W or W6 and N).

(9) Connect one lead of the megger to the ground connection point in the terminal box. Connect the other lead to the terminal box.

(10) Crank or operate the megger 2 or 3 turns. The megger should indicate zero ohms. A zero reading shows that the ground is ok. If the megger does not read zero, move the clips to make better contact and keep checking until a zero reading is obtained.

(11) Remove the lead from the terminal box and connect it to generator lead U or terminal U. Crank the megger at approximately 120 rpm (2 turns per second) for 10 seconds and record the reading.

(12) A reading of 1.5 megohms or above is satisfactory.

(13) A reading of 0.5 to 1.5 (or 5.0 megohms for 4160 volt generators) indicates that the main insulation is marginal. Dry the generator insulation and test again. Refer to step i. of this procedure.

NOTE

A reading of less than 0.5 megohms indicates an accidental grounding or a severe insulation problem. Recheck to make sure no terminals are touching the frame.

(14) Check the main stator leads for worn insulation. Repair or replace as necessary.

(15) Recheck to make sure that no control equipment or instrumentation is connected to terminals U, V, W or N.

(16) Repeat step (13) as necessary.

(17) To measure the insulation resistance of the main exciter stator, remove the megger lead from terminal U and reconnect it to terminal X at the AVR box.

(18) Crank the megger at approximately 120 rpm (2 turns per second) for 10 seconds and record the reading.

(19) A reading of 1.2 megohms or above indicates the insulation resistance of the main exciter stator is satisfactory.

(20) A reading of 0.5 to 1.2 megohms indicates the insulation resistance is marginal. Dry the generator and test again. Refer to step i. of this procedure.

NOTE

* A reading of less than 0.5 megohms indicates an accidental grounding or a severe insulation problem.

* Check for worn or damaged lead insulation where the X and XX leads go through the terminal box. Also check where the leads go through the main generator frame. Dry the generator and test again. Refer to step i. of this procedure.

(21) Repeat step (20) as necessary.

(22) To measure the insulation resistance of the permanent magnet exciter windings:

(a) Remove the permanent magnet exciter end cover.

(b) Disconnect the three wire permanent magnet exciter harness at the plug.

(c) Connect one megger lead to any of the three prongs extending from the plug.

(d) Connect the other megger lead to a convenient part of the frame.

(23) Crank the megger at approximately 120 rpm (2 turns per second) for 10 seconds and record the reading.

(24) A reading of 1.2 megohms or above indicates that the insulation resistance of the permanent magnet exciter windings is satisfactory.

NOTE

A reading of less than 1.2 megohms indicates that the permanent magnet exciter insulation is marginal or that there is an accidental grounding.

(25) Remove the permanent magnet exciter stator. Check the exciter and the leads going to the plug for worn or damaged insulation.

(26) Repair any damaged lead insulation with vinyl tape.

(27) Dry the permanent magnet exciter stator and test again. Refer to step i. of this procedure.

i. Drying generator windings.

(1) For generators connected to a runable engine, remove the terminal box sides. Connect the three generator output leads together and connect this junction to the frame ground. This is a grounded three-phase short circuit connection.

NOTE

Wires connecting the generator output leads together must be capable of carrying 3/4 of the rated generator output amps. The wire connecting the junction of the three output leads to the frame must be #10 or larger.

(2) Remove the AVR from the AVR box by removing the four cover captive screws, the cover, the four threaded pillars, and then the AVR. Remove the X and XX leads from the AVR.

NOTE

Use a dc power source or storage battery, capable of producing 0.5 amp at 12 volts but not exceeding 13.2 volts to provide power to the generator X and XX leads.

(3) Connect the positive (+) lead of power supply to the main exciter lead X at the AVR. Connect the negative (-) power supply lead to the dc exciter lead XX.

(4) Start the engine. After 5 minutes at low idle, bring the engine up to rated speed.

(5) After 1 hour at rated speed, stop the engine, disconnect the voltage form the dc exciter, and disconnect the shorted generator output leads from the generator frame.

(6) Measure the main stator insulation resistance with the megger. Refer to step h. procedures.

(7) The generator is satisfactory if the reading is 1.5 megohms or above.

(8) If the readings are below 1.5 megohms, continue drying.

(9) Reconnect all three output terminals and repeat all previous drying steps.

NOTE

For generators not connected to a runable engine, use forced warm air to dry the generator windings.

(10) Direct the warm air from one or two fan heaters into the openings at either end of the generator. Make sure that the air flows over the windings through the generator.

NOTE

Do not exceed 80°C (176°F) air temperature when drying the generator.

(11) After 2 hours, measure the main stator insulation resistance. Refer to step h.

(12) If the insulation resistance is satisfactory, put the unit into service.

(13) If the insulation resistance is still too low, repeat all the previous drying steps.

NOTE

The permanent magnet exciter stator cannot be dried by the previous procedures.

(14) To dry the permanent magnet exciter stator insulation, remove the permanent magnet stator from the generator. Refer to Disassembly procedures.

(15) Inspect the stator. Check the leads going to the plug for worn or damaged insulation. Repair as required.

(16) Recheck the insulation resistance. Refer to step h.

(17) If the insulation resistance is still below 1.2 megohms, place the stator in an oven at 230°F (110°C) for 3 hours.

(18) Remove the stator from the oven. Allow it to cool to room temperature. Measure the insulation resistance.

(a) If the reading is 1.2 megohms or above, reassemble the generator.

(b) If the reading is below 1.2 megohms, repeat the previous drying steps.

NOTE

Insulation resistance goes down rapidly as temperature rises. Measuring a hot (212°F (100°C)) stator can give a low reading.

j. No load dc excitation test.

NOTE

The no load dc excitation test will indicate whether a generator problem is in the AVR or the generator.

(1) Remove the AVR. Refer to step h.(1).

(2) Temporarily insulate (tape) all of the lead terminals except X and XX that were removed from the AVR.

(3) Using a multimeter set to measure ohms, measure the resistance between terminals X and XX at the AVR box. Acceptable resistance values are 23.7 to 27.5 ohms.

(4) Remove all loads that may be connected to the generator. This includes fans, coolant pumps, heaters and any other equipment powered from the generator.

(5) Open the main line circuit breaker, if the generator has one.

(6) Start the engine and bring it up to rated speed.

NOTE

Use a dc power source or storage battery capable of producing 0.5 amp at 12 volts but not exceeding 13.2 volts to provide power to the generator X and XX leads.

(7) Connect the power source positive (+) lead to the X terminal at the AVR box. Connect the negative (-) lead to the XX terminal. Temporarily insulate (tape) the X and XX terminals to prevent accidental shorting.

(8) Check the engine speed. Engine speed should be 1797 to 1803 rpm (59.9 to 60.1 Hz). Adjust the engine speed as necessary.

(9) Measure the dc voltage at terminals X and XX. This voltage must be 12.0 to 13.2 volts. If it is not, adjust the dc power supply voltage, check the battery lead connections, and connect a charger to the battery or replace the battery with a fresh one.

(10) Measure and record the line-to line voltage. Also record the voltage at the auxiliary terminals 2 and 3. Use the same meter to make all checks.

(11) The line to line voltages must all be within 1 percent of the average voltage. If there is a voltage unbalance, recheck for any load on the generator. A load can cause a voltage unbalance condition.

(12) If there is a voltage unbalance at no load, disconnect the power supply from X and XX, stop the engine, remove the generator from the engine, and have it repaired orreplaced.

(13) A voltage unbalance at no load indicates shorted turns in the main generator windings. Shorted turns will destroy the insulation and can damage the main stator laminations.

(14) Using the multimeter set to measure dc voltage, measure the voltage at the auxiliary terminal block. Terminals 2 and 3 should be 10 to 19 volts dc. Check the dropper transformer (two transformers for three-phase sensing) connections. Check the auxiliary terminal block connections. Check the three-phase sensing module connections.

(15) The no load line to line voltage range that should be obtained with 13.0 volts dc connected to exciter leads X and XX is 305 to 335 volts.

(16) Balanced line to line voltage within this range indicates that the generator windings and rotating rectifiers are all in good working order. The correct voltage at the auxiliary terminal block, terminals 2 and 3, indicates that the AVR is receiving the correct no load voltage.

(17) If the generator output voltage is not within the 305-335 volts range, check the rotating diodes. Refer to paragraph 3-13.

(18) Repeat the 13 volt no load dc excitation test. Measure the line voltage (305-335 volts).

(19) If the generator voltage is still not within the 305-335 volt range, there probably is a defect in a rotor winding.

(20) After determining that all rotating diodes and the surge suppressor are good, check the rotor windings as follows:

(a) Install the AVR by reversing step h.(l) procedures.

(b) Remove any loads connected to the generator.

(c) Open the main line circuit breaker, if equipped with one.

(d) Start the engine and bring it up to rated speed.

(21) Adjust the line to line voltage to 240 volts.

(22) Check the engine speed at 1797 to 1803 rpm (59.9 to 60.1 Hz). Adjust engine speed as necessary.

(23) Measure dc voltage.

(24) Measure and record the voltage at terminals X and XX on the auxiliary terminal block.

(25) The voltage readings should be 5 to7 volts.

(26) If the X to XX voltage is above 7 volts:

(a) Check to make sure the meter is set to dc voltage.

(b) Check to make sure the generator voltage is at the specified value.

(c) Check to make sure the engine rpm or frequency is at the specified value.

(d) If all the above are correct, there is a defect in the generator rotor winding.

(27) Stop the engine. Remove the generator from the engine. Refer to paragraph 3-12.

(28) Remove the rotor from the generator. Refer to Disassembly procedures.

(29) If the X to XX is below 5 volts:

(a) The frequency may be too high.

(b) The generator output voltage may be too low.

(c) The generator leads may be incorrectly connected.

k. Automatic voltage regulator adjustments.

NOTE

- A quick test for proper operation of the AVR is to operate the engine at 1500 rpm, turn the voltage adjust rheostat on the AVR from maximum to minimum volts, and observe the generator output voltage change.

- Before installing a new AVR, check to see that the top jumper is installed on the top "C" (common) and "60 volt" terminals. This jumper sets the protective voltage level in the AVR.

- Check to see that the bottom jumper is installed between the bottom "C" and the "4P60" (4 pole, 60 Hz) terminals. The placement of this jumper determines the speed range where underfrequency protection begins.

(1) Connect all ten leads to the AVR. Mount the AVR in the AVR box using the four threaded pillars

(2) Turn the AVR coarse voltage control (1, Figure 4-5) all the way counterclockwise.

(3) Start and bring the engine up to rated speed.

(4) Turn the coarse voltage control (1) clockwise until the generator is producing approximately rated voltage. Turn the remote voltage trimmer control to obtain the voltage required.

(5) The AVR gain control (2) is difficult to locate. It is on the main AVR control board and is accessible through a 0.160 in. (4 mm) diameter hole

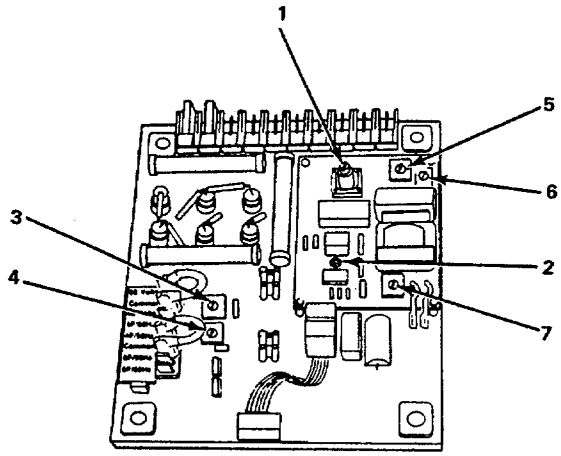


FIGURE 4-5. AVR Auxiliary Board.

in the approximate left center of the auxiliary board. The hole is below a rectangular red capacitor on the auxiliary board. The AVR gain control is preset and sealed. Normally, the AVR gain control should not be adjusted. If the voltage is unstable after a block load reduction, turn the AVR Gain control counter-clockwise. Any gain adjustment affects the generator output voltage. Reset the output voltage after any AVR gain adjustment. Turn the AVR gain clockwise if rated voltage cannot be obtained by means of the coarse and trimmer voltage controls.

(6) The excitation overload (3) is a manufacturing adjustment. It is factory calibrated and sealed. Normally the excitation overload control should not be adjusted. Turning the excitation overload control clockwise raises the 60 volt protective circuit trip voltage.

(7) The Under Frequency Roll Off (UFRO) knee point (4) is preset and sealed at 97% (58.2 Hz and 48.5 Hz) ofated frequency. Normally, the UFRO knee point control should not be adjusted. Turning the UFRO knee point control clockwise raises the frequency at which voltage becomes dependent on frequency. If the unit is operated on the UFRO slope, the generator output voltage will change with temperature as well as with frequency.

(8) The voltage dip limit (5) (top right square potentiometer) is preset and sealed at approximately 30 percent of the operating voltage. Normally, the voltage dip limit control should not be adjusted. Turning the voltage dip limit control clockwise increases the voltage dip on large load pickup. This will make it easier for the engine to pick up load. Turning the control counterclockwise reduces the voltage dip (makes the AVR "stiffer"). The engine may not be able to pick up the load if the voltage dip limit is set too far counterclockwise.

(9) The dwell (recover time delay) (6) rectangular, 20 turn potentiometer is preset and sealed at the maximum (full clockwise) position. Normally, the dwell control should not be adjusted. Turning the dwell control counter-clockwise will reduce the dwell time and make the voltage return to rated value quicker.

(10) The VAr/P.F. sensitivity (7) potentiometer adjusts the response of the AVR to the signal from a VAr/P.F. controller. This control has no effect on the AVR unless a VAr/P.F. controller is used. The control is set at midrange.

CAUTION

If either of leads 2 or 3, which sense generator output voltage, is broken or disconnected, the no load generator output voltage will immediately rise to greater than 2 times the normal voltage. The overvoltage module accessory protects equipment from this high voltage.

NOTE

The generator will sustain a short circuit current of 2.5 to 3 times rated current for approximately 10 seconds without damage to the generator. In order to prevent damage to the generator from short circuit current for longer periods, a protection circuit is included in the AVR. This circuit senses excess voltage (over 60 volts) across the dc exciter terminals X and XX. When the voltage exceeds 60 volts, a timing circuit is activated. In approximately 10 seconds after it is activated, the protection circuit de-energizes the dc exciter, collapsing generator output. The protection circuit will not reset until after the engine has stopped (approximately 10 seconds).

ASSEMBLY

a. Replace the rectifier assembly.

(1) Position the positive and negative rectifier assembly plates (1, Figure 4-4) on the molded base (6) and install washers and nuts.

(2) Install the varistor (5) and connect the terminal lead. Torque the terminal lead to 36-42 in-lb (4.8 N•m).

(3) Install the positive and negative diodes (2, 4). Refer to paragraph 3-13.

(4) Refer to tags and connect rotor wiring to their terminals on the rectifier assembly. Remove tags.

b. Install the bearing and bearing cartridge.

NOTE

The bearing will be easier to install in the cartridge if the cartridge is heated. Heat the cartridge in an oven at 212°F (100°C) for one hour.

WARNING

Use insulated gloves to handle the cartridge.

CAUTION

When installing the bearing in the cartridge, press the OUTER race only, to avoid damage to the bearing.

(1) Press the new bearing into the bearing cartridge using an arbor press (Figure 4-6a).

(2) Use insulated gloves. Install the bearing on the shaft. Quickly push the bearing on the shaft until it seats against the shaft shoulder. The bearing should slide on the shaft and be seated without excessive force (Figure 4-6b).

CAUTION

Applying pressure to the outer bearing race can damage the bearing.

(3) If the bearing binds on the shaft before being fully seated, use a length of pipe with an inside diameter slightly larger than the shaft to drive the bearing against the shaft seat. Apply pressure to the inner race of the bearing only (Figure 4-6c).

(4) Install the large snap ring on the generator shaft next to the inner race of the bearing. Make sure that the snap ring is seated in the grove (Figure 4-3c).

(5) Install the bearing cap (Figure 4-3b and 4-3a).

c. Install the generator main rotor assembly.

(1) Put a sling around the main generator rotor at the approximate center balance point. The best location for the sling is where only a slight downward force on the fan is required to balance the assembly (Figure 4-2g).

(2) Position the rotor into the stator as far as the sling will allow. Use care to avoid bumping the main exciter rotor into the main generator stator (Figure 4-2f).

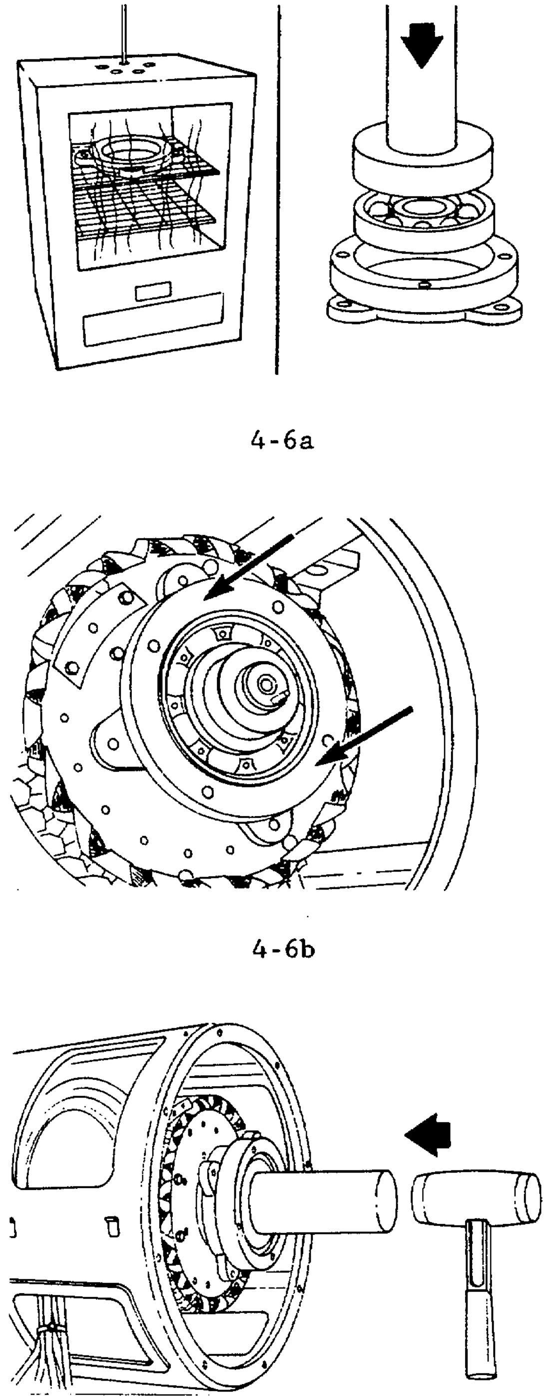
NOTE

This operation will be easier with a second person supporting and guiding the non-drive end of the shaft.

CAUTION

Do not wrap the sling around the rotor winding end turns. A sling can damage the rotor winding end turn insulation.

(3) Lower the support and re-position the sling closer to the fan. Lift the rotor and continue installation until the sling can no longer be used (Figure 4-2e).



4-6a

4-6b

4-6c

FIGURE 4-6. Bearing Installation.

(4) Finish installing the rotor in the generator stator by hand. Rock the rotor from side to side or twist it while pushing it into the stator. Continue until the main rotor poles are even with the main stator (Figure 4-2d).

d. Install the end bracket (1, Figure 4-2).

NOTE

Make sure that the permanent magnet exciter harness attached to the stator is through the end bracket and the harness is retained by the internal wire clamp. The harness is difficult to install when the end bracket is on the generator. Make sure that the main exciter stator leads will be at the top of the generator.

(1) Lift the end bracket and rotor to pilot the end bracket into the generator frame recess (Figure 4-2b).

(2) Install the capscrews which hold the end bracket to the generator frame. Tap the end bracket lightly as the capscrews are tightened (Figure 4-2b).

(3) Pull the main exciter leads (X and XX) and the permanentmagnetic exciter stator leads (P2, P3 and P4) through the hole in the frame terminal box and connect the leads to the corresponding terminals on the auxiliary terminal box.

e. Install the permanent magnet exciter rotor and stator as follows:

(1) Place the permanent magnet exciter rotor on the generator shaft. Align the dowel pin in the shaft with the locating hole in the rotor and push rotor into position (Figure 4-1f).

(2) Install the center rotor retaining capscrew (Figure 4-1e) and torque to 15 to 20 ft-lb (20 to 27 N•m).

(3) Install the permanent magnet exciter stator housing in the end bracket recess with the stator leads at the top (Figure 4-1d). Tap the housing lightly to seat it into the recess.

CAUTION

The rotor is highly magnetic and attracts the stator. Use care not to damage the stator winding during installation. Also be careful not to get your fingers pinched in the installation process.

(4) Align the location mark on the permanent magnetic excitor housing with the location mark on the end bracket.

(5) Install the four capscrews and clamps that hold the permanent magnetic excitor housing to the end bracket (Figure 4-1c). Torque the capscrews to 15 to 20 ft-lb (20 to 27 N•m).

(6) Pull the plug, attached to the leads extending from the generator rear end bracket, through the stator opening. Insert the plug into the receptacle attached to the stator windings (Figure 4-1b).

(7) Install the access cover (Figure 4-1a).

f. Install the generator assembly (paragraph 3-13).

NOTE

The angular position of the permanent magnet stator housing is important to the performance of the control system. When the permanent magnet rotor or stator, or the main stator, has been replaced, the positioning of the stator must be checked and corrected to ensure proper operation.

g. Check and correct the angular position of the permanent magnet stator housing.

NOTE

The generator assembly must be completely installed and ready for normal operation.

(1) Start the generator in a "NO LOAD" condition.

(2) Connect a voltmeter across the main output terminals, so the reading can be observed while adjusting the permanent magnet position.

(3) Run the machine up to full speed and while firmly holding the stator housing in position; loosen the clamp washer bolts approximately one turn, until slight movement is allowed.

CAUTION

Under no circumstances should the permanent magnet stator housing be allowed to move out of its recess, even slightly, as there is a risk that the stator will foul on the rotor. If there is any doubt, two people should be employed in loosening the bolts and holding the housing in position.

(4) Make an identification mark at the 12 o'clock position on the permanent magnet stator housing.

NOTE

The voltage variation will be approximately 5 percent from maximum to minimum. The maximum movement clockwise or minimum movement counterclockwise is approximately 25 degrees (80 mm).

(5) Rotate stator housing counterclockwise until the voltmeter reading across output terminals is at a minimum level. Make an identification mark on the end bracket adjacent to the mark on the permanent magnet stator housing.

(6) Rotate stator housing clockwise until voltmeter reading across output terminals is at a maximum level. Make an identification mark on the end bracket adjacent to the mark on the permanent magnet stator housing.

(7) Reset permanent stator housing in the mid position between the two identification marks on the end bracket

(8) This setting will give a good starting point, but fine tuning between the two marks on the end bracket is necessary to achieve the optimum setting for voltage response and voltage regulation.

(9) The permanent magnet stator is now positioned correctly for ideal voltage response and regulation. The clamp washers should now be tightened and the position should be marked permanently with a punch or chisel on the end bracket and permanent magnet stator housing.

4-11. REPAIR CYLYNDER HEAD GROUP.

This task covers:
a. Dissembly b. Repair c. Assembly

INITIAL SETUP

Tools

Tool kit, general mechanic's rail
and marine diesel engines,
5180-00-629-9783.
Adapter plate P/N 3376686
Valve spring compression tester
4910-01-142-4929
Drive unit, counterbore P/N 3376685
Cutter plate P/N 3377235
Gauge block P/N 3376200
Torque wrench kit P/N 3377216
Combination wrench set 5120-01-046-4979
Valve tester 4910-01-141-8387
Valve seat insert tool kit P/N ST-257
Valve seat insert cutter P/N ST-662
Valve guide arbor P/N ST-663
Valve facing machine P/N 3376256
Valve guide reamer P/N ST-646
Valve head checking tool P/N 3375933
Valve seat grinder P/N ST-685
Valve guide mandrel P/N 3375282
Drill press 5130-00-293-1949
Dial bore gauge PN 3376619
Head holding fixture P/N ST-583
Engine lifting sling P/N 3375958
Injector sleeve holding tool
P/N ST-1179
Hydrostatic tester P/N ST-1012
Tester adapter plate P/N ST-1013
Staking tool driver P/N ST-1122
Staking tool P/N ST-1124
1/2" Electric drill 4130-00-889-9002
Valve seat reamer P/N ST-1188
Valve seat extractor P/N ST-1279
Valve guide reamer P/N ST-1187
Crosshead guide spacer P/N ST-633
Water hole counter boring tool kit
P/N ST-1010
Injector sleeve puller P/N ST-1244
Bead cutting tool P/N ST-188
Holder and pilot P/N ST-884-1,
ST-884-6
Machinists Measuring Set
5280-00-278-9919

Equipment Condition

Engine cooled below 120°F (50°C).
TM 55-1905-223-10.
Cylinder head removed, para. 2-43.

Tools (Cont'd)

Injector sleeve driver P/N ST-1227
Injector sleeve expander P/NST-880
Injector seat cutter P/N ST-884
Vernier depth gauge

Materials/Parts

Lubricating oil, Item 2, Appendix C
Metal cleaning solvent,
Item 6, Appendix C
Teflon pipe thread lubricant, Item 11,
Appendix C
RTV sealant, Item 45, Appendix C
Prussian blue compound, Item 25, Appendix C
Crocus cloth, (fine) Item 26, Appendix C
Preformed packing P/N 131026, P/N3007759
Crosshead assembly valve P/N 3030038
Setscrew P/N 4147389
Plain hexagon nut P/N 4203131
Valve spring retainer lock P/N 127554
Helical compression spring seat P/N 170296
Helical compression spring P/N 211999
Valve spring guide P/N 3202144
Valve stem guide P/N 3050369
Valve stem guide P/N 3006456
Engine poppet valve P/N 3040830, P/N 135957
Valve seat P/N 3017759
Valve seat P/N 200354
Fuel injection nozzle cooling sleeve P/N 3011934

DISASSEMBLY

a. Clean the cylinder head assembly.

b. Put the cylinder head in the head holding fixture or an equivalent tool to hold the cylinder head during disassembly.

c. Use the valve spring compressor stand and the valve spring compressor plate to compress the valve springs (Figure 4-7).

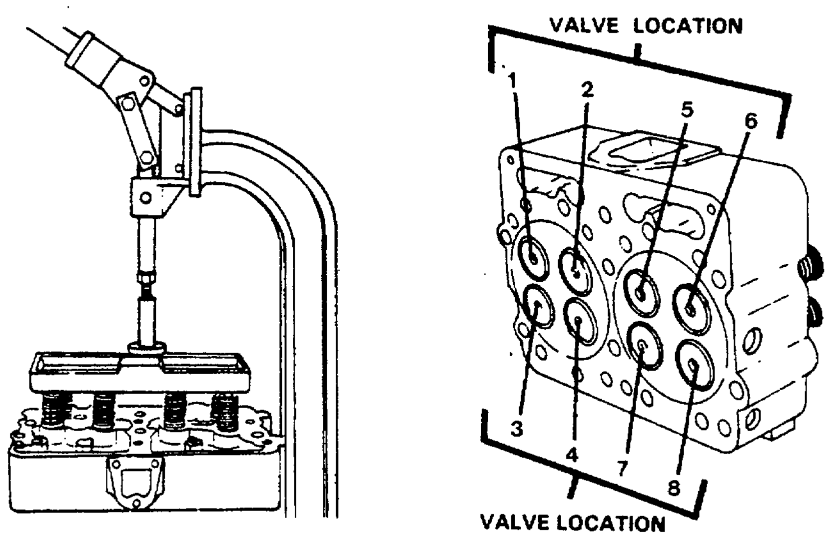


FIGURE 4-7. Removing and Marking Valves.

(1) Be sure that the valve spring compressor stand is fastened to the work bench.

(2) Align the center of the cylinder head with the plunger of the compressor stand.

(3) Position the compressor plate on the cylinder head so the valve stems will be in the center of the holes in the plate.

(4) Pull down the handle on the stand. Make sure the valve stems stay in the center of the holes.

(5) Bring the handle all the way down so the locking pin will engage the hole in the plunger. The locking pin holds the plunger against the plate that compresses the springs.

(6) Remove the valve spring retainer locks (2, Figure 4-8).

(7) Push down on the stand handle and disengage the plunger. Raise the plunger from the cylinder head.

(8) Remove the helical compression springs (1, Figure 4-8), helical compression spring seats (15, 3), and engine poppet valves (9) from the cylinder head (10).

(9) Mark each valve as it is removed to identify its location in the cylinder head. See Figure 4-7.

d. Remove the pipe plug (12, Figure 4-8).

e. Remove the expansion plugs (5, 6, 7, and 11).

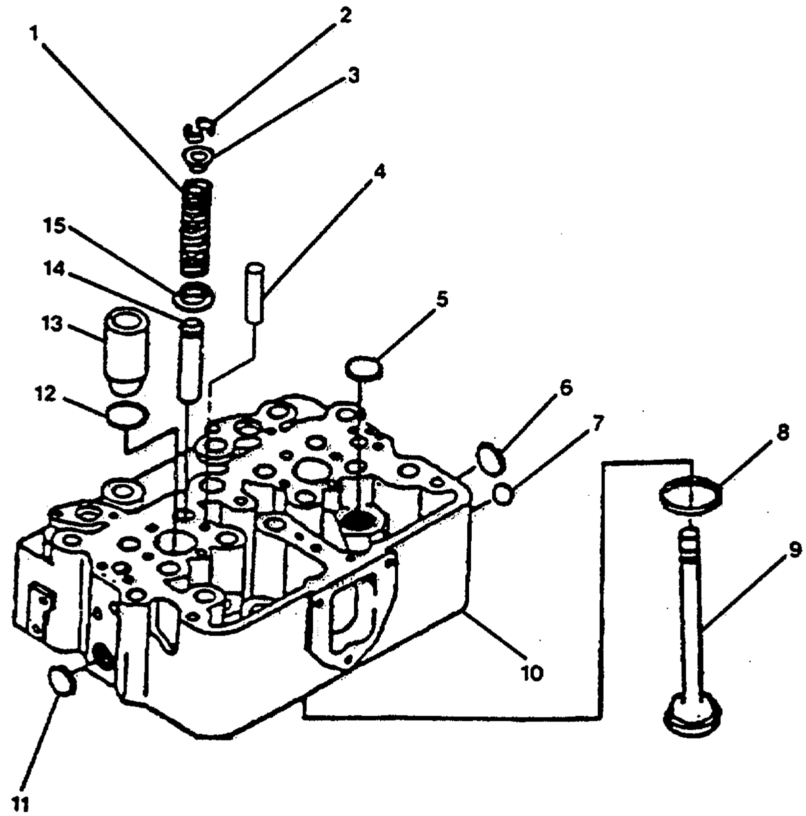


FIGURE 4-8. Cylinder Head Group.

(1) Use a hammer and punch to loosen the cup plug. Hold the punch against the plug, near the outside diameter of the plug, and hit the punch with a hammer to cause one side of the plug to move from its correct location.

(2) Use a screwdriver or pliers to pull the plug from the hole.

REPAIR

a. Clean and inspect the cylinder head and capscrews.

(1) Blow out all capscrew holes, fuel passages, and oil passages.

(2) Use a gasket scraper to remove heavy dirt and debris fom the cylinder head gasket surface.

(3) Use a razor blade scraper and solvent to remove any remaining material from the cylinder head gasket surface.

(4) Clean the head with solvent.

(5) Clean the rocker housing gasket surface on each cylinder head.

(6) Visually inspect the cylinder heads for cracks or damage. Replace the head if cracked or damaged.

(7) Visually inspect the valves for indications of leakage or burning. If indications of leakage or burning are found, the valves and the seats must be replaced.

CAUTION

Do not use caustic or acid solutions to clean the cylinder head capscrews.

(8) Clean the capscrews thoroughly with solvent.

(9) Visually inspect the cylinder head capscrews for damaged threads, corroded surfaces, or other damage.

NOTE

Do not reuse a capscrew that has damaged threads or a reduced diameter from having been stretched.

(10) Replace damaged, worn, and corroded capscrews.

(11) Immediately after cleaning and inspecting, apply a film or clean engine lubricating oil to capscrews that are to be used again.

(12) Clean the valves, springs, and retainers with approved solvent.

b. Cylinder head pressure test procedures.

(1) Install two injector sleeve holding tools in each cylinder head, (Figure 4-9). Each injector sleeve holding tool consists of two hexhead capscrews (1, 5), flat washer (2), anvil (3) and mandrel (4).

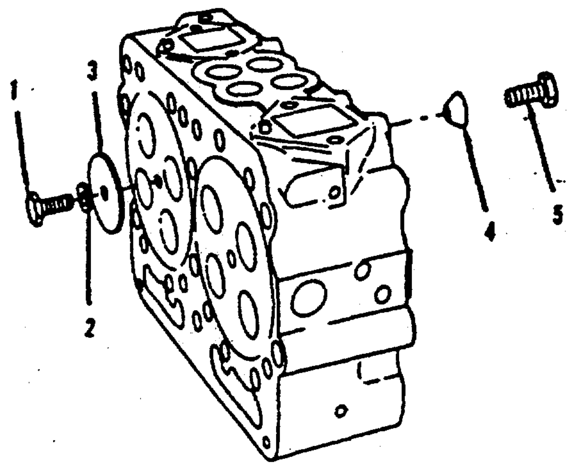


FIGURE 4-9. Injector Sleeve Holding Tool.

(2) Tighten the injector sleeve holding tool capscrews to the following torque values:

(a) Tighten to 45 in-lb torque.

(b) Tighten to 90 in-lb torque.

(c) Tighten to 130 in-lb torque.

(3) Install the cylinder head in a hydrostatic tester and hydrostatic tester adapter plate (Figure 4-10) as follows:

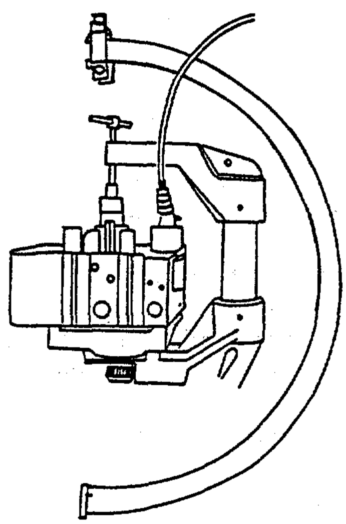


FIGURE 4-10. Hydrostatic Tester and Plate.

(a) Install the plates on the cylinder head. Engage the locating pins for the plates with the holes in the cylinder head.
(b) Install the clamping assembly over the plates on the cylinder head. Engage the locating pins for the clamping assembly with the holes in the plate.
(c) Tighten the screw for the clamping assembly. Make sure the drain valve in the adapter plate is in the closed position.
(d) Use the pins that are supplied with the quadrant to fasten the clamping assembly to the quadrant. Fasten the longer bracket of the quadrant to the bottom of the clamping assembly.

(4) Connect a regulated air supply hose to the test fixture plate.

(5) Adjust the air pressure to 30 to 40 psi (207 to 276 kPa).

(6) Use a hoist to place the cylinder head in a tank of warm water heated to 140°F (60°C).

(7) Completely submerge the cylinder head in the water.

(8) Visually inspect for air bubbles rising from the water.

(9) If air bubbles are observed, replace the cylinder head.

(10) Lift the cylinder head from the tank.

(11) Disconnect air supply hose from test fixture plate.

c. Water pressure test the cylinder head.

(1) Install a pressure regulator and gauge into a hose that connects to the water and air supply.

NOTE

The water and air supply must have shut-off valves.

(2) Set the pressure at 35 to 85 psi (241 to 586 kPa).

(3) Heat water temperature to 180° to 200°F (82° to 93°C).

(4) Connect the hose to the fitting in the plate. Open the drain valve to remove the air from the cylinder head.

(5) Open the valve for the water to fill the cylinder head with water.

(6) Close the valves for the water and drain when all the air has been removed from the head.

(7) Open the valve for the air pressure.

(8) Check the cylinder head for leaks. Be sure to check the areas around the valve seats and the injector sleeve for leaks or cracks.

(9) If leaks are observed, replace the valve seats and/or injector sleeve as necessary.

(10) Close the valve for the air pressure.

(11) Open the valve for the water drain to check the water flow through the cylinder head. If the water does not flow freely, remove the plugs and injector sleeves and clean the deposits from the water passages.

(12) Remove test equipment.

d. Valve Seat Inserts. Inspection and replacement procedures. See Table 4-3 for oversize valve seat insert specifications.

NOTE

To find loose valve seat inserts before they are removed, carefully hit the head with a wood or rubber hammer. If the insert is loose enough so that it moves, replace the insert.

(1) Check the seat area width. If the width is more than 0.125 inch (3.18 mm) and cannot be cut narrower, replace the insert.

(2) Use the following tools to cut the counterbore:

Valve seat insert tool kit
Valve seat insert cutter
Valve guide arbor

(a) Install the arbor into the valve stem guide. Put the adapter sleeve from the tool kit onto the arbor.

(b) Loosen the clamp screws for the swivel and the gear case.

(c) Remove the gear case.

(d) Install the base and swivel onto the arbor and adapter sleeve.

(e) Be sure that the base is flat against the cylinder head.

(f) Use a capscrew to fasten the base to the cylinder head. Do not tighten the capscrew.

(3) Use a seat driver from the tool kit.

(a) The driver must have the same diameter as the cutter.

(b) Install the driver over the arbor and adapter sleeve and through the swivel.

(4) Adjust the position of the base and swivel so the driver will move freely on the arbor.

(a) Tighten the capscrew to hold the base to the cylinder head.

(b) Tighten the clamp screw for the swivel.

(5) Be sure that the alignment is correct, then remove the driver. Use the T-handle arbor puller and remove the arbor.

(6) Apply lubricating oil to the arbor and the hold in the adapter sleeve.

(a) Put the cutter into position over the valve seat.

(b) Install the arbor into the valve guide.

(c) Install the adapter sleeve onto the arbor.

(7) Install the gear case into the swivel.

(a) Engage the bottom of the drive shaft with the top of the cutter. Ensure the drive shaft is against the cutter.

(b) Tighten the clamp screw to hold the gear case and drive shaft in the swivel.

(8) To set the depth of the cutter:

(a) Rotate the feed depth knob counterclockwise four or five complete turns.

(b) Put the new valve seat insert under the knob.

(c) Turn the feed depth knob clockwise until it is against the valve seat insert.

(d) Turn the knob counterclockwise until there is 0.006 to 0.010 inch (0.15 to 0.25 mm) clearance between the knob and the insert.

(9) Turn the feed engaging knob clockwise to engage the feed mechanism. Attach the chuck of a 1/2 inch electric drill to the drive shank.

(10) Start the drill and cut the counterbore until the feed depth knob is against the gear case.

(a) Let the cutter turn two or three more revolutions to ensure the counterbore surface is even.

(b) If the feed engagement knob disengages before the knob is against the gear case, turn the knob by hand to complete the cut.

(11) Loosen the clamp screw for the gear case. Remove the gear case, arbor and cutter. Be careful not to move the base or swivel.

(12) Remove all metal particles and dirt from the counterbore.

(13) Position the valve seat insert in the counterbore.

(14) Be sure that the chamfer on the insert is against the cylinder head.

(15) Install the driver adapter and valve seat driver through the swivel.

(a) Hit the valve seat driver with a heavy hammer to install the valve seat insert into the counterbore.

(b) Ensure the valve seat goes to the bottom of the counterbore.

(c) Remove the adapter, driver, base, and swivel from the cylinder head.

CAUTION

Be careful not to damage the cylinder head when you stake the valve seat insert.

(16) Use the staking tool driver and the staking tool to stake the valve seat insert in the cylinder head. If the staking tool and driver are not available, use a punch to stake the valve seat insert. Be sure that the end of the punch is round.

e. Valve Guides. Inspection and replacement procedures.

(1) Inspection.

(a) Check the inside diameter of the valve guide. Replace the guide if the bore is worn larger than 0.455 inch (11.56 mm).

(b) Measure the bore at four points spaced 90 degrees apart to find if the bore is out-of-round. Check the full length of the bore. Replace the guide if it is out-of-round.

(c) Visually check the guide for damage. Replace if damage.

(2) Replacement.

(a) Remove the worn valve guides. Use the valve guide mandrel to install the new guides.

(b) If the bore for the valve guide is damaged and is to be repaired, use the reamer to cut the bore to measure 0.760 to 0.761 inch (19.30 to 19.33 mm) inside diameter. Ensure the reamer cuts the entire bore. Remove all sharp edges.

NOTE

If the damage to the valve guide bore is not removed by using the reamer, use the reamer to cut the bore to the next largest size. Repeat steps (1) and (2) to cut the bore to measure 0.765 to 0.766 inch (19.43 to 19.46 mm). Install the oversize valve guide. You can ream the hole in the valve spring guides to measure 0.768 to 0.775 inch (19.51 to 19.63 mm) so the spring guides will fit the oversize valve guides.

(c) Use the valve guide mandrel to install the valve guide. Be sure that the height of the valve guide is 1.270 to 1.280 inch (32.26 to 32.51 mm) after it is installed.

(d) Use a new valve to check the inside diameter of the guide. Insert the valve into the guide. The valve stem must move freely.

(e) If the valve does not move freely in the guide, use the valve guide reamer to ream the guide.

(f) Use a drill press that has a floating tool holder to ream the valve guide. Install the reamer in the drill press.

(g) Apply lubricating oil to the reamer while the guide is being reamed.

(h) Do not ream the inside diameter of the guide larger than 0.4532 inch (11.511 mm).

f. Valves. Inspection, grinding and replacement.

(1) Visually inspect the valves as follows:

(a) Clean the valves and polish with fine crocus cloth.

(b) Check the valve head for damage. Measure the thickness of the valve head rim (A, Figure 4-11). The rim must measure a minimum of 0.105 inch (2.67 mm).

(c) Measure the outside diameter of the valve stem. Discard the valve if the stem is damaged or measures less than 0.449 inch (11.44 mm).

(d) Check the grooves in the valve stem for wear. The valve spring retainer lock must fit tightly in the grooves. Discard the valve if the grooves are worn enough that the lock is loose.

(2) Valve grinding.

(a) Use a valve facing machine to grind the face of the valve. Check the setting of the facing machine by using a new valve and an indicator gauge.

(b) Put the valve to be ground in the chuck of the machine. Tighten the chuck on the guide area of the valve stem.

(c) Position the tip of the indicator against the valve face.

(d) Turn the valve. Put a mark on the valve face where the indicator shows the highestreading.

(e) Remove the valve from the chuck.

(f) Turn the valve 180 degrees from the original position in the chuck.

(g) Put the valve in the chuck and tighten the chuck.

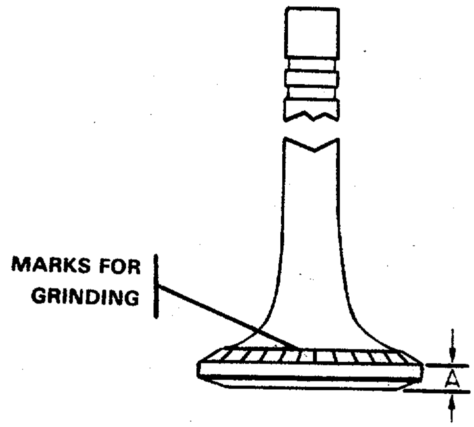


FIGURE 4-11. Rim Measurements and Grinding Marks.

(h) Repeat steps (b) and (c).

(i) If the highest indicator reading is the same, and in the same location of the face when the valve is positioned as in steps (a) and (d) the valve is distorted.

(j) If the highest readings are at different locations on the valve face in steps (a) and (d), the chuck is not in alignment.

(k) The indicator must not show more than 0.001 inch (0.02 mm) difference around the circumference of the valve face.

(l) Grind the face of the valve. Ensure the coolant will spray on the valve head, not on the grinding wheel.

(m) Grind the valve face to an angle exactly 30 degrees from the horizontal position of the valve.

(n) Check the thickness of the valve head rim, Figure 4-11, to ensure that the rim thickness is not less than 0.124 inch (3.15 mm).

(o) Be sure that the valve face has the correct contact against the valve seat.

(p) Put marks on the valve face as shown in Figure 4-11. Use a liquid metal marker.

(q) Install the valve in the valve guide.

(r) Hold the valve against the valve seat and rotate the valve at least 10 degrees. The correct contact against the set will cause the marks on the valve face to be broken.

(s) If the marks are not broken, check the adjustment of the facing machine and the condition of the grinding wheel.

(t) Valves and valve seats that are correctly machined do not require the use of lapping compound to make an airtight seal. If the Valve Seating Test shows leakage, you can use a small amount of lapping compound on the valve and seat to make an airtight seal.

(u) The correct conditions of the valve and valve seats are:

1 No marks or scratches on the valve face or valve seat.

2 No marks or scratches in the valve guide.

3 The angle of the valve face must be exactly 30 degrees.

4 Valve guide to valve stem clearance must be a minimum of 0.0022 inch (0.056 mm).

(3) Replace any valves which have any cracks or damage or which do not have a rim thickness of at least 0.124 inch (3.15 mm).

g. Valve Springs. Inspection and replacement.

NOTE

Weak valve springs can cause wear and damage to the valve and valve seat. Weak springs can also change the valve timing and cause the valve to hit the top of the piston.

(1) Use the valve spring tester to test the valve spring. Compress the spring to the "working length" given in Table 4-1.

(2) Use spacers under the valve spring when the valve and valve seat have had a total of 0.030 inch (0.76 mm) material removed. Do not use more than two spacers under a valve spring.

Table 4-1. Valve Spring Data-inch (mm) lb (N)

	Approximate Working Force to Compress		
Free Length-in (mm)	Length-in (mm)	Minimum-lb (N)	Maximum-lb (N)
2.685 (68.20)	1.724 (43.79)	147.25 (655)	162.75 (724)

(3) Replace any springs that do not meet the specifications in Table 4-3. (See other spring specifications in Table 4-6.)

h. Crossheads and pins. Inspection and replacement.

(1) Crossheads (Figure 4-12).

(a) Check the inside diameter of the bore (3). Replace the crosshead if the bore exceeds 0.440 inch (11.18 mm).

(b) Use a bore gauge to check the bore at two points spaced 90 degrees apart to find if the bore is out-of-round. Replace as required.

(c) Inspect the rocker lever contact surface (1, Figure 4-11) and the valve stem contact surface (2) for wear. Check the adjusting screw and threads in the crosshead (4) for wear or damage.

(d) Replace the crosshead if there is damage to the threads in the crosshead.

(2) Straight headless pin (crosshead guide) (4, Figure 4-8).

(a) Be sure that the pin (guide) is straight. Replace any pin (guide) that is not straight.

(b) Use a micrometer to measure the outside diameter of the pin (guide). The diameter must not be worn to less than 0.432 inch (10.97 mm). Replace as required.

(c) The pin (guide) must be at a right angle to the surface of the cylinder head. Replace the pin (guide) if it is not.

(d) Use the pin (crosshead guide) spacer to install the pin.

(e) Use a spacer or press to install the pin (crosshead guide). Ensure the height of the pin (guide) is between 1.860 to 1.880 inch (47.24 to 47.75 mm) after it is installed.

(f) If the bore for the pin (crosshead guide) is damaged:

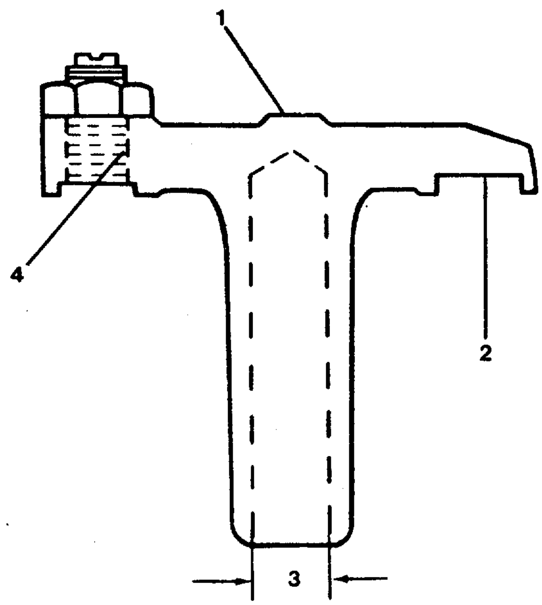


FIGURE 4-12. <u>Crosshead Inspection Areas</u>.

<u>1</u> Use a 29/64 inch drill to cut the bore. Cut the oversize bore to the same depth as the original bore.

<u>2</u> Use a 15/32 reamer to ream the bore. Apply lubricating oil to the reamer as the bore is being reamed.

<u>3</u> Install the pin (crosshead guide) as in steps (e) or (f) ofthis procedure.

i. Cylinder head water holes. Inspection and repair.

(1) Inspection. The surface of the cylinder head around the water holes must not have any scratches, cracks or corrosion deeper than 0.003 inch (0.08 mm). There must not be any defect which extends more than 3/32 inch (2.38 mm) from the edge of the water hole.

(2) Repair.

(a) To repair the water holes, use the following tools from the water hole counterboring tool kit:

Bushing Plate	Drive adapter
Adapter screw	Locating pin
Stop collar	Allen wrench
Counterbore cutter	Gauge block

(b) Adjust the depth of the counterbore cutter:

1 Put the bushing plate on a flat surface with the side of the plate marked "Top" away from the surface.

2 Install the counterbore cutter in the 5/8 inch (15.8 mm) bushing. Ensure the cutter is against the flat surface.

3 Slide the stop collar up on the counterbore cutter.

4 Put the gauge block on top of the bushing plate. Hold the curve at the plate against the cutter.

5 Slide the stop collar down against the gauge block (Figure 4-13). Tighten the setscrew in the stop collar.

6 Remove the cutter and gauge block from the bushing plate.

(c) Put the bushing plate on the cylinder head with the side of the plate marked "Top" away from the cylinder head.

(d) Fasten the busing plate to the cylinder head. Insert the adapter screw through an injector hole and through the bushing plate. Install the adapter knob on the end of the adapter screw.

(e) Insert the locating pin through the 5/8 inch bushing and into the water hole to be repaired. Use your hand to tighten the adapter knob to approximately 50 ft-lb (67 N•m) torque.

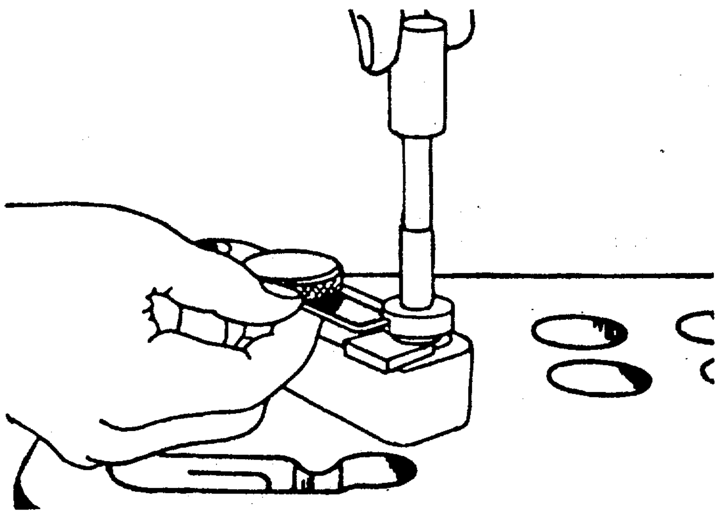


FIGURE 4-13. Adjusting Counterbore Cutter.

(f) Remove the locating pin.

(g) Install the counterbore cutter in the bushing.

(h) Install the drive adapter in an electric drill.

(I) Engage the drill adapter with the counterbore cutter.

(j) Apply minimum downward force while cutting the hole.

(k) Remove the counterbore cutter and bushing plate from the cylinder head.

(l) To install the water passage sleeve:

1 Be sure that the hole is clean and all metal particles and sharp edges are removed.

2 Slide the sleeve into the end of the bushing driver.

3 Apply a coat of sealant to the sleeve.

4 Align the sleeve with the water hole. Hit the bushing driver with a hammer to install the sleeve into the water hole.

5 Cut the sleeve so that it is even with the surface at the cylinder head. Use a flat, wide mill file to cut the sleeve. Be careful and do not damage the surface of the cylinder head when you cut the sleeve.

j. Fuel injector nozzle cooling sleeves (13, Figure 4-8). Inspection and replacement.

(1) Inspection and removal of sleeves.

(a) Check the sleeve for scratches and other damage.

(b) Replace any sleeve which leaks or has damage. Use the injector sleeve puller to remove the sleeve from the cylinder head (Figure 4-14).

NOTE

Do not tighten the hexagon nuts on the injector puller.

(c) Install the puller into the sleeve so that the legs of the bridge of the puller (5, Figure 4-14) are against the surface of the cylinder head.

(d) Install the driver (1) on the puller (5). The driver must be against the large hexagon nut (2). Hit the driver with a large hammer to push the forming collar (4) into the sleeve. Remove the driver.

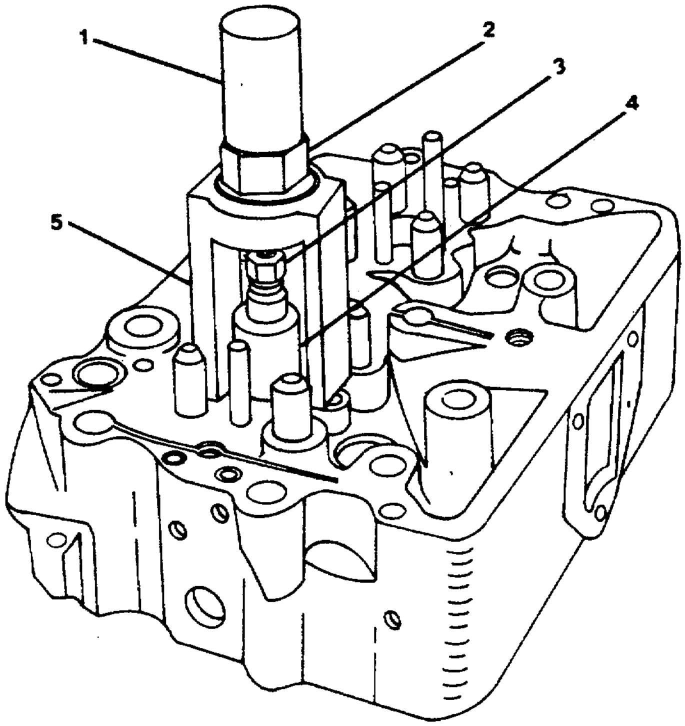


FIGURE 4-14. Injector Sleeve Puller/Driver.

(e) Tighten the small hexagon nut (3) to 50 ft-lb (67 N•m) torque. Do not tighten the nut to more than 60 ft-lb (81 N•m) torque.

(f) Turn the large nut (2) clockwise to pull the sleeve from the cylinder head.

(g) Remove the sleeve from the puller

1 Loosen the large and small nuts (2, 3, Figure 4-14).

2 Hit the small end of the sleeve lightly to loosen it from the puller.

3 Turn the sleeve 120 degrees and slide it from the puller.

(h) Be sure that the bead in the bottom of the injector bore is smooth. Use the bead cutting tool with the holder and pilot to cut the bead in the bore.

(2) Installing new sleeves.

(a) Apply a coat of clean lubricating oil to a new sleeve packing. Install the packing into the groove in the bore for the sleeve (Figure 4-15).

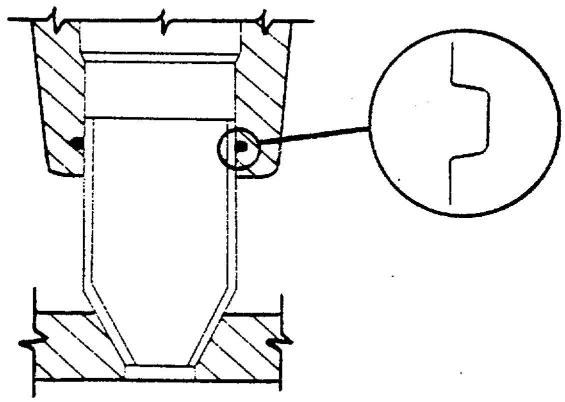


FIGURE 4-15. Installing Injector Sleeve Packing

CAUTION

Do not use a hammer to drive sleeve into bore.

(b) Use the injector sleeve driver to push the sleeve into the bore.

(c) Remove the driver from the sleeve.

(d) Install the injector sleeve holding tool into the sleeve. Tighten the capscrews to 35 to 40 ft-lb (47 to 54 N•m) torque.

(e) Install the driver in the sleeve.

(f) Hit the driver two times with a hammer to ensure the sleeve is against the bottom of the bore.

(g) Remove the driver and tighten the holding tool capscrew again to35 to 49 ft-lb (47 to 54 N•m) torque.

(h) Use the injector sleeve expander to expand the upper section of the sleeve to cause a seal between the sleeve and the cylinder head.

CAUTION

Be careful when you expand the sleeve. Do not damage the sleeve and O-ring.

1 Install the expander into the sleeve. Use an inch-pound torque wrench to turn the mandrel of the expander.

2 Turn the mandrel until the torque wrench indicates 75 in-lb (8.4 N•m).

(i) Remove the expander and the holding tool from the sleeve.

(j) Use the injector seat cutter to cut the injector seat in the sleeve.

1 Install the injector in the cylinder head; tighten the capscrews to 10 to 12 ft-lb (13 to 16 N•m) torque.

2 Use the gauge block to measure the protrusion of the injector tip to find the amount to cut from the sleeve (Figure 4-16).

3 The protrusion of the injector tip must be 0.060 to 0.070 inch (1.52 to 1.78 mm). Remove the injector.

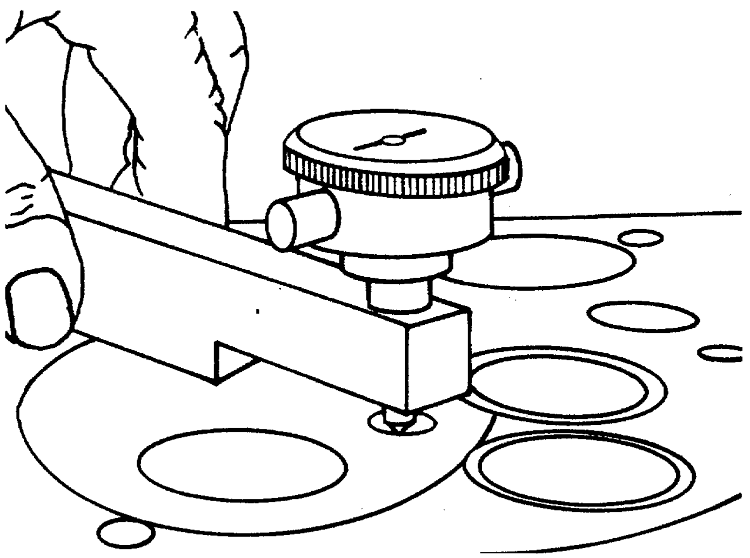


FIGURE 4-16. Using Gauge Block.

(k) Install the cutter and pilot in a drill press.

(1) Cut the seat for the injector. Be sure to use enough oil while cutting the seat.

(m) The seat must have a smooth surface.

(n) Apply Prussian blue compound to the inside of the sleeve at the area of the injector seat. When the injector is installed, the compound must show completely around the injector and must be a minimum width of 0.060 inch (1.52 mm).

(3) Check injector protrusion. Check the sleeve to ensure the protrusion of the injector tip and the seating pattern is correct.

(a) Apply a light coat of blue compound to the injector cup.

(b) Install the injector assembly into the sleeve.

(c) Tighten the capscrews to 10 to 12 ft-lb (13 to 16 N•m) torque.

(d) Remove the injector and check the pattern of the blue compound in the sleeve.

(e) The pattern in the sleeve must be a minimum of 0.060 inch (1.52 mm) wide and 0.469 inch (11.91 mm) from the bottom surface of the cylinder head (Figure 4-17).

(f) If the sleeve does not meet those specifications, it must be replaced.

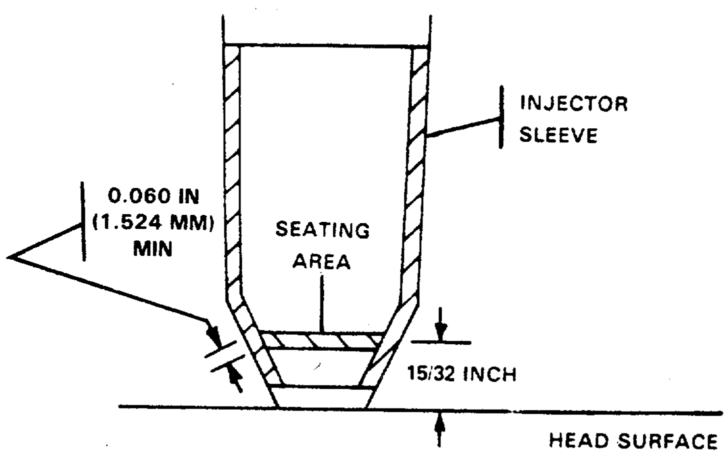


FIGURE 4-17. Injector Sleeve Measurements.

(g) Install the injector assembly into the sleeve.

(h) Install the capscrews and tighten to 10 to 12 ft-lb (13 to 16 N•m) torque.

(i) Use the gauge block to measure the protrusion of the injector tip (Figure 4-16)

(j) The protrusion of the tip must measure 0.060 to 0.070 inch (1.52 to 1.78 mm).

(k) Specifications. Table 4-2 lists specifications for cylinder head, valves, crosshead pins, and injector sleeves. See Figure 4-17 for reference numbers in Table 4-2.

Table 4-2. Specifications for Cylinder Head, Valves, Crosshead Pins, and Injector Sleeves - inch (mm) (Reference No. Keyed to Figure 4-8 Callouts)

Ref. No.	Worn Measurement	New Limit	New Minimum	Maximum
1	Valve Spring Assembled Height (refer to Table 4-4 for free length and wear limits)			2.250 (57.15)
4	Crosshead Pin Outside Diameter	0.432 (10.97)	0.433 (11.00)	0.4335 (11.011)
	Assembled Height		1.860 (47.24)	1.880 (47.75)
	Crosshead Bore	0.440 (11.18)	0.434 (11.02)	0.436 11.07)
8	Valve Seat Insert Outside Diameter (refer to Table 4-3 for oversize speci-fications)		2.0025 (50.864)	2.0035 (50.889)
	Cylinder Head Inside Diameter		1.9995 (50.787)	2.00005 (50.813)
	Insert Height		0.278 (7.06)	0.282 (7.16)

Table 4-2. Specifications for Cylinder Head, Valves, Crosshead Pins, and Injector Sleeves - inch (mm) - CONT

Ref. No.	Worn Measurement	New Limit	New Minimum	Maximum
8	Valve Seat Insert-CONT			
	Run Out in 360 Degrees	0.002 (0.05)		
	Refaced Seat Width		0.063 (1.59)	0.125 (3.18)
9	Valve Stem			
	Outside Diameter	0.449 (11.41)	0.450 (11.43)	0.451 (11.46)
	Face Angle		30 degree	30 degree
10	Cylinder Head			
	Height	4.340 (110.24)	4.370 (111.00)	4.380 (111.25)
13	Injector Sleeve			
	Tip Protrusion		0.060 (1.52)	0.070 (1.78)
14	Valve Guide			
	Inside Diameter	0.455 (11.56)	0.4525 (11.494)	0.451 (11.511)
	Assembled Height		1.270 (32.26)	1.280 (32.51)

Table 4-3. Oversize Valve Seat Insert Specifications - inch (mm)

Oversize Diameter	Oversize Depth	Insert O.D.	Cylinder Head I.D.	Insert Thickness
0.005 (0.13)	Std.	2.0075/2.0085 (50.991/51.016)	2.0045/2.0055 (50.914/50.940)	0.278/0.282 (7.06/7.16)
0.010 (0.25)	Std.	2.0125/2.0135 (51.118/51.143)	2.0095/2.0105 (51.041/51.067)	0.278/2.282 (7.06/7.16)
0.020 (0.50)	0.005 (0.13)	2.0225/2.0235 (51.372/51.397)	2.0195/2.0205 (51.372/51.397)	0.238/0.287 (7.19/7.29)
0.030 (0.76)	0.010 (0.25)	2.0325/2.0335 (51.626/51.651)	2.0295/2.0303 (51.549/51.575)	0.288/0.292 (7.32/7.42)

NOTE

Be sure to measure the insert before machining the head or installing the inset.

Table 4-4. Valve Spring Measurements and Wear Limits - inch (mm)

Free Length Inch (mm)	No. Coils	Wire Diameter Inch (mm)	Length Inch (mm)	Lb (N) Worn Limit	Lb (N) New Minimum	Lb (N) New Maximum
2.685 (68.20)	9	0.177 (4.50)	1.724 (43.79)	143 (636)	147.25 (655)	162.75 (724)

ASSEMBLY

a. Install the pipe plugs, fuel inlet and fuel drain fittings into the fuel passages.

(1) Ensure the fittings and plugs are installed in the same location as their original location.

(2) Apply teflon tape or teflon pipe thread lubricant to the threads.

(3) Tighten the pipe plugs to the torque value given in Table 4-5.

Table 4-5. Pipe Plug Torque - ft-lb (N•m)

Plug Size Inch	Minimum Torque	Maximum Torque
1/16	3 (4)	6 (8)
1/8	5 (7)	10 (14)
3/8	35 (47)	45 (61)
1/2	60 (81)	70 (95)
3/4	65 (88)	75 (102)
1	135 (182)	145 (197)

(4) Apply a coat of expansion plug sealant to the outside diameter of the expansion (cup) plug. Apply a coat of the sealant to the inside diameter at the water hole.

(5) Use the correct expansion plug driver to install the expansion plug (cup) plug.

NOTE

If you do not have expansion plug drivers you can use a mandrel of the correct size to install the plug. Install the plug so it will be even with 0.090 inch (2.29 mm) below the bore chamfer, Figure 4-18. Do not push the plug to the bottom of the counterbore.

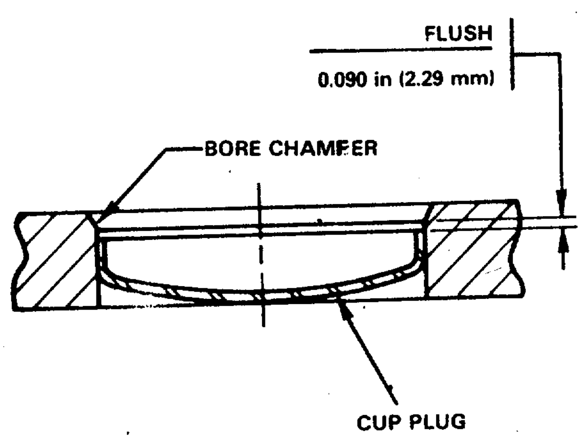


FIGURE 4-18. Expansion (Cup) Plug Specifications.

NOTE

Apply clean lubricating oil to the valve stems.

b. Install the valves in their original positions in the cylinder head and the valve springs in the cylinder head as follows (refer to Figure 4-19):

(1) Engine Poppet Valve - A

(2) Helical Compression Spring Seat - B

(3) Helical Compression - C

(4) Helical Compression Spring Seat - D

(5) Valve Spring Retainer Lock (Collets) - E

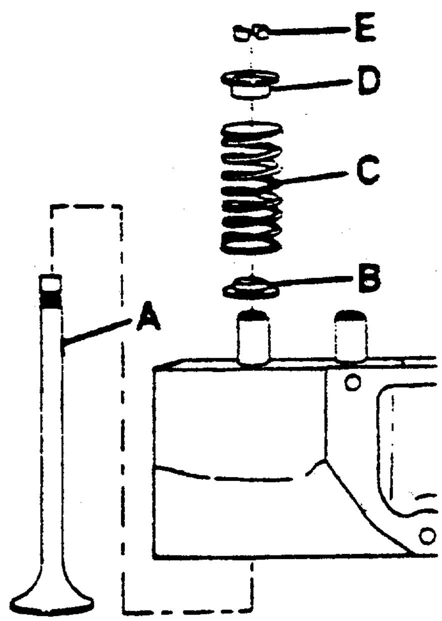


FIGURE 4-19. Valve and Spring Installation Order.

CAUTION

Put the cylinder head on a wood surface to prevent damage to the surface of the cylinder head

c. Compress the valve springs and install new valve spring retainer lock (collets).

NOTE

Cylinder heads that have two valve springs for each exhaust valve require a heavy duty spring guide at the top of the springs, and two spring wear plates at the bottom of the springs.

d. Test the valve seats.

CAUTION

Never vacuum test a cylinder head with the injectors installed. Installing the injectors can cause the valves to be out of alignment and will show leakage during the vacuum test. When the cylinder head is installed to the cylinder block, installing the injectors will not cause the valves to go out of alignment.

(1) Use the valve vacuum tester to check the seal between the valve and the valve seat.

(2) Be sure that the valve and valve seats are clean and dry.

(3) Put the vacuum cup over the valve. The O-ring in the cup must make a seal on the cylinder head around the valve.

(4) Turn the shutoff valve to the open position. Hold down on the pushbutton to stop the vacuum pump.

(5) Operate the vacuum pump until the vacuum gauge indicates between 18 to 25 in. Hg (457 to 635 mm Hg).

(6) Turn the shutoff valve to the closed position. Release the pushbutton to stop the vacuum pump.

(7) Check the time for the gauge to indicate a decrease in vacuum.

(a) Start timing when the gauge indicates "18".

(b) Lightly hit the valve stem with a soft hammer.

(c) Check the connections on the vacuum tester for leaks by starting the pump and holding the cup against a smooth surface. A decrease in vacuum indicates a loose or leaking connection.

(8) If there are no loose or leading connections on the tester, check for leaks between the valve seat insert and counterbore.

(a) Apply a coat of grease to the outside diameter of the insert to make a grease seal between the insert and the counterbore.

(b) Vacuum test and inspect the grease seal. A break in the seal indicates a leak between the insert and counterbore.

(c) Stake the valve seat insert and vacuum test for leaks.

(9) If leaks are indicated in step (8) above, disassemble and grind the valve face and/or the valve seat insert.

(10) Always clean the cylinder head after any grinding or cutting operation.

(11) Reassemble the cylinder head.

e. Install the cylinder head (paragraph 2-43).

4-12. Replace/Repair Cam Follower Housing Group

This task covers: a. Removal b. Inspection c. Installation

INITIAL SETUP:

Tools

Tool kit, general mechanic's rail and marine diesel engines, 5180-00-629-9783
Timing tool P/N 3375522
Combination wrench set 5120-01-046-4979
Dial bore gauge P/N 3376619
Plug gauge P/N ST-195
Lever bushing block/mandrel set P/N 3376026
Mandrel and block P/N ST-249
Machinist Measuring Set 5280-00-278-9919

Materials/Parts

Soap, solid cake, Item 39, Appendix C
Aluminum oxide abrasive paper (240 grit), Item 38, Appendix C
Metal cleaning solvent, Item 6, Appendix C
Engine poppet valve rocker arm P/N 3036935, P/N 3036937
Prussian blue compound, Item 25, Appendix C

Equipment Condition

Cam follower housings removed, para. 3-18, and push rods removed from their sockets.

REMOVAL

a. Remove the lockscrews (1, Figure 4-20) that hold the shafts in the housing (Figure 4-20).

b. Remove the expansion plugs (2) from the ends of the housing.

(1) Use a punch with a sharp point to make a hole in the center of the plugs. Hit one edge of the plug to loosen it.

(2) Use pliers to remove the plug.

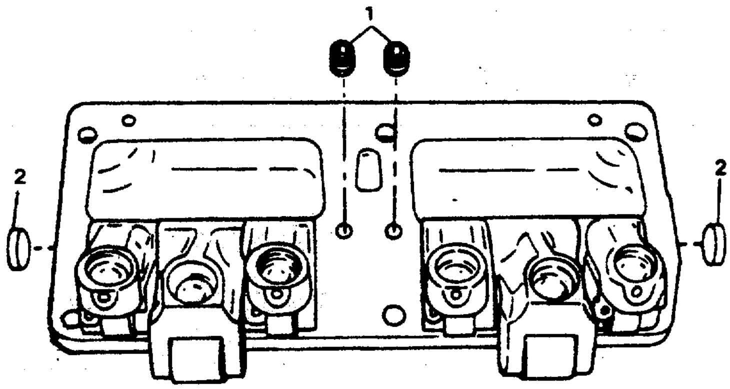


FIGURE 4-20. Cam Follower Lockscrews and Plugs.

c. Push the shaft from the housing.

NOTE

To prevent increased wear, mark the cam follower shafts and the levers to identify their location as they are removed (Figure 4-21).

d. Remove the cam follower levers (engine poppet valve rocker arms) from the housing.

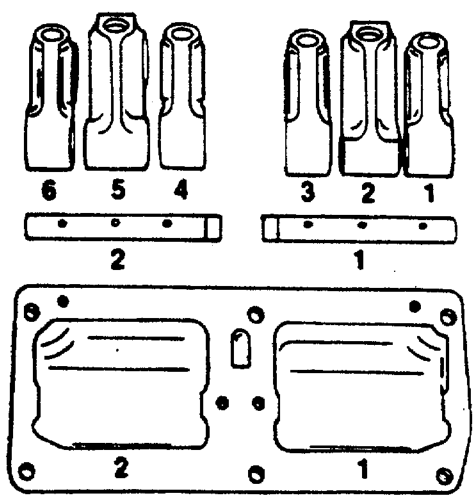


FIGURE 4-21. Marking Cam Follower Levers and Shafts.

REPAIR

a. Cleaning.

WARNING

High pressure compressed air tanks, piping systems, and air operated devices possess potential for serious injury to eyes and exposed areas of skin due to escaping air pressure.

(1) Clean the cam follower shafts in a container of mineral spirits. Use compressed air to dry the shafts.

(2) Clean the other parts with an approved cleaning solvent and dry with compressed air.

CAUTION

Be sure that the oil passages in the levers are clean.

b. Inspecting. Table 4-6 lists specifications for the cam follower assembly. See Figure 4-22 for reference numbers in Table 4-6.

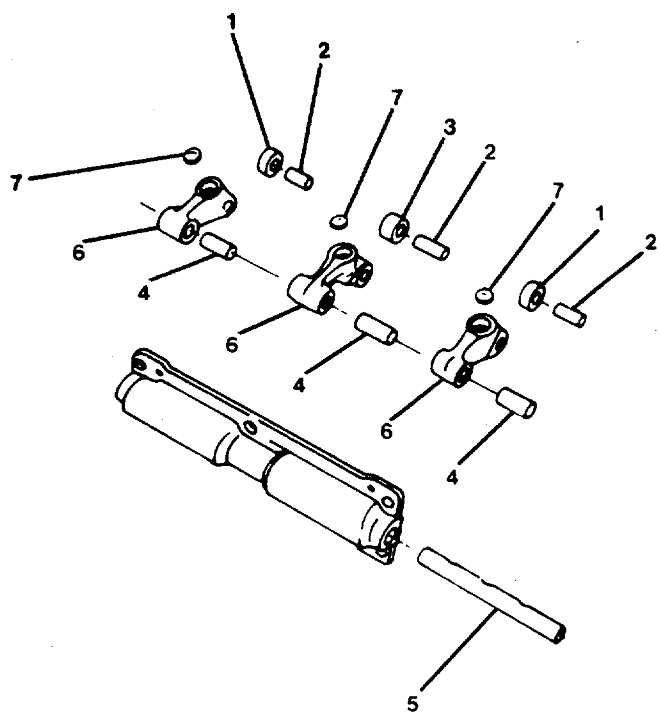


FIGURE 4-22. Cam Follower Housing Group (Push Rods Removed) with Callouts for Table 4-6 References.

Table 4-6. Cam Follower Group Specifications - inch (mm)
(Reference No. Keyed to Figure 4-22 Callouts)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
1	Valve Cam Rollers			
	Inside Diameter	0.503 (12.78)	0.5005 (12.773)	0.5015 (12.708)
	Outside Diameter	1.2485 (31.71)	1.2495 (31.73)	1.2505 (31.76)
2	Roller Pin Diameter			
	Valve	0.497 (12.62)	0.4997 (12.692)	0.500 (12.70)
	Injector	0.697 (17.70)	0.6997 (17.772)	0.7000 (17.780)
	Diameter of Bore for the Roller Pin			
	Valve		0.4990 (12.674)	0.4995 (12.687)
	Injector		0.6992 (17.759)	0.6997 (17.772)
3	Injector Cam Roller			
	Inside Diameter	0.705 (17.91)	0.7030 (17.86)	0.7040 (17.88)
	Outside Diameter	1.2485 (31.71)	1.2495 (31.73)	1.2505 (31.75)
4	Bushing Inside Diameter	0.752 (19.10)	0.7501 (19.053)	0.7511 (19.078)
5	Shaft Outside Diameter	0.748 (19.00)	0.7485 (19.012)	0.7490 (19.02)

(1) Use a micrometer to measure the outside diameter of the shaft.

(a) The shaft must measure 0.7485 to 0.7490 inch (18.012 to 19.01 mm).

(b) Replace the shaft if it is damaged or the outside diameter measures less than 0.748 inch (19.00 mm).

NOTE

On the part of the shaft for the lockscrew, ensure that the grooves are clean.

(2) Inspect the cam follower housing for cracks or other damage. Discard if damaged or worn.

(3) Check the bushing in the cam follower lever for scratches or other damage.

(a) Use inside micrometer to measure the inside diameter of the bushing.

(b) The bushing must measure 0.7501 to 0.7511 inch (19.053 to 19.078 mm).

(c) Replace the bushing if it measures more than 0.752 inch (19.10 mm).

(4) Use a magnetic inspection method to check the levers for cracks. Apply coil magnetization to the levers. Use 300 to 500 amperes with residual Magnaglo. Figure 4-23 shows the areas of the lever to check carefully for cracks.

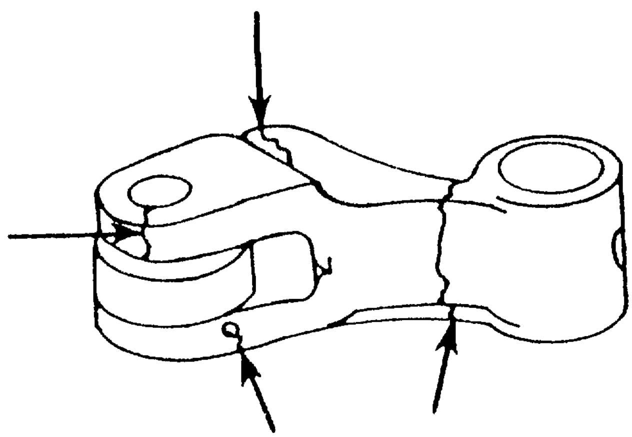


FIGURE 4-23. <u>Inspecting Levers for Cracks.</u>

(5) Check the expansion plug holes in the housing for damage or sharp edges.

(a) Use 240 grit aluminum oxide paper to remove any sharp edges.

(b) Put the aluminum paper in a rod that has a slot in the end to hold the paper. Install the rod in an electric drill.

(c) Start the drill and push the paper through the hole.

(d) Make a chamfer on the edge of the hole and remove any sharp edges.

(6) Check the insert in the cam follower lever for wear or damage.

(a) Use a new push rod ball or a 0.625 inch (15.88 mm) checking ball to check the insert.

(b) Apply a Prussian blue compound to the ball. Put the ball into the insert in the lever and rotate the ball 180 degrees.

(c) Replace the insert if it is damaged or has less than 80percent contact with the ball.

(7) Remove the roll pins, roller pins, and rollers from the cam levers.

(8) Inspect the rollers.

(a) Use a small bore gauge to measure the inside diameter of the rollers.

(b) Check the rollers to be sure they are not out-of-round. See Table 4-8 for the dimensions of the rollers.

(c) Use micrometer to measure the outside diameter at the roller.

(d) The outside diameter of the roller must have a common center within 0.002 inch (0.05 mm).

(9) Use micrometer to measure the outside diameter of the roller pins. See Table 4-8 for dimensions of the roller pins.

(10) Measure the roller pin bore in the cam follower lever. See Table 4-6 for dimensions.

(11) If the rollers are damaged, be sure to inspect the camshaft for damage. Replace any part that is damaged or worn beyond the limits in Table 4-6.

(12) Replace the cam followers if they have any damage or cracks.

(13) Replace the cam followers if they are worn beyond the limit.

(14) Inspect the push rods.

(a) Inspect for engine oil in the push rods as follows:

1 Hold the push rod horizontally and drop it from a height of 6 inches.

2 The push rod may be used if a ringing sound is heard.

3 If a dull (or non-ringing) sound is heard, the push rod contains engine oil and must be discarded.

(b) Inspect the straightness of the push rod by rolling it on a level surface. Replace the push rod if it is bent. Do not use a bent push rod.

(c) Visually inspect the ball and the socket ends of the push rods for uneven wear or scratches.

(d) Visually inspect the push rod ball end for excessive wear.

(e) Visually inspect the seating pattern in the push rod socket for excessive wear.

NOTE

- o If excessive wear is found on the push rod ball end, inspect the cam follower sockets.
- o If excessive wear is found on the socket end, inspect the adjusting screws.

c. Remove the bushing in the cam follower if the inside diameter of the bushing is more than 0.752 inch (19.10 mm). Use the lever bushing block and mandrel to remove the bushing.

WARNING

High pressure compressed air tanks, piping systems, and air operated devices possess potential for serious injury to eyes and exposed areas of skin due to escaping air pressure.

d. Use compressed air to clean the oil passages.

e. Use the bushing block and mandrel to install a new bushing in the lever. Ensure the oil hole in the bushing is aligned with the oil hole in the lever.

f. Cut a chamfer on each end of the bushing. Use a drill press at a slow speed and a chamfer tool that cuts a 60 degree angle chamfer.

g. Put soap into the oil hole in the bushing. This will prevent metal particles from entering the oil hole.

h. Cut the bore in the bushing to measure 0.7501 to 0.7511 inch (19.053 to 19.978 mm).

i. Use the plug gauge to check the bore.

WARNING

High pressure compressed air tanks, piping systems, and air operated devices possess potential for serious injury to eyes and exposed areas of skin due to escaping air pressure.

j. Use compressed air to remove the soap from the oil holes. Wash the lever in cleaning solvent and dry with compressed air.

k. If the cam follower insert (7, Figure 4-22) in cam follower lever was removed, install new insert.

CAUTION

If a new cam follower insert is installed in the lever, a new push rod must also be used.

REPLACEMENT

a. Hold a 0.006 inch (0.15 mm) feeler gauge between the cam follower lever (6, Figure 4-22) and roller (1).

(1) Install the roller pin (2) through the lever (6) and roller (1).

(2) Install the other rollers & pins into the levers.

(3) Install a bushing (4) into each roller (6).

b. Assemble the levers and shafts in the housing. Be sure that the lever for the injector is in the center position in each assembly.

NOTE

Be sure that the push rod sockets in the levers and the dowel holes in the housing are to the top when the assembly is mounted on the engine.

c. Install a temporary screw in the shaft. This will prevent breakage of the lockscrew when the plug is installed in the housing.

d. Apply a light coat of sealant to the cup plug hole in each end of the housing.

(1) Install the expansion plugs (2, Figure 4-20).

(2) Install the plug so it is at least even with the edge of the hole or not more than 0.010 inch (0.25 mm) below the edge of the hole in the housing.

e. Remove the temporary screws and install the lockscrews (1, Figure 4-20) in the shafts.

f. Install the cam follower housing and push rods (paragraph 3-18).

4-13. Repair Camshaft and Gear Group

This task covers: a. Repair

INITIAL SETUP:

Tools

Tool kit, general mechanic's rail
and marine diesel engines,
5180-00-629-9783
Hydraulic press P/N 2009-13
Machinists Measuring Set
5280-00-278-9919

Materials/Parts

Lubricating oil, Item 2, Appendix C
Metal cleaning solvent,
Item 6, Appendix C
Crocus cloth (fine),
Item 26, Appendix C
Lubriplate, Item 28, Appendix C
Wood blocks (to support gear if
removed)
Protective gloves, Item 40, Appendix C
Camshaft P/N 3049024
Spur gear P/N 3035195
Thrust washer P/N 215233

Equipment Condition

Camshaft removal and replacement,
para. 3-23.

REPAIR

a. Inspect the camshaft and gear.

(1) Clean the camshaft and gear with an approved solvent and dry.

NOTE

After the camshaft has been cleaned, do not touch the machined surfaces with bare hands. This will cause rust to form. Lubricate the camshaft with clean engine oil before handling.

(2) Visually inspect the camshaft lobes for cracks, scratches, or other damage. Replace the camshaft if any damage is found.

(3) Use a feeler gauge to measure the clearance between the gear and the shoulder of the camshaft. The clearance must not exceed 0.005 inch (0.13 mm). See Figure 4-24.

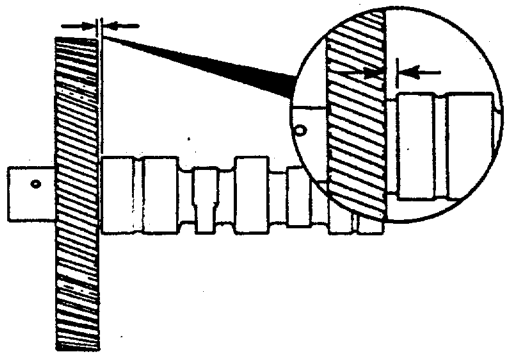


FIGURE 4-24. Measuring Gear and Shoulder Clearance.

(4) Measure the seven bushing journals on the camshaft. They should be between 2.495 inches (63.37 mm) and 2.497 inches (63.42 mm). Replace camshaft if required.

(5) Measure the camshaft thrust washer. The washer thickness should be between 0.090 inch (2.29 mm) and 0.098 inch (2.49 mm). Replace washer if required.

(6) Visually inspect the gear for cracks, chipped or broken teeth, and other damage. Replace the gear if damaged.

b. Remove, inspect, and replace the camshaft gear.

(1) Remove the gear.

CAUTION

Place a wooden block under the camshaft to avoid damage as the camshaft drops free from the cam gear.

(a) Install the camshaft and gear assembly in a hydraulic press. Place V- blocks under the gear. Ensure the V-blocks support the hub area of the gear (Figure 4-25).

CAUTION

Do not use a heating torch to remove the gear. If heating torch is used, a new gear must be installed.

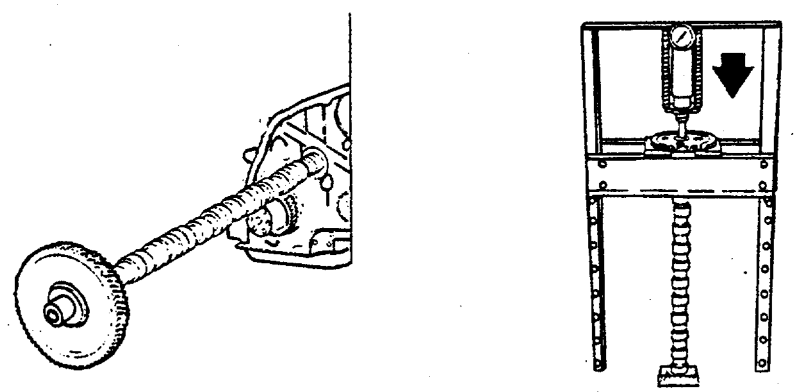


FIGURE 4-25. Removing Camshaft Gear.

(b) Push the shaft from the gear.

NOTE

If the camshaft key is marked with an arrow, record the direction in which it is pointed.

(c) Use a flat chisel and a hammer to remove the camshaft key.

CAUTION

If the inside diameter of the gear is damaged in excess of a 0.125 inch (3.175 mm) wide band, do not use the gear. This damage can result in gear movement on the camshaft nose which can cause camshaft nose failure.

(2) Inspect the gear and gear fit area of the camshaft.

(a) Inspect the bore of the gear for burrs or other damage.

NOTE

If burrs or other damage cannot be removed with a fine crocus cloth, replace the gear.

(b) Inspect the gear keyway for burrs.

(c) Remove burrs with a fine crocus cloth.

NOTE

If the keyway is damaged or the burrs cannot be removed with a fine crocus cloth, the gear must be replaced.

(d) Measure the gear bore (Figure 4-26).

NOTE

Tables 4-7 and 4-8 list I.D. and O.D. of camshaft gear bore.

(e) Visually inspect the camshaft nose in the gear fit area for burrs or other damage.

Table 4-7. Camshaft Gear Bore I.D.

	mm		in
Flanged Camshaft	44.455 44.475	MIN MAX	1.7052 1.7510
Flangeless Camshaft	45.662 45.682	MIN MAX	1.7977 1.7985

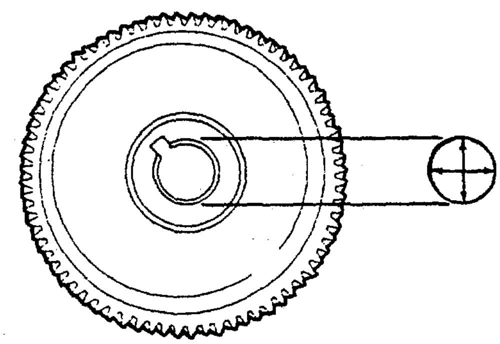


FIGURE 4-26. Measuring Gear Bore.

NOTE

If burrs or other damage cannot be removed with a fine crocus cloth, replace the camshaft.

(f) Measure the camshaft nose in the gear press fit area (Figure 4-27).

(3) Install the gear onto the camshaft.

NOTE

Table 4-9 lists the camshaft key degree of offset, and the approximate injector timing change from nominal.

Table 4-8. Camshaft Gear Bore O.D.

	mm		in
Flanged Camshaft	45.526 44.539	MIN MAX	1.7530 1.7535
Flangeless Camshaft	45.733 45.745	MIN MAX	1.8005 1.8010

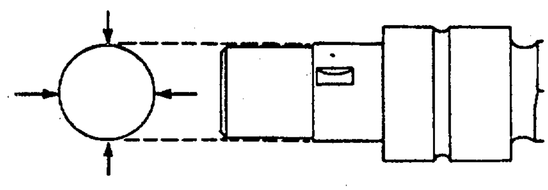


FIGURE 4-27. Measuring Camshaft Nose.

Table 4-9. Camshaft Key Data

Offset (mm)	Inch	Timing Change	Change in Push Rod Travel At 19° BTDC (mm)	Inch
(1.30)	0.0510	Retard	(0.65)	0.0255

(a) Install the camshaft gear key in the camshaft (use a leather hammer).

NOTE

If the same camshaft and gear are used again, use the same part number key as the one that was removed. Ensure the arrow on the key is pointing in the same direction as when it was removed.

(b) Put the camshaft in a vertical position with the gear fit area (nose) pointing up.

(c) Apply Lubriplate or its equivalent to the camshaft gear fit area before installing the gear.

WARNING

Wear protective gloves to prevent personal injury when handling parts that have been heated.

(d) Heat the gear to 500°F (260°C) for a minimum of 1 hour.

NOTE

Install the gear on the camshaft within 30 seconds after it is removed from the oven.

CAUTION

The timing marks and the gear part number must be facing away from the camshaft.

(e) Align the gear keyway with the key in the camshaft, and install the gear.

NOTE

Keep the camshaft in a vertical position with the gear up until the gear has cooled.

(f) If the gear does not seat against the locating shoulder on the camshaft, use a brass drift and a hammer to drive the gear up against the shoulder.

(g) Use a feeler gauge to check the clearance between the camshaft gear and the shoulder. The clearance must not exceed 0.0050 inch (0.13 mm). See Figure 4-24.

c. Install the camshaft (paragraph 3-23).

NOTE

Check the engine timing after engine assembly has been completed (paragraph 3-18).

4-14. Repair Connecting Rod and Piston Group.

This task covers: **a. Disassembly** **b. Inspection** **c. Repair,** **d. Assembly**

INITIAL SETUP:

Tools

Tool kit, general mechanic's
rail and marine diesel engine,
5180-00-629-9783
Piston ring expander P/N ST-763
Piston ring compressor P/N 3822736
Connecting rod guide pins P/N 3375601
Bushing driver P/N ST-1242
Rod checking fixture P/N ST-561
Locating mandrel P/N ST-563
Boring machine P/N 3375115
Arbor press, 4920-00-373-9376
Piston ring groove wear gauge
P/N ST-560
Internal snap ring pliers,
5120-00-595-9551
Dial indicator, 5210-00-277-8840
Dial bore gauge P/N 3376619

Materials/Parts

Piston ring set P/N 3801056
Machine bolt P/N 219153
Piston pin P/N 70550
Piston ring bushing P/N 187420
Bearing P/N 214950
Retaining ring P/N 175755
Piston pin P/N 191970
Lubriplate, Item 28, Appendix C

Equipment Condition

Piston assembly and connecting rods
removed (para. 3-24).

DISASSEMBLY

a. Disassemble the engine connecting rods as follows (1, Figure 4-28):

(1) Remove the machine bolts (10) and separate the connecting rod (1).

(2) Remove the bearings (11).

(3) Mark the cylinder number and the letter "u" in the flat surface of the bearing tang.

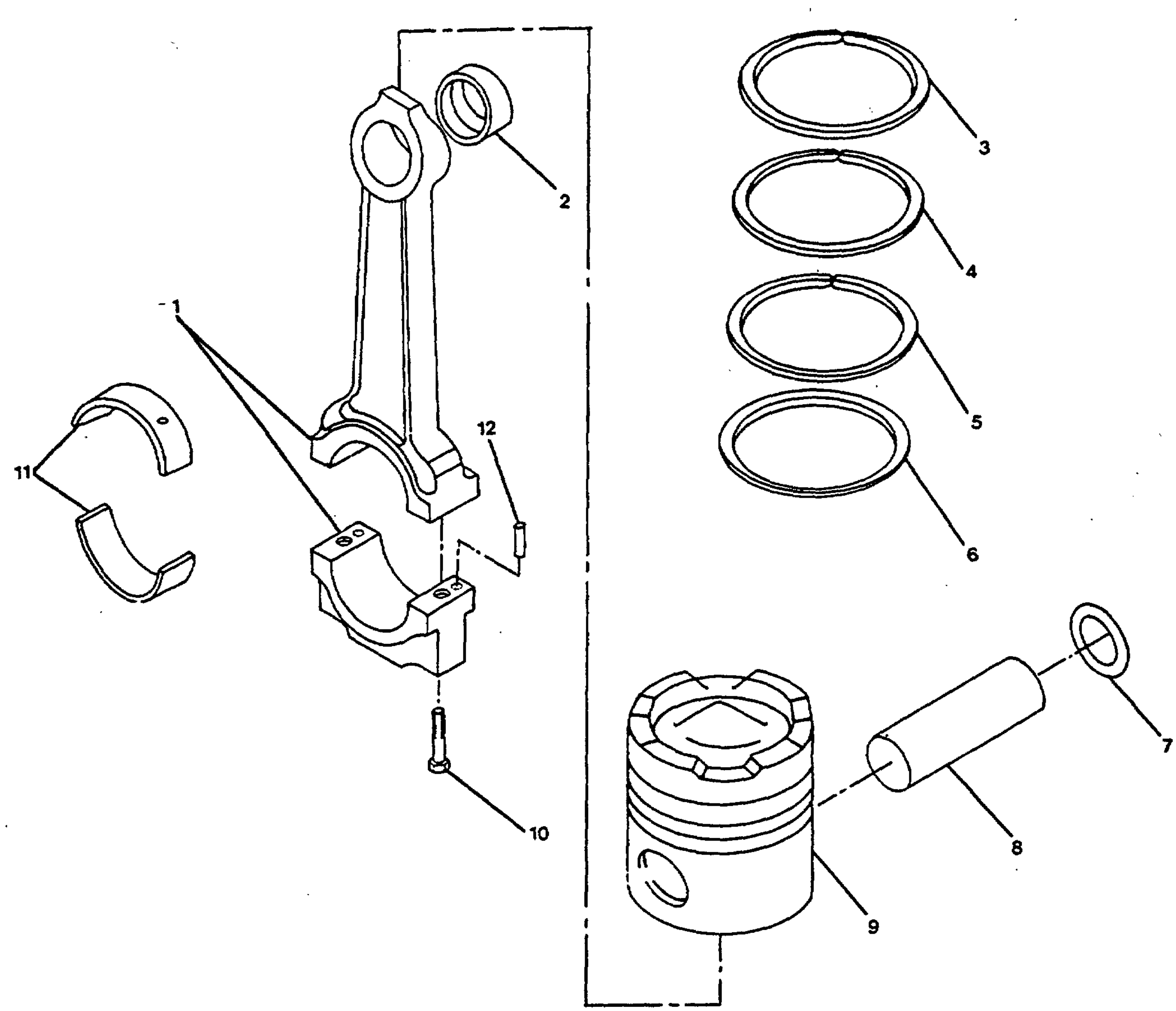


FIGURE 4-28. <u>Connecting Rod and Piston Group</u>.

(4) Remove the (dowel) pins (12) from the connecting rods(1).

b. Use the piston ring expander to remove the piston rings (Figure 4-29).

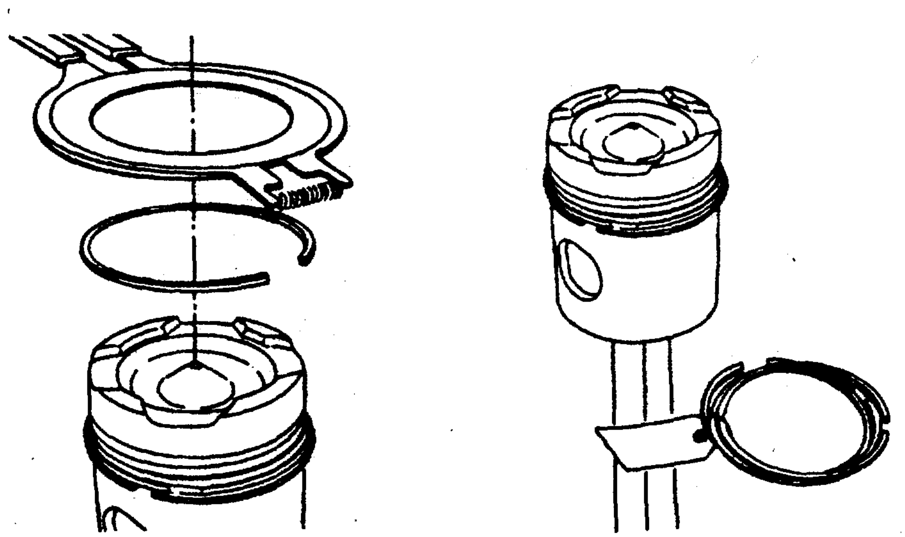


FIGURE 4-29. Removing Piston Rings.

c. Place a tag on the rings, and record the cylinder number of the piston on the tag for future reference (if required).

d. Use internal snap ring pliers to remove the snap rings from both sides of the piston.

e. Put the piston rod assembly in a container of water.

WARNING

Use insulated gloves to prevent injury from boiling water or heated piston.

f. Heat the piston in boiling water for 15 minutes.

CAUTION

Do not use a hammer to remove the piston pins. The piston can distort and cause the piston to seize in the liner.

g. Remove the piston from the water, and use a blunt tool to push the piston pin from the piston and rod assembly.

INSPECTION

a. Inspect the connecting rod bearings (11, Figure 4-28).

(1) Clean the bearings (11) with solvent.

(2) Visually inspect the rods (1), the connecting rod bearing saddles, and the machine bolts (10) for nicks, cracks, burrs, scratches, or fretting.

(3) Visually inspect the bearings (11) for damage.

NOTE

- o Replace any bearings with lock tang damage or scratches (deep enough to be felt with a fingernail). Also replace any bearings which show pitting, flaking, or corrosion in the copper lining.
- o Bearing shells (12) are available for crankshafts which are 0.010 inch (0.25 mm), 0.020 inch (0.51 mm), 0.030 inch (0.76 mm), or 0.040 inch (1.02 mm) undersize. Crankshafts which are ground undersize in the connecting rod or the main bearing journals are marked on the front counterweight. If the crankshaft is marked, check the bearing shell to make sure the correct bearing size is used (Figure 4-30).

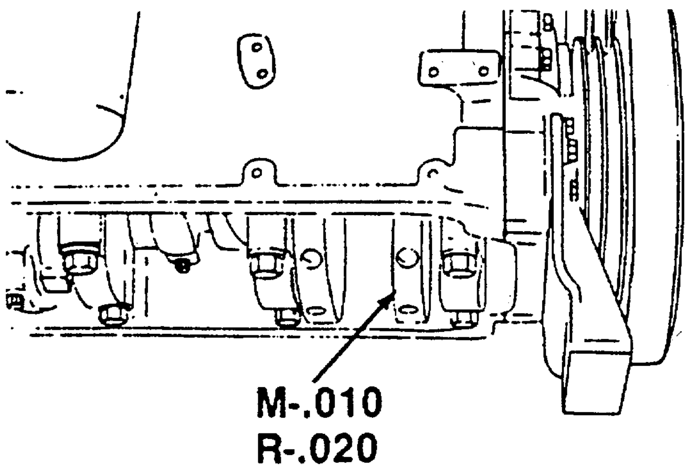


FIGURE 4-30. Counterweight Markings for Bearing Sizes.

NOTE

Normal bearing wear produces a smooth finish that will wear into the copper lining. Exposed copper does not always indicate worn bearings. If large areas of copper lining are visible in the bearings before the engine has accumulated 3,750 hours, inspect the engine for contamination from fine dirt particles and correct the problem.

(4) Visually inspect the bearing seating surface for nicks or burrs.

(5) If nicks or burrs can not be removed with a fine crocus cloth, the bearings (11, Figure 4-28) must be replaced.

(6) Measure the rod bearing shell (11) thickness with an outside micrometer that has a ball tip.

(7) The bearing thickness should be between 0.093 inches (2.362 mm) and 0.0947 inches (2.405 mm). Replace bearing shell (11) if it is not within these measurements.

b. Clean and inspect the connecting rods (1).

(1) Use steam or solvent to clean the connecting rods (1).

(2) Use a nylon bristle brush to clean the oil drillings.

(3) Dry with compressed air.

(4) Replace the rod (1) if the I-Beam is nicked or damaged.

(5) Inspect the rod pin bore bushing (2) for damage or misalignment of the oil passage and the bushing.

(6) Use the magnetic particle detection kit to find cracks in the connecting rods (1) and machine bolts (10). Discard the part if cracks are found.

NOTE

Some joints in the forging will show as cracks. Make sure to check the rod for the location of these joints. These lines are not an indication of cracks. Do not discard parts with these marks.

(7) Inspect the connecting rod pin bushing boreand crankshaft bore.

(a) Be sure to keep the connecting rod (1) and the cap together.

(b) Assemble the rod (1) and tighten the machine bolts (10) to the correct torque in the correct sequence. Figure 4-31 shows the correct sequence, and Table 4-10 gives torque specifications.

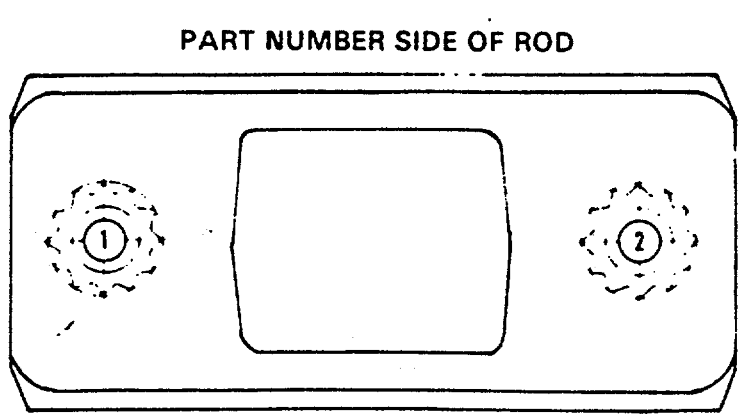


FIGURE 4-31. <u>Connecting Rod Torque Sequence</u>.

Table 4-10. Connecting Rod Torque Specifications

		Minimum ft-lb.	Maximum ft-lb.
Step 1.	Tighten to	70	75
Step 2.	Tighten to	140	150
Step 3.	Loosen completely		
Step 4.	Tighten to	25	30
Step 5.	Tighten to	70	75
Step 6.	Tighten to	140	150

(c) Measure the crankshaft bore in the connecting rod (1, Figure 4-28) with a dial bore gauge.- The connecting rods must have a crankshaft bore with a diameter between 3.3157 to 3.3167 inches (84.219 to 84.244 mm).

(d) Measure the inside diameter of the piston pin bushing (2). Use a dial bore gauge. The inside diameter must measure between 2.0010 to 2.0015 inch (50.825 to 50.838 mm).

(e) If the crankshaft bore is not correct, the connecting rod (1) must be machined to the correct size or replaced.

(f) Discard all connecting rods (1) that have cuts, scratches or other damage that is deeper than 1/32 inch (0.80 mm) on the I-Beam.

(8) Calibrate the rod checking fixture, ST-561, and locating mandrel, ST-563, and check the connecting rod length.

(a) Use a new connecting (master) rod that measures 12.000 inches (304.80 mm) between the centers of the crankshaft bore and the piston pin bore to calibrate the fixture.

(b) Select the correct piston pin mandrel from the locating mandrel and install it in the piston pin bore.

(c) Install the arbor in the crankshaft bore and expand the arbor.

(d) Make sure the pin on the arbor is down and locked in position in the center of the connecting rod.

(e) Put the connecting rod (1) in the fixture. Move the dial holder so that the contact points of the indicators are touching the mandrel in the piston pin bore.

(f) Tighten the bracket to hold the indicators and set the indicator dials at zero.

(g) Remove the connecting rod (1) from the fixture.

(h) Turn the rod (1) horizontally 180 degrees and put the rod (1) in the fixture.

(i) If the dial indicators show any change from the first reading, adjust the dials to half of the indicated change.

(j) In either position that the connecting rod (1) is put in the fixture, the dials will show the same reading, but in opposite directions on the dials. At this point the fixture is calibrated.

(9) Check the alignment of the connecting rod (1).

(a) Install the mandrel and arbor in the connecting rod (1) to be checked. See steps (12) (b), (c) and (d) in the calibration procedure above.

(b) Put the connecting rod (1) in the fixture.

(c) Measure the length. The rod (1) must be no longer than the master rod and no more than 0.002 inch (0.05 mm) shorter.

(d) Check the bore alignment by using the difference between the indicator readings. It must not be more than 0.10 inch (0.25 mm) without a bushing installed or 0.004 inch (0.10 mm) with a bushing installed.

(10) Measure the amount of twist in the rod (1).

(a) Measure with a feeler gauge between the mandrel and the dial indicator holding plate.

(b) Without a piston pin bushing (2), the twist must be no more than 0.020 inch (0.51 mm).

(c) With a bushing (2) installed and machined to the correct size, the twist must be no more than 0.010 inch (0.25 mm).

(11) Measure the connecting rod machine bolts (10).

(a) Check the smallest diameter. Discard if the diameter is less than 0.583 inch (14.81 mm).

(b) Replace any machine bolts (10) that have damaged threads.

(12) Measure the pilot bore in the bolt holes.

(a) If the pilot bore in the rod (1) is larger than 0.6249 inch (15.872 mm), discard the rod.

(b) If the pilot bore in the cap (11) is larger than 0.6252 inch (15.880 mm), discard the cap (11).

(13) Check the radius on the bolt pad.

(a) The pad must have a fillet radius of 0.045 to 0.055 inch (1.14 to 1.40 mm). See Figure 4-32.

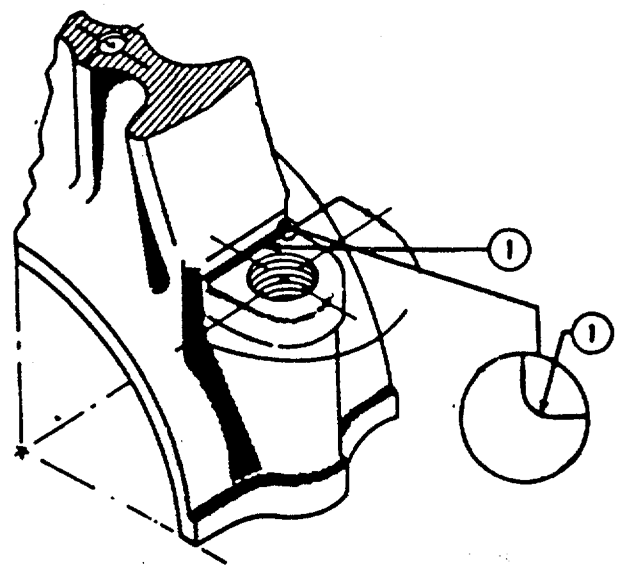


FIGURE 4-32. Fillet Radius.

(b) A maximum of 0.0625 inch (1.587 mm) material can be cut from the pad to repair the radius.

(c) Remove any sharp edges from the pad.

c. Clean and inspect the pistons.

CAUTION

To avoid damage to the pistons, make sure the cleaning solvent is approved for aluminum. Refer to Federal Specification PD-680.

(1) Allow the piston to soak for a minimum of 30 minutes in a tank containing an approved cleaning solvent for aluminum.

(2) Use a hot, soapy solution and a nonmetallic brush to remove carbon deposits.

CAUTION

- Do not use a metal brush. A metal brush will damage the piston ring grooves. Do not use glass beads to clean the grooves. Walnut shell blasting may be used on grooves with a ni-resist insert and on the dome of the piston.
- Use the minimum effective pressure and do not concentrate the spray in one area for an extended period of time.
- Do not use walnut shell blasting on the pin bores or aluminum grooves. This can damage pin bore surface finish or prevent the rings from seating correctly in the grooves.

(3) Steam clean the pistons and dry with compressed air.

(4) Visually inspect the piston bowl, pin bore, and skirt for cracks or damage. Replace damaged parts as required.

NOTE

Do not use pistons with dome cracks.

(5) Use the piston ring groove wear gauge ST-560 to inspect the top and second grooves.

NOTE

The widest part (shoulder) of the tool must not come in contact with the piston. Replace the piston if the shoulder touches the piston.

(6) Hold a new ring in the groove. Install a 0.006 inch (0.152 mm) feeler gauge. If the feeler gauge enters the groove without resistance, there is too much wear. Replace the piston.

(7) Measure the outside diameter of the piston as follows:

(a) Measure at right angles to the piston pin bore.

(b) Piston temperature must be between 70ºF (21ºC) to 90ºF (32ºC).

(c) Replace piston that measure less than 5.483 inches (139.27 mm) outside diameter.

(8) Measure the piston pin bore inside diameter when the piston temperature is 68 ° F (20 ° C).
It should be between 1.9985 inches (50.762 mm) and 2.0000 inches (58.8 mm).

NOTE

Add 0.0005 inch (0.013) to the bore inside diameter per 10°F (5°C) temperature rise up to 90°F (32° C).

(9) Inspect the piston pin for scratches, grooves, or other damage. Replace the pin if damage.

(10) Measure the piston pin outside diameter. It must be between 1.9985 inches (50.762 mm)
and 1.9990 inches (50.775 mm).

(11) Discard the piston pin if it is more than 0.001 inch (0.03 mm) out-of- round.

(12) To check the ring gap, install the new piston rings in the cylinder liner in which they will be used.

(13) Use the top part of the piston to position the ring in the liner correctly.

(14) Use a feeler gauge to inspect the ring gap. Replace the ring if it does not meet the following specifications:

Piston Ring Gap

Position	MIN	MAX
Top	0.017-inch (0.43 mm)	0.027-inch (0.68 mm)
Second	0.020-inch (0.51 mm)	0.030-inch (0.76 mm)
Third	0.019-inch (0.48 mm)	0.029-inch (0.74 mm)
Oil	0.010-inch (0.25 mm)	0.025-inch (0.64 mm)

NOTE

Add 0.003 inch (0.08 mm) to the maximum limit for each 0.001 inch (0.03 mm) wear in the cylinder inner wall (Figure 4-33).

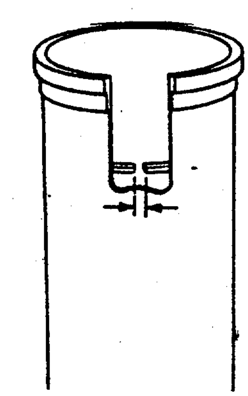


FIGURE 4-33. Ring Gap.

REPAIR

a. Repair the crankshaft bore of the connecting rod (1, Figure 4-28) if:

(1) The bore is larger than 3.3167 inch (84.244 mm).

(2) The face of the connecting rod (1) is damaged.

b. To make repairs:

(1) Use the bushing driver, ST-1242, to remove the piston pin bushing (2).

(2) Install the cap on the connecting rod (1) and tighten the machine bolts (10) to the torque listed in Table 4-10.

(3) Use the checking fixture, ST-561, to measure the length of the rod (1). Discard the rod if the length is 11.991 inches (304.57 mm) or less.

(4) Remove the cap from the rod (1).

NOTE

- A maximum of 0.009 inch (0.23 mm) can be removed from the rod and cap. Equal amounts of material must be removed from the rod and the cap. The length of the rod must be 12.000 inches (304.80 mm) before you can remove a maximum of 0.009 inch (0.23 mm) from the rod and cap. If the maximum of 0.009 inch (0.23 mm) had to be removed, the rod must measure 11.991 inches (304.57 mm) in length after machining.

- The alignment of the bolt bores in the rod (1) and cap must not change. Hold the rod (1) and cap in a clamp that holds the rod in alignment when cutting material from the surfaces.

- Use lapping compound to polish the surfaces that were machined. Apply a blue compound to the surfaces and check them against a flat plate.

- The area outside the centerline of the bolt bores (the area farthest from the crankshaft bore) must show 100 percent contact. The remaining area must show a minimum of 75 percent contact.

(5) Install the cap on the rod (1) and tighten the machine bolts (10) to the torque listed in Table 4-10.

(6) Cut the crankshaft bore with the boring machine, P/N 3375115, that has a precision fixture to keep the piston pin bore and crankshaft bore in alignment. The surface of the bore must be smooth within 75 micro-inches.

(7) Put the connecting rod (1) in the fixture, ST-561, and check the alignment.

(8) Cut the inside diameter of the bore for rods with bolts and nuts to measure 3.2722 to 3.2732 inches (83.114 to 83.139 mm), or cut the inside diameter of the bore for rods with capscrews to measure 3.3157 to 3.3167 inches (84.219 to 83.139 mm).

c. Install the piston pin bushing (7, Figure 4-34).

(1) Put the bushing (7), on the mandrel (1).

(2) Put the sleeve (4) and then the cup (2) on the mandrel (ST-1242).

(3) Fasten the cup (2) on the mandrel (1) with the locking pin (6).

(4) Put the connecting rod (8) on the block (3) and hold it in a horizontal position.

(5) Insert the mandrel (1) into the bore of the connecting rod (8).

(6) Align the sleeve (4) with the middle of the boss on the connecting rod (8).

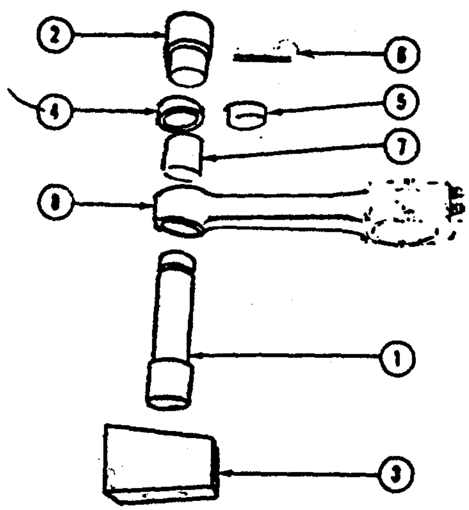


FIGURE 4-34. Installing Piston Pin Bushing.

NOTE

Make sure the oil holes are in alignment.

(7) Use an arbor press to push the bushing (7) into the bore until the sleeve (4) is in contact with the connecting rod (8).

(8) Check the alignment of the oil holes. Make sure an 1/8 inch (3.17 mm) diameter rod can move freely through the connecting rod (8) and bushing (7).

d. Cut the bore in the piston pin bushing (7).

(1) Fill the oil holes with soap to prevent metal particles from entering the holes.

(2) Install the connecting rod (8) in the boring machine.

NOTE

To put the connecting rod in the correct position to cut the bore in the bushing, use only the two horizontal blades of the lower mandrel on the machine.

(3) The instructions for the boring machine are included with the machine.

(4) Cut the bushing (2) to 2.0010 to 2.0015 inches (50.825 to 50.838 mm) inside diameter.

(5) Remove the rod (8) from the boring machine and check the bore with a dial bore gauge.

(6) Remove all sharp edges.

(7) Remove any metal particles and the soap from the oil holes.

(8) Wash the bores and holes with mineral spirits and dry with compressed air.

(9) Use the checking fixture ST-561 to check all the dimensions.

ASSEMBLY

a. Piston pin.

(1) Install a new snap ring (7, Figure 4-28) in the snap ring groove of the piston pin bore at each position.

(2) Heat the pistons (9) in boiling water for 15 minutes or in an oven for 30 minutes at 212°F (100ºC).

(3) Use clean engine oil to lubricate the connecting rod piston pin bore and the piston pin (8).

WARNING

Use insulated gloves to prevent injury from boiling water or the heated piston.

(4) Remove the piston (9) from the water or the oven.

(5) Align the pin bore of the rod (1) with the pin bore of the piston (9), and install the piston pin (8).

CAUTION

Do not use a hammer to install the piston pin. The piston will be damaged.

NOTE

The cylinder number on the piston top must be toward the bearing tang side of the rod.

(6) Install a new snap ring (7) in the second piston pin bore snap ring groove. The snap ring must be seated completely in the snap ring groove.

b. Piston rings.

(1) Use a piston ring expander to install the piston rings (3, 4, 5, 6) with the part number, mark, or the work "TOP" toward the top of the piston (Figure 4-35).

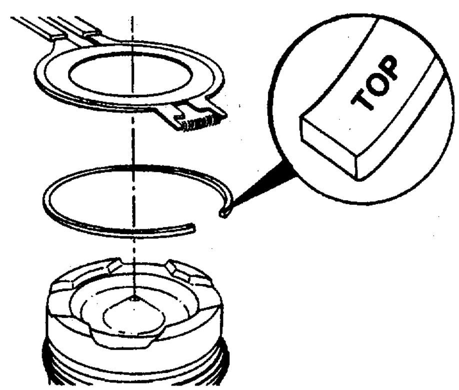


FIGURE 4-35. Installing Rings

(2) A cross-sectioned view of an oil control ring is shown. The two-piece oil control ring must be installed with the expander ring gap 180 degrees from the gap of the oil ring (Figure 4-36).

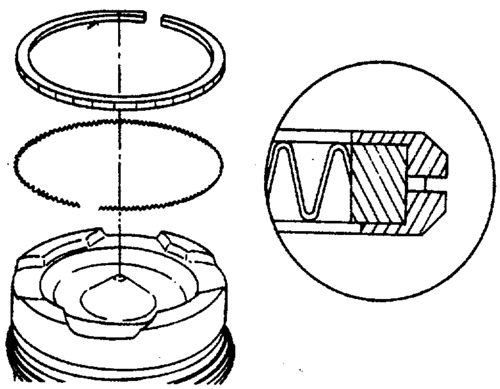


FIGURE 4-36. Oil Control Ring.

(3) The piston ring shipping package identifies the location of each piston by ring part number. Install the rings in the position shown (Figure 4-37).

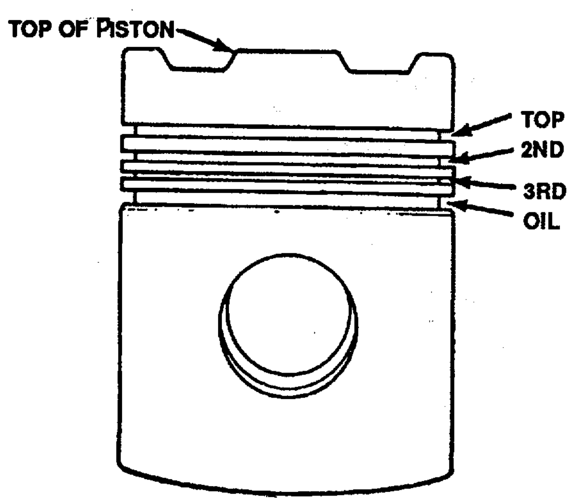


FIGURE 4-37. Ring Positions.

c. Rod bearings.

(1) Install the upper and lower bearings in the connecting rod (1, Figure 4-28).

(2) If used bearings are to be installed, each bearing must be installed in its original location.

NOTE

The tang of the bearing must be in the slot of the rod.

(3) Use clean Lubriplate 105 or equivalent to lubricate the bearings.

(4) Apply a heavy film of clean engine oil to the liner.

(5) Install the (dowel) pins (12) in the connecting rod (1).

(6) Join the connecting rod halves (1).

(7) Install machine bolts (10).

d. Install piston assembly and connecting rods (para. 3-23).

4-15. REPAIR FLYWHEEL AND FLYWHEEL HOUSING GROUP

This task covers: **a. Repair.**

INITIAL SETUP

Tools

Tool kit, general mechanic's rail
and marine diesel engines,
5180-00-629-9783
Engine lifting fixture P/N 3822512
Engine lifting sling P/N 3375958
Torque wrench kit P/N 3377216
Combination wrench set 5120-01-046-4979
Magnetic crack detector ST-1166

Materials/Parts

Coil, electric P/N 3034572
Heat determining crayon or
equivalent, Item 41, Appendix C
Metal cleaning solvent,
Item 6, Appendix C
Crocus cloth (fine),
Item 26, Appendix C
Spur gear P/N 4851
Protective gloves, Item 40, Appendix C

Equipment Condition

Flywheel and housing removed,
para. 3-25.

REPAIR

a. Clean the flywheel (13, Figure 4-38) with solvent.

b. Inspect for nicks or burrs. Check for cracks with magnetic crack detector ST-1166.

c. Use a fine crocus cloth to remove small nicks and burrs.

WARNING

Do not use a cracked or resurfaced flywheel. It can break, causing serious personal injury or property damage.

d. Inspect the flywheel spur gear (14) teeth for cracks and chips.

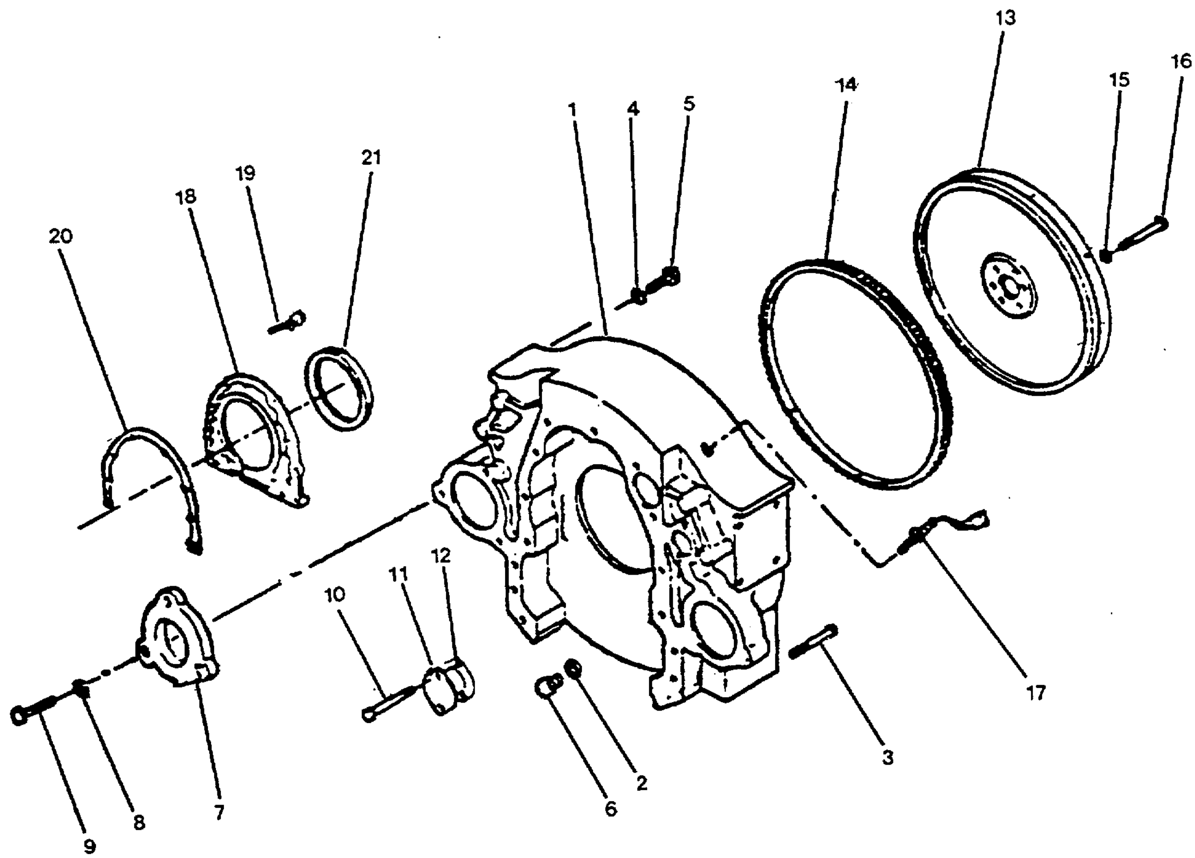


FIGURE 4-38. Flywheel and Housing Group.

NOTE

If the ring gear teeth are cracked or broken, the ring gear must be replaced.

e. Inspect the flywheel housing (1).

(1) Use solvent to clean the housing.

(2) Visually inspect all surfaces for nicks, burrs, or cracks.

(3) Use a fine crocus cloth to remove small nicks and burrs.

f. Flywheel spur gear replacement (14).

(1) Remove the spur gear (14) from the engine flywheel as follows.

CAUTION

Do not use a cutting torch to heat the spur gear. The flywheel can be damaged. Use a heating torch to heat the ring gear.

(a) Heat the outside diameter of the spur gear (14).

(b) Use a blunt chisel and a hammer to remove the gear from the flywheel (13).

(2) Install a new spur gear (14) on the flywheel (13):

(a) Heat the gear to 600ºF (316°C) for a minimum of 1 hour. Use a heat determining crayon, or equivalent, to check the gear temperature before installing it on the flywheel.

NOTE

Do not overheat the spur gear. The metal hardness will be changed.

WARNING

Wear protective gloves to prevent personal injury when handling parts that have been heated.

(b) Install the spur gear (14) on the flywheel (13) immediately after heating.

g. Install the mechanical drive (flywheel) housing (1). Refer to paragraph 3-24.

h. Install and adjust the magnetic pickup (17) (paragraph 3-24).

4-16. REMOVE/REPAIR CRANKSHAFT GROUP.

This task covers: a. Removal, b. Repair, c. Replacement

INITIAL SETUP

Tools

Tool kit, general mechanic's rail
and marine diesel engines,
5180-00-629-9783
Engine lifting fixture P/N 3822512
Engine lifting sling P/N 3375958
Main bearing cap puller
P/N ST-1178
Gear puller P/N 3375082

Materials/Parts

Metal cleaning solvent,
Item 6, Appendix C
Lubriplate, Item 28, Appendix C
Crocus cloth (fine),
Item 26, Appendix C
Ring, retaining (dowel) P/N 3037045
Crankshaft, engine P/N 360883
Lubricating oil, Item 2, Appendix C
Protective gloves, Item 40, Appendix C

Equipment Condition

Crankshaft pulley and dampener
removed, para. 3-26.
Gear cover assembly removed,
para. 3-20.
Oil pan group removed, para. 3-21.

REMOVAL

CAUTION

Do not damage the crankshaft when removing the key.

a. Remove the crankshaft gear (10, Figure 4-39) with a gear puller and remove key (9).

b. Remove the engine main bearings (1, 2, 4, 6, 7, and 8) and thrust bearings (3) as follows:

CAUTION

The main bearing caps are marked for position on the camshaft side and the cylinder block identification on the exhaust side. Mark any caps that are not marked before removing them from the cylinder block.

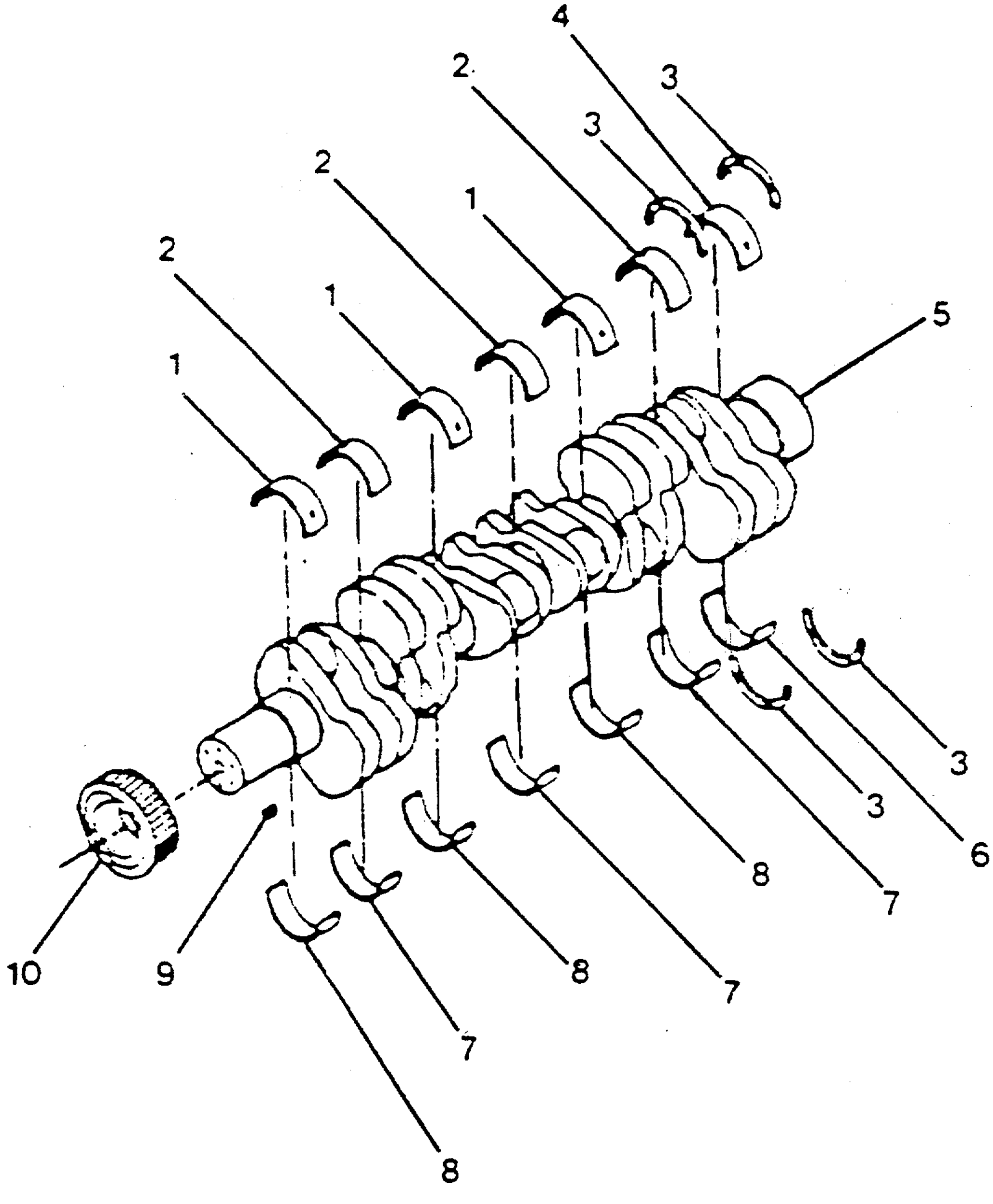


FIGURE 4-39. Crankshaft Group.

CAUTION

Replace main bearings one at a time.

(1) Remove the No. 7 main bearing cap capscrews and washers (Figure 4-40).

NOTE

The No. 7 main bearing cap has thrust bearings and dowel pins.

CAUTION

The main bearing cap puller must be centered on the cap.

(2) Use the main bearing cap puller to remove the cap.

(3) Remove the lower main bearing shell from the crankshaft journal.

NOTE

Mark the bearing shells with the journal number from which they were removed (1, Figure 4-41).

(4) Remove the dowel ring (2, Figure 4-41).

(5) Remove the thrust bearings (3, Figure 4-39) from the No. 7 cap.

(6) Mark these bearings from the No. 7 cap.

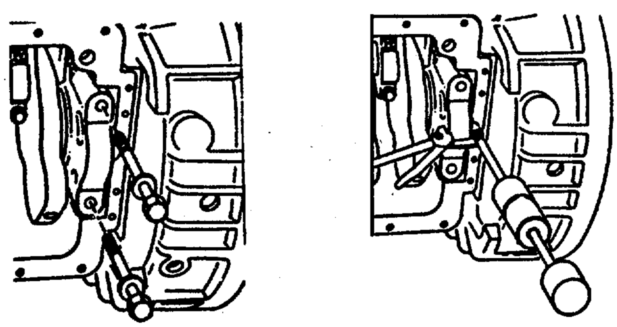


FIGURE 4-40. Removing Main Bearing Cap.

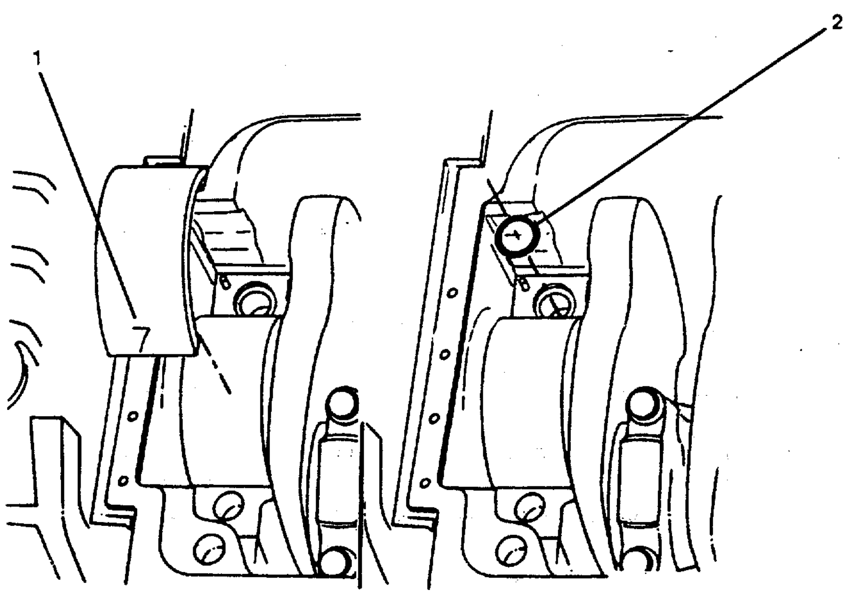


FIGURE 4-41. Remove Dowel Ring.

CAUTION

Do not damage the crankshaft when removing the thrust bearings.

(7) Remove the upper thrust bearings.

(8) Mark these bearings as top front and top rear thrust bearings.

WARNING

A lifting fixture is required to support and lift the crankshaft.

c. With the main bearing caps, bearings, and shells removed, use a lifting fixture and remove the crankshaft.

REPAIR

Repair of the crankshaft group is by replacement of parts removed in the Removal step of this procedure.

REPLACEMENT

a. Install the crankshaft gear (10, Figure 4-39) on the crankshaft (5).

(1) Install the key (9) in the crankshaft keyway.

(2) Heat the gear for a minimum of 1 hour at 400ºF (205°C).

WARNING

Wear protective gloves to prevent personal injury when handling parts that have been heated.

NOTE

The gear must be installed within 30 seconds after being heated.

CAUTION

The timing mark and the gear part number must be facing away from the crankshaft.

(3) Align the gear keyway and the key, and install the gear firmly on the crankshaft.

CAUTION

It will be necessary to align the timing marks (Figure 3-42) of the crankshaft and the camshaft gears when the crankshaft is installed (paragraph 3-23).

b. Install the crankshaft.

CAUTION

The cylinder block saddle and the cap mating surfaces must be clean and dry when the bearing shells are installed. Used bearings must be installed in their original location.

NOTE

The upper main bearing shells have a groove and oil hole to permit lubrication of the crankshaft. The upper shells for the No's 2, 4 and 6 are the same. The groove in the shell for No. 7 is not in the center of the shell. Install the No. 7 shell so the wider part of the shell, from the groove, is toward the flywheel end of the cylinder block. Also, each shell has a groove for the dowel ring. Install the shell so the groove will be next to the counterbore in the cylinder block.

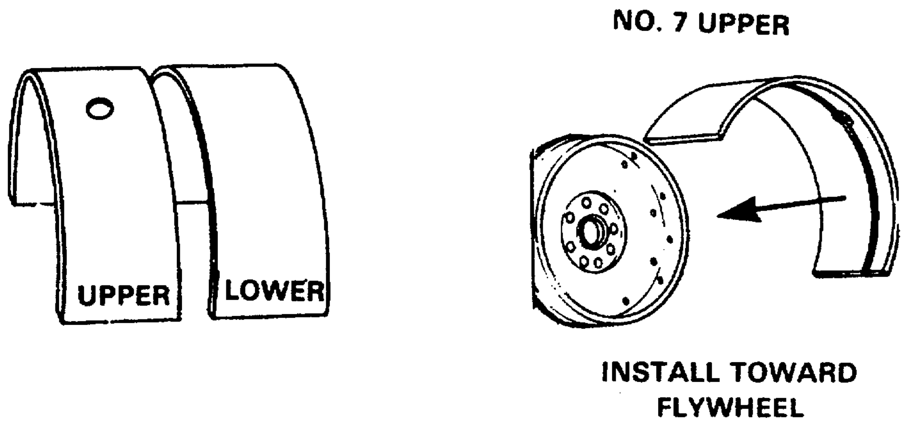


FIGURE 4-42. *Bearing Shell Identification.*

(1) Install the upper main bearing shells.

(2) Use clean Lubriplate or its equivalent to lubricate the upper main bearing shell to crankshaft journal mating surface.

CAUTION

The groove for the dowel ring must be next to the dowel ring counterbore in the cylinder block.

(3) Install the main bearing dowel rings (2, Figure 4-39).

WARNING

A lifting fixture is required to support and lift the crankshaft.

(4) Install the crankshaft. Check the marks on the rear counterweight of the crankshaft to find the size of the thrust rings.

(5) Install the upper thrust bearings in the No. 7 main bearing saddle.

CAUTION

The grooves must be against the crankshaft flange (Figure 4-43).

NOTE

Push the crankshaft toward the rear of the engine to install the front bearing and to the front of the engine to install the rear bearing.

(6) Install the lower main bearing shell as follows:

(a) Use clean Lubriplate or its equivalent to lubricate the bearing shell and the crankshaft journal mating surface.

(b) Align the lower bearing shell (1, Figure 4-44) with the dowel ring (2).

(c) Push on the side of the bearing shell opposite the dowel ring to install the bearing shell (Figure 4-44).

(7) Use clean Lubriplate or its equivalent to lubricate the lower thrust bearings.

CAUTION

The grooves of the thrust bearing must be toward the crankshaft flange. The locating dowels must not protrude above the thrust bearing surface.

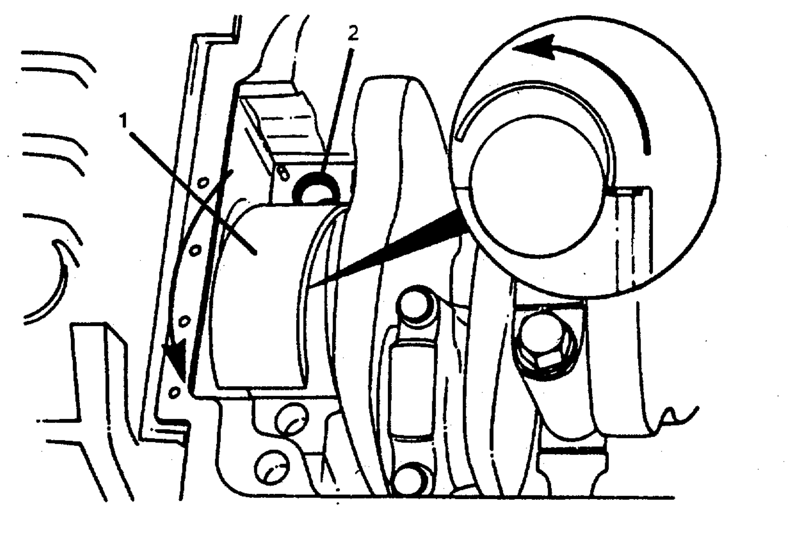


FIGURE 4-43. Positioning Bearing Grooves.

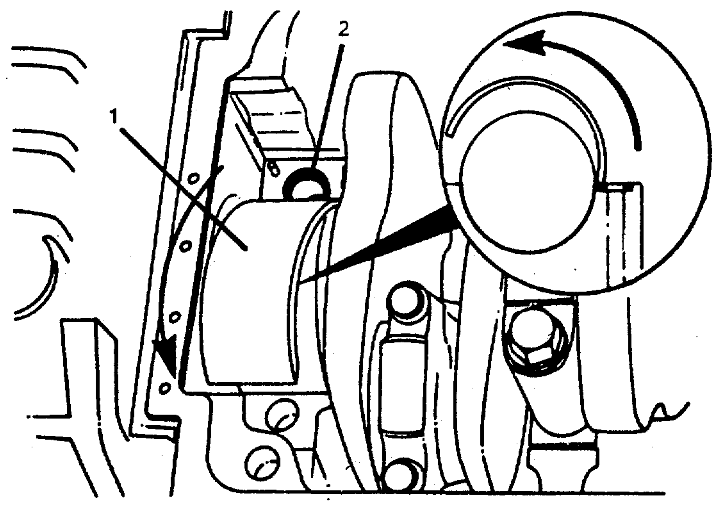


FIGURE 4-44. Installing the Bearing Shell.

(8) Install the lower thrust bearings in the No. 7 main bearing cap.

CAUTION

The main bearing caps are marked for position (1, Figure 4-45) on the camshaft side and the cylinder block identification (2) on the exhaust side. The cylinder block identification number (3) is stamped on the pan rail on the camshaft side of the block. Install the caps in the correct position with the position number to the camshaft side and its part number toward the rear of the engine.

(9) Install the main bearing caps as follows:

(a) Align the capscrew holes in the cap with the holes in the cylinder block. Be sure that the ring dowel and the lower bearing shell are in position.

(b) Use clean engine oil to lubricate the capscrew threads and the flat washers.

(c) Drain the excess oil from the capscrews before installing them.

(d) Install the capscrews, new lockplates and the washers through the cap and into the cylinder block.

(e) Finger tighten the capscrews two to three threads.

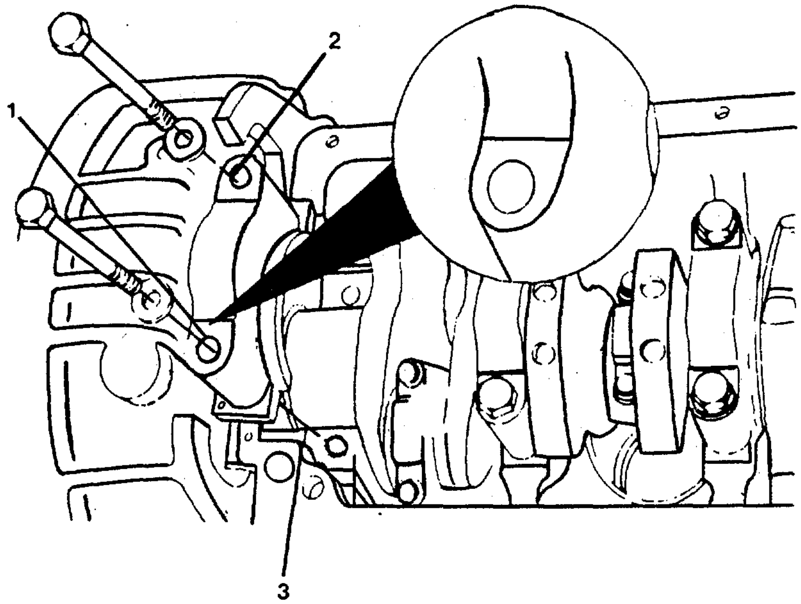


FIGURE 4-45. <u>Bearing Cap Location Marks.</u>

<u>CAUTION</u>

When hitting the cap, be sure that the bearing shell and dowel ring do not move.

(f) Hit the caps with a rubber mallet to push it into the correct position.

(10) Tighten all of the capscrews for the main bearing caps. Use the sequence shown in Figure 4-46 when you tighten the capscrews.

(a) Tighten the capscrews on a main bearing cap on engines built with 1-inch diameter main bearing capscrews to the following values:

<u>1</u> Tighten both to 110 ft-lb (149 N•m) torque.

<u>2</u> Tighten both to 210 ft-lb (284 N•m) torque.

<u>3</u> Tighten both to 305 ft-lb (413 N•m) torque.

<u>4</u> Loosen capscrews completely.

<u>5</u> Tighten again as described above.

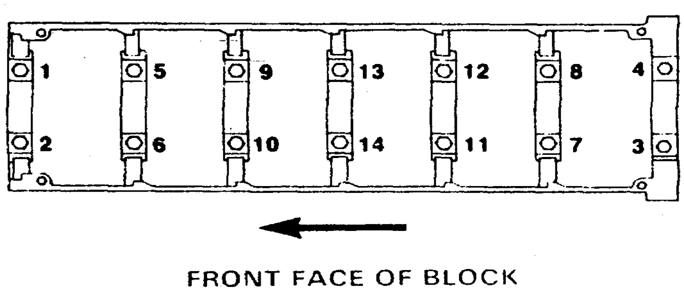


FIGURE 4-46. <u>Bearing Cap Torque Sequence.</u>

(b) Tighten the capscrews on a main bearing cap on engines built with 3/4-diameter main bearing capscrews to the following values:

1 Tighten both to 90 ft-lb (122 N•m) torque.

2 Tighten both to 170 ft-lb (230 N•m) torque.

3 Tighten both to 255 ft-lb (345 N•m) torque.

4 Loosen capscrews completely.

5 Tighten again as described above.

c. Install the gear cover (paragraph 3-20).

d. Install the oil pan (paragraph 3-21).

e. Install the crankshaft pulley and dampener (paragraph 3-25).

(1) Check the crankshaft to make sure it rotates freely. Use your hands to rotate the crankshaft.

(2) Check the end clearance of the crankshaft. The end clearance must be between 0.007 inch (0.18 mm) and 0.018 inch (0.45 mm) for new crankshafts and thrust rings.

(a) Install a dial indicator gauge to the rear face of the cylinder block. Put the contact tip of the gauge against the end of the crankshaft.

(b) Push the crankshaft toward the front of the cylinder block.

(c) Adjust the indicator to read "0" (zero).

(d) Push the crankshaft toward the rear of the cylinder block. Read the indicator to find the amount of end clearance.

(3) If the end clearance is less than 0.007 inch (0.18 mm):

(a) Loosen the capscrews one turn.

(b) Push the crankshaft toward the front and then toward the rear of the cylinder block.

(c) Follow the instructions in step (10) to tighten the capscrews.

(d) Check the end clearance.

NOTE

Make sure the end clearance for a used crankshaft is not more than the worn limit of 0.022 inch (0.56 mm). If the clearance is more than 0.022 inch (0.56 mm), you must use oversize thrust rings.

(4) Bend the tang of the lockplates against the head of the capscrews.

3-17. REPAIR CYLINDER BLOCK GROUP.

This task covers: **Repair**

INITIAL SETUP

Tools

Tool kit, general mechanic's rail
and marine diesel engines,
5180-00-629-9783
Combination wrench set,
5120-01-046-4979
Cylinder liner clamp set,
P/N 3822503
Cylinder liner puller P/N 3376015
Cylinder liner driver P/N ST-1229
Kit, camshaft bushing
P/N 3376633
Drive assembly camshaft bushing
P/N 3376637
Torque wrench kit P/N 3377216
Gauge block P/N 3376220
Machinists Measuring Set
5280-00-278-9919

Materials/Parts

Metal, liquid marker
Item 33, Appendix C
Vegetable oil, Item 44, Appendix C
RVT sealant, Item 45, Appendix C
Metal cleaning solvent,
Item 6, Appendix C
Crocus cloth (fine),
Item 26, Appendix C
Sleeve cylinder P/N 3801826
Piston cooling nozzle assembly
P/N 3014404
Gasket P/N 70089-1
Straight hexagon pin P/N 202903
Sleeve bushings P/N 3028075,
P/N 3028269
Sleeve bearing P/N 3011951
Dust and moisture seal protective cap
P/N 3011952
Gasket set P/N-3801468
Parts kit, cylinder P/N 3801328

Equipment Condition

Cylinder block disassembled,
para. 3-27.
Crankshaft group disassembled,
para. 4-16.

REPAIR

Repair to the cylinder block group consists of replacing cylinder sleeve assembly (1, Figure 4-47), access cover gasket (8), pins (10), bushings (13, 14), bearing (12) and piston cooling nozzles (15).

a. Replace the cylinder sleeve set.

(1) Remove the liner (4, Figure 4-47).

CAUTION

The liner puller must be installed and used as described to avoid damage to the cylinder block.

(a) Insert the liner puller in the top of the cylinder block.

1 The liner puller must be centered on the top of the cylinder block.

2 When using liner puller shown in Figure 4-48 the feet on the extension arms must be extended below the bottom of the liner.

3 With liner puller shown in Figure 4-49, the puller plate must be parallel to the main bearing saddles and it must not overload the liner outside diameter.

(b) Turn the puller jackscrew clockwise.

(c) Use both hands to remove the liners.

(d) Remove and discard the preformed packings (2, Figure 4-47) and gasket (3).

NOTE

Do not discard the shims (5, Figure 4-47) which may be used under the cylinder liner flange.

(e) Use a liquid metal marker to mark the cylinder number on each liner.

(f) If the shims were removed, perform the following:

1 Tag and record cylinder number.

2 Measure and record the thickness of the shims used in each cylinder.

(2) Inspect the liner bore and counterbore as follows:

(a) Clean the cylinder block bore and counterbore with an approved cleaning solvent.

(b) Remove any rough edges with crocus cloth.

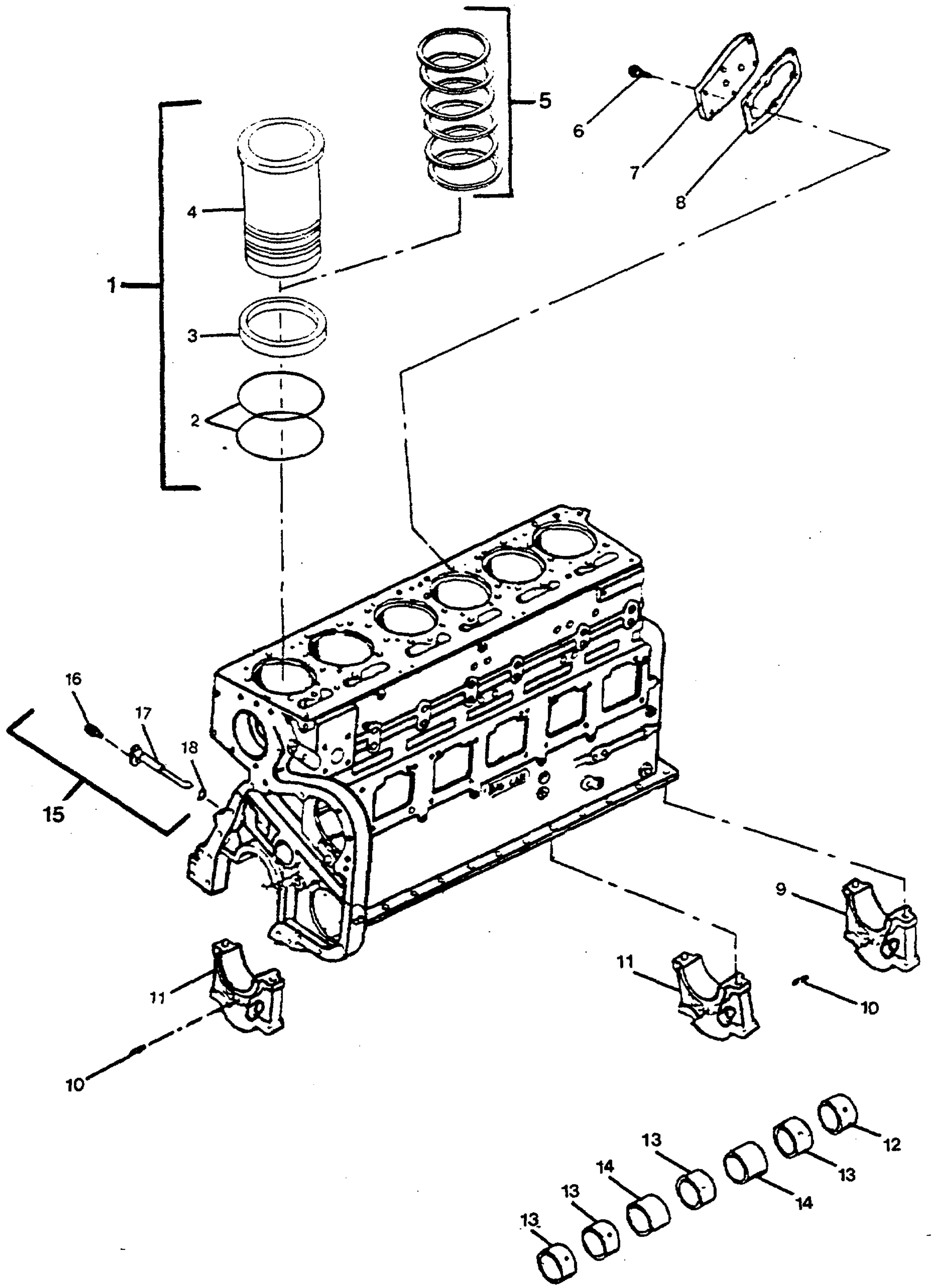


FIGURE 4-47. Cylinder Block Group.

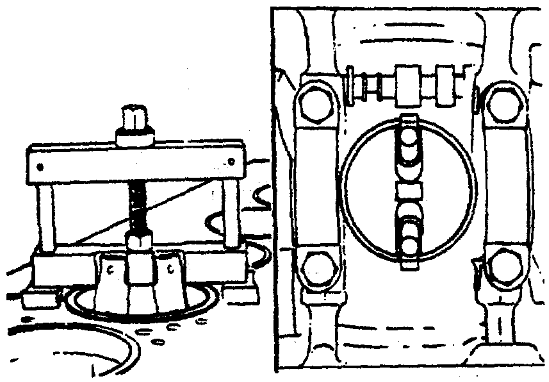


FIGURE 4-48. Extended Foot Type Puller.

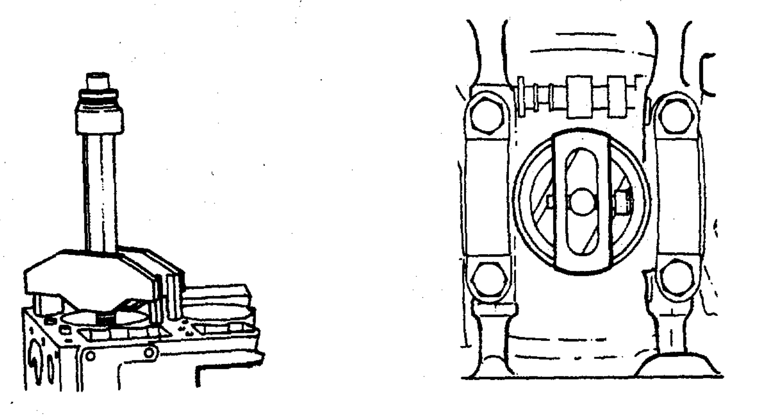


FIGURE 4-49. Parallel Plate Type Puller.

(c) Clean the cylinder block deck surface.

NOTE

The top of the cylinder block must be flat and without damage or distortion. Use a straight edge and a 0.002 inch (0.05 mm) feeler gauge to check the surface.

(d) Inspect the liner bore and counterbore for cracks. If cracks are present, the cylinder block may be used if:

1 Circumferential cracks do not extend into a cylinder head capscrew hole or water jacket hole.

2 Circumferential cracks do not extend beyond one-half the width of the counterbore ledge from the radius.

CAUTION

Do not attempt to reuse the cylinder block if radial cracks extend into the water jacket or the lubricating oil or water passages.

(e) Measure the diameter of the counterbore in the liner press fit area (Figure 4-50).

1 Measure the counterbore from the top deck to 0.100 inch (2.54 mm) below the top deck of the cylinder block.

2 If the counterbore diameter does not exceed 6.5635 inches (166.713 mm) standard liners may be used.

3 If the counterbore diameter exceeds 6.5635 inches (166.713 mm) in the press fit area, replace the cylinder block.

(f) Measure the depth of the counterbore at locations 1 and 2, Figure 4-51, at four equally spaced points around the bore.

1 Measure at point 1 as close to the counterbore wall as possible.

2 Measure at point 2 as far from the counterbore wall as possible.

3 There must not be more than a total of 0.001 inches (0.03 mm) difference in the measurements around the circumference of the counterbore.

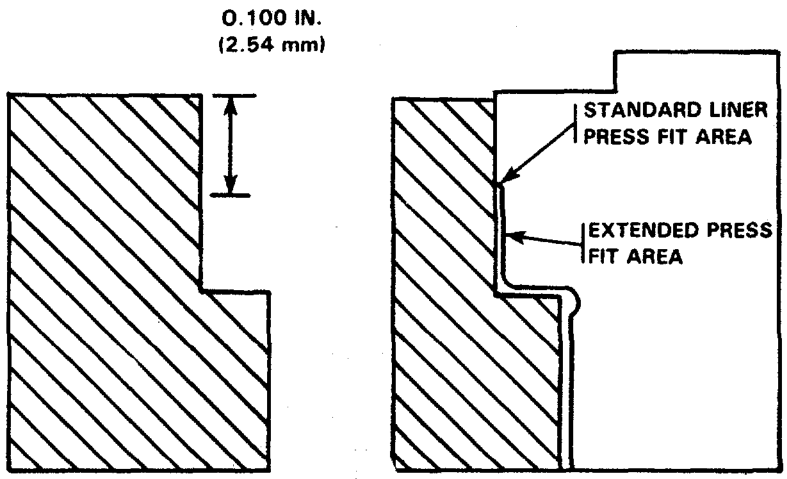


FIGURE 4-50. Liner Press Fit Area.

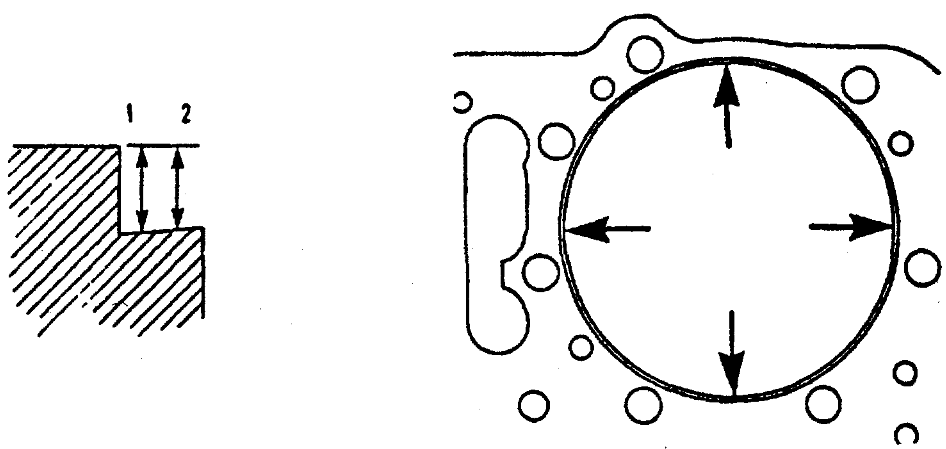


FIGURE 4-51. Measuring Counterbore.

CAUTION

A concave condition in the counterbore can cause liner breakage.

4 Measurement 2 must never exceed measurement 1 (concave) or be less than measurement 1 (convex) by more than 0.0014 inches (0.036 mm).

(3) Install the cylinder sleeves (liners).

NOTE

- Be sure that the cylinder block and all parts are clean before assembly. If used liners are being installed again, any shims (5, Figure 4-47) that were removed must be installed.
- Lubricate preformed packing with vegetable oil. Do not use lubricating oil on preformed packing because they will increase in size after they have been lubricated.

(a) Lubricate new liner preformed packings (2, Figure 4-47) and gasket (3) with vegetable oil.

(b) Install the performed packings (2) and the gasket (3) as follows:

1 Install the gasket (3) in the top groove of the liner (4).

2 Install the preformed packings (2) in the center and the bottom grooves.

CAUTION

Do not use excessive amount of sealant. Excessive sealant can cause problems in the cooling system.

(c) Apply a bead of RTV type sealant on either the cylinder block counterbore or the liner flange. The liner must be installed within 5 minutes after the sealant is apply (Figure 4-52).

NOTE

The diameter of the bead must be at least 3/64-inch and not more than 1/16-inch.

(d) Lubricate the gasket and the preformed packing with vegetable oil. Install the liner in the bore with a quick push.

NOTE

Be sure that the oil does not touch the counterbore or the liner flange and that the preformed packing does not move from the grooves.

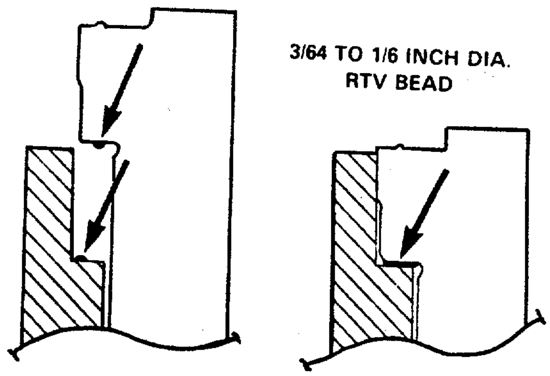


FIGURE 4-52. Applying Sealant to Liner.

(e) Use the cylinder liner driver and a leather mallet to drive the flange of the liner against the counterbore ledge.

(f) Check the protrusion of the cylinder liner as follows:

1 Install the cylinder liner clamp set.

2 Tighten the capscrews to 50 ft-lb (67 N•m) torque. Do not damage the liner bead.

3 Use the gauge block to measure the liner protrusion at four points 90 degrees apart (Figure 4-53). The protrusion must be from 0.003 inch (0.08 mm) to 0.006 inch (0.15 mm).

(g) Use a feeler gauge to measure the clearance between the liner and the lower liner bore (Figure 4-54). The clearance must be from 0.002 inch (0.05 mm) to 0.006 inch (0.15 mm).

NOTE

- The clamp set uses two cylinder head capscrews. The clamps must be installed 180 degrees from each other to apply equal amounts of pressure on the liner (Figure 4-53).
- If the liner protrusion is below the specifications, liner shims might be required.

(h) Measure the liner bore for out of roundness as follows: (Figure 4-55)

1 Measure at points "C", "D", "E", "F", and "G".

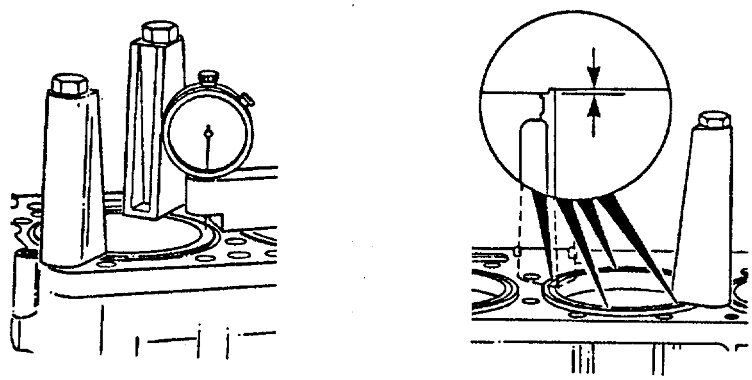


FIGURE 4-53. <u>Measuring Liner Protrusion</u>.

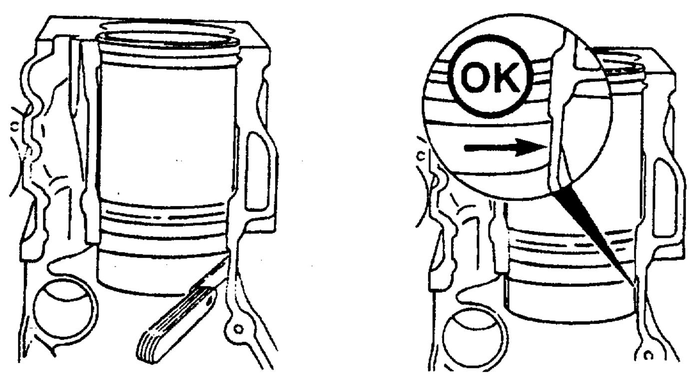


FIGURE 4-54. <u>Liner and Lower Liner Bore Clearance</u>.

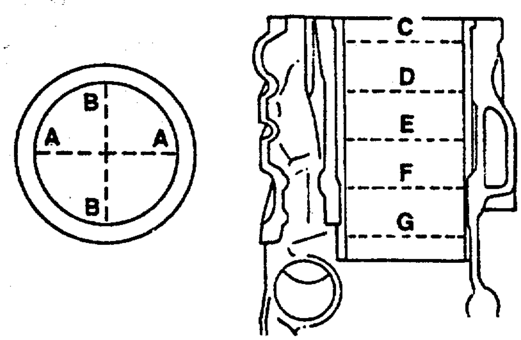


FIGURE 4-55. Checking Liner Bore.

2 Measure each point in the direction "AA" and "BB".

3 At point "C", the liner cannot be more than 0.003 inch (0.08 mm) out-of-round.

4 At points "D", "E", "F", and "G", the liner bore cannot be more than 0.002 inch (0.15 mm).

(i) Check the following and replace liners again as necessary.

1 Liner protrusion.

2 Liner and cylinder block lower liner bore.

3 Liner bore out-of-round.

(j) Check for twisted preformed packing.

(k) Clean the liner flange and the cylinder block liner counterbore.

(l) Inspect the liner flange for burrs.

(m) Inspect the cylinder block liner counterbore for burrs.

(n) Remove the burrs, or replace the damaged parts.

(o) Repeat steps (a) through (h).

b. Remove and inspect the piston cooling nozzles (15, Figure 4-47, and Figure 4-56).

(1) Remove the six self-backing screws (16, Figure 4-47) and pull the nozzles (17) fom the cylinder block as illustrated in Figure 4-47.

(2) Remove and discard the preformed packing (18).

(3) Clean the piston cooling nozzles with an approved solvent.

(4) Blow out the oil passages with compressed air.

(5) Visually inspect the cooling nozzles for cracks or damage.

(6) Visually inspect the screws for damaged threads.

(7) Replace any damaged parts.

(8) Lubricate the new preformed packing with vegetable oil.

(9) Install the preformed packing in the groove of the piston cooling nozzle.

CAUTION

Be sure that the oil passage opening in the piston cooling nozzle is pointing up toward the piston.

(10) Install the nozzles in the cylinder block.

(11) Install the self-locking screws.

(a) Tighten the capscrews to 140 in-lb (15.8 N-m) torque.

(b) Tighten the slotted head screws to 95 in-lb (10.7 N.m) torque.

c. Replace the camshaft bushings and bearing (13, 14, 12, Figure 4-47).

NOTE

The bushings and bearing must be removed in the order shown in Figure 4-57.

(1) Using the camshaft bushing driver kit and driver, remove the No. 1 bushing first and then the remaining six (6) bushings in order from front to rear.

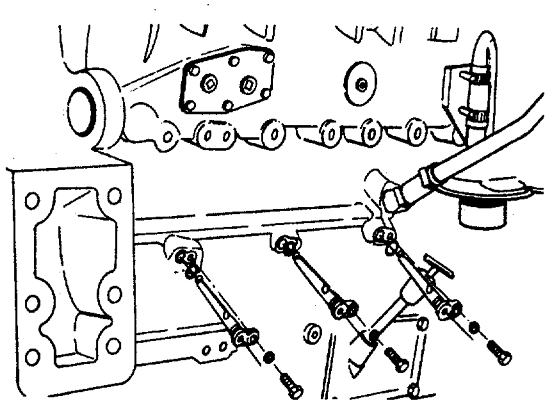


FIGURE 4-56. <u>Piston Cooling Nozzles</u>.

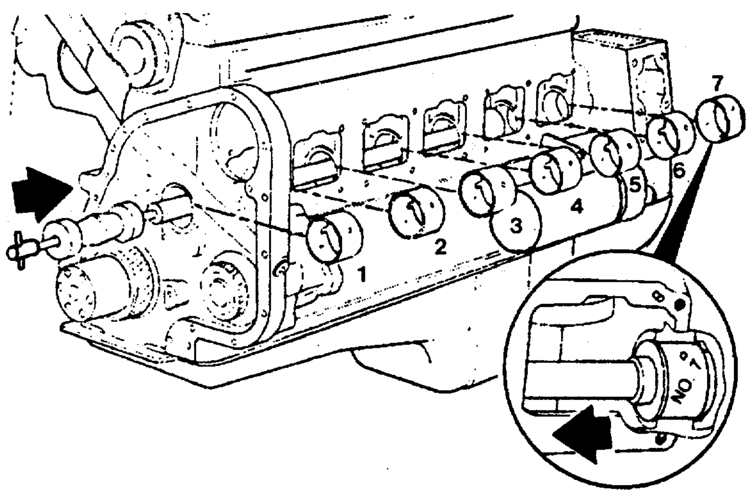


FIGURE 4-57. <u>Camshaft Bushing/Bearing Removal Sequence</u>.

(a) To remove bushing No. 1 through No. 6, insert the tools assembly through the camshaft bore until the driver is against the bushing.

(b) Hit the slide hammer against the shaft assembly until the bushing is driven from the bore.

(c) Using the camshaft bushing driver kit and puller, remove the No. 7 bushing. Insert the tool assembly through the bore until the pins of the puller assembly are engaged behind the bushing.

(d) Hit the slide hammer against the T-handle until the bushing is removed from the bore.

CAUTION

Incorrect installation will result in severe damage to the engine. Refer to the numbers stamped on the bushings to determine the correct cylinder block cam bore location in which the bushings are to be installed. Install the camshaft bushings in the following order: No. 7, No. 6, No. 5, No. 4, No. 3, No. 2, and No. 1.

(2) Install the tool assembly through the camshaft bore until driver is in the cavity between the No. 6 and No. 7 bores.

(3) Install the camshaft bushing guide in the No. 5 and No. 6 bores.

(4) Install the bushing marked No. 7 on the driver with the location notch to the rear of the engine and at the 6 o'clock position.

(a) Push the bushing in the bore until the oil holes in the bushing are aligned with the drillings in the bore.

(b) Use a 0.094 (2.39 mm) diameter rod to check the position and the location at the oil hole in the bushing and the cylinder block.

(c) The rod must pass through the oil holes in the bushing and into the oil supply drillings in the cylinder block.

CAUTION

The locating notch in the No. 2 through No. 6 bushings must face the rear of the engine and be located at the 9 o'clock position when looking at it from the front of the engine.

NOTE

- Use bushing driver (1) to install bushing No. 1, No. 2, No. 4, and No. 6. Use bushing driver (2) to install bushing No. 3 and No. 5 (Figure 4-58).
- Install the No. 6 through No. 2 bushings in the same manner as No. 7.

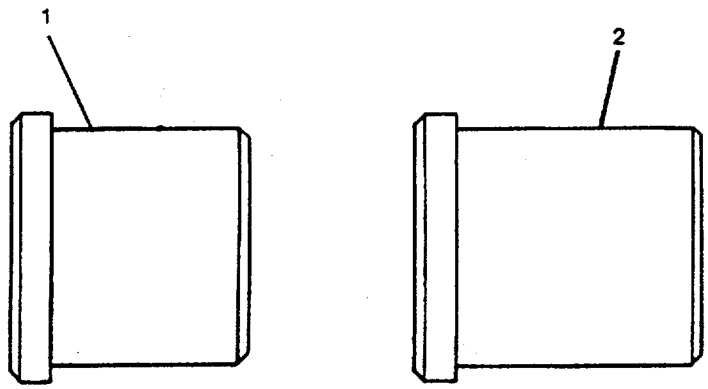


FIGURE 4-58. Bushing Driver Identification.

(5) Install the tool assembly through the camshaft bore until the driver is in the cavity between the bores where the bushing is to be installed.

(6) Install the bushing guide in the camshaft bore next to the bore where the bushing is to be installed.

(7) Install the bushing marked for that location on the driver with the locating notch to the rear of the engine and at the 9 o'clock position.

(a) Push the bushing in the bore until the oil holes in the bushings are aligned with the drillings in the bore.

(b) Use a 0.094-inch (2.39 mm) diameter rod to check the position and the location of the oil hole in the bushing and the cylinder block.

(c) The rod must pass through the oil holes in the bushing and into the oil supply drillings in the cylinder block.

NOTE

The camshaft bushing guide is not used to install the No. 1 bushing.

(8) Install bushing No. 1 on the driver with the notch to the rear of the engine and at the 9 o'clock position when looking at it from the front of the engine.

(a) Push the bushing in the bore until the oil holes in the bushings are aligned with the drillings in the bore.

(b) Use a 0.094 inch (2.39 mm) diameter rod to check the position and the location of the oil holes in the bushing and the cylinder block.

(c) The rod must pass through the oil holes in thebushing and into the oil supply drillings in the cylinder block.

(9) Measure the camshaft bushings installed inside diameter. The measurement should be between 2.4983 inches (63.457 mm) and 2.5023 inches (63.558 mm).

d. Replace the gasket (8, Figure 4-47) as follows:

(1) Remove the six assembled washer screws (6, Figure 4-45) and remove the access cover (7).

(2) Remove the gasket (8).

(3) Position a new gasket (8) and install the access cover (7) with capscrews (6).

e. The pillow block (main bearing) caps (9, 11, 17, Figure 4-47) were removed with the crankshaft group (paragraph 4-25). The pins (10) may be removed and replaced in the bearing caps.

SECTION VI. PREPARATION FOR STORAGE OR SHIPMENT

Refer to Chapter 2, Section VI.

APPENDIX A

REFERENCES

A-1. Scope. This paragraph lists the manuals, bulletins, specifications, and miscellaneous publications referenced in this manual or required for maintenance activities.

A-2. Field Manuals.

FM 21-11	First Aid for Soldiers
FM 31-70	Basic Cold Weather Manual
FM 55-501	Marine Crewman's Handbook

A-3. Technical Manuals.

TM 43-0139	Painting Instructions for Field Use
TM 55-1905-223-10	Operator's Manual for Landing Craft, Utility (LCU)
TM 55-1905-223-24-18	LCU 2000 Class Basic Craft Maintenance Manual
TM 55-1905-223-24P	Repair Parts and Special Tools List for the LCU 200 Class Watercraft
TM 750-244-3	Destruction of Army Materiel to Prevent Enemy Use

A-4. Technical Bulletins.

TB 43-0144	Painting of Vessels
TB 55-1900-207-24	Treatment of Cooling Water in Marine Diesel Engines
TB 740-97-4	Preservation of Vessels for Storage.

A-5. Military Specifications.

MIL-C-16173C	Rust Preventive, Type P-1
MIL-L-644	Preservative Oil, Type P-9
MIL-L-21260	Preservative Oil, Type P-10

A-6. Miscellaneous Publications.

DA Pam 738-750	The Army Maintenance Management System
LO 55-1905-223-12	Lubrication Order for the LCU 2000 Class Watercraft
*AMC-R 750-11	Use of Lubricants, Fluids, and Associated Products

A-7. Forms.

DA Form 2028 and DA Form 2028-2	Recommended Changes to Publications and Blank Forms
DA Form 2404	Equipment Maintenance and Inspection Worksheet
DA Form 2408-16	Logsheet
DA Form 2410	Logsheet
SF Form 368	Quality Deficiency Report

*Supercedes Darcom-R 750-11

APPENDIX B

MAINTENANCE ALLOCATION CHART

SECTION I. INTRODUCTION

B-1. General.

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

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 categories.

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 will be 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 (for example, 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, that is, 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 or exact position, or by setting the operating characteristics to specified parameters.

e. Align. To adjust specified variable elements of an item to bring about optimum or desired performance.

f. Calibrate. To determine and cause corrections to be made or to be adjusted on instruments or test, measuring, and diagnostic equipments 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 is shown as the third position code of the SMR code.

i. Repair. The application of maintenance services', including fault location/troubleshooting2, removal/installation, and disassembly/assembly3 procedures, and maintenance actions4 to identify troubles and restore serviceability to an item by correcting specific damage, fault, malfunction, or failure in a part, subassembly, module (component or assembly), end item, or system.

j. Overhaul. That maintenance effort (service/action) necessary to restore an item to a completely serviceable/operational condition as required by maintenance standards in appropriate technical publications [i.e., Depot Maintenance Work Requirements (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 (hours, miles, etc.) considered in classifying Army equipments/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. End item group number shall be "00."

[1]Services-inspect, test, service, adjust, align, calibrate, and/or replace.
[2]Fault locate/troubleshoot-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]Disassemble/assemble-encompasses the step-by-step taking apart (or breakdown) of a spare/functional group coded item to the level of its least componency identified as maintenance significant (that is, assigned an SMR code) for the category of maintenance under consideration.
[4]Actions-welding, grinding, riveting, straightening, facing, remachinery, and/or resurfacing.

b. Column 2, Component/Assembly. Column 2 contains the noun names of components, assemblies, subassemblies, and modules for which maintenance is authorized.

c. Column 3, Maintenance Function. Column 3 lists the functions to be performed on the item listed in Column 2. (For detailed explanation of these functions, see paragraph B-2.)

d. Column 4, Maintenance Category. Column 4 specifies, by the listing of a work time figure in the appropriate subcolumn(s), the category of maintenance authorized to perform the function listed in Column 3. This figure represents the active time required to perform that maintenance function at the indicated category of maintenance. If the number or complexity of the tasks within the listed maintenance function vary at different maintenance categories, appropriate work time figures will be shown for each category. 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/quality control 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 categories are as follows:

UNIT	C-Operator or Crew O-Organizational Maintenance
INTERMEDIATE	F-Direct Support Maintenance H-General Support Maintenance
DEPOT	D-Depot

e. Column 5, Tools and Equipment. Column 5 specifies, by code, those common tool sets (not individual tools) and special tools, TMDE, and support equipment required to perform the designated function.

f. Column 6, Remarks. This column shall, when applicable, contain a letter code, in alphabetic order, which shall be keyed to the remarks contained in Section IV.

B-4. Explanation of Columns in Tool and Test Equipment Requirements, Section III.

a. Column 1, Reference Code. The tool and test equipment reference code correlates with a code used in the MAC, Section II, Column 5.

b. Column 2, Maintenance Category. The lowest category 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.

B-5. Explanation of Columns in Remarks, Section IV.

a. Column 1, Reference Code. This 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 SHIP'S SERVICE GENERATOR

(1) GROUP NUMBER	(2) COMPONENT ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE LEVEL UNIT C	UNIT O	INTERMED F	INTERMED H	DEPOT D	(5) TOOLS & EQUIPMENT	(6) REMARKS
03	SHIP SERVICE GENERATOR SET, ELECTRIC START	INSPECT	0.7						J
		TEST	1.5						
		SERVICE	1.0					1	
		ADJUST	1.0					1, 2	
		REPLACE			35.0			1, 2	
		REPAIR	2.0	3.0	15.0	65.0		1-97	
		OVERHAUL					*	1-97	A
03	SHIP SERVICE GENERATOR SET, AIR START	INSPECT	0.7					1	K
		TEST	1.5						
		SERVICE	1.0					1	
		ADJUST	1.0					1, 2	
		REPLACE			35.0			1, 2	
		REPAIR	2.0	3.0	15.0	65.0		1-97	
		OVERHAUL					*	1-97	A
0301	GENERATOR ASSEMBLY	INSPECT	0.2					1, 2	
		TEST			1.0			1-4, 28	
		SERVICE	0.5					1-4	
		ADJUST		0.5				1-4	
		REPLACE			10.0			1-4, 28	
		REPAIR		1.5	1.5	15.0		1-4, 28, 57, 58	
		OVERHAUL				*		1-97	A
0302	ENGINE, DIESEL, AIR START	INSPECT	0.5					1	
		SERVICE	1.0					1	
		ADJUST	0.5					1	
		REPLACE			30.0			1-4, 12	
		REPAIR	1.5	2.0	10.0	60.0		1-4, 12, 27, 33	
		OVERHAUL					*		A
0302	ENGINE, DIESEL, ELECTRIC START	INSPECT	0.5					1	
		SERVICE	1.0					1	
		ADJUST	0.5					1	
		REPLACE			30.0			1-4, 12	
		REPAIR	1.5	2.0	10.0	60.0		1-4, 12, 27, 33	
		OVERHAUL					*		A

SECTION II: MAINTENANCE ALLOCATION CHART FOR SHIP'S SERVICE GENERATOR

(1) GROUP NUMBER	(2) COMPONENT ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE LEVEL UNIT C	UNIT O	INTERMED F	INTERMED H	DEPOT D	(5) TOOLS & EQUIPMENT	(6) REMARKS
030201	STARTER, ENGINE, AIR	REPLACE	1.5					1, 12	M
		REPAIR			4.0			1	B
030202	ELECTRIC STARTING MOTOR/ MAGNETIC SWITCH GROUP	REPLACE	1.0					1, 12	L
		REPAIR	0.5	1.5				1, 12	B
030203	INSTRUMENT PANEL ASSEMBLY	INSPECT	0.1					1	
		REPLACE		3.0				1	
		REPAIR		1.5				1	
03020301	TERMINAL BOARD	REPLACE		0.5				1	
		REPAIR		1.5				1	
030204	WATER FILTER ASSEMBLY	INSPECT	0.1					1	
		SERVICE	0.5					1, 8, 12, 43	
		REPLACE		0.5				1, 8, 12, 43	
		REPAIR	0.2	0.5				1	
030205	THERMOSTAT HOUSING GROUP	INSPECT	0.1						
		SERVICE	0.5					1, 5, 6	
		REPLACE	1.0					1, 5, 6, 12	
		REPAIR	0.5	1.0				1, 5, 6, 12	
030206	AIR CLEANER GROUP	REPLACE		0.5				1	
		REPAIR		1.5				1	
03020601	AIR CLEANER, INTAKE	INSPECT	0.1					1	
		SERVICE	0.3					1	
		REPLACE		0.5				1	
		REPAIR	0.2	1.5				1	
030207	TURBOCHARGER AND EXHAUST GROUP	REPLACE	0.7					1, 12	B, C
		REPAIR	4.5					1, 12	C

SECTION II: MAINTENANCE ALLOCATION CHART FOR SHIP'S SERVICE GENERATOR

(1) GROUP NUMBER	(2) COMPONENT ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE LEVEL UNIT C	UNIT O	INTERMED F	INTERMED H	DEPOT D	(5) TOOLS & EQUIPMENT	(6) REMARKS
030208	FUEL FILTER GROUP	INSPECT	0.1						
		SERVICE	0.5					1, 8, 12	
		REPLACE		0.7				1, 8, 12	
		REPAIR	0.2	0.5				1, 8, 12	B
030209	SUMP PUMP GROUP	REPLACE		0.7				1	
		REPAIR		0.3				1	
030210	WATER PUMP AND IDLER GROUP	INSPECT	0.1						
		SERVICE	0.2					1, 12	
		ADJUST	0.3					1, 12, 43	
		REPLACE	1.0					1, 12, 43	
		REPAIR	1.5					1, 12, 43	
03021001	ADJUSTING DEVICE, BELT-CHAIN TENSION	REPLACE	1.0						
		REPAIR	1.5						
03021002	PUMP, COOLING SYSTEM, ENGINE	REPLACE	1.0						
		REPAIR	1.5						
030211	LUBRICATING OIL COOLER/ FILTER GROUP	INSPECT	0.2						
		SERVICE	0.2					1, 7, 9, 12	
		REPLACE		1.0				1, 12	
		REPAIR	0.2	1.0	1.0			1, 12, 31, 34, 35	
03021101	LUBRICATING OIL COOLER ASSEMBLY	REPLACE		1.0					
		REPAIR			1.0				
0302110101	COOLER, FLUID, TRANSSISSION	REPLACE		1.0					
		REPAIR			1.0			1, 7, 9, 12	
030212	LUBE OIL BYPASS FILTER GROUP	INSPECT	0.1					7, 9	
		SERVICE	0.3					7	
		REPLACE		0.5				1, 7	
		REPAIR	0.2	0.5				1, 7	

SECTION II: MAINTENANCE ALLOCATION CHART FOR SHIP'S SERVICE GENERATOR

(1) GROUP NUMBER	(2) COMPONENT ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE LEVEL UNIT C	UNIT O	INTERMED F	INTERMED H	DEPOT D	(5) TOOLS & EQUIPMENT	(6) REMARKS
030213	COOLANT HEATER GROUP	REPLACE REPAIR		0.7 0.5				1, 29 1, 29	
030214	PUMP, FUEL, METERING AND DISTRIBUTING ASSEMBLY	REPLACE REPAIR	0.7		 2.0			1, 12 1, 12, 28	
03021401	DAMPENER, FLUID PRESSURE	REPLACE REPAIR			2.0 0.5				
03021402	FUEL PUMP GEAR ASSEMBLY	REPLACE REPAIR			2.0 0.5				
03021403	SHUTOFF VALVE ASSEMBLY	REPLACE REPAIR			2.0 0.5				
030215	FUEL TUBING GROUP	REPLACE REPAIR		0.5 0.5				1	
030216	ROCKER LEVER HOUSING COVER GROUP	REPLACE REPAIR	0.7 0.7		 1.5			1 1, 11, 12, 32, 37, 38 54, 55	
03021601	LEVER HOUSING, ROCKER	REPLACE REPAIR	0.7 0.7		 0.5				
0302160101	ROCKER ARM, ENGINE POPPET VALVE	REPLACE REPAIR	0.7		 0.5				
0302160102	ROCKER ARM, ENGINE POPPET VALVE	REPLACE REPAIR	0.7		 0.5				
0302160103	LEVER, INJECTOR ROCKER	REPLACE REPAIR	0.7		 0.5			 1	

SECTION II: MAINTENANCE ALLOCATION CHART FOR SHIP'S SERVICE GENERATOR

(1) GROUP NUMBER	(2) COMPONENT ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE LEVEL UNIT C	UNIT O	INTERMED F	INTERMED H	DEPOT D	(5) TOOLS & EQUIPMENT	(6) REMARKS
030217	INJECTOR GROUP	INSPECT	0.5						
		REPLACE		0.5				1, 10-12, 32	B
		REPAIR		1.0				1, 10-12, 32	B
030218	AFTERCOOLER GROUP	REPLACE		0.5				1, 12	
		REPAIR		1.0				1, 12	
030219	EXHAUST MANIFOLD GROUP	REPLACE		0.7				1, 3, 4, 12	
		REPAIR		1.0				1, 3, 4, 12;	
030220	CYLINDER HEAD GROUP	REPLACE	2.0					1, 3, 4, 10-12	D
		REPAIR	2.0			3.0		1, 3, 4, 10-16, 30, 31, 37, 48, 59, 66, 69-95	
03022001	CYLINDER HEAD, DIESEL ENGINE	REPLACE	2.0					1, 12-16	D
		REPAIR				3.0			
03022002	VALVE, CROSSHEAD ASSEMBLY	REPLACE				0.5			
		REPAIR				0.5			
030221	CAN FOLLOWER HOUSING GROUP	REPLACE			0.5			1, 12, 17	
		REPAIR			0.5	1.0		1, 12, 17, 37, 44 59, 66, 96, 97	
03022101	HOUSING, CAN FOLLOWER	REPLACE			0.5				
		REPAIR				1.0			
0302210101	ROCKER ARM, ENGINE POPPET VALVE	REPLACE				0.5			
		REPAIR				0.5			

SECTION II: MAINTENANCE ALLOCATION CHART FOR SHIP'S SERVICE GENERATOR

(1) GROUP NUMBER	(2) COMPONENT ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE LEVEL UNIT C	O	INTERMED F	H	DEPOT D	(5) TOOLS & EQUIPMENT	(6) REMARKS
0302210-102	ROCKER ARM, ENGINE POPPET VALVE	REPLACE REPAIR				0.5 0.5			
030222	ACCESSORY DRIVE AND PULLEY GROUP	REPLACE REPAIR			0.5 0.7			1, 12 1, 12, 37, 40-42, 45	E
03022201	PULLEY, FLAT, ASSEMBLY	REPLACE REPAIR			0.5 0.7				
03022202	POWER TAKEOFF, TRANSMISSION	REPLACE REPAIR			0.5 0.7			 1	
0302220-201	DRIVE, CONSTANT SPEED, MECHANICAL	REPLACE REPAIR			0.5 0.7				
030223	GEAR COVER AND SUPPORT GROUP	REPLACE			1.0			1, 3, 4, 12 37, 44, 46, 47, 54	
		REPAIR			1.5			1, 3, 4, 12; 37, 44, 46, 47, 54	
03022301	COVER, GEAR	REPLACE REPAIR			1.0 1.5				
030224	OIL PAN GROUP	REPLACE REPAIR			1.0 1.5			1, 12 1, 12	
030225	OIL PUMP ASSEMBLY, ENGINE	REPLACE			0.5			1, 12, 48-53, 59	
		REPAIR			0.7			1, 39, 48-53, 59	
030226	CAMSHAFT AND GEAR GROUP	REPLACE REPAIR			3.0	 0.5		1, 19, 54 1, 37, 58	

SECTION II: MAINTENANCE ALLOCATION CHART FOR SHIP'S SERVICE GENERATOR

(1) GROUP NUMBER	(2) COMPONENT ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE LEVEL UNIT C	UNIT O	INTERMED F	INTERMED H	DEPOT D	(5) TOOLS & EQUIPMENT	(6) REMARKS
03022601	CAMSHAFT	REPLACE				3.0			
		REPAIR				0.5			
030227	CONNECTING ROD AND PISTON GROUP	REPLACE			1.0			1, 22-24	F, G
		REPAIR				0.3		1, 22-24, 44, 45, 54, 60-66	
03022701	CONNECTING ROD, PISTON	REPLACE			1.0				
		REPAIR				0.3			
03022702	PISTON, INTERNAL COMBUSTION ENGINE ASSEMBLY	REPLACE			1.0				
		REPAIR				0.3			
030228	FLYWHEEL AND FLYWHEEL HOUSING GROUP	REPLACE			2.5			1, 3, 4, 12, 51 54-56, 68	
		REPAIR			2.5	1.0		1, 4, 12, 28, 51, 54-56, 59, 67	
03022801	FLYWHEEL, ENGINE ASSEMBLY	REPLACE			2.5				
		REPAIR				1.0			
030229	CRANKSHAFT GROUP	REPLACE				3.0		1, 3, 4, 18	
		REPAIR			1.0	0.5		1, 3, 4, 18, 49, 54	
030230	CYLINDER BLOCK GROUP	REPLACE			30.0			1, 3, 4, 12, 13	I
		REPAIR			30.0	60.0		1, 3, 4, 12, 13, 20, 21, 25-27, 37, 59	

SECTION II: MAINTENANCE ALLOCATION CHART FOR SHIP'S SERVICE GENERATOR

(1) GROUP NUMBER	(2) COMPONENT ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE LEVEL UNIT C	UNIT O	INTERMED F	INTERMED H	DEPOT D	(5) TOOLS & EQUIPMENT	(6) REMARKS
03023001	BLOCK, ENGINE, DIESEL	REPLACE			30.0			1, 12, 13, 37	I
		REPAIR				60.0		1, 12, 13	
0302300-101	NOZZLE, PISTON COOLING ASSEMBLY	REPLACE				0.5			I
		REPAIR				0.5			
0303	SUBBASE GROUP	REPLACE			1.0			1, 3, 4	B
		REPAIR			1.5			1, 3, 4	

SECTION III: TOOL AND TEST EQUIPMENT REQUIREMENTS FOR SHIP'S SERVICE GENERATOR

TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE CATEGORY	NOMENCLATURE	NATIONAL/NATO STOCK NUMBER	TOOL NUMBER
1	C, F	Tool kit, general mechanic's, rail and marine diesel engines	5180-00-629-9783	(50980) SC-5180-CL -N55
2	C, F, H	Tool kit, electrician's	5180-00-391-1087	(80064) 9000S202-73125ALT2
3	O, F, H	Engine Lifting fixture		(15434) 3822512
4	O, F, H	Engine lifting sling	3940-01-183-9412	(15434) 3375958
5	O	Thermostat seal mandrel		(15434) ST-1225
6	O	Thermostat seal mandrel		(15434) ST-1226
7	C	Filter wrench	5120-01-160-8863	(15434) 3375049
8	C	Strap wrench	5120-01-262-7306	(15434) 3376807
9	C	Fitter cutter	5120-01-262-7305	(15434) 3376579
10	C	Injector puller	5120-00-116-7604	(15434) 3376000
11	O, F	Injector adjustment kit		(15434) 3375842
12	O, F, H	Torque wrench kit		(15434) 3377216
13	H	Gauge block	5120-01-157-3091	(15434) 3376220
14	H	Drive unit, counterbore		(15434) 3376685
15	H	Adapter plate		(15434) 3376686

SECTION III: TOOL AND TEST EQUIPMENT REQUIREMENTS FOR SHIP'S SERVICE GENERATOR

TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE CATEGORY	NOMENCLATURE	NATIONAL/NATO STOCK NUMBER	TOOL NUMBER
16	H	Cutter plate		(15434) 3377235
17	F, H	Timing tool	4910-00-999-1269	(15434) 3375522
18	H	Bearing cap puller		(15434) ST-1178
19	F	Camshaft installation pilots		(15434) 3375268
20	H	Bearing and bushing inserter		(15434) 3376637
21	H	Kit, driver, bushing	5120-01-146-7131	(15434) 3376633
22	H, F	Connecting rod guide pins		(15434) 3375601
23	H	Piston ring expander		(15434) ST-763
24	H, F	Piston ring compressor		(15434) 3822736
25	H	Cylinder liner clamp set	5120-01-262-7309	(15434) 3822503
26	H	Cylinder liner driver		(15434) ST-1229
27	H	Cylinder liner puller	5120-01-143-2032	(15434) 3376015
28	F, H	Digital multimeter	6625-01-139-2512	(80058) AN/PSM-45
29	C	DCA test kit		(15434) 3300846S
30	H	Valve tester	4910-01-141-8387	(15434) ST-1257

SECTION III: TOOL AND TEST EQUIPMENT REQUIREMENTS FOR SHIP'S SERVICE GENERATOR

TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE CATEGORY	NOMENCLATURE	NATIONAL/NATO STOCK NUMBER	TOOL NUMBER
31	F, H	Valve spring compression tester	4910-01-142-4929	(15434) 3375182
32	C	Rocker lever actuator		(15434) 3375790
33	F	Diesel tool kit	5780-00-629-9783	
34	F	Mandarel, o-ring		(15434) ST-1218
35	F	Tube bundle tester		(15434) 3375253
36	H	Megger		(15434) 3376304
37	F, H	Measuring set, machinists	5280-00-278-9919	(50980) SC 5280-95-CL-A01
38	F	Magnaglo tester		H260
39	F	Gear spacer mandrel		(15434) ST-1157
40	F	Standard Puller		(15434) ST-647
41	F	Pulley installation tool		(15434) 3376326
42	F	Coupling puller		(15434) ST-1249
43	C	Belt tension gauge		(15434) ST-1293
44	H	Mandrel and block		(15434) ST-249
45	F, H	Arbor press	4920-00-373-9376	(55974) 0873001
46	F	Oil seal puller/installer		(15434) ST-1259

SECTION III: MAINTENANCE ALLOCATION CHART FOR SHIP'S SERVICE GENERATOR

TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE CATEGORY	NOMENCLATURE	NATIONAL/NATO STOCK NUMBER	TOOL NUMBER
47	F	Fuel pump drive oil seat mandarel		(15434) ST-1173
48	H	Depth vernier		(15434) ST-537
49	F, H	Gear puller		(15434) 3375082
50	F	Gear puller		(15434) 3375083
51	F	Dowell puller		(15434) ST-1134
52	F	Bushing mandrel		(15434) ST-1158
53	F	L.O. pump boring tool		(15434) 3375206
54	C, F, H	Dial indicator	5210-00-277-8840	3376050
55	C, F	Dial indicator attachment		(15434) ST-1325
56	F	Crack detection kit		(15434) 3375432
57	H	Mechanical puller	5120-00-595-9304	(15434) ST-647
58	H	Hydraulic press		(15434) 2009-13
59	F, H	Combination wrench set	5120-01-046-4979	(55719) GOEXM-714
60	H	Bushing driver		(15434) ST-1242
61	H	Rod checking fixture		(15434) ST-561

SECTION III: TOOL AND TEST EQUIPMENT REQUIREMENTS FOR SHIP'S SERVICE GENERATOR

TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE CATEGORY	NOMENCLATURE	NATIONAL/NATO STOCK NUMBER	TOOL NUMBER
62	H	Locating mandrel		(15434) ST-563
63	H	Boring machine		(15434) 3375115
64	H	Piston ring groove wear gauge		(15434) ST-560
65	H	Internal snap ring pliers	5120-00-595-9551	(79588) 407
66	H	Dial bore gauge		(15434) 3376619
67	H	Magnetic crack detector		(15434) ST-1166
68	F	Crankshaft oil seal driver		(15434) ST-997
69	H	Valve seat insert toot kit		(15434) ST-257
70	H	Valve seat insert cutter		(15434) ST-662
71	H	Valve guide arbor		(15434) ST-663
72	H	Valve' facing machine		(15434) 3376256
73	N	Valve guide reamer		(15434) ST-646
74	H	Valve head checking tool		(15434) 3375933
75	H	Valve seat grinder		(15434) ST-685
76	H	Valve guide mandrel		(15434) 3375282

SECTION III: TOOL AND TEST EQUIPMENT REQUIREMENTS FOR SHIP'S SERVICE GENERATOR

TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE CATEGORY	NOMENCLATURE	NATIONAL/NATO STOCK NUMBER	TOOL NUMBER
77	H	Drill press	5130-00-293-1949	
78	H	Head holding fixture		(15434) ST-583
79	H	Injector sleeve holding tool		(15434) ST-1179
80	H	Hydrostatic tester		(15434) ST-1012
81	H	Tester adapter plate		(15434) ST-1013
82	H	Staking tool driver		(15434) ST-1122
83	H	Staking tool		(15434) ST-1124
84	H	1/2" Electric drill	4130-00-889-9002	
85	H	Valve seat reamer		(15434) ST-1188
86	H	Valve seat extractor		(15434) ST-1279
87	H	Valve guide reamer		(15434) ST-1187
88	H	Crosshead guide spacer		(15434) ST-633
89	H	Water hole counterboring tool kit		(15434) ST-1010
90	H	Injector sleeve puller		(15434) ST- 1244
91	H	Bead cutting tool		(15434) ST-188
92	H	Holder and pilot		(15434) ST-844-1 ST-844-6

SECTION III: TOOL AND TEST EQUIPMENT REQUIREMENTS FOR SHIP'S SERVICE GENERATOR

TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE CATEGORY	NOMENCLATURE	NATIONAL/NATO STOCK NUMBER	TOOL NUMBER
93	H	Injector sleeve driver		(15434)ST-1227
94	H	Injector sleeve expander		(15434)ST-880
95	H	Injector seat cutter		(15434)ST-884
96	H	Plug gauge		(15434)ST-537
97	H	Lever bushing block/mandrel set		(15434)3376026

SECTION IV. REMARKS

SHIP'S SERVICE GENERATOR SET

REFERENCE CODE	REMARKS
A	Depot maintenance will be performed on a case by case basis subject to approval and funding by the National Maintenance Point (NMP).
B	This item is a candidate for direct exchange with the vendor.
C	During disassembly of the engine, put a cover tape over the inset and olutlet of the turbocharger.
D	Remove the capscrews in the opposite sequence as that used for installing the cylinder heads
E	When a flanged locknut is used to hold the pulley on the shaft, you must not let the accessory drive shaft turn when the locknut is removed. When the flanged locknut is installed, it is tightened to 270 to 340 ft. lbs. torque.
F	Do not use a hammer or screwdriver to remove the caps from the connecting rods.
G	Do not use a hammer or other tools to remove the piston pin.
H	You do not need to use shims for thecylinder liner unless the counterbore has been repaired.
I	Inspect the cylinder block on a flat surface to prevent distortion. Do not inspect the cylinder block in the engine stand.
J	Electric start engine.
K	Air start engine.
L	Used on electric start engine only.
M	Used on air start engine only.

*U.S. GOVERNMENT PRINTING OFFICE: 1994 - 555-028/000212

PIN: 065781-005

APPENDIX C

EXPENDABLE/DURABLE SUPPLIES AND MATERIALS LIST

SECTION I. INTRODUCTION

C-1. **Scope**. This appendix lists expendable supplies and materials needed to operate and maintain the LCU 2000 Class Watercraft. These items are authorized by CTA 50-970, Expendable/Durable Items (except Medical, Class V, Repair Parts and Heraldic Items), or CTA 8-100, Army Medical Department Expendable Items.

C-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 material (for example, "Use cleaning compound, Item 5, App. C").

b. Column (2) - Level. This column identifies the lowest level of maintenance that requires the listed item.

As applicable:

C - Operator/Crew
O - Organizational Maintenance
F - Direct Support Maintenance
H - General Support Maintenance

c. Column (3) - National Stock Number. This is the National stock number assigned to the item; use it to request or requisition the item.

d. Column (4) - Description. Indicates the Federal item name and, if required, a description to identify the item. The last line for each item indicates the Federal Supply Code for Manufacturers (FSCM) in parentheses followed by the part number.

e. Column (5) - Unit of Measure (U/M). Indicates the measure used in performing the actual maintenance function. This measure is expressed by a two- character alphabetical abbreviation (for example, ea, in, pr). If the unit of measure differs from the unit of issue, requisition the lowest unit of issue that will satisfy your requirements.

SECTION II. EXPENDABLE / DURABLE SUPPLIES AND MATERIAL LIST

(1) ITEM NUMBER	(2) LEVEL	(3) NATIONAL STOCK NUMBER	(4) DESCRIPTION	(5) U/M
1	0		Fuel oil, No. 2 diesel	
2	0		Oil, lubricating	
3	0		Water, distilled	
4	0		Rags	
5	0		Brush, cleaning, non-metallic	
6	0		Solvent, metal cleaning	
7	0		Plastic sheeting	
8	0		Coolant (antifreeze)	
9	0		Compound, pipe thread, anti-seize	
10	0		Container, waste oil/fuel, 1 GL	
11	0		Lubricant, pipe thread, Teflon	
12	0		Emery cloth (240 Grit)	
13	0		Tape, masking	
14	F		Compound, heat sink, silicone	
15	F		Loctite 105	
16	F		Grease, all purpose	
17	F		Alkaline solution	
18	F		Acid, muriatic	
19	F		Acid, oxalic	
20	F		Pyridene	
21	F		Sodium carbonate	
22	F		Emery cloth (200 Grit)	

SECTION II. EXPENDABLE/DURABLE SUPPLIES AND MATERIAL LIST - CONT

(1) ITEM NUMBER	(2) CATEGORY	(3) NATIONAL STOCK NUMBER	(4) DESCRIPTION	(5) U/M
23	O, F		Petroleum jelly	
24	O, F		Bottle brush	
25	F		Compound, Prussian blue	
26	O, F		Crocus cloth (fine)	
27	O, F		Sealant, pipe	
28	O		Lubriplate	
29	O, F		Rubber bands	
30	F		Chalk, lithium base	
31	O, H		Solvent, petroleum distillate	
32	O, H		Grease, lithium base	
33	H		Marker, metal, liquid	
34	O, H		Compound, lapping	
35	O, H		Tape, Teflon	
36	H		Compound, liquid lead	
37	O, H		Mineral spirits	
38	O, H		Paper, abrasive, aluminum oxide (240 Grit)	
39	O,H		Soap, solid cake	
40	O, H		Gloves, protective	
41	H		Crayon, heat determining (tempilstik)	
42	O		Brush, steel wire, hand	
43	O		Towel, paper, lint-free	

SECTION II. EXPENDABLE/DURABLE SUPPLIES AND MATERIAL LIST - CONT

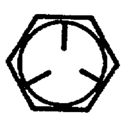
(1) ITEM NUMBER	(2) CATEGORY	(3) NATIONAL STOCK NUMBER	(4) DESCRIPTION	(5) U/M
44	O,F,H		Oil, vegetable	
45	O,H		Sealant, RTV	
46	O		Guide studs, cylinder head mounting	
47	O		Guide studs, aftercooler mounting	
48	O		Guide studs, exhaust manifold mounting	
49	F		Guide studs, flywheel mounting	
50	F		Guide studs, flywheel housing mounting	
51	F		Guide studs, gear cover mounting	
52	F		T-handle studs	
53	F		Guide studs, crankshaft end	
54	O		Vacuum cleaner	
55	H		Guide studs, generator end bracket	
56	H		Guide studs, generator drive coupling	

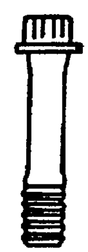
APPENDIX D

TORQUE VALUES

Table D-1. Torque Values for Capscrews, Bolts, and Nuts

Torque (ft-lb) for Course and Fine Threads					
Nominal Thread Diameter	SAE Grades 5 as Received	SAE Grades 5 Lubri cated	SAE Grades 8 as Received	SAE Grades 8 Lubri cated	Screws for Universal Joint Bearing Caps Lubricated
1/4	9 ±1	7 ±1	14±1	11 ±1	.....
5/16	19 ±2	15 ±2	27 ±2	22 ±2	.....
3/8	33 ±3	27 ±2	46 ±4	38 ±3	.....
7/16	52 ±4	40 ±3	73 ±6	60 ±5	64 ±4
1/2	80 ±6	65 ±5	112 ±8	90 ±7	100
9/16	112 ±8	90 ±8	158 ±12	130 ±10	.....
5/8	158 ±12	130 ±10	224 ±16	180 ±15	190 ±10
3/4	280 ±20	225 ±20	390 ±30	320 ±25	330 ±17
7/8	448 ±32	360 ±30	630 ±50	510 ±40	510 ±25
1	680 ±50	540 ±45	960 ±70	775 ±60	.....
1 1/8	850 ±60	675 ±60	1360 ±(100)	1100 ±85	.....
1 1/4	1175 ±85	925 ±75	1850 ±150	1500 ±125	.....





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APPENDIX D - CONT

Table D-2. Torque Values for Tapered Pipe Plugs

	Recommended Torque (ft-lb)	
NPTF Size	In Cast Iron or Steel	Lubricated In Aluminum
1/16-27	8.5 ± 1.0	5.5 ± 0.7
1/8-27	10.5 ± 1.3	6.5 ± 0.8
1/4-18	25 ± 3	16 ± 2
3/8-18	27 ± 3	17 ± 2
1/2-14	50 ± 6	30 ± 4
3/4-14	54 ± 7	34 ± 4
1 -11 1/2	80 ±10	50 ± 6
1 1/4-11 1/2	85 ±10	55 ± 7
1 1/2-11 1/2	85 ±10	55 ± 7

Table D-3. Torque Values for Straight Threaded Tube Fittings, Hose Fittings, and Plugs with "O-Rings"

For 37°, 45°, and Inverted Flared Fittings PER SAE Standards J512, J514, and J516 (See Note)

Nominal Thread od	**Nominal Tube Size**	**Tightening Torque ft-lb Nuts & Plugs**	**Torque in-lb Equiv.**
5/16	1/8	3.6 ± 0.5	43 ± 6
3/8	3/16	8.6 ± 1.0	103 ± 12
7/16	1/4	12 ± 1.5	144 ± 18
1/2	5/16	15 ± 1.5	180 ± 24
9/16 & 5/8	3/8	18 ± 2	
11/16	7/16	25 ± 3	
3/4	1/2	30 ± 4	
7/8	5/8	40 ± 5	
1-1/16	3/4	55 ± 7	
1-3/16 & 1-1/4	7/8	65 ± 8	
1-5/16 & 1-3/8	1	80 ±10	
1-5/8	1-1/4	100 ±12	
1-7/8	1-1/2	120 ±15'	
2-1/2	2	230 ±30	

NOTE: This chart does not apply to other than the 3 flared designs quoted.

Table D-4. Fuel Pump Torque Specifications

	Minimum	Maximum
EFC Actuator Capscrews (in-lb (N-m))	40 (4.5)	50 (5.6)
Front Cover		
Drive coupling capscrew (ft-lb (Nm))	5 (7)	
Mounting capscrew (ft-lb (Nm))	9 (12)	11 (15)
Mounting Allen screws (ft-lb (N-m))	4 (5)	5 (7)
Tachometer Drive Housing (ft-lb (Nm))	35 (47)	45 (61)
Fuel Pump Housing		
Filter screen cap (ft-lb (Nm))	8 (11)	12 (16)
Throttle stop locknuts (in-lb (Nm))	70 (8)	90 (10)
Throttle shaft plunger pipe plug (in-lb (N-m))	40 (4.5)	55 (6.2)
Torque modification device (ft-lb (Nm))	17 (23)	20 (27)
VS governor barrel setscrew (in-lb (N-m))	70 (8)	90 (10)
Pressure regulator cap (ft-lb (Nm))	20 (27)	25 (34)
Governor Spring Assembly		
Cover capscrews (ft-lb (Nm))	9 (12)	11 (15)
Gear Pump		
Cover to body capscrew (ft-lb (Nm))	11 (15)	13 (18)
Gear pump to fuel pump housing (ft-lb (Nm))	11 (15)	13 (18)
Fuel damper to gear pump (ft-lb (N-m))	11 (15)	13 (18)
Fuel damper assembly capscrews (ft-lb (N-m))	9 (12)	11 (15)
Check valve in the gear pump (ft-lb (Nm))	5 (7)	14 (19)
Shutoff Valve		
Coil capscrews (in-lb (Nm))	25 (2.8)	30 (3.4)
Mounting capscrews (ft-lb (Nm))	9 (12)	11 (15)
Pipe Plugs		
1/4 inch (ft-lb (N-m))	25 (34)	30 (41)
1/8 inch in bottom of housing (ft-lb (Nm))	5 (7)	8 (11)

GLOSSARY

ABBREVIATIONS

ac	alternating current
AFC	automatic flow control
AOAP	Army Oil Analysis Program
ATDC	after top dead center
ATV	automatic trip valve
AVR	automatic voltage regulator
BDC	bottom dead center
BTDC	before top dead center
cc	cubic centimeter
cfm	cubic feet per minute
cm	centimeter
cm Hg	centimeters Mercury
CPL	Control Parts List
dc	direct current
DCA	diesel coolant additive
EFC	electric fuel control
EIR	Equipment Improvement Recommendations
FFC	full flow cooling
ft	foot
ft-lb	foot-pound
H_20	water
HP	Horsepower
Hz	Hertz
id	inside diameter
ILS	Isochronous Load Sharing
in	inch
in^2	square inch
in^3	cubic inch
in Hg	inch-Mercury
in H_20	inch-water
in-lb	inch-pound
kg	kilogram
kPa	Kilos Pascal (metric equivalent to psi)
kw	kilowatt
lb	pounds
lm	liters per pound
mm	millimeter
mm Hg	millimeter-mercury
N•m	Newtons
N•	Newtons-metric (equivalent to ft-lb)
od	outside diameter
psi	pounds per square inch
psig	pounds per square inch gauge
PT	pressure time
rpm	revolutions per minute
TDC	top dead center
TIR	total indicator reading
VAC	volts, alternating current
VS	variable speed

GLOSSARY - CONT

DEFINITIONS

AMBIENT TEMPERATURE	The atmospheric temperature of the immediate surrounding area.
ANODS	Active metals such as zinc and magnesium which, when attached to steel or other metal in a water environment, prevent the corrosion of the metal. The anodes corrode and are sacrificed instead of the steel.
ANTIFREEZE	A solution which, when mixed with water, lowers the freezing point.
ALTERNATING CURRENT	Electrical current which repeatedly varies from zero to a positive maximum value to zero to a negative maximum value and back to zero at a periodic rate. Since the applied voltage continually reverses polarity, the resultant current flow alternates in direction within the circuit.
AIR GAP	The radial space between the rotating andthe stationary elements of a generator. The magnetic field passes through this space.
AMMETER	An instrument designed to measure electric current.
AMP	An abbreviation for the term Ampere.
AMPERE	The unit of measure of electrical current flow. One ampere of current will flow when one volt of electrical potential is applied across one ohm of resistance.
CAPACITOR	A device possessing the property of capacitance. A typical capacitor consists of two conducting surfaces separated by an insulating material. A capacitor stores electrical energy, blocks the flow of dc, and permits the flow of ac to a degree largely dependent on the capacitance and the frequency of the applied ac.
CIRCUIT	An electrical path through which an electric current may flow from a voltage or complete circuit is one where current is flowing. An open circuit is one where the path has been disrupted, such as an open switch or circuit breaker, thus stopping current flow.
CIRCUIT BREAKER	A protective device for opening a circuit when current when current flow exceeds a predetermined value.

GLOSSARY -CONT

DEFINITIONS - CONT

COOLANT	The circulating element, generally fresh water, which carries away the head generated by the friction of moving parts of an engine.
CONDUCTOR	A wire, cable, bus, or other device intended to distribute current from the supply to the load. Technically, a conductor is any device which will permit the flow of current.
CONTACTOR	A device for opening and closing an electric circuit. Contractors are normally used in motorcircuit where large amounts of current are controlled.
CURRENT	The flow of electrons in a circuit forced by an applied voltage potential (See Alternating Current and direct Current).
CYCLE	A complete set of events before repetition occurs in alternating current or voltage, a cycle starts at zero, continues to a maximum positive value, returns to zero, continues to a maximum negative value, and is completed at zero.
DIODE	A two terminal solid-state device which permits current to flow in one direction, but not in the other. In alternating current circuits, a diode will permit one half cycle to flow but will resist the flow of the opposite half cycle of current. Thus, alternating current is converted to direct current by a diode.
EXCITATION	The direct current input to the field coils of a generator which produces the magnetic flux required for inducing voltage into the generator stator coils.
EXCITER	An electrical device used for supplying the excitation to the generator field (see Exciter Rotor and Exciter Stator).
EXCITER CURRENT	The direct current supplied to the exciter field coils which is controlled by the voltage regulator.
EXCITER ROTOR	rotating member of the exciter into which a three-phase alternating voltage is induced. The resulting ac is then rectified into direct current and applied to the rotating generator field windings.

GLOSSARY - CONT

DEFINITIONS - CONT

EXCITER STATOR	The stationary member of the exciter which serves as the exciter field producing the magnetic field from the direct current supplied by the automatic voltage regulator.
FIELD	That part of the generator and exciter which, when supplied with direct current, will produce a magnetic field. The exciter stator serves as the exciter field while the main generator rotor serves as the generator field.
FREQUENCY	The number of complete cycles of alternating current per unit of time. Typically, frequency is expressed in cycles per second or Hertz (Hz).
GENERATOR ROTOR	The rotating member of the generator.
GENERATOR STATOR	The stationary member of the main generator which supplies the three-phase output power to the load.
GLYCOLS	A group of chemicals used to lower the freezing point of water.
GOVERNOR	A device which controls engine speed and thus the generator output frequency.
GROUND	A connection, either accidental or intentional, between an electrical potential and the earth or some conducting body serving in place of the earth.
HEAT SINK	A device which absorbs heat from electrical devices such as diodes and SCRs and dissipates the heat to the surrounding air.
HERTZ	A term equivalent to cycles per second (see frequency).
HUNTING	Oscillation in frequency or in voltage where steady-state conditions are not reached, particularly after a load transient change.
INSULATION	A non-conductive material such as rubber or plastic intended to prevent current from flowing. Technically, insulation is any material which resists the flow of current.
INSULATION RESISTANCE	A measure of the ability of insulation to prevent current from flowing. A megohmmeter is used to measure the resistance in millions of ohms between the windings and metal frame of a generator to determine the insulation resistance of the windings.

GLOSSARY - CONT

DEFINITIONS - CONT

ISOCHRONOUS	As it applies to engine governors, maintaining constant steady-state speed regardless of the load within the rating of the engine. Thus, a generator set is said to be Isochronous if the frequency remains the same regardless of load.
LINE-TO-LINE-VOLTAGE	The voltage between any two phases of a multi-phase system.
MEGOHMMETER	A high range high voltage ohmmeter. By measuring the current flow caused by the applied voltage, insulation resistance can be determined.
OHM	The unit of measure of electrical resistance. One ohm of resistance will allow a current of one ampere to flow with an applied potential of one volt.
OHMMETER	An instrument for measuring electrical resistance.
PARALLEL OPERATION	The method by which two or more generators having the same voltage and frequency characteristics are connected to a common load.
PHASE	The windings or an ac generator into which a voltage is induced. In a three-phase system, there are three sets of windings, each set having a voltage alternating within it exactly one-third of a cycle after the one ahead of it because of the physical arrangement of the coils.
PITTING	Corrosion attack in localized areas, resulting in the formation of tiny cavities.
POLARITY current	An electrical term which indicates the direction in which current flows in a conductor. In a direct current system, current constantly flows in the same direction. In an alternating system, current changes direction as the polarity of the ac voltage source changes.
RECTIFIER A	A device used to convert alternating current to direct current. diode is one of several devices which act as rectifiers.
RELAY	An electromechanical device having a magnetic coil which, when energized, opens or closes several sets of contacts.
RESISTANCE	Opposition to the flow of current.
RESISTOR	A component which possesses resistance.

GLOSSARY - CONT

DEFINITIONS - CONT

RHEOSTAT	A variable resistor.
ROTOR	The rotating part of a generator.
SCALE	Insoluble materials that settle out of cooling water and adhere to the metallic surfaces; buildup of hard materials which interfere with the transfer of heat.
SOLENOID	An electromechanical device which, when energized, acts on a movable core or plunger in the center of the energizing coil to perform mechanical work.
STABILITY	A condition which describes engines governor and generator voltage regulator. These systems provide frequency and voltage stability if they can maintain or quickly re-establish steady-state regulation after a load change.
STATOR	The stationary part of a generator or exciter.
SURGE SUPPRESSOR	A device capable of conducting current in either direction in the presence of high transient voltages, thus protecting devices that could otherwise be damaged.
VARISTOR	A surge suppresser.
VOLTAGE REGULATOR	A device which controls the voltage output of a generator at a preset value regardless of the amount of load applied (see Firing Circuit).
VOLTMETER	An instrument designed to measure electrical potential or voltage.

ALPHABETICAL INDEX

ALPHABETICAL INDEX - CONT

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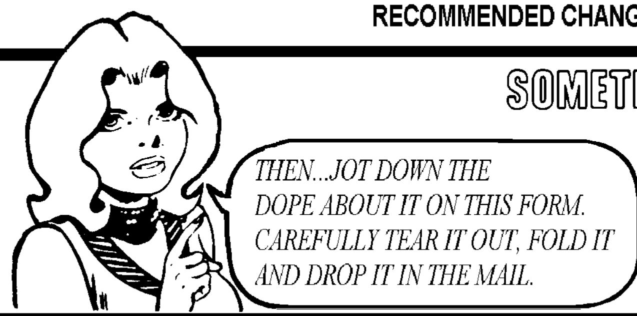

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The Metric System and Equivalents

Linear Measure

1 centimeter = 10 millimeters = .39 inch
1 decimeter = 10 centimeters = 3.94 inches
1 meter = 10 decimeters = 39.37 inches
1 decameter = 10 meters = 32.8 feet
1 hectometer = 10 decameters = 328.08 feet
1 kilometer = 10 hectometers = 3,280.8 feet

Liquid Measure

1 centiliter = 10 milliters = .34 fl. ounce
1 deciliter = 10 centiliters = 3.38 fl. ounces
1 liter = 10 deciliters = 33.81 fl. ounces
1 dekaliter = 10 liters = 2.64 gallons
1 hectoliter = 10 deciliters = 26.42 gallons
1 kilometer = 10 hectoliters = 264.18 gallons

Weights

1 centigram = 10 milligrams = .15 grain
1 decigram = 10 centigrams = 1.54 grains
1 gram = 10 decigram = .035 ounce
1 decagram = 10 grams = .35 ounce
1 hectogram = 10 decagrams = 3.52 ounces
1 kilogram = 10 hectograms = 2.2 pounds
1 quintal = 100 kilograms = 220.46 pounds
1 metric ton = 10 quintals = 1.1 short tons

Square Measure

1 sq. centimeter = 100 sq. millimeters = .155 sq. inch
1 sq. decimeter = 100 sq. centimeters = 15.5 sq. inches
1 sq. meter (centare) = 100 sq. decimeters = 10.76 sq. feet
1 sq. decameter (are) = 100 sq. meters = 1,076.4 sq. feet
1 sq. hectometer (hectare) = 100 sq. decameters = 2.47 acres
1 sq. kilometer = 100 sq. hectometers = .386 sq. mile

Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch
1 cu. decimeter = 1000 cu. centimeters = 61.02 cu. inches
1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

Approximate Conversion Factors

To change	*To*	*Multiply by*	*To change*	*To*	*Multiply by*
inches	centimeters	2.540	ounce-inches	Newton-meters	.007062
feet	meters	.305	centimeters	inches	.394
yards	meters	.914	meters	feet	3.280
miles	kilometers	1.609	meters	yards	1.094
square inches	square centimeters	6.451	kilometers	miles	.621
square feet	square meters	.093	square centimeters	square inches	.155
square yards	square meters	.836	square meters	square feet	10.764
square miles	square kilometers	2.590	square meters	square yards	1.196
acres	square hectometers	.405	square kilometers	square miles	.386
cubic feet	cubic meters	.028	square hectometers	acres	2.471
cubic yards	cubic meters	.765	cubic meters	cubic feet	35.315
fluid ounces	milliliters	29,573	cubic meters	cubic yards	1.308
pints	liters	.473	milliliters	fluid ounces	.034
quarts	liters	.946	liters	pints	2.113
gallons	liters	3.785	liters	quarts	1.057
ounces	grams	28.349	liters	gallons	.264
pounds	kilograms	.454	grams	ounces	.035
short tons	metric tons	.907	kilograms	pounds	2.205
pound-feet	Newton-meters	1.356	metric tons	short tons	1.102
pound-inches	Newton-meters	.11296			

Temperature (Exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

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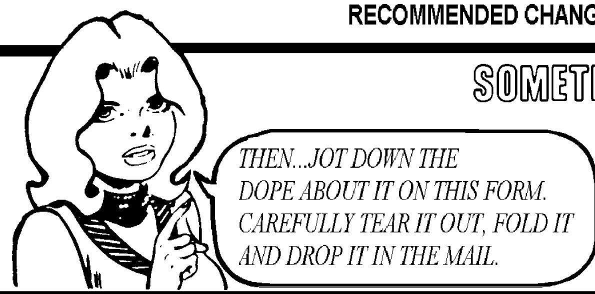

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