

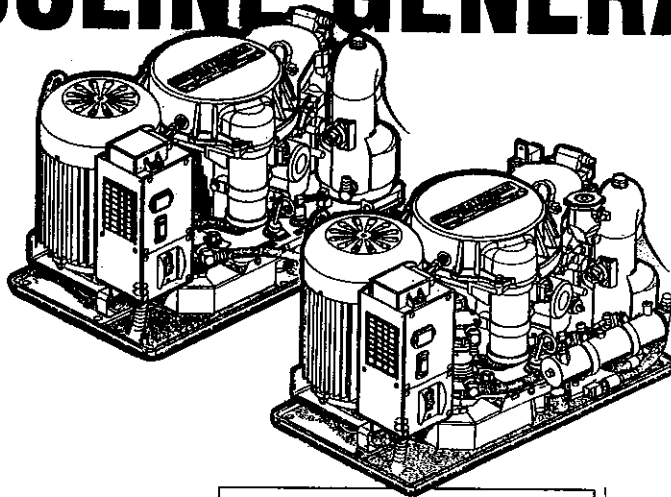


SERVICE MANUAL

3.0KW BPMG 60Hz and 50Hz

SINGLE PHASE

GASOLINE GENERATORS



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 WESTERBEKE

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 Member National Marine Manufacturers Association

⚠ WARNING

Exhaust gasses contain Carbon Monoxide, an odorless and colorless gas. Carbon Monoxide is poisonous and can cause unconsciousness and death. Symptoms of Carbon Monoxide exposure can include:

- **Dizziness**
- **Nausea**
- **Headache**
- **Weakness and Sleepiness**
- **Throbbing in Temples**
- **Muscular Twitching**
- **Vomiting**
- **Inability to Think Coherently**

IF YOU OR ANYONE ELSE EXPERIENCE ANY OF THESE SYMPTOMS, GET OUT INTO THE FRESH AIR IMMEDIATELY. If symptoms persist, seek medical attention. Shut down the unit and do not restart until it has been inspected and repaired.



A WARNING DECAL is provided by WESTERBEKE and should be fixed to a bulkhead near your engine or generator. WESTERBEKE also recommends installing CARBON MONOXIDE DETECTORS in the living/sleeping quarters of your vessel. They are inexpensive and easily obtainable at your local marine store.

**CALIFORNIA
PROPOSITION 65 WARNING**

Marine diesel and gasoline engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

SAFETY INSTRUCTIONS

INTRODUCTION

Read this safety manual carefully. Most accidents are caused by failure to follow fundamental rules and precautions. Know when dangerous conditions exist and take the necessary precautions to protect yourself, your personnel, and your machinery.

The following safety instructions are in compliance with the American Boat and Yacht Council (ABYC) standards.

PREVENT ELECTRIC SHOCK

⚠ WARNING: Do not touch AC electrical connections while engine is running, or when connected to shore power. Lethal voltage is present at these connections!

- Do not operate this machinery without electrical enclosures and covers in place.
- Shut off electrical power before accessing electrical equipment.
- Use insulated mats whenever working on electrical equipment.
- Make sure your clothing and skin are dry, not damp (particularly shoes) when handling electrical equipment.
- Remove wristwatch and all jewelry when working on electrical equipment.
- Do not connect utility shore power to vessels AC circuits, except through a ship-to-shore double throw transfer switch. Damage to vessels AC generator may result if this procedure is not followed.
- Electrical shock results from handling a charged capacitor. Discharge capacitor by shorting terminals together.

PREVENT BURNS — HOT ENGINE

⚠ WARNING: Do not touch hot engine parts or exhaust system components. A running engine gets very hot!

- Always check the engine coolant level at the coolant recovery tank.

⚠ WARNING: Steam can cause injury or death!

- In case of an engine overheat, allow the engine to cool before touching the engine or checking the coolant.

PREVENT BURNS — FIRE

⚠ WARNING: Fire can cause injury or death!

- Prevent flash fires. Do not smoke or permit flames or sparks to occur near the carburetor, fuel line, filter, fuel pump, or other potential sources of spilled fuel or fuel vapors. Use a suitable container to catch all fuel when removing the fuel line, carburetor, or fuel filters.
- Do not operate without a Coast Guard Approved flame arrester. Backfire can cause severe injury or death.
- Do not operate with the air cleaner/silencer removed. Backfire can cause severe injury or death.
- Do not smoke or permit flames or sparks to occur near the fuel system. Keep the compartment and the engine/generator clean and free of debris to minimize the chances of fire. Wipe up all spilled fuel and engine oil.
- Be aware — diesel fuel will burn.

PREVENT BURNS — EXPLOSION

⚠ WARNING: Explosions from fuel vapors can cause injury or death!

- Follow re-fueling safety instructions. Keep the vessels hatches closed when fueling. Open and ventilate cabin after fueling. Check below for fumes/vapor before running the blower. Run the blower for four minutes before starting your engine.
- All fuel vapors are highly explosive. Use extreme care when handling and storing fuels. Store fuel in a well-ventilated area away from spark-producing equipment and out of the reach of children.
- Do not fill the fuel tank(s) while the engine is running.
- Shut off the fuel service valve at the engine when servicing the fuel system. Take care in catching any fuel that might spill. DO NOT allow any smoking, open flames, or other sources of fire near the fuel system or engine when servicing. Ensure proper ventilation exists when servicing the fuel system.
- Do not alter or modify the fuel system.
- Be sure all fuel supplies have a positive shutoff valve.
- Be certain fuel line fittings are adequately tightened and free of leaks.
- Make sure a fire extinguisher is installed nearby and is properly maintained. Be familiar with its proper use. Extinguishers rated ABC by the NFPA are appropriate for all applications encountered in this environment.

SAFETY INSTRUCTIONS

ACCIDENTAL STARTING

⚠ WARNING: Accidental starting can cause injury or death!

- Disconnect the battery cables before servicing the engine/generator. Remove the negative lead first and reconnect it last.
- Make certain all personnel are clear of the engine before starting.
- Make certain all covers, guards, and hatches are re-installed before starting the engine.

BATTERY EXPLOSION

⚠ WARNING: Battery explosion can cause injury or death!

- Do not smoke or allow an open flame near the battery being serviced. Lead acid batteries emit hydrogen, a highly explosive gas, which can be ignited by electrical arcing or by lit tobacco products. Shut off all electrical equipment in the vicinity to prevent electrical arcing during servicing.
- Never connect the negative (-) battery cable to the positive (+) connection terminal of the starter solenoid. Do not test the battery condition by shorting the terminals together. Sparks could ignite battery gases or fuel vapors. Ventilate any compartment containing batteries to prevent accumulation of explosive gases. To avoid sparks, do not disturb the battery charger connections while the battery is being charged.
- Avoid contacting the terminals with tools, etc., to prevent burns or sparks that could cause an explosion. Remove wristwatch, rings, and any other jewelry before handling the battery.
- Always turn the battery charger off before disconnecting the battery connections. Remove the negative lead first and reconnect it last when disconnecting the battery.

BATTERY ACID

⚠ WARNING: Sulfuric acid in batteries can cause severe injury or death!

- When servicing the battery or checking the electrolyte level, wear rubber gloves, a rubber apron, and eye protection. Batteries contain sulfuric acid which is destructive. If it comes in contact with your skin, wash it off at once with water. Acid may splash on the skin or into the eyes inadvertently when removing electrolyte caps.

TOXIC EXHAUST GASES

⚠ WARNING: Carbon monoxide (CO) is a deadly gas!

- Ensure that the exhaust system is adequate to expel gases discharged from the engine. Check the exhaust system regularly for leaks and make sure the exhaust manifolds/water-injected elbow is securely attached.
- Be sure the unit and its surroundings are well ventilated. Run blowers when running the generator set or engine.
- Do not run the generator set or engine unless the boat is equipped with a functioning marine carbon monoxide detector that complies with ABYCA-24. Consult your boat builder or dealer for installation of approved detectors.
- For additional information refer to ABYC T-22 (educational information on Carbon Monoxide).

⚠ WARNING: Carbon monoxide (CO) is an invisible odorless gas. Inhalation produces flu-like symptoms, nausea or death!

- Do not use copper tubing in diesel exhaust systems. Diesel fumes can rapidly destroy copper tubing in exhaust systems. Exhaust sulfur causes rapid deterioration of copper tubing resulting in exhaust/water leakage.
- Do not install exhaust outlet where exhaust can be drawn through portholes, vents, or air conditioners. If the engine exhaust discharge outlet is near the waterline, water could enter the exhaust discharge outlet and close or restrict the flow of exhaust. Avoid overloading the craft.
- Although diesel engine exhaust gases are not as toxic as exhaust fumes from gasoline engines, carbon monoxide gas is present in diesel exhaust fumes. Some of the symptoms or signs of carbon monoxide inhalation or poisoning are:
 - Vomiting Inability to think coherently
 - Dizziness Throbbing in temples
 - Headache Muscular twitching
 - Nausea Weakness and sleepiness

AVOID MOVING PARTS

⚠ WARNING: Rotating parts can cause injury or death!

- Do not service the engine while it is running. If a situation arises in which it is absolutely necessary to make operating adjustments, use extreme care to avoid touching moving parts and hot exhaust system components.

SAFETY INSTRUCTIONS

- Do not wear loose clothing or jewelry when servicing equipment; tie back long hair and avoid wearing loose jackets, shirts, sleeves, rings, necklaces or bracelets that could be caught in moving parts.
- Make sure all attaching hardware is properly tightened. Keep protective shields and guards in their respective places at all times.
- Do not check fluid levels or the drive belts tension while the engine is operating.
- Stay clear of the drive shaft and the transmission coupling when the engine is running; hair and clothing can easily be caught in these rotating parts.

HAZARDOUS NOISE

 **WARNING: High noise levels can cause hearing loss!**

- Never operate an engine without its muffler installed.
- Do not run an engine with the air intake (silencer) removed.
- Do not run engines for long periods with their enclosures open.

 **WARNING: Do not work on machinery when you are mentally or physically incapacitated by fatigue!**

OPERATORS MANUAL

Many of the preceding safety tips and warnings are repeated in your Operators Manual along with other cautions and notes to highlight critical information. Read your manual carefully, maintain your equipment, and follow all safety procedures.

GASOLINE ENGINE AND GENERATOR INSTALLATIONS

Preparations to install an engine should begin with a thorough examination of the American Boat and Yacht Council's (ABYC) standards. These standards are a combination of sources including the USCG and the NFPA.

Sections of the ABYC standards of particular interest are:

- H-2 Ventilation
- P-1 Exhaust Systems
- P-4 Inboard Engines
- E-9 DC Electrical Systems

All installations must comply with the Federal Code of Regulations (FCR).

ABYC, NFPA AND USCG PUBLICATIONS FOR INSTALLING DIESEL ENGINES

Read the following ABYC, NFPA and USCG publications for safety codes and standards. Follow their recommendations when installing your engine.

ABYC (American Boat and Yacht Council)
"Safety Standards for Small Craft"

Order from:

ABYC
3069 Solomon's Island Rd.
Edgewater, MD 21037

NFPA (National Fire Protection Association)
"Fire Protection Standard for Motor Craft"

Order from:

NFPA
11 Tracy Drive
Avon Industrial Park
Avon, MA 02322

USCG (United States Coast Guard)
"USCG 33CFR183"

Order from:

U.S. Government Printing Office
Washington, D.C. 20404

INSTALLATION

When installing WESTERBEKE engines and generators it is important that strict attention be paid to the following information:

CODES AND REGULATIONS

Strict federal regulations, ABYC guidelines, and safety codes must be complied with when installing engines and generators in a marine environment.

SIPHON-BREAK

For installations where the exhaust manifold/water injected exhaust elbow is close to or will be below the vessel's waterline, provisions must be made to install a siphon-break in the raw water supply hose to the exhaust elbow. This hose must be looped a minimum of 20' above the vessel's waterline. *Failure to use a siphon-break when the exhaust manifold injection port is at or below the load waterline will result in raw water damage to the engine and possible flooding of the boat.*

If you have any doubt about the position of the water-injected exhaust elbow relative to the vessel's waterline under the vessel's various operating conditions, *install a siphon-break.*

NOTE: *A siphon-break requires periodic inspection and cleaning to ensure proper operation. Failure to properly maintain a siphon-break can result in catastrophic engine damage. Consult the siphon-break manufacturer for proper maintenance.*



AVAILABLE FROM
YOUR WESTERBEKE
DEALER

EXHAUST SYSTEM

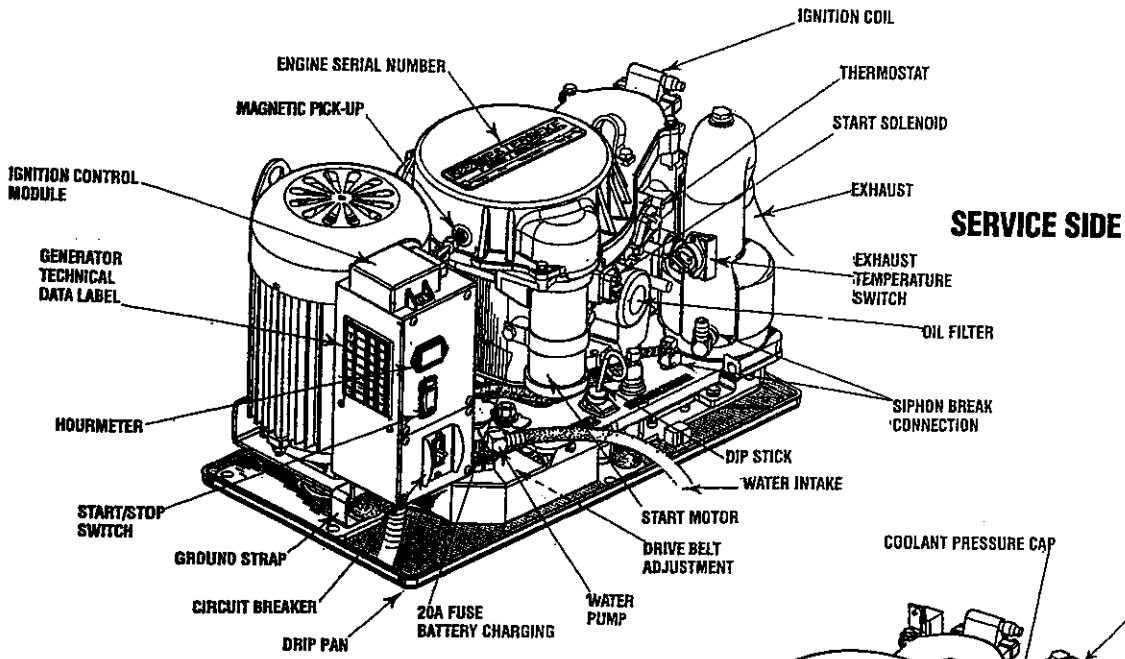
The exhaust hose must be certified for marine use. The system must be designed to prevent water from entering the exhaust under any sea conditions and at any angle of the vessels hull.

A detailed Installation Manual is furnished with the generator. The Operators manual also has specific installation data for the 3.0 generator.

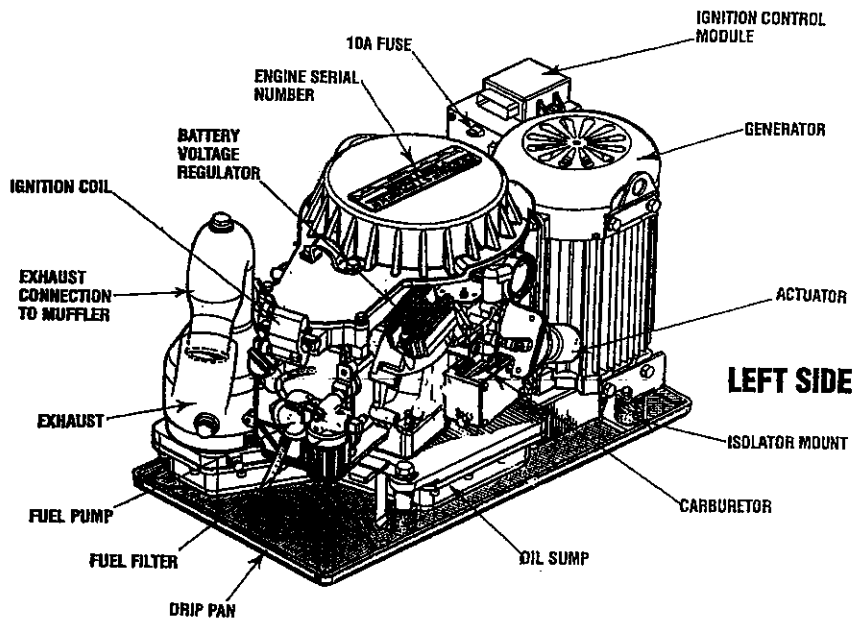
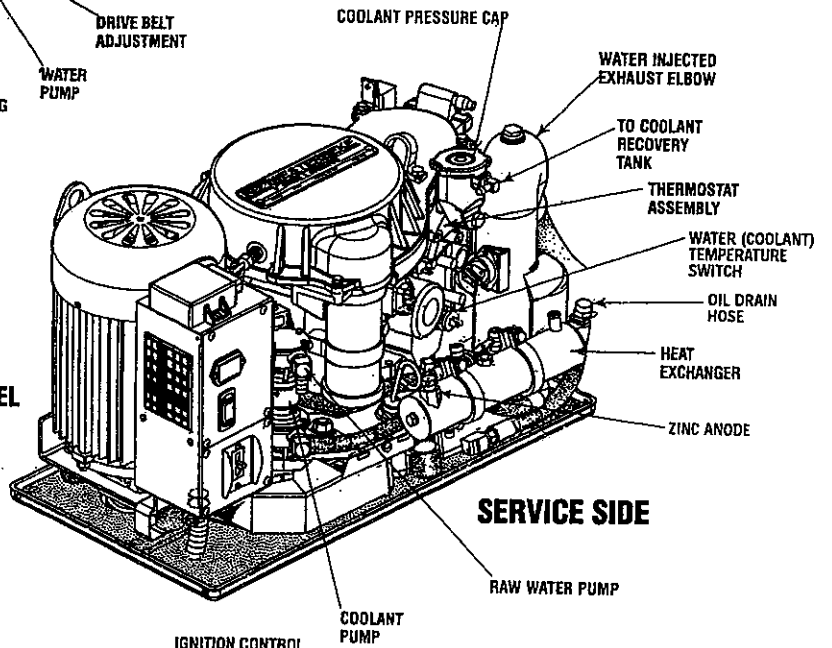
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PARTS IDENTIFICATION



FRESH WATER (COOLANT) MODEL



TESTING FOR OVERHAUL

HOW TO DETERMINE ENGINE OVERHAUL PERIOD

Cause of Low Compression

Generally, the time at which an engine should be overhauled is determined by various conditions such as lowered engine power output, decreased compression pressure, and increased fuel and oil consumption. The lowered engine power output is not necessarily due to trouble with the engine itself, but is sometimes caused by improper oil, clogged filters or a faulty carburetor.

The decrease in compression pressure is caused by many factors. It is, therefore, necessary to determine a cause or causes on the basis of data produced by periodic inspection and maintenance. Oil analysis on a seasonal basis is a good means of monitoring engine internal wear. When caused by worn cylinders or piston rings, the following symptoms will occur:

- 1 Low engine power output
- 2 Increased fuel consumption
- 3 Increased oil consumption
- 4 Hard engine starting
- 5 Noisy engine operation

These symptoms often appear together. Symptoms 2 and 4 can result also from improper fuel regulation or a faulty carburetor. They are caused also by defective electrical devices such as the battery, starter or spark plugs. Therefore it is desirable to judge the optimum engine overhaul time by the lowered compression pressure caused by worn cylinders and pistons plus increased oil consumption. Satisfactory combustion is obtained only under sufficient compression pressure. If an engine lacks compression pressure, incomplete combustion of fuel will take place even if other parts of the engine are operating properly. To determine the period of engine overhaul, it is important to measure the engine compression pressure regularly. At the same time, the engine speed at which the measurement of compression pressure is made should be checked because the compression pressure varies with engine rpm. The engine rpm can be measured at the front end of the crankshaft.

NOTE: To test engine compression see the *ENGINE ADJUSTMENT* section of this manual.

OVERHAUL CONDITIONS

Compression pressure tends to increase a little in a new engine until piston rings and valve seats have been broken in. Thereafter, it decreases gradually with the progress of wear of these parts.

When decrease of compression pressure reaches the repair limit, the engine must be overhauled.

The engine requires overhaul when oil consumption is high, blowby evident, and compression values are at minimum or below.

TROUBLESHOOTING GUIDE 3.0 KW BPMG

When troubleshooting indicates an electrical problem, see the ELECTRICAL SYSTEM WIRING DIAGRAM, as this may reveal other possible causes of the problem which are not listed below.

The following troubleshooting tables are based upon certain engine problem indicators and the most likely causes of the problems

PROBLEM	PROBABLE CAUSE	PROBLEM	PROBABLE CAUSE
Engine does not crank.	<ol style="list-style-type: none"> 1. Voltage drop at starter solenoid terminal. 2. Main 10 amp fuse blown. 4. Battery is low or dead. 5. Loose battery connections. 6. Faulty wire connection. 7. Faulty start switch. 8 Faulty pc board 9. Faulty starter solenoid 10. Water filled cylinders. 	Engine misfires.	<ol style="list-style-type: none"> 1. Poor quality fuel. 2. Faulty ignition control module. 3. Dirty flame arrester. 4. Faulty ignition wires. 5. Spark plugs are worn. 6. Binding actuator linkage. 7. High exhaust back-pressure. 8. Valve clearances are incorrect. 9. Valve clearances are incorrect.
Engine starts, runs and then shuts down.	<ol style="list-style-type: none"> 1. Faulty shutdown switch,(oil pressure, or exhaust temperature). 2. Faulty overspeed switch. 3. Dirty fuel/water separator filter. 4. Clogged fuel line. 5. Low oil level in sump. 6. Faulty fuel pump. 7. No fuel 8. Clogged fuel filter 	Engine backfires.	<ol style="list-style-type: none"> 1. Faulty ignition control module. 2. Incorrect timing. 3. Engine is flooded. See <i>Engine is flooded under Engine cranks but fails to start.</i> 4. Dirty flame arrester. 5. Faulty ignition coil. 6. High exhaust back-pressure.
Engine starts, runs but does not come up to speed.	<ol style="list-style-type: none"> 1. Faulty mag-pickup sensor. 2. Electronic governor controller faulty, 3. Fuel pump. 4. Fuel supply to engine restricted. 5. Actuator linkage binding. 6. Actuator or electrical connections faulty. 7. Air intake restricted. 8. Exhaust restricted. 	Engine overheats.	<ol style="list-style-type: none"> 1. Blockage in cooling water flow: inspect the raw water intake, intake strainer, pump impellers, and look for broken or seperated hoses. 2. Belts may be loose or broken. 3. Obstructed by-pass hose.
Engine cranks but fails to start. (Engine will crank for 15 seconds)	<ol style="list-style-type: none"> 1. Out of fuel. 2. Engine is flooded. 3. Faulty carburetor. (<i>See Carburetor page</i>) 4. Faulty choke solenoid 5. Faulty ignition coil. 6. Bad spark plugs 	Low oil pressure.	<ol style="list-style-type: none"> 1. Low oil level. 2. Wrong SAE type oil in the engine. 3. Oil diluted with fuel. 4. Relief valve is stuck. 5. Faulty oil pump. 6. Faulty engine bearings. 7. Boat heeled over too much. 8. Faulty oil filter.
Engine hunts.	<ol style="list-style-type: none"> 1. Controller gain adjustment needed. 2. Faulty fuel pump. 3. Faulty PC board. 4. Improper drive belt tension. 5. Low DC battery voltage. 6. High exhaust back pressure. 7. Dirty fuel filter 8. Generator overload. 9. Valves need adjustment. 	High oil pressure.	<ol style="list-style-type: none"> 1. Dirty oil or wrong SAE type oil in the engine. 2. Relief valve is stuck.
		No DC charge to the starting battery.	<ol style="list-style-type: none"> 1. Faulty connections to battery charging control. 2. 20 amp fuse blown/faulty. 3. Faulty voltage regulator. 4. Faulty magneto.

TROUBLESHOOTING GUIDE 3.0 KW BPMG

PROBLEM	PROBABLE CAUSE
Blue Exhaust Smoke Discharge from the Engine	<ol style="list-style-type: none"> 1. Lube oil is diluted. 2. High lube oil level. 3. Crankcase breather hose is clogged. 4. Valves are worn or adjusted incorrectly. 5. Piston rings are worn or unseated.
Black exhaust smoke Discharge from the Engine	<ol style="list-style-type: none"> 1. Dirty flame arrester. 2. Faulty carburetor. 3. Idle mixture jet too rich. 4. Accelerator diaphragm leaking. 5. Valves are worn or incorrectly adjusted. 6. Piston rings are worn or unseated.
Poor performance at generator speed	<ol style="list-style-type: none"> 1. Contaminates in carburetor. 2. Faulty fuel pump/contaminated. 3. Electronic governor controller needs adjustment.
Starter stays energized after start	<ol style="list-style-type: none"> 1. Faulty MPU suspected. Check MPU. 2. Faulty starter solenoid.
Unit starts and runs at idle speed	<ol style="list-style-type: none"> 1. Check MPU signal. 1.5 - 2.0 VAC cranking. 2. Faulty overspeed board.

Note: MPU voltages to PC board:
 Cranking: 1.5 - 2.0 VAC
 Running: 4.0 - 5.0 VAC
 (2200 rpm)

DISASSEMBLY / ASSEMBLY PROCEDURES

DISASSEMBLY

- Before disassembly and cleaning, carefully check for defects which cannot be found after disassembly and cleaning.
- Drain water, fuel and oil before disassembly.
- Clean or wash the engine exterior.
- Do not remove or disassemble the parts that require no disassembly.
- Perform disassembly in a proper order using proper tools. Keep disassembled parts in order. Apply oil when necessary. Take special care to keep the fuel system parts from intrusion of dust and dirt.
- Parts must be restored to their respective components from which they were removed at disassembly. This means that all parts must be set aside separately in groups, each marked for its component, so that the same combination or set can be reproduced at assembly.
- Pay attention to marks on assemblies, components and parts for their positions or directions. Put on marks, if necessary, to aid assembly.
- Carefully check each part or component for any sign of faulty condition during removal or cleaning. The part will tell you how it acted or what was abnormal about it more accurately during removal or cleaning.

The parts assembled with the silicone can be easily disassembled without use of a special method. In some case, however, the sealant between the joined surfaces may have to be broken by lightly striking with a mallet or similar tool. A flat and thin gasket scraper may be lightly hammered in between the joined surfaces. In this case, care must be taken to prevent damage to the joined surfaces. For removal of the oil pan, use a special "oil pan remover".

ASSEMBLY

- Wash all parts, except for oil seals, O-rings, rubber sheets, etc., with cleaning solvent and dry them with pressure air.
- Always use tools that are in good condition and be sure you understand how to use them before performing any job.
- Use only good quality lubricants. Be sure to apply a coat of oil, grease or sealant to parts as specified.
- Be sure to use a torque wrench to tighten parts for which torques are specified.
- When the engine is assembled, new gaskets and O-rings must be installed.

Surface Preparation

Thoroughly removes all substances deposited on the gasket application surfaces using a gasket scraper or wire brush. Check to ensure that the surfaces to which the silicone gasket is to be applied is flat. make sure that there are no oils, greases and foreign substances deposited on the application surfaces. Do not forget to remove the old sealant that remains in the bolt holes.

GASKET INFORMATION

The engine has several areas where form-in-place RTV silicone gaskets are used such as LOCTITE 598 or GE RTV 100. To ensure that the gasket fully serves its purpose, it is necessary to observe some precaution when applying the gasket. Bead size, continuity and location are very important. Too thin a bead could cause leaks and too thick a bead could be squeezed out of location causing blocking or narrowing of the fluid feed lines. To eliminate the possibility of leaks from a joint, it is necessary to apply the gasket evenly without a break while observing the correct bead size.

The gasket material used in the engine is a room temperature vulcanization (RTV) type and is supplied in a 14oz (400 gram) applicator/tube. The RTV hardens as it reacts with the moisture in the atmospheric air and can be used for sealing both engine oil and coolant assemblies.

APPLICATION OF SEALANTS AND LUBRICANTS

Parts Name	Items										Remarks				
	Three Bond 1342	Three Bond 1373B	Instantaneous Adhesive Three Bond 1741	Three Bond 1207B	Loctite 518	Bond G17	Insulated Grease	Teflon Grease	Cold-resistant Lithium Grease	Grease for OBM		4st Engine Oil	Specified Gear Oil	Oil Compound Jyotsu-Silicone KS-64	Loctite 5900
Engine block	Cylinder liner										●				Inside wall
	Piston										●				Ring groove, Periphery
	Piston ring										●				Periphery
	Piston pin										●				Periphery
	Connecting rod										●				Inside big and small ends
	Metal (Cylinder block, crank case)										●				Both sides
	Crank shaft (thrust place)										●				Sliding surfaces
	Crank shaft oil seal								●						Lips
	Crank case cylinder mating surface					●									Joint part
	Valve (IN, EX)										●				Shaft, Stem head
	Valve stem seal (IN, EX)										●				Lips
	Retainer										●				Complete
	Valve spring seat										●				Complete
	Valve spring										●				Complete
	Camshaft										●				Bearing, cam
	Camshaft oil seal								●						Lips
	Cam pulley bolt	●													Thread
	Rocker arm										●				Bearing, Slipper
	Rocker arm shaft										●				Shaft, side
	Tappet adjust screw										●				Complete
	Washer (rocker arm, t=0.5)										●				Complete
	Washer (rocker arm, t=2.5)										●				Complete
	Spring (rocker arm, free length 30 mm and 51 mm)										●				Complete
	Fuel pump										●				Periphery of O-ring, end of plunger
	Oil pump										●				2ml at Suction port and discharge port, Boss part O-ring
	Oil pump O-ring (ø1.5 - 10.7)										●				
	Oil pump O-ring (ø1.5 - 8.5)										●				
	Oil pump O-ring (ø1.5 - 15.5)										●				
	Oil pressure switch	●													Thread

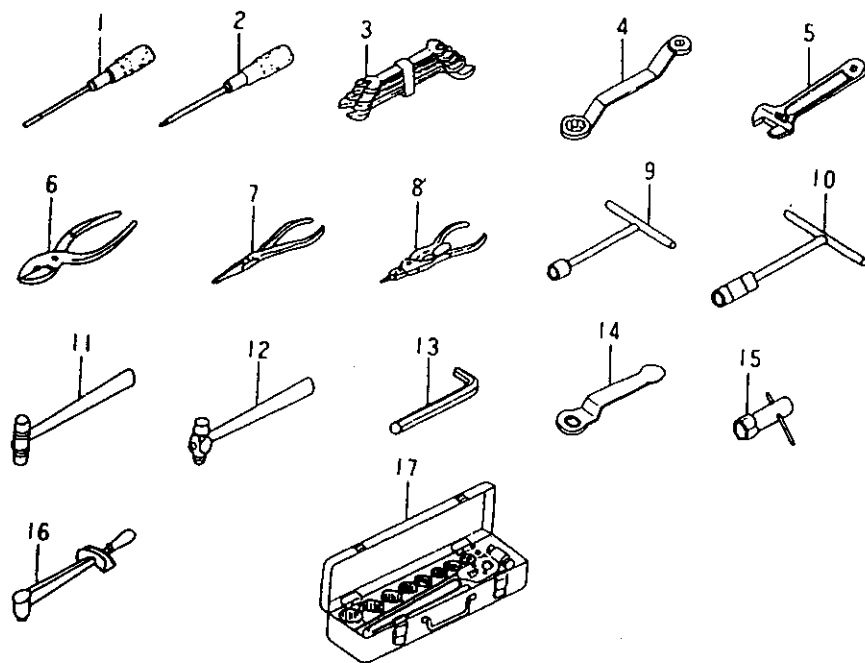
APPLICATION OF SEALANTS AND LUBRICANTS

	Items											Remarks							
		Parts Name		Three Bond	Three Bond	Instantaneous Adhesive Three Bond	Three Bond	Loctite	Bond	Insulated Grease	Teflon Grease		Cold-resistant Lithium Grease	Grease for OBM	4st Engine Oil	Specified Gear Oil	Oil Compound Jyoeitsu-Silicone	Loctite	Silicone Sealant
		1342	1373B	1741	1207B	518	G17									KS-64	5900		
Engine block	Oil filter												●				●	Seal	
	Oil filter bolt	●																Thread	
	Plunger ass'y																●	Inside (Pour 1ml)	
	Filter cap, O-ring																●	Periphery	
	Solenoid switch									●								Terminal	
	Spark plug cap																●	Spark plug insertion part	
								●										High tension cord	
	Starter motor									●								Terminal	
													●					Spread at pinion part slightly	
	Starter case		●															Bolt and screw for Reel	
												●						Friction plate, reel shaft part, Spiral spring, ratchet	
	Starter seal rubber				●														
Engine oil																●	Oil; at oil change 1000ml at overhaul 1200ml		
Oilpan gasket					●														
Bolt (upper pump case)		●															Thread		
Upper pump case																●	Impeller sliding surfaces Joint part for water pipe guide		

TORQUE SPECIFICATIONS

	Item	Thread size	Bolt or Nut	Tightening Torque		
				N-m	kg-m	lb-ft
Engine	Cylinder Block – Cylinder Head	M8 × 1.25	Bolt	28-30	2.8-3.0	20-22
		M6 × 1.0	Bolt	8-10	0.8-1.0	5.8-7.2
	Cylinder Block – Crank Case	M8 × 1.25	Bolt	23-25	2.3-2.5	17-18
		M6 × 1.0	Bolt	8-10	0.8-1.0	5.8-7.2
	Connecting Rod	M7 × 1.0	Bolt	11-13	1.1-1.3	8.0-9.4
	Tappet Lock Nut	M6 × 0.75	Nut	6-8	0.6-0.8	4.4-5.8
	Flywheel Cup	M16 × 1.5	Nut	70-80	7-9	51-65
	Drive (Timing) Pulley	M26 × 1.0	Nut	34-36	3.4-3.6	25-26
	Driven (Camshaft) Pulley	M6 × 1.0	Bolt	10-12	1.0-1.2	5.8-8.7
	Plunger Assembly	M16 × 1.5	–	19-21	1.9-2.1	12-15
	Oil Filter	M20 × 1.5	–	18	1.8	13
	Oil Pressure Switch	PT1/8	–	7-9	0.7-0.9	5-6
	Cylinder Head Cover	M6 × 1.0	Bolt	8-10	0.8-1.0	5.8-7.2
	Inlet Manifold	M6 × 1.0	Bolt	8-10	0.8-1.0	5.8-7.2
	Spark Plug	M12 × 1.25	–	15-20	1.5-2.0	11-15
	Engine Assembly	M8 × 1.25	Bolt	29-31	2.9-3.1	21-22

REQUIRED TOOLS



1. Straight-point screwdriver (200 mm)

– do. – (150 mm)

– do. – (100 mm)

2. Phillips screwdriver (200 mm)

– do. – (150 mm)

– do. – (100 mm)

3. Set of wrenches (6 pieces)

4. Box wrenches (10 × 13)

– do. – (17 × 21)

– do. – (21 × 23)

5. Adjustable wrench (300 mm)

6. Pliers

7. Needle-nose pliers

8. Snap ring pliers

9. T-bar socket wrench (10 mm)

– do. – (12 mm)

– do. – (13 mm)

– do. – (17 mm)

10. T-bar universal wrench (10 mm)

– do. – (12 mm)

– do. – (13 mm)

11. Plastic hammer

12. Hammer

13. L-shape hexagon wrench (8 mm)

– do. – (10 mm)

14. Box wrench (16 mm)

15. Socket wrench (16 mm)

16. Torque wrench (100 N – m)

– do. – (12 N – m)

– do. – (5 N – m)

Pre-setting type box torque wrench

(10 mm, 7N – m) for the tappet lock nut

17. Socket wrench set

USING SPECIAL TOOLS

5. How to Use Special Tools

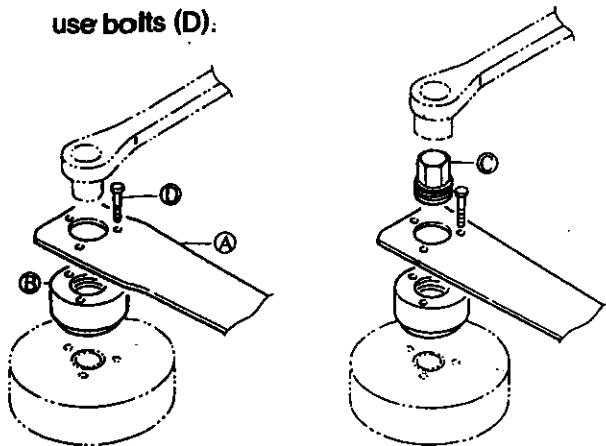
1. Flywheel cup puller

① When disassembling

Fasten the tools **A** and **B** to the flywheel with the bolts **C**, and remove the magneto nut (right-hand screw) with the socket wrench of the correct size 24.

Next, screw tool **C** into tool **B** and tighten **C** with the socket wrench of the correct size 24.

The flywheel can be removed. Be sure to use bolts **D**.



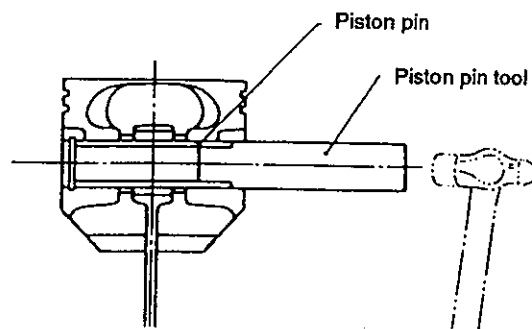
② When reassembling

Before replacing the flywheel make sure that the magneto key has properly been set. After setting the washer and nut on the crank shaft, fasten tools **A** and **B** to the flywheel and tighten the nut.

Tightening torque: 70-90 N-m (7.0-9.0 kg-m)
(51-65 lb-ft)

2. Piston pin tool

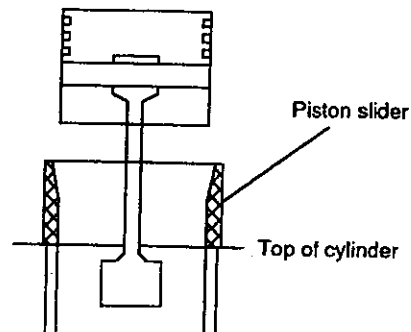
After removing the piston pin clip, insert the tip of the piston pin tool into the piston pin hole and lightly tap the other end of the tool with a hammer. Hold the piston with your hand to prevent damage to the connecting rod. (When inserting the piston pin again, take the same care as removing.)



3. Piston slider

This tool is to be used for inserting the piston into the cylinder. After inserting the piston into the tapered end of the piston slider, set the piston slider together with the piston tightly on the top of the cylinder and insert the piston into the cylinder by pushing the piston crown with fingers.

Note:
Don't stop inserting the piston into the cylinder until all the piston rings enter the cylinder.



SERVICE STANDARDS/REPAIR LIMITS/MAINTENANCE

Part Name	Check/Inspect	Standard Value/Maintenance	Repair Limit
Cylinder Head	<ol style="list-style-type: none"> Carbon deposit on the combustion chamber Scratch depth and distortion of the mounting surface. Corrosion in the mated surface. Clogged cooling water passage. 	<ol style="list-style-type: none"> Remove carbon deposit and clean. Scratch depth or distortion is 0.1mm (0.004in) or more. Repair or replace depending on the situation. Clean and remove foreign matters. 	<ol style="list-style-type: none"> Repair (set #240-#400 sandpaper the surface plate and polish the surface for repair. Use #600 sandpaper for finishing).
Cylinder	<ol style="list-style-type: none"> Deposit in the water jacket. Wear of the inside cylinder diameter. Measure the bore with a cylinder gauge Seizure Scratch and wearing down in the cylinder liner. Mating surfaces of the cylinder and cylinder head. or more. 	<ol style="list-style-type: none"> Clean and remove foreign matters. 59.00mm (2.3228in) Replace or use an over-sized piston after boring the cylinder. When the liner cannot be repaired by means of #400-#600 sandpaper because it is extremely scratched or scored, or the difference between the maximum wear and minimum wear is 0.06mm (0.0024in) or more. When the depth of scratch or distortion in/of the mating surface is 0.1mm (0.004in) 	<ol style="list-style-type: none"> 59.06mm (2.3252in) or more (If wear is exceeding the repair limit, replace or bore the cylinder and finish by honing. Over-sized piston is 0.5mm. refer to item 4). Bore and hone to $\varnothing 59.5K0.01mm$ ($\varnothing 2.3425 \pm 0.0004in$). Use oversize piston and rings. Use #400 sandpaper on the surface plate and polish the surface. Use #600 sandpaper for finishing.
Piston	<ol style="list-style-type: none"> Outside Diameter <ol style="list-style-type: none"> Measure the diameter at a point 7mm above the lower end of the piston skirt. Piston Clearance Carbon deposit on the piston crown and in the piston ring groove. Scratch on the sliding surface. Measurement of clearance between the piston ring and ring groove. Measurement of diameter of the piston pin hole. 	<ol style="list-style-type: none"> Diameter: 58.960mm (2.3213in) <ol style="list-style-type: none"> Piston clearance: 0.020-0.055mm (0.0008-0.0022in) Remove carbon residuum and clean. Repair with #400-#600 sandpaper depending on the situation. Top: 0.04-0.08mm (0.0016-0.0031in) 2nd: 0.03-0.07mm (0.0012-0.0028in) Oil: 0.01-0.18mm (0.0004 - 0.0071in) NOTE: To be replaced with a new oil ring, when replacing with new top and/or second rings. Sandpaper means water proof paper. Clearance between pin and hole Loose: 0.002-0.012mm (0.00008-0.00005in) 	<ol style="list-style-type: none"> Outer Diameter: 58.90mm (2.3189in) or more. <ol style="list-style-type: none"> Piston Clearance: 0.15mm (0.0059in) or more Top: 0.10mm (0.004in) or more 2nd: 0.09mm (0.0035in) or more Oil: 0.21mm (0.0083in) or more 0.04mm (0.0016in) or more
Piston Ring	<ol style="list-style-type: none"> End Gap NOTE: Measurement of the end gap: when no ring gauge is available, measure the lower part of the cylinder bore. <ol style="list-style-type: none"> Top Second Oil 	<ol style="list-style-type: none"> Replace with new piston ring if wear of the cylinder liner is within the repair limit. <ol style="list-style-type: none"> Top: 0.15-0.35mm (0.006-0.014in) Second: 0.30-0.50mm (0.012-0.020in) Oil: 0.20-0.7mm (0.008-0.028in) 	<ol style="list-style-type: none"> Top: 0.5mm (0.020in) or more Second: 0.7mm (0.028in) or more Oil Ring: to be replaced with a new oil ring, when replacing with new top and/or second rings. Sandpaper means water proof paper.
Piston Pin	<ol style="list-style-type: none"> Outer diameter 	<ol style="list-style-type: none"> 16.00mm (0.6299in) 	<ol style="list-style-type: none"> 15.97mm (0.629in) or less.
Crankshaft	<ol style="list-style-type: none"> Deflection of the crankshaft. Both the main bearings of the crankshaft should be supported with V-blocks. Outer diameter of the crankpin. Outer diameter of the bearing. Oil clearance of the bearing. Side clearance of the crankshaft. 	<ol style="list-style-type: none"> Less than 0.05mm (0.002in)-both ends. 29.98mm (1.1803in) 31.99mm (1.2594in) 0.012 - 0.044mm (0.0005 - 0.0017in) 0.1 - 0.2mm (0.004 - 0.008in) 	<ol style="list-style-type: none"> 0.05mm (0.002in) or more. 29.95mm (1.179in) or less. 31.97mm (1.259in) or less. 0.06mm (0.002in) or more. 0.6mm (0.024in) or more.

SERVICE STANDARDS/REPAIR LIMITS/MAINTENANCE

Part Name	Check/Inspect	Standard Value/Maintenance	Repair Limit
Connecting Rod	<ol style="list-style-type: none"> 1. Inner diameter of the small end. 2. Oil clearance of the big end. 3. Side clearance of the big end. 	<ol style="list-style-type: none"> 1. 16.01mm (0.630in) 2. 0.015 - 0.041mm (0.0006 - 0.0016in) 3. 0.1 - 0.25mm (0.004 - 0.01in) 	<ol style="list-style-type: none"> 1. 16.04mm (0.631in) or more. 2. 0.060mm (0.002in) or more. 3. 0.6mm (0.024in) or more.
Magneto	<ul style="list-style-type: none"> ● Inition timing ● Spark performance ● Spark plug ● Spark gap ● Alternator output ● Resistance of coils <p>Between white wire and yellow wire</p> <p>Between red-white wire and black wire</p> <p>Between black-red wire and blue wire</p> <p>Between yellow-red wire and yellow -red wire</p> <ul style="list-style-type: none"> ● ESG for high speed ● ESG for low speed 	BTDC 5° - 5° (electric ignition advance) 10mm (0.4in) or more/500 rpm (measured by genuine spark tester. NGK DCPR6E 0.8 - 0.9mm (0.032 - 0.035in) 12V, 130W (5000 rpm) 0.27 - 0.41Ω 148 - 222Ω 12.5 - 18.8Ω 1.40 - 2.10Ω Restricting at 6250 rpm Reducing at 2000rpm	1.2mm 9 0.0047in) or more
Ignition Coil	<ul style="list-style-type: none"> ● Resistance of primary coil between black wire and orange wire ● Resistance of secondary coil between high tension cord and core 	0.26 - 0.35Ω 6800 - 10200Ω	
Battery	Output Clutch <ol style="list-style-type: none"> 1) Brush length 2) Commutator under-cut 3) Commutator diameter 	12V - 70AH to 12V - 100AH 12V 0.6KW Over-running clutch <ol style="list-style-type: none"> 1) 12.5mm (0.49in) 2) 0.5-0.8mm (0.02-0.03in) 3) 30mm (1.18in) 	<ol style="list-style-type: none"> 1) 9.5mm (0.37in) or less 2) 0.2mm (0.008in) or less 3) 29 mm (1.14in) or less
Fuse	Capacity	120A	
Thermostat	Operation of thermostat	<ul style="list-style-type: none"> ● Start to open: 60°C ± 1.5°C (140 ± 3°F) ● Temperature at which valve opens full: 75°C (167°F) 	If the valve opens at room temperature, replace the thermostat. While immersing the thermostat in water, raise the water temperature and check the temperature at which the valve opens.
Pump Impeller	Worn-out, crack	Replace	
Pump Case Liner	Worn-out	Replace	
Guide Plate	Worn-out	Replace	
Intake Valve Exhaust Valve	<ol style="list-style-type: none"> 1) Valve Clearance 2) Outer diameter of valve stem 3) Inner diameter of valve guide 4) Clearance to valve stem 5) Contact width of valve seat 	IN: 0.13 - 0.17mm (0.005 - 0.007in) EX: 0.18 - 0.22mm (0.007 - 0.008in) IN: 0.13 - 0.17mm (0.005 - 0.007in) EX: 0.18 - 0.22mm (0.007 - 0.008in) IN: 0.13 - 0.17mm (0.005 - 0.007in) EX: 0.18 - 0.22mm (0.007 - 0.008in) IN: 0.13 - 0.17mm (0.005 - 0.007in) EX: 0.18 - 0.22mm (0.007 - 0.008in) IN: 0.13 - 0.17mm (0.005 - 0.007in) EX: 0.18 - 0.22mm (0.007 - 0.008in)	5.46mm (0.215in) or less 5.44mm (0.214in) or less 5.55mm (0.218in) or more 5.57mm (0.219in) or more 0.07mm (0.0028in) or more 0.10mm (0.004in) or more 2.0mm (0.079in) or more 2.0mm (0.079in) or more
Valve Spring	Free length	35mm (1.38in)	33.5mm (1.319in) or less
Camshaft	<ol style="list-style-type: none"> 1) Height of cam (both IN and EX) 2) Outer diameter of bearing 3) Clearance of holder (bearing) 	<ol style="list-style-type: none"> 1) 23.90mm (0.94in) 2) Pulley side: 17.98mm (0.708in) Oil pump side: 15.97mm(0.629in) 3) 0.02 - 0.05mm (0.0008 - 0.0020in) 	<ol style="list-style-type: none"> 1) 23.75mm (0.935in) or less 2) 17.95mm (0.707in) or less 15.95mm (0.628in) or less 3) 0.09mm (0.0035in) or more
Rocker Arm and Shaft	<ol style="list-style-type: none"> 1) Inner diameter 2) Outer diameter 3) Shaft Clearance 	<ol style="list-style-type: none"> 1) 13.01mm (0.512in) 2) 12.99mm (0.511in) 3) 0.006 - 0.035mm (0.00024 - 0.00138in) 	<ol style="list-style-type: none"> 1) 13.05mm (0.514in) or less 2) 12.94mm (0.509in) or less 3) 0.6 mm (0.0024in) or less
Timing Belt	Tension and appearance	Wear, crack or lengthen-replace	

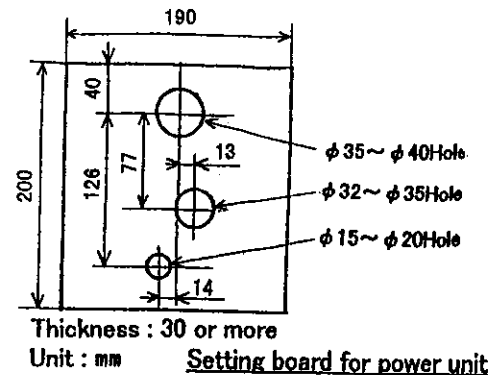
SERVICE STANDARDS/REPAIR LIMITS/MAINTENANCE

Part Name	Check/Inspect	Standard Value/Maintenance	Repair Limit
Engine Block	With de-compressor	0.4 ± 0.1 MPa (5 ± 1 kg/cm ² , 71 psi)	Pay heed to pressure leak in compression from the rotation, sliding and sealing parts.
	Without de-compressor (rocker arm in EX side is removed)	0.93 ± 0.1 MPa (9.5 ± 1 kg/cm ² , 135 psi)	
Carburetor	<ul style="list-style-type: none"> ● Setting mark ● Throttle/Venturi bore ● Main jet (MJ) ● Main air jet (MAJ) ● Inner diameter of main nozzle ● Slow jet (SJ) ● Slow air jet (SAJ) ● Opening angle of throttle (at W.O.T.) ● Pilot screw (PS) - Blind ● Fuel level (from flange surface to float bottom) ● Resistance of PTC* heater for auto-bystarter at 20° C (68° F) (*PTC: positive temperature coefficient thermistor)	3H8A 23/11.5mm #68 #135 2.2mm #42 #115 80° 1-3/4 14mm (0.55in) 20Ω	
Oil Pump	<ul style="list-style-type: none"> 1) Inner diameter of pump body 2) Clearance between outer rotor and body 3) Height of outer rotor 4) Clearance between rotor and body side 5) Clearance between outer rotor and inner rotor 	1) 29.04mm (1.143in) or more 2) 0.36mm (0.014in) or more 3) 14.96mm (0.589in) or less 4) 0.11mm (0.0043in) or more (incl. wear of the pump cover) 5) 0.16mm (0.006in) or more	

ENGINE DISASSEMBLY

Bolts, nuts, and washers are indicated by the symbols below.

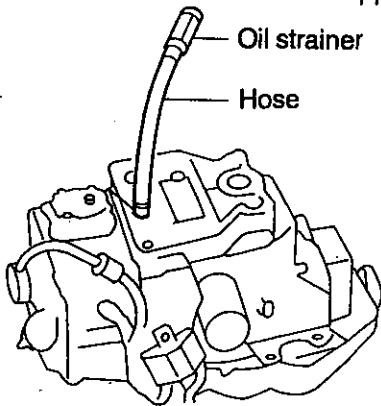
H820 – Hexagon headed bolt	Diameter 8 mm Length 20 mm
N8 – Normal hexagon nut	Diameter 8 mm
L8 – Hexagon lock nut	Diameter 8 mm
W6 – Plain washer	Diameter 6 mm
SW6 – Spring washer	Diameter 6 mm
Screw 620 – Pan headed screw	Diameter 6 mm Length 20 mm



Removing Parts

Oil strainer

- ① Cut the hose band and then remove the oil strainer with the hose from the nipple.



Ignition coil

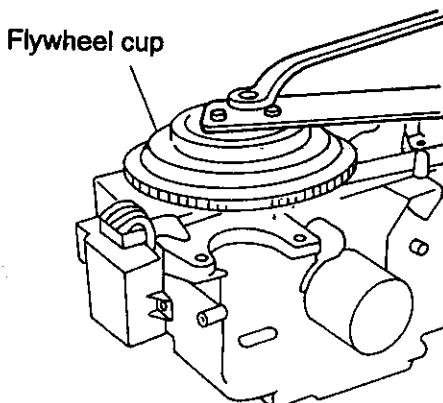
- ① Remove the plug cap from the spark plug.
- ② Remove the ignition coil fitting bolt and then remove ignition coil.

C. D. Unit

- ① Remove the C.D. unit fitting bolt then remove the C.D. unit.

Magneto flywheel cup

- ① Remove the flywheel cup with a special tool according to the instructions of "How to Use Special Tools".



Alternator

- ① Remove the alternator fitting screw and then remove the alternator.

Pulser coil

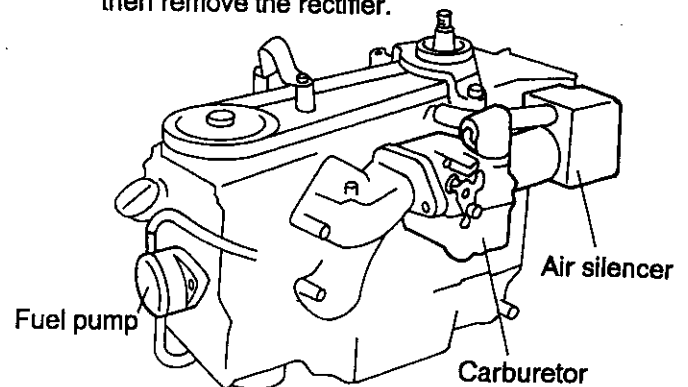
- ① Remove the pulser coil fitting screw and then remove the pulser coil.

Starter motor and starter solenoid

- ① Remove the starter motor fitting bolt and then remove the starter motor.
- ② Pull the starter solenoid from the electric bracket.

Rectifier

- ① Remove the rectifier fitting bolt then remove the rectifier.



Carburetor

- ① Remove the carburetor fitting bolt and then remove the carburetor together with the air silencer, insulator and gaskets.

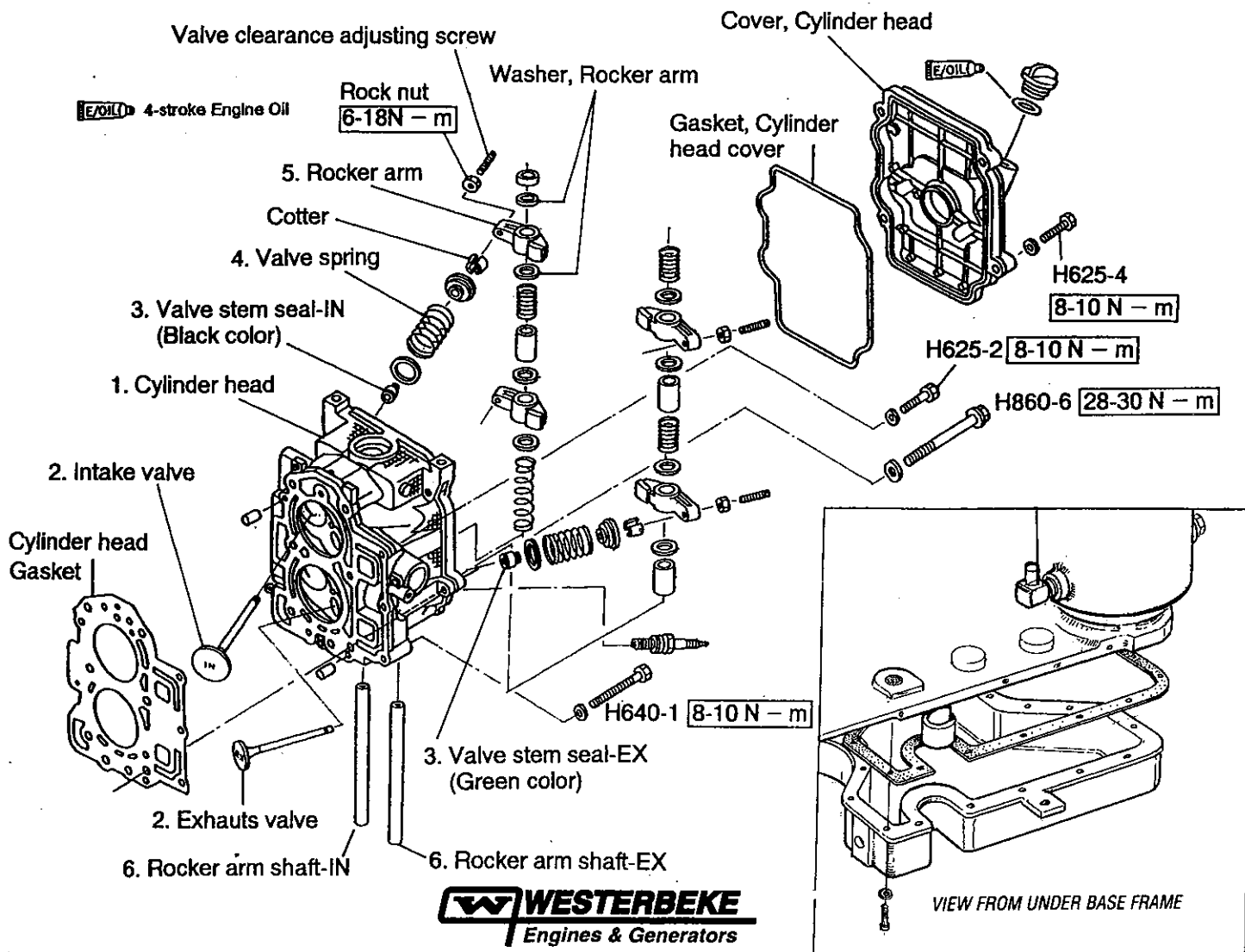
Fuel pump

- ① Remove the fuel pump fitting bolt then remove the fuel pump.

ENGINE DISASSEMBLY

POWER UNIT Cylinder head, valves and relating parts

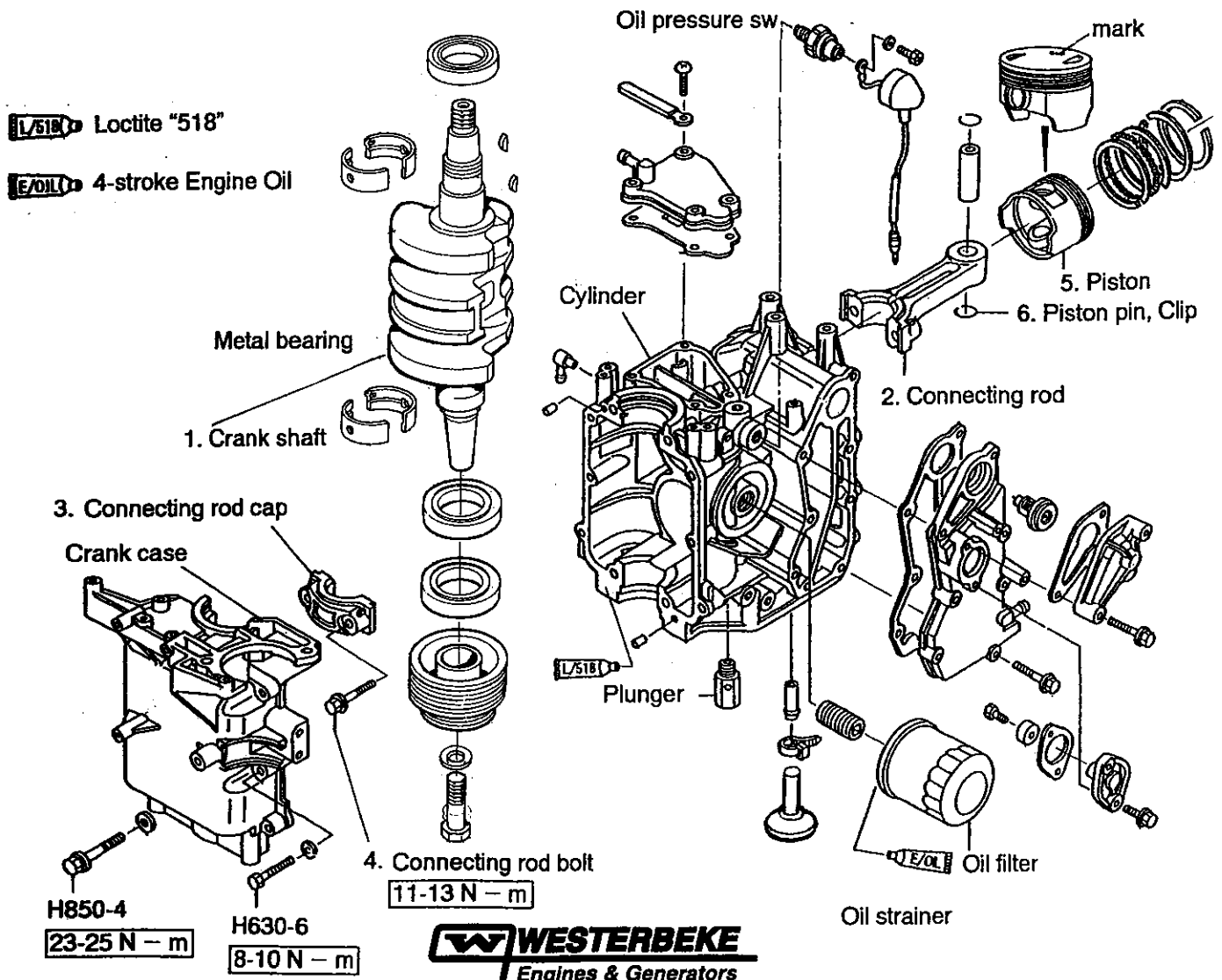
NO	Part name	Check point, etc.
	Gasket & O-ring	Note: Must be replaced by new parts whenever they are once removed for disassembling.
1	Cylinder head	<ul style="list-style-type: none"> ● Carbon deposit in combustion chamber ● Surface width and roughness between valve seat and valve ● Scratch or distortion
2	Intake valve Exhaust valve	<ul style="list-style-type: none"> ● Surface width and roughness between valve seat and intake/exhaust valve ● Carbon deposit
3	Valve stem seal – IN Valve stem seal – EX	Black color: Wear of contact surface with valve stem Green color: Wear of contact surface with valve stem
4	Valve spring	● Weakness
5	Rocker arm	● Wear of three contact points: contact surface with cam, rocker arm shaft and rocker arm washer.
6	Rocker arm shaft	● Wear of contact surface with rocker arm



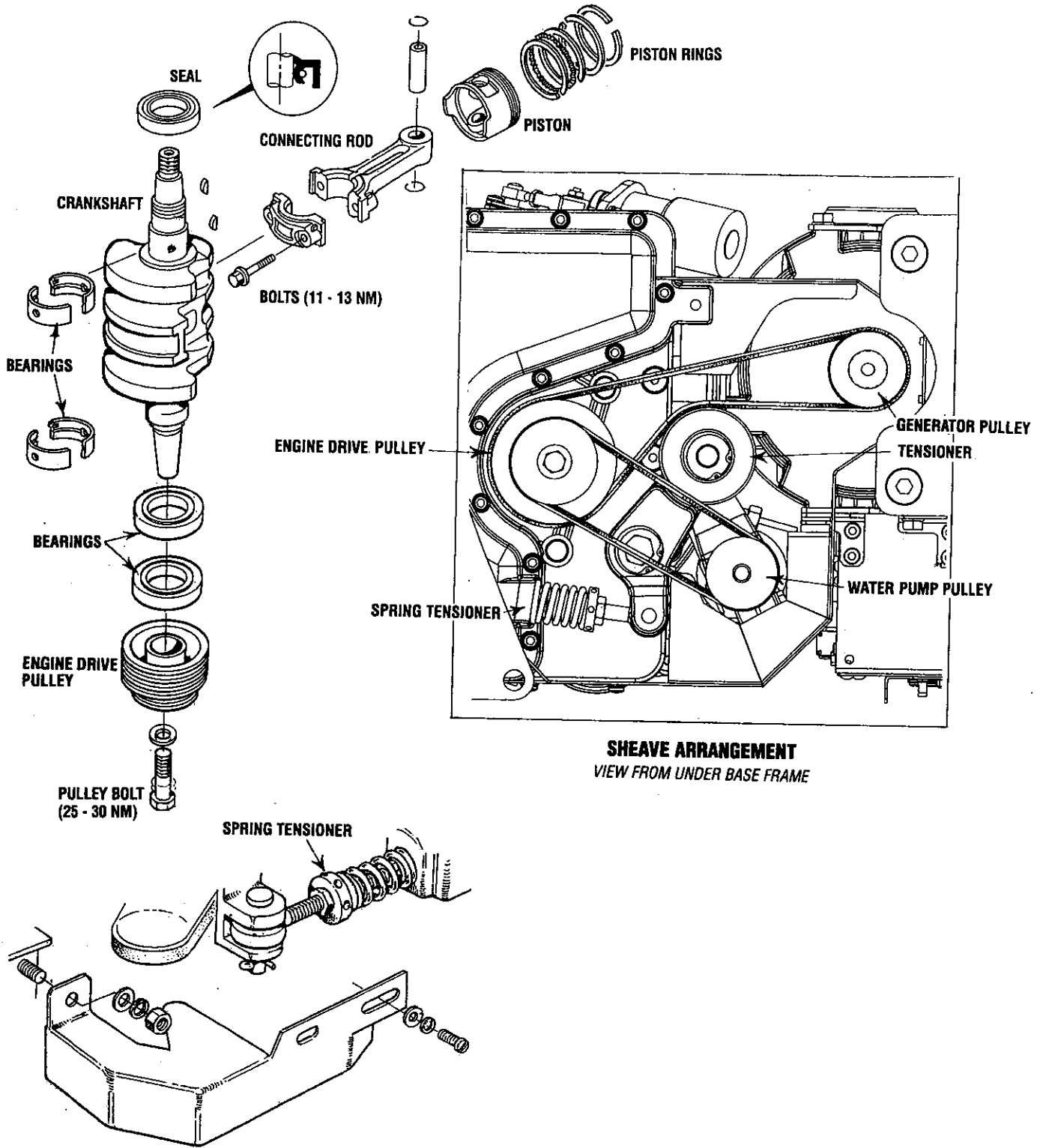
ENGINE DISASSEMBLY

POWER UNIT Crank shaft, pistons, cylinder/crank case and related parts

NO.	Part name	Check point, etc.
1	Crankshaft	<ul style="list-style-type: none"> ● Oil clearance at main bearings ● Oil clearance at big end of connecting rod Note: Align the tab of the metal bearing with the notch in the cylinder/crank case Note: There are two type of metal bearings (Thickness code: Black color and Brown color)
2	Connecting rod	Note: Pay attention to the connecting rod orientation for reassembling ("UP" mark must face the magneto side)
3	Connecting rod cap	Note: Mate the markings of the cap and connecting rod with each other ("UP" mark must face the magneto side)
4	Connecting rod bolt	Note: Tighten the bolts in careful manner; Gradually tighten the two bolts alternately several times so that they are evenly tightened.
5	Piston	Note: Pay attention to the piston direction ("UP" mark faces the magneto side)
6	Piston pin clip	Note: Don't use the clip that is once removed. Be sure to use a new part for reassembling.



ENGINE DISASSEMBLY

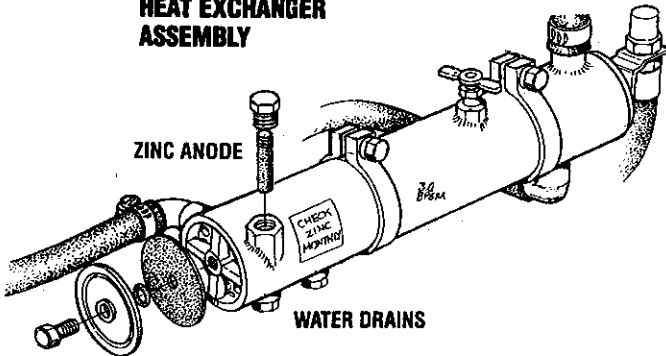


ENGINE DISASSEMBLY

POWER UNIT Cam shaft, oil pump and related parts

NO.	Part name	Check point, etc.
1	Cam shaft	● Smooth movement of decompressor weight Note: This part is very weak against impact.
2	Timing belt	Note: Be sure to keep clean free from oil and grease
3	Drive pulley	Note: Be sure to keep clean free from oil and grease Note: Pay attention of direction ("UP" mark faces the magneto side)
4	Driven pulley	Note: Be sure to keep clean free from oil and grease Note: Pay attention of direction ("UP" mark faces the magneto side)
5	Oil pump	

HEAT EXCHANGER ASSEMBLY



HEAT EXCHANGER (FRESH WATER COOLED MODELS)

The heat exchanger should be removed, inspected, and cleaned. Install a new zinc and fresh hoses with new clamps at reassembly. If suspect, a local automotive radiator shop should be able to clean and pressure test the heat exchanger.

The water injected exhaust elbow should be removed and inspected for defects and corrosion. Also inspect the siphon break hose and its connections.

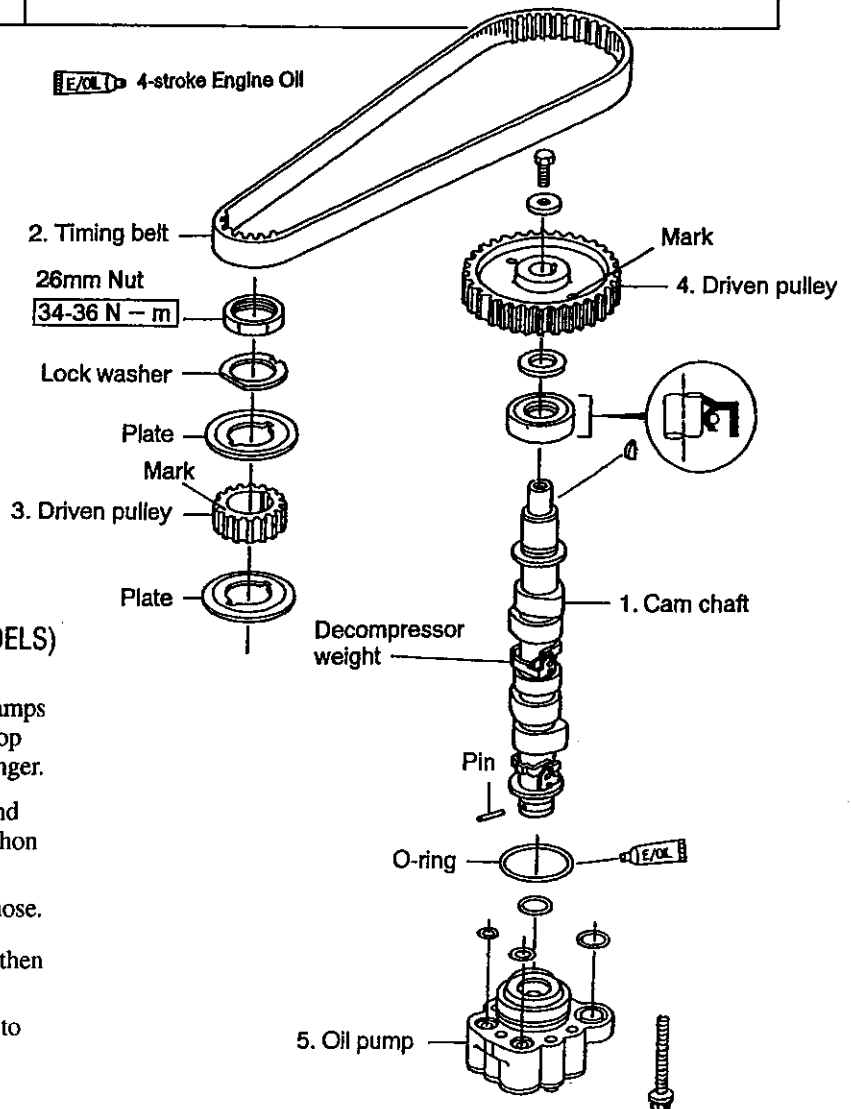
Flush out the coolant recovery tank and its connecting hose.

Loosen the raw water pump, remove the drive belt and then remove the raw water pump.

Remove the engines coolant pump. For servicing, refer to *COOLANT PUMP*.

Remove the thermostat assembly and clean the interior chambers. Inspect the seals in the pressure cap when reassembling. Replace the thermostat and gasket.

4-stroke Engine Oil



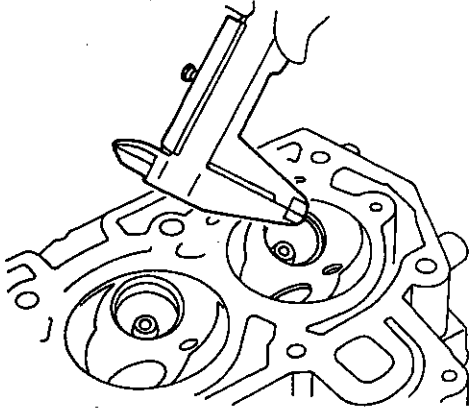
INSPECTION AND MEASUREMENTS

POWER UNIT

Measurement with vernier calipers

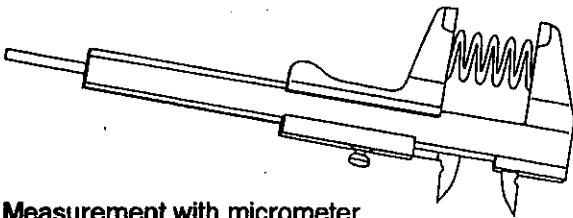
● Valve seat width

Standard value	Out of the limit to use
1.0 mm 0.0393 in	If 2.0 mm (0.079 in) or more, it needs replacement or repair.



● Valve spring free length

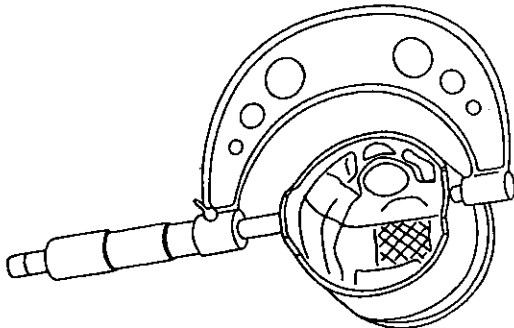
Standard value	Out of the limit to use
35 mm 1.38 in	If 33.5 mm (1.319 in) or less, it needs replacement.



Measurement with micrometer

● Outer diameter of piston skirt

Standard value	Out of the limit to use
58.960 mm 2.3213 in	If 58.90 mm (2.3189 in) or less, it needs replacement.

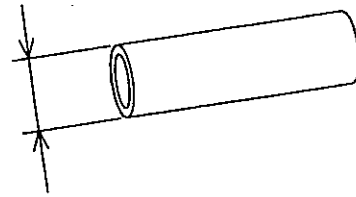


● Piston clearance (Clearance between piston and cylinder)

Standard value	Out of the limit to use
0.020 – 0.055 mm 0.0008 – 0.0022 in	If 0.15 mm (0.0059 in) or more, it needs replacement.

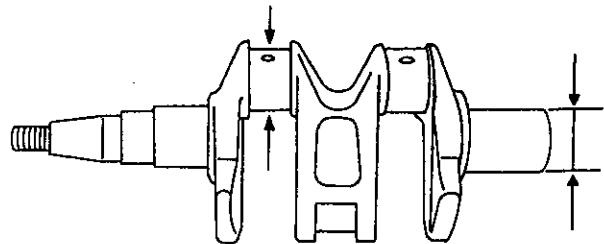
● Outer diameter of piston pin

Standard value	Out of the limit to use
16.00 mm 0.6299 in	If 15.97 mm (0.629 in) or less, it needs replacement.



● Outer diameter of crank pin

Standard value	Out of the limit to use
29.98 mm 1.1803 in	If 29.95 mm (1.179 in) or less, it needs replacement.



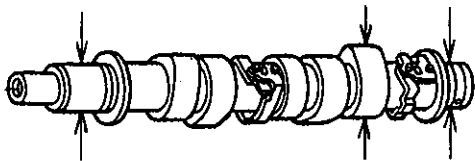
● Outer diameter of crank shaft in metal bearing

Standard value	Out of the limit to use
31.99 mm 1.2594 in	If 31.97 mm (1.259 in) or less, it needs replacement.

INSPECTION AND MEASUREMENTS

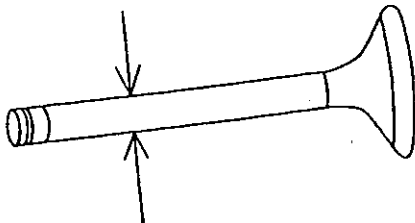
● Cam shaft

	Standard value	Out of the limit to use
Outer dia. in bearing (Upper)	17.98 mm 0.708 in	If 17.95 mm (0.707 in) or less, it needs replacement.
Outer dia. in bearing (Lower)	15.97 mm 0.629 in	If 15.95 mm (0.628 in) or less, it needs replacement.
Cam height IN & EX	23.90 mm 0.94 in	If 23.75 mm (0.935 in) or less, it needs replacement.



● Valve stem

	Standard value	Out of the limit to use
IN	5.48 mm 0.216 in	If 5.46 mm (0.215 in) or less, it needs replacement.
EX	5.46 mm 0.215 in	If 5.44 mm (0.214 in) or less, it needs replacement.

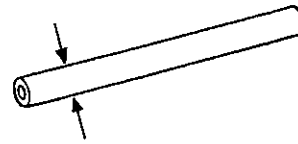


● Clearance between valve guide and valve stem

	Standard value	Out of the limit to use
IN	0.008 – 0.04 mm 0.003 – 0.0016 in	If 0.07 mm (0.0028 in) or more, it needs replacement.
EX	0.025 – 0.057 mm 0.0010 – 0.0022 in	If 0.10 mm (0.004 in) or more, it needs replacement.

● Outer diameter of rocker arm shaft

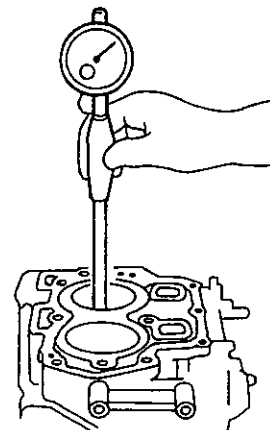
Standard value	Out of the limit to use
12.99 mm 0.511 in	If 12.94 mm (0.509 in) or less, it needs replacement.



Measurement with cylinder gauge

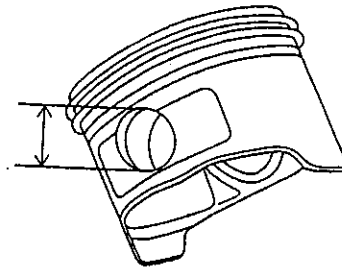
● Inner diameter of cylinder

Standard value	Out of the limit to use
59.00 mm 2.3228 in	If 59.06 mm (2.3252 in) or more, it needs replacement.



● Diameter of piston pin hole

Standard value	Out of the limit to use
16.002 mm 0.630 in	Depends on clearance between pin and hole.



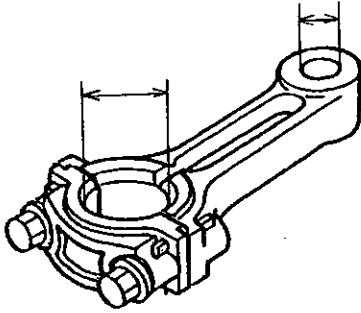
● Clearance between piston pin and piston pin hole

Standard value	Out of the limit to use
0.002 – 0.012 mm 0.00008 – 0.0005 in	If 0.04 mm (0.0016 in) or more, it needs replacement.

INSPECTION AND MEASUREMENTS

● Oil clearance at big end of connecting rod

Standard value	Out of the limit to use
0.015 – 0.041 mm 0.0006 – 0.0016 in	If 0.060 mm (0.002 in) or more, it needs replacement.

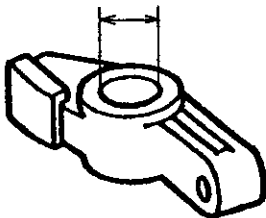


● Inner diameter of small end of connecting rod

Standard value	Out of the limit to use
16.01 mm 0.630 in	If 16.04 mm (0.631 in) or more, it needs replacement.

● Inner diameter of rocker arm

Standard value	Out of the limit to use
13.01 mm 0.512 in	If 13.05 mm (0.514 in) or more, it needs replacement.

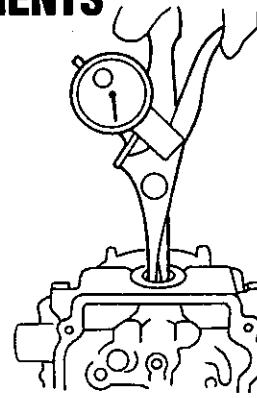


● Oil clearance between rocker arm and shaft

Standard value	Out of the limit to use
0.006 mm – 0.035 mm 0.00024 – 0.00138 in	If 0.06 mm (0.0024 in) or more, it needs replacement.

● Inner diameter (bearing) of cam shaft holder

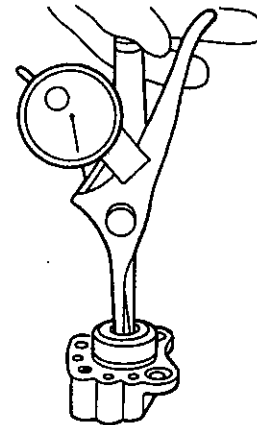
	Standard value
Upper (Cylinder head)	18.01-18.025 mm 0.709 – 0.710 in
Lower (Oil pump)	



● Oil clearance between cam shaft and holder

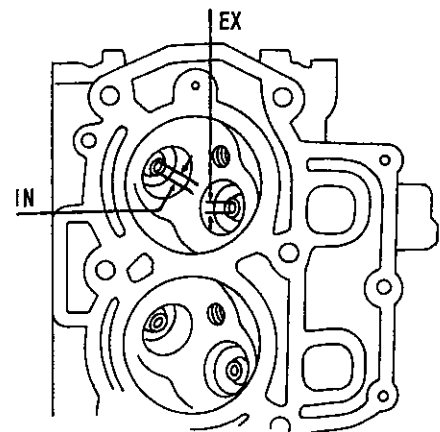
	Standard value	Out of the limit to use
Upper	0.02 – 0.05 mm 0.0008 – 0.0020 in	0.09 mm (0.0035 in) or more
Lower	0.02 – 0.05 mm 0.0008 – 0.0020 in	0.09 mm (0.0035 in) or more

If the oil clearance is out of the limit, replace cylinder head and/or cam shaft and/or oil pump.



● Inner diameter of valve guide

	Standard value	Out of the limit to use
IN	5.51 mm 0.217 in	If 5.55 mm (0.218 in) or more, it needs replacement.
EX	5.51 mm 0.217 in	If 5.57 mm (0.219 in) or more, it needs replacement.

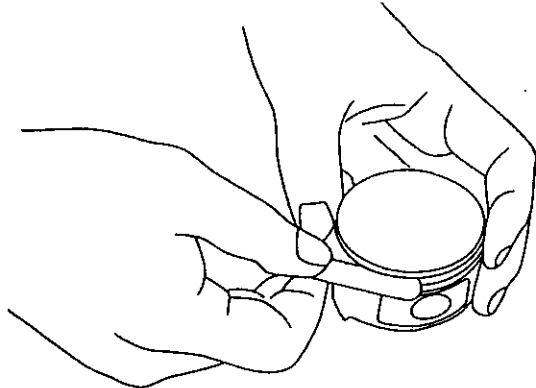


INSPECTION AND MEASUREMENTS

Measurement with thickness gauge

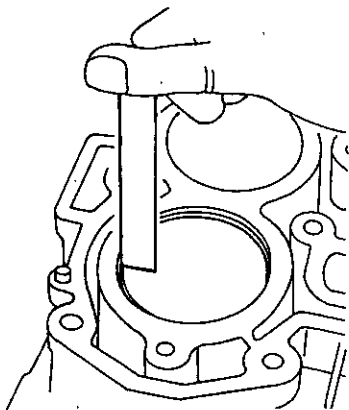
● Clearance between piston ring and ring groove

	Standard value	Out of the limit to use
Top	0.04 – 0.08 mm 0.0016 – 0.0031 in	If 0.10 mm (0.004 in) or more, it needs replacement.
Second	0.03 – 0.07 mm 0.0012 – 0.0028 in	If 0.09 mm (0.0035 in) or more, it needs replacement.
Oil	0.01 – 0.18 mm 0.0004 – 0.0071 in	If 0.21 mm (0.0083 in) or more, it needs replacement.



● Piston ring end gap

	Standard value	Out of the limit to use
Top	0.15 – 0.35 mm 0.006 – 0.014 in	If 0.5 mm (0.020 in) or more, it needs replacement.
Second	0.30 – 0.50 mm 0.012 – 0.020 in	If 0.7 mm (0.028 in) or more, it needs replacement.
Oil	0.20 – 0.70 mm 0.008 – 0.028 in	

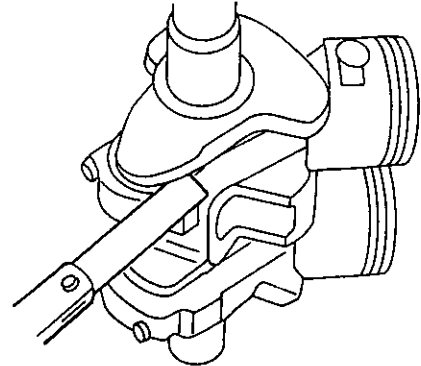


Note:

- Set the piston ring by pressing it in the piston crown side.
- To be replaced with a new oil ring when replacing with new top and/or second rings.

● Side clearance at big end of connecting rod

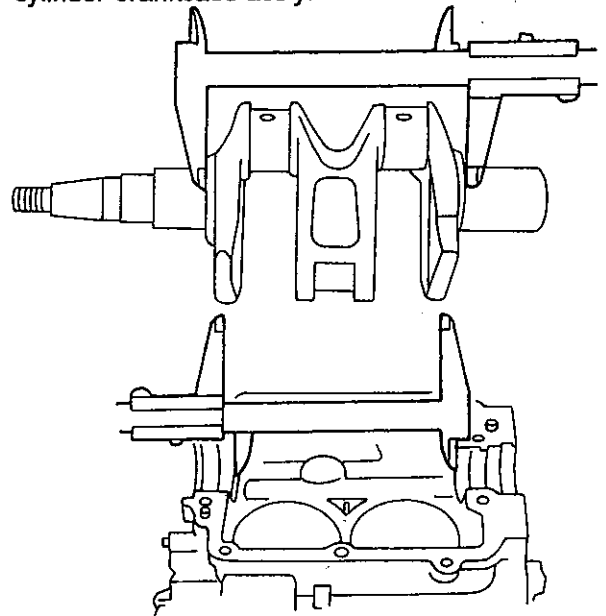
Standard value	Out of the limit to use
0.1 – 0.25 mm 0.004 – 0.01 in	If 0.6 mm (0.024 in) or more, it needs replacement.



● Side clearance of crankshaft

Standard value	Out of the limit to use
0.1 – 0.3 mm 0.004 – 0.012 in	0.6 mm (0.024 in) more

If the side clearance is out of the limit, measure length of the crankcase (cylinder side) and the crankshaft and replace crankshaft and/or cylinder-crankcase ass'y.

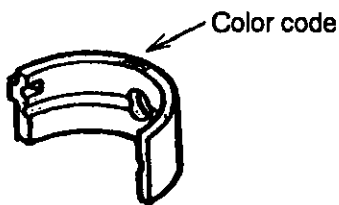


	Standard value
Crankshaft length	126.8 – 126.9 mm 4.992 – 4.996 in
Crankcase length	127.0 – 127.1 mm 5.000 – 5.004 in

INSPECTION AND MEASUREMENTS

● Metal bearing thickness code

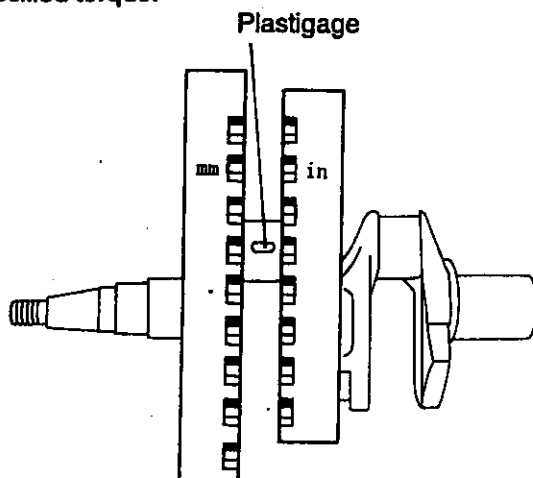
The codes are painted on the side of the bearing.



Color code	Thickness
Brown	1.488 – 1.494 mm 0.0586 – 0.0588 in
Black	1.494 – 1.500 mm 0.0588 – 0.0590 in

● Oil clearance at big end of connecting rod

- 1) Wipe oil out of the crank pin and big end bearing of connecting rod.
- 2) Set the Plastigage to the crank pin and fit it to the connecting rod. Tighten the bolt with the specified torque.



Tightening torque: 11-13 N-m (1.1-1.3 kg-m)
(8.0-9.4 lb-ft)

Note:

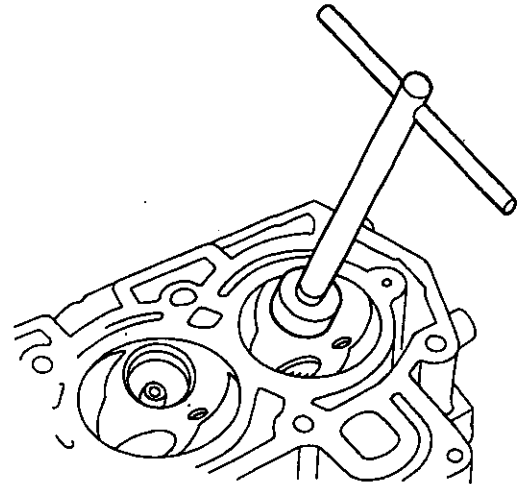
Do not turn the connecting rod.

- 3) Remove the connecting rod and check the Plastigage reading.

Standard value	Out of the limit to use
0.015 – 0.041 mm 0.0006 – 0.0016 in	If 0.06 mm (0.002 in) or less, it needs replacement

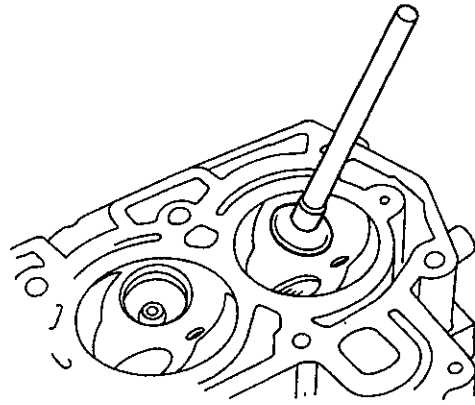
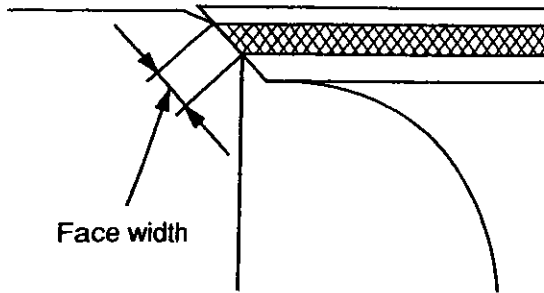
● Repair of valve seat

- 1) Plane the valve seat face with the 45° valve seat cutter.
- 2) Depending on the situation (the contact position of the seat is too high or too low), use the 30° cutter or 60° cutter and then repair the surface area with the 45° cutter.



- 3) Apply Prussian Blue compound (or equivalent) evenly on the seat face. While turning the valve with the valve lapper, check face width between the valve and valve seat. If necessary, repair the face width with the valve seat cutter.

INSPECTION AND MEASUREMENTS



	Standard value	Limit that needs repair
IN	1.0 mm 0.04 in	2.0 mm or more 0.08 in
EX	1.0 mm 0.04 in	2.0 mm or more 0.08 in

4) After repair of the valve seat, lap the valve for good fitting.

Apply lapping compound thinly on the seat and lap the valve while turning and tapping it with the valve lapper.

Remarks: Since the lapping compound is supplied in a set of three grades (coarse, medium and fine), lap the valve with all of them in order from coarse, medium and fine.

Notes:

- When using lapping compound of a different grade, completely wipe out the previously used compound beforehand.
- After lapping is complete, wash the valve and valve seat after completely wiping the compound out of them.

ASSEMBLY

POWER UNIT

Reassembling Engine

Reassemble the engine in the reverse order of disassembling with careful attention to the following points.

(1) Cylinder head and related parts

● Valve stem seal

- There are two kinds of valve stem seals, namely, the valve stem seal for the intake valve is identified by the black color while the other for the exhaust valve is identified by the green color.
- On installing the valve stem seal to the cylinder head, apply the engine oil for the 4-stroke cycle engine to the insertion point. For setting the valve stem seal, press it into the valve guide with fingers.

● Intake valve, Exhaust valve

- The intake valve and exhaust valve are different from each other, namely the intake valve is identified by the "IN" mark while the exhaust valve is identified by the "EX" mark.
- Apply the engine oil for the 4-stroke cycle engine to the valve stem. Then, insert the valve into the valve guide while twisting it.
- After setting the cotter on-to the valve stem, tap the valve shaft end with a small plastic hammer several times for stabilizing the cotter in setting.
- After reassembling the valves, apply the engine oil for the 4-stroke cycle engine to the upper side of the retainer and its periphery.

● Cam shaft

- Carefully press the oil pump pin so that it does not come out of the cam shaft.
- When reassembling the cam shaft to the cylinder head, apply the engine oil for the 4-stroke cycle engine to the cam and bearing beforehand and then insert the cam shaft into the cylinder head from the oil pump side while twisting it with care not to turn over the oil seal lip.

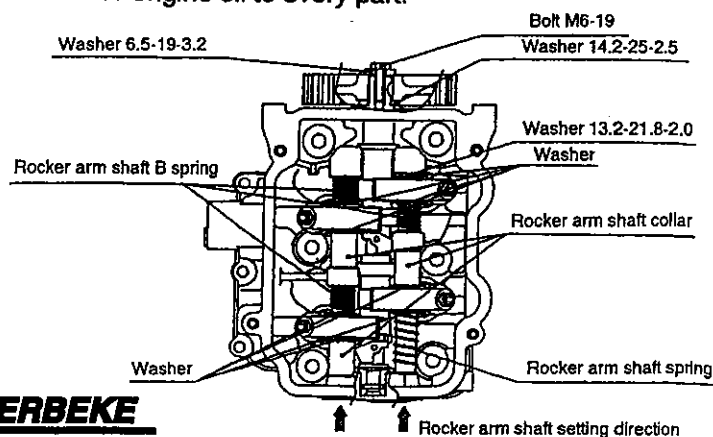
● Rocker arm

- Temporarily set the tappet adjusting screw and tappet adjusting nut to the rocker arm.

Note:

Set the tappet adjusting nut with the chamfered side down.

- Apply the engine oil for the 4-stroke cycle engine to the rocker arm shaft.
- Set the rocker arm shaft from the side of the oil pump of the cylinder head. Pay heed to orientation of the rocker arm shaft so that the tapped hole side is positioned in the oil pump side.
- Set the rocker arm shaft spring, washer, rocker arm, rocker arm shaft collar to the rocker arm shaft from the bottom side in this order.
- When setting the above-mentioned parts, apply the engine oil to every part.



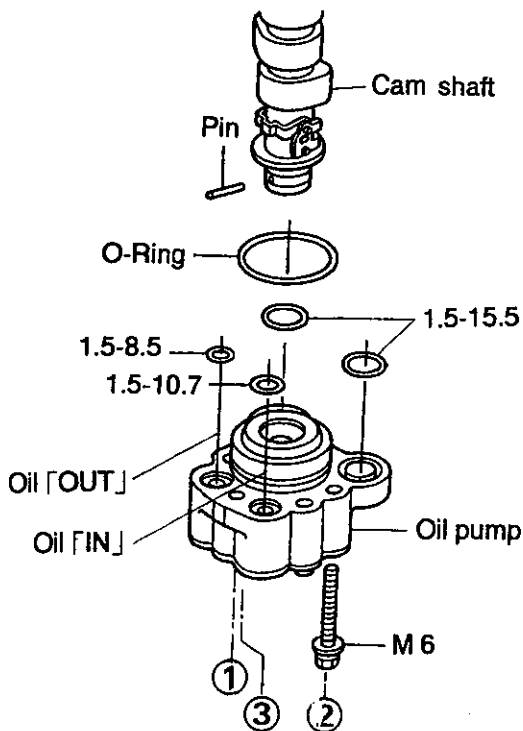
ASSEMBLY

● Oil pump

- Pour the engine oil of approximately 2.0 ml into the oil pump through the inlet and outlet ports.
- Apply the engine oil for the 4-stroke cycle engine to the O-rings (1.5-10.7 ϕ , 1.5-8.5 ϕ , 1.5-15.5 ϕ) and the O-ring at the boss before setting them in the oil pump.
- When assembling the oil pump to the cylinder head, carefully set it so that the cam shaft pin and the notch on the oil pump shaft meet each other.
- Fasten the oil pump with the three M6 bolts with the tightening torque and in the tightening order specified below.

Tightening order: ①, ② and ③

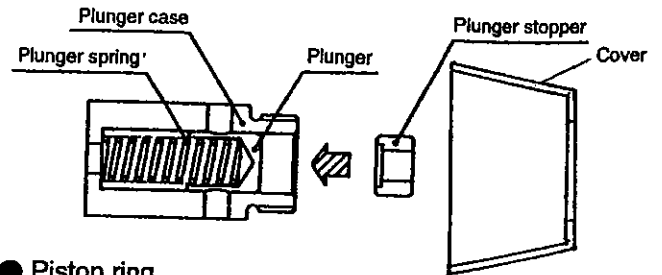
Tightening torque: 5-6 N - m (0.5-0.6 kg - m)



● Plunger

- When setting the plunger stopper into the plunger case, pay attention to the orientation of the plunger stopper so that it is set as shown.
- When assembling the plunger assembly to the cylinder, fasten it together with the cover.

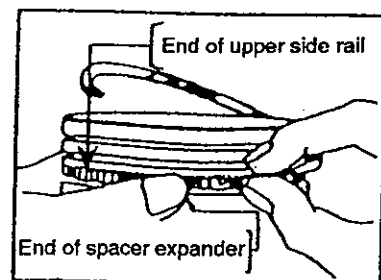
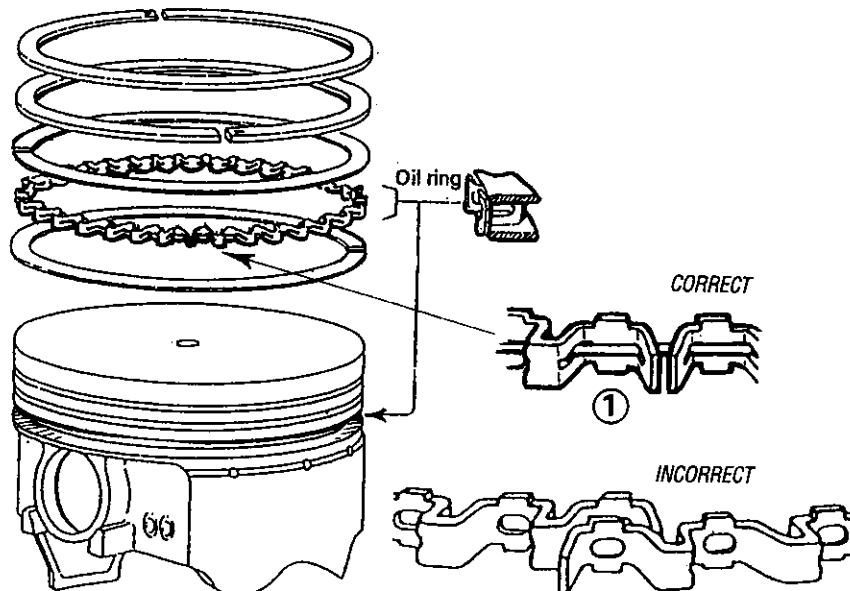
Tightening torque: 19-21 N - m (1.9-2.1 kg - m)
(12-15 lb - ft)



● Piston ring

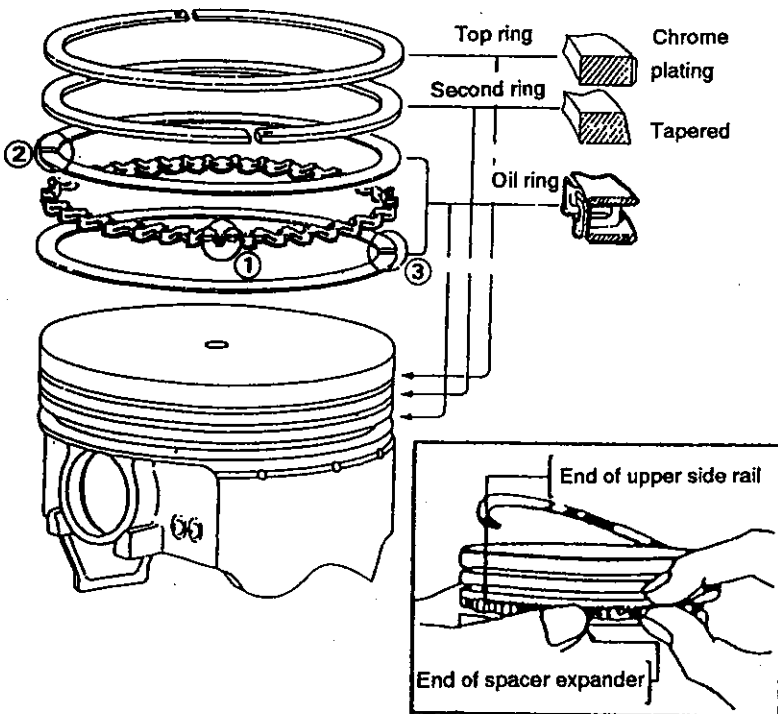
Fitting oil rings to piston

1. Set the spacer expander in the oil ring groove, and check to see if both the ends of it correctly link with each other as shown in ①.



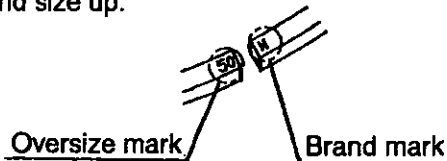
ASSEMBLY

2. While holding down the slit of the spacer expander with a thumb, set the upper rail as its slit is deviated from the slit of the spacer expander at an angle of 90° in the counterclockwise direction. ②
3. In the same manner as the preceding step, set the lower rail as its slit is deviated from the slit of the spacer expander at an angle of 90° in the clockwise direction. ③



Fitting compression rings to piston

Fit the compression rings onto the piston in the correct order to start with the lower ring. Set each compression ring with the side marked with the brand and size up.

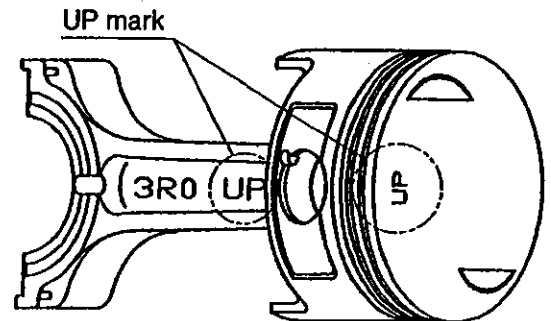


Check of correct setting of each piston ring

1. Check to see if the slit of each piston ring is not set in the piston thrust direction or piston pin direction.
2. After the assembling work is complete, make sure that each piston ring is set as shown once again.

● Piston and Connecting rod

- Assemble the connecting rod and connecting rod cap to each other as they were put together before removing. (Before removing the connecting rod cap, be sure to leave a marking at a mated point between the connecting rod and connecting rod cap as a reference for reassembling.)



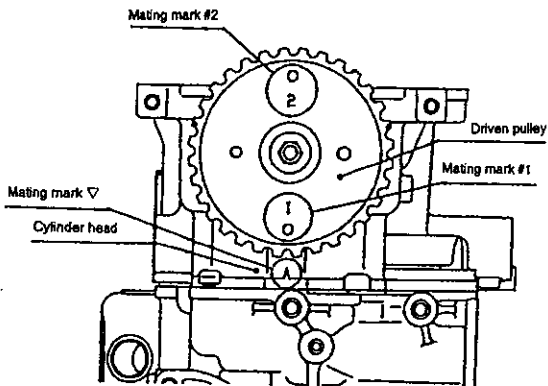
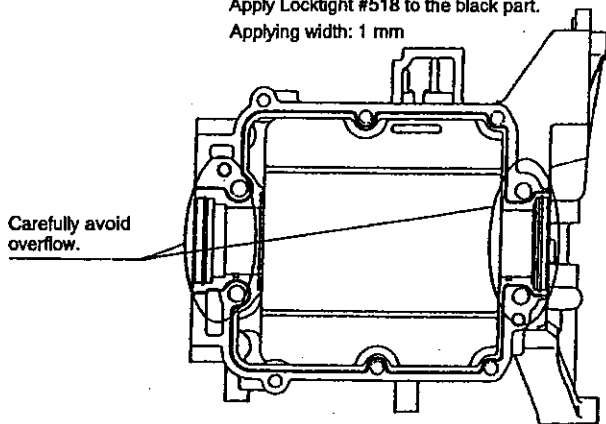
- The upper sides of the connecting rod cap, connecting rod and piston are identified by the "UP" mark.
- For inserting the piston and connecting rod assembly into the cylinder, use the piston slider. Apply the engine oil for the 4-stroke cycle engine to the cylinder liner, piston rings before inserting the assembled piston.

ASSEMBLY

● Cylinder and Crank case

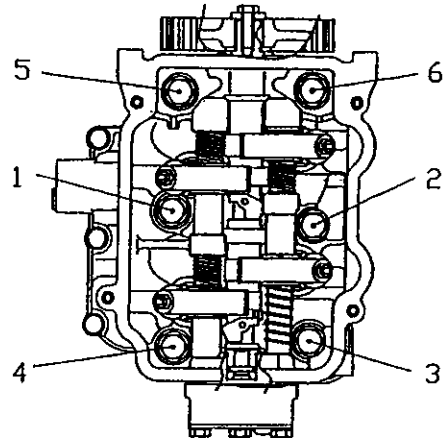
- When fitting the metal bearing to the cylinder and crank case, set the tab in the notch.
- Apply the engine oil for the 4-stroke cycle engine to the metal bearing.
- Degrease the mating surface between the cylinder and crank case.
- Apply the Locktight #518 to either of the cylinder and crank case with careful attention to the applying part and width so as to avoid overflow.

Apply Locktight #518 to the black part.
Applying width: 1 mm



● Fitting cylinder head to cylinder

- Before fitting the cylinder head to the cylinder, set the piston at the top dead center.
- When fastening the cylinder head, carefully tighten the bolts with the specified tightening torque and in the correct order.

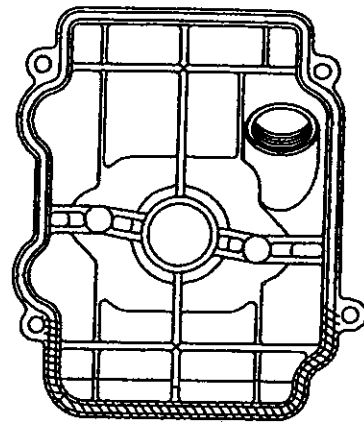


Tightening torque:

M8 bolt: 28-30 N – m (2.8-3.0 kg – m)
(20-22 lb – ft)
M6 bolt: 8-10 N – m (0.8-1.0 kg – m)
(5.8-7.2 lb – ft)

● Cylinder head cover

- Fit the gasket to the cylinder head cover and apply the Three Bond #1207B to the shaded part shown.



Apply the sealant to the shaded part.
Shaded part (Part shown by slanted lines)

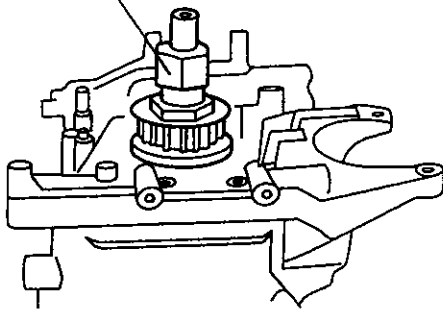
Tightening torque: 8-10 N – m (0.8-1.0 kg – m)
(5.8-7.2 lb – ft)

ASSEMBLY

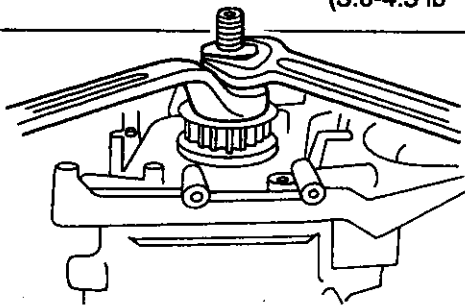
● Fuel pump

- Make sure that the marks "2" and "0" on the driven pulley and the mark "▽" on the cylinder head are aligned in a straight line.
- Apply the engine oil for the 4-stroke cycle engine to the top of the plunger and O-ring of the fuel pump.

Crank shaft holder



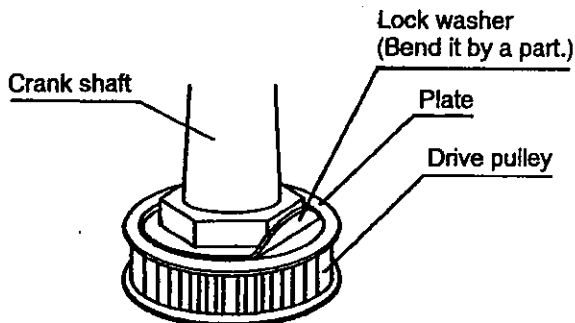
Tightening torque: 5-6 N - m (0.5-0.6 kg - m)
(3.6-4.3 lb - ft)



● Drive pulley

- For tightening the nut to fasten the drive pulley, use the crank shaft holder.

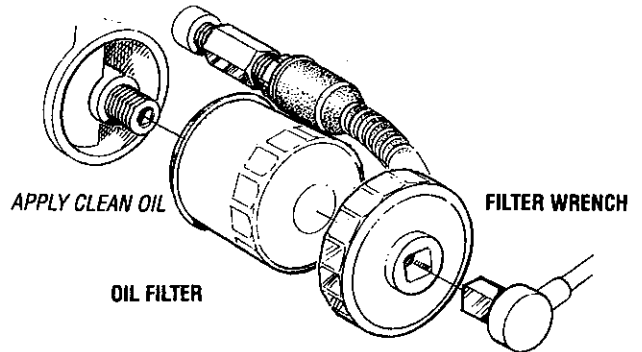
Tightening torque: 34-36 N - m (3.4-3.6 kg - m)
(25-26 lb - ft)



- After tightening the nut, bend up the lock washer by a part.

● Oil filter

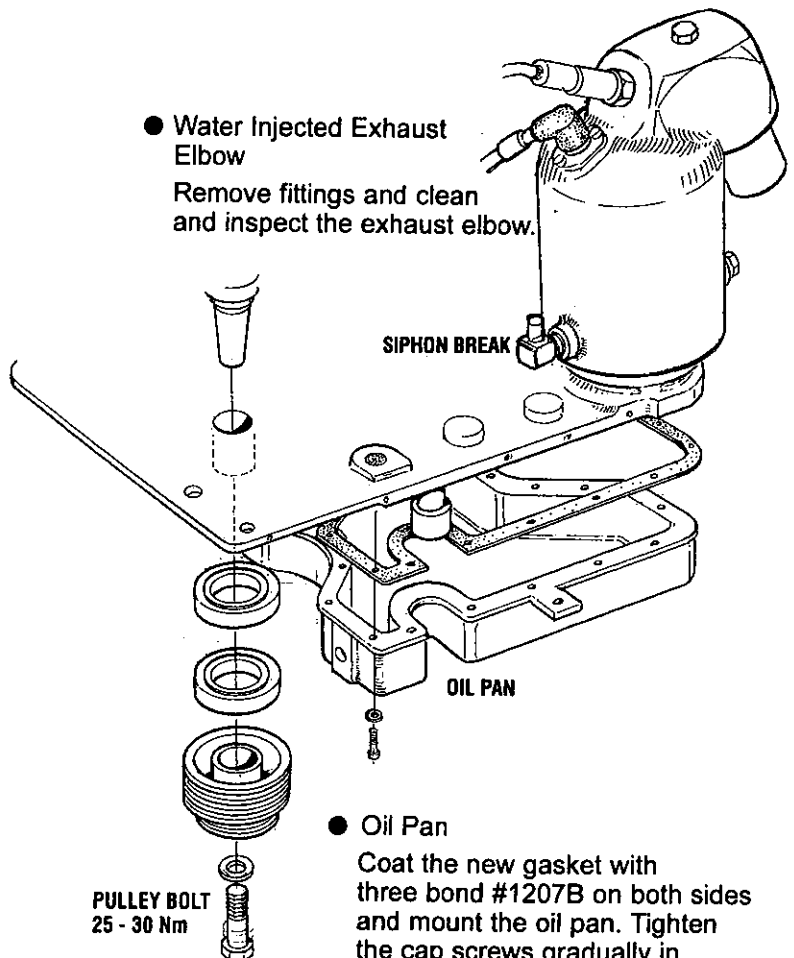
- Apply the engine oil for the 4-stroke cycle engine to the rubber seal of the oil filter.



Tightening torque: 18 N - m (1.8 kg - m)
(13 lb - ft)

● Water Injected Exhaust Elbow

- Remove fittings and clean and inspect the exhaust elbow.



● Oil Pan

- Coat the new gasket with three bond #1207B on both sides and mount the oil pan. Tighten the cap screws gradually in opposing order.

Torque at 28 - 30 Nm (20 - 22 lb-ft)

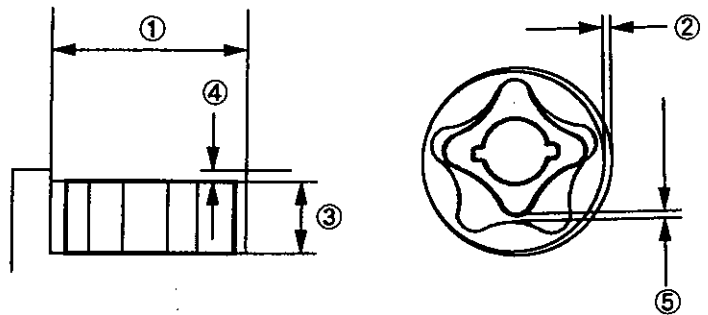
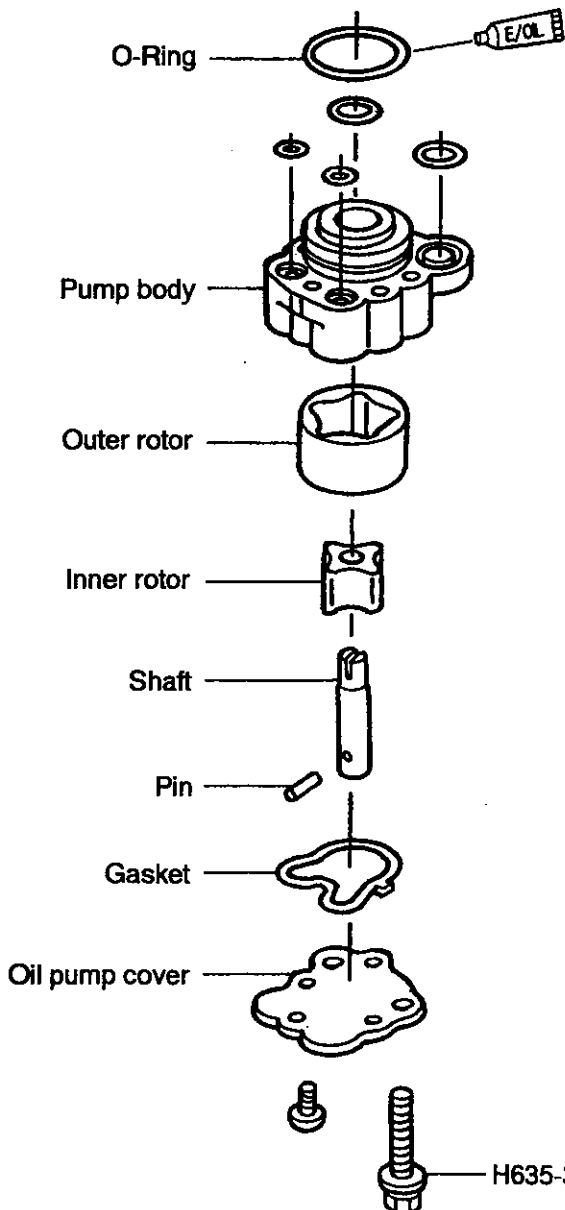
PULLEY BOLT
25 - 30 Nm

LUBRICATION SYSTEM

OIL PUMP

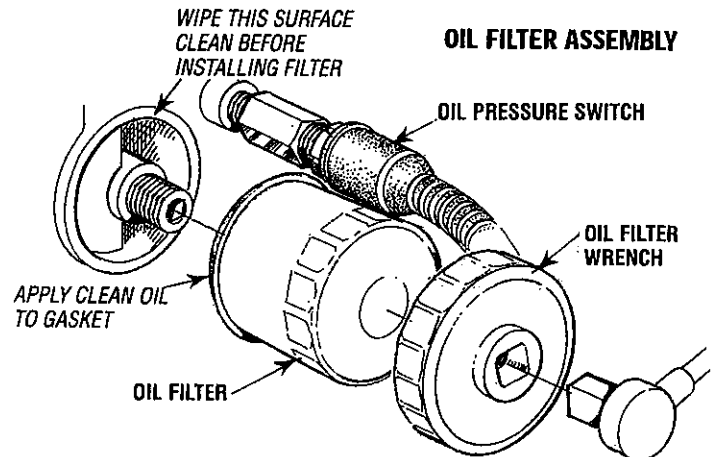
Using a micrometer, cylinder gauge, depth gauge and feeler gauge, measure the following oil pump clearances. Replace if worn or out of specification.

① Inner diameter of pump body	29.04 mm (1.143 in) or more
② Clearance between outer rotor and body	0.36 mm (0.014 in) or more
③ Height of outer rotor	14.96 mm (0.589 in) or less
④ Clearance between rotor and body side	0.11 mm (0.0043 in) or more (incl. wear of the pump cover)
⑤ Clearance between outer rotor and inner rotor	0.16 mm (0.006 in) or more



OIL INSPECTION

Always observe the old oil as it is removed. A yellow/gray emulsion indicates the presence of water in the oil. Although this condition is rare, it does require prompt attention to prevent serious damage. Call a competent mechanic if water is present in the oil. Water present in the oil can be the result of a fault in the exhaust system attached to the engine and/or a siphoning through the water cooling circuit into the exhaust, filling it up into the engine. Use an oil test kit and send a sample of the engine oil to a qualified oil test lab for analysis.



FUEL SYSTEM

FUEL PUMP

DISASSEMBLY

Before disassembly, make a aligning line on the out side of fuel pump for correctly reassembling.

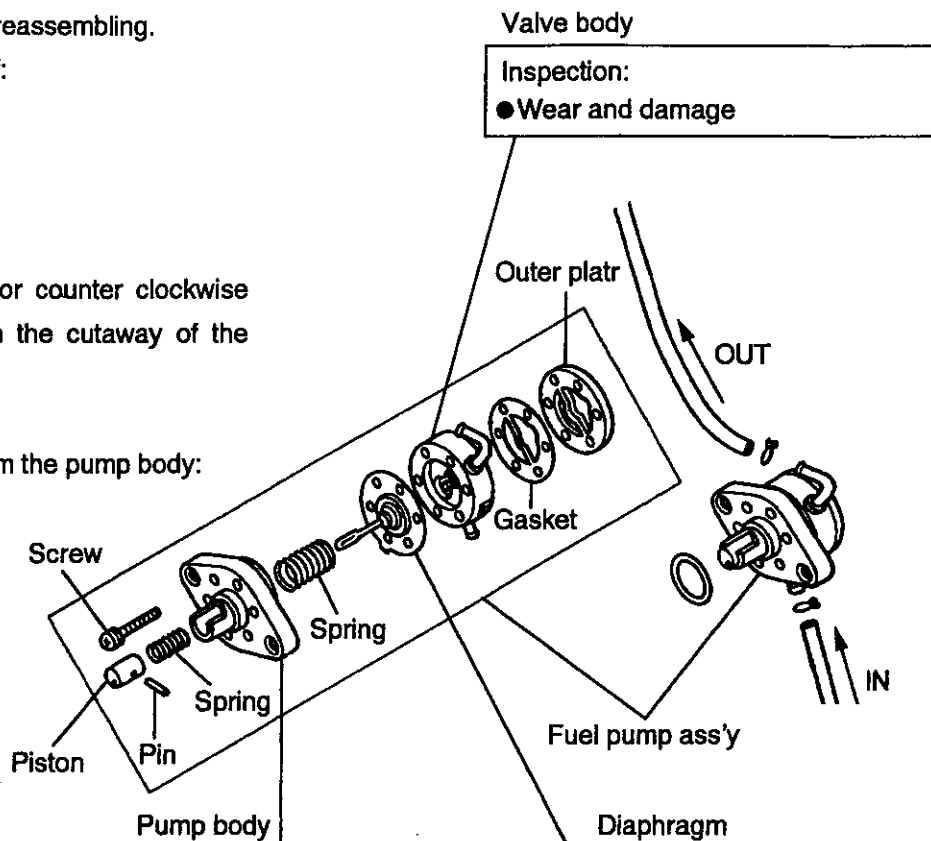
① Remove screw, and take off:

- Outer plate
- Gasket
- Valve body

② Turn the piston clockwise or counter clockwise until you look the pin from the cutaway of the pump body.

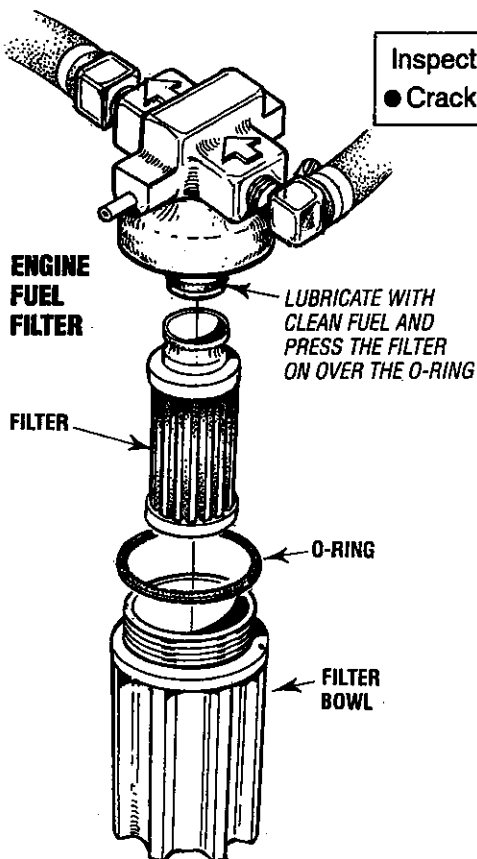
③ Pull the pin, and remove from the pump body:

- Piston
- Spring
- Diaphragm
- Spring



Inspection:
● Crack and damage

Inspection:
● Burst, crack and swelling

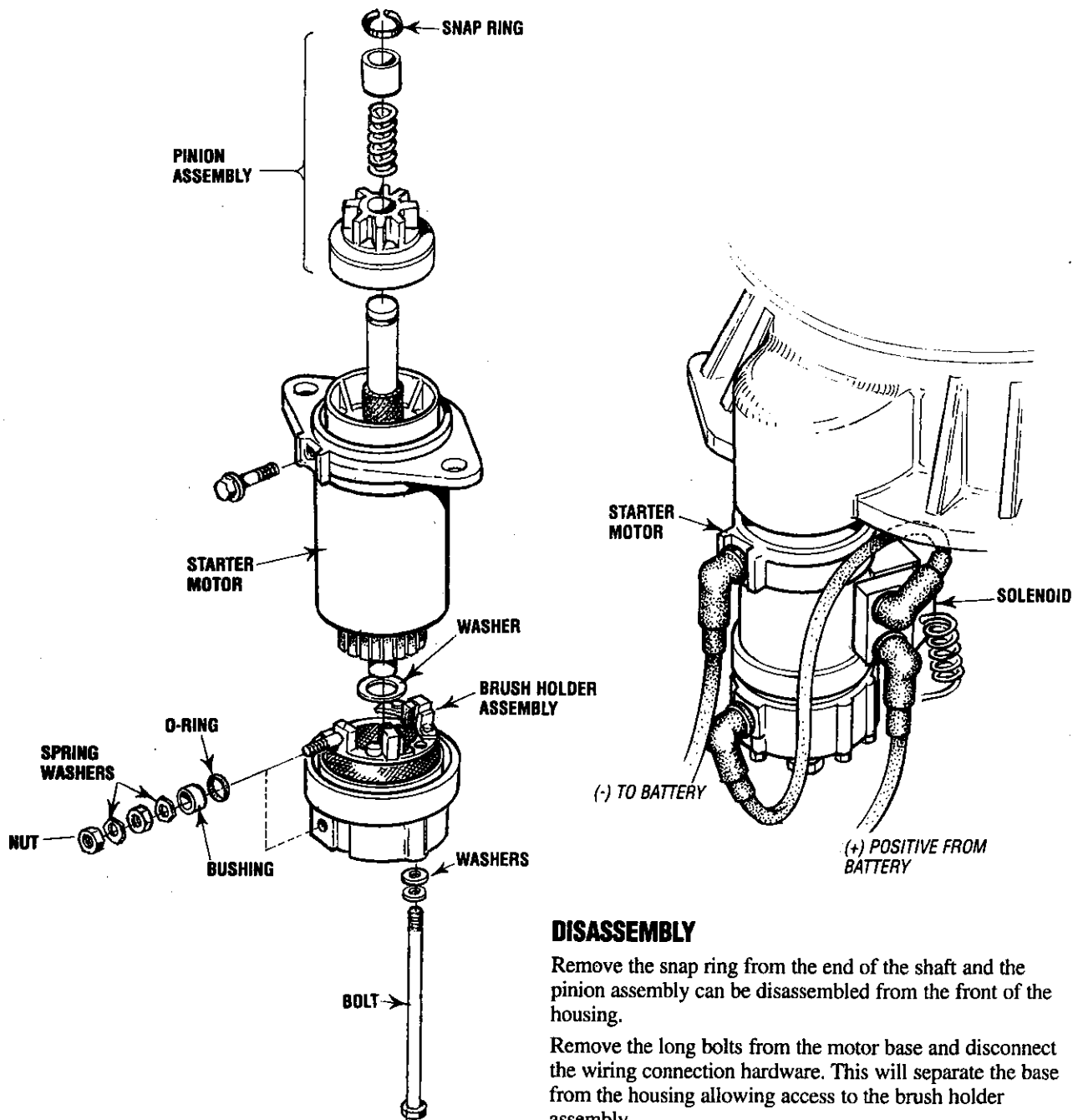


REASSEMBLY

Reassembly is reverse order of disassembly

Note:
After connecting the diaphragm rod to the piston with pin, align the diaphragm holes (6) to the pump body holes so that the pin will not come out through pump body cutaway.

STARTER MOTOR

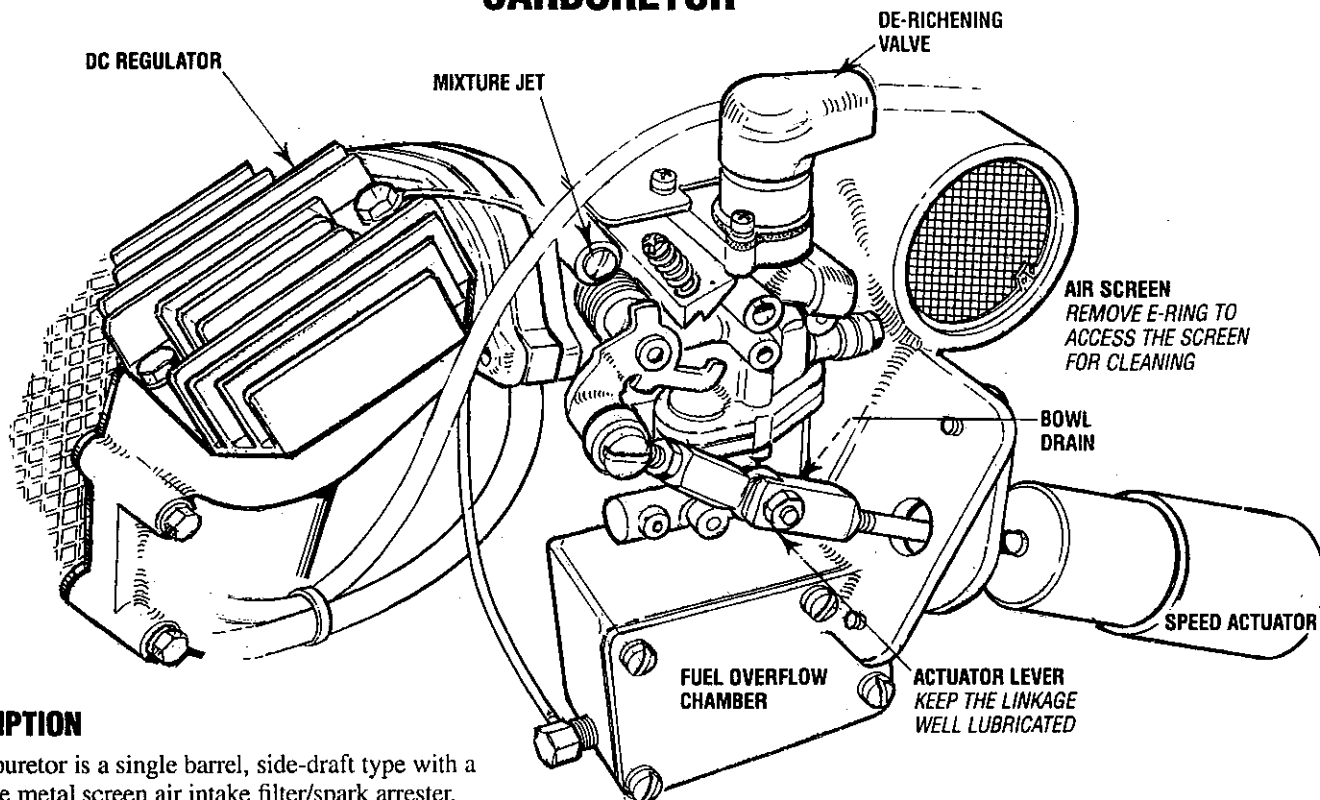


DISASSEMBLY

Remove the snap ring from the end of the shaft and the pinion assembly can be disassembled from the front of the housing.

Remove the long bolts from the motor base and disconnect the wiring connection hardware. This will separate the base from the housing allowing access to the brush holder assembly.

CARBURETOR



DESCRIPTION

The carburetor is a single barrel, side-draft type with a cleanable metal screen air intake filter/spark arrester.

The choke is operated by a 12 VDC solenoid. The choke solenoid is activated when the start switch is depressed and is controlled by the I.C.M.

Air Screen/Flame Arrester

The air screen can easily be removed. Clean after the first 50 hours of operation and every 100 hours from then on. Clean the air screen in a water soluble cleaner such as GUNK.

Fuel Overflow Chamber

Excess fuel drains into the fuel overflow chamber but is drawn out again at start-up. This chamber should be kept free of contaminants. Cleaning every 250 operating hours should be sufficient unless there is a fuel problem.

Idle Mixture Jet

Adjustment is performed with the generator operating. Screw the jet slowly in until it seats, then back it out 2 to 3 turns. Maximum adjustment is 5 turns.

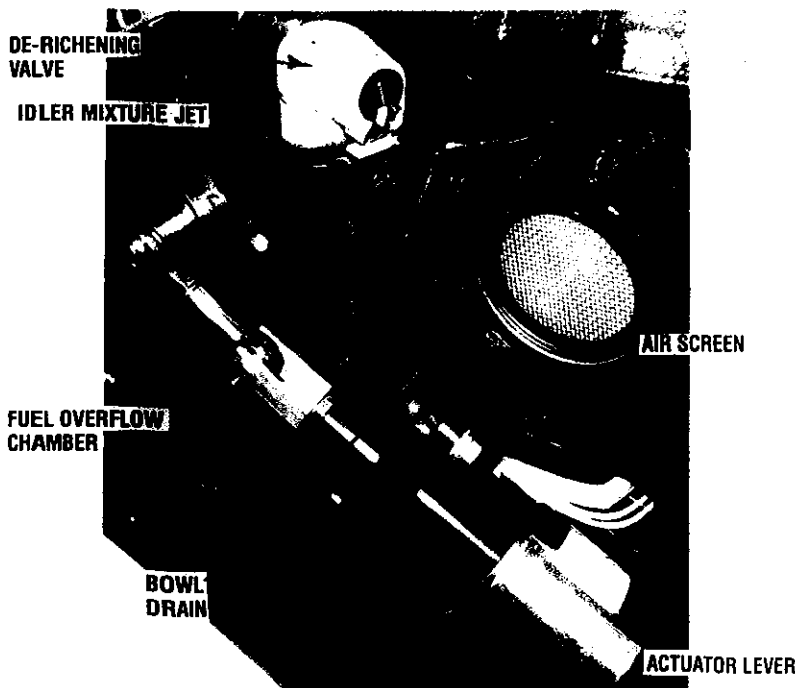
NOTE: An idle mixture jet adjusted too far off its seat can induce a sooty exhaust discharge at engine start-up and shut-down.

De-Richening Valve

The de-richening valve closes off a fuel port that is supplying additional fuel on a cold start after start up. This is a thermal electric device that slowly moves a needle outward when DC power is applied after start up to close this fuel port. To check this valve, remove from the carburetor (cold) and apply DC voltage across its electrical connections. The device should get hot and the needle will slowly move outward. The device will remain hot during engine operation.

Carburetor Bowl Drain

A bowl drain slotted plug is located on the lower right corner of the carburetor bowl. This is located just inboard of the actuators ball joint/clevis.



CARBURETOR WITH SPEED ACTUATOR

RAW WATER PUMP

DESCRIPTION

Coolant (fresh water) cooled generators have dual water pumps while the raw water cooled models use a single water pump. The pumps are essentially the same. The upper pump mounts to the top of the lower pump and has a tang on the shaft that fits into the shaft of the lower pump. Both pumps are driven simultaneously by the engines drive belt.

The following instructions apply to either pump:

PUMP OVERHAUL

Disassembly

The pump when removed from the engine will have the hose attachment nipple threaded into the inlet and outlet ports of the pump along with a drive pulley attached to the shaft of the pump. remove these attachments noting their positions before starting the pump disassembly.

1. Remove the four cover plate screws, cover plate, and sealing O-ring.

Dual Pumps

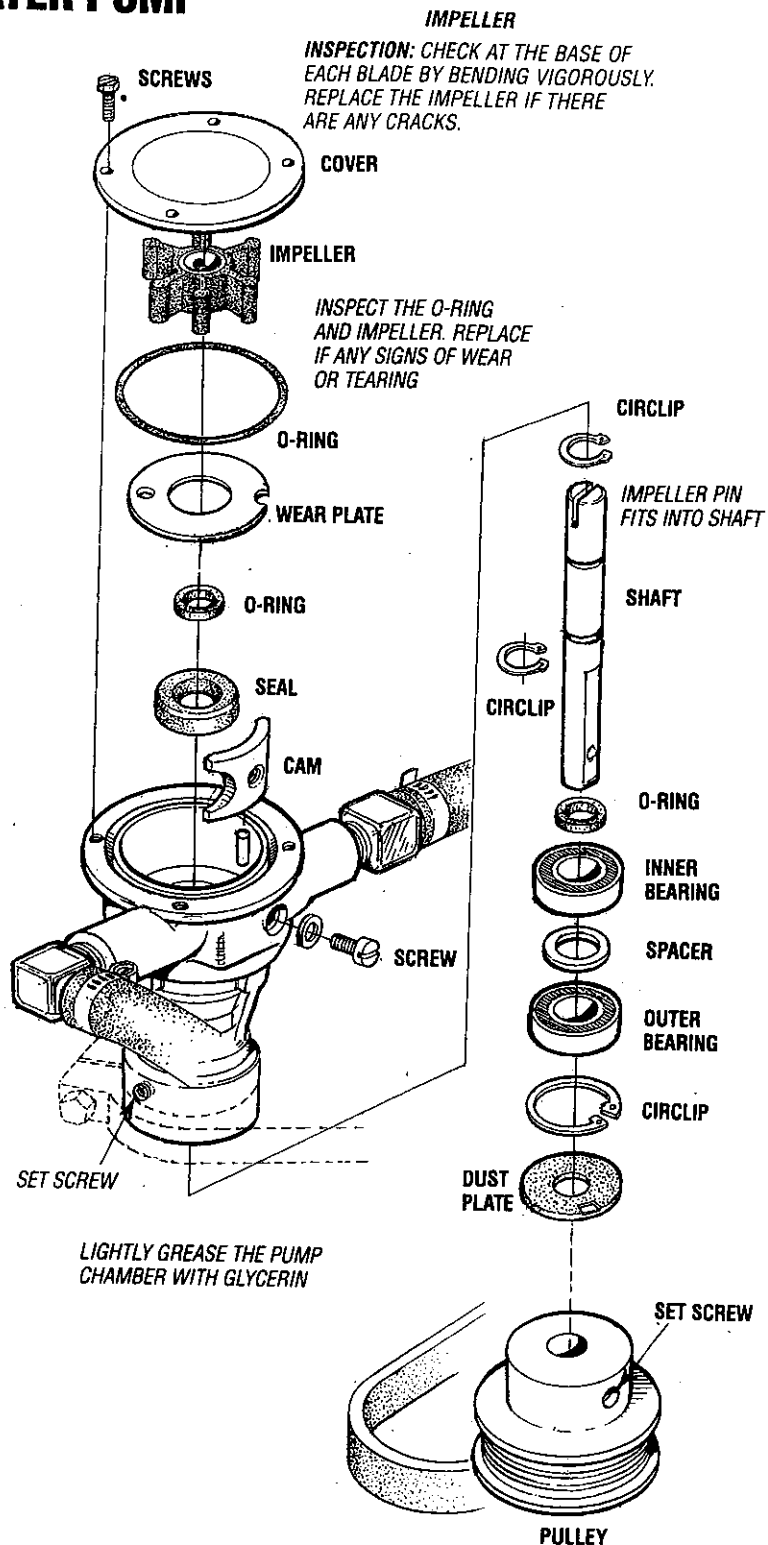
Remove the cover screws and the cover will separate the upper pump (raw water) from the fresh water (coolant) pump as shown in the illustration.

Remove the wear plate to expose the impeller. Notice the direction the impeller blades are working in so as to install the replacement impeller with blades working in the same direction.

2. Remove the impeller using a pair of pliers, grasping the hub and pulling it out of the pump with a twisting motion.
3. Remove the screw and sealing washer that hold the cam in place. remove the cam and inner wear plate behind it.
4. Remove the dust plate and circlip.
5. Support the pump body on an arbor press and with a drift, press the shaft and bearing assembly out of the pulley end of the pump.
6. Remove the O-ring from the shaft.
7. Support the outer bearing and push the shaft out of the bearing.
8. Remove the spacer and circlip .

Inspection

Inspect all parts and replace those showing wear and corrosion.



RAW WATER PUMP

Reassembly

Wipe the inside surface of the pump dry. Apply a film of glycerin supplied in the impeller kit to the inside pump surfaces and to the exposed area of the shaft lip seal.

1. Install a new shaft seal in the pump body. Apply some glycerin to the lip of the seal.
2. Install the circlip on the shaft. Support the outer bearing and push the shaft into the bearing until the bearing contacts the circlip
3. Install the spacer against the circlip. Support the inner bearing and push the shaft into the bearing until it contacts the spacer.
4. Apply some glycerin onto the O-ring and install it on the shaft approximately 1/8" away from the inner bearing.
5. Support the pump body on an arbor press. With a twisting motion, install the shaft and bearing assembly into the shaft seal until the inner bearing contacts the pump body. Then assemble into the pump body so that the outer bearing just clears the boss for circlip.
6. Install circlip and push the shaft and bearing assembly so the outer bearing contacts the circlip.
7. Install the dust plate.
8. Install wear plate and cam and secure in place with washers and screw.

Dual Pumps

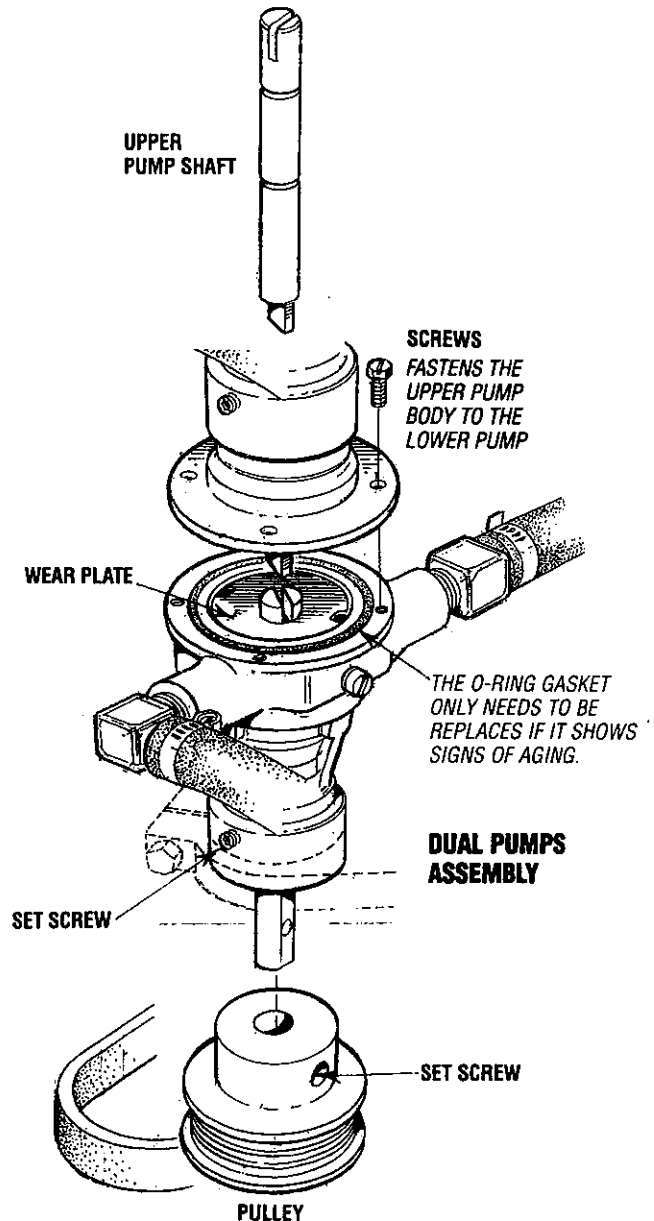
The wear plate is assembled above the impeller.

9. Apply some glycerin to the surface of the impeller housing, impeller inner surface of the cover plate and O-ring.
10. With a twisting motion, install the impeller into the pump. Install the O-ring and secure the cover with the four screws.

NOTE: Install the new impellers with a rotating motion so the blades are working in the same direction of those of the removed impeller.

Dual Pumps

Assemble the upper pump to the lower pump as illustrated making sure the mounting screws are tight.



ENGINE TUNING

TEST RUN AND INSPECTION AFTER COMPLETE ASSEMBLY

After reassembly, the engine must be tuned. This will ensure that the engine operates at its maximum efficiency.

- Mount the engine on a test bench.
- Connect the electrical wiring. refer to the *WIRING DIAGRAM*.
- Connect the air intake line to the air cleaner.
- Connect the exhaust.
- Fill the engine cooling system with coolant and the engine oil sump with lube oil.
- Connect the fuel lines.
- Crank the engine with the starter (non-ignition operation) for about twenty seconds. This will pre-lubricate the engine internal components.
- Start the engine and allow it to run five minutes.
- Remove the cylinder head cover while the engine is running.
- Check that the engine oil is continuously circulating from the oil pump to the valve rockers through the cylinder head.
If there is no oil circulation or if the oil circulation is sluggish, stop the engine and make the appropriate repairs and adjustments.
- Re-install the cylinder head cover.
- Check the engine for oil, fuel, coolant, and air intake leakage.
- Check for abnormal noise and odor.
- Check for abnormal electrical charging.
- Check the engine fastening parts for looseness.
- Check the operation of the start/stop switch and LED panel lights.
- Adjust the engine speed to the specified value for generator operation.
- Stop the engine to complete the tuning procedure.
- Additional tightening after test run. Check the tightening condition of respective bolts and nuts after test run, and additionally tighten them with the specified tightening torques.

ENGINE ADJUSTMENTS

ENGINE COMPRESSION TEST

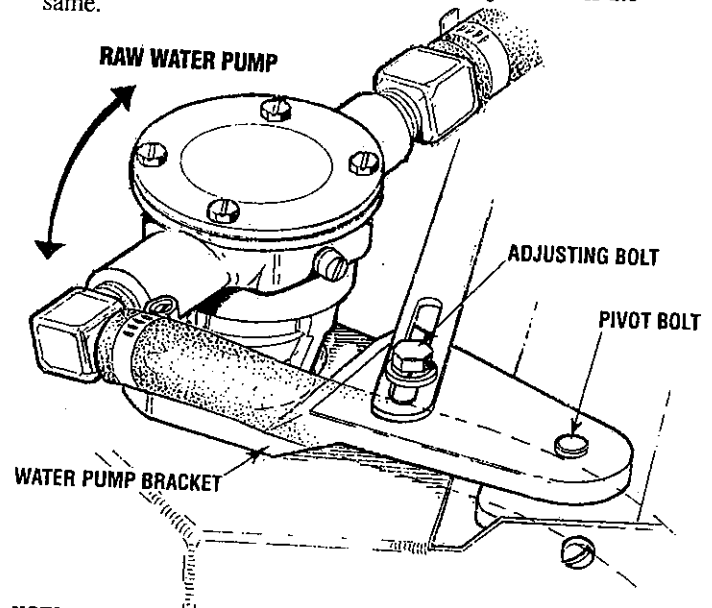
To check the engine's compression pressure, warm up the engine, then shut it down.

1. Remove both spark plug caps and both spark plugs.
2. Install a compression adapter and gauge in a spark plug hole.
3. Close the thru hull valve (seacock).
4. Crank the engine several times quickly so that the gauge pointer reaches it's maximum.
STANDARD COMPRESSION PRESSURE AT 500 RPM:
71 PSI (5 ± 1 Kg/cm²) (0.4 ± 0.1 MPa)
5. Test the compression pressure on the other cylinder. If either cylinder is below the standard try adding a small amount of engine oil through the spark plug hole and repeat the test.
 - (a) If additional oil causes an increase of pressure, the piston ring and/or cylinder may be worn or damaged.
 - (b) If additional oil does not increase compression pressure suspect poor valve contact, valve seizure or valve wear.
6. Reinstall the two plugs, connect the wires and open the thru hull valve (seacock).

WATER PUMP BELT

To remove, replace or adjust the belt, loosen the pivot bolt and release the adjusting bolt. Slide the water pump bracket to slacken the belt for removal. When replacing and adjusting the belt, set the belt very tight and tighten the bolt and nut.

The dual water pumps on the *FRESH WATER COOLED MODELS* use the same drive belt and the adjustment is the same.



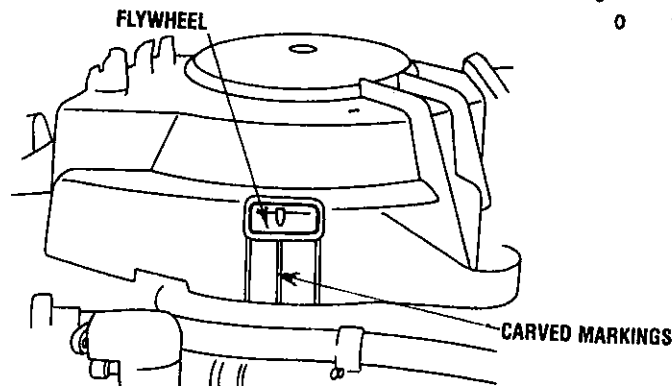
NOTE: The adjustment is the same for the *FRESH WATER COOLED MODEL* dual pumps.

IGNITION TIMING

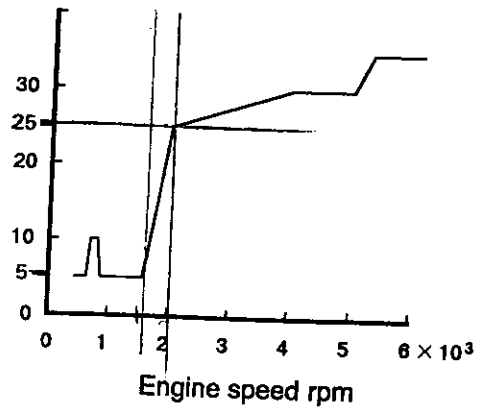
The magneto employs the electric ignition advance system that advances ignition timing with an increase of engine speed. While running the engine, check the ignition timing with a timing light.

There are nine (9) markings (TDC, ATDC 5° and BTDC 5°, 10°, 15°, 20°, 25°, 30°, 35) on the flywheel cup.

Check the timing while observing the position of the carved marking on the starter case.



BTDC
IGNITION TIMING
IN DEGREES

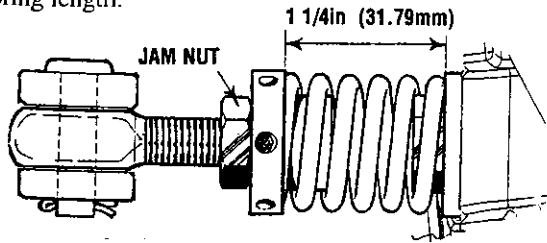


ENGINE ADJUSTMENTS

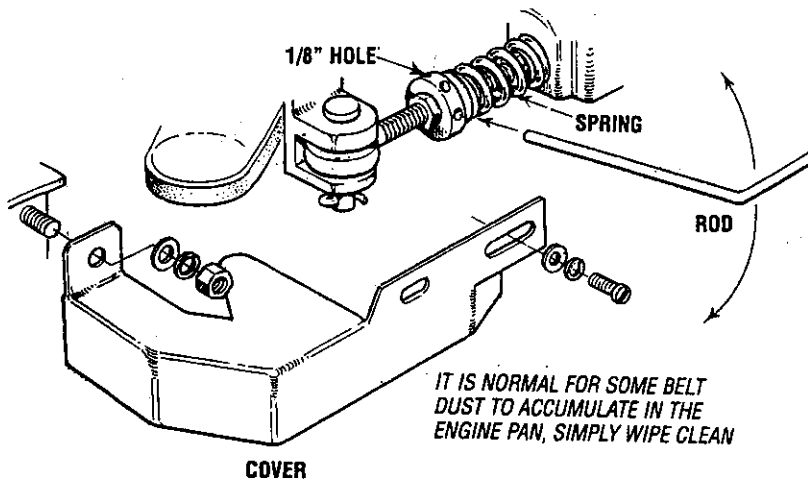
ADJUSTING THE DRIVE BELT

The engine's drive belt is located under the engine. To access the belt, for inspection and/or adjustment, remove the cover as shown. Inspect the belt for wear along the edges and for proper belt tension (belt should be tight).

The belt tension can be checked by measuring the spring length.

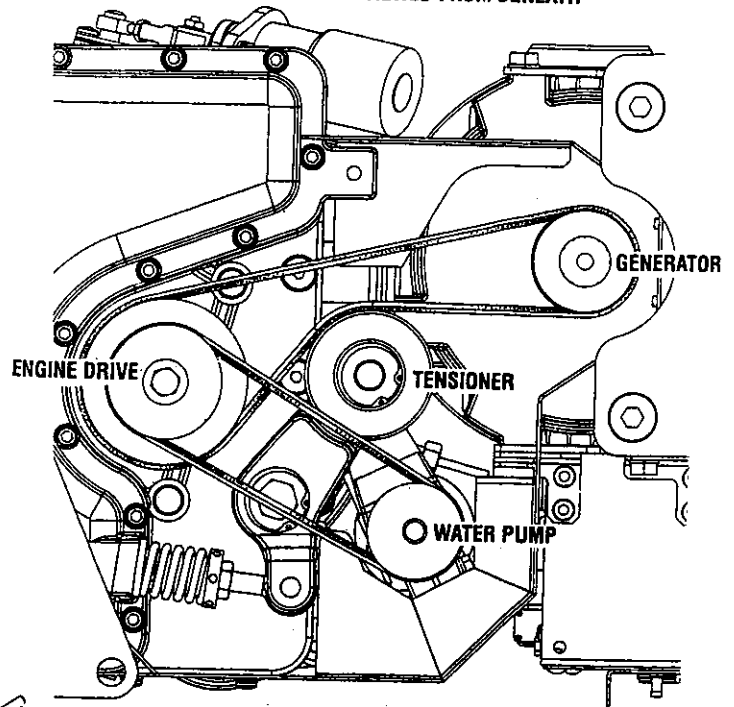


To set the spring tension at 1-1/4", release the jam nut and use a rod such as an allen wrench to turn the adjusting nut (as shown) to tighten or loosen the spring tension, which in turn adjusts the tension on the belt.



BELT ASSEMBLY VIEWED FROM BELOW

BELT ASSEMBLY VIEWED FROM BENEATH



OIL PRESSURE

The lubricating system is a pressure feeding system using an oil pump. The engine oil is drawn from the oil sump by the oil pump, which drives the oil, under pressure, through the oil filter and various lubricating parts in the engine. The oil then returns to the oil sump to repeat the continuous cycle. When the oil pressure exceeds the specified pressure, the oil pushes open the relief valve in the oil pump and returns to the oil sump, keeping the oil pressure within its specified range.

TESTING OIL PRESSURE

To test the oil pressure, remove the oil switch and install a mechanical oil pressure gauge in its place, it will be necessary to connect the two switch wires together for the engine to run. After warming up the engine, with the engine speed at 2200 rpm, read the oil pressure gauge.

OIL PRESSURE: between 30 and 40 psi at 2200 rpm

NOTE: A newly starter (cold) engine may have an oil pressure up to 40 psi. A warmed engine can have an oil pressure as low as 30 psi. Oil pressure will vary depending on the load placed on the generator.

OIL PRESSURE SWITCH/SENSOR

The generator is fitted with an oil pressure shutdown switch. Should the engine's oil pressure drop below the safe minimum, the switch will shut the engine down to prevent damage by interrupting the DC voltage to the ignition coil.

NOTE: The specified minimum oil pressure is 5 psi. A gradual loss of oil pressure usually indicates worn bearings. For additional information on low oil pressure readings, see the ENGINE TROUBLESHOOTING chart.

ENGINE ADJUSTMENTS

SPARK PLUGS

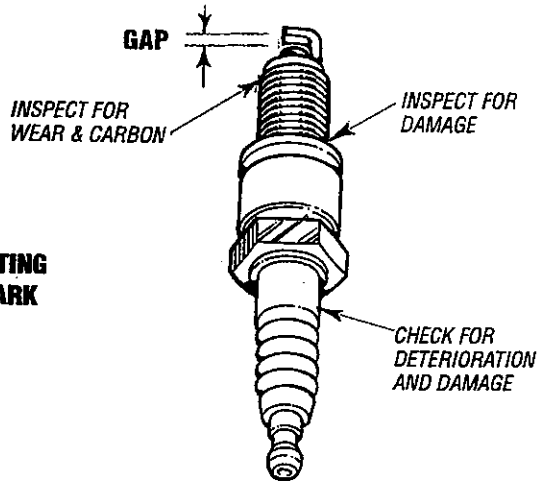
The spark plugs should be cleaned and re-gapped after the first 50 hour break-in period, then inspected every 250 hours thereafter and replaced as needed.

WARNING: Do not remove the spark plugs while the engine is hot. Allow the engine to cool before removing them.

SPARK PLUG GAP: 0.032 - 0.035in. (0.8 - 0.9mm).

SPARK PLUG TORQUE: 11 - 15 lb-ft (15 - 26 Nm).

NOTE: Loctite Anti-Seize applied to the threaded portion of the spark plugs will retard corrosion, making future removal of the spark plugs easier.



INSPECTING THE SPARK PLUGS

CHOKE SOLENOID

The choke solenoid is a 12 volt DC operated unit that is an integral part of the carburetor. When the engine is cold, extra fuel is supplied to the engine. The choke is controlled by the ignition control module and requires no adjustments.

ZINC ANODE [Raw Water Cooled Models]

The zinc anode is located just below the thermostat cover and next to the oil filter. The purpose of the zinc anode is to sacrifice itself to electrolysis action taking place in the raw water cooling circuit, thereby reducing the effects of electrolysis on other components of the system. The condition of the zinc anode should be checked monthly and the anode cleaned or replaced as required. Spare anodes should be carried on board.

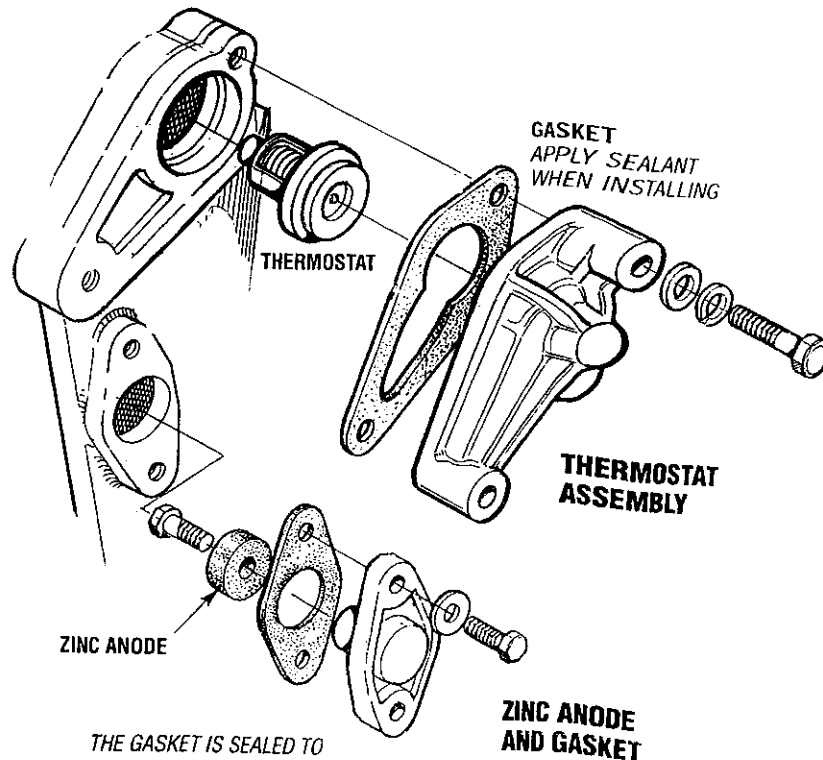
NOTE: Refer to the Cooling System pages for Fresh Water Cooled Thermostat and Zinc Anode assemblies.



THERMOSTAT [Raw Water Cooled Models]

A thermostat controls the coolant temperature as the raw water continuously flows through the closed cooling circuit. When the engine is first started, the closed thermostat prevents the water from flowing (some water is by-passed around the thermostat to provide coolant circulation in the engine block). As the engine warms up, the thermostat gradually opens. The thermostat is accessible and can be checked, cleaned, or replaced easily. Carry a spare thermostat and gasket.

If you suspect a faulty thermostat, place it in a pan of water and bring to a boil. A working thermostat should open when heated and close when cold.



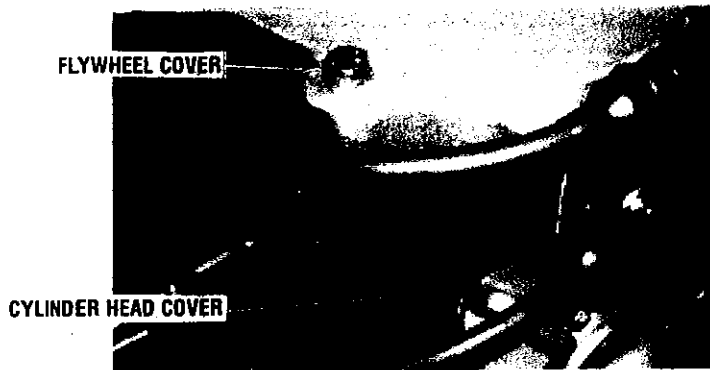
THE GASKET IS SEALED TO THE CASTING AND, UNLESS DAMAGED, CAN BE LEFT IN POSITION. ADD SEALANT TO THE GASKET SURFACE WHEN REASSEMBLING THE COVER.

ENGINE ADJUSTMENTS

VALVE CLEARANCE

It is routine maintenance to adjust the valve clearance after the first fifty hours of operation. Valve clearance adjustment must be performed when the engine is cool and the piston must be at the top dead center of the compression stroke. Perform the following adjustment steps:

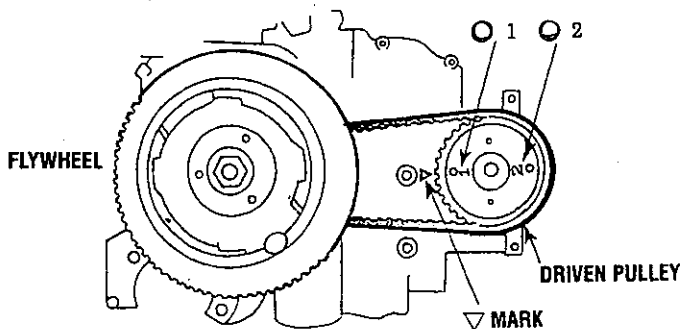
1. Remove the fuel pump and fuel filter from the cylinder head cover. This assembly can be set aside without disconnecting the hoses.
2. Remove the cylinder head cover.



3. Remove the flywheel cover to access the flywheel and driven pulley.

NOTE: The governor sensor (mag pick-up) wires can be disconnected at the side of the control panel.

4. Turn the driven gear and align the "I and O" mark on the driven pulley with the "∇" mark on the cylinder head.



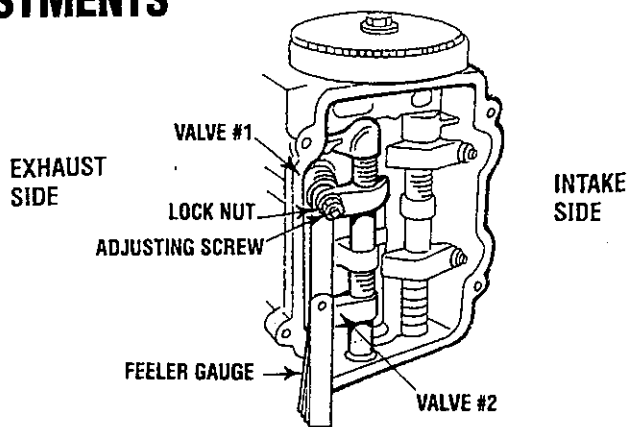
5. Adjust the intake and exhaust valve clearance for cylinder #1.
 - a. Loosen the lock nut.
 - b. Insert a feeler gauge between the valve end and the adjusting screw.
 - c. Set the valve clearance by the adjusting screw.

VALVE CLEARANCE:

INTAKE: 0.13 - 0.17mm (0.005 - 0.007in)

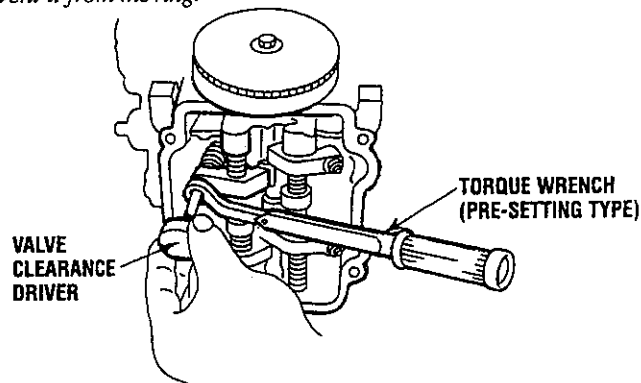
E EXHAUST: 0.18 - 0.22mm (0.007 - 0.009in)

- d. Tighten the lock nut.
 - e. Again, check the valve clearance.
6. Turn the driven gear and align the "2 and O" mark on the driven pulley with the "∇" mark on the cylinder head.



7. Adjust the intake and exhaust valve clearance for cylinder #2 using the same sequence.

NOTE: When loosening and tightening the lock nut, hold the adjusting screw with a valve clearance driver to prevent it from moving.

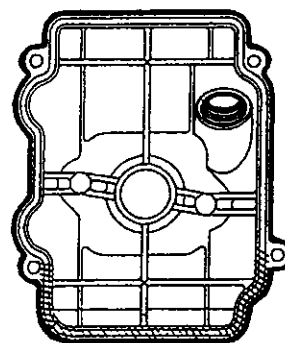


8. Install the cylinder head cover. Apply sealant to the inside rim of the cover as indicated by the shaded area of the drawing.

BOLT TORQUE:

8 - 10 Nm (0.8 - 1.0 kg-m) 5.8 - 7.2 lb-ft

9. Install the flywheel cover and re-attach the sensor wires.



ENGINE ADJUSTMENTS

INSPECTION/REPLACING OF THE TIMING BELT

If cracks, wear, lengthening or other damage is found, replace the timing belt.

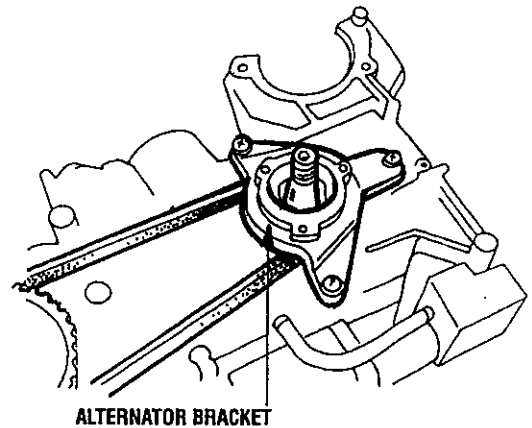
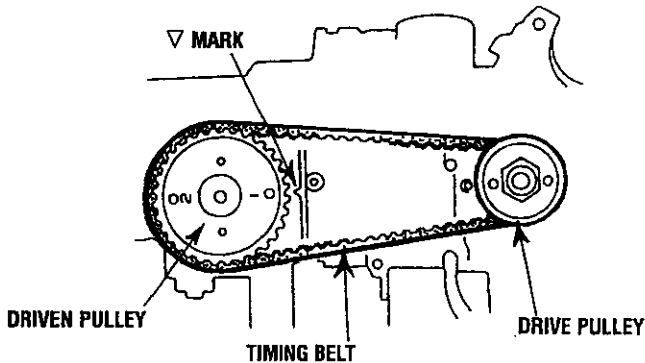
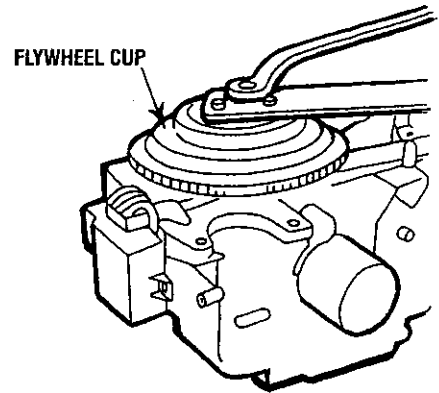
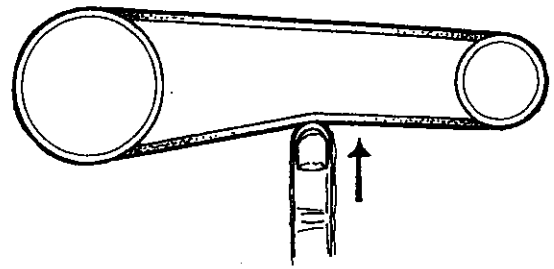
LIMIT OF ELONGATION: MORE THAN 10mm (0.4 IN) DEFLECTION BY PUSHING WITH YOUR FINGER

Replacement of the Timing Belt

1. Remove the parts in the following order:
 - a. Spark plugs
 - b. Recoil starter
 - c. Magneto flywheel cup
 - d. Alternator assembly
 - e. Alternator bracket
2. Turn the crankshaft and align "○" mark on the drive pulley and the "○" mark on the cylinder head.
3. Remove the timing belt from the driven pulley side.
4. Install the timing belt from the drive pulley side.

NOTE: After installing the timing belt, when the aligning "○" mark on the drive pulley with "○" on the cylinder block. Please confirm that the "1 & ○" or "2 & ○" mark on the driven pulley are aligned with the "▽" mark on the cylinder head.

NOTE: Always keep the timing belt away from any oil and grease.



ELECTRONIC GOVERNOR

CONTROLLER

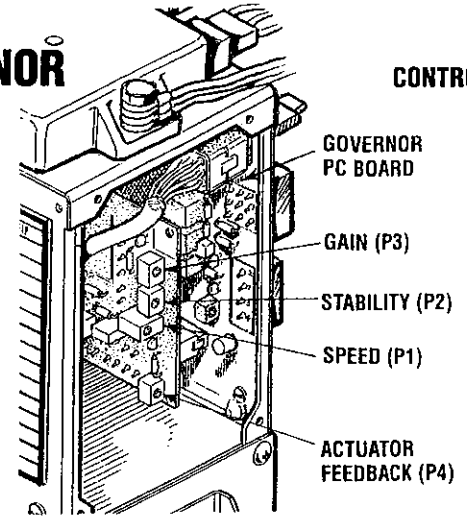
DESCRIPTION

The system is composed of three basic components.

1. **Controller.** The PC board that governs the system is located in the control panel.
2. **Sensor.** Mounted on the flywheel cover, the sensor measures the speed of the engine (via the ring gear).
3. **Actuator.** Electronically controls the carburetor throttle. The sensor and actuator are wired thru the wiring harness to the controller (PC board).



ACTUATOR



CONTROL PANEL
(INTERIOR VIEW)

Following are the basic procedures for adjusting the speed (P1), stability (P2), gain (P3), and actuator feedback (P4) pots.

The adjusting pots (except speed) have physical internal stops. Turn to the right (clockwise) to increase, turn to the left (counter-clockwise) to decrease.

Before starting the engine

- Remove all loads and turn off the AC circuit breaker to insure that loads will not be subjected to voltage variations while these adjustments are made.
- Decrease the speed pot to prevent overspeed at start up.
- Turn the other adjustment pots to the middle position.

Start the engine, monitor speed and adjust to the hertz rating of the unit by adjusting the **SPEED (P1)** as needed. Verify that the AC voltage output is in the correct range.

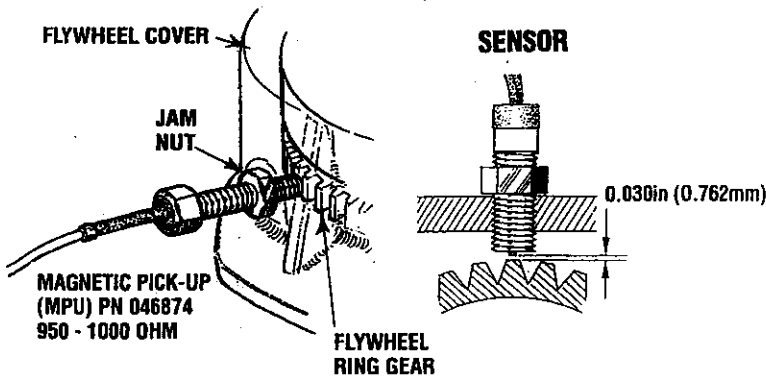
Decreasing the gain (P3) dampens no load hunting. With the engine running at no load and proper speed, manually bump the throttle lever to cause hunting. If necessary, decrease the gain in small increments to eliminate hunting.

After the engine's no load speed and gain are set correctly, the AC circuit breaker can be turned on and the ship's load applied. In the event of speed variations with loads applied, the stability (P2) pot may need adjustment. This adjustment also changes how the engine responds to generator load changes.

If the range of adjustment of either gain (P3) or stability (P2) pots do not correct engine hunting, the actuator feedback (P4) pot can be increased. This adjustment dampens the signals to the throttle control actuator. Increasing this adjustment will decrease the amount of throttle control resolution. Because of this, it is recommended the adjustment be made in very small increments. The gain and stability pots may now need to be readjusted.

Most hunting problems occur because of mechanical problems with the linkage between the actuator and the carburetor. Insure that the linkage is free of any debris or corrosion and that it moves freely. It is recommended that the linkage be lubricated with a graphite lubricant. Do not use oil because it tends to collect dirt and dust.

NOTE: Adjustments to one parameter may affect others, such as speed. It may be necessary to readjust some pots throughout this process.



ADJUSTMENT PROCEDURE

Speed. This adjustment is used to raise or lower the engine's speed. This generator engine is set to run at 2200 RPM.

Gain. Adjusts the overall set of the engine. If too low, the engine seems sluggish, too high causes the engine to hunt.

Stability. Adjusts the engine's response to generator load changes.

Alternator Feedback. Adjusts the stability of the speed signal to the throttle actuator.

NOTE: These adjustments are extremely delicate and require proper meters for measuring voltage and RPM'S. The potentiometers are linked and adjustments to one may upset the balance of another.

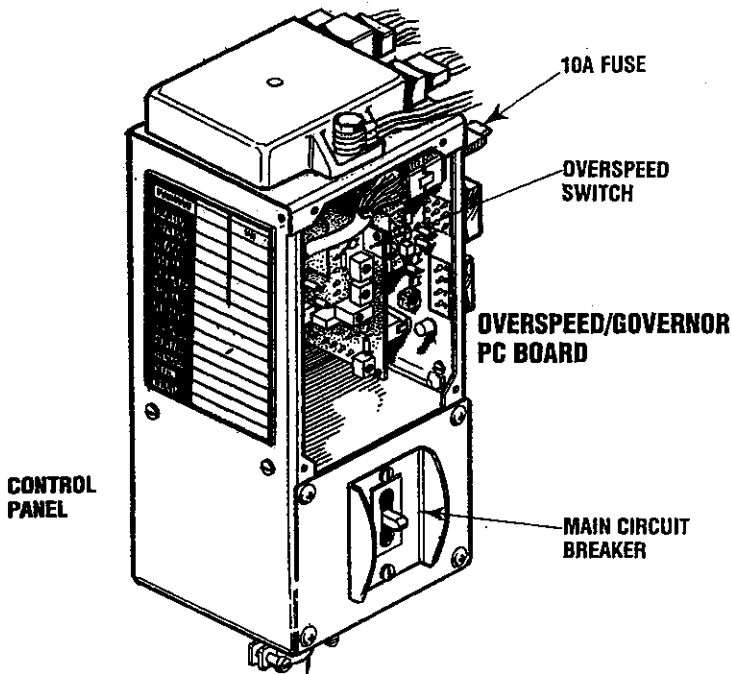
SAFETY SHUTDOWN SWITCHES

SAFETY SHUTDOWN SWITCHES

This engine is protected by three shutdown switches and two fuses. Should a shutdown occur, *do not attempt to restart without finding and correcting the cause*. Refer to the heading *Engine starts, runs and then shuts down* in the *ENGINE TROUBLESHOOTING* section of this manual.

OVERSPEED SWITCH

The overspeed PC board inside the control panel will shut the engine down if the engine speed (RPM'S) exceeds the operating speed required to run the generator. The overspeed PC board will reset itself once the engine shuts down.



MAIN CIRCUIT BREAKER AC 25A

The main circuit breaker at the control panel will automatically disconnect the AC power if there is an electrical overload.

This circuit breaker should be manually switched off when servicing the engine/generator to ensure that no power is coming into the boat. The breaker is reset manually.

FUSES

A 10A fuse located on the side of the control panel protects the DC electrical wiring. If an electrical overload occurs the fuse will blow and shut the engine down.

An 20A in-line fuse protects the battery charging circuit. If this fuse fails, the engine will continue to run but the battery will not be charging.



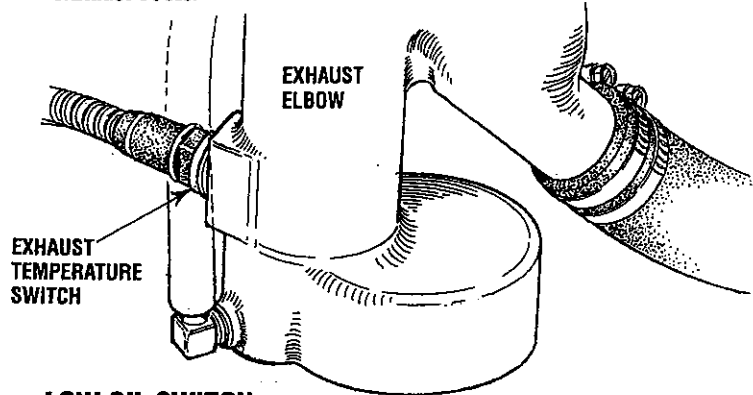
10A FUSE



20A FUSE
BATTERY CHARGING

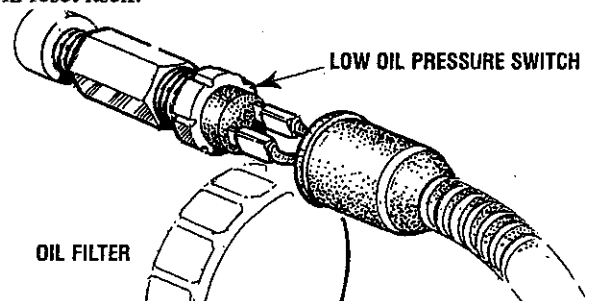
EXHAUST TEMPERATURE SWITCH

An exhaust temperature switch located at the base of the exhaust elbow sensors an excessive exhaust temperature (an inadequate supply of cooling water). A temperature above 240° F will shut the engine down. Inspect the cooling system, water pump, pump belt, seacock, water strainer, water hoses, etc. This switch will reset itself when the exhaust cools.



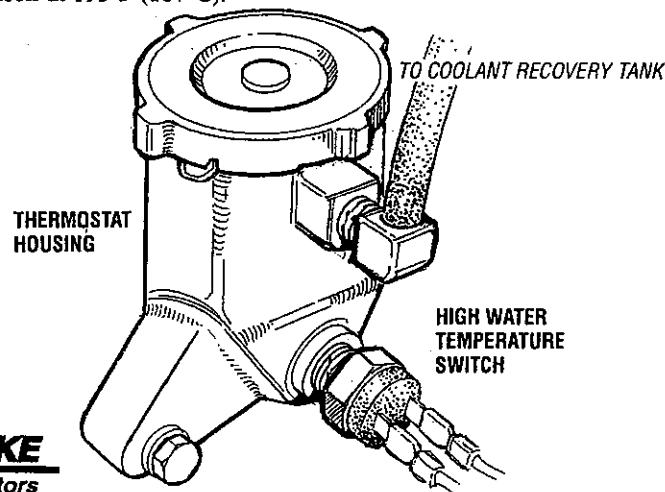
LOW OIL SWITCH

Located just to the right of the oil filter, this switch sensors the engine's oil pressure if the oil pressure falls to below 5 psi. This switch will shut the engine down. Check the angle of operation, dipstick oil level and oil filter. The switch will reset itself.



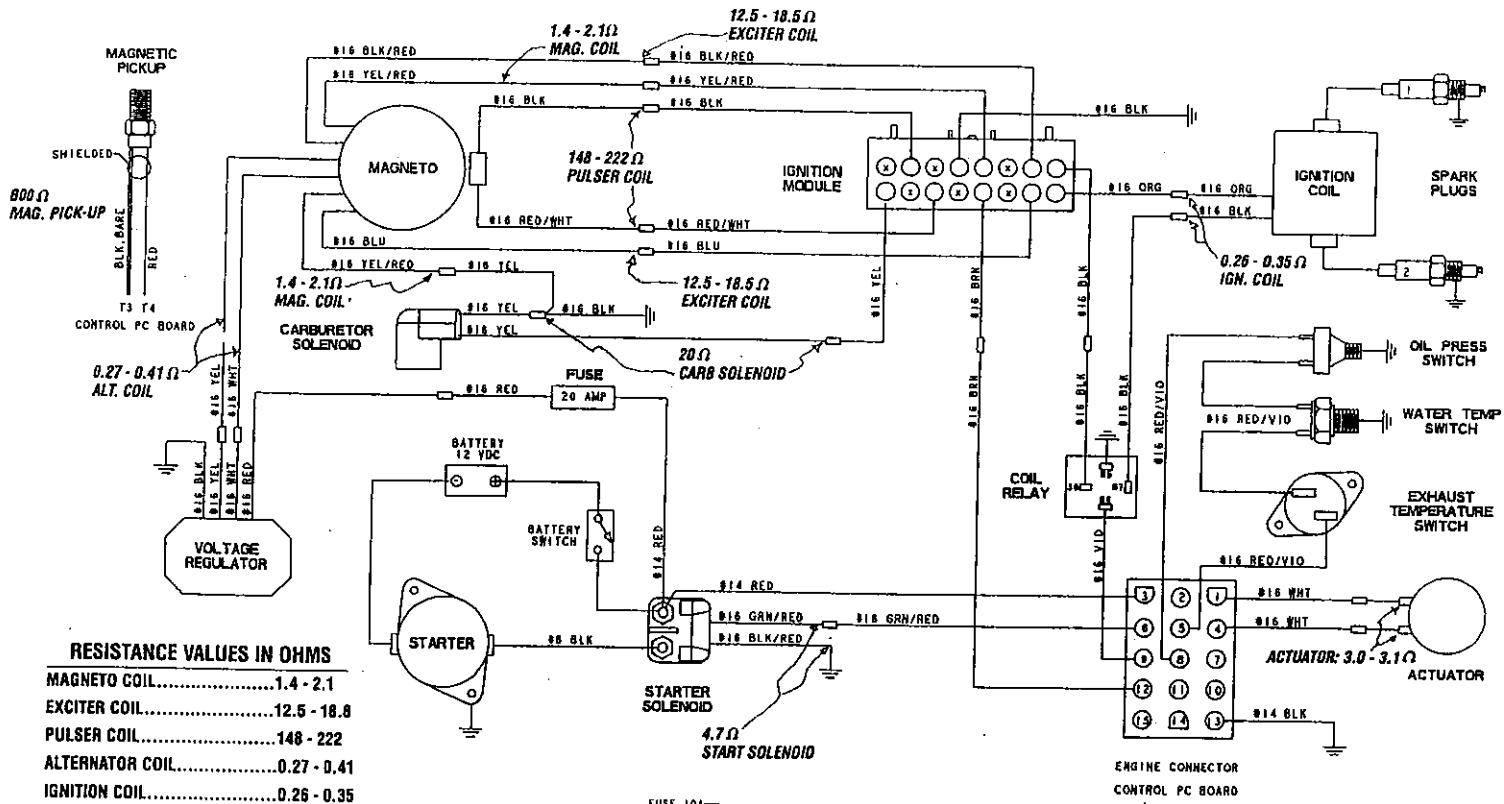
HIGH WATER TEMPERATURE SWITCH (Fresh Water Cooled Model)

A high water temperature switch is located at the thermostat housing. Normally closed, this switch, should the fresh water coolant's operating temperature reach approximately 210°F (99°C), will open and shut the engine down. This switch resets itself at 195°F (107°C).



GENERATOR WIRING DIAGRAM

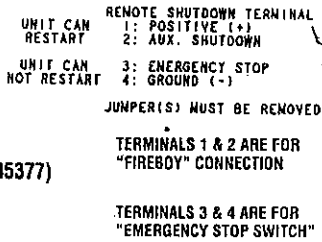
RESISTANCE VALUES IN OHMS IN BLACK ITALIC



RESISTANCE VALUES IN OHMS

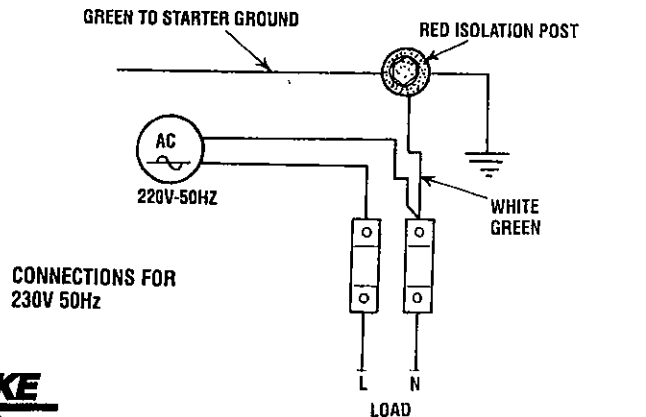
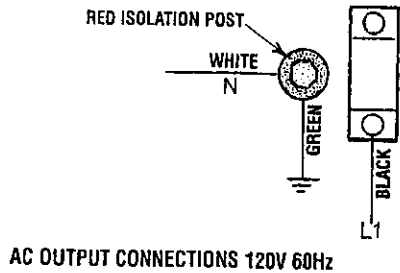
MAGNETO COIL.....	1.4 - 2.1
EXCITER COIL.....	12.5 - 18.8
PULSER COIL.....	148 - 222
ALTERNATOR COIL.....	0.27 - 0.41
IGNITION COIL.....	0.26 - 0.35
(Primary)	
MAGNETIC PICK-UP.....	800
START SOLENOID.....	4.7
HIGH TENSION LEADS.....	6,800-10,000
CARBURETOR SOLENOID.....	20
ACTUATOR.....	3.0 - 3.1

NOTE: TESTER USED - FLUKE MULTIMETER
TOLERANCE ± 20%

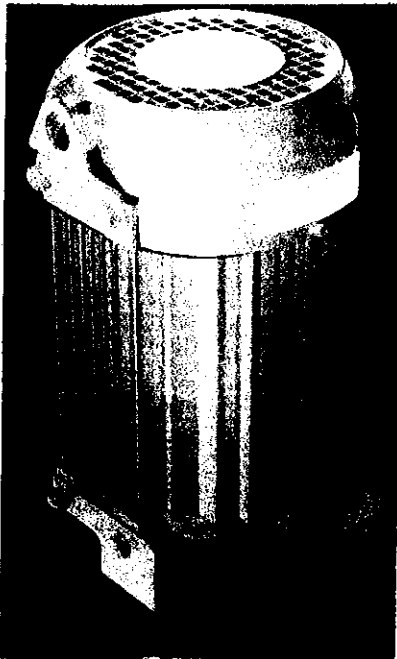


OVERSPEED PC BOARD (PN #045377)

PART NUMBERS: REMOTE STOP/START PANEL #048056 PANEL EXTENSION HARNESS 15FT #048200, 30 FT #048201



AC GENERATOR



PERMANENT MAGNET GENERATOR

Engine rpm at 2200

Generator turns at 3600 (60 Hz), 3000 (50Hz)

60Hz 120 volts/25 amps, 50 Hz 230 volts/13 amps

WARNING: Do not attempt to make adjustments or repairs to the generator. The generator is maintenance free. If the generator fails (no ac output), contact your WESTERBEKE dealer or distributor.

Required Operating Speed

Run the generator first with no load applied, then at half the generators capacity, and finally loaded to its full capacity as indicted on the generators data plate. The output voltage should be checked periodically to ensure proper operation of the generating plant and the appliances it supplies. To monitor voltage and load, check it with a portable meter and amprobe.

Generator Maintenance

Maintaining reasonable cleanliness is important. Connections of terminal boards and rectifiers may become corroded, and insulation surfaces may start conducting if salts, dust, engine exhaust, carbon, etc. are allowed to build up. Clogged ventilation openings may cause excessive heating and reduced life of windings.

In addition to periodic cleaning, the generator should be inspected for tightness of all connections, evidence of overheated terminals and loose or damaged wires.

MOTOR DATA

The power required to start an electric motor is considerably more than is required to keep it running after it is started. Some motors require much more current to start them than others. Split-phase (AC) motors require more current to start, under similar circumstances, than other types. They are commonly used on easy-starting loads, such as washing machines, or where loads are applied after the motor is started, such as small power tools. Because they require 5 to 7 times as much current to start as to run, their use should be avoided, whenever possible, if the electric motor is to be driven by a small generator. Capacitor and repulsion-induction motors require from 2 to 4 times as much current to start as to run. The current required to start any motor varies with the load connected to it. An electric motor connected to an air compressor, for example, will require more current than a motor to which no load is connected.

In general, the current required to start 115-Volt motors connected to medium starting loads will be approximately as follows:

MOTOR SIZE (HP)	AMPS FOR RUNNING (AMPERES)	AMPS FOR STARTING (AMPERES)
1/6	3.2	6.4 to 22.4*
1/4	4.6	9.2 to 32.2*
1/3	5.2	10.4 to 72.8*
1/2	7.2	14.4 to 29.2*
3/4	10.2	20.4 to 40.8*
1	13	26 to 52

***NOTE:** In the above table the maximum Amps for Starting is more for some small motors than for larger ones. The reason for this is that the hardest starting types (split-phase) are not made in larger sizes.

Because the heavy surge of current needed for starting motors is required for only an instant, the generator will not be damaged if it can bring the motor up to speed in a few seconds. If difficulty is experienced in starting motors, turn off all other electrical loads and, if possible, reduce the load on the electric motor.

GENERATOR FAILURE

Should a failure occur in the permanent magnet generator, contact your Westerbeke dealer of the Westerbeke factory.

NOTE: It would be important to inspect the pulley and drive belt under the generator base frame.

3.0 KW BPMG GENERATOR SPECIFICATIONS

ENGINE SPECIFICATIONS

Engine Type	Two cylinder, four stroke gasoline engine.
Bore & Stroke	2.32 x 2.36 inches (59 x 60 mm)
Total Displacement	20.01 Cubic Inches (.33 liter)
Bearings	Two main bearings.
Valve System	Overhead cam-cross flow.
Compression Ratio	9:1
Firing Order	1 - 2
Aspiration	Naturally aspirated.
Direction of Rotation	Counterclockwise viewed from the back end.
Inclination	25° maximum angle of operation
Dry Weight	165 lbs (75 Kg)
Governor	Electronic

FUEL SYSTEM

Fuel Pump	Mechanical fuel pump.
Fuel	Unleaded 89 octane or higher gasoline.
Ignition Timing	BTDC 25° (not adjustable).
Ignition Coil	12 volt.
Flame Arrester	Metal screen type.
Carburetor	Single barrel side draft.
Fuel Consumption (Full Load)	0.4 GPH @ 2200 RPM/25 Amps
Ignition Timing	12-Volt flywheel magneto.

ELECTRICAL SYSTEM

Start Motor	12-Volt reduction gear with solenoid.
Starting Battery	12-Volt, (-) negative ground
Battery Capacity	600-900 Cold Cranking Amps (CCA)
Battery Charging	11 Amp
DC Amperage Draw	70 Amps DC

LUBRICATION SYSTEM

Type	Wet sump system trochoid type pump.
Oil Filter	Fuel flow, paper element, spin-on disposals.
Oil Capacity	1.5 qts. (91.4 L)
Oil Grade	API SJ 10W-30, 15W-40

COOLING SYSTEM

General	Water cooled via raw water pump.
Raw Water Pump	Positive displacement type, rubber impeller, belt driven.
Raw Water Flow (into water injected exhaust elbow)	1.75 GPM (6.6 LPM) (before thermostat opens) 2.0 GPM (7.5 LPM) (thermostat open)
Operating Temperature	140°F (60°C)

AC GENERATOR (SINGLE PHASE)

Type	Permanent magnet (two pole)
Speed	3600 RPM/60Hz 3000RPM/50Hz
3.0 Kw	3.0 KW - 60 Hz single phase, 120 volts 2 wire, 25 amp 3.0 KW - 50 Hz single phase, 230 volts 2 wire, 13 amp

TUNE-UP SPECIFICATIONS

Spark Plug Gap	0.032 - 0.035in (0.8 - 0.9mm)
Spark Plug Torque	11 - 15 lb-ft (15 - 20 Nm)
Bolt Torque	See <i>TORQUING THE CYLINDER HEAD.</i>

AIR REQUIREMENTS

Engine Combustion	13 CFM (0.287 cmm)
Generator Cooling	200 CFM (5.66 cmm)

FRESH WATER COOLED MODELS

Cooling System	Fresh water cooled block, thermostatically controlled thru a heat exchanger.
Fresh Water (coolant) Pump	Positive displacement, rubber impeller belt driven
Raw Water Pump	Positive displacement, rubber impeller belt driven
Raw Water Flow (into water injected exhaust elbow)	2.5 - 3.0 GPM 9.5 - 11.3 LPM
Operating Temperature	180° F (82°C)

ENGLISH TO METRIC CONVERSION CHART

Multiply Temperature	By	To get equivalent number of:
Degree Fahrenheit (°F)	(°F-32) ÷ 1.8	Degree Celsius (°C)
Multiply Acceleration	By	To get equivalent number of:
Foot/second ² (ft/sec ²)	0.3048	Meter/second ² (m/s ²)
Inch/second ² (in./sec ²)	0.0254	Meter/second ² (m/s ²)
Multiply Torque	By	To get equivalent number of:
Pound-inch (lb-in.)	0.11298	Newton-meters (N-m)
Pound-foot (lb-ft)	1.3558	Newton-meters (N-m)
Multiply Power	By	To get equivalent number of:
Horsepower (hp)	0.746	Kilowatts (kW)
Multiply Pressure or Stress	By	To get equivalent number of:
Inches of water (in. H ₂ O)	0.2491	Kilopascals (kPa)
Pounds/square in. (lb/in. ²)	6.895	Kilopascals (kPa)
Multiply Energy or Work	By	To get equivalent number of:
British Thermal Unit (Btu)	1055	Joules (J)
Foot-pound (ft-lb)	1.3558	Joules (J)
kilowatt-hour (kW-hr)	3,600,000. or 3.6 x 10 ⁶	Joules (J = one W/s)
Multiply Light	By	To get equivalent number of:
Foot candle (fc)	1.0764	Lumens/meter ² (lm/m ²)
Multiply Fuel Performance	By	To get equivalent number of:
Miles/gal (mile/gal)	0.4251	Kilometers/liter (km/L)
Gallons/mile (gal/mile)	2.3527	Liter/kilometer (L/km)
Multiply Velocity	By	To get equivalent number of:
Miles/hour (mile/hr)	1.6093	Kilometers/hour (km/hr)

Multiply Length	By	To get equivalent number of:
Inch (in.)	25.4	Millimeters (mm)
Foot (ft)	0.3048	Meters (m)
Yard (yd)	0.9144	Meters (m)
Mile (mile)	1.609	Kilometers (km)
Multiply Area	By	To get equivalent number of:
Inch ² (in. ²)	6452	Millimeters ² (mm ²)
Inch ² (in. ²)	6.45	Centimeters ² (cm ²)
Foot ² (ft ²)	0.0929	Meters ² (m ²)
Yard ² (yd ²)	0.8361	Meters ² (m ²)
Multiply Volume	By	To get equivalent number of:
Inch ³ (in. ³)	16387	Millimeters ³ (mm ³)
Inch ³ (in. ³)	16.387	Centimeters ³ (cm ³)
Inch ³ (in. ³)	0.0164	Liters (L)
Quart (qt)	0.9464	Liters (L)
Gallon (gal)	3.785	Liters (L)
Yard ³ (yd ³)	0.7646	Meters ³ (m ³)
Multiply Mass	By	To get equivalent number of:
Pound (lb)	0.4536	Kilograms (kg)
Ton (ton)	907.18	Kilograms (kg)
Ton (ton)	0.907	Tonne (t)
Multiply Force	By	To get equivalent number of:
Kilogram (kg)	9.807	Newtons (N)
Ounce (oz)	0.2780	Newtons (N)
Pound (lb)	4.448	Newtons (N)

STANDARD AND METRIC CONVERSION DATA

LENGTH-DISTANCE

Inches (in) x 25.4 = Millimeters (mm) x .0394 = Inches

Feet (ft) x .305 = Meters (m) x 3.281 = Feet

Miles x 1.609 = Kilometers (km) x .0621 = Miles

DISTANCE EQUIVALENTS

1 Degree of Latitude = 60 Nm = 111.120 km

1 Minute of Latitude = 1 Nm = 1.852 km

VOLUME

Cubic Inches (in³) x 16.387 = Cubic Centimeters x .061 = in³

Imperial Pints (IMP pt) x .568 = Liters (L) x 1.76 = IMP pt

Imperial Quarts (IMP qt) x 1.137 = Liters (L) x .88 = IMP qt

Imperial Gallons (IMP gal) x 4.546 = Liters (L) x .22 = IMP gal

Imperial Quarts (IMP qt) x 1.201 = US Quarts (US qt) x .833 = IMP qt

Imperial Gallons (IMP gal) x 1.201 = US Gallons (US gal) x .833 = IMP gal

Fluid Ounces x 29.573 = Milliliters x .034 = Ounces

US Pints (US pt) x .473 = Liters(L) x 2.113 = Pints

US Quarts (US qt) x .946 = Liters (L) x 1.057 = Quarts

US Gallons (US gal) x 3.785 = Liters (L) x .264 = Gallons

MASS-WEIGHT

Ounces (oz) x 28.35 = Grams (g) x .035 = Ounces

Pounds (lb) x .454 = Kilograms (kg) x 2.205 = Pounds

PRESSURE

Pounds Per Sq In (psi) x 6.895 = Kilopascals (kPa) x .145 = psi

Inches of Mercury (Hg) x .4912 = psi x 2.036 = Hg

Inches of Mercury (Hg) x 3.377 = Kilopascals (kPa) x .2961 = Hg

Inches of Water (H₂O) x .07355 = Inches of Mercury x 13.783 = H₂O

Inches of Water (H₂O) x .03613 = psi x 27.684 = H₂O

Inches of Water (H₂O) x .248 = Kilopascals (kPa) x 4.026 = H₂O

TORQUE

Pounds-Force Inches (in-lb) x .113 = Newton Meters (Nm) x 8.85 = in-lb

Pounds-Force Feet (ft-lb) x 1.356 = Newton Meters (Nm) x .738 = ft-lb

VELOCITY

Miles Per Hour (MPH) x 1.609 = Kilometers Per Hour (KPH) x .621 = MPH

POWER

Horsepower (Hp) x .745 = Kilowatts (Kw) x 1.34 = MPH

FUEL CONSUMPTION

Miles Per Hour IMP (MPG) x .354 = Kilometers Per Liter (Km/L)

Kilometers Per Liter (Km/L) x 2.352 = IMP MPG

Miles Per Gallons US (MPG) x .425 = Kilometers Per Liter (Km/L)

Kilometers Per Liter (Km/L) x 2.352 = US MPG

TEMPERATURE

Degree Fahrenheit (°F) = (°C X 1.8) + 32

Degree Celsius (°C) = (°F - 32) x .56

LIQUID WEIGHTS

Diesel Oil = 1 US gallon = 7.13 lbs

Fresh Water = 1 US gallon = 8.33 lbs

Gasoline = 1 US gallon = 6.1 lbs

Salt Water = 1 US gallon = 8.56 lbs

DECIMAL TO METRIC EQUIVALENT CHART

Fractions of an inch	Decimal (in.)	Metric (mm)	Fractions of an inch	Decimal (in.)	Metric (mm)
1/64	0.015625	0.39688	33/64	0.515625	13.09687
1/32	0.03125	0.79375	17/32	0.53125	13.49375
3/64	0.046875	1.19062	35/64	0.546875	13.89062
1/16	0.0625	1.58750	9/16	0.5625	14.28750
5/64	0.078125	1.98437	37/64	0.578125	14.68437
3/32	0.09375	2.38125	19/32	0.59375	15.08125
7/64	0.109375	2.77812	39/64	0.609375	15.47812
1/8	0.125	3.175	5/8	0.625	15.87500
9/64	0.140625	3.57187	41/64	0.640625	16.27187
5/32	0.15625	3.96875	21/32	0.65625	16.66875
11/64	0.171875	4.36562	43/64	0.671875	17.06562
3/16	0.1875	4.76250	11/16	0.6875	17.46250
13/64	0.203125	5.15937	45/64	0.703125	17.85937
7/32	0.21875	5.55625	23/32	0.71875	18.25625
15/64	0.234375	5.95312	47/64	0.734375	18.65312
1/4	0.250	6.35000	3/4	0.750	19.05000
17/64	0.265625	6.74687	49/64	0.765625	19.44687
9/32	0.28125	7.14375	25/32	0.78125	19.84375
19/64	0.296875	7.54062	51/64	0.796875	20.24062
5/16	0.3125	7.93750	13/16	0.8125	20.63750
21/64	0.328125	8.33437	53/64	0.828125	21.03437
11/32	0.34375	8.73125	27/32	0.84375	21.43125
23/64	0.359375	9.12812	55/64	0.859375	21.82812
3/8	0.375	9.52500	7/8	0.875	22.22500
25/64	0.390625	9.92187	57/64	0.890625	22.62187
13/32	0.40625	10.31875	29/32	0.90625	23.01875
27/64	0.421875	10.71562	59/64	0.921875	23.41562
7/16	0.4375	11.11250	15/16	0.9375	23.81250
29/64	0.453125	11.50937	61/64	0.953125	24.20937
15/32	0.46875	11.90625	31/32	0.96875	24.60625
31/64	0.484375	12.30312	63/64	0.984375	25.00312
1/2	0.500	12.70000	1	1.00	25.40000

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