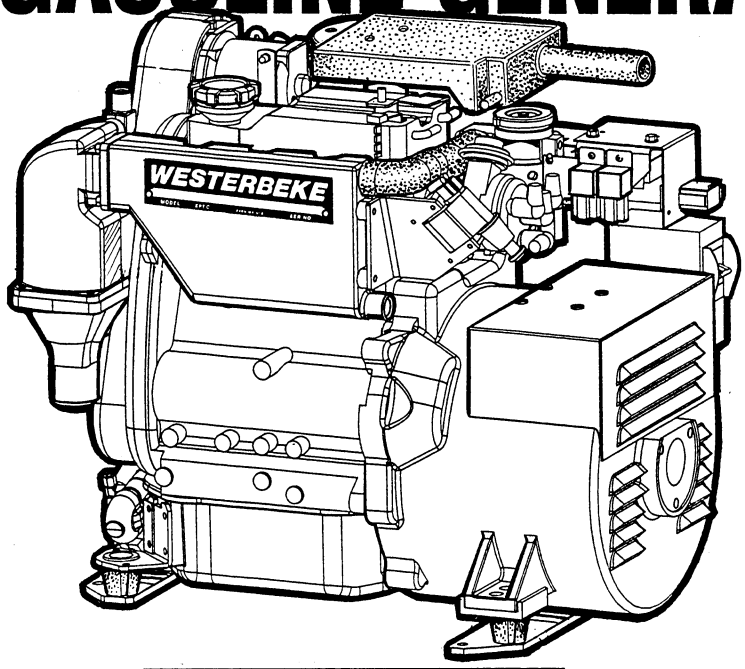
SERVICE MANUAL

BCGB GASOLINE GENERATORS



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WESTERBEKE

WESTERBEKE CORPORATION • 150 JOHN HANCOCK ROAD
MYLES STANDISH INDUSTRIAL PARK • TAUNTON MA 02780
WEBSITE: WWW.WESTERBEKE.COM

Gasoline with an ETHANOL content higher than 10% (E10) is not allowed and may void warranty.

WESTERBEKE™

Engines & Generators

⚠ 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.

This 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.

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 vessel's AC circuits, except through a ship-to-shore double throw transfer switch. Damage to vessel's 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 with a Coast Guard Approved flame arrester removed. 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 vessel's 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 are securely attached and no warping exists. Pay close attention to the manifold, water injection elbow, and exhaust pipe nipple.
- Be sure the unit and its surroundings are well ventilated.
- In addition to routine inspection of the exhaust system, install a carbon monoxide detector. 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

  Dizziness

  Throbbing in temples

  Muscular twitching

  Intense headache

  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 belt's 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.

ENGINE 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
15 East 26th Street
New York, NY 10010

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

Order from:

National Fire Protection Association
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 UNIVERSAL 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.*

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 40 page Marine Installation Manual covering gasoline and diesel, engines and generators, is available from your UNIVERSAL dealer.

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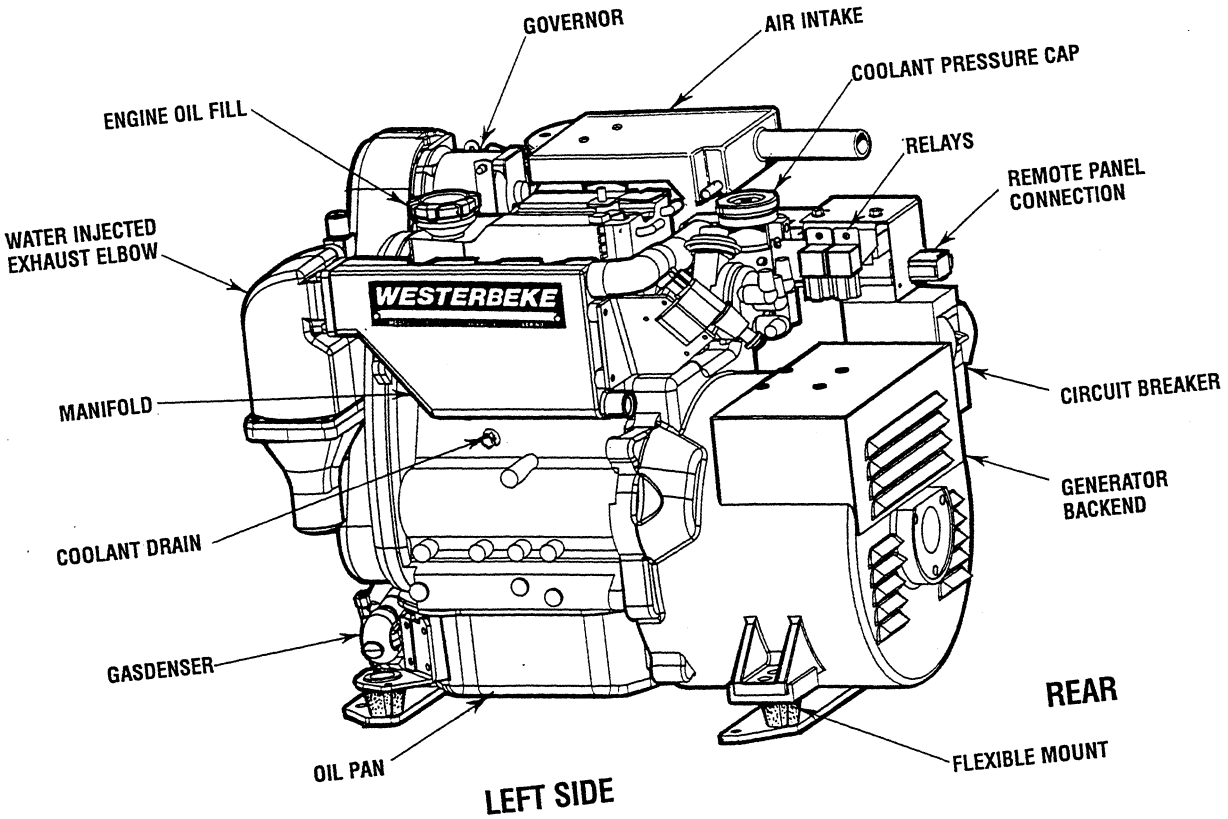
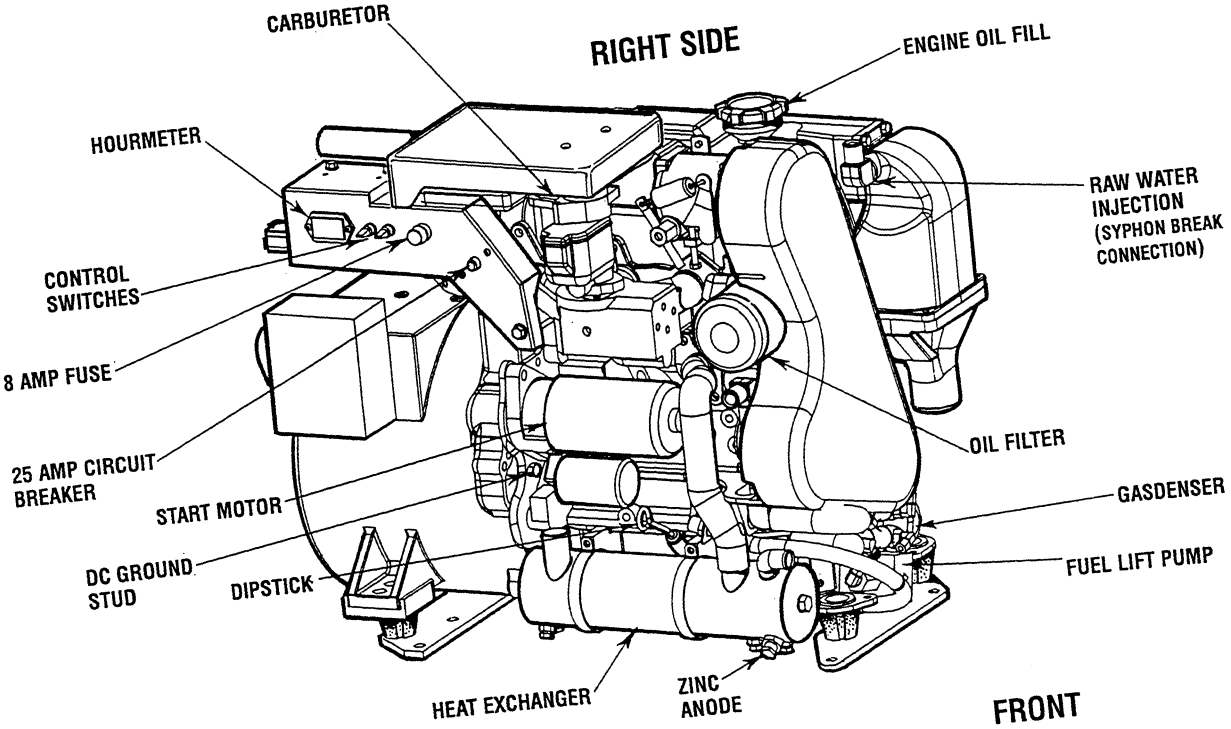
BCGB PARTS IDENTIFICATION





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. *Engine compression should be 178 psi (1260 Kpa) at 400 rpm. With a limit 137 psi (860 Kpa). Pressure should not differ by more than 14 psi (100 Kpa) between cylinders. See ENGINE COMPRESSION in this manual.*

ENGINE OVERHAUL

The following sections contain detailed information relating to the major components and systems of the engine. Included are disassembly and inspection instructions for the guidance of suitable equipped and staffed marine engine service and rebuilding facilities. The necessary procedures should be undertaken only by such facilities.

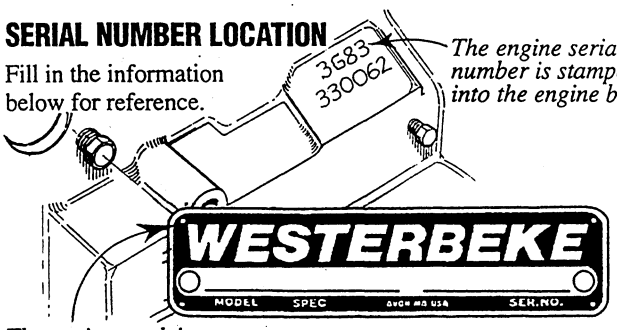
Additional detailed information and specifications are provided in other sections of this manual, covering the generator, alternator, starter motor, engine adjustments, cooling pumps, etc.

DISASSEMBLY

1. Before disassembly and cleaning, carefully check for defects which cannot be found after disassembly and cleaning.
2. Clean the engine exterior.
3. 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.

SERIAL NUMBER LOCATION

Fill in the information below for reference.



The engine serial number is stamped into the engine block.

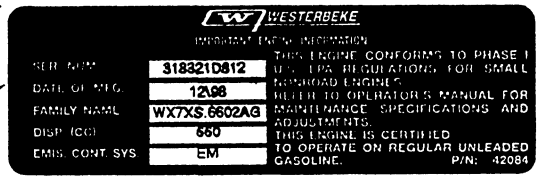
The engine model number and serial number are printed on a decal on the engine manifold.

The generator serial number is stamped on the top of the generator housing.

The generator specifications are printed on a decal on the side of the generator.

SPECIFICATION	50 HZ.	60 HZ.
MODEL		
RPM		
KW		
KVA		
VOLTS		
AMPS		
ENG. HP		
ENG. SER. NO.		
GEN. SER. NO.		
PF/PHASE	/	
WIRES		
RATING		
INSUL. CLASS		
TEMP. RISE		
BATTERY		
C.I.D.		

An additional decal is located on the top of the generator housing.



TESTING OIL PRESSURE / ENGINE COMPRESSION

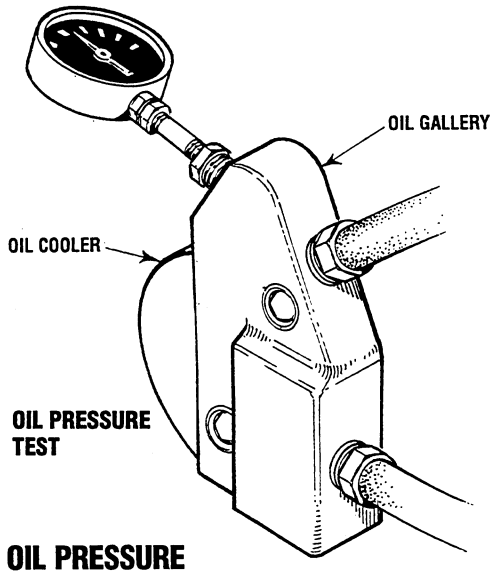
NOTE: *WESTERBEKE recommends that the following engine adjustments be performed by a competent engine mechanic. The information below is provided to assist the mechanic.*

TESTING OIL PRESSURE

To test the oil pressure, remove the hex head plug from the oil manifold and install a mechanical oil pressure gauge in its place. After warming up the engine, set the engine speed at 1800 rpm and read the oil pressure gauge.

Oil Pressure **Between 30 and 40 psi at 1800/1500 rpm.**

Note: *A newly started (cold) engine may have an oil pressure up to 70 or 80 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.*



LOW OIL PRESSURE

The specified safe minimum oil pressure is 4.3 + 1.4 psi (0.3 + 0.1 kg/cm^2). A gradual loss of oil pressure usually indicates worn bearings.

ENGINE COMPRESSION TEST

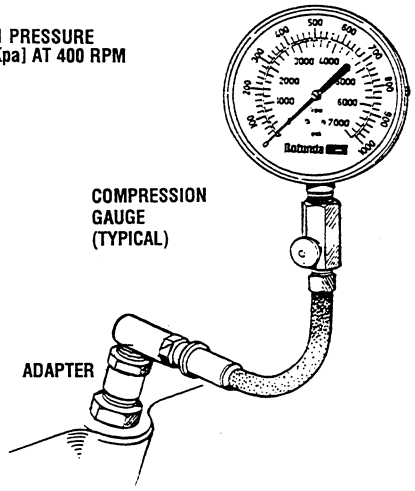
1. To check the engine's compression pressure, warm up the engine then shut it down.
2. Remove the three spark plug caps and remove the three spark plugs.
3. Install a compression adapter and gauge in the spark plug hole.
4. Close off the raw water intake seacock.
5. Crank the engine with the start motor and unplug the ignition coil and allow the compression gauge to reach a maximum reading and record.
6. Measure the compression pressure for all the cylinders. Ensure that compression pressure differential for each cylinder is within the specified unit.

   Compression pressure should not differ by more than 14 psi (100 Kpa).
7. If a cylinder's compression or pressure differential is below the limit, add a small amount of engine oil through the spark plug hole and repeat steps 4 and 5.

   (a) If additional of oil causes an increase of pressure, the piston ring and/or cylinder wall may be worn or damaged.

   (b) If additional oil does not increase compression pressure suspect poor valve contact, valve seizure, or valve wear.
8. Reinstall three plugs and ignition wires.
9. **Open the raw water thru seacock.**

COMPRESSION PRESSURE
178 PSI [1260Kpa] AT 400 RPM



BCGB GENERATOR TROUBLESHOOTING

The following troubleshooting chart describes certain problems relating to engine service, the probable causes of these problems, and the recommendations to overcome these problems.

This chart may be of assistance in determining the need for an engine overhaul. For back-end troubleshoting, refer to the *BC GENERATOR ELECTRICAL TESTING* section in this manual.

Problem	Probable Cause	Verification/Remedy
HARD STARTING OR FAILURE TO START	1. High exhaust pressure. 2. Timing belt. 3. AC generator overload. 4. Check valve at fuel supply. 5. Defective starter. 6. Faulty fuel regulator. 7. Raw water in cylinders.	1. Install a larger diameter exhaust. 2. Inspect timing belt-replace. 3. Remove loads before starting. 4. Repair or replace.. 5. Repair or replace starter. 6. Replace regulator. 7. Failure of exhaust system or syphon break. Clear cylinders-Engine may need overhaul.
SMOKY EXHAUST	**WHITISH , PURPLE OR BLUE SMOKE** 1. Excessive engine oil. 2. Excessive rise of oil into combustion chamber. a. Poor piston contact. b. Seized piston ring. c. Excessive piston-to-cylinder clearance. d. Worn valve stem and valve guide. e. Low engine oil viscosity. f. Excessive oil pressure. g. Piston rings are worn or unseated. 3. Insufficient compression.	 1. Correct oil level. 2. Engine overhaul. a. Check standard. b. Replace or clean. c. Replace or correct. d. Replace. e. Replace. f. Correct. g. Engine overhaul. 3. See *LOW COMPRESSION; HARD STARTING.*
	BLACKISH OR DARK GRAY 1. Poor compression. 2. Improper valve clearance. 3. Insufficient intake air (air cleaner clogged). 4. Improper fuel.	 1. See *LOW COMPRESSION.* 2. Valve adjustment. 3. Replace air cleaner. 4. Replace with proper fuel.
EXCESSIVE OIL CONSUMPTION	**OIL LEAKAGE** 1. Defective oil seals. 2. Broken gear case gasket. 3. Loose gear case attaching bolts. 4. Loose drain plug. 5. Loose oil pipe connector. 6. Broken rocker cover gasket. 7. Loose rocker cover attaching bolts.	 1. Replace oil seals. 2. Replace gasket. 3. Retighten bolts. 4. Retighten plug. 5. Retighten oil connections. 6. Replace gasket. 7. Retighten attaching bolts.
	OIL LEVEL RISING 1. Dead cylinder. 2. Displaced or twisted connecting rod. 3. Worn piston ring.	 1. Check compression. 2. Replace connecting rod. 3. Replace ring.
ENGINE BACKFIRES, MISFIRES	1. Incorrect valve clearances. 2. Valves are out of adjustment.	1. Adjust valves and clearances. 2. Adjust valves and clearances.

BCGB ENGINE TROUBLESHOOTING

PROBLEM	PROBABLE CAUSE	VERIFICATION/REMEDY
ABNORMAL SOUND OR NOISE	**CRANKSHAFT AND MAIN BEARING**	
	1. Badly worn bearing.	1. Replace bearing and grind crankshaft.
	2. Badly worn crankshaft.	2. Grind crankshaft.
	3. Melted bearing.	3. Replace bearing and check lubrication system.
	CONNECTING ROD AND CONNECTING ROD BEARING	
	1. Worn connecting rod big end bearing.	1. Replace bearing.
	2. Worn crankpin.	2. Grind crankshaft.
	3. Bent connecting rod.	3. Correct bend or replace.
	PISTON, PISTON PIN, AND PISTON RING	
	1. Worn cylinder.	1. Rebore cylinder to oversize and replace piston.
	2. Worn piston pin.	2. Replace piston.
	3. Piston seized.	3. Replace piston and rebore cylinder.
	4. Piston seized and ring worn or damaged.	4. Replace piston and rings.
	VALVE MECHANISM	
	1. Worn camshaft.	1. Replace.
	2. Excessive valve clearance.	2. Adjust.
	3. Worn timing gear.	3. Replace.
	4. Worn fan pulley bearing.	4. Replace.
LOW COMPRESSION	**MAIN ENGINE TROUBLES**	
	1. Incorrect valve clearance.	1. Adjust valve clearance.
	2. Inadequate contact of valve seat.	2. Lap valve.
	3. Valve stem seized.	3. Replace valve and valve guide.
	4. Broken valve spring.	4. Replace valve spring.
	5. Compression leaks through cylinder head gasket.	5. Replace gasket.
	6. Piston ring seized.	6. Replace piston and piston ring.
	7. Worn piston ring and cylinder,	7. Overhaul engine.
	8. Worn engine bearings.	8. Overhaul engine.
EXCESSIVE FUEL CONSUMPTION	1. Noisy knocking.	1. See *KNOCKING.*
	2. Smoky exhaust.	2. See *SMOKY EXHAUST.*
	3. Moving parts nearly seized or excessively worn.	3. Repair or replace.
	4. Poor compression.	4. See *LOW COMPRESSION; HARD STARTING.*
	5. Improper valve timing.	5. Adjust.
	6. Improper valve clearance.	6. Adjust.
	INSUFFICIENT INTAKE AIR	
	1. Air intake obstructed.	1. Remove obstruction.
	NOZZLE TROUBLES	
	1. Seized nozzle.	1. Replace.
	2. Worn nozzle.	2. Replace.
KNOCKING	**ENGINE KNOCKS WITHOUT MUCH SMOKE**	
	1. Main engine troubles.	
	a. Overheated cylinder.	a. See *OVERHEATING; LOW OUTPUT.*
	b. Carbon deposits in cylinder.	b. Clean.
	KNOCKING WITH DARK SMOKE	
	1. Poor compression.	1. See *LOW COMPRESSION; HARD STARTING.*
LOW OIL PRESSURE	1. Worn Bearings.	1. Engine overhaul replace bearings.
	2. Relief valve malfunction.	2. Overhaul oil pump.
	3. Clogged oil cooler/filter.	3. Repair and replace.
	4. Diesel dilution of the oil.	4. Injection pump repair.

ENGINE ASSEMBLY

GENERAL INFORMATION

- Be careful not to mix bolts and nuts. Metric and S.A.E. bolts are used on various engine assemblies.
- During assembly, recheck clearances and insure that parts are being assembled in their proper order and facing in the correct direction in relation to the engine block, such as, pistons, piston rings, bearings and bearing caps.
- Apply lubricating oil to moving parts during assembly. Insure that moving parts, when assembled on the engine, rotate or slide and are not subject to binding or excessive tension.
- If there are mating marks scribed during disassembly, reference them correctly for assembly.
- Use new gaskets, lockwashers, O-rings, packings and seals.
- Tighten the bolts and nuts on important parts of the engine to specified torques using a reliable torque wrench.
- When required, use liquid sealants when required on nuts, bolts and gaskets. Refrain from using tape sealants.
- Most gaskets and many bolt washers are asymmetrical, make certain they are positioned properly.

Torquing Hardware

Prevent mechanical damage by running fasteners down in three steps-1/2, 2/3, and 1/1 torque. Exceptions are torque-to-yield bolts and rocker arm shaft fasteners. The former are torqued as indicated. The latter-rocker shaft fasteners-should be brought down in very small increments, working from the center bolts out. Gaskets, especially head gaskets, might be damaged during assembly, they should be positioned with great care. See *TORQUE SPECIFICATIONS* thru out this manual.

Sealants and Lubricants

Oil based PERMATEX #2 and its HIGH TACK equivalent are excellent all purpose sealers. They are effective in just about any joint in contact with coolant, raw water, oil, or fuel. A light coating of oil or LIQUID TEFLON can be used on rubber gaskets and o-rings.

LOCTITE hydraulic red sealant should be used on oil adapter hoses and the oil filter assembly.

Coat both surfaces of the oil pan gasket with high temp RED SILICONE SEALER.

When installing gaskets that seal around water (coolant) passages, coat both sides with WHITE SILICONE GREASE.

Do not use sealant when installing a new gasket.

HIGH-COPPER ADHESIVE SPRAYS are useful for holding a gasket in position during assembly.

Specialized gasket sealers such as HYLOMAR work well in applications requiring non-hardening properties. HYLOMAR is particularly effective on copper cylinder-head gaskets and resists fuel, oil , and water.

NOTE: *TAPE SEALANTS should be used on pipe plugs and fitting that connect water coolant passages.*

Bolts and Fasteners

Lightly oil head bolts and other fasteners as you assemble them. Bolts and other plugs that penetrate the water jacket should be sealed with PERMATEX #2 or HIGH TACK.

When assembling the flywheel, coat the bolt threads with LOCTITE blue.

LITHIUM based grease is waterproof, ideal for water pump bearings and stuffing boxes.

Antiseize compounds and thread locking adhesives such as LOCTITE protect threaded components yet allow them to come apart when necessary. LOCKTITE offers levels of locking according to the job.

Heavily oil all sliding and reciprocating components, always use clean engine oil.

GENERATOR / ENGINE DISASSEMBLY

DESCRIPTION

The engine component of the BCGB generator is not as bulky or heavy as most engines [approv. 75 lbs] so it can be disassembled and repaired on a sturdy work bench. Make certain however that the engine is securely fastened so it can not topple off the bench and that the bench also is secure and can not tip over.

Set the generator breakers and panel switches in the off position. Disconnect the AC wiring connections at the terminal block/circuit breaker and unplug the harness at the control panel. Disconnect the battery cable connections and the engine ground cables.

Close off the raw water seacock and disconnect the raw water components. Separate the exhaust hose at the water injection elbow and disconnect the fuel supply and return lines.

Unfasten the generator from its mounting rails or the mounting rails from the platform and remove the generator from the boat.

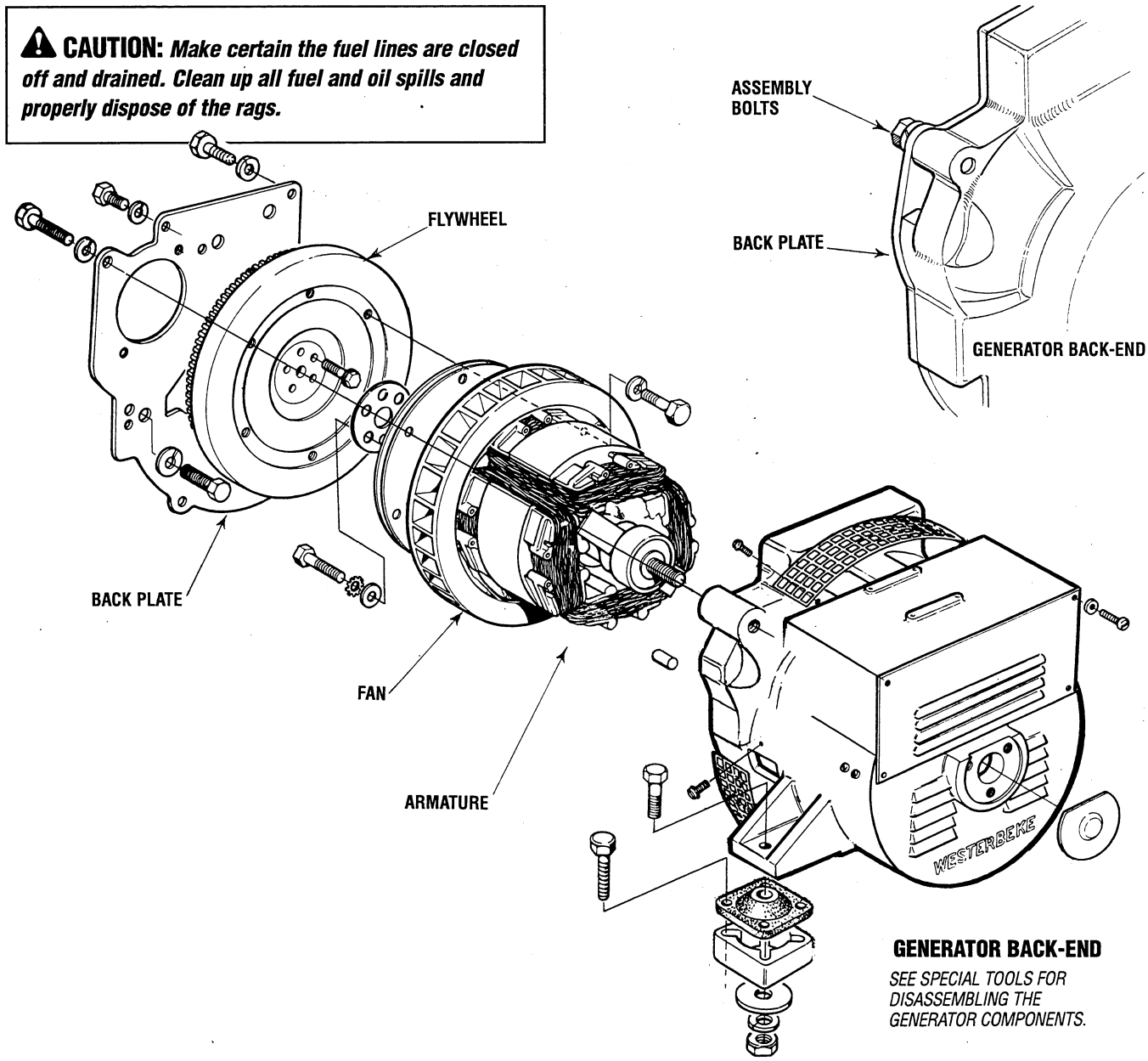
Once the generator is securely mounted on a work bench, drain the engine oil and coolant.

Remove the starter motor. Disconnect and remove the wiring harness, be certain to tag all the wiring connections as you separate them.

Separate the generator back-end from the engine by removing the 3 bolts (one is the engine ground), one stud and one allen flat head that fasten the engine back-plate to the housing. Once the housing is removed, the remaining generator components can be disassembled from the engine back-plate.

NOTE: *For servicing and testing of the back end [generator], refer to the GENERATOR section in this manual.*

> ⚠ **CAUTION:** ***Make certain the fuel lines are closed off and drained. Clean up all fuel and oil spills and properly dispose of the rags.***



GENERATOR BACK-END

SEE SPECIAL TOOLS FOR DISASSEMBLING THE GENERATOR COMPONENTS.

ENGINE DISASSEMBLY

INTRODUCTION

The following text describes the disassembly, inspection, repair, and reassembly of the engine when preforming a complete engine overhaul.

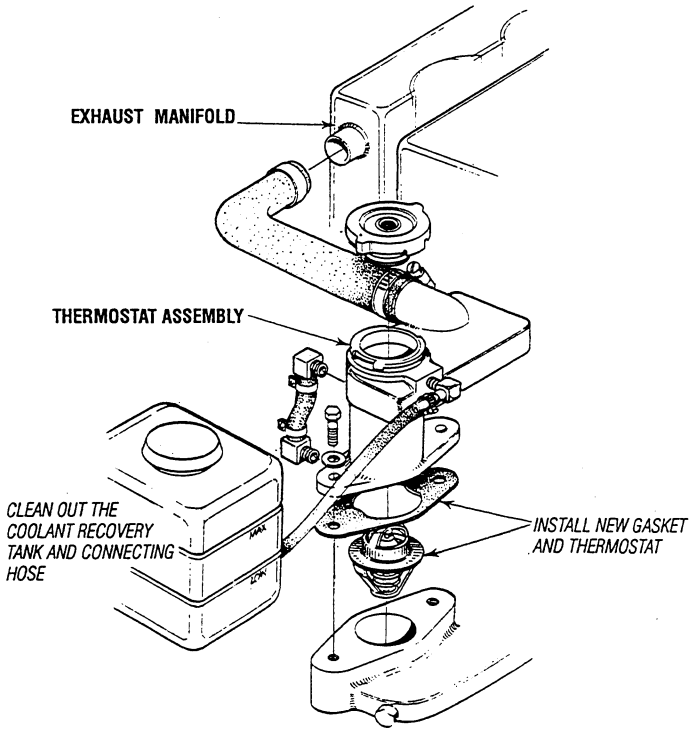
This manual also includes a breakdown of sub assemblies, engine adjustments, generator information and all related technical data.

NOTE: *The cylinder head, rocker arms and valves can be inspected and adjusted with the engine in the boat. Timing belt adjustment and replacement can also be accomplished without removing the engine.*

Suggested Sequence of Disassembly

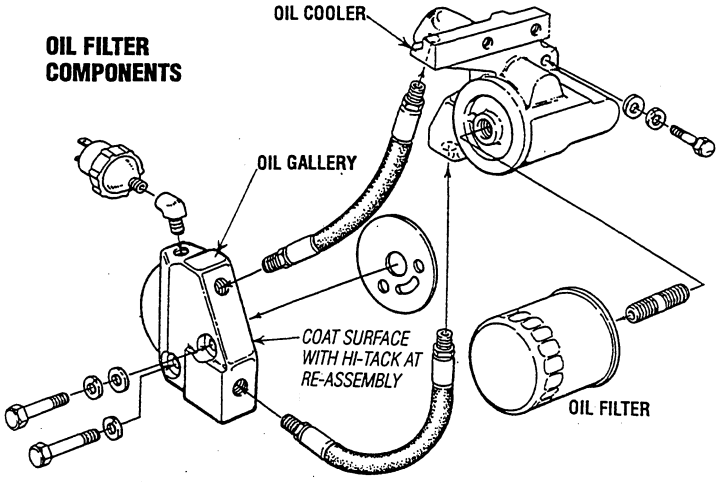
1. Remove the heat exchanger and set it aside for servicing. See *HEAT EXCHANGER* in this manual.
2. Remove the starter motor. The starter motor should be cleaned, inspected, and repainted. Refer to *STARTER MOTOR.*
3. Disconnect the exhaust temperature switch and disassemble the exhaust elbow and manifold from the engine. Set this assembly aside for servicing. Refer to *EXHAUST SYSTEM* in this manual.

   Remove the water temperature switch and sender and disassemble the thermostat assembly.



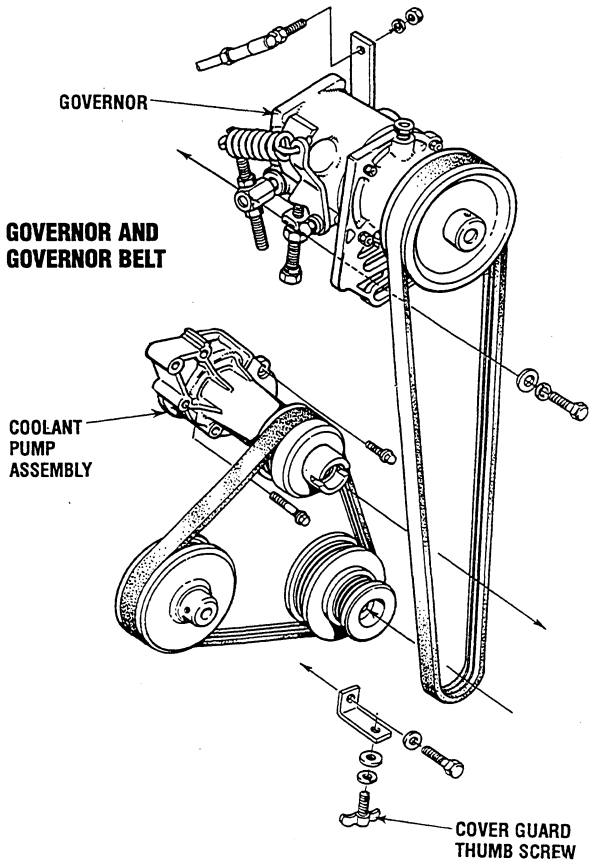
THERMOSTAT ASSEMBLY

5. Disconnect and drain the oil hoses. Remove, clean, and inspect the oil gallery/filter assembly.



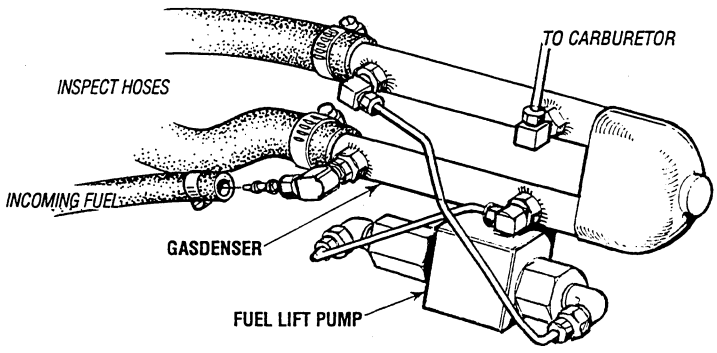
OIL FILTER COMPONENTS

6. Loosen the belt guard thumb screws and remove the belt guard sections and their gaskets.
7. Disconnect the linkage arm between the governor and the carburetor at the ball joint and remove the carburetor. When servicing the carburetor, refer to the *CARBURETOR SECTION* in this manual.
8. Release the governor belt and remove the governor assembly and belt. See *GOVERNOR MAINTENANCE.*



GOVERNOR AND GOVERNOR BELT

9. Remove the gasdenser and the connecting fuel lines from the front of the engine and remove the fuel lift pump.



FUEL LIFT PUMP & GASDENSER

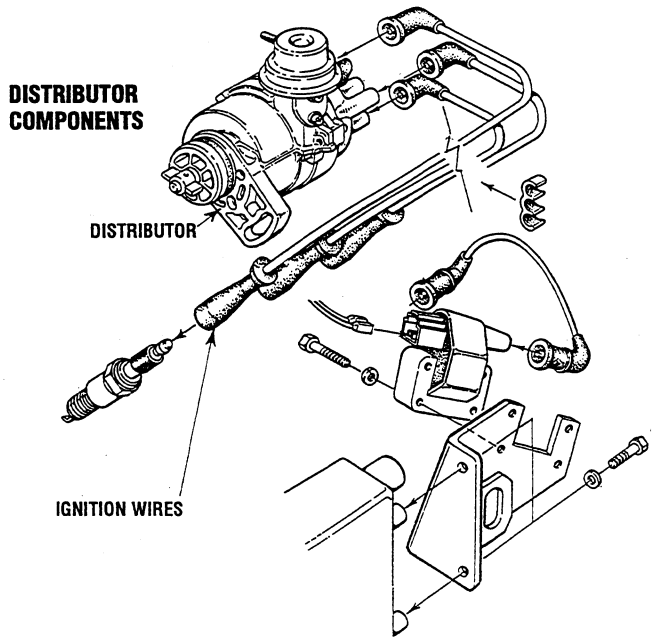
10. Loosen the raw water pump, remove the drive belt and then remove the raw water pump.

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

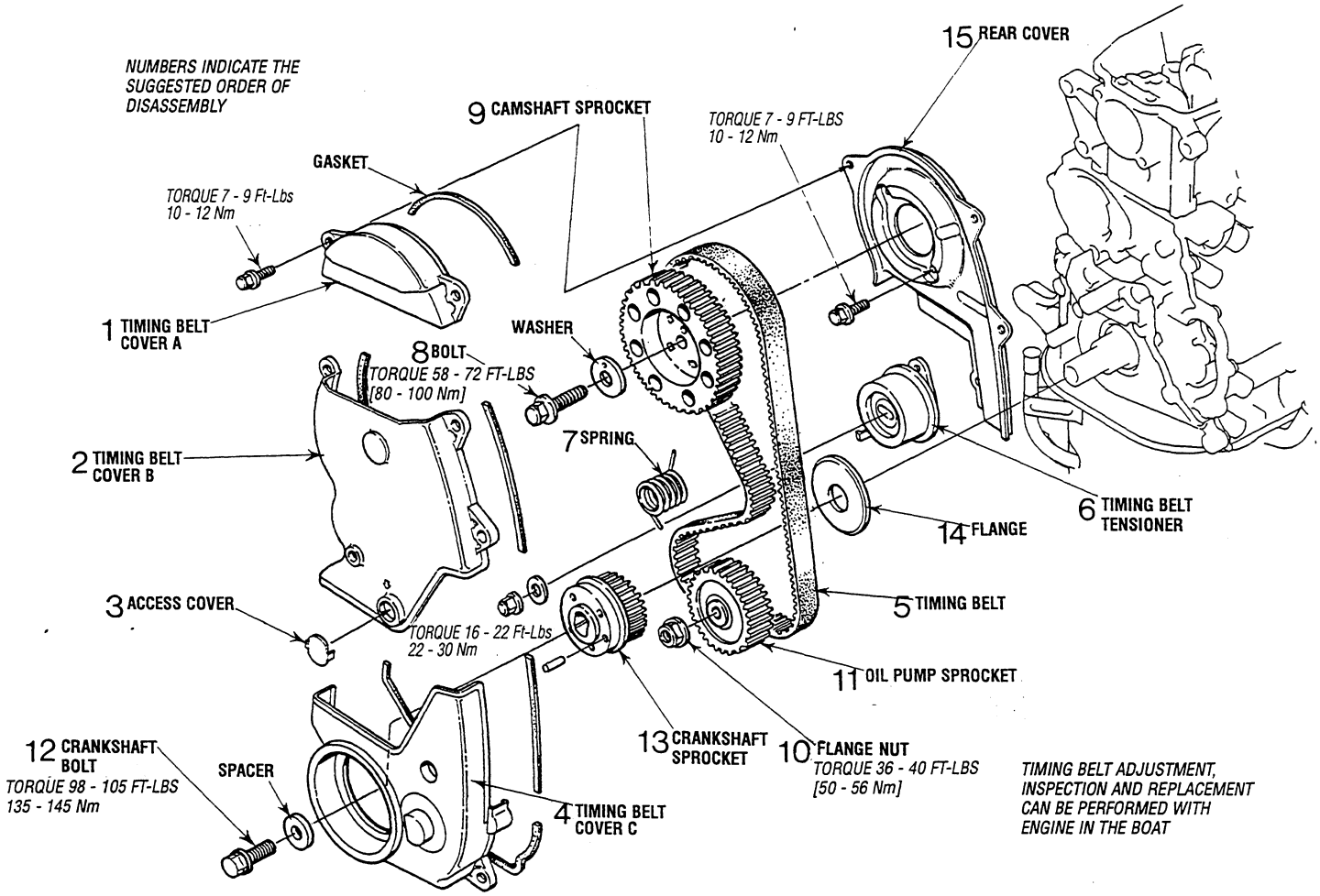
11. Detach and remove the ignition wires, the distributor, and the spark plugs.

Refer to *DISTRIBUTOR DISASSEMBLY* in this manual.

See *ENGINE ADJUSTMENTS* for information on ignition wires and spark plugs.



TIMING BELT DISASSEMBLY



INSTRUCTIONS FOR INSPECTING AND REPLACING THE TIMING BELT

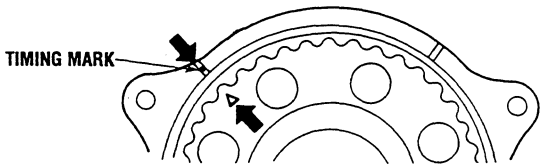
WESTERBEKE requires as normal maintenance, replacing the timing belt after 1000 engine operating hours. The timing belt should always be replaced during an engine overhaul.

The adjustments, inspection, and replacement procedures may be performed without removing the generator from the boat. **THE TIMING BELT PART NUMBER IS #043036**

Timing Belt Removal

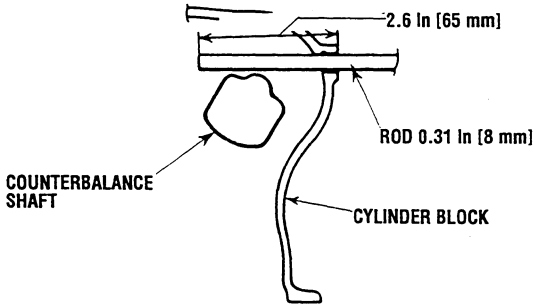
1. Turn the crankshaft clockwise to align the timing mark on the camshaft sprocket and timing belt rear cover.

NOTE: *Always turn the crankshaft clockwise.*

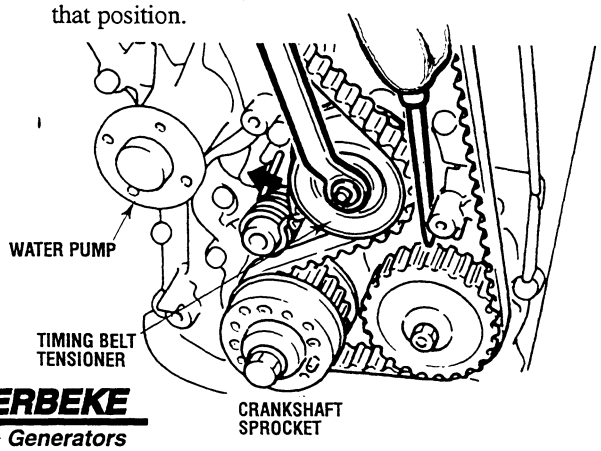


2. Remove the plug on the left surface of the cylinder block and insert a rod with a diameter of 0.31 in (8 mm) to lock the counterbalance shaft.

NOTE: *Be sure to use an inserting rod with a diameter of 0.31 in (8 mm).*



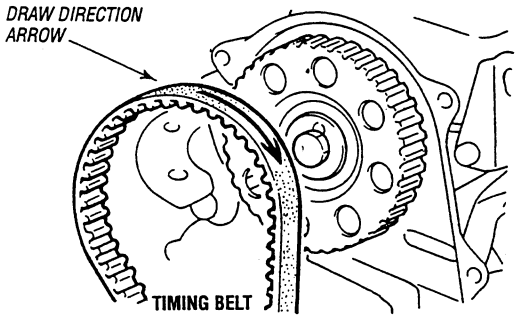
3. Loosen the timing belt tensioner nut.
4. Move the timing belt tensioner toward the water pump, and temporarily tighten the nut to hold the tensioner in that position.



TIMING BELT DISASSEMBLY

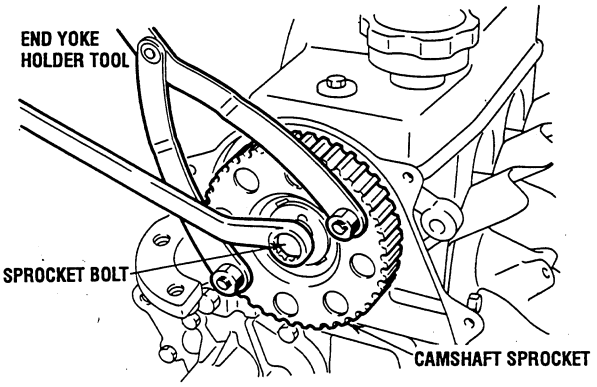
5. Remove the timing belt.

   NOTE: *If the timing belt is to be reused, draw an arrow on the belt to indicate the direction of rotation (clockwise).*



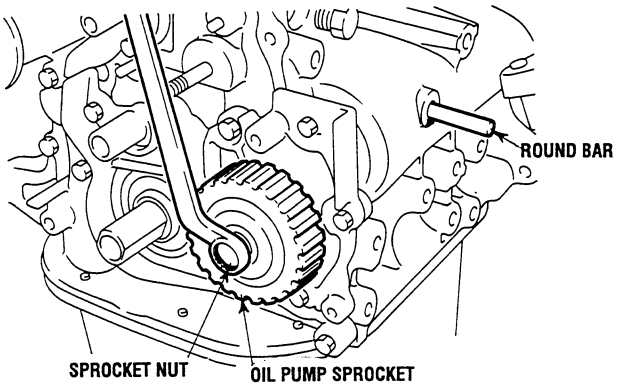
Camshaft Sprocket Removal

1. Remove the camshaft sprocket bolt without turning the camshaft.



Oil Pump Sprocket Flange Nut Removal

1. Remove the plug from the left side of the cylinder block.
2. Insert an 0.31 in (8 mm) diameter round bar to lock the counterbalance shaft.
3. Remove the oil pump sprocket flange nut.



Crankshaft Bolt Removal

1. Lock the crankshaft in position.

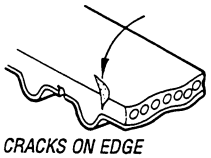
   NOTE: *Do not turn the crankshaft.*

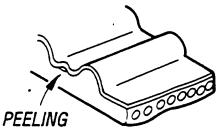
2. Remove the crankshaft bolt.

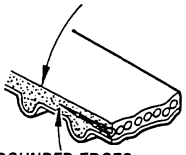
Timing Belt Inspection

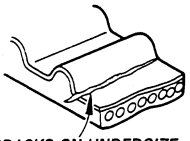
Replace the belt if any of the following conditions exist:

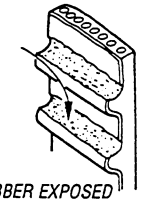
- Hardening of the back rubber, leaves no indent when pressed with fingernail (back side is glossy).
- Cracks on rubber back.
- Cracks or peeling of canvas.
- Cracks on tooth bottom.
- Cracks on belt.
- Abnormal wear of belt sides. The sides are normal if they are sharp as if cut by a knife.
- Abnormal wear on teeth.
- Tooth missing and canvas fiber exposed.

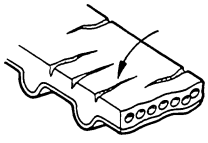












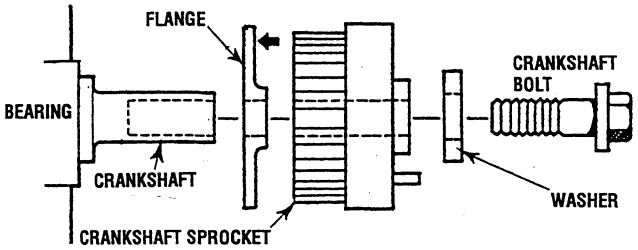
Tensioner Inspection

1. Replace the tensioner if the pulley binds, rattles or is noisy when turned.

ENGINE TIMING BELT

Flange Installation

1. Mount the flange so that its side shown by the heavy arrow in the illustration faces toward the sprocket.



Crankshaft Bolt Installation

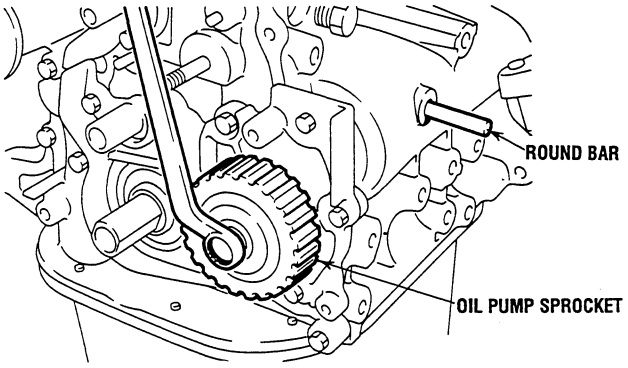
1. Lock the crankshaft.

   NOTE: *Do not turn the crankshaft.*

2. Tighten the crankshaft bolt to the specified torque.

Oil Pump Sprocket Flange Nut Installation

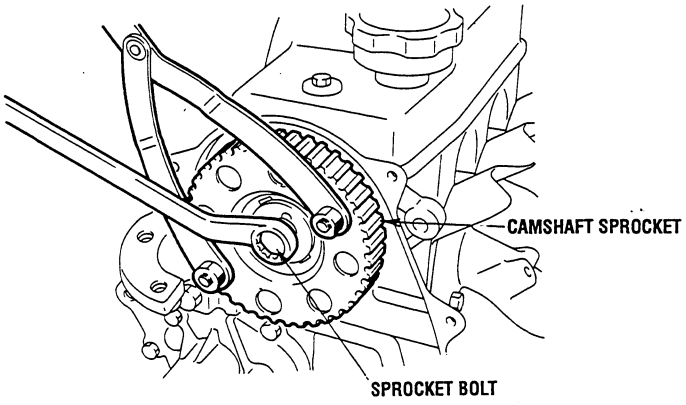
1. Insert the round bar into the plug hole in the left side of the cylinder block to keep the counterbalance shaft from turning.
2. Install the oil pump sprocket.
3. Tighten the nut to the specified torque.



Camshaft Sprocket Bolt Installation

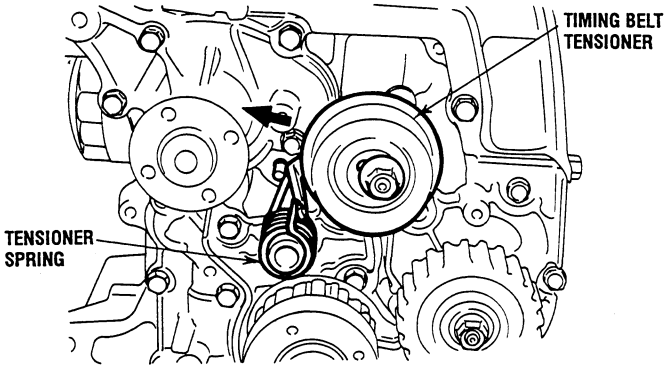
1. Tighten the bolt to the specified torque.

   CAMSHAFT BOLT TORQUE 58 - 72 Ft-lbs (80 -100 Nm)



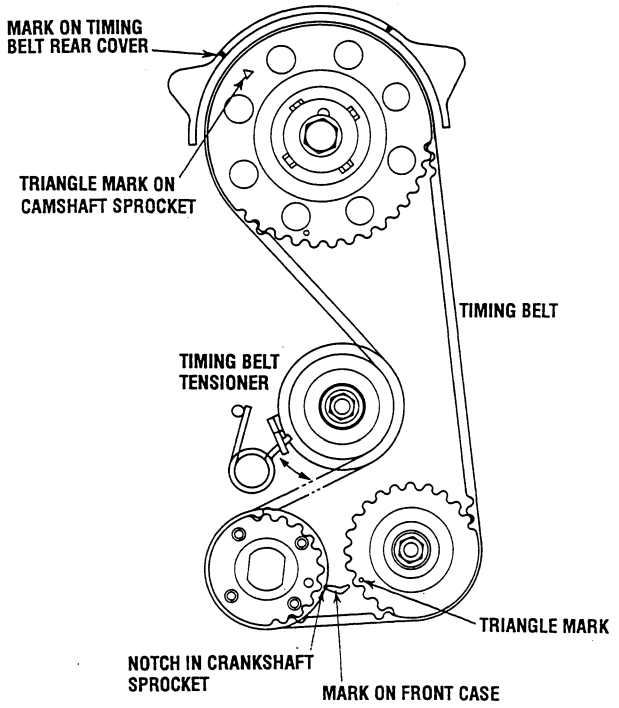
Tensioner Spring/Timing Tensioner Installation

1. Install the tensioner spring and timing belt tensioner.
2. Hook the tensioner spring onto the bend of the timing belt tensioner bracket and the stopper pin on the cylinder block.
3. Move the timing belt tensioner as close as possible to the water pump; temporarily tighten the tensioner nut.



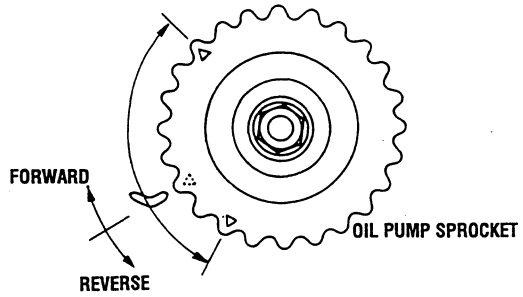
Timing Belt Installation

1. Align the triangular marking on the camshaft sprocket with a marking on the timing belt rear cover.
2. Align the notch in the crankshaft sprocket flange with the marking on the front case.
3. Align the triangular marking on the oil pump sprocket with the marking on the front case, and then insert a 2.56 in. (65 mm.) or longer, 0.31 in (8mm.) diameter round bar into the plug hole in the left side of the cylinder block.



At this time, check that the moveable range of teeth on the oil pump sprocket is according to specifications.

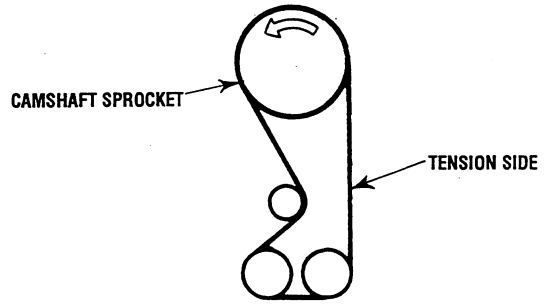
STANDARD VALUE: 4 to 5 teeth in forward direction.
1 to 2 teeth in reverse direction.



4. If the movable range of the teeth on the oil pump sprocket exceeds the specified range, correct as follows:
   a. Pull out the round bar from the plug hole in the left side of the cylinder block.
   b. Turn the oil pump sprocket one turn at a time until the round bar can again be inserted.
   c. Check that the movable range of the oil pump sprocket is in the specified value.
5. Set the timing belt over the crankshaft sprocket and then over the oil pump sprocket and camshaft sprocket, in that order.

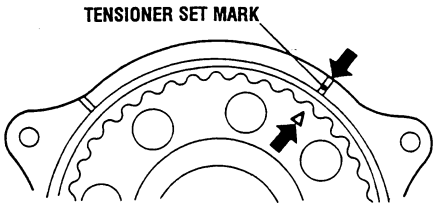
NOTE: *Ensure that the tension side of the timing belt is not slack. Keep the round bar inserted until the timing belt has been placed. After this step, be sure to remove the round bar.*

6. Apply counterclockwise force to the camshaft sprocket to make the belt taut on the tension side, and make sure that all timing marks are lined up.



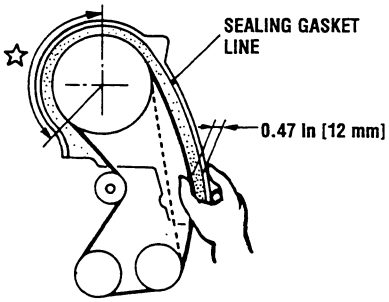
7. Loosen the temperorarily tightened tensioner nut on the water pump side 1 or 2 turns, and tension the belt making use of the spring force.
8. Turn the crankshaft *clockwise* by nine camshaft sprocket teeth (81°) to align the timing mark on the camshaft sprocket with the tensioner set mark on the timing belt rear cover.

> ⚠ **CAUTION:** ***This operation is performed to give a proper tension to the timing belt, so do not turn the crankshaft counterclockwise and push the belt to check the tension.***



9. Make sure that the timing belt teeth are engaged with the camshaft sprocket teeth along the portion of the sprocket shown by the curved arrow in the illustration below. Then tighten the tensioner nut.
10. Pull the timing belt in the center of the tension side toward the sealing gasket line for the belt cover, as illustrated. Make sure that the clearance between the back of the belt and the sealing line is the standard value.

STANDARD VALUE: 0.47in. (12mm)

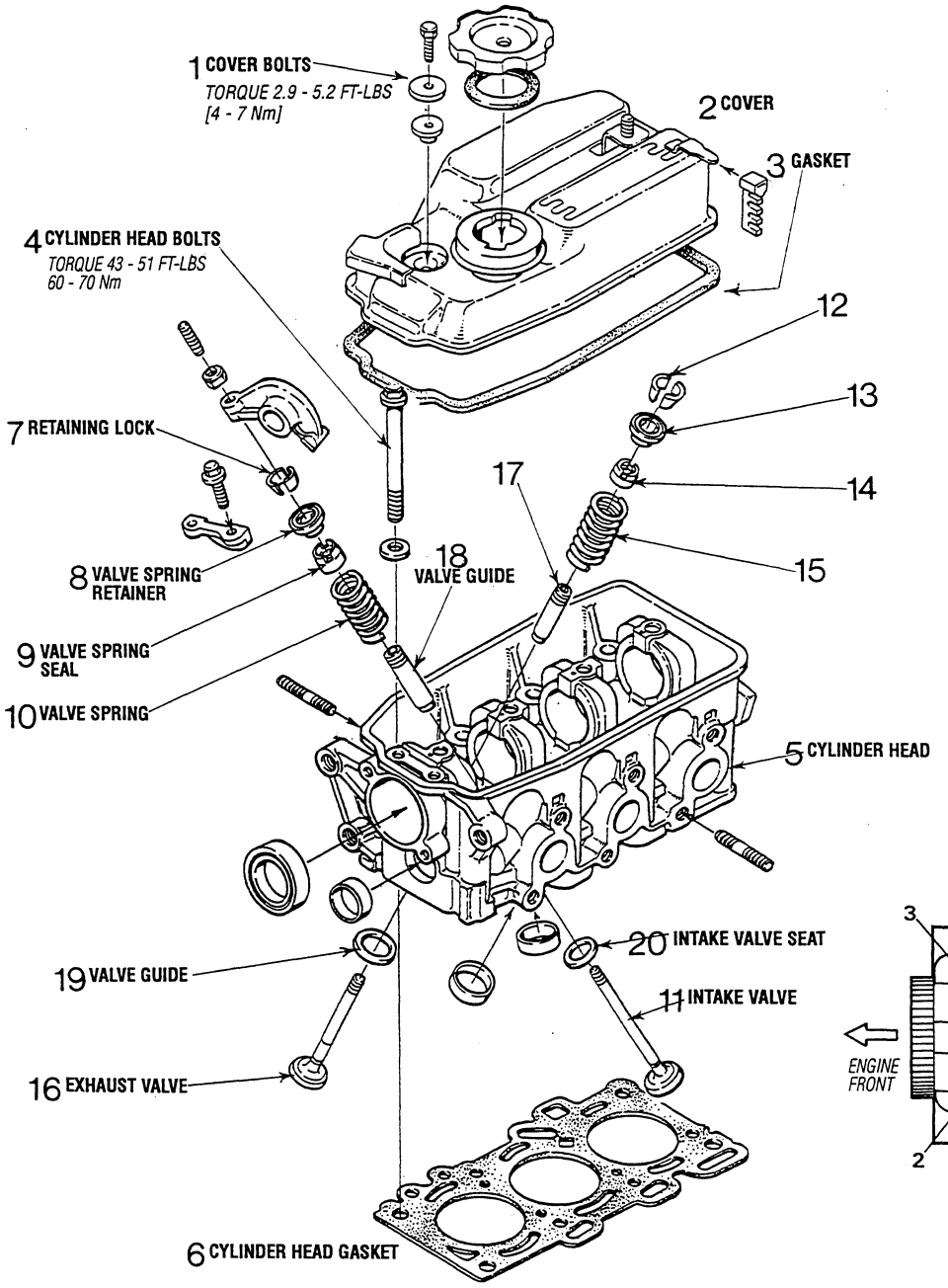


11. Pull out the rod from the plug hole on the left surface of the cylinder block and apply the specified sealant. Then tighten the plug to the specified torque.

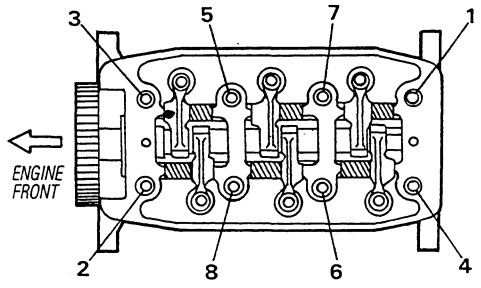
    Specified sealant value: 3M ATD Part No. 8660 or equivalent.

TIGHTENING TORQUE: 11-16 ft.lbs. (15-22 Nm)

CYLINDER HEAD AND VALVES



NUMBERS INDICATE THE SUGGESTED ORDER OF DISASSEMBLY



CYLINDER HEAD BOLTS LOOSENING SEQUENCE

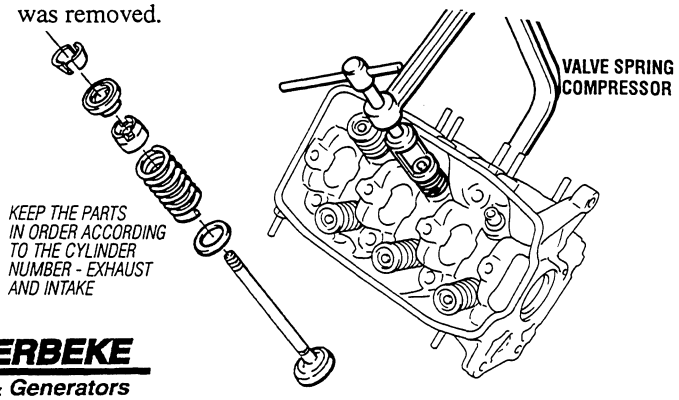
REMOVING THE CYLINDER HEAD FROM THE CYLINDER BLOCK

Disassemble the cover bolts as shown above, taking care not to lose the washer and insert. Remove the rocker cover and rocker cover gasket.

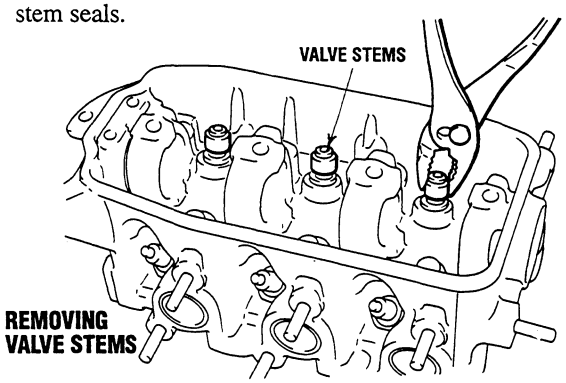
Loosen each of the cylinder head bolts, a little at a time so as to avoid the possibility of distorting the cylinder. Repeat several times until the bolts are unfastened. Follow the sequence shown in the diagram.

Remove the cylinder head and the cylinder head gasket.

Remove the valve retainers, valve springs and valves from the cylinder head. When removing each valve retainer, depressing the retainer against the valve spring and remove the retainer lock. Identify each valve by putting a mark indicating the number of the cylinder from which the valve was removed.



Use pliers to remove the valve stem seals. Do not reuse the stem seals.

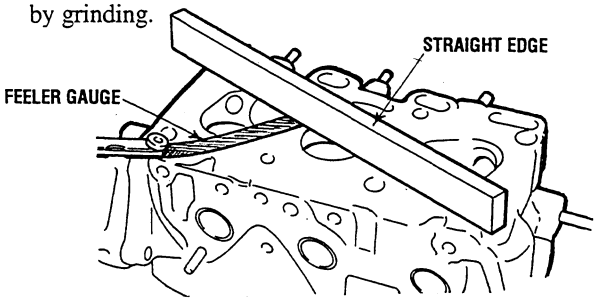


CYLINDER HEAD INSPECTION

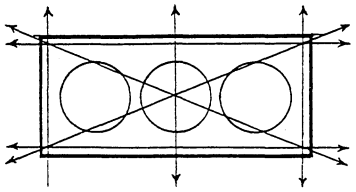
Before cleaning check the cylinder head for water leaks, cracks and other possible damage.

Clean by completely removing the oil, scaling, carbon and sealant. After flushing the oil passage, blow air thru to ensure that no portion of the oil passage is clogged.

To check the cylinder head bottom surface for flatness and distortion, as indicated in the diagram, use a straight edge and a feeler gauge. If distortion exceeds the limit correct by grinding.



CHECKING CYLINDER HEAD FLATNESS



CYLINDER HEAD FLATNESS

Standard 0.020in (0.05mm) Limit 0.079 (0.2mm)

CYLINDER HEAD GRINDING LIMIT

0.079in (0.2mm)

Total resurfacing depth of cylinder head and block

CYLINDER HEAD HEIGHT (NEW)

4.287 - 4.295in (108.9 - 109.1mm)

> ⚠ **CAUTION:** ***No more than 0.079in (0.2mm) of stock may be removed from the cylinder head and cylinder block mating surfaces in total.***

See the *STANDARDS AND LIMITS CHART* for cylinder head rework dimensions of the valve seat hole.

VALVE ASSEMBLY INSPECTION

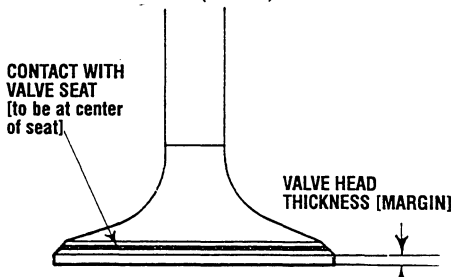
Valve Stem/Valve Seat

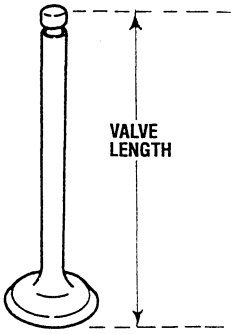
If the valve stem is bent or worn, replace the valve. Check contact between the valve and valve seat by applying a thin coat of Prussion Blue (or Redhead) on the valve seat contact face, then insert the valve into the valve guide and press-fit the valve on the valve seat. Do not rotate the valve.

Check if the valve seat contact face contacts the center position of the valve contact face. If it is not correct concentric, correct the valve seat. If the margin is out of the limit, replace the valve.

THICKNESS OF VALVE HEAD MARGIN

	Standard	Limit
Intake	0.039in (1.0mm)	0.020in (0.508mm)
Exhaust	0.051in (1.3mm)	0.031in (0.787mm)





VALVE LENGTH: Intake 3.60in (100.6mm)
Exhaust 3.968in (100.8mm)

VALVE SEAT WIDTH OF CONTACT

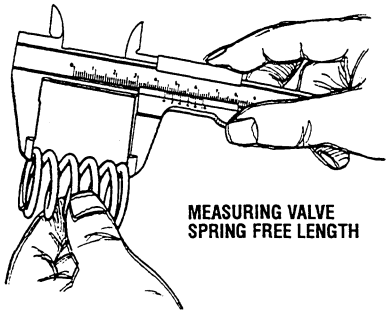
Standard 0.035in - 0.051 (0.9 - 1.3mm)

Valve Spring

Measure the free height of the valve spring and replace the spring if it is out of limit.

VALVE SPRING FREE LENGTH

Standard 1.823in (46.3mm)_____Limit 1.783in (45.3 mm)

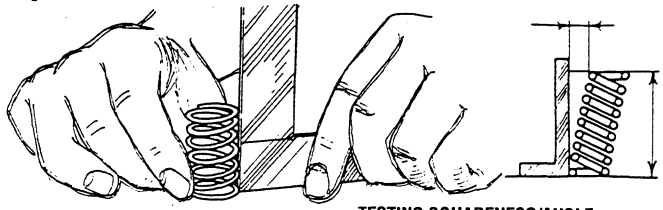


Also check the spring for squareness and if it exceeds the limit replace the spring.

VALVE SPRING SQUARENESS

Standard less than 2°_____Limit 4°

Refer to the Standards/Limits chart for additional specifications on valves.

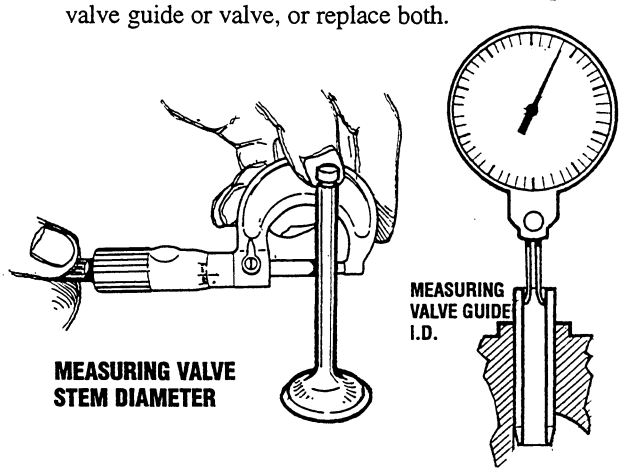


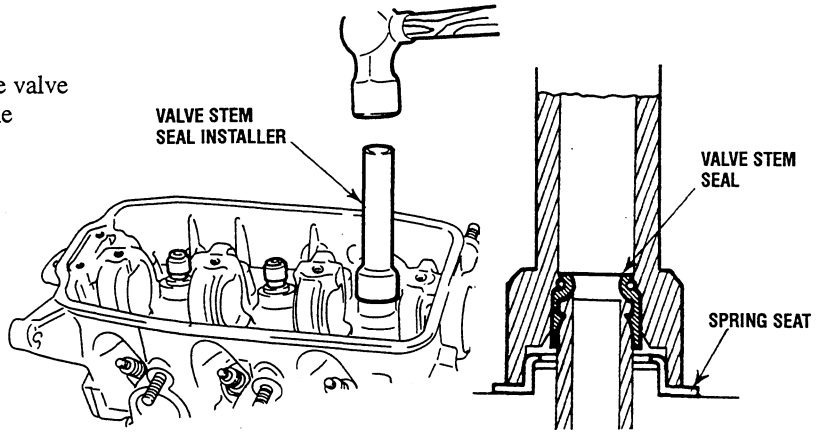
TESTING SQUARENESS/ANGLE

CYLINDER HEAD AND VALVES

Valve Stem and Guides

Measure the clearance between the valve guide and the valve stem and , if the clearance exceeds the limit, replace the valve guide or valve, or replace both.





VALVE STEM SEAL TO VALVE GUIDE CLEARANCE

Standard	Intake	0.0008 - 0.0020in (0.7 - 0.05mm)
	Exhaust	0.020 - 0.0033in (0.50 - 0.085mm)
Limit	Intake	0.0039in (0.10mm)
	Exhaust	0.0059in (0.15mm)

VALVE STEM OUTER DIAMETER

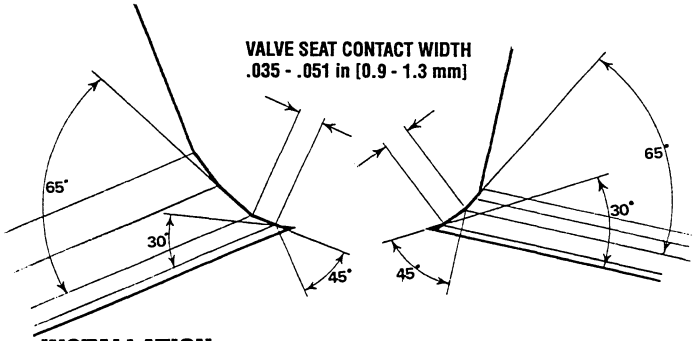
Standard	Intake	0.2585 - 0.2591in (6.565 - 6.580mm)
	Exhaust	0.2571 - 0.2579in (6.330 - 6.550mm)

Valve Seat Reconditioning

Before correcting the valve seat, check for clearance between the valve guide and the valve. replace the valve guide if necessary.

To recondition, use a valve and seat cutter and a pilot or a seat grinder, repair so that the seat width and seat angle are the specified configuration.

After correction, the valve and the valve seat should be lapped with lapping compound.



INSTALLATION

Valve Stem Seal

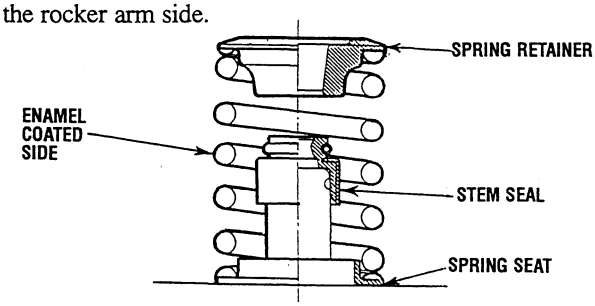
Install the valve spring seat, then using the valve stem seal installer, install a new stem seal to the valve guide.

Do not use the old valve stem seal.

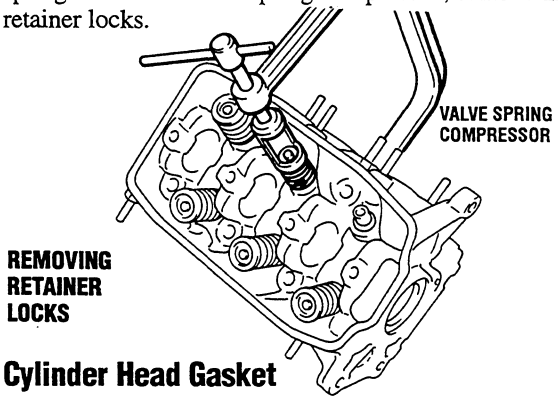
NOTE: *Use the installer tool to insert the stem seal, improper installation can cause oil to leak into the cylinder.*

Valve Springs

Install the valve spring with it's enamel coated side toward the rocker arm side.



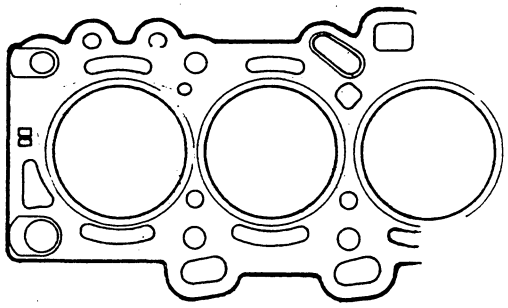
Use the valve spring compressor to compress the valve springs. With the valve spring compressed, remove the retainer locks.



Cylinder Head Gasket

Clean the residue of gasket and oil from the gasket mounting surface of the cylinder block and the cylinder head.

Place a new cylinder head gasket on the cylinder block facing its identification mark upward.



CYLINDER HEAD GASKET

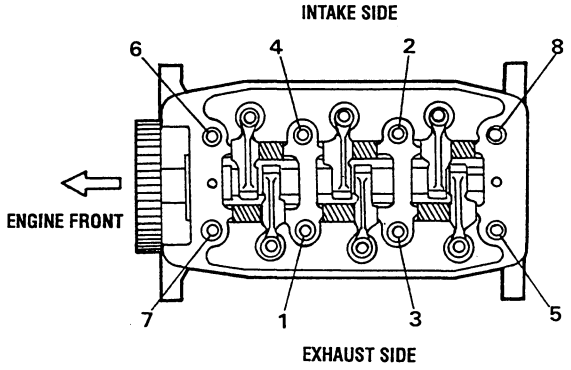
CYLINDER HEAD AND VALVES

Cylinder Head Bolts

Tighten the cylinder head bolts in the order shown in the diagram using a stepped-up tightening torque.

1. Temporarily tighten the bolts in numerical order to 14 - 22ft-lbs (20 - 30 Nm).
2. Tighten the bolts again in numerical order to 29 - 36ft-lbs (40 - 50Nm).
3. Tighten the bolts in numerical order to the specified torque.

CYLINDER HEAD TORQUE 43 -51ft-lbs (60 - 70Nm)



CYLINDER HEAD BOLTS TIGHTENING SEQUENCE

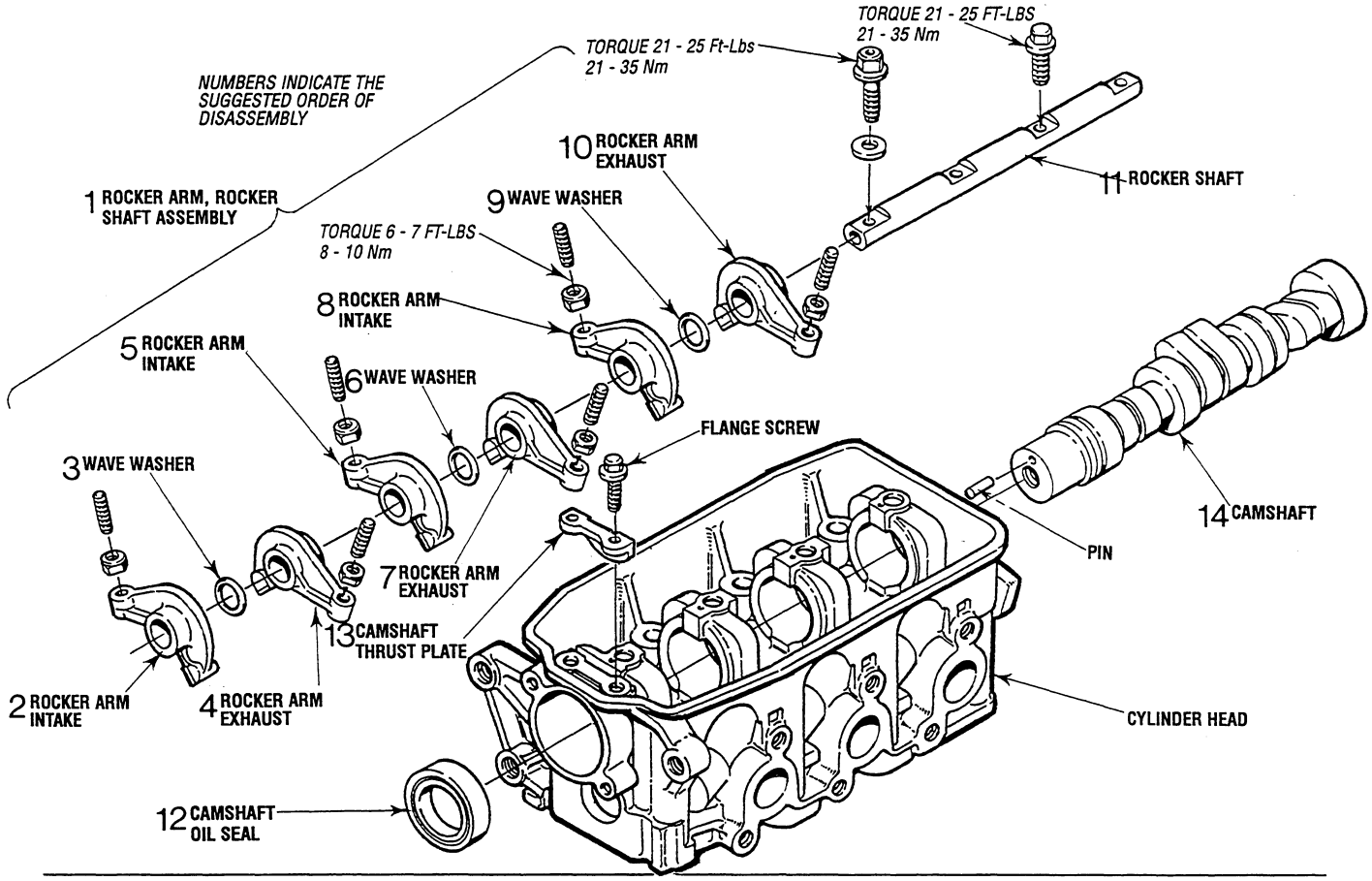
Rocker Cover

Install the rocker cover using a new gasket (slightly coat both sides with clean oil). Gradually tighten the cover bolts to the specified torque making certain the cover gasket is positioned properly.

ROCKER COVER BOLT TORQUE (6mm BOLT)

2.9 - 5.2 ft-lbs (4 - 7Nm)

CAMSHAFT AND ROCKER ARMS



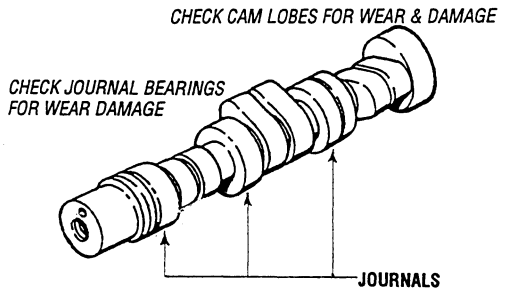
INSPECTING THE CAMSHAFT

1. Visually inspection the camshaft for cracks and damage. If necessary, replace the camshaft.

NOTE: *If the damage is slight, you may be able to correct the camshaft with an oil soaked fine emery grindstone. Take special care to not damage the original cam form.*

2. Inspect the camshaft journal and, if wearing exceeds the limit, replace the camshaft.

CAMSHAFT JOURNAL DIAMETER
STANDARD 1.6118 - 1.6124in (40.940 - 40.955mm)

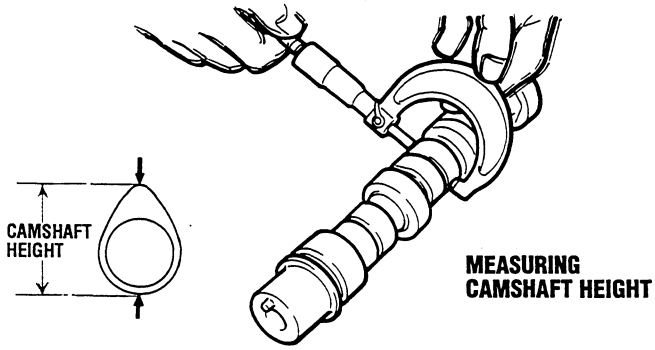


Camshaft

NOTE: *If the Journal is seized, also check the cylinder head!*

3. Measure the cam height and, if it is less than the limit, replace the camshaft.

CAMSHAFT HEIGHT		STANDARD	LIMIT
Intake	#1	1.3815in (35.09mm)	1.3618in (34.59mm)
	#2	1.3807in (35.07mm)	1.3610in (34.57mm)
	#3	1.3803in (35.06mm)	1.3606in (34.56mm)
Exhaust	#1	1.3839in (35.15mm)	1.3642in (34.65mm)
	#2	1.3831in (35.13mm)	1.3634in (34.63mm)
	#3	1.3854in (35.19mm)	1.3657in (34.69mm)



MEASURING CAMSHAFT HEIGHT

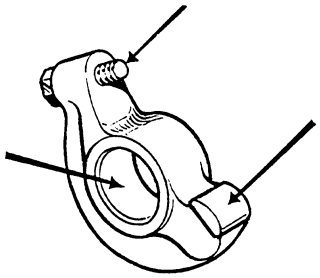
4. Inspect the clearance between the camshaft journal and the camshaft support bore as follows:
   a. Measure the camshaft journal diameter and the camshaft support bore.
   b. Calculate the clearance and replace the camshaft or cylinder head if the clearance exceeds the limit.

BEARING OIL CLEARANCE
STANDARD 0.0018 - 0.0033in (.045 - 0.085mm)

CAMSHAFT AND ROCKER ARMS

Rocker Arm

Check each component part of the rocker arm assembly and carefully inspect the individual rockers where the arrows indicate.



Inspecting Clearance Rocker Arm And Shaft

Check the clearance between the rocker arm and shaft and, if it exceeds the limit, replace the rocker arm or shaft.

ROCKER ARM CLEARANCE (ROCKER ARM TO SHAFT)

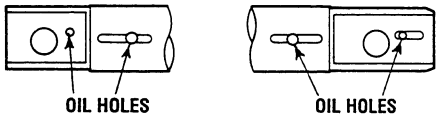
Standard	0.0005 - 0.0017in (0.012 - 0.043mm)
Limit	0.004in (0.1mm)

Rocker Shaft

1. Inspect the rocker shaft where the rocker arms sit for water and damage. Replace the shaft if worn.
2. Measure the shaft length and the shaft outer diameter (O.D.). If the shaft fails to meet the standards, replace the shaft.

ROCKER SHAFT LENGTH Standard 9.134in (232mm)

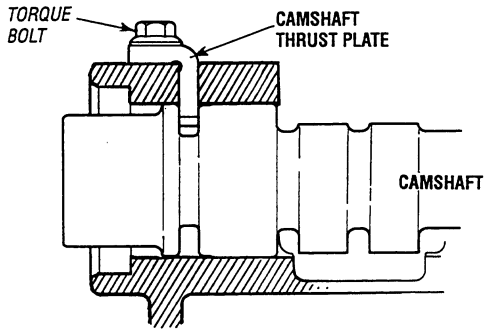
ROCKER SHAFT O.D. Standard 16.985 - 16.988in (0.6687 - 0.6693mm)



INSTALLATION

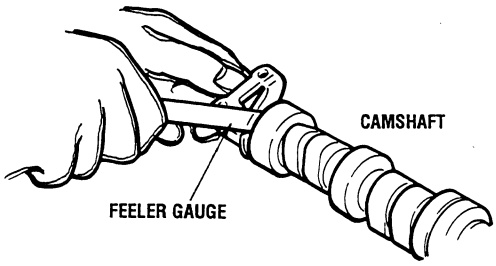
1. Apply a coating of engine oil to the camshaft journals and cams and insert the camshaft through the rear of the cylinder head.
2. Install the camshaft thrust plate as shown in the diagram tighten the bolts to the specified torque.

THRUST PLATE BOLT TORQUE 7 - 9ft-lbs (10 - 12Nm)

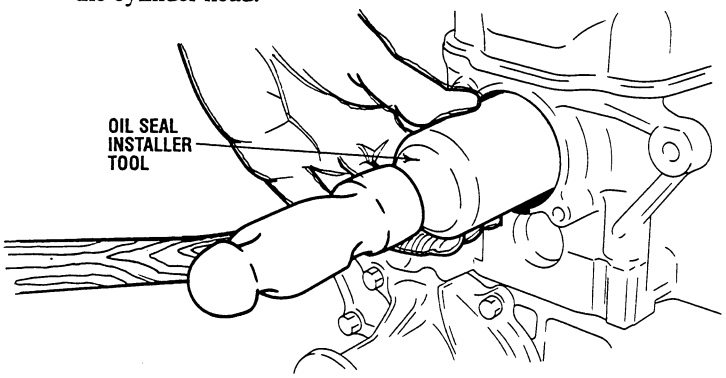


3. Measure the end play of the camshaft by inserting a feeler gauge in the gap between the rear of the thrust plate and the new front camshaft journal.

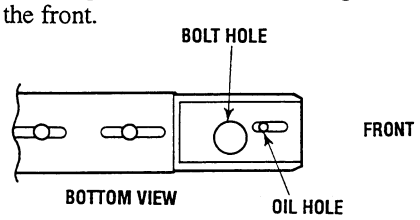
VALVE Standard 0.236 - 0.0551in (0.06 - 0.14mm)
Limit 0.118in (0.3mm)



4. Using the oil seal installer tool, install the front oil seal in the cylinder head.



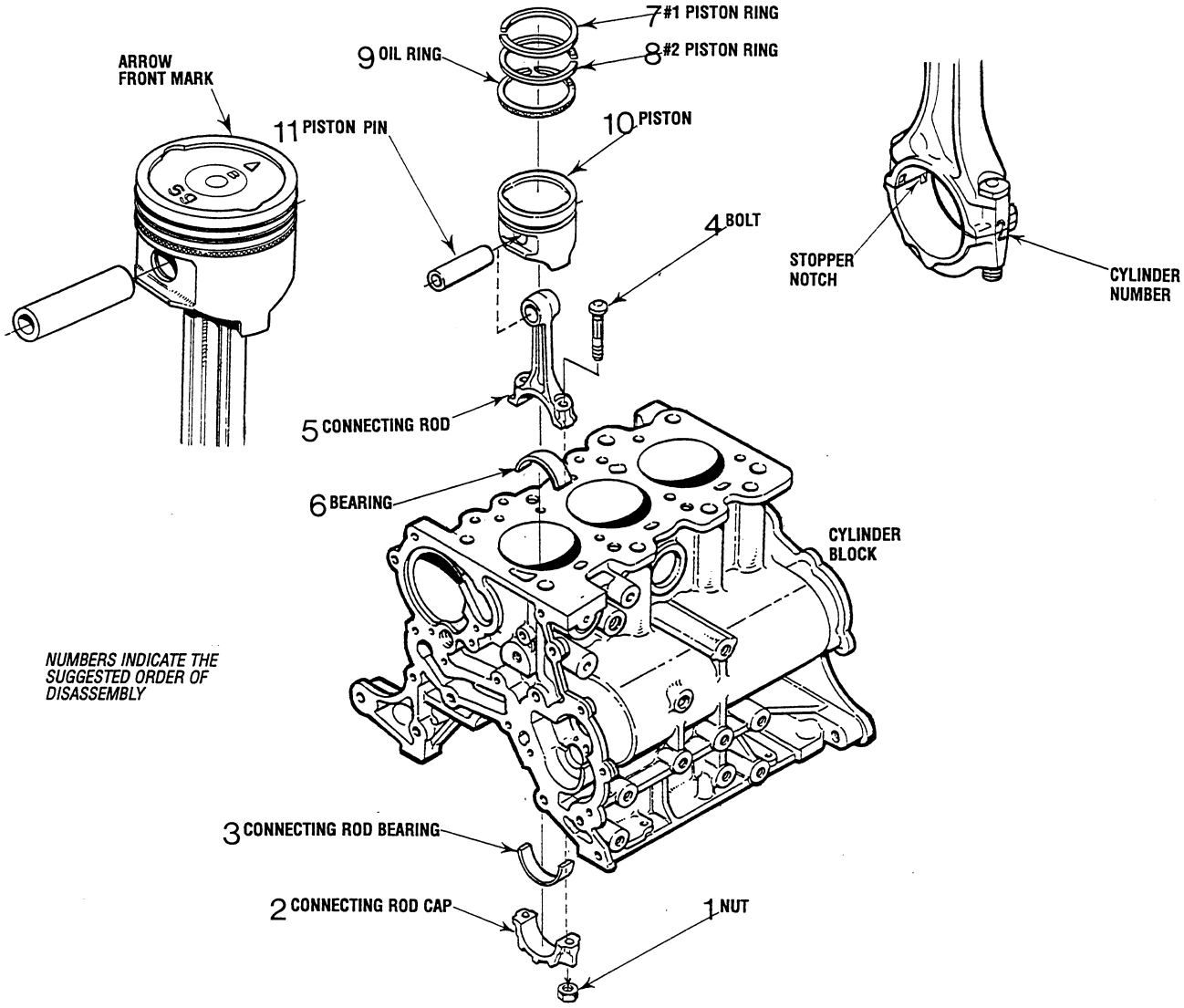
5. Install the rocker arm/rockershaft assembly. Install the rocker shaft so the portion shown in the diagram is located on the front.



6. Tighten the rocker arm shaft bolts (4 bolts) uniformly and then to the specified torque.

ROCKER ARM SHAFT BOLT TORQUE 21 - 25ft-lbs (29 - 35 Nm)

PISTONS AND CONNECTING RODS

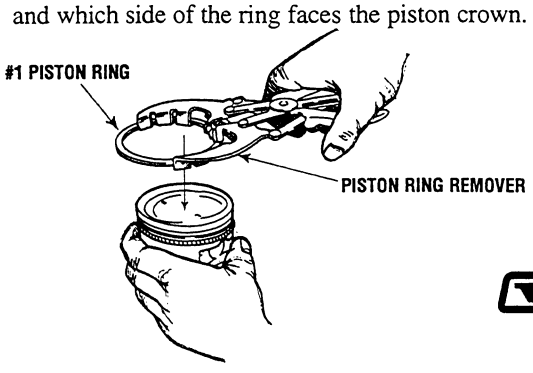


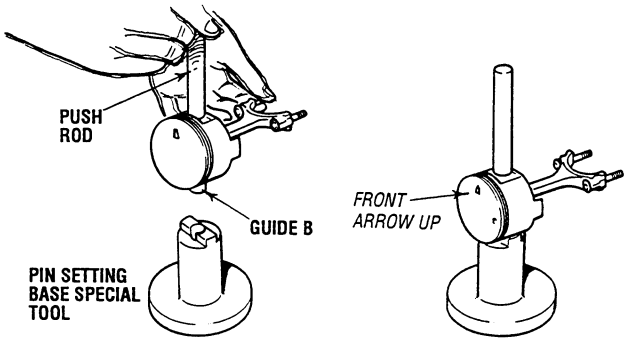
REMOVING THE CONNECTING RODS/PISTONS

Turn the engine over and remove the connecting rod bearing caps and the connecting rod bearings, note the markings on the bearing cap and keep the disassembled parts (connecting rod, rod cap, piston, etc. classified by cylinder. If the marks are worn away be certain to remark them.

Disassemble the Pistons

Using the ring remover, remove the piston rings. While removing the piston rings, note the order they are removed and which side of the ring faces the piston crown.





Remove the Piston Pins

Insert the special tool, push the rod, and guide B into the piston pin then set the piston and connecting rod assembly on the pin setting base. Make certain that the front (arrow) stamped on the piston top surface faces upwards. Using a press, drive out the piston pin.

NOTE: *Keep the disassembled piston, piston pin and connecting rod in order according to the cylinder number.*

PISTONS AND CONNECTING RODS

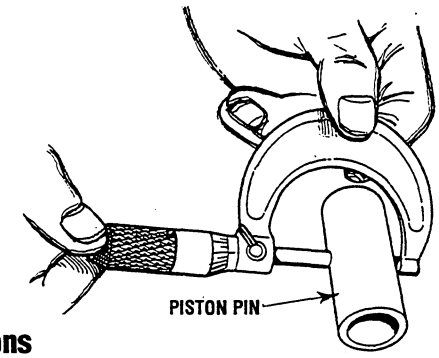
PISTON PIN INSPECTION

Reinsert the piston pin into the piston hole with your thumb. You should feel a slight resistance, if the bore is misaligned the pin will click or bind as it enters. Try the pin from both sides. Replace the piston if the pin can be too easily inserted or if there is excessive play.

NOTE: *The piston pin and piston are replaced as an assembly.*

Measure the outside diameter of the piston pin.

PISTON PIN O.D.0.6300 - 0.6302in (16.001 - 16.007mm)



Pistons

Check the piston surfaces for wear, seizure, cracks and streaking. If any damage is evident, replace the piston. Inspect the oil return hole in the oil ring groove and the oil hole in the piston boss. Clean the piston if these are clogged. Check the piston pin hole for signs of seizure or damage. Replace the piston if damage is evident. Measure the piston diameter at 90° (perpendicular) to the pin bore axis.

PISTON O.D.2.5579 - 2.5591in (64.97 - 65.00mm)

If the piston diameter is less then the standard replace the piston.

NOTE: *The piston and piston pin are replaced as an assembly.*

Piston Rings

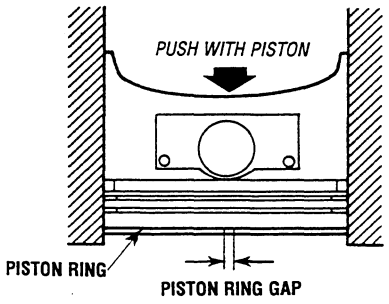
Insert the piston ring into the cylinder bore placing it against the top of the piston head and pressing it in. When it marks a right angle, measure the piston ring gap with a feeler gauge. When the gap is too large, replace the piston ring.

PISTON RING GROOVE

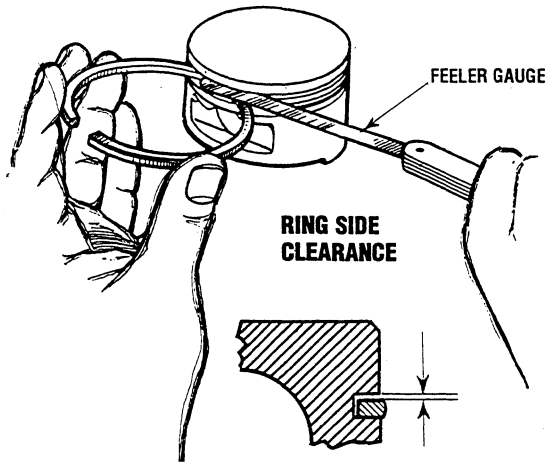
	Standard
No.1	0.0480 - 0.0488in (1.22 - 1.24mm)
No 2	0.0476 - 0.0484in (1.21 - 1.23mm)
Oil	0.1108 - 0.1116in (2.815 - 2.835mm)

PISTON RING END GAP

	Standard	Limit
No.1	0.0059 - 0.0118in (0.15 - 0.30mm)	0.8in (0.0315mm)
No.2	0.0138 - 0.0197in (0.35 - 0.50mm)	0.8in (0.0315mm)
Oil	0.008 - 0.028in (0.2 - 0.7mm)	1.0in (0.0394mm)



Check the piston ring for damage, wear, seizure and bends replacing the rings if anything unusual is noted. Always replace the piston rings when installing a new piston.



Check the clearance between the piston ring and the ring groove, if it exceeds the limit, replace the rings, the piston or both.

PISTON RING SIDE CLEARANCE

	Standard	Limit
No.1 ring	0.0012 - 0.0028in (0.03 - 0.07mm)	0.0047in (0.12mm)
No.2 ring	0.0008 - 0.0024in (0.02 - 0.06mm)	0.0039in (0.10mm)

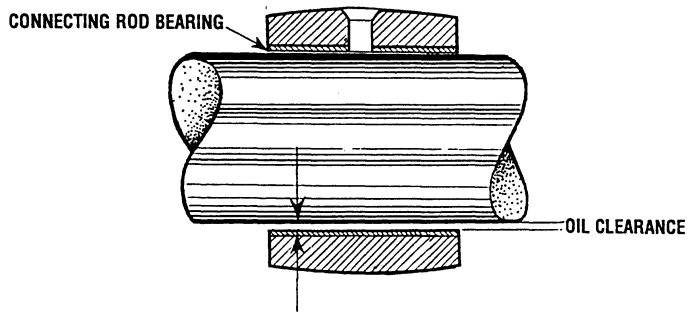
Connecting Rod Bearing

Visually check the surface of the bearing. Replace those which are lopsided, streaked or seized. When streaks or seizure are excessive, check the crankshaft. If damage is discovered on the crankshaft, either replace it or reuse after undersize machining. If the connecting rod bearing indicates severe thermal damage, replace the bearing.

Measure the inner diameter of the connecting rod bearing and the outer diameter of the crankshaft pin. If the gap (oil clearance) exceeds the limit, replace the bearing, and, if necessary, the crankshaft...or undersize machine the crankshaft and replace the bearings with an appropriate undersize type.

CONNECTING ROD BEARING OIL CLEARANCE

Standard	Limit
0.009 - 0.0020in (0.022 - 0.052mm)	0.004in (0.1mm)

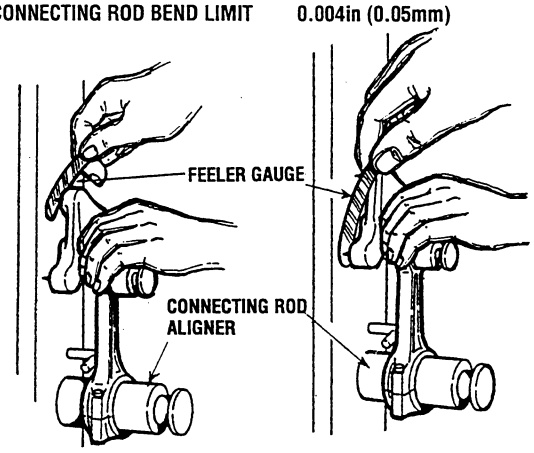


PISTONS AND CONNECTING RODS

NOTE: *See Crankshaft/Bearing section for measuring the oil clearance with a Plastigauge.*

Use a rod aligner to check the connecting rod for bend and twist.

CONNECTING ROD BEND LIMIT **0.004in (0.05mm)**



CONNECTING ROD TWIST LIMIT **0.004in (0.1mm)**

CONNECTING ROD BIG END TO CRANKSHAFT SIDE CLEARANCE

Standard **0.0039 - 0.0098in (0.10 - 0.25mm)**

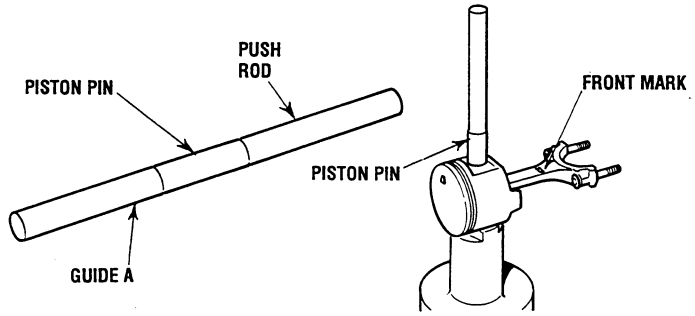
CONNECTING ROD CENTER LENGTH

Standard **4.0138 - 4.0178in (101.95 - 102.05mm)**

ASSEMBLY

Piston Connecting Rod, Piston

Using the special tool (pin setting base) assemble the piston and connecting rod and press-in the piston pin. First, install the piston pin into the special tool,



Set up the piston and connecting rod on the piston pin setting base. Make sure that the front marks are facing up. Apply engine oil to the outer circumference of the piston pin and insert the pin, Guide A and the push rod (assembled) into the piston and connecting rod.

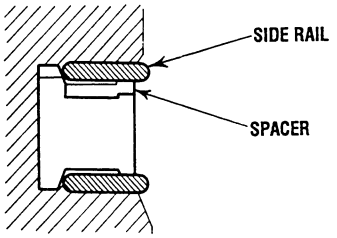
Using a press, load the push rod top end and press-fit the piston pin in the connecting rod. The piston pin is press fitted in the specified position by press-fitting the Guide A bottom end surface until it is seated on the bottom surface of the base. If the press-fitting load is out of the specification, replace the pin (piston assembly) or connecting rod, or both.

PISTON PIN PRESS-FITTING LOAD **1102 - 3307lbs (5000 - 1500Nm)**

Oil Ring

Assemble the oil ring spacer into the piston ring groove. Then, after assembling the upper side rail, assemble the lower side rail.

NOTE: *There is no difference between the upper and lower side rails or the spacers.*



The chart below identifies the color coding on new spacer and side rails according to size.

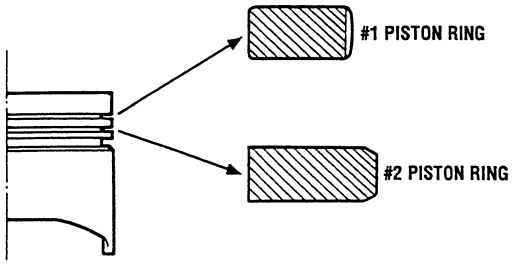
SPACER AND SIDE RAIL CODING

SIZE	Color Identification
S.T.D.	——
0.0098in (0.25mm) Oversize	Two Blue Lines
0.0197in (0.50mm) Oversize	One Red Line
0.0295in (0.75mm) Oversize	Two red lines
0.0394in (1.00mm) Oversize	One Yellow Line

Install the three-piece oil ring in the piston. Then, make certain the side rails move smoothly in both directions. The side rail my be easily installed by pushing it in with your finger after fitting the one end over the piston groove. Do not use an expander ring on the oil ring.

Piston Rings

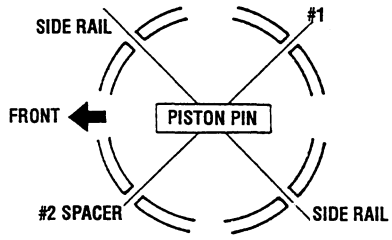
Use a piston ring expander and install the piston rings with the marker and size marks facing up toward the piston top. Notice the difference in shapes between No.1 and No.2 ring.



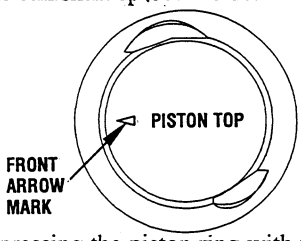
PISTONS AND CONNECTING RODS

Installing the Piston Assembly

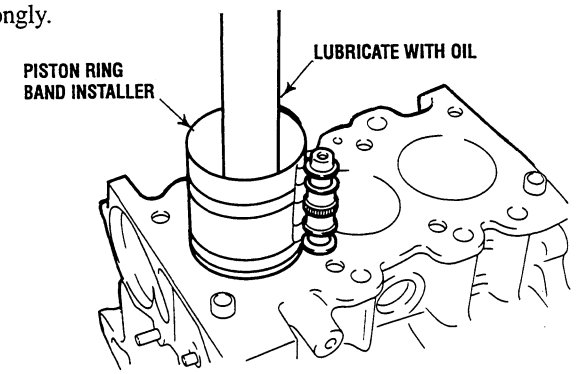
Apply an ample amount of oil to the outside surfaces of the piston and the piston rings. Position the piston rings and oil ring (side rail spacer) end gaps as shown.



Insert the piston and connecting rod assembly into the cylinder, working from the arrow mark on the piston top toward the camshaft sprocket side.

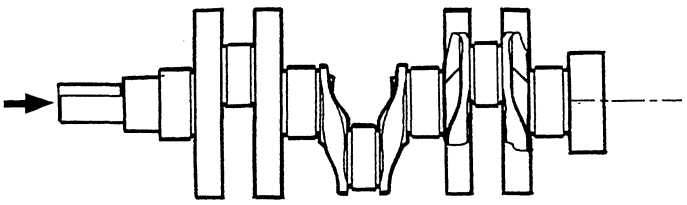


Securely pressing the piston ring with the ring band, insert the piston and connecting rod assembly into the cylinder. Keep in mind that the piston ring may be damaged if hit too strongly.

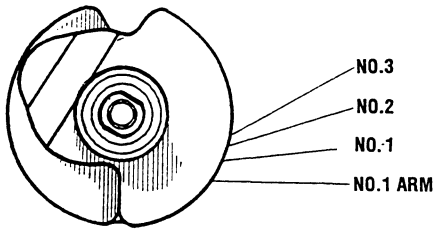


Crankshaft/Bearing Assembly

When the bearings are to be replaced, select the appropriate bearings for assembly according to the identification marks for the crankshaft and the connecting rod.



CRANKSHAFT



CRANKSHAFT PIN DIAMETER

Identification marks	Journal Diameter
(1) /\	1.4171 - 1.4173in (35.995 - 36.000mm)
(2) =	1.4167 - 1.4171in (35.985 - 38.995mm)
(3) ⊏	1.4165 - 1.4167in (35.980 - 35.985mm)

CONNECTING ROD BIG END INNER DIAMETER

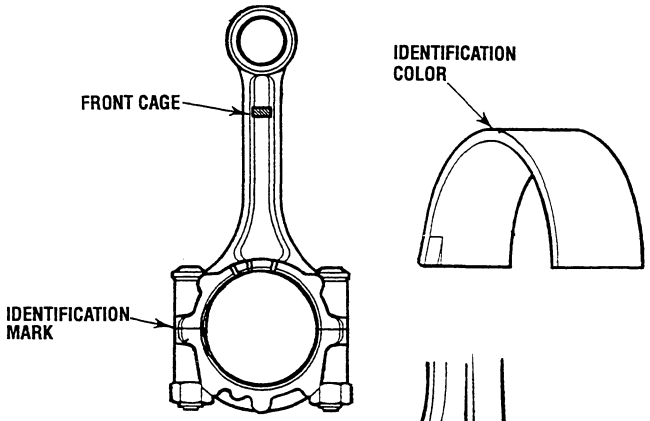
Identification Marks	Big End Inner Diameter
O	1.5354 - 1.5356in (39.000 - 39.005mm)
I	1.5356 - 1.5360in (39.005 - 39.015mm)
II	1.5360 - 1.5362in (39.015 - 39.020mm)

CONNECTING ROD BEARING THICKNESS

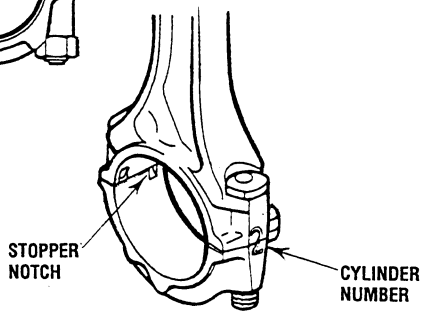
Identification Color	Bearing Thickness
Brown	0.0586 - 0.0588in (1.488 - 1.493mm)
——	0.0588 - 0.0590in (1.493 - 1.498mm)
Blue	0.0590 - 0.0592in (1.498 - 1.503mm)

CONNECTING ROD BEARING SELECTION TABLE

Crankshaft Pin Identification Marks	Connecting Rod Bearing Identification Marks	
(1) /\	I	Brown
	II	Brown
	III	——
(2) =	I	Brown
	II	——
	III	Blue
(3) ⊏	I	——
	II	Blue
	III	Blue



CONNECTING ROD



Installing the Connecting Rod Bearing Caps

Since the connecting rod cap bolts and nuts are torqued using the plastic area tightening method, the bolts should be examined before reuse. If the bolt threads are "necked down", the bolt should be replaced.

Necking can be checked by running a nut with fingers to the full length of the bolt threads. If the nut does not run smoothly, the bolt should be replaced.

Before installation of each nut, apply clean engine oil to the thread portion and bearing surface of the nut.

Install each nut to the bolt and tighten it with your fingers. Then tighten the nuts alternately to install the cap properly. Tighten the nuts to the proper torque.

CAP NUT TIGHTENING TORQUE 11+90° turn (15Nm +90° turn)

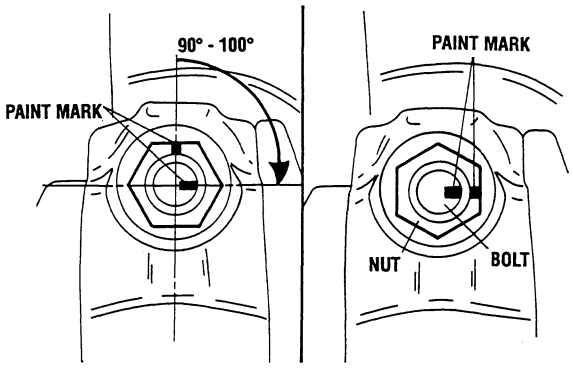
> ⚠ **CAUTION:** ***If the cylinder head has been installed before installing the connecting rod cap nut, remove the spark plugs.***

Make a paint mark on the head of each nut. Make a paint mark on the bolt end at the position 90° to 100° from the paint mark made on the nut in the direction of the tightening nut.

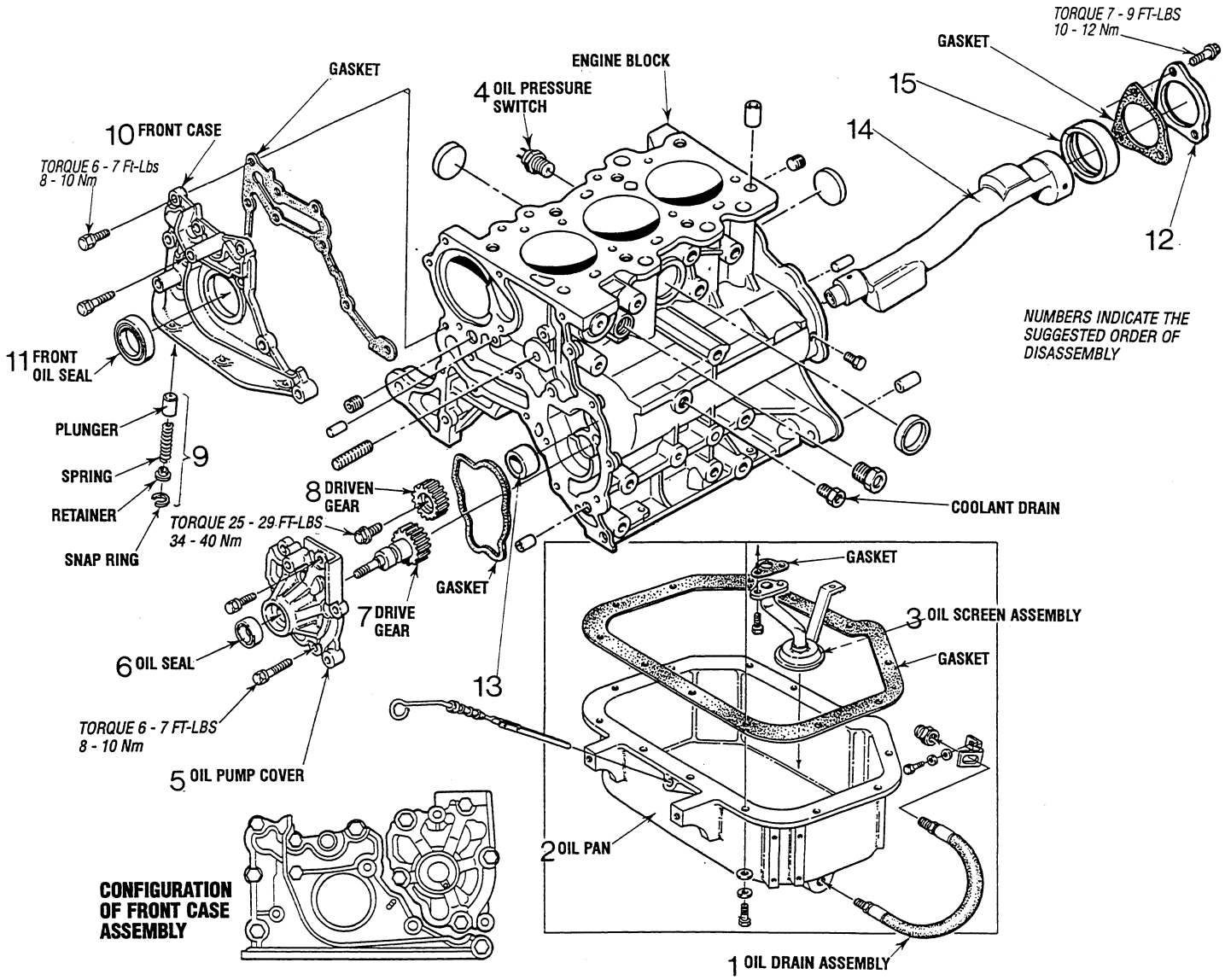
Give a 90° to 100° turn to the nut and make sure that the paint mark on the nut and that on the bolt are in alignment.

If the nut is turned less than 90°, proper fastening performance may not be expected. When tightening the nut, turn it sufficiently.

If the nut is overtightend (exceeding 100°), loosen the nut completely and then retighten it by repeating the tightening procedure.

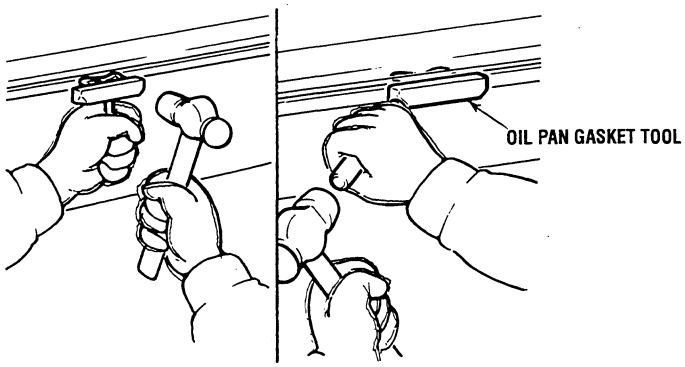


FRONT CASE / COUNTERBALANCE SHAFT AND OIL PAN



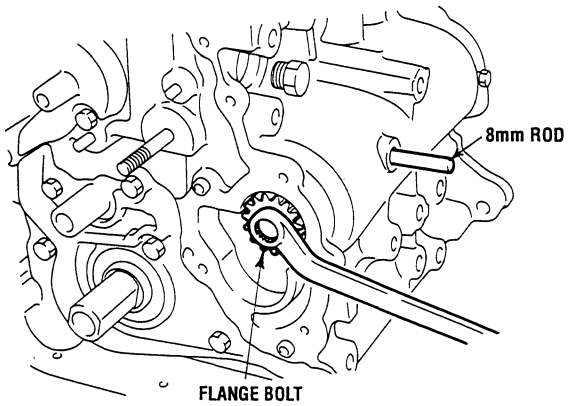
OIL PAN REMOVAL

Remove the oil drain hose assembly. Remove the oil pan bolts and then use the special tool to break the pan seal.

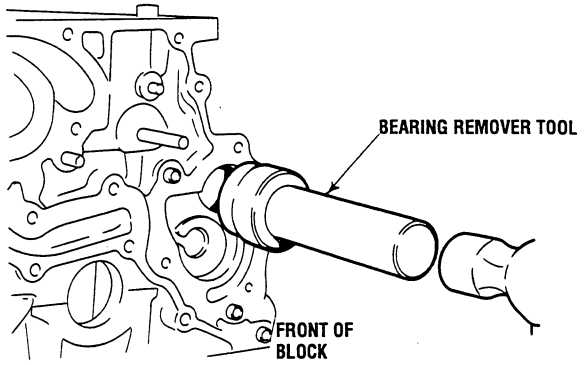


COUNTERBALANCE SHAFT REMOVAL

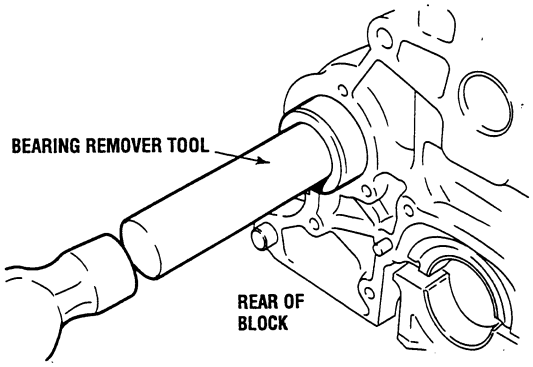
1. Remove the plug on the cylinder block and insert an 0.32in (8mm) rod into the hole to lock the counterbalance shaft.
2. Remove the oil pump cover and gasket. Discard the gasket.
3. Remove the oil pump driven gear tightening flange bolts to release the counterbalance shaft.
4. Remove the counterbalance shaft. Drive it from the front.



4. Using a special tool drive the counterbalance shaft front bearing from the cylinder block.



5. Use the same tool and drive the counterbalance shaft rear bearing from the cylinder block.



OIL PUMP ASSEMBLY - INSPECTION

Fit the oil pump gear into the cylinder block, then, using a feeler gauge, check the clearance with the body at the points indicated in the diagram below.

DRIVEN GEAR BODY CLEARANCE STANDARD

A.	0.0161 - 0.0266in (0.410 - 0.675mm)
B.	0.0051 - 0.0069in (0.130 - 0.175mm)

DRIVE GEAR BODY CLEARANCE STANDARD

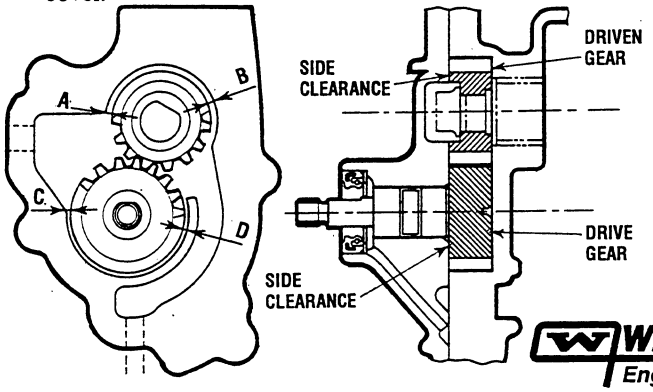
C.	0.0173 - 0.0276in (0.44 - 0.70mm)
D.	0.0059 - 0.077in (o.150 - 0.195mm)

DRIVEN GEAR SIDE CLEARANCE .0024 - 0.0047in (0.06 - 0.12mm)

DRIVE GEAR SIDE CLEARANCE 0.0027 - 0.0051in (0.07 - 0.13mm)

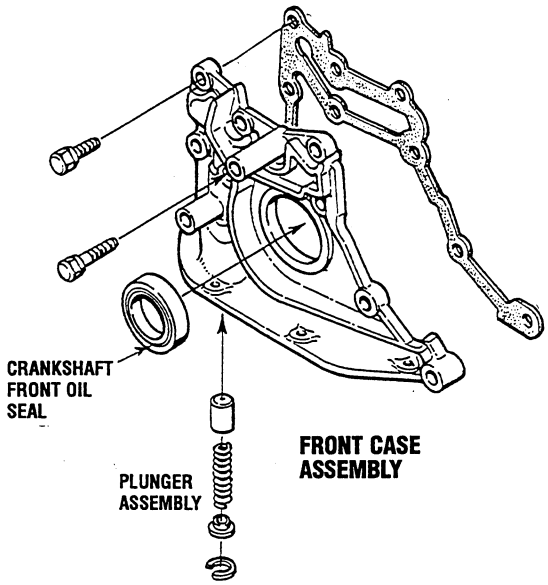
Using a straight edge, check the side clearance at the point indicated in the illustration with a feeler gauge.

There should be no uneven wear on the contact surfaces of the cylinder block or on the pump gear side of the pump cover.



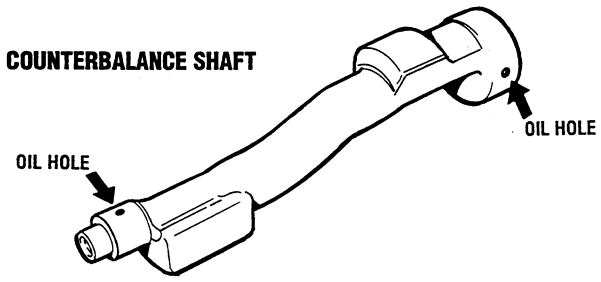
FRONT CASE - INSPECTION

Check the front case for cracks or other damage also inspect the oil holes. If the oil holes are clogged, use compressed air or solvent to clean them out.



CRANKSHAFT FRONT OIL SEAL - INSPECTION

Check the oil seal for wear and damage. Inspect the oil seal lip for hardening. If there any signs of wear, replace the seal.



COUNTERBALANCE SHAFT - INSPECTION

Inspect the oil holes for clogging and clean if necessary. Inspect the shaft journal for seizure, damage and its contact with the bearing. Check the counterbalance shaft oil clearance. Replace the counterbalance shaft if it fails to meet the standards.

COUNTERBALANCE SHAFT STANDARDS

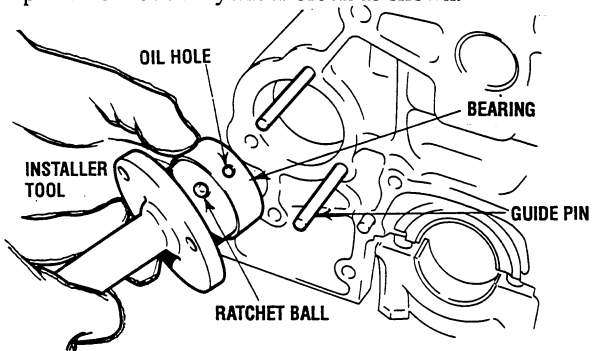
Front Journal Diameter	0.7869 - 0.7874in (19.987 - 20.000mm)
Rear Journal Diameter	1.7317 - 1.7322in (43.984 - 44.000mm)
Front Journal Oil Clearance	0.0014 - 0.0027in (0.035 - 0.068mm)
Rear Journal Oil Clearance	0.0014 - 0.0028in (0.035 - 0.071mm)

FRONT CASE / COUNTERBALANCE SHAFT AND OIL PUMP

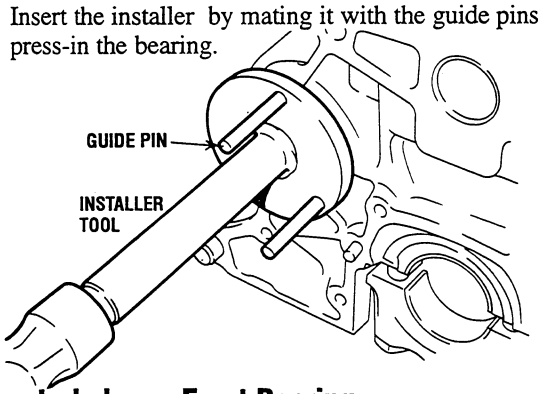
INSTALLATION

Counterbalance Rear Bearing

1. Install the special tool guide pins (bearing Installer) in the tapered hole of the cylinder block as shown.

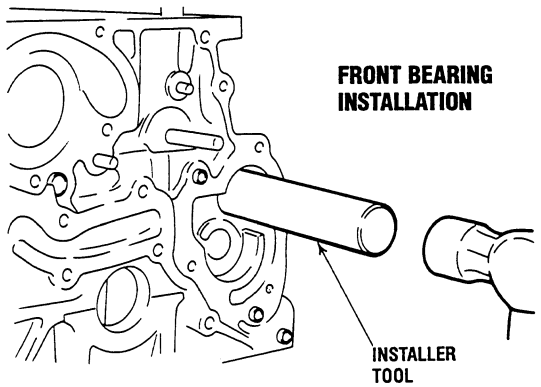


2. Mate the ratchet ball of the bearing in the oil hole of the rear bearing and install the bearing in the bearing installer.
3. Apply clean engine oil to the outer circumference of the bearing and the bearing hole in the cylinder block.
4. Insert the installer by mating it with the guide pins and press-in the bearing.



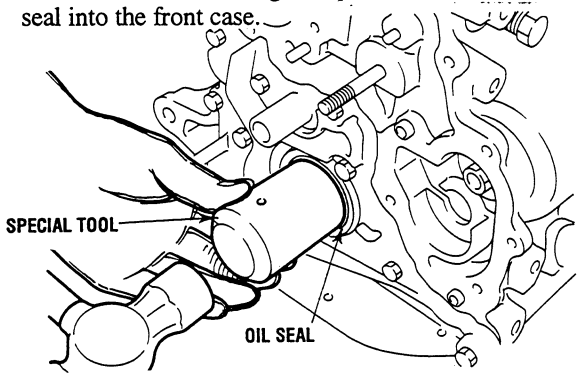
Counterbalance Front Bearing

1. Apply engine oil to the bearing outer circumference and the bearing hole in the cylinder block.
2. Press-in the front bearing using the installer tool.



Crankshaft Oil Seal

1. Apply oil to the crankshaft front oil seal lip inner circumference, and using the special tool, knock the oil seal into the front case.



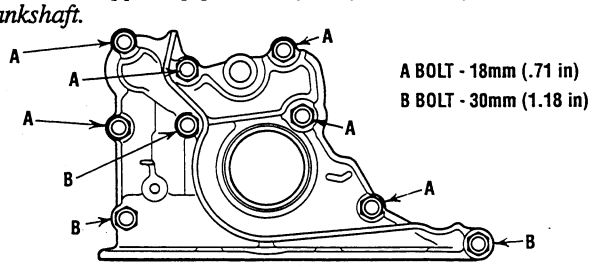
Front Case Assembly

Install the front case assembly through the gasket and tighten the bolts to the specified torque.

FRONT CASE BOLTS TORQUE 6 - 7ft.lbs. (8 - 10 Nm)

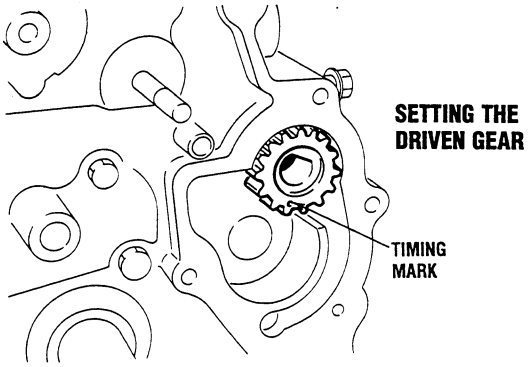
There are two different length front case bolts. Make certain they are positioned properly. See the diagram.

NOTE: *When installing the front case assembly, apply oil to the inner circumference of the oil seal lip. When installing the front case assembly take care not to damage the oil seal lip on the stepped up portion of the front end of the crankshaft.*



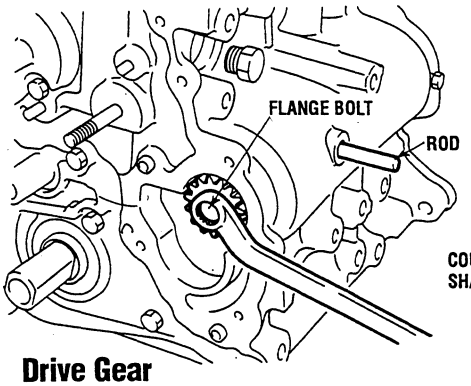
Oil Pump Driven Gear

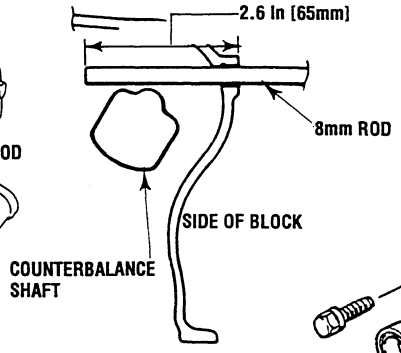
1. Apply an ample amount of clean engine oil to the oil pump driven gear and insert it so that the timing mark is positioned as shown.
2. Using the same hole on the side of the cylinder block, reinsert the 8mm rod to lock the counterbalance shaft. Then tighten the flange bolt to the specified torque.



DRIVEN GEAR FLANGE BOLT TORQUE 25 - 29ft.lbs. (34 - 40Nm)

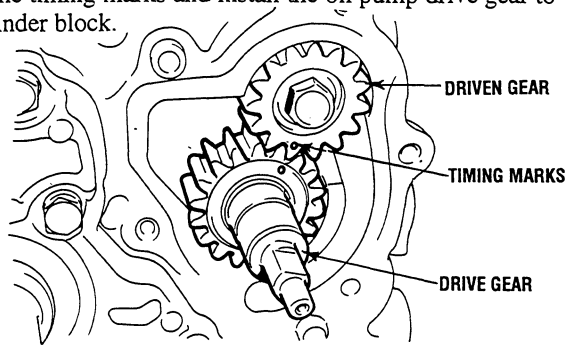
FRONT CASE / OIL PUMP AND OIL PAN

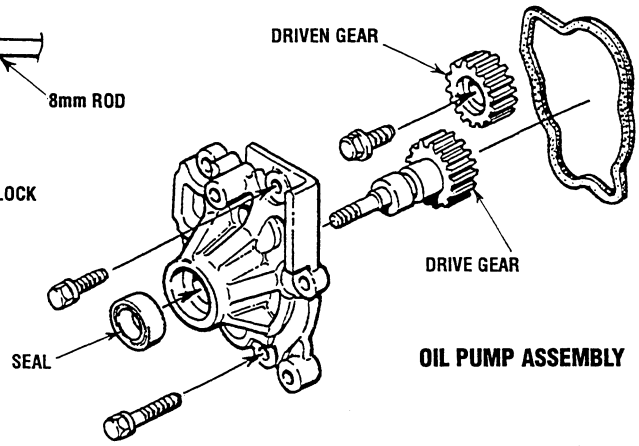




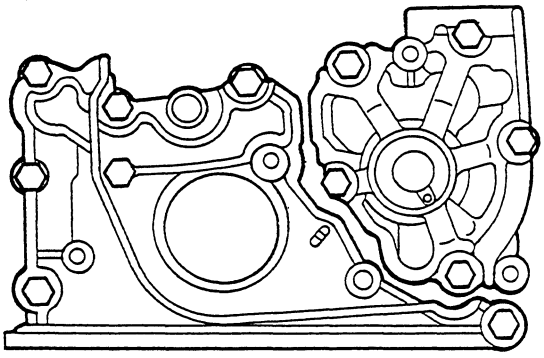
Drive Gear

Align the timing marks and install the oil pump drive gear to the cylinder block.





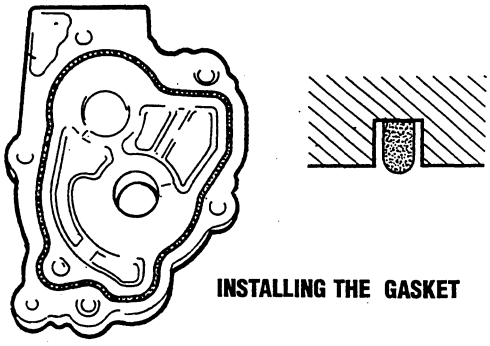
OIL PUMP ASSEMBLY



FRONT CASE CONFIGURATION

Oil Pump Cover Gasket

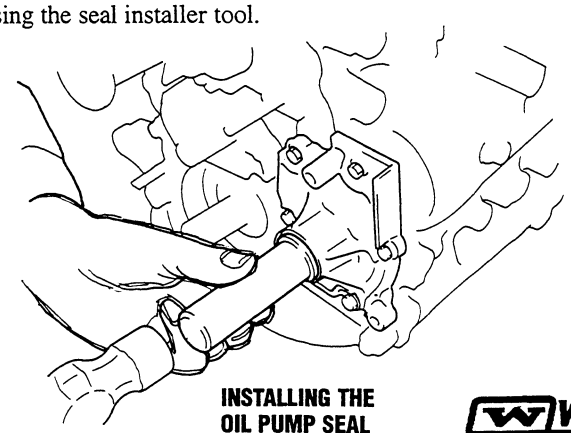
Fit a new oil pump cover gasket into the groove in the oil pump cover. The flat side of the gasket is positioned against the pump cover.



INSTALLING THE GASKET

Oil Pump Seal

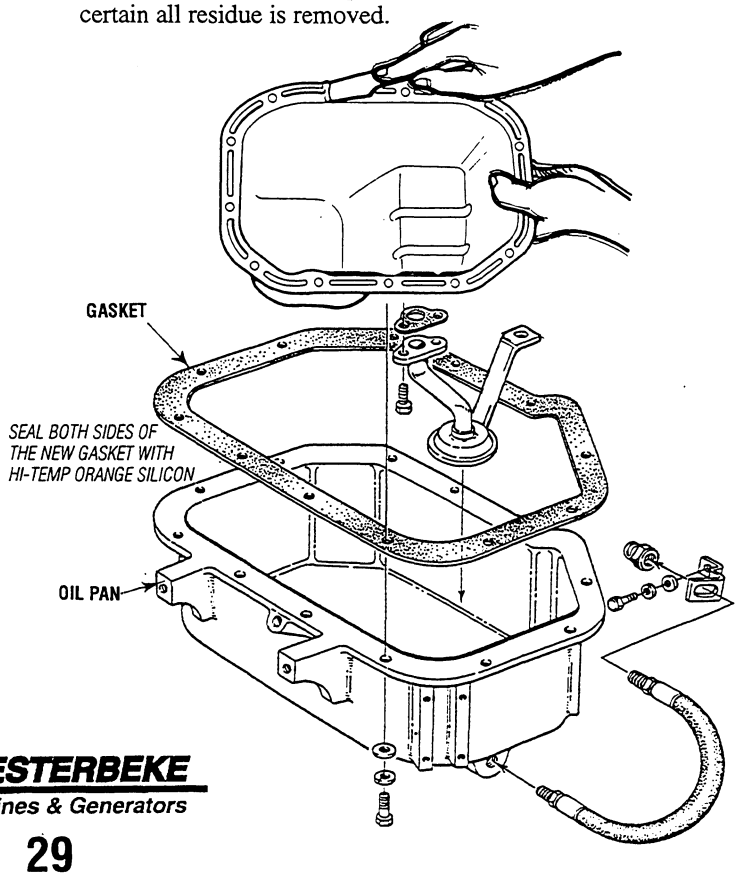
Press the seal into the oil pump cover flush with the surface using the seal installer tool.



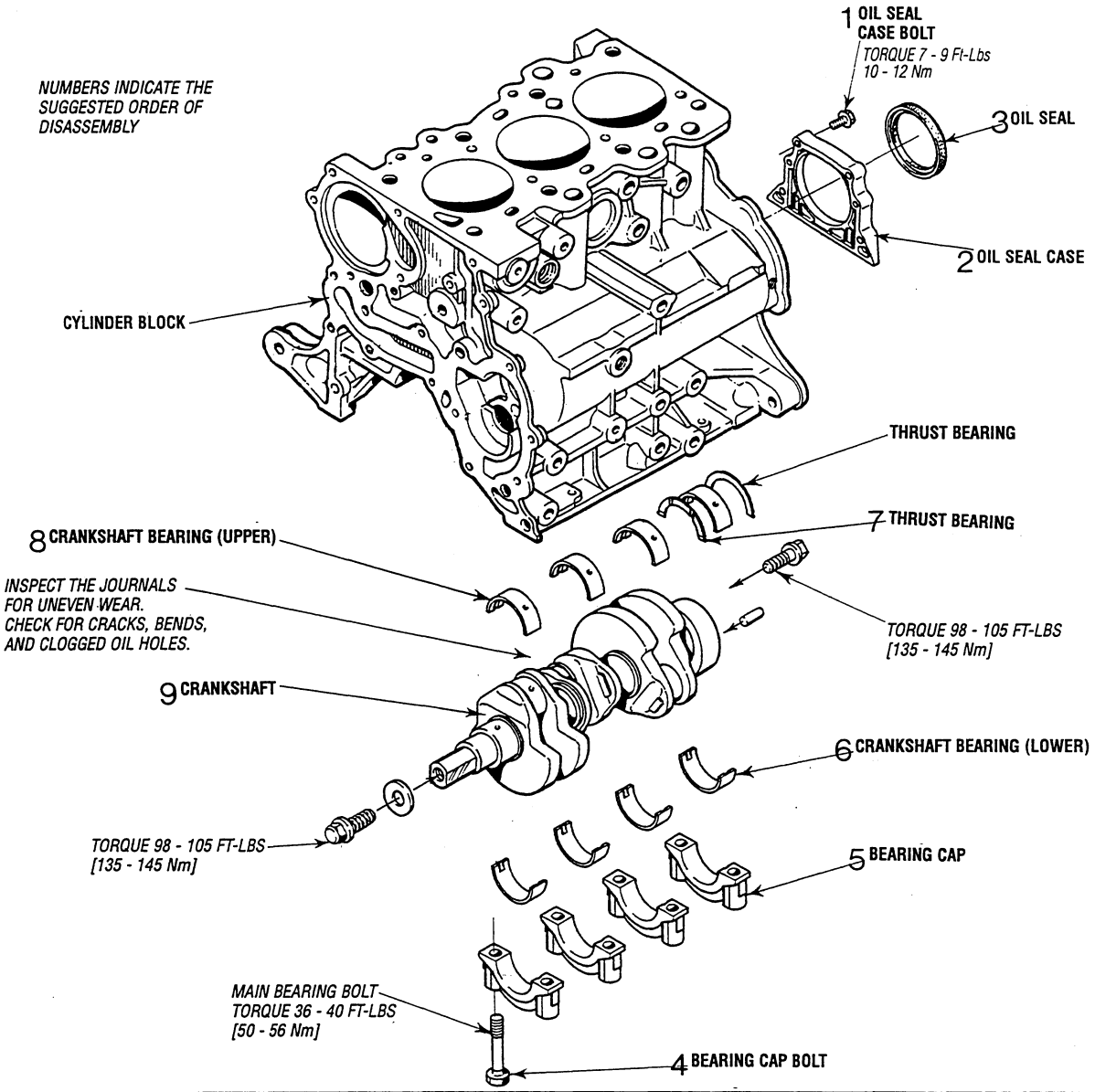
INSTALLING THE OIL PUMP SEAL

Oil Pan

Remove the old gasket and sealant from the oil pan and cylinder block with a scraper, wire brush, solvent, etc. Make certain all residue is removed.



CRANKSHAFT / BEARINGS AND OIL SEAL

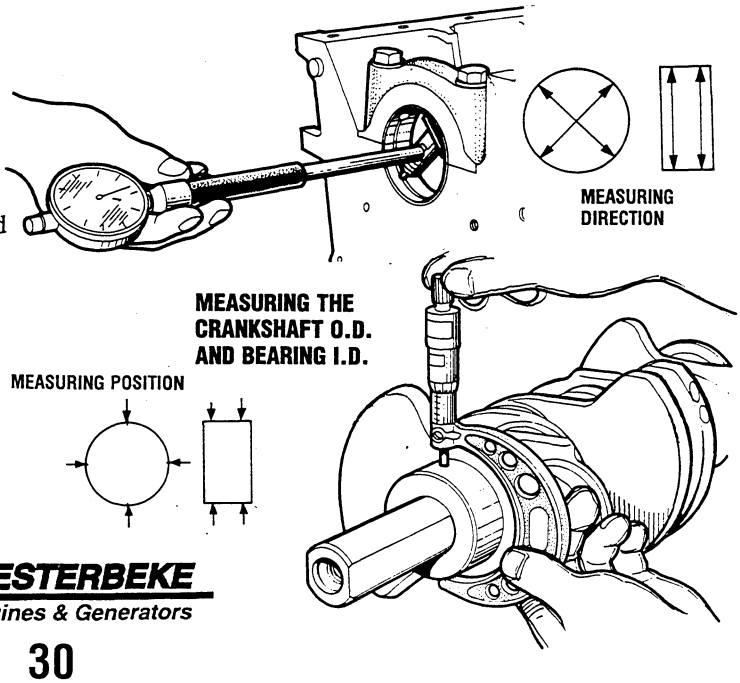


CRANKSHAFT INSPECTION

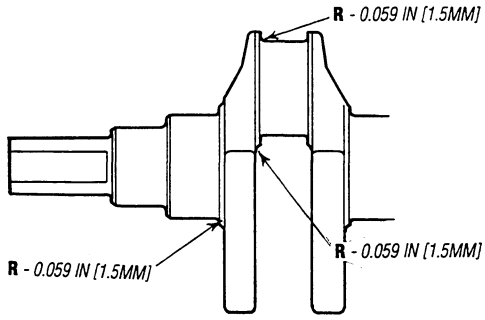
1. Check the journals and pins for damage, seizure and cracks. Check the journals contact surface for uneven wear and replace if badly damaged.
2. Measure the outside diameter of the journal and the inside diameter of the main bearing. If the clearance (oil clearance) exceeds the limit, replace the main bearing and also the crankshaft, if necessary. Otherwise, fabricate an undersized crankshaft and replace the main bearing with an undersized one.

Standard	Limit
0.0008 - 0.0018in (0.021 - 0.045mm)	.004in (0.1mm)

3. When grinding the crankshaft to under-size, take note of the "R" dimensions of the fillets of the journal and pin area.



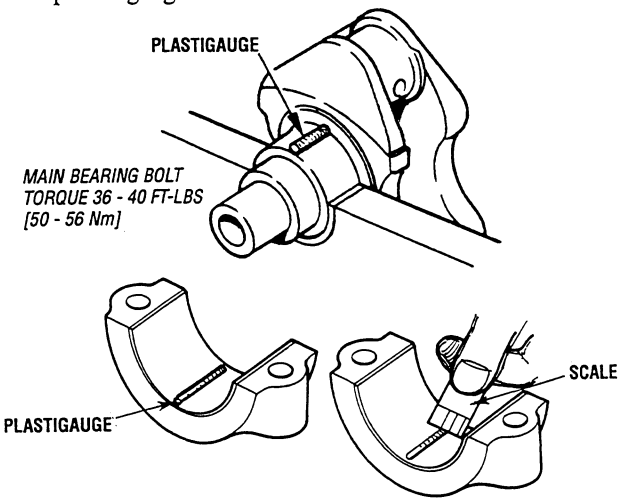
CRANKSHAFT, BEARING AND OIL SEAL



MEASURE THE CRANKSHAFT OIL CLEARANCE

The crankshaft oil measured by using a plastic gauge as follows:

1. The oil and grease and other foreign matters form the crankshaft journal and bearing inner surface.
2. Install the crankshaft.
3. Cut the plastic gauge to the same length as the width of the bearing and place it on the journal in parrallel with its axis.
4. Gently place the main bearing cap over it and tighten the bolts to the specified torque.
5. Remove the bolts and gently remove the main bearing cap. Measure the width of the smashed plastic gauge (at its widest section) by using the scale printed on the plastic gauge.



INSPECTING THE CRANKSHAFT REAR OIL SEAL

1. Inspect the oil clearance lip for wear or damage. Check the rubber portion for deterioration and hardening. Replace the seal if at all suspect.
2. Check the oil case for cracks and damage. If here is damage, replace the case.

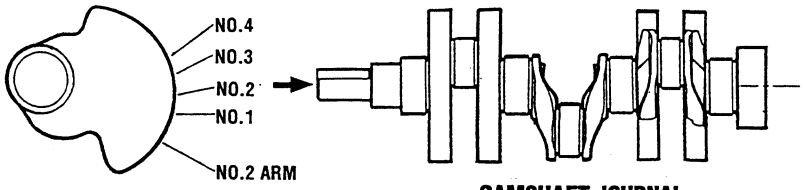
CRANKSHAFT BEARINGS SPECIFICATIONS

Upper and Lower

When the bearings are to be replaced, select the correct ones and install them in positions according to the identification marks stamped on the crankshaft and the top surface of the cylinder block.

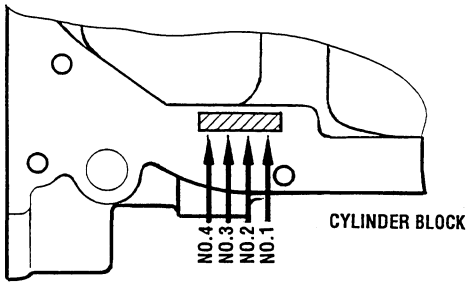
CRANKSHAFT JOURNAL DIAMETER

Identification Marks	Journal Diameter
1	1.5746 - 1.5748 in (39.994 - 40.000mm)
2	1.5743 - 1.5746 in (39.988 - 39.994mm)
3	1.5741 - 1.5743 in (39.982 - 39.988mm)



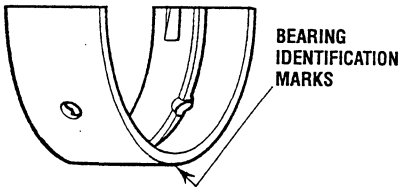
CRANKSHAFT BEARING THICKNESS

Identification Colors	Bearing Thickness
brown	0.0783 - 0.0784 in (1.988 - 1.991mm)
—	0.0784 - 0.0785 in (1.991 - 1.994mm)
blue	0.0785 - 0.0786 in (1.994 - 1.997mm)
yellow	0.0786 - 0.0787 in (1.997 - 2.000mm)
green	0.0787 - 0.0789 in (2.000 - 2.003mm)



CYLINDER BLOCK BEARING DIAMETER

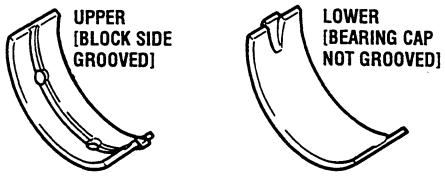
Identification Marks	Bearing Inner Diameter
0	1.7323 - 1.7325 in (44.000 - 44.006mm)
I	1.7325 - 1.7328 in (44.006 - 44.012mm)
II	1.7328 - 1.7330 in (44.012 - 44.018mm)



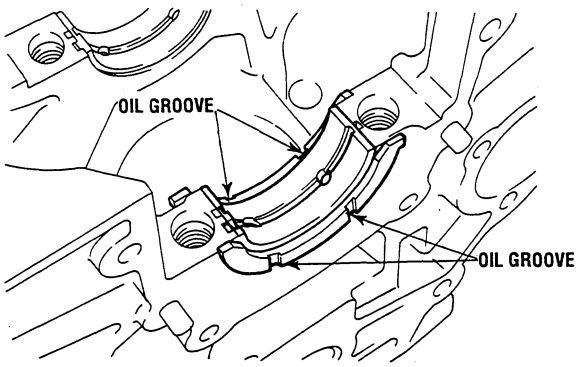
CRANKSHAFT BEARING SELECTION CHART

Crankshaft Journal Identification Marks	Crankshaft Bearing Identification Marks	Cylinder Block Bearing Identification Marks
1	brown	0
	—	I
	blue	II
2	—	0
	blue	I
	yellow	II
3	blue	0
	yellow	I
	green	II

CRANKSHAFT/ BEARING AND OIL SEAL

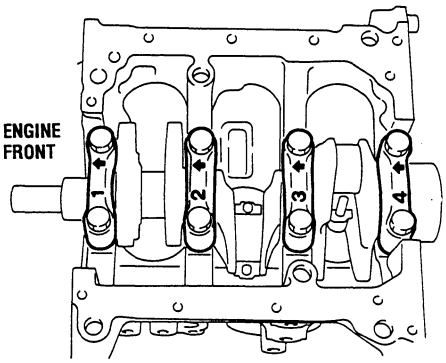


CRANKSHAFT BEARINGS



INSTALLING THE THRUST BEARINGS

1. Apply a coat of oil to the thrust beating and install so that the oil groove faces outward as illustrated.



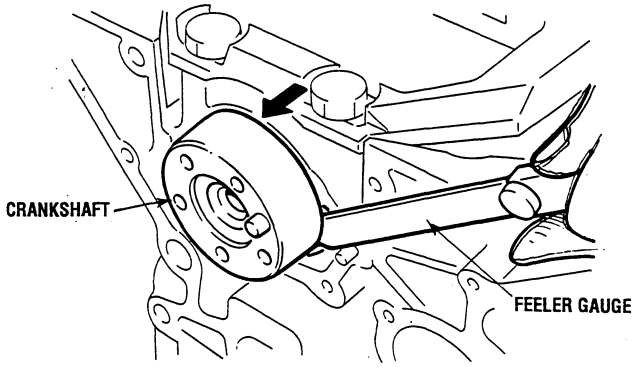
2. Install the bearing cap paying careful attention to the cap number and the arrow mark. Apply oil to the bolt threads.
3. Tighten the bearing cap to the specified torque.

BEARING CAP BOLT TORQUE 36 - 40 ft-lbs (50 - 55Nm)

MEASURING END PLAY

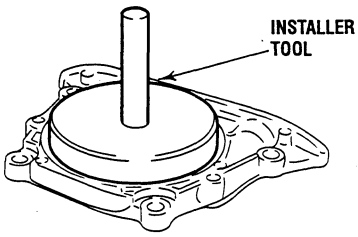
Push the crankshaft to the rear. Then, insert a feeler gauge in the gap between the crankshaft journal side surface and the thrust bearing end surface to measure the end play.

CRANKSHAFT END PLAY 1.5740 - 1.5748 in (0.05 - 0.025mm)

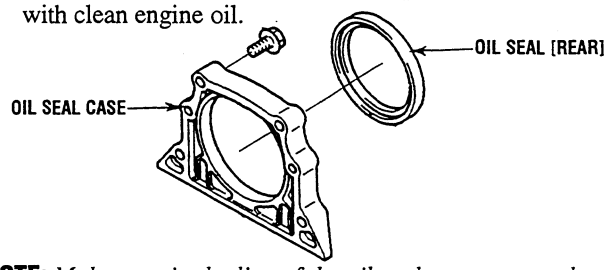


CRANKSHAFT REAR OIL SEAL

1. Apply engine oil to the rear cover and to the oil seal.
2. Press the oil seal into the seal case using the special tool.



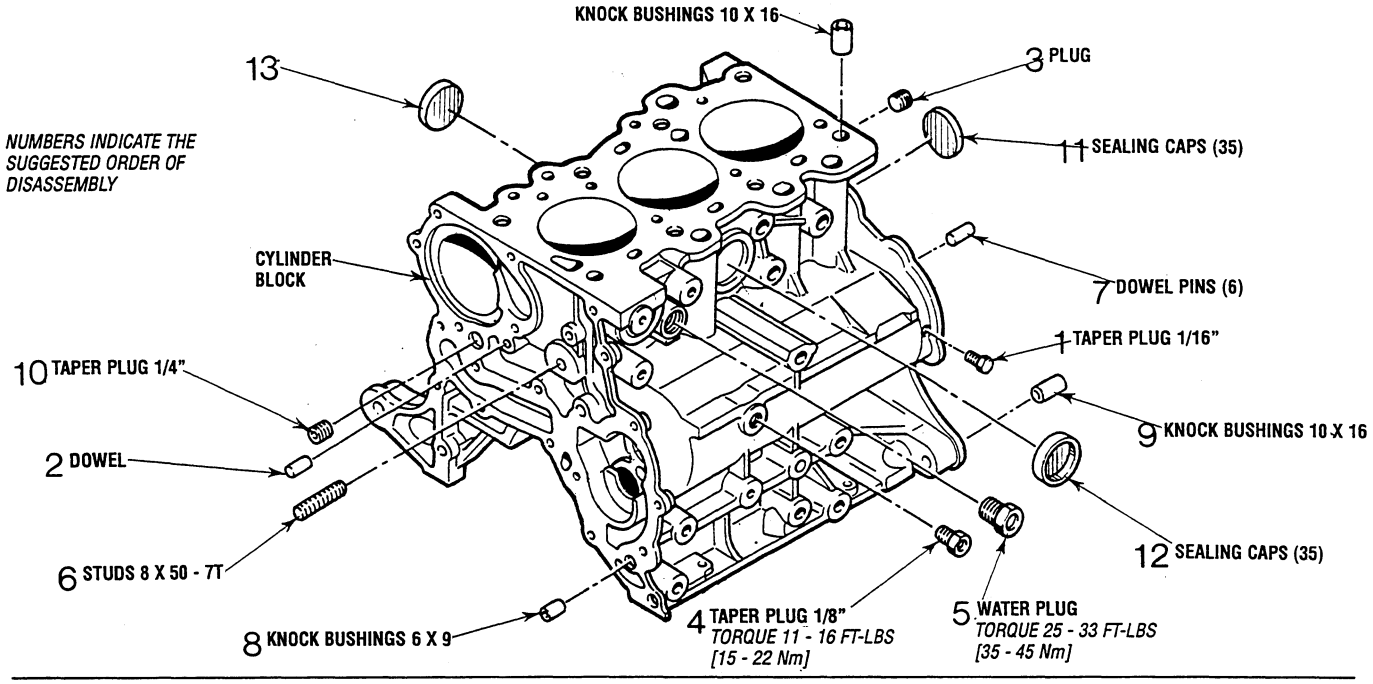
3. Install the oil seal case into the cylinder block through the gasket. (If there is no gasket, coat with sealant.) The entire circumference of the oil seal lip should be coated with clean engine oil.



NOTE: *Make certain the lips of the oil seal are not turned up.*

OIL CASE BOLT TORQUE: 7 - 9 Ft-lbs (10 - 12Nm)

CYLINDER BLOCK INSPECTION AND PISTON CLEARANCE

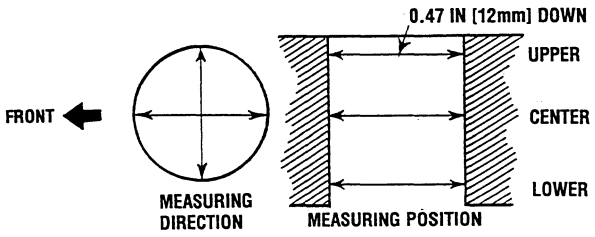


CYLINDER BLOCK INSPECTION

1. Before inspecting, clean the cylinder block to ensure that the water and oil holes are not plugged. If clogged, clear with compressed air.
2. Check for cracks and damage. Use a flaw detecting compound as needed. Replace the block if defective.
3. Inspect the mating surface. Using a straight edge and feeler gauge measure the flatness of the top surface. Grind or replace if the limit is exceeded.

   FLATNESS STANDARD VALUE: 0.0020 in (0.05 mm)
   LIMIT: 0.004 in (0.1 mm)
4. Inspect the cylinder bore. Using a cylinder gauge, measure the bore at six places (as shown in the diagram). Calculate the difference between the max. and min. values. If worn or damaged, rebore or replace the cylinder.

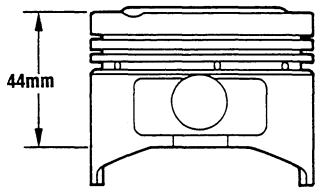
   CYLINDRICITY STANDARD VALUE: 0.0004 in (0.01 mm) or less
   CYLINDER BORE: 2.5591 - 2.5602 in (65.00 - 65.03 mm)



CHECKING THE PISTON CLEARANCE

Calculate the difference between the minimum cylinder bore in the thrust direction and the piston outer diameter shown in the illustration. If the difference exceeds the specified range, replace the piston or cylinder block, or rebore the cylinder.

PISTON TO CYLINDER CLEARANCE STANDARD:
0.0008 - 0.0016 in (0.0 - 0.04 mm)



BORING THE CYLINDER

1. Select an oversize piston based on the cylinder with the maximum bore and maximum damage depth.
2. Using the outer diameter (at the specified measurement point) of the selected oversize piston, calculate the boring dimension.

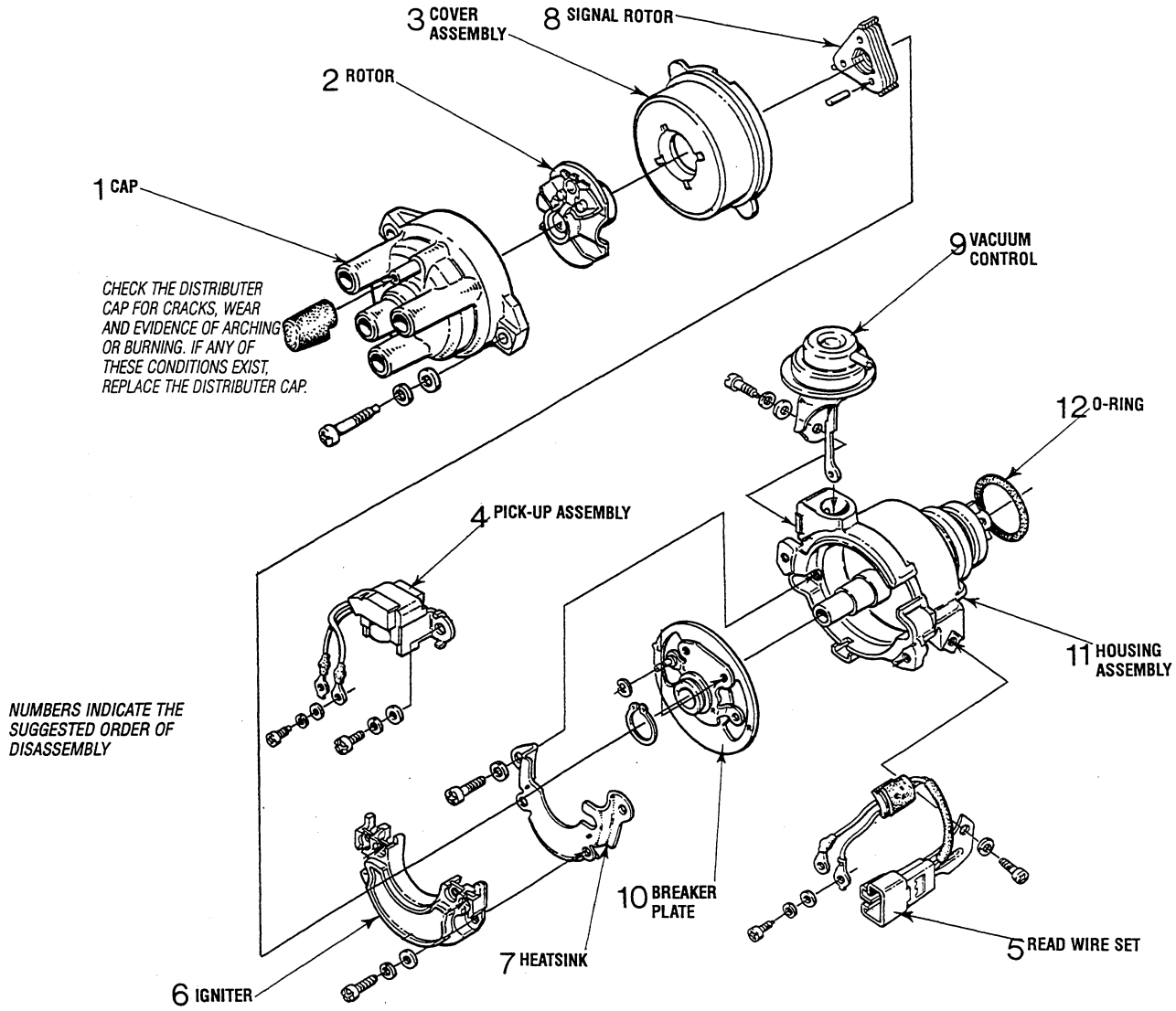
Boring dimension =
(Piston O.D.) + (piston clearance) - (honing margin : 0.0008in (0.02mm))

OVERSIZE PISTON OUTSIDE DIAMETER AND CYLINDER (INNER DIAMETER FINISH DIMENSION (REF))

Size	Mark	Piston Dia.	Cylinder Inner Dia.
0.25 O.S.	25	2.5677 - 2.5689in (65.22 - 65.25mm)	2.5693 - 2.5697in (65.26 - 65.27mm)
0.50 O.S.	50	2.5776 - 2.5787in (65.47 - 65.50mm)	2.5791 - 2.5795in (65.51 - 65.52mm)
0.75 O.S.	75	2.5874 - 2.5886in (65.72 - 65.75mm)	2.5890 - 2.5894in (65.76 - 65.77mm)
1.00 O.S.	100	2.5972 - 2.5984in (65.97 - 66.00m)	2.5988 - 2.5992in (66.01 - 66.02mm)

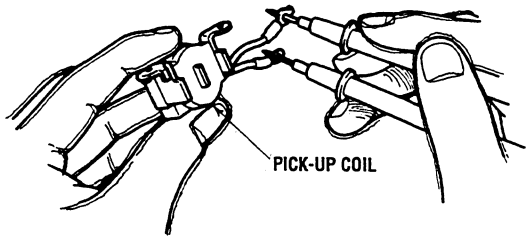
3. Bore the cylinder to obtain the calculated dimensions.
4. Hone to finish the cylinder inner diameter.
5. Check again for cylindricity and piston clearance.

DISTRIBUTOR

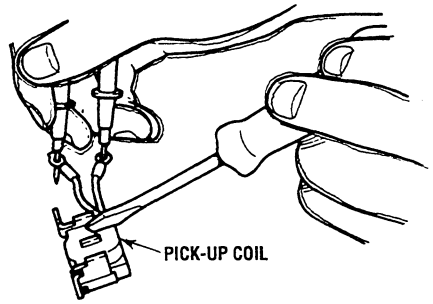


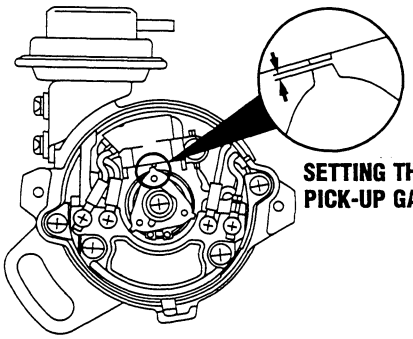
TESTING THE PICK UP COIL

STANDARD RESISTANCE VALUE: 420 - 540 KΩ



Check that when a screwdriver is passed near the iron core of the pick-up assembly the needle of the tester deflects.





Adjust the point gap of the pick-up assembly between the rotor and the pick-up.

STANDARD GAP: 0.35mm TO 0.40mm

INSPECTING SPARK PLUGS

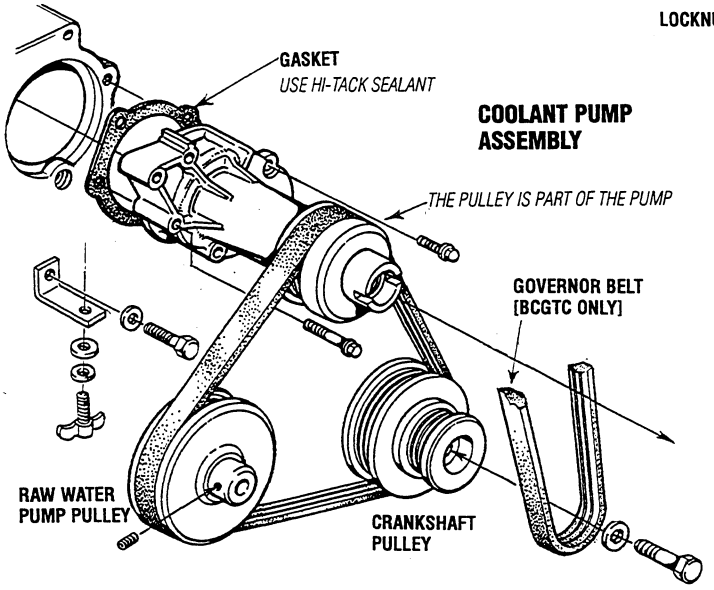
Check the plugs for carbon build-up and burning. Check the plug gap.

SPARK PLUG GAP: 0.028 - 0.031 in (o.7 - 0.8 mm)

COOLANT CIRCULATING PUMP

REMOVING THE COOLANT PUMP

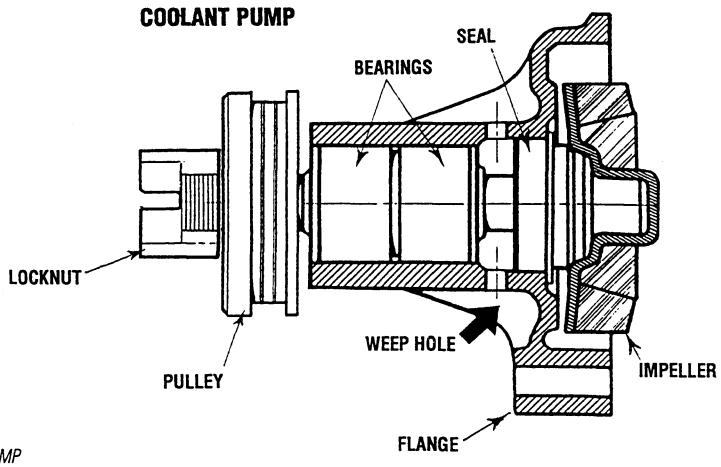
1. Loosen the belt guards thumbscrews and remove the engine's belt guard from its brackets at the front of the engine.
2. Ease the belt tension by releasing the raw water pump and remove the engine drive belt [on carburetor models it will be necessary to remove the governor belt].
3. Unscrew the five bolts that hold the pump to the engine and remove the coolant pump and its gasket. Note that the pulley is an integral part of the pump assembly.



INSPECTION

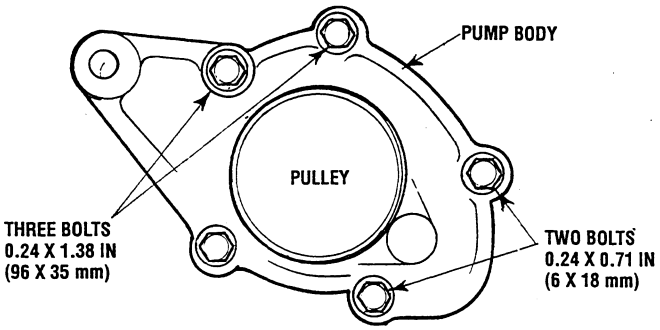
Carefully check the pump body and impeller for cracks and damage. Inspect the weep holes for signs of water leakage and rust that would indicate a faulty seal. The pulley should turn the shaft (and impeller) smoothly, without noise or sluggish rotation.

The pulley edges should be smooth and undamaged and the locknut should be drawn up tight.



REPAIR

If the pump does not pass inspection, replace the entire pump assembly which includes the pulley.



INSTALLATION

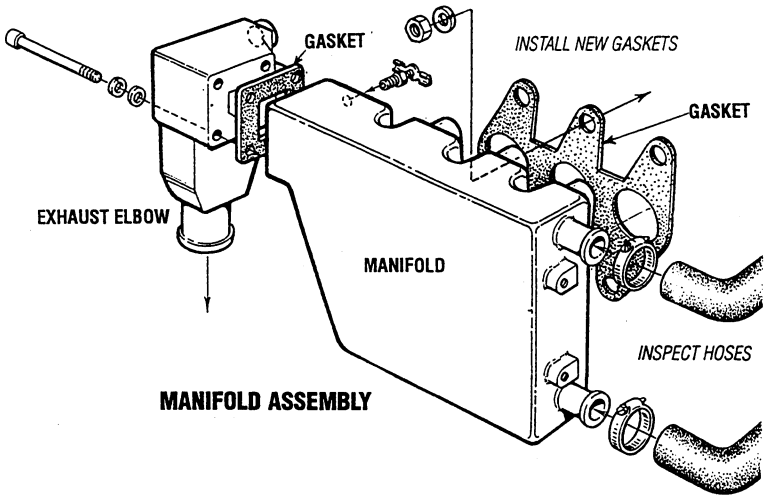
When reinstalling the pump use a new gasket. There are five bolts in two sizes that fasten the pump in place, make certain they are positioned properly. See the diagram above. Use sealant when assembling the new gasket.

CIRCULATING PUMP BOLT TORQUE **6 - 7 ft - lbs (8 - 10 Nm)**

EXHAUST MANIFOLD / HEAT EXCHANGER

EXHAUST MANIFOLD

The exhaust manifold, which was disassembled from the cylinder head, should be inspected before reassembly.



1. Remove the exhaust elbow from the manifold. Scrape off and discard the old gasket. Inspect the exhaust elbow for corrosion and damage, replace if necessary.
2. If the exhaust elbow passes inspection, remove the high temperature sensor and clean and re-paint the elbow with WESTERBEKE heat resistant enamel.
3. Carefully inspect the exhaust manifold, remove the hose connections noting the location of each for proper alignment at reassembly. Clean the exterior and interior manifold. If the manifold can be reused, repaint with WESTERBEKE heat resistant enamel.

ASSEMBLY

1. If the manifold was removed as an assembly and left intact, it can be replaced on the cylinder head in the reverse order of removal. Install a new gasket.
   MANIFOLD MOUNTING BOLTS TORQUE 12 - 17 ft-lb (16 - 23 Nm)
2. Attach the hose connections to the manifold and the exhaust elbow. Once the engine has been re-installed and running, carefully check these assemblies and hose connections for leaks.

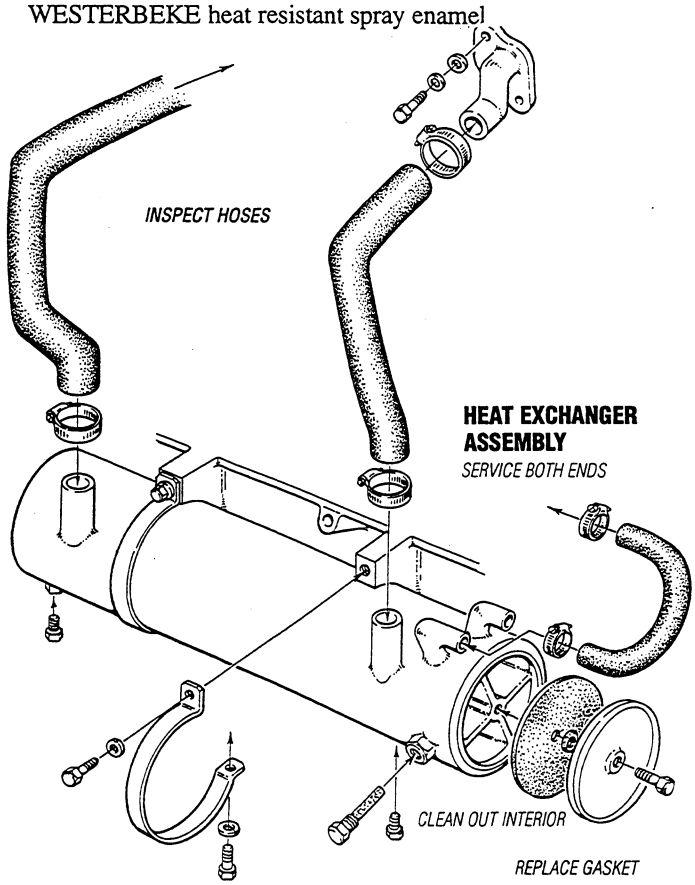
HEAT EXCHANGER

The heat exchanger should be inspected and serviced during an engine overhaul.

1. Disconnect the hoses and remove the hose fittings, petcock, drain plugs and zinc anode. Also, remove the end fittings and gaskets.
2. Inspect the tube (casing) for wear and dents, if at all suspect replace the heat exchanger.
3. Clean out any zinc debris and pressure test the coolant and raw water passages.
4. When reassembling, install new gaskets and O-rings. Apply some lubricant to the new gaskets and to the petcocks and fittings as you install them.
5. Install a new zinc anode.

NOTE: *All of the above can be accomplished by sending the heat exchanger to a heat exchanger/radiator service shop. They will also service transmission and engine oil coolers.*

6. Repaint the assembled heat exchanger with WESTERBEKE heat resistant spray enamel



HEAT EXCHANGER ASSEMBLY

Reinstall the heat exchanger. Tighten down the holdown brackets and once the engine is running, check the heat exchanger and hose connections for leaks.

RAW WATER PUMP

Inspect the pump before disassembly, if the drive shaft is frozen or rotates with excessive play or roughness, replace the entire pump.

NOTE: *Since rebuilding a pump from individually purchased parts would almost match the cost of a new pump, WESTERBEKE recommends purchasing a new pump and using the old pump for spares.*

PUMP OVERHAUL

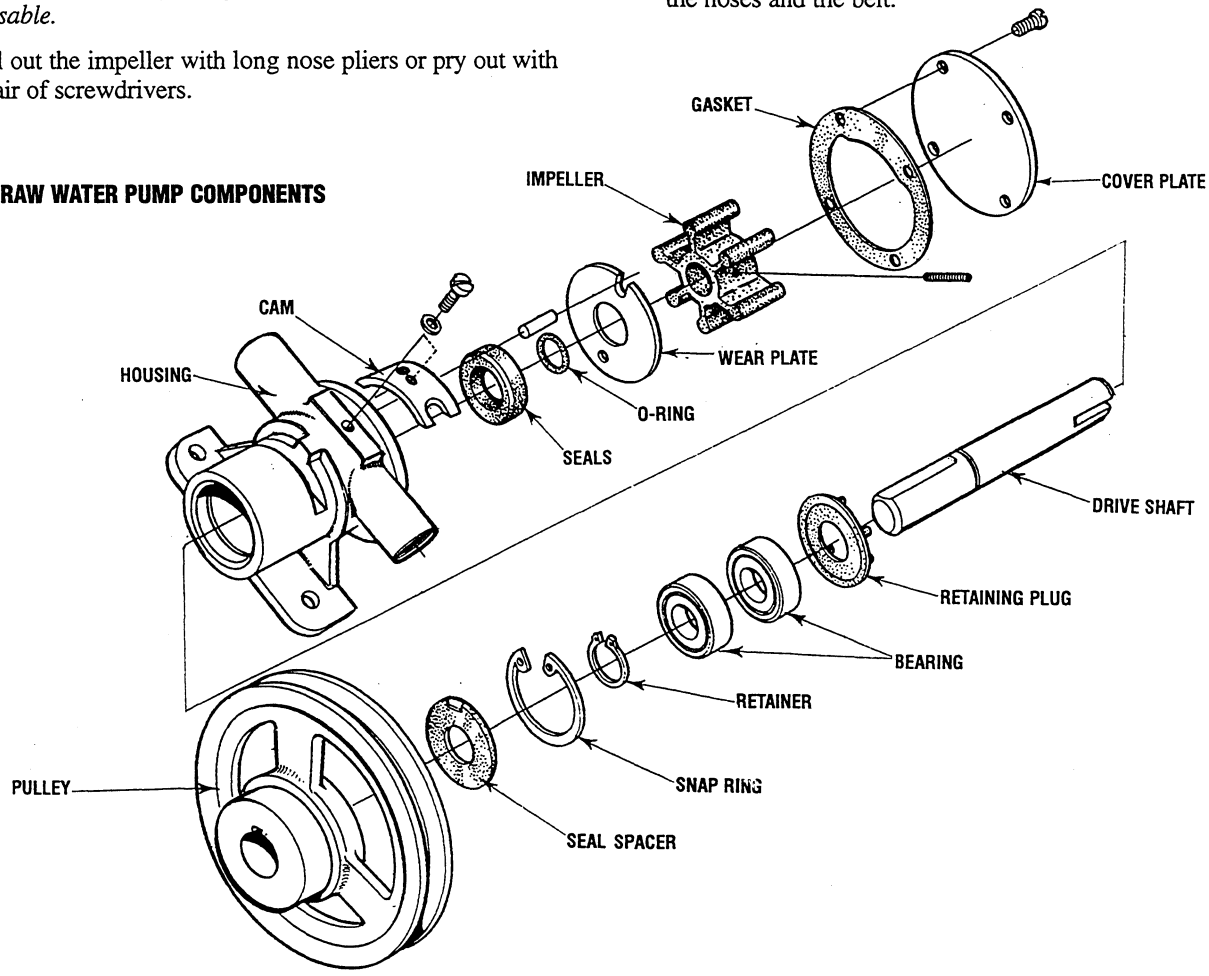
The pump, as removed from the engine, will have hose attachment nipples threaded into its inlet and outlet port. They may be left in place or removed if they interfere with the pump disassembly. Note the port location and positioning if removed.

1. Loosen the set screw with an allen wrench and remove the water pump pulley from the shaft.
2. Remove the four cover screws, the cover plate and the cover plate gasket.

   NOTE: *Replacement of the cover plate gasket is recommended; however, it you are going to reuse it, keep the gasket well lubricated until the pump is reassembled. If it's allowed to dry, the gasket will shrink and not be reusable.*
3. Pull out the impeller with long nose pliers or pry out with a pair of screwdrivers.
4. Remove the wear plate and the O-ring.
5. Remove the cam screw, washer, and cam.
6. Remove the bearing assembly, releasing the shaft, bearing and seal assembly. This will allow the bearings and seals to be disassembled for inspection.

   NOTE: *It may be necessary to use a drift and arbor press to press the bearing and seal assembly from the shaft.*
7. Inspect all parts and replace those showing wear or erosion.
8. Use the illustration to assist in reassembling the raw water pump.
   a. Apply a small amount of petroleum jelly to the seal's inner race and to the impeller shaft at reassembly.
   b. When positioning the cam in the housing use a small amount of Permatex #1 on the inner cam surface and cam screw heads; remove any excess from the impeller housing.
   c. Apply a light film of silicon or petroleum jelly to the inner surface of the housing for the impeller
9. When the pump is assembled, reposition and tighten the hose nipples. Assemble the pump to the engine and attach the hoses and the belt.

RAW WATER PUMP COMPONENTS



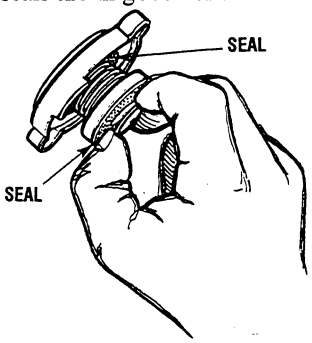
THERMOSTAT ASSEMBLY / FUEL PUMP

COOLANT RECOVERY TANK

Flush out the recovery tank and the hose that connects to the pressure cap assembly. Use a pipe cleaner or compressed air to clear the passage where the hose connects to the casting. Also clear the by-pass hose fittings. Replace the plastic tank and hose if it fails to pass inspection.

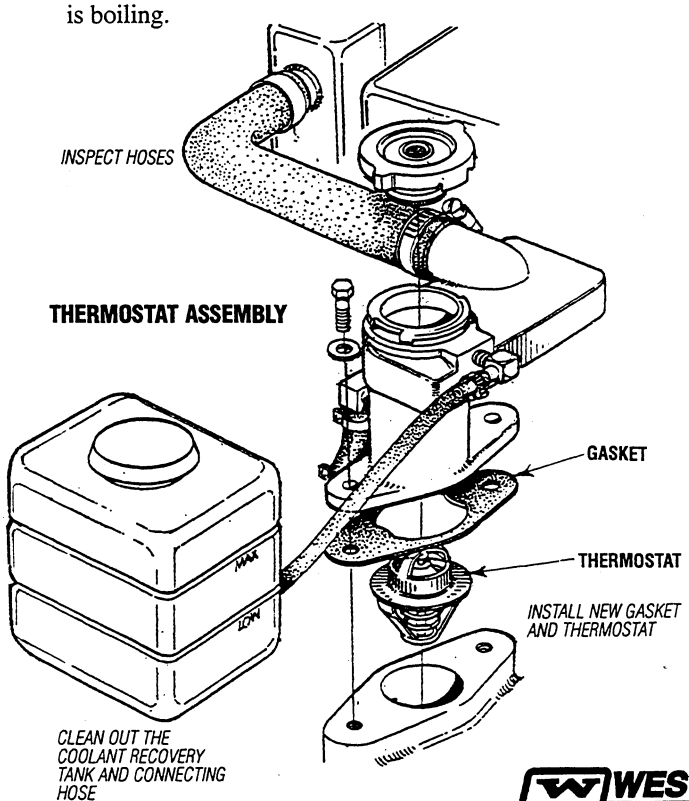
PRESSURE CAP

Check the manifold pressure cap. Open the valve by pulling it and make sure it closes when released. Make certain the upper and lower seals are in good condition. If any doubt, replace the cap.



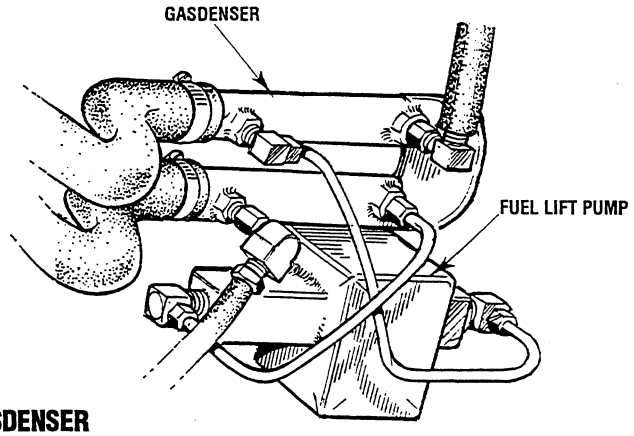
THERMOSTAT

1. Inspect the thermostat housing and housing gasket. Apply some sealant to the gasket when reassembling.
2. Install a new thermostat and gasket (the old thermostat can become a spare). When installing the new thermostat and gasket, apply a thin coat of sealant to both sides of the gasket.
3. A thermostat can be checked for proper operation by placing it in a pan of cold water and then raising the temperature of the water to a boil. The thermostat should open noticeably (with travel on the order of 1/4 - 1/2 in 0.0098 - 0.0197mm) and be fully opened when the water is boiling.



FUEL PUMP

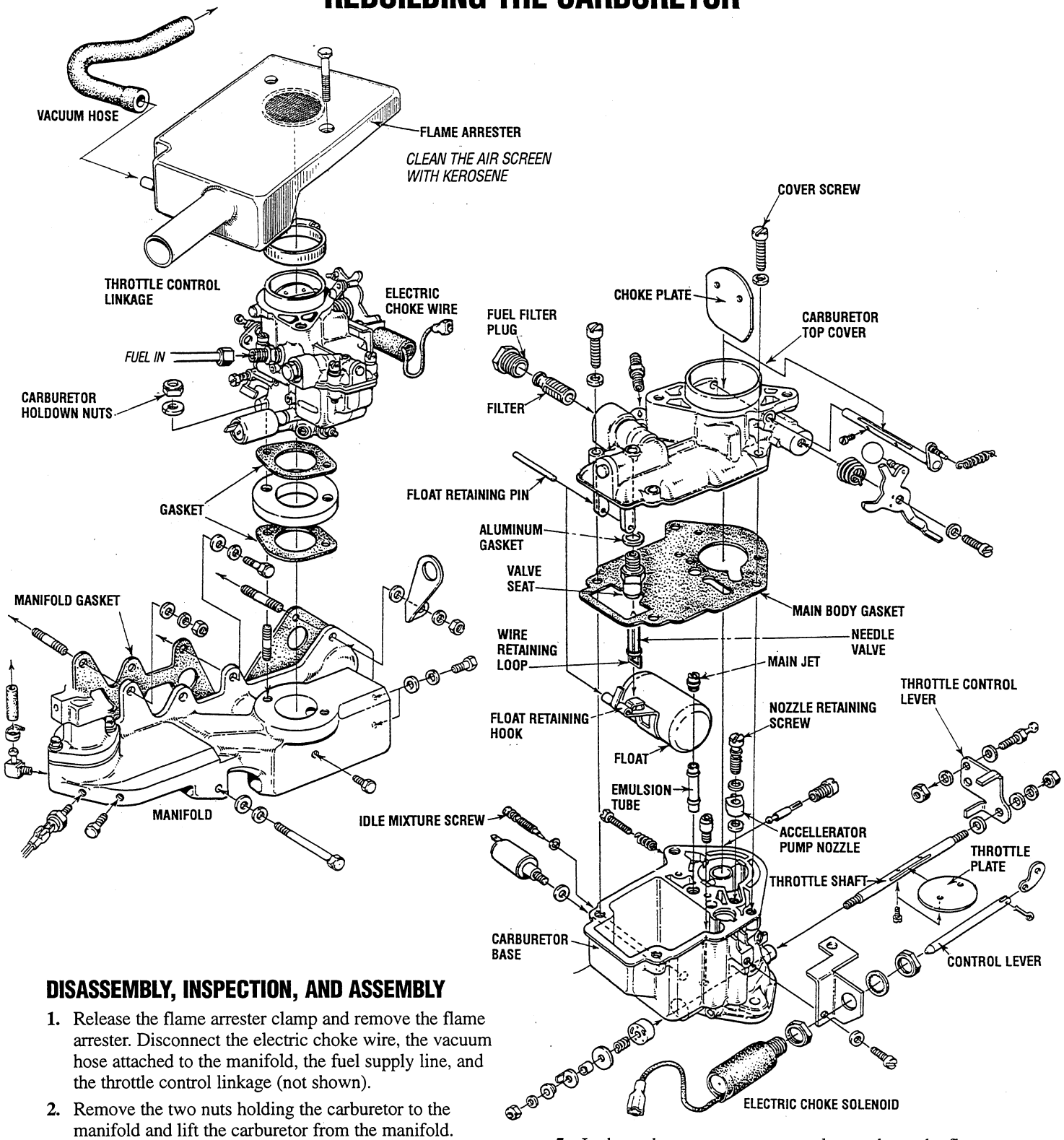
This solid state lift pump requires no maintenance. To test: simulate a start, the pump should produce a clicking sound indicating the piston in the pump is working. If no clicking is heard, check that 12 volts are present at the pump connection and the pump is grounded. If it fails to work, replace the pump.



GASDENSER

The gasdenser cools the fuel to prevent vapor lock, there is no maintenance required except making certain the fuel fittings are tight and secure.

REBUILDING THE CARBURETOR



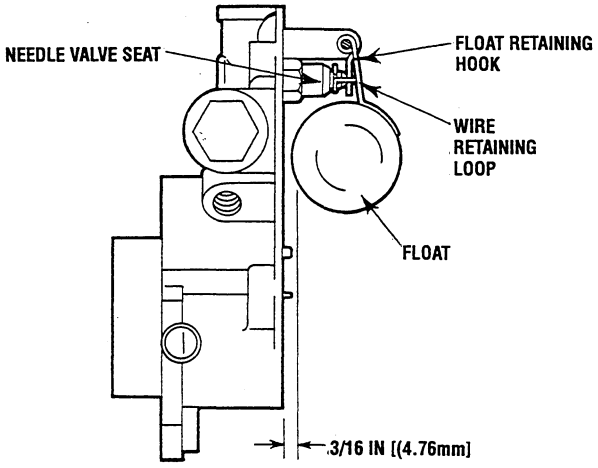
DISASSEMBLY, INSPECTION, AND ASSEMBLY

1. Release the flame arrester clamp and remove the flame arrester. Disconnect the electric choke wire, the vacuum hose attached to the manifold, the fuel supply line, and the throttle control linkage (not shown).
2. Remove the two nuts holding the carburetor to the manifold and lift the carburetor from the manifold.
3. Disconnect the vacuum hose. Remove the cotter pin from the electric choke control lever and remove the electric choke assembly.
4. Remove the four cover screws and washers. Lift the carburetor top cover straight up and away from the carburetor base.
5. In the carburetor top cover, gently punch out the float retaining pin in the opposite direction of the split side of the pivot bracket and remove the float. Make certain you catch the needle valve that hangs from the float retaining hook under the float pivot arm. Place the needle valve aside.
6. Remove the main body gasket.

REBUILDING THE CARBURETOR

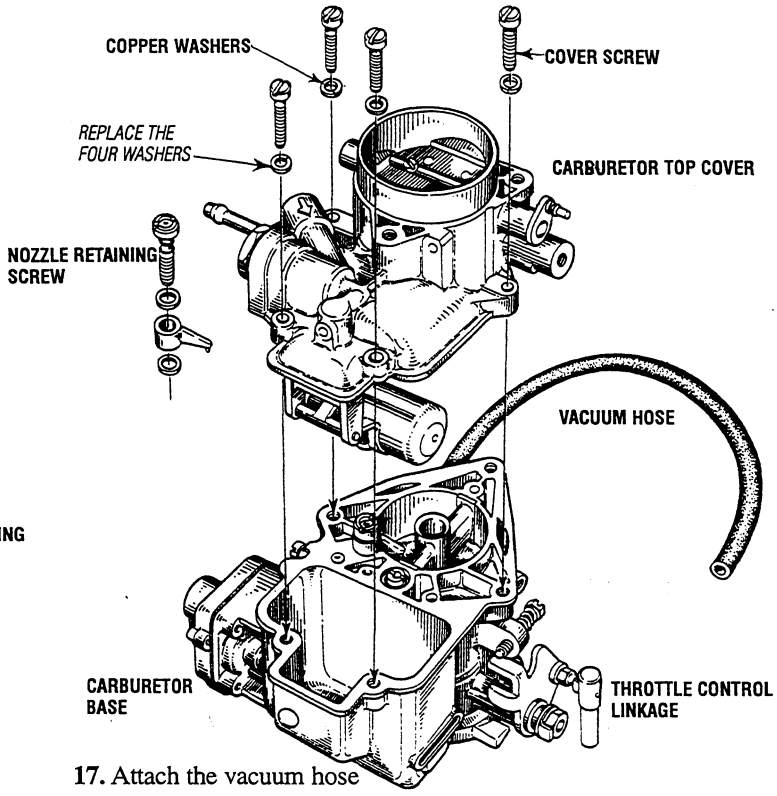
7. Shake the float. If you hear any sand like particles moving inside, replace the float.
8. Use a 10mm wrench and remove the needle valve seat. Make certain the seats aluminum gasket is also removed
9. Screw in a new seat and gasket.
10. Replace the main body gasket. Do not use any gasket sealer on the main body gasket.
11. Gently place the needle valve in the needle valve seat. Re-install the float and the float retaining pin so that the needle valves wire retaining loop hooks onto the floats retaining hook.
12. Check the float level distance from the housing mating surface with the housing held vertically.

DISTANCE FROM THE MATTING SURFACE **3/16 in (4.76mm)**

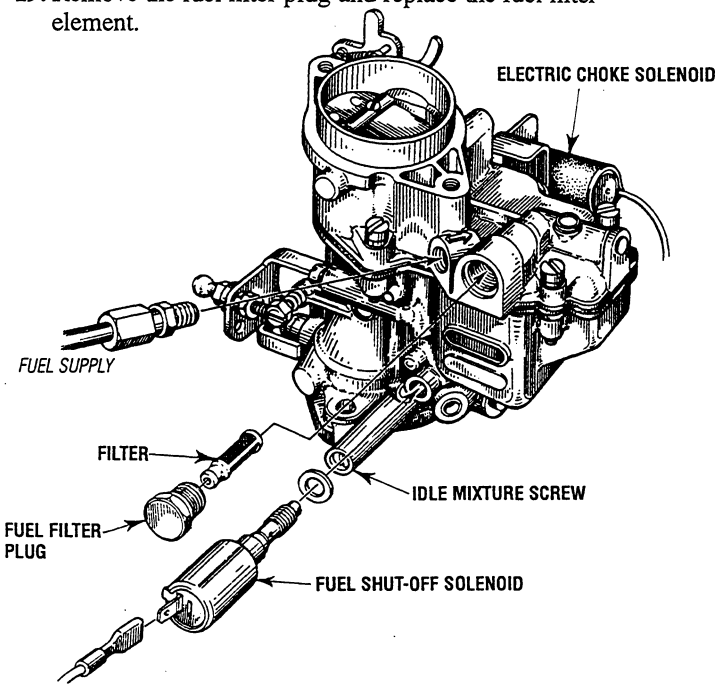


13. On the carburetor base, remove the retaining screw to the accelerator pump nozzle, the nozzle, and the two copper washers that fit above and below the nozzle.
14. Replace the two copper washers and reinstall the accelerator pump nozzle. Snug down the nozzles retaining screw. **Do not overtighten the screw.**

    NOTE: *With the carburetor disassembly, clean and inspect all the components, replace any damaged or worn parts.*
15. Place the carburetor top cover straight down on the carburetor base. Replace the four washers with new ones and hand tighten the four cover screws in the order shown. **Do not overtighten.**
16. Re-assemble the electric choke to the carburetor and replace the two choke assembly retaining screws and their washers. Re-attach the electric choke control lever and insert the cotter pin.



17. Attach the vacuum hose
18. Replace the idle mixture screw's O-ring, the rotary throttle shaft valve and the shaft valve spring.
19. Remove the fuel filter plug and replace the fuel filter element.



20. Make certain all the carburetor screws are properly tightened. Fasten the assembled carburetor on the intake manifold using new gaskets (use sealant). Replace the two nuts and washers and tighten the carburetor to the manifold.

CARBURETOR TO MANIFOLD TORQUE **12 - 14 ft-lbs (16 - 23 Nm)**

21. Reconnect the throttle control linkage, the fuel supply line, the vacuum hose, and the electric choke wire.
22. Replace the flame arrester on the carburetor and tighten the flame arrester clamp.

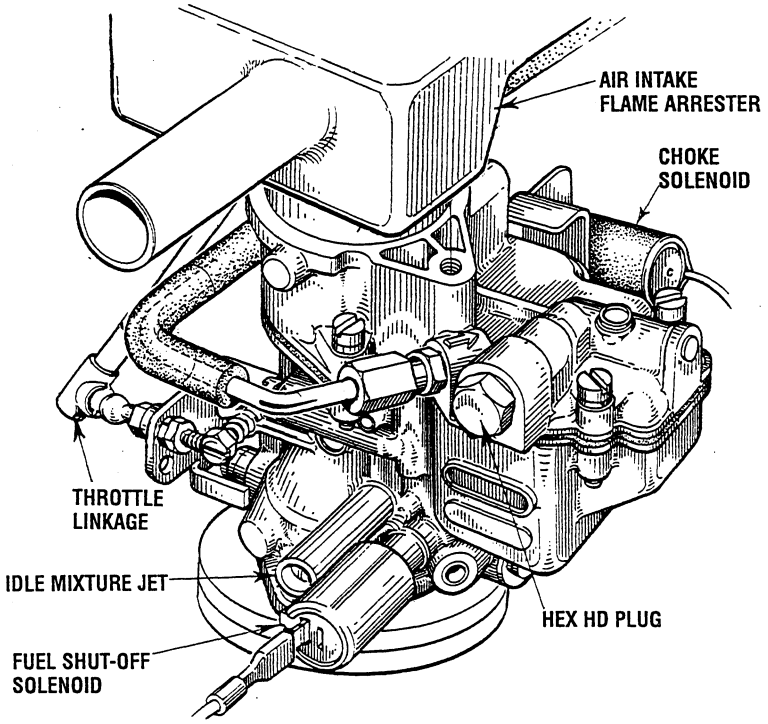
CARBURETOR ADJUSTMENT

Basic Jet Adjustment is performed with the generator operating. Screw the jet slowly in until it seats, then back it out 11/2 to 2 turns. This jet adjustment can be made in the 3600 rpm range to improve engine performance.

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

NOTE: *At idle speed, oil pressure will be lower than the rating of the oil pressure switch. Jump this switch to prevent engine shutdown at idle speed.*

Run Mixture Jet is presized at the factory and is not adjustable.

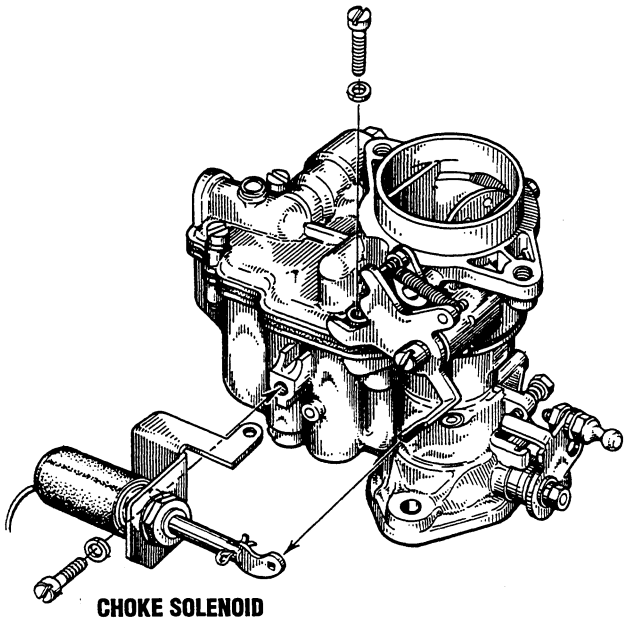


CHOKE SOLENOID

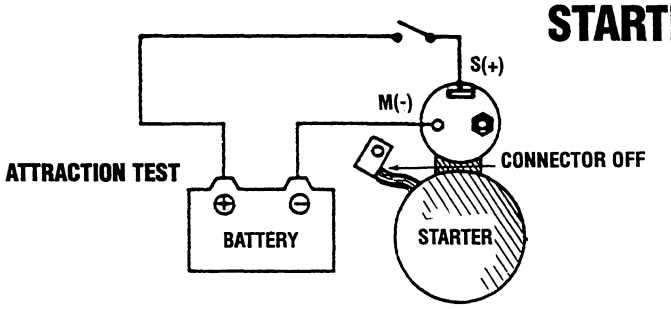
The choke solenoid is a 12 volt DC operated unit that functions to close the choke plate in the carburetor when the ON switch is depressed during engine start-up.

The choke solenoid de-energizes once the engine starts and the ON switch is released. Some unstable running may be present when the engine starts cold but should smooth out as the engine reaches operating temperature.

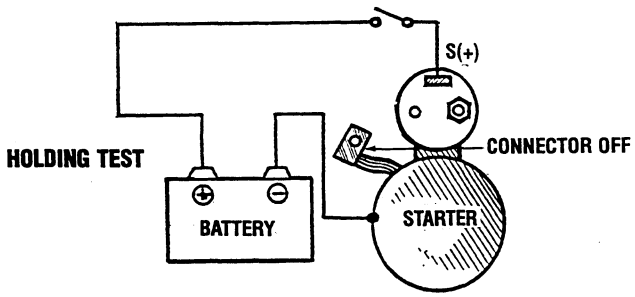
Keep this solenoid dry and periodically lubricate the linkage between the solenoid and the choke lever.



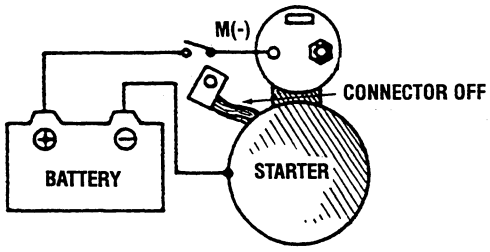
STARTER MOTOR



3. *Holding test.* With a battery connected to the solenoid terminal S (+) and to the starter body, manually pull out the pinion fully. The pinion must remain at that position even when released from holding with your hand.



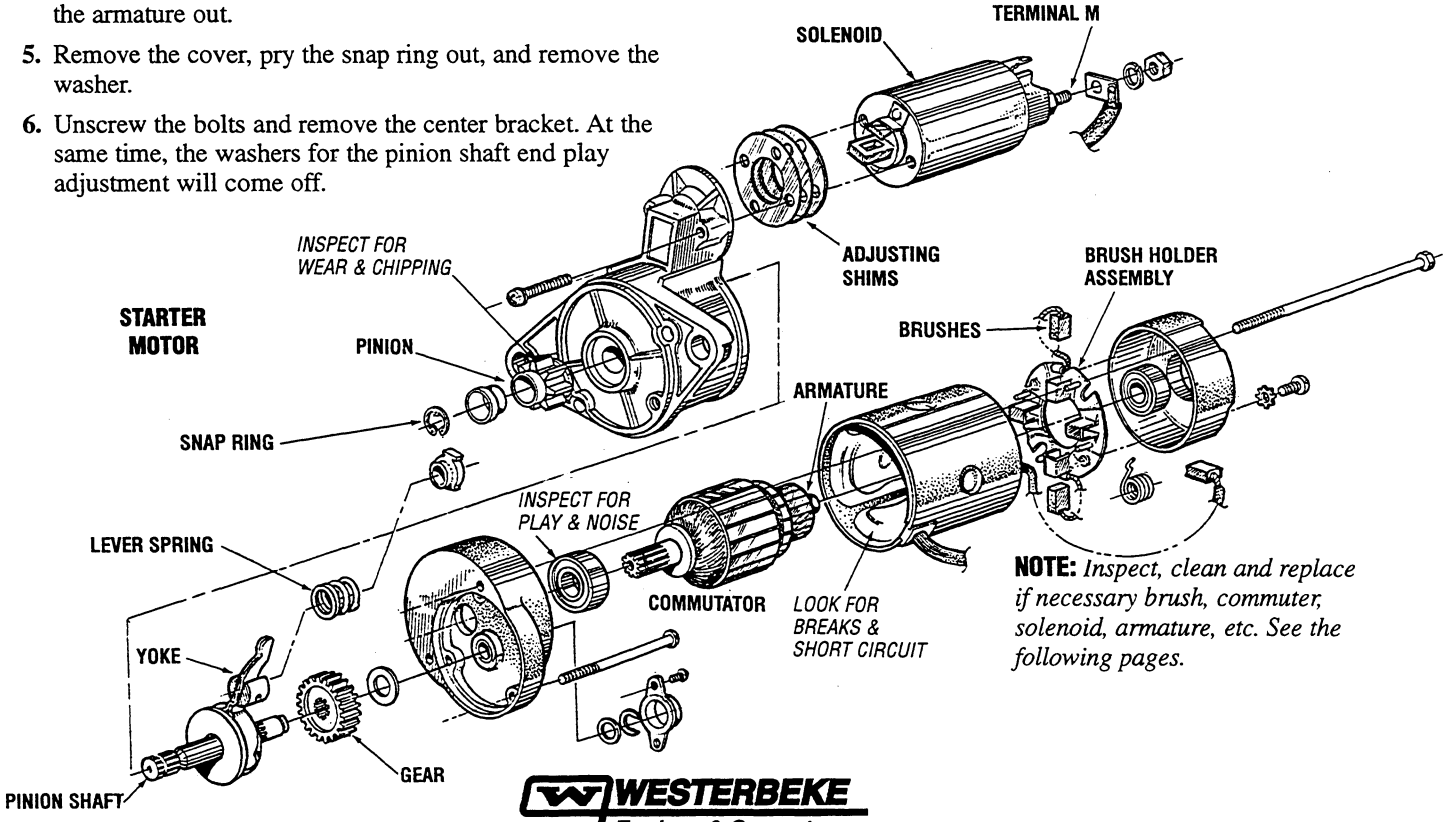
4. *Return test:*. With a battery connected to the solenoid terminal M (-) and to the starter body, manually pull out the pinion fully. The pinion must return to its original position when released from holding by hand.



RETURN TEST

STARTER DISASSEMBLY

1. Disconnect the wire from the solenoid terminal M (-).
2. Loosen the two screws fastening the solenoid. Remove the solenoid assembly.
3. Remove the two long through bolts and two screws fastening the brush holder. Remove the rear bracket.
4. With the brushes pulled away from the armature, remove the yoke and brush holder assembly. Then pull the armature out.
5. Remove the cover, pry the snap ring out, and remove the washer.
6. Unscrew the bolts and remove the center bracket. At the same time, the washers for the pinion shaft end play adjustment will come off.
7. Pull out the reduction gear lever and lever spring from the front bracket.
8. On the pinion side, pry the snap ring out, and pull out the pinion and pinion shaft.
9. At each end of the armature, remove the ball bearing with a bearing puller. It is impossible to replace the ball bearing press-fitted in the front bracket. If that bearing has worn off, replace the front bracket assembly.

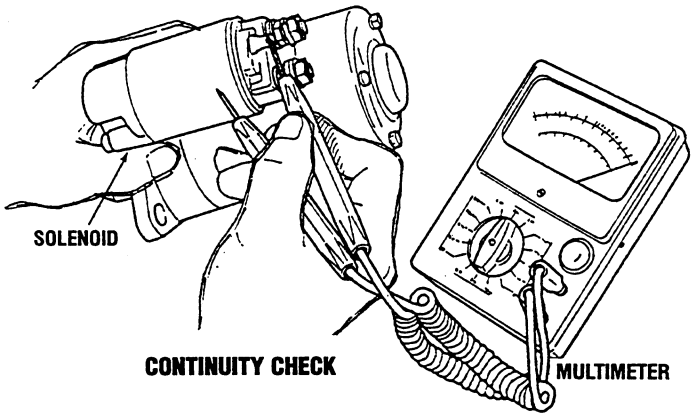


NOTE: *Inspect, clean and replace if necessary brush, commuter, solenoid, armature, etc. See the following pages.*

STARTER INSPECTION

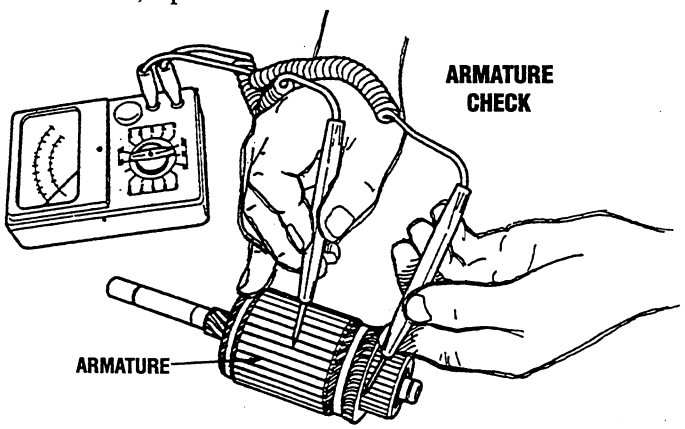
Solenoid

Inspect the solenoid for continuity between terminals S and M and between terminals S and body. No continuity should be found between S and M. Continuity should be found between S and the body and M and the body.

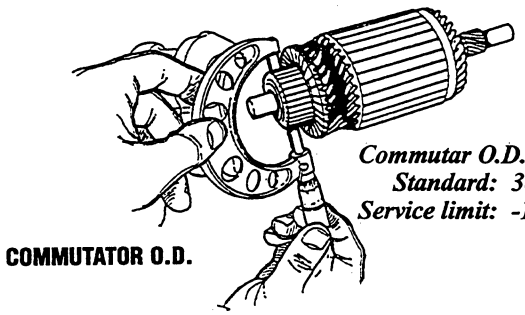


Inspecting The Armature

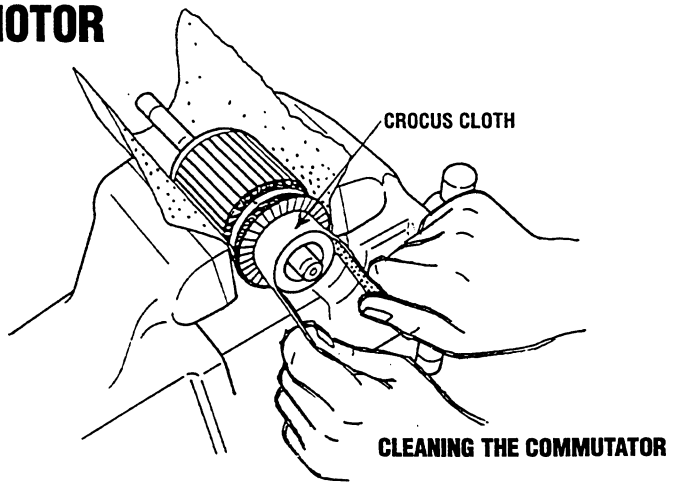
1. Check the armature with a growler tester. If it's short circuited, replace the armature. Also check for insulation between the communicator and its shaft. If poorly insulated, replace the armature.



2. Measure the commutator O.D. and the depth of undercut. Repair or replace it if the service limit is exceeded. Also check the commutator outside surface for dirtiness and roughness. If rough, polish the commutator with fine crocus cloth.



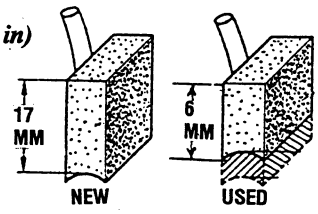
Commutar O.D. Standard
Standard: 38.7 mm (1.523 in)
Service limit: -1.0 mm (-0.039 in)



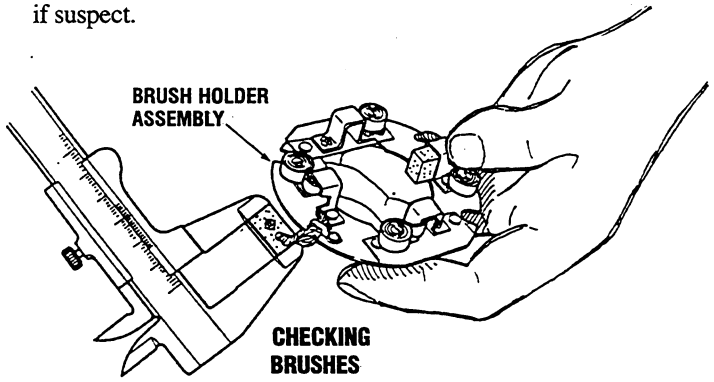
Brush and Brush Holder Inspection

1. Check the brushes. If worn out beyond the service limit, replace the brushes.

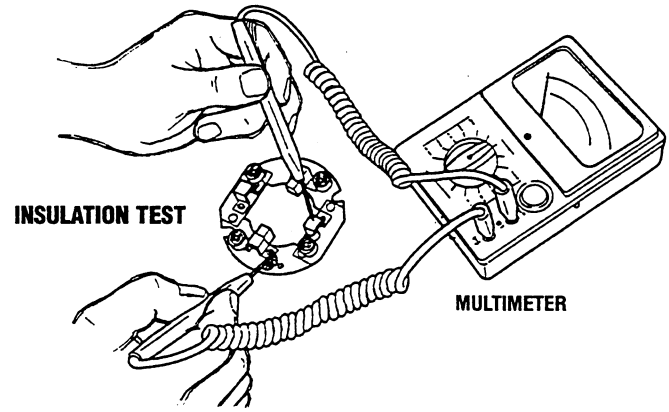
Brush Height
Standard 17 mm (o.669 in)
Limit 6 mm (0.236 in)



2. Check the brush spring tension. A weak or defective spring will cause excessive brush wear; replace the springs if suspect.

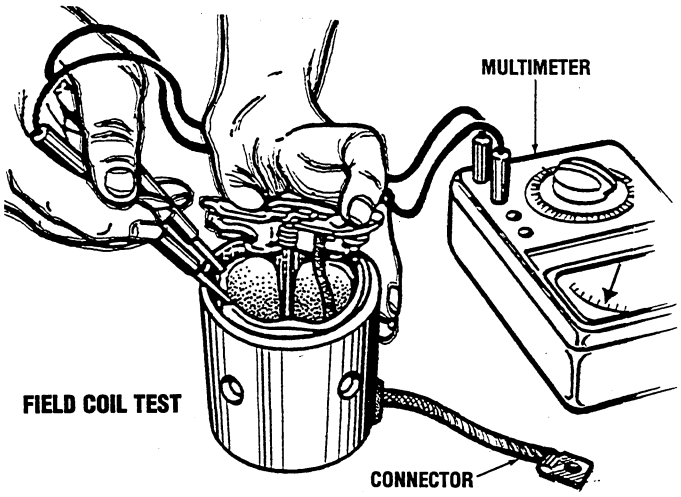


3. Check for insulation between the positive brush holder and holder base. If poorly insulated, replace the holder assembly. Also check the brush holders for proper staking.



Field Coil Inspection

1. Check for insulation between one end (brush) of the coil and yoke.
2. Check for continuity between both ends (brushes) of the coil
3. Check the poles and coil for tightness.



STARTER ADJUSTMENT AND REASSEMBLY

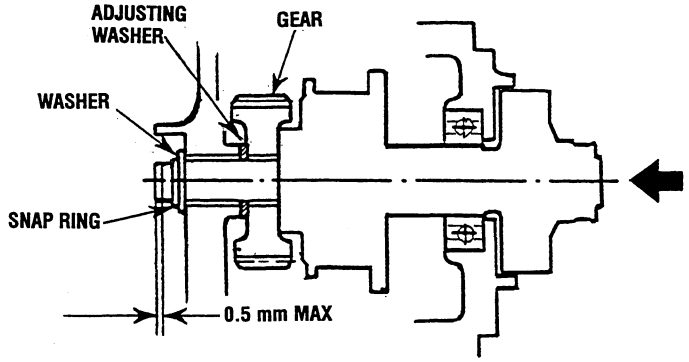
> ⚠ **CAUTION:** ***Before installing, thoroughly clean the starter flange and mounting surfaces, remove all oil, old paint, and rust. Starter performance largely depends on the quality of the wiring. Use wire of sufficient size and grade between the battery and starter and fully tighten to the terminal.***

Reassemble the starter assembly in the reverse order of disassembly, making sure of the following:

1. *Pinion shaft end play adjustment.* Set the end play (thrust gap) to between 0.5 to 2 mm by inserting an adjusting washer between the center bracket and the reduction gear.
   a. Fit the pinion shaft, reduction gear washer and snap ring to the center bracket.
   b. Measure end play by moving the pinion shaft in the axial direction. If the end play exceeds 0.5 mm, increase the number of adjusting washers inserted.
2. *Greasing.* Whenever the starter has been overhauled, apply grease to the following parts:
   a. Armature shaft gear and reduction gear.
   b. All bearings.
   c. Bearing shaft washers and snap rings.
   d. Bearing sleeves.
   e. Pinion.
   f. Sliding portion of lever.

> ⚠ **CAUTION:** ***Never smear the starter fitting surface, terminals, brushes, or commutator with grease.***

3. After reassembly, check by conducting a no-load test again.



PINION SHAFT END PLAY

ENGINE ADJUSTMENTS

NOTE: *WESTERBEKE recommends that the following engine adjustments be performed by a competent engine mechanic. The information below is provided to assist the mechanic.*

ENGINE SPEED (HERTZ) ADJUSTMENT

Governor

The belt-driven, mechanically operated governor maintains the engine's rpm under various load conditions. Engine speed determines the hertz and voltage output of the generator.

Governor Adjustments

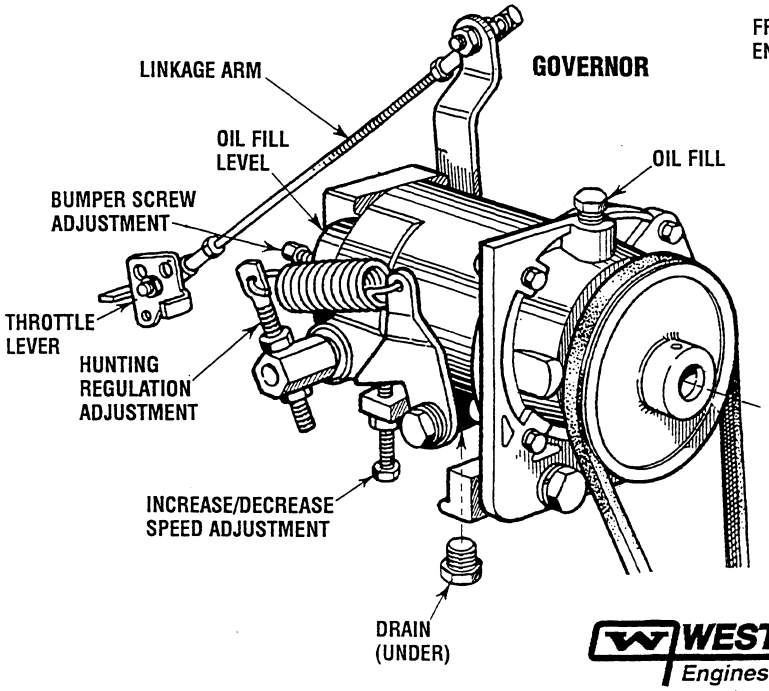
Operate the generator to bring the unit up to operating temperature before adjusting the governor.

NOTE: *If the governor is severely out of adjustment, manually adjust the linkage at no-load to obtain a safe output voltage before proceeding with the adjustment.*

There are three adjusting points on the governor (see illustration).

1. ***Increase/Decrease Speed Adjustment.*** This adjusting bolt sets the no-load speed of the engine. (The linkage arm between the governor arm and throttle lever should be adjusted to hold the throttle full open when the engine is not running.) Make sure this linkage moves freely and that the ball joint connectors are properly lubricated. Use graphite lube for this purpose. Disconnect the ball joint and apply graphite lube to the inside of the joint.
2. ***Hunting/Regulation Adjustment.*** If the variation in engine speed between no-load and full-load is too great, adjust this eye bolt to draw the spring closer to the lever hub. The increase/decrease speed bolt may need to be adjusted as well.

   If the governor surges under load, adjust this eye bolt to move the spring away from the lever hub (check speed adjustment).
3. ***Bumper Screw Adjustment.*** This screw is used to remove a no-load surge ONLY. *NEVER* turn the bumper screw into the governor so far that it increases the no-load speed.



Governor Maintenance

1. Periodically lubricate the linkage arm attaching points at the governor arm and throttle lever. Use a graphite lubricant or equivalent.

   NOTE: *Free movement of this linkage arm is important for proper governor/throttle operation.*
2. Governor oil capacity – 3 ounces 10/30 engine oil.

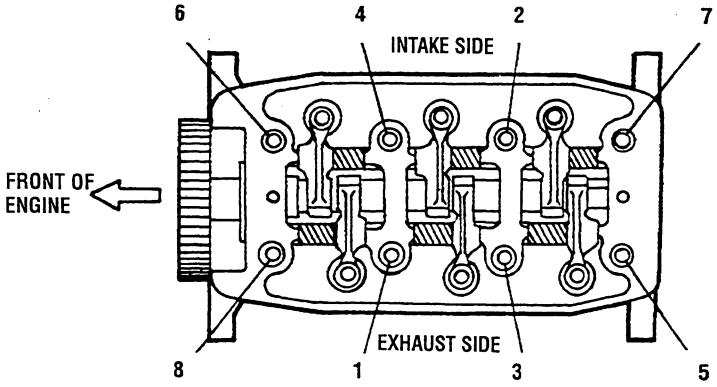
   NOTE: *Do not overfill the governor.*
3. Change the governor oil every 250 hours of operation.

   To change the oil, remove the governor from the engine, remove the oil fill and the fill level plug, and drain all the oil. Reinstall on the engine and fill with 3 ounces of 10/30 engine oil. Replace the plugs.
4. Periodically adjust the governor belt tension (see *DRIVE BELTS ADJUSTMENT*). Since belts stretch slightly, this stretching will, to some degree, affect the govenor's action.

TORQUING THE CYLINDER HEAD BOLTS

After the initial break-in period (approximately 50 hours), the cylinder head bolts should be re-torqued.

Tighten the cylinder head bolts according to the sequence shown. Make sure the engine is cold when this is done, and loosen one head bolt one-half turn and then tighten it between 43 - 51 lb-ft (60 - 70 Nm). Then proceed to the next head bolt in the sequence. Tighten the RS (rocker cover stud) securely.



ENGINE ADJUSTMENTS

SPARK PLUGS

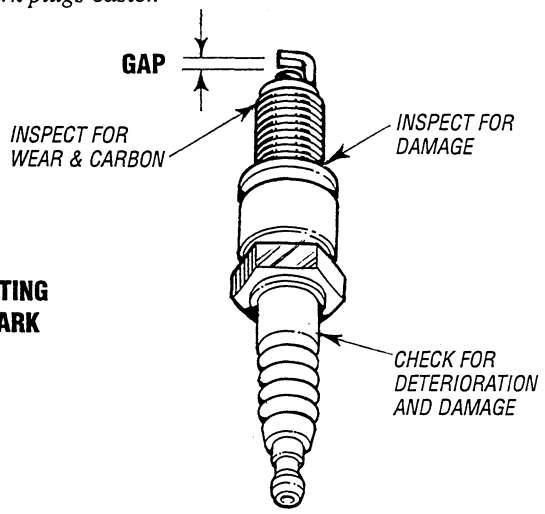
The spark plugs should be cleaned and regapped after the first 50 hour break-in period, then inspected every 250 hours thereafter and replaced as needed.

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

Spark plug gap: 0.031 +/– 0.0002 in. (0.8 – 0.05 mm).

Spark plug torque: 10 – 15 lb-ft (1.5 – 2.31 kg-m).

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

DRIVE BELT ADJUSTMENT

The drive belt must be properly tensioned. Excessive drive belt tension can cause rapid wear of the belt and reduce the service life of the fresh water pump's bearing. A slack belt or the presence of oil on the belt can cause belt slipping, resulting in high operating temperatures.

The BCGB generator has two drive belts, one drives the governor and alternator and the other drives the raw water pump. The tension adjustment procedure for both belts is as follows:

1. Remove the belt guard.
2. To adjust the governor drive belt, loosen the two governor mounting bolts.

   To adjust the raw water pump/fresh water pump drive belt, loosen the two raw water pump mounting bolts.
3. With the belt(s) loose, inspect for wear, cracks and frayed edges, and replace if necessary.
4. To loosen or tighten the governor drive belt, slide the governor in or out as required, then retighten its mounting bolts.

   To loosen or tighten the raw water pump/fresh water pump drive belt, slide the raw water pump in or out as required, then retighten its mounting bolts.
5. The drive belts are properly adjusted if it can be deflected no less than 3/8 inch (10mm) and no more than 1/2 inch (12mm) as the belt is depressed with the thumb at the midpoint between the two pulleys on the longest span of the belt.

   NOTE: *Maintain a 22 lb pressure to the belt's outer face for proper belt operation. Spare belts should always be carried on board.*

> **⚠ WARNING:** ***Never attempt to check or adjust a drive belt's tension while the engine is in operation.***

6. Operate the generator for about 5 minutes, then shut down the generator and recheck the belt(s) tension.
7. Replace the belt guard.

ENGINE ADJUSTMENTS

NOTE: *WESTERBEKE recommends that the following engine adjustments be performed by a competent engine mechanic. The information below is provided to assist the mechanic.*

VALVE CLEARANCE ADJUSTMENT

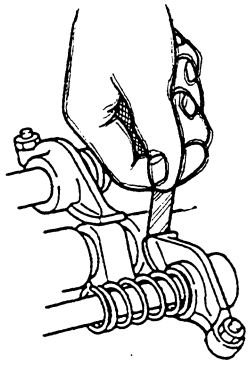
NOTE: *Retorque the cylinder head bolts before adjusting the engine's valves (see TORQUING THE CYLINDER HEAD BOLTS).*

1. Remove the rocker cover and gasket.
2. Rotate the crankshaft in the normal direction of rotation, placing the No. 1 piston at the top of its compression stroke with the exhaust and intake valves completely closed. Adjust the intake and exhaust valves for No. 1 cylinder, the exhaust valve for No. 2 cylinder, and the intake valve for No. 3 cylinder (see chart).
3. Rotate the crankshaft 180° in its normal direction of rotation. Locate the piston in No. 1 cylinder at the top of its exhaust stroke. Adjust the intake valve for No. 2 cylinder and the exhaust valve for No. 3 cylinder (see chart).

CRANK ANGLE		CYLINDER #		
		1	2	3
When No. 1 piston is set at top of compression stroke	IN	●		●
	EX	●	●	
When No. 1 piston is positioned at top of exhaust stroke	IN		●	
	EX			●

4.. Replace the rocker cover along with a new rocker cover gasket..

Rocker cover torque: 2.9–5.1 lb-ft (4 - 7 Nm)



VALVE CLEARANCE

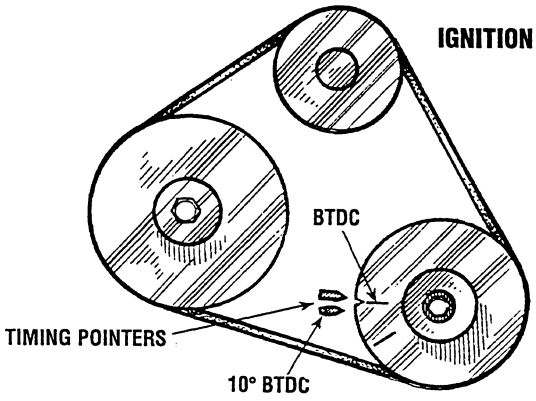
Valve Clearance: **Intake** **0.20mm (.008 inches)**
Exhaust **0.30mm (.0012 inches)**

IGNITION TIMING

1. Attach a timing light to the #1 spark plug and mark the front timing pointer to indicate 15°. Locate the timing mark on the crankshaft pulley and mark it with white chalk or a crayon.
2. Start the engine and warm it up to its normal operating temperature. Make sure the generator is operating ***without a load on it.***
3. Using the timing light, align the timing mark in the front crankshaft pulley so it is just slightly before the first timing pointer. Do this by loosening and slowly rotating the distributor body. Use the following timing specifications:

Timing Specifications: 15° ± .5° BTDC at 1800 rpm
(no load on generator)

IGNITION TIMING

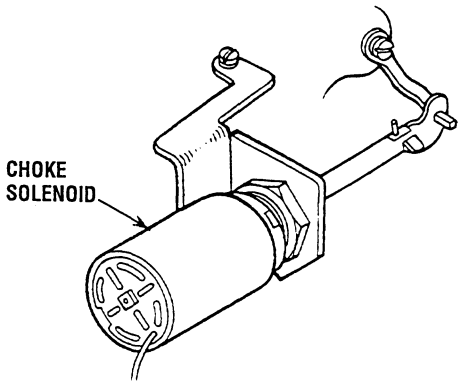


CHOKE SOLENOID

The choke solenoid is a 12 volt DC operated unit that functions to close the choke plate in the carburetor when the ON switch is depressed during engine start-up.

The choke solenoid de-energises once the engine starts and the ON switch is released. Some unstable running may be present when the engine starts cold but should smooth out as the engine reaches operating temperature.

Keep this solenoid dry and periodically lubricate the linkage between the solenoid and the choke lever.



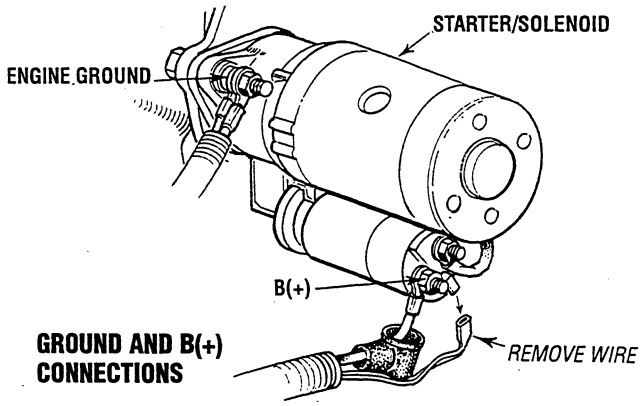
COMPONENT TESTING

NOTE: *WESTERBEKE recommends that the following engine testing adjustments be performed by a competent technician.*

GENERAL

All DC voltage measurements are made to the engine battery negative ground point unless specified otherwise. In making test measurements, make sure that a good ground for the meter is established, preferably the point where the negative battery is connected to the engine. Battery positive voltage is indicated as B+ and should measure no less than 11.5 volts.

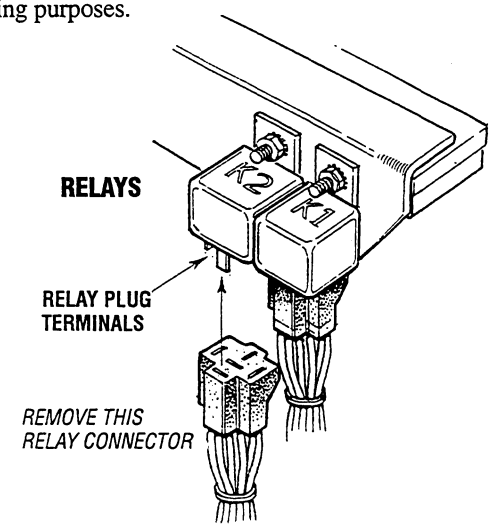
AC voltage measurements should be made with a true RMS AC meter to insure measurement accuracy.

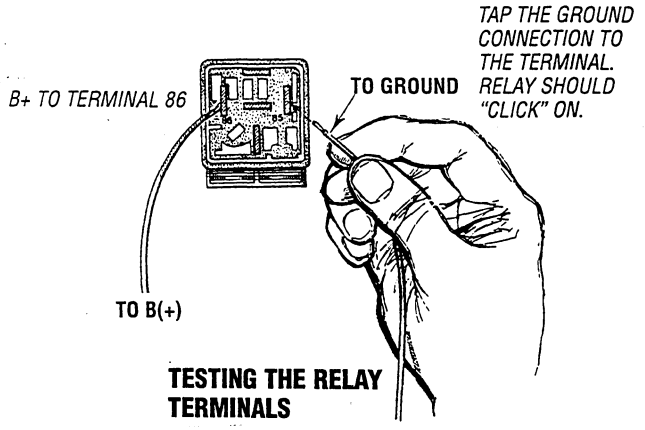


GROUND AND B(+) CONNECTIONS

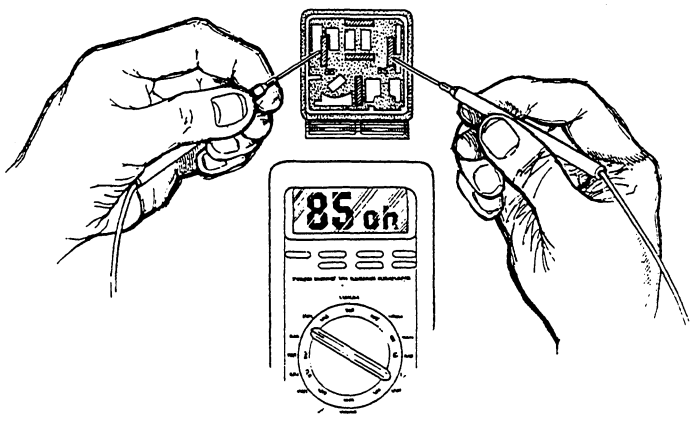
RELAYS

The relays used in the control system have coils which are polarized by the fact that they have internal free wheeling suppression diodes across them. Relay coil terminal 86 must be maintained (+), terminal 85(–). The relay coil is rated 12V DC, and the coil resistance is typically 85 ohms. With B+ on terminal 86, direct grounding of terminal 85 is permissible for testing purposes.





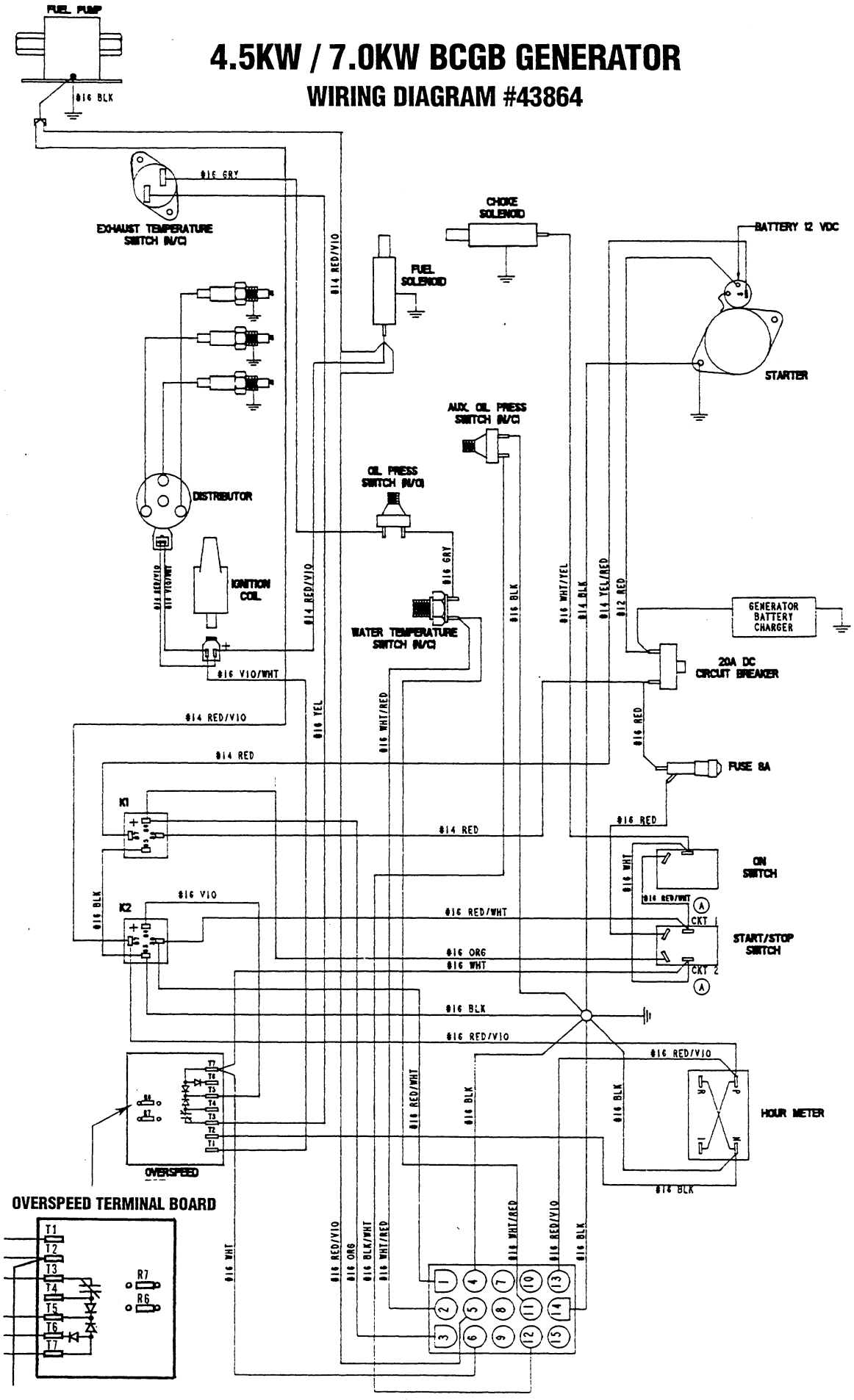
TESTING THE RELAY TERMINALS



TESTING COIL RESISTANCE

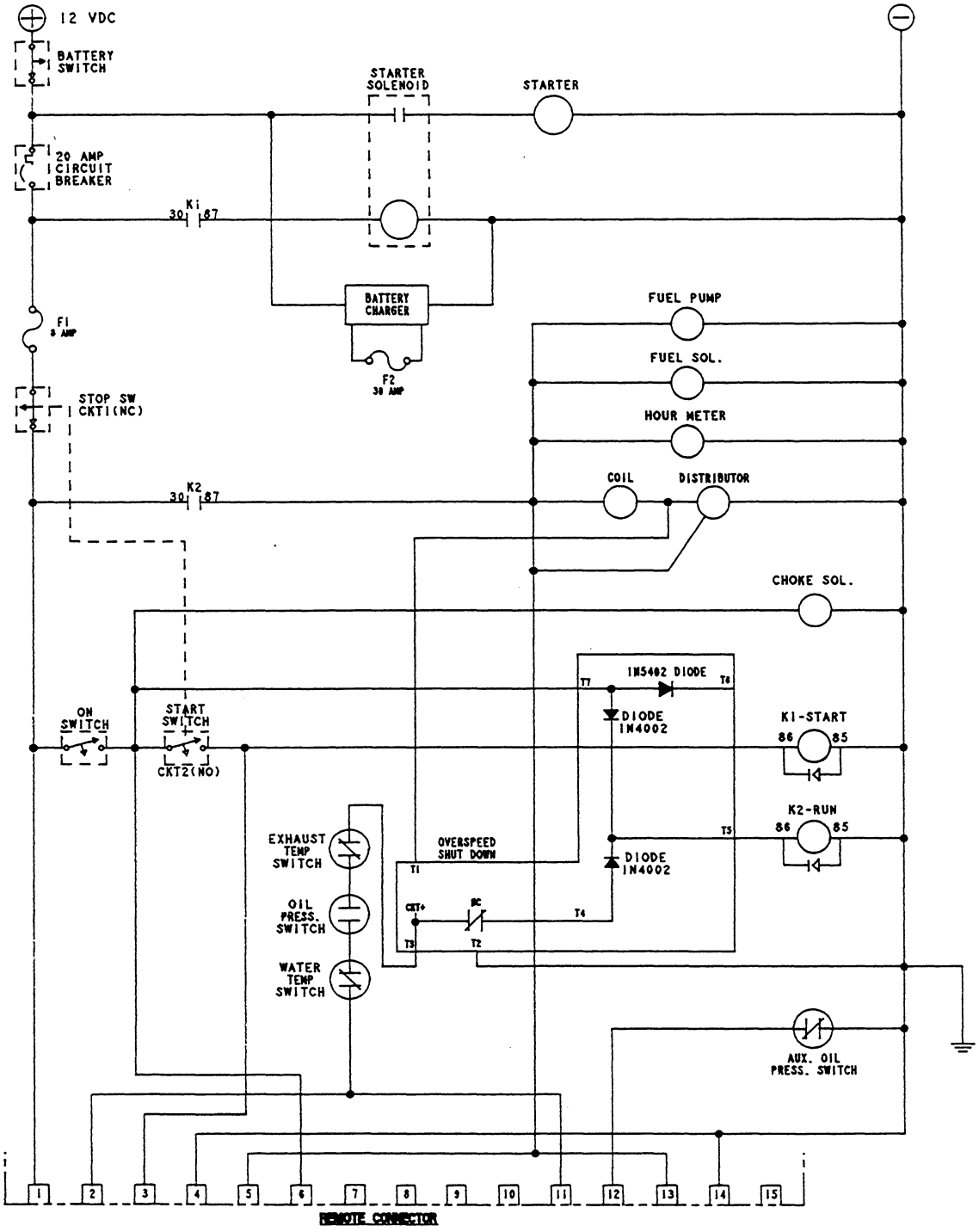
4.5KW / 7.0KW BCGB GENERATOR

WIRING DIAGRAM #43864



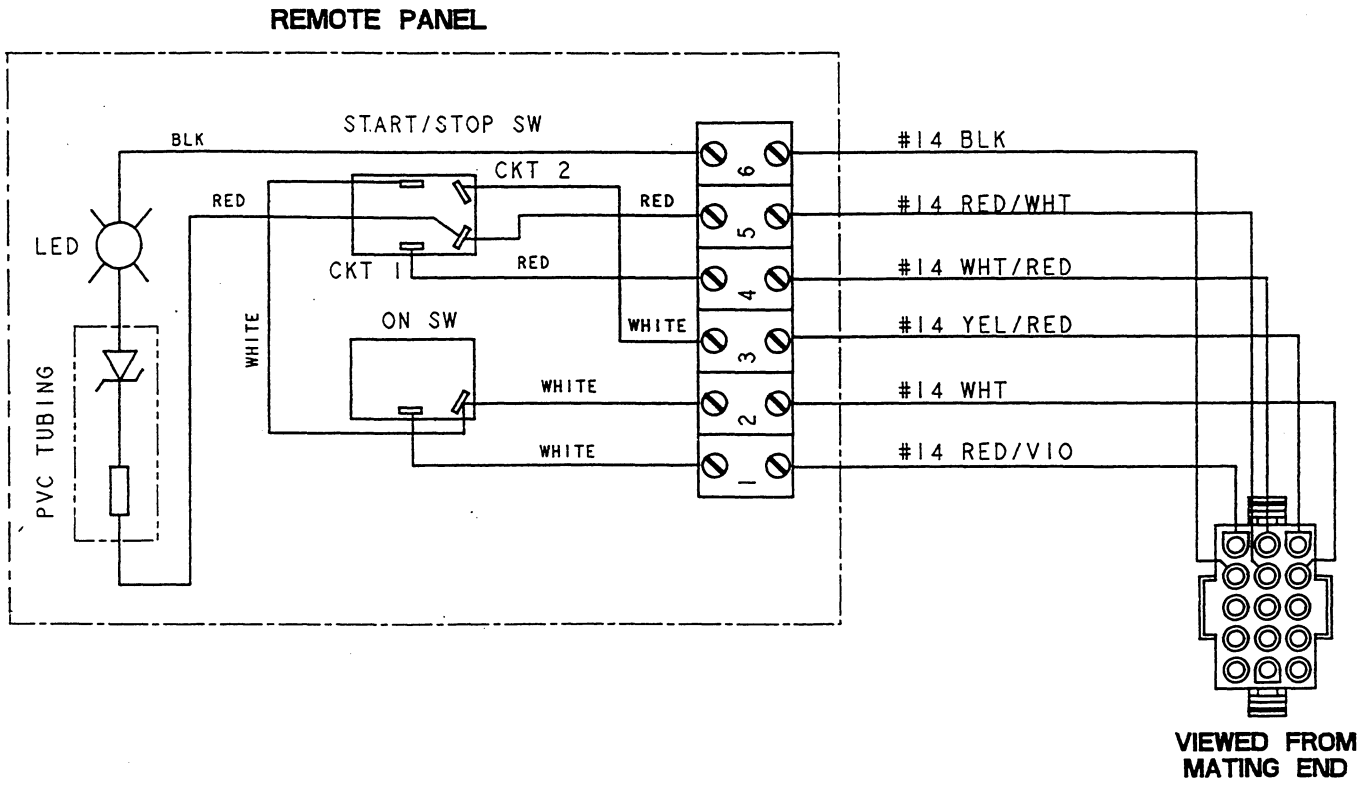
4.5KW / 7.0KW BCGB GENERATOR

WIRING SCHEMATIC #43864



REMOTE PANEL WIRING

SCHEMATIC #043912



SERVICE DATA / STANDARDS AND LIMITS - BCGB ENGINE/GENERATOR

Component	Specified Value / Standard inches(mm)	Repair Limit inches(mm)
FRONT CASE/COUNTERBALANCE SHAFT		
Oil Pump Side Clearance		
Driven Gear	0.0024-0.0047 (0.06-0.12)	
Drive Gear	0.0027-0.0051 (0.07-0.13)	
Counterbalance Shaft Front Journal Diameter		
. .	0.7869-0.7874 (19.987-20.000)	
Counterbalance Shaft Rear Journal Diameter		
. .	1.7317-1.7322 (43.984-44.000)	
Counterbalance Shaft Front Journal Oil Clearance		
. .	0.0014 - 0.0027 (0.035 - 0.068)	
Counterbalance Shaft Rear Journal Oil Clearance		
. .	0.0014 - 0.0028 (0.035 - 0.071)	
CYLINDER BLOCK		
Cylinder Bore	2.5591-2.5602 (65.00-65.03)	
Out-of-Roundness and Taper of Cylinder Bore	0.0004 (less than 0.05)	
Gasket Surface Flatness	0.0020 (less than 0.05)	0.0039 (0.1)
CYLINDER HEAD		
Flatness of Gasket Surface	0..0019 (Less than 0.05)	0.0079 (0.2)
Overall Height	4.287-4.295 (108.9-109.1)	
Cylinder Head oversize rework dimension of valve seat hole		
Intake 0.3 O.S.	1.2323 - 1.2333 (31.300 - 3.325)	
Intake 0.6 O.S.	1.2441 - 1.2451 (31.600 - 31.625)	
Exhaust 0.3 O.S.	1.1535 - 1.1544 (29.300 - 29.321)	
Exhaust 0.6 O.S.	1.1653 - 1.1662 (29.600 - 29.621)	
Cylinder Head rework of valve guide hole (both intake and exhaust)		
0.05 O.S.	0.4744 - 0.4751 (12.050 - 12.068)	
0.25 O.S.	0.4823 - 0.4830 (12.250 - 12.268)	
0.50 O.S.	0.4921 - 0.4928 (12.500 - 12.518)	
Intake Valve Seat Angle.	45°	
Exhaust Valve Seat Angle.	30°	
Intake Valve Seat Width	0.079 (2.0)	0.004 (0.1)
Exhaust Valve Seat Width	0.079 (2.0)	0.004 (0.1)
Valve Clearance		
Exhaust	0.012 (0.30)	
Intake	0.008 (0.20)	
Valve Head Thickness (margin)		
(Intake)	039 (1.0)	020 (.5)
(Exhaust)	051 (1.3)	031 (8)
Valve Length		
(Intake)	3.960 (100.6)	
(Exhaust)	3.968 (100.8)	
Valve Stem O.D.		
Intake	0.2585 - 0.2591 (6.565 - 6.580)	
Exhaust	0.2571 - 0.2579 (6.530 - 6.550)	
Stem to Guide Clearance		
Intake	0.0008 - 0.0020 (0.02 - 0.05)	0.0039 (0.10)
Exhaust	0.0020 - 0.0033 (0.0050 - 0.0085)	0.0059 (0.15)
Valve Guide Length		
(Intake)	1.73 (44)	
(Exhaust)	1.949 (49.5)	

Component	Specified Value / Standard inches(mm)	Repair Limit inches(mm)
VALVES		
Valve Guide Service Size	0.05, 0.25, 0.50 oversize	
Valve Seat Width of Seat Contact	035-.051 (0.9-1.3)	
Valve Seat Angle	30°/44°/65°	
Valve Seat Sink		0.008 (0.2)
Valve Spring Free Length	1.823 (46.3)	1.783 (45.3)
Valve Spring Load/Installed Height lbs./in (N/mm)	46/1.48 (210/37.7)	
Squareness	less than 2°	4°
TIMING BELT		
. .	47 (12)	
ROCKER ARM		
Camshaft Height		
No. 1 (Intake)	1.3815 (35.09)	1.3618 (34.59)
No. 2 (Intake)	1.3807 (35.07)	1.3610 (34.57)
No. 3 (Intake)	1.3803 (35.06)	1.3606 (34.56)
No. 1 (Exhaust)	1.3839 (35.15)	1.3642 (34.65)
No. 2 (Exhaust)	1.3831 (35.13)	1.3634 (34.63)
No. 3 (Exhaust)	1.3854 (35.190)	1.3657 (34.69)
Camshaft Journal Diameter	1.6118-1.6124(40.940-40.955)	
Bearing Oil Clearance	0.0018-0.0033 (.45-0.085)	
End Play	0024-.0055 (.06-.14)	118 (.03)
Rocker Shaft Length	9.134 (232)	
Rocker Arm Shaft		
Outer Diameter	0.6687 - 0.6692 (16.985 - 16.998)	
Clearance	0.0005 - 0.0017 (0.012 - 0.043)	0.004 (0.1)
PISTON AND CONNECTING ROD		
Piston Outer Diameter	2.5579-2.5591 (64.97-65.00)	
Piston to Cylinder Clearance		
. .	0.0008 - 0.0016 (0.02 - 0.04)	
Piston Ring Grove Width		
No.1	0.0480 - 0.0488 (1.22 - 1.24)	
No.2	0.0476 - 0.0484 (1.21 - 1.23)	
Oil	0.1108 - 0.1116 (2.815 - 2.835	
Piston Service Size	0.25, 0.50, 0.75, 1.00 OS	
Piston Ring End Gap		
No.1	0.0059 - 0.0118 (0.15 - 0.30)	0.0315 (0.8)
No.2	0.0138 - 0.0197 (0.35 - 0.50)	0.0315 (0.8)
Oil	0.008 - 0.028 (0.2 - 0.7)	0.0394 (1.0)
Piston Side Clearance		
No.1	0.0012 - 0.0028 (0.03 - 0.07)	0.0047 (0.12)
No.2	0.0008 - 0.0024 (0.02 - 0.06)	0.0039 (0.10)
Piston Pin O.D.	0.6300 - 0.6302 (16.001 - 16.007)	
Piston Pin Press-in Load lbs(N)		
. .	1102 - 3307 (5000 - 15000)	
End Play	0.0059 - 0.0118 (0.15 - 0.28)	

SERVICE DATA / STANDARDS AND LIMITS - BCGB ENGINE/GENERATOR

Component	Specified Value / Standard inches(mm)	Repair Limit inches(mm)

PISTON AND CONNECTING ROD

Piston Pin Press-in temperature
. . ..ordinary temperature

Connecting Rod Center length
. . ..4.0138 4.0178 (101.95 - 102.05)

Parallelism between Big End and Small End
. . ..0.004 (0.05)

Connecting Rod Twist.....0.004 (0.1)

Connecting Rod Big End to Crankshaft Side Clearance
. . ..0.0039 - 0.0098 (0.10 - 0.25).....0.16 (0.4)

Component	Specified Value / Standard inches(mm)	Repair Limit inches(mm)

CRANKSHAFT, BEARING

Crankshaft End Play.....0.0020 - 0.0098 (0.05 - 0.25) .....

Crankshaft Journal O.D. ..1.5740 - 1.5748 (39.98 - 40.0)

Crankshaft Pin O.D. .....1.4165 - 1.4173 (35.98 - 36.00)

Cylindericity of Journal and Pin
. . ..Less than 0.0002 (0.005)

Concentricity of Journal and Pin
. . ..Less than 0.0006 (0.015)

Oil Clearance of Journal
. . ..0.0008 - 0.0018 (0.021 - 0.045).....0.0039 (0.1)

Oil Clearance of Pin .....0.0009 - 0.0020 (0.022 - 0.052)

Undersize rework dimension of Journal
0.25 U.S. .....1.5644 - 1.5650 (39.735 - 39.750)
0.50 U.S. .....1.5545 - 1.5551 (39.485 - 39.500)
0.75 U.S. .....1.5447 - 1.54539 (39.235 - 39.250)

Undersize rework of dimension of pin
0.25 U.S. .....1.4069 - 1.4075 (35.735 - 39.750)
0.50 U.S. .....1.3970 - 1.3976 (35.485 - 35.500)
0.75 U.S. .....1.3872 - 1.3878 (35.235 - 35.250)

ENGINE HARDWARE TORQUES

Timing Belt	Nm	ft. lbs.
Crankshaft bolt	135-145	98-105
Timing belt cover bolts	10-12	7-9
Camshaft sprocket bolts	80-100	58-72
Oil pump sprocket nuts	50-57	36-41
Timing tensioner nuts	22-30	16-22
Timing belt rear cover bolts	10-12	7-9
Rocker Arms and Rocker Shaft		
Rocker cover shaft	29-35	21-25
Camshaft thrust plate bolt	10-12	7-9
Rocker arm adjust nut	8-10	6-7
Cylinder Head, Valve		
Cylinder head bolt (cold engine)	60-70	43-51
Spark plug	15.2	10.8
Rocket cover	12-13	9-10
Miscellaneous		
Coolant temperature sender	12-18	9-13
Coolant temperature switch	12-18	9-13
Generator mounts	34-47	23-34
Exhaust manifold	16-23	12-17
Thermostat housing	8-11	6-8
Carburetor to manifold	16-23	12-17

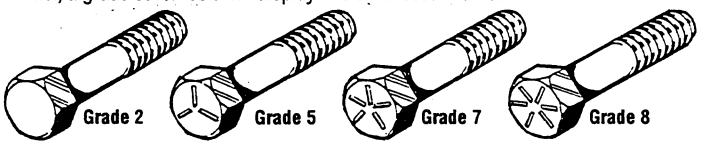
Front Case, Counterbalance Shaft	Nm	ft. lbs.
Front case bolts	8-10	6-7
Oil pump cover bolts	8-10	6-7
Oil pan bolts	10-12	7-9
Oil drain plug	35-45	25-33
Oil screen bolts	15-22	11-16
Oil pump driven gear bolt	34-40	25-29
Rear cover bolts	10-12	7-9
Piston and Connecting Rod		
Connecting rod cap nut	15 + 90° turn	11 + 90° turn
Crankshaft, Bearing		
Oil seal case bolts	10-12	7-9
Bearing cap bolts	50-55	36-40
Cylinder Block		
Taper plug 1/16	8-12	6-9
Taper plug 1/8	15-22	11-16
Water drain plug	35-45	25-33
Taper plug 1/4 NPT	35-45	25-33
Oil pressure switch	12-18	9-13
Oil pressure sender	12-18	9-13
Water Pump		
Water pump	8-10	6-7

STANDARD HARDWARE

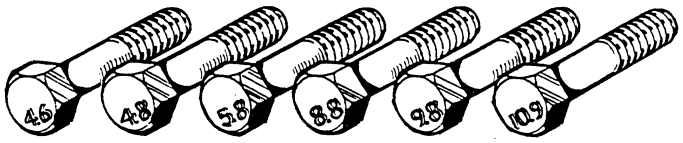
BOLT HEAD MARKINGS

Bolt strength classes are embossed on the head of each bolt.

Customary (inch) bolts are identifed by markings two to grade eight (strongest). The marks correspond to two marks less than the actual grade, i.e.; a grade seven bolt will display five embossed marks.



Metric bolt class numbers identify bolts by their strength with 10.9 the strongest.



NOTES: 1. *Use the torque values listed below when specific torque values are not available.*
2. *These torques are based on clean, dry threads. Reduce torque by 10% when engine oil is used.*
3. *Reduce torques by 30% or more, when threading capscrews into aluminum.*

STANDARD BOLT & NUT TORQUE SPECIFICATIONS

Capsrew Body Size (Inches) - (Thread)	SAE Grade 5 Torque Ft-Lb (Nm)	SAE Grade 6-7 Torque Ft-Lb (Nm)	SAE Grade 8 Torque Ft-Lb (Nm)
1/4 - 20	8 (11)	10 (14)	12 (16)
- 28	10 (14)		14 (19)
5/16 - 18	17 (23)	19 (26)	24 (33)
- 24	19 (26)		27 (37)
3/8 - 16	31 (42)	34 (46)	44 (60)
- 24	35 (47)		49 (66)
7/16 - 14	49 (66)	55 (75)	70 (95)
- 20	55 (75)		78 (106)
1/2 - 13	75 (102)	85 (115)	105 (142)
- 20	85 (115)		120 (163)
9/16 - 12	110 (149)	120 (163)	155 (210)
- 18	120 (163)		170 (231)
5/8 - 11	150 (203)	167 (226)	210 (285)
- 18	170 (231)		240 (325)
3/4 - 10	270 (366)	280 (380)	375 (508)
- 16	295 (400)		420 (569)
7/8 - 9	395 (536)	440 (597)	605 (820)
- 14	435 (590)		675 (915)
1 - 8	590 (800)	660 (895)	910 (1234)
- 14	660 (895)		990 (1342)

METRIC BOLT & NUT TORQUE SPECIFICATIONS

Bolt Dia.	Wrench Size	Grade 4.6 Ft-Lb (Nm)	Grade 4.8 Ft-Lb (Nm)	Grade 8.8 - 9.8 Ft-Lb (Nm)	Grade 10.9 Ft-Lb (Nm)
M3	5.5 mm	0.3 (0.5)	0.5 (0.7)	1 (1.3)	1.5 (2)
M4	7 mm	0.8 (1.1)	1 (1.5)	2 (3)	3 (4.5)
M5	8 mm	1.5 (2.5	2 (3)	4.5 (6)	6.5 (9)
M8	10 mm	3 (4)	4 (5.5)	7.5 (10)	11 (15)
M9	13 mm	7 (9.5)	10 (13)	18 (25)	35 (26)
M10	16 mm	14 (19)	18 (25)	37 (50)	55 (75)
M12	18 mm	26 (35)	33 (45)	63 (85)	97 (130)
M14	21 mm	37 (50)	55 (75)	103 (140)	151 (205)
M16	24 mm	59 (80)	85 (115)	159 (215)	232 (315)
M18	27 mm	81 (110)	118 (160)	225 (305)	321 (435)
M20	30 mm	118 (160)	166 (225)	321 (435)	457 (620)
M22	33 mm	159 (215)	225 (305)	435 (590)	620 (840)
M24	36 mm	203 (275)	288 (390)	553 (750)	789 (1070)
M27	41 mm	295 (400)	417 (565)	811 (1100)	1154 (1565)
M30	46 mm	402 (545)	568 (770)	1103 (1495)	1571 (2130)
M33	51 mm	546 (740)	774 (1050)	1500 (2035)	2139 (2900)
M36	55 mm	700 (950)	992 (1345)	1925 (2610)	2744 (3720)

SEALANTS & LUBRICANTS

GASKETS/SEALANTS

Oil based PERMATEX #2 and it's HIGH TACK equivalent are excellent all purpose sealers. They are effective in just about any joint in contact with coolant, raw water, oil or fuel.

A light coating of OIL or LIQUID TEFLON can be used on rubber gaskets and O-rings.

LOCTITE hydraulic red sealant should be used on oil adapter hoses and the oil filter assembly.

Coat both surfaces of the oil pan gasket with high temp RED SILICONE sealer.

When installing gaskets that seal around water (coolant) passages, coat both sides with WHITE SILICONE grease.

High-copper ADHESIVE SPRAYS are useful for holding gaskets in position during assembly.

Specialized gasket sealers such as HYLOMAR work well in applications requiring non-hardening properties. HYLOMAR is particlarly effective on copper cylinder-head gaskets as it resists fuel, oil and water.

Use LIQUID TEFLON for sealing pipe plugs and fillings that connect coolant passages. **Do not use tape sealants!**

BOLTS & FASTENERS/ASSEMBLIES

Lightly oil head bolts and other fasteners as you assemble them. Bolts and plugs that penetrate the water jacket should be sealed with PERMATEX #2 or HIGH TACK.

When assembling the flywheel, coat the bolt threads with LOCTITE blue.

Anti-seize compounds and thread locking adhesives such as LOCTITE protect threaded components yet allows them to came apart when necessary. LOCTITE offers levels of locking according to the job.

LITHIUM based grease is waterproof, ideal for water pump bearings and stuffing boxes.

Heavily oil all sliding and reciprocating components when assembling. **Always use clean engine oil!**

BCGB ENGINE/GENERATOR SPECIFICATIONS

ENGINE SPECIFICATIONS

Engine Type	3 cylinder, 4 cycle, overhead camshaft w/counterbalance shaft, carbureted, water cooled gasoline engine
Bore and Stroke	2.56 x 2.61 in. (65 mm x 66.3 mm)
Total Displacement	40.3 cubic inches (.66 liter)
Bearings	Four main bearings
Combustion Chamber	Semi-spherical
Compression ratio	9.8 – 1
Firing Order	1 – 3 – 2
Direction of Rotation	Counterclockwise viewed from the back end
Inclination	25° continuous, all directions 30° temporary, all directions
Governor	Mechanical

FUEL SYSTEM

Fuel Pump	Electric fuel pump
Fuel	Unleaded 89 octane or higher gasoline
Distributor	Breakerless distributor
Spark Plugs	14 mm
Ignition Coil	12 volt
Flame Arrester	Metal screen type
Carburetor	Single-barrel downdraft type

ELECTRICAL SYSTEM

Start Motor	12 volt reduction gear w/solenoid
Starting Battery	12 volt negative ground
Battery Capacity	300 cold cranking amps (CCA)(min)
Battery Charging	Integral electric, 17 amps

AIR REQUIREMENTS

Generator Cooling	225-250 CFM (6.3-7.0cmm)
Engine Combustion (all models)	42 CFM (1.2 cmm)
Engine Cooling	100 CFM (2.8 cmm)

EXHAUST EMISSIONS CONTROL SYSTEM

EM	Engine Modification

COOLING SYSTEM

General	Fresh water-cooled block through raw water-cooled heat exchanger circuit
Fresh Water Pump	Centrifugal type, metal impeller belt-driven
Raw Water Pump	Positive displacement, rubber impeller
Cooling Water Capacity	3.5 qts. (3.4 liters)

LUBRICATION SYSTEM

Type	Forced lubrication by gear pump
Oil Filter	Fuel flow, paper element spin-on disposals
Oil Capacity	2.7 qts. (2.6 liters)
Oil Grade	API specification SJ class

AC GENERATOR SPECIFICATIONS

Type	Brushless, four pole capacitor, regulated
Rating	
4.5KW	120/240 volts, 37.5/18.7 amps, 60 Hz, single phase, 4 wire, 1.0 power factor
3.8KW	230 volts, 13 amps, 50 Hz, single phase, 4 wire, 1.0 power factor
7.0KW	120/240 volts, 58.3/29.2 amps, 60 Hz, single phase, 4 wire, 1.0 power factor
5.0KW	230 volts, 13 amps, 50 Hz, single phase, 4 wire, 1.0 power factor

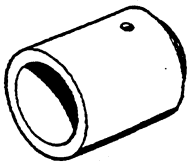
TUNE-UP SPECIFICATIONS

Spark Plug Gap	0.031 ± 0.002 inches (0.8 ±0.05mm)
Spark Plug Torque	10.8 – 15.2 lb-ft
Valve Clearances	Intake valves: 0.20 mm (0.008 in) Exhaust valves: 0.30 mm (.012 in)
Cylinder Head Bolt Torque	60 – 70 Nm 43-51 ft-lbs see *TORQUING THE CYLINDER HEAD BOLTS* under *ENGINE ADJUSTMENTS.*

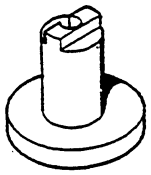
SPECIAL TOOLS - ENGINE

NOTE: *These special tools are available from your local Mitsubishi Automotive Dealer*

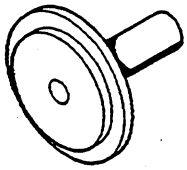
CAMSHAFT OIL SEAL INSTALLER
MD 999569



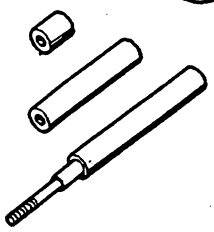
PISTON PIN SETTING BASE
Used to pull-out and press in the piston pin.
MD 999583



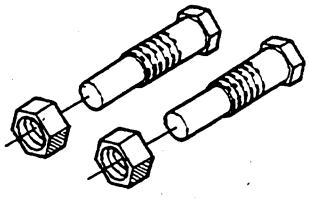
CRANKSHAFT REAR OIL SEAL INSTALLER
MD 998376



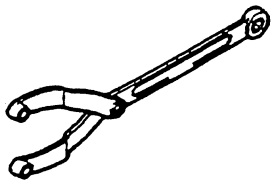
PUSH ROD AND PIN SET GUIDE
Used to pull-out and press in the piston pin.
MD 999584



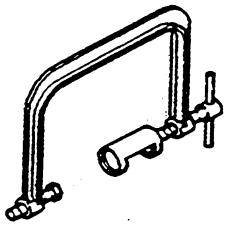
PIN *For supporting the sprocket when the camshaft sprocket is loosened or tightened.*
MD 998715



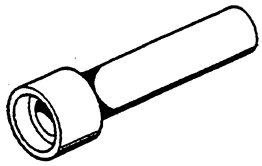
END YOKE HOLDER
For supporting the sprocket when the camshaft sprocket is loosened or tightened.
MD 990767



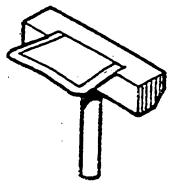
VALVE SPRING COMPRESSOR
MD 999597



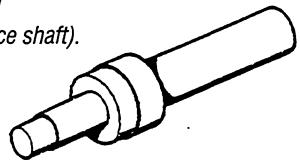
VALVE STEM SEAL INSTALLER
MD 998302



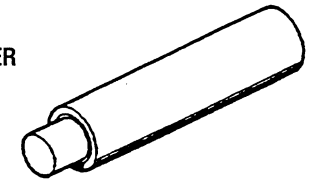
OIL PAN GASKET CUTTER
For removing the oil pan to break the oil pan seal.
MD 998727



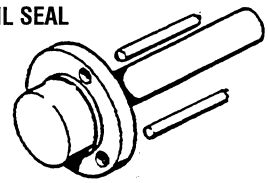
BEARING REMOVER
For pulling out the front and rear bearings (counterbalance shaft).
MD 999593



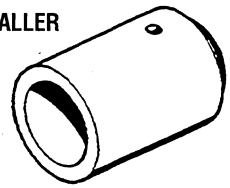
FRONT BEARING INSTALLER
(Counterbalance shaft).
MD 999591



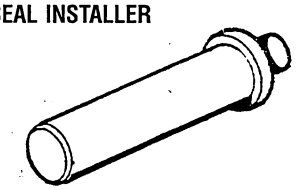
INSTALLER FOR THE REAR OIL SEAL
(Counterbalance shaft).
MD 999592



CRANKSHAFT FRONT OIL SEAL INSTALLER
MD 999570



OIL PUMP OIL SEAL INSTALLER



BC GENERATOR ELECTRICAL TESTING

The following field tests should be performed by a qualified technician. Proper safety precautions must be followed as most of these tests are executed with the generator operating or connected to ships power. **AC voltage is lethal.**

If generator problems persist, contact your Westerbeke dealer.

BC GENERATOR ELECTRICAL TESTING

DESCRIPTION

The BC generator is a brushless, self-excited generator which requires only the driving force of the engine to produce an AC output. The stator houses two sets of windings; the main stator windings and the exciter windings. When the generator is started, residual magnetism in the four rotating poles induces a voltage in the stator which then generates an even larger voltage in the exciter windings. This mutual build up of voltage in the four rotating poles and in the exciter windings quickly reaches the saturation point of the capacitor(s) and a regulated energy field is then maintained in the stator. At the same time, this regulated field produces a steady voltage in the stator windings which can then be drawn off the generator's AC terminals to operate AC equipment. The generator is a single-phase, reconnectable 120 volt AC two-wire or 115 volt AC two-wire or 230 volt AC two-wire, at 50 hertz.

The generator's data plate gives the voltage, current and frequency rating of the generator. An AC wiring decal is affixed to the inside of the louvered cover at the generator end. A diagram of the various AC voltage connections is provided on the decal. An Integral Controller (IC) is mounted inside the generator and supplies a continuous DC charge to the generators starting battery when the generator is running.

INTRODUCTION TO TROUBLESHOOTING

The following test procedures can be used to troubleshoot WESTERBEKE'S *4 POLE SINGLE AND DUAL CAPACITOR BRUSHLESS GENERATORS*. Due to the simplicity of the generator, troubleshooting is relatively easy.

Field testing and repairing can be accomplished with basic tools and repair parts which should include the following:

A quality multimeter [multitester] capable of reading less than one ohm and with a specific diode testing function.

Basic electrical tools including cutters, soldering iron, wire strapper/crimper, terminals connectors, etc.

Repair parts such as diodes, fuses, bridge rectifier, etc.

PRELIMINARY CHECKING

Before electrical testing check for proper engine speed/hertz adjustment. Low engine speed will cause low AC voltage output, high engine speed-high AC output.

Refer to WESTERBEKE'S operators manual or service manual for engine speed/hertz adjustment or for other possible engine related problems.

Before testing, get a clear explanation of the problem that exists, be certain it relates to generator components.

> ⚠ **WARNING:** ***AC and DC circuits often share the same distributor panel. Be certain to unplug AC power cords and shutdown DC/AC inverters. Simply switching off circuit breakers will not do the job since it will still leave hot wires on the supply side of the panel.***

GENERATOR TROUBLESHOOTING CHART

A, B, C, & D refer to the components of the *INTERNAL WIRING DIAGRAM* and their test procedures in the following pages.

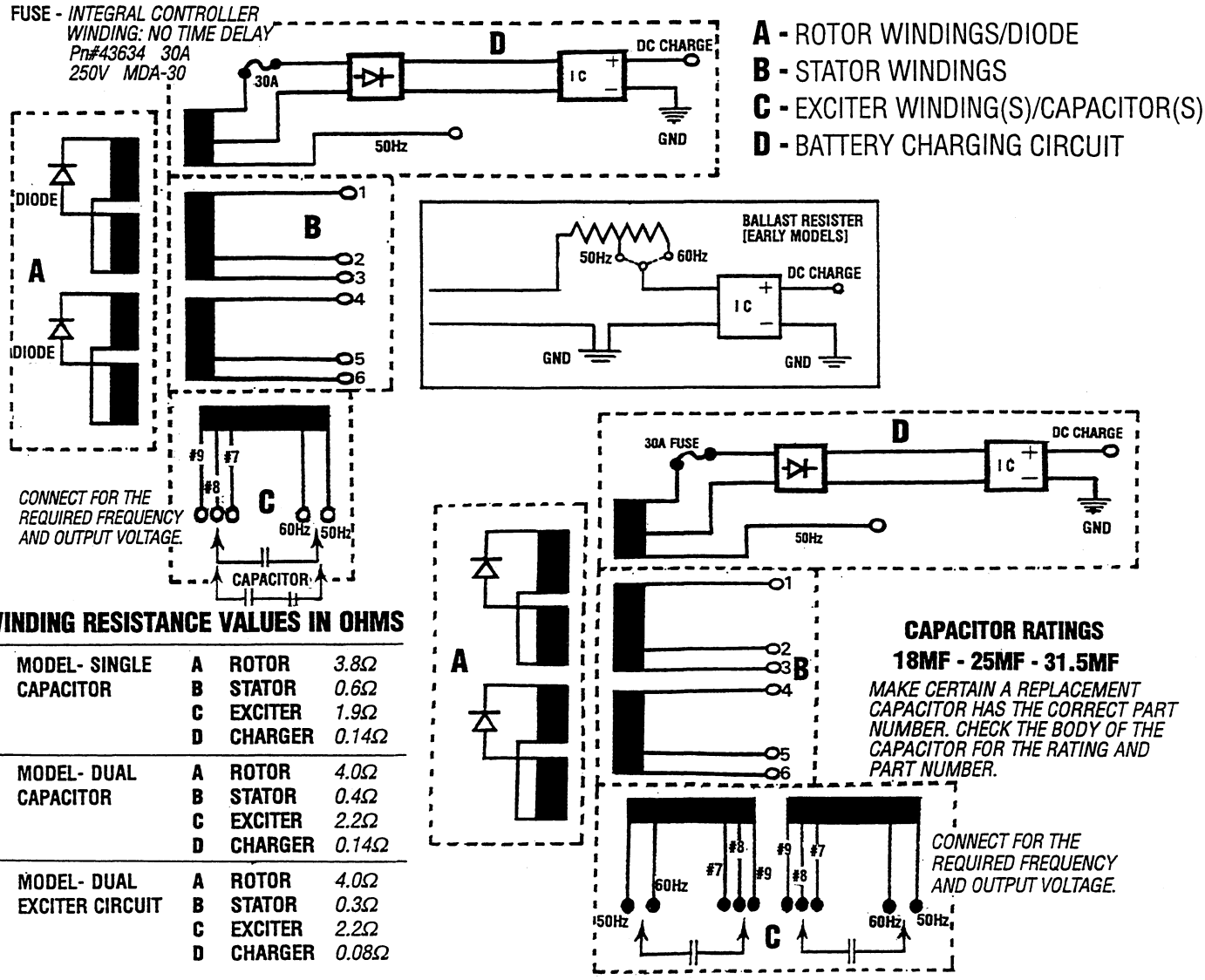
NOTE: *This fault finding chart is compiled assuming the engine is operating at the correct speed/hertz.*

FAULT	CAUSE	TEST/CORRECTION
No AC Output	Shorted stator	**B**
	Open stator	**B**
	Shorted diodes [two]	**A**
Residual Voltage 4-6 VAC (Hot N) at no-load	Faulty capacitor	**C**
	Open exciter	**B**
	Shorted exciter	**B**
	Engine speed [hertz] is too low	Adjust*
	Electrical connections are faulty	Inspect wiring connections
High AC Output at No-Load	Incorrect voltage tap on capacitor	**C**
	Incorrect capacitor	**C**
	Incorrect hertz tap on capacitor	**C**
	Engine speed [hertz] is too high	Adjust*
Low AC Output 60-106V	Faulty rotor winding	**A**
	Faulty diode	**A**
	Faulty capacitor	**B**
Voltage Drop Under Load (or at No-Load)	Faulty diode	**A**
	Faulty capacitor	**C**
	Engine speed [hertz] is too low	Adjust*
No Battery Charge Low Battery Charge	Faulty bridge rectifier	**D**
	Faulty integral controller	**D**
	Blown fuse	**B**
	Faulty winding	**B**
High Voltage Output when Load is applied	Engine speed [hertz] is too high	Adjust*
Unstable Voltage	Electrical connections are faulty, loose	Inspect wiring connections
Noisy Operation	Faulty support bearing	Inspect rear bearing**
	Generator rotor connection to engine is loose	Check rotor security**

** Refer to the GENERATORS OPERATOR MANUAL*
*** Refer to the GENERATORS SERVICE MANUAL*

INTERNAL WIRING SCHEMATIC

DC BATTERY CHARGING CIRCUIT



A - ROTOR WINDINGS/DIODE
B - STATOR WINDINGS
C - EXCITER WINDING(S)/CAPACITOR(S)
D - BATTERY CHARGING CIRCUIT

WINDING RESISTANCE VALUES IN OHMS

MODEL- SINGLE CAPACITOR	A	ROTOR	*3.8Ω*
	B	STATOR	*0.6Ω*
	C	EXCITER	*1.9Ω*
	D	CHARGER	*0.14Ω*
MODEL- DUAL CAPACITOR	A	ROTOR	*4.0Ω*
	B	STATOR	*0.4Ω*
	C	EXCITER	*2.2Ω*
	D	CHARGER	*0.14Ω*
MODEL- DUAL EXCITER CIRCUIT	A	ROTOR	*4.0Ω*
	B	STATOR	*0.3Ω*
	C	EXCITER	*2.2Ω*
	D	CHARGER	*0.08Ω*

CAPACITOR RATINGS

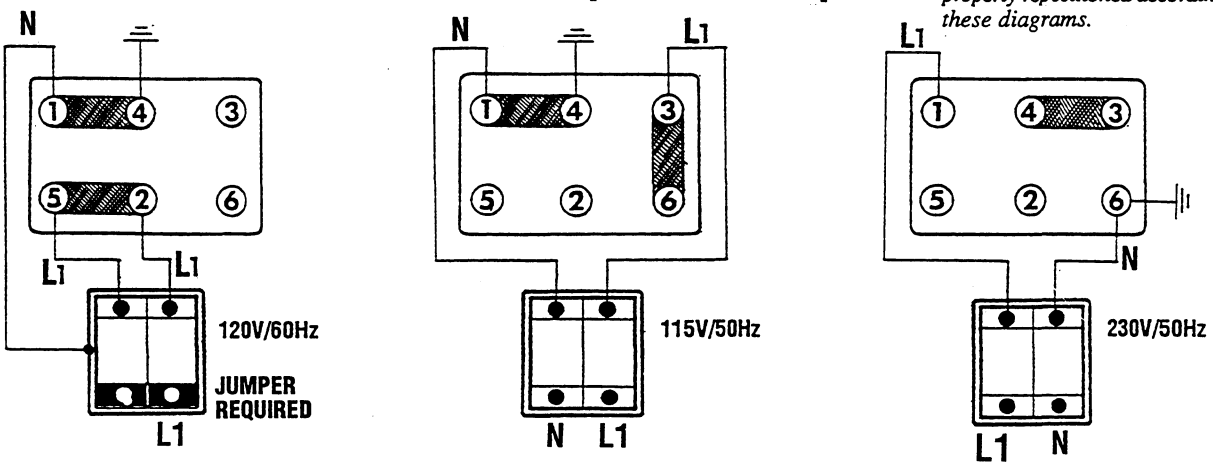
18MF - 25MF - 31.5MF

MAKE CERTAIN A REPLACEMENT CAPACITOR HAS THE CORRECT PART NUMBER. CHECK THE BODY OF THE CAPACITOR FOR THE RATING AND PART NUMBER.

A C TERMINAL BOARD CONNECTIONS

WITH CIRCUIT BREAKER [CURRENT MODELS]

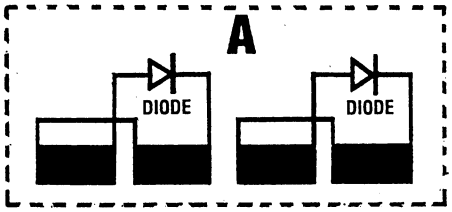
NOTE: *When changing from 60Hz to 50Hz, make certain the ground wire is properly repositioned according to these diagrams.*



LOW VOLTAGE - ROTATING FIELD AUXILIARY WINDINGS TESTS

> ⚠ **WARNING:** ***Some of the following tests require the generator to be running, make certain the front pulley cover and timing belt covers are in place.***

ROTATING FIELD/AUXILIARY WINDINGS



Description

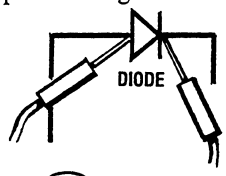
Two sets of windings are found in the rotor assembly. An AC voltage is produced in two groups of windings as the rotor turns at rated rpm. The AC voltage passes through each of the two diodes mounted on the isolated fixture just before the rotor carrier bearing. The AC sine wave is changed to a DC and this DC voltage is passed through the two groups of rotating field windings producing a DC field around these windings. This field affects the AC winding of the two main stator groups inducing an AC voltage in these windings that is available at the AC terminal block connections.

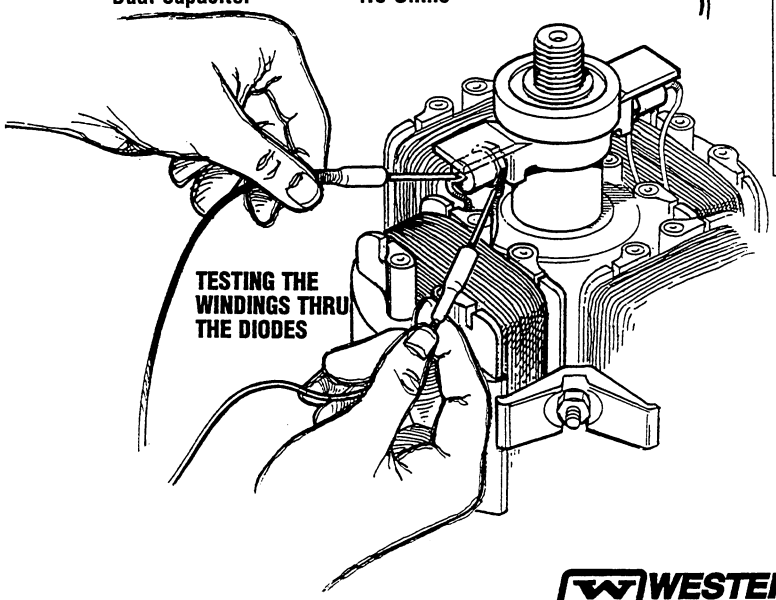
Testing The Windings Thru the Diodes

To check the resistance values, rotate the engine's crankshaft to position the diode(s) on the generator's shaft at 12 o'clock. To make a quick check of these windings, presume the diode is OK and place one of the ohmmeter's leads on the connection at the top of the diode and the other lead at the connection at the base of the diode. Compare readings with the figures below.

STANDARD RESISTANCE VALUES
ROTATING FIELD / AUXILIARY WINDINGS

Single Capacitor	**3.8 Ohms**
Dual Capacitor	**4.0 Ohms**

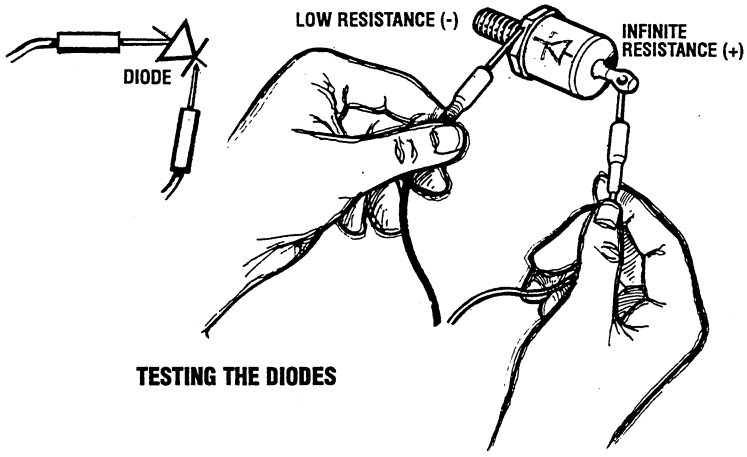




TESTING THE DIODES

If a distinct difference is noted in the ohm value, carefully unsolder the lead on the top of the diode and remove the diode from its isolated heat sink using a thin walled, deep well 7/16 in (11 mm) socket.

To check the diode, unsolder the connection from the top of the diode. Place one ohmmeter lead on the connection at the top of the diode and the other ohmmeter lead to the diode's base. Then reverse the position of the ohmmeter leads.



TESTING THE DIODES

A low resistance should be found with the leads in one direction, and infinite resistance (blocking) in the other direction.

DIODES 8 - 9.5 OHMS (APPROXIMATELY) *USING A 260 SIMPSON ANALOG METER.*

NOTE: *Different meter models may show different ohm values, but should read the same for both diodes.*

DIODE RATING: 1600 AMPS 26 AMPS

The diode's rating is far in excess of the circuit's requirements. Most likely a diode failure will result from an overspeed or load surge.

> ⚠ **CAUTION:** ***[ON SOLDERING] When soldering, use a large enough soldering iron to get the job done quickly. Excessive heat will damage the diodes. Also make certain no soldering splashes onto the windings as it will melt the insulation.***

LOW VOLTAGE - ROTATING FIELD AUXILIARY WINDINGS TESTS

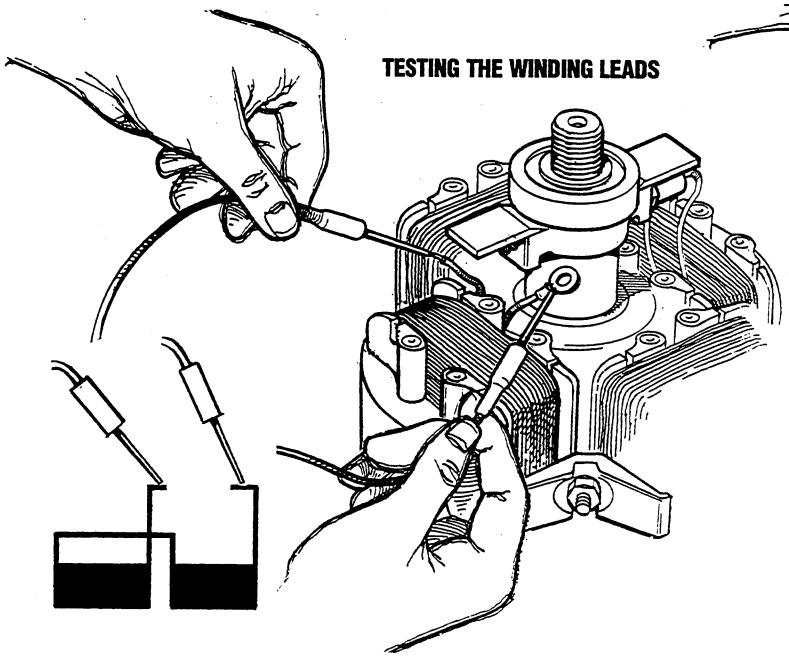
Testing the Rotor Field Auxiliary Windings

With the diode removed, both leads for the first group of rotating field/auxiliary windings will be isolated with no interference from a possibly faulty diode.

Check the resistance value of the rotating windings by placing the ohmmeter's probes across the two exposed leads.

ROTOR WINDINGS RESISTANCE VALUES

Single Capacitor	**3.8 ohms**
Dual Capacitor	**4.0 ohms**
Dual Exciter Circuit	**4.0 ohms**

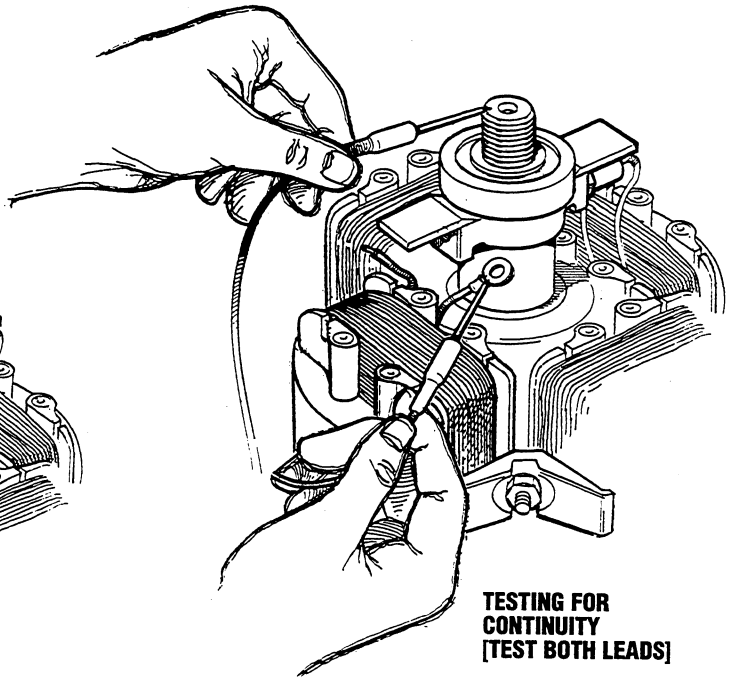


TESTING THE WINDING LEADS

Testing Continuity

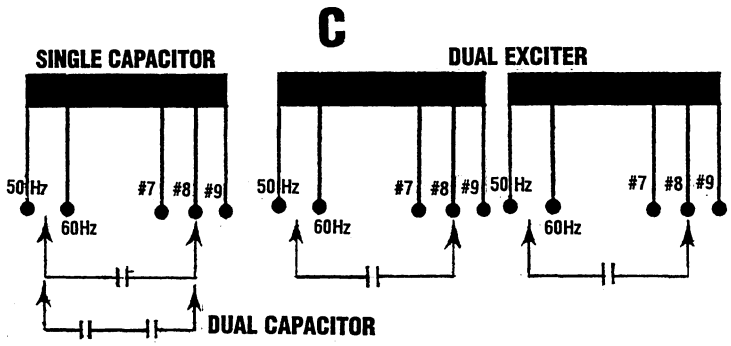
Check that no continuity exists between either of the winding leads and the generator shaft. If continuity is found, there is a short in the windings.

Repeat the above tests on the second set of windings on the opposite side.



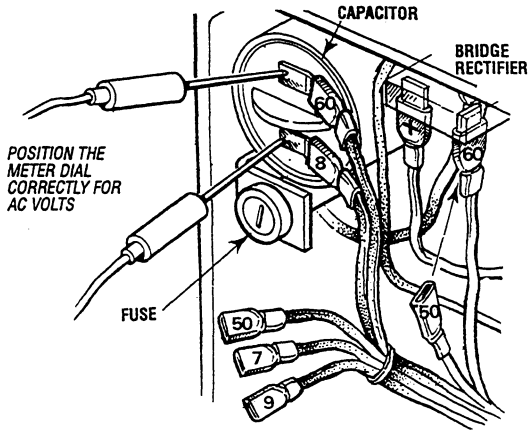
TESTING FOR CONTINUITY [TEST BOTH LEADS]

RESIDUAL VOLTAGE - EXCITER CIRCUIT TESTS



TESTING THE EXCITER WINDINGS

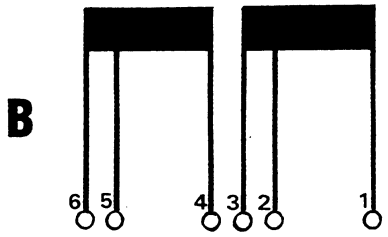
AC voltage can be measured across the capacitor(s) while the generator is operating. This voltage may be as high as 400 to 500 volts AC. This voltage buildup is accomplished as the exciter windings charge the capacitor(s) and the capacitor(s) discharge back into the exciter windings. This AC voltage reading is taken between the #60 Hertz connector and the # connection plugged into the capacitor(s) while the generator is operating at its rated Hertz (60.5 - 61.5 for gasoline models and 61.5 - 62.0 for diesel models). This flow of saturating AC in the exciter windings produces a phase-imbalance type of field that effects the auxiliary windings: a beneficial result that produces good motor starting characteristics for this type of generator.



MEASURING AC VOLTAGE

GENERATOR RUNNING

NO VOLTAGE OUTPUT - MAIN STATOR WINDINGS TESTS



EXCITING THE GENERATOR

The generator may be excited using 12 volts DC taken from the engine's starting battery. This voltage is applied across the #50 and #9 leads of the exciter circuit windings (unplugged) with any other numbered leads unplugged from the capacitors. The generator's reaction during flashing will help determine its fault.

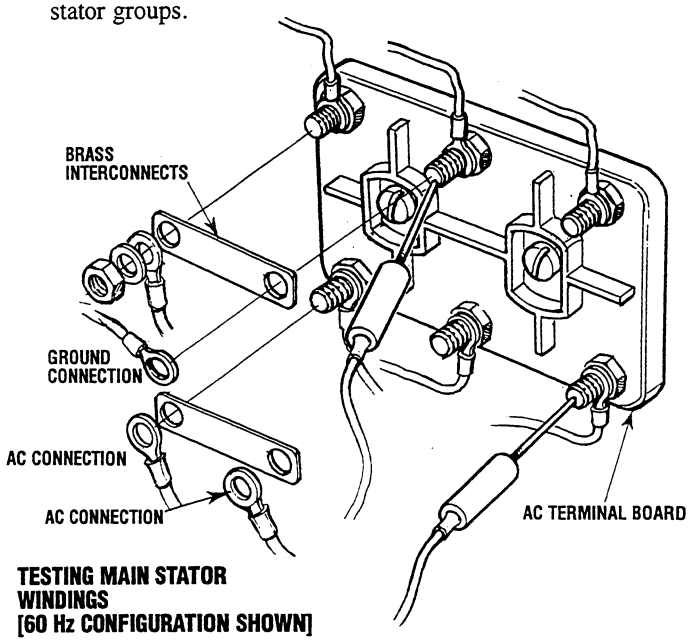
NORMAL VOLTAGE OUTPUT RANGE DURING 12 VOLT EXCITATION

Single Capacitor	**22 - 26 VAC**
Dual Capacitor	**24 -28 VAC**
Dual Exciter	**12 -14 VAC**

- ☐ A slight rise in the output voltage with the loading of the engine and/or a growling noise from the generator end will indicate a fault in the main stator windings.
- ☐ No rise or a very slight rise in the output voltage will indicate a fault in the exciter windings.
- ☐ Normal output voltage as specified above, check exciter circuit.

TESTING THE MAIN STATOR WINDINGS

Test the main stator windings at the AC terminal board by first removing all the AC output leads, the ground connection, and the brass interconnects. This will isolate the six leads on the terminal board which make up the two stator groups.



TESTING MAIN STATOR WINDINGS [60 Hz CONFIGURATION SHOWN]

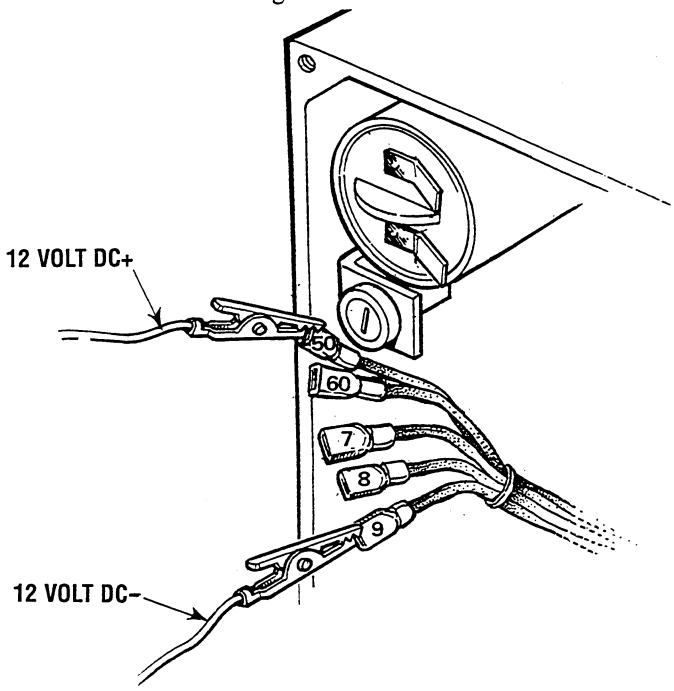
NOTE: *The studs on the AC terminal board are identified by the six red wire that attach to them. These wires are numbered 1 thru 6. There are no numbers on the terminal block.*

TESTING RESIDUAL VOLTAGE

Test for residual voltage between terminal #1 and terminal #3. Then test between terminal #4 and #6 (shown above).

RESIDUAL VOLTAGE **2 - 3 VOLTS AC**

Correct readings will indicate the stator windings are okay. Check the exciter windings.



CHECK RESISTANCE

GROUP 1 - Test the resistance value between the #1 terminal and the #3 terminal.

GROUP 2 - Test the resistance value between the #4 terminal and the #6 terminal.

RESISTANCE VALUES

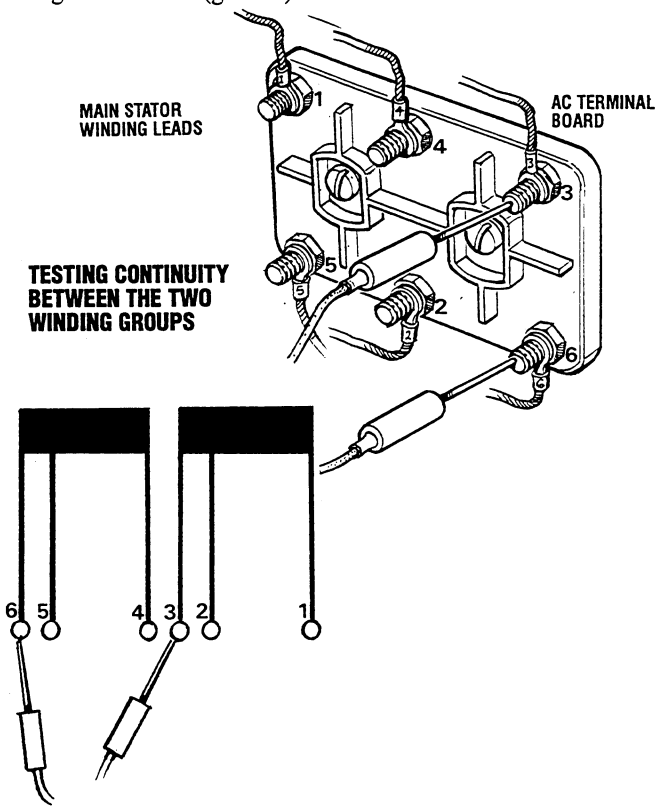
Single Capacitor	**0.6 ohms**
Dual Capacitor	**0.5 ohms**
BCA Model	**0.3 ohms**
Dual Exciter Circuit	**0.5 ohms**

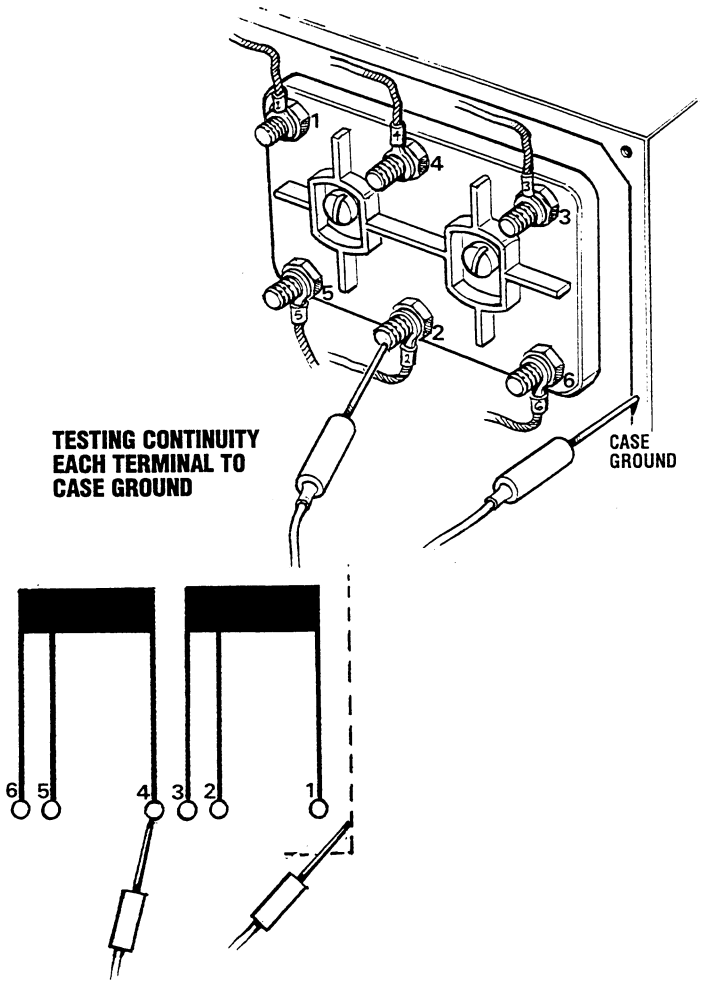
NO VOLTAGE OUTPUT - MAIN STATOR WINDINGS TESTS

Testing Continuity

There should not be any continuity between these two winding groups. Test between terminal #3 and terminal #6. If continuity exists, there is a short in the windings.

There also should be no continuity between the terminals and the generator case (ground).





EXCITER CIRCUIT CAPACITOR(S) TESTS

Measuring Resistance

To measure the resistance of the exciter winding locate the #9 and the #50 Hertz capacitor connections.

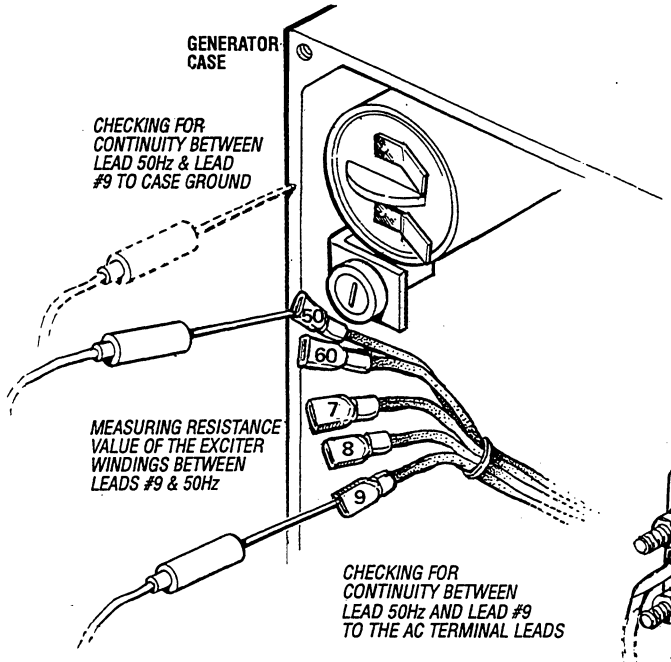
NOTE: *Three numbered capacitor connections exist: #7, #8, and #9; and two Hertz connections #50 and #60.*

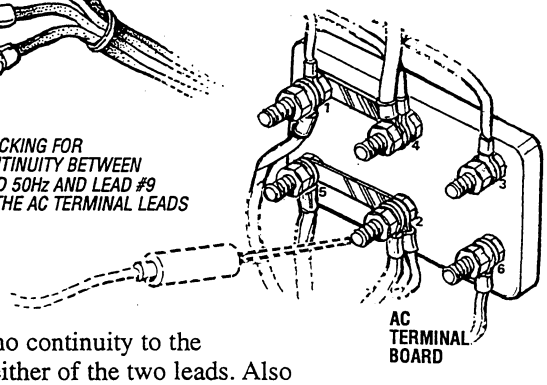
Unplug any other connections from the capacitor noting their position on the capacitor. Place one probe of the multimeter on plug connection #9 and the other probe on the 50 Hertz lead. Measure the resistance value of the exciter windings and compare to the figures below.

NOTE: *Lower residual voltage along with a lower winding resistance will confirm a faulty winding.*

EXCITER WINDINGS RESISTANCE

Single Capacitor	Dual Capacitor	Dual Exciter	BCA Model
1.9 ohms	2.2 ohms	1.3 ohms	1.5 ohms





Checking Continuity

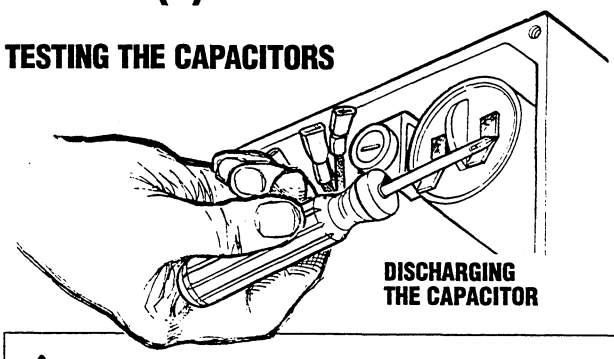
Check to make sure there is no continuity to the ground/generator case from either of the two leads. Also check that no continuity exists between either the #50 Hertz plug or the #9 plug and any of the main stator winding leads on the AC output. If continuity is found here, a fault exists between these two winding groups.

An AC voltage is induced in these windings by the rotating field. Checking the residual voltage output from this winding can determine the condition of the winding when troubleshooting. Test between leads #50 and #9 with leads lifted off the capacitor(s).

RESIDUAL VOLTAGE:

Single Capacitor Model:	**10 - 14 Volts AC from each winding**
Dual Exciter Model:	**7 - 9 Volts AC from each winding**
Dual Capacitor Model:	**14 - 16 Volts AC from each winding**

TESTING THE CAPACITORS



⚠ WARNING: ***Capacitors must be discharged before handling as they store electricity and can pack a potentially lethal charge even when disconnected from their power source.***

Discharge the capacitor by a bridging the terminals with an insulated screwdriver.

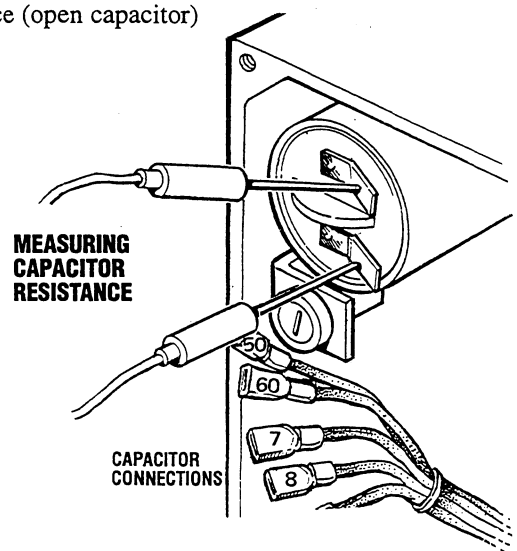
Connect a multitester (highest ohm scale) to the capacitor terminals. The meter should go to zero ohms and slowly return to high. Discharge the capacitor again and reverse the leads, the same results should be obtained.

If the meter goes down and stays at zero ohms, the capacitor is faulty (shorted).

If the meter fails to go down to zero, the capacitor is faulty (open circuited).

Indications of a defective capacitor:

- ☐ Infinite resistance, or no rise in resistance (shorted capacitor)
- ☐ Infinite resistance (open capacitor)



CAPACITOR RATINGS

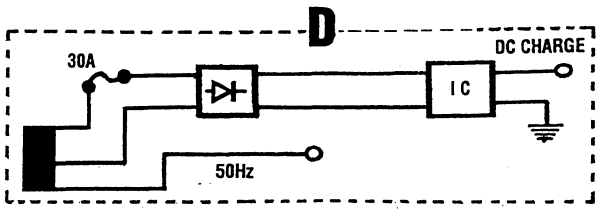
Single Capacitor Models	**25.0 MFD**	**Pn#035985**
Dual Capacitor Models	**31.5 MFD**	**Pn#035978**
Dual Exciter Models	**18.0 MFD**	**Pn#039556**

NOTE: *The older single capacitor models have 25.0 microfarad capacitors. New models now have 31.5 microfarad capacitors. Dual exciter models have a 18.0 MFD capacity.*

The capacitor rating is marked on the housing of the capacitor.

BATTERY CHARGING CIRCUIT / BRIDGE RECTIFIER

TESTING THE BATTERY CHARGING CIRCUIT

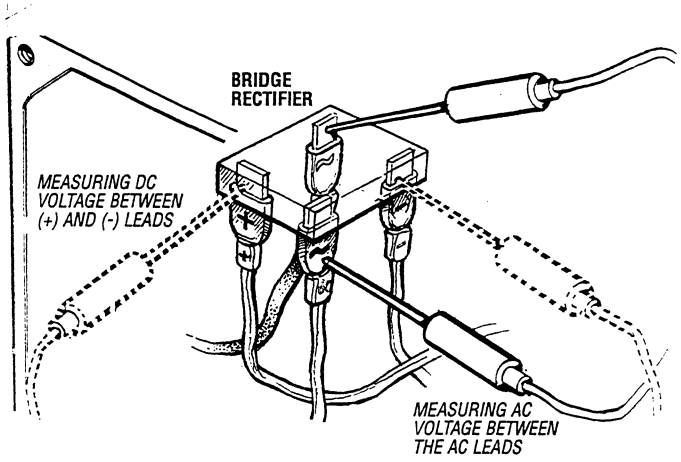


NOTE: *The battery charging circuit is totally separate from the AC output of the generator. The generator output affects the circuits output, but not the reverse.*

Normal AC voltage running to the rectifier (while the engine is operating at 1800 rpm) is measured across the two AC connections on the bridge rectifier (shown below).

AC VOLTAGE TO THE BRIDGE RECTIFIER (APPROXIMATELY):

No-load off the generator	**16.0 volts AC**
Full-load off the generator	**17.5 volts AC**



Normal DC voltage running out of the rectifier (in volts DC) is measured across the two DC connections of the bridge rectifier, that is + and - as illustrated.

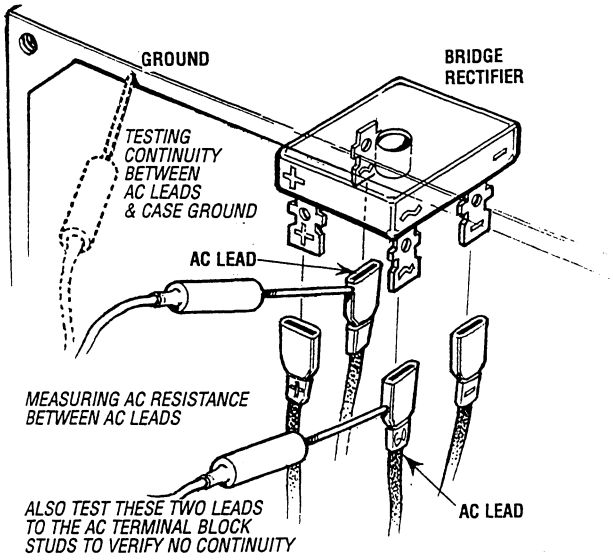
DC VOLTAGE FROM THE BRIDGE RECTIFIER (APPROXIMATELY):

No-load off the generator	**17.0 volts DC**
Full-load off the generator	**18.5 volts DC**

Lift the two AC wire leads off the bridge rectifier and measure the resistance between these two leads. It should measure 0.14 ohm. No continuity should exist between these two leads and the ground or the main stator windings.

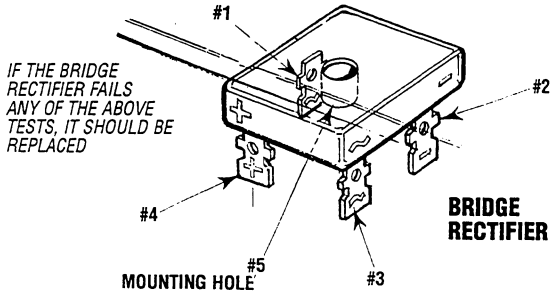
RESISTANCE BETWEEN AC LEADS **0.14 OHMS**

RESISTANCE BETWEEN DUAL EXCITERS **0.08 OHMS**

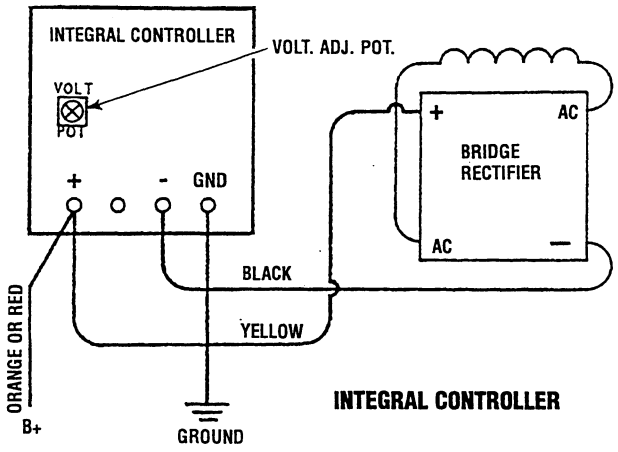


TESTING THE BRIDGE RECTIFIER

1. Set your multimeter's scale on RX1 (+DC) and set the needle to zero.
2. Connect the (+) positive lead from the multimeter to point #4. Taking the multimeter's negative (-) probe, momentarily touch points #1, #2, #3, and #5. The multimeter should register no deflection for any of the points touched.
3. Remove the positive (+) probe from point #4 and connect the negative (-) probe, momentarily touch points #1, #2, and #3. The multimeter's needle should deflect when each point is touched.
4. Leaving the negative multimeter (-) probe on point #4, touch point #5 with the positive probe. No deflection should take place.
5. Place the positive (+) probe on point #1 and the negative probe (-) on point #3. The multimeter again should not register any deflection (no deflection indicates infinite resistance). Reverse these connections and the multimeter should again register no deflection.



INTEGRAL CONTROLLER



INTEGRAL CONTROLLER

INTEGRAL CONTROLLER (I.C.)

The Integral Controller (I.C.) is an encapsulated, solid-state unit that supplies a DC charging voltage to the generator's starting battery while the generator is operating.

Charging Voltage: 13.0 - 14.0 volts DC
Charging Amperage: 0 - 10 amps DC [Early Models]
Charging Amperage: 0 - 17 amps DC [Current Models]

A separate group of stator windings supplies AC voltage to a bridge rectifier which converts the AC current to supply the I.C. unit. The I.C. unit senses the needs of the starting battery and supplies a DC charge when one is needed. If you suspect that the I.C. unit is faulty (that is, if the battery's charge is low), check the charging circuit and it's components as described in the following steps. Check all connections for cleanliness and tightness including the ground before replacing the I.C. unit.

NOTE: *When the generator is first started, the I.C. unit will produce a low charging rate. This charging rate will rise as the generator is operated.*

The Integral Controller is mounted inside the generator housing in the 12:00 position. There is a voltage output adjustment on the controller that will allow a DC voltage output adjustment of ± 2 volts.

BATTERY CHARGING

The generator supplies a continuous 17 amp charge from its battery charger to the starting battery.

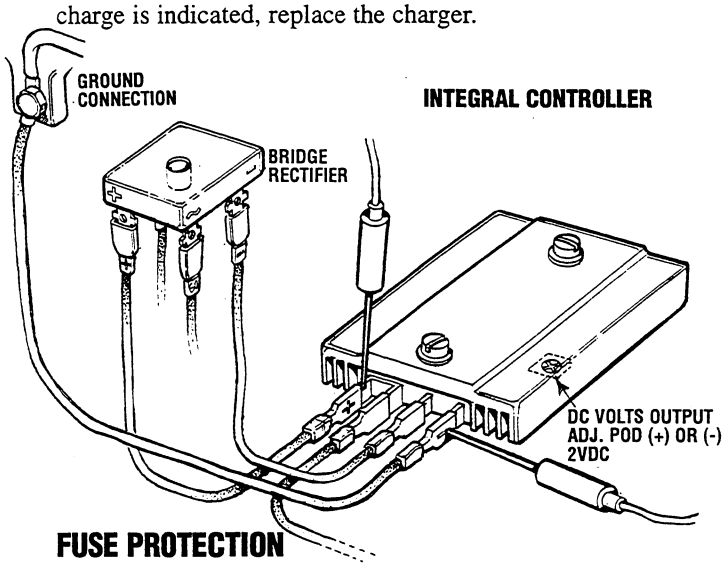
The DC Circuit on the BCGB functions to start, operate and stop the generator's engine. The circuit is best understood by reviewing the DC Wiring Diagram and Wiring Schematic. The engine's DC wiring is designed with three simple basic circuits: start, run and stop.

The engine has a 12 volt DC electrical control circuit that is shown on the Wiring Diagrams. Refer to these diagrams when troubleshooting or when servicing the DC electrical system or the engine.

INTEGRAL CONTROLLER / NO-LOAD VOLTAGE ADJUSTMENT

TESTING THE INTEGRAL CONTROLLER

To test the battery charger, put a multimeter between the positive (+) and negative (-) leads to the battery. It should indicate 13.5V to 14V with the engine running. If only the battery voltage is indicated, check that the battery charger terminal connections are tight. With the unit running, test between the (+) and (-) terminals for 13.5V to 14V. If no charge is indicated, replace the charger.

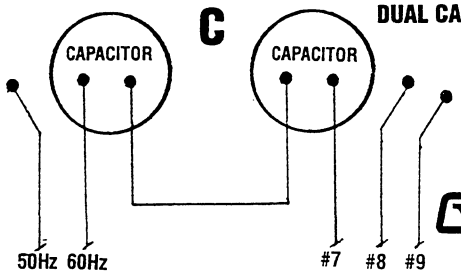


FUSE PROTECTION

A 30 amp fuse protects the windings from a failure of the bridge rectifier or integral controller (high amperage or a short)

SINGLE AND DUAL CAPACITOR NO-LOAD VOLTAGE ADJUSTMENT

1. Remove the louvered metal plate, at the back of the generator, covering the AC terminal connections and the capacitor(s).
2. Start the generator and allow it to run for approximately five minutes so the engine can warm up. Make sure the generator is operating without any equipment drawing AC current from the generator (that is, shut off all electrical appliances). Make sure the engine's speed (Hertz) is correct. Adjust the governor as needed to obtain the correct engine speed before proceeding.
3. Refer to the AC TERMINAL BOARD CONNECTIONS DIAGRAM for the correct configuration then check the generator's no-load voltage by measuring the voltage across the neutral lead and the hot lead with a voltmeter. Make sure you record this reading. The generator's no-load voltage is 115 - 124 volts at 60.5 - 61.5 Hertz. If the voltage output is higher or lower than specified, proceed.
4. *Shut off* the generator. Make sure the correct Hertz lead (60 Hertz #6, or 50 Hertz #5) is plugged into the capacitor(s).

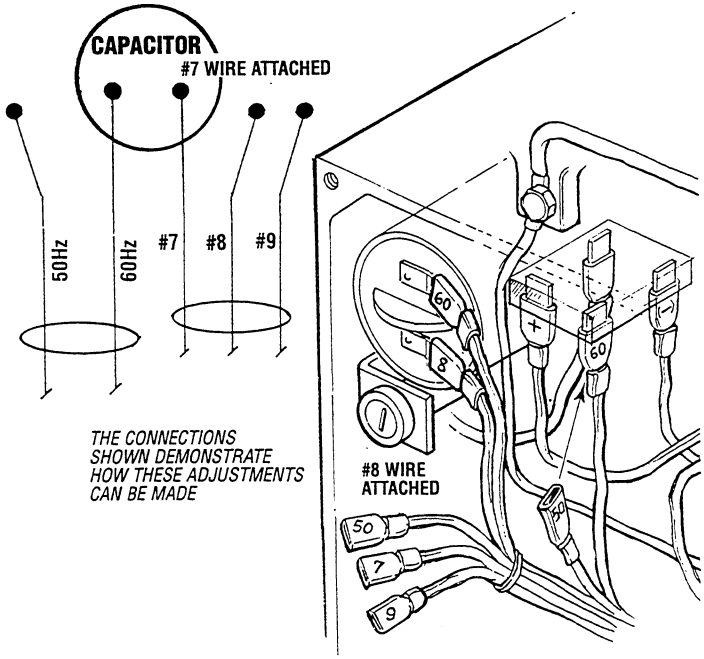


⚠ WARNING: ***Capacitors must be discharged before handling as they store electricity and can pack a potentially lethal charge even when disconnected from their power source.***

NOTE: *Simply cross the capacitor's two terminals with an insulated (plastic handle) screwdriver. This will discharge any excess electricity.*

⚠ WARNING: ***Do not attempt to make a no-load voltage adjustment while the generator is operating. The capacitor can produce a 400-500 volt charge. Touching any wiring can produce a severe electrical shock. In addition, attempting to make a no-load voltage adjustment while the generator is operating could cause your fingers to be caught in the generator's rotor.***

5. There are three plugs grouped for the right capacitor terminal, #7, #8, and #9. If the generator's no-load voltage is low, then disconnect the lower numbered plug and connect the plug with the next higher number. If the generator's no-load voltage is high, then disconnect the higher numbered plug and connect the plug with the next lower number. Note that the plug presently connected to this terminal may be any one of the three plugs available.
6. If the generator's no-load voltage cannot be adjusted because the voltage needs to be increased and the highest numbered plug is already connected to the right terminal, or the voltage needs to be lowered and the lowest numbered plug is connected, refer to *HERTZ ADJUSTMENT* in the operators manual.



THE CONNECTIONS SHOWN DEMONSTRATE HOW THESE ADJUSTMENTS CAN BE MADE

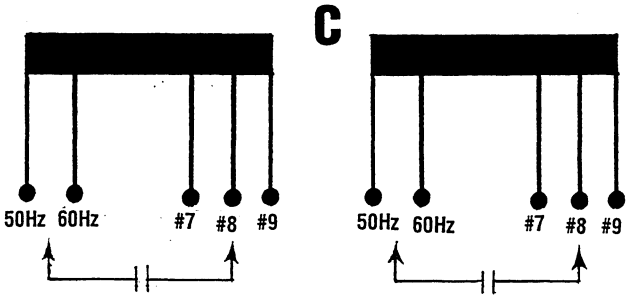
NO-LOAD VOLTAGE ADJUSTMENT DUAL EXCITER

DUAL EXCITER CIRCUIT MODEL

These generators have dual Hertz and no-load voltage adjustment connectors at each capacitor. There are five connectors available for each capacitor. Two connectors are for Hertz selection, 60 Hertz or 50 Hertz, and three connectors, #7, #8, and #9, are for no-load voltage adjustment.

When making Hertz change or no-load voltage adjustments proceed as follows:

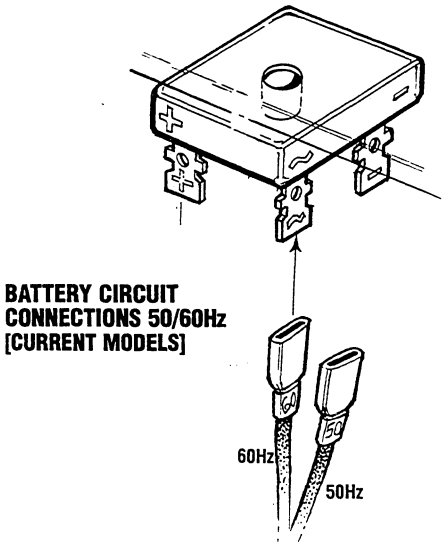
1. Shut the generator down.
2. Select the appropriate Hertz connection to plug into each capacitor #60, 60 Hertz, 1800 RPM or #50 Hertz, 1500 RPM. The three other connectors at each capacitor, #7, #8, and #9, will have an effect on the no-load voltage produced by the generator. One connector from each group can be plugged into each capacitor. No-load voltage will increase or decrease approximately 8 - 10 volts between connectors used in any pair combination to achieve the prescribed no-load voltage.



⚠ WARNING: ***Make certain the insulating covers on the unused leads are in place and are NOT in contact with each other or in contact with the generator's housing.***

NOTE: *When changing Hertz produced by the generator, an engine speed adjustment at the governor* ***must*** *be made. The AC output connections on the terminal blocks* ***must*** *be selected for the voltage and Hertz to be produced. The Hertz plug connection at the capacitor must be changed for 50 Hertz (#5) or 60 Hertz (#6). The frame ground wire* ***must*** *be moved when changing from 115 volts, 50 Hertz to 230 volts, 50 Hertz. Refer to the AC TERMINAL BOARD CONNECTIONS.*

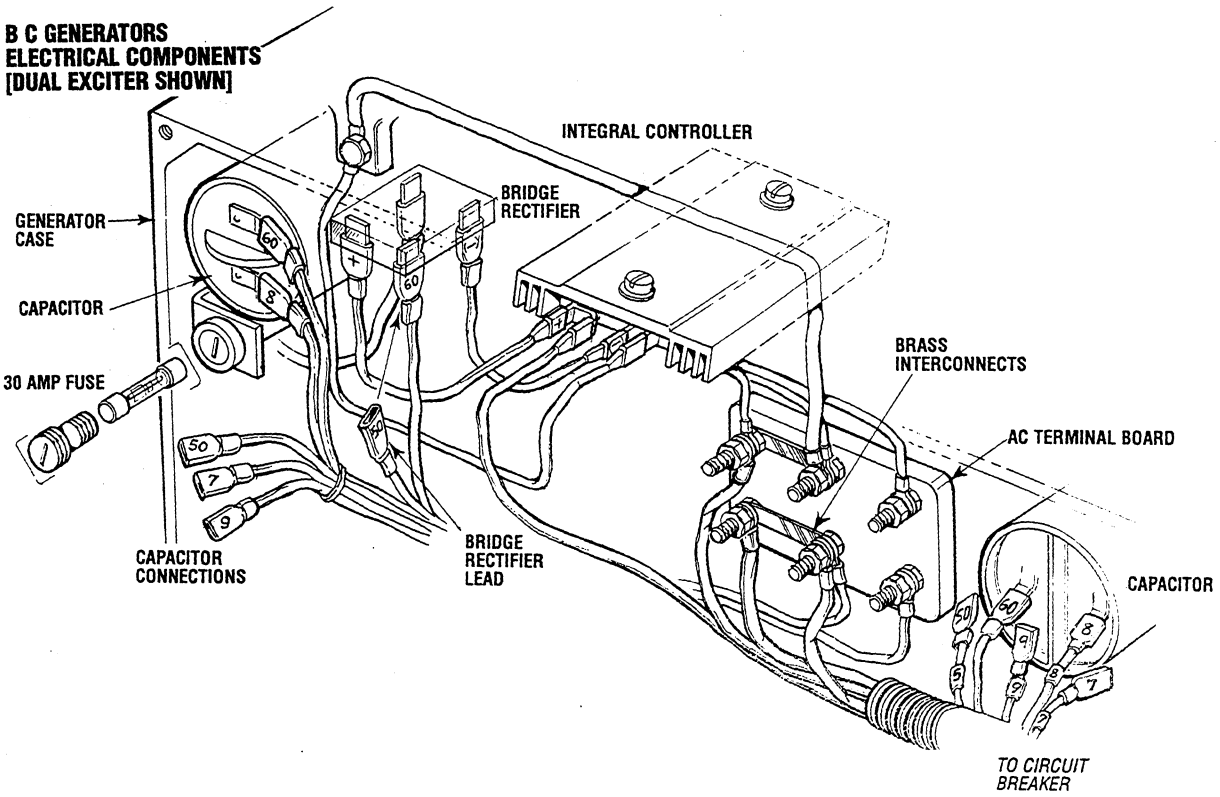
3. On later model BC generators, a 50Hz/60Hz connection is provided for the DC battery circuit. When changing hertz, connect the proper lead (50Hz or 60Hz) to the bridge rectifier.

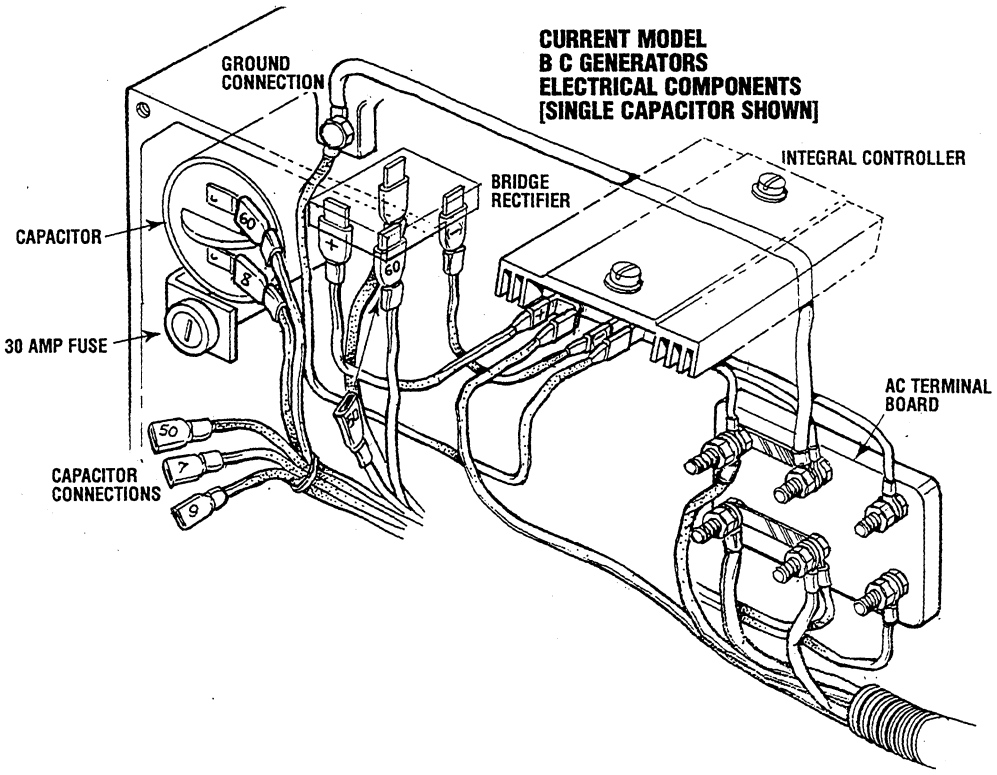


BATTERY CIRCUIT CONNECTIONS 50/60Hz [CURRENT MODELS]

AC CONNECTION

BC GENERATORS PARTS IDENTIFICATION





SPECIAL TOOLS - GENERATOR

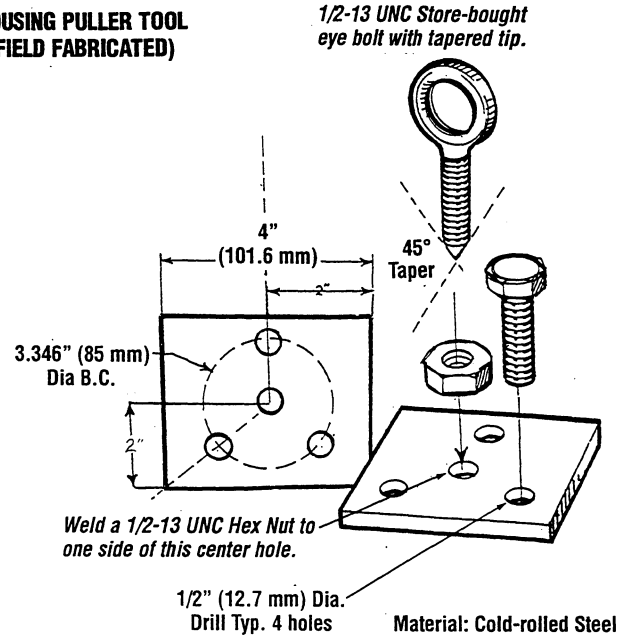
FIELD FABRICATED TOOLS

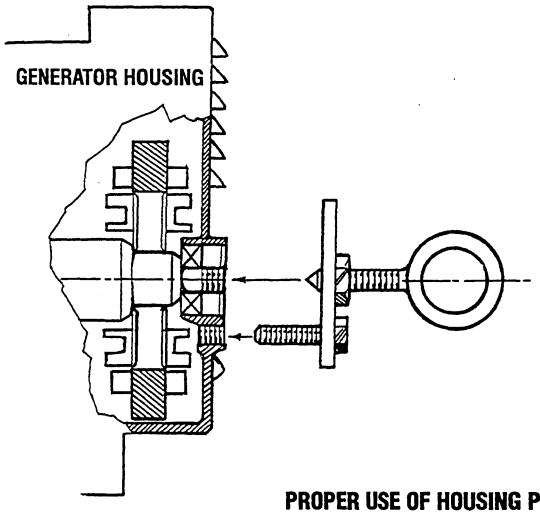
These drawings provide a means by which simple tools can be made to assist in the removal of the generator end from the engine and in the replacement of the generator end on the engine. A local machine shop should be able to fabricate these tools at a modest price, but first check with your local WESTERBEKE dealer to see if these tools are on hand for loan.

Housing Puller Tool

This tool allows the bearing in the generator housing to be gently pushed straight off the housing without any twisting. If a nut of the same specifications as that of the tapped hole in the pilot tool were to be welded on the end of the eye bolt, this tool would be able to pull the bearing back into place without any twisting. Please refer to these drawings before the generator end is removed.

HOUSING PULLER TOOL (FIELD FABRICATED)

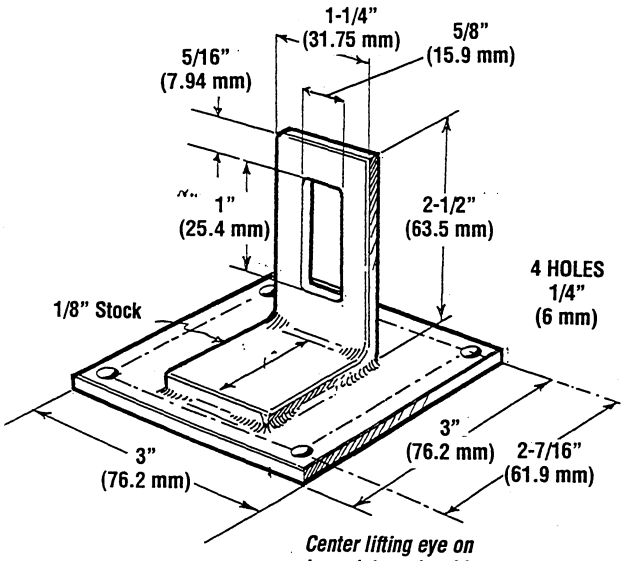




PROPER USE OF HOUSING PULLER

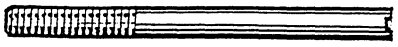
Lifting Eye Tool

This tool allows a mechanic to safely remove the generator end from the engine by attaching this Generator End Lifting Eye to the four screw holes located under the control panel. To use this Lifting Eye, remove the generator's control panel and screw the Lifting Eye to the generator end.



Disk Alignment Tool

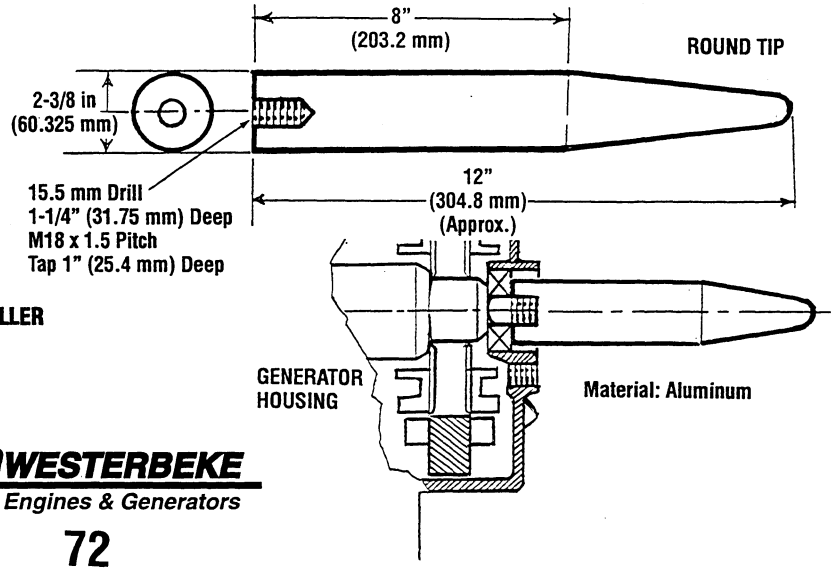
This tool allows a mechanic to safely remove and install the generator drive disks by aligning the disks with the Drive Plate Guide Pin. The Pin screws into the flywheel and acts as a guide. Also the pin helps to support some of the rotor and the drive plate's weight while removing or replacing these parts.



Material: One M8 bolt with the hex head machined off and a screwdriver slot cut in the machined end.

Pilot Tool

Screwed into the end of the rotor shaft, this tool can be used to pull the stator assembly away from the engine without damaging the stator windings. This tool can be used at reassembly.



ENGINE/GENERATOR TROUBLESHOOTING
OPERATING PROCEDURES

The following chart is repeated from the operators manual. The problems described do not relate to problems consistent with an engine overhaul. This chart is included only as a convenience to the operator or service technician.

ENGINE TROUBLESHOOTING

If the engine stops while running for no apparent reason and the remote control panel indicator lamp is flashing, this indicates that an engine operating fault has occurred as a result of one or more of the following conditions:

1. Low oil pressure
2. High engine water temperature
3. High exhaust temperature
4. Low battery voltage

Before restarting the engine, the cause of the problem should be determined and corrected.

The tables that follow suggest a troubleshooting procedure based upon certain engine problem indicators and the most likely causes of the problem.

When troubleshooting indicates an electrical problem refer to the *WIRING DIAGRAMS* in this manual, these diagrams may reveal other possible causes of the problem which are not listed below.

PROBLEM	PROBABLE CAUSE
Engine does not crank.	1. Voltage drop at starter solenoid terminal. 2. Engine 20A circuit breaker has tripped. 3. Battery is low or dead. 4. Loose battery connections. 5. Faulty wire connection. 6. Faulty start switch. 7. Faulty starter solenoid. 8. High exhaust back-pressure. 9. Sea water filled cylinders.
Engine starts, runs but does not come up to speed.	1. Fuel line restriction. 2. Dirty fuel filter. 3. Throttle plate binding. 4. Faulty fuel pump. 5. AC generator overload. 6. High exhaust pressure.
Engine starts, runs and then shuts down.	1. Faulty shutdown switch, (oil pressure, water or exhaust temperature). 2. High engine water or exhaust temperature. 3. Dirty fuel filters. 4. Mechanical check valve at the fuel supply faulty. 5. Low oil level in sump. 6. Faulty fuel pump. 7. High exhaust back pressure.

PROBLEM	PROBABLE CAUSE
Engine hunts.	1. Throttle plate is binding. 2. Low battery voltage. 3. Generator is overloaded. 4. Dirty fuel filter. 5. Damaged vacuum hose. 6. Cracked distributor cap. 7. Faulty high tension wires. 8. Faulty fuel pump. 9. High exhaust back-pressure. 10. Valves are out of adjustment.
Engine cranks but fails to start.	1. Out of fuel. 2. Fuel pump inoperative. 3. Engine is flooded. a. Carburetor float needle valve is open or damaged. Clean or replace the needle valve. b. Float in carburetor is leaking. Repair or replace float. c. Float chamber gasket damaged or securing screws are loose. Replace gasket and/or tighten screws. 4. High tension wires grounding (wet system). 5. Faulty ignition coil 6. Faulty distributor. 7. Faulty wire connection. 8. Worn or faulty spark plugs. 9. Faulty run relay (K2). 10. Timing belt. 11. No engine compression. 12. Faulty idle adjustment. 13. High exhaust back pressure.

ENGINE/GENERATOR TROUBLESHOOTING
OPERATING PROCEDURES

PROBLEM	PROBABLE CAUSE
Engine misfires.	1. Poor quality fuel. 2. Incorrect timing. 3. Dirty flame arrester. 4. Dirty throttle body. 5. Throttle plate is binding. 6. Cracked distributor cap. 7. Faulty high tension wires. 8. Spark plugs are worn. 9. High exhaust back-pressure. 10. Valve clearances are incorrect.
Engine backfires.	1. Spark plug wires are connected wrong. 2. Incorrect timing. 3. Engine is flooded. 4. Dirty flame arrester. 5. Cracked distributor cap. 6. High exhaust back-pressure.
Engine overheats.	1. Coolant loss (pressure test cooling system). 2. Faulty raw water pump impeller. 3. Belts are loose or broken. 4. Raw water pump worn. 5. High exhaust back-pressure. 6. Faulty thermostat.
Black exhaust smoke discharge from the engine.	1. Dirty flame arrester. 2. Faulty vacuum hose.. 3. Faulty carburetor.
High oil pressure.	1. Dirty oil or wrong SAE type oil in the engine. 2. Relief valve is stuck.

PROBLEM	PROBABLE CAUSE
No DC charge to the starting battery.	1. Faulty connections to battery voltage regulator. 2. Faulty battery voltage regulator. 3. Faulty bridge rectifier. 4. Faulty generator charger windings.
Alternator excitation failure	1. Low engine speed, check RPM'S. 2. Faulty condenser, check/replace. 3. Faulty windings, check resistance
High no-load voltage	1. High engine speed, adjust RPM'S. 2. Faulty condenser, check/replace.
Low no-load voltage	1. Low engine speed, adjust RPM'S. 2. Faulty rotary diodes, check/replace. 3. Breakdown in windings, check resistance. 4. Faulty condenser, check/replace.
Proper no-load but low loaded voltage.	1. Low loaded speed, regulate RPM. 2. Load too heavy, reduce load. 3. Short circuit in rotary diodes, check/replace.
Proper no-load but high loaded voltage.	1. RPM too high, regulate RPM.
Unstable voltage.	1. Loose contacts, check connections. 2. Uneven rotation, check for uniform
Noisy generator backend.	1. Broken bearings, replace. 2. Poor couplings, check/repair.

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

VOLUME

Cubic Inches (in^3) x 16.387 = Cubic Centimeters x .061 = in^3
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 (H_2O) x .07355 = Inches of Mercury x 13.783 = H_2O
Inches of Water (H_2O) x .03613 = psi x 27.684 = H_2O
Inches of Water (H_2O) x .248 = Kilopascals (kPa) x 4.026 = H_2O

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

METRIC CONVERSIONS

INCHES TO MILLIMETERS / MILLIMETERS TO INCHES

Inches	mm	Inches	mm	mm	Inches	mm	Inches
1	25.40	15	381.00	1	0.0394	15	0.5906
2	50.80	20	508.00	2	0.0787	20	0.7874
3	76.20	25	635.00	3	0.1181	25	0.9843
4	101.60	30	762.00	4	0.1575	30	1.1811
5	127.00	35	889.00	5	0.1969	35	1.3780
10	254.00	40	1016.00	10	0.3937	40	1.5748

10 MILLIMETERS = 1 CENTIMETER, 100 CENTIMETERS = 1 METER = 39.37 INCHES (3.3 FEET)

INCHES TO METERS / METERS TO INCHES

Inches	Meters	Inches	Meters	Meters	Inches	Meters	Inches
1	0.0254	7	0.1778	0.1	3.937	0.7	27.559
2	0.0508	8	0.2032	0.2	7.874	0.8	31.496
3	0.0762	9	0.2286	0.3	11.811	0.9	35.433
4	0.1016	10	0.2540	0.4	15.748	1.0	39.370
5	0.1270	11	0.2794	0.5	19.685	1.1	43.307
6	0.1524	12	0.3048	0.6	23.622	1.2	47.244

TO CONVERT METERS TO CENTIMETERS, MOVE DECIMAL POINT TWO PLACES TO THE RIGHT

YARDS TO METERS / METERS TO YARDS

Yards	Meters	Yards	Meters	Meters	Yards	Meters	Yards
1	0.91440	6	5.48640	1	1.09361	6	6.56168
2	1.82880	7	6.40080	2	2.18723	7	7.65529
3	2.74320	8	7.31520	3	3.28084	8	8.74891
4	3.65760	9	8.22960	4	4.37445	9	9.84252
5	4.57200	10	9.14400	5	5.46807	10	10.93614

MOVE DECIMAL POINT FOR HIGHER VALUES — e.g. 6,000 METERS = 6,561.68 YARDS

POUNDS TO KILOGRAMS / KILOGRAMS TO POUNDS

lb	kg	lb	kg	kg	lb	kg	lb
1	0.454	6	2.722	1	2.205	6	13.228
2	0.907	7	3.175	2	4.409	7	15.432
3	1.361	8	3.629	3	6.614	8	17.637
4	1.814	9	4.082	4	8.818	9	19.842
5	2.268	10	4.536	5	11.023	10	22.046

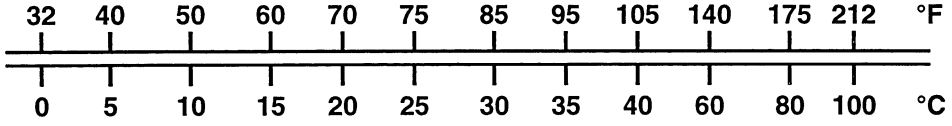
GALLONS TO LITERS / LITERS TO GALLONS

Gallons	Liters	Gallons	Liters	Liters	Gallons	Liters	Gallons
1	3.79	10	37.86	1	0.26	60	15.66
2	7.57	20	75.71	2	0.53	90	23.77
3	11.36	30	113.57	5	1.32	120	31.32
4	15.14	40	151.42	10	2.64	150	39.62
5	18.93	50	189.28	20	5.28	180	47.54

PINTS TO LITERS / LITERS TO PINTS

Pints	Liters	Pints	Liters	Liters	Pints	Liters	Pints
1	0.47	6	2.84	1	2.11	6	12.68
2	0.95	7	3.31	2	4.23	7	14.79
3	1.42	8	3.79	3	6.34	8	16.91
4	1.89	9	4.26	4	8.45	9	19.02
5	2.37	10	4.73	5	10.57	10	21.13

TEMPERATURE



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