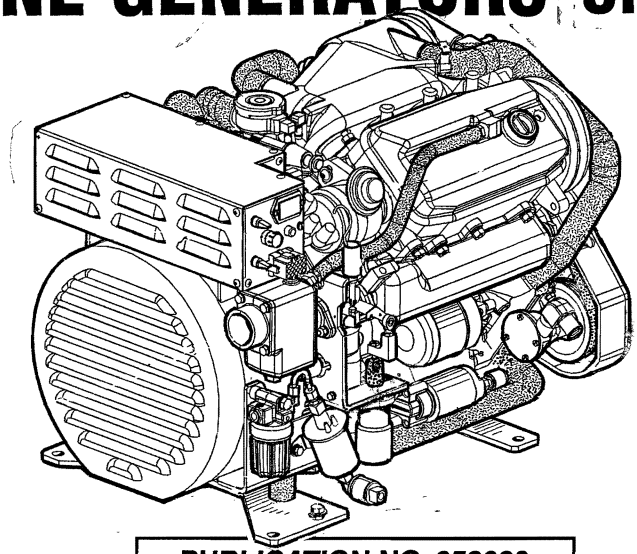
SERVICE MANUAL

5.0KW BCG-60Hz / 4.2 KW BCG-50Hz
5.0KW BCGA-60Hz / 4.2KW BCGA-50Hz
7.0KW BCGC-60Hz / 5.9KW BCGC-50Hz
7.0KW BCGD-60Hz / 5.9KW BCGD-50Hz
GASOLINE GENERATORS Single Phase



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WESTERBEKE

member NMMA

WESTERBEKE CORPORATION • 150 JOHN HANCOCK ROAD
MYLES STANDISH INDUSTRIAL PARK • TAUNTON MA 02780
WEB SITE: 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.

A WARNING DECAL is provided by WESTERBEKE and should be fixed to a bulkhead near your engine or generator.

WESTERBEKE also recommends installing CARBON MONOXIDE DETECTORS in the living/sleeping quarters of your vessel. They are inexpensive and easily obtainable at your local marine store.

CALIFORNIA PROPOSITION 65 WARNING

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

SAFETY INSTRUCTIONS

INTRODUCTION

Read this safety manual carefully. Most accidents are caused by failure to follow fundamental rules and precautions. Know when dangerous conditions exist and take the necessary precautions to protect yourself, your personnel, and your machinery.
The following safety instructions are in compliance with the American Boat and Yacht Council (ABYC) standards.

PREVENT ELECTRIC SHOCK

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

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

PREVENT BURNS — HOT ENGINE

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

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

⚠ WARNING: ***Steam can cause injury or death!***

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

PREVENT BURNS — FIRE

⚠ WARNING: ***Fire can cause injury or death!***

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

PREVENT BURNS — EXPLOSION

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

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

SAFETY INSTRUCTIONS

ACCIDENTAL STARTING

⚠ WARNING: ***Accidental starting can cause injury or death!***

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

BATTERY EXPLOSION

⚠ WARNING: ***Battery explosion can cause injury or death!***

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

BATTERY ACID

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

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

TOXIC EXHAUST GASES

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

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

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

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

Vomiting	Inability to think coherently
Dizziness	Throbbing in temples
Headache	Muscular twitching
Nausea	Weakness and sleepiness

AVOID MOVING PARTS

⚠ WARNING: ***Rotating parts can cause injury or death!***

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

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

HAZARDOUS NOISE

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

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

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

OPERATORS MANUAL

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

GASOLINE ENGINE AND GENERATOR INSTALLATIONS

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

Sections of the ABYC standards of particular interest are:

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

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

ABYC, NFPA AND USCG PUBLICATIONS FOR INSTALLING DIESEL ENGINES

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

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

Order from:

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

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

Order from:

NFPA
11 Tracy Drive
Avon Industrial Park
Avon, MA 02322

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

Order from:

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

INSTALLATION

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

CODES AND REGULATIONS

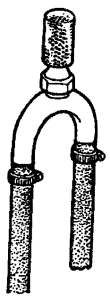
Strict federal regulations, ABYC guidelines, and safety codes must be complied with when installing engines and generators in a marine environment.

SIPHON-BREAK

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

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

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



AVAILABLE FROM YOUR WESTERBEKE DEALER

EXHAUST SYSTEM

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

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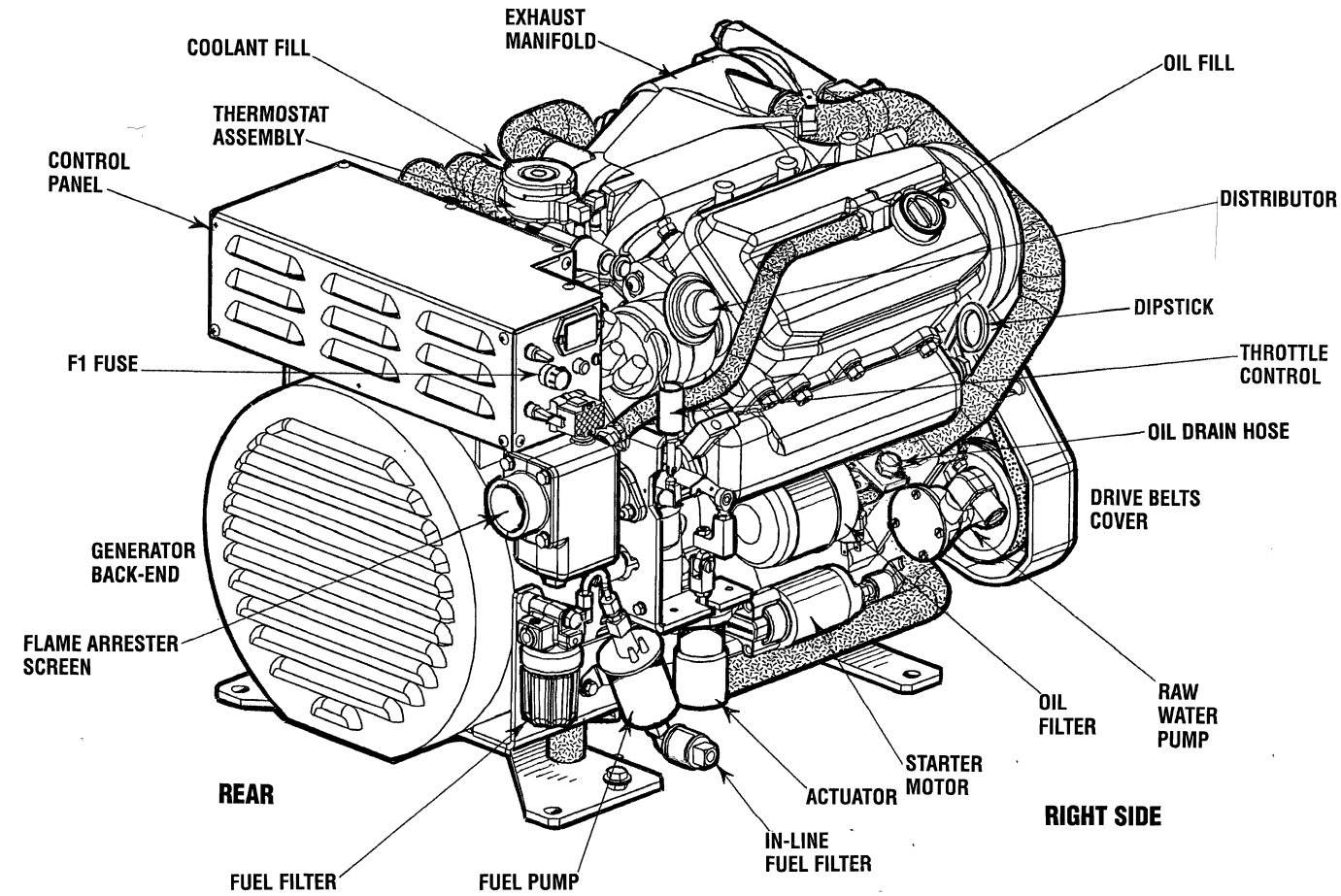
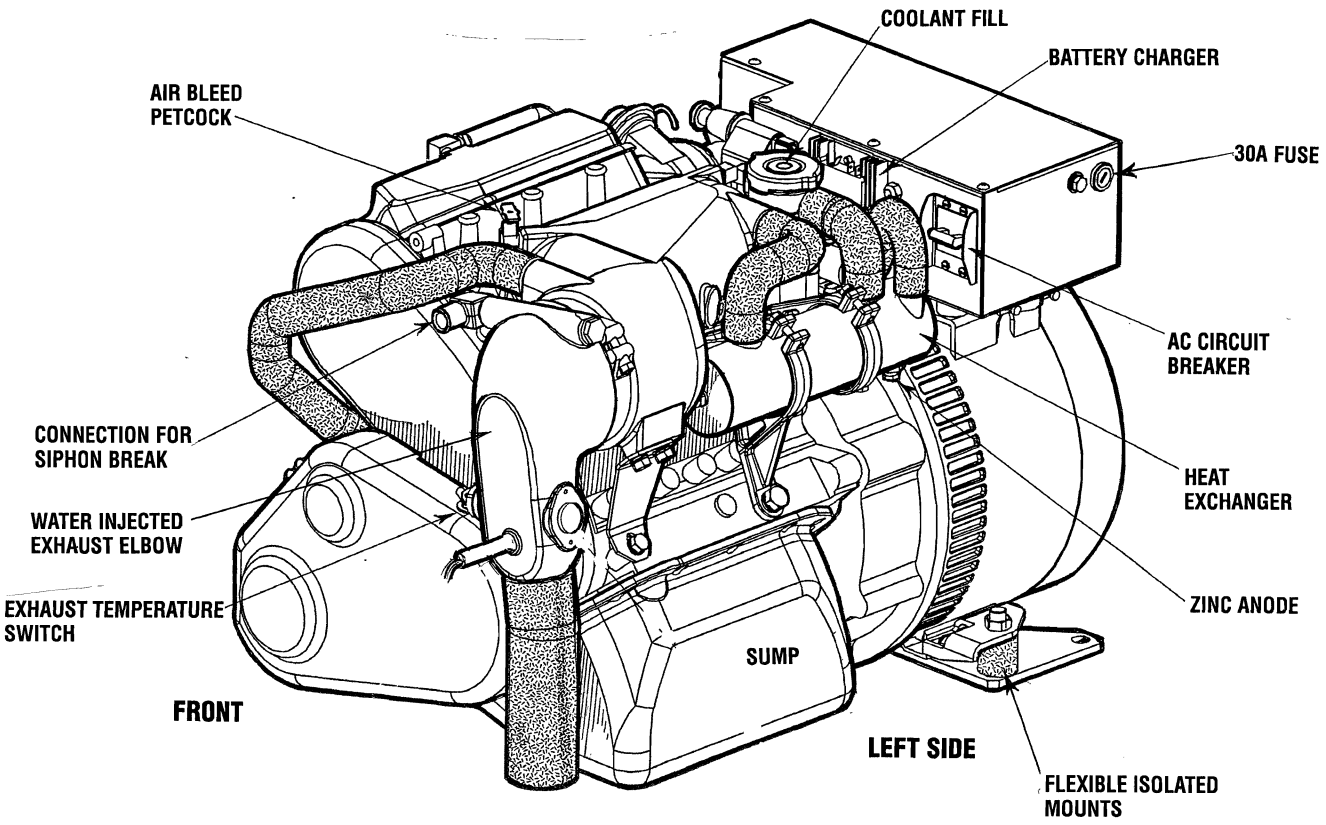
PARTS IDENTIFICATION





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.

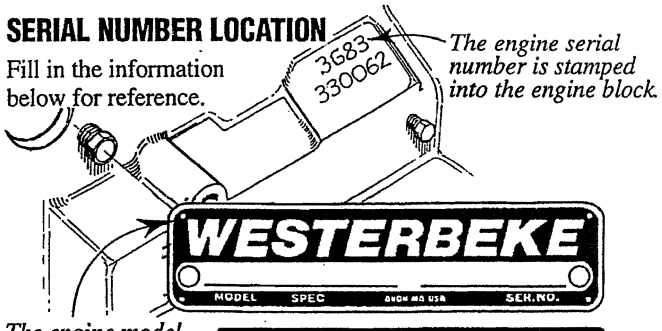
Additional detailed information and specifications are provided in other sections of this manual, covering the generator, alternator, starter motor, engine adjustments, cooling pumps, etc.

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.

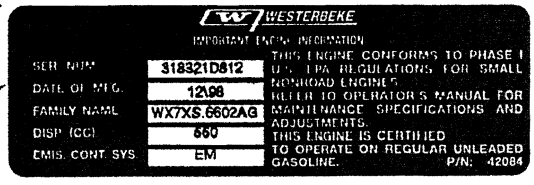
The engine model number and serial number are printed on a decal on the engine manifold.

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.		

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.

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



BCG 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.

BCG 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.

GENERATOR / ENGINE DISASSEMBLY

DESCRIPTION

The engine component of the BC generator is not as bulky or heavy as most engines (approx. 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 pane. 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 at the water injection elbow and disconnect the fuel supply.

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

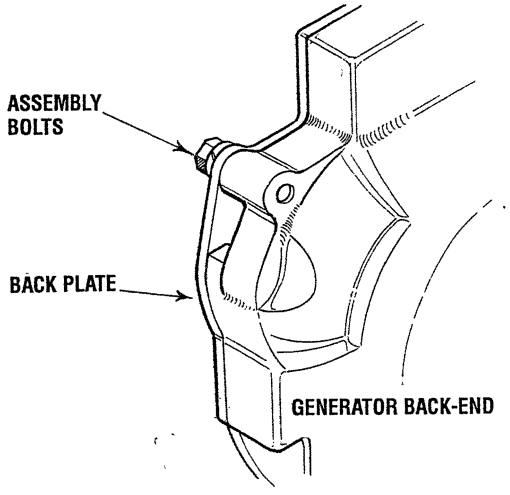
Unfasten the generator from its mounting rails or the mounting rails from the platform and remove the generator from the boat.

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

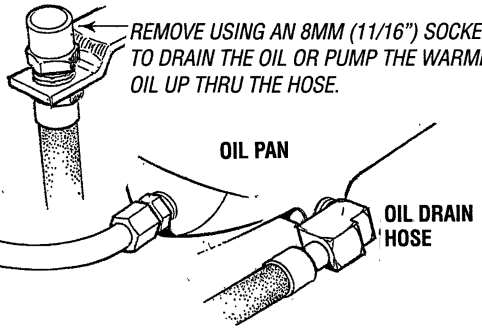
Remove the starter motor. Disconnect and remove the wiring harness, be certain to tag all the wiring connections so you can separate them.

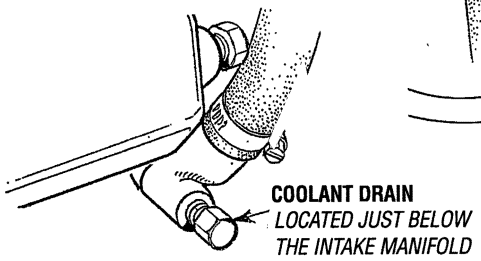
Separate the generator back-end from the engine. Once the housing is removed, the remaining generator components can be disassembled from the engine back-plate.

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



TYPICAL BC GENERATOR BACK-END ASSEMBLY





GENERATOR BACK-END
SEE SPECIAL TOOLS FOR DISASSEMBLING THE GENERATOR COMPONENTS

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.

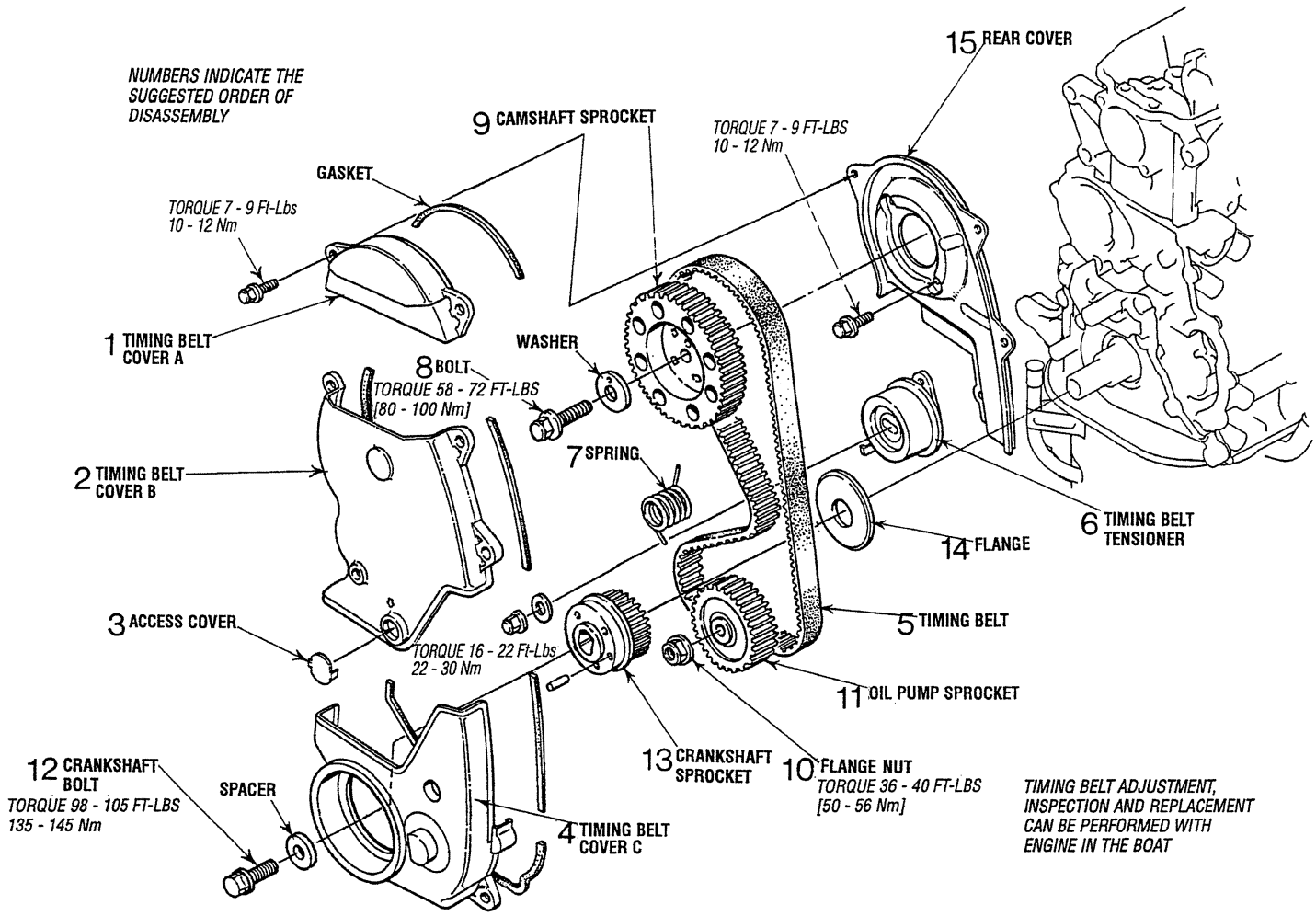
When assembling the flywheel, coat the bolt threads with LOCTITE blue.

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.

TIMING BELT DISASSEMBLY



INSTRUCTIONS FOR INSPECTING AND REPLACING THE TIMING BELT

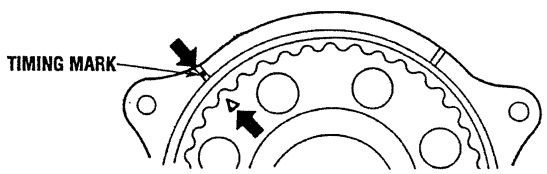
WESTERBEKE requires as normal maintenance, replacing the timing belt after 1000 engine operating hours. The timing belt should always be replaced during an engine overhaul.

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

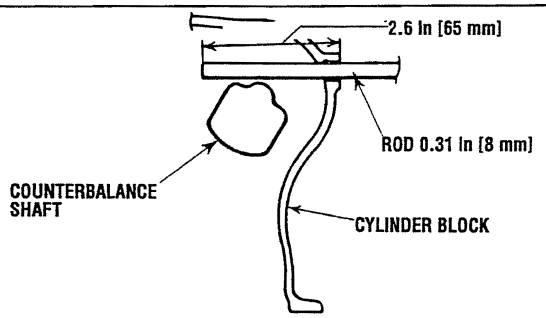
1. Turn the crankshaft clockwise to align the timing mark on the camshaft sprocket and timing belt rear cover.

NOTE: *Always turn the crankshaft clockwise.*

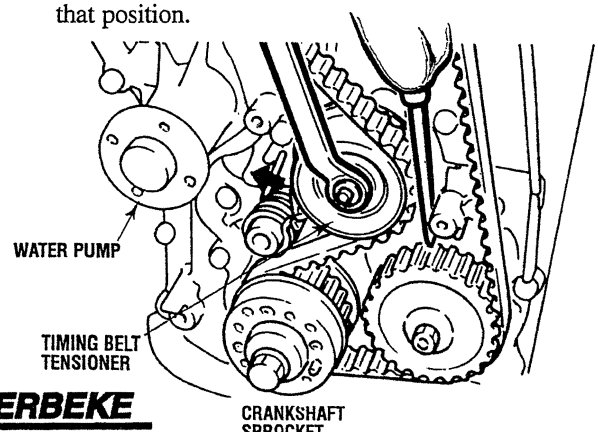


2. Remove the plug on the left surface of the cylinder block and insert a rod with a diameter of 0.31 in (8 mm) to lock the counterbalance shaft.

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



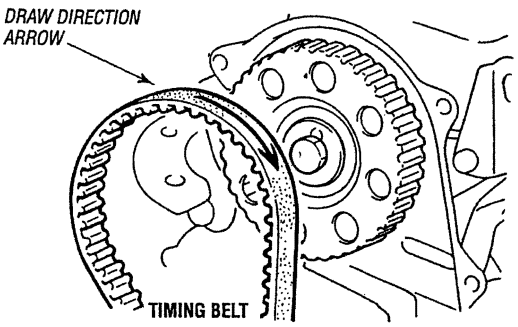
3. Loosen the timing belt tensioner nut.
4. Move the timing belt tensioner toward the water pump, and temporarily tighten the nut to hold the tensioner in that position.



TIMING BELT DISASSEMBLY

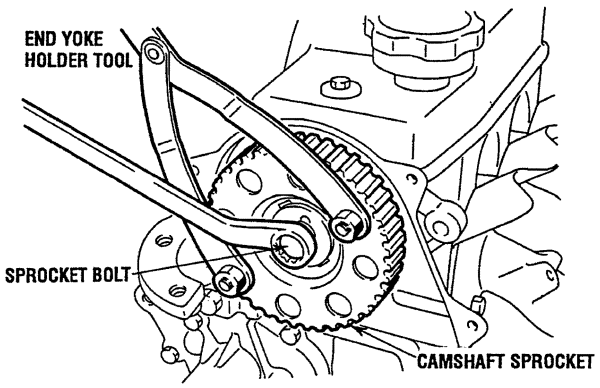
5. Remove the timing belt.

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



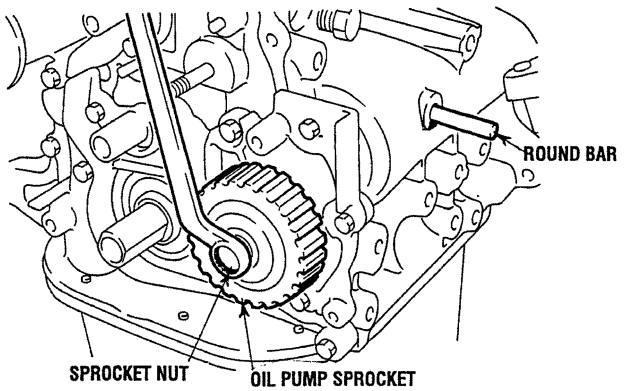
Camshaft Sprocket Removal

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.

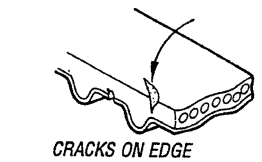
   NOTE: *Do not turn the crankshaft.*

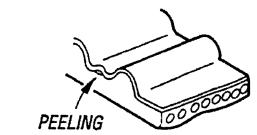
2. Remove the crankshaft bolt.

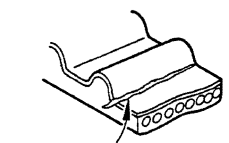
Timing Belt Inspection

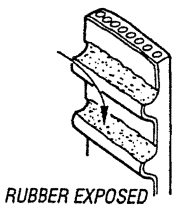
Replace the belt if any of the following conditions exist:

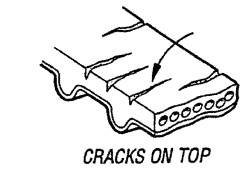
- Hardening of the back rubber, leaves no indent when pressed with fingernail (back side is glossy).
- Cracks on rubber back.
- Cracks or peeling of canvas.
- Cracks on tooth bottom.
- Cracks on belt.
- Abnormal wear of belt sides. The sides are normal if they are sharp as if cut by a knife.
- Abnormal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

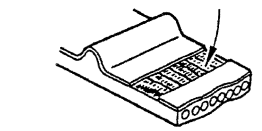












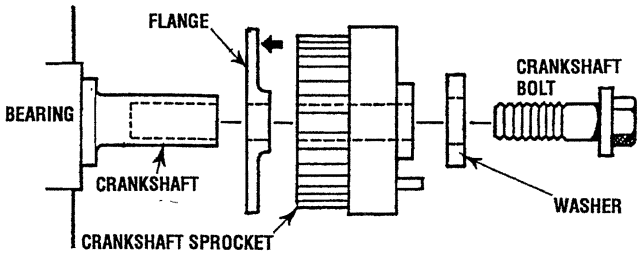
Tensioner Inspection

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

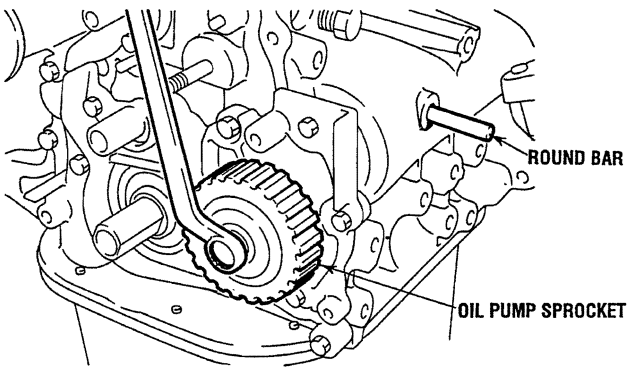
1. Lock the crankshaft.

   NOTE: *Do not turn the crankshaft.*

2. Tighten the crankshaft bolt to the specified torque.

Oil Pump Sprocket Flange Nut Installation

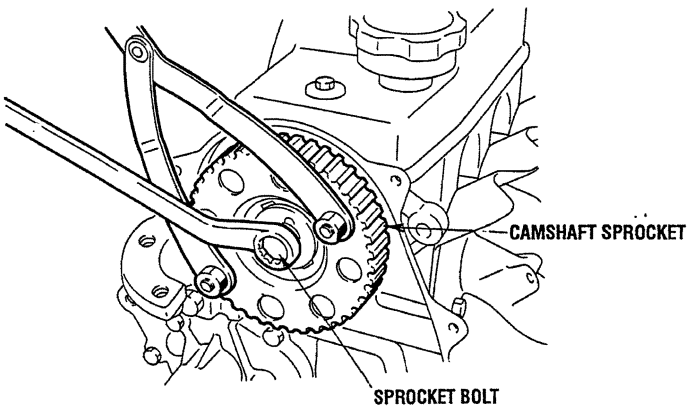
1. Insert the round bar into the plug hole in the left side of the cylinder block to keep the counterbalance shaft from turning.
2. Install the oil pump sprocket.
3. Tighten the nut to the specified torque.



Camshaft Sprocket Bolt Installation

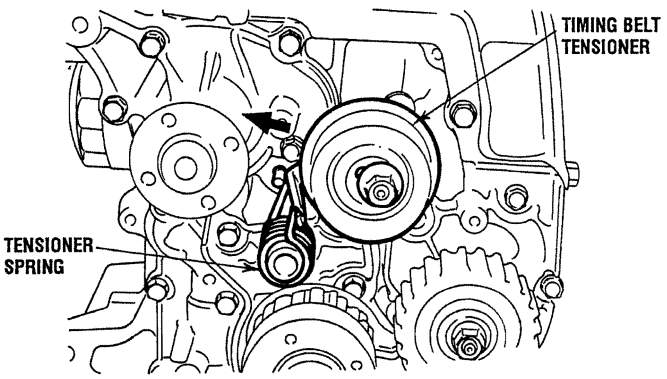
1. Tighten the bolt to the specified torque.

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



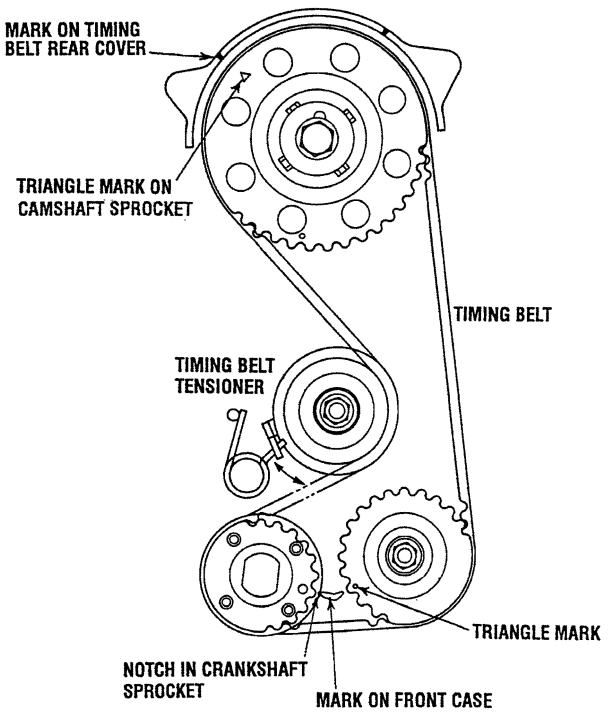
Tensioner Spring/Timing Tensioner Installation

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.



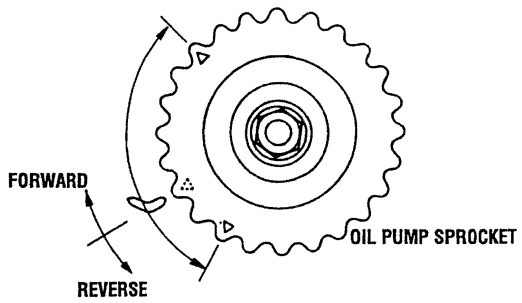
Timing Belt Installation

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.

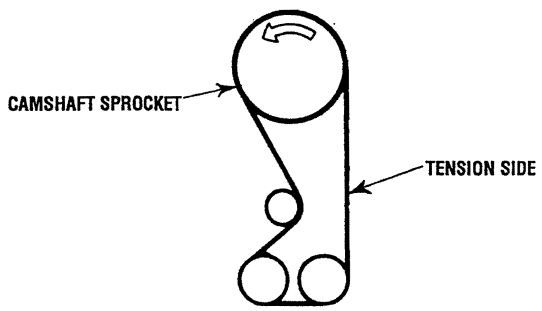
STANDARD VALUE: 4 to 5 teeth in forward direction.
1 to 2 teeth in reverse direction.



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.

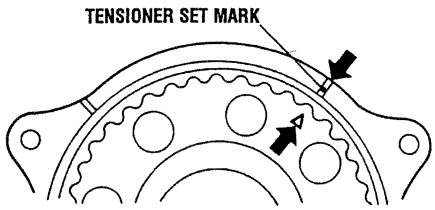
NOTE: *Ensure that the tension side of the timing belt is not slack. Keep the round bar inserted until the timing belt has been placed. After this step, be sure to remove the round bar.*

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.



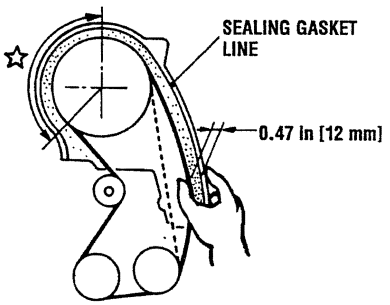
7. Loosen the temperorarily tightened tensioner nut on the water pump side 1 or 2 turns, and tension the belt making use of the spring force.
8. Turn the crankshaft *clockwise* by nine camshaft sprocket teeth (81°) to align the timing mark on the camshaft sprocket with the tensioner set mark on the timing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

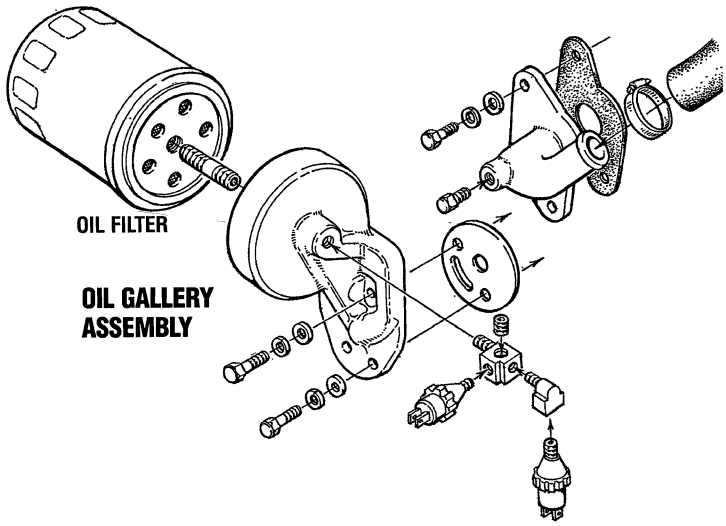


11. Pull out the rod from the plug hole on the left surface of the cylinder block and apply the specified sealant. Then tighten the plug to the specified torque.

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

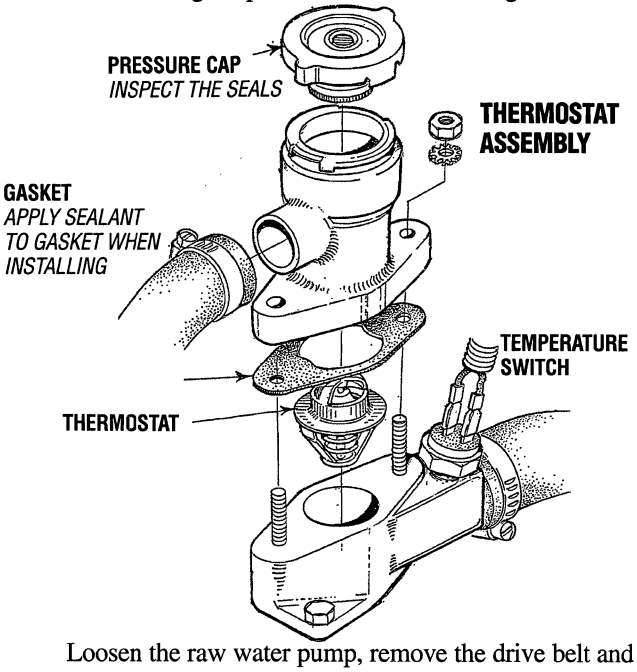
TIGHTENING TORQUE: 11-16 ft.lbs. (15-22 Nm)

ENGINE DISASSEMBLY

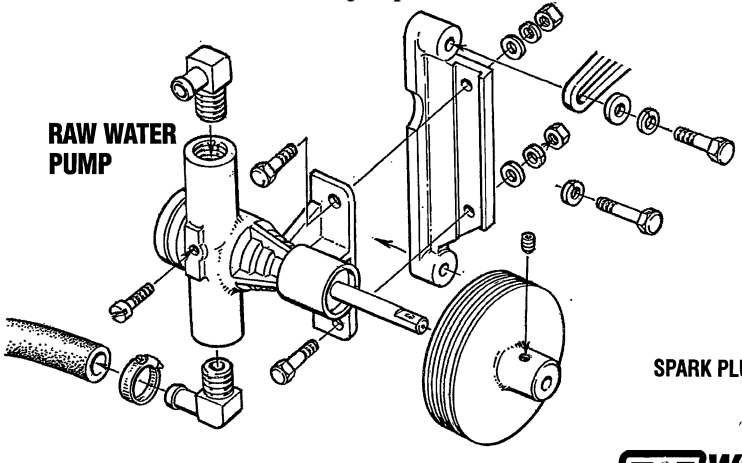


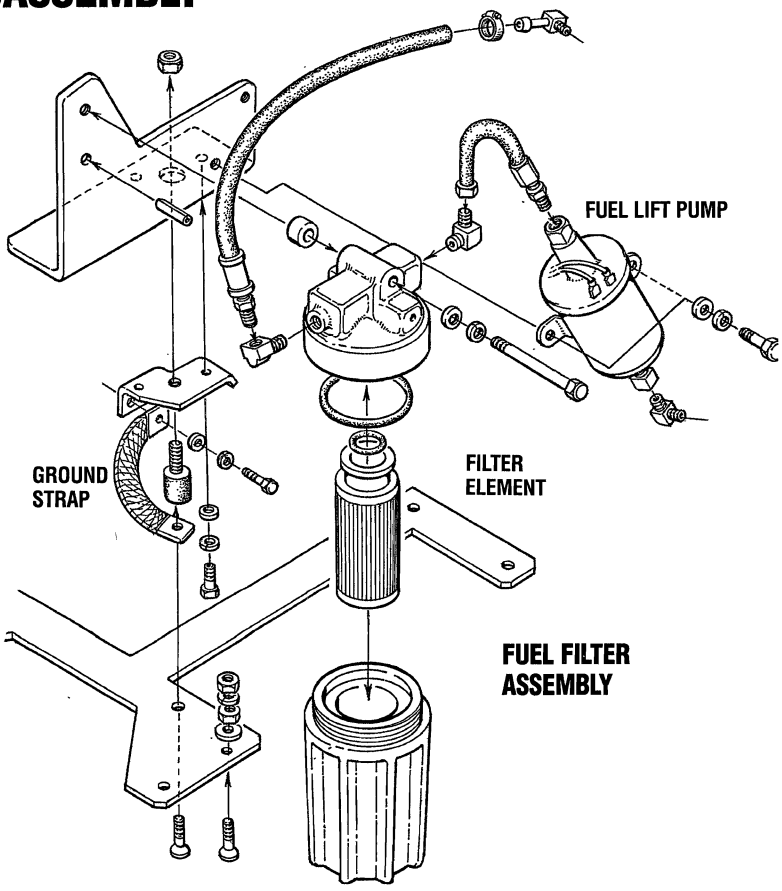
Disconnect and drain the oil hoses. remove, clean and inspect the oil gallery/filter assembly, replace the filter.

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



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



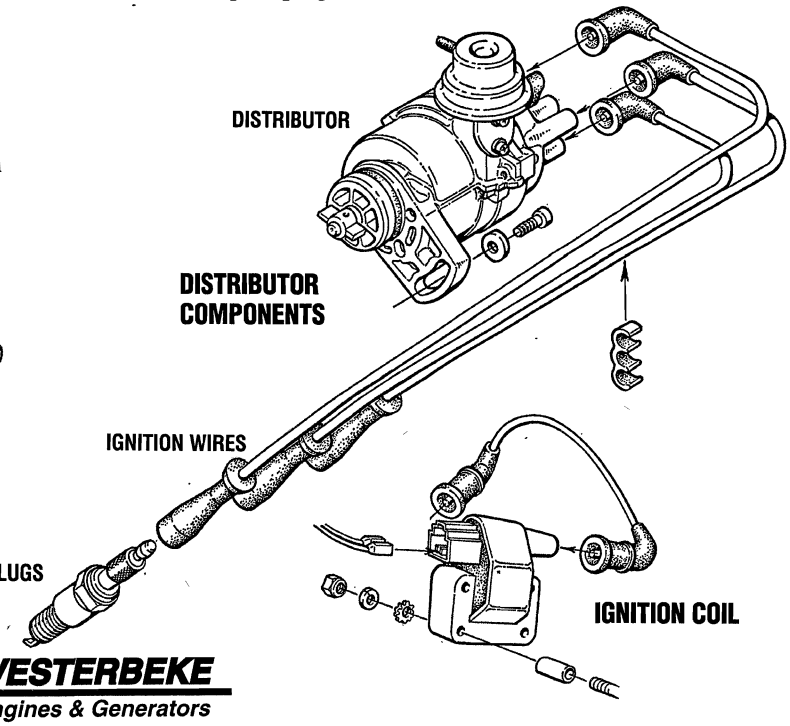


Remove the fuel filter assembly. Drain and inspect the hoses. Inspect the O-ring and replace the filter element.

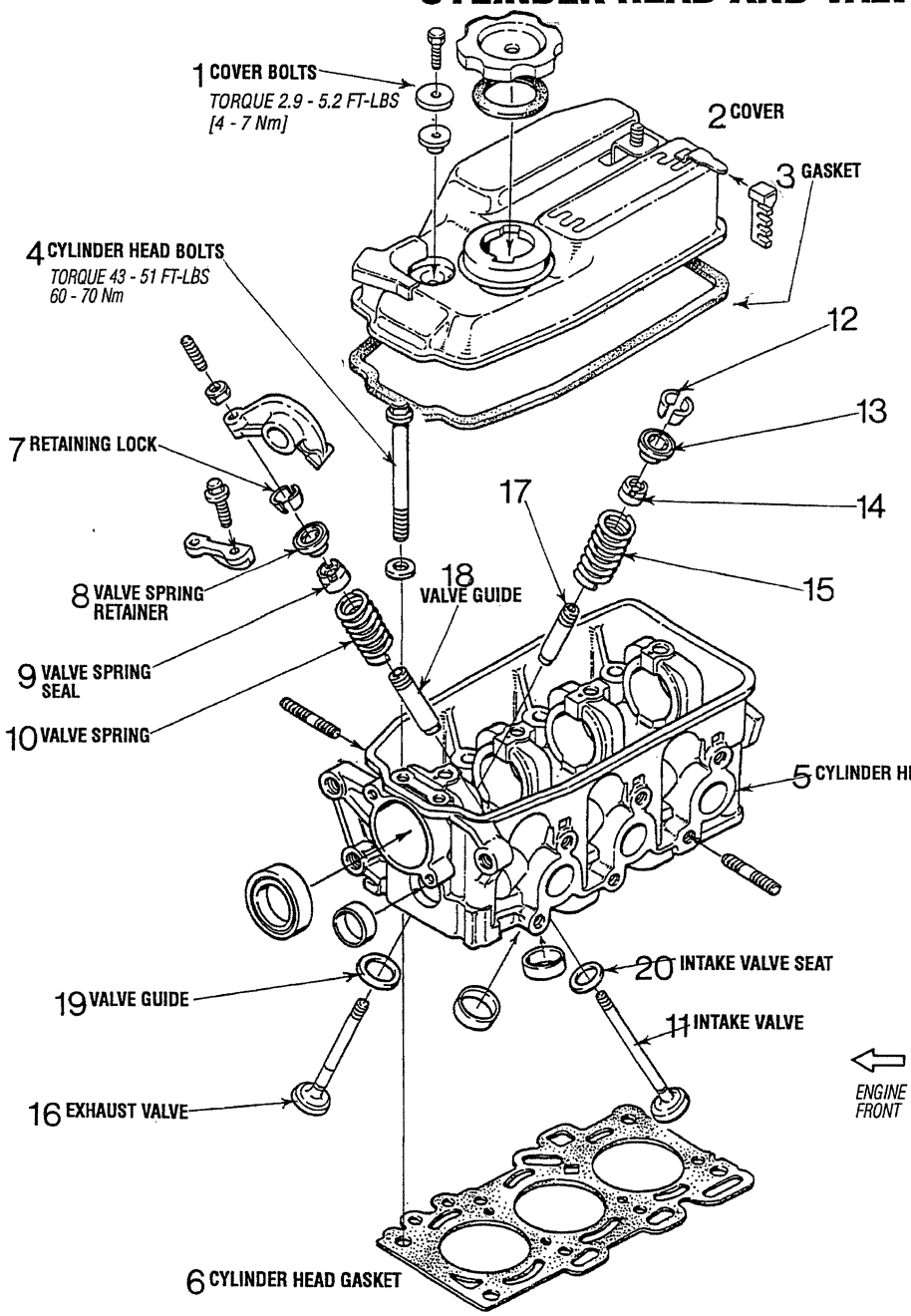
Remove the engines coolant pump. For servicing, refer to *COOLANT PUMP*.

Detach and remove the ignition wires, the distributor and spark plugs. Refer to *DISTRIBUTOR DISASSEMBLY* in this manual.

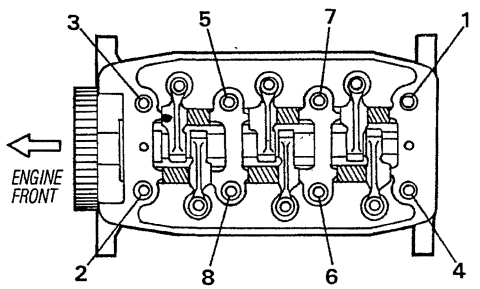
See *ENGINE ADJUSTMENTS* for information on ignition wires and spark plugs.



CYLINDER HEAD AND VALVES



NUMBERS INDICATE THE SUGGESTED ORDER OF DISASSEMBLY



CYLINDER HEAD BOLTS LOOSENING SEQUENCE

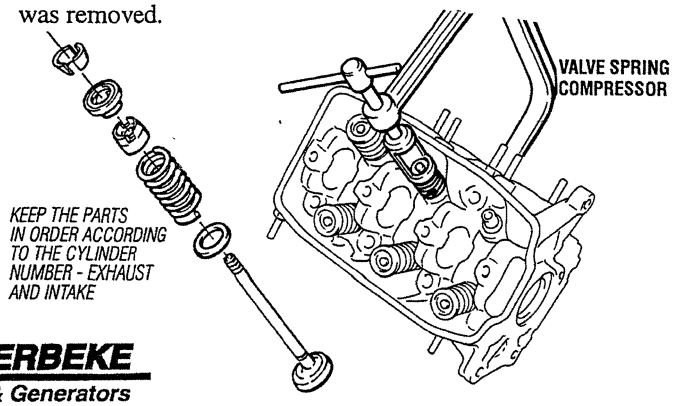
REMOVING THE CYLINDER HEAD FROM THE CYLINDER BLOCK

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.

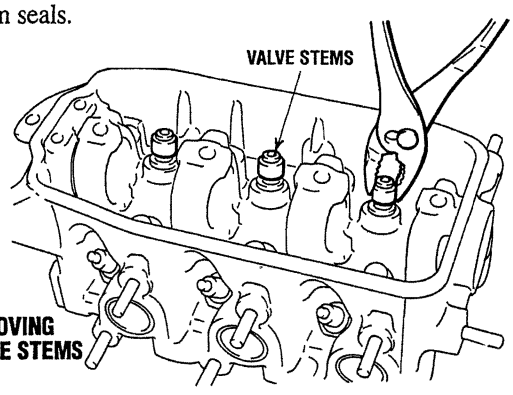
Remove the cylinder head and the cylinder head gasket.

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.



CYLINDER HEAD AND VALVES

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

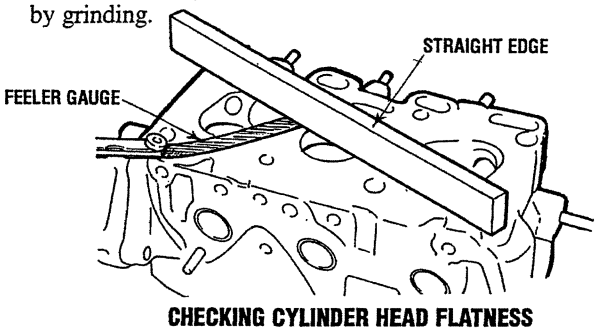


CYLINDER HEAD INSPECTION

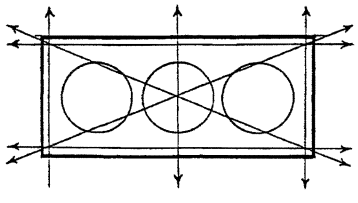
Before cleaning check the cylinder head for water leaks, cracks and other possible damage.

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

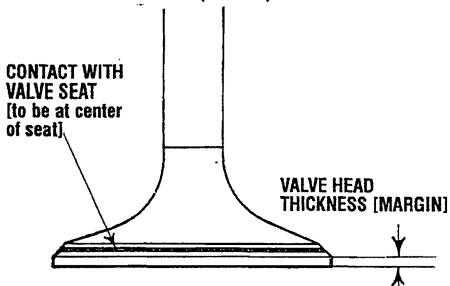
Valve Stem/Valve Seat

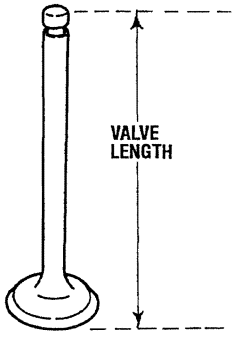
If the valve stem is bent or worn, replace the valve. Check contact between the valve and valve seat by applying a thin coat of Prussion Blue (or Redhead) on the valve seat contact face, then insert the valve into the valve guide and press-fit the valve on the valve seat. Do not rotate the valve.

Check if the valve seat contact face contacts the center position ø 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

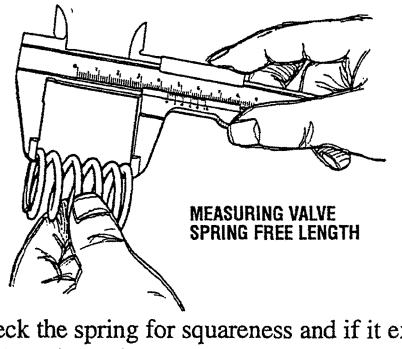
Standard 0.035in - 0.051 (0.9 - 1.3mm)

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)



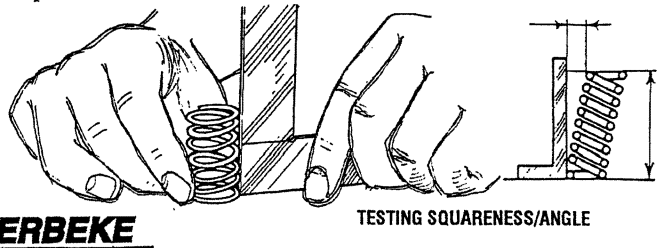
MEASURING VALVE
SPRING FREE LENGTH

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.

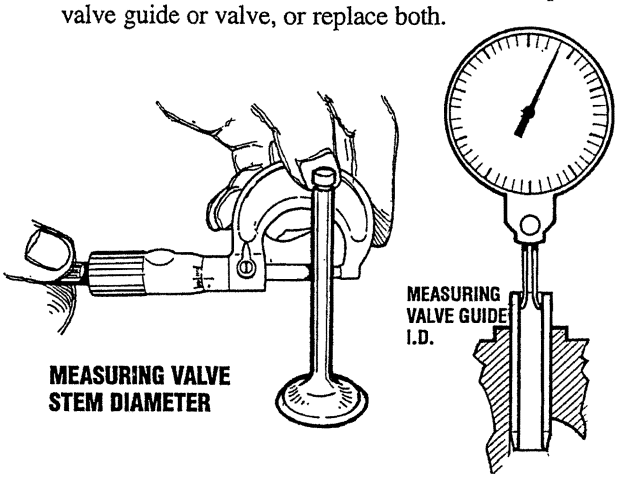


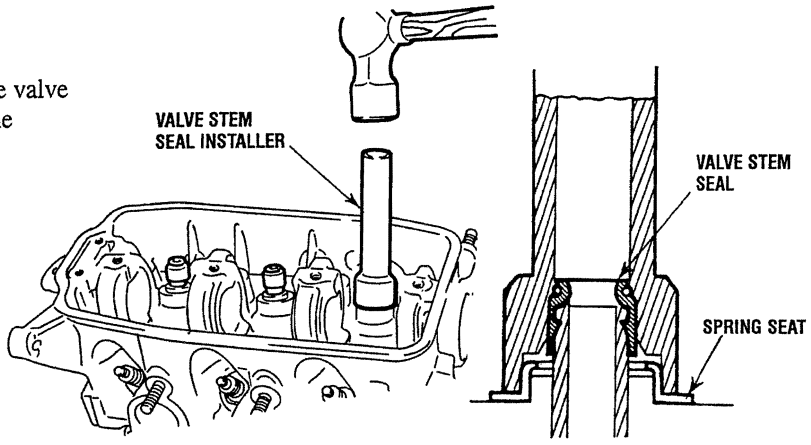
TESTING SQUARENESS/ANGLE

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

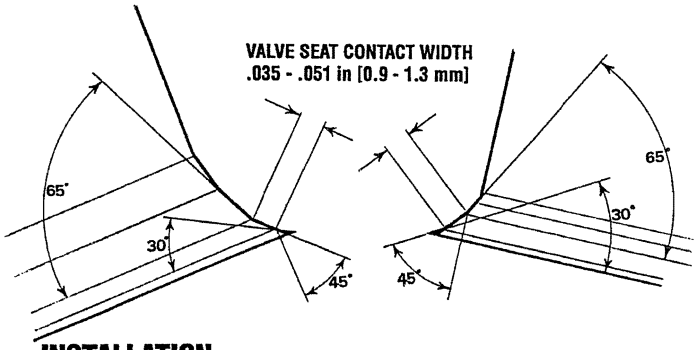
Standard	Intake	0.2585 - 0.2591in (6.565 - 6.580mm)
	Exhaust	0.2571 - 0.2579in (6.330 - 6.550mm)

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

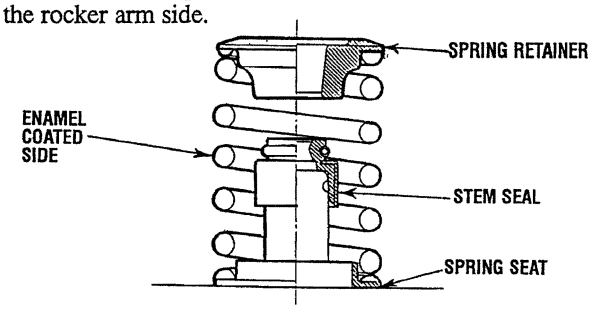
Install the valve spring seat, then using the valve stem seal installer, install a new stem seal to the valve guide.

Do not use the old valve stem seal.

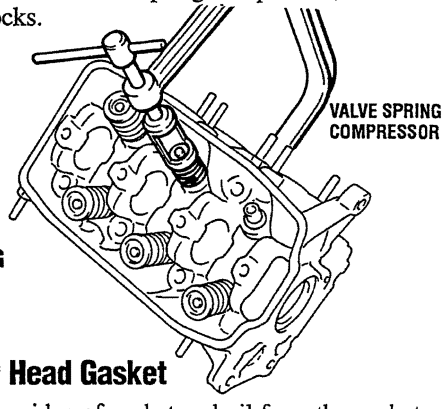
NOTE: *Use the installer tool to insert the stem seal, improper installation can cause oil to leak into the cylinder.*

Valve Springs

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



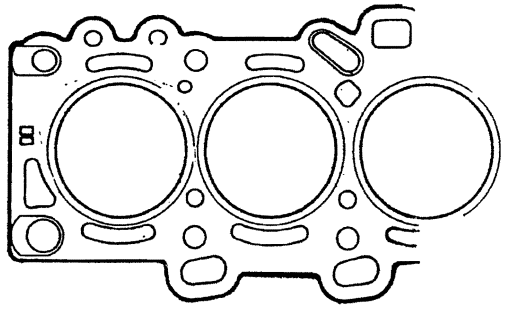
Use the valve spring compressor to compress the valve springs. With the valve spring compressed, remove the retainer locks.



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

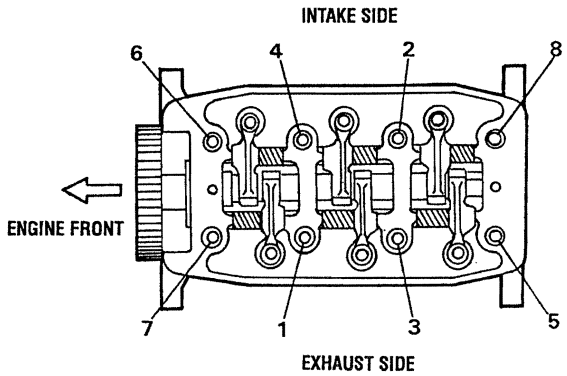
CYLINDER HEAD AND VALVES

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

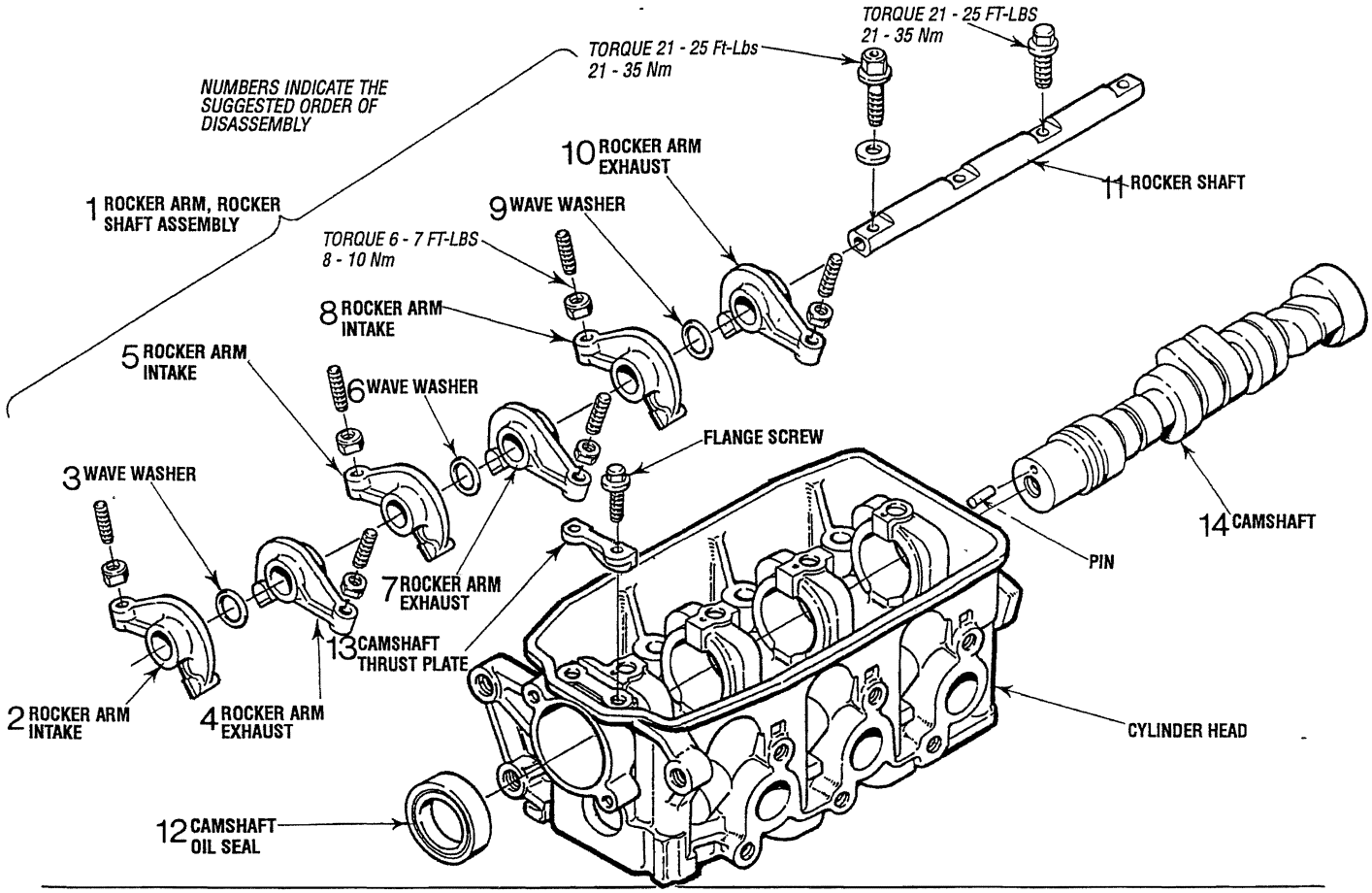
Rocker Cover

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



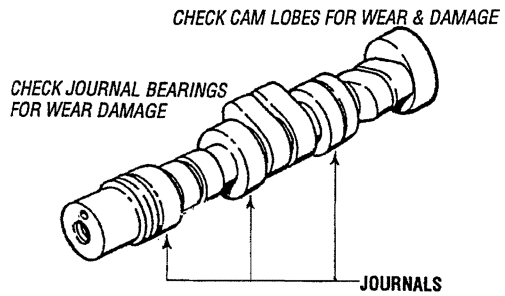
INSPECTING THE CAMSHAFT

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)

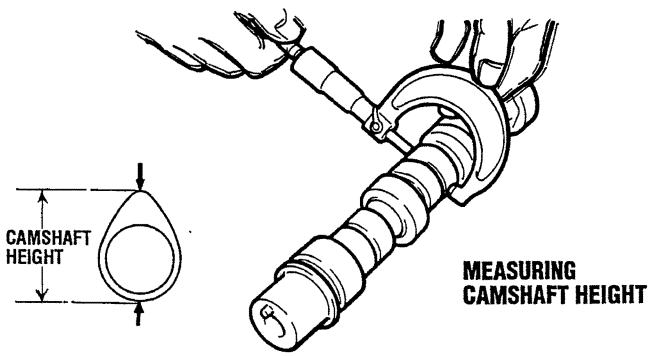


Camshaft

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

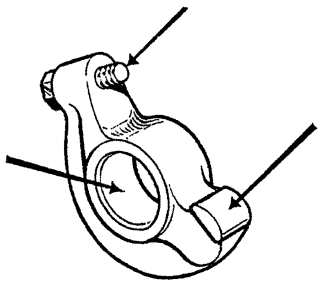
4. Inspect the clearance between the camshaft journal and the camshaft support bore as follows:
   a. Measure the camshaft journal diameter and the camshaft support bore.
   b. Calculate the clearance and replace the camshaft or cylinder head if the clearance exceeds the limit.

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.



ROCKER ARM INSPECTION

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)

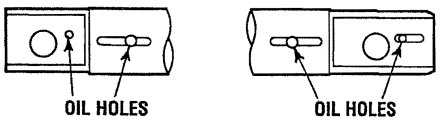
Standard	0.0005 - 0.0017in (0.012 - 0.043mm)
Limit	0.004in (0.1mm)

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)

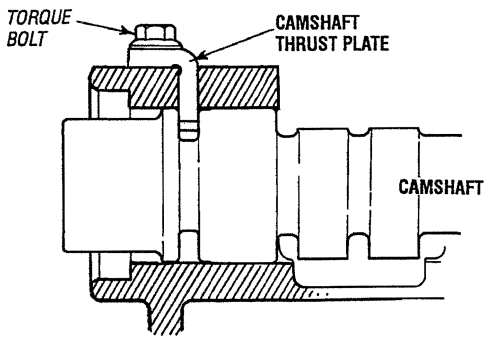
ROCKER SHAFT O.D. Standard 16.985 - 16.988in (0.6687 - 0.6693mm)



INSTALLATION

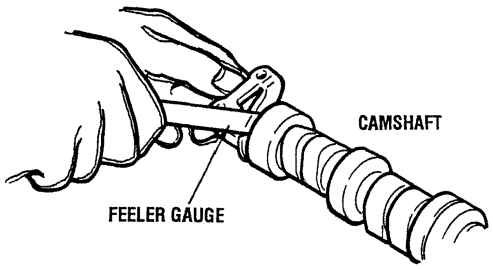
1. Apply a coating of engine oil to the camshaft journals and cams and insert the camshaft through the rear of the cylinder head.
2. Install the camshaft thrust plate as shown in the diagram tighten the bolts to the specified torque.

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

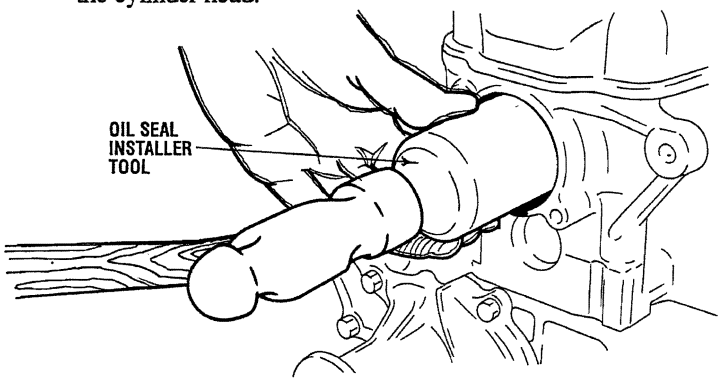


3. Measure the end play of the camshaft by inserting a feeler gauge in the gap between the rear of the thrust plate and the new front camshaft journal.

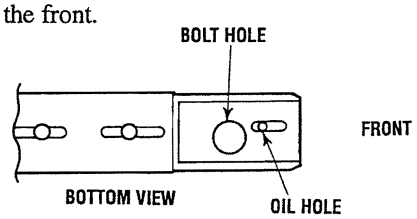
VALVE Standard 0.236 - 0.0551in (0.06 - 0.14mm)
Limit 0.118in (0.3mm)



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



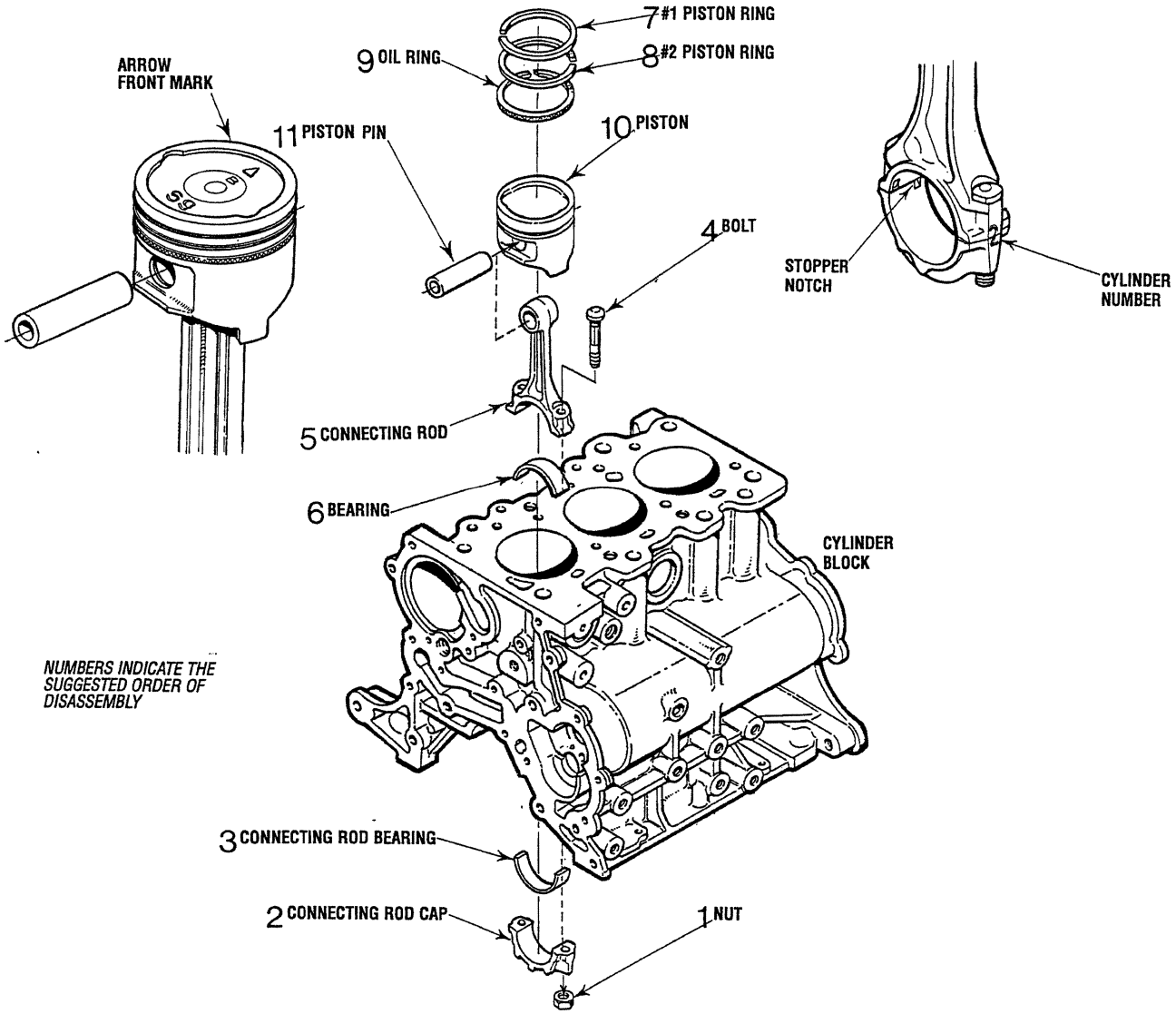
5. Install the rocker arm/rockershaft assembly. Install the rocker shaft so the portion shown in the diagram is located on the front.



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

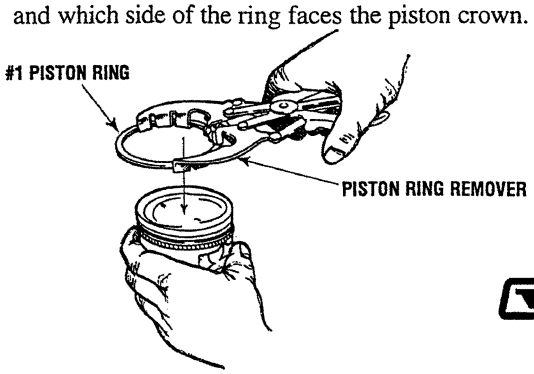


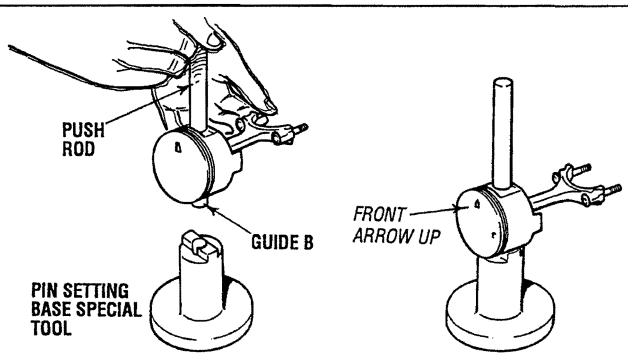
REMOVING THE CONNECTING RODS/PISTONS

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

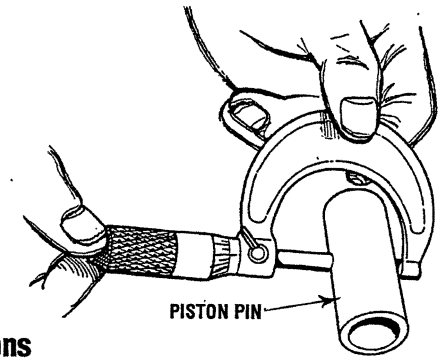
PISTON PIN INSPECTION

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

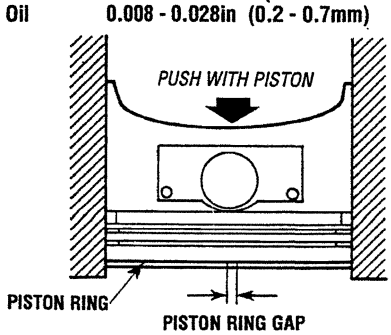
Insert the piston ring into the cylinder bore placing it against the top of the piston head and pressing it in. When it marks a right angle, measure the piston ring gap with a feeler gauge. When the gap is too large, replace the piston ring.

PISTON RING GROOVE

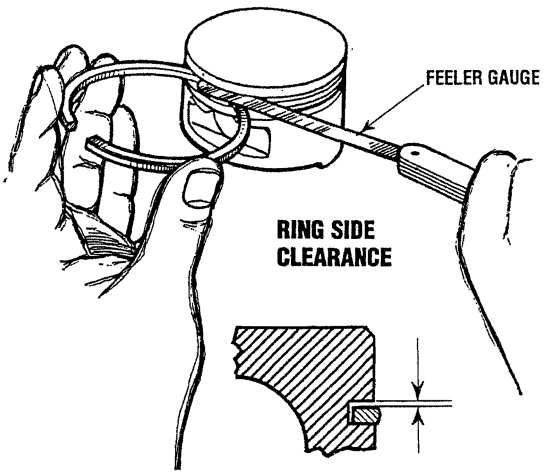
	Standard
No.1	0.0480 - 0.0488in (1.22 - 1.24mm)
No 2	0.0476 - 0.0484in (1.21 - 1.23mm)
Oil	0.1108 - 0.1116in (2.815 - 2.835mm)

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)

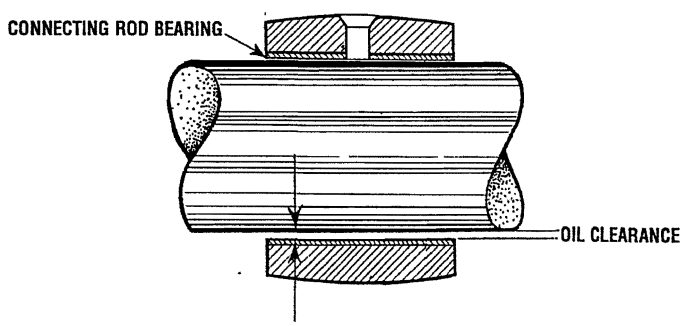
Connecting Rod Bearing

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)

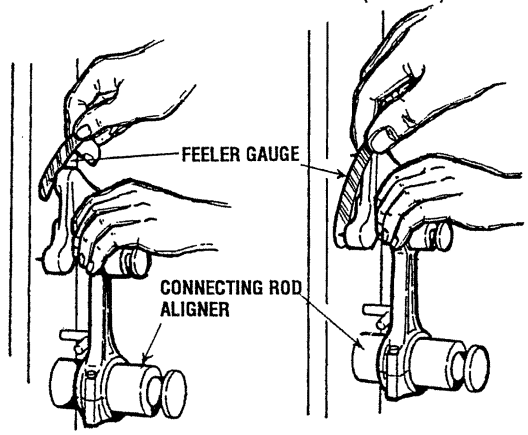


PISTONS AND CONNECTING RODS

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)

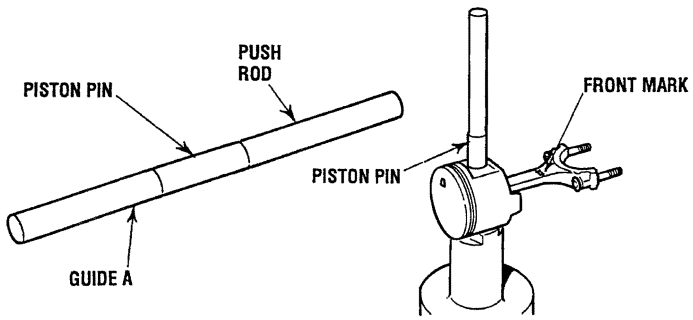
CONNECTING ROD CENTER LENGTH

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.

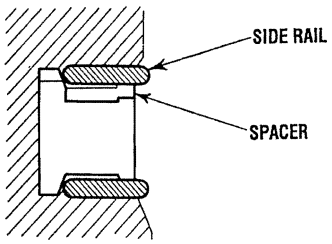
Using a press, load the push rod top end and press-fit the piston pin in the connecting rod. The piston pin is press fitted in the specified position by press-fitting the Guide A bottom end surface until it is seated on the bottom surface of the base. If the press-fitting load is out of the specification,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

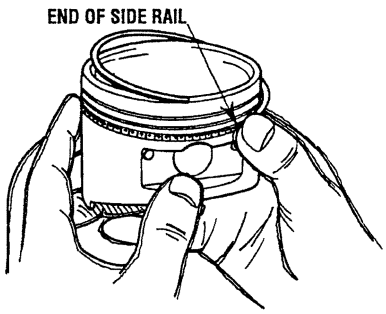


The chart below identifies the color coding on new spacer and side rails according to size.

SPACER AND SIDE RAIL CODING

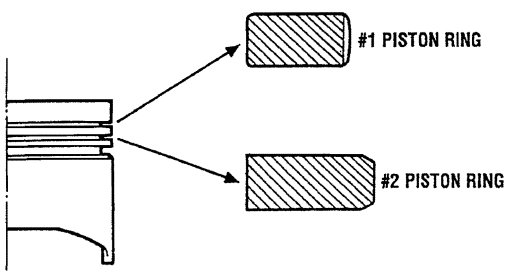
SIZE	Color Identification
S.T.D.	—
0.0098in (0.25mm) Oversize	Two Blue Lines
0.0197in (0.50mm) Oversize	One Red Line
0.0295in (0.75mm) Oversize	Two red lines
0.0394in (1.00mm) Oversize	One Yellow Line

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.



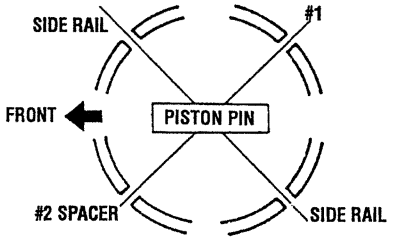
Piston Rings

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.

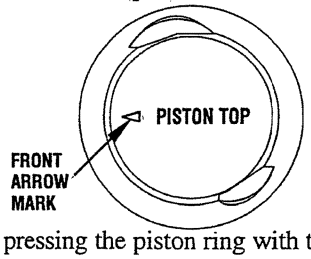


Installing the Piston Assembly

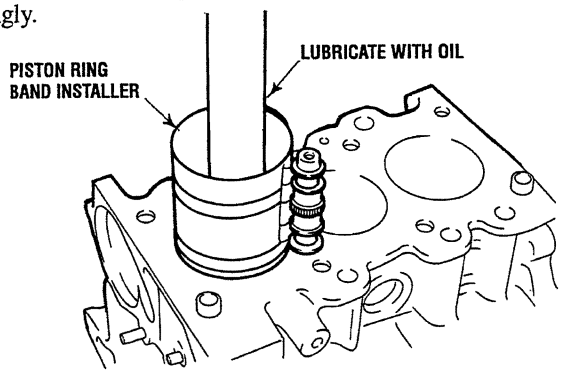
Apply an ample amount of oil to the outside surfaces of the piston and the piston rings. Position the piston rings and oil ring (side rail spacer) end gaps as shown.



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

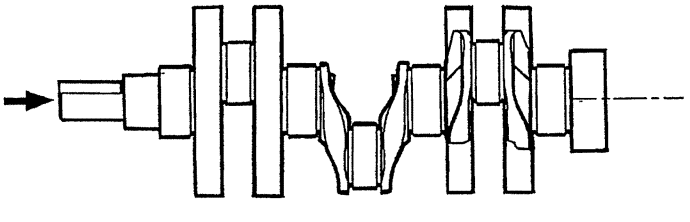


Securely pressing the piston ring with the ring band, insert the piston and connecting rod assembly into the cylinder. Keep in mind that the piston ring may be damaged if hit too strongly.

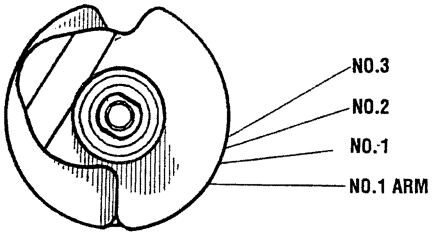


Crankshaft/Bearing Assembly

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

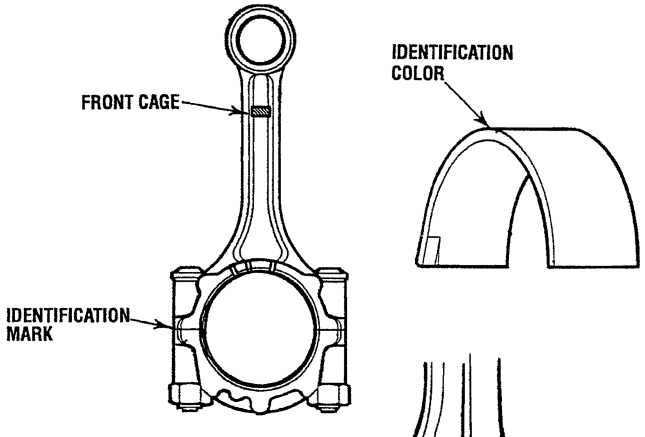
Identification Marks	Big End Inner Diameter
0	1.5354 - 1.5356in (39.000 - 39.005mm)
I	1.5356 - 1.5360in (39.005 - 39.015mm)
II	1.5360 - 1.5362in (39.015 - 39.020mm)

CONNECTING ROD BEARING THICKNESS

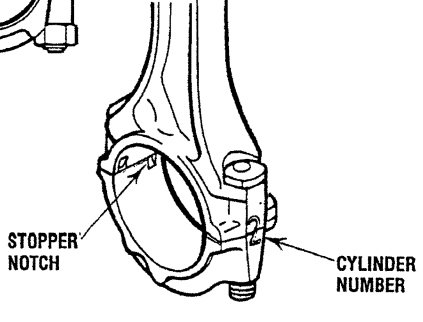
Identification Color	Bearing Thickness
Brown	0.0586 - 0.0588in (1.488 - 1.493mm)
——	0.0588 - 0.0590in (1.493 - 1.498mm)
Blue	0.0590 - 0.0592in (1.498 - 1.503mm)

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

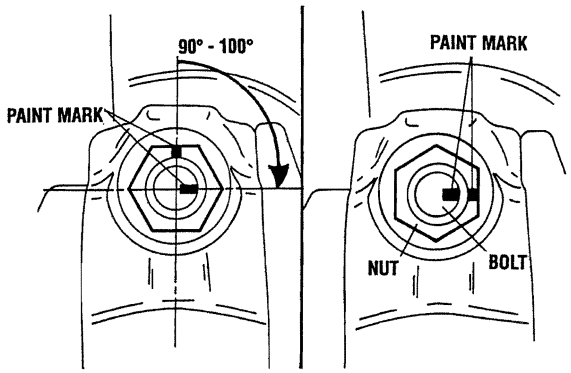
Since the connecting rod cap bolts and nuts are torqued using the plastic area tightening method, the bolts should be examined before reuse. If the bolt threads are "necked down", the bolt should be replaced.

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.***

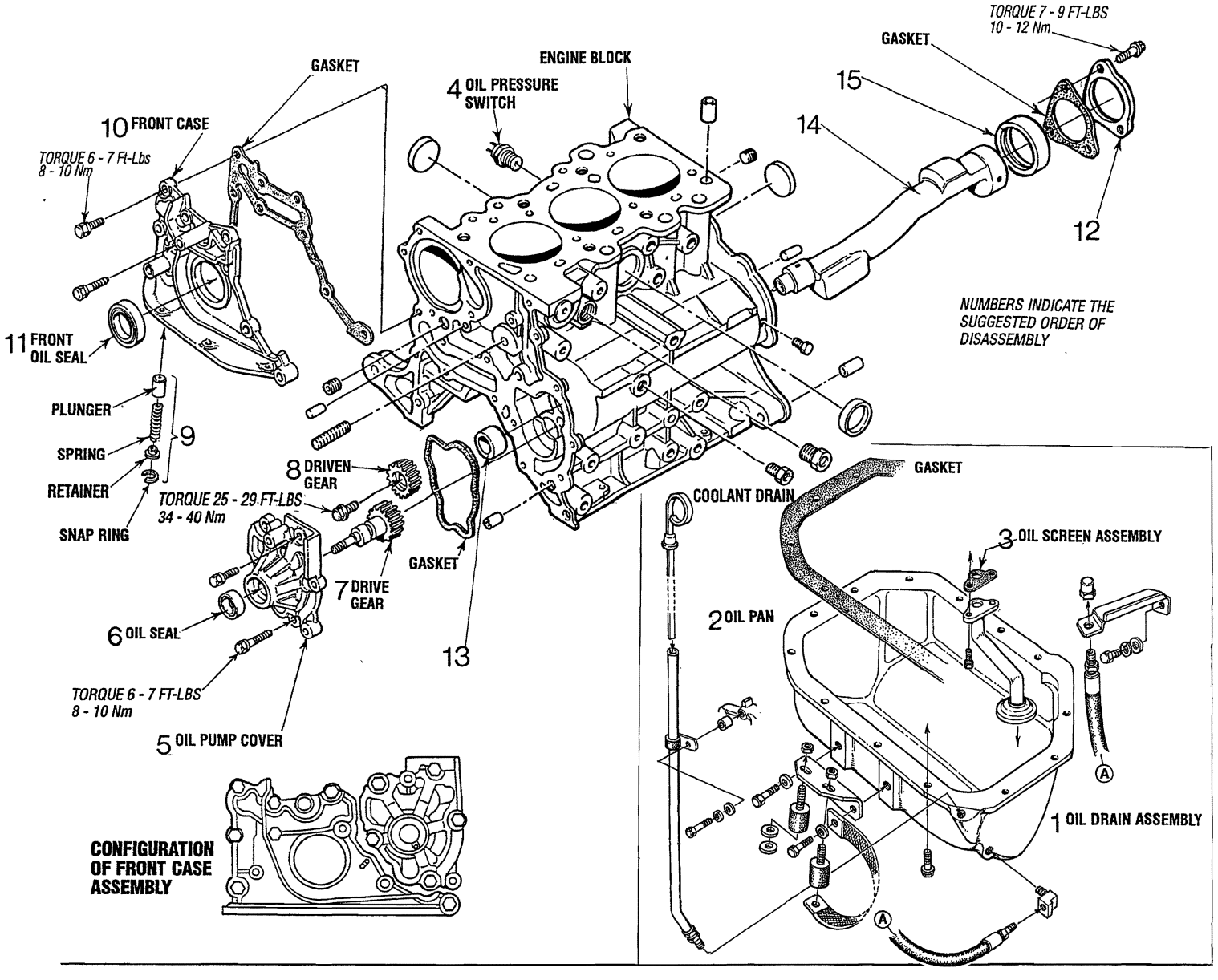
Make a paint mark on the head of each nut. Make a paint mark on the bolt end at the position 90° to 100° from the paint mark made on the nut in the direction of the tightening nut.

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.

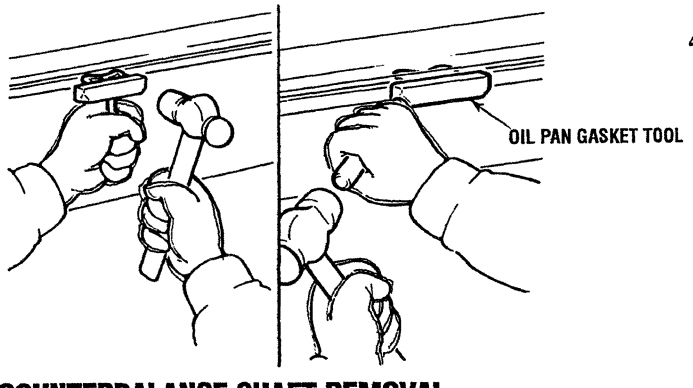
If the nut is overtightend (exceeding 100°), loosen the nut completely and then retighten it by repeating the tightening procedure.

FRONT CASE / COUNTERBALANCE SHAFT AND OIL PAN



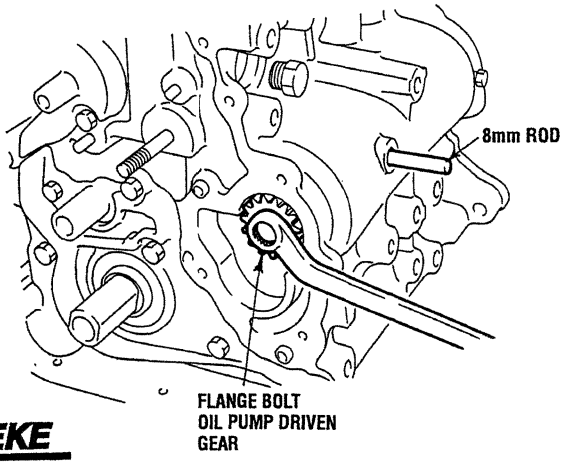
OIL PAN REMOVAL

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



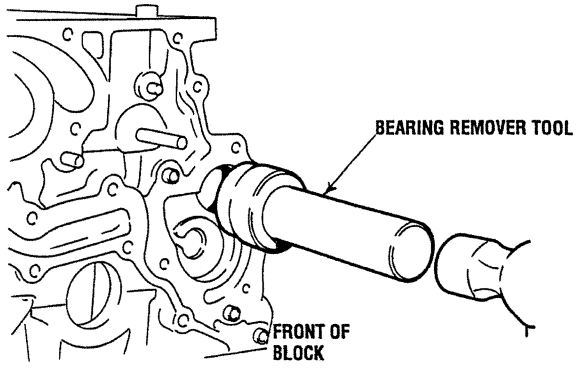
COUNTERBALANCE SHAFT REMOVAL

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.

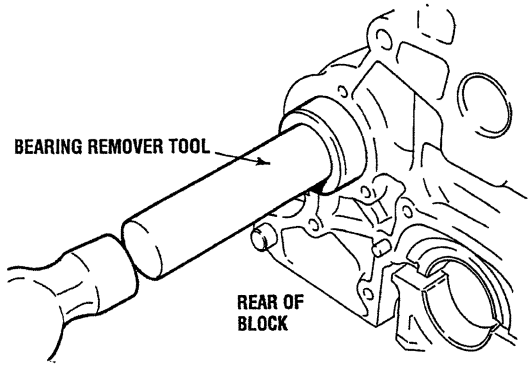


FRONT CASE / COUNTERBALANCE SHAFT AND OIL PUMP

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

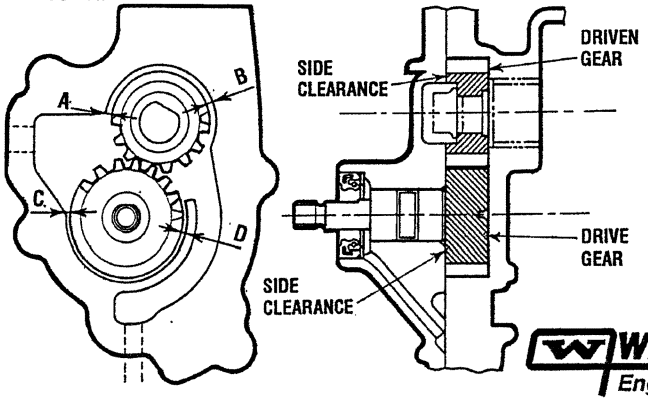
C.	0.0173 - 0.0276in (0.44 - 0.70mm)
D.	0.0059 - 0.077in (0.150 - 0.195mm)

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

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

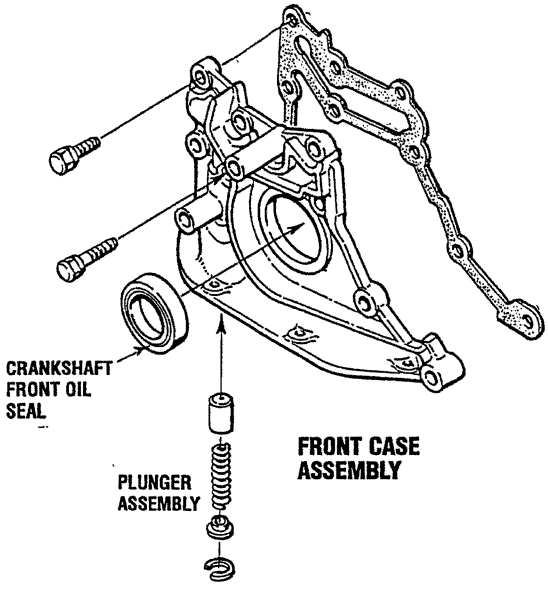
Using a straight edge, check the side clearance at the point indicated in the illustration with a feeler gauge.

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



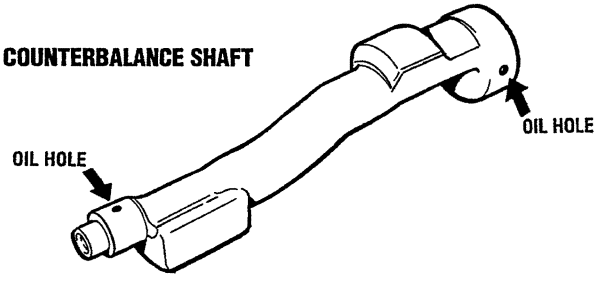
FRONT CASE - INSPECTION

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

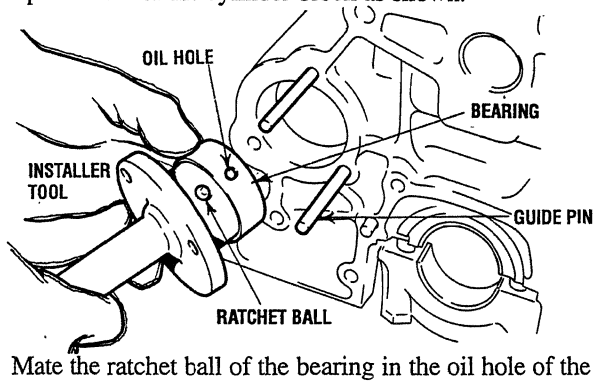
Front Journal Diameter	0.7869 - 0.7874in (19.987 - 20.000mm)
Rear Journal Diameter	1.7317 - 1.7322in (43.984 - 44.000mm)
Front Journal Oil Clearance	0.0014 - 0.0027in (0.035 - 0.068mm)
Rear Journal Oil Clearance	0.0014 - 0.0028in (0.035 - 0.071mm)

FRONT CASE / COUNTERBALANCE SHAFT AND OIL PUMP

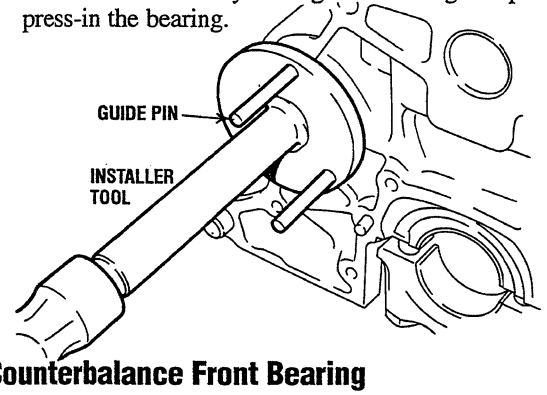
INSTALLATION

Counterbalance Rear Bearing

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

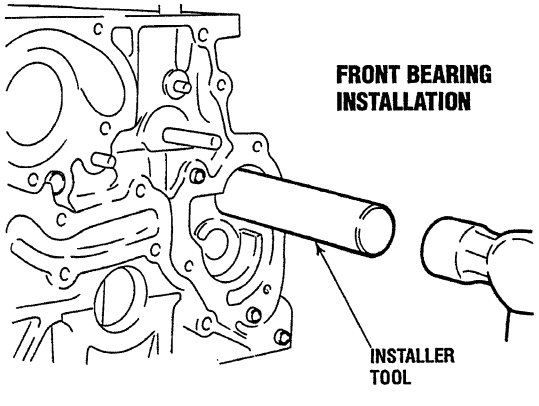


2. Mate the ratchet ball of the bearing in the oil hole of the rear bearing and install the bearing in the bearing installer.
3. Apply clean engine oil to the outer circumference of the bearing and the bearing hole in the cylinder block.
4. Insert the installer by mating it with the guide pins and press-in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



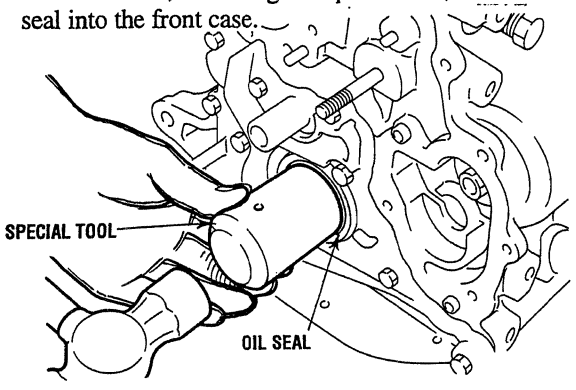
Counterbalance Front Bearing

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.



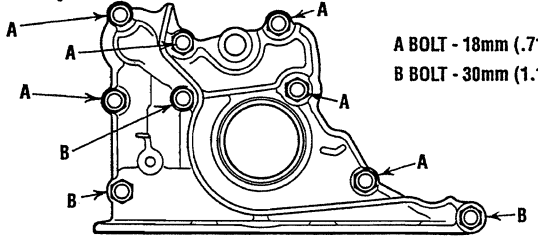
Front Case Assembly

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)

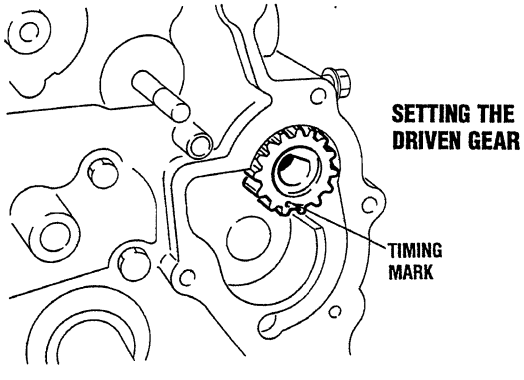
There are two different length front case bolts. Make certain they are positioned properly. See the diagram.

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.*



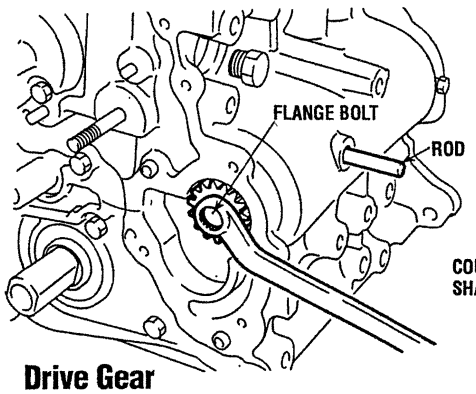
Oil Pump Driven Gear

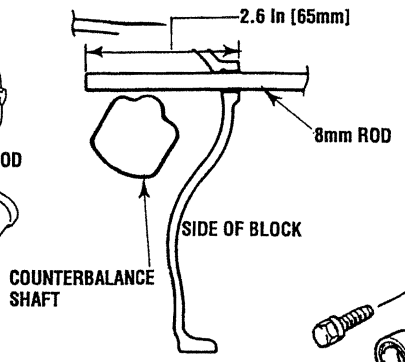
1. Apply an ample amount of clean engine oil to the oil pump driven gear and insert it so that the timing mark is positioned as shown.
2. Using the same hole on the side of the cylinder block, reinsert the 8mm rod to lock the counterbalance shaft. Then tighten the flange bolt to the specified torque.

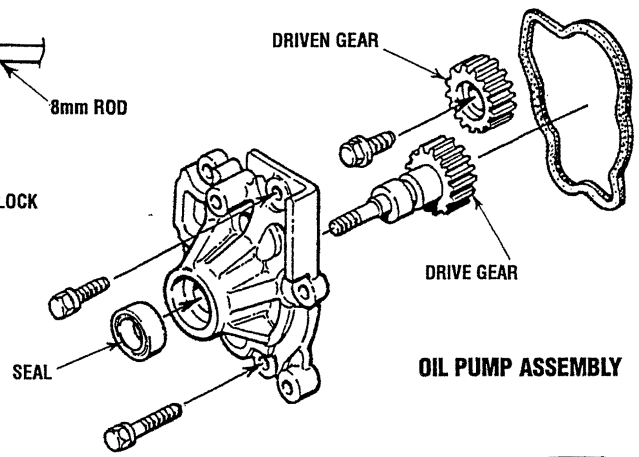


DRIVEN GEAR FLANGE BOLT TORQUE 25 - 29ft.lbs. (34 - 40Nm)

FRONT CASE / OIL PUMP AND OIL PAN



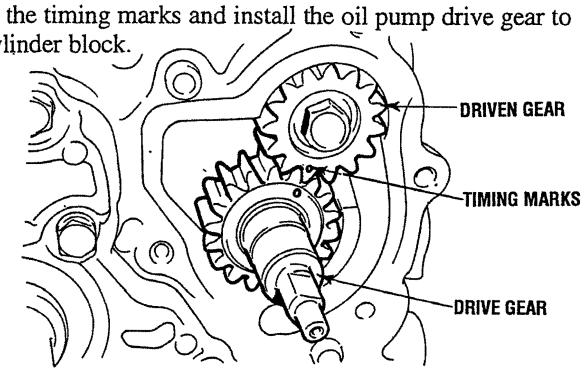


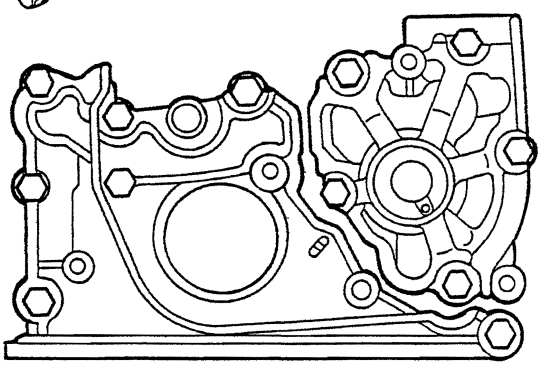


OIL PUMP ASSEMBLY

Drive Gear

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

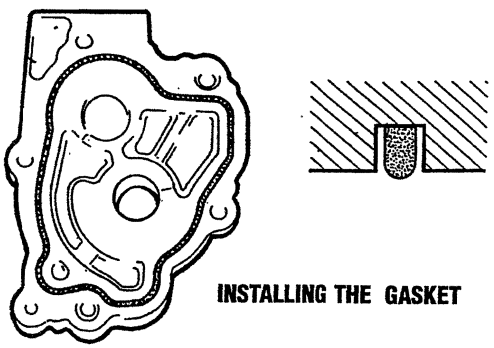




FRONT CASE CONFIGURATION

Oil Pump Cover Gasket

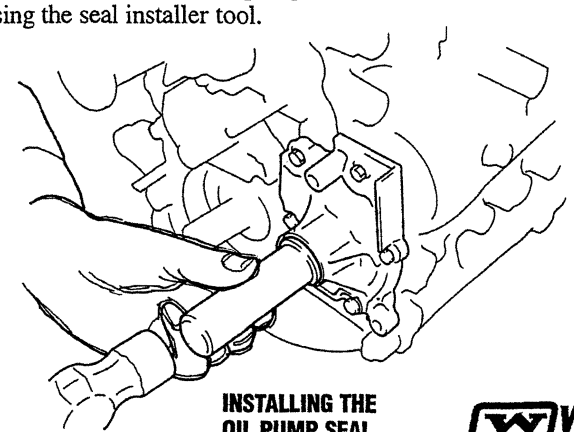
Fit a new oil pump cover gasket into the groove in the oil pump cover. The flat side of the gasket is positioned against the pump cover.



INSTALLING THE GASKET

Oil Pump Seal

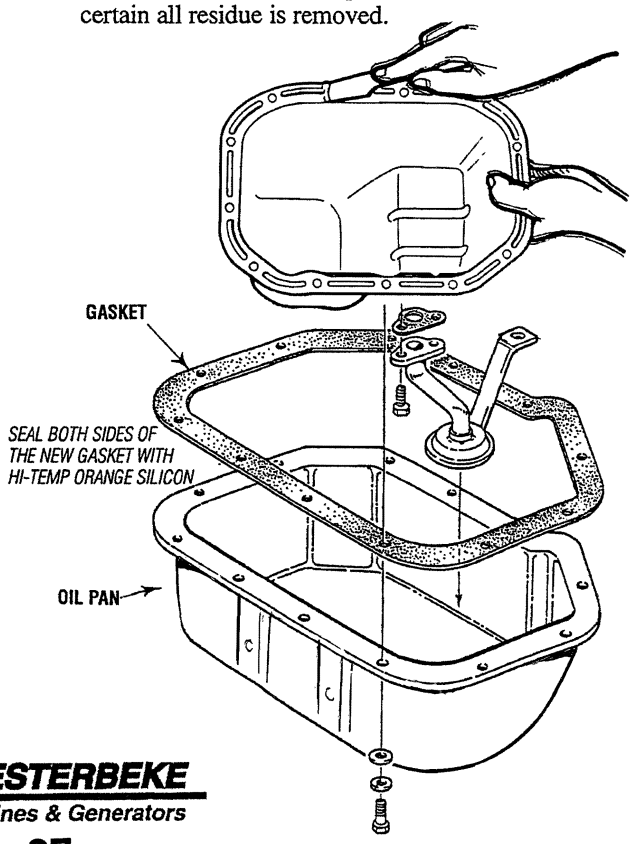
Press the seal into the oil pump cover flush with the surface using the seal installer tool.



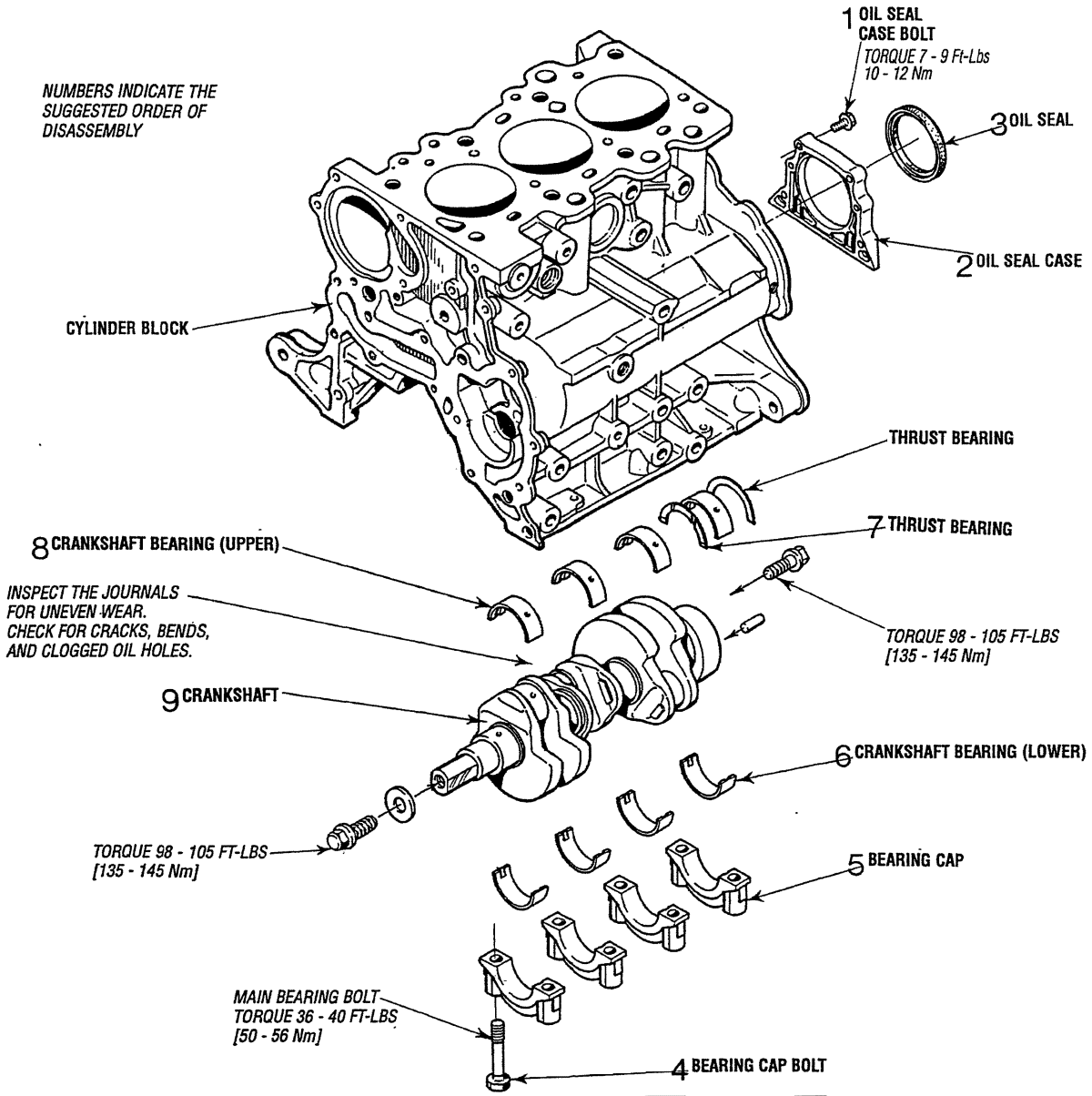
INSTALLING THE OIL PUMP SEAL

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

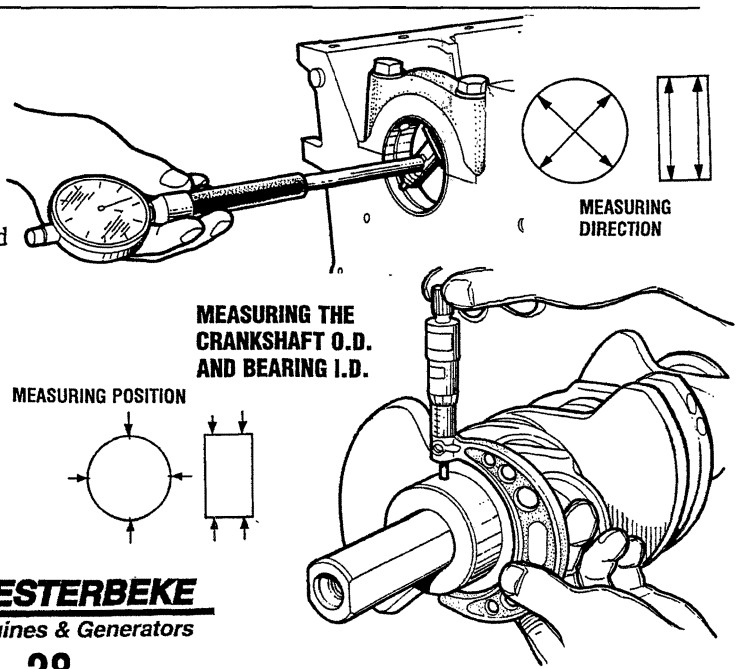


CRANKSHAFT INSPECTION

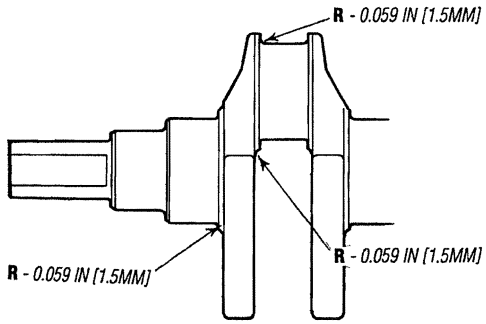
1. Check the journals and pins for damage, seizure and cracks. Check the journals contact surface for uneven wear and replace if badly damaged.
2. Measure the outside diameter of the journal and the inside diameter of the main bearing. If the clearance (oil clearance) exceeds the limit, replace the main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



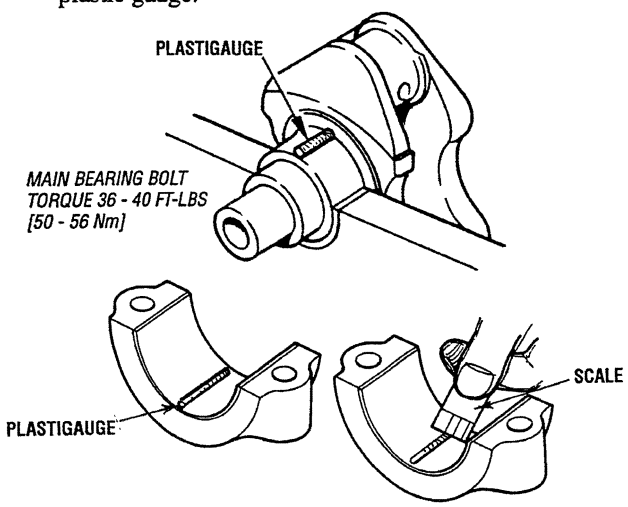
CRANKSHAFT, BEARING AND OIL SEAL



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.

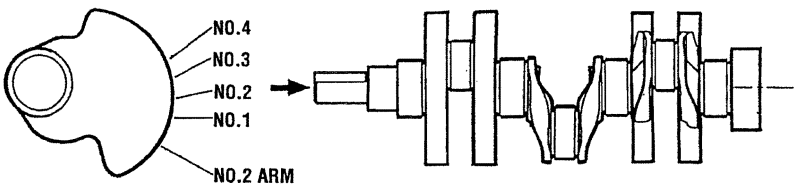
CRANKSHAFT BEARINGS SPECIFICATIONS

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.

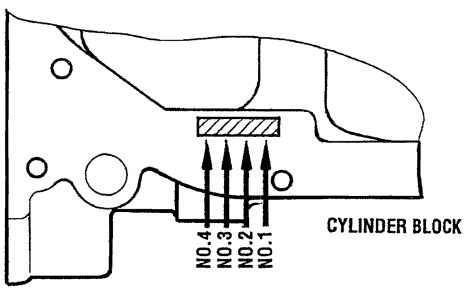
CRANKSHAFT JOURNAL DIAMETER

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)



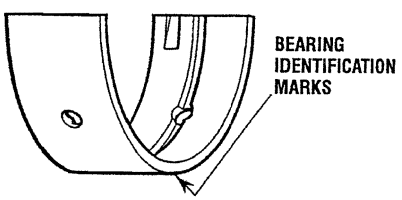
CRANKSHAFT BEARING THICKNESS

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

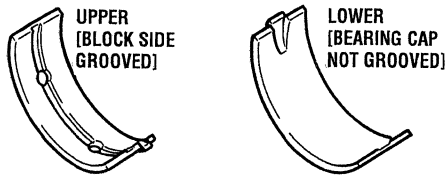
Identification Marks	Bearing Inner Diameter
0	1.7323 - 1.7325 in (44.000 - 44.006mm)
I	1.7325 - 1.7328 in (44.006 - 44.012mm)
II	1.7328 - 1.7330 in (44.012 - 44.018mm)



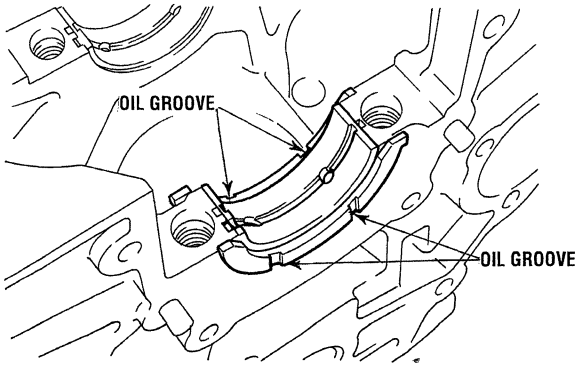
CRANKSHAFT BEARING SELECTION CHART

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

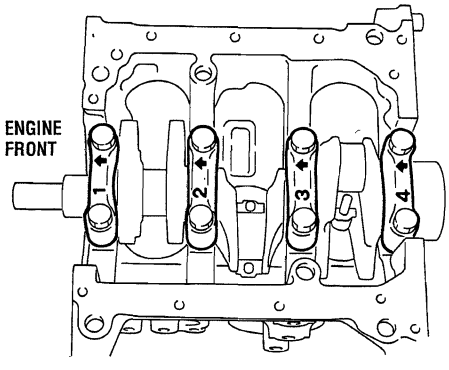


CRANKSHAFT BEARINGS



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.



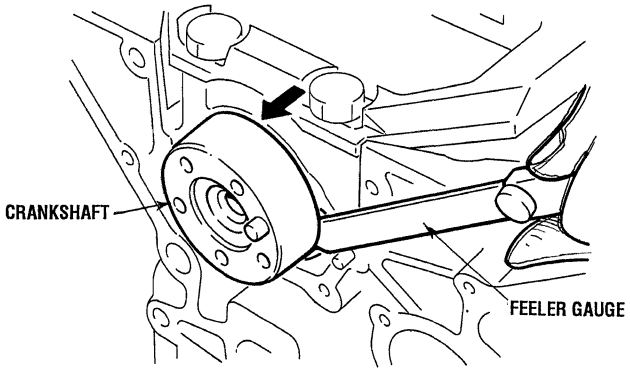
2. Install the bearing cap paying careful attention to the cap number and the arrow mark. Apply oil to the bolt threads.
3. Tighten the bearing cap to the specified torque.

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

MEASURING END PLAY

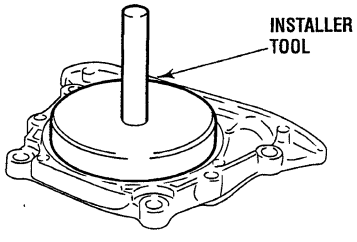
Push the crankshaft to the rear. Then, insert a feeler gauge in the gap between the crankshaft journal side surface and the thrust bearing end surface to measure the end play.

CRANKSHAFT END PLAY: 0.0020 - 0.0009in (0.05 - 0.025mm)

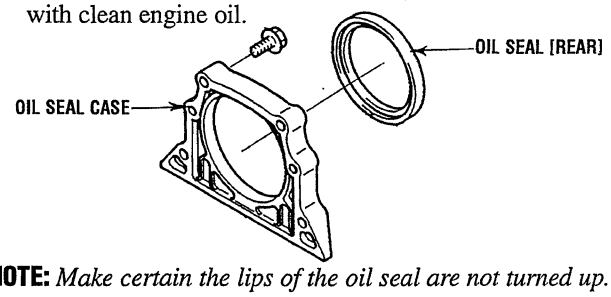


CRANKSHAFT REAR OIL SEAL

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.



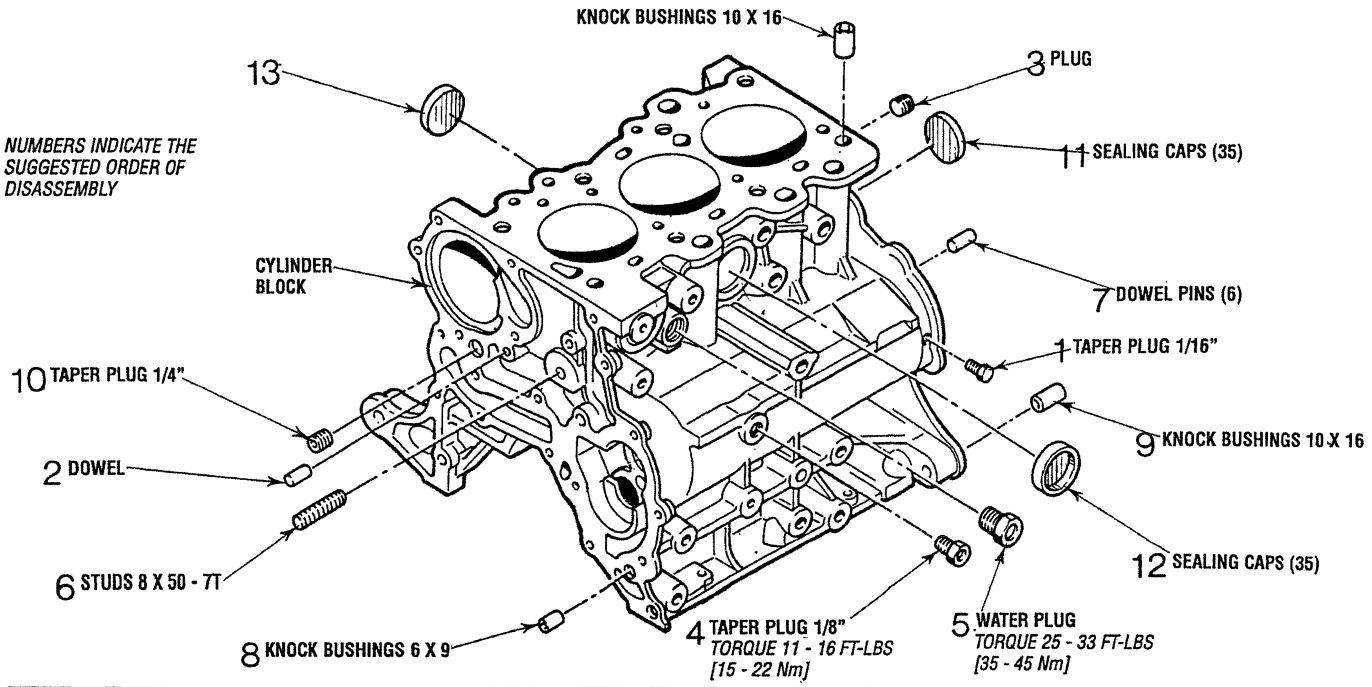
3. Install the oil seal case into the cylinder block through the gasket. (If there is no gasket, coat with sealant.) The entire circumference of the oil seal lip should be coated with clean engine oil.



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

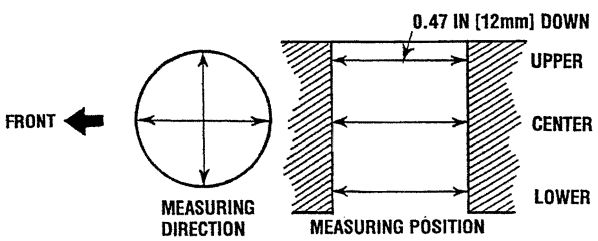


CYLINDER BLOCK INSPECTION

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.

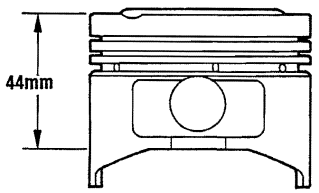
   CYLINDRICITY STANDARD VALUE: 0.0004 in (0.01 mm) or less
   CYLINDER BORE: 2.5591 - 2.5602 in (65.00 - 65.03 mm)



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.

SERVICE DATA / STANDARDS AND LIMITS - BCG 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 - BCG 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

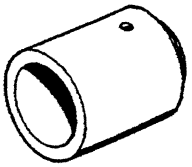
Timing Belt	Nm	ft. lbs.
Crankshaft bolt	135-145	98-105
Timing belt cover bolts	10-12	7-9
Camshaft sprocket bolts	80-100	58-72
Oil pump sprocket nuts	50-57	36-41
Timing tensioner nuts	22-30	16-22
Timing belt rear cover bolts	10-12	7-9
Rocker Arms and Rocker Shaft		
Rocker cover shaft	29-35	21-25
Camshaft 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

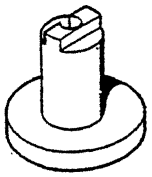
SPECIAL TOOLS - ENGINE

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

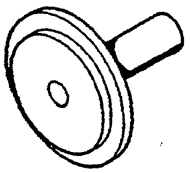
CAMSHAFT OIL SEAL INSTALLER
MD 999569



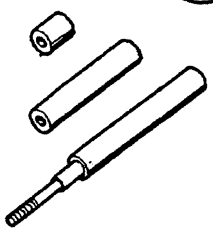
PISTON PIN SETTING BASE
Used to pull-out and press in the piston pin.
MD 999583



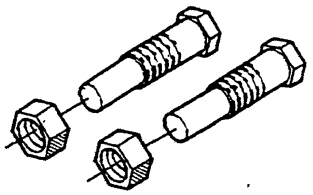
CRANKSHAFT REAR OIL SEAL INSTALLER
MD 998376



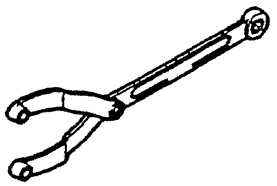
PUSH ROD AND PIN SET GUIDE
Used to pull-out and press in the piston pin.
MD 999584



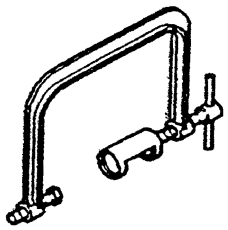
PIN *For supporting the sprocket when the camshaft sprocket is loosened or tightened.*
MD 998715



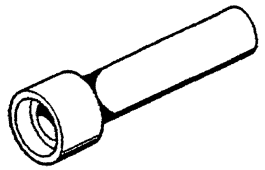
END YOKE HOLDER
For supporting the sprocket when the camshaft sprocket is loosened or tightened.
MD 990767



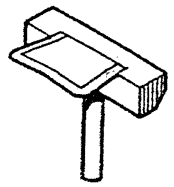
VALVE SPRING COMPRESSOR
MD 999597



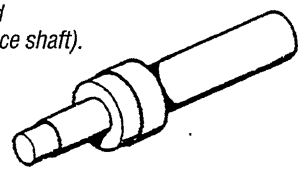
VALVE STEM SEAL INSTALLER
MD 998302



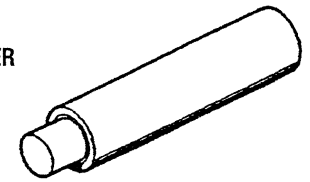
OIL PAN GASKET CUTTER
For removing the oil pan to break the oil pan seal.
MD 998727



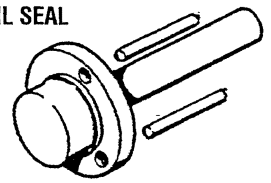
BEARING REMOVER
For pulling out the front and rear bearings (counterbalance shaft).
MD 999593



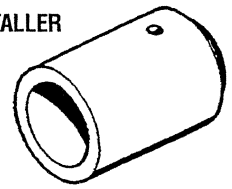
FRONT BEARING INSTALLER
(Counterbalance shaft).
MD 999591



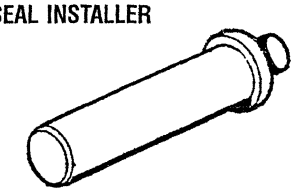
INSTALLER FOR THE REAR OIL SEAL
(Counterbalance shaft).
MD 999592



CRANKSHAFT FRONT OIL SEAL INSTALLER
MD 999570



OIL PUMP OIL SEAL INSTALLER



EXHAUST MANIFOLD / HEAT EXCHANGER

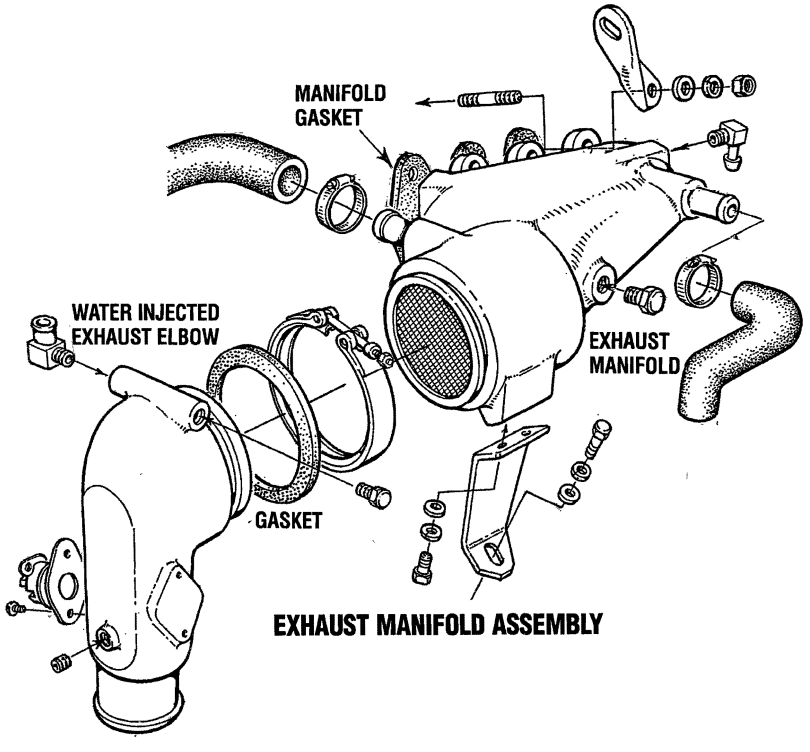
EXHAUST MANIFOLD

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

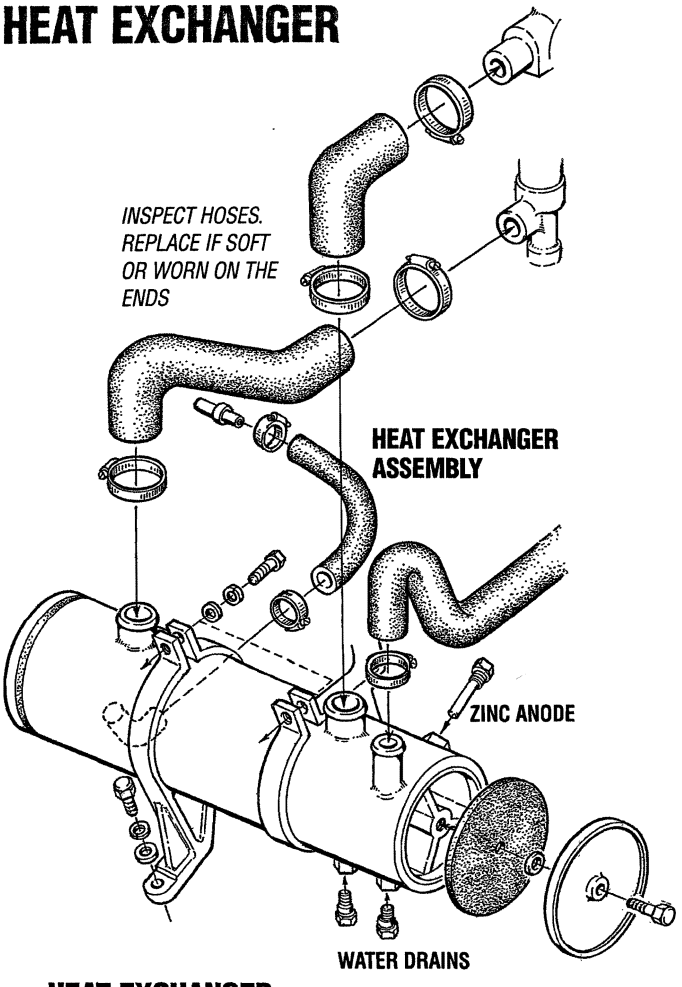
1. Remove the exhaust elbow from the manifold. Scrape off and discard the old gasket. Inspect the exhaust elbow for corrosion and damage, replace if necessary.
2. If the exhaust elbow passes inspection, remove the high temperature sensor and clean and re-paint the elbow with WESTERBEKE heat resistant 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.



EXHAUST MANIFOLD ASSEMBLY



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

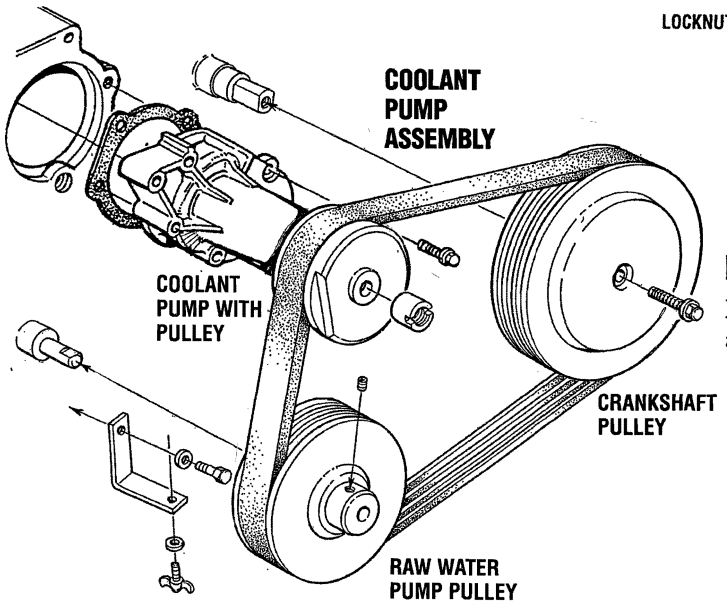
HEAT EXCHANGER ASSEMBLY

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

COOLANT CIRCULATING PUMP

REMOVING THE COOLANT PUMP

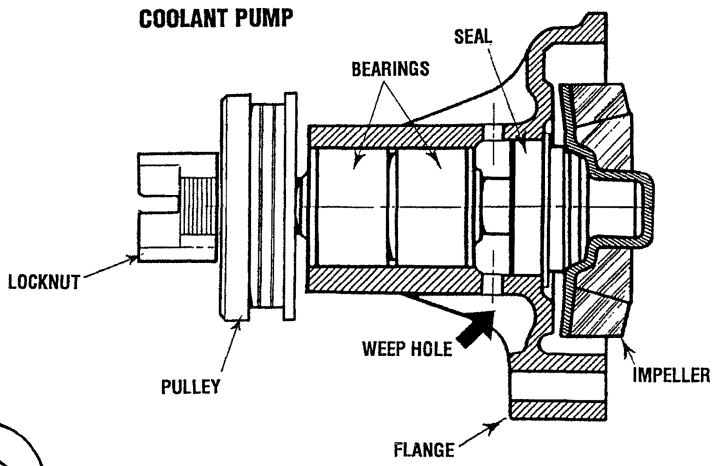
1. Loosen the belt guards thumbscrews and remove the engine's belt guard from its brackets at the front of the engine.
2. Ease the belt tension by releasing the raw water pump and remove the engine drive belt [on carburetor models it will be necessary to remove the governor belt].
3. Unscrew the five 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

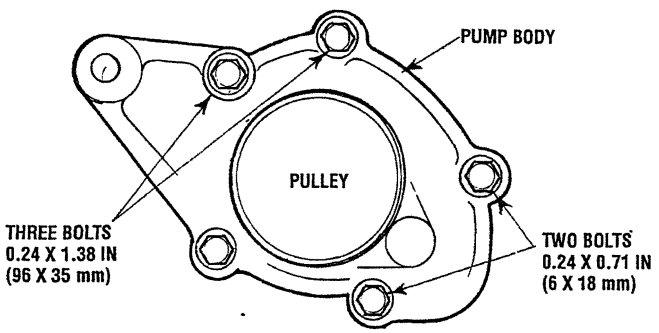
Carefully check the pump body and impeller for cracks and damage. Inspect the weep holes for signs of water leakage and rust that would indicate a faulty seal. The pulley should turn the shaft (and impeller) smoothly, without noise or sluggish rotation.

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.

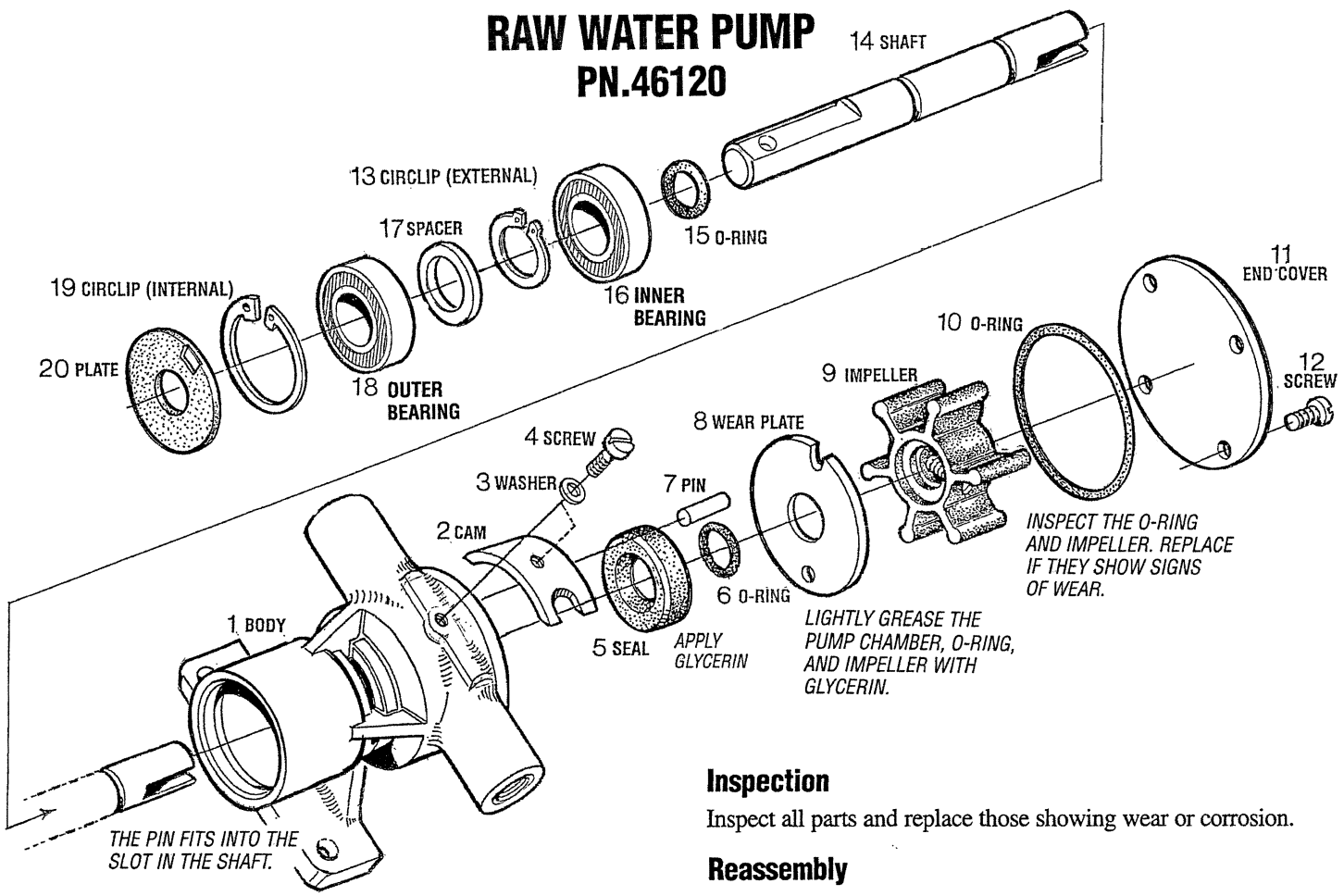


INSTALLATION

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)**

RAW WATER PUMP
PN.46120



PUMP OVERHAUL

Disassembly

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

1. Remove the four cover plate screws #12, cover plate #11 and sealing O-ring #10.
2. Remove the impeller #9 using a pair of pliers, grasping the hub and pulling it out of the pump with a twisting motion.
3. Remove the screw #4 and sealing washer #3 that hold the cam in place. Remove the cam #2 and inner wear plate #8 behind it.
4. Remove dust plate #20 and circlip #19.
5. Support the pump body on an arbor press and with a drift, press the shaft and bearing assembly out the pulley end of the pump.
6. Remove the O-ring from the shaft.
7. Support the outer bearing #18 and push the shaft out of the bearing.
8. Remove the spacer #17 and circlip #13.

Inspection

Inspect all parts and replace those showing wear or corrosion.

Reassembly

1. Install a new shaft seal #5 in the pump body. Apply some glycerin to the lip of the seal.
2. Install the circlip #13 on the shaft. Support the outer bearing #18 and push the shaft into the bearing until the bearing contacts circlip.
3. Install spacer #17 against the circlip. Support the inner bearing #16 and push the shaft into the bearing until it contacts the spacer.
4. Apply some glycerin onto the O-ring #6 and install it on the shaft approximately 1/8" away from the inner bearing.
5. Support the pump body on an arbor press. With a twisting motion, install the shaft and bearing assembly into the shaft seal #5 until the inner bearing contacts the pump body. Then with the push shaft and bearing, assembly into the pump body so that the outer bearing just clears the boss for circlip #19.
6. Install circlip #19 and push the shaft and bearing assembly so the outer bearing #18 contacts the circlip #19.
7. Install the dust plate #20.
8. Install wear plate #8, cam 32 and secure it in place with washers and screw #4.
9. Apply some glycerin to the surface of the impeller housing, impeller inner surface of the cover plate #11 and O-ring #10.
10. With a twisting motion, install the impeller #9 into the pump. Install the O-ring #10 and secure the cover plate #11 with the four screws #12.
11. Install the pulley on the shaft and the hose nipples back into the pump. Mount the pump on the engine. Check pulley alignment. Attach the raw water hoses.

CARBURETOR - LOW PROFILE

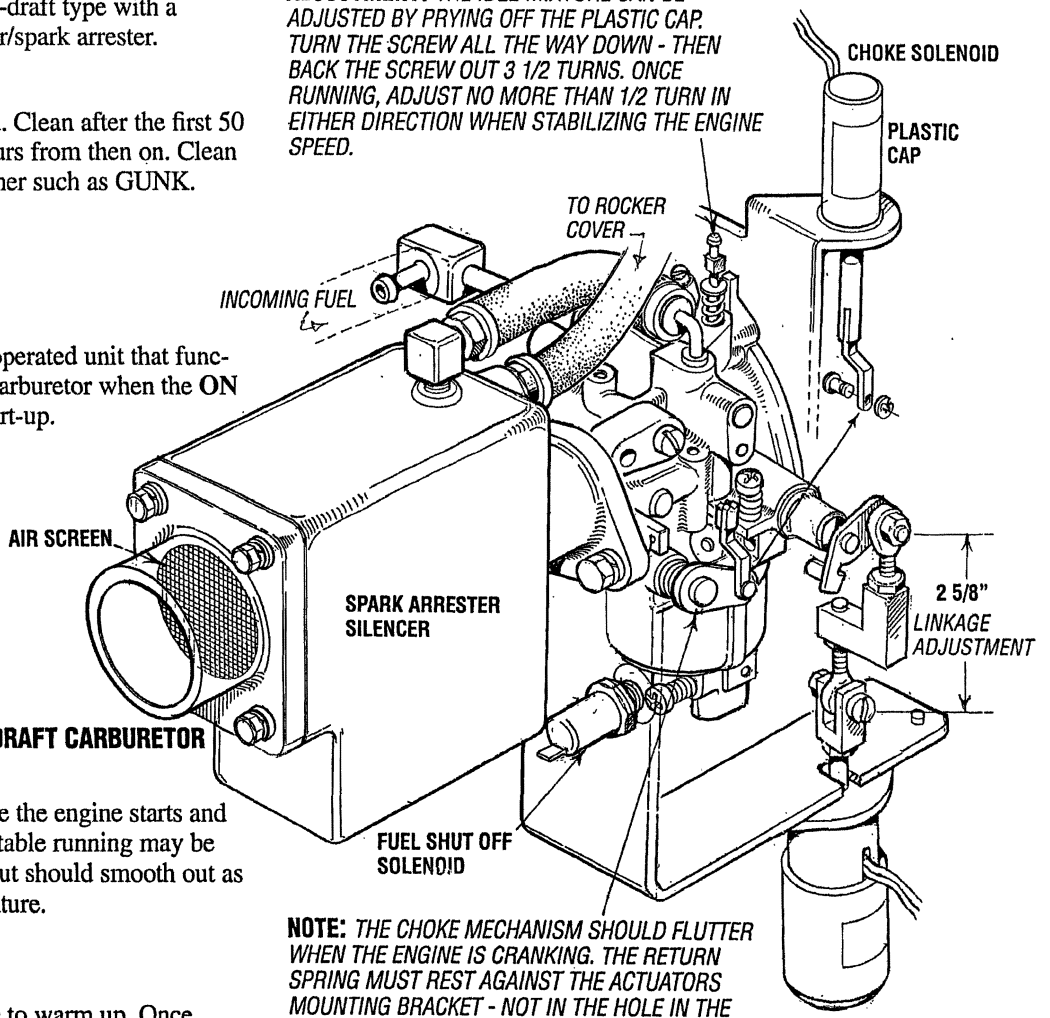
CARBURETOR

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

Air Screen

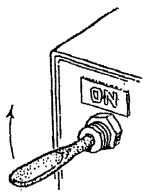
The air screen can easily be removed. Clean after the first 50 hours of operation and every 100 hours from then on. Clean the air screen in a water soluble cleaner such as GUNK.

ADJUSTMENT: *THE IDLE MIXTURE CAN BE ADJUSTED BY PRYING OFF THE PLASTIC CAP. TURN THE SCREW ALL THE WAY DOWN - THEN BACK THE SCREW OUT 3 1/2 TURNS. ONCE RUNNING, ADJUST NO MORE THAN 1/2 TURN IN EITHER DIRECTION WHEN STABILIZING THE ENGINE SPEED.*



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.



ON SWITCH [CHOKE ENERGIZED]

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.

NOTE: *THE CHOKE MECHANISM SHOULD FLUTTER WHEN THE ENGINE IS CRANKING. THE RETURN SPRING MUST REST AGAINST THE ACTUATORS MOUNTING BRACKET - NOT IN THE HOLE IN THE CASTING BOSS.*

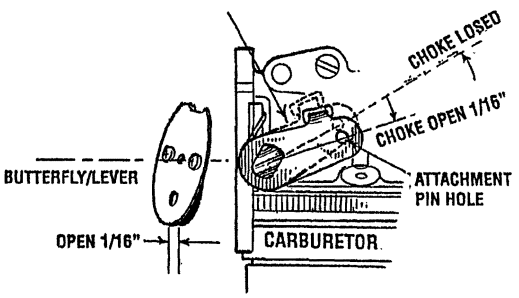
SPEED ACTUATOR: *THE SPEED ACTUATOR SHOULD MOVE FREELY. KEEP THE SOLENOID DRY AND LUBRICATE THE LINKAGE WITH TEFLON OR GRAPHITE LUBRICANT ONLY.*

Confirm Proper Operation

Start the engine and allow the engine to warm up. Once warm, engage the **ON** switch. If the engine chokes and stops, the choke linkage needs to be lengthened to hold the choke open slightly more. *If the engine slows but continues to run, the adjustment is ok.*

Linkage Adjustment

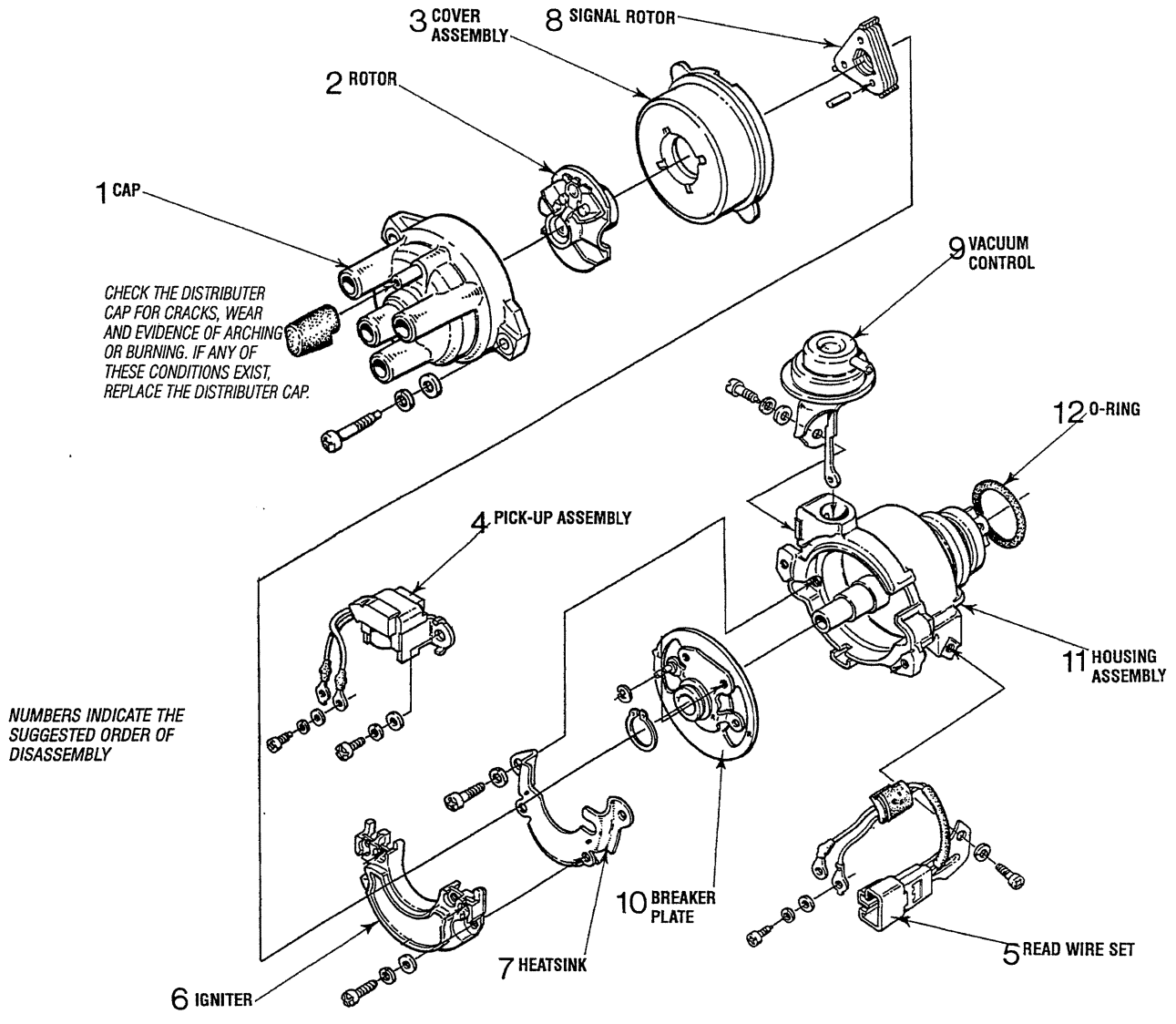
Adjust the linkage so that when the choke solenoid is energized, the choke butterfly/.lever is open approximately 1/16". Adjust the linkage so the pin hole in the linkage is approximately 1/16" beyond the fully closed choke lever,. then connect the choke lever to the linkage. Refer to the *IDLE MEASURE ADJUSTMENT* at the top of this page.



Speed Actuator Adjustment

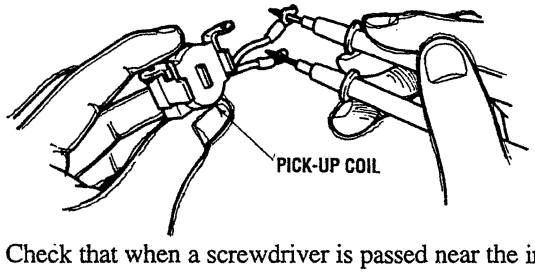
The speed actuator adjustment should be the only device in control of the throttle's position. The throttle linkage's eye bolts must be 2 5/8" apart (see illustration. The throttle should be in full fuel position when the unit is shutdown.

DISTRIBUTOR

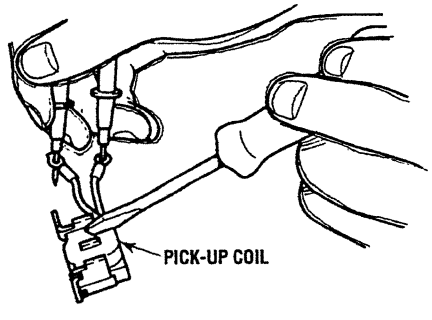


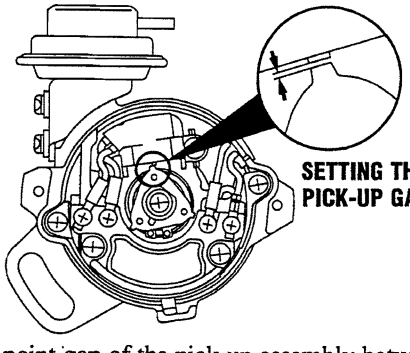
TESTING THE PICK UP COIL

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

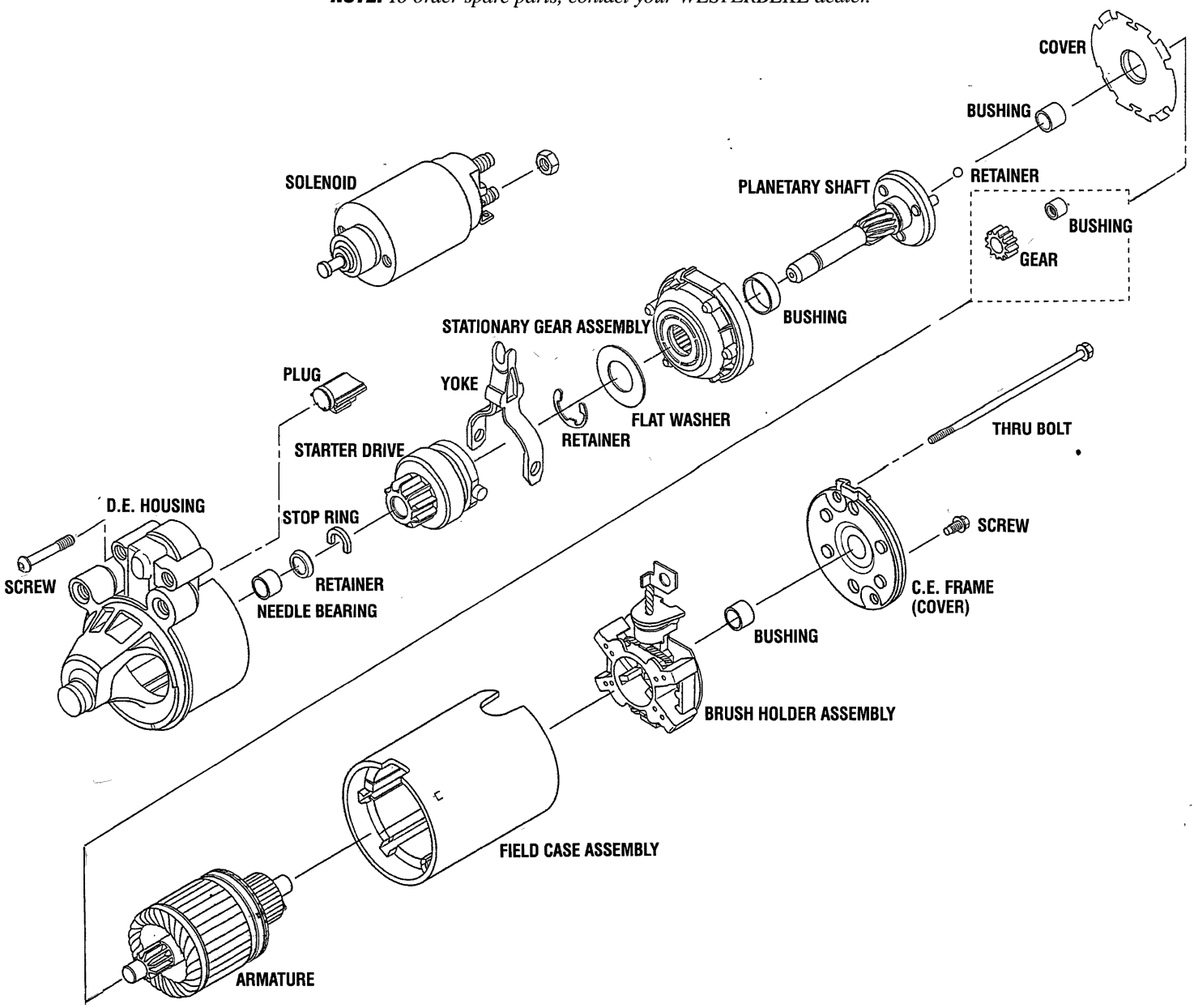
INSPECTING SPARK PLUGS

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

SPARK PLUG GAP: 0.028 - 0.031 in (0.7 - 0.8 mm)

STARTER MOTOR

NOTE: *To order spare parts, contact your WESTERBEKE dealer.*



STARTER DISASSEMBLY

Disconnect the wires and remove the solenoid from the motor.

Remove the thru bolts and screws from the back of the motor and separate the frame. This will provide access to the brush holder assembly and the armature.

Use this exploded view drawing to disassemble and reassemble the starter motor.

The following pages describe the testing and repair of the starter motor assembly.

STARTER MOTOR

DESCRIPTION

The starter can be roughly divided into the following sections:

- A motor section which generates a drive power.
- An overrunning clutch section which transmits an armature torque, preventing motor overrun after starting.
- A switch section (solenoid) which is operated when actuating the overrunning clutch through a lever and which supplies load current to the motor.

The starter is a new type, small, light-weight and is called a high-speed internal-reduction starter. The pinion shaft is separate from the motor shaft; the pinion slides only on the pinion shaft. A reduction gear is installed between the motor shaft and a pinion shaft. The pinion sliding part is not exposed outside the starter so that the pinion may slide smoothly without becoming fouled with dust and grease. The motor shaft is supported at both ends on ball bearings. The lever mechanism, switch and overrunning clutch inner circuit are identical to conventional ones.

ADJUSTMENT AND REPAIR

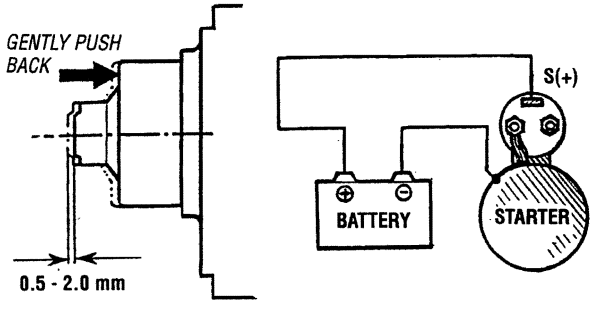
If any abnormality is found by the following tests, the starter should be disassembled and repaired.

Pinion Gap Inspection

1. Connect a battery (12V) between the starter terminal S and the starter body, and the pinion drive should rotate out and stop.

> ⚠ **CAUTION:** ***Never apply battery voltage for over 10 seconds continuously.***

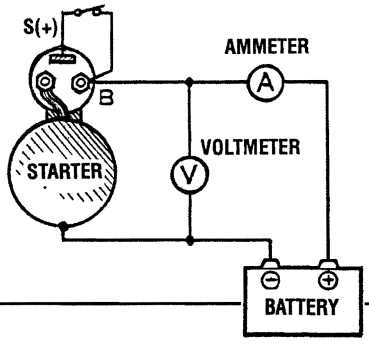
2. Lightly push the pinion back and measure the return stroke (called pinion gap).
3. If the pinion gap is not within the standard range, (0.5 to 2.0 mm), adjust it by increasing or decreasing the number of shims on the solenoid. The gap is decreased as the number of shims increases.



PINION GAP

No-Load Test

1. Connect the ammeter, voltmeter, and battery to the starter as illustrated.
2. When the switch is closed, the pinion must protrude and the starter must run smoothly (at 3000 rpm or more). If the current or starter speed is out of specification, disassemble the starter and repair it.

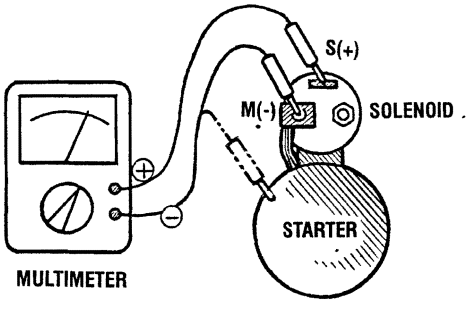


> ⚠ **CAUTION:** ***Use thick wires as much as possible and tighten every terminal securely. This is a solenoid shift-type starter which makes a rotating sound louder than that of a direct-drive type starter. When detecting starter rotation at the pinion tip, be careful not to come in contact with the pinion gear when it protrudes.***

SOLENOID

Perform the following tests. If any test result is not satisfactory, replace the solenoid assembly.

1. Inspect the solenoid for continuity between terminals (+) and (-) and between terminals S and the body and M and the body. There should be no continuity found between terminals S and M. Continuity will be found between terminals S and the body and terminal M and the body.



NOTE: *Disconnect the wire from terminal M.*

2. Connect a battery to the solenoid's terminal S for (+) and M for (-). Have a switch in the + lead and close it. The pinion drive should extend fully out.

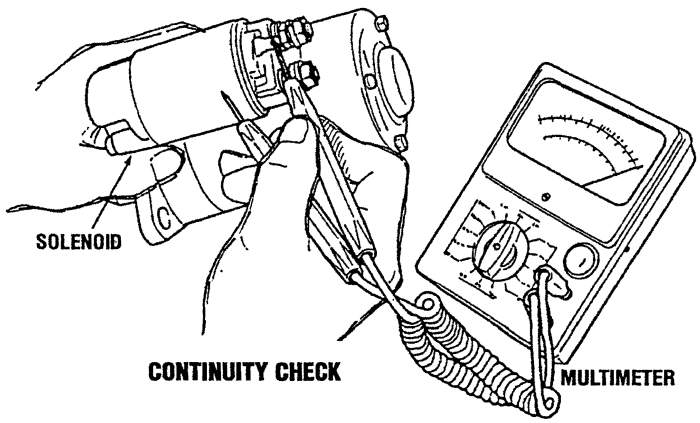
> ⚠ **CAUTION:** ***Do not apply battery current for more than 10 seconds when testing the solenoid.***

STARTER MOTOR

STARTER INSPECTION

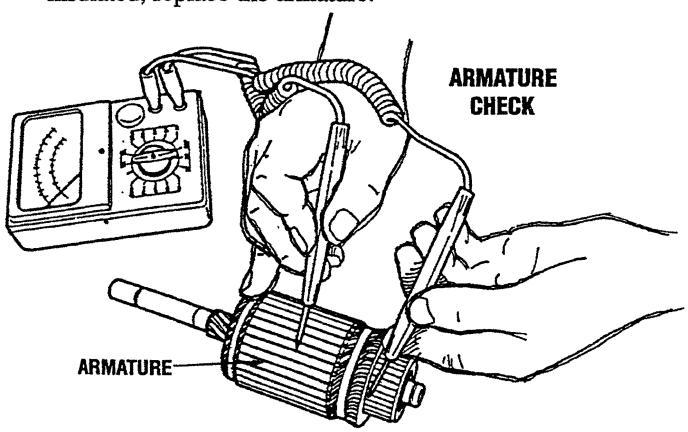
Solenoid

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.

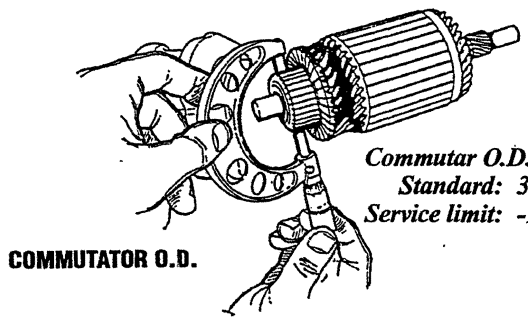


Inspecting The Armature

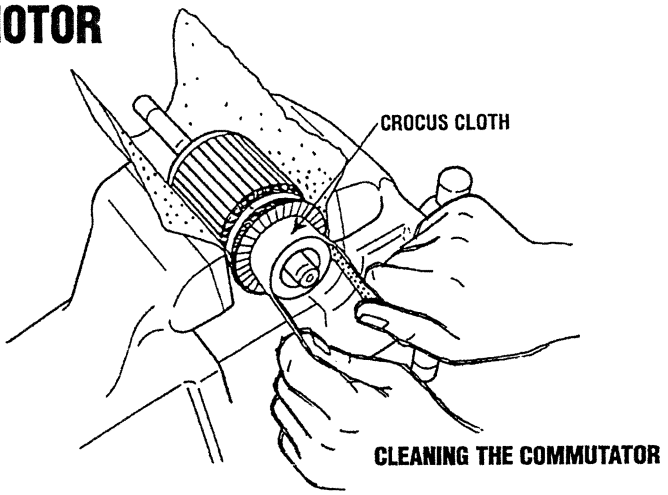
1. Check the armature with a growler tester. If it's short circuited, replace the armature. Also check for insulation between the communicator and its shaft. If poorly insulated, replace the armature.



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.



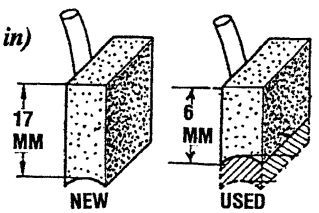
Commutar O.D. Standard
Standard: 38.7 mm (1.523 in)
Service limit: -1.0 mm (-0.039 in)



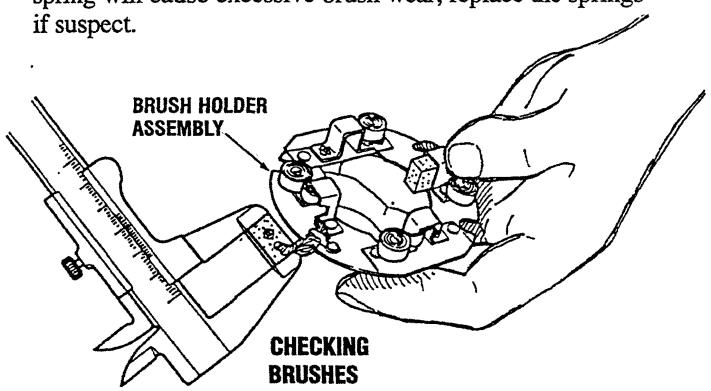
Brush and Brush Holder Inspection

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

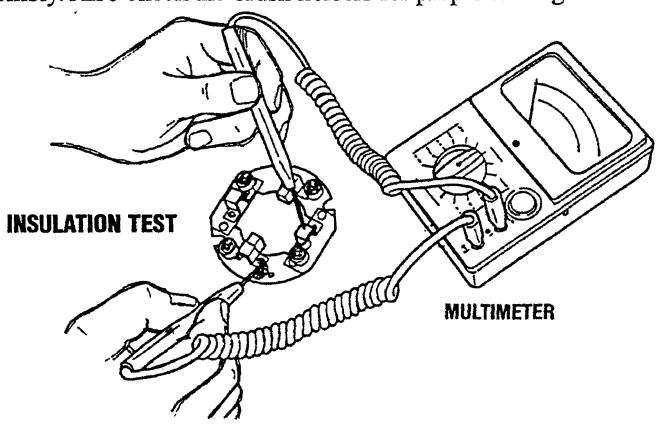
Brush Height
Standard 17 mm (o.669 in)
Limit 6 mm (0.236 in)



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

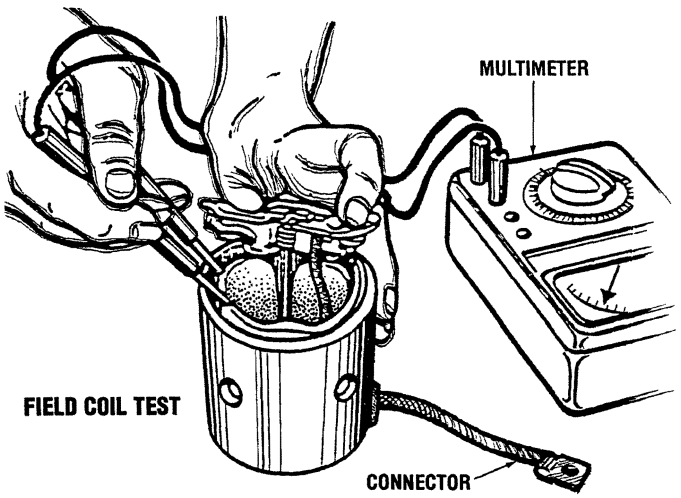


3. Check for insulation between the positive brush holder and holder base. If poorly insulated, replace the holder assembly. Also check the brush holders for proper staking.



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

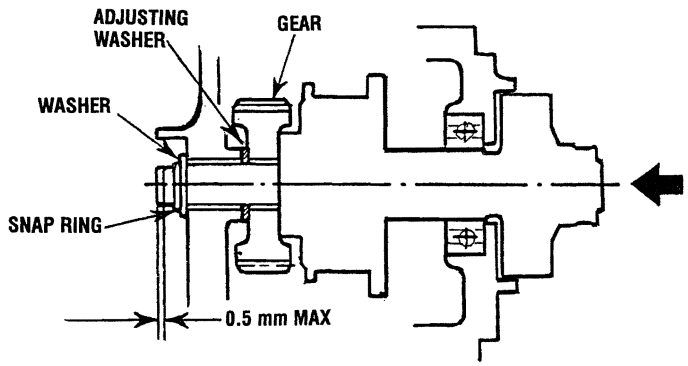
> ⚠ **CAUTION:** ***Before installing, thoroughly clean the starter flange and mounting surfaces, remove all oil, old paint, and rust. Starter performance largely depends on the quality of the wiring. Use wire of sufficient size and grade between the battery and starter and fully tighten to the terminal.***

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.

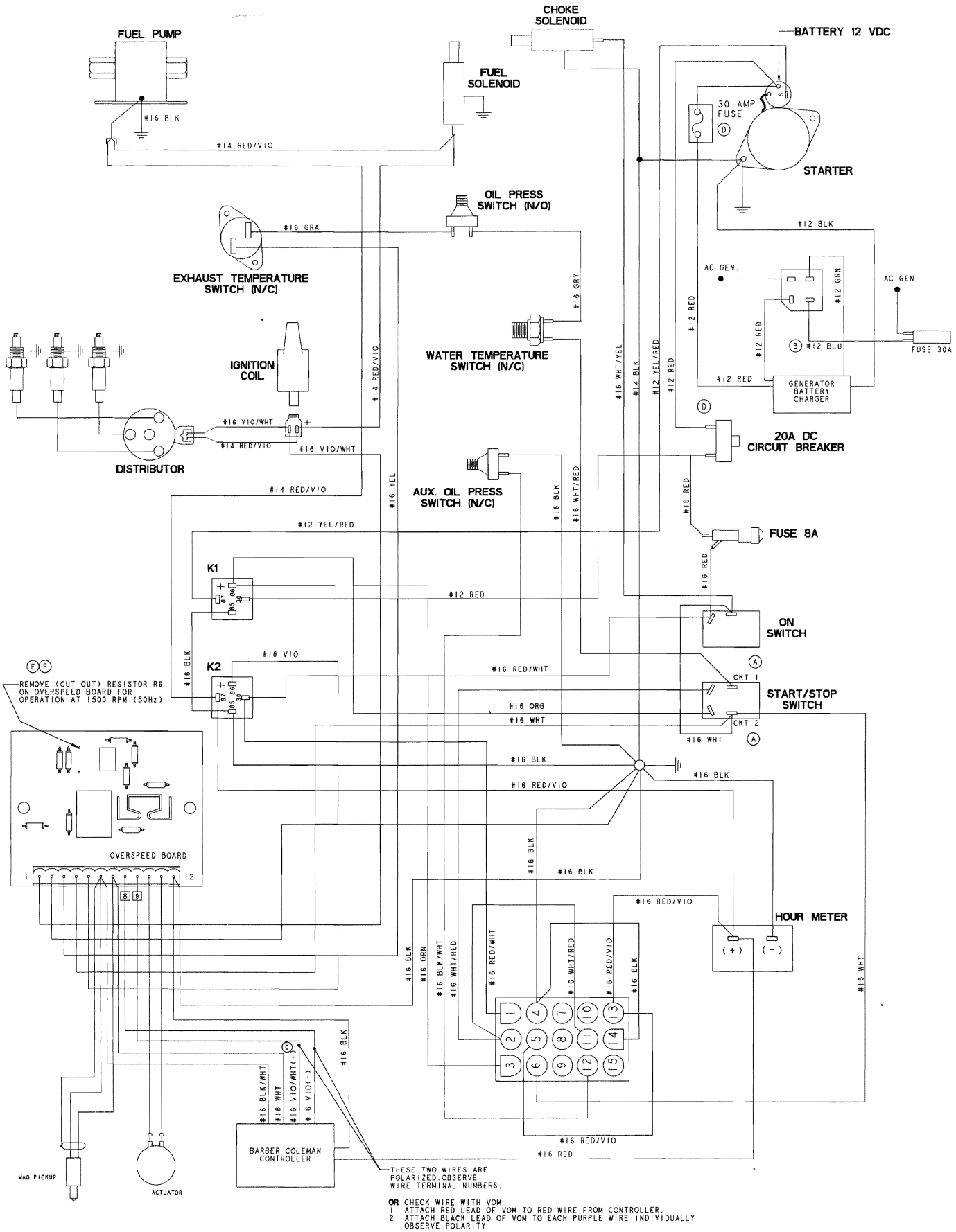
> ⚠ **CAUTION:** ***Never smear the starter fitting surface, terminals, brushes, or commutator with grease.***

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

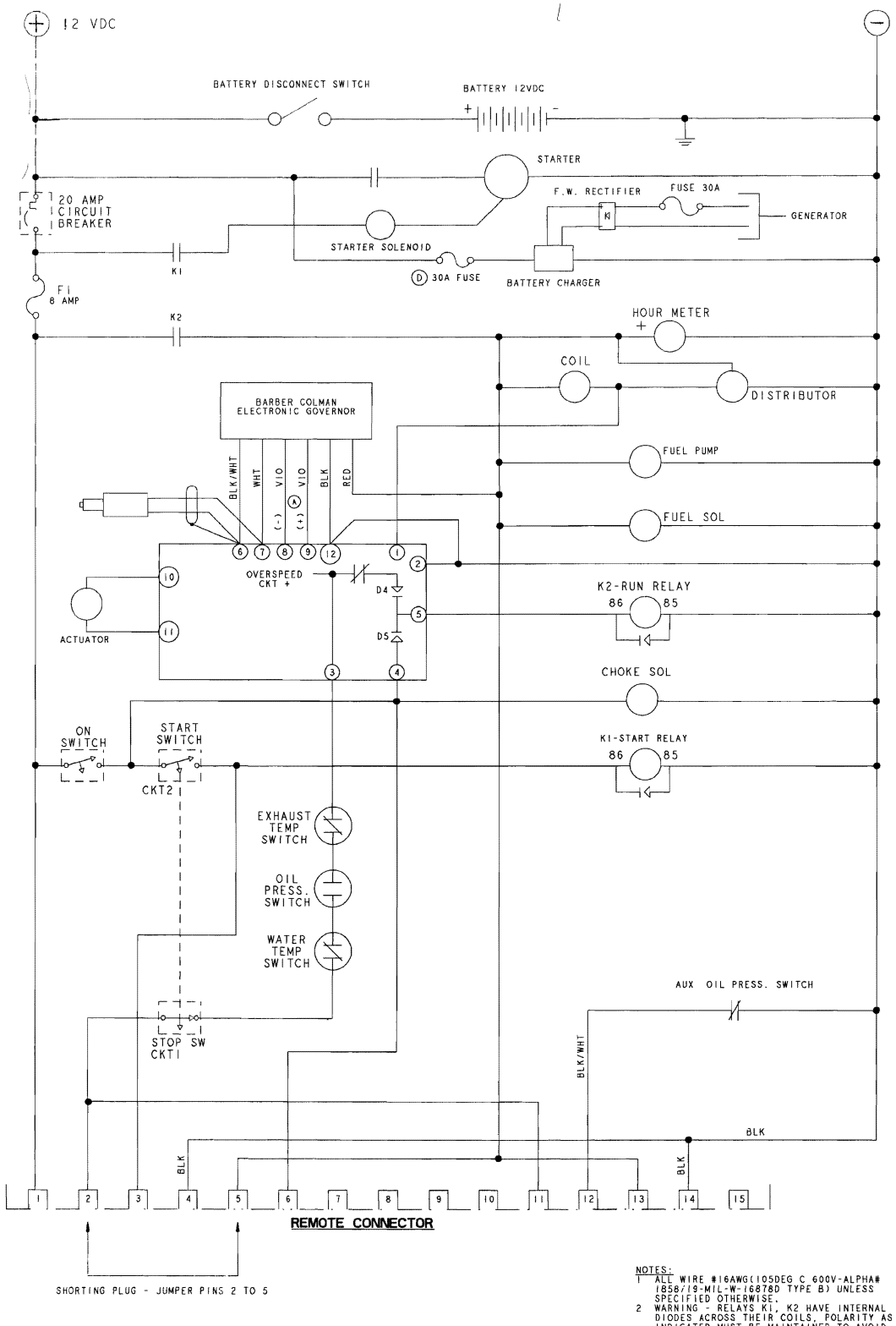


PINION SHAFT END PLAY

GENERATOR
WIRING DIAGRAM



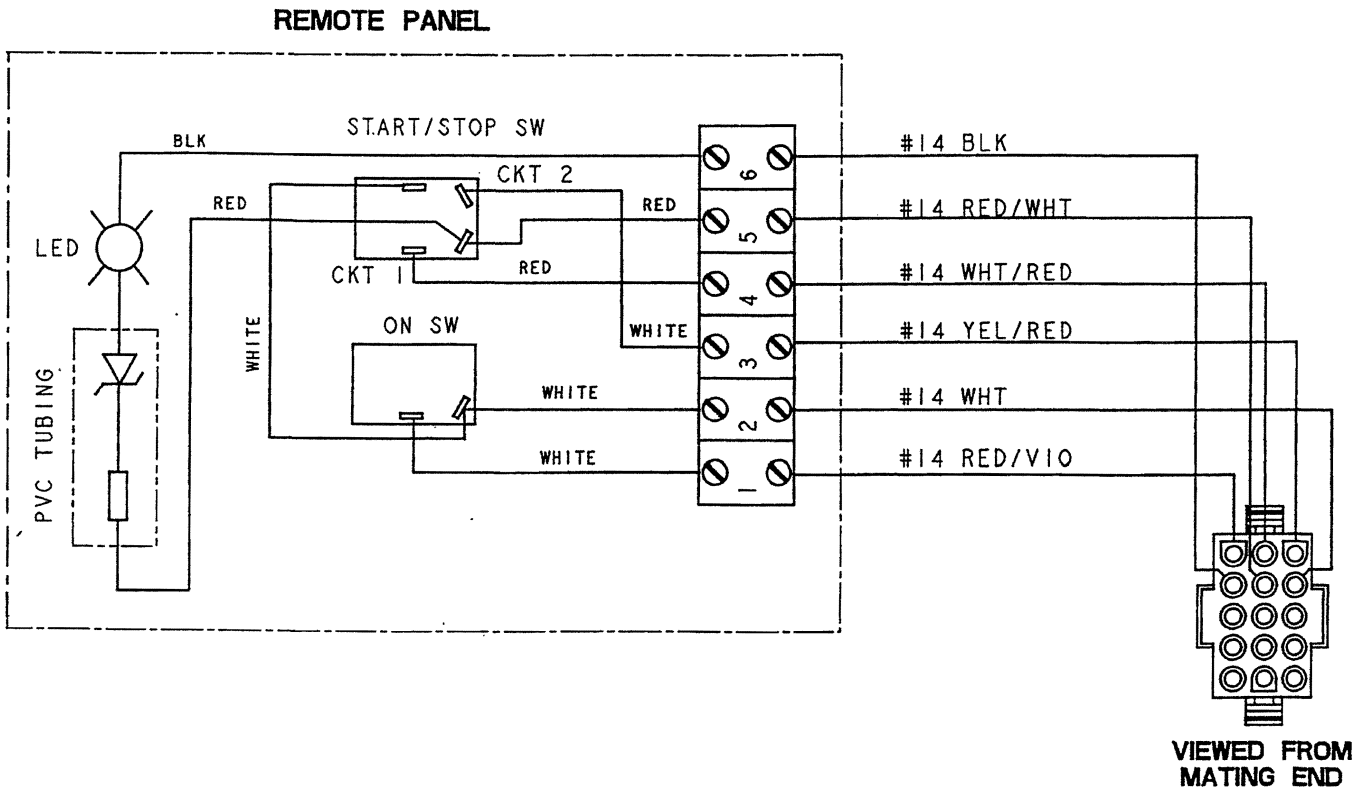
GENERATOR
WIRING SCHEMATIC



NOTES:
1. ALL WIRE #16AWG(105DEG C 600V-ALPHA# 1858/19-MIL-W-16878D TYPE B) UNLESS SPECIFIED OTHERWISE.
2. WARNING - RELAYS K1, K2 HAVE INTERNAL DIODES ACROSS THEIR COILS. POLARITY AS INDICATED MUST BE MAINTAINED TO AVOID DAMAGE TO THE RELAYS

REMOTE PANEL WIRING

SCHEMATIC #043912

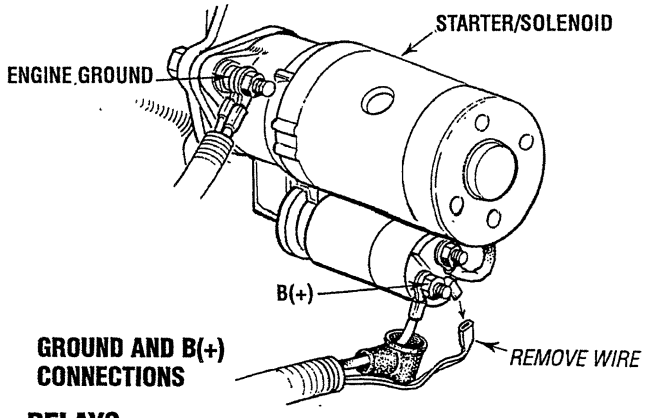


TESTING RELAYS

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.

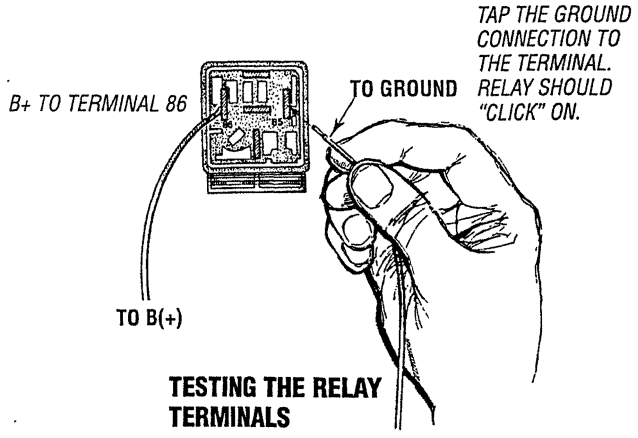
AC voltage measurements should be made with a true RMS AC meter to insure measurement accuracy.



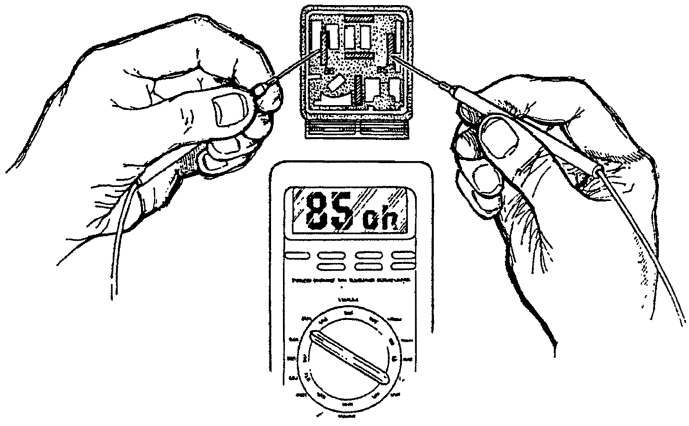
GROUND AND B(+) CONNECTIONS

RELAYS

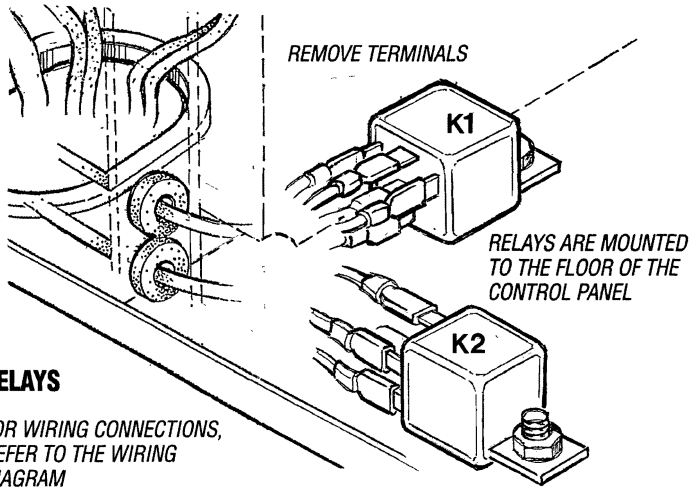
The relays used in the control system have coils which are polarized by the fact that they have internal free wheeling suppression diodes across them. Relay coil terminal 86 must be maintained (+), terminal 85(–). The relay coil is rated 12V DC, and the coil resistance is typically 85 ohms. With B+ on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



TESTING THE RELAY TERMINALS



TESTING COIL RESISTANCE



RELAYS

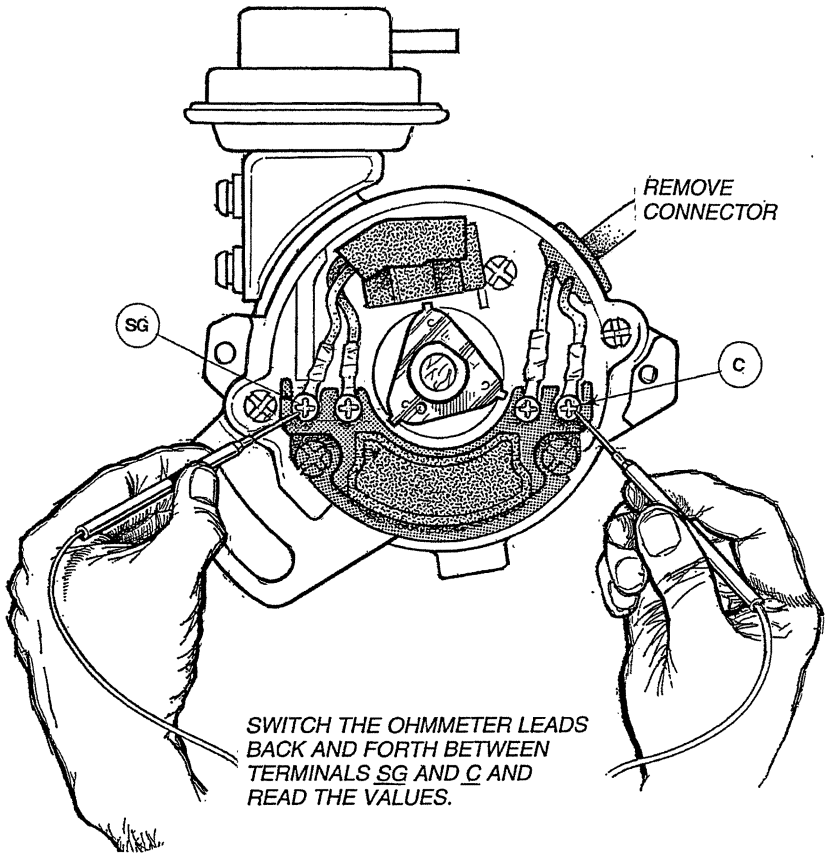
FOR WIRING CONNECTIONS, REFER TO THE WIRING DIAGRAM

TESTING THE IGNITER

DESCRIPTION

Unplug the two connector's at the distributor plug. Take care to note the two separate connections as they must be reconnected in the exact same position. Place your ohmmeter leads on the terminals **SG** and **C** shown below and read the meter. Then reverse the ohmmeter leads and again read the meter.

In one direction the ohm reading will be 100 ohms less. In the other direction there should be no ohm reading. Any value above 100 ohms indicates a faulty igniter. Any ohm value found with the meter connections in either direction, the igniter is faulty.



GOVERNOR SYSTEM COMPONENTS and OPERATION

DESCRIPTION

The Electronic Governor consists of three components, the **CONTROLLER**, a pc board installed in the control panel. A **MAGNETIC PICK-UP** (MPU) installed in the bellhousing over the engine flywheel and the linear **ACTUATOR** mounted on the engine and attached by linkage to the injection pump throttle control.

SYSTEM OPERATION

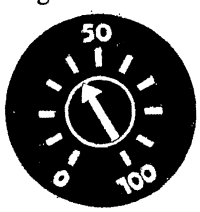
On start up system DC voltage is supplied to the controller to use for actuator operation. When the starter is energized and the engine cranks, the magnetic pick-up (MPU) that is positioned over the engines flywheel ring gear sends a low AC signal to the controller (1.5 - 2.5 AC volts).

The controller interprets this as engine cranking speed and sends a DC voltage to the actuator to operate the carburetor's throttle arm. The position of the throttle by the actuator has been previously determined by the speed adjustment on the speed controller. The engine carries up to a set speed determined by the AC voltage sent by the MPU.

The speed controller maintains this signal no load to full load by varying the DC voltage to the actuator providing more or less throttle depending on the generator load.

Gain Adjustment

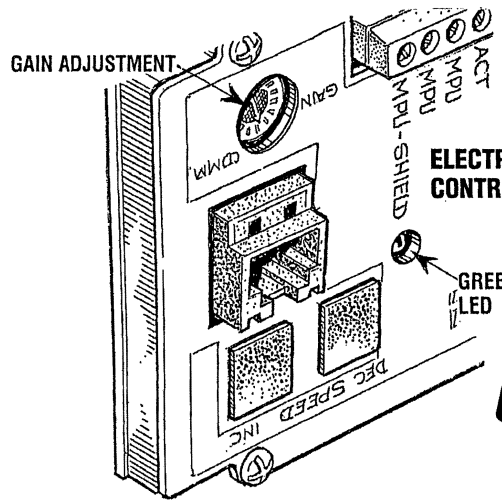
The gain can be adjusted using a small screwdriver. Adjustment should be between 30% and 40% as is required to dampen speed oscillation under load. An adjustment of more than 40% can cause the unit to race (speed up) when the load is removed or go into a hunting mode.



GAIN ADJUSTMENT

Speed Controller

The speed controller has a green LED indicating power to the controller, a plus and minus speed adjustment (buttons) and a gain adjustment. The green LED blinks when the power is turned on and after it receives a signal from the magnetic pick-up, it blinks at a faster rate.



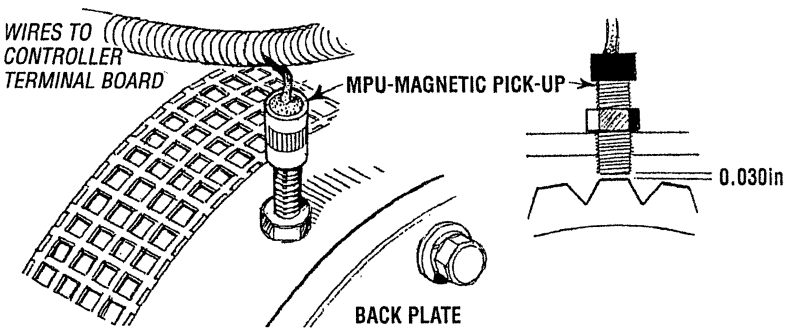
MAGNETIC PICK-UP [MPU] INSTALLATION

The MPU is installed in the threaded opening on the side of the flywheel bellhousing. This positions the MPU over the teeth of the flywheel ring gear.

Viewing through this opening, manually rotate the engine crankshaft so as to position the flat of one of the ring gear's teeth directly under the opening. Thread the MPU into the opening until it gently contacts the flat of this tooth (Thread is 3/8" x 24). Back the MPU out of the opening one turn and then lock it in this position with the jam nut. This will position the end of the MPU approximately 0.030 inches away from the flats of the ring gear teeth.

To ensure the MPU is positioned correctly, slowly rotate the crankshaft by 360° by hand to assure there is no physical contact between the MPU and the ring gear teeth.

If contact is felt between the MPU and the flywheel teeth, the MPU may be damaged. Remove the MPU and inspect it. Replace if necessary and repeat the above installation procedure.



NOTE: *If replacing the Magnetic Pick-Up (MPU) it **MUST** be replaced without cutting and splicing into the existing wiring cable. Doing so will cause a erratic AC signal to the controller.*

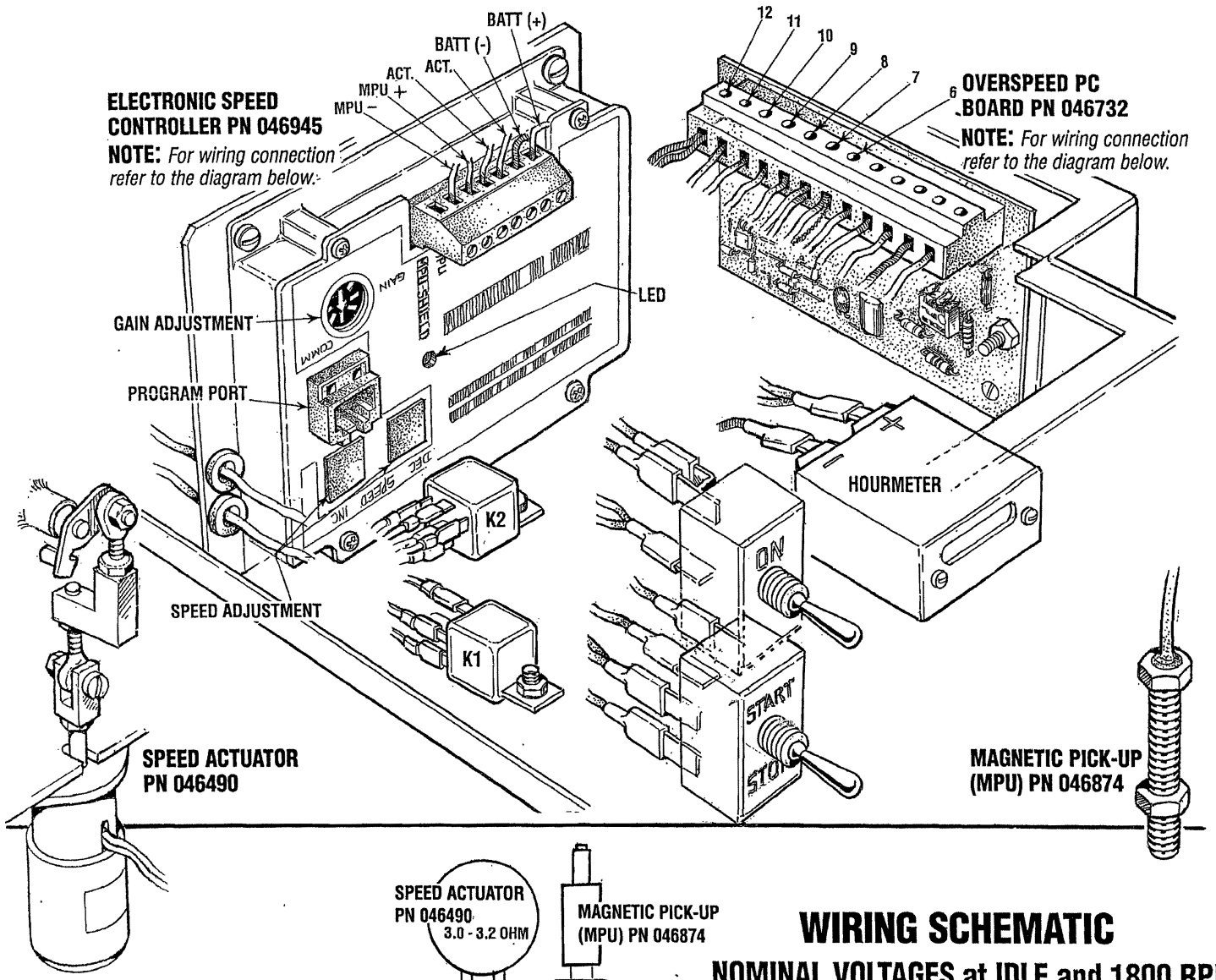
GOVERNOR CIRCUIT VOLTAGES

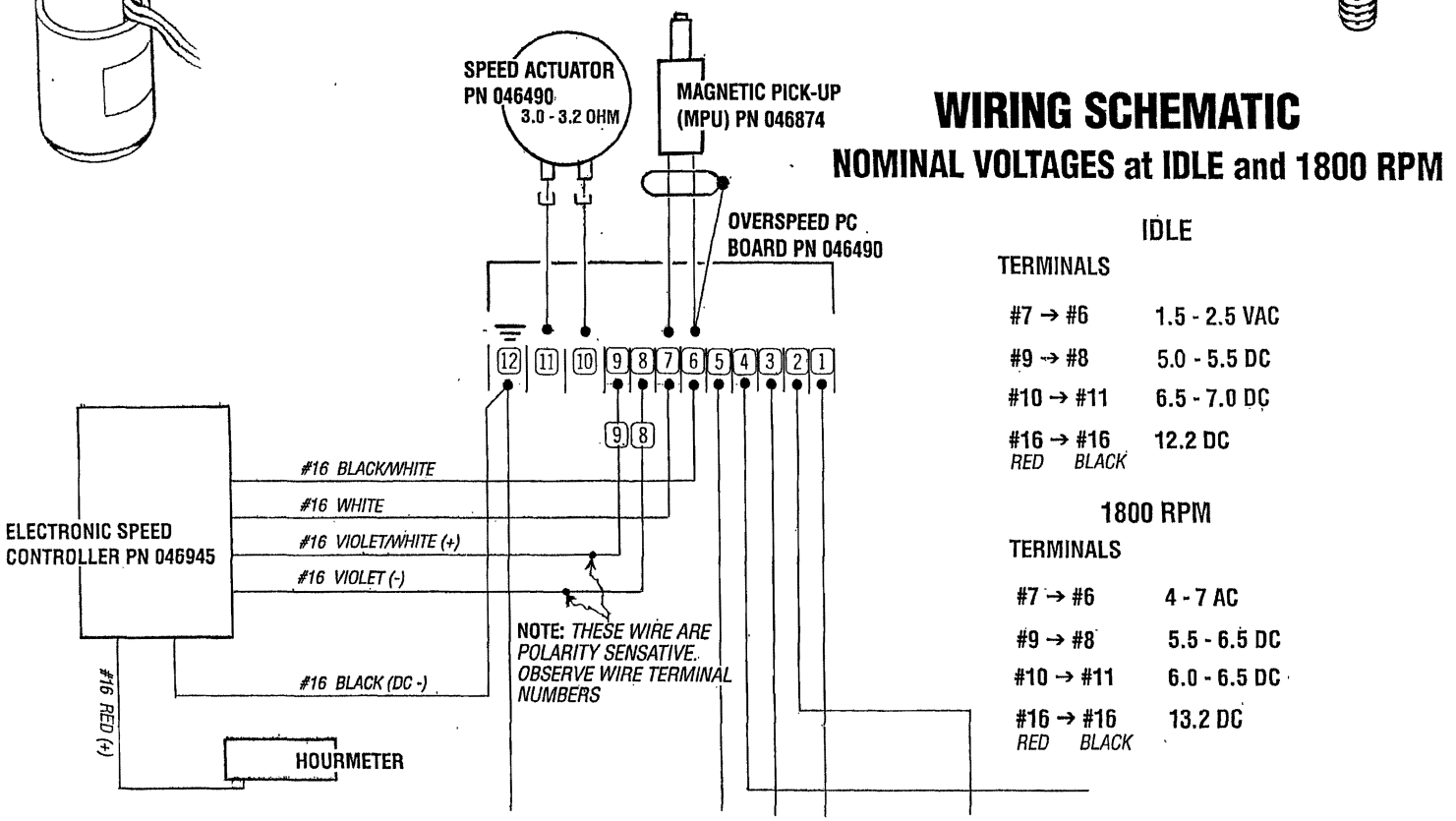
Monitoring the voltages found in the electronic governor's circuit will be helpful in determining where in the circuit the operating fault lies and with which component.

The circuit voltages listed with the circuit "wiring schematic" are the approximate voltages found in the governor circuit with the unit running at idle and at normal 1800rpm.

The electronic governor's circuit voltages can all be read and monitored from the connections on the 12 position terminal strip as illustrated.

PANEL COMPONENTS/WIRING





WIRING SCHEMATIC

NOMINAL VOLTAGES at IDLE and 1800 RPM

IDLE

TERMINALS	
#7 → #6	1.5 - 2.5 VAC
#9 → #8	5.0 - 5.5 DC
#10 → #11	6.5 - 7.0 DC
#16 → #16 RED BLACK	12.2 DC

1800 RPM

TERMINALS	
#7 → #6	4 - 7 AC
#9 → #8	5.5 - 6.5 DC
#10 → #11	6.0 - 6.5 DC
#16 → #16 RED BLACK	13.2 DC

ELECTRONIC GOVERNOR TROUBLESHOOTING

PROBLEM	TEST/CHECK	CORRECTION
Unit starts, then overspeeds and shuts down. **NOTE:** *When troubleshooting, manually operate the throttle to prevent an overspeed or disconnect the throttle from the actuator and operate manually.*	**1.** Check DC voltage between terminal #12 and + connection on hourmeter when ON switch is depressed.	**1.** Charge starting battery. Start unit, troubleshoot battery, charge circuit.
	2. Check the AC signal from the MPU while cranking, voltage should be 1.5 - 2.5 VAC.	**2.** Check the MPU resistance value and positioning. Adjust and replace as needed.
	3. Check the actuator.	**3.** Check the resistance value. Apply 12VDC across leds. Should fully retract. Replace as needed.
	4. Check the controller.	**4.** Manually control unit. Start and check DC voltage between #9 and #8, between #11 and #10. Replace controller or OS board as needed.
Unit starts, runs at idle. **NOTE:** *Less than one volt DC found between terminals #9 and #8 and high DC voltage-10 volts or higher between terminals #11 and #10 indicated a faulty controller.*	**1.** Incorrect speed adjustments.. **2.** Faulty governor controller..	**1.** Check and adjust speed adjustment. **2.** Check DC voltages from controller to O/S board and O/S board to actuator.
Actuator hunts during operation. **NOTE:** *Check carburetor adjustments before proceeding.*	**1.** Improper controller adjustment.	**1.** Lessen GAIN adjustment.
	2. Linkage or rod end bearings are sticking or binding.	**2.** Lubricate and replace as needed.
	3. Inadequate DC supply voltage.	**3.** Manually stabilize the unit. Check the DC voltage to the controller. Correct as needed.
	4. MPU positioned marginally too far away from the flywheel teeth, giving an erratic AC input signal to the controller.	**4.** Check the MPU signal. Adjust positioning as needed.

THE ELECTRONIC GOVERNOR

GENERATOR MODELS UP TO JUNE 2004

DESCRIPTION

A generators engine must run at a constant speed to enable the generator to produce the stable AC power (hertz) required.

The Electronic Governor consists of three components, the **CONTROLLER**, a pc board installed in the control panel. A **MAGNETIC PICK-UP** (MPU) installed in the bellhousing over the engine flywheel and the linear **ACTUATOR** mounted on the engine and attached by linkage to the injection pump throttle control.

The Electronic Governor regulates the engine speed by sensing the engine's RPM with the magnetic pick-up at the flywheel. The governor's controller continuously monitors the engines speed and if there is any discrepancy, the controller signals the actuator and the actuator adjusts the engine to the desired speed electronically.

CONTROLLER ADJUSTMENT

The controller has two adjustments: the **SPEED** adjustment is used to increase or decrease the the engine's speed to the desired hertz. The **GAIN** adjustment affects the reaction time of the actuator to the generator load changes.

NOTE: *A high gain adjustment can induce an oscillating of the actuator producing a hunting mode. In such cases, lessen the gain adjustment.*

CALIBRATION

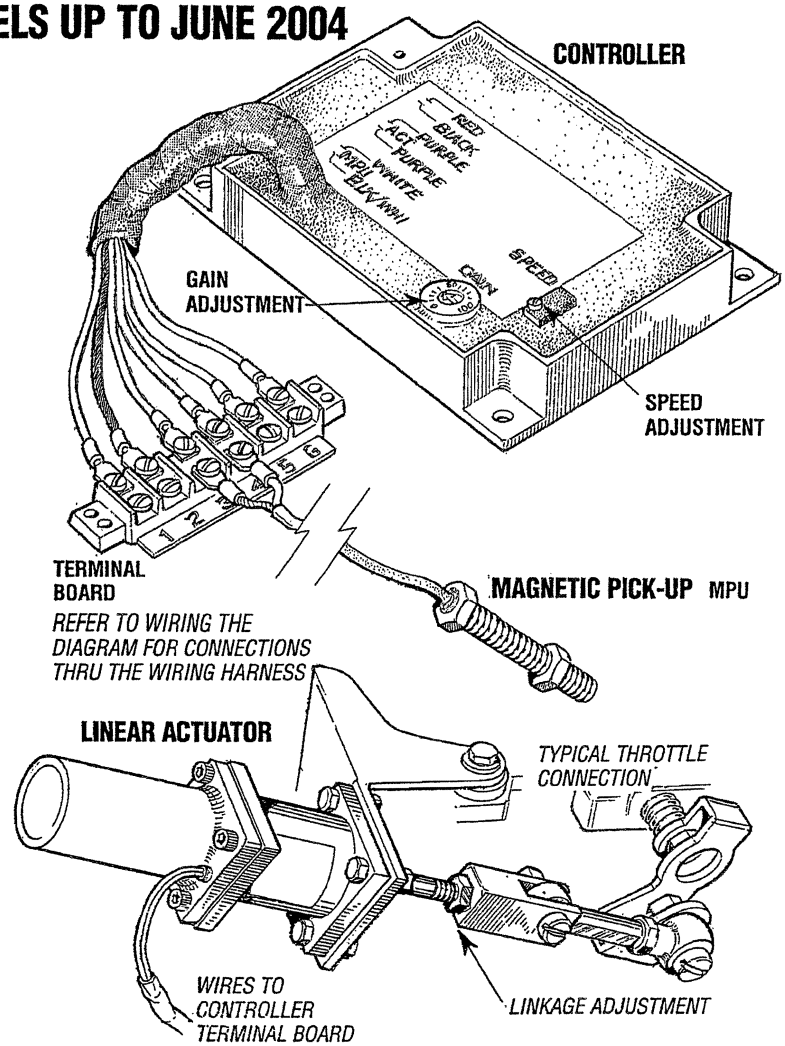
1. With no power to the governor (engine not running), adjust the **GAIN** potentiometer to 9:00 o'clock.
2. Start the engine and adjust the speed by turning the speed pod clockwise to desired speed.

   NOTE: *Controllers are factory adjusted to minimum RPM. However, for safety, one should be capable of disabling the engine if an overspeed should exist.*
3. At no load, turn the **GAIN** potentiometer clockwise until the engine begins to hunt. If the engine does not hunt, physically upset the actuator linkage.
4. Turn the **GAIN** potentiometer counterclockwise until engine runs stable.

   NOTE: *Controllers are available in 12 and 24 VDC models. The operating voltage range is + or - 20%. If the voltage varies above or below this range, the controller will not operate and the engine will run in the idle mode until proper DC voltage is supplied to the controller.*

ELECTRONIC GOVERNOR ADJUSTMENTS

The controller has two adjustment pods. You need a mini screw driver to adjust these. One is speed and one is gain. These are noted on the drawing of the controller.



Start the engine. The speed should be in the low idle range 600-700 rpm. If the engine speed is higher than this idle range, shut the engine down. Check the linkage between the actuator and throttle arm. The throttle arm stop should be about touching the open idle stop screw boss. Adjust the linkage to position the throttle lever. Restart the engine and using the speed adjustment buttons bring the engine speed to 1800 rpm (60Hz), 1500 rpm (50Hz). Momentarily push the actuator linkage towards the actuator and release. The actuator should quickly regain proper speed. If there is any hunting, adjust the gain towards zero (0) until this hunting is removed.

When the gain is adjusted, you may need to re-adjust the speed at no load, shut the generator down.

Start the generator.

Check speed (hertz) set at 50Hz/60Hz.

Load the generator.

If the governor is slow to react and maintain 50Hz/60Hz, adjust the gain clockwise. Again you may need to adjust the speed at no load.

You will find the governor will maintain set engine RPM ± 0.5 Hz right up to the full rated amperage output for the generator.

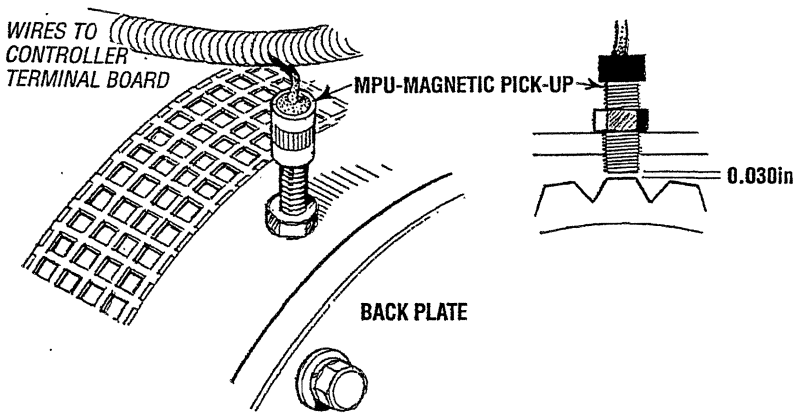
MAGNETIC PICK-UP [MPU] INSTALLATION

The MPU is installed in the threaded opening on the side of the flywheel bellhousing. This positions the MPU over the teeth of the flywheel ring gear.
Viewing through this opening, manually rotate the engine crankshaft so as to position the flat of one of the ring gear's teeth directly under the opening. Thread the MPU into the opening until it gently contacts the flat of this tooth (Thread is 3/8" x 24). Back the MPU out of the opening one turn and then lock it in this position with the jam nut. This will position the end of the MPU approximately 0.030 inches away from the flats of the ring gear teeth.

To ensure the MPU is positioned correctly, slowly rotate the crankshaft by 360° by hand to assure there is no physical contact between the MPU and the ring gear teeth.

If contact is felt between the MPU and the flywheel teeth, the MPU may be damaged. Remove the MPU and inspect it. Replace if necessary and repeat the above installation procedure.

NOTE: *When replacing the Magnetic Pick-Up (MPU) it **MUST** be replaced without cutting and splicing into the existing wiring cable. Doing so will cause a erratic AC signal to the controller.*



GOVERNOR CIRCUIT VOLTAGES

Below are the voltages normally found in the governor circuit when the system is functioning normally. These voltages are an approximate and should be of help in troubleshooting a system that is not functioning correctly.

DC Voltage into Controller
Bat + to Bat - (battery charging voltage 13.5 - 14.5 VDC)
(Terminal block #1 and #2)

DC Voltage to Actuator
ACT to ACT (5.5 - 6.5 VDC)
(Terminal block #5 and #6)

AC Voltage from MPU into Controller
MPU to MPU (2.5 - 7.0 VAC)
(Terminal block #3 and #4)

This voltage spread is the result of the distance the MPU is positioned from the flat of the flywheel ring gear tooth. The closer to the tooth, the higher the AC signal. The further away, the lower the AC signal.

ELECTRONIC GOVERNOR TROUBLESHOOTING

Problem	Test/Check	Correct
System appears dead. (No actuator movement) Engine runs, but at idle speed	**1.** Check the battery voltage at the controller terminal block with the Preheat/On switch depressed.	**1.** Inspect the DC circuit back to the starting battery.
	2. Inspect the linkage for binding or sticking.	**2.** Free up the linkage and clean and lubricate the linkage.
	3. If there is no signal or a weak signal from the MPU, measure the AC voltage between the white and black/white wire leads from the MPU on the controller terminal block. While cranking the engine or with the engine running at idle, voltage should be 1.5-2.5 VAC. **NOTE:** *The AC input impedance of meter must be 5000 ohms/volts or greater.* **NOTE:** *When making this test on diesel units, disable the preheat solenoid by disconnecting the "S" terminal connection so as not to damage the glow plugs.*	**3.** Check for damage to or improper adjustment of magnetic pick-up. Replace or re-adjust.
	4. Check the actuator with the preheat/on switch depressed. This provides DC voltage to the controller. Measure the DC voltage between the actuator connections on the controller block and the black DC (-) power connection on the controller terminal block. Both connections should have battery voltage +0.00 or -0.75 VDC.	**4.** Low voltage (1.0-2.0 VDC) at either actuator connections.
	a. Purple lead to Black DC (-).	
	b. Purple lead/purple/white lead to Black DC (-). **NOTE:** *Continue this test (ONLY) if the battery voltage is not present.*	**b.** Replace the controller if battery voltage is not present at both the Purple leads.
	c. The following checks are performed between the connections at the actuator and the Black DC (-) connection on the controller terminal block. This is to determine if there is a break in the line between the controllers terminal block connection and the actuator connections or the actuator leads themselves.	
	1) Low voltage (1.0-2.0 VDC) at either actuator connections.	**1)** Broken actuator lead, repair.
	2) Battery voltage at both actuator connections.	**2)** Broken actuator lead, repair or replace actuator.
	3) Battery voltage at one actuator connection but not at the second.	**3)** Check actuator winding for open. Replace actuator.
Actuator lever goes to full extension when the preheat switch is depressed and stays extended.	**1.** Check the controller by removing the two. purple leads one at a time that come from the actuator off the controller terminal block. Lift one actuator lead and depress the preheat/on switch. Reconnect and do the same with the second. **NOTE:** *Early controllers had two solid purple leads for the actuator connections. Later model controllers have one solid purple and a purple/white stripe for the actuator connection. The purple/white lead is designated (+) and is specific only in gasoline DC circuits.*	**1.** Check for a shorted actuator lead. Replace the controller because it should not cause the actuator lever to go to full fuel when the engine is not running.
	a. Actuator goes to full extension (Diesel),. Does not retract (Gasoline).	**a.** Check for shorted actuator load.
	b. Actuator does not extend (Diesel).	**b.** Replace controller.
Actuator hunts during operation.	**1.** Linkage or rod end bearings are sticking or binding.	**1.** Lubricate or replace.
	2. Improper governor adjustment.	**2.** Re-adjust the calibration.
	3. Inadequate power supply voltage. **a.** Connect a DC voltmeter to Red (+) and Black (-) leads at the controller terminal block. **b.** Disconnect both leads coming from actuator from controller terminal block. **c.** Connect one lead from the actuator to the Red (+) on the terminal block and the other actuator lead to the Black (-)on the terminal block. **d.** Momentarily depress the preheat/on switch. The actuator should extend fully and stay extended (diesel) and retract (gasoline) as long as the switch is depressed. Measure the DC voltage across the Red (+) and Black (-) leads while performing this test. DC voltage must be greater than 80% of the DC voltage measured across the battery supply. 24 VDC @ 80% = 19.2 VDC 12 VDC @ 80% = 9.6 VDC **NOTE:** *Reconnect the actuator leads properly after completing this test.*	**3.** If actuator doesn't fully extend (diesels) or retract (gasoline)then check the actuator leads. If the voltage is less than specified, check for loose or poor connections in the DC circuit back to the battery, check the K2 relay and its connections.
	e. MPU positioned marginally too far away from flywheel teeth giving erratic AC input to controller.	**e.** Check the position of the MPU.

If problems continue to persist, contact your WESTERBEKE dealer for additional assistance.

ENGINE ADJUSTMENTS

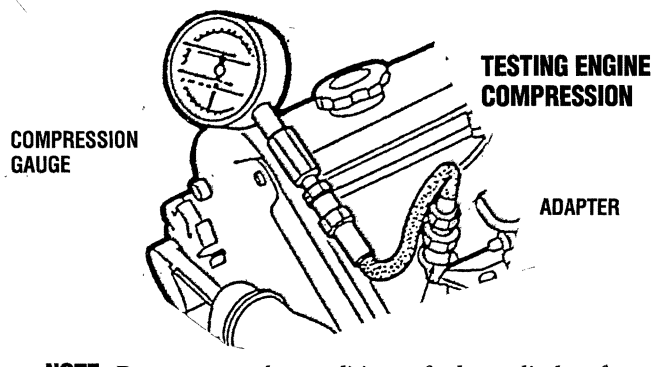
ENGINE COMPRESSION TEST

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 the raw water 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 189PSI (1260 Kpa) at 400 RPM
   Compression Pressure should not differ by more than 14 psi (100Kpa)
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 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 seacock.**



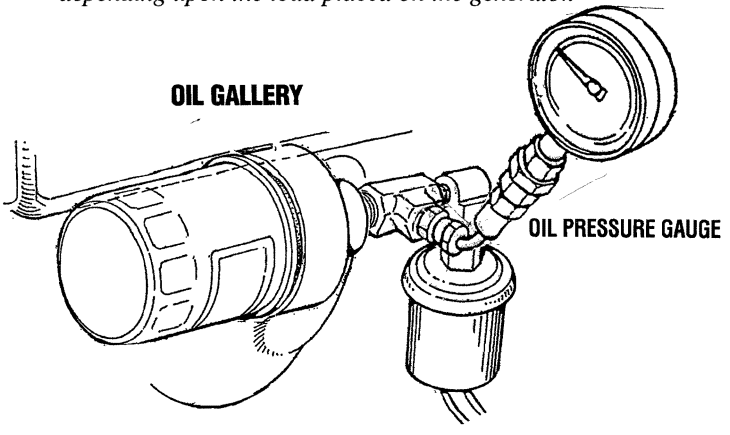
NOTE: *Do not guess the conditions of other cylinders from a result of testing one cylinder. Be sure to measure the compression pressure for each cylinder. Look for cylinders with dramatically (at least 20%) lower compression than the average of the other cylinders. If the weak cylinder is flanked by healthy cylinders, the problem is either valve or head-gasket related. very low compression in an adjacent cylinder indicates gasket failure. Abnormally high readings on all cylinders indicate heavy carbon accumulations, a condition that might be accompanied by high pressure and noise.*

TESTING OIL PRESSURE

To test oil pressure, remove the hex head plug from the oil gallery 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 reading up to 70 or 80 psi. A warmed engine can have an oil pressure reading as low as 30 psi. Oil pressure will vary depending upon the load placed on the generator.*

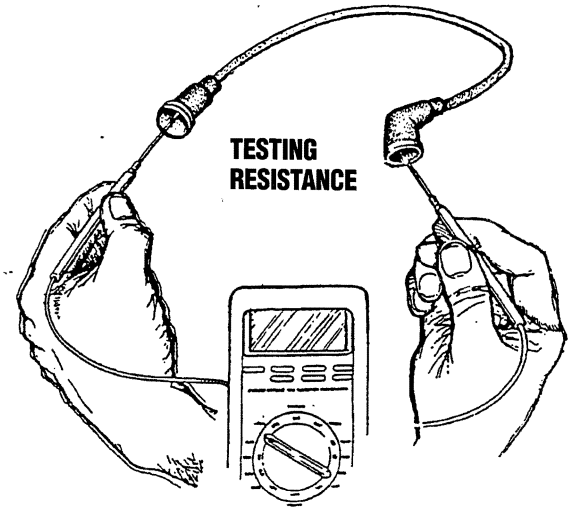


HIGH TENSION CORDS (IGNITION WIRES)

Check the ignition wires every 500 operating hours as engine compartment heat can deteriorate the wires.

Check the resistance of each wire. Do not pull on the wire because the wire connection inside the cap may become separated or the insulator may be damaged. When removing the wires from the spark plug, grasp and twist the moulded cap, then pull the cap off the spark plug.

THE RESISTANCE VALUE IS 410 OHM PER INCH OF WIRE.

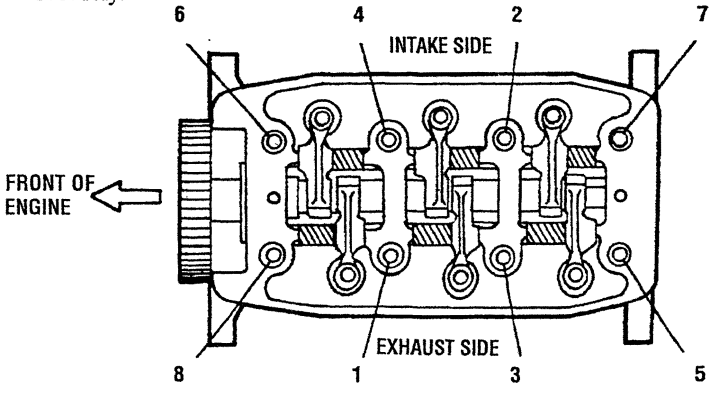


ENGINE ADJUSTMENTS

TORQUING THE CYLINDER HEAD BOLTS

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

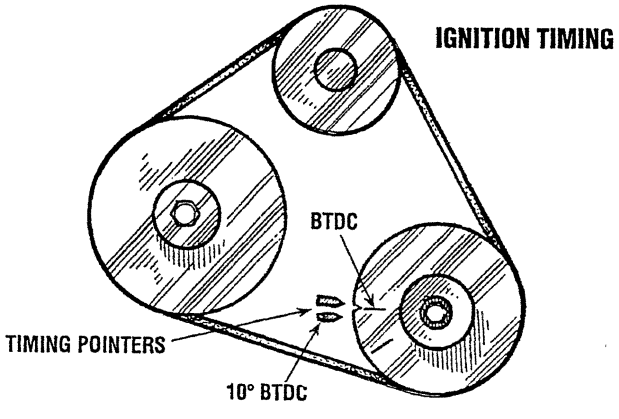
Tighten the cylinder head bolts according to the sequence shown. Make sure the engine is cold when this is done, and loosen one head bolt one-half turn and then tighten it between 43 - 51 lb-ft (60 - 70 Nm). Then proceed to the next head bolt in the sequence. Tighten the RS (rocker cover stud) securely.



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)



VALVE CLEARANCE ADJUSTMENT

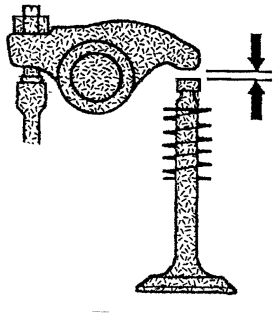
NOTE: *Retorque the cylinder head bolts before adjusting the engine's valves (see TORQUING THE CYLINDER HEAD BOLTS).*

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: **INTAKE .008 inches (0.20mm)**
EXHAUST .012 inches (0.30mm)

ENGINE ADJUSTMENTS

SPARK PLUGS

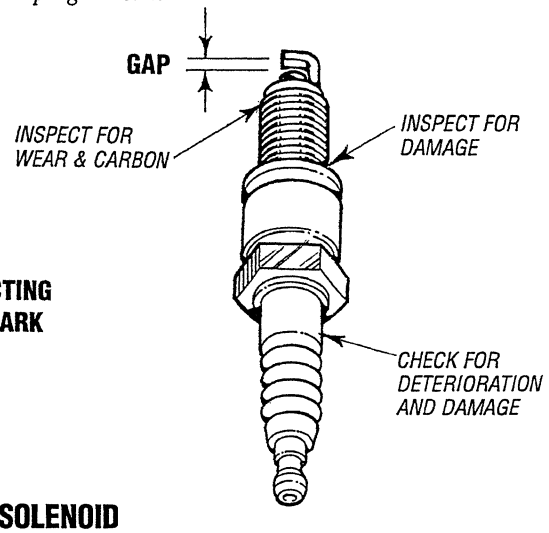
The spark plugs should be cleaned and regapped after the first 50 hour break-in period, then inspected every 250 hours thereafter and replaced as needed.

> ⚠ **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.*



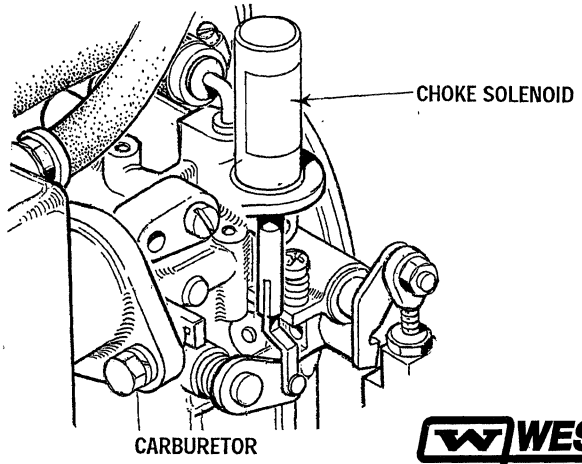
INSPECTING THE SPARK PLUGS

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.



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.

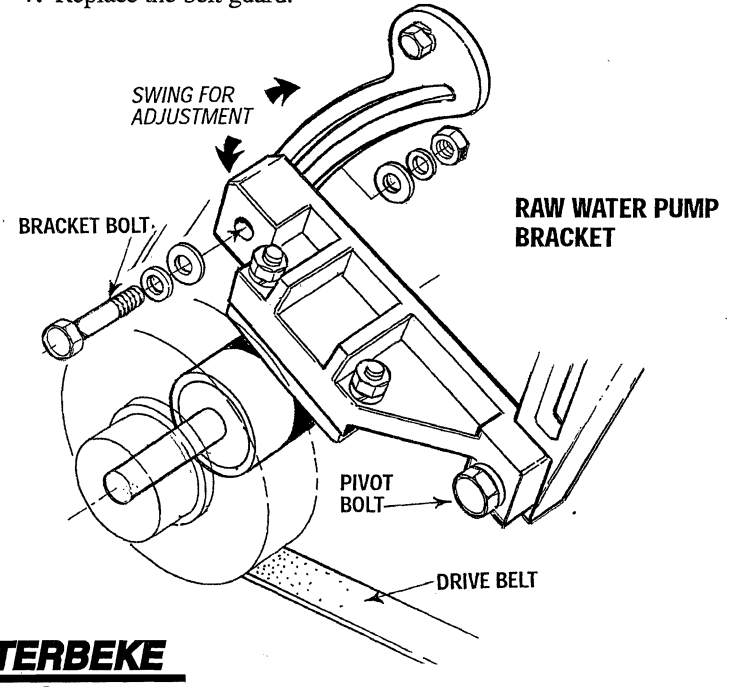
The BCGB generator has two drive belts, one drives the governor and alternator and the other drives the raw water pump. The tension adjustment procedure for both belts is as follows:

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



BATTERY CHARGE CONTROLLER

THE CHARGING SYSTEM

Westerbeke's low profile generators are equipped with a battery charge controller that is powered from a separate winding in the generator. The battery charger controller 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: 13.1 - 13.4 volts DC
Charging Amperage: 0 - 17- amps DC

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.*

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

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

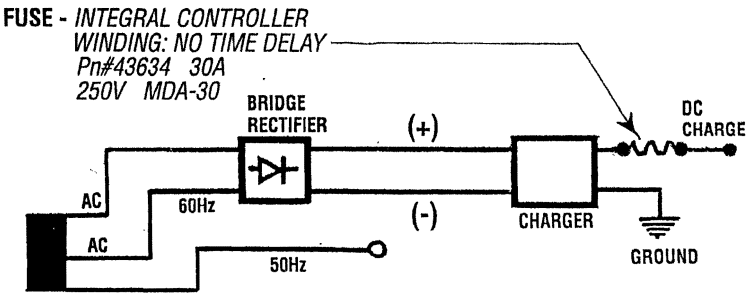
Fuse Protection

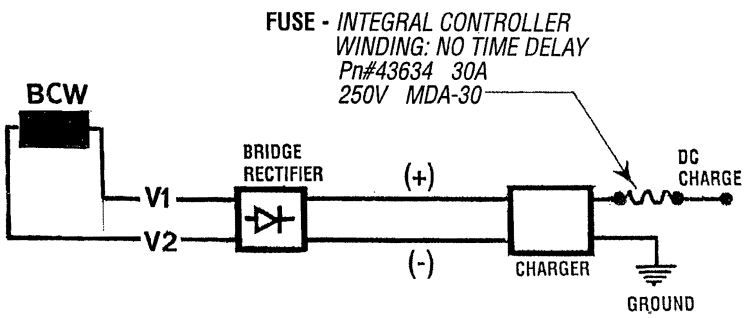
A 30 amp fuse protects the windings from a failure of the bridge rectifier or the battery charger caused by a high amperage or a short circuit.

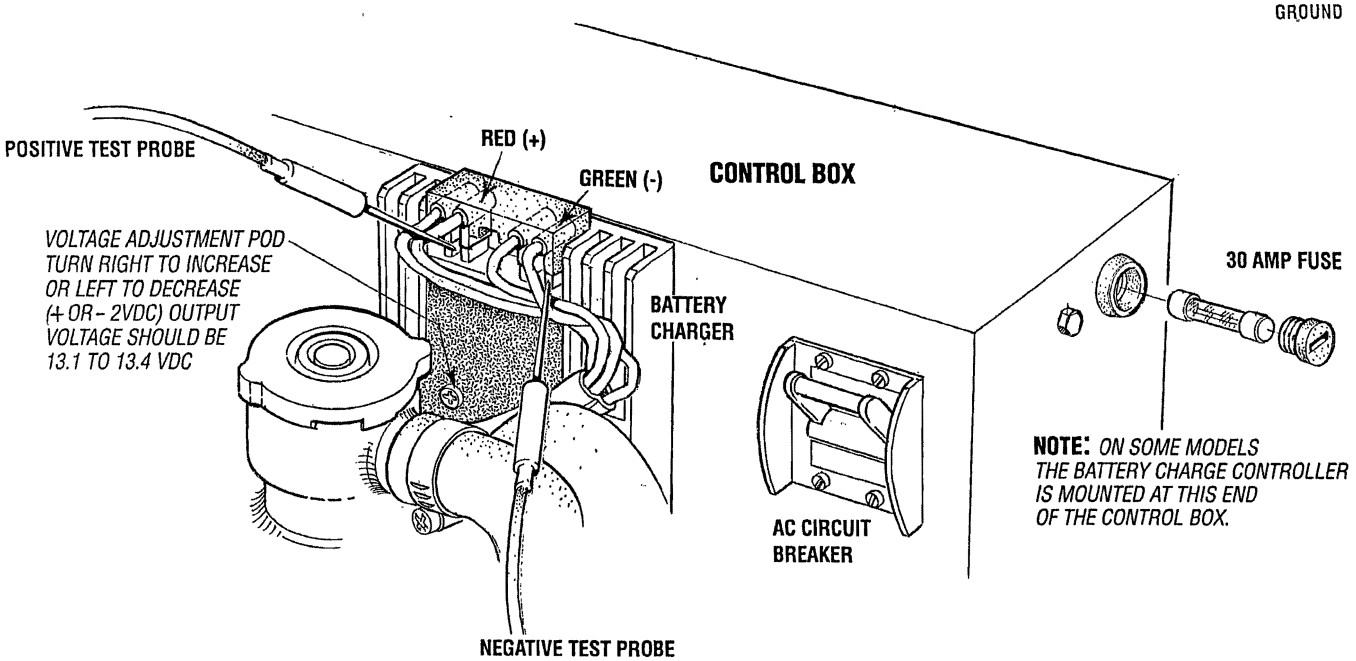
Testing the Battery Charger

To test the battery charger, put a multimeter between the positive (+) and negative (-) leads to the battery. It should indicate 13.1V to 13.4V 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 (-) on the battery charger (as illustrated) for 13.1V to 13.4V. If no charge is indicated, replace the charger.

Use of a dedicated and isolated starting battery is strongly recommended.







7.0 KW BCGC/BCGD GENERATOR SPECIFICATIONS

ENGINE SPECIFICATIONS

Engine Type	3-cylinder, 4-cycle, , overhead camshaft w/counterbalance shaft, water cooled gasoline engine
Bore & Stroke	2.56 x 2.61 inches (65.0 x 66.3 mm)
Total Displacement	40.3 cubic inches (0.66 liters)
Bearings	Four main bearings
Compression Chamber	Semi-spherical
Compression Ratio	9.8:1
Hp@1800/1500 rpm	8.0/6.5
Firing Order	1 - 3 - 2
Aspiration	Naturally aspirated
Direction of Rotation	Counterclockwise viewed from the back end
Inclination	25° continuous, all directions
Dry weight	307 lbs (139.3 Kgs)
Governor	Electronic

FUEL SYSTEM

Fuel Pump	Open flow, self bleeding
Fuel	Unleaded 89 octane or fiigher gasoline
Distributor	Breakerless distributor
Spark Plugs	14 mm
Ignition Coil	12 volt
Flame Arrester	Metal screen type
Carburetor	Single draft type
Fuel Consumption (Full Load)	.8 GPH@ 1800 rpm

ELECTRICAL SYSTEM

Start Motor	12-Volt reduction gear with solenoid
Starting Battery	12-Volt, (-) negative ground
Battery Capacity	105 Cold Cranking Amps (CCA)(min))
Battery Charging	Integral electric, 17 amps

EXHAUST EMISSIONS SYSTEMS

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, belt-driven.
Raw Water Flow,	4.9 US gpm at 1800 rpm (approx. measure before discharging into exhaust elbow).
Cooling Water Capacity	3 qts (2.8 liters).
Operating Temperature	150° - 170° F (65 - 77° C)

LUBRICATION SYSTEM

General	Forced lubrication by gear pump.
Oil Filter	Full flow, paper element. spin-on disposals.
Oil Capacity	2.5 qts. (2.4 liters).
Operating Oil Pressure	40 - 60 psi (2.8 - 4.2 kg/cm^2).
Oil Grade	API Specification SJ class

AC GENERATOR (Single Phase)

Single Phase	Brushless, four-pole capacitor, regulated. 1800 rpm/60Hz, 1500 rpm/50Hz
Ratings:	
7.0KW	120 volts, 58.3 amps, 60Hz single phase, 4 wire, 10. power factor
5.9KW	230 volts, 25.6 amps, 50Hz single phase, 4 wire, 10. power factor

TUNE-UP SPECIFICATIONS

Spark plug Gap	0.031 ± .002 inches (0.8 ± 0.05mm)
Spark Plug Torque	10.8 - 15.2 lb-ft
Cylinder Head Torque	60-70 Nm (43-51 ft-lbs)
Bolt Torque	See *TORQUING THE CYLINDER HEAD*

5.0 KW BCG\BCGA GENERATOR SPECIFICATIONS

ENGINE SPECIFICATIONS

Engine Type	3 cylinder, 4 cycle, overhead camshaft w/counterbalance shaft, water cooled gasoline engine
Bore & Stroke	2.56 x 2.61 inches (65.0 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
Hp@1800/1500 rpm	8.0/6.5
Firing Order	1 - 3 - 2
Aspiration	Naturally aspirated
Direction of Rotation	Counterclockwise viewed from the back end
Inclination	25° continuous, all directions
Dry Weight	307 lbs (139.3 Kg)
Governor	Electronic

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 draft type
Fuel Consumption (Full Load)	.8 GPH @ 1800 rpm

ELECTRICAL SYSTEM

Start Motor	12 volt reduction gear with solenoid
Starting Battery	12 volt negative ground
Battery Capacity	105 Cold Cranking Amps(CCA)(min)
Battery Charging	Integral electric, 17 amps

EXHAUST EMISSIONS SYSTEMS

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, belt driven.
Raw Water Flow (measured before discharge into exhaust elbow) Approx.	4.9 gpm at 1800 rpm
Cooling Water Capacity	3 qts (2.8 liters)
Operating Temperature	150° - 170° F (65° - 77° C)

LUBRICATING SYSTEM

Type	Forced lubrication by gear pump
Oil Filter	Fuel flow, paper element, spin-on disposals
Oil Capacity	2.5 qts. (2.4 liters)
Oil Grade	API Specification SJ class
Operating Oil Pressure	40 - 60 psi (2.8 - 4.2 kg/cm²)

AC GENERATOR (SINGLE PHASE)

Type	Brushless, four pole capacitor,regulated. 1800 rpm/60Hz, 1500 rpm/50Hz
Ratings	
5.0KW	120 volts, 41.6 amps, 60 Hz single phase, 4 wire, 1.0 power factor
4.2KW	230 volts, 18.2 amps, 50 Hz, single phase, 4 wire, 1.0 power factor

TUNE-UP SPECIFICATIONS

Spark Plug Gap	0.031 ± .002 inches (0.8 ± 0.05 mm)
Spark Plug Torque	10.8 - 15.2 lb-ft
Cylinder Head Torque	60 - 70 Nm 43 - 51 ft-lbs
Bolt Torque	See *TORQUING THE CYLINDER HEAD*

GENERATOR INFORMATION

USE OF ELECTRIC MOTORS

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

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

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

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

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

Required Operating Speed

Run the generator first with no load applied, then at half the generator's capacity, and finally loaded to its full capacity as indicted on the generator's data plate. The output voltage should be checked periodically to ensure proper operation of the generating plant and the appliances it supplies. If an AC voltmeter or ampmeter is not installed to monitor voltage and load, check it with a portable meter and amp probe.

Generator Frequency Adjustment

Frequency is a direct result of engine/generator speed, as indicated by the following:

☐ When the generator is run at 1800 RPM, the AC voltage output frequency is 60 Hertz.

Therefore, to change the generator's frequency, the generator's drive engine's speed must be changed .along with a reconfiguring of the AC output connections at the generator.

Generator Maintenance

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

☐ For unusually severe conditions, thin rust-inhibiting petroleum-base coatings, should be sprayed or brushed over all surfaces to reduce rusting and corrosion.

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

☐ The drive discs on single bearing generators should be checked periodically if possible for tightness of screws and for any evidence of incipient cracking failure. Discs should not be allowed to become rusty because rust may accelerate cracking. The bolts which fasten the drive disc to the generator shaft must be hardened steel SAE grade 8, identified by 6 radial marks, one at each of the 6 corners of the head.

☐ The rear armature bearing is lubricated and sealed; no maintenance is required. However, if the bearing becomes noisy or rough-sounding, have it replaced.

☐ Examine bearing at periodic intervals. No side movement of shaft should be detected when force is applied. If side motion is detectable, inspect the bearing and shaft for wear. Repair must be made quickly or major components will rub and cause major damage to generator.

Carbon Monoxide Detector

WESTERBEKE recommends mounting a carbon monoxide detector in the vesssel's living quarters. **Carbon Monoxide, even in small amounts, is deadly.**

The presence of carbon monoxide indicates an exhaust leak from the engine or generator or from the exhaust elbow/ exhaust hose, or that fumes from a nearby vessel are entering your boat.

If carbon monoxide is present, ventilate the area with clean air and correct the problem immediately!

BC GENERATORS 5.0/7.0 KW

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.

Winding Connections: The single-phase synchronous generator has 4 stator leads and can be configured to 120 volt output.

Bearings: The bearings are sealed type and permanently greased requiring no maintenance during their working life (approx. 30,000 hours).

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 shut down 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.***

INTRODUCTION TO TROUBLESHOOTING

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

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

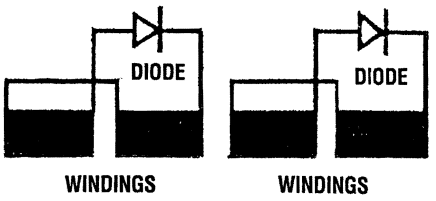
A quality multimeter (multitester) capable of reading less than one ohm and with a specific diode testing function.

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

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

> ⚠ **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.***

ROTATING FIELD/AUXILIARY WINDINGS



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 its rated rpm. This 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 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.

BC GENERATORS TROUBLESHOOTING CHART MECC ALTE

(REFER TO THE WIRING SCHEMATIC BELOW)

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.*

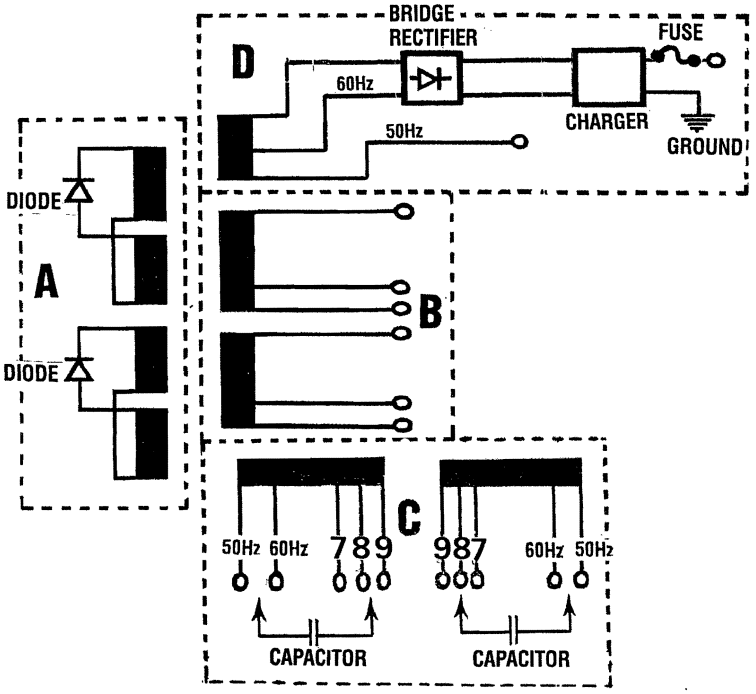
FAULT	CAUSE	TEST/CORRECTION
No AC Output	Shorted stator	**B**
	Open stator	**B**
	Shorted diode (two)	**A**
Residual Voltage 4-6 VAC (Hot N) at No-Load	Faulty capacitor (two)	**C**
	Open exciter	**B**
	Shorted exciter	**B**
	Engine speed (hertz) is too low	Adjust*
	Electrical connections are faulty	Inspect 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) too high.	Adjust*
Low AC Output 60-160V	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 wiring	**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*

WINDING RESISTANCE VALUES (OHMS)

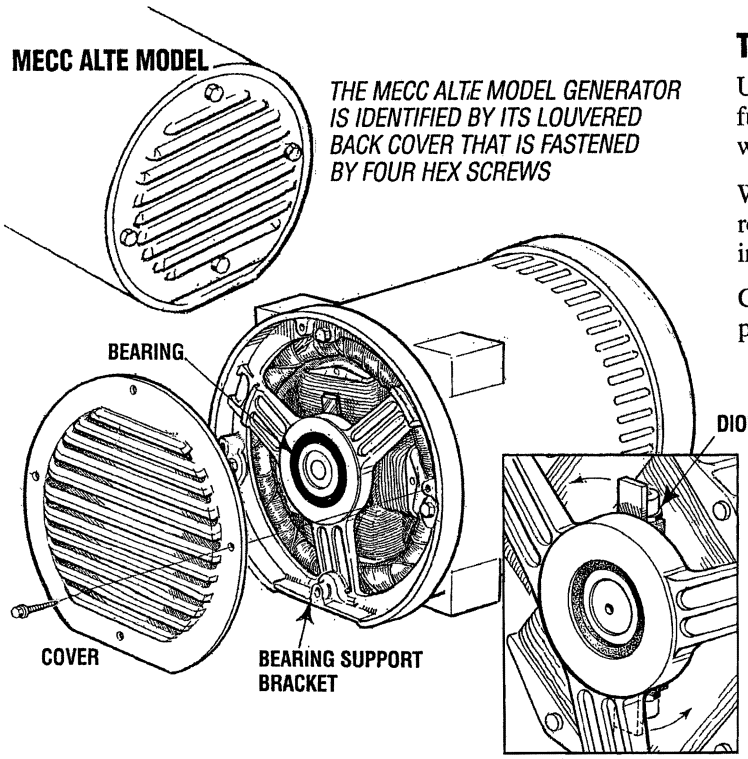
	5.0KW	7.0KW
MAIN STATOR:		
#1 TO #3	0.4	0.2
#4 TO #6	0.4	0.2
ROTOR: (Each pair)	4.0	2.0
EXCITER: (Each winding)	3.9	2.5
CHARGE WINDING:	0.08	0.08

INTERNAL WIRING SCHEMATIC



A - ROTOR WINDINGS
B - STATOR WINDINGS
C - CAPACITOR WINDING
D - BATTERY CHARGE WINDING

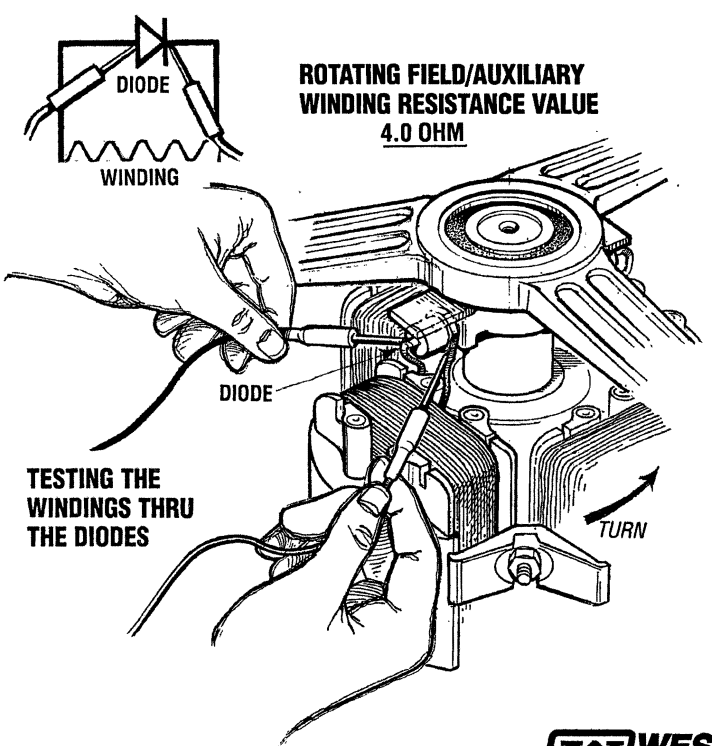
TESTING THE BC ROTOR (MECC ALTE MODEL)



Testing the Mecc Alte generator can be accomplished without removing the bearing support bracket. Simply turn the armature to allow access for the testing as shown.

TESTING THE WINDINGS THROUGH THE DIODES

Rotate the armature into position to access a diode. To make a quick test of the windings, assume the diode to be OK and test the connection at each end of the diode. Turn the armature and test the other side.

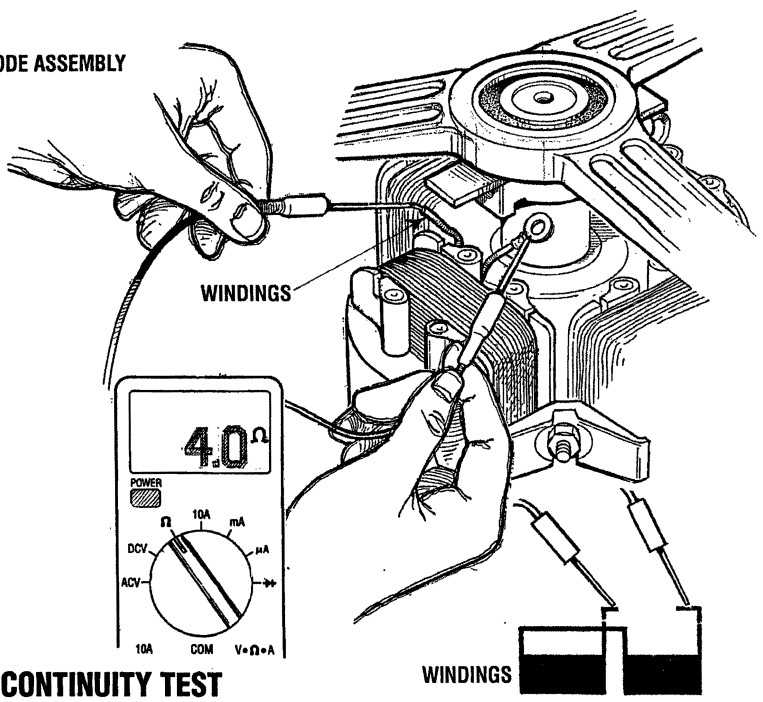


TESTING THE ROTOR FIELD WINDINGS

Unsolder the winding connection from the diode and carefully remove the diode from its isolated heat sink using a thin walled, deep well 7/16" (11mm) socket.

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.

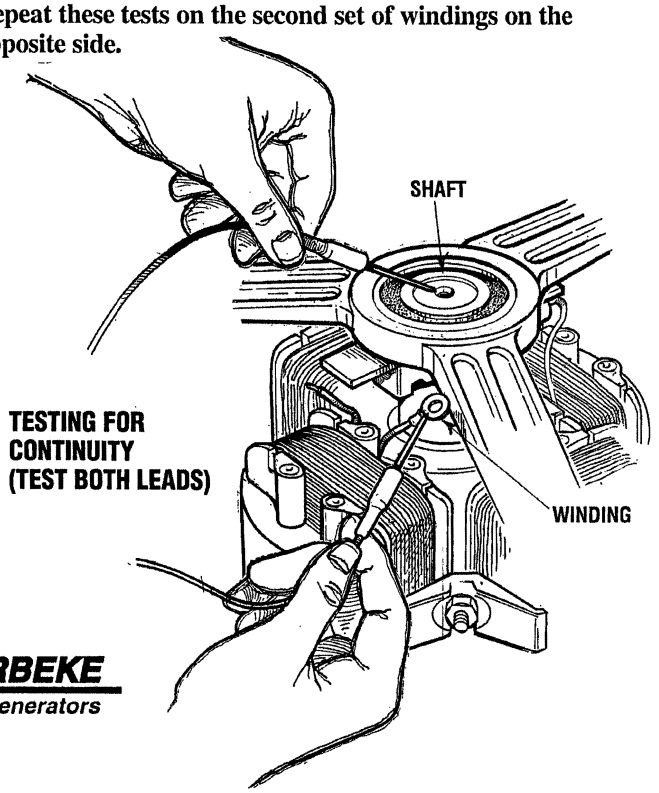
Check the resistance value of the rotating windings by placing an ohmmeter's probes across the two exposed leads.



CONTINUITY TEST

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 these tests on the second set of windings on the opposite side.



BC GENERATORS TROUBLESHOOTING CHART COLISEUM MODEL

(REFER TO THE WIRING SCHEMATIC)

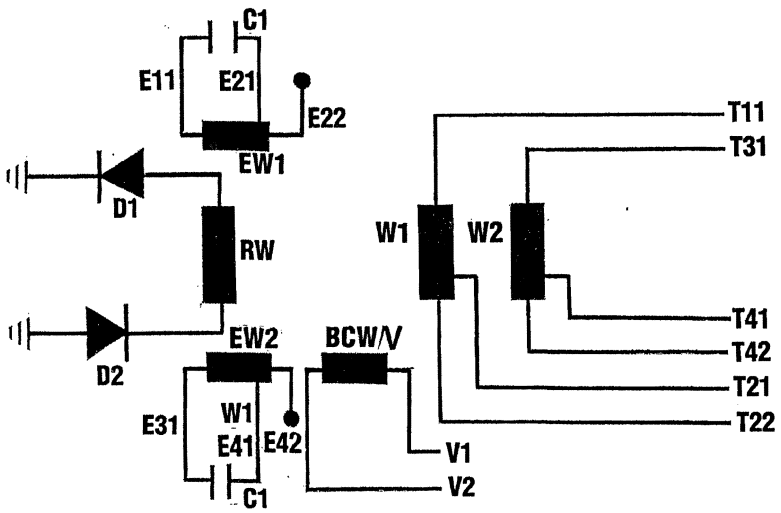
FAULT	CAUSE	TEST
NO AC VOLTAGE OUTPUT	1. Shorted stator 2. Open stator 3. Rotor diode open/shorted	1. W1 & W2 2. W1 & W2 3. D1 & D2
RESIDUAL VOLTAGE 3-4 VAC LINE TO N AT NO LOAD	1. Faulty capacitor 2. Open exciter winding 3. Shorted exciter 4. Engine speed low 5. Electrical connection	1. C1 2. EW1 - EW2 3. EW1 - EW2 4. Adjust 5. Inspect
HIGH AC OUTPUT AT NO LOAD	1. Engine speed too high 2. Capacitor connection	1. Adjust 2. Correct
LOW AC OUTPUT 60-100 VAC	1. Faulty rotor winding 2. Faulty diode (shorted) 3. Faulty capacitor 4. Faulty exciter windings	1. RW 2. D1 or D2 3. Check rating 4. Check windings
VOLTAGE DROP UNDER LOAD	1. Faulty diode 2.Engine speed low 3. Faulty capacitor	1. D1 or D2 2. Check/adjust 3 Check rating
HIGH VOLTAGE OUTPUT (NO LOAD/LOADED)	1. Engine speed	1. Check/adjust
UNSTABLE OUTPUT	1. Electrical connection 2. Engine speed	1.Check 2. Check/adjust

GENERATOR WINDING SCHEMATIC

NOTES: *For 60Hz operation: Connect capacitors to E31-E41 and to E11-E21.*

For 50Hz operation: Connect capacitors to E31-E42 and E11-E22.

EW1-*Exciter Windings 1*
EW2-*Exciter Windings 2*
BCW-*Battery charging windings*
RW-*Rotor Winding*
W1-*Stator Winding 1*
W2-*Stator Winding 2*
C-*Capacitor*
D1/D2-*Diodes*



POTENTIAL BC PROBLEMS

Diodes

1. An open diode will cause the loss of any rotating field.
2. A shorted diode will weaken the rotating field.

Field Windings

1. An open field winding will cause the loss of the rotating field.
2. A shorted field winding will cause a weak rotating field.
3. Test each diode individually. A resistance value should be found through the diode in one direction and, with the meter probes reversed, show no ohm value.

RESIDUAL VOLTAGE TEST (unit operating at rated hertz)
Exciter circuit capacitor disconnected from exciter windings

MAIN STATOR RESIDUAL VOLTAGE (Live to neutral)
3-4 VAC

EXCITER WINDING GROUP

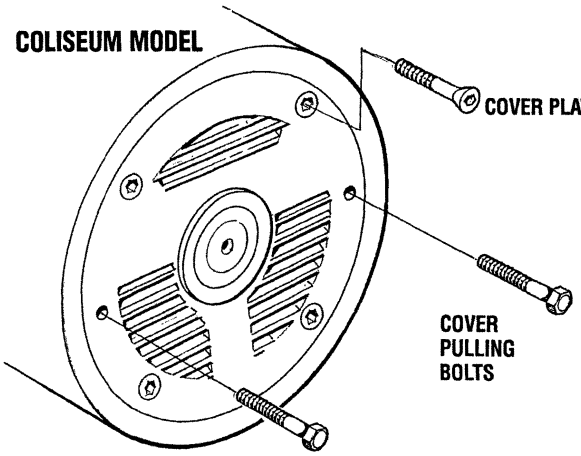
EW1	E31-E42	5-6 VAC
EW2	E11 to E22	5-6 VAC

NOTE: *The presence of correct residual voltage is an indication the winding is O.K. (main stator or exciter windings).*

WINDING RESISTANCE VALUES (OHMS)

	5.0KW	7.0KW
EXCITER WINDINGS:		
EW1 (E11 & E22)	3.4	2.2
EW2 (E31 & E42)	3.4	2.2
BATTERY CHARGING:		
BCW	0.5	0.5
STATOR WINDINGS:		
W1 (T11 & T22)	0.6	0.9
W2 (T31 & T42)	0.6	0.9
ROTOR WINDINGS:		
RW	1.7	2.2

TESTING THE BC ROTOR COLISEUM MODEL



REMOVE THE COVER PLATE

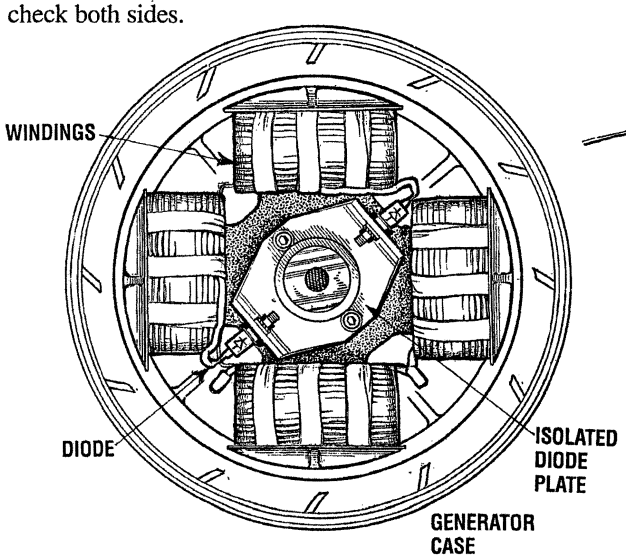
1. Remove the four cover plate screws.
2. Insert two 8mm x 35mm-1.25 pitch bolts into the two left and right vacant holes as shown.
3. Tighten these two bolts in sequence. This will pull the cover plate off the generator, exposing the rotor assembly with the bearing in place.
4. When re-installing, place a small amount of petroleum jelly on the rotor bearing "O" ring located in the cover boss.

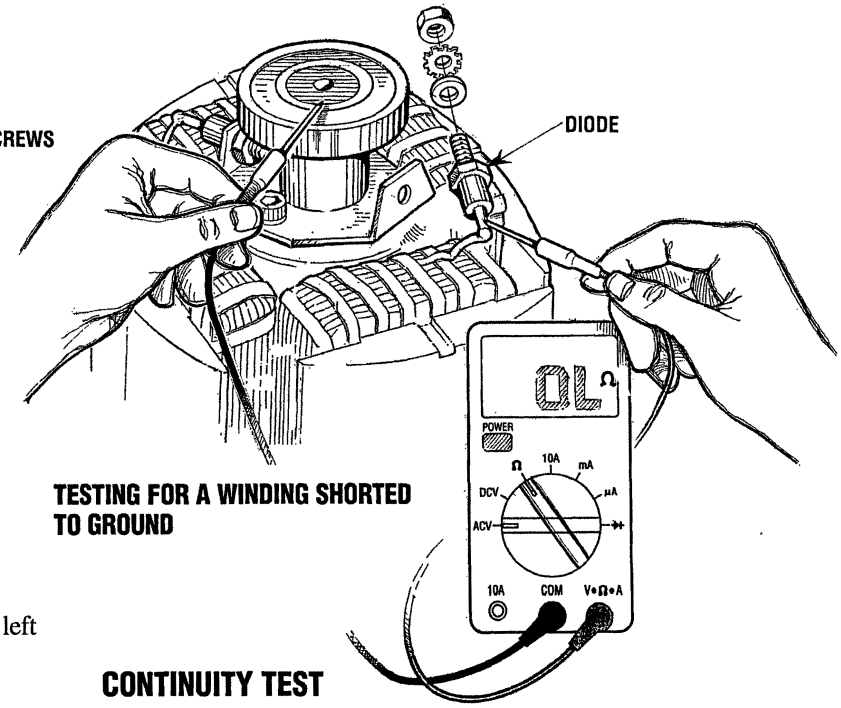
   Position the cover onto the bearing and thread the allen head screws back into place finger tight).

   Tighten the screws in a cris-cross manner drawing the end cover onto the bearing. When fully on, tighten the screws securely.

TESTING THE ROTOR FIELD WINDINGS

Use a thin walled, deep well 7/16" (11mm) socket and remove the diodes from the isolated plate. With the winding connection still attached to the diode test between the connection and the metal of the rotor shaft as shown above, check both sides.

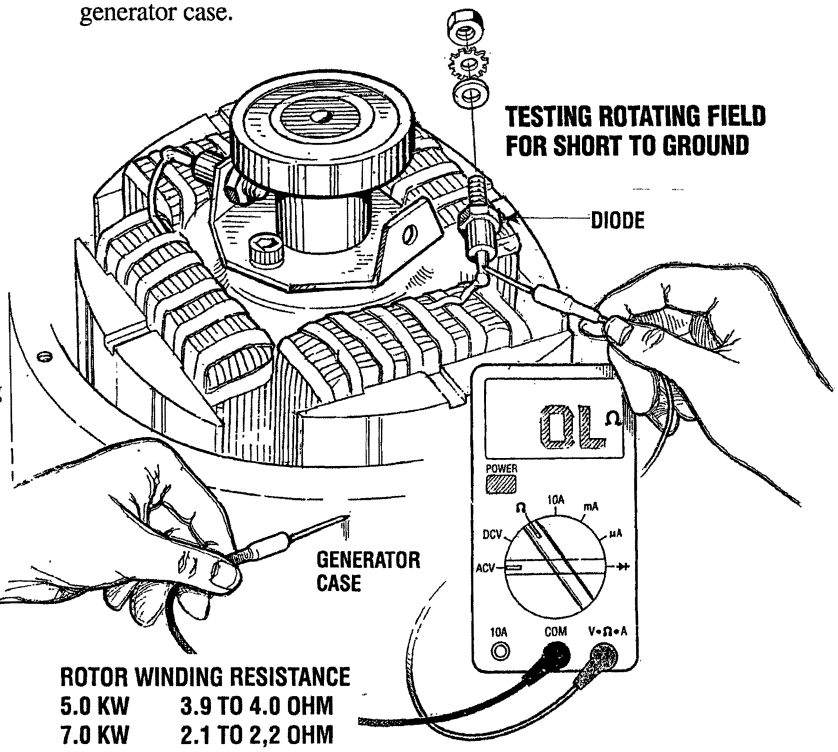




TESTING FOR A WINDING SHORTED TO GROUND

CONTINUITY TEST

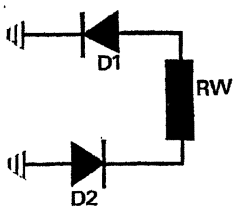
With the diode still removed from the isolated plate, test the continuity between the winding/diode connection and the generator case.

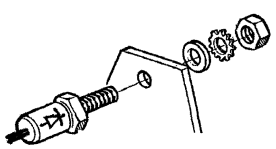


TESTING ROTATING FIELD FOR SHORT TO GROUND

ROTOR WINDING RESISTANCE

5.0 KW	3.9 TO 4.0 OHM
7.0 KW	2.1 TO 2,2 OHM





TESTING THE DIODES

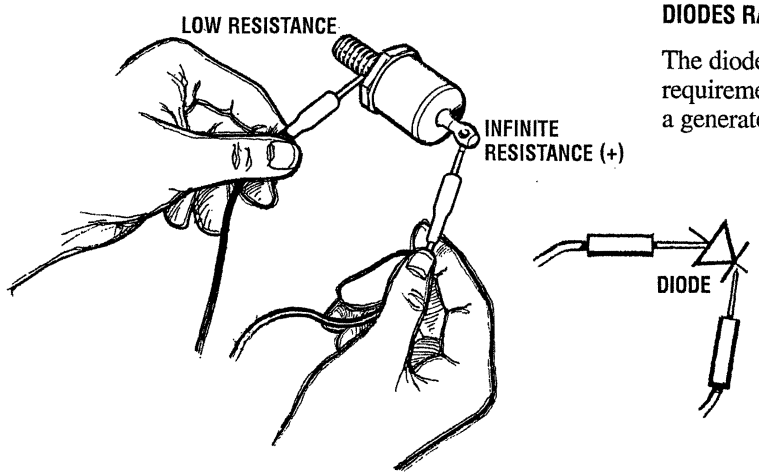
Refer to the following pages.

TESTING THE DIODES/CONTROL PANEL

TESTING THE DIODES - ALL MODELS

Carefully unsolder the winding connection to the diode and remove the diode using a thin walled, deep well 7/16" (11mm) socket and a box wrench as needed.

Test the diode as shown with ohmmeter leads at both ends, then reverse the positions.



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

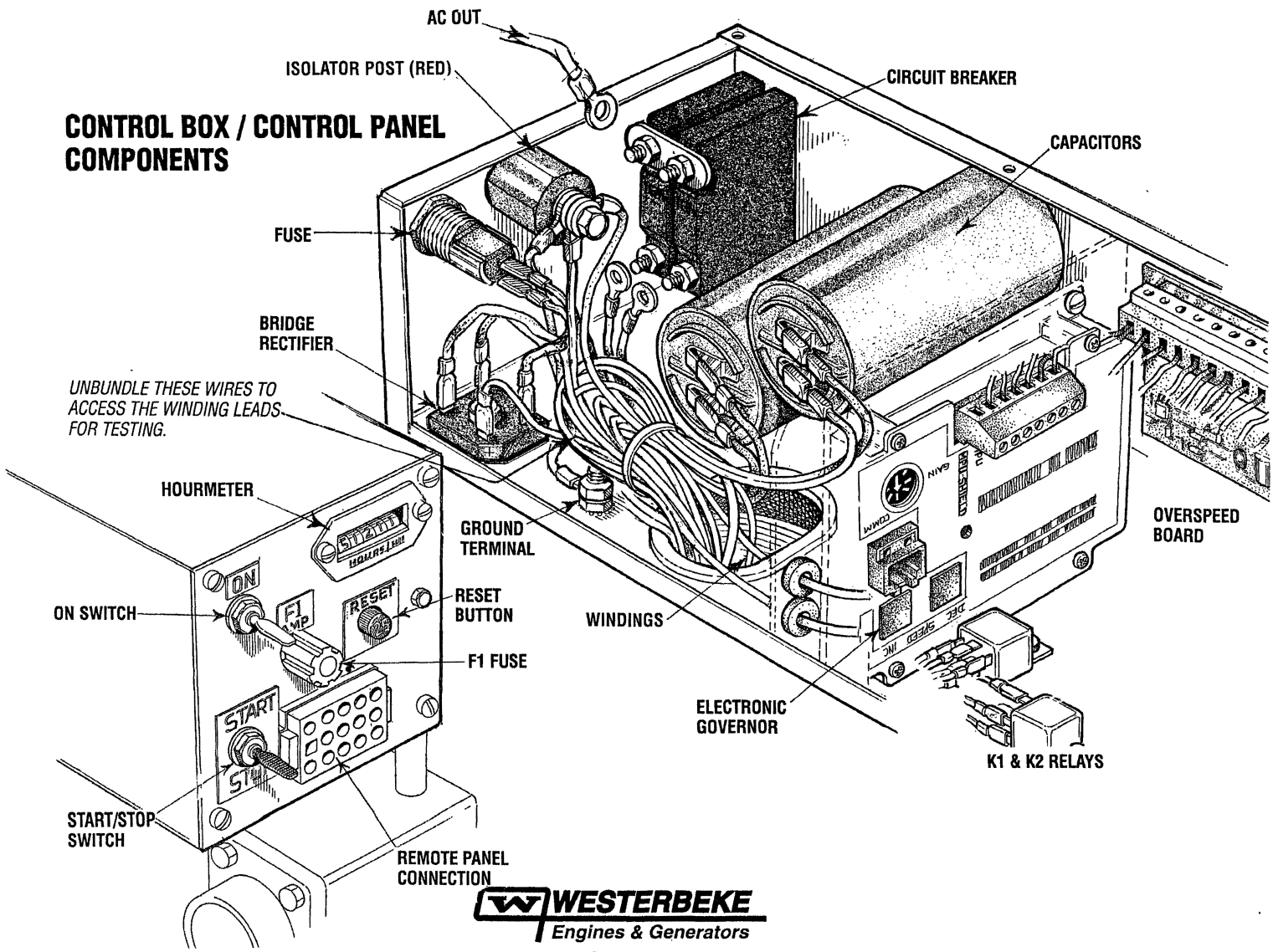
DIODES: 1.4 - 1.5 OHMS (APPROX.) *USING A 260 FLUKE 76 METER.*

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

DIODES RATING 1600 VOLTS 26 AMPS

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

CONTROL BOX / CONTROL PANEL COMPONENTS



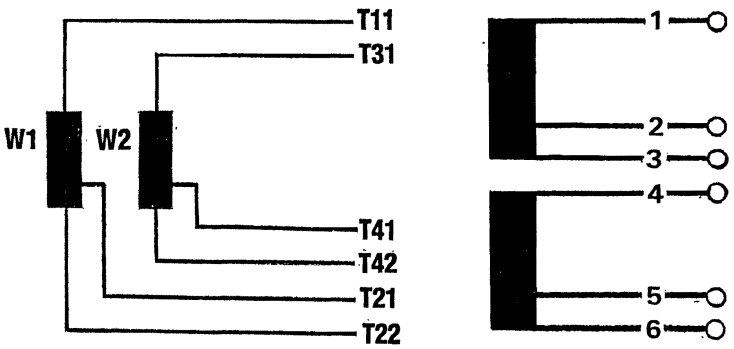
NO AC VOLTAGE OUTPUT

EXCITING THE GENERATOR

To quickly determine a short or an open in the main stator winding, excite the generator with 12 VDC using one exciter winding group to accomplish this.

The AC voltage that the generator will produce measured between the line and neutral during excitation will be very low.

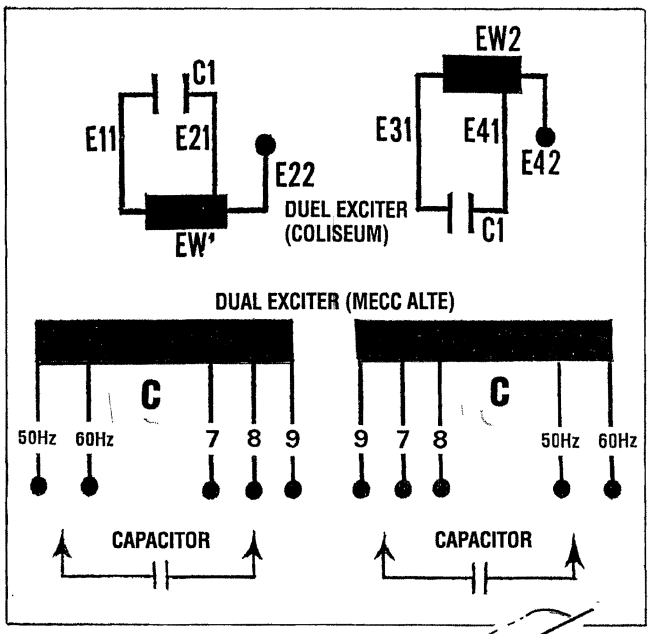
NORMAL AC VOLTAGE DURING 12 VDC EXCITATION:
12 - 16 VOLTS AC

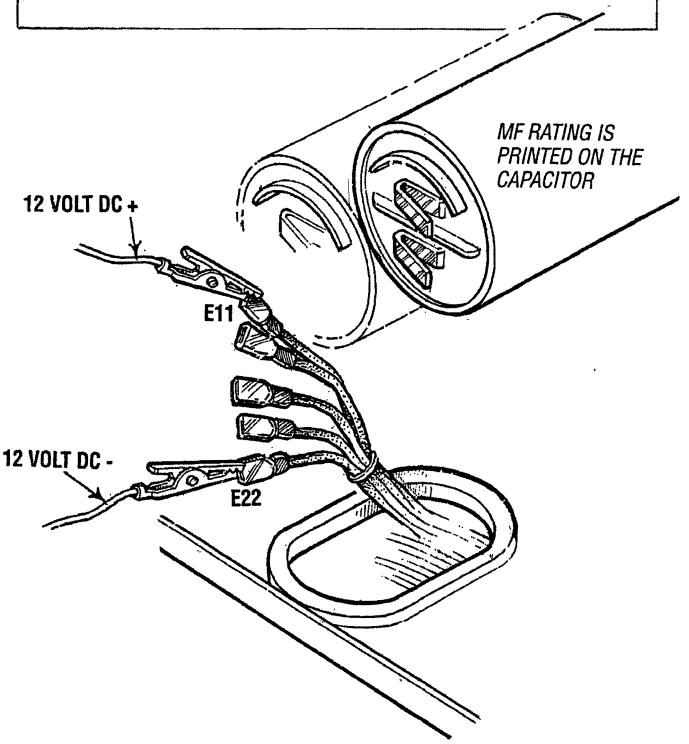


EXCITING PROCEDURE

Locate one of the exciter winding groups in the generator. Unplug all connections from both capacitors. Connect 12 VDC across the winding using the winding end connection.

For example: Winding group EW1 between connection E11 and E22. Winding group C between #50Hz and #9.





REACTION DURING EXCITATION

(Unit running-12VDC applied to winding)

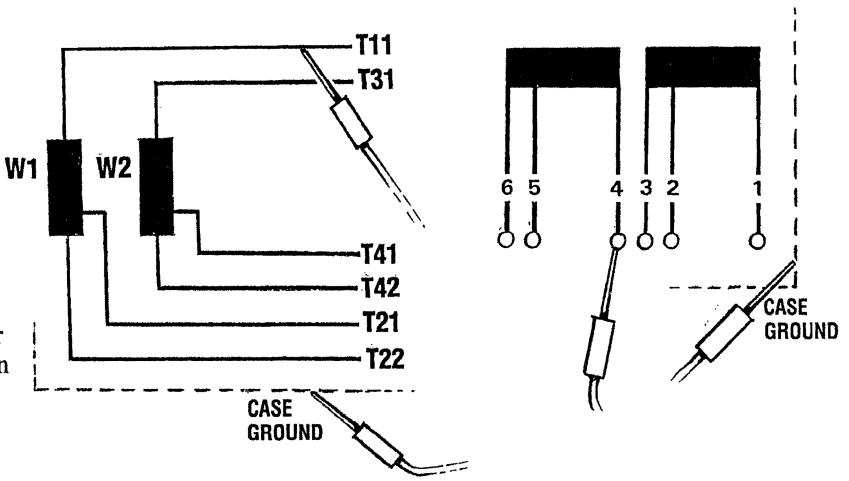
1. A very low AC outout and loading of the drive engine and a growling noise from the generator end.

   This indicates a shorted stator winding to ground or the stator windings are shorted to each other. Isolate the winding groups and verify a short to ground. No continuity should be found between the two isolated stator winding groups.

2. No reaction from the generator or drive engine. No AC output.

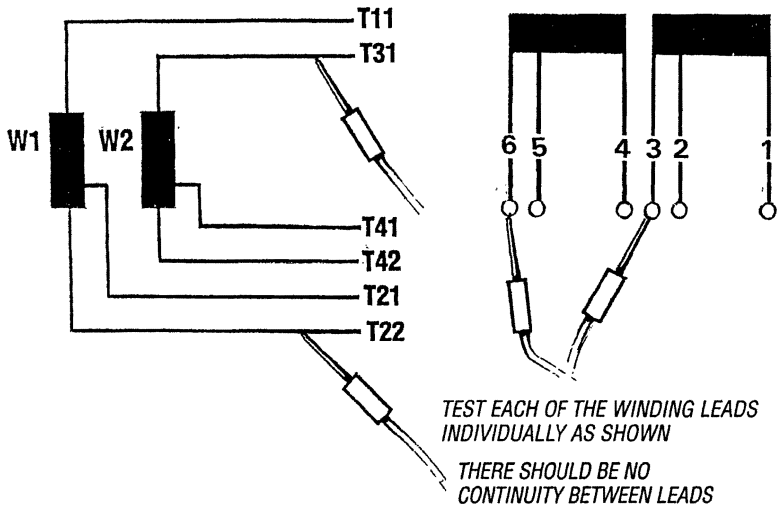
   This is an indication of an open in one of the main stator winding groups. Isolate the winding groups and verify an open winding.

No Continuity between Isolated Stator Windings and Ground



TEST EACH WINDING TO CASE GROUND

No Continuity between Isolated Stator Winding Groups



TEST EACH OF THE WINDING LEADS INDIVIDUALLY AS SHOWN

THERE SHOULD BE NO CONTINUITY BETWEEN LEADS

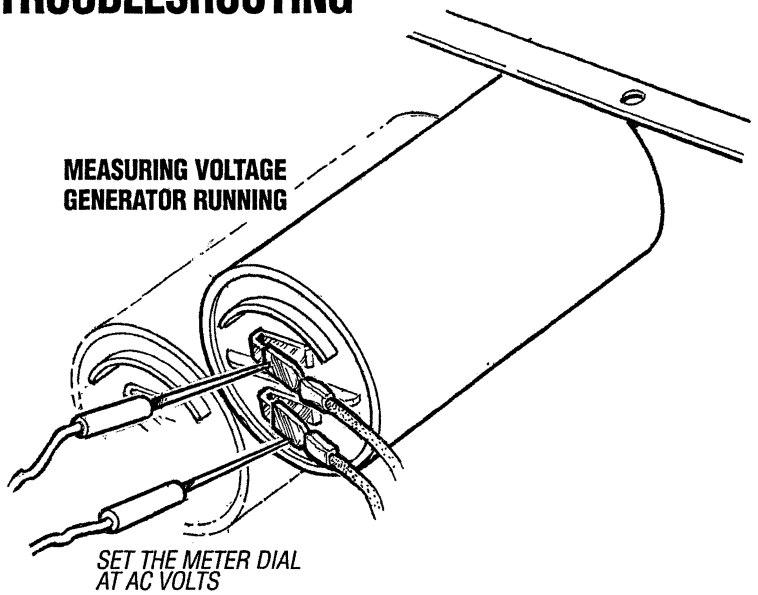
BC GENERATORS TROUBLESHOOTING

TESTING THE EXCITER WINDINGS

AC voltage can be measured across the capacitor electrical connections while the generator is operating. This voltage may be as high as 350 to 400 volts AC.

This AC voltage build-up is accomplished as the exciter winding for each capacitor charges the capacitor and the capacitor discharges back into the winding. This flow of saturating AC in the exciter winding produces a phase-imbalance type of filed that affects the auxiliary windings of the rotor.

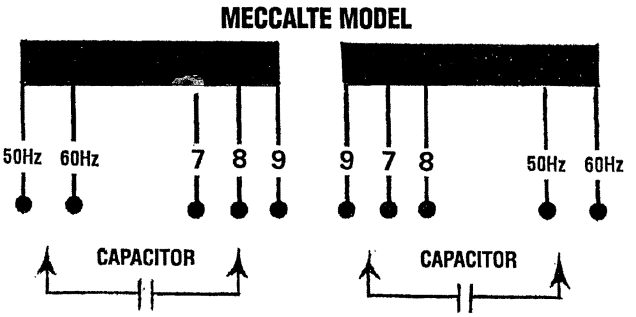
The AC voltage reading is taken between the two electrical connections on each separate capacitor with the generator operating at its correct no load speed.



EXCITER WINDING INTEGRITY (RESIDUAL AC VOLTAGE)

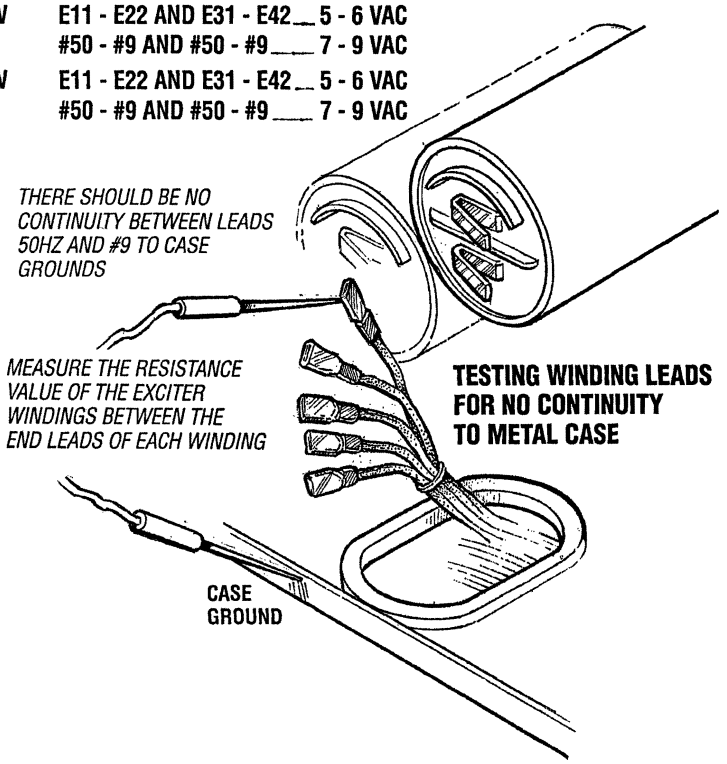
The condition of each exciter winding can be determined by the residual AC voltage each exciter winding should be producing with the generator running at proper no load speed.

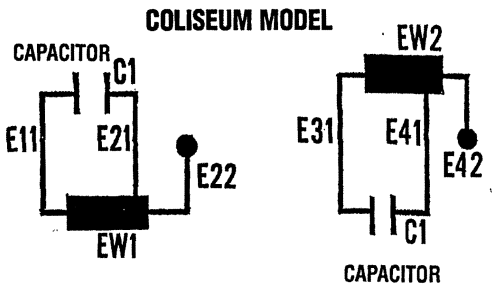
To do this: Unplug all connections from the capacitor. Locate the electrical connection for each winding end. Place your AC volt meter connects across these two connections. Start the generator and observe the residual AC voltage produced by the winding. Check the other exciter winding in the same way. Residual AC voltage lower than listed below will indicate a faulty winding.



RESIDUAL AC VOLTAGES (Each exciter winding)

5.0 KW	**E11 - E22 AND E31 - E42**	**5 - 6 VAC**
	#50 - #9 AND #50 - #9	**7 - 9 VAC**
7.0 KW	**E11 - E22 AND E31 - E42**	**5 - 6 VAC**
	#50 - #9 AND #50 - #9	**7 - 9 VAC**





MAIN STATOR WINDING RESISTANCE
LESS THAN ONE OHM FOR EACH WINDING GROUP

MAIN STATOR RESIDUAL VOLTAGE
LINE TO NEUTRAL 4-6 AC VOLTS
(THIS INDICATES GOOD STATOR WINDINGS)

BC GENERATORS TROUBLESHOOTING

TESTING CONTINUITY

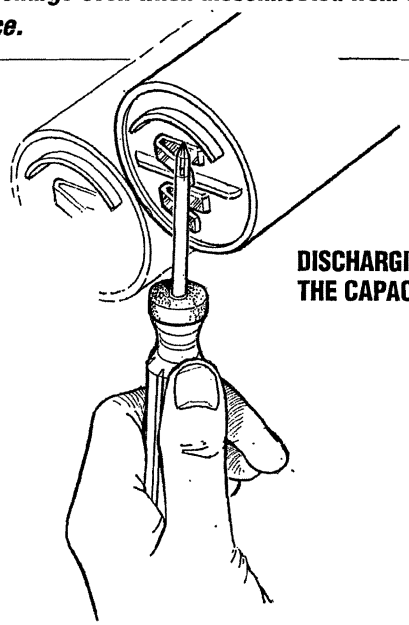
Quick field check (no capacitance scale on meter).

Connect a digital ohm meter or analog ohm meter (high scale) to the capacitor terminals. The meter will register and arbitrary ohm value for the material in the capacitor. the meter's battery will then start to charge the capacitor and the ohm value will increase.

If the meter does not react as above, the capacitor is faulty.

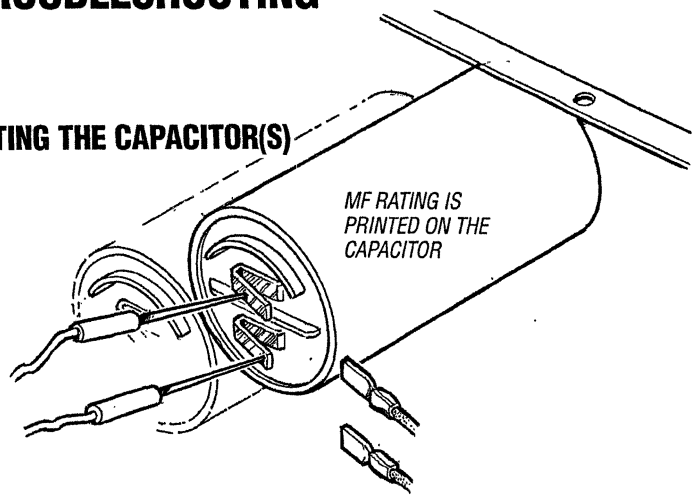
The method above indicates a presumably good capacitor, but does not verify it's microfared rating as would be necessary when troubleshooting a capacitor whose MF rating has dropped causing a low AC voltage output. In such cases, the capacitors rating *MUST* be verified accurately.

⚠ 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.***



DISCHARGING THE CAPACITOR

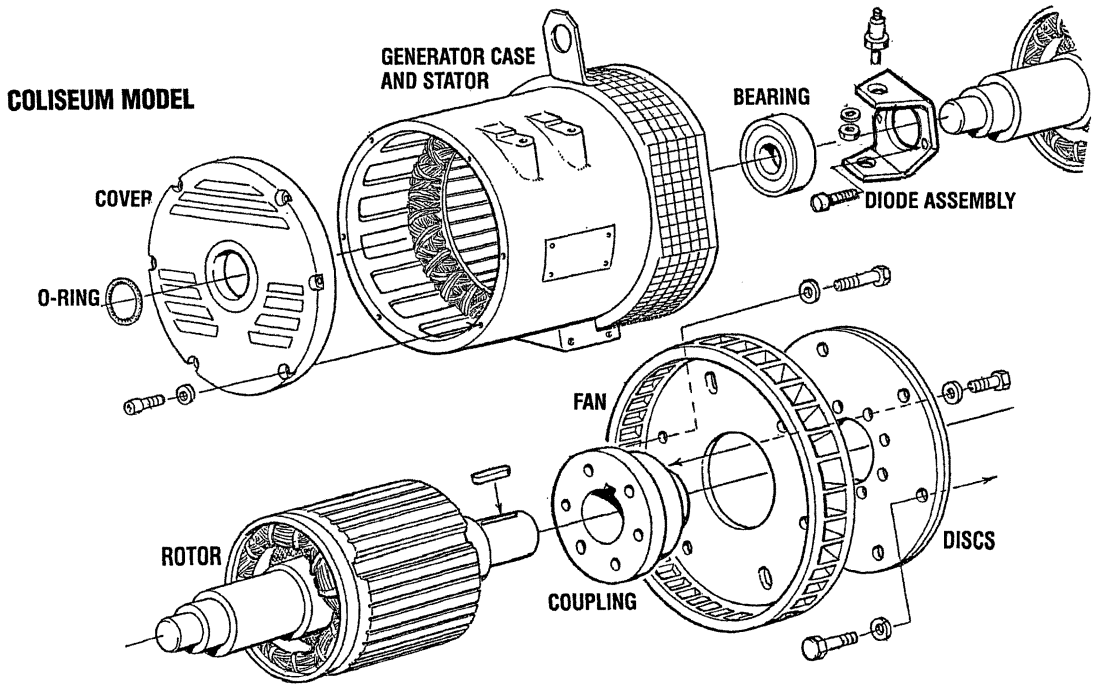
TESTING THE CAPACITOR(S)

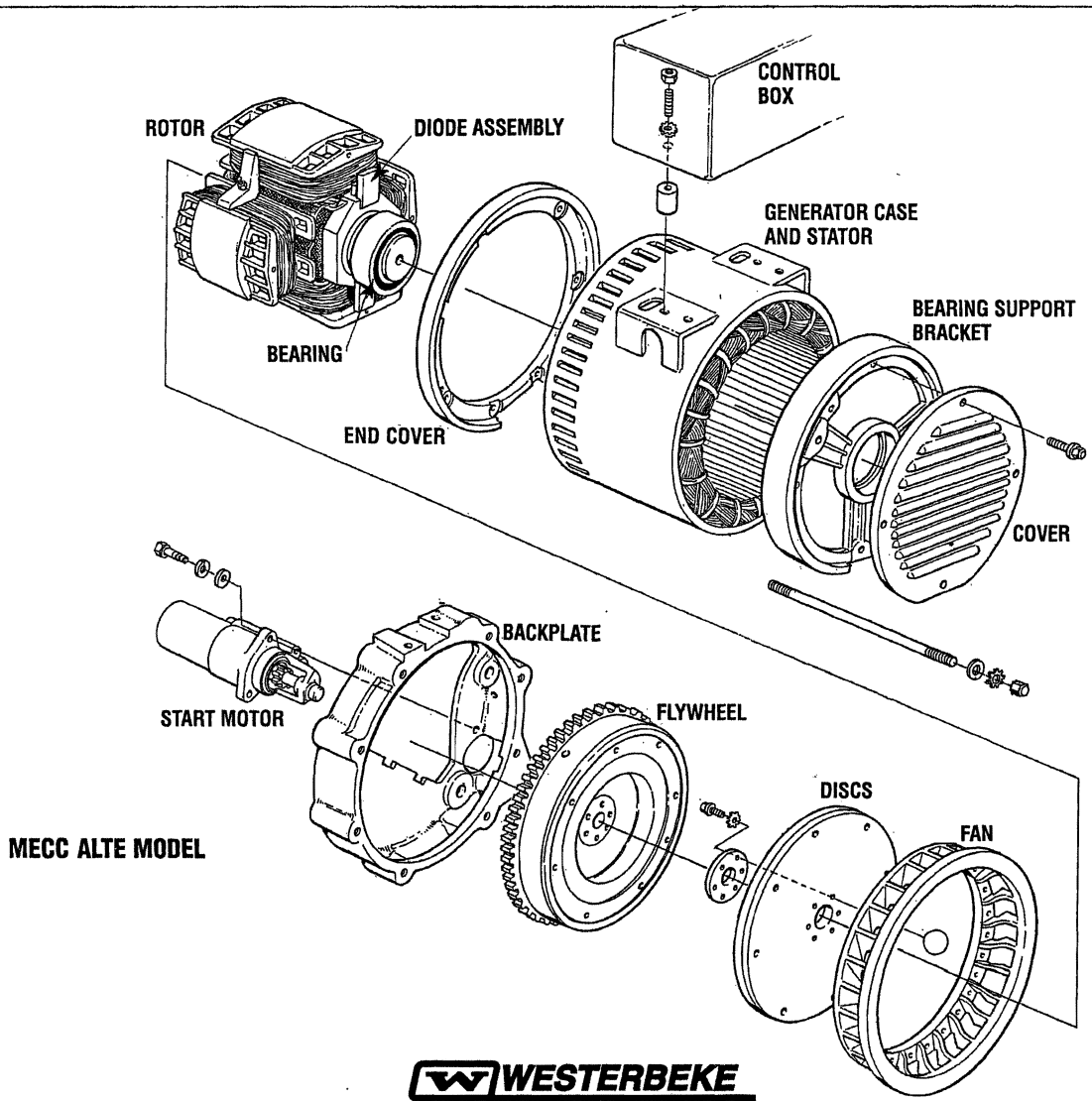


CAPACITOR RATINGS AND PART NUMBERS

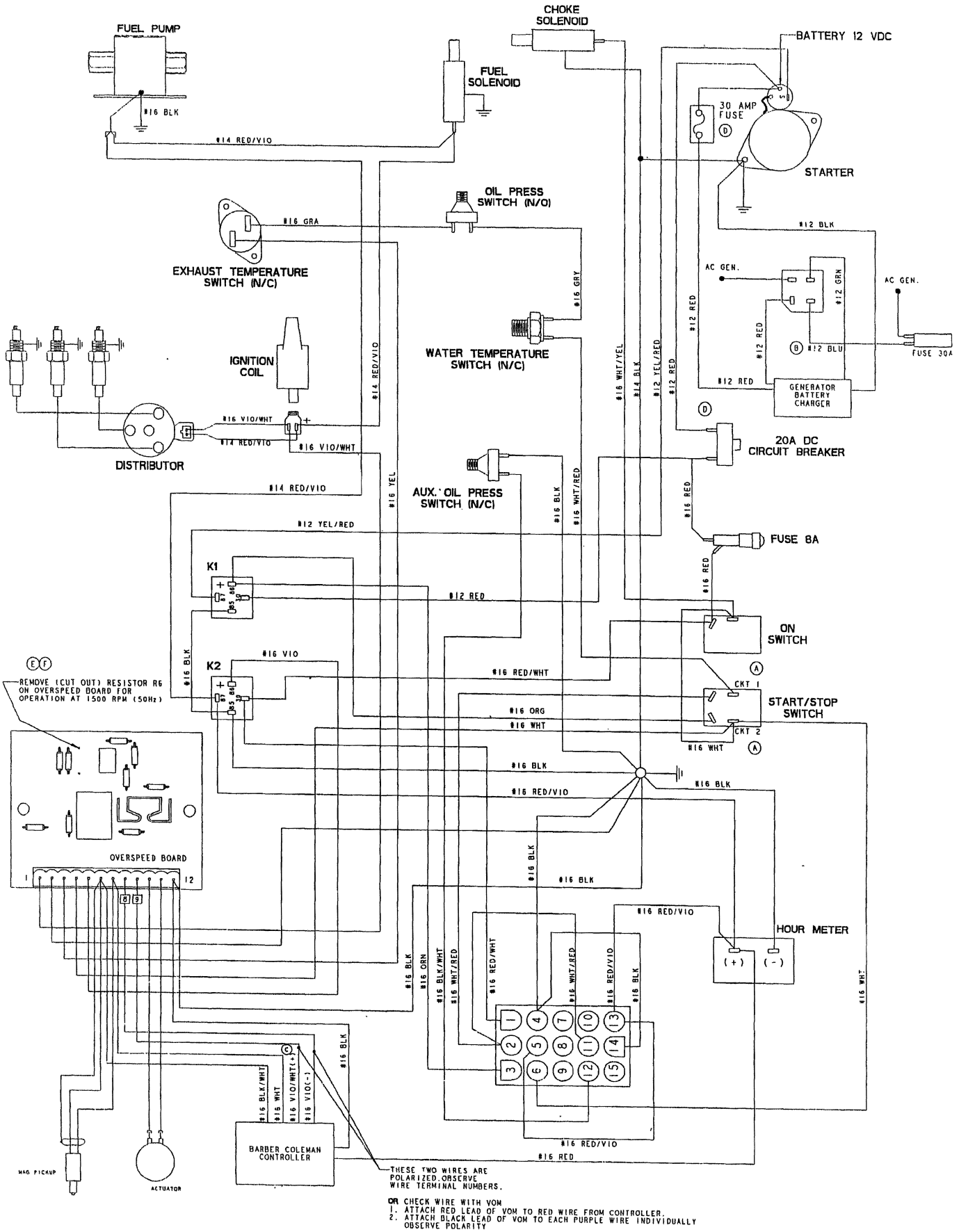
25MFD	Pn#046875
35MFD	Pn#049627
55MFD	Pn#048816
60MFD	Pn#048018

BC GENERATOR COMPONENTS

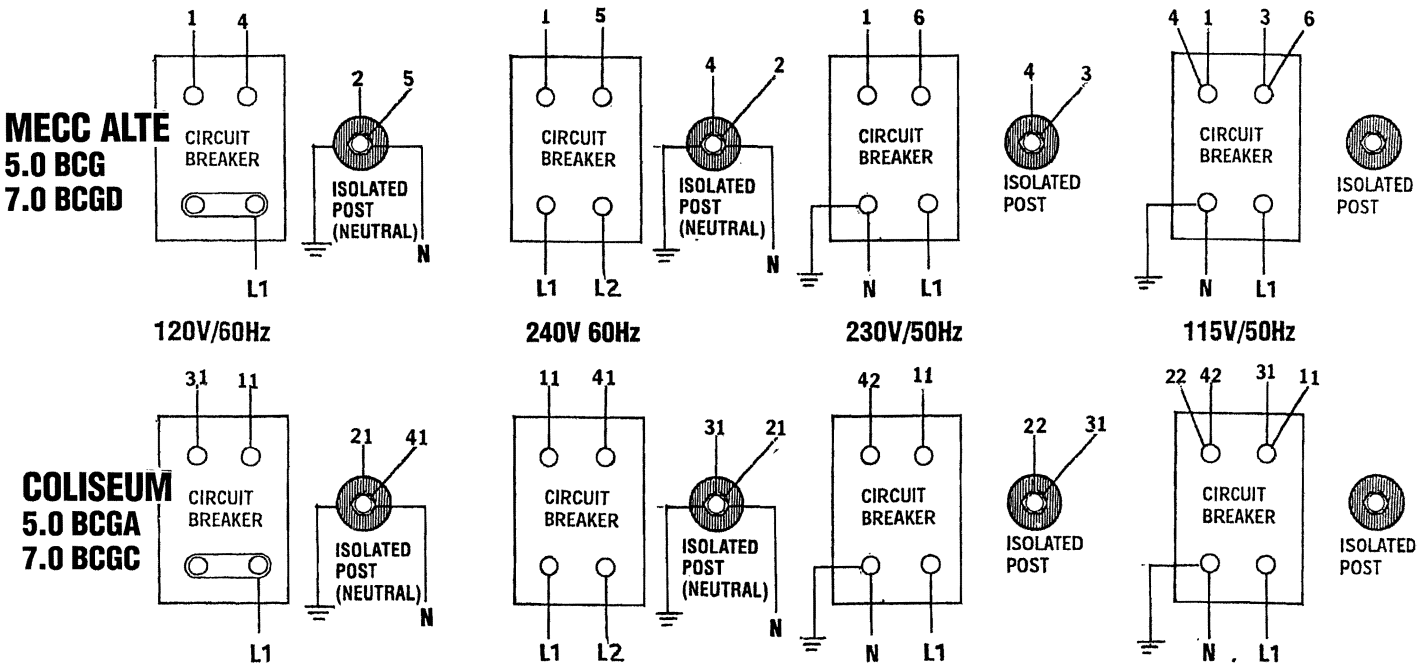


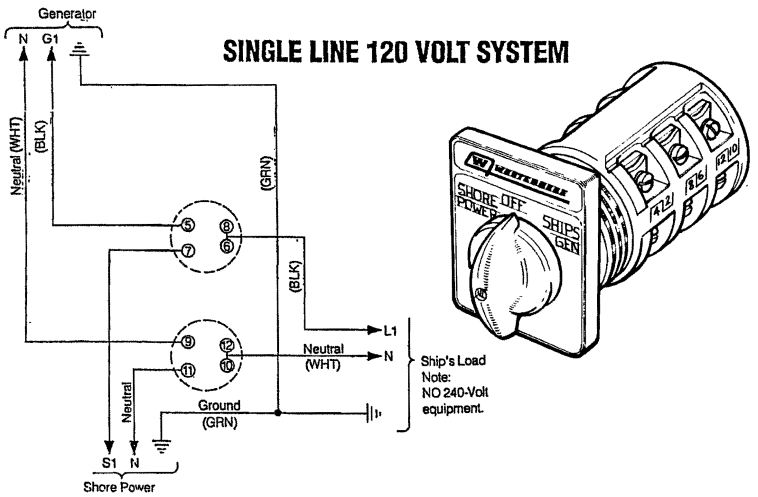


GENERATOR WIRING DIAGRAM #46876

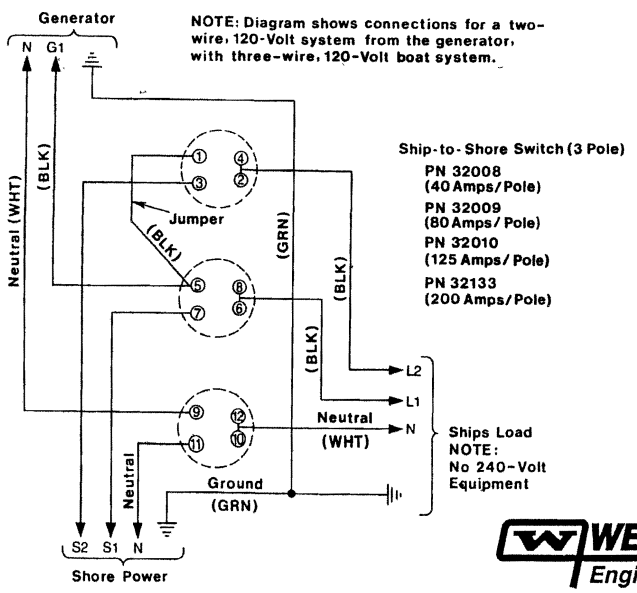


AC TERMINAL BOARD CONNECTIONS





120 VOLT/60 HERTZ TWO WIRE CONFIGURATION

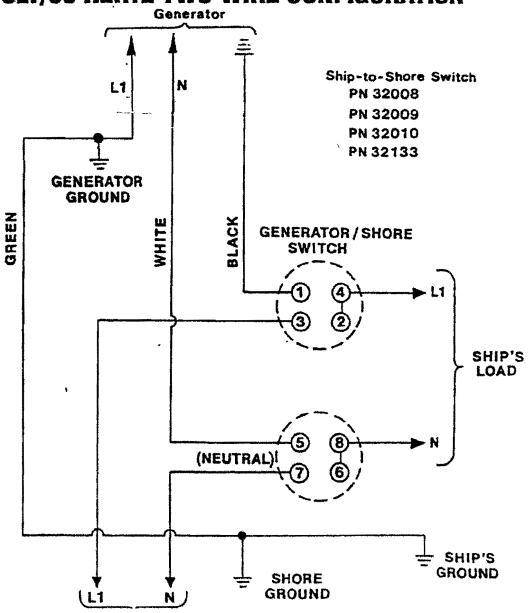


SHORE POWER TRANSFER SWITCH

If the installer connects shore power to the vessel's AC circuit, this must be done by means of the Shore Power Transfer Switch. Set the transfer switch shown in the diagrams to the OFF position. This switch prevents simultaneous connection of shore power to generator output.

⚠ CAUTION: ***Damage to the generator can result if utility shore power and generator output are connected at the same time. This type of generator damage is not covered under the warranty; it is the installer's responsibility to make sure all AC connections are correct.***

230 VOLT/50 HERTZ TWO WIRE CONFIGURATION



SPECIAL TOOLS - GENERATOR

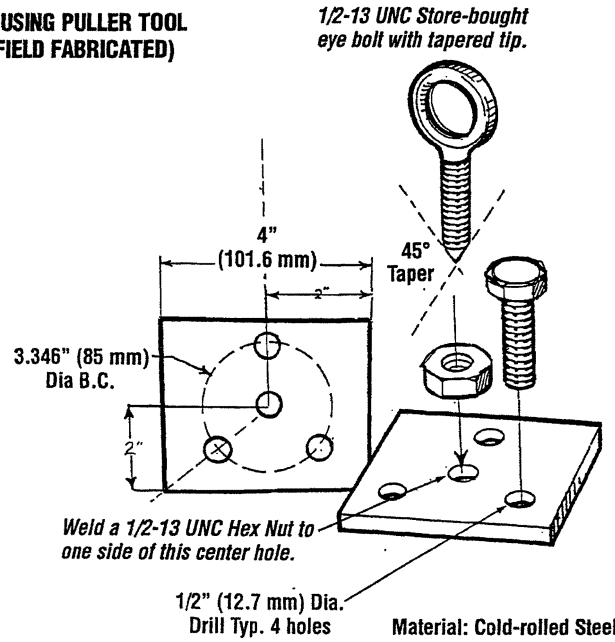
FIELD FABRICATED TOOLS

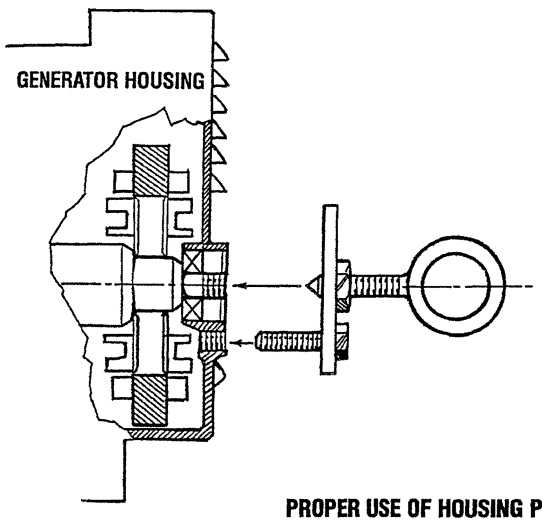
These drawings provide a means by which simple tools can be made to assist in the removal of the generator end from the engine and in the replacement of the generator end on the engine. A local machine shop should be able to fabricate these tools at a modest price, but first check with your local WESTERBEKE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

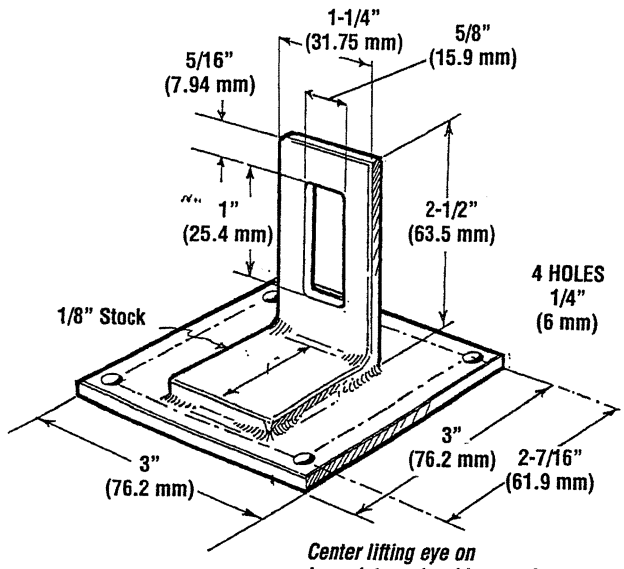




PROPER USE OF HOUSING PULLER

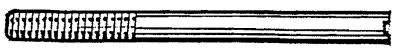
Lifting Eye Tool

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

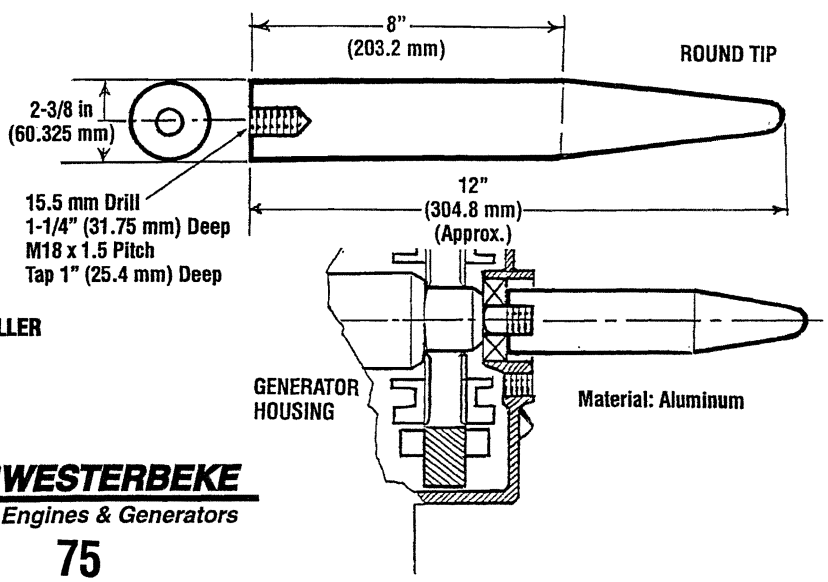
This tool allows a mechanic to safely remove and install the generator drive disks by aligning the disks with the Drive Plate Guide Pin. The Pin screws into the flywheel and acts as a guide. Also the pin helps to support some of the rotor and the drive plate's weight while removing or replacing these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



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

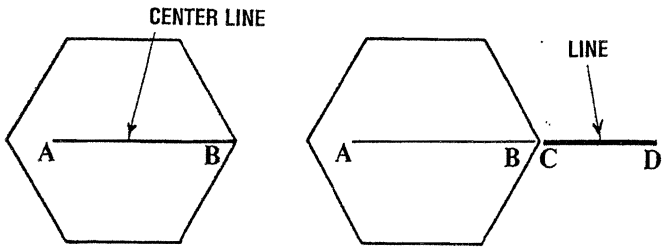
Pilot Tool

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.

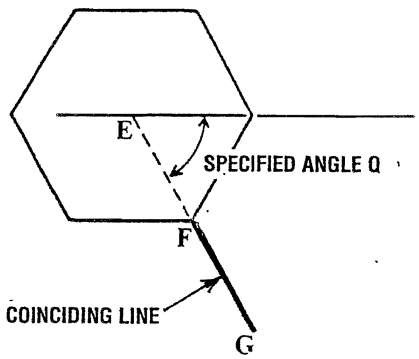


ANGULAR NUT AND BOLT TIGHTENING METHOD

1. Carefully wash the nuts and bolts to remove all oil and grease.
2. Apply a coat of molybdenum disulfide grease to the threads and setting faces of the nuts and bolts.
3. Tighten the nuts and bolts to the specified torque (snug torque) with a torque wrench.



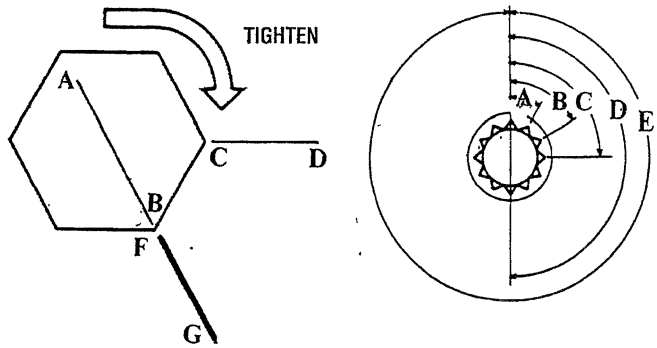
4. Draw a line (A-B) across the center of each bolt.
5. Draw another line (C-D) on the face of each of the parts to be clamped. This line should be an extension of the line (A-B).



6. Draw another line (F-G) on the face of each of the parts to be clamped. This line will be in the direction of the specified angle (Q) across the center (E) of the nut or bolt.
7. Use a socket wrench to tighten each nut or bolt to the point where the line (A-B) is aligned with the line (F-G).

Example: Specified Angle and Tightening Rotation

A	30°	1/12 of a turn
B	60°	1/6 of a turn
C	90°	1/4 of a turn
D	180°	1/2 of a turn
E	360°	One full turn

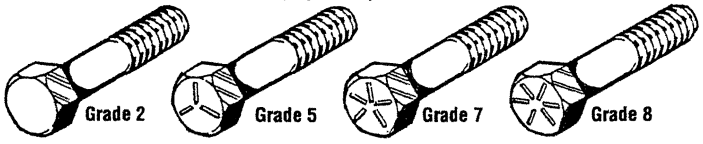


STANDARD HARDWARE

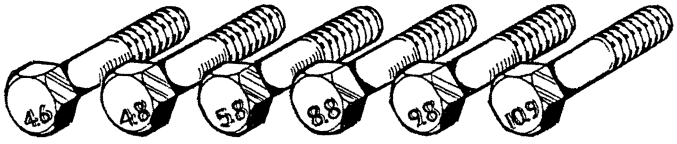
BOLT HEAD MARKINGS

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!**

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

DECIMAL TO METRIC EQUIVALENT CHART

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

ENGLISH TO METRIC CONVERSION CHART

Multiply Temperature	By	To get equivalent number of:
Degree Fahrenheit (°F)	(°F-32) ÷ 1.8	Degree Celsius °C)
Multiply Acceleration	**By**	**To get equivalent number of:**
Foot/second^2(ft/sec^2)	0.3048	Meter/second^2(m/s^2)
Inch/second^2(in./sec^2)	0.0254	Meter/second^2 (m/s^2)
Multiply Torque	**By**	**To get equivalent number of:**
Pound-inch (lb·in.)	0.11298	Newton-meters (N·m)
Pound-foot (lb·ft)	1.3558	Newton-meters (N·m)
Multiply Power	**By**	**To get equivalent number of:**
Horsepower (hp)	0.746	Kilowatts (kW)
Multiply Pressure or Stress	**By**	**To get equivalent number of:**
Inches of water (in. H_2O)	0.2491	Kilopascals (kPa)
Pounds/square in. (lb/in.^{2})	6.895	Kilopascals (kPa)
Multiply Energy or Work	**By**	**To get equivalent number of:**
British Thermal Unit (Btu)	1055	Joules (J)
Foot-pound (ft·lb)	1.3558	Joules (J)
kilowatt-hour (kW·hr)	3,600,000. or 3.6×10^6	Joules (J = one W/s)
Multiply Light	**By**	**To get equivalent number of:**
Foot candle (fc)	1.0764	Lumens/meter^2(lm/m^2)
Multiply Fuel Performance	**By**	**To get equivalent number of:**
Miles/gal (mile/gal)	0.4251	Kilometers/liter (km/L)
Gallons/mile (gal/mile)	2.3527	Liter/kilometer (L/km)
Multiply Velocity	**By**	**To get equivalent number of:**
Miles/hour (mile/hr)	1.6093	Kilometers/hour (km/hr)

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

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