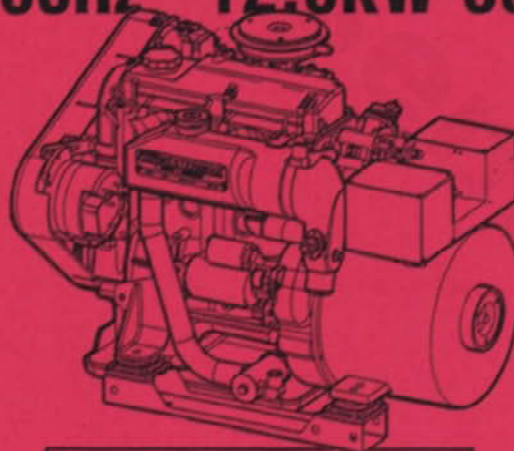




# **SERVICE MANUAL**

## **MARINE GASOLINE GENERATORS**

**8.0KW-60Hz      6.4KW-50Hz BEG**  
**10.0KW-60Hz    8.0KW-50Hz BEG**  
**12.5KW-60Hz    10.0KW-50Hz BEG**  
**15.0KW-60Hz    12.5KW-50Hz BEG**



**PUBLICATION NO.44240**  
**FIRST EDITION**  
**SEPTEMBER 2003**



**CALIFORNIA PROPOSITION 65  
WARNING**

Exhaust gas from diesel and gasoline engines (and some of its constituents) are known to the State of California to cause cancer, birth defects, and other reproductive harm.

**⚠ 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.**



## INTRODUCTION

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

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

## PREVENT ELECTRIC SHOCK

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

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

## PREVENT BURNS — HOT ENGINE

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

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

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

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

## PREVENT BURNS — FIRE

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

- Prevent flash fires. Do not smoke or permit flames or sparks to occur near the carburetor, fuel line, filter, fuel pump, or other potential sources of spilled fuel or fuel vapors. Use a suitable container to catch all fuel when removing the fuel line, carburetor, or fuel filters.
- Do not operate with a Coast Guard Approved flame arrester removed. Backfire can cause severe injury or death.
- Do not operate with the air cleaner/silencer removed. Backfire can cause severe injury or death.
- Do not smoke or permit flames or sparks to occur near the fuel system. Keep the compartment and the engine/generator clean and free of debris to minimize the chances of fire. Wipe up all spilled fuel and engine oil.
- Be aware — diesel fuel will burn.

## PREVENT BURNS — EXPLOSION

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

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



# SAFETY INSTRUCTIONS

## ACCIDENTAL STARTING

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

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

## BATTERY EXPLOSION

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

- Do not smoke or allow an open flame near the battery being serviced. Lead acid batteries emit hydrogen, a highly explosive gas, which can be ignited by electrical arcing or by lit tobacco products. Shut off all electrical equipment in the vicinity to prevent electrical arcing during servicing.
- Never connect the negative (-) battery cable to the positive (+) connection terminal of the starter solenoid. Do not test the battery condition by shorting the terminals together. Sparks could ignite battery gases or fuel vapors. Ventilate any compartment containing batteries to prevent accumulation of explosive gases. To avoid sparks, do not disturb the battery charger connections while the battery is being charged.
- Avoid contacting the terminals with tools, etc., to prevent burns or sparks that could cause an explosion. Remove wristwatch, rings, and any other jewelry before handling the battery.
- Always turn the battery charger off before disconnecting the battery connections. Remove the negative lead first and reconnect it last when servicing 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 manifold/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.
- Don't run the generator set or engine unless the boat is equipped with a functioning marine carbon monoxide detector that complies with ABYCA-24. Consult your boat builder or dealer for installation of approved detectors.
- For additional information refer to ABYC T-22 (educational information on Carbon Monoxide).

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

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

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

## AVOID MOVING PARTS

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

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



## SAFETY INSTRUCTIONS

- Do not wear loose clothing or jewelry when servicing equipment; 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/generator 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 a generator without its muffler installed.
- Do not run an engine with the air intake (silencer) removed.
- Do not run engines or generators 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 a gasoline engine or generator should begin with a thorough examination of the American Boat and Yacht Council's (ABYC) standards. These standards are from a combination of sources including the USCG and the NFPA.

Sections of the ABYC standards of particular interest are:

- H-2 Ventilation
- H-24 Gasoline fuel systems
- 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 GASOLINE AND DIESEL ENGINES AND GENERATORS

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

**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  
1 Batterymarch Park  
P.O. Box 9101  
Quincy, MA 02269-9101

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

Order From:  
U.S. Government Printing Office  
Washington, D.C. 20404



[www.torresen.com](http://www.torresen.com)

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GENERAL									
Engine Type	Gasoline, four-cycle, four-cylinder, fresh water-cooled, vertical in-line overhead mechanism.								
Governor	Hoof, flybal type, 5% speed reduction.								
Combustion Chamber	Semi-spherical type.								
Bore & Stroke	2.97 x 3.23 cu.in. (75.5 x 82.0mm)								
Piston Displacement	89.6 cubic inches (1468 cubic centimeters).								
Firing Order	1 - 3 - 4 - 2								
Direction of Rotation	Clockwise, when viewed from the front.								
Compression Ratio	9:0:1								
Weight	<table border="0"> <tr> <td><b>8.0Kw</b></td> <td>440 Lbs (199 Kg)</td> </tr> <tr> <td><b>10.0Kw</b></td> <td>466 Lbs (211 Kg)</td> </tr> <tr> <td><b>12.5Kw</b></td> <td>497 Lbs (497 Kg)</td> </tr> <tr> <td><b>15.0 Kw</b></td> <td>525 Lbs (238 Kg)</td> </tr> </table>	<b>8.0Kw</b>	440 Lbs (199 Kg)	<b>10.0Kw</b>	466 Lbs (211 Kg)	<b>12.5Kw</b>	497 Lbs (497 Kg)	<b>15.0 Kw</b>	525 Lbs (238 Kg)
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TUNE-UP SPECIFICATIONS	
Compression Pressure (limit of difference between cylinders)	165psi at 300 rpm 14psi
Valve Seat Angle	Intake 45° Exhaust 45°
Valve Clearance (engine hot)	Intake 0.08 inches (0.20 mm) Exhaust 0.09 inches (0.25 mm)
Engine Timing	20° BTDC at 1800 rpm ± .5°

EXHAUST EMISSIONS SYSTEMS	
Emission Control System	Meets U.S.C.G. Regulation 33 CFR 183

LUBRICATION SYSTEM	
General	Forced lubrication by geared pump.
Oil Filter	Full flow, spin-on replaceable type.
Sump Capacity (not including filter)	3.5 U.S. qts (3.3 liters) plus filter
Operating Oil Pressure (engine hot)	50 - 60 psi
Oil Grade	API Specification of SJ class.

ELECTRICAL SYSTEM	
Start Motor	12 Volt, reduction gear/solenoid.
Starting Battery	12 Volt, (-) negative ground
CCA	300-600 Amps
Battery Capacity	150 Cold Cranking Amps (CCA).

IGNITION SYSTEM	
General	Battery ignition 12V negative ground. Distributor with ignition module and igniter. Ignition coil and spark plugs.
Distributor	Equipped with auto timing controller, ignition coil built-in breakerless type.
Spark Plug Thread Size	14mm X 1.25 pitch

IGNITION SYSTEM (CONT.)	
Carburetor (STD Type)	Down draft type, single barrel. U.S.C.G. approved flame arrester.
Spark Plug Gap	.030 inches (0.8 mm)

FUEL SYSTEM									
General	Conventional carburetor type with electric fuel pump.								
Fuel	Regular or unleaded gasoline with an octane rating of 89 or better.								
Fuel Lift Pump	Electric-lift capability of 6 ft. (18mm)								
Fuel Consumption (approximate)	<table border="0"> <tr> <td><b>8.0Kw</b></td> <td>1.1 gph</td> </tr> <tr> <td><b>10.0Kw</b></td> <td>1.25 gph</td> </tr> <tr> <td><b>12.5Kw</b></td> <td>1.45 gph</td> </tr> <tr> <td><b>15.0 Kw</b></td> <td>1.7 gph</td> </tr> </table>	<b>8.0Kw</b>	1.1 gph	<b>10.0Kw</b>	1.25 gph	<b>12.5Kw</b>	1.45 gph	<b>15.0 Kw</b>	1.7 gph
<b>8.0Kw</b>	1.1 gph								
<b>10.0Kw</b>	1.25 gph								
<b>12.5Kw</b>	1.45 gph								
<b>15.0 Kw</b>	1.7 gph								
Fuel Filter (on engine)	Replaceable cartridge-screw on.								
Air cleaner (flame arrester)	Metal screen type - cleanable.								
Air Flow (engine combustion)	46.6 cfm (1.3 cmm).								

COOLING SYSTEM	
General	Fresh water-cooled block, thermostatically-controlled with heat exchanger.
Operating Temperature	140 - 160° F (61 - 71° C)
Fresh Water Pump	Centrifugal type, metal impeller, belt-driven.
Raw Water Pump	Positive displacement, rubber impeller, belt-driven.
Raw Water Flow at 1800 rpm.	5.5 gpm (5.20 lpm).
System Capacity (coolant)	5.5 US qts (5.20 liters)

AC GENERATOR (SINGLE PHASE)	
Single Phase	Brushless six-pole, revolving field. Sealed lubricated single-bearing design. Reconnectable, single-phase transformer with solid-state voltage regulation.
Voltage	120 or 120/240 Volts - 60 Hertz 230 Volts - 50 Hertz.
Voltage regulation:	±5% no load to full load.
Frequency regulation:	3 Hertz (5%) no load to full load.
Rating (Volts AC)	
<b>8.0Kw</b>	120/240 volts - 66/33
<b>10.0Kw</b>	120/240 volts) - 83/41
<b>12.5Kw</b>	120/240 volts - 104/52
<b>15.0 Kw</b>	120/240 volts - 125/62
Generator Cooling Air Requirements (60 Hertz at 1800 rpm)	200- 225 cfm (5.6 - 8.4 cmm) <b>NOTE: Increase air supply 15% for 50 Hertz operation (1500 rpm).</b>
Engine Combustion Air Requirements (60 Hertz at 1800 rpm)	46.6 cfm (1.3 cmm)
Generator Compartment Cooling Requirements	100-200 cfm (2.83-5.66 cmm).





## 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 worn plugs or fuel/carburetor problems. 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 carburetor performance or worn plugs. They are caused also by defective electrical devices such as the battery, alternator or starter. 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.

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

The engine requires overhaul when oil consumption is high, blow-by evident, and compression valves are at minimum or below.

**NOTE:** Make certain the engines valve clearances are properly adjusted. An incorrect valve clearance can cause symptoms that might, incorrectly, suggest an engine overhaul (cylinder misfire, white smoke, noise, etc).

Before preparing for an engine overhaul, adjust the valve clearances to the correct specification, install a new cover gasket and test the engine.

## DISASSEMBLY

**NOTE:** Before disassembly and cleaning, carefully check for defects which cannot be found after disassembly and cleaning.

- All disassembled parts should be carefully arranged in the order of reassembly. Mark or label the parts as needed to insure proper mating and reassembly in the proper directions and positions.
- If the disassembly procedure is complex requiring many parts to be disassembled, the parts should be disassembled in a way that will allow them to be efficiently reassembled without any change in the engine's external appearance or its performance.
- Do not remove or disassemble parts that require no disassembly.
- Carefully inspect each parts after removal for damage, deformation, and other problems.
- Carefully check gaskets, packings and oil seals, even if checking is not specified. Replace with new ones if defective.
- Be careful not to damage the disassembled parts. Keep the parts clean.
- Use the proper tools. Apply oil when necessary. Take special care to keep the fuel system parts free from the intrusion of dust and dirt.

# TROUBLESHOOTING GUIDE

The following engine troubleshooting guide may be helpful in determining if a complete or partial overhaul is necessary.

<p><b>Insufficient Power</b></p>	<p><b>Insufficient Compression</b>                      Compression leakage from valve seat                      Seized valve stem                      Weak or broken valve spring                      Burned cylinder head gasket                      Cracked or distorted cylinder head                      Sticking, damaged, or worn piston ring                      Cracked or worn piston</p> <p><b>Malfunction of Fuel System</b></p> <p><b>Malfunction of Ignition System</b></p>	<p><b>Engine Noise</b></p>	<p><b>Crankshaft or bearing related parts</b>                      Excessive main bearing oil clearance                      Main bearing seized or heat damaged                      Excessive crankshaft end play                      Excessive connecting rod bearing oil clearance                      Connecting rod bearing seized or heat damaged</p> <p><b>Piston related parts</b>                      Worn Cylinder                      Worn piston or piston pin                      Seized piston                      Damaged piston ring                      Bent Connecting Rod</p> <p><b>Malfunction of Ignition System</b></p> <p><b>Valve or timing related parts</b>                      Malfunction of HLA *                      Broken valve spring                      Excessive clearance between valve stem and guide                      Insufficient lubrication of rocker arm</p> <p><b>Others</b>                      Malfunction of water pump bearing                      Malfunction of alternator bearing                      Malfunction of timing belt tensioner</p>
<p><b>Excessive Oil Consumption</b></p>	<p><b>Oil Working Up</b>                      Worn or sticking piston ring or piston ring groove                      Worn piston or cylinder</p> <p><b>Oil Working Down</b>                      Bad valve seal                      Worn valve stem or guide</p> <p><b>Oil Leakage</b></p>	<p><b>Engine Misfires</b></p>	<p>Poor quality fuel.                      Incorrect timing.                      Dirty flame arrester.                      Cracked distributor cap.                      Faulty ignition wires.                      Spark plugs are worn.                      High exhaust back-pressure.                      Valve clearances are incorrect.</p>
<p><b>Difficult Starting</b></p>	<p><b>Malfunction of Engine-related Components</b>                      Burned valve                      Worn piston, piston ring, or cylinder                      Burned cylinder head gasket</p> <p><b>Malfunction of Fuel System</b></p> <p><b>Malfunction of Electrical System</b></p>	<p><b>Engine Backfires</b></p>	<p>Spark plug wires are connected wrong.                      Incorrect timing.                      Engine is flooded.                      Dirty flame arrester.                      Cracked distributor cap.                      High exhaust back-pressure.                      Choke is stuck closed.</p>
<p><b>Abnormal Combustion</b></p>	<p><b>Malfunction of Engine-related Components</b>                      Sticking or burned valve                      Weak or broken valve spring                      Carbon accumulated in combustion chamber</p> <p><b>Malfunction of Fuel System</b></p> <p><b>Malfunction of Ignition System</b></p>		
<p><b>Poor Idling</b></p>	<p><b>Malfunction of Engine-related Components</b>                      Poor valve-to-valve seat contact                      Failure of cylinder head gasket</p> <p><b>Malfunction of Fuel System</b></p> <p><b>Malfunction of Ignition System</b></p>		

\* Tapet noise may occur if the engine is not operated for a period of time. Tapet noise should stop within 10 minutes after operating the engine.



## TROUBLESHOOTING GUIDE

<b>Engine Overheats</b>	Coolant loss. Pressure test cooling system. Faulty raw water pump impeller. Belts are loose or broken. Raw water pump worn. Faulty thermostat. Heat exchanger is clogged. Collapsed hose.
<b>Low Oil Pressure</b>	Low oil level. Faulty oil pressure sender Wrong SAE type oil in the engine. Faulty gauge Wrong type oil filter. Relief valve is stuck. Faulty oil pump. Faulty engine bearings.
<b>Starting Battery</b>	Loose alternator drive belt Faulty battery voltage regulator. Connections to the alternator are loose or faulty. Faulty alternator. No excitation to the regulator
<b>High Oil Pressure</b>	Faulty sender or gauge Dirty oil or wrong SAE type oil in the engine. Relief valve is stuck.
<b>Blue Exhaust Smoke Discharge from the Engine</b>	Lube oil is diluted. High lube oil level. Crankcase breather hose is clogged. Valves are worn or adjusted incorrectly. Piston rings are worn or unseated.
<b>Black exhaust smoke Discharge from the Engine</b>	Dirty flame arrester. Faulty carburetor. Idle mixture jet too rich. Accelerator diaphragm leaking. Valves are worn or incorrectly adjusted. Lube oil is diluted. Piston rings are worn or unseated.

**NOTE:** *The engines control system (electrical system) is protected by a 20 Ampere manual reset circuit breaker located just outboard of the starter motor.*



# SAFETY SHUTDOWN SWITCHES

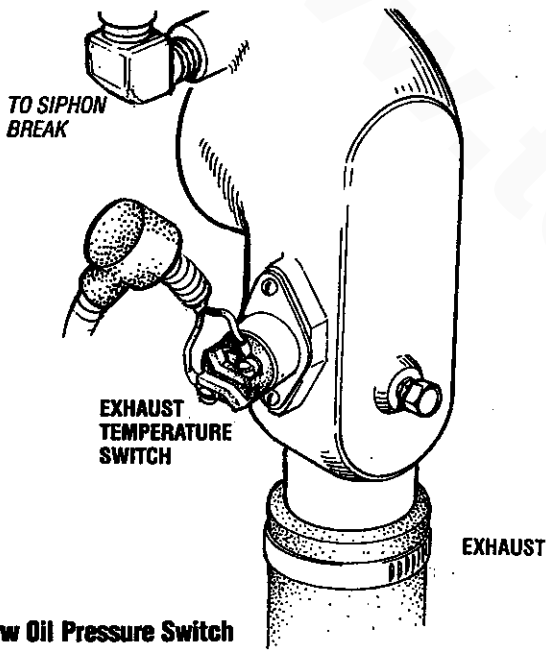
## SAFETY SHUTDOWN SWITCHES

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

The following is a description of these automatic shutdown switches:

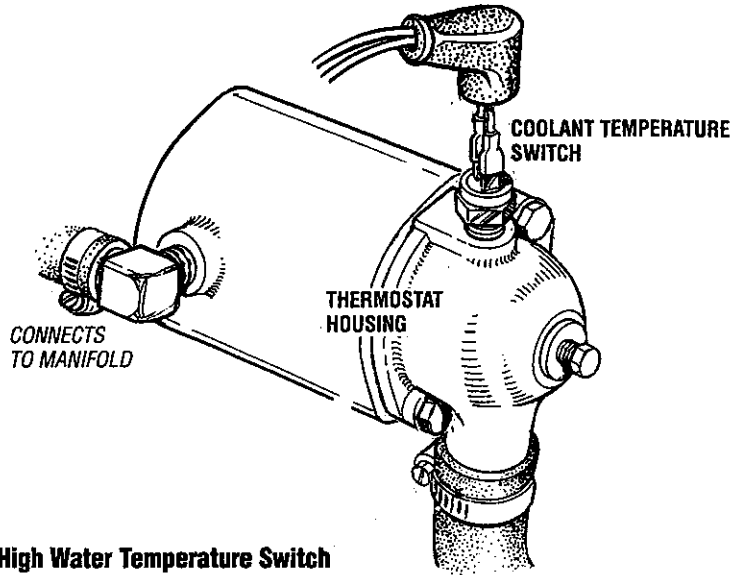
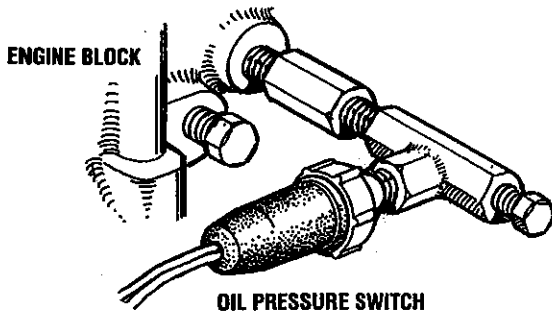
### High Exhaust Temperature Switch

An exhaust temperature switch is located on the exhaust elbow. Normally closed, this switch will open and interrupt the DC voltage (shutting off the engine) should the switch's sensor indicate an excessive exhaust temperature (an inadequate supply of raw water causes high exhaust temperatures). This switch opens at 260-270°F (127-132°C). This switch resets at approximately 225°F (107°C).



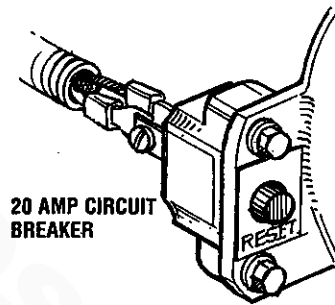
### Low Oil Pressure Switch

A low oil pressure shutdown switch is located off the engine's oil gallery. Normally open in a static state, this switch's sensor monitors the engine's oil pressure. Should the engine's oil pressure fall to 5-10 psi, this switch will open interrupting the DC voltage thereby shutting off the engine.



### High Water Temperature Switch

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



### Engine Circuit Breaker

The generator's engine is protected by an engine mounted manual reset circuit breaker (20 amps DC). Excessive current draw or electrical overload anywhere in the instrument panel wiring or engine wiring will cause the breaker to trip. In this event the generator will shut down because the opened breaker interrupts the DC circuit. If this should occur, check and repair the source of the problem. After repairing the fault, reset the breaker and restart the generator.

## HIGH RPM SHUTDOWN SWITCH

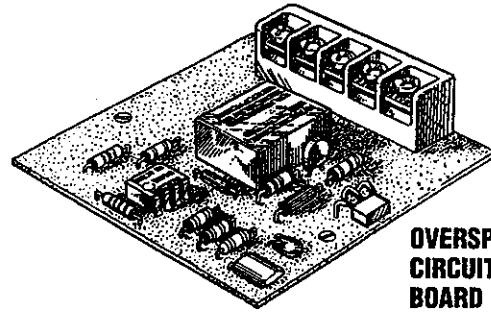
### DESCRIPTION

An overspeed switch in the DC circuit shuts off the generator's engine by grounding out the ignition system if the engine's speed reaches 2175 rpm (approximately). After correcting the problem, this switch can be reset by momentarily depressing the stop switch. Refer to the *WIRING DIAGRAMS* in this manual.

If the overspeed switch is faulty, (resetting with the stop switch fails to reset the circuit), lift the white/yellow wire off the T5 terminal and connect it with the red/purple wire on the T4 terminal. Now restart the generator.

If this bypass is successful, replace the faulty overspeed switch.

**NOTE:** *Overspeed switches draw a small amount of amperage (25 milliamps) at all times once the generator is connected to its starting battery. This amounts to approximately 18 amp-hours in a month. It is not necessary to be concerned with this slight amperage draw during normal seasonal operation. However, if the generator set is to be unused for many months, it is best to either remove the 8 amp ignition fuse from the control panel on the generator or turn off the generator's starting battery switch.*



**OVERSPEED  
CIRCUIT  
BOARD**

**⚠ CAUTION:** *It is very important that the overspeed shutdown always be installed and functioning. Any tampering with the overspeed shutdown module, which would cause it to malfunction, could be a cause of injury should the generator's belt-driven governor fail and cause the generator to run away.*

# DISASSEMBLY AND ASSEMBLY PROCEDURES

## DISASSEMBLY

- Before disassembly and cleaning, carefully check for defects which cannot be found after disassembly and cleaning.
- Drain water, fuel and oil before disassembly.
- Clean or wash the engine exterior.
- Do not remove or disassemble parts.
- Perform disassembly in a proper order using proper tools. Keep disassembled parts in order. Apply oil when necessary. Take special care to keep the fuel system parts from intrusion of dust and dirt.
- Parts must be restored to their respective components from which they were removed at disassembly. This means that all parts must be set aside separately in groups, each marked for its component, so that the same combination or set can be reproduced at assembly.
- Pay attention to marks on assemblies, components and parts for their positions or directions. Put on marks, if necessary, to aid assembly.
- Carefully check each part or component for any sign of faulty condition during removal or cleaning. The part will tell you how it acted or what was abnormal about it more accurately during removal or cleaning.

## ASSEMBLY

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

## TORQUING DATA

Parts of the engine use plastic region tightening bolts. The tightening procedure for these is different from that of conventional bolts and is described in this manual. Note that plastic region tightening bolts have fixed service limits. These limits are indicated in this manual and must be strictly observed.

- Plastic region tightening bolts are used for the following applications:
  1. Cylinder head bolts
  2. Connecting rod cap bolts
- The tightening procedure is basically as follows: After tightening a bolt to the specified torque, tighten it by a further 90° + 90° or by a further 90-100°. The exact tightening procedure differs depending on the bolt and is described where it applies in this manual.

## GASKET INFORMATION

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

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

## Disassembly

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

## Surface Preparation

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

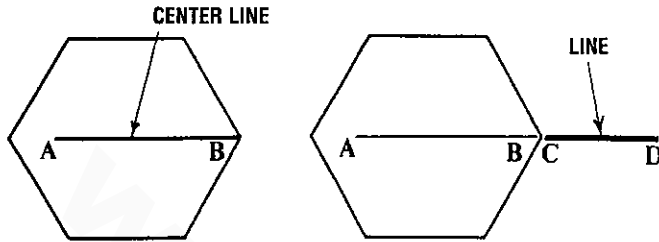
## Form-in-place Gasket Application

When assembling parts with the silicone gasket, you must observe some precautions but the procedures are very simple as in the case of a conventional precut gasket.

The applied gasket bead should be the specified size and without breaks. Be sure to encircle the bolt hole circumference with a completely continuous bead. The gasket material can be wiped away unless it has hardened. While the gasket is still moist, mount the parts in position. When the parts are mounted, make sure that the gasket is applied to the required area only. Do not apply oil or water to the sealing locations or start the engine until a sufficient amount of time has passed after installation is completed.

The gasket application procedure may vary on different areas. Observe the procedure described in the text when applying the gasket silicone and follow the directions on the applicator/tube.

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

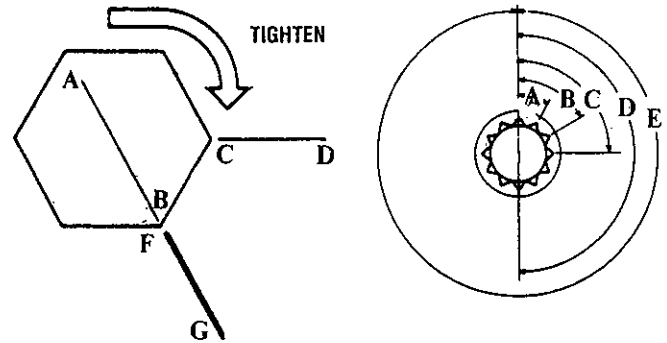
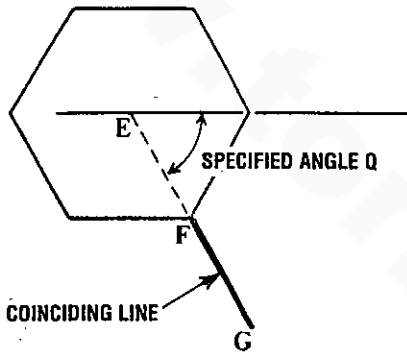


- Draw another line (F-G) on the face of each of the parts to be clamped. This line will be in the direction of the specified angle (Q) across the center (E) of the nut or bolt.
- Use a socket wrench to tighten each nut or bolt to the point where the line (A-B) is aligned with the line (F-G).

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

- Draw a line (A-B) across the center of each bolt.
- 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).



## NEW TIGHTENING METHOD USING PLASTIC REGION TIGHTENING BOLTS

Parts of the engine use plastic region tightening bolts. The tightening procedure for these is different from that of conventional bolts and is described in this manual.

**NOTE:** The plastic region tightening bolts have fixed service limits. These limits are indicated where they occur in this manual and must be strictly observed.

Plastic region tightening bolts are used for the following applications:

- Cylinder Head Bolts
- Connecting Rod Cap Bolts

The tightening procedure is as follows:

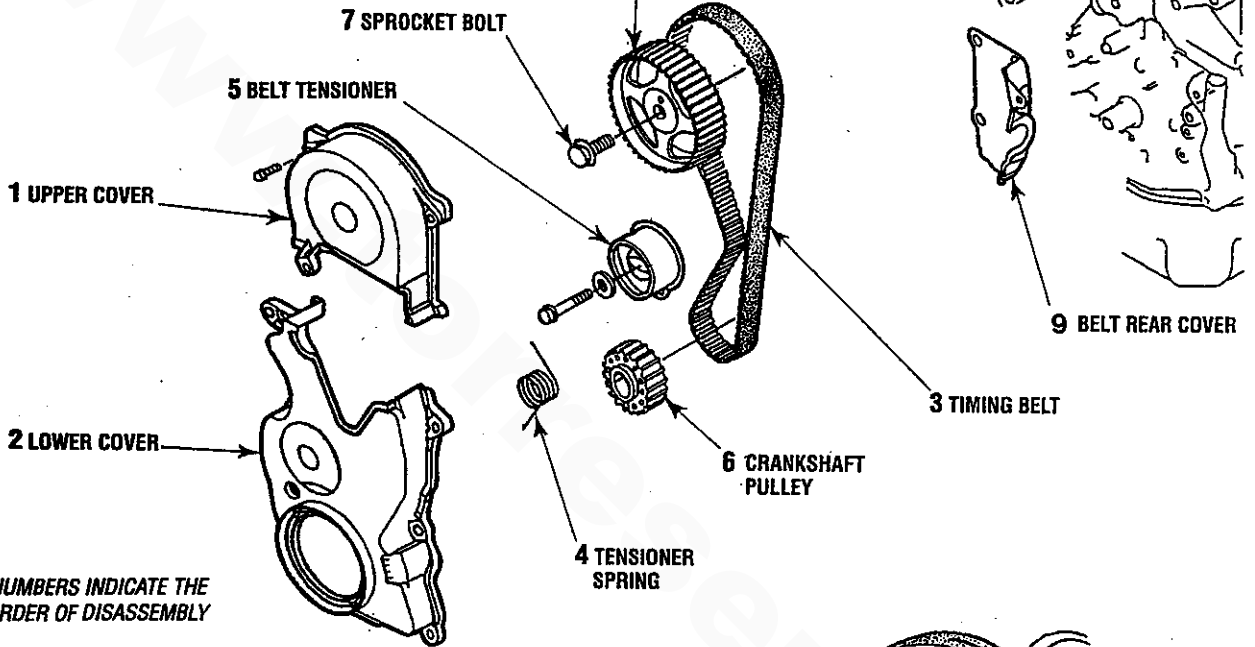
After tightening a bolt to the specified torque, tighten it by a further 90° + 90° or by a further 90° to 100°. The exact tightening procedure differs depending on the bolt and is described as it occurs in this manual.

# ENGINE-DISASSEMBLY, INSPECTION AND ASSEMBLY

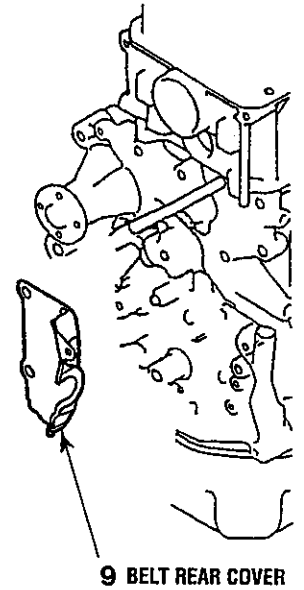
**NOTE:** In most cases the inspection and replacement of the timing belt can be performed with the engine/generator in the boat.

## TIMING BELT INSPECTION AND REPLACEMENT

**CAUTION:** Water or oil on the timing belt severely reduces the service life of the belt. Keep the timing belt sprocket and tensioner free of oil and grease. These parts should never be cleaned. Replace if seriously contaminated with dirt or oil. If oil is evident on these parts, check the front case, oil pump oil seals, and crankshaft oil seals for a possible leak.



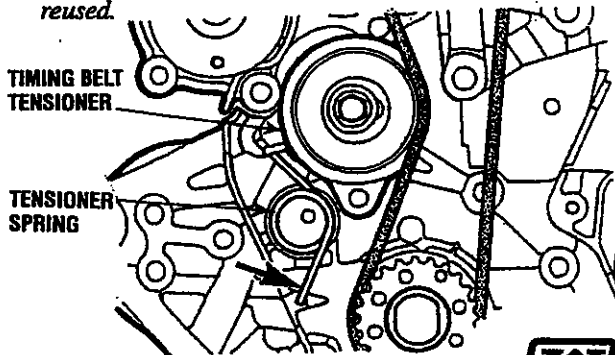
## TIMING BELT ASSEMBLY



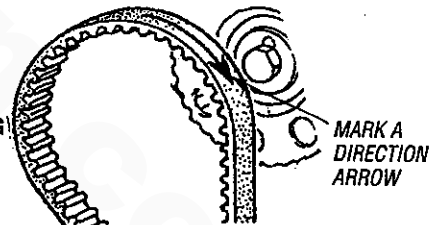
## TIMING BELT REMOVAL

Using pliers, grip the tensioner spring projection and remove it from the oil pump case stopper. Then, remove the tensioner spring and the timing belt tensioner.

**NOTE:** If the timing belt is to be reused, chalk an arrow on the belt to indicate the direction of rotation before removing it. This will ensure the timing belt is fitted correctly when reused.

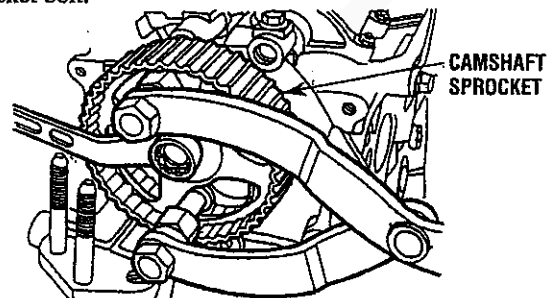


REMOVING THE TIMING BELT



## SPROCKET BOLT REMOVAL (CAMSHAFT)

Using the special tools shown in the illustration, lock the camshaft sprocket in position and then loosen the camshaft sprocket bolt.



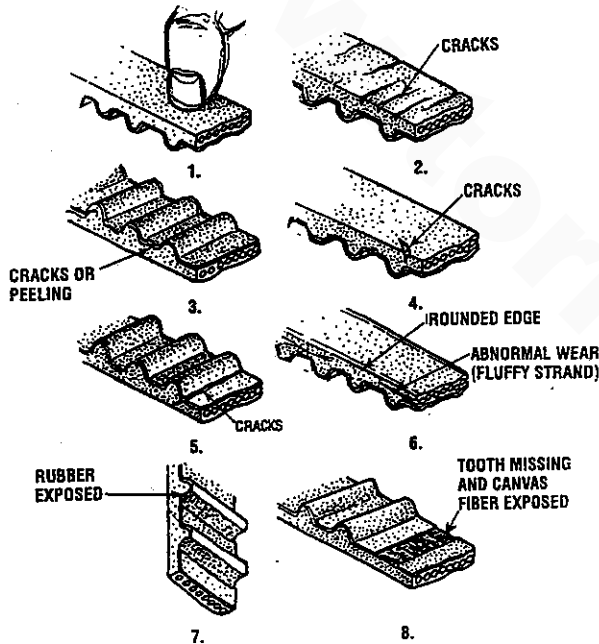


**NOTE:** In most cases the inspection and replacement of the timing belt can be performed with the engine/generator in the boat.

### Timing Belt Inspection

Replace the belt if any of the following conditions exist:

1. Hardening of back rubber-back side is glossy, without resilience, and leaves no indent when pressed with fingernail.
2. Cracks on rubber back.
3. Cracks or peeling of canvas.
4. Cracks on tooth bottom.
5. Cracks on belt.
6. Abnormal wear of belt sides. The sides are normal if they are sharp as if cut by a knife.
7. Abnormal wear on teeth.
8. Tooth missing and canvas fiber exposed.

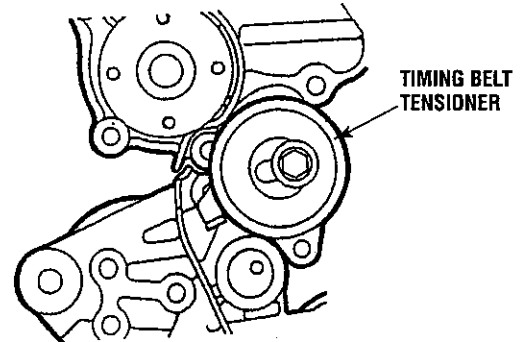


### Belt Tensioner Inspection

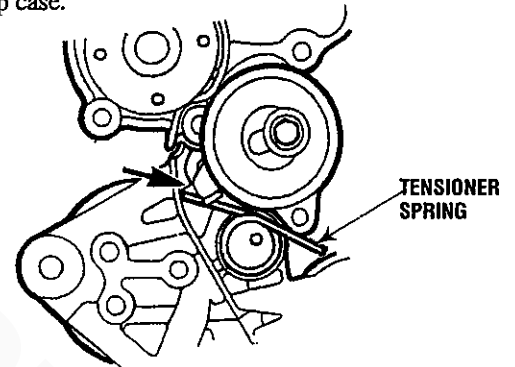
Replace the belt tensioner if it binds, rattles, or is noisy when turned.

### Tensioner Spring Installation

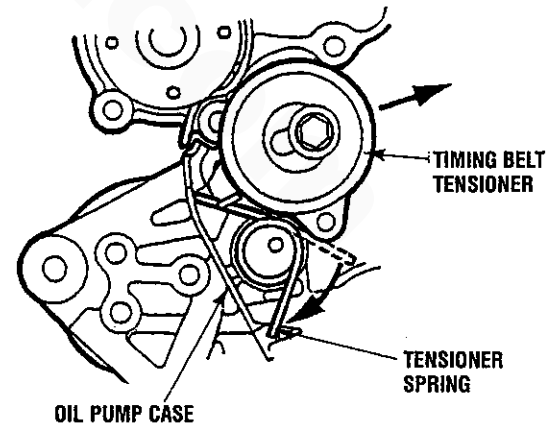
1. Lock the timing belt tensioner in the illustrated position.



2. Fit one of the tensioner spring projections over the hooked portion of the belt tensioner and fit the tensioner onto the oil pump case.

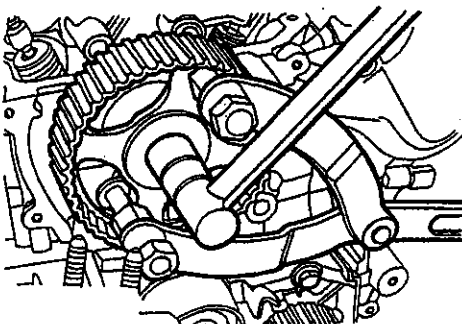


3. Grip the other tensioner spring projection and fit it onto the oil pump case lug as shown in the illustration. Move the timing belt tensioner in the direction shown and temporarily tighten the bolt.



### Sprocket Bolt Installation (Camshaft)

Using the special tools shown in the illustration, lock the camshaft sprocket in position and tighten the camshaft sprocket bolt to the specified torque.



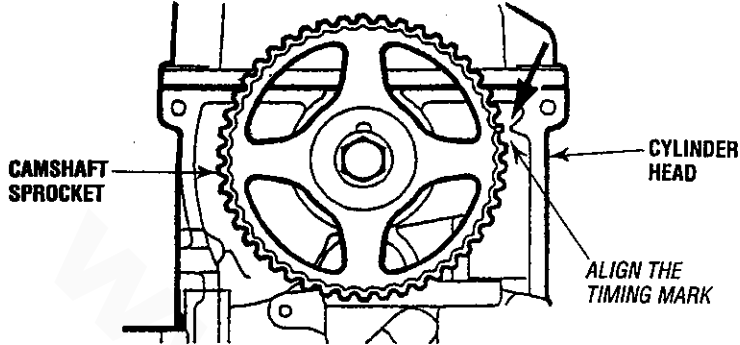
**LOCKING THE CAMSHAFT SPROCKET**  
 88Nm (64.9 ft-lb)



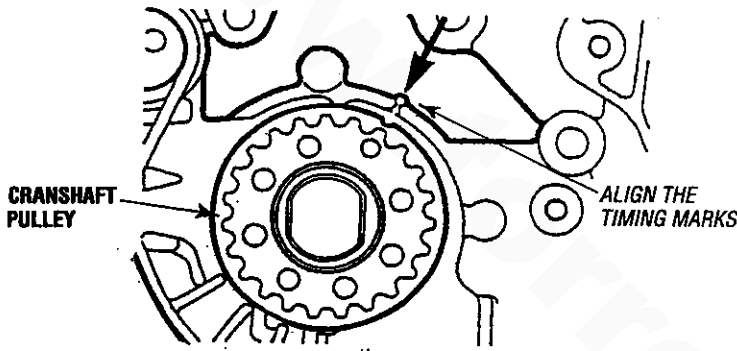
# ENGINE-DISASSEMBLY, INSPECTION AND ASSEMBLY

**NOTE:** In most cases the inspection and replacement of the timing belt can be performed with the engine/generator in the boat.

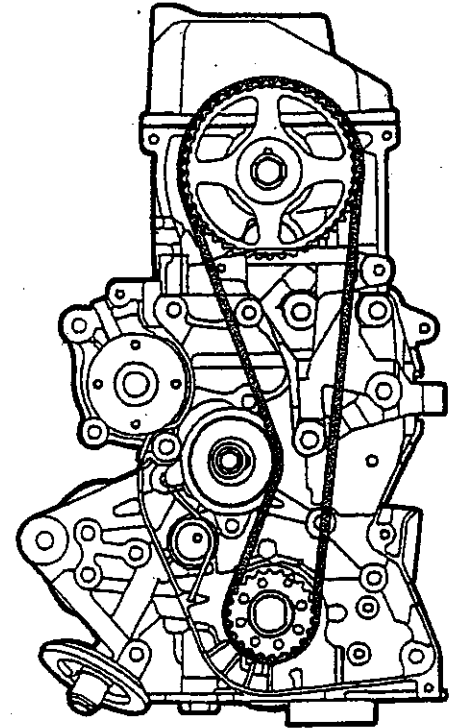
## Timing Belt Installation



1. Align the camshaft timing mark with the timing mark on the cylinder head.



2. Align the crankshaft timing mark with the timing mark on the front case.
3. Keeping the tension side of the timing belt tight, fit the timing belt onto the crankshaft sprocket, camshaft sprocket, and tensioner pulley in that order.
4. Loosen the tensioner pulley mounting bolts by 1/4 to 1/2 of a turn and allow the tensioner spring to apply tension to the timing belt.



5. Turn the crankshaft twice in the normal rotating direction (clockwise) and check that the timing marks are correctly aligned.

**CAUTION:** This procedure utilizes the camshaft's driving torque to apply tension evenly to the timing belt. Be sure to turn the crankshaft as described above. Do not turn the crankshaft in reverse.

6. Tighten the tensioner pulley mounting bolts.  
IDLER PULLEY BOLTS TORQUE 23 Nm (17 ft-lb)
7. Replace the timing belt covers.  
TIMING BELT COVER BOLTS TORQUE 11 Nm (8 ft-lb)



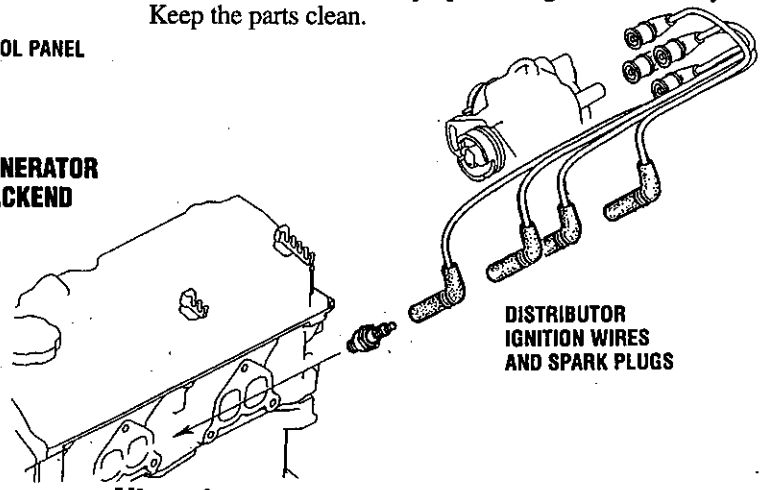
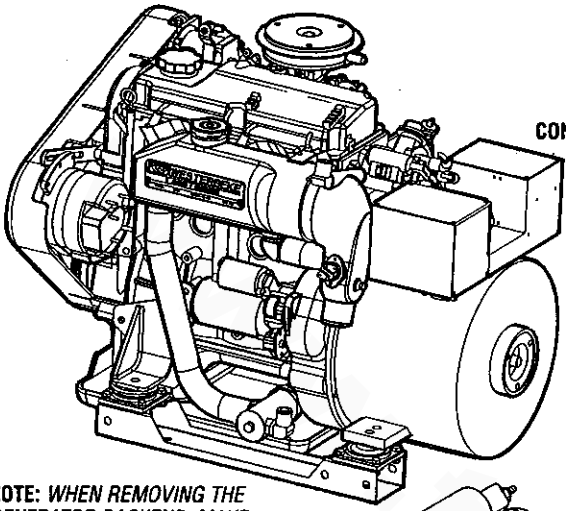
**DISASSEMBLY PROCEDURE**

Before mounting the engine on an engine stand, unbolt and remove the generator backend. Make sure the back end is properly supported. Refer to the generator section of this manual for additional information and an exploded view of the generator components. Also remove the engine flywheel before mounting the engine.

Mounting the engine on a suitable engine stand and begin removing the exterior engine components.

Note the following when disassemble these components.

- Drain any engine oil or coolant left in the engine.
- Clean the exterior of the engine of any deposits of dirt and oil.
- Be careful not to damage the disassembled parts.
- Arrange parts in the order of disassembly. Mark or label parts as needed to insure proper mating and reassembly. Keep the parts clean.



**NOTE: WHEN REMOVING THE GENERATOR BACKEND, MAKE CERTAIN IT IS PROPERLY SUPPORTED UNDERNEATH**

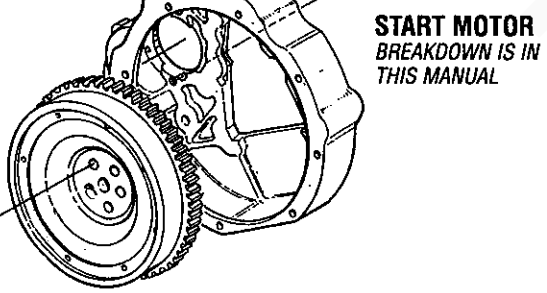
**Alternator**

When rebuilding the engine, the alternator should be cleaned and inspected. The housing can be wiped off with a solvent and the alternator terminal studs should be cleaned with a wire brush. Make certain the studs are tight and clean the wiring connections that connect to the wiring harness.

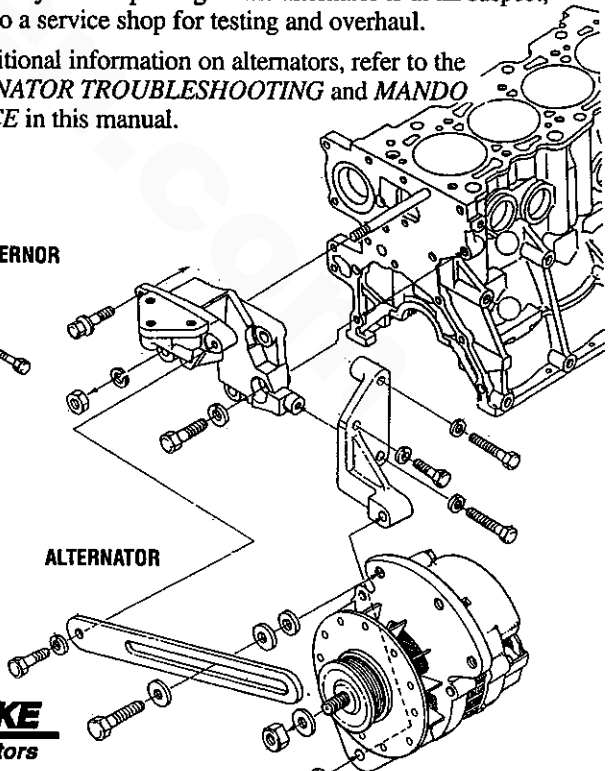
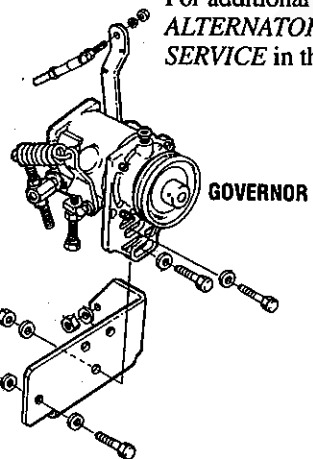
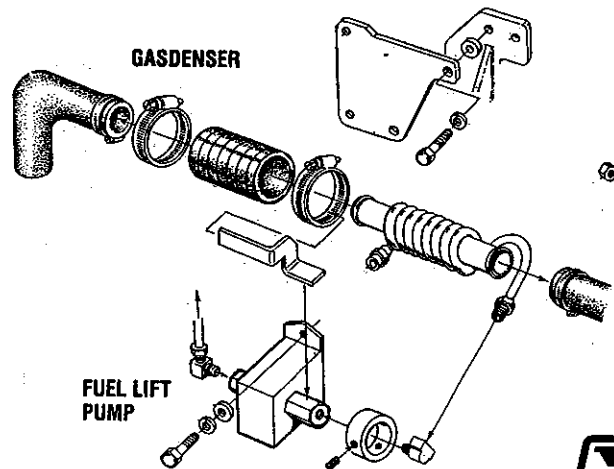
Turn the rotor pulley by hand. It should turn smoothly.

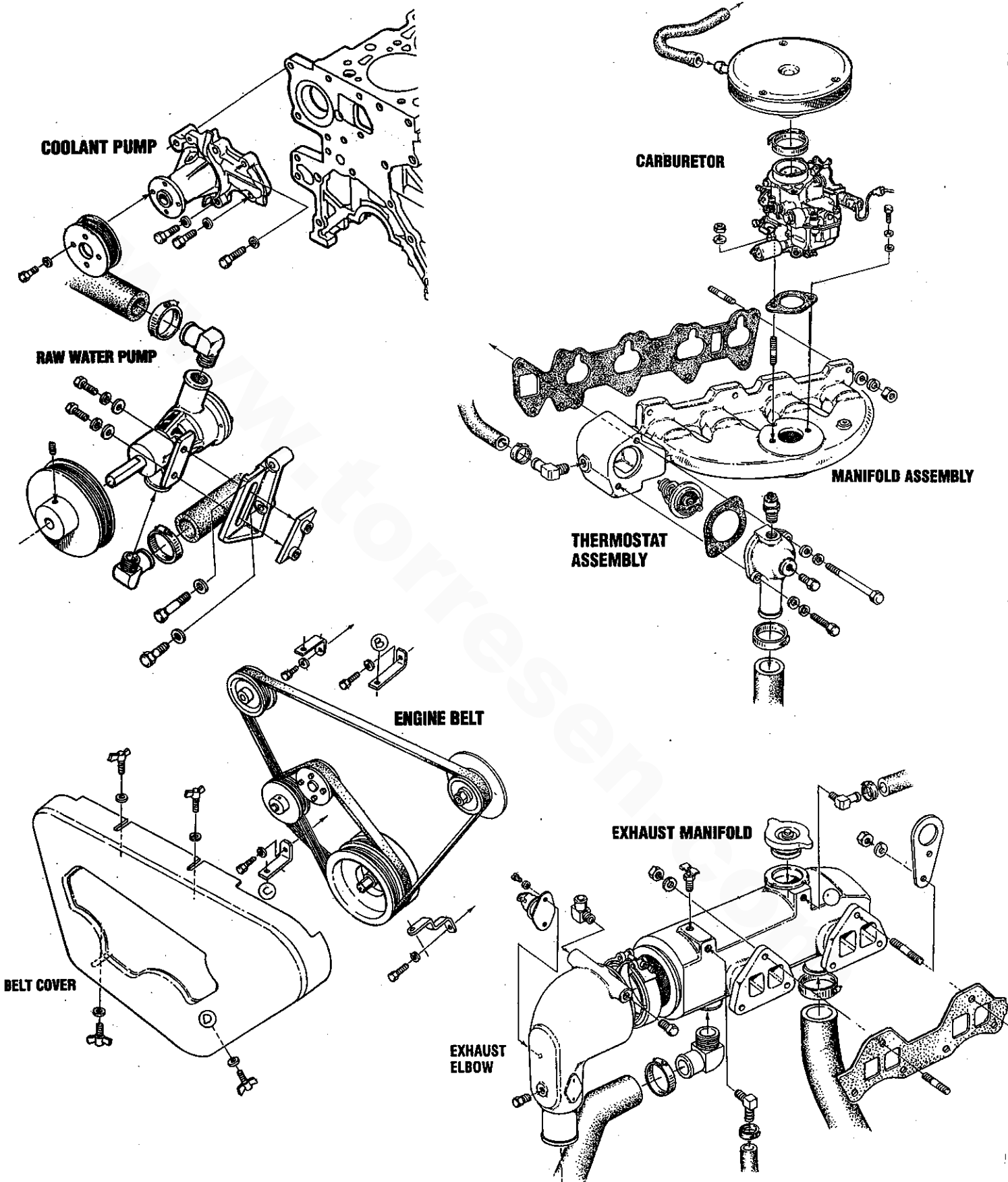
Depending on when the alternator was last serviced, the brushes may need replacing. If the alternator is at all suspect, send it to a service shop for testing and overhaul.

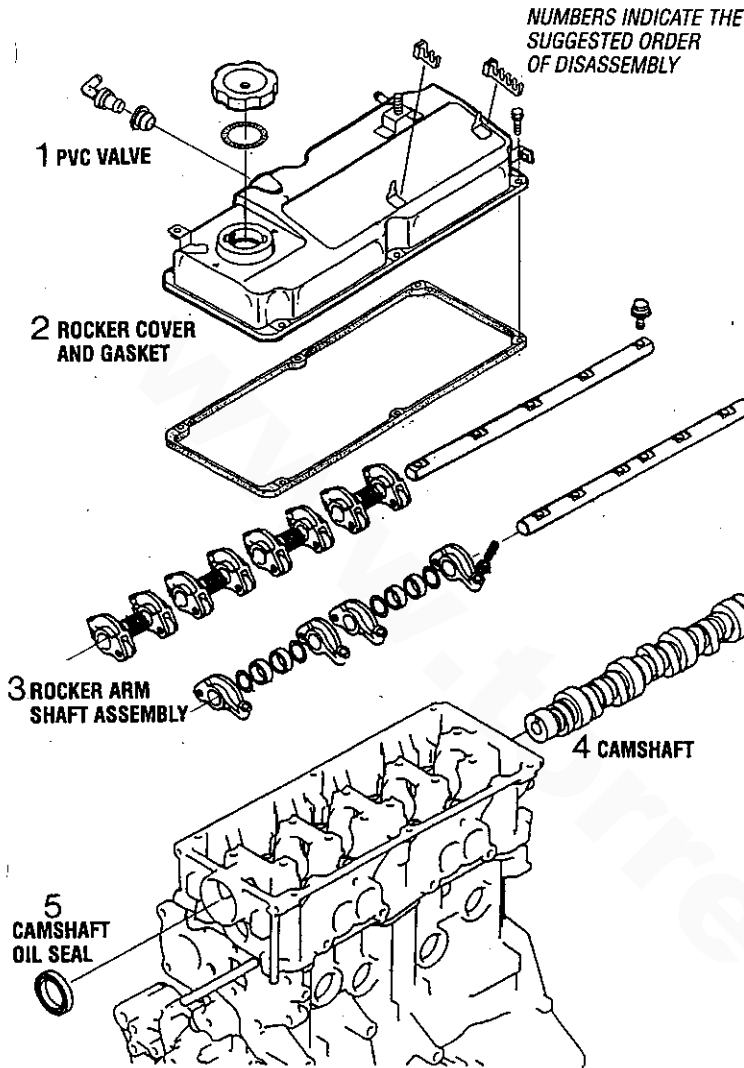
For additional information on alternators, refer to the **ALTERNATOR TROUBLESHOOTING** and **MANDO SERVICE** in this manual.



**BELL HOUSING/FLYWHEEL ASSEMBLY**







**ROCKER ARMS AND CAMSHAFT**

**Camshaft**

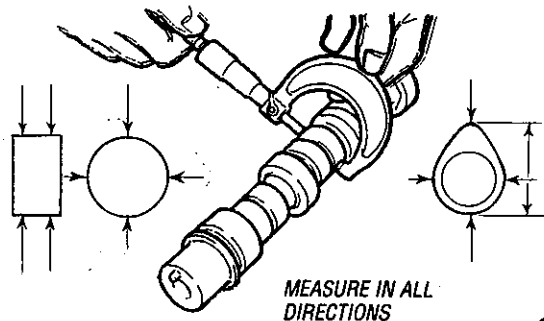
Measure the cam heights and replace the camshaft if any height is less than the specified limit.

**STANDARD VALUE:**

- INTAKE 38.78mm (1.527in)
- EXHAUST 39.10mm (1.540in)

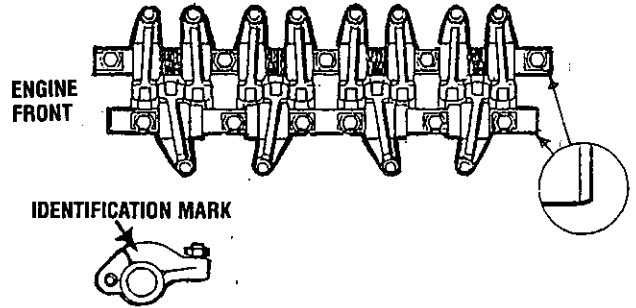
**LIMIT:**

- INTAKE 38.28mm (1.508in)
- EXHAUST 38.60mm (1.521in)



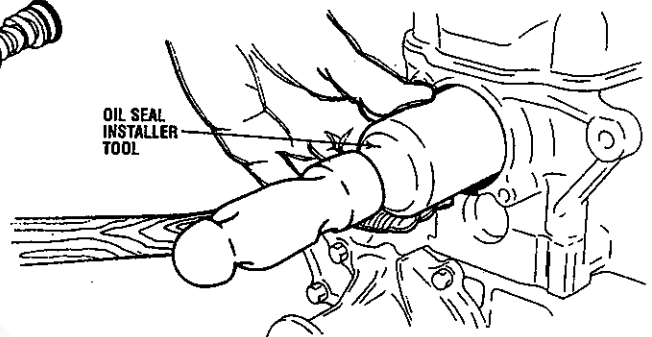
**ROCKER ARM /ROCKER ASSEMBLY INSTALLATION**

Assembly the rocker arms and rocker shaft, paying attention to the identification marks. Then, mount the assembly on the cylinder head.



**CAMSHAFT OIL SEAL INSTALLATION**

Using the oil seal installer tool, install the camshaft oil seal.

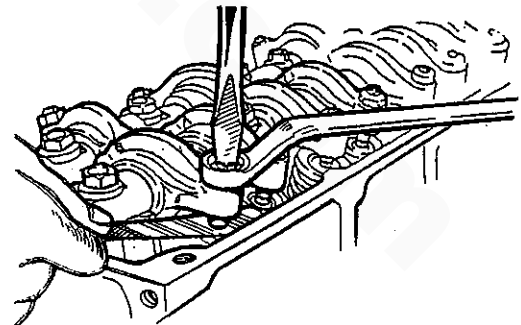


**ADJUSTING THE VALVE CLEARANCE**

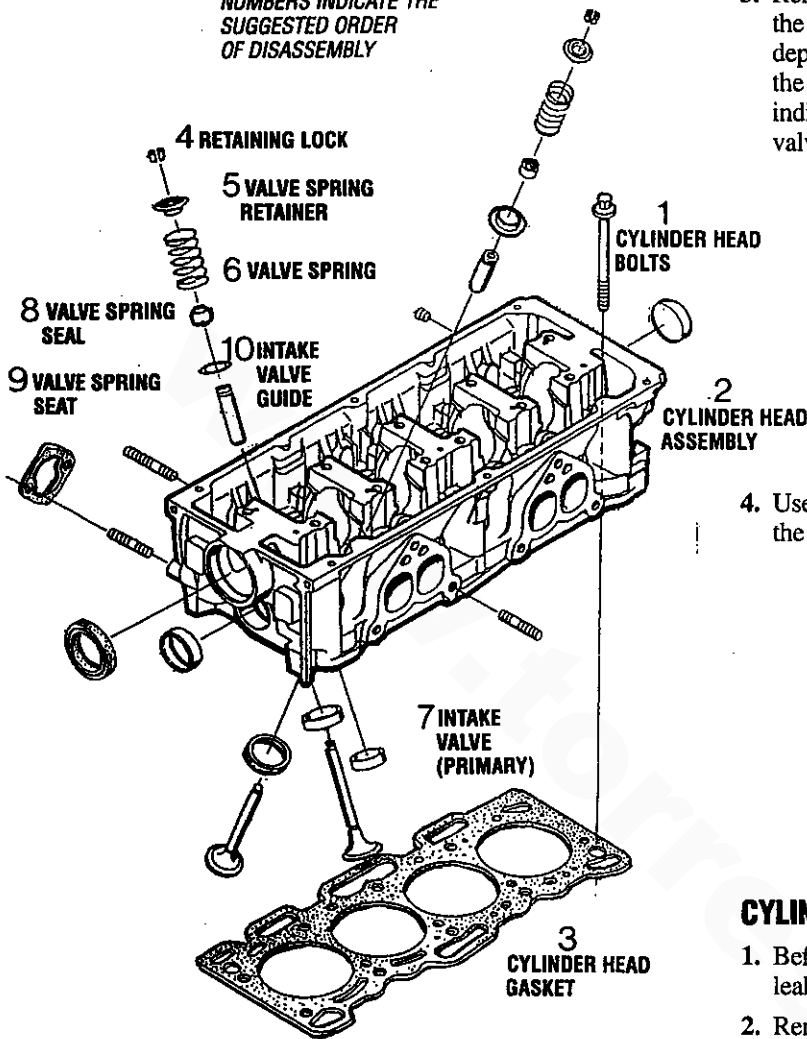
**NOTE:** Refer to the VALVE CLEARANCE ADJUSTMENT procedure in this manual, however when adjusting the valve clearance on a cold engine, use the following data.

**VALVE CLEARANCE ON A COLD ENGINE**

- INTAKE 0.09mm (0.0035in)
- EXHAUST 0.17mm (0.0066in)

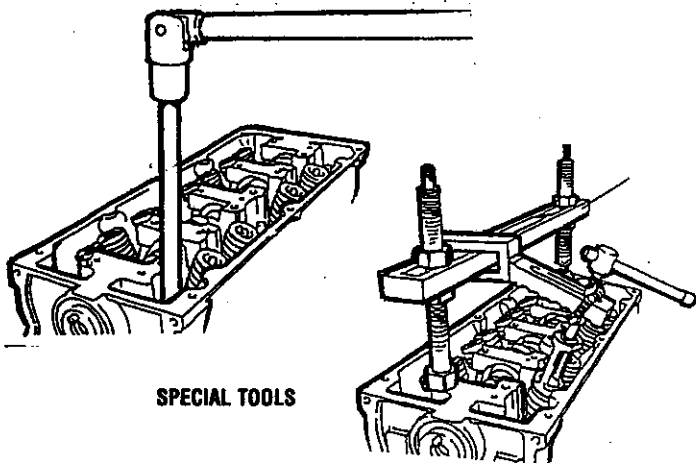


NUMBERS INDICATE THE SUGGESTED ORDER OF DISASSEMBLY

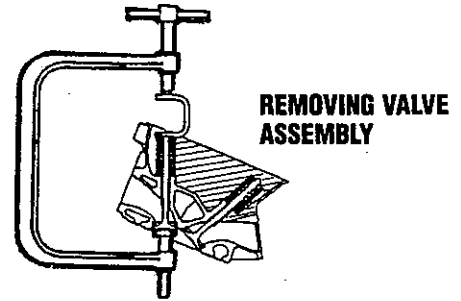


### REMOVING THE CYLINDER HEAD FROM THE CYLINDER BLOCK

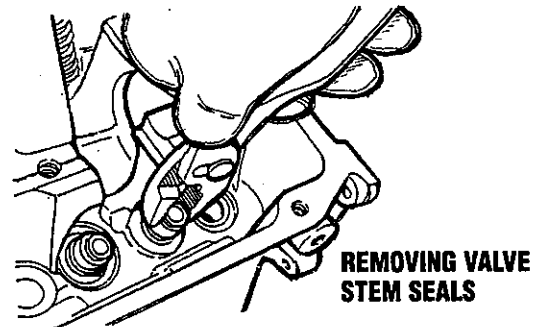
1. Loosen each of the cylinder head bolts, a little at a time so as to avoid the possibility of distorting the cylinder. repeat several times until the bolts are unfastened.
2. Remove the cylinder head and the cylinder head gasket.



3. Remove the valve retainers, valve springs and valves from the cylinder head. When removing each valve retainer, depress 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.



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



### CYLINDER HEAD INSPECTION

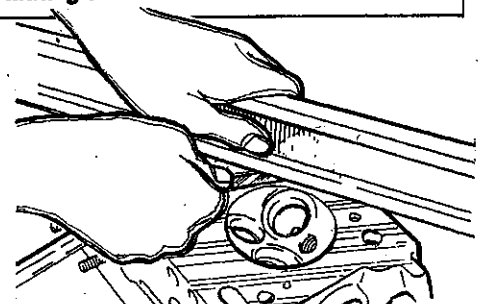
1. Before cleaning the cylinder head, check it for water leaks, gas leaks, cracks, and other damage.
2. Remove all oil, water scale, sealant, and carbon. After cleaning the oil passages, blow air through them to verify that they are not blocked.
3. Check for distortion in the cylinder head gasket surface using a straight edge and thickness gauge. If distortion exceeds the specified limit, grind the gasket surface to specification.

#### GASKET SURFACE DISTORTION

STANDARD VALVE	0.05mm (.00197in) or less
LIMIT	0.2mm (.00788in)
GRINDING LIMIT	0.2mm (.00788in)

CYLINDER HEAD HEIGHT (SPECIFICATION WHEN NEW)  
 106.9 - 107.1mm (4.21 - 4.219in)

**CAUTION:** No more than 0.2mm (.00788in) of stock may be removed from the cylinder head and cylinder block mating surfaces in total.



### VALVES

1. Check the valve face for correct contact. If contact is uneven or incomplete, reface the valve seat.
2. If the margin is less than specified, replace the valve.

**STANDARD VALUE:**

INTAKE 1.0mm (.0394in)  
 EXHAUST 1.5mm (.059in)

**LIMIT:**

INTAKE 0.5mm (.0197in)  
 EXHAUST 1.0mm (.0394in)

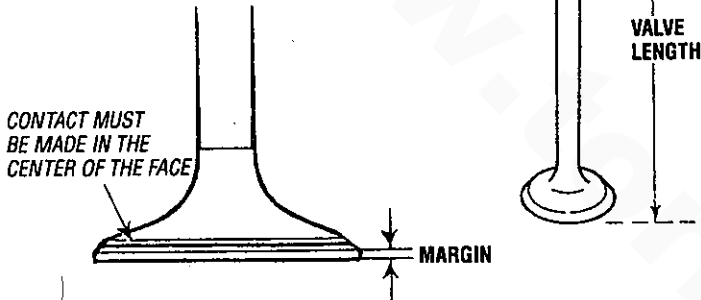
3. Measure the valves total length. If the measurement is less than specified, replace the valve.

**STANDARD VALUE:**

INTAKE 100.75mm (3.969in)  
 EXHAUST 101.05mm (3.98in)

**LIMIT:**

INTAKE 100.25mm (3.95in)  
 EXHAUST 100.55mm (3.96in)



### VALVE SPRINGS

1. Measure the valve springs free height. If the measurement is less than specified, replace the spring.

**STANDARD VALUE:**

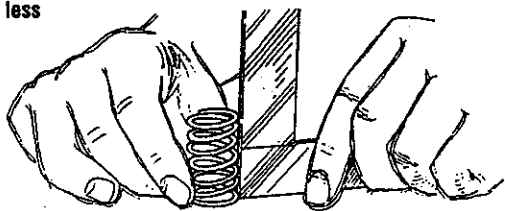
INTAKE 46.1mm (1.81in)  
 EXHAUST 46.8mm (1.84in)

**LIMIT:**

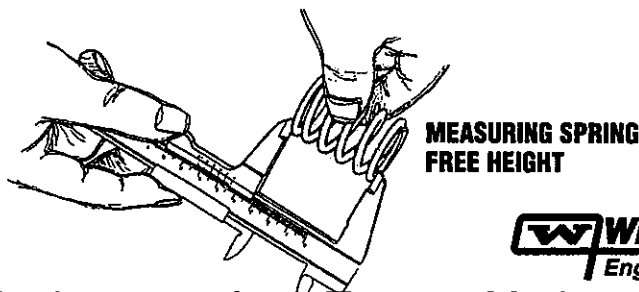
EXHAUST 46.3mm (1.82in)

2. Measure the squareness of the spring. If the measurement exceeds the specified limit, replace the spring.

**STANDARD VALUE:** 2° or less  
**LIMIT:** 2° or less



**MEASURING SPRING SQUARENESS**



**MEASURING SPRING FREE HEIGHT**

### VALVE GUIDES

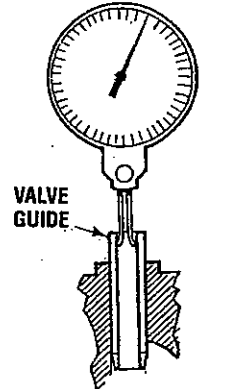
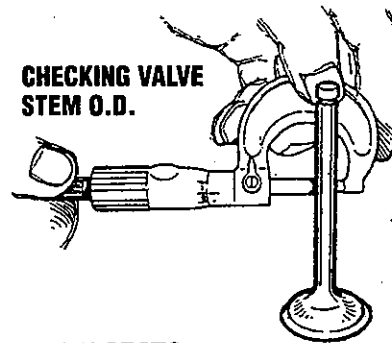
1. Measure the clearance between the valve guide and the valve stem. If the clearance exceeds the specified limit, replace either or both components.

**STANDARD VALUE:**

INTAKE 0.020 - 0.050mm (.00078 - .00197in)  
 EXHAUST 0.050 - 0.085mm (.00197 - .0033in)

**LIMIT:**

INTAKE 0.10mm (0.00394in)  
 EXHAUST 0.15mm (0.0059in)



### VALVE SEATS

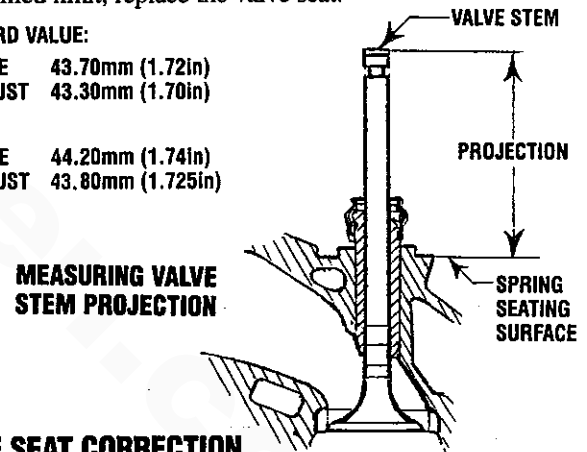
1. Assemble the valve, then measure the valve stem projection between the end of the valve stem and the spring seating surface. If the measurement exceeds the specified limit, replace the valve seat.

**STANDARD VALUE:**

INTAKE 43.70mm (1.72in)  
 EXHAUST 43.30mm (1.70in)

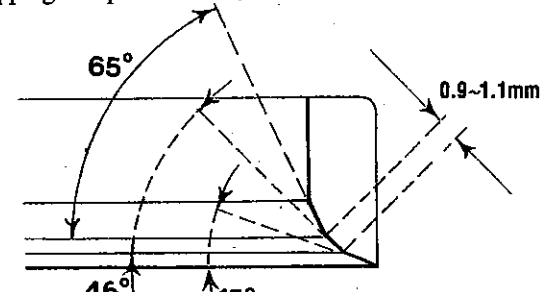
**LIMIT:**

INTAKE 44.20mm (1.74in)  
 EXHAUST 43.80mm (1.725in)



### VALVE SEAT CORRECTION

1. Before correcting the valve seat, check the clearance between the valve guide and valve. If necessary, replace the valve guide.
2. Using the appropriate special tool or seat grinder, correct the valve seat to achieve the specified seat width and angle.
3. After correcting the valve seat, lap the valve and valve seat using lapping compound. Then, check the valve stem projection.



### VALVE SEAT REPLACEMENT

1. Cut the valve thickness to be replaced from the inside to reduce the wall thickness. Then, remove the valve seat.
2. Rebore the valve seat hole in the cylinder head to match the selected oversize valve seat diameter.

#### INTAKE VALVE SEAT HOLE DIAMETERS (0.3 oversize)

PRIMARY 27.300 - 27.325mm (1.075 - 1.076in)  
 SECONDARY 32.300 - 32.325mm (1.272 - 1.273in)

#### INTAKE VALVE SEAT HOLE DIAMETERS (0.6 oversize)

PRIMARY 27.600 - 27.625mm (1.087 - 1.088in)  
 SECONDARY 32.600 - 32.625mm (1.284 - 1.28in)

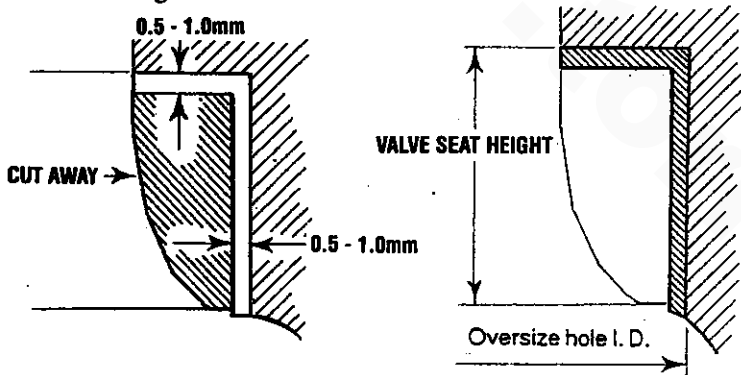
#### EXHAUST VALVE SEAT HOLE DIAMETERS (0.3 oversize)

35.300 - 35.325mm (1.390 - 1.391in)

#### EXHAUST VALVE SEAT HOLE DIAMETERS (0.6 oversize)

35.600 - 35.625mm (1.402 - 1.403in)

3. Prevent galling of the cylinder head bore by cooling the valve seat with liquid nitrogen before press-fitting it.
4. Correct the valve seat to achieve the specified width and angle.



### VALVE GUIDE REPLACEMENT

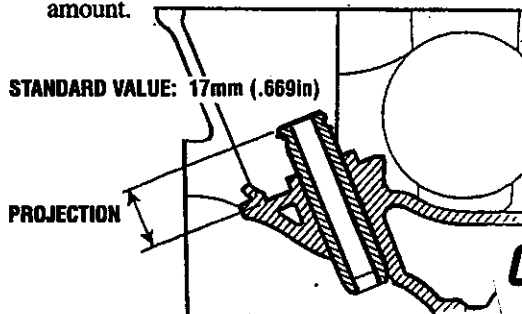
1. Using a press, push the valve guide out toward the cylinder block side.
2. Rebore the valve guide hole in the cylinder head to match the oversize valve guide that is to be fitted.

**CAUTION:** Do not install a valve guide of the same size again.

#### VALVE GUIDE HOLE DIAMETERS

0.05 OVERSIZE: 12.050 - 12.068mm (.474 - .475in)  
 0.25 OVERSIZE: 12.250 - 12.268mm (.482 - .483in)  
 0.50 OVERSIZE: 12.500 - 12.518mm (.4925 - .4932in)

3. Press-fit the valve guide until it projects by the specified amount.

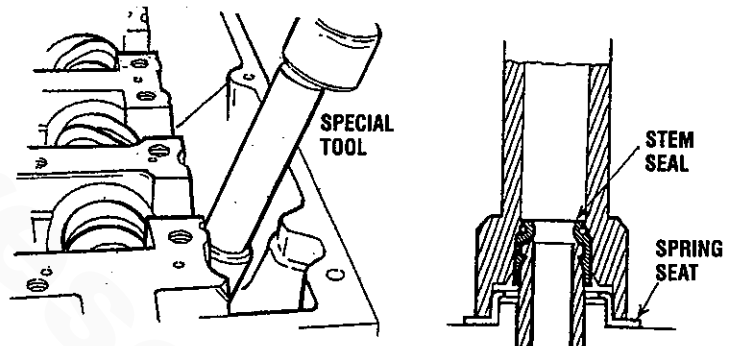


**CAUTION:** The valve guide must be installed from the upper side of the cylinder head. The valve guides differ in length on the intake and exhaust sides. After press-fitting the valve guide, insert a new valve and check that it slides smoothly.

### VALVE STEM SEAL INSTALLATION

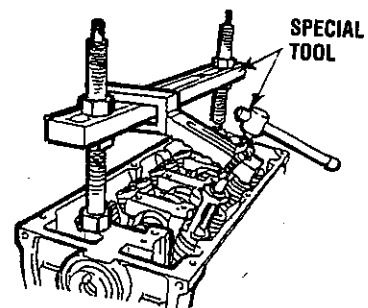
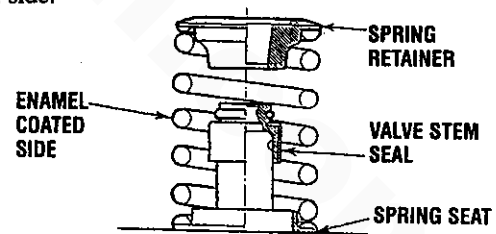
1. Install the valve spring seat.
2. Install a new valve stem seal using the special tool shown.

**CAUTION:** Valve stem seals cannot be re-used. New valve stem seals must be installed using the correct special tool. Incorrect installation could result in oil leaking past the valve guide.



### VALVE SPRING INSTALLATION

1. Install the valve spring with the painted end on the rocker arm side.

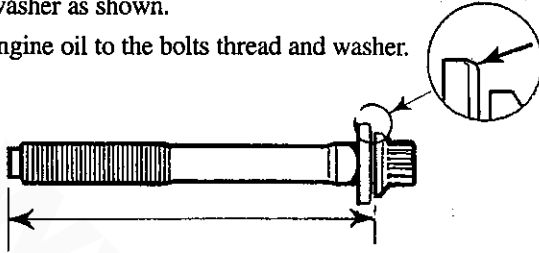




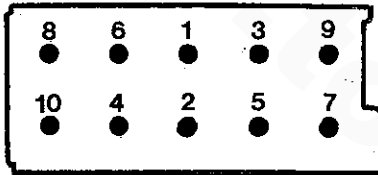
**CYLINDER HEAD BOLT INSTALLATION**

1. Before re-using the cylinder head bolt, check that its normal length does not exceed the specified limit. Replace the bolt if this measurement exceeds the limit.  
**LIMIT: 103.2mm (4.066in)**

2. Fit the washer as shown.
3. Apply engine oil to the bolts thread and washer.

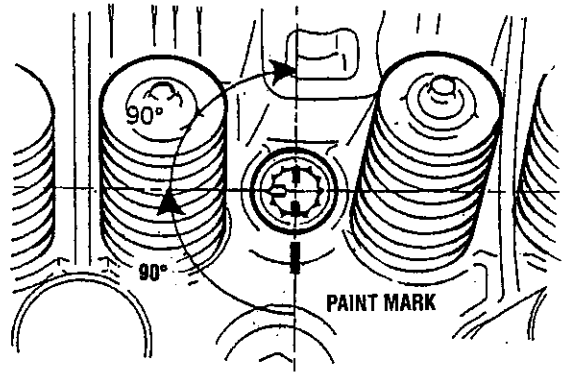


4. Tighten the bolts in the sequence shown until each is torqued to **TORQUE TO 49Nm (36.1 ft-lb)**
5. Completely loosen the bolts.
6. Retighten the bolts in the sequence shown until each is torqued to **TORQUE TO 20Nm (14.7 ft-lb)**



7. Apply paint marks to the cylinder head bolt heads and cylinder head as shown.
8. In accordance with the tightening sequence, tighten each bolt by 90°.
9. Tighten each bolt by a further 90° and check that the paint marks on the bolt head and cylinder head are aligned.

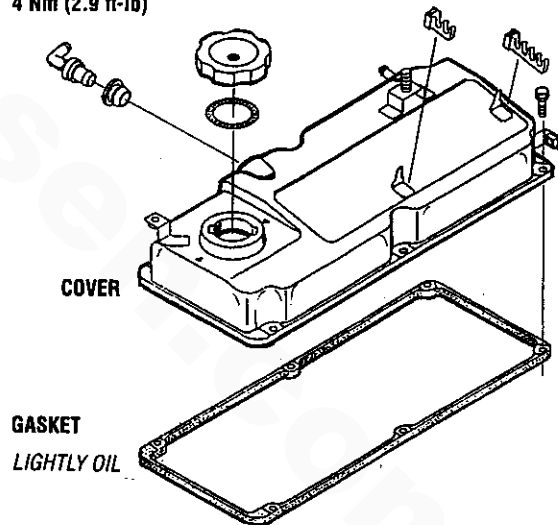
**CAUTION:** If the bolts are tightened by an angle of less than 90°, they may not hold the cylinder head with sufficient strength.  
 If the bolts are tightened by an angle exceeding 90°, completely remove them and carry out the installation procedure again.



**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.

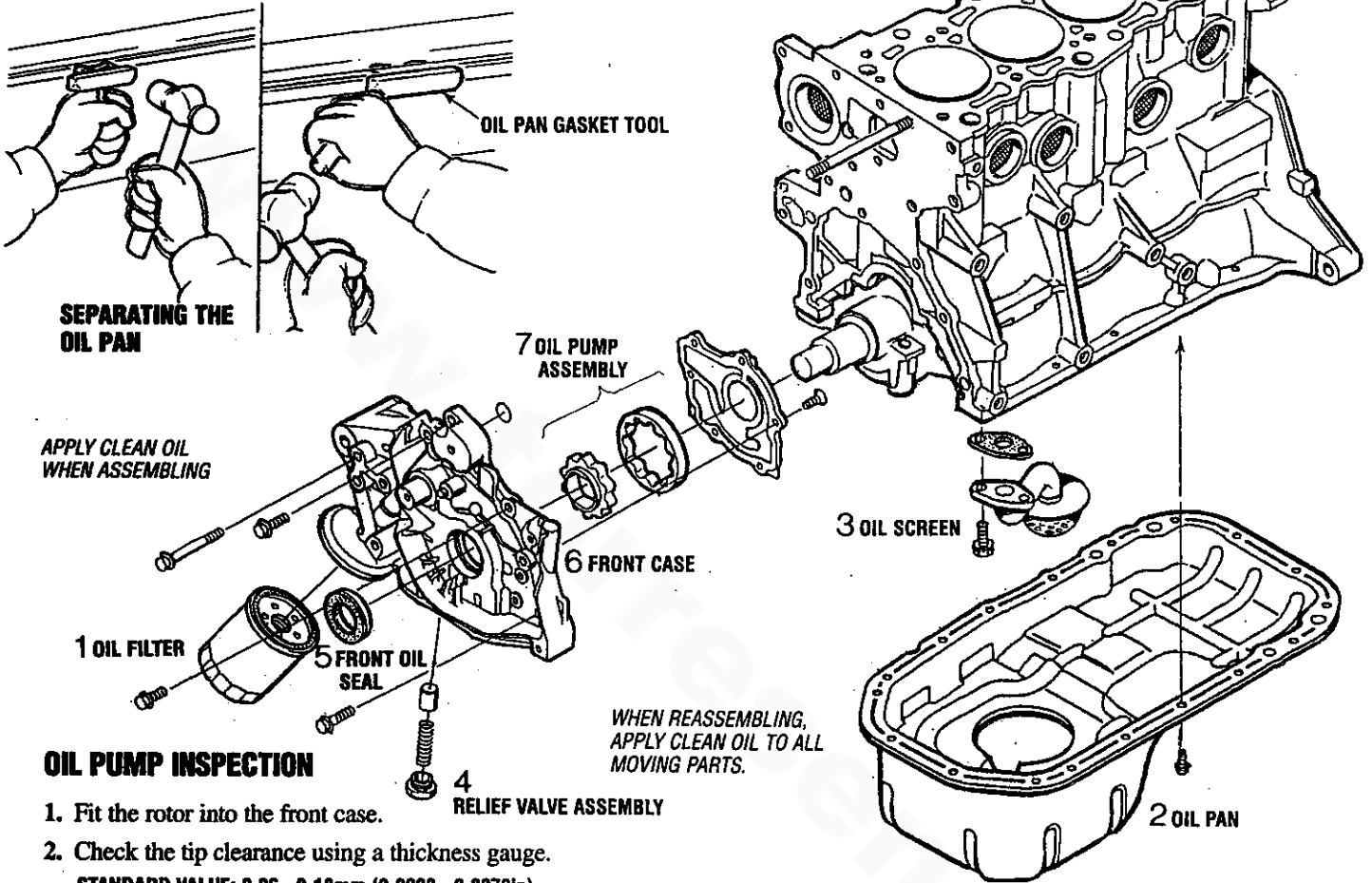
**ROCKER COVER BOLT TORQUE**  
 4 Nm (2.9 ft-lb)



**OIL PAN REMOVAL**

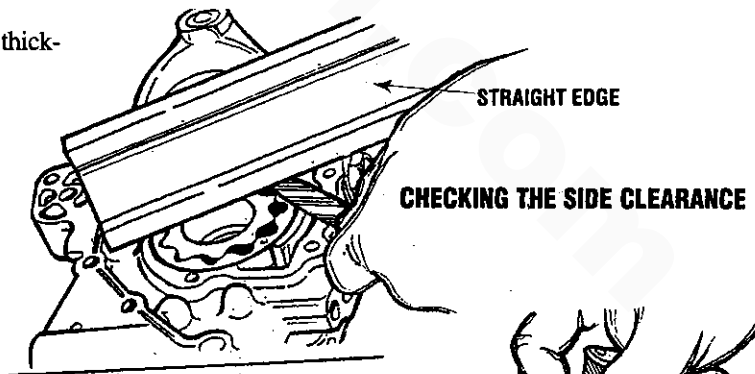
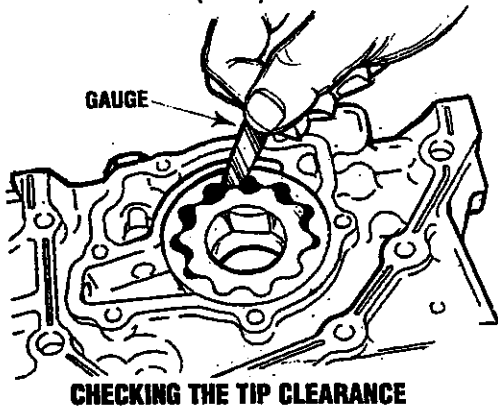
1. Remove the oil pan mounting bolts.
2. Knock the special tool between the oil pan and cylinder block as shown in the illustration.
3. Tapping the side of the special tool slide the tool along the oil pan/cylinder block seal and remove the oil pan.

NUMBERS INDICATE THE SUGGESTED ORDER OF DISASSEMBLY

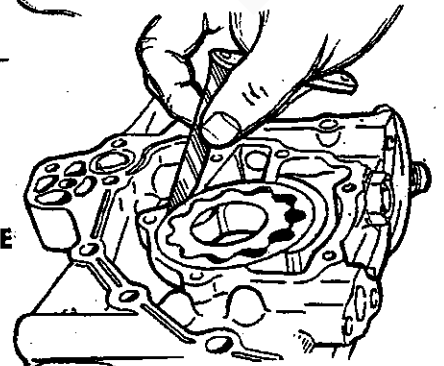


**OIL PUMP INSPECTION**

1. Fit the rotor into the front case.
2. Check the tip clearance using a thickness gauge.  
**STANDARD VALUE: 0.06 - 0.18mm (0.0023 - 0.0070in)**
3. Check the side clearance using a straight edge and thickness gauge.  
**STANDARD VALUE: 0.04 - 0.10mm (0.0015 - 0.0039in)**
4. Check the body clearance using a thickness gauge.  
**STANDARD VALUE: 0.04 - 0.10mm (0.0015 - 0.0039in)**  
**LIMIT: 0.35mm (0.13in)**

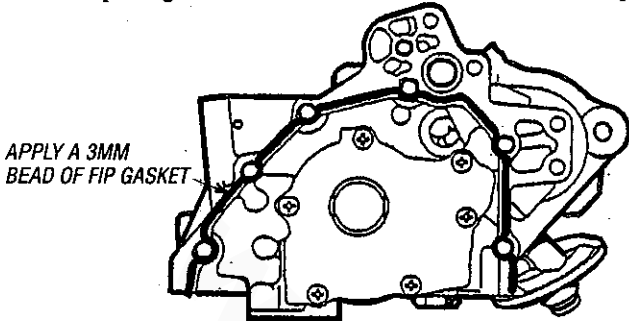


**CHECKING THE BODY CLEARANCE**



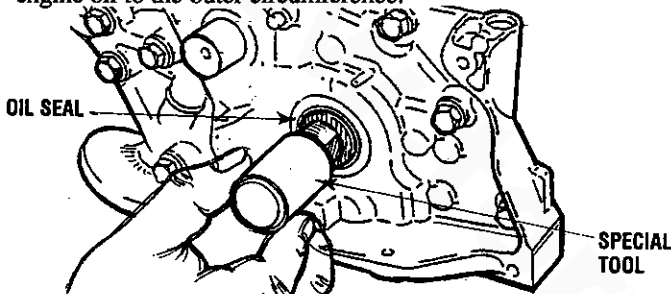
### FRONT OIL SEAL CASE INSTALLATION

Clean the sealant application surfaces on the cylinder block and front oil seal case and apply a 3mm bead of form-in-place gasket to the entire circumference of the oil pan flange.

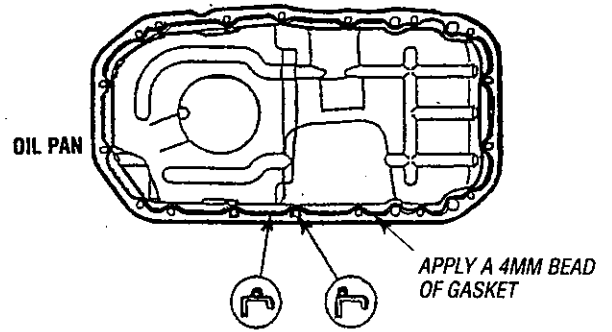
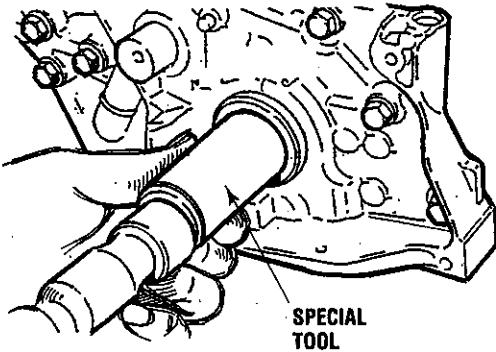


### FRONT OIL SEAL INSTALLATION

Place the special tool on the crankshaft front end and apply engine oil to the outer circumference.



Apply engine oil to the oil seal lip, then push the oil-seal along the guide by hand until it touches the front case. Tap the oil seal into place using the special tool.



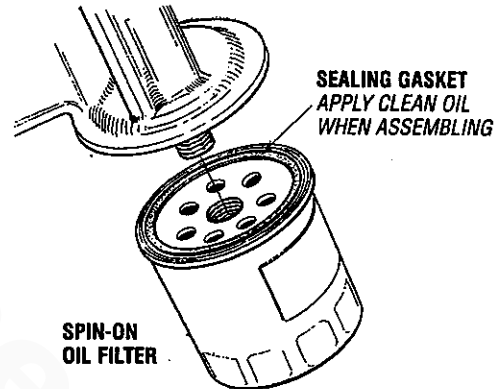
### OIL PAN INSTALLATION

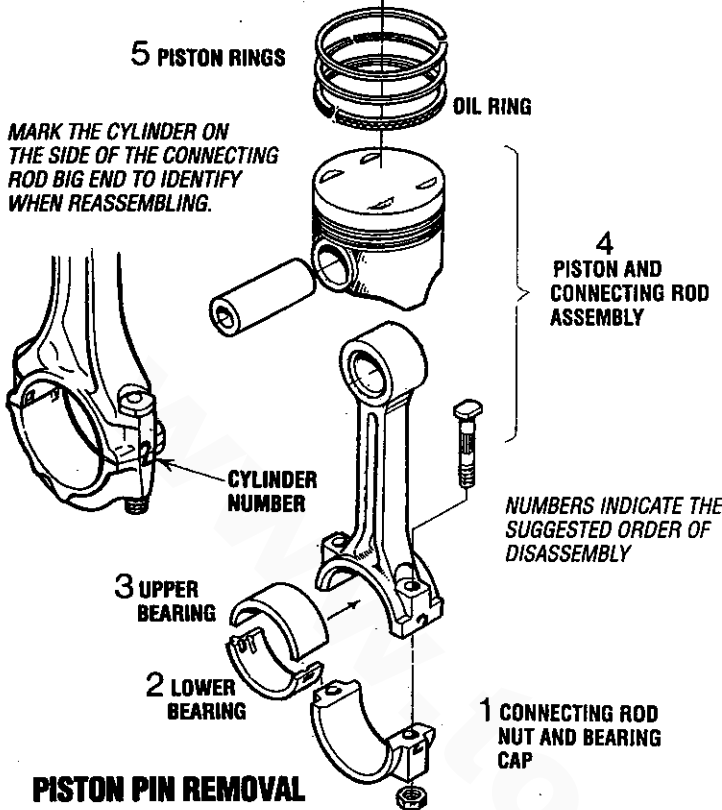
Before installing the oil pan, inspect the oil pan drain hose and fittings for cracks and wear, replace if necessary.

Clean the mating surfaces of the cylinder block and oil pan. Apply a 4mm bead of form-in-place gasket to the outer circumference of the oil pan flange.

### INSTALL A NEW OIL FILTER

Screw the oil filter in until the sealing gasket contacts the front case, then tighten 3/4 turn.

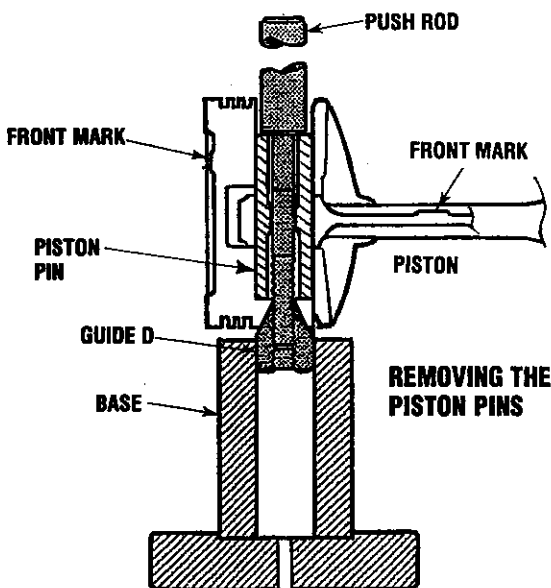




**PISTON PIN REMOVAL**

1. Insert the Push Rod (special tool) from the front arrow mark side, then fit guide D.
2. Mount the piston and connecting rod assembly on the Piston Pin Setting Base (special tool) with the piston's front mark pointing upward.
3. Remove the piston pin using a press.

**NOTE:** After removing the piston pin, keep the piston, piston pin, and connecting rod together. Do not allow pistons, piston pins, and connecting rods from different cylinders to become mixed up.

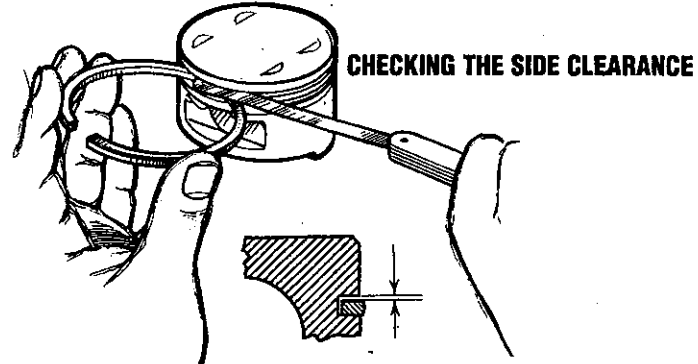


**PISTON RINGS - INSPECTION**

1. Check the piston ring side clearance. If the clearance exceeds the specified limit, replace the ring or piston, or both.

**STANDARD VALUE:**

NO.1 RING:	0.03 - 0.07mm (.00118 - .00275in)
NO.2 RING:	0.02 - 0.06mm (.00078 - .0023in)



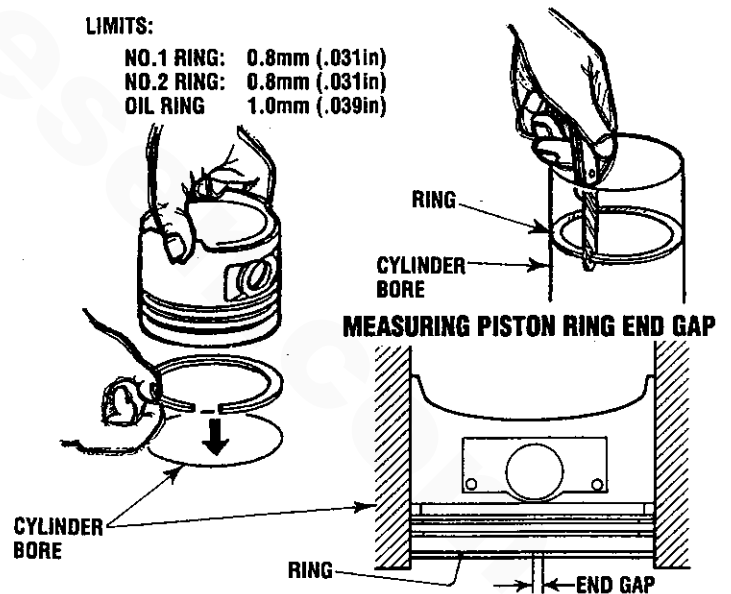
2. Insert the piston ring into the cylinder bore and push it down with a piston. Ensure that the piston's crown is in contact with the ring so that the ring is at 90° to the cylinder wall. Then measure the end gap with a thickness gauge. If the gap is too large, replace the piston ring.

**STANDARD VALUE:**

NO.1 RING:	0.20 - 0.35mm (.00788 - .013in)
NO.2 RING:	0.35 - 0.50mm (.013 - .019in)
OIL RING	0.20 - 0.50mm (.00788 - .019in)

**LIMITS:**

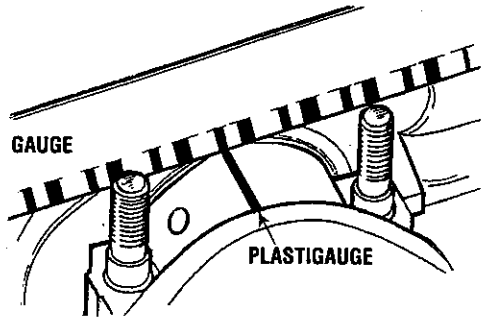
NO.1 RING:	0.8mm (.031in)
NO.2 RING:	0.8mm (.031in)
OIL RING	1.0mm (.039in)



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

**NOTE:** If replacing piston rings, check the piston ring gaps. New rings are packaged with detailed instructions that often supersede the service manual text.

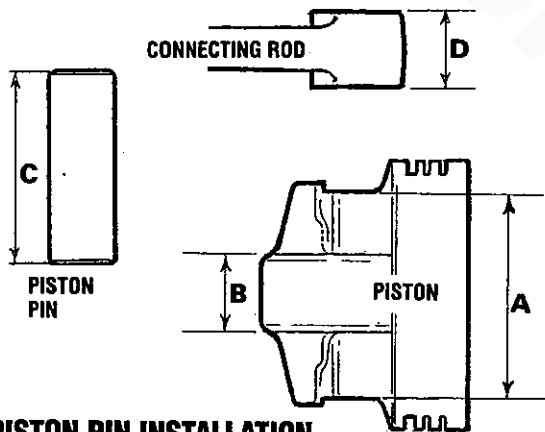




**CRANKSHAFT PIN OIL CLEARANCE (PLASTIC GAUGE METHOD)**

1. Wipe all the oil off the crankshaft pin and the connecting rod bearing.
2. On the pin, place a plastic gauge that is cut to the same length as the bearings width. The plastic gauge must be centered on the pin in parallel with the pins axis.
3. Gently place the connecting rod cap in position and tighten the bolts to the specified torque.
4. Remove the bolts and gently remove the connecting rod cap.
5. Measure the compressed part of the plastic gauge at its widest point using the scale printed on the plastic gauge.

STANDARD VALUE 0.02 - 0.04mm (.000788 - .0015in)  
 LIMIT 0.1mm (.0039in)

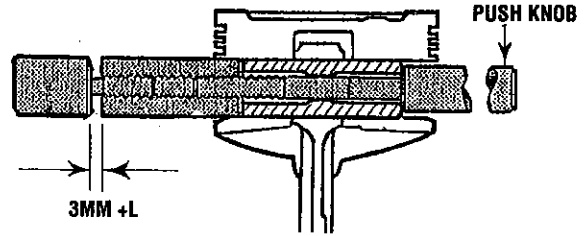


**PISTON PIN INSTALLATION**

1. Measure the following lengths (as shown):  
 A: Piston boss-to-piston boss outside dimension.  
 B: Piston boss-to-piston boss inside dimension  
 C: Piston pin length.  
 D: Connecting rod small end eye thickness.
2. Enter the measured values into the following formula:  

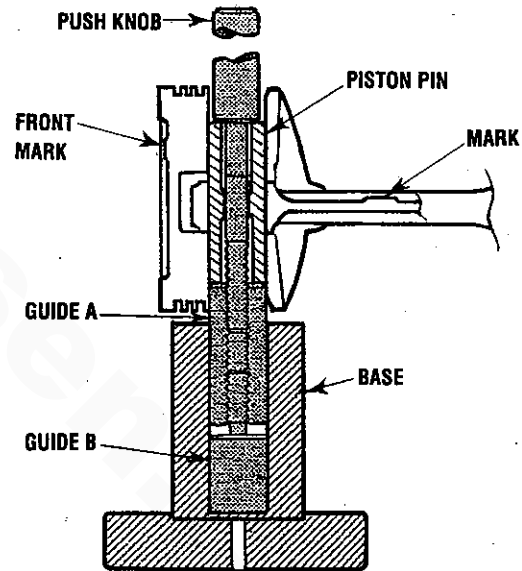
$$L = \frac{A - C - B - D}{2}$$
3. Insert the Push Rod (special tool) into the piston pin, then fit guide A (special tool) as shown.
4. Fit the piston and connecting rod together such that their front marks are on the same side.

5. Apply engine oil to the outside of the piston pin.
6. Into the front-mark side of the piston, insert the guide A, piston pin, and Push Rod, starting with guide A.
7. Screw guide B into guide A. Leave a gap between the two guides of 3mm plus the value (L) calculated in step 2.



8. Mount the piston and connecting rod on the Piston Pin Setting Base (special tool) with the pistons front mark pointing upward.
9. Install the piston pin using a press. If the press-fitting load is out of specification, replace the piston pin and piston assembly or the connecting rod, or both.

STANDARD VALUE 4,900 - 14,700 Nm (36,162 - 10,848 ft-lbs)

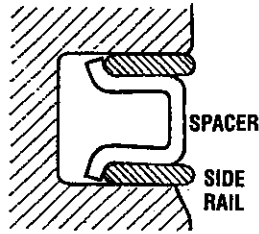
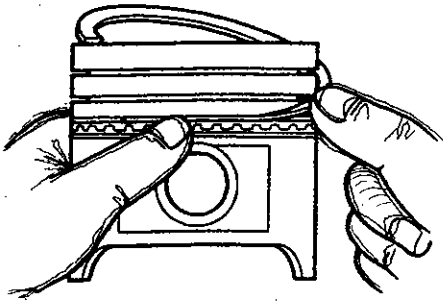


**PISTON RINGS INSTALLATION**

1. Fit the oil ring spacer into the piston groove. Then, assemble the upper and lower side rails.
2. The spacer and side rails may be fitted in either direction. No distinction is made between top and bottom. The spacer and the side rails sizes are color coded as follows:

SIZE	COLOR
STD	None
0.50mm oversize	Blue
1.00mm oversize	Yellow



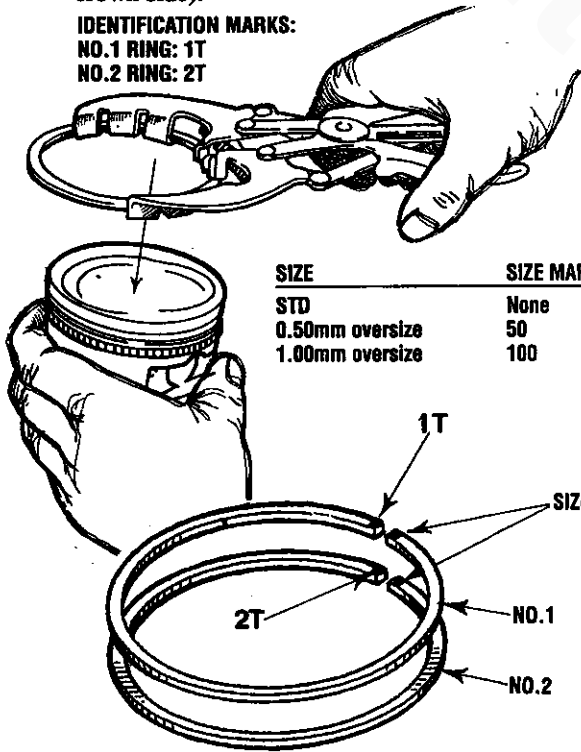


- To install a side rail, fit one end of the rail into the groove then press the rest of the rail into position by hand as shown.

**CAUTION:** Do not fit side rails using a piston ring expander since they may break.

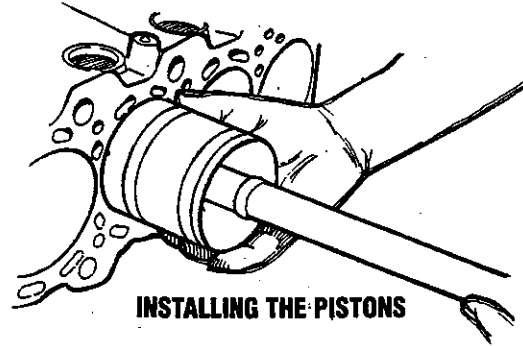
- After installing the side rails, check that they move smoothly in both directions.
- Using a ring expander, fit ring No.2 and ring No.1 with their identification marks facing upward (on the piston crown side).

**IDENTIFICATION MARKS:**  
 NO.1 RING: 1T  
 NO.2 RING: 2T



SIZE	SIZE MARK
STD	None
0.50mm oversize	50
1.00mm oversize	100

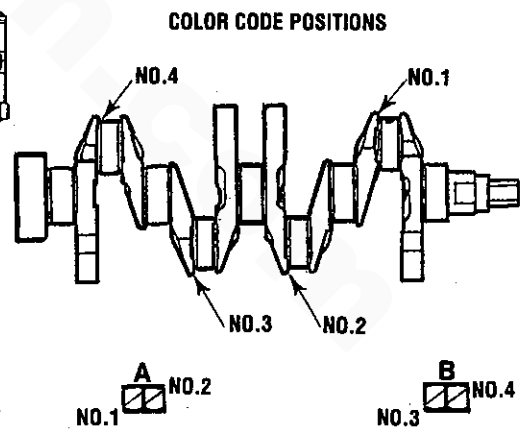
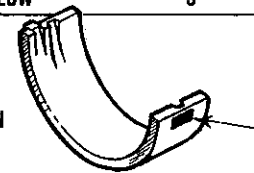
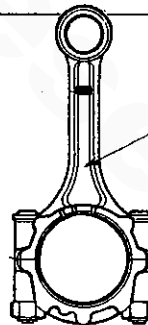
- Compress the piston rings tightly with a suitable ring compression tool, then press the piston and connecting rod fully into the cylinder. Do not strike the piston hard since the piston rings may break and the crank pin may be nicked.



### CONNECTING ROD BEARING INSTALLATION

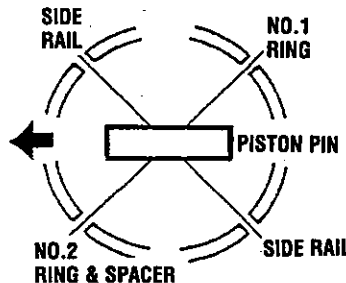
Select bearings according to the crankshaft and connecting rod identification marks or color codes, referring to the following table.

CRANKSHAFT IDENTIFICATION MARK	CONNECTING ROD IDENTIFICATION COLOR	BEARING IDENTIFICATION MARK
I, YELLOW	WHITE	1
	NONE	1
	YELLOW	2
II, NONE	WHITE	1
	NONE	2
	YELLOW	3
III, WHITE	WHITE	2
	NONE	3
	YELLOW	3

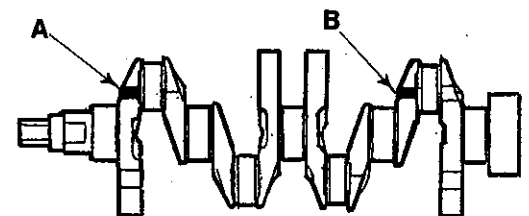


### PISTON AND CONNECTING ROD ASSEMBLY INSTALLATION

- Apply oil to the piston, piston rings, and oil ring.
- Align the gaps of the piston rings and oil ring (side rails and spacer) as shown.
- With the piston crowns front arrow mark pointing toward the timing belt side, press the piston and connecting rod assembly into the cylinder from the top of the cylinder.

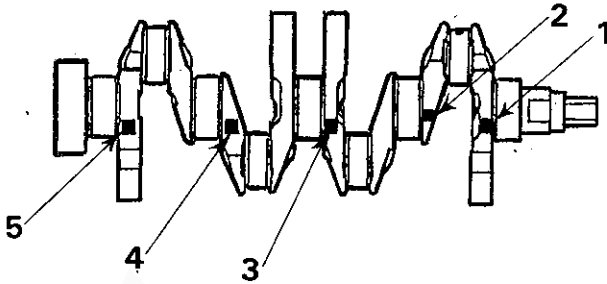


### CRANKSHAFT

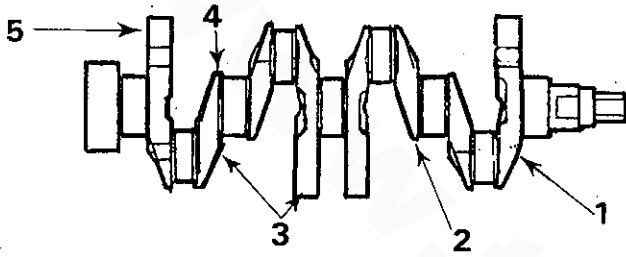


IDENTIFICATION MARKS

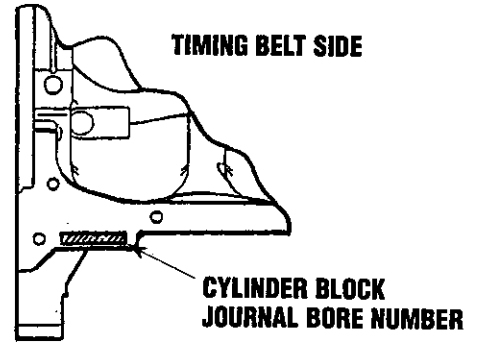
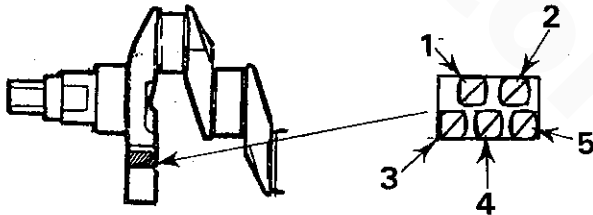
**COLOR CODE POSITIONS (TYPE 1)**



**COLOR CODE POSITIONS (TYPE 2)**



**IDENTIFICATION MARK POSITIONS**

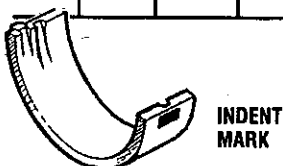
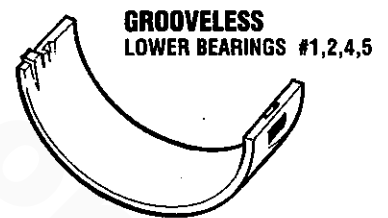
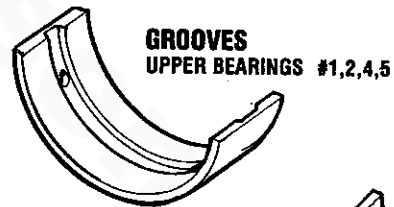


- Identification marks showing the cylinder block bearing bore diameter are stamped in the position shown, with No.1 at the front of the engine. Bearings must be selected and installed in accordance with these identification marks.
- Based on the identification markings verified in steps 1 and 2, select bearings from the chart. Note the following example:  
 If the measured crankshaft journal diameter is 48,000mm, this corresponds to classification 1 in the above table.  
 If the identification mark on the cylinder block bearing hole is "1", select a bearing with an identification mark of "2".
- Except for the center bearing, all the upper bearings are grooved. the center bearings are grooveless and have flanges. The center bearings are the same at the top and bottom.
- The lower bearings are all grooveless.

**CRANKSHAFT BEARING INSTALLATION**

- Select bearings according to the crankshaft identification marks or color codes, referring to the following chart. If they are not identifiable, measure the crankshaft journals and choose bearings to match the measurements.

CRANKSHAFT JOURNAL			CYLINDER BLOCK BEARING BORE DIAMETER	BEARING	
RANGE	COLOR CODE	IDENT. MARK		IDENT. MARK	IDENT. MARK
1	YELLOW	1	47.995-48.000 (1.8910-1.8912)	0	1
				1	2
				2	3
2	NONE	2	47.985-47.995 (1.8906-1.8910)	0	2
				1	3
				2	4
3	WHITE	3	47.980-48.985 (1.8904-1.93)	0	3
				1	4
				2	5

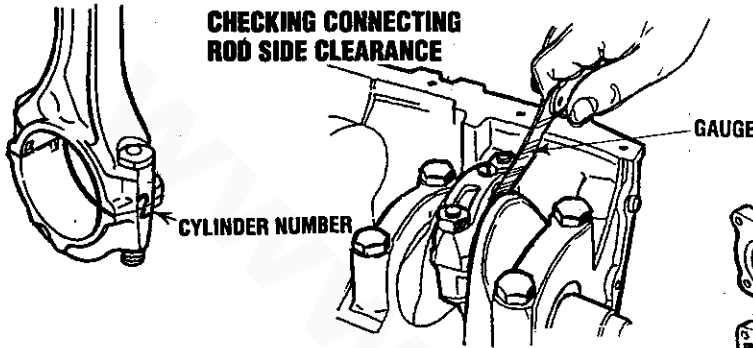


# ENGINE DISASSEMBLY, INSPECTION AND ASSEMBLY

## CONNECTING ROD CAP INSTALLATION

1. Align the marks made during disassembly and fit the bearing cap onto the connecting rod. If the connecting rod is new and has no index mark, ensure that the bearing locking notches are both on the same side.
2. Check that the connecting rod big end side clearance conforms with the specifications.

STANDARD VALUE 0.10 - 0.25mm (.00394 - .00985in)  
LIMIT 0.4mm (.015in)



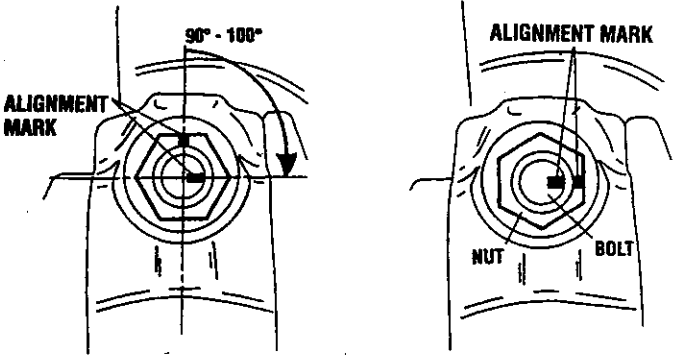
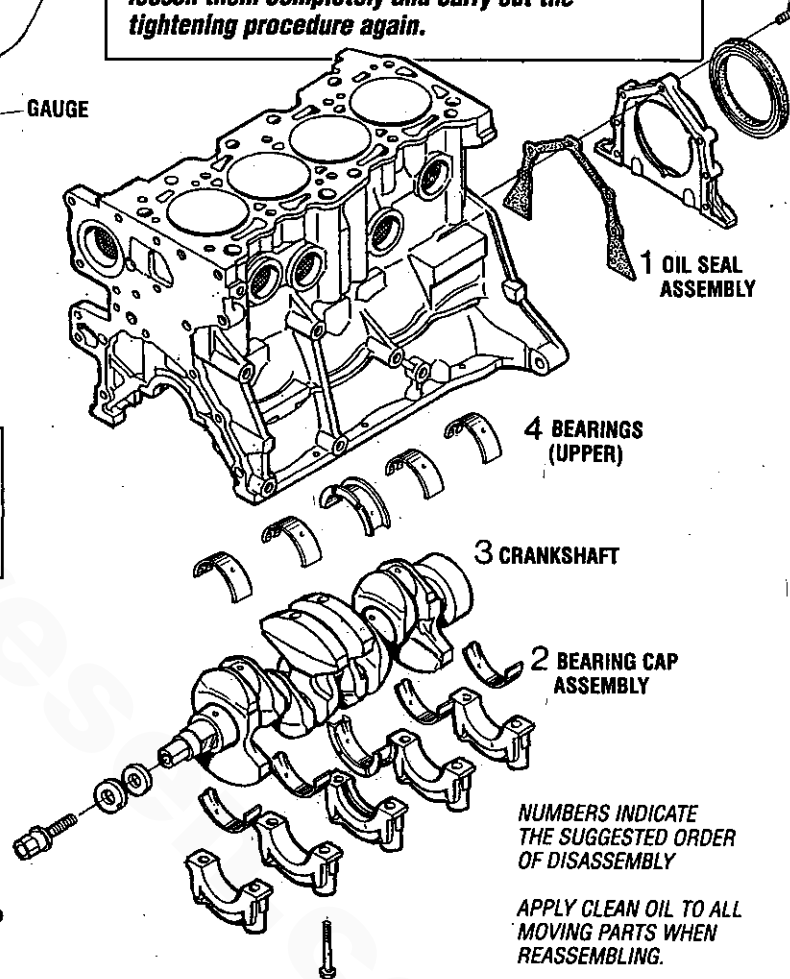
5. Make a paint mark on the top of each nut as shown.
6. Make paint marks on the bolts 90° to 100° clockwise from the paint marks on the nut.
7. Turn the nuts until their paint marks align with the paint marks on the bolts.

**CAUTION:** If the nuts are turned by less than 90°, the cap may not be held on with sufficient strength. If the nuts are turned by more than 100°, loosen them completely and carry out the tightening procedure again.

## CONNECTING ROD CAP NUT INSTALLATION

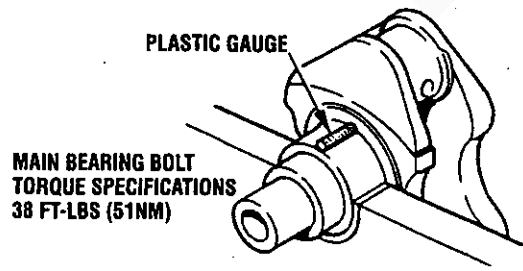
**CAUTION:** To fit the connecting rod cap nuts with the cylinder head in place, first remove the spark plugs.

1. The connecting rod bolts and nut utilize the plastic region tightening method. the bolts must therefore be checked for stretching before reuse. To check a bolt for stretching, screw the nut down the entire length of the thread by hand. Unless the nut turns smoothly all the way, the bolts threaded section is stretched and the bolt must be replaced.
2. Before fitting the nuts, apply engine oil to their threads and seating surfaces.
3. Fit the nuts onto the bolts and turn them until they are finger tight. The nuts must then be tightened alternately to ensure the correct fitting of the cap.
4. Tighten the nuts to a torque of 17Nm (12.5 ft-lb).

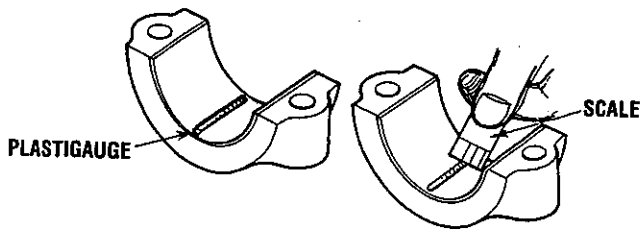


## CONNECTING ROD BEARING INSTALLATION

The crankshaft oil clearance can be measured easily using a plastic gauge. To check the crankshaft oil clearance with a plastic gauge, carry out the following procedure:

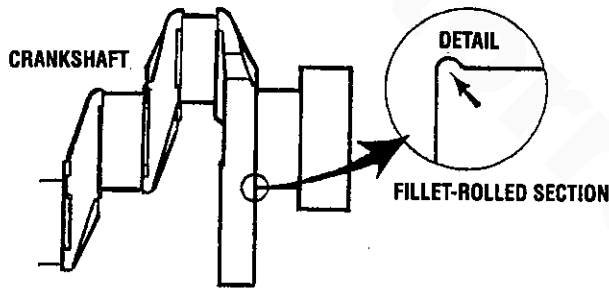






1. Wipe all oil off the crankshaft journal and the bearings inside surfaces.
2. Install the crankshaft.
3. Cut the plastic gauge such that its length matches the width of the bearing, then place it on the journal along the journals axis.
4. Gently fit the crankshaft bearing cap and tighten the bolts to the specified torque.
5. Remove the bolts and gently remove the crankshaft bearing cap.
6. Using the scale printed on the plastic gauge bag, measure the plastic gauges crushed section at its widest point.

**STANDARD VALUE** 0.02 - 0.04mm (.000788 - .00157in)  
**LIMIT** 0.1mm (.00394in)

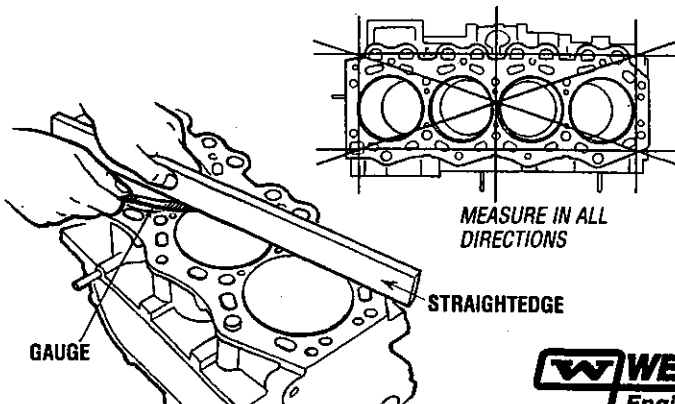


**NOTE:** The crankshaft pins and journals are fillet-rolled and must not be machined to undersize dimensions.

### CYLINDER BLOCK

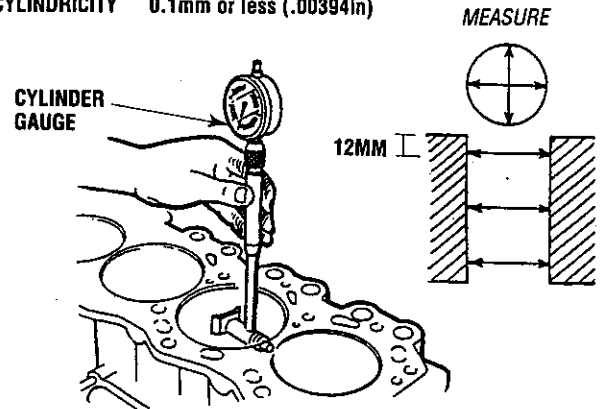
1. Visually check for cracks, rust and corrosion and inspect the cylinder block using a flaw detecting agent. Rectify defects where possible or replace the cylinder block.
2. Ensure that the top surface is free of gasket chips and other foreign material. Check the cylinder blocks top surface for distortion using a straight edge and thickness gauge.

**STANDARD VALUE** 0.05mm (.00197in)  
**LIMIT** 0.1mm (.00394in)



3. Check the cylinder walls for cracks and seizure marks. If defects are evident, bore all the cylinders to oversize or replace the cylinder block.
4. Using a cylinder gauge, measure each cylinders bore and cylindricity. If any cylinder is severely worn, bore all the cylinders to oversize and replace the piston and piston rings accordingly. Take measurements at the points shown.

**STANDARD VALUE:**  
**CYLINDER BORE** 75.5mm (2.97in)  
**CYLINDRICITY** 0.1mm or less (.00394in)



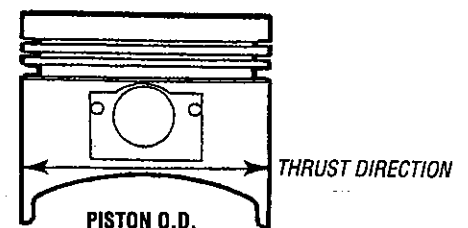
### BORING CYLINDERS

1. Oversize pistons to be used should be determined on the basis of the cylinder with the largest bore.
2. Oversize pistons are available with the following oversize dimensions: 0.25mm, 0.50mm, 0.75mm and 1.00mm. Measure the diameter of the piston to be used. Boring must be carried out such that the piston-to-cylinder clearance complies with the standard value. The pistons diameter should be measured at the points shown.
3. Calculate the boring finish dimension based on the piston diameter dimension.  
**BORING FINISH DIMENSION = PISTON O.D. + PISTON-TO-CYLINDER CLEARANCE (0.02 - 0.04mm (.000788 - .00157in)) - HONING MARGIN (0.02MM)**
4. Bore each cylinder to the calculated boring finish dimension.

**CAUTION:** To prevent distortion caused by heat increased during boring, bore the cylinders in the following order: No.2, No.4, No.1 and No.3.

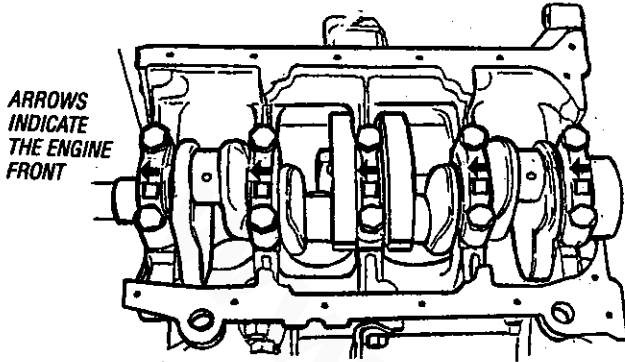
- 5.hone the cylinders to the final finish dimension (piston O.D. + piston-to-cylinder clearance).
6. Check the clearance between the pistons and cylinders.

**STANDARD VALUE** 0.02 - 0.04mm (.000788 - .00157in)



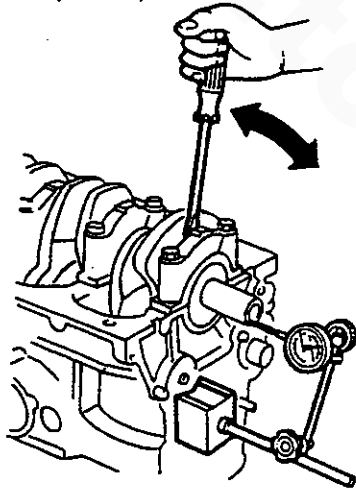
### BEARING CAP INSTALLATION

1. On the bottom surface of each bearing cap is the caps number and an arrow. Starting at the timing belt side, fit the bearing caps in numerical order. Ensure that the arrows point toward the timing belt side.



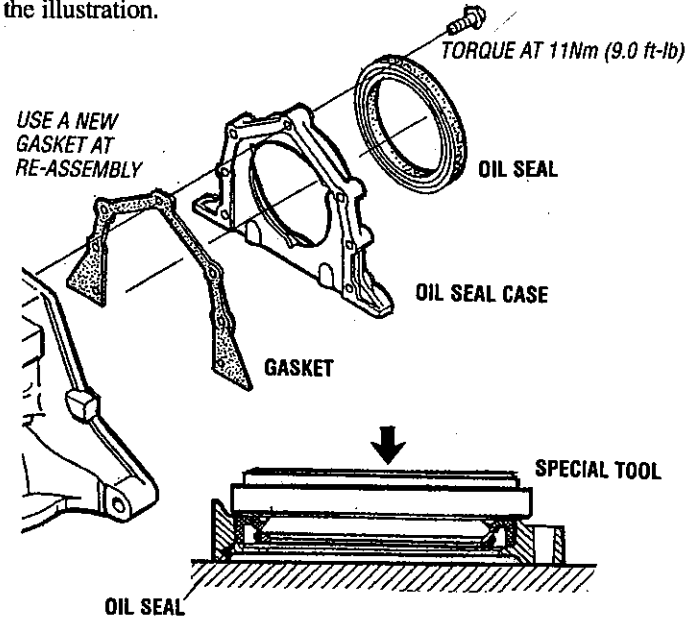
2. After fitting the bearing caps, measure the end play in the crankshaft. If the measurement exceeds the specified limit, replace the crankshaft bearings.

**STANDARD VALUE** 0.05 - 0.18mm (.00197 - .0070in)  
**LIMIT** 0.25mm (.00985in)



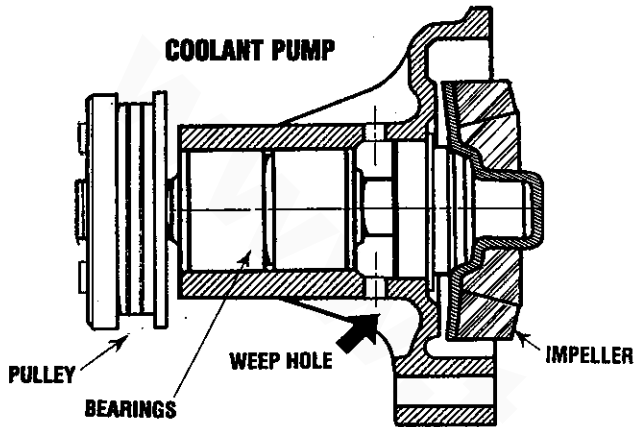
### REAR OIL SEAL INSTALLATION

1. Press-fit the rear oil seal using the special tool shown in the illustration.



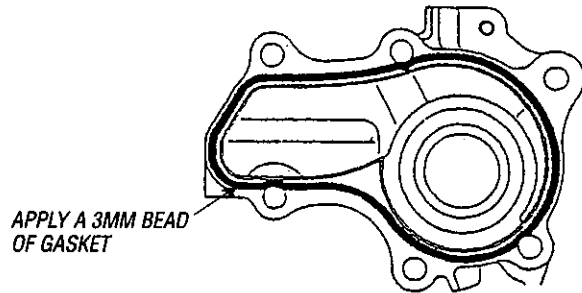
### REMOVING THE COOLANT PUMP

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 bolts that hold the pump to the engine and remove the coolant pump.



### 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 and the pulley edges should be smooth and undamaged.



### WATER PUMP INSTALLATION

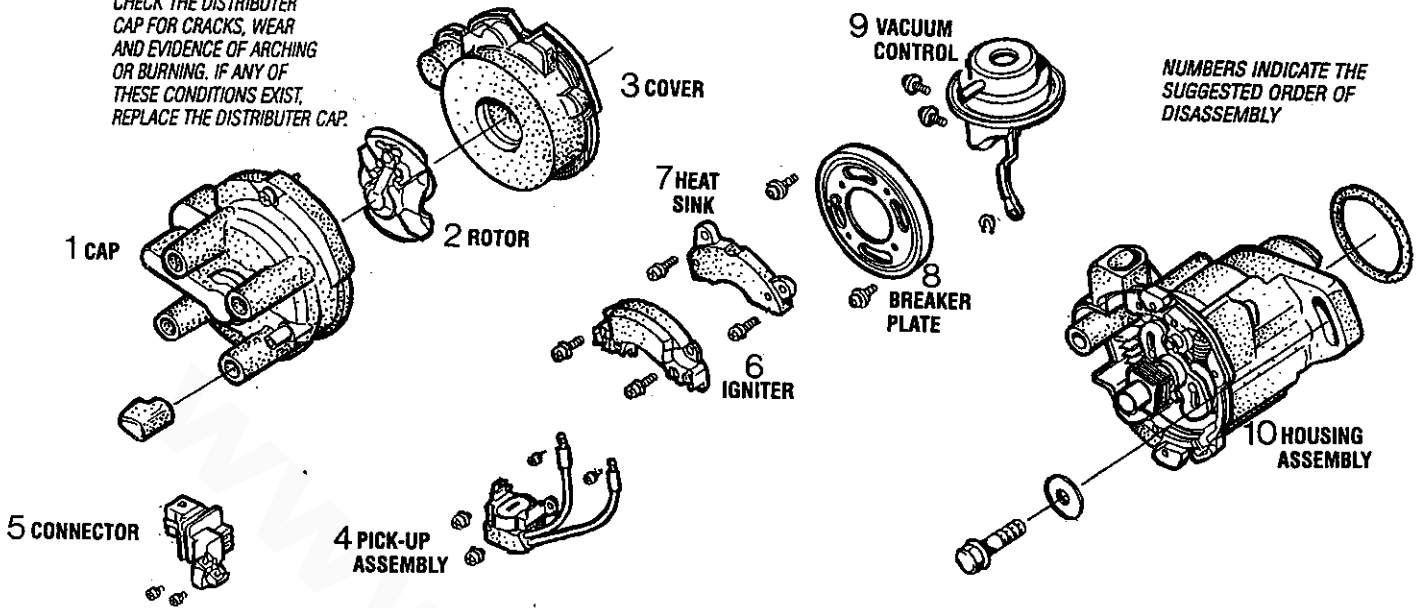
Apply a 3mm bead of form-in-place gasket to the mounting surface.

Tighten the mounting bolts a little at a time.

**TORQUE AT 13Nm (9.59 ft-lb)**

# DISTRIBUTER

CHECK THE DISTRIBUTER CAP FOR CRACKS, WEAR AND EVIDENCE OF ARCHING OR BURNING. IF ANY OF THESE CONDITIONS EXIST, REPLACE THE DISTRIBUTER CAP.



## IGNITION COIL INSPECTION

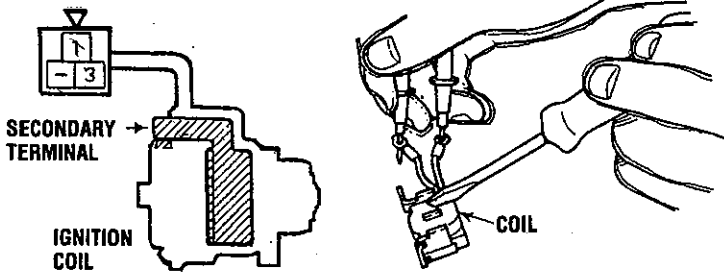
Use a tester to measure the primary and secondary coil resistance.

Primary coil resistance between terminals 1 and 3.

STANDARD VALUE 0.9 - 1.2Ω

Secondary coil resistance between terminals 1 and 3 and secondary terminal.

STANDARD VALUE 20 - 29kΩ

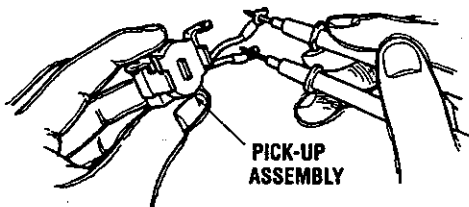


## PICK-UP ASSEMBLY

Use a tester to measure pick-up coil resistance.

STANDARD VALUE 420 - 540kΩ

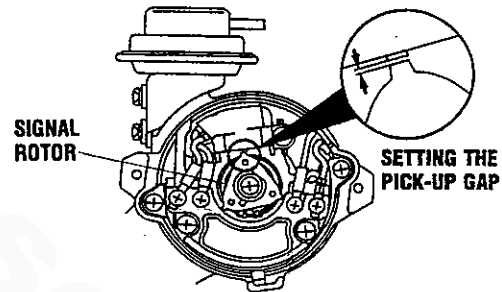
Check that when a screwdriver is passed near the iron core of the pick-up assembly the needle of the tester deflects.



## INSTALLATION OF PICK-UP ASSEMBLY

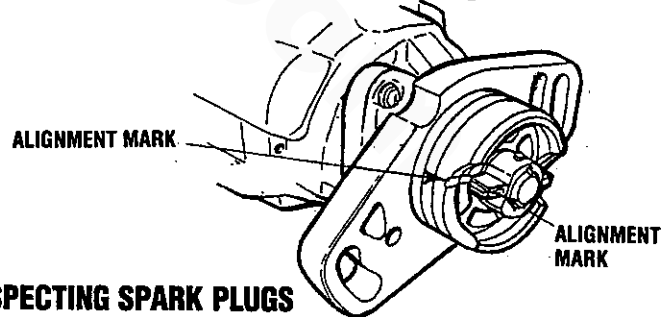
Adjust the gap between the signal rotor and the pick-up assembly.

STANDARD VALUE 0.05mm (.00197in) SB .275mm OR .010"



## DISTRIBUTOR INSTALLATION

1. Turn the crankshaft clockwise until the No.1 cylinder is a TDC on its compression stroke.
2. Align the alignment marks on the distributor housing and coupling.
3. Fit the distributor onto the engine, aligning the stud bolts with the slots in the distributor mounting flange.



## INSPECTING SPARK PLUGS

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

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



## TESTING THE IGNITER

### DESCRIPTION

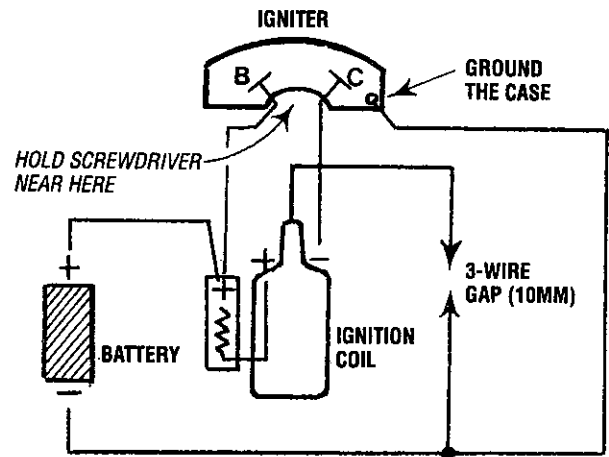
Prepare the wiring as shown so electric current will flow in the ignition coil.

Place the tip of a screwdriver close to the center of the pick-up coil of the igniter to see if sparks occur. If sparks occur, the igniter is good.

**CAUTION:** *Never bring a magnet near the center of the pick-up coil.*

*Do not mix up the wire connections to terminals B and C as that would damage the igniter.*

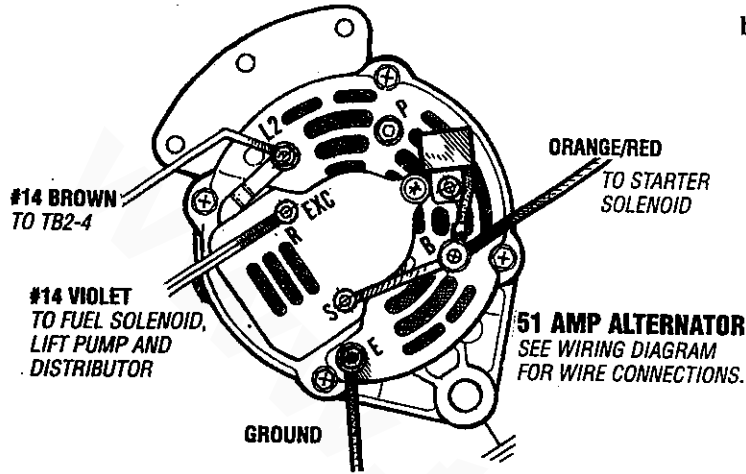
*If the distributor is operated with the external resistor left shorted, the igniter and coil will overheat.*



TESTING DIAGRAM

**ALTERNATOR**

The charging system consists of a DC belt driven alternator with a voltage regulator, an engine DC wiring harness, a mounted DC circuit breaker and a battery with connecting cables. Because of the use of integrated circuits (IC's), the electronic voltage regulator is very compact and is mounted internally or on the back of the alternator.



**ALTERNATOR TROUBLESHOOTING**

**WARNING:** A failed alternator can become very hot. Do not touch until the alternator has cooled down.

Use this troubleshooting section to determine if a problem exists with the charging circuit or with the alternator. If it is determined that the alternator or voltage regulator is faulty, have a qualified technician check it.

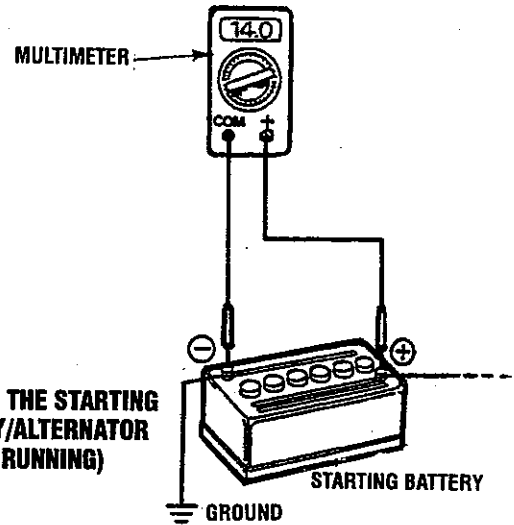
The alternator charging circuit charges the starting battery and the service battery. An isolator with a diode, a solenoid or a battery selector switch is usually mounted in the circuit to isolate the batteries so the starting battery is not discharged along with the service battery. If the alternator is charging the starting battery but not the service battery, the problem is in the service battery's charging circuit and not with the alternator.

**Testing the Alternator**

**CAUTION:** Before starting the engine make certain that everyone is clear of moving parts! Keep away from sheaves and belts during test procedures.

**WARNING:** When testing with a multimeter: DC and AC circuits are often mixed together in marine applications. Always disconnect a shore power cord, isolate DC and AC converters, and shut down the engine before performing DC testing. No AC tests should be made without a proper knowledge of AC circuits.

1. Start the engine.
2. After the engine has run for a few minutes, measure the starting battery voltage at the battery terminals using a multimeter set on DC volts.
  - a. If the voltage is increasing toward 14 volts, the alternator is working; omit Steps 3 through 8 and go directly to "Checking the Service Battery" on the next page.
  - b. If the voltage remains around 12 volts, a problem exists with either the alternator or the charging circuit; continue with Steps 3 through 8.

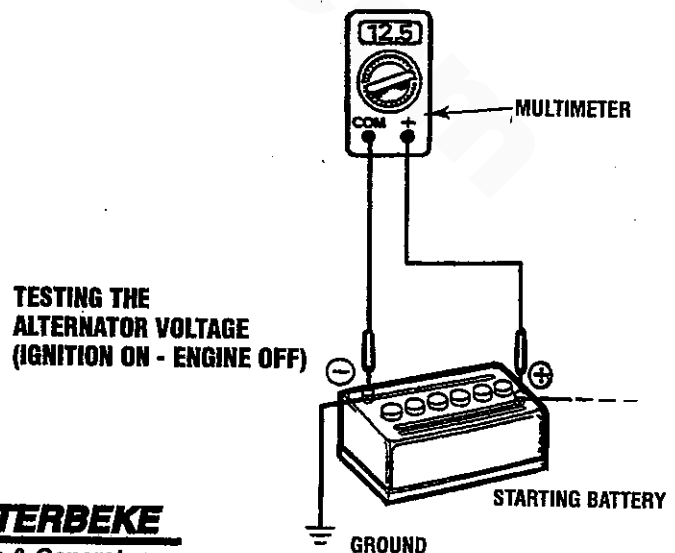


**TESTING THE STARTING BATTERY/ALTERNATOR (ENGINE RUNNING)**

3. Turn off the engine. Inspect all wiring and connections. Ensure that the battery terminals and the engine ground connections are tight and clean.

**CAUTION:** To avoid damage to the battery charging circuit, never shut off the engine battery switch when the engine is running!

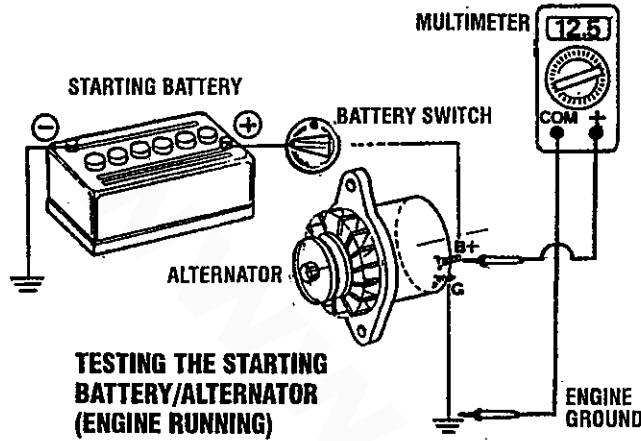
4. If a battery selector switch is in the charging circuit, ensure that it is on the correct setting.
5. Turn on the ignition switch, but do not start the engine.
6. Check the battery voltage. If the battery is in good condition, the reading should be 12 to 13 volts.



**TESTING THE ALTERNATOR VOLTAGE (IGNITION ON - ENGINE OFF)**



7. Now check the voltage between the alternator output terminal (B+) and ground. If the circuit is good, the voltage at the alternator will be the same as the battery, or if an isolator is in the circuit the alternator voltage will be zero. If neither of the above is true, a problem exists in the circuit between the alternator and the battery. Check all the connections — look for an opening in the charging circuit.



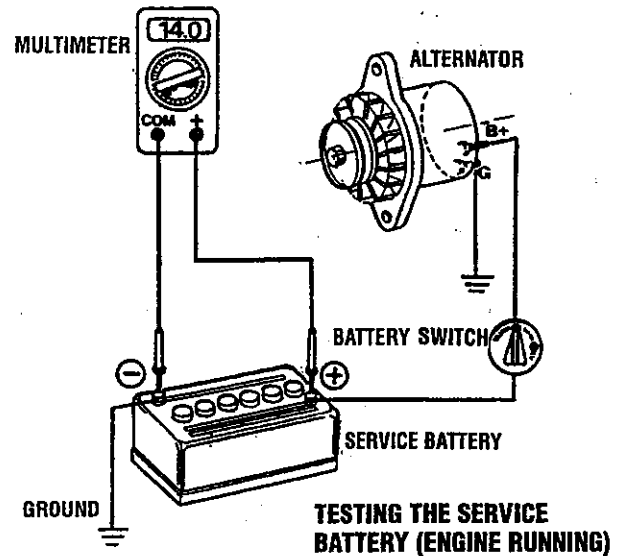
8. Start the engine again. Check the voltage between the alternator output and ground.  
 The voltage reading for a properly operating alternator should be between 13.5 and 14.5 volts. If your alternator is over- or under-charging, have it repaired at a reliable service facility.

**NOTE:** Before removing the alternator for repair, use a voltmeter to ensure that 12 volts DC excitation is present at the EXC terminal if the previous test showed only battery voltage at the B output terminal.

If 12 volts is not present at the EXC terminal, trace the wiring and look for breaks and poor connections.

### Checking the Service Battery

Check the voltage of the service battery. This battery should have a voltage between 13 and 14 volts when the engine is running. If not, there is a problem in the service battery charging circuit. Troubleshoot the service battery charging circuit by checking the wiring and connections, the solenoid, isolator, battery switch, and the battery itself.



**CAUTION:** To avoid damaging the alternator diodes, do not use a high voltage tester (i.e. a megger) when performing tests on the alternator charging circuit.

### 12 VOLT DC CONTROL CIRCUIT

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

**CAUTION:** To avoid damage to the battery charging circuit, never shut off the engine battery switch while the engine is running. Shut off the engine battery switch, however, to avoid electrical shorts when working on the engine's electrical circuit.

### BATTERY

The minimum recommended capacity of the battery used in the engine's 12 volt DC control circuit is 600 – 900 Cold Cranking Amps (CCA).

### Battery Care

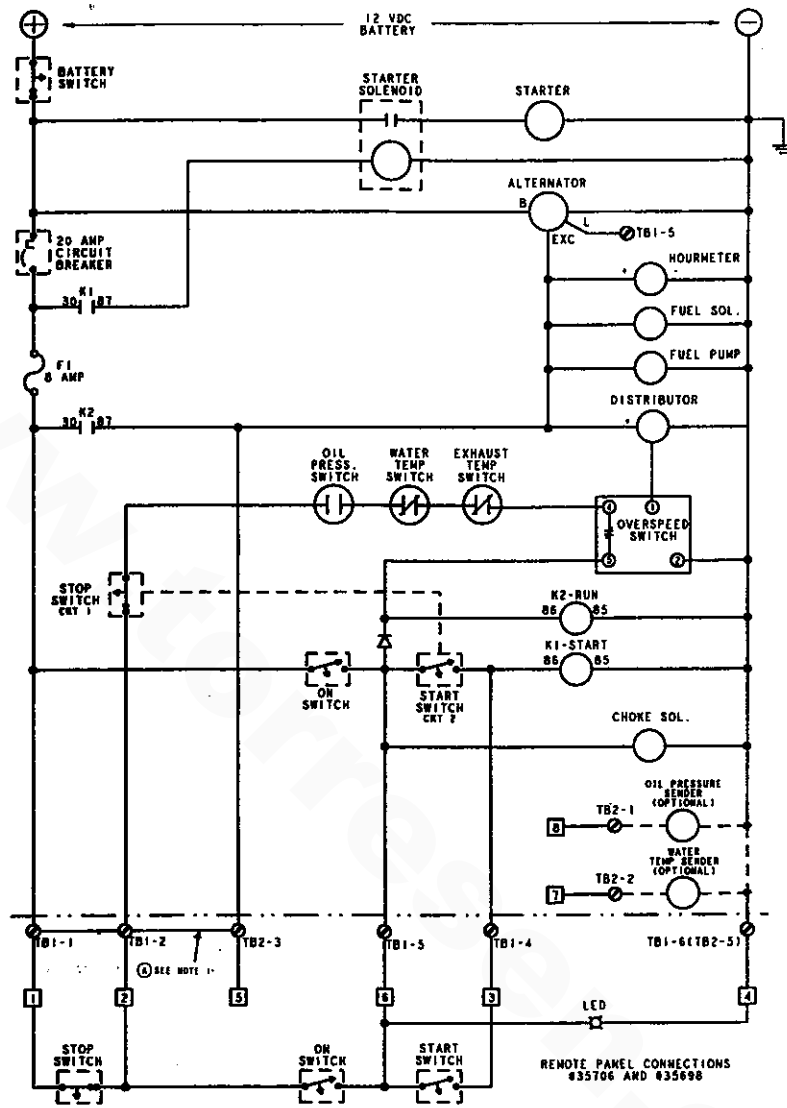
Review the manufacturer's recommendations and then establish a systematic maintenance schedule for your engine's starting batteries and house batteries.

- Monitor your voltmeter for proper charging during engine operation.
- Check the electrolyte level and specific gravity with a hydrometer.
- Use only distilled water to bring electrolytes to a proper level.
- Make certain that battery cable connections are clean and tight to the battery posts (and to your engine).
- Keep your batteries clean and free of corrosion.

**WARNING:** Sulfuric acid in lead batteries can cause severe burns on skin and damage clothing. Wear protective gear.

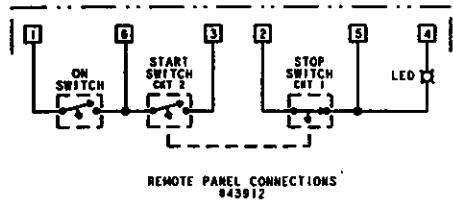


# #46094



NOTES:  
 1. REMOVE JUMPER (ON 15 PIN PLUG) BETWEEN TB1-2 AND TB2-3 WHEN USING A REMOTE PANEL.

□ DENOTES REMOTE CONNECTOR PIN NUMBERS



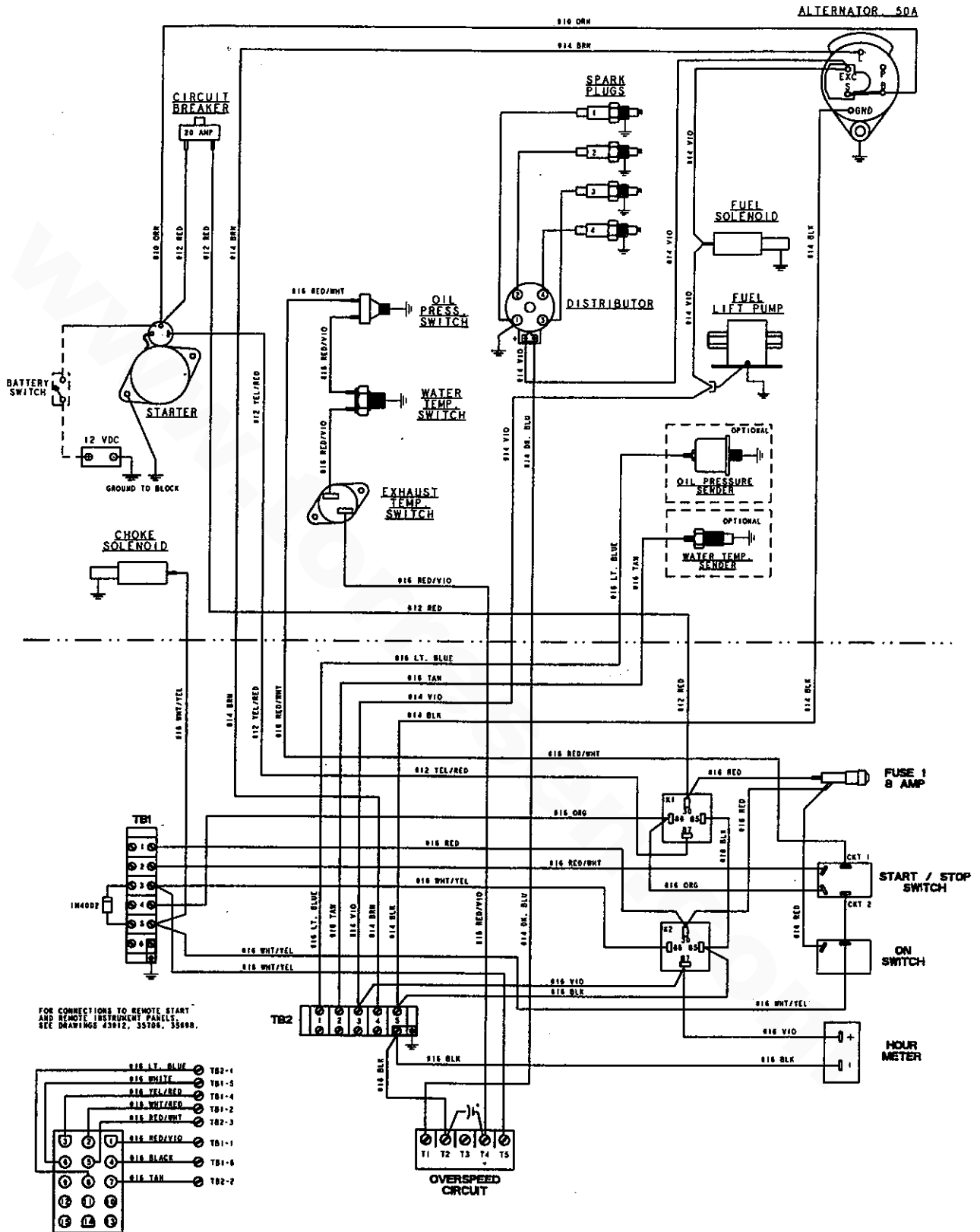
REMOTE PANEL CONNECTIONS 443912



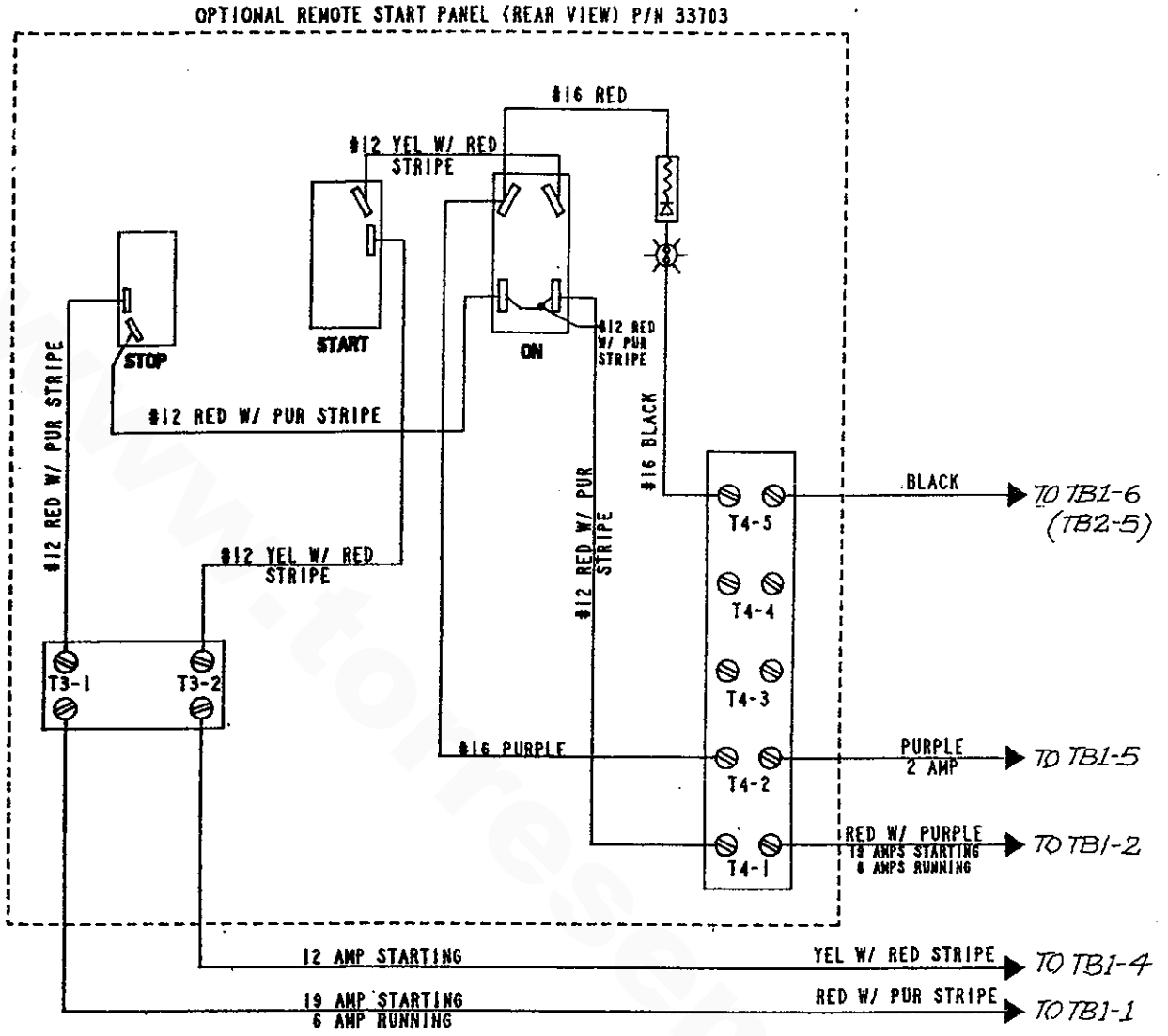


# WIRING DIAGRAM GASOLINE GENERATORS

## #46094



**WIRING DIAGRAM #035706**



**NOTE:** Use #14 wire for all connections up to 100', increase to #12 wire for connections over 100'.

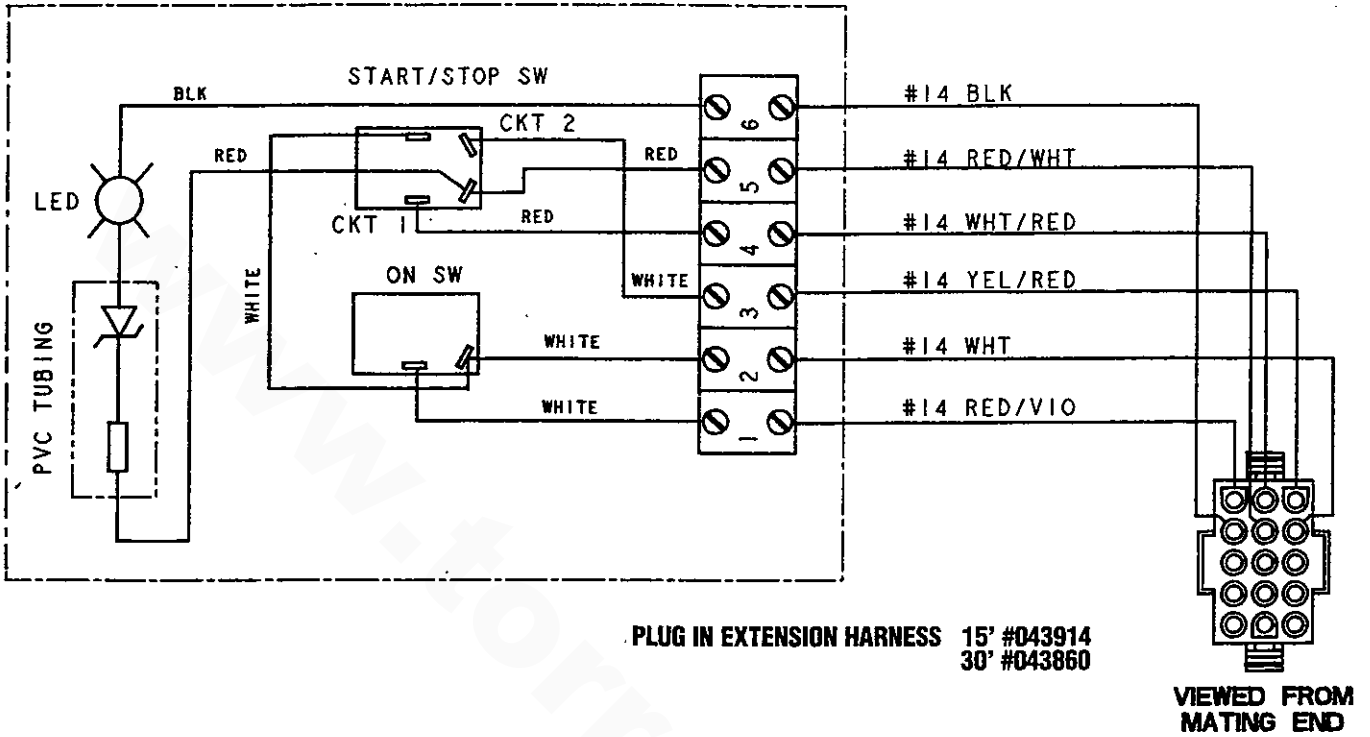
**NOTE:** When installing this panel, remove the external plug connector.





# REMOTE PANEL WIRING SCHEMATIC #043912

REMOTE PANEL #043912



## ENGINE ADJUSTMENTS

### OIL PRESSURE

#### DESCRIPTION

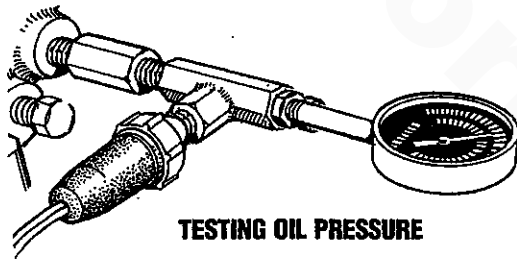
The lubricating system is a pressure feeding system using an oil pump. The engine oil is drawn from the oil sump by the oil pump, which drives the oil, under pressure, through the oil filter, oil cooler and various lubricating points in the engine. The oil then returns to the oil sump to repeat the continuous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

#### TESTING OIL PRESSURE

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

Oil Pressure Between 50 and 60 psi at 1800 rpm.

**Note:** A newly started (cold) engine may have an oil pressure up to 70 or 80 psi. A warmed engine can have an oil pressure as low as 30 psi. Oil pressure will vary depending on the load placed on the generator.



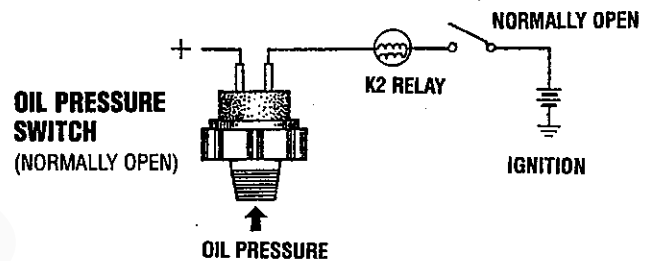
#### LOW OIL PRESSURE

The specified safe minimum oil pressure is 4.3 + 1.4 psi (0.3 + 0.1 kg/cm<sup>2</sup>). A gradual loss of oil pressure usually indicates worn bearings. For additional information on low oil pressure readings, see the *ENGINE TROUBLESHOOTING* chart.

#### OIL PRESSURE SWITCH

The generator is fitted with an oil pressure sender and an oil pressure shutdown switch. Should the engine's oil pressure drop below the safe minimum, the switch will open and shut the engine down to prevent damage.

**⚠ CAUTION: OIL PRESSURE SWITCH-Do not use lock pliers, vise grips or pipe wrenches on the oil pressure switch. Use the correct socket which is available from Snap-on, Proto, New Britain and others. Damage to the switch will cause oil leaks and/or switch failure.**

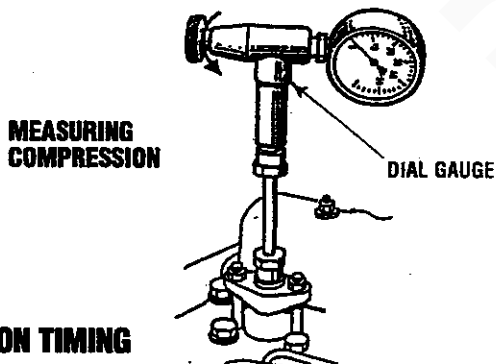


### ENGINE COMPRESSION TEST

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

**COMPRESSION PRESSURE SHOULD NOT DIFFER BY MORE THAN 14 psi (100Kpa)**

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



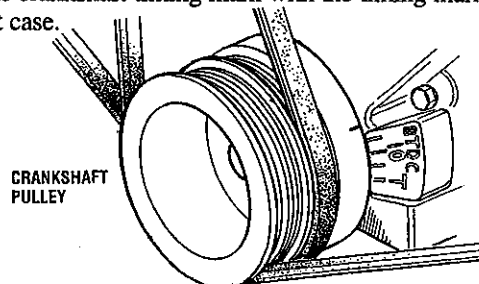
### IGNITION TIMING

1. Attach a timing light to the #1 spark plug and mark the front crankshaft timing groove and the timing mark on the scale embossed on the engine's front cover. Each timing mark represents 5°.
2. Start the engine and warm the engine to its normal operating temperature.
3. Using the timing light, align the timing groove in the front crankshaft pulley with the proper timing mark on the ignition timing scale embossed on the engine's front cover. Do this by loosening and slowly rotating the distributor body. Refer to the timing specifications:

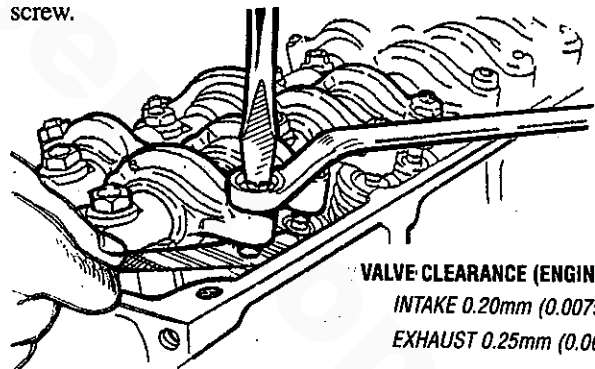
**IGNITION TIMING AT 1800 RPM: 20° BTDC ±1°**

### VALVE CLEARANCE ADJUSTMENT

1. Start the engine and allow it to warm up until the engine coolant reaches operating temperature.
2. Remove all spark plugs from the cylinder head for easy inspection.
3. Remove the rocker cover.
4. Align the crankshaft timing mark with the timing mark on the front case.



5. Move the rocker arms on the No.1 and No.4 cylinders up and down by hand to determine which cylinder has its piston at the top dead center on the compression stroke. If both intake and exhaust valve rocker arms have a valve lash, the piston in the cylinder corresponding to these rocker arms is at the top dead center on the compression stroke.
6. Valve clearance inspection and adjustment can be performed on rocker arms indicated by the white arrow mark when the No.1 cylinder piston is at the top dead center on the compression stroke, and on rocker arms indicated by the black arrow mark when the No.4 cylinder piston is at the top dead center on the compression stroke.
7. Measure the valve clearance. If the valve clearance is not as specified, loosen the rocker arm lock nut and adjust the clearing using a feeler gauge while turning the adjusting screw.



8. While holding the adjusting screw with a screwdriver to prevent it from turning, tighten the lock nut to the specified torque of 15 Nm.
9. Rotate clockwise the crankshaft one complete turn (360°)
10. Repeat steps 7 and 8 on the other valves.
11. Install the rocker cover.
12. Install the spark plugs and tighten to 25 Nm.

### SPARK PLUGS

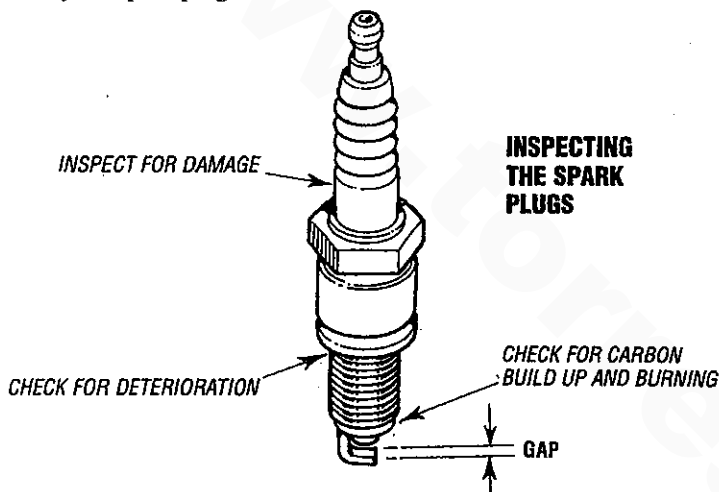
The spark plugs should be cleaned and regapped after the first 50 hour break-in period, then inspected every 250 hours thereafter and replaced as needed.

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

SPARK PLUG GAP:  $0.031 \pm 0.002$  in. (0.8 - 0.05 mm).

SPARK PLUG TORQUE: 25 Nm. (18.45 ft-lb)

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

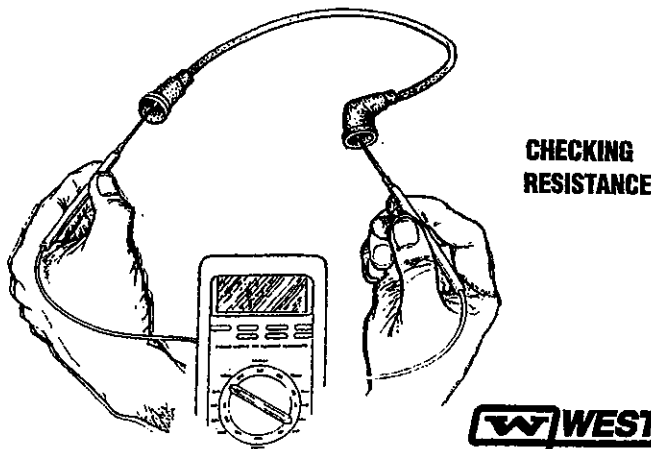


### HIGH TENSION CORDS (IGNITION WIRES)

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 plugs, grasp and twist the molded cap, then pull the cap off the spark plug.

The resistance value is 410 ohm per inch of wire.



### DRIVE BELT ADJUSTMENT

The drive belts must be properly tensioned. Excessive drive belt tension can cause rapid wear of the belts 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.

This 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/alternator drive, loosen the two governor 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 alternator drive belt, slide the alternator 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.

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

6. Operate the engine for about 5 minutes, then shut down the engine and recheck the belts tension.
7. Replace the belt guard.

# CARBURETOR ADJUSTMENTS

## CARBURETOR

The carburetor is a single barrel, down-draft type with a cleanable metal screen air intake filter/spark arrester. The choke is operated by a 12-VOLT solenoid activated when the ON switch is depressed.

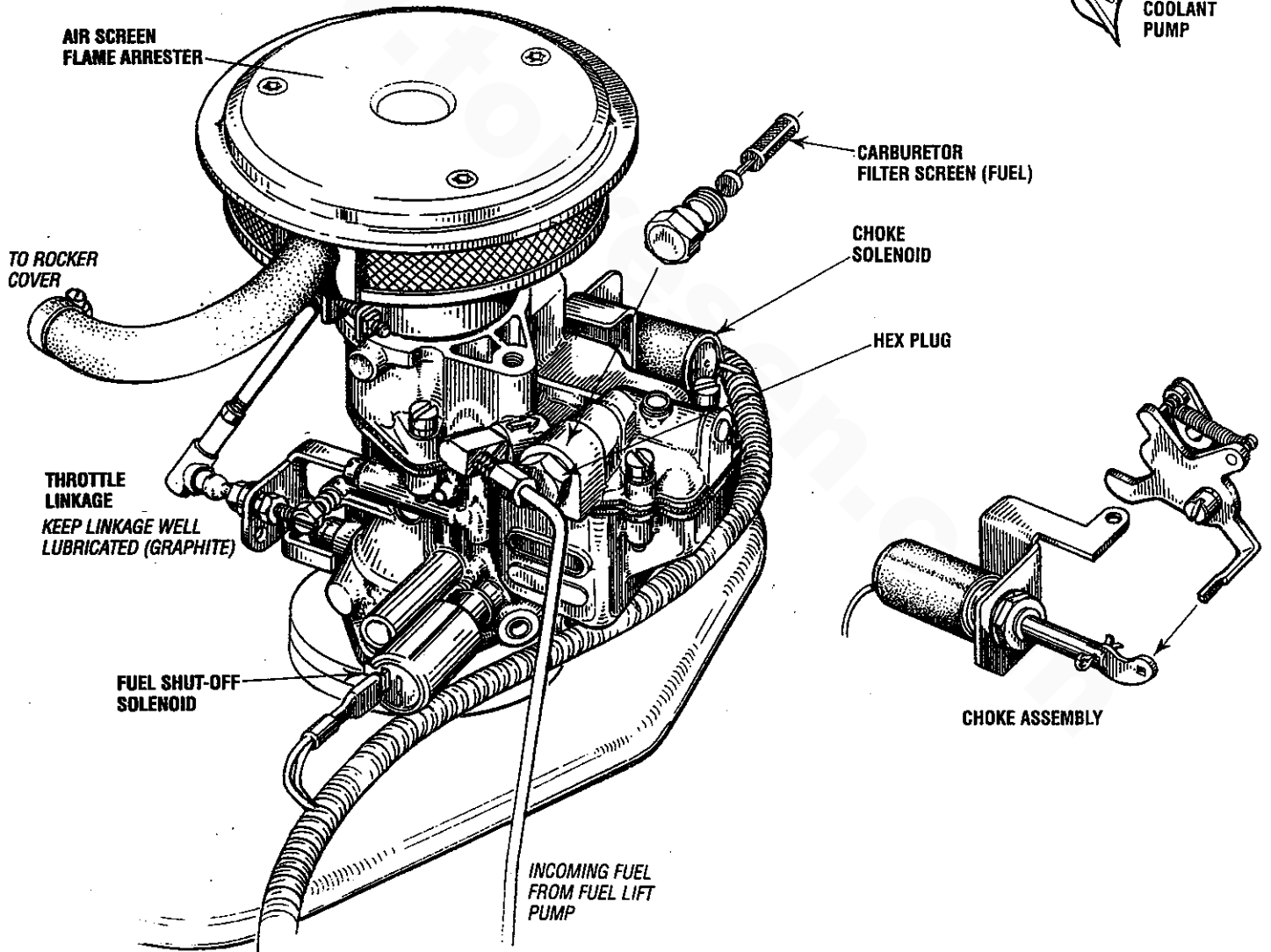
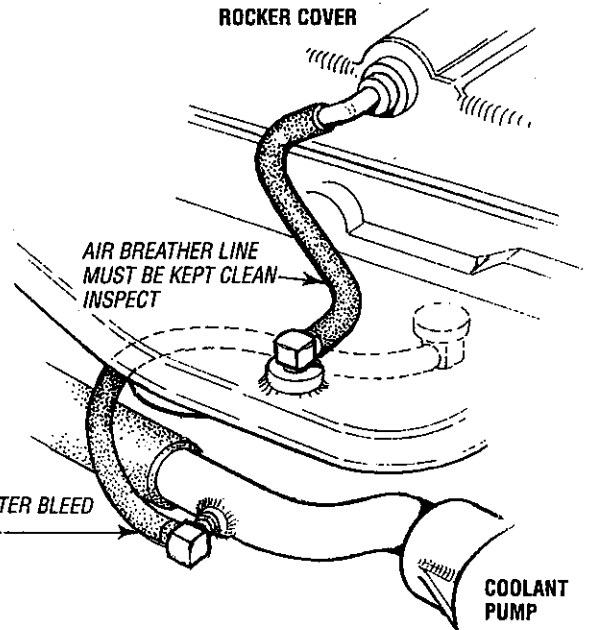
### Air Screen/Flame Arrester

The air screen/flame arrester can easily be removed by releasing the hold-down clamp. Clean after the first 50 hours of operation, every 100 hours from then on. Clean the air screen in a water soluble cleaner such as GUNK.

### Carburetor Filter Screen

Clean this filter element after the first 50 hours of operation, then clean and inspect every 250 operating hours. Replace the screen if necessary. Tighten the plug and make certain there are no leaks.

*NOTE: CARBURETOR MODELS MAY VARY ON DIFFERENT GENERATORS*





## ENGINE ADJUSTMENTS

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

### ENGINE SPEED (HERTZ) ADJUSTMENT

#### Governor

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

#### Governor Adjustments

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

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

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

1. **Increase/Decrease Speed Adjustment.** This adjusting bolt sets the no-load speed of the engine. (The linkage arm between the governor arm and throttle lever should be adjusted to hold the throttle full open when the engine is not running.) Make sure this linkage moves freely and that the ball joint connectors are properly lubricated. Use graphite lube for this purpose. Disconnect the ball joint and apply graphite lube to the inside of the joint.
2. **Hunting/Regulation Adjustment.** If the variation in engine speed between no-load and full-load is too great, adjust this eye bolt to draw the spring closer to the lever hub. The increase/decrease speed bolt may need to be adjusted as well.  
If the governor surges under load, adjust this eye bolt to move the spring away from the lever hub (check speed adjustment).
3. **Bumper Screw Adjustment.** This screw is used to remove a no-load surge ONLY. NEVER turn the bumper screw into the governor so far that it increases the no-load speed.

### Governor Maintenance

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

**NOTE:** Free movement of this linkage arm is important for proper governor/throttle operation.

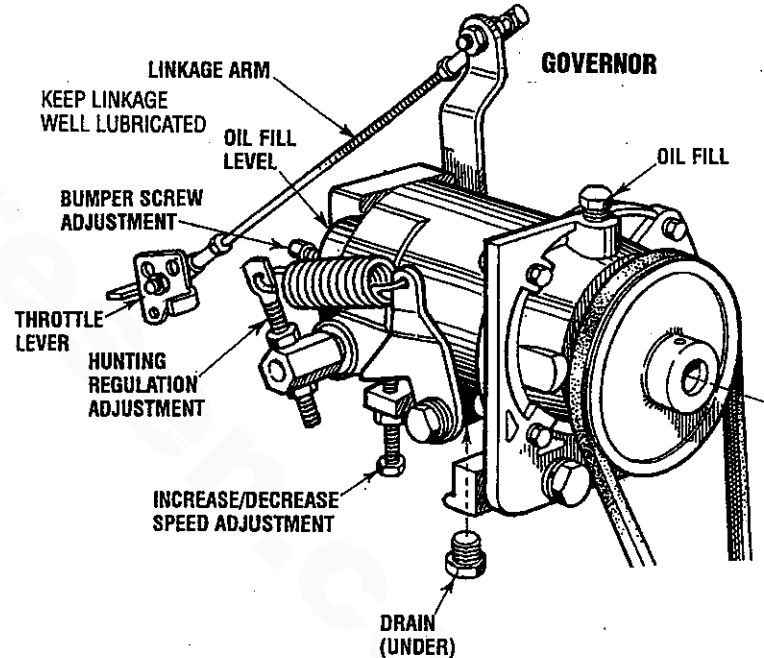
2. Governor oil capacity – 3 ounces 10/30 engine oil.

**NOTE:** Do not overfill the governor.

3. Change the governor oil every 250 hours of operation.

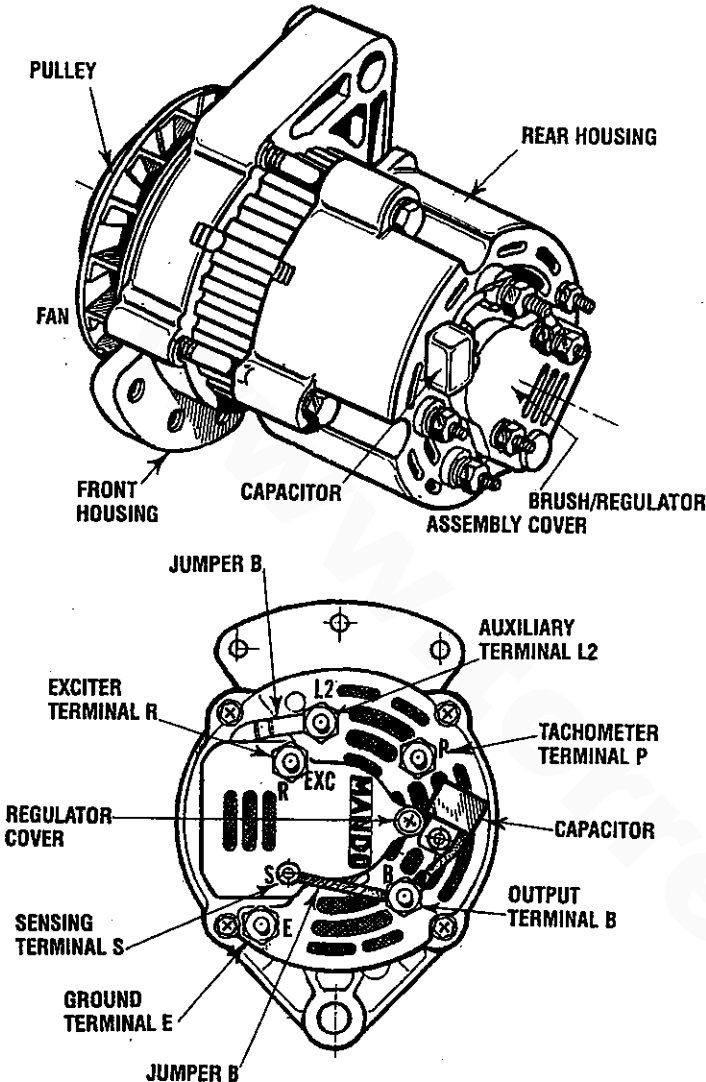
To change the oil, remove the governor from the engine, remove the oil fill and the fill level plug, and drain all the oil. Reinstall on the engine and fill with 3 ounces of 10/30 engine oil. Replace the two plugs.

4. Periodically adjust the governor belt tension (see **DRIVE BELTS ADJUSTMENT**). Since belts stretch slightly, this stretching will, to some degree, affect the governor's action.



# WESTERBEKE 51A MANDO ALTERNATOR

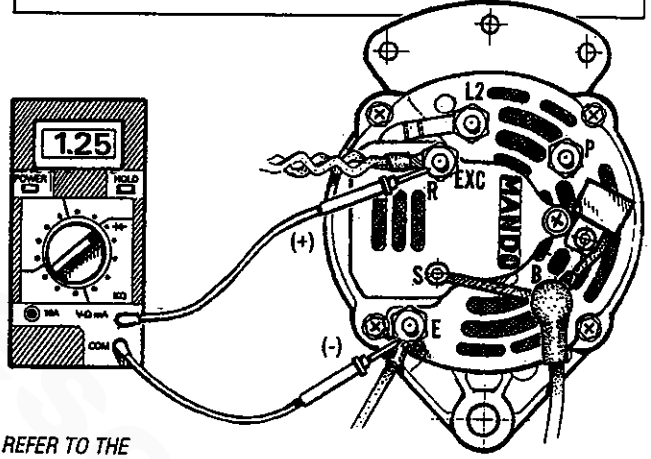
## DISASSEMBLY AND TESTING



**⚠ WARNING:** A failed alternator can become very hot. Do not touch until the alternator has cooled down.

**⚠ WARNING:** Before starting the engine, make certain that everyone is clear of moving parts! Keep away from sheaves and belts during test procedures.

**⚠ WARNING:** Multimeters and DC Circuits  
DC and AC circuits are often mixed together in marine applications. Always disconnect shore power cords, isolate DC and AC converters and shut down generators before performing DC testing. No AC tests should be made without proper knowledge of AC circuits.



REFER TO THE WIRING DIAGRAMS FOR THE ABOVE WIRING HARNESS CONNECTIONS

### TESTING THE OUTPUT CIRCUIT

1. Connect the positive voltmeter lead to the output terminal B and connect the negative lead to the ground terminal E on the alternator.
2. Wiggle the engine wiring harness while observing the voltmeter. The meter should indicate the approximate battery voltage, and should not vary. If no reading is obtained, or if the reading varies, check the alternator output circuit for loose or dirty connections or damaged wiring.

**NOTE:** Prior to any alternator testing, inspect the entire alternator system wiring for defects. Check all connections for tightness and cleanliness, particularly battery cable clamps and battery terminals. Inspect the alternator drive belt for excessive wear and replace if necessary. Also adjust for proper belt tension.

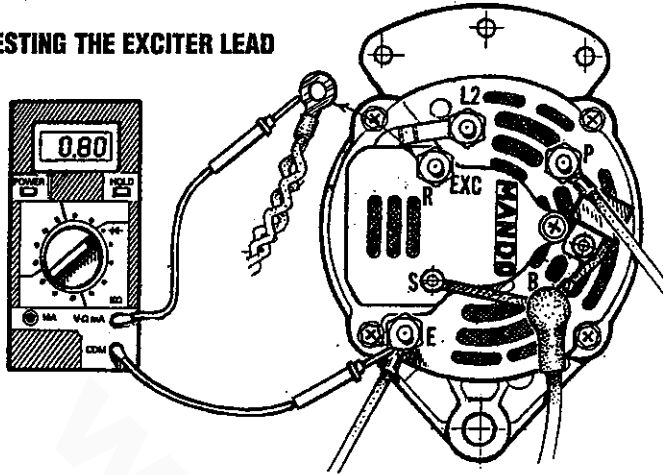
### TESTING THE EXCITATION CIRCUIT

1. Connect the positive (+) voltmeter lead to the excitation terminal R on the alternator and the negative (-) lead to the ground terminal E on the alternator.
2. Turn the ignition switch to the on position and note the voltmeter reading. The reading should be 1.3 to 2.5 volts (see illustration).
3. If the reading is between .75 and 1.1 volts, the rotor field circuit probably is shorted or grounded. Disassemble the alternator and test the rotor as described under *CLEAN AND TEST ALTERNATOR COMPONENTS* in this section.
4. If the reading is between 6.0 and 7.0 volts, the rotor field circuit probably is open. Remove the regulator and inspect it for worn brushes or dirty slip rings. Replace the brushes if they are less than 1/4in. (6 mm) long. If the brushes and slip rings are in good condition, disassemble the alternator and test the rotor, as outlined under *CLEAN AND TEST ALTERNATOR COMPONENTS* in this section.



# MANDO ALTERNATOR SERVICE

## TESTING THE EXCITER LEAD



5. If no reading is obtained, an open exists in the alternator-excitation lead or in the excitation circuit of the regulator. Disconnect the lead from exc terminal R. Connect the positive voltmeter lead to the excitation lead and the negative voltmeter lead to ground terminal E. If the voltmeter now indicates an approximate battery voltage, the voltage regulator is defective and must be replaced. If no voltage is indicated, check the excitation circuit for loose or dirty connections or damaged wiring.

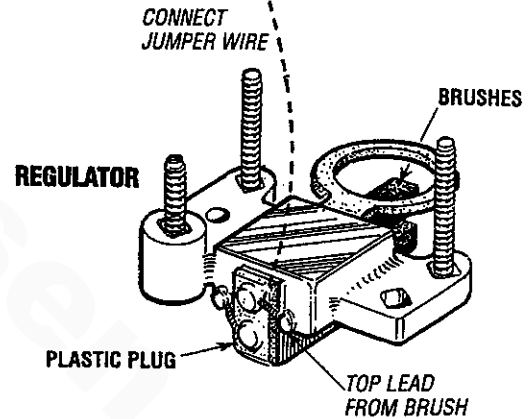
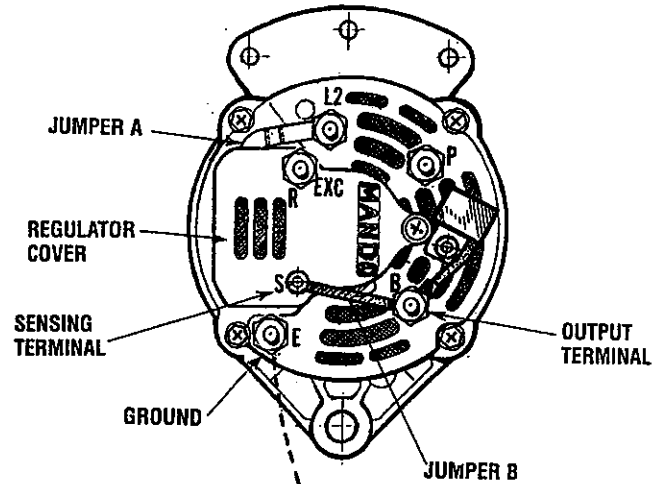
## TEST VOLTAGE REGULATOR

Perform this test to determine if the voltage regulator is operating correctly, using a 0 – 20 volt DC voltmeter.

**NOTE:** The battery must be fully charged to obtain a proper voltage reading in this test. If necessary, charge the battery with a battery charger or allow the engine to run a sufficient length of time to fully charge the battery before taking a reading.

1. Connect the positive (+) voltmeter lead to the positive battery terminal and the negative (-) voltmeter lead to the negative terminal.
2. Start the engine and run it at fast idle until the engine reaches its normal operating temperature. Adjust the engine speed to 1500 – 2000 rpm and observe the voltmeter for the highest reading. The reading should be between 13.7 and 14.7 volts.
3. If the reading is high, check for a loose or dirty alternator ground lead connection. If the connection is good, the voltage regulator is faulty and must be replaced. Be sure to disconnect the battery cables before attempting to remove the alternator.
4. If the reading is low:
  - a. Stop the engine and remove the alternator wiring connections.
  - b. Remove the Phillips cover screw from the regulator cover (see illustration).
  - c. Remove the nut from the output terminal and the nut from the sensing terminal, and remove Jumper (A).
  - d. Remove another nut from the sensing terminal, and the nut from the excitation terminal.

- e. Remove the regulator cover.
- f. Temporarily re-install Jumper (A) and all associated nuts. Leave Jumper (B) installed.
- g. Remove the plastic plug from the side of the regulator.
- h. Connect a jumper between the top brush lead and the ground.

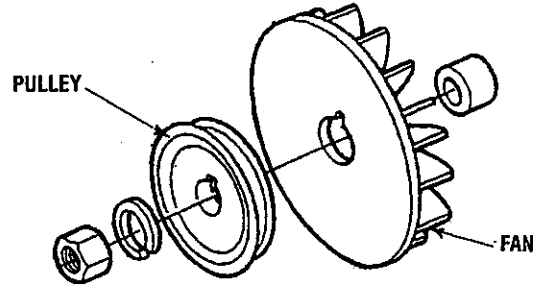
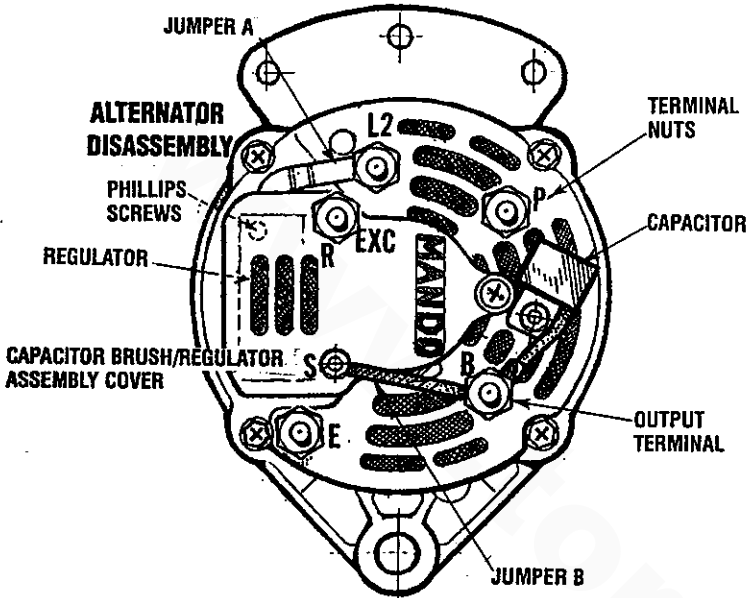


- i. Repeat steps 1 and 2.
- NOTE:** Do not let the voltage exceed 16 volts.
- j. If a voltmeter reading of 14.5 volts or above is now obtained, the voltage regulator is faulty and must be replaced. If the voltmeter reading is below 14.5 volts, inspect the brushes and slip rings for wear, dirt or damage. If the brushes and slip rings are good, the alternator is fault internally. Disassemble the alternator and test the components, as outlined in this section.

**REMOVE ALTERNATOR**

1. Disconnect the negative (-) battery ground cable.
2. Disconnect the wiring leads.
3. Loosen the screws. Holding the alternator, rotate it toward the engine and lift the belt off the pulley.
4. Remove the screws and washers and remove the alternator.

10. Place an oversized V-belt around the pulley and fasten the pulley in a vise.
11. Use a 7/8 in. box wrench to loosen and remove the pulley nut.
12. Remove the pulley nut, lockwasher, pulley, fan, and spacer.



**PULLEY AND FAN COMPONENTS**

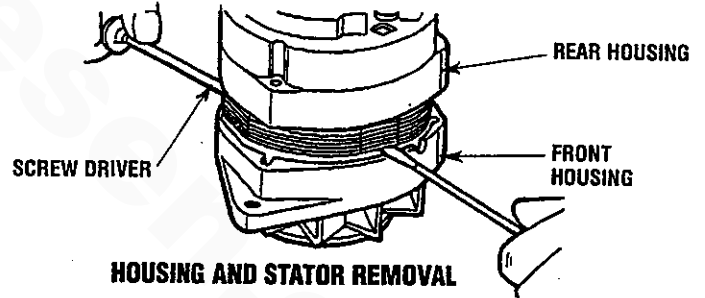
**CAUTION:** DO NOT insert screwdriver blades more than 1/16 in. (1.6 mm). Damage to the stator winding could result from deeper penetration.

**NOTE:** Score the stator, and the front and rear housings so the unit may be reassembled correctly.

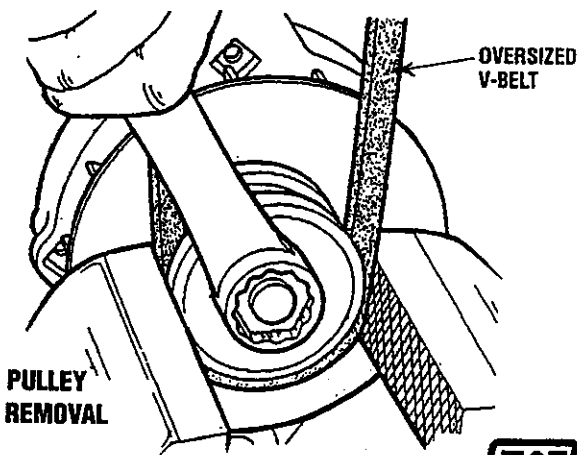
**DISASSEMBLE ALTERNATOR**

1. Remove the terminal nuts to remove the jumper (see illustration).
2. Remove the remaining terminal nuts.
3. Remove the capacitor.
4. Remove the Phillips screw from the regulator cover.
5. Remove the brush/regulator-assembly cover.
6. Remove the nut from the terminal.
7. Remove the jumper.
8. Remove the terminal insulators.
9. Remove the two Phillips screws and remove the brush/regulator assembly.

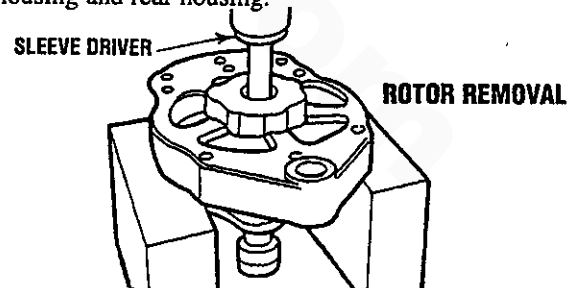
13. Remove the four through-bolts and carefully pry the front housing away from the rear housing using two screwdrivers.



**HOUSING AND STATOR REMOVAL**



14. Carefully push the rotor assembly out of the front housing and rear housing.

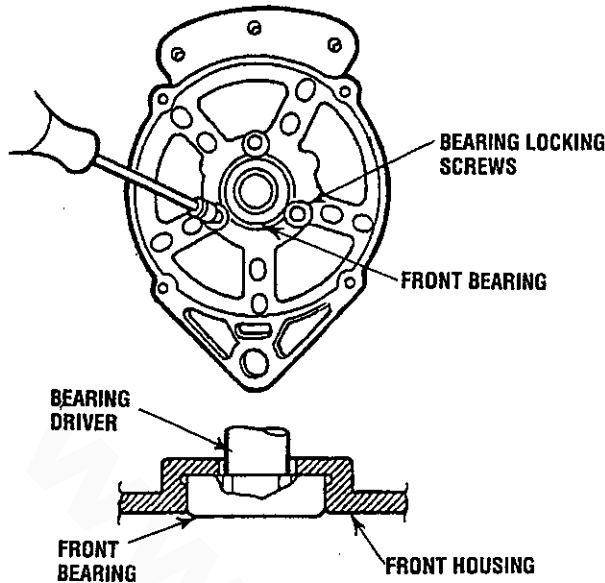


**NOTE:** If the bearing is removed from the housing, a new bearing must be installed.

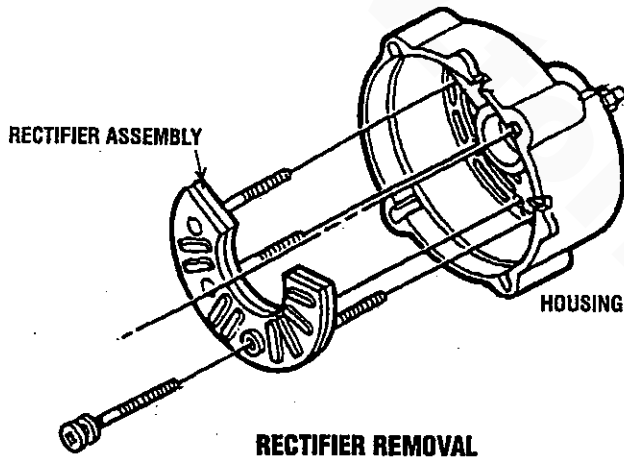
15. After removing the three bearing locking screws, carefully press the front bearing out of the housing. Press against the inner race of the bearing.



**MANDO ALTERNATOR SERVICE**



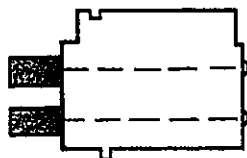
16. Remove the rectifier assembly by removing the Phillips screw and lifting out the assembly.



**CLEAN AND TEST ALTERNATOR COMPONENTS**

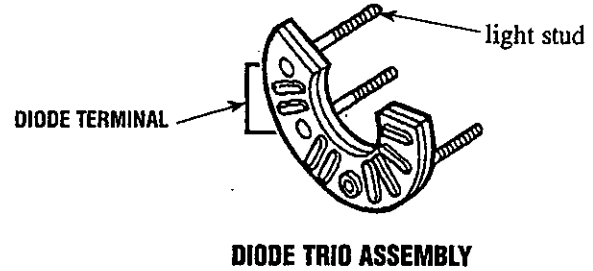
1. Inspect and test the brush/regulator assembly. The brush set may be reused if the brushes are 1/4 in. (6 mm) or longer. The brushes must not be oil soaked, cracked or grooved.

Test for continuity between 1 and 2, and 3 and 4 using a test lamp or an ohmmeter. These checks will indicate a good brush/regulator assembly; replace the complete assembly, if necessary.

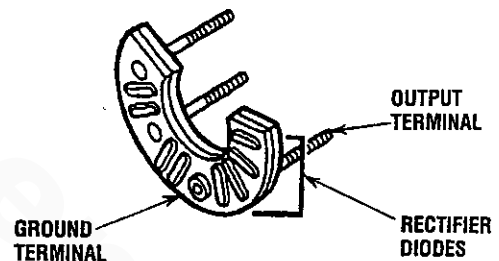


**TESTING BRUSH ASSEMBLY**

2. Inspect and test the diode-trio assembly:
  - a. Using a commercial diode tester, a 12-volt DC test lamp or an ohmmeter, check the resistance between each of the three diode terminals and the indicator light stud.



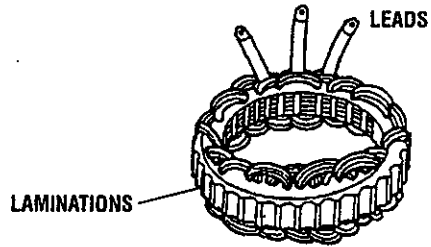
- b. Reverse the tester leads and repeat the resistance checks.
  - c. A very low resistance should be indicated in one direction and a very high resistance should be indicated in the other direction if the diodes are normal.
  - d. If any diode appears to be defective, replace the complete assembly. Do not attempt to replace an individual diode.
3. Test the diode-rectifier bridge as follows:
    - a. Using a commercial diode tester, check for continuity from each of three terminals to the output terminal.



- b. Reverse the tester leads and repeat Step a.
- c. Continuity should exist in only one direction and all diodes should check alike.
- d. Perform the same continuity checks between the three terminals and strap ground terminal. This should show continuity in only one direction through the diodes and all diodes should check alike.
- e. If any diode appears to be defective, replace the rectifier assembly.



4. Clean and inspect the front and rear housings:
  - a. Inspect the rear housing for cracks or breaks in the casting, stripped threads or a damaged bearing bore. Replace the housing if any of these conditions exist.
  - b. Inspect the front housing for cracks, stripped or damaged threads in the adjusting ear, or an out-of-round bore in the mounting foot. If possible, correct slightly damaged threads using a tap. Replace the housing, if necessary.
  - c. If the housings are to be reused, clean them in solvent and dry with compressed air.

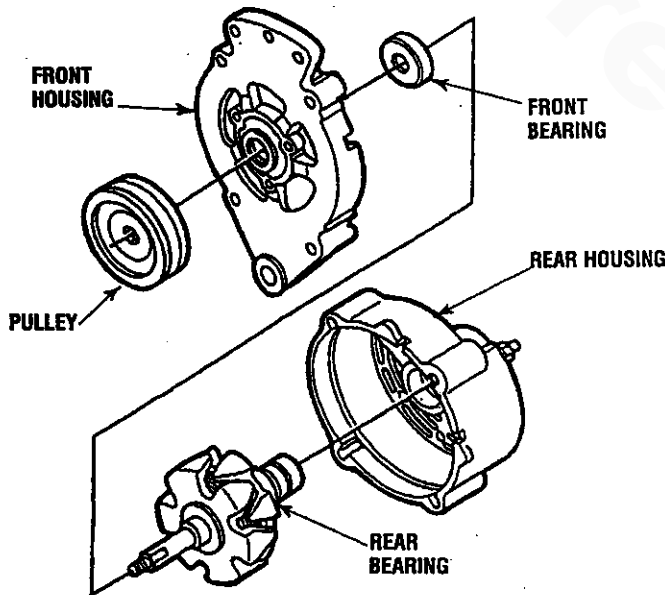


5. Clean and inspect the rotor shaft bearings:
 

**NOTE: Do not use a solvent on the rear rotor bearing since it is serviced as a unit with the rotor.**

  - a. The bearings should be wiped clean with a lint-free cloth containing a moderate amount of commercial solvent. Do not immerse a bearing in solvent, or use pressurized solvent or air.
  - b. Check the bearings for obvious damage, looseness or rough rotation. Replace a bearing if any doubt exists as to its condition.
 

**NOTE: If the rear rotor bearing needs replacement, replace the entire rotor.**
6. Inspect the belt pulley for rough or badly worn belt grooves or keyway, and for cracks or breaks. Remove minor burrs and correct minor surface damage; replace a badly worn or damaged pulley.



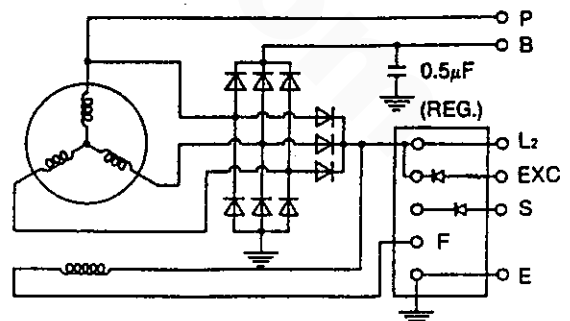
- b. Check the resistance from each lead (1, 2, and 3) to the laminations (4). There should be no continuity if the insulation is good.
- c. Inspect the stator windings for signs of discoloration. A discolored winding should be replaced.
- d. If a winding shows a high resistance or an open circuit between any two of the three winding terminals or indicates poor insulation between the windings and the laminations, the stator must be replaced.

8. Check the rotor assembly as follows:

**NOTE: If slip rings need to be replaced, you must replace the entire rotor.**

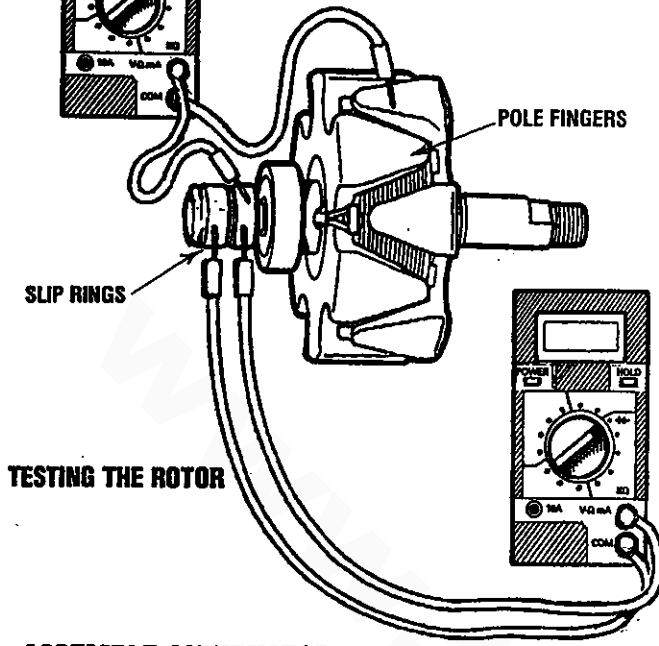
- a. Visually inspect for physical defects such as damaged shaft threads, worn or damaged bearing areas, burned or pitted slip rings or scuffed pole fingers.
  - b. Measure the winding resistance across the slip rings (A). Place the ohmmeter leads on the edges of the slip rings, not on the brush contact surfaces. The correct winding resistance at 70 – 80° F (21 – 27° C) is 4.1 to 4.7 ohms.
  - c. Minor burning or pitting of the slip ring surfaces can be removed using a crocus cloth. Thoroughly wipe the slip rings clean after polishing, removing all grit and dust.
  - d. Check for a grounded slip ring or rotor winding by measuring the resistance from each slip ring to the rotor body or pole finger (B). An open circuit should be indicated in both cases for a good rotor.
  - e. If the windings are defective or physical damage cannot be corrected, replace the rotor assembly.
9. Use a commercial capacitor checker to test the capacitor for capacity, shorts, leakage, and series resistance.

7. Test the stator windings as follows:
  - a. Using an ohmmeter or test lamp, check for continuity between all three leads (1, 2, and 3). A low ohm reading or lit test lamp should be observed.

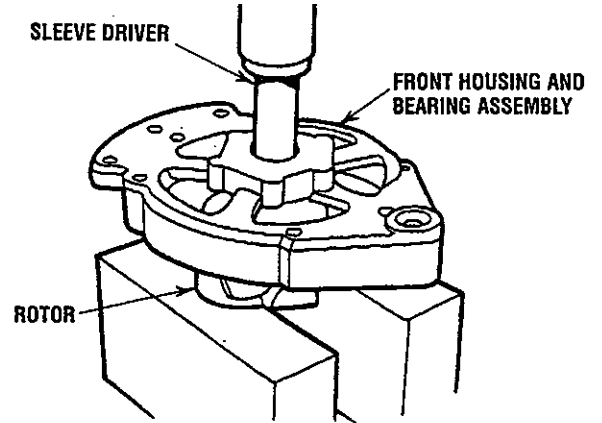


**INTERNAL CIRCUIT WIRING**





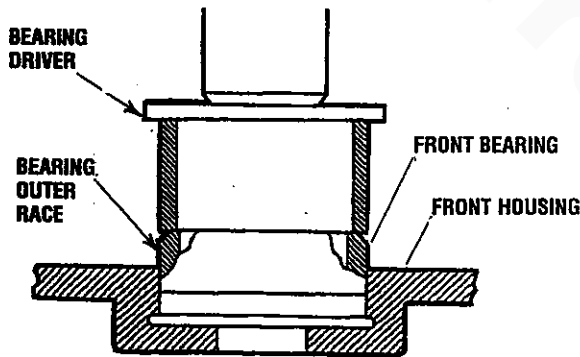
2. Place the rotor (pulley end up) on the bed of an arbor press, on two steel blocks.
3. Press the front housing and bearing assembly down onto the rotor shaft. Press against the bearing's inner race only, using a sleeve driver. Take care to insure that the rotor leads clear the steel blocks.



**INSTALLING THE FRONT HOUSING ON THE ROTOR ASSEMBLY**

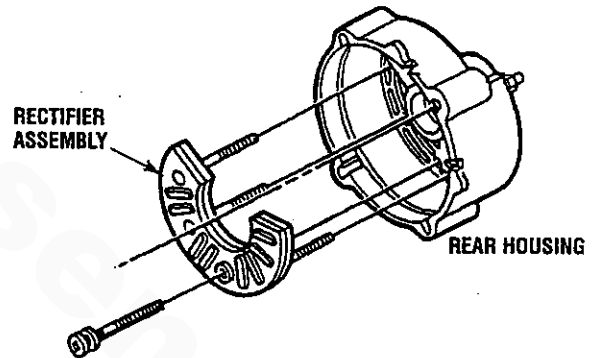
**ASSEMBLE ALTERNATOR**

1. Carefully press the front bearing into the front housing, pushing against the bearing's outer race using a bearing driver. Lock the bearing in place with screws.  
**TORQUE: 25 - 35 lb-in (2.8 - 4.0 Nm)**

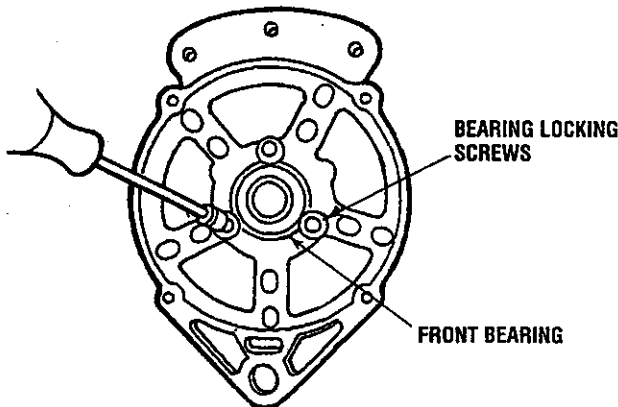


**FRONT BEARING ASSEMBLY**

4. Install the rectifier assembly into the rear housing.
5. Insert the Phillips screw and tighten it.



6. Assemble the front and rear housings as follows:
  - a. Put the stator winding in the front housing with the stator leads away from the front housing and the notches in the stator laminations aligned with the four through-bolt holes in the housing.
  - b. Align the scribe marks you made in the stator, and front and rear housings during disassembly.
  - c. Slip the rear housing into place over the rotor shaft. Align the mounting holes and put the stator leads through the holes at the top of the rear housing.
  - d. Install the four bolts and tighten them.  
**TORQUE: 35 - 65 lb-ft (4.0 - 7.3 Nm)**



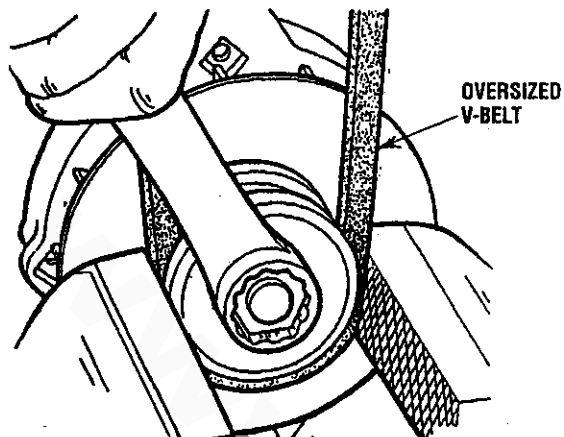
**ASSEMBLING THE BEARINGS**

**NOTE:** If the front housing is new, the through-bolt will not be tapped.



# MANDO ALTERNATOR SERVICE

7. Install the spacer and the fan. Then push the pulley, lockwasher and nut onto the shaft. Turn the nut a few turns.
8. Place an oversized V-belt around the pulley and fasten the pulley in a vise.



**INSTALLING THE PULLEY AND THE FAN NUT**

9. Use a torque wrench to the tighten the nut.  
*TORQUE: 35 - 50 lb-ft (47 - 68 Nm)*
10. Carefully install the brush/regulator assembly on the rear housing with the two mounting screws.
11. Install the small terminal insulators.
12. Install the large terminal insulator.
13. Install the jumper.
14. Install the nut on the terminal.
15. Install the brush/regulator assembly cover.
16. Install the Phillips screw for the brush/regulator assembly cover.  
*TORQUE: 25 - 35 lb-ft (2.8 - 5.1 Nm)*
17. Install the capacitor.
18. Install the terminal nuts.
19. Install the jumper.
20. Install the last terminal nut.

## INSTALL ALTERNATOR

1. Install the alternator, screws and washers.
2. Connect the wiring leads.
3. Put the belt on the alternator, crankshaft and coolant pump pulleys.
4. Adjust the alternator belt's tension (see *DRIVE BELT ADJUSTMENT* under *ENGINE ADJUSTMENTS*).

### MANDO ALTERNATOR SPECIFICATIONS

Battery Voltage	12 Volt
Maximum Speed	13500 RPM
Cut in Speed	Max. 2000 RPM (at exc.) Max. 1500 RPM (at L2)
Reg. Set Voltage	14.7 Volts
Ambient Temp.	-20°C - 100°C
Ground	Negative



# 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

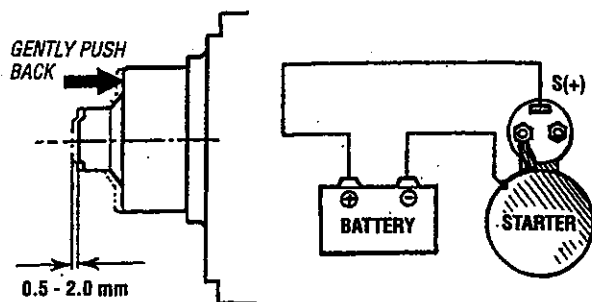
If any abnormality is found by the following tests, the starter should be disassembled and repaired.

### 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.

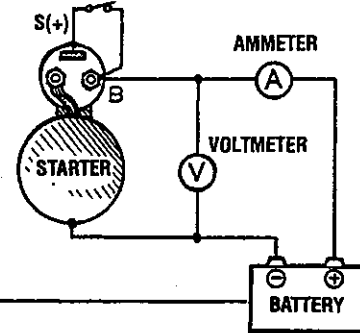
2. Lightly push the pinion back and measure the return stroke (called pinion gap).
3. If the pinion gap is not within the standard range, (0.5 to 2.0 mm), adjust it by increasing or decreasing the number of shims on the solenoid. The gap is decreased as the number of shims increases.



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.

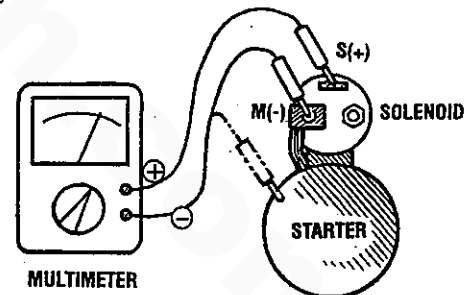


**CAUTION:** Use thick wires as much as possible and tighten every terminal securely. This is a solenoid shift-type starter which makes a rotating sound louder than that of a direct-drive type starter. When detecting starter rotation at the pinion tip, be careful not to come in contact with the pinion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



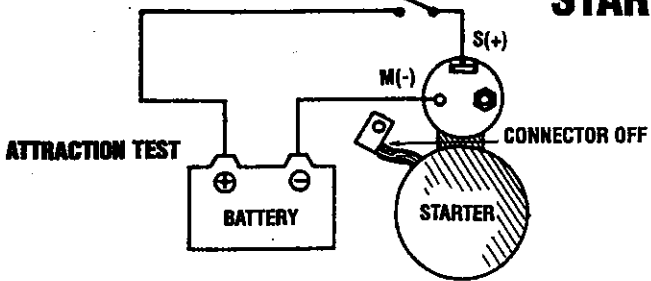
**NOTE:** Disconnect the wire from terminal M.

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.

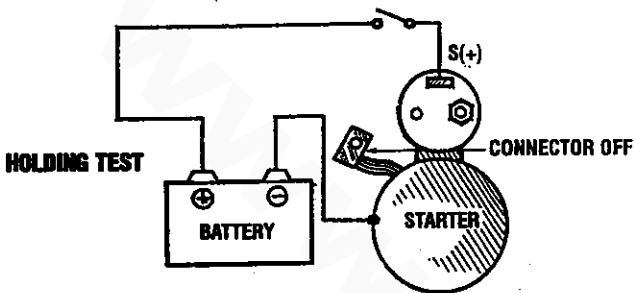


# STARTER MOTOR



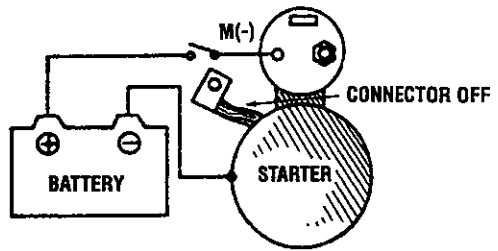
**ATTRACTION TEST**

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



**HOLDING TEST**

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

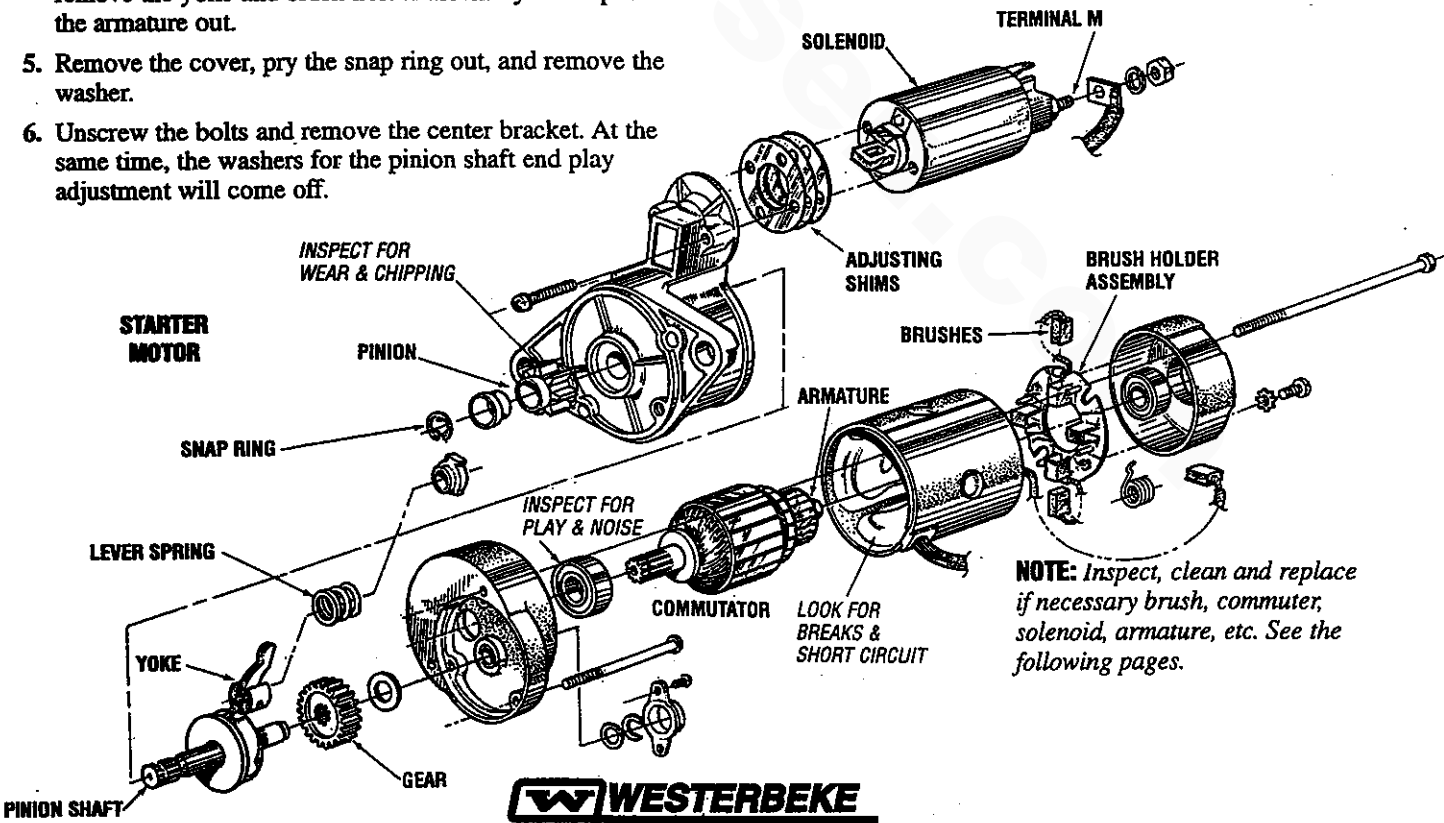


**RETURN TEST**

## STARTER DISASSEMBLY

1. Disconnect the wire from the solenoid terminal M (-).
2. Loosen the two screws fastening the solenoid. Remove the solenoid assembly.
3. Remove the two long through bolts and two screws fastening the brush holder. Remove the rear bracket.
4. With the brushes pulled away from the armature, remove the yoke and brush holder assembly. Then pull the armature out.
5. Remove the cover, pry the snap ring out, and remove the washer.
6. Unscrew the bolts and remove the center bracket. At the same time, the washers for the pinion shaft end play adjustment will come off.

7. Pull out the reduction gear lever and lever spring from the front bracket.
8. On the pinion side, pry the snap ring out, and pull out the pinion and pinion shaft.
9. At each end of the armature, remove the ball bearing with a bearing puller. It is impossible to replace the ball bearing press-fitted in the front bracket. If that bearing has worn off, replace the front bracket assembly.



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



# COLISEUM GENERATOR

## DESCRIPTION

The Coliseum (4-pole) generators are self-exciting, synchronous, brushless models. Brushless excitation is obtained by electromagnetic transmission of the excitation power through the air gap of the synchronous exciter. The generators are single-phase 4 leads at 60Hz and are manufactured and tested according to NEMA standards, ISO standards and IEC recommendations.

**Generator:** The generator design is based on a multilaminated magnetic circuit with salient poles on the rotor. The rotor is of a special compact construction with an integral damper cage and a field winding section conductor wound directly on the rotor. A special interpole fixation combined to the mechanical compactness of the winding ensures a highly efficient generator..

**Exciter:** The exciter is a six-pole synchronous generator with salient poles on the stator and a cylindrical armature on the rotor. The exciter rotor and the rotating rectifier are mounted on the shaft with the main generator rotor.

**Excitation System:** The system is excited automatically by means of residual magnetism of the magnetic circuits of the generator and exciter and stabilized by the permanent magnet in one of the exciter poles.

**Winding Connections:** The single-phase synchronous generator has 4 stator leads and can be configured to 120 or 240 volt output.

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

## 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, bearings are wearing or wear on shaft of bearing socket outside bearing has occurred. 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 vessels living quarters. **Carbon monoxide, even in small amounts is deadly.**

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

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



**TO ACCESS THE ROTOR ASSEMBLY FOR TROUBLESHOOTING**

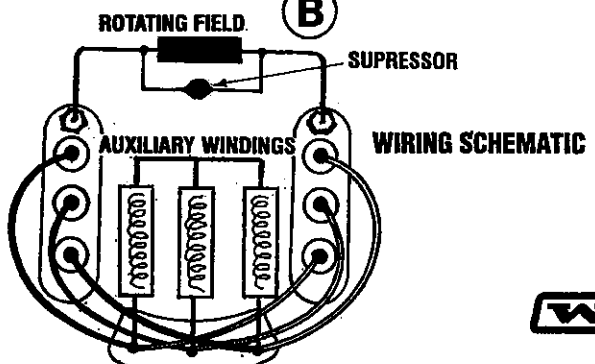
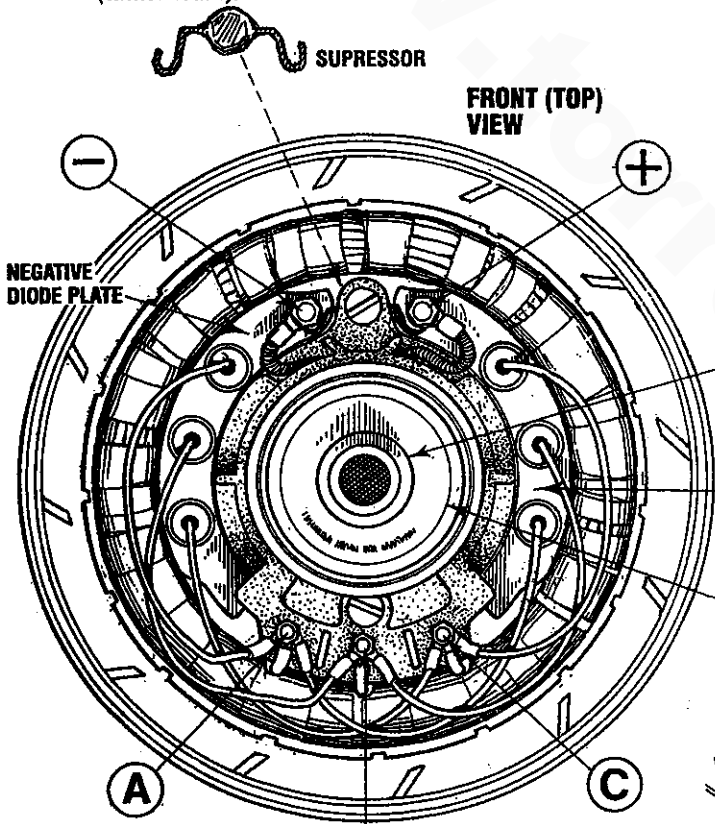
1. Remove the six (5mm) allen head screws that hold the end cover to the generator housing.
2. At the 9:00 and 3:00 O'clock position are threaded bosses. Thread a bolt (8mm - 1.5 x 50mm) into these two bosses. This will push the end cover off the housing exposing the rotor assembly.

**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 six (5mm) allen head screws back in place (finger tight).

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

**NOTE:** A transient voltage supressor is connected between the (+) and (-) terminals of the rotating field windings (underneath).



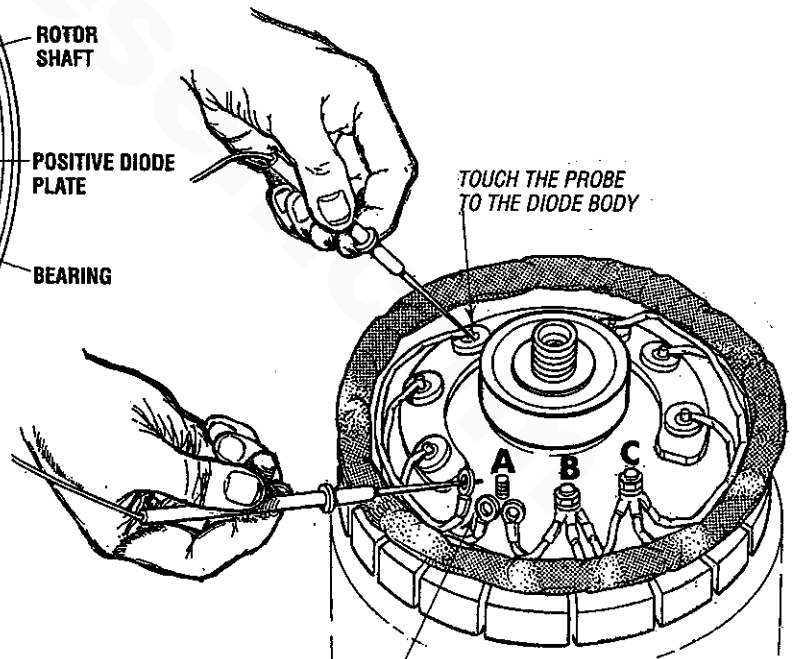
**ROTOR TROUBLESHOOTING (Low voltage Output)**

**Rotating Field Winding**

1. Position the rotor as shown above with the (+) and (-) connections at 12 O'Clock.
2. Place the ohm meter leads across the (+) and (-) connections and record the ohm value. Also check that there is no continuity between either the (+) or the (-) connections and the rotor shaft.

**Diodes and Auxiliary Windings**

1. Test the diodes on the (+) and (-) sides by lifting the leads from the auxiliary winding studs A, B, and C as illustrated. Test each diode for an open or short.
- NOTE:** The three pairs of windings should have the same ohm values.
2. Test the auxiliary windings in pairs. Check the ohm values between A and B, B and C, A and C and record. Check that there is no continuity between the rotor shaft and windings A, B, and C.
  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. The ohm value found for each diode should be approximately the same.



TEST EACH OF THE WINDING LEADS INDIVIDUALLY AS SHOWN THEN DO THE SAME WITH B AND C.

A FAULTY DIODE CAN BE PRESSED OUT AND REPLACED



# COLISEUM GENERATOR

## TROUBLESHOOTING

In some cases, it is difficult to find out on the basis of the existing indications on which part of the generator the fault has occurred. For this reason, it is recommended to follow the step by step procedure below:

1. Inspect visually the condition of all connections, terminal boards, terminals and the excitation system components.
2. Inspect visually for indications of damage to the windings on the generator.
3. Check the operation of the voltage regulator. Check if the voltage regulator is connected correctly and properly adjusted.

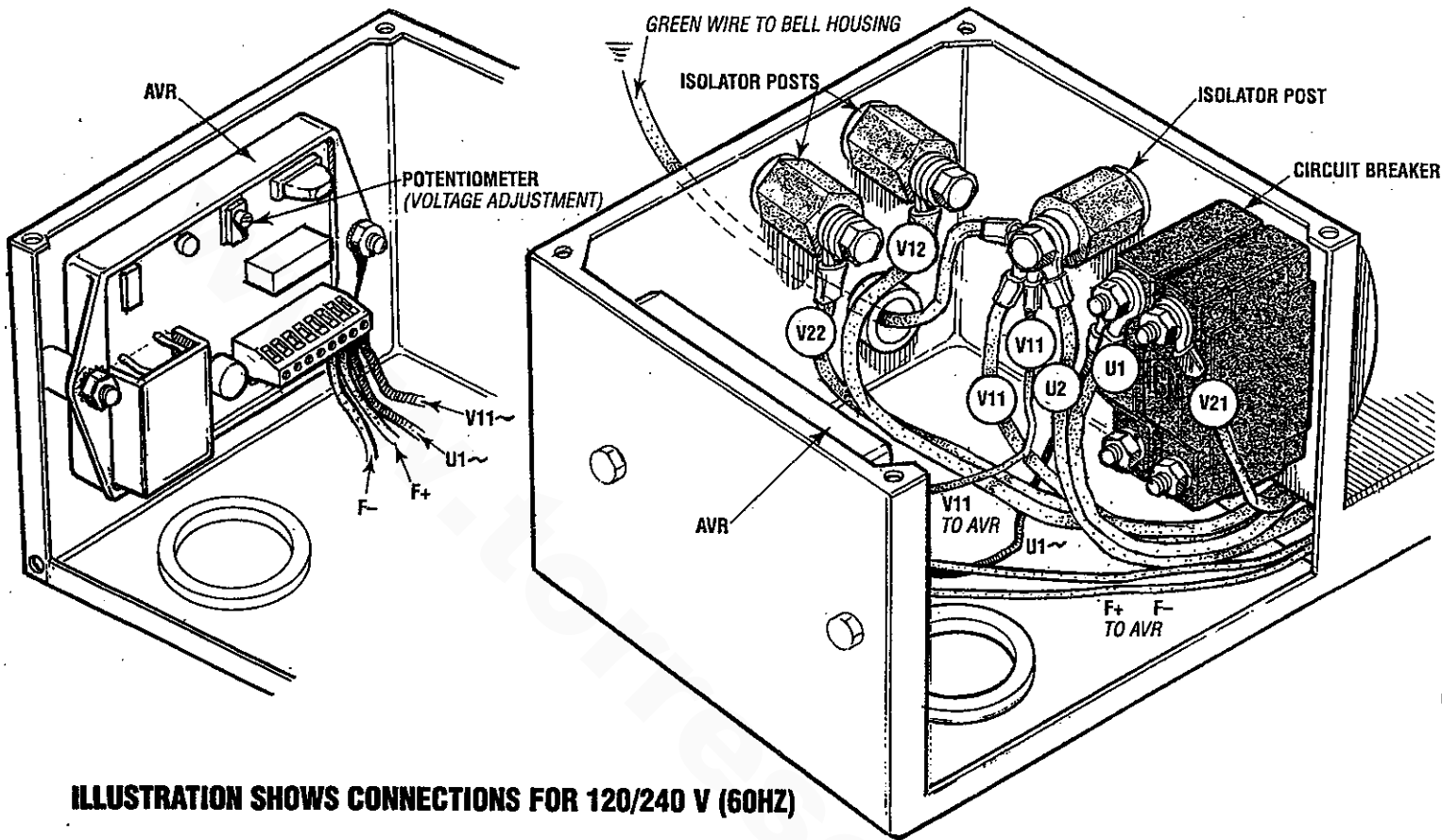
4. In case of a faulty regulator operation, the trouble may lie also in the generator. This can be easily verified by checking the generator operation with separate excitation. For this check it is necessary to follow the *EXCITATION MAGNETIZATION PROCEDURE* outlined on page 5 in this manual.
5. A burning smell or signs of smoke would indicate a short in the windings or a mechanical failure.

FAULT	PROBABLE CAUSE	
<b>NO AC VOLTAGE OUTPUT AT NO LOAD.</b>	<ol style="list-style-type: none"> <li>1. Short or open in the main stator winding.</li> <li>2. Four or more shorted or open diodes on exciter rotor.</li> </ol>	<ol style="list-style-type: none"> <li>3. Open in exciter stator winding.</li> <li>4. Open in rotating field winding.</li> <li>5. Shorted supressor.</li> </ol>
<b>RESIDUAL VOLTAGE PRODUCED AT NO LOAD 15 - 20 VOLTS AC.</b>	<ol style="list-style-type: none"> <li>1. Faulty voltage regulator.</li> <li>2. Short or open in the AC wiring to the voltage regulator.</li> </ol>	
<b>LOW AC VOLTAGE OUTPUT AT NO LOAD 60 - 100 VAC.</b>	<ol style="list-style-type: none"> <li>1. Reset voltage potentiometer.</li> <li>2. Shorted diodes in exciter rotor 1 to 3 diodes.</li> <li>3. Shorted exciter rotor winding.</li> </ol>	<ol style="list-style-type: none"> <li>4. Faulty voltage regulator.</li> <li>5. Short in exciter stator windings.</li> <li>6. Short in rotating field winding.</li> </ol>
<b>HIGH AC OUTPUT VOLTAGE 150 VAC OR HIGHER.</b>	<ol style="list-style-type: none"> <li>1. Reset voltage potentiometer.</li> <li>2. Faulty voltage regulator.</li> </ol>	
<b>UNSTABLE VOLTAGE OUTPUT. (ENGINE SPEED STEADY)</b>	<ol style="list-style-type: none"> <li>1. The potentiometer on the voltage regulator needs adjusting.</li> </ol>	<ol style="list-style-type: none"> <li>2. Faulty voltage regulator.</li> </ol>
<b>AC VOLTAGE DROP UNDER LOAD 60 - 100 VOLTS AC.</b>	<ol style="list-style-type: none"> <li>1. Diode(s) on exciter rotor breaking down when load is applied (inductive) 1-3 diodes.</li> </ol>	
<b>VERY LOW AC OUTPUT VOLTAGE 4 - 10 VAC</b>	<ol style="list-style-type: none"> <li>1. Loss of residual magnetism.</li> </ol>	

**NOTE: AC GENERATOR TROUBLESHOOTING MUST BE PERFORMED WITH THE ENGINE OPERATING AT 60 HZ.**



## COLISEUM GENERATOR CONTROL PANEL



### ILLUSTRATION SHOWS CONNECTIONS FOR 120/240 V (60HZ)

The illustration above shows the on-engine control panel and illustrates the AC connections and voltage regulator board.

Connections not used (50 Hertz) are shrink wrap ends and are tied off in the control panel.

AC voltage adjustment, troubleshooting the exciter circuit and AC voltage output can be easily accomplished with access to the on-engine control panel.

# COLISEUM GENERATOR

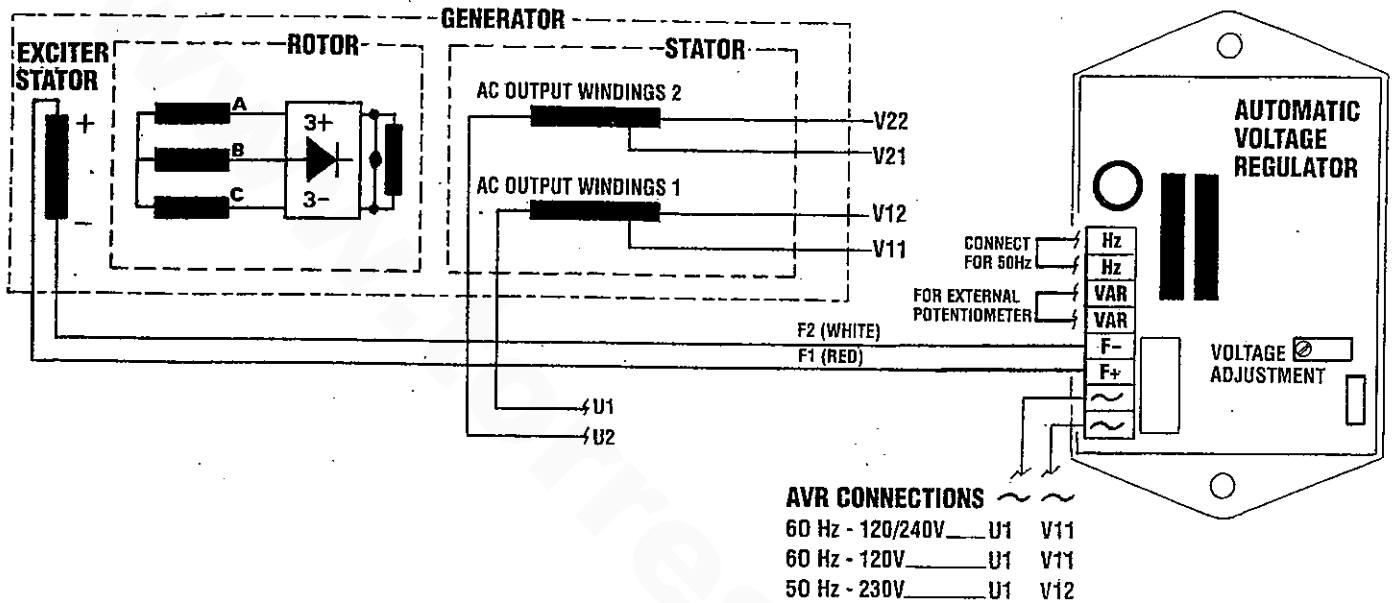
## MAIN STATOR WINDINGS TROUBLESHOOTING

Very low or no AC voltage output is an indication of a shorted or open main stator. To determine if it is a short or open, excite the generator with 12VDC across the F+ and F- leads lifted off the voltage regulator with the unit running.

If a short exists the excitation will produce a load on the drive engine. A growling noise will be produced by the AC generator. The short will produce heat affecting the windings adjacent to it and smoke may be produced.

If a short is not found but rather an open is indicated, the two main stator windings will have to be electrically isolated and the windings checked with an ohm meter. Test between V12 and U1 for an open circuit or check for an open between V22 and U2.

## INTERNAL WIRING DIAGRAM



## RESISTANCE VALUES (IN OHMS)

WESTERBEKE GENERATORS	8.0Kw	10.0Kw	12.5Kw	15.0Kw
<b>Exciter Stator</b>	23.5	25.1	25.5	26.6
<b>Main Stator</b>				
V22 to U2	0.3	0.3	0.4	0.4
V12 to U1	0.3	0.3	0.4	0.4
<b>Exciter Rotor</b>				
A to B	1.2	0.6	0.6	0.4
B to C	1.2	0.6	0.6	0.4
C to A	1.2	0.6	0.6	0.4
<b>Rotor Field</b>	2.2	2.4	2.8	3.0
<b>Supressor</b>	NO RESISTANCE			



# COLISEUM GENERATOR

## EXCITATION OF THE GENERATOR TO DETERMINE FAULT

1. Disconnect the F+ lead from the voltage regulator.
2. Disconnect the F- lead from the voltage regulator.

**NOTE:** Be sure to maintain DC polarity.

3. Connect the 12 DC+ to the F+ lead
4. Connect the 12 DC- to the F- lead.
5. Leave the 12VDC connected for 5 minutes.  
Disconnect and reconnect F+ and F- leads to the regulator.
6. Start the generator and observe the voltage build-up.  
If the voltage build-up does not occur, repeat steps 1 thru 5.

**NOTE:** Steps 1 thru 4 are performed when flashing the exciter field (stator) to determine the cause of a fault in the generator.

**Step 5:** Start the generator and observe/note the reaction of the generator while applying 12VDC to the exciter stator. Record the AC voltage output/generator.

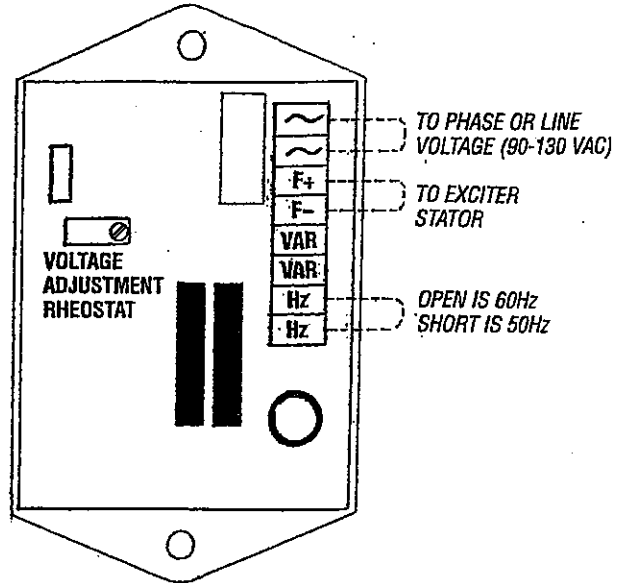
**Step 6:** Stop the generator. and remove the 12VDC lead from F+ and F- and reconnect it to the regulator board.

## VOLTAGE REGULATOR

Normal DC voltage to exciter stator winding generator at no load.

F+ F- → 8 - 9 VDC

Normal AC input voltage to regulator. 120 VAC - 60Hz  
230 VAC - 50Hz





### RESTORING RESIDUAL MAGNETISM TO THE GENERATOR

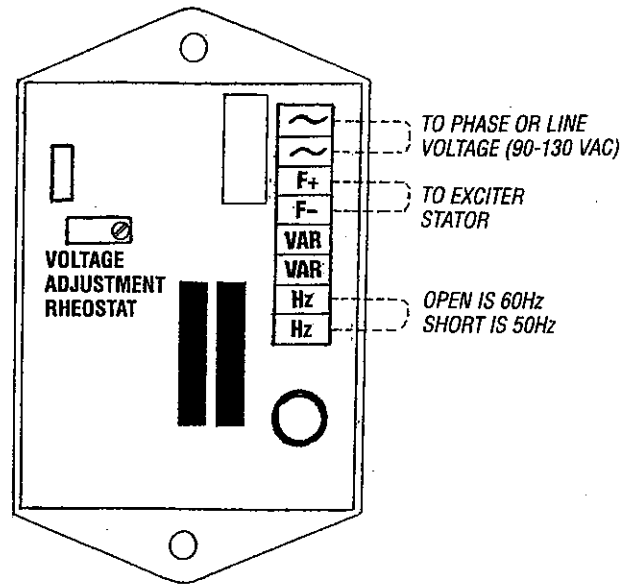
The initial excitation of the generator is assured by the permanent magnet built in one of the exciter stator poles. Trouble with the initial excitation can occur after prolonged storage or after a service repair that dismantles the exciter. In some rare instances, it may be the result of rough transport or handling. To restore the residual magnetism necessary to begin the voltage build-up, excite the generator with 40 - 60VDC by following the procedure below:

1. Disconnect the F+ lead from the voltage regulator.
2. Disconnect the F- lead from the voltage regulator.

**NOTE:** Be sure to maintain DC polarity.

3. Connect the 40 - 60VDC+ to the F+ lead
4. Connect the 40 - 60VDC- to the F- lead.
5. Leave connected for 2 - 3 seconds.  
Disconnect and reconnect F+ and F- leads to the regulator.
6. Start the generator and observe the voltage build-up.  
If the voltage build-up does not occur, repeat steps 1 thru 5.

**CAUTION:** Damage to the voltage regulator will occur if the regulator is not disconnected from the exciter field during flashing.



**AC VOLTAGE CONNECTIONS**

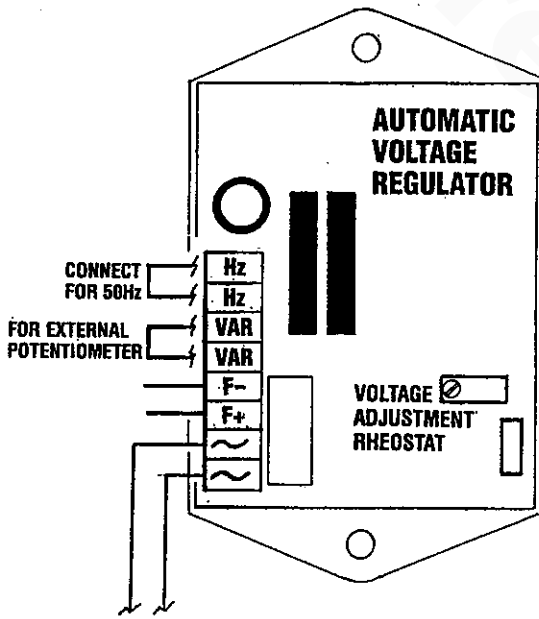
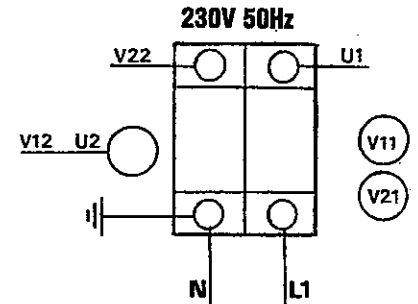
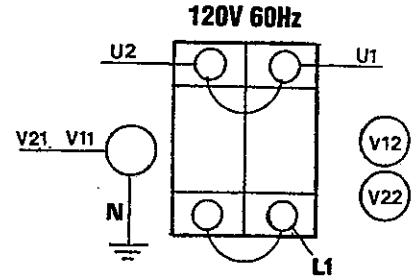
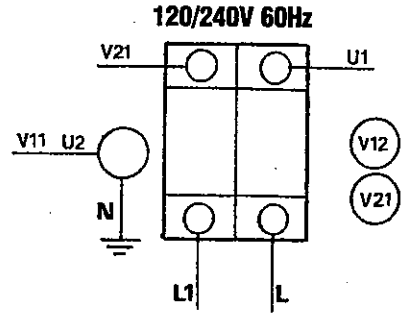
The frame ground wire (green) must be properly positioned when changing the AC output configuration of the AC terminal block. For making connections to the AC breaker, use terminal ends for 1/4 inch studs that will accept multi-strand copper wire sized for the amperage rating from the hot lead connection. The frame ground green wire connects between the neutral stud and the generator frame.

**Generator Frequency**

1. Frequency is a direct result of engine/generator speed:  
 1800 rpm = 60 hertz; 1500 rpm = 50 hertz.
2. To change generator frequency, follow the steps below:  
 Connect the AC leads to the AC breaker and isolation posts as the illustrations show for the hertz/voltage desired. Ensure that the case ground wire is connected to the correct isolation post neutral ground stud.
3. Remove or install the jumper on the automatic regulator (depending on the frequency).

**NOTE:** The green ground wire may be removed in those installations where the AC circuit has a separate neutral and ground circuit. This will prevent the unit from being a ground source in the vessel.

4. Open the AC circuit breaker.
5. Start the generator and adjust the engine speed to the correct no-load hertz, then adjust the voltage rheostat on the regulator to the corresponding AC output.



**AVR CONNECTIONS**

- 60 Hz - 120/240V \_\_\_\_\_ U1 V11
- 60 Hz - 120V \_\_\_\_\_ U1 V11
- 50 Hz - 230V \_\_\_\_\_ U1 V12



**GENERATOR DISASSEMBLY**

The generator layout should be studied carefully before disassembly.

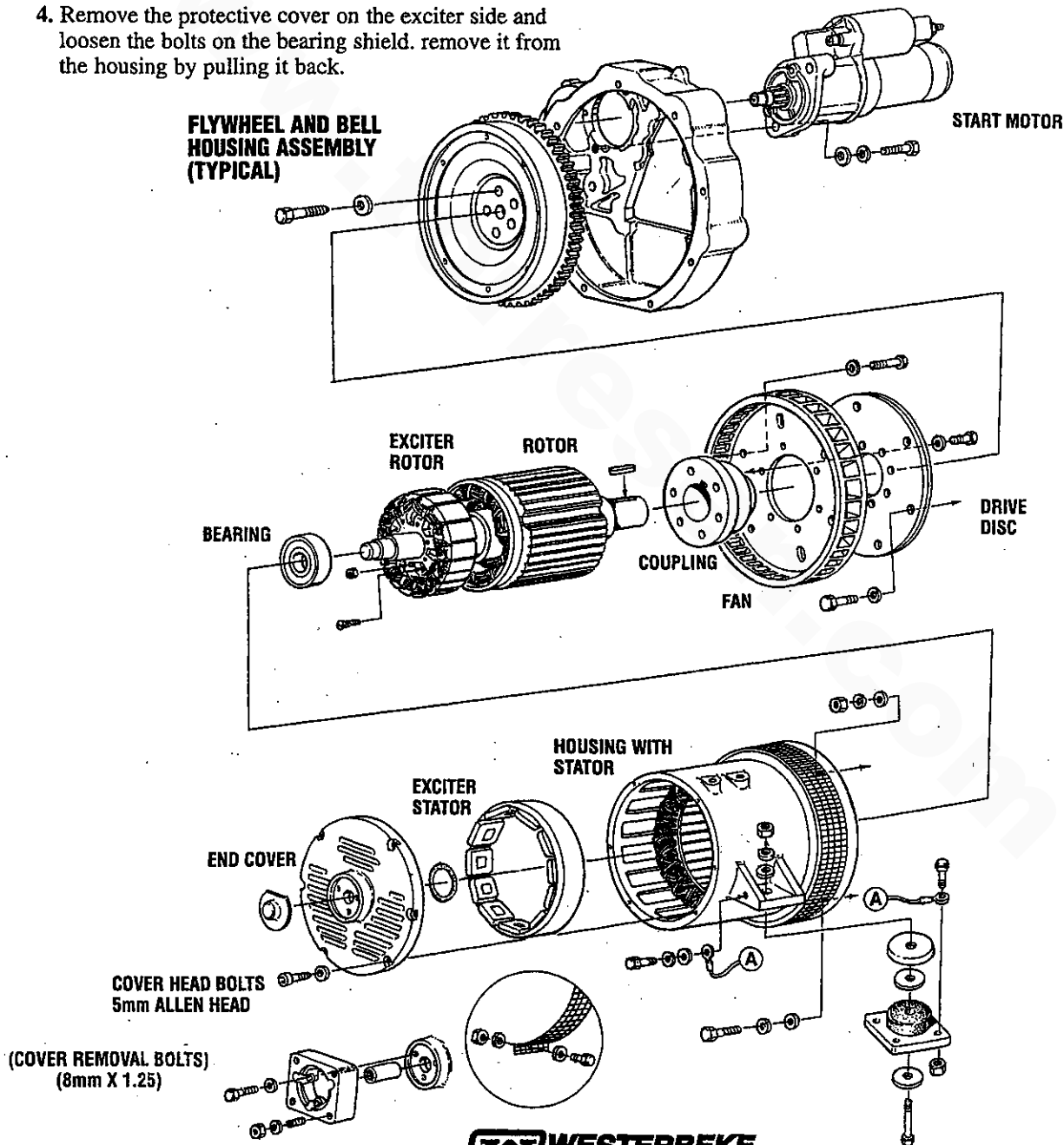
1. Remove terminal box cover. Disconnect the wire leads from the generator. If necessary, disassemble the voltage regulator support (if the Automatic Voltage Regulator is mounted in the terminal box) and the box complete.
2. Disconnect the voltage regulator leads and the leads from the exciter stator F+ and F- to the voltage regulator.
3. Remove the fastening bolts to the generator and disassemble the generator from the prime mover by disconnecting the adapter housing and the coupling disc from the flywheel.
4. Remove the protective cover on the exciter side and loosen the bolts on the bearing shield. remove it from the housing by pulling it back.

5. Remove the rotor horizontally through the flange end of the generator.
6. When the rotating rectifier is to be removed, the bearing should be pulled out first.

**NOTES:** During the transport of the single bearing generator, the rotor of the generator should be fixed to the housing with the coupling disc on the flange.

Closed type bearings are used on this series of generators. During the dismantling, be careful not to damage the protective cover rings.

To prevent damage to the rotor and stator windings while removing the rotor, place cardboard between the packages and remove the rotor by pulling it out gently.



## SERVICE SPECIFICATIONS

<i>Component</i>	<i>Standard mm (inches)</i>	<i>Limit mm (inches) (repair or replace)</i>	
<b>ROCKER ARMS, ROCKER SHAFTS, CAMSHAFT</b>			
CAMSHAFT CAM HEIGHT	Intake (primary)	38.78 (1.527)	38.28 (1.5082)
	Intake (secondary)	38.78 (1.527)	38.28 (1.5082)
	Exhaust	39.10 (1.5405)	38.60 (1.5208)
CAMSHAFT JOURNAL DIAMETER	45.93 - 45.94 (1.8096 - 1.8100)		
<b>CYLINDER HEAD AND VALVES</b>			
FLATNESS OF CYLINDER HEAD GASKET SURFACE	0.05 or less (0.002)		
CYLINDER HEAD GASKET SURFACE GRINDING LIMIT (including grinding of cylinder block gasket surface)	0.2 (0.0078)		
CYLINDER HEAD OVERALL HEIGHT	106.9 - 107.1 (4.2118 - 4.2197)		
CYLINDER HEAD BOLT NOMINAL LENGTH	103.2 (4.0660)		
VALVE MARGIN	Intake	1.0 (0.0394)	0.5 (0.0197)
	Exhaust	1.5 (0.05910)	1.0 (0.0394)
VALVE STEM DIAMETER	6.6 (0.2600)		
VALVE STEM-TO-GUIDE CLEARANCE	Intake	0.020 - 0.050 (0.0007 - 0.0019)	0.10 (0.0039)
	Exhaust	0.050 - 0.085 (0.0019 - 0.0034)	0.15 (0.0059)
VALVE FACE ANGLE	45° - 45.5°		
VALVE STEM PROJECTION	Intake	43.70 (1.7217)	44.20 (1.7414)
	Exhaust	43.30 (1.7060)	43.80 (1.7257)
OVERALL VALVE LENGTH	Intake	100.75 (3.9695)	100.25 (3.9498)
	Exhaust	101.05 (3.9813)	105.55 (4.1586)
VALVE SPRING FREE HEIGHT	Intake	46.1 (1.8163)	45.6 (1.7966)
	Exhaust	46.8 (1.8439)	46.3 (1.8242)
VALVE SPRING LOADED (installed height)	Intake	226 (40.0)	
	Exhaust	284 (39.6)	
VALVE SPRING SQUARENESS	2°	4°	
VALVE SEAT CONTACT WIDTH	0.9 - 0.18 (0.0354 - 0.0512)		
VALVE GUIDE INTERNAL DIAMETER	6.6 (0.260)		
VALVE GUIDE PROJECTION	17.0 (0.6698)		
<b>OIL PUMP AND OIL PAN</b>			
OIL PUMP TIP CLEARANCE	0.06 - 0.18 (0.00236 - 0.0070)		
OIL PUMP SIDE CLEARANCE	0.04 - 0.10 (0.00157 - 0.0039)		
OIL PUMP BODY CLEARANCE	0.10 - 0.18 (0.0039 - 0.0070)	0.35 (0.01379)	
<b>PISTONS AND CONNECTING RODS</b>			
PISTON OUTSIDE DIAMETER	075.5 (2.9747)		
PISTON RING SIDE CLEARANCE	No.1 Ring	0.02 - 0.06 (0.00078 - 0.0023)	
	No.2 Ring	0.02 - 0.06 (0.00078 - 0.0023)	
PISTON RING END GAP CLEARANCE	No.1 Ring	0.20 - 0.35 (0.0078 - 0.0137)	0.8 (0.0315)
	No.2 Ring	0.35 - 0.50 (0.0137 - 0.0197)	0.8 (0.0315)
	Oil Ring	0.20 - 0.50 (0.0078 - 0.0197)	1.0 (0.0394)
PISTON PIN O.D.	18.0 (0.7092)		
PISTON PIN PRESS-IN LOAD (at room temperature)	4,900 - 14,700Nm (3,616 - 10,848 ft-lb)		



## SERVICE SPECIFICATIONS

<i>Component</i>	<i>Standard mm (inches)</i>	<i>Limit mm (inches) (repair or replace)</i>
<b>PISTONS AND CONNECTING RODS</b>		
CRANKSHAFT PIN OIL CLEARANCE	0.02 - 0.04 (0.00078 - 0.00157)	0.1 (0.0039)
CONNECTING ROD BIG END SIDE CLEARANCE	0.10 - 0.25 (0.00394 - 0.00985)	0.4 (0.0157)
<b>CRANKSHAFT AND CYLINDER BLOCK</b>		
CRANKSHAFT END PLAY	0.05 - 0.18 (0.00197 - 0.00709)	0.25 (0.00985)
CRANKSHAFT JOURNAL DIAMETER	48.0 (1.891)	
CRANKSHAFT PIN DIAMETER	42.0 (1.6548)	
CRANKSHAFT JOURNAL OIL CLEARANCE	0.02 - 0.04 (0.0007 - 0.0015)	0.1 (0.0039)
CYLINDER BLOCK GASKET SURFACE FLATNESS	0.05 OR less (0.00197)	
CYLINDER BLOCK GASKET SURFACE GRINDING LIMIT (including grinding of cylinder head gasket surface)		0.2 (0.00078)
CYLINDER BLOCK OVERALL HEIGHT	256 (10.0864)	
CYLINDER CYLINDRICITY	0.01 (0.00039)	
CYLINDER I.D.	75.5 (2.9747)	
PISTON-TO-CYLINDER CLEARANCE	0.02 - 0.04 (0.0007 - 0.00157)	

## REWORK DIMENSIONS

<i>Component</i>	<i>Standard mm (inches)</i>	
<b>CYLINDER HEAD AND VALVES</b>		
	<b>OVERSIZE</b>	
CYLINDER HEAD OVERSIZE	0.05	12.050 - 12.068 (0.47477 - 0.47547)
VALVE GUIDE HOLE DIAMETER	0.25	12.250 - 12.268 (0.48265 - 0.48335)
	0.50	12.500 - 12.516 (0.4925 - 0.4932)
OVERSIZE VALVE SEAT	INTAKE (primary) 0.3	27.300 - 27.325 (1.07562 - 1.07660)
RING HOLE DIAMETER	0.6	27.600 - 27.625 (1.08744 - 1.08842)
	INTAKE (secondary) 0.3	32.300 - 32.325 (1.27262 - 1.2736)
	0.6	32.600 - 32.625 (1.2844 - 1.28542)
	EXHAUST 0.3	35.300 - 35.325 (1.39082 - 1.39180)
	0.6	35.600 - 35.625 (1.4026 - 1.4036)



## TORQUE SPECIFICATIONS

<b>Component</b>	<b>Nm</b>	<b>Ft-lb</b>
<b>ALTERNATOR/IGNITION SYSTEM</b>		
WATER PUMP PULLEY BOLT	9	6.6
OIL LEVEL GAUGE GUIDE	23	16.9
CRANKSHAFT BOLT		
SPARK PLUG	25	18.5
DISTRIBUTOR	11	8.2
<b>TIMING BELT</b>		
TIMING BELT COVER	11	8.2
TIMING BELT TENSIONER	23	16.9
ENGINE SUPPORT BRACKET (left)	35	25.8
IDLER PULLEY	35	25.8
CAMSHAFT SPROCKER BOLT	88	64.9
<b>WATER PUMP</b>		
ENGINE HANGER	11	8.2
COVER	12	8.8
WATER PUMP	13	9.5
<b>ROCKER ARMS, ROCKER SHAFTS AND CAMSHAFT</b>		
ROCKER COVER	4	2.9
ROCKER SHAFT ASSEMBLY	31	22.8
ADJUSTING SCREW	15	11
BEARING CAP	24	17.7
BEARING CAP BOL	11	8.2

<b>Component</b>	<b>Nm</b>	<b>Ft-lb</b>
CYLINDER HEAD COVER	4	3
<b>CYLINDER HEAD AND VALVES</b>		
CYLINDER HEAD BOLT	20	
	turn +90°-90°	
<i>(Tighten to 49Nm (36 ft-lb), then loosen and retighten as described)</i>		

<b>OIL PUMP/OIL PAN</b>		
OIL PAN	7	5.1
DRAIN PLUG	39	28.7
OIL SCREEN	18	13.2
FRONT CASE	13	9.5
RELIEF PLUG	44	32.4
OIL PUMP COVER	10	7.38

<b>PISTONS/CONNECTING RODS</b>		
CONNECTING ROD NUT	17	12.5
	turn +90°-100°	

<b>CRANKSHAFT/CYLINDER BLOCK</b>		
REAR OIL SEAL CASE	11	8.2
BEARING CAP BOLT	51	37.6
FLYWHEEL TO CRANKSHAFT	81	60
BELLHOUSING TO BLOCK	20	15

**CRANKSHAFT BOLT 12mm**      28-137Nm    94-101

**NOTE: ENGINES MANUFACTURED AFTER AUGUST 2003  
HAVE A LARGER DIAMETER CRANKSHAFT BOLT. CONTACT YOUR  
WESTERBEKE DEALER WITH YOUR ENGINE SERIAL NUMBER IF IN  
DOUBT.**

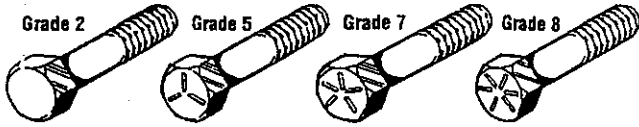
**CRANKSHAFT BOLT**      176-186Nm      129-137  
**(AFTER 8/2003) 14mm**



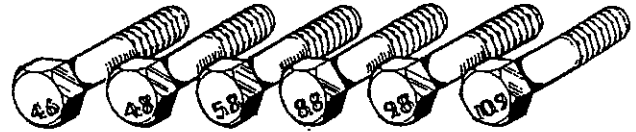
**BOLT HEAD MARKINGS**

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

Customary (inch) bolts are identified 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			
Capscrew 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 - 28	8 (11) 10 (14)	10 (14)	12 (16) 14 (19)
5/16 - 18 - 24	17 (23) 19 (26)	19 (26)	24 (33) 27 (37)
3/8 - 16 - 24	31 (42) 35 (47)	34 (46)	44 (60) 49 (66)
7/16 - 14 - 20	49 (66) 55 (75)	55 (75)	70 (95) 78 (106)
1/2 - 13 - 20	75 (102) 85 (115)	85 (115)	105 (142) 120 (163)
9/16 - 12 - 18	110 (149) 120 (163)	120 (163)	155 (210) 170 (231)
5/8 - 11 - 18	150 (203) 170 (231)	167 (226)	210 (285) 240 (325)
3/4 - 10 - 16	270 (366) 295 (400)	280 (380)	375 (508) 420 (569)
7/8 - 9 - 14	395 (536) 435 (590)	440 (597)	605 (820) 675 (915)
1 - 8 - 14	590 (800) 660 (895)	660 (895)	910 (1234) 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 M4 M5	5.5 mm 7 mm 8 mm	0.3 (0.5) 0.8 (1.1) 1.5 (2.5)	0.5 (0.7) 1 (1.5) 2 (3)	1 (1.3) 2 (3) 4.5 (6)	1.5 (2) 3 (4.5) 6.5 (9)
M8 M9 M10	10 mm 13 mm 16 mm	3 (4) 7 (9.5) 14 (19)	4 (5.5) 10 (13) 18 (25)	7.5 (10) 18 (25) 37 (50)	11 (15) 35 (26) 55 (75)
M12 M14 M16	18 mm 21 mm 24 mm	26 (35) 37 (50) 59 (80)	33 (45) 55 (75) 85 (115)	63 (85) 103 (140) 159 (215)	97 (130) 151 (205) 232 (315)
M18 M20 M22	27 mm 30 mm 33 mm	81 (110) 118 (160) 159 (215)	118 (160) 166 (225) 225 (305)	225 (305) 321 (435) 435 (590)	321 (435) 457 (620) 620 (840)
M24 M27 M30	36 mm 41 mm 46 mm	203 (275) 295 (400) 402 (545)	288 (390) 417 (565) 568 (770)	553 (750) 811 (1100) 1103 (1495)	789 (1070) 1154 (1565) 1571 (2130)
M33 M36	51 mm 55 mm	546 (740) 700 (950)	774 (1050) 992 (1345)	1500 (2035) 1925 (2610)	2139 (2900) 2744 (3720)

**NOTE:** Formula to convert Ft-Lbs to Nm (Newton Meters) multiply Ft-Lbs by 1.356.

**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 particularly 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.

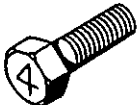



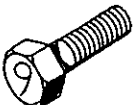
Anti-seize compounds and thread locking adhesives such as LOCTITE protect threaded components yet allows them to come apart when necessary. LOCTITE offers levels of locking according to the job.

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!**



**NOTE:** The torque values given in the following table should be applied where a particular torque is not specified.

Bolt identification Bolt diameter × pitch (mm)	kg-m				
					
<b>M 6 × 1.0</b>	0.6 ±0.2	0.7 <sup>+0.2</sup> <sub>-0.3</sub>	0.8 <sup>+0.2</sup> <sub>-0.3</sub>	0.9 <sup>+0.2</sup> <sub>-0.3</sub>	—
<b>M 8 × 1.25</b>	1.3 ±0.5	1.6 <sup>+0.4</sup> <sub>-0.6</sub>	1.8 <sup>+0.5</sup> <sub>-0.6</sub>	2.1 <sup>+0.5</sup> <sub>-0.7</sub>	2.4 ±0.7
<b>M10 × 1.25</b>	2.8 ±0.7	3.3 <sup>+0.8</sup> <sub>-0.9</sub>	3.8 <sup>+0.9</sup> <sub>-1.0</sub>	4.3 ±0.9	5.1 ±1.3
<b>*M10 × 1.5</b>	2.7 ±0.7	3.2 ±0.8	3.7 ±0.9	4.2 ±1.0	4.9 ±1.2
<b>M12 × 1.25</b>	6.2 <sup>+1.3</sup> <sub>-1.2</sub>	6.7 <sup>+1.4</sup> <sub>-1.3</sub>	7.7 <sup>+1.6</sup> <sub>-1.5</sub>	8.8 <sup>+1.8</sup> <sub>-1.7</sub>	9.7 <sup>+1.9</sup> <sub>-2.0</sub>
<b>*M12 × 1.75</b>	5.8 ±1.2	6.3 ±1.2	7.2 ±1.4	8.2 ±1.6	9.1 ±1.8
<b>M14 × 1.5</b>	9.7 <sup>+2</sup> <sub>-1.9</sub>	10.4 <sup>+2</sup> <sub>-2.1</sub>	11.9 <sup>+2.3</sup> <sub>-2.4</sub>	13.6 <sup>+2.6</sup> <sub>-2.8</sub>	14.5 ±2.9
<b>*M14 × 2.0</b>	9.1 ±1.8	9.8 ±1.9	11.2 ±2.2	12.8 ±2.5	13.6 ±2.7
<b>M16 × 1.5</b>	13.3 ±2.7	15.1 ±3.1	17.3 ±3.5	19.7 ±4.0	20.4 ±4.1
<b>*M16 × 2.0</b>	12.7 ±2.5	14.4 ±2.9	16.5 ±3.3	18.8 ±3.8	19.5 ±3.9
<b>M18 × 1.5</b>	19.2 ±3.8	21.7 <sup>+4.4</sup> <sub>-4.3</sub>	24.9 ±5.0	28.4 ±5.7	29.3 ±5.9
<b>*M18 × 2.5</b>	19.2 ±3.8	21.8 <sup>+4.4</sup> <sub>-4.3</sub>	25.0 ±5.0	28.5 ±5.7	29.4 <sup>+5.9</sup> <sub>-5.8</sub>
<b>M20 × 1.5</b>	26.3 ±5.3	30.0 <sup>+6.1</sup> <sub>-6</sub>	34.4 ±6.9	39.2 <sup>+7.9</sup> <sub>-7.8</sub>	40.4 ±8.1
<b>*M20 × 2.5</b>	24.3 ±4.9	27.8 <sup>+5.5</sup> <sub>-5.6</sub>	31.8 ±6.4	36.3 <sup>+7.2</sup> <sub>-7.3</sub>	37.4 ±7.5
<b>M22 × 1.5</b>	32.0 <sup>+10.2</sup> <sub>-6.4</sub>	40.4 ±8.1	46.3 <sup>+9.2</sup> <sub>-9.3</sub>	52.8 <sup>+10.5</sup> <sub>-10.6</sub>	54.1 ±10.8
<b>*M22 × 2.5</b>	27.8 ±5.6	37.6 ±7.5	43.1 ±8.6	49.1 ±9.8	50.3 ±10.1
<b>M24 × 2.0</b>	45.8 ±9.2	47.9 <sup>+15.4</sup> <sub>-9.6</sub>	54.9 <sup>+17.6</sup> <sub>-11.0</sub>	62.6 <sup>+20.1</sup> <sub>-12.6</sub>	70.6 ±14.1
<b>*M24 × 3.0</b>	43.1 ±8.6	45.1 ±9.0	51.7 ±10.3	58.9 <sup>+11.8</sup> <sub>-11.7</sub>	66.4 ±13.3

**NOTE:** Bolts marked with an asterisk are used for female threaded parts made of soft materials such as castings.



# METRIC CONVERSIONS

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

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

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

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

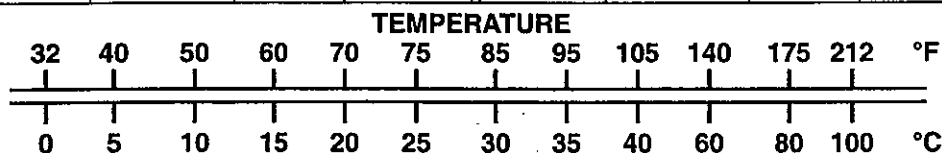
YARDS TO METERS				METERS TO YARDS			
Yards	Meters	Yards	Meters	Meters	Yards	Meters	Yards
1	0.91440	6	5.48640	1	1.09361	6	6.56168
2	1.82880	7	6.40080	2	2.18723	7	7.65529
3	2.74320	8	7.31520	3	3.28084	8	8.74891
4	3.65760	9	8.22960	4	4.37445	9	9.84252
5	4.57200	10	9.14400	5	5.46807	10	10.93614

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

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

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

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



# STANDARD AND METRIC CONVERSION DATA

## LENGTH-DISTANCE

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

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

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

## DISTANCE EQUIVALENTS

1 Degree of Latitude = 60 Nm = 111.120 km

1 Minute of Latitude = 1 Nm = 1.852 km

## VOLUME

Cubic Inches (in<sup>3</sup>) x 16.387 = Cubic Centimeters x .061 = in<sup>3</sup>

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<sub>2</sub>O) x .07355 = Inches of Mercury x 13.783 = H<sub>2</sub>O

Inches of Water (H<sub>2</sub>O) x .03613 = psi x 27.684 = H<sub>2</sub>O

Inches of Water (H<sub>2</sub>O) x .248 = Kilopascals (kPa) x 4.026 = H<sub>2</sub>O

## TORQUE

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

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

## VELOCITY

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

## POWER

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

## FUEL CONSUMPTION

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

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

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

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

## TEMPERATURE

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

Degree Celsius (°C) = (°F - 32) x .56

## LIQUID WEIGHTS

Diesel Oil = 1 US gallon = 7.13 lbs

Fresh Water = 1 US gallon = 8.33 lbs

Gasoline = 1 US gallon = 6.1 lbs

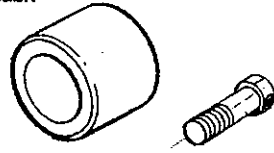
Salt Water = 1 US gallon = 8.56 lbs



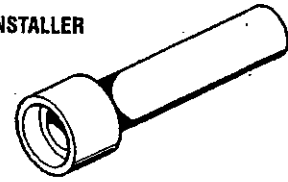
# SPECIAL TOOLS

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

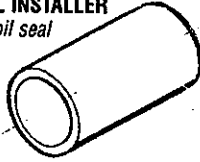
**CAMSHAFT OIL SEAL INSTALLER**  
MD 998713



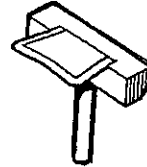
**VALVE STEM SEAL INSTALLER**  
MD 998760



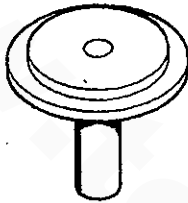
**CRANKSHAFT OIL SEAL INSTALLER**  
For installing the front oil seal  
MD 998305



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

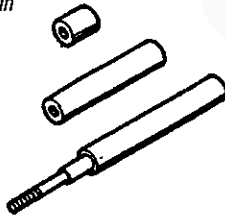


**CRANKSHAFT REAR OIL SEAL INSTALLER**  
For installing the rear oil seal.  
MD 998011

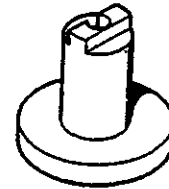


**VALVE SPRING COMPRESSOR**  
MD 998772

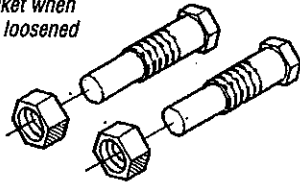
**PUSH ROD AND PIN SET GUIDE**  
Used to pull-out and press in  
the piston pin.  
MD 999584



**PISTON PIN SET TOOL**  
For press fitting piston pins  
MD 998780



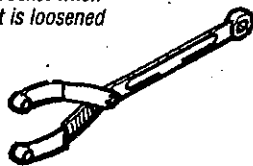
**PIN**  
For supporting the sprocket when  
the camshaft sprocket is loosened  
or tightened.  
MD 998715



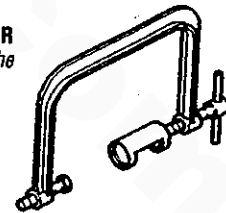
**GUIDE D**  
For removing and pressing  
piston pins  
MD 991659



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



**VALVE SPRING COMPRESSOR**  
For removing and installing the  
valve springs.  
MD 998735



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