ENGINES & GENERATORS WORLDWIDE

WESTERBEKE

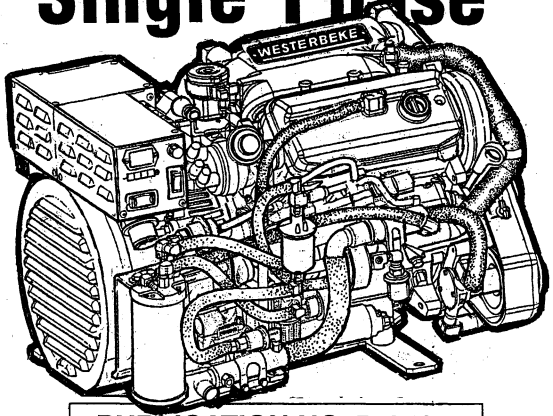
75 years

SINCE 1937

SERVICE MANUAL

MARINE GASOLINE GENERATORS

6.5KW SBCG-60HZ 5.4KW SBCG-50HZ
5.0KW SBCG-60HZ 4.2KW SBCG-50HZ
Single Phase



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WESTERBEKE™ GENERATORS

EFI Low-CO

Low Carbon Monoxide Emissions

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.

WESTERBEKE
Engines & Generators

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

WESTERBEKE™

Engines & Generators

SAFETY INSTRUCTIONS

INTRODUCTION

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

PREVENT ELECTRIC SHOCK

> ⚠ **WARNING:** ***Do not touch AC electrical connections while engine is running. 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.
- 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, fuel filters. or other fuel system components.
- Do not operate with the air cleaner/silencer or flame arrester screen 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 and gasoline fuel will burn.

PREVENT BURNS — EXPLOSION

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

- 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.

ACCIDENTAL STARTING

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

- To prevent accidental starting when servicing the generator, remove the buss fuse or tuen off the DC circuit breaker located on the generator's control panel.
- 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.

SAFETY INSTRUCTIONS

BATTERY EXPLOSION

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

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

BATTERY ACID

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

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

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

- Ensure that the exhaust system is adequate to expel gases discharged from the engine. Check the exhaust system regularly for leaks and make sure the exhaust manifolds are securely attached and no warping exists. Pay close attention to the manifold, water injection elbow, and exhaust pipe nipple.
- Be sure the unit and its surroundings are well ventilated.
- In addition to routine inspection of the exhaust system, install a **carbon monoxide detector.** Consult your boat builder or dealer for installation of approved detectors.

⚠ 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.
- 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	Muscular twitching
Dizziness	Intense headache
Throbbing in temples	Weakness and sleepiness

AVOID MOVING PARTS

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

- Do not service the engine while it is running. If a situation arises in which it is absolutely necessary to make operating adjustments, use extreme care to avoid touching moving parts and hot exhaust system components.
- Do not wear loose clothing or jewelry when servicing equipment; tie back long hair and avoid wearing loose jackets, shirts, sleeves, rings, necklaces or bracelets that could be caught in moving parts.
- Make sure all attaching hardware is properly tightened. Keep protective shields and guards in their respective places at all times.
- Do not check fluid levels or the drive belt's tension while the engine is operating.

HAZARDOUS NOISE

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

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

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

SAFETY INSTRUCTIONS

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 DIESEL ENGINES

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

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

Order from:

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

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

Order from:

NFPA
11 Tracy Drive
Avon Industrial Park
Avon, MA 02322

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

Order from:

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

CARBON MONOXIDE "CO"/ LOW-CO GENERATORS
IMPORTANT INFORMATION

DESCRIPTION

Carbon monoxide "CO" is a component of engine exhaust. It is a colorless, tasteless, odorless, lighter than air poisonous gas that can kill you without any warning. CO poisoning is one of the major safety risks associated with boating. It is a threat that must not be underestimated.

Westerbeke Low-CO generators are designed to reduce normal levels of CO in the engine exhaust by approximately 99%.

Several standards for CO have been published, expressed in parts per million "ppm" and hours of exposure:

Regulator	CO ppm	Exposure Hours
EPA	9	8
ACGIH	25	8
EPA	35	1
NIOSH	35	8
OSHA	50	8
ACGIH	125	0.5
NIOSH	200	0.0
NIOSH (IDLH)	1200	0.0

1200 ppm is the so-called IDLH concentration - IMMEDIATELY DANGEROUS TO LIFE AND HEALTH.

A city in California characterizes the effect of CO concentration this way:

Parts per Million	Responses
25	Permissible exposure level, no apparent toxic symptoms.
100	No poisoning for long period. Allowable for several hours.
200	Should not be exposed above this level for any period of time. A possible mild frontal headache in two to three hours.

Even though the generator normally produces very low levels Westerbeke Low-CO generators are designed to reduce normal levels of CO in the engine exhaust by approximately 99%., an exhaust leak of untreated exhaust would be extremely dangerous. For this reason it is extremely important to install a CO detector near the generator and to be sure it is always turned on and functioning properly. If this detector sounds, do not turn it off, assuming it is a false signal. You can not taste, smell, or otherwise detect CO. Leave the detector on, turn off all engines and generators, evacuate the boat leaving ports and hatches open, and seek professional help.

As soon as CO leaves the exhaust outlet, the level is subject to dilution in the open air. The closer a person is to the exhaust outlet, the higher the concentration of CO.

In a closed space, such as the engine compartment, the boat, or underneath a stern swim platform, concentrations will potentially rise to the undiluted level emanating from the exhaust system due to a lack of fresh air to dilute the exhaust gas. Therefore, one should never rely on dilution of the exhaust to provide a margin of safety.

Westerbeke Low-CO generators achieve an approximate 99% reduction of typical CO by precise control control of the engine's air/fuel ration coupled with after treatment in a special catalyst. CO emissions are not the same for every model because each engine is different. Also, certain fuel system components are commonized across several engine models being adequate for some and extra-adequate for others, thus producing different CO levels for different models.

The fuel system which accomplishes the required precise air/fuel ratio control is comprised of many different components: purchased sub-assemblies, machined castings, sensors, electronics and others. Because of the extreme level of CO reduction, any variability in the functioning of any these components can and will cause variability of the CO output.

CO concentration also varies with load. Usually, but not always, the worst case CO concentration occurs at maximum load.

INSPECTION

The catalyst is critical to optimizing CO levels. Any water intrusion into the engine's exhaust system will likely quickly compromise the proper operation of the catalyst. Westerbeke's exhaust system installation instructions dated May 2004 2nd Edition must be adhered to.

NOTE: *Water intrusion is not a product defect and is not covered under warranty, neither Westerbeke's normal product warranty nor the emissions specific warranty mandated by various regulating authorities such as EPA and CARB.*

Maintenance of any components affecting the flow of air into the engine or the flow of fuel to the engine is critically important. Fuel filters, air filters, flame arrester screens MUST be properly maintained.

Inspection of the catalyst at the prescribed intervals is critically important. The exhaust elbow is removed by loosening the metal clamp to provide a view of the output surface of the catalyst. Any visual irregularity of the normal flush, honeycomb appearance is most likely a result of water intrusion. The cause of the irregularity must be identified and addressed. If there is irregularity, the catalyst and sealing gasket must be replaced. The water injected exhaust elbow casting must be inspected also for corrosion and replaced as needed. Upon careful reassembly of the catalyst, new sealing gasket, and exhaust elbow, check for the presence of CO while the engine is running. This must be performed with a CO analyzer.

CARBON MONOXIDE "CO"/ LOW-CO GENERATORS
IMPORTANT INFORMATION

Catalyst performance will degrade over time. As the generator accumulates operating hours, CO concentrations will increase. **The catalyst must be replaced every 2,000 hours of engine operation.**

Verification of satisfactory CO levels must be done seasonally or each 500 hours (which ever occurs first). Verification involves actual sampling of exhaust gas with an appropriate CO analyzer.

There are two locations where exhaust gas can be sampled. Dry, but hot, exhaust gas can be sampled at the 1/8NPT plugged opening on the top of the water injected exhaust elbow's cast. Measurements at this location may not be practical in all instances due to the high exhaust temperature, temperature limits of the analyzer, safety concerns over temperatures involved or the possibility of high levels of CO. The other location is the boat's exhaust outlet, which contains entrained cooling water (except dry stack exhaust systems). Only analyzers with probes should be used at this location and it is critical that the probe not ingest water. Probe-type analyzers have an air pump drawing a gas sample through the probe. As a result, they tend to ingest water when it is present. Be sure to aim the probe downwards with the opening pointed in the direction of the water flow and just out of the flow. Position the analyzer as high as possible with the tubing leading to the probe running continuously downhill. Observe the usually translucent tubing between the probe and the analyzer and be sure no water is being ingested. If any water is ingested into the analyzer, it must be repaired or replaced and recalibrated.

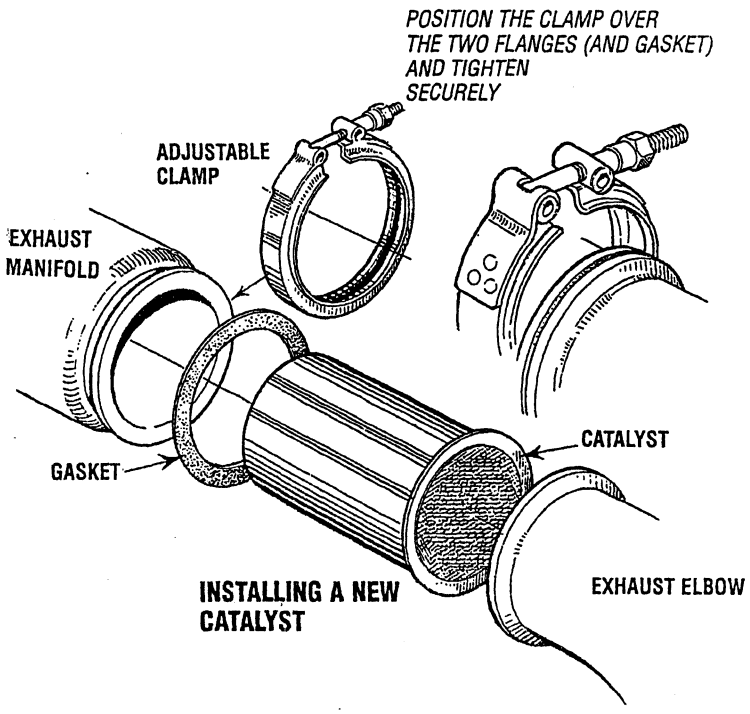
When measuring CO at the exhaust outlet be aware of the ambient CO level by also measuring CO away from and upwind of the exhaust outlet, especially in marinas. the CO level at the exhaust will be influenced upwards by the ambient level.

For changing the exhaust catalyst and measuring the exhaust back pressure, refer to the Table of Contents.

Whenever taking the time to verify proper CO levels from the exhaust with a CO analyzer, always take theopportunity to use the analyzer to "sniff" around the engine looking for CO from exhaust leaks. Pay close attention to the connection of the cylinder block to the sump plate, the sump plated to the water injected exhaust elbow casting and all subsequent downstream exhaust components and hoses and connection points. Remember, exhaust gas that has not yet passed through the catalyst is raw exhaust, untreated exhaust gas and is very high in CO content.

Analyzers usually require periodic calibration. Follow the instructions that come with the analyzer very carefully regarding calibration.

The following are manufacturers that offer CO analyzers: Extech, TIF, Testo, TSI, Bacharach, Fluke, Monoxor, Fyrite, Zellwgwer Analytics, Industrial Scientific Corp, GFG, TPI, Teledyne and others. Westerbeke recommends analyzers with a probe connected to the analyzer by a length of transparent tubing. They are slightly more expensive than those with sensor built into one end of the analyzer, but they allow to sample the exhaust coming out of the boat's exhaust c



INSTALLING A NEW CATALYST

EMISSIONS

This genset meets the requirements of California's Exhaust Emissions Standards as stated on the nameplate.

California users of this genset should be aware that unauthorized modifications or replacement of fuel, exhaust, air intake, or speed control system components that affect engine emissions are prohibited. Unauthorized modification, removal or replacement of the engine label is prohibited.

Federal Emissions Compliance Period: The Federal Emissions Compliance Period referred to on the nameplate indicates the number of operating hours for which the engine has been shown to meet Federal Emissions requirements.

Catagory C= 250 hrs, B=500 hrs,m A =1000.hrs.

You should carefully review operator (Owner) Installation and other manuals and information you receive with your genset. If you are unsure that the installation, use, maintenance or service of your genset is authorized, you should seek assistance from an approved WESTERBEKE dealer.

California genset users may use the table below as an aid in locating information related to the California Air Resources Board requirements for emissions control.

EMISSIONS CONTROL INFORMATION TABLE

Emissions Warranty Information	The California emissions control warranty statement is located in the same packet, if information as this manual when the genset is shipped from the factory.
Engine Fuel Requirements	The engine is certified to operate on unleaded gasoline. See *FUEL RECOMMENDATIONS.*
Engine Valve Adjustment	See *MAINTENANCE SCHEDULE.*
Engine Ignition Timing	See *MAINTENANCE SCHEDULE.*
Engine Lubricating Oil Requirements	See *ENGINE OIL RECOMMENDATIONS.*
Engine Adjustments	ECU.
Engine Emission Contol System	The engine emission control system consists of engine design and precision manufacture.
Catalyst	See *MAINTENANCE SCHEDULE.*
Oxygen Sensor	See *MAINTENANCE SCHEDULE.*
Back Pressure	See *MAINTENANCE SCHEDULE.*

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ENGINE TESTING

ENGINE ADJUSTMENTS AND TESTING

NOTE: *The Manuals preliminary pages IV, V, VI provide data on Carbon Emissions, Catalyst Replacement, and Testing Back-Pressure.*

ENGINE DISASSEMBLY, INSPECTION AND ASSEMBLY

TESTING FOR OVERHAUL

HOW TO DETERMINE ENGINE OVERHAUL PERIOD

Cause of Low Compression

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

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

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

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

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

OVERHAUL CONDITIONS

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

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

The engine requires overhaul when oil consumption is high, blowby evident, and compression values are at minimum or below. *Engine compression should be 178 psi (1260Kpa) at 400 rpm. With a limit 137 psi (860 Kpa). Pressure should not differ by more than 14 psi (100 Kpa) between cylinders. See ENGINE ADJUSTMENTS in this manual.*

ENGINE OVERHAUL

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

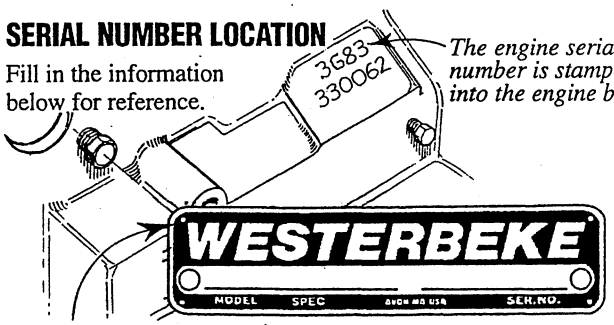
Additional detailed information and specifications are provided in other sections of this manual, covering the generator, alternator, starter motor, engine adjustments, cooling pumps, etc.

DISASSEMBLY

1. Before disassembly and cleaning, carefully check for defects which cannot be found after disassembly and cleaning.
2. Clean the engine exterior.
3. Perform disassembly in a proper order using proper tools. Keep disassembled parts in order. Apply oil when necessary. Take special care to keep the fuel system parts from intrusion of dust and dirt.

SERIAL NUMBER LOCATION

Fill in the information below for reference.



The engine serial number is stamped into the engine block.

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

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

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

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

PC INTERFACE SOFTWARE

Prior to overhaul, it is advised to operate the unit with PC Interface Software connected to the ECU. This will help determine system operation and whether system components may need replacement during overhaul.

ENGINE TROUBLESHOOTING

PROBLEM	PROBABLE CAUSE
Engine backfires.	1. Spark plug wires are connected wrong. 2. Incorrect timing. 3. Dirty flame arrester. 4. Cracked distributor cap. 5. High exhaust back-pressure.
Engine overheats.	1. Coolant loss. Pressure test cooling system. 2. Faulty raw water pump impeller. 3. Belts are loose or broken. 4. Raw water pump worn. 5. Faulty thermostat.
Low oil pressure.	1. Low oil level. 2. Wrong SAE type oil in the engine. 3. Wrong type oil filter. 4. Relief valve is stuck. 5. Faulty oil pump. 6. Faulty engine bearings. 7. Faulty oil filter.
High oil pressure.	1. Dirty oil or wrong SAE type oil in the engine. 2. Relief valve is stuck.

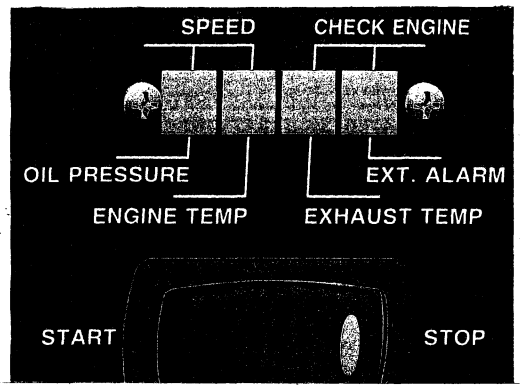
PROBLEM	PROBABLE CAUSE
No DC charge to the starting battery.	1. Faulty 30 amp buss fuse or 30 amp AGM fuse. Ref. DC wiring diagram. 2. Faulty connections to battery charging control. 3. Faultybattery charging control. 4. Faulty bridge rectifie. 5. Faulty generator charger windings.
Blue exhaust smoke discharge from the engine.	1. Lube oil is diluted. 2. High lube oil level. 3. Crankcase breather hose is clogged. 4. Valves are worn or adjusted incorrectly. 5. Piston rings are worn or unseated.
Black exhaust smoke discharge from the engine.	1. Dirty flame arrester. 2. Lube oil is diluted. 3. Valves are worn or incorrectly adjusted. 4. Piston rings are worn or unseated. 5. Cankcase breather hose is clogged.
Poor Performance at generator speed.	1. Fuel injector not functioning properly. 2. Fuel pump clogged. Remove and replace. 3. Throttle body filter screen dirty. Remove and clean.

ENGINE TROUBLESHOOTING/SOFTWARE DIAGNOSTICS

DIAGNOSTIC SOFTWARE

This Diagnostic Software is designed to aide the technician in monitoring the Safe CO generator's operation and ECU (Electronic Control Unit) functions.
The Diagnostic Software will run on WINDOWS 98 and newer based operating systems. These must have a minimum of 128 megabytes of RAM (Random-Access Memory) and the communications cable plugs into a serial connection or an adapter to convert from serial to USB (Universal Service Bus). When using serial to USB adapters, the communication port that the adapter is using MUST be known in order to configure the Diagnostic Software.

The Westerbeke communication cable (pn#049998) is unique to this Diagnostic Software and must be used or otherwise damage the ECU will occur if any communications cable is substituted. The Diagnostic Software is designed with multiple screen, tabs and pull down menus to aide the user in the diagnostic process.
The Diagnostic Software is for monitoring ONLY. It is read only so none of the values can be changed.



TEST PROCEDURE FOR DATA LOGGING USING THE GASOLINE DIAGNOSTIC SOFTWARE PC INTERFACE

DIAGNOSTIC SOFTWARE IS A VALUABLE TOOL IN SOLVING ENGINE PROBLEMS. IT SHOULD NOT REPLACE BASIC TROUBLESHOOTING OR COMMON SENSE. THE FOLLOWING PROCEDURES WILL HELP IN GATHERING VALUABLE INFORMATION.

ON-BOARD DIAGNOSTICS 1 PC INTERFACE SOFTWARE

After installing the PC Interface Diagnostics Software on your laptop, shut off the 20 amp DC breaker on the generators control box. Attach one end of the Westerbeke communication cable to one of your laptops serial ports. If your laptop does not have a serial port, you must use an adapter that goes from a serial port to a USB. Attach the other end of the communication cable to the 10 pin connection on the ECU. Make sure that the red wire on the communications cable lines up with the pin number 1 on the ECU. Reference the label on the ECU to identify pin number 1. Turn on the 20 amp DC breaker as soon as the communication cable is connected to both the ECU and your laptop.

Open the Interface Software and under *communication* select *comm port.* Select the *comm port* that the cable is connected to. Under *communication* select start comm or crtl +S. The word *communication* under the menu bar should turn from **RED** to **GREEN** if the communication link is properly achieved. If it does not turn green, check the connections at the PC and the ECU. Make sure that the connector is properly positioined on the ECU and that all the pins are in the connector. Verify the computer Comm Port selected is correct. Make sure the main DC circuit breaker is turned on.

The EC10 interface is divided into four sections. *Engine Conditions, Wideband O2 Sensor Control, Engine Control States and Emissions Records Display.*

ENGINE CONDITIONS

This section monitors the running conditions of the engine.

Coolant Temperature

Coolant temperature is displayed in degrees C and degrees F.

Air Temperature

Air temperature is displayed in degrees C and degrees F.

Engine Oil Pressure

Oil pressure is displayed in BAR and PSI.

Battery Voltage

Battery voltage at the ECU is displayed in Vdc.

Engine Hours

Engine runtime is displayed in hours.

Engine Speed

Engine speed is displayed in RPM.
60Hz operation = 1800 rpm and 50Hz operation = 1500 rpm.

Lambda

ExhaustAir/Fuel mixture. You should see readings going abve and below 1.000 continuously as the ECU adjusts the Air/Fuel mxture.

Throttle Position

Indicates the position of the throttle control unit in steps relative to the fully closed position.

Pulse Width

Indicates the fuel injector pulse width.

Manifold Pressure

Indicates the pressure in the intake manifold in kPa.

WIDEBAND 02 SENSOR CONTROL

This section monitors the operating conditions of the wideband oxygen sensor.

WB 02 Sensor States

There are seven wide band sensor states.

1. WB Time Stamp is the initialization state for the wide band lambda sensor.
2. WB OL Delay occures during the post-crank enrichment period. This is an open loop fueling period. This state is present until the WB02 heater comes up to its operation temperature.
3. WB CL Start Comp is the beginning of closed-loop fueling for the post-startup. The closed loop control targets a rich lambda set point. The lambda set point is a function of engine coolant and this set point leans out as a function of time.
4. WB Warmup is entered only if the engine coolant temperature is not above a certain threshold.
5. WB CL No Fault Checks occurs when the lambda closed loop control is trying to control the fuel delivery to Stoich *(Lambda = 1.000)* but no checks for emissions faults are performed.
6. WB Closed Loop is closed loop lambda control with a target set point of Stoich and emissions faults checks occurs.
7. WB Open Loop state occurs if an emission malfunction is detected. The closed loop lambda control is disabled.

WB 02 Heater Status

There are three states for the Heater Status. Low Temperature, High Temperature, and Normal Temperature. The Normal Temperature is at 893mV.

WB 02 Crossing Stoich

There are three states for Crossing Stoich. Initialize indicates the initialization period for the sensor. Rich indicates a Lambda lower than 1.000. Lean indicates a Lambda higher than 1.000.

Running Closed Loop PI Control

Indicator will be **RED** when running *Open Loop* and will turn **GREEN** when running *closed loop.*

WB 02 Heater Voltage

This indicator reads the Wideband Heater status in milli-volts. The set point for this function is 893mV.

ON-BOARD DIAGNOSTICS 1 PC INTERFACE SOFTWARE

ENGINE CONTROL STATES

This section monitors the control conditions of the genset.

Emission Conditions

There are four Emission Conditions.

1. **Closed Loop Disabled** - This condition will display if the Wideband O2 Sensor Control has been disabled
2. **Normal Operation** - This condition will display when the engine is running and everything is operating properly.
3. **Sensor Out Of Range** - This condition will display when the lambda is extemely rich (less than 0.8) or very lean (greater than 4.6)..
4. **Not Crossing Stoich** - This condition will display if the engine has been running too Rich or too lean for more than the allotted time period. A perfect Stoich reading in the display is 1.000.

Heater Malfunction - This condition will display if the heater on the Wideband O2 Sensor has failed.. If this condition displays it is probably time to change the Wideband O2 Sensor.

Engine Shutdowns

Along with the PC Interface to display shutdowns, the Genset is equipped with an LCD display to indicate shutdown. Refer to your Owners Manual for a description of the display. When the Genset is operational and everything is operating properly, this box will display Normal Conditions.

There are ten Engine Shutdowns that are controlled by the ECU.

1. **Over-Crank Timeout** - This will display if after the start button is pressed and the starter motor is cranking the engine but it does not start the engine in about six seconds.
2. **High Engine Coolant Temperature** - This will display if the temperature of the engine coolant exceeds 95°C.
3. **Overspeed** - This will display if the engine speed exceeds 20% of the desired set speed. (2160 rpm for 60Hz and 1800 rpm for 50Hz).
4. **Underspeed** - This will display if the engine speed falls below 20% of the desired set speed. (1440 rpm for 60Hz and 1200rpm for 50Hz).
5. **Speed Loss** - This will display if there is a loss of speed signal due to a sensor failure or the engine has stopped running due to some other malfunction not covered under the ECU shutdowns. *Sometimes if the Genset runs out of fuel this shutdown or Low Oil Pressure may be displayed.*
6. **High Exhaust Temperature** - This will display if the exhaust elbow overheats due to a lack of raw water discharge. *Check the raw water pump for flow if this failure occurs.*
7. **Low Oil Pressure** - This will display if the oil pressure falls below 8 psi.
8. **Oil Pressure Sensor Shorted** - This will display if there is a short in the oil pressure sensor wire.
9. **External Fault** - This will display if the device connected to the auxiliary fault terminal such as a fire boy device has been triggered.
10. **Low Battery Level on Crank** - This will display if the battery voltage is too low to crank the engine long enough to start.

Engine State

There are five Engine States.

1. **Idle** - This is the state when the engine is turned off..
2. **Crank** - This is the state when the starter motor is engaged and cranking the engine over for starting.
3. **Run** - This is the state when the engine is running.
4. **Shutdown** - This is the state after the stop button has been pressed and the engine is shutting down.
5. **Idle Wait** - This is a short period, approximately 3 seconds, after the stop button has been pressed before the start button can be pressed again. This allows the engine to stop turning before attempting a restart.

Firmware Revision Number

The Firmware Revision Number consists of three parts. The first part is the Part Number, the second part is the Major Revision Number, and the third part is the Major Revision Number.

NOTE: *When requesting service information, please reference the complete Firmware Revision Number.*

Frequency Option

This box displays the position of the Frequency Option Switch on the ECU. On the top of the ECU there is a four position dip switch block. Switch Number 1 is for selecting the desired engine speed. When the switch is in the ON position, the engine will run at 1500 rpm for 50Hz operation. When the switch is in the OFF position, the engine will run at 1800 rpm for 60Hz operation.

NOTE: *To change the speed selection, the engine must be OFF and the Main DC Circuit Breaker on the panel box must be switched OFF. When switching from one frequency to another, there are wiring changes that must be performed before operating the Genset. See you Owner's Manual for further details.*

Start off by collecting date from the time that the engine is started. If you have a genset that has the idle mode, start the PC interface communicating and data logging before you start the engine. If you have an engine that does not have an idle mode, start the PC Interface as soon as possible after the engine is running. Let the engine warm up for about 10 to 15 minutes before trying to apply an AC load. Monitor and record AC volts and amps if possible.

After the engine is warmed up, start applying an AC load by turning on various devices. Let the unit run at each load change for a couple of minutes so that the unit is stable. Monitor and record AC volts and amps if possible at each load site. Continue to as AC load until the unit is at or near full power rating. Power is determined by multiplying the AC voltage times the AC amperage. This will determine if the unit is overloaded or not.

After loading up the genset, begin to reduce the AC load. Let the unit run at each load site for a couple of minutes to stabilize. Continue to reduce the AC load and monitor voltage and amperage until there is no AC load on genset. This will give a technician a baseline of what is going on when the engine is running under a controlled load condition.

Finally, after running the controlled baseline test, this might sound strange, but sometimes the customer might know a particular scenario that will cause a problem for the unit. Sometimes we hear customers say that the unit runs fine for awhile and when my air conditioner shuts off something happens. Try repeating the scenario that the customer mentions. Always start by recording date from the start up for a least a couple of minutes with no load on the generator to get a starting point. Then continue to record data until the problem shows up.

If you have a unit with no idle mode, and the unit shut down under some kind of fault, the date log will automatically stop and save the file. If you have a unit with an idle mode, and the unit was to shut down under some kind of fault, you will have to manually stop the data log to save it. Or in the case of shutting of the DC circuit breaker, this will also cause the data file to stop and save itself.

WHAT TO DO WITH THE DATA

All of the data that is being recorded is also being displayed on the PC Interface in the various boxes. The following information applies whether you are looking at the data file after it has been recorded or watching it live in the PC Interface. The data file can be opened in most spreadsheet software such as Microsoft Excel.

Some of the data that is being collected is pretty much self explanatory and simple to follow. For example, I think that engine temp, air temp, oil pressure, and battery volts would be easy to figure out. Some of the other items may be less familiar.

Speed

Simple enough, this is the speed that the engine is running, the genset is set up to operate at 60 Hz, then the engine needs to run at 1800 rpm (belt driven units may be different). If the unit is set up for 50 Hz operation then the engine speed will be 1500 rpm.

When a genset is governing properly, you should see readings slightly above and below the desired speed. Even a well tuned engine will vary a little. The point is you should see readings above and below the desired speed. If you see speed readings remain more than 20 rom above or below the desired speed for a prolonged period of time, there could be a problem, especially if this is noticed with no AC load applied.

If the speed is too high with no AC load applied, check the data box labeled Stepper Pos. (steps). The throttle is controlled by a stepper motor. Usually the step count for the engine running with no AC load is typically in the 20-30 steps range. A couple of steps above or below this range does not indicate a problem. However, if the step count is in the single digit numbers or even showing a zero, the problem maybe that the thrrottle body assembly may be out of calibration or not functioning properly. The stepper motor can only go to a positioin that it thinks is zero. If the calibration is off, the stepper cannot move the throttle closed enough to slow the engine down. An engine that has this problem will run at the proper speed once some AC load has been added. However, when that load is dropped, the speed will be too high, and in some cases may cause the engine to over-speed and shut down.

If the engine speed is too low with no AC load applied, there is probably a totally different problem. Again, look at the Stepper Position. Is the speed low but steps are high? This would mean that the throttle is being opened to compensate for loss of speed but the speed is not coming up. Check to make sure that the fuel level is full in the fuel system and that the fuel is good and the filters are clear. Bleed the fuel system to remove any air. Check to make sure that the air intake screens are clean. Check to make sure that the spark plugs have not fouled.

If the engine speed is okay when running with no AC load, but once underway with some AC load being aplied the speed drops and stays below the desired speed, first check the AC power by multiplying the total AC amperage times the AC volts to get the kilowatts. If this number is higher than what the unit is rated for, then it is overloaded., Shut off some of the devices until the speed returns to normal and check the power again. If there is only a small AC load applied and the speed cannot maintain, follow the same suggestions from the previous paragraph.

Pressure (kPa) - This is the pressure that exists in the intake manifold. At no-load the kPa will be lower than at full load. The wider the throttle plate is open, the closer it gets to atmosphere which is about 100 kPa. Typically a genset running at no-load will see a kPa value around 30, while at full load it would be around 90 kPa. If the kPa is stuck at 70 and never moves then there is a problem with either the MAP sensor or the wiring to the MAP sensor, as 70 is a default value that is in the code.

WB Heater Set-point - This is the set-point in millivolts of the heater temperature in the Wideband 02 Sensor. Curently in all the units that do not have an idle mode, the set point is 893. In other units the set-point will vary but wll be displayed in this box.

WB Current Temp - This is the actual value in millivolts of the heater temperature in the Wideband 02 Sensor. If the heater is working properly, you will typically see values stay within 20 millivolts of the set-point. The higher the number is, the colder the heater is. Typically a reading in the 4000 area means that the heater is not working at all. If the value is swinging dramatically above and below the set-point, the sensor is probably failing. The sensor should be replaced.

Lambda - Lambda represents the ratio of the amount present in a combustion chamber compared to the amount that should have been present in order to obtain "prefect" combustion. Thus, when a mixture contains exactly the amount of oxygen required to burn the amount of fuel present the ratio will be one to one and lamba will equal 1,000. If the mixture contains too much oxygen for the amount of fuel (a lean mixture), lamba will be greater then 1,000. If a mixture contains too little oxygen for the amount of fuel (a rich mixture), lamba will be less than 1,000.

Perfect combustion requires an air/fuel ratio of approximately 14.7:1 (by weight) under normal condtions. Thus a lean air/fuel ratio of, say, 16:1 would translate to a lambda value of 1.088. (To calculate, divide 16 by 14.7.) A lamba of .97 would indicate an air/fuel ratio of 14.259:1 (derived by multiplying .97 by 14.7).

In our applications we want to see lambda reading around 1,000. Because of the combustion involved this number will constantly be changing, ideally you should see the value of lamba fluctuating slightly above and below the 1,000 target.

Immediately after a startup it is typical to see a rich readings for lambda. This is part of the startup process and usually takes a couple of minutes for sensors to warm up and take control of the air fuel mixture.

If you see a problem in this area first check the Wideband heater value to make sure that the heater is working. Remember that it takes about three minutes after starting an engine for it to be totally in control. Physically remove the sensor and check it for corrosion and build up of deposits. from the water being injected through the exhaust. Salt water deposited on the senor will be very damaging. If there is any evidence of build up, replace the sensor.

After checking the senor and the genset is running too rich, check the air intake screens and spark plugs to make sure they are clean and functioning properly. If the genset is running too lean, check the fuel levels and the quality of the fuel. Water in the gas will cause the genset to run lean.

Lambda PW Trim - Is the fueling trim precentage that the wideband oxygen sensor is contributing. In most cases 15% is the maximum.

Wideband P, I & D Term - These values are the lambda value controlling terms. Their job is to keep the lambda reading at 1,000 by enriching or enleaning the fueling.

Lambda P & I Term - These values are the lambda value controlling terms. Their job is to keep the lambda reading at 1,000 enriching or enleaning the fueling.

NB STT - (Narrowband Short Term Trim) If you genset is equipped with a narrowband oxygen sensor, this will be the value of its contribution. Max contribustion is 1%.

Stepper Pos (steps) - The throttle shaft is controlled by a stepper motor. The value displayed is in steps. Zero steps being the closed position. Most units will run at no load in the 20 to 30 steps range. These values will vary from engine to engine.

Pulse Width - Is the fueling duration in milliseconds (ms). The value will be lower at no load than at full load.

Ip Current - Is the electrical value equivalent of the Lambda reading. There is not much to learn from this number.

Main Fuel Comp (%) - Is the fueling compensation that is derived from a value in the fuel table, which is based on the engine rpm and the MAP pressure.

Air Temp and Engine Temp Comp (%) - Is the fueling compensation based on the air temperature and engine temperature. This value can be both positive and negative. This value is added or subtracted from the main fuel compensation value.

Frequency Option - TIs the value of the speed selector on the ECU, whether it is 50 or 60 Hz. Some interfaces may not show this column but will display the Frequency Option in the Title area at the top of the data log.

The Generator Frequency - Is a function of engine speed. For most applications, 50 Hz operation is with an engine speed of 1500 rpm, while 60 Hz operation is with an engine speed of 1800 rpm. **Note:** *Belt drive applications will be different, check your owner's manual for engine speed.*

De-rated P Term - This code provided for the P(Proportional) Term, in the speed PID control, to be de-rated right after start-up for a short period of time. This allows the engine to warm up with out having an aggressive P value which could cause "hunting" or instability when the engine is cold. On some older units there is also a trim pot on the top on the EUC that can manually de-rate the P value. This will be reflected in this box.

Speed P, I & D Terms - These values reflect the engine speed governing process. These values are constantly changing and it is very hard to get any information from them. The only thing I can say on the subject is that you should see these values constantly changing. If for some reason there are all zeroes in these columns than the engine is probably not running.

EMISSIONS RECORDS DISPLAY

This will display the emissions records stored in the memory of the ECU.

Display Emissions Records

Pressing this button will populate the Emissions Records Display with any emissions records which may have been recorded. Your Genset is equipped with a *MIL Light* (Malfunctioning Indicator Light) on the main control panel. If this light stays on after the Genset is running, an emission malfunction record has been logged. The Emissions Records Display will show the type of emissions condition and the time in engine hours that the condition occurred.

When the engine has been running properly, *Normal Conditions* will appear in the Emissions Records Display. If there are no conditions recorded, the message *There are no emissions records to display* will appear. This should only display when the engine has never been run or the ECU has been replaced.

NOTE: *The engine must be in the Idle state with the main DC circuit breaker ON for this function to work.*

Clear the Display

Pressing this button will clear the Emissions records Display window only. It will not clear the records that are stored in the ECU. This function works with the engine running or in *Idle* mode as long as the main DC circuit breaker is on.

TO CLEAR THE MIL LIGHT

See your owners manual for a more detailed explanation of the Mil Light. The only way to clear the MIL Light is to have three successful restarts and shutdowns.

The Mil light can be activated by either a mechanical malfunction of some component on the Genset, or some external influence such as overloading the Genset or bad fuel. After correcting the malfunction, restart the Genset and run it until the *Running Closed Loop PI Control* indicator turns **GREEN** indicating that the engine has gone trough its startup routine. Press the START/STOP switch to shutdown the Genset.

NOTE: *It is very important to use the START/STOP switch to stop the Genset. If the DC circuit breaker is used to shutdown the Genset, no Emissions Record will be logged.*

Follow this procedure two more times to shutoff the MIL Light and to ensure that the Genset is working properly.

TO CLOSE THE MONITOR

Click the X in the top right hand corner of the Window or Click File/Exit.

ENGINE ADJUSTMENTS

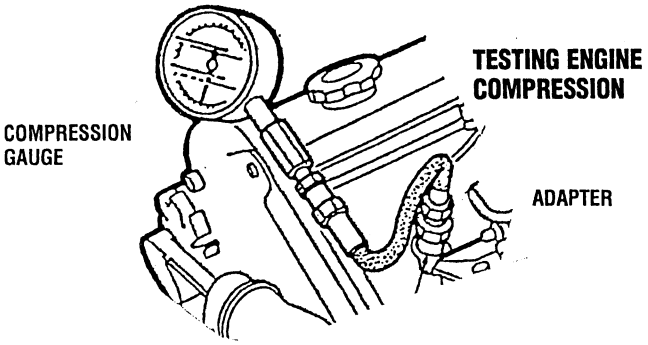
ENGINE COMPRESSION TEST

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

   COMPRESSION PRESSURE 178 PSI at 400 RPM
   Cylinder pressures should not differ more than 14 psi
7. If a cylinder's compression or pressure differential is below the limit, add a small amount of engine oil through the spark plug hole and repeat steps 4 and 5.

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

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



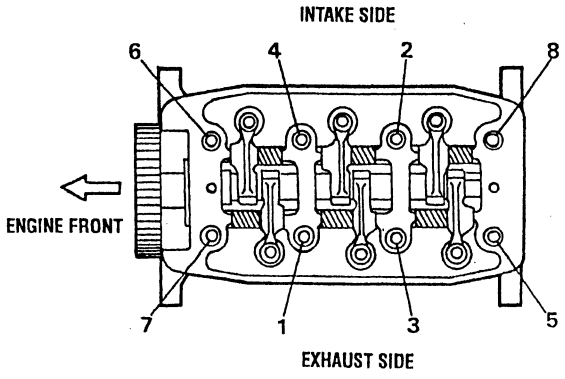
NOTE: *Do not guess the conditions of other cylinders from a result of testing one cylinder. Be sure to measure the compression pressure for each cylinder. Look for cylinders with dramatically (at least 20%) lower compression than the average of the other cylinders. If the weak cylinder is flanked by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

Cylinder Head Bolts

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

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

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



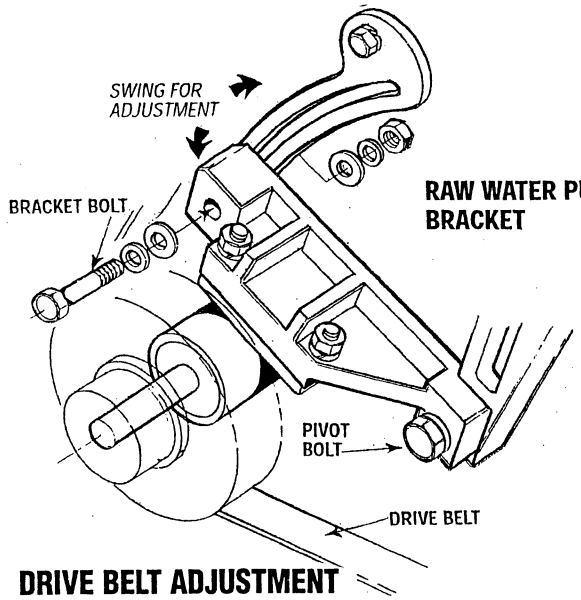
CYLINDER HEAD BOLTS TIGHTENING SEQUENCE

Rocker Cover

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

ROCKER COVER BOLT TORQUE (6mm BOLT)
2.9 - 5.2 ft-lbs (4 - 7Nm)

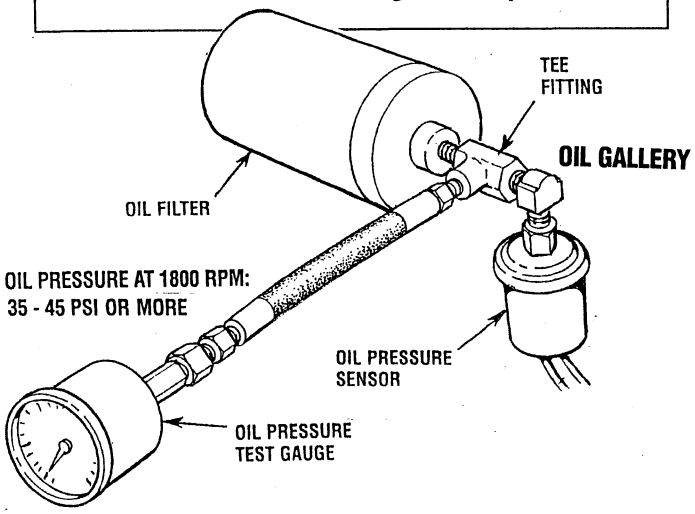
ENGINE ADJUSTMENTS



DRIVE BELT ADJUSTMENT

The generators have two drive belts, one drives the governor and alternator and the other drives the raw water pump. 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.

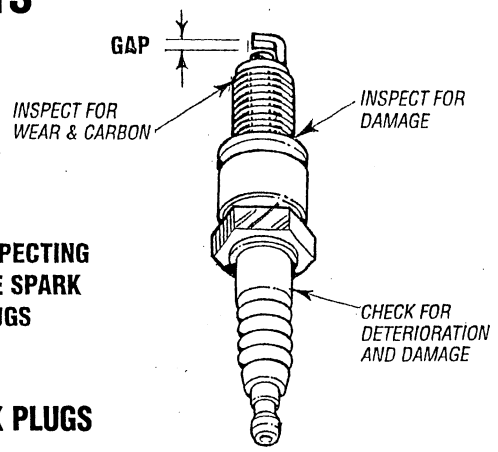
> ⚠ **WARNING:** ***Never attempt to check or adjust the drive belt's tension while the engine is in operation.***



TESTING OIL PRESSURE

To test engine oil pressure, remove the hex plug (1/8npt threads) in the tee fitting located on the oil filter adapter. Install an accurate mechanical oil pressure test gauge in its place. Start the engine and allow it to operate at normal running RPM (1800). Observe and record the pressure.

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



INSPECTING THE SPARK PLUGS

SPARK PLUGS

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

SPARK PLUG GAP: 0.031 – 0.002in. (0.8 - 0.7mm).

SPARK PLUG TORQUE: 11 – 15 lb-ft (1.5 – 2.31 kg-m).

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

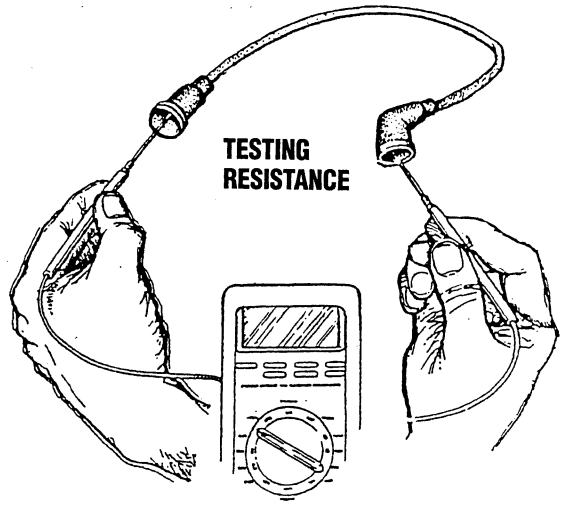
> ⚠ **WARNING:** ***Do not remove the spark plugs while the engine is hot. Allow the engine to cool before removing them.***

HIGH TENSION CORDS (IGNITION WIRES)

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

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

THE RESISTANCE VALUE IS 410 OHM PER INCH OF WIRE.



VALVE CLEARANCE / IGNITION TIMING

VALVE CLEARANCE ADJUSTMENT

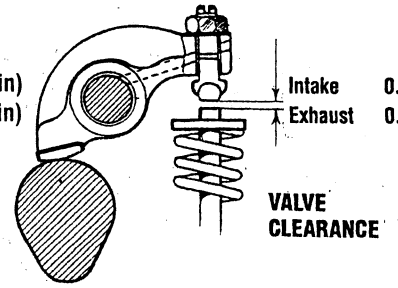
NOTE: *Retorque the cylinder head bolts before adjusting the engine'e valves. See TORQUING THE CYLINDER HEAD BOLTS.*

1. Remove the rocker cover and gasket.
2. Remove the spark plugs to observe the piston position in each cylinder head when positioning that piston at TDC.
3. Adjust the intake and exhaust valves in the firing order of the engine (1-3-2) as follows:

   Rotate the crankshaft in its normal direction of rotation, observing valve movement and piston locatiion placing No.1 piston at TDC (Top Dead Center) of its compression stroke with the intake and exhaust valves completely closed. Then adjust the intake and exhaust valve clearances.

VALVE CLEARANCE

INTAKE VALVES	**0.20mm (.008in)**
EXHAUST VALVES	**0.30mm (.012in)**



Intake 0.20mm (.008 inches)
Exhaust 0.30mm (.012 Inches)

   Rotate the crankshaft 120 degrees to position the piston in cylinder #3 at TDC of its compression stroke and adjust this cylinders exhaust and intake valves. Rotate the crankshaft another 120 degrees to position the piston in cylinder #2 at TDC of its compression stroke and adjust this cylinders intake and exhaust valves.

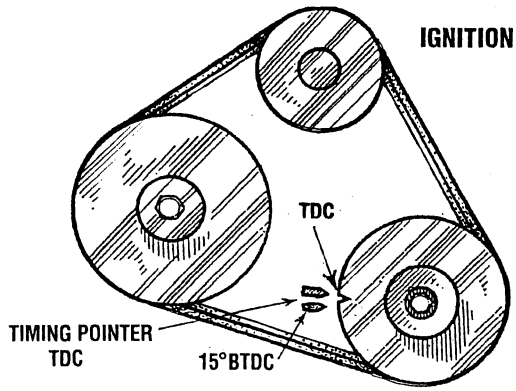
4. Replace the rocker cover and rocker cover gasket.

   ROCKER COVER TORQUE 2.9 - 5.1 lb-ft (0.4 - 0.7 kg-m)

IGNITION TIMING

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

   TIMING SPECIFICATIONS 15° ± 1.0° BTDC at 1800 RPM (No-load on generator)



IGNITION TIMING

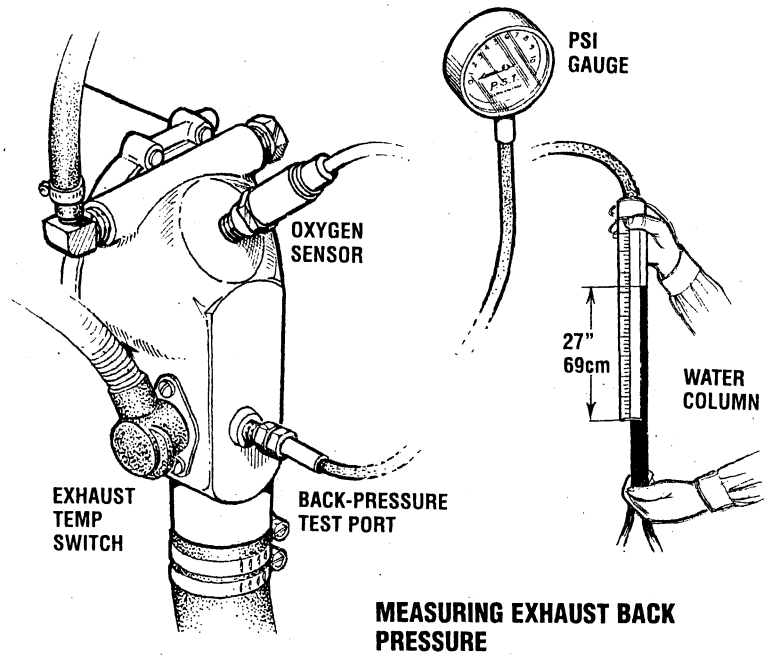
MEASURING EXHAUST BACK PRESSURE

Exhaust systems normally produce resistance to the flow of exhaust gases, causing back-pressure. Back-pressure must be kept within a certain limit. **Check the back-pressure before the generator is put back into service.**

To test exhaust pressure, connect either a water column or PSI tube to the test part on the exhaust elbow as shown.

Check the exhaust back-pressure before the generator is put into service. Measure the back-pressure after the engine has reached its normal operating temperature, and at the point where it is about to reach its rated load at either 1500 rpm (for 50Hz applications) or 1800 rpm (for 60Hz applications). Back-pressure should not exceed 1.5 psi (0.11 kg/cm^2).

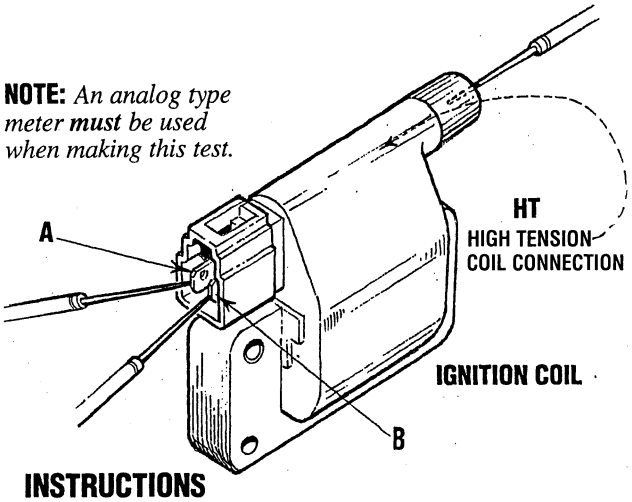
A water column can be made by taping one end of a clear plastic tube along a yardstick and fitting the other end of the tube with a 1/4" NPT pipe fitting.
Back-pressure should not exceed 27in (69cm) of water in the water column.



MEASURING EXHAUST BACK PRESSURE

TESTING THE IGNITION COIL

NOTE: *An analog type meter **must** be used when making this test.*



INSTRUCTIONS

Unplug the electrical connections fron the coil carefully noting the position of the two electrical connections **A** and **B** as they must be reconnected in the exact same position.

Place the ohmmeter leads on terminals **A** and **B** as shown.

A to **B - 1.5 ohm**

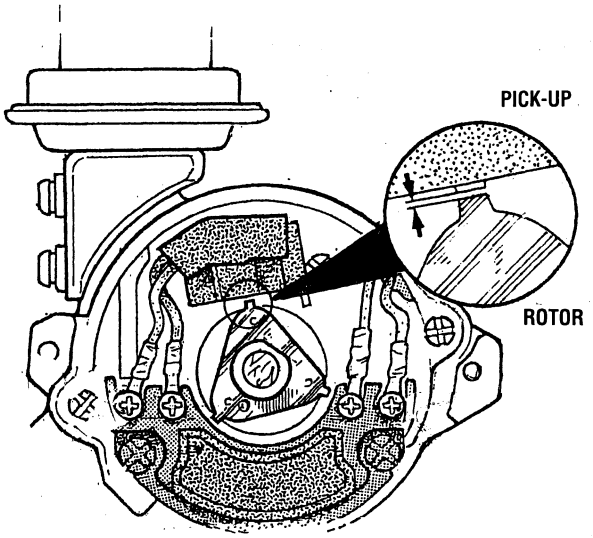
Place the leads between **A** and the high tension coil **HT** connection.

A to **HT - 25.4 ohm**

Place the leads between **B** and the high tension coil **HT** connection.

B to **HT - 25.4 ohm**

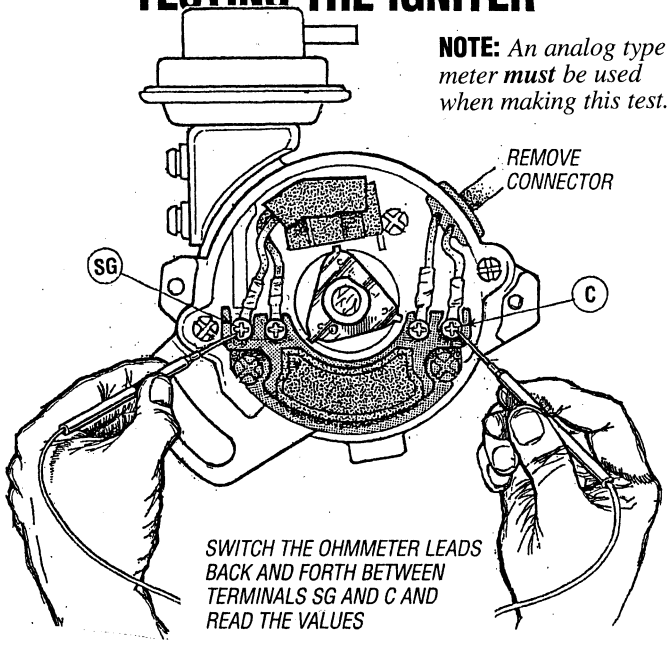
ADJUSTING THE PICK-UP GAP



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

TESTING THE IGNITER

NOTE: *An analog type meter **must** be used when making this test.*

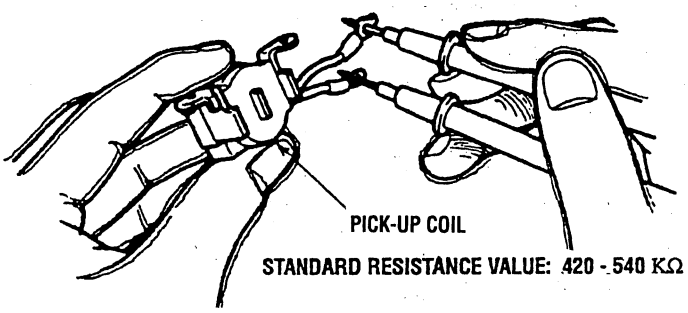


Instructions

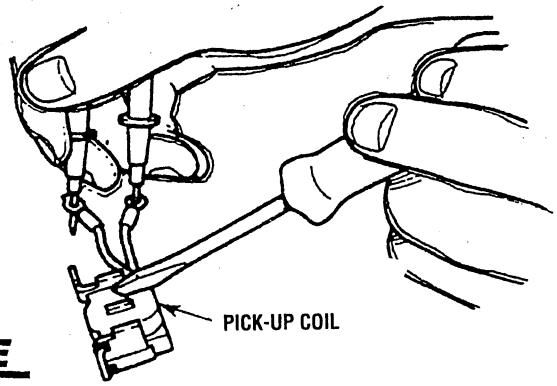
Unplug the two connectors at the distribution plug. Take care to **note the two seperate connections, they must be reconnected in the exact same position**. Place your ohmmeter leads on the terminals **SG** and **C** as shown and read the meter. Then reverse the ohmmeter leads and again read the meter.

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

TESTING THE PICK-UP COIL



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



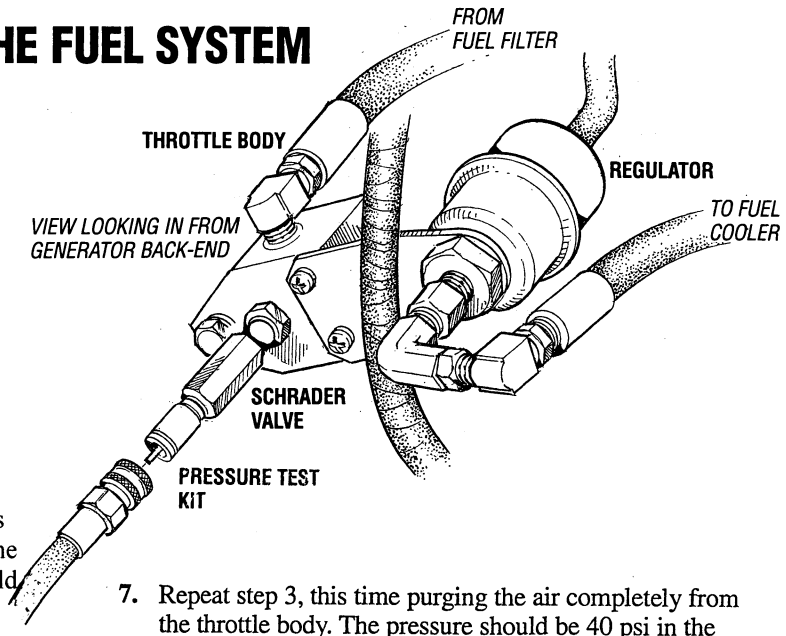
BLEEDING THE FUEL SYSTEM

BLEEDING THE FUEL SYSTEM

1. Insure that the fuel cell ***is not*** connected to the wiring harness, and that the lift pump ***is*** connected.
2. Attach Snap On MT337B, OTC 7211 or equivalent fuel pressure gauge set to the Schrader valve on fuel cell.

> ⚠ **CAUTION:** ***Follow manufacturer's instructions for safe use of the gauge sets to purge a high-pressure fuel system.***

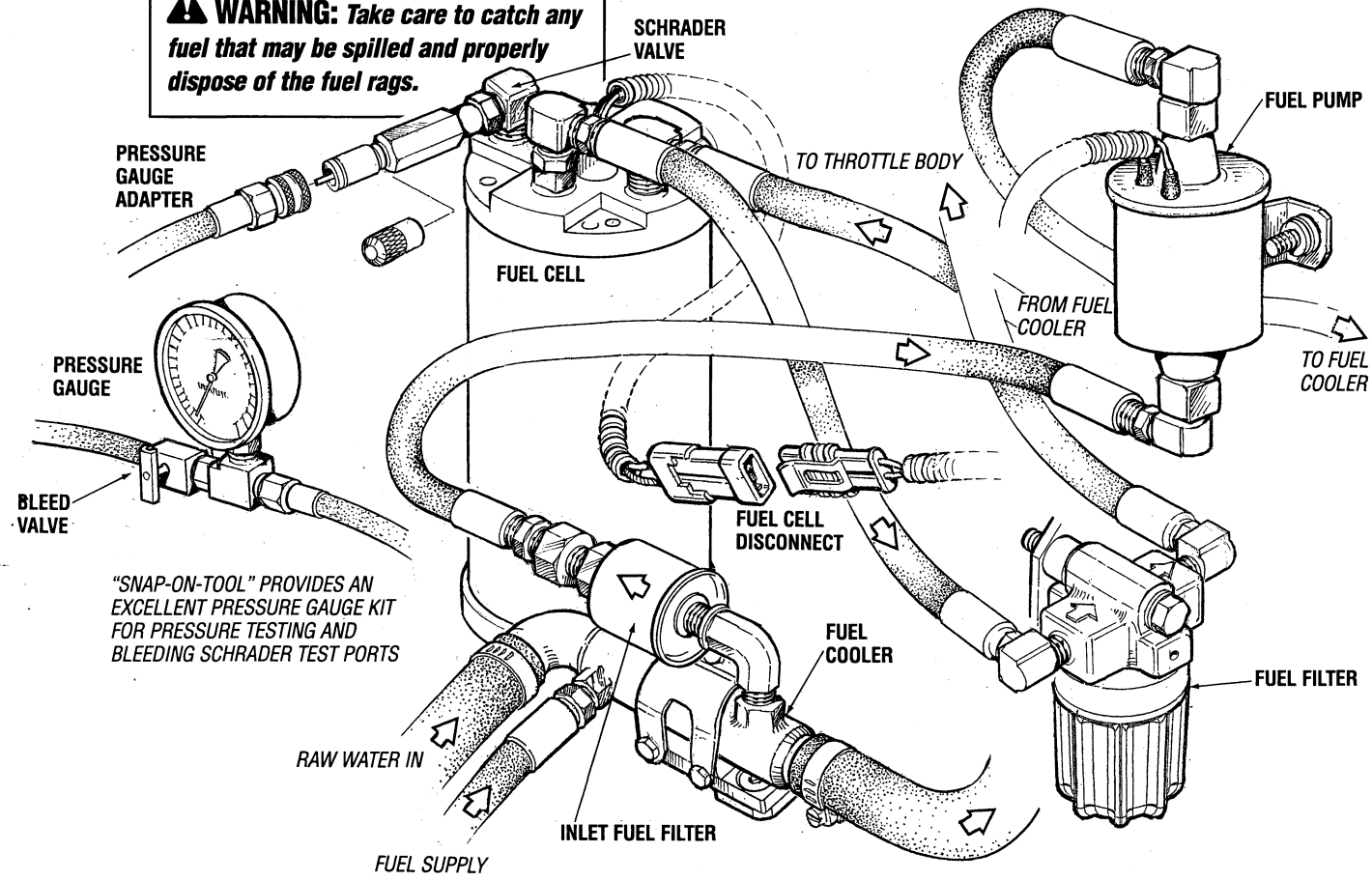
3. While holding the stop switch in the (**prime**) depressed position, purge the air from the fuel cell. The fuel cell is purged when no air bubbles are visible escaping from the drain line attached to the Schrader valve. Pressure should typically be 3-4 psi.
4. Remove the pressure gauge set from the fuel cell and connect it to the Schrader valve on the throttle body.
5. Connect the fuel cell to the wiring harness.
6. Open the valve on the fuel pressure gauge purge line. Do not prime the system without the fuel gauge purge valve open or air can be forced back into the fuel cell. If this happens, repeat steps 1, 2, and 3 to remove the trapped air from the fuel cell.



7. Repeat step 3, this time purging the air completely from the throttle body. The pressure should be 40 psi in the throttle body after purging the system.

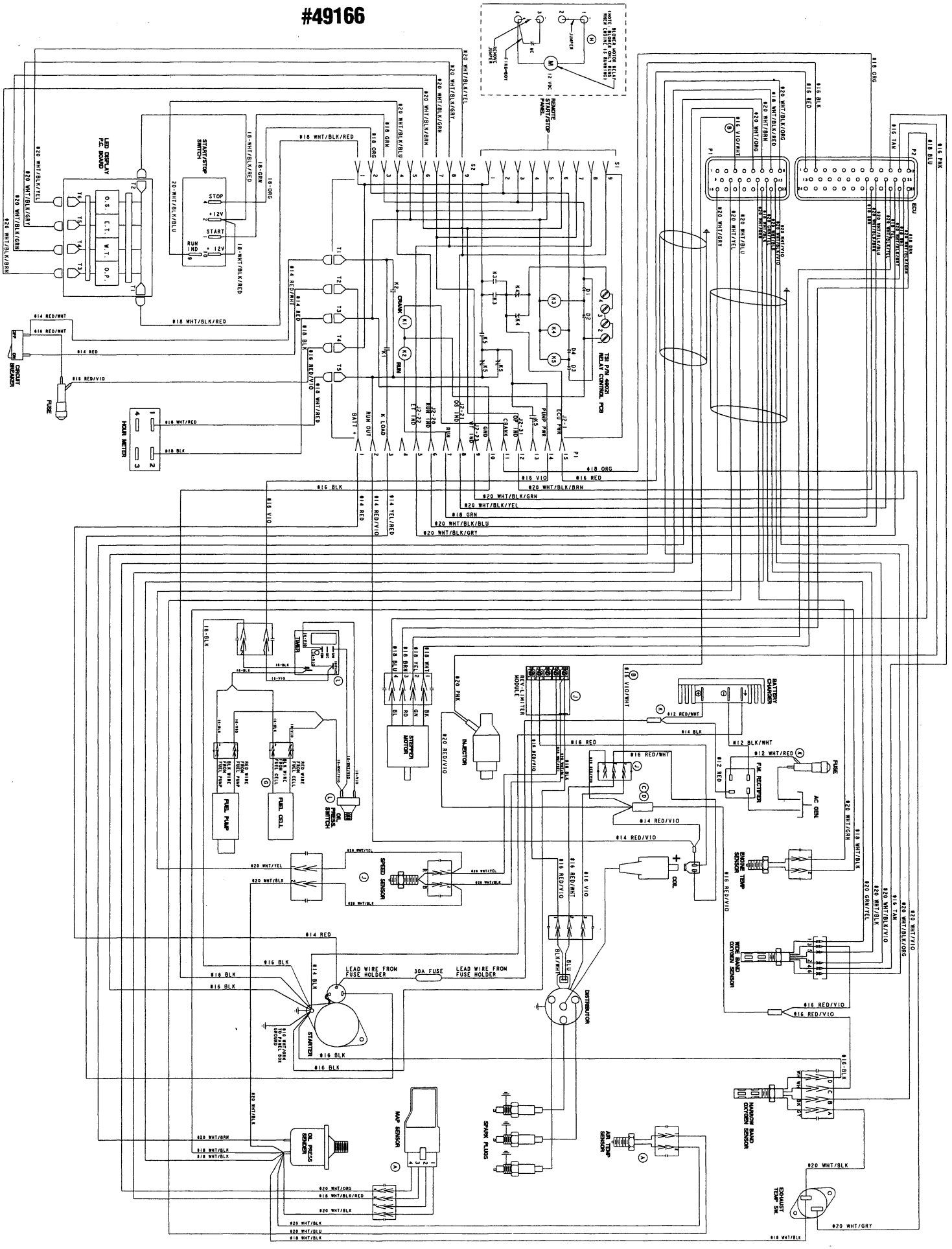
   NOTE: *The system can develop 40 psi without being fully purged. The system is fully purged when no bubbles are visible in the purge line.*
8. Remove the pressure gauge set, and cap all Schrader valves.
9. Insure that all wire connections are secure and that there are no leaks in the fuel system.

> ⚠ **WARNING:** ***Take care to catch any fuel that may be spilled and properly dispose of the fuel rags.***



WIRING DIAGRAM 5 AND 6.5 KW SBCG

#49166



RELAY CONTROL PC BOARD OPERATION

DESCRIPTION

The Main Control PC Board (pn#49021) is an analog electrical devuce that causes continuois power flow (latching) to the on engine computer (ECU) after momentarily pressing the start switch. It utilizes five relays (K) for on engine accessory power as well as run and start/stop functions. Normally open K1 provides a starter solenoid signal, normally open K2 is for run or engine accessory power, normally open K3 is the power latching relay, normally closed K4 is the shut down relay amd K5 has both normally open and normally closed contactors and its primary function is for fuel pump power. The combination of these relays and four diodes (D), in their designated orientation, provide a means of high current power flow to on engine components based on low current capacity signals from the ECU and "latching" of power.

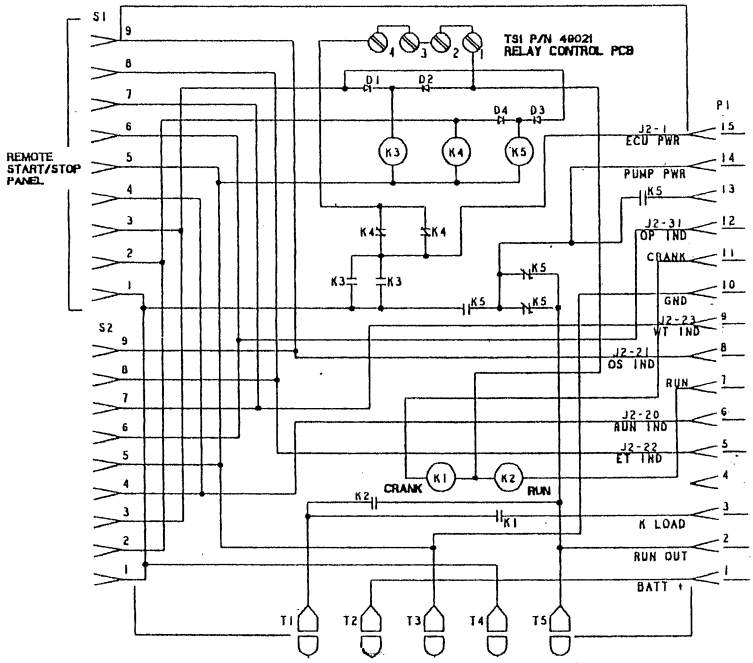
The coil side of K3, K4 and K5 have ground continuously on one side. The K3 and K5 relays rely initially on power provided by the start/stop switchs to actuate them. The K4 relay relies solely upon power from the stop switch to actuate it. The K1 and K2 relays rely on power to their coil provided after the K3 relay latches and ground signals from the ECU for actuation.

Momentarily pressing the start switch sends power through D1 and D3. Power through D1 flows to the coil of K3 closing its normally open contacters which causes power to flow through the normally closed contactors of K4 and to the ECU. Power through D3 at the same time flows to the coil of K5 which then actuates closing its normally open contactor sending power to the fuel pump timer's common and initiate connections. The closed contactors of K4 provide flow through the in series connections of the fire biy terminal strip and through D2 as well as to the coil side of K1 and K2. Power flow through D2 is at that point is providing continuous power to the K3 relay coil causing it to stay closed or "latched". There is continuous power to the ECU at this point and it will stay this way until the stop switch is pressed.

Latching K3 and powering up the ECU, 12V power is measured between p2-1 and P2-2, is called booting up the ECU or initiation of the start sequence., After initiation of the start sequence the ECU immediately illuminates the green LED on the start/stop switch and it provides a ground signal to the K2 relay. When the K2 relay closes power then flows to the on engine accessories such as the hour meter and ignition coil and through the normallyclosed contactors on K5 providing continuous power to the lift pump circuit. After a 2 to 3 second delay for priming the fuel system, the ECU then sends a ground signal to the K1 relay, the starter cranks the engine and it begins running.

When the engine starts, the magnetic pick-up signals the ECU to stop cranking the starter, the computer takes over. The ECU takes information from all of the on engine sensors and it controls all fuel delivery and speed control functions.

When the stop switch is momentarily pressed, it actuates the K4 and K5 relays. When the K4 relay sees a signal from the stop switch it opens its contactors off power to the K3 relay coil making it un-latch turning off power to the ECU. Interrupting power to the ECU shuts off the K2 relay and the unit shuts down. Pressing and holding the stop button closes the K5 relay allowing power flow to the lift pump timer initiate and comon connections for purposes of bleed air from the fuel system.



OIL PRESSURE PROTECTIVE CIRCUIT

There is an Oil Pressure Protective Circuit that insures that power to the fuel pumps is shit-off when the engine is not rotating. The primary component is a very robust mechanical pressure switch that disconnects power to the fuel pumps when oil pressure drops below 5 psi. There is a timer module that allows the pumps to run briefly when there is no oil pressure. This is required for two purposes, one is for start-up before oil pressure is built up and the other is when the fuel system is manually primed.

CONTROL CIRCUIT OPERATION

DESCRIPTION

When the engine start/stop switch and the remote start/stop switch are in their center positions and the green LED is not illuminated and the generator is not running, the ECU and all the engine electrical components are in an off state.

When the start switch is actuated (momentarily depressed), the ECU is powered up and a start is assumed. The green LED will illuminate. The K2 run relay will energize turning on the ignition and the fuel pump. After a time delay of approximately 4 seconds, the K1 relay will energize, which in turn energizes the starter solenoid and an engine cranking sequence will result - starting the engine.

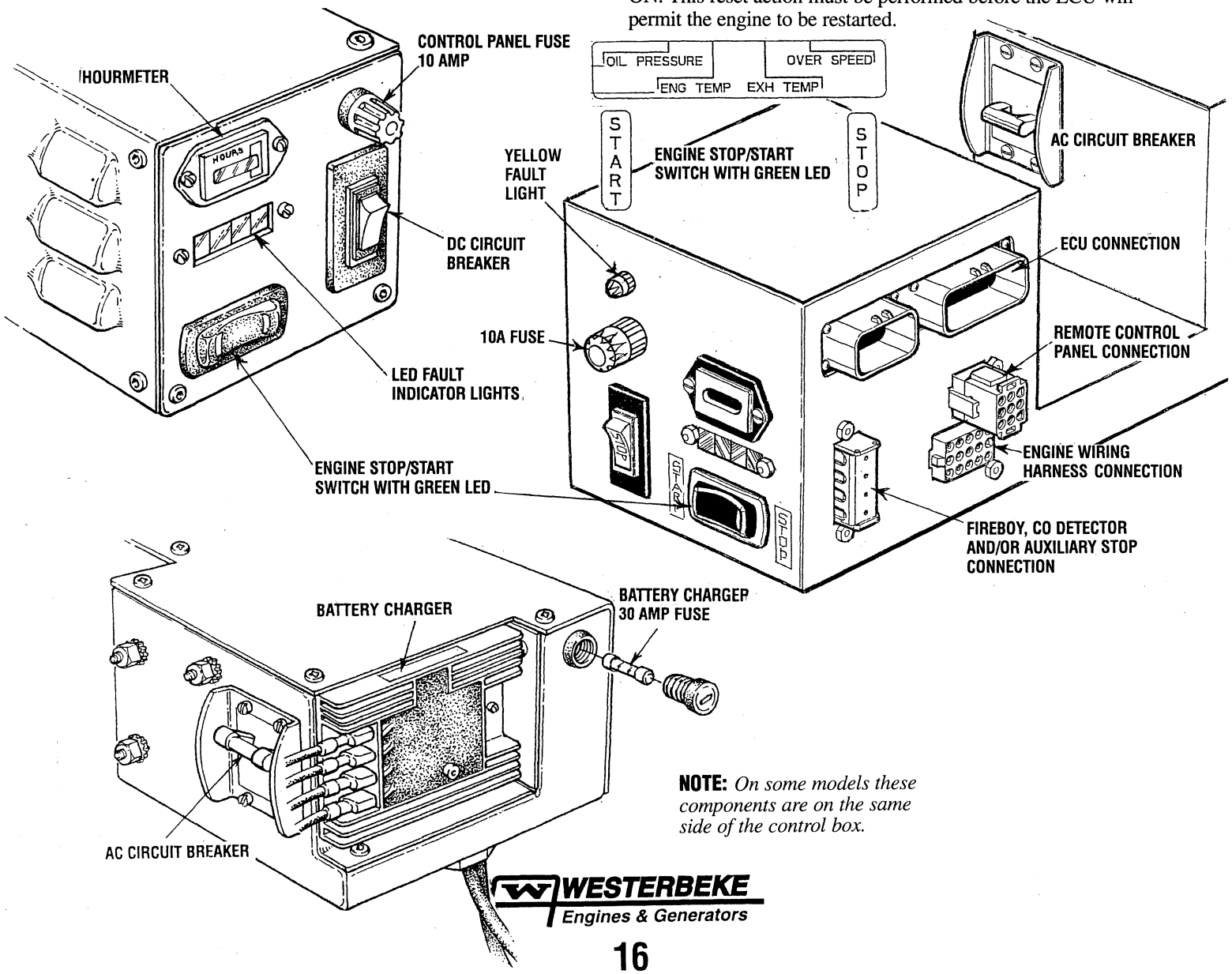
Should the engine fail to start within approximately 10-12 seconds, the start sequence will be terminated and the ECU will go to the off state and the green LED light will go out.

When the engine starts, the starter will automatically disengage (start relay K1 is de-energized). The green LED light on the switch is on and circuit power to the ECU is latched on. The generator will come up to speed and the engine is now under the control of the ECU.

When a stop is initiated by momentarily depressing the stop switch, the ECU will take this command and then de-energize the K2 run relay. This removes DC power to the ignition, the fuel pump, and the injector, shutting down the engine. Once the ECU senses zero rpm engine speed (no MPU AC signal) it then releases the latch, which holds the circuit power on. The green LED light will go out and the ECU will revert to an off state.

Should a fault occur to initiate an engine shutdown as a result of low oil pressure, high water injected exhaust elbow temperature, high engine antifreeze coolant temperature, high engine rpm or low engine rpm, the ECU will acknowledge this as a valid stop command. The stop sequence will be as previously described except that the circuit power will remain on and the fault LED board will register the faulty cause by illuminating the related fault LED. This fault LED will remain on and will not allow the engine to be restarted.

To reset the ECU and turn off the fault LED, the DC circuit breaker on the control panel must be cycled OFF and then ON. This reset action must be performed before the ECU will permit the engine to be restarted.



NOTE: *On some models these components are on the same side of the control box.*

ELECTRONIC CONTROL UNIT (ECU)

DESCRIPTION

The ECU (Electronic Control Unit) is factory programmed and requires no adjustments by the generator operator. It controls all starting, operating and safety shutdown features on the engine.

The Gain Pot (early models) is set at #50 midpoint for optimum system response.Later/current models, the Gain Pot has been removed from the ECU

Program dipswitches are in the OFF position and should not be disturbed.

The vacant program connector is used by the factory to input the operating program into the ECU.

The electrical connections from the engine electrical harness are made to the ECU through two plug connections, one 23 pin and one 35 pin and may therefore vary in number according to the generator model. For further details, consult the engine circuit wiring diagram in this manual.

The ECU is set to operate the generator at the specific hertz when the generator is factory tested. On earlier models, the hertz could be field changed with positioning of the dipswitch #1 on the ECU. **Off** for **60 hertz** and **On** for **50 hertz** operation. On later models, the ECU must be factory programmed when a field gertz is made.

ECU ADJUSTMENTS

Stability Trim

When changing engine speed, or if an engine hunting condition should occur, the gain pot may require adjustment. There is no specific set point for this adjustment and it is normally set to the middle of its range or to a point in its range which obtains optimal engine speed response without any tendency of hunting.

Setting Engine Speed

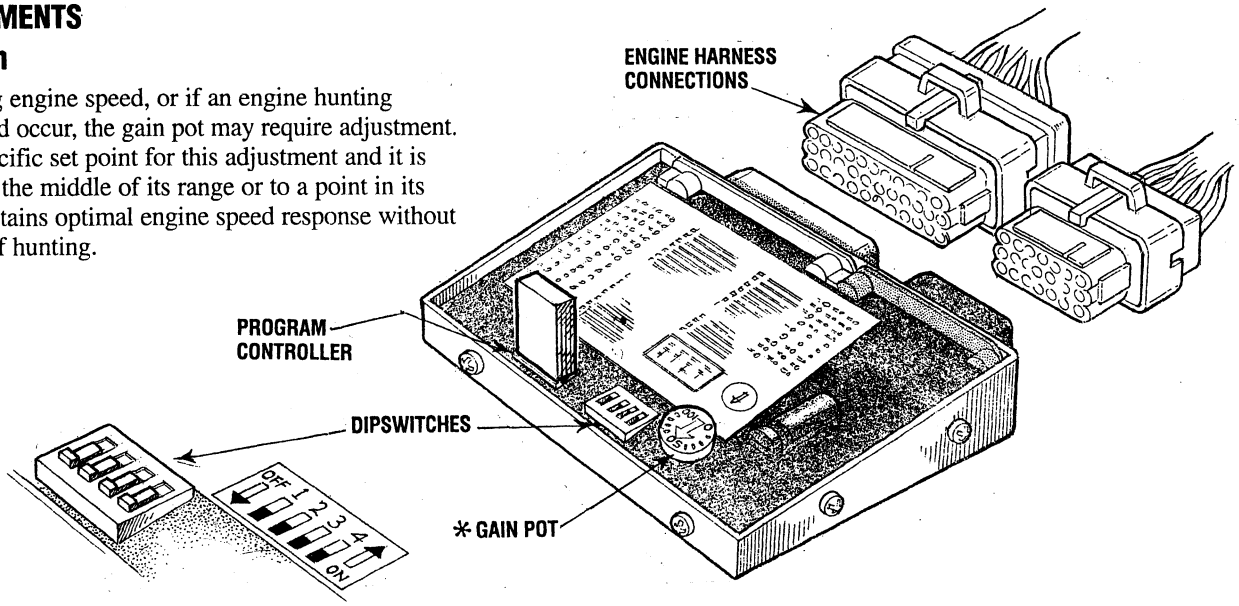
The engine's speed (earlier models) by positioning of the ECU dipswitch #1 for 60 or 50 hertz, 1800 rpm for 60 hertz and 1500 rpm for 50 hertz. On later (current models), the ECU must be factory reprogrammed for a hertz change in the field.

1. Set up whatever equipment is to be used to measure engine speed or generator output frequency.
2. Start up and run the generator at the current operating speed and frequency.
3. Adjust the GAIN setting between 40 - 60 for best system reaction to AC amperage load changes.

   NOTE: *A higher GAIN adjustment can induce unstable engine operation. In such cases, lessen the GAIN adjustment.*

On later models the GAIN pot was removed from the ECU

ELECTRONIC CONTROL UNIT (ECU)



REPLACING THE ECU

Remove the control box ɔfore attempting to remove the ECU, turn OFF DC ɾ either removing the buss fuse from its holder in th panel or turn OFF the control panel's DC break ıg the engine harness connections to the ECU. ı nen unscrew the four securing side screws holding the ECU in place and remove the ECU from its holder.

INSTALLING THE NEW ECU

To install the new ECU, reverse the above procedure.

ELECTRONIC FUEL INJECTION

DESCRIPTION

The illustration shows the throttle body assembly that attaches to the intake manifold.

An electronic control unit (ECU) controls the fuel injector and the throttle actuator.

The ECU is supplied with engine operating conditions from sensors that monitor intake air tempeature, engine coolant temperature, map sensor)intake manifold absolute pressure), engine rpm and battery voltage.

The ECU interprets this information to determine the appropriate injector pulse rate and throttle opening position.

A high pressure fuel pump supplies fuel to the area around the injector and the regulator maintains the fuel pressure in that area at 35 - 40 PSI maximum.

The injector is a solenoid operated pintle valve that meters fuel into the intake manifold depending on engine operating conditions and generator amperage load as determined by the ECU.

Air flow into the intake manifold.engine is controlled by the ECU's operation of the throttle plate via the stepper motor. Throttle plate positioning for proper air flow into the engine is accomplished through the ECU's interpretation of the engine's operating conditions. The Schrader valve on the throttle body is used to bleed the system and top monitor/check fuel pressure around the fuel injector.

NOTE: *The Stepper Motor must never be disassembled in the field as this will upset the calibration of the throttle plate and seriously affect the operation of the engine.*

THROTTLE BODY

The throttle body, mounted on the intake manifold, is an assembly of the principal components of the EFI (Electronic Fuel Injection System).

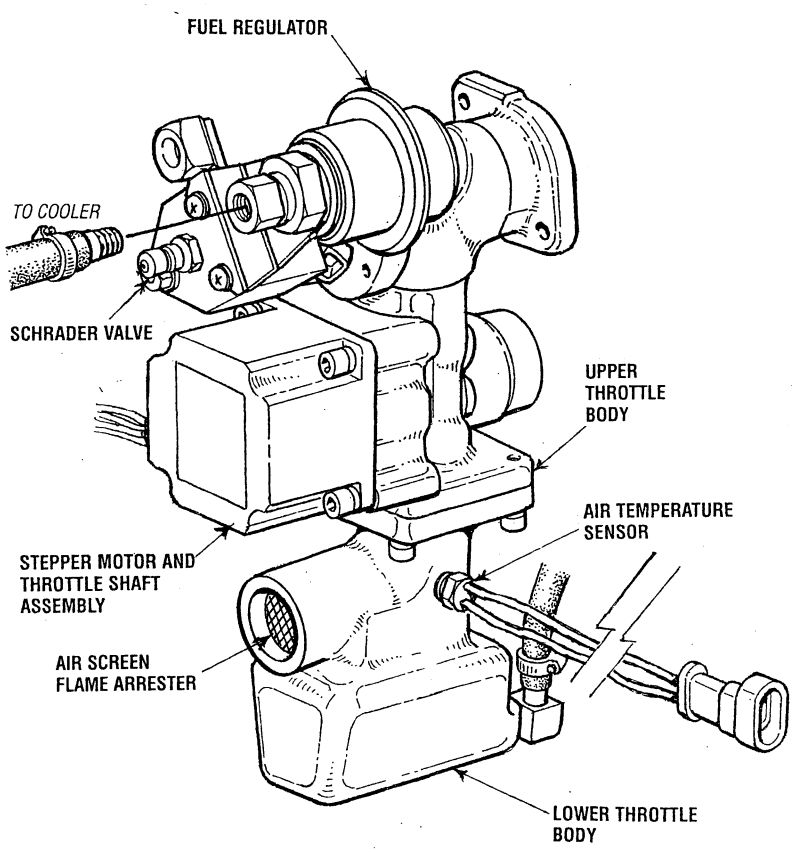
The EFI is controlled by the ECU (Electronic Control Unit) which interprets data from sensors that monitor the vital parts of the engine. The ECU uses this continuous flow of data to determine the appropriate injector pulse rate and throttle opening position.

A high pressure fuel pump supplies fuel to the area around the injector and the regulator maintains the fuel pressure in that area at 35 - 40 PSI.

The injector is a solenoid operated pintle valve that meters fuel into the intake manifold depending on engine operating conditions and generator amperage load as determined by the ECU.

Air flow into the intake manifold is through the flame arrester/air filter and is controlled by the ECU operation of the throttle plate via the actuator (stepper motor). The throttle plate positioning for proper air flow into the engine is accomplished through the ECU interpretation of the engine operating conditions. The Schrader valve is used to monitor the fuel pressure at the fuel injector and to bleed air after fuel system servicing.

On some models an air intake heater is positioned in the intake to heat the incoming air during a cold start.

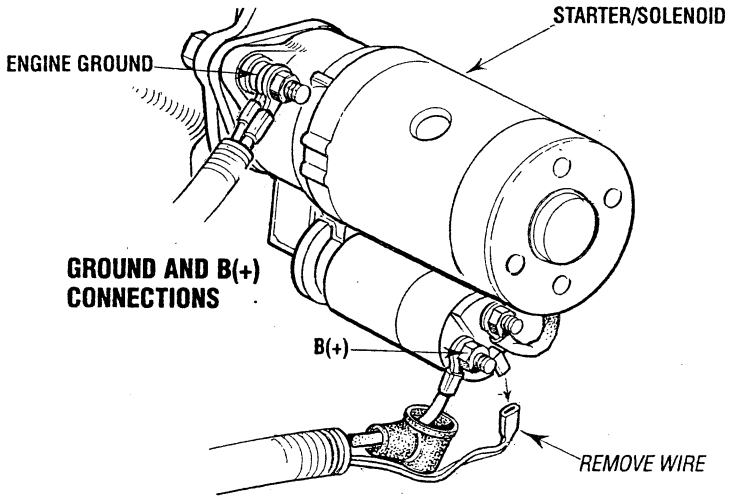


COMPONENT STATIC TESTING

GENERAL

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

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



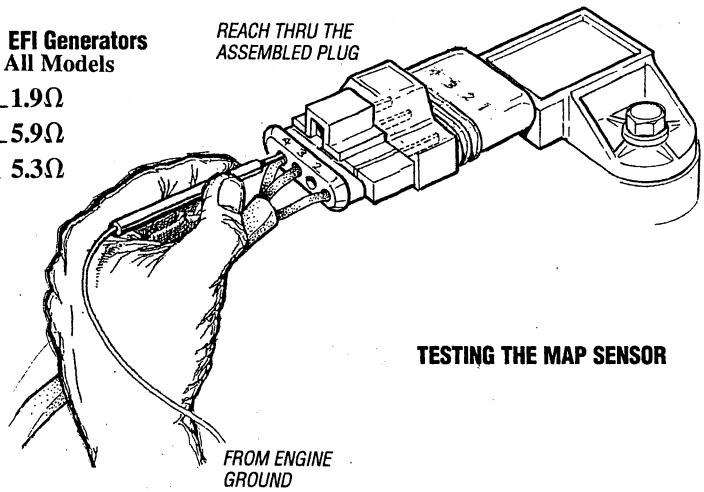
MAP SENSOR

The Manifold Absolute Pressure (MAP) sensor is a solid state pressure transducer which measures the intake manifold pressure (vacuum). It derives its operating power (+5V, Pin 4; Gnd, Pin 1) from the ECU and receives power only when the ECU is in an *on* state. Its output (Pin 3) is measured to ground.

Typical output voltages are as follows:

Map Sensor -- Voltages	**EFI Generators 5.0/6.5Kw**
Pin 4 (sig) to Grnd (at rest)	**0 VDC**
Pin 4 (sig) to Grnd (prime delay in start mode)	**4.089 VDC**
Pin 4 (sig) to Grnd (running 1800 rpm no AC load)	**1.73 VDC (typical)**
Pin 3 (+5V) to Grnd (at rest)	**0 VDC**
Pin 3 (+5V) to Grnd (prime delay in start mode)	**4.997 VDC**
Pin 3 (+5V) to Grnd (running 1800 rpm no AC load)	**5.005 VDC (typical)**

Map Sensor -- Resistances	**EFI Generators All Models**
Pin 1 (grnd) to Pin 2	**1.9Ω**
Pin 1 (grnd) to Pin 3	**5.9Ω**
Pin 1 (grnd) to Pin 4	**5.3Ω**



TESTING THE MAP SENSOR

COMPONENT TESTING

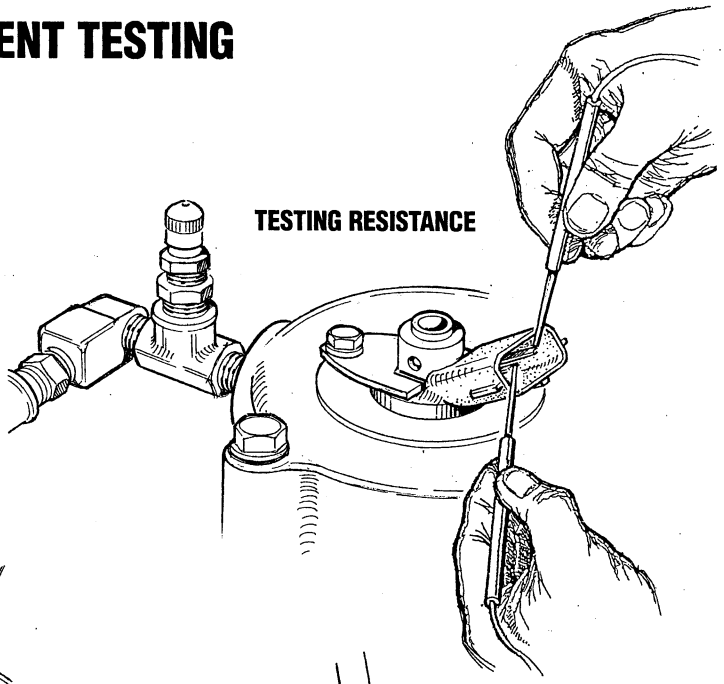
STEPPER MOTOR

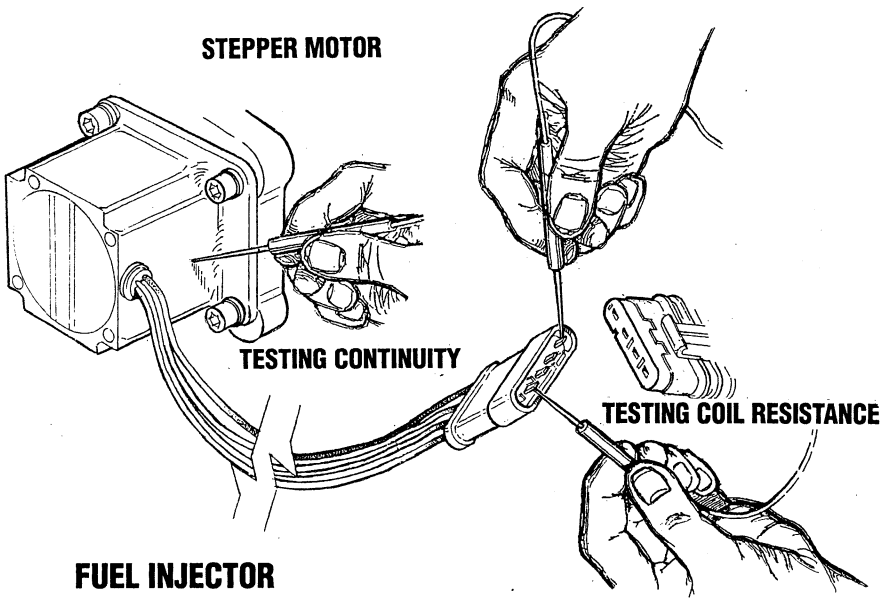
The throttle plate rotary stepper motor operates on a low DC voltage supplied from the ECU. There are two independent operating coils in the stepper motor. Each coil resistance is typically 2.61 ohms.

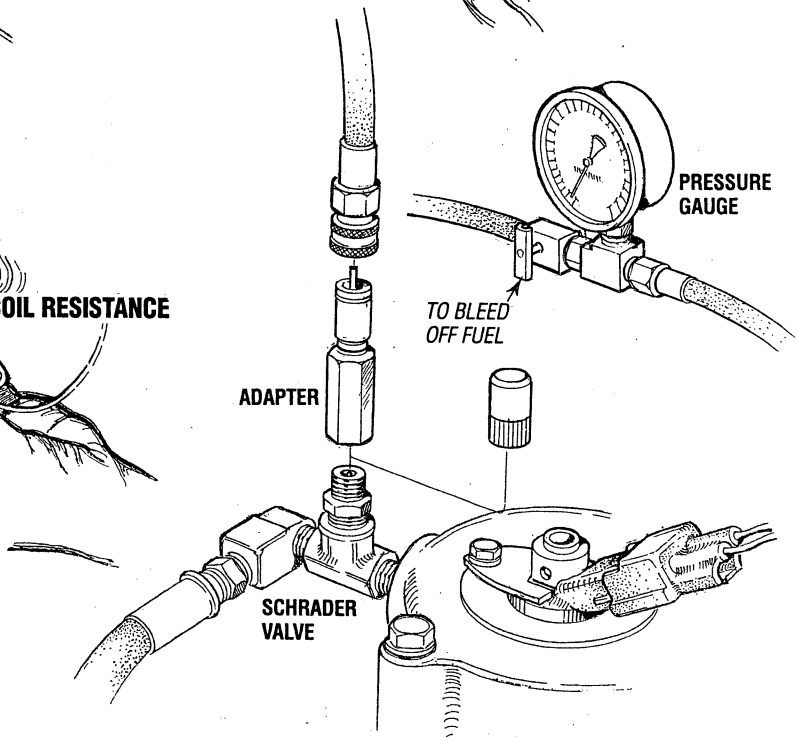
A resistance value test only should be performed on the stepper motors two coils. Do not apply 12VDC to these coils as it will damage the coils.

Check the resistance value of each coil between coil #1 (blue and red) and coil #2 (black and green).

There should be no continuity found between any of the coil connectors and the metal case of the stepper body.







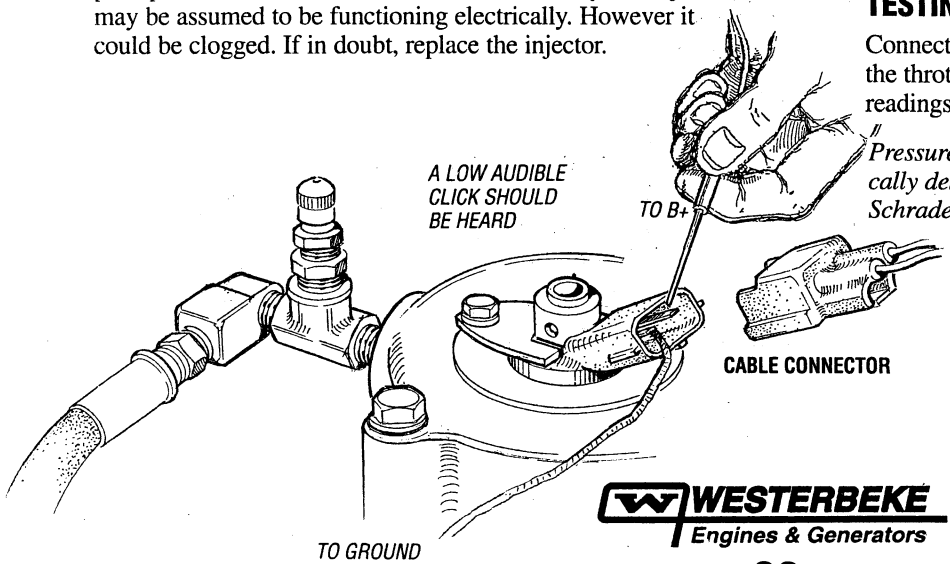
FUEL INJECTOR

The fuel injector has no polarity and operates on 12 VDC. The coil resistance is typically in the order of 14 to 16 ohms. The positive wire to the injector is supplied power through the contacts of relay K2, which is off when the engine is not running. To test the injector, disconnect its cable connector and connect a ground wire to one of its input pins. Connect a wire from a point of B+ and repeatedly touch the other input pin. When touched, a low audible click should be perceptible; if not, resistance test the coil. If okay, the injector may be assumed to be functioning electrically. However it could be clogged. If in doubt, replace the injector.

TESTING SYSTEM FUEL PRESSURE

Connect a fuel pressure test gauge to the Schrader valve on the throttle body as shown and run the engine. Pressure readings should indicate 35 - 40 psi.

Pressure gauge kit MT 337B "SNAP -ON-TOOL" is specifically designed for fast accurate testing of fuel pressure for Schrader test ports.



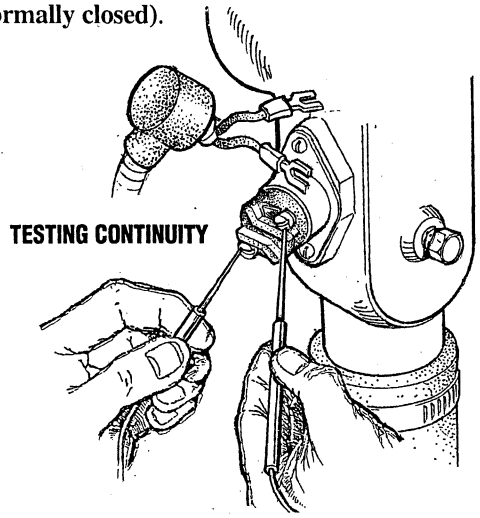
COMPONENT STATIC TESTING

TESTING THE EXHAUST TEMPERATURE SWITCH

An exhaust temperature switch is located on the water injected exhaust elbow. Normally closed, this switch will open and the ECU will interpret this as a high exhaust temperature and open the K2 run relay stopping the generator. The exhaust temperature LED on the panel will illuminate.

The switch opens at 260 - 270°F (127 - 132°C). This switch resets (contacts close) at approximately 225°F (107°C).

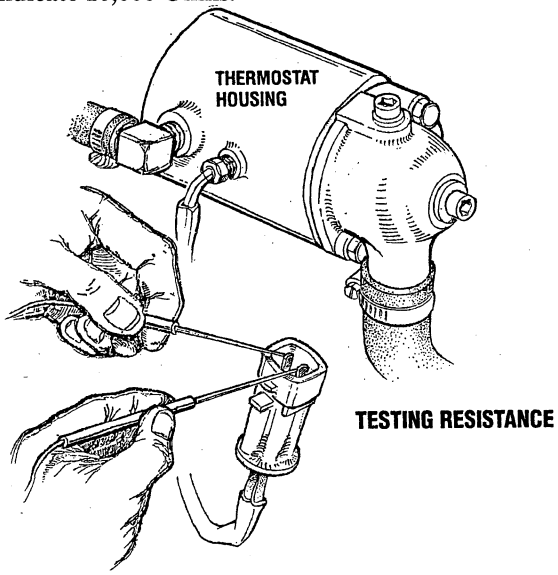
When testing, continuity should be found (switch is normally closed).



COOLANT (WATER) TEMPERATURE SENSOR

A temperature sensor is located at the thermostat housing. This sensor sends a DC voltage to the ECU that it interprets as engine (antifreeze) coolant temperature. Should this voltage reach a set value, the ECU will interpret this as a high temperature and open the K2 run relay, stopping the generator. The overheat LED on the panel will then illuminate.

Test the sensor as shown. Resistance at room temperature should indicate 10,000 Ohms.

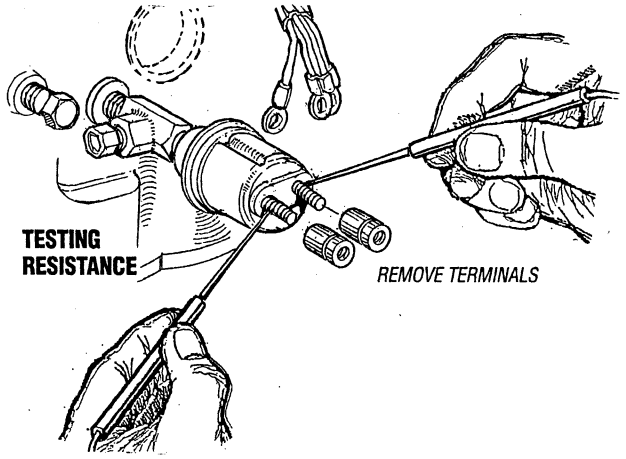


TESTING THE OIL PRESSURE SENSOR

The oil pressure sensor sends a DC voltage to the ECU that the ECU interprets as oil pressure. Should this voltage fall below a certain level, the ECU will shut the generator down and illuminate the oil pressure LED.

Test the sensor by checking resistance (at rest):

Ohm Value - 240 - 270Ω



ENGINE DC CIRCUIT BREAKER

The generator's engine DC circuit is protected by a rocker type DC 20 amp breaker mounted on the control box (this also serves as an Emergency Stop Switch). Excessive DC current draw or DC electrical overload anywhere in the instrument panel wiring or engine wiring will cause the breaker to trip to the OFF position. In this event, the DC power to the ECU will be interrupted, stopping the generator. No panel LED will illuminate. Check and repair the source of the problem. After repairing the fault, reset the breaker and restart the generator.

HIGH/LOW RPM SHUTDOWN

The ECU monitors engine speed by the AC voltage produced by the MPU. Should this voltage reach a preset value, the ECU will interpret this as an engine overspeed (2175 rpm approximately) and open the K2 relay, stopping the generator. The panel Overspeed LED will illuminate. Should the MPU produce a low AC voltage that the ECU interprets as an underspeed condition, the ECU will open the K2 relay and stop the generator. The Overspeed LED will then blink.

COMPONENT TESTING

TESTING THE MAGNETIC PICK UP COIL

Test the magnetic pick-up AC voltage output while cranking. Voltages are listed below.

Test the magnetic pick-up coil winding in a static mode.Resistance values are shown below., If the AC output voltage is not present or lower than listed and the resistance value of the coil winding is correct, debris maybe insulating the MPU tip end. remove the MPU and examine and clean the tip end of debris.

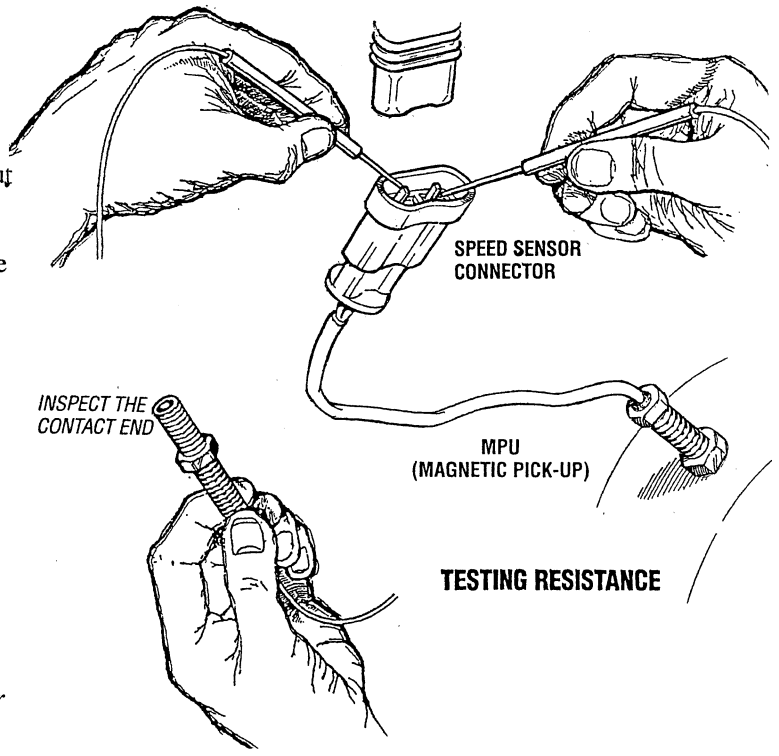
Coil winding resistance being lower or not present would damage the MPU.

NOTE: *Carefully follow the installation instructions provided with the new MPU.*

Speed Sensor Test Values Voltage
(while cranking)
5.0, 6.5 Kw EFI - 1.33 VAC
8, 10, 12.5, 14 Kw EFI - 0.98 VAC
20, 22.5 Kw EFI - 1.26 VAC

Resistance (at rest) - 950-1000Ω (all models)

NOTE: *The AC signal produces by the MPU will be greater the closer the MPU is positioned to the flat of the ring gear tooth and weaker the farther away from the tooth.*



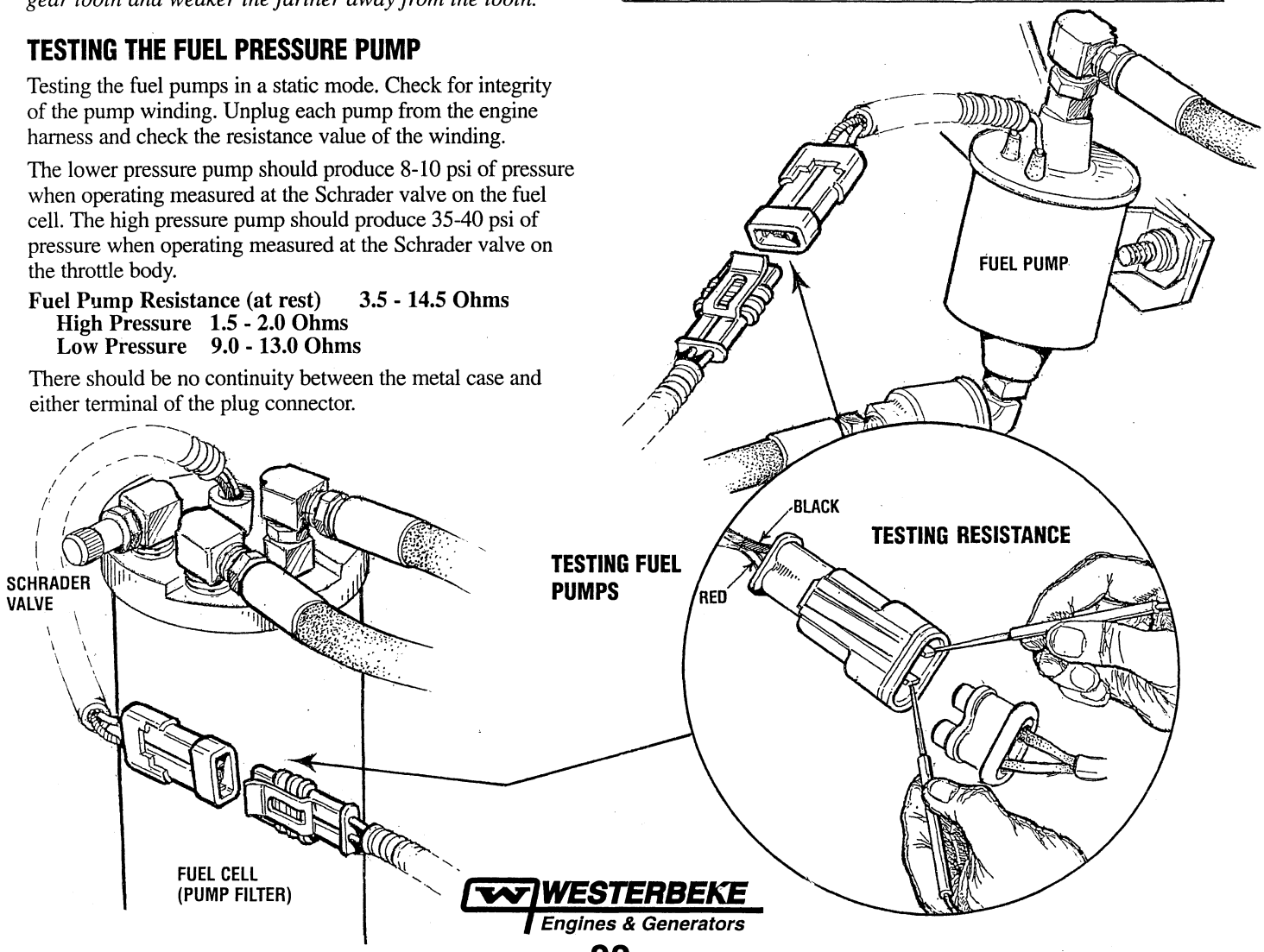
TESTING THE FUEL PRESSURE PUMP

Testing the fuel pumps in a static mode. Check for integrity of the pump winding. Unplug each pump from the engine harness and check the resistance value of the winding.

The lower pressure pump should produce 8-10 psi of pressure when operating measured at the Schrader valve on the fuel cell. The high pressure pump should produce 35-40 psi of pressure when operating measured at the Schrader valve on the throttle body.

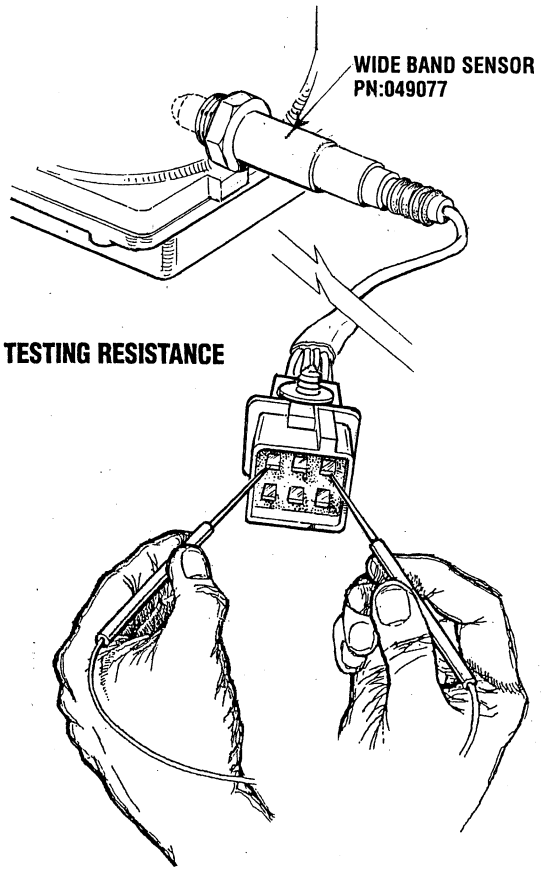
Fuel Pump Resistance (at rest) 3.5 - 14.5 Ohms
High Pressure 1.5 - 2.0 Ohms
Low Pressure 9.0 - 13.0 Ohms

There should be no continuity between the metal case and either terminal of the plug connector.



TESTING OXYGEN SENSORS

Two oxygen sensors are used in the EFI system. A narrow band sensor on the exhaust inlet side of the catalyst and a wide band sensor on the exhaust discharge side of the catalyst. These sensors monitor engine operation that the ECU interprets and adjusts air/fuel ratios accordingly.



TESTING THE OXYGEN SENSORS IN A STATIC MODE

Narrow Band Sensor: Unplug the sensor from the engine harness. Locate the 2 white pin leads, measure across these two pins with an ohm meter.

Resistance Value 2.0 - 4.0 OHM (approximately)

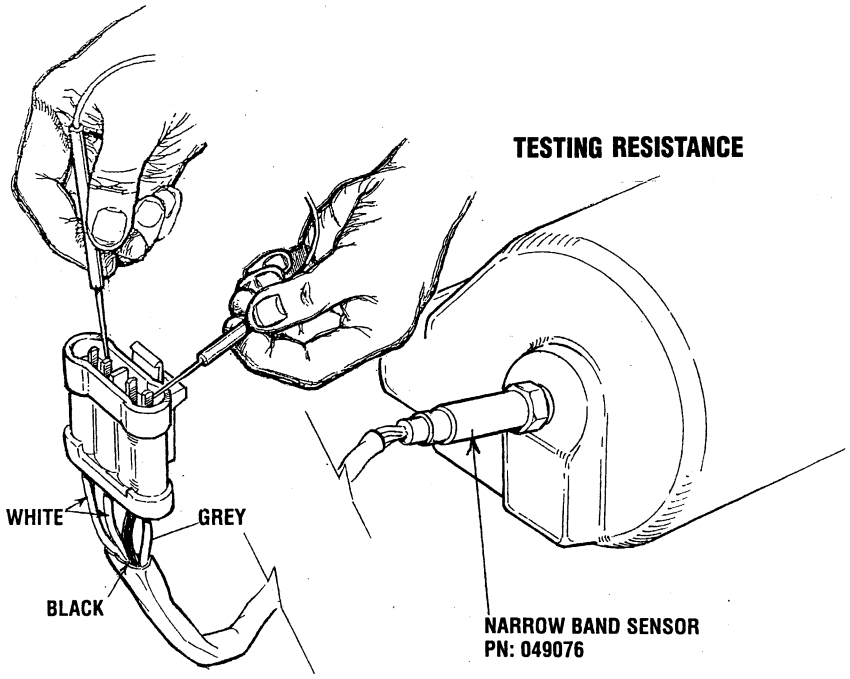
There should be no continuity between either of the two white lead pins and the black or grey lead pins.

Wide Band Sensor: Unplug the sensor from the engine harness. Locate the red pin lead and the vacant black pin lead. Measure across these two pins with an ohm meter.

Resistance Value 110.0 - 130.0 OHM (approximately)

No continuity should be found between these two pins and any of the other four.

Sensors not meeting these tests are presumed faulty. care should be taken when installing a replacement sensor. Do not scratch, damage, or handle the sensor end in any way.

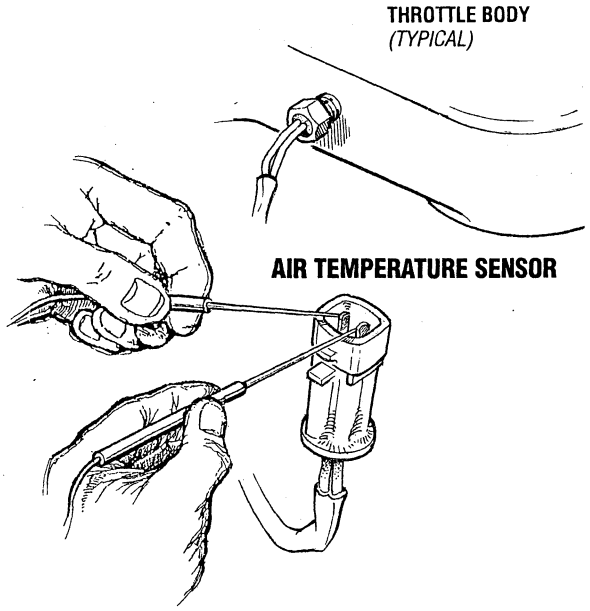


AIR, COOLANT, AND WATER HEATER TEMPERATURE SENSORS

These three sensors contain as their sensing elements identical negative temperature coefficient (NTC) thermistors whose internal resistance inversely changes to a change in temperature (i.e., temperature increase, resistance decrease). The thermistors nominal resistance value at 77° F (25° C) is 10,000 ohms. When the ECU is in an *on* state, the thermistors (–) lead is connected to ground, and its (+) lead is connected to the ECU and then through a fixed series 10,000 ohm resistor to the +5V power source. Therefore, the voltage at the thermistors (+) lead should be approximately +2.5 volts at a temperature of 77° F and decreases to a voltage of approximately +.25V at 220° F. The voltage – temperature relationship however, is not linear over this range and therefore it should only serve as an indicator that the thermistor is functioning.

Resistance Values (at room temperature)
Air Temperature Sensor - 10,000Ω
Coolant Temperature Sensor - 10,000Ω

Generally, the thermistor may be assumed to be good if there is a perceptual resistance change for a corresponding temperature over the indicated range, otherwise replace the sensor.



INTAKE HEATER ELEMENT

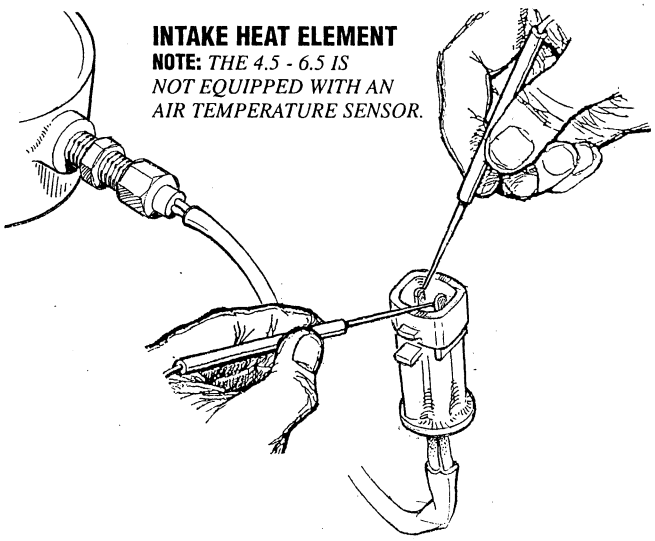
An intake heater is located in the air inlet area of the throttle body on all four cylinder models. the heater operates to warm incoming air on a cold engine start and in adverse cold operating conditions.

Testing (static) the Heater Element

Unplug the heater from the engine harness. Put the ohmmeter probes across the two heater plug pin contacts.

Resistance Value 1.5 - 2.5 OHM (approximately)

There should be no continuity between either of the two pin contacts and the metal case of the element.



BATTERY CHARGING CIRCUIT

DESCRIPTION

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

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

BATTERIES

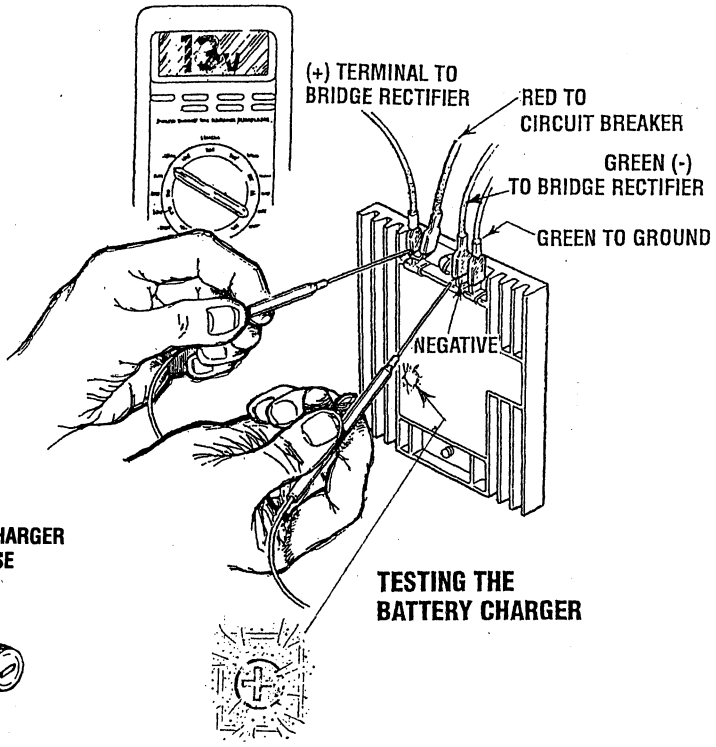
⚠ CAUTION: ***To avoid damage to the battery charging circut, never shut off the engine battery switch while the engine is running. Shut off the engine battery switch, however, to avoid electrical shorts when working on the engine's electrical circuit.***

Specifications

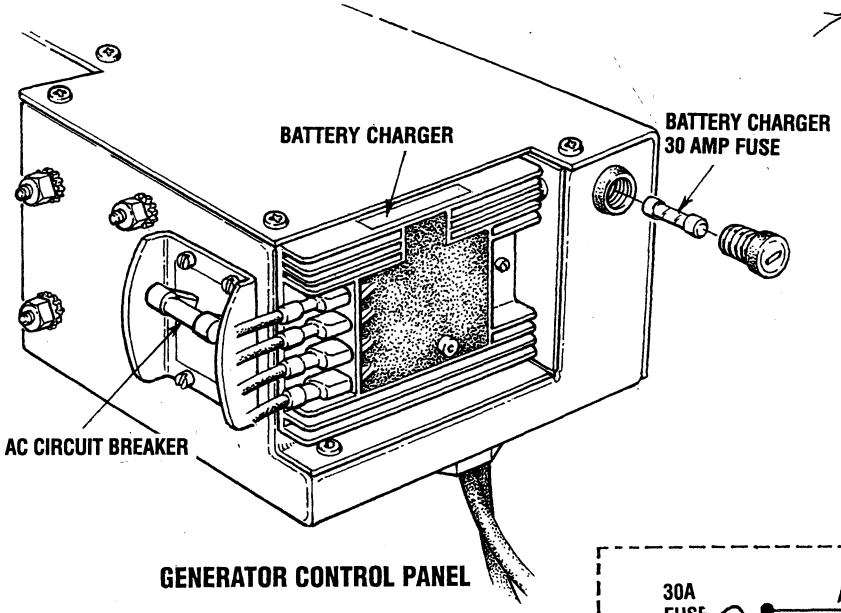
The minimum recommended capacity of the battery used in the engine's 12-volt DC control circuit is 800 CCA.

BATTERY CHARGING/TESTING

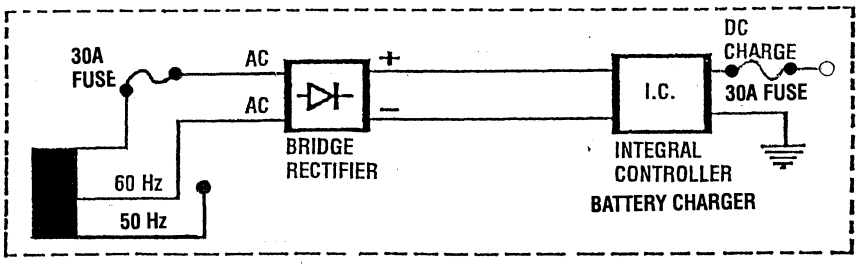
The generator supplies a continuous 12 amp (maximum) charge from its battery charger to the starting battery. To test the battery charger, put a multimeter between the positive (+) and negative (-) leads to the battery. It should indicate 13.0V to 13.4V with the engine running. If only the battery voltage is indicated, check that the battery charger terminal connections are tight. With the unit running, test between the (+) and (-) terminals for 13.0V to 13.4V. If no charge is indicated, replace the charger.



TESTING THE BATTERY CHARGER



GENERATOR CONTROL PANEL



CHARGING SYSTEM SCHEMATIC

EFI GENERATOR ELECTRICAL TESTING VALUES

DEVICE AND CONDITION	GENERATOR MODELS			
	All Models	5.0/6.5Kw	8,10,12.5.14Kw	20/22Kw EFI
Speed Sensor-Voltage (while cranking) (AC Volts)		1.33	0.98	1.26
Speed Sensor-Resistance (at rest) (in Ohms)	950-1000Ω			
Distributor-Voltages (in AC volts)				
Red (ECU) and Black/White (+)		0.55	0.447	0.253
Red (ECU) and Blue (-)		0.44	0.44	0.177
Blue (-) and Black/White (+)		0	0	0
Black/White (+) and Engine Ground		0.072	0.011	0
Blue (-) and Engine Ground		0	0	0
Red (ECU) and Engine Ground		0.60	0.45	0.277
Distributor-Resistance (in Ohms)				
Red (ECU) and Black/White (+)	None (open)			
Red (ECU) and Blue (-)	None (open)			
Blue (-) and Black/White (+)	None (open)			
Black/White (+) and Engine Ground	None (open)			
Blue (-) and Engine Ground	None (open)			
Red (ECU) and Engine Ground	None (open)			
Map Sensor-Voltages (in DC Volts)				
Pin 4 (sig) to Ground (at rest)			0	0
Pin 4 (sig) to Ground (prime delay in start mode)			4.05	4.056
Pin 4 (sig) to Ground (running 1800 rpm no AC load)			1.25*	1.300*
Pin 3 (+5V) to Ground (at rest)			0	0
Pin 3 (+5V) to Ground (prime delay in start mode)			4.997	4.999
Pin 3 (+5V) to Ground (running 1800 rpm no AC load)			5.003*	5.014*
Map Sensor-Resistance (in Ohms)				
Pin 1 (grnd) to Pin 2	1.9Ω			
Pin 1 (grnd) to Pin 3	5.9Ω			
Pin 1 (grnd) to Pin 4	5.3Ω			
Intake Heater Element in Ohms	1.5 - 2.5Ω			
Air Temperature Sensor (room temp.)in Ohms	10,000Ω			
Water Temperature Sensor (room temp.)in Ohms	10,000Ω			
Oil Pressure Sensor (at rest)in Ohms	245Ω			
Stepper Motor (at rest)in Ohms				
Black and Green	2.61Ω			
Red and Blue	2.61Ω			
Stepper Motor-Resistance (in Ohms)				
Purple: Part #42221				14.55Ω
Blue: Part #48921			14.55Ω	
Black: Part #49556		12.50Ω		
K1, 2, or 3 Relay (between terminal 86 and 86)in Ohms			86Ω	86Ω
Mando Alternator-part #39139 (in DC Volts)				
B+ (typical at rest)			12.7	12.7
B+ (typical while running)			14.1	14.5
At Excitation (typical while running)			13.4	13.6
At Excitation (at rest)			0	0
Fuel Pump in Ohms				
Low Pressure	1.5 - 2.0Ω			
High Pressure	9.0 - 13.0Ω			

Note: * Approximate Voltages

GENERATOR / ENGINE DISASSEMBLY

DESCRIPTION

The engine component of the BC generator is not as bulky or heavy as most engines (approx. 250 lbs) so it can be disassembled and repaired on a sturdy work bench. Make certain however that the engine is securely fastened so it can not topple off the bench and that the bench is also secure and can not tip over.

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

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

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

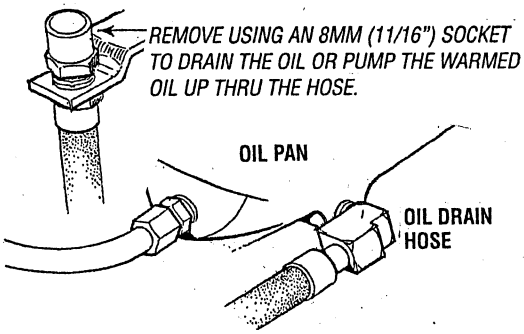
Unfasten the generator from its mounting rails or the mounting rails from the platform and remove the generator from the boat.

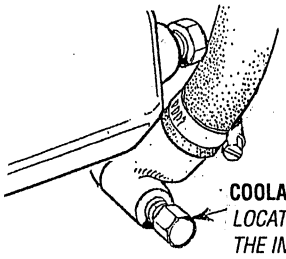
Once the generator is securely mounted on the work bench, drain the engine oil and coolant.

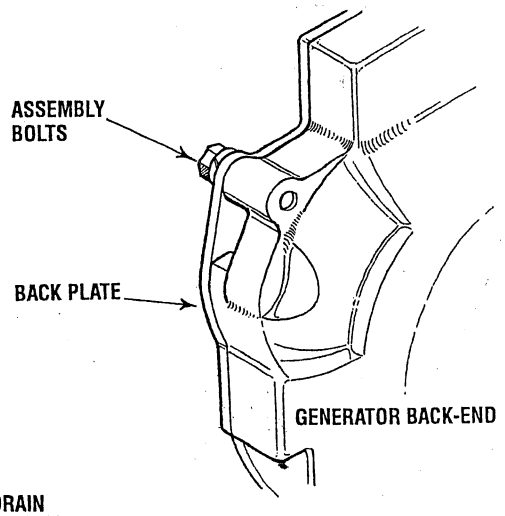
Remove the starter motor. Disconnect and remove the wiring harness, be certain to tag all the wiring connections so you can separate them.

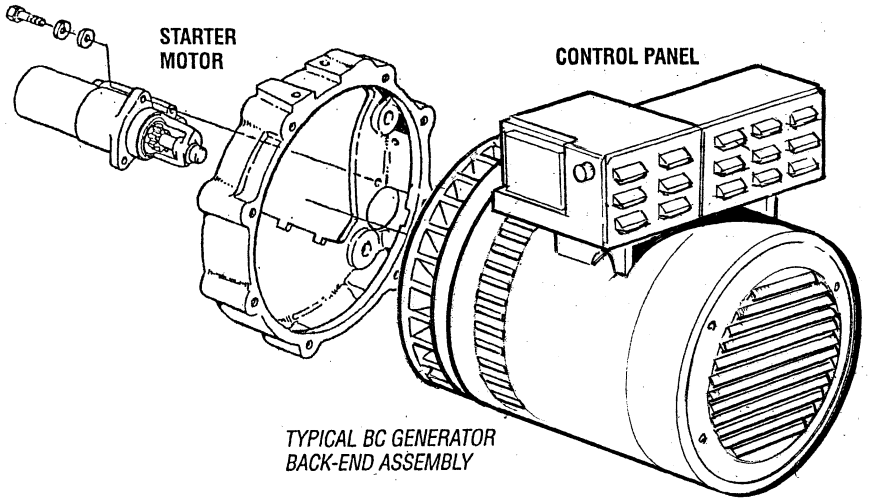
Separate the generator back-end from the engine. Once the housing is removed, the remaining generator components can be disassembled from the engine back-plate.

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









TYPICAL BC GENERATOR BACK-END ASSEMBLY

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

ENGINE ASSEMBLY

GENERAL INFORMATION

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

Torquing Hardware

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

Sealants and Lubricants

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

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

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

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

Do not use sealant when installing a new gasket.

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

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

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

Bolts and Fasteners

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

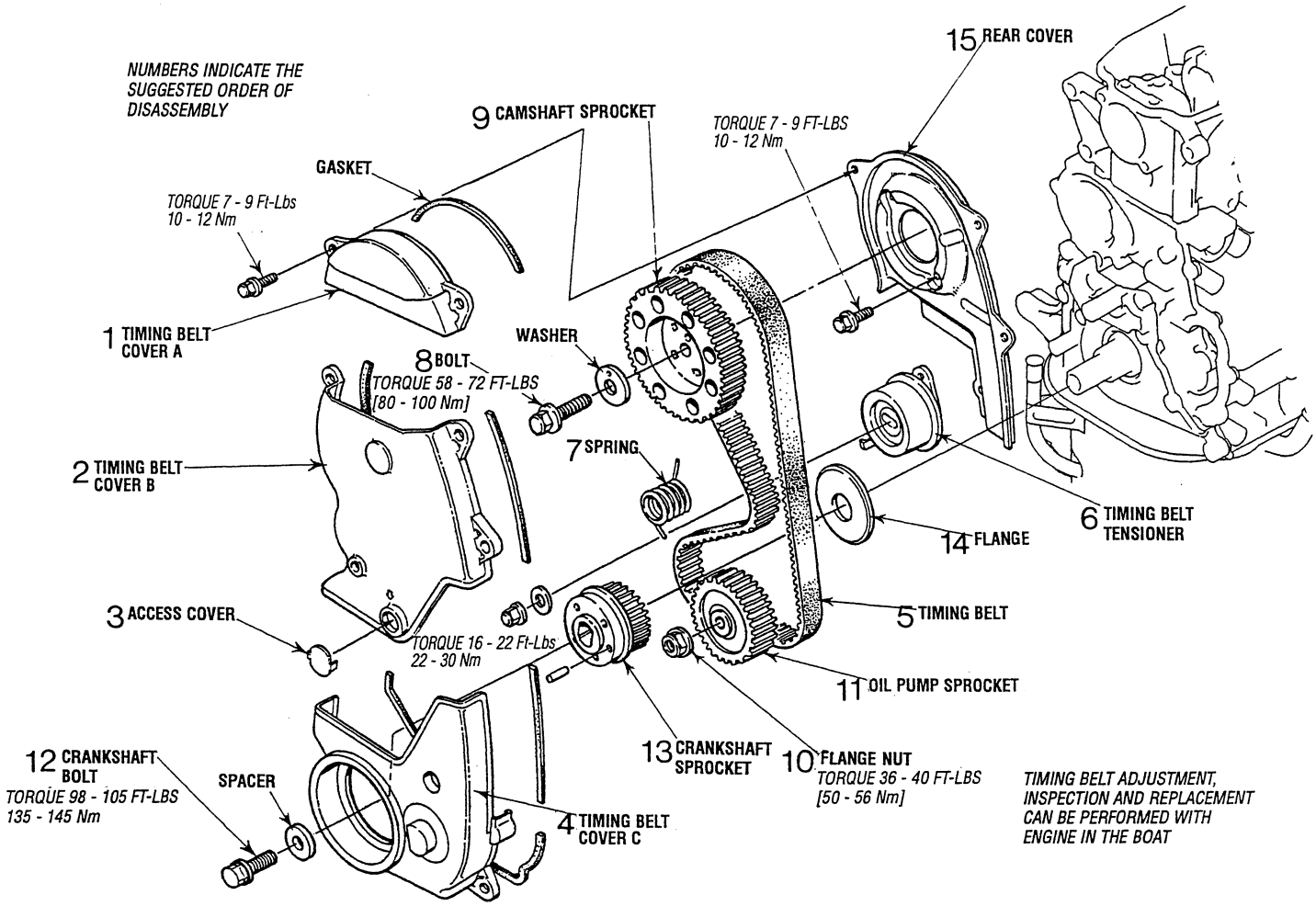
When assembling the flywheel, coat the bolt threads with LOCTITE blue.

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

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

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

TIMING BELT DISASSEMBLY



INSTRUCTIONS FOR INSPECTING AND REPLACING THE TIMING BELT

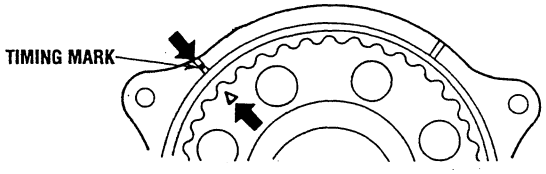
WESTERBEKE requires as normal maintenance, replacing the timing belt after 1000 engine operating hours. The timing belt should always be replaced during an engine overhaul.

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

Timing Belt Removal

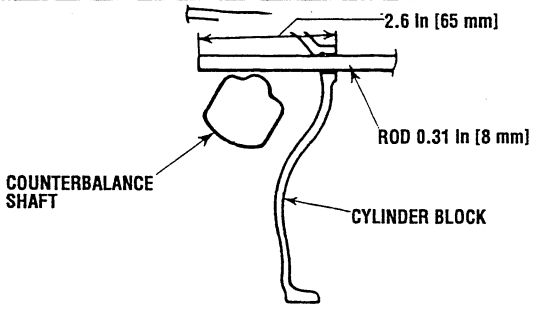
1. Turn the crankshaft clockwise to align the timing mark on the camshaft sprocket and timing belt rear cover.

NOTE: *Always turn the crankshaft clockwise.*

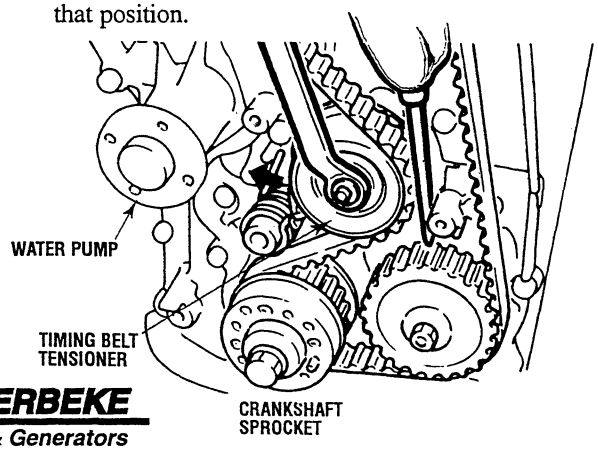


2. Remove the plug on the left surface of the cylinder block and insert a rod with a diameter of 0.31 in (8 mm) to lock the counterbalance shaft.

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



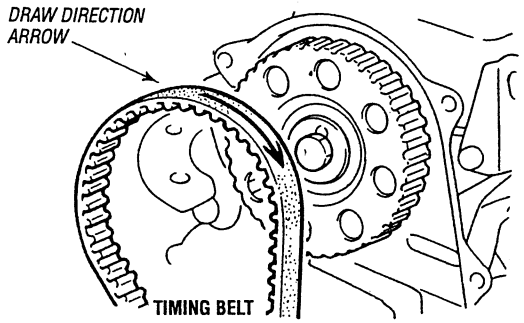
3. Loosen the timing belt tensioner nut.
4. Move the timing belt tensioner toward the water pump, and temporarily tighten the nut to hold the tensioner in that position.



TIMING BELT DISASSEMBLY

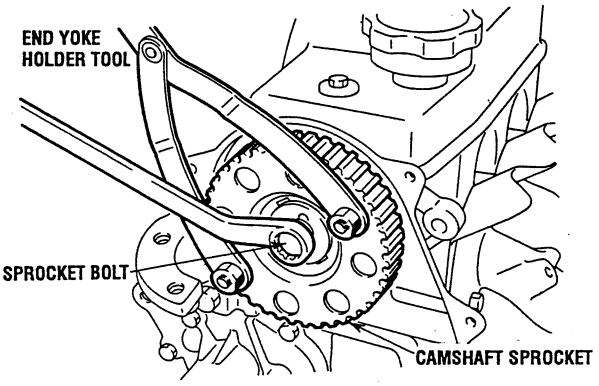
5. Remove the timing belt.

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



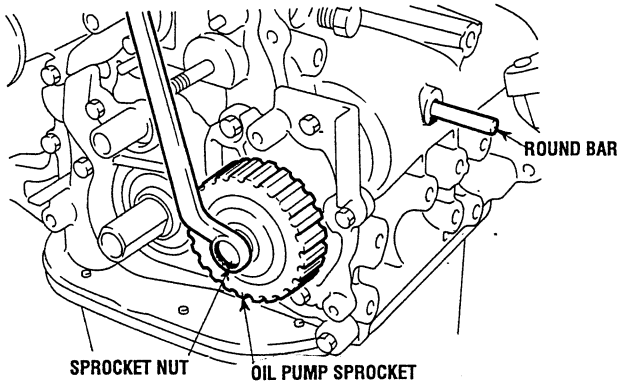
Camshaft Sprocket Removal

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



Oil Pump Sprocket Flange Nut Removal

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



Crankshaft Bolt Removal

1. Lock the crankshaft in position.

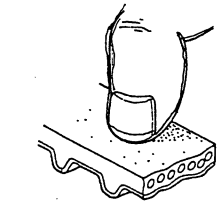
   NOTE: *Do not turn the crankshaft.*

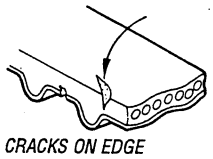
2. Remove the crankshaft bolt.

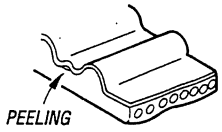
Timing Belt Inspection

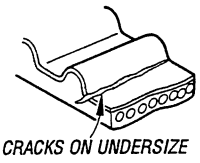
Replace the belt if any of the following conditions exist:

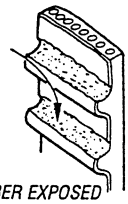
- Hardening of the back rubber, leaves no indent when pressed with fingernail (back side is glossy).
- Cracks on rubber back.
- Cracks or peeling of canvas.
- Cracks on tooth bottom.
- Cracks on belt.
- Abnormal wear of belt sides. The sides are normal if they are sharp as if cut by a knife.
- Abnormal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

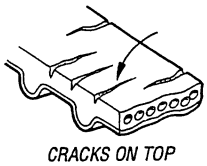












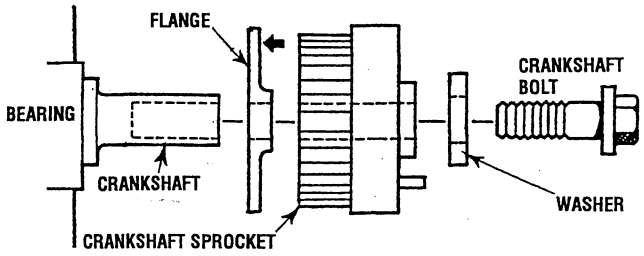
Tensioner Inspection

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

ENGINE TIMING BELT

Flange Installation

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



Crankshaft Bolt Installation

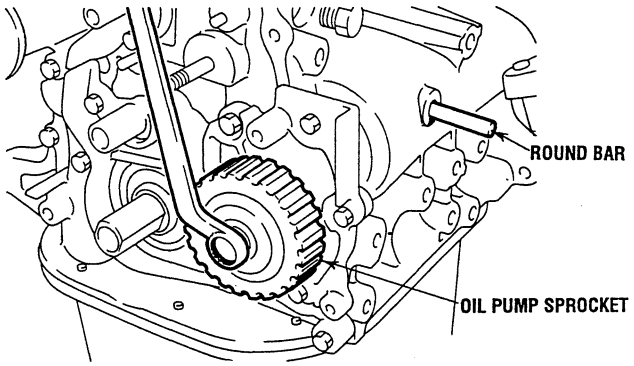
1. Lock the crankshaft.

   NOTE: *Do not turn the crankshaft.*

2. Tighten the crankshaft bolt to the specified torque.

Oil Pump Sprocket Flange Nut Installation

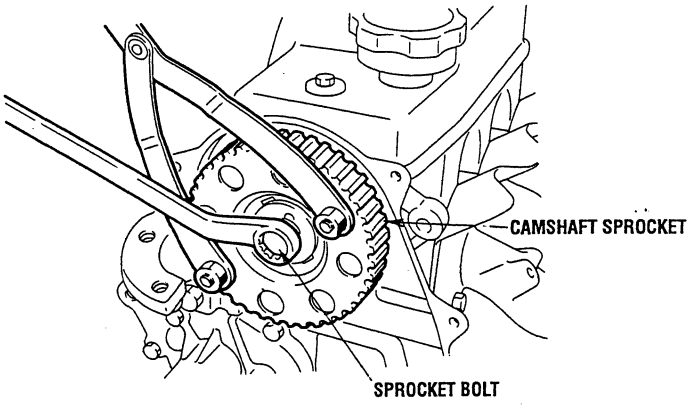
1. Insert the round bar into the plug hole in the left side of the cylinder block to keep the counterbalance shaft from turning.
2. Install the oil pump sprocket.
3. Tighten the nut to the specified torque.



Camshaft Sprocket Bolt Installation

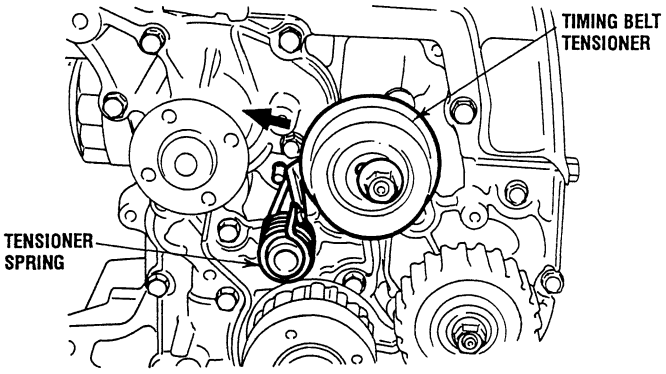
1. Tighten the bolt to the specified torque.

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



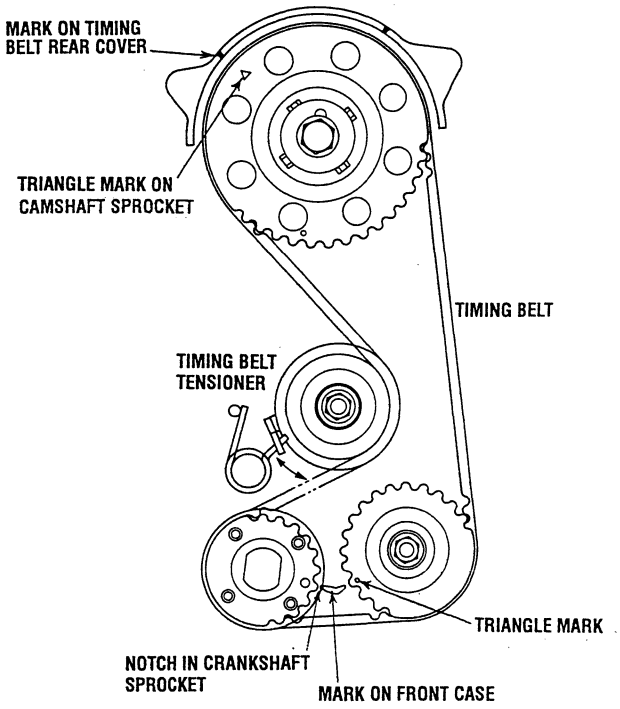
Tensioner Spring/Timing Tensioner Installation

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



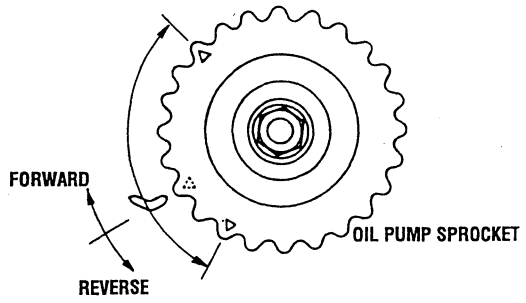
Timing Belt Installation

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



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

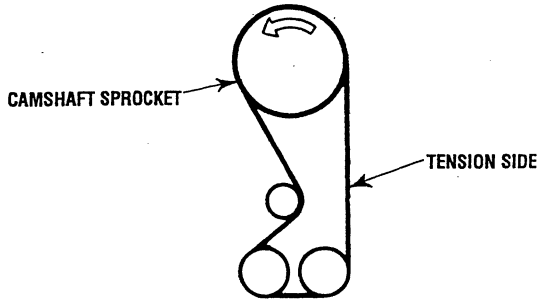
STANDARD VALUE: 4 to 5 teeth in forward direction.
1 to 2 teeth in reverse direction.



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

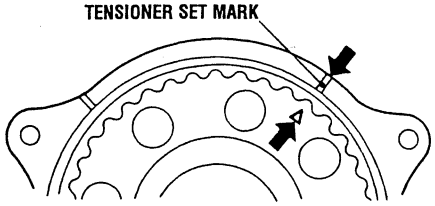
NOTE: *Ensure that the tension side of the timing belt is not slack. Keep the round bar inserted until the timing belt has been placed. After this step, be sure to remove the round bar.*

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



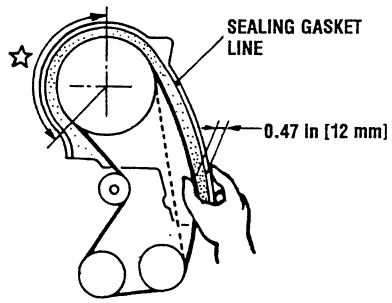
7. Loosen the temperorarily tightened tensioner nut on the water pump side 1 or 2 turns, and tension the belt making use of the spring force.
8. Turn the crankshaft *clockwise* by nine camshaft sprocket teeth (81°) to align the timing mark on the camshaft sprocket with the tensioner set mark on the timing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

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



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

STANDARD VALUE: 0.47in. (12mm)

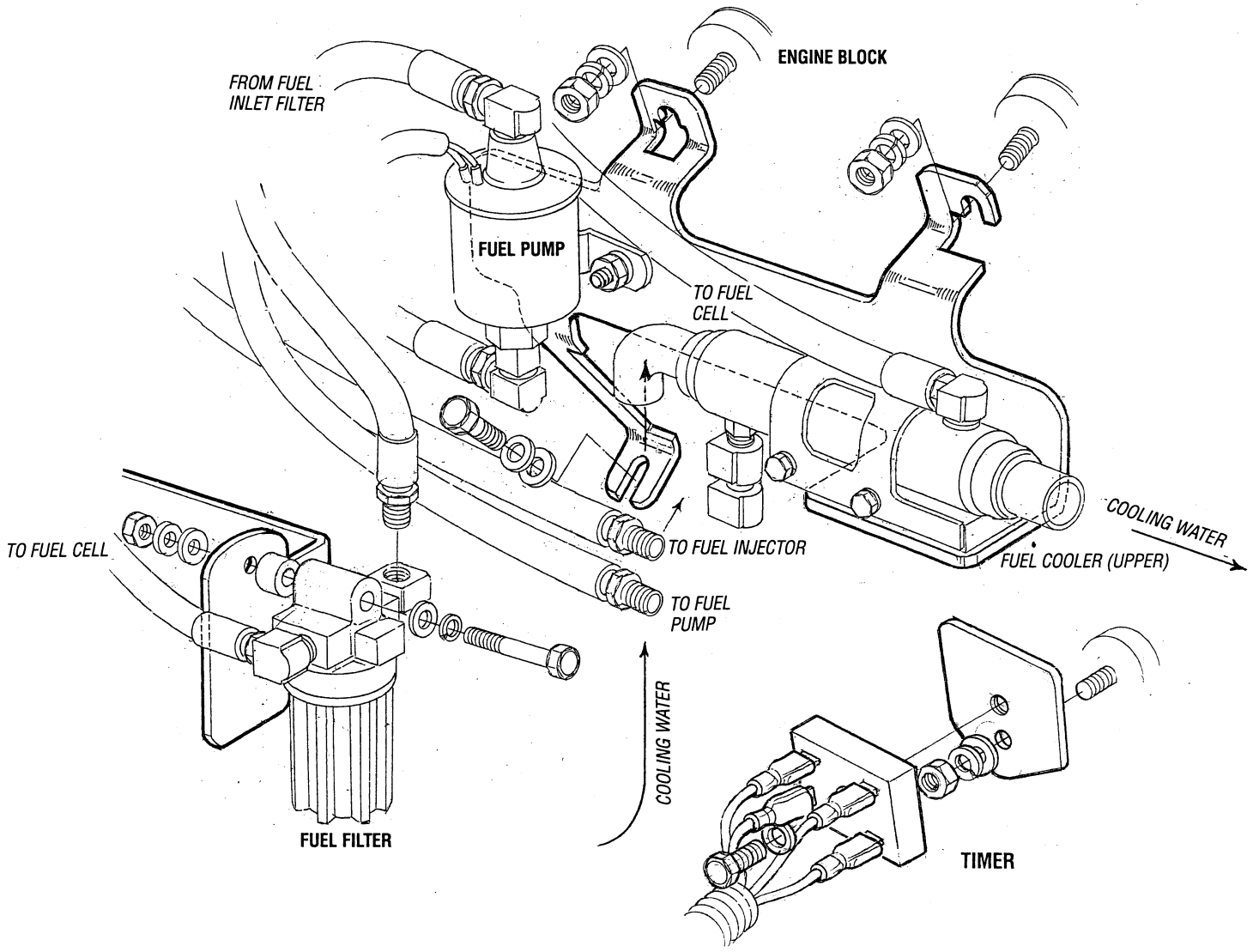


11. Pull out the rod from the plug hole on the left surface of the cylinder block and apply the specified sealant. Then tighten the plug to the specified torque.

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

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

DISSASSEMBLY OF "SAFE CO" COMPONENTS



DISASSEMBLY

NOTE: *Be prepared to drain off any fuel and cooling water that may have accumulated in the hoses and fuel lines.*

Unplug the wiring harness connections and lift the harness up and off the engine. The wiring connections should be tagged for re-connection.Remove the cooling water hoses.

Using the illustration above as a guide, disassemble the bracket that holds the fuel pump and the upper fuel cooler from the engine block. Remove the fuel filter, fuel lines (blue) can be disconnected as necessary.

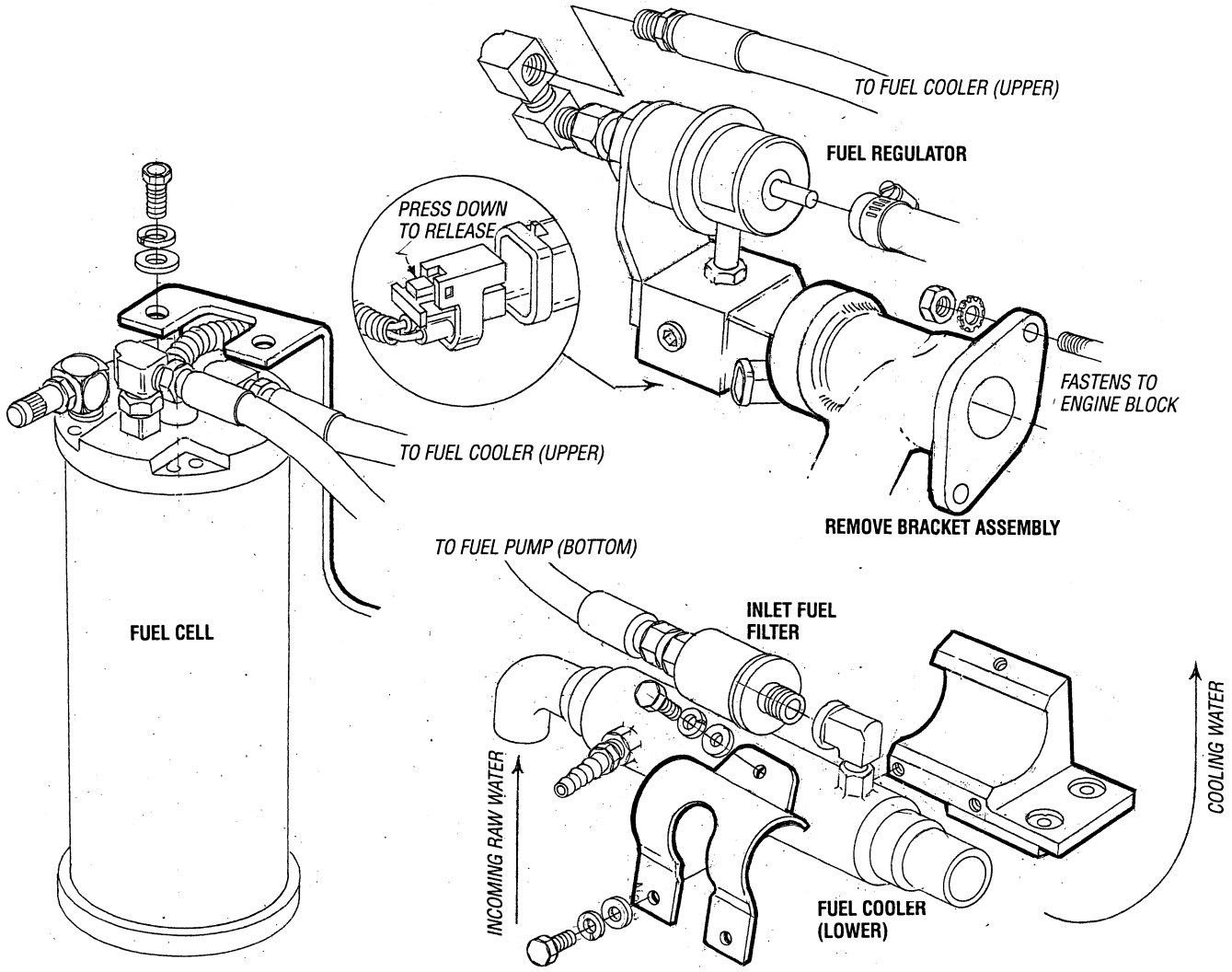
Remove the lower fuel cooler, the fuel cell, and the bracket their mounted on. Unplug the wiring connection at the fuel injector and disconnect the fuel hose.

The bracket assembly can now be removed from the engine block.

Set all the components aside and cover them over to protect them.

The **Timer** shown in the illustraction above on later models is mounted inside the unit's control box. The **Timer** function is to terminate DC voltage to the unit's fuel pumps at engine shutdown.

DISSASSEMBLY OF "SAFE CO" COMPONENTS



DISASSEMBLY (cont.)

Remove the lower field fuel cooler, the fuel cell, and the bracket they are mounted on. Unplug the wiring connection at the fuel injector and disconnect the fuel hose.

The bracket assembly can now be removed from the engine block.

Set all these components aside and cover them over to protect them.

COMPONENT MAINTENANCE

Fuel coolers should be cleaned in a mild muriatic acid bath and pressure tested to 50 psi.

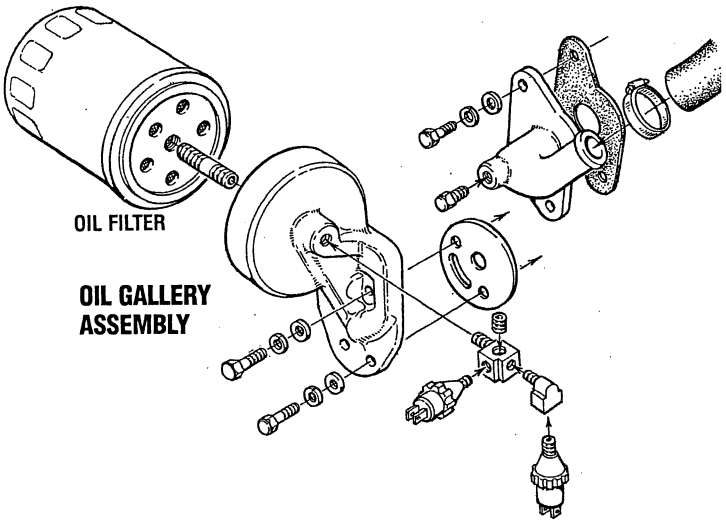
No air bubbles should occur when submerged in water for 30 seconds with the inside of the cooler shell being pressurized to 50 psi.

The fuel regulator should be changed.

All the fuel filters should be changed and replaced.

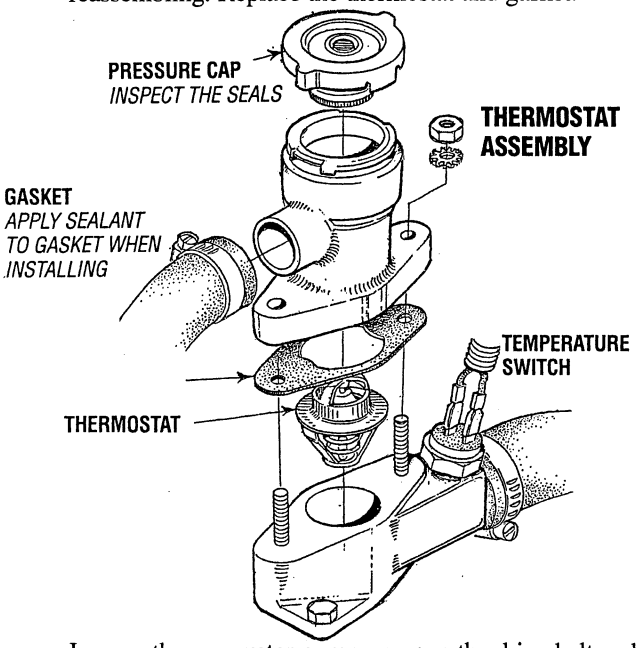
Inspect carefully all the hoses and replace as needed.

ENGINE DISASSEMBLY

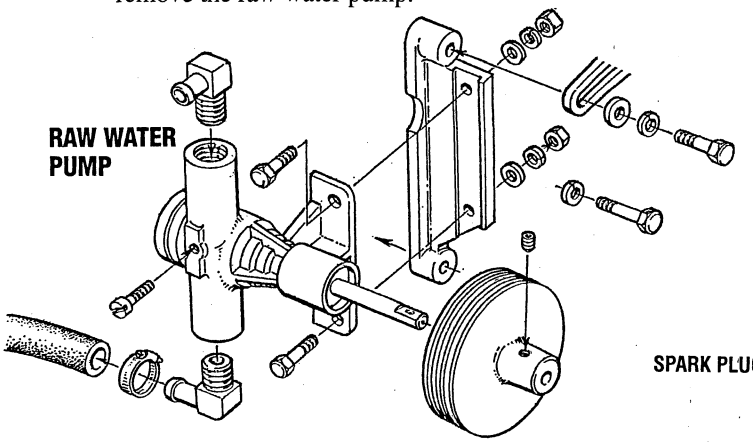


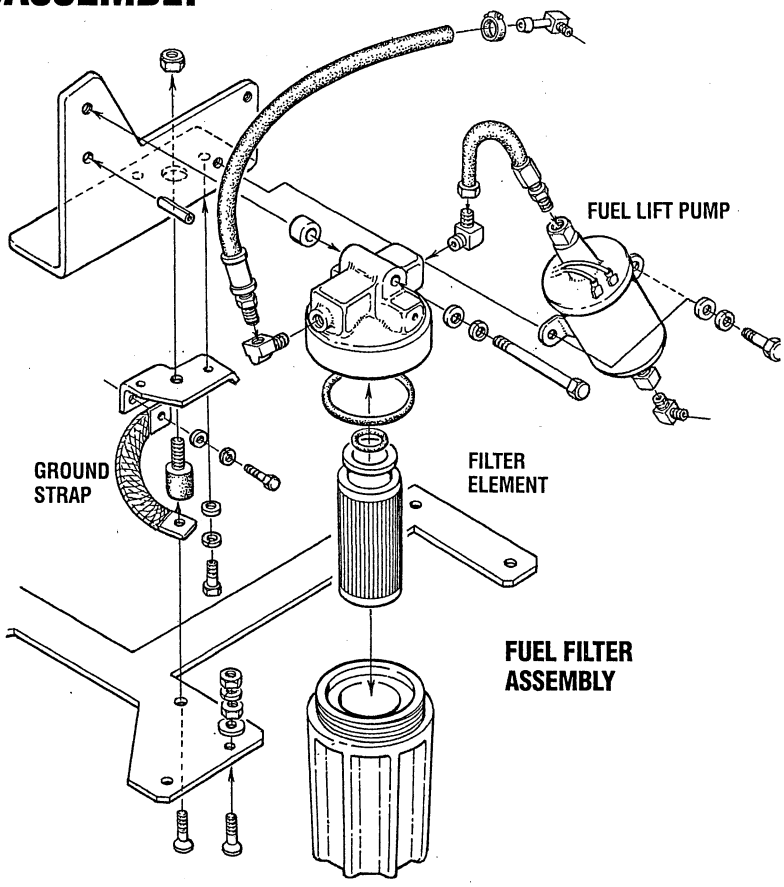
Disconnect and drain the oil hoses. remove, clean and inspect the oil gallery/filter assembly, replace the filter.

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



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



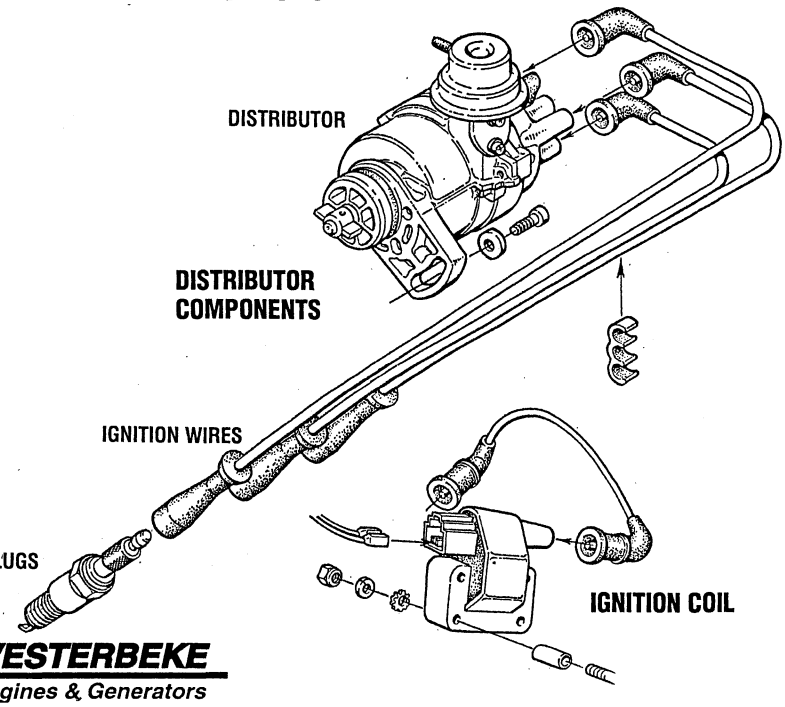


Remove the fuel filter assembly. Drain and inspect the hoses. Inspect the O-ring and replace the filter element.

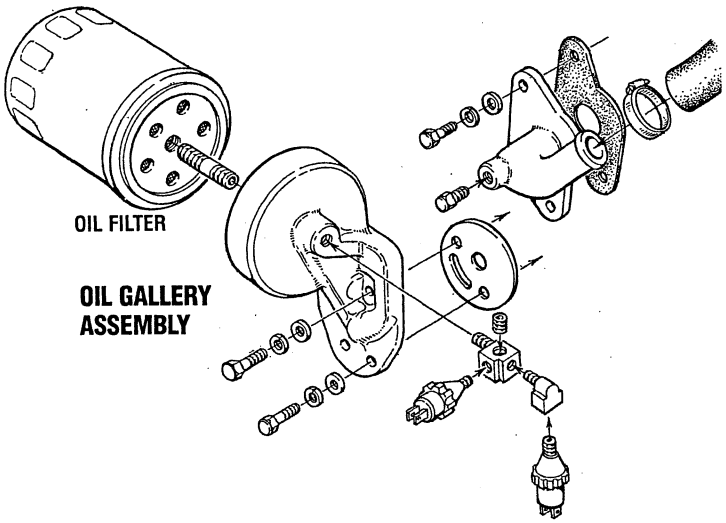
Remove the engines coolant pump. For servicing, refer to *COOLANT PUMP*.

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

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



ENGINE DISASSEMBLY



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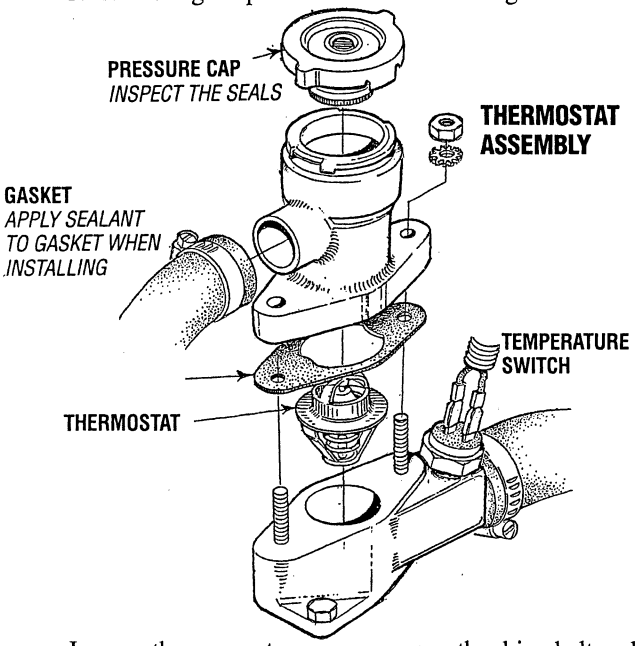
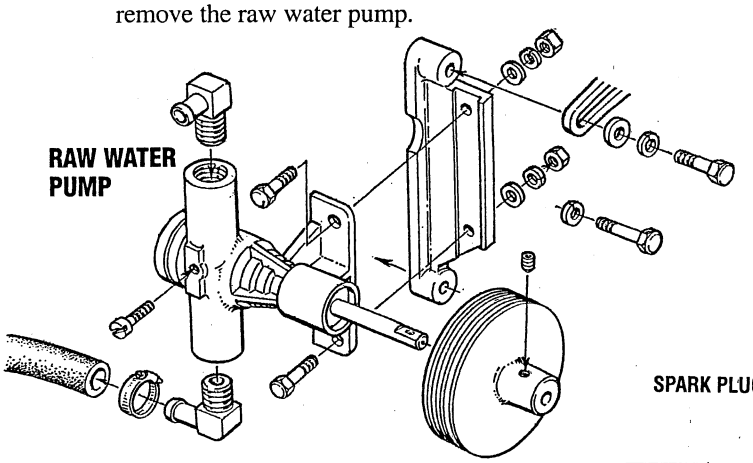
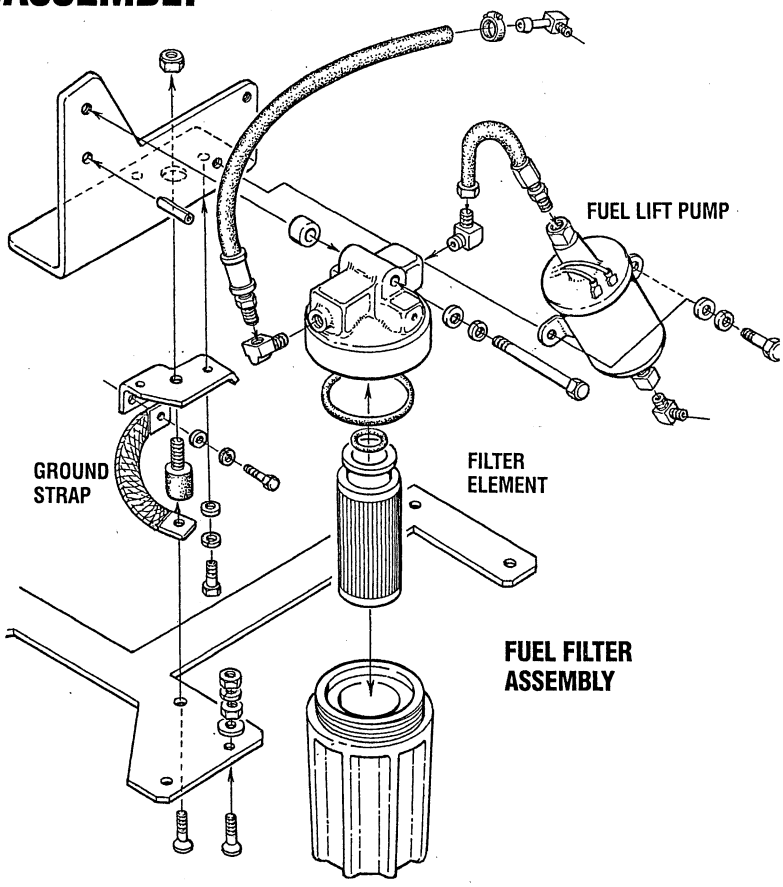


Loosen the raw water pump, remove the drive belt and then remove the raw water pump.





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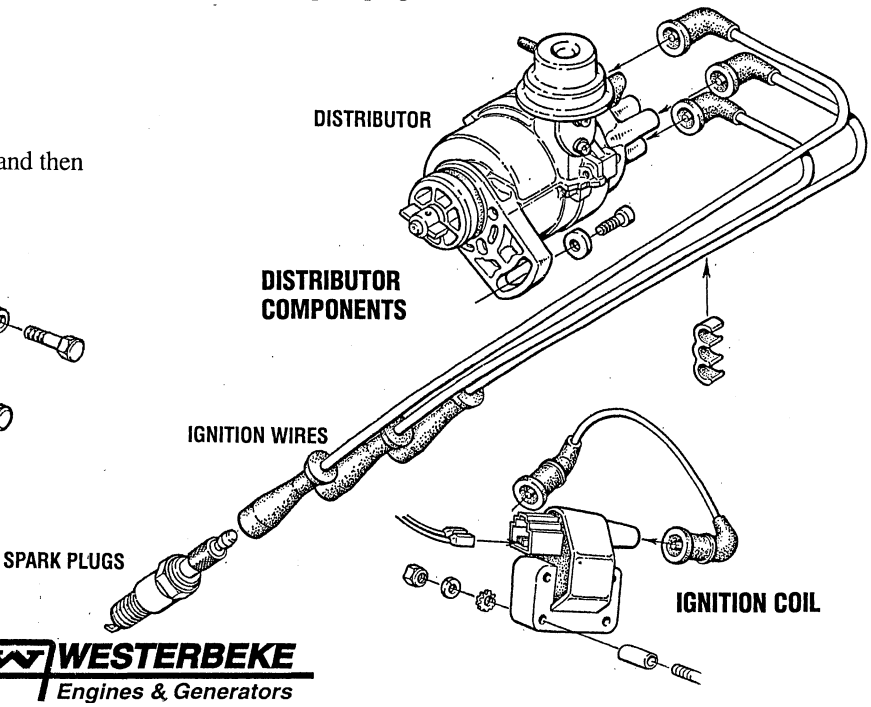
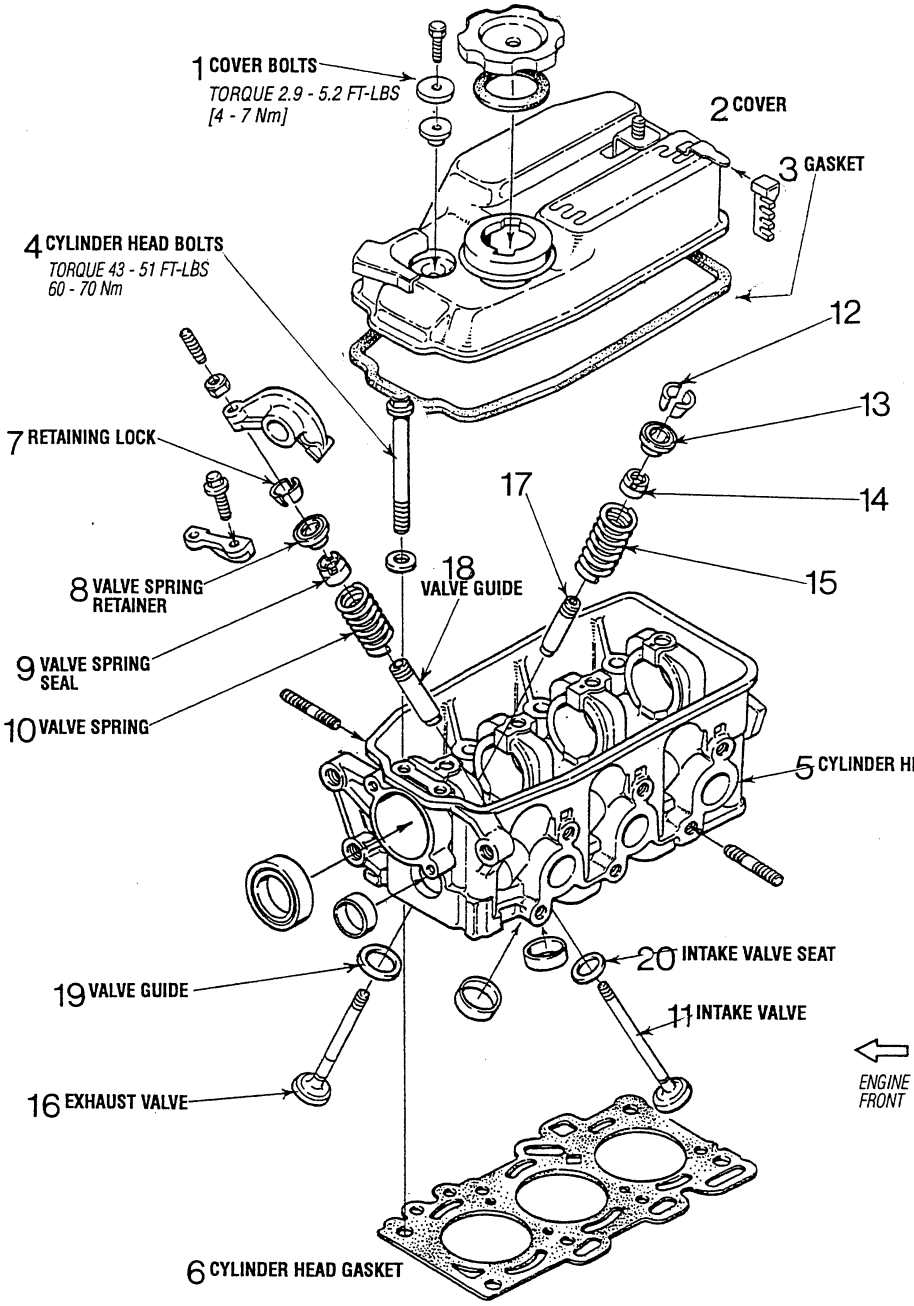
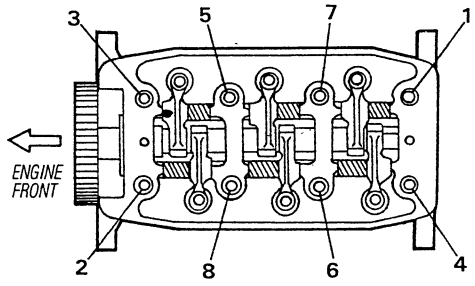
See *ENGINE ADJUSTMENTS* for information on ignition wires and spark plugs.



CYLINDER HEAD AND VALVES



NUMBERS INDICATE THE SUGGESTED ORDER OF DISASSEMBLY



CYLINDER HEAD BOLTS LOOSENING SEQUENCE

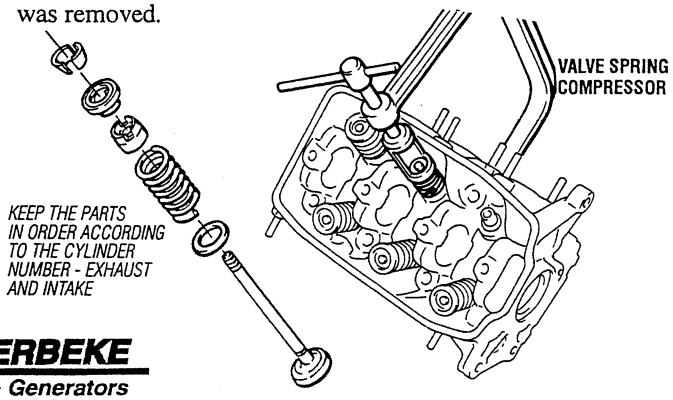
REMOVING THE CYLINDER HEAD FROM THE CYLINDER BLOCK

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

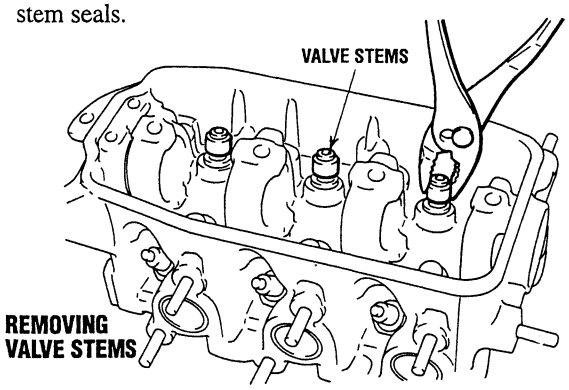
Loosen each of the cylinder head bolts, a little at a time so as to avoid the possibility of distorting the cylinder. Repeat several times until the bolts are unfastened. Follow the sequence shown in the diagram.

Remove the cylinder head and the cylinder head gasket.

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



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



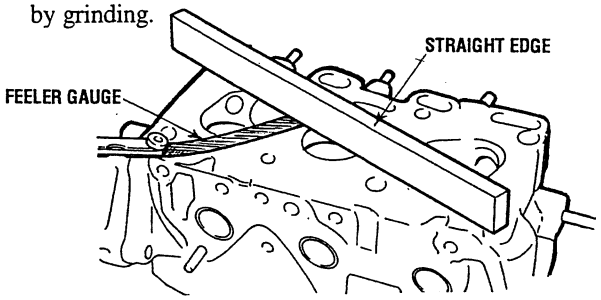
REMOVING VALVE STEMS

CYLINDER HEAD INSPECTION

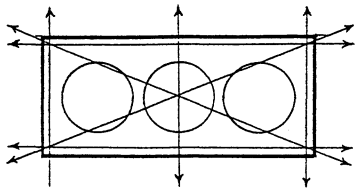
Before cleaning check the cylinder head for water leaks, cracks and other possible damage.

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

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



CHECKING CYLINDER HEAD FLATNESS



CYLINDER HEAD FLATNESS

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

CYLINDER HEAD GRINDING LIMIT

0.079in (0.2mm)
Total resurfacing depth of cylinder head and block

CYLINDER HEAD HEIGHT (NEW)

4.287 - 4.295in (108.9 - 109.1mm)

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

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

VALVE ASSEMBLY INSPECTION

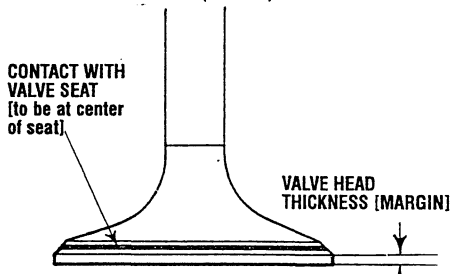
Valve Stem/Valve Seat

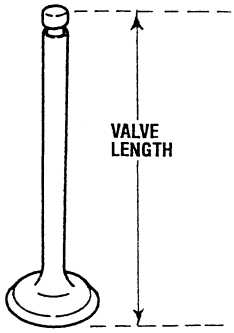
If the valve stem is bent or worn, replace the valve. Check contact between the valve and valve seat by applying a thin coat of Prussion Blue (or Redhead) on the valve seat contact face, then insert the valve into the valve guide and press-fit the valve on the valve seat. Do not rotate the valve.

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

THICKNESS OF VALVE HEAD MARGIN

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





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

VALVE SEAT WIDTH OF CONTACT

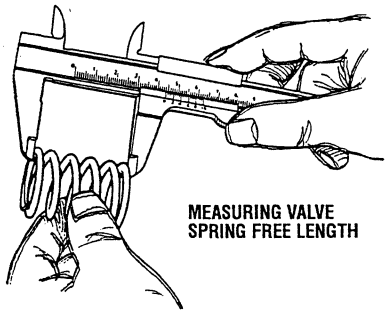
Standard 0.035in - 0.051 (0.9 - 1.3mm)

Valve Spring

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

VALVE SPRING FREE LENGTH

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

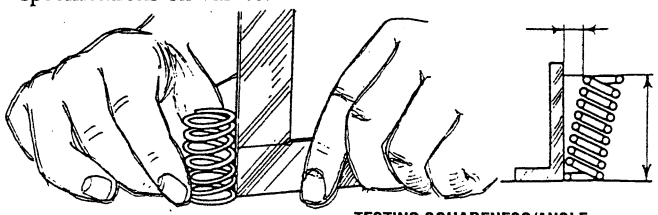


Also check the spring for squareness and if it exceeds the limit replace the spring.

VALVE SPRING SQUARENESS

Standard less than 2°_____Limit 4°

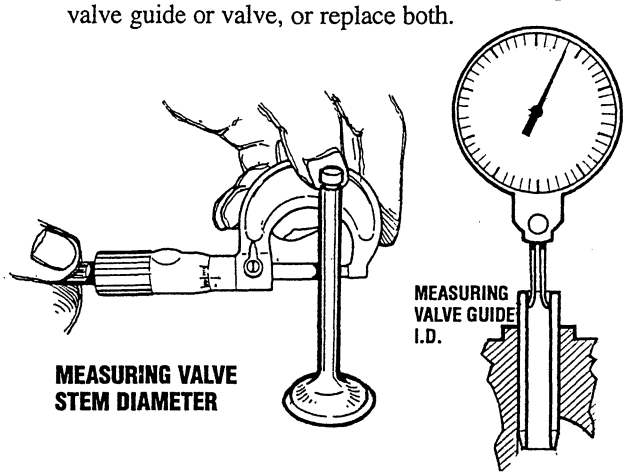
Refer to the Standards/Limits chart for additional specifications on valves.

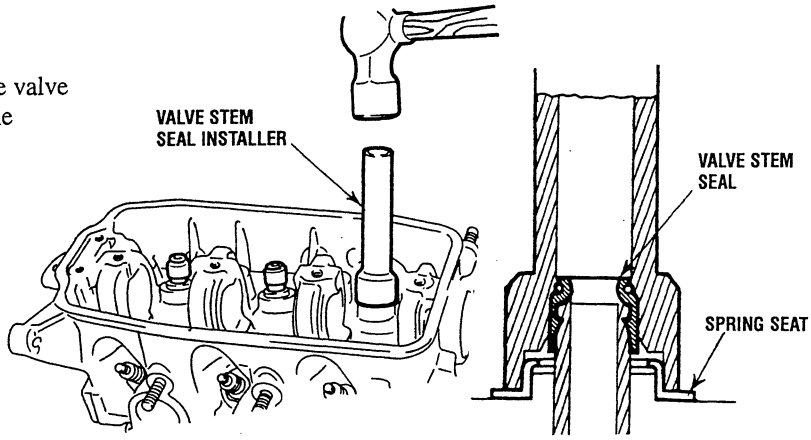

TESTING SQUARENESS/ANGLE

CYLINDER HEAD AND VALVES

Valve Stem and Guides

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





VALVE STEM SEAL TO VALVE GUIDE CLEARANCE

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

VALVE STEM OUTER DIAMETER

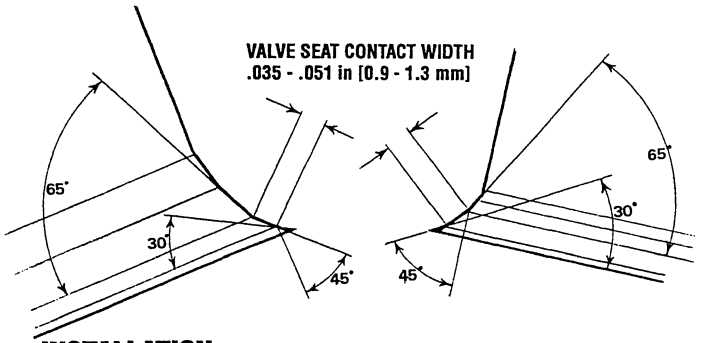
Standard	Intake	0.2585 - 0.2591in (6.565 - 6.580mm)
	Exhaust	0.2571 - 0.2579in (6.330 - 6.550mm)

Valve Seat Reconditioning

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

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

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



INSTALLATION

Valve Stem Seal

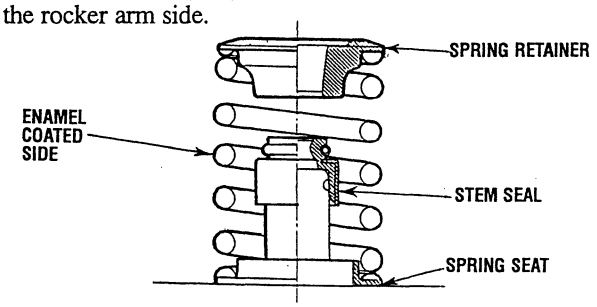
Install the valve spring seat, then using the valve stem seal installer, install a new stem seal to the valve guide.

Do not use the old valve stem seal.

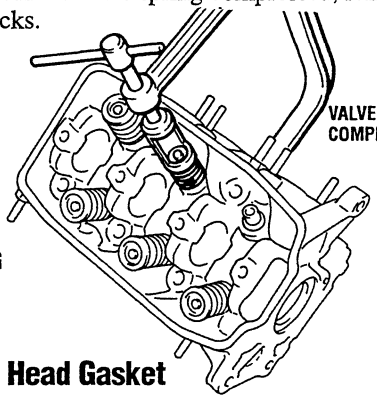
NOTE: *Use the installer tool to insert the stem seal, improper installation can cause oil to leak into the cylinder.*

Valve Springs

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



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

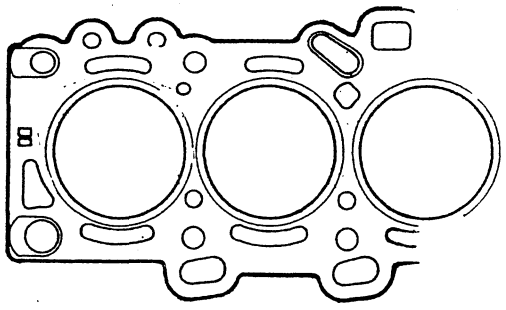


REMOVING RETAINER LOCKS

Cylinder Head Gasket

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

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



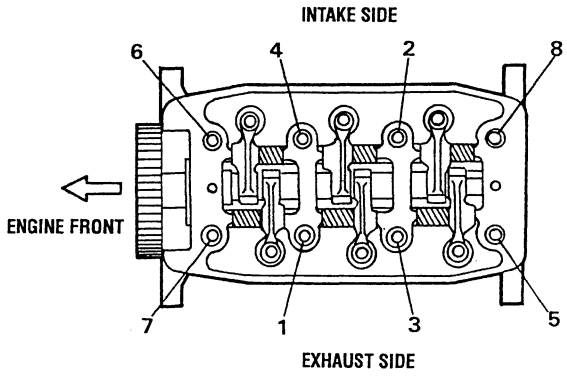
CYLINDER HEAD GASKET

Cylinder Head Bolts

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

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

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



CYLINDER HEAD BOLTS TIGHTENING SEQUENCE

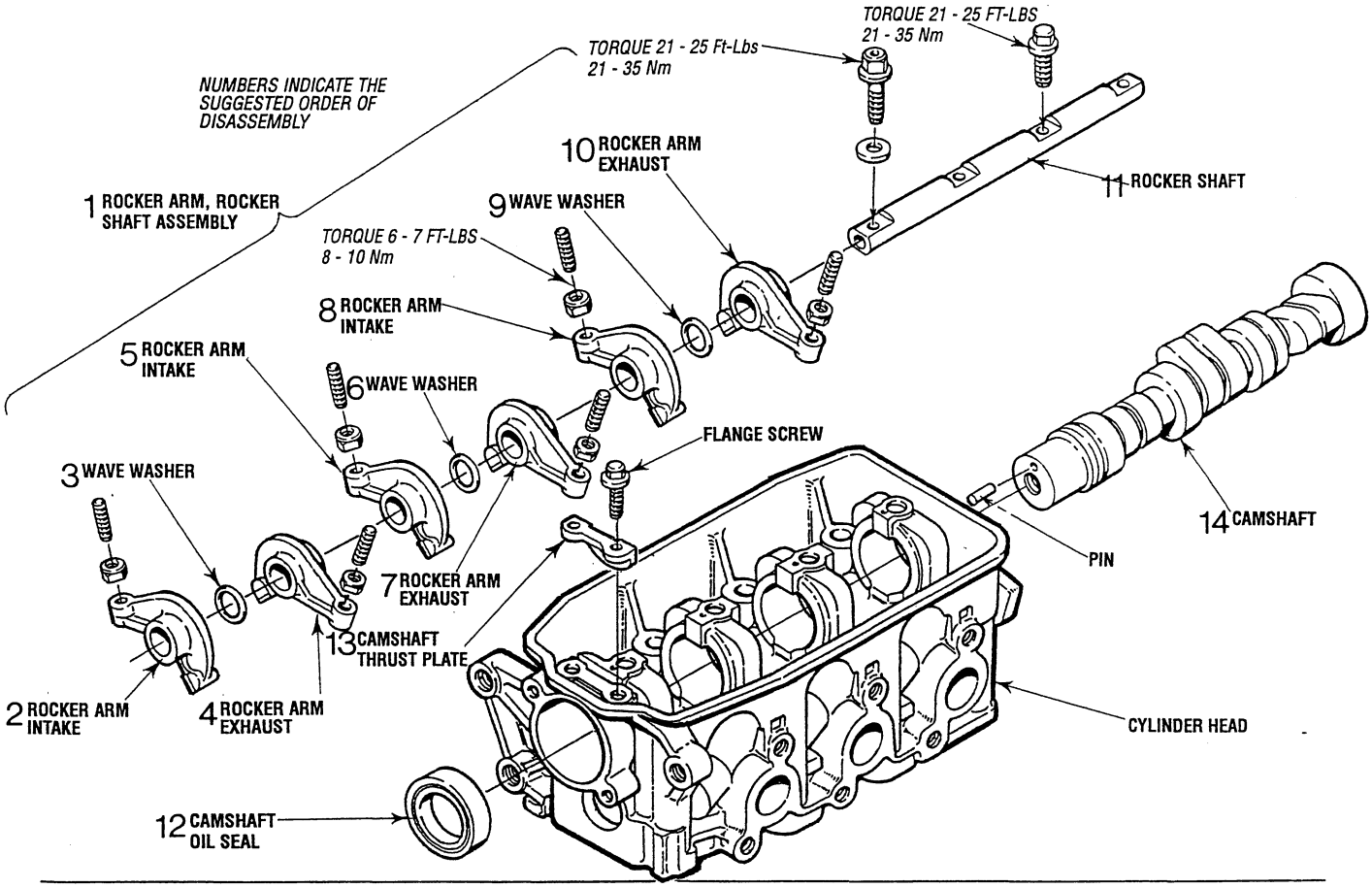
Rocker Cover

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

ROCKER COVER BOLT TORQUE (6mm BOLT)

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

CAMSHAFT AND ROCKER ARMS



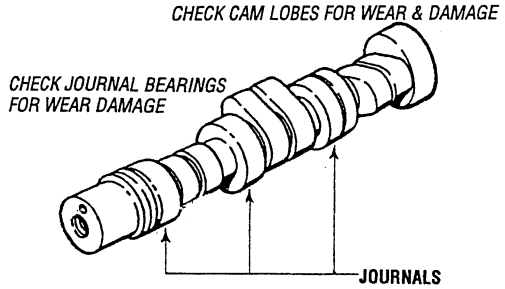
INSPECTING THE CAMSHAFT

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

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

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

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

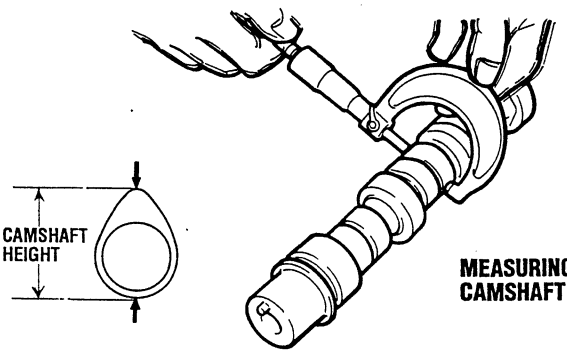


Camshaft

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

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

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



MEASURING CAMSHAFT HEIGHT

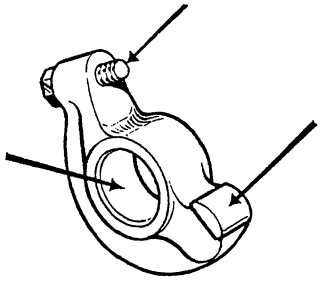
4. Inspect the clearance between the camshaft journal and the camshaft support bore as follows:
   a. Measure the camshaft journal diameter and the camshaft support bore.
   b. Calculate the clearance and replace the camshaft or cylinder head if the clearance exceeds the limit.

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

CAMSHAFT AND ROCKER ARMS

Rocker Arm

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



ROCKER ARM INSPECTION

Inspecting Clearance Rocker Arm And Shaft

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

ROCKER ARM CLEARANCE (ROCKER ARM TO SHAFT)

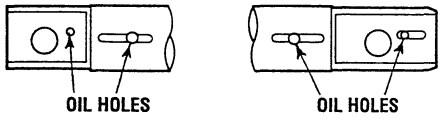
Standard	0.0005 - 0.0017in (0.012 - 0.043mm)
Limit	0.004in (0.1mm)

Rocker Shaft

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

ROCKER SHAFT LENGTH Standard 9.134in (232mm)

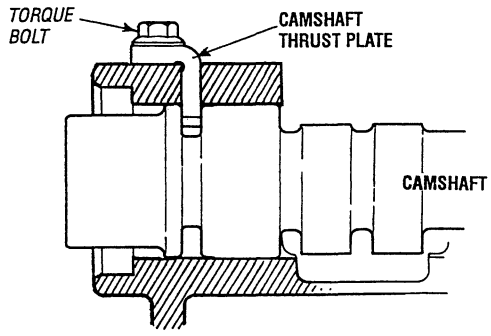
ROCKER SHAFT O.D. Standard 16.985 - 16.988in (0.6687 - 0.6693mm)



INSTALLATION

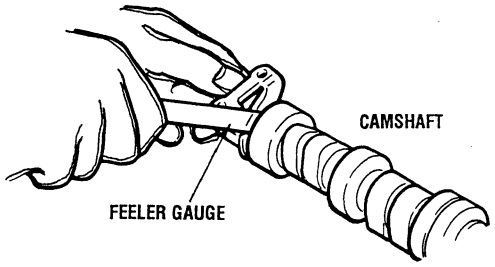
1. Apply a coating of engine oil to the camshaft journals and cams and insert the camshaft through the rear of the cylinder head.
2. Install the camshaft thrust plate as shown in the diagram tighten the bolts to the specified torque.

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

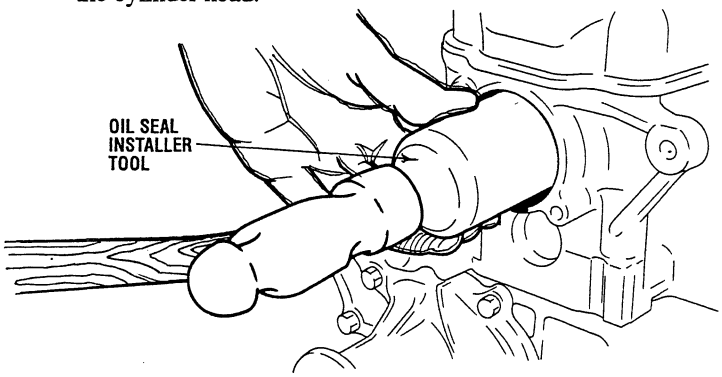


3. Measure the end play of the camshaft by inserting a feeler gauge in the gap between the rear of the thrust plate and the new front camshaft journal.

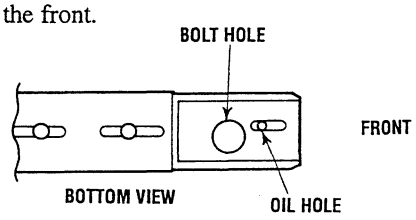
VALVE Standard 0.236 - 0.0551in (0.06 - 0.14mm)
Limit 0.118in (0.3mm)



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



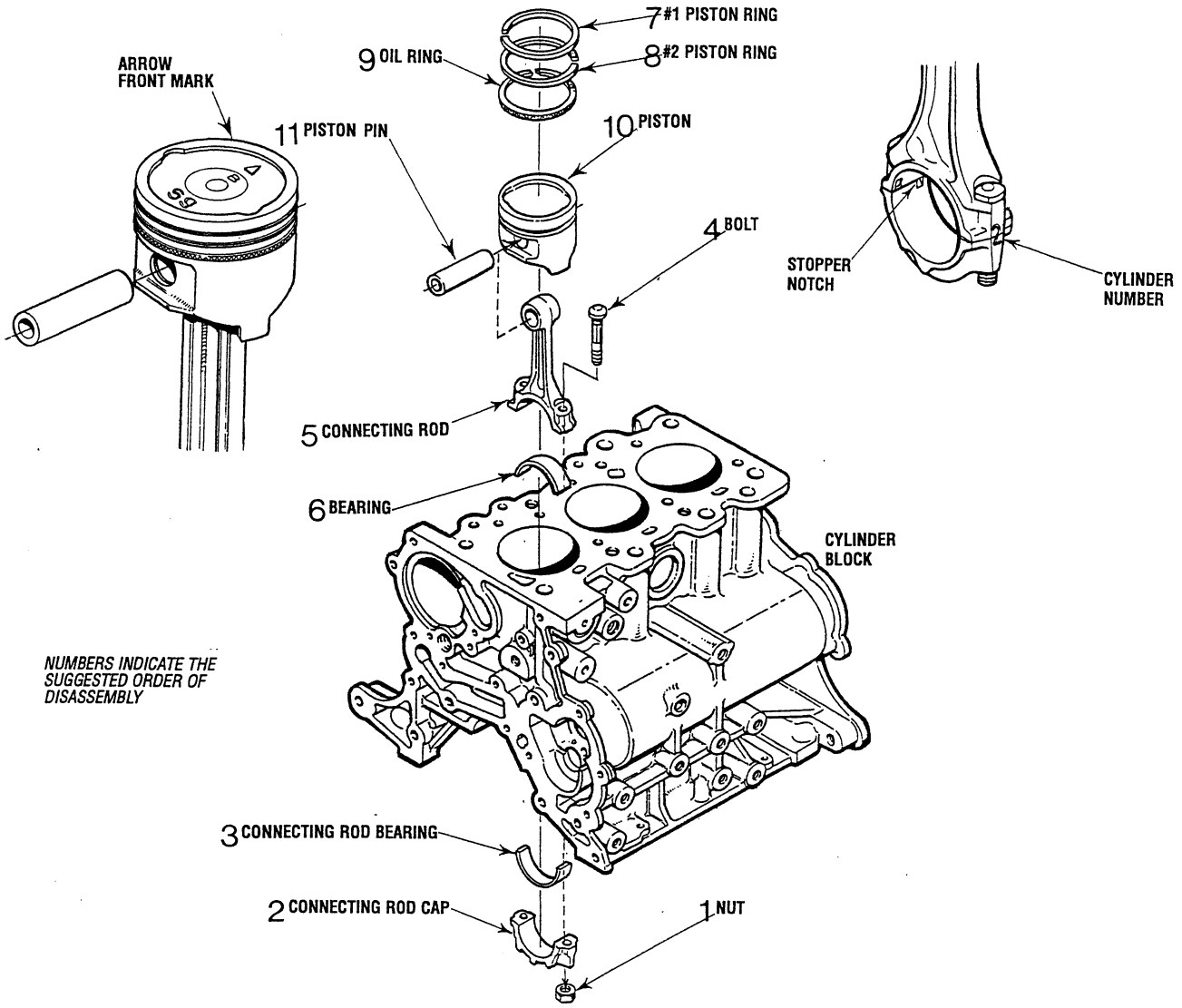
5. Install the rocker arm/rockershaft assembly. Install the rocker shaft so the portion shown in the diagram is located on the front.



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

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

PISTONS AND CONNECTING RODS

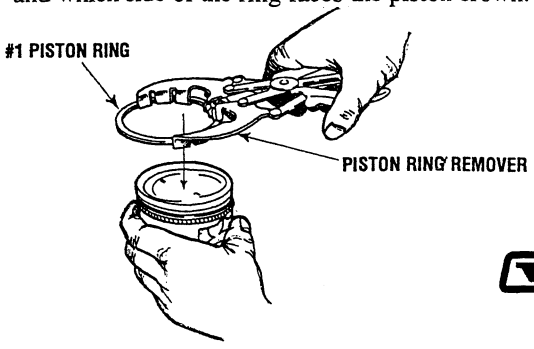


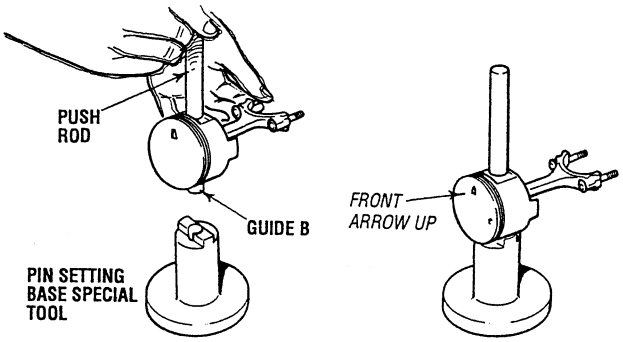
REMOVING THE CONNECTING RODS/PISTONS

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

Disassemble the Pistons

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





Remove the Piston Pins

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

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

PISTONS AND CONNECTING RODS

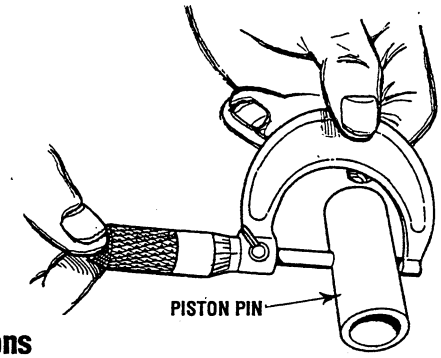
PISTON PIN INSPECTION

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

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

Measure the outside diameter of the piston pin.

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



Pistons

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

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

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

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

Piston Rings

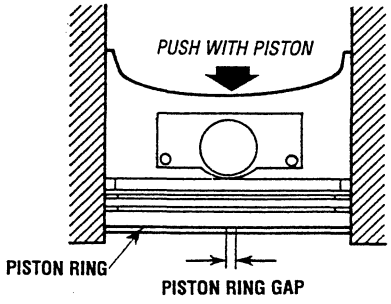
Insert the piston ring into the cylinder bore placing it against the top of the piston head and pressing it in. When it marks a right angle, measure the piston ring gap with a feeler gauge. When the gap is too large, replace the piston ring.

PISTON RING GROOVE

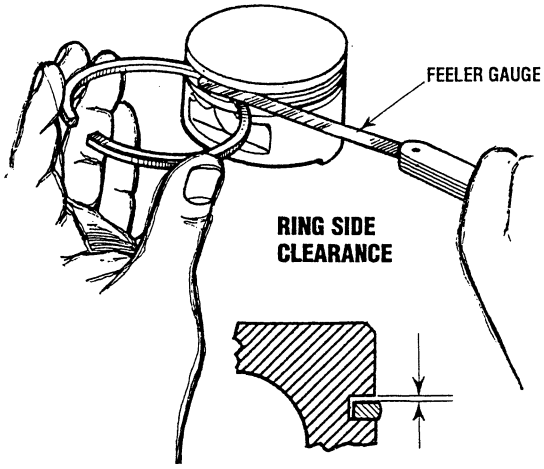
	Standard
No.1	0.0480 - 0.0488in (1.22 - 1.24mm)
No 2	0.0476 - 0.0484in (1.21 - 1.23mm)
Oil	0.1108 - 0.1116in (2.815 - 2.835mm)

PISTON RING END GAP

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



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



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

PISTON RING SIDE CLEARANCE

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

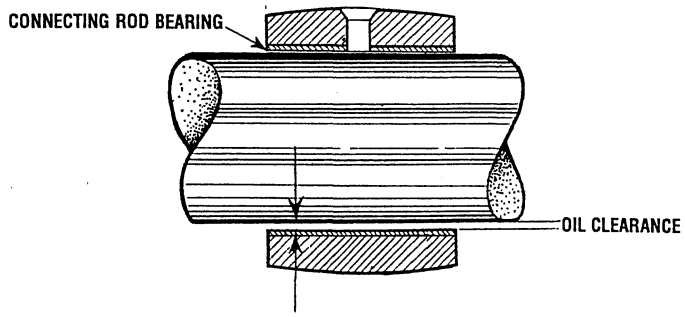
Connecting Rod Bearing

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

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

CONNECTING ROD BEARING OIL CLEARANCE

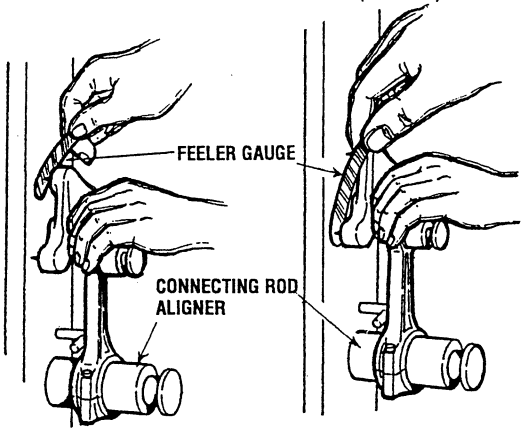
Standard	Limit
0.009 - 0.0020in (0.022 - 0.052mm)	0.004in (0.1mm)



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

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

CONNECTING ROD BEND LIMIT 0.004in (0.05mm)



CONNECTING ROD TWIST LIMIT 0.004in (0.1mm)

CONNECTING ROD BIG END TO CRANKSHAFT SIDE CLEARANCE

Standard 0.0039 - 0.0098in (0.10 - 0.25mm)

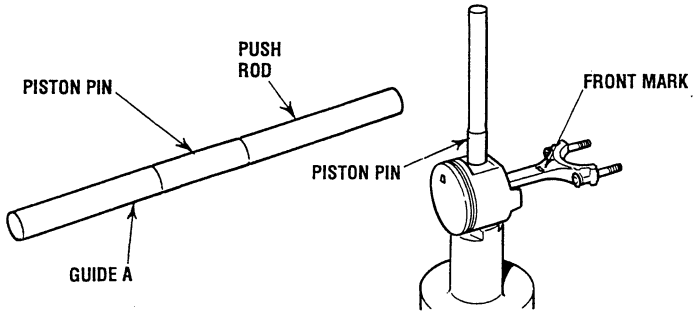
CONNECTING ROD CENTER LENGTH

Standard 4.0138 - 4.0178in (101.95 - 102.05mm)

ASSEMBLY

Piston Connecting Rod, Piston

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



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

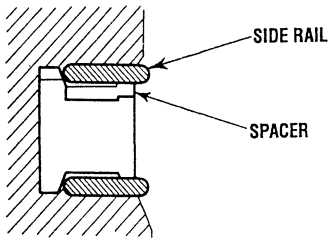
Using a press, load the push rod top end and press-fit the piston pin in the connecting rod. The piston pin is press fitted in the specified position by press-fitting the Guide A bottom end surface until it is seated on the bottom surface of the base. If the press-fitting load is out of the specification,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

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

Oil Ring

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

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

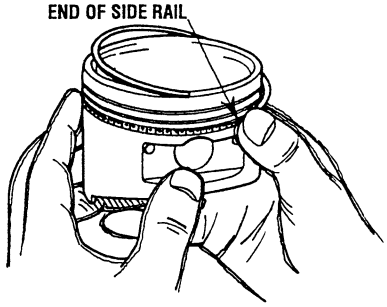


The chart below identifies the color coding on new spacer and side rails according to size.

SPACER AND SIDE RAIL CODING

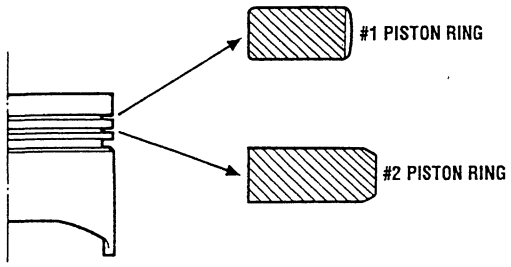
SIZE	Color Identification
S.T.D.	——
0.0098in (0.25mm) Oversize	Two Blue Lines
0.0197in (0.50mm) Oversize	One Red Line
0.0295in (0.75mm) Oversize	Two red lines
0.0394in (1.00mm) Oversize	One Yellow Line

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



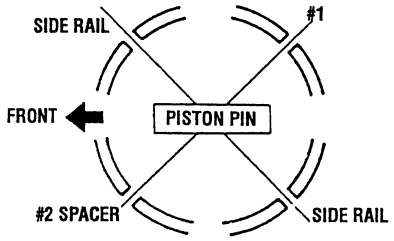
Piston Rings

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

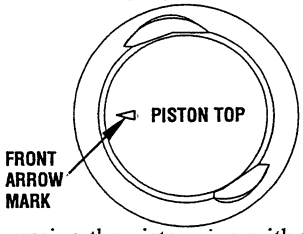


Installing the Piston Assembly

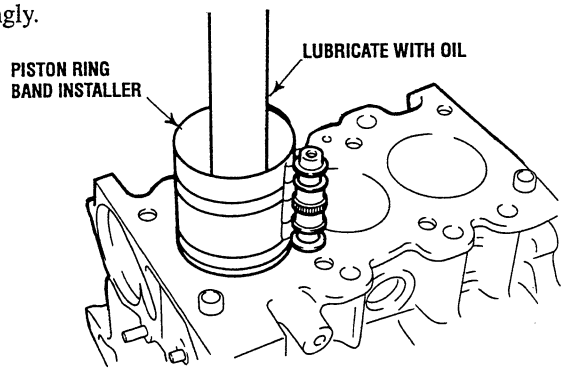
Apply an ample amount of oil to the outside surfaces of the piston and the piston rings. Position the piston rings and oil ring (side rail spacer) end gaps as shown.



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

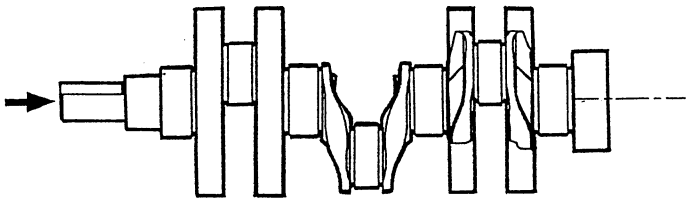


Securely pressing the piston ring with the ring band, insert the piston and connecting rod assembly into the cylinder. Keep in mind that the piston ring may be damaged if hit too strongly.

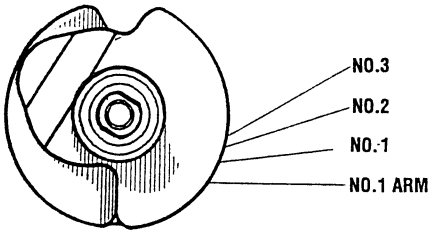


Crankshaft/Bearing Assembly

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



CRANKSHAFT



CRANKSHAFT PIN DIAMETER

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

CONNECTING ROD BIG END INNER DIAMETER

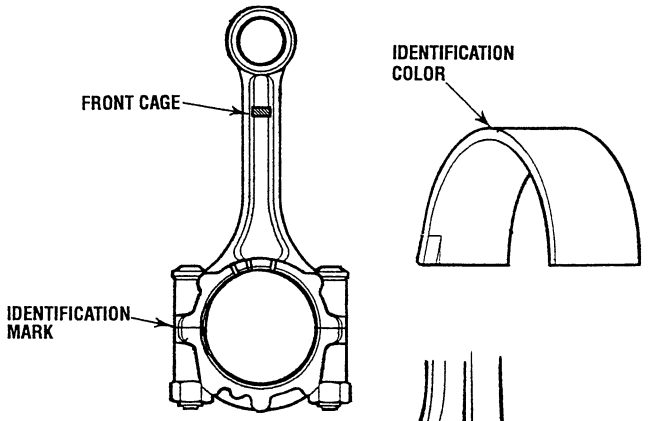
Identification Marks	Big End Inner Diameter
	1.5354 - 1.5356in (39.000 - 39.005mm)
I	1.5356 - 1.5360in (39.005 - 39.015mm)
II	1.5360 - 1.5362in (39.015 - 39.020mm)

CONNECTING ROD BEARING THICKNESS

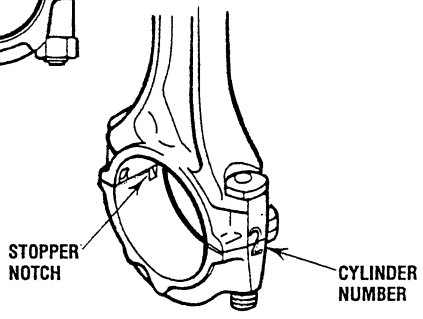
Identification Color	Bearing Thickness
Brown	0.0586 - 0.0588in (1.488 - 1.493mm)
——	0.0588 - 0.0590in (1.493 - 1.498mm)
Blue	0.0590 - 0.0592in (1.498 - 1.503mm)

CONNECTING ROD BEARING SELECTION TABLE

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



CONNECTING ROD



Installing the Connecting Rod Bearing Caps

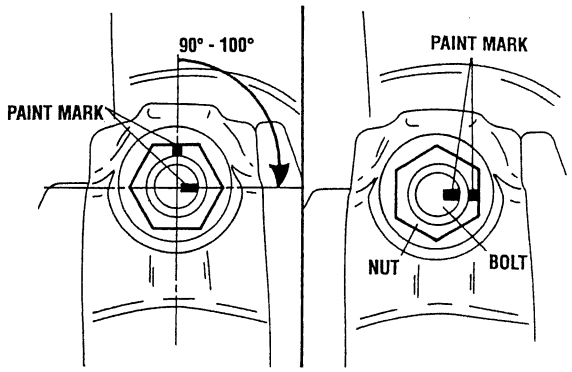
Since the connecting rod cap bolts and nuts are torqued using the plastic area tightening method, the bolts should be examined before reuse. If the bolt threads are "necked down", the bolt should be replaced.

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

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

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

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



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

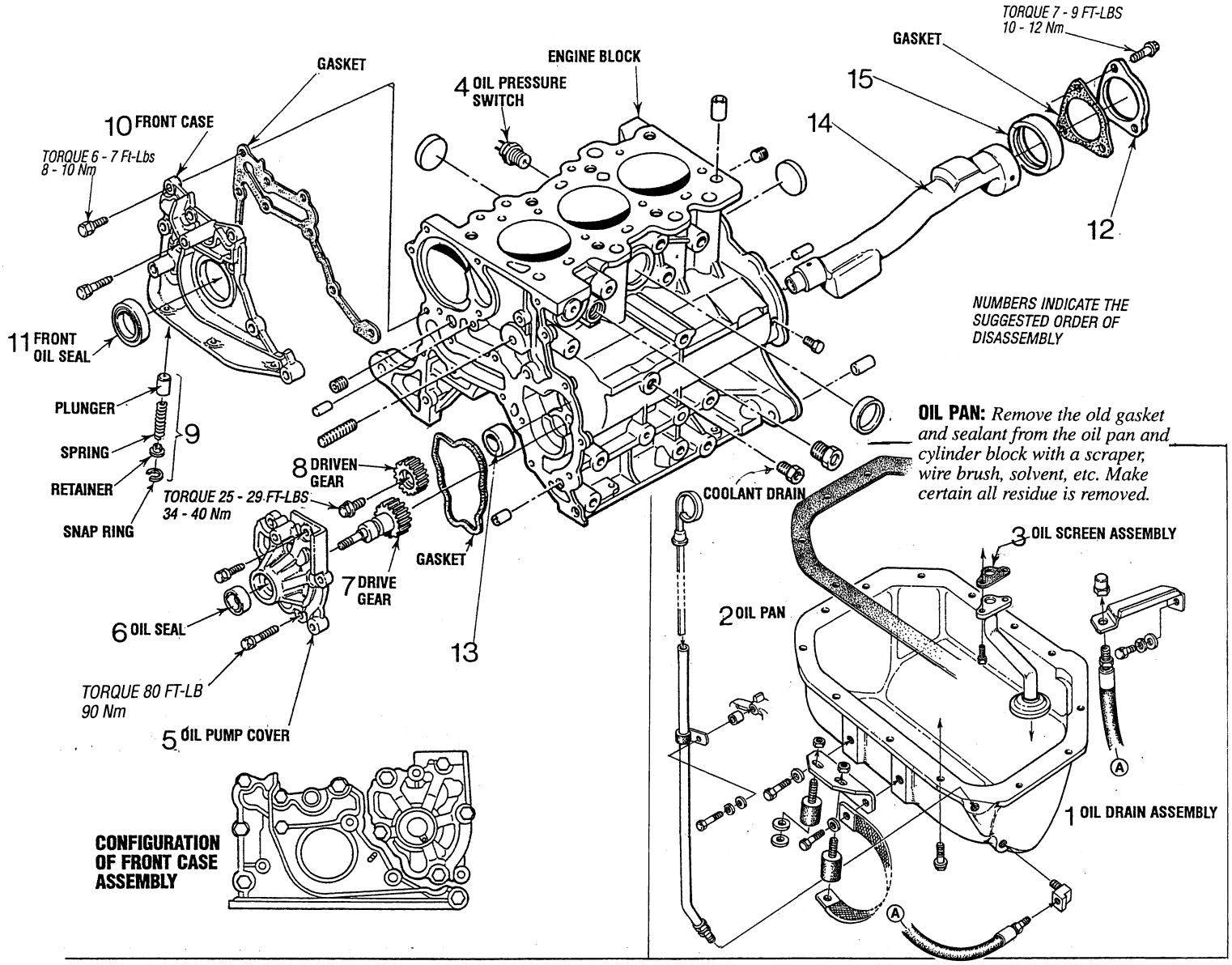
Make a paint mark on the head of each nut. Make a paint mark on the bolt end at the position 90° to 100° from the paint mark made on the nut in the direction of the tightening nut.

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

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

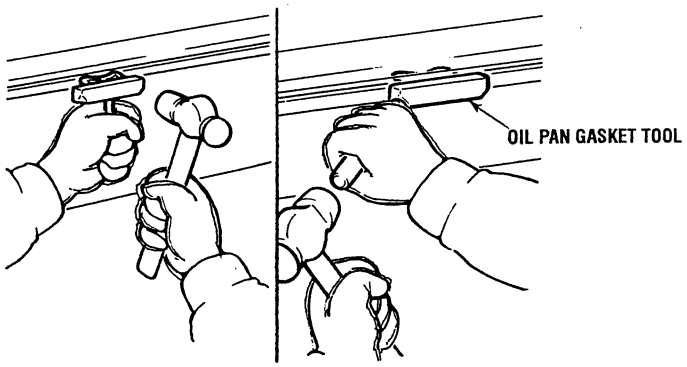
If the nut is overtightend (exceeding 100°), loosen the nut completely and then retighten it by repeating the tightening procedure.

FRONT CASE / COUNTERBALANCE SHAFT AND OIL PAN



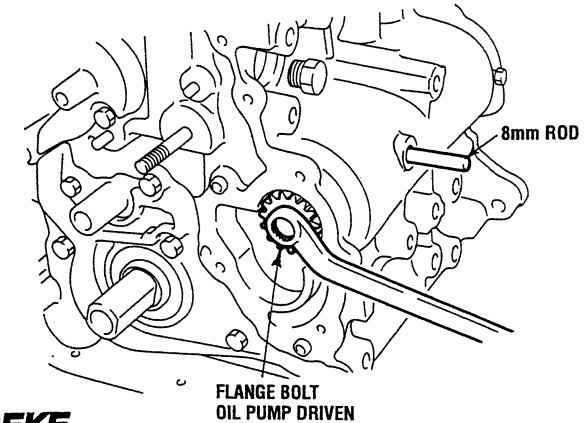
OIL PAN REMOVAL

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



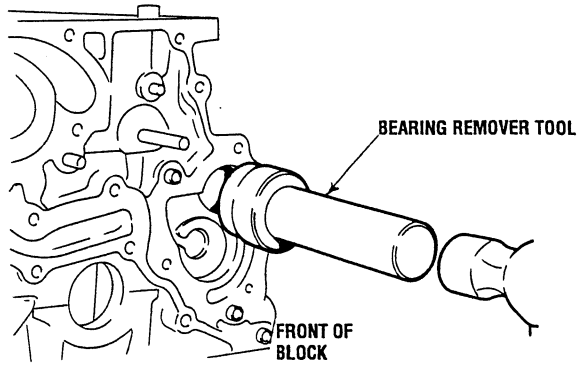
COUNTERBALANCE SHAFT REMOVAL

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

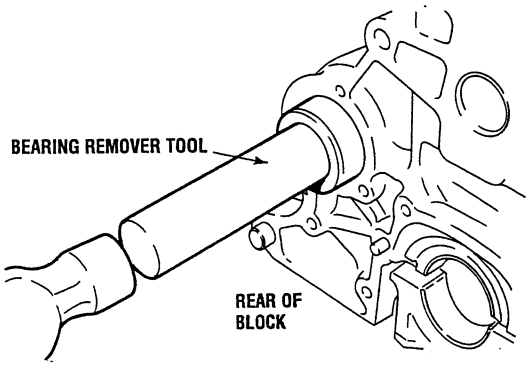


FRONT CASE / COUNTERBALANCE SHAFT AND OIL PUMP

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



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



OIL PUMP ASSEMBLY - INSPECTION

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

DRIVEN GEAR BODY CLEARANCE STANDARD

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

DRIVE GEAR BODY CLEARANCE STANDARD

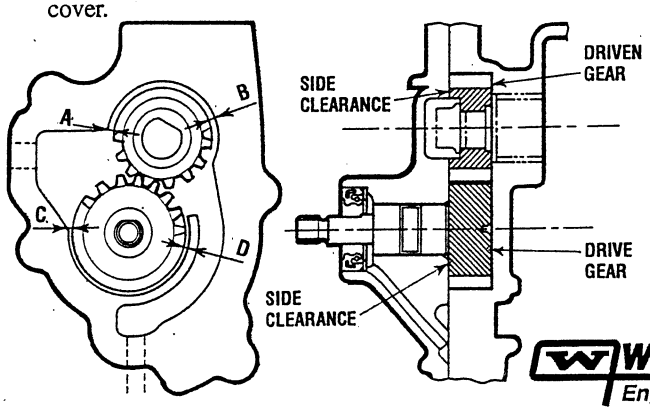
C.	0.0173 - 0.0276in (0.44 - 0.70mm)
D.	0.0059 - 0.077in (o.150 - 0.195mm)

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

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

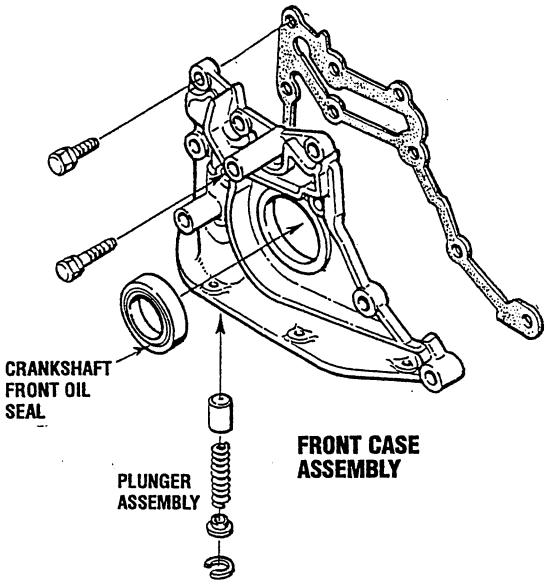
Using a straight edge, check the side clearance at the point indicated in the illustration with a feeler gauge.

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



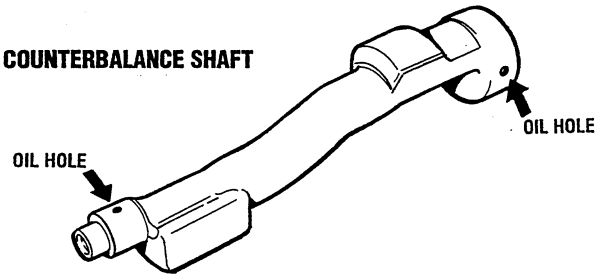
FRONT CASE - INSPECTION

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



CRANKSHAFT FRONT OIL SEAL - INSPECTION

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



COUNTERBALANCE SHAFT - INSPECTION

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

COUNTERBALANCE SHAFT STANDARDS

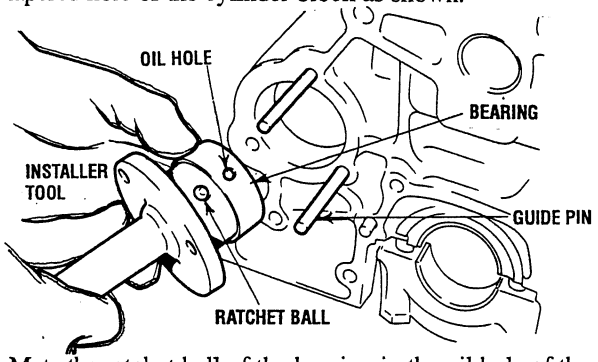
Front Journal Diameter	0.7869 - 0.7874in (19.987 - 20.000mm)
Rear Journal Diameter	1.7317 - 1.7322in (43.984 - 44.000mm)
Front Journal Oil Clearance	0.0014 - 0.0027in (0.035 - 0.068mm)
Rear Journal Oil Clearance	0.0014 - 0.0028in (0.035 - 0.071mm)

FRONT CASE/BEARINGS AND OIL PUMP

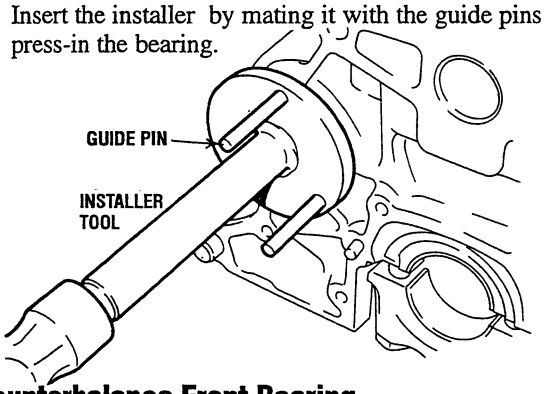
INSTALLATION

Counterbalance Rear Bearing

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

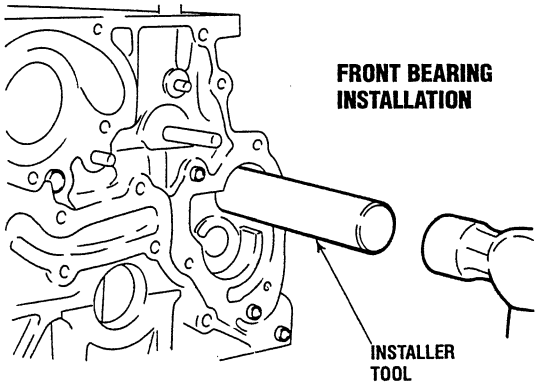


2. Mate the ratchet ball of the bearing in the oil hole of the rear bearing and install the bearing in the bearing installer.
3. Apply clean engine oil to the outer circumference of the bearing and the bearing hole in the cylinder block.
4. Insert the installer by mating it with the guide pins and press-in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



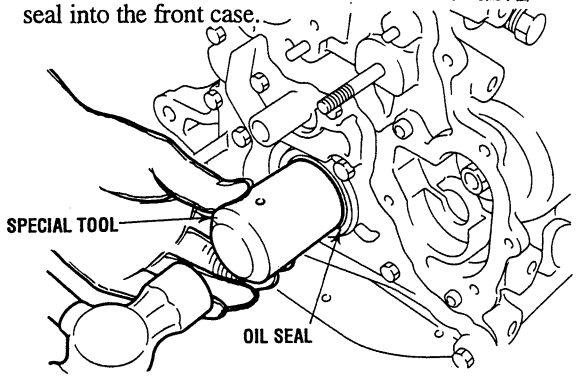
Counterbalance Front Bearing

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



Crankshaft Oil Seal

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



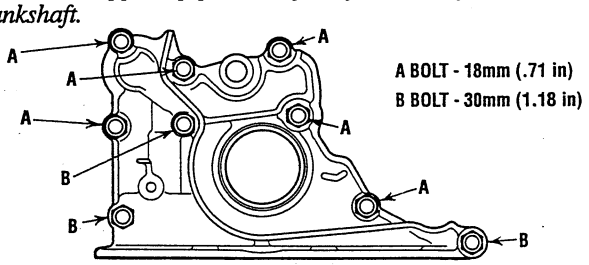
Front Case Assembly

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

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

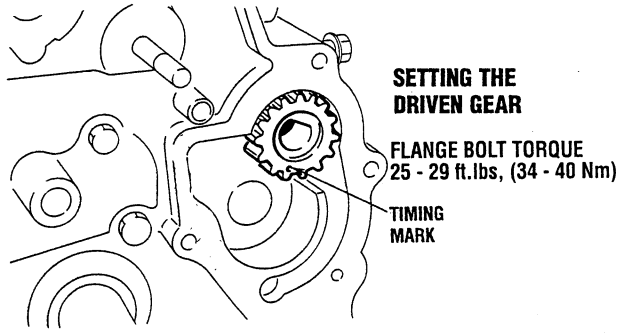
There are two different length front case bolts. Make certain they are positioned properly. See the diagram.

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

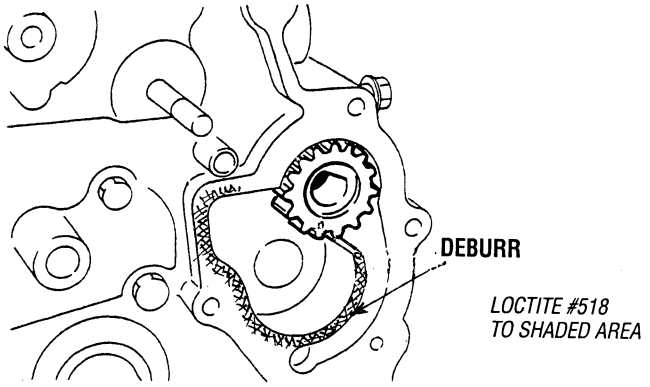


Oil Pump Driven Gear

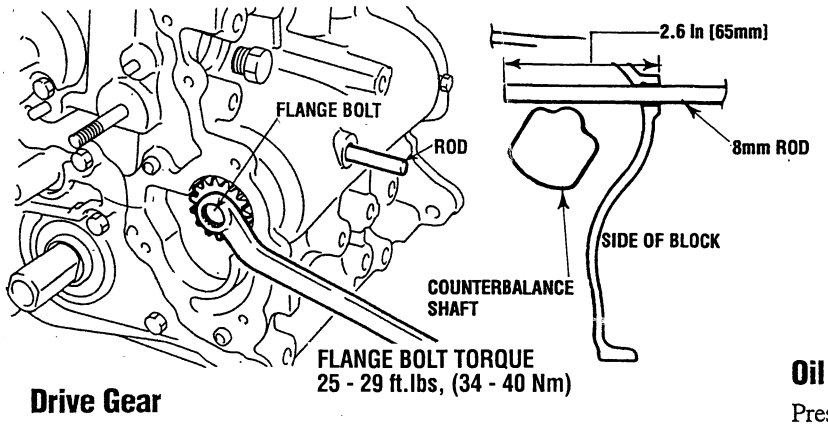
1. Apply an ample amount of clean engine oil to the oil pump driven gear and insert it so that the timing mark is positioned as shown.
2. Using the same hole on the side of the cylinder block, reinsert the 8mm rod to lock the counterbalance shaft. Then tighten the flange bolt to the specified torque.



FRONT CASE AND OIL PUMP

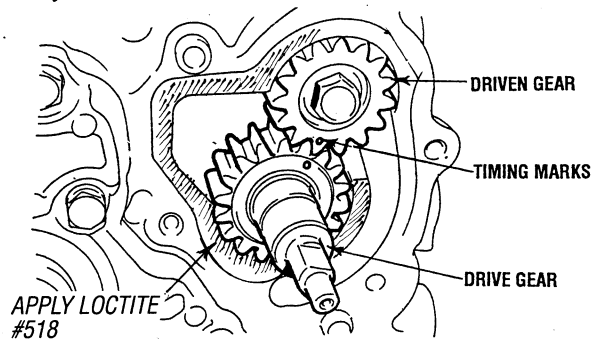


NOTE: *Deburr this edge area as shown. Clean off all metal from the deburring process and clean with a cleaning agent. Wipe dry with a clean cloth and use compressed air to blow dry. the block surface and oil pump cover must be clean and free of oil.*



Drive Gear

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

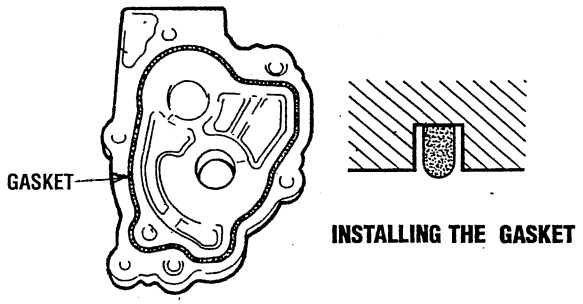


Oil Pump Block Surface

Apply a very small bead of LOCTITE #518 to the engine block surface as shown. Spread it into a thin, even layer on the surface. Remove any excess.

Oil Pump Cover Gasket

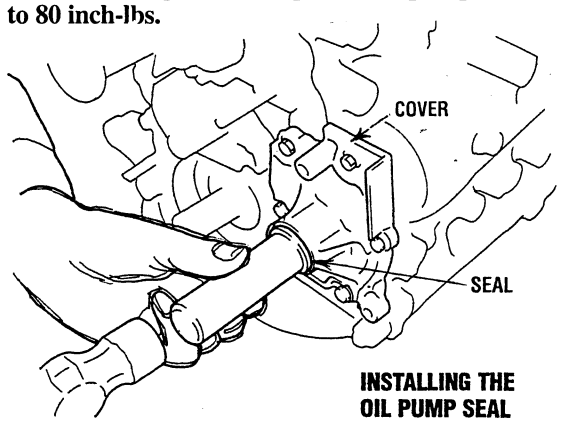
Fit a new oil pump cover gasket into the groove in the oil pump cover. The flat side of the gasket is positioned against the pump cover.



INSTALLING THE GASKET

Oil Pump Cover

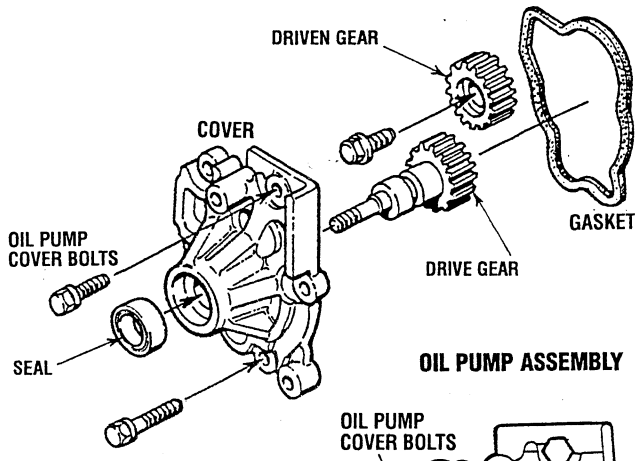
Re-install the pump cover. Press or lightly tap the cover onto the alignment sleeves. the two long bolts go where the sleeves are - install these bolts first. Install the rest of the bolts in a criss-cross pattern. **Torque the oil pump cover bolts to 80 inch-lbs.**



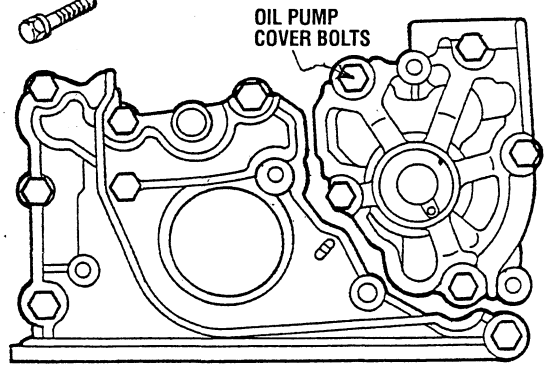
INSTALLING THE OIL PUMP SEAL

Oil Pump Seal

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

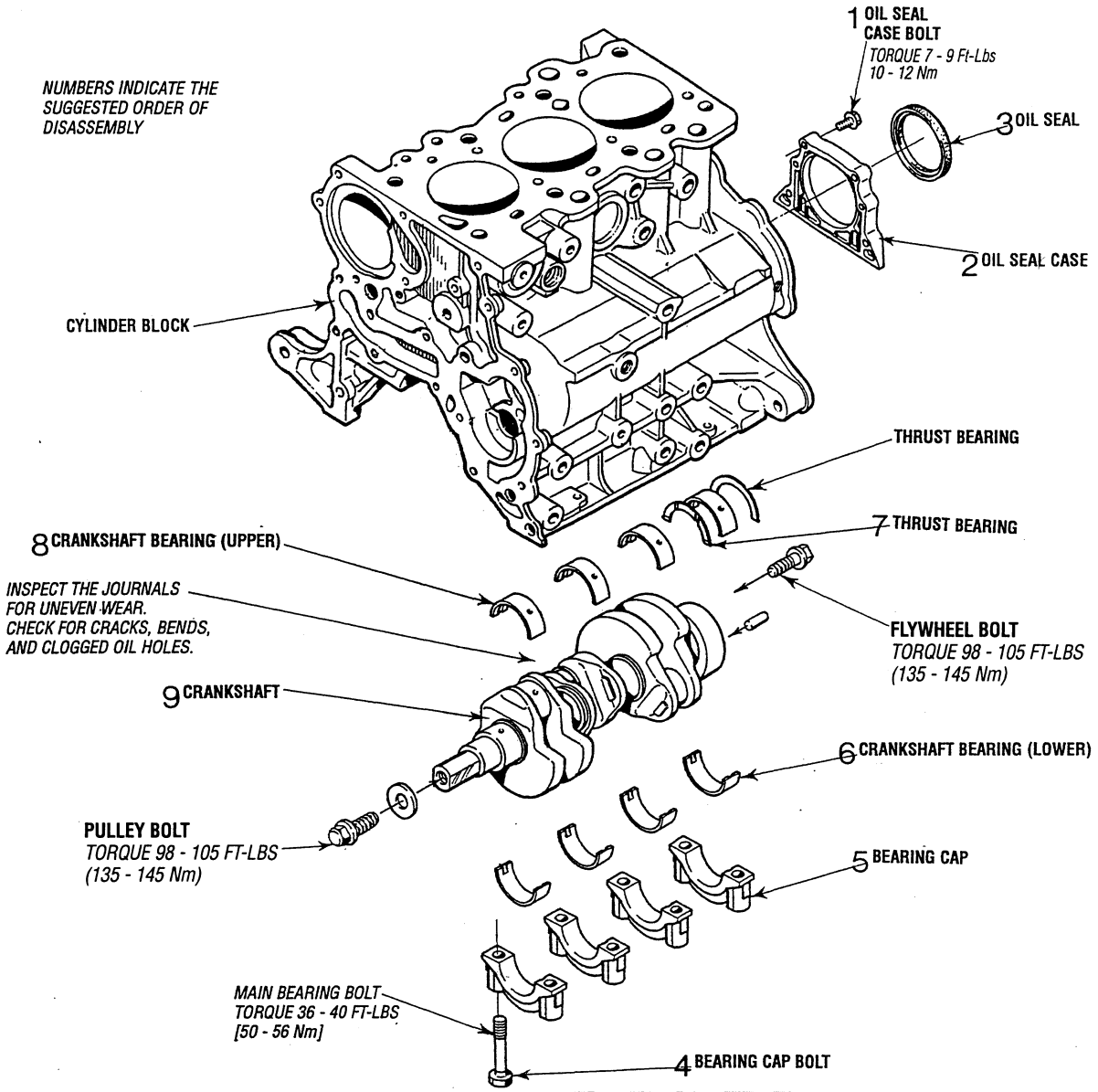


OIL PUMP ASSEMBLY



FRONT CASE CONFIGURATION

CRANKSHAFT / BEARINGS AND OIL SEAL

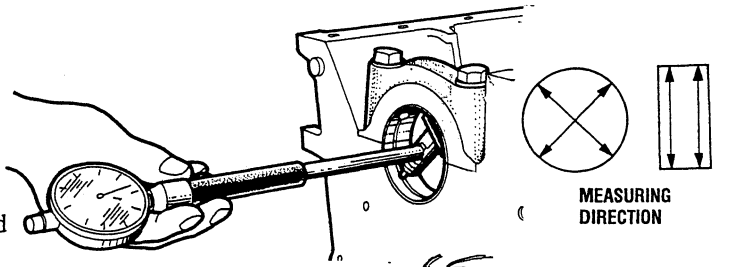


CRANKSHAFT INSPECTION

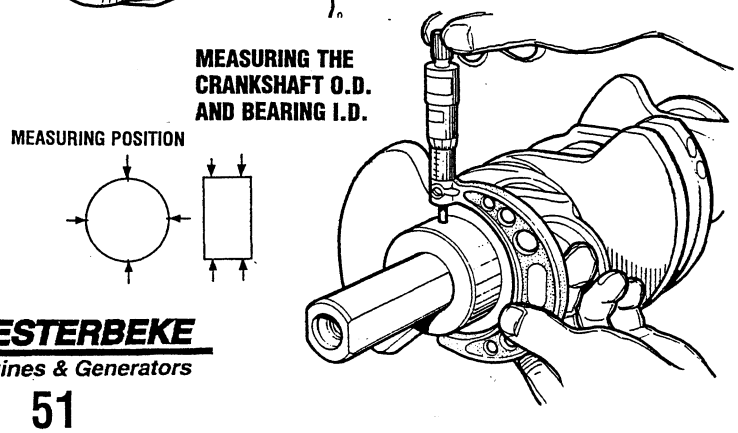
1. Check the journals and pins for damage, seizure and cracks. Check the journals contact surface for uneven wear and replace if badly damaged.
2. Measure the outside diameter of the journal and the inside diameter of the main bearing. If the clearance (oil clearance) exceeds the limit, replace the main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

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

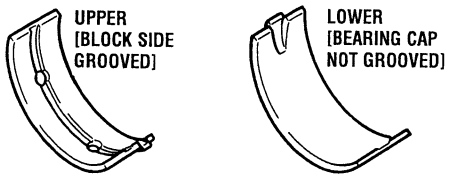
3. When grinding the crankshaft to under-size, take note of the "R" dimensions of the fillets of the journal and pin area.



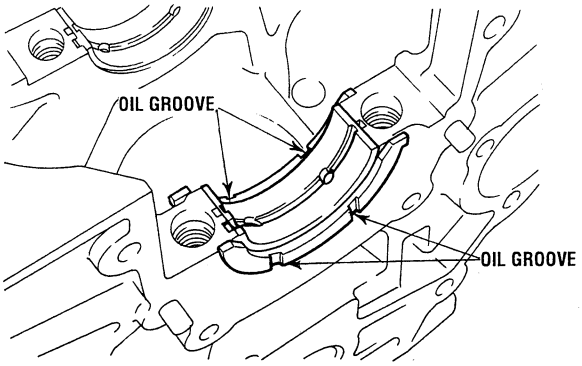
MEASURING THE CRANKSHAFT O.D. AND BEARING I.D.



CRANKSHAFT/ BEARING AND OIL SEAL

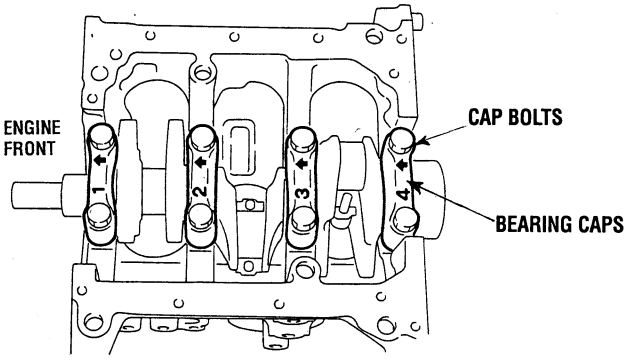


CRANKSHAFT BEARINGS



INSTALLING THE THRUST BEARINGS

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



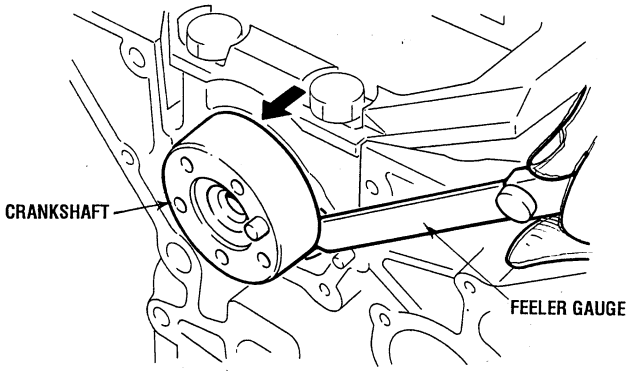
2. Install the bearing cap paying careful attention to the cap number and the arrow mark. Apply oil to the bolt threads.
3. Tighten the bearing cap to the specified torque.

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

MEASURING END PLAY

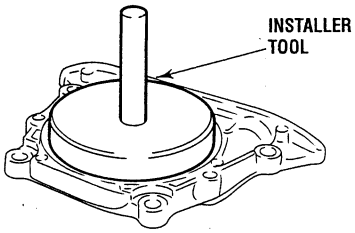
Push the crankshaft to the rear. Then, insert a feeler gauge in the gap between the crankshaft journal side surface and the thrust bearing end surface to measure the end play.

CRANKSHAFT END PLAY: 0.0020 - 0.0098 in (0.05 - 0.025 mm)

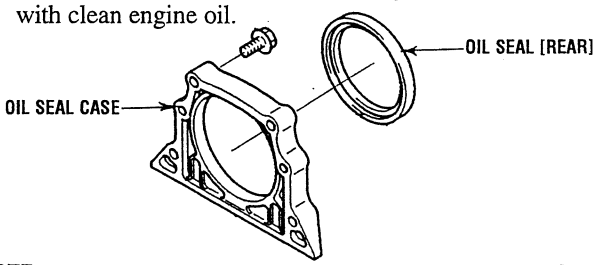


CRANKSHAFT REAR OIL SEAL

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



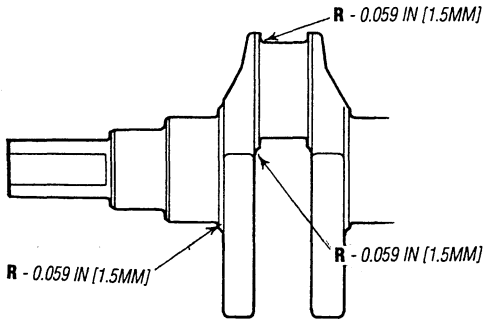
3. Install the oil seal case into the cylinder block through the gasket. (If there is no gasket, coat with sealant.) The entire circumference of the oil seal lip should be coated with clean engine oil.



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

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

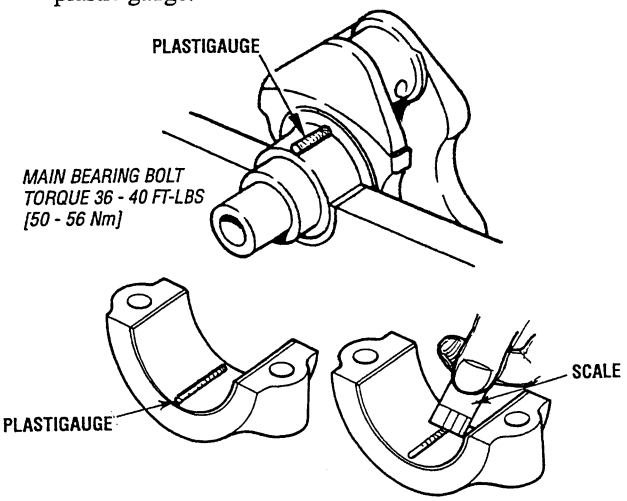
CRANKSHAFT, BEARING AND OIL SEAL



MEASURE THE CRANKSHAFT OIL CLEARANCE

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

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



INSPECTING THE CRANKSHAFT REAR OIL SEAL

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

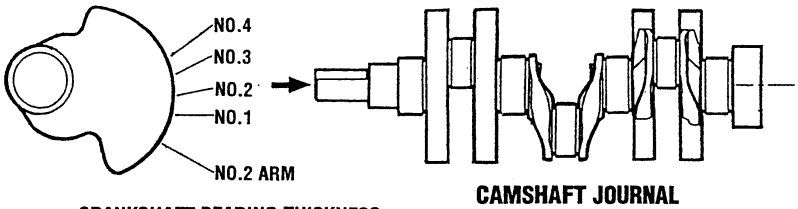
CRANKSHAFT BEARINGS SPECIFICATIONS

Upper and Lower

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

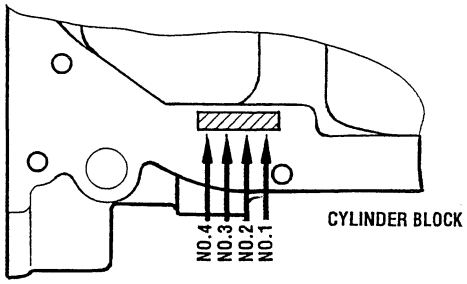
CRANKSHAFT JOURNAL DIAMETER

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



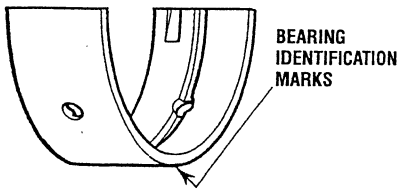
CRANKSHAFT BEARING THICKNESS

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



CYLINDER BLOCK BEARING DIAMETER

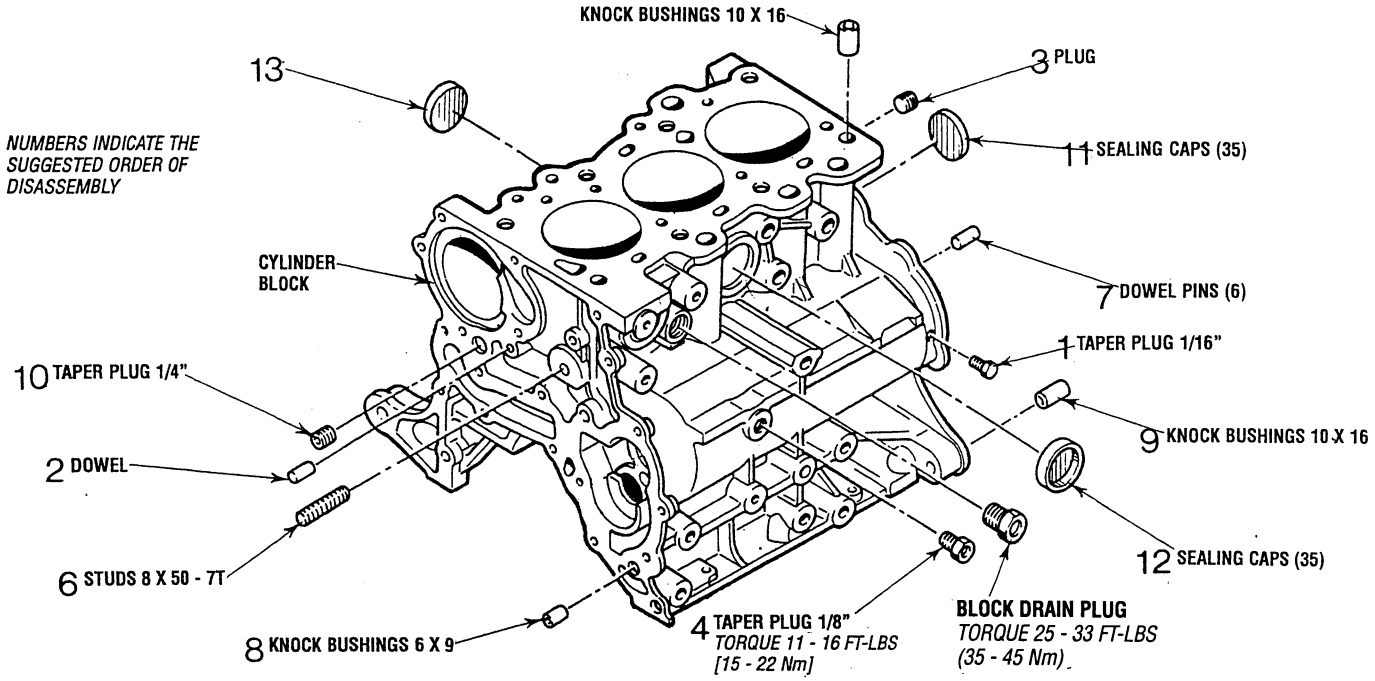
Identification Marks	Bearing Inner Diameter
0	1.7323 - 1.7325 in (44.000 - 44.006mm)
I	1.7325 - 1.7328 in (44.006 - 44.012mm)
II	1.7328 - 1.7330 in (44.012 - 44.018mm)



CRANKSHAFT BEARING SELECTION CHART

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

CYLINDER BLOCK INSPECTION AND PISTON CLEARANCE

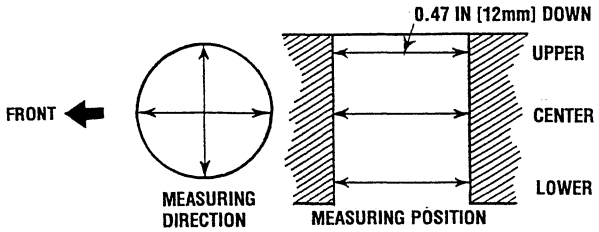


CYLINDER BLOCK INSPECTION

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

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

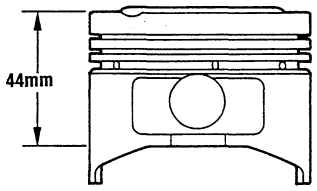
   CYLINDRICITY STANDARD VALUE: 0.0004 in (0.01 mm) or less
   CYLINDER BORE: 2.5591 - 2.5602 in (65.00 - 65.03 mm)



CHECKING THE PISTON CLEARANCE

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

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



BORING THE CYLINDER

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

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

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

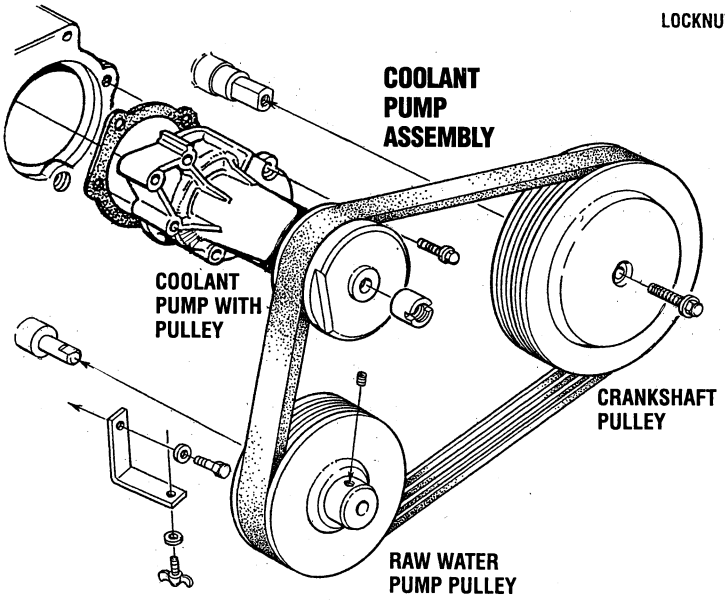
Size	Mark	Piston Dia.	Cylinder Inner Dia.
0.25 O.S.	25	2.5677 - 2.5689in (65.22 - 65.25mm)	2.5693 - 2.5697in (65.26 - 65.27mm)
0.50 O.S.	50	2.5776 - 2.5787in (65.47 - 65.50mm)	2.5791 - 2.5795in (65.51 - 65.52mm)
0.75 O.S.	75	2.5874 - 2.5886in (65.72 - 65.75mm)	2.5890 - 2.5894in (65.76 - 65.77mm)
1.00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

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

COOLANT CIRCULATING PUMP

REMOVING THE COOLANT PUMP

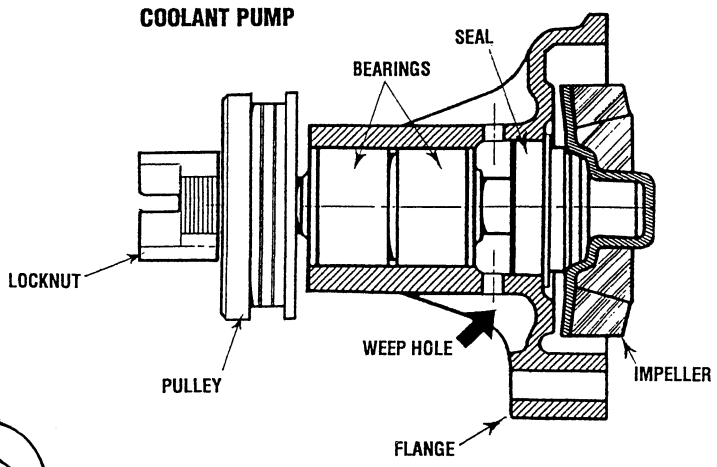
1. Loosen the belt guards thumbscrews and remove the engine's belt guard from its brackets at the front of the engine.
2. Ease the belt tension by releasing the raw water pump and remove the engine drive belt [on carburetor models it will be necessary to remove the governor belt].
3. Unscrew the five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



INSPECTION

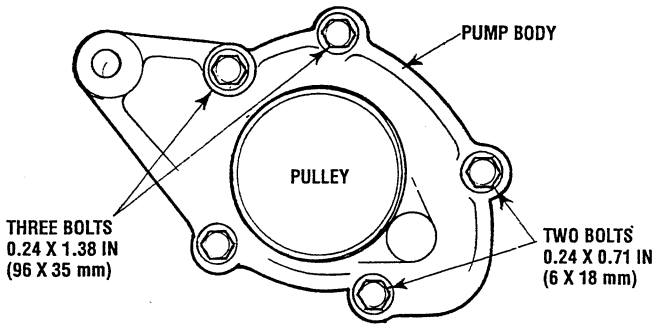
Carefully check the pump body and impeller for cracks and damage. Inspect the weep holes for signs of water leakage and rust that would indicate a faulty seal. The pulley should turn the shaft (and impeller) smoothly, without noise or sluggish rotation.

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



REPAIR

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



INSTALLATION

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

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

EXHAUST MANIFOLD / HEAT EXCHANGER

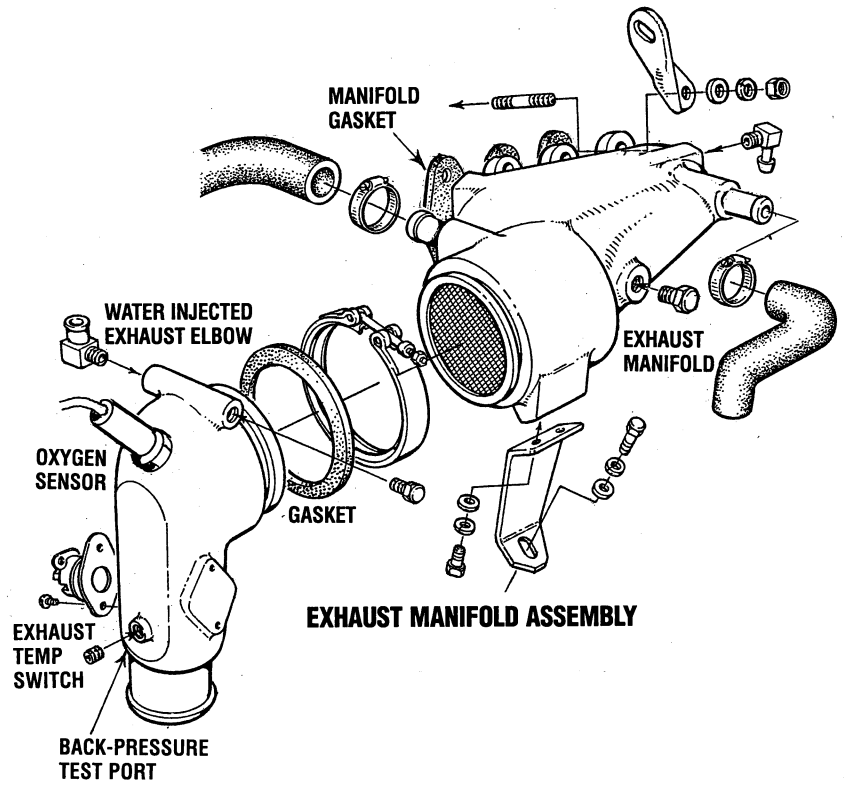
EXHAUST MANIFOLD

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

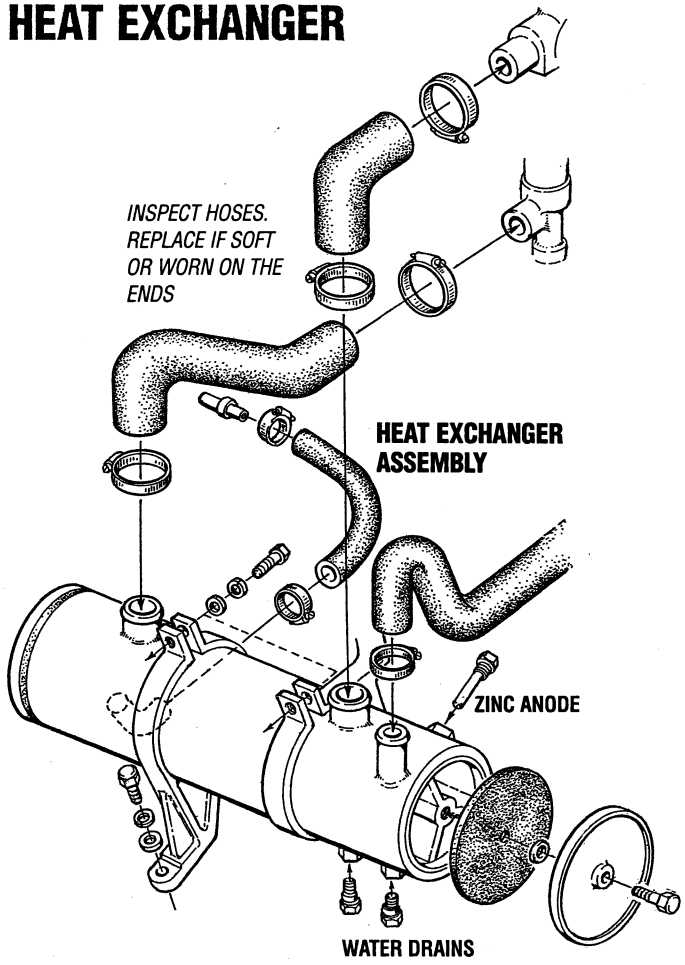
1. Remove the exhaust elbow from the manifold. Scrape off and discard the old gasket. Inspect the exhaust elbow for corrosion and damage, replace if necessary.
2. If the exhaust elbow passes inspection, remove the high temperature sensor and clean and re-paint the elbow with WESTERBEKE heat resistant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

ASSEMBLY

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



EXHAUST MANIFOLD ASSEMBLY



HEAT EXCHANGER

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

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

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

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

HEAT EXCHANGER ASSEMBLY

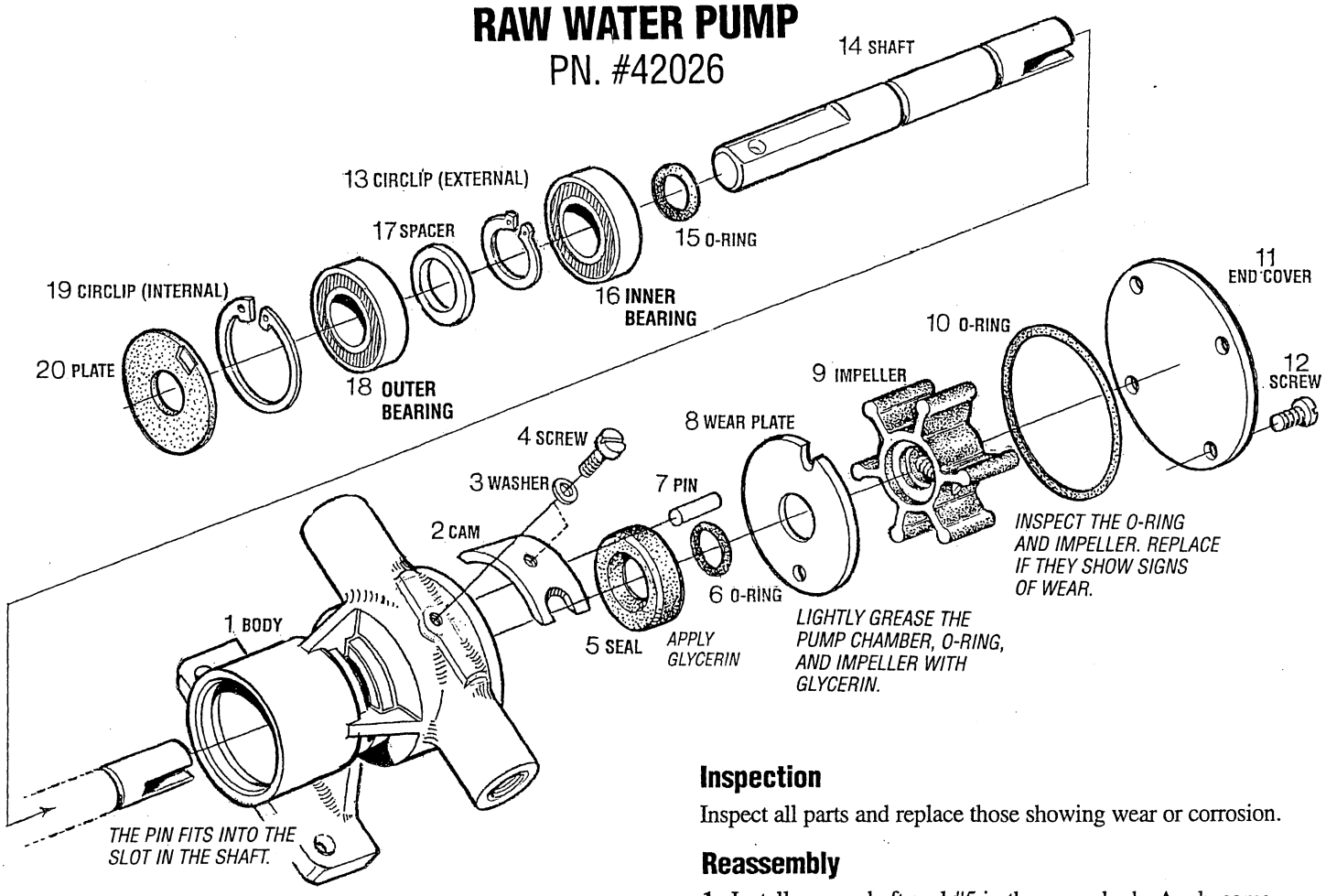
Reinstall the heat exchanger. Tighten down the holdown brackets and once the engine is running, check the heat exchanger and hose connections for leaks.

ENGINE HARDWARE TORQUES

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

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

RAW WATER PUMP
PN. #42026



PUMP OVERHAUL

Disassembly

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

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

Inspection

Inspect all parts and replace those showing wear or corrosion.

Reassembly

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

STARTER MOTOR

BENCH TESTING THE STARTER MOTOR

When bench testing the starter motor, make certain it is securely held in place.

Motor Test

1. Using a fully charged battery, run a jumper from the batteries (+) post to the connecting lead that has been removed from terminal **C**..
2. Connect another jumper from the battery (-) post to the starter motor's housing (momentarily). If the motor fails to run, the motor is the problem.

DISASSEMBLING THE MOTOR

NOTE: *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 gentle.

Magnetic Switch Test

1. Connect a jumper lead from the starter's **S** terminal to the battery (+) post.
2. Connect a jumper from the battery (-) post to the starter motor's **C** terminal (momentarily).
3. If the pinion gear fails to pop out, the problem is with the magnetic switch.

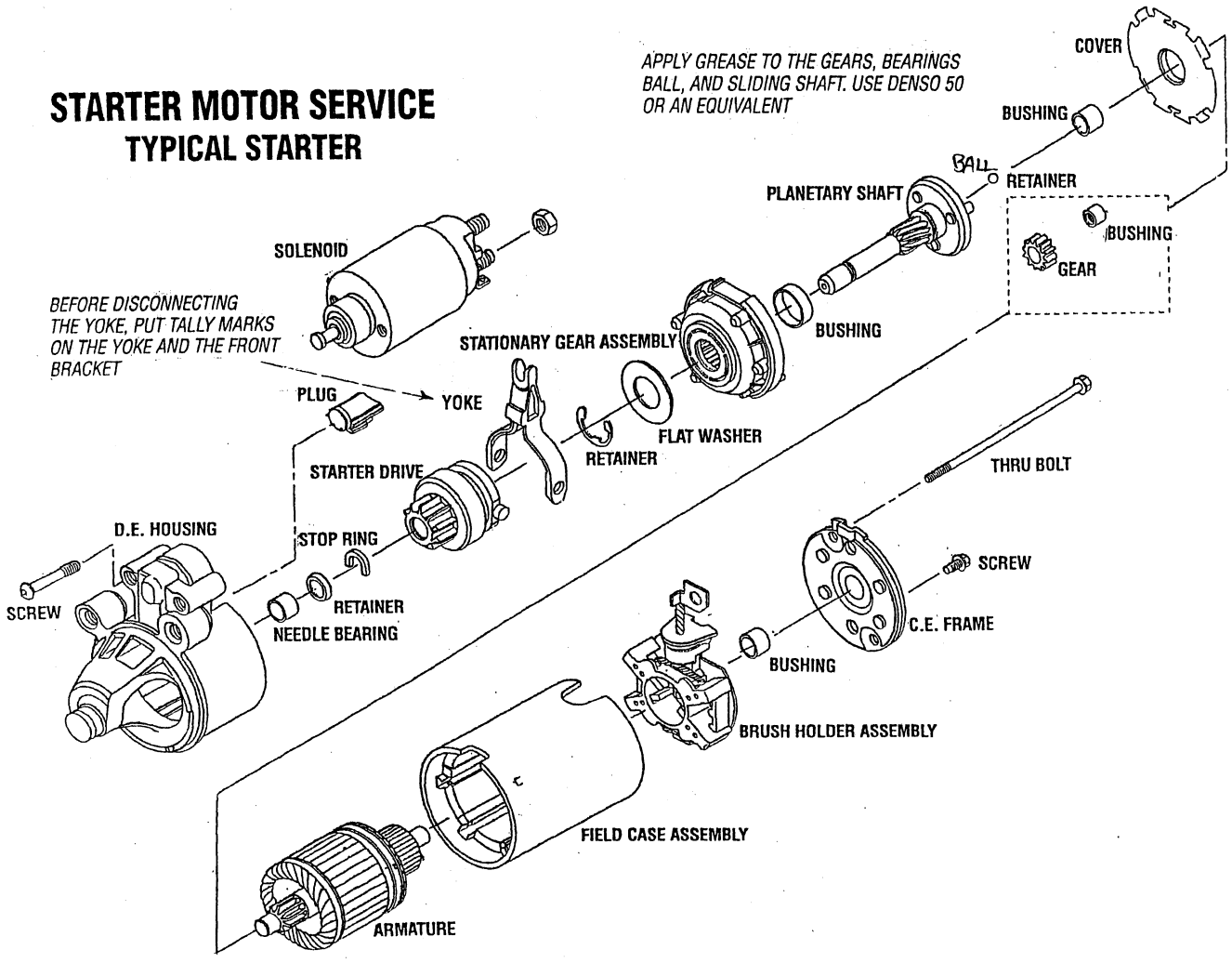
DISASSEMBLING THE MAGNETIC SWITCH

1. Remove the drive end frame mounting screws.
2. Disassemble carefully the overrunning clutch, ball, spring, gears, rollers, and retainer.
3. Remove the plunger end cover screws and take out the plunger.

NOTE: *When reassembling, apply grease to all the gear teeth, the overrunning clutch and the ball.*

TIGHTENING TORQUE B TERMINAL NUT	5.9 - 11.8 Nm 4.3 - 8.7 ft-lb

STARTER MOTOR SERVICE
TYPICAL STARTER

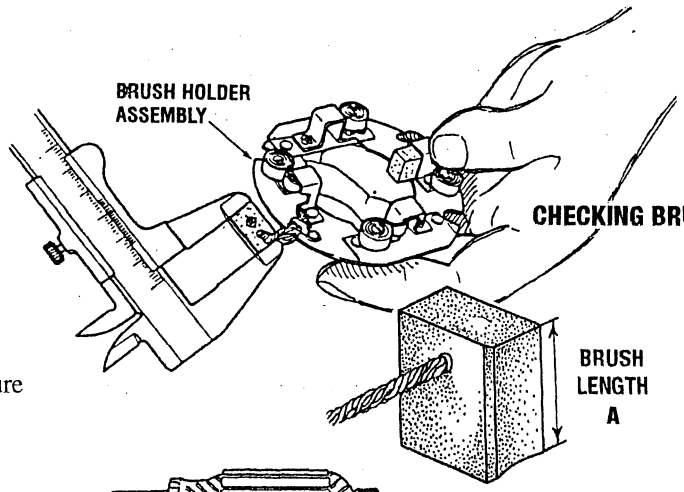


STARTER MOTOR SERVICE

BRUSH WEAR

1. If the contact face of the brush is dirty or dusty, clean it with emery paper.
2. Measure the brush length (A) with vemler calipers.
3. If the length is less than the allowable limit, replace the yoke assembly and brush holder.

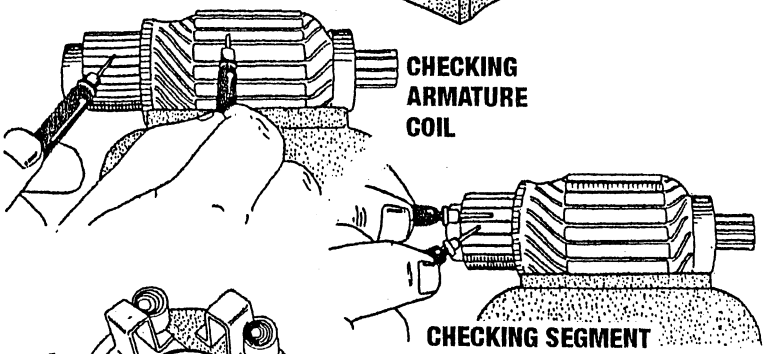
BRUSH LENGTH (A) 18.0MM (0.7086IN)
LIMIT 11.0MM (0.4331IN)



ARMATURE COIL

1. Check the continuity across the commutator and armature coil core with an ohmmeter.
2. If it conducts, replace the armature.
3. Check the continuity across the segments of the commutator with an ohmmeter.
4. If it does not conduct, replace the armature.

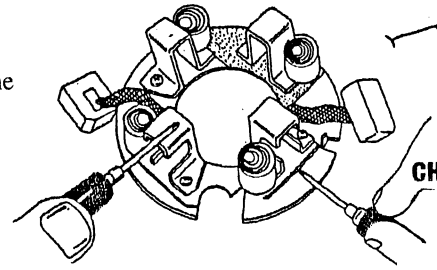
RESISTANCE: COMMUTATOR ARMATURE COIL - INFINITY
COMMUTATOR SEGMENT - 0Ω



BRUSH HOLDER

1. Check the continuity across the brush holder and the holder support with an ohmmeter.
2. If it conducts, replace the brush holder.
3. If the length is less than the allowable limit, replace the yoke assembly and brush holder.

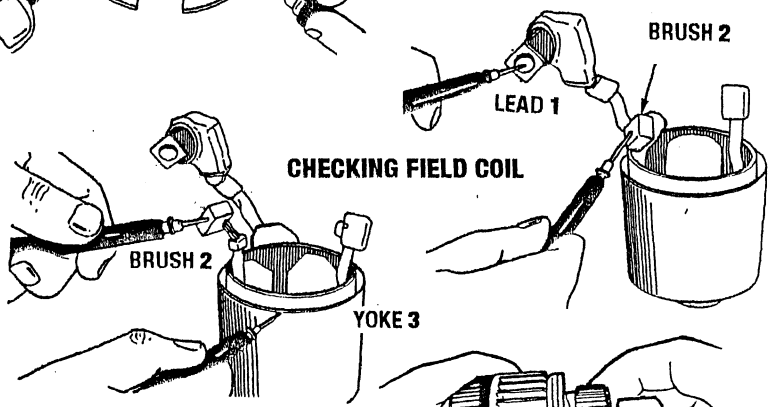
RESISTANCE: BRUSH HOLDER TO HOLDER SUPPORT - INFINITY



FIELD COIL

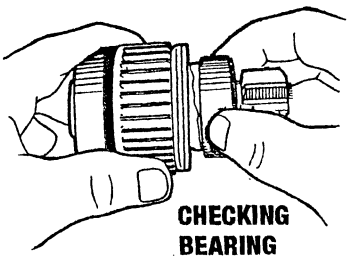
1. Check the continuity across the lead (1) and brush (2) with an ohmmeter.
2. If it does not conduct, replace the yoke assembly.
3. Check the continuity across the brush (2) and yoke (3) with an ohmmeter.
4. If it conducts, replace the yoke assembly.

RESISTANCE: LEAD (1) - BRUSH (2) 0Ω / BRUSH (2) - YOKE (3) - INFINITY



BEARING

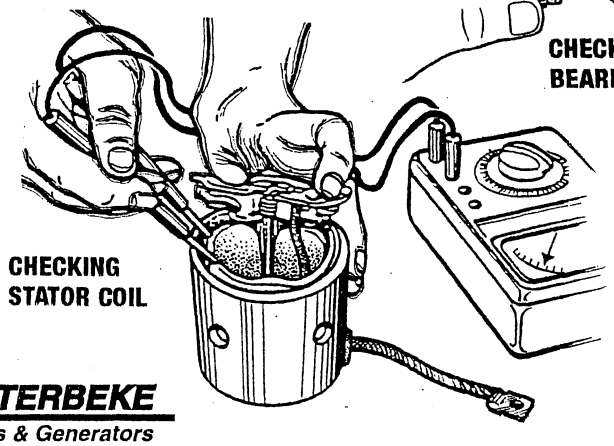
1. Check the bearing for smooth rotation.
2. If it does not rotate smoothly, replace it.



STATOR

1. Measure the resistance across each lead of the stator coil with an ohmmeter.
2. If the measurement is not within factory specifications, replace it.
3. Check the continuity across each stator coil lead and core with an ohmmeter.
4. If infinity in not indicated, replace it.

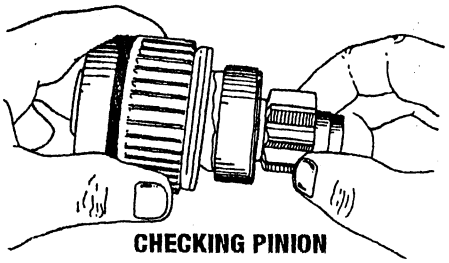
RESISTANCE: LESS THAN 1.0Ω



STARTER MOTOR SERVICE

OVER-RUNNING CLUTCH

1. Inspect the pinion gear for wear or damage. If there is any defect, replace the over-running clutch assembly.
2. Check that the pinion gear turns freely and smoothly in the over-running direction and does not slip in the cranking direction. If the pinion slips or fails to rotate in both directions, replace the over-running clutch assembly.

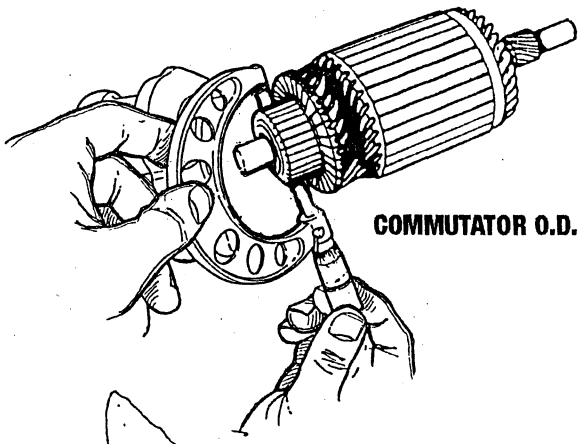


CHECKING PINION

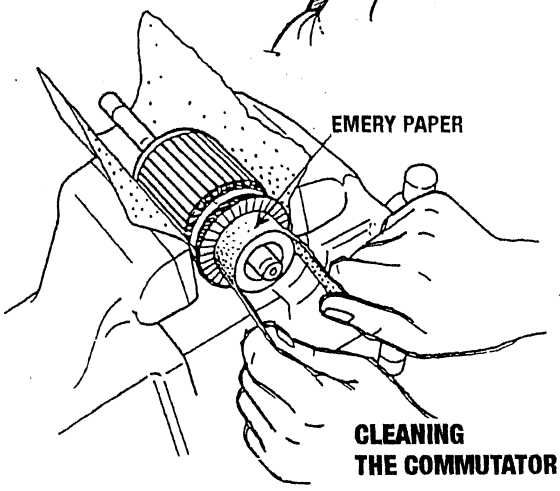
COMMUTATOR AND MICA

1. Check the contact face of the commutator for wear, and grind the commutator with emery paper if it is slightly worn.
2. Measure the commutator O.D. with an outside micrometer at several points.
3. If the minimum O.D. is less than the allowable limit, replace the armature.
4. If the difference of the O.D. exceeds the allowable limit, correct the commutator on a lathe to the factory specifications.
5. Measure the mica undercut.
6. If the undercut is less than the allowable limit, correct it with a saw blade and chamfer the segment edges.

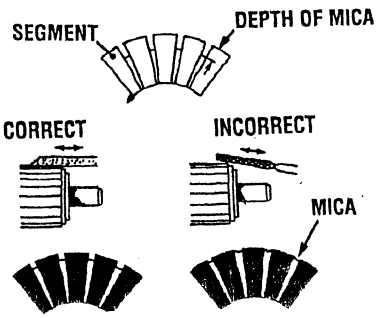
COMMUTATOR O.D. - 32MM (1.2598IN)
LIMIT - 31.4MM (1.2362IN)
MICA UNDERCUT - 0.50 - 0.80MM (0.0197 - 0.0315IN)
LIMIT - 0.20MM (0.0079IN)



COMMUTATOR O.D.



CLEANING THE COMMUTATOR



CHECKING MICA

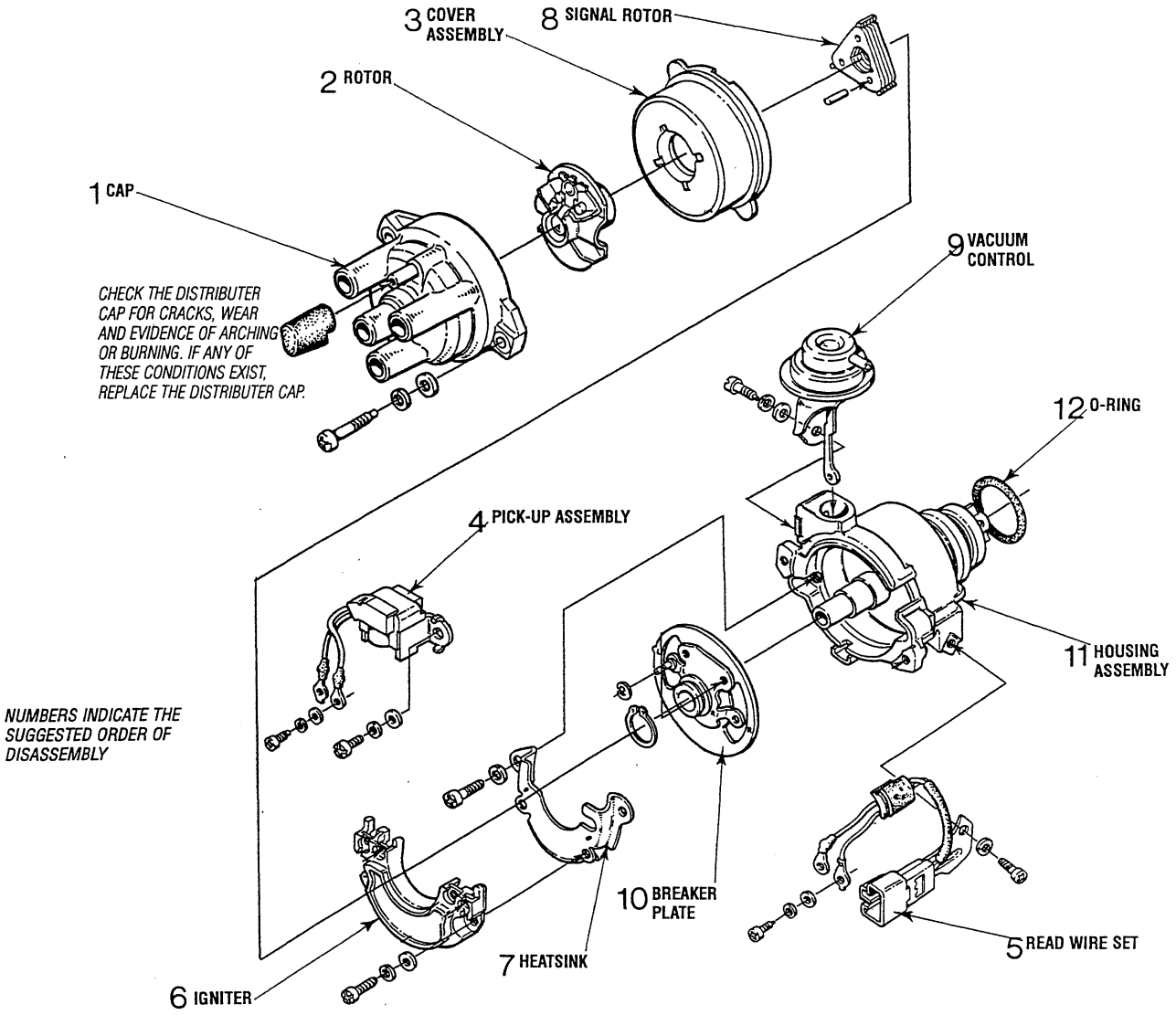
⚠ CAUTION: ***Before installing, thoroughly clean the starter flange and mounting surfaces, remove all old paint and rust. Starter performance largely depends on the quality of the wiring. Use wire of sufficient size and grade between the battery and starter and fully tighten to the terminal.***

DISTRIBUTOR

DISTRIBUTOR CAP INSPECTION

Check the following points. Replace if necessary.

1. Cracks or carbon deposits.
2. Burnt or corroded terminals.
3. Worn distributor center contact.



SERVICE DATA / STANDARDS AND LIMITS - BCG ENGINE/GENERATOR

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

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

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

PISTON AND CONNECTING ROD

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

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

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

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

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

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

CRANKSHAFT, BEARING

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

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

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

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

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

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

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

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

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

STANDARD HARDWARE TORQUES

NOTE: *Unless stated otherwise for a specific assembly, use the following torque values when tightening standard hardware.*

Grade 4	Pitch	lb-ft	kg-m
6mm bolt head/nut	1	2.9-5.1	0.4-0.7
8mm bolt head/nut	1.25	7.2-11.6	1.0-1.6
10mm bolt head/nut	1.25	13.7-22.4	1.9-3.1
10mm bolt head/nut	1.5	13.0-21.7	1.8-3.0
12mm bolt head/nut	1.25 (ISO)	25.3-39.8	3.5-5.5
12mm bolt head/nut	1.5	25.3-39.8	3.5-5.5
12mm bolt head/nut	1.75	21.7-36.2	3.0-5.0
13mm bolt head/nut	1.5	32.5-50.6	4.5-7.0
14mm bolt head/nut	1.5	36.2-57.9	5.0-8.0
14mm bolt head/nut	2	34.0-55.7	4.7-7.7
16mm bolt head/nut	1.5	54.2-79.6	7.5-11.0
16mm bolt head/nut	2	51.4-76.7	7.1-10.6
Grade 6T			
6mm bolt head/nut	1	4.3-6.5	0.6-0.9
8mm bolt head/nut	1.25	10.8-15.9	1.5-2.2
10mm bolt head/nut	1.25	21.7-32.5	3.0-4.5
10mm bolt head/nut	1.5	19.5-30.4	2.7-4.2
12mm bolt head/nut	1.25 (ISO)	36.2-57.9	5.0-8.0
12mm bolt head/nut	1.5	36.2-50.6	5.0-7.0
12mm bolt head/nut	1.75	34.7-49.2	4.8-6.8

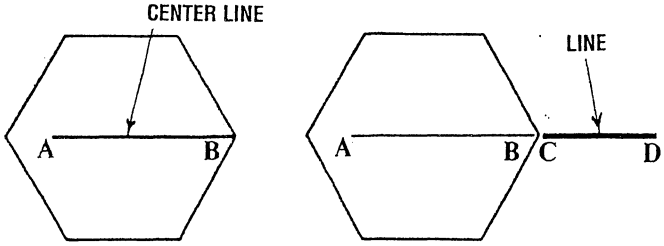
Grade 7T, 8T and 8.8	Pitch	lb-ft	kg-m
6mm bolt head/nut	1	5.8-8.7	0.8-1.2
8mm bolt head/nut	1.25	14.5-21.7	2.0-3.0
10mm bolt head/nut	1.25	28.9-39.8	4.0-5.5
10mm bolt head/nut	1.5	26.8-37.6	3.7-5.2
12mm bolt head/nut	1.25 (ISO)	54.2-75.9	7.5-10.5
12mm bolt head/nut	1.5	50.6-65.1	7.0-9.0
12mm bolt head/nut	1.75	43.4-61.5	6.0-8.5
13mm bolt head/nut	1.5	57.9-86.8	8.0-12.0
14mm bolt head/nut	1.5	72.3-108.5	10.0-15.0
14mm bolt head/nut	2	68.7-101.3	9.5-14.0
16mm bolt head/nut	1.5	108.5-166.4	15.0-23.0
16mm bolt head/nut	2	101.3-159.1	14.0-22.0
Grade 5 Cap Screw			
1/4 UNC		9-11	1.2-1.5
1/4 UNF		11-13	1.5-1.8
5/16 UNC		18-20	2.5-2.8
5/16 UNF		21-23	2.9-3.2
3/8 UNC		28-33	3.7-4.6
3/8 UNF		30-35	4.1-4.8
7/16 UNC		44-49	6.1-6.8
7/16 UNF		50-55	6.9-7.6
1/2 UNC		68-73	9.4-10.1
1/2 UNF		73-80	10.1-11.1

BOLT DIAMETER	BOLT HEAD MARK		
	4	7	10
M6	0.3 - 0.5	0.8 - 1.0	1.0 - 1.3
M8	1.0 - 1.3	1.5 - 2.2	2.5 - 3.5
M10	1.8 - 2.5	3.0 - 4.2	5.0 - 7.0
M12	3.0 - 4.2	5.5 - 7.5	9.5 - 12.0
M14	5.0 - 7.0	8.0 - 11.0	16.0 - 19.0

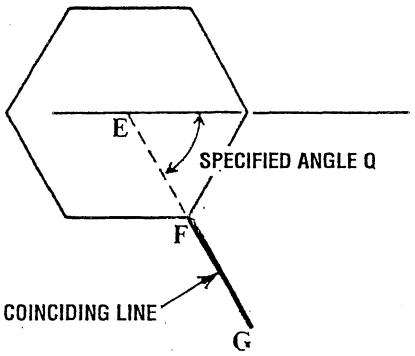
PARTS REQUIRING SEALANT	SURFACES REQUIRING SEALANT (where to mount sealant coated parts)	SEALANT
Taper Screw 1/2"	Thread portion (Gear Case)	Liquid Teflon
Taper Screw 1/4"	Thread portion (Cylinder Block right side, pump cover)	Liquid Teflon
Taper Screw 1/8"	Thread portion (Cylinder Head rear surface)	Liquid Teflon
Water Drain Plug	Thread portion (Cylinder Block right side, rear middle portion)	Liquid Teflon
Oil Pressure Switch	Thread portion (Cylinder Block right side surface)	Liquid Teflon
Side Seal	Periphery (Main Bearing Caps No. 1 and No. 5)	Permatex #6B
Bearing Cap No. 1	Contact surface with Cylinder Block	Permatex #6B

ANGULAR NUT AND BOLT TIGHTENING METHOD

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



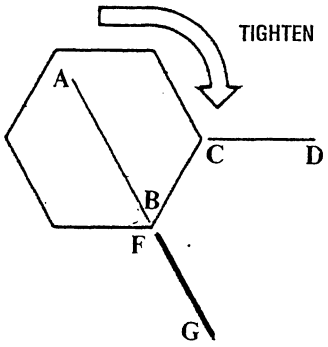
4. Draw a line (A-B) across the center of each bolt.
5. Draw another line (C-D) on the face of each of the parts to be clamped. This line should be an extension of the line (A-B).

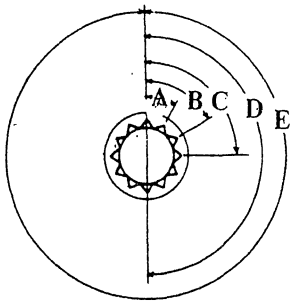


6. Draw another line (F-G) on the face of each of the parts to be clamped. This line will be in the direction of the specified angle (Q) across the center (E) of the nut or bolt.
7. Use a socket wrench to tighten each nut or bolt to the point where the line (A-B) is aligned with the line (F-G).

Example: Specified Angle and Tightening Rotation

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

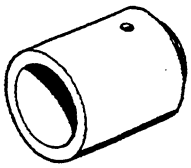




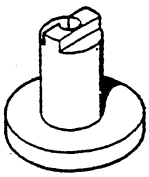
SPECIAL TOOLS - ENGINE

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

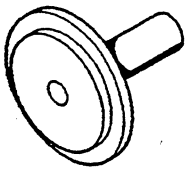
CAMSHAFT OIL SEAL INSTALLER
MD 999569



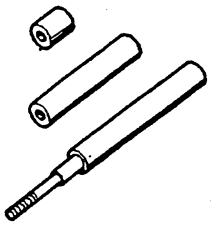
PISTON PIN SETTING BASE
Used to pull-out and press in the piston pin.
MD 999583



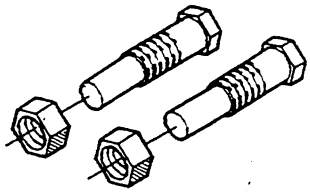
CRANKSHAFT REAR OIL SEAL INSTALLER
MD 998376



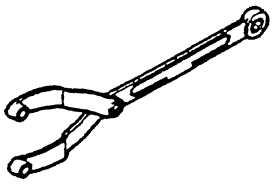
PUSH ROD AND PIN SET GUIDE
Used to pull-out and press in the piston pin.
MD 999584



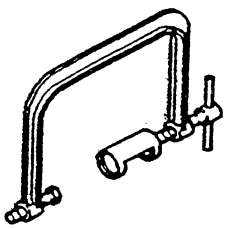
PIN *For supporting the sprocket when the camshaft sprocket is loosened or tightened.*
MD 998715



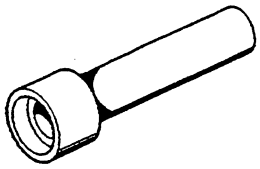
END YOKE HOLDER
For supporting the sprocket when the camshaft sprocket is loosened or tightened.
MD 990767



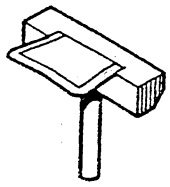
VALVE SPRING COMPRESSOR
MD 999597



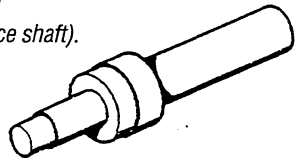
VALVE STEM SEAL INSTALLER
MD 998302



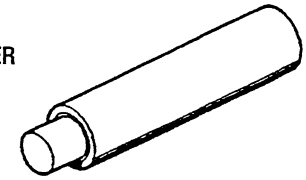
OIL PAN GASKET CUTTER
For removing the oil pan to break the oil pan seal.
MD 998727



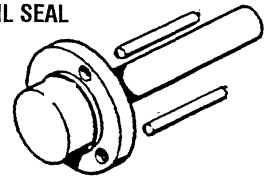
BEARING REMOVER
For pulling out the front and rear bearings (counterbalance shaft).
MD 999593



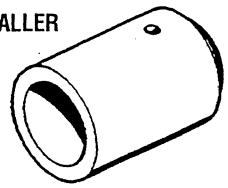
FRONT BEARING INSTALLER
(Counterbalance shaft).
MD 999591



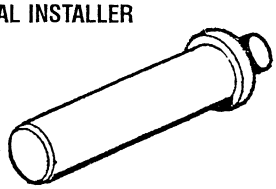
INSTALLER FOR THE REAR OIL SEAL
(Counterbalance shaft).
MD 999592



CRANKSHAFT FRONT OIL SEAL INSTALLER
MD 999570



OIL PUMP OIL SEAL INSTALLER



BC GENERATORS

DESCRIPTION

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

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

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

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

INTRODUCTION TO TROUBLESHOOTING

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

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

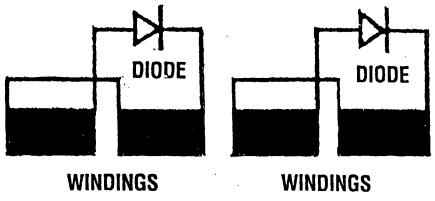
A quality multimeter (multitester) capable of reading less than one ohm and with a specific diode testing function.

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

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

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

ROTATING FIELD/AUXILIARY WINDINGS



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

BC GENERATOR TROUBLESHOOTING →

BC GENERATORS TROUBLESHOOTING CHART

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

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

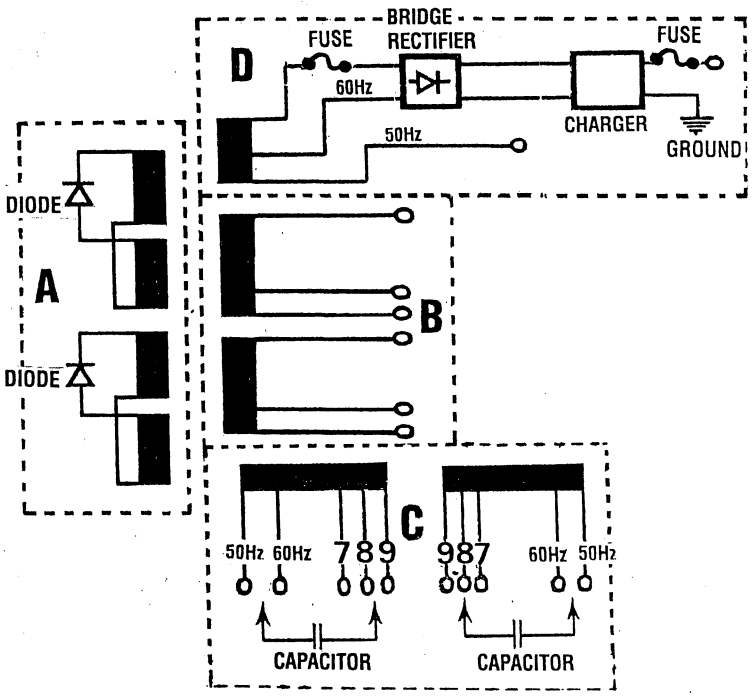
FAULT	CAUSE	TEST/CORRECTION
No AC Output	Shorted stator	**B**
	Open stator	**B**
	Shorted diode (two)	**A**
Residual Voltage 4-6 VAC (Hot N) at No-Load	Faulty capacitor (two)	**C**
	Open exciter	**B**
	Shorted exciter	**B**
	Engine speed (hertz) is too low	Adjust*
	Electrical connections are faulty	Inspect wiring connections
High AC Output at No-Load	Incorrect voltage tap on capacitor	**C**
	Incorrect capacitor	**C**
	Incorrect hertz tap on capacitor	**C**
	Engine speed (hertz) too high.	Adjust*
Low AC Output 60-160V	Faulty rotor winding	**A**
	Faulty diode	**A**
	Faulty capacitor	**B**
Voltage Drop Under Load (or at No-Load)	Faulty diode	**A**
	Faulty capacitor	**C**
	Engine speed (hertz) is too low	Adjust*
No Battery Charge Low Battery Charge	Faulty Bridge rectifier	**D**
	Faulty integral controller	**D**
	Blown fuse (s)	**B**
	Faulty wiring	**B**
High Voltage Output when Load is applied	Engine speed (hertz) is too high	Adjust*
Unstable Voltage	Electrical connections are faulty, loose	Inspect wiring connections
Noisy Operation	Faulty support bearing	Inspect rear bearing**
	Generator rotor connection to engine is loose	Check rotor security**

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

WINDING RESISTANCE VALUES (OHMS)

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

INTERNAL WIRING SCHEMATIC



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

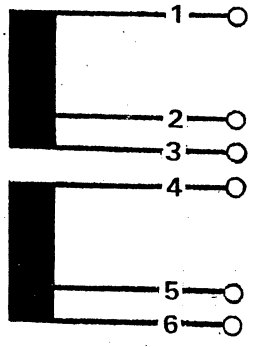
NO AC VOLTAGE OUTPUT

EXCITING THE GENERATOR

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

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

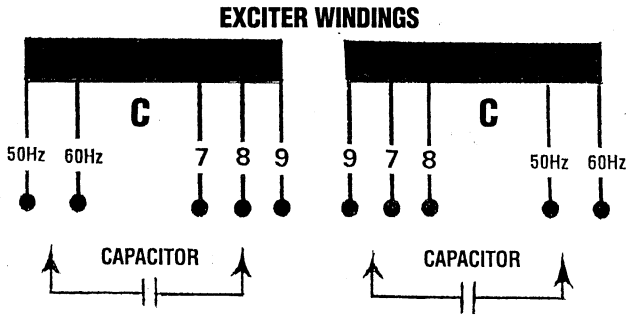
NORMAL AC VOLTAGE DURING 12 VDC EXCITATION:
12 - 16 VOLTS AC

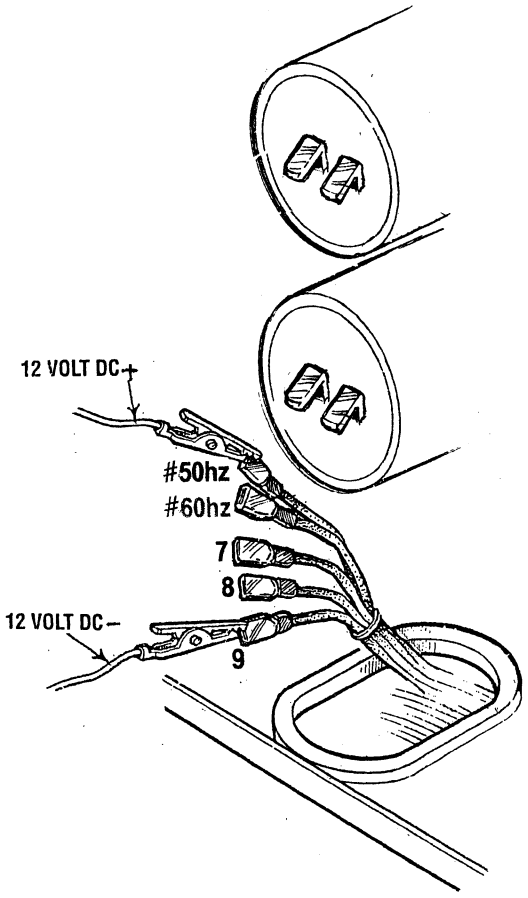


MAIN STATOR

EXCITING PROCEDURE

Locate one of the exciter winding groups in the generator. Unplug all connections from both capacitors. Connect 12 VDC across the winding using the winding end connection, Winding group between #50Hz and #9.





BC GENERATORS TROUBLESHOOTING

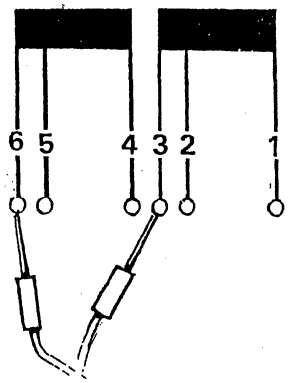
REACTION DURING EXCITATION

(Unit running - 12 VDC applied to winding)

NORMAL VOLTAGE DURING EXCITATIIN IS 12 - 16 VOLTS AC

1. A very low AC output and loading of the drive engine and a growling boise from the generator end.
   This indicates a shorted stator winding to ground or the stator windings are shorted to each other. Isolate the winding groups and verify a short to ground. No continuity should be found between the two isolated stator winding groups.
2. No reaction from the generator or drive engine. No AC output.
   This is an indication of an open in one of the main stator winding groups. Isolate the winding groups and verify and open winding.

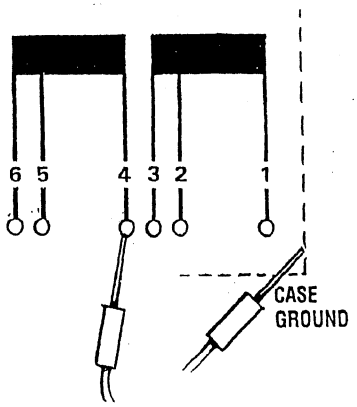
No Continuity between Isolated Stator Winding Groups



TEST EACH OF THE WINDING LEADS INDIVIDUALLY AS SHOWN

THERE SHOULD BE NO CONTINUITY BETWEEN LEADS

No Continuity between Isolated Stator Windings and Ground



TEST EACH WINDING TO CASE GROUND

BC GENERATORS TROUBLESHOOTING

TESTING CONTINUITY

Quick field check (no capacitance scale on meter).

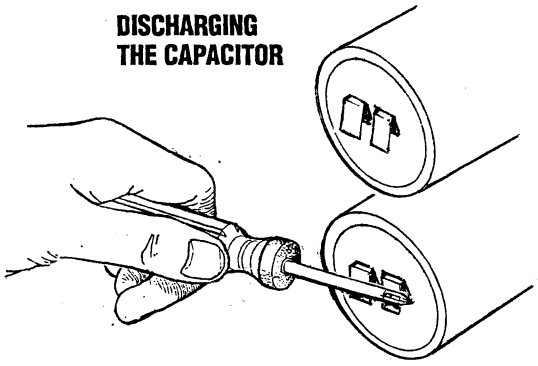
Connect a digital ohm meter or analog ohm meter (high scale) to the capacitor terminals. The meter will register and arbitrary ohm value for the material in the capacitor. the meter's battery will then start to charge the capacitor and the ohm value will increase.

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

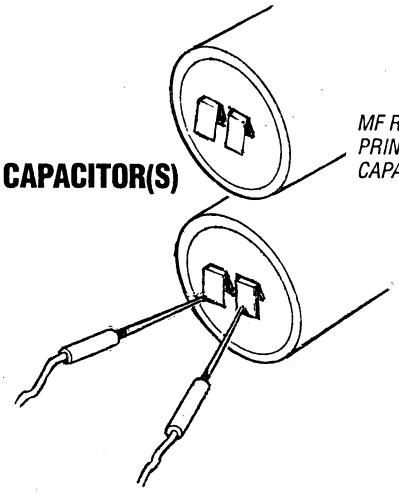
The method above indicates a presumably good capacitor, but does not verify it's microfared rating as would be necessary when troubleshooting a capacitor whose MF rating has dropped causing a low AC voltage output. In such cases, the capacitors rating *MUST* be verified accurately.

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

DISCHARGING THE CAPACITOR



TESTING THE CAPACITOR(S)



MF RATING IS PRINTED ON THE CAPACITOR

CAPACITOR RATINGS AND PART NUMBERS

25MFD	Pn.#046875
31.5MFD	Pn.#046978
35MFD	Pn.#049627
40MFC	Pn.#054730

NOTE: *When changing a capacitor due to a capacitor failure, reference the capacitor rating as printed on the body of the capacitor and order the correct replacement. Installing a capacitor of a higher MFD rating will result in high AC output voltage and installing a capacitor of a lower MFD rating will result in low AC output voltage.*

BC GENERATORS TROUBLESHOOTING

TESTING THE EXCITER WINDINGS

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

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

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

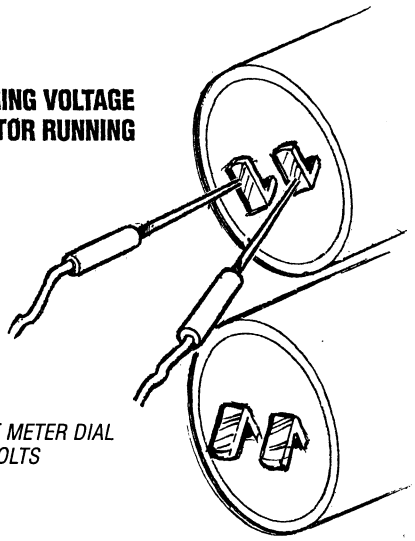
EXCITER WINDING INTEGRITY (RESIDUAL AC VOLTAGE)

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

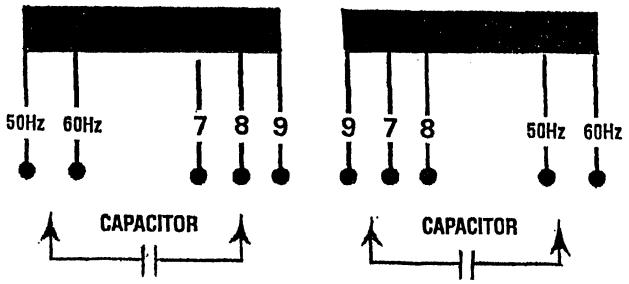
To do this: Unplug all connections from the capacitor. Locate the electrical connection for each winding end. Place your AC volt meter connects across these two connections. Start the generator and observe the residual AC voltage produced by the winding. Check the other exciter winding in the same way.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

RESIDUAL VOLTAGE (EACH WINDING GROUP)
MEASURED BETWEEN #50 AND #9 OF EACH GROUP
7-9 VOLTS AC.

MEASURING VOLTAGE GENERATOR RUNNING



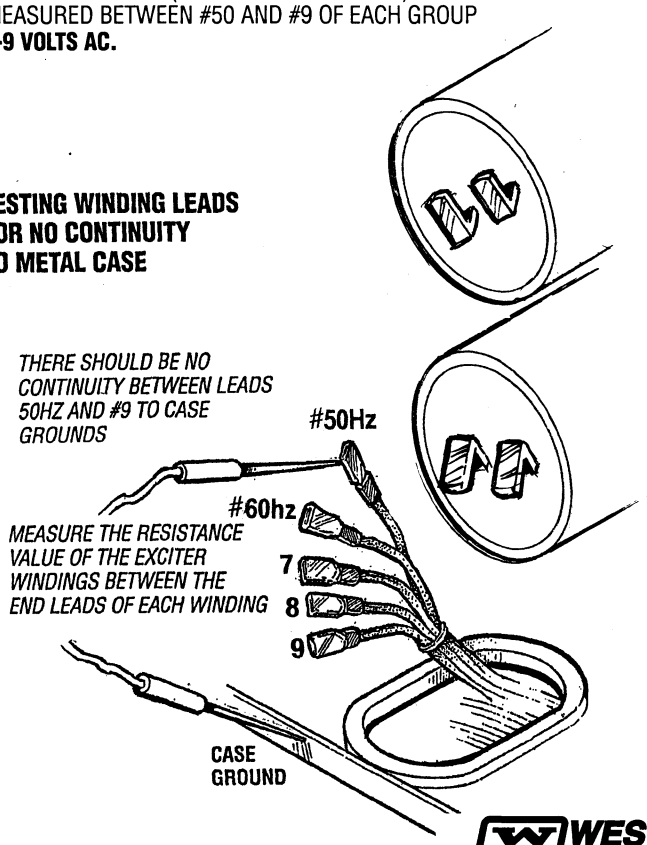
SET THE METER DIAL AT AC VOLTS



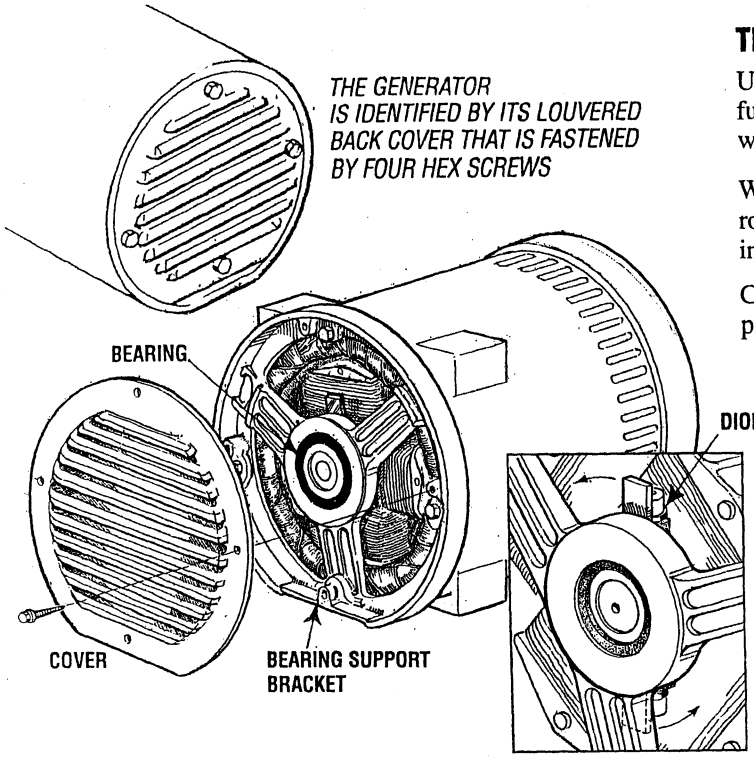
MAIN STATOR WINDING RESISTANCE
LESS THAN ONE OHM FOR EACH WINDING GROUP

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

TESTING WINDING LEADS FOR NO CONTINUITY TO METAL CASE



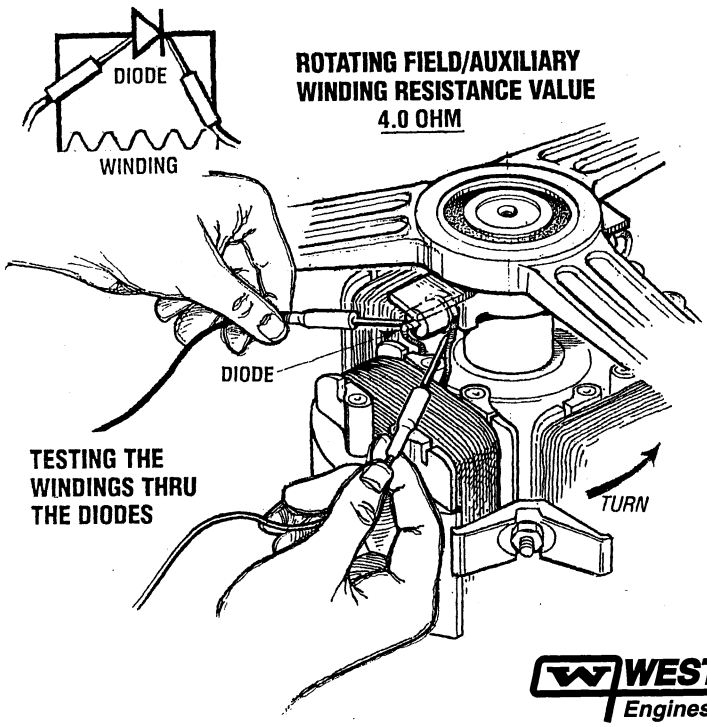
TESTING THE BC ROTOR



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

TESTING THE WINDINGS THROUGH THE DIODES

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

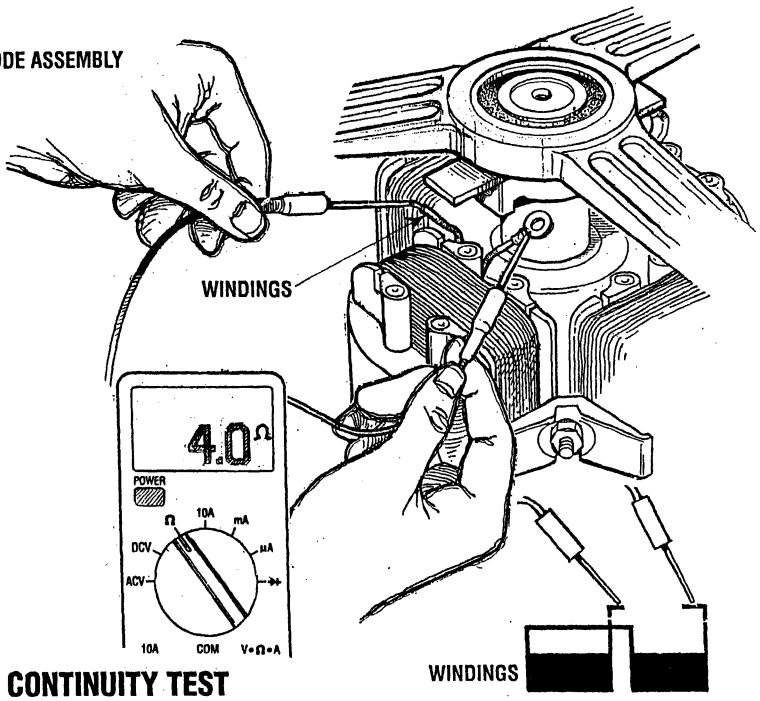


TESTING THE ROTOR FIELD WINDINGS

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

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

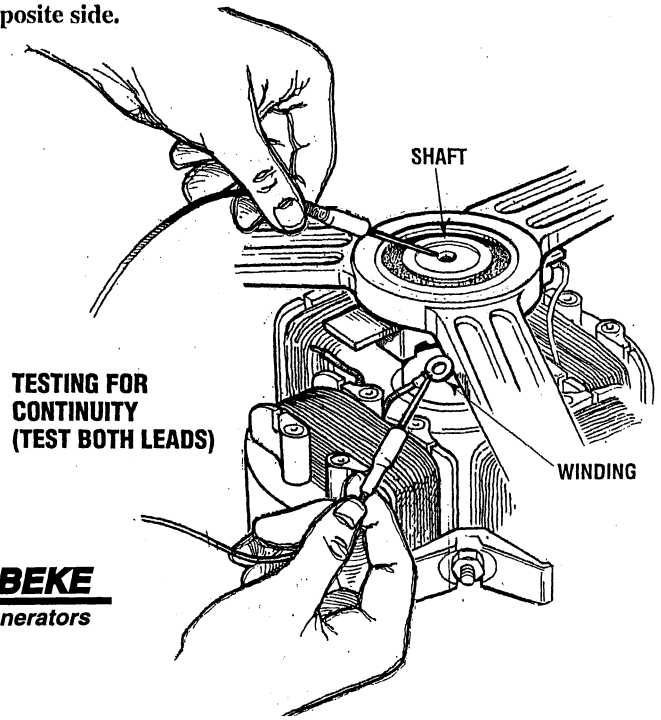
Check the resistance value of the rotating windings by placing an ohmmeter's probes across the two exposed leads.



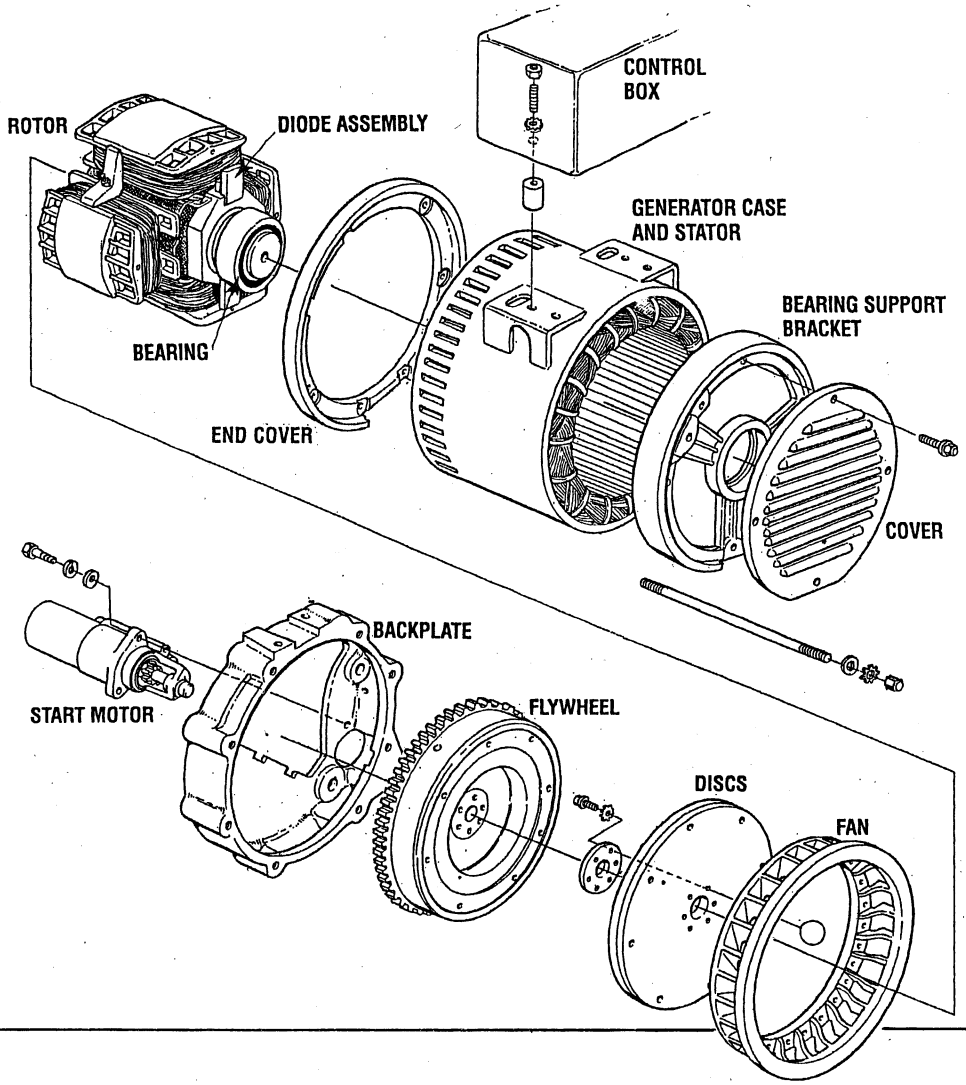
CONTINUITY TEST

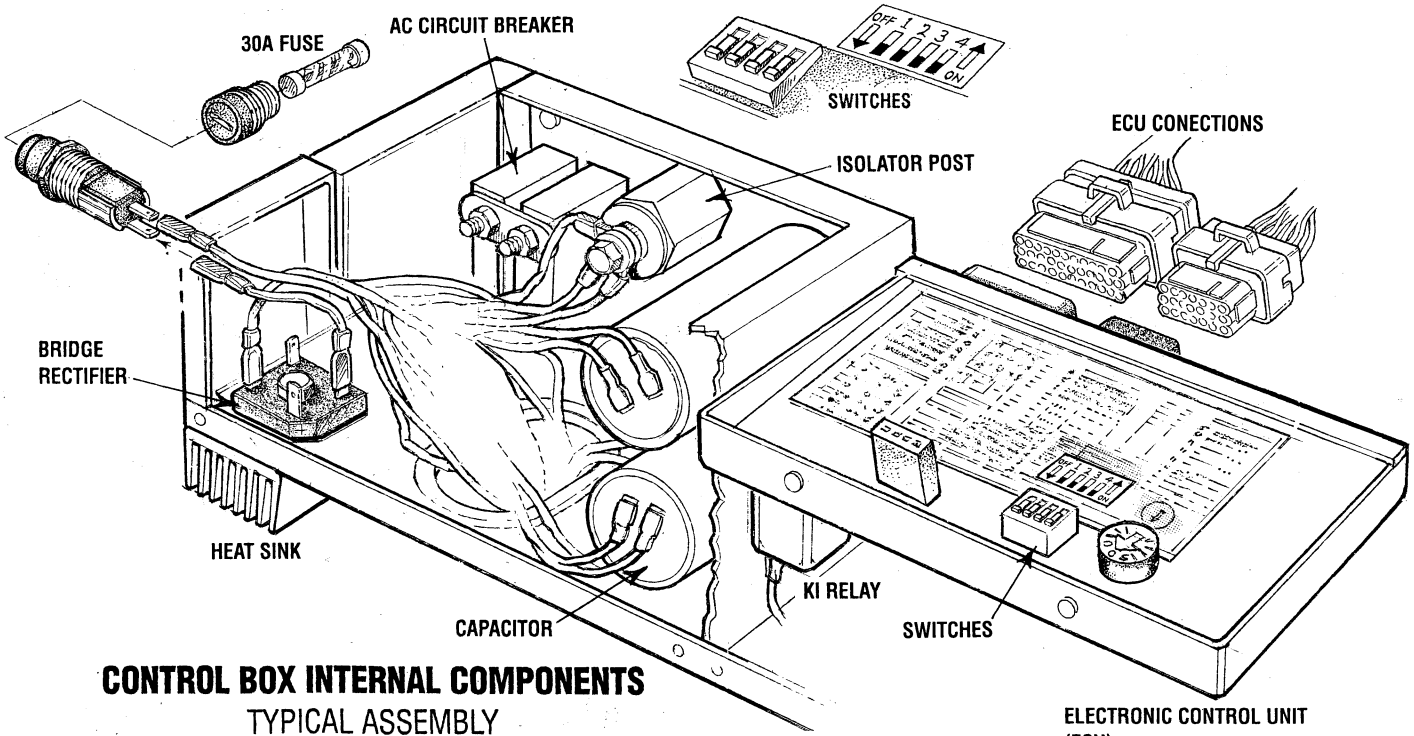
Check that no continuity exists between either of the winding leads and the generator shaft. If continuity is found, there is a short in the windings.

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



BC GENERATOR COMPONENTS





CONTROL BOX INTERNAL COMPONENTS

TYPICAL ASSEMBLY

INTEGRAL CONTROLLER (I.C.)

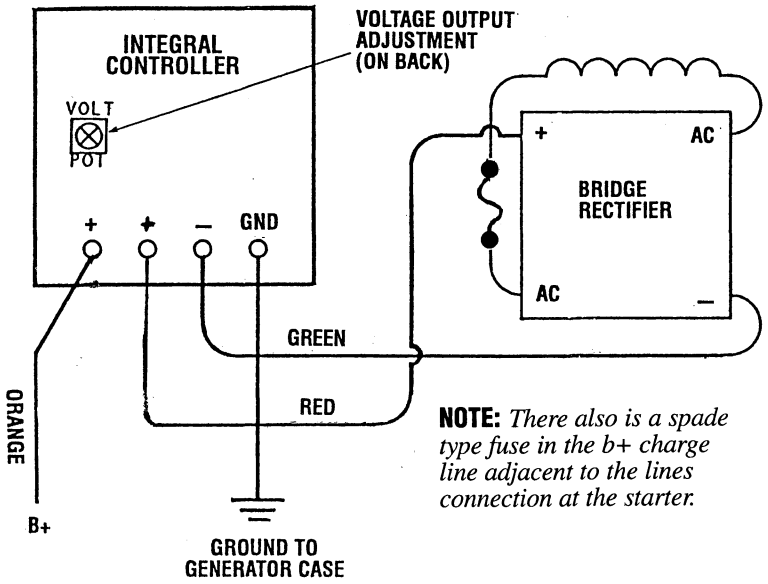
The Integral Controller (I.C.) is an encapsulated, solid-state unit that supplies a DC charging voltage to the generator's starting battery while the generator is opening.

Charging Voltage: 13.0 - 13.40 volts DC
Charging Amperage: .5 - 12.0- amps DC

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

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

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



NOTE: *There also is a spade type fuse in the b+ charge line adjacent to the lines connection at the starter.*

Testing the Battery Charging Circuit

1. **Bridge Rectifier**

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

   AC voltage running to the bridge rectifier (approximate):
   No-load off the generator 16.0 volts AC
   Full-load off the generator 17.5 volts AC

   Normal DC voltage running out of the rectifier (in volts DC) is measured across the two DC connections of the bridge rectifier; that is + and –.

   DC voltage running from the bridge rectifier (approximate):
   No-load off the generator 17.0 volts DC
   Full-load off the generator 18.5 volts DC

2. **AC winding: 0.10 ohm**

   Lift the two AC wire leads off the bridge rectifier and measure, the resistance between these two leads with an ohmmeter. It should measure 0.10 ohm. No continuity should exist between these two leads and the ground or the main AC stator windings.

3. **Testing the Bridge Rectifier** (meter used - Simpson 260)

   a. Set your ohmmeter's scale on RX1 (+ DC) and set the needle to zero.

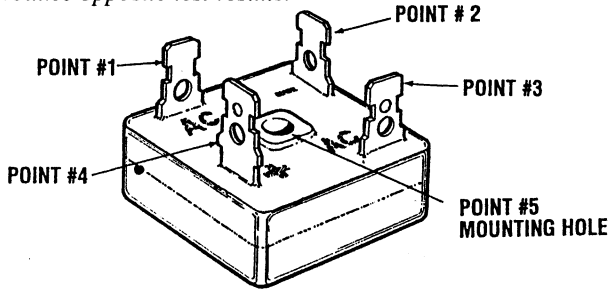
   b. Connect the (+) positive lead from the ohmmeter to point #4. Taking the ohmmeter's negative (–) lead, momentarily touch points #1, #2, #3, and #5. The ohmmeter should register no deflection for any of the points touched.

   c. Remove the positive (+) lead from point #4 and connect the negative (–) lead; momentarily touch points #1, #2, and #3. The ohmmeter's needle should deflect when each point is touched.

   d. Leaving the negative ohmmeter (–) lead on point #4, touch point #5 with the positive lead. No deflection should take place.

   e. Place the positive (+) lead on point #1 and the negative (–) lead on point #3. The ohmmeter again should not register any deflection (no deflection indicated infinite resistance). Reverse these connections and the ohmmeter should again register no deflection. If the rectifier fails any of the previous tests (A-E), replace the rectifier because it is defective.

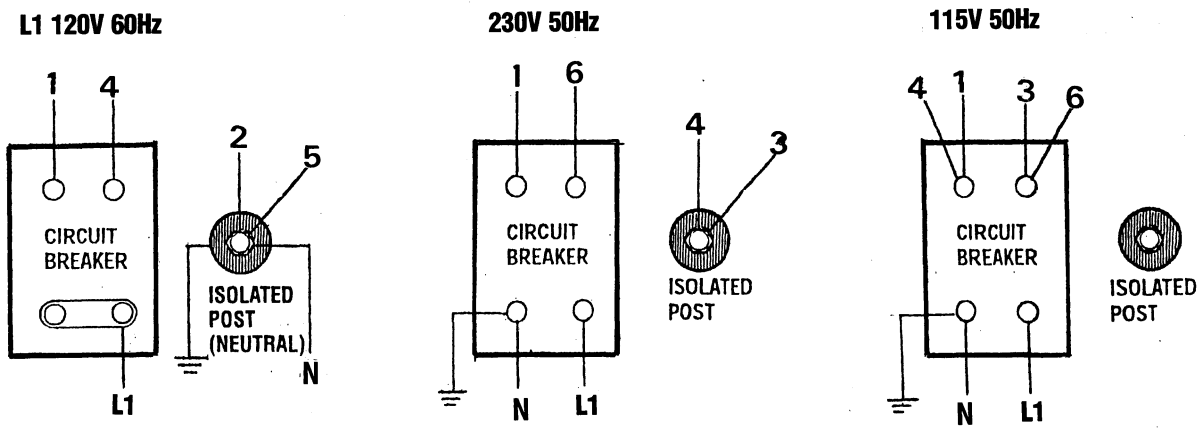
NOTE: *Different types and/or brands of test meters may produce opposite test results.*



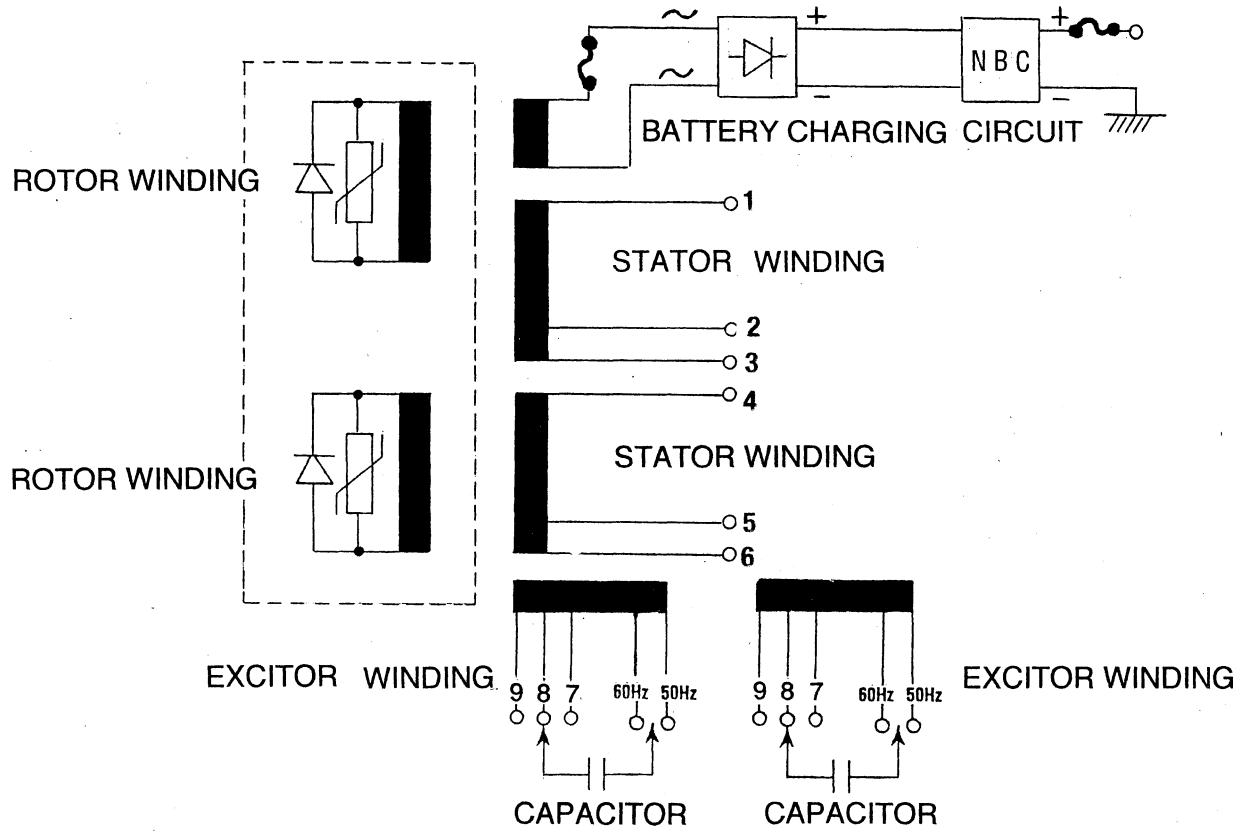
BRIDGE RECTIFIER

AC TERMINAL CONNECTIONS

NOTE: *Correctly position the case ground wire (white/green) onto the neutral/ground terminal.*



SBCG GENERATOR WINDINGS SCHEMATIC



SPECIAL TOOLS - GENERATOR

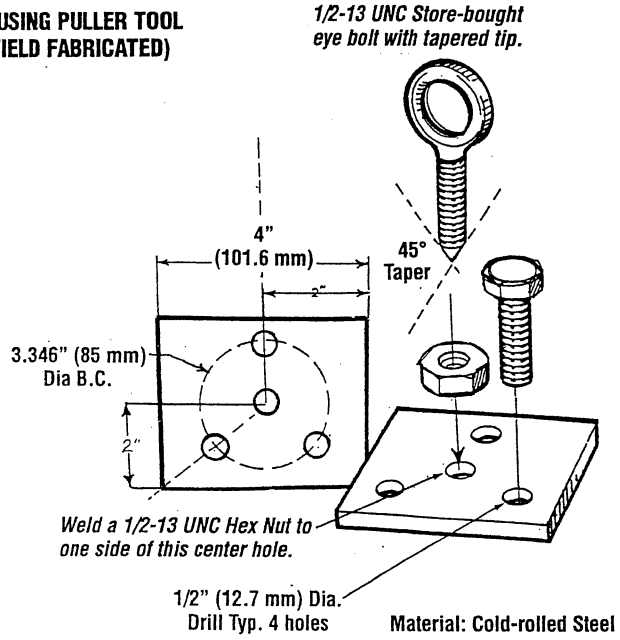
FIELD FABRICATED TOOLS

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

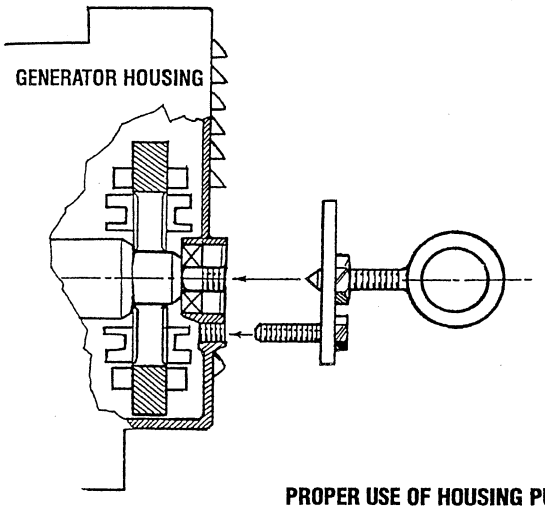
Housing Puller Tool

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

HOUSING PULLER TOOL (FIELD FABRICATED)



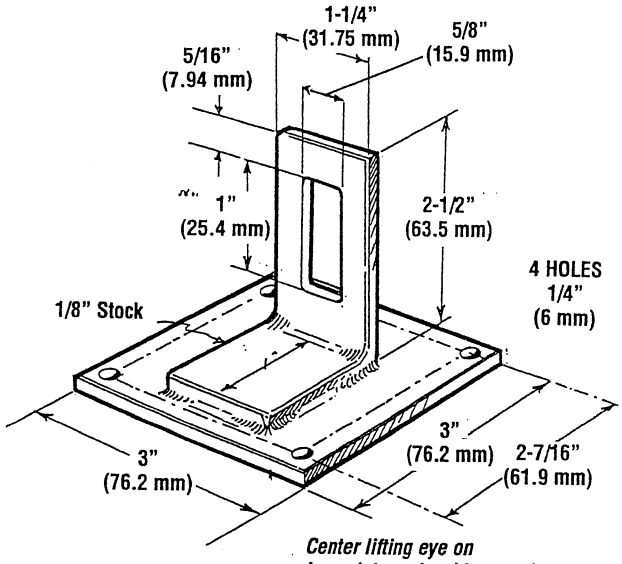
Material: Cold-rolled Steel



PROPER USE OF HOUSING PULLER

Lifting Eye Tool

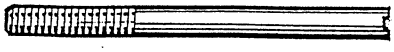
This tool allows a mechanic to safely remove the generator end from the engine by attaching this Generator End Lifting Eye to the four screw holes located under the control panel. To use this Lifting Eye, remove the generator's control panel and screw the Lifting Eye to the generator end.



Center lifting eye on baseplate and weld securely.

Disk Alignment Tool

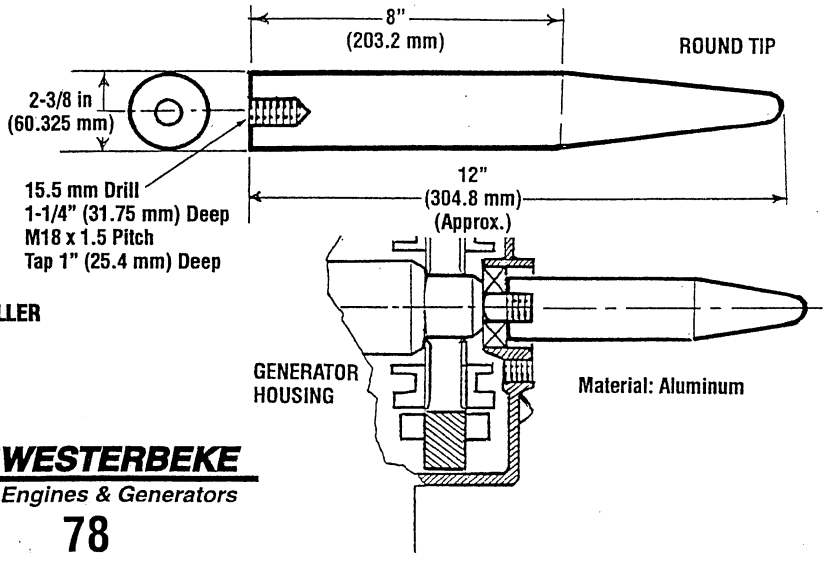
This tool allows a mechanic to safely remove and install the generator drive disks by aligning the disks with the Drive Plate Guide Pin. The Pin screws into the flywheel and acts as a guide. Also the pin helps to support some of the rotor and the drive plate's weight while removing or replacing these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



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

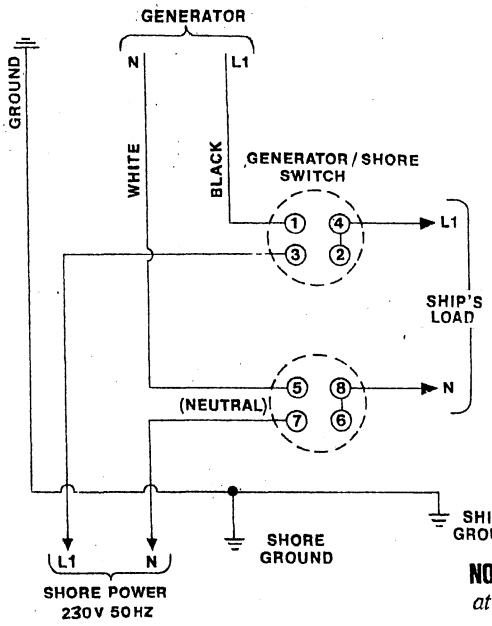
Pilot Tool

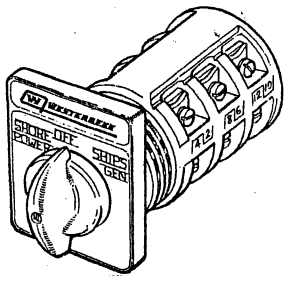
Screwed into the end of the rotor shaft, this tool can be used to pull the stator assembly away from the engine without damaging the stator windings. This tool can be used at reassembly.



SHORE POWER TRANSFER SWITCH

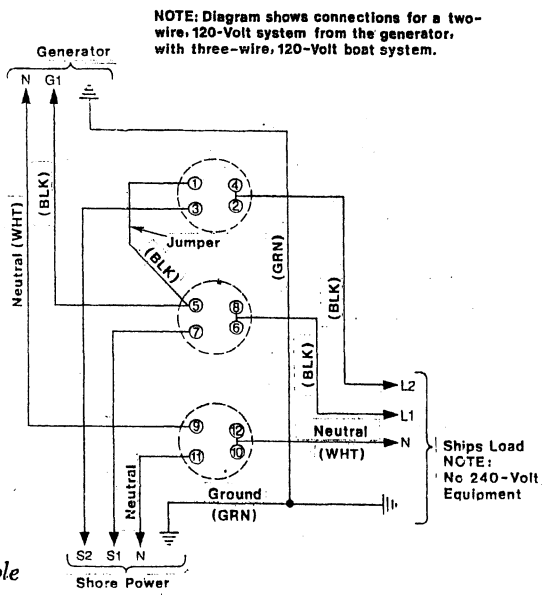
GENERATOR HERTZ CONVERSION LOW PROFILE GASOLINE GENERATOR MODELS





Ship-to-Shore Switch (3 Pole)
PN 32008
(40 Amps/Pole)
PN 32009
(80 Amps/Pole)
PN 32010
(125 Amps/Pole)
PN 32133
(200 Amps/Pole)

NOTE: *Ship to shore switches are available at your WESTERBEKE dealer.*



230 VOLT/50 HZ TWO WIRE CONFIGURATION

Switching Shore Power to Generator Power

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

1. Reconfigure the AC stator output leds to the voltage configuration/hertz desired. Reference previous page illustrating these connections and others.

   NOTE: *Ensure the case ground wire (white/green) is correctly positioned.*
2. The DC battery charge circuit. Place the correct hertz connection on the AC terminal of the charge circuit bridge rectifier.
3. The Exciter circuit capacitors. Place the corresponding hertz connection on one terminal of each capacitor
4. Shut off the 20 amp DC breaker on the panel box and move the hertz dipswitch 31 on the ECU (Electronic Control Unit) in the panel box to the corresponding position for the hertz desired. **ON for 50 hertz, OFF for 60 Hertz.** Dipswitches 2, 3, and 4 have no functions.
5. Install the correct amperage rated AC circuit breaker.
6. Shut off the AC circuit breaker and start the unit. Monitor the AC voltage output and hertz with your meter. Turn **ON** the AC circuit breaker and load the generator and monitor operation.

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

120 VOLT/60 HZ THREE WIRE CONFIGURATION

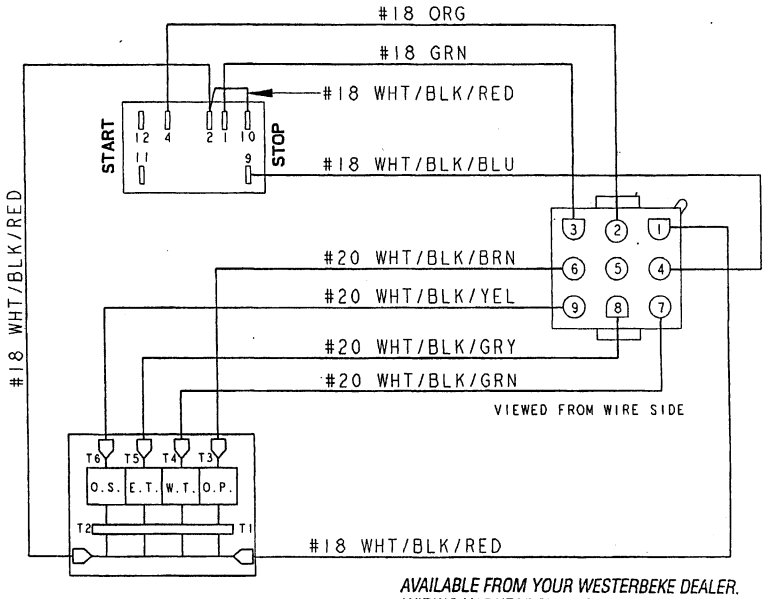
1. Reconfigure the AC stator output leads to the voltage configuration/hertz desired. Reference the configure illustrations elsewhere in this manual.

   NOTE: *Ensure the case ground wire (white/green) off the Neutral is correctly positioned.*
2. Install the correct rated AC circuit breaker and connect the AC output leads correctly to it.
3. The DC battery charge circuit. Place the correct hertz connection on the AC terminal of the charge circuit bridge rectifier.
4. The Exciter circuit capacitor(s). Place the corresponding hertz connection on one terminal of each capacitor(s).
5. Install the correct Overspeed PC Board corresponding to the hertz operation.
6. Open the AC circuit breaker. Start the engine and adjust engine speed using the speed adjustment buttons on the Electronic Governors Control Board to the hertz desired. Check AC output voltage between Line and Neutral. Adjust No-Load AC output voltage if needed using capacitor taps #7, #8, or #9.

   NOTE: *Stop unit when changing taps.*
7. Close AC circuit breaker, start unit and monitor AC voltage and load test unit.
8. Test Overspeed PC Board by turning OFF the AVC breaker and manually operating throttle to bring engine speed up. Overspeed should shut unit down when 8-10 hertz rise in speed is reached.

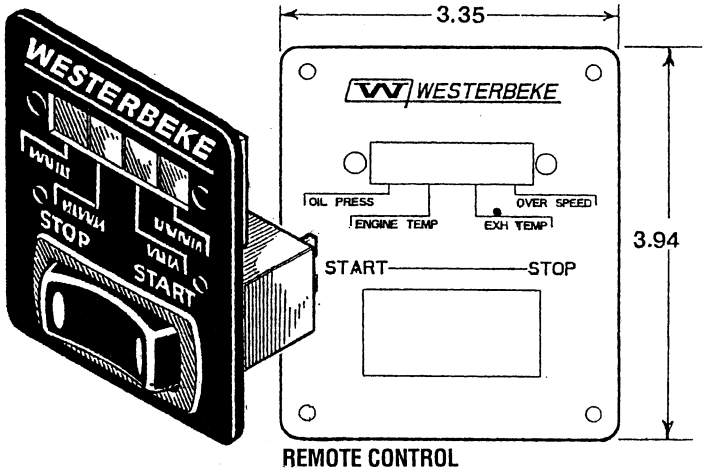
⚠ CAUTION: ***Heavy motor leads should be shut off before switching shore power to generator power or vice-versa because voltage surges induced by switching with heavy AC loads on the vessel being operated may cause damage to the exciter circuit components in the generator.***

REMOTE START/STOP PANEL WIRING DIAGRAM
SCHEMATIC #49209



AVAILABLE FROM YOUR WESTERBEKE DEALER.
WIRING HARNESS EXTENSIONS:

15 FT. PART NO. 49210
30 FT. PART NO. 49211
50 FT. PART NO. 49667
75 FT. PART NO. 49668
100 FT. PART NO. 49669



REMOTE CONTROL PANEL PN.049148

5.0KW and 6.5KW SBCG GENERATOR SPECIFICATIONS

ENGINE SPECIFICATIONS

Engine Type	3-cylinder, 4-cycle, , overhead camshaft w/counterbalance shaft, water cooled gasoline engine
Bore & Stroke	2.56 x 2.61 inches (65.0 x 66.3 mm)
Total Displacement	40.3 cubic inches (0.66 liters)
Bearings	Four main bearings
Compression Chamber	Semi-spherical
Compression Ratio	9.8:1
Hp@1800/1500 rpm	10.0
Firing Order	1 - 3 - 2
Aspiration	Naturally aspirated
Direction of Rotation	Counterclockwise viewed from the back end
Inclination	25° continuous, all directions
Dry weight	381 lbs (172.8 Kgs)
Governor	Electronic

FUEL SYSTEM

General	Throttle body fuel injection
Fuel	Unleaded gasoline with an octane rating of 89 or higher
Fuel Consumption (full load) **5.0/5.4 SBCG**	.7 GPH @ 1800 rpm .6 GPH @ 1500 rpm
Fuel Consumption (full load) **5.0/4.2 SBCG**	.6 GPH @ 1800 rpm .5 GPH @ 1500 rpm
Fuel Hose Size (supply and return)	1/4" I.D. minimum - 3/8" I.D. maximum
Fuel Pump	12 volt electric (high pressure)
Fuel Filter (on engine)	Replaceable cartridge-canister type
Air Cleaner (flame arrester)	Metal screen type - cleanable

ELECTRICAL SYSTEM

Start Battery	12 Volt, (-) negative ground Battery must be totally dedicated to the generator and maintained only by the DC charge controller system in the AC generator
Starting Capacity	800-1000 Cold Cranking Amps (CCA) (minimum)
Starter	120 Volt, reduction-solenoid mounted
DC Charging	Solid state controller, 12 amp rated
DC Cold Cranking Amps	150-176 amps

AIR REQUIREMENTS

Generator Cooling	225 -250 CFM (6.3 - 7.0 cmm)
Engine Combustion (all models)	21 CFM (0.6 cmm)
Engine Cooling	100 CFM (2.8 cmm)

NOTE: *Forced ventilation should be provided to maintain the generators compartment temperature below 122° F (50° C)*

COOLING SYSTEM

General	Fresh water-cooled block through raw water-cooled heat exchanger circuit
Fresh Water Pump	Centrifugal type, metal impeller, belt-driven.
Raw Water Pump	Positive displacement, rubber impeller, belt-driven.
Raw Water Flow,	4.9 US gpm (18.5 liters) @ 1800 rpm (approx. measure before discharging into exhaust elbow).
Cooling Water Capacity	3.5 qts (3.3 liters).
Operating Temperature	170° - 190° F (77 - 887° C)

LUBRICATION SYSTEM

General	Forced lubrication by gear pump.
Oil Filter	Full flow, paper element. spin-on disposals.
Oil Capacity	3.0 qts. (2.8 liters).
Operating Oil Pressure	30 - 50 psi (2.1 - 3.5 kg/cm^2).
Oil Grade	API Specification SJ,SL or SM class

AC GENERATOR (Single Phase)

Single Phase	Brushless, four-pole capacitor, regulated. 1800 rpm/60Hz, 1500 rpm/50Hz
Ratings: **5.0KW** **4.2KW**	 120 volts, 41.6 amps 230 volts, 18.2 amps
6.5KW **5.4KW**	120 volts, 54.1 amps 230 volts, 23.4 amps

TUNE-UP SPECIFICATIONS

Spark Plugs	14mm
Ignition Coil	12 volt
Distributor	Breakerless with ignitor and pick-up assembly
Spark plug Gap	0.031 ± .002 inches (0.8 ± 0.05mm)
Spark Plug Torque	10.8 - 15.2 lb-ft
Cylinder Head Torque	60-70 Nm (43-51 ft-lbs)
Bolt Torque	See *TORQUING THE CYLINDER HEAD*

IGNITION SYSTEM

General	Battery Ignition 12 volts negative ground. Distributor with ignition module and ignitor. Ignition coil and spark plugs
Distributor	Solid state type with signal generator and ignitor
Spark Plug Thread Gap	11mm x 1.25 pitch
Spark Plug Gap	0.028 - 0.031 inches (0.7 - 0.8mm_
Ignition Timing	15° BTDC at 1800 RPM ±1°

DECIMAL TO METRIC EQUIVALENT CHART

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

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^3) x 16.387 = Cubic Centimeters x .061 = in^3
Imperial Pints (IMP pt) x .568 = Liters (L) x 1.76 = IMP pt
Imperial Quarts (IMP qt) x 1.137 = Liters (L) x.88 = IMP qt
Imperial Gallons (IMP gal) x 4.546 = Liters (L) x .22 = IMP gal
Imperial Quarts (IMP qt) x 1.201 = US Quarts (US qt) x .833 = IMP qt
Imperial Gallons (IMP gal) x 1.201 = US Gallons (US gal) x .833 = IMP gal
Fluid Ounces x 29.573 = Milliliters x .034 = Ounces
US Pints (US pt) x .473 = Liters(L) x 2.113 = Pints
US Quarts (US qt) x .946 = Liters (L) x 1.057 = Quarts
US Gallons (US gal) x 3.785 = Liters (L) x .264 = Gallons

MASS-WEIGHT

Ounces (oz) x 28.35 = Grams (g) x .035 = Ounces
Pounds (lb) x .454 = Kilograms (kg) x 2.205 = Pounds

PRESSURE

Pounds Per Sq In (psi) x 6.895 = Kilopascals (kPa) x .145 = psi
Inches of Mercury (Hg) x .4912 = psi x 2.036 = Hg
Inches of Mercury (Hg) x 3.377 = Kilopascals (kPa) x .2961 = Hg
Inches of Water (H_2O) x .07355 = Inches of Mercury x 13.783 = H_2O
Inches of Water (H_2O) x .03613 = psi x 27.684 = H_2O
Inches of Water (H_2O) x .248 = Kilopascals (kPa) x 4.026 = H_2O

TORQUE

Pounds-Force Inches (in-lb) x .113 = Newton Meters (Nm) x 8.85 =in-lb
Pounds-Force Feet (ft-lb) x 1.356 = Newton Meters (Nm) x .738 = ft-lb

VELOCITY

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

POWER

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

FUEL CONSUMPTION

Miles Per Hour IMP (MPG) x .354 = Kilometers Per Liter (Km/L)
Kilometers Per Liter (Km/L) x 2.352 = IMP MPG
Miles Per Gallons US (MPG) x .425 = Kilometers Per Liter (Km/L)
Kilometers Per Liter (Km/L) x 2.352 = US MPG

TEMPERATURE

Degree Fahrenheit (°F) = (°C X 1.8) + 32
Degree Celsius (°C) = (°F - 32) x .56

LIQUID WEIGHTS

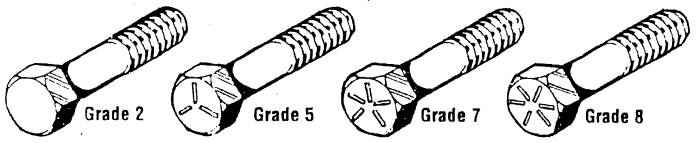
Diesel Oil = 1 US gallon = 7.13 lbs
Fresh Water = 1 US gallon = 8.33 lbs
Gasoline = 1 US gallon = 6.1 lbs
Salt Water = 1 US gallon = 8.56 lbs

STANDARD HARDWARE

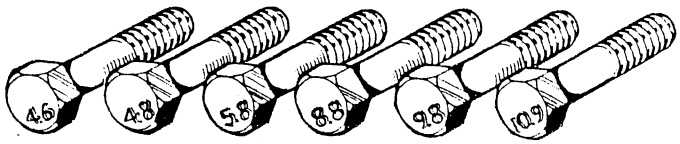
BOLT HEAD MARKINGS

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

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



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



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

STANDARD BOLT & NUT TORQUE SPECIFICATIONS

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

METRIC BOLT & NUT TORQUE SPECIFICATIONS

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

SEALANTS & LUBRICANTS

GASKETS/SEALANTS

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

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

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

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

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

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

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

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

BOLTS & FASTENERS/ASSEMBLIES

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

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

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

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

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

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