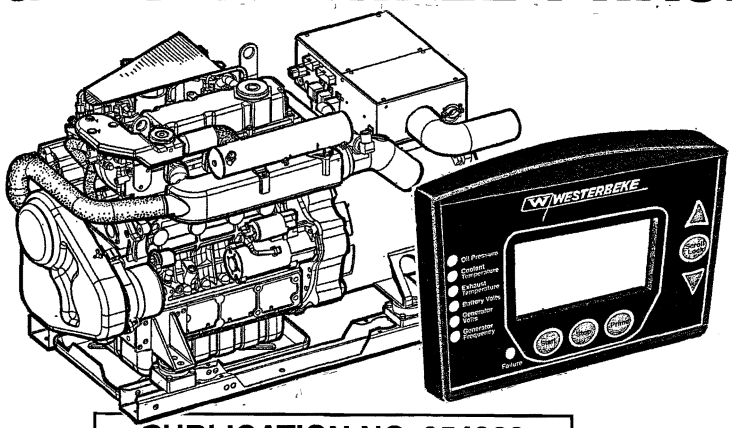
SERVICE MANUAL

D-NET DIESEL GENERATORS

22.0KW EDE
17.0KW EDE
at 60 Hertz

17.0KW EDE
13.5KW EDE
at 50 Hertz

SINGLE AND THREE PHASE



PUBLICATION NO. 054369
FIRST EDITION
JULY 2008

WESTERBEKE

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⚠ WARNING

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

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

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

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

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

CALIFORNIA PROPOSITION 65 WARNING

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

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SERIAL NUMBER LOCATION

The engine's model number and serial number are located on a nameplate mounted on the side of the engine's manifold. The engine's serial number can also be found stamped into the engine block on the flat surface of the block just above and inboard of the injection pump.

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

An identification plate on the top of the engine air intake also displays the engine model and serial number.

NOTE: *Use the two name plates above to write in the data from your engine while it is accessable. In years to come it will always be available in your manual.*

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, in the case of diesel engines, is not necessarily due to trouble with the engine itself, but is sometimes caused by injector nozzle wear or injection pump wear. It is most reasonable to judge by a decrease in compression pressure. 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 excessive fuel injection, improper injection timing, and wear of plugs and nozzles. They are caused also by defective electrical devices such as the battery, alternator, starter and glow 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. In diesel engines, 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 reaches the repair limit, the engine must be overhauled. The engine requires overhaul when oil consumption is high, blowby evident, and compression valves are at minimum or below. **Engine compression should be 512 to 583 psi/36 to 41 kgf/cm² @290 rpm (difference between cylinders must not exceed 10%).**

Precautions for Disassembly and Reassembly

When servicing an engine, keep in mind the following precautions.

Disassembly

1. Before disassembly and cleaning, carefully check for defects which cannot be found after disassembly and cleaning.
2. Drain water, fuel and oil before disassembly.
3. Clean or wash the engine exterior.
4. Do not remove or disassemble parts that do not require disassembly.
5. 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.

Reassembly

1. Carefully check gaskets, packings and oil seals even if checking is not specified. Replace with new ones if defective.
2. Be sure to install components in proper directions and positions. (Pay attention to dowel pins, mating marks and specified directions.) Where tightening torque is not specified, tighten evenly to an ordinary torque. Apply sealant where specified.
3. After completion of reassembly, recheck for any abnormalities. Prepare for starting the engine, and idle the engine sufficiently for a test run.

PRECAUTIONS

- 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, etc.
- Tighten the bolts and nuts on important parts of engine to specified torques using a reliable torque wrench.
- Use liquid sealants when required on nuts, bolts and gaskets. Refrain from using tape sealants.

ENGINE TROUBLESHOOTING

The following troubleshooting chart describes certain problems relating to engine service, the probable causes of these problems, and the recommendations to overcome these problems.This chart may be of assistance in determining the need for an engine overhaul.

PROBLEM	PROBABLE CAUSE	VERIFICATION/REMEDY
HARD STARTING	**LOW CRANKING SPEED**	
	1. Engine oil viscosity too high.	1. Replace engine oil with less viscous oil.
	2. Run-down battery.	2. Recharge battery.
	3. Worn battery.	3. Replace battery.
	4. Battery terminals loosely connected.	4. Clean terminals and correct cables.
	5. Defective starter.	5. Repair or replace starter.
	6. Defective main drive section.	6. Check clutch for disengagement.
	DEFECTIVE INJECTION SYSTEM	
	1. Air trapped in fuel passage.	1. Bleed air from fuel system.
	2. Clogged fuel filter.	2. Clean or replace filter.
	3. Low injection pressure.	3. Adjust injection pressure.
	4. Inadequate spray.	4. Clean or replace nozzle.
	5. Injection pump delivering insufficient fuel.	5. Repair or replace injection pump.
	6. Injection too early.	6. Adjust injection timing.
	MAIN ENGINE TROUBLES	
	1. Low compression.	
	a. Incorrect valve clearance.	a. Adjust valve clearance.
	b. Inadequate contact of valve seat.	b. Lap valve.
	c. Valve stem seized.	c. Replace valve and valve guide.
	d. Broken valve spring.	d. Replace valve spring.
	e. Compression leaks through cylinder head gasket.	e. Replace gasket.
	f. Piston ring seized.	f. Replace piston and piston ring.
	g. Worn piston ring and cylinder.	g. Overhaul engine.
	2. Burnt glow plug.	2. Replace glow plug.
	3. Faulty glow plug operation.	3. Correct lead wire connection.
	4. Incorrect governor lever position.	4. Set lever to starting position.
	5. Governor spring out of POSITION	5. Correct spring
LOW OUTPUT	**LOW COMPRESSION**	**See *HARD STARTING***
	INJECTION SYSTEM OUT OF ADJUSTMENT	
	1. Incorrect injection timing.	1. Adjust injection timing.
	2. Insufficient injection.	2. Repair or replace injection pump.
	3. Low injection pressure.	3. Check injection nozzle and adjust pressure.
	INSUFFICIENT FUEL	
	1. Air trapped in fuel system.	1. Check and retighten connector.
	2. Clogged filter.	2. Clean or replace filter.
	3. Contaminated fuel tank.	3. Clean tank.
	INSUFFICIENT INTAKE AIR	
	1. Clogged air cleaner.	1. Clean or replace air cleaner.

(continued)

ENGINE TROUBLESHOOTING

PROBLEM	PROBABLE CAUSE	VERIFICATION/REMEDY
LOW OUTPUT *(cont.)*	**OVERHEATING**	
	1. Low coolant level.	1. Add coolant.
	2. Loose V-belt.	2. Adjust or replace V-belt.
	3. Incorrect injection timing.	3. Adjust injection timing.
	4. Low engine oil level.	6. Add engine oil.
EXCESSIVE OIL CONSUMPTION	**OIL LEAKAGE**	
	1. Defective oil seals.	1. Replace oil seals.
	2. Broken gear case gasket.	2. Replace gasket.
	3. Loose gear case attaching bolts.	3. Retighten bolts.
	4. Loose drain plug.	4. Retighten plug.
	5. Loose oil pipe connector.	5. Retighten oil connections.
	6. Broken rocker cover gasket.	6. Replace gasket.
	7. Loose rocker cover attaching bolts.	7. Retighten attaching bolts.
	OIL LEVEL RISING	
	1. Incorrectly positioned piston ring gaps.	1. Correct ring gap positions.
	2. Displaced or twisted connecting rod.	2. Replace connecting rod.
	3. Worn piston ring.	3. Replace ring.
	4. Worn piston or cylinder.	4. Replace piston and rebore cylinder.
	OIL LEVEL FALLING	
	1. Defective stem seal.	1. Replace stem seal.
	2. Worn valve and valve guide.	4. Replace a valve and valve guide.
EXCESSIVE FUEL CONSUMPTION	**ENGINE BODY TROUBLES**	
	1. Noisy knocking.	1. See *KNOCKING.*
	2. Smoky exhaust.	2. See *SMOKY EXHAUST.*
	3. Moving parts nearly seized or excessively worn.	3. Repair or replace.
	4. Poor compression.	4. See *LOW COMPRESSION; HARD STARTING.*
	5. Improper valve timing.	5. Adjust.
	6. Improper valve clearance.	6. Adjust.
	INSUFFICIENT INTAKE AIR	
	1. Air intake obstructed.	1. Remove obstruction.
	NOZZLE TROUBLES	
	1. Seized nozzle.	1. Replace.
	2. Worn nozzle.	2. Replace.
	IMPROPER FUEL	Replace with proper fuel.
	FUEL LEAKS	Find fuel leaks.
SMOKY EXHAUST	**WHITISH OR PURPLISH**	
	1. Excessive engine oil.	1. Correct oil level.
	2. Excessive rise of oil into combustion chamber.	
	a. Poor piston contact.	a. Check.
	b. Seized piston ring.	b. Replace or clean.
	c. Excessive piston-to-cylinder clearance.	c. Replace or correct.

(continued)

ENGINE TROUBLESHOOTING

PROBLEM	PROBABLE CAUSE
Low oil pressure.	1. Low oil level. 2. Wrong SAE type oil in the engine. 3. Faulty or 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.
No DC charge to the starting battery.	1. Loose/corroded battery charge circuit connection(s). 2. Faulty alternator regulator. 3. Faulty DC alternator. 4. Slipping alternator drive belt. 5. Broken alternator drive belt.

PROBLEM	PROBABLE CAUSE
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 pump clogged. Remove and replace. 2. Throttle body filter screen dirty. 3. Fuel filter contaminated.

DISASSEMBLY PROCEDURES

GENERATOR

PISTON

The piston's skirt is coated with molybdenum disulfied, which reduces the piston slap noise and the entire operating noise. This serves as a solid lubricant, like graphite or teflon and helps resist metal wear even with little lube oil.

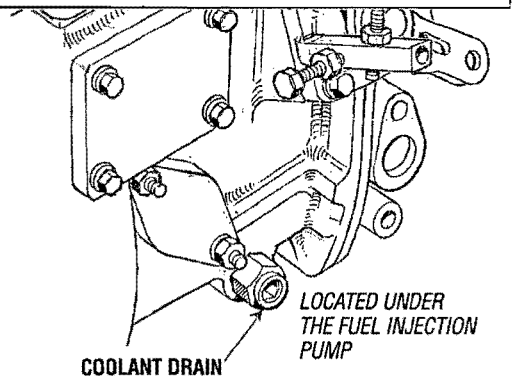
DYNAMIC BALANCER

An engine will vibrate due to piston reciprocation. Three-cylinder engines are much less prone to cause vibration than a four-cylinder engine (second inertia). However, every engine has many moving parts in addition to its pistons and cannot be completely free from vibration. These engines are fitted with two balancers to absorb the second inertia and reduce vibration. One is on the intake side and the other is at the exhaust side.

DRAINING THE COOLANT

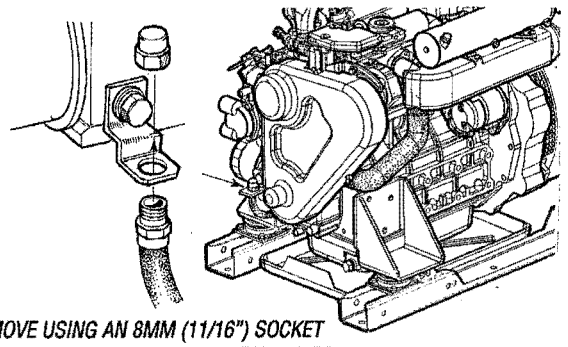
Drain the coolant by removing the coolant drain plug on the engine block. Also remove the manifold pressure cap and open both drain plugs on the heat exchanger.

> ⚠ **WARNING:** ***Beware of the hot engine coolant. Wear protective gloves.***



DRAINING THE OIL

Drain the oil using the sump drain hose attached to the front of the engine. The oil can also be pumped up thru the dipstick hole.



REMOVE USING AN 8MM (11/16") SOCKET TO DRAIN THE OIL OR PUMP THE WARMED OIL UP THRU THE HOSE.

Always observe the used oil as it is removed. A yellow/gray emulsion indicates the presence of water in the oil. Although this condition is rare, it does require prompt attention to prevent serious damage. Call a qualified mechanic should water be present in the oil. Raw water present in the oil can be the result of a fault in the exhaust system attached to the engine and/or a siphoning of raw water through the raw water cooling circuit into the exhaust, filling the engine. This problem is often caused by the absence of an anti-siphon valve, its poor location or lack of maintenance.

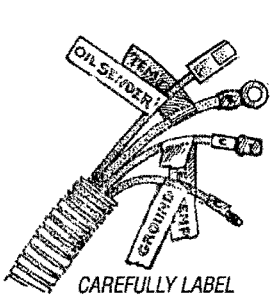
PREPARATION FOR DISASSEMBLY

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

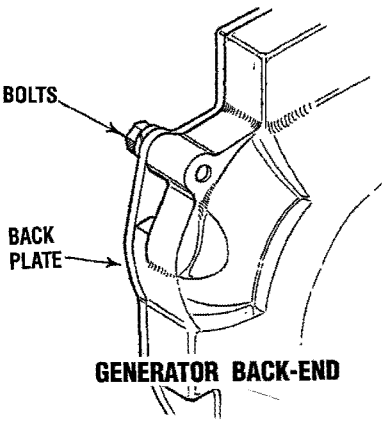
DISASSEMBLY

With the engine securely mounted on an engine stand, begin disassembling the engine in a logical order. When removing electrical components (alternator, start motor, etc) carefully label the cables and wires.

With the exterior components removed, use the detailed instructions in this manual to disassemble/assemble the main engine.



CAREFULLY LABEL TERMINAL CONNECTIONS AND CABLES



GENERATOR BACK-END

ASSEMBLY PROCEDURES

GENERAL INFORMATION

Surface Preparation

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

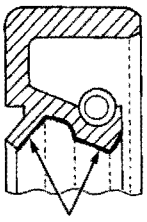
ASSEMBLY

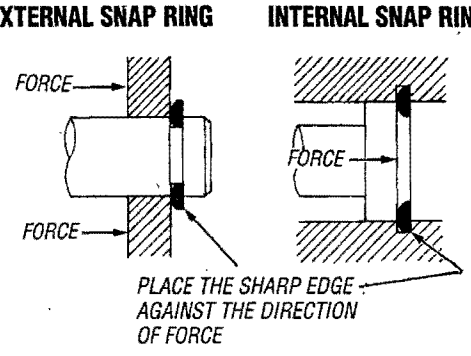
- Wash all parts, except for oil seals, O-rings, rubber sheets, etc. with cleaning solvent and dry them with air pressure.
- Always use tools that are in good condition and be sure you understand how to use them before performing any job.
- Use only good quality lubricants. Be sure to apply a coat of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

GASKET INFORMATION

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

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





When reassembling external or internal snap rings, position them so that the sharp edge faces against the direction from which force is applied.

ALTERNATOR INSPECTION

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

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

Depending on when the alternator was last serviced, the brushes may need replacing. If the alternator is at all suspect, send it to a service shop for testing and overhaul, or refer to the more detailed alternator section in this manual.

ASSEMBLY INSTRUCTIONS

Be aware of these common problems that can occur during assembly.

Insufficient Lubrication. Heavily oil sliding and reciprocating parts, lightly oil head bolts and other fasteners, except those that penetrate into the water jacket. These fasteners should be sealed with Permatex No. 2 or the high-tech equivalent.

Reversed orientation. Most gaskets, many bolt washers, and all thermostats are asymmetrical.

Mechanical damage. Run fasteners down in approved torque sequences and 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 also be damaged during assembly, they should be positioned with great care.

ASSEMBLY

NOTE: *The exhaust manifold, which was disassembled from the cylinder head, should be inspected before re-assembly.*

a. **Remove the exhaust elbow from the lower surface of the manifold. Clean and inspect for cracks and defects. Replace as needed.**

b. **Remove the exhaust nipples, elbows and plugs from the manifold and heat exchanger.**

c. **Remove water connectors from the ends of the manifold. Be sure to note the proper location and arrangement of each for proper alignment.**

d. **Examine all parts for defects, corrosion and wear and replace as needed.**

e. **Flush out the coolant recovery tank and clear its hose passage. Set aside to re-install on the boat.**

HEAT EXCHANGER

Install the heat exchanger, replace the heat exchanger zinc and attach new hoses with new clamps to the cooling system. Refer to the *COOLING SECTION* in this manual for *HEAT EXCHANGER* service.

ENGINE TUNING OPERATION

After re-assembly, the engine must be tuned. This will ensure that the engine operates at its maximum efficiency. Fill the engine cooling system with an antifreeze mixture and the engine oil sump with a lube oil API specification of CF, CG-4, CH-4, CZ-4, or SAE 15W-4C.

1. **Mount the engine on a test bench and connect the fuel lines.**
2. **Connect the electrical wiring.** Refer to the *WIRING DIAGRAM*.
3. **Connect the air intake line to the air cleaner.**
4. **Connect the exhaust pipe.**
5. **Crank the engine with the starter (non-ignition operation) for about twenty seconds.** This will pre-lubricate the engines internal components and fill the fuel lines.
6. **Start the engine and allow it to run at a rated rpm for five minutes.**
7. **Remove the cylinder head cover while the engine is running.**
8. **Check that the engine oil continuously circulating from the oil pump to the valve rockers through the cylinder head.**

   If there is no oil circulation or if the oil circulation is sluggish, stop the engine and make the appropriate repairs or adjustment.

   Re-install the cylinder head cover.
9. **Mount the engine on a test bench and connect the fuel lines.**
10. **Check the engine for oil, fuel, coolant and air intake leakage.**
11. **Check for abnormal noise and odor.**
12. **Check for abnormal electrical charging.**
13. **Check the engine fastening parts for looseness.**
14. **When the engine coolant temperature reaches 75°C (167°F) or more, increase the engine speed to 2000 rpm and allow it to run for twenty seconds.**

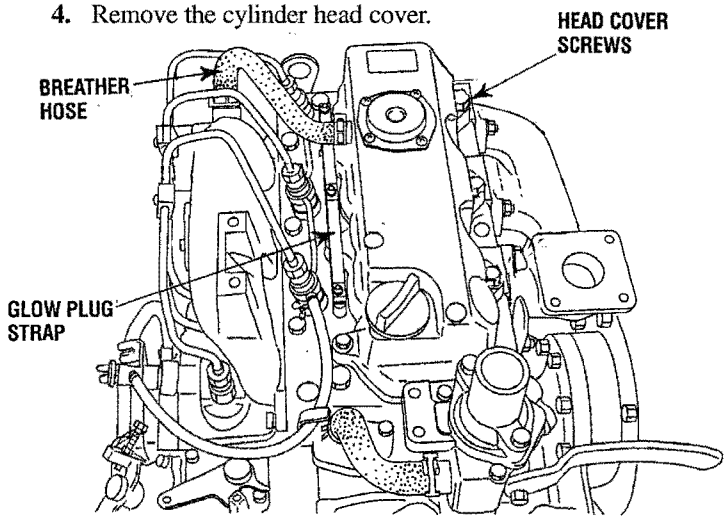
    This will give the engine the essential run-in operating time.
15. **Adjust the engine operation speed to the specific value.**
16. **Stop the engine to complete the tuning procedure.**

Refer to the following pages for details of sub-assemblies. These sections also include: Wiring Diagrams, Engine Specifications, Torque Diagrams, Starter Motor, Alternator and Raw Water Pump.

DISASSEMBLY/ASSEMBLY

CYLINDER HEAD COVER

1. Remove the top of each glow plug and remove the glow plug strap.
2. Remove the breather hose.
3. Remove the head cover bolts.
4. Remove the cylinder head cover.

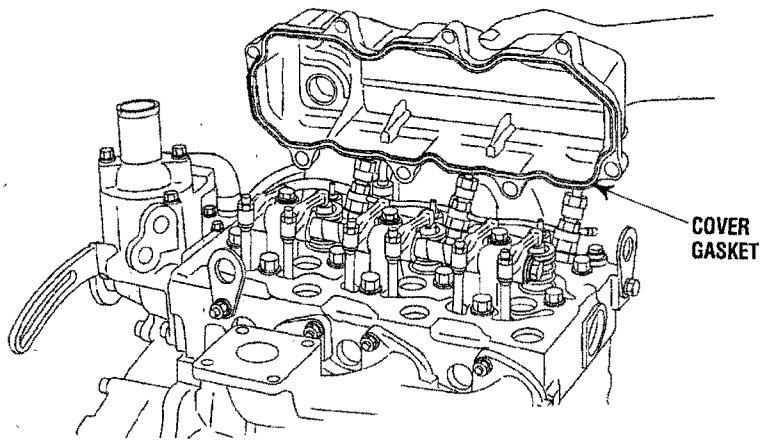


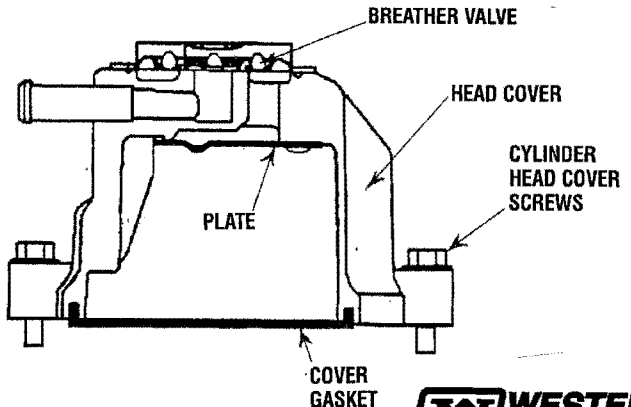
When Reassembling

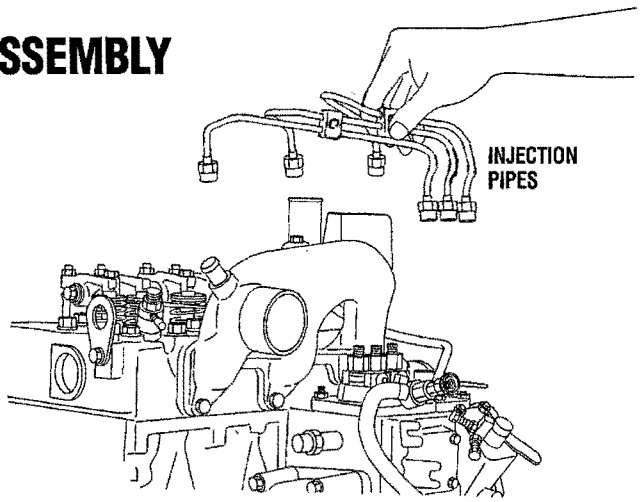
Check to see if the cylinder head cover gasket is not defective.

TIGHTENING TORQUE

CYLINDER HEAD COVER SCREW ____ 6.9 - 11.3 N-m
0.7 - 1.15 Kgf-m
5.1 - 8.32 ft-lbs







INJECTION PIPES

1. Loosen the scerws on the pipe clamps.
2. Detach the injection pipes.

When Reassembling

Blow out dust inside the pipes.

TIGHTENING TORQUE

INJECTION PIPE RETAINING NUT ____ 24.5 - 34.3 N-m
2.5 - 3.5 Kgf-m
18.1 - 25.3 ft-lbs

NOZZLE HOLDER ASSEMBLY AND GLOW PLUG

1. Remove the overflow pipe assembly.
2. Remove the nozzle holder assemblies using a 21mm socket wrench.
3. Remove the copper gasket and heat seal.
4. Remove the glow plugs

When Reassembling

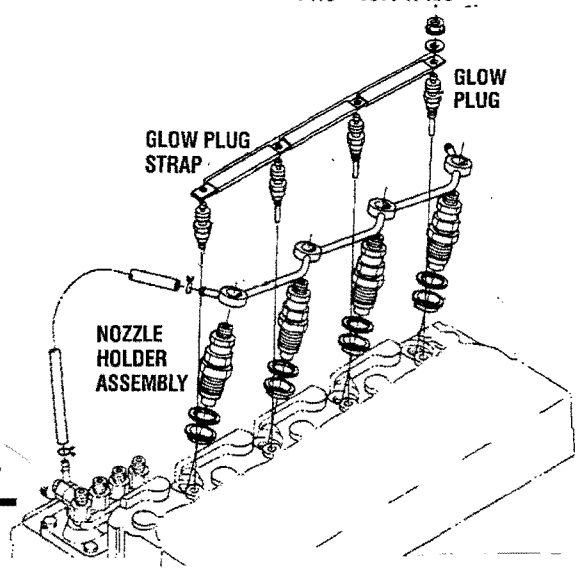
Replace the copper gasket and heat seal with a new one.

TIGHTENING TORQUE

NOZZLE HOLDER ASSEMBLY ____ 49.0 - 68.6 N-m
5.0 - 7.0 Kgf-m
36.2 - 50.6 ft-lbs

OVERFLOW PIPE ASSEMBLY
RETAINING NUT ____ 19.6 - 24.5 N-m
2.0 - 2.5 Kgf-m
14.5 - 18.1 ft-lbs

GLOW PLUG ____ 19.6 - 24.5 N-m
2.0 - 2.5 Kgf-m
14.5 - 18.1 ft-lbs



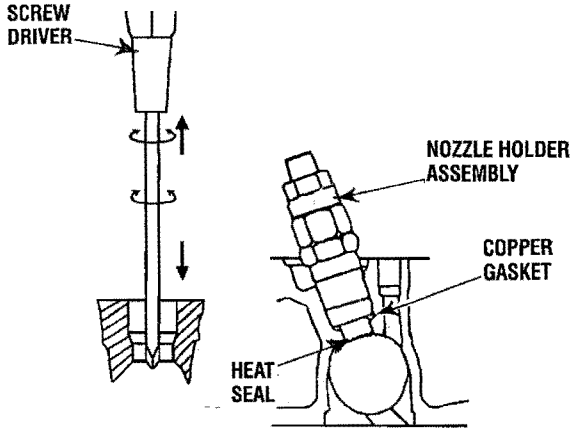
NOZZLE HEAT SEAL REMOVAL PROCEDURE

NOTE: *Use a Phillips head screw driver that has a diameter that is bigger than the seal hole. Approximately 1/4" (6mm)*

1. Place the screw driver lighly into the heat seal hole.
2. Turn the screw driver three or four times each way.
3. While turning, slowly pull the heat seal out together with the copper gasket.
4. If the heat seal drops, repeat the procedure.

When Reassembling

The heat seal and the copper gasket must be changed when the injection nozzle is removed for cleaning or service.



ROCKER ARM AND PUSH ROD

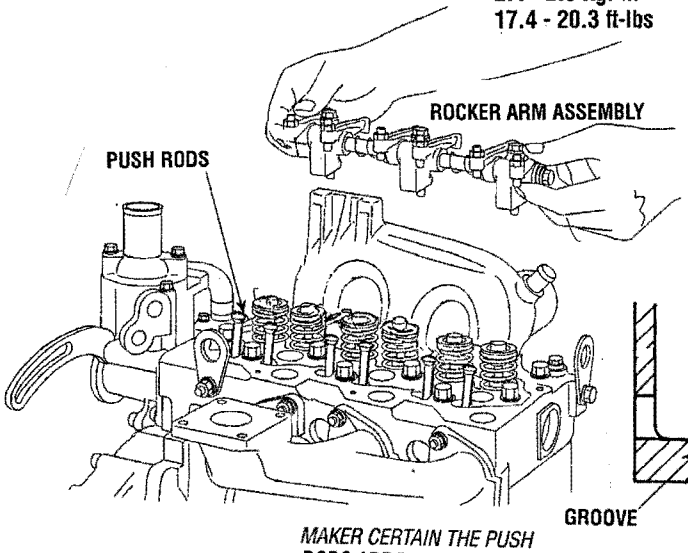
1. Remove the rocker arm bracket mounting bolts.
2. Detach the rocker arm assembly.
3. Remove the push rods.

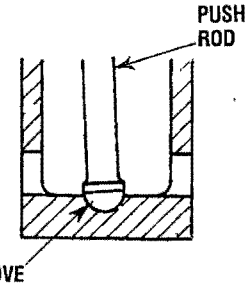
When Reassembling

After installing the rocker arm, be sure to adjust the valve clearance.

TIGHTENING TORQUE

ROCKER ARM BRACKET SCREW 23.5 - 37.5 N-m
2.4 - 2.8 Kgf-m
17.4 - 20.3 ft-lbs

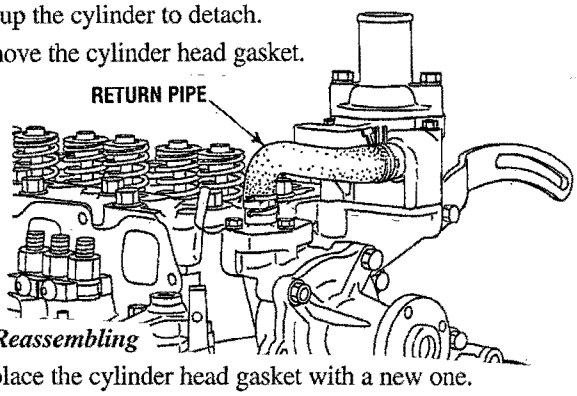




MAKER CERTAIN THE PUSH RODS ARE PROPERLY ENGAGED IN THE GROOVES WHEN REASSEMBLING.

CYLINDER HEAD

1. Loosen the pipe clamp and remove the water return pipe.
2. Remove the cylinder head screw in the order of **R** or **N** to **A**.
3. Lift up the cylinder to detach.
4. Remove the cylinder head gasket.

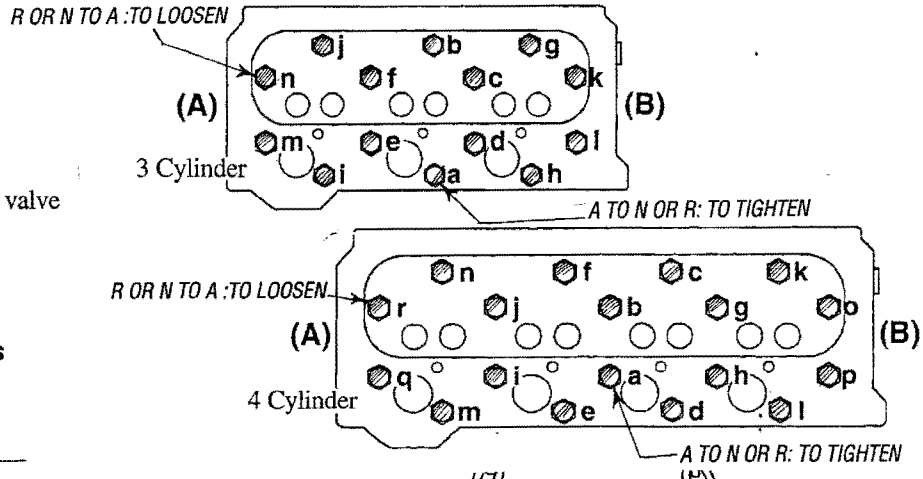


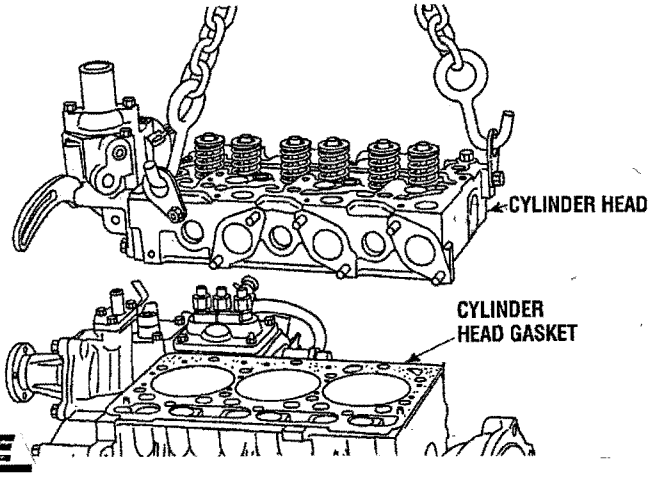
When Reassembling

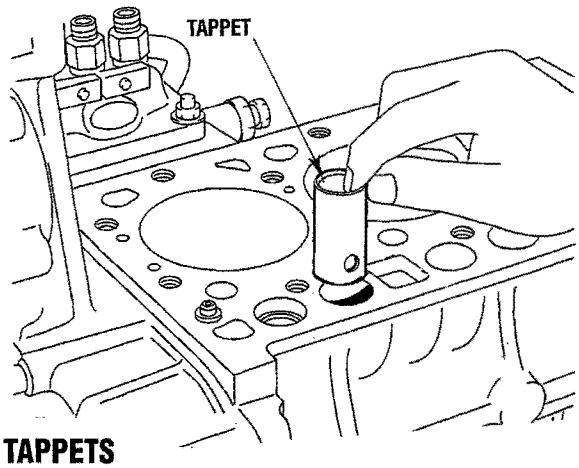
1. Replace the cylinder head gasket with a new one.
2. Tighten the cylinder head screws after applying sufficient oil.
3. Tighten the cylinder head screws in a diagonal sequence starting from the center in the order of **A** to **N** or **R**.
4. Tighten them uniformly or the head may deform in the long run.

TIGHTENING TORQUE

CYLINDER HEAD SCREW 93.1 - 98.0 N-m
9.5 - 10.0 Kgf-m
68.7 - 72.3 ft-lbs







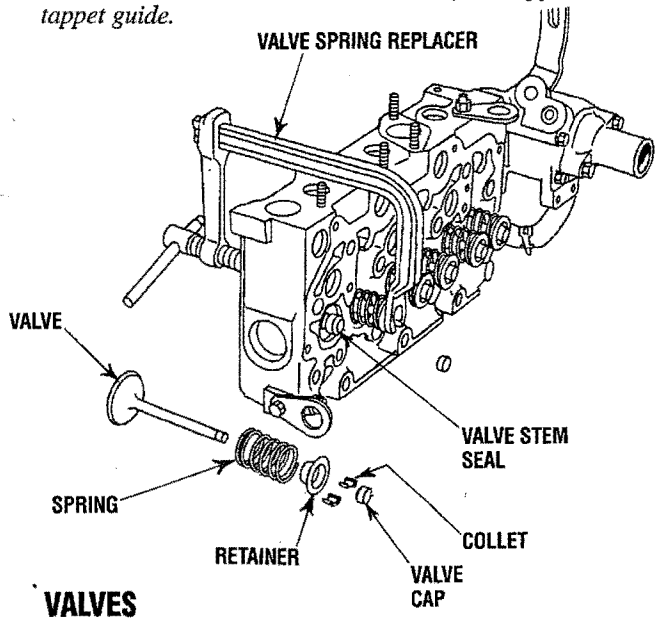
TAPPETS

1. Remove the tappets from the crankcase.

When Reassembling

1. Visually check the contact between the tappets and cams for proper rotation. If a defect is found, replace the tappets.
2. Before installing the tappets, apply engine oil thinly around them.

NOTE: *Do not change the combination of the tappet and the tappet guide.*



VALVES

1. Remove the valve caps.
2. Remove the valve spring collet, pushing the valve spring retainer by the valve spring replacer.
3. Remove the valve spring retainer, valve spring and valve stem seal.
4. Remove the valve

When Reassembling

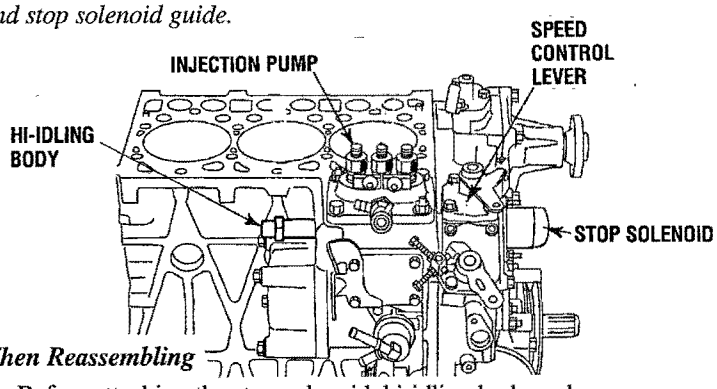
1. Wash the valve stem seal and the valve guide hole and apply engine oil sufficiently.
2. After installing the valve spring collets, lightly tap the stem to assure proper fit with a plastic hammer.

NOTE: *Do not change the combination of the valve and the valve guide.*

INJECTION PUMP

1. Remove the stop solenoid and the hi-idling body.
2. Remove the engine stop lever and stop solenoid guide.
3. Remove the fuel injection pump assembly.

NOTE: *Before removing the injection pump assembly, be sure to remove the stop solenoid, hi-idling body, engine stop lever and stop solenoid guide.*

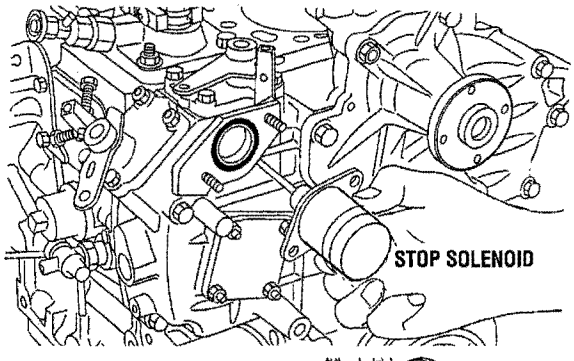


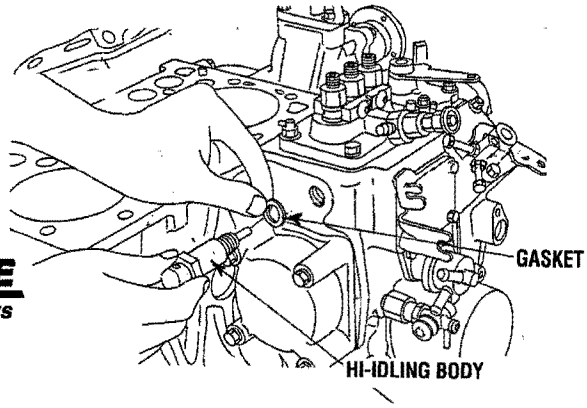
When Reassembling

1. Before attaching the stop solenoid, hi-idling body and solenoid guide, install the injection pump first into position.
2. Replace the hi-idling body gasket with a new one.
3. Before fitting the stop lever to the gear case, install the solenoid guide first into position. Then attach the stop lever and use it to see if it functions well.
4. Before fitting the idling limiter in place, attach the solenoid guide and the engine stop lever in their respective positions.
5. When installing the stop solenoid, be careful to keep the O-ring in place.
6. Be sure to insert the push rod of the stop solenoid into the hole at the center of the solenoid guide.

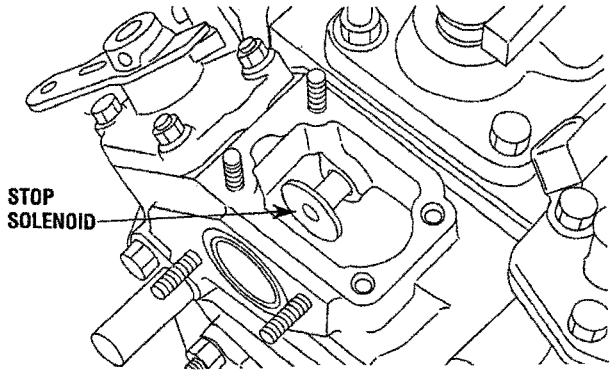
TIGHTENING TORQUE

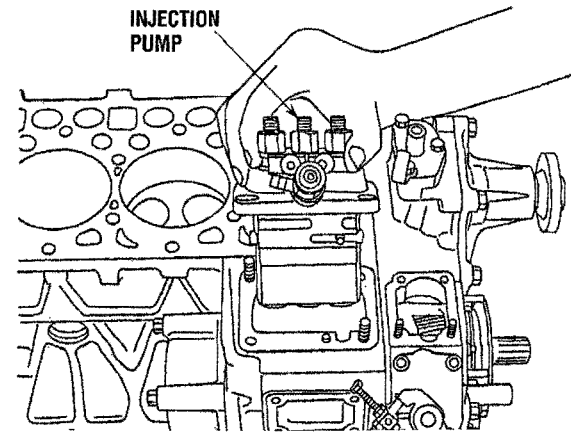
HI-IDLING BODY_____ 44.1 - 49.0 N-m
4.5 - 5.0 Kgf-m
32.6 - 36.2 ft-lbs





INJECTION PUMP (CONT.)





GOVERNOR SPRINGS AND SPEED CONTROL PLATE

NOTE: *Use a 1.2mm diameter hard wire with its end hooked, overall length of 200mm (7.87 in). The tip of a wire is bent t like a hook to grasp the governor springs.*

1. Remove the injection pump cover.
2. Remove the speed control plate mounting nuts and bolts.
3. Using the special tool, undo the large governor spring from the fork lever.
4. Using the special tool, undo the small governor spring from the fork lever.
5. Set the speed control lever as shown.
6. Take out the speed control plate with care and do not let the large and small governor springs come off this plate and fall into the gear case.

When Reassembling

1. Hook the small spring first and then the large governor spring on the speed control plate.
2. Put the specific tool from the injection pump side to catch the large governor spring., Keep this spring slightly extended and place the speed control plate in its specified position.
3. Using the special tool, hook the small governor spring onto the fork lever.

NOTE: *Be careful not to stretch the small governor spring too long because it may get deformed permanently.*

Using the specific tool, hook the large governor spring onto the fork lever.

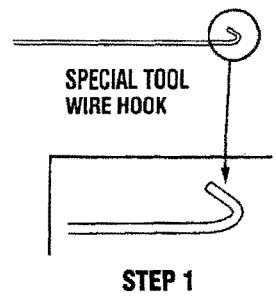
Make sure both the governor springs are tight on the fork lever.

Apply and tighten up the two bolts and two nuts on the speed control panel.

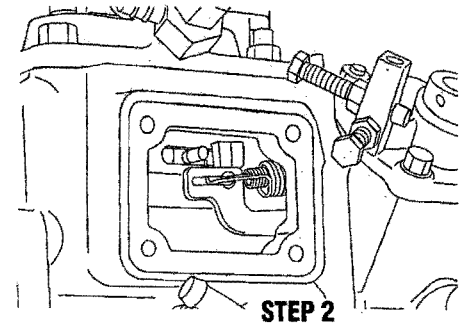
Check that the speed control lever positions at low idle after assembling the governor springs.

Check that the speed control lever returns to the high idle position rather than the low idle position after moving the lever to the maximum speed position.

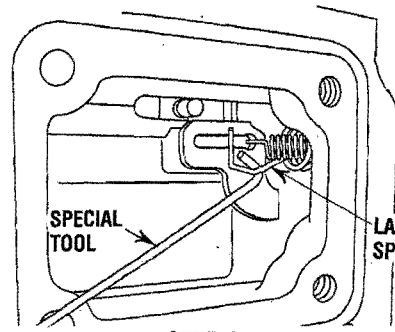
Finally attach the injection pump cover in position.



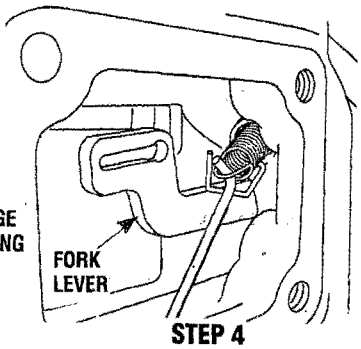
STEP 1



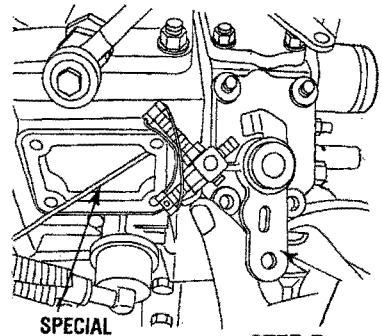
STEP 2



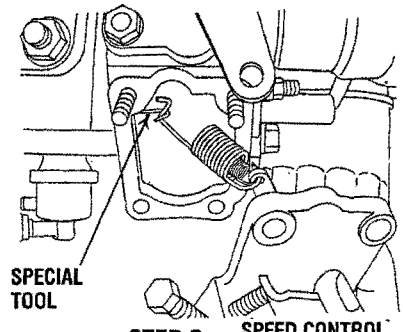
STEP 3



STEP 4

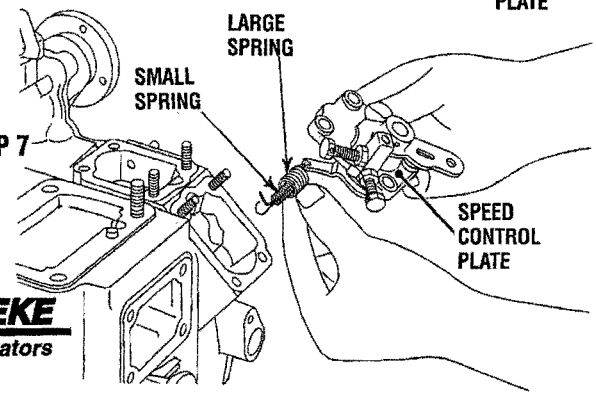


STEP 5



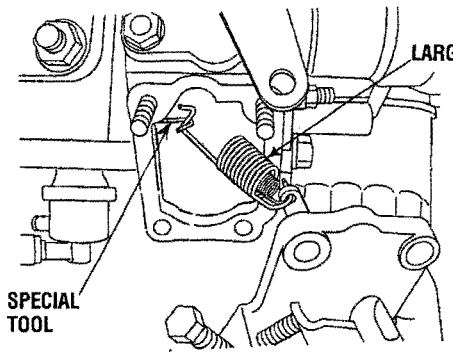
STEP 6

SPEED CONTROL
PLATE

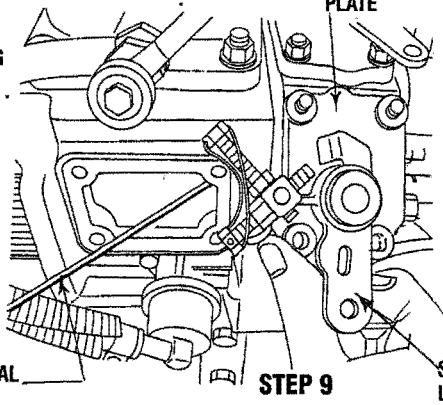


STEP 7

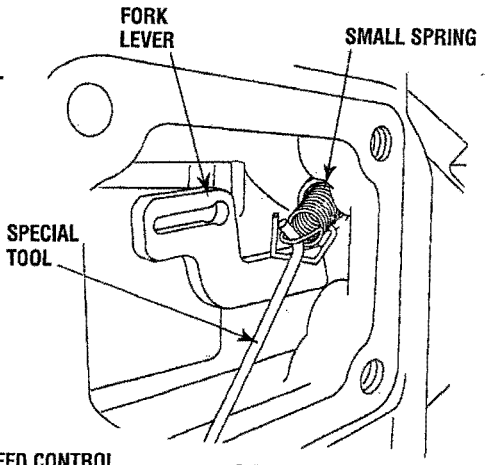
GOVERNOR SPRINGS AND SPEED CONTROL PLATE (CONT.)



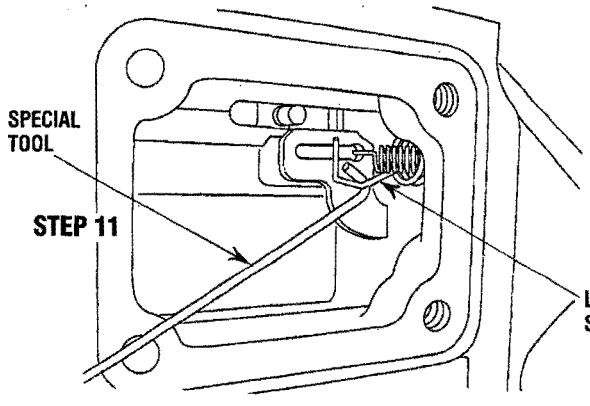
STEP 8



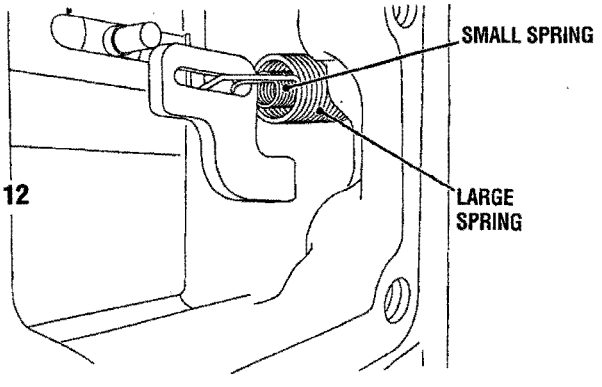
STEP 9



STEP 10



STEP 11



STEP 12

DRIVE PULLEY

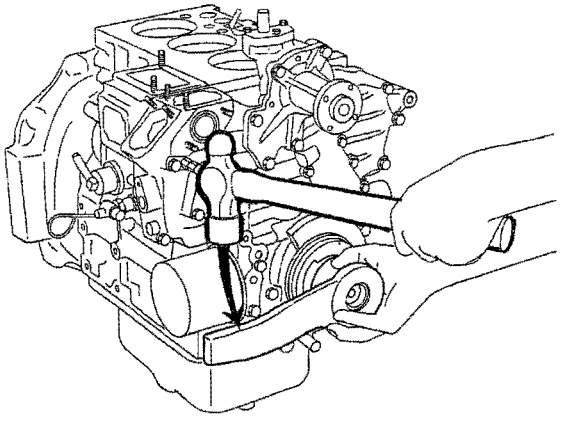
1. Lock the flywheel.
2. Remove the drive pulley mounting nut.
3. Remove the drive pulley with gear puller.
4. Remove the feather key

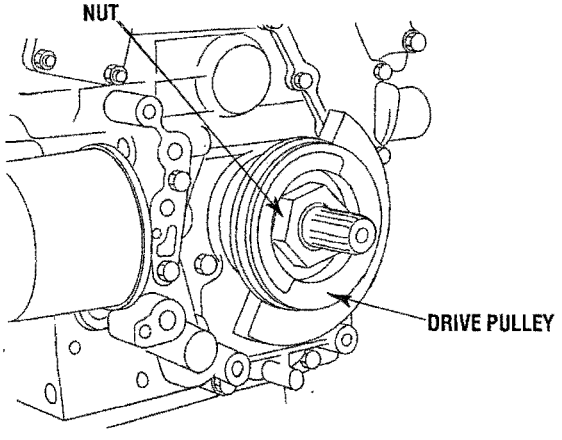
When Reassembling

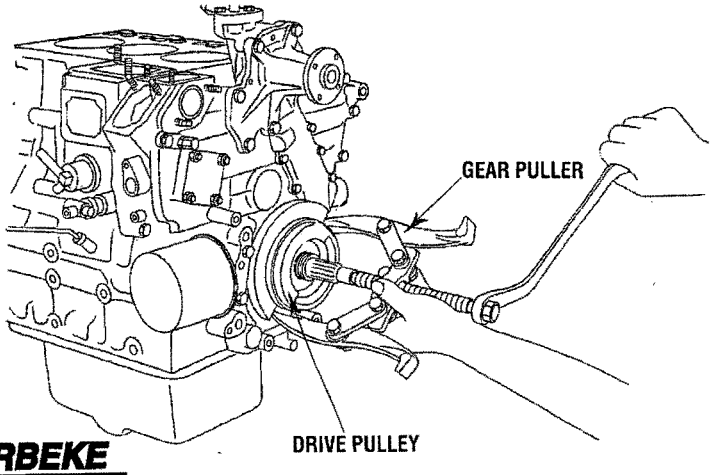
Apply grease to the splines of the coupling.

TIGHTENING TORQUE

FAN DRIVE PULLEY MOUNTING NUT	**137.3 - 156.9 N-m**
	14.0 - 16.0 Kgf-m
	101.3 - 115.7 ft-lbs





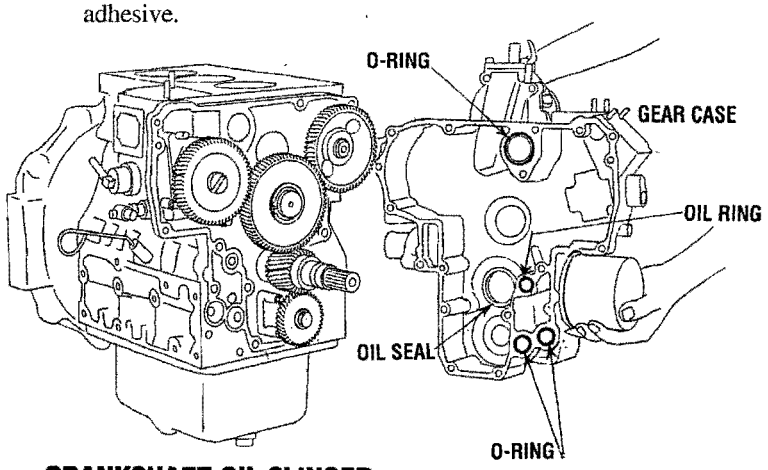


GEAR CASE

1. Remove the hour meter gear case (if equipped).
2. Remove the gear case.
3. Remove the O-rings.

When Reassembling

1. Apply liquid gasket (Three bond 1215 or equivalent) both sides of the hour meter gear case gasket.
2. Check to see if there are four O-rings inside the gear case.
3. Apply a thin film of engine oil to the oil seal and install it.
4. Before installing the gear case gasket, apply a non-drying adhesive.

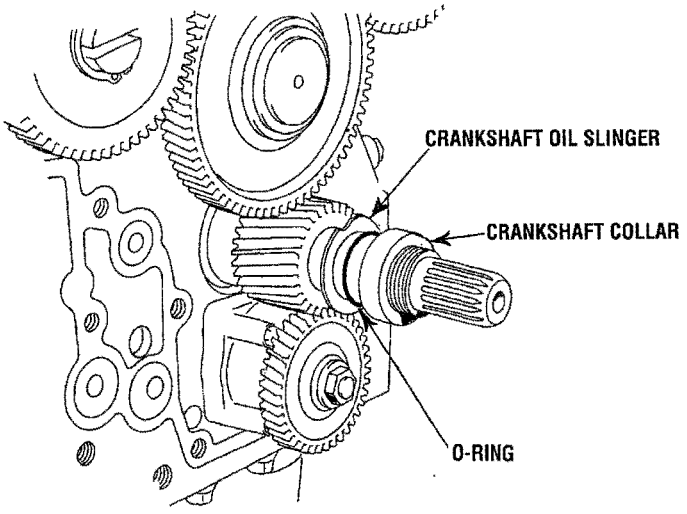


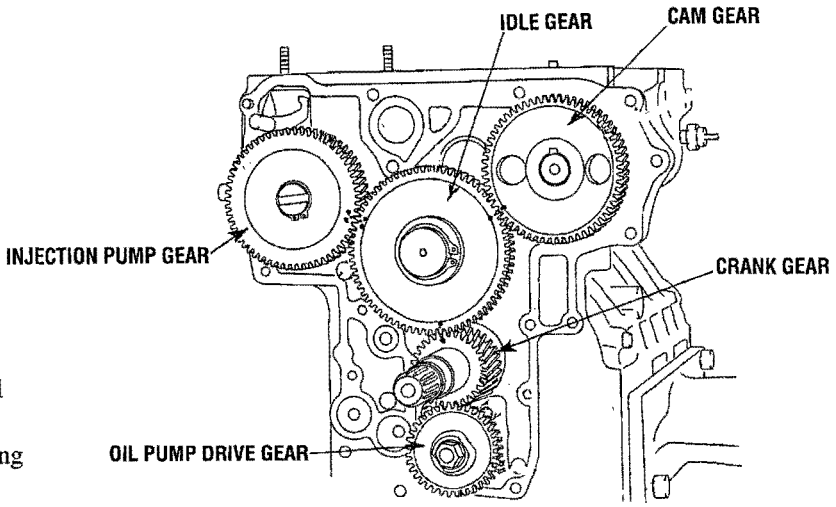
CRANKSHAFT OIL SLINGER

1. Remove the crankshaft collar.
2. Remove the O-ring.
3. Detach the crankshaft oil slinger.

When Reassembling

1. Insert the crankshaft collar after installing the gear case to the cylinder body.





IDLER GEAR

1. Remove the external snap ring.
2. Detach the idler gear collar.
3. Detach the idler gear.

When Reassembling

1. Check to see that each gear below is aligned with its aligning mark.

   Idle gear and crank gear

   Idle gear and camshaft gear

   Idle gear and injection pump gear

IDLER GEAR (FOR BALANCER MODEL)

1. Remove the external snap ring.
2. Detach the idler gear collar.
3. Detach the idler gear.

When Reassembling

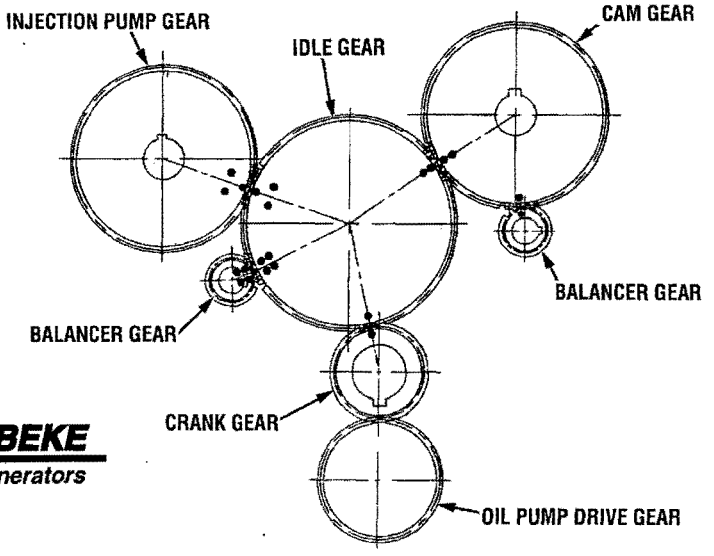
1. Check to see that each gear below is aligned with its aligning mark.

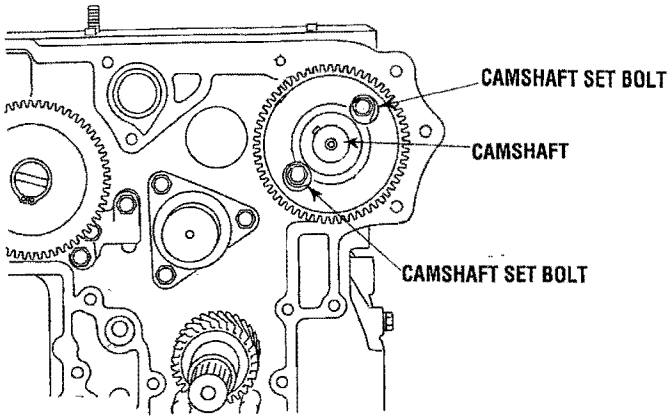
   Idle gear and crank gear

   Cam gear and balancer gear

   Idle gear and injection pump gear

   Idler gear and balancer gear





CAMSHAFT

1. Remove the camshaft set bolts and draw out the camshaft.

When Reassembling

1. When installing the idler gear, be sure to align the alignment marks on the gears.

TIGHTENING TORQUE

CAMSHAFT SET BOLT_____ 23.5 - 27.5 N-m
2.4 - 2.8 Kgf-m
17.4 - 20.3 ft-lbs

CAMSHAFT AND BALANCER SHAFT

1. Remove the camshaft set bolts and draw out the camshaft.
2. Remove the balancer shaft 1 set bolts and draw out the balancer shaft 1.
3. Remove balancer shaft 2 set bolts and draw out the balancer shaft 2.

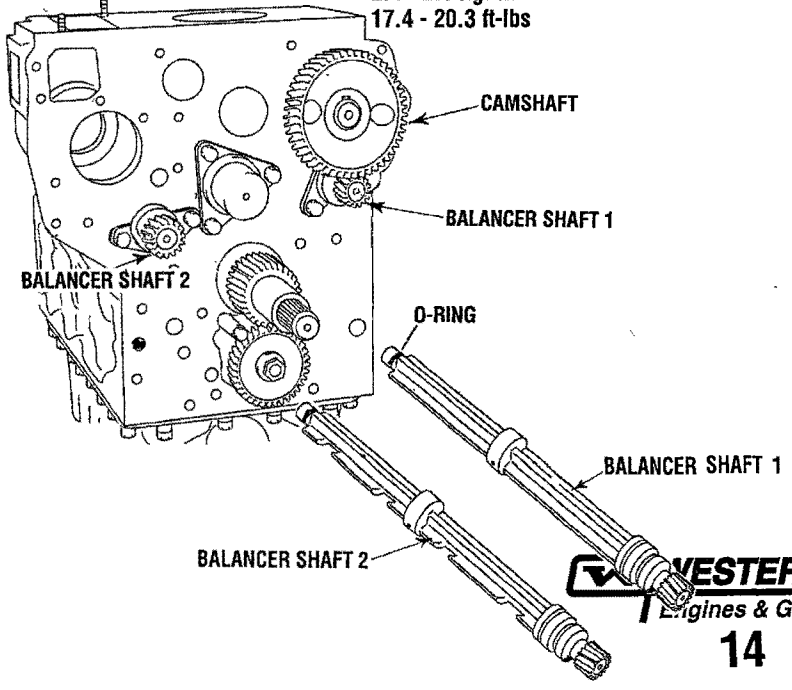
When Reassembling

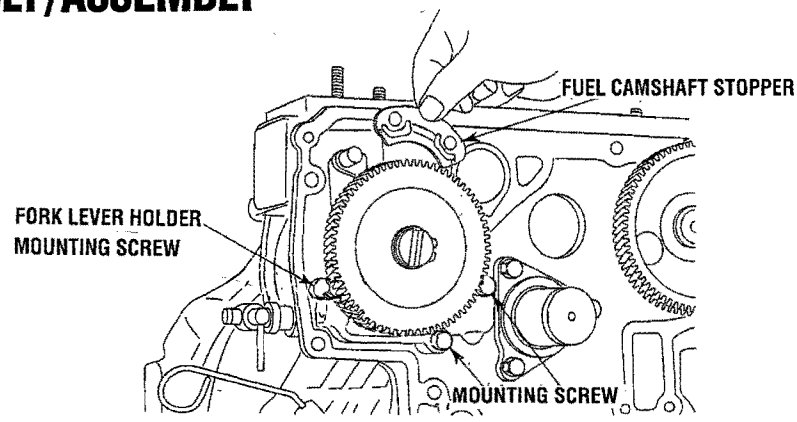
1. When installing the balancer shaft 1 and 2, be sure to place the 1st and 4th cylinder pistons at the top dead center in compression, then align all marks on each gear to assemble the timing gears, set the idle gear last.

TIGHTENING TORQUE

CAMSHAFT SET BOLT_____ 23.5 - 27.5 N-m
2.4 - 2.8 Kgf-m
17.4 - 20.3 ft-lbs

BALANCER SHAFT SET BOLT____ 23.5 - 27.5 N-m
2.4 - 2.8 Kgf-m
17.4 - 20.3 ft-lbs



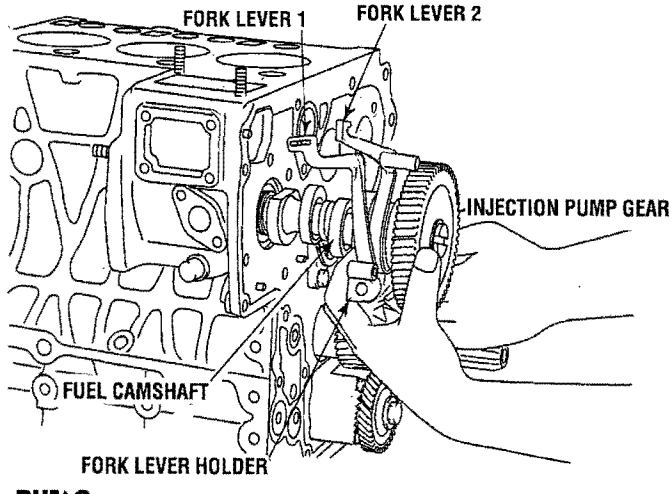


FUEL CAMSHAFT AND FORK LEVER ASSEMBLY

1. Remove the fuel feed pump.
2. Detach the fuel camshaft retainer.
3. Remove the three fork lever holder mounting screws.
4. Draw out the fuel camshaft assembly and fork lever assembly at the same time.

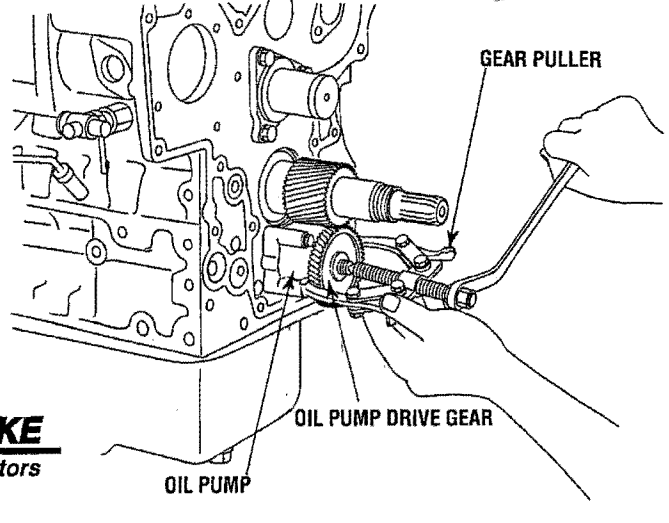
When Reassembling

1. After installation, check to see that the fork lever is fixed to the fork lever shaft and that they can turn smoothly in the holder.



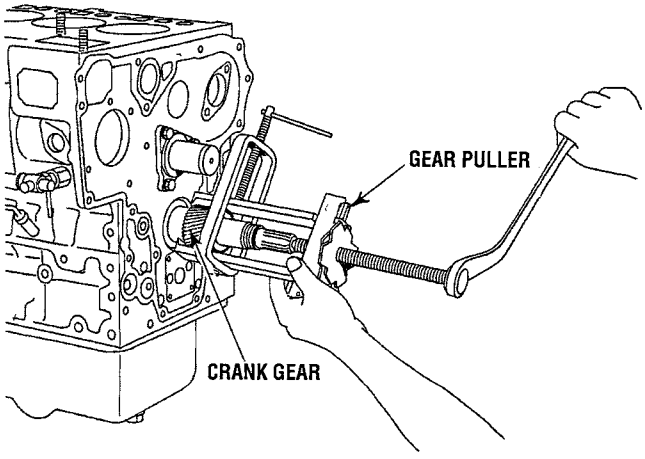
OIL PUMP

1. Remove the nut.
2. Draw out the oil pump drive gear with a gear puller.
3. Remove the four oil pump mounting screws and detach the oil pump.



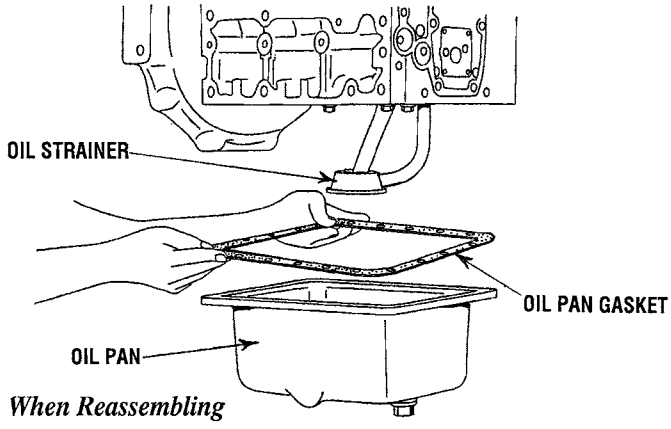
CRANK GEAR

1. Draw out the crank gear with a puller.
2. Remove the feather key.



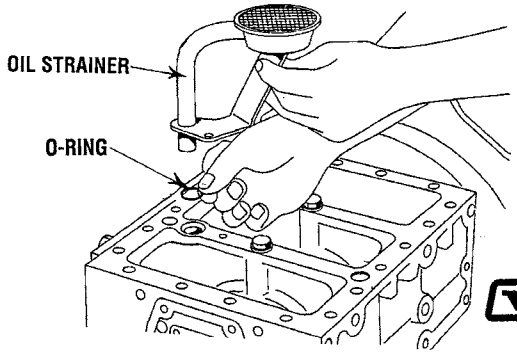
OIL PAN AND OIL STRAINER

1. Remove the oil pan mounting screws.
2. Remove the oil pan by lightly tapping the rim of the pan with a wooden hammer.
3. Remove the oil pan gasket.
4. Remove the oil strainer and O-ring.



When Reassembling

1. After cleaning the oil strainer, check to see that the filter mesh is clean and install it.
2. Visually check the O-ring, apply engine oil and install it.
3. Securely fit the O-ring to the oil strainer.
4. Apply a liquid gasket (Three bond 1215 or equivalent) to the oil pan side of the oil pan gasket.
5. To avoid uneven tightening, tighten the oil pan mounting screws in diagonal order from the center.



PISTONS

1. Completely clean the carbon out of the cylinders.
2. Remove the connecting rod cap.
3. Turn the flywheel to bring the piston to top dead center.
4. Draw the piston upward by lightly tapping it from the bottom of the crankcase with the handle of a hammer.
5. Draw out the other piston in the same method as above.

When Reassembling

1. Before inserting the piston into the cylinder, apply enough engine oil to the piston.
2. When inserting the piston into the cylinder, face the mark on the connecting rod to the injecting pump.

NOTE: *Do not change the combination of cylinder and piston. Make sure of the position of each piston by marking it.*

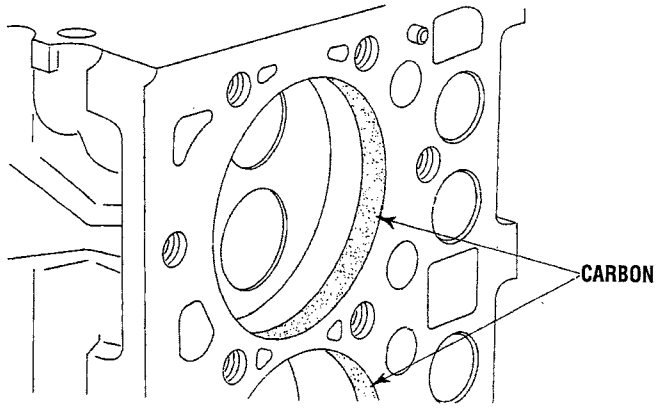
Place the piston rings with their gaps at 0.79 rad (45°) from the pistons pin direction.

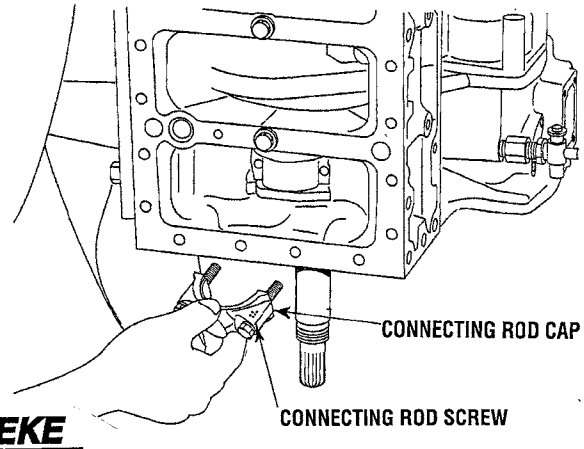
Carefully insert the pistons using a piston ring compressor.

When inserting the piston in place, be careful not to scrape the molybdenum disulfide coating off its skirt. This coating is useful in minimizing the clearance with the cylinder liner. Just after the piston pin has been press-fitted, the piston is still hot and the coating easily peels off. Wait until the piston cools down.

TIGHTENING TORQUE

CONNECTING ROD SCREW	44.1 - 49.0 N-m
	4.5 - 5.0 Kgf-m
	32.5 - 36.2 ft-lbs





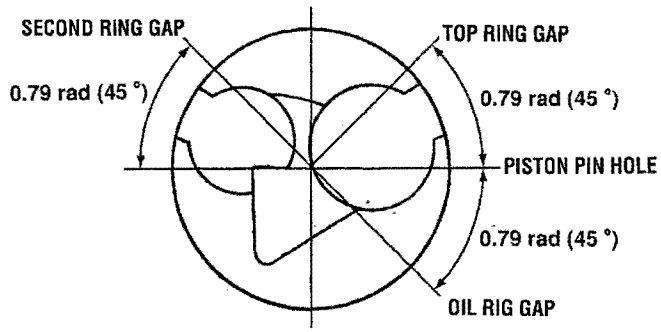
PISTON RING AND CONNECTING ROD

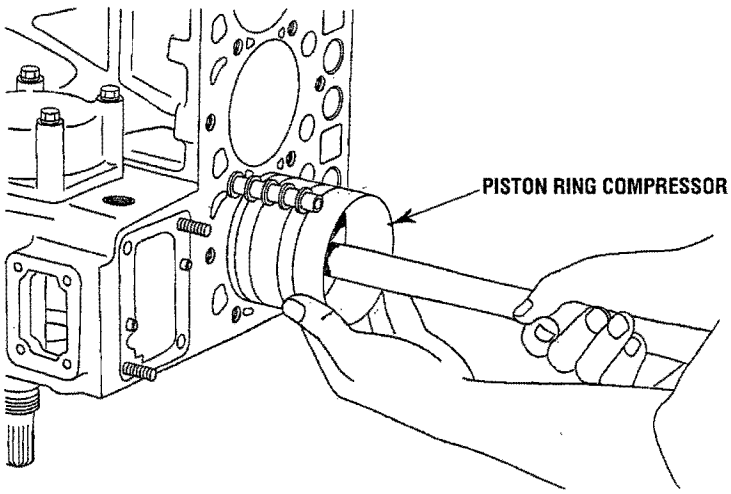
1. Remove the piston rings using a piston ring tool.
2. Remove the piston pin and separate the connecting rod from the piston.

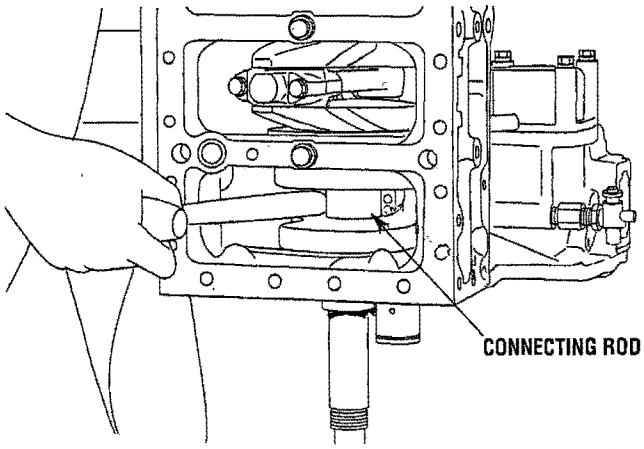
When Reassembling

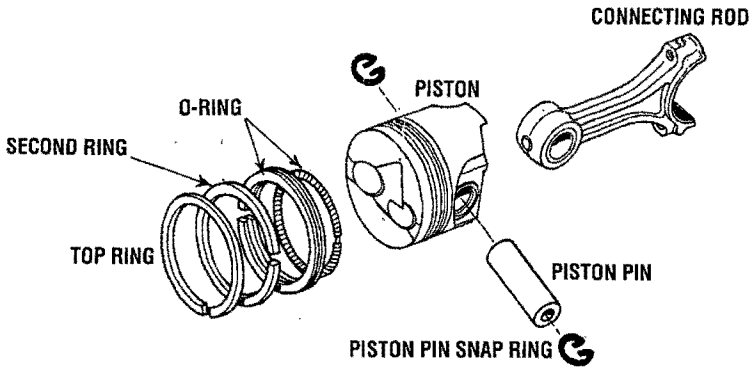
1. When installing the rings, assemble the rings so that the manufacturers mark near the gap faces the top of the piston.
2. When installing the oil ring onto the piston, place the expander joint on the opposite side of the oil ring gap.
3. Apply engine oil to the piston pin.
4. When installing the piston pin, immerse the piston in 80°C (176°F) oil for 10-15 minutes and insert the piston pin into the piston.
5. When installing the connecting rod to the piston, align the mark on the connecting rod to the fan-shaped concave.

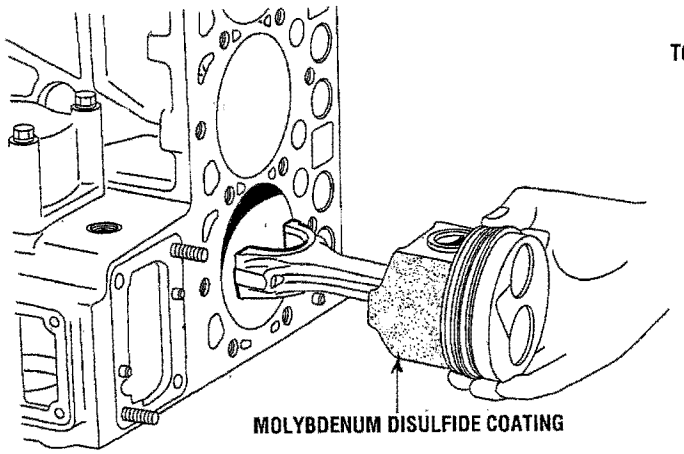
NOTE: *Mark the same number on the connecting rod and the piston so not to change the combination.*

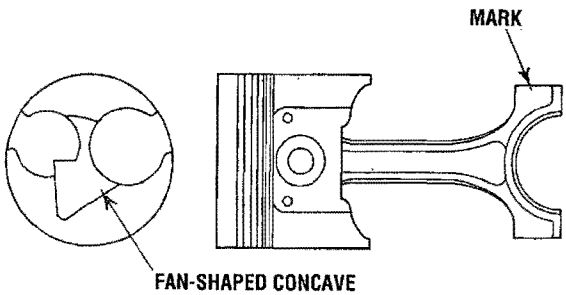




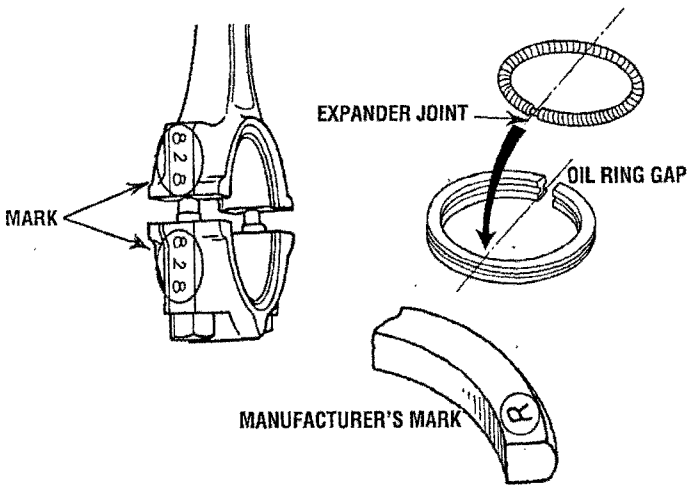








PISTON RING AND CONNECTING ROD (CONT.)



FLYWHEEL

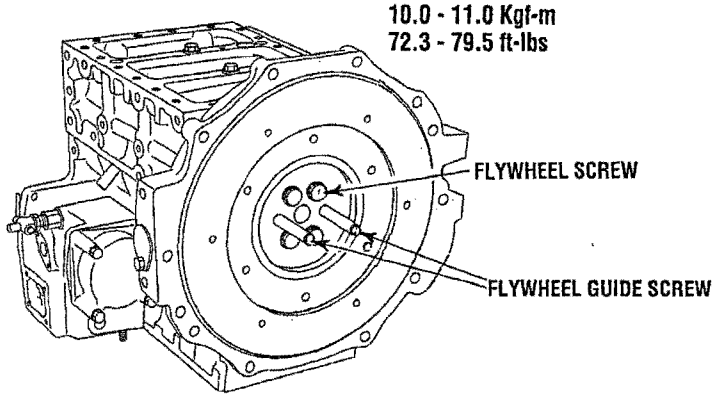
1. Lock the flywheel.
2. Remove two of the flywheel screws.
3. Insert two flywheel guide screws in the holes.
4. Remove the remaining flywheel screws.
5. Remove the flywheel slowly along the guide screws.

When Reassembling

1. Insert two of the flywheel guide screws.
2. Check to see that there are no metal particles on the flywheel mounting surfaces.
3. Apply engine oil to the threads and the undercut surface of the flywheel bolt and fit the bolt.

TIGHTENING TORQUE

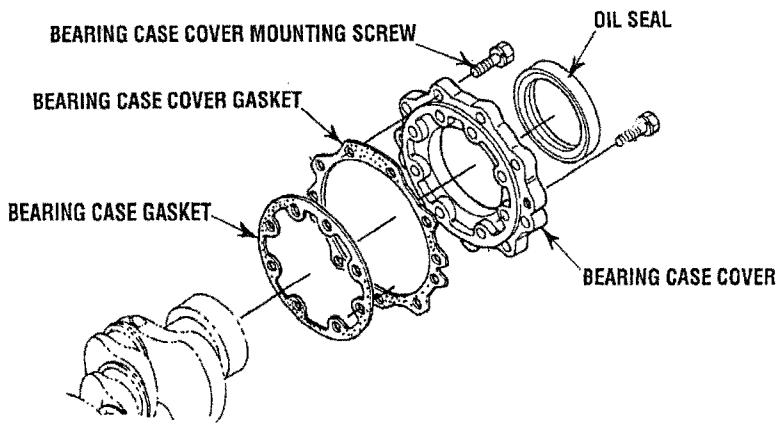
FLYWHEEL SCREWS	98.0 - 107.8 N-m 10.0 - 11.0 Kgf-m 72.3 - 79.5 ft-lbs



BEARING CASE COVER

1. Remove the bearing case cover mounting screws. Remove the inside screws first and then the outside screws.
2. Screw the two removed screws into the screw hole of the bearing case cover to remove it.

NOTE: *The length of the inside screws and outside screws are different sizes. Be aware of the size of the inside and outside screws.*

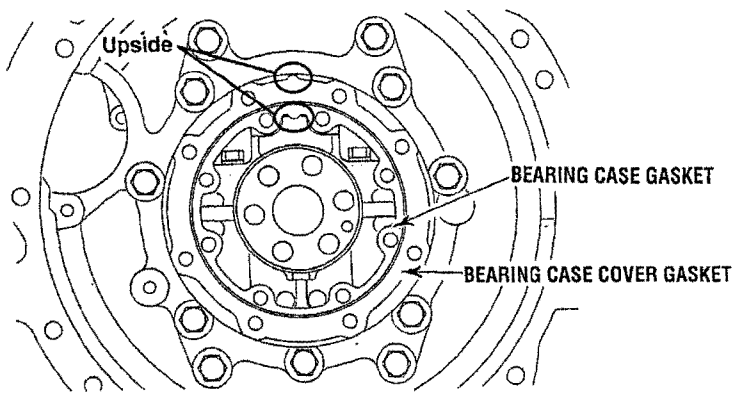


When Reassembling

1. Align the bearing case gasket and the bearing case cover gasket.
2. Install the bearing case cover positioning the casting mark **UP**.
3. Apply engine oil to the oil seal lip and be careful that it is not rolled when installing.
4. Tighten the bearing case cover mounting screws evenly in a diagonal order.

TIGHTENING TORQUE

BEARING CASE COVER MOUNTING SCREW	23.5 - 27.5 N-m 2.4 - 2.8 Kgf-m 17.4 - 20.3 ft-lbs



CRANKSHAFT

NOTE: *Before disassembling and during reassembly, check the side clearance of the crankshaft.*

4 Cylinder

1. Remove the main bearing case screw.
2. Pull out the crankshaft assembly, take care not to damage the crankshaft bearing.

3 Cylinder

1. Remove the main bearing case screw.
2. Turn the crankshaft to set the crank pin of the third cylinder to the bottom dead center. Then draw out the crankshaft until the crank pin of the second cylinder comes to the center of the third cylinder.
3. Turn the crankshaft by 2.09 rad (120°) counterclockwise to set the crank pin of the second cylinder to the bottom dead center. Draw out the crankshaft until the crank pin of the first cylinder comes to the center of the third cylinder.
4. Repeat the above steps to draw the crankshaft completely out.

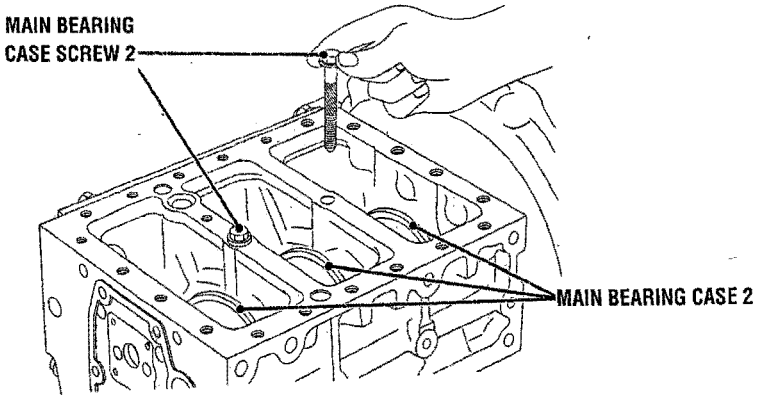
When Reassembling

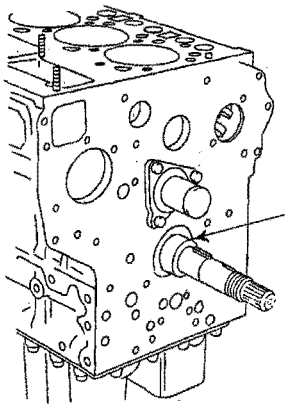
1. Install the crankshaft sub assembly, aligning the screw hole of the main bearing case 2 with the screw hole of the cylinder block.
2. When tightening the main bearing case screw 2, apply oil to the screw and screw by hand before tightening the specific torque.

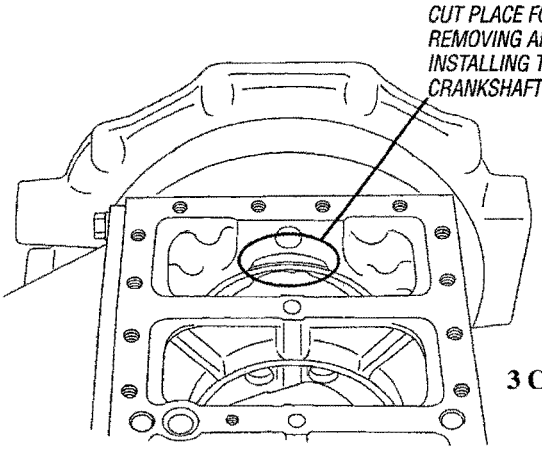
   If it is not smooth to screw by hand, align the screw holes between the cylinder block and the main bearing case.

TIGHTENING TORQUE

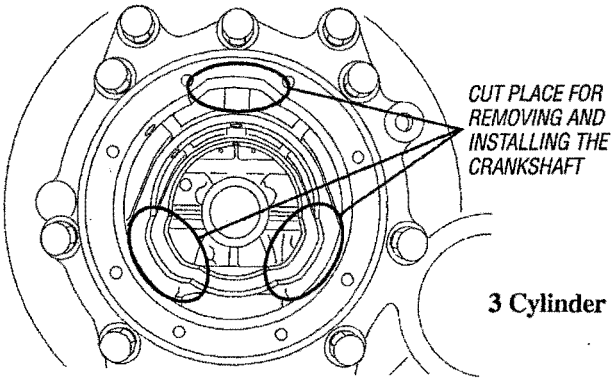
MAIN BEARING CASE SCREWS 2 ____ 68.6 - 73.5 N-m
7.0 - 7.5 Kgf-m
50.6 - 54.2 ft-lbs



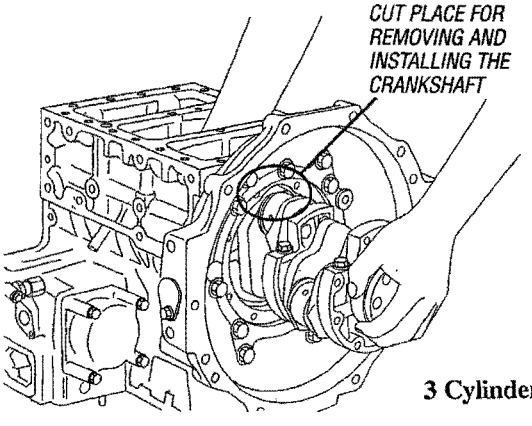




3 Cylinder



3 Cylinder



3 Cylinder

MAIN BEARING CASE ASSEMBLY

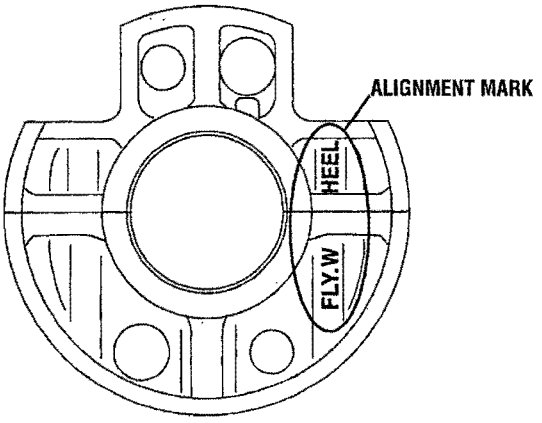
1. Remove the two main bearing case screws and remove the main bearing case assembly being cautious with the thrust bearing and crankshaft bearing.
2. Remove the main bearing case.

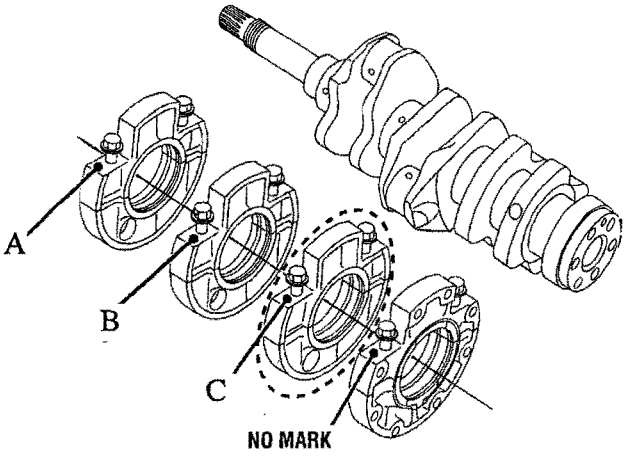
When Reassembling

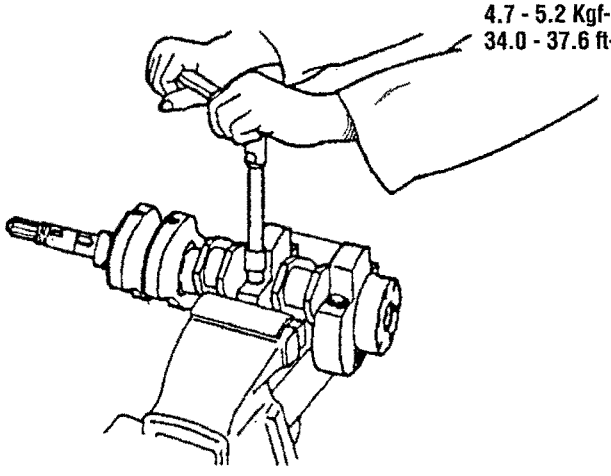
1. Clean the oil passage in the main bearing case.
2. Apply clean engine oil on the bearings.
3. Install the main bearing case assemblies in the original positions. The diameters of the main bearing cases may vary so install them in the order of the markings (A, B for 3 cylinders and A, B, C for 4 cylinders) from the gear case side.
4. Match the alignment numbers and mark on the main bearing case.
5. When installing the main bearing case, face the mark **FLYWHEEL** to the flywheel.
6. Install the thrust bearing with its oil groove facing outward.
7. Confirm that the main bearing case moves smoothly after tightening the main bearing case screw to the specified torque.

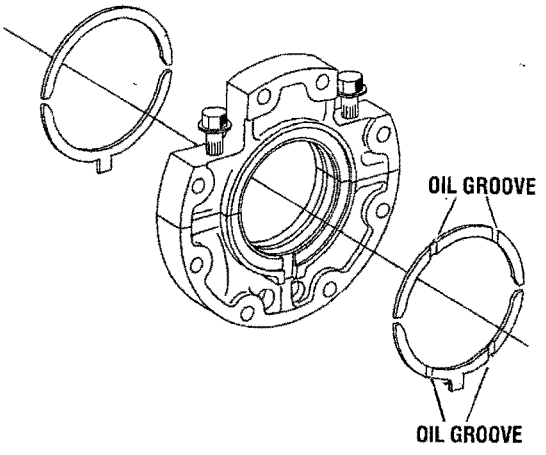
TIGHTENING TORQUE

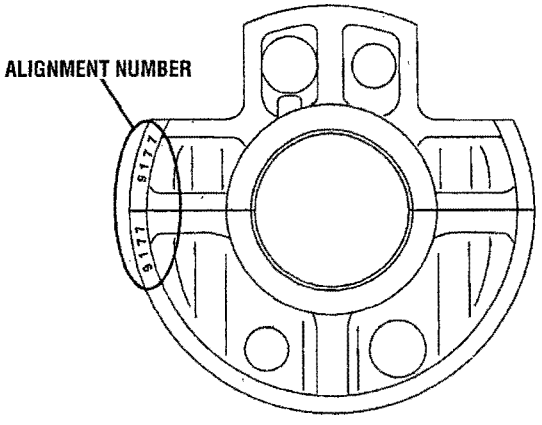
MAIN BEARING CASE SCREW ..... **46.1 - 50.9 N-m**
4.7 - 5.2 Kgf-m
34.0 - 37.6 ft-lbs





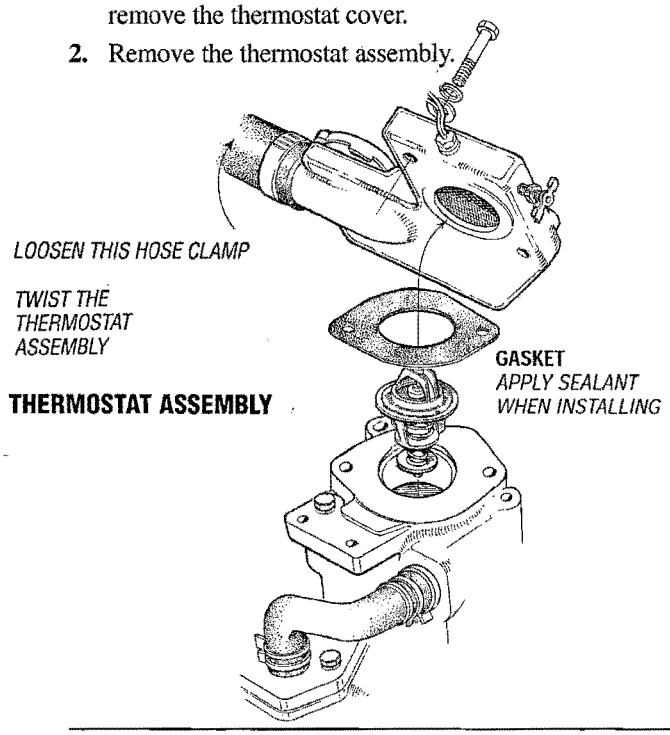


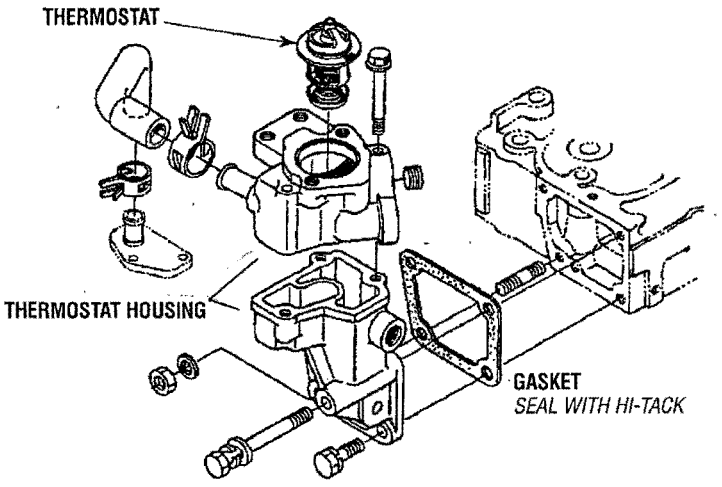




THERMOSTAT ASSEMBLY

1. Remove the thermostat cover mounting screws and remove the thermostat cover.
2. Remove the thermostat assembly.





When Reassembling

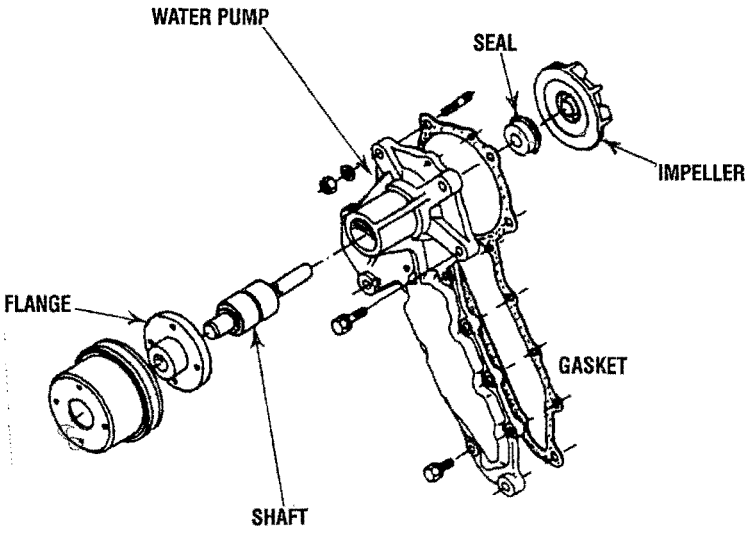
1. Apply a liquid gasket (Three bond 1215 or equivalent) only at the thermostat cover side of the thermostat cover gasket.

WATER PUMP ASSEMBLY

1. Loosen the alternator mounting bolts and remove the belt.
2. Remove the pulley.
3. Remove the water pump assembly from the gear case cover.
4. Remove the water pump flange.
5. Press out the water pump shaft with the impeller on it.
6. Remove the impeller from the water pump shaft.
7. Remove the mechanical seal.

When Reassembling

1. Apply a liquid gasket (Three bond 1215 or equivalent) to the both sides of the gasket.
2. Replace the mechanical seal with a new one.



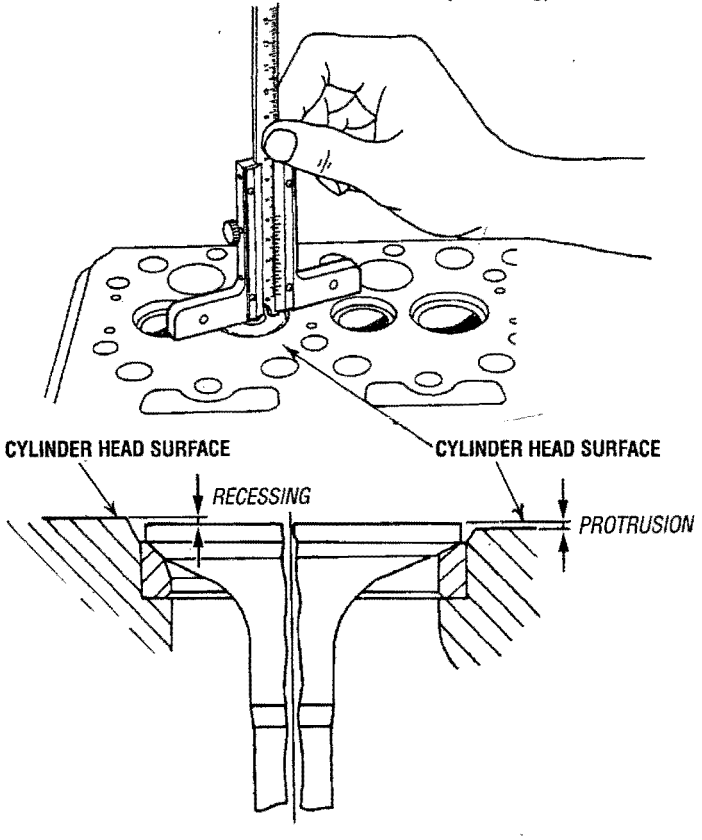
VALVE RECESSING

1. Clean the cylinder head surface, valve face and valve seat.
2. Insert the valve into the valve guide.
3. Measure the valve recessing with a depth gauge.
4. If the measurement exceeds the allowable limit, replace the valve.
5. If it still exceeds the allowable limit after replacing the valve, replace the valve seat.

VALVE RECESSING

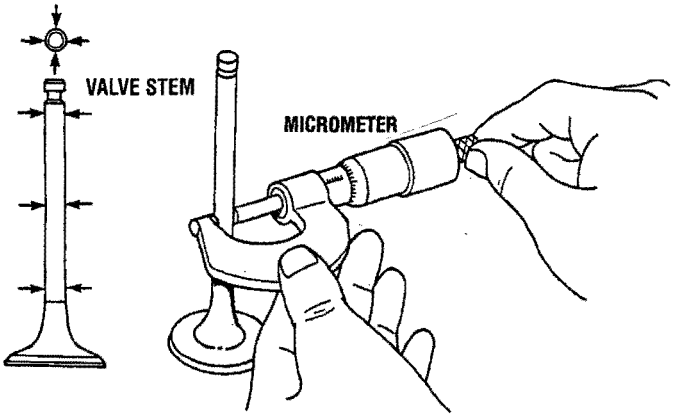
FACTORY SPECIFICATIONS — **0.05mm (protrusion) to 0.15mm (recessing)**
0.0020in (protrusion) to 0.0059in (recessing)

ALLOWABLE LIMIT — **0.40mm (recessing)**
0.0157in (recessing)



CLEARANCE BETWEEN VALVE STEM AND VALVE GUIDE

1. Remove carbon from the valve guide section.
2. Measure the valve stem O.D. with an outside micrometer.
3. Measure the valve guide I.D. with a small hole gauge and calculate the clearance.
4. If the clearance exceeds the allowable limit, replace the valves. If it still exceeds the allowable limit, replace the valve guide.



CLEARANCE BEWTEEN VALVE STEM AND VALVE GUIDE

FACTORY SPECIFICATIONS — **0.040-0.070mm**
0.00157 - 0.00276in

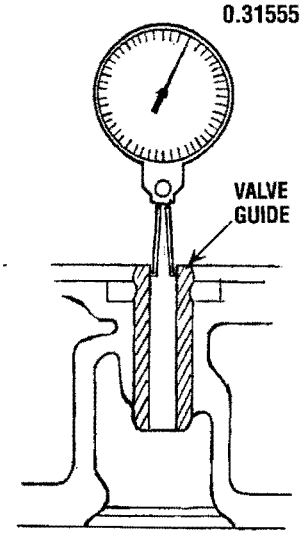
ALLOWABLE LIMIT — **0.10mm**
0.0039in

VALVE STEM O.D.

FACTORY SPECIFICATIONS — **7.960 - 7.975mm**
0.31339 - 0.31398in

VALVE STEM I.D.

FACTORY SPECIFICATIONS — **8.015 - 8.030mm**
0.31555 - 0.31614in



REPLACING VALVE GUIDE

When Removing

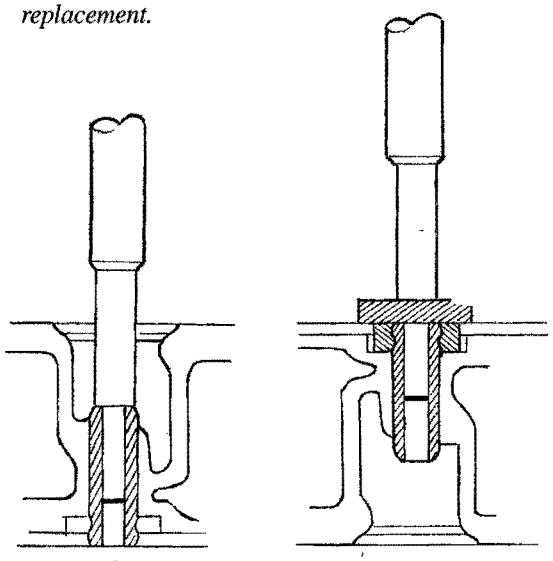
1. Press out the used valve guide using a valve guide replacing tool

When Installing

1. Clean a new valve guide and valve guide bore and apply engine oil to them.
2. Press in a new valve guide using a valve guide replacing tool.
3. Ream precisely the I.D. of the valve guide to the specified dimension.

VALVE GUIDE I.D. (INTAKE AND EXHAUST)
FACTORY SPECIFICATIONS ..... 8.015 - 8.030mm
0,31555 - 0.31614in

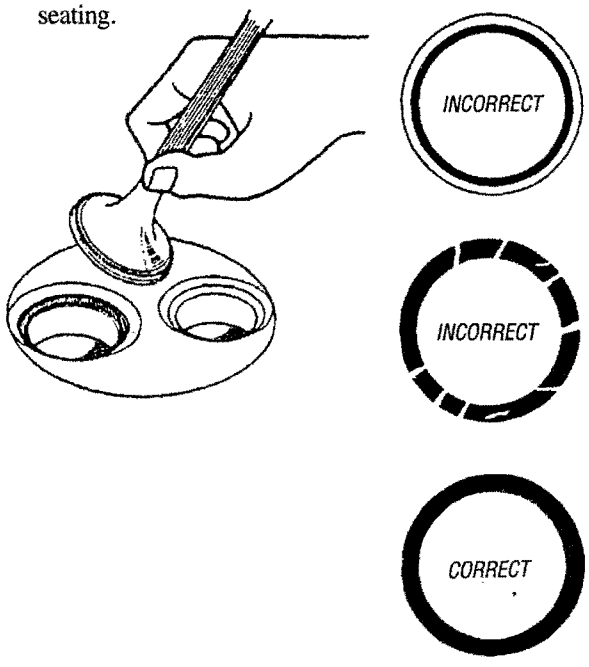
Do not hit the valve guide with a hammer during replacement.



WHEN REMOVING *WHEN INSTALLING*

VALVE SEATING

1. Coat the valve face lightly with prussian blue and put the valve on its seat to check the contact.
2. If the valve does not seat all the way around the valve seat or the valve contact is less than 70%, correct the valve seating as follows.
3. If the valve contact does not comply with the reference valve, replace the valve or correct the contact of the valve seating.



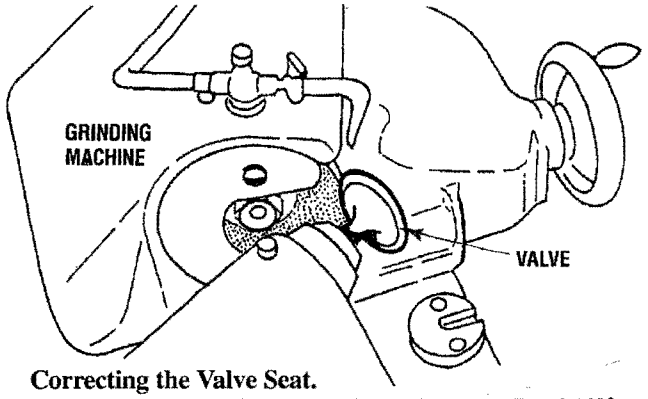
VALVE SEATING (CONT.)

Before correcting the valve and seat, check the valve stem and the I.D. of the valve guide section, repair them if necessary.

After correcting the valve seat, be sure to check the valve recessing.

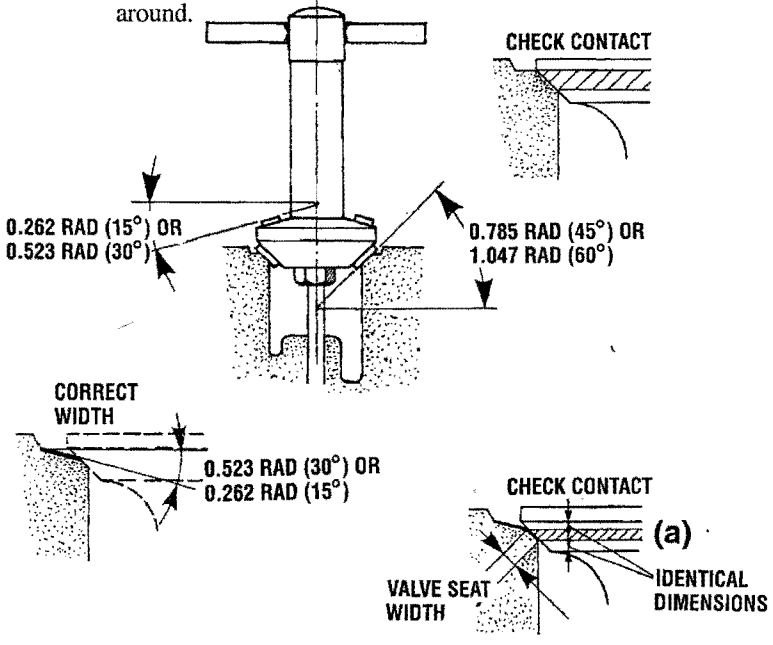
Correcting the Valve.

1. Correct the valve with a valve refacer.



Correcting the Valve Seat.

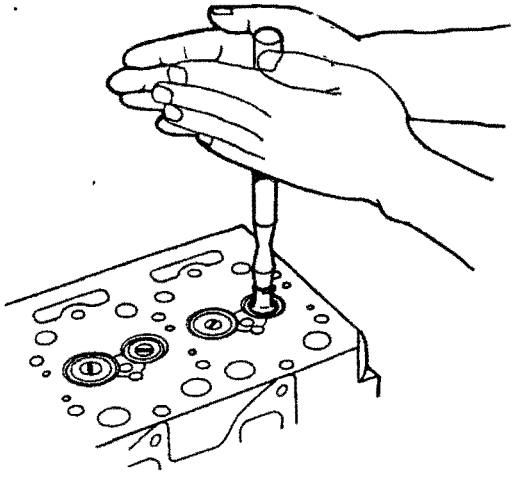
1. Slightly correct the seat surface with a 1.047 rad (60°) intake valve or a 0.785 rad (45°) exhaust valve seat cutter tool.
2. Resurface the seat surface with a 0.523 rad (30°) valve seat cutter to the intake valve seat and with a 0.262 rad (15°) valve seat cutter to the exhaust valve seat so that the width is close to the specified valve seat width (2.12mm, 0.0835in).
3. After resurfacing the seat, inspect for even valve seating. Apply a thin film of compound between the valve face and valve seat and fit them with a lapping tool.
4. Check the valve seating with prussian blue. The valve seating surface should show good contact all the way around.



VALVE LAPPING

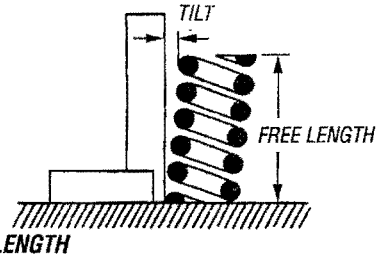
1. Apply compound evenly to the valve lapping surface.
2. Insert the valve into the valve guide. Lap the valve onto its seat with a valve flapper or screwdriver.
3. After lapping the valve, wash the compound away and apply oil, then repeat valve lapping with oil.
4. Apply prussian blue to the contact surface to check the seated rate. If it is less than 70%, repeat the valve lapping again.

When valve lapping is performed, be sure to check the valve recessing and adjust the valve clearance after assembling the valve.



FREE LENGTH AND TILT OF THE VALVE SPRING

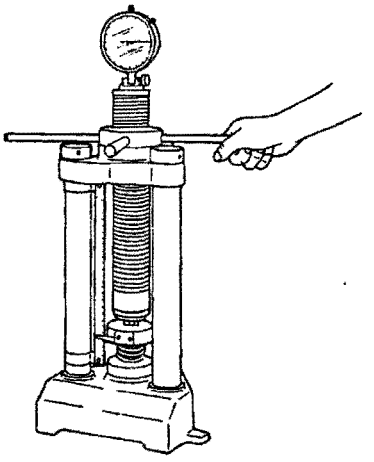
1. Measure the free length of the valve spring with vernier calipers. If the measurement is less than the allowable limit, replace it.
2. Put the valve spring on a surface plate, place a square on the side of the valve spring.
3. Check to see if the entire side is in contact with the square. Rotate the valve spring and measure the maximum tilt. If the measurement exceeds the allowable limit, replace it.
4. Check the entire surface of the valve spring for scratches. If there is any defect, replace it.



FREE LENGTH
FACTORY SPECIFICATIONS ____ 41.7 - 42.2mm
1.6417 - 1.6614in

ALLOWABLE LIMIT ____ 41.2mm
1.6220in

TILT
ALLOWABLE LIMIT ____ 1.0mm
0.039in



VALVE SPRING SETTING LOAD

1. Place the valve spring on a tester and compress it to the same length it is actually compressed in the engine.
2. Read the compression load on the gauge.
3. If the measurement is less than the allowable limit, replace it.

SETTING LOAD/SETTING LENGTH
FACTORY SPECIFICATIONS ____ 117.6N/35.0mm
12.0kgf/35.0mm
26.4lbs/1.3780in

ALLOWABLE LIMIT ____ 100N/35.0mm
10.2kgf/35.0mm
22.5lbs/1.3780in

OIL CLEARANCE BETWEEN THE ROCKER ARM AND ROCKER ARM SHAFT

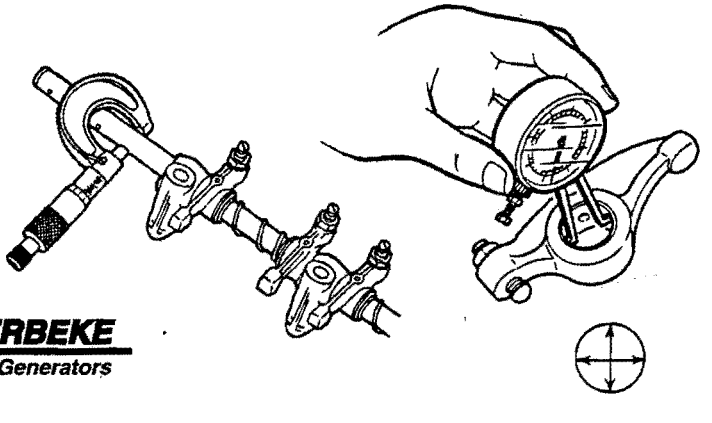
1. Measure the rocker arm O.D. with an outside micrometer.
2. Measure the rocker arm I.D. with an inside micrometer and then calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit, replace the rocker arm and measure the oil clearance again. If it still exceeds the allowable limit, replace the rocker arm shaft.

OIL CLEARANCE BETWEEN ROCKER ARM AND ROCKER SHAFT
FACTORY SPECIFICATIONS ____ 0.016 - 0.045mm
0.00063 - 0.00177in

ALLOWABLE LIMIT ____ 0.10mm
0.0039in

ROCKER ARM SHAFT O.D.
FACTORY SPECIFICATIONS 13.973 - 13.984mm
0.55012 - 0.55055in

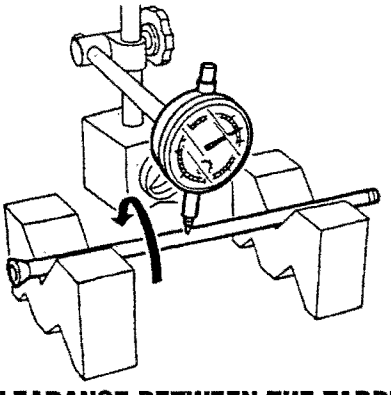
ROCKER ARM SHAFT I.D.
FACTORY SPECIFICATIONS ____ 14.000 - 14.018mm
0.55118 - 0.55189in



PUSH ROD ALIGNMENT

1. Place the push rod on V blocks on a surface plate.
2. Measure the push rod alignment.
3. If the measurement exceeds the allowable limit, replace the push rod.

PUSH ROD ALIGNMENT
ALLOWABLE LIMIT_____0.25mm
0.0098in



OIL CLEARANCE BETWEEN THE TAPPET AND TAPPET GUIDE BORE

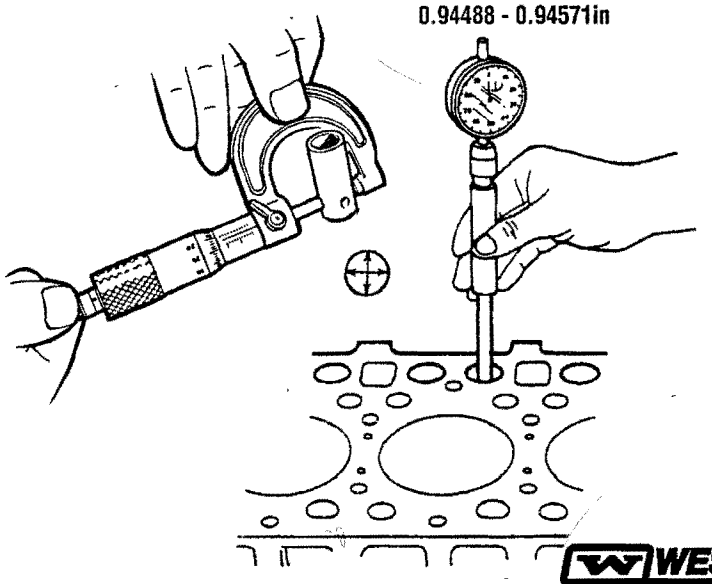
1. Measure the tappet O.D. with an outside micrometer.
2. Measure the I.D. of the tappet guide bore with a cylinder gauge and calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit or the tappet is damaged, replace the tappet.

OIL CLEARANCE BETWEEN TAPPET AND THE TAPPET GUIDE BORE
FACTORY SPECIFICATIONS 0.020 - 0.062mm
0.00079 - 0.11244in

ALLOWABLE LIMIT_____0.07mm
0.0028in

TAPPET O.D.
FACTORY SPECIFICATIONS_____23.959 - 23.980mm
00.94327 - 0.94410in

TAPPET GUIDE BORE I.D.
FACTORY SPECIFICATIONS_____24.000 - 24.021mm
0.94488 - 0.94571in



TIMING GEAR BACKLASH

1. Set a dial indicator (lever type) with its tip on the gear tooth.
2. Move the gear to measure the backlash, holding its mating gear.
3. If the backlash exceeds the allowable limit, check the oil clearance of the shafts and the gear.
4. If the oil clearance is not proper, replace the gear.

BACKLASH BETWEEN IDLER GEAR AND CRANK GEAR
FACTORY SPECIFICATIONS_____0.0415 - 0.1122mm
0.00163 - 0.00442in

ALLOWABLE LIMIT_____0.15mm
0.0059in

BACKLASH BETWEEN IDLER GEAR AND CAM GEAR
FACTORY SPECIFICATIONS_____0.0415 - 0.1154mm
0.00163 - 0.00454in

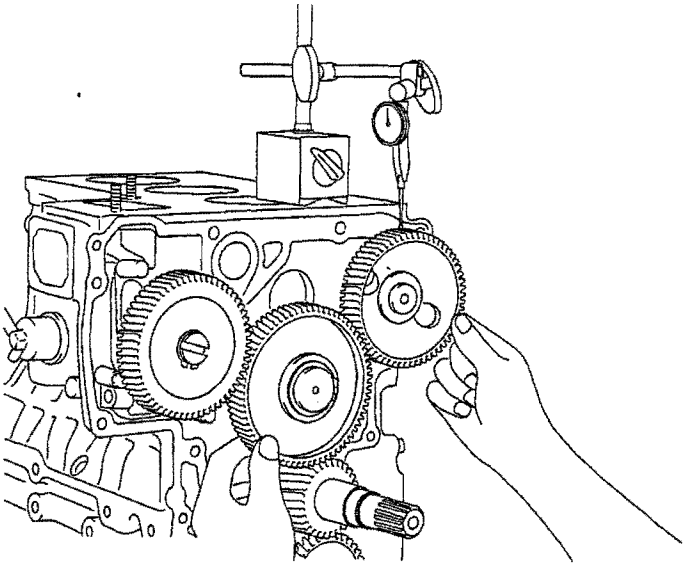
ALLOWABLE LIMIT_____0.15mm
0.0059in

BACKLASH BETWEEN IDLER GEAR AND INJECTION PUMP GEAR
FACTORY SPECIFICATIONS_____0.0415 - 0.1154mm
0.00163 - 0.00454in

ALLOWABLE LIMIT_____0.15mm
0.0059in

BACKLASH BETWEEN IDLER GEAR AND INJECTION PUMP GEAR
FACTORY SPECIFICATIONS_____0.0415 - 0.1090mm
0.00163 - 0.00429in

ALLOWABLE LIMIT_____0.15mm
0.0059in



For Balancer Model Only

BACKLASH BETWEEN IDLER GEAR AND BALANCER GEAR
FACTORY SPECIFICATIONS_____0.0350 - 0.1160mm
0.00138 - 0.00457in

ALLOWABLE LIMIT_____0.15mm
0.0059in

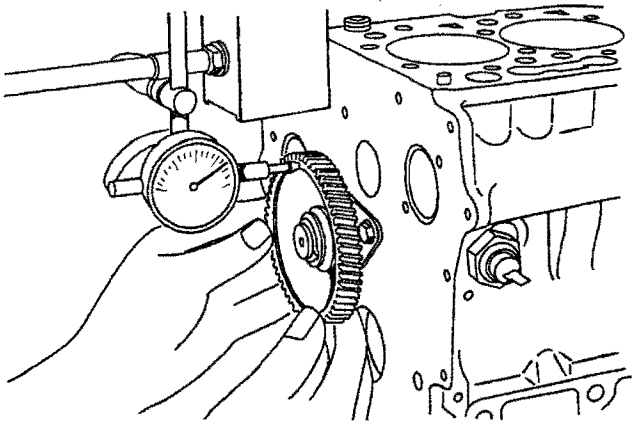
IDLER GEAR SIDE CLEARANCE

1. Set a dial indicator with its tip on the idle gear.
2. Measure the side clearance by moving the idle gear to the front and rear.
3. If the measurement exceeds the allowable limit, replace the idle gear collar.

IDLER GEAR SIDE CLEARANCE

FACTORY SPECIFICATIONS — **0.12 - 0.48mm**
0.0047 - 0.0189in

ALLOWABLE LIMIT — **0.90mm**
0.0354in



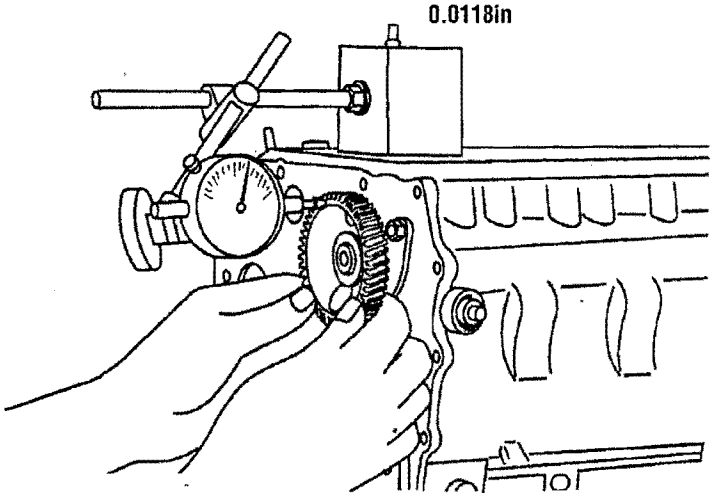
CAMSHAFT SIDE CLEARANCE

1. Set a dial indicator with its tip on the cam gear.
2. Measure the side clearance by moving the cam gear to the front and rear.
3. If the measurement exceeds the allowable limit, replace the camshaft stopper.

CAMSHAFT SIDE CLEARANCE

FACTORY SPECIFICATIONS — **0.07 - 0.22mm**
0.0028 - 0.0087in

ALLOWABLE LIMIT — **0.30mm**
0.0118in



CAMSHAFT SIDE CLEARANCE

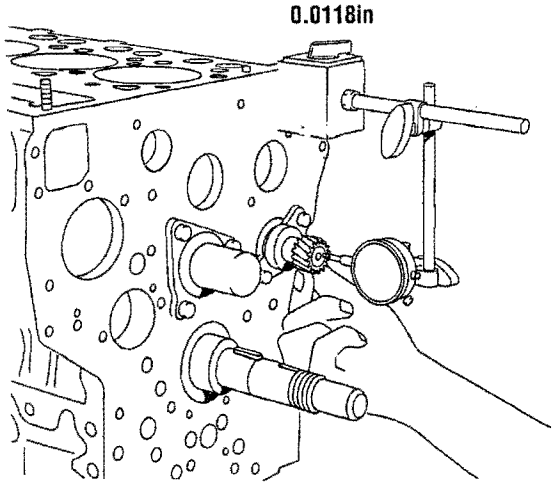
BALANCER SHAFT SIDE CLEARANCE (For Balancer Models Only)

1. Set a dial indicator with the tip on the balancer shaft.
2. Measure the side clearance by moving the balancer shaft to the front and rear.
3. If the measurement exceeds the allowable limit, replace the balancer shaft.

SIDE CLEARANCE OF BALANCER SHAFT

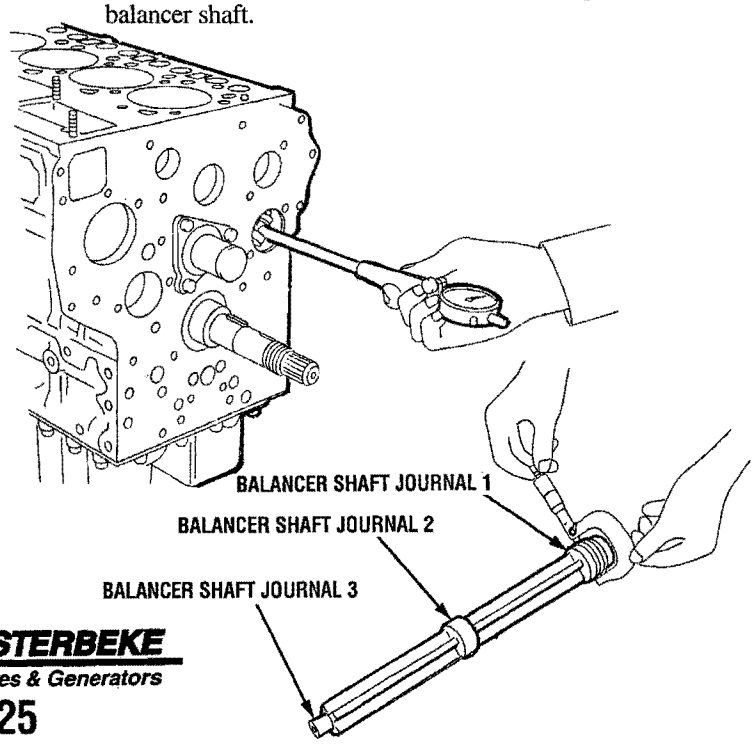
FACTORY SPECIFICATIONS — **0.07 - 0.22mm**
0.0028 - 0.0087in

ALLOWABLE LIMIT — **0.3mm**
0.0118in



OIL CLEARANCE OF THE BALANCER SHAFT JOURNAL (For Balancer Models Only)

1. Measure the balancer shaft journal O.D. with an outside micrometer.
2. Measure the cylinder block bore I.D. for balancer shaft with an inside micrometer or cylinder gauge.
3. If the clearance exceeds the allowable limit, replace the balancer shaft.



(CONT.)

OIL CLEARANCE OF BALANCER SHAFT JOURNAL 1
FACTORY SPECIFICATIONS 0.030 - 0.111mm
0.00118 - 0.00437in

ALLOWABLE LIMIT 0.2mm
0.0079in

BALANCER SHAFT JOURNAL 1 O.D.
FACTORY SPECIFICATIONS 43.934 - 43.950mm
1.72968 - 1.73031in

BALANCER SHAFT JOURNAL 1 I.D.
FACTORY SPECIFICATIONS 43.980 - 44.045mm
1.73149 - 1.73405in

OIL CLEARANCE OF BALANCER SHAFT JOURNAL 2
FACTORY SPECIFICATIONS 0.030 - 0.111mm
0.00118 - 0.00437in

ALLOWABLE LIMIT 0.2mm
0.0079in

BALANCER SHAFT JOURNAL 2 O.D.
FACTORY SPECIFICATIONS 41.934 - 41.950mm
1.65094 - 1.65157in

BALANCER SHAFT JOURNAL 2 I.D.
FACTORY SPECIFICATIONS 41.980 - 42.045mm
1.65275 - 1.65531in

OIL CLEARANCE OF BALANCER SHAFT JOURNAL 3
FACTORY SPECIFICATIONS 0.020 - 0.094mm
0.00079 - 0.00370in

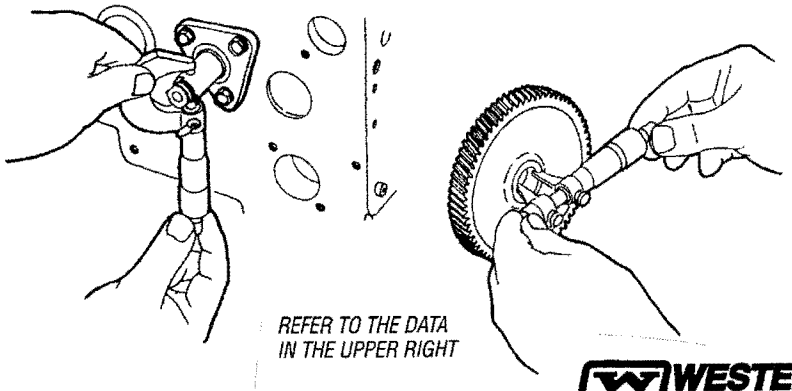
ALLOWABLE LIMIT 0.2mm
0.0079in

BALANCER SHAFT JOURNAL 3 O.D.
FACTORY SPECIFICATIONS 21.947 - 21.960mm
0.86405 - 0.86456in

BALANCER SHAFT JOURNAL 3 I.D.
FACTORY SPECIFICATIONS 21.980 - 22.041mm
0.86535 - 0.86775in

OIL CLEARANCE BETWEEN IDLER GEAR SHAFT AND IDLER GEAR BUSHING

1. Measure the idler gear bushing O.D. with an outside micrometer.
2. Measure the idler gear bushing I.D. with an inside micrometer and calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit, replace the bushing.
4. If it still exceeds the allowable limit, replace the idler gear shaft.



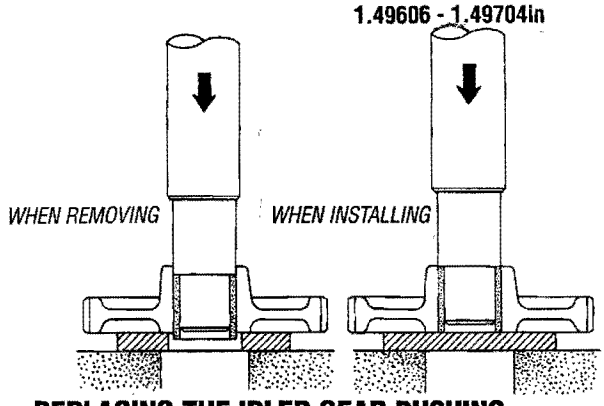
REFER TO THE DATA IN THE UPPER RIGHT

OIL CLEARANCE BETWEEN THE IDLER GEAR SHAFT AND THE IDLER GEAR BUSHING
FACTORY SPECIFICATIONS 0.025 - 0.066mm
0.00098 - 0.00260in

ALLOWABLE LIMIT 0.10mm
0.0039in

IDLER GEAR SHAFT O.D.
FACTORY SPECIFICATIONS 37.959 - 37.975mm
1.49445 - 1.49508in

IDLER GEAR BUSHING I.D.
FACTORY SPECIFICATIONS 38.000 - 38.025mm
1.49606 - 1.49704in



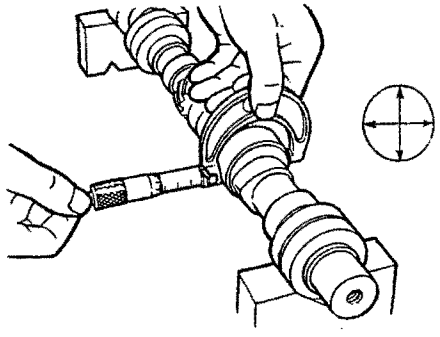
REPLACING THE IDLER GEAR BUSHING

When Removing

1. Press out the used idler gear bushing using an idler gear bushing replacing tool.

When Installing

1. Clean a new idler gear bushing and idler gear bore and apply engine oil to them.
2. Press in a new bushing using an idler gear bushing replacing tool, until it is flush with the end of the idler gear.



CAMSHAFT ALIGNMENT

1. Support the camshaft with V blocks with both ends of the journals sitting on a surface plate.
2. Use a dial indicator or a micrometer.
3. Measure the camshaft alignment.
4. If the measurement exceeds the allowable limit, replace the camshaft.

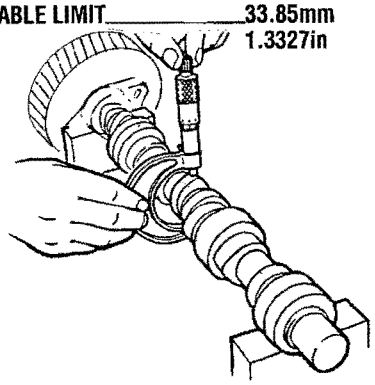
CAMSHAFT ALIGNMENT
ALLOWABLE LIMIT 0.01mm
0.0004in

CAM HEIGHT

1. Measure the height of the cam at its highest point with an outside micrometer.
2. If the measurement is less than the allowable limit, replace the camshaft.

CAM HEIGHT OF INTAKE AND EXHAUST
FACTORY SPECIFICATIONS ____ 33.90mm
1.3346in

ALLOWABLE LIMIT ____ 33.85mm
1.3327in



OIL CLEARANCE OF THE CAMSHAFT JOURNAL

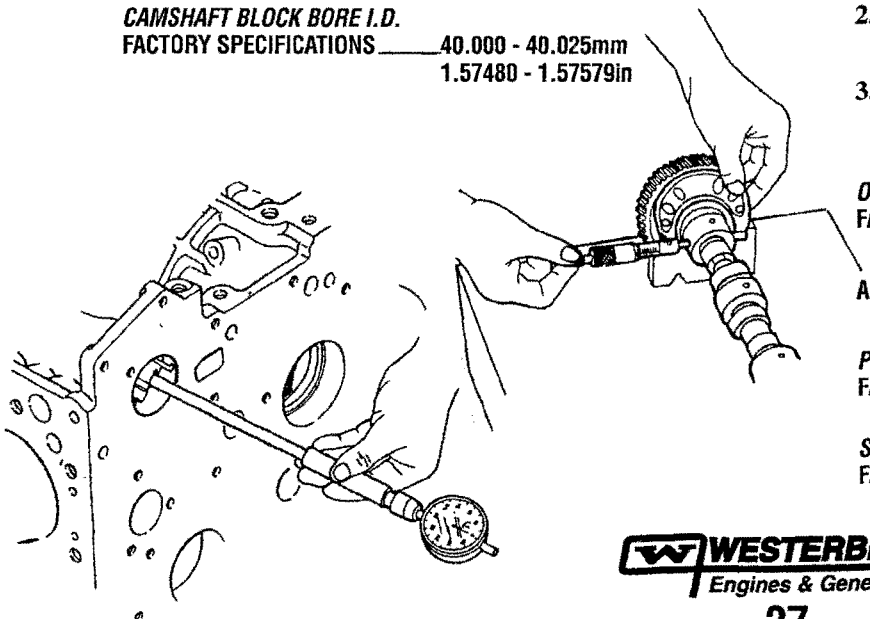
1. Measure the camshaft journal O.D. with an outside micrometer.
2. Measure the cylinder block bore I.D. for the camshaft with a cylinder gauge and calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit, replace the camshaft.

OIL CLEARANCE OF CAMSHAFT JOURNAL
FACTORY SPECIFICATIONS ____ 0.050 - 0.091mm
0.00197 - 0.00358in

ALLOWABLE LIMIT ____ 0.15mm
0.0059in

CAMSHAFT JOURNAL O.D.
FACTORY SPECIFICATIONS ____ 39.934 - 39.950mm
1.57221 - 1.57284in

CAMSHAFT BLOCK BORE I.D.
FACTORY SPECIFICATIONS ____ 40.000 - 40.025mm
1.57480 - 1.57579in

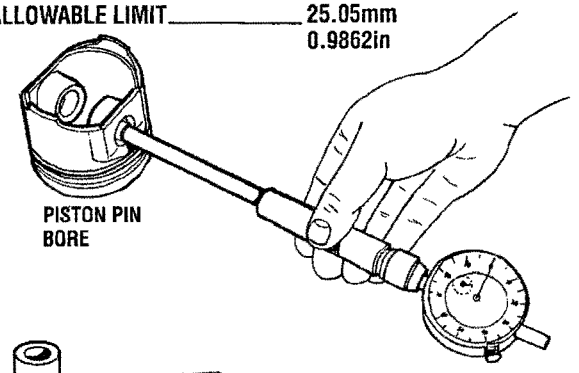


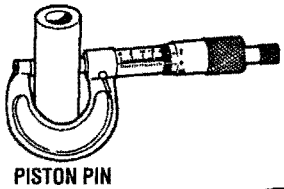
PISTON PIN BORE I.D.

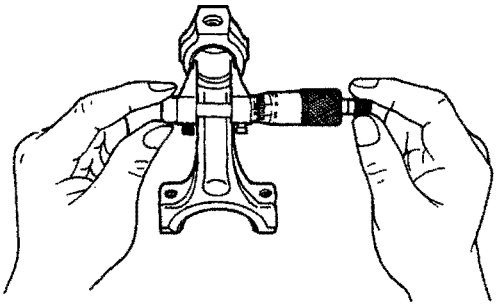
1. Measure the piston pin bore I.D. in both the horizontal and vertical directions with a cylinder gauge.
2. If the measurement exceeds the allowable limit, replace the piston.

PISTON PIN BORE I.D.
FACTORY SPECIFICATIONS ____ 25.00 - 25.013mm
0.98425 - 0.98477in

ALLOWABLE LIMIT ____ 25.05mm
0.9862in







OIL CLEARANCE BETWEEN THE PISTON PIN AND THE SMALL END BUSHING

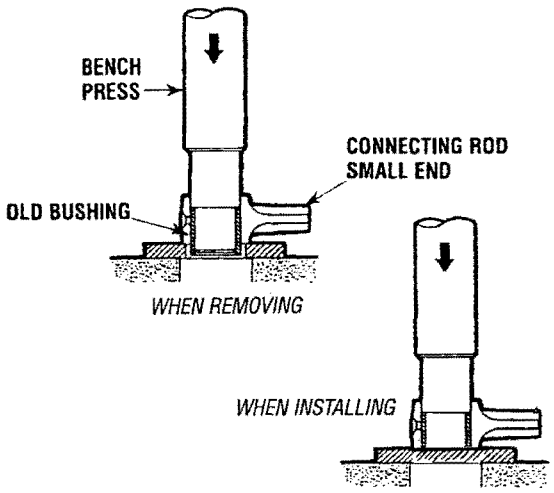
1. Measure the piston pin O.D. where it contacts the bushing with an outside micrometer.
2. Measure the small end bushing I.D. with an inside micrometer and calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit, replace the bushing. If it still exceeds the allowable limit, replace the piston pin.

OIL CLEARANCE BETWEEN PISTON PIN AND SMALL END BUSHING
FACTORY SPECIFICATIONS ____ 0.014 - 0.038mm
0.00055 - 0.00150in

ALLOWABLE LIMIT ____ 0.15mm
0.0059in

PISTON PIN O.D.
FACTORY SPECIFICATIONS ____ 25.002 - 25.011mm
0.98433 - 0.98468in

SMALL END BUSHING I.D.
FACTORY SPECIFICATIONS ____ 25.025 - 25.040mm
0.98523 - 0.98582in



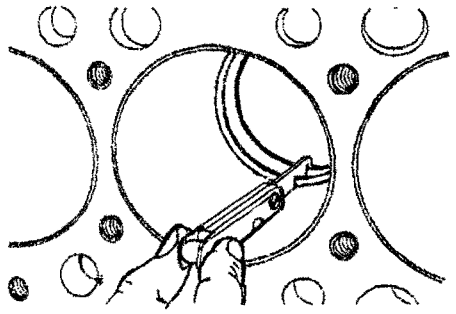
REPLACING THE CONNECTING ROD SMALL END BUSHING

When Removing

1. Press out the small end bushing with a connecting rod small end bushing replacing tool.

When Installing

1. Clean a new small end bushing and bore, apply engine oil to them.
2. Press fit the new bushing, taking care to see that the connecting oil rod hole matches the bushing oil hole.



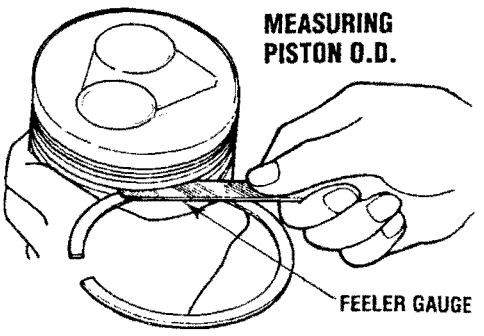
PISTON RING GAP

1. Insert the piston ring into the lower part of the liner (the least worn out part) with the piston.
2. Measure the ring gap with a feeler gauge.
3. If the gap exceeds the allowable limit, replace the ring.

TOP RING
FACTORY SPECIFICATIONS ____ 0.25 - 0.40mm
0.0098 - 0.0157in
ALLOWABLE LIMIT ____ 1.25mm
0.0492in

SECOND RING
FACTORY SPECIFICATIONS ____ 0.30 - 0.45mm
0.0118 - 0.0179in
ALLOWABLE LIMIT ____ 1.25mm
0.0492in

OIL RING
FACTORY SPECIFICATIONS ____ 0.25 - 0.45mm
0.0098 - 0.0177in
ALLOWABLE LIMIT ____ 1.25mm
0.0492in



CLEARANCE BETWEEN PISTON RING AND GROOVE

1. Remove the carbon from the ring grooves.
2. Measure the clearance between the ring and the groove with a feeler gauge or depth gauge.
3. If the clearance exceeds the allowable limit, replace the ring.
4. If the clearance still exceeds the allowable limit after replacing the ring, replace the piston.

SECOND RING
FACTORY SPECIFICATIONS ____ 0.093 - 0.128mm
0.0037 - 0.0050in
ALLOWABLE LIMIT ____ 0.2mm
0.0079in

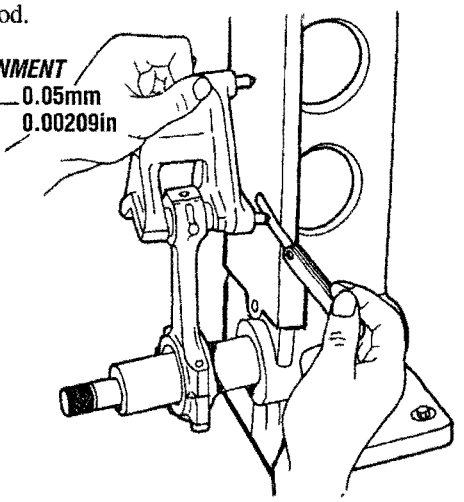
OIL RING
FACTORY SPECIFICATIONS ____ 0.020 - 0.060mm
0.0008 - 0.0021in
ALLOWABLE LIMIT ____ 0.15mm
0.0059in

CONNECTING ROD ALIGNMENT

Since the I.D. of the connecting rod small end bushing is the basis of this check, check the bushing for wear beforehand.

1. Install the piston pin into the connecting rod.
2. Install the connecting rod on the connecting rod alignment tool.
3. Put a gauge over the piston pin and move it against the face plate.
4. If the gauge does not fit squarely against the face plate, measure the space between the pin of the gauge and the face plate.
5. If the measurement exceeds the allowable limit, replace the connecting rod.

CONNECTING ROD ALIGNMENT
ALLOWABLE LIMIT ____ 0.05mm
0.00209in

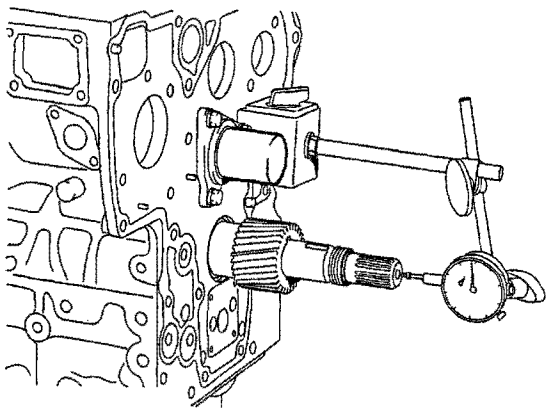


SIDE CLEARANCE OF THE CRANKSHAFT

1. Move the crankshaft to the flywheel side.
2. Set a dial indicator on the crankshaft.
3. Measure the end play by pulling the crankshaft toward the crank gear.
4. If the measurement exceeds the allowable limit, replace the thrust bearing 1 and 2.

CRANKSHAFT SIDE CLEARANCE

FACTORY SPECIFICATIONS	0.15 - 0.31mm 0.0059 - 0.0122in
ALLOWABLE LIMIT	0.5mm 0.0197in



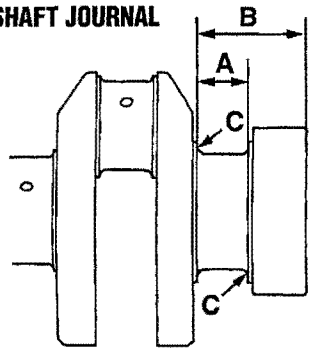
OVERSIZE DIMENSIONS OF CRANKSHAFT JOURNAL

OVERSIZE	0.2mm 0.008in	0.4mm 0.016in
DIMENSION A	26.20 - 26.25mm 1.0315 - 1.0335in	26.40 - 26.45mm 1.0394 - 1.0413in
DIMENSION B	54.5 - 54.7mm 2.1456 - 2.1535in	54.6 - 54.8mm 2.1496 - 2.1574in
DIMENSION C (RADIUS)	2.8 - 3.2mm 0.1102 - 0.1260in	2.8 - 3.2mm 0.1102 - 0.1260in

The crankshaft journal must be fine-finished to higher than (0.8-S)

▽▽ ▽▽

CRANKSHAFT JOURNAL

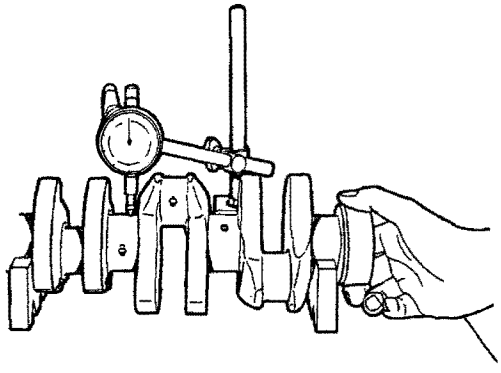


CRANKSHAFT ALIGNMENT

1. Support the crankshaft with V blocks on a surface plate and set a dial indicator with its tip on the intermediate journal at a right angle.
2. Rotate the crankshaft on the V blocks and get the misalignment (half the measurement).
3. If the misalignment exceeds the allowable limit, replace the crankshaft.
4. If the measurement exceeds the allowable limit, replace the thrust bearing 1 and 2.

CRANKSHAFT ALIGNMENT

ALLOWABLE LIMIT	0.02mm 0.00079in



OIL CLEARANCE BETWEEN THE CRANKPIN AND THE CRANKPIN BEARING

1. Clean the crankpin and crankpin bearing.
2. Put a strip of plastigage on the center of the crankpin in each direction as shown.
3. Install the connecting rod cap and tighten the connecting rod screws to the specified torque and remove the cap again.
4. Measure the amount of the flattening with the scale to get the oil clearance.
5. If the oil clearance exceeds the allowable limit, replace the crankpin bearing.
6. If the same size bearing is useless because of the crankpin wear, replace it with an undersize bearing, referring to the specifications below.

Never insert the plastigage into the crankpin oil hole.

Be sure not to move the crankshaft while the connecting rod screws are tightened.

OIL CLEARANCE BETWEEN CRANKPIN AND CRANKPIN BEARING

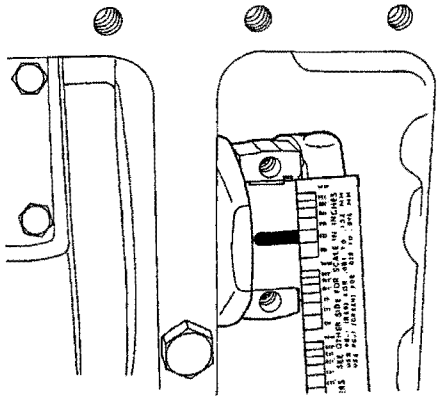
FACTORY SPECIFICATIONS	0.025 - 0.087mm 0.00098 - 0.000343in
ALLOWABLE LIMIT	0.2mm 0.0079in

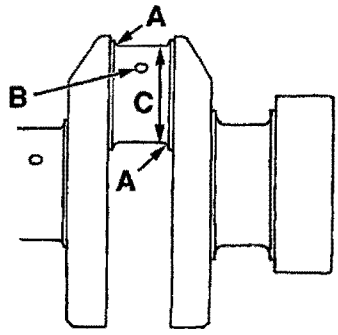
CRANKPIN O.D.

FACTORY SPECIFICATIONS	46.959 - 46.975mm 1.84878 - 1.84941in

CRANKPIN BEARING I.D.

FACTORY SPECIFICATIONS	47.000 - 47.046mm 1.85039 - 1.85220in





UNDERSIZE DIMENSIONS OF CRANKPIN

UNDERSIZE	0.2mm 0.008in	0.4mm 0.016in
DIMENSION A (RADIUS)	3.3 - 3.7mm 0.1299 - 0.1457in	3.3 - 3.7mm 0.1299 - 0.1457in
DIMENSION B (RADIUS)	1.0 - 1.5mm 0.0394 - 0.0591in	1.0 - 1.5mm 0.0394 - 0.0591in
DIMENSION C (DIA.)	46.759 - 46.775mm 1.84091 - 1.84154in	46.559 - 46.575mm 1.83303 - 1.83366in

The crankpin must be fine-finished to higher than (0.8-S)
▽▽ ▽▽

OIL CLEARANCE BETWEEN THE CRANKSHAFT JOURNAL AND THE CRANKSHAFT BEARING 1

1. Measure the O.D. of the crankshaft journal with an outside micrometer.
2. Measure the I.D. of the crankshaft bearing 1 with an inside micrometer and calculate the oil clearance.
3. If the clearance exceeds the allowable limit, replace crankshaft bearing 1.
4. If the same size bearing is useless because of the crankshaft journal wear, replace it with an undersize bearing referring to the specifications below.

Be sure not to move the crankshaft while the bearing case screws are tightened.

OIL CLEARANCE BETWEEN CRANKSHAFT AND CRANKSHAFT BEARING 1

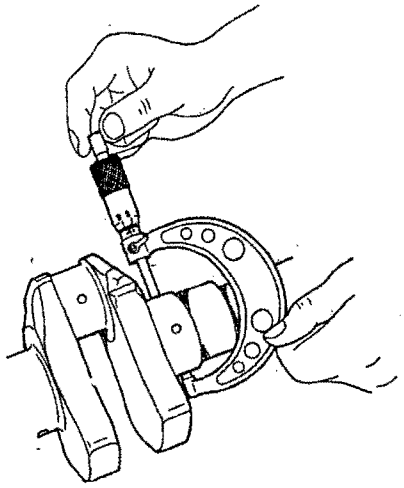
FACTORY SPECIFICATIONS	0.040 - 0.118mm 0.00157 - 0.00465in
ALLOWABLE LIMIT	0.20mm 0.0079in

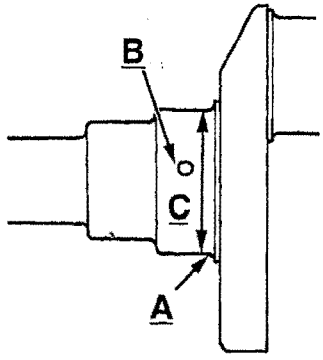
CRANKSHAFT O.D.

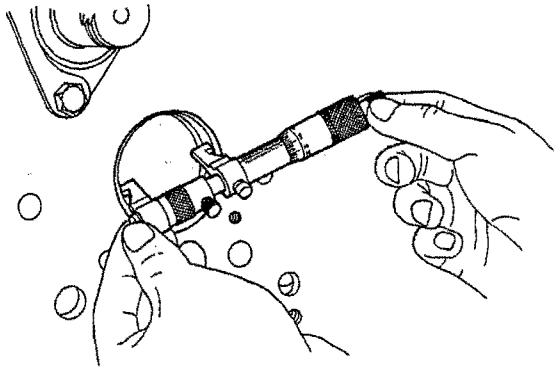
FACTORY SPECIFICATIONS	59.921 - 59.940mm 2.35909 - 2.35984in

CRANKSHAFT BEARING 1 I.D.

ALLOWABLE LIMIT	59.980 - 60.039mm 2.36142 - 2.36374in







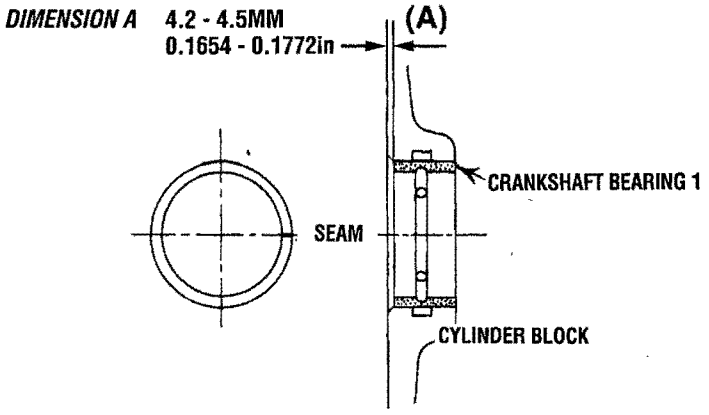
REPLACING THE CRANKSHAFT BEARING 1

When Removing

1. Press out the used crankshaft bearing 1 using a crankshaft bearing 1 replacing tool.

When Installing

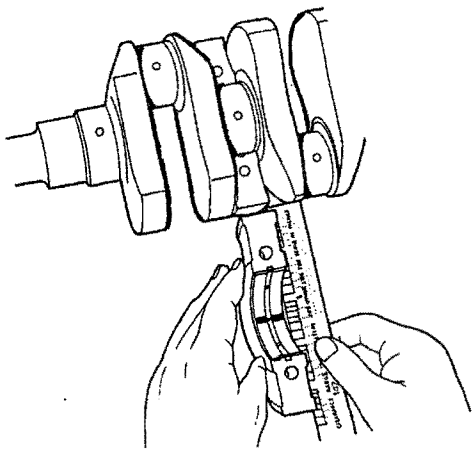
1. Clean a new crankshaft bearing 1 and crankshaft journal bore, apply engine oil to them.
2. Using a crankshaft bearing 1 replacing tool, press in a new bearing 1 so that its seam directs toward the exhaust manifold side.



UNDERSIZE DIMENSIONS OF CRANKSHAFT JOURNAL

UNDERSIZE	0.2mm 0.008in	0.4mm 0.016in
DIMENSION A (RADIUS	2.8 - 3.2mm 0.1102 - 0.1260in	2.8 - 3.2mm 0.1102 - 0.1260in
DIMENSION B (RADIUS)	1.0 - 1.5mm 0.0394 - 0.0591in	1.0 - 1.5mm 0.0394 - 0.0591in
DIMENSION C,D	59.721 - 59.740mm 2.35122 - 2.35197in	59.521 - 59.540mm 2.34335 - 2.34409in

The crankshaft journal must be fine-finished to higher than (0.8-S)



OIL CLEARANCE BETWEEN THE CRANKSHAFT JOURNAL AND THE CRANKSHAFT BEARING 2

1. Put a strip of plastigage on the center of the journal.
2. Install the bearing case and tighten the bearing case screws to the specified torque and remove the bearing case agaiun.
3. Measure the amount of the flattening with the scale to get the oil clearance.
4. If the clearance exceeds the allowable limit, replace crankshaft bearing 2.
5. If the same size bearing is useless because of the crankshaft journal wear, replace it with an undersize bearing referring to the specifications below.

Be sure not to move the crankshaft while the bearing case screws are tightened.

OIL CLEARANCE BETWEEN CRANKSHAFT AND CRANKSHAFT BEARING 2

FACTORY SPECIFICATIONS 0.040 - 0.104mm
0.00157 - 0.00409in

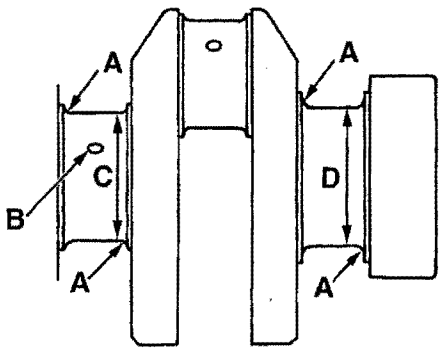
ALLOWABLE LIMIT 0.20mm
0.0079in

CRANKSHAFT O.D.

FACTORY SPECIFICATIONS 59.921 - 59.940mm
2.35909 - 2.35984in

CRANKSHAFT BEARING 2 I.D.

FACTORY SPECIFICATIONS 59.980 - 60.025mm
2.36142 - 2.363180in



REFER TO THE DATA IN THE UPPER RIGHT

UNDERSIZE DIMENSIONS OF CRANKSHAFT JOURNAL

UNDERSIZE	0.2mm 0.008in	0.4mm 0.016in
DIMENSION A (RADIUS	2.8 - 3.2mm 0.1102 - 0.1260in	2.8 - 3.2mm 0.1102 - 0.1260in
DIMENSION B (RADIUS)	1.0 - 1.5mm 0.0394 - 0.0591in	1.0 - 1.5mm 0.0394 - 0.0591in
DIMENSION C,D	59.721 - 59.740mm 2.35122 - 2.35197in	59.521 - 59.540mm 2.34335 - 2.34409in

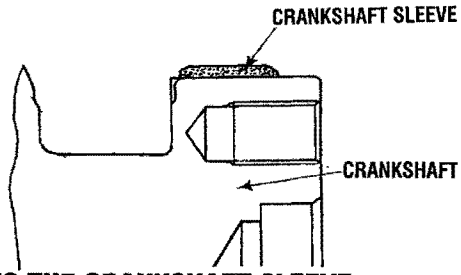
The crankshaft journal must be fine-finished to higher than (0.8-S)

CRANKSHAFT SLEEVE WEAR

1. Check the wear on the crankshaft sleeve.
2. If the wear exceeds the allowable limit or if the engine oil leaks, replace the crankshaft sleeve.

WEAR OF SLEEVE

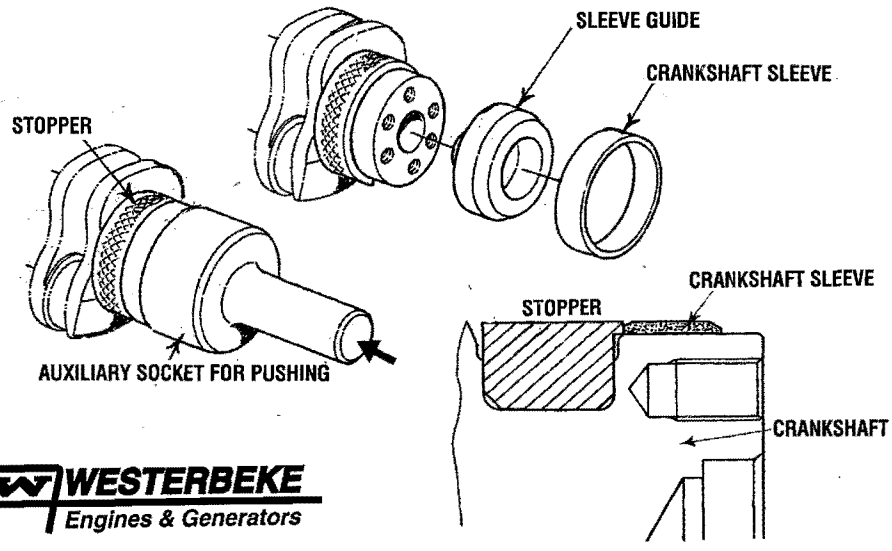
ALLOWABLE LIMIT 0.1mm
0.00039in



REPLACING THE CRANKSHAFT SLEEVE

1. Remove the used crankshaft sleeve using a special puller set.
2. Set the sleeve guide to the crankshaft.
3. Set the stopper to the crankshaft as shown.
4. Heat a new sleeve to a temperature between 150° - 200°C (302° - 392° F)
5. Press fit the sleeve using the auxiliary socket for pushing.

Mount the sleeve with its largely chamfered surface facing outward.

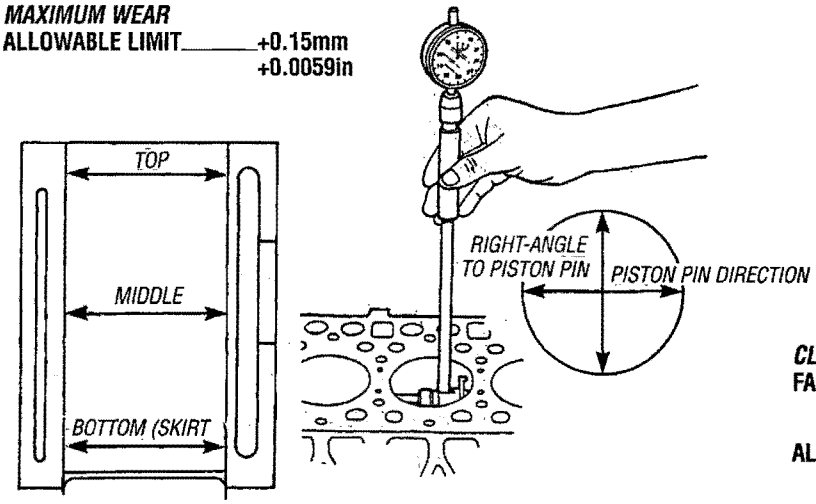


CYLINDER WEAR

1. Measure the I.D. of the cylinder at the six positions with a cylinder gauge to find the maximum and minimum I.D.
2. Get the difference (maximum wear) between the maximum and the minimum I.D.
3. If the wear exceeds the allowable limit, bore and hone to the oversize dimension. Refer to *CORRECTING THE CYLINDER.*
4. Visually check the cylinder wall for scratches. If deep scratches are found, the cylinder should be bored.

CYLINDER I.D.
FACTORY SPECIFICATIONS ____ **87.000 - 87.022mm**
3.42519 - 3.42606in

MAXIMUM WEAR
ALLOWABLE LIMIT ____ **+0.15mm**
+0.0059in



CORRECTING THE CYLINDER (Oversize +0.25mm)

1. When the cylinder is worn beyond the allowable limit, bore and hone it to the specified dimension.

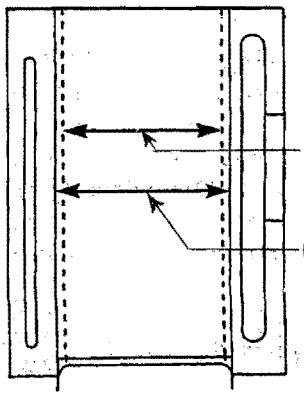
OVERSIZE CYLINDER I.D.
FACTORY SPECIFICATIONS ____ **87.250 - 87.272mm**
3.43503 - 3.43590in

MAXIMUM WEAR
ALLOWABLE LIMIT ____ **+0.15mm**
+0.0059in

FINISHING
HORN TO 2.2 - 3.0 UM Rmax
0.00087 - 0.00118 in Rmax ▽▽ ▽▽

2. Replace the piston and piston rings with oversize (+0.25mm) ones.

When the oversize cylinder is worn beyond the allowable limit, sleeve the block to standard dimensions.

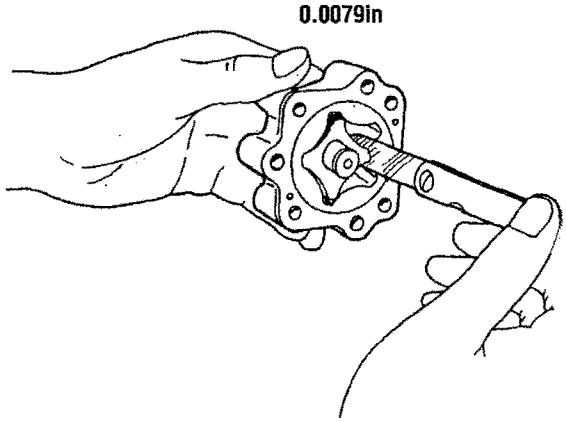


ROTOR LOBE CLEARANCE

1. Measure the clearance between the lobes of the inner rotor and outer rotor with a feeler gauge.
2. Measure the clearance between the outer rotor and the pump body with a feeler gauge.
3. If the clearance exceeds the factory specifications, replace the oil pump rotor assembly.

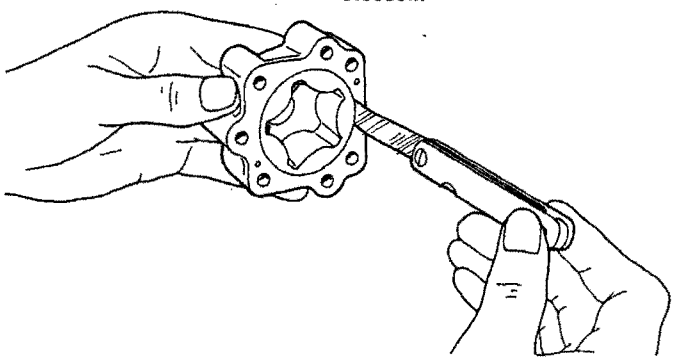
CLEARANCE BETWEEN THE INNER ROTOR AND OUTER ROTOR
FACTORY SPECIFICATIONS ____ **0.03 - 0.14mm**
0.0012 - 0.0055in

ALLOWABLE LIMIT ____ **0.2mm**
0.0079in

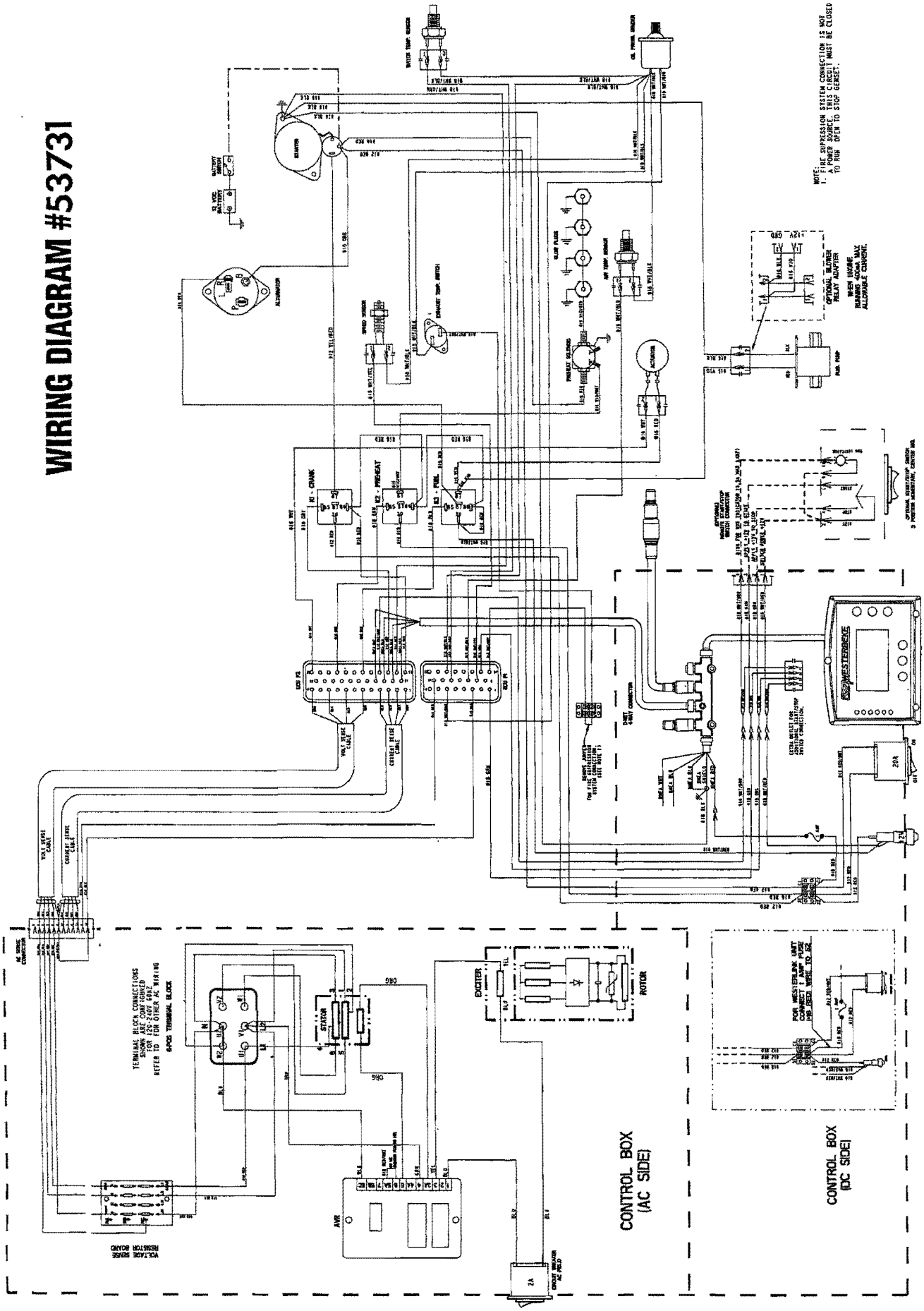


CLEARANCE BETWEEN THE OUTER ROTOR AND PUMP BODY
FACTORY SPECIFICATIONS ____ **0.11 - 0.19mm**
0.0012 - 0.0055in

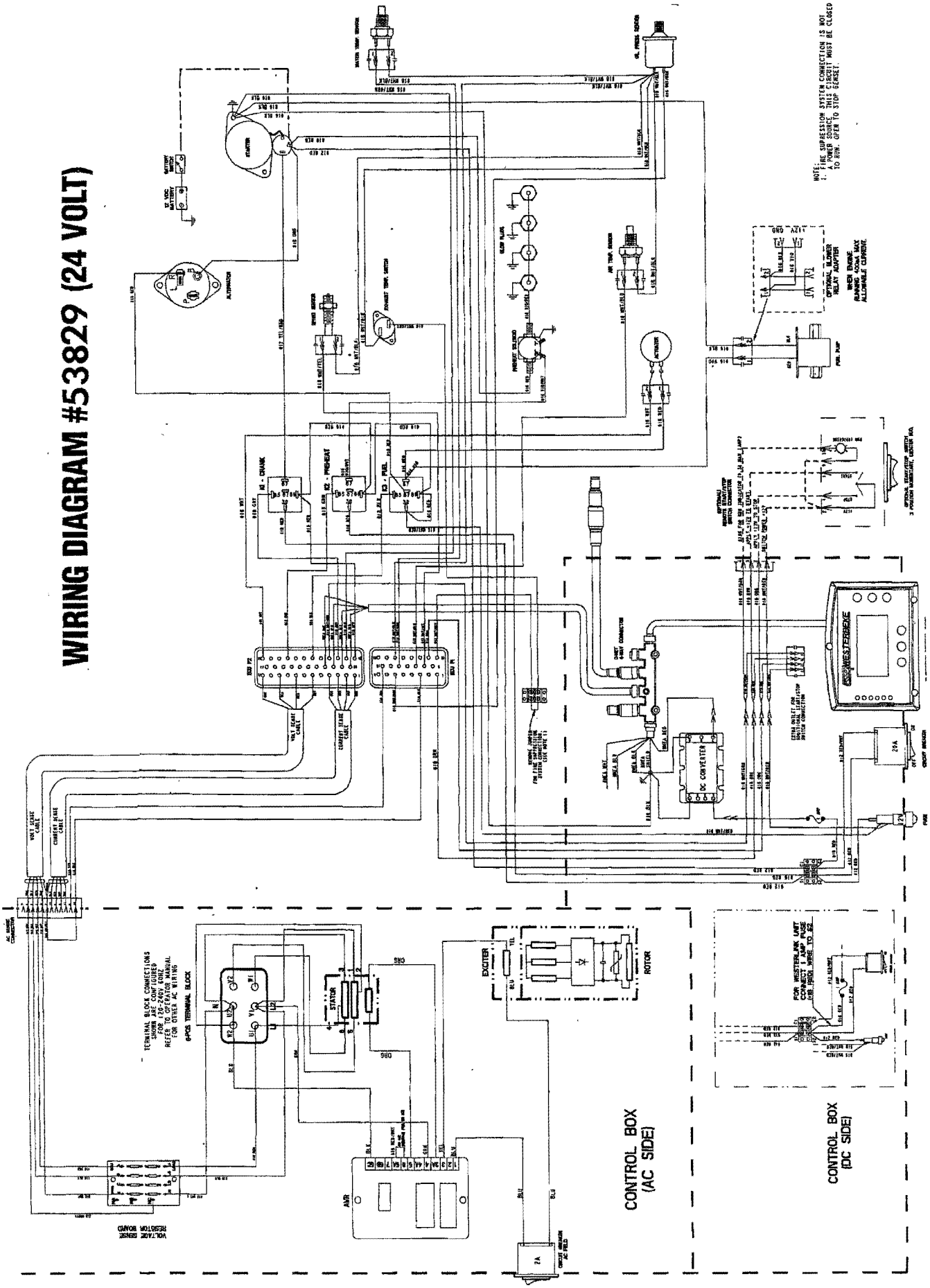
ALLOWABLE LIMIT ____ **0.25mm**
0.0098in



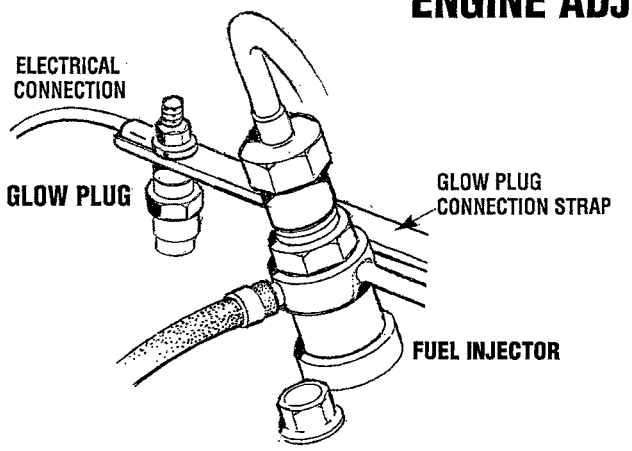
WIRING DIAGRAM #53731



WIRING DIAGRAM #53829 (24 VOLT)



ENGINE ADJUSTMENTS



GLOW PLUGS

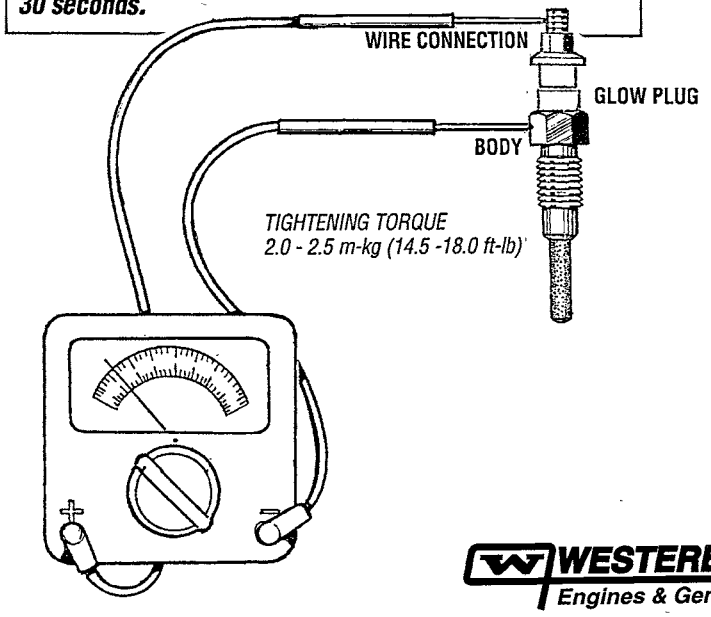
> ⚠ **WARNING:** ***These glow plugs will become very hot to the touch. Be careful not to burn your fingers when testing plugs.***

To inspect the plug, remove the electrical terminal connections, then unscrew or unclamp each plug from the cylinder head. Thoroughly clean each plug's tip and threads with a soft brush and cleaning solution to remove all the carbon and oil deposits. While cleaning, examine the tip for wear and burn erosion; if it has eroded too much, replace the plug.

An accurate way to test glow plugs is with an ohmmeter. Touch one prod to the glow plug's wire connection, and the other to the body of the glow plug, as shown. A good glow plug will have a 0.9 ohm resistance. This method can be used with the plug in or out of the engine. You can also use an ammeter to test the power drain (13 amps per plug).

Re-install the plugs in the engine and test them again. The plugs should get very hot (at the terminal end) within 5 to 10 seconds. If the plugs don't heat up quickly, check for a short circuit. When reinstalling the glow plugs, use anti-seize compound on the threads.

> ⚠ **CAUTION:** ***Do not keep glow plug on for more than 30 seconds.***



Drive belt adjustment. Proper inspection, service and maintenance of the drive belts is important for the efficient operation of your engine.

Drive belts must be properly tensioned. Loose drive belts will not provide proper alternator charging and will eventually damage the alternator. Drive belts that are too tight will pull the alternator out of alignment and/or cause the alternator to wear out prematurely. Excessive drive belt tension can also cause rapid wear of the belt and reduce the service life of the coolant pump's bearing. A slack belt or the presence of oil on the belt can cause belt slipping, resulting in high operating temperatures and tachometer variations.

The drive belt is properly adjusted if the belt 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. A spare belt or belts should always be carried on board.

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

Adjusting Belt Tension

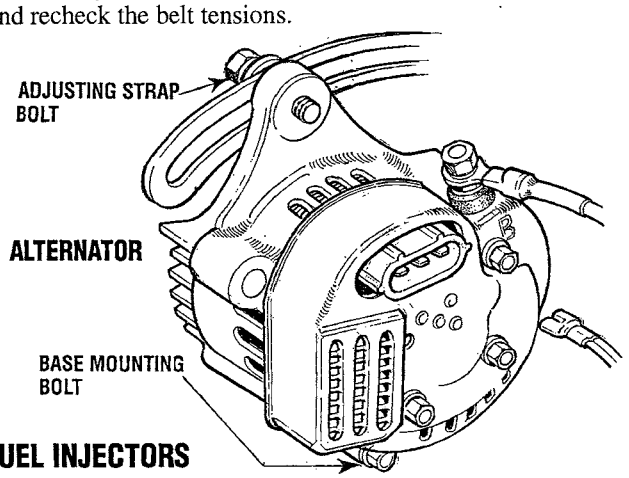
a. Loosen the alternator adjusting strap bolt and the base mounting bolt.

b. With the belt loose, inspect for wear, cracks and frayed edges.

c. Pivot the alternator on the base mounting bolt to the left or right as required, to loosen or tighten.

d. Tighten the base mounting bolt and the adjusting strap bolt.

e. Run the engine for about 5 minutes, then shut down and recheck the belt tensions.



FUEL INJECTORS

In case of severe vibrations and detonation noise, have the injectors checked and overhauled by an authorized fuel injection service center. Poor fuel quality, contaminant's and loss of positive fuel pressure to the injection pump can result in injector faults. Since fuel injectors must be serviced in a clean room environment, it is best to carry at least one extra injector as a spare should a problem occur. **Refer to the following page for injector testing.**

ENGINE ADJUSTMENTS

REMOVING THE INJECTORS

NOTE: *Injector must be serviced in a "clean room" environment.*

1. Disconnect the high pressure lines from the injectors and loosen the lines at their attachment to the injection pump and move them out of the way of the injectors. Avoid bending the lines.
2. Using a 17mm long socket, remove the fuel return line in its entirety from the top of the injectors. Take care not to lose the two sealing washers and banjo bolt that attaches the fuel return line to each injector.

   NOTE: *Clean the area around the base of the injector prior to lifting it out of the cylinder head to help prevent any rust or debris from falling down into the injector hole. If the injector will not lift out easily and is held in by carbon build up or the like, work the injector side to side with the aid of the 17mm deep socket wrench to free it and then lift it out.*
3. The injector seats in the cylinder head on a copper sealing washer. This washer should be removed with the injector and replaced with a new washer when the injector is reinstalled.

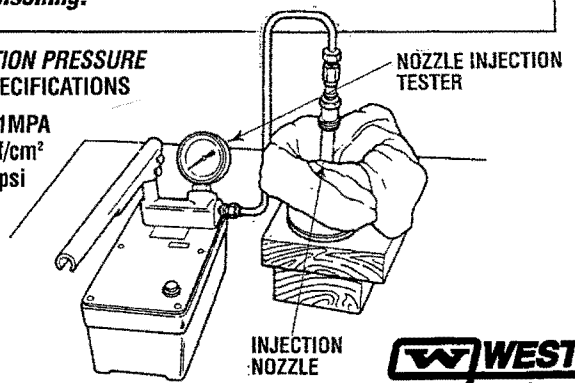
INJECTION TESTING

1. Using the nozzle tester, check the spray pattern and injection starting pressure of nozzle and, if it exceeds the limit, adjust or replace the nozzle. When using nozzle tester, take the following precautions:
   a. If the diesel fuel of the nozzle tester is discolored, replace it. At the same time, clean or replace the filter.
   b. Set the nozzle tester in a clean place where there is no dust or dirt.
   c. Mount the nozzle and nozzle holder on the nozzle tester.
   d. Use the fuel at the approximate temperature of 68° F (20° C)
   e. Operate the hand lever of nozzle tester several times to bleed the air in the nozzle line, then move the hand lever at intervals of one stroke per second while reading the injection starting pressure.

⚠ CAUTION: ***The spray injected from the nozzle is of such velocity that it may penetrate deeply into the skin of fingers and hands, destroying tissue. If it enters the bloodstream, it may cause blood poisoning.***

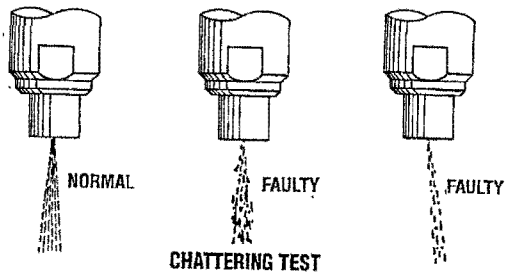
FUEL INJECTION PRESSURE
FACTORY SPECIFICATIONS

13.73 - 14.71MPA
140 - 150 kgf/cm²
1991 - 2134 psi



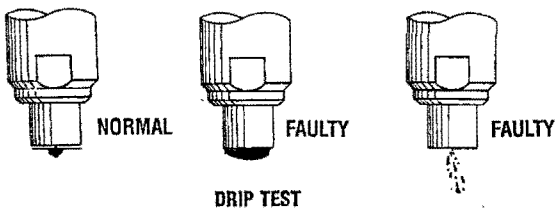
Inspecting Spray Pattern

1. Operate the hand lever of the nozzle tester at intervals of one stroke per second to check if the fuel is injected correctly in its axial direction. A nozzle is defective if it injects fuel in an oblique direction or in several separate strips. Also, a spray in the form of particles indicates a defect. These defects may sometimes be caused by clogging with dust and, therefore, all parts should be carefully cleaned before reassembly. (Care should be taken not to expose ones skin to this spray as it may penetrate the skin and cause infection.)



CHATTERING TEST

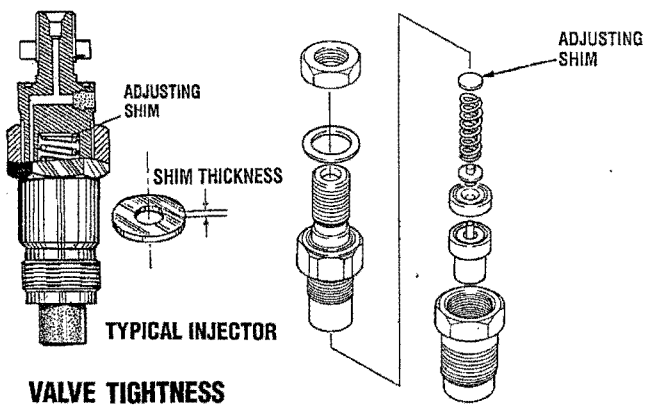
2. Apply the pressure of 1991 kg/cm² (140 lb/in²) to nozzle by operating the hand lever, and check the drips from the nozzle tip. If it drips or has a large accumulation of fuel on the bottom, it is considered defective and should be replaced. A very small amount of fuel may sometimes remain on the tip of the nozzle; however, this does not indicate a defect.



DRIP TEST

The injection starting pressure for the injectors is adjusted by increasing or decreasing the thickness of the adjusting shim.

Pressure variation with 0.01mm (0.004in) difference of adjusting washer thickness. 235 kPa (2.4 kgf/cm², 4 psi)



TYPICAL INJECTOR

VALVE TIGHTNESS

1. Set the injector nozzle to a nozzle tester.
2. Raise the fuel pressure and keep it at 12.75 MPa (130kgf/cm², 1849 psi) for 10 seconds.
3. If a fuel leak is found, replace the nozzle piece.

FACTORY SPECIFICATIONS
No fuel leak at: 12.75MPA
130 kgf/cm²
1849 psi

CHECKING VALVE CLEARANCE

Valve clearance must be checked and adjusted when engine is cold.

1. Remove the head cover.
2. Align the **ITC** mark line on the flywheel and projection on the housing so that the No.1 piston comes to the compression or overlap top dead center.
3. Check the following valve clearance (1) marked with ☆ using a feeler gauge.
4. If the clearance is not within the factory specification, adjust with the adjusting screw.

VALVE CLEARANCE 0.18 - 0.22mm (0.0071 - 0.0087 in)

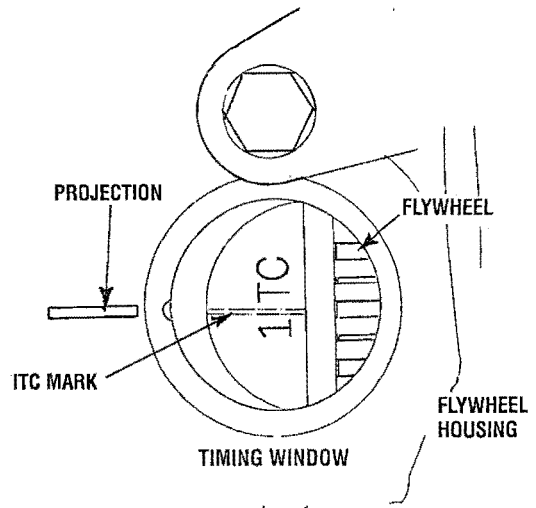
The **TC** marking line on the flywheel is just for the No. 1 There is no **TC** marking for the other cylinders. The No.1 piston comes to the top dead center position when the **TC** marking is aligned with the projection in the window on the flywheel-housing. Turn the flywheel 0.26 radius (15°) clockwise and counterclockwise to see if the piston is at the compression top dead center or the overlap position. Now, referring to the table below, readjust the valve clearance. The piston is at the top dead center when both the IN. and EX. valves do not move. It is at the overlap position when both the valves move.

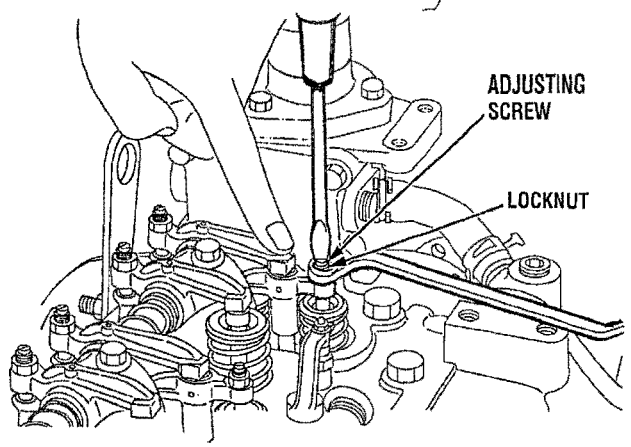
Finally, turn the flywheel 6.28 radius (360°) and align the **TC** marking and the projection perfectly. Adjust all the other valve clearances as required.

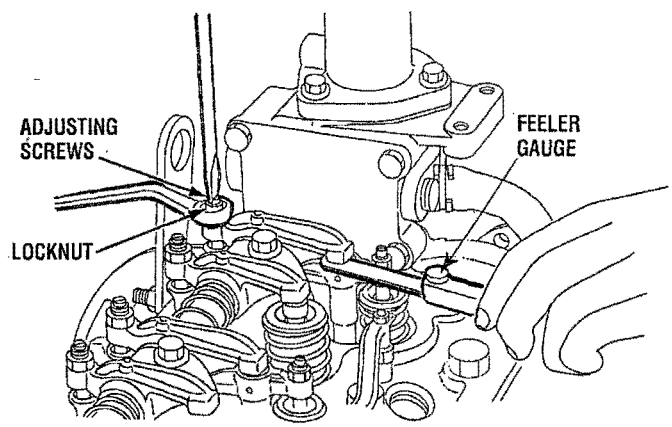
After turning the flywheel counterclockwise twice or three times, recheck the valve clearance.

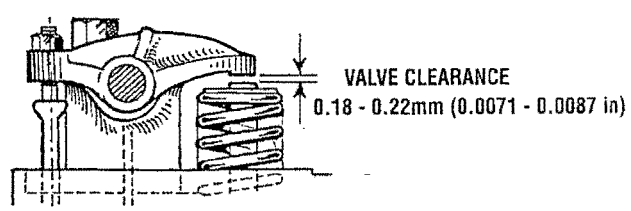
After adjusting the valve clearance, firmly tighten the locknut of the adjusting screw.

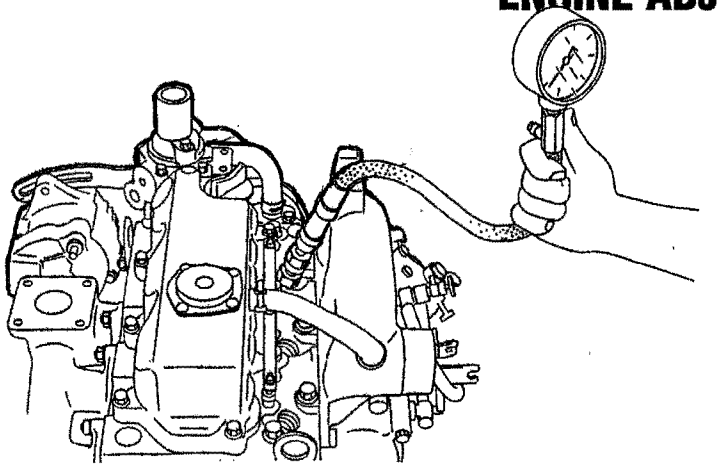
Adjustable cylinder location of piston		Valve arrangement			
		3 CYL.		4 CYL.	
		IN.	EX.	IN.	EX.
When No. 1 piston is compression top dead center	No. 1	☆	☆	☆	☆
	No. 2		☆	☆	
	No. 3	☆			☆
	No. 4	—	—		
When No. 1 piston is overlap position	No. 1				
	No. 2	☆			☆
	No. 3		☆	☆	
	No. 4	—	—	☆	☆











TESTING ENGINE COMPRESSION

Check the compression pressure. To do this warm the engine, remove all fuel injectors, or glow plugs, disconnect the fuel shut-off solenoid wire, and install a compression adapter in the injector hole or glow plug hole. Connect a compression tester on the adapter and crank the engine with the starter motor until the pressure reaches a maximum value. Repeat this process for each cylinder. Look for cylinders with dramatically (at least 20%) lower compression than the average of the others. Compression pressure should not differ by more than 35.5 psi (2.5 kg/cm²) at 280 rpm.

STANDARD COMPRESSION PRESSURE 512 - 583 PSI (370 PSI LIMIT)

If a weak cylinder is flanked by healthy cylinder, the problem is either valve or piston related. Check the valve clearances for the weak cylinder, adjust as needed and test again. If the cylinder is still low, apply a small amount of oil into the cylinder to seal the rings and repeat the test. If compression comes up - the rings are faulty.

Abnormally high readings on all cylinders indicates heavy carbon accumulations, a condition that might be accompanied by high pressures and noise.

NOTE: *In case of severe vibrations and detonation noise, the cause may be fuel injector problems, see* FUEL INJECTORS. *Poor fuel quality, contaminates and loss of positive fuel pressure to the injection pump will result in injector faults.*

When re-installing the glow plugs use anti-seize compound.

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

TESTING OIL PRESSURE

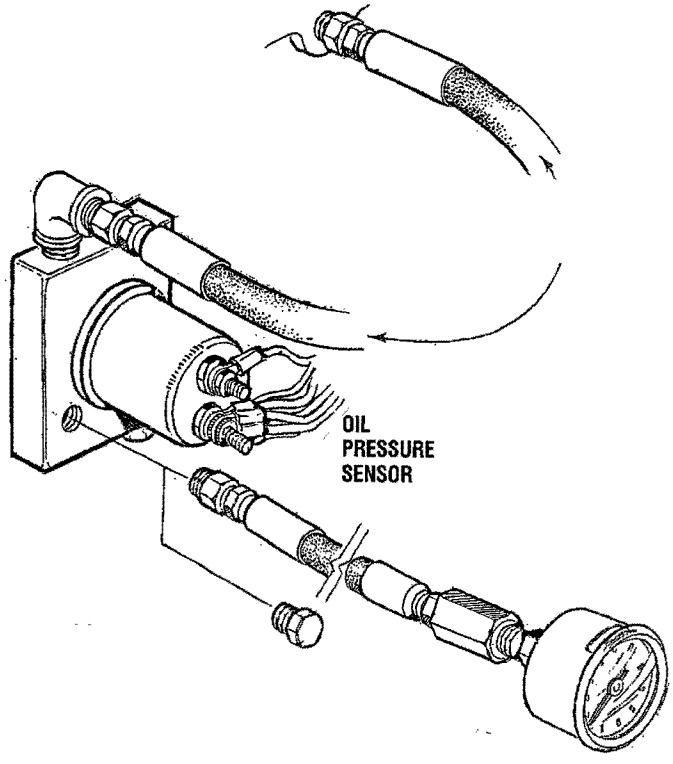
To test oil pressure, remove the hex head plug from the oil gallery and install a mechanical oil pressure gauge in its place. After warming up the engine, set the engine speed at 1800 rpm and read the oil pressure gauge.

OIL PRESSURE BETWEEN 30 AND 40 PSI AT 1800/1500 RPM

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

OIL PRESSURE SENSOR

An oil pressure sensor is mounted on the oil manifold for the engine. It sends a voltage signal to the ECU that is interpreted as pressure. Should this signal fall below a set point in the ECU, the ECU will open the K2 run relay, shutting the unit down. It will then display the fault on the LCD Display screen. Engine oil pressure dropping 10 -15 psi will cause this to occur.



ENGINE ADJUSTMENTS

TESTING THE MAGNETIC PICK UP COIL

Test the speed sensor connector for voltage and resistance values.

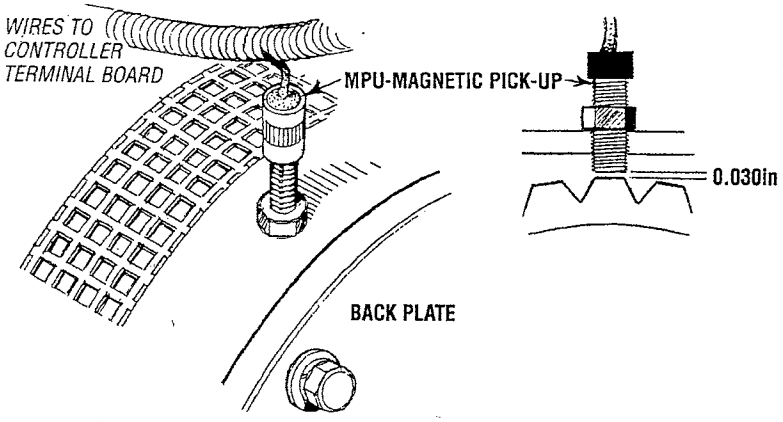
If the values are correct, remove and inspect the magnetic pick up. With the wires disconnected, unscrew the magnetic pick up from the generator housing and visually inspect the contact end. If any damage is detected, replace the unit.

NOTE: *Carefully follow the installation instructions provided with the new magnetic pick up coil.*

SPEED SENSOR TEST VALUES
VOLTAGE (while cranking)

1.5 - 2.5 VAC

RESISTANCE (at rest) **950 - 1000 ohm**



MAGNETIC PICK-UP [MPU] INSTALLATION

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

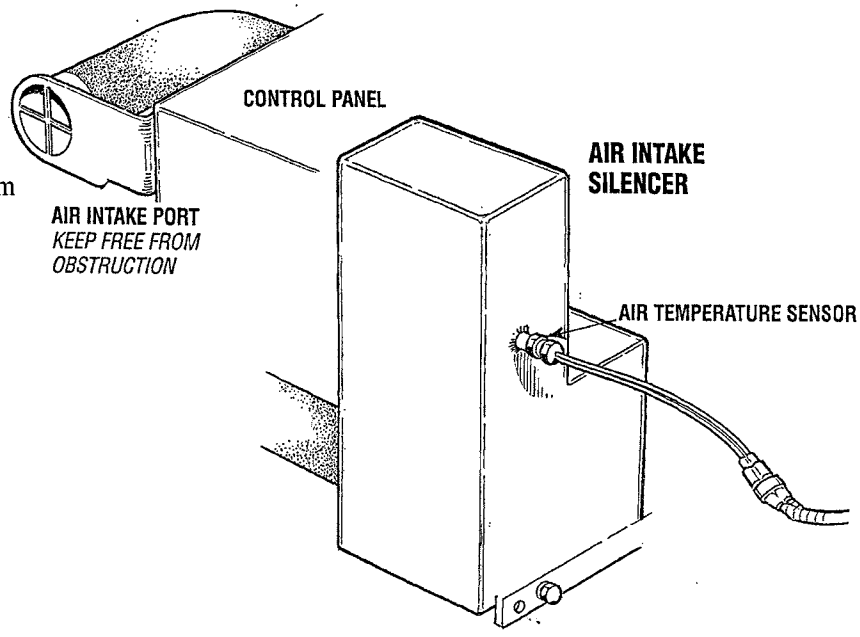
To ensure the MPU is positioned correctly, slowly rotate the crankshaft by 360° by hand to assure there is no physical contact between the MPU and the ring gear teeth.

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

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

AIR INTAKE/SILENCER

The air intake port supplies air to the control panel electronics. This air flow continues to the engines air intake/silencer to supply fresh air to the engine. This system requires no maintenance but during a general overhaul, compressed air can be used to flush out any accumulated debris.



NOTE: Pages 41 and 42 were intentionally removed from this manual.

SPECIFICATIONS 17.0/13.5 EDE

ENGINE SPECIFICATIONS

Engine Type	Diesel, four-cycle, three-cylinder, fresh water-cooled, vertical in-line overhead valve mechanism.
Aspiration	Naturally aspirated
Compression Ratio	23.8:1
Governor	Electronic
Combustion Chamber	Spherical type
Bore & Stroke	87 x 92.4 mm (3.43 x 3.64 inches)
Piston Displacement	2.19 liters (134.07 cubic inches)
Fuel Consumption at rated amperage outlet	1.50 gph (5.7 lph) at 1800 pm 1.22 gph (4.6 lph) at 1500 rpm
HP @ 1800/1500 RPM	38.0/25.6
Engine Combustion Air Requirements	1800 rpm 58 cfm (1.64 cmm) 1500 rpm 48 cfm (1.36 cmm)
Firing Order	1 - 2 - 4
Inclination	Continuous 20° Temporary 30° (not to exceed 10 min.)
Weight (dry)	829 lbs (376.0 kgs)

TUNE-UP SPECIFICATIONS

Compression Pressure (allowable limit)	512 - 583 psi (36 - 41 kgf/cm²) at 250 rpm 370 psi (26 kgf/cm²) at 250 rpm
Variation between cylinders	10% or less
Injection Timing	18° BTDC
Engine Speed	1800 rpm 60 Hertz 1500 rpm 50 Hertz
Valve Clearance (engine cold)	0.23 to 0.27 mm (0.00091 to 0.0106 inches)
Injector Pressure	1991 to 2134 psi (140 to 150 kgf/cm²)
Valve Timing	Intake Opens 14° BTDC Intake Closes 36° ABDC Exhaust Opens 45° BBDC Exhaust Closes 17° ATDC

ELECTRICAL SYSTEM

Starting Battery	12-Volt DC (-) negative ground
Battery Capacity	800-1000 CCA
DC Charging Alternator	40 Amp rated, belt-driven
Starter	2.0 Kw, 12VDC direct drive
Starting Aid	Glow plugs, sheathed type
DC Cranking Current	240 (includes glow plugs)

LUBRICATION SYSTEM

General	Pressure fed system with external relief valve
Oil Filter	Full flow, paper element, spin-on type
Sump Capacity (includes oil filter)	6.3 U.S. qts (6.0 liters)

LUBRICATION SYSTEM

Operating Oil Pressure (engine hot)	28 - 57 psi (2.0 - 4.0 kg/cm²)
Oil Grade	API Specification CF, CG-4, CF-4 or CH-4 SAE 10W-30, 15W-40

COOLING SYSTEM

General	Fresh water-cooled engine block, thermostatically-controlled with heat exchanger.
Operating Temperature	160 - 180° F (71 - 82° C)
Fresh Water Pump	Centrifugal type, metal impeller, belt-driven
Raw Water Pump	Positive displacement, rubber impeller, gear-driven.
System Capacity (fresh water)	5 qts (4.7 liters)
Raw Water Flow Rate (at 1800 rpm)	6.0 gpm (22.7 lpm)

FUEL SYSTEM

General	Open flow, self bleeding, self priming (electromagnetic fuel pump)
Fuel	No. 2 diesel (cetane rating of 45 or higher)
Fuel Injection Pump	Bosch type mini-pump
Fuel Injection Timing	8° BTDC (spill)
Injector Nozzle	Bosch throttle type
Fuel Filter	Spin-on type
Air Intake	Metal screen/intake silencer box
Air Flow Combustion	70.0 cfm (1.9 cmm)

GENERATOR COOLING

Air Requirements (generator cooling)	250 - 275 cfm (7.08 - 7.8 cmm)

NOTE: *Increase cooling air flow 15% for slower turning 50hz units.*

Generator Compartment Ambient Temperature	122° F (50° C) maximum

AC GENERATOR (Single Phase)

General-Single phase	Brushless, four-pole, revolving field. Sealed lubricated, single-bearing design. 6 wire reconnectable with solid state voltage regulator.
Voltage - Single Phase	120 or 120/240 volts 60 Hz 230 volts 50 Hz
Voltage Regulation	± 2% no load to full load.
Frequency Regulation	± 3 Hertz (.5%) no load to full rated amperage outlet
AC Amperage	120 volts/141.7 amps - 240 volts70.8 amps 230 volts/58.7 amps

NOTE: Pages 41 and 42 were intentionally removed from this manual.

GENERATOR SPECIFICATION 3 PHASE

17.0/13.5 EDE

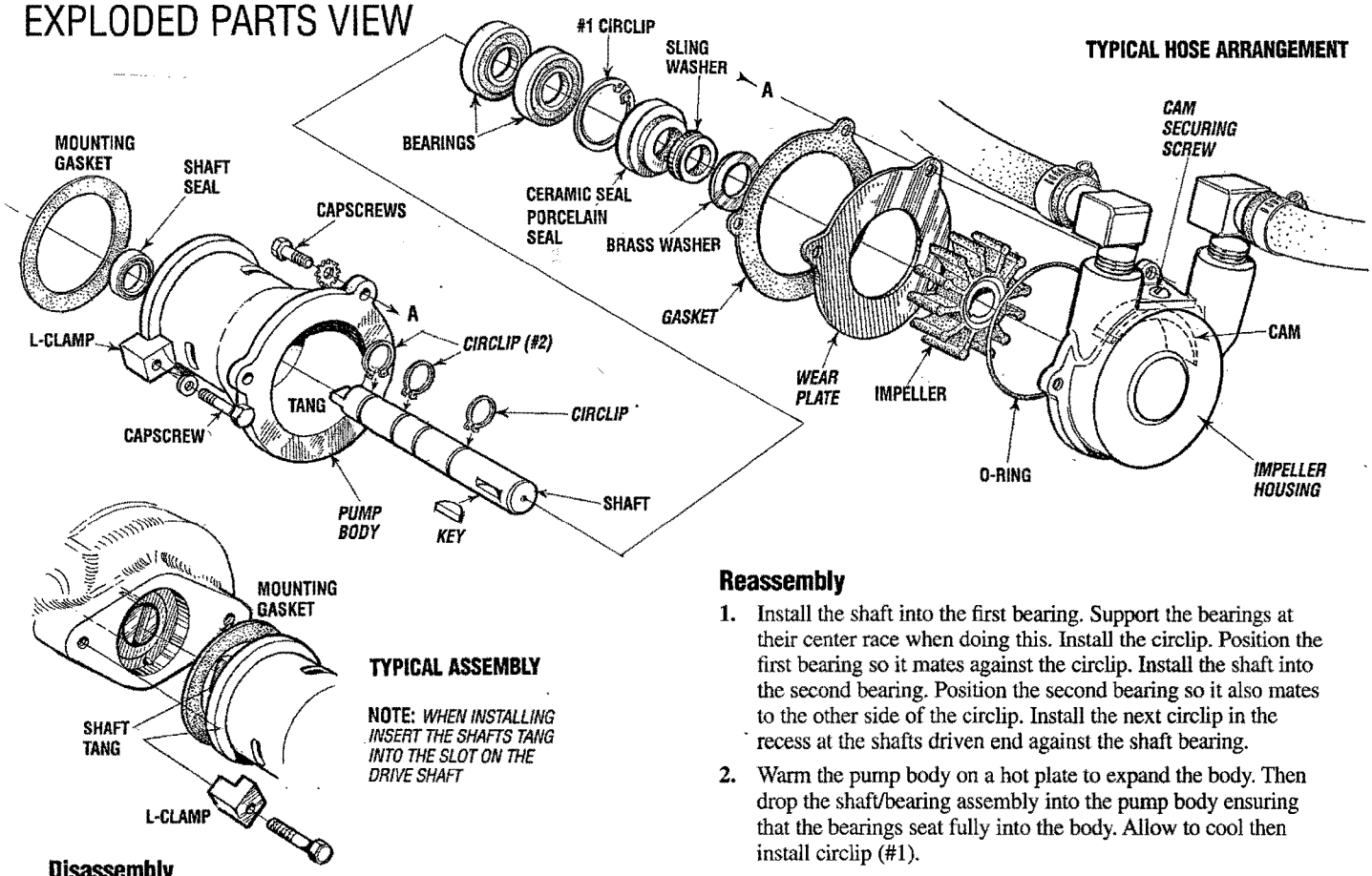
AC GENERATOR (3 Phase)		
Three Phase 17.0 Kw - 60 Hertz 13.5 Kw - 50 Hertz	Brushless, six- pole, revolving field. Sealed lubricated, single-bearing design. 12 Lead reconnectable for low voltage WYE, high voltage Delta. Solid state voltage regulator with protection circuitry.	
Voltage - 3 phase (60 Hertz)	Low Voltage WYE High Voltage WYE DELTA	240 Volts 480 Volts 240 Volts
Voltage - 3 Phase (50 Hertz)	High Voltage WYE DELTA	400 Volts 230 Volts
Amperage - 3 phase (60 Hertz)	Low Voltage WYE High Voltage WYE DELTA	51 Amps 25 Amps 51 Amps
Amperage - 3 phase (50 Hertz)	High Voltage WYE DELTA	24 Amps 42 Amps
Generator Compartment Ambient Temperature Recommendations	122°F (50°C) maximum **NOTE:** *Forced ventilation should be provided to maintain generator compartment temperatures below 122°F (50°C).*	
Air Requirement Generator Cooling	250 - 275 cfm (7.08 - 7.8 cmm) **NOTE:** *Increase air flow by 15% for slower turning 50 Hz units.*	

22.0/17.0 EDE

AC GENERATOR (3 Phase)		
Three Phase 22.0 Kw - 60 Hertz 17.0 Kw - 50 Hertz	Brushless, six- pole, revolving field. Sealed lubricated, single-bearing design. 12 Lead reconnectable for low voltage WYE, high voltage Delta. Solid state voltage regulator with protection circuitry.	
Voltage - 3 phase (60 Hertz)	Low Voltage WYE High Voltage WYE DELTA	240 Volts 480 Volts 240 Volts
Voltage - 3 Phase (50 Hertz)	High Voltage WYE DELTA	400 Volts 230 Volts
Amperage - 3 phase (60 Hertz)	Low Voltage WYE High Voltage WYE DELTA	66 Amps 33 Amps 66 Amps
Amperage - 3 phase (50 Hertz)	High Voltage WYE DELTA	30 Amps 53 Amps
Generator Compartment Ambient Temperature Recommendations	122°F (50°C) maximum **NOTE:** *Forced ventilation should be provided to maintain generator compartment temperatures below 122°F (50°C).*	
Air Requirement Generator Cooling	250 - 300 cfm (7.08 - 8.5 cmm) **NOTE:** *Increase air flow by 15% for slower turning 50 Hz units.*	

RAW WATER PUMP (PN #042175)

EXPLODED PARTS VIEW



TYPICAL HOSE ARRANGEMENT

TYPICAL ASSEMBLY

NOTE: *WHEN INSTALLING INSERT THE SHAFTS TANG INTO THE SLOT ON THE DRIVE SHAFT*

Disassembly

Close off the raw water intake and remove the pump from the engine. The pump will have hose attachment nipples threaded into its inlet and outlet ports. These may be left in place as they will not interfere with the disassembly.

1. Remove the three cap screws and washers that hold the impeller housing to the pump body. remove the impeller housing, exposing the impeller.
2. Remove the O-ring, the inner wear plate and gasket.
3. Remove the cam securing screw along with the cam.
4. Remove the impeller and its key from the shaft.
5. Remove the brass washer and slide the ceramic face seal off the shaft and then remove the spring loaded porcelain seal off the shaft. This will leave the pressed in portion of this seal in the body of the pump. Pry this out.
6. Remove the circlip (#1).
7. Using a suitable support, press the shaft and bearing assembly out of the pump body through the open area that the circlip (#1) was removed from.
8. Remove the rubber slinger washer.
9. Remove the circlip (#2) and using a suitable support, press both bearings off the shaft.

NOTE: *A circlip (#2) is located on the shaft between the two bearings.*

Inspection

Clean and inspect all the parts and replace any parts that show wear or corrosion. Inspect the impeller by bending each impeller blade. There should not be any cracks.

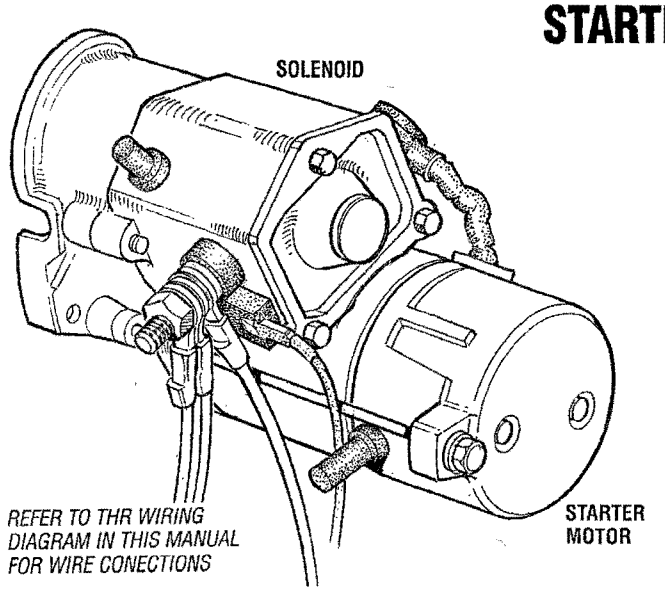
Reassembly

1. Install the shaft into the first bearing. Support the bearings at their center race when doing this. Install the circlip. Position the first bearing so it mates against the circlip. Install the shaft into the second bearing. Position the second bearing so it also mates to the other side of the circlip. Install the next circlip in the recess at the shafts driven end against the shaft bearing.
2. Warm the pump body on a hot plate to expand the body. Then drop the shaft/bearing assembly into the pump body ensuring that the bearings seat fully into the body. Allow to cool then install circlip (#1).
3. Install the rubber sling washer flush against the inner bearing.
4. Apply some gasket sealant to the outet meter body of the spring loaded porcelain seal and with a suitable fixture contacting the outer meal edge of the seal press it into the pump body so it full seats.

NOTE: *If the spring loaded seal is removed from its metal base, note that the base center is similar to a three cornered hat and that the inner circumference of the spring seal has three mating slots for these corners when installing it back into its metal base.*

5. Slide the white ceramic faced seal onto the shaft with the white face contacting the spring loaded porcelain seal. Slide the brass washer onto the shaft and against the seal compressing it. Install the securing circlip (#1).
6. Install the shaft seal. Apply sealant to the outer edges of the seal and some oil to the shaft and lip of the seal. then, with a suitable fixture, press it into the pump body until it is flush.
7. Install the key into the shaft keyway.
8. Position the gasket and wear plate into the pump body.
9. Slide the impeller onto the shaft and keyway.
10. Place some gasket sealant on the inner surface of the cam and on the threads of its securing screw and secure the cam into the housing impeller.
11. Coat the impeller housing over the impeller and secure it to the pump body with the three capscrews and washers.
12. Install the impeller housing over the impeller and secure it to the pump body with the three capscrews and washers.
13. Assemble the pump to the engine and attach the coolant hoses securing them properly to the pump hose nipples with stainless steel hose clamps.

STARTER MOTOR



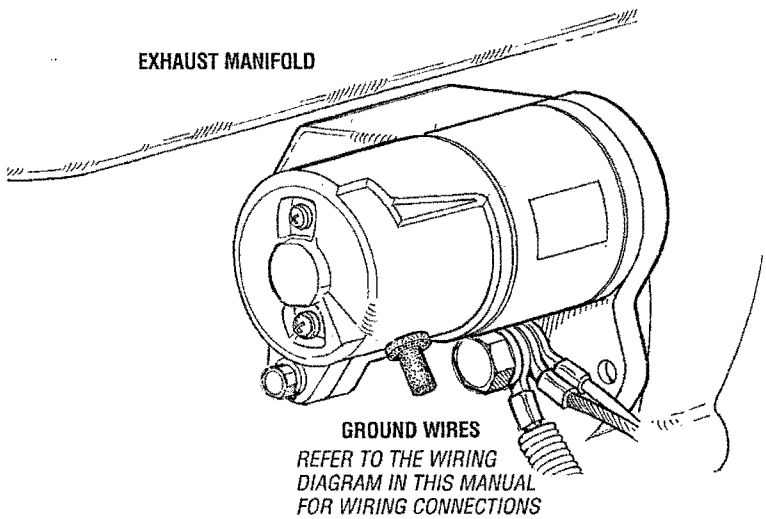
DESCRIPTION

The starting system includes the battery, starter motor/ solenoid, and the ignition switches - Start/Preheat.

When the start button is depressed, current flows and energizes the starter's solenoid coil. The energized coil becomes an electromagnet, which pulls the plunger into the coil, and closes a set of contacts which allow high current to reach the starter motor. At the same time, the plunger also serves to push that starter pinion to mesh with the teeth on the flywheel.

To prevent damage to the starter motor when the engine starts, the pinion gear incorporates an over-running (one-way) clutch which is splined to the starter armature shaft. The rotation of the running engine may speed the rotation of the pinion but not the starter motor itself.

Once the start switch is released, the current flow ceases, stopping the activation of the solenoid. The plunger is pulled out of contact with the battery-to-start cables by a coil spring, and the flow of electricity is interrupted to the starter. This weakens the magnetic fields and the starter ceases its rotation.As the solenoid plunger is released, its movement also pulls the starter drive gear from its engagement with the engine flywheel.



TROUBLESHOOTING

Prior to testing, make certain the ships batteries are at full charge and that the starting system wiring connections (terminals) are clean and tight. Pay particular attention to the ground wire connections on the engine block.

To check the wiring, try cranking the starter for a few seconds, never more than 10 seconds at a time, then run your hand along the wires and terminals looking for warm spots that indicate resistance. Repair or replace any trouble spots.

Using a multimeter, test the voltage between the positive terminal stud on the start solenoid and the engine block (ground).

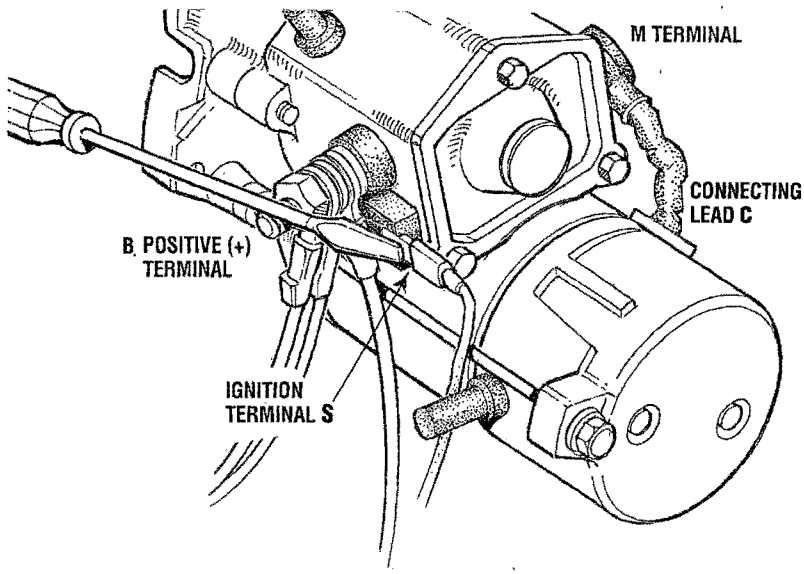
If you read 12 volts, the starter is faulty.

To test the ignition circuit, locate the ignition(s) terminal

Use a screwdriver, don't touch the blade, to jump from that ignition terminal to the positive battery connection terminal on the solenoid.

If the starter cranks, the fault lies with the ignition circuit.

If the solenoid clicks but nothing happens, the starter motor is probably faulty.



If nothing happens at all, the solenoid is not getting current.. Check the battery and inspect the wiring connections. It is also possible that the solenoid is defective.

> ⚠ **WARNING:** ***There will be arching and sparks will fly when jumping terminals. Be certain the engine space is free of potentially explosive fumes, especially gasoline, and that there are NO flammable solvents or materials stored nearby.***

STARTER MOTOR

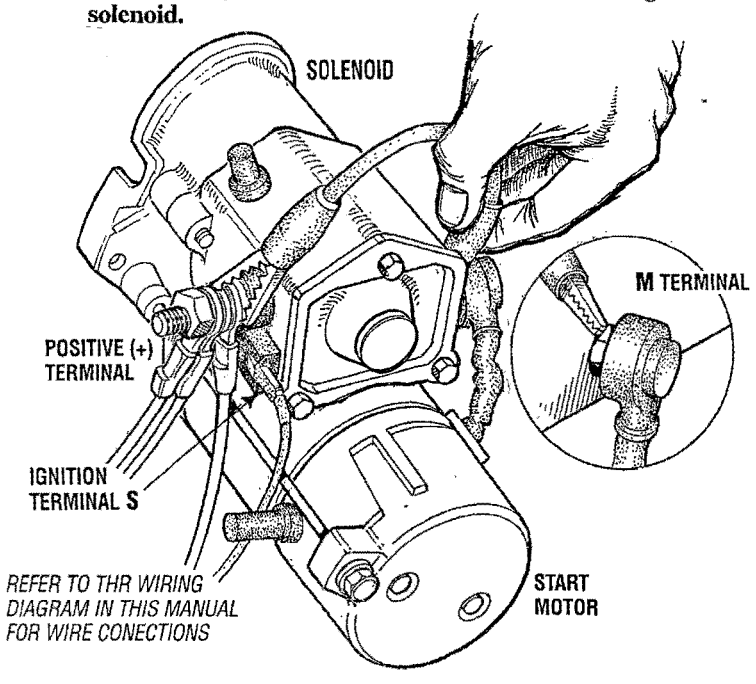
Test again by jumping the positive terminal to the **M** terminal. Pull back the covering on the **M** terminal to expose the connection. Attach a jumper cable to the positive (+) terminal. Use a battery type cable #8 or better. Tap the **M** terminal with the opposite end to see the results. Do not allow the jumper cable end to touch the solenoid or starter casing. This would cause a short.

> ⚠ **WARNING:** ***There will be arching as the full starting current should be flowing thru the jumper***

If the starter spins, the solenoid is faulty.

If the starter fails to spin, the motor is probably faulty.

If no arching occurred, there is no current reaching the solenoid.



> ⚠ **WARNING:** ***When performing these procedures, position yourself safely away from the moving parts of the engine in case the engine starts-up. Also warn other crew members of the danger.***

NOTE: *Starter motors are either inertia type or pre-engaged. In the pre-engaged model, the solenoid also moves an arm that engages the starter motor to the flywheel of the engine. using a screwdriver to bypass the solenoid on such a starter will run the motor without engaging the flywheel.*

SERVICE

WESTERBEKE uses a standard starter motor which can be serviced or rebuilt at any starter motor automotive service center.

If replacing the starter motor, make certain the new motor is certified for marine use. Automotive starters do not meet USCG standards. If in doubt, contact your WESTERBEKE dealer.

TO REMOVE FOR SERVICE

1. Disconnect the negative battery cable.
2. If necessary, remove any components to gain full access to the starter motor.
3. Label and disconnect the wiring from the starter. (Do not allow wires to touch, tape over the terminals).
4. Remove the starter mounting bolts.
5. Remove the starter from the engine. In some cases the starter will have to be turned to a different angle to clear obstructions,

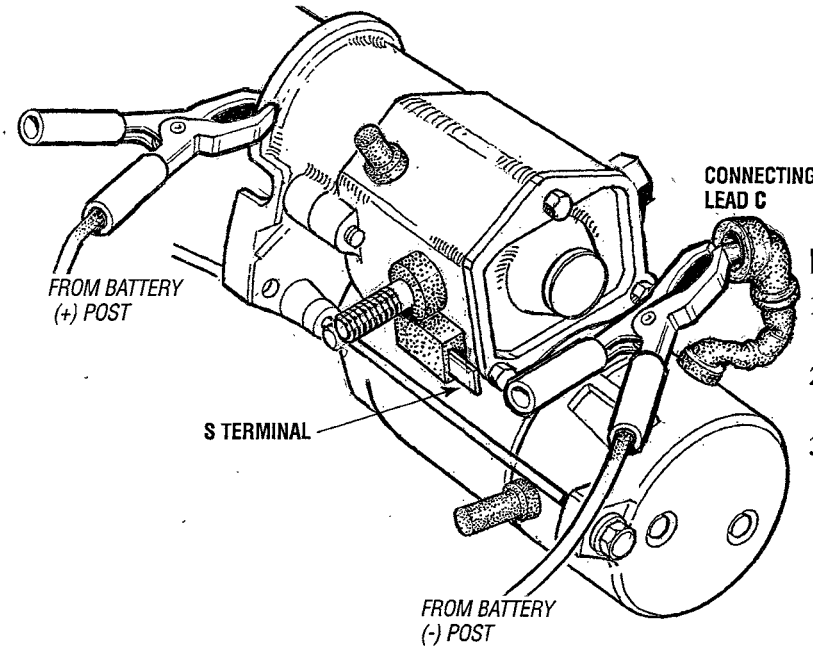
STARTER MOTOR

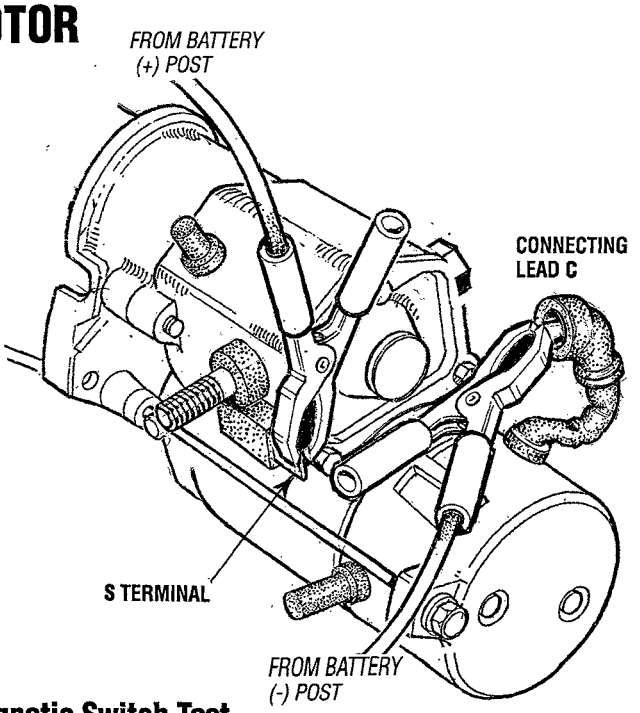
BENCH TESTING THE STARTER MOTOR

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.





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 **C** terminal (momentarily).
3. If the pinion gear fails to pop out, the problem is with the magnetic switch.

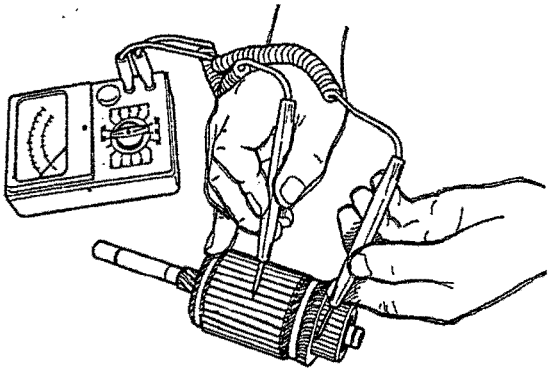
STARTER MOTOR

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

STARTER INSPECTION

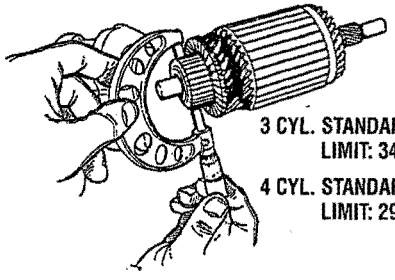
Solenoid

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



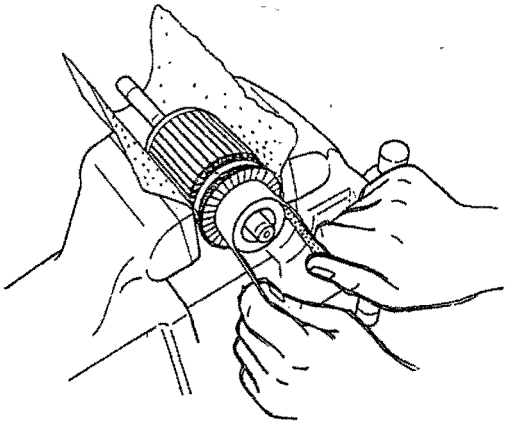
Inspecting The Armature

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

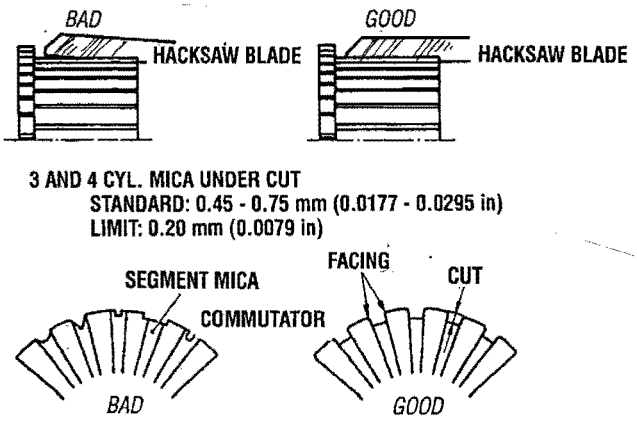


3 CYL. STANDARD: 35.0 mm (1.378 in)
LIMIT: 34.0 mm (1.339 in)
4 CYL. STANDARD: 30.0 mm (1.181 in)
LIMIT: 29.0 mm (1.142 in)

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



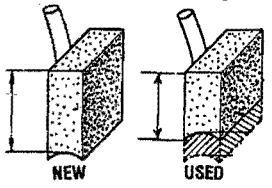
3. Check the commutator mica under cut and correct with a hacksaw blade if the under cut has become to shallow.



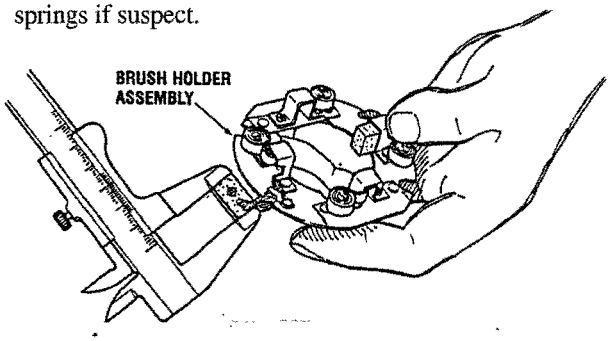
Brush and Brush Holder Inspection

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

BRUSH HEIGHT:
3 CYL.STANDARD: 15 mm (0.591 in)
LIMIT: 9 mm (0.356 in)
4 CYL. STANDARD: 15 mm (0.591 in)
LIMIT: 11 mm (0.433 in)

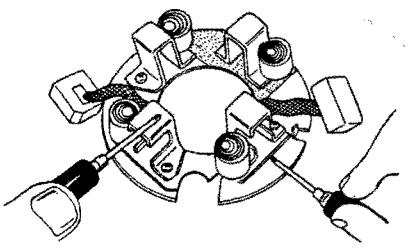


2. Check the brush spring tension. A weak or defective spring will cause excessive brush wear; replace the springs if suspect.

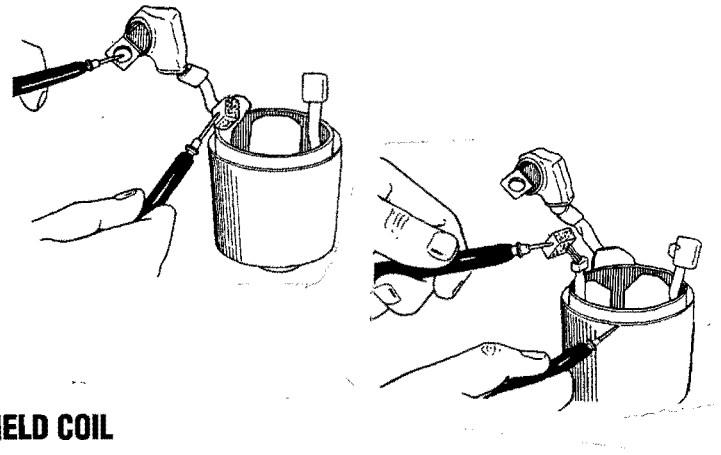


3. Check the continuity across the brush holder and its support with an ohmmeter. If it conducts, replace the brush holder.

BRUSH HOLDER - SUPPORT RESISTANCE .....INFINITY



STARTER MOTOR

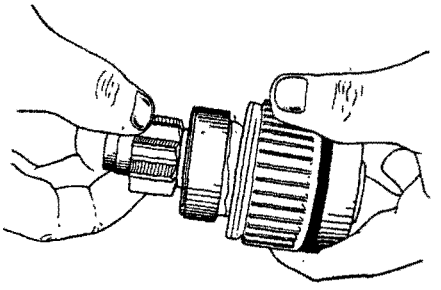


FIELD COIL

1. Inspect the continuity across the lead and brush with an ohmmeter, if it does not conduct, replace the yoke assembly.
2. Check the continuity across the brush and yoke, if it conducts, replace the yoke assembly.

OVERRUNNING CLUTCH

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



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

STARTER MOTOR

DISASSEMBLING THE MOTOR

1. Unscrew the nut and disconnect the connecting lead from the magnetic switch.
2. Remove the two long bolts and separate the end frame, yoke, and armature.
3. Remove the two screws that hold the brush holder and take the brush holder out of the end frame.
4. Remove the brush while holding the spring up.

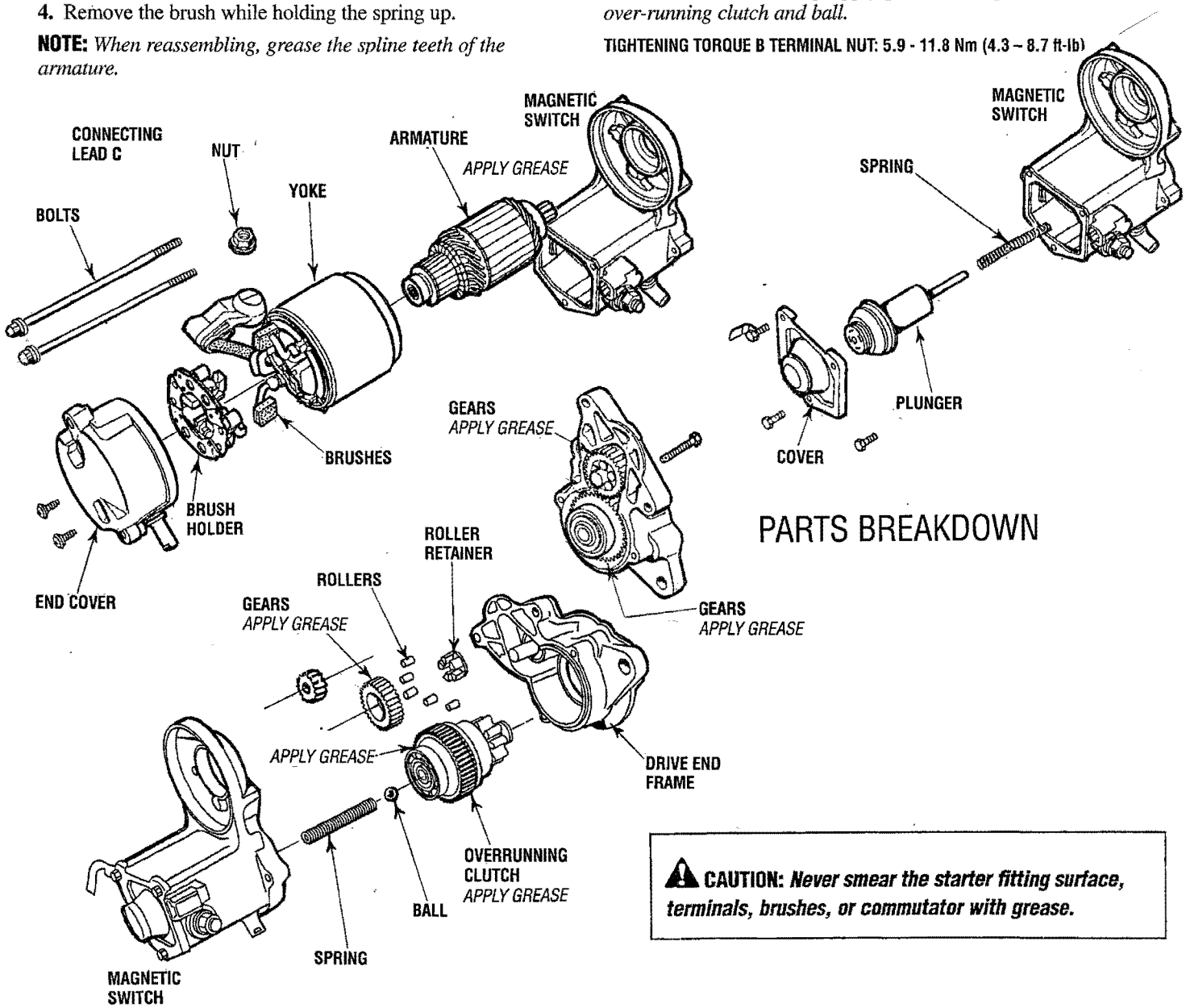
NOTE: *When reassembling, grease the spline teeth of the armature.*

DISASSEMBLING THE MAGNETIC SWITCH

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

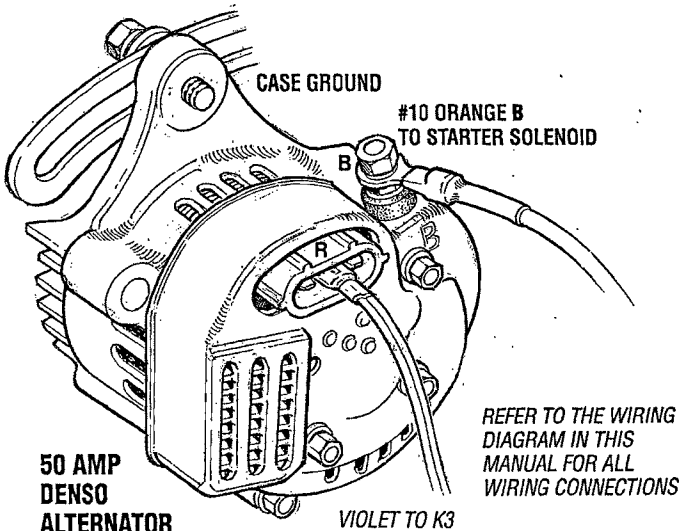
NOTE: *When reassembling, apply grease to all gear teeth, the over-running clutch and ball.*

TIGHTENING TORQUE B TERMINAL NUT: 5.9 - 11.8 Nm (4.3 – 8.7 ft-lb)



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

ALTERNATORS TESTING/TROUBLESHOOTING



DESCRIPTION

The following information applies to the standard alternators that are supplied with WESTERBEKE'S Engines and Generators.

ELECTRICAL CHARGING CIRCUIT

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

It is desirable to test the charging system (alternator and voltage regulator) using the wiring harness and electrical loads that are a permanent part of the system and will then provide the technician with an operational test of the charging system as well as the major components of the electrical system.

ALTERNATOR DESCRIPTION

The stator is connected to a three-phase, full-wave bridge rectifier package which contains six diodes. The bridge converts the AC generated in the stator to a DC output for battery charging and accessories,

Power to the regulator and the field of the integral regulator alternator is provided by the field diode (or diode trio) package contained in the alternator.

These alternators produce a rated output of 50 or 51 amps. rated output is achieved at approximately 6000 alternator rpm at an ambient temperature of 75°F (23.8°C). The alternators are designed to operate in an ambient temperature range of -40° to 212°F (-40° to 100°C).

VOLTAGE REGULATOR

The integral voltage regulator is an electronic switching device which senses the system voltage level and switches the voltage applied to the field in order to maintain a proper system voltage.

The regulator design utilizes all-silicon semi conductors and thick-film assembly techniques. After the voltage has been adjusted to the proper regulating valve, the entire circuit is encapsulated to protect the circuit and the components from possible damage due to handling or vibration.

ALTERNATOR TROUBLESHOOTING

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

> ⚠ **WARNING:** ***A working alternator runs hot. A failed alternator can become very hot. Do not touch the alternator until if has cooled.***

LOW BATTERY/FAULTY CIRCUIT

If the starter only moans or makes a clicking sound instead of spinning the engine to life it is likely a low battery or a faulty connection in the starting circuit and not an alternator problem.

PRELIMINARY INSPECTION

Before starting the actual alternator and voltage regulator, testing the following checks are recommended.

1. Make certain your alternator is securely mounted.
2. Check the drive belts for proper tension. Replace the belt if it is worn or glazed.
3. Check that all terminals, connectors and plugs are clean and tight. Loose or corroded connections cause high resistance and this could cause overcharging, undercharging or damage to the charging system. Badly corroded battery cables could prevent the battery from reaching a fully charged condition.
4. Check the condition of the battery and charge if necessary. A low or discharged battery may cause false or misleading readings in the tests.

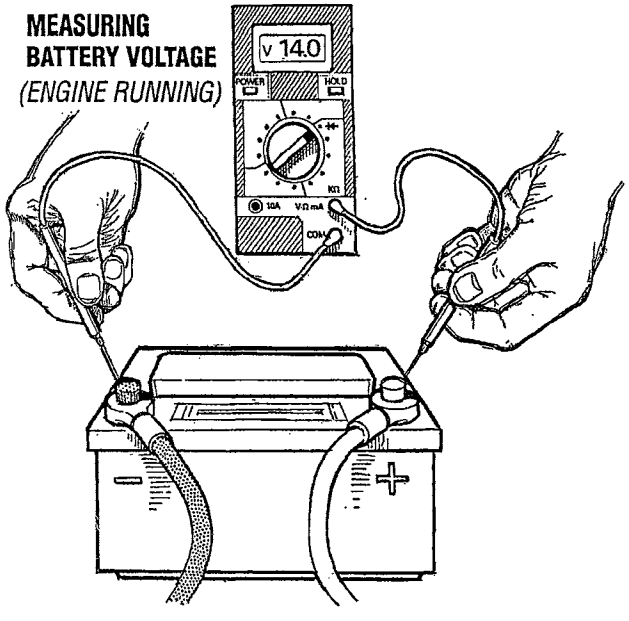
NOTE: *An isolator with a diode, a solenoid, or a battery selector switch is usually mounted in the circuit to isolate the batteries so the starting battery is not discharged along with the house batteries. If the isolator is charging the starting battery but not the house battery, the alternator is OK and the problem is in the battery charging circuit.*

ALTERNATORS TESTING/TROUBLESHOOTING

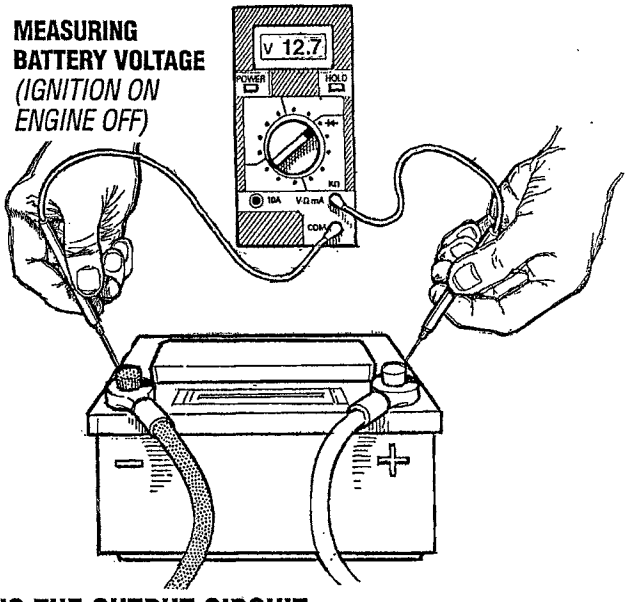
TESTING THE ALTERNATOR

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

1. Start the Engine.
2. After the engine has run for a few minutes, measure the starting battery voltage at the battery terminals using a multimeter set on DC volts.
   a. If the voltage is increasing toward 14 volts, the alternator is working.
   b. If the voltage remains around 12 volts, a problem exists with either the alternator or the charging circuit; continue with Steps 3 through 6.

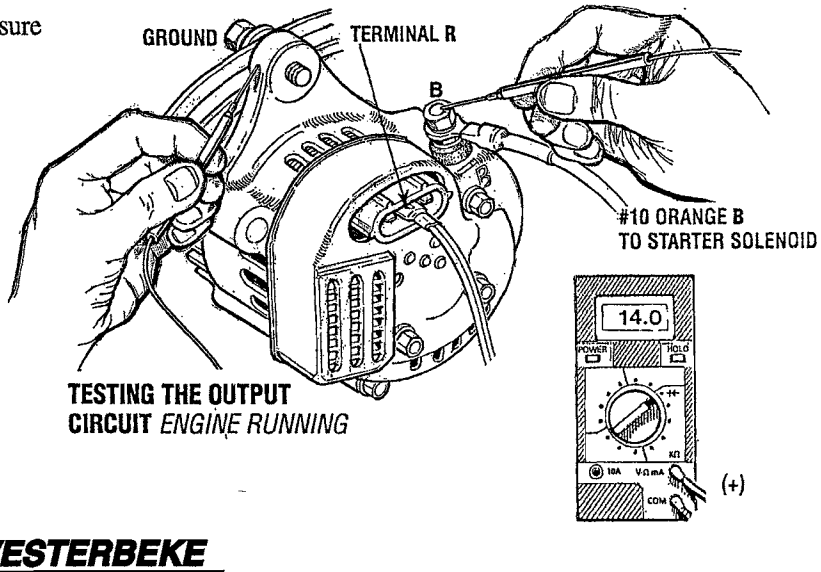


3. **Turn off the engine.** Inspect all wiring and connections. Ensure that the battery terminals and the engine ground connections are tight and clean
4. If a battery selector switch is in the charging circuit,ensure that it is on the correct setting.
5. **Turn on the ignition switch, but do not start the engine.**
6. Check the battery voltage. If your battery is in good condition the reading should be 12 to 13 volts.



TESTING THE OUTPUT CIRCUIT

1. Connect the positive probe to the output terminal **B** and connect the negative probe to ground.
2. Wiggle the engine wiring harness while observing the voltmeter. The meter should indicate the approximate battery voltage, and should not vary. If no reading is obtained, or if the reading varies, check the alternator output circuit for loose or dirty connections or damaged wiring.
3. **Start the engine.**
4. Repeat the same measurement, the negative probe to ground, the positive probe to **B** with the engine running. The voltage reading should be between 13.5 and 14.5 volts. If your alternator is over or under-charging, have it repaired at a reliable service shop.
5. If the previous test reads only battery voltage at terminal **B**, use the meter to measure the DC excitation terminal. If 12 volts is not present at exciter terminal **R**, inspect the wiring for breaks and poor connections. Jump 12 volts from a 12 volt source (such as the battery) and operate the alternator. If the voltage output is 13-14 volts, . . then the alternator is OK.

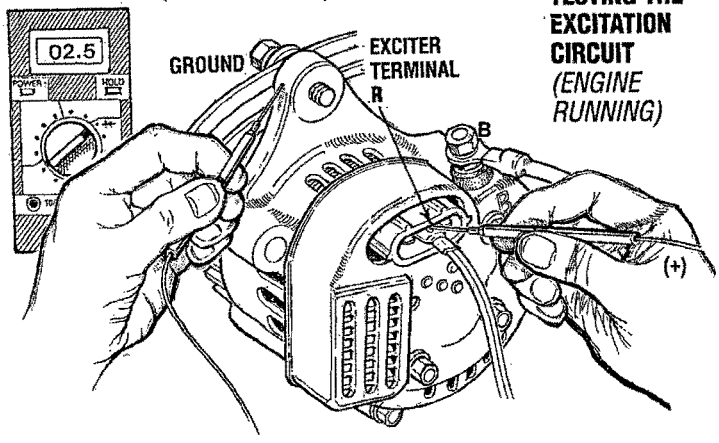


TESTING THE OUTPUT CIRCUIT *ENGINE RUNNING*

ALTERNATORS TESTING/TROUBLESHOOTING

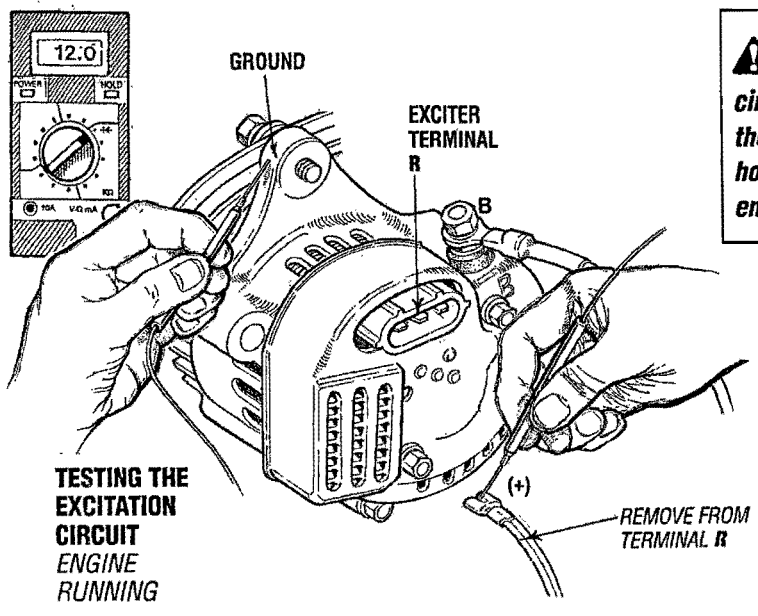
TESTING THE EXCITATION CIRCUIT

1. Connect the positive (+) multimeter probe to the excitation terminal **R** on the alternator and the negative (–) lead to ground.
2. **Turn the ignition switch to the on position** and note the multimeter reading. The reading should be 1.3 to 2.5 volts (see illustration).



TESTING THE EXCITATION CIRCUIT *(ENGINE RUNNING)*

3. **If the reading is between .75 and 1.1 volts,** the rotor field circuit probably is shorted or grounded.
4. **If the reading is between 6.0 and 7.0 volts,** the rotor field circuit probably is open.
5. **If no reading is obtained,** an open exists in the alternator-excitation lead or in the excitation circuit of the regulator. Disconnect the lead from exc terminal **R**. Connect the positive multimeter probe to the excitation lead and the negative multimeter probe to ground. If the multimeter now indicates an approximate battery voltage, the voltage regulator is defective and must be replaced. If no voltage is indicated, check the excitation circuit for loose or dirty connections or damaged wiring.



TESTING THE EXCITATION CIRCUIT *ENGINE RUNNING*

CHECKING THE SERVICE BATTERY

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

When the problem has been solved and before the alternator is back in operation, take the time to tighten and clean the terminal studs. Also clean the connecting terminals from the wiring harness.

ALTERNATOR REPAIR

If tests indicate a failed alternator, it will need to be disassembled and repaired. Any good alternator service shop can do the job.

NOTE: *WESTERBEKE'S Service Manual has detailed instructions for the disassembly and repair of their standard alternators.*

BATTERY CARE

The minimum recommended capacity of the battery used in the engine's 12 volt DC control circuit is 800-1000 Cold Cranking Amps (CCA).

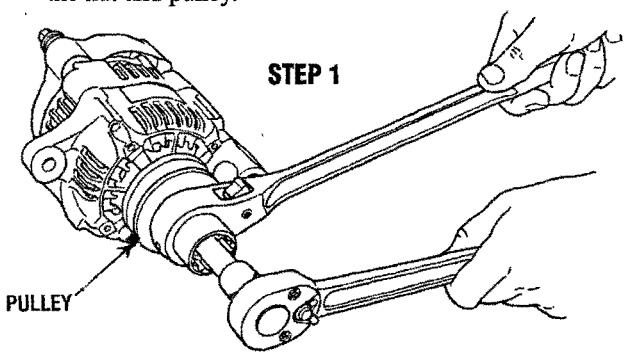
Review the manufacturer's recommendations and then establish a systematic maintenance schedule for your engine's starting batteries and house batteries.

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

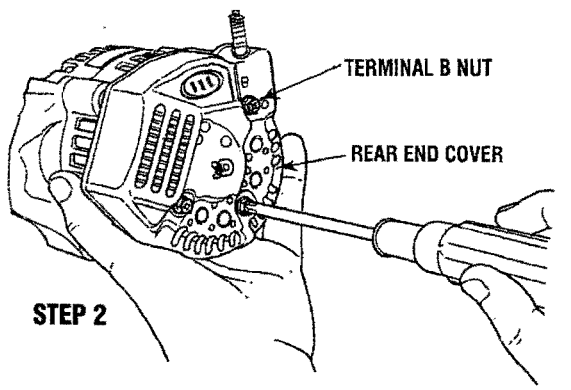
> ⚠ **CAUTION:** ***To avoid damage to the battery charging circuit, never shut off the engine battery switch while the engine is running. Shut off the engine battery switch, however, to avoid electrical shorts when working on the engine's electrical circuit.***

ALTERNATOR SERVICE
DISASSEMBLY

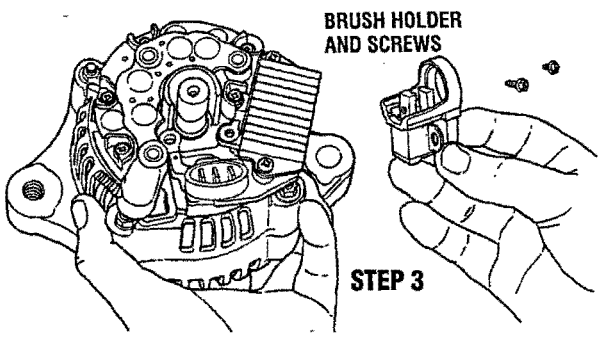
1. Secure the hex end of the pulley shaft with a ratchet wrench, then loosen the nut and remove the nut and pulley.



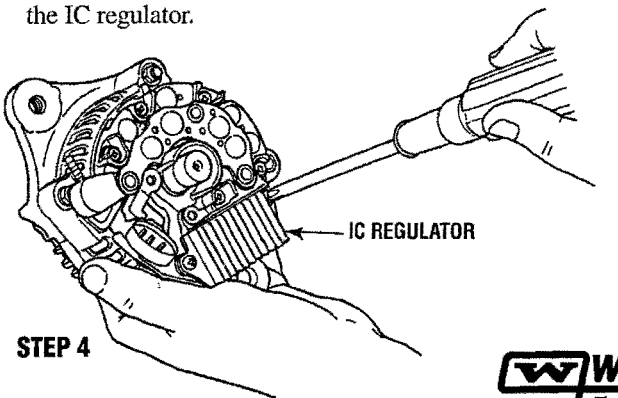
2. Unscrew the 3 rear end cover screws and the **B** terminal nut and remove the rear end cover.

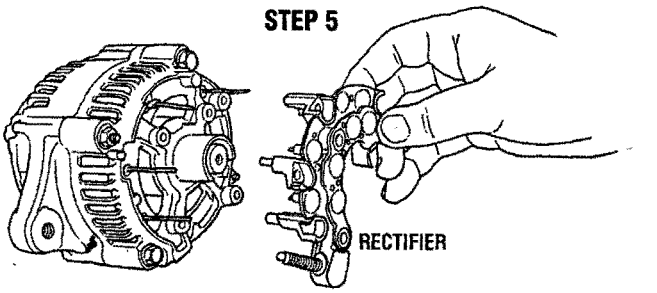


3. Unscrew the 2 screws holding the brush holder and remove the brush holder.

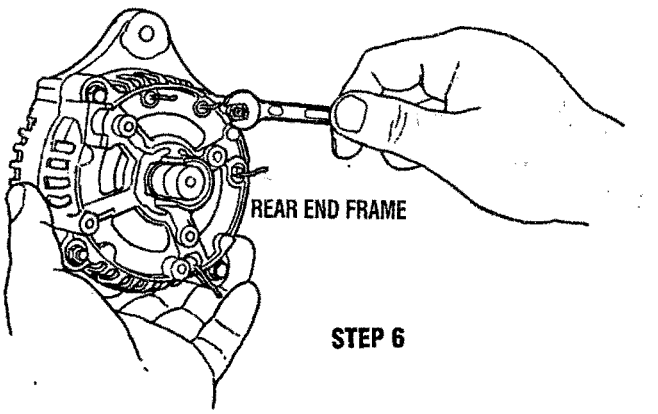


4. Unscrew the 3 screws holding the IC regulator and remove the IC regulator.

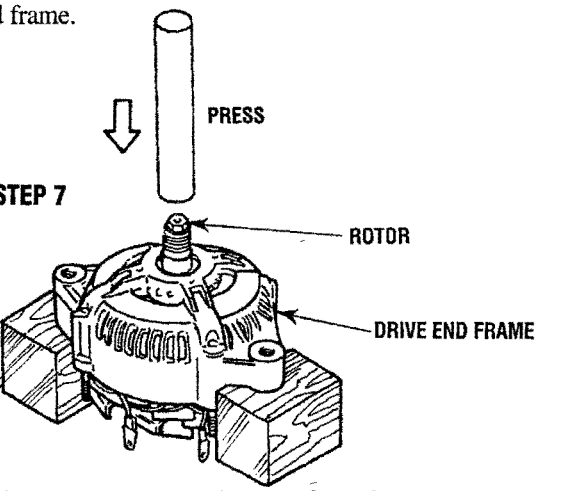




5. Remove the 4 screws holding the rectifier and the stator lead wires, remove the rectifier.



6. Unscrew the 2 nuts and 2 screws that hold the drive end frame and remove the drive end frame.

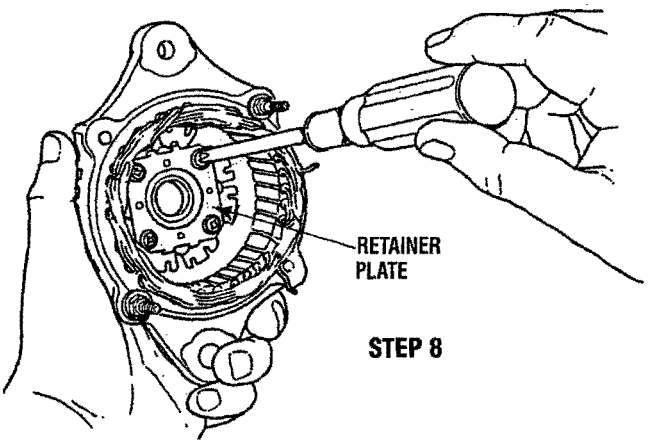


7. Using a press, remove the rotor from the drive end frame.
   Take care not to drop the rotor as that could damage the fan or slip ring.

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.

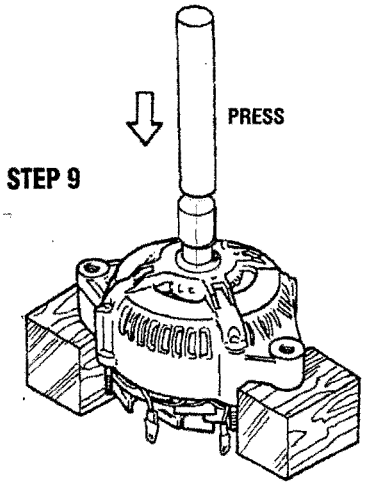
ALTERNATOR SERVICE
DISASSEMBLY

8. Unscrew the 4 screws holding the retainer plate and remove the retainer plate.



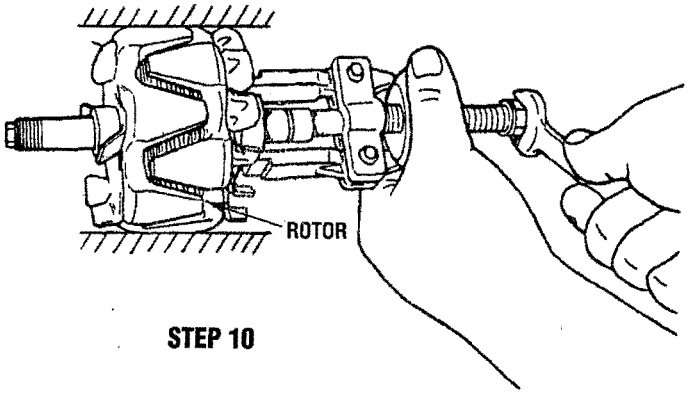
STEP 8

9. Press out the bearing from the drive end frame with a press and a jig.



STEP 9

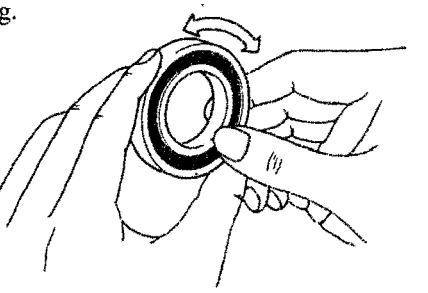
10. Lightly secure the rotor with a vise to prevent damage then remove the bearing with a puller.



STEP 10

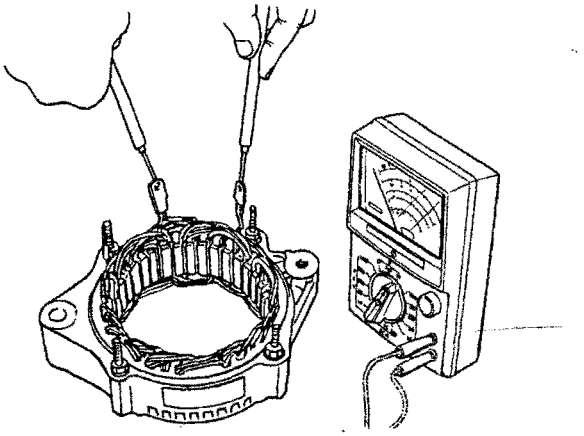
ALTERNATOR TESTING

1. Check the bearing for smooth rotation and worn appearance. if it does not rotate smoothly, replace the bearing.

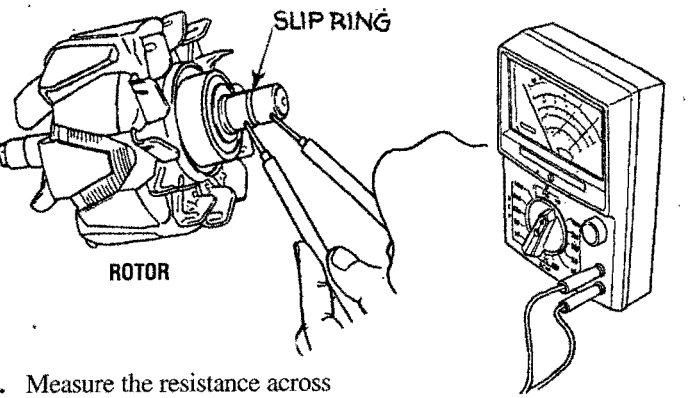


2. Measure the resistance across each lead of the stator coil with an ohmmeter. If the measurement is not within factory specifications, replace it.

RESISTANCE: LESS THAN 1.0 OHM



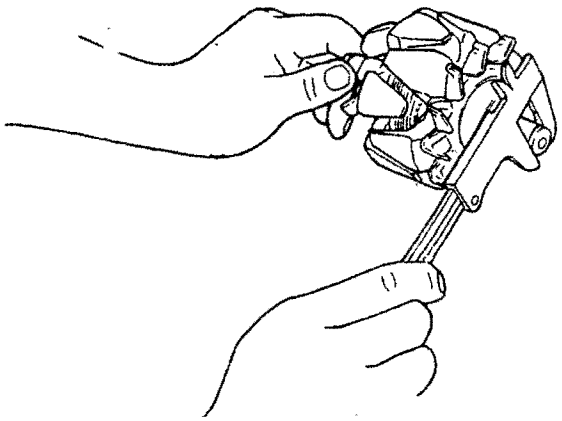
3. Check for continuity across each stator coil lead and core. If infinity is not indicated, replace it.



4. Measure the resistance across the slip ring. If the resistance does not meet factory specifications, replace it.

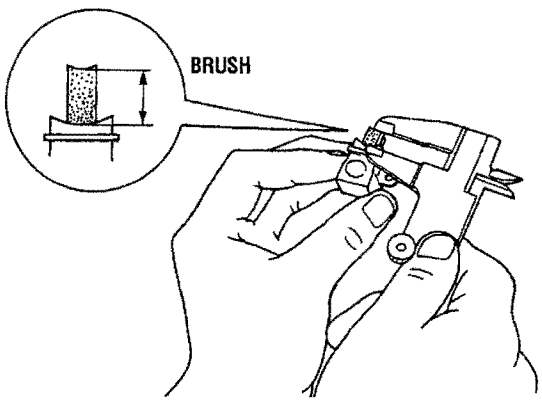
5. Check the continuity across the slip rings and core. If infinity is not indicated, replace it.

ALTERNATOR TESTING



6. Inspect the slip ring for scoring. If scored, correct with an emery paper or on a lathe.
7. Measure the O.D. of the slip ring with calipers, if the measurement is less than the allowable limit, replace it.

SLIP RING O.D. ALLOWABLE LIMIT 14MM/0.551 IN



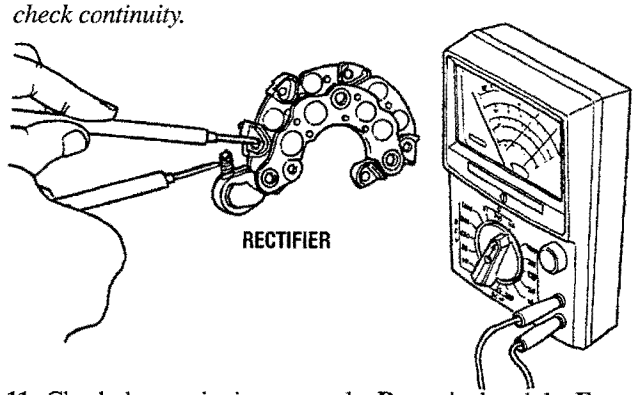
8. Measure the brush length with vernier calipers. If the measurement is less the the allowable limit, replace it.

BRUSH LENGTH ALLOWABLE LIMIT 8.4 MM/0.331 IN

9. Inspect the brush, it should move smoothly and have no defects.
10. Test the continuity across each rectifier diode with an analog ohmmeter. Conduct the test in the (Rx1) setting. The rectifier is normal if the diode conducts in one direction and not in the other.

NOTE: *Do not use a 500V Megger for tests as it will destroy the rectifier!*

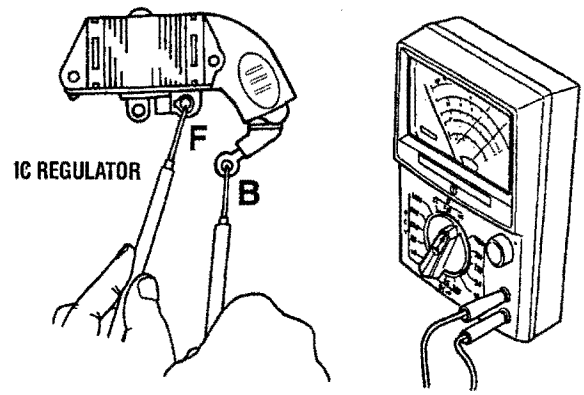
Do not use an auto digital multimeter as it is difficult to check continuity.



11. Check the continuity across the **B** terminal and the **F** terminal of the IC regulator with an analog ohmmeter using the (Rx1) setting. The IC regulator is normal if it conducts in one direction and not the other.

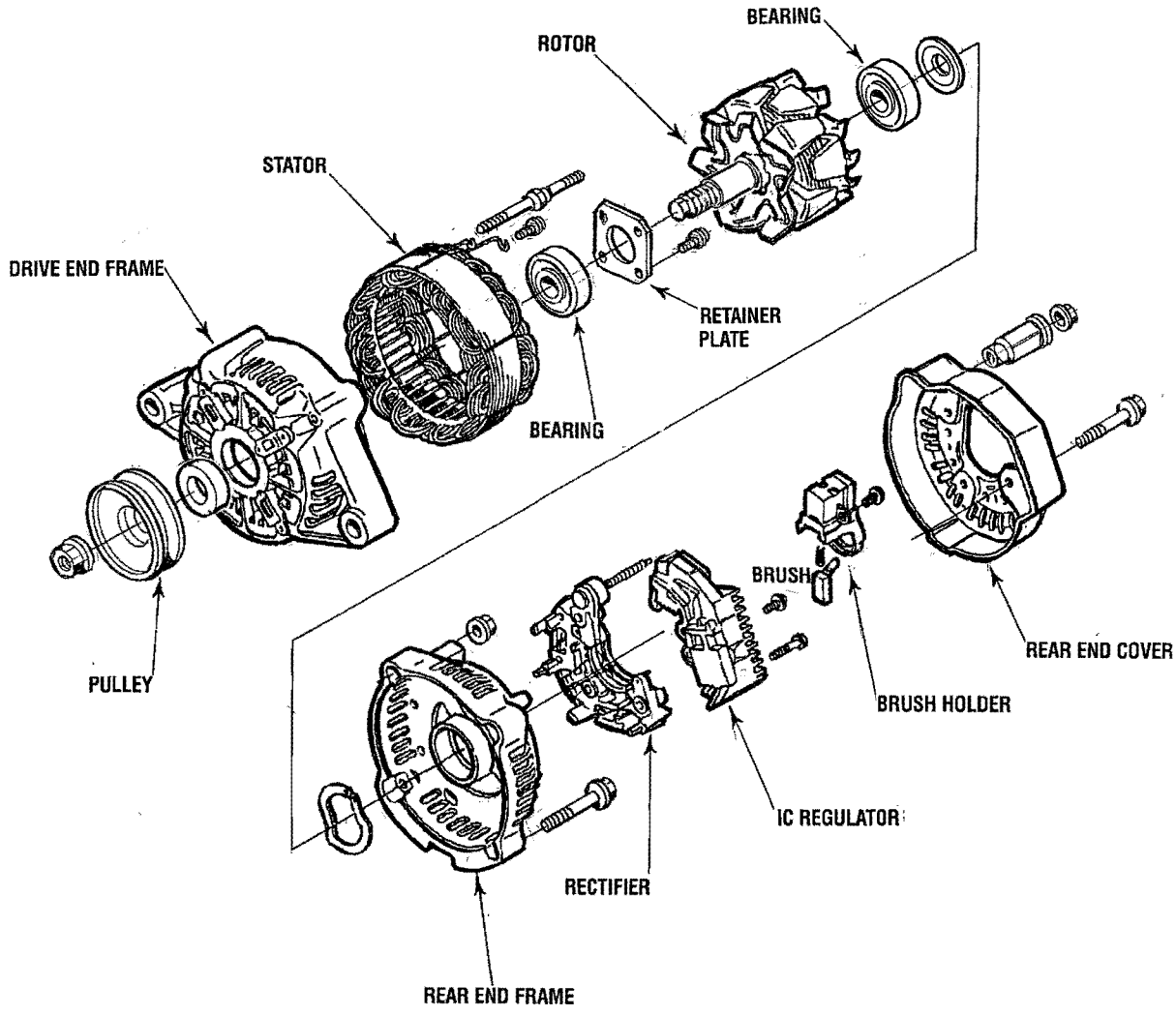
NOTE: *Do not use a 500V Megger for tests as it will destroy the rectifier!*

Do not use an auto digital multimeter as it is difficult to check continuity.

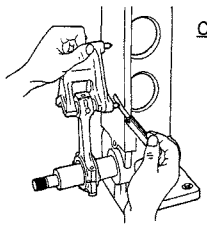


ALTERNATOR SERVICE

EXPLODED PARTS VIEW



SPECIAL TOOLS



Connecting Rod Alignment Tool

Code No : 07909-31661

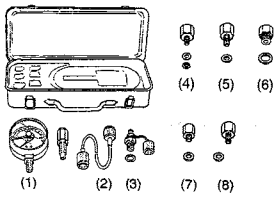
Application : Use to check the connecting rod alignment.

Applicable : Connecting rod big end I.D.

range 30 to 75 mm (1.18 to 2.95 in.) dia.

Connecting rod length

65 to 300 mm (2.56 to 11.81 in.)

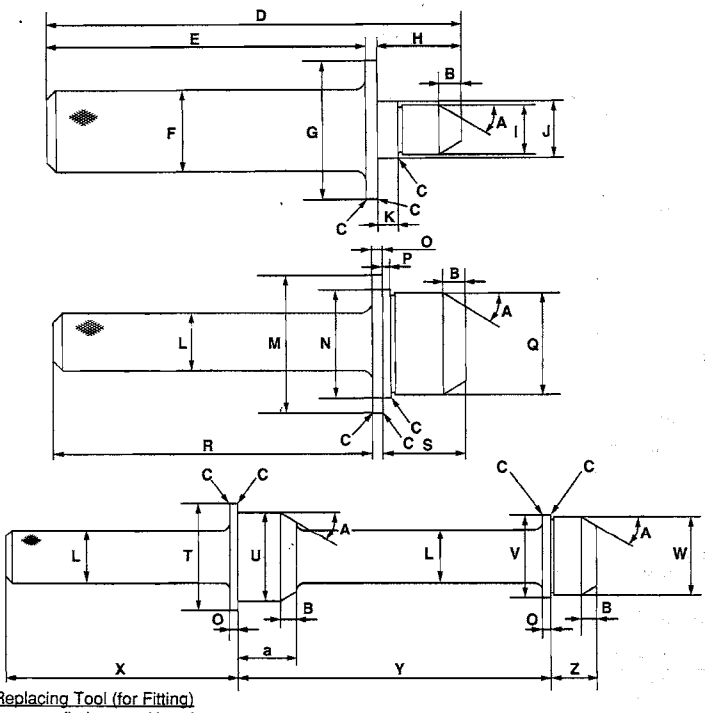


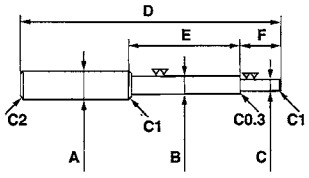
Oil Pressure Tester

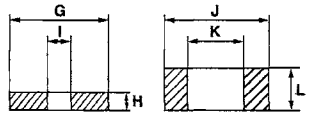
Code No : 07916-32032

Application : Use to measure lubricating oil pressure.

(1) Gauge
(2) Cable
(3) Threaded Joint
(4) Adaptor **1**
(5) Adaptor **2**
(6) Adaptor **3**
(7) Adaptor **4**
(8) Adaptor **5**







Balancer Metal Replacing Tool (for Fitting)

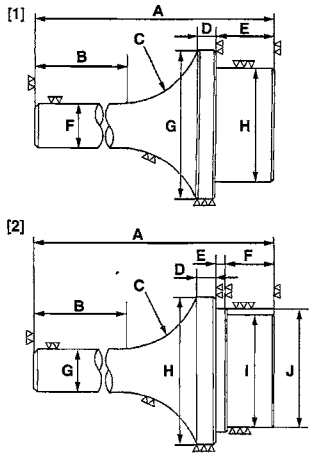
Application:Use to press fit the metal bearing.

A	0.52 rad (30 °)	O	5 mm (0.20 in.)
B	10 mm (0.39 in.)	P	3.3 to 3.7 mm (0.130 to 0.146 in.)
C	Chamfer 0.3 mm (0.01 in.)	Q	43.934 to 43.950 mm dia. (1.7297 to 1.7303 in. dia.)
D	182 mm (7.16 in.)	R	140 mm (5.51 in.)
E	140 mm (5.51in.)	S	36 mm (1.42 in.)
F	35 mm dia. (1.38 in dia.)	T	60 mm dia. (2.36 in. dia.)
G	60 mm dia. (2.36 in dia.)	U	46.950 to 46.975 mm dia. (1.8484 to 1.8494 in. dia.)
H	37 mm (1.46 in.)	V	44.950 to 44.975 mm dia. (1.7697 to 1.7707 in. dia.)
I	21.947 to 21.960 mm dia. (0.8641 to 0.8646 in. dia.)	W	41.934 to 41.950 mm dia. (1.6509 to 1.6516 in. dia.)
J	24.959 to 24.980 mm dia. (0.9826 to 0.9835 in. dia.)	X	145 mm (5.71 in.)
K	8.8 to 9.2 mm (0.346 to 0.362 in.)	Y	195.25 to 195.75 mm (7.687 to 7.707 in.)
L	25 mm dia. (0.98 in. dia.)	Z	29 mm (1.14 in.)
M	60 mm dia. (2.36 in. dia.)	a	36 mm (1.42 in.)
N	46.950 to 46.975 mm dia. (1.8484 to 1.8494 in. dia.)		

Valve Guide Replacing Tool

Application : Use to press out and press fit the valve guide.

A	20 mm dia. (0.79 in. dia.)
B	11.7 to 11.9 mm dia. (0.460 to 0.468 in.dia.)
C	6.5 to 6.6 mm dia. (0.256 to 0.259 in.dia.)
D	225 mm (8.86 in.)
E	70 mm (2.76 in.)
F	45 mm (1.77 in.)
G	25 mm (0.98 in.)
H	5 mm (0.197 in.)
I	6.7 to 7.0 mm dia. (0.263 to 0.275 in.dia.)
J	20 mm dia. (0.787 in.dia.)
K	12.5 to 12.8 mm dia. (0.492 to 0.504 in.dia.)
L	8.9 to 9.1 mm (0.350 to 0.358 in.)
C1	Chamfer 1.0 mm (0.039 in.)
C2	Chamfer 2.0 mm (0.079 in.)
C0.3	Chamfer 0.3 mm (0.012 in.)



Crankshaft Bearing 1 Replacing Tool

Application : Use to press out and press fit the crankshaft bearing 1.

1. Extracting tool

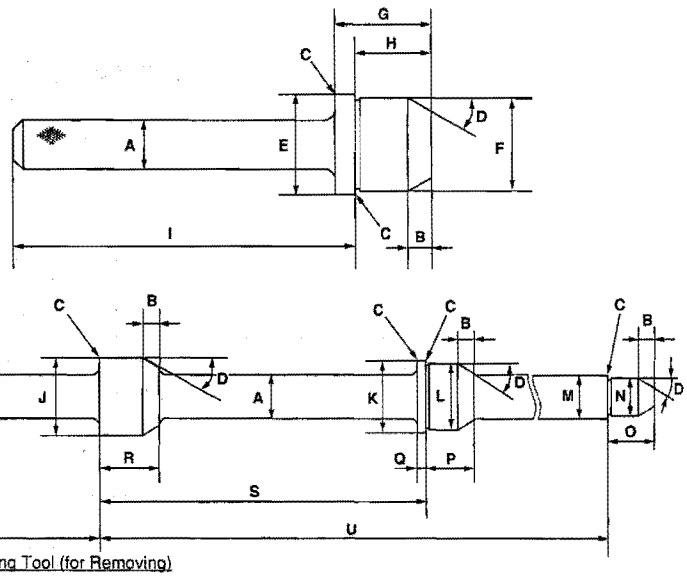
A	135 mm (5.31 in.)
B	72 mm (2.83 in.)
C	R40 mm (R1.57 in.)
D	10 mm (0.39 in.)
E	20 mm (0.79 in.)
F	20 mm dia. (0.79 in. dia.)
G	64.8 to 64.9 mm dia. (2.551 to 2.555 in. dia.)
H	59.8 to 59.9 mm dia. (2.354 to 2.358 in. dia.)

2. Inserting tool

A	130 mm (5.12 in.)
B	72 mm (2.83 in.)
C	R40 mm (R1.57 in.)
D	9 mm (0.35 in.)
E	4 mm (0.16 in.)
F	20 mm (0.79 in.)
G	20 mm dia. (0.79 in. dia.)
H	68 mm dia. (2.68 in. dia.)
I	59.8 to 59.9 mm dia. (2.354 to 2.358 in. dia.)
J	64.8 to 64.9 mm dia. (2.551 to 2.555 in. dia.)

NOTE: *Tools (dimension drawings) need to be fabricated. The others are available from your WESTERBEKE dealer.*

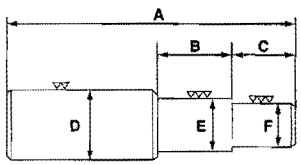
SPECIAL TOOLS



Balancer Metal Replacing Tool (for Removing)

Application:Use to remove the metal bearing.

A	25 mm (0.98 in. dia.)	L	41.934 to 41.950 mm dia. (1.6509 to 1.6516 in. dia.)
B	10 mm (0.39 in.)	M	24.959 to 24.980 mm dia. (0.9826 to 0.9835 in. dia.)
C	Chamfer 0.3 mm (0.01 in.)	N	21.947 to 21.960 mm dia. (0.8641 to 0.8646 in. dia.)
D	0.52 rad (30 °)	O	28 mm (1.10 in.)
E	46.950 to 46.975 mm dia. (1.8484 to 1.8494 in. dia.)	P	29 mm (1.14 in.)
F	43.934 to 43.950 mm dia. (1.7297 to 1.7303 in. dia.)	Q	5 mm (0.20 in.)
G	41 mm (1.61 in.)	R	36 mm (1.42 in.)
H	32.5 mm (1.28 in.)	S	195.25 to 195.75 mm (7.687 to 7.707 in.)
I	148.5 mm (5.85 in.)	T	145 mm (5.71 in.)
J	46.50 to 46.75 mm dia. (1.831 to 1.841 in. dia.)	U	384.75 to 385.25 mm (15.148 to 15.167 in.)
K	44.950 to 44.975 mm dia. (1.7697 to 1.7707 in. dia.)		



Bushing Replacing Tools

Application : Use to press out and press fit the bushing.

1. For small end bushing

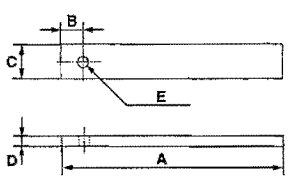
A	162 mm (6.38 in.)
B	35 mm (1.38 in.)
C	27 mm (1.06 in.)
D	35 mm dia. (1.38 in. dia.)
E	27.90 to 27.95 mm dia. (1.098 to 1.100 in. dia.)
F	25.00 to 25.01 mm dia. (0.984 to 0.985 in. dia.)

2. For idle gear bushing

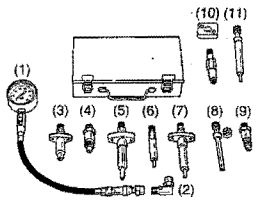
A	175 mm (6.89 in.)
B	40 mm (1.57 in.)
C	38 mm (1.49 in.)
D	45 mm dia. (1.77 in. dia.)
E	41.90 to 41.95 mm dia. (1.650 to 1.652 in. dia.)
F	37.95 to 37.97 mm dia. (1.494 to 1.495 in. dia.)

Flywheel Stopper

Application : Use to loosen and tighten the flywheel screw.



A	200 mm (7.87 in.)
B	20 mm (0.79 in.)
C	30 mm (1.18 in.)
D	8 mm (0.31 in.)
E	10 mm dia. (0.39 in. dia.)

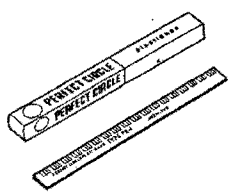


Diesel Engine Compression Tester

Code No : 07909-30208 (Assembly) 07909-31251 (G)
07909-30934 (A to F) 07909-31271 (I)
07909-31211 (E and F) 07909-31281 (J)
07909-31231 (H)

Application : Use to measure diesel engine compression and diagnostics of need for major overhaul.

(1) Gauge
(2) L Joint
(3) Adaptor **A**
(4) Adaptor **B**
(5) Adaptor **C**
(6) Adaptor **E**
(7) Adaptor **F**
(8) Adaptor **G**
(9) Adaptor **H**
(10) Adaptor **I**
(11) Adaptor **J**

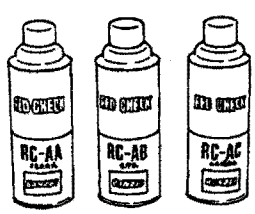


Plastigage

Code No : 07909-30241

Application : Use to check the oil clearance between crankshaft and bearing, etc..

Measuring range : Green.....0.025 to 0.076 mm (0.001 to 0.003 in.)
Red.....0.051 to 0.152 mm (0.002 to 0.006 in.)
Blue.....0.102 to 0.229 mm (0.004 to 0.009 in.)



Red Check

Code No : 07909-31371

Application : Use to check cracks on cylinder head, cylinder block, etc..

ENGINE BODY

Item		Factory Specification	Allowable Limit
Cylinder Head Surface	Flatness	—	0.05 mm / 500 mm 0.0020 in. / 19.69 in.
Compression Pressure (When Cranking with Starting Motor)	—	3.53 to 4.02 MPa / 290 min^{-1} (rpm) 36 to 41 kgf/cm^2 / 290 min^{-1} (rpm) 512 to 583 psi / 290 min^{-1} (rpm)	2.55 MPa / 290 min^{-1} (rpm) 26 kgf/cm^2 / 290 min^{-1} (rpm) 370 psi / 290 min^{-1} (rpm)
	Difference among Cylinders	—	10 % or less
Top Clearance		0.55 to 0.70 mm 0.0217 to 0.0276 in.	—
Valve Clearance (When Cold)		0.18 to 0.22 mm 0.0071 to 0.0087 in.	—
Valve Seat	Width (Intake)	2.12 mm 0.0835 in.	—
	Width (Exhaust)	2.12 mm 0.0835 in.	—
Valve Seat	Angle (Intake)	1.047 rad 60 °	—
	Angle (Exhaust)	0.785 rad 45 °	—
Valve Face	Angle (Intake)	1.047 rad 60 °	—
	Angle (Exhaust)	0.785 rad 45 °	—
Valve Stem to Valve Guide	Clearance	0.040 to 0.070 mm 0.00157 to 0.00276 in.	0.1 mm 0.0039 in.
	Valve Stem (O.D.)	7.960 to 7.975 mm 0.31339 to 0.31398 in.	—
	Valve Guide (I.D.)	8.015 to 8.030 mm 0.31555 to 0.31614 in.	—
Valve Recessing	Protrusion	0.05 mm 0.0020 in.	—
	Recessing	0.15 mm 0.0059 in.	0.4 mm 0.0157 in.
Valve Timing (Intake Valve)	(Open)	0.21 rad (12 °) before T.D.C.	—
	(Close)	0.63 rad (36 °) after B.D.C.	—

SERVICE DATA - STANDARDS AND LIMITS

Item		Factory Specification	Allowable Limit
Valve Timing (Exhaust Valve)	(Open)	1.05 rad (60 °) before B.D.C.	—
	(Close)	0.21 rad (12 °) after T.D.C.	—
Valve Spring	Free Length	41.7 to 42.2 mm 1.6417 to 1.6614 in.	41.2 mm 1.6220 in.
	Setting Load / Setting Length	117.6 N / 35.0 mm 12.0 kgf / 35.0 mm 26.4 lbs / 1.3780 in.	100.0 N / 35.0 mm 10.2 kgf / 35.0 mm 22.5 lbs / 1.3780 in.
	Tilt	—	1.0 mm 0.039 in.
Rocker Arm Shaft to Rocker Arm	Clearance	0.016 to 0.045 mm 0.00063 to 0.00177 in.	0.1 mm 0.0039 in.
	Rocker Arm Shaft (O.D.)	13.973 to 13.984 mm 0.55012 to 0.55055 in.	—
	Rocker Arm (I.D.)	14.000 to 14.018 mm 0.55118 to 0.55189 in.	—
Push Rod	Alignment	—	0.25 mm 0.0098 in.
Tappet to Tappet Guide	Clearance	0.020 to 0.062 mm 0.00079 to 0.00244 in.	0.07 mm 0.0028 in.
	Tappet (O.D.)	23.959 to 23.980 mm 0.94327 to 0.94410 in.	—
	Tappet Guide (I.D)	24.000 to 24.021 mm 0.94488 to 0.94571 in.	—
Timing Gear	Crank Gear to Idle Gear (Backlash)	0.0415 to 0.1122 mm 0.00163 to 0.00442 in.	0.15 mm 0.0059 in.
	Idle Gear to Cam Gear (Backlash)	0.0415 to 0.1154 mm 0.00163 to 0.00454 in.	0.15 mm 0.0059 in.
	Idle Gear to Injection Pump Gear (Backlash)	0.0415 to 0.1154 mm 0.00163 to 0.00454 in.	0.15 mm 0.0059 in.
	Crank Gear to Oil Pump Gear (Backlash)	0.0415 to 0.1090 mm 0.00163 to 0.00429 in.	0.15 mm 0.0059 in.
	Idle Gear to Balancer Gear (Backlash) (Balancer Model Only)	0.0350 to 0.1160 mm 0.00138 to 0.00457 in.	0.15 mm 0.0059 in.

SERVICE DATA / STANDARDS AND LIMITS

Item		Factory Specification	Allowable Limit
Idle Gear	Side Clearance	0.12 to 0.48 mm 0.0047 to 0.0189 in.	0.9 mm 0.0354 in.
Idle Gear Shaft to Idle Gear Bushing	Clearance	0.025 to 0.066 mm 0.00098 to 0.00260 in.	0.1 mm 0.0039 in.
	Idle Gear Shaft (O.D.)	37.959 to 37.975 mm 1.49445 to 1.49508 in.	—
	Idle Gear Bushing (I.D.)	38.000 to 38.025 mm 1.49606 to 1.49704 in.	—
Camshaft	Side Clearance	0.07 to 0.22 mm 0.0028 to 0.0087 in.	0.3 mm 0.0118 in.
Camshaft	Alignment	—	0.01 mm 0.0004 in.
Cam	Height (Intake / Exhaust)	33.90 mm 1.3346 in.	33.85 mm 1.3327 in.

Item		Factory Specification	Allowable Limit
Camshaft Journal to Cylinder Block Bore	Clearance	0.050 to 0.091 mm 0.00197 to 0.00358 in.	0.15 mm 0.0059 in.
	Camshaft Journal (O.D.)	39.934 to 39.950 mm 1.57221 to 1.57284 in.	—
	Cylinder Block Bore (I.D.)	40.000 to 40.025 mm 1.57480 to 1.57579 in.	—
Balancer Shaft (Balancer Model Only)	Side Clearance	0.07 to 0.22 mm 0.0028 to 0.0087 in.	0.3 mm 0.0118 in.
Balancer Shaft Journal 1 to Balancer Shaft Bearing 1 (Balancer Model Only)	Clearance	0.030 to 0.111 mm 0.00118 to 0.00437 in.	0.2 mm 0.0079 in.
	Balancer Shaft Journal 1 (O.D.)	43.934 to 43.950 mm 1.72968 to 1.73031 in.	—
	Balancer Shaft Journal 1 (I.D.)	43.980 to 44.045 mm 1.73149 to 1.73405 in.	—
Balancer Shaft Journal 2 to Balancer Shaft Bearing 2 (Balancer Model Only)	Clearance	0.030 to 0.111 mm 0.00118 to 0.00437 in.	0.2 mm 0.0079 in.
	Balancer Shaft Journal 2 (O.D.)	41.934 to 41.950 mm 1.65094 to 1.65157 in.	—
	Balancer Shaft Journal 2 (I.D.)	41.980 to 42.045 mm 1.65275 to 1.65531 in.	—
Balancer Shaft Journal 3 to Balancer Shaft Bearing 3 (Balancer Model Only)	Clearance	0.020 to 0.094 mm 0.00079 to 0.00370 in.	0.2 mm 0.0079 in.
	Balancer Shaft Journal 3 (O.D.)	21.947 to 21.960 mm 0.86405 to 0.86456 in.	—
	Balancer Shaft Journal 3 (I.D.)	21.980 to 22.041 mm 0.86535 to 0.86775 in.	—
Piston Pin Bore	I.D.	25.000 to 25.013 mm 0.98425 to 0.98476 in.	25.05 mm 0.9862 in.

SERVICE DATA / STANDARDS AND LIMITS

Item		Factory Specification	Allowable Limit
Top Ring	(Ring Gap)	0.25 to 0.40 mm 0.0098 to 0.0157 in.	1.25 mm 0.0492 in.
Second Ring to Ring Groove	Clearance	0.093 to 0.128 mm 0.0037 to 0.0050 in.	0.2 mm 0.0079 in.
Oil Ring to Ring Groove	Clearance	0.020 to 0.060 mm 0.0008 to 0.0021 in.	0.15 mm 0.0059 in.
Second Ring	(Ring Gap)	0.30 to 0.45 mm 0.0118 to 0.0177 in.	1.25 mm 0.0492 in.
Oil Ring	Ring Gap	0.25 to 0.45 mm 0.0098 to 0.0177 in.	1.25 mm 0.0492 in.
Connecting Rod	Alignment	—	0.05 mm 0.0020 in.
Piston Pin to Small End Bushing	Clearance	0.014 to 0.038 mm 0.00055 to 0.00150 in.	0.15 mm 0.0059 in.
	Piston Pin (O.D.)	25.002 to 25.011 mm 0.98433 to 0.98468 in.	—
	Small End Bushing (I.D.)	25.025 to 25.040 mm 0.98523 to 0.98582 in.	—
Crankshaft	Alignment	—	0.02 mm 0.00079 in.
Crankshaft Journal to Crankshaft Bearing 1	Oil Clearance	0.040 to 0.118 mm 0.00157 to 0.00465 in.	0.2 mm 0.0079 in.
	Crankshaft Journal (O.D.)	59.921 to 59.940 mm 2.35909 to 2.35984 in.	—
	Crankshaft Bearing 1 (I.D.)	59.980 to 60.039 mm 2.36142 to 2.36374 in.	—
Crankshaft Journal to Crankshaft Bearing 2	Oil Clearance	0.040 to 0.104 mm 0.00157 to 0.00409 in.	0.2 mm 0.0079 in.
	Crankshaft Journal (O.D.)	59.921 to 59.940 mm 2.35909 to 2.35984 in.	—
	Crankshaft Bearing 2 (I.D.)	59.980 to 60.025 mm 2.36142 to 2.36374 in.	—

SERVICE DATA / STANDARDS AND LIMITS

ELECTRICAL SYSTEM

Item		Factory Specification	Allowable Limit
Starter	Commutator (O.D.) 4 Cylinder	30.0 mm 1.181 in.	29.0 mm 1.142 in.
	Commutator (O.D.) 3 Cylinder	35.0 mm 1.378 in.	34.0 mm 1.339 in.
	Mica (Under Cut)	0.45 to 0.75 mm 0.0177 to 0.0295 in.	0.20 mm 0.0079 in.
	Brush (Length) 4 Cylinder	15.0 mm 0.591 in.	11.0 mm 0.433 in.
	Brush (Length) 3 Cylinder	15.0 mm 0.591 in.	9.0 mm 0.354 in.
	Brush Holder and Holder Support (Resistance)	Infinity	—
Alternator	No-load voltage	More than 13.5 V	—
	Stator (Resistance)	Less than 1.0 Ω	—
	Rotor (Resistance)	2.9 Ω	—
	Slip Ring (O.D.)	14.4 mm 0.567 in.	14.0 mm 0.551 in.
	Brush (Length)	10.5 mm 0.413 in.	8.4 mm 0.331 in.
Glow Plug	Resistance	Approx. 0.9 Ω	—
Stop Solenoid	Pulling Coil (Resistance)	Approx. 0.375 Ω	—
	Holding Coil (Resistance)	Approx. 15.6 Ω	—

FUEL SYSTEM

Item		Factory Specification	Allowable Limit
Injection Pump	Injection Timing	0.297 to 0.331 rad (17 to 19 °) before T.D.C.	—
Injection Nozzle	Injection Pressure	13.73 to 14.71 MPa 140 to 150 kgf/cm^2 1991 to 2133 psi	—
Injection Nozzle Valve Seat	Valve Seat Tightness	When the pressure is 12.75 MPa (130 kgf/cm^2, 1849 psi), the valve seat must be fuel tightness.	—

SERVICE DATA / STANDARDS AND LIMITS

Item		Factory Specification	Allowable Limit
Crankpin to Crankpin Bearing	Oil Clearance	0.025 to 0.087 mm 0.00098 to 0.00343 in.	0.2 mm 0.0079 in.
	Crankpin (O.D.)	46.959 to 46.975 mm 1.84878 to 1.84941 in.	—
	Crankpin Bearing (I.D.)	47.000 to 47.046 mm 1.85039 to 1.85220 in.	—
Crankshaft	Side Clearance	0.15 to 0.31 mm 0.0059 to 0.0122 in.	0.5 mm 0.0197 in.
Crankshaft Sleeve	Wear	—	0.1 mm 0.0039 in.

Item		Factory Specification	Allowable Limit
Cylinder Bore [Standard]	(I.D.)	87.000 to 87.022 mm 3.42519 to 3.42606 in.	+ 0.15 mm + 0.0059 in.
Cylinder Bore [Oversize]	(I.D.)	87.250 to 87.272 mm 3.43503 to 3.43590 in.	+ 0.15 mm + 0.0059 in.

LUBRICATING SYSTEM

Item		Factory Specification	Allowable Limit
Engine Oil Pressure	At Idle Speed	98 kPa or more 1.0 kgf/cm^2 or more 14 psi or more	49 kPa 0.5 kgf/cm^2 7 psi
	At Rated Speed	294 to 441 kPa 3.0 to 4.5 kgf/cm^2 43 to 64 psi	245 kPa 2.5 kgf/cm^2 36 psi
Engine Oil Pressure Switch	Working Pressure	49 kPa 0.5 kgf/cm^2 7 psi	—
Inner Rotor to Outer Rotor	Clearance	0.03 to 0.14 mm 0.0012 to 0.0055 in.	0.2 mm 0.0079 in.
Outer Rotor to Pump Body	Clearance	0.11 to 0.19 mm 0.0043 to 0.0075 in.	0.25 mm 0.0098 in.
Inner Rotor to Cover	Clearance	0.105 to 0.150 mm 0.00413 to 0.00591 in.	0.2 mm 0.0079 in.

COOLING SYSTEM

Thermostat	Valve Opening Temperature (At Beginning)	69.5 to 72.5 °C 157.1 to 162.5 °F	—
	Valve Opening Temperature (Opened Completely)	85 °C 185 °F	—

TORQUE SPECIFICATIONS

■ NOTE
- For "*" marked screws, bolts and nuts on the table, apply engine oil to their threads and seats before tightening.
- The letter "M" in Size x Pitch means that the screw, bolt or nut dimension stands for metric. The size is the nominal outside diameter in mm of the threads. The pitch is the nominal distance in mm between two threads.

Item	Size x Pitch	N·m	kgf·m	ft-lbs
Cylinder head cover screw	M6 x 1.0	6.9 to 11.3	0.7 to 1.15	5.1 to 8.32
*Cylinder head screw	M11 x 1.25	93.1 to 98.0	9.5 to 10.0	68.7 to 72.3
*Main bearing case screw 1	M9 x 1.25	46.1 to 50.9	4.7 to 5.2	34.0 to 37.6
*Main bearing case screw 2	M10 x 1.25	68.6 to 73.5	7.0 to 7.5	50.6 to 54.2
*Flywheel screw	M12 x 1.25	98.0 to 107.8	10.0 to 11.0	72.3 to 79.5
*Connecting rod screw	M8 x 1.0	44.1 to 49.0	4.5 to 5.0	32.5 to 36.2
*Rocker arm bracket screw	M8 x 1.25	23.5 to 27.5	2.4 to 2.8	17.4 to 20.3
*Idle gear shaft screw	M8 x 1.25	23.5 to 27.5	2.4 to 2.8	17.4 to 20.3
drive pulley mounting nut	—	137.3 to 156.9	14.0 to 16.0	101.3 to 115.7
*Bearing case cover screw	M8 x 1.25	23.5 to 27.5	2.4 to 2.8	17.4 to 20.3
Glow plugs	M10 x 1.25	19.6 to 24.5	2.0 to 2.5	14.5 to 18.1
Nozzle holder assembly	M20 x 1.5	49.0 to 68.6	5.0 to 7.0	36.2 to 50.6
Oil pressure switch	R 1/8	14.7 to 19.6	1.5 to 2.0	10.8 to 14.5
Injection pipe retaining nut	M12 x 1.5	24.5 to 34.3	2.5 to 3.5	18.1 to 25.3
Overflow pipe assembly retaining nut	—	19.6 to 24.5	2.0 to 2.5	14.5 to 18.1
Camshaft set screw	M8 x 1.25	23.5 to 27.5	2.4 to 2.8	17.4 to 20.3
Hi-idling body	—	44.1 to 49.0	4.5 to 5.0	32.5 to 36.2
Balancer shaft set bolt	M8 x 1.25	23.5 to 27.5	2.4 to 2.8	17.4 to 20.3
Alternator pulley nut	—	58.3 to 78.9	5.95 to 8.05	43.0 to 58.2

When the tightening torques are not specified, tighten the screws, bolts and nuts according to the table below.

Grade / Nominal Diameter / Unit	Standard Screw and Bolt ④			Special Screw and Bolt ⑦		
	N·m	kgf·m	ft-lbs	N·m	kgf·m	ft-lbs
M6	7.9 to 9.3	0.80 to 0.95	5.8 to 6.9	9.8 to 11.3	1.00 to 1.15	7.23 to 8.32
M8	17.7 to 20.6	1.8 to 2.1	13.0 to 15.2	23.5 to 27.5	2.4 to 2.8	17.4 to 20.3
M10	39.2 to 45.1	4.0 to 4.6	28.9 to 33.3	48.1 to 55.9	4.9 to 5.7	35.4 to 41.2
M12	62.8 to 72.6	6.4 to 7.4	46.3 to 53.5	77.5 to 90.2	7.9 to 9.2	57.1 to 66.5

Screw and bolt material grades are shown by numbers punched on the screw and bolt heads. Prior to tightening, be sure to check out the numbers as shown below.

Punched number	Screw and bolt material grade
None or 4	Standard screw and bolt SS41, S20C
7	Special screw and bolt S43C, S48C (Refined)

GENERATOR INFORMATION

USE OF ELECTRIC MOTORS

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

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

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

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

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

REQUIRED OPERATING SPEED

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

NOTE: *When the vessel in which the generator is installed contains AC equipment of 120 volts only, it is recommended that the generator's AC terminal block be configured to provide one 120 volt AC hot leg for the vessel's distribution panel. This will ensure good motor starting response from the generator.*

GENERATOR FREQUENCY ADJUSTMENT

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

- When the generator is run at 1800 rpm, the AC voltage output frequency is 60 Hertz.
- When the generator is run at 1500 rpm, the AC voltage output frequency is 50 Hertz.

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

GENERATOR MAINTENANCE

- Maintaining reasonable cleanliness is important. Connections of terminal boards and rectifiers may become corroded, and insulation surfaces may start conducting if salts, dust, engine exhaust, carbon, etc. are allowed to build up. Clogged ventilation openings may cause excessive heating and reduce life of windings.
- For unusually severe conditions, thin rust-inhibiting petroleum based coatings should be sprayed or brushed over all surfaces to reduce rusting and corrosion.
- In addition to periodic cleaning, the generator should be inspected for tightness of all connections, evidence of overheated terminals and loose or damaged wires.
- The drive discs on single bearing generator's should be checked periodically if possible for tightness of screws and for any evidence of incipient cracking failure. Discs should not be allowed to become rusty because rust may accelerate cracking. The bolts which fasten the drive disc to the generator shaft must be hardened steel SAE grade 8, identified by 6 radial marks, one at each of the 6 corners of the head.
- The rear armature bearing is lubricated and sealed; no maintenance is required. However, if the bearing becomes noisy or rough-sounding, have it replaced.
- Examine the bearing at periodic intervals. No side movement of the shaft should be detected when force is applied. If side motion is detectable, inspect the bearing and shaft for wear. Repair must be made quickly or major components will rub and cause major damage to the generator.

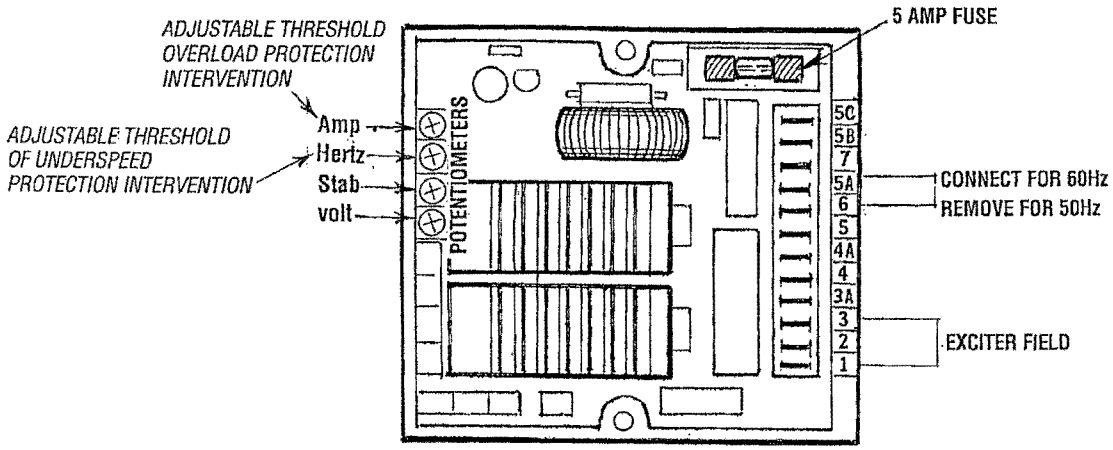
Carbon Monoxide Detector

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

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

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

ELECTRONIC REGULATION SR7-2G AVR



DESCRIPTION

The voltage regulator (AVR) ensures optimum AC generator performance. This advanced design AVR is equipped with circuitry protection to guard against operating conditions that could be detrimental to the AC generator. The following information details the voltage regulators adjustments and connections. These procedures should be performed by a qualified technician.

TERMINAL CONNECTIONS

#1. Excitation field DC negative.

#2. Exciter field jumper to 3 if the regulator AC supply between 5 and 3A is less than 160 VAC.

#3. Exciter field DC positive.

#3A. Supply voltage to regulator (AC).

#4. Sensing voltage.

#5. Supply voltage to regulator (AC).

#6. Jumper to 5A for 60 Hz operation.

#7. Not used.

#5B. Not used.

#5C. Sensing voltage.

POSSIBLE CONNECTIONS

Exciter Field: The exciter field negative should be connected to terminal **1** of the electronic regulator (normally dark blue or black), while the positive (normally red or yellow) should be connected to terminal **3**.

Supply: There are two possibilities.

1. The supply coincides with the sensing. In this case the SR7/2 supply should be connected to terminals **3** and **5** (in case of three-phase generators, terminal **5** is normally connected with the star point). Terminals **3** and **4** should be connected to each other in such a way that the supply is also sensing. This connection in necessary when the generator does not have auxiliary winding for supplying the regulator.
2. The supply and sensing separate. This is the case of a generator equipped with auxiliary winding for regulator supply. Supply is always connected to terminals **3** and **5** of the regulator.

In both of these cases, the SR7/2 supply can vary from 80 to 270 VAC. But it should be noted that terminals 2 and 3 should be bridged for supply with voltage between 80 and 160 VAC, while the same terminals should be left open if the voltage is between 160 and 270 VAC.

Sensing: Sensing should be connected to terminals **4** and **5** and can vary from 80 to 350 VAC. The sensing is single phase only and therefore is normally connected to one alternator phase.

Operation at 60 Hz: When operating at 60 Hz, terminals **5A** and **6** should be connected to each other in order to keep the low frequency protection correctly regulated.

> ⚠ **WARNING:** ***Be aware that high voltages may be present. Take all necessary precautionms to safe guard against electrical hazards.***

FUNCTIONS OF THE REGULATOR POTENTIOMETERS

Volt: With this potentiometer, it is possible to adjust the voltage generated by the alternator in a very simple way. If the screw is turned clockwise, the voltage increases, if the screw is turned counterclockwise it decreases.

Stab: This potentiometer optimizes alternator performance. If turned clockwise, the stability decreases and the response time decreases but the voltage tends to be less stable. If turned counterclockwise, the response time increases and the voltage tends to be more stable.

In order to adjust this potentiometer correctly, we advise using the following method.

1. The generator must be working, starting from zero load and the potentiometer must be at maximum stability (turned fully counterclockwise).
2. Slightly turn clockwise until the light generated by the filament lamp oscillates, at this point, turn the potentiometer slowly counterclockwise until the light stabilizes.

ELECTRONIC REGULATION SR7-2G AVR

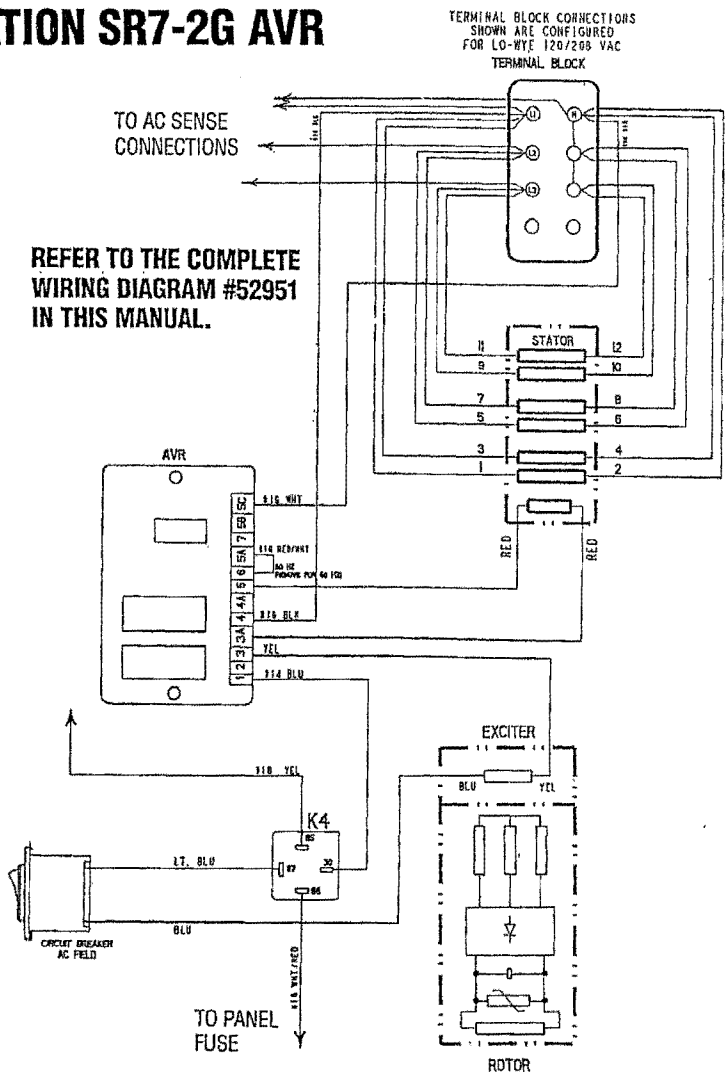
Hertz: With this potentiometer, which is normally pre-calibrated then sealed by the manufacturer, it is possible to adjust the low frequency protection intervention. To recalibrate this protection, you must take the generator to a normal zero load condition, turn the potentiometer clockwise until the limit position is reached, then decrease the nominal speed by 10 %. Then turn the potentiometer counterclockwise and measure the voltage value until it has decreased by 5 volts.

When the speed decreases by more than 10% of the nominal value, the voltage also decreases proportionally, blocking generator overheating. Even if we advise calibrating this protection at 10% of the nominal value, it is obviously possible to calibrate the threshold at other values.

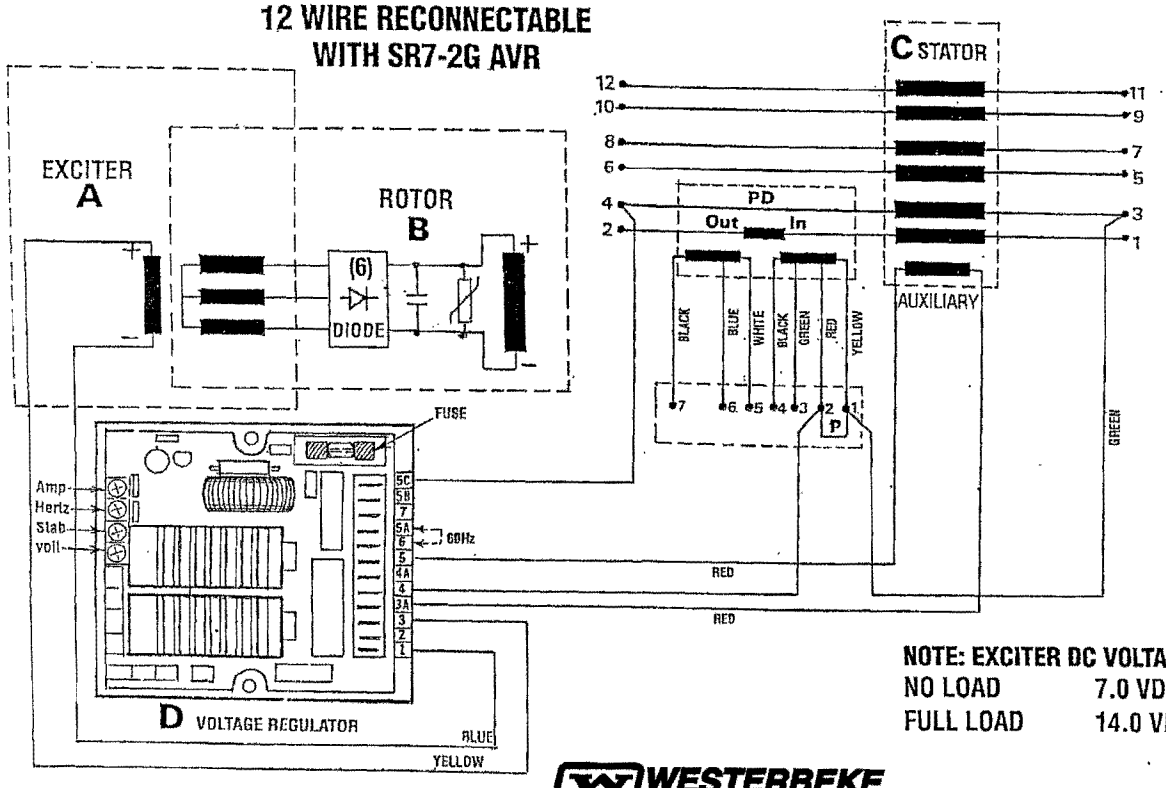
Amp: With this potentiometer, it is possible to adjust the intervention level of the overload protection. This protection system has an intervention delay, which permits a temporary overload, necessary when starting motors or similar applications.

To modify this protection, you must overload the generator by 15% of the normal load, turn the potentiometer to minimum (counterclockwise) and wait about twenty seconds. During this period of time the voltage value decreases. In this condition and while turning the potentiometer clockwise, fix the generator voltage value at 10% less than the nominal one. At this point, while the initial overload is being removed, the voltage increases to the nominal value.

Fuse: The electronic regulator is equipped with a fuse, which protects the alternator from overheating in cases of regulator malfunction. The fuse (250V-5A, quick acting, F type) can be replaced easily.



INTERNAL WIRING DIAGRAM 12 WIRE RECONNECTABLE WITH SR7-2G AVR



COMPONENT RESISTANCE VALUES IN OHMS (AT 86°F)

STATOR (each winding)	0.041
AUXILIARY	0.9
EXCITER STATOR	11.3
EXCITER ROTOR (each pair)	0.72
ROTOR	2.7

NOTE: EXCITER DC VOLTAGE / AUXILIARY VOLTAGE

NO LOAD	7.0 VDC	215 VAC
FULL LOAD	14.0 VDC	222 VAC

EXCITER ROTOR TROUBLESHOOTING

LOW VOLTAGE - EXCITER ROTOR AND ROTATING FIELD

Position the exciter rotor/rotating field so the transient suppressor is visible at the 12 O'Clock position.

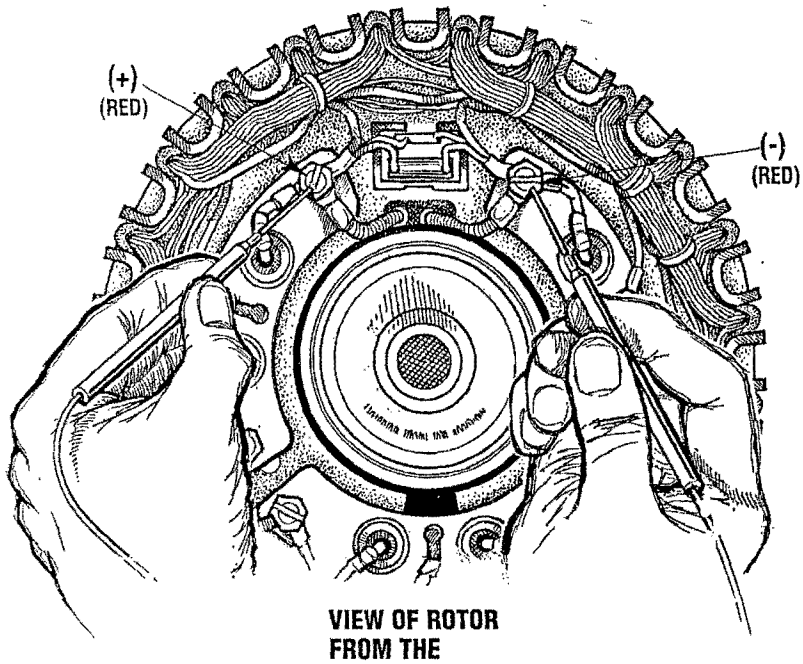
TESTING THE ROTATING FIELD WINDINGS

Place the ohm meter probes on the two large red wires (+) and (-). These are the connecting wires for the rotating field windings.

These wires do not need to be lifted off their connections unless, when testing, there is an ohm valve discrepancy or a continuity to ground (the rotor shaft).

If this occurs, lift these two flarge field wires off the diode plates, isolate them, and repeat the above test.

NOTE: *When removing these wires, be careful not to drop the screws or washers into the rotor.*

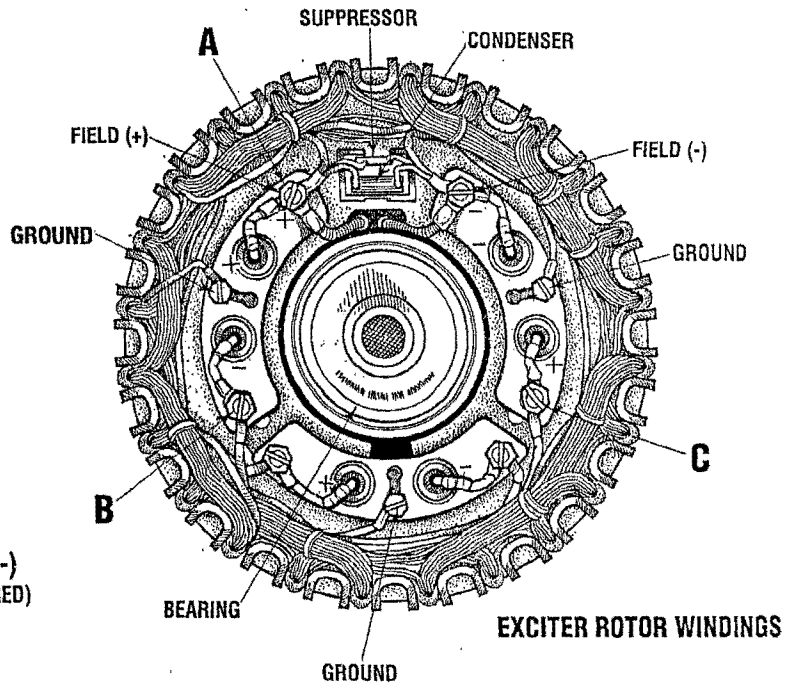


VIEW OF ROTOR FROM THE BEARING END

12 O-CLOCK POSITION

TESTING THE EXCITER ROTOR WINDINGS

These windings are tested in pairs: **A** to **B**, **B** to **C**, and **C** to **A** as shown on the drawing.



EXCITER ROTOR WINDINGS

Disconnect these three wires from the diode bridge plates taking care not to drop any screws or washers.

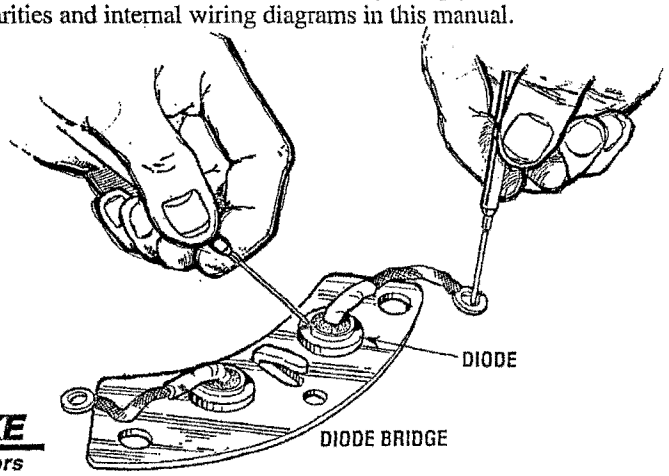
With the wires clear from the bridge plates, test each pair with an ohm meter, **A** to **B**, **B** to **C**, and **C** to **A.**

No continuity should be found between the rotor and any of these three winding pairs.

TESTING THE DIODES

Diodes can be checked with an ohmmeter. Disconnect the wire of the particular diode and test its resistance in both directions. A perfectly functioning diode will show a very high resistance in one direction and a very low resistance in the opposite direction. A faulty diode will show either a very low resistance, or an infinite resistance in both directions.

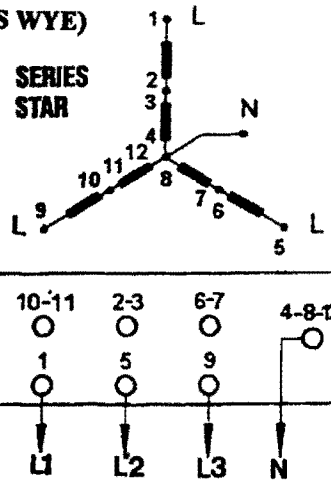
Should the whole bridge be replaced, remember to tighten the screws with a suitable wrench and strictly comply with the polarities and internal wiring diagrams in this manual.



TWELVE LEAD WINDING/TERMINAL BOARD CONNECTIONS
AND (NOMINAL) VOLTAGES

(SERIES WYE)

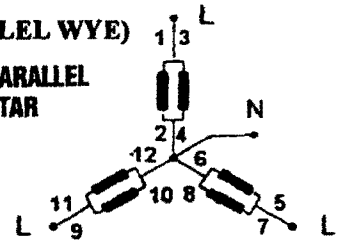
SERIES STAR

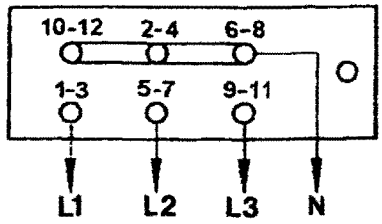


50 Hz L-L 400 volts
50 Hz L-N 230 volts
60 Hz L-L 480 volts
60 Hz L-N 277 volts

(PARALLEL WYE)

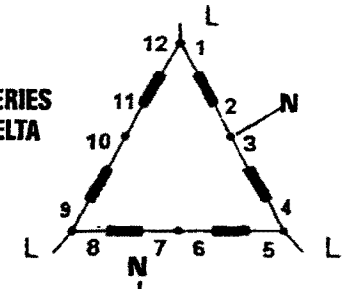
PARALLEL STAR

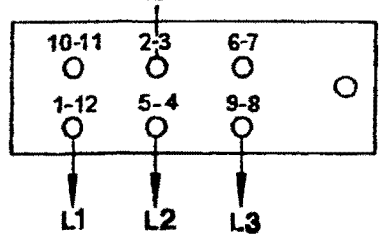




50 Hz L-L 200 volts
50 Hz L-N 115 volts
60 Hz L-L 240 volts
60 Hz L-N 138 volts

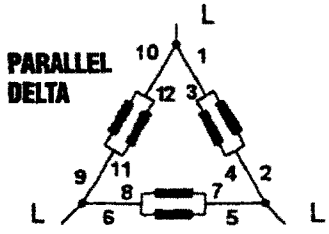
SERIES DELTA

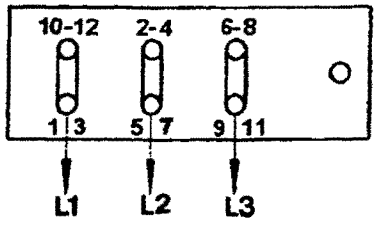




50 Hz L-L 230 volts
50 Hz L-N 115 volts
60 Hz L-L 277 volts
60 Hz L-N 138 volts
(Refer to Note #1)

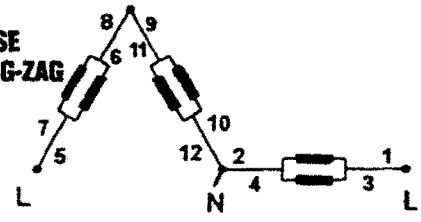
PARALLEL DELTA

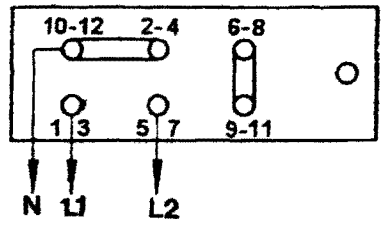




50 Hz L-L 115 volts
60 Hz L-L 138 volts

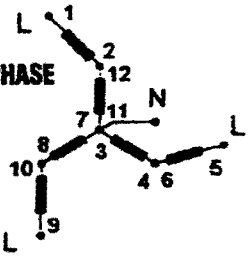
SINGLE PHASE PARALLEL ZIG-ZAG

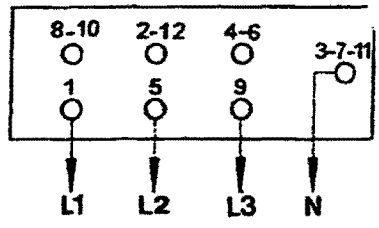




50 Hz L-L 230 volts
50 Hz L-N 115 volts
60 Hz L-L 277 volts
60 Hz L-N 138 volts
(Refer to Note #1)

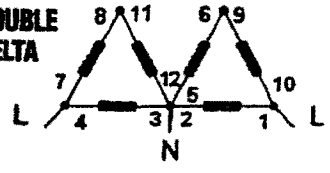
THREE PHASE ZIG-ZAG

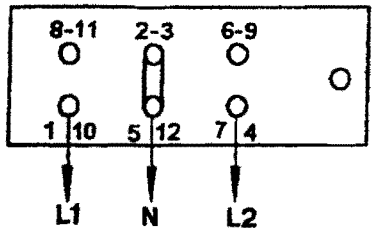




50 Hz L-L 346 volts
50 Hz L-N 200 volts
60 Hz L-L 415 volts
60 Hz L-N 240 volts
(Refer to Note #2)

DOUBLE DELTA
3-wire



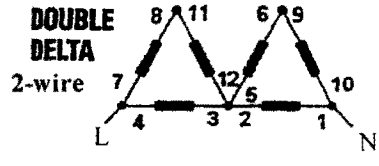


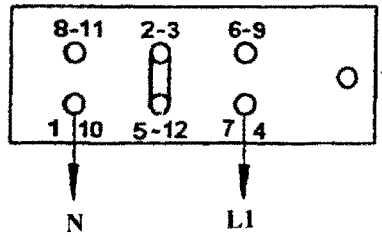
50 Hz L-L 230 volts
50 Hz L-N 115 volts
60 Hz L-L 240 volts
60 Hz L-N 120 volts

Note #1 *Single phase amperage load. The phase current must not exceed the nominal value.*

Note #2 *Three phase zig-zag connection. The rated power must be multiplied by 0.866.*

DOUBLE DELTA
2-wire





50 Hz L-N 230 volts
60 Hz L-N 240 volts

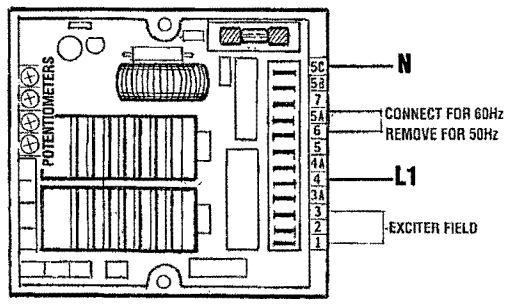
CHANGING HERTZ AND VOLTAGE

⚠ CAUTION: ***As a precaution against an unintentional start, shut OFF the 20 Amp DC breaker on the control panel.***

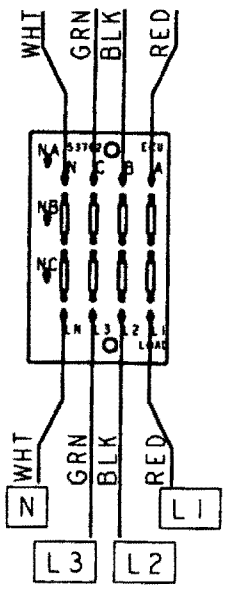
1. Refer to the previous page that illustrates the various AC voltage output configurations for both the 60 Hertz and 50 Hertz applications. Select the configuration for the Hertz/Voltage required.
2. Reconfigure the 6/12 AC connections on the terminal board carefully following the illustration. Reference below the voltage sensing diagram and it's connections to the AC terminal block. There are three line connections when needed and a neutral. These connections **MUST** correspond to and be connected to the line (L) connections on the AC terminal board and the neutral connection as well to it's corresponding connection.

NOTE: *Failure to properly connect these voltage sense connections can result in an AC output voltage fault shut down either from low or high AC voltage or incorrect AC voltage displayed on the LCD display.*

3. There are three line connections. When an L3 is not present on the AC terminal block, insulate and tie off the L3 connection from the Voltage Sensing Board.
4. Inside the control box, locate the ECU and position the Hertz/Frequency dip switch in the correct position for the Hertz/Frequency desired.
5. Verify all connections are correct and turn off any AC panel breakers.
6. Start the generator and monitor the AC output voltage at the generator's terminal board. Line to line, line to neutral. Adjust the voltage regulator board as needed to obtain the correct voltage. Check the generator hertz/frequency with your hertz meter.
7. Turn on the AC panel breakers and load unit and monitor the operation.

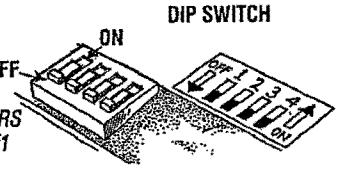


AUTOMATIC VOLTAGE REGULATOR



VOLTAGE SENSING BOARD

DIP SWITCH

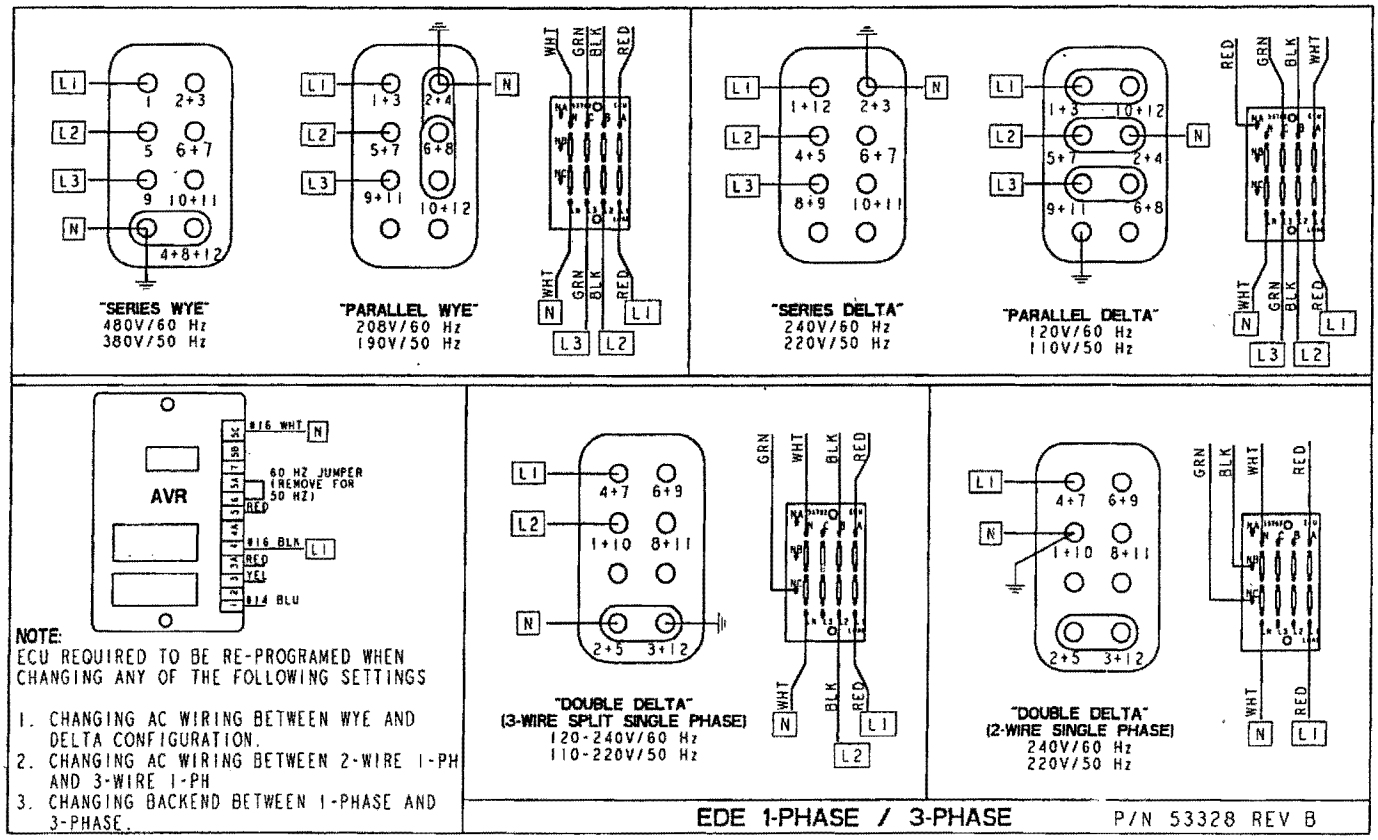


WHEN CHANGING THE GENERATORS FREQUENCY (50/60 HZ) SWITCH #1 ON THE CONTROL PANEL ECU BOARD MUST BE SWITCHED: ON FOR 50 HZ AND OFF FOR 60 HZ.

ECU SWITCHES

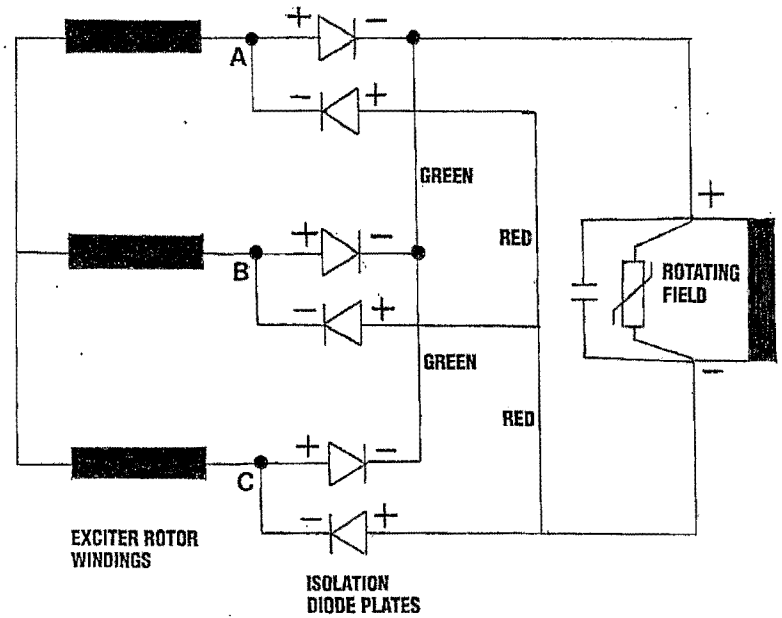
AC OUTPUT CONFIGURATIONS

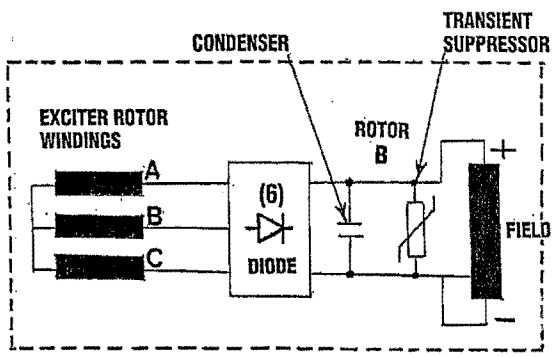
VOLTAGE SENSING BOARD CONNECTIONS



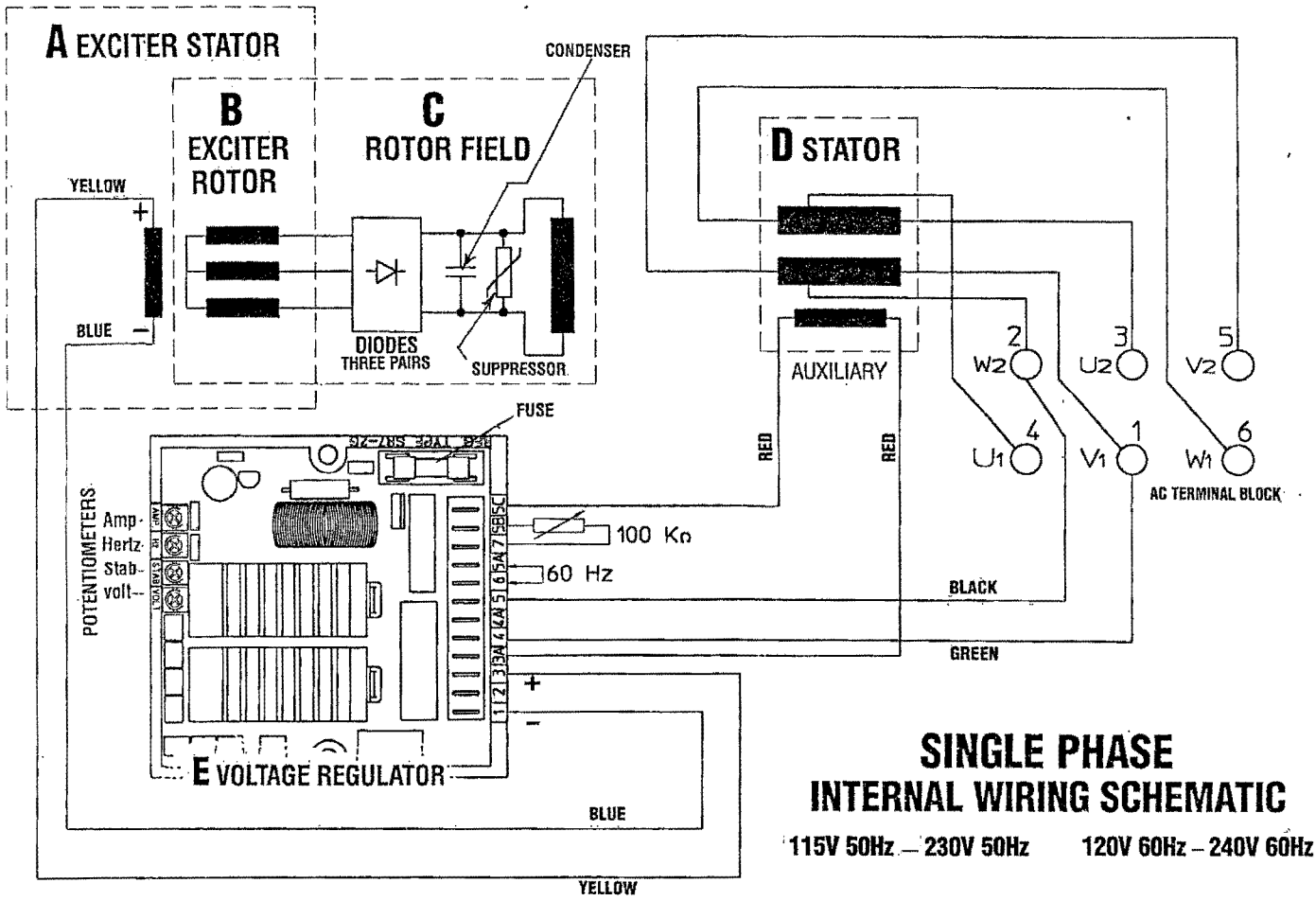
INTERNAL WIRING SCHEMATIC

EXCITER ROTOR/ROTATING FIELD



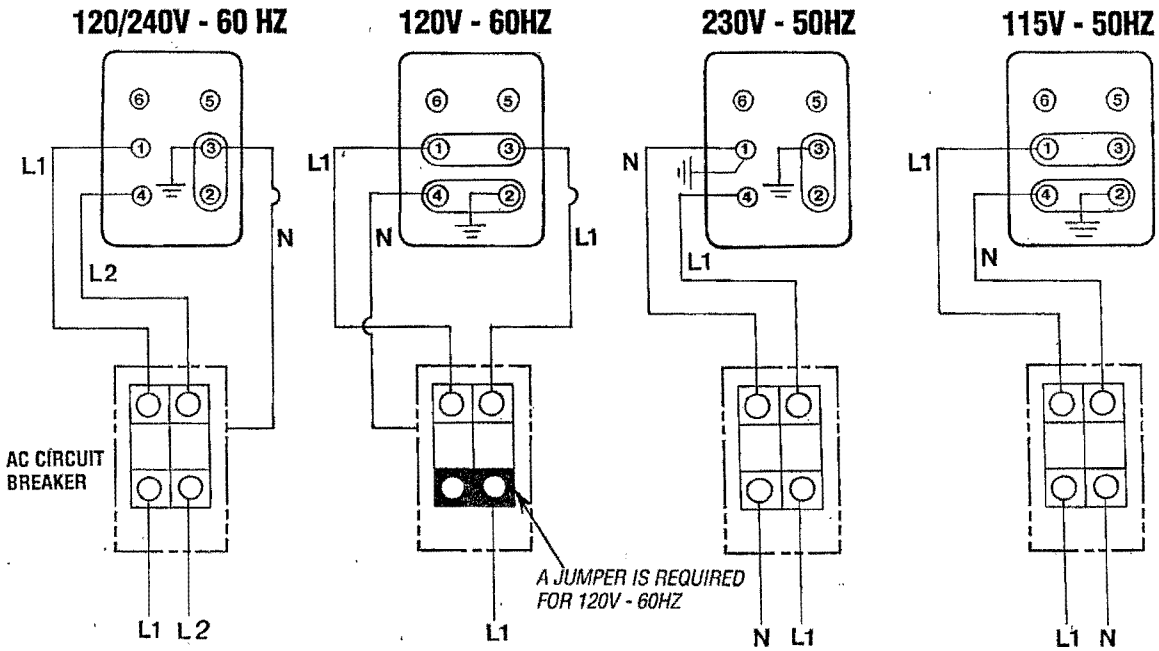


GENERATOR WIRING SCHEMATICS



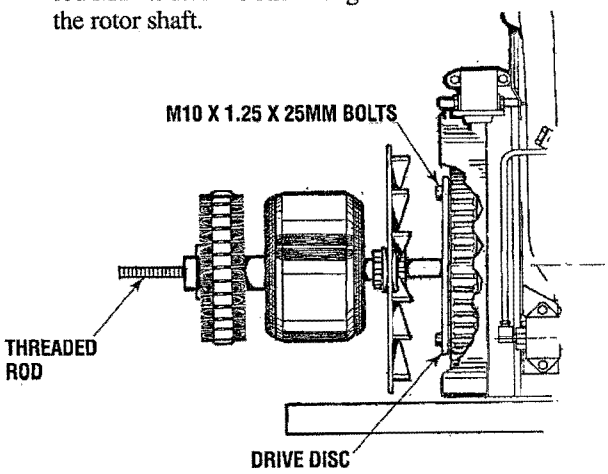
SINGLE PHASE
INTERNAL WIRING SCHEMATIC

115V 50Hz – 230V 50Hz 120V 60Hz – 240V 60Hz

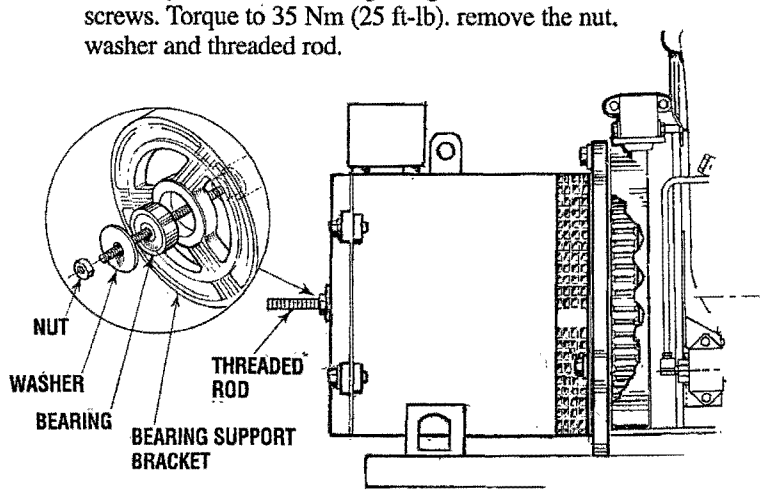


ASSEMBLY OF THE GENERATOR TO THE ENGINE

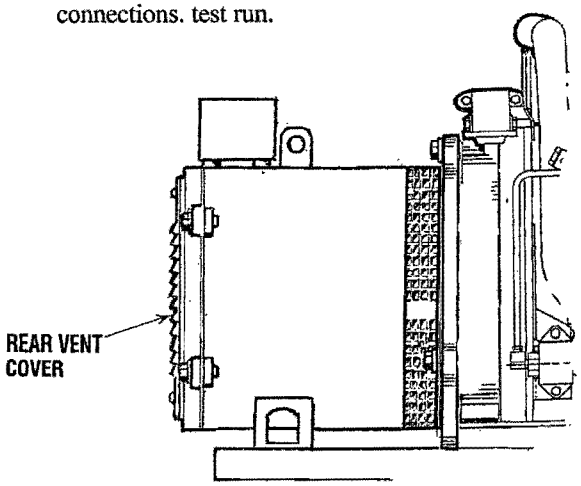
1. Position the rotor assembly onto the flywheel aligning the holes in the drive discs with the holes in the flywheel. Install the M8 x 1,25 x 25mm bolts (blue loctite on threads) and torque to 21 Nm (16 ft-lb). Install a threaded rod M12 x 1.75 x 90mm long into the threaded end of the rotor shaft.



2. With the aid of a sling or fabricated lifting eye, support the stator housing assembly and carefully guide it over the rotor assembly until the rear bearing contacts the bearing boss in the rear support.
3. Place a large washer of at least 80mm in diameter with a center hole of 15mm onto the threaded rod followed by a 12mm x 1.75 nut. Center the rear bearing in the bearing boss of the support plate. Tighten the nut until the bearing seats fully into the boss. Secure the stator housing assembly to the bell housing using the four M10 x 35mm screws. Torque to 35 Nm (25 ft-lb). remove the nut, washer and threaded rod.



4. Rotate the generator by hand two full revolutions to ensure the generator rotates freely. Reinstall the rear vent cover.
5. Secure the generator to its rear isolators. Route the generator wiring into the control box and mount the control box to the generator. Reconnect all wire connections. test run.



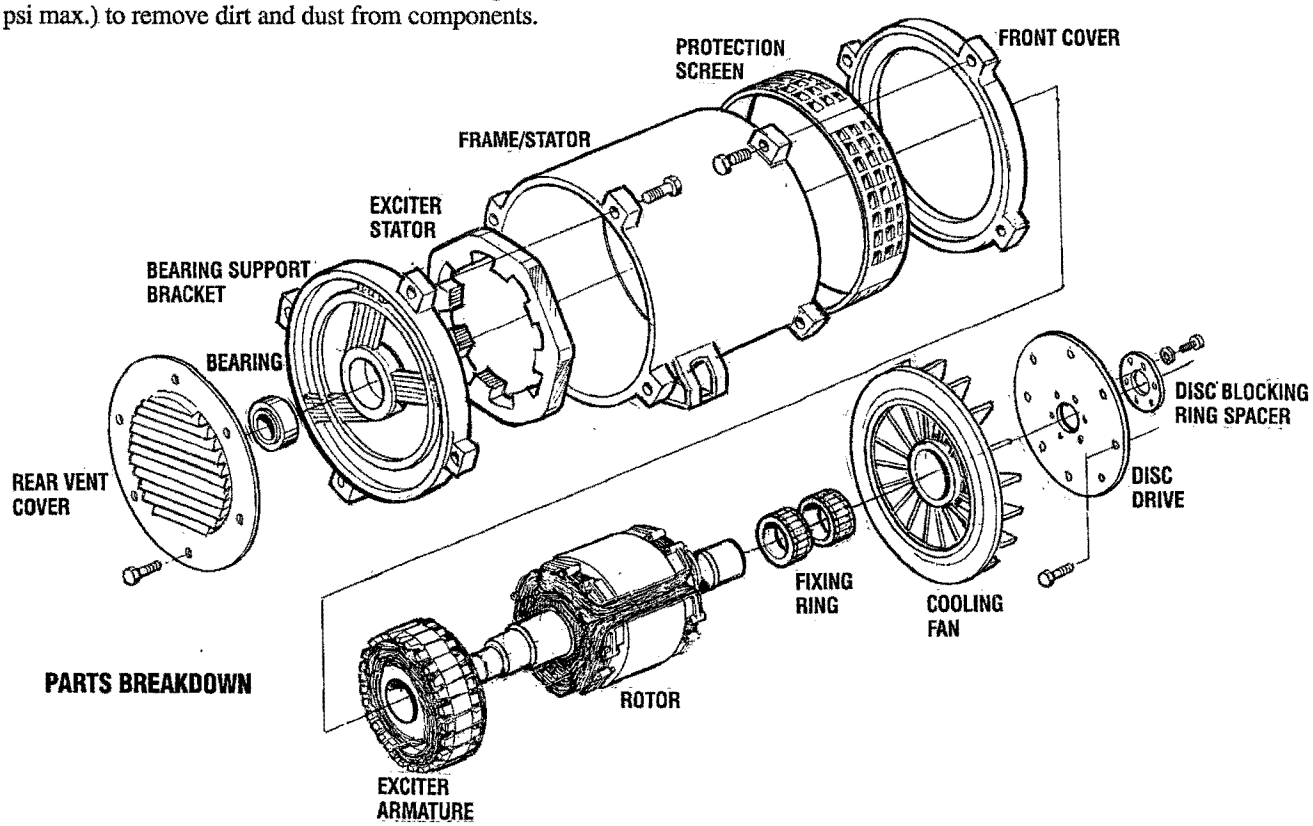
MECC ALTE GENERATOR
MAINTENANCE/PARTS BREAKDOWN

INSPECTION/CLEANING

Periodically inspect the rotor carrier bearing. Replace this bearing at 10,000 hours of normal operation or sooner if wear is evident.

Inspect and clean the control box interior, look for loose, broken, or burned wires and terminals. Use low air pressure (25 psi max.) to remove dirt and dust from components.

Remove all dirt, oil, grease and dust build up from the external surface of the generator. Build-up reduces heat dissipation and causes the AC generator end to operate at a higher temperature. This results in a loss of efficiency and reduces service life.

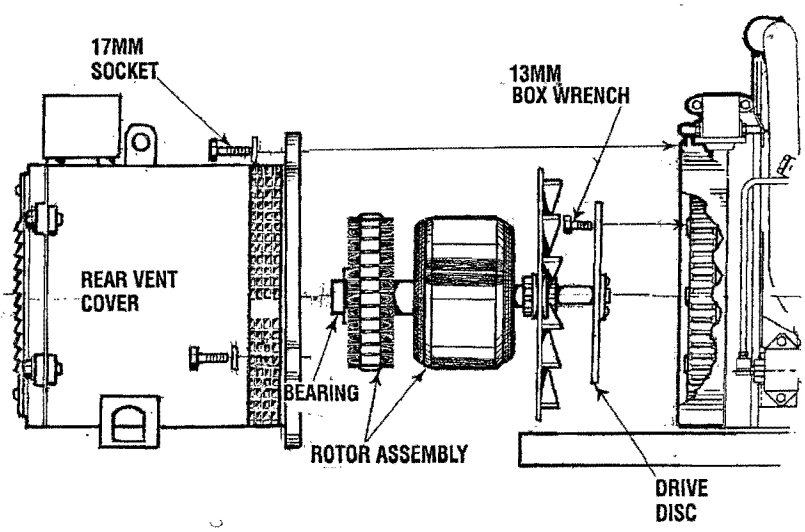


PARTS BREAKDOWN

DISASSEMBLY

Should it become necessary to disassemble the stator/rotor assembly from the engine, use the following as a guide.

1. Properly support/lift the rear of the engine to allow the generator to be unbolted from the rear support isolators.
2. Mark, then disconnect the electrical leds that exit the generator from their connections in the control box. Be sure to properly mark the connection points the generator leds connect to. Make an illustration if needed whether the generator is to be reinstalled or a replacement is to be installed. This is to ensure proper reconnection of electrical leds. Unbolt the control box and lift it off the generator.
3. Remove the rear vent cover. Support the generator with a sling or fabricated lifting eye. Using a 17mm socket wrench remove the four bolts that attach the generator stator housing assembly to the flywheel housing. carefully work the stator assembly off the rear bearing and off and over the rotor assembly.
4. Support the rotor assembly with a sling and using a 17mm box wrench, unbolt the rotor assembly from the flywheel.



BE TROUBLESHOOTING

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

FAULT	PROBABLE CAUSE	
NO AC VOLTAGE OUTPUT AT NO LOAD.	1. Short or open in the main stator winding. 2. Shorted pozi-resistor on exciter rotor. 3. Four or more shorted or open diodes on exciter rotor.	4. Open in exciter stator winding. 5. Open in rotating field winding.
RESIDUAL VOLTAGE PRODUCED AT NO LOAD 15 - 20 VOLTS AC.	1. Blown 6 AMP fuse auxiliary circuit feed to AVR. 2. Faulty voltage regulator	3. Shorted or open main stator auxiliary winding.
LOW AC VOLTAGE OUTPUT AT NO LOAD 60 - 100 VAC.	1. Reset voltage potentiometer. 2. Open or shorted diodes in. exciter rotor 1 to 3 diodes. 3. Faulty voltage regulator	4. Short in rotating field winding. rotor winding. 5. Short in exciter stator.
HIGH AC OUTPUT VOLTAGE 150 VAC OR HIGHER.	1. Reset voltage potentiometer.	
UNSTABLE VOLTAGE OUTPUT.	1. STB pod on regulator needs adjustment.	2. Faulty voltage regulator.
AC VOLTAGE DROP UNDER LOAD 60 - 100 VOLTS AC.	1. Diode(s) on exciter rotor breaking down when load is applied (inductive) 1-3 diodes.	

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

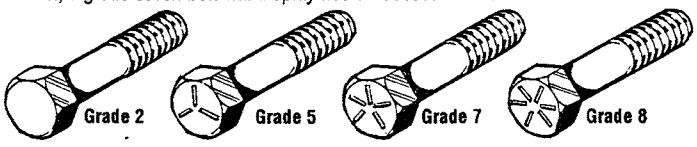
Diesel Oil = 1 US gallon = 7.13 lbs
Fresh Water = 1 US gallon = 8.33 lbs
Gasoline = 1 US gallon = 6.1 lbs
Salt Water = 1 US gallon = 8.56 lbs

STANDARD HARDWARE

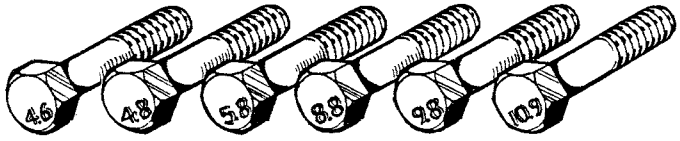
BOLT HEAD MARKINGS

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!**

METRIC CONVERSIONS

INCHES TO MILLIMETERS / MILLIMETERS TO INCHES

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

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

INCHES TO METERS / METERS TO INCHES

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

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

YARDS TO METERS / METERS TO YARDS

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

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

POUNDS TO KILOGRAMS / KILOGRAMS TO POUNDS

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

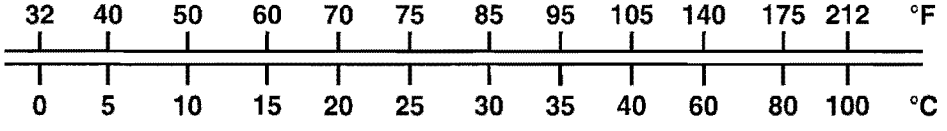
GALLONS TO LITERS / LITERS TO GALLONS

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

PINTS TO LITERS / LITERS TO PINTS

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

TEMPERATURE



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