

TECHNICAL MANUAL

WESTERBEKE

**4 CYLINDER
MARINE GASOLINE
GENERATOR SETS**

TWG SERIES

6.5KW, 8KW, 11KW

Publication # 34645

Edition Two

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WESTERBEKE CORPORATION
MYLES STANDISH INDUSTRIAL PARK
150 JOHN HANCOCK ROAD, TAUNTON, MA 02780-7319

SAFETY PRECAUTIONS

The following symbols appear in this manual to call attention to and emphasize conditions potentially dangerous to the operator.

WARNING

The above symbol is used in the manual to warn of possible serious personal injury or loss of life.

CAUTION

The above symbol is used in the manual to caution personnel of possible damage to equipment.

Read the manual carefully and thoroughly before attempting to operate the equipment. Know when dangerous conditions can exist and take necessary precautions to protect personnel and equipment.

Fuels, exhaust gases, batteries, electrical equipment, and moving and hot parts are potential hazards that could result in serious personal injury or death. Follow recommended procedures carefully.

Always operate bilge blowers for at least five minutes before starting a gasoline-fueled engine; ensure no gasoline fumes are present before starting.

● Prevent Electric Shock

Shut off electric power before accessing electrical equipment.

Use insulated mats whenever working on electrical equipment.

Make sure your clothing is dry, not damp (particularly shoes), and keep your skin surfaces dry when handling electrical equipment.

Remove wristwatch and jewelry when working on electrical equipment.

Do not connect utility shore power to vessel's AC circuits, except through a ship-to-shore double-throw transfer switch. Damage to vessel's AC generator may result if this is not done.

Be extremely careful when working on electrical components. High voltage can cause injury or death.

● Exhaust Gases Are Toxic

Ensure that the exhaust system is adequate to expel gases discharged from the engine. Check exhaust system regularly for leaks and make sure the exhaust manifolds are securely attached and no warping exists.

Be sure the unit and its surroundings are well-ventilated.

● Use Extreme Care When Handling Engine Fuel (A constant danger of explosion or fire exists)

Do not fill fuel tank(s) while the engine is running.

Do not smoke or use an open flame near the engine or the fuel tank.

● Do Not Alter or Modify the Fuel System

Be sure all fuel supplies have a positive shutoff valve.

Be certain fuel line fittings are adequately tightened and free of leaks.

Make sure a fire extinguisher is installed nearby and is properly maintained. Be familiar with its proper use. Extinguishers rated ABC by the NFPA are appropriate for all applications encountered in this environment.

● Use Extreme Care When Servicing Batteries

Wear rubber gloves, a rubber apron, and eye protection when servicing batteries.

Lead acid batteries emit hydrogen, a highly-explosive gas, which can be ignited by electrical arcing or by a lighted cigarette, cigar, or pipe. Do not smoke or allow an open flame near the battery being serviced. Shut off all electrical equipment in the vicinity to prevent electrical arcing during servicing.

● Avoid Moving Parts

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

Do not wear loose clothing or jewelry when servicing equipment; avoid wearing loose jackets, shirts or sleeves, rings, necklaces, or bracelets that might be caught in moving parts.

Make sure all attaching hardware is properly tightened. Keep protective shields and guards in their respective place at all times.

Do not check fluid levels or drivebelt tension while the unit is operating.

Do not work on the equipment when mentally or physically incapacitated by fatigue.

TABLE OF CONTENTS

INTRODUCTION	3
INSTALLATION.....	4
OPERATION	14
MAINTENANCE.....	18
ENGINE TECHNICAL DATA	21
TABLE OF TIGHTENING TORQUES.....	28
TABLE OF STANDARD TIGHTEING TORQUES	29
DISASSEMBLY FOR OVERHAUL.....	30
ENGINE INSPECTION AND REPAIR	35
ENGINE ASSEMBLY	47
LUBRICATION SYSTEM	60
COOLING SYSTEM.....	66
GOVERNOR	73
CARBURETOR AND FUEL SYSTEM.....	75
DC ELECTRICAL SYSTEM	78
DC WIRING DIAGRAM.....	79
AC GENERATOR.....	89
LAY-UP AND RECOMMISSIONING	98
SERVICE BULLETINS	101

IMPORTANT

PRODUCT SOFTWARE NOTICE

Product software of all kinds, such as brochures, drawings, technical data, operator's and workshop manuals, parts lists and parts price lists, and other information, instructions and specifications provided from sources other than Westerbeke, is not within Westerbeke's control and, accordingly, is provided to Westerbeke customers only as a courtesy and service. WESTERBEKE CANNOT BE RESPONSIBLE FOR THE CONTENT OF SUCH SOFTWARE, MAKES NO WARRANTIES OR REPRESENTATIONS WITH RESPECT THERETO, INCLUDING THE ACCURACY, TIMELINESS OR COMPLETENESS THEREOF, AND WILL IN NO EVENT BE LIABLE FOR ANY TYPE OF DAMAGES OR INJURY INCURRED IN CONNECTION WITH, OR ARISING OUT OF, THE FURNISHING OR USE OF SUCH SOFTWARE.

For example, components and sub-assemblies incorporated in Westerbeke's products and supplied by others (such as engine blocks, fuel systems and components, transmissions, electrical components, pumps and other products) are generally supported by their manufacturers with their own software, and Westerbeke must depend on such software for the design of Westerbeke's own product software. Such software may be outdated and no longer accurate. Routine changes made by Westerbeke's suppliers, of which Westerbeke rarely has notice in advance, are frequently not reflected in the supplier's software until after such changes take place.

Westerbeke customers should also keep in mind the time span between printings of Westerbeke product software, and the unavoidable existence of earlier, non-current Westerbeke software editions in the field. Additionally, most Westerbeke products include customer-requested special features that frequently do not include complete documentation.

In sum, product software provided with Westerbeke products, whether from Westerbeke or other suppliers, must not and cannot be relied upon exclusively as the definitive authority on the respective product. It not only makes good sense but is imperative that appropriate representatives of Westerbeke or the supplier in question be consulted to determine the accuracy and currency of the product software being consulted by the customer.

INTRODUCTION

This manual is a basic guide to the installation, start-up, operation, maintenance, overhaul and troubleshooting of your Westerbeke gasoline engine driven generator. The information contained within is important to the unit's dependability and service life.

- A. Read it.
- B. Keep it in a safe, dry place.
- C. Keep it handy for reference at all times.

Understanding the Gasoline Driven Generator

The gasoline engine driving the AC generator is in many ways similar to the gasoline engine in your automobile. The cylinders are vertical in line, overhead camshaft chain driven. Solid state type distributor, horizontally mounted, camshaft driven. Pressure type lubrication system with fresh water cooled engine block. Thermostat controlled. It follows therefore to a great extent that the gasoline engine used to drive our generator requires the same preventative maintenance that any intelligent operator would give the gasoline engine in his automobile. The most important factors to unit longevity are proper ventilation, maintenance of the fuel system, ignition system, cooling system and generator end. Care at the factory during assembly and thorough testing have resulted in a Westerbeke gasoline engine driven generator capable of many thousands of hours of dependable service. What we as the manufacturer cannot control is the treatment the unit receives in the field. That part is up to you.

Ordering Parts

Whenever replacement parts are needed, always include the complete part description and part number (see separately furnished Parts List). Be sure to include the engine's serial number along with that of the generator and its model number. Also, be sure to insist upon Westerbeke factory packaged parts, because "will fit" parts are frequently not made to the same specifications as original equipment.

INSTALLATION

Forward

Since the yachts in which these generators are installed vary (Power Yacht - Sailing Yacht), details on the installation also vary. The purpose of this section is to aid the installer in placing our generator into an environment that will not be detrimental to it.

Inspection of Equipment

The generator is shipped from our factory securely mounted and properly crated. Accessory items are shipped in separate small boxes. These are usually packed in the same crate as the generator. Before accepting shipment from the transportation company, the crate should be opened and an inspection made for concealed damage. If either visible or concealed damage is noted, you should require the delivering agent to sign "Received in damaged condition". Also check contents of the shipment against the packing list and make sure note is made of any discrepancies. This is your protection against loss or damage. Claims for loss or damage must be made to the carrier, not to J. H. Westerbeke Corporation.

Rigging and Lifting

The generator is fitted with lifting eyes.

Rope or chain slings should be attached to the eyes and the engine lifted by means of tackle attached to this sling. The lifting eyes have been designed to carry the full weight of the generator; therefore, auxiliary slings are not required or desired.

CAUTION: Slings must not be so short as to place the generator lifting eyes in significant sheer stress. Strain on the generator lifting eyes must not be in excess of 10° from the vertical.

The general rule in moving generators is to see that all equipment used is amply strong and firmly fixed in place. Move the engine a little at a time and see that it is firmly supported. Eliminate possibility of accidents by avoiding haste. Do not lift from the front crankshaft pulley.

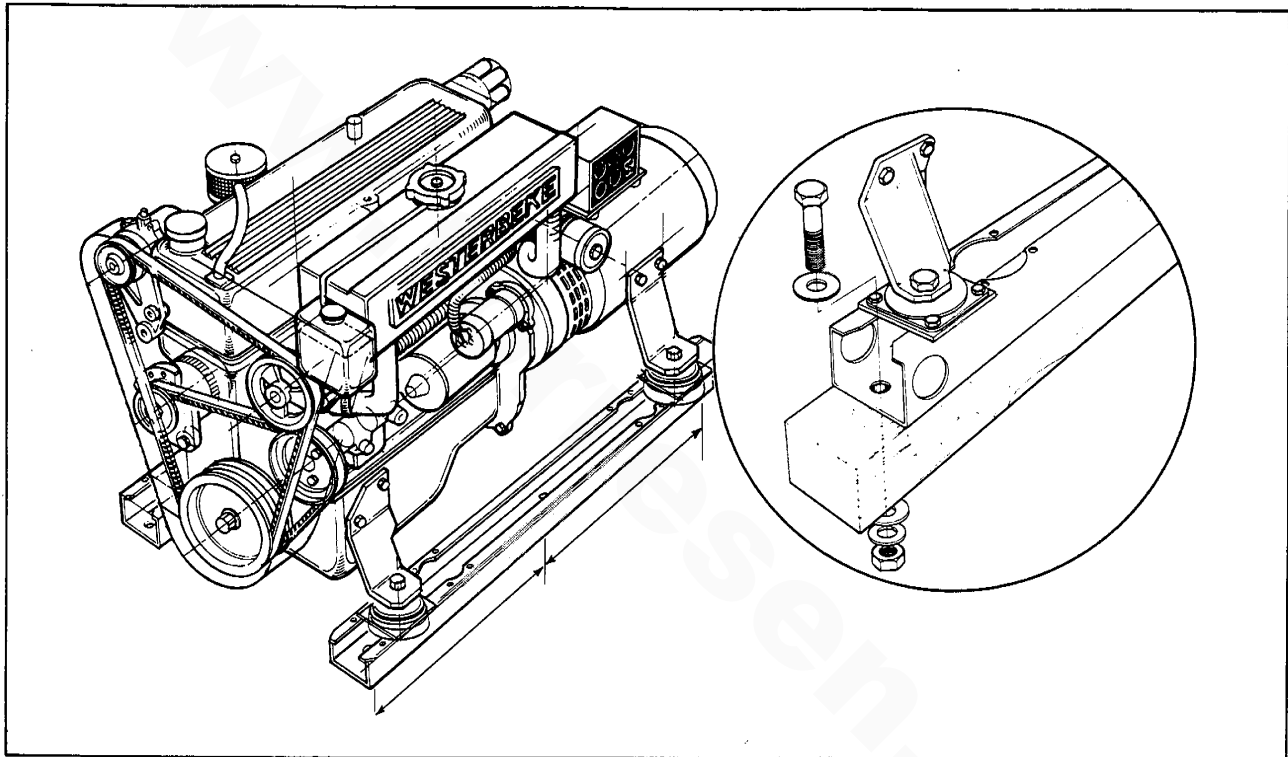
In some cases it may be necessary to lift the engine in other than the regular horizontal position. It may be that the engine must be lowered endwise through a small hatchway which cannot be made larger. If the opening is extremely restricted, it is possible to reduce, to some extent, the outside clearances by the removal of the alternator, cooling piping, manifold, filters, mounting lugs, etc. This accessory equipment should be removed by a competent mechanic and special care should be taken to avoid damage to any exposed parts and to avoid dirt entering openings. The parts which have been removed should be replaced once the unit has been positioned.

In cases where it is necessary to hoist the generator front end upwards or generator end upwards, the attachment of lifting slings must be done very carefully to avoid the possibility of damage to parts that the lifting sling bear against due to the weight of the generator.

It is wiser that special rigging work be done by experienced and competent people knowledgeable in the handling of heavy equipment. Extreme caution and care cannot be stressed enough.

Generator Mounting - Location

The complete generator unit is mounted on lightweight rails through soft flexible isolator mounts that prevent the transfer of vibration from the generator to the rails. Three 1/2 inch bolt holes are in each generator mounting rail to be used in properly securing the generator to its mounting platform. These holes are on 15 inch mounting centers.



The location should be such that it is dry and above low-lying vapor areas and away from being splashed by bilge water or water from above. It should be properly ventilated and accessible for minor servicing and repairs. Access for major repairs should be given consideration as well. The location should be properly ventilated. The platform on which the generator is mounted should be strong enough to support the generator and securely hold the mounting rails fastened to it at all angles of vessel operation.

The generator set needs fresh cool air in whatever location in the vessel it is installed. Air is needed for combustion within the engine cylinders and is of prime importance for cooling the generator end. Heat from the generator end must be removed to insure proper generator efficiency and longevity.

Air Requirements (Minimum Values)

Model	Engine	Generator
6.5 KW	40 cu.ft./min	200 cu.ft./min
8 KW	40 cu.ft./min	220 cu.ft./min
11 KW	53 cu.ft./min	250 cu.ft./min

In confined compartments fresh cool air should be brought into the compartment by means of AC or DC blowers and necessary ducting. This air should be directed at the generator end bell opening.

Unwanted hot air should be allowed to exhaust from the compartment.

Sizing

The proper sized generator to maintain the average vessel load should be installed, otherwise compromises when loading will have to be worked out.

An inventory of the vessel's AC loads should be made paying particular attention to motor loads that the generator will have to start and run. (The amperage draw of a motor when starting can be as much as 3 - 5 times its normal running amperage.)

Determine the average AC load of the vessel and size the generator to handle this load with reserve.

Model	Volts	Amps
6.5-614 (60 Hertz)	115/230	56/28
4.9-514 (50 Hertz)	115/230	43/21
8.0-614 (60 hertz)	115/230	70/35
6.0-514 (50 Hertz)	115/230	52/26
11.0-614 (60 Hertz)	115/230	94/47
8.5-514 (50 Hertz)	115/230	74/37

Exhaust System

All exhaust systems should be such that the entry of water into the engine exhaust manifold and cylinders is prevented while the engine is not running, when the vessel is under sail or power, heaving, backing down, from following seas or any other conditions. Special attention must be made to insure that the system is secure and tight and free of leaks.

WARNING

CARBON MONOXIDE EXHAUST GAS IS DEADLY.

Exhaust System

WARNING

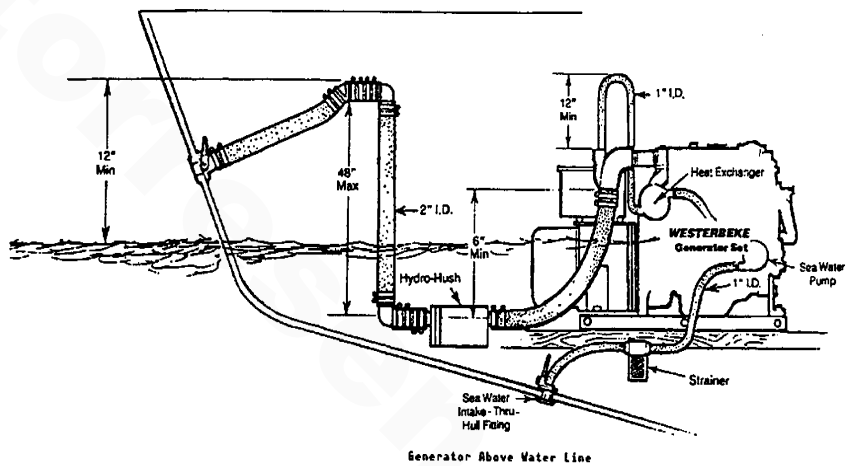
CARBON MONOXIDE EXHAUST GAS IS DEADLY. Carbon monoxide is a dangerous gas that can cause unconsciousness and is potentially lethal. Some of the symptoms or signs of carbon monoxide inhalation or poisoning are listed below.

- o Dizziness
- o Intense Headache
- o Weakness and sleepiness
- o Vomiting
- o Muscular twitching
- o Throbbing in temples

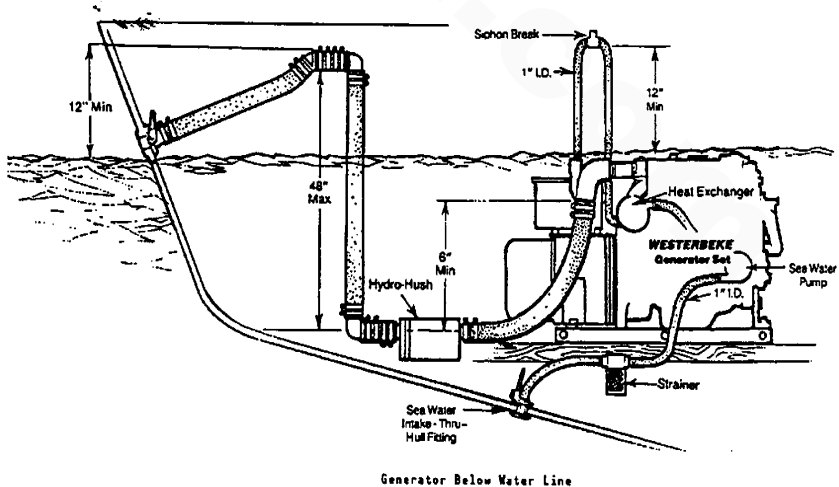
All exhaust systems should be such that the entry of sea water into the engine's exhaust manifold and cylinders is prevented while the engine is not running, when the vessel is under sail or power, heeling, backing down, from following seas or any other conditions. Special attention must be made to ensure that the exhaust system is secure and tight and free of leaks.

The sea water supply thru-hull sea cock fittings *must* be of the flush-hull type. High-speed scoop type fittings should not be used, as they tend to encourage siphoning.

When a water lift type exhaust system is used, the exhaust muffler should be mounted as close to the engine as practical. The exhaust discharge should always drop downward into the exhaust muffler. Loops in the exhaust hose between the water-injected exhaust elbow and the water lift muffler should be avoided as these will trap and hold water.



For installations where the exhaust manifold/water-injected exhaust elbow is at or below the vessel's water line, provisions must be made to install a siphon-break or a vent in the sea water supply hose to the water-injected exhaust elbow to stop the flow of raw water through the raw water cooling system, filling the exhaust and engine cylinders when the engine is shut down. This sea water supply hose must be looped above the water line and the siphon-break or vent installed in the high point of the loop above the water line. This siphon-break or vent



must always be above the water line at all angles of vessel operation to prevent siphoning. The vent, when used, must have its vent hose or tube routed so as to be above the water line and to remain empty of water when the engine is shut down to allow air to enter through this vent and prevent siphoning.

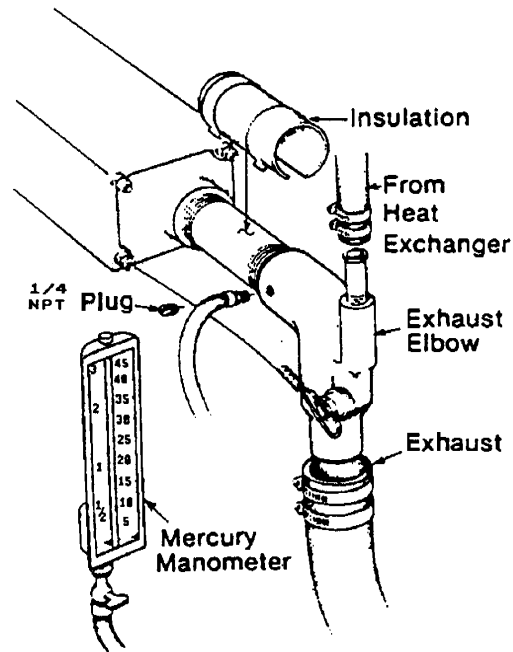
Exhaust Back-Pressure

The exhaust discharge hose must be of adequate size and minimal run to prevent excessive exhaust back-pressure. Exhaust back-pressure should be checked before a generator is put into service. (Refer to the illustration.) Excessive back-pressure will affect the engine's performance and the generator's power output.

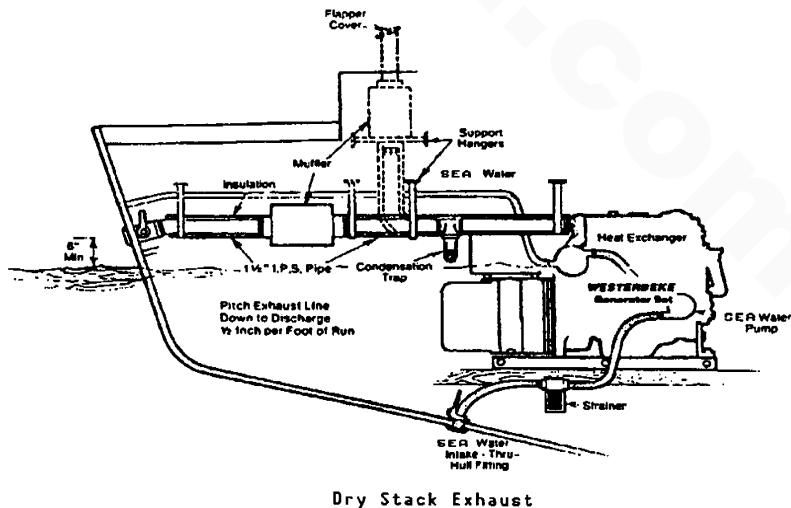
To measure the engine's back-pressure, either a mercury manometer, a water column, or another pressure measuring gauge has to be used. If the generator set does not have a tapped hole in its exhaust elbow, one must be drilled and tapped for a 1/4-inch NPT fitting.

Measure the engine's back-pressure at the exhaust elbow while the generator is under a full load. Back pressure, as measured by a gauge instrument, should not exceed the following specifications:

- 3 inches of mercury (0.104 kg/cm²)
- 39 inches of water in a water column (.099 kg/cm² at 4° C)
- 22 ounces psi
- 1 1/2 psi



Excessive back-pressure can be caused by a small diameter exhaust hose, a small muffler, sharp bends in the exhaust hose, fittings, water pockets, and a high volume of water in the exhaust system due to the length of the exhaust discharge hose. The use of elbows and fittings in the exhaust discharge hose's routing should be limited since these will create flow restrictions and contribute to exhaust back-pressure. The generator's exhaust system must be separate from any other engine's exhaust system. Dry portions of the exhaust system between the engine's exhaust manifold and the water injected exhaust elbow must be insulated to hold in the heat. Dry stack type exhaust systems must be attached to the generator engine's exhaust manifold by means of a flexible connector pipe. This system must be properly supported and insulated to prevent water entry into the engine's cylinders. Provisions must be made for the discharge of the engine's cooling sea water.

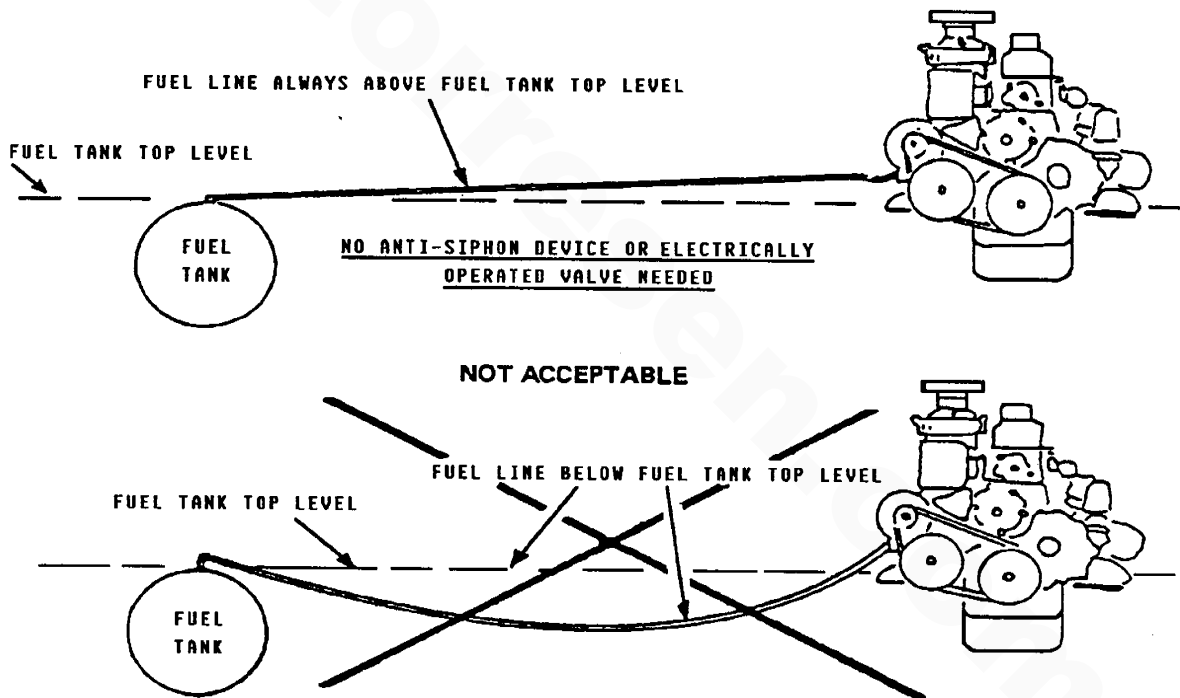


Fuel System

The generator must have its own fuel supply line; in other words, it must have its own pickup tubes and primary filter/water separator. **DO NOT** tee off another engine's fuel supply. Installations with the fuel tank(s) at or above the generator with the fuel supply lines to the engine's carburetor routed below the level of the fuel tank's top must have a means of shutting off the fuel to the generator's engine when the engine is not running. This installation procedure helps guard against the possibility of gasoline siphoning through this supply line into the engine through the carburetor, should the carburetor float needle valve stick in the open position or not seat properly, or should the fuel line rupture between the engine and fuel tank.

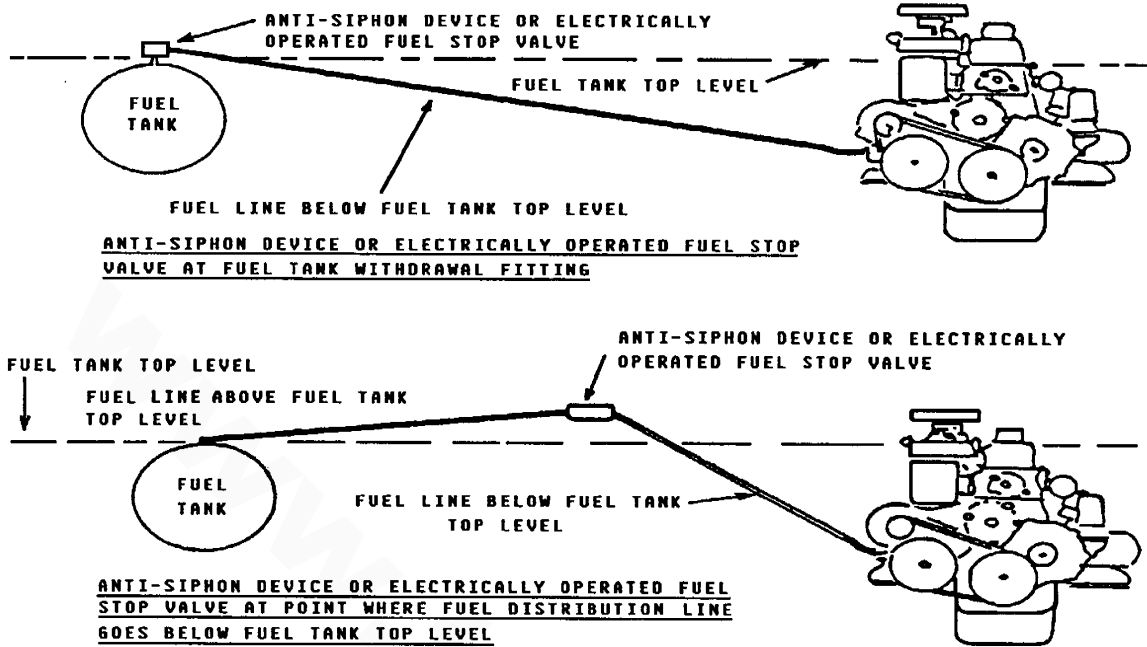
This (anti-siphon) shut-off valve can be electrically-operated (with manual override) to open when the generator's engine is started, or when it is shut down. A manually-operated valve can also be installed and should be operationable from the generator's start/stop panel or from the vessel's deck. Installations where the generator is located above the fuel tank(s), whereby the routing of the fuel supply line to the generator's carburetor remains above the top level of the fuel tank, do not require this (anti-siphon) shut-off valve. A manually-operated service shut-off valve should be located between the fuel pickup at the tank and the service shut-off valve located at the fuel connection to the generator.

The two illustrations that follow were taken from the Coast Guard publication *Fuel System Compliance Guideline*. These illustrations show basic fuel system layouts that incorporate anti-siphon protection.



All fuel lines should be routed and supported to prevent leaks from vibration and chaffing. The line should be supported every 12 - 14 inches. Use as few connections as possible.

The fuel tank's vent should be located so that its discharge route cannot allow water to enter through to the fuel tank(s). Moisture must not be allowed to accumulate in the vent's line.



NOTE: The use of check valves instead of a solenoid shut off valve is not recommended, as these may tax the fuel lift pump's ability to draw fuel through a check valve. Check valves can trap debris under their seat which inhibits the valve's ability to close. In addition, if a check valve's cracking pressure is too high, it may cause vapor lock.

It is recommended that an approved filter/separator be used in the fuel supply between the fuel tank and the generator's engine to help remove contaminants in the fuel before the fuel reaches the engine-mounted fuel lift pump and carburetor.

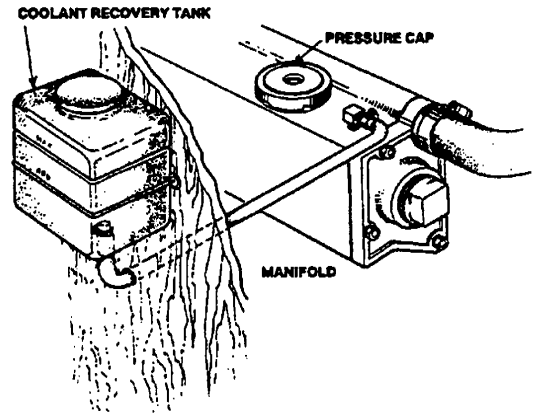
WARNING

Gasoline leakage in or around the generator compartment is a potential cause of fire and/or explosion. Repair leaks promptly and ensure that the compartment is properly ventilated.

Cooling System

The generator's engine is fresh water cooled by an engine-mounted heat exchanger. Sea water is used as the heat exchanger's cooling medium. Sea water is pumped through the heat exchanger by a belt-driven, positive displacement rubber impeller pump. After the sea water cools the fresh water that circulates through the heat exchanger, the sea water is then injected into the exhaust discharge, carrying with it the heat removed from the engine's fresh water system.

The engine's fresh water coolant is circulated by means of a belt-driven, centrifugal type metal impeller pump mounted on the side of the engine. The fresh water coolant's temperature is thermostatically controlled. A plastic fresh water system coolant recovery tank is supplied with each engine. It is recommended that this coolant recovery tank be installed and used.



COOLANT RECOVERY TANK

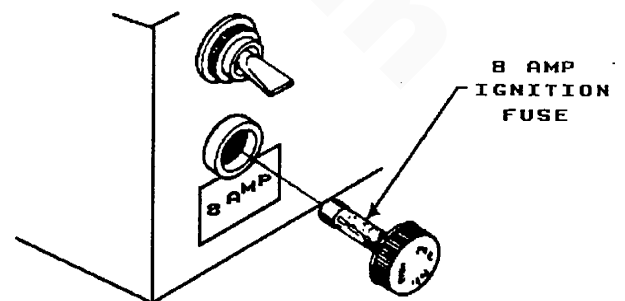
DC Control Circuit

This circuit is designed and manufactured in compliance with United States Coast Guard Standards (33 CFR PART 183). No modifications may be made to it by the installer or user. It is the installer's responsibility to assure that the installation of the generator set and any remote start panels or remote instrument panels are installed in compliance with the above Coast Guard Standards. Failure to observe these requirements could be the cause of injury.

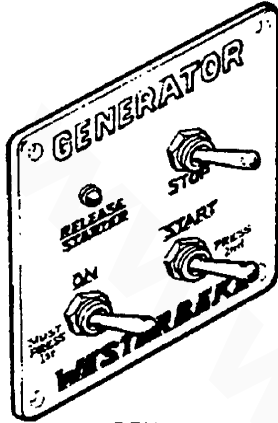
Electrical System Characteristics

The generator is started by a conventional, separate cranking motor which includes a self-contained, positive-engaging starter solenoid. Battery recharging capacity is provided by an alternator with approximately 50 Amps output capacity. A circuit breaker, located within 7 inches of the battery connection to the starter solenoid, protects all subsequent wiring. This circuit breaker is manually resettable. Three manually-operated momentary toggle switches are used to start and stop the generator set. To keep the control circuit simple and reliable in a marine environment, no relays have been incorporated in this electrical design.

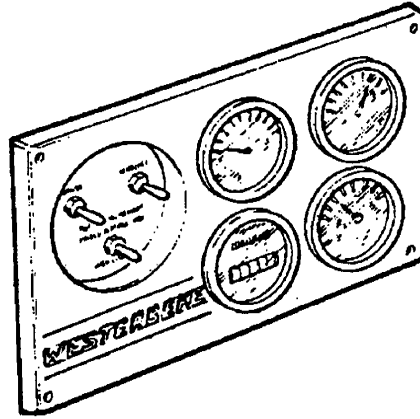
The choke is automatic and electrically operated. The ignition system is electronic and does not require conventional breaker points. An overspeed shutdown switch shuts off the generator set by grounding the out the ignition system should the engine's rpms reach approximately 2175. This shutdown consumes 25 milliamps (.025 or 1/4th of an Amp) at all times once the generator is connected to its battery. As this only amounts to about 18 Amp-hours in a month, it is unnecessary to be concerned with this slight discharge during normal operation. If the generator set were to be unattended for many months, the two easiest ways to stop this slight drain is to first turn off the main battery switch providing 12 volts to the generator set, and second to remove the ignition fuse on the generator-mounted control panel. An optional remote start



panel is available for controlling the generator from a remote location. Remote start panels include a green LED which lights when the engine runs at approximately 600 rpm. The purpose of the LED is to alert the operator to release the starter toggle switch in addition to continue indicating that the generator set is running. An optional remote instrument panel is available, which includes starting controls. This panel also includes a water temperature gauge, oil pressure gauge, battery voltmeter, operating hourmeter and start-stop control switches.



REMOTE START PANEL



REMOTE GAUGE PANEL

DC Circuit Description

The two-pole ON switch is operated to bypass the protective shutdown switches during starting. The second pole provides a source of B+ to the START toggle switch. While continuing to hold the ON switch, to provide B+ to the start switch and to bypass the protective shutdown switches, the START switch is pressed to energize the starter to crank the engine. If you are starting the generator at the generator set, release the START switch when the generator is running. If starting the generator at a remote location, release the START switch when the green LED lights, but continue depressing the ON switch. After releasing the START switch continue holding the ON switch until oil pressure is sufficient to close the oil pressure safety switch, providing the normal B+ path to the ignition system. Note that it is now impossible to energize the starter while the generator is running until someone again operates the ON switch first. Should the generator shut down from an overspeed condition, the overspeed circuit *must* be reset before attempting to restart the generator. This is done by simply depressing the STOP switch momentarily and then proceeding with the normal starting procedure.

WARNING

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

To STOP the generator, depress the STOP switch, which opens the normally closed B+ path on the ON and START switches. The STOP switch must be held open until the generator comes to a complete stop. Remote start panels may be connected to the generator set as indicated. A jumper has to be removed between the T1 and T2 connections at the panel connection terminal board.

WARNING

When installing the optional remote start panel or the optional remote instrument panel, it is the installer's responsibility to comply with U.S. Coast Guard Standards 33 CFR PART 183.

Generator AC Load Connections

CAUTION

ALL 115 VOLT LOADS MUST BE DIVIDED UP AND CONNECTED IN SUCH A MANNER THAT CURRENT FLOWING IN ANY OF THE THREE LEGS (G1, G4, G2/G3) DOES NOT EXCEED THE LOWEST AMPERAGE RATING ON THE GENERATOR'S DATA PLATE.

The generator data plate gives the voltage, amperage and hertz rating of the generator. The generator set wiring decal located on the cover of the generator mounted control panel shows the electrical connections for 115 or 230 volt AC output.

This is a single phase, 4 lead with voltage combinations of 115 volt, two wire, or 115/230 volt, three wire.

All 115 volt devices must be connected to one of the two 115 volt sources and all 230 volt devices must be connected to the 230 volt source.

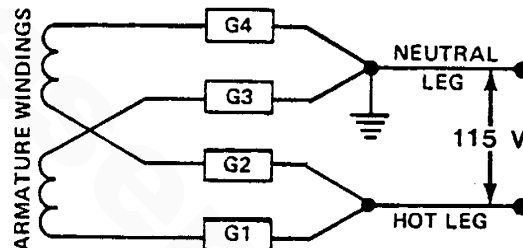
For all 115 volt loads, half of the generator's rated capacity may be taken from leads G1 and G2/G3 and half from G4 and G2/G3.

230 Volt loads are connected to G1 and G4 at full generator rated capacity.

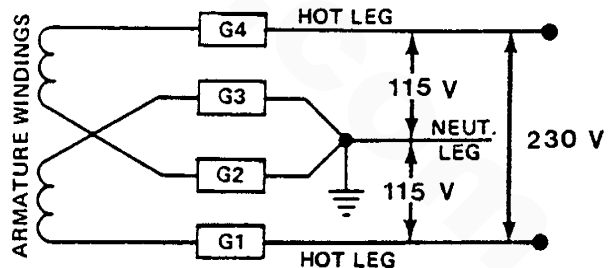
CAUTION: ALL 115 VOLT LOADS MUST BE DIVIDED UP AND CONNECTED IN SUCH A MANNER THAT CURRENT FLOWING IN ANY OF THE THREE LEGS (G1, G4, G2/G3) DOES NOT EXCEED THE LOWEST AMPERAGE RATING ON THE DATA PLATE.

4 WIRE

1. WHEN THE ELECTRICAL SYSTEM IS A TWO WIRE TYPE REQUIRING ONLY 120 VOLTS:



2. WHEN THE ELECTRICAL SYSTEM IS A THREE WIRE TYPE REQUIRING 120V. OR 120/240 VOLTS:

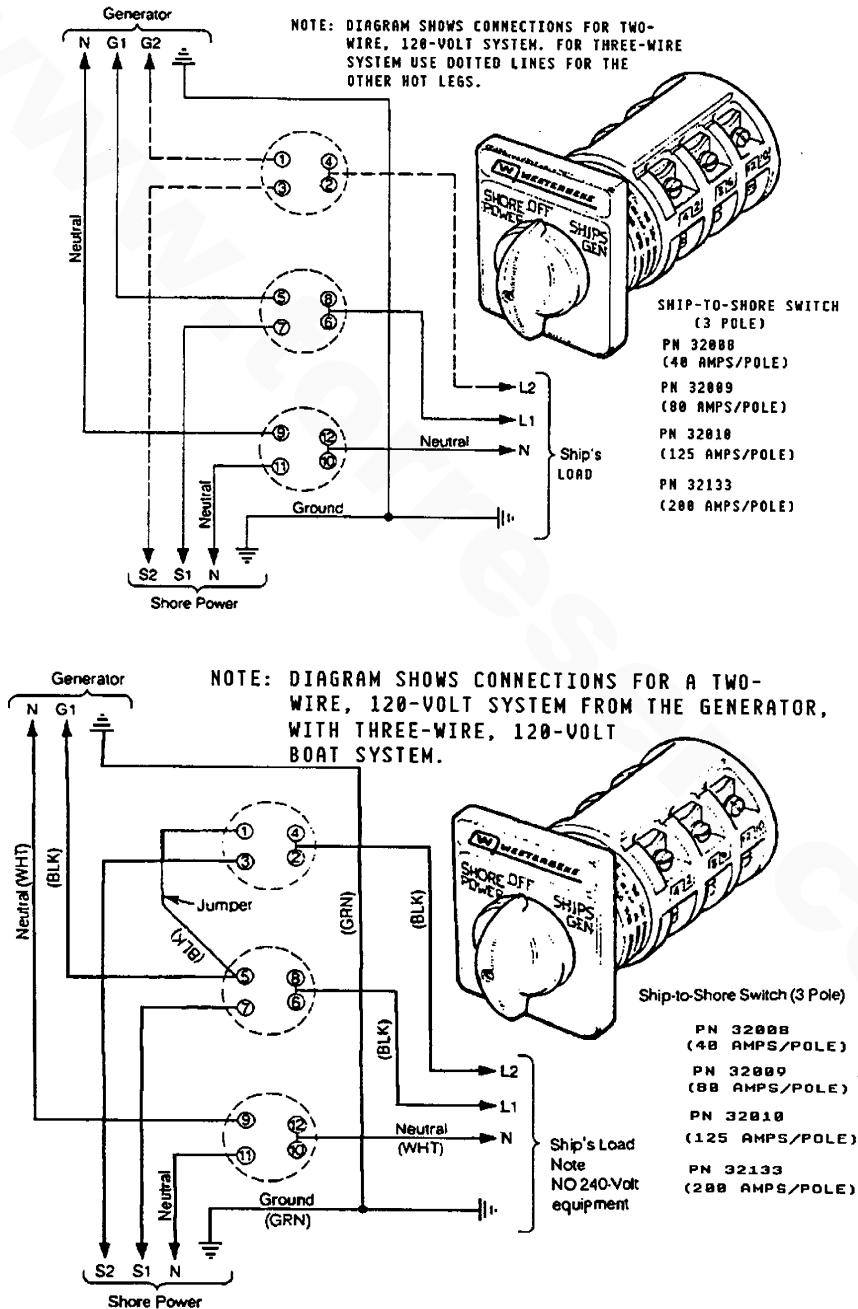


Shore Power Connections

If the installer connects shore power into the vessel's AC circuit, this must be done by means of the SHORE POWER/OFF/SHIPS GEN, center position-off transfer switch as shown below.

CAUTION

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



Shore Power Switch Connection Diagram

IMPORTANT RULES

Important

Important

Important

Always

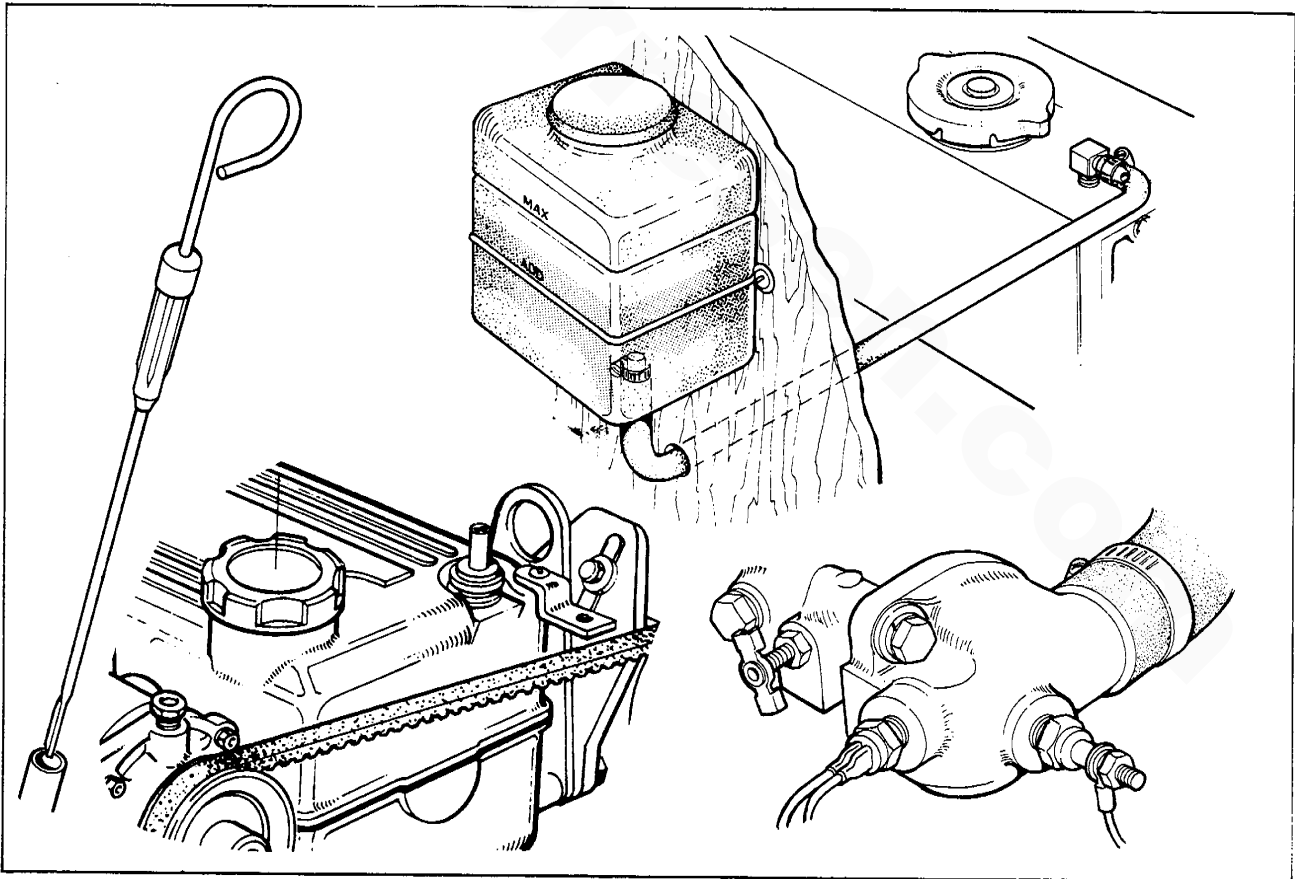
1. Ventilate the generator compartment before attempting to start the generator.
2. Keep this manual handy for reference whenever in doubt.
3. Check engine coolant level before each day's use.
4. Check engine lubricating oil level before each day's use.
5. Avoid moving parts, keep belt guard in place. Remove only when servicing front of engine.
6. When working on electrical equipment, beware of electrical shock.
Do not wear jewelry.
Disconnect electrical power before working on electrical equipment.
Use properly insulated tools and equipment.
7. Beware of exhaust gas leaks. Carbon monoxide exhaust gas can be deadly. Carbon monoxide is a colorless and odorless gas, a product of combustion from a gasoline engine.
To protect yourself from this gas, inspect the exhaust system regularly and repair any exhaust leaks immediately.
8. Do not overload the generator.
9. Allow the generator engine to warm up and stabilize before applying heavy loads.
10. Maintain your generator in a dry, well ventilated environment.

OPERATION

Preparing the Engine for Initial Start-Up

The generator engine is shipped dry with the lubricating oil and coolant drained from the engine. Therefore be sure to follow these recommended procedures carefully before attempting to start the engine for the first time.

1. Remove the oil fill cap from the engine rocker shaft cover and fill the engine oil sump with the proper amount of lubricating oil as specified in the Engine Specification section of this manual. Use a good brand of oil having an A.P.I. Spec. of SE or SE-CC.
2. Fill the fresh water cooling system with a mixture of anti-freeze and fresh water. Follow the antifreeze manufacturer's instruction and add rust inhibitors if needed. Do not use an overconcentration of antifreeze. To properly fill the engine's fresh water cooling system, remove the manifold fill cap and open/remove the air bleed petcock or remove the 1/8 NPT plug found at the lower rear portion of the cylinder head near the thermostat housing.



Mix your antifreeze solution and slowly pour it into the manifold filler neck.

While filling observe the open bleed petcock/plug at the back of the cylinder head and when coolant begins to flow out of this petcock/plug opening, close the petcock/replace the plug. Continue filling the system at the filler neck and the manifold until the coolant level is approximately 1/2 inch from the filler neck base. Once the engine is started, this level should be monitored and antifreeze solution added as needed as the engine reaches operating temperature (170-190° F), and air is expelled from the system.

Top the system off with the antifreeze mixture and install the filler neck pressure cap. Fill the coolant recovery tank to a level between the ADD and MAX mark. Observe that the level in the recovery tank rises as the engine is run and lowers when the engine is shut down and cools. This will indicate the recovery system is working. Monitor engine coolant level via this recovery tank and add antifreeze mixture as needed.

3. Check AC electrical connections to the generator output leads for 120 or 240 volt output. An AC wiring schematic is affixed to the control panel cover for reference when making these connections. Insure these connections are secure and properly insulated to prevent shorts and that any leads routed through the control panel metal box are routed through grommetted holes to protect the AC leads against chaffing.

4. Connect DC starting battery leads securely to the tagged connection points on the engine.

Always connect the ground lead last. The starting battery switch should be in the OFF position and the three fuses in the control panel removed from their respective holders when making these connections. Reinstall the fuses in their respective holders after the connections have been made.

5. Fill the fuel tanks with a good grade of gasoline (unleaded or regular).

The engine has mounted on it a 12 volt electric fuel pump. This pump can be used to prime the engine's fuel system. It is activated by depressing the ON switch in the control panel. When using the electric pump for this purpose unplug the "+" lead on the carburetor electric choke to prevent activation of the choke during system priming. Reconnect after the system is primed.

NOTE: The choke may have to be readjusted for the climate in which the generator will be operating.

6. Raw water supply should be connected to the engine sea water pump using a good grade of wire reinforced hose. Sea water pump suction can collapse hose having soft wall construction.
7. Connect the engine to the exhaust system. Check all connections that they are tight and there is no likelihood of an exhaust leak.

CARBON MONOXIDE EXHAUST GAS IS DEADLY.

Check the exhaust system carefully once the engine is started for leaks and correct them.

Starting the Generator Engine

(Ventilate the Generator Compartment for 5 minutes prior to attempting to start the engine).

1. Depress the ON switch (black), and hold it.
2. Depress the START switch (white). This will engage the starter and crank the engine over to start it.
3. If the engine fails to start in 20 - 30 seconds, release the two switches. Check for fuel and choke operation. Then repeat steps 1 and 2.

NOTE: Starter overheating and damage can occur from excessive cranking and there is a possibility of filling the exhaust system with raw water which may back up into the engine.

When the Generator Engine Starts

1. When the generator engine starts, release the START switch and continue to hold the ON switch depressed for 5 - 10 seconds. This is to allow oil pressure to build up and activate the oil pressure switch to maintain the ignition circuit.
2. Check for raw water flow being discharged with the exhaust.

NOTE: There will be some hunting evident when initially starting a cold engine. This will subside once the governor warms up.

3. Allow the engine to run and warm up (initial commissioning). Check AC output. Once engine is warmed up, shut engine down by depressing the STOP switch (red). Keep switch depressed until engine stops completely. Check engine sump oil level and fresh water coolant level (initial start). Add oil and coolant as needed. This is to replenish oil that is now filling internal oil galleries and the filter. Coolant is needed to replace air that has been expelled from the fresh water cooling system. Top the system up fully, replace the pressure cap and add coolant to the plastic remote recovery tank.

WARNING: The fresh water cooling system is under pressure when the engine is running and hot. Any time the manifold pressure cap is removed with the engine hot, it is advised that the cap be removed slowly and the hands are protected from escaping hot coolant. Depress the pressure cap slightly and rotate it counterclockwise until the resistance of the safety stops are felt. Carefully release pressure from the cap and allow system pressure to bleed off. Again press the cap down, now more firmly to clear the safety stops and rotate counterclockwise to remove and lift off the cap. Always fill the system full before replacing the cap. Check plastic recovery tank level; add as needed.

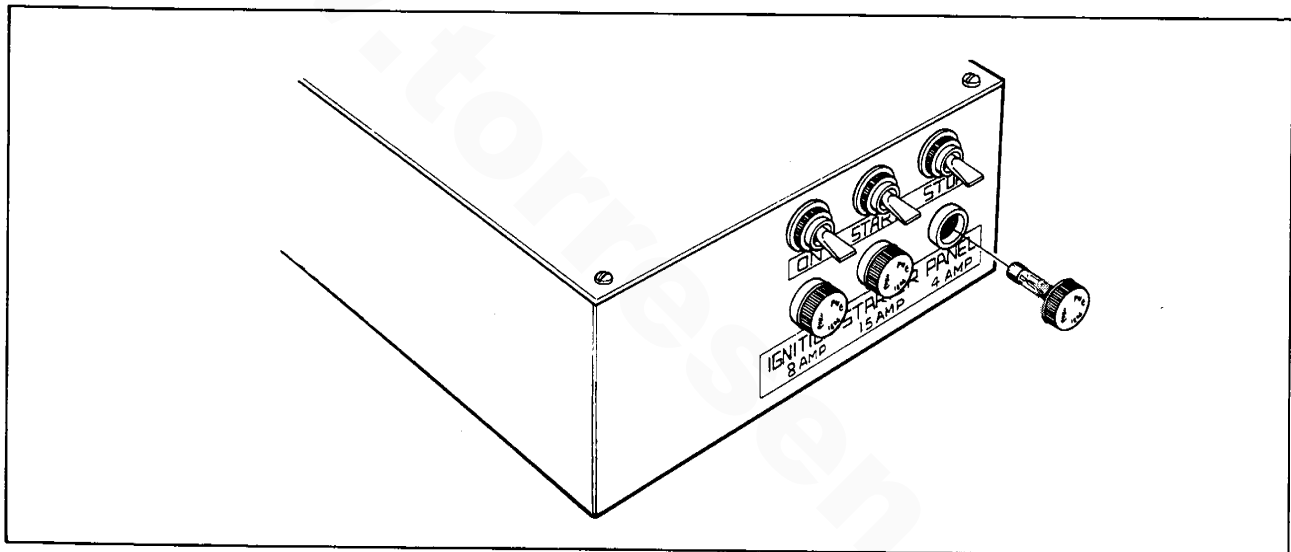
NOTE: Coolant recovery tanks mounted above the manifold fill cap will drain into the manifold when the pressure cap is removed. To

prevent this, pinch off the clear plastic hose running from the manifold to the plastic recovery tank.

- Restart the generator. Check the AC output. Load the generator. (Check data tag for rating). During generator break in (first 50 hours), avoid light loads. Vary the loads. Load the generator gradually.

Stopping the Generator

- Remove all the AC load from the generator.
- Allow the engine to run for 5 minutes to dissipate engine heat and stabilize temperature.
- Depress the STOP switch (red) and hold until the engine stops completely.



NOTE: Starter overheating and damage can occur from excessive cranking.

CAUTION

Prolonged cranking intervals without the engine starting can result in filling the exhaust system attached to the engine with sea water coolant. This may happen because sea water pump is pumping sea water through the sea water cooling system during cranking. This sea water can enter the engine's cylinders by way of the exhaust manifold once the exhaust system fills. Prevent this from happening by closing the sea water supply thru-hull shutoff, drain the exhaust muffler, and correct the cause for the excessive engine cranking needed to obtain a start. Engine damage resulting from this type of sea water entry is not a warrantable issue; the owner/operator should keep this in mind.

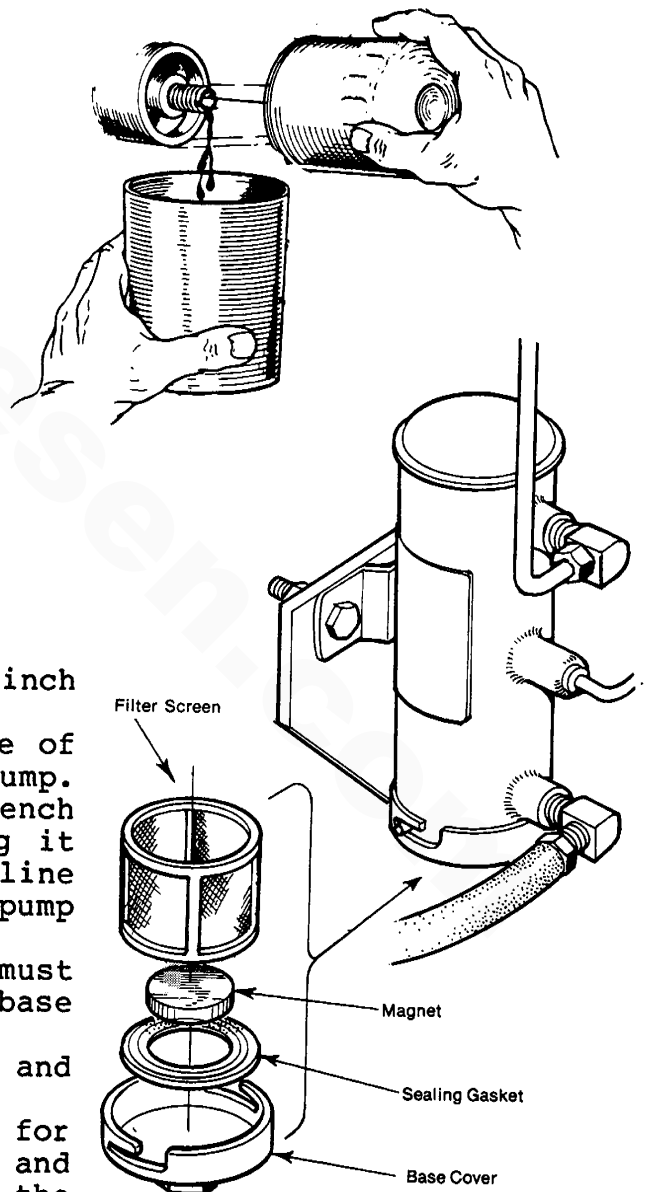
MAINTENANCE

Daily Checks (before initial daily start-up)

1. Check the level of oil in the lube oil sump with the dipstick. Keep the oil level between the upper and lower marks on the dipstick.
2. Check the engine coolant level in the plastic coolant recovery tank. (Maintain the coolant level between ADD and MAX when cold.)
3. Periodically remove belt guard and check belt tensions, 3/8 - 1/2 inch deflection between widest span. Belts will stretch affecting governor action, engine cooling and alternator charging.
4. Visually look over the engine and generator for any visible faults. Correct as needed.

Fifty Hour Service Check

1. Change the engine lube oil and oil filter. Use a good brand of oil with an SAE number suitable for the area in which the generator is operating. The oil must have an API spec. of SE or SE-CC.
2. Retorque the cylinder head hold-down bolts (engine warm).
3. Adjust the valve clearances (engine warm).
4. Clean and regap spark plugs.
5. Check zinc anode in heat exchanger. Clean and replace as needed. If zinc is flaking, scrape clean. Check zinc end of exchanger for zinc pieces and clean from exchanger.
6. Check belt tensions, 3/8 - 1/2 inch deflection at widest span.
7. Clean filter screen found in base of engine mounted electric fuel pump. Remove the base by placing a wrench on the base hex nut and twisting it loose. (Be careful of gasoline spillage when removing the pump base.)
A new base sealing gasket #34706 must be installed each time the pump base is removed and reinstalled.
8. Check hose clamps, fittings, nuts and bolts for security and tightness.
9. Check all electrical connections for security and proper insulation and that there is no chafing of the wiring on the generator or that wiring running to and from it.



10. Inspect the exhaust system that it is secure and tight (no leaks).
11. Remove and clean air screen inlet on carburetor.
12. Clean and lube linkage between governor and throttle. Insure that it moves freely with no binding.
13. Adjust carburetor choke if needed. The choke index mark is located on the choke cover lower right inboard side.
14. Check security of cooling fan inside generator end bell. Visually inspect electrical connections and components inside generator end bell.
15. Clean the carburetor inlet filter.

Seasonal Servicing

1. Change engine lube oil and oil filter every 100 hours of engine operation or once a season, whichever occurs first.
2. Clean the fuel filter screen in the electric fuel pump and the inlet filter screen in the carburetor every 300 hours.
3. Check the zinc anode in the main engine heat exchanger periodically through the season, clean and replace it as needed.
4. Check belt tension, 3/8 - 1/2 inch deflection between widest span. Check for wear; replace as needed.
5. Check for loose fittings, clamps, electrical connections, nuts and bolts and coolant circulating hoses for good condition.
6. Clean and/or replace primary fuel filters.
7. Check condition and strength of antifreeze mixture in the fresh water cooling circuit. Strengthen the mixture as needed. Drain the coolant and replenish should the coolant become discolored.
8. Clean the carburetor air inlet screen every 300 hours of engine operation or more frequently as needed.
9. Check ignition circuit every 300 - 400 hrs.
 - A. Clean rotor and cap.
 - B. Check engine timing.
 - C. Adjust carburetor.
 - D. Check coil and plug leads.
 - E. Clean and gap spark plugs.
10. Torque cylinder head holddown bolts and adjust valves every 500 hours of engine operation.
11. Check condition of sea water pump impeller and replace as needed. Check sea water pump for internal wear. Replace pump components as needed.
12. Check generator brush rig initially at 500 hours and then every 500 hours thereafter. Brushes worn to 1/2 inch in length should be replaced.

End of Season Service (Winterization)

1. Check engine fresh water coolant antifreeze mixture for proper strength against freezing. Drain and add additional mixture as needed. Operate the engine to insure complete circulation through the system and recheck.
2. Inspect the condition of the zinc anode #11885 in the engine heat exchanger. Clean or replace it as needed. (Keep spares).
3. Clean filter screen in engine mounted electric fuel pump.

NOTE: Electric fuel pump base gasket #34706 must be replaced.

4. Clean carburetor inlet filter screen.
5. Change engine lubrication oil and oil filter.
- 6A. Flush the raw water circuit with fresh water and then run an antifreeze mixture through the raw water circuit to protect it against freezing.

NOTE: Feed the raw water circuit out of a bucket to both flush the circuit and supply it with an antifreeze mixture.

- 6B. Fogging the engine should be done as the last of the antifreeze mixture is drawn into the raw water circuit. Remove the air intake screen and spray mystery oil or a commercially available fogging oil into the carburetor while the engine is running, stalling it and coating the inner cylinder, piston and valve surfaces with this oil. Remove the spark plugs and spray a small amount into each spark plug hole and turn the engine over by hand, two or three complete revolutions. Loosely reinstall the spark plugs as these will need to be cleaned and gapped prior to recommissioning. Close off the carburetor air intake with an oily rag.
7. Remove the impeller from the sea water pump and inspect its condition. Do not reinstall it in the pump until the engine is recommissioned.
8. Check alternator and raw water pump drive belts.
9. Insure fuel tanks are full and, when filling, gasoline stabilizers and conditioners as well as carburetor conditioners should be added at that time according to the conditioner manufacturer's instructions.
10. Lubricate the linkage between the carburetor throttle and the governor arm.
11. Remove the starter motor and clean and lubricate the drive pinion.

NOTE: Remove DC power to the engine prior to removing the starter motor.

12. Check over the engine and see if external items such as hoses or belts need replacing come recommissioning. Check over your basic spares kit and order items not on hand or that were used during this lay-up, such as filters and zincs.
13. Generator engine starting battery, if left on board during this winter lay-up period should be in a full state of charge to prevent freeze damage to the battery. If not, it is wise to remove it to a warm location.

ENGINE TECHNICAL DATA

Type	Gasoline, four cycle
Number and arrangement of cylinders	Four cylinders in line, vertical type
Bore and stroke 6.5 and 8KW	70.0 mm x 69.6 mm (2.76 in x 2.74 in)
11KW	77.0 mm x 80.0 mm (3.03 in x 3.15 in)
Total piston displacement 6.5 & 8KW	1071 CC (65.4 cubic inches)
11KW	1490 CC (90.9 cubic inches)
Compression ratio 6.5 and 8KW	9.2:1
11KW	9.0:1
Valve system	Single overhead cam (OHC) chain driven
Valve Timing 6.5 & 8KW	
Intake opens	15° BTDC
Intake closes	44° ABDC
Exhaust opens	53° BBDC
Exhaust closes	6° ATDC
Valve timing 11KW	
Intake opens	15° BTDC
Intake closes	58° ABDC
Exhaust opens	58° BBDC
Exhaust closes	15° ATDC
Compression Pressure	
Standard	12.0 kg/cm ² (170 lb/in ²) at 300 RPM
Limit	9.0 kg/cm ² (128 lbs/in ²) at 300 RPM
Limit of difference between cylinders	2.0 kg/cm ² (2.8 lbs/in ²)
Valve clearances (engine warm)	
Valve side	
Intake	0.25 mm (0.010 in)
Exhaust	0.30 mm (0.012 in)
Cam side	
Intake	0.18 mm (0.007 in)
Exhaust	0.22 mm (0.009 in)

Cylinder head	
Height	90.5 mm (3.563 in)
Warp limit	0.15 mm (0.006 in)
Grinding limit	0.20 mm (0.008 in)
Valve seat	
Seat sinking (Dim "L")	
Standard	39.5 mm (1.555 in)
Wear limit	1.5 mm (0.059 in)
Seat Angle	
Intake	45°
Exhaust	45°
Seat Width	
Intake	1.4 mm (0.055 in)
Exhaust	1.4 mm (0.055 in)
Valve guide, valve and valve spring	
Valve stem to guide clearance	
Standard	0.018 - 0.053 mm (0.007 - 0.0021 in)
Wear limit	0.20 mm (0.0079 in)
Guide inner diameter	8.063 - 8.083 mm (0.3174 - 0.3182 in)
Valve stem diameter	
Intake	
Standard	8.080 - 8.045 mm (0.3161 - 0.3167 in)
Wear limit	7.980 mm (0.3142 in)
Exhaust	
Standard	8.025 - 8.045 mm (0.3159 - 0.3167 in)
Wear limit	7.975 mm (0.3140 in)
Valve head diameter	
Intake	35.95 - 36.05 mm (1.4154 - 1.4193 in)
Exhaust	30.95 - 31.05 mm (1.2185 - 1.2225 in)
Valve face angle	
Intake and exhaust	45°
Minimum valve head thickness (margin)	1.0 mm (0.0394 in)
Valve spring squareness limit	1.51 mm (0.059 in)
Free length of valve spring	
Intake and exhaust	
Standard	43.3 mm (1.705 in)
Wear limit	42.0 mm (1.654 in)
Valve spring constant	2.925 kg/mm (164 lb/in)
Rocker arm and rocker arm shaft	
Bore in rocker arm	19.0 - 19.033 mm (0.7480 - 0.7473 in)
Clearance in rocker arm	
Standard	0.020 - 0.074 mm (0.0008 - 0.0029 in)
Wear limit	0.10 mm (0.0039 in)

Camshaft	
Camshaft run-out	0.30 mm (0.0012 in)
Camshaft end-play	
Standard	0.02 - 0.18 mm (0.001 - 0.007 in)
Wear limit	0.20 mm (0.008 in)
Camshaft journal diameter	
Front and rear	41.949 - 41.965 mm (1.6515 - 1.6522 in)
Center	41.919 - 41.935 mm (1.6504 - 1.651 in)
Wear limit of journal	0.05 mm (0.0020 in)
Camshaft bearing clearance (oil clearance)	
Front and rear	0.035 - 0.076 mm (0.0014 - 0.0030 in)
Center	0.065 - 0.106 mm (0.0026 - 0.0042 in)
Oil clearance limit	0.15 mm (0.0059 in)
Cam lobe height	
6.5 & 8KW Intake and exhaust	
Standard	44.119 mm (1.7401 in)
Wear limit	43.919 mm (1.7291 in)
11KW Intake and exhaust	
Standard	44.114 mm (1.7337 in)
Wear limit	43.914 mm (1.7258 in)
Connecting rod and connecting rod bearing	
Length (center to center)	135.95 - 136.05 mm (5.352 - 5.356 in)
Maximum allowable twist	Less than 0.04 mm (0.0016 in) per 100 mm (3.9370 in)
Piston pin bore	19.948 - 19.961 mm (0.7854 - 0.7859 in)
Clearance between piston pin and pin bore	-0.015 - -0.040 mm (-0.0006 - -0.0016 in)
Connecting rod side clearance	
Standard	0.11 - 0.262 mm (0.004 - 0.010 in)
Wear limit	0.3 mm (0.012 in)
Connecting rod journal bearing clearance (Oil clearance)	
Standard	0.024 - 0.048 mm (0.0009 - 0.0019 in)
Wear limit	0.10 mm (0.0039 in)
Available undersize connecting rod bearing	0.25 mm (0.010 in) 0.50 mm (0.020 in) 0.75 mm (0.030 in)
Crankshaft and main bearings	
Crankshaft run-out	Less than 0.03 mm (0.0012 in)

Connecting rod journal diameter	
Standard	39.940 - 39.956 mm (1.5724 - 1.5734 in)
Wear limit	0.05 mm (0.002 in)
Grinding limit	0.75 mm (0.030 in)
Main bearing journal diameter	
Standard	49.938 - 49.956 mm (1.9661 - 1.9668 in)
Wear limit	0.05 mm (0.002 in)
Grinding limit	0.75 mm (0.030 in)
Main journal bearing clearance	
Standard	0.023 - 0.042 mm (0.0009 - 0.0017 in)
Available undersize main bearing	0.25 mm (0.010 in) 0.50 mm (0.020 in) 0.75 mm (0.030 in)
Crankshaft end play	
Standard	0.10 - 0.15 mm (0.0039 - 0.0059 in)
End play limit	0.30 mm (0.0118 in)
Available oversize thrust bearing	0.25 mm (0.010 in) 0.50 mm (0.020 in) 0.75 mm (0.030 in)
Cylinder block, piston and piston ring	
Limit of distortion of cylinder block top surface	0.15 mm (0.006 in)
Cylinder bore diameter	
6.5 & 8 KW Standard	70.00 - 70.019 mm (2.7559 - 2.7567 in)
11 KW Standard	77.00 - 77.019 mm (3.0315 - 3.0323 in)
Maximum cylinder bore taper	0.09 mm (0.0035 in)
Maximum difference in cylinder bore	0.15 mm (0.0059 in)
Oversize cylinder bore	
6.5 & 8KW	0.25 mm (0.010 in) 0.50 mm (0.020 in) 0.75 mm (0.030 in) 1.00 mm (0.040 in)
11KW	0.25 mm (0.010 in) 0.50 mm (0.020 in)
Piston diameter (Diameter measured at 90° to piston pin axis and 18mm (0.709 in) below oil ring groove	
6.5 & 8KW	69.944 - 69.964 mm (2.7537 - 2.7545 in)
11KW	76.954 - 76.974 mm (3.0297 - 3.0305 in)
Piston and cylinder clearance	
6.5 & 8 KW Standard	0.036 - 0.075 mm (0.0014 - 0.0030 in)
11 KW Standard	0.026 - 0.065 mm (0.0010 - 0.0026 in)
Wear limits	0.15 mm (0.0059 in)

Piston ring groove width	
Top	1.22 - 1.24 mm (0.048 - 0.050 in)
Second	1.52 - 1.54 mm (0.0598 - 0.0606 in)
Oil scraper	4.02 - 4.04 mm (0.1583 - 0.1591 in)
Piston ring thickness	
Top	1.17 - 1.19 mm (0.0461 - 0.0469 in)
Second	1.47 - 1.49 mm (0.0579 - 0.0587 in)
Oil scraper	none given
Clearance between piston ring and ring groove	
Top	0.03 - 0.07 mm (0.0012 - 0.0028 in)
Second	0.03 - 0.07 mm (0.0012 - 0.0028 in)
Oil scraper	none given
Wear limit	0.15 mm (0.0059 in)
Piston ring end gap	
Top	0.2 - 0.4 mm (0.008 - 0.016 in)
Second	0.2 - 0.04 mm (0.008 - 0.016 in)
Oil scraper	0.3 - 0.9 mm (0.012 - 0.035 in)
Wear limit	1.0 mm (0.039 in)
Oversized piston rings available	
6.5 & 8KW	0.25 mm (0.010 in) 0.50 mm (0.020 in) 0.75 mm (0.030 in) 1.00 mm (0.040 in)
11KW	0.25 mm (0.010 in) 0.50 mm (0.020 in)
Piston pin diameter	19.976 - 19.988 mm (0.7865 - 0.7869 in)
Interference fit in a piston pin boss	0 - 0.024 mm (0 - 0.0009 in)
Pressure to install piston pin in piston pin boss	500 - 1,500 kg (1,102 - 3,307 lb)
Flywheel run-out	0.20 mm (0.008 in)

Lubricating System
Lubricating method

Full Forced

Oil Pump

Type

Trochoid pump

Oil pressure at engine speed
1800 RPM

1.75 - 2.50 kg/cm²
(25 - 35 lb/in²)

700 RPM (idle)

.7 - 1.75 kg/cm²
(10 - 25 lb/in²)

Outer rotor and pump body clearance
Standard

0.20 - 0.294 mm
(0.0078 - 0.0116 in)

Wear limit

0.35 mm (0.0134 in)

Clearance between rotor lobes
Standard

0.03 - 0.12 mm
(0.0012 - 0.0047 in)

Wear limit

0.25 mm (0.0098 in)

Rotor end float
Standard

0.04 - 0.10 mm
(0.0016 - 0.0039 in)

Wear limit

0.15 mm (0.0059 in)

Pump shaft and body clearance
Standard

0.02 - 0.056 mm
(0.0008 - 0.0022 in)

Wear limit

0.10 mm (0.0029 in)

Free length relief valve spring

45.5 mm (1.791 in)

Sprocket drive gear pressing

pressure to install on pump shaft

700 - 1300 kg
(1543 - 2865 lb)

Oil Filter

Type

Full flow, spin on cartridge

Oil pressure switch (normally open)

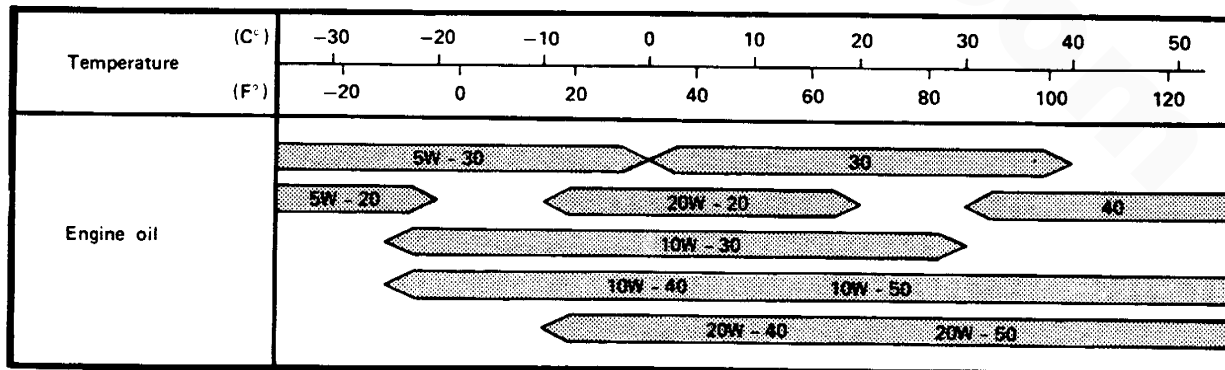
close 4.5-6.8 kg (10 - 15 lb)

Oil capacity sump and filter

3.7 liters (3.9 quarts)
(3.3 Imp. quarts)

Lubricant

Oil brand meeting A.P.I. spec SE or SE/CC



Cooling System

Fresh water circuit coolant capacity approximately	
6.5 & 8KW	4.7 liters (5 quarts)
11KW	6.6 liters (7 quarts)
Fresh water pump	Belt driven centrifugal type
Metal impeller press fit to pump shaft	
Raw water pump	1200 - 1300 kg (2645 - 2866 lb)
	Positive displacement type, neoprene impeller belt drive type
Raw water pump flow rate 1800 RPM (measured at exchanger discharge)	
6.5 & 8KW	25.3 ltr/min (6.7 gal/min)
11KW	26.5 ltr/min (7 gal/min)
Water temperature switch (normally closed)	Opens 95°C (205°F)

Fuel System

Carburetor	Single barrel - downdraft
Air filter	Metal screen
Choke	Mechanical 12 volt activated
Throttle control	Belt driven governor, mechanically linked to throttle arm.
	Engine speed 1800 RPM \pm 50 RPM
Fuel Pump	12 volt pulsating type with self contained filter screen (cleanable)
Fuel flow (free flow)	0.8 ltr/min (0.84 qt/min)
Fuel pump lift capacity	1.8 m (6 ft)
Engine fuel consumption at full rated KW output approximate	
6.5KW	4.16 ltr/hr (1.10 gal/hr)
8KW	4.73 ltr/hr (1.25 gal/hr)
11KW	6.05 ltr/hr (1.60 gal/hr)

Electrical System (Engine)

Type	12 volt - negative ground
Alternator	12 volt - 50 amps internal regulator, belt driven
Starter	12 volt, solenoid mounted
Ignition system	Spark plug type ignition
Spark plug gap	0.80 \pm 0.05 mm (0.031 \pm 0.002 in)
Spark plug firing order	1 - 3 - 4 - 2
Ignition timing at 1800 RPM	14° BTDC \pm 1°
Distributor	Solid state breaker assembly type
Ignition coil and high tension plug leads	
Resistance of primary coil (R X 1)	0.8 ohm \pm 0.2
Resistance of secondary coil (R X 1000)	80 ohm \pm 10
Resistance of high tension leads (R X 1)	410 ohm/inch
Coil insulation resistance	10 megohms +

Generator
Type

Four pole revolving armature inherently regulated, self limiting, rectifier excited, stationary field, AC slip rings, single bearing design. 1800 RPM operation (1500 for 50 Hertz)

Ratings (standard)

6.5KW

115/230 volts, 56/28 amps
60 Hertz, single phase

8KW

115/230 volts, 70/35 amps
60 Hertz, single phase

11KW

115/230 volts, 94/47 amps
60 Hertz, single phase

Cooling air requirements for generator end

6.5KW

5.66 cu m/min (200 cu ft/min)

8KW

6.23 cu m/min (220 cu ft/min)

11KW

7.80 cu m/min (250 cu ft/min)

TABLE OF TIGHTENING TORQUES

	<u>kg-m</u>		<u>lb-ft</u>	
Cylinder head	7.8	- 8.2	56	- 59
Manifold				
Intake	1.9	- 2.6	14	- 19
Exhaust	1.9	- 2.3	14	- 17
Main bearing caps	6.6	- 7.1	48	- 51
Connecting rod bearing caps	3.0	- 3.5	22	- 25
Camshaft sprocket nut	7.0	- 8.0	51	- 58
Crankshaft pulley nut	11.0	- 12.0	80	- 87
Flywheel	8.3	- 9.0	60	- 65
Backplate	7.0	- 10.0	51	- 72
Spark plugs	1.5	- 2.3	11	- 17
Timing chain cover	1.9	- 3.1	14	- 22
Oil filter	Tighten by hand			
Oil pan	0.7	- 1.2	5	- 9
Oil pump	1.9	- 3.1	14	- 22
Thermostat housing	1.9	- 3.1	14	- 22
Fresh water pump	1.9	- 3.1	14	- 22
Generator cooling fan nut	3.5		25	
Drive disc to armature	6.9	- 7.6	50	- 55
Drive disc to flywheel	2.5	- 2.8	18	- 20

TABLE OF STANDARD HARDWARE TIGHTENING TORQUES

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

	Pitch	lb-ft	kg-m
<u>Grade 4T</u>			
6mm bolt head/nut	1	2.9 - 5.1	0.4 - 0.7
8mm bolt head/nut	1.25	7.2 - 11.6	1.0 - 1.6
10mm bolt head/nut	1.25	13.7 - 22.4	1.9 - 3.1
10mm bolt head/nut	1.5	13.0 - 21.7	1.8 - 3.0
12mm bolt head/nut	1.25 (ISO)	25.3 - 39.8	3.5 - 5.5
12mm bolt head/nut	1.5	25.3 - 39.8	3.5 - 5.5
12mm bolt head/nut	1.75	21.7 - 36.2	3.0 - 5.0
13mm bolt head/nut	1.5	32.5 - 50.6	4.5 - 7.0
14mm bolt head/nut	1.5	36.2 - 57.9	5.0 - 8.0
14mm bolt head/nut	2	34.0 - 55.7	4.7 - 7.7
16mm bolt head/nut	1.5	54.2 - 79.6	7.5 - 11.0
16mm bolt head/nut	2	51.4 - 76.7	7.1 - 10.6
<u>Grade 6T</u>			
6mm bolt head/nut	1	4.3 - 6.5	0.6 - 0.9
8mm bolt head/nut	1.25	10.8 - 15.9	1.5 - 2.2
10mm bolt head/nut	1.25	21.7 - 32.5	3.0 - 4.5
10mm bolt head/nut	1.5	19.5 - 30.4	2.7 - 4.2
12mm bolt head/nut	1.25 (ISO)	36.2 - 57.9	5.0 - 8.0
12mm bolt head/nut	1.5	36.2 - 50.6	5.0 - 7.0
12mm bolt head/nut	1.75	34.7 - 49.2	4.8 - 6.8
<u>Grade 7T, 8T and 8.8</u>			
6mm bolt head/nut	1	5.8 - 8.7	0.8 - 1.2
8mm bolt head/nut	1.25	14.5 - 21.7	2.0 - 3.0
10mm bolt head/nut	1.25	28.9 - 39.8	4.0 - 5.5
10mm bolt head/nut	1.5	26.8 - 37.6	3.7 - 5.2
12mm bolt head/nut	1.25 (ISO)	54.2 - 75.9	7.5 - 10.5
12mm bolt head/nut	1.5	50.6 - 65.1	7.0 - 9.0
12mm bolt head/nut	1.75	43.4 - 61.5	6.0 - 8.5
13mm bolt head/nut	1.5	57.9 - 86.8	8.0 - 12.0
14mm bolt head/nut	1.5	72.3 - 108.5	10.0 - 15.0
14mm bolt head/nut	2	68.7 - 101.3	9.5 - 14.0
16mm bolt head/nut	1.5	108.5 - 166.4	15.0 - 23.0
16mm bolt head/nut	2	101.3 - 159.1	14.0 - 22.0
<u>Grade 5 capscrew</u>			
1/4 UNC		9 - 11	1.2 - 1.5
1/4 UNF		11 - 13	1.5 - 1.8
5/16 UNC		18 - 20	2.5 - 2.8
5/16 UNF		21 - 23	2.9 - 3.2
3/8 UNC		28 - 33	3.7 - 4.6
3/8 UNF		30 - 35	4.1 - 4.8
7/16 UNC		44 - 49	6.1 - 6.8
7/16 UNF		50 - 55	6.9 - 7.6
1/2 UNC		68 - 73	9.4 - 10.1
1/2 UNF		73 - 80	10.1 - 11.1

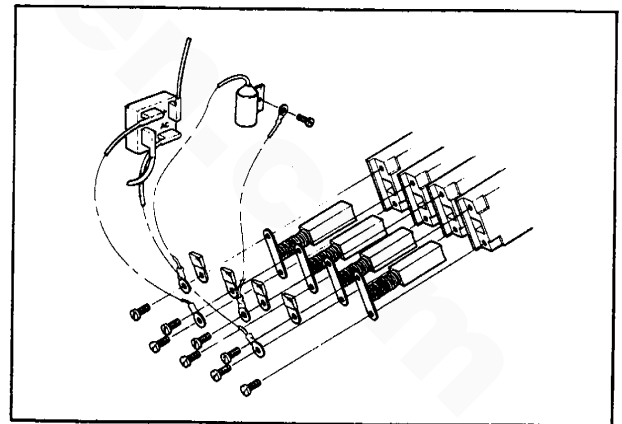
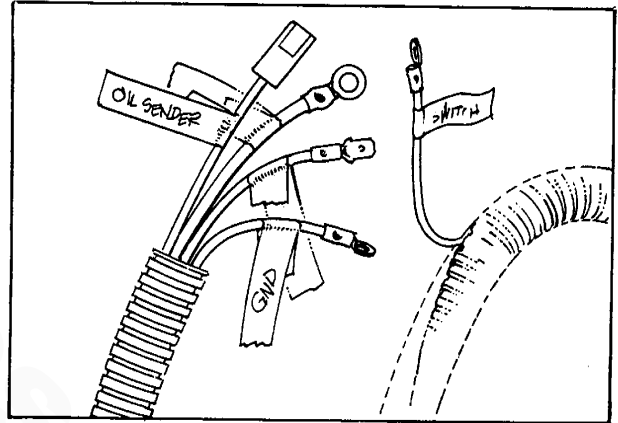
DISASSEMBLY FOR OVERHAUL

Removal

1. Remove all AC and DC power connections from the unit.
2. Shut off and disconnect fuel, raw water and exhaust connections.
3. Unbolt unit and remove to the overhaul shop.
4. Drain all lubricating oil and coolant from the engine and exchanger system.

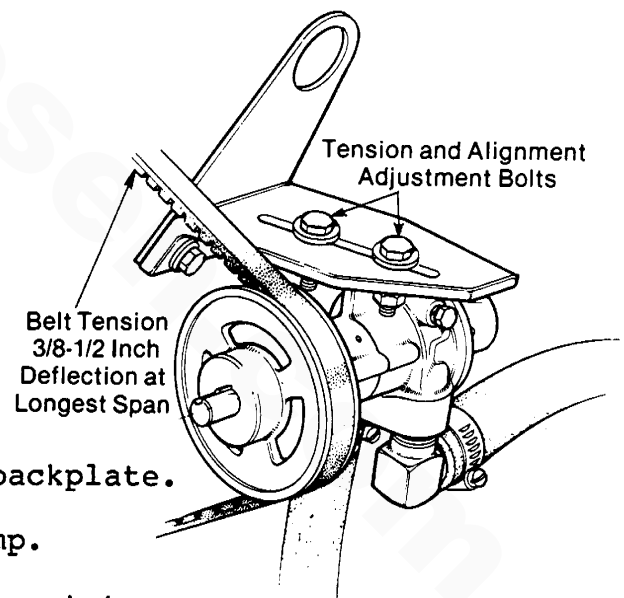
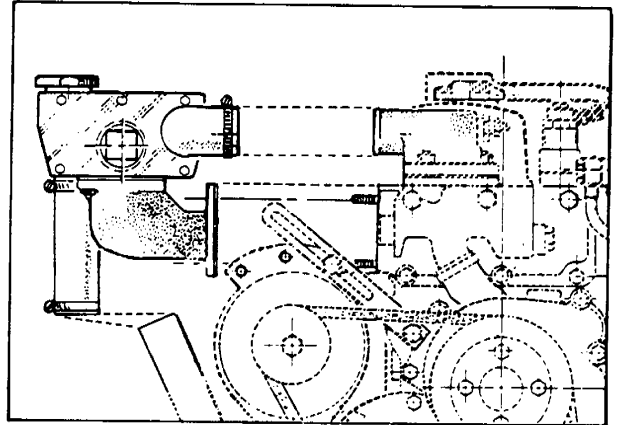
Generator Removal from Engine

1. Disconnect engine wiring harness leads from engine connections, tag and mark harness connections. Unbolt control panel from generator control panel as one assembly.
2. Support the rear of the engine and unbolt the generator end bell cover exposing the cooling fan and brush rig assembly.
3. Remove the generator fan.
4. Remove each brush from its holder individually and resecure the electrical connections to the respective brush holder as each brush is removed. This is to help insure keeping the connections on the correct holder. Examine each brush and, if worn to 1/2 inch in length, replace.
5. Remove the exhaust screen from the bellhousing and remove the 4 bolts and lockwashers holding the outer generator housing to the engine bellhousing.
6. With the aid of a puller attached to the end bearing support web and armature shaft, carefully draw the generator outer housing off the rear support bearing. In some cases the rear support bearing may be pulled off the armature shaft along with the generator housing.
7. When clear of the bearing and/or shaft, manually slide the generator housing carefully off the armature.



NOTE: Rest the generator housing on its side, not on the inner end as damage to the field coil windings may result.

8. Unbolt the armature and drive disc assembly from the flywheel, supporting the armature. Then, cocking the armature, draw its drive disc through the bellhousing clearing the generator outer housing securing bolt bosses.
9. Remove the exhaust manifold and related hoses as a unit. Disassemble and inspect as needed.
10. Remove the heat exchanger and related hoses and mounts from the rear of the engine. Have heat exchanger cleaned and tested at a local radiator repair shop or replace as needed.
11. Remove the starter motor and circuit breaker assembly. Examine starter and repair or replace as needed.
12. Remove sea water pump, drive belt and mounting bracket.
13. Remove governor and mounting bracket.
14. Remove 12 volt alternator and mounting bracket.
15. Remove carburetor, fuel pump and intake manifold.
16. Remove ignition coil and mounting bracket.
17. Remove bellhousing, flywheel and backplate.
18. Remove fresh water circulating pump.
19. Remove thermostat housing and thermostat.
20. Remove oil pressure switch, oil pressure sender and oil manifold tee.

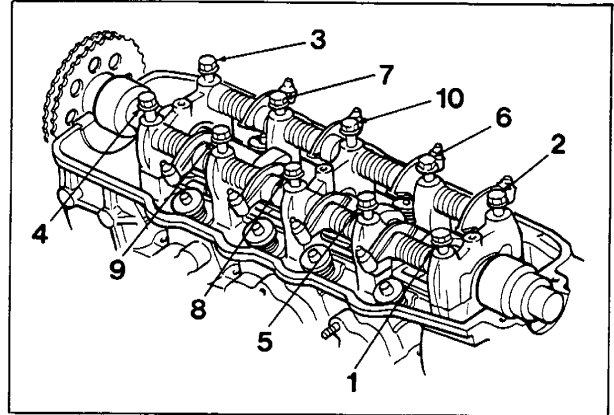


This should leave the basic engine block assembly for disassembly, cleaning, inspection and repair as needed.

Disassembly of the Engine Block

1. Remove the engine rocker cover and baffle assembly.
2. Rotate the engine crankshaft so as to position the camshaft drive chain so that the master link is in a position that it can be disassembled. Remove the chain tensioner from the front timing gear cover. Disassemble the master link to separate the chain.

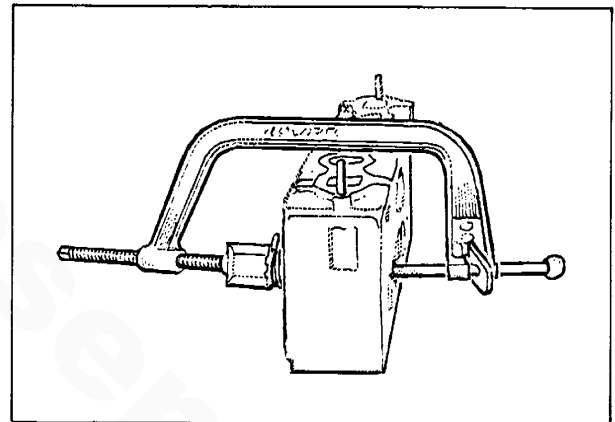
3. Loosen cylinder head bolts in the numerical order shown in the figure. Make sure bolts are loosened a few turns at a time.



4. Remove the rocker shaft assembly and camshaft with drive gear.

5. Remove the cylinder head with valves.

6. Remove the valves with the aid of a suitable valve spring compressor tool. Make sure the removed valves are kept in sequence for each cylinder.

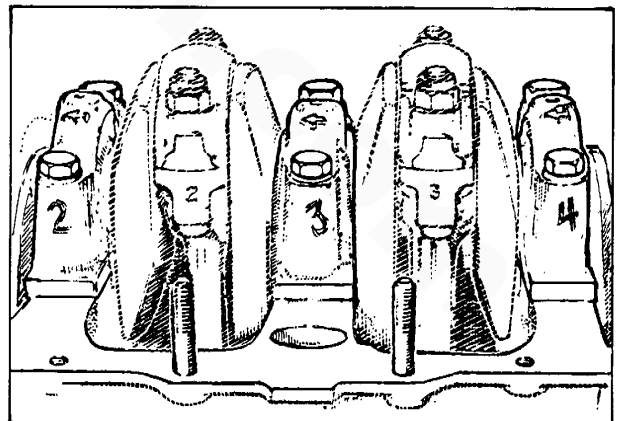


7. Remove the engine oil sump.

8. Remove the front crankshaft pulley and front timing gear cover.

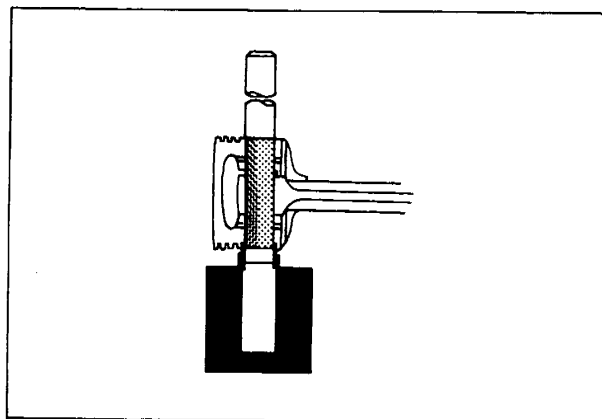
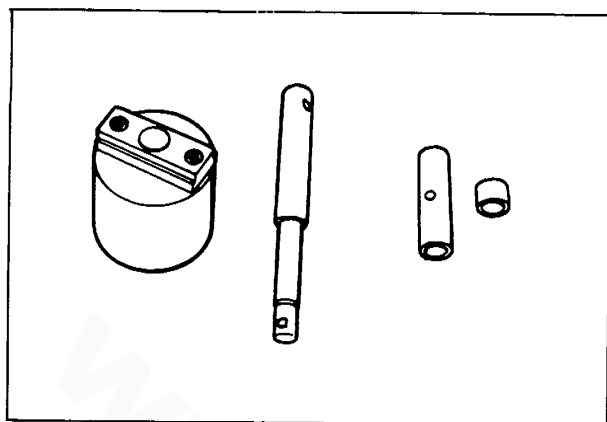
9. Remove the lube oil pump assembly and drive chain.

10. Remove each connecting rod bearing cap and remove the connecting rod and piston assembly from the engine block by carefully forcing it out the top of the block.

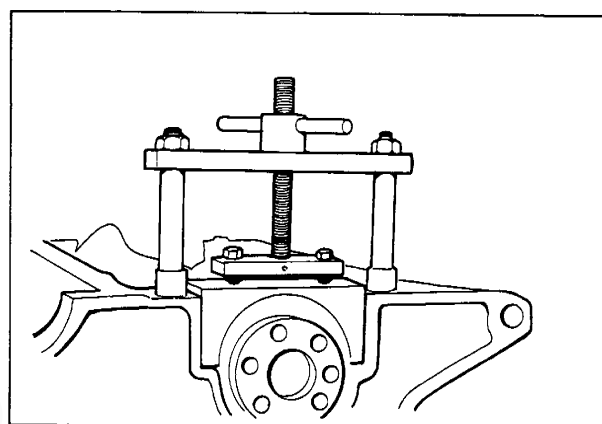


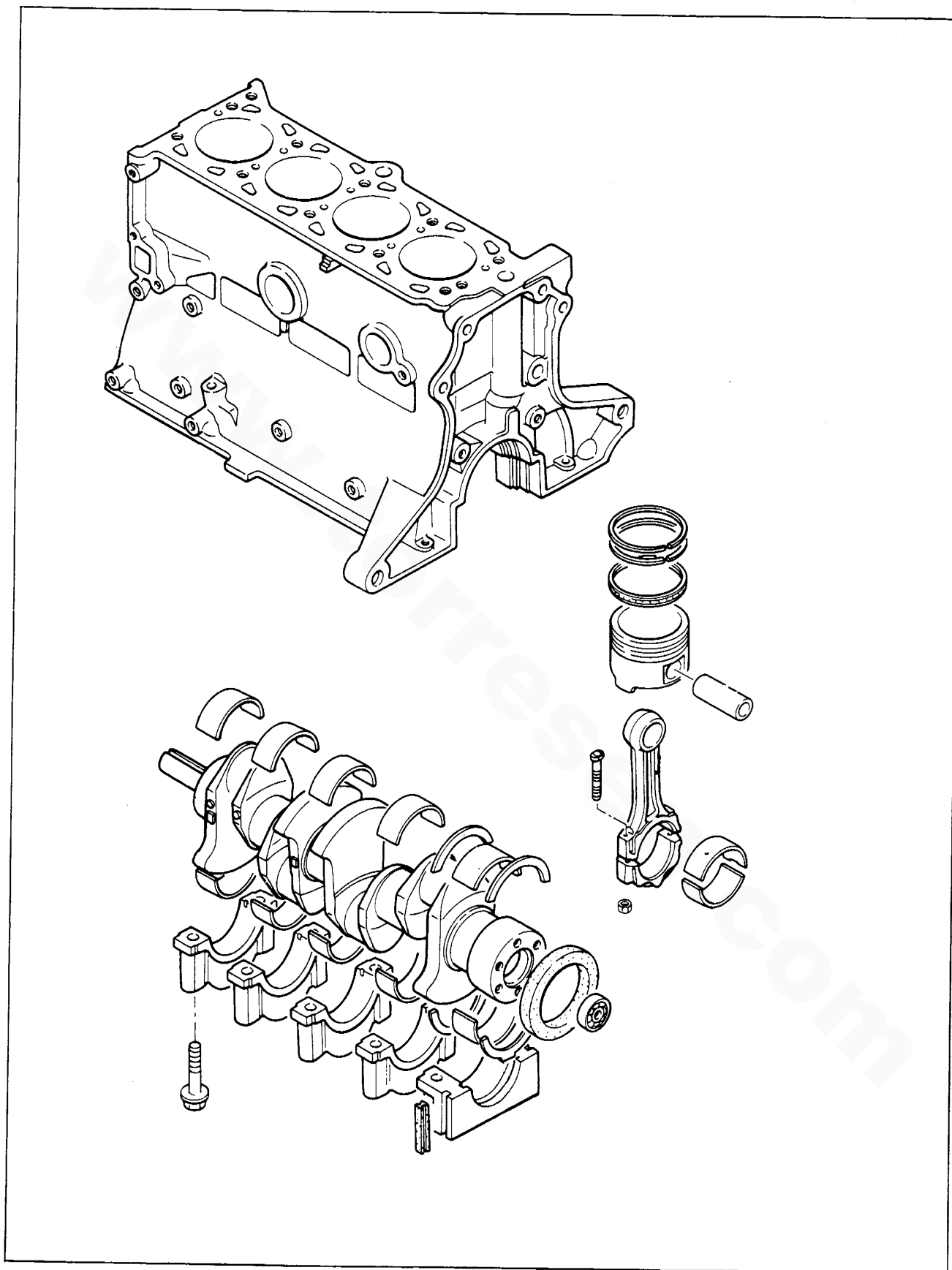
NOTE: Keep rods and caps together. Number them as needed.

11. Press out the piston pin with piston pin setting tool. Make sure that disassembled pistons and piston rings are kept in sequence for each cylinder.



12. Remove the main bearing cap with main bearing cap puller.
13. Remove the crankshaft main bearing inserts and thrust washers.



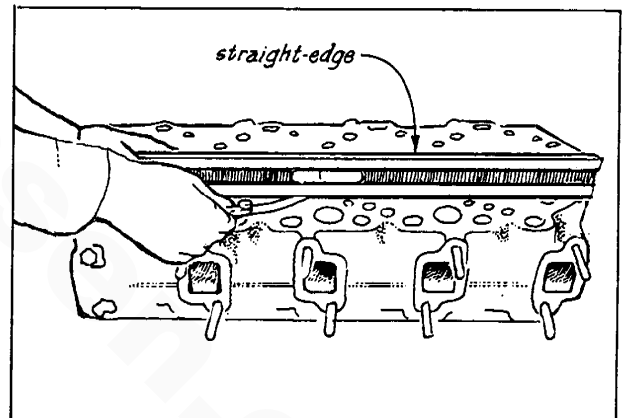
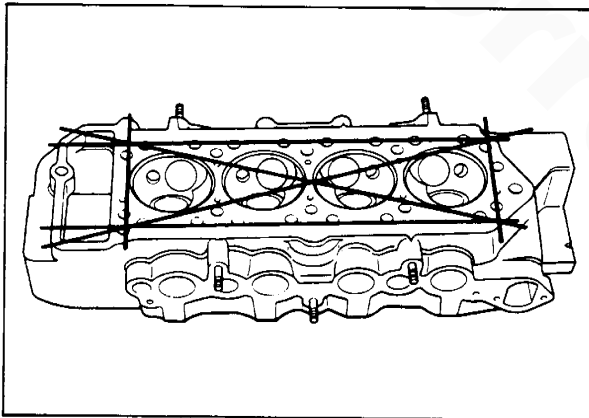


ENGINE INSPECTION AND REPAIR

NOTE: Before washing the cylinder head and block, check them for indications of water leaks, gas leaks, damage or cracks. Before checking, wash each part to remove any adhered foreign matter (pieces of gasket, dust, oil, carbon, scale, etc.) Since the cylinder head, cylinder head cover, timing chain cover and other engine parts are made of aluminum, handle them carefully to ensure against damage. Do not use cleaning solutions that will be harmful to the aluminum.

Checking Cylinder Head

1. Replace the cylinder head, if it has any damage, such as water leaks, gas leaks or cracks.
2. Measure the extent of warping (flatness) on the lower surface along the areas shown in the figure. If the warping is more than specifications, grind the surface or replace.



Height of cylinder head: 90.5 mm (3.5630in)
Warp limit: 0.15 mm (0.006in)
Grinding limit: 0.2 mm (0.008 in)

Checking Valve Guide

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

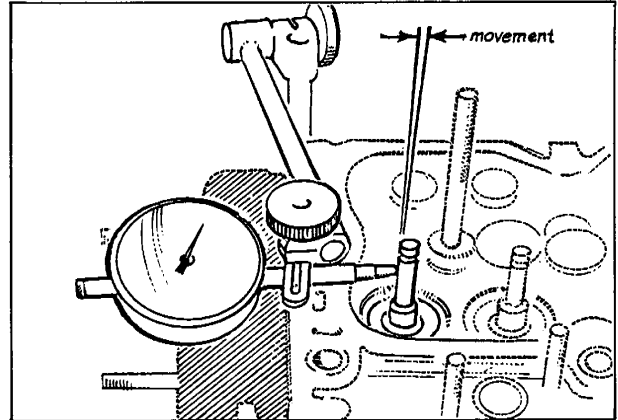
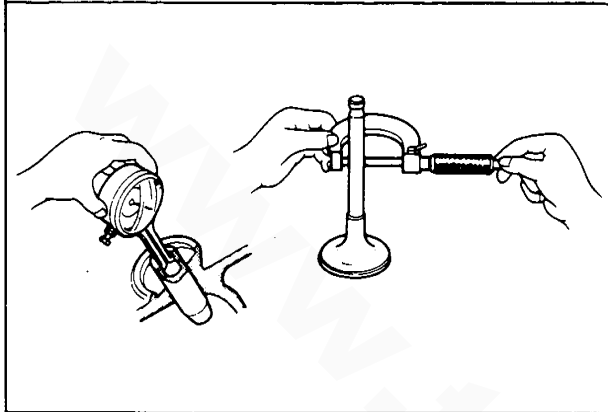
Clearance limit: 0.20 mm
(0.0079 in)

Measuring Method #1:

Check the difference between the inner diameter of the guide and the diameter of the valve stem.

Measuring Method #2:

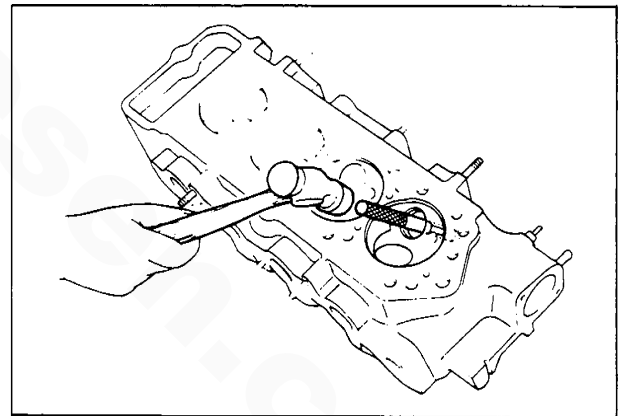
Check the valve deflection with a mounted dial indicator by moving the valve stem from side to side.



NOTE: Separate the valve from the valve seat before measuring. Measure at a position near the valve guide.

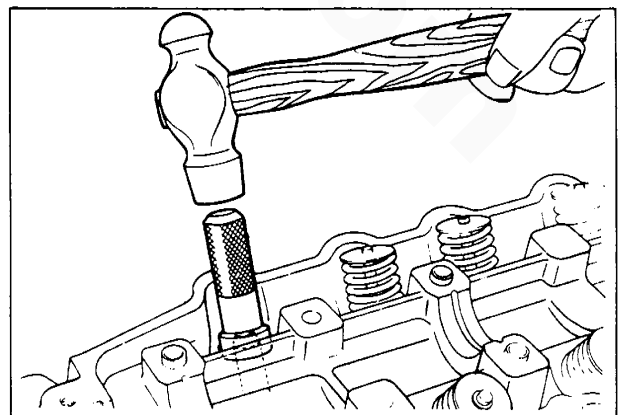
Replacing the Valve Guide

1. Remove the valve seal from the valve guide.
2. Knock the guide out toward the opposite side of the combustion chamber with a valve guide installer.
3. Place a clip on the new valve guide and drive it in from the opposite side of the combustion chamber with the valve guide installer.



NOTE: The shape of the intake valve guides differs from that of the guides on the exhaust side.

4. Install the valve seal on the valve guide with a valve seal pusher.



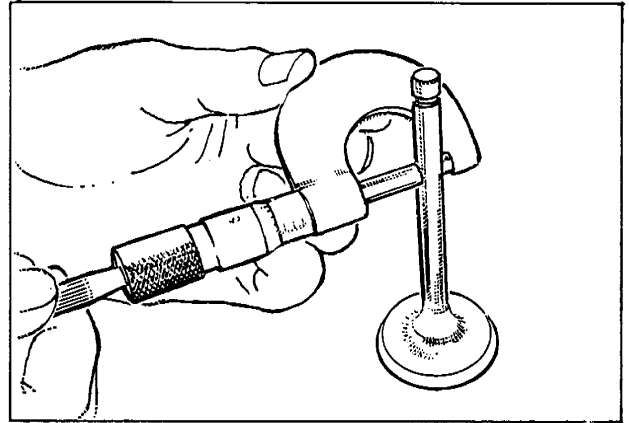
Checking Valve

1. Check the contact surface of the valve face and valve seat for damage. Minor or rough surface may be repaired with a valve grinder.
2. If the valve stem is worn, damaged, bent or the end surface of the stem is dented, replace the valve.
3. Check the valve stem diameter with a micrometer; if the wear exceeds the limit, replace the valve.

Valve stem diameter limit:

Intake valve: 7.980 mm
(0.3142 in)

Exhaust valve: 7.975 mm
(0.3140 in)



4. Check the thickness of valve head (margin) and the diameter. Replace if less than the specified limit.

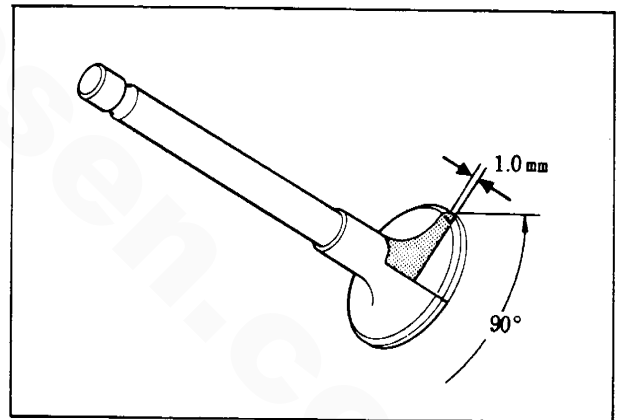
Minimum valve head thickness:

1.0mm (0.00394 in)

Limit of reduction in diameter:

Intake: 7.980 mm
(0.3142 in)

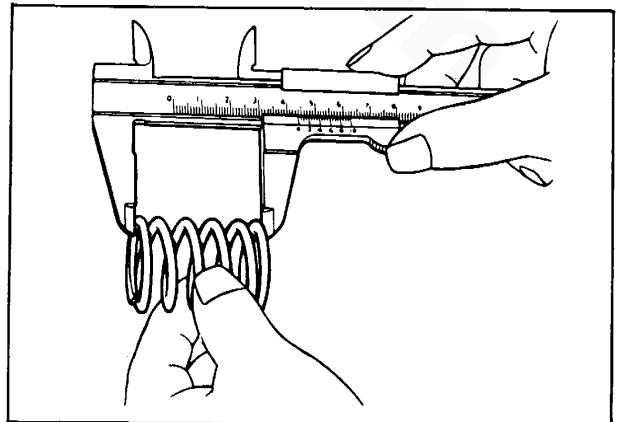
Exhaust: 7.975 mm
(0.3140 in)



Checking Valve Spring

1. Check the valve spring for corrosion or damage and replace, if necessary.
2. Check the spring length and replace the spring if the free length is less than the following dimensions.

Free length limit: 42.0 mm
(1.654 in)



3. Check the squareness of valve spring. If it exceeds the limit, replace with a new one.

Squareness limit: Less than 3 mm (0.118 in) per 100 mm (3.937 in)

Checking Valve seat

1. Check the protruding length of the valve stem (dimension "L"). If it exceeds the specification, correct it as follows.

Dimension "L" (standard):

39.5 mm (1.555 in)

When the dimension "L" becomes 0-0.5 mm larger than the standard, replace the valve.

When the dimension "L" becomes 0.5-1.5 mm larger than the standard, replace the valve and adjust the dimension "L" to the standard by adding some washers between the lower spring seat and cylinder head.

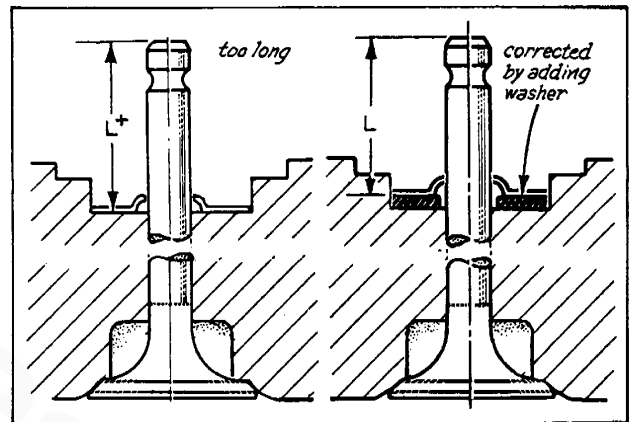
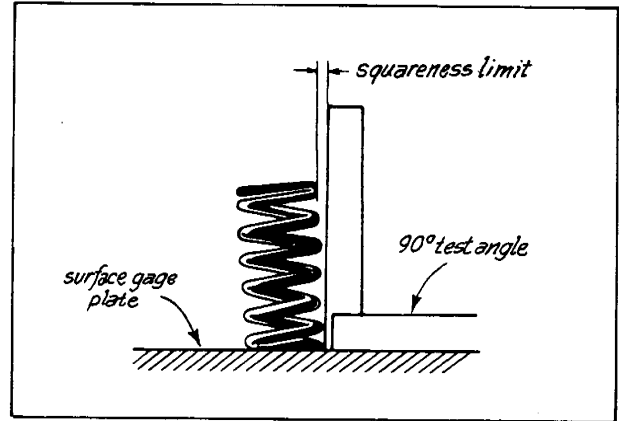
When the dimension "L" becomes more than 1.5 mm larger than the standard, replace both the valve and cylinder head.

2. Check for contact between the valve and valve seat as follows:
 - a. Apply a thin coat of Prussian Blue (or Redlead) on the valve seat contact face.
 - b. Insert the valve into the valve guide and press fit the valve on the valve seat.
 - c. Check if the valve seat contact face contacts the center position of the valve contact face. If the contact position is not centered, recut and surface the valve seat and valve.

NOTE: Do not rotate the valve.

Refacing Valve and Valve Seat

Reface in the following order:



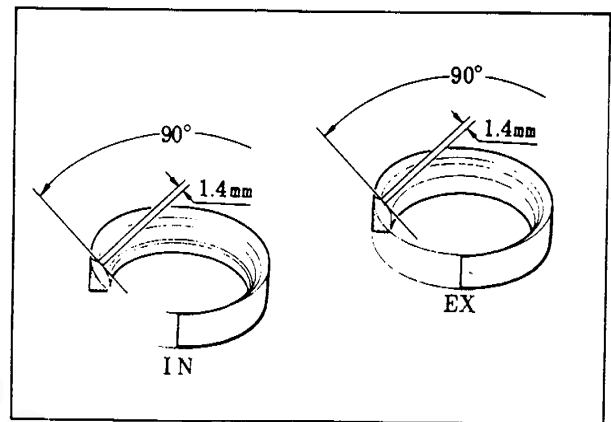
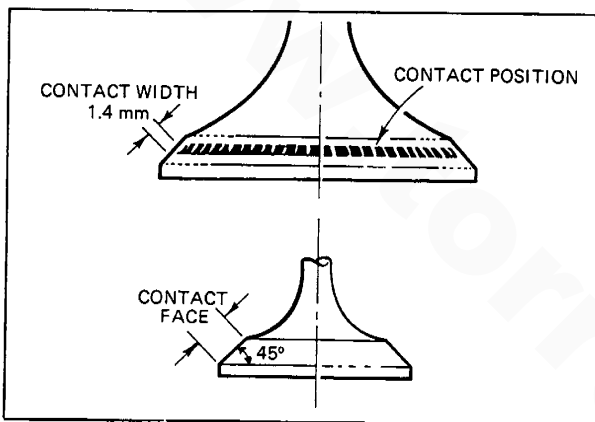
1. Reface the valve with a valve grinder to the specified angle.

Valve face angle: 45°

2. Reface the valve seat with a valve seat cutter while checking the contact between the valve and valve seat.

NOTE: Reface the valve seat taking care that the valve seat contacts the center position of the valve.

	Intake	Exhaust
Valve seat angle:	45°	45°
Valve seat width:	1.4 mm (0.055 in)	1.4 mm (0.055 in)



3. Reface the valve and valve seat with a good valve lapping compound.
4. Measure the dimension "L".
5. Adjust the dimension "L" to the standard by adding some washers between the lower spring seat and cylinder head.

Checking Rocker Arm and Shaft

1. Check each component part of the rocker arm assembly for damage or cracks. If necessary, replace with a new one.
2. Check to see that the oil passages of the rocker arm and shaft are open. If any clogs are found, remove them or replace.
3. Check the clearance between the rocker arm bore and shaft. If it exceeds the limit, replace the rocker arm bushing and shaft.

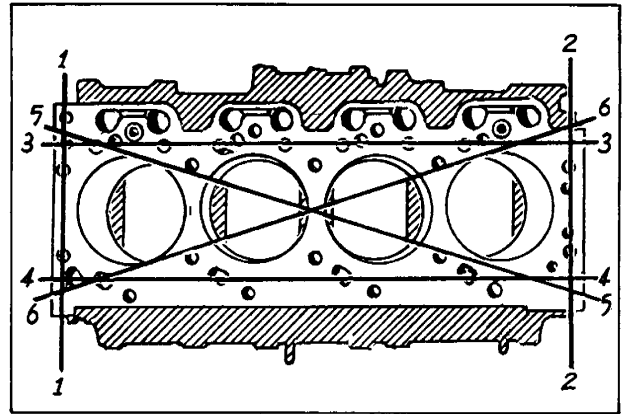
Clearance between rocker arm and shaft:

Standard: 0.020 - 0.074 mm (0.0008 - 0.0029 in)

Limit: 0.10 mm (0.0039 in)

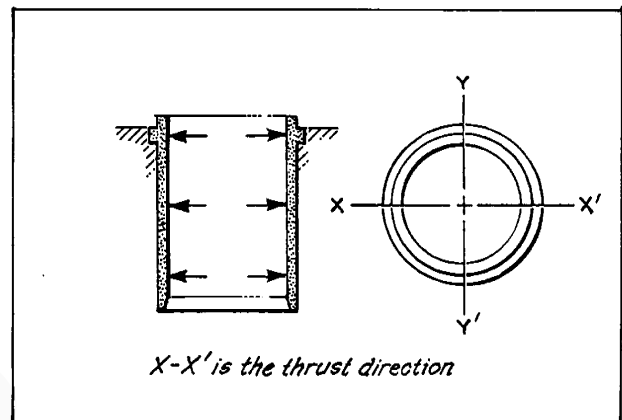
Checking Cylinder Block

1. Check the cylinder block for damage or cracks. If necessary, repair or replace the cylinder block.
2. Check to see that the oil passages and coolant passages of the cylinder block are open. If clogged, remove with compressed air or a wire probe.
3. Check the cylinder block for distortion. If it exceeds the limit, repair or replace the cylinder block.



Warp limit: 0.15 mm (0.006 in)

4. Check for scratches or burns on the cylinder walls. If necessary, repair by boring or replace the cylinder block.
5. Measure the wear on the cylinder bores at the six positions shown in the figure with an inside micrometer. (The wear is the difference between the maximum and minimum diameters.) If the wear is more than the specified limit, rebore the cylinder.



If the wear is more than the specified limit, rebore the cylinder.

Standard bore diameter:

11 KW: 77.0 - 77.019 mm (3.0315 - 3.0323 in)

6.5 & 8 KW: 70.0 - 70.019 mm (2.7559 - 2.7567 in)

Maximum difference in bore: 0.15 mm (0.0059 in)

Inner diameter error of each cylinder: 0.09 mm (0.0035 in) or more

Select oversize pistons according to the maximum wear on the cylinder bore.

Oversize pistons available: 0.25 mm (0.010 in)
 0.50 mm (0.020 in)
 *0.75 mm (0.030 in)
 *1.00 mm (0.040 in)

*for 6.5 & 8 KW only

Checking Piston

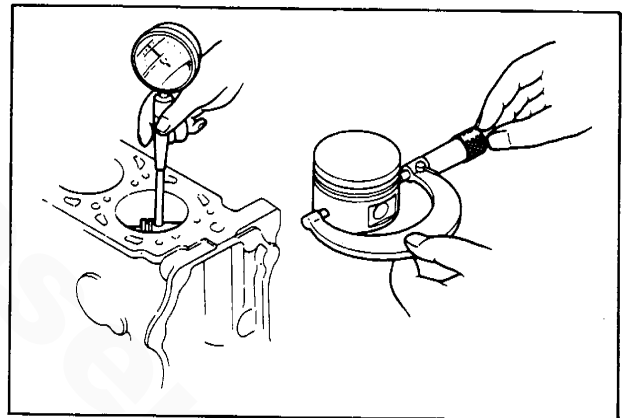
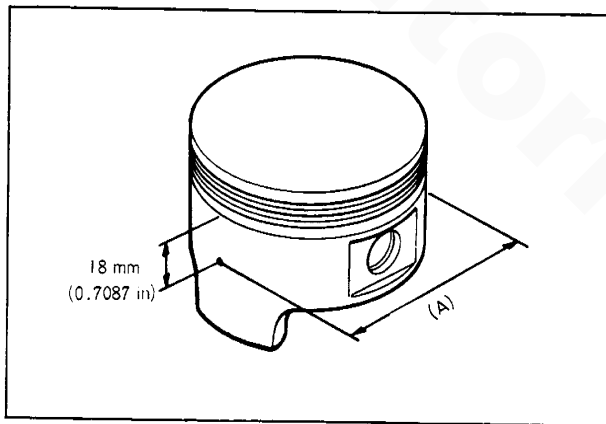
1. Check pistons carefully and replace, if severe burns or scratches on the external circumference of the piston are found.
2. Measure the piston diameter 18 mm (0.7087 in) under the oil ring groove, at right angles with the piston pin location (but without the pin in place).

Standard piston diameter:

6.5 & 8 KW: 69.944 - 69.964 mm
(2.7537 - 2.7545 in)
11 KW: 76.954 - 76.974 mm
(3.0297 - 3.0305 in)

3. Check the clearance between the piston and cylinder wall.

Clearance limit: 0.15 mm (0.0059 in)

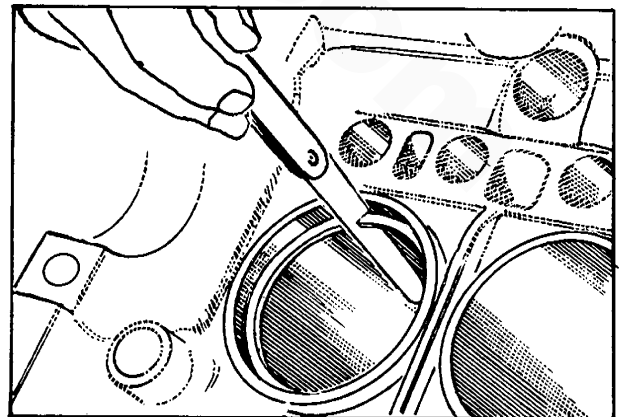


Checking Piston Rings

1. Check the piston rings for cracks, burning or wear and replace, if necessary.
2. Measure the piston ring end gap. Replace if it exceeds the limit.

NOTE: Push a ring into the cylinder with a piston until it is about 2 inches from the block surface.

End gap limit: 1.0 mm
(0.039 in)

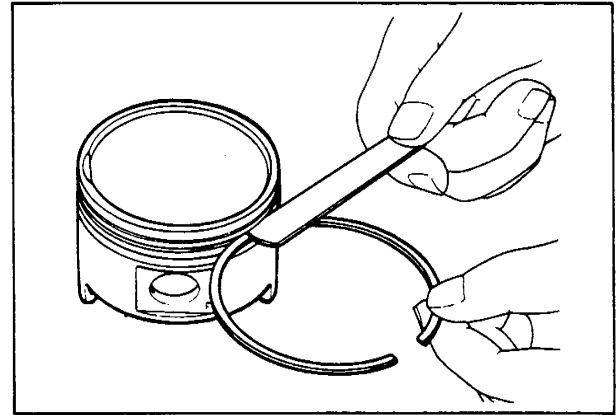


3. Measure the side clearance between the piston ring and ring groove.

NOTE: Measure the clearance around the total circumference of the ring groove.

Side clearance limit:

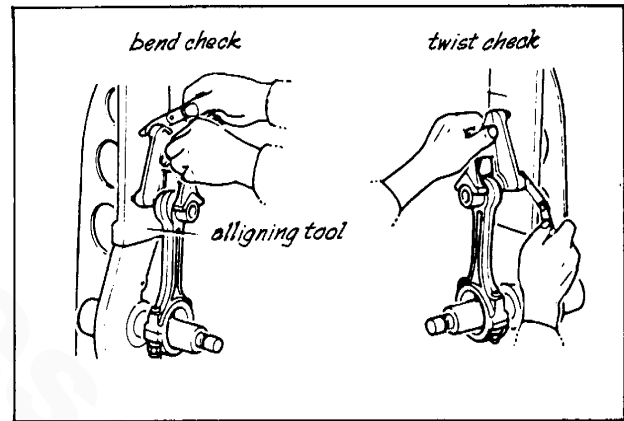
0.15 mm (0.006 in)



Side clearance limit: 0.15 mm (0.006 in)

Checking Connecting Rod

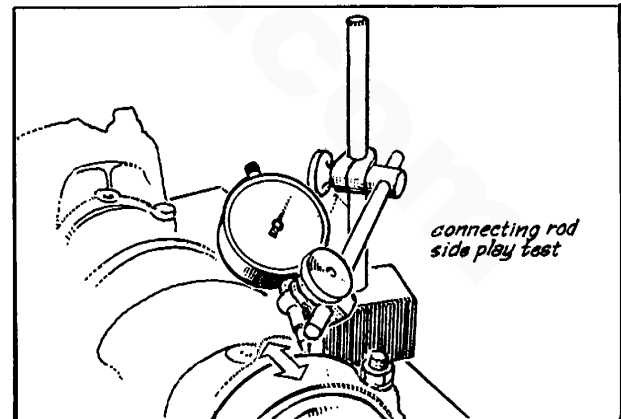
1. Check the side of the connecting rod small end and large end for cracks or damage. If necessary, replace the connecting rod.
2. Check the connecting rod for bends or twists with a suitable alignment fixture. If realignment is necessary, correct by using a press and applying a gradual pressure to the rod or replace the connecting rod.



Permissible deflection: 0.04 mm per 100 mm
(0.002 in per 4 in)

3. Check the connecting rod side play with a dial indicator or a feeler gauge as shown in the figure. If it exceeds the limit, replace the connecting rod or crankshaft.

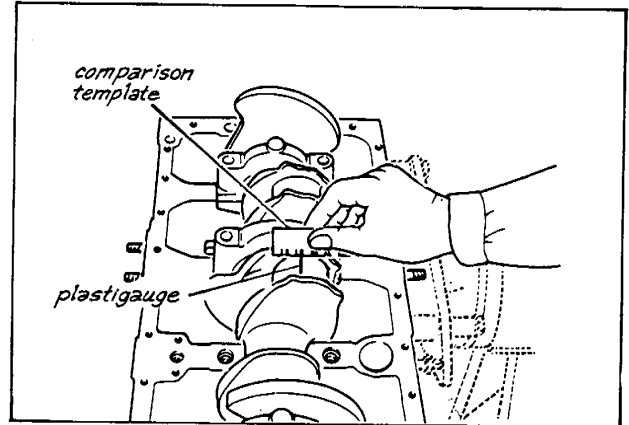
End play limit: 0.3 mm
(0.012 in)



Checking Connecting Rod Bearing

1. Check the connecting rod bearing carefully and replace if it is worn, scored or flaked.
2. Check the connecting rod bearing clearance with a "plastigauge". If it exceeds the limit, correct the crankpins with a suitable grinder and use with suitable undersize bearings.

NOTE: Tighten the connecting rod cap bolts to the specified torque.



Cap tightening torque: 3.0 - 3.5 kg-m (22 - 25 lb-ft)

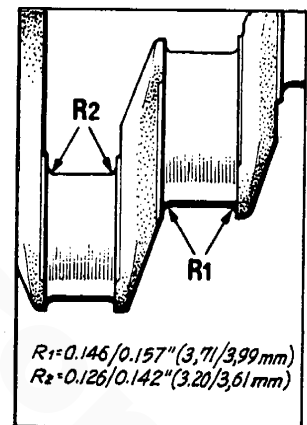
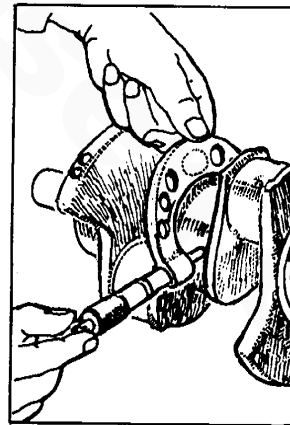
Bearing clearance:

Standard: 0.024 - 0.048 mm (0.0009 - 0.0019 in)

Limit: 0.10 mm (0.0039 in)

Checking Crankshaft

1. Check the crankshaft for cracks or other damage. If necessary, replace the crankshaft.
2. Check to see that the oil passages of the crankshaft are open. If any clogs are found, remove them with compressed air or a suitable wire.
3. Check the crankshaft for wear. If it exceeds the limit, correct the crankshaft with a suitable grinder and use with suitable undersize main bearings.

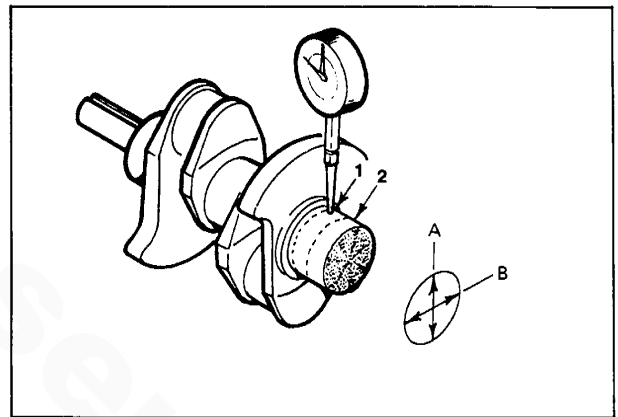


NOTE: Measure the diameter of each of the crankpins and main journals at two points (the front and rear portions) at 90 degrees to the crankshaft axis, as shown in the figure.

	Main Journal	Crankpin
Standard	49.938 - 49.956 mm (1.9661-1.9668 in)	39.940 - 39.956 mm (1.5724-1.5734 in)
Undersize 0.254	49.690 - 49.705 mm (1.9528-1.9534 in)	39.690 - 39.706 mm (1.5598-1.5604 in)
Undersize 0.508	49.440 - 49.455 mm (1.9430-1.9436 in)	39.440 - 39.456 mm (1.5500-1.5506 in)
Undersize 0.762	49.190 - 49.205 mm (1.9332-1.9338 in)	39.190 - 39.206 mm (1.5402-1.5408 in)

NOTE: When grinding the crankshaft, take care of the following points.

- a. When grinding the crankshaft, finish the place of "R" as shown in the figure.
- b. The crankshaft processing diameters are as shown in the table above.



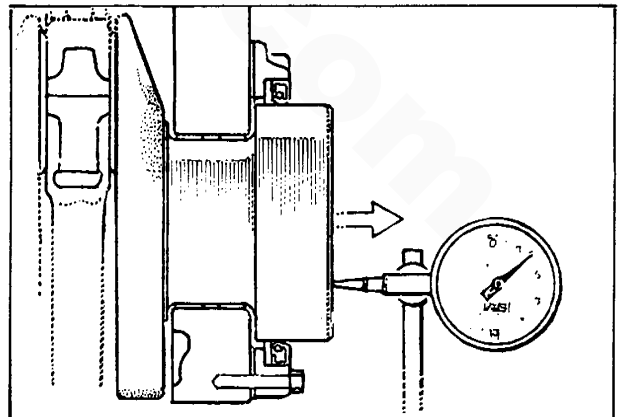
4. Check the crankshaft alignment. If it exceeds the limit, replace with a new one.

Maximum allowable run-out:

0.05 mm (0.0020 in)

5. Check the crankshaft end play with a dial indicator as shown in the figure. If it exceeds the limit, replace the thrust bearing with an oversized thrust bearing.

End play limit: 0.30 mm
(0.0118 in)

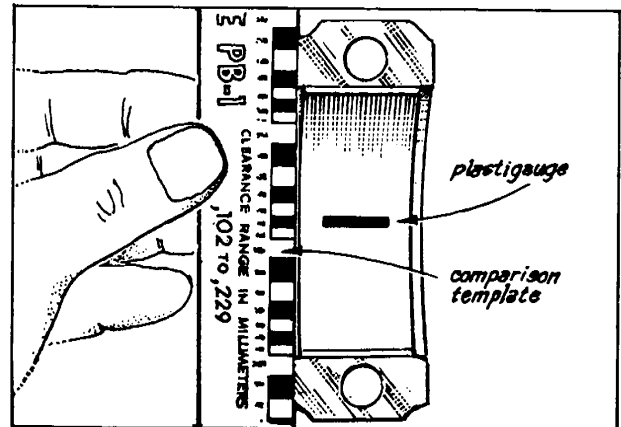


NOTE: Any crankshaft grinding should be done by a qualified machine shop.

Checking Main Bearing

1. Check the main bearing carefully and replace if it is worn, scored or flaked.
2. Check the main bearing clearance with a "plastigauge". If it exceeds the limit, correct the main journals by having the crankshaft ground for undrsized main bearings.

NOTE: Tighten the main bearing cap bolts to the specified torque.



Cap tightening torque: 6.6 - 7.1 kg-m (48 - 51 lb-ft)

Bearing clearance:

Standard: 0.023 - 0.042 mm (0.0009 - 0.0017 in)

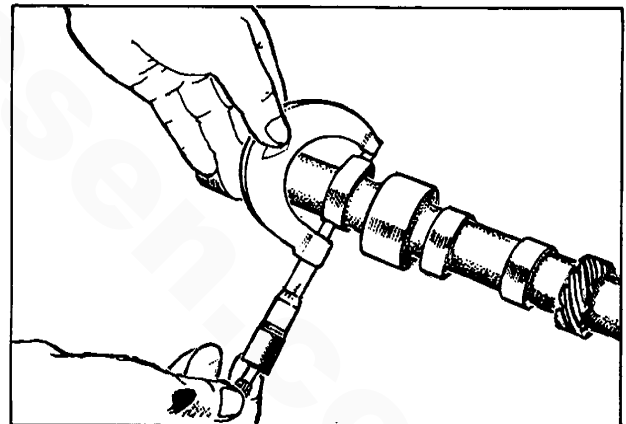
Limit: 0.08 mm (0.0031 in)

Checking Camshaft

1. Check the camshaft for cracks, wear or damage and replace if necessary.
2. Measure the run-out. If it exceeds the limit, replace the camshaft.

Limit of runout: 0.03 mm
(0.0012 in)

3. Measure the cam lobe height and replace if the wear exceeds the limit.



Cam Lobe Height:

6.5 & 8 KW

11 KW

Standard

Limit

44.119 mm
(1.7401 in)

43.919 mm
(1.7291 in)

44.114 mm
(1.7337 in)

43.914 mm
(1.7258 in)

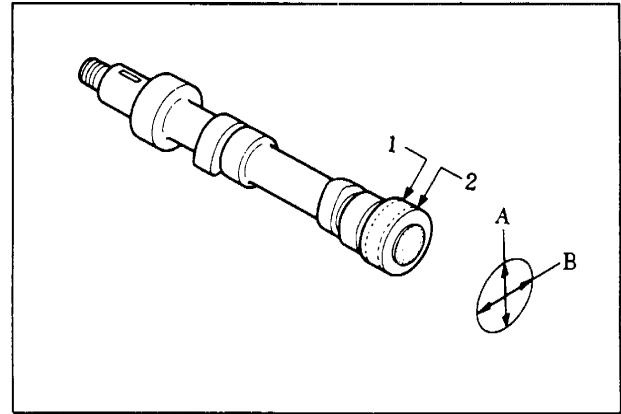
4. Measure the extent of uneven wear on the journals at four locations (direction A and B, front and back). Replace if limit is exceeded.

Uneven wear limit: 0.05 mm
(0.020 in)

Diameter of journal
(standard):

Front and rear:
41.949 - 41.965 mm
(1.6515 - 1.6522 in)

Center: 41.919 - 41.935 mm (1.6504 - 1.651 in)



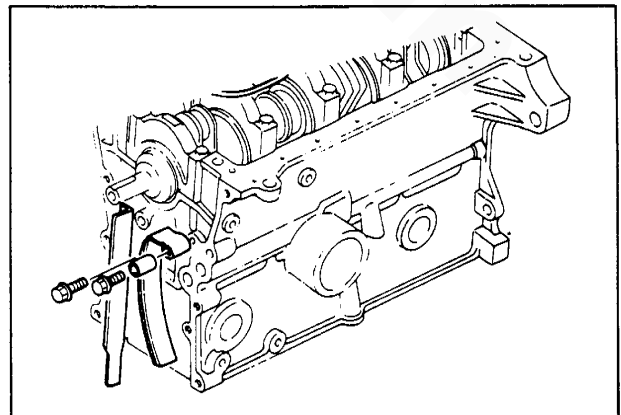
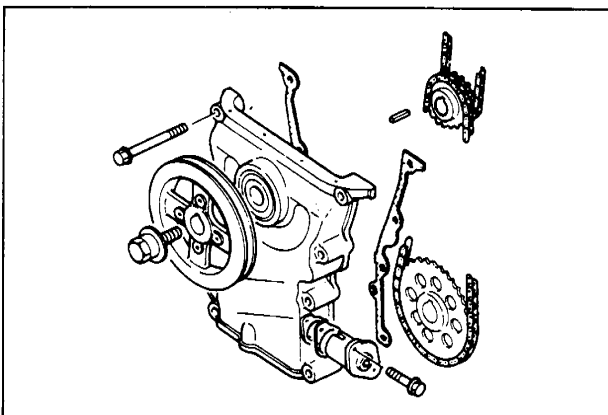
Checking Flywheel and Ring Gear

1. Check the flywheel for damage or wear on ring gear tooth surface and replace, if necessary.
2. Replace the ring gear by the following procedure:
 - a. Heat the ring with a torch.
 - b. Remove the ring gear by striking its circumference.
 - c. Heat the new ring gear to 250 - 300°C (480 - 570°F) on a hot plate or in an oven. Before slipping it onto the flywheel, make sure that the chamfered side of the ring gear is directed toward the engine.

NOTE: Excessive heat may destroy original heat treatment and cause premature failure of the ring gear.

Checking Chain, Chain Adjuster Blade, Damper and Sprocket

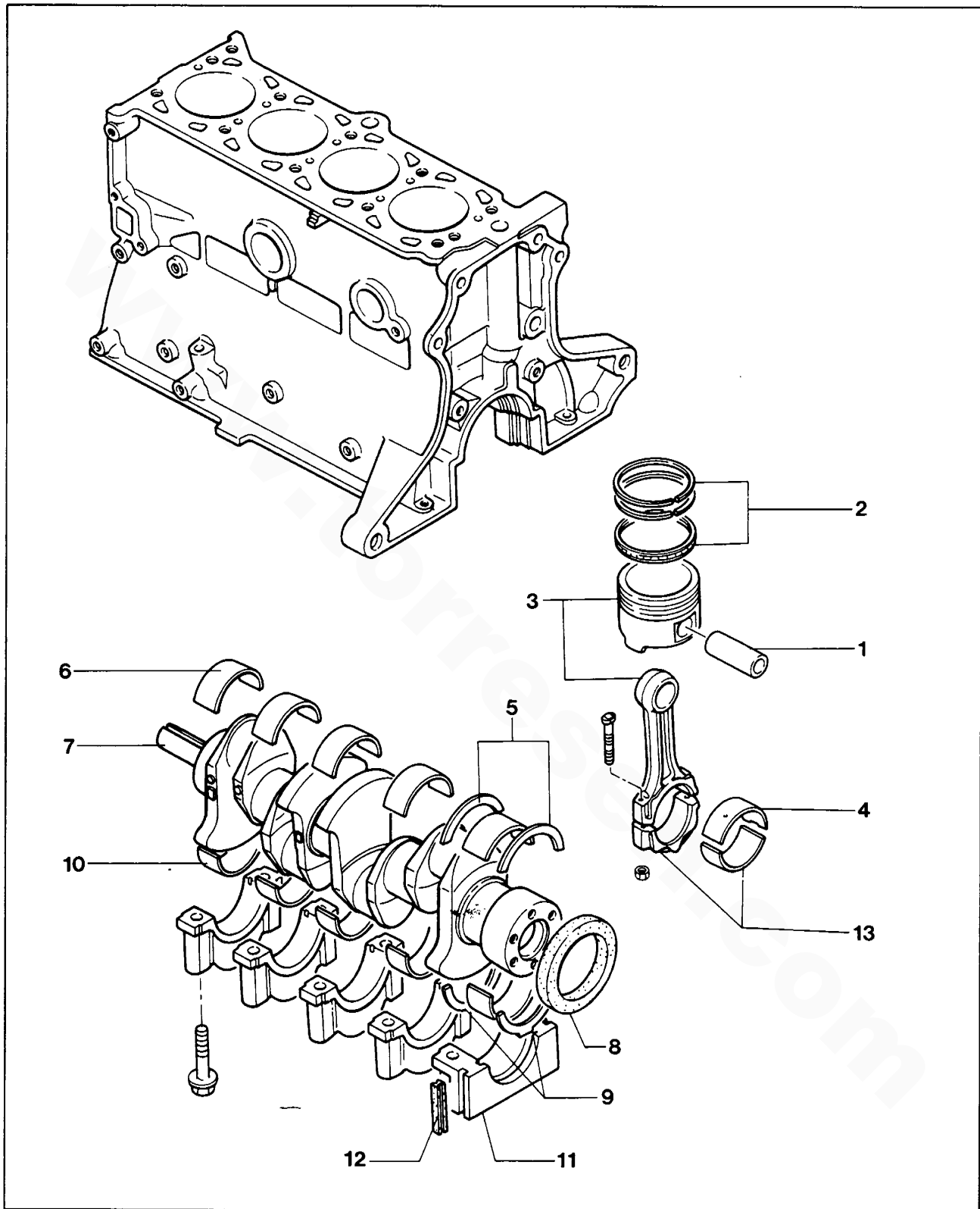
1. Check for wear or damage and replace any faulty parts.



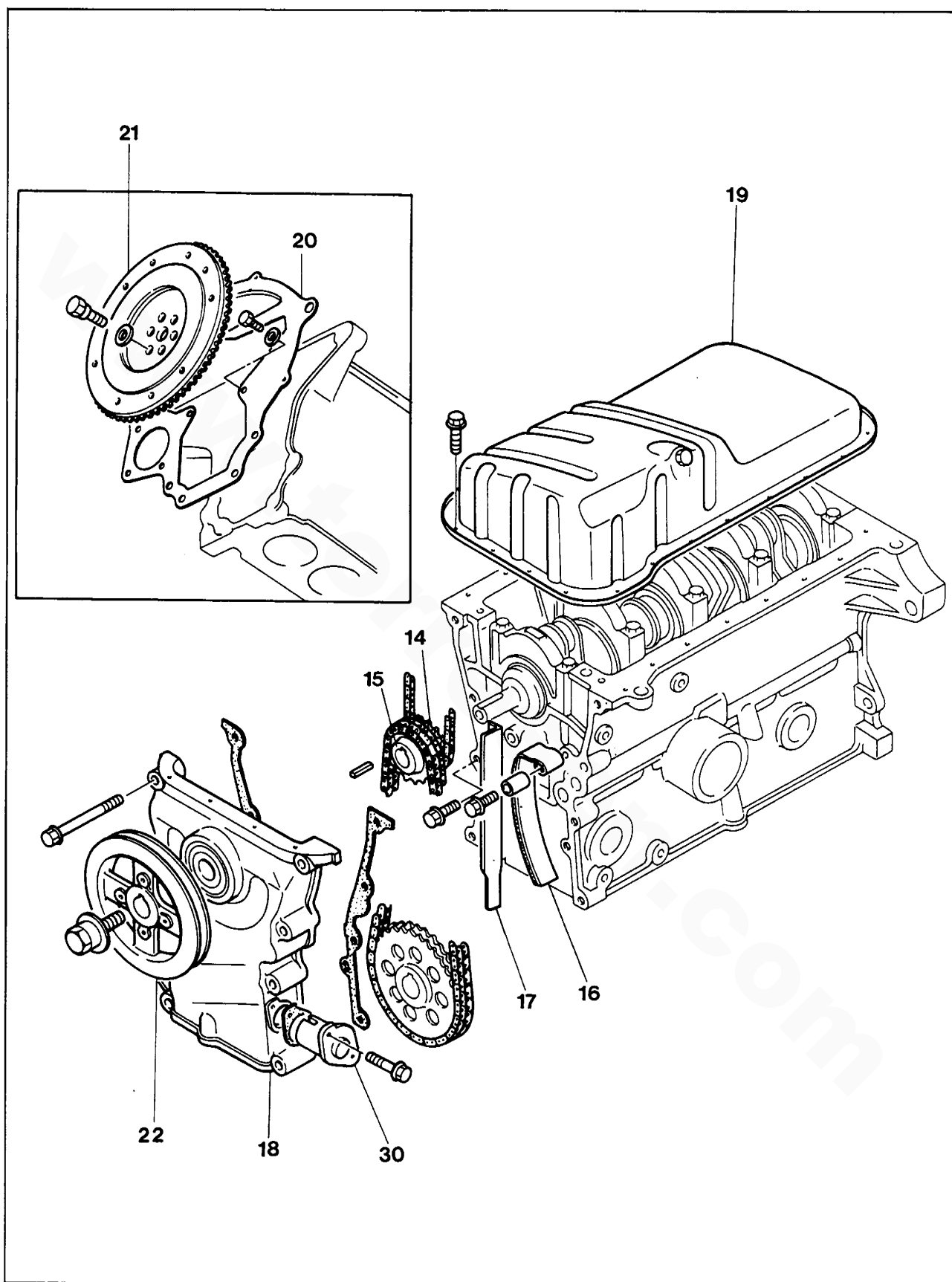
ENGINE ASSEMBLY

Take the following precautions:

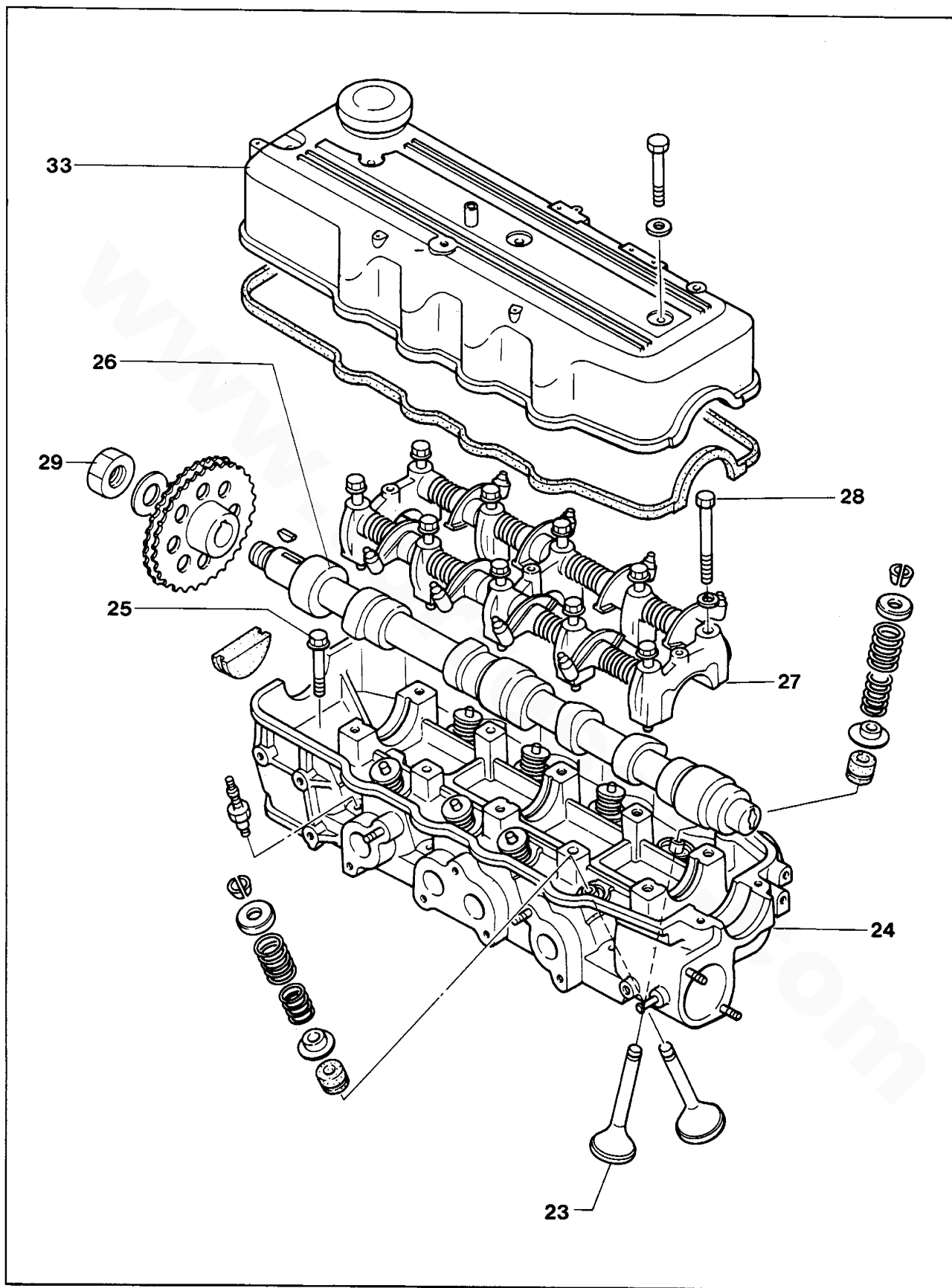
- A. Make sure that all parts to be assembled are thoroughly cleaned.
- B. Be careful not to mix nuts and bolts. Metric and S.A.E. bolts are used on various engine assemblies.
- C. During assembly, recheck clearances and insure parts are being assembled in their proper order and facing in the correct direction in relation to the engine block, e.g., pistons, piston rings, bearings and bearing caps.
- D. 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.
- E. If there are mating marks scribed during disassembly, reference them correctly for assembly.
- F. Use new gaskets, lockwashers, o-rings, etc.
- G. Tighten the bolts and nuts on important parts of engine to specified torques using a reliable torque wrench.
- H. Use liquid sealants when required on nuts, bolts and gaskets. Refrain from using tape sealants.



- | | | |
|------------------------------|-------------------|------------------------------------|
| 1. Piston pin | 6. Main bearing | 11. Main bearing cap |
| 2. Piston ring | 7. Crankshaft | 12. Side seal |
| 3. Piston and connecting rod | 8. Oil seal | 13. Connecting rod bearing and cap |
| 4. Connecting rod bearing | 9. Thrust washers | |
| 5. Thrust washers | 10. Main bearing | |



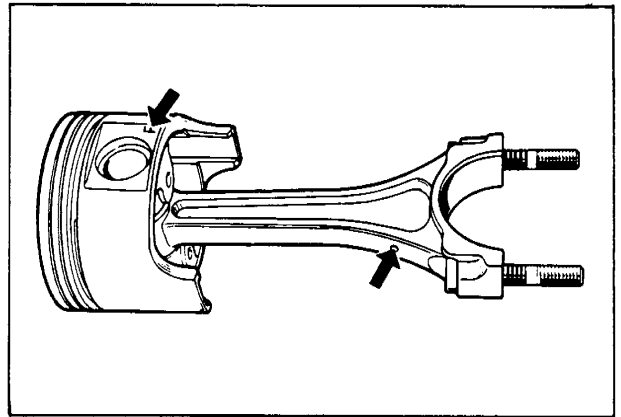
- | | | |
|---------------------------------|------------------------|-----------------------|
| 14. Oil pump chain and sprocket | 17. Chain damper | 20. End plate |
| 15. Timing chain and sprocket | 18. Timing chain cover | 21. Flywheel |
| 16. Adjuster blade | 19. Oil pan | 22. Crankshaft pulley |



- | | | |
|---|---------------------------------|--------------------|
| 23. Valve | 26. Camshaft | 30. Chain adjuster |
| 24. Cylinder head | 27. Rocker arm | |
| 25. Bolt (cylinder head - timing chain cover) | 28. Cylinder head bolt | |
| | 29. Locknut (camshaft sprocket) | |

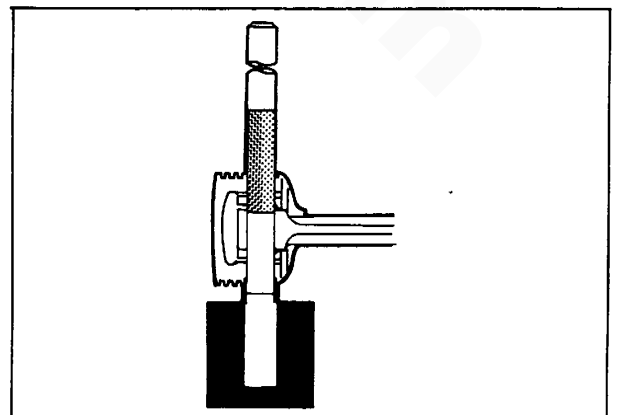
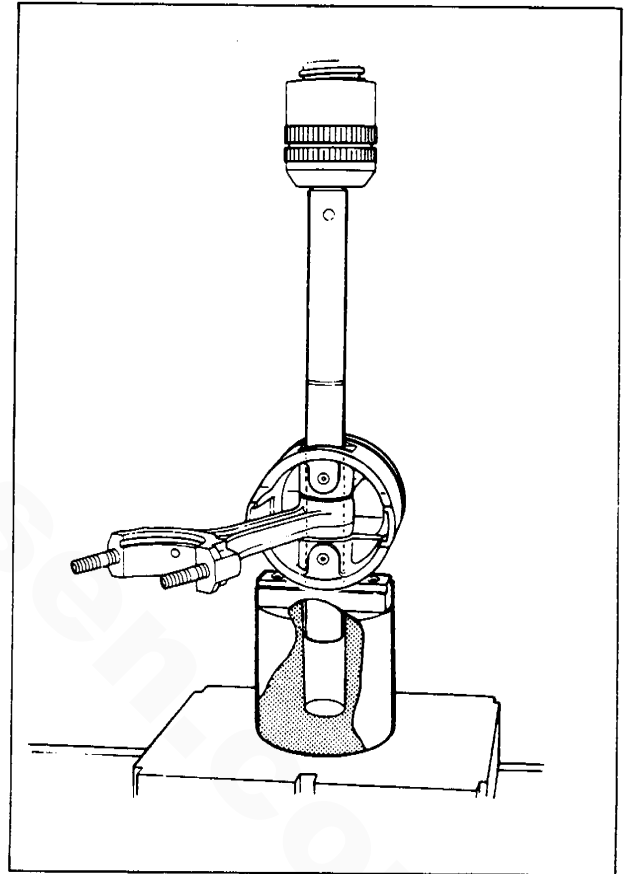
1. Assemble the pistons and connecting rods according to the following procedure. Use piston setting tool.

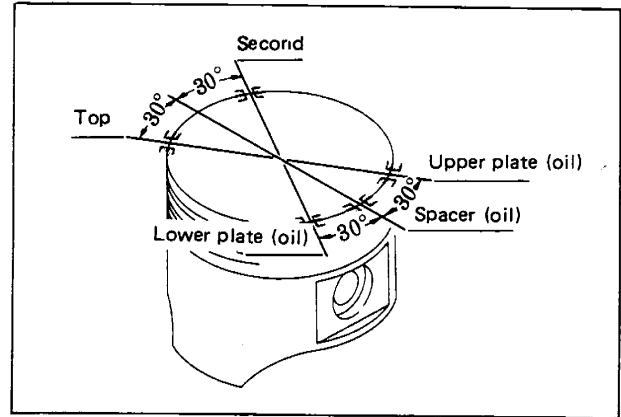
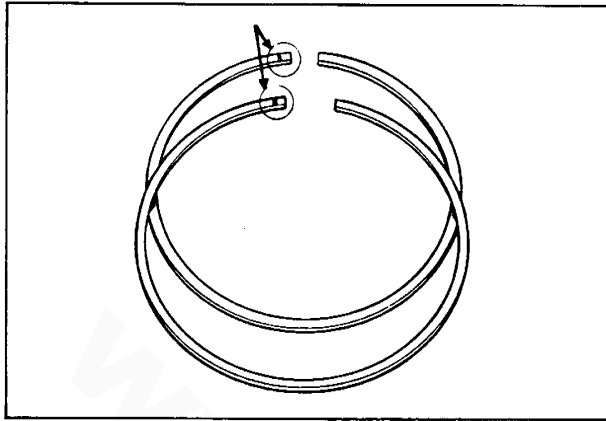
- a. Assemble as shown in figure.
- b. Apply engine oil to the external circumference of piston pin.
- c. Set special tool and piston pin as shown in the figure.
- d. Press fit by pressing the top end of installer. The piston pin is in the specified position when the lower end of guide touches the bottom of block. The pressing load is 500 - 1500 kg (1100 - 3300 lbs). If the load is other than 500 - 1500 kg, replace the piston pin or connecting rod.



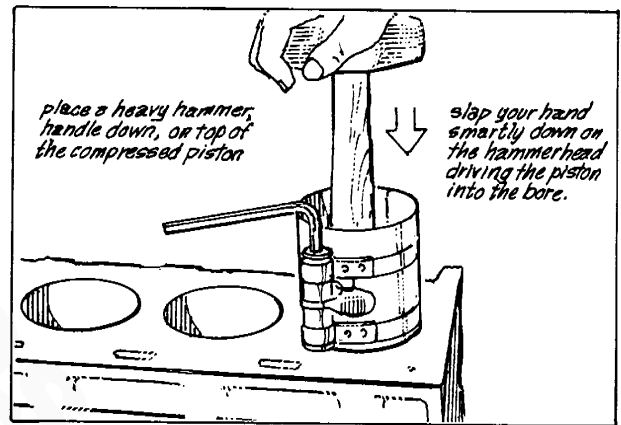
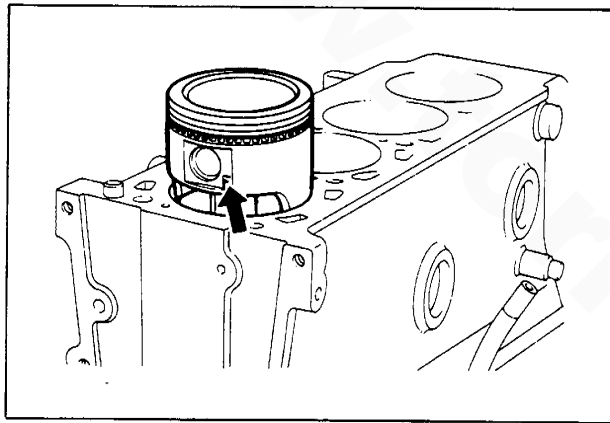
2. Assemble piston rings using a suitable piston ring expander.

- a. Install both rings (second and top rings) with "R" mark on the top surface.
- b. Set the open end of each ring in the positions shown in the figure.

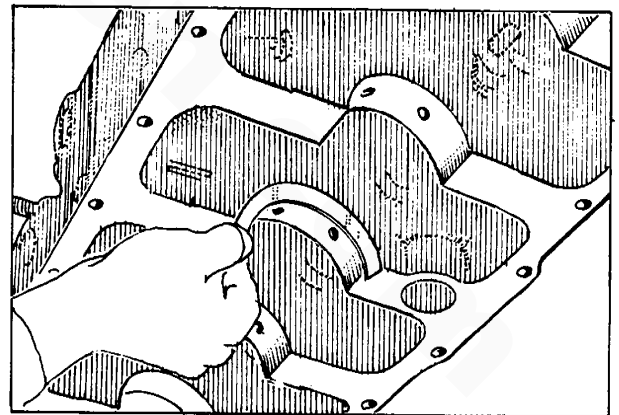




3. Insert the piston into the cylinder block, ensuring that "F" mark stamped on the piston is facing toward the crankshaft pulley end (engine front). Use a suitable piston ring compressor.



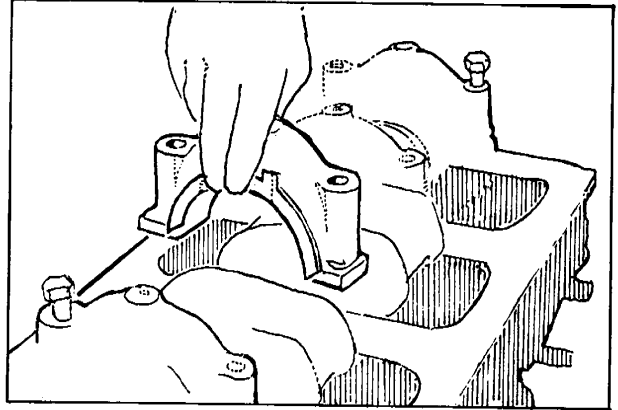
4. Insert main bearings on the block insuring the bearing oil ports are properly aligned.



5. Install the upper thrustwashers with the groove in the washer being directed outward (crankshaft thrust side).
6. Crankshaft.
Be careful that the thrustwashers do not drop as the crankshaft settles in place.

7. Rear oil seal.
8. Install the lower thrustwashers with the groove in the washer being directed outward.
9. Insert lower main bearings.
10. Main bearing caps.

NOTE: Match the main bearing cap with the "Cap No.", and the arrow mark should point towards the front of the engine.

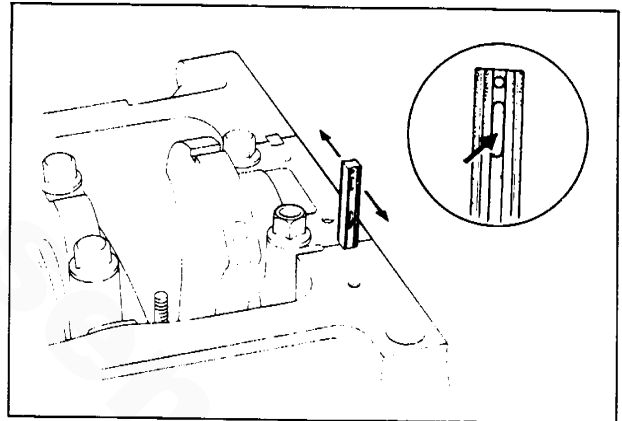


11. Tighten the main bearing cap bolts.

NOTE: Make sure the crankshaft rotates smoothly after installing.

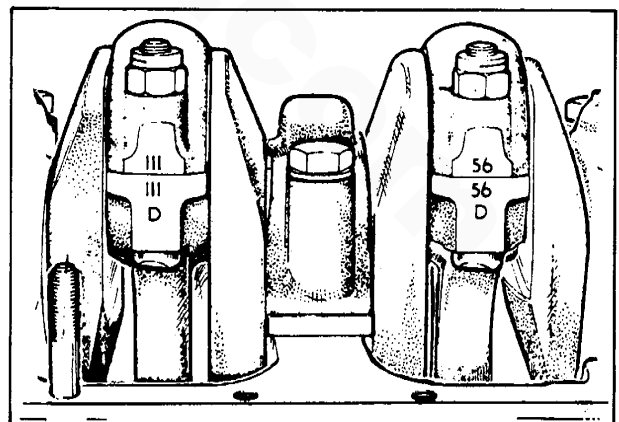
Cap bolt tightening torque: 6.6 - 7.1 kg-m (48 - 51 lb-ft)

12. Insert the side seal, ensuring that the hole in seal is pointed either toward the inside or outside of cylinder block.



13. Connecting rod caps.

NOTE: Apply engine oil onto the surface of the connecting rod bearing prior to installing. Insure that the rod caps are properly matched to the proper rod.



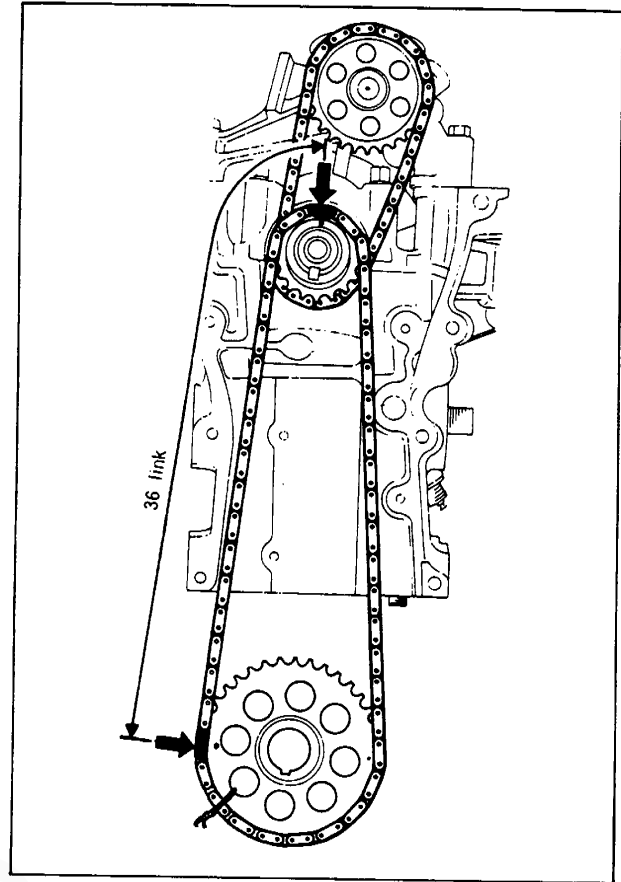
14. Connecting rod cap bolts.

Tightening torque: 3.0 - 3.5 kg-m (21.7 - 25.3 lb-ft)

15. Install the oil pump with the drive chain on both the crankshaft and oil pump sprocket.

16. Timing chain and sprockets.

- a. Match the ring plate mark (shiny link) of timing chain with the timing mark of the crankshaft sprocket.
- b. Install the crankshaft sprocket on the crankshaft, ensuring not to change the assembled position of the timing chain and sprocket.
- c. Match the other shiny marked link to the camshaft sprocket. Tie the chain and sprocket together with wire, so the assembled position of the timing chain and camshaft sprocket is not changed.



17. Timing chain adjuster blade.

18. Timing chain damper.

19. Timing chain front cover.

NOTE: Cut off any excess portions of the cover gasket at both ends.

Tightening torque: 1.9 - 3.1 kg-m (14 - 22 lb-ft)

20. Oil pan.

21. Backplate.

Tightening torque: 7 - 10 kg-m (51 - 72 lb-ft)

22. Flywheel.

NOTE: Install the flywheel by placing it on the crankshaft and rotating it to properly align the mounting bolt holes. Install the tabwasher and mounting bolts. After torquing, bend one tab against a flat of each of the mounting bolts.

Tightening torque: 8.3 - 9.0 kg-m (60 - 65 lb-ft)

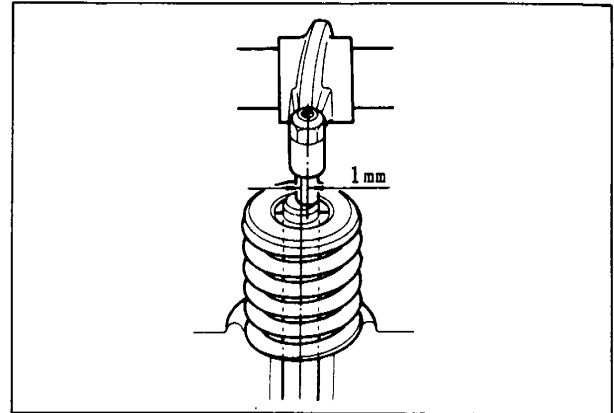
23. Front crankshaft pulley.

Apply sealant to the threads of crankshaft pulley bolt and torque.

Tightening torque: 11.0 - 12.0 kg-m (80 - 87 lb-ft)

24. Valves.

Assemble the valves in the cylinder head with a valve spring lifter and pivot.

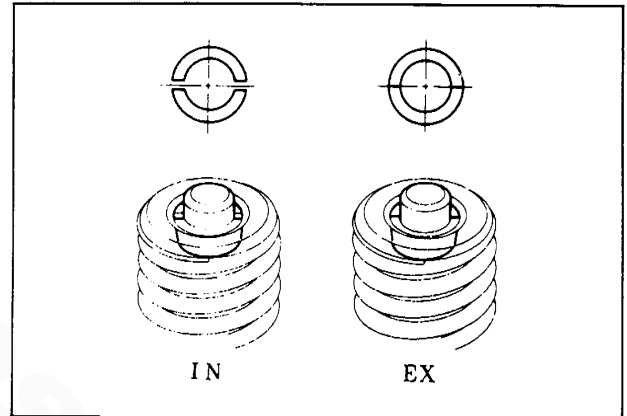


25. Cylinder head.

- Position the head gasket on the block.
- Position the cylinder head.
- Install capscrew through the head into the timing chain cover.

26. Camshaft.

- Slide the timing chain sprocket on the camshaft making sure the position of chain and timing mark on the sprocket are correct.
- Position the camshaft on the cylinder head.

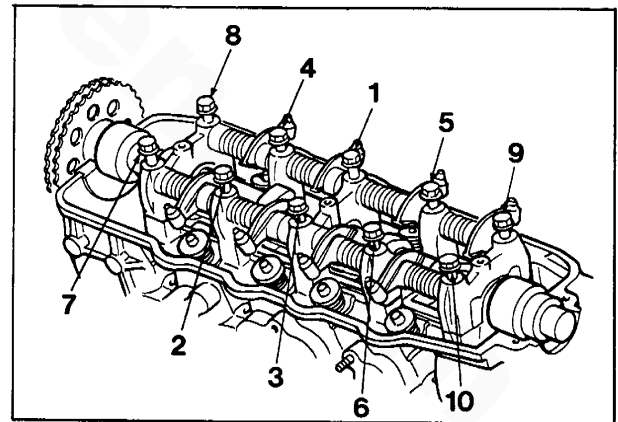


27. Rocker shaft assembly.

Install the valve rocker arms on the rocker arm shaft. Insure that there is 1 mm (.039 in) of offset between the center of the rocker arm adjusting screw and that of the exhaust valve stem.

28. Cylinder head bolts.

NOTE: Tighten the cylinder head bolts in the order shown in the figure.



Tightening torque:

7.8 - 8.2 kg-m
(56 - 59 lb-ft) (when cool)

29. Check the oil clearance between the camshaft and cap with a "plastigauge".

NOTE: Make sure head bolts are properly torqued after checking oil clearance.

Limit of camshaft oil clearance: 0.15 mm (0.0059 in)

30. Install the camshaft drive sprocket washer and nut.

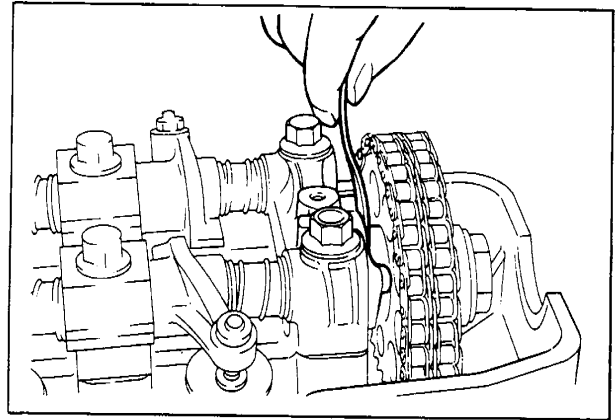
Tightening torque:

7.0 - 8.0 kg-m
(51 - 58 lb-ft)

31. Check the camshaft end play (clearance between sprocket and thrust plate). If the end play exceeds the specified limit, replace the thrust plate.

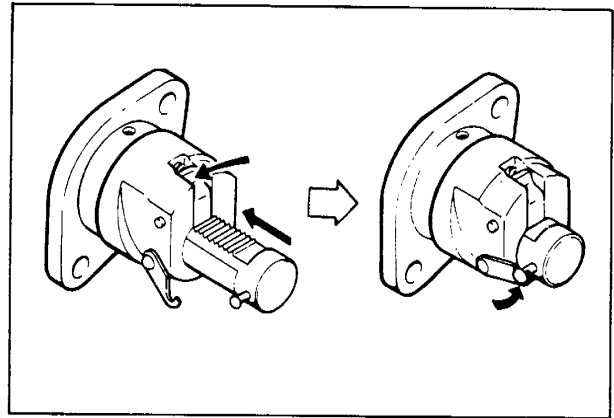
Limit of camshaft end play:

0.20 mm (0.008 in)



32. Timing chain tension adjuster. Install the chain adjuster on the timing chain cover according to the following procedure.

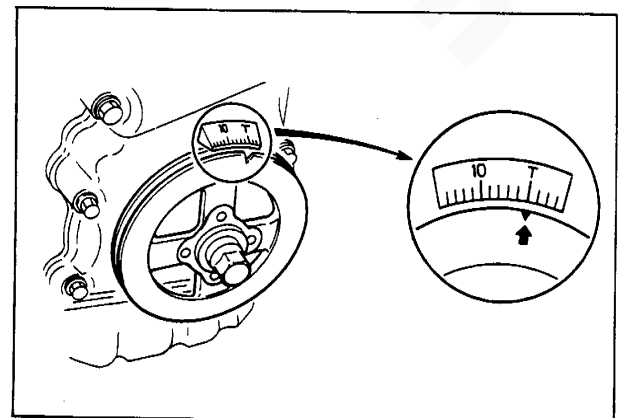
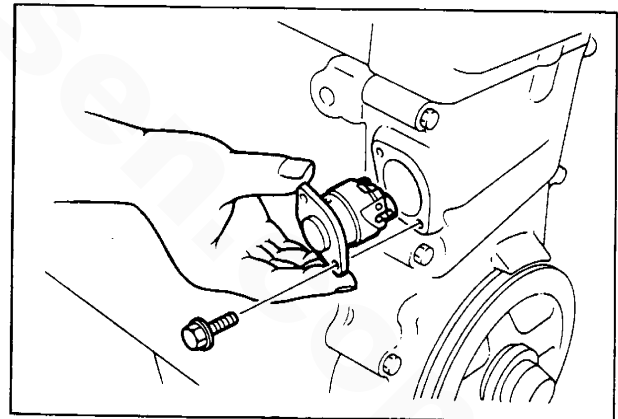
- a. Push the sleeve into the body completely and lock it with the pin and hook.
- b. Install the chain adjuster.



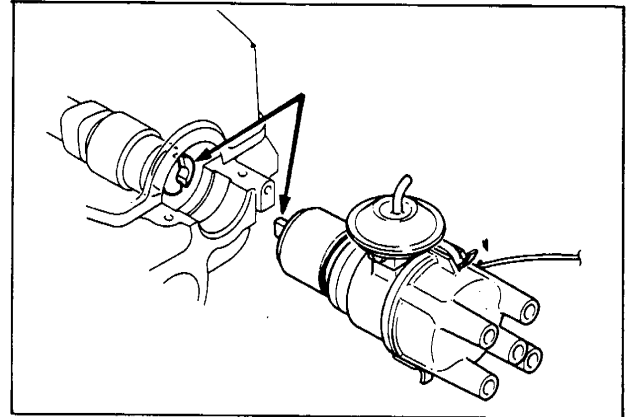
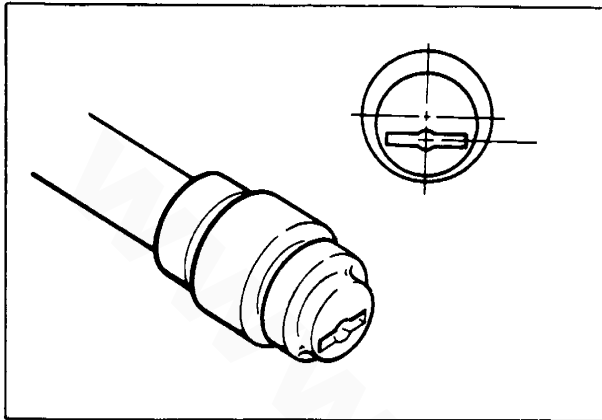
NOTE: After the adjuster is installed, the pin is released by the action of the timing chain which is actuated when the engine is cranked once or twice and the sleeve projects automatically, thus applying tension to the camshaft drive chain.

33. Distributor.

- a. Turn the crankshaft until the piston in No. 1 cylinder reaches top dead center of the compression stroke. Make sure that the mark on the crankshaft matches the top mark (T) on the timing chain cover.
- b. Apply engine oil sparingly to the o-ring fitted on the distributor shaft. Insure the rotor is pointing toward No. 1 spark plug high tension lead terminal.



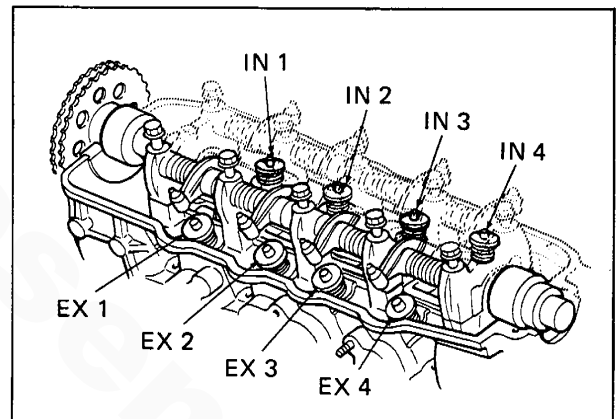
- c. Insert the distributor shaft by turning it, ensuring that the distributor shaft fits into the groove on the rear end of the camshaft. This groove is offset so the distributor can only be installed correctly to the camshaft.



34. Adjust engine timing according to specifications in the Engine Technical Data Section.

35. Adjust the valve clearance.

- a. Adjust the valves exhaust #1 and #3 and intake #1 and #2 with the piston at the top dead center of the compression stroke of No. 1 cylinder.
- b. Rotate the crankshaft 360° and adjust the remaining valves.



Intake valve

Exhaust valve

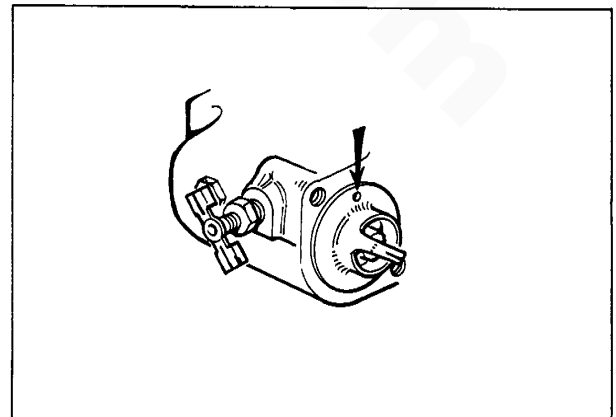
Valve side	0.25 mm (0.010 in)	0.30 mm (0.012 in)
Cam side	0.18 mm (0.007 in)	0.23 mm (0.009 in)

36. Thermostat.

NOTE: Be sure to position the thermostat with the bleed hole at 12 o'clock. Insure thermostat body is inboard of the block. Install the thermostat housing.

36. Oil filter.

NOTE: Apply engine oil sparingly to the o-ring of an oil filter and tighten the filter fully by hand.



- 38. Rocker cover.
- 39. Oil manifold tee, oil pressure sender and switch.
- 40. Fresh water pump.
- 41. Bellhousing.
- 42. Ignition coil and bracket.
- 43. Intake manifold.

Tightening torque: 1.9 2.6 kg-m (14 - 19 lb-ft)

- 44. Carburetor and fuel pump.
- 45. Alternator and bracket.
- 46. Governor.
- 47. Sea water pump.
- 48. Starter motor and circuit breaker.
- 49. Heat exchanger and related hoses.
- 50. Exhaust manifold assembly and related hoses.

Tightening torque: 1.9 - 2.3 kg-m (14 - 17 lb-ft)

- 51. Armature and drive disc assembly.

Tightening torque:

Drive disc to armature: 6.9 - 7.6 kg-m (50 - 55 lb-ft)
Drive disc to flywheel: 2.5 - 2.8 kg-m (18 - 20 lb-ft)

- 52. Generator housing.

NOTE: Be sure bearing seats properly and that the bearing lock pin is in place.

- 53. Exhaust screen.
- 54. Generator brushes.
- 55. Generator fan.

Tightening torque: 3.5 kg-m (25 lb-ft)

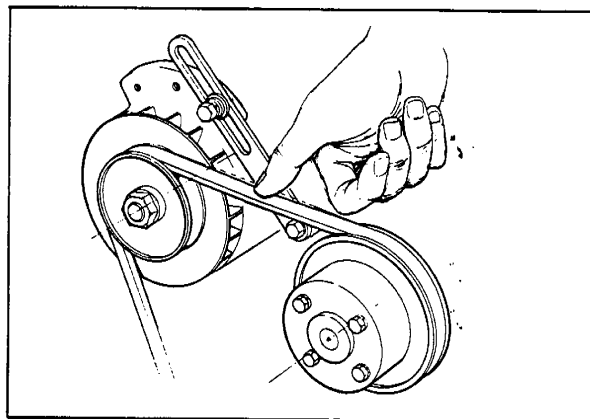
- 56. Generator fan cover.
- 57. Mounts and rails.
- 58. Control panel and wiring harness.

59. Adjust "V" belt tension.

"V" belt deflection exerting
10 kg (22 lbs) force:

For new belt: 9 - 11 mm
(0.35 - 0.43 in)

For used belt: 10 - 12 mm
(0.39 - 0.47 in)

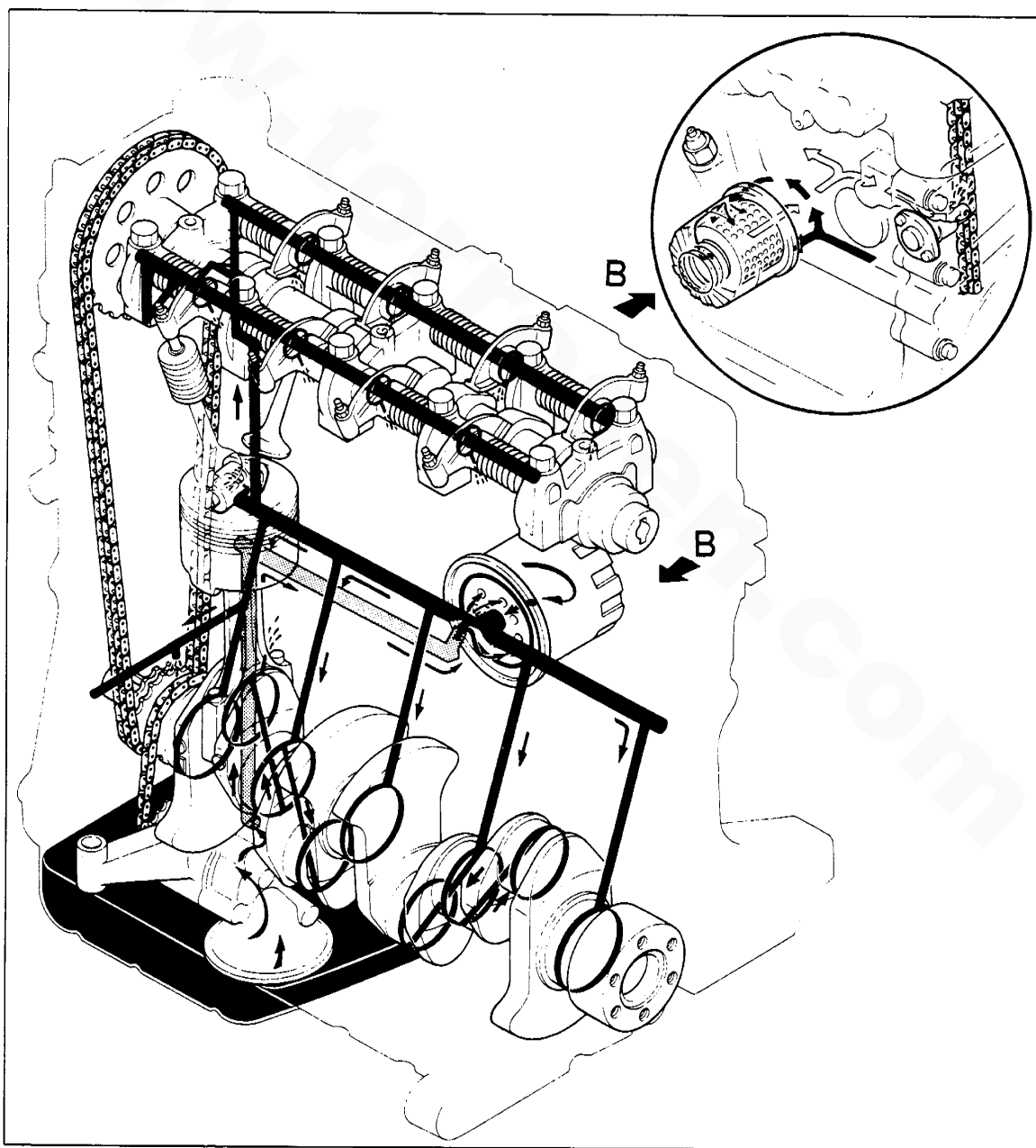


LUBRICATING SYSTEM

Operation

The lubricating system is a pressure feeding system using an oil pump. The engine oil forced out of the oil pump is passed through the oil filter. The oil passes through the oil filter and then to the various lubricating points in the engine and then returns to the lube oil sump.

When the oil pressure exceeds the specified pressure, the oil pushes open the relief valve in the oil pump and returns to the oil pan, thereby keeping the oil pressure within its specified range.



Checking Engine Oil

1. Check for any engine oil leakage. Should leakage be detected, correct as needed. Tightening of fittings and bolts is considered normal maintenance and is the responsibility of the owner.
2. Check engine oil level with the lube oil dipstick at least once daily prior to engine usage. Add oil as needed.
3. Make sure that the oil is higher than the mid point between the "F" and "L" marks of the dipstick. If found lower than the "L" mark, replenish up to the "F" mark.

NOTE: Maintaining proper engine oil level is the responsibility of the engine owner/operator. Any damage to the engine due to lack of adequate oil is the responsibility of the owner/operator. Gauges and alarms are provided to warn against loss of proper engine oil pressure. Monitoring of engine operating gauges is the responsibility of the owner/operator.

Engine oil capacity:

All (including filter)	3.7 liters	(3.9 U.S. quarts)
		(3.3 Imp. quarts)
Oil Sump	3.0 liters	(3.2 U.S. quarts)
		(2.6 Imp. quarts)

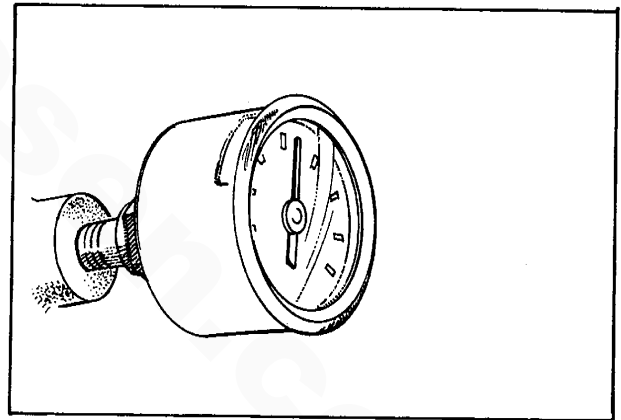
Troubleshooting the Oil System

<u>Trouble</u>	<u>Possible Cause</u>	<u>Remedy</u>
Oil leak	1. Loose oil drain hose	1. Tighten or replace.
	2. Oil pan to cylinder block leakage	2. Tighten securing belts or replace pan gasket.
	3. Damaged or loose timing chain cover or rocker cover	3. Replace or tighten bolts.
	4. Damaged or loose cylinder head gasket	4. Tighten or replace.
	5. Loose or damaged oil filter	5. Tighten or replace.
	6. Loose or damaged pressure switch or sender	6. Tighten or replace.

<u>Trouble</u>	<u>Possible Cause</u>	<u>Remedy</u>
Low Oil Pressure (unit shut-down)	1. Oil leaks	1. Refer to above.
	2. Low oil level or incorrect grade	2. Add oil to proper level or change.
	3. Faulty oil pressure switch	3. Test and replace.
	4. Clogged oil filter	4. Remove and replace oil filter.
	5. Clogged oil pump strainer	5. Remove and clean.
	6. Worn or fatigued oil pressure relief valve spring	6. Remove and replace.
	7. Faulty electrical circuit	7. Check circuit and repair as needed.

Checking Oil Pressure with Mechanical Gauge

1. Remove the oil pressure sender and connect a mechanical oil pressure gauge instead.
2. Electrically jump the oil pressure switch connections.
3. Start the engine, operate at 1800 RPM and allow engine to warm up.
4. Measure the oil pressure. If less than the specification, check the lubricating system.

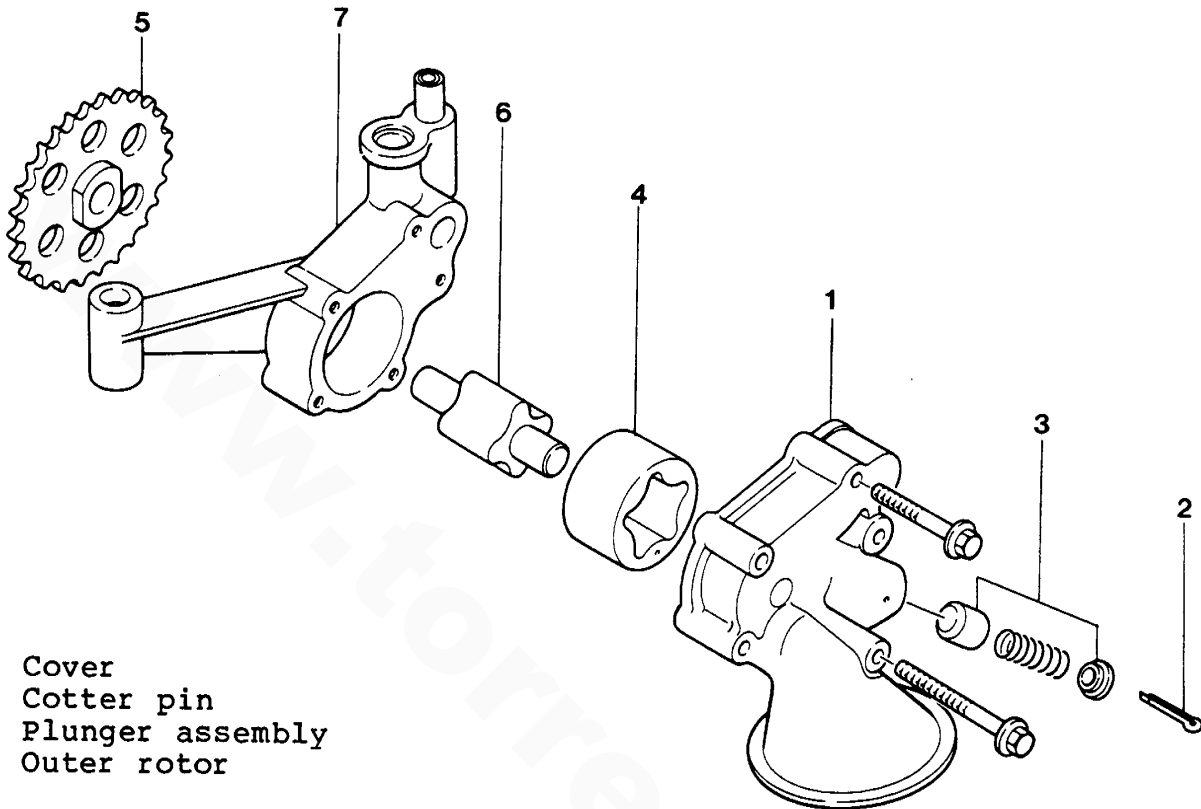


Oil pressure: $1.75 - 2.5 \text{ kg/cm}^2 + .7 \text{ kg/cm}^2$
 $(25 - 35 \text{ PSI} \pm 5 \text{ lb/in}^2)$

NOTE: Insure proper oil is being used that meets temperature requirements and the A.P.I. Spec. of SE or SE/CC.

Disassembling Oil Pump

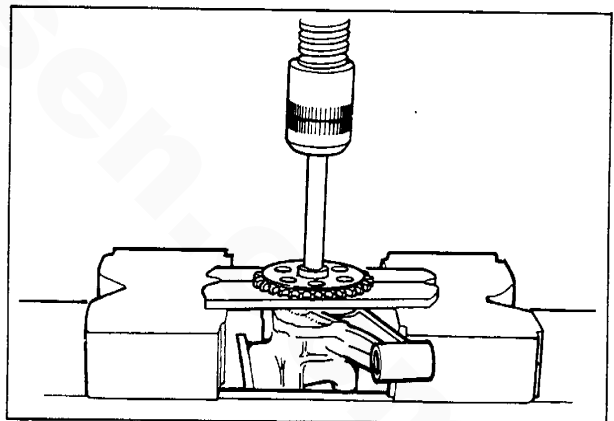
Disassemble in the following order.



1. Cover
2. Cotter pin
3. Plunger assembly
4. Outer rotor

5. Sprocket
Remove the sprocket by supporting the sprocket and pressing the shaft out.

6. Shaft and inner rotor assembly
7. Pump body

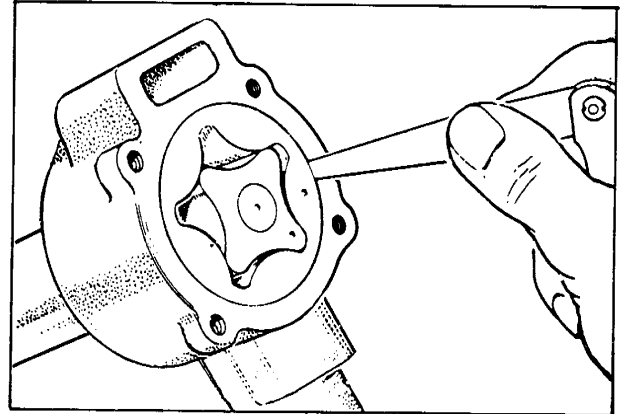


Checking Oil Pump

1. Examine the following parts and replace, if necessary.
 - a. Pump body and cover, deformed or damaged.
 - b. Plunger worn or damaged.
2. Check the clearance between the lobes of the rotors with a feeler gauge. If the clearance exceeds the limit, replace both rotors.

Clearance limit: 0.25 mm (0.010 in)

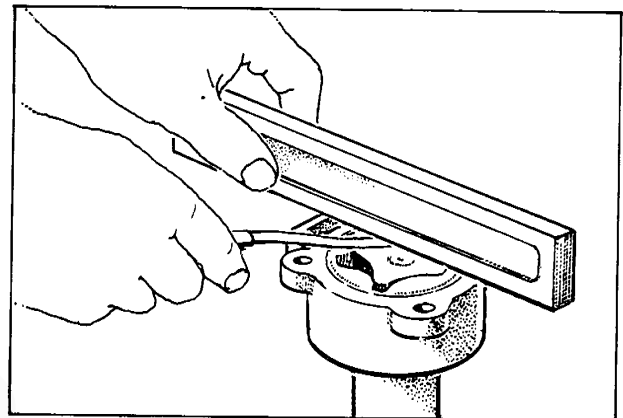
3. Check the clearance between the outer rotor and pump body with a feeler gauge. If the clearance exceeds the limit, replace the rotor or pump body.



Clearance limit:

0.35 mm (0.014 in)

4. Check the end float of the rotors. Place a straight edge across the pump body and measure the clearance between the rotor and straight edge with a feeler gauge. If the clearance exceeds the limit, replace the drive gear, drive shaft, inner rotor, outer rotor and pump body.



Clearance limit:

0.15 mm (0.0059 in)

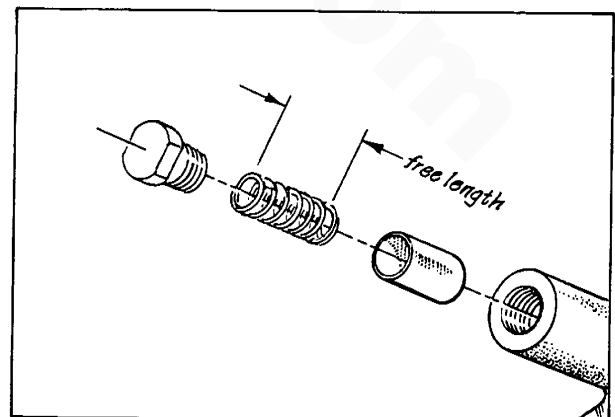
5. Then, place a straight edge across the pump cover and measure the clearance between the straight edge and cover. If the cover exceeds the limit, correct the pump cover by grinding or replace it.

Clearance limit: 0.15 mm (0.0059 in)

6. Check the relief valve for worn plunger and fatigued spring.

Spring free length:

45.5 mm (1.791 in)



7. Clean the pick up strainer.

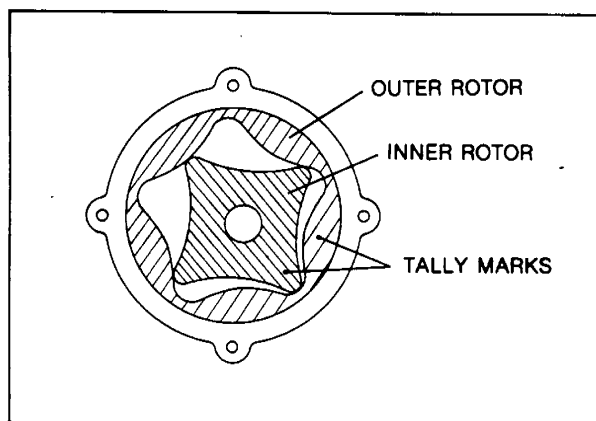
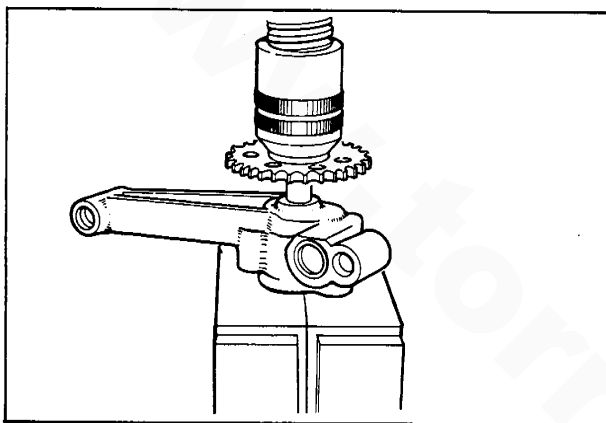
Assembling the Oil Pump

Assemble in the reverse order of disassembling.

NOTE: Press the drive gear onto the pump shaft until the end surface becomes flush with the end surface of the shaft. If the pressing pressure is less than the specified value, replace either the sprocket or shaft, or both.

Pressing pressure: 700 - 1300 kg (1540 - 2860 lbs)

NOTE: Make sure that when assembled, the tally marks on both outer rotor and inner rotor face toward the outside (cover side).



Reinstall the pump in the engine.

COOLING SYSTEM

Description

Westerbeke marine generators are equipped with fresh water cooling. Transfer of heat from engine fresh water to sea water is accomplished by a heat exchanger, similar in function to an automotive radiator. Sea water flows through the tubes of the heat exchanger while fresh water flows around the tubes. The sea water and fresh water never mix with the result that the cooling water passages in the engine stay clean.

Fresh Water Circuit

Heat rejected during combustion, as well as heat developed by friction, is absorbed by the fresh water, whose flow is created by a fresh water circulating pump. The fresh water flows from the engine through a fresh water cooled exhaust manifold, a heat exchanger and returns to the suction side of the fresh water circulating pump. When starting a cold engine, most of the external flow to the heat exchanger is prevented by the closed thermostat. Some amount of bypass is maintained to prevent overheating in the exhaust manifold. As the engine warms up, the thermostat begins to open up allowing full flow of engine fresh water through the external cooling system.

Sea Water Circuit

The sea water flow is created by a positive displacement neoprene impeller pump. Normally the pump draws sea water directly from the ocean via the sea cock and sea water strainer. Sea water then flows directly from the discharge of the sea water pump to the heat exchanger sea water inlet. After passing through the tubes of the heat exchanger, the sea water enters a water injected, wet exhaust system, the most popular type of exhaust system in use. In the case of larger engines, the sea water flow is divided prior to entering the exhaust systems so that a portion is used to cool the exhaust system. Full sea water flow would create unnecessary exhaust back pressure.

Sea Water Pump

The sea water pump is self priming and positive displacement. It is a rotary pump with a non-ferrous housing and a neoprene impeller. The impeller has flexible vanes which wipe against a curved cam plate within the impeller housing, producing a pumping action. On no account should this pump be run dry. There should always be a spare impeller and impeller cover gasket aboard.

Fresh Water Pump Removal

1. Drain coolant from engine block.
2. Remove pump drive belt by loosening the 12 volt alternator adjusting strap and pivot bolt.
3. Remove coolant hose from pump to manifold.
4. Remove belts mounting pump to engine block and remove pump.

Checking Fresh Water Pump

1. Check for water leaks. Replace cover gasket, cover or pump as necessary.
2. Replace pump if abnormal noise or bearing squeak is present.
3. Examine pump and impeller for damage and replace if necessary.

Sea Water Pump Impeller Replacement

The following instructions are general and indicative only. Specific instructions where applicable may be packaged with your replacement impeller.

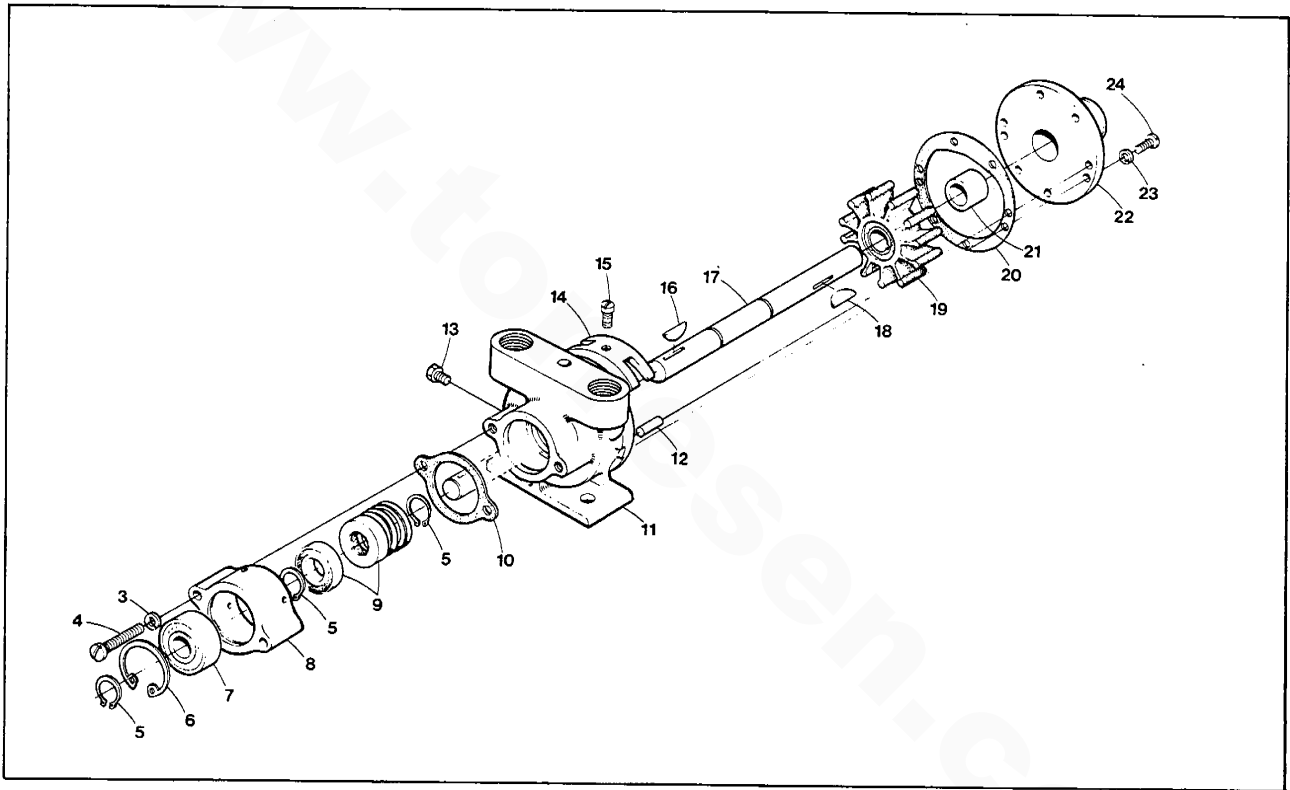
1. Remove the front cover gasket.
2. Remove the impeller by pulling straight outwards, parallel to the pump shaft. This is best done with a pair of pliers applied to the impeller hub.
3. Coat the replacement impeller and the chamber into which it mounts with grease.
4. Carefully align the impeller keyway, or other locking mechanism, with the shaft. Take care that all the impeller blades bend in the same direction and trailing.
5. Inspect the front cover for wear. A worn front cover should ultimately be replaced. Sometimes it can be reversed as an emergency measure, but not when stamped markings would break the seal between the cover and the impeller blades.
6. Reinstall the end cover with a new gasket.
7. Be doubly sure to check quickly for sea water flow when starting the engine. The absence of flow indicates that the pump may not be priming itself properly. This situation must be investigated immediately or damage to the new impeller will result from overheating.

Sea Water Pump Removal

1. Remove inlet and outlet hoses connected to nipples on pump. Note connections on pump for proper assembly.
2. Loosen bolts mounting pump to support bracket and remove drive belt.
3. Remove mounting nuts and bolts and lift pump from engine.

Raw Water Pump Disassembly

Disassemble in the following order.



1. Impeller cover with graphite bushing, screws, lockwashers and gasket (Ref. 20 - 24)
2. Impeller and key (Ref. 18 - 19)
3. Drive pulley and key (Ref. 16)
4. Bearing housing, screws and lockwashers
NOTE: Shaft #17 withdrawn through the front of the pump with the bearing housing, bearing and seal assembly. (Ref. 5 - 10)
5. Cam and screw (Ref. 14 - 15)
6. Small retaining ring and seal (Ref. 5 & 9)
7. Large retaining ring (Ref. 6)
8. Bearing housing (Ref. 8) from shaft and bearing
9. Small retaining rings (Ref. 5)
10. Bearing (Ref. 7)
11. Drain plug and dowels (Ref. 12 - 13)

NOTE: Drive pulley not shown.

Thermostat Removal

The thermostat is mounted inside a housing on the back of the cylinder head next to the distributor.

1. Drain the coolant.
2. Remove the hose from thermostat housing to heat exchanger.
3. Remove thermostat cover housing and bolts.
4. Remove thermostat.
5. Remove housing gasket.

Checking Thermostat

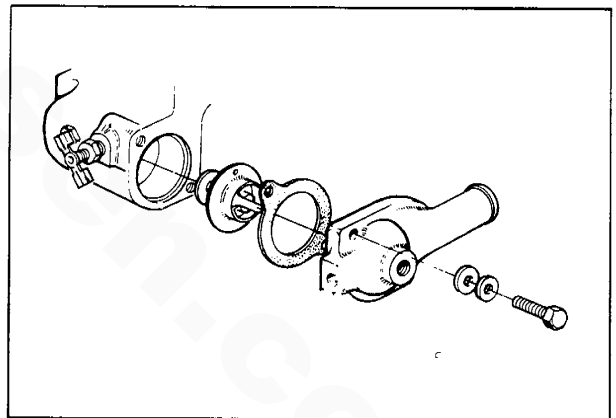
A thermostat can be checked for proper operation by placing it in a pan of cold water and then raising the temperature of the water to a boil. The thermostat should open noticeably (with travel on the order of 1/4" - 1/2") and be fully opened when the water is boiling.

Thermostat Installation

1. Install in reverse order using a new housing gasket coated on both sides with gasket cement.

NOTE: Insure that the small vent hole in the thermostat is at the 12 o'clock position when the thermostat is installed.

2. Replenish the coolant and start the engine and check that there are no leaks.



Engine Coolant

It is recommended that an antifreeze mixture be used in the engine fresh water cooling system. An Ethylene - Glycol base antifreeze only should be used. The mixture should be according to the manufacturer's instructions. Rust and scale inhibitors should be added if not found in the antifreeze used.

Filling and Draining Fresh Water System

Draining system coolant: Two points on the engine fresh water cooling system should be opened to drain fresh water coolant from the engine block, manifold and exchanger.

POINT #1: Drain petcock located on the right inboard side of the engine heat exchanger.

POINT #2: Remove the hose connected to the inlet of the fresh water circulating pump.

Filling system with coolant:

1. Replace inlet hose to fresh water circulating pump and close petcock on heat exchanger.
2. Open air bleed petcock at thermostat housing (early models remove 1/8 pipe plug).
3. Fill system with appropriate antifreeze mixture through filler neck on exhaust manifold. When coolant flows from bleed petcock or open plug, close petcock or replace plug and continue filling until coolant is 1/4 - 1/2 inch from filler neck.
4. Start engine and add coolant to maintain level at filler neck.
5. With engine at operating temperature, fill manifold completely and install pressure cap. Add coolant to plastic recovery tank until level is between MIN and MAX. Monitor coolant level from recovery tank. Add coolant as needed. Should an extreme loss of coolant be found, investigate cause before further engine operation.

Exhaust Manifold Removal

Removal of the exhaust manifold from the engine should be done as a complete assembly in the following manner.

1. Drain the engine and cooling system of all coolant.
2. Remove the exhaust connection.
3. Loosen and remove all hose connections to the manifold.
4. Loosen and remove the nuts and bolts attaching the manifold assembly to the cylinder head.
5. Remove the manifold from the cylinder head as a complete unit.

Exhaust Manifold Servicing

1. Remove the exhaust elbows from the lower surface of the manifold. Clean and inspect for cracks and defects. Replace as needed.
2. Remove exhaust nipples, elbows and plugs from the manifold.
3. Remove water connectors from the ends of the manifold and the end plates. Be sure to note the proper location and arrangement of each for proper replacement.

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

Exhaust Manifold Installation

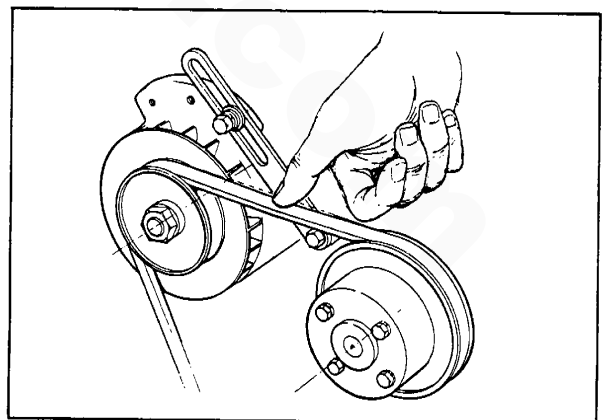
1. If the manifold was removed as an assembly and left intact, it can be replaced on the cylinder head in the reverse order of removal. Do not reuse the gaskets; install new ones and torque the bolts or nuts to the proper specification (10 - 12 lb-ft).
2. If the manifold has been disassembled, follow the steps below.
 - a. Loosely attach the elbows to the cylinder head and the manifold using new gaskets. Do not use any gasket sealant.
 - b. Gradually tighten each fitting to make sure of proper alignment of all the parts. This should be done in three steps. Torque to 10 - 12 lb-ft.
 - c. Reassemble the end plates, connectors on the manifold. Be sure to use new gaskets and coat the gasket surfaces with a suitable gasket cement such as "High Tack". Torque the nuts to 8 - 10 lb-ft.
 - d. Reinstall the exhaust connections and plug into the manifold using "Loctite-Anti-Seize" on the threads.
 - e. Reconnect all hoses, replacing them as needed.
 - f. Refill the system with coolant as detailed above.
 - g. Pressure test system and check for leaks.

Adjust "V" Belt Tension

"V" belt deflection exerting 10 kg (22 lbs) force:

For new belt: 9 - 11 mm
(0.35 - 0.43 in)

For used belt: 10 - 12 mm
(0.39 - 0.47 in)



Cooling System Troubleshooting

<u>Trouble</u>	<u>Possible Cause</u>	<u>Remedy</u>
1. Coolant leaks: It is recommended that when trying to locate a leak in the cooling system that the system be pressure tested using commercially available pressure tester such as the STANT #ST255. Follow instructions with the tester. Locate and correct the leak.	2. Leaking pressure cap	2. Test with above unit and/or replace.
	3. Faulty plastic coolant recovery tank	3. Check and tighten connections or replace tank.
2. Overheating (Fresh Water System)	1. Insufficient coolant	1. Replenish coolant and check for cause of loss.
	2. Loose or broken water pump drive belt	2. Adjust or replace.
	3. Faulty thermostat	3. Remove and replace.
	4. Faulty overheat switch	4. Remove and replace.
	5. Scale and sediment in cooling system	5. Flush engine cooling system and heat exchanger; replenish coolant.
	6. Faulty circulating pump	6. Remove and replace.
3. Overheating (Raw Water System)	1. Loose or broken raw water pump drive belt	1. Adjust or replace.
	2. Faulty raw water pump	2. Check raw water pump for wear, defective impeller. Repair or replace as needed.
	3. Clogged heat exchanger	3. Remove exchanger, clean and flush.
	4. Scale in exhaust	4. Remove elbow and clean

Other causes of engine overheating may be caused from faults in the raw water circuit supplying coolant to the raw water pump on the engine. Examine the off circuit for possible contributing faults.

GOVERNOR

Governor Description

The governor is belt-driven, mechanically operated and maintains engine RPM under varying conditions of generator load. The engine speed determines the Hertz and voltage output of the generator.

NOTE: Belt tension: 3/8 - 1/2 inch deflection at center of widest span with 22 lbs pressure applied to belt outer face. Maintain belt tension for proper governor operation. Replace drive belt when worn, frayed or cracked.

The governor will maintain engine RPM to within 3 Hertz of generator frequency output from no load to full rated load of the generator. (Generator Data Plate)

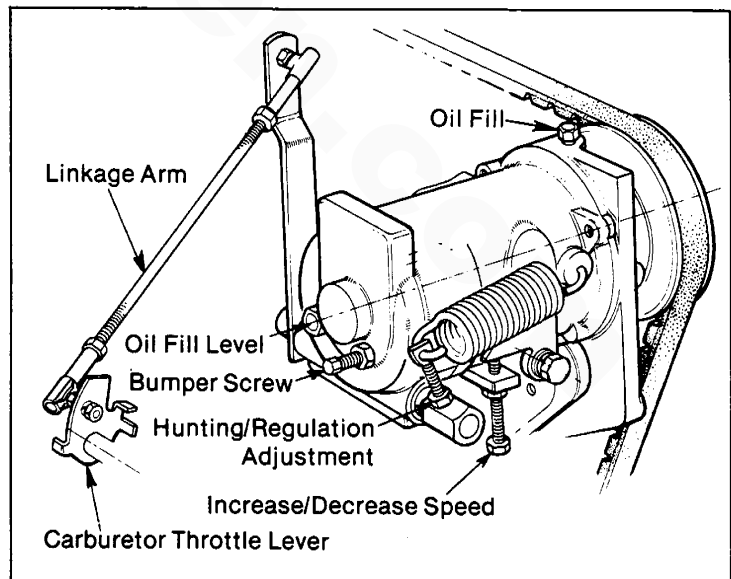
Governor Adjustments

Operate the generator set to bring the unit up to operating temperature before attempting an adjustment.

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

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

1. Increase/Decrease Speed
This adjusting bolt is used to set the no load speed of the engine. (The linkage arm between the governor arm and throttle lever should be adjusted to hold the throttle full open when the engine is not running.) Insure this linkage moves freely and that the ball joint connectors are properly lubricated. Use graphite lube for this purpose. Disconnect the ball joint and apply graphite lube to the inside of the joint.



2. Hunting/Regulation

If variation in engine speed between no load and full load is too great, adjust this eye bolt to draw the spring closer to the lever hub.

The increase/decrease speed bolt may need to be adjusted as well.

If the governor surges under load, adjust this eye bolt to move the spring away from the lever hub. (Check speed adjustment.)

3. Bumper Screw

This screw is used to remove a no load surge ONLY.

NEVER turn the bumper screw into the governor far enough so that it increases the no load speed.

Governor Maintenance

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

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

2. Governor oil capacity - 3 ounces #10/30 motor oil.

NOTE: Do not overfill governor.

3. Change governor oil every 2000 hours of operation.

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

CARBURETOR AND FUEL SYSTEM

Carburetor

The carburetor is a single barrel down draft type with a metal screened air intake filter (cleanable).

The carburetor has two metering jets, one of which is adjustable (idle mixture). The other fast running jet is set at the factory and will accept no adjustment.

Any adjustment to the idle mixture jet should be done with the engine warmed up and no load on the generator.

Electric Choke

The electric choke uses a 12 volt heating element which opens the choke automatically once the engine starts and is running.

NOTE: Some hunting will be present when the generator is started and on choke with no load on the generator.

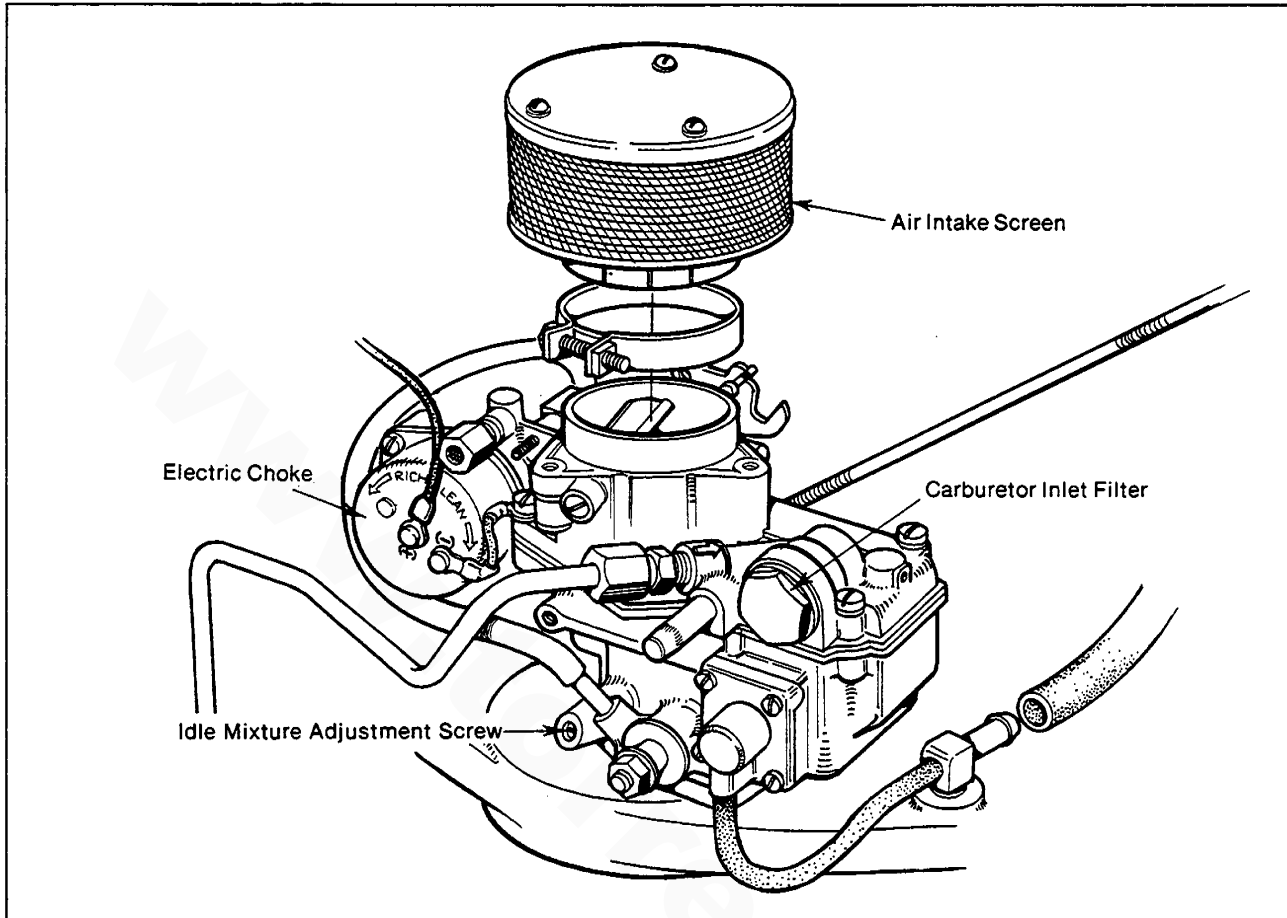
The choke is adjusted with the engine off and at room temperature. Adjust the choke by loosening the three cover securing screws and rotating the cover clockwise to LEAN the choke and counterclockwise to ENRICH the choke. The choke is initially set at the factory for an average of 70°F room temperature.

The choke may need readjustment at engine commissioning for the ambient temperature of the area the engine is operating in.

The choke index mark is located on the choke cover lower right inboard side.

CAUTION: The choke housing will normally get hot during engine operation.

NOTE: Initial engine start up (commissioning) or after fuel system servicing, prime the engine fuel system by using the engine mounted fuel pump by depressing the control panel ON switch. To prevent unwanted activation of the carburetor's electric choke, unplug the 12 volt (+) lead at the electric choke during this priming and reconnect it after priming to start the engine.

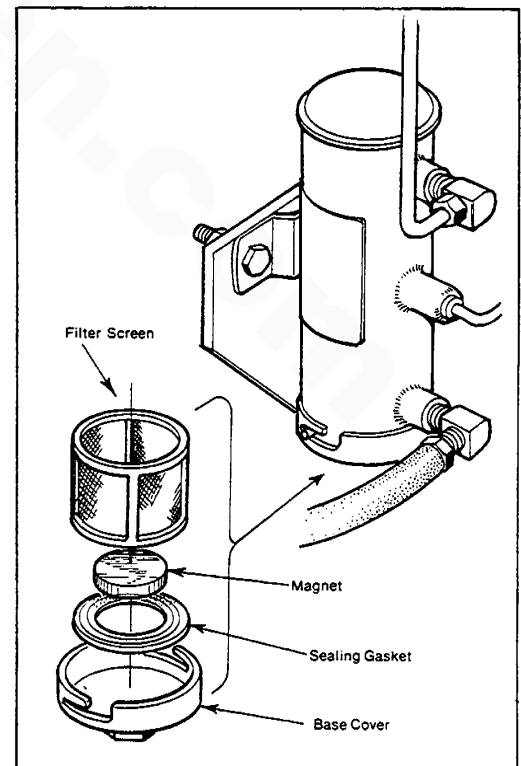


Electric Fuel Pump

The engine mounted electric fuel pump supplies fuel to the engine carburetor during engine operation. A cleanable filter screen is contained in its base.

Remove the base by placing a wrench on the hex nut and twisting it loose from the bayonet fittings. Clean the screen as needed. A new base gasket #34706 must be installed each time the pump base is removed and reinstalled.

WARNING: Shut off fuel service valve at engine when servicing fuel system. Take care to catch fuel when opening filter elements. DO NOT allow any smoking, open flames, sparks or other sources of fire near the fuel system when servicing. Insure proper ventilation when servicing the fuel system.



Troubleshooting the Fuel System

<u>Trouble</u>	<u>Possible Cause</u>	<u>Remedy</u>
1. Hard starting	1. Faulty check	1. Check choke adjustment and operation.
	2. Fuel	2. Check fuel supply and correct type.
	3. Fuel pump	3. Check pump operation and clean filter screen.
	4. Faulty idle jet adjustment	4. Adjust idle jet.
2. Flooded	1. Carburetor float needle valve open or damaged	1. Clean or replace the needle valve.
	2. Float in carburetor leaking	2. Repair or replace float.
	3. Float chamber gasket damaged or securing screws are loose	3. Replace gasket and/or tighten screws.
3. Poor performance at generator speed	1. Main jet clogged	1. Remove and clean.
	2. Carburetor inlet filter clogged	2. Remove and clean.
	3. Fuel pump filter clogged	3. Remove and clean.
	4. Air intake filter screen dirty.	4. Remove and clean.

DC ELECTRICAL SYSTEM

Safety Information

This circuit is designed and manufactured in compliance with United States Coast Guard Standards (33 CFR PART 183). No modifications may be made to it by the installer or user. It is the installer's responsibility to assure that the installation of the generator set and any remote start panels or remote instrument panels are installed in compliance with the above Coast Guard Standards. Failure to observe these requirements could be the cause of injury.

Circuit Description

The two pole ON switch is operated to bypass the protective shutdown switches during starting. The second pole provides a source of B+ to the start toggle switch.

While continuing to hold the ON switch to provide B+ to the start switch and to bypass the protective shutdown switches, the start switch is operated to cause the starter to crank the engine. If starting at the generator set, release the start switch when the generator is running. If starting at a remote location, release the start switch when the green LED shines.

Continue depressing the ON switch. It is only necessary to continue holding the ON switch after releasing the start switch until oil pressure is sufficient to close the oil pressure safety switch, providing the normal B+ path to the ignition system. Note that it is now impossible to energize the starter while the generator is running until one again operates the ON switch first.

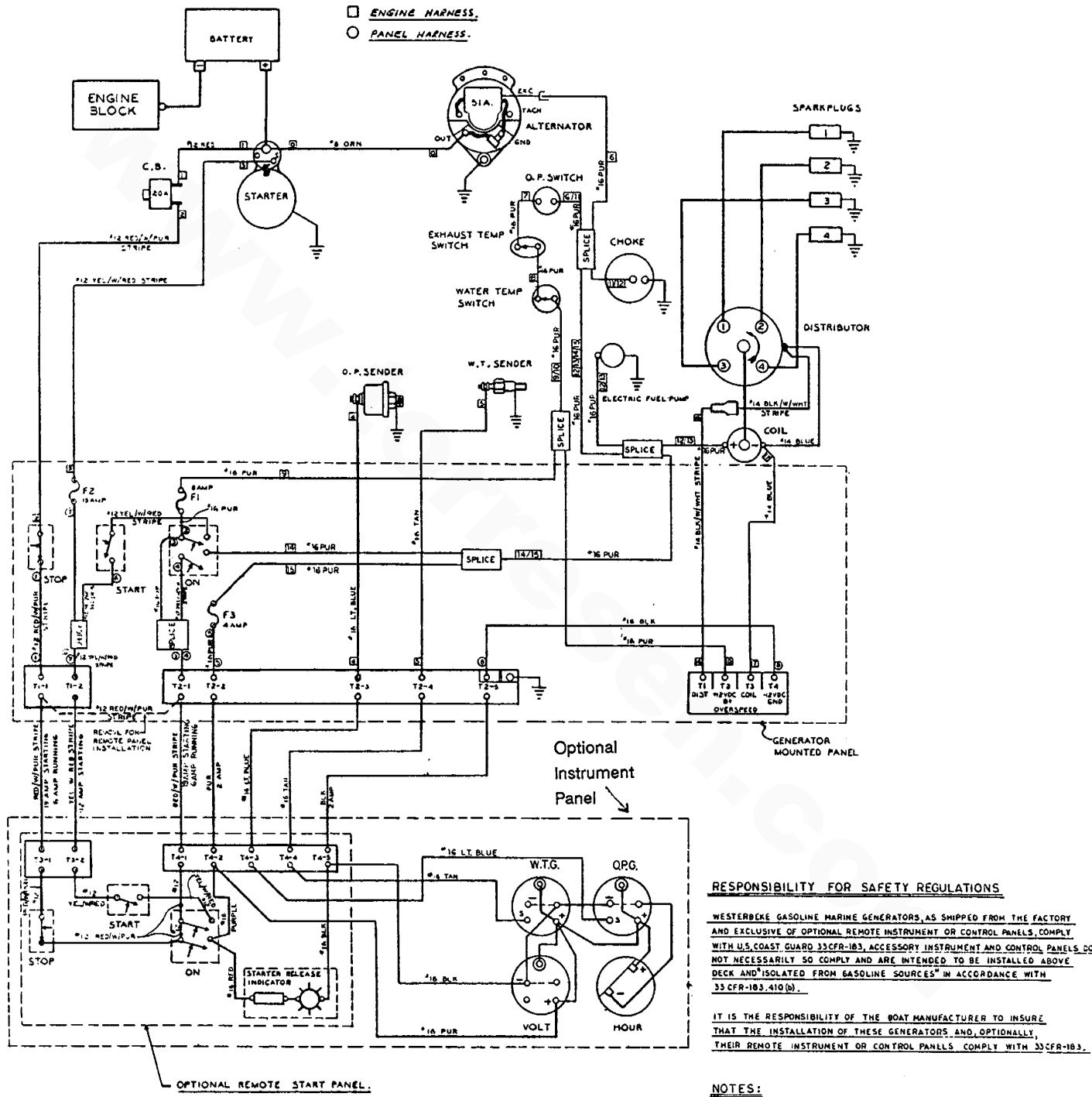
While operating, the overspeed shutdown module monitors engine RPM and will ground the ignition system if it senses engine RPM at approximately 2175 RPM.

Should the generator shut down from an overspeed condition, the overspeed circuit MUST be reset before attempting to restart the generator. This is done by simply depressing the STOP switch momentarily and then proceeding with the normal starting procedure.

SAFETY WARNING:

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

To STOP the generator, depress the STOP switch which opens the normally closed B+ path on the ON and START switches. The STOP switch must be held open until the generator comes to a stop. Remote start panels may be connected to the generator set as indicated. A jumper has to be removed between T1 and T2 at the panel connection terminal board.



RESPONSIBILITY FOR SAFETY REGULATIONS

WESTERBEKE GASOLINE MARINE GENERATORS, AS SHIPPED FROM THE FACTORY AND EXCLUSIVE OF OPTIONAL REMOTE INSTRUMENT OR CONTROL PANELS, COMPLY WITH U.S. COAST GUARD 33CFR-103, ACCESSORY INSTRUMENT AND CONTROL PANELS DO NOT NECESSARILY SO COMPLY AND ARE INTENDED TO BE INSTALLED ABOVE DECK AND ISOLATED FROM GASOLINE SOURCES IN ACCORDANCE WITH 33CFR-103.410(b).

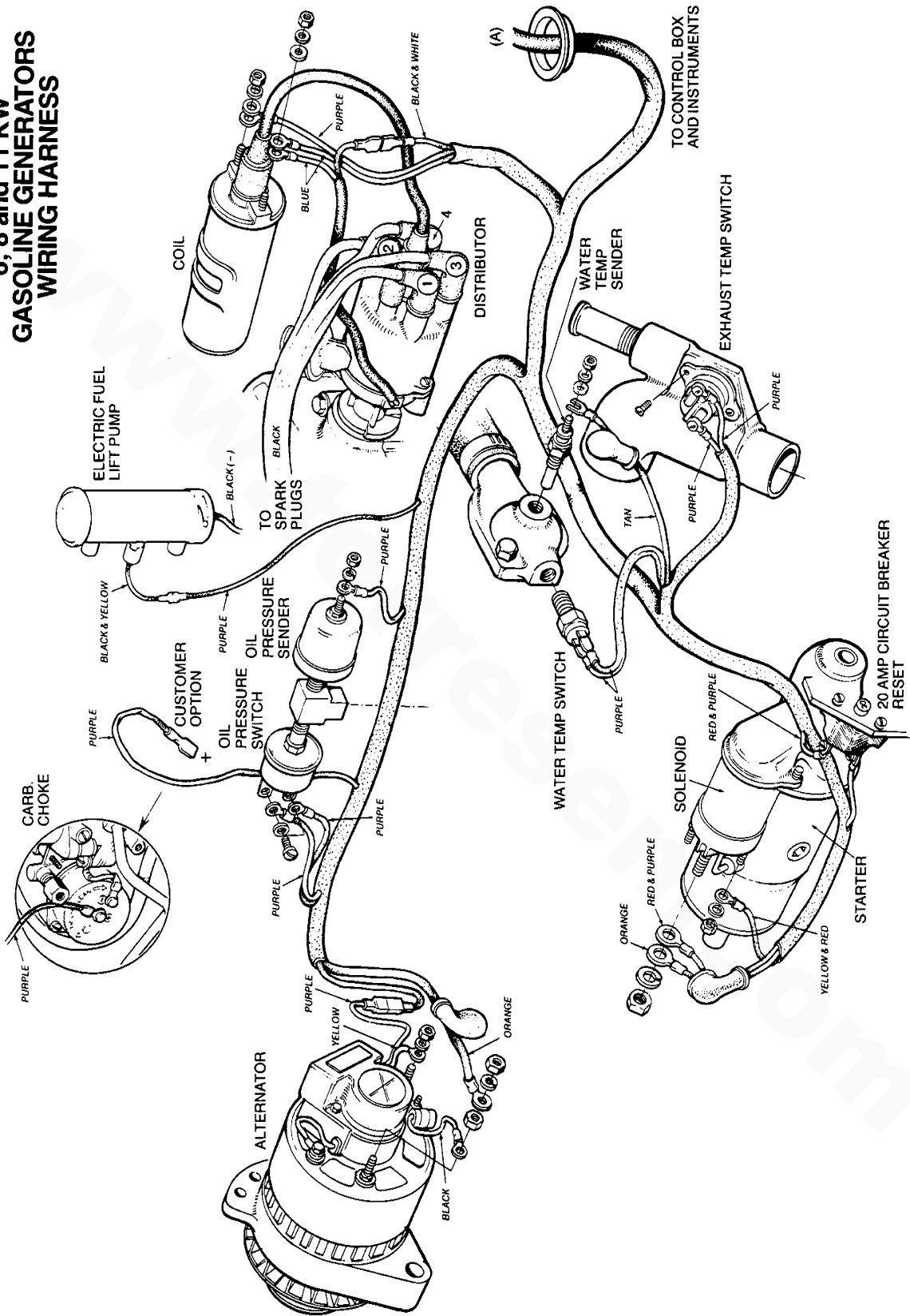
IT IS THE RESPONSIBILITY OF THE BOAT MANUFACTURER TO INSURE THAT THE INSTALLATION OF THESE GENERATORS AND, OPTIONALLY, THEIR REMOTE INSTRUMENT OR CONTROL PANELS COMPLY WITH 33CFR-103.

NOTES:

1. THE MINIMUM VOLTAGE REQUIRED AT THE STARTER SOLENOID IS 9 VOLTS. THEREFORE, WIRE GAUGES FROM T81-1 TO T83-1 AND FROM T81-2 TO T83-2 SHOULD BE SELECTED TO GIVE A MAXIMUM VOLTAGE DROP OF 1 VOLT OR LESS. THIS WILL PROVIDE 9 VOLTS AT THE STARTER SOLENOID WHEN BATTERY TERMINAL VOLTAGE IS DOWN TO 10 VOLTS, INDICATIVE OF A DEEPLY DISCHARGED BATTERY.

2. WHERE #16 WIRE IS SHOWN IN THE TABLE OF MINIMUM WIRE GAUGES BELOW, WE RECOMMEND USING #14 WIRE FOR GREATER STRENGTH AND LOWER VOLTAGE DROPS.

6, 8 and 11 KW GASOLINE GENERATORS WIRING HARNESS



Distributor

The distributor is a solid state type without breaker points and therefore requires no adjustment. It consists of a cap, rotor, signal generator, igniter and centrifugal advance system.

The signal generator consists of a signal rotor, magnet and pickup coil. The magnetic flux from the magnet flow through the pickup coil and signal rotor. When the signal rotor is driven, the amount of magnetic flux through the pickup coil varies and an electric signal is conducted at both ends of the pickup coil and sent to the igniter.

The centrifugal advance controls the signal generator timing so as to control the ignition timing according to the engine speed and load.

Checking the Distributor

1. The cap and rotor should be examined when servicing the spark plugs and checked for cracks and that the terminals are clean and free of corrosion. Replace if defective.
2. Remove the high tension cord from one of the spark plugs and hold its tip 5 - 10 mm (0.20 - 0.40 in) away from a grounded surface. Crank the engine. An intense bluish-white spark should be visible under normal conditions. If no spark is visible, it is possible that the igniter and/or pickup coil are defective. Replace both the igniter and pickup coil after checking the overspeed module, coil and high tension wiring and recheck.

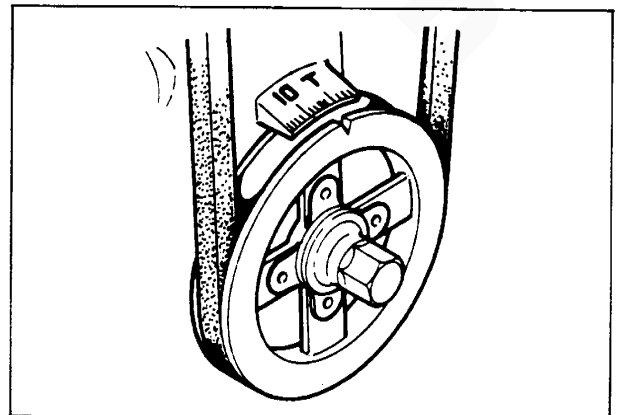
Ignition Timing

1. Attach a timing light to #1 spark plug and mark the front crankshaft timing groove and the timing mark on the scale embossed on the engine front cover.
2. Start the engine and warm it up to normal operating temperature.
3. Using the timing light, align the timing groove in the front crankshaft pulley with the proper timing mark on the ignition timing scale embossed on the engine front cover. Do this by loosening and slowly rotating the distributor body.

Timing:

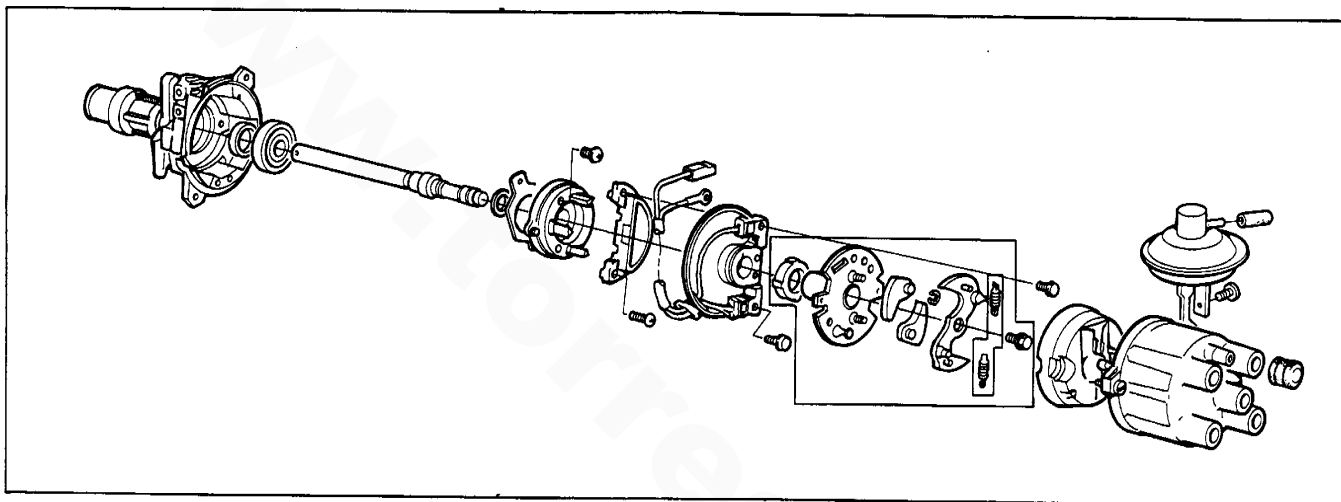
14° BTDC \pm 1° at 1800 RPM

NOTE: Timing marks are in 2 degree increments.



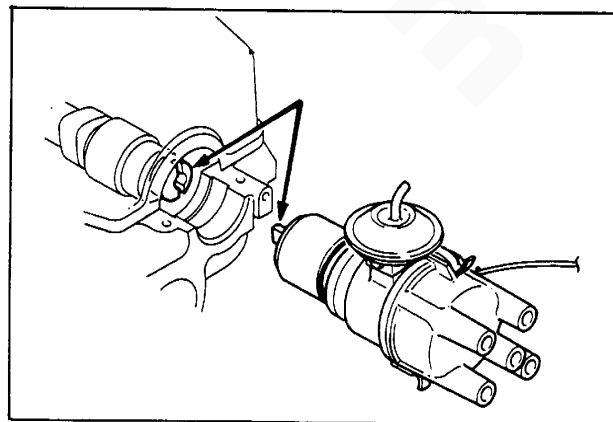
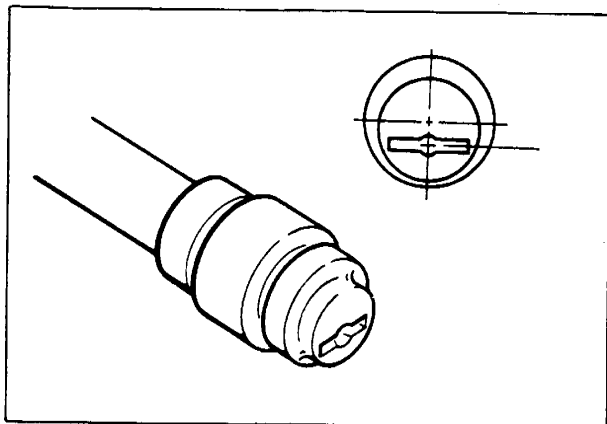
Distributor Disassembly

1. Remove wires from distributor noting their position for replacement.
2. Remove distributor from engine.
3. Remove cap.
4. Remove rotor.
5. Remove governor assembly.
6. Remove pickup coil and igniter.



Distributor Assembly

1. Assemble in the reverse order of disassembly.
2. Apply engine oil sparingly to the o-ring on the distributor shaft.
3. Insert the distributor shaft by turning it, ensuring that the distributor shaft fits into the groove on the rear of the camshaft which is offset to provide proper timing.
4. Adjust engine timing according to the specifications in the Engine Technical Data Section.



Spark Plugs

Service spark plugs, clean gap or replace as needed.

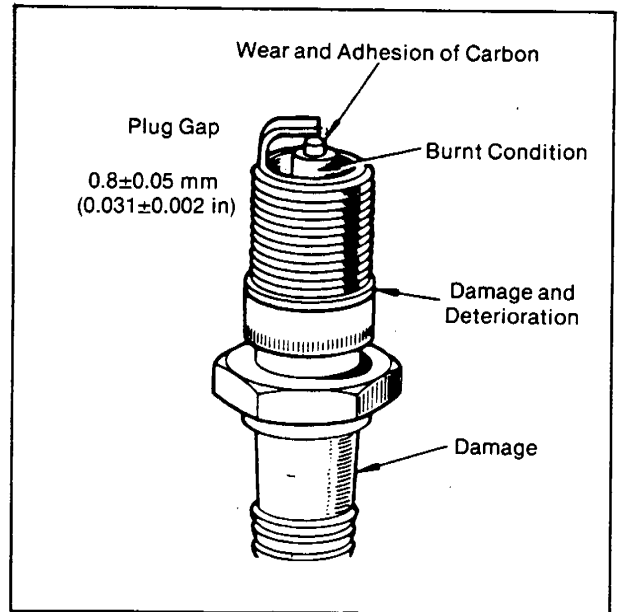
Spark plug gap: 0.8 ± 0.05 mm
(0.031 ± 0.002 in)

Spark plug torque:

1.5 - 2.3 kg-m
(10.8 - 16.6 lb-ft)

Check plugs for damage and/or wear.

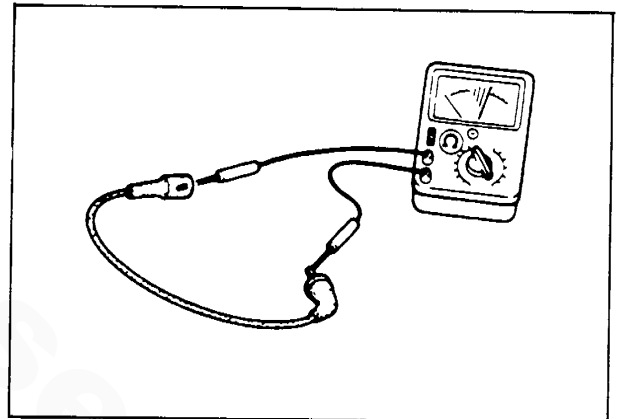
NOTE: Loc-tite "Anti-Seize" applied to thread will retard corrosion making future removal easier.



High Tension Leads

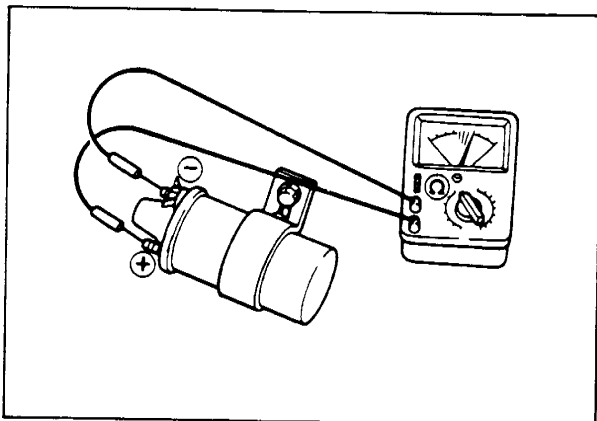
Check leads for clean and secure terminal ends. Resistance value of high tension lead wire is 410 ohms per inch of wire.

NOTE: When removing leads from spark plugs, be sure to pull at the plug cap, not at the high tension lead.

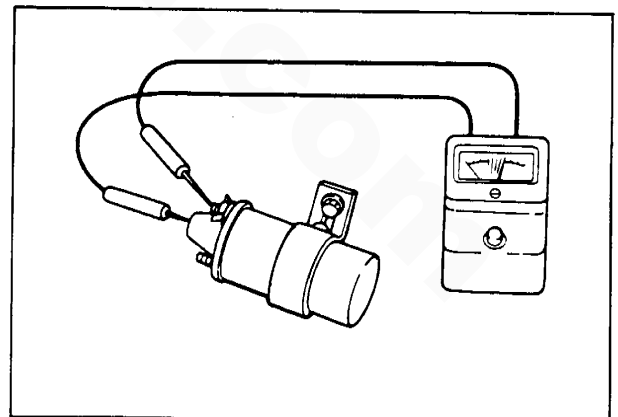


Ignition Coil (Resistance Check)

1. Resistance value of primary coils is 0.8 ± 0.2 ohms. (Ohmmeter RX1 scale)



Checking Primary Coil



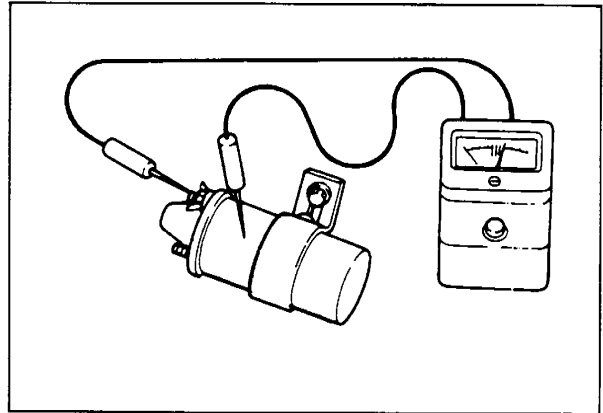
Checking Secondary Coil

2. Resistance value of secondary coils is 80 ± 10 ohms. (Ohmmeter RX1000 scale)

3. Checking the insulation resistance between the primary terminal and the coil case. (Megohmmeter 500 volt)

Normal resistance: 10 megohms +

The coil should be replaced should it not meet the resistance values given above.



Checking Overspeed Module

1. With generator running, manually move the throttle lever to full open. Generator set should stop.
2. Depress ON and START switches. Generator should not start.
3. Depress STOP switch to reset overspeed module circuit. Then depress ON and START; the generator should start properly.
4. To bypass the overspeed module to check safety circuit, disconnect the black with white stripe wire from the distributor at the connector in the harness. Use a jumper wire to connect this to the B+ of the coil. Remove all four wires from the overspeed module, ensuring that they do not touch each other or ground.

SAFETY WARNING:

Overspeed module **MUST** be properly reconnected and functioning **BEFORE** operating generator.

Voltmeter

The voltmeter in the remote instrument panel can be a useful instrument in determining the status of your electrical system and warn you when an abnormality occurs. The voltmeter will indicate differently, depending when the readings are taken.

Fully charged batteries that are in a static state should read between 12.3 and 12.6 volts on the dial. The term static means that the battery has not been charged or discharged for at least 2 hours. If the reading is between 11 and 11.5 volts, then the battery is about half discharged and should be charged to insure its usefulness. If the engine is started and the needle does not go up, this would indicate that no charge is being delivered to the battery.

When the battery is being charged, the needle should be between 12.6 and 13 volts. The needle may move up to about the 14.6 volt range toward the end of the charge cycle, at which time the needle drops back to the 12.6 to 13 volt range, as voltage regulation controls this function. If the battery voltage exceeds 15 volts, this indicates

that the battery is being overcharged and will damage the battery if left unchecked. The voltage regulator is most likely at fault.

When the battery is being charged (having electrical loads placed upon it and no charging current applied), it is normal for the needle to indicate between 11.4 and 12.6 volts.

Electrical System Troubleshooting

<u>Trouble</u>	<u>Possible Cause</u>	<u>Remedy</u>
ON switch depressed, electric fuel pump not energized	1. Battery switch or power not on	1. Check switch and/or battery connections.
	2. 20 amp circuit breaker tripped	2. Reset breaker if it opens again, check preheat solenoid circuit and "run" circuit for shorts to ground.
No ignition, cranks, does not start	1. Overspeed module tripped	1. Reset circuit by depressing stop switch.
	2. Fuse blown	2. Check fuses; replace if necessary.
	3. Lack of fuel	3. Check for fuel to generator set. Check fuel lift pump.
	4. Choke faulty	4. Check to see that it is not jammed. Should be closed if engine is cold.
	5. Coil faulty	5. Check coil.
	6. Distributor faulty	6. Check distributor, cap and wires.
	7. Wiring faulty	7. Check wires and connections for shorts, breaks and corrosion.
Starts, stops when ON switch released	1. Safety circuit switch or wiring faulty	1. Inspect all wiring for shorts, corrosion or loose connections. Check operation of switches.
	2. Fuse blown	2. Check fuses.
	3. Overspeed module faulty	3. Check module.

<u>Trouble</u>	<u>Possible Cause</u>	<u>Remedy</u>
Engine stops	1. Low oil pressure or overheated	2. Check oil, fresh water and sea water cooling.
	2. Low oil pressure switch fails to close	2. Check for satisfactory operation with switch bypassed.
	3. High water or exhaust temperature switches open at too low a temperature	3. Same as above.
	4. Overspeed module	4. Check engine speed. Check module for proper operation.
	5. Switch and wiring	5. Inspect all wiring for loose connections and short circuits.
Not charging battery or battery runs down	1. Alternator drive	1. Check drivebelt and its tension. Be sure alternator turns freely. Check for loose connections.
	2. Oil pressure switch	2. Observe if gauges and light are on when engine is not running. Test the normally open oil pressure switch by disconnecting one lead. If lights go out replace oil pressure switch.
	3. High resistance leak to ground	3. Check wiring. Insert sensitive (0-.25 amp) meter in battery lines. (Do not start engine.) Remove connections and replace until short is located
	4. Low resistance leak to ground	4. Check all wires for temperature rise to locate fault.

<u>Trouble</u>	Possible Cause	<u>Remedy</u>
	5. Alternator	5. Disconnect alternator at output, after a good battery charging. If leakage stops, replace alternator protective diode plate. That failing, replace alternator.
	6. Overspeed circuit drained battery	6. Unit not run for months and fuse left in circuit drawing 0.025 amp.

REMOTE PANEL INSTALLATION

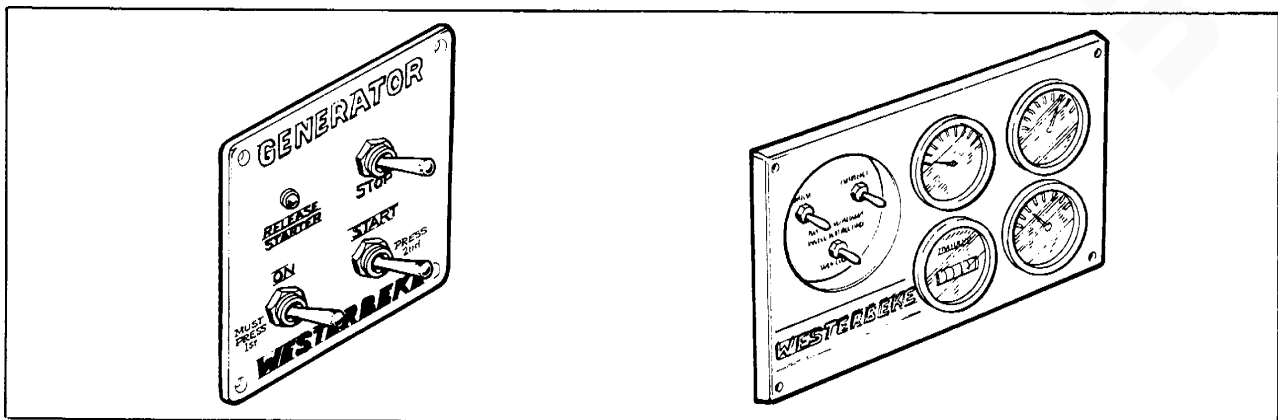
INSTALLER'S/OWNER'S RESPONSIBILITY

1. Wiring between the generator set and either a remote start panel or remote instrument panel must comply with U.S. Coast Guard Safety Regulations 33 CFR-183.
2. The minimum voltage required at the starter solenoid is 9 volts. Therefore, wire gauges from TB1-1 to TB3-1 and from TB1-2 to TB3-2 should be selected to give a maximum voltage drop of 1 volt or less. This will provide 9 volts at the starter solenoid when battery terminal voltage is down to 10 volts, indicative of a deeply discharged battery.
3. Where #16 wire is shown in the table of Minimum Wire Gauges below, we recommend using #14 wire for greater strength and/or lower voltage drops.

MINIMUM WIRE GAUGES (AWG)

Wire Length from Generator to Remote Panel

<u>Terminals</u>	<u>0-16'</u>	<u>16-20'</u>	<u>20-25'</u>	<u>25-32'</u>	<u>32-40'</u>	<u>40-50'</u>	<u>50-65'</u>
TB1-1 to TB3-1	#12	#10	#10	#8	#8	#6	#6
TB1-2 to TB3-2	14	12	12	10	10	8	8
TB2-1 to TB4-1	14	14	12	10	10	8	8
TB2-2 to TB4-2	14	14	14	14	14	14	14
TB2-3 to SENDER	14	14	14	14	14	14	14
TB2-4 to SENDER	14	14	14	14	14	14	14
TB2-5 to TB4-3	14	14	14	14	14	14	14



AC GENERATOR

GENERATOR DESCRIPTION AND MODEL RATING

Characteristics

Design: Four pole revolving armature, inherently regulated, self limiting, rectifier excited, A.C. slip rings, single bearing designs.

Voltage Regulation: \pm 7 percent no load to full load.

Frequency Regulation: 3 Hertz (5%) no load to full load.

Insulation: Class F as defined by NEMA MGI-1.65.

Temperature Rise: Within NEMA MGI-22.40 definition when operating at full load.

Cooling: Centrifugal blower, direct connected.

Radio Interference Level: Capacitors minimize interference within the limits of most marine applications.

Armature: Balanced laminated steel, double dipped and baked.

Ratings

115/230 VAC or 115 VAC, single phase, 4 wire, 1.0 power factor, 1800 RPM at 60 Hertz, 1500 RPM at 50 Hertz.

Model	Amp	Hertz	KW
TWG 6.5	56/28	60	6.5
TWG 8	70/35	60	8.0
TWG 11	94/47	60	11.0

Deratings

1. 3.5 percent for each 1000 feet above sea level.
2. 1 percent for each 10° Farenheit above 85°F ambient.
3. 10 percent for continuous duty.

GENERATOR TROUBLESHOOTING

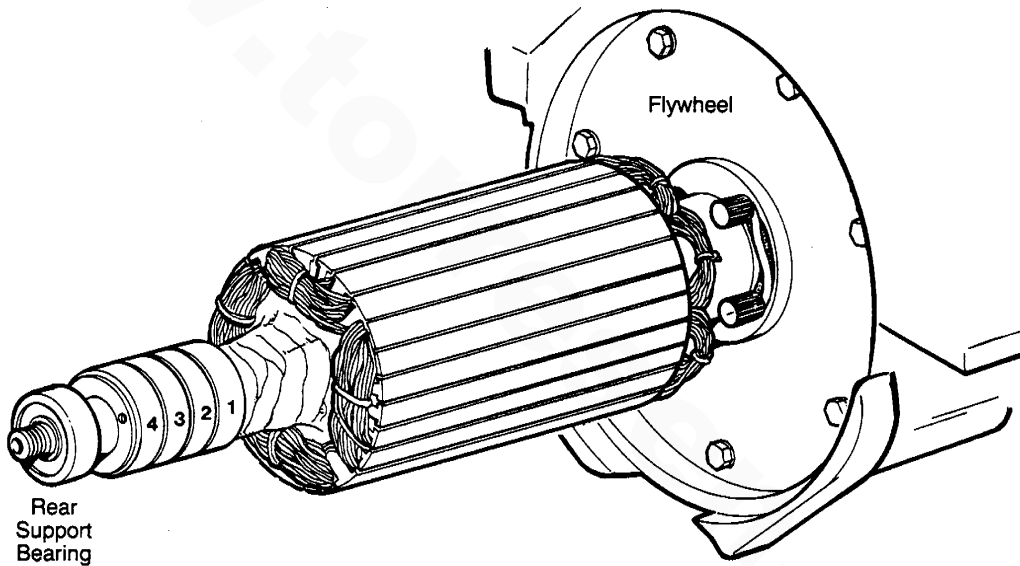
TWG MODELS

6.5KW, 8KW, 11KW

No Electrical Output

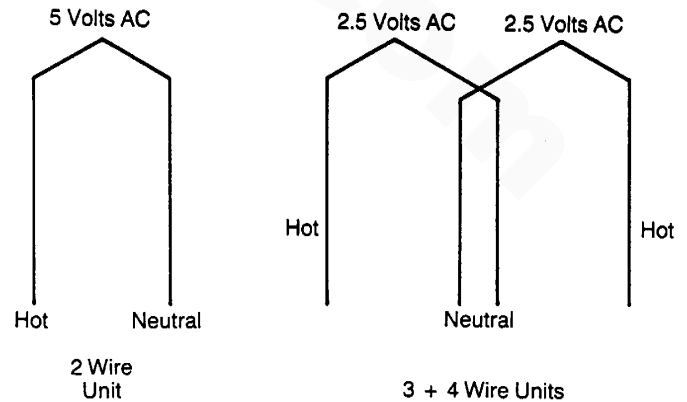
1. Remove load from generator and verify no output directly at generator output leads with voltmeter.
2. Check for proper electrical connections. Refer to Internal Wiring diagrams.

NOTE: Generator armature slip rings and brush rigs are numbered from inboard at the windings or flywheel end outward toward the rear support bearing.



2A. Residual Voltage Check

Disconnect field leads from bridge rectifier. (Note position of leads on rectifier (+) to (+) and (-) to (-).) Operate the generator and check AC output (no load on generator). Measure voltage between neutral lead and hot lead(s).



2-wire unit 5 Volts AC (Hot lead to neutral)
 3 and 4 wire unit 2.5 volts AC (each hot lead to neutral approximate)

Residual Voltage checks O.K. You can assume the rotating armature and brush rig are O.K. The generator problem lies in the rectifier and/or field coils.

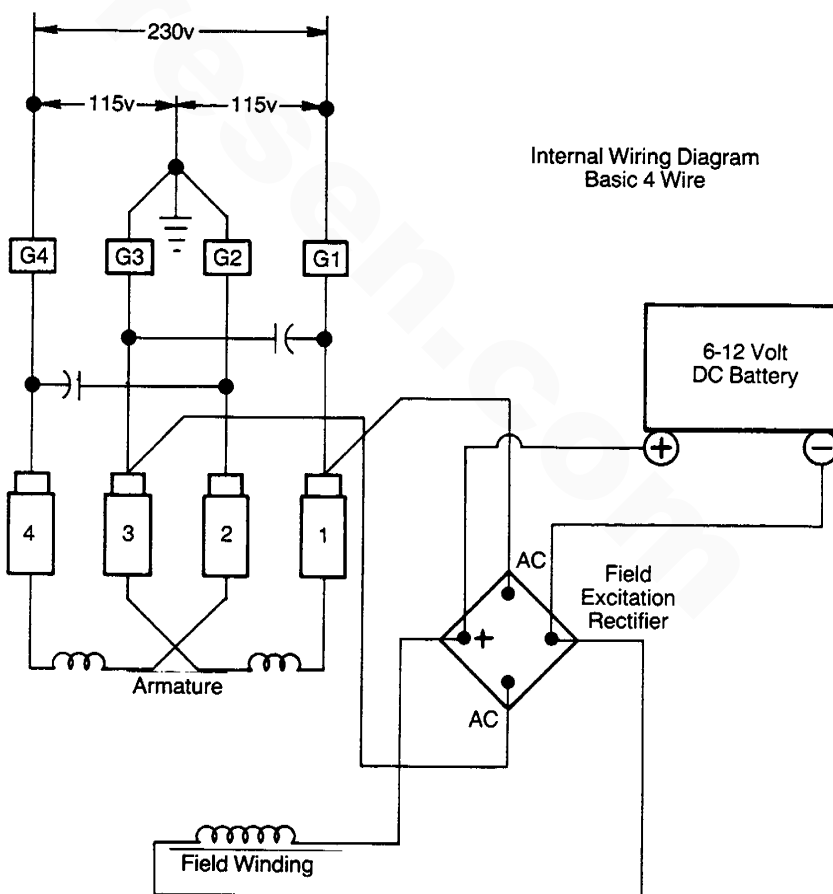
Residual voltage not present. Check brush rig and static capacitors. Check rotating armature resistance values and continuity check found elsewhere in this manual.

3. Test operation of generator by by-passing bridge rectifier. Apply 12 volts DC to field leads on bridge rectifier (+) to (+) and (-) to (-). Run generator (no load). Measure voltage output at generator leads. Generator output with 12 volts DC excitation to the field coils should be 50 to 70 Volts AC. If 50 to 70 volts AC is produced, this should indicate that the generator is O.K., and that the bridge rectifier is defective.
4. If no voltage is produced, check the static capacitor(s) that it is not shorted to ground. If found faulty, remove connection from output terminal at brush rig and repeat Step #3.

5. Flash Field Coils

Units may lose their residual magnetism from extended storage, rough handling during installation or disassembly and assembly for installation, etc., requiring the field coils to be excited with 6 to 12 volts DC to restore the magnetism to the generator. This is done in the following manner:

Stop the engine and remove the generator end bell cover. This will expose the cooling fan, brush rig assembly and rectifier. Check internal wiring; refer to figure. The positive (+) lead from the field coils is connected



to the positive marked terminal on the rectifier and the negative (-) lead from the field coils is connected to the opposite UNMARKED terminal on the rectifier. Using jumper leads with insulated alligator clips, connect 6 to 12 volts DC battery positive to the positive of the rectifier and negative to the UNMARKED terminal of the rectifier for approximately 10 seconds. This should restore magnetism to the stationary field coils. (Be careful not to connect DC voltage to the AC terminals on the rectifier, as this will damage the rectifier.)

Remove the alligator clip connections; replace the end bell cover and operate the generator and check AC output voltage.

6. Check for a short or open in the rotating armature or in the stationary field coils.

ROTATING ARMATURE (RESISTANCE VALUES)

TWG 6.5KW, 8KW, 11KW

1 ohm or less between slip rings (1 & 3) and (2 & 4).

NOTE: 3- and 4-wire units: There should be no continuity found between slip rings (1 & 2), (2 & 3) and (3 & 4). If continuity is found, an internal short exists between these windings and the armature should be replaced.

NOTE: All units: There should be no continuity found between any of the slip rings and the armature's central steel shaft. If continuity is found, the windings are shorted to the shaft and the armature should be replaced.

Rotating armature slip rings are numbered from inboard of the generator flywheel end outward to the rear support bearing. When referring to 2, 3 and 4-wire units, these are the number of generator output leads being connected to the load. You will find on the 11.0 and 12.5KW units that there are 8 leads coming from the brush rig and are combined for a total of 4 output leads. The number of wires can also be related to the number of slip rings on the rotating armature.

FIELD COIL RESISTANCE (TOTAL)

TWG 6.5KW	22.2 ohms	± 5%
TWG 8KW	22.2 ohms	± 5%
TWG 11KW	14.2 ohms	± 5%

NOTE: There should be no continuity found between the field coils and the generator body.

7. Replacement of Field Coil(s)

Field coils are connected in series and the resistance value given above in this text is the total of the four field coils. To determine the resistance value of one, divide by four. Each field coil has a mounting position on the generator housing and cannot be interchanged with another field coil.

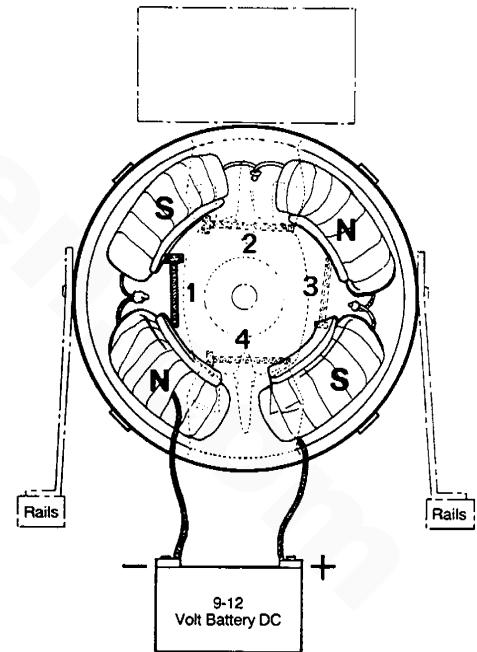
When installing a replacement field coil(s), the installer must insure that the coil is correct for the mounting position in the housing and will have the correct polarity when excited with 9 - 12 volts DC.

The field coil shoes that hold the coil securely to the generator housing are held in place by bolts that must be properly tightened when the coil and shoe are installed to the generator housing. When connecting the coils in series insure the butt connections are good and secure and positioned away from rotating parts.

To insure the field coils have been positioned properly in the generator housing and will have the correct polarity, the following test must be made before reassembly of the generator.

- (1) Connect a 9 - 12 volt DC battery to the leads off the coils that would normally be connected to the (+) and (-) connectors of the bridge rectifier. These leads are unmarked and the polarity in their connection to the DC battery is not important. NOTE: When removing the leads from the battery and reconnecting them to the bridge rectifier, you should maintain the same polarity as used in this test, plus lead to (+) on rectifier and negative to unmarked (-) connection on rectifier.

- (2) With a 3 inch iron bolt or its equivalent, place this bolt between each adjoining field coil shoe. It should be held in place by the magnetic attraction set up between the coil/shoes by the 9 - 12 volts excitation of the field coils. Should this fail to happen between any of the four adjoining coils/shoes, then an incorrect coil is installed and must be removed and the correct one installed; otherwise the generator when assembled will not produce proper voltage.



Low Voltage Output

1. Verify voltage output at generator output leads with load applied to generator; check no load condition also. Check voltage at the load. Check rating for generator and verify load with amp probe at output leads. Check all connections to insure they are clean and secure. Insure that the wire size carrying the voltage to the load is of sufficient size so as not to produce a voltage drop.

NOTE: Beware of motor starting loads and the amperage draw placed on the generator from these types of loads. Generally, the amperage draw of a motor at start up will be 3 - 5 times the amperage needed when running.

2. Check generator with Hertz meter:

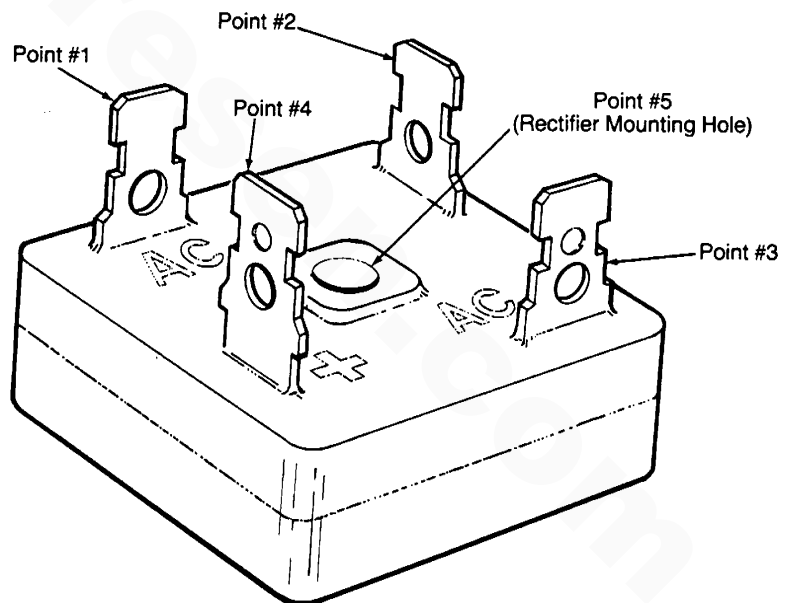
No Load Hertz	61 - 61.5 (51 - 51.5)
No Load Voltage	131 - 135 Volts (Generator Cold)
No Load Voltage	126 - 130 Volts (Generator Hot)

3. Test Bridge Rectifier:

Bridge rectifier may be faulty and should be checked as follows.

- (1) Set ohmmeter scale on Rx1 (+DC) zero the meter.

- (2) Connect the (+) lead from the meter to Point #4, with the (-) lead from the meter momentarily contact points #1, #2, #3 and #5. No deflection of the needle should occur showing infinite resistance.



- (3) Remove the (+) lead from Point #4 and connect the (-) lead to Point #4 and with the (+) lead, momentarily touch Points #1, #2 and #3. Points #1 and #3 should show an 8-ohm resistance ± 2 ohms. Point #2 should show a 40-ohm resistance ± 5 ohms.
- (4) Touch Point #5 with the (+) lead, no deflection of the needle should occur. IF THE RECTIFIER FAILS ANY OF THE ABOVE TESTS, IT IS DEFECTIVE AND SHOULD BE REPLACED.

4. Check field coil resistance as per specification given in A-6.
5. Insufficient cooling of the generator. Ambient air entering the generator should not exceed 104°F (40°C).
Operating efficiency of the generator decreases as the ambient air temperature entering the generator end bell increases above 104°F. Generators in confined areas may require the ducting of cool outside air into the compartment and directed toward the inlet at the generator end bell.
6. Check condition of brushes for wear and contact with slip rings on armature. Insure brushes are not sticking in holders.

High Voltage Output

1. Verify voltage at generator output leads.
No load voltage 126 - 130 volts (Generator Hot)
61 - 61.6 Hertz
(51 - 51.5 Hertz)
2. Check internal wiring of generator leads attached to brush rig and leads from brush rig feeding AC to bridge rectifier. Refer to Internal wiring schematics. These internal wiring diagrams are applicable to related 50 Hertz units as well.

TECHNICAL DATA

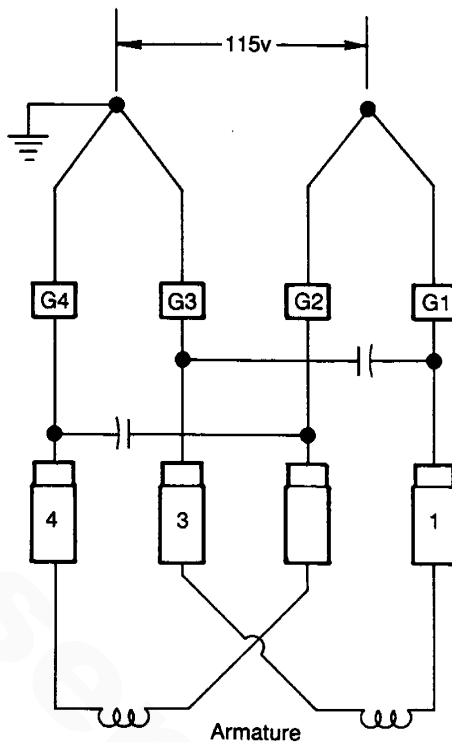
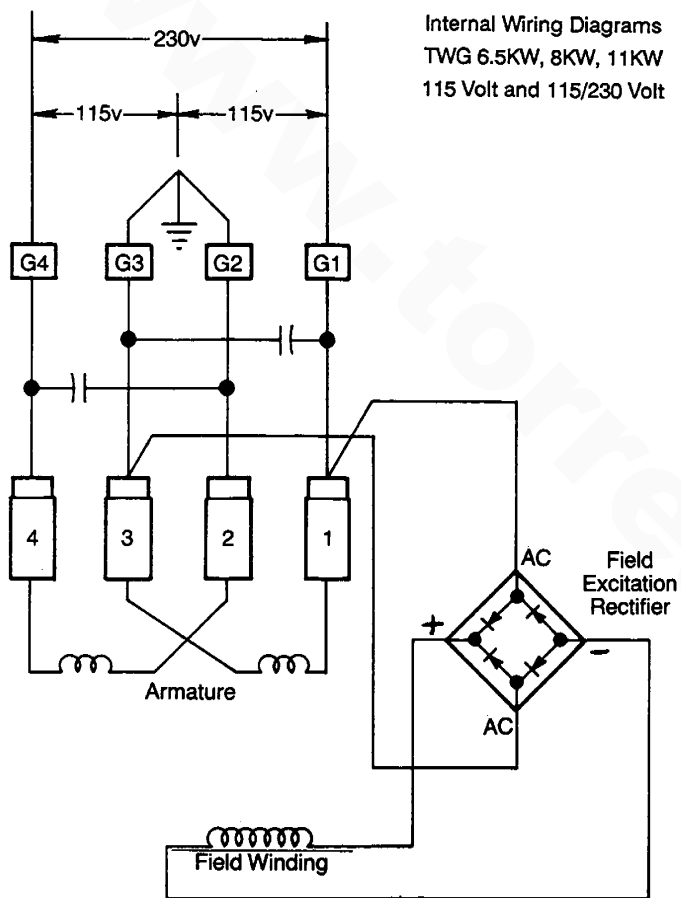
TWG 6.5KW	115 or 115/230 Volts AC	27.0 AMP at 230 Volts AC
TWG 8.0KW	115 or 115/230 Volts AC	34.0 AMP at 230 Volts AC
TWG 11KW	115 or 115/230 Volts AC	46.0 AMP at 230 Volts AC

Frequency 60 Hertz standard
(50 Hertz available at reduced rating)

RPM 1800 - 60 Hertz
1500 - 50 Hertz

Voltage
Normal 115 VAC 230 VAC
Maximum - no load 132 VAC 264 VAC
Minimum - full load 108 VAC 216 VAC

Excitation Voltage 115 VAC (output voltage)



Field Excitation Rectifier Wiring
 Same as for 230v

LAY-UP AND RECOMMISSIONING

General

Many owners rely on their boatyards to prepare their craft, including engines and generators, for lay-up during the off-season or for long periods of inactivity. Others prefer to accomplish lay-up preparation themselves.

The procedures which follow will allow you to perform your own lay-up and recommissioning, or to use as a check list if others do the procedures.

These procedures should afford your engine protection during a lay-up and also help familiarize you with the maintenance needs of your engine.

If you have any questions regarding lay-up procedures, call your local servicing dealer; he will be more than willing to provide assistance.

Fresh Water Cooling System

A 50-50 solution of antifreeze and fresh water is recommended for use in the fresh water cooling system at all times. This solution may require a higher concentration of antifreeze, depending on the area's winter climate. Check the solution to ensure that the antifreeze protection is adequate.

Should more antifreeze be needed, drain an appropriate amount from the engine block and add a more concentrated mixture. Operate the engine to ensure a complete circulation and mixture of the antifreeze concentration throughout the cooling system. Now recheck the antifreeze solution's strength.

Lubrication System

With the engine warm, drain all the lubricating oil from the oil sump. Remove and replace the oil filter. (Place some paper towels and a plastic bag around the filter to catch the oil during its removal.)

When installing the new oil filter, be sure to apply a small amount of oil on the rubber sealing gasket at the base of the filter. Fill the sump with the correct amount of oil for your engine model. Use an oil with an API specification of SC or SD. Run the engine and check for proper oil pressure and ensure that there are no leaks.

CAUTION

Do not leave the engine's old lubricating oil in the sump over the lay-up period. Lubricating oil and combustion deposits combine to produce harmful chemicals which can reduce the life of your engine's internal parts.

Fuel System

Top off your fuel tanks with regular or unleaded gasoline with an octane rating of 89 or better. Fuel additives should be added at this time to control algae and condition the fuel. Care should be taken that the additives used are compatible with the primary filter/water separator used in the system. Change the element in your primary fuel filter/water separator, if the fuel system contains one, and clean the separator sediment bowl. Clean the filter screen in the fuel lift pump and in the carburetor.

Sea Water Circuit

Close the thru-hull seacock. Remove the sea water intake hose from the seacock. Place the end of this hose into a 5-gallon bucket of clean fresh water. Before starting the engine, check the zinc anode found in the primary heat exchanger on the engine and clean or replace it as required. Clean the sea strainer, if one is installed in the inside of the hull.

Start the engine and allow the sea water pump to draw fresh water through the system. When the bucket is empty, stop the engine and refill the bucket with an antifreeze solution slightly stronger than needed for winter freeze protection in your area.

Start the engine and allow all of this mixture to be drawn through the sea water system. Once the bucket is empty, stop the engine. This antifreeze mixture should protect the sea water circuit from freezing during the winter lay-up, as well as providing corrosion protection.

Remove the impeller from your sea water pump (some antifreeze mixture will accompany it, so catch it in a bucket). Examine the impeller. Acquire a replacement, if needed, and a cover gasket. Do not replace the impeller (into the pump) until recommissioning, but replace the cover and gasket.

Intake Manifold and Through-Hull Exhaust

Place a clean cloth, lightly soaked in lubricating oil, around the air arrester. Be sure to remove this cloth before recommissioning. Make a note to remove the cloth prior to start-up. The through-hull exhaust part can be blocked in the same manner.

Starter Motor

Lubrication and cleaning of the starter drive pinion is advisable, if access to the starter permits its easy removal. Ensure that the battery connections are shut off before attempting to remove the starter. Take care in properly replacing any electrical connections removed from the starter.

Cylinder Lubrication

Fogging the engine should be done as the last of the antifreeze mixture is drawn into the sea water circuit. Remove the air intake screen (the air filter) and spray Marvel Mystery Oil or another commercially available fogging oil into the carburetor while the engine is running. Spray enough oil to stall the engine. This will coat the walls of the cylinders, pistons, and valve surfaces with this protective oil. Remove the spark plugs and spray a small amount of this oil into each spark plug hole and turn the engine over two or three complete revolutions by hand. Reinstall, but do not tighten, the spark plugs, as these will need to be cleaned and gapped prior to recommissioning. Close off the carburetor's air filter with an oily rag.

Spares

Lay-up time provides a good opportunity to inspect the equipment to see if external items such as drive belts or coolant hoses need replacement. Check your basic spares kit and order items not on hand, or replace those items used during the lay-up, such as filters and zinc anodes.

Batteries

If batteries are to be left on board during the lay-up period, ensure that they are fully charged, and will remain that way, to prevent them from freezing. If there exists any doubt that the batteries will not remain fully charged, or that they will be subjected to severe environmental conditions, remove the batteries and store them in a warmer, more compatible environment.

Recommissioning

The recommissioning of your Westerbeke unit after a seasonal lay-up generally follows the same procedures as those presented in the "Preparation for Starting" section, page 14, regarding preparation for starting and normal starts. However, some of the lay-up procedures will need to be counteracted before starting the engine.

1. Remove the oil-soaked cloths from the intake manifold and from the through-hull exhaust port.
2. Remove the sea water pump cover and gasket. Discard the gasket. Install the sea water pump impeller removed during lay-up (or a replacement, if required). Install the sea water pump cover with a new cover gasket.

WARNING

Wear rubber gloves, a rubber apron, and eye protection when servicing batteries.

Lead acid batteries emit hydrogen, a highly-explosive gas, which can be ignited by electrical arcing or a lighted cigarette, cigar, or pipe. Do not smoke or allow an open flame near the battery being serviced. Shut off all electrical equipment in the vicinity to prevent electrical arcing during servicing.

3. Reinstall the batteries that were removed during the lay-up, and reconnect the battery cables, making sure the terminals are clean and that the connections are tight. Check to ensure that the batteries are fully-charged.
4. Check the condition of the zinc anode in the sea water circuit and clean or replace the anode as needed. Note that it is not necessary to flush the antifreeze/fresh water solution from the sea water coolant system. When the unit is put into operation, the system will self-flush in a short period of time with no adverse affects.
5. Start the unit in accordance with those procedures found in the "OPERATION" section of this manual.

SERVICE BULLETINS

The following Bulletins contain supplementary and updated information about various components and service procedures which are important to the proper functioning of your engine and its support systems.

You should familiarize yourself with the subjects and make sure that you consult the appropriate Bulletin(s) whenever your engine requires service or overhaul.

SERVICE BULLETIN

DATE: 6/15/69

BULLETIN NUMBER: 20

MODEL: All Engines

SUBJECT: Connecting Pressure Sensing Devices to Oil Galleries

Oil pressure sensing devices, such as senders and switches, must never be connected directly to any oil gallery of an engine. The reason is simply that continued engine vibration causes fatigue of the fittings used to make such a connection. If these fittings fail, the engine loses its oil pressure and very quickly seizes.

Such pressure sensing devices must be bulkhead mounted and connected to the oil gallery using an appropriate grade of lubricating oil hose. Any fittings used to connect the hose to the gallery must be of steel or malleable iron. Brass must not be used for this purpose.

SERVICE BULLETIN

DATE: 5/6/74

BULLETIN NUMBER: 69

MODEL: All Marine Generators and Marine Engines

SUBJECT: Exhaust System Failures

When engine sea water is fed into an exhaust system so that the full stream strikes a surface, erosion may cause premature failures.

Proper design of either a water jacketed or a water injected ("wet") exhaust system to prevent this problem requires that the sea water inlet be positioned so that the entering stream of sea water does not strike a surface directly. Also, the velocity of the entering sea water stream should be as low as possible which is achieved by having inlet fittings as big in diameter as possible.

In addition to the above design considerations, it is usually advantageous to divide the sea water flow at the point of entry to the exhaust system so that only a portion of it enters the exhaust system. The remainder is normally piped directly over the side. The proper proportion of the sea water flow to pass through the exhaust system can only be determined by trial and error. The goal is to prevent excessive exhaust temperatures with the least amount of sea water.

SERVICE BULLETIN

DATE: 4/4/83

BULLETIN NUMBER: 87

MODEL: All marine engines

SUBJECT: Alternator Output Splitter

GENERAL DESCRIPTION: The splitter is a solid state device which allows two batteries to be recharged and brought to the same ultimate voltage from a single alternator as large as 120 amp and, at the same time, isolates each battery so that discharging one will have no effect on the other. Charging rates are in proportion to the batteries' voltage (state of discharge). This method precludes the necessity, and even the desirability, of a rotary switch for selecting which battery is to be charged. It also assures that ships' services cannot drain the engine starting battery.

INSTALLATION:

1. Mount splitter on metal surface other than the engine, preferably in an air stream if available. Do not install near engine exhaust system. Install with cooling fins aligned vertically.
2. Be sure to use a wire size appropriate to the output of the associated alternator. In full power systems number 4 wire is recommended from the alternator to the splitter and from the splitter to the batteries.
3. Connect the alternator output terminal to the center splitter terminal.
4. Connect one splitter side terminal to one battery(s).
5. Connect the other splitter side terminal to the other battery(s).
6. When the splitter is installed, both batteries will see a charging voltage 8/10 volts less than usual. This voltage drop can be regained, if desired, by connecting the regulator wire directly to the alternator output terminal instead of the regulator terminal.

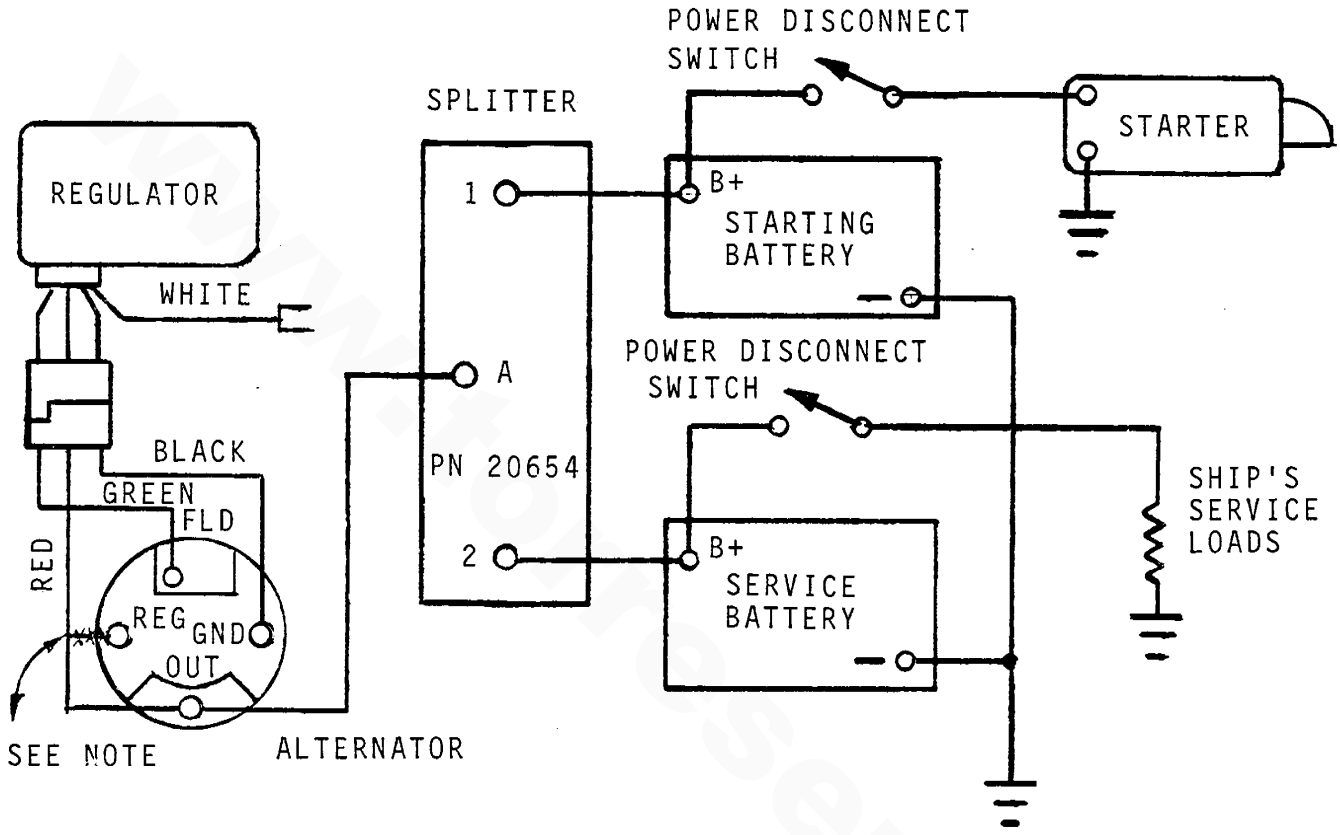
TEST INFORMATION: When the engine is not running, the side splitter terminals should read the voltage of the respective battery. The center splitter should read zero voltage.

With the engine running and alternator charging, the side splitter terminals should read the same voltage which should be the voltage of the regulator or somewhat less. The center splitter terminal should read .82 volts higher than the readings of the side terminal.

This unit is sealed for maximum life and is not repairable.

Continued.....

BYPASSING SPLITTER: In the event of failure, batteries may be charged directly from alternator by connecting either splitter terminal #1 or #2 to terminal A, bypassing the splitter itself. This should not be done simultaneously for both batteries unless they are, and will remain at, the same voltage (state of charge).



NOTE: On alternators which have an isolation diode between their output and regulator terminals, such as the Motorola units used with most WESTERBEKE engines, the regulator wire should be removed from the REG terminal and reconnected to the OUTPUT terminal as shown. The diode in the splitter will provide an equivalent voltage drop.

SERVICE BULLETIN

DATE: 4/28/76

BULLETIN NUMBER: 92

MODEL: All

SUBJECT: Troubleshooting Water Temperature and Oil Pressure Gauges

Given a presumably faulty gauge indication with the instrument panel energized, the first step is to check for 12 VDC between the ign. (B+) and neg. (B-) terminals of the gauge.

Assuming there are 12 volts as required, leave the instrument panel energized and perform the following steps:

1. Disconnect the sender wire at the gauge and see if the gauge reads zero, the normal reading for this situation.
2. Connect the sender terminal at the gauge to ground and see if the gauge reads full scale, the normal reading for this situation.

If both of the above gauge tests are positive, the gauge is undoubtedly OK and the problem lies either with the conductor from the sender to the gauge or with the sender.

If either of the above gauge tests is negative, the gauge is probably defective and should be replaced.

Assuming the gauge is OK, proceed as follows. Check the conductor from the sender to the sender terminal at the gauge for continuity.

Check that the engine block is connected to ground. Some starters have isolated ground terminals and if the battery is connected to the starter (both plus and minus), the ground side will not necessarily be connected to the block.

If the sender to gauge conductor is OK and the engine block is grounded, the sender is probably defective and should be replaced.

SERVICE BULLETIN

DATE: 12/6/83

BULLETIN NUMBER: 133

MODEL: W10Two, W13, W21, W27, W30, W33, W40, W50, W52, W58, W70, W80, W100, W120 (All Related Generators)

SUBJECT: Zinc Pencil - #11885

A zinc pencil PN 11885 is located in the sea water cooling circuit of all primary heat exchangers on the above models. The purpose of the zinc pencil is to sacrifice itself to electrolysis action taking place in the salt water cooling circuit. This zinc pencil should be periodically checked by unscrewing it from its mounting boss on the exchanger. For the location of the zinc on your model, refer to the cooling system section in your parts manual. Replace the zinc pencil as inspection dictates. (Refer to Illustration A.)

Should material be flaking off the zinc, it should be scraped clean, or be replaced by a good solid zinc pencil.

If it appears that a lot of material has been flaking off the zinc, then it is advised that the end cap of the exchanger be removed, and the flaked material be cleaned from the area of the exchanger. A new end cap gasket should be on hand in case it is needed when replacing the end cap.

Refer to Service Bulletin #84 when removing end caps made of rubber.

ILLUSTRATION A



ZINC #11885



REPLACE



CLEAN/REPLACE

(ACTUAL SIZE)

SERVICE BULLETIN

DATE: 4/3/84

BULLETIN NUMBER: 137

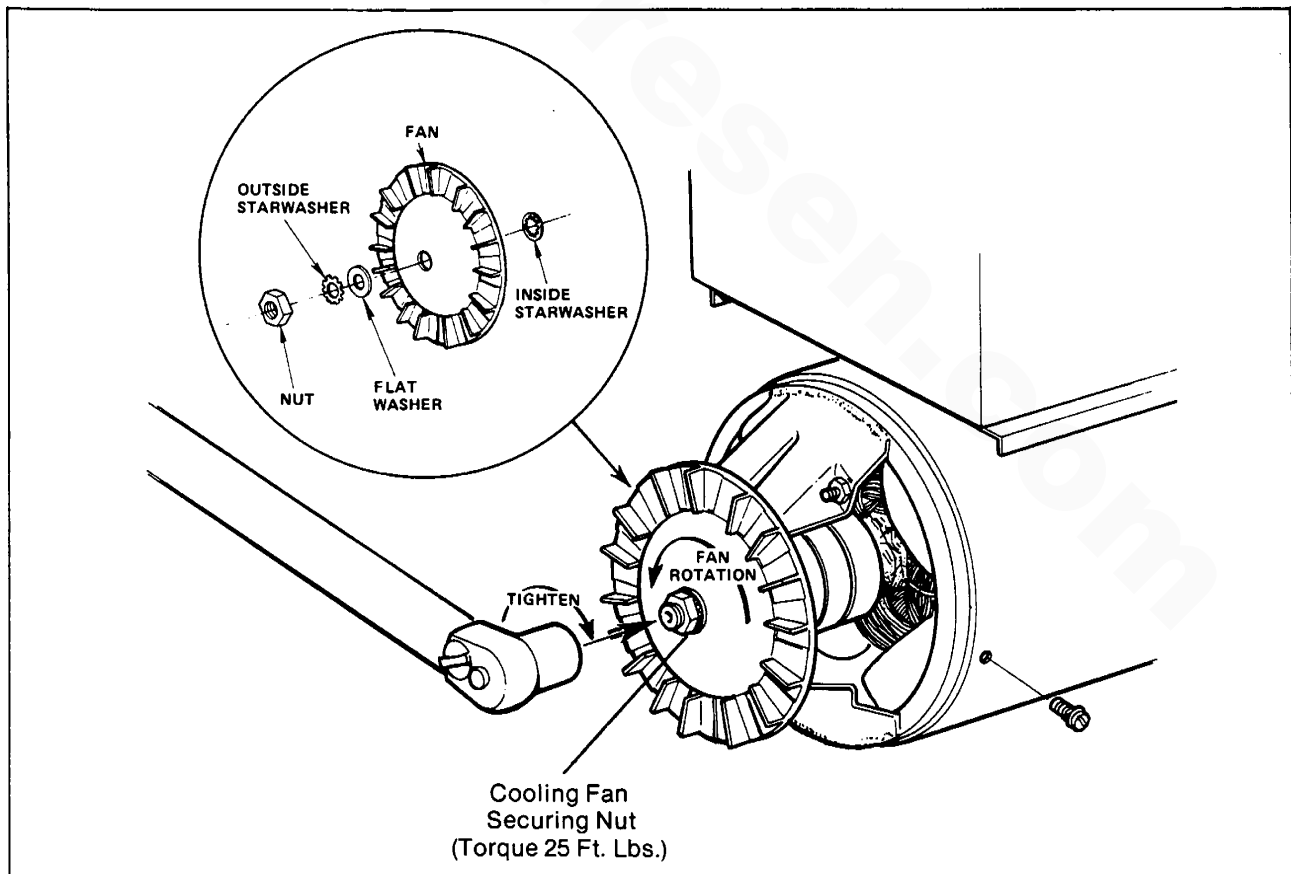
MODEL: 3KW, 4.4KW, 7.7KW, 8KW, 11KW, 12.5KW
(Also Related 50 Hertz Units)

SUBJECT: Cooling Fan Securing Nut

Generator units must have proper air circulation while running to provide for combustion air for use by the engine and for cooling the generator unit (minimum 250 C.F.M. all units through 12.5KW for generator end cooling).

The fan on the back end of the above model generators plays an important part in moving air through the generator for cooling. In installations where surrounding air is limited, outside air should be ducted to the area of the screened end bell inlet to provide this needed air for cooling, and combustion as well.

The security of the generator fan holddown nut should be checked at installation (commissioning), at the initial 50-hour servicing of the generator unit, and periodically thereafter (200 - 300 hours).



Continued.....

The cooling fan securing nut should be tight enough so that when force is applied to rotate the fan by pushing on the outer edge and blades with the palm of your hand (protect the hand with a cloth or a glove), you should be able to turn the generator and engine without the fan slipping on the shaft. If properly torqued and the fan still slips, replace the lockwashers.

Recirculation of generator cooling air through the generator must be avoided. The generator compartment ventilation must be sufficient to prevent generator air recirculation.

Insure that the screened end bell inlet and the screened discharge slots at the flywheel are not obstructed, preventing good air circulation through the generator while it is running.

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SERVICE BULLETIN

DATE: 5/25/84

BULLETIN NUMBER: 139

MODEL: All Propulsion and Generator Models

SUBJECT: Hydro-Hush Muffler Installations

The illustrations shown with this text should be used as a guide when making an installation of a Hydro-Hush Muffler.

When used in conjunction with a propulsion engine, the Hydro-Hush Muffler should be mounted close to the for-aft center line of the boat. When used with a generator unit, the muffler should be as close as possible to the generator.

All installations should be such that the entry of water into the engine exhaust manifold and cylinders is prevented while under sail and at various angles of heel, from following seas, when backing down or any other condition.

Units installed with the exhaust manifold/water injected exhaust elbow at or below the water line of the vessel must install a vent or syphon break in the sea water supply line to the water injected exhaust elbow. The sea water supply line must be looped above the water line a minimum of six inches (6") with the vent or syphon break installed at the top of this loop.

The vented loop, when used, can be a mechanical syphon break as shown in the illustration or a simple tee arrangement with a small hose or tube (3/16 - 1/4 inch I.D.) routed to the transom exhaust discharge or to a separate thru-hull fitting located above the water line. This hose or tube must be routed in such a way that it will drain of water when the engine is shut down and allow air into the sea water supply hose and injection elbow.

The syphon break or vent is installed to break the vacuum in the sea water cooling circuit and thereby discourage syphoning of sea water through this circuit, and subsequent filling of the exhaust and engine cylinders with sea water. When used, syphon breaks should be checked periodically for proper operation and should be installed in a location where, should they leak sea water, water would not leak onto the engine or its accessories.

The Hydro-Hush Muffler remains approximately 30 percent full of water after engine shutdown when there is a maximum of 48 inches of lift on the discharge side.

Continued.....

The installation information given in this text is to be used as a guide only. WESTERBEKE cannot be responsible in any way for muffler installations. WESTERBEKE presumes the installer to have a basic knowledge of marine installation requirements.

Use as few right angle fittings as possible. The use of wire reinforced hose is recommended and the hose should be routed to produce the bends needed.

The use of 90 degree and 45 degree fittings contribute to the rise of engine exhaust back pressure. (Refer to the Unit Technical Manual for back pressure specifications.)

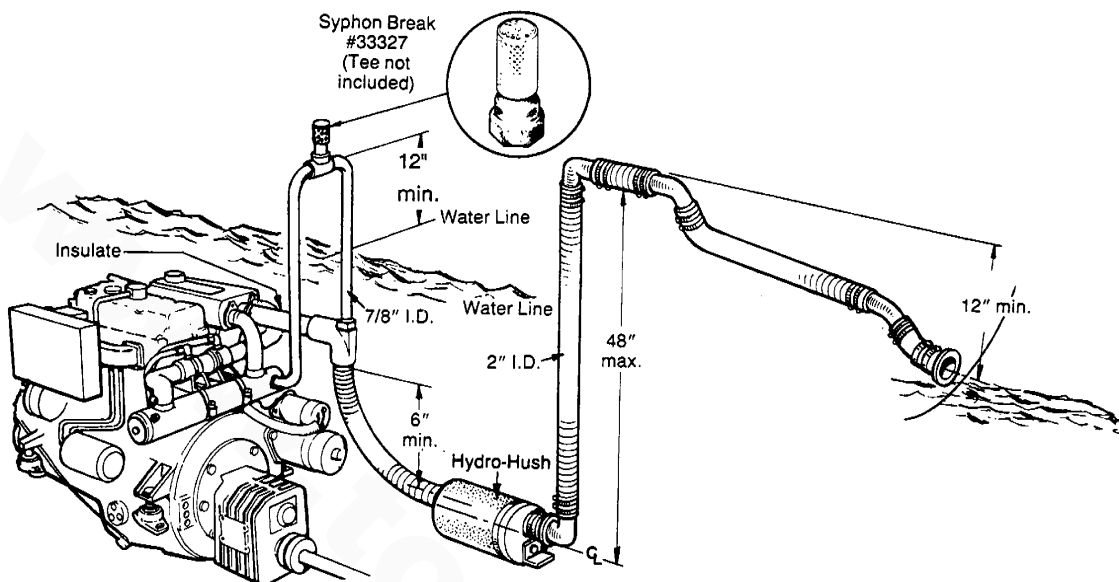
The exhaust hose diameters shown are minimums. Exhaust hose diameter for the discharge hose will have to be increased if the length of run from the Hydro-Hush Muffler to the thru-hull discharge is excessive (25 - 30 feet depending on the number of bends).

CAUTION

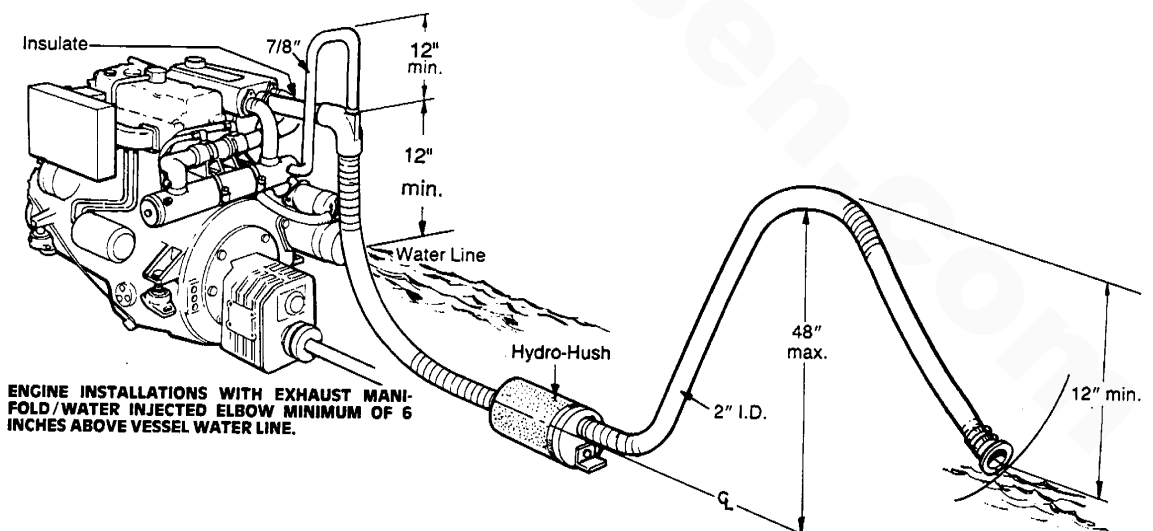
THE SEA WATER PUMP WILL CONTINUE TO FILL THE EXHAUST SYSTEM WITH SEA WATER DURING CRANKING. THE ENGINE EXHAUST PRESSURE DURING CRANKING MAY NOT BE STRONG ENOUGH TO EXPEL THE WATER FROM THE MUFFLER AND PREVENT THE SYSTEM FROM FILLING UP WITH SEA WATER AND ENTERING THE EXHAUST MANIFOLD AND CYLINDERS.

IF ENGINE CRANKING EXCEEDS 30 - 40 SECONDS APPROXIMATELY, CLOSE THE SEA WATER THRU-HULL AND OPEN IT IMMEDIATELY AFTER THE ENGINE STARTS.

ENGINE INSTALLATIONS

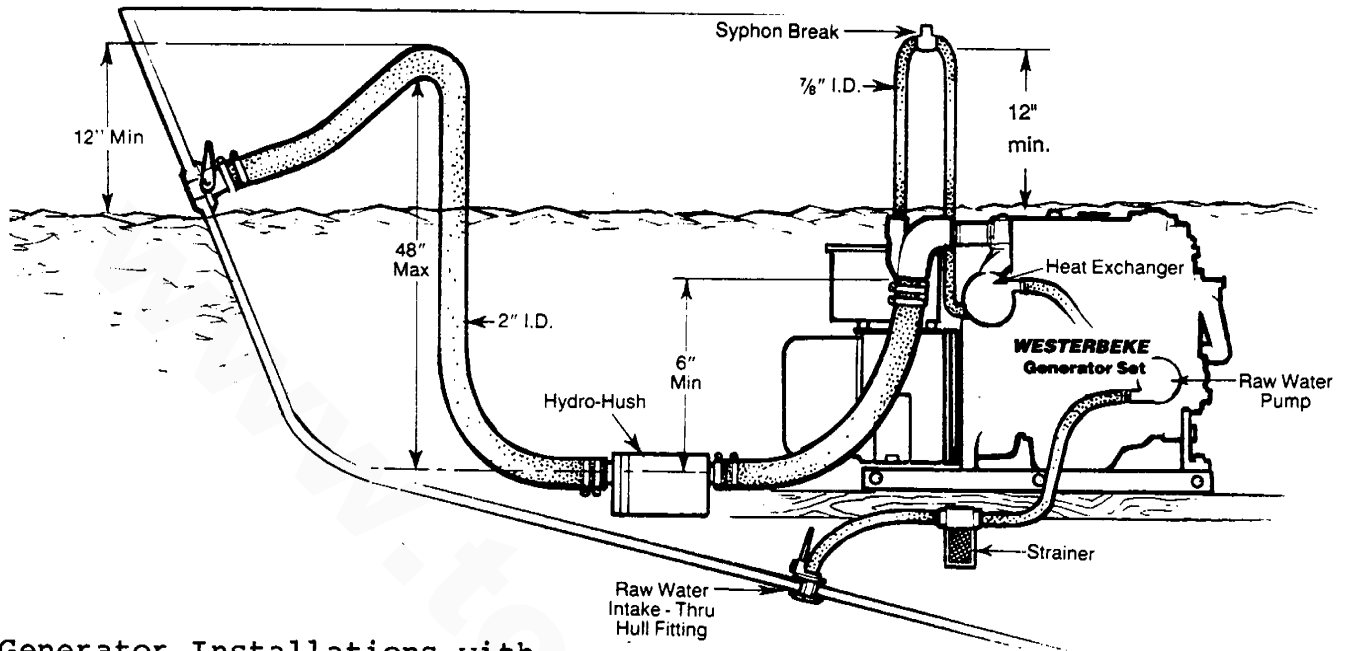


ENGINE INSTALLATIONS WITH EXHAUST MANIFOLD/WATER INJECTED ELBOW AT OR BELOW VESSEL WATER LINE

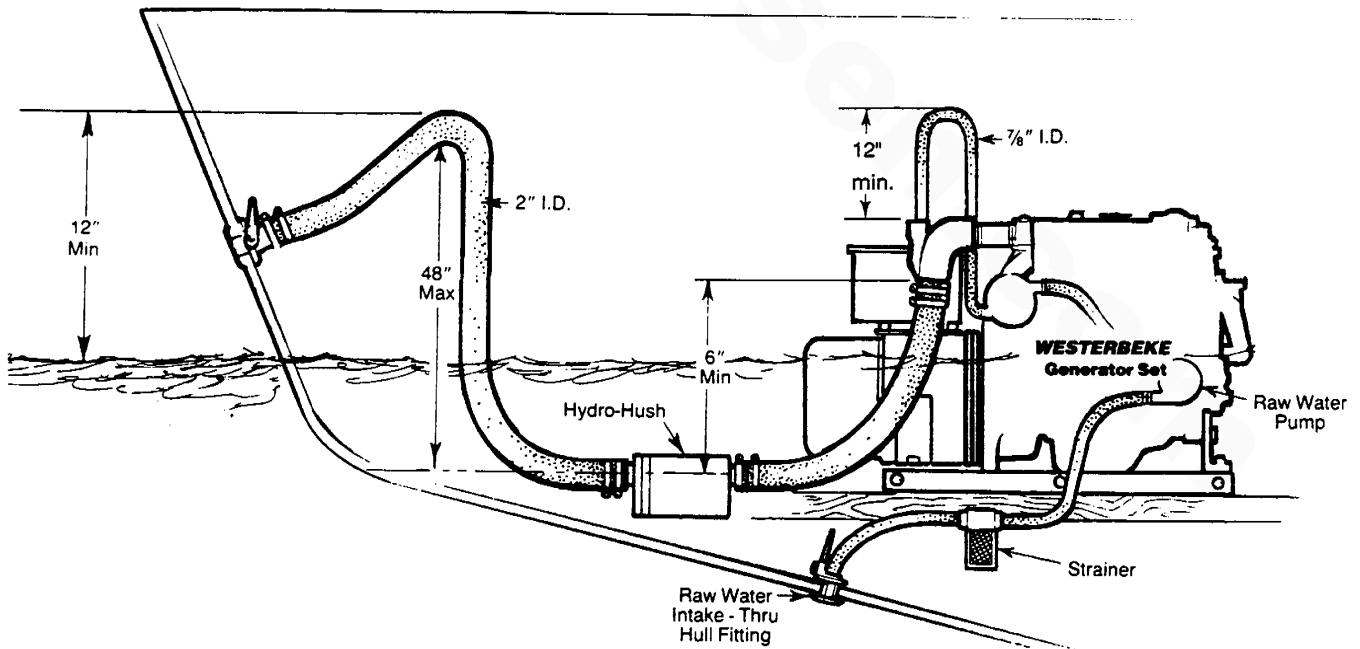


ENGINE INSTALLATIONS WITH EXHAUST MANIFOLD/WATER INJECTED ELBOW MINIMUM OF 6 INCHES ABOVE VESSEL WATER LINE.

GENERATOR INSTALLATIONS



Generator Installations with exhaust manifold/water injected elbow at or below vessel water line. Generator Below Water Line



Generator Installations with exhaust manifold/water injected elbow minimum of 6 inches above vessel water line. Generator Above Water Line

SERVICE BULLETIN

DATE: 1/17/85

BULLETIN NUMBER: 147

MODEL: W10Two, W13, W18, W21, W27, W33, W46, W52, W58, W70, W100
3KW, 4.4KW, 7.7KW, 6KW, 6.5KW, 8KW, 11KW, 12.5KW, 15KW,
20KW, 25KW, 32KW

SUBJECT: Installation - Coolant Recovery Tank Kit #24977

A coolant recovery tank kit is supplied with each Westerbeke generator (gasoline and diesel) and propulsion engine. The purpose of this recovery tank is to allow for coolant expansion and contraction during engine operation without the loss of coolant and without introducing air into the cooling system.

This coolant recovery tank should be installed in a location where it can be monitored and coolant added to it as needed. A stainless steel mounting bracket is supplied with each kit, along with a 30" length of clear plastic hose with clamps to connect between the engine manifold fitting and the hose spud on the base of the recovery tank.

The coolant recovery tank should be mounted at engine manifold level or above it, where it will be accessible for monitoring and filling.

FILLING THE ENGINE'S COOLING SYSTEM:

- A. The engine cooling system must be filled completely full and be free of all air. Pay particular attention to propulsion engines having domestic hot water heaters plumbed to the engine's fresh water cooling circuit, ensuring that that portion of the system is free of air, and engine coolant circulation is taking place through the coils of the domestic water heater.
- B. With the engine filled with coolant and free of air, the manifold pressure cap can then be installed and coolant added to the plastic recovery tank. Fill this tank so the level is between ADD and MAX. Replace the plastic cap on the recovery tank.

Coolant from the engine, when heated during engine operation, will expand and lift the spring-loaded manifold pressure cap and enter the recovery tank via the hose connecting the recovery tank to the manifold.

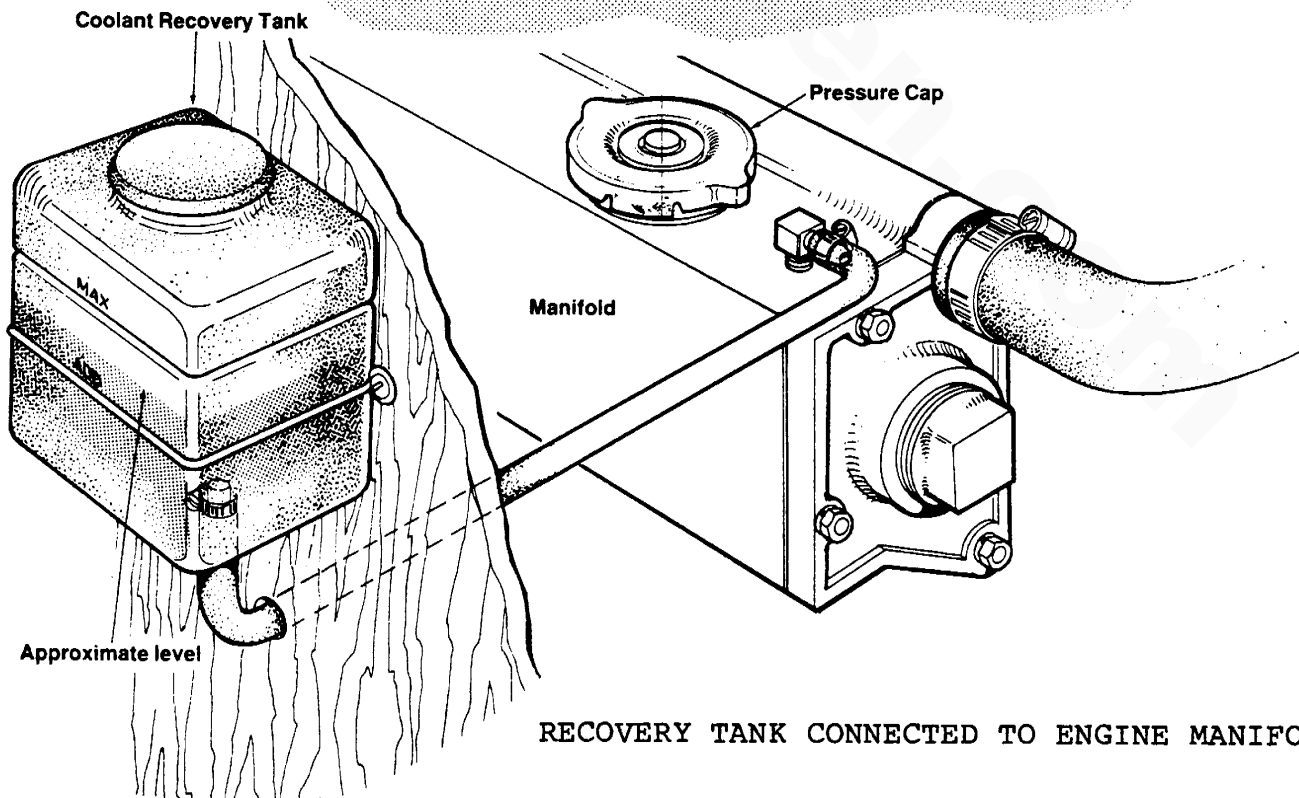
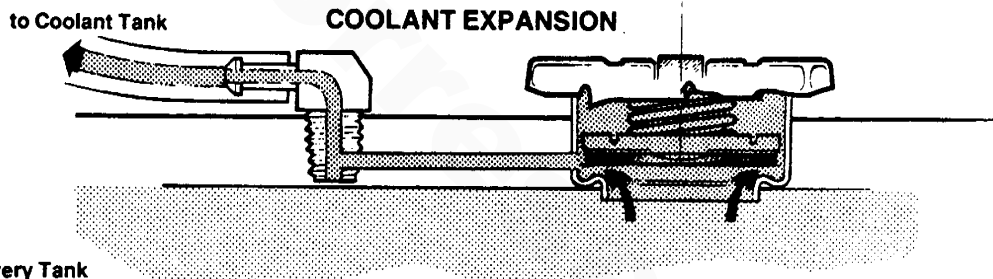
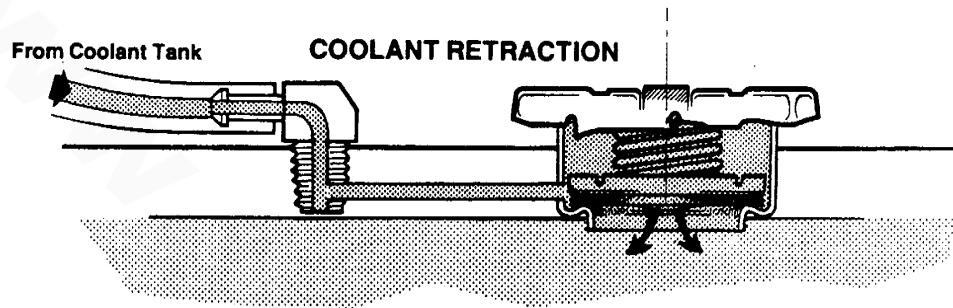
When the engine is shut down and cools, a small check valve in the pressure cap is opened by the contraction of the engine coolant, allowing some of the coolant in the recovery tank to be drawn back into the engine's cooling system free of air and without loss.

Continued.....

Propulsion engines having domestic hot water heaters plumbed to the engine's cooling system and the domestic water heater is higher than the engine manifold, require the use of our metal Remote Expansion Tank Kit #24177; then the plastic coolant recovery tank should not be used, and the hose attachment fitting on the engine tank manifold should be removed and plugged (1/8 N.P.T. Plug).

The remote expansion tank serves the engine cooling system basically in the same manner as the plastic coolant recovery tank. On a cold engine, the tank should be kept filled between 1/4 and 1/2 full.

FUNCTION OF MANIFOLD PRESSURE CAP



SERVICE BULLETIN

DATE: April 13, 1985

BULLETIN NUMBER: 153

MODEL: All Current Production Propulsion and Generator Models

SUBJECT: Check valves and Fuel Pick-up Screens

1. Fuel starvation problems have occurred, resulting from the installer placing a check valve in the fuel supply line to the engine. Check valves can restrict the engine mounted fuel pump's ability to draw fuel from the fuel tank through the check valve and any in-line filters to the engine. This results in air being drawn into the system, causing loss of engine power and/or engine stoppage.

Check valves should not be installed in the fuel supply line to the engine.

2. Fuel tank pick-up tubes have been found to randomly have fine gauze screens installed in them by the tank manufacturer. These gauze screens can clog from debris in the fuel and stop fuel flow from the tank, resulting in loss of engine power and/or engine stoppage.

If a fuel starvation problem is encountered, check fuel supply to the engine from the fuel tank and examine the pick-up tube for the presence of a gauze screen and, if present, remove it. Gauze type screens should not be installed in fuel tank pick-up tubes. Fuel filtering must be accomplished by the serviceable fuel filters/separators between the fuel tank and engine as well as by the filters in the engine mounted fuel system.

NOTE: Monitoring return fuel can give an indication of supply restriction and/or air.

Return fuel should be free of air.

SERVICE BULLETIN

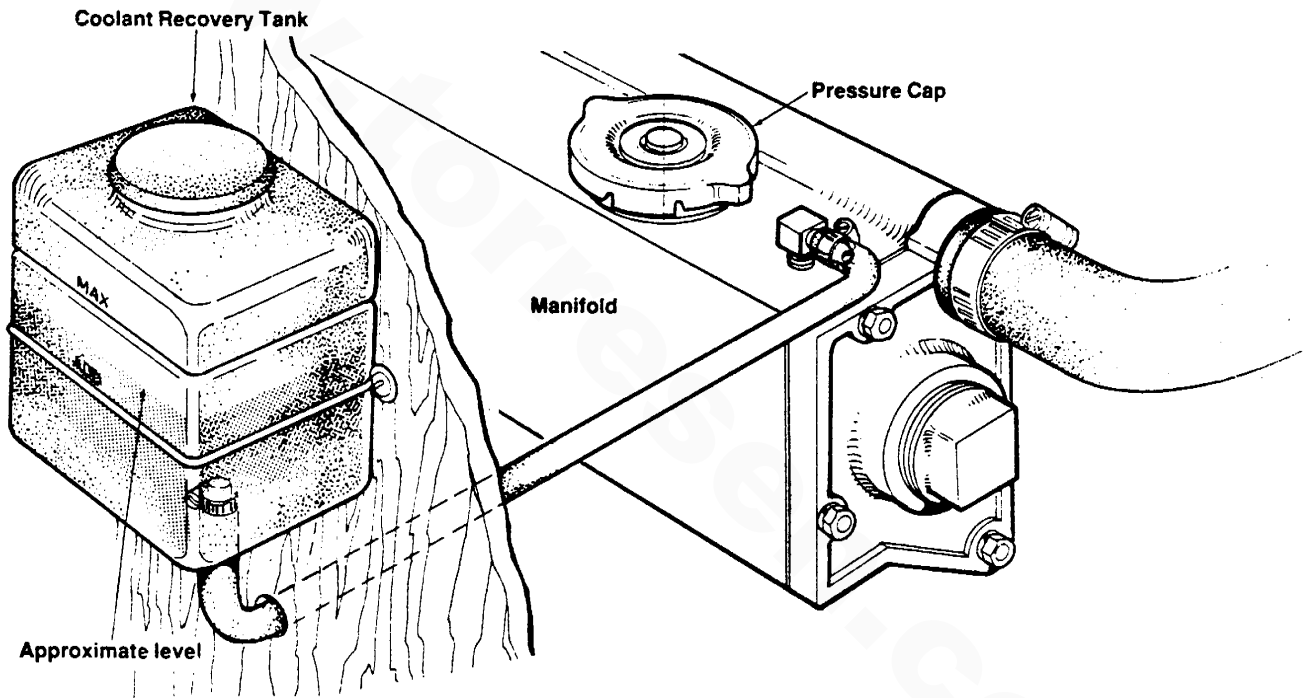
DATE: June 21, 1985

BULLETIN NUMBER: 156

MODEL: Westerbeke 6.5KW, 8.0KW and 11.0KW Gasoline Generators

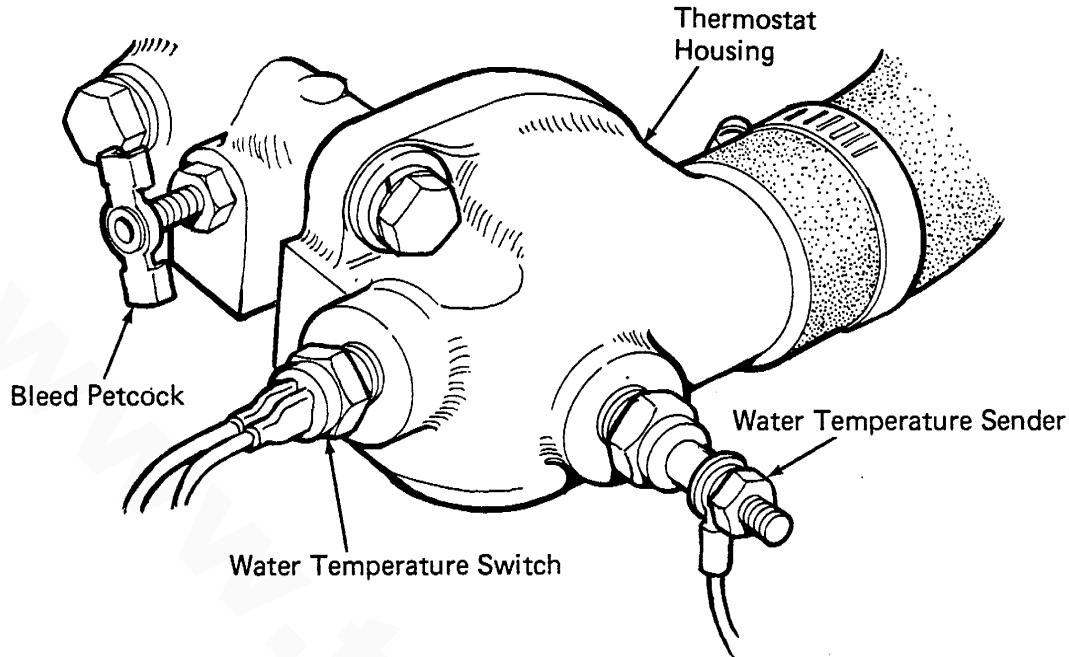
SUBJECT: Filling the Fresh Water Cooling System

1. A mixture of ethylene glycol based antifreeze and fresh water should be used in the fresh water cooling system of the 6.5KW, 8.0KW and 11.0KW gasoline generators. A 50/50 mixture of anti-freeze and fresh water is recommended in the fresh water cooling circuit. Follow the mixture directions as given by the antifreeze manufacturer.
2. Insure that the coolant recovery tank supplied with each generator is installed as shown in Service Bulletin #147.



3. Remove the pressure cap from the manifold and open the air bleed petcock located just forward of the thermostat housing which is beneath the distributor.

NOTE: On early models, a 1/8 pipe plug is used.



4. Add the antifreeze mixture at the filler neck (pressure cap) on the manifold until the mixture flows from the bleed petcock with no air, then close the petcock and continue to fill until the manifold is full.
5. Start the engine, monitor the coolant level in the manifold and add coolant to keep it full. As the engine starts to warm up, open momentarily the bleed petcock to allow any more air that has accumulated in that area to be expelled. Clean coolant should flow from the opened petcock. Add more coolant to the manifold to keep it full.
6. When the thermostat opens and flow is noted at the manifold filler neck, top off the manifold and install the pressure cap. Add antifreeze mixture to the coolant recovery tank to bring its level up to between the ADD and MAX.
7. Engine fresh water coolant level is now monitored from the recovery tank.

NOTE: Should a coolant leak develop in the engine's cooling system, the system will have to be refilled as in Steps 3 through 6 above.

SERVICE BULLETIN

DATE: January 6, 1987
MODEL: All Gasoline Models
SUBJECT: Fuel System Components

BULLETIN NUMBER: 167

Installers are advised that with the increased availability and use of butane/alcohol blended gasolines, fuel system components MUST be compatible with these types of blended gasolines. Failure to ensure compatibility will result in the component's failure and possible injury to the user.

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