Service

Marine Generator Sets

(Includes Engine Maintenance)

Models:

4EOZ

3.5EFOZ

ISO 9001 KOHLER POWER SYSTEMS NATIONALLY REGISTERED

KOHLER® POWER SYSTEMS

TP-6137 5/03

Product Identification Information

Product identification numbers determine service parts. Record the product identification numbers in the spaces below immediately after unpacking the products so that the numbers are readily available for future reference. Record field-installed kit numbers after installing the kits.

Generator Set Identification Numbers

Record the product identification numbers from the generator set nameplate(s).

Model Designation _____

Specification Number _____

Serial Number _____

Accessory Number	Accessory Description

Engine Identification

Record the product identification information from the engine nameplate.

Manufacturer _____

Model Designation _____

Serial Number _____

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Table of Contents

IMPORTANT SAFETY INSTRUCTIONS. Electromechanical equipment, including generator sets, transfer switches, switchgear, and accessories, can cause bodily harm and pose life-threatening danger when improperly installed, operated, or maintained. To prevent accidents be aware of potential dangers and act safely. Read and follow all safety precautions and instructions. SAVE THESE INSTRUCTIONS.

This manual has several types of safety precautions and instructions: Danger, Warning, Caution, and Notice.

DANGER

Danger indicates the presence of a hazard that ***will cause severe personal injury, death***, or ***substantial property damage***.

WARNING

Warning indicates the presence of a hazard that ***can cause severe personal injury, death,*** or ***substantial property damage***.

CAUTION

Caution indicates the presence of a hazard that ***will*** or ***can cause minor personal injury*** or ***property damage***.

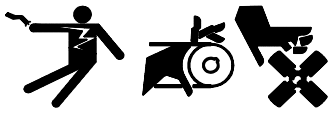
NOTICE

Notice communicates installation, operation, or maintenance information that is safety related but not hazard related.

Safety decals affixed to the equipment in prominent places alert the operator or service technician to potential hazards and explain how to act safely. The decals are shown throughout this publication to improve operator recognition. Replace missing or damaged decals.

Accidental Starting

WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set on/off button to shut down the generator set. All indicator lamps dim. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

Battery

WARNING

Sulfuric acid in batteries.
Can cause severe injury or death.

Wear protective goggles and clothing. Battery acid may cause blindness and burn skin.

Battery electrolyte is a diluted sulfuric acid. Battery acid can cause severe injury or death. Battery acid can cause blindness and burn skin. Always wear splashproof safety goggles, rubber gloves, and boots when servicing the battery. Do not open a sealed battery or mutilate the battery case. If battery acid splashes in the eyes or on the skin, immediately flush the affected area for 15 minutes with large quantities of clean water. Seek immediate medical aid in the case of eye contact. Never add acid to a battery after placing the battery in service, as this may result in hazardous spattering of battery acid.

Battery acid cleanup. Battery acid can cause severe injury or death. Battery acid is electrically conductive and corrosive. Add 500 g (1 lb.) of bicarbonate of soda (baking soda) to a container with 4 L (1 gal.) of water and mix the neutralizing solution. Pour the neutralizing solution on the spilled battery acid and continue to add the neutralizing solution to the spilled battery acid until all evidence of a chemical reaction (foaming) has ceased. Flush the resulting liquid with water and dry the area.

Battery gases. Explosion can cause severe injury or death. Battery gases can cause an explosion. Do not smoke or permit flames or sparks to occur near a battery at any time, particularly when it is charging. Do not dispose of a battery in a fire. To prevent burns and sparks that could cause an explosion, avoid touching the battery terminals with tools or other metal objects. Remove all jewelry before servicing the equipment. Discharge static electricity from your body before touching batteries by first touching a grounded metal surface away from the battery. To avoid sparks, do not disturb the battery charger connections while the battery is charging. Always turn the battery charger off before disconnecting the battery connections. Ventilate the compartments containing batteries to prevent accumulation of explosive gases.

Battery short circuits. Explosion can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Disconnect the battery before generator set installation or maintenance. Remove all jewelry before servicing the equipment. Use tools with insulated handles. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery. Never connect the negative (-) battery cable to the positive (+) connection terminal of the starter solenoid. Do not test the battery condition by shorting the terminals together.

Engine Backfire/Flash Fire

⚠ WARNING

Fire.
Can cause severe injury or death.

Do not smoke or permit flames or sparks near fuels or the fuel system.

Servicing the fuel system. A flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the carburetor, fuel line, fuel filter, fuel pump, or other potential sources of spilled fuels or fuel vapors. Catch fuels in an approved container when removing the fuel line or carburetor.

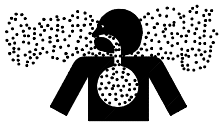
Servicing the air cleaner. A sudden backfire can cause severe injury or death. Do not operate the generator set with the air cleaner/silencer removed.

Combustible materials. A sudden flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the fuel system. Keep the compartment and the generator set clean and free of debris to minimize the risk of fire. Wipe up spilled fuels and engine oil.

Combustible materials. A fire can cause severe injury or death. Generator set engine fuels and fuel vapors are flammable and explosive. Handle these materials carefully to minimize the risk of fire or explosion. Equip the compartment or nearby area with a fully charged fire extinguisher. Select a fire extinguisher rated ABC or BC for electrical fires or as recommended by the local fire code or an authorized agency. Train all personnel on fire extinguisher operation and fire prevention procedures.

Exhaust System

⚠ WARNING



Carbon monoxide.
Can cause severe nausea, fainting, or death.

The exhaust system must be leakproof and routinely inspected.

Carbon monoxide symptoms. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is a poisonous gas present in exhaust gases. Carbon monoxide poisoning symptoms include but are not limited to the following:

- Light-headedness, dizziness
- Physical fatigue, weakness in joints and muscles
- Sleepiness, mental fatigue, inability to concentrate or speak clearly, blurred vision
- Stomachache, vomiting, nausea

If experiencing any of these symptoms and carbon monoxide poisoning is possible, seek fresh air immediately and remain active. Do not sit, lie down, or fall asleep. Alert others to the possibility of carbon monoxide poisoning. Seek medical attention if the condition of affected persons does not improve within minutes of breathing fresh air.

Copper tubing exhaust systems. Carbon monoxide can cause severe nausea, fainting, or death. Do not use copper tubing in diesel exhaust systems. Sulfur in diesel exhaust causes rapid deterioration of copper tubing exhaust systems, resulting in exhaust/water leakage.

Inspecting the exhaust system. Carbon monoxide can cause severe nausea, fainting, or death. For the safety of the craft's occupants, install a carbon monoxide detector. Consult the boat builder or dealer for approved detector location and installation. Inspect the detector before each generator set use. In addition to routine exhaust system inspection, test the carbon monoxide detector per the manufacturer's instructions and keep the detector operational at all times.

Operating the generator set. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Use the following precautions when installing and operating the generator set. Do not install the exhaust outlet where exhaust can be drawn in through portholes, vents, or air conditioners. If the generator set exhaust discharge outlet is near the waterline, water could enter the exhaust discharge outlet and close or restrict the flow of exhaust. Never operate the generator set without a functioning carbon monoxide detector. Be especially careful if operating the generator set when moored or anchored under calm conditions because gases may accumulate. If operating the generator set dockside, moor the craft so that the exhaust discharges on the lee side (the side sheltered from the wind). Always be aware of others, making sure your exhaust is directed away from other boats and buildings. Avoid overloading the craft.

Fuel System

⚠ WARNING

Explosive fuel vapors.
Can cause severe injury or death.

Use extreme care when handling, storing, and using fuels.

The fuel system. Explosive fuel vapors can cause severe injury or death. Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

Draining the fuel system. Explosive fuel vapors can cause severe injury or death. Spilled fuel can cause an explosion. Use a container to catch fuel when draining the fuel system. Wipe up spilled fuel after draining the system.

Installing the fuel system. Explosive fuel vapors can cause severe injury or death. Fuel leakage can cause an explosion. Do not modify the tank or the propulsion engine fuel system. Equip the craft with a tank that allows one of the two pickup arrangements described in the installation section. The tank and installation must conform to USCG Regulations.

Pipe sealant. Explosive fuel vapors can cause severe injury or death. Fuel leakage can cause an explosion. Use pipe sealant on all threaded fittings to prevent fuel leakage. Use pipe sealant that resists gasoline, grease, lubrication oil, common bilge solvents, salt deposits, and water.

Ignition-protected equipment. Explosive fuel vapors can cause severe injury or death. Gasoline vapors can cause an explosion. USCG Regulation 33CFR183 requires that all electrical devices (ship-to-shore transfer switch, remote start panel, etc.) must be ignition protected when used in a gasoline and gaseous-fueled environment. The electrical devices listed above are not ignition protected and are not certified to operate in a gasoline and gaseous-fueled environment such as an engine room or near fuel tanks. Acceptable locations are the wheelhouse and other living areas sheltered from rain and water splash.

Hazardous Noise

⚠ CAUTION

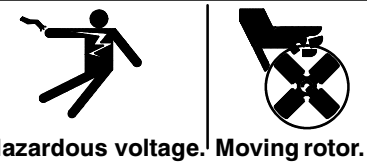
Hazardous noise.
Can cause hearing loss.

Never operate the generator set without a muffler or with a faulty exhaust system.

Engine noise. Hazardous noise can cause hearing loss. Generator sets not equipped with sound enclosures can produce noise levels greater than 105 dBA. Prolonged exposure to noise levels greater than 85 dBA can cause permanent hearing loss. Wear hearing protection when near an operating generator set.

Hazardous Voltage/ Electrical Shock

⚠ WARNING



Hazardous voltage. Moving rotor.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Open the main circuit breakers of all power sources before servicing the equipment. Configure the installation to electrically ground the generator set, transfer switch, and related equipment and electrical circuits to comply with applicable codes and standards. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Disconnecting the electrical load. Hazardous voltage can cause severe injury or death. Disconnect the generator set from the load by opening the line circuit breaker or by disconnecting the generator set output leads from the transfer switch and heavily taping the ends of the leads. High voltage transferred to the load during testing may cause personal injury and equipment damage. Do not use the safeguard circuit breaker in place of the line circuit breaker. The safeguard circuit breaker does not disconnect the generator set from the load.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

Handling the capacitor. Hazardous voltage can cause severe injury or death. Electrical shock results from touching the charged capacitor terminals. Discharge the capacitor by shorting the terminals together. *(Capacitor-excited models only)*

Electrical backfeed to the utility. Hazardous backfeed voltage can cause severe injury or death. Connect the generator set to the building/marina electrical system only through an approved device and after the building/marina main switch is opened. Backfeed connections can cause severe injury or death to utility personnel working on power lines and/or personnel near the work area. Some states and localities prohibit unauthorized connection to the utility electrical system. Install a ship-to-shore transfer switch to prevent interconnection of the generator set power and shore power.

Testing live electrical circuits. Hazardous voltage or current can cause severe injury or death. Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment manufacturer when performing voltage tests. Observe the following precautions when performing voltage tests: (1) Remove all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Do not touch the enclosure or components inside the enclosure. (4) Be prepared for the system to operate automatically. *(600 volts and under)*

Hot Parts

⚠ WARNING

Hot engine and exhaust system. Can cause severe injury or death.

Do not work on the generator set until it cools.

Servicing the exhaust system. Hot parts can cause severe injury or death. Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

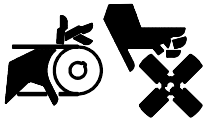
Moving Parts

⚠ WARNING


Hazardous voltage. Moving rotor. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

⚠ WARNING



Rotating parts. Can cause severe injury or death.

Operate the generator set only when all guards, screens, and covers are in place.

⚠ WARNING

Airborne particles. Can cause severe injury or blindness.

Wear protective goggles and clothing when using power tools, hand tools, or compressed air.

Tightening the hardware. Flying projectiles can cause severe injury or death. Loose hardware can cause the hardware or pulley to release from the generator set engine and can cause personal injury. Retorque all crankshaft and rotor hardware after servicing. Do not loosen the crankshaft hardware or rotor thrubolt when making adjustments or servicing the generator set. Rotate the crankshaft manually in a clockwise direction only. Turning the crankshaft bolt or rotor thrubolt counterclockwise can loosen the hardware.

Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

Sound shield removal. Exposed moving parts can cause severe injury or death. The generator set must be operating in order to perform some scheduled maintenance procedures. Be especially careful if the sound shield has been removed, leaving the belts and pulleys exposed. *(Sound-shield-equipped models only)*

Notice

NOTICE

This generator set has been rewired from its nameplate voltage to

246242

NOTICE

Voltage reconnection. Affix a notice to the generator set after reconnecting the set to a voltage different from the voltage on the nameplate. Order voltage reconnection decal 246242 from an authorized service distributor/dealer.

NOTICE

Hardware damage. The engine and generator set may use both American Standard and metric hardware. Use the correct size tools to prevent rounding of the bolt heads and nuts.

NOTICE

When replacing hardware, do not substitute with inferior grade hardware. Screws and nuts are available in different hardness ratings. To indicate hardness, American Standard hardware uses a series of markings, and metric hardware uses a numeric system. Check the markings on the bolt heads and nuts for identification.

NOTICE

Fuse replacement. Replace fuses with fuses of the same ampere rating and type (for example: 3AB or 314, ceramic). Do not substitute clear glass-type fuses for ceramic fuses. Refer to the wiring diagram when the ampere rating is unknown or questionable.

NOTICE

Saltwater damage. Saltwater quickly deteriorates metals. Wipe up saltwater on and around the generator set and remove salt deposits from metal surfaces.

Notes

Introduction

This manual provides troubleshooting and repair instructions for 4EOZ/3.5EFOZ model generator sets.

Refer to the engine service manual for generator set engine service information.

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This manual may be used for models not listed on the front cover.

Information in this publication represents data available at the time of print. Kohler Co. reserves the right to change this publication and the products represented without notice and without any obligation or liability whatsoever.

Read this manual and carefully follow all procedures and safety precautions to ensure proper equipment operation and to avoid bodily injury. Read and follow the Safety Precautions and Instructions section at the beginning of this manual. Keep this manual with the equipment for future reference.

The equipment service requirements are important for safe and efficient operation. Inspect the parts often and perform required service at the prescribed intervals. Maintenance work must be performed by appropriately skilled and suitably-trained maintenance personnel familiar with generator set operation and service.

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Service Assistance

For professional advice on generator power requirements and conscientious service, please contact your nearest Kohler distributor or dealer.

- Consult the Yellow Pages under the heading Generators—Electric
- Visit the Kohler Power Systems website at KohlerPowerSystems.com
- Look at the labels and stickers on your Kohler product or review the appropriate literature or documents included with the product
- Call toll free in the US and Canada 1-800-544-2444
- Outside the US and Canada, call the nearest regional office

Africa, Europe, Middle East
London Regional Office
Langley, Slough, England
Phone: (44) 1753-580-771
Fax: (44) 1753-580-036

Asia Pacific
Power Systems Asia Pacific Regional Office
Singapore, Republic of Singapore
Phone: (65) 264-6422
Fax: (65) 264-6455

China
North China Regional Office, Beijing
Phone: (86) 10 6518 7950
(86) 10 6518 7951
(86) 10 6518 7952
Fax: (86) 10 6518 7955

East China Regional Office, Shanghai
Phone: (86) 21 6288 0500
Fax: (86) 21 6288 0550

India, Bangladesh, Sri Lanka
India Regional Office
Bangalore, India
Phone: (91) 80 3366208
(91) 80 3366231
Fax: (91) 80 3315972

Japan, Korea
North Asia Regional Office
Tokyo, Japan
Phone: (813) 3440-4515
Fax: (813) 3440-2727

Latin America
Latin America Regional Office
Lakeland, Florida, USA
Phone: (863) 619-7568
Fax: (863) 701-7131

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Notes

1.1 General

This manual covers the operation, maintenance, troubleshooting, and repair of the alternating current marine generator sets.

Have an authorized service dealer/distributor perform required servicing to assure your unit continues to meet USCG requirements.

Please take a few moments to read this manual, then carefully follow all service recommendations. Keep this manual aboard your craft for future reference. See Figure 1-1 for identification and location of components.

Your craft is equipped with a dependable 120 volt (60 Hz) or 230 volt (50 Hz), single phase, alternating current generator set.

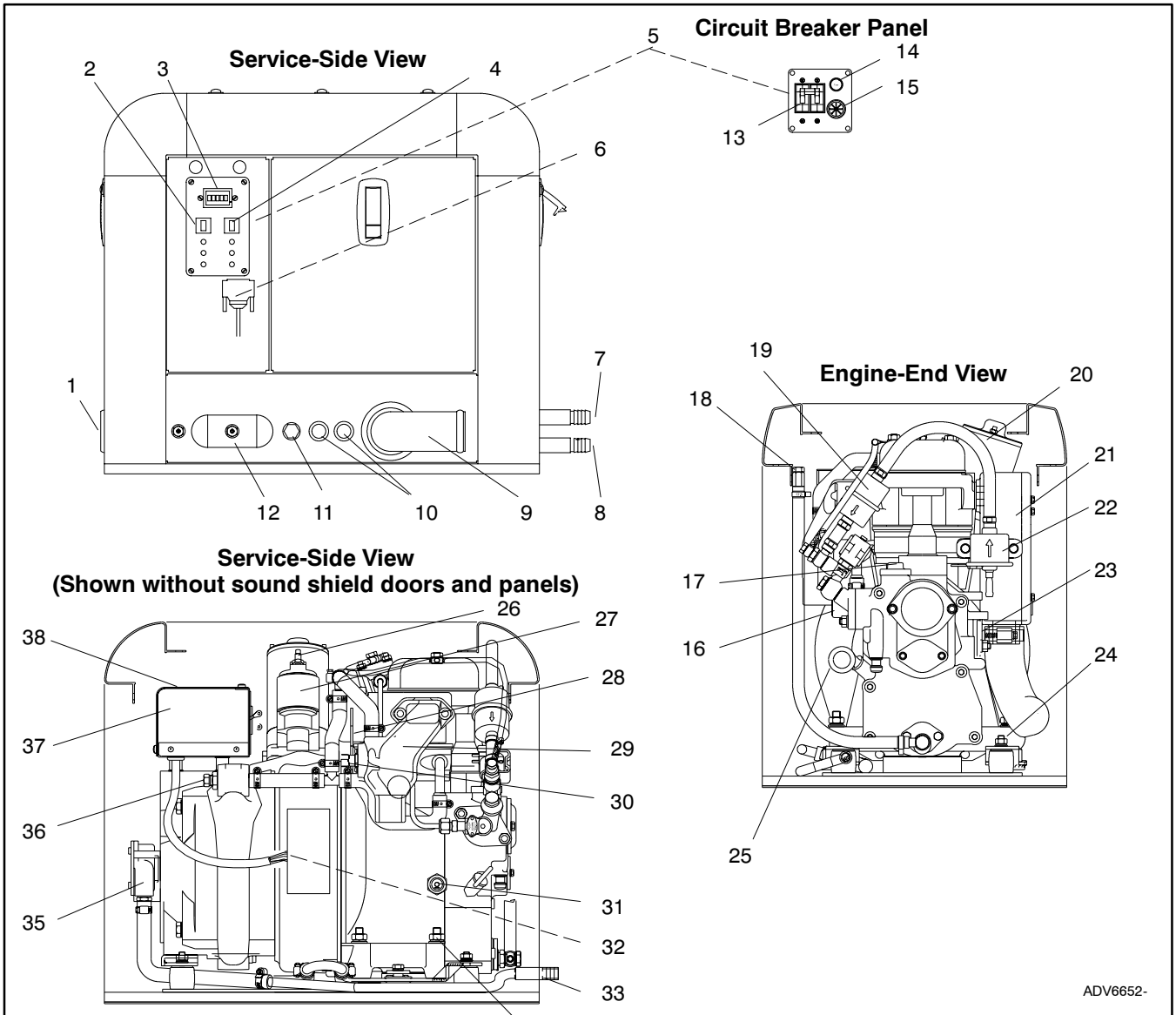
The 4EOZ/3.5EFOZ models are powered by a Farymann one-cylinder, direct water-cooled, four-cycle diesel engine.

Kohler Co. develops all Kohler® marine generator set ratings using accepted reference conditions of 25°C (77°F) and pressure of 98.9 kPa (29.2 in. Hg) dry barometer. ISO 3046 and ISO 8528-1 include reference conditions and output calculations. Obtain technical information bulletin (TIB-101) on ratings guidelines for complete ratings definitions.

1.2 Generator

Generator Model	**4EOZ**	**3.5EFOZ**
Dimensions, mm (in.)		
Length	560 (22.05)	
Width	390 (15.35)	
Height	490 (19.29)	
Weight, kg (lbs.)	209.5 (95.0)	
Air requirements—combustion, L/min. (cfm)	436 (15.4)	363 (12.8)
Fuel consumption, Lph. (gph) at % load		
25%	0.64 (0.17)	0.60 (0.16)
50%	1.02 (0.27)	0.96 (0.25)
75%	1.36 (0.36)	1.28 (0.34)
100%	1.70 (0.45)	1.60 (0.42)
Generator type	2 pole, rotating field	
Coupling type	Tapered hub	
Excitation type	Brushless exciter	
Shaft RPM	3600	3000
Number of output leads	4	2
Voltage regulation model	Capacitor type	
Voltage regulation	±5 %	
Frequency regulation	±3 %	
Voltage	120	230
Amps @ 25 °C (77 °F)	29.2/14.6	13.9
kW/kVA @ 25 °C (77 °F)	3.5	3.2
Phase (Hz)	1 (60 Hz)	1 (50 Hz)
Cold main field (rotor) resistance (ohms)	2.57	
Cold stator resistance (ohms)		
1-2	0.96	1.23
3-4	0.96	-
C1-C2	2.32	2.87
10-11	0.068	0.091

1.3 Service Views



1. Cooling air inlet
2. On/off button
3. Hourmeter
4. Start button
5. Circuit breaker panel
6. Remote panel connector
7. Fuel inlet
8. Fuel return
9. Water outlet/exhaust outlet
10. Siphon break connection
11. Customer load lead access
12. Remote panel harness access
13. AC circuit breaker
14. Input fuse
15. Customer load lead access connection
16. Fuel injection pump
17. Oil fill
18. Oil drain valve and hose
19. Fuel filter
20. High engine water temperature safety shutdown switch
21. Air cleaner
22. Fuel feed pump
23. Governor
24. Battery connection (-)
25. Oil check
26. Battery connection (+)
27. Starter solenoid/starter motor
28. Lifting eye
29. Mixing elbow
30. High exhaust temperature safety shutdown switch
31. Low oil pressure safety shutdown switch
32. Control panel connector
33. Seawater inlet
34. Ground lug (equipment ground)
35. Seawater pump (water inlet)
36. Anticorrosion zinc anode
37. Controller
38. Nameplate

Figure 1-1 Service Views

1.4 Engine

Generator Model	4EOZ	3.5EFOZ
Engine manufacturer	Farymann Diesel	
Engine model	18 W	
Number of cylinders	1	
Cylinder block material	Cast iron	
Cylinder head material	Cast iron	
Piston rings	2 compression/1 oil	
Crankshaft material	Stamped forging	
Connecting rod material	Aluminum	
Governor	Centrifugal, mechanical	
Bore x stroke, mm (in.)	82 x 55 (3.23 x 2.17)	
Displacement, L (cu. in.)	0.29 (17.7)	
Compression ratio	20:1	
Horsepower, 60/50 Hz	5.9	5.6
RPM, 60/50 Hz	3600	3000
Direction of rotation (as viewed from generator end)	Counterclockwise	
Lubrication system	Pressure, trochoid pump	
Lube oil capacity w/filter, L (qts.)	1.25 (1.32)	
Oil recommendation, API	CD, CD/CC, or CC	
Fuel injection timing (BTDC)	22°–22.5°	17°–18.5°
Fuel injection pressure, bar (psi)	200 (2900)	
Combustion system	Direct injection	
Battery voltage	12 volt, negative ground	
Battery recommendation, min.	500 CCA, 100 amp hr.	
Battery charging (alternator)	15 amps @ 12 volts	
Fuel recommendation	Diesel, DIN 51601 (ASTM D 975–67 ID + 2D/BS 2869 1967 A1 + A2)	
Fuel shutoff solenoid system	Electric	
Fuel feed pump	Electric, solenoid type	
Fuel pump priming	Electric	
Max. recommended fuel pump lift, m (ft.)	0.9 (3)	
Thermostat, freshwater/seawater	75°C (167°F)/50°C (122°F)	
Starter motor	12 volt	
Intake/exhaust valve clearance (cold), mm (in.)	0.2 (0.008)	
Inlet water line hose ID (seawater pump inlet), mm (in.)	16 (5/8)	
Outlet water line hose ID (mixing elbow outlet), mm (in.)	51 (2.0)	
Fuel inlet (fuel pump inlet)	1/4 NPT	
Fuel return size type	1/4 NPT	

1.5 Torque Specifications

Torque Specifications—Nm (ft. lbs.)	4EOZ/3.5EFOZ
Cylinder head nuts	30–33 (22–24.5)
Connecting rod nuts	30–33 (22–24.5)
Valve cover nuts	8–12 (6–9)
Main bearing plate nuts	30–33 (22–24.5)
Fuel pump nuts	30–33 (22–24.5)
Delivery valve holder–fuel pump	34–39 (25–29)
High pressure fuel pipe nut–fuel pump	18–22 (13.5–16)
High pressure fuel pipe nut–injector	25–30 (18.5–22)
Injector clamp nuts	8–12 (6–9)
Governor on crankshaft	55–60 (40.5–44.5)
Flywheel nut	216–226 (159.5–166.5)
Gear cover screws	34–38 (25–28)
Tappet block screws	8–10 (6–7.5)
Oil pump screws	16–20 (12–15)
Oil cooler screws	9–11 (6.5–8)
Banjo bolt on fuel pump	25–35 (18.5–26)
Body–injector nut	25–30 (18.5–22)
Starter screws	20 (15)
Flywheel/rotor hub nuts	25 (18.5)
Nut fixing the rotor	25 (18.5)
Stator screws	30 (22)
Alternator bracket screws	50 (37)
Engine bracket screws	50 (37)

2.1 Prestart Checklist

To ensure continued satisfactory operation perform the following checks or inspections before or at each startup, as designated, and at the intervals specified in the service schedule. In addition, some checks require verification after the unit starts.

Air Inlets. Check for clean and unobstructed air inlets.

Air Shrouding. Check for securely installed and positioned air shrouding.

Battery. Check for tight battery connections. Consult the battery manufacturer's instructions regarding battery care and maintenance.

Exhaust System. Check for exhaust leaks and blockages. Check the silencer and piping condition and check for tight exhaust system connections.

Inspect the exhaust system components (exhaust manifold, mixing elbow, exhaust line, hose clamps, silencer, and outlet flapper) for cracks, leaks, and corrosion.

- Check the hoses for softness, cracks, leaks, or dents. Replace the hoses as needed.
- Check for corroded or broken metal parts and replace them as needed.
- Check for loose, corroded, or missing clamps. Tighten or replace the hose clamps and/or hangers as needed.
- Check that the exhaust outlet is unobstructed.
- Visually inspect for exhaust leaks *(blowby)*. Check for carbon or soot residue on exhaust components. Carbon and soot residue indicates an exhaust leak. Seal leaks as needed.
- Ensure that the carbon monoxide detector(s) is (1) in the craft, (2) functional, and (3) energized whenever the generator set operates.

Note: Never operate the generator set without a functioning carbon monoxide detector.

Fuel Level. Check the fuel level and keep the tank(s) full to ensure adequate fuel supply.

Oil Level. Maintain the oil level at or near, not over, the full mark on the dipstick.

Operating Area. Check for obstructions that could block the flow of cooling air. Keep the air intake area clean. Do not leave rags, tools, or debris on or near the generator set.

Seawater Pump Priming. Prime the seawater pump before initial startup. To prime the pump: (1) close the seacock, (2) remove the hose from the water-filter outlet, (3) fill the hose and seawater pump with clean water, (4) reconnect the hose to the water filter outlet, and (5) open the seacock. Confirm seawater pump operation on startup as indicated by water discharge from the exhaust outlet.

2.2 Marine Inspection

Kohler Co. recommends that all boat owners have their vessels—especially the exhaust system attached to the generator set—inspected at the start of each boating season by the local Coast Guard Auxiliary. If there is no Coast Guard Auxiliary in the area, contact an authorized Kohler distributor/dealer for the inspection.

2.3 Angular Operation

See Figure 2-1 for angular operation limits for units covered in this manual.

Continuous	Intermittent— 3 minutes or less
25°	30°
Maximum value for all directions	

Figure 2-1 Angular Operation

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2.4 Operation in European Union Member Countries

This generator set is specifically intended and approved for operation below the deck in the engine compartment. Operation above the deck and/or outdoors would constitute a violation of European Union Directive 2000/14/EC noise emission standard.

2.5 Exercising the Generator Set

Operate the generator set under load once each week for one hour with an operator present.

The operator should perform all of the prestart checks before starting the exercise procedure. Start the generator set according to the starting procedure in the controller section of this manual. While the generator set is operating, listen for a smooth-running engine and visually inspect the generator set for fluid or exhaust leaks.

x:op:001:005

2.6 Starting and Stopping Procedure

Note: Opening seacock. Before starting the generator set, open the seacock to allow cooling water passage. Failure to do so could damage the seawater pump impeller and cause serious engine overheating damage.

Note: Transfer switch. Check that the marine ship-to-shore transfer switch, if equipped, is in the ship position.

Note: Close seacock if engine fails to start. If the engine fails to start after the first attempt, close the seacock before the next starting attempt. Failure to close the seacock may cause seawater to enter the exhaust piping, silencer, and/or engine. A water-filled exhaust piping and silencer may further hinder generator starting and cause seawater entry into the engine cylinder through the exhaust valve. Water ingested into the engine may cause major engine damage that the Kohler Co. warranty does not cover.

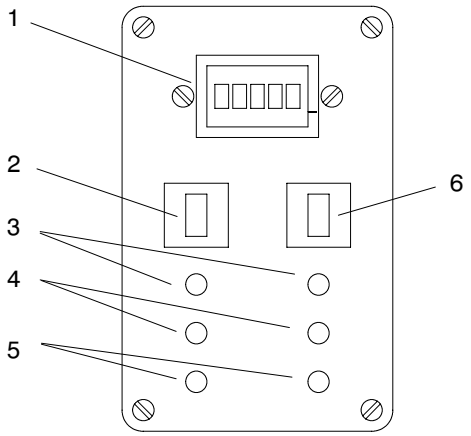
Note: Close seacock if water enters the exhaust system. If water enters the exhaust system, close the seacock and drain the water from the exhaust system at the silencer's drain plug before attempting to start the generator set. If excessive cranking is a chronic problem, have the unit, including the exhaust system, serviced by an authorized Kohler® distributor/dealer.

Note: Starter motor cooldown. Do not crank the engine continuously for more than 10 seconds at a time. Allow a 60-second cooldown period between cranking attempts if the engine does not start. If the unit fails to start after 3 attempts, contact an authorized Kohler® distributor/ dealer for repair. Failure to follow these guidelines may result in starter motor burnout.

2.6.1 Controls and Indicators

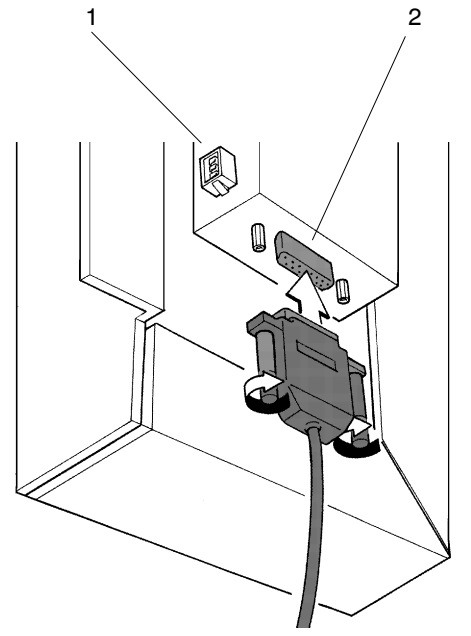
The following table describes the controls and indicators located at the controller. See Figure 2-2.

Name	Description
On/Off Button	Use this button to initiate the start procedure or to stop the generator set. Press the button to the ON position before starting the generator set. Press the button to the OFF position to stop the generator set.
Start Button	Use this button to start the generator set. Press the start button to start the generator set.
Hourmeter	The meter records total generator set operating hours for reference in maintenance scheduling.
AC Circuit Breaker	The circuit breaker trips when a fault occurs in the output circuit. During maintenance of craft or generator set wiring, the circuit breaker disconnects the generator set. Place the circuit breaker(s) in the ON position to close the circuit breaker. See Figure 1-1.
Oil Pressure Lamp	The lamp illuminates (red) if the generator set shuts down because of low oil pressure.
Engine Lamp	The lamp illuminates (red) if the generator set shuts down because of high engine temperature.
Exhaust Lamp	The lamp illuminates (red) if the generator set shuts down because of high exhaust temperature.
Remote Start Connectors	A 4-pin connector on the controller's side allows the connection of the (optional) remote start/stop switch and hourmeter panel kit. See Figure 2-3.
	A 25-pin connector underneath the controller allows the connection of the (optional) remote start/stop switch, hourmeter, and indicator panel kit. See Figure 2-3.



1. Hourmeter
2. On/Off button
3. Oil pressure lights
4. Engine temperature lights
5. Exhaust temperature lights
6. Start button

Figure 2-2 Controls and Indicators



1. 4-pin connector
2. 25-pin connector

Figure 2-3 Remote Panel Connections

2.6.2 Starting the Generator Set

The following table describes the actions required to start the generator set.

Step	Action
1	**Fuel shutoff valve** Open the manual fuel shutoff valve, if equipped.
2	**Initiate Starting** Press the controller on/off button to the ON position. Note: The controller's oil pressure, engine, and exhaust lamps illuminate.
3	**Starting** Hold the generator set controller start button until the generator set starts. Green LEDs indicate good water engine and exhaust temperature performance. Note: If the start button is pressed before a normal start procedure, an electrical device disconnects the starter pinion.

2.6.3 Stopping the Generator Set

The following table describes the actions required to stop the generator set.

Step	Action
1	**Cooldown** Run the generator set at no load for 5 minutes to ensure adequate engine cooldown.
2	**Stopping** Press the controller on/off button to the OFF position to stop the generator set. Note: The controller's oil pressure, engine, and exhaust lamps darken.
3	**Fuel shutoff valve** Close the manual fuel shutoff valve, if equipped.

2.6.4 Engine Safety Shutdown Switches

The engine is protected by 3 shutdown switches which automatically reset when the engine failure is corrected. The engine safety shutdown switches become functional when the unit comes up to speed, AC voltage is available, and after a 3–5 second time delay.

The engine will shut down when:

- The engine oil pressure is 0.3–0.7 bar (30–70 kPa) or less.
- The engine water temperature is 78–83° C (172–181° F) or higher.
- The water temperature in the mixer elbow is 94–100° C (201–212° F) or higher

Note: The low oil pressure switch is not a low oil level shutdown. Check the oil level regularly to protect against engine damage from low oil level.

2.6.5 Circuit Protection

The AC circuit breaker trips when a fault is detected in the output circuit. After correcting the fault, reset the AC circuit breaker by placing in the ON position. See Figure 1-1 for circuit breaker location.

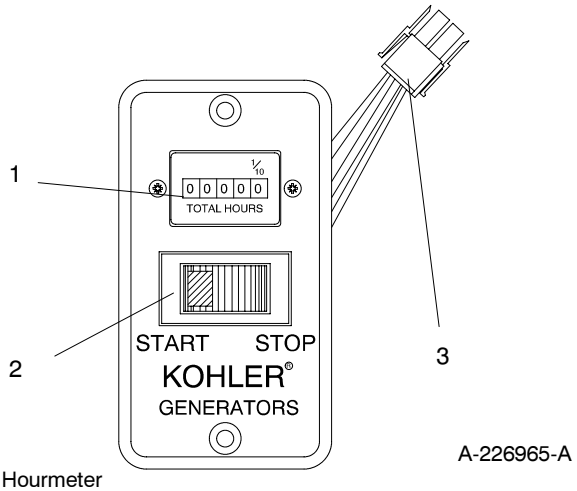
Note: Replace the 25-amp fuse installed in the control box after a fault. See Figure 1-1 for the fuse location. Unit is now ready for restart.

2.7 Remote Panel Kits

Remote start/stop panels allow starting or stopping the generator set from a remote location.

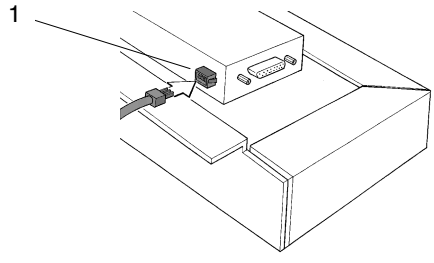
2.7.1 Remote Start/Stop Panel Kit

The remote start/stop panel includes an hourmeter and start/stop switch. The generator set includes a 4-pin connector for connection of the remote start/stop panel. Order a 4- to 6-pin harness kit to connect the panel to the 4-pin connector located at the controller. See Figure 2-4 and Figure 2-5.



1. Hourmeter
2. Start/Stop switch
3. 6-pin connector

Figure 2-4 Remote Start/Stop Panel Features

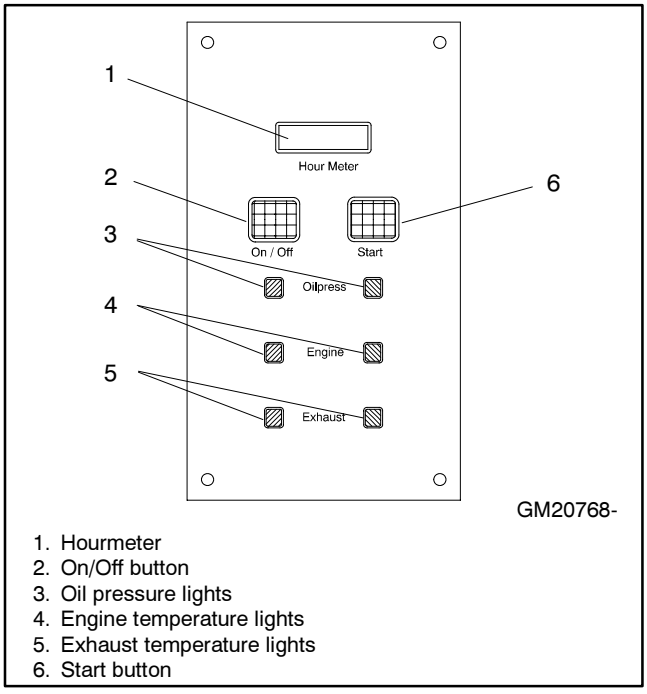


1. Start/Stop switch connection

Figure 2-5 Remote Start/Stop Panel Connection

2.7.2 Remote Panel Kit

The remote panel kit includes a start button, an on/off button, an hourmeter to record total generator set operating hours, an engine oil pressure light, an engine water temperature light, and an exhaust gas light. Order additional extension harnesses for panel connection to the 25-pin connector.

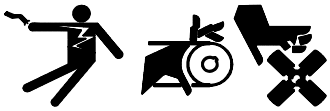


1. Hourmeter
2. On/Off button
3. Oil pressure lights
4. Engine temperature lights
5. Exhaust temperature lights
6. Start button

Figure 2-6 Remote Panel Features

3.1 General

⚠ WARNING

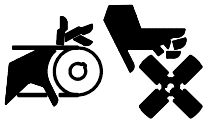


Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set on/off button to shut down the generator set. All indicator lamps dim. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

⚠ WARNING



Rotating parts.
Can cause severe injury or death.

Operate the generator set only when all guards, screens, and covers are in place.

Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

Sound shield removal. Exposed moving parts can cause severe injury or death. The generator set must be operating in order to perform some scheduled maintenance procedures. Be especially careful if the sound shield has been removed, leaving the belts and pulleys exposed.
(Sound-shield-equipped models only)

NOTICE

Saltwater damage. Saltwater quickly deteriorates metals. Wipe up saltwater on and around the generator set and remove salt deposits from metal surfaces.

NOTICE

Hardware damage. The engine and generator set may use both American Standard and metric hardware. Use the correct size tools to prevent rounding of the bolt heads and nuts.

See the Safety Precautions and Instructions at the beginning of this manual before attempting to service, repair, or operate the generator set. Have an authorized distributor/dealer perform generator set service.

Engine Service. Perform generator set engine service at the intervals specified by the engine operation manual.

Generator Set Service. Perform generator set service at the intervals specified.

If the generator set operates under dusty or dirty conditions, use *dry* compressed air to blow dust out of the alternator. With the generator set running, direct the stream of air in through the cooling slots at the alternator end.

Routine Maintenance. Refer to the following generator set service schedule, the engine service schedule, and the hourmeter located on the generator set controller to determine when to schedule routine maintenance. Service more frequently generator sets that are subject to extreme weather or dusty or dirty conditions.

Service Log. Use the Operating Hour Service Log located in the back of this manual to document performed services.

Service Schedule. Perform maintenance on each item in the service schedule at the designated intervals for the life of the generator set. For example, an item requiring service every 100 hours or 3 months also requires service after 200 hours or 6 months, 300 hours or 9 months, and so on.

x:sm:004:001

3.2 Service Schedule—3.5EFOZ and 4EOZ Models

Perform Service at Intervals Indicated (X)	Daily	Every 50 Hrs. or 1 Month	Every 100 Hrs. or 3 Months	Every 200 Hrs. or 6 Months	Every 400 Hrs. or 12 Months	Every 600 Hrs. or 18 Months
FUEL SYSTEM						
Check the fuel level and fill as necessary	X (Before operation)					
Check for any abnormal fuel injection sound †	X (During operation)					
Remove the sediment from the fuel tank and drain the fuel tank †§			X			
Drain water from the fuel filter and strainer *†		X (Break-in period)	X			
Clean the filter inserts of the fuel transfer pump *†						X
Replace the fuel filter *				X		
Check the fuel injection nozzles/check the injection spray condition *†‡					X	
LUBRICATION SYSTEM						
Check the crankcase oil level and add oil as necessary	X (Before operation)					
Replace the oil in the crankcase *		X (Break-in period)	X			
Clean the oil strainer *†				X		
COOLING SYSTEM						
Check the seawater outlet and clean as necessary	X					
Check the function of the siphon break, if equipped			X			
Check the anticorrosion zinc anode's condition *			X			
Check/replace the seawater pump impeller *†			X (Check)		X (Replace)	
Replace the anticorrosion zinc anode *†						X

* Requires removal of the sound shield, if installed
† Consult your local distributor/dealer for service
‡ Read the WARNING found at the beginning of the manual
§ Consult the operating instructions supplied with the craft
‖ Should be performed by your local distributor/dealer

Perform Service at Intervals Indicated (X)	Daily	Every 50 Hrs. or 1 Month	Every 100 Hrs. or 3 Months	Every 200 Hrs. or 6 Months	Every 400 Hrs. or 12 Months	Every 600 Hrs. or 18 Months
INTAKE/EXHAUST SYSTEM						
Inspect the exhaust system components *	X (Before operation)					
Check the exhaust gas condition. If the exhaust is blue or black, contact your local distributor/dealer	X (During operation)					
Clean the intake silencer element *			X			
Clean the exhaust/water mixing elbow *†				X		
Replace the intake silencer element *					X	
Inspect the complete exhaust system ‖					X	
ELECTRICAL SYSTEM						
Keep the battery charged and in good condition §	X (Before operation)					
Check and tighten the electrical connections *		X				
Clean the battery cables †					X	
ENGINE AND MOUNTING						
Check for water, fuel, and oil leakage *†‡	X (After operation)					
Retighten any loose nuts and bolts *	X (Before operation)					X
Check the mounting bolts/vibromounts and tighten if necessary *				X		
Adjust the intake/exhaust valve clearance *†			X			
Head bolt retightening *†						X
REMOTE CONTROL SYSTEM						
Check the remote control operation		X (Break-in period)			X	
GENERATOR						
Test run the generator set		X (Weekly)				
Blow dust out of the generator *†					X	

* Requires removal of the sound shield, if installed
† Consult your local distributor/dealer for service
‡ Read the WARNING found at the beginning of the manual
§ Consult the operating instructions supplied with the craft
‖ Should be performed by your local distributor/dealer

3.3 Lubrication System

See the Service Schedule for oil change and oil filter replacement intervals. See Section 1 for the oil drain, oil check, and oil fill locations.

3.3.1 Oil Specifications

Use HD oil that meets the American Petroleum Institute (API) classification of CD, CC/CD, or CC. Using an unsuitable oil or neglecting an oil change may result in damage and a shorter engine life. Figure 3-1 shows the recommended Society of Automotive Engineers (SAE) viscosity designation for given operating temperature ranges.

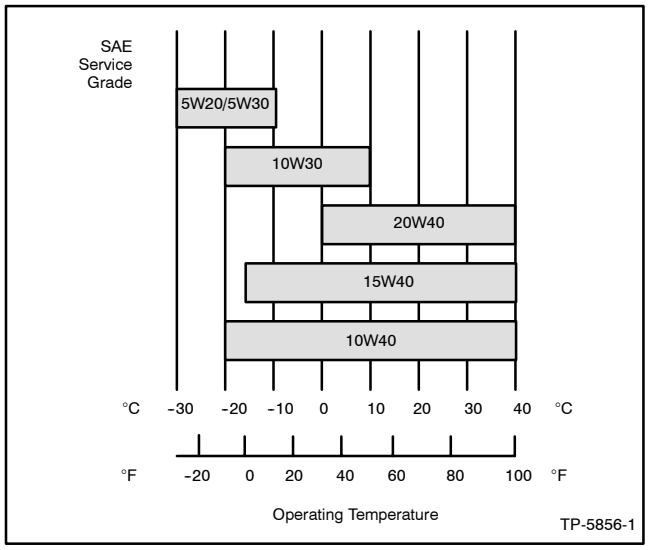
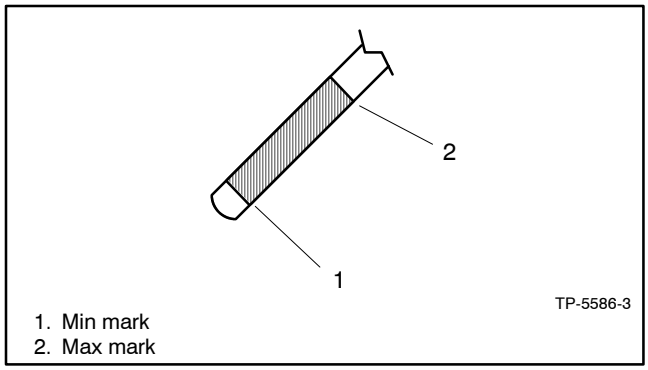


Figure 3-1 Engine Oil Selection

Note: Failure to observe the oil specifications may cause inadequate lubrication/oil pressure and cold-starting difficulties.

3.3.2 Oil Check

Check the oil level in the crankcase daily or before each startup to ensure that the level is in the safe range. To check the oil level, remove the dipstick and wipe the end clean, reinsert as far as possible, and remove. Maintain the oil level between the Min and Max marks on the dipstick, as shown in Figure 3-2. See Section 1, Figure 1-1, for dipstick location.



1. Min mark
2. Max mark

Figure 3-2 Oil Level Check Marks

Note: Do not operate the set if the oil level is below the Min mark or above the Max mark.

3.3.3 Oil Change

Change the oil more frequently if the generator operates under dirty, dusty conditions. See Figure 3-3 for oil capacities.

Model	L (Qts.)
3.5EFOZ/4EOZ	1.25 (1.32)

Figure 3-3 Oil Capacities

Oil Change Procedure

Whenever possible, drain the oil while it is still warm.

1. **Drain the oil.**

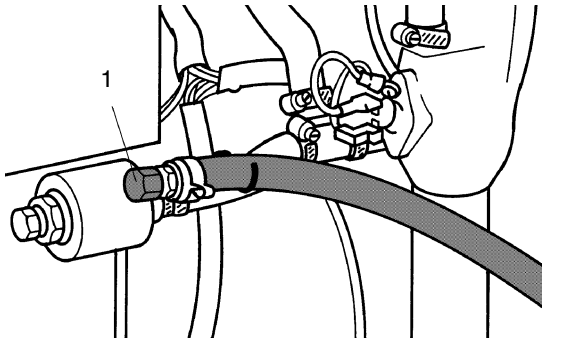
   a. Press the generator set on/off button to stop the generator set.

   b. Disconnect the power to the battery charger, if equipped.

   c. Disconnect the generator set engine starting battery, negative (–) lead first.

d. Remove the oil drain hose from its retaining clip. See Figure 3-4. Remove the cap from the oil drain hose and lower the hose into an oil collection container.

Electric Oil Drain/Oil Fill Pump Procedure: Connect the pump to the end of the oil drain hose. Place the outlet of the pump into an oil collection container. Remove the oil fill cap.



1. Oil drain hose

Figure 3-4 Oil Drain Hose

e. Allow time for the engine oil to drain completely.

Electric Oil Drain/Oil Fill Pump Procedure: Activate the pump until all of the oil is removed. Go to step 2.

f. Replace the cap on the oil drain hose. Replace the oil drain hose in its retaining clip.

Note: Dispose of all waste materials (engine oil, fuel, filter, etc.) in an environmentally safe manner.

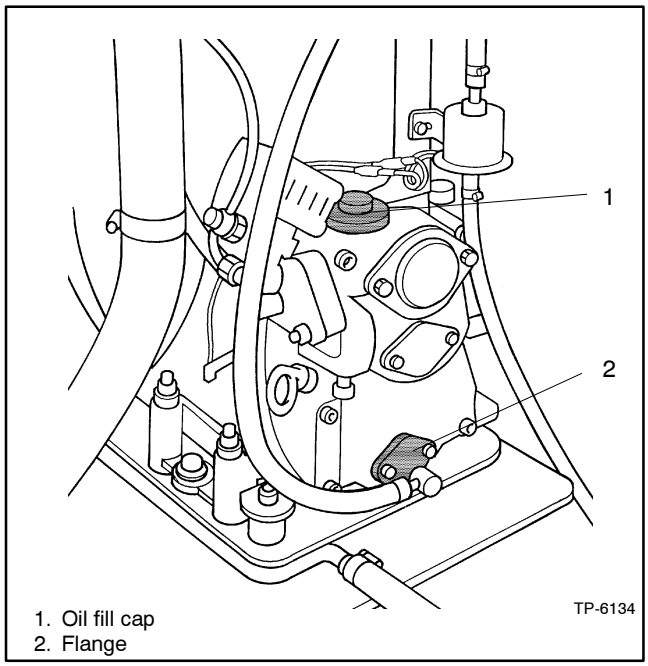
2. **Oil Strainer Service.** Clean the oil strainer at the interval listed in the Service Schedule.

a. Remove the flange on the crankcase. See Figure 3-5 for location.

b. Remove the end of the oil drain hose.

c. Remove the metallic screen (oil strainer).

d. Clean the oil stainer using diesel oil, but no gasoline. Consult the engine operation manual.



1. Oil fill cap
2. Flange

Figure 3-5 Oil Strainer

3. **Fill with oil.** Add new oil of the weight, grade, and quantity specified in Section 3.3.3.

Electric Oil Drain/Oil Fill Pump Procedure: Disconnect the pump. Close the oil drain valve. Replace the cap on the oil drain hose.

4. **Check for leaks.**

a. Check that the generator set on/off button is in the OFF position.

b. Reconnect the generator set engine starting battery, negative (–) lead last.

c. Reconnect the power to the battery charger, if equipped.

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3.4 Battery

Consult the battery manufacturer's instructions regarding battery care and maintenance.

⚠ WARNING

Sulfuric acid in batteries.
Can cause severe injury or death.

Wear protective goggles and clothing. Battery acid may cause blindness and burn skin.

Battery electrolyte is a diluted sulfuric acid. Battery acid can cause severe injury or death. Battery acid can cause blindness and burn skin. Always wear splashproof safety goggles, rubber gloves, and boots when servicing the battery. Do not open a sealed battery or mutilate the battery case. If battery acid splashes in the eyes or on the skin, immediately flush the affected area for 15 minutes with large quantities of clean water. Seek immediate medical aid in the case of eye contact. Never add acid to a battery after placing the battery in service, as this may result in hazardous spattering of battery acid.

Battery gases. Explosion can cause severe injury or death. Battery gases can cause an explosion. Do not smoke or permit flames or sparks to occur near a battery at any time, particularly when it is charging. Do not dispose of a battery in a fire. To prevent burns and sparks that could cause an explosion, avoid touching the battery terminals with tools or other metal objects. Remove all jewelry before servicing the equipment. Discharge static electricity from your body before touching batteries by first touching a grounded metal surface away from the battery. To avoid sparks, do not disturb the battery charger connections while the battery is charging. Always turn the battery charger off before disconnecting the battery connections. Ventilate the compartments containing batteries to prevent accumulation of explosive gases.

3.5 Generator Storage Procedure

Perform the following storage procedure before taking a generator set out of service for three months or longer. Follow the engine manufacturer's recommendations, if available, for fuel system and internal engine component storage.

x:sm:002:001

3.5.1 Lubricating System

Prepare the engine lubricating system for storage as follows:

1. Run the generator set for a minimum of 30 minutes to bring it to normal operating temperature.
2. Stop the generator set.
3. With the engine still warm, drain the oil from the crankcase.
4. Refill the crankcase with oil suited to the climate.
5. Run the generator set for two minutes to distribute the clean oil.
6. Stop the generator set.
7. Check the oil level and adjust, if needed.

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3.5.2 Fuel System

Prepare the fuel system for storage as follows:

Diesel-Fueled Engines

1. Fill the fuel tank with #2 diesel fuel.
2. Condition the fuel system with compatible additives to control microbial growth. See the engine operation manual.
3. Change the fuel filter and bleed the fuel system. See Section 5.

x:sm:002:004

3.5.3 Cooling System

Prepare the cooling system for storage as follows:

1. Unscrew the seawater pump cover to drain the cooling water from the engine.
2. Remove the hose from the fitting to drain the cooling water from the alternator.

3.5.4 Exterior

Prepare the exterior for storage as follows:

1. Clean the exterior surface of the generator set.
2. Seal all engine openings except for the air intake with nonabsorbent adhesive tape.
3. To prevent impurities from entering the air intake and to allow moisture to escape from the engine, secure a cloth over the air intake.
4. Mask electrical connections.
5. Spread a light film of oil over unpainted metallic surfaces to inhibit rust and corrosion.

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3.5.5 Battery

Perform battery storage after all other storage procedures.

1. Place the generator set master switch in the OFF/RESET position.
2. Disconnect the battery(ies), negative (–) lead first.
3. Clean the battery.
4. Place the battery in a cool, dry location.
5. Connect the battery to a float/equalize battery charger or charge it monthly with a trickle battery charger. Refer to the battery charger manufacturer's recommendations.

   Maintain a full charge to extend battery life.

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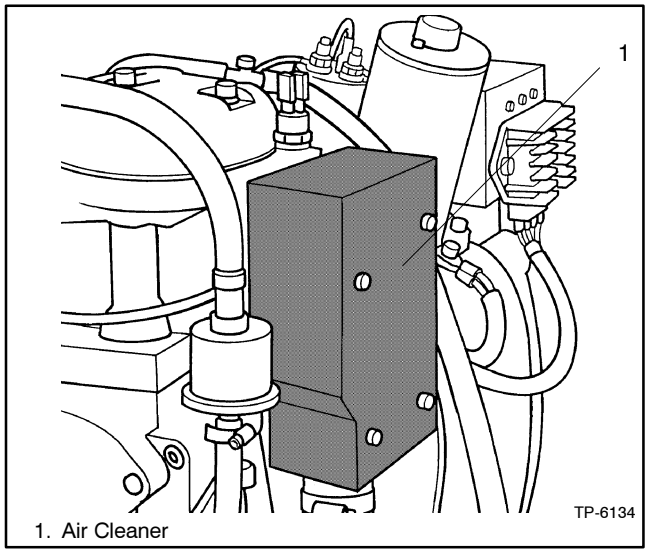
Notes

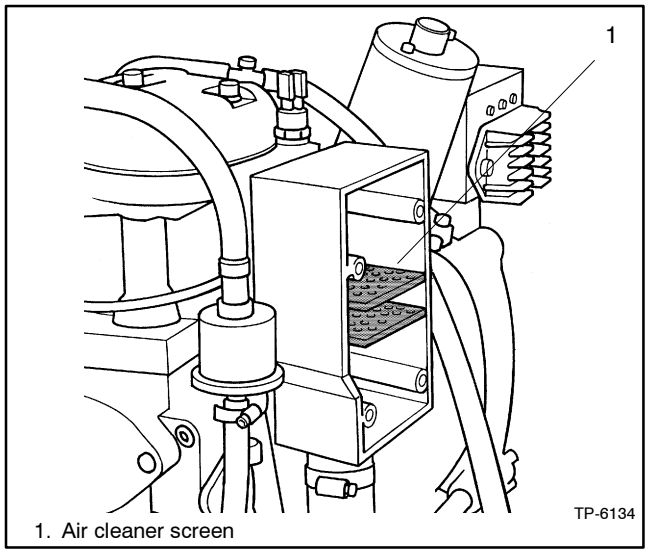
4.1 Air Intake Silencer/Filter

At the interval specified in the service schedule, clean the air intake screen. Clean the silencer more frequently if the generator set operates in dirty, dusty conditions.



1. Air Cleaner

Figure 4-1 Air Cleaner



1. Air cleaner screen

Figure 4-2 Air Cleaner Screen

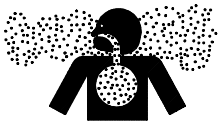
Air Cleaner Service/Replacement

A dry-type air cleaner silences and filters the intake air. The air intake silencer assembly connects to the intake manifold via a flexible hose.

1. Remove the four screws to remove the air cleaner cover.
2. Remove the air cleaner screen.
3. Tap the screen lightly against a flat surface to dislodge loose surface dirt. Do not clean in any liquid or use compressed air as these will damage the screen.
4. Examine the screen and housing for damage and wear. Replace the screen or housing if necessary.
5. Wipe the air cleaner cover and base with a clean rag to remove any dirt. Ensure that dirt does not enter the intake port.
6. Make sure that the sealing surfaces fit correctly, and replace the four screws.

4.2 Exhaust System

⚠ WARNING



Carbon monoxide.
Can cause severe nausea, fainting, or death.

The exhaust system must be leakproof and routinely inspected.

Inspecting the exhaust system. Carbon monoxide can cause severe nausea, fainting, or death. For the safety of the craft's occupants, install a carbon monoxide detector. Consult the boat builder or dealer for approved detector location and installation. Inspect the detector before each generator set use. In addition to routine exhaust system inspection, test the carbon monoxide detector per the manufacturer's instructions and keep the detector operational at all times.

At the interval specified in the service schedule, inspect the exhaust system. See Section 1 for the exhaust outlet location.

Inspection Points

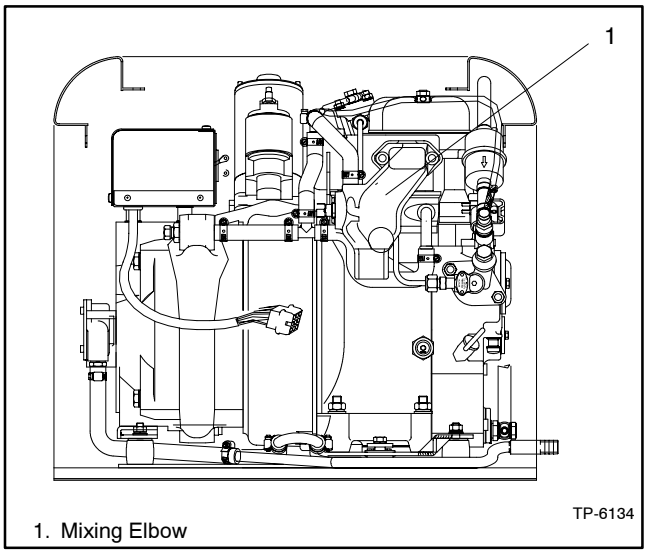
Inspect the the exhaust system components (exhaust manifold, mixing elbow, exhaust line, hose clamps, silencer, and outlet flapper) for cracks, leaks, and corrosion.

- Check the hoses for softness, cracks, leaks, or dents. Replace the hoses as needed.
- Check for corroded or broken metal parts and replace them as needed.
- Check for loose, corroded, or missing clamps. Tighten or replace the hose clamps and/or hangers as needed.
- Check that the exhaust outlet is unobstructed.
- Visually inspect for exhaust leaks *(blowby)*. Check for carbon or soot residue on exhaust components. Carbon and soot residue indicates an exhaust leak. Seal leaks as needed.
- Ensure that the carbon monoxide detector is (1) in the craft, (2) functional, and (3) energized whenever the generator set operates.

x:op:001:002

4.3 Mixing Elbow

Check the mixing elbow for carbon buildup and corrosion inside the pipe. Clean the residual carbon buildup with a wire brush. Inspect the exhaust manifold flange for cracking and corrosion. The mixing elbow combines high temperature exhaust and cooling seawater. The mixture, when exposed to engine vibration, makes conditions conducive to rapid deterioration and failure if not correctly maintained. If any damage is detected with the mixing elbow or other exhaust components, replace the damaged components to prevent engine exhaust (carbon monoxide) leakage.



1. Mixing Elbow

Figure 4-3 Mixing Elbow Location

5.1 General

⚠ WARNING

Fire.
Can cause severe injury or death.

Do not smoke or permit flames or sparks near fuels or the fuel system.

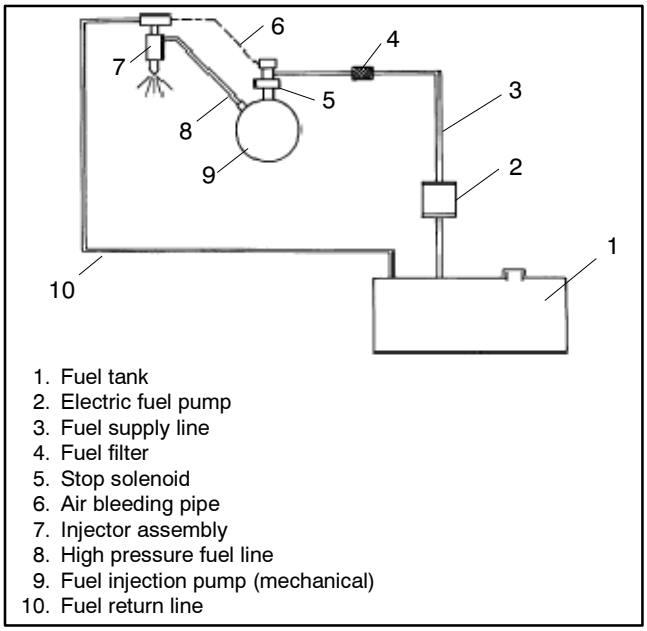
Combustible materials. A sudden flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the fuel system. Keep the compartment and the generator set clean and free of debris to minimize the risk of fire. Wipe up spilled fuels and engine oil.

In most installations, both the generator set and the propulsion engine operate from a common fuel tank with a dual dip tube arrangement. The generator set dip tube is shorter than the propulsion engine's dip tube. With this arrangement, fuel may not be available to the generator set when the fuel supply is low.

Description

An electric fuel pump draws fuel from the tank. The fuel flows in the fuel supply line, through the electric pump, the filter, the engine stop solenoid, and then reaches the fuel injection mechanical pump.

The injection pump pushes the fuel from the nipple valve to the injector. The injector ejects and atomizes the required fuel at high pressure before the piston reaches TDC. Any excess fuel returns to the tank. The rubber pipe located between the mechanical pump and the injector's banjo return bolt allows for bleeding air from the fuel system.



1. Fuel tank
2. Electric fuel pump
3. Fuel supply line
4. Fuel filter
5. Stop solenoid
6. Air bleeding pipe
7. Injector assembly
8. High pressure fuel line
9. Fuel injection pump (mechanical)
10. Fuel return line

Figure 5-1 Fuel System Schematic Typical

5.2 Fuel Specifications

Use a clean, good quality diesel fuel oil with a cetane number of 45 or greater. Clean fuel prevents diesel fuel injectors and pumps from clogging.

Fuel Recommendation
DIN 51601 (ASTM D 975-67 ID + 2D/BS 2869 1967 A1 + A2)

Note: Never store diesel fuel in galvanized containers; diesel fuel and the galvanized coating react chemically to produce flaking that quickly clogs filters or causes fuel pump or injector failure.

Avoid storing fuel for more than one month. Take special precautions to keep all dirt, water, and other contaminants out of fuel to prevent the growth of microbes. Microbes form slime that clogs the fuel filter and lines.

Do not run the generator set out of fuel because the fuel lines will draw in air and necessitate bleeding the fuel system before restarting the unit.

5.3 Fuel Filter

The fuel filter prevents the entry of dirt into the fuel system and preserves the injector and fuel injection pump. The quality and condition of the fuel largely determine the filter's useful life. Replace the fuel filter as listed in the service schedule. See Figure 5-2.

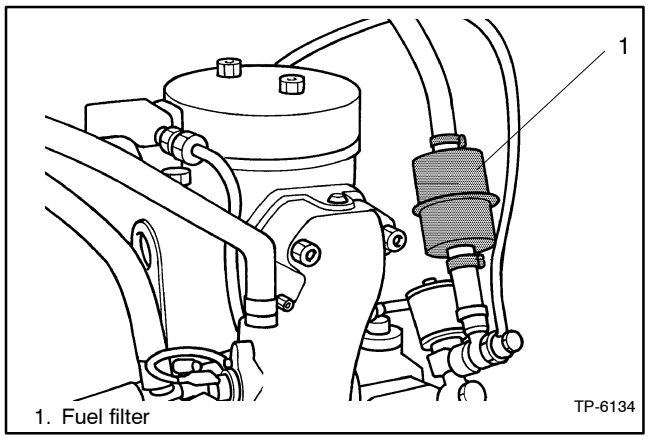


Figure 5-2 Fuel Filter Location

Fuel Filter Cleaning/Replacement Procedure

1. Close the fuel supply valve.
2. Using a rag, clean the fuel line.
3. To avoid fuel leakage, clamp off the fuel supply line near the filter.
4. Disconnect the inlet and outlet lines to the fuel filter. Ensure that dirt does not enter the fuel system. See Figure 5-3.

Figure 5-3 Disconnect the Fuel Line

5. Remove and discard the fuel filter.

   Note: Dispose of all waste materials (engine oil, fuel, filter, etc.) in an environmentally safe manner.

6. Replace the fuel filter with the arrow on the fuel filter housing indicating the direction of fuel flow. See Figure 5-4.

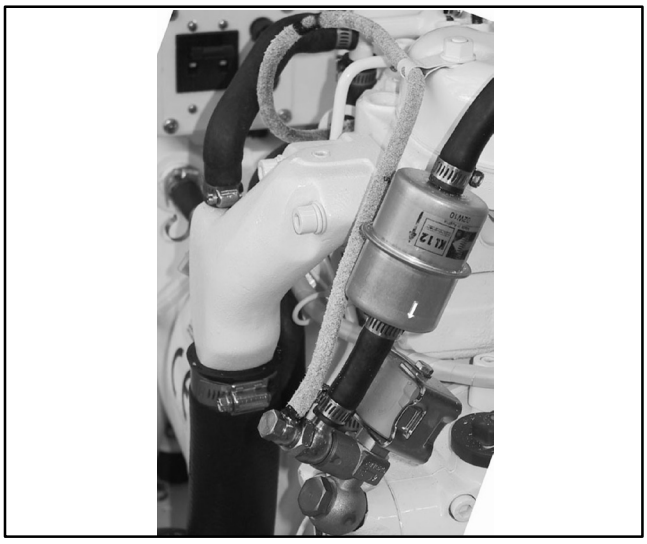


Figure 5-4 Fuel Filter Arrow

7. Reconnect the pipes to the fuel filter.
8. Remove the clamp from the fuel supply line.
9. Open the fuel supply valve.
10. Bleed the system. See Section 5.9, Bleeding the Fuel System.

5.4 Fuel Injector Nozzle

The fuel injector nozzle ejects and atomizes the fuel in the cylinder under high pressure. As it is located in the combustion chamber, it operates at high temperatures and strong mechanical stress. Clean and adjust the injector as described below.

Injector Cleaning

1. Use a brass wire brush to remove residual combustion products on the nozzle's surface.
2. A special tool/needle is required to clean the injector nozzle's spray hole. Consult the engine service manual for more information.

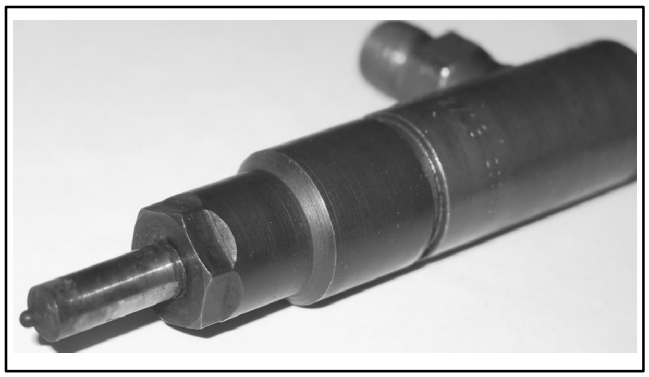
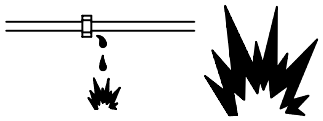


Figure 5-5 Injector

Injector Pressure Test

⚠ WARNING



Explosive fuel vapors.
Can cause severe injury or death.

Use extreme care when handling, storing, and using fuels.

1. Connect the injector to a tester to check the injection pressure value. See Figure 5-6.
2. Using the hand pump lever of the tester, pump fuel in the injector until it ejects at the specified pressure.
3. During this operation, the ejected fuel must be evenly atomized without leakage or dripping.

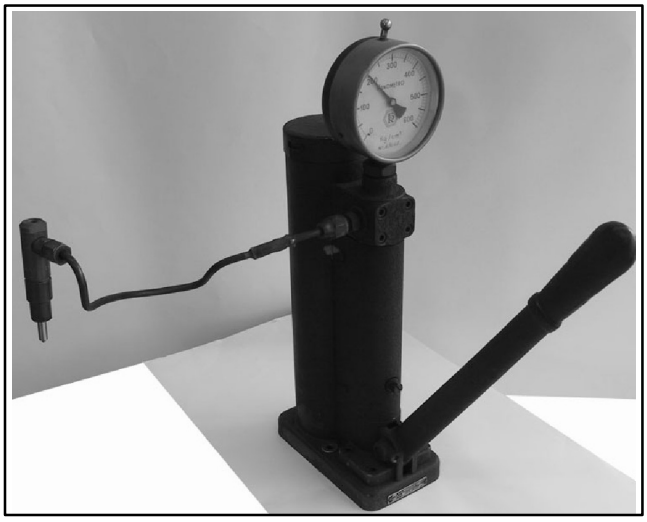


Figure 5-6 Tester

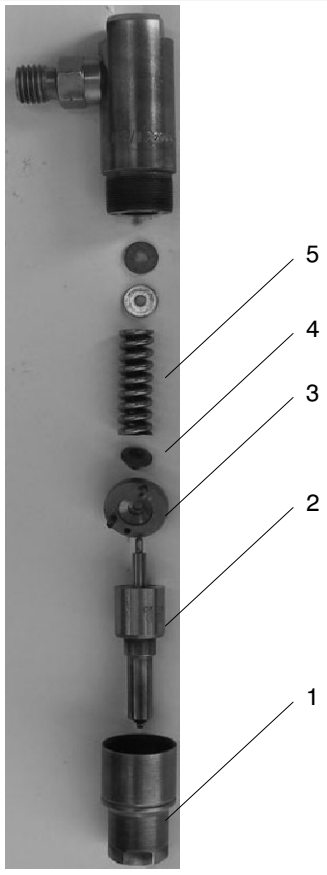
Injector Adjustment

1. If, during the injector pressure test, the pressure values are not correct, replace the shims in the injector.

   a. Unscrew the injector nut.

   b. Remove the nozzle assembly, pressure piece, spring seat's conical stop, spring, and shims. See Figure 5-7.

   Note: A change of 0.1 mm (.004 in.) shim size can modify the pressure value of the injector of 10 bar (145 psi). The thicker shim increases the pressure value of the injector while the thinner shim decreases the pressure value of the injector. Add or remove shims to obtain the correct pressure value.



1. Injector nut
2. Nozzle assembly
3. Pressure piece
4. Spring seat's conical stop
5. Spring

Figure 5-7 Injector Components

Injector Overhaul

1. Inspect the injector assembly to ensure that the nozzle's needle is in the hole of the pressure piece.

2. If the nozzle leaks or does not atomize, replace the entire nozzle.

3. Lapping of the nozzle needle is not recommended.

5.5 Excess Fuel Start Device

The engine is equipped with a device that supplies extra fuel to facilitate engine starting. See Figure 5-8. When the device's button is pulled down, its upper conical surface releases the fuel control lever and the fuel injection pump pin performs a longer movement thus increasing the fuel rate at the injector.

Figure 5-8 Excess Fuel Start Device Button

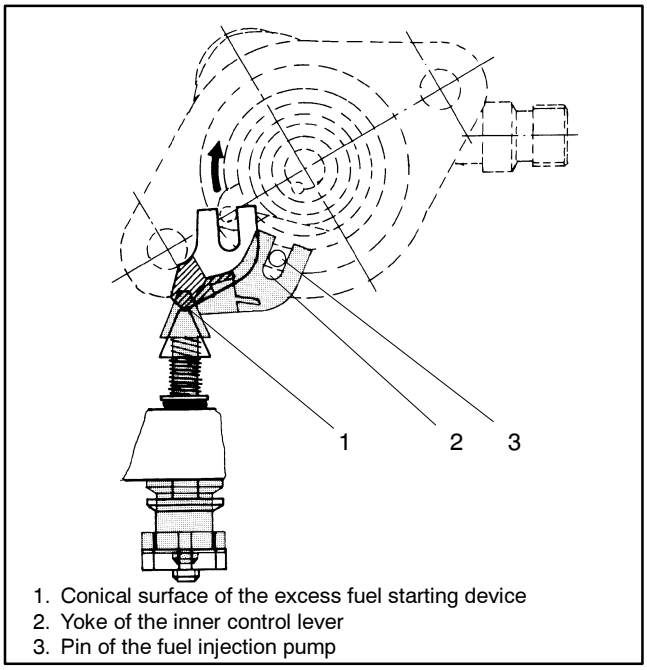
If the excess fuel start device is activated, the engine, without load, reaches the higher speed. The governor pushes the injection pump's control lever towards the lower value of supplying fuel and the excess fuel start device button returns to its initial position.

Before pulling down the device's button, start the engine without load to allow it to reach it's highest engine speed.

Note: To avoid heavy engine damage and engine overload, never operate with the device's button pulled down.

The engine's output power is dependant upon the position of the upper conical surface of the excess fuel button in the gear cover. The shorter its insertion in the gear cover, the more fuel arrives at the injector. The longer its insertion in the gear cover, the less fuel arrives at the injector.

Note: The unit's output power with the correct adjustment of the excess fuel device is factory set. Do not alter its setting. However, if the excess fuel device and or gear cover are removed or replaced, the high rate of supplied fuel at the injector must be readjusted on the test bench.



1. Conical surface of the excess fuel starting device
2. Yoke of the inner control lever
3. Pin of the fuel injection pump

Figure 5-9 Excess Fuel Start Device Button

5.6 The Injection Pump's Fuel Starting Delivery Point

For proper engine operation, ensure the correct adjustment of the fuel starting delivery point. As the fuel pump timing is fixed, check or readjust it only when altering engine speed, installing a new injection pump, or replacing the camshaft or gear cover.

1. Move the engine towards the compression stroke.

2. Put a mark on the flywheel at the 5 o'clock position with the piston that is before Top Dead Center (TDC).

3. Remove the injection pump's allen head screw and sealing washer from the fuel pump body and install in its place a drip tube with a sealing washer located between the pump and the tube. See Figure 5-10.

Note: Fuel will flow from the pump immediately after loosening the allen screw.

Figure 5-10 Drip Tube

4. To locate the injection pump's fuel starting delivery point, put the accelerator lever in the higher speed position and keep the inner control lever in the higher fuel rate position.

Note: In order for fuel to reach the injection pump, perform this check with the fuel solenoid valve and the electric fuel pump energized.

5. Engine stop condition. Move the engine in the counterclockwise direction (as viewed from the flywheel) and check the drip tube. Fuel will flow freely and then cease.

6. Obtain the correct fuel starting delivery point when the plunger has reached and closed the injection pump's allen head screw's hole and only a drop of fuel comes out from the tube every second. See Figure 5-11.

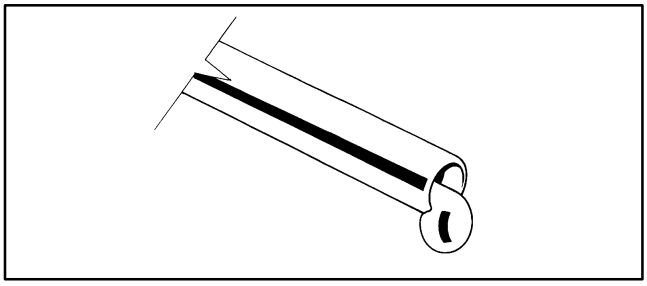


Figure 5-11 Fuel Drop

5.7 Fuel Pump Adjustment Timing

To obtain the correct adjustment timing of the fuel pump, use a ruler and measure the distance between the mark on the flywheel and the mark on the crankcase when the plunger is in the fuel starting delivery point. See Figure 5-12.

Acceptable values are between
40 ± 2 mm (1.5748 ± 0.0394 in.) for 3000 RPM units and
50 ± 1 mm (1.968 ± 0.0394 in.) for 3600 RPM unit.

If this value is not obtained, readjust the fuel starting delivery point by adding or removing shims between the pump and the gear cover's surface.

Every thickness of ± 1/10 mm (0.0040 in.) under the injection pump increases or decreases the distance between the marks on the flywheel and crankcase by ± 2 mm (± 0.78 in.).

Adding or removing shims between the gear cover and the fuel pump's body decreases or increases the distance between the fuel pump flange and the cam of the camshaft. Adjust the starting delivery point so that its value is within the above mentioned value.

Figure 5-12 Flywheel Mark

5.8 Fuel Pump and Gear Cover Installation

1. If replacing one of these parts, check the distance between the fuel pump surface on the gear cover and the roller tappet cam follower edge.

2. Measure the distance between the parts and add the shim thickness. Total distance should be between 57.5–59.1 mm (2.263–2.327 in.). See Figure 5-13.

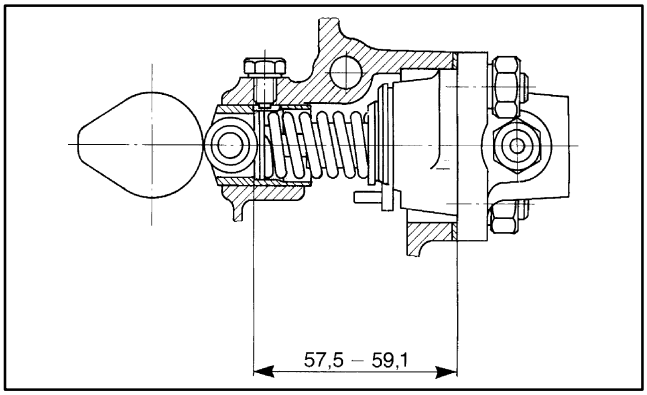


Figure 5-13 Acceptable Distance

Note: The thickness of the fitted shims under the injection pump is stamped on the front surface of the pump in 1/10 mm (0.004 in.) (e.g. 15 indicates 1.5 mm (0.0600 in.) thickness).

Note: The value stamped on the pump is for factory installed fuel pumps. Fuel pump or injection timing modifications alter the thickness values.

Figure 5-14 Stamp

5.9 Bleeding the Fuel System

Bleed air from the fuel system to prevent starting failures and/or erratic operation. One or more of the following causes air to collect in the fuel system:

- Operating the generator set until the fuel supply is emptied.
- Developing air leaks in the suction side of the fuel system.
- Replacing the fuel filter.

Procedure to Bleed the Fuel System

1. Loosen the vent screw. See Figure 5-15.

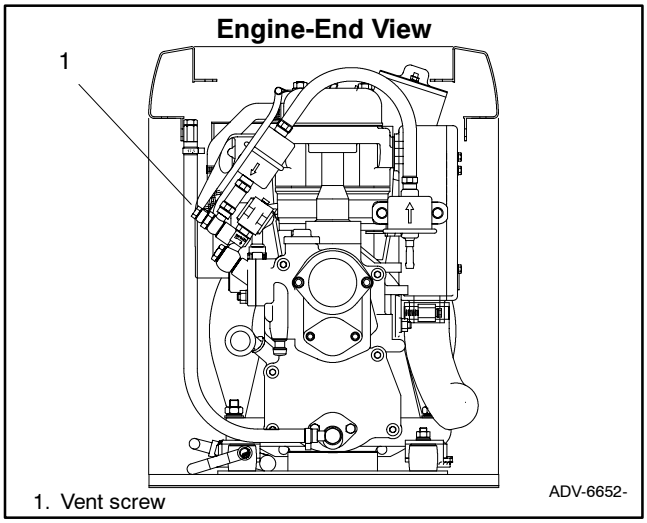


Figure 5-15 Vent Screw Location

2. Operate the generator set until fuel, free of air bubbles, flows from the vent screw.
3. Tighten the screw.

Note: Wipe up all spilled diesel fuel after bleeding the system. Wash hands after any contact with fuel oil.

5.10 Governor

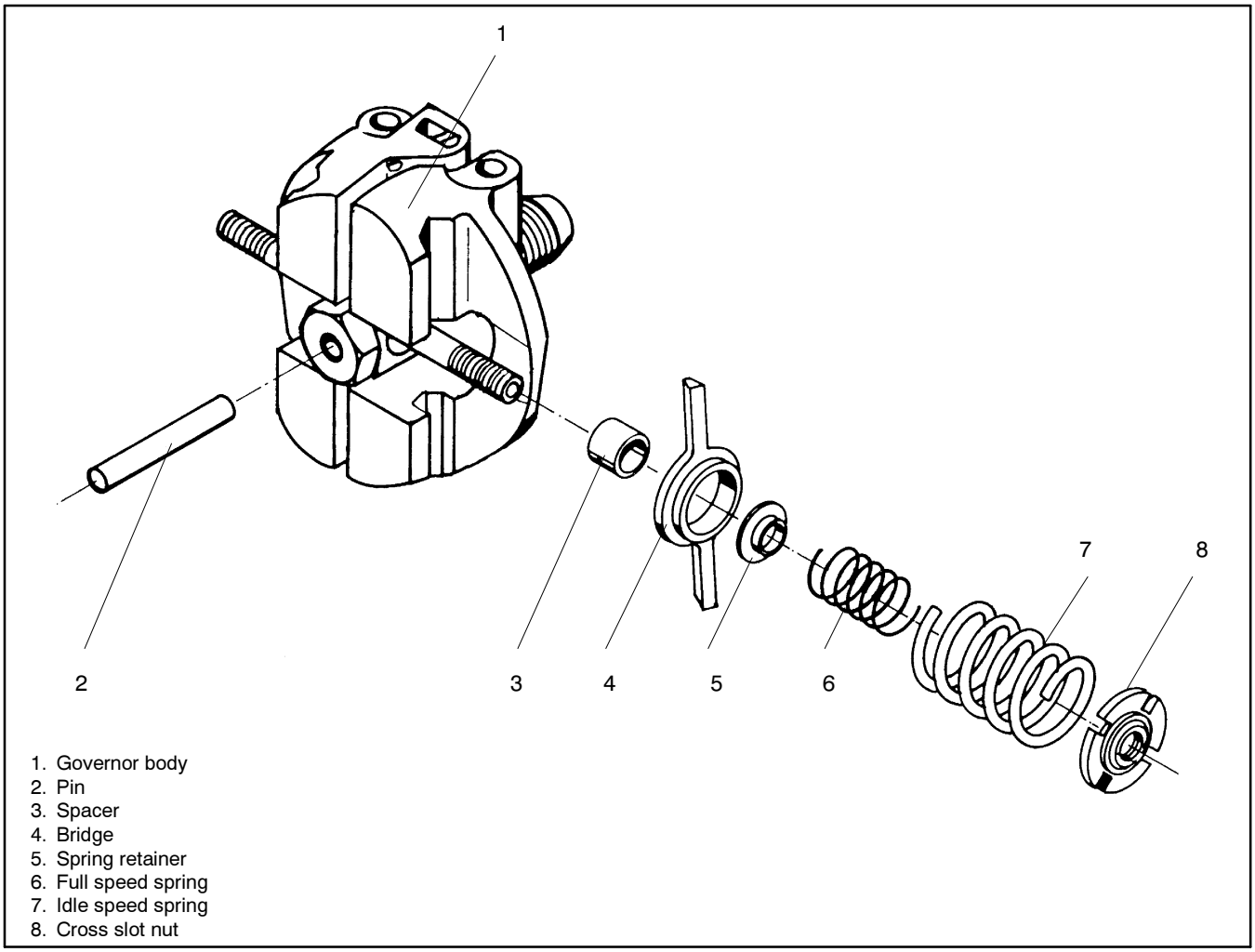


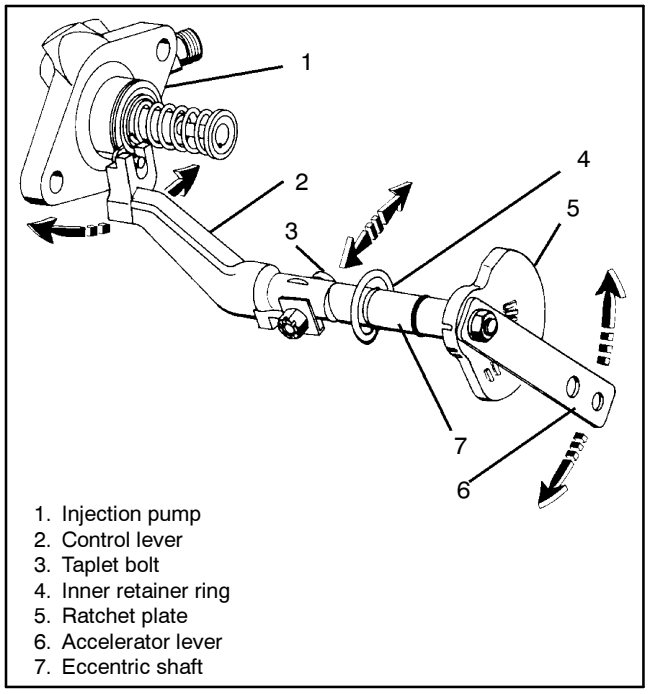
Figure 5-16 Governor Components

The centrifugal, mechanical governor keeps the engine speed constant by automatically adjusting the amount of fuel supplied to the engine according to changes in the load. No regular service is required on the governor. The factory adjusts the governor during run-in, and further adjustment should not be needed unless poor governor control develops after extended generator usage.

Governor Construction and Function

The governor consists of two flyweights and a set of springs that balance the centrifugal forces of the governor flyweights.

The governor is installed at the crankshaft and turns with similar speed. If the engine operates with a decreasing load, the engine speed will increase. The centrifugal force spreads the governor weights and its pin pushes the tappet bolt of the inner control lever. It pivots on the eccentric shaft so that the injection pump pin moves towards the position for lower fuel supply rate. During conditions with less fuel, the engine speed decreases, the governor pin returns to its hole, and the inner control lever moves the injection pump pin towards the position for higher fuel supply rate to increase the engine speed. Consequently, the engine speed has permanent oscillations but these are so small that only a very sensitive revolution meter could detect them.



1. Injection pump
2. Control lever
3. Taplet bolt
4. Inner retainer ring
5. Ratchet plate
6. Accelerator lever
7. Eccentric shaft

Figure 5-17 Speed Controller Shaft Assembly Components

Governor and Speed Controller Shaft Adjustment

If the governor or the speed controller shaft has been removed or tampered with, they need to be readjusted.

Figure 5-18 Cover Plate

1. Remove the governor cover plate on the gear cover. See Figure 5-18.
2. Move the engine until the governor flyweights are in the vertical position.
3. Keep the accelerator lever in the higher engine speed position.
4. Open the lock plate of the taplet bolt and loosen the nut.
5. Screw the taplet bolt completely until it rests on the inner control lever.
6. Insert a screwdriver between the flyweights and force them apart to the maximum opening. See Figure 5-19.
7. Turn the taplet bolt until it contacts the governor pin.

Note: No play should be felt when pushing the inner control lever with the hand.

8. Release the flyweights and turn the taplet bolt a half turn further.

Figure 5-19 Taplet Bolt Position

9. Hold the taplet bolt in this position and tighten the nut. See Figure 5-19.
10. Bend the lock plate and reassemble the cover plate on the gear cover.

Note: It is essential for adequate engine operation to obtain the correct adjustment between the taplet bolt and the governor pin. The engine will go into overspeed if a clearance exists between the taplet bolt and the governor pin while a forced contact produces an engine speed drop.

11. With the engine stopped, adjust both the cross slotted nuts so that their upper surfaces are at the same height as the governor bolt. See Figure 5-20.
12. Start the engine and check its speed.

13. If the engine speed needs modification, turn the cross slotted nuts.

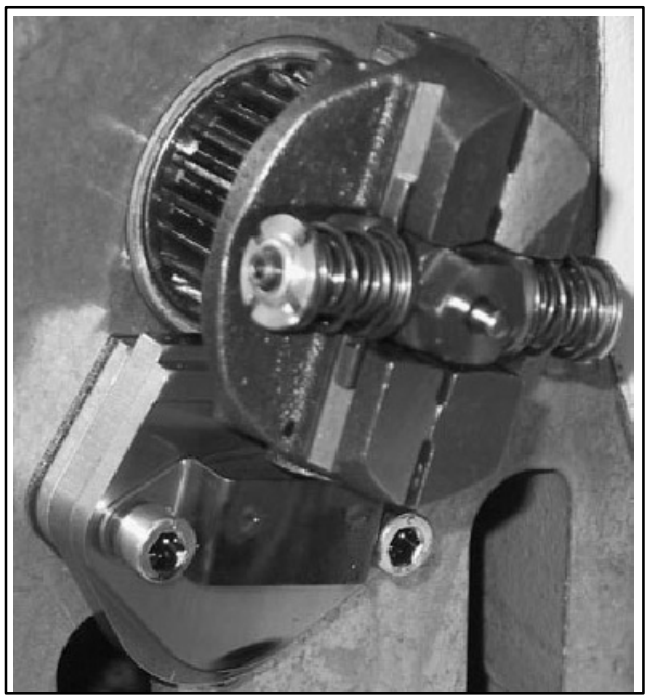


Figure 5-20 Engine Speed Adjustment

Note: Tightening both cross slot nuts increases engine speed because the axial movement of the governor pin does not permit the control lever to push the fuel pump pin in a position for lower fuel supply.

Loosening both cross slot nuts decrease engine speed because the governor pin pushes the control lever towards the position for lower fuel supply.

A half turn (180°) of both cross slot nuts generally change the engine speed ±50 RPM.

Note: Keep the cross slotted nuts at least on the flat end of the stud bolt. Otherwise the nuts self-securing effect will not work. Normally, the stud bolt protrudes out of the cross slotted nuts.

For larger speed variations, replace the governor springs. Replace the cross slotted nuts whenever unscrewing a nut. Check every engine speed modification in a controlled environment on a test bench or with a revolution counter.

Accelerator Lever

The accelerator lever is fixed by its hole at the pin of the eccentric shaft. The ratchet plate is installed with its slot at the eccentric shaft pin and kept in place with an 8 mm nut. As the ratchet plate spring is used as a buffer for engine deceleration (it holds the accelerator lever in the higher engine speed position), the correct adjustment between the accelerator lever and the ratchet plate is very important. Perform this adjustment leaving a half notch of the plate visible. See Figure 5-21.

If an incorrect adjustment is achieved and more notches are visible, a manual engine stop operation may be obstructed because the accelerator lever touches the lower stop notch on the crankcase without cutting off the fuel supply at the engine. If no notch is visible, damage to the speed controller shaft linkage may occur.

To relocate the ratchet plate and accelerator lever on the speed controller shaft, hold the accelerator lever and move the ratchet plate until its slot is against the speed shaft pin. At this position, tighten the 8 mm nut.

Figure 5-21 Ratchet Plate Notches

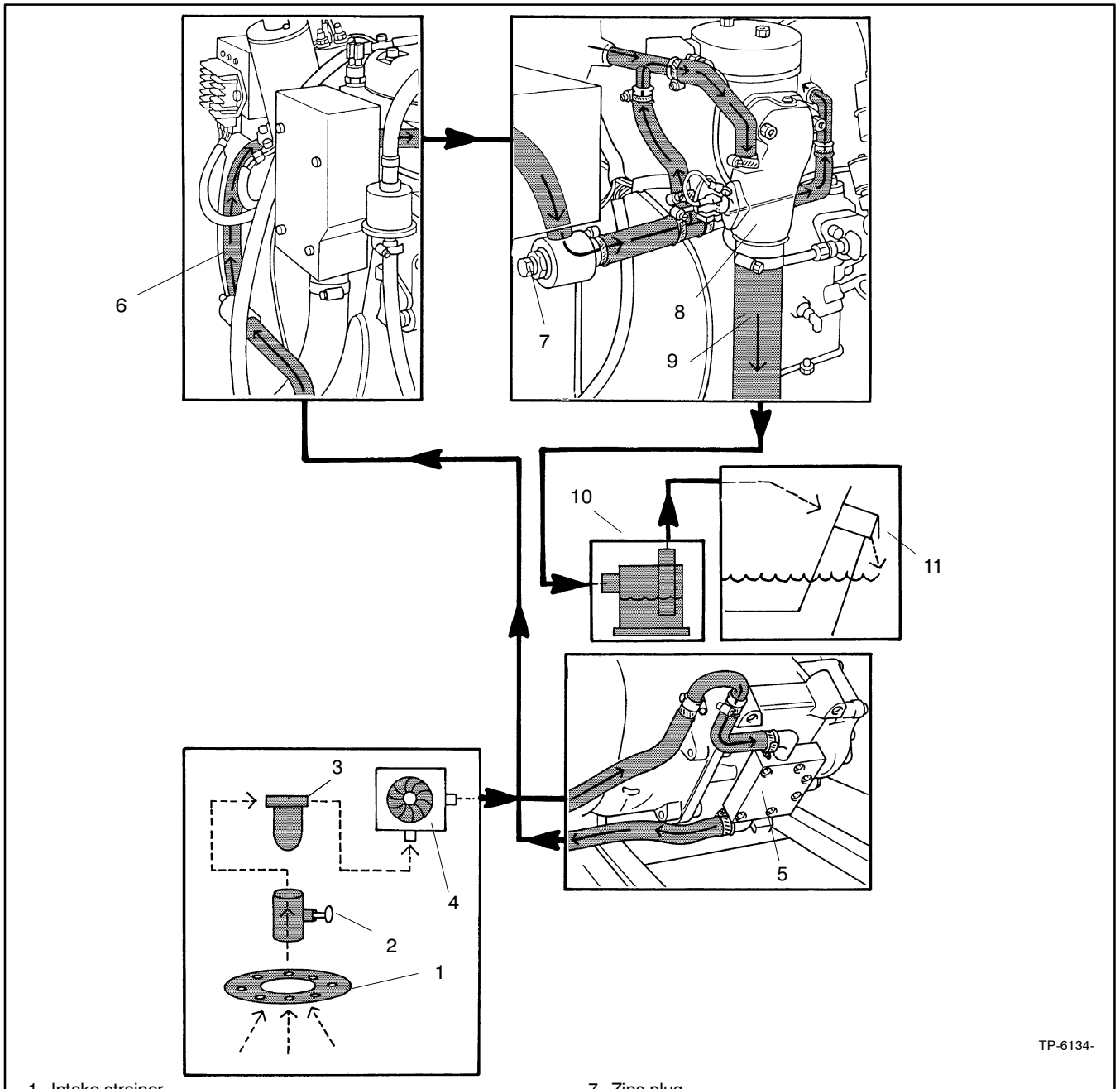
Notes

6.1 Direct Water Cooled

In a direct seawater cooling system, the impeller pump circulates the seawater around the cylinder and through the cylinder head. A thermostat controls the cooling water circuit temperature. Consult Figure 6-1 and the engine operation manual for the cooling water circuit diagrams.

NOTICE

Saltwater damage. Saltwater quickly deteriorates metals. Wipe up saltwater on and around the generator set and remove salt deposits from metal surfaces.



1. Intake strainer
2. Seacock
3. Seawater strainer
4. Engine-driven seawater pump
5. Oil exchanger
6. Alternator water cooler
7. Zinc plug
8. Exhaust manifold elbow
9. Exhaust hose
10. Silencer (customer supplied)
11. Outlet flapper (exhaust/water discharge)

Figure 6-1 Direct Water-Cooled Cooling System (3.5EFOZ and 4EOZ Models)

6.2 Thermostat

In a direct seawater cooling system, the impeller pump circulates the seawater around the cylinder and through the cylinder head. A thermostat controls the cooling water circuit temperature. See Figure 6-2 for thermostat settings. Consult the engine operation manual for the thermostat cleaning and checking procedures.

Thermostat Settings (Max. Temp.)	
Seawater	50°C (122°F)
Freshwater	75°C (167°F)

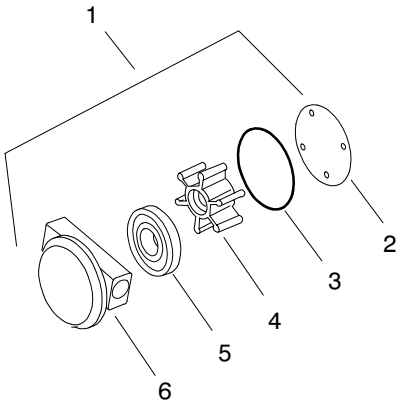
Figure 6-2 Thermostat Settings

6.3 Seawater Pump and Impeller

The gear driven seawater pump is located on the alternator side of the generator set. Check and change the seawater pump impeller at the interval specified in the service schedule. Follow the instructions included with the impeller kit. If the instructions are not included with the kit, use the following procedure:

Impeller Inspection and Replacement Procedure:

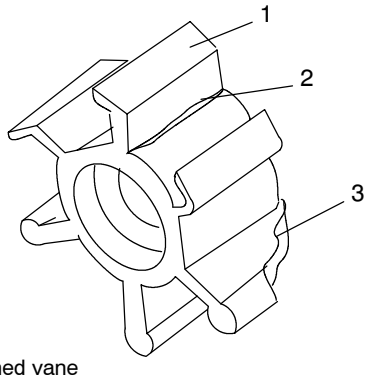
1. Close the seacock.
2. Remove the seawater pump coverplate. See Figure 6-3.



1. Seawater pump
2. Coverplate
3. Gasket
4. Impeller
5. Bearing
6. Housing

Figure 6-3 Seawater Pump, Typical

3. Remove the impeller.
4. Inspect the impeller for damaged, cracked, broken, missing or flattened vanes. The impeller vanes should be straight and flexible. See Figure 6-4. Replace the impeller if it is damaged.



1. Flattened vane
2. Crack
3. Broken vane

Figure 6-4 Worn Impeller

5. Lubricate the impeller with soapy water before installation.
6. Install the impeller.

   Note: During installation push and rotate the impeller in the same direction as the engine rotation until it is thoroughly seated in the impeller housing.

7. Inspect the coverplate and gasket for corrosion and/or damage. Replace components as necessary.
8. Lubricate the gasket with silicon grease and attach the gasket and coverplate to the seawater pump housing.
9. Open the seacock.
10. Start the generator set and check for leaks.
11. Stop the generator set and repair leaks or replace damaged or worn components.

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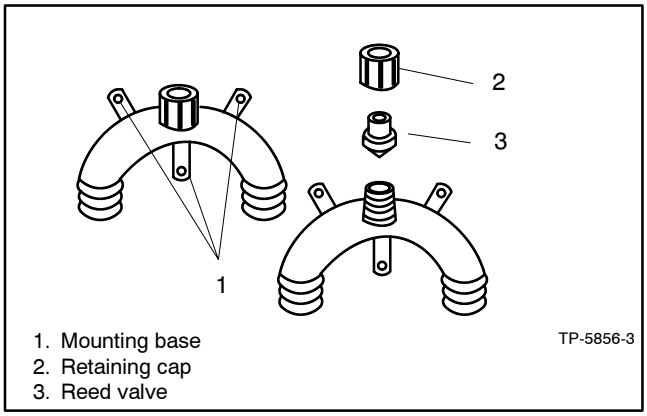
6.4 Siphon Break

A siphon break prevents seawater entry into the generator set's engine when the engine exhaust manifold outlet is less than 230 mm (9 in.) above the waterline of a fully loaded, docked or stationary craft. The siphon break may malfunction when the generator set operates while the craft is in contaminated waters or saltwater. Use the following procedure to inspect the siphon break at the intervals listed in the service schedule.

Siphon Break Inspection

1. Stop the generator set.
2. Remove the retaining cap and remove the reed valve for inspection. See Figure 6-5.
3. Use a mild detergent to remove residue and oxidation from the reed valve.
4. Clear blockages from the reed valve opening.
5. Replace the siphon break if the reed valve is cracked or if the reed valve material has hardened or deteriorated.
6. Install the reed valve into the mounting base with the valve downward. See Figure 6-5, item 3.
7. Install and only finger tighten the retaining cap. Do not overtighten it.



1. Mounting base
2. Retaining cap
3. Reed valve

Figure 6-5 Siphon Break

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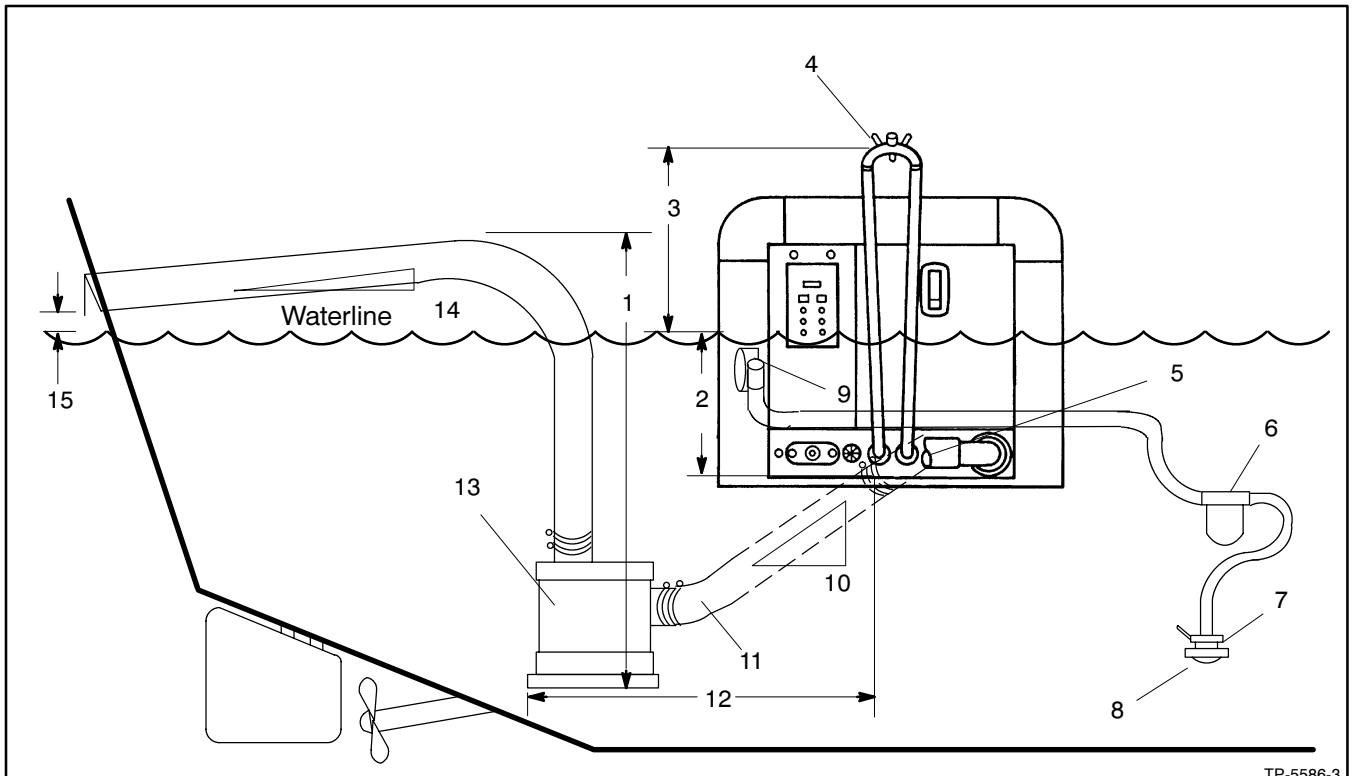


1. Silencer vertical lift 1.2 m (4 ft.) max.
2. Exhaust outlet distance from the waterline. Use a siphon break if the exhaust mixer outlet is located less than 23 cm (9 in.) above the waterline.
3. Siphon break distance above waterline 30.5 cm (1 ft.) min.
4. Siphon break
5. Exhaust outlet
6. Seawater strainer
7. Seacock
8. Intake strainer
9. Gear-driven seawater pump
10. Exhaust hose pitch 1.3 cm per 30.5 cm (0.5 in. per ft.) min.
11. Water lock (optional)
12. Silencer distance from exhaust outlet 3 m (10 ft.) max.
13. Silencer (customer supplied)
14. Exhaust hose pitch 1.3 cm per 30.5 cm (0.5 in. per ft.) min.
15. Exhaust outlet distance above the waterline 10 cm (4 in.) min.

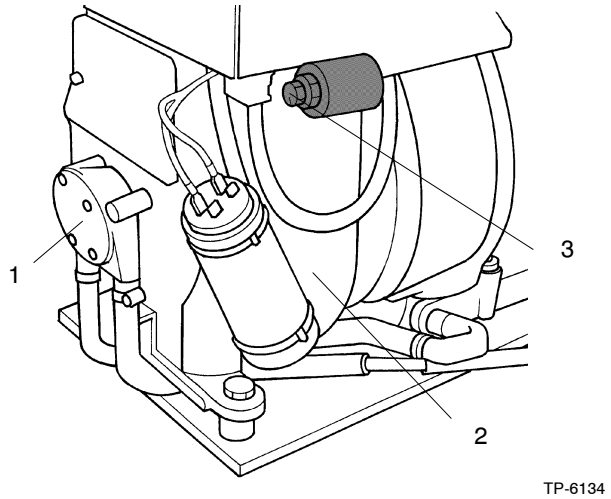
Figure 6-6 Siphon Break, Plastic “U” Type

Note: Do not locate the siphon break directly above the generator set.

6.5 Anticorrosion Zinc Anode

The generator set includes an anticorrosion zinc anode (plug) to prevent electrolytic corrosion by seawater.

Check and replace the anticorrosion zinc anode at intervals recommended in the service schedule. Depending upon operating conditions and seawater properties, the anticorrosion zinc anode may require more frequent replacement. See Figure 6-7 for the location and use the following procedure.



1. Seawater pump
2. Water-cooled alternator
3. Anticorrosion zinc anode (seawater drain)

Figure 6-7 Anticorrosion Zinc Anode

Anticorrosion Zinc Anode Replacement

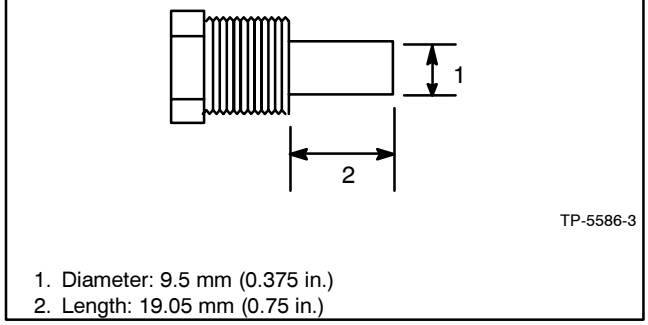
1. With the generator set cooled, close the seacock, open the petcock on the engine, and drain the coolant into a suitable container.

2. Remove the anticorrosion zinc anode (plug).

3. Use a wire brush to remove the loose corrosion on the anticorrosion zinc anode. Replace the anode according to Figure 6-8 and Figure 6-9.

Anticorrosion Zinc Anode Replacement	
New Anode Dimensions mm (in.)	**Replace When Percent of Zinc Remaining Is:**
10 (0.39) x 20 (0.79)	<50% of length/diameter

Figure 6-8 Anticorrosion Zinc Anode (Plug) Measurements



1. Diameter: 9.5 mm (0.375 in.)
2. Length: 19.05 mm (0.75 in.)

Figure 6-9 Anticorrosion Zinc Anode (Plug)

4. If necessary, cut the anticorrosion zinc to the correct length. Clean the threaded hole of the engine and coat the threads of the anticorrosion zinc anode (plug) with pipe sealant suitable for marine applications. Install the anticorrosion zinc anode into the threaded hole.

5. Close the petcock on the engine and open the seacock.

6. Refill the seawater cooling system.

7. Start the generator set and check for leaks at the anticorrosion zinc anode location. The pump is operating if the cooling water flows from the exhaust outlet. If water is not discharging at the exhaust outlet, see Section 2, Prestart Checklist, Seawater Pump Priming in the operation manual.

Notes

7.1 General

When troubles occur, do not overlook simple causes. Improper fuel or an empty fuel tank could cause a starting problem. The following charts indicates some common problems. Consult the safety precaution section of this manual before servicing the generator set. If the procedures in this manual do not explain how to correct the problem, bring the generator set to an authorized Kohler distributor or dealer. Tell the distributor or dealer exactly what happened when the problem occurred and any adjustments made to the generator set.

Problem	Possible Cause	Corrective Action
Unit will not crank	Weak or dead battery.	Recharge or replace the battery.
	Reversed or poor battery connections. Poor ground.	Check the connections.
	Circuit breaker tripped in the controller.	Reset the circuit breaker.
	Inoperative start/stop switch.	Check function; replace as necessary.
	Inoperative starter solenoid.	Check the starter solenoid and wiring. Replace as necessary.
	Inoperative starter.	Attempt starting by direct connection to the battery. Repair/replace as necessary.
Unit cranks but will not start	Fault shutdown.	Check the shutdown switches.
	Out of fuel.	Replenish fuel supply.
	Fuel shut-off valve closed.	Open the fuel shut-off valve.
	Inoperative fuel feed pump.	Replace the fuel feed pump.
	Clogged fuel filter.	Service the fuel filter element.
	Air in the fuel system.	Bleed the air.
	Water or dirt in the fuel system.	Drain and flush the fuel system.
	Dirty or faulty fuel injectors.	Contact your local Kohler generator set distributor for service.
	Incorrect compression.	Contact your local Kohler generator set distributor for service.
	Incorrect fuel type.	Use the correct fuel type. Consult the fuel supplier.
	Incorrect lube oil type for ambient temperature.	Use the correct lube oil.
	Faulty fuel solenoid.	Replace the solenoid.
	Air intake screen clogged.	Clean or replace.
	Faulty ground (–) connection.	Clean and retighten.
	Weak or dead battery.	Recharge or replace.
	Engine malfunction.	Contact your local Kohler generator set distributor for service.
Engine starts but does not continue to run after start switch is released	Inoperative high exhaust temperature (HET), low oil pressure (LOP), and/or high water temperature (HWT) shutdown switch(es).	Check the HET, LOP and/or HWT shutdown switch(es).
	No/low oil pressure.	Check the oil pressure and pump.
	No generator output voltage.	Check the AC voltage.

Problem	Possible Cause	Corrective Action
Stops suddenly	Out of fuel.	Replenish fuel supply.
	Air intake clogged.	Service the air intake screen.
	Circuit breaker tripped in the controller.	Reset the circuit breaker.
	Inoperative seawater pump impeller.	Replace the impeller.
	Clogged seawater strainer.	Clean the strainer.
	Fuel line restricted.	Check the fuel lines and the fuel tank.
	Dirty fuel filter.	Clean the fuel filter.
	No/low oil pressure.	Check the oil pressure and pump.
	High temperature.	Check the engine cooling system.
	Inoperative high exhaust temperature (HET), low oil pressure (LOP), and/or high water temperature (HWT) shutdown switch(es).	Check the HET, LOP, and HWT shutdown switch(es).
	Loss of AC output.	Contact your local Kohler generator set distributor for service.
Operates erratically	Air intake clogged.	Service the air intake screen.
	Stale or bad fuel.	Replace the fuel.
	Clogged fuel filter.	Service the fuel filter.
	Vent in fuel tank cap obstructed.	Clean the cap in solvent; blow dry.
	Water, dirt, or air in the fuel system.	Drain, flush, fill, and bleed air in the system.
	Dirty or faulty injectors.	Contact your local Kohler generator set distributor for service.
	Faulty governor link.	Contact your local Kohler generator set distributor for service.
	Inoperative fuel feed pump.	Replace the fuel feed pump.
	Incorrect valve clearance.	Contact your local Kohler generator set distributor for service.
	Inoperative valve spring.	Contact your local Kohler generator set distributor for service.
	Incorrect compression.	Contact your local Kohler generator set distributor for service.
Engine knocks	Improper fuel type.	Use proper fuel type; consult fuel supplier.
	Improper fuel injection timing.	Contact your local Kohler generator set distributor for service.
	Improper cylinder top clearance.	Contact your local Kohler generator set distributor for service.
	Inoperative piston or piston ring.	Contact your local Kohler generator set distributor for service.
	Inoperative crankshaft bearing or piston pin bearing.	Contact your local Kohler generator set distributor for service.
	Improper valve clearance piston pin bearing.	Contact your local Kohler generator set distributor for service.
	Air in injectors.	Bleed air.
Loses power	Air intake clogged.	Service the air intake screen.
	Bad or stale fuel.	Replace the fuel.
	Engine not operating at rated RPM.	Check the governor.
	Governor adjustments incorrect.	Adjust the governor.

Problem	Possible Cause	Corrective Action
Loses power (continued)	Carbon build up.	Clean the carbon from the cylinder head.
	Improper cooling.	Inspect the cooling system.
	Fuel line restricted.	Check the fuel lines.
	Engine overloaded.	Reduce the load.
	Dirty fuel filter.	Service the fuel filter.
	Improper valve clearance.	Contact your local Kohler generator set distributor for service.
	Dirty or faulty injectors.	Contact your local Kohler generator set distributor for service.
	Incorrect fuel injection timing.	Contact your local Kohler generator set distributor for service.
	Improper engine compression.	Contact your local Kohler generator set distributor for service.
	Vent in fuel tank obstructed.	Clean the cap in solvent; blow dry.
Overheats	Improper cooling.	Check the intake and outlet openings. Check the raw water strainer.
	Inoperative thermostat.	Replace the thermostat.
	Air intake clogged.	Service the air intake screen.
	Engine overloaded.	Reduce the load.
	Cooling system need flushing.	Flush the cooling system.
	Inoperative temperature switches.	Replace shutdown switches.
	Cooling water leaks from the water passage.	Check the water passage.
Engine emits black or gray exhaust smoke.	Incorrect fuel type.	Use correct fuel.
	Clogged or dirty air intake screen.	Service the air intake screen.
	Inoperative injection pump.	Contact your local Kohler generator set distributor for service.
	Faulty injectors.	Contact your local Kohler generator set distributor for service.
	Incorrect fuel injection timing.	Contact your local Kohler generator set distributor for service.
	Incorrect valve clearance.	Contact your local Kohler generator set distributor for service.
	Lube oil level too high.	Drain out surplus.
	Incorrect lube oil.	Use correct viscosity oil.
Low lube oil pressure	Low lube oil level.	Add lube oil.
	Incorrect lube oil viscosity.	Drain; fill with correct lube oil.
	Inoperative lube oil pump.	Contact your local Kohler generator set distributor for service.
	Inoperative oil pressure switch.	Replace the shutdown switch.
High lube oil consumption	Too light viscosity oil.	Use correct viscosity lube oil.
	Oil leaks.	Check for leaks in lines, around gasket, and drain plug.
	Incorrect oil type.	Use correct viscosity lube oil.
	Clogged breather system.	Clean the breather system.
	Inoperative piston ring, piston, cylinder block, valve guide, and seat.	Contact your local Kohler generator set distributor for service.

Problem	Possible Cause	Corrective Action
High fuel consumption	Incorrect fuel type.	Use correct fuel.
	Clogged or dirty air intake screen.	Service the air intake screen.
	Engine overloaded.	Reduce the load.
	Incorrect valve clearance.	Contact your local Kohler generator set distributor for service.
	Incorrect fuel injection timing.	Contact your local Kohler generator set distributor for service.
	Low engine temperature.	Check the thermostat.
	Incorrect compression.	Contact your local Kohler generator set distributor for service.
	Fuel leakage.	Check for leaks at the fuel tank, lines, and engine fuel system.
Unit is noisy	Exhaust system leak.	Check the exhaust system.
	Exhaust system not securely installed.	Check for loose parts.
	Broken or damaged vibromounts.	Check the vibromounts.
	No installation clearance. Units hits the craft structure or compartment.	Check the clearance.
	No compartment sound insulation.	Install approved insulation.
	Excessive vibration.	Contact your local Kohler generator set distributor for service.
	Loose or vibrating sheet metal.	Tighten all bolts.
Abnormal noise	Worn or inoperative bearing or gear.	Contact your local Kohler generator set distributor for service.
	Loose bolt or screw.	Tighten the hardware.
	Low lube oil level.	Add lube oil.
Battery will not charge	Loose or corroded connections.	Clean and tighten connections.
	Sulfated or worn battery connections.	Check the electrolyte level and specific gravity (batteries with filler caps only).
	Inoperative battery charging system.	Check the charging system.
	Battery charging fuse blown.	Replace the fuse. If the fuse blows again, contact your local Kohler generator set distributor for service.
Starter does not work properly	Loosened or corroded connections.	Clean and tighten the loose connections.
	Low battery output power.	Check the electrolyte level and specific gravity (batteries with filler caps only). Check battery voltage.
	Inoperative starter solenoid.	Replace the starter solenoid.
	Inoperative start/stop switch.	Replace the switch.
	Inoperative wiring.	Check the wiring.
Starter cranks slowly	Low battery output.	Check the electrolyte level and specific gravity (batteries with filler caps only).
	Too heavy viscosity lube oil.	Use proper viscosity oil.
	Loosened or corroded wiring.	Clean and tighten loose connections.
	High starter current draw.	Rebuild or replace the starter.
	Battery cable undersized.	See the installation manual.

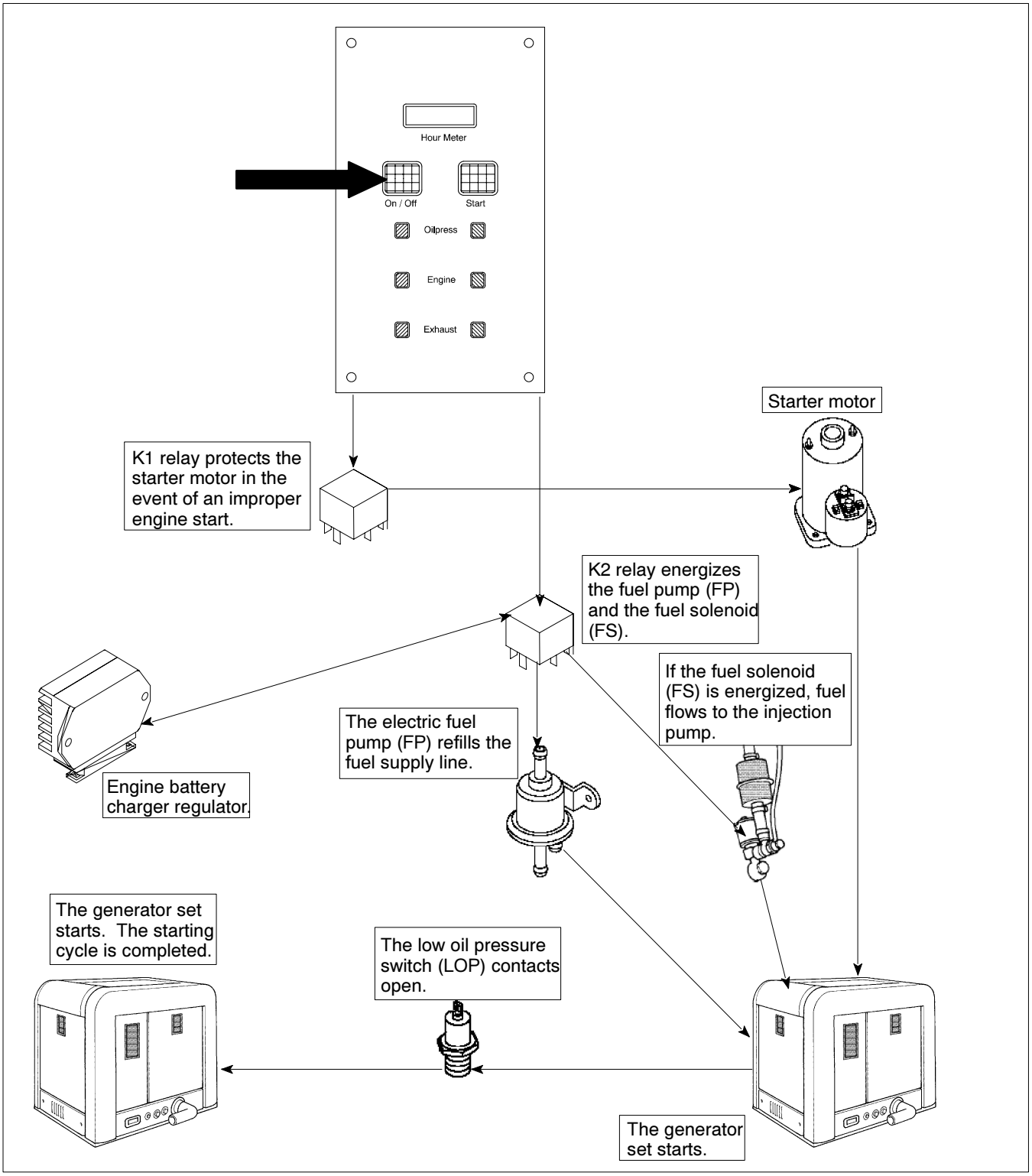
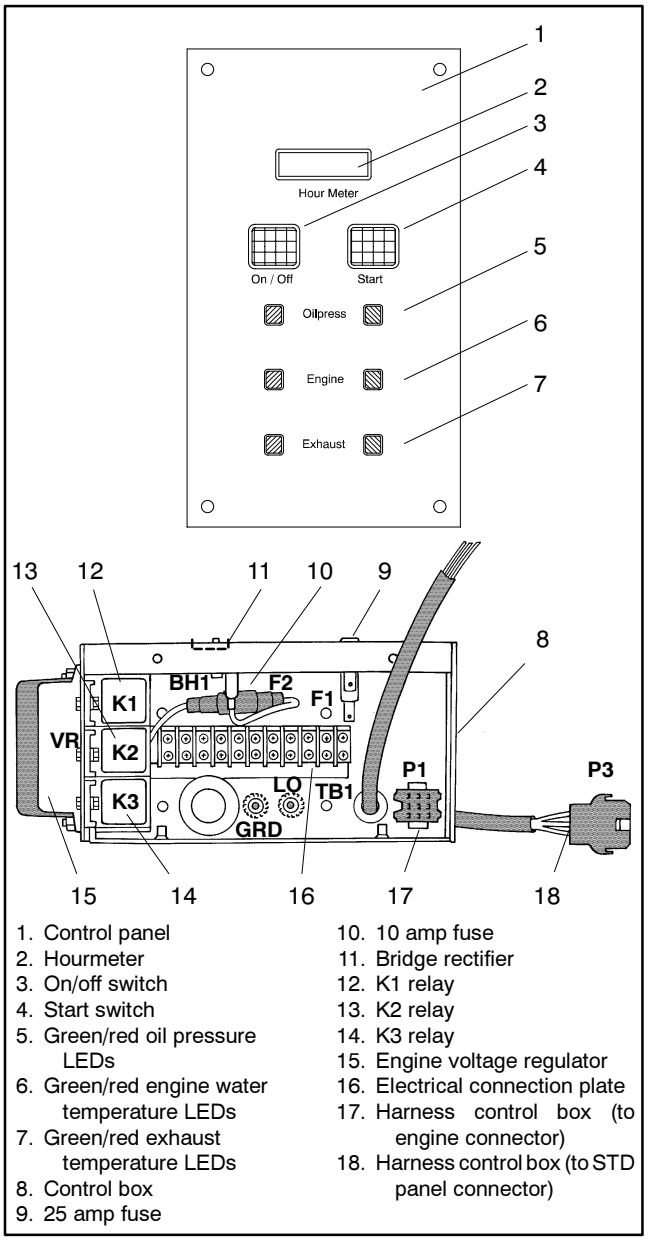


Figure 8-1 Generator Set Starting Cycle

8.1 General

The following section covers the controller troubleshooting procedure. Refer to Figure 8-2 to identify the controller components.



1. Control panel
2. Hourmeter
3. On/off switch
4. Start switch
5. Green/red oil pressure LEDs
6. Green/red engine water temperature LEDs
7. Green/red exhaust temperature LEDs
8. Control box
9. 25 amp fuse
10. 10 amp fuse
11. Bridge rectifier
12. K1 relay
13. K2 relay
14. K3 relay
15. Engine voltage regulator
16. Electrical connection plate
17. Harness control box (to engine connector)
18. Harness control box (to STD panel connector)

Figure 8-2 Controller Internal Components

8.1.1 On/Off Switch

After pressing the On/Off switch on the control panel (local or remote), two green LEDs and one red LED (oil engine) light. This operation energizes the control panel and permits DC to the K2 relay. This in turn energizes the fuel solenoid (FS) and the fuel pump (FP) because the normally open contacts of the K2 relay close.

8.1.2 Start

Press the START switch (local or remote) the K1 relay energizes. The normally open K1 contacts close allowing DC to the normally open contacts of the starter motor's solenoid (S). The energized starter starts the generator set's engine.

8.1.3 Run

After reaching correct engine and generator set performance, the two generator set wires marked 10 and 11 energize the K3 relay (AC crank disconnect) that opens its normally closed contacts.

DC supplied to the starter is interrupted, every starting operation is eliminated.

The generator set wires marked C1 and C2 connect at the capacitor supplying AC. As it gives or receives current in accordance with variable loads, its capacity changes to hold the correct AC voltage value.

When good engine oil pressure operation is reached, the normally closed contacts of the low oil pressure (LOP) switch close. The red LED on the control panel cuts off and the green LED lights.

If all three green LEDs on the control panel are lit at the same time, good engine performance is achieved and AC is supplied to the windings L1, L2, L3 and L4.

8.1.4 On/Off Switch (Stop)

If the On/Off switch (local or remote) is repressed, the K2 relay deenergizes. The fuel solenoid (FS) and fuel pump (FP) do not receive DC, the normally open K2 contacts reopen and the engine stops.

8.2 Engine Safety Shutdown Switches

8.2.1 Low Oil Pressure (LOP) Shutdown

If the oil pressure drops while operating the engine, the normally closed low oil pressure (LOP) switch contacts close. DC travels to connection 5 on the control panel and the K2 relay is deenergized.

DC does not travel to the fuel solenoid (FS) or to the fuel pump (FP) and the engine stops. The red oil pressure LED on the control panel lights immediately while the green oil pressure LED cuts off.

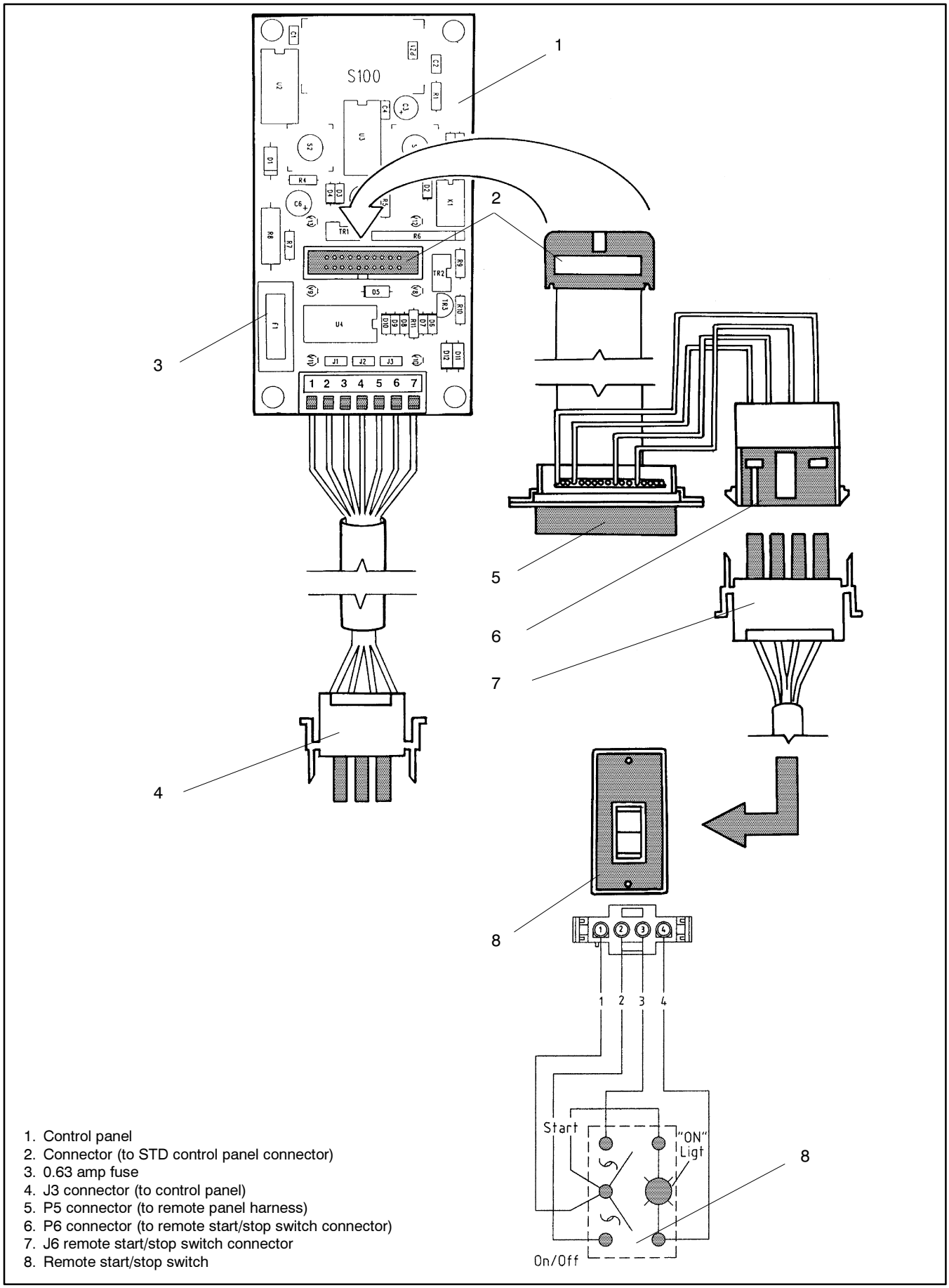
Check and correct the generator set fault.

8.2.2 High Water Temperature and High Exhaust Temperature Shutdown Switch

If high engine water temperature or exhaust gas temperature is encountered, the normally open contacts of the HCHT and HET switch close. DC travels to connection 3 or 4 on the control panel deenergizing the K2 relay.

DC does not travel to the fuel solenoid (FS) or to the fuel pump (FP) and the engine stops. The red LED of the high water temperature and/or high exhaust gas temperature light immediately while the corresponding green LED cuts off.

Check and correct the generator set fault.



1. Control panel
2. Connector (to STD control panel connector)
3. 0.63 amp fuse
4. J3 connector (to control panel)
5. P5 connector (to remote panel harness)
6. P6 connector (to remote start/stop switch connector)
7. J6 remote start/stop switch connector
8. Remote start/stop switch

Figure 8-3 Control Panel

8.3 Operation Sequence

Use the following controller operation sequence to help localize and control possible inconveniences. Follow the wiring diagram sequence shown in Section 10. If a repair is needed, be sure to disconnect the battery. Consult the safety precautions in the beginning of this manual.

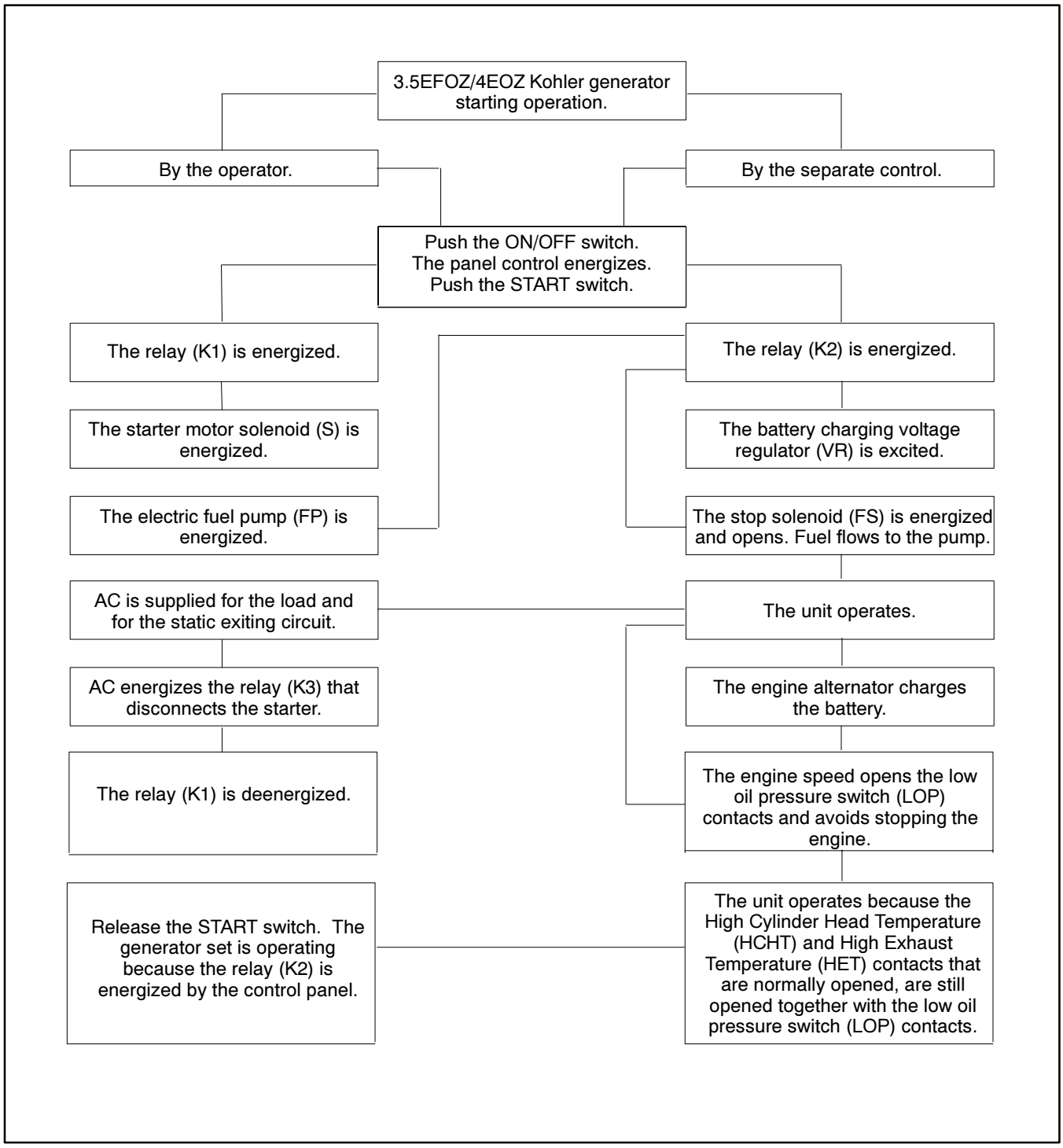


Figure 8-4 Starting Operation

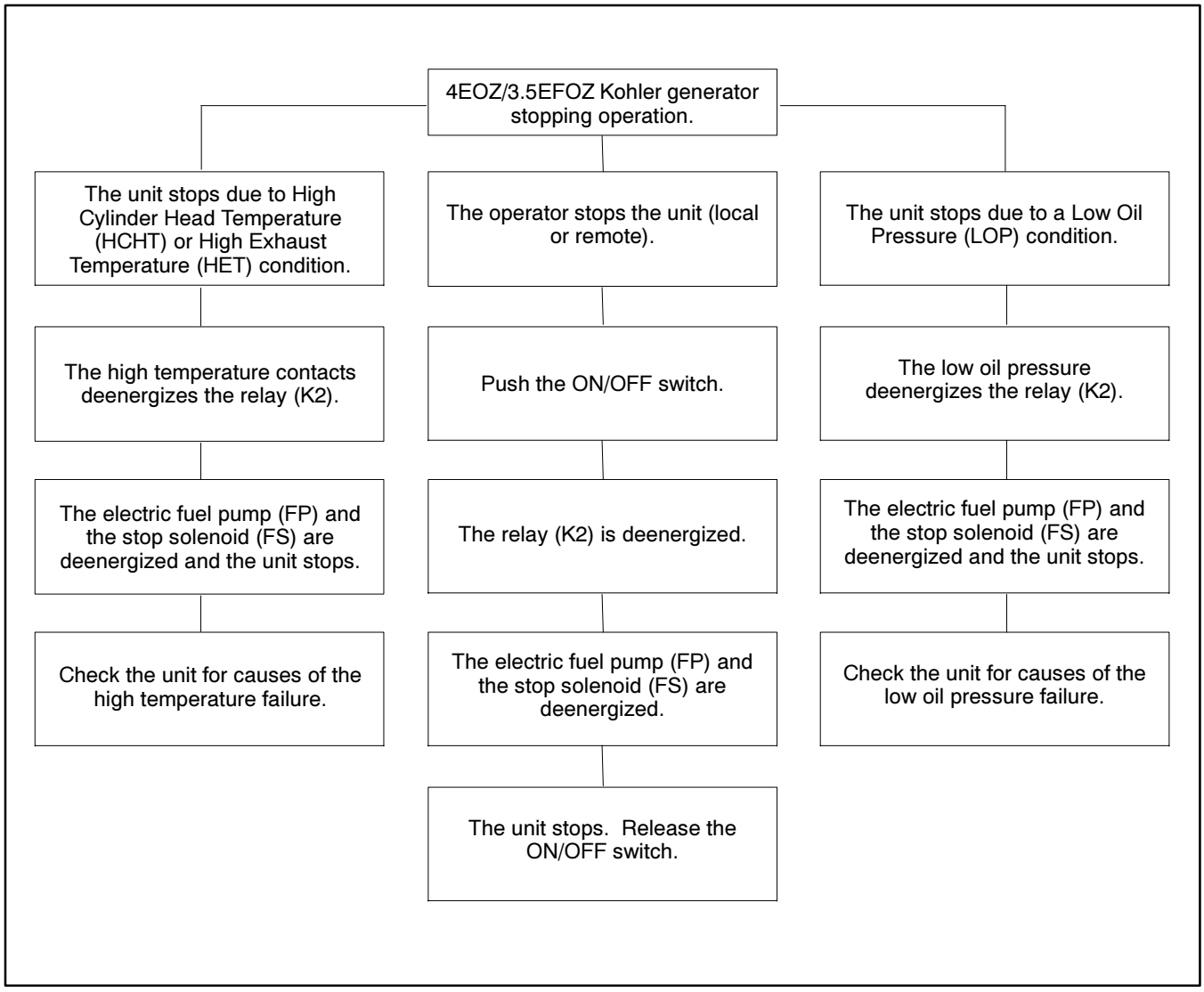


Figure 8-5 Stopping Operation

8.4 Troubleshooting

Use the following flowcharts as an aid in troubleshooting the main control panel and the entire generator set. If the prescribed remedy does not correct the problem, replace the control panel. Consult the safety precautions in the beginning of this manual.

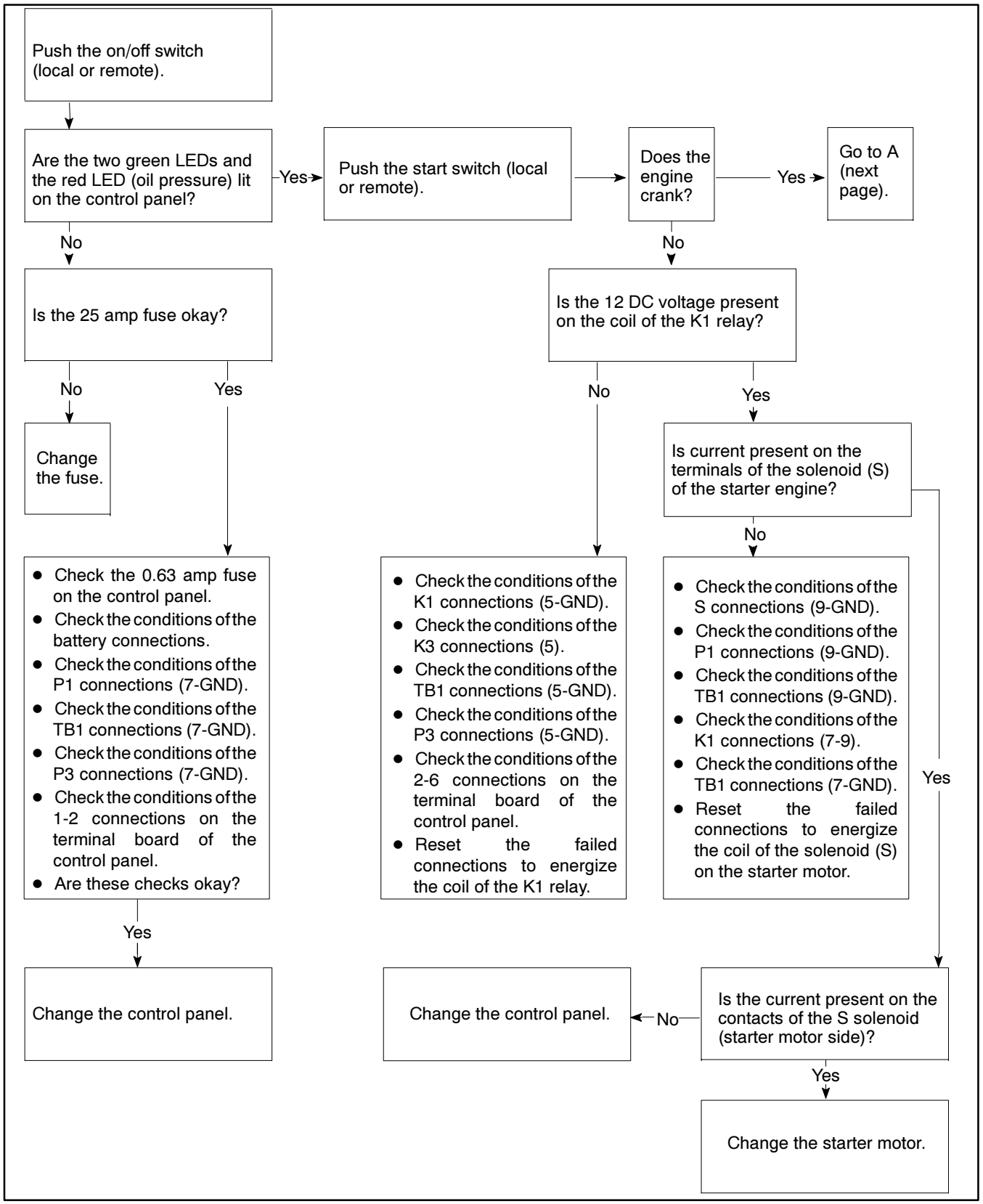


Figure 8-6 Troubleshooting Relay Controller Control Panel (1 of 4)

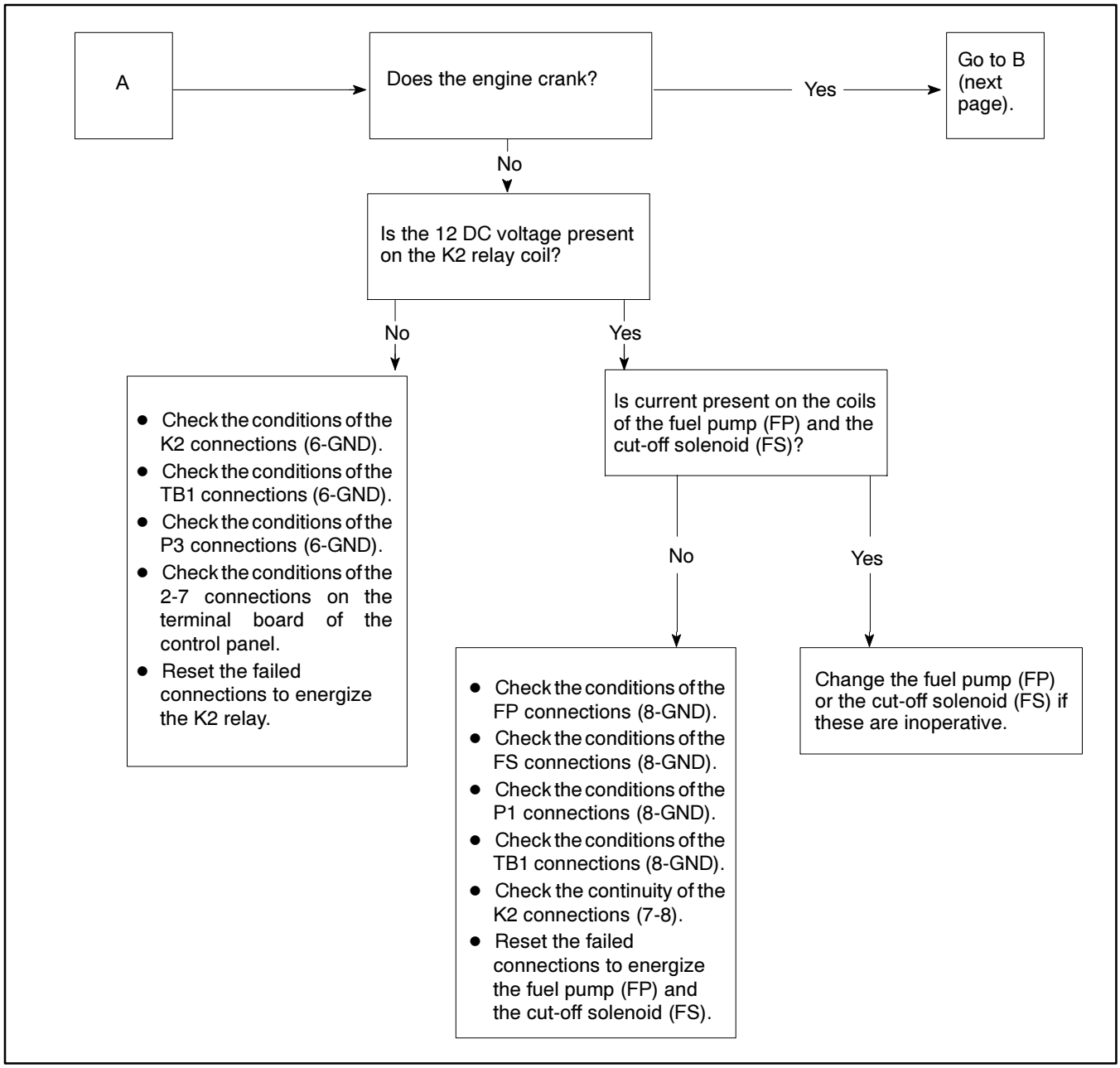


Figure 8-7 Troubleshooting Relay Controller Control Panel (2 of 4)

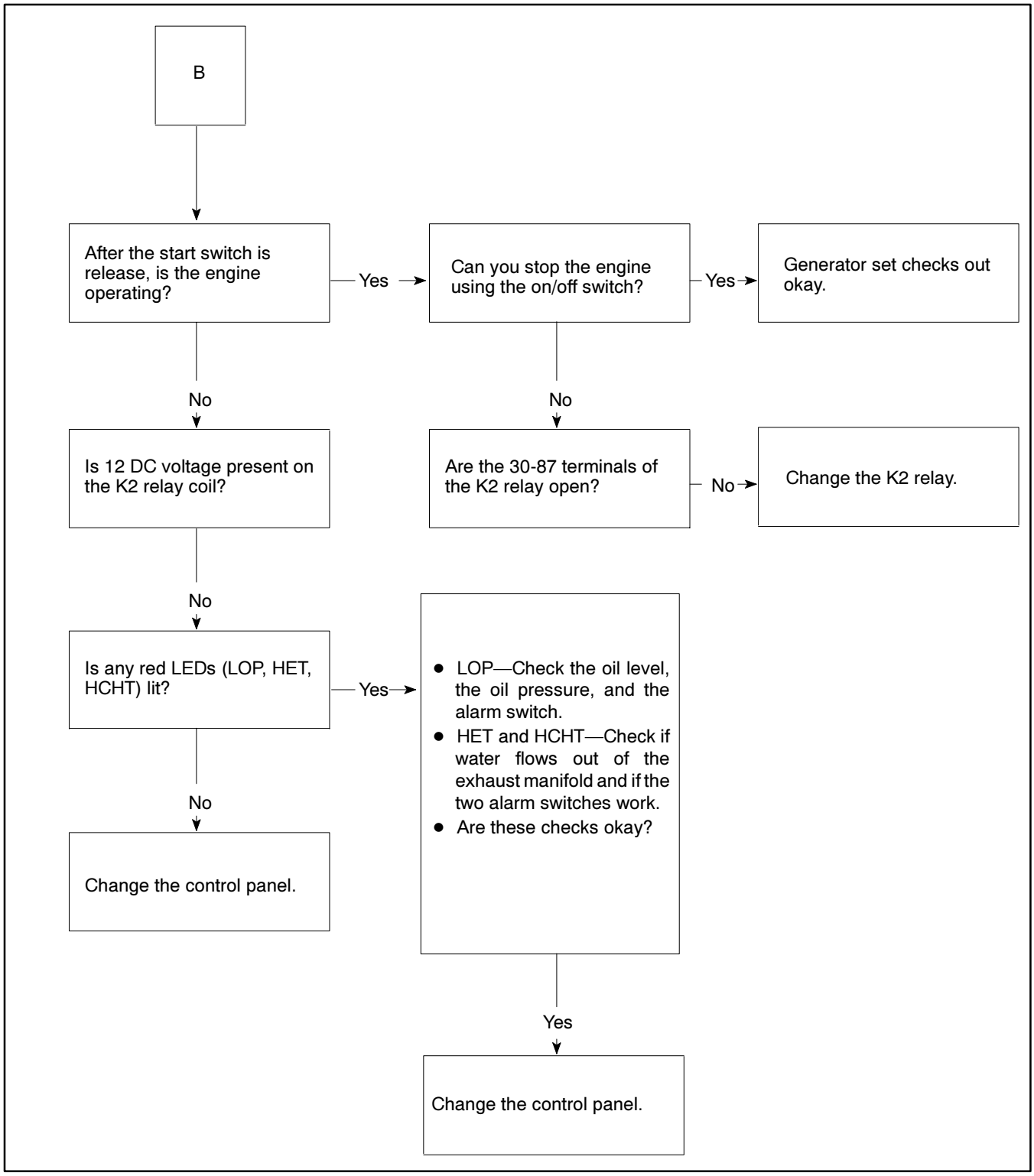


Figure 8-8 Troubleshooting Relay Controller Control Panel (3 of 4)

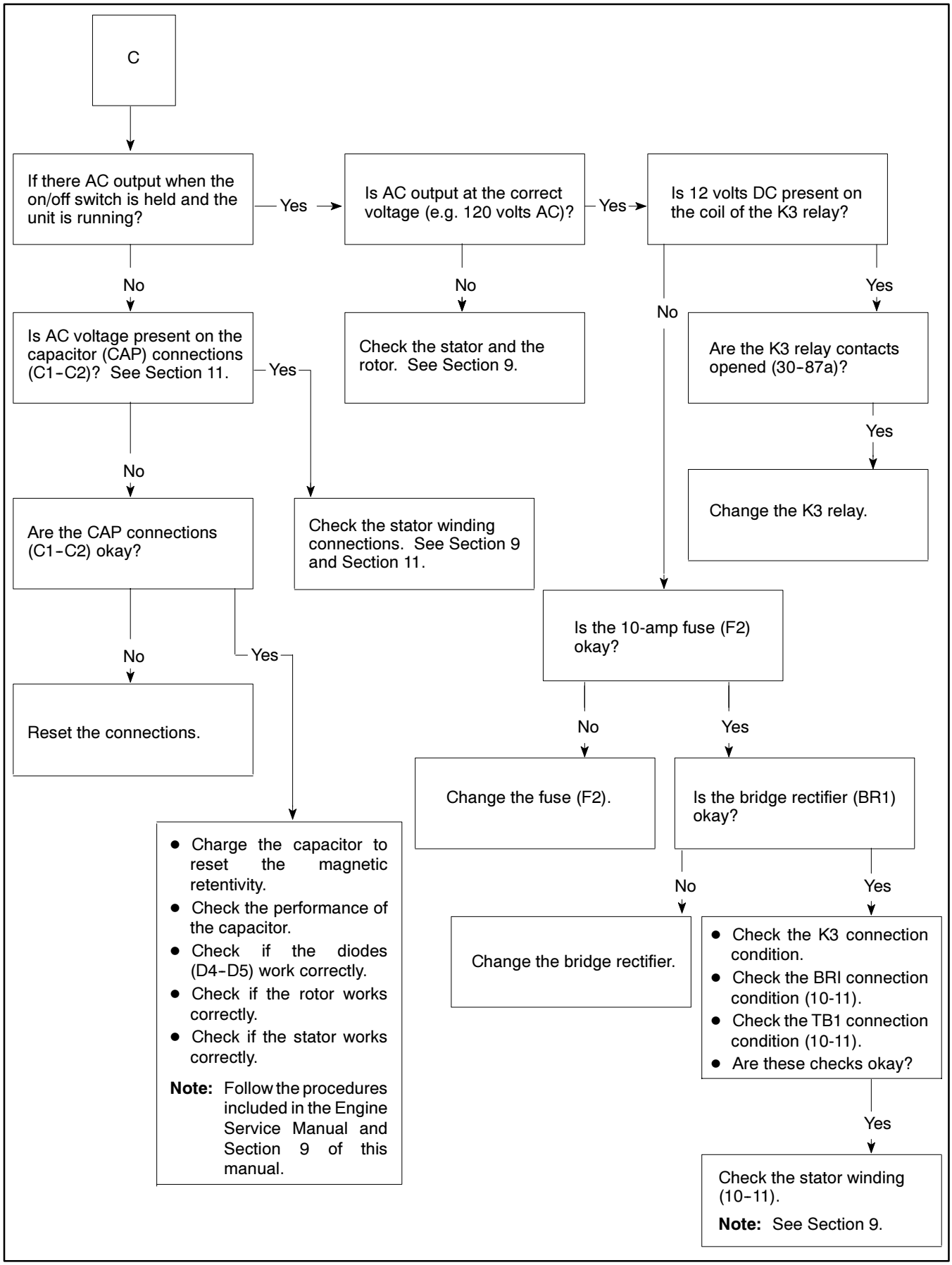


Figure 8-9 Troubleshooting Relay Controller Control Panel (4 of 4)

9.1 General

Before beginning the following troubleshooting procedures, read all the safety precautions at the beginning of this manual. The following tests include additional safety precautions; OBSERVE THESE PRECAUTIONS!

⚠ WARNING

Hazardous voltage. Moving rotor. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Handling the capacitor. Hazardous voltage can cause severe injury or death. Electrical shock results from touching the charged capacitor terminals. Discharge the capacitor by shorting the terminals together. *(Capacitor-excited models only)*

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Open the main circuit breakers of all power sources before servicing the equipment. Configure the installation to electrically ground the generator set, transfer switch, and related equipment and electrical circuits to comply with applicable codes and standards. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

High voltage test. Hazardous voltage can cause severe injury or death. Follow the instructions of the test equipment manufacturer when performing high-voltage tests on the rotor or stator. An improper test procedure can damage equipment or lead to generator set failure.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

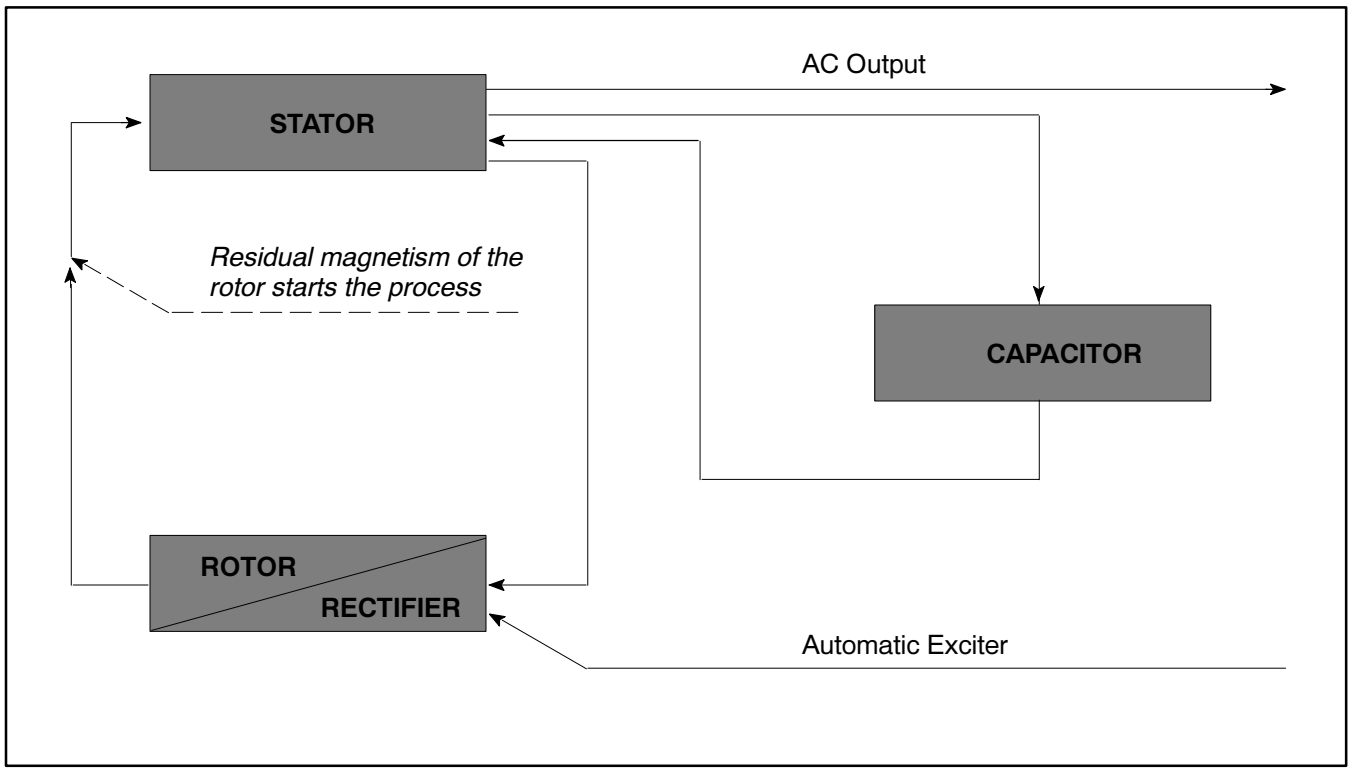


Figure 9-1 Alternator and Exciter Diagram

9.2 Theory of Operation, Brushless Generator Sets

These generator sets use a two-pole, revolving-field alternator.

The generator set's alternator is a "brushless" design, utilizing capacitor excitation. This system does not use brushes, slip rings, or a voltage regulator. In order to obtain generator output, the rotor (field) must be energized and moving. The rotor is directly connected to the flywheel by a tapered coupling. A ball bearing, located in the stator frame, holds the rear portion of the rotor. The engine moves the rotor (field) past the stator main winding, which induces an AC voltage across the stator leads. The rotor core holds enough residual magnetism to produce low AC output from the stator during start-up. As the generator speed increases, the stator auxiliary winding connected to the capacitor (leads C1 and C2) induces a voltage on the rotor field winding. A diode on the rotor rectifies the voltage to produce DC field current in the rotor. AC output is drawn from the stator winding that supplied 12 VDC to the K3 relay (start protection) and feed the capacitor. As current in the stator main winding increases with the load, additional current is induced in the rotor field to supplement the current being supplied by the stator auxiliary winding.

The generator cannot be disconnected or removed from the engine as a single unit.

9.3 Output Voltage and Frequency.

The 3.5EFOZ model generator set supplies 230 volts at 50 Hz while the 4EOZ model supplies 120/240 volts at 60 Hz in accordance with the preselected winding connection and engine speed.

9.3.1 Voltage Rating and Rotation Speed

Always check the generator set's output voltage at the nominal speed rotation. The alternators are preset at the factory to supply voltage slightly higher (5–6%) than the voltage at the nominal engine speed rotation.

The difference between the engine rotation and the nominal one can cause slight deviation of output voltage. Keep in mind that the output voltage varies proportionally to the rotation speed. If requiring output voltage correction of the generator set at a defined rotation, vary the capacity of the excitation capacitor. By increasing or decreasing the capacity value of the capacitor, voltage changes.

Note: Do not operate the generator set with voltages that deviate more than 10% of the nominal speed rotation.

9.3.2 Bearing

The alternator's rear bearings are self-lubricating and do not require maintenance for 10,000 operating hours. Replace the rear bearings during a complete engine overhaul.

9.4 Rotor Test

The two-pole rotor creates the magnetic field needed to raise the alternating current in the stator windings.

Before testing, inspect the rotor for visible damage to the pole shoes, insulation, and exposed coil windings. Check the rotor bearings for noisy operation, excessive wear, and heat discoloration. Replace or repair these components if any of the above conditions exist.

Procedure to test the rotor's insulation.

1. Disconnect the two rotor field diodes (D4 and D5). See the wiring diagrams in Section 11.

2. Using a Megger set at 500 volts DC, check the winding insulation resistance value to ground. Check every part isolated from the others. See Figure 9-2 Normally, windings with a resistance value to ground greater than 1 MOhm are considered good. If resistance is lower than 1 MOhm, replace the rotor.

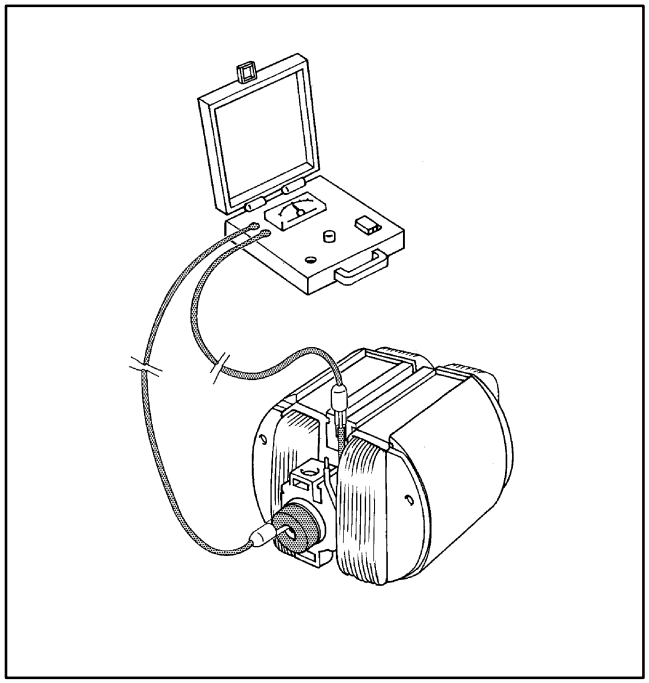


Figure 9-2 Rotor Insulation Test

Procedure to test the rotor's continuity.

1. Using an Ohmmeter test, check if the rotor winding is opened. See Figure 9-3. If an accurate ohmmeter is not available, check the circuit's continuity using a 12 VDC battery and a suitable lamp. See Figure 9-4. Replace the rotor if it is grounded, has an opened or short circuit.

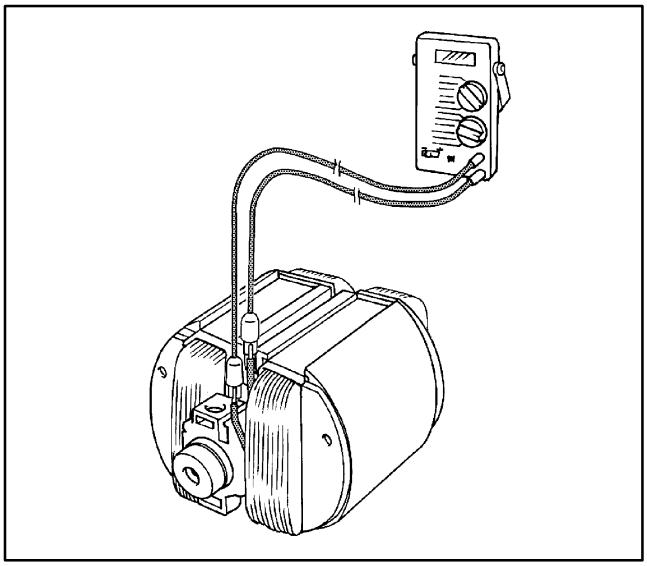


Figure 9-3 Rotor Continuity Test with Ohmmeter

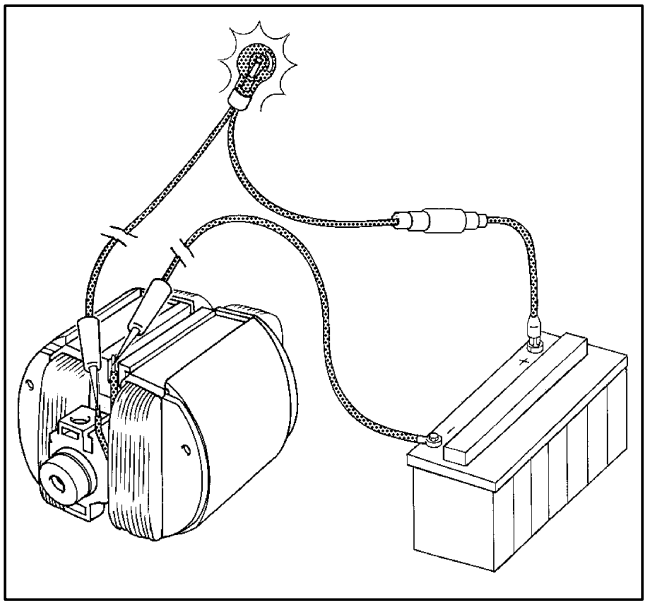


Figure 9-4 Rotor Continuity Test with AC Test Lamp

Procedure to test the rotor's resistance.

1. To test the rotor resistance, use a Wheatstone bridge. See Figure 9-5. See Figure 9-6 for resistance values.

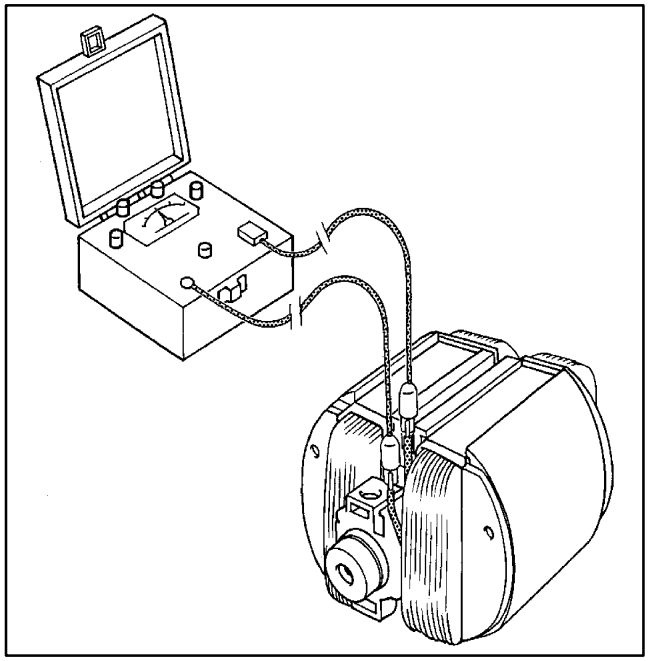


Figure 9-5 Rotor Resistance Test

Model	Resistance in Ohms at 20° C (68 ° F)
4EOZ (60 Hz)	2.57 ±10%
3.5EFOZ (50 Hz)	2.57 ±10%

Figure 9-6 Rotor Resistance Values

9.5 Field Diode Test

Check the rotor's field diodes using a multimeter. Disconnect the field diodes from the rotor and check the forward and reverse resistance. A good diode performance is indicated with a very high resistance in the reverse direction and a low resistance in the forward direction. See Figure 9-7. A failed diode gives a full deflection reading in both directions with the ohmmeter on 10,000 Ohms or an infinity reading in both directions.

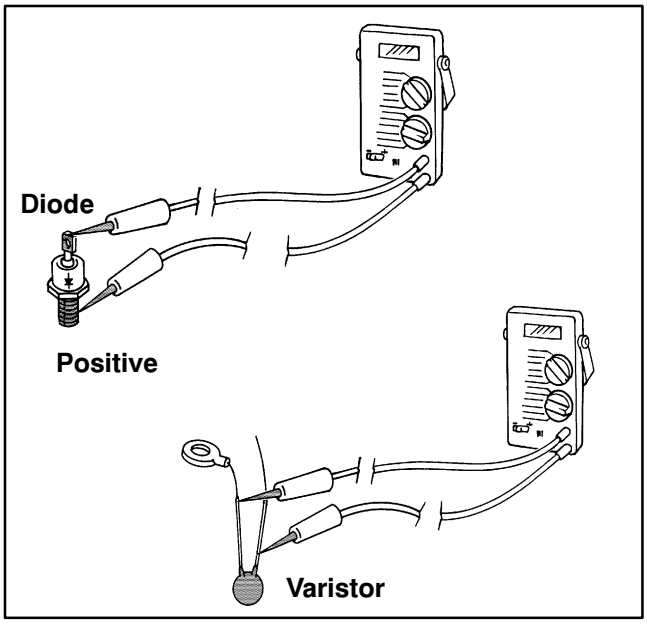


Figure 9-7 Field Diodes and Varistors Test

Failed Diodes Replacement

The rectifier assemblies are two sets of diodes and two varistors, one for each rotor winding. Take care to ensure that each diode is installed with the correct polarity:

1. Check that the arrow on the diode surface direct towards the fixing plate.
2. Check that the wire end with the eye terminal is located between the diode and the fixing plate. The other winding end must be welded at the upper part of the diode.
3. While fitting the diodes at the plate, carefully tighten the nuts to ensure good mechanical and electrical contacts.

Surge Suppressor

The surge suppressor is a metal-oxide varistor shunted to the field diodes to prevent high transient reverse voltages in the field windings thus damaging the diodes. The varistor is not polarized and shows, on a standard ohmmeter, a virtually infinitive reading in both directions. See Figure 9-7. If it is defective, normally a visible inspection shows burning signs, it gives a full deflection reading (short circuit).

9.6 Stator Test

Stator Insulation, Continuity, and Winding Resistance Test

1. Disconnect the generator set's AC output leads from the control box.

Note: Refer to the Wiring Diagrams in Section 11 and Figure 9-8 for output lead coding.

2. Check the windings insulation resistance to ground.

Note: Remember that while checking, isolate each part from the others.

3. Use a Megger set at 500 volts DC. If winding resistance values to ground is ≥ 1 MOhm, consider the insulation good. If the resistance is lower than 1 MOhm, replace the stator.

4. Using an ohmmeter, test for an open circuit in the stator winding.

Note: If an accurate ohmmeter is unavailable, check the circuit's continuity using a 12 volt DC battery and a suitable lamp.

5. Replace the stator if it has an open or short circuit in the windings.

Note: Some generators have ground connections to the frame (to ground), check the Wiring Diagrams in Section 11.

6. Using a Kelvin bridge or an accurate microhmmeter, test the resistance of each stator windings and compare the resistances obtained. See Figure 9-9. All windings of equal output voltage should indicate about the same resistance. An unusually low reading indicates a short circuit while a high reading indicates an open circuit.

7. If an open or short circuit exists, replace the stator.

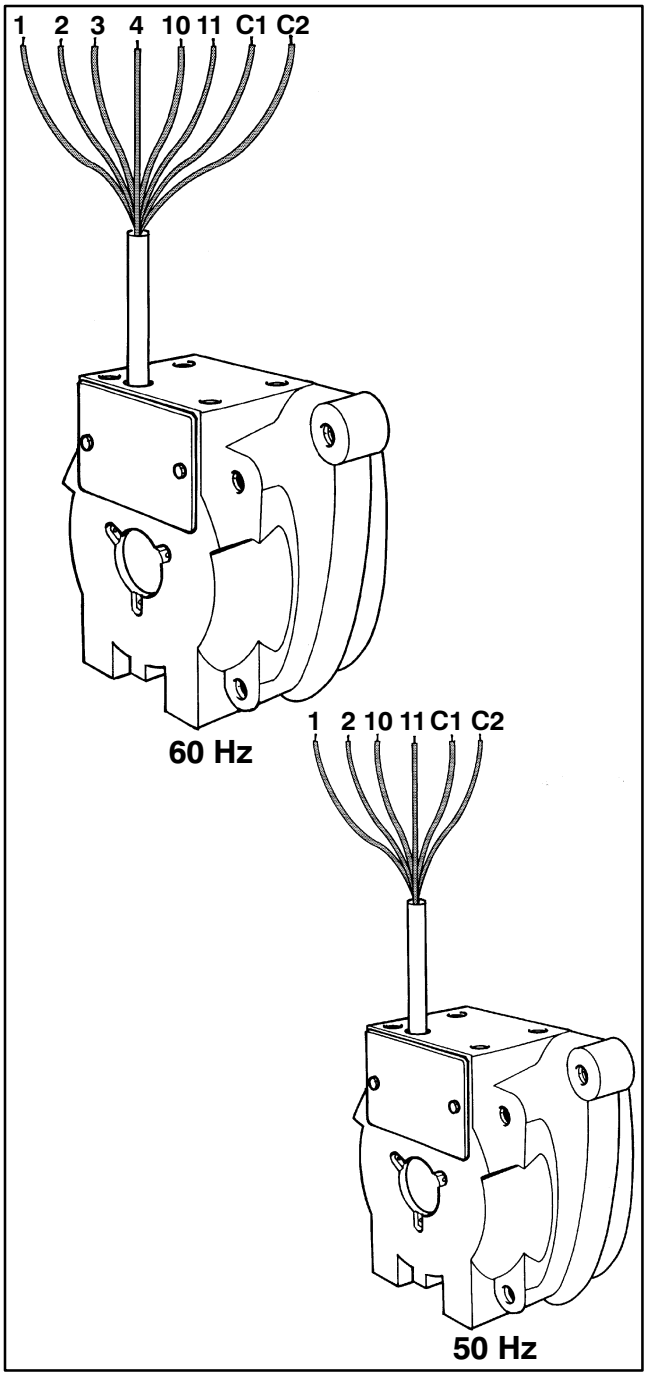


Figure 9-8 Stator Windings

Model	Resistance in Ohms at 20° C (68° F) Stator Leads 1-2	1-2 3-4	C1-C2	10-11
4EOZ (60 Hz)		0.96 ±10%	2.32 ±10%	0.068 ±10%
3.5EFOZ (50 Hz)	1.23 ±10%		2.87 ±10%	0.091 ±10%

Figure 9-9 Resistance Values

Alternator Troubleshooting and Corrective Action		
Problem	**Possible Cause**	**Corrective Action**
No output	Low revolving speed	Check and adjust the revolving speed.
	Incorrect connections	Check the wiring diagram and reset the connections.
	Inoperative capacitor	Replace the capacitor.
	Winding breakage	Check the winding resistance and replace the damaged parts.
	Rotating diode(s) damage	Check and replace the diode(s).
Low no-load voltage	Low revolving speed	Check and adjust the revolving speed.
	Rotating diode(s) damage	Check and replace the diode(s).
	Capacitor with low capacity	Increase the capacitor capacity.
	Winding breakage	Check the winding resistance and replace the damaged parts.
High no-load voltage	Capacitor with high capacity	Reduce the capacitor capacity.
	High speed	Adjust the revolving speed.
Correct no-load voltage but low voltage at load	Rotating diode(s) damage	Check and replace the diode(s).
	Low speed at full load	Operate on the speed governor.
	Load too high	Reduce the voltage supplied
Unstable voltage	Uneven rotation	Check the engine
	Poor connection contacts	Check the wiring diagram and reset the connections.
	Uneven load	Check the load and eliminate the uneven loads.
Unit is noisy	Poor coupling	Check and correct the coupling.
	Short circuit in winding or load	Check windings and loads and replace the damaged parts.
	Bearing breakage	Replace the broken bearing

9.7 Alternator Excitation

As a result of disassembling the generator set, the alternator can get deenergized. It is then necessary to excite the alternator (after reassembly to the engine) by applying 12 volts DC to the line terminals. Connect in series a 10 amp, 250 volt fuse to the positive wire going to the battery. See Figure 9-10.

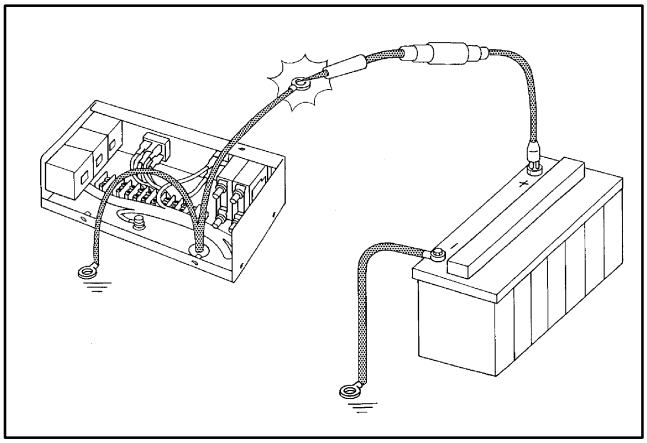
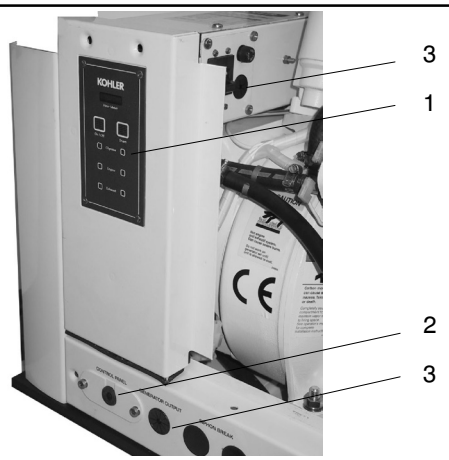


Figure 9-10 Alternator Excitation

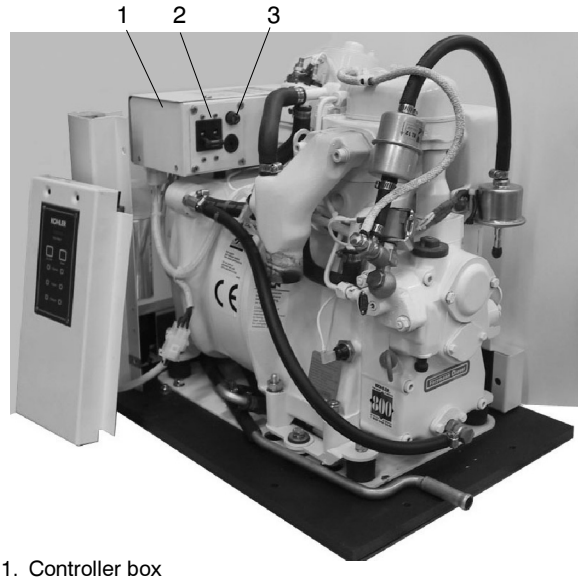
10.1 Generator Alternator Disassembly

Disconnect all the external connections—battery cables at the battery (negative (–) lead first), AC-output leads in the controller, remote start panel at the controller connector, water line at the seawater pump, fuel line at the fuel pump filter inlet, and exhaust line at the mixing elbow. Observe all the safety precautions listed at the beginning of this manual during the disassembly/ reassembly procedures.



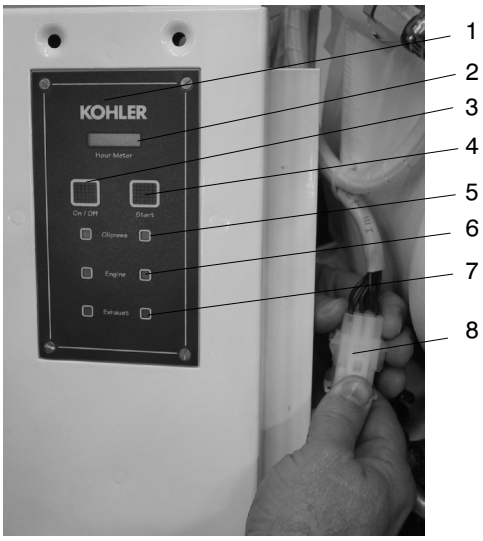
1. Standard controller panel
2. Harness outlet hole to the remote control panel
3. AC harness inlet holes to the control panel

Figure 10-1 Remote Controller Panel Components



1. Controller box
2. Circuit breaker
3. Controller fuse

Figure 10-2 Controller Components



1. Standard controller panel
2. Hourmeter
3. On/Off switch
4. Start switch
5. Engine low oil pressure LEDs
6. Engine water overheating temperature LEDs
7. Exhaust gas overheating temperature LEDs
8. Connection between the standard controller panel and the controller box

Figure 10-3 Controller Components

Controller Removal

1. Using a 10 mm socket wrench, loosen the four M6 nuts that hold the controller box on the stator housing. See Figure 10-4.

Figure 10-4 Controller Box Removal

2. Disconnect all of the controller box wires that do not permit its removal.

Note: It is possible to connect the output leads in various positions for different volt configurations. Marks the leads for correct reconnection.

3. Carefully lift the controller box. See Figure 10-5.

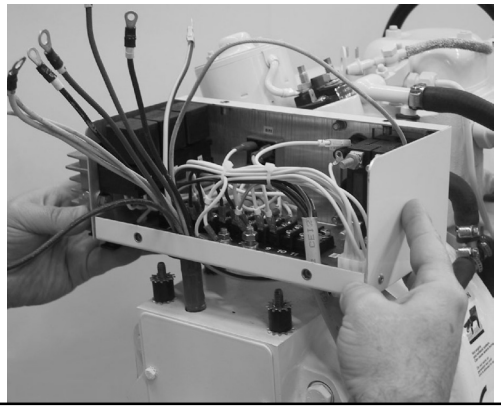


Figure 10-5 Controller Box Removal

Seawater Pump Cover Removal

1. Using a 7 mm socket wrench, release the four M4 x 8 screws from the seawater pump cover. See Figure 10-6.

Note: Remove the entire seawater pump every time alternator disassembly is required in order to check electrical components.

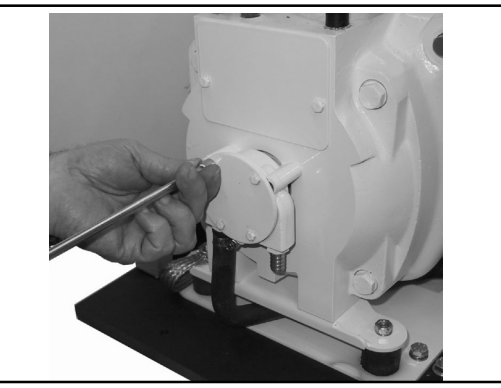


Figure 10-6 Seawater Pump Cover Removal

Seawater Pump Impeller Removal

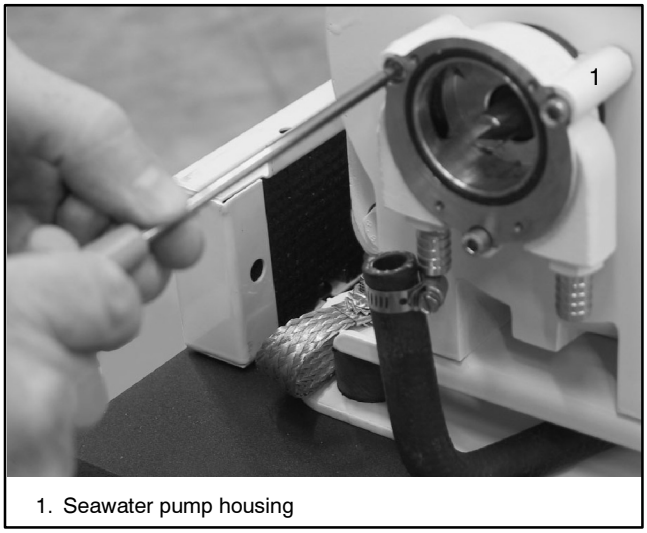
1. Carefully remove the seawater pump impeller from its housing. See Figure 10-7.

Figure 10-7 Seawater Pump Impeller

Seawater Pump Housing Removal

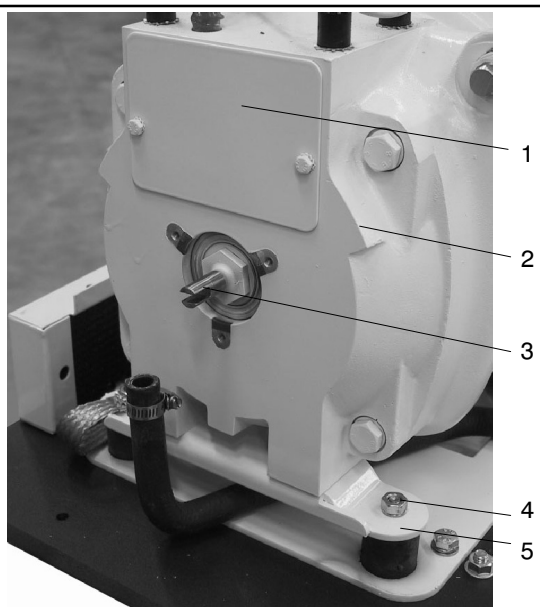
1. After disconnecting the inlet and outer water tubes from the seawater pump housing, loosen the three M5 x 40 socket screws with a 4 mm setscrew wrench.

2. Remove the housing from the alternator.



1. Seawater pump housing

Figure 10-8 Seawater Pump Housing



1. Cover for field diode and rotor inspection
2. Stator housing (alternator)
3. Seawater pump shaft
4. Vibromount nut
5. Alternator bracket

Figure 10-9 Alternator Components

Engine and Stator Housing Disconnection

1. Using a 27 mm socket wrench, unscrew the seawater pump shaft nut. See Figure 10-10.

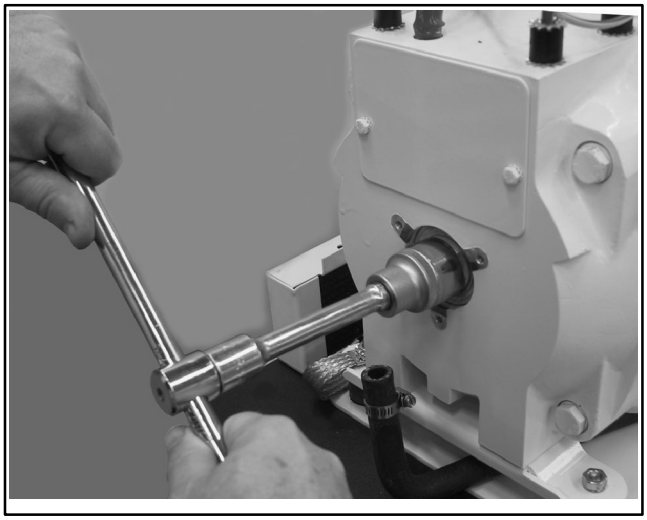
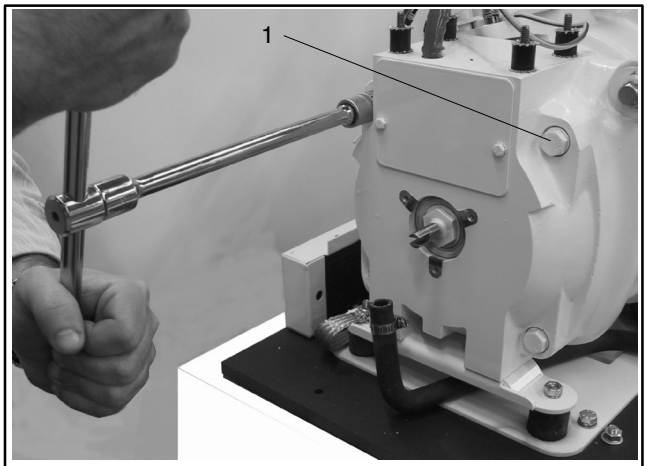


Figure 10-10 Seawater Pump Shaft Nut

2. Using a 17 mm socket wrench, loosen the four M10 x 140 screws to disconnect the alternator from the engine flywheel housing. See Figure 10-11.



1. M10 x 140 Screws (qty. 4)

Figure 10-11 Disconnect the Alternator

3. Release the two M8 nuts from the vibromounts using a 13 mm socket wrench.

4. Using a hoist, hook the stator bracket and lift the alternator to release the vibromount bolts from the alternator bracket.

5. Install a jawpuller with three M5 threaded screws into the seawater pump housing holes. See Figure 10-12.

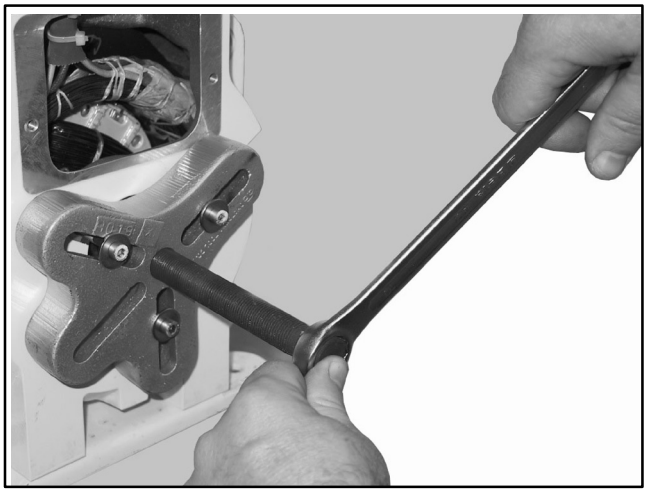


Figure 10-12 Jawpuller Installation

6. Slowly turn the jawpuller bolt to free the alternator from the engine.

7. As the puller bolt turns on the head of the alternator through stud, ensure no damage occurs.

Note: With a suitable puller it is possible to reuse the original seawater pump screws.

8. Remove the stator housing from the rotor. See Figure 10-13.

Figure 10-13 Remove the Stator Housing

Rotor and Alternator Through Stud Disconnection

1. With an uphand hammer, tap the outer surface of the rotor and release the connection between the rotor and the alternator through stud. See Figure 10-14.

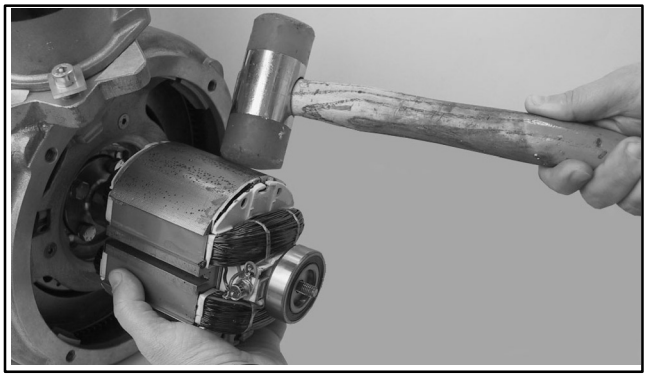


Figure 10-14 Rotor Removal

Engine and Rotor Hub Disconnection

1. Using a 13 mm socket wrench, loosen the four M8 x 35 screws and remove the alternator/engine hub from the engine flywheel. See Figure 10-15.

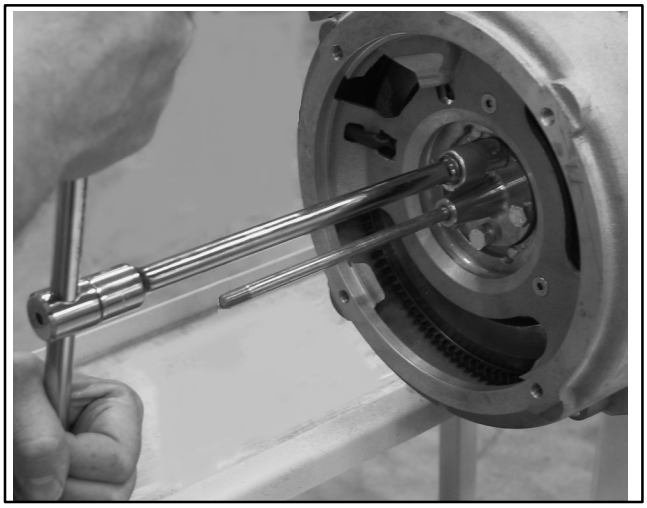
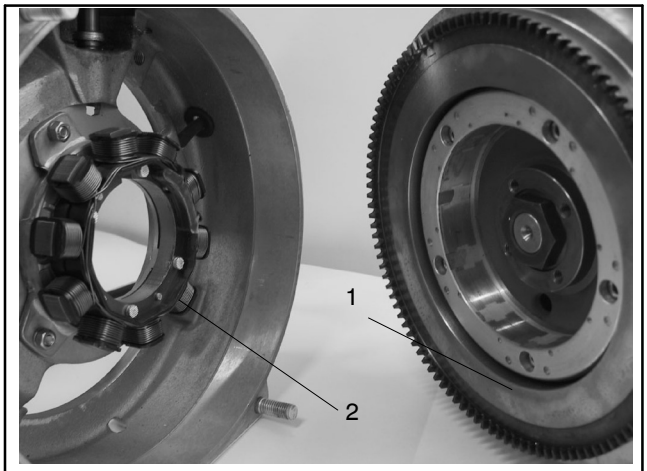


Figure 10-15 Engine/Rotor Hub

Stator Removal

1. The moveable and permanent magnet rotor is connected at the engine flywheel with five M6 x 30 socket screws. The stator is installed with three M6 x 16 bolts on the engine flywheel housing. See Figure 10-16.



1. Permanent magnet
2. Stator

Figure 10-16 Stator and Flywheel

10.2 Generator Alternator Reassembly

Note: See Section 1.5 for specified torque values.

Engine and Rotor Hub Installation

1. To reinstall the engine/rotor hub at the flywheel, tighten the four M8 x 35 screws at the specified torque (see section 1.5) with a 13 mm socket wrench. See Figure 10-17.

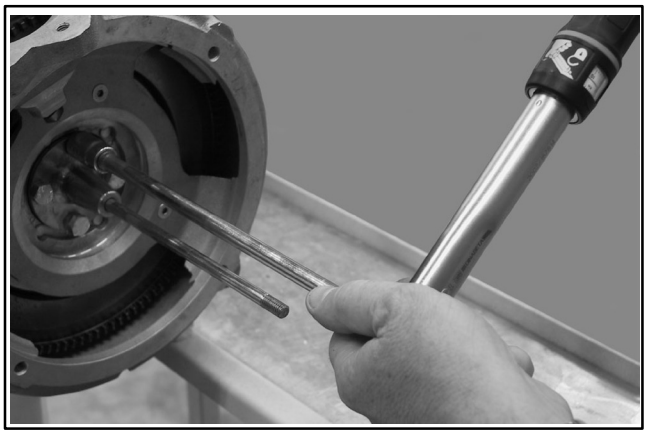


Figure 10-17 Engine/Rotor Hub

Rotor Installation

1. Apply antiseize compound to the keyed end of the rotor shaft.

2. Guide the rotor on the alternator through stud and push it towards the flywheel. See Figure 10-18.

Note: To prevent the rotor from falling, screw (without tightening) the 27 mm nut of the seawater pump shaft on the rotor through stud.

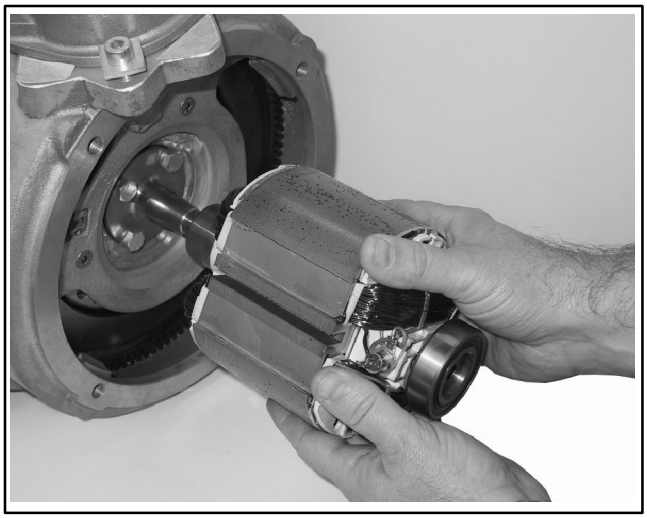


Figure 10-18 Rotor Replacement

Stator Housing Installation

1. Guide the stator housing towards the engine flywheel housing as far as possible. An O-ring in the bearing seat hole stops it.

2. Ensure that the holes of the fixing stator housing screws (M10 x 140) are aligned with the screws of the engine flywheel housing.

3. Using a light uphand hammer, turn the stator housing towards the engine flywheel until it enters and the stator housing rear side supports the rotor bearing. See Figure 10-19.

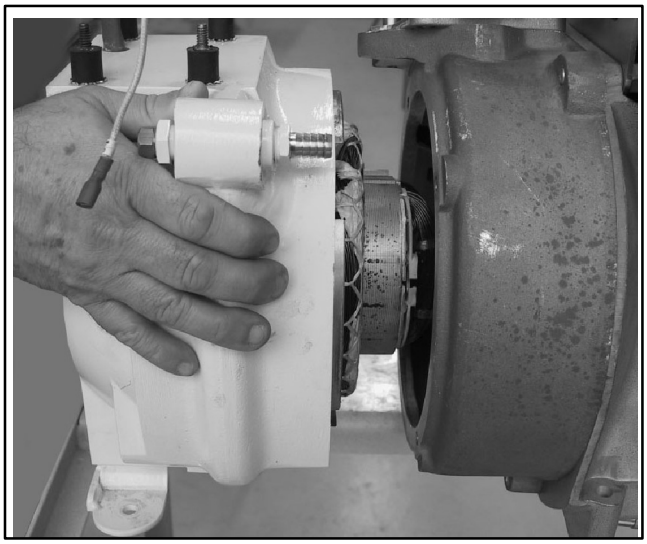


Figure 10-19 Stator Housing Replacement

4. Screw (without tightening) the four M10 x 140 stator housing screws with a 17 mm socket wrench. See Figure 10-20.

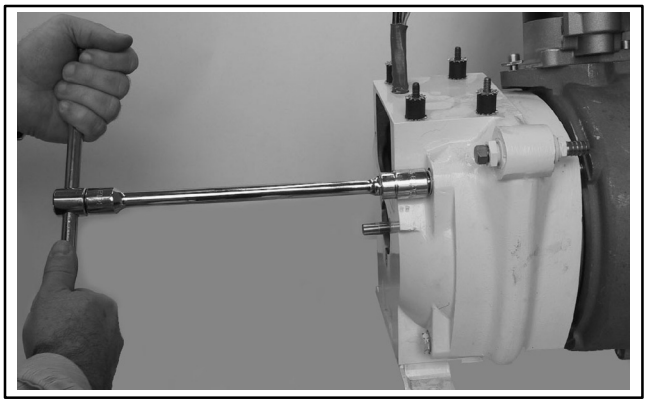


Figure 10-20 Stator Housing

5. Tighten the four M10 x 140 screws at the specified torque. See section 1.5. See Figure 10-21.

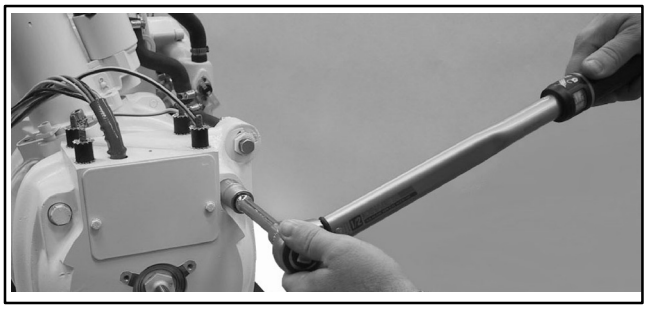


Figure 10-21 Alternator Connection

6. Put the holes of the alternator bracket on the two vibromount mounting bolts and screw the two M8 nuts at the specified torque (see section 1.5) with a 13 mm socket wrench.

7. Tighten the 27 mm nut of the seawater pump shaft at the specified torque (see section 1.5) to strengthen the tapered connection between the rotor and the alternator through stud. See Figure 10-22.

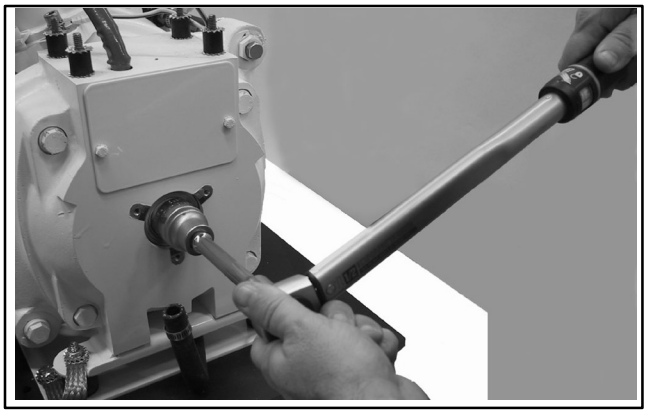


Figure 10-22 Seawater Pump Shaft

Seawater Pump Installation

1. Assemble on the rear side of the stator housing the seawater pump housing. Tighten the three M5 x 40 screws at the specified torque (see section 1.5) with a 4 mm setscrew wrench.

2. Push the impeller in the housing turning it slowly until it is on the shaft. See Figure 10-23.

Figure 10-23 Seawater Pump Impeller

3. Set the O-ring and install the seawater pump cover. Tighten the four M4 x 8 screws at the specified torque (see section 1.5) with a 6 mm socket wrench.

Note: Check the generator set's nameplate to verify the original voltage configuration. See Section 10 for more information regarding voltage reconnection.

4. Reconnect all external connections—the exhaust line to the mixing elbow, the fuel lines, the water line to the seawater pump, the remote panel, the AC output leads, and the battery cable to the battery (negative (–) lead last).

5. Open the seacock and the fuel valve.

10.3 Generator Engine Disassembly

Disconnect all the external connections—battery cables at the battery (negative (–) lead first), AC-output leads in the controller, remote start panel at the controller P3 connector, water line at the seawater pump, fuel line at the fuel pump filter inlet, and exhaust line at the mixing elbow. Observe all the safety precautions listed at the beginning of this manual during the disassembly/reassembly procedures.

Note: This section includes engine disassembly/reassembly procedures unique to the marine generator set. Consult the engine service manual for engine torque specs, special tool requirements, and further engine service information.

Oil Drain

1. Place a container under the oil drain hole.
2. Remove the oval flange of the oil drain. See Figure 10-24.
3. Drain the oil. Allow time for a complete oil drain.

Note: If necessary, slightly tip the engine to ensure a complete oil drain.

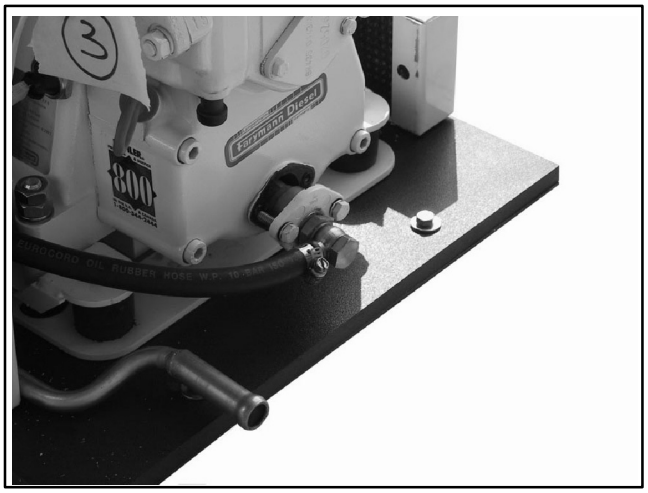


Figure 10-24 Oil Drain

Remove the air intake's antiresonator device

1. Remove the air cleaner cover's four flat screws.
2. Before removing the electric fuel pump, clean the inside of the antiresonator housing with a rag.
3. Ensure that dirt or debris does not enter the cylinder.
4. Remove the antiresonator housing by removing the two screws. See Figure 10-25.
5. Discard the gasket located between the housing and the engine head.

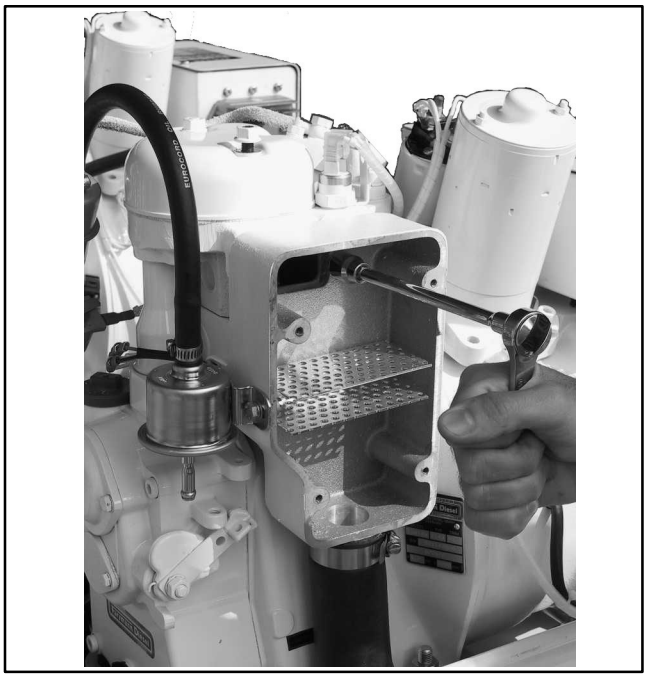


Figure 10-25 Antiresonator Housing

Remove the exhaust elbow (mixer)

1. Disconnect the water pipe located between the thermostat and the exhaust elbow. See Figure 10-26.
2. Loosen the upper clamp on the outlet water pipe.
3. Remove the two hex socket screws that attach the exhaust elbow to the engine head.
4. Remove the exhaust elbow without damaging the high exhaust temperature switch or its electrical connection.

5. Discard the gasket located between the exhaust elbow and the engine head.

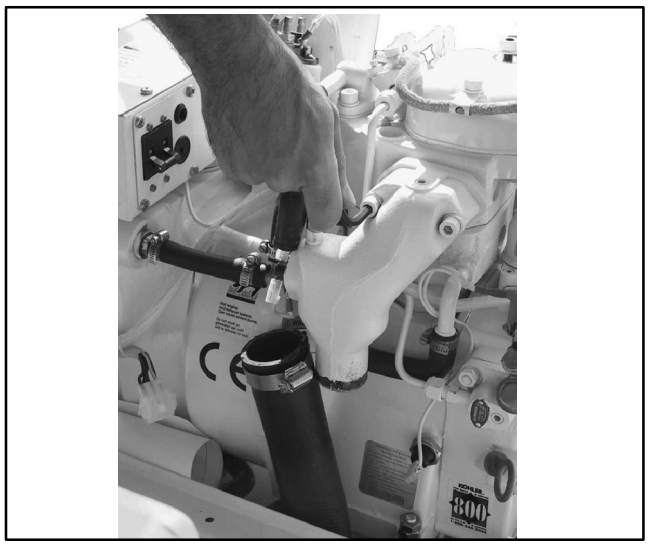


Figure 10-26 Exhaust Elbow (Mixer)

Disconnect the fuel supply and return lines

1. To remove the fuel supply line and prevent fuel spills, close the fuel supply line using a clamp or a flat-nose pliers located between the filter and the electric fuel pump.

2. Close the fuel return line to the tank using another clamp located after the injector's banjo fitting.

Remove the rocker cover

1. Remove the two rocker cover nuts, washer, cover and gasket. See Figure 10-27.

Note: If the cover is difficult to remove, tap it lightly with a soft-faced hammer.

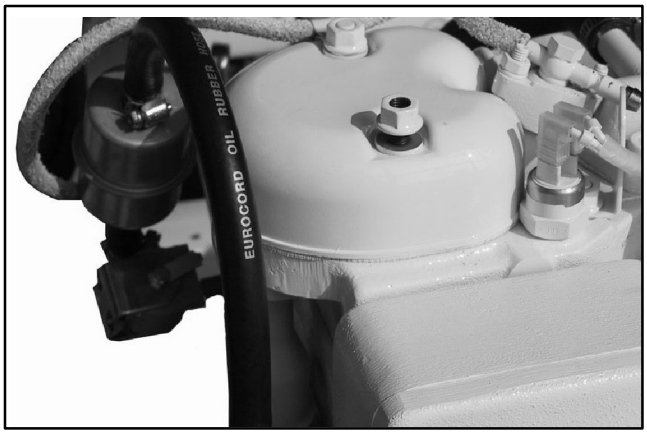


Figure 10-27 Rocker Cover

Disconnect the high-pressure fuel line

1. Hold a 14 mm wrench on the fuel injector pump's nipple valve. See Figure 10-28.

2. Loosen the high-pressure line using a 17 mm wrench.

Figure 10-28 High-Pressure Fuel Line on the Delivery Valve

3. Repeat this procedure on the nut that connects the high-pressure line to the injector body. See Figure 10-29.

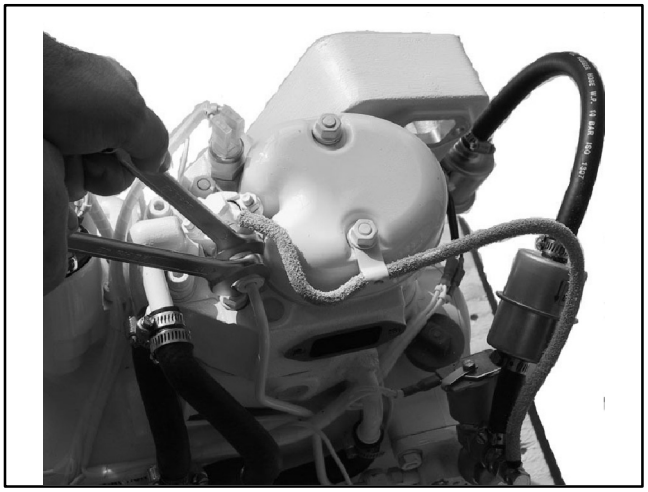


Figure 10-29 High Pressure Fuel Line on the Fuel Injector

Remove the fuel injector

1. Remove the two nuts from the injector clamp. See Figure 10-30.

2. Remove the injector from its seat. If it's locked, tap the injector lightly and carefully with a soft-faced hammer. Be careful not to damage the injector.

Note: Remove the copper washer located between the head and the injector.

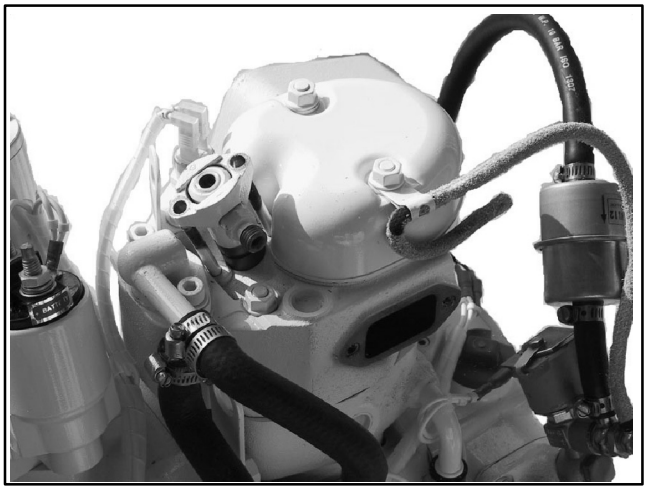


Figure 10-30 Fuel Injector

Remove the cylinder head

1. Remove the two locknuts and washers that hold the protective tube retaining spring.

2. Loosen and remove the four cylinder head nuts. See Figure 10-31.

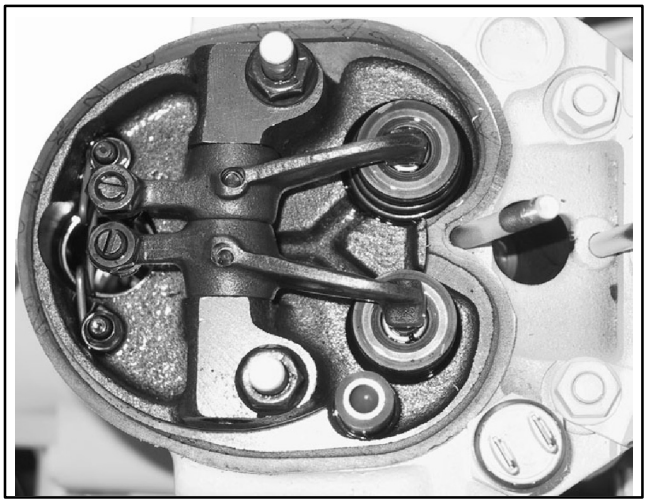


Figure 10-31 Cylinder Head

Remove the rocker arms

1. Using a chisel and hammer, drive out the rocker arm shaft. See Figure 10-32.

2. Remove the rocker arms and push rods.

3. The cup-shaped cover holds the arm's shaft in its bracket. Remove any snap rings during this disassembly.

4. Hold the protective tube and remove the cylinder head. See Figure 10-33.

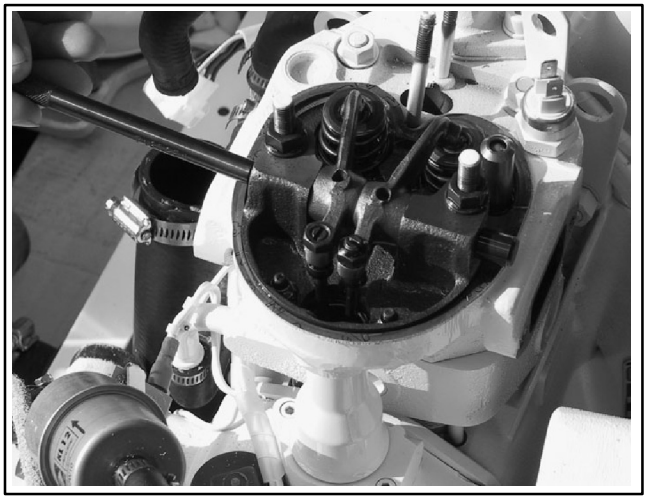


Figure 10-32 Rocker Arms

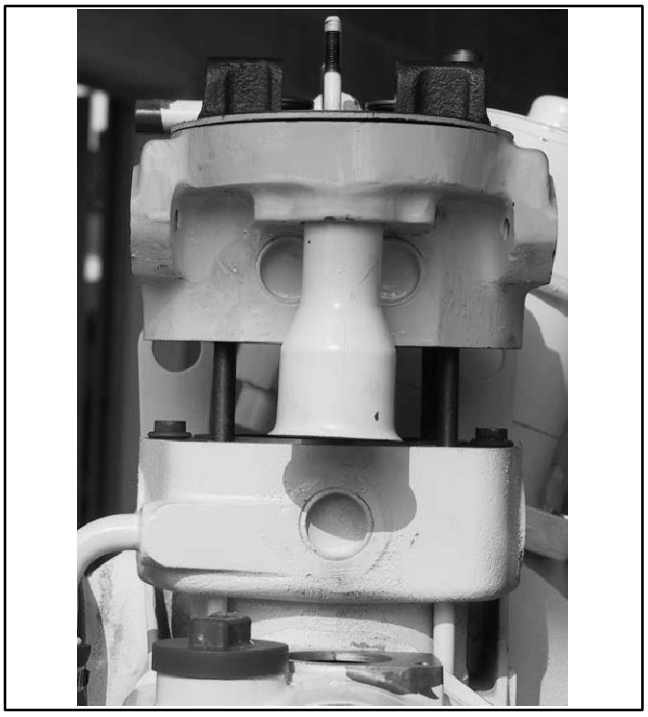


Figure 10-33 Protective Tube

Disassembly the valves

1. Use the special tool shown in Figure 10-34 to disassemble the valves. Consult the engine service manual.

Note: Be aware of the two thin steel washers located under the intake valve spring.

Figure 10-34 Valve

Replacing the valve guides

1. If valve guide replacement is necessary, use the proper driver and press out the old guides from the head. See Figure 10-35.

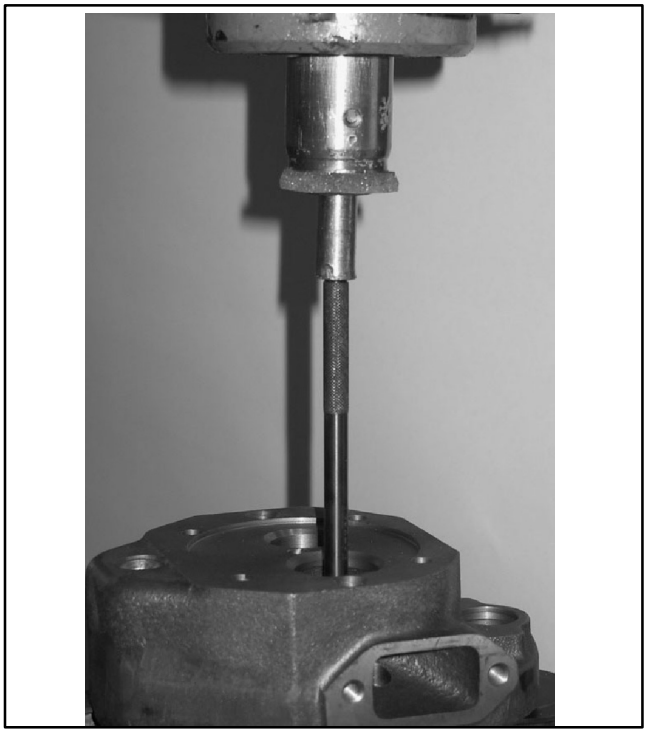


Figure 10-35 Valve Guide

Replacing the seats

The cylinder head is equipped with two valve ring seats of wear-resistant steel. Consult the engine service manual and the following procedure if the head seats are so worn that a grinding valve rework will not ensure a good gas proof. Use a valve seat cutter if a surface rework is needed.

1. Insert the guide pin into the valve guide.

2. Rotate the cutting surface of the T-handled tool applying light pressure to touch the ring seat. See Figure 10-36.

Note: Do not cut too deep or use grinding compound. Observe the allowable valve recess.

To check the sealing valves:

1. Put the sealing valves in their guides.

2. Install the springs and fill the intake/exhaust openings on the head with a small amount of diesel fuel oil.

3. A good valve seal occurs when the diesel fuel oil leaks about 2 drops per minute.

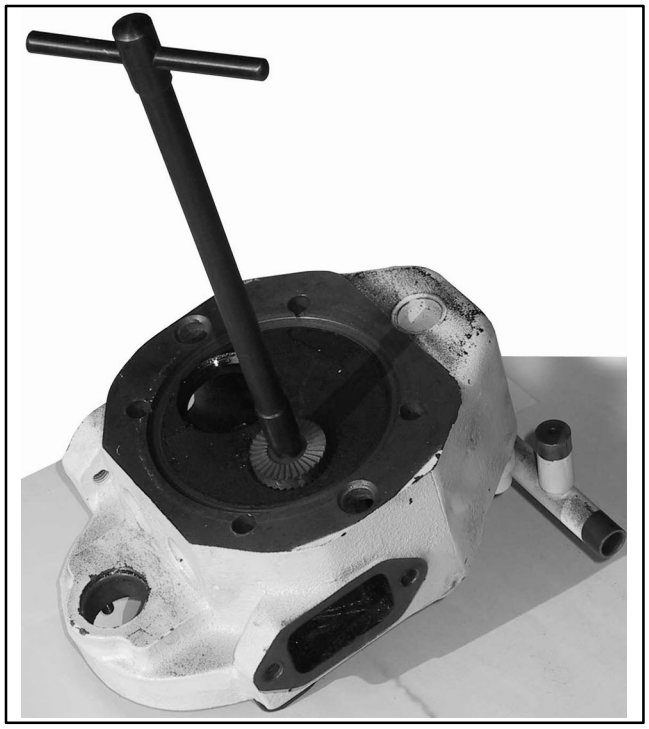


Figure 10-36 T-Handle Tool

Tappets block

1. Release the two push rods by loosening the two hex cap screws and removing them from the upper surface of the gear case. See Figure 10-37

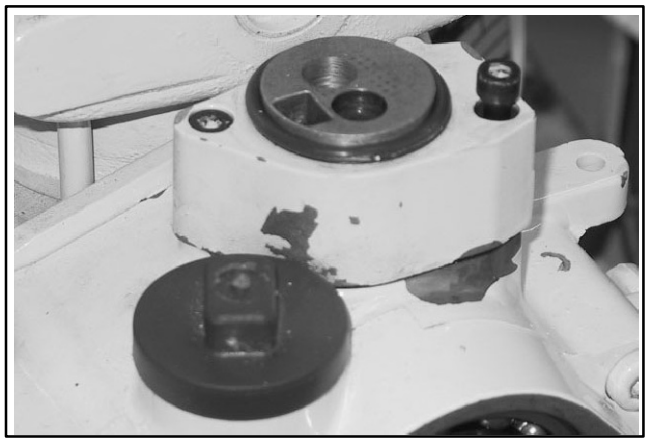


Figure 10-37 Gear Case

Cylinder

1. Rotate the flywheel until the piston reaches the Bottom Dead Center (BDC) so that the studs are a guideline to remove the cylinder from the crankcase. See Figure 10-38.

Note: If the repair does not require replacing the piston or liner, keep the liner on the piston. Lift up the liner enough so that the piston pin hole is free. Continue with the following step.

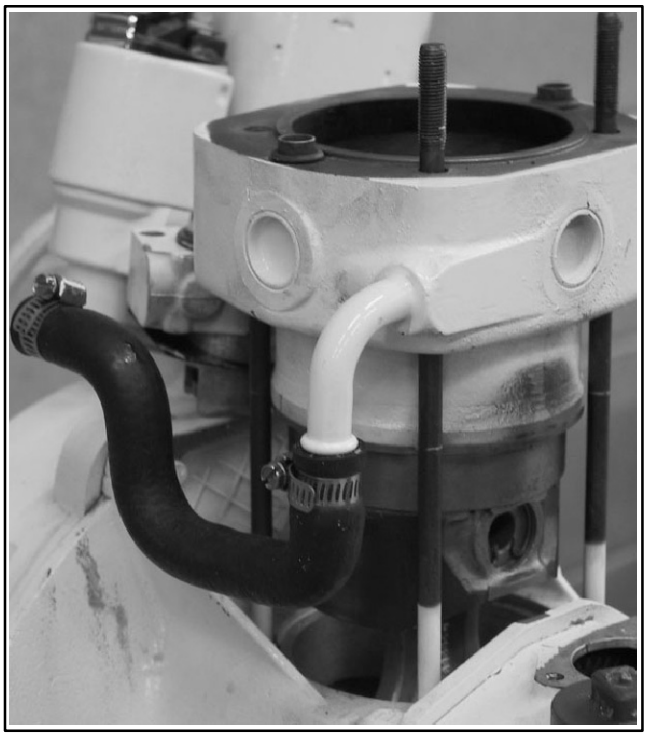


Figure 10-38 Cylinder

Piston

1. Rotate the flywheel until the piston reaches Top Dead Center (TDC).

2. Using a needle-nose pliers, remove the piston pin retainer from the groove in the piston. See Figure 10-39.

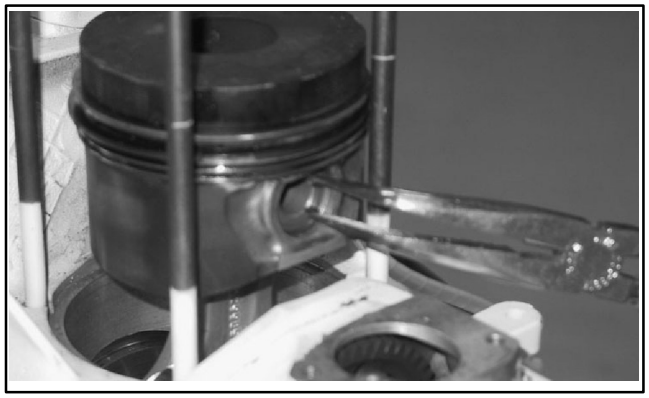


Figure 10-39 Piston

3. Gently push the piston pin out of the piston from the flywheel side. See Figure 10-40.

Note: If the piston pin sticks in the piston, remove the piston together with the connecting rod. Remove the assembly from the engine and hammer out the piston pin.

Figure 10-40 Piston

Connecting Rod

1. Lay the engine, on its flywheel side, on a work bench.

2. Move the flywheel until the piston reaches the Bottom Dead Center (BDC) of its stroke.

3. Loosen the six hex cap head screws of the oil cooler housing and remove it from the engine. If the screws are tight, tap them with a hammer and a flat-faced punch to loosen them. See Figure 10-41.

4. Using a 13 mm socket wrench, unscrew the two connecting rod nuts. Pull the connecting rod cap downwards while pushing the connecting rod upwards. See Figure 10-42.

5. If the two half shells of the connecting rod need to be reinstalled, mark them so that proper repositioning occurs during reassembly.

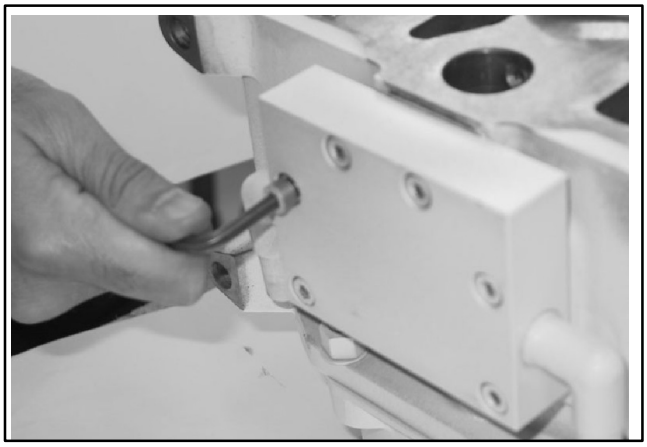


Figure 10-41 Oil Cooler Housing

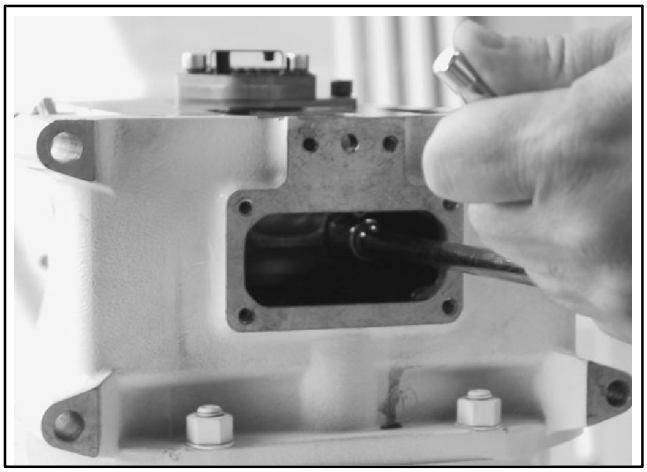


Figure 10-42 Connecting Rod Nuts

Gear Cover

1. Remove the six hex cap head screws to remove the gear cover. If necessary, tap the cover with a soft-faced hammer to remove it. See Figure 10-43.

2. If, during cover removal, the cover catches on the governor, move the flywheel to release the governor's cover. Do not disassemble or remove the gear cover any further unless necessary. Otherwise, modifications to the delivery start of the fuel pump, gear timing adjustment, and the engine speed values may be required.

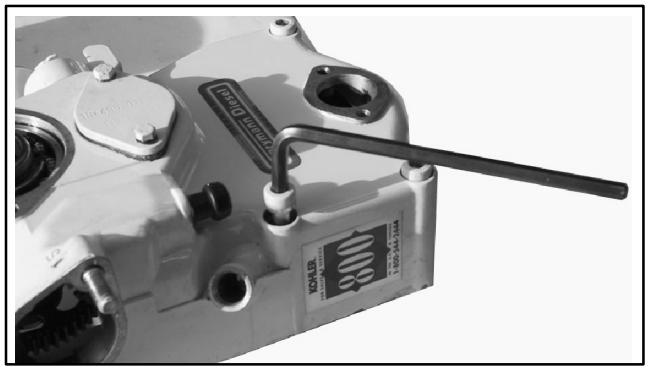


Figure 10-43 Gear Cover

3. If disassembly of the injection pump, camfollower, camshaft, camshaft gear, or camshaft bearing is necessary, proceed to the following sections.

Injection Pump

1. Remove the two hex nuts of the injection pump and remove the pump from the gear cover.

Note: To avoid losing the shims or the gasket, reinstall them on the cover and reinstall the washers and nuts. See Figure 10-44.

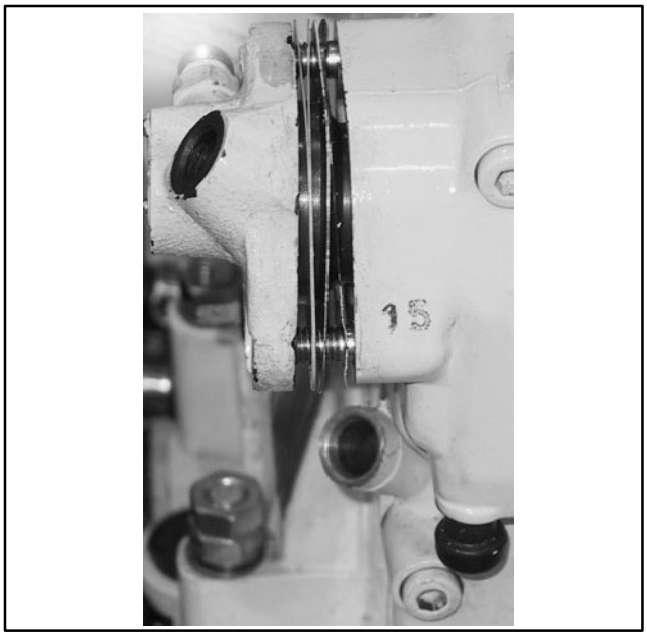
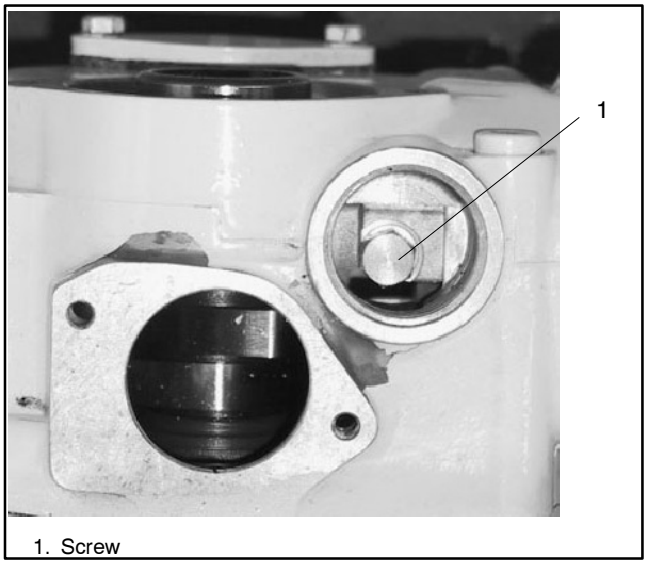


Figure 10-44 Injection Pump Removal

Camfollower

1. To remove the camfollower, unscrew the screw shown in Figure 10-45 through the oil filling hole.



1. Screw

Figure 10-45 Camfollower

Camshaft

1. Release the snap ring that holds the camshaft in the gear cover.

2. Using a driver, press out the camshaft. See Figure 10-46.

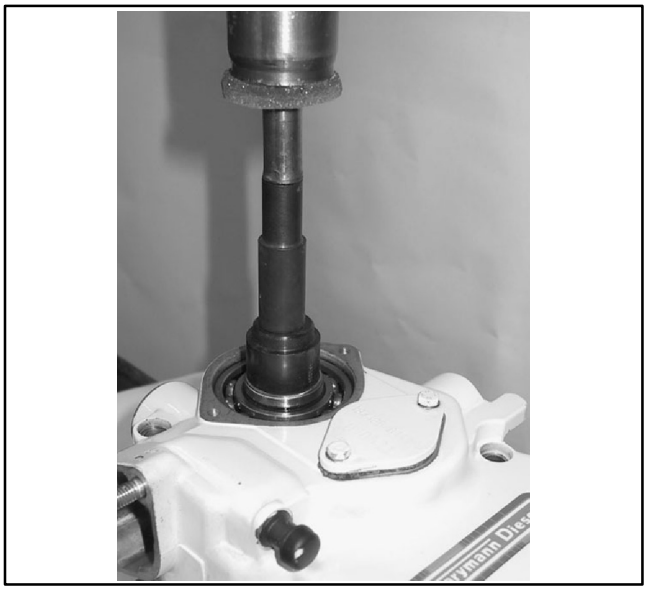


Figure 10-46 Camshaft

Camshaft Gear

1. Remove the gear from the camshaft using a puller or by pressing it off from the shaft. See Figure 10-47.

Figure 10-47 Camshaft

Camshaft Bearing

1. Remove the camshaft's ball bearing from inside of the gear cover by using a socket pushed with a hydraulic press. See Figure 10-48.

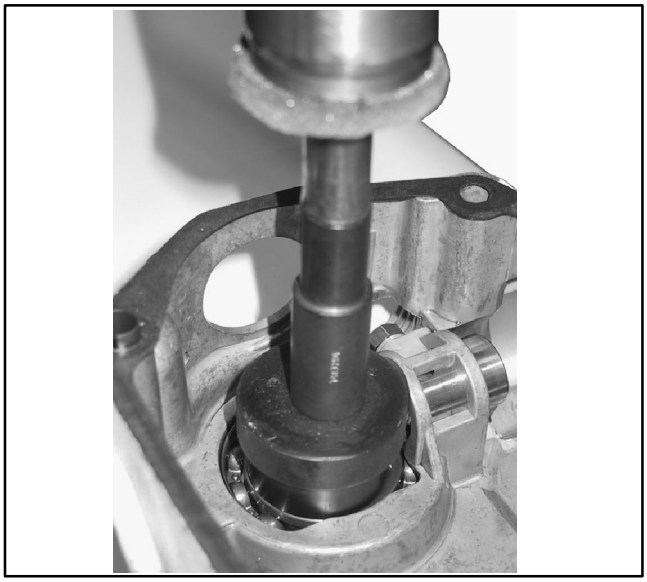
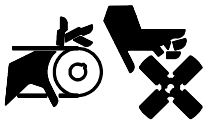


Figure 10-48 Camshaft Bearing

Speed Control Shaft

1. Put the gear cover on the work bench.
2. Using a pliers, remove the inner retainer ring from the eccentric shaft.
3. Pull the eccentric shaft towards the outer side of the gear cover so that the fuel pump pin is released.

⚠ WARNING



Rotating parts.
Can cause severe injury or death.

Operate the generator set only when all guards, screens, and covers are in place.

4. Carefully, using a pliers, unhook the outer torsional return spring from its boss.
5. Hold the inner control lever and turn down the accelerator lever until the inner torsional return spring releases its tension.
6. Release the inner control lever from the eccentric shaft.

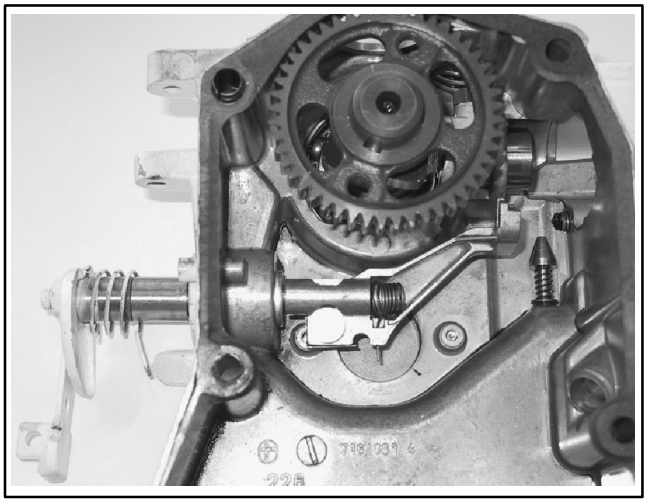


Figure 10-49 Speed Control Shaft

Governor

1. Install a holding device and remove the governor pin. See Figure 10-50.
2. Spread the flyweights with a sturdy driver.
3. Use a socket wrench to unscrew the governor.

Note: The governor has a left-hand thread. Unscrew the governor in a clockwise direction.

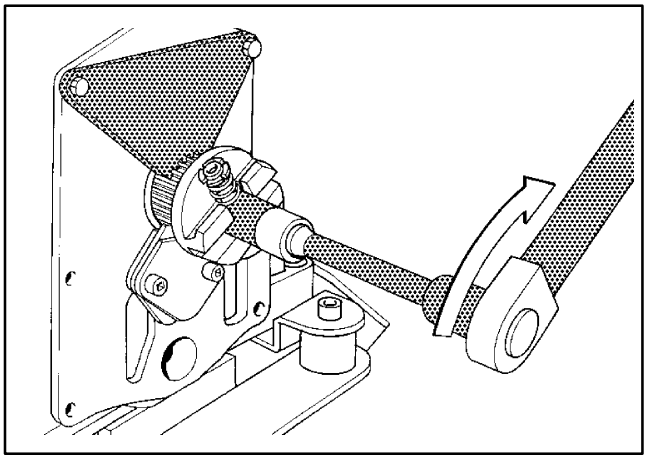


Figure 10-50 Governor

Oil Pump

1. Loosen the three hex cap screws to remove the oil pump from the crankcase. See Figure 10-51.

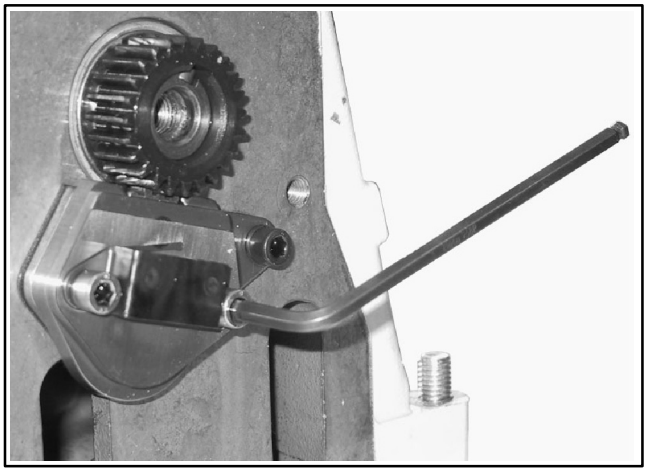


Figure 10-51 Oil Pump

Flywheel

1. Use a socket wrench and striker tool to loosen the flywheel nut two turns. Keep the flywheel nut on the shaft. See Figure 10-52.

Note: If removing the flywheel from the engine without removing the governor, place the accelerator lever in the higher speed (full load) position. Otherwise, damage may occur to the regulation linkage.

2. Install the flywheel puller.

3. Turn the two screws until the flywheel breaks loose from the tapered side of the engine crankshaft. See Figure 10-53.

4. Remove the nut and the flywheel.

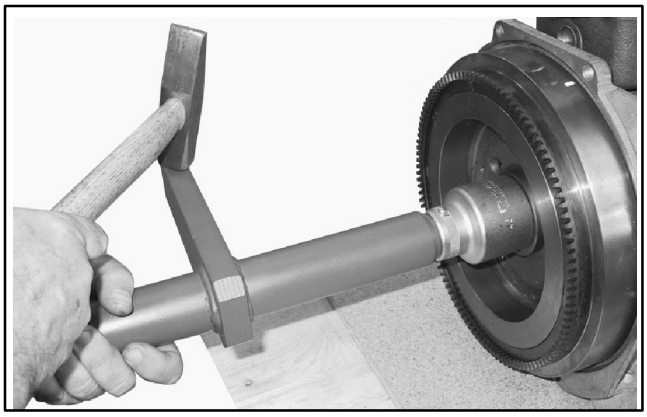


Figure 10-52 Flywheel Nut

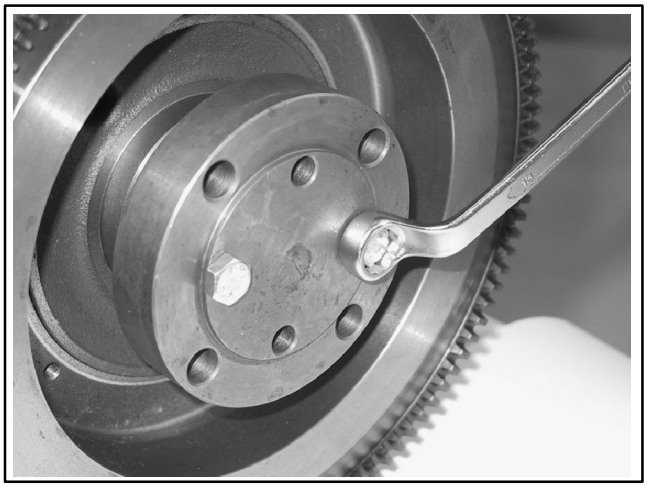


Figure 10-53 Flywheel

Main Bearing Cover

1. Put the engine crankcase on the work bench so that the flywheel side is in the upper position.

2. Remove the four main bearing cover nuts and washers.

3. Install two screws (M6 x 30) in the threaded holes of the cover and turn them until the cover is released from the crankcase. See Figure 10-54.

4. Remove the key, O-ring, two angle rings, and two elastic washers. See Figure 10-55 and Figure 10-56.

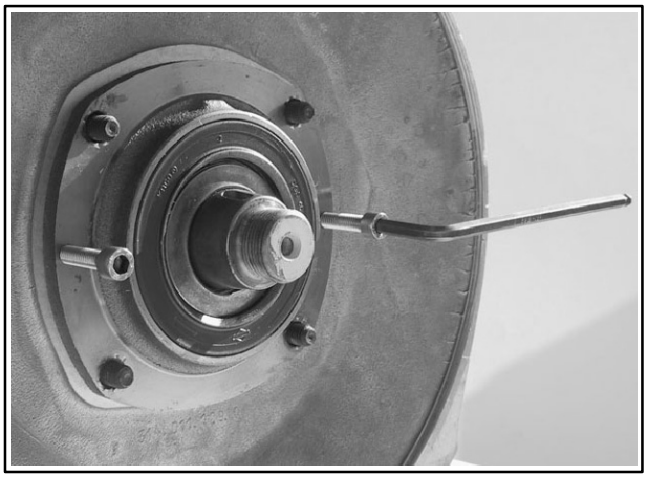


Figure 10-54 Main Bearing Cover

Figure 10-55 Main Bearing

Figure 10-56 Main Bearing

Crankshaft

1. Carefully remove the crankshaft from the crankcase.

Note: Avoid touching/scratching the main bearing bushing.

2. Use a puller to release the gear wheel from the crankshaft. See Figure 10-57.

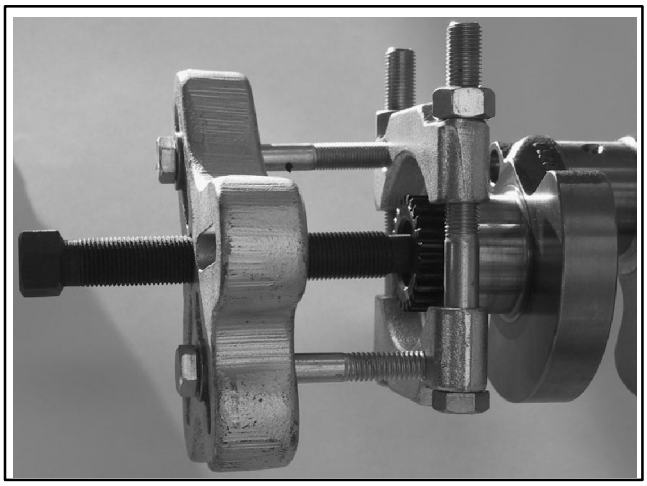


Figure 10-57 Crankshaft

3. For ball bearing replacement:

a. Place the main bearing cover under a press and support its outer side with two mountings.

b. Press out the crankshaft. See Figure 10-58.

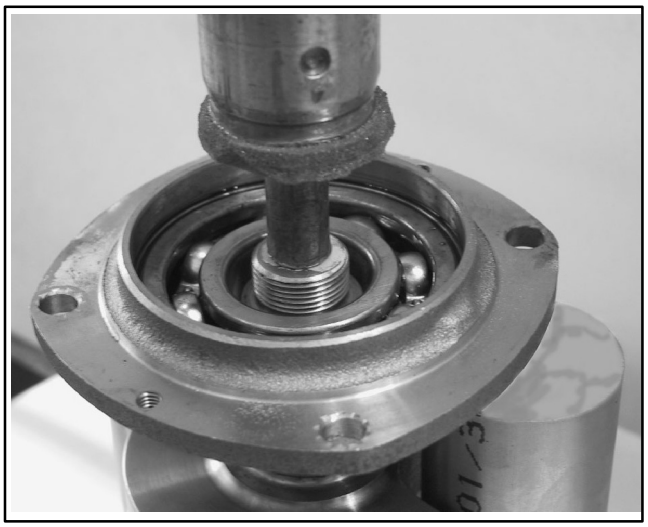


Figure 10-58 Crankshaft

c. Remove the snap ring of the bearing's outer race.

d. With a socket, press on the inner race until the bearing is out from its seat.

Note: The engine is completely disassembled. Clean all parts with suitable cleaning solution. After the parts are dried, check for any damage, wear or tear. Replace any parts that are questionable.

10.4 Generator Engine Reassembly

Crankcase Bushing

1. Using a driver, press the crankshaft's bush bearing on the crankcase. Ensure that its edge is inside the crankcase as indicated in Figure 10-59. Also, ensure that its oil holes are horizontal and aligned with the crankcase groove.

Figure 10-59 Crankcase Bushing

Crankshaft Gear

1. To install the crankshaft gear, heat it in an oil bath or on an electrical heater plate at a temperature of 90–100° C (195–210° F). See Figure 10-60.

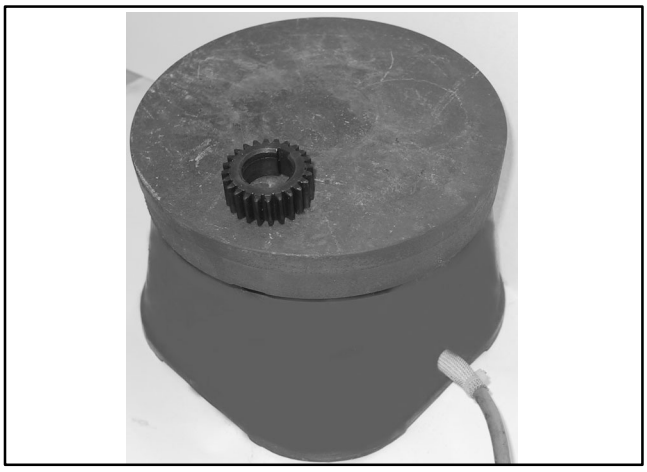


Figure 10-60 Crankshaft Gear

2. Using a socket and a hydraulic press, push it down on the shaft.

3. Lubricate the bush bearing and slide the crankshaft into the housing without damaging the bush bearing with the gear teeth. See Figure 10-61.

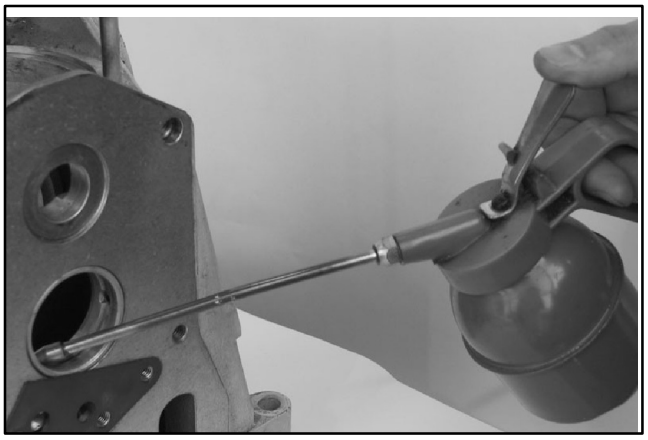
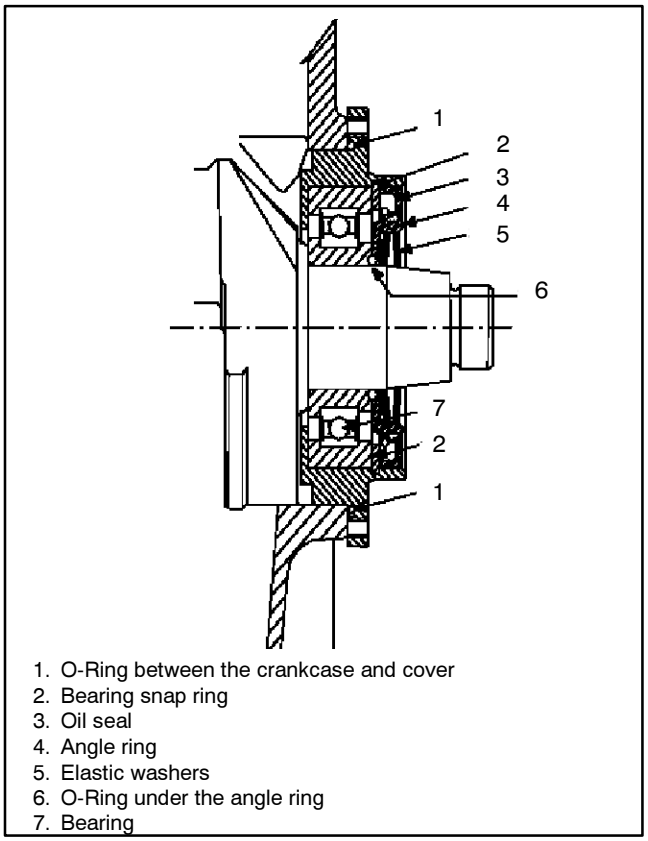


Figure 10-61 Bush Bearing

Main Bearing Cover

1. Using a hydraulic press and socket, install the ball bearing in the main bearing cover until the outer race is against its seat. See Figure 10-62.



1. O-Ring between the crankcase and cover
2. Bearing snap ring
3. Oil seal
4. Angle ring
5. Elastic washers
6. O-Ring under the angle ring
7. Bearing

Figure 10-62 Main Bearing Cover Assembly

2. Lock the bearing's outer race with the snap ring in the cover.

3. Set the crankshaft on the board of a press and carefully clean the tapered surface of the bearing seat.

4. Put the main bearing cover on the crankshaft so that the snap ring is towards the flywheel side.

5. Using a socket, press the main bearing cover on the crankshaft until the inner race bearing is in its seat, against the shoulder of the crankshaft.

6. Lubricate the oil seal lip and the tapered surface of the crankshaft and assemble the oil seal on the cover. Do not use grease.

7. Put the O-ring between the crankcase and cover and tap lightly with a soft-faced hammer to seat the cover.

8. Tighten the nuts to the appropriate torque. See Section 1.5.

9. Install on the outside of the main bearing cover the O-ring, the angle ring, and the two elastic washers as shown in Figure 10-62.

Note: The cover installs correctly on the crankcase by turning it in the correct position.

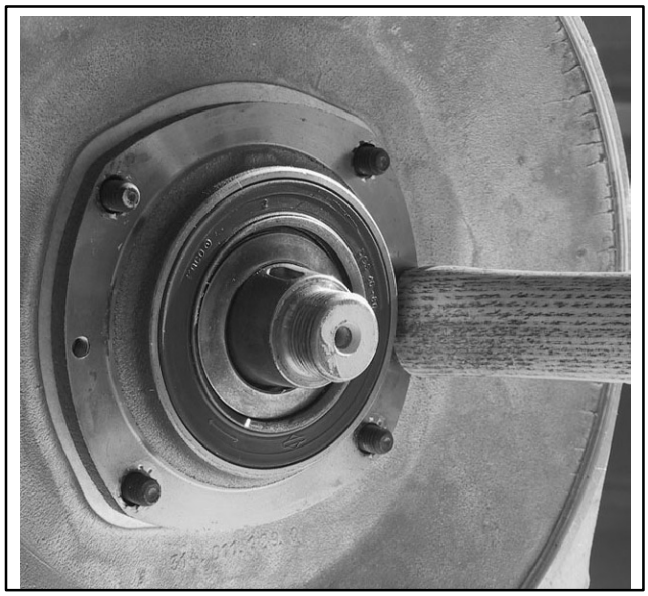


Figure 10-63 Main Bearing Cover

Flywheel

1. Remove any oil or grease from the flywheel and the tapered side of the crankshaft.

2. Place the flywheel key in its groove.

3. Install the flywheel on the tapered side of the crankshaft and tighten the nut at the specified torque. See Section 1.5. See Figure 10-64.

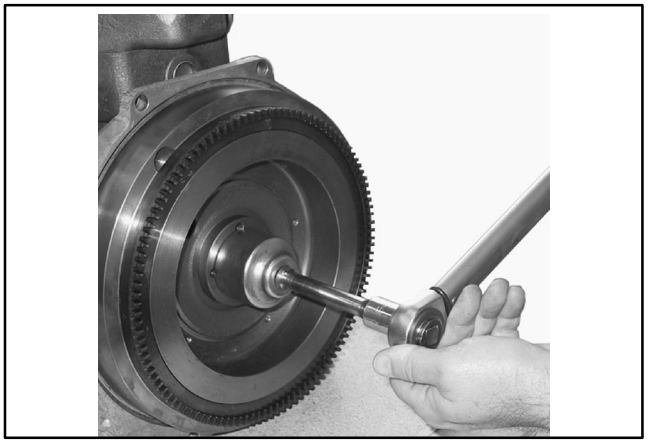


Figure 10-64 Flywheel

Oil Pump

1. Assemble the oil pump together with the thin covering plate valve and gasket to the crankcase. See Figure 10-65 and Figure 10-66.

2. Pull the pump downwards before tightening the screws at the specified torque. See Section 1.5.

3. The clearance on the pump screw holes allows enough backlash between the crankshaft gear and the pump gear.

Note: The 4EOZ/3.5EFOZ model's engine have a counterclockwise rotation (as viewed from the engine flywheel). Also, the oil pump is located on the crankcase's left side.

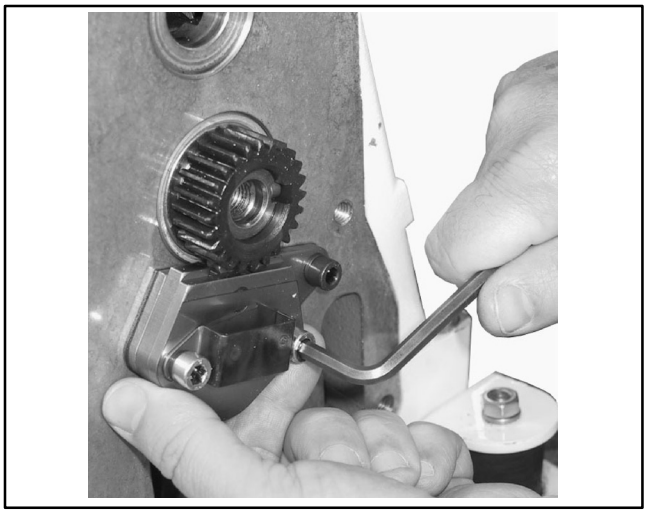


Figure 10-65 Oil Pump

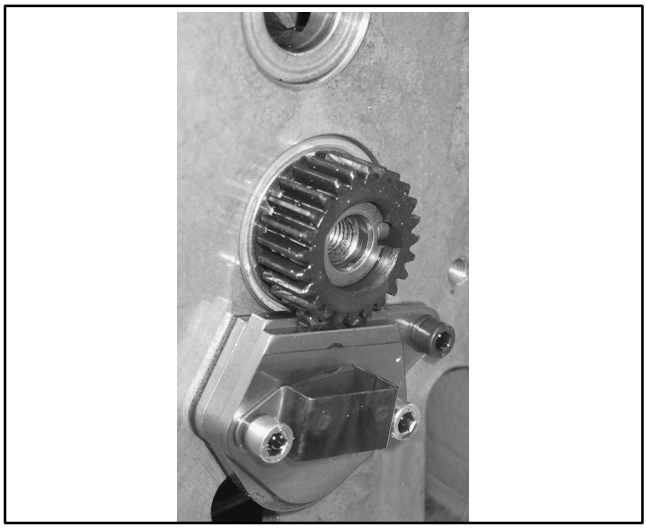


Figure 10-66 Oil Pump

Governor

1. Install the holding device so that all of its teeth are engaged with the teeth of the crankshaft gear. See Figure 10-67.

2. Remove any oil or grease from the threaded hole of the crankshaft and governor screw. Apply a thin film of Loctite No. 270 (or equivalent) on the governor screw threads.

Note: The governor screw has left-hand threads. To correctly install the governor, ensure that the governor flyweights have spread entirely and that the socket wrench holds the entire head of the governor screw. Tighten the screw at the specified torque value and remove the holding device. See Section 1.5.

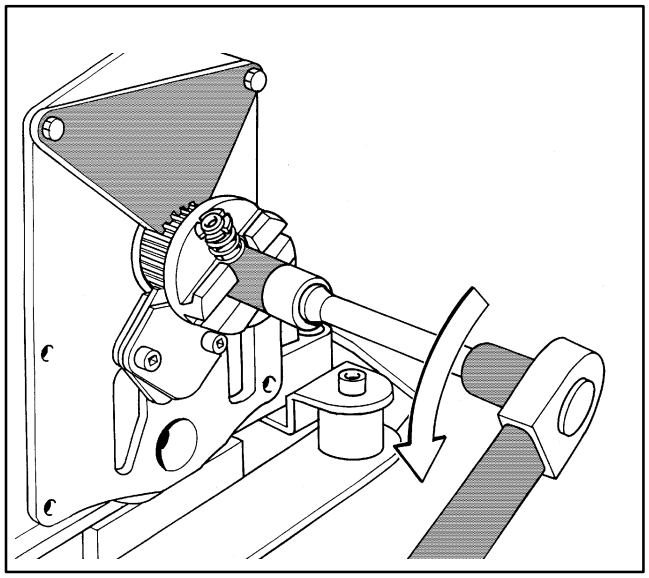


Figure 10-67 Governor

Connecting Rod

1. To install new bearing shells, take a half shell and place it about 3/4 into the connecting rod cap.

2. Using a sliding movement, press the shell in its seat until the lip goes into its relief.

   Note: Avoid touching/scratching the connecting rod bushing.

3. Repeat this procedure for the other half shell to be placed in the connecting rod trunk.

4. Find the casting numbers located on the connecting rod trunk and cap surfaces. See Figure 10-68. Similar numbers identify connecting rod parts that are matched together. The connecting rod assembly must contain the two parts with similar numbers.

5. Lubricate the bearing shells.

6. Drive the connecting rod trunk and its cap in the crankcase around the crankshaft journal. See Figure 10-69.

Note: The stamped numbers must be aligned on the same side of the connecting rod but it is not important which engine side (flywheel or gear cover) the numbers face.

7. Tighten the connecting rod nuts at the specified torque. See Section 1.5.

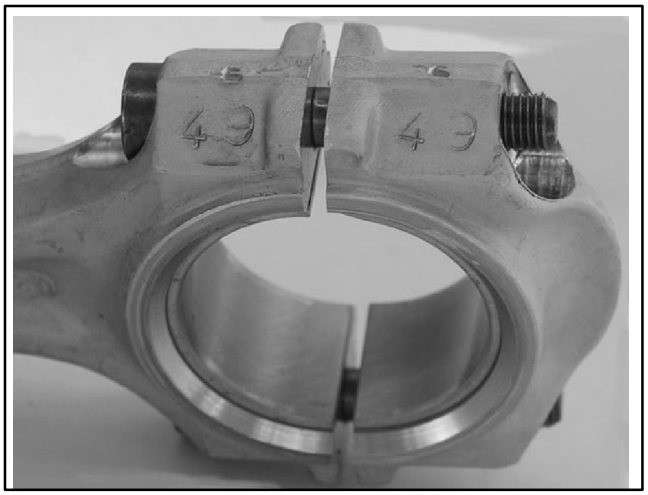


Figure 10-68 Connecting Rod

Figure 10-69 Connecting Rod

8. Install the oil cooler and screws torqued to the specified value. See Section 1.5.

Camshaft Gear

1. Put the camshaft gear wheel in an oil bath or an electric heater plate at a temperature of 90–100° C (95–210° F). See Figure 10-70.

2. Using a socket and hydraulic press, push the gear in its seat on the camshaft.

Note: For a correct gear adjustment timing, the chisel mark on the gear must face the camshaft side.

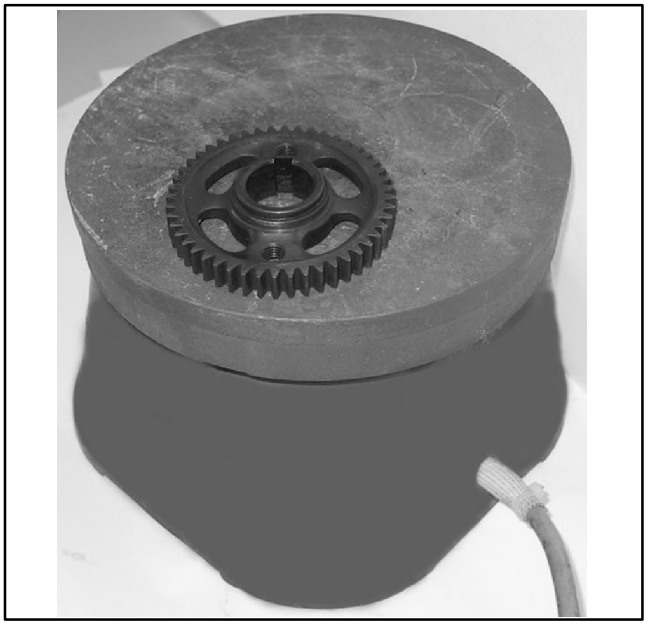


Figure 10-70 Camshaft Gear

Camshaft Bearing

1. Using a socket, install the camshaft bearing on the gear cover until it is against its seat. See Figure 10-71.

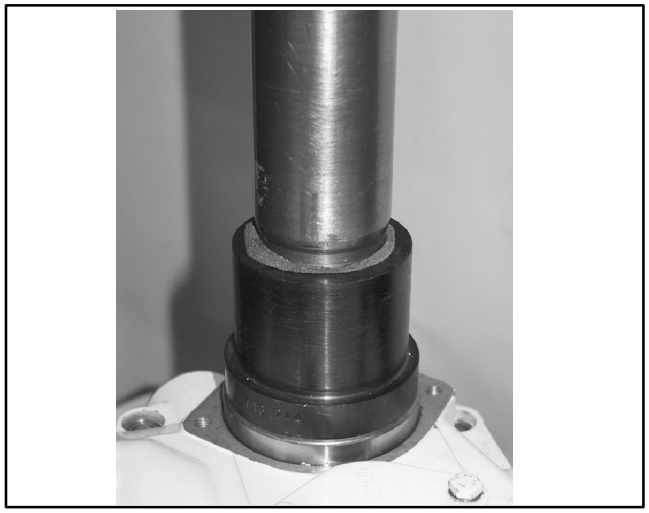


Figure 10-71 Camshaft Bearing

Camshaft

1. Install the O-ring.
2. From inside the gear cover, use a socket to push the camshaft into the bearing hole. See Figure 10-72.
3. Put a fitted socket under the outer bearing race to avoid an improper installation of the camshaft.
4. Set the camshaft's snap ring in its groove to lock it.

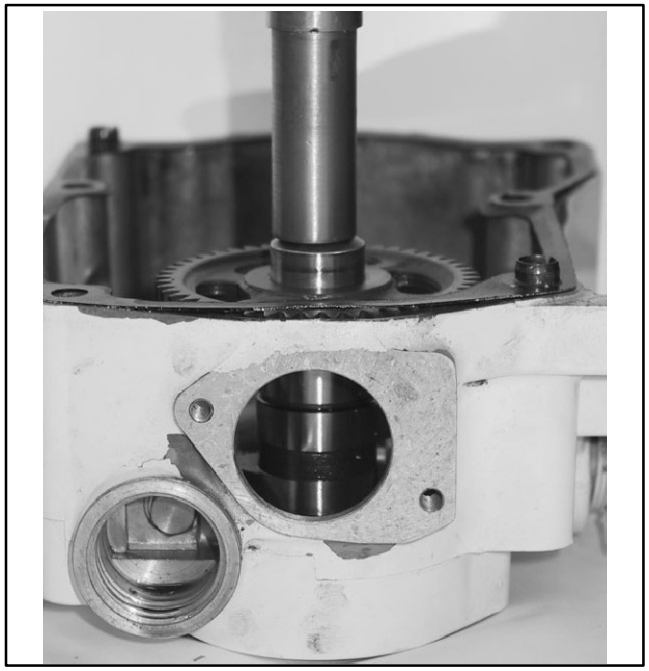


Figure 10-72 Camshaft

Injection Pump Camfollower

1. Assemble the injection pump camfollower and tighten its fixing nut through the oil fill hole .

Speed Control Shaft

1. Set the inner torsion return spring in the control lever's (fuel pump lever's) hole. See Figure 10-73.
2. Insert the end leg of the spring in the inner control lever hole.
3. Put the control lever on the bench.
4. Install the ratchet plate and the accelerator lever on the pin of the eccentric speed shaft. It will engage with the ratchet plate's slot and the accelerator lever hole.
5. Install the outer torsion return spring on the eccentric shaft and hook its end leg in the middle notch of the ratchet plate. See Figure 10-74.

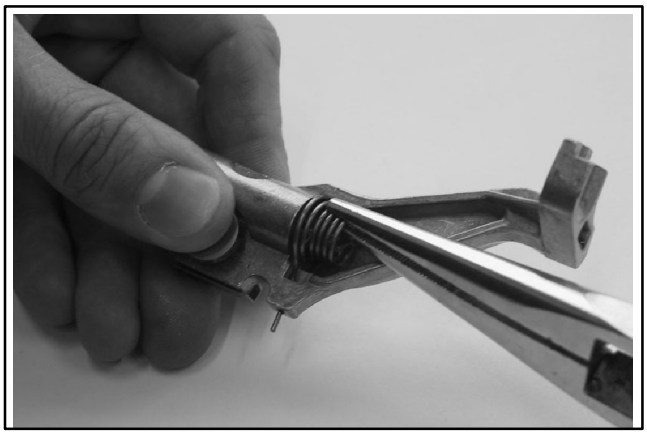


Figure 10-73 Control Lever

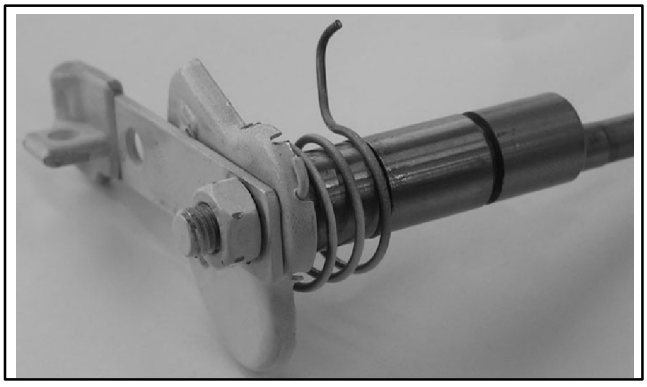


Figure 10-74 Ratchet Plate and Accelerator Lever

6. Guide the eccentric shaft through the bushing housing until it meets the inner control lever. See Figure 10-75.

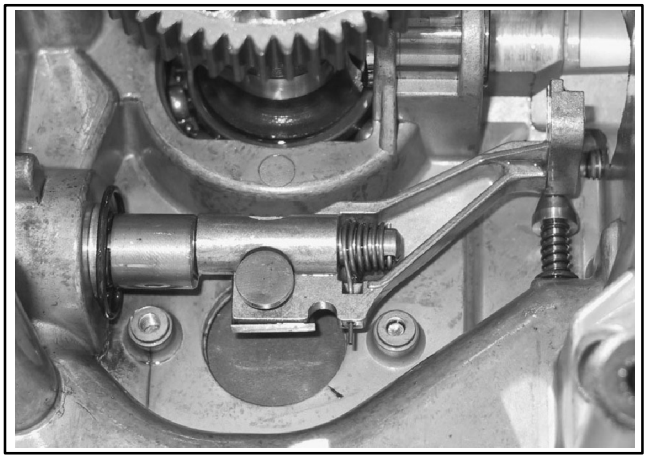


Figure 10-75 Eccentric Shaft

7. Turn the ratchet plate towards the lower position until the inner spring can be hooked with the other end leg at the groove of the eccentric shaft.

8. Move the ratchet plate between its two stop notches on the gear housing.

9. Use a looping wire to move and to hook the other end leg of the outer spring at the gear housing boss. See Figure 10-76.

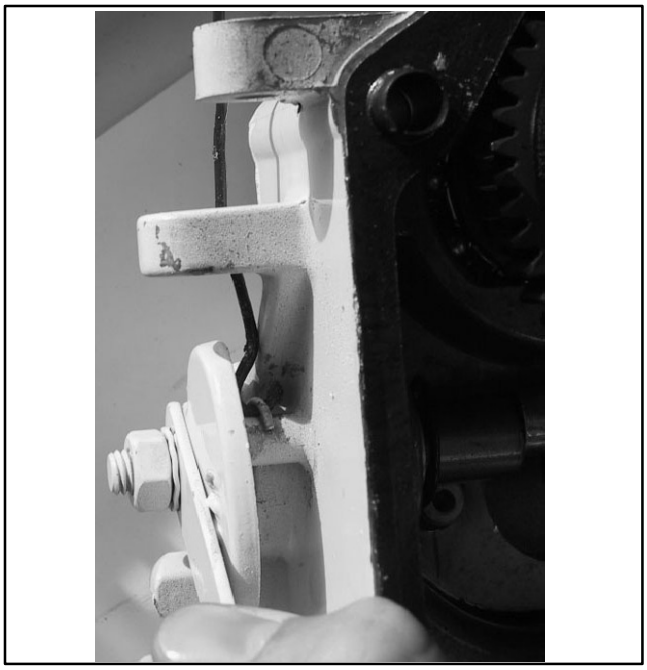


Figure 10-76 Gear Housing Boss

10. Push the eccentric speed shaft further until it locks with the inner retainer ring. See Figure 10-77.

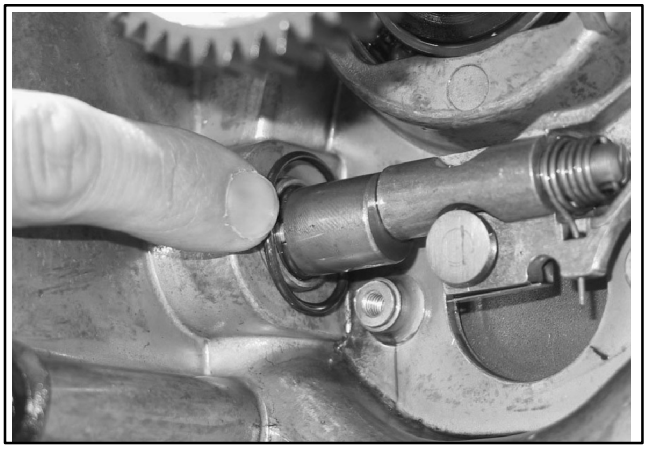


Figure 10-77 Inner Retainer Ring

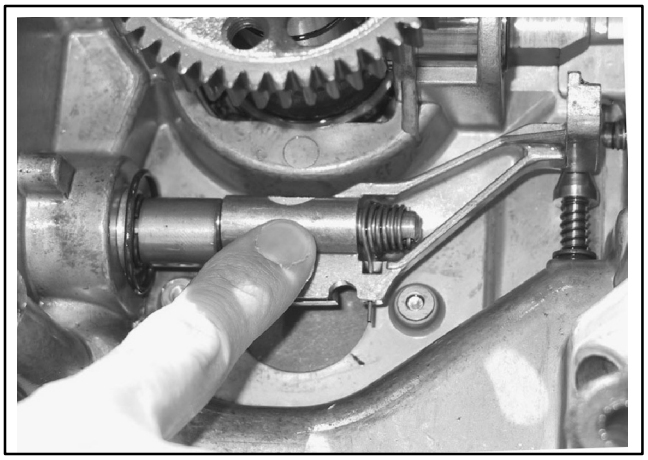


Figure 10-78 Inner Spring

11. Check the speed control shaft performance and check its springs. The inner spring is correctly set if it rejects the push of the governor pin. See Figure 10-78.

12. The outer spring is correctly set when the accelerator lever is held in position during a higher engine speed rate. Increase its tension by changing the position on the ratchet plate. Also, check its reaction in the opposite direction. See Figure 10-79.

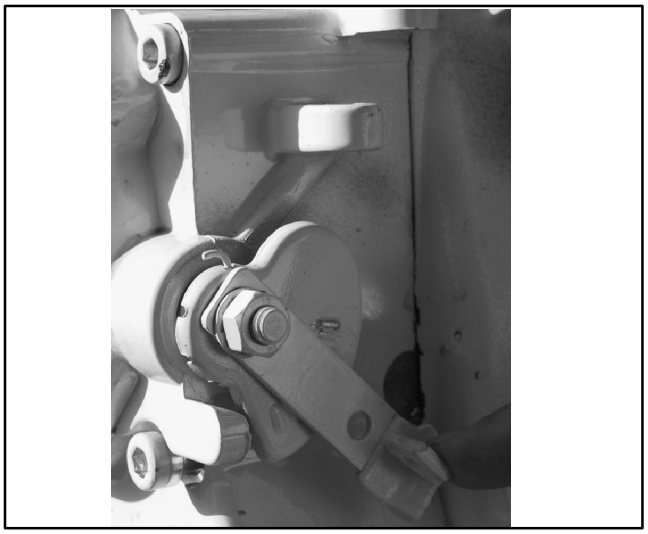


Figure 10-79 Ratchet Plate

Piston

1. Using a ring expander tool, install the piston rings so that the “Top Marks” are towards the piston crown. See Figure 10-80.

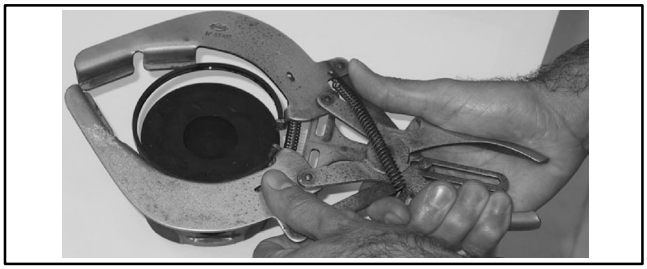


Figure 10-80 Piston and Ring Expander Tool

2. Lubricate the rings and the piston skirt.

3. Check that the piston ring gaps are at 120° offset.

4. Put the cylinder on the bench with its upper side touching the bench.

Note: Never tap on the piston crown.

Note: Never install the piston from the upper side of the cylinder because the liner is narrower and lightly tapered in this position.

5. Compress all of the rings with a ring compressor tool and drive the piston in the cylinder.

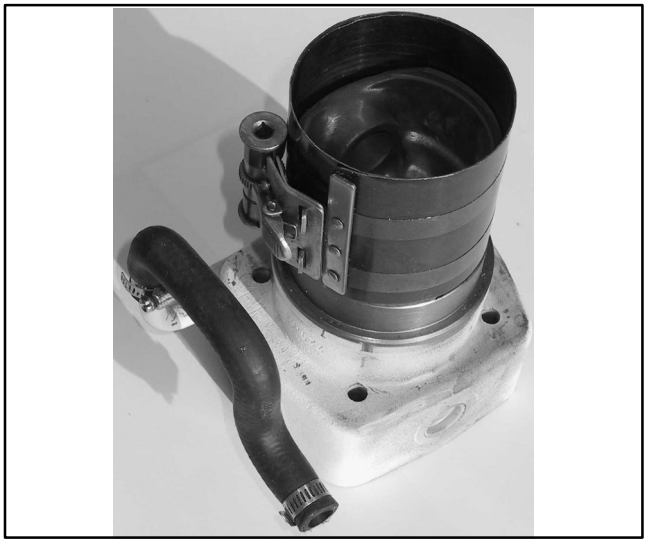


Figure 10-81 Ring Compressor

6. Guide the piston into the cylinder liner until the piston hole is slightly to the upper edge of the cylinder. This will allow for the connection between the piston assembly and the connecting rod.

7. Carefully slide the cylinder towards the crankcase until its lower part is inserted into the block.

8. Align the piston and connecting rod holes and install the pin with its retainers. See Figure 10-82.

Note: If the piston has to be reinstalled on the engine, mark it before its removal.

Figure 10-82 Piston Assembled

Valve Guides

1. Press the valve guides in the proper head holes. Carefully ensure that they are installed in an upright position at the head surface. See Figure 10-83.

Note: Assemble the rotocap valve's retainer ring before pressing the exhaust valve guide.

Figure 10-83 Valve Guides

Valve

Note: The exhaust valve has a larger counterbore than the intake valve when viewing the head from the upper surface. The exhaust valve has a smaller hole when viewing the head from the opposite side.

Note: The rotocap and conical shaped spring belong to the exhaust valve. See Figure 10-84.

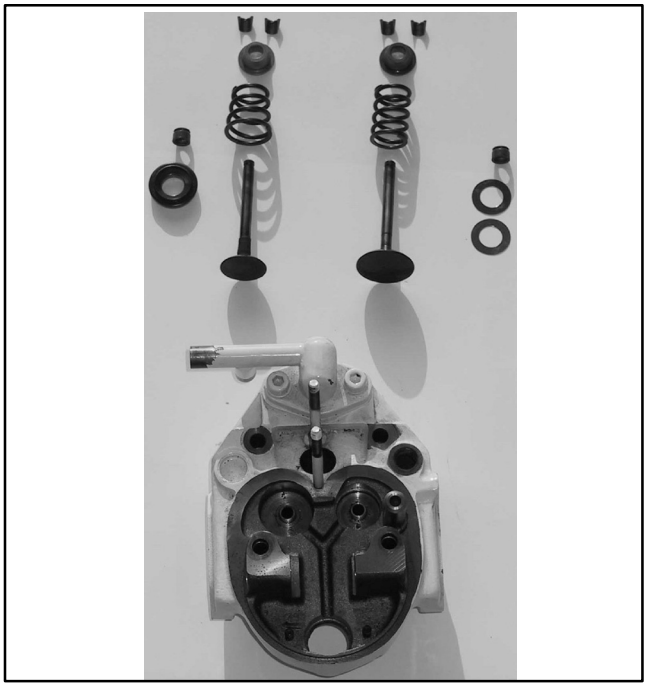


Figure 10-84 Intake and Exhaust Valve Components

1. Install the two thin steel washers under the intake valve spring.
2. Grind the valves and set new cup seals on the valve guide's head.
3. Before installing the rotocap, check for proper operation by spinning the cap washer and releasing it. Replace the rotocap if it produces a an ununiform, rattling sound or if it is hard to move.
4. Fit the cylinder head gasket. See Figure 10-85.
5. Slide the head onto the cylinder.

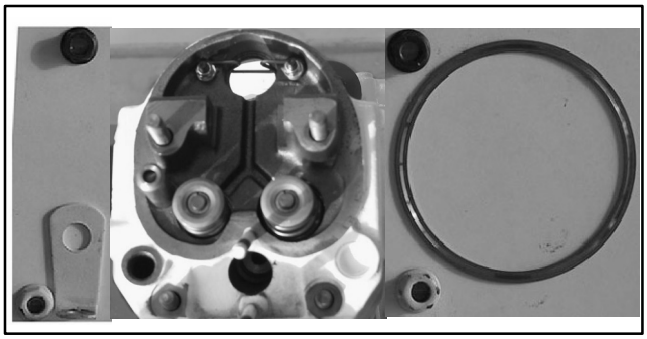


Figure 10-85 Cylinder Head and Gasket

6. On the shorter stud, put the engine lifting bracket.
7. Tighten the nuts at the specified torque. See Section 1.5.

Gear Cover

1. Move the piston to Top Dead Center (TDC) and check the alignment between the mark on the flywheel and the mark on the crankcase at the 3 o'clock position. See Figure 10-86.

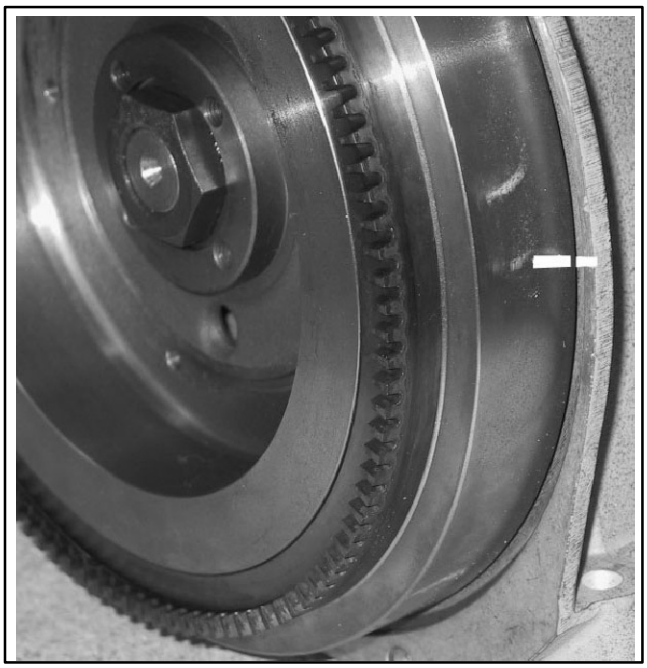


Figure 10-86 Flywheel and Crankcase Marks

2. Set the governor pin into the governor hole using grease to keep it in place.

3. Align the mark on the camshaft gear with the mark on the gear cover. See Figure 10-87.

4. Put the cover gasket in place. Slowly guide the gear cover towards the crankcase without moving the camshaft.

5. Check that the distance between the flywheel mark and the crankcase mark is within ± 2 mm (0.0787 in.). If within this range, the timing gear operation is correct.

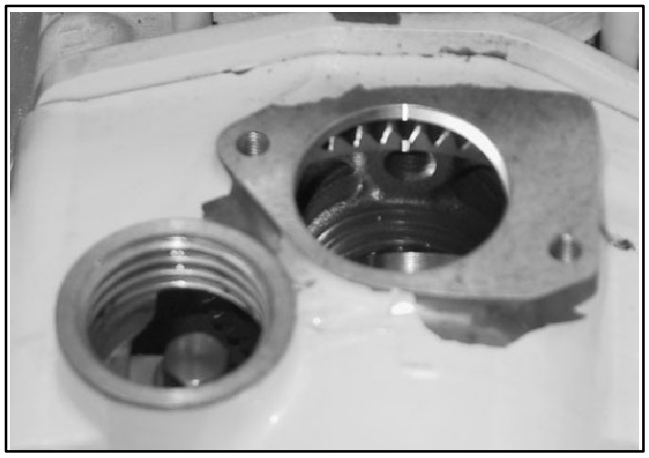


Figure 10-87 Camshaft Gear and Gear Cover Marks

6. The crankshaft could stop in a position that causes difficulty installing the gear cover because the governor touches its lower side. If this happens, follow this procedure to install the cover:

   a. Move the flywheel until its mark aligns with the threaded hole on the crankcase at the 1 o'clock position. See Figure 10-88.

   b. Move the camshaft gear until its mark is exactly three teeth to the left of the gear cover mark. See Figure 10-89.

   c. Install the gear cover and turn the flywheel until the camshaft mark aligns with the one on the gear cover.

   d. Check the distances between the flywheel mark and the crankcase mark located in the 3 o'clock position is within ± 2 mm (0.0787 in.) of each other. If it is, the valve timing adjustment is acceptable.

Figure 10-88 Flywheel Mark

Figure 10-89 Camshaft and Gear Cover Mark

7. When installing the gear cover screws, note that the upper two screws and the one screw located in the middle left position are longer than the other three screws.

8. Place a new gasket under the front plate of the gear cover and tighten the two screws.

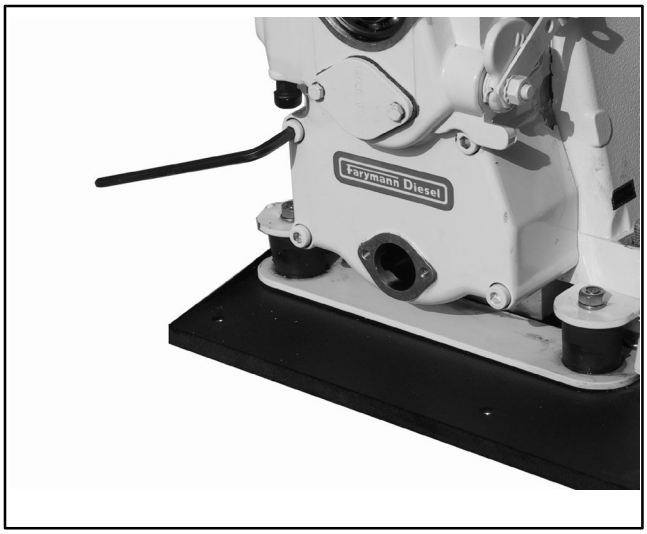


Figure 10-90 Gear Cover Screws

Block Tappets

1. Check that the tappets movement in their block is not forced. Check the surface wear that touches the camshaft. See Figure 10-91.

Figure 10-91 Block Tappets

Push Rods and Protective Tube

1. Install the O-rings and push down the protective tube of the push rods towards the gear cover.
2. Put the retainer spring in the upper side of the head as shown in Figure 10-92.
3. Do not tighten the nuts.
4. Guide the push rods in the tube until they touch the tappets.

Note: Both rods look alike. However, place the intake valve's push rod in the hole closer to the crankcase.

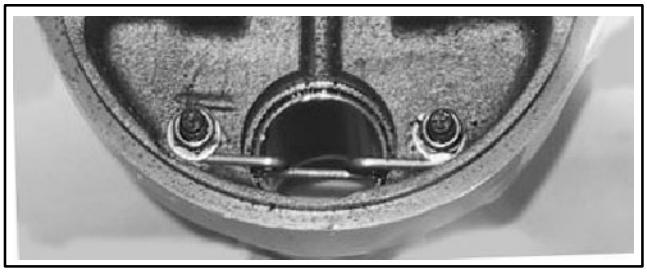


Figure 10-92 Retainer Spring In Cylinder Head

Rocker Arms

1. Ensure that the piston is in the Top Dead Center (TDC) position.
2. Lubricate and then drive the rocker arm shaft into its support.
3. Align the push rods with the correct rocker arms.
4. Ensure a clearance between these parts to prevent damaging the head nuts after tightening.
5. Tighten the head nuts at the specified torque in three steps after the retaining spring nuts. See Section 1.5. See Figure 10-93.

Figure 10-93 Cylinder Head Nuts

Valve Adjustment

1. Move the piston in the compression stroke until it's at Top Dead Center (TDC).

2. Loosen the locknuts of the valve adjustment screws and drive a 0.2 mm (0.78 in.) feeler gage between the upper surface of the valve stem and the rocker arm. See Figure 10-94.

3. Adjust the clearance until a slight drag is felt on the feeler gage when turning the valve adjustment screws with a screwdriver.

4. Hold the valve adjustment screws and tighten the locknuts.

5. Recheck the clearance.

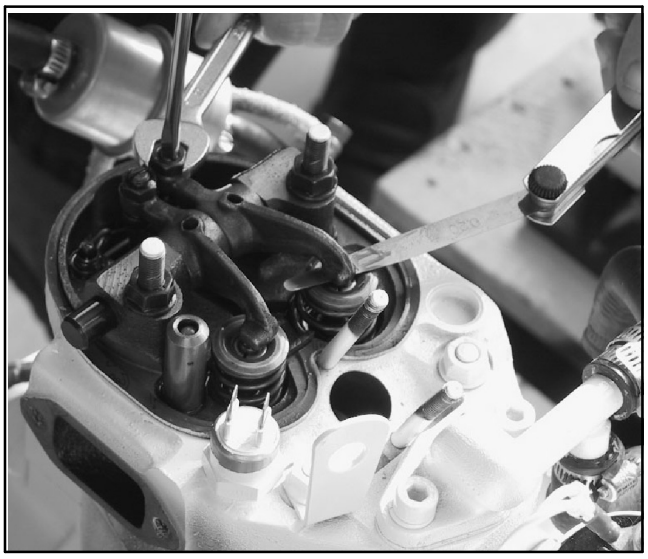


Figure 10-94 Feeler Gage

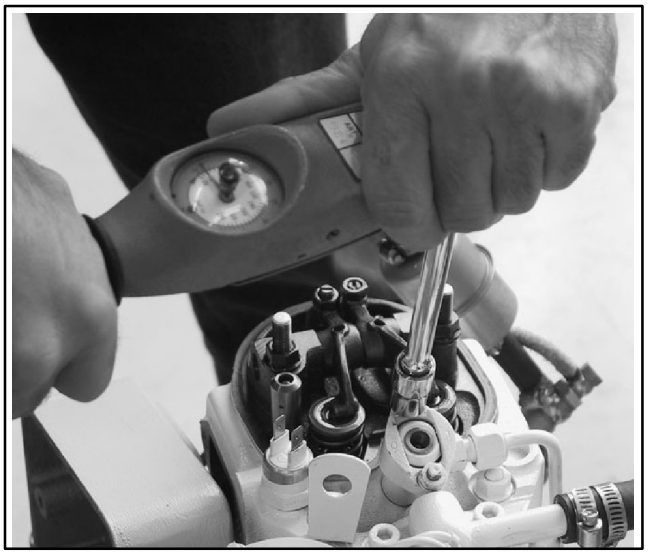


Figure 10-95 Adjustment

Fuel Injector

1. Replace the washer located under the injector and in the seat of the cylinder head.

Note: Use only a gasket under the injector and ensure that the old gasket is removed.

2. Install the injector and the clamp.

3. Tighten the injector nuts at the specified torque. See Section 1.5.

Injection Pump and Speed Control Shaft Connection

1. Keep the accelerator lever in the higher position.

2. Pull down the fuel excess start device's button.

Note: As the inner return spring pushes the control lever, it goes towards the timing gear cover and stops against it.

3. Set the pin of the fuel injection pump in the higher-fuel supply position (towards the right, front fuel pump view).

4. Guide the injection pump in the timing gear cover and ensure that its pin is in the yoke of the control lever's arm.

5. Reinstall the injection pump using the same number and type of shims.

Note: Before installing the shims, put the paper gasket on the cover because a direct contact does not permit adequate sealing.

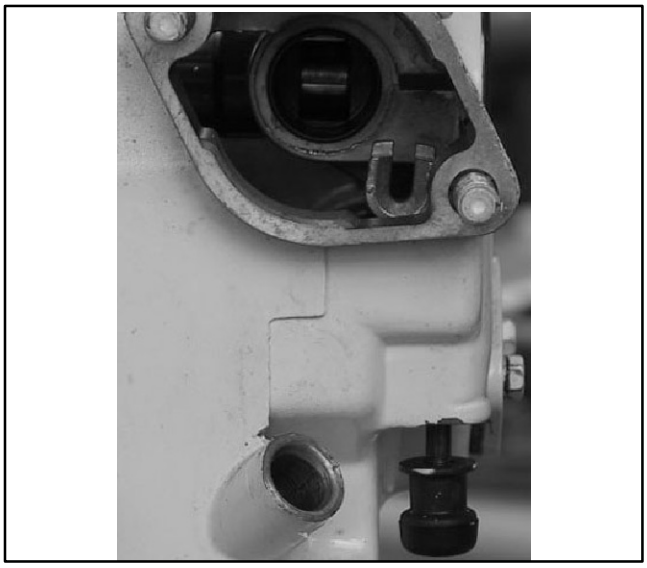


Figure 10-96 Injection Pump

High Pressure Line

1. Install the high pressure line and tighten the nuts at the injector nipple and at the nonreturn valve nipple located on the fuel injection pump body.

Note: Perform step 1 while holding the injector and nonreturn valve nipples with a 14 mm wrench. See Figure 10-97.

2. Tighten the fuel line nuts with a 17 mm wrench.

Figure 10-97 High Pressure Line

Valve Cover

1. Install the valve cover gasket on the upper surface of the head. See Figure 10-98.

2. Reinstall the valve cover.

3. Put the synthetic rubber washers under the cover nuts and tighten at the specified torque. See Section 1.5.

Note: To avoid oil leaks, check and hold the right side of the gasket on the head during this operation.

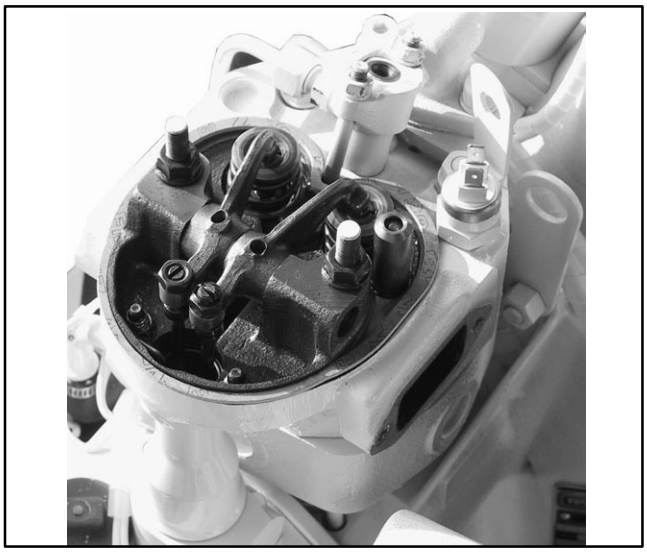


Figure 10-98 Valve Cover Gasket

10.5 Engine Component Dimensions and Wear

Part Description	Dimensions		
	Original		Max. Limit
	Max. mm (in.)	Min. mm (in.)	mm (in.)
Cylinder Liner			
Bore: upper diameter	81.900 (3.2244)	81.880 (3.2236)	82.000 (3.2283)
below diameter	82.030 (3.2295)	82.010 (3.2287)	82.130 (3.2335)
Note: It is not possible to rehone the liner because of the conical shape. We always suggest to exchange the cylinder together with the piston and rings.			
Piston			
Crown diameter	81.967 (3.2270)	81.953 (3.2265)	–
1st compression ring groove height	2.120 (0.0835)	2.100 (0.0827)	–
2nd compression ring groove height	2.070 (0.0815)	2.050 (0.0807)	–
Oil scrapper ring groove height	4.040 (0.1591)	4.020 (0.1583)	–
Diameter of the piston pin hole	22.010 (0.8665)	22.04 (0.8663)	–
Clearance between:			
groove/1st comp. ring height	0.145 (0.0057)	0.110 (0.0043)	0.170 (0.0067)
groove/2nd comp. ring height	0.092 (0.0036)	0.060 (0.0024)	0.140 (0.0055)
groove/oil scrapper ring height	0.065 (0.0026)	0.030 (0.0012)	0.110 (0.0043)
1st and 2nd compression ring gaps	0.500 (0.0197)	0.300 (0.0118)	1.000 (0.0394)
oil scrapper ring gap	0.500 (0.0197)	0.250 (0.0098)	1.000 (0.0394)
Note: The excessive clearances or gaps are because of the abnormal wears of the cylinder liner, piston, and rings. We always suggest to exchange the cylinder together with the piston and rings.			
Crankshaft			
Journal diameter (D1)	40.080 (1.5780)	40.060 (1.5772)	–
Journal diameter (D3)	35.023 (1.3789)	35.015 (1.3785)	–
Journal diameter (D2)	40.030 (1.5760)	40.020 (1.5756)	–
Journal diameter : undersize of 0.25 mm (0.010 in.)			
D1	39.830 (1.5681)	39.810 (1.5673)	–
D2	39.780 (1.5661)	39.770 (1.5657)	–
Journal diameter : undersize of 0.50 mm (0.020 in.)			
D1	39.580 (1.5583)	39.560 (1.5575)	–
D2	39.530 (1.5563)	39.520 (1.5559)	–
Crankshaft gear diameter	22.000 (0.8661)	21.970 (0.8650)	–
Diameter of crankshaft gear journal	22.029 (0.8673)	22.008 (0.8665)	–
Clearance:			
Con rod bearing and crankshaft journal diameter	0.060 (0.0024)	0.030 (0.0012)	0.110 (0.0043)
Bushing and crankshaft journal diameter	0.050 (0.0020)	0.020 (0.0008)	0.080 (0.0031)

10.6 Engine Component Dimensions and Wear (Continued)

Part Description	Dimensions		
	Original		Max. Limit
	Max. mm (in.)	Min. mm (in.)	mm (in.)
Connecting Rod			
Large bore diameter (without bearing)	43.666 (1.7191)	43.650 (1.7185)	–
Small bore diameter (without bearing)	24.986 (0.9837)	24.974 (0.9832)	–
Outer bushing diameter	25.075 (0.9872)	25.035 (0.9856)	–
Inner bushing diameter	22.050 (0.8681)	22.030 (0.8673)	–
Piston Pin			
Outer diameter	22.000 (0.8661)	21.996 (0.8660)	–
Camshaft			
Camshaft gear journal diameter	22.031 (0.8674)	22.022 (0.8670)	–
Camshaft gear hole diameter	22.000 (0.8661)	21.980 (0.8654)	–
Crankcase hole diameter	21.970 (0.8650)	21.960 (0.8645)	21.990 (0.8657)
Camshaft journal (in the crankcase) diameter	21.930 (0.8634)	21.910 (0.8626)	21.860 (0.8606)
Cylinder Head			
Inner guide diameter	7.014 (0.2761)	7.005 (0.2758)	–
Outer guide diameter	10.019 (0.3944)	10.010 (0.3941)	–
Head protrusion of the intake valve guide	5.700 (0.2244)	(*)	–
Head protrusion of the exhaust valve guide	6.200 (0.2441)	(*)	–
Clearance between the guide and stem valve	0.049 (0.0019)	0.025 (0.0009)	0.15 (0.0059)
Valve face angle	45°	–	–
Valve guide (in the head) hole diameter	9.988 (0.3932)	9.979 (0.3929)	–
Valve head recessing	0.200 (0.0079)	0.100 (0.0039)	0.600 (0.0236)
(*) Press down until the lower guide edge is at the level of the flat surface.			

Notes

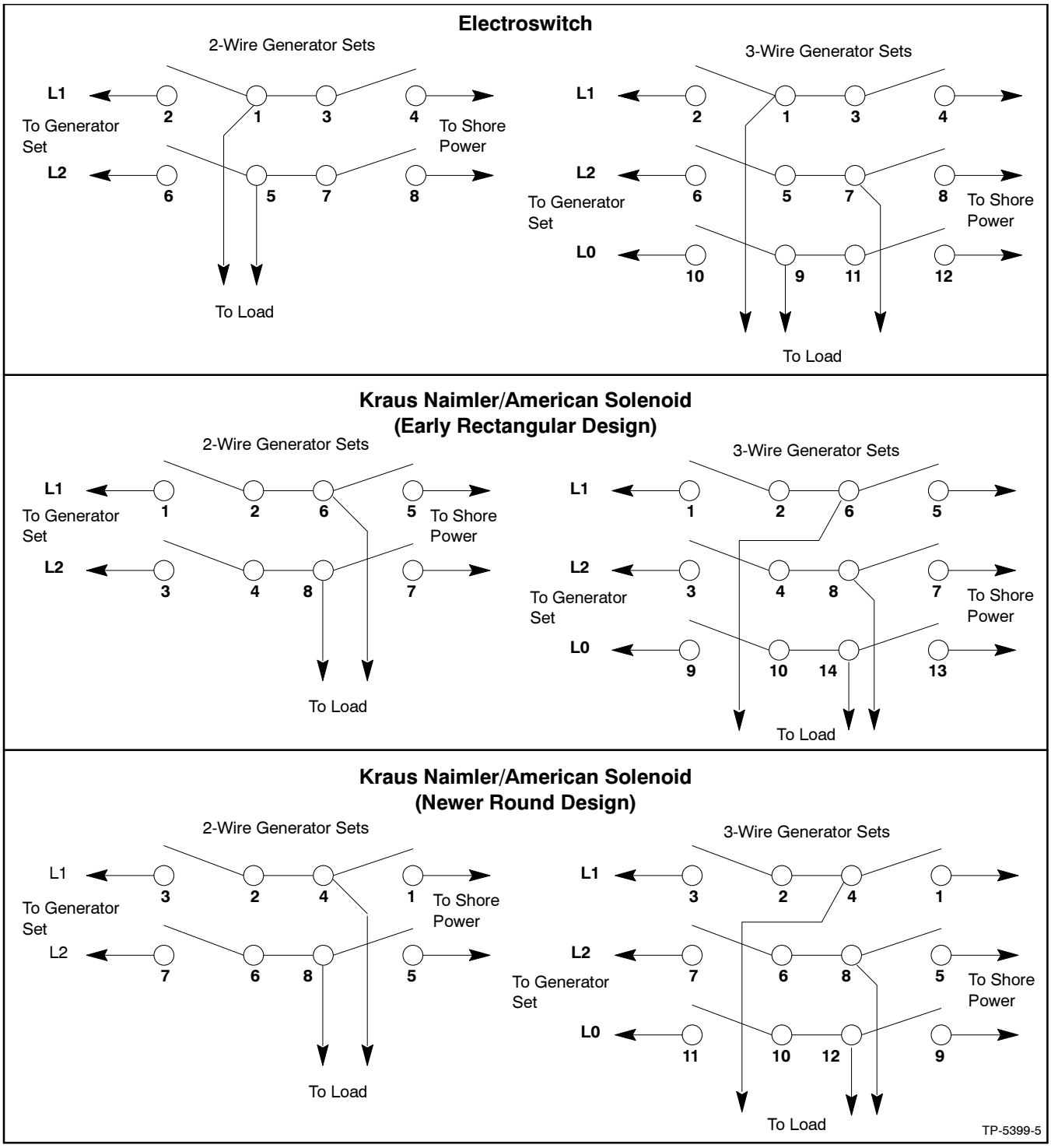
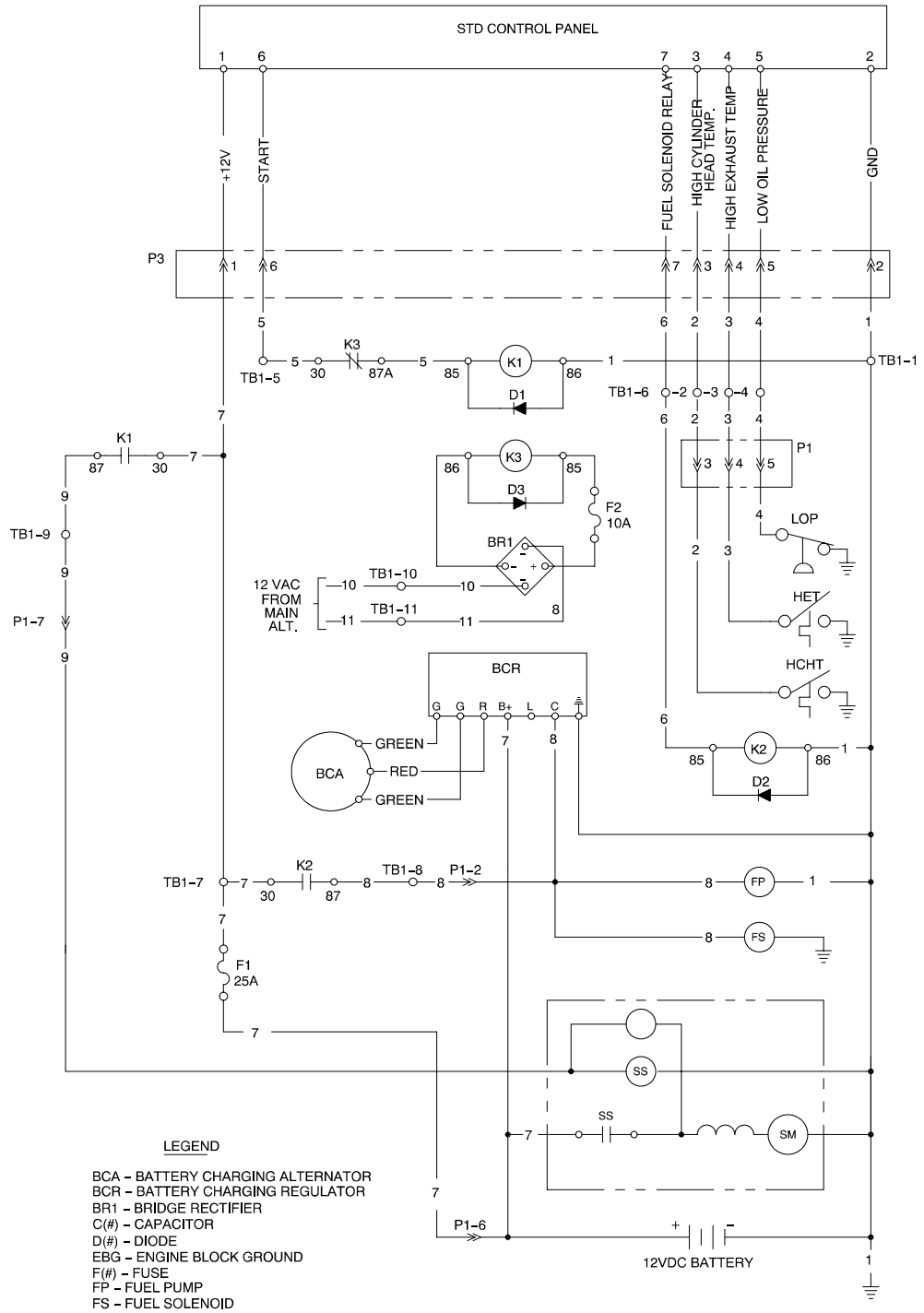


Figure 11-1 Marine Manual (Ship-to-Shore) Transfer Switch

11.1 Wiring Diagram, Schematic

SCHEMATIC



LEGEND

BCA – BATTERY CHARGING ALTERNATOR
BCR – BATTERY CHARGING REGULATOR
BR1 – BRIDGE RECTIFIER
C(#) – CAPACITOR
D(#) – DIODE
EBG – ENGINE BLOCK GROUND
F(#) – FUSE
FP – FUEL PUMP
FS – FUEL SOLENOID
GND – CONTROLLER BOX GROUND
HCHT – HIGH CYLINDER HEAD TEMPERATURE
HET – HIGH EXHAUST TEMPERATURE
J(#) – JACK
K1 – START RELAY
K2 – FUEL SOLENOID RELAY
K3 – AC CRANK DISCONNECT RELAY
LOP – LOW OIL PRESSURE
P(#) – PLUG
SM – STARTER MOTOR
SS – STARTER SOLENOID
TB(#) – TERMINAL BLOCK
TW – PIN

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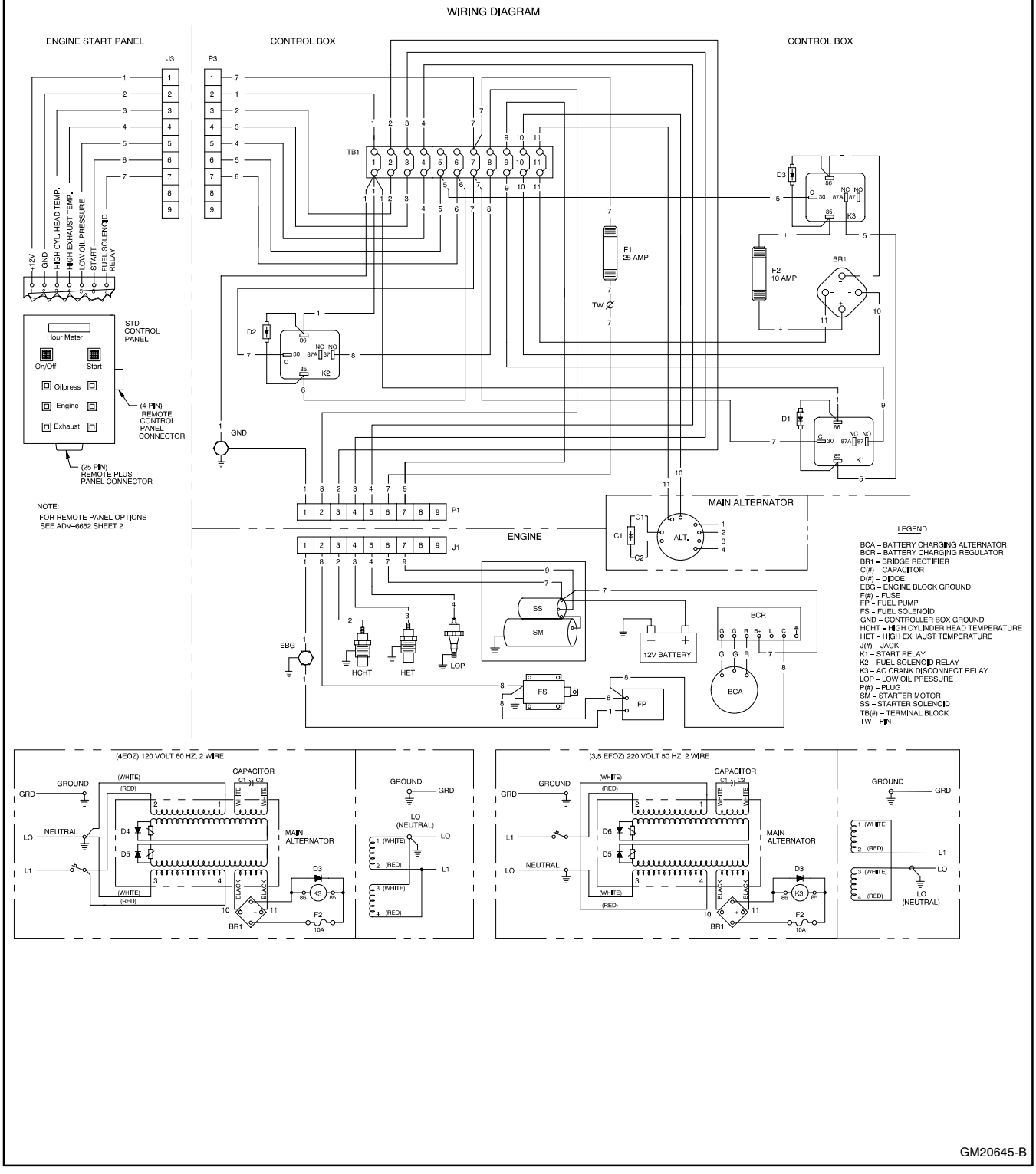
11.2 Wiring Diagram, Point-to-Point



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Notes

Appendix A Abbreviations

The following list contains abbreviations that may appear in this publication.

A, amp	ampere
ABDC	after bottom dead center
AC	alternating current
A/D	analog to digital
ADC	analog to digital converter
adj.	adjust, adjustment
ADV	advertising dimensional drawing
AHWT	anticipatory high water temperature
AISI	American Iron and Steel Institute
ALOP	anticipatory low oil pressure
alt.	alternator
Al	aluminum
ANSI	American National Standards Institute (formerly American Standards Association, ASA)
AO	anticipatory only
API	American Petroleum Institute
approx.	approximate, approximately
AR	as required, as requested
AS	as supplied, as stated, as suggested
ASE	American Society of Engineers
ASME	American Society of Mechanical Engineers
assy.	assembly
ASTM	American Society for Testing Materials
ATDC	after top dead center
ATS	automatic transfer switch
auto.	automatic
aux.	auxiliary
A/V	audiovisual
avg.	average
AVR	automatic voltage regulator
AWG	American Wire Gauge
AWM	appliance wiring material
bat.	battery
BBDC	before bottom dead center
BC	battery charger, battery charging
BCA	battery charging alternator
BCI	Battery Council International
BDC	before dead center
BHP	brake horsepower
blk.	black (paint color), block (engine)
blk. htr.	block heater
BMEP	brake mean effective pressure
bps	bits per second
br.	brass
BTDC	before top dead center
Btu	British thermal unit
Btu/min.	British thermal units per minute
C	Celsius, centigrade
cal.	calorie
CARB	California Air Resources Board
CB	circuit breaker
cc	cubic centimeter
CCA	cold cranking amps
ccw.	counterclockwise
CEC	Canadian Electrical Code
cfh	cubic feet per hour
cfm	cubic feet per minute
CG	center of gravity
CID	cubic inch displacement
CL	centerline
cm	centimeter
CMOS	complementary metal oxide substrate (semiconductor)
cogen.	cogeneration
Com	communications (port)
conn.	connection
cont.	continued
CPVC	chlorinated polyvinyl chloride
crit.	critical
CRT	cathode ray tube
CSA	Canadian Standards Association
CT	current transformer
Cu	copper
cu. in.	cubic inch
cw.	clockwise
CWC	city water-cooled
cyl.	cylinder
D/A	digital to analog
DAC	digital to analog converter
dB	decibel
dBA	decibel (A weighted)
DC	direct current
DCR	direct current resistance
deg., °	degree
dept.	department
dia.	diameter
DI/EO	dual inlet/end outlet
DIN	Deutsches Institut fur Normung e. V. (also Deutsche Industrie Normenausschuss)
DIP	dual inline package
DPDT	double-pole, double-throw
DPST	double-pole, single-throw
DS	disconnect switch
DVR	digital voltage regulator
E, emer.	emergency (power source)
EDI	electronic data interchange
EFR	emergency frequency relay
e.g.	for example (*exempli gratia)*
EG	electronic governor
EGSA	Electrical Generating Systems Association
EIA	Electronic Industries Association
EI/EO	end inlet/end outlet
EMI	electromagnetic interference
emiss.	emission
eng.	engine
EPA	Environmental Protection Agency
EPS	emergency power system
ER	emergency relay
ES	engineering special, engineered special
ESD	electrostatic discharge
est.	estimated
E-Stop	emergency stop
etc.	et cetera (and so forth)
exh.	exhaust
ext.	external
F	Fahrenheit, female
fglass.	fiberglass
FHM	flat head machine (screw)
fl. oz.	fluid ounce
flex.	flexible
freq.	frequency
FS	full scale
ft.	foot, feet
ft. lbs.	foot pounds (torque)
ft./min.	feet per minute
g	gram
ga.	gauge (meters, wire size)
gal.	gallon
gen.	generator
genset	generator set
GFI	ground fault interrupter
GND, ⏚	ground
gov.	governor
gph	gallons per hour
gpm	gallons per minute
gr.	grade, gross
GRD	equipment ground
gr. wt.	gross weight
H x W x D	height by width by depth
HC	hex cap
HCHT	high cylinder head temperature
HD	heavy duty
HET	high exhaust temperature
hex	hexagon
Hg	mercury (element)
HH	hex head
HHC	hex head cap
HP	horsepower
hr.	hour
HS	heat shrink
hsg.	housing
HVAC	heating, ventilation, and air conditioning
HWT	high water temperature
Hz	hertz (cycles per second)
IC	integrated circuit
ID	inside diameter, identification
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMS	improved motor starting
in.	inch
in. H_2O	inches of water
in. Hg	inches of mercury
in. lbs.	inch pounds
Inc.	incorporated
ind.	industrial
int.	internal
int./ext.	internal/external
I/O	input/output
IP	iron pipe
ISO	International Organization for Standardization
J	joule
JIS	Japanese Industry Standard
k	kilo (1000)
K	kelvin
kA	kiloampere
KB	kilobyte (2^{10} bytes)

kg	kilogram
kg/cm^2	kilograms per square centimeter
kgm	kilogram-meter
kg/m^3	kilograms per cubic meter
kHz	kilohertz
kJ	kilojoule
km	kilometer
kOhm, kΩ	kilo-ohm
kPa	kilopascal
kph	kilometers per hour
kV	kilovolt
kVA	kilovolt ampere
kVAR	kilovolt ampere reactive
kW	kilowatt
kWh	kilowatt-hour
kWm	kilowatt mechanical
L	liter
LAN	local area network
L x W x H	length by width by height
lb.	pound, pounds
lbm/ft^3	pounds mass per cubic feet
LCB	line circuit breaker
LCD	liquid crystal display
ld. shd.	load shed
LED	light emitting diode
Lph	liters per hour
Lpm	liters per minute
LOP	low oil pressure
LP	liquefied petroleum
LPG	liquefied petroleum gas
LS	left side
L_{wa}	sound power level, A weighted
LWL	low water level
LWT	low water temperature
m	meter, milli (1/1000)
M	mega (10^6 when used with SI units), male
m^3	cubic meter
m^3/min.	cubic meters per minute
mA	milliampere
man.	manual
max.	maximum
MB	megabyte (2^{20} bytes)
MCM	one thousand circular mils
MCCB	molded-case circuit breaker
meggar	megohmmeter
MHz	megahertz
mi.	mile
mil	one one-thousandth of an inch
min.	minimum, minute
misc.	miscellaneous
MJ	megajoule
mJ	millijoule
mm	millimeter
mOhm, mΩ	milliohm
MOhm, MΩ	megohm
MOV	metal oxide varistor
MPa	megapascal
mpg	miles per gallon
mph	miles per hour
MS	military standard
m/sec.	meters per second
MTBF	mean time between failure
MTBO	mean time between overhauls
mtg.	mounting
MW	megawatt
mW	milliwatt
μF	microfarad
N, norm.	normal (power source)
NA	not available, not applicable
nat. gas	natural gas
NBS	National Bureau of Standards
NC	normally closed
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
Nm	newton meter
NO	normally open
no., nos.	number, numbers
NPS	National Pipe, Straight
NPSC	National Pipe, Straight-coupling
NPT	National Standard taper pipe thread per general use
NPTF	National Pipe, Taper-Fine
NR	not required, normal relay
ns	nanosecond
OC	overcrank
OD	outside diameter
OEM	original equipment manufacturer
OF	overfrequency
opt.	option, optional
OS	oversize, overspeed
OSHA	Occupational Safety and Health Administration
OV	overvoltage
oz.	ounce
p., pp.	page, pages
PC	personal computer
PCB	printed circuit board
pF	picofarad
PF	power factor
ph., ∅	phase
PHC	Phillips head crimptite (screw)
PHH	Phillips hex head (screw)
PHM	pan head machine (screw)
PLC	programmable logic control
PMG	permanent-magnet generator
pot	potentiometer, potential
ppm	parts per million
PROM	programmable read-only memory
psi	pounds per square inch
pt.	pint
PTC	positive temperature coefficient
PTO	power takeoff
PVC	polyvinyl chloride
qt.	quart
qty.	quantity
R	replacement (emergency) power source
rad.	radiator, radius
RAM	random access memory
RDO	relay driver output
ref.	reference
rem.	remote
RFI	radio frequency interference
RH	round head
RHM	round head machine (screw)
rly.	relay
rms	root mean square
rnd.	round
ROM	read only memory
rot.	rotate, rotating
rpm	revolutions per minute
RS	right side
RTV	room temperature vulcanization
SAE	Society of Automotive Engineers
scfm	standard cubic feet per minute
SCR	silicon controlled rectifier
s, sec.	second
SI	*Systeme international d'unites,* International System of Units
SI/EO	side in/end out
sil.	silencer
SN	serial number
SPDT	single-pole, double-throw
SPST	single-pole, single-throw
spec, specs	specification(s)
sq.	square
sq. cm	square centimeter
sq. in.	square inch
SS	stainless steel
std.	standard
stl.	steel
tach.	tachometer
TD	time delay
TDC	top dead center
TDEC	time delay engine cooldown
TDEN	time delay emergency to normal
TDES	time delay engine start
TDNE	time delay normal to emergency
TDOE	time delay off to emergency
TDON	time delay off to normal
temp.	temperature
term.	terminal
TIF	telephone influence factor
TIR	total indicator reading
tol.	tolerance
turbo.	turbocharger
typ.	typical (same in multiple locations)
UF	underfrequency
UHF	ultrahigh frequency
UL	Underwriter's Laboratories, Inc.
UNC	unified coarse thread (was NC)
UNF	unified fine thread (was NF)
univ.	universal
US	undersize, underspeed
UV	ultraviolet, undervoltage
V	volt
VAC	volts alternating current
VAR	voltampere reactive
VDC	volts direct current
VFD	vacuum fluorescent display
VGA	video graphics adapter
VHF	very high frequency
W	watt
WCR	withstand and closing rating
w/	with
w/o	without
wt.	weight
xfmr	transformer

Appendix B Common Hardware Application Guidelines

Use the information below and on the following pages to identify proper fastening techniques when no specific reference for reassembly is made.

Bolt/Screw Length: When bolt/screw length is not given, use Figure 1 as a guide. As a general rule, a minimum length of one thread beyond the nut and a maximum length of 1/2 the bolt/screw diameter beyond the nut is the preferred method.

Washers and Nuts: Use split lock washers as a bolt locking device where specified. Use SAE flat washers with whiz nuts, spiralock nuts, or standard nuts and preloading (torque) of the bolt in all other applications.

See General Torque Specifications and other torque specifications in the service literature.

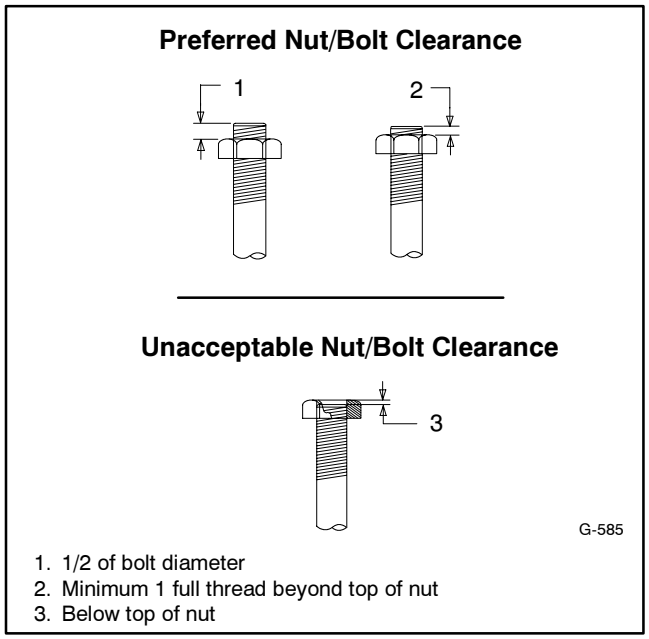


Figure 1 Acceptable Bolt Lengths

Steps for common hardware application

1. Determine entry hole type: round or slotted.
2. Determine exit hole type: fixed female thread (weld nut), round, or slotted.

   For round and slotted exit holes, determine if hardware is greater than 1/2 inch in diameter, or 1/2 inch in diameter or less. Hardware that is *greater than 1/2 inch* in diameter takes a standard nut and SAE washer. Hardware *1/2 inch or less* in diameter can take a properly torqued whiz nut or spiralock nut. See the diagram below.
3. Follow these SAE washer rules after determining exit hole type:
   a. Always use a washer between hardware and a slot.
   b. Always use a washer under a nut (see 2 above for exception).
   c. Use a washer under a bolt when the female thread is fixed (weld nut).
4. Refer to the diagram below, which depicts the preceding hardware configuration possibilities.

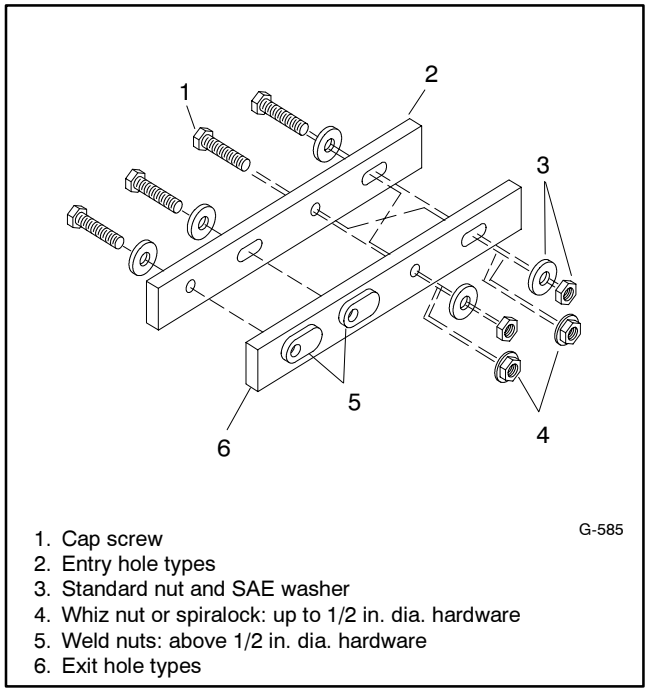


Figure 2 Acceptable Hardware Combinations

Appendix C General Torque Specifications

Use the following torque specifications when service literature instructions give no specific torque values. The charts list values for new plated, zinc phosphate, or oiled threads. Increase values by 15% for nonplated threads. All torque values are +0%/–10%.

American Standard Fasteners Torque Specifications

Size	Torque Measurement	Assembled into Cast Iron or Steel			Assembled into Aluminum
		Grade 2	Grade 5	Grade 8	Grade 2 or 5
8-32	in. lbs. (Nm)	16 (1.8)	20 (2.3)	—	16 (1.8)
10-24	in. lbs. (Nm)	26 (2.9)	32 (3.6)	—	26 (2.9)
10-32	in. lbs. (Nm)	26 (2.9)	32 (3.6)	—	26 (2.9)
1/4-20	in. lbs. (Nm)	60 (6.8)	96 (10.8)	132 (14.9)	60 (6.8)
1/4-28	in. lbs. (Nm)	72 (8.1)	108 (12.2)	144 (16.3)	72 (8.1)
5/16-18	in. lbs. (Nm)	120 (13.6)	192 (21.7)	264 (29.8)	120 (13.6)
5/16-24	in. lbs. (Nm)	132 (14.9)	204 (23.1)	288 (32.5)	132 (14.9)
3/8-16	ft. lbs. (Nm)	18 (24)	28 (38)	39 (53)	18 (24)
3/8-24	ft. lbs. (Nm)	20 (27)	31 (42)	44 (60)	20 (27)
7/16-14	ft. lbs. (Nm)	29 (39)	44 (60)	63 (85)	—
7/16-20	ft. lbs. (Nm)	32 (43)	50 (68)	70 (95)	—
1/2-13	ft. lbs. (Nm)	44 (60)	68 (92)	96 (130)	—
1/2-20	ft. lbs. (Nm)	49 (66)	76 (103)	108 (146)	—
9/16-12	ft. lbs. (Nm)	60 (81)	98 (133)	138 (187)	—
9/16-18	ft. lbs. (Nm)	67 (91)	109 (148)	154 (209)	—
5/8-11	ft. lbs. (Nm)	83 (113)	135 (183)	191 (259)	—
5/8-18	ft. lbs. (Nm)	94 (128)	153 (208)	216 (293)	—
3/4-10	ft. lbs. (Nm)	147 (199)	240 (325)	338 (458)	—
3/4-16	ft. lbs. (Nm)	164 (222)	268 (363)	378 (513)	—
1-8	ft. lbs. (Nm)	191 (259)	532 (721)	818 (1109)	—
1-12	ft. lbs. (Nm)	209 (283)	582 (789)	895 (1214)	—

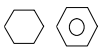
Metric Fasteners Torque Specifications, Measured in ft. lbs. (Nm)

Size (mm)	Assembled into Cast Iron or Steel			Assembled into Aluminum
	Grade 5.8	Grade 8.8	Grade 10.9	Grade 5.8 or 8.8
M6 x 1.00	4 (5.6)	7 (9.9)	10 (14)	4 (5.6)
M8 x 1.25	10 (13.6)	18 (25)	26 (35)	10 (13.6)
M8 x 1.00	16 (21)	18 (25)	26 (35)	16 (21)
M10 x 1.50	20 (27)	35 (49)	50 (68)	20 (27)
M10 x 1.25	29 (39)	35 (49)	50 (68)	29 (39)
M12 x 1.75	35 (47)	61 (83)	86 (117)	—
M12 x 1.50	48 (65)	65 (88)	92 (125)	—
M14 x 2.00	55 (74)	97 (132)	136 (185)	—
M14 x 1.50	74 (100)	103 (140)	142 (192)	—
M16 x 2.00	85 (115)	148 (200)	210 (285)	—
M16 x 1.50	104 (141)	155 (210)	218 (295)	—
M18 x 2.50	114 (155)	203 (275)	288 (390)	—
M18 x 1.50	145 (196)	225 (305)	315 (425)	—

Appendix D Common Hardware Identification

Screw/Bolts/Studs	
Head Styles	
Hex Head or Machine Head	
Hex Head or Machine Head with Washer	
Flat Head (FHM)	
Round Head (RHM)	
Pan Head	
Hex Socket Head Cap or Allen™ Head Cap	
Hex Socket Head or Allen™ Head Shoulder Bolt	
Sheet Metal Screw	
Stud	
Drive Styles	
Hex	
Hex and Slotted	
Phillips®	
Slotted	
Hex Socket	

Nuts	
Nut Styles	
Hex Head	
Lock or Elastic	
Square	
Cap or Acorn	
Wing	
Washers	
Washer Styles	
Plain	
Split Lock or Spring	
Spring or Wave	
External Tooth Lock	
Internal Tooth Lock	
Internal-External Tooth Lock	

Hardness Grades	
American Standard	
Grade 2	
Grade 5	
Grade 8	
Grade 8/9 (Hex Socket Head)	
Metric	
Number stamped on hardware; 5.8 shown	

Allen™ head screw is a trademark of Holo-Krome Co.

Phillips® screw is a registered trademark of Phillips Screw Company.

Sample Dimensions

American Standard (Screws, Bolts, Studs, and Nuts)

1/4-20 x 1

- Length In Inches (Screws and Bolts)
- Threads Per Inch
- Major Thread Diameter In Fractional Inches Or Screw Number Size

Metric (Screws, Bolts, Studs, and Nuts)

M8-1.25 x 20

- Length In Millimeters (Screws and Bolts)
- Distance Between Threads In Millimeters
- Major Thread Diameter In Millimeters

Plain Washers

9/32 x 5/8 x 1/16

- Thickness
- External Dimension
- Internal Dimension

Lock Washers

5/8

- Internal Dimension

Appendix E Common Hardware List

The Common Hardware List lists part numbers and dimensions for common hardware items.

American Standard

Part No.	Dimensions
Hex Head Bolts (Grade 5)	
X-465-17	1/4-20 x .38
X-465-6	1/4-20 x .50
X-465-2	1/4-20 x .62
X-465-16	1/4-20 x .75
X-465-18	1/4-20 x .88
X-465-7	1/4-20 x 1.00
X-465-8	1/4-20 x 1.25
X-465-9	1/4-20 x 1.50
X-465-10	1/4-20 x 1.75
X-465-11	1/4-20 x 2.00
X-465-12	1/4-20 x 2.25
X-465-14	1/4-20 x 2.75
X-465-21	1/4-20 x 5.00
X-465-25	1/4-28 x .38
X-465-20	1/4-28 x 1.00
X-125-33	5/16-18 x .50
X-125-23	5/16-18 x .62
X-125-3	5/16-18 x .75
X-125-31	5/16-18 x .88
X-125-5	5/16-18 x 1.00
X-125-24	5/16-18 x 1.25
X-125-34	5/16-18 x 1.50
X-125-25	5/16-18 x 1.75
X-125-26	5/16-18 x 2.00
230578	5/16-18 x 2.25
X-125-29	5/16-18 x 2.50
X-125-27	5/16-18 x 2.75
X-125-28	5/16-18 x 3.00
X-125-22	5/16-18 x 4.50
X-125-32	5/16-18 x 5.00
X-125-35	5/16-18 x 5.50
X-125-36	5/16-18 x 6.00
X-125-40	5/16-18 x 6.50
X-125-43	5/16-24 x 1.75
X-125-44	5/16-24 x 2.50
X-125-30	5/16-24 x .75
X-125-39	5/16-24 x 2.00
X-125-38	5/16-24 x 2.75
X-6238-2	3/8-16 x .62
X-6238-10	3/8-16 x .75
X-6238-3	3/8-16 x .88
X-6238-11	3/8-16 x 1.00
X-6238-4	3/8-16 x 1.25
X-6238-5	3/8-16 x 1.50
X-6238-1	3/8-16 x 1.75
X-6238-6	3/8-16 x 2.00
X-6238-17	3/8-16 x 2.25
X-6238-7	3/8-16 x 2.50
X-6238-8	3/8-16 x 2.75
X-6238-9	3/8-16 x 3.00
X-6238-19	3/8-16 x 3.25
X-6238-12	3/8-16 x 3.50
X-6238-20	3/8-16 x 3.75
X-6238-13	3/8-16 x 4.50
X-6238-18	3/8-16 x 5.50
X-6238-25	3/8-16 x 6.50

Part No.	Dimensions
Hex Head Bolts, cont.	
X-6238-14	3/8-24 x .75
X-6238-16	3/8-24 x 1.25
X-6238-21	3/8-24 x 4.00
X-6238-22	3/8-24 x 4.50
X-6024-5	7/16-14 x .75
X-6024-2	7/16-14 x 1.00
X-6024-8	7/16-14 x 1.25
X-6024-3	7/16-14 x 1.50
X-6024-4	7/16-14 x 2.00
X-6024-11	7/16-14 x 2.75
X-6024-12	7/16-14 x 6.50
X-129-15	1/2-13 x .75
X-129-17	1/2-13 x 1.00
X-129-18	1/2-13 x 1.25
X-129-19	1/2-13 x 1.50
X-129-20	1/2-13 x 1.75
X-129-21	1/2-13 x 2.00
X-129-22	1/2-13 x 2.25
X-129-23	1/2-13 x 2.50
X-129-24	1/2-13 x 2.75
X-129-25	1/2-13 x 3.00
X-129-27	1/2-13 x 3.50
X-129-29	1/2-13 x 4.00
X-129-30	1/2-13 x 4.50
X-463-9	1/2-13 x 5.50
X-129-44	1/2-13 x 6.00
X-129-51	1/2-20 x .75
X-129-45	1/2-20 x 1.25
X-129-52	1/2-20 x 1.50
X-6021-3	5/8-11 x 1.00
X-6021-4	5/8-11 x 1.25
X-6021-2	5/8-11 x 1.50
X-6021-1	5/8-11 x 1.75
273049	5/8-11 x 2.00
X-6021-5	5/8-11 x 2.25
X-6021-6	5/8-11 x 2.50
X-6021-7	5/8-11 x 2.75
X-6021-12	5/8-11 x 3.75
X-6021-11	5/8-11 x 4.50
X-6021-10	5/8-11 x 6.00
X-6021-9	5/8-18 x 2.50
X-6239-1	3/4-10 x 1.00
X-6239-8	3/4-10 x 1.25
X-6239-2	3/4-10 x 1.50
X-6239-3	3/4-10 x 2.00
X-6239-4	3/4-10 x 2.50
X-6239-5	3/4-10 x 3.00
X-6239-6	3/4-10 x 3.50
X-792-1	1-8 x 2.25
X-792-5	1-8 x 3.00
X-792-8	1-8 x 5.00

Part No.	Dimensions	Type
Hex Nuts		
X-6009-1	1-8	Standard
X-6210-3	6-32	Whiz
X-6210-4	8-32	Whiz
X-6210-5	10-24	Whiz
X-6210-1	10-32	Whiz
X-6210-2	1/4-20	Spiralock
X-6210-6	1/4-28	Spiralock
X-6210-7	5/16-18	Spiralock
X-6210-8	5/16-24	Spiralock
X-6210-9	3/8-16	Spiralock
X-6210-10	3/8-24	Spiralock
X-6210-11	7/16-14	Spiralock
X-6210-12	1/2-13	Spiralock
X-6210-15	7/16-20	Spiralock
X-6210-14		Spiralock
X-85-3	5/8-11	Standard
X-88-12	3/4-10	Standard
X-89-2	1/2-20	Standard

Washers

Part No.	ID	OD	Thick.	Bolt/ Screw
X-25-46	.125	.250	.022	#4
X-25-9	.156	.375	.049	#6
X-25-48	.188	.438	.049	#8
X-25-36	.219	.500	.049	#10
X-25-40	.281	.625	.065	1/4
X-25-85	.344	.687	.065	5/16
X-25-37	.406	.812	.065	3/8
X-25-34	.469	.922	.065	7/16
X-25-26	.531	1.062	.095	1/2
X-25-15	.656	1.312	.095	5/8
X-25-29	.812	1.469	.134	3/4
X-25-127	1.062	2.000	.134	1

Metric

Hex head bolts are hardness grade 8.8 unless noted.

Part No.	Dimensions
Hex Head Bolts (partial thread)	
M931-06040-60	M6-1.00 x 40
M931-06055-60	M6-1.00 x 55
M931-06060-60	M6-1.00 x 60
M931-06070-60	M6-1.00 x 70
M931-06075-60	M6-1.00 x 75
M931-06090-60	M6-1.00 x 90
M931-08035-60	M8-1.25 x 35
M931-08040-60	M8-1.25 x 40
M931-08040-82	M8-1.25 x 40*
M931-08045-60	M8-1.25 x 45
M931-08050-60	M8-1.25 x 50
M931-08055-82	M8-1.25 x 55*
M931-08060-60	M8-1.25 x 60
M931-08070-60	M8-1.25 x 70
M931-08070-82	M8-1.25 x 70*
M931-08075-60	M8-1.25 x 75
M931-08080-60	M8-1.25 x 80
M931-08090-60	M8-1.25 x 90
M931-08095-60	M8-1.25 x 95
M931-08100-60	M8-1.25 x 100
M931-10040-60	M10-1.50 x 40
M931-10045-60	M10-1.50 x 45
M931-10050-60	M10-1.50 x 50
M931-10055-60	M10-1.50 x 55
M931-10060-60	M10-1.50 x 60
M931-10065-60	M10-1.50 x 65
M931-10070-60	M10-1.50 x 70
M931-10080-60	M10-1.50 x 80
M931-10090-60	M10-1.50 x 90
M931-10100-60	M10-1.50 x 100
M931-12045-60	M12-1.75 x 45
M931-12050-60	M12-1.75 x 50
M931-12055-60	M12-1.75 x 55
M931-12060-60	M12-1.75 x 60
M931-12065-60	M12-1.75 x 65
M931-12080-60	M12-1.75 x 80
M931-12090-60	M12-1.75 x 90
M931-12100-60	M12-1.75 x 100
M931-12110-60	M12-1.75 x 110
M931-16090-60	M16-2.00 x 90
M931-20065-60	M20-2.50 x 65
M931-20120-60	M20-2.50 x 120
M931-20160-60	M20-2.50 x 160
M931-22090-60	M22-2.50 x 90
M931-22120-60	M22-2.50 x 120
M931-22160-60	M22-2.50 x 160
M931-24090-60	M24-3.00 x 90
M931-24120-60	M24-3.00 x 120
M931-24160-60	M24-3.00 x 160

Part No.	Dimensions
Hex Head Bolts (full thread)	
M933-04006-60	M4-0.70 x 6
M933-05050-60	M5-0.80 x 50
M933-06010-60	M6-1.00 x 10
M933-06014-60	M6-1.00 x 14
M933-06016-60	M6-1.00 x 16
M933-06020-60	M6-1.00 x 20
M933-06025-60	M6-1.00 x 25
M933-06040-60	M6-1.00 x 40
M933-06050-60	M6-1.00 x 50
M933-08016-60	M8-1.25 x 16
M933-08020-60	M8-1.25 x 20
M933-08025-60	M8-1.25 x 25
M933-08030-60	M8-1.25 x 30
M933-10012-60	M10-1.50 x 12
M961-10020-60	M10-1.25 x 20
M933-10020-60	M10-1.50 x 20
M933-10025-60	M10-1.50 x 25
M933-10030-60	M10-1.50 x 30
M933-10030-82	M10-1.50 x 30*
M961-10035-60	M10-1.25 x 35
M933-10035-60	M10-1.50 x 35
M933-12016-60	M12-1.75 x 16
M933-12020-60	M12-1.75 x 20
M933-12025-60	M12-1.75 x 25
M933-12025-82	M12-1.75 x 25*
M933-12030-60	M12-1.75 x 30
M933-12040-60	M12-1.75 x 40
M933-12040-82	M12-1.75 x 40*
M961-14025-60	M14-1.50 x 25
M933-14025-60	M14-2.00 x 25
M961-16025-60	M16-1.50 x 25
M933-16025-60	M16-2.00 x 25
M933-16030-82	M16-2.00 x 30*
M933-16035-60	M16-2.00 x 35
M933-16040-60	M16-2.00 x 40
M933-16050-60	M16-2.00 x 50
M933-16050-82	M16-2.00 x 50*
M933-16060-60	M16-2.00 x 60
M933-18050-60	M18-2.50 x 50
M933-18060-60	M18-2.50 x 60
Pan Head Machine Screws	
M7985A-03010-20	M3-0.50 x 10
M7985A-03012-20	M3-0.50 x 12
M7985A-04020-20	M4-0.70 x 20
M7985A-05010-20	M5-0.80 x 10
M7985A-05012-20	M5-0.80 x 12
Flat Head Machine Screws	
M965A-05016-20	M5-0.80 x 16

Part No.	Dimensions	Type
Hex Nuts		
M934-03-50	M3-0.50	Standard
M934-04-50	M4-0.70	Standard
M934-05-50	M5-0.80	Standard
M982-05-80	M5-0.80	Elastic Stop
M6923-06-80	M6-1.00	Spiralock
M934-06-64	M6-1.00	Std. (green)
M982-06-80	M6-1.00	Elastic Stop
M6923-08-80	M8-1.25	Spiralock
M934-08-60	M8-1.25	Standard
M982-08-80	M8-1.25	Elastic Stop
M6923-10-80	M10-1.50	Spiralock
M982-10-80	M10-1.50	Elastic Stop
M6923-12-80	M12-1.75	Spiralock
M982-12-80	M12-1.75	Elastic Stop
M982-14-80	M14-2.00	Elastic Stop
M6923-16-80	M16-2.00	Spiralock
M982-16-80	M16-2.00	Elastic Stop
M982-18-80	M18-2.50	Elastic Stop
M934-20-80	M20-2.50	Standard
M982-20-80	M20-2.50	Elastic Stop
M934-22-80	M22-2.50	Standard
M982-22-80	M22-2.50	Elastic Stop
M934-24-80	M24-3.00	Standard
M982-24-80	M24-3.00	Elastic Stop

Washers

Part No.	ID	OD	Thick.	Bolt/ Screw
M125A-03-80	3.2	7.0	0.5	M3
M125A-04-80	4.3	9.0	0.8	M4
M125A-05-80	5.3	10.0	1.0	M5
M125A-06-80	6.4	12.0	1.6	M6
M125A-08-80	8.4	16.0	1.6	M8
M125A-10-80	10.5	20.0	2.0	M10
M125A-12-80	13.0	24.0	2.5	M12
M125A-14-80	15.0	28.0	2.5	M14
M125A-16-80	17.0	30.0	3.0	M16
M125A-18-80	19.0	34.0	3.0	M18
M125A-20-80	21.0	37.0	3.0	M20
M125A-24-80	25.0	44.0	4.0	M24

* This metric hex bolt's hardness is grade 10.9.

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