YANMAR

SERVICE MANUAL

INDUSTRIAL ENGINES

Diesel Powered Generators

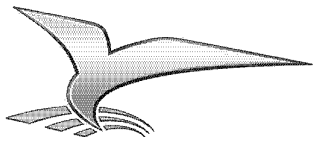
YDG2700EV-6EH
YDG3700EV-6EI
YDG5500EV-6EI

California
Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the state of California to cause cancer, birth defects, and other reproductive harm.

California
Proposition 65 Warning

Battery posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the state of California to cause cancer and reproductive harm.
Wash hands after handling.



YAMAHA®

YDG series

SERVICE MANUAL

Diesel Powered Generators
YDG2700EV-6EH
YDG3700EV-6EI
YDG5500EV-6EI

P/N: 0BYDG-G00100

INDUSTRIAL ENGINES

This *Service Manual* has been developed for the exclusive use of service and repair professionals such as Yanmar authorized Distributors and Yanmar authorized Dealers. It is written with these professionals in mind and may not contain the necessary detail or safety statements that may be required for a non-professional to perform the service or repair properly and / or safely. Please contact an authorized Yanmar repair or service professional before working on your Yanmar product.

Disclaimers:

All information, illustrations and specifications in this manual are based on the latest information available at the time of publishing. The illustrations used in this manual are intended as representative reference views only. Moreover, because of our continuous product improvement policy, we may modify information, illustrations, and / or specifications to explain and / or exemplify a product, service, or maintenance improvement. We reserve the right to make any change at any time.

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Section 1

INTRODUCTION

This manual describes the service procedures for the YDG series generator units powered by the LV series air-cooled, vertical single-cylinder, 4-stroke, direct injection engines.

These engines are certified by the U.S. EPA, California ARB and/or the 97/68/EC Directive for industrial use.

The use of this manual is recommended for safe, efficient and accurate servicing of the engine.

Use this manual together with the current model specific parts catalog for additional exploded part diagrams and identification of parts numbers. Part catalogs are intended for part number identification only. Exploded part diagrams within part catalogs should not be used as an assembly reference, follow the assembly procedures within the correct service manual for proper assembly instructions.

The information and procedures within this manual are for a typical engine, some specifications and components may be different from your engine. All photographs and illustrations within this manual are intended as reference only and may not depict actual engine components or equipment.

When servicing optional engine equipment refer to the documentation supplied by that optional equipment manufacturer for specific service instructions.

This manual may not include current field modifications or service updates that were not available at the time of printing. Contact an authorized Yanmar industrial engine dealer or distributor for current field modifications and service information.

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Section 2

YANMAR WARRANTIES

YANMAR LIMITED WARRANTY

What is Covered by this Warranty?

Yanmar warrants to the original retail purchaser that a new Yanmar YDG Diesel Generator will be free from defects in material and / or workmanship for the duration of the warranty period.

THIS WARRANTY IS PROVIDED IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED. YANMAR SPECIFICALLY DISCLAIMS ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, except where such disclaimer is prohibited by law. IF SUCH DISCLAIMER IS PROHIBITED BY LAW, THEN IMPLIED WARRANTIES SHALL BE LIMITED IN DURATION TO THE LIFE OF THE EXPRESS WARRANTY.

How Long is the Warranty Period?

The Yanmar standard limited warranty period begins on the date of the delivery of the new Yanmar YDG Diesel Generator to the first retail purchaser and extends for a period of **twenty-four (24) months or two-thousand (2000) engine operation hours**, whichever occurs first. The warranty period (by duration or operation hours) begins on the date of delivery to the original retail purchaser and is valid only until the applicable warranted duration has passed or the operation hours are exceeded, whichever comes first.

Yanmar Limited Warranty - Continued

What the Generator Owner Must Do:

If you believe your Yanmar generator has experienced a failure due to a defect in material and / or workmanship, you must contact an authorized Yanmar industrial engine dealer or distributor within thirty (30) days of discovering the failure. You must provide proof of ownership of the generator, proof of the date of the generator purchase and delivery, and documentation of the generator operation hours. Acceptable forms of proof of delivery date include, but are not limited to: the original warranty registration or sales receipts or other documents maintained in the ordinary course of business by Yanmar dealers and / or distributors, indicating the date of delivery of the Yanmar product to the original retail purchaser. This information is necessary to establish whether the Yanmar product is still within the warranty period. Thus, Yanmar strongly recommends you register your generator as soon as possible after purchase in order to facilitate any future warranty matters.

You are responsible for the transportation of the generator to and from the repair location as designated by Yanmar.

To Locate an Authorized Yanmar Industrial Engine Dealer or Distributor:

You can locate your nearest authorized Yanmar industrial engine dealer or distributor by visiting the Yanmar Corp., LTD. website at:

http://www.yanmar.co.jp (The Japanese language page will be displayed.) For English language “click” on “English Page.”)

- “Click” on “Network” in the website heading to view the “Yanmar Worldwide Network.”
- Choose and “Click” on the desired product group.
- “Click” on the Icon closest to your region.
- “Click” on the desired country or Associate company to locate your nearest authorized Yanmar industrial engine dealer or distributor.
- You may also contact Yanmar by clicking on “Inquiry” in the website heading and typing in your question or comment.

What Yanmar Will Do:

Yanmar warrants to the original retail purchaser of a new Yanmar generator that Yanmar will make such repairs and / or replacements at Yanmar’s option, of any part(s) of the Yanmar product covered by this warranty found to be defective in material and / or workmanship. Such repairs and / or replacements will be made at a location designated by Yanmar at no cost to the purchaser for parts or labor.

YANMAR WARRANTIES

Yanmar Limited Warranty - Continued

What is Not Covered by this Warranty?

This Warranty does not cover parts affected by or damaged by any reason other than defective materials or workmanship including, but not limited to, accident, misuse, abuse, “Acts of God,” neglect, improper installation, improper maintenance, improper storage, the use of unsuitable attachments or parts, the use of contaminated fuels, the use of fuels, oils, lubricants, or fluids other than those recommended in your Yanmar Operation Manual, unauthorized alterations or modifications, ordinary wear and tear, and rust or corrosion. This Warranty does not cover the cost of parts and / or labor required to perform normal / scheduled maintenance on your Yanmar generator. This Warranty does not cover consumable parts such as, but not limited to filters, fuel injector nozzle, lubricants and cleaning fluids. This warranty does not cover the cost of shipping the product to or from the warranty repair facility.

Warranty Limitations:

The foregoing is Yanmar's only obligation to you and your exclusive remedy for breach of warranty. Failure to follow the requirements for submitting a claim under this Warranty may result in a waiver of all claims for damages and other relief. **In no event shall Yanmar or any authorized industrial engine dealer or distributor be liable for incidental, special or consequential damages.** Such consequential damages may include, but not be limited to, loss of revenue, loan payments, cost of rental of substitute equipment, insurance coverage, storage, lodging, transportation, fuel, mileage and telephone costs. The limitations in this Warranty apply regardless of whether your claims are based on breach of contract, tort (including negligence and strict liability) or any other theory. Any action arising hereunder must be brought within one (1) year after the cause of action accrues or it shall be barred. Some states and countries do not allow certain limitations on warranties or for breach of warranties. **This Warranty gives you specific legal rights, and you may also have other rights which vary from state to state and country to country.** Limitations set forth in this paragraph shall not apply to the extent that they are prohibited by law.

Warranty Modifications:

Except as modified in writing and signed by the parties, this Warranty is and shall remain the complete and exclusive agreement between the parties with respect to warranties, superseding all prior agreements, written and oral, and all other communications between the parties relating to warranties. **No person or entity is authorized to give any other warranty or to assume any other obligation on behalf of Yanmar, either orally or in writing.**

Questions:

If you have any questions or concerns regarding this Warranty, please call or write to the nearest authorized Yanmar industrial engine dealer or distributor or other authorized facility.

Yanmar Limited Warranty - Continued

Retail Purchaser Registration

It is very important for the original retail purchaser to register the Yanmar product. Registration enables Yanmar to provide the best support for your Yanmar YDG Diesel Generator.

At the time of purchase, Yanmar highly recommends registering the retail purchaser's information through website http://www.yanmar.co.jp as soon as possible.

If it is not possible to access the website, please contact the nearest authorized Yanmar industrial engine dealer or distributor.

EMISSION SYSTEM WARRANTY

YANMAR CO., LTD. LIMITED EMISSION CONTROL SYSTEM WARRANTY - USA ONLY

Your Warranty Rights and Obligations:

California

The California Air Resources Board (CARB), the Environmental Protection Agency (EPA) and Yanmar Co., Ltd. hereafter referred to as Yanmar, are pleased to explain the **emission control system warranty** on your industrial compression-ignition engine. In California, model year 2000 or later off-road compression-ignition engines must be designed, built and equipped to meet the State's stringent anti-smog standards. In all states, 1998 and later non-road compression-ignition engines must be designed, built and equipped to meet the United States EPA emissions standards. Yanmar warrants the emission control system on your engine for the periods of time listed below provided there has been no abuse, neglect or improper maintenance of your engine.

Your emission control system may include parts such as the fuel injection system and the air induction system. Also included may be hoses, belts, connectors and other emission-related assemblies.

Where a warrantable condition exists, Yanmar will repair your non-road compression-ignition engine at no charge to you including diagnosis, parts and labor.

Manufacturer's Warranty Period:

The model year 1998 or later certified and labeled non-road compression-ignition engines are warranted for the periods listed below. If any emission-related part on your engine is found to be defective during the applicable warranty period, the part will be replaced by Yanmar.

Engine Type	Warranty Period by Number of Years or Hours of Operation
Constant speed engines rated at or above 50 hp SAE (37 kW)	The warranty period is five (5) years or 3,000 hours of use, whichever occurs first. In the absence of a device to measure the hours of use, the engine has a warranty period of five (5) years.
Constant speed engines rated under 50 hp SAE (37 kW) with rated speeds greater than or equal to 3,000 rpm	The warranty period is two (2) years or 3,000 hours of use, whichever occurs first. In the absence of a device to measure the hours of use, the engine has a warranty period of two (2) years.
Engines rated at or above 26 hp SAE (19 kW)	The warranty period is five (5) years or 3,000 hours of use, whichever occurs first. In the absence of a device to measure the hours of use, the engine has a warranty period of five (5) years.
Engines rated under 26 hp SAE (19 kW)	The warranty period is two (2) years or 3,000 hours of use, whichever occurs first. In the absence of a device to measure the hours of use, the engine has a warranty period of two (2) years.

Limited Emission Control System Warranty - USA Only - Continued

Warranty Coverage:

This warranty is transferable to each subsequent purchaser for the duration of the warranty period. Repair or replacement of any warranted part will be performed at an authorized Yanmar industrial engine dealer or distributor.

Warranted parts not scheduled for replacement as required maintenance in the Operation Manual shall be warranted for the warranty period. Warranted parts scheduled for replacement as required maintenance in the operation manual are warranted for the period of time prior to the first scheduled replacement. Any part repaired or replaced under warranty shall be warranted for the remaining warranty period.

During the warranty period, Yanmar is liable for damages to other engine components caused by the failure of any warranted part during the warranty period.

Any replacement part which is functionally identical to the original equipment part in all respects may be used in the maintenance or repair of your engine, and shall not reduce Yanmar's warranty obligations. Add-on or modified parts that are not exempted may not be used. The use of any non-exempted add-on or modified parts shall be grounds for disallowing a warranty.

Warranted Parts:

This warranty covers engine components that are a part of the emission control system of the engine as delivered by Yanmar to the original retail purchaser. Such components may include the following:

- Fuel Injection System
- Cold Start Enrichment System
- Intake Manifold
- Turbocharger Systems
- Exhaust Manifold
- Positive Crankcase Ventilation System
- Hoses, belts, connectors and assemblies associated with emission control systems

Since emissions-related parts may vary slightly between models, certain models may not contain all of these parts and other models may contain the functional equivalents.

YANMAR WARRANTIES

Limited Emission Control System Warranty - USA Only - Continued

Exclusions:

Failures other than those arising from defects in material and / or workmanship are not covered by this warranty. The warranty does not extend to the following: malfunctions caused by abuse, misuse, improper adjustment, modification, alteration, tampering, disconnection, improper or inadequate maintenance or use of non-recommended fuels and lubricating oils; accident-caused damage, and replacement of expendable items made in connection with scheduled maintenance. Yanmar disclaims any responsibility for incidental or consequential damages such as loss of time, inconvenience, loss of use of equipment / engine or commercial loss.

Owner's Warranty Responsibilities:

As the engine owner, you are responsible for the performance of the required maintenance listed in your owner's manual. Yanmar recommends that you retain all documentation, including receipts, covering maintenance on your non-road compression-ignition engine, but Yanmar cannot deny warranty solely for the lack of receipts, or for your failure to ensure the performance of all scheduled maintenance.

Yanmar may deny your warranty coverage of your non-road compression-ignition engine if a part has failed due to abuse, neglect, improper maintenance or unapproved modifications.

Your engine is designed to operate on diesel fuel only. Use of any other fuel may result in your engine no longer operating in compliance with applicable emissions requirements.

You are responsible for initiating the warranty process. You must present your engine to a Yanmar dealer as soon as a problem exists. The warranty repairs should be completed by the dealer as expeditiously as possible. If you have any questions regarding your warranty rights and responsibilities, or would like information on the nearest Yanmar dealer or authorized service center, you should contact Yanmar America Corporation at 1-800-872-2867.

Section 3

SAFETY

SAFETY STATEMENTS

Yanmar is concerned for your safety and your machine's condition. Safety statements are one of the primary ways to call your attention to the potential hazards associated with Yanmar YDG Generator operation. Follow the precautions listed throughout the manual before operation, during operation and during periodic maintenance procedures for your safety, the safety of others and to protect the performance of your generator set. Keep the labels from becoming dirty or torn and replace them if they are lost or damaged. Also, if you need to replace a part that has a label attached to it, make sure you order the new part and label at the same time.

This safety alert symbol appears with most safety statements. It means attention, become alert, your safety is involved! Please read and abide by the message that follows the safety alert symbol.

⚠ DANGER

Indicates a hazardous situation which, if not avoided, *will* result in death or serious injury.

⚠ WARNING

Indicates a hazardous situation which, if not avoided, *could* result in death or serious injury.

⚠ CAUTION

Indicates a hazardous situation which, if not avoided, *could* result in minor or moderate injury.

NOTICE

Indicates a situation which can cause damage to the machine, personal property and / or the environment or cause the equipment to operate improperly.

SAFETY PRECAUTIONS

⚠ DANGER

The safety messages that follow have DANGER level hazards.

There is no substitute for common sense and careful practices. Improper practices or carelessness can cause burns, cuts, mutilation, asphyxiation, other bodily injury or death. This information contains general safety precautions and guidelines that must be followed to reduce risk to personal safety. Special safety precautions are listed in specific procedures. Read and understand all of the safety precautions before operation or performing repairs or maintenance.

NEVER permit anyone to install or operate the generator set without proper training.

- Read and understand this *Service Manual* before you operate or service the generator set to ensure that you follow safe operating practices and maintenance procedures.
  - Safety signs and labels are additional reminders for safe operating and maintenance techniques.
  - See your authorized Yanmar industrial dealer or distributor for additional training.

Exhaust Hazard

NEVER operate the generator in an enclosed area. Operating a generator indoors CAN KILL YOU IN MINUTES. Generator exhaust contains carbon monoxide. This is a poison you cannot see or smell. Only operate the generator OUTSIDE and far away from windows, doors and vents.

Electric Shock Hazard

NEVER use the generator in a location exposed to rain, snow or water spray. If the generator must be used outside, protect it from the weather. Moisture or ice can cause a malfunction or short circuit in the electrical components which could result in electrocution.

NEVER touch the generator with wet hands or when the generator is wet.

ALWAYS ground the generator. Connect a length of heavy wire between the generator ground terminal and an external ground.

NEVER handle live terminals or bare wires.

NEVER use the generator near standing water or snow.

NEVER use if the generator is wet or damp.

NEVER use the generator in highly conductive areas. These areas include metal decking and steelwork.

NEVER use metal pipe that carries combustible materials or gases to ground the generator.

Fire Hazard

NEVER use metal pipe that carries combustible materials or gases to ground the generator.

Do not put the generator indoors while the engine is still hot.

NEVER jump-start the engine. Sparks caused by shorting the battery to the starter terminals may cause a fire or explosion.

Keep the generator at least 3.3 ft (1 m) away from buildings and other equipment or sources of combustion during operation.

⚠ DANGER

Explosion Hazard

Diesel fuel is flammable and explosive under certain conditions. ALWAYS store any containers containing fuel in a well-ventilated area, away from any combustibles or sources of ignition. Wipe up all spills immediately and NEVER use a shop rag to catch spilled fuel.

While the engine is running or the battery is charging, hydrogen gas is being produced and can easily be ignited. ALWAYS keep the area around the battery well-ventilated and keep sparks, open flames and any other form of ignition out of the area.

NEVER jump-start the engine. Sparks caused by shorting the battery to the starter terminals may cause a fire or explosion. ONLY use the key switch or manual starter (if equipped) to start the engine.

Falling Hazard

ALWAYS secure the generator set to prevent the generator set from falling during maintenance.

⚠ WARNING

The safety messages that follow have WARNING level hazards.

Explosion Hazard

While the engine is running or the battery is charging, hydrogen gas is being produced and can be easily ignited. Keep the area around the battery well-ventilated and keep sparks, open flame and any other form of ignition out of the area.

ALWAYS turn off the battery switch (if equipped) or disconnect the negative battery cable before servicing the equipment.

Fire Hazard

Have appropriate safety equipment available.

•Keep fire extinguishers handy in case of fire. Clearly indicate the location of the fire extinguishers with a safety sign.

- Ensure that the type of fire extinguishers are appropriate for material that might catch fire. Check with local authorities.
- Have all fire extinguishers checked periodically for proper operation and / or readiness.
- Post evacuation routes prominently. Periodically conduct fire drills.

ALWAYS read and follow safety-related precautions found on containers of hazardous substances like parts cleaners, primers, sealants and sealant removers.

ALWAYS wipe up all spills immediately.

⚠ WARNING

Entanglement Hazard

Rotating parts can cause severe injury or death. NEVER wear jewelry, unbuttoned cuffs, ties or loose fitting clothing and ALWAYS tie long hair back when working near moving / rotating parts such as the flywheel or PTO shaft. Keep hands, feet and tools away from all moving parts.

ALWAYS stop the engine before beginning service.

NEVER leave the key in the key switch when servicing the generator set. Someone may accidentally start the engine and not realize you are servicing it. Attach a “Do Not Operate” tag near the key switch while performing maintenance on the equipment.

Shock Hazard

Check the electrical harnesses for cracks, abrasions and damaged or corroded connectors. ALWAYS keep the connectors and terminals clean.

Electrical Hazard

Make welding repairs safely:

•ALWAYS turn off the battery switch (if equipped) or disconnect the negative battery cable and the leads to the engine charging system when welding on the equipment.

- Remove the multi-pin connector to the engine control unit. Connect the weld clamp to the component to be welded and as close as possible to the welding point.
- NEVER connect the weld clamp to the engine or in a manner which would allow current to pass through a mounting bracket.
- When welding is completed, reconnect the leads to the engine charging system prior to reconnecting the batteries.

Exhaust Hazard

NEVER block windows, vents, or other means of ventilation if the engine is operating in an enclosed area. All internal combustion engines create carbon monoxide gas during operation and special precautions are required to avoid carbon monoxide poisoning.

ALWAYS ensure that all connections are tightened to specifications after repair is made to the exhaust system. All internal combustion engines create carbon monoxide gas during operation and special precautions are required to avoid carbon monoxide poisoning.

Burn Hazard

Some of the engine surfaces become very hot during operation and shortly after shut-down. Keep hands and other body parts away from hot engine surfaces.

Handle hot components with heat-resistant gloves.

Lifting Hazard

If you need to transport an generator set for repair, have a helper assist you in attaching it to a hoist and load it on a truck.

Alcohol and Drug Hazard

NEVER operate the generator set while you are under the influence of alcohol or drugs or are feeling ill.

Tool Hazard

Always remove any tools or shop rags used during maintenance from the area before operation.

⚠ WARNING

Exposure Hazard

ALWAYS wear personal protective equipment including appropriate clothing, gloves, work shoes, eye and hearing protection as required by the task at hand.

Slip and Trip Hazard

Keep the generator free of oil, mud and other foreign matter.

Remove anything that creates slippery areas around the generator.

Sever Hazard

Rotating parts can cause severe injury or death. NEVER operate the generator set without the guards in place.

Shock Hazard

Check the electrical harnesses for cracks, abrasions and damaged or corroded connectors. ALWAYS keep the connectors and terminals clean.

ALWAYS turn off the battery switch (if equipped) or disconnect the negative battery cable before servicing the equipment.

ALWAYS keep the electrical connectors and terminals clean. Check the electrical harnesses for cracks, abrasions and damaged or corroded connectors.

Lifting Hazard

Additional equipment is necessary to lift the generator set. ALWAYS use lifting equipment with sufficient capacity to lift the generator.

Sudden Movement Hazard

Before you start the engine, make sure that all bystanders are clear of the area.

Check before starting the engine that any tools or shop rags used during maintenance have been removed from the area.

ALWAYS stop the engine before beginning service.

⚠ CAUTION

The safety messages that follow have CAUTION level hazards.

ALWAYS wear eye protection when servicing the generator set or when using compressed air or high-pressure water. Dust, flying debris, compressed air, pressurized water or steam may injure your eyes.

Poor Lighting Hazard

Ensure that the work area is adequately illuminated. ALWAYS install wire cages on portable safety lamps.

Tool Hazard

ALWAYS use tools appropriate for the task at hand and use the correct size tool for loosening or tightening machine parts.

Electrical Hazard

This generator uses a negative ground 12V DC starting system. ALWAYS shut down the engine before removing or attaching battery cables. ALWAYS remove the negative (-) cable first. ALWAYS attach the negative (-) cable last.

NOTICE

The safety messages that follow have NOTICE level hazards.

Any part which is found defective as a result of inspection or any part whose measured value does not satisfy the standard or limit must be replaced.

ALWAYS run the engine at full speed. NEVER run engine at lower speeds. At full speed, the engine runs at 3600 rpm under load. The engine must maintain 3600 rpm for generator to create correct voltage. Running engine at lower speeds will damage generator and powered items.

ALWAYS turn off the battery switch (if equipped) or disconnect the negative battery cable before servicing the equipment.

NEVER attach tools or appliances to the generator before it is started. ALWAYS disconnect tools and appliances from the generator before starting.

ALWAYS tighten components to the specified torque. Loose parts can cause equipment damage or cause it to operate improperly.

Only use replacement parts specified. Other replacement parts may affect warranty coverage.

Modifications may impair the engine's safety and performance characteristics and shorten the engine's life. Any alterations to this engine may void its warranty. Be sure to use Yanmar genuine replacement parts.

ALWAYS be environmentally responsible.

Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.

NOTICE

NEVER dispose of hazardous materials by dumping them into a sewer, on the ground or into ground water or waterways.

If any indicator illuminates during engine operation (if equipped), stop the engine immediately. Determine the cause and repair the problem before you continue to operate the engine.

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Section 4

GENERAL SERVICE INFORMATION

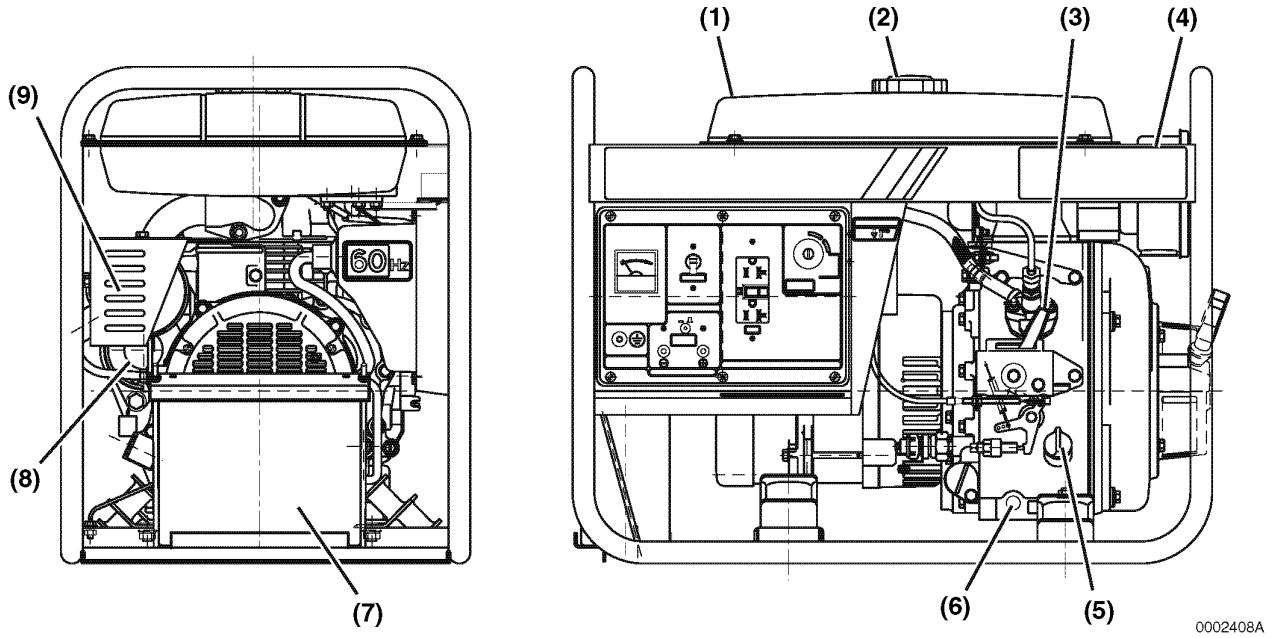
Page

COMPONENT IDENTIFICATION

Note: Images used throughout this manual may not illustrate the exact engine used in the YDG generator set being serviced. The LV series engines used with the YDG generators do not incorporate built in fuel tanks, as the fuel tanks are incorporated into the generator set.

Note: L48V “standard” engines are not equipped with top engine covers. The illustrations in this manual show “typical” L70V and L100V engines and may show engines with “optional” and/or “non-standard” equipment.

YDG2700EV-6EH

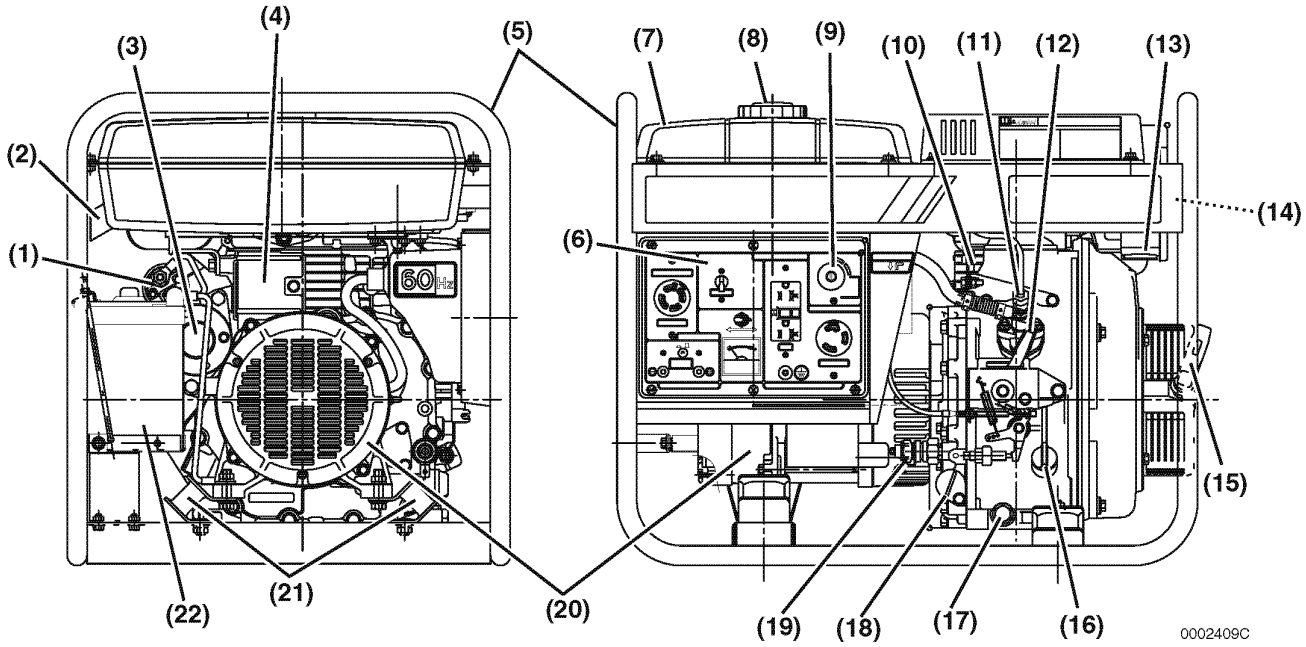


1 – Fuel Tank
2 – Fuel Filler Cap
3 – Engine Control Lever
4 – Air Cleaner
5 – Oil Filler Cap / Dipstick
6 – Oil Drain Plug (one located on each side of engine)
7 – Battery
8 – Starter Motor
9 – Muffler

Figure 4-1

GENERAL SERVICE INFORMATION

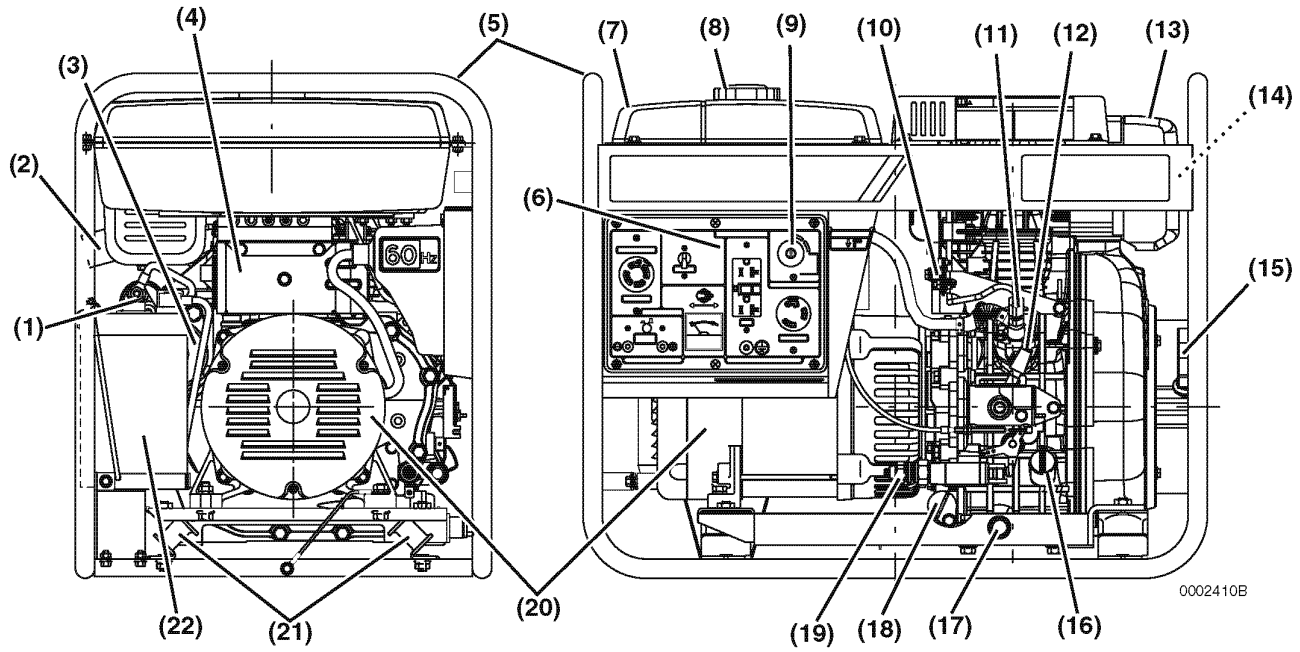
YDG3700EV-6EI



1 – Starter Solenoid
2 – Muffler
3 – Starter Motor
4 – Engine Nameplate Decal
5 – Frame
6 – Control Panel (*See Control Panel Layout - Model YDG3700EV-6EI, YDG5500EV-6EI on page 7-14*)
7 – Fuel Tank
8 – Fuel Filler Cap
9 – Starter Switch
10 – Compression Release Lever
11 – Fuel Injection Pump
12 – Engine Control Lever
13 – Air Cleaner
14 – Generator Set Model and Serial Number Decal (Behind upper frame rail)
15 – Recoil Starter
16 – Oil Filler Cap / Dipstick
17 – Oil Drain Plug (one located on each side of engine)
18 – Oil Filter
19 – Oil Pressure Switch
20 – Generator Unit
21 – Generator / Engine Damper Mounts
22 – Battery

Figure 4-2

YDG5500EV-6EI



1 – Starter Solenoid
2 – Muffler
3 – Starter Motor
4 – Engine Nameplate Decal
5 – Frame
6 – Control Panel (*See Electrical Schematic - YDG3700EV-6EI, YDG5500EV-6EI on page 7-19*)
7 – Fuel Tank
8 – Fuel Filler Cap
9 – Starter Switch
10 – Compression Release Lever
11 – Fuel Injection Pump
12 – Engine Control Lever
13 – Air Cleaner
14 – Generator Set Model and Serial Number Decal (Behind upper frame rail)
15 – Recoil Starter
16 – Oil Filler Cap / Dipstick
17 – Oil Drain Plug (one located on each side of engine)
18 – Oil Filter
19 – Oil Pressure Switch
20 – Generator Unit
21 – Generator / Engine Damper Mounts
22 – Battery

Figure 4-3

GENERAL SERVICE INFORMATION

LOCATION OF DECALS

Safety Decals YDG2700EV-6EH

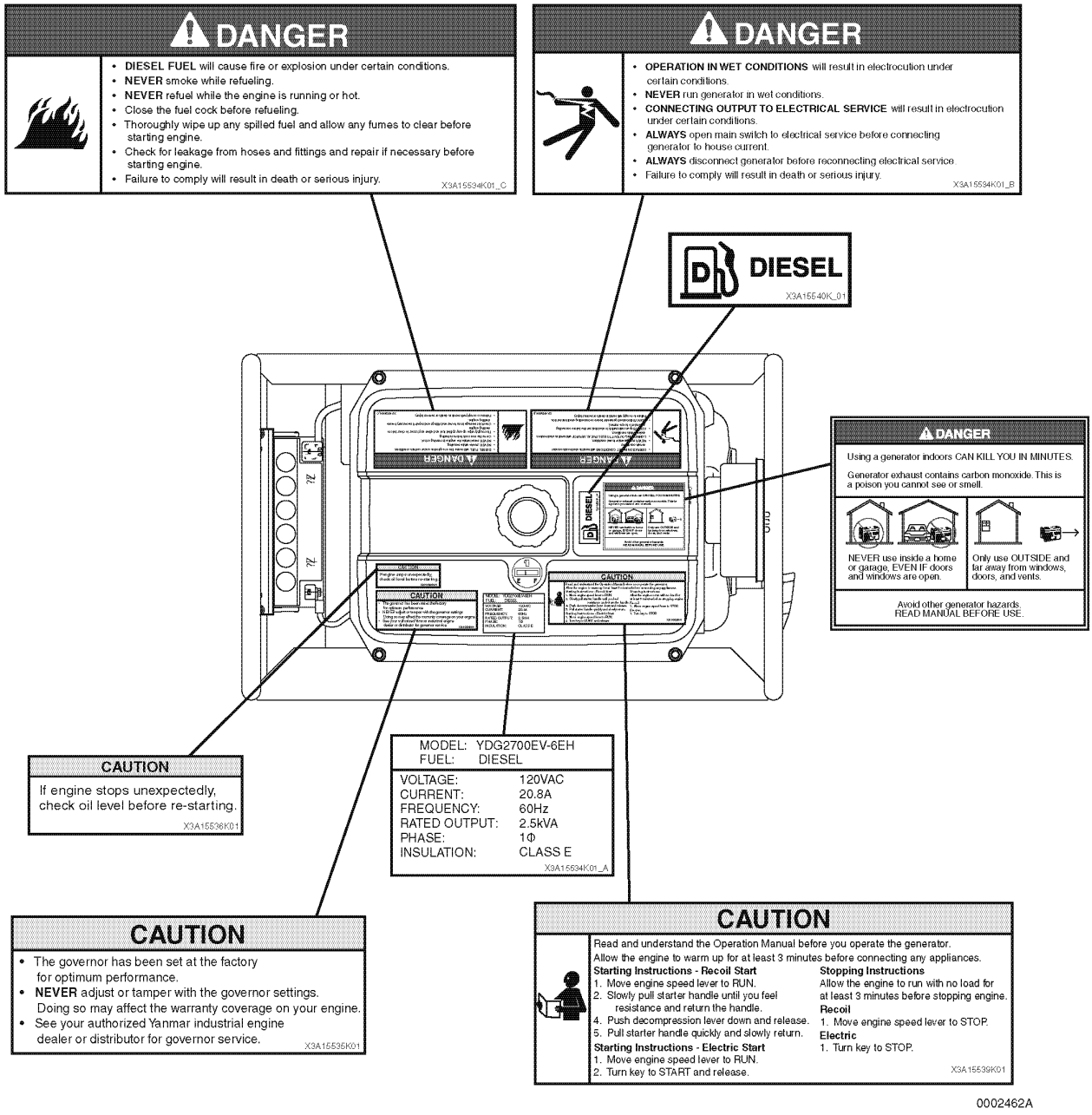


Figure 4-4

Safety Decals YDG3700EV-6EI, YDG5500EV-6EI

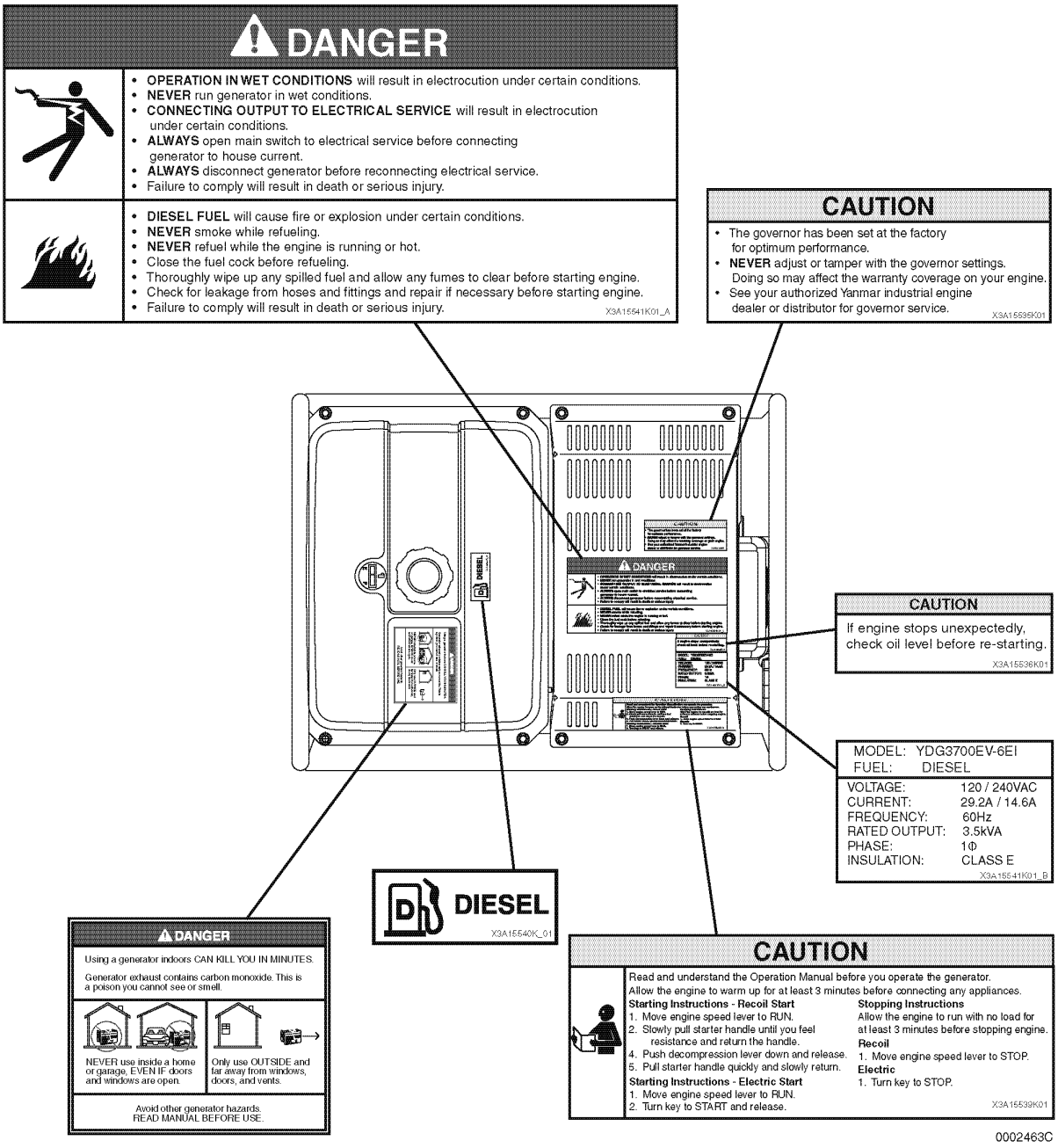


Figure 4-5

Generator Set Decals

The YDG generator set model and serial number information decal **(Figure 4-6)** is located inside the top front frame rail.

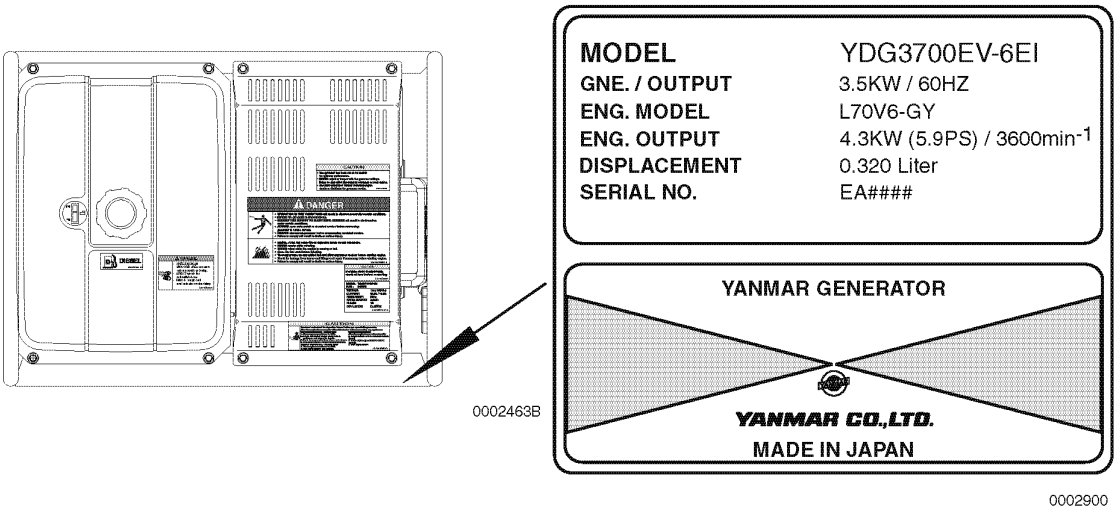


Figure 4-6

Engine Decal

The engine nameplate **(Figure 4-8)** is located **(Figure 4-7, (1))** on the cooling shroud on the PTO side of engine above the starter.

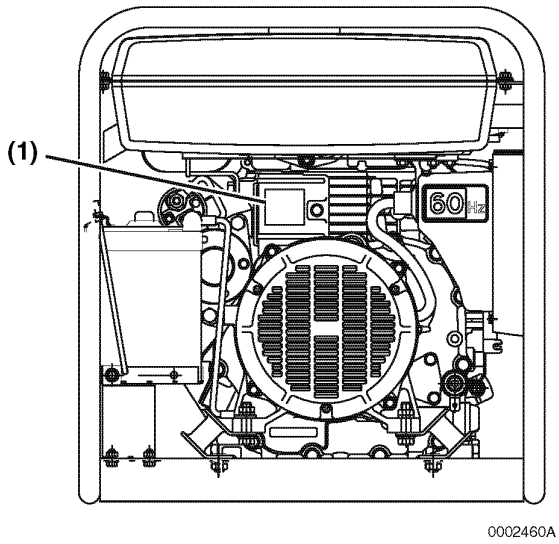


Figure 4-7

Engine Nameplate (Typical)

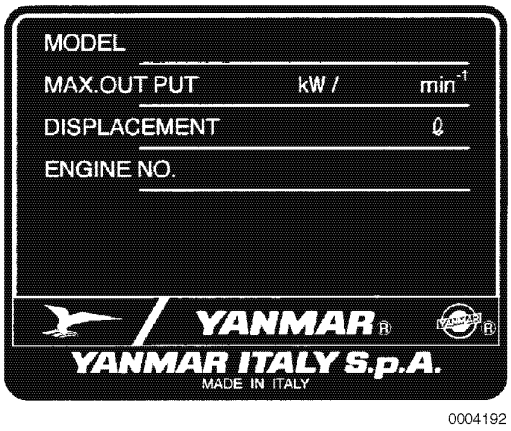
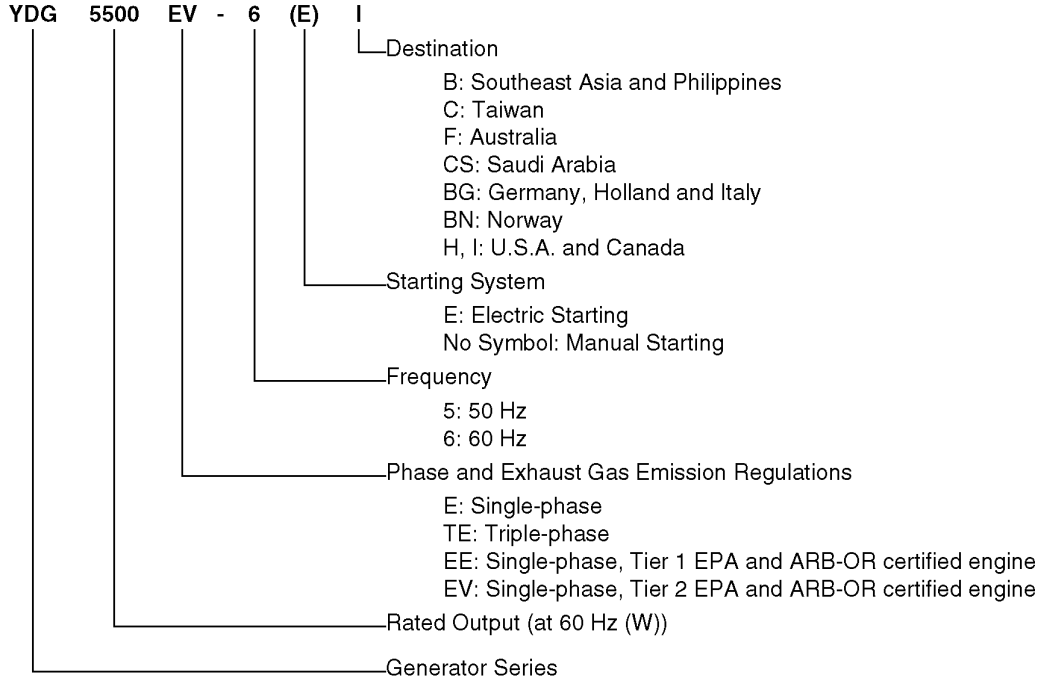


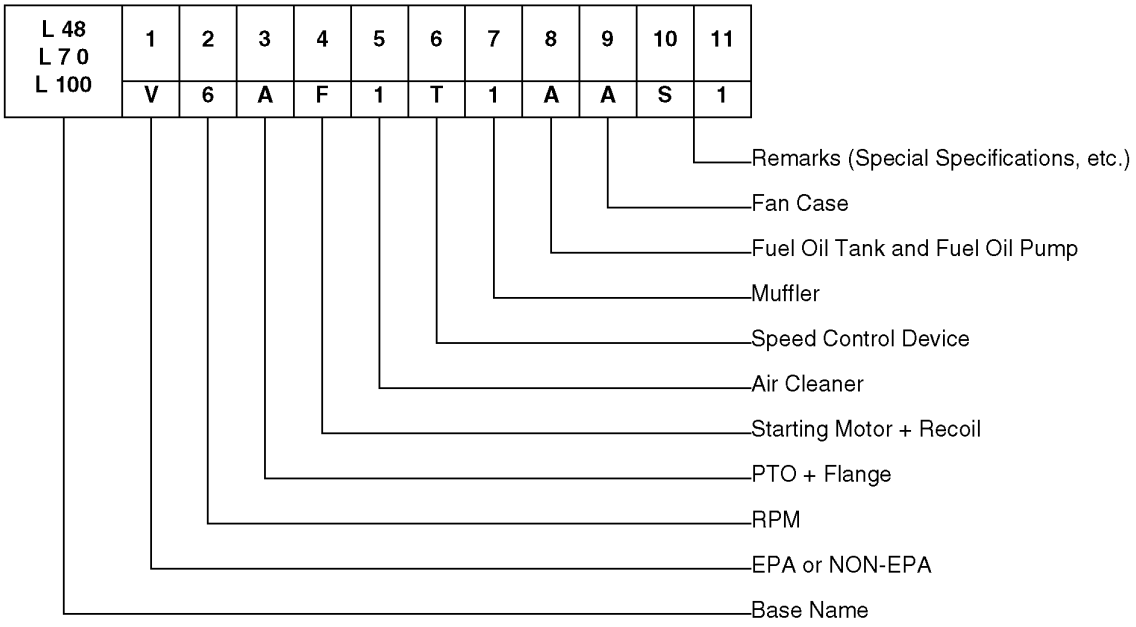
Figure 4-8

SPECIFICATIONS

Description of Generator Set Model Number



Description of Engine Model Number



General Generator Specifications

Model			YDG2700EV-6EH	YDG3700EV-6EI	YDG5500EV-6EI
Generator	Type		Revolving-field type AC generator (with brush)		
	Excitation		Self-excited		
	Voltage Regulation		Automatic Voltage Regulator (AVR)		
	Frequency		60 Hz		
	Maximum Speed		3600 RPM		
	Rated Output		2.4 AC kVA	3.5 AC kVA	5.0 AC kVA
			12VDC - 8.3A		
	Rated Voltage		120V	120/240V	
	Rated Current		20A	29.2 / 14.6A	41.7 / 20.8A
	Power Factor		1.0		
	Phase		Single-phase		
	No. of Poles		2		
	Type of Insulation		B-class	E-class	
	Bearing System		Ball bearing (Grease-enclosed)		
	Output Terminal	AC	125V - 20A (GFCI) x 2	125V - 20A (GFCI) x 2 125V - 30A (Twist Lock) x 1 (3 - pin) 125/250V - 20A (Twist Lock) x 1 (4 - pin)	
		DC	Terminal x 1		
	Breaker	AC	21A (NFB)	16A (NFB)	22A (NFB)
		DC	12A (Thermal breaker)		
	Voltmeter		AC120/240V		
	Emergency Stop System		Engine stop device by low level oil sensor		
Generator Unit	Dimension	L	25.5 in. (649 mm)	25.5 in. (650 mm)	28.3 in. (720 mm)
		W	16.3 in. (416 mm)	19.5 in. (496 mm)	18.8 in. (480 mm)
		H	19.6 in. (500 mm)	20.8 in. (530 mm)	22.7 in. (578 mm)
	Dry Weight		141 lb.(64 kg)	176.3 lb. (80 kg)	238 lb. (108 kg)

Model		YDG2700EV-6EH	YDG3700EV-6EI	YDG5500EV-6EI	Remarks
Frequency Under Load	AC	59 - 62 Hz			Under rated operation
Voltage Under Load		122 ± 3V	122 ± 3/244 ± 6V		
Voltage Under No Load		MAX 132V	MAX 132 / 265V		After warming-up
Voltage Regulation Range		7%			
Waveform Distortion		25%			
Rated Current	DC	8.3A			
Voltage Under Load		11 ± 1V			
Voltage Under No Load		MAX 20V			
Frequency Regulation	Instantaneous maximum speed difference	10%			When continuous rated output is abruptly changed to output at no load
	Steady state speed band	6%			
	Recovery time	5 sec.			
	Stability	±1 Hz			After warming up
Permissible Angle of Inclination	Continuous	MAX 20 deg			forward / backward and rightward / leftward
Noise level (at rated operation) (Average in 4 directions)		92 dB (A)	93 dB (A)	96 dB (A)	Measured 1 meter away from external wall of generator set
Lowest starting temperature		-10 °C			
		14 °F			

General Engine Specifications

Engine Model		L48V	L70V	L100V
Type		4-stroke, Vertical Cylinder, Air-Cooled Diesel Engine		
Combustion System		Direct Injection		
No. of Cylinders		1		
Bore × Stroke		2.76 x 2.24 in. (70 × 57 mm)	3.07 x 2.64 in. (78 × 67 mm)	3.39 x 2.95 in. (86 × 75 mm)
Displacement		13.4 cu in (0.219 L)	19.5 cu in. (0.320 L)	26.5 cu in. (0.435 L)
Compression Ratio		20.6	21.1	21.2
Continuous Rated Output	RPM (min^{-1})	3600	3600	3600
	hp SAE	4.0	5.8	8.3
	kW	3.0	4.3	6.2
	PS	4.1	5.9	8.4
Max. Rated Output (Net)	RPM (min^{-1})	3600	3600	3600
	hp SAE	4.4	6.4	9.1
	kW	3.3	4.8	6.8
	PS	4.5	6.5	9.3
High Idling	RPM (min^{-1})	3800 ± 30	3800 ± 30	3800 ± 30
Fuel Injection Timing	BTDC by FIC (A)	17.5°	16°	15.5°
Valve Clearance		0.006 ± 0.002 in. (0.15 ± 0.05 mm)		
PTO Position		Crankshaft		
Direction of Rotation		Counterclockwise viewed from PTO Side		
Fuel Injection Pump		BOSCH-type, with upper lead plunger		
Fuel Injection Nozzle		P-size, VCO		
Valve Opening Pressure		19.6 MPa (200 kgf/cm^2)		
Fuel Selection		*See Diesel Fuel Specifications on page 4-17*		
Fuel Filter		Paper Element, Fuel Tank Built-in Type		
Governor		All Speed Type, Mechanical		
Balancer Shaft		Single Shaft		
Engine Weight (Dry)	With Electric Start	70.5 lb (32.0 kg)	90.4 lb (41.0)	118 lb (53.5 kg)
	Without Electric Start	59.5 lb (27.0 kg)	79.4 lb (36.0)	107 lb (48.5 kg)
Cooling System		Forced Air by Flywheel Fan		
Lubricating System		Forced Lubrication with Trochoid Pump Splash Lubrication for Valve Rocker Arm Chamber		
Oil Selection		*See Engine Oil on page 4-20.*		
Oil Filter		Resin, 60 Mesh		

Engine Model		L48V			L70V	L100V		
Permissible Angle of Inclination		20° (momentary 30°)						
Air Cleaner		Wet-Type Paper Element Filter			Dry-Type Paper Element Filter			
Muffler		Expansion Silencer with Cover						
Starting System		Electric Start / Recoil Start						
Dimensions (L x W x H)		13.1 x 15.1 x 16.4 in. (332 x 384 x 417 mm)			14.9 x 16.6 x 17.8 in. (378 x 422 x 453 mm)	16.2 x 18.5 x 19.4 in. (412 x 471 x 494 mm)		
Engine Oil Pan Capacity	Dipstick Upper Limit	0.85 qt (0.8 L) 0.58 qt (0.55 L)			1.11 qt (1.05 L)	1.7 qt (1.6 L)		
	Dipstick Lower Limit				0.69 qt (0.65 L)	1.06 qt (1.0 L)		
Fuel Tank Capacity (Standard Fuel Tank)		2.0 qt (1.9 L)			2.85 qt (2.7 L)	5.0 qt (4.7 L)		
Battery Capacity								
Ambient Temp. usage by model	L48V	-10°C (14°F) or higher		-30°C (-22°F) or higher				
	L70V		-10°C (14°F) or higher		-30°C (-22°F) or higher			
	L100V				-10°C (14°F) or higher		-30°C (-22°F) or higher	
Battery Capacity (Recommended)		100 CCA	135 CCA	170 CCA	200 CCA	225 CCA	250 CCA	
		18 Ah	24 Ah	30 Ah	35 Ah	40 Ah	45 Ah	

Note:

1. The information described in *"General Engine Specifications" on page 12* is for a "standard" engine. To obtain the information for the engine installed in your driven machine, please refer to the manual provided by the driven machine manufacturer.
2. Engine rating conditions are as follows (SAE J1349, ISO 3046/1):

- Atmospheric Condition: Room temperature 77°F (25°C), Atmospheric pressure 29.53 in. Hg (100 kPa, 750 mm Hg), Relative humidity 30%
- Fuel Temperature at Fuel Injector Pump Inlet: 104°F (40°C)
- With Cooling Fan, Air Cleaner, Muffler: Yanmar Standard
- After Engine Break-In Period. Output Allowable Deviation: ± 3%
- 1 PS = 0.7355 kW
- 1 hp SAE (Society of Automotive Engineers) = 0.7457 kW

EPA / ARB EMISSION CONTROL INFORMATION

EPA / ARB Emission Control Regulations - USA Only

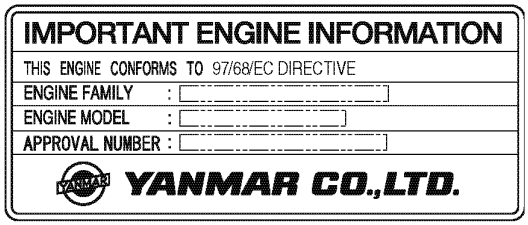
Yanmar LV Series engines meet Environmental Protection Agency (EPA) (U.S. Federal) emission control standards as well as the California Air Resources Board (ARB, California) regulations. Only engines that conform to ARB regulations can be sold in the State of California.

Refer to the specific EPA / ARB installation (see *EPA / ARB Installation Requirements - USA Only on page 5-6*) and maintenance (see *Required EPA / ARB Maintenance - USA Only on page 5-5*) in the *Periodic Maintenance* section of this manual. Also refer to the "Yanmar Co., Ltd. Limited Emission Control System Warranty - USA Only" on page 8.

The 97/68/EC Directive Certified Engines

The engines described in this manual have been certified by the 97/68/EC Directive.

To identify the engines that meet this certification, the 97/68/EC emission control decal is affixed on the engines.

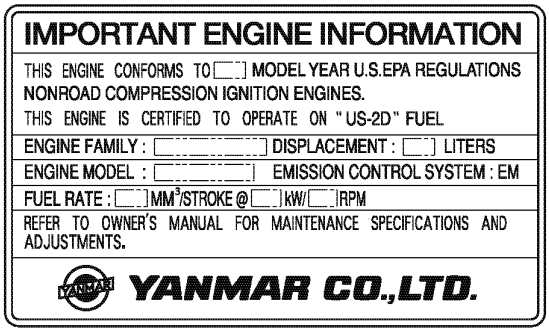


(97/68/EC)

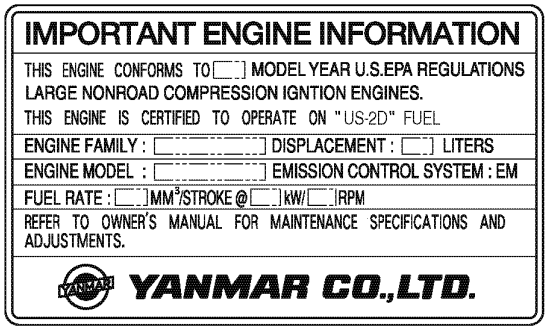
Figure 4-9

EPA / ARB Emission Control Decals - USA Only

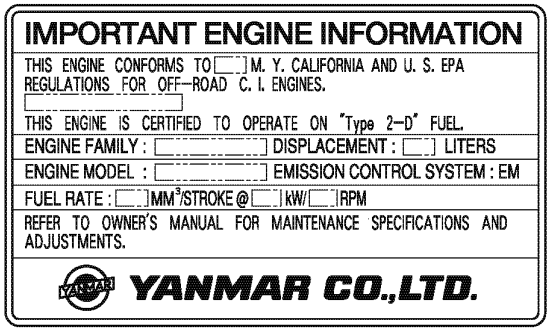
Since emission control regulations are being issued on a global basis, it is necessary to identify which regulations a particular engine complies with. We have listed several different types of decals you might find on your engine.



(EPA) Less than 50 HP SAE (37kW)



(EPA) Greater than or Equal to 50 HP SAE (37kW)

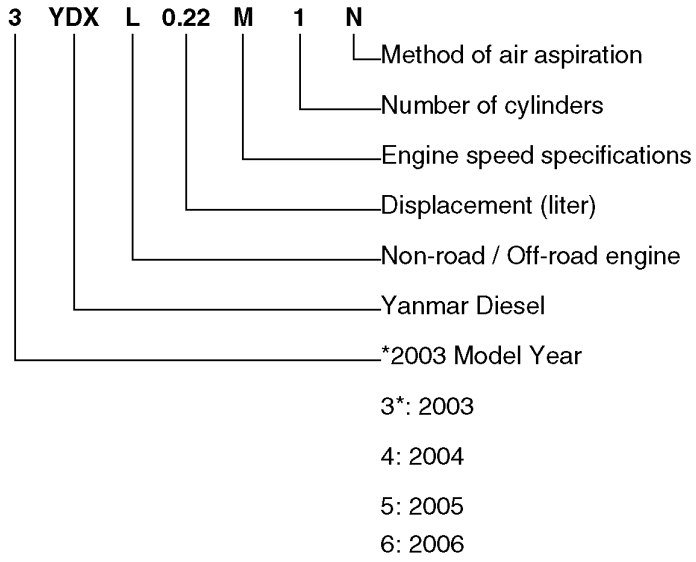


(EPA and ARB) 0000086

Figure 4-10

Description of Emission Control Engine Family Number

The EPA / ARB decal and the 97/68/EC decal all have an *Engine Family* field. The following is an explanation of the *Engine Family* designation:



FUNCTION OF MAJOR GENERATOR SET COMPONENTS

Components	Functions
Air Cleaner	The air cleaner prevents airborne contaminants from entering the engine. Periodic replacement of the air cleaner filter element is necessary. *See Periodic Maintenance Schedule on page 5-7* for the replacement frequency.
Dynamo	If the engine is equipped with electric start. A charging dynamo is located under the engine flywheel. The dynamo supplies regulated electricity to the engine systems and charges the battery while the engine is running.
Low Engine Oil Shutdown	The generator is equipped with a low oil shutdown feature. If the engine is run when it is low on oil, the oil pressure will drop. The oil pressure switch will sense the drop in pressure and activate the stop solenoid, which will shut the engine down. Once the oil level is corrected, and pressure is normal the engine can be run again.
Engine Oil Filter	The engine oil filter removes contaminants and sediments from the engine oil. Periodic cleaning of the oil filter is necessary. *See Periodic Maintenance Schedule on page 5-7* for the frequency of cleaning.
Fuel Filters	Inlet and outlet fuel filters are provided to remove contaminants and sediments from the diesel fuel. Periodic cleaning / replacement is required. *See Periodic Maintenance Schedule on page 5-7*.
Fuel Tank	The fuel tank is a reservoir that holds diesel fuel. When fuel leaves the fuel tank it goes to the fuel injection pump. Since fuel is used to keep fuel system components cool and lubricated, more fuel than is necessary for combustion enters the fuel system. Any fuel that is not used for combustion is returned to the fuel tank.
Oil Cap / Dipstick (Engine Oil)	The engine oil cap / dipstick combines the oil cap and dipstick in one assembly. The dipstick part of the assembly is used to determine the amount of engine oil in the crankcase.
Side Filler Ports (Engine Oil)	You can fill the crankcase with engine oil from either side of the engine depending upon which filler port is most convenient.
Starter Motor	The starter motor is powered by the battery. When you turn the key switch to the START position, the starter motor engages with the ring gear installed on the flywheel and starts the flywheel in motion.
Control Panel	The control panel houses all the controls, switches, terminals, outlets and meters of the generator. All electrical power created by the generator is directed to the control panel and output is sent through various outlets and terminals located on the control panel.
Generator	The generator is coupled to the engine to produce electrical power to operate various loads and or machines. The generator is constructed as a self-exciting single phase A/C, and is comprised of a stator, rotor, automatic voltage regulator, rectifier and housing components.

DIESEL FUEL

Diesel Fuel Specifications

Diesel fuel should comply with the following specifications. The table lists several worldwide specifications for diesel fuels.

Diesel Fuel Specification	Location
No. 2-D, No. 1-D, ASTM D975-94	USA
EN590:96	European Union
ISO 8217 DMX	International
BS 2869-A1 or A2	United Kingdom
JIS K2204 Grade No. 2	Japan
KSM-2610	Korea
GB252	China

Additional Technical Fuel Requirements

- The fuel cetane number should be equal to 45 or higher.
- The sulfur content must not exceed 0.5% by volume. Less than 0.05% is preferred.
- Bio-Diesel fuels. *See Bio-Diesel Fuels on page 4-17.*
- NEVER mix kerosene, used engine oil, or residual fuels with the diesel fuel.
- The water and sediment in the fuel should not exceed 0.05% by volume.
- Keep the fuel tank and fuel-handling equipment clean at all times.
- Poor quality fuel can reduce engine performance and / or cause engine damage.
- Fuel additives are not recommended. Some fuel additives may cause poor engine performance. Consult your Yanmar representative for more information.
- The ash content must not exceed 0.01% by volume.
- The carbon residue content must not exceed 0.35% by volume. Less than 0.1% is preferred.
- The total aromatics content should not exceed 35% by volume. Less than 30% is preferred.
- The PAH (polycyclic aromatic hydrocarbons) content should be below 10% by volume.
- The metal content of Na, Mg, Si, and Al should be equal to or lower than 1 mass ppm. (Test analysis method JPI-5S-44-95)
- Lubricity: The wear mark of WS1.4 should be Max. 0.018 in (460 µm) at HFRR test.

Bio-Diesel Fuels

In Europe and in the United States, as well as some other countries, non-mineral oil based fuel resources such as RME (Rapeseed Methyl Ester) and SOME (Soybean Methyl Ester), collectively known as FAME (Fatty Acid Methyl Esters), are being used as extenders for mineral oil derived diesel fuels.

Yanmar approves the use of bio-diesel fuels that do not exceed a blend of 5% (by volume) of FAME with 95% (by volume) of approved mineral oil derived diesel fuel. Such bio-diesel fuels are known in the marketplace as B5 diesel fuels.

These B5 diesel fuels must meet certain requirements.

1. The bio-fuels must meet the minimum specifications for the country in which they are used.
   - In Europe, bio-diesel fuels must comply with the European Standard EN14214.
   - In the United States, bio-diesel fuels must comply with the American Standard ASTM D-6751.
2. Bio-fuels should be purchased only from recognized and authorized diesel fuel suppliers.

Precautions and concerns regarding the use of bio-fuels:

1. Free methanol in FAME may result in corrosion of aluminum and zinc FIE components.
2. Free water in FAME may result in plugging of fuel filters and increased bacterial growth.
3. High viscosity at low temperatures may result in fuel delivery problems, injection pump seizures, and poor injection nozzle spray atomization.
4. FAME may have adverse effects on some elastomers (seal materials) and may result in fuel leakage and dilution of the engine lubricating oil.
5. Even bio-diesel fuels that comply with a suitable standard as delivered, will require additional care and attention to maintain the quality of the fuel in the equipment or other fuel tanks. It is important to maintain a supply of clean, fresh fuel. Regular flushing of the fuel system, and / or fuel storage containers, may be necessary.
6. The use of bio-diesel fuels that do not comply with the standards as agreed to by the diesel engine manufacturers and the diesel fuel injection equipment manufacturers, or bio-diesel fuels that have degraded as per the precautions and concerns above, may affect the warranty coverage of your engine.
See Yanmar Limited Warranty on page 2-4.

Filling the Fuel Tank

DANGER! ALWAYS fill the fuel tank only with specified diesel fuel. Filling the fuel tank with gasoline may result in a fire and will damage the engine. NEVER refuel with the engine running. ALWAYS wipe up all spills immediately. ALWAYS keep sparks, open flames or any other form of ignition (match, cigarette, static electric source) well away when refueling. NEVER overfill the fuel tank. Store any containers containing fuel in a well-ventilated area, away from any combustibles or sources of ignition.

DANGER! Be sure to place the diesel fuel container on the ground when transferring the diesel fuel from the pump to the container. Hold the hose nozzle firmly against the side of the container while filling. This prevents static electricity buildup which could cause sparks and ignite fuel vapors. NEVER place diesel fuel or other flammable material such as oil, hay or dried grass close to the engine during engine operation or shortly after shut down.

Note: A typical fuel tank is shown in **(Figure 4-11)**. The fuel tank on your engine may be different. *NOTICE: ALWAYS make sure the inlet fuel screen remains inside of the fuel tank while fueling.*

1. Clean the area around the fuel cap **(Figure 4-11, (1))**.
2. Remove the fuel cap from the fuel tank. *NOTICE: Only use diesel fuels recommended by Yanmar for the best engine performance, to prevent engine damage and to comply with EPA / ARB warranty requirements. Only use clean diesel fuel.*
3. Stop fueling when the fuel is at the same level as the red ring **(Figure 4-11, (2))** at the bottom of the inlet fuel screen. NEVER overfill the fuel tank. Overfilling the fuel tank may allow contaminated fuel to bypass the intake fuel filter by entering through the air bleed hole in the top of the fuel filter. *NOTICE: NEVER remove inlet fuel screen from the filler port. If removed, dirt and debris could get into the fuel system causing blockage or damage to the fuel system components.*
4. Replace the fuel cap and hand-tighten. Over-tightening the fuel cap will damage it.

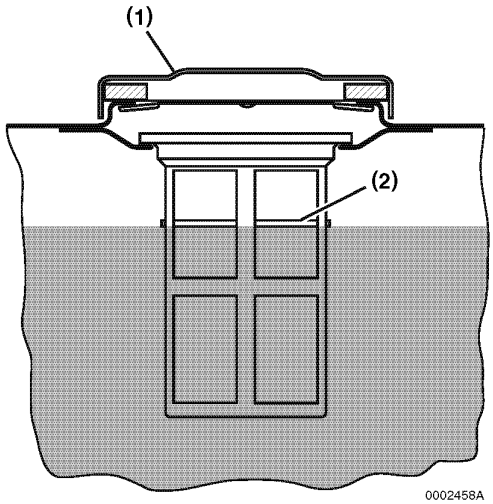


Figure 4-11

Priming the Fuel System

The fuel system needs to be primed under certain conditions.

- Before starting the engine for the first time.
- After running out of fuel and fuel has been added to the fuel tank.
- After fuel system maintenance such as changing the fuel filter and draining the fuel filter / water separator, or replacing a fuel system component.

1. Place the engine speed control lever in the HIGH-IDLE position.
2. Allow 20-30 seconds for fuel to reach the fuel injection pump.
3. Loosen the high pressure fuel injection line nut at the fuel injector fitting approximately 1/2 turn. **DANGER! ALWAYS wear eye protection when servicing the fuel system. Diesel fuel is flammable and explosive under certain conditions. Wipe up all spills immediately.**

Note: To prevent “rounding” the fuel line nuts always use a “line” or “flare nut” wrench. Always use a wrench to hold the fuel injection pump fuel delivery valve to prevent loosening of the delivery valve when loosening or tightening the high-pressure fuel injection lines.

4. Set and hold the compression release lever in the RELEASE position.
5. Using the recoil starter, crank the engine over until the fuel coming out of the fuel injector fitting is free of bubbles.
6. Tighten the high pressure fuel injection line nut. *See Special Torque Specifications on page 9-5.*

ENGINE OIL

Engine Oil Specifications

Use an engine oil that meets or exceeds the following guidelines and classifications:

Service Categories

- API Service Categories CD or higher
- ACEA Service Categories E-3, E-4, and E-5
- JASO Service Category DH-1

Definitions

- API Classification [American Petroleum Institute]
- ACEA Classification [Association des Constructeurs Européens d'Automobilies]
- JASO [Japanese Automobile Standards Organization]

Note:

- Be sure the engine oil, engine oil storage containers, and engine oil filling equipment are free of sediments and water.
- Change the engine oil after the first 50 hours of operation and then at every 250 hours thereafter.
- Select the oil viscosity based on the ambient temperature where the engine is being operated. See the SAE Service Grade Viscosity Chart **(Figure 4-12)**.
- Yanmar does not recommend the use of engine oil “additives.”

Additional Technical Engine oil Requirements

The engine oil must be changed when the Total Base Number (TBN) has been reduced to 2.0. TBN (mgKOH/g) test method; JIS K-201-5.2-2 (HCl), ASTM D4739 (HCl).

Engine Oil Viscosity

Select the appropriate engine oil viscosity based on the ambient temperature and use the SAE Service Grade Viscosity Chart in **(Figure 4-12)**.

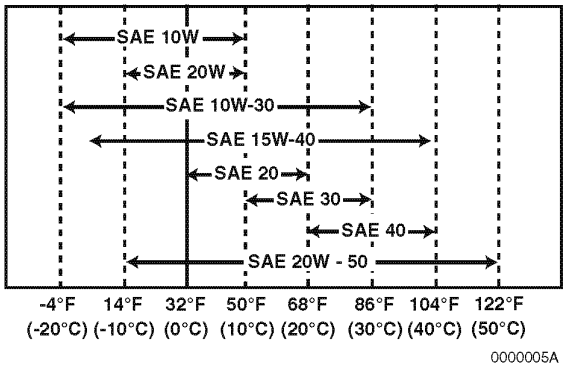


Figure 4-12

Engine Oil Capacity (Typical)

The following are the engine oil capacities for Yanmar YDG generators.

Engine / Generator Model	Dipstick Upper Limit/ Lower Limit
Engine-LV48 (Generator-YDG2700)	0.85 / 0.58 qt (0.80 / 0.55 L)
Engine-L70 (Generator-YDG3700)	1.11 / 0.69 qt (1.05 / 0.65 L)
Engine-LV100 (Generator-YDG5500)	1.7 / 1.06 qt (1.6 / 1.0 L)

Checking Engine Oil

1. Make sure engine is level.
2. Remove oil cap / dipstick **(Figure 4-13, (1))** and **(Figure 4-14, (1))** from either location and wipe with clean cloth. *NOTICE: Prevent dirt and debris from contaminating the engine oil. Always clean the oil cap / dipstick and the surrounding areas before you remove the cap.*
3. Reinsert oil cap / dipstick into the crankcase and turn clockwise for one half revolution to engage the first thread in the crankcase opening.
4. Remove oil cap / dipstick. The oil level should be between upper **(Figure 4-13, (2))** and lower **(Figure 4-14, (3))** lines on the oil cap / dipstick. *NOTICE: ALWAYS keep the oil level between the upper and lower lines on the oil cap / dipstick.*
5. Fully reinsert oil cap / dipstick and hand-tighten. Over-tightening the oil cap / dipstick will damage it.

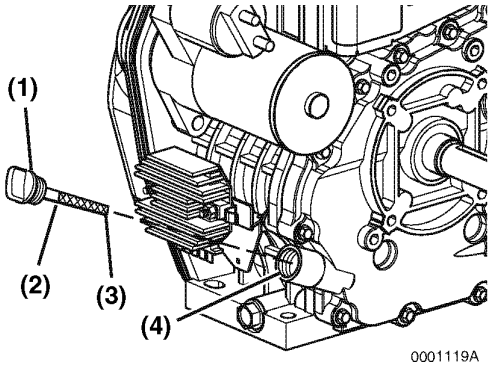


Figure 4-13

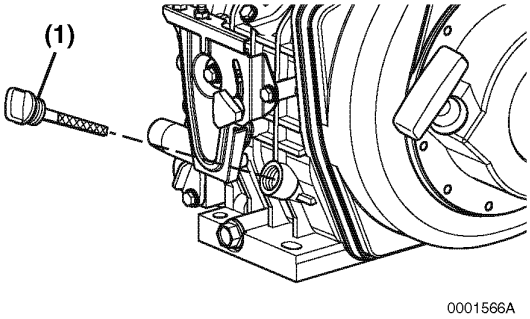


Figure 4-14

Adding Engine Oil

1. Make sure engine is level.
2. Remove oil cap / dipstick **(Figure 4-13, (1))** or **(Figure 4-14, (1))**.
3. Add indicated amount of engine oil at either of the engine oil filler ports **(Figure 4-13, (4))**. *NOTICE: NEVER overfill. Overfilling may result in white exhaust smoke, engine overspeed or internal damage.*
4. Wait one minute and check oil level.
5. Add more oil if necessary.
6. Fully reinsert oil cap / dipstick and hand-tighten. Over-tightening the oil cap / dipstick will damage it.

EMERGENCY STOP SYSTEM

Low Oil Pressure Stop Solenoid System Operation

NOTICE: ALWAYS ensure the emergency stop system is in proper operating condition. If the emergency stop system is faulty or does not operate, engine damage will result if the engine is not turned OFF when oil pressure drops lower than 14.2 ± 0.42 psi (1.00 ± .03 Kg/cm2).

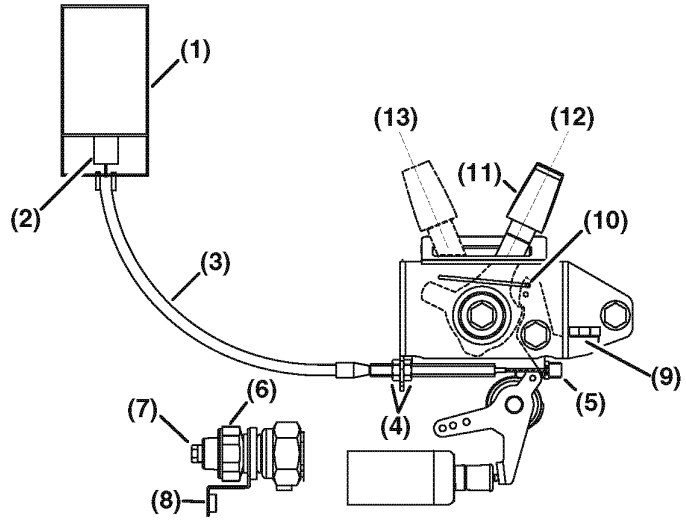
The low oil pressure stop solenoid **(Figure 4-15, (1))** turns the engine OFF when oil pressure drops lower than 14.2 ± 0.42 psi (1.00 ± .03 Kg/cm2) to help prevent engine damage.

Engine oil pressure drops when oil intake volume decreases as the engine oil level decreases.

The emergency stop system uses an oil pressure switch **(Figure 4-15, (6))** to activate the stop solenoid relay which activates the stop solenoid and moves the plunger **(Figure 4-15, (2))** to mechanically move the stop solenoid cable **(Figure 4-15, (3))** to activate the engine stop lever **(Figure 4-15, (9))**.

The oil pressure switch is normally open under operating oil pressure. When oil pressure drops below 14.2 ± 0.42 PSI (1.00 ± .03 Kg/cm2), the oil pressure switch closes and allows the completion of the low oil pressure stop solenoid electrical circuit. When this circuit is activated, the solenoid energizes and pulls the solenoid plunger in.

The solenoid plunger is connected to the stop solenoid cable which is connected to the stop lever **(Figure 4-15, (9))**. When the cable is pulled by the solenoid it trips the stop lever to turn the engine to the OFF **(Figure 4-15, (13))** position.



1 – Stop Solenoid
2 – Stop Solenoid Plunger
3 – Stop Solenoid Cable
4 – Cable Adjustment Nuts
5 – Inner Cable End
6 – Oil Pressure Switch
7 – Oil Pressure Switch Sender Lead Terminal
8 – Oil Pressure Switch Ground Lead Terminal
9 – Stop Lever
10 – Speed Lever Return Spring Located in Upper Hole
11 – Speed Control Lever
12 – RUN Position
13 – OFF Position

Figure 4-15

Stop Solenoid System Inspection and Troubleshooting

Inspect all cable and linkage components for corrosion, binding or damage and replace as necessary. Lightly lubricate all linkage joints and moving parts with grease.

Note: For wiring details of the stop solenoid, stop solenoid relay, oil pressure switch and key switch. *See Control Panel Layout - Model YDG2700EV-6EH on page 7-13* or *See Control Panel Layout - Model YDG3700EV-6EI, YDG5500EV-6EI on page 7-14 depending on model being serviced.*

Oil Pressure Switch Troubleshooting

To test the operation of the Low Oil Pressure Shut-Off System, start the engine and run at no load. Using a jumper wire connect the two terminals of the oil pressure switch **(Figure 4-16, (1))**. This will close the circuit and activate the stop solenoid which should stop the engine.

If the stop solenoid is not activated, test the stop solenoid. *See Stop Solenoid Troubleshooting on page 4-25*.

If the oil pressure switch is suspected of malfunction or failure. With the engine not running, remove the switch. Use a pump style pressure tester to apply pressure to the switch, while connecting an ohmmeter across the terminals testing continuity. The meter should show no continuity (open) as the switch is pressurized to 14.2 ± 0.42 psi (1.00 ± .03 Kg/cm^2). Once the pressure applied reaches or exceeds 14.2 ± 0.42 psi (1.00 ± .03 Kg/cm^2) the meter should show continuity across the terminals of the switch (closed). Replace the oil pressure switch as needed.

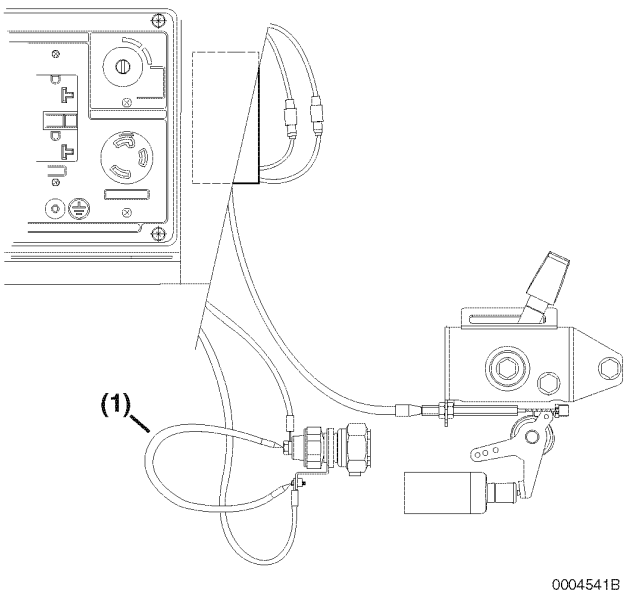


Figure 4-16

Stop Solenoid Troubleshooting

To test the stop solenoid electrical operation and the mechanical operation of the emergency stop system, proceed with the following procedure.

With the engine NOT running, test the stop solenoid by disconnecting the red and blue bullet wire connectors **(Figure 4-17, (1))** at the stop solenoid. Using jumper leads from a 12V battery, connect the positive lead of the battery to the blue lead of the solenoid and the negative lead of the battery to the red lead of the solenoid.

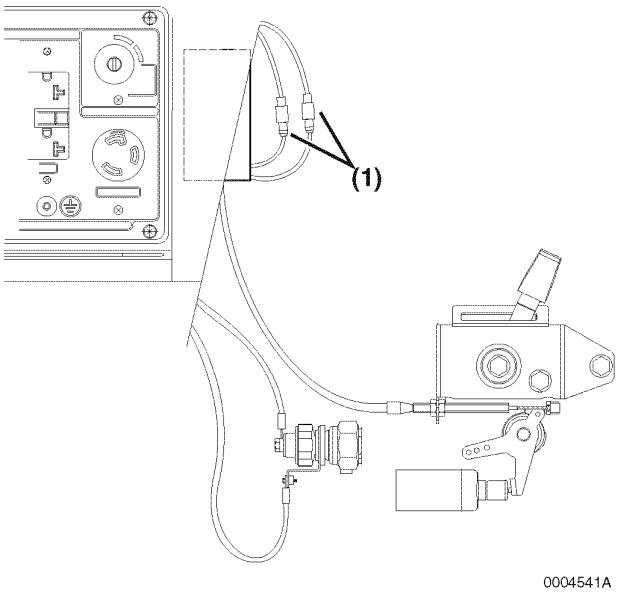


Figure 4-17

- If the solenoid is in proper working order, the solenoid will activate, pulling in the solenoid plunger and cable, activating the stop lever.
- If the solenoid does not activate, check:
  - The solenoid electrical leads for damage or open circuit of the solenoid. The solenoid should show 14.4 ± 1.4 Ohms when tested with an Ohm meter across the red and blue leads. A reading of no continuity (open) indicates an open circuit in the solenoid, repair or replace the solenoid as needed.
- If the solenoid does activate, but the stop lever is not activated when the solenoid is activated, check:
  - The solenoid plunger for movement and wear. Also check the plunger bore for excessive wear or binding, Repair or replace and necessary.
  - The cable for binding, or any restriction of movement. The inner cable should move freely in the outer cable casing. Also check the inner cable for stretching or damage.
  - Confirm cable freeplay measurement. *See Stop Solenoid Cable Adjustment on page 4-26.*
  - The stop lever linkage for binding, or any restriction of movement. All moving parts should move freely without binding.

Stop Solenoid Troubleshooting Relay Operation and Troubleshooting

Note: For wiring details of the stop solenoid, stop solenoid relay, oil pressure switch and key switch. *See Control Panel Layout - Model YDG2700EV-6EH on page 7-13* or *"Control Panel Layout - Model YDG3700EV-6EI, YDG5500EV-6EI" on page 14 depending on model being serviced.*

The stop solenoid relay is used to activate the stop solenoid from both the oil pressure switch and the generator set key switch.

When the oil pressure switch is activated (closed), current flows through the switch and activates the stop solenoid relay which completes the solenoid circuit activating the solenoid.

When the generator key switch is in the RUN position, an open circuit occurs between the "B" (Black lead) and "E" (Black with White stripe lead) terminals on the key switch. These two leads are connected to the stop solenoid relay.

When the generator key switch is in the OFF position, a closed circuit occurs between the "B" (Black lead) and "E" (Black with White stripe lead) terminals on the key switch, allowing current to activate the stop solenoid relay which completes the solenoid circuit activating the solenoid.

If the relay or relay circuit malfunctions and does not allow the stop solenoid to activate, the engine will not STOP when the oil pressure switch is closed and or when the key switch is turned to OFF. If this situation occurs, inspect the relay circuit wiring and repair as needed and or replace the relay.

Stop Solenoid Cable Adjustment

1. Confirm the speed lever return spring is in the upper mounting hole position **(Figure 4-18, (7))**.
2. To check the travel of the stop solenoid plunger **(Figure 4-18, (2))** stroke. Set the speed control lever **(Figure 4-18, (8))** to the OFF position **(Figure 4-18, (9))** then push in on the end of the stop cable inner cable end **(Figure 4-19, (3))**.

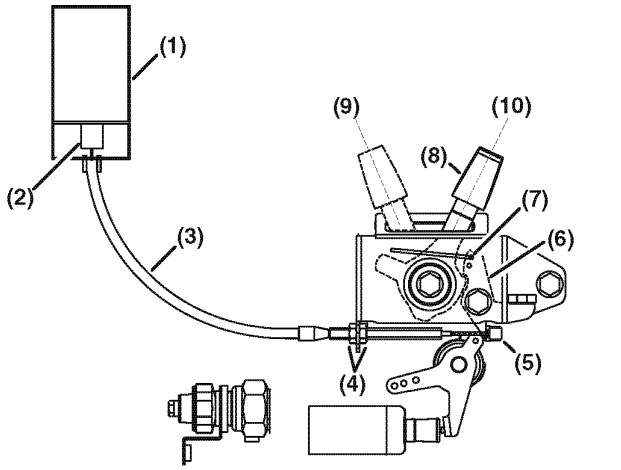


Figure 4-18

3. Measure the solenoid plunger travel by the length the inner cable moves, it should be 4.4 - 4.8 mm **(Figure 4-19, (2))** to the stop lever **(Figure 4-19, (1))**. If the travel is incorrect replace the solenoid and / or cable as required.

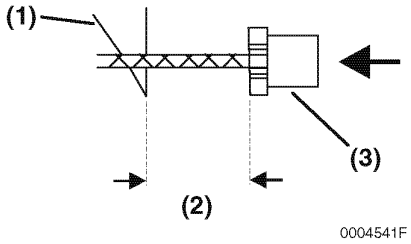


Figure 4-19

4. To check the adjustment of the cable. Set the speed control lever in the RUN position **(Figure 4-19, (10))** then lightly pull out on the inner cable **(Figure 4-20, (3))** and check the free play. The correct free play is 0 - 0.5mm **(Figure 4-20, (2))** between the cable end and the stop lever **(Figure 4-20, (1))**. To adjust the free play, thread the cable adjustment nuts **(Figure 4-18, (4))** forward or back to obtain the correct free play and tighten once the correct free play is achieved.

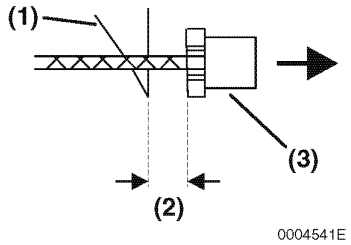


Figure 4-20

If excessive cable stroke is necessary to activate the stop lever:

- Confirm cable freeplay measurement
- Check that all moving parts move freely without binding.
- Check inner cable for stretching or damage. Replace cable if necessary.
- Check solenoid plunger and plunger bore for excessive wear or binding, Repair or replace and necessary.

BATTERY

Activating the Battery

*NOTICE: Do not remove the aluminum foil or sealing tape **(Figure 4-21, (3))** from the battery until it is ready to be filled with electrolyte. Removing the foil or sealing tape will cause the battery to lose its dry charge.*

1. Loosen nuts **(Figure 4-21, (1))** that secure the battery hold-down **(Figure 4-21, (2))**.
2. Loosen nuts enough so battery hold-down can be moved off the top of battery. The nuts just need to be loosened; they do not need to be removed.
3. Lift battery out of frame onto a work bench.

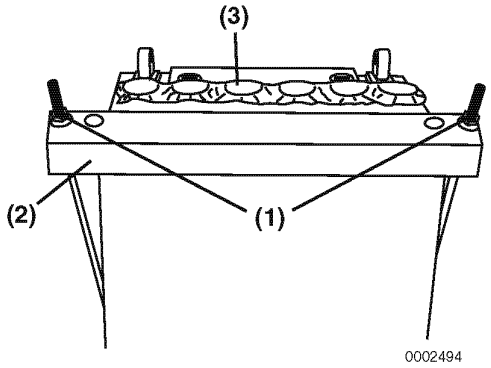


Figure 4-21

4. Fill the battery with electrolyte.

   NOTICE: The battery is shipped dry and needs to be filled with electrolyte. The battery will require approximately 1.9 qt (1.8 L) of electrolyte to be filled. See your local auto parts store to purchase electrolyte for your battery.

5. Remove the aluminum foil or sealing tape from the top of the battery.

6. Carefully fill the battery with electrolyte up to the upper level line **(Figure 4-22, (1))**. **WARNING! Batteries contain sulfuric acid. NEVER allow battery fluid to come in contact with clothing, skin or eyes. Severe burns could result. ALWAYS wear safety goggles and protective clothing when servicing the battery. If battery fluid contacts the eyes and / or skin, immediately flush the affected area with a large amount of clean water and obtain prompt medical treatment**.
7. Let battery stand for half an hour to allow any trapped gases to escape.
8. After letting battery stand, top off battery with electrolyte, if needed, so it is at the upper level line **(Figure 4-22, (1)).** Battery level should never be below the lower level line **(Figure 4-22, (2))**. *NOTICE: ALWAYS keep the electrolyte level between the upper and lower lines on the battery.*
9. If battery was filled with electrolyte immediately after aluminum foil or sealing tape was removed, battery does not need to be charged. If battery needs to be charged, *see "Charging the Battery" on page 29*.

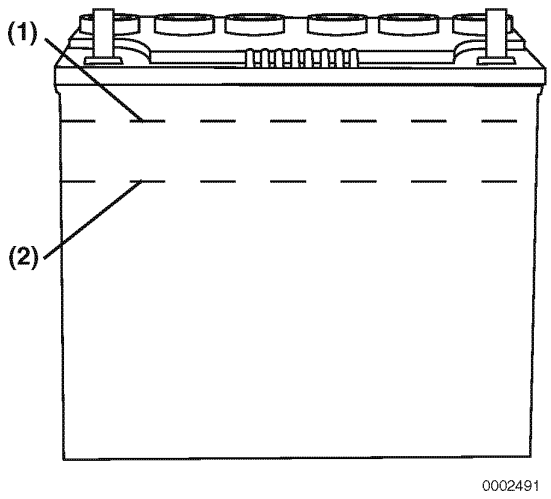


Figure 4-22

10. Install caps **(Figure 4-23, (1))** onto battery. Hand-tighten caps. Do not over-tighten.

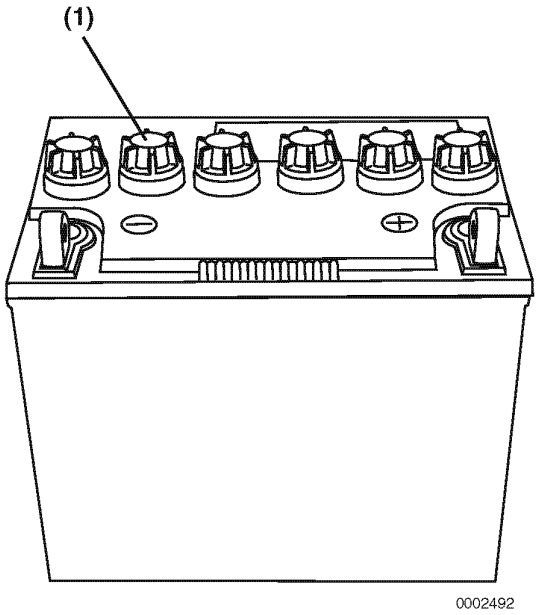


Figure 4-23

11. Install battery into generator.
12. Reinstall battery hold-down **(Figure 4-24, (1))** onto battery.
13. Tighten nuts **(Figure 4-24, (2))** until battery hold-down is tight. Do not over-tighten nuts.
14. Connect battery cables to battery. *See Disconnecting and Connecting Battery Cables on 4-30.*
15. Install boot **(Figure 4-24, (3))** onto the positive (+) terminal of the battery.

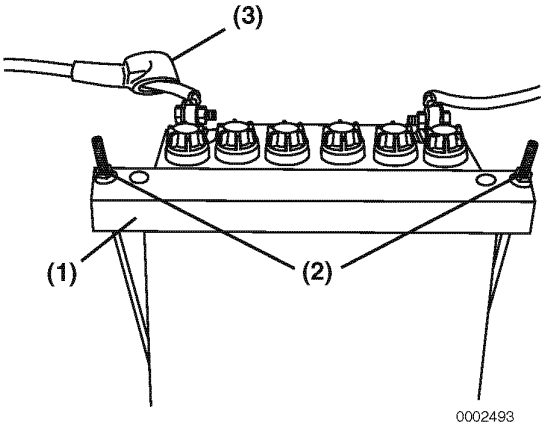


Figure 4-24

Checking Battery Electrolyte Level

DANGER! NEVER check the remaining battery charge by shorting out the terminals. This will result in a spark and may cause an explosion or fire. Use a hydrometer to check the remaining battery charge.

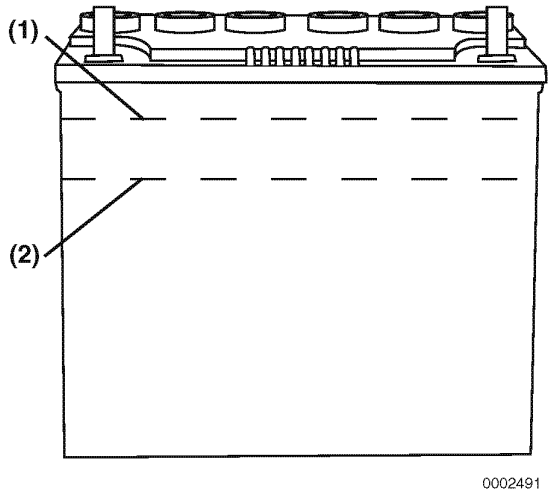


Figure 4-25

- When the amount of fluid nears the lower limit line **(Figure 4-25, (2))**, remove caps and fill with distilled water so it is at the upper limit line **(Figure 4-25, (1))**. If operation continues with insufficient battery fluid, the battery life is shortened, and the battery may overheat and explode. During the summer, check the fluid level more often than specified. **WARNING! Batteries contain sulfuric acid. NEVER allow battery fluid to come in contact with clothing, skin or eyes. Severe burns could result. ALWAYS wear safety goggles and protective clothing when servicing the battery. If battery fluid contacts the eyes and / or skin, immediately flush the affected area with a large amount of clean water and obtain prompt medical treatment.**
- If the engine cranking speed is so slow that the engine does not start, recharge the battery.
- If the engine still will not start after charging, have your authorized Yanmar industrial engine dealer or distributor check the battery and the engine's starting system.
- If operating the machine where the ambient temperature could drop to 14°F (-10°C) or less, remove the battery from the machine at the end of the day. Store the battery in a warm place until the next use. This will help start the engine easily at low ambient temperatures.

Charging the Battery

1. Disconnect the battery cables from the battery. *See Disconnecting and Connecting Battery Cables on page 4-30.*
2. Clean terminals on the battery and clamps on the end of the cables.
3. Connect the positive (+) clamp from the charger to the positive (+) terminal on the battery. **DANGER! If the electrolyte is frozen, slowly warm the battery before you recharge it. DANGER! Before charging, remove the cap from each cell of the battery and ALWAYS make sure there is plenty of ventilation when charging battery. Discontinue charging if the electrolyte temperature exceeds 117°F (45°C). While the engine is running or the battery is charging, hydrogen gas is being produced and can be easily ignited. ALWAYS keep the area around the battery well-ventilated and keep sparks, open flames and any other form of ignition out of the area.**

   DANGER! NEVER charge the battery while connected. The diodes will be damaged by the high voltage. Connect the (+) lead of the charger to the (+) terminal of the battery, and the (–) lead to the (–) terminal. Reversed polarity will damage the charger rectifier or the battery. After charging is completed, connect the battery cables correctly to the battery. Reversed polarity wiring will damage the diodes. Quick-charging should only be done in an emergency; slow charging is recommended.

4. Connect the negative (–) clamp from the charger to the negative (–) terminal on the battery.

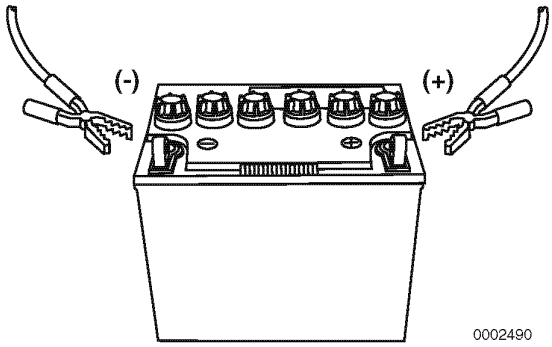


Figure 4-26

5. When finished charging the battery, unplug the charger before disconnecting clamps from the battery. *See Disconnecting and Connecting Battery Cables on page 4-30.*

Disconnecting and Connecting Battery Cables

CAUTION! This generator uses a negative ground 12V DC starting system. ALWAYS shut down the engine before removing or attaching battery cables. ALWAYS remove the negative (–) cable first. ALWAYS attach the negative (–) cable last.

1. When disconnecting cables, loosen and disconnect negative (–) cable **(Figure 4-27, (1))** first from battery.
2. Disconnect positive (+) cable **(Figure 4-27, (2))** from battery last.

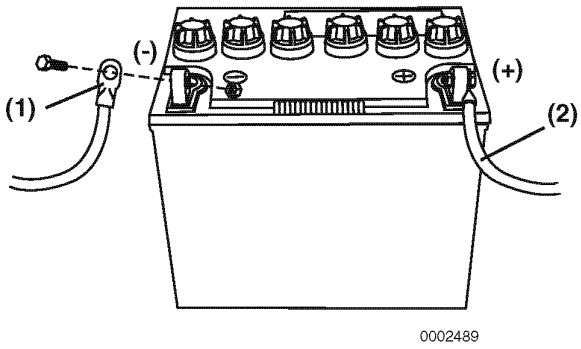


Figure 4-27

3. When connecting cables to battery connect the positive (+) cable **(Figure 4-28, (1))** first. **CAUTION! When you install a battery, ALWAYS use correct polarity when you connect battery cables to the battery. ALWAYS make sure the battery terminals are clean and tight.**
4. Connect the negative (–) cable **(Figure 4-28, (2))** to the battery last.

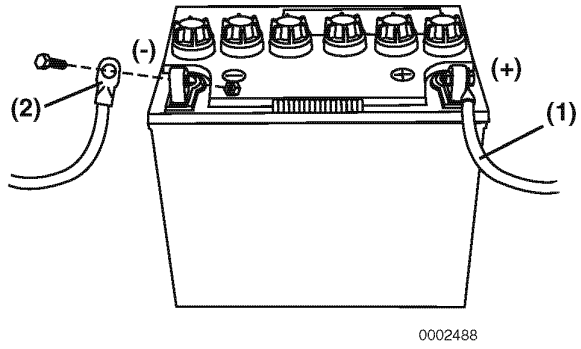


Figure 4-28

ABBREVIATIONS AND SYMBOLS

Abbreviations

A	ampere
AC	alternating current
ACEA	Association des Constructeurs Européens d'Automobilies
Ah	ampere-hour
API	American Petroleum Institute
ARB	Air Resources Board
ATDC	after top dead center
BDC	bottom dead center
BTDC	before top dead center
°C	degree Celsius
CARB	California Air Resources Board
CCA	cold cranking amp
cfm	cubic feet per minute
cm	centimeter
cm³	cubic centimeter
cm³/min	cubic centimeter per minute
cu in.	cubic inch
D	diameter
DC	direct current
DI	direct injection
DVA	direct volt adapter
EPA	Environmental Protection Agency
ESG	electronic speed governor
°F	degree Fahrenheit
fl oz	fluid ounce (U.S.)
fl oz/min	fluid ounce (U.S.) per minute
ft	foot
ft-lb	foot pound
ft-lbf/min	foot pound force per minute
g	gram
gal	gallon (U.S.)
gal/hr	gallon (U.S.) per hour
gal/min	gallon (U.S.) per minute
GL	gear lubricant
hp	horsepower (U.S.)
hr	hour
I.D.	inside diameter
ID	identification
IDI	indirect injection
in.	inch
inHg	inches Mercury
in.-lb	inch pound
j	joule
JASO	Japanese Automobile Standards Organization
k	kelvin
kg	kilogram
kgf/cm²	kilogram force per square centimeter
kgf/m	kilogram force per meter
km	kilometers
kPa	kilopascal
kW	kilowatt
L	liter
L/hr	liter per hour
lb	pound
lb-ft	pound foot
lb-in.	pound inch
lbf	pound force
m	meter
mL	milliliter
mm	millimeter
mmAq	millimeter Aqueous
MPa	megapascal
mV	millivolt
N	newton
N·m	newton meter
No.	number
O.D.	outside diameter
oz	ounce
Pa	pascal
PS	horsepower (metric)
psi	pound per square inch
qt	quart (U.S.)
R	radius
RPM	revolutions per minute
SAE	Society of Automotive Engineers
sec.	second
t	short ton 2000 lb
TBN	total base number
TDC	top dead center
V	volt
VAC	volt alternating current
VDC	volt direct current
W	watt

Symbols

°	degree
+	plus
-	minus
±	plus or minus
Ω	ohm
μ	micro
%	percent

UNIT CONVERSIONS

Unit Prefixes

Prefix	Symbol	Power
mega	M	x 1,000,000
kilo	k	x 1,000
centi	c	x 0.01
milli	m	x 0.001
micro	μ	x 0.000001

Units of Length

mile	x	1.6090	= km
ft	x	0.3050	= m
in.	x	2.5400	= cm
in.	x	25.4000	= mm
km	x	0.6210	= mile
m	x	3.2810	= ft
cm	x	0.3940	= in.
mm	x	0.0394	= in.

Units of Volume

gal (U.S.)	x	3.78540	= L
qt (U.S.)	x	0.94635	= L
cu in.	x	0.01639	= L
cu in.	x	16.38700	= mL
fl oz (U.S.)	x	0.02957	= L
fl oz (U.S.)	x	29.57000	= mL
cm^3	x	1.00000	= mL
cm^3	x	0.03382	= fl oz (U.S.)

Units of Mass

lb	x	0.45360	= kg
oz	x	28.35000	= g
kg	x	2.20500	= lb
g	x	0.03527	= oz

Units of Force

lbf	x	4.4480	= N
lbf	x	0.4536	= kgf
N	x	0.2248	= lbf
N	x	0.1020	= kgf
kgf	x	2.2050	= lbf
kgf	x	9.8070	= N

Units of Torque

ft-lb	x	0.1383	= kgf·m
in.-lb	x	0.0115	= kgf·m
lb-ft	x	1.3558	= N·m
lb-ft	x	0.1383	= kgf·m
lb-in.	x	0.1130	= N·m
lb-in.	x	0.0115	= kgf·m
kgf·m	x	7.2330	= lb-ft
kgf·m	x	86.8000	= lb-in.
kgf·m	x	9.8070	= N·m
N·m	x	0.7376	= lb-ft
N·m	x	8.8510	= lb-in.
N·m	x	0.1020	= kgf·m

Units of Pressure

psi	x	0.0689	= bar
psi	x	6.8950	= kPa
psi	x	0.0703	= kg/cm^2
bar	x	14.5030	= psi
bar	x	100.0000	= kPa
bar	x	29.5300	= inHg (60°F)
kPa	x	0.1450	= psi
kPa	x	0.0100	= bar
kPa	x	0.0102	= kg/cm^2
kg/cm^2	x	98.0700	= psi
kg/cm^2	x	0.9807	= bar
kg/cm^2	x	14.2200	= kPa
inHg (60°)	x	0.0333	= bar
inHg (60°)	x	3.3770	= kPa
inHg (60°)	x	0.0344	= kg/cm^2

Units of Power

hp (metric or PS)	x	0.9863201	= hp SAE
hp (metric or PS)	x	0.7354988	= kW
hp SAE	x	1.0138697	= hp (metric or PS)
hp SAE	x	0.7456999	= kW
kW	x	1.3596216	= hp (metric or PS)
kW	x	1.3410221	= hp SAE

Units of Temperature

°F = (1.8 x °C) + 32
°C = 0.556 x (°F - 32)

TIGHTENING TORQUES FOR STANDARD BOLTS AND NUTS

Use the correct amount of torque when you tighten fasteners on the machine. Applying excessive torque may damage the fastener or component and not enough torque may cause a leak or component failure.

NOTICE: The tightening torque in the Tightening Torques for Standard Bolts and Nuts chart should be applied only to the bolts with a "7" head. (JIS strength classification: 7T)Apply 60% torque to bolts that are not listed. Apply 80% torque when tightened to aluminum alloy.

Item	Nominal Thread Diameter x Pitch	Tightening Torque	Remarks
Hexagon Bolt (7T) and Nut	M6 x 1.0 mm	7 - 9 lb-ft (87 - 104 lb-in), 9.8 - 11.8 N·m, 1.0 - 1.2 kgf/m)	Use 80% of the value at left when the tightening part is aluminum. Use 60% of the value at left for 4T bolts and locknuts.
	M8 x 1.25 mm	17 - 21 lb-ft (200 - 251 lb-in., 22.6 - 28.4 N·m 2.3 - 2.9 kgf/m)	
	M10 x 1.5 mm	33 - 40 lb-ft (44.1 - 53.9 N·m, 4.5 - 5.5 kgf/m)	
	M12 x 1.75 mm	58 - 72 lb-ft (78.4 - 98.0 N·m, 8.0 - 10 kgf/m)	
	M14 x 1.5 mm	94 - 108 lb-ft (127.5 - 147.1 N·m, 13 - 15 kgf/m)	
	M16 x 1.5 mm	159 - 174 lb-ft (215.7 - 235.4 N·m, 22 - 24 kgf/m)	
PT Plug	1/8 mm	7 lb-ft (87 lb-in., 9.8 N·m, 1.0 kgf/m)	-
	1/4 mm	14 lb-ft (173 lb-in., 19.6 N·m, 2.0 kgf/m)	
	3/8 mm	22 lb-ft (29.4 N·m, 3.0 kgf/m)	
	1/2 mm	43 lb-ft (58.8 N·m, 6.0 kgf/m)	
Pipe Joint Bolt	M8	9 - 12 lb-ft (112 - 148 lb-in., 12.7 - 16.7 N·m, 1.3 - 1.7 kgf/m)	-
	M10	14 - 19 lb-ft (173 - 225 lb-in., 19.6 - 25.4 N·m, 2.0 - 2.5 kgf/m)	
	M12	18 - 25 lb-ft (24.5 - 34.3 N·m, 2.5 - 3.5 kgf/m)	
	M14	29 - 36 lb-ft (39.2 - 49.0 N·m, 4.0 - 5.0 kgf/m)	
	M16	36 - 43 lb-ft (49.0 - 58.8 N·m, 5.0 - 6.0 kgf/m)	

Note: Torque values shown in this manual are for clean, non-lubricated fasteners unless otherwise specified.

TIGHTENING TORQUES FOR SPECIAL BOLTS AND NUTS

Component	Model	Thread Diameter and Pitch	Torque	Lubricating Oil Application (Thread Portion and Seat Surface)
Crankcase Cover Bolt	L48V	14-M6 x 1.0 mm	96 - 114 lb-in. (10.8 - 12.8 N·m, 1.1 - 1.3 kgf/m)	Not Applied
	L70V, L100V	13-M8 x 1.25 mm	225 - 243 lb-in. (25.5 - 27.5 N·m, 2.6 - 2.8 kgf/m)	
Stiffener Bolts on Crankcase Cover	All Models	M8 x 1.25 mm	225 - 242 lb-in. (25.5 - 27.4 N·m 2.6 - 2.8 kgf/m)	Not Applied
Connecting Rod Nuts and Bolts	L48V, L70V	2-M7 x 1.0 mm	200 - 243 lb-in. (22.6 - 27.5 N·m, 2.3 - 2.8 kgf/m)	Applied
	L100V	2-M8 x 1.0 mm	32.5 - 36 lb-ft (44.1 - 49.0 N·m, 3.75 - 4.25 kgf/m)	
Flywheel Nut	L48V	M16 x 1.5 mm	101.5 - 108.7 lb-ft (137.3 - 147.1 N·m, 14.0 - 15.0 kgf/m)	Applied
	L70V	M16 x 1.5 mm	116 - 123.2 lb-ft (156.9 - 166.7 N·m, 16.0 - 17.0 kgf/m)	
	L100V	M18 x 1.5 mm	159 - 166 lb-ft (215.7 - 225.6 N·m, 22.0 - 23.0 kgf/m)	
Cylinder Head Nuts (Final Torque)	L48V	M8 x 1.25 mm	21.5 - 24.4 lb-ft (29.4 - 33.3 N·m, 3.0 - 3.4 kgf/m)	Applied
	L70V	M9 x 1.5 mm	34.8 - 37.8 lb-ft (47 - 51 N·m, 4.8 - 5.2 kgf/m)	
	L100V	M10 x 1.25 mm	44.0 - 46.9 lb-ft (59.8 - 63.7 N·m, 6.1 - 6.5 kgf/m)	
Valve Rocker Arm Support	L48V, L70V	M6 x 1.00 mm	88 - 106 lb-in. (10 - 12 N·m, 1.0 - 1.2 kgf/m)	Not Applied
	L100V	M8 x 1.5 mm	225 - 243 lb-in. (25.5 - 27.5 N·m, 2.6 - 2.8 kgf/m)	Not Applied

Component	Model	Thread Diameter and Pitch	Torque	Lubricating Oil Application (Thread Portion and Seat Surface)
Fuel Injector Retaining Nuts	All Models	2-M6x1.0	87 - 104 lb-in. (9.8 - 11.8 N·m, 1.0 - 1.2 kgf/m)	Not Applied
Fuel Pump Delivery Valve		M14x15	22 - 25 lb-ft (29.4 - 34.3 N·m, 3.0 - 3.5 kgf/m)	Not Applied
High-Pressure Fuel Injection Line Nuts			2.74 - 3.25 lb-ft (26.9 - 31.9 N·m, 20 - 24 kgf/m)	Not Applied
Fuel Injection Pump Mounting Nuts		3-M6x1.0	87 - 104 lb-in. (9.8 - 11.8 N·m, 1.0 - 1.2 kgf/m)	Not Applied
Fuel Injection Pump Inspection WIndow Plate Nut		3-M6x1.0	87 - 104 lb-in. (9.8 - 11.8 N·m, 1.0 - 1.2 kgf/m)	Not Applied
Fuel Limiter Mounting Nut			215 - 218 lb-in. (24.2 - 24.6 N·m, 24.7 - 25.1kgf/m)	Not Applied
Fuel Injector Nozzle Case Nut		1-0.605-40UNS-2B	29 - 33 lb-ft (39.2 - 44.1 N·m, 4.0 - 4.5 kgf/m)	Not Applied
Fuel Injector Nozzle Nuts		2-M6x1.0	87 - 104 lb-in. (9.8 - 11.8 N·m, 1.0 - 1.2 kgf/m)	Not Applied

See Tightening Torques for Standard Bolts and Nuts on page 4-33 for standard hardware torque values.

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Section 5

PERIODIC MAINTENANCE

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BEFORE YOU BEGIN SERVICING

Before performing any service procedures within this section, review the *Safety* section on page *3-1*.

PRECAUTIONS

The Importance of Periodic Maintenance

Engine deterioration and wear occurs in proportion to length of time the generator has been in service and the conditions the generator is subject to during operation. Periodic maintenance prevents unexpected downtime, reduces the number of accidents due to poor machine performance and helps extend the life of the engine.

CAUTION! Establish a periodic maintenance plan according to the engine application and make sure you perform the required periodic maintenance at intervals indicated. Failure to follow these guidelines will impair the engine's safety and performance characteristics, shorten the engine's life and may affect the warranty coverage on your engine. *See Yanmar Limited Warranty on page ii-iii*. Consult your authorized Yanmar industrial engine dealer or distributor for assistance when checking items marked with a ●.

Performing Periodic Maintenance

Perform periodic maintenance procedures in an open, level area free from traffic. If possible, perform the procedures indoors to prevent environmental conditions, such as rain, wind, or snow, from damaging the machine.

The Importance of Daily Checks

Periodic Maintenance Schedules assume that the daily checks are performed on a regular basis. Make it a habit of performing daily checks before the start of each shift. *See Daily Checks on page 3-36.* **CAUTION! It is important to perform daily checks. Periodic maintenance prevents unexpected downtime, reduces the number of accidents due to poor engine performance and helps extend the life of the engine.**

Keep a Log of Generator Hours and Daily Checks

Keep a log of the number of hours the generator is run each day and a log of the daily checks performed. Also note the date, type of repair, and parts needed for any service needed between the periodic maintenance intervals. Periodic maintenance intervals are every 50, 200, 400, 1000, 1500 and 2000 hours of generator operation. Failure to perform periodic maintenance will shorten the life of the generator.

Yanmar Replacement Parts

Yanmar recommends that you use genuine Yanmar parts when replacement parts are needed. Genuine replacement parts help ensure long generator life.

Tools Required

Before you start any periodic maintenance procedure make sure you have the tools you need to perform all of the required tasks.

Ask Your Authorized Yanmar Industrial Engine Dealer or Distributor For Help

Yanmar professional service technicians have the expertise and skills to help you with any maintenance or service related procedures.

Required EPA / ARB Maintenance - USA Only

To maintain optimum engine performance and compliance with the Environmental Protection Agency (EPA) Regulations Non-Road Engines and the California Air Resources Board (ARB, California), it is essential that you follow the "Periodic Maintenance Schedule" on page 6 and *Periodic Maintenance Procedures which start on 5-8*.

EPA / ARB Installation Requirements - USA Only

The following are the installation requirements for the EPA / ARB. Unless these requirements are met, the exhaust gas emissions will not be within the limits specified by the EPA and ARB.

Maximum Exhaust Gas Restriction shall be:

- L48V: 0.53 psi (3.628 kPa; 370 mmAq) or less
- L70V: 0.54 psi (3.727 kPa; 380 mmAq) or less
- L100V: 0.63 psi (4.315 kPa; 440 mmAq) or less

Maximum Air Intake Restriction shall be:

- L48V: 0.10 psi (0.69 kPa; 70 mmAq) or less
- L70V: 0.20 psi (1.37 kPa; 140 mmAq) or less
- L100V: 0.21 psi (1.47 kPa; 150 mmAq) or less

Clean or replace the air cleaner element if the air intake restriction exceeds the above mentioned value.

Tightening Fasteners

Use the correct amount of torque when you tighten fasteners on the machine. Applying excessive torque may damage the fastener or component and not enough torque may cause a leak or component failure.

PERIODIC MAINTENANCE SCHEDULE

Daily and periodic maintenance is important to keep the engine in good operating condition. The following is a summary of maintenance items by periodic maintenance intervals. Periodic maintenance intervals vary depending on engine application, loads, diesel fuel and engine oil used and are hard to establish definitively. The following should be treated only as a general guideline.

○: Check ◇: Replace ●: Contact your authorized Yanmar industrial engine dealer or distributor for these maintenance services.

System	Check Item	Daily	Periodic Maintenance Interval					
			Every 50 hours	Every 200 hours	Every 400 hours	Every 1000 hours	Every 1500 hours	Every 2000 hours
Air Intake	Clean or Replace Air Cleaner Element - (may need more frequent service in dusty conditions)			○				
Cylinder Head	Adjust Intake / Exhaust Valve Clearance				●			
	Check Compression					●		
Electrical Equipment	Check Battery (If Equipped) and Add Water as Necessary	○ before operation						
	Check Battery Indicator (If Equipped) and Other Driven Machine Indicators (If Equipped)	○ when engine is started						
	Wiring Harness				●			
	Voltmeter				●			
Emission Control Warranty	Inspect, Clean and Test Fuel Injection Nozzle						●	
Engine Oil	Check Engine Oil Level and Add Engine Oil As Necessary	○ before operation						
	Drain and Refill Engine Oil		◇ 1st time	◇ 2nd and after				
	Clean Engine Oil Filter - Replace If Damaged				◇ 2nd and after			
	Check for Engine Oil Leakage	○ before and after operation						
Engine Speed Control	Check for Proper Operation Verify Adjustment	○ 1st time		○ 2nd and after				

○: Check ◇: Replace ●: Contact your authorized Yanmar industrial engine dealer or distributor for these maintenance services.								
System	Check Item	Daily	Periodic Maintenance Interval					
			Every 50 hours	Every 200 hours	Every 400 hours	Every 1000 hours	Every 1500 hours	Every 2000 hours
Exhaust System	Check Spark Arrester for Clogging (If Equipped)	○ before operation						
Fuel	Check Fuel Tank Level and Add Fuel As Necessary	○ before operation						
	Drain and Clean Fuel Tank			○				
	Clean Inlet Fuel Screen		○					
	Replace Outlet Fuel Filter			○	◇			
	Check for Fuel Leakage	○ before and after operation						
Hoses	Replace Fuel System Hose(s)							● or every 2 years whichever comes first
Generator	Check Brushes for Wear or Damage				●			
	Check Slip Rings for Wear or Damage				●			
	Check Coils and Automatic Voltage Regulator (AVR) for correct operation.				●			
Frame	Check Main and Sub Frames for Damage				●			
	Check Engine/Frame Dampers for Wear, Damage and Tightness.					●		
	Check all Fasteners for Damage and Tightness.				●			
GFCI Outlet	Test Outlet		●					

Note: These procedures are considered normal maintenance and are performed at the owners expense.

PERIODIC MAINTENANCE PROCEDURES

Daily, Before Operation

Before performing periodic maintenance procedures, read the complete procedure including safety information.

Perform the following maintenance daily before operation.

- **Check Battery**
- **Check Battery Indicator**
- **Check Engine Oil Level**
- **Check for Engine Oil Leakage**
- **Check Engine Speed Control (First Time Only)**
- **Check Spark Arrester**
- **Check Fuel Level**
- **Check for Fuel Leakage**

Check Battery

Check the battery electrolyte level. *See Checking Battery Electrolyte Level on page 4-29.*

Check Battery Indicator

Visually check the battery indicator (if equipped) and any other indicator provided by the driven machine manufacturer.

Check Engine Oil Level

Before you operate the engine check the engine oil level. *See Checking Engine Oil on page 4-21.*

Check for Engine Oil Leakage

Before you operate the engine check for any engine oil leaks.

Check Engine Speed Control

Before you operate the driven machine check the engine speed control. *See Check and Adjust Engine Speed Control on page 5-15* for adjustment procedure.

Check Spark Arrester

A clogged spark arrester hinders exhaust gas flow which reduces engine output, increases fuel consumption and makes starting difficult. Clean the spark arrester regularly. **WARNING! NEVER touch hot engine surfaces such as the muffler, exhaust pipe, turbocharger (if equipped) and engine block during operation and shortly after you shut the engine down. These surfaces are extremely hot while the engine is operating and could seriously burn you.**

Clean the spark arrester **(Figure 5-1, (1))** as follows. *NOTICE: A clogged spark arrester hinders the flow of exhaust gas. This reduces engine output, increases fuel consumption and makes starting difficult.*

1. Remove the locknut **(Figure 5-1, (2))**, end cap **(Figure 5-1, (3))** and diffuser discs **(Figure 5-1, (4))** from the spark arrester.

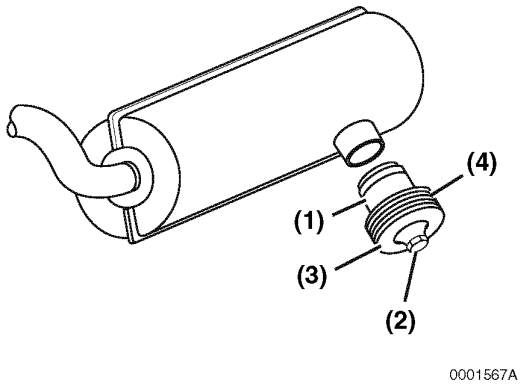


Figure 5-1

2. Clean any carbon deposits from the spark arrester.
3. Reinstall the diffuser discs **(Figure 5-1, (4))** and end cap **(Figure 5-1, (3))** on the spark arrester **(Figure 5-1, (1))** and secure with the locknut **(Figure 5-1, (2))**.

Check Fuel Level

Before you operate the engine check the fuel level. *See Filling the Fuel Tank on page 4-18.*

Check for Fuel Leakage

Before you operate the engine check for any fuel leaks. If you discover a fuel leak see your authorized Yanmar industrial engine dealer or distributor to repair the engine. **WARNING! NEVER check for a fuel leak with your hands. ALWAYS use a piece of wood or cardboard. Have your authorized Yanmar industrial engine dealer or distributor repair the damage.**

Daily, After Operation

- **Check for Engine Oil Leakage**
- **Check for Fuel Leakage**

Check for Engine Oil Leakage

After you shut down the engine check for any engine oil leaks. **WARNING! AVOID being burned by contact with hot engine oil.**

Check for Fuel Leakage

After you shut down the engine check for any fuel leaks. If you discover a fuel leak see your authorized Yanmar industrial engine dealer or distributor to repair the engine. **WARNING! ALWAYS wear eye protection when servicing the fuel system. NEVER check for a fuel leak with your hands. ALWAYS use a piece of wood or cardboard. Have your authorized Yanmar industrial engine dealer or distributor repair the damage.**

After Initial 50 Hours of Operation

Perform the following maintenance after the initial 50 hours of operation.

- **Replace Engine Oil**
- **Clean / Inspect Engine Oil Filter**

Replace Engine Oil

NOTICE: The engine oil on a new engine becomes contaminated from the initial break-in of internal parts. The initial 50 hour oil change and filter cleaning is very important.

Drain the engine oil as follows:

1. Make sure the engine is level.
2. Start the engine and bring it up to operating temperature.
3. Stop the engine.
4. Position a container under the engine to collect waste oil.
5. Remove one of the drain plugs located on the bottom of the cylinder block **(Figure 5-2, (2))** or **(Figure 5-3, (2))**. Allow oil to drain. **WARNING! The engine oil will be hot after engine operation. ALWAYS stay clear of hot engine oil to avoid being burned.**

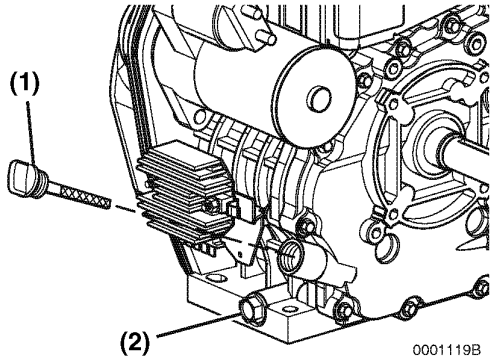


Figure 5-2

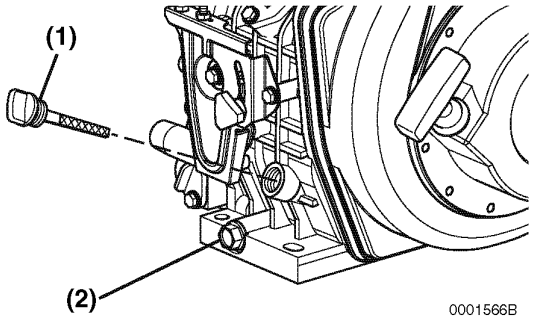


Figure 5-3

6. Remove the oil cap / dipstick **(Figure 5-2, (1))** or **(Figure 5-3, (1))** to allow the engine oil to drain more easily. *NOTICE: Prevent dirt and debris from contaminating the engine oil. Carefully clean the oil cap/dipstick and the surrounding area before you remove the cap.*
7. After all oil has been drained from the engine, reinstall the drain plug **(Figure 5-2, (2))** and tighten to 173 - 208 lb-in.lb-in. (19.6 - 23.5 N·m, 2.0 - 2.4 kgf/m.
8. Dispose of used oil properly. *NOTICE: ALWAYS be environmentally responsible. Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility. NEVER dispose of hazardous materials by dumping them into a sewer, on the ground or into ground water or waterways.*
9. Inspect engine oil filter. *See Clean / Inspect Engine Oil Filter on page 5-11.*

10. Add engine oil **(Figure 5-4, (4))** as needed until the level is between the upper **(Figure 5-4, (2))** and lower lines **(Figure 5-4, (3))** on the oil cap / dipstick **(Figure 5-4, (1))**. *NOTICE: NEVER overfill the engine with engine oil. ALWAYS keep the oil level between the upper and lower lines on the oil cap / dipstick.*
NOTICE: ALWAYS use only the engine oil specified. Other engine oils may affect warranty coverage, cause internal engine components to seize and / or shorten engine life. NEVER mix different types of engine oil. This may adversely affect the lubricating properties of the engine oil.

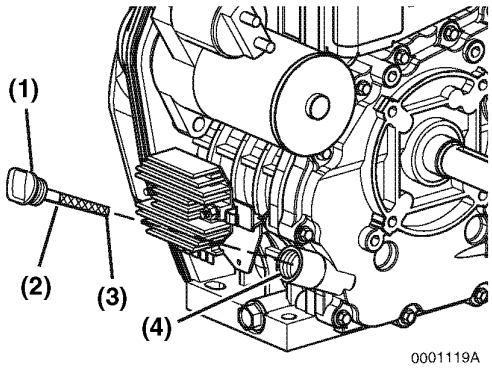


Figure 5-4

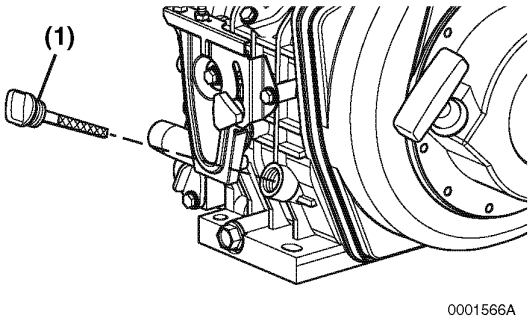


Figure 5-5

11. Warm up the engine by running it for five minutes and check for any engine oil leaks.
12. After engine is warm, shut it off and let it sit for 10 minutes.
13. Recheck the engine oil level by reinserting the oil cap / dipstick into the crankcase and turn clockwise for one half revolution to engage the first thread in the crankcase opening. *See Checking Engine Oil on page 4-21.*
14. Add oil if necessary. *NOTICE: NEVER overfill the engine with engine oil. ALWAYS keep the oil level between the upper and lower lines on the oil cap / dipstick.*
15. Replace the oil cap / dipstick and tighten by hand. Over-tightening may damage the cap. If any engine oil is spilled, wipe it away with a clean cloth.

Clean / Inspect Engine Oil Filter

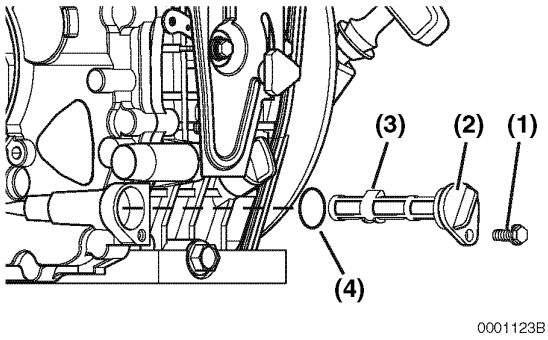


Figure 5-6

Note: It is recommended that this procedure be performed at the same time as the *Replace Engine Oil* procedure.

1. Remove the oil filter retaining bolt **(Figure 5-6, (1))**.
2. Drain engine oil. *See Replace Engine Oil on page 5-10.*
3. Pull the oil filter cap **(Figure 5-6, (2))** out and remove the oil filter **(Figure 5-6, (3))**.
4. Clean the oil filter in suitable parts cleaner or replace if damaged.
5. Lubricate the O-ring **(Figure 5-6, (4))** with oil and reinstall the oil filter **(Figure 5-6, (3))**. Replace filter if damaged.

Applicable Engine Oil Filter Part No.	
L48V, L70V and L100V	114250-35070

6. Make sure the oil filter cap is fully seated **(Figure 5-6, (2))**.
7. Reinstall and tighten the oil filter retaining bolt **(Figure 5-6, (1))**.
8. Add new engine oil to the engine as specified in *Adding Engine Oil on page 4-21*.
9. Warm up the engine by running it for five minutes and check for any engine oil leaks.
10. After engine is warm, shut it off and let it sit for 10 minutes.
11. Recheck the engine oil level by reinserting the oil cap / dipstick into the crankcase and turn clockwise for one half revolution to engage the first thread in the crankcase opening. *See Checking Engine Oil on page 4-21*.
12. Replace the oil cap / dipstick **(Figure 5-6, (1))** and tighten by hand. Over-tightening may damage the cap. If any engine oil is spilled, wipe it away with a clean cloth.

Every 50 Hours of Operation

Perform the following maintenance every 50 hours of operation.

- **Clean Inlet Fuel Screen**
- **Test GFCI Outlet**

Clean Inlet Fuel Screen

1. Clean the area around the fuel cap **(Figure 5-7, (1))**.
2. Remove the fuel cap from the fuel tank.

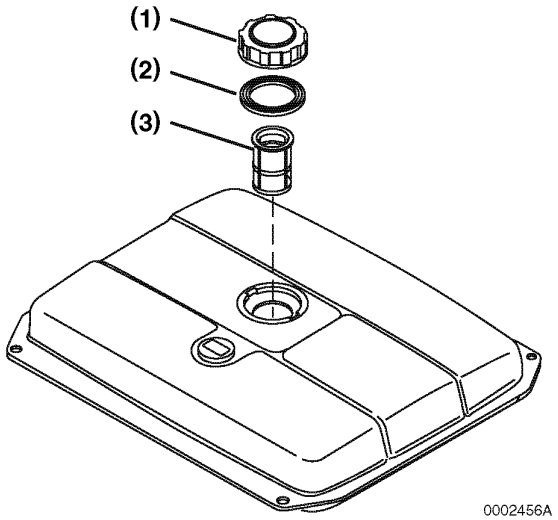


Figure 5-7

3. Lift out the inlet fuel screen **(Figure 5-7, (3))**. **CAUTION! Wipe up all spills immediately.**
4. Clean the inlet fuel screen or replace if damaged.
5. Inspect fuel cap gasket **(Figure 5-7, (2))** and replace if damaged.
6. Reinstall the inlet fuel screen.
7. Reinstall the fuel cap and hand-tighten. Over-tightening the fuel cap will damage it.

Test GFCI Outlet

1. To test the GFCI outlet press the TEST button **(Figure 5-8, (1))**
2. The RESET button **(Figure 5-8, (2))** should pop out. If the RESET button does not pop out, notify your Yanmar industrial engine dealer or distributor. Do not use the generator until this condition is fixed.
3. To restore power, press the RESET button firmly until an audible click is heard. When reset properly, the RESET button is flush with the surface of the TEST button.
4. When both the TEST and RESET buttons are flush all power is restored to the outlets.

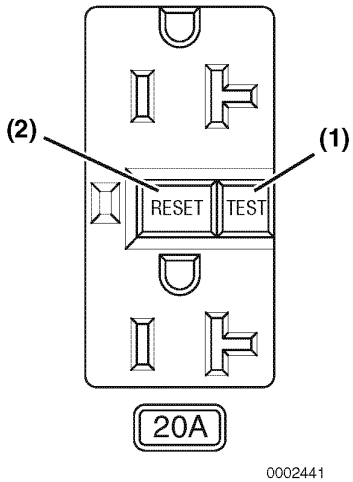


Figure 5-8

Every 200 Hours of Operation

Perform the following maintenance every 200 hours of operation.

- **Clean Air Cleaner Element**
- **Replace Engine Oil and Clean / Inspect Engine Oil Filter**
- **Check Engine Speed Control**
- **Drain the Fuel Tank and Replace Outlet Fuel Filter**

Clean Air Cleaner Element

NOTICE: Engine performance is adversely affected when the air cleaner element is clogged with dust. Be sure to clean or replace the air cleaner element periodically.

NOTICE: Avoid operating in extremely dusty conditions. When the engine is operated in dusty conditions, clean the air cleaner element more frequently. NEVER operate the engine with the air cleaner element(s) removed. This may cause foreign material to enter the engine and damage it.

NOTICE: Clean or replace the air cleaner element if the air intake restriction exceeds the following specifications:

(L48V: 0.10 psi (0.69 kPa; 70 mm Aq) or less), (L100V: 0.21 psi (1.47 kPa; 150 mm Aq) or less), (L70V: 0.20 psi (1.37 kPa; 140 mm Aq) or less).

L48V Models

The L48V model engines use a “wet” type air filter element. The air filter element is sealed inside a metal housing and coated in a light coat of oil to help filter debris. This type of air filter element is **NOT WASHABLE** and should be replaced every 200 hours or earlier if found excessively dirty.

1. Remove the wing nut **(Figure 5-9, (5)**) and gasket **(Figure 5-9, (4))**.
2. Remove the air cleaner cover **(Figure 5-9, (3))**.

3. Remove the air cleaner element **(Figure 5-9, (2))**.
4. Visually inspect the element and determine if replacement is needed. If there is any doubt the element is usable, it should be replaced.
5. Clean the inside and outside of the air cleaner housing and cover **(Figure 5-9, (1, 3))**.
6. Reinstall (or install the new) air cleaner element **(Figure 5-9, (2))** into the air cleaner housing.
7. Reinstall the air cleaner cover.
8. Reinstall the wing nut and gasket and hand-tighten. Over-tightening the wing nut will damage the air cleaner assembly.

Air Cleaner Element Part No.	
L48V	114250-12581

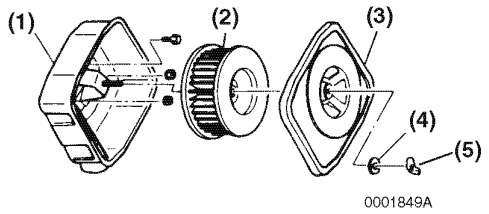


Figure 5-9

L70V and 100V Models

The L70 and 100V model engines use a “dry” type air filter element. The air filter element is an open paper type element. This type of air filter element should be cleaned or replaced every 200 hours or earlier if found excessively dirty.

1. Remove the wing nut **(Figure 5-10, (1))**.
2. Remove the air cleaner cover **(Figure 5-10, (2))**.
3. Remove the wing nut **(Figure 5-10, (3))**.
4. Remove the air cleaner element **(Figure 5-10, (4))** and outer foam element **(Figure 5-10, (5))**.
5. Blow air through both elements using 42 - 71 psi (0.29 - 0.49 MPa, 3.0 - 5.0 kgf/cm^2) compressed air to remove any debris. Blow air from the inside to the outside of the filter element using the lowest possible air pressure to remove dust without damaging the elements. **CAUTION! ALWAYS wear eye protection when servicing the engine and when using compressed air or high-pressure water. Dust, flying debris, compressed air, pressurized water or steam may injure your eyes.**
6. Check the condition of the air filter element by shining a flashlight from the backside of the air filter element. If light is not visible on the outside of the air filter element, replace the air filter element.
7. If either element is damaged replace both of them. (They are not sold individually.)
8. Clean the inside of the air cleaner cover **(Figure 5-10, (2))**.

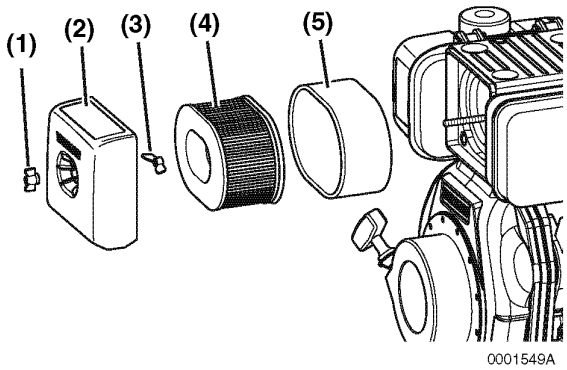


Figure 5-10

9. Reinstall the air cleaner element **(Figure 5-10, (4))** into the air cleaner housing.
10. Slide the outer foam element **(Figure 5-10, (5))** over the air cleaner element **(Figure 5-10, (4))**.
11. Reinstall the wing nut **(Figure 5-10, (3))** and hand-tighten. Over-tightening the wing nut will damage the air cleaner assembly.
12. Reinstall the air cleaner cover **(Figure 5-10, (2))**.

13. Reinstall the wing nut **(Figure 5-10, (1))** and hand-tighten. Over-tightening the wing nut will damage the air cleaner assembly.

Air Cleaner Element Part No.	
L70V and L100V	114210-12590

Replace Engine Oil and Clean / Inspect Engine Oil Filter

Change the engine oil every 200 hours of operation after the initial change at 50 hours. Clean and inspect the engine oil filter at the same time. *See Replace Engine Oil on page 5-10* and *Clean / Inspect Engine Oil Filter* on page *5-11*.

Check and Adjust Engine Speed Control

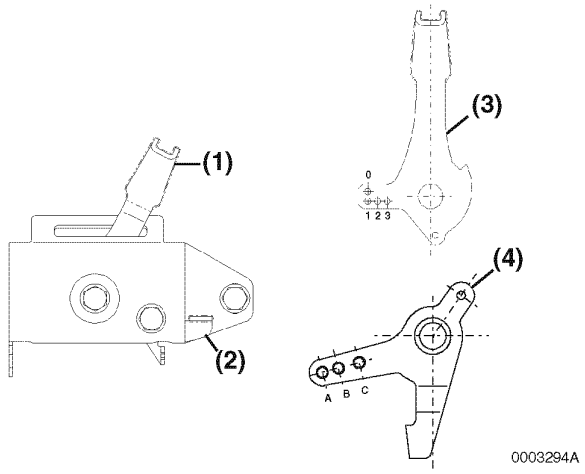
After you operate the engine for 200 hours, check the engine speed control. *NOTICE: NEVER attempt to adjust the low or high idle speed limit screw. This may impair the safety and performance of the machine and shorten its life. If adjustment is ever required, contact your authorized Yanmar industrial engine dealer or distributor.*

A constant speed control device is used on YDG generator sets, to govern the engine speed to a pre-set constant engine speed under various loads. When moved to the full throttle position, the speed control lever “locks” at full throttle.

Never force the throttle lever to move. This may deform the governor lever and cause irregular operation of the engine speed control. *NOTICE: ALWAYS run the engine at full speed. NEVER run engine at lower speeds. At full speed, the engine runs at 3600 rpm under load. The engine must maintain 3600 rpm for generator to create correct voltage. Running engine at lower speeds will damage generator and powered items.*

1. Check that the speed control lever **(Figure 5-11, (1))** locks into the full speed position when advanced and returns to the stop position when the stop lever **(Figure 5-11, (2))** is actuated. *See No Load Maximum Speed Control Adjustment on page 9-27*.

Engine	L48V		L70V	L100V
RPM Rating	3600 RPM	3450 RPM	3600 RPM	3600 RPM
Position of Regulator Spring	1-B	1-B	1-B	1-B



1 – Speed Control Lever
2 – Speed Control Release Lever
3 – Control Lever
4 – Governor Lever

Figure 5-11

Drain the Fuel Tank and Replace Outlet Fuel Filter

1. Position an approved container under the fuel tank to collect the fuel. **DANGER! ALWAYS wipe up all spills immediately. Diesel fuel is flammable and explosive under certain conditions. Store any containers containing fuel in a well-ventilated area, away from any combustibles or sources of ignition. Wipe up all spills immediately and NEVER use a shop rag to catch spilled fuel.**
2. Remove the fuel cap **(Figure 5-12, (1))**.
3. Remove the fuel tank drain plug **(Figure 5-12, (8))** and gasket **(Figure 5-12, (9))** to drain the fuel. Inspect the gasket and replace if damaged. *NOTICE: ALWAYS be environmentally responsible. Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.*
4. Remove clamps **(Figure 5-12, (2))** and disconnect fuel supply **(Figure 5-12, (3))** and return lines **(Figure 5-12, (4))**.
5. Remove the fuel tank mounting bolts and remove the fuel tank from the generator frame.
6. Remove the three fuel filter nuts **(Figure 5-12, (5))** and pull the fuel filter **(Figure 5-12, (6))** out through bottom of the tank.

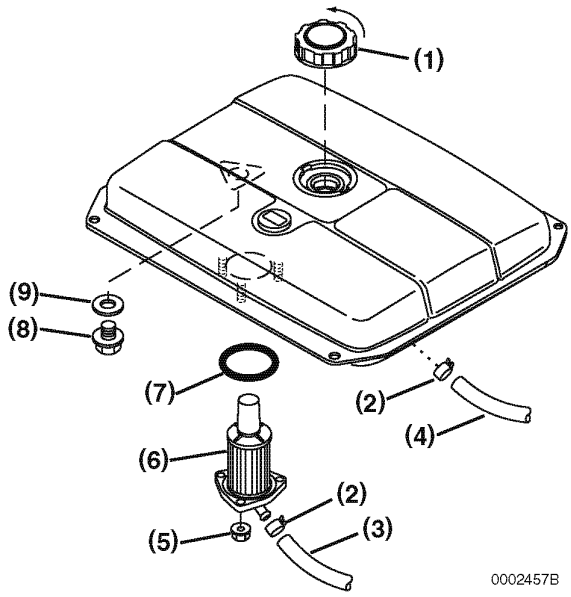


Figure 5-12

7. Install a new filter into the tank using a new O-ring **(Figure 5-12, (7))**.
8. Reinstall the three fuel filter nuts and tighten securely.
9. Reinstall the drain plug and gasket.
10. Reinstall the fuel tank into the generator frame and secure with mounting bolts.
11. Reconnect the fuel supply and return lines to the tank with clamps.
12. Fill the fuel tank with fuel and inspect for leaks. Repair or replace components as necessary.

Every 400 Hours of Operation

Perform the following maintenance every 400 hours of operation.

- **Adjust Intake and Exhaust Valve Clearance**
- **Check Brushes for Wear or Damage**
- **Check Slip Rings for Wear or Damage**
- **Check Coils and Automatic Voltage Regulator (AVR) for correct operation.**
- **Check Main and Sub Frames for Damage**
- **Check all Fasteners for Damage and Tightness.**

Adjust Intake and Exhaust Valve Clearance

Proper adjustment is necessary to maintain the correct timing for opening and closing the valves. Improper adjustment will cause the engine to run noisily, resulting in poor engine performance and engine damage. *See Measuring and Adjusting Valve Clearance on page 8-35.*

Check Brushes for Wear or Damage

Check the generator brushes for wear and damage. Generator brushes wear with normal use of the generator over time. It is important to check the condition of the brushes to ensure generator performance is maintained at an optimum. *See Brush Inspection on page 7-32.*

Check Slip Rings for Wear or Damage

Check the generator slip rings for wear and damage. Generator slip rings wear with normal use of the generator over time. It is important to check the condition of the slip rings to ensure generator performance is maintained at an optimum. *See Rotor Slip Ring on page 7-41.*

Check Coils and Automatic Voltage Regulator (AVR) for correct operation

Check the generator coils and AVR for correct operation and output. It is important to check the condition of the generator coils and AVR to ensure generator performance is maintained at an optimum. *See AVR (Automatic Voltage Regulator) Circuit Continuity Test on page 7-32.*

Check Main and Sub-Frames for Damage

Check the main frame and sub-frame for damage. The main and sub-frame are the structural support for the engine, generator, fuel tank and all other generator controls and components. Any damage to the frames, including corrosion may compromise the structural integrity of the frame and should be repaired or replaced to avoid costly repairs and / or personal injury. *See Inspection of Engine Dampers and Frame on page 6-6.*

Check all Fasteners for Damage and Tightness

Check all fasteners used on the generator set. All fasteners should be properly installed and tightened to the specified value given in the specific sections throughout this manual, See Special Torque Specifications in each service section of this manual. For fasteners that do not have special torque specifications. *See Tightening Torques for Standard Bolts and Nuts on page 4-33.*

Every 1000 Hours of Operation

Perform the following maintenance every 1000 hours of operation.

- **Check Compression**
- **Check Engine/Frame Dampers for Wear, Damage and Tightness**

Check Compression

An engine compression check is required every 1000 hours to obtain optimum engine performance. *See Troubleshooting By Measuring Compression Pressure on page 13-4.*

Check Engine and Frame Dampers for Wear, Damage and Tightness

Inspect all frame components for damage and repair or replace as required.

The damper mount butyl rubber has excellent shock absorption performance. Prevent contaminating the damper with diesel oil or gasoline as much as possible during work, to prevent deterioration of the rubber damper.

1. Check for separation at rubber baked portion **(Figure 5-13, (1))**.
2. Check the damper rubber material **(Figure 5-13, (2))** for cracks and deformation. Replace the damper if cracked or deformed.

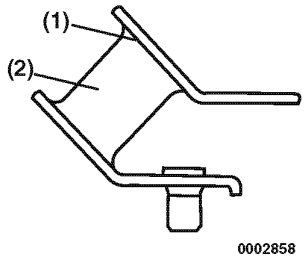


Figure 5-13

Every 1500 Hours of Operation

Perform the following maintenance every 1500 hours of operation.

- **Inspect, Clean and Test Fuel Injection Nozzle**

Inspect, Clean and Test Fuel Injection Nozzle

Proper operation of the fuel injectors is required to obtain the optimum injection pattern for full engine performance. The EPA / ARB requires that you have the injectors inspected, cleaned and tested every 1500 hours. *See Testing of Fuel Injector on page 9-23.*

Every 2000 Hours of Operation

Perform the following maintenance every 2000 hours of operation.

- Check and Replace Fuel Hoses

Check and Replace Fuel Hoses

Regularly check the fuel system hoses. If they are cracked or degraded, replace them. Replace rubberized fuel hoses every two years or every 2000 hours of engine operation, whichever comes first, even if the engine has been out of service. Rubberized fuel lines tend to dry out and become brittle after two years or 2000 hours of operation, whichever comes first.

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Section 6

GENERATOR SET

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BEFORE YOU BEGIN SERVICING

Before performing any service procedures within this section, review the *Safety section on page 3-1*.

NOTICE

When you install a battery:

- ALWAYS use correct polarity when you connect battery cables to the battery. This generator uses a negative ground, 12V DC starting system.
- Make sure battery terminals are clean.
- Make sure cable connections are tight.
- ALWAYS shut down engine before removing or attaching battery cables.
- ALWAYS remove the negative (-) cable first. Always attach negative (-) cable last.

INTRODUCTION

This section of the *Service Manual* describes the procedures necessary to remove the engine and generator unit from the frame and service the main frame, subframe and its associated components.

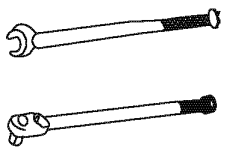
SPECIFICATIONS

Special Torque Specifications

Component	Tightening Torque	Lubricating Oil Application (Thread Portion and Seat Surface)
Engine Mount Bolts	173.5 - 260.2 lb-in. (19.6 - 29.4 N·m, 2.0 - 3.0 kgf/m)	Not Applied
Fuel Tank Bolts	43.4 - 69.0 lb-in. (4.9 - 7.8 N·m, 0.5 - 0.8 kgf/m)	Not Applied
Engine Damper Bolts	173.5 - 260.2 lb-in. (19.6 - 29.4 N·m, 2.0 - 3.0 kgf/m)	Not Applied
Sub-Frame Bolts (If equipped)	173.5 - 260.2 lb-in. (19.6 - 29.4 N·m, 2.0 - 3.0 kgf/m)	Not Applied
Upper Engine Mount Bolts	173.5 - 260.2 lb-in. (19.6 - 29.4 N·m, 2.0 - 3.0 kgf/m)	Not Applied

Note: *See Tightening Torques for Standard Bolts and Nuts on page 4-20*, for standard hardware torque values.

SPECIAL SERVICE TOOLS

No.	Tool Name	Application	Illustration
1	Torque Wrench (Available Locally)	For tightening nuts and bolts to the specified torque	 0000840

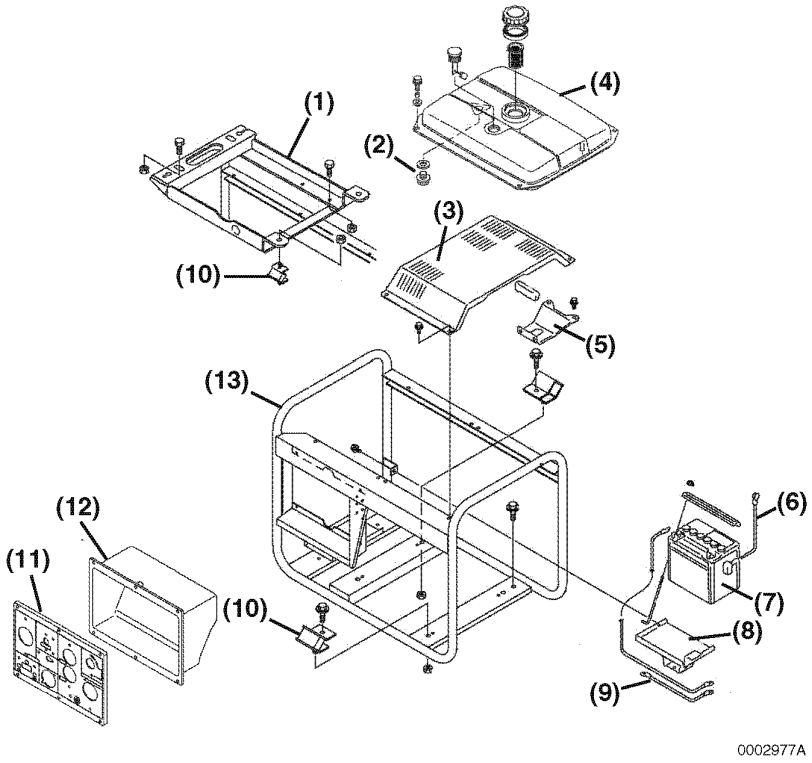
GENERATOR SET

Generator Set Components

The primary components of the generator set consist of the engine, generator, control panel and components, fuel tank **(Figure 6-1, (4))**, battery **(Figure 6-1, (7))** and frames.

The main frame **(Figure 6-1, (13))** is constructed from steel pipes. The sub-frame (5500 Models Only) **(Figure 6-1, (1))** is constructed of angle bars. Rubber dampers **(Figure 6-1, (10))** used to isolate engine vibration are used to mount the engine and generator to the frame and sub-frame.

The fuel tank and engine cover are mounted on top of the main frame. A battery tray **(Figure 6-1, (1))** is located on one side of the main frame.



1 – Subframe (5500 Models)
2 – Fuel Drain Plug
3 – Engine Cover
4 – Fuel Tank
5 – Upper Engine Mount
6 – Battery Cable
7 – Battery
8 – Battery Tray
9 – Battery Cable
10 – Damper Mount
11 – Control Panel
12 – Control Panel Box
13 – Main Frame

Figure 6-1

Disassembly of Generator Set

To service the engine or frame, remove the fuel tank and engine / generator components.

Removal of Engine

1. Disconnect the positive and negative battery cables from battery (if equipped).

Note: Always disconnect the negative (-) terminal (black) first and then the positive (+) terminal (red).

2. Remove the battery hold down clamp and remove the battery from the battery tray. Remove battery tray from frame.
3. Remove the engine oil drain plug and drain engine oil into an appropriate container. *See Replace Engine Oil on page 5-10.*
4. Turn off any fuel valves. Disconnect the fuel supply and fuel return lines at the engine. *See Removal of Fuel Injection Pump on page 9-17.*
5. Drain the fuel from tank into a container. Do not allow any fuel to spill and clean any fuel that spills immediately. *See Drain the Fuel Tank and Replace Outlet Fuel Filter on page 5-16.*
6. Remove the four fuel tank screws and fuel tank from frame.
7. Remove the exhaust muffler.
8. Remove the four upper engine cover screws and cover from frame.
9. Remove the upper engine mount screws and remove mount from engine and frame.
10. The control panel may be removed to ease in engine removal at this time. *See Removal of Control Panel on page 7-45.*
11. Disconnect the throttle cable, any external engine shut-off linkage, external compression release linkage and any wire connectors.
12. Remove the engine and generator lower mount damper fasteners. **WARNING! ALWAYS secure the engine solidly to prevent injury or damage to parts due to the engine falling during work on the engine.**

    Remove the engine and generator unit from frame.
13. Remove the engine and generator lower mount damper fasteners.
14. Remove the subframe (if necessary).
15. Remove the damper mount fasteners and damper mounts from frame (if necessary).
16. Clean the engine and frame by washing with solvent, air or steam cleaning. Cover or plug any open connectors, hoses or fittings. Do not allow any debris to enter the engine.

Inspection of Engine Dampers and Frame

See Check Engine and Frame Dampers for Wear, Damage and Tightness on page 5-18.

Reassembly of Generator Set

Use standard torque values for all fasteners. *See Tightening Torques for Standard Bolts and Nuts on page 4-33* for all main frame and subframe fasteners.

1. Reinstall subframe and damper mounts to frame. Tighten fasteners to specified torque. *See Special Torque Specifications on page 6-4*.

Installation of Engine

All electrical connections and frame components must be fastened securely to prevent loosening from vibration, which could cause unit damage and personal injury.

1. Reinstall and fasten the engine and generator unit onto frame damper mounts. Tighten fasteners to specified torque, *See Special Torque Specifications on page 6-4*.
2. Reinstall and fasten the upper engine mount. Tighten fasteners to specified torque, *See Special Torque Specifications on page 6-4*.
3. Reinstall the control panel if removed. *See Installation of Control Panel on page 7-48*.
4. Reinstall the fuel tank and connect all fuel lines. Tighten fasteners to specified torque, *See Special Torque Specifications on page 6-4*.
5. Reinstall the upper engine cover to frame.
6. Reinstall the battery tray, battery and secure with hold-down clamp.
7. Connect the throttle cable, any external engine shut-off linkage, external compression release linkage and any wire connectors.
8. Install the exhaust muffler.
9. Fill the engine with oil. *See Adding Engine Oil on page 4-21.*
10. Connect the battery cables to battery (if equipped).

Note: Always connect the positive (+) terminal (red) first and then the negative (-) terminal (black).

11. Fill the fuel tank with fuel.
12. Prime the fuel system *See Priming the Fuel System on page 4-19*.
13. Check for fuel leaks. Repair any leaks.

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Section 7

CONTROL PANEL AND GENERATOR

BEFORE YOU BEGIN SERVICING

Before performing any service procedures within this section, read the following safety information and review the *Safety* section on page *3-1*.

⚠ DANGER

Electric Shock Hazard

ALWAYS follow the manufacturer's instructions for safe and correct usage of test meters.

ALWAYS verify the type of current to be measured before connecting test meter leads and that the correct current and voltage range is selected on the meter.

NEVER let test meter leads come in contact with one another while they are both in contact with their respective points on the circuit. A short circuit, spark and or flame may be created.

ALWAYS secure test meter leads to the points of contact when testing a high-voltage circuit.

ALWAYS de-energized circuits and components first before measuring resistance. A spark and or flame may be created.

ALWAYS use caution when testing electrical circuits and components. Exposure to electric current can cause personal injury and or death.

CONTROL PANEL AND GENERATOR

⚠ DANGER

Electric Shock Hazard

Disconnect the negative battery cable before servicing the electrical system

---

ALWAYS use caution when testing electrical circuits and components in high moisture content areas or where water is present. Water is an electrical conductor and can provide a path for electrical current to flow causing personal injury and or death.

NOTICE

NEVER reverse the positive (+) and negative (-) ends of the battery cable. The engine charging system diode and stator coil will be damaged.

ALWAYS use a specialized battery charger to recharge a battery with a voltage of 8 volts or less. Booster starting a battery with a voltage of 8 volts or less will generate an abnormally high voltage and destroy electrical equipment.

Most electric appliances require more than their rated wattage for start-up. NEVER exceed the specified current limit for any one electrical socket.

When you install a battery:

- ALWAYS use correct polarity when you connect battery cables to the battery. This generator uses a negative ground, 12VDC starting system.
- Make sure battery terminals are clean.
- Make sure cable connections are tight.
- ALWAYS shut down engine before removing or attaching battery cables.
- ALWAYS remove the negative (-) cable first. Always attach negative (-) cable last.

If you remove battery from generator, insulate the terminal on the end of the red, positive (+) battery cable. If the terminal is not insulated, it may spark when generator runs. Sparks may cause damage to the generator's electronic circuits

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ALWAYS verify the electrical test meter is capable of performing the test required in a safe manner before using the meter, see the test meter manufacturer's instructions and specifications.

INTRODUCTION

This section of the *Service Manual* describes the procedures necessary to service the generator, control panel and associated components.

SPECIFICATIONS

General Generator Specifications

Model			YDG2700EV-6EH	YDG3700EV-6EI	YDG5500EV-6EI
Generator	Type		Revolving-field type AC generator (with brush)		
	Excitation		Self-excited		
	Voltage Regulation		Automatic Voltage Regulator (AVR)		
	Frequency		60 Hz		
	Maximum Speed		3600 RPM		
	Rated Output		2.4 AC kVA	3.5 AC kVA	5.0 AC kVA
			12VDC - 8.3A		
	Rated Voltage		120VAC	120/240VAC	
	Rated Current		20A	29.2 / 14.6A	41.7 / 20.8A
	Power Factor		1.0		
	Phase		Single-phase		
	No. of Poles		2		
	Type of Insulation		B-class	E-class	
	Bearing System		Ball bearing (Grease-enclosed)		
	Output Terminal	AC	125V - 20A (GFCI) x 2	125V - 20A (GFCI) x 2 125V - 30A (Twist Lock) x 1 (3 - pin) 125/250V - 20A (Twist Lock) x 1 (4 - pin)	
		DC	Terminal x 1		
	Breaker	AC	21A (NFB)	16A (NFB)	22A (NFB)
		DC	12A (Thermal breaker)		
	Voltmeter		120/240VAC		
	Emergency Stop System		Engine stop device by low level oil sensor		
Generator Unit	Dimension	L	25.5 in. (649 mm)	25.5 in. (650 mm)	28.3 in. (720 mm)
		W	16.3 in. (416 mm)	19.5 in. (496 mm)	18.8 in. (480 mm)
		H	19.6 in. (500 mm)	20.8 in. (530 mm)	22.7 in. (578 mm)
	Dry Weight		141 lb.(64 kg)	176.3 lb. (80 kg)	238 lb. (108 kg)

General Generator Specifications - Continued

Model		YDG2700EV-6EH	YDG3700EV-6EI	YDG5500EV-6EI	Remarks
Frequency Under Load	AC	59 - 62 Hz			Under rated operation
Voltage Under Load		122 ± 3V	122 ± 3/244 ± 6V		
Voltage Under No Load		MAX 132V	MAX 132 / 265V		After warming-up
Voltage Regulation Range		7%			
Waveform Distortion		25%			
Rated Current	DC	8.3A			-
Voltage Under Load		11 ± 1V			
Voltage Under No Load		MAX 20V			
Frequency Regulation	Instantaneous maximum speed difference	10%			When continuous rated output is abruptly changed to output at no load
	Steady state speed band	6%			
	Recovery time	5 sec.			
	Stability	±1 Hz			After warming up
Permissible Angle of Inclination	Continuous	MAX 20 deg			forward / backward and rightward / leftward
Noise level (at rated operation) (Average in 4 directions)		92 dB (A)	93 dB (A)	96 dB (A)	Measured 1 meter away from external wall of generator set
Lowest starting temperature		-10 °C			-
		14 °F			-

Control Panel Component Electrical Specifications

Component	Voltage / Current	YDG2700EV-6EH	YDG3700EV-6EI	YDG5500EV-6EI
GFCI Receptacle	Rated Voltage	125VAC		
	Current Capacity	20A		
AC Twist Lock Receptacle	Rated Voltage	-	125VAC	
	Current Capacity		30A (NEMA-Standard L5-30R)	
AC Twist Lock Receptacle	Rated Voltage	-	125VAC / 250VAC	
	Current Capacity		20A (NEMA-Standard L14-20R)	
Engine Start Key Switch	Rated Voltage	12VDC		
	Current Capacity	10A		
AC Circuit Breaker	Rated Voltage	250VAC		
	Current Capacity	21A	16A (2 Poles)	22A (2Poles)
DC Circuit Breaker	Rated Voltage	125VAC		
	Current Capacity	12A		
AC Voltage Selector Switch	Rated Voltage	-	250VAC	
	Current Capacity		25A	

Voltage Meter	Rated Voltage	120/240VAC
DC Output Receptacle	Rated Voltage	125VAC
	Current Capacity	10A

Generator Component Electrical Specifications

Model	Stator						Rotor			Rectifier		AVR	Brushes
	Armature Coil		Exciter Coil		DC Coil		Field Coil		Slip Ring Diameter	Rectifier		Auto Voltage Regulator	Brush Length
	VAC	Ω	VAC	Ω	VAC	Ω	VAC)	Ω	mm	VAC	Ω	Ω*1	mm
YDG2700EV-6EH	128	0.97	97	3.02	37.5	0.74	12	18.6	37.7	24	2.8	20	9
YDG3700EV-6EI	128	0.44	141	2.81	37.5	0.47	17	22.3	37.7	25	2.8	20	9
YDG5500EV-6EI	128	0.21	131	2.27	37.5	0.39	22	27.6	44.6	13.5	2.8	20	9
Operation Limit (% against standard value)	±10	±20	±10	±20	±10	±20	±10	±20	-4	±10	±30	±30	-55

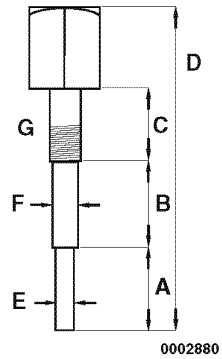
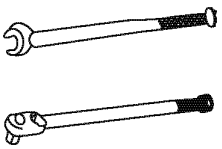
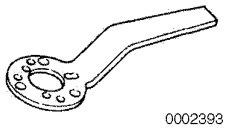
Note: All voltages listed are measured at the Engine Maximum Rated Output - 3600 RPM.

Special Torque Specifications

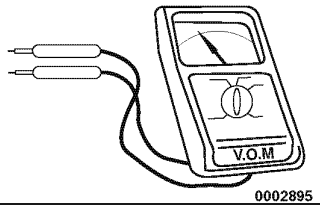
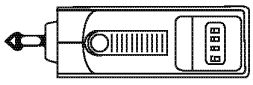
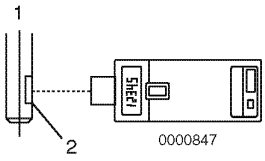
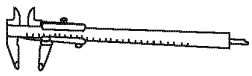
Component	Tightening Torque		Lubricating Oil Application (Thread Portion and Seat Surface)
	YDG2700EV-6EH	YDG3700EV-6EI YDG5500EV-6EI	
Rotor Bolt	173.5 - 216.8 lb-in. (19.6 - 24.5 N·m, 2.0 - 2.5 kgf/m)	173.5 -260.2 lb-in. (19.6 - 29.4 N·m, 2.0 - 3.0 kgf/m)	Not Applied
Front Housing Bolts (To engine crankcase)	173.5 - 216.8 lb-in. (19.6 - 24.5 N·m, 2.0 - 2.5 kgf-m		Not Applied
Generator Damper Mount Bolts	130.1 - 216.8 lb-in. (14.7 - 24.5 N·m, 1.5 - 2.5 kgf/m)	173.5 - 260.2 lb-in. (19.6 - 29.4 N·m, 2.0 - 3.0 kgf/m)	Not Applied
Rear Housing Bolts (To front housing)	43.4 - 69.0 lb-in. (4.9 - 7.8 N·m, 0.5 - 0.8 kgf/m		Not Applied
AVR Bolts	27.4 - 62.8 lb-in. (3.1 - 7.1 N·m, 0.3 - 0.7 kgf/m		Not Applied

Note: See“Tightening Torques for Standard Bolts and Nuts” on page 33, for standard hardware torque values.

SPECIAL TOOLS

Tool Name	Applicable Model (YDG)	Schematic Drawing	Description	Part Code
Rotor Puller	2700VE-6EH		A = 1.38 in. (35 mm), B = 6.10 in. (155 mm), C = 0.98 in. (25 mm), D = 9.25 in. (235 mm), E = 0.26 in. (6.5 mm), F = 0.31 in. (8 mm), G = M10 x 1.5	183754-92350
	3700EV-6EI		A = 1.57 in. (40 mm), B = 6.06 in. (154 mm), C = 1.18 in. (30 mm), D = 9.61 in. (244 mm), E = 0.32 in. (8.2 mm), F = 0.39 in. (10 mm), G = M112 x 1.5	183854-92350
	5500EV-6EI		A = 1.57 in. (40 mm), B = 7.87 in. (200 mm), C = 1.97 in. (50 mm), D = 12.20 in. (310 mm), E = 0.32 in. (8.2 mm), F = 0.39 in. (10 mm), G = M112 x 1.5	183976-92350
Torque Wrench (Available Locally)			-	-
Flywheel Holder			-	-

MEASURING INSTRUMENTS

Tool Name	Applicable Model (YDG)	Schematic Drawing	Description	Part Code
Multimeter Note: Analog VOM meter is required for some tests.	All Models		N/A	Obtain locally
Tachometer	All Models		Contact Type -For measuring revolution by contacting the mortise in the revolving shaft.	
			Photoelectric Type - For Measuring revolution by sensing the reflecting mark on the outer periphery of the revolving shaft. 1-Revolving Shaft 2-Reflection Mark	
Calipers	All Models		0 - 5.91 in. (0 - 150 mm) by 0.05 unit	

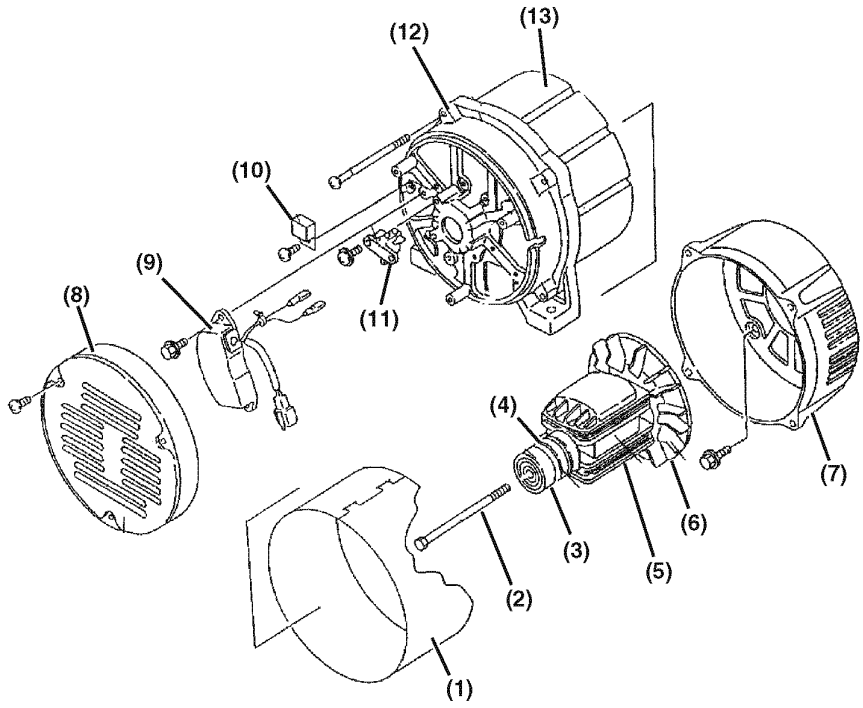
COMPONENTS

Generator

The generator is a self-exciting, single-phase AC generator with brushes.

The generator rear housing **(Figure 7-1, (12))** houses the stator **(Figure 7-1, (13))** and rotor assembly **(Figure 7-1, (5))** and provides support for the rotor bearing **(Figure 7-1, (3))**. Electrical parts mounted in the rear housing include the (AVR) automatic voltage regulator **(Figure 7-1, (9))**, the rectifier **(Figure 7-1, (10))**, and the brush holder and brushes **(Figure 7-1, (11))** all of which are protected by the end cover **(Figure 7-1, (8))**.

The rotor assembly includes field coil windings, a cooling fan **(Figure 7-1, (6))**, a sealed ball bearing all integrated onto a common shaft. The rotor shaft is connected to the engine crankshaft by a taper fit fastened with a bolt **(Figure 7-1, (2))** through the rotor shaft.



1 – Band
2 – Rotor Through-Bolt
3 – Ball Bearing
4 – Slip Ring
5 – Rotor
6 – Cooling Fan
7 – Front Housing
8 – End Cover
9 – Automatic Voltage Regulator (AVR)
10 – Rectifier
11 – Brush Holder and Brushes
12 – Rear Housing
13 – Stator

Figure 7-1

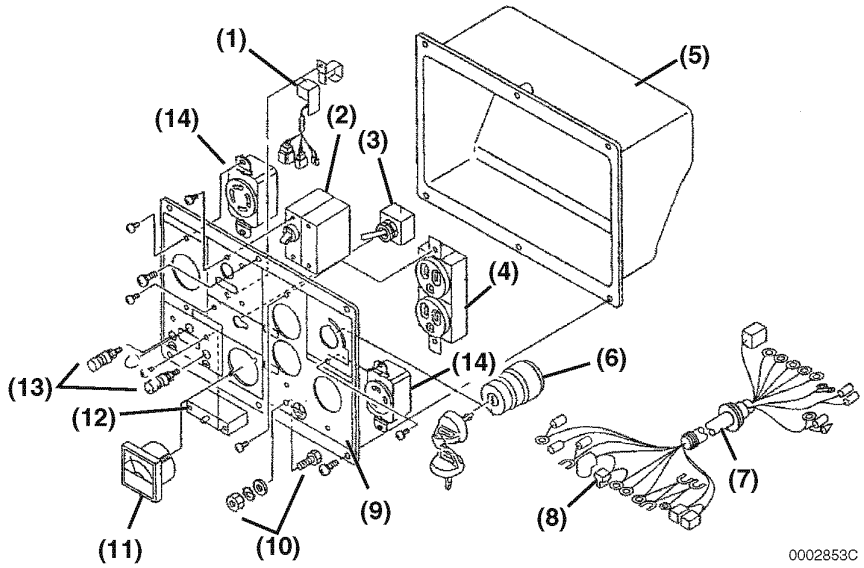
CONTROL PANEL AND GENERATOR

Control Panel

The control panel unit consists of the control panel **(Figure 7-2, (9))**, the panel box **(Figure 7-2, (5))** which covers the rear of the control panel, electrical devices and wiring harness **(Figure 7-2, (7))**.

The control panel includes an AC receptacle **(Figure 7-2, (4))**, DC terminals **(Figure 7-2, (13))**, AC line voltage selection switch **(Figure 7-2, (3))**, voltage meter **(Figure 7-2, (11))**, AC breaker **(Figure 7-2, (2))** with switch function, DC breaker **(Figure 7-2, (12))** without switch function, grounding terminal **(Figure 7-2, (10))**, relay **(Figure 7-2, (1))** for automatically stopping the engine in an emergency and various other electrical parts.

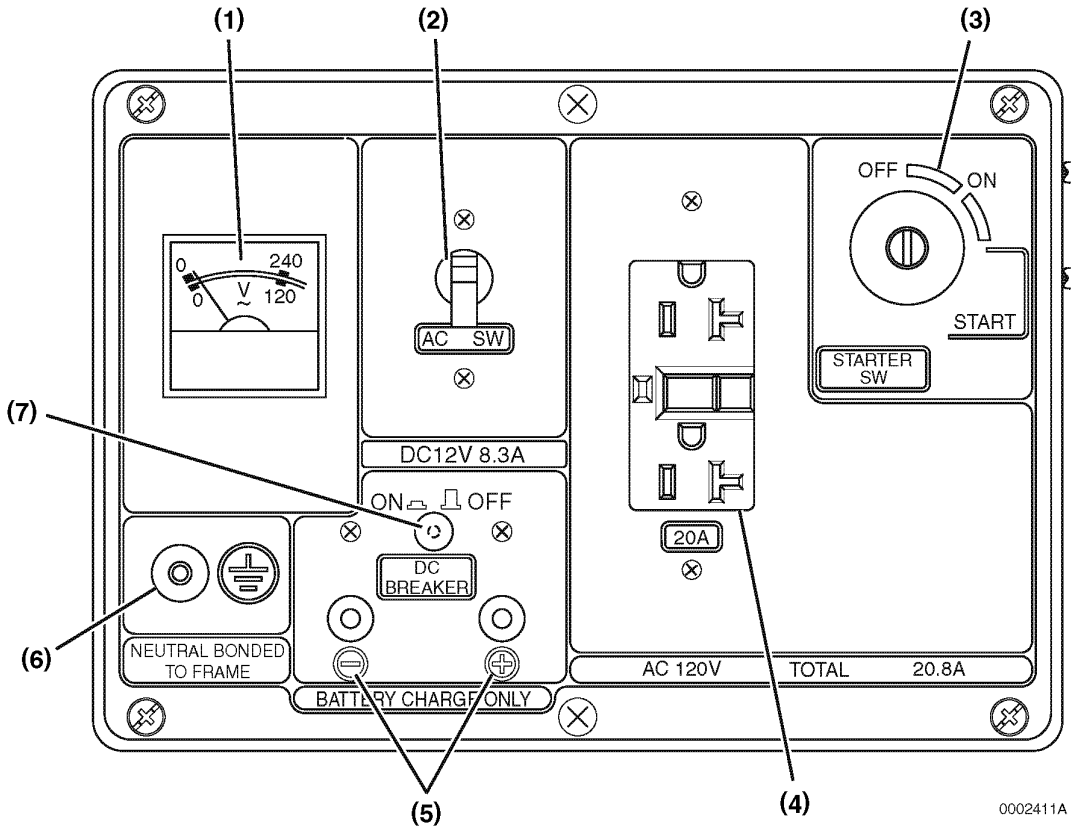
YDG3700EV-6EI / YDG5500EV-6EI Control Panel



1 – Relay
2 – AC Breaker (Generator Main Switch-Circuit Breaker)
3 – AC Line Voltage Switch
4 – AC Receptacle (Standard)
5 – Panel Box
6 – Key Switch
7 – Wire Harness
8 – Wire Connectors
9 – Control Panel
10 – Grounding Terminal
11 – Voltage Meter
12 – DC Breaker
13 – DC Terminals
14 – AC Receptacles (Twist Lock)

Figure 7-2

Control Panel Layout - Model YDG2700EV-6EH

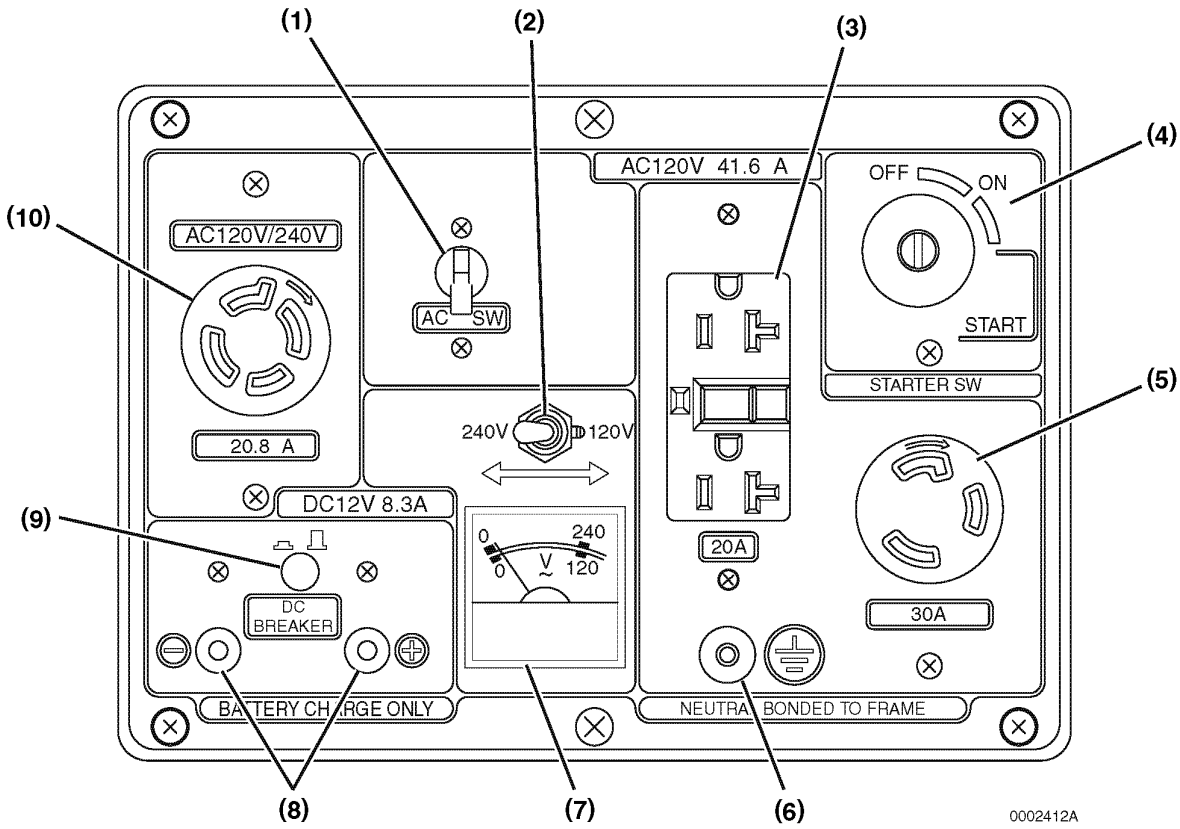


1 – Voltage Meter
2 – AC Circuit Breaker (Generator Main Switch-Circuit Breaker)
3 – Engine Start Key Switch
4 – 120VAC Receptacle with GFCI
5 – 12VDC Output Receptacle (For 12VDC Battery Charging Only)
6 – Grounding Terminal
7 – DC Circuit Breaker

Figure 7-3

CONTROL PANEL AND GENERATOR

Control Panel Layout - Model YDG3700EV-6EI, YDG5500EV-6EI



1 – AC Circuit Breaker (Generator Main Switch-Circuit Breaker)
2 – Voltage Selector Switch (120/240VAC)
3 – 120VAC Receptacle with GFCI
4 – Engine Start Key Switch
5 – 120VAC Twist Lock Receptacle
6 – Grounding Terminal
7 – Voltage Meter
8 – 12VDC Receptacle (For 12VDC Battery Charging Only)
9 – DC Circuit Breaker (12VDC Output)
10 – 120/240VAC Twist Lock Receptacle

Figure 7-4

GENERATOR

General Information

Within this section a *"Quick Reference AC Voltage Output Troubleshooting Chart" on page 23* and electrical schematics on page *7-17* and *7-19* are provided with detailed testing procedures to help diagnose generator electrical problems. The troubleshooting steps are structured in sequence to systematically test the components of the generator in an accurate and efficient manner.

Basic generator and control panel component service and inspection procedures are also provided within this section.

Basic Operation

When the engine is started the permanent magnets of the rotor assembly (connected to the engine crankshaft) rotate inside the stator assembly. AC voltage is generated from the rotation of the rotor inducing alternating current into the exciter coil on the stator.

The exciter coil AC voltage is then converted into DC voltage and regulated by the AVR (Automatic Voltage Regulator). This regulated DC voltage is then supplied from the AVR through the brushes and into the rotor field coil. This excitation of the rotor field coil causes the magnetism of the rotor to increase by creating a variable strength electromagnet. The AVR measures AC output voltage and regulates the DC coil voltage to maintain a specified AC voltage under varying electrical load conditions.

When magnetism strength of the rotor is increased, electrical current is induced into the AC armature coils on the stator assembly. This AC voltage is then directed to the AC receptacles on the control panel. The AC voltage output is proportional to rotor speed, therefore the engine must operate at 3600 RPM continuously to provide the maximum voltage output under load.

DC voltage is generated from the rotation of the rotor inducing AC current into the DC coil on the stator. The AC voltage is directed to a rectifier that changes the AC voltage into DC voltage and then is directed to the DC receptacles on the control panel.

Measuring Voltage

Both AC (Alternating Current) and DC (Direct Current) circuits are used in the generator. When performing DC electrical tests, confirm the polarity ((+) positive and (-) negative) of the circuit before connecting a test meter.

All voltages are to be measured at No-Load Maximum Speed (engine running at 3600 RPM with no electrical load connected to the generator).

Measuring Resistance

Temperature can affect resistance measurements. Resistance measurements should be taken at or near 68°F (20°C) ambient temperature.

It may be necessary to measure the resistance of components while the components are at or near operating temperature (hot), in order to find a problem with a component that may only occur when hot. Under these circumstances it is recommended to record measurements at operating temperature and at ambient temperature.

Electrical parts may contain diodes. Pay attention to measurements as measured values vary in the forward and reverse directions.

Electrical Schematic - YDG2700EV-6EH

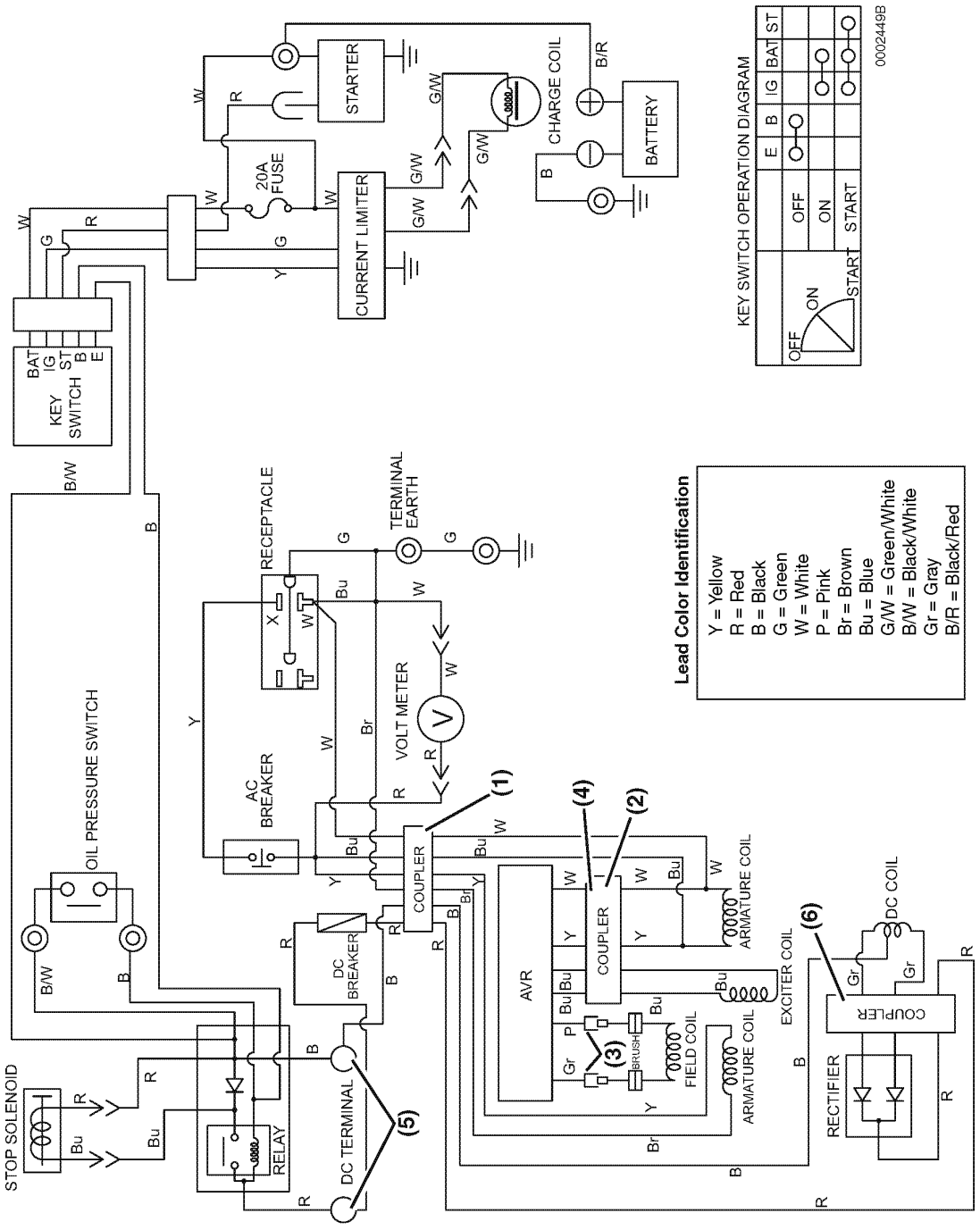


Figure 7-5

Electrical Schematic - YDG2700EV-6EH
Electrical Test Connector Identification

1. Armature Coil Voltage and Resistance Tests - *See Armature Coil Voltage Test on page 7-27* and *See Armature Coil Resistance Test on page 7-28*.
   - Single six lead connector. Tests are preformed on the armature coil side of the harness connector.
2. Exciter Coil Voltage and Resistance Tests - *See Exciter Coil Voltage Test on page 7-29* and *See Exciter Coil Resistance Test on page 7-29*.
   - Single four lead connector. Tests are preformed on the exciter coil side of the harness connector.
3. Field Coil Voltage Test - *See Field Coil Voltage Test on page 7-30*.
   - Two single lead connectors. Test is preformed at each connector while connected.
4. AVR Circuit Continuity Test - *See AVR (Automatic Voltage Regulator) Circuit Continuity Test on page 7-32*.
   - Two single lead connectors and one four lead connector. Tests are preformed with all connectors and leads disconnected from the AVR on the AVR.
5. DC Voltage Receptacle Test and DC Rectifer Voltage Tests - *See DC Voltage Receptacle Test on page 7-33* and“DC Rectifier Voltage Test” on page 35.
   - Two single female terminals located on the front of the control panel. Tests are performed with meter test leads on each DC terminal on the control panel.
   - DC Rectifier Voltage Test (Secondary Test)
   - Single six lead connector. Test is performed with connector disconnected, on the rectifier side of the connector.
6. DC Coil Voltage and DC Coil Resistance Tests.
   - Single four position connector (ONLY three leads are used), there is one empty position in the connector). Tests are performed with the connector disconnected from the DC rectifer, testing leads in connector to DC coil.
   - 6A. DC Rectifier Test - Single four position connector (ONLY three leads are used), there is one empty position in the connector). Tests are performed with the connector disconnected from the DC rectifer, testing the terminals on the DC rectifier.

Electrical Schematic - YDG3700EV-6EI, YDG5500EV-6EI

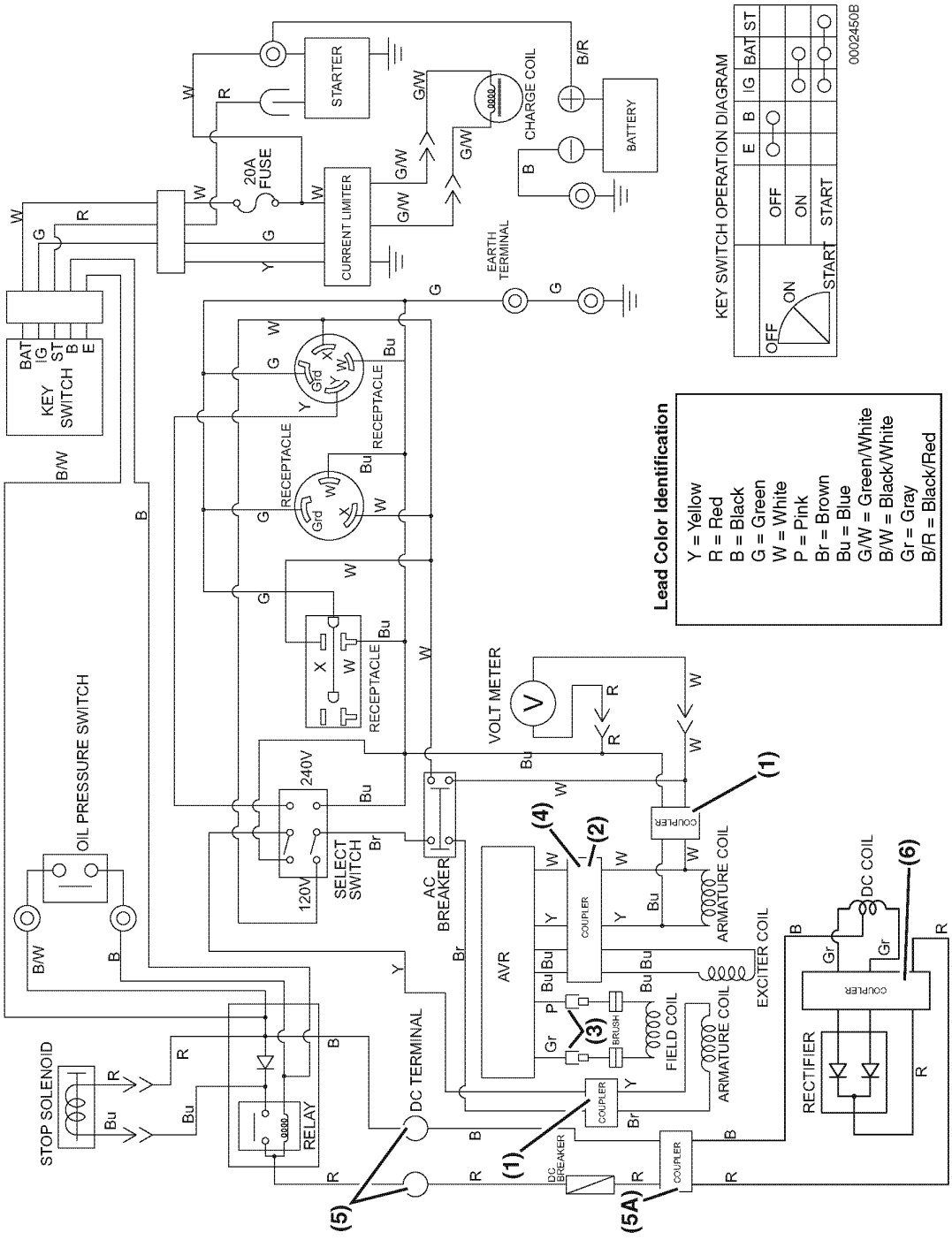


Figure 7-6

Electrical Schematic - YDG3700EV-6EI, YDG5500EV-6EI
Electrical Test Connector Identification

1. Armature Coil Voltage and Resistance Tests - *See Armature Coil Voltage Test on page 7-27* and *See Armature Coil Resistance Test on page 7-28*.
   - Two separate two lead connectors. Tests are preformed on the armature coil side of the harness connector.
2. Exciter Coil Voltage and Resistance Tests - *See Exciter Coil Voltage Test on page 7-29* and *See Exciter Coil Resistance Test on page 7-29*.
   - Single four lead connector. Tests are preformed on the exciter coil side of the harness connector.
3. Field Coil Voltage Test - *See Field Coil Voltage Test on page 7-30*.
   - Two single lead connectors. Test is preformed at each connector while connected.
4. AVR Circuit Continuity Test - *See AVR (Automatic Voltage Regulator) Circuit Continuity Test on page 7-32*.
   - Two single lead connectors and one four lead connector. Tests are preformed with all connectors and leads disconnected from the AVR on the AVR.
5. DC Voltage Receptacle Test and DC Rectifer Voltage Tests - *See DC Voltage Receptacle Test on page 7-33* and *See DC Rectifier Voltage Test on page 7-35*.
   - Two single female terminals located on the front of the control panel. Tests are performed with meter test leads on each DC terminal on the control panel.
   - 5A DC Rectifier Voltage Test (Secondary Test) - Single two terminal connector. Test is performed with connector disconnected, on the rectifier side of the connector.
6. DC Coil Voltage and DC Coil Resistance Tests.
   - Single four position connector (ONLY three leads are used), there is one empty position in the connector). Tests are performed with the connector disconnected from the DC rectifer, testing leads in connector to DC coil.

   6A. DC Rectifier Test - Single four position connector (ONLY three leads are used), there is one empty position in the connector). Tests are performed with the connector disconnected from the DC rectifer, testing the terminals on the DC rectifier.

BEFORE TROUBLESHOOTING

To make a quick and accurate diagnosis of generator problems, the following procedure can be used to determine the area of failure and then to identify component(s) failure.

1. Confirm generator set model and serial number.
2. Ask customer:
   - for a detailed repair history
   - to describe failure
   - to describe under what operating conditions the failure occurred
   - what size and type of electrical load is powered by the generator during the failure
   - to describe when the failure occurs
3. Check for modification of the generator or use of unsuitable replacement parts.
4. Perform visual inspection of the generator set. Inspect for excessive dust or dirt, water ingestion, corrosion, general damage and signs of overheating.
   - Review the following troubleshooting information:.
   - Effects on generator components from operation in high moisture conditions. (On this page)
   - “Effects on generator components from electrical overload” on page 22.
   - “Effects on generator components from insufficient engine speed” on page 22.
5. Operate the generator to verify the problem or confirm the failure.
   - Determine if the problem is on the AC or DC voltage supply side and proceed to the appropriate troubleshooting procedure.
   - Proceed to the“AC Voltage Output Troubleshooting” on page 24.
   - Proceed to the“DC Voltage Output Troubleshooting” on page 33.

Effects on generator components from operation in high moisture conditions

The generator is not recommended for use in high moisture areas such as near oceans, lakes marshes or any body of water. Operation of the generator in the rain, snow or high humidity conditions is not recommended.

Do not allow water to enter the generator when washing. If water is ingested, use compressed air to blow as much of the residual water out of the generator and then run the generator to help dry or dissipate any remaining residual water.

The use of a pedestal or other suitable device is recommended to isolate the generator from any nearby water standing on the ground. Covers or containers may be used to help isolate the generator from rain or snow, however they must not interfere with the intake and exhaust air flow and cooling of the generator.

The following failure result list represents possible symptoms and failures that can occur when the generator is used in conditions where moisture and or water can be ingested into the generator.

- Rust or corrosion on metallic generator components.
- Slip rings, brushes and or brush holder show evidence of burning.
- Rotor bearings failed or show signs of corrosion or roughness while rotating
- Corrosion on surface of slip rings
- Damage or burning of slip ring insulator between slip rings
- Field coil burned, overheated or failed
- AVR failed due to field coil burned, overheated or failed.

Effects on generator components from electrical overload

Using loads that exceed the generators output capacity can overheat and damage the generator components.

The following failure result list represents possible symptoms and failures that can occur when the generator is used in a electrically overloaded condition.

The conditions listed below may also exhibit the following conditions while the generator is operated with or without a load connected. During overloaded operation current does not stabilize. Excessive or low voltage is present when a load is connected. Circuit breaker continues to trip or fails open or closed.

- Slip rings, brushes and or brush holder show evidence of burning or excessive dust from wear.
- Rotor bearings failed or show signs of dryness, discoloration or roughness while rotating
- Damage or burning of slip ring insulator between slip rings
- Field coil burned, overheated, expanded, discolored or failed
- Armature coil burned, overheated or failed
- Exciter coil burned, overheated or failed
- DC coil burned, overheated or failed
- AVR failed due to field coil or armature coil burned, overheated or failed.
- Circuit breaker fails open or closed

Effects on generator components from insufficient engine speed

The generator is designed to operate at a consistent operating speed of 3600 RPM. Operating the generator at speeds lower than 3600 RPM can cause overheating of generator components due to the generator struggling to supply power for the electrical load, even if the load is within the generators output capacity. In addition low engine speed does not allow the generator cooling fan (integrated to the rotor) to flow enough air to sufficiently cool the generator. Low engine RPM equates to low generator speed, which equates to low generator output and insufficient cooling.

The following failure result list represents possible symptoms and failures that can occur when the generator is used at speeds under 3600 RPM.

- Slip rings, brushes and or brush holder show evidence of burning or excessive dust from wear.
- Rotor bearings failed or show signs of dryness, discoloration or roughness while rotating
- Damage or burning of slip ring insulator between slip rings
- Field coil burned, overheated, expanded, discolored or failed
- Armature coil burned, overheated or failed
- Exciter coil burned, overheated or failed
- DC coil burned, overheated or failed
- AVR failed due to field coil or armature coil burned, overheated or failed.

Quick Reference AC Voltage Output Troubleshooting Chart

Possible Cause	Trouble Symptom	No generation of AC power	No AC voltage is generated under load	AC Power is generated: AC Voltage is excessive	AC Power is generated: AC Voltage is low	AC Power is generated: AC Voltage drops when loaded	AC Power is generated: AC Voltage surges
	Check engine operation	O	O			O	O
Control Panel	AC circuit breaker is OFF or faulty	O			O	O	
Control Panel	GFCI receptacle is OFF or faulty	O			O		
Control Panel	120 / 240VAC Voltage switch faulty	O			O		
Control Panel	120/240VAC Twist lock receptacle faulty				O		
Control Panel	Wiring harness / electrical connection - open, short or poor connection	O		O	O	O	O
Control Panel	Voltmeter faulty	O	O	O	O	O	O
Generator Unit	Brushes - open or poor connection	O	O	O	O	O	O
Generator Unit	Slip Ring - dirty or damaged surface	O	O	O	O	O	O
Generator Unit	Rotor - Loss of residual magnetism	O	O		O	O	
Generator Unit	Exciter Coil - open or shorted	O			O	O	
Generator Unit	Auto Voltage Regulator (AVR) - inoperative	O		O	O	O	
Generator Unit	Wiring harness / electrical connection - open, short or poor connection	O		O	O	O	O
Generator Unit	Armature Coil Circuit - open or shorted	O	O		O	O	O
Generator Unit	Field Coil Circuit - open or shorted (check when hot)	O			O		O
Load	Electrical Output Overload - Check load		O	O			
Load	Electrical Output Unbalanced - Check load					O	

AC VOLTAGE OUTPUT TROUBLESHOOTING

DANGER! REVIEW the safety information at the beginning of this section and in the safety section of this manual (*See Safety on page 3-1*), BEFORE performing any of the following procedures.

AC Voltage Receptacle Test

All models are equipped with one 120VAC GFCI receptacle **(Figure 7-7)**. The GFCI receptacle is protected by a Ground Fault Circuit Interrupter (GFCI) unit.

Test the GFCI function of the receptacle, depress the TEST button. The RESET button should extend. If the RESET button does not extend, replace the receptacle.

Note: YDG3700EV-6EI and YDG5500EV-6EI models are also equipped with twist lock AC receptacles for 120VAC and 120VAC / 240VAC outputs.

1. Start and run engine at the maximum rated output engine RPM of 3600 RPM, and switch the main circuit breaker to the ON position.
2. Using a test meter set to read AC voltage, check each of the outlets for output voltage at the 120VAC receptacles **(Figure 7-7)**. The polarity of the test leads are not critical.

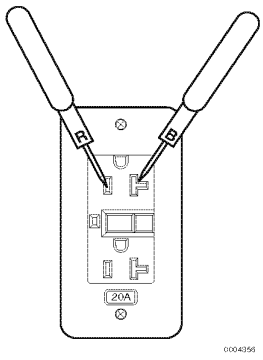


Figure 7-7

Test Results

Voltage Output at 120VAC Receptacle	
YDG2700EV-6EH	128 ± 10VAC
YDG3700EV-6EI	
YDG5500EV-6EI	

If the 120VAC receptacle voltage measured is within specifications, test voltage output of the 120VAC / 240VAC receptacle (move voltage selector switch to 120VAC / 240VAC position) if applicable.

- If voltage measured on 120VAC / 240VAC receptacle is within specifications, Check and repair the driven machine (electrical appliance) for overload or failure.

If the 120VAC or 120VAC / 240VAC receptacle voltage measured is not within specifications:

1. Check engine RPM, *See Engine RPM Check on page 7-25*.
2. Check the AC circuit breaker, *See AC Circuit Breaker Check on page 7-26*.
3. Check the voltmeter, *See Voltmeter Check on page 7-25*.
4. Check the AC receptacle for failure. Repair or replace as necessary and re-test.
5. Test 120VAC and 120VAC / 240VAC selector switch for continuity and correct operation, replace if needed and retest.
6. Check the harness leads and connections between the control panel and the AC receptacle for failure or looseness.
   - Check the wiring harness terminals for corrosion and clean or replace terminals as needed.
   - Check the resistance (electrical continuity) between the harness and receptacle terminals. There should be minimal to no resistance. If the resistance is excessive, check for open circuit or excessive corrosion of terminals, replace or repair components as needed.

- Check the condition of the wiring harness **(Figure 7-8)** looking for cracks or hardening of the insulation on the wires. Replace as needed.

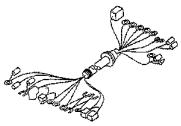


Figure 7-8

Engine RPM Check

Start and run the engine. Verify the engine runs continuously at the maximum rated output engine RPM of 3600 RPM with no electrical load attached to the generator.

If the engine does not run continuously at 3600 RPM verify the mechanical condition and performance of the engine and repair as necessary and re-test. *NOTICE: ALWAYS run the engine at full speed. NEVER run engine at lower speeds. At full speed, the engine runs at 3600 rpm under load. The engine must maintain 3600 rpm for generator to create correct voltage. Running engine at lower speeds will damage generator and powered items.*

Verify the generator is not mechanically failed and is not binding or dragging and preventing the engine from performing properly. If the generator is mechanically failed, *See Generator and Control Panel Service on page 7-39.*

Voltmeter Check

1. Check the control panel voltmeter **(Figure 7-9)** for proper operation. The volt meter should display the rated voltage during operation. If the meter does not display the correct voltage:
   - Check the terminals for corrosion and clean or replace terminals as needed.
   - Check the face of the voltmeter for any evidence of corrosion or water entry, replace as needed.
   - Does the needle zero properly? Replace as needed.

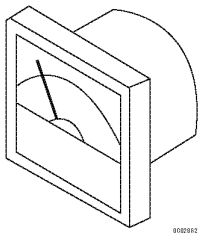


Figure 7-9

2. Proceed to"AC Circuit Breaker Check" on page 26.

AC Circuit Breaker Check

The main AC circuit breaker is a no-fuse type breaker with switch function.

Trip Check

1. With the engine running, check the main breaker **(Figure 7-10)** operation and position. If the main breaker has tripped, reset the main breaker and reapply the load.

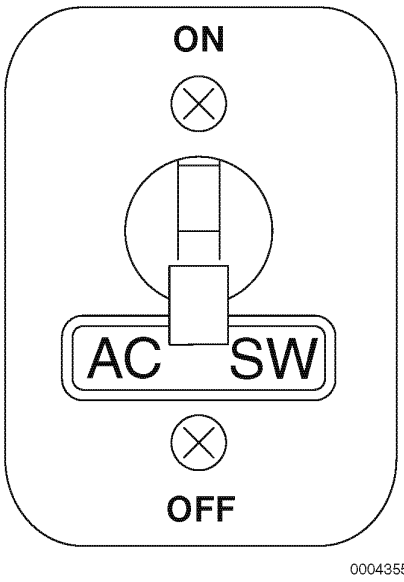


Figure 7-10

Results

1. If the main breaker trips, while a load is connected, disconnect the load and reset the breaker.
   - If the main breaker does not trip with the load disconnected, check and repair the driven machine (electrical appliance) for any lead insulation breakdown, current leakage or over load. Repair or replace as necessary and re-test.
   - If the main breaker trips when the load is disconnected, check all leads from generator and control panel and check for any lead insulation breakdown or current leakage. Check the voltage selector switch and all AC receptacles for failure. Repair or replace as necessary and re-test.
   - If the main breaker has failed or is not is proper working order:
     1 – Check the main breaker terminals for corrosion and burning, clean or replace as needed.
     2 – Check the mechanical operation of the reset switch, replace as needed.
     3 – Check the resistance (electrical continuity) between the terminals. There should be minimal to no resistance. Replace the breaker if found faulty or in question.
2. If the main breaker is in proper working condition and the original problem exists proceed to“Armature Coil Voltage Test” on page 27.

Armature Coil Voltage Test

Note: YDG2700EV-6EH models only, remove the battery cables from the battery and remove the battery from the battery tray.

1. With the engine not running, remove the three generator end cover screws **(Figure 7-11, (1))** and cover **(Figure 7-11, (2))**.

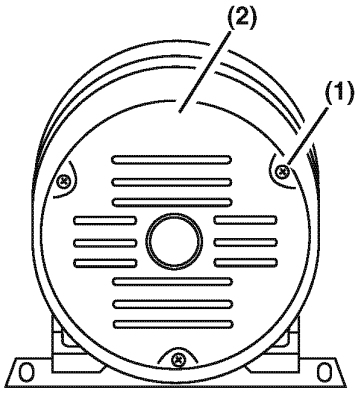


Figure 7-11

2. Disconnect the armature coil lead coupler(s) **(Figure 7-12, (1) - YDG2700EV-6EH)** or **(Figure 7-12, (2) - YDG3700EV-6EI and YDG5500EV-6EI)** between the generator and the control panel. *See Electrical Schematic - YDG2700EV-6EH on page 7-17* ***(Callout (1))*** or *See Electrical Schematic - YDG3700EV-6EI, YDG5500EV-6EI on page 7-19* ***(Callout (1))*** depending on model being serviced.
3. Check the terminals for corrosion. Clean or replace components as needed.

Note: On YDG2700EV-6EH models only, reconnect the battery cables to the battery with the battery outside of and next to the frame of the generator. This is necessary in order to allow access to the rear of the generator to be operated for testing. It may be necessary to reposition the battery cable from the front engine mount bolt to the rear engine mount bolt in order for the battery cable to reach the battery.

4. While running the engine at the maximum rated output engine RPM of 3600 RPM, use an AC test meter and check the output voltage at the armature coil lead coupler(s) on the armature coil side between the white and blue leads and then between the brown and yellow leads.

Note: In **(Figure 7-12, (1) - YDG2700EV-6EH)** and **((Figure 7-12, (2) - YDG3700EV-6EI and YDG5500EV-6EI)** the solid circles represent test meter lead connections (positive to negative) between the dashed lines. The polarity of the test meter leads is not critical.

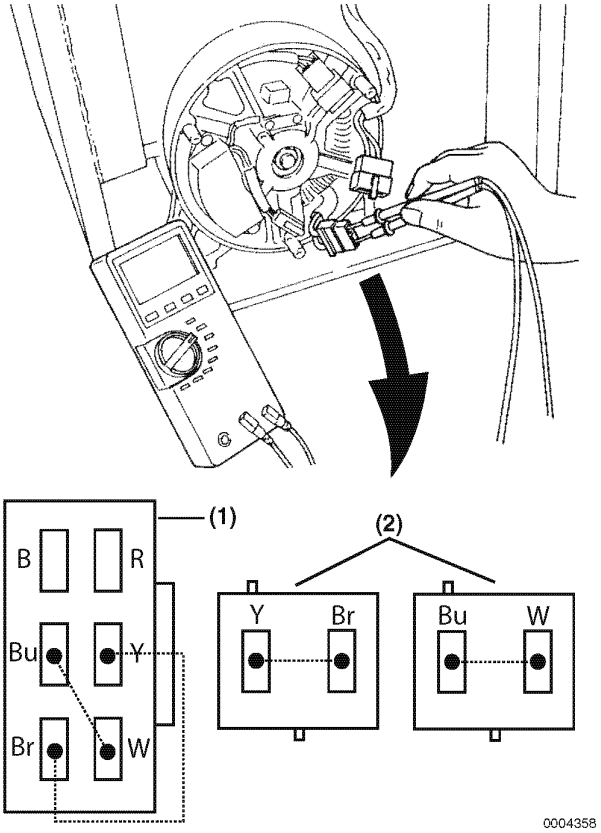


Figure 7-12

CONTROL PANEL AND GENERATOR

Test Results

Voltage Output at Armature Coil	
YDG2700EV-6EH	128 ± 12.8VAC
YDG3700EV-6EI	
YDG5500EV-6EI	

1. If output voltage is within specifications re-check wiring and receptacles from armature coil connector to the control panel and receptacles
2. If the voltage is not within specifications proceed"Armature Coil Resistance Test" on page 28.

Armature Coil Resistance Test

1. With the engine not running, disconnect the armature coil lead coupler(s) **(Figure 7-13, (1) - YDG2700EV-6EH) or (Figure 7-13, (2) - YDG3700EV-6EI and YDG5500EV-6EI)** between the generator and the control panel. *See Electrical Schematic - YDG2700EV-6EH on page 7-17* ***Callout (1)*** or *See Electrical Schematic - YDG3700EV-6EI, YDG5500EV-6EI on page 7-19* ***Callout (1)*** depending on model being serviced.
2. Use an Ohm meter and check the resistance of the armature coil at the lead coupler(s) on the armature coil side between the white and blue leads and then between the brown and yellow leads.

Note: In **(Figure 7-13, (1) - YDG2700EV-6EH) and (Figure 7-13, (2) - YDG3700EV-6EI and YDG5500EV-6EI)** the solid circles represent test meter lead connections (positive to negative) between the dashed lines. The polarity of the test meter leads is not important.

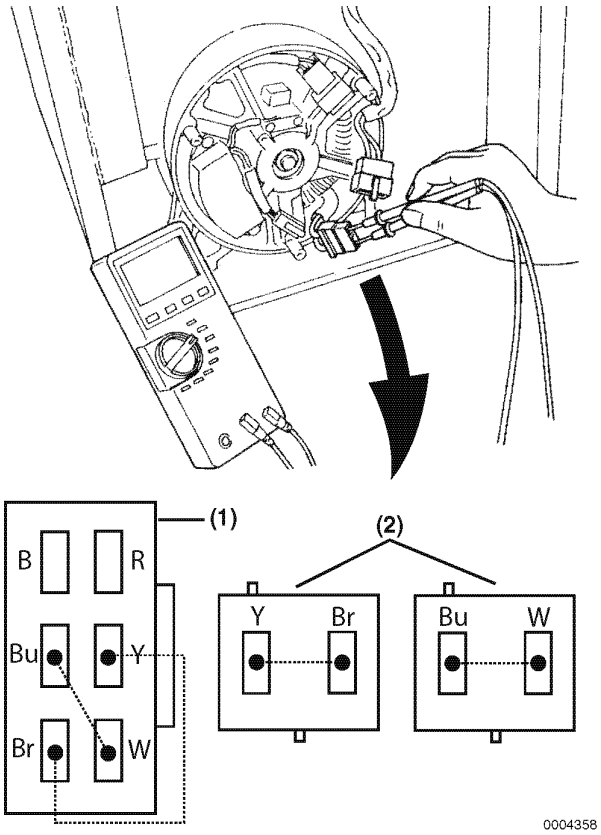


Figure 7-13

Test Results

Armature Coil Resistance Specifications	
YDG2700EV-6EH	0.97 ± 0.19 Ohms
YDG3700EV-6EI	0.44 ± 0.08 Ohms
YDG5500EV-6EI	0.21 ± 0.04 Ohms

1. If the output voltage measured in the"Armature Coil Voltage Test" on page 27 and or resistance is not within specifications, replace the stator and re-test"Armature Coil Voltage Test" on page 27.
2. If the output voltage measured in the"Armature Coil Voltage Test" on page 27 and or resistance is within specifications, proceed to"AVR (Automatic Voltage Regulator) Circuit Continuity Test" on page 32.

Exciter Coil Voltage Test

1. With the engine not running, disconnect the four terminal connector from the AVR to the exciter and armature coils (yellow, white, blue and blue leads). *See Electrical Schematic - YDG2700EV-6EH on page 7-17* ***Callout (2)*** or *See Electrical Schematic - YDG3700EV-6EI, YDG5500EV-6EI on page 7-19* ***Callout (2)*** depending on model being serviced.
2. Run the engine at maximum speed under no load (3600 RPM).
3. Using an AC volt meter measure the voltage between the blue lead and the other blue lead on the same connector on the exciter coil side **(Figure 7-14)**.

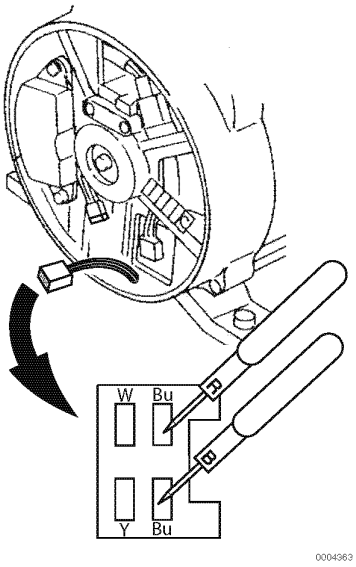


Figure 7-14

Test Results

Exciter Coil Voltage Specifications	
YDG2700EV-6EH	97 ± 9.7VAC
YDG3700EV-6EI	141 ± 14.1VAC
YDG5500EV-6EI	131 ± 13.1VAC

1. Record measurements and proceed to"Exciter Coil Resistance Test" on page 29.

Exciter Coil Resistance Test

1. With the engine not running, disconnect the four terminal connector from the AVR to the exciter and armature coils (yellow, white, blue and blue leads). *See Electrical Schematic - YDG2700EV-6EH on page 7-17* ***Callout (2)*** or *See Electrical Schematic - YDG3700EV-6EI, YDG5500EV-6EI on page 7-19* ***Callout (2)*** depending on model being serviced.
2. Using an Ohm meter measure the resistance between the blue lead and the other blue lead on the same connector on the exciter coil side **(Figure 7-15)**.

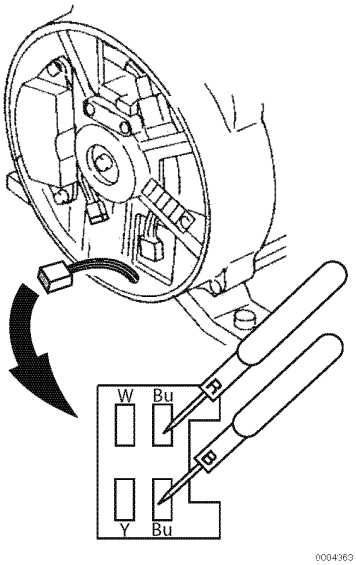


Figure 7-15

Test Results

Exciter Coil Resistance Specifications	
YDG2700EV-6EH	3.02 ± 0.60 Ohms
YDG3700EV-6EI	2.81 ± 0.56 Ohms
YDG5500EV-6EI	2.27 ± 0.45 Ohms

1. If the exciter coil voltage and resistance readings are within specifications, proceed to "Field Coil Voltage Test" on page 30.

2. If the voltage output measured in the“Exciter Coil Voltage Test” on page 29 and or exciter coil resistance is not within specifications:
   - Verify residual magnetism of rotor magnets and replace rotor if needed.
   - Replace stator and re-test.

Field Coil Voltage Test

1. Run the engine at maximum speed under no load (3600 RPM).
2. Using a DC volt meter **(Figure 7-16)**, measure the voltage between the pink lead and the gray lead terminals where the AVR connects to the brushes. *See Electrical Schematic - YDG2700EV-6EH on page 7-17* ***Callout (3).*** *See Electrical Schematic - YDG3700EV-6EI, YDG5500EV-6EI on page 7-19* ***Callout (3)*** depending on model being serviced.
3. Connect the positive test lead to the pink brush lead **(Figure 7-17, (1))**, and the negative test lead to the gray lead **(Figure 7-17, (2))**. The connectors from the AVR to the brushes must be left connected during measurement.

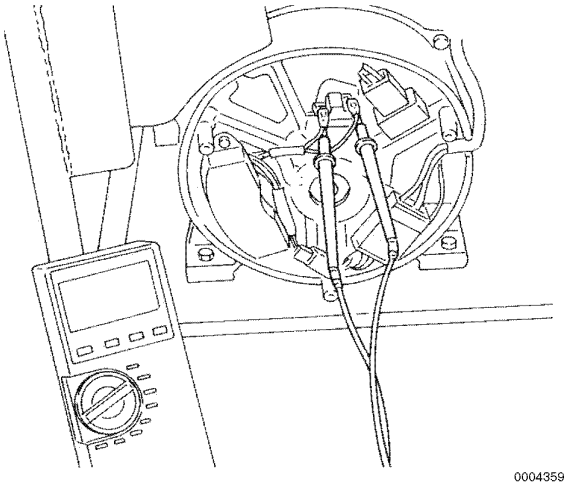


Figure 7-16

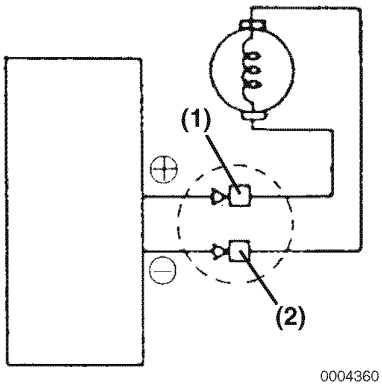


Figure 7-17

Test Results

Brush (Field Coil) Voltage Specifications	
YDG2700EV-6EH	12 ± 1.2VDC
YDG3700EV-6EI	17 ± 1.7VDC
YDG5500EV-6EI	22 ± 2.2VDC

1. Record the measurements and proceed to “Field Coil Resistance Test” on page 31.

Field Coil Resistance Test

1. With the engine not running, disconnect the brush connector (pink and gray leads) at the brush terminals, and remove the brushes and brush holder.
2. Using an Ohm meter measure the resistance in a suitable resistance range by applying the test leads of a tester to each of the slip rings **(Figure 7-19, (1))** on the rotor. Inspect the insulator ring **(Figure 7-19, (2))** for damage.

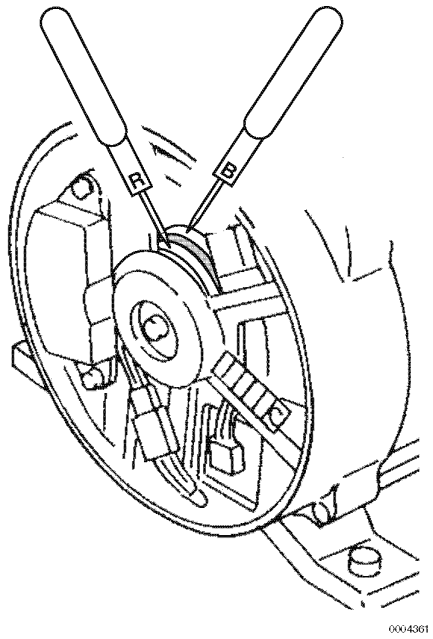


Figure 7-18

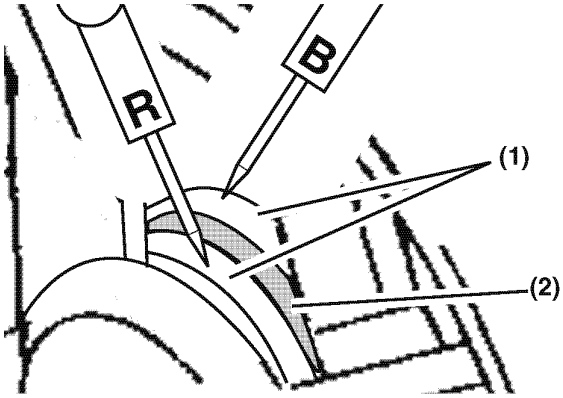


Figure 7-19

Test Results

Field Coil Resistance Specifications	
YDG2700EV-6EH	18.6 ± 3.7 Ohms
YDG3700EV-6EI	22.3 ± 4.4 Ohms
YDG5500EV-6EI	27.6 ± 5.5 Ohms

1. If the resistance and voltage is within specifications verify condition of:
   - Brushes, *See Brush Inspection on page 7-32*.
   - Rotor and slip rings, see rotor in"Visual Component Inspection" on page 41.
   - If the brushes and rotor are in good condition proceed to"AVR (Automatic Voltage Regulator) Circuit Continuity Test" on page 32.
2. If the field coil voltage measured in the"Field Coil Voltage Test" on page 30 and or resistance is not within specifications:
   - Check the brushes and connections and replace as needed, *See Brush Inspection on page 7-32*.
   - Check the condition of the slip rings, for pitting, scoring, carbonization or damage. The slip rings should be smooth and shiny. The slip rings may be dressed using very fine emery cloth or crocus cloth. Re-test to determine rotor condition, see rotor in"Visual Component Inspection" on page 41.
   - If the slip rings cannot be dressed the rotor must be replaced.
   - If the slip rings are in good condition and the resistance is not within specifications, replace the rotor and re-test.
3. If the brushes, rotor and slip rings are all in good condition, replace AVR and retest.

Brush Inspection

Note: Proper brush installation is very important. *See Reassembly and Installation of Generator on page 7-42*.

1. Measure brush length **(Figure 7-20, (1))** to check total wear and one-sided wear.

Results

Standard length	Minimum operating length
9 mm	4 mm

1. If the total wear is excessive or one brush is worn more than the other, replace the complete brush assembly. Inadequate contact can cause excessive resistance. Replace the brushes if there is any doubt of operation or condition.

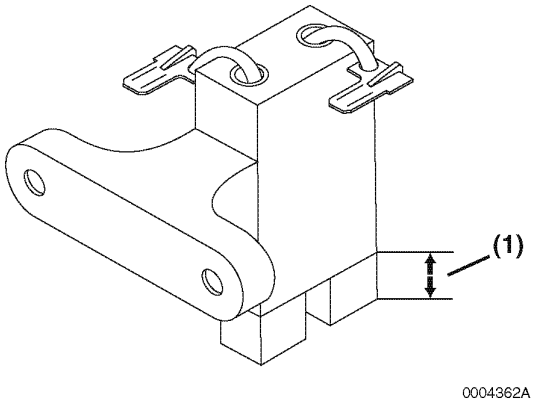


Figure 7-20

AVR (Automatic Voltage Regulator) Circuit Continuity Test

1. Disconnect the two terminal connector from the AVR to the brushes (pink and gray leads) and the four terminal connector from the AVR to the exciter and armature coils (yellow, white, blue and blue leads) **(Figure 7-21)**. *See Electrical Schematic - YDG2700EV-6EH on page 7-17* ***Callout (4)***. *See Electrical Schematic - YDG3700EV-6EI, YDG5500EV-6EI on page 7-19* ***Callout (4)*** depending on model being serviced.

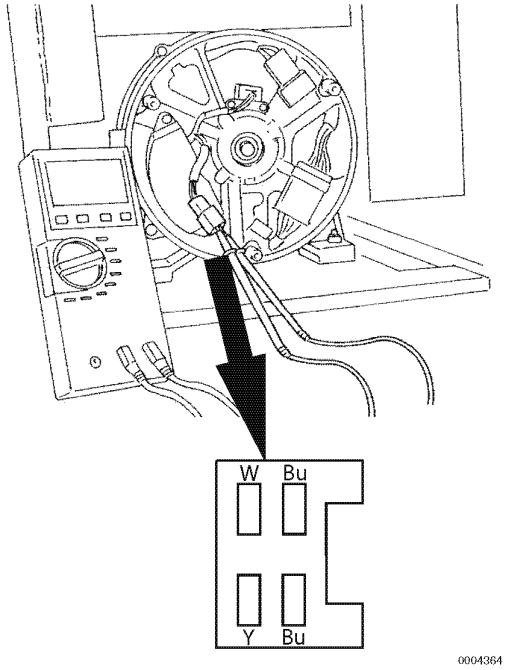


Figure 7-21

2. Check the terminals for corrosion. Clean or replace components as needed.
3. Measure the resistance of the AVR circuits as shown on the following chart.

Note: It is recommended that an analog Ohmmeter be used on R X 1 scale.

In the chart below:

NC = No Continuity or "Infinity" reading
C = Continuity (Approximately 25 Ohms)

AVR Resistance Specifications		Black Tester Lead (-)					
		Blue	Blue	Pink	Gray	White	Yellow
Red Tester Lead (+)	Blue		NC	NC	NC	NC	NC
	Blue	NC		NC	NC	NC	NC
	Pink	C	C		C	NCf	NC
	Gray	NC	NC	NC		NC	NC
	White	NC	NC	NC	NC		NC
	Yellow	NC	NC	NC	NC	NC	

Test Results

1. Replace the AVR if any measurement taken as shown in the chart above does not meet the specification and re-test for AC voltage output.
2. If the AVR resistance tests are correct and all previous steps determine all other components are in good condition, replace the AVR and re-test.

DC VOLTAGE OUTPUT TROUBLESHOOTING

DC Voltage Receptacle Test

All models are equipped with one 12VDC receptacle **(Figure 7-22)**.

1. Start and run engine at the maximum rated output engine RPM of 3600 RPM, and switch the DC circuit breaker to the ON position.
2. Using an DC test meter, check the output voltage at the 12VDC receptacles **(Figure 7-22)**.

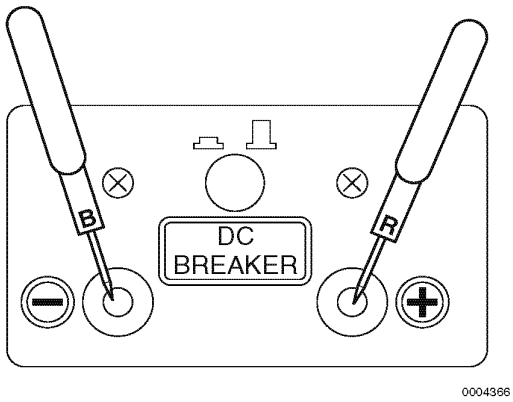


Figure 7-22

Test Results

Voltage Output at Receptacle	
YDG2700EV-6EH	14.5VDC ± 2.9VDC
YDG3700EV-6EI	
YDG5500EV-6EI	

If the 12VDC receptacle voltage measured is not within specifications:

1. *See Engine RPM Check on page 7-25.*
2. *See DC Circuit Breaker Check on page 7-34.*
3. Check the DC receptacle for failure. Repair or replace as necessary and re-test.
4. Check the harness leads and connections between the control panel and the DC receptacle for failure or looseness.

- Check the DC output terminals for corrosion and clean or replace terminals as needed.
- Check the resistance (electrical continuity) between wiring harness and DC output terminals. The resistance should measure 380 ± 76 Ohms. If the resistance is not within specifications, check for an open circuit or excessive corrosion of terminals, replace or repair components as needed.
- Check the condition of the wiring harness **(Figure 7-23)** check for cracks in the insulation covering the wires, replace as needed.

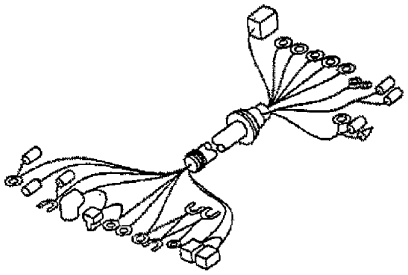


Figure 7-23

DC Circuit Breaker Check

If no or low voltage is measured on the DC receptacle, then verify the condition and position of the DC circuit breaker **(Figure 7-24)** on the control panel.

Note: The DC breaker is a no-fuse thermostat type breaker with a reset function.

- The DC breaker cannot be reset for about 10 seconds after operation. A thermostat type breaker must cool before it can reset.
- Check the terminals for corrosion and burning, clean or replace as needed.
- Check the mechanical operation of the reset button switch, replace the breaker as needed.
- Remove the wires from the two terminals on the rear of the breaker and check the resistance (continuity) between the terminals on the breaker. The resistance should measure 0.1 - 0.2 Ohms. If the resistance is not within specifications, check for damage, corrosion and replace the breaker if necessary.
- If the DC circuit breaker is in good condition and switched ON and no or low voltage is measured, proceed to"DC Rectifier Voltage Test" on page 35.

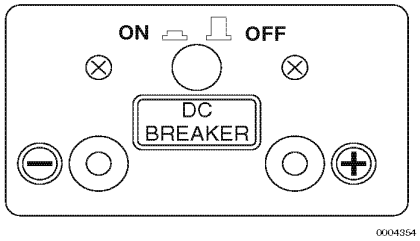


Figure 7-24

DC Rectifier Voltage Test

1. Run the engine at maximum speed under no load (3600 RPM).
2. Measure the voltage using an DC volt meter between the red and black receptacles on the control panel **(Figure 7-25)**.

   See Electrical Schematic - YDG2700EV-6EH on page 7-17 ***Callout (5)*** or *See Electrical Schematic - YDG3700EV-6EI, YDG5500EV-6EI on page 7-19* ***Callout (5)*** depending on model being serviced.

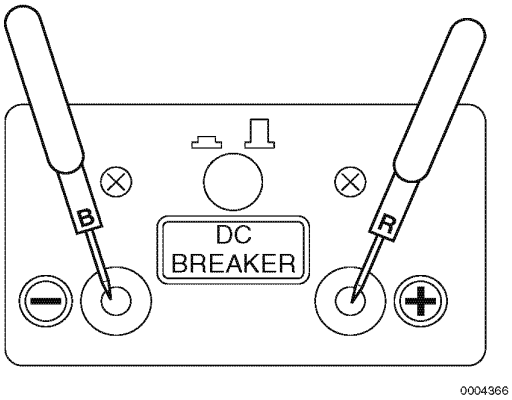


Figure 7-25

Test Results

DC Rectifier Voltage Specifications	
YDG2700EV-6EH	24 ± 2.4 VDC
YDG3700EV-6EI	25 ± 2.5 VDC
YDG5500EV-6EI	13.5 ± 1.3 VDC

1. If the voltage is within specifications, proceed to "DC Rectifier Resistance Test" on page 36.
2. **(Secondary Test)** If the voltage is not within specifications:
   - With the engine not running, disconnect the terminal connector between the DC rectifier and the control panel.
   - *See Electrical Schematic - YDG2700EV-6EH on page 7-17* ***(Callout (5)*** Secondary Test) or *See Electrical Schematic - YDG3700EV-6EI, YDG5500EV-6EI on page 7-19* (***Callout (5A)*** Secondary Test) depending on model being serviced.
   - Measure DC voltage with the engine running at 3600 RPM at the connector between the red and black leads on the rectifier side of the connector.
   - If the voltage is not within specifications, check all related leads to the breaker and rectifier. Repair or replace is needed.
   - If all related leads are in working condition, proceed to"DC Rectifier Resistance Test" on page 36.

DC Rectifier Resistance Test

1. With the engine not running, disconnect the 4 terminal connector from DC rectifier **(Figure 7-26, (3))** (only three leads are actually used in the connector, gray, gray and red).

   See Electrical Schematic - YDG2700EV-6EH on page 7-17 ***Callout (6A)*** or *See Electrical Schematic - YDG3700EV-6EI, YDG5500EV-6EI on page 7-19* ***Callout (6A)*** depending on model being serviced.

2. Use an Ohm meter and check the resistance of the DC rectifier between the gray and red terminals on the rectifier **(Figure 7-26, (3))** (use the matching lead connector to identify the terminals). Reverse the leads of the meter to measure resistance in both directions, resistance should only be present in one direction. Measure between the red lead and each gray lead and their opposites for a total of four total measurements.

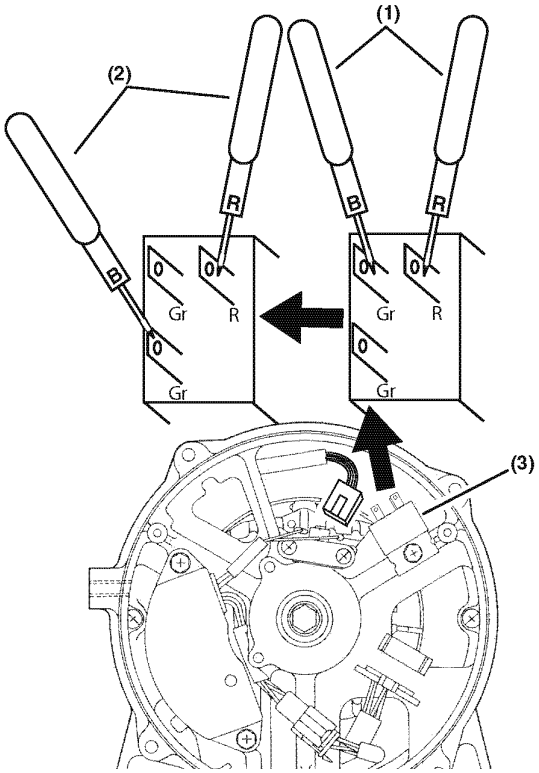


Figure 7-26

DC Rectifier Resistance Test			
	R (-)	Gr	Gr
R (+)	-	4	4
Gr	2.8 Ohms	-	4
Gr	2.8 Ohms	4	-

Test Results

DC Rectifier Resistance Specifications	
YDG2700EV-6EH	2.8 ±.8 Ohms
YDG3700EV-6EI	
YDG5500EV-6EI	

1. If resistance (continuity) can be measured in both directions **(Figure 7-26, (1))**, replace the rectifier and re-test.
2. If resistance (continuity) can be measured in both directions **(Figure 7-26, (2))**, replace the rectifier and re-test.
3. If the voltage measured in the“DC Rectifier Voltage Test” on page 35 and or resistance is not within specifications replace the rectifier and re-test.
4. If the voltage measured in the“DC Rectifier Voltage Test” on page 35 and or resistance is within specifications and the original problem still exists, proceed to“DC Coil Voltage Test” on page 37.

DC Coil Voltage Test

1. Disconnect the four terminal connector from the DC coil to the rectifier (only three leads are used, gray, gray and red).

See Electrical Schematic - YDG2700EV-6EH on page 7-17 ***Callout (6)*** or *See Electrical Schematic - YDG3700EV-6EI, YDG5500EV-6EI on page 7-19* ***Callout (6)*** depending on model being serviced.

1. Check the terminals for corrosion. Clean or replace components as needed.
2. Run the engine at maximum speed under no load (3600 RPM).
3. Measure the voltage using an AC volt meter between the gray and gray leads on the DC coil connector side **(Figure 7-27)**.

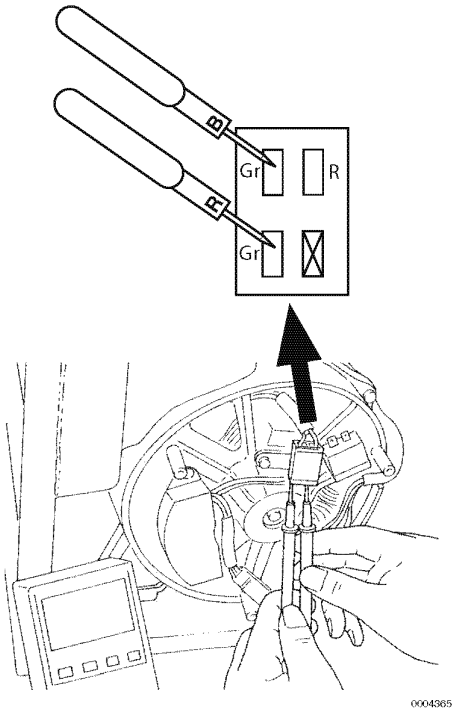


Figure 7-27

Test Results

DC Coil Voltage Specifications	
YDG2700EV-6EH	37.5 ± 7.5 VAC
YDG3700EV-6EI	37.5 ± 7.5 VAC
YDG5500EV-6EI	37.5 ± 7.5 VAC

1. Record measurements and proceed to"DC Coil Resistance Test" on page 37.

DC Coil Resistance Test

1. Disconnect the four terminal connector from the DC coil to the rectifier (only three leads are used, gray, gray and red).

   See Electrical Schematic - YDG2700EV-6EH on page 7-17 ***Callout (6)*** or *See Electrical Schematic - YDG3700EV-6EI, YDG5500EV-6EI on page 7-19* ***Callout (6)*** depending on model being serviced.

2. Use an Ohm meter and check the resistance of the DC coil between the gray and gray leads on the DC coil connector side **(Figure 7-28)**.

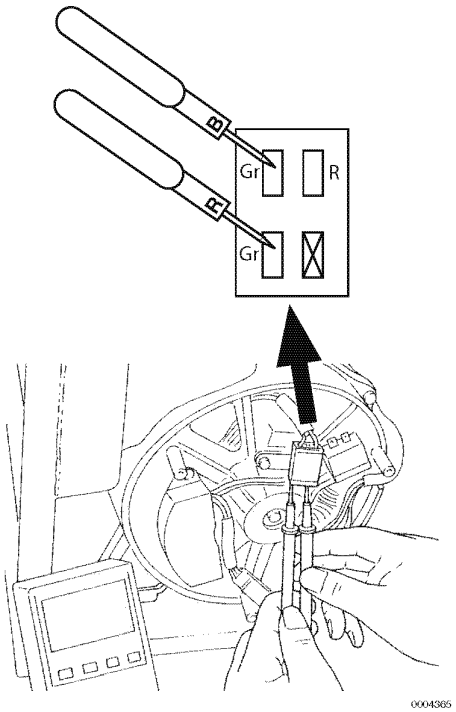


Figure 7-28

Test Results

DC Coil Resistance Specifications	
YDG2700EV-6EH	0.74 ± 0.14 Ohms
YDG3700EV-6EI	0.47 ± 0.09 Ohms
YDG5500EV-6EI	0.39 ± 0.78 Ohms

1. If the voltage measured in the“DC Coil Voltage Test” on page 37 and or resistance measured is not within specifications:
   - Verify the condition of the rotor and if found to be in good condition then replace the stator.

GENERATOR AND CONTROL PANEL SERVICE

Generator Disassembly

Note: Mark all electrical leads before disassembly to ensure correct reassembly.

NOTICE: Always disconnect the negative (-) terminal (black) first and then the positive (+) one (red).

1. Disconnect the positive (+) and negative (-) battery cables from the battery and remove the battery.
2. Remove the generator cover screws and the generator cover **(Figure 7-31, (1)).**

Note: YDG2700EV-6EH models use one six terminal connector **(Figure 7-29, (1))** from the control panel and one ground wire **(Figure 7-29, (2))** fastened to the rear housing.

Note: YDG3700EV-6EI and YDG5500EV-6EI models use three separate two terminal connectors **(Figure 7-30, (1, 2, 3))** from the control panel and one ground wire **(Figure 7-30, (4))** fastened to the rear housing.

3. Disconnect the electrical connectors from the control panel harness to the generator and ground wire inside generator.

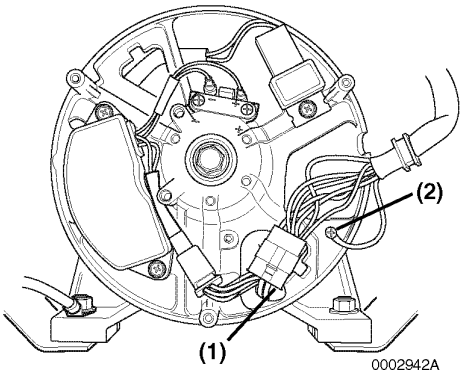


Figure 7-29

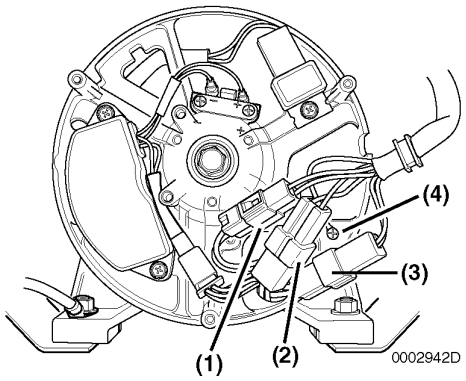


Figure 7-30

4. Disconnect the four terminal connector from the AVR and the pink and gray leads from the AVR to the brushes.
5. Remove the two bolts fastening the AVR **(Figure 7-31, (3))** and remove the AVR.
6. Disconnect the electrical connector from the rectifier and remove the one bolt fastening the rectifier **(Figure 7-31, (4))** and remove the rectifier.
7. Remove the two bolts fastening the brush holder **(Figure 7-31, (5))** and remove the brush holder together with the brushes.

Note: On YDG2700EV-6EH models, support the generator before damper removal to avoid damaging the generator during removal.

Note: On YDG2700EV-6EH models remove the generator damper mounts anchoring the generator to frame.

Note: On YDG 3700EV-6EI and 5500EV-6EI models remove the bolts fastening the generator frame cross member.

8. Remove the four bolts fastening the rear housing to the front housing and remove the stator **(Figure 7-31, (6))** together with the rear housing **(Figure 7-31, (7))** and band **(Figure 7-31, (8))**.

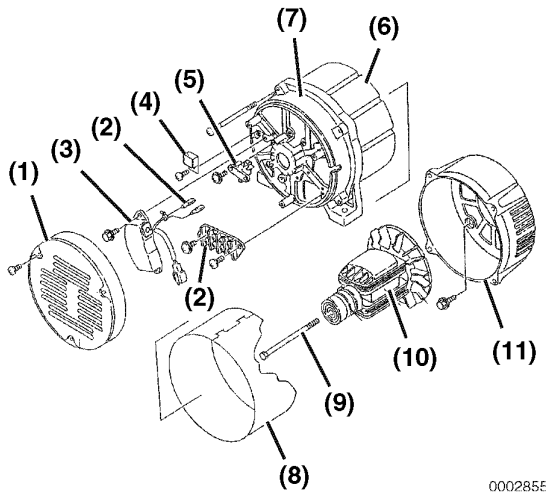


Figure 7-31

9. Remove the engine recoil starter housing.
10. Use a flywheel holding wrench, strap wrench or ring gear holding tool (if electric start equipped) to hold the engine flywheel and crankshaft while removing the rotor through bolt. *See Special Tools on page 7-9*.
11. Remove the rotor through bolt **(Figure 7-31, (9)).**
12. Use a flywheel holding wrench, strap wrench or ring gear holding tool (if electric start equipped) to hold the engine flywheel and crankshaft while tightening the rotor removal tool.
13. To remove the rotor **(Figure 7-31, (10))**, install the appropriate special rotor removal tool **(Figure 7-32, (1))**. *See Special Tools on page 7-9*.

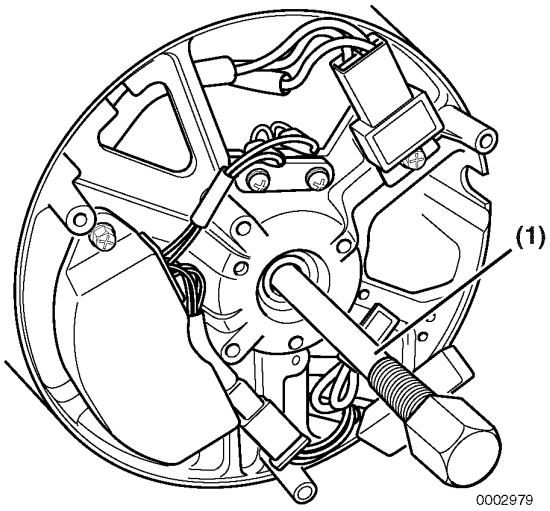


Figure 7-32

14. Tighten the rotor removal tool securely into the rotor. Use a heavy plastic hammer and sharply tap the tool end.
15. Continue to tighten and tap the tool until the rotor assembly comes free from crankshaft.

Note: Using excessive force to tighten tool may cause the rotor to release too quickly and may cause damage to the rotor assembly.

16. Remove the four front housing screws and front housing from engine block **(Figure 7-31, (11))**.

Visual Component Inspection

Check all components, leads and terminals for:

- Hardened or cracked lead insulation.
- Corrosion
- Water or moisture damage.
- Excessive dirt, or dust build up
- Loose or broken parts and general damage
- Burning or discoloration

Replace or repair as necessary.

Rotor Ball Bearing

1. Inspect the rotor ball bearing **(Figure 7-33, (1))** for:
   - Continuous or intermittent noises while the bearing is rotating.
   - Excessive play between the inner and outer races.
   - Burning or discoloration
2. Inspect rear housing bearing seat for damage and wear.

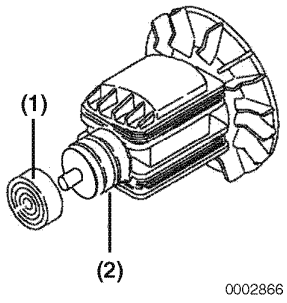


Figure 7-33

Rotor Slip Ring

1. Inspect the condition of the slip rings **(Figure 7-33, (2))** for:
   - Excessive dirt, or dust build up
   - Roughness, scoring, corrosion, and general damage
   - Evidence of water or moisture damage
   - Burning or discoloration
   - Uneven brush wear pattern

Note: The surface of the slip rings may be lightly cleaned with fine emery cloth (#300 to #500) if necessary. If imperfections or damage cannot be cleaned with light cleaning, replace the rotor assembly.

2. Measure the diameter of the slip rings **(Figure 7-33, (2))** for wear. If the wear exceeds the wear limit, replace the rotor assembly

Slip Rings	Standard diameter	Minimum operating diameter
YDG2700EV-6EH, 3700EV-6EI	37.7 mm	36.7 mm
YDG5500EV-6EI	44.6 mm	42.8 mm

3. Inspect the condition of the slip ring isolator for:
   - Burning or discoloration
   - Roughness, scoring, corrosion, and general damage

Rotor Field Coil

1. Inspect the magnet cores for:
   - Damage due to contact with stator
   - Roughness, scoring, corrosion, and general damage
   - Loose or broken magnets
2. Inspect the field coils of the rotor for:
   - Damage due to contact with stator
   - Excessive dirt, or dust build up
   - Evidence of water or moisture damage
   - Burning or discoloration

Stator Assembly

Inspect the armature and DC coils of the stator **(Figure 7-34, (1))** for:

- Damage due to contact with rotor
- Excessive dirt, or dust build up
- Evidence of water or moisture damage
- Burning or discoloration

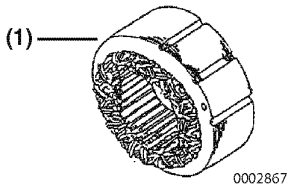


Figure 7-34

Reassembly and Installation of Generator

CAUTION! All electrical connections and generator components must be fastened and connected securely to prevent loosening from vibration, which could cause unit damage and personal injury.

Note: Use standard torque values see "Tightening Torques for Standard Bolts and Nuts" on page 33, for all fasteners except where special toque values are specified, see"Special Torque Specifications" on page 8.

1. Install the generator front housing to engine block and tighten bolts to specifications. *See Special Torque Specifications on page 7-8.*
2. Use a flywheel holding wrench, strap wrench or ring gear holding tool (if electric start equipped) to hold the engine flywheel and crankshaft while installing the rotor through bolt.
3. Install the rotor to the engine crankshaft. Install and torque the rotor through bolt to specifications. *See Special Torque Specifications on page 7-8.*

Note: There should be no contact between the rotor assembly and stator assembly while rotating.

4. Carefully align and install the band together with the stator and rear housing assembly to the front housing over the rotor. The rear housing must fit securely to the rotor ball bearing without binding and flush to the front housing.

Note: YDG2700EV-6EH model, support the generator while installing the damper mounts.

Note: YDG3700EV-6EI and YDG5500EV-6EI, rest the feet of the rear housing on the frame cross member while installing the bolts that fasten the rear housing to the frame cross member. Tighten bolts to specifications. *See Tightening Torques for Standard Bolts and Nuts on page 4-33*.

5. Install and tighten in a cross pattern the four rear housing bolts to specifications. *See Special Torque Specifications on page 7-8*.
6. Install the AVR with two bolts to rear housing. *See Special Torque Specifications on page 7-8*.
7. Install the rectifier with one bolt fastening the rectifier to the rear housing. *See Tightening Torques for Standard Bolts and Nuts on page 4-33*.

Note: When installing the brushes, position the brush holder directly above the slip rings and move straight downward until aligned with the mounting holes in the rear housing. Continue to hold the brushes in that position while installing the two screws.

8. Install the brush holder and brushes with two bolts fastening the brush holder to the rear housing. *See Tightening Torques for Standard Bolts and Nuts on page 4-33. NOTICE: When installed the brushes must have uniform contact* ***(Figure 7-35, (1))*** *with the slip rings and be able to move freely under their spring pressure. NOTICE: Check the brush holder position after fastening the two bolts. The brush holder must be anchored so that each brush contacts its slip ring uniformly* **(Figure 7-36, *(1)*)**. *If the brush holder is fastened in an incorrect manner* **(Figure 7-36, *(2)*)** *excessive brush wear, improper brush contact and possible generator malfunction can occur.*

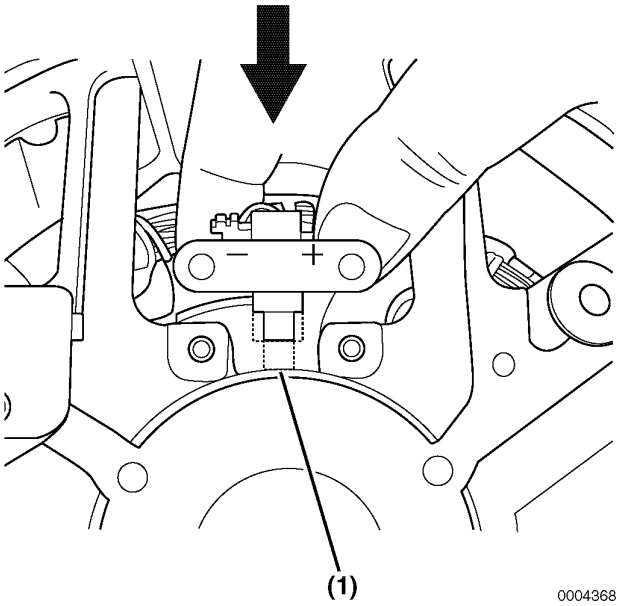


Figure 7-35

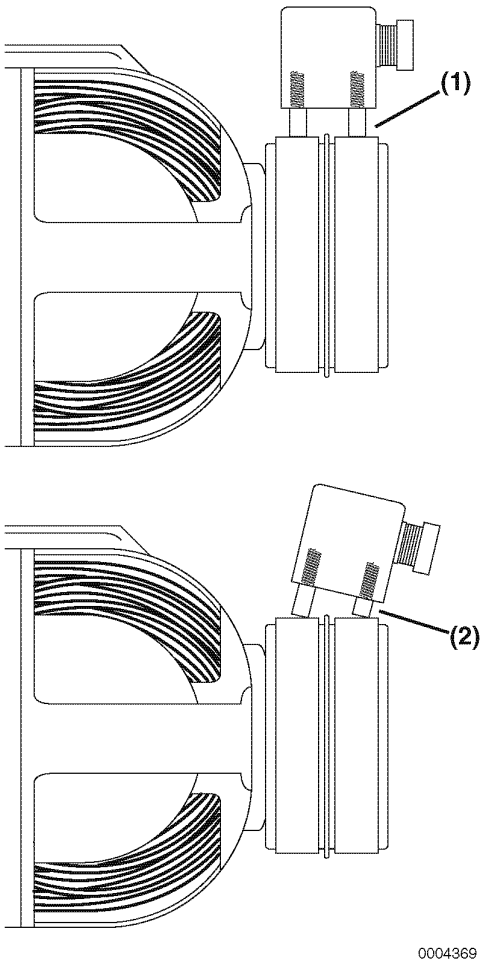


Figure 7-36

9. Connect the four terminal connector to the AVR and the pink and gray leads from the AVR to the brushes.
10. Connect the electrical connector to the rectifier.

Note: To prevent electrical shorts, confirm all installed connectors and all leads are not in contact with any moving parts or pinched in any manner with generator cover installed.

Note: YDG2700EV-6EH models use one six terminal connector ***(Figure 7-37,* (1))** from the control panel and one ground wire ***(Figure 7-37,* (2))** fastened to the rear housing.

Note: YDG3700EV-6EI and YDG5500EV-6EI models use three separate two terminal connectors **(Figure 7-38, (1, 2, 3))** from the control panel and one ground wire **(Figure 7-38, (4))** fastened to the rear housing.

11. Connect the electrical connectors from the control panel harness to the generator and ground wire inside generator.

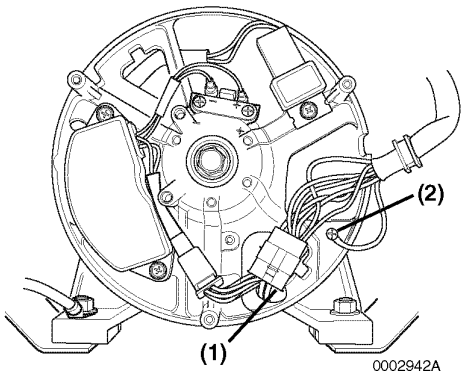


Figure 7-37

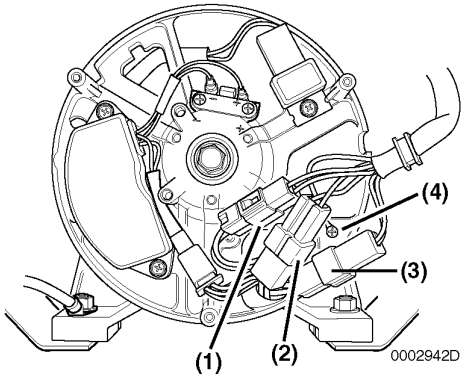


Figure 7-38

12. Install the generator cover and fasten screws securing the generator cover. *See Tightening Torques for Standard Bolts and Nuts on page 4-33.*
13. Install generator damper mounts anchoring generator to frame, if removed. Tighten damper bolts to specifications. *See Special Torque Specifications on page 7-8.*
14. Install engine starter recoil assembly.

Note: Always connect the positive battery (+) lead (red) first and then the negative (-) terminal (black).

15. Install the battery into the battery tray and secure. Connect the positive (+) and negative (-) battery cables to the battery.

Removal of Control Panel

See Electrical Schematic - YDG2700EV-6EH on page 7-17 and *See Electrical Schematic - YDG3700EV-6EI, YDG5500EV-6EI on page 7-19* electrical circuit details.

Note: Mark all electrical leads before disassembly to ensure correct reassembly.

Note: There are four harnesses from the control panel:

- Rectifier harness
- Oil Pressure Sending Unit harness
- Stop Solenoid harness
- Generator harness

1. Disconnect the positive and negative battery cables from battery and remove the battery.

Note: Always disconnect the negative (-) terminal (black) first and then the positive (+) one (red).

2. Remove the tie straps **(Figure 7-39, (1))** and disconnect the wire harness and connector from the control panel to the rectifier **(Figure 7-39, (2))**.

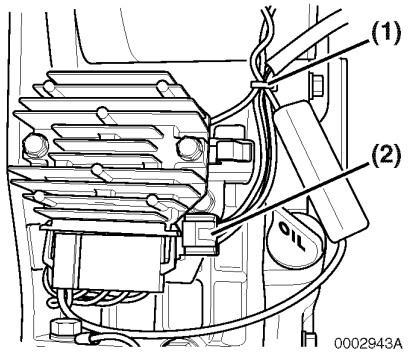


Figure 7-39

3. Disconnect the oil pressure sending unit wires **(Figure 7-40, (1))** and all ground wires from engine block to frame.
4. Disconnect the two bullet connectors **(Figure 7-40, (2))** from the stop solenoid. One red lead and one blue lead.

CONTROL PANEL AND GENERATOR

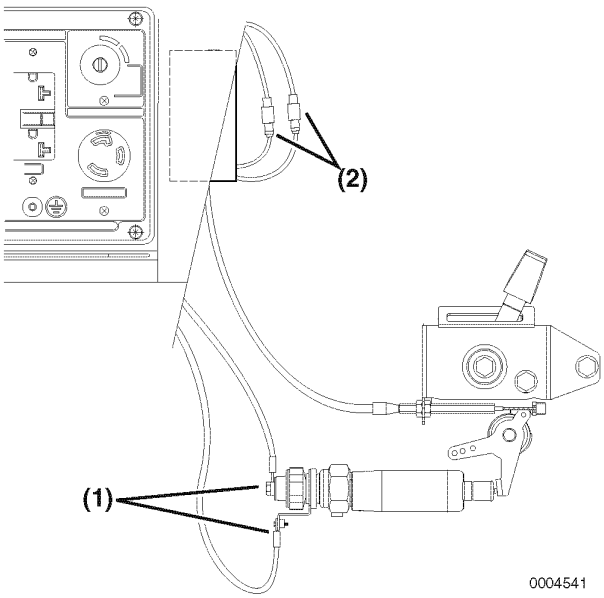


Figure 7-40

5. Remove the generator cover screws and remove the cover.

Note: YDG2700 models use one six terminal connector **(Figure 7-41, (1))** from the control panel and one ground wire **(Figure 7-41, (2))** fastened to the rear housing.
YDG3700 and YDG5500 models use three separate two terminal connectors **(Figure 7-42, (1, 2, 3))** from the control panel and one ground wire **(Figure 7-42, (4))** fastened to the rear housing.

6. Disconnect the electrical connectors from the control panel harness to the generator and ground wire inside generator.

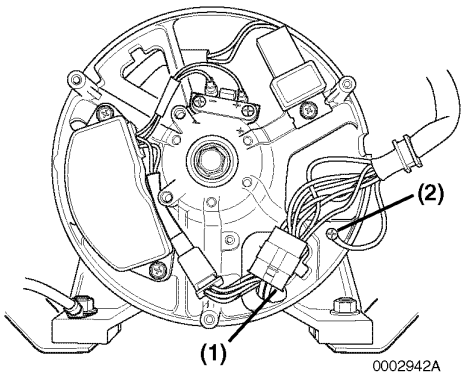


Figure 7-41

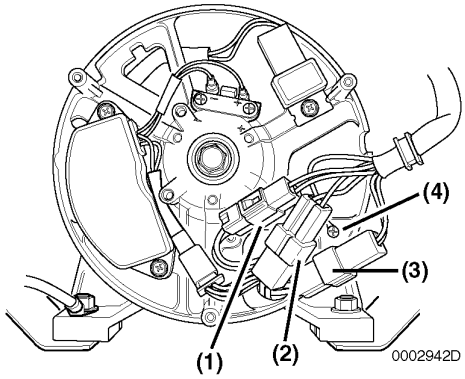


Figure 7-42

Note: There are six screws that fasten the control panel to the generator frame. The four corner control panel screws fasten the panel to the generator frame. The two screws in the top center and bottom center fasten the control panel to the panel box.

7. Remove the screws from control panel and then remove the control panel unit as a set.
8. Remove the control panel **(Figure 7-43, (1))** from panel box **(Figure 7-43, (2))**.

Disassembly of Control Panel

Note: Mark all electrical leads and terminals to assure they are reconnected to their original position during reassembly.

1. Pull all wiring harnesses **(Figure 7-43, (4))** through the panel box **(Figure 7-43, (2))** just far enough in the direction of the arrow enough to allow access to the rear of the panel **(Figure 7-43, (1))** to disconnect the electrical components **(Figure 7-43, (3))**.

Note: The wiring harness cannot be pulled completely through the panel box without disassembly of the harness.

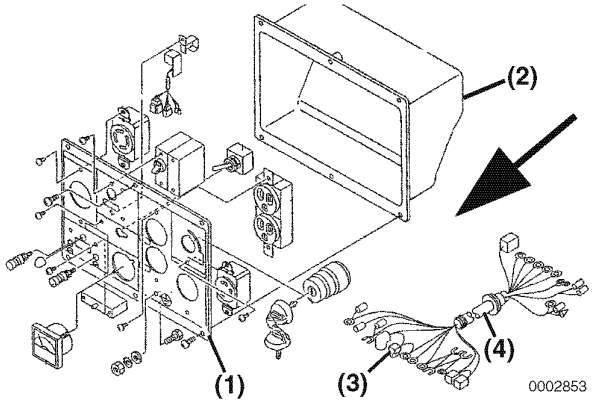


Figure 7-43

Inspection of Control Panel Components

Check all electrical components, leads and terminals for:

- Hardened or cracked lead insulation.
- Corrosion of terminals.
- Inoperative switches and other mechanical parts.
- Abnormal resistance values and electrical continuity of electrical circuits.
- Water or moisture damage.

Reassembly of Control Panel

See Electrical Schematic - YDG2700EV-6EH on page 7-17 and See Electrical Schematic - YDG3700EV-6EI, YDG5500EV-6EI on page 7-19 for electrical circuit details.

1. Reinstall any terminals, outlets, switches, meters and related components to the control panel that were removed or replaced.
2. Reconnect any wiring harness and all terminals **(Figure 7-44, (3))**, outlets, switches, meters and related components that were removed or replaced.
3. Pull the wiring harnesses **(Figure 7-44, (4))** through the panel box **(Figure 7-44, (2))** in the direction of the arrow and install the panel box.
4. Install the control panel **(Figure 7-44, (1))** to panel box.

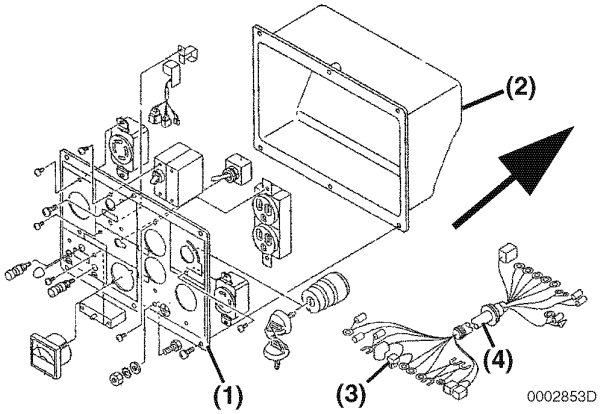


Figure 7-44

Installation of Control Panel

See Electrical Schematic - YDG2700EV-6EH on page 7-17 and *See Electrical Schematic - YDG3700EV-6EI, YDG5500EV-6EI on page 7-19* for electrical circuit details.

1. Verify the battery cables are disconnected from battery.
2. Using four screws install the control panel and panel box to frame and tighten the screws securely.

Note: YDG2700EV-6EH models use one six terminal connector ***(Figure 7-45,* (1))** from the control panel and one ground wire ***(Figure 7-45,* (2))** fastened to the rear housing.

Note: YDG3700EV-6EI and YDG5500EV-6EI models use three separate two terminal connectors ***(Figure 7-46,* (1, 2, 3))** from the control panel and one ground wire ***(Figure 7-46,* (4))** fastened to the rear housing.

3. Connect the electrical connectors from the control panel harness to the generator and ground wire inside generator.

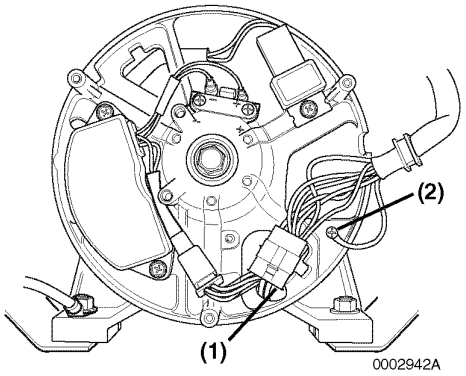


Figure 7-45

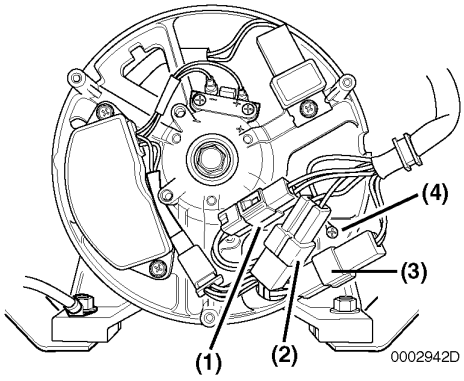


Figure 7-46

4. Install the generator cover and screws.
5. Reconnect the two bullet connectors, (one red and one blue lead) to the stop solenoid.
6. Reconnect the oil pressure sending unit leads.

7. Connect the wire harness connector from control panel to rectifier **(Figure 7-47, (2))** and secure with a tie strap **(Figure 7-47, (1))**.

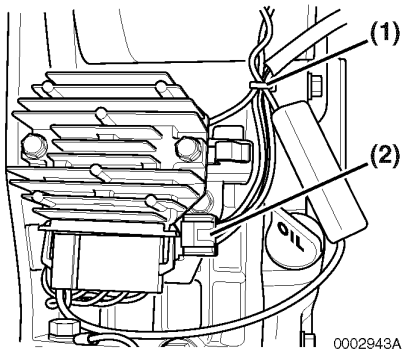


Figure 7-47

Note: Always connect the positive (+)one (red) first and then the negative (-) terminal (black).

8. Install the battery into the battery tray and secure with the battery hold down hardware.
9. Reconnect the battery cables to battery and install the battery into the battery tray.

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Section 8

ENGINE

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BEFORE YOU BEGIN SERVICING

Before performing any service procedures within this section, review the *Safety* section on page *3-1*.

INTRODUCTION

This section of the *Service Manual* describes the disassembly, inspection, and reassembly of the engine.

SPECIFICATIONS

Note: All dimensions given are for standard original components. Oversize pistons and piston rings, as well as undersize bearings, are available and may have been installed some time during the life of the engine. Add the oversize or subtract the undersize from the standard dimension to measure these replacement parts. Refer to the parts catalog for the available sizes.

Cylinder Head Assembly

Valve Clearance

Inspection Item	Standard	Limit	Reference Page
All Models - Intake / Exhaust	0.006 ± 0.002 in. (0.15 ± 0.05 mm)	-	*See Measuring and Adjusting Valve Clearance on page 8-35.*

Cylinder Head

Inspection Item				Standard	Limit	Reference Page
Combustion Surface Distortion (Flatness)				0.0020 in. (0.05 mm) or less	0.0059 in. (0.15 mm)	*See Cylinder Head Distortion on page 8-28.*
Valve Recession - All Models				0.016 - 0.032 in. (0.4 - 0.8 mm)	0.039 in. (1.0 mm)	*See Valve Recession on page 8-25.*
Valve Seat	Width	L48V	Intake / Exhaust	0.1003 in. (2.55 mm)	-	*See Valve Face and Valve Seat on page 8-24.*
		L70V, L100V	Intake / Exhaust	0.0551 in. (1.4 mm)	-	
	Angle	All	Intake / Exhaust	90°	-	

Intake / Exhaust Valve Seat

Inspection Item			Standard	Limit	Reference Page
Seat Angle - All Models		Intake / Exhaust	90°	-	*See Valve Face and Valve Seat on page 8-24.*
Seat Width	L48V	Intake / Exhaust	0.100 in. (2.55 mm)	-	
	L70V, L100V	Intake / Exhaust	0.055 in. (1.40 mm)	-	

Intake / Exhaust Valves, Guides and Seals

Inspection item			Standard	Limit	Reference Page
L48V	Intake	Guide Inside Diameter	0.2165 - 0.2171 in. (5.500 - 5.515 mm)	0.220 in. (5.58 mm)	*See Valves and Valve Guides on page 8-25 and "Reassembly of Intake / Exhaust Valves" on page 8-28.*
		Valve Stem Outside Diameter	0.1757 - 0.1761 in. (5.465 - 5.475 mm)	0.213 in. (5.40 mm)	
	Exhaust	Guide Inside Diameter	0.2165 - 0.2171 in. (5.500 - 5.515 mm)	0.220 in. (5.58 mm)	
		Valve Stem Outside Diameter	0.1755 - 0.1761 in. (5.460 - 5.475 mm)	0.213 in. (5.40 mm)	
	Seal	Installed Height	0.374 in. (9.5 mm)	-	
L70V	Intake	Guide Inside Diameter	0.2362 - 0.2368 in. (6.000 - 6.015 mm)	0.239 in. (6.08 mm)	
		Valve Stem Outside Diameter	0.2346 - 0.2352 in. (5.960 - 5.975 mm)	0.232 in. (5.90 mm)	
	Exhaust	Guide Inside Diameter	0.2362 - 0.2368 in. (6.000 - 6.015 mm)	0.239 in. (6.08 mm)	
		Valve Stem Outside Diameter	0.2342 - 0.2346 in. (5.950 - 5.960 mm)	0.232 in. (5.90 mm)	
	Seal	Installed Height	0.334 in. (8.5 mm)	-	
L100V	Intake	Guide Inside Diameter	0.2756 - 0.2762 in. (7.000 - 7.015 mm)	0.279 in. (7.08 mm)	
		Valve Stem Outside Diameter	0.2740 - 0.2746 in. (6.960 - 6.975 mm)	0.272 in. (6.90 mm)	
	Exhaust	Guide Inside Diameter	0.2756 - 0.2762 in. (7.000 - 7.015 mm)	0.279 in. (7.08 mm)	
		Valve Stem Outside Diameter	0.2734 - 0.2740 in. (6.945 - 6.96 mm)	0.272 in. (6.90 mm)	
	Seal	Installed Height	0.531 in. (13.5 mm)	-	

Push Rod

Inspection Item		Standard	Limit	Reference Page
Push Rod Length	L48V	5.110 - 5.126 in. (129.8 - 130.2 mm)	-	-
	L70V	6.390 - 6.406 in. (162.3 - 162.7 mm)	-	-
	L100V	7.748 - 7.764 in. (196.8 - 197.2 mm)	-	-
Push Rod Bend	All Models	Less than: 0.002 in. (0.05 mm)	0.012 in. (0.3 mm)	*See Push Rod Bend on page 8-27.*

Valve Spring

Inspection Item		Standard	Limit	Reference Page
L48V	Free Length	1.102 in. (28.0 mm)	1.043 in. (26.5 mm)	*See Valve Springs on page 8-26.*
	Inclination	Less than: 0.295 in. (0.75 mm)	-	
	Spring Tension / mm	2.5 - 3.1 lbf (11.2 - 13.7 N, 1.14 - 1.40 kgf)	-	
L70V	Free Length	1.299 in. (33.0 mm)	1.240 in. (31.5 mm)	
	Inclination	Less tan: 0.0236 (1.16 mm)	-	
	Spring Tension / mm	2.8 - 3.4 lbf (12.5 - 15.2 N, 1.27 - 1.55 kgf)	-	
L100V	Free Length	1.575 in. (42.0 mm)	1.551 in. (39.5 mm)	
	Inclination	Less than: 0.039 in. (1.0 mm)	-	
	Spring Tension (Measured compressed at minimum of 8 mm.)	4.0 - 5.5 lbf (17.7 - 24.6 N, 1.8 - 2.51 kgf)	-	

Rocker Arm and Shaft

Inspection Item		Standard	Limit	Reference Page
L48V, L70V	Shaft Hole Diameter	0.4730 - 0.4737 in. (12.016 - 12.034 mm)	0.47638 in. (12.10 mm)	*See Rocker Arms and Push Rods on page 8-27.*
	Shaft Outside Diameter	0.4720 - 0.4724 in. (11.989 - 12.0 mm)	0.4685 in. (11.90 mm)	
L100V	Shaft Hole Diameter	0.5918 - 0.5923 in. (15.032 - 15.045 mm)	0.59449 in. (15.10 mm)	
	Shaft Outside Diameter	0.5901 - 0.5905 in. (15.989 - 15.0 mm)	0.58661 in. (14.90 mm)	

Crankshaft, Balancer Shaft, Piston and Connecting Rod

Crankshaft

Inspection Item				Standard	Limit	Reference Page
Connecting Rod Journal	L48V	Outside Diameter		1.1797 - 1.1803 in. (29.965 - 29.982 mm)	1.1771 in. (29.90 mm)	*See Cranksh aft on page 8-44.*
		Oil Clearance		0.0001 - 0.0020 in. (0.004 - 0.053 mm)	-	
	L70V	Outside Diameter		1.4159 - 1.4166 in. (35.965 - 35.982 mm)	1.4133 in. (35.90 mm)	
		Oil Clearance		0.0001 - 0.0020 in. (0.004 - 0.053 mm)	-	
	L100V	Outside Diameter		1.5734 - 1.5740 in. (39.965 - 39.982 mm)	1.5708 in. (39.90 mm)	
		Oil Clearance		0.0007 - 0.0030 in. (0.018 - 0.077 mm)	-	
Main Bearing Journal	L48V	Crankcase Cover End	Journal Outside Diameter	1.1811 - 1.1817 in. (30.002 - 30.015 mm)	1.1776 in. (29.91 mm)	
			Oil Clearance	0.001 - 0.002 in. (0.025 - 0.058 mm)	0.0067 in. (0.17 mm)	
		Flywheel End	Journal Outside Diameter	1.1811 - 1.1817 in. (30.002 - 30.015 mm)	-	
			Ball Bearing Inside Diameter	1.1807 - 1.1811 in. (29.990 - 30.000 mm)	-	
			Interference Fit	0.0001 - 0.001 in. (0.002 - 0.025 mm)	-	
	L70V	Crankcase Cover End	Journal Outside Diameter	1.3782 - 1.3787 in. (35.007 - 35.018 mm)	1.3744 in. (34.91 mm)	
			Oil Clearance	0.001 - 0.002 in. (0.025 - 0.058 mm)	0.0067 in. (0.17 mm)	
		Flywheel End	Journal Outside Diameter	1.3782 - 1.3787 in. (35.007 - 35.018 mm)	-	
			Ball Bearing Inside Diameter	1.3774 - 1.3779 in. (34.988 - 35.000 mm)	-	
			Interference Fit	0.00028 - 0.0012 in. (0.007 - 0.030 mm)	-	
	L100V	Crankcase Cover End	Journal Outside Diameter	1.575 - 1.5755 in. (40.007 - 40.018 mm)	1.5713 in. (39.91 mm)	
			Oil Clearance	0.001 - 0.0022 in. (0.025 - 0.056 mm)	0.0067 in. (0.17 mm)	
		Flywheel End	Journal Outside Diameter	1.575 - 1.5755 in. (40.007 - 40.018 mm)	-	
			Ball Bearing Inside Diameter	1.5743 - 1.5747 in. (39.988 - 40.000 mm)	-	
			Interference Fit	0.00028 - 0.0012 in. (0.007 - 0.030 mm)	-	

ENGINE

Balancer Shaft

Inspection Item			Standard	Limit	Reference Page
Cylinder Block	L48V	Balancer Shaft Diameter	0.5899 - 0.5903 in. (14.983 - 14.994 mm)	-	*See Balancer Shaft on page 8-46.*
		Cylinder Block Bore Diameter	1.3756-1.3766 in. (34.941-34.966 mm)	-	
		Ball Bearing Inside Diameter	0.5902-0.5906 in. (14.992-15.000 mm)	-	
		Ball Bearing Outside Diameter	1.3775 - 1.3780 in. (34.989-35.000 mm)	-	
		Radial Clearance of Ball Bearing	0.00043 - 0.00098 in. (0.011 - 0.025 mm)	0.0016 in. (0.040 mm)	
Crankcase Cover		Same as Cylinder Block			
Cylinder Block	L70V	Balancer Shaft Diameter	0.6686 - 0.6691 in. (16.983 - 16.994 mm)	-	*See Balancer Shaft on page 8-46.*
		Cylinder Block Bore Diameter	1.5725 - 1.5735 in. (39.941 - 39.966 mm)	-	
		Ball Bearing Inside Diameter	0.6690 - 0.6693 in. (16.992 - 17.000 mm)	-	
		Ball Bearing Outside Diameter	1.5744 - 1.5748 in. (39.989 - 40.000 mm)	-	
		Radial Clearance of Ball Bearing	0.00043 - 0.00098 in. (0.011 - 0.025 mm)	0.0016 in. (0.040 mm)	
Crankcase Cover		Same as Cylinder Block			
Cylinder Block	L100V	Balancer Shaft Diameter	0.7867 - 0.7872 in. (19.983 - 19.994 mm)	-	*See Balancer Shaft on page 8-46.*
		Cylinder Block Bore Diameter	2.0449 - 2.0459 in. (51.941 - 51.966 mm)	-	
		Ball Bearing Inside Diameter	0.7870 - 0.7874 in. (19.990 - 20.000 mm)	-	
		Ball Bearing Outside Diameter	2.0467 - 2.0472 in. (51.987 - 52.000 mm)	-	
		Radial Clearance of Ball Bearing	0.00051 - 0.00110 in. (0.013 - 0.028 mm)	0.0016 in. (0.040 mm)	
Crankcase Cover		Same as Cylinder Block			

Piston

Inspection Item			Standard	Limit	Reference Page
Piston Outside Diameter (Measure 90° to the wrist pin.)		L48V	2.7545 in. (69.965 mm)	2.7441 in. (69.700 mm)	*See Piston, Piston Rings and Wrist Pin on page 8-41.*
		L70V	3.0695 in. (77.965 mm)	3.0591 in. (77.700 mm)	
		L100V	3.3841 in. (85.955 mm)	3.3740 in. (85.700 mm)	
Piston Diameter Measurement Location (Upward from the bottom of the piston)		All Models	0.472 in. (12 mm)		
Clearance Between Piston and Sleeve		L48V, L70V	0.0016 - 0.0024 in. (0.040 - 0.060 mm)	-	
		L100V	0.0020 - 0.0028 in. (0.050 - 0.070 mm)	-	
Wrist Pin	L48V	Hole Inside Diameter	0.7474 - 0.7478 in. (18.985 - 18.996 mm)	0.7508 in. (19.07 mm)	
		Pin Outside Diameter	0.7476 - 0.7480 in. (18.991 - 19.0 mm)	0.7448 in. (18.920 mm)	*See Piston, Piston Rings and Wrist Pin on page 8-41.*
		Oil Clearance	0.0002 - 0.0006 in. (0.005 - 0.015 mm)	-	
	L70V	Hole Inside Diameter	0.8261 - 0.8266 in. (20.983 - 20.996 mm)	0.8295 in. (21.07 mm)	
		Pin Outside Diameter	0.8264 - 0.8267 in. (20.991 - 21.000 mm)	0.8232 in. (20.91 mm)	
		Oil Clearance	0.0002 - 0.00067 in. (0.005 - 0.017 mm)	-	
	L100V	Hole Inside Diameter	0.9048 - 0.9053 in. (22.983 - 22.996 mm)	0.90830 in. (23.07 mm)	
		Pin Outside Diameter	0.9051 - 0.9055 in. (22.991 - 23.000 mm)	0.9020 in. (22.91 mm)	
		Oil Clearance	0.0002 - 0.00067 in. (0.005 - 0.017 mm)	-	

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Piston Ring

Inspection Item			Standard	Limit	Reference Page
L48V	Top Ring	Thickness	0.0578 - 0.05846 in. (1.470 - 1.485 mm)	0.0535 in. (1.36 mm)	*See Piston, Piston Rings and Wrist Pin on page 8-41.*
		Side Clearance	0.00255 - 0.00374 in. (0.065 - 0.095 mm)	0.0059 in. (0.15 mm)	
		End Gap	0.00787 - 0.01377 in. (0.200 - 0.350 mm)	0.0394 in. (1.00 mm)	
	Second Ring	Thickness	0.0578 - 0.0586 in. (1.470 - 1.490 mm)	0.0535 in. (1.36 mm)	
		Side Clearance	0.00118 - 0.00255 in. (0.030 - 0.065 mm)	0.0059 in. (0.15 mm)	
		End Gap	0.01181 - 0.01771 in. (0.300 - 0.450 mm)	0.0394 in. (1.00 mm)	
	Oil Ring	Thickness	0.1366 - 0.1374 in. (3.470 - 3.490 mm)	0.1322 in. (3.36 mm)	
		Side Clearance	0.00078 - 0.0026 in. (0.020 - 0.055 mm)	0.0059 in. (0.15 mm)	
		End Gap	0.0059 - 0.01377 in. (0.150 - 0.350 mm)	0.0394 in. (1.00 mm)	
L70V	Top Ring	Thickness	0.0578 - 0.0585 in. (1.470 - 1.485 mm)	0.0535 in. (1.36 mm)	
		Side Clearance	0.0025 - 0.0037 in. (0.065 - 0.095 mm)	0.0059 in. (0.15 mm)	
		End Gap	0.0079 - 0.0138 in. (0.200 - 0.350 mm)	0.0393 in. (1.0 mm)	
	Second Ring	Thickness	0.0578 - 0.0586 in. (1.470 - 1.490 mm)	0.0535 in. (1.36 mm)	
		Side Clearance	0.0012 - 0.0026 in. (0.030 - 0.065 mm)	0.0059 in. (0.15 mm)	
		End Gap	0.0118 - 0.0177 in. (0.300 - 0.450 mm)	0.0394 in. (1.0 mm)	
	Oil Ring	Thickness	0.1366 - 0.1374 in. (3.470 - 3.490 mm)	0.1322 (3.36 mm)	
		Side Clearance	0.0008 - 0.0026 in. (0.020 - 0.055 mm)	0.0059 in. (0.15 mm)	
		End Gap	0.0059 - 0.0138 in. (0.150 - 0.350 mm)	0.0394 in. (1.0 mm)	

Inspection Item			Standard	Limit	Reference Page
L100V	Top Ring	Thickness	0.0775 - 0.0781 in. (1.970 - 1.985 mm)	0.0732 in. (1.86 mm)	*See Piston, Piston Rings and Wrist Pin on page 8-41.*
		Side Clearance	0.0026 - 0.0037 in. (0.065 - 0.095 mm)	0.0059 in. (0.15 mm)	
		End Gap	0.0079 - 0.0138 in. (0.200 - 0.350 mm)	0.0394 in. (1.0 mm)	
	Second Ring	Thickness	0.0775 - 0.0783 in. (1.970 - 1.990 mm)	0.0732 in. (1.86 mm)	
		Side Clearance	0.0012 - 0.0026 in. (0.030 - 0.065 mm)	0.0059 in. (0.15 mm)	
		End Gap	0.0118 - 0.0177 in. (0.300 - 0.450 mm)	0.0394 in. (1.0 mm)	
	Oil Ring	Thickness	0.1562 - 0.1570 in. (3.970 - 3.990 mm)	0.1519 in. (3.86 mm)	
		Side Clearance	0.0008 - 0.0026 in. (0.020 - 0.055 mm)	0.0059 in. (0.15 mm)	
		End Gap	0.0059 - 0.0138 in. (0.150 - 0.350 mm)	0.0394 in. (1.0 mm)	

Connecting Rod

Inspection Item			Standard	Limit	Reference Page
L48V	Big End (Crankshaft)	Inside Diameter **(See Figure 8-1 (1))**	1.1816 - 1.1818 in. (29.986 - 30.018 mm)	1.1846 in. (30.09 mm)	*See Connecting Rod on page 8-43.*
		Oil Clearance	0.00015 - 0.002 in. (0.004 - 0.053 mm)	-	
	Small End (Wrist Pin Bushing)	Inside Diameter **(See Figure 8-1 (2))**	0.7490 - 0.7495 in. (19.025 - 19.038 mm)	0.7519 in. (19.10 mm)	
		Oil Clearance	0.0008 - 0.0020 in. (0.021 - 0.053 mm)	-	
L70V	Big End (Crankshaft)	Inside Diameter **(See Figure 8-1(1))**	1.4178 - 1.4180 in. (35.986 - 36.018 mm)	1.4208 in. (36.09 mm)	
		Oil Clearance	0.00015 - 0.002 in. (0.004 - 0.053 mm)	-	
	Small End (Wrist Pin Bushing)	Inside Diameter **(See Figure 8-1 (2))**	0.8277 - 0.8282 in. (21.025 - 21.038 mm)	0.8307 in. (21.10 mm)	
		Oil Clearance	0.0008 - 0.0021 in. (0.021 - 0.055 mm)	-	
L100V	Big End (Crankshaft)	Inside Diameter **(See Figure 8-1 (1))**	1.5748 - 1.5764 in. (40.0 - 40.042 mm)	1.5779 in. (40.08 mm)	
		Oil Clearance	0.0007 - 0.0030 in. (0.018 - 0.077 mm)	-	
	Small End (Wrist Pin Bushing)	Inside Diameter **(SeeFigure 8-1 (2))**	0.9064 - 0.9070 in. (23.025 - 23.038 mm)	0.9094 in. (23.10 mm)	
		Oil Clearance	0.0008 - 0.0021 in. (0.021 - 0.055 mm)	-	

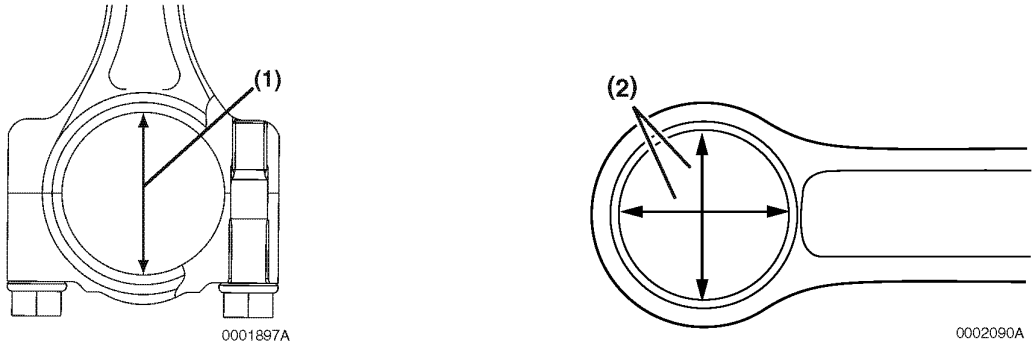

Figure 8-1

Camshaft and Tappet

Camshaft

Inspection Item			Standard	Limit	Reference Page
End Play - All Models			0.002 - 0.011 in. (0.040 - 0.280 mm)	0.018 in. (0.45 mm)	*See Camshaft and Tappet on page 8-45.*
Cylinder Block - All Models		Camshaft Journal Outside Diameter	0.5905 - 0.5909 in. (4.989 - 15.000 mm)	0.5874 in. (14.920 mm)	
		Needle Bearing Inside Diameter	0.5911 - 0.5918 in. (15.016 - 15.034 mm)	-	
		Oil Clearance	0.0006 - 0.0017 in. (0.016 - 0.045 mm)	-	
Crankcase Cover	L48V	Camshaft Journal Outside Diameter	0.9834 - 0.9839 in. (24.980 - 24.993 mm)	0.9803 in. (24.900 mm)	
		Bearing Inside Diameter	0.985 - 0.9858 in. (25.020 - 25.041 mm)	-	
		Oil Clearance	0.0010 - 0.0024 in. (0.027 - 0.061 mm)	-	
	L70V	Camshaft Journal Outside Diameter	1.1803 - 1.1808 in. (29.980 - 29.993 mm)	1.1771 in. (29.900 mm)	
		Bearing Inside Diameter	1.1818 - 101827 in. (30.020 - 30.041 mm)	-	
		Oil Clearance	0.0010 - 0.0024 in. (0.027 - 0.061 mm)	-	
	L100V	Camshaft Journal Outside Diameter	1.3771 - 1.3776 in. (34.980 - 34.993 mm)	1.374 in. (34.900 mm)	
		Bearing Inside Diameter	1.3787 - 1.3795 in. (35.020 - 35.041 mm)	-	
		Oil Clearance	0.0010 - 0.0024 in. (0.027 - 0.061 mm)	-	

Tappet

Inspection Item		Standard	Limit	Reference Page
Valves - All Models	Tappet Hole (Block) Inside Diameter	0.2755 - 0.2761 in. (7.000 - 7.015 mm)	0.2779 in. (7.06 mm)	*See Camshaf t and Tappet on page 8-45.*
	Tappet Stem Outside Diameter	0.2740 - 0.2755 in. (6.960 - 6.980 mm)	0.2704 in. (6.87 mm)	
	Oil Clearance	0.0007 - 0.0021 in. (0.020 - 0.055 mm)	-	
Fuel Injection Pump - All Models	Tappet Hole (Block) Inside Diameter	0.9448 - 0.9461 in. (24.000 - 24.033 mm)	0.9472 in. (24.06 mm)	
	Tappet Stem Outside Diameter	0.9831 - 0.9446 in. (23.972 - 23.993 mm)	0.9405 in. (23.89 mm)	
	Oil Clearance	0.00027 - 0.0024 in. (0.007 - 0.061 mm)	-	

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Cylinder Block and Crankcase Cover

Cylinder Block

Inspection Item			Standard	Limit	Reference Page
Crankshaft Ball Bearing	L48V	Housing Bore Inside Diameter	2.8343 - 2.8349 in. (71.9905 - 72.0095 mm)	-	*See Crankshaft on page 8-44.*
		Ball Bearing Outside Diameter	2.8341 - 2.8346 in. (71.987 - 72.0 mm)	-	
		Interference Fit	0.0003 - 0.0008 in. (0.0095 - 0.0225 mm)	-	
	L70V	Housing Bore Inside Diameter	3.1488 - 3.1494 in. (79.98 - 79.996 mm)	-	
		Ball Bearing Outside Diameter	3.1490 - 3.1496 in. (79.987 - 80.0 mm)	-	
		Interference Fit	0.0003 - 0.0007 in. (0.009 - 0.020 mm)	-	
	L100V	Housing Bore Inside Diameter	3.5426 - 3.5433 in. (89.984 - 90.0 mm)	-	
		Ball Bearing Outside Diameter	3.5427 - 3.5433 in. (89.985 - 90.0 mm)	-	
		Interference Fit	0.0005 - 0.0006 in. (0.015 - 0.016 mm)	-	
Camshaft Needle Bearing Bore - All Models		Inside Diameter	0.8250 - 0.8259 in. (20.957 - 20.978 mm)	-	*See Camshaft and Tappet on page 8-45.*
Cylinder Bore Inside Diameter		L48V	2.7559 - 2.7571 in. (70.000 - 70.030 mm)	2.7622 in. (70.16 mm)	*See Cylinder Bore on page 8-47.*
		L70V	3.0709 - 3.0720 in. (78.000 - 78.030 mm)	3.0779 in. (78.18 mm)	
		L100V	3.3858 - 3.3870 in. (86.000 - 86.030 mm)	-	

Crankcase Cover

Inspection Item			Standard	Limit	Reference Page
Crankshaft Sleeve Bearing	L48V	Bore Diameter in Cover	1.3385 - 1.3395 in. (34.000 - 34.025 mm)	-	*See Bearings on page 8-45.*
		Bearing Outside Diameter	1.3413 - 1.3427 in. (34.070 - 34.105 mm)	-	
		Interference Fit	0.0017 - 0.0041 in. (0.045 - 0.105 mm)	-	
		Bearing Metal Inside Diameter	1.1826 - 1.1834 in. (30.040 - 30.060 mm)	1.1862 in. (30.130 mm)	
	L70V	Bore Diameter in Cover	1.5354 - 1.5364 in. (39.000 - 39.025 mm)	-	
		Bearing Outside Diameter	1.5381 - 1.5395 in. (39.070 - 39.105 mm)	-	
		Interference Fit	0.0017 - 0.0041 in. (0.045 - 0.105 mm)	-	
		Bearing Metal Inside Diameter	1.3796 - 1.3804 in. (35.043 - 35.063 mm)	1.383 in. (35.130 mm)	
	L100V	Bore Diameter in Cover	1.7322 - 1.7332 in. (44.000 - 44.025 mm)	-	
		Bearing Outside Diameter	1.7356 - 1.737 in. (44.085 - 44.120 mm)	-	
		Interference Fit	0.0023 - 0.0047 in. (0.060 - 0.120 mm)	-	
		Bearing Metal Inside Diameter	1.5764 - 1.5772 in. (40.043 - 40.063 mm)	1.5799 in. (40.130 mm)	
Camshaft Ball Bearing	L48V	Bore Diameter in Cover	2.045 - 2.0458 in. (51.945 - 51.965 mm)	-	*See Camshaft and Tappet on page 8-45.*
		Ball Bearing Outside Diameter	2.0467 - 2.0472 in. (51.987 - 52.000 mm)	-	
		Interference Fit	0.0008 - 0.0021 in. (0.022 - 0.055 mm)	-	
	L70V	Bore Diameter in Cover	2.4385 - 2.4393 in. (61.940 - 61.960 mm)	-	
		Ball Bearing Outside Diameter	2.4404 - 2.4409 in. (61.987 - 62.000 mm)	-	
		Interference Fit	0.001 - 0.0023 in. (0.027 - 0.060 mm)	-	
	L100V	Bore Diameter in Cover	2.832 - 2.8328 in. (71.935 - 71.955 mm)	-	
		Ball Bearing Outside Diameter	2.8341 - 2.8346 in. (71.987 - 72.000 mm)	-	
		Interference Fit	0.0012 - 0.0025 in. (0.032 - 0.065 mm)	-	

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Oil Pump (Trochoid Pump)

Inspection Item		Standard	Limit	Reference Page
All Models	Outer Rotor Outside Diameter	1.1401 - 1.1409 in. (28.960 - 28.980 mm)	1.1377 in. (28.900 mm)	*See installation of crankcase cover on page 8-59.*
	Oil Pump Cavity Diameter (Crankcase Cover)	1.1456 - 1.1464 in. (29.100 - 29.121 mm)	1.1488 in. (29.180 mm)	
	Outer Rotor-to-Crankcase Cover Bore Clearance	0.0047 - 0.0063 in. (0.120 - 0.161 mm)	-	
	Outer and Inner Rotor Width	0.3137 - 0.3149 in. (7.970 - 8.000 mm)	0.3110 in. (7.900 mm)	
	Oil Pump Cavity Depth (Crankcase Cover)	0.3157 - 0.3169 in. (8.020 - 8.050 mm)	0.3188 in. (8.100 mm)	
	Rotor Recess	0.0007 - 0.0031 in. (0.020 - 0.080 mm)	-	
	Inner Rotor-to-Outer Rotor Clearance	0.0000 - 0.0055 in. (0.000 - 0.140 mm)	0.0098 in. (0.25 mm)	

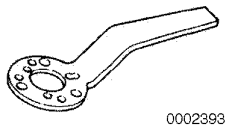
Special Torque Specifications

Component	Model	Thread Diameter and Pitch	Torque	Lubricating Oil Application (Thread Portion and Seat Surface)
Crankcase Cover Bolt	L48V	14-M6 x 1.0 mm	96 - 114 lb-in. (10.8 - 12.8 N·m, 1.1 - 1.3 kgf/m)	Not Applied
	L70V, L100V	13-M8 x 1.25 mm	225 - 243 lb-in. (25.5 - 27.5 N·m, 2.6 - 2.8 kgf/m)	
Stiffener Bolts on Crankcase Cover	All Models	M8 x 1.25 mm	225 - 242 lb-in. (25.5 - 27.4 N·m 2.6 - 2.8 kgf/m)	Not Applied
Connecting Rod Nuts and Bolts	L48V, L70V	2-M7 x 1.0 mm	200 - 243 lb-in. (22.6 - 27.5 N·m, 2.3 - 2.8 kgf/m)	Applied
	L100V	2-M8 x 1.0 mm	32.5 - 36 lb-ft (44.1 - 49.0 N·m, 3.75 - 4.25 kgf/m)	
Flywheel Nut	L48V	M16 x 1.5 mm	101.5 - 108.7 lb-ft (137.3 - 147.1 N·m, 14.0 - 15.0 kgf/m)	Applied
	L70V	M16 x 1.5 mm	116 - 123.2 lb-ft (156.9 - 166.7 N·m, 16.0 - 17.0 kgf/m)	
	L100V	M18 x 1.5 mm	159 - 166 lb-ft (215.7 - 225.6 N·m, 22.0 - 23.0 kgf/m)	

Component	Model	Thread Diameter and Pitch	Torque	Lubricating Oil Application (Thread Portion and Seat Surface)
Cylinder Head Nuts (Final Torque)	L48V	M8 x 1.25 mm	21.5 - 24.4 lb-ft (29.4 - 33.3 N·m, 3.0 - 3.4 kgf/m)	Applied
	L70V	M9 x 1.5 mm	34.8 - 37.8 lb-ft (47 - 51 N·m, 4.8 - 5.2 kgf/m)	
	L100V	M10 x 1.25 mm	44.0 - 46.9 lb-ft (59.8 - 63.7 N·m, 6.1 - 6.5 kgf/m)	
Valve Rocker Arm Support	L48V, L70V	M6 x 1.00 mm	88 - 106 lb-in. (10 - 12 N·m, 1.0 - 1.2 kgf/m)	Not Applied
	L100V	M8 x 1.5 mm	225 - 243 lb-in. (25.5 - 27.5 N·m, 2.6 - 2.8 kgf/m)	Not Applied
Fuel Injector Retaining Nuts	All Models	2-M6x1.0	87 - 104 lb-in. (9.8 - 11.8 N·m, 1.0 - 1.2 kgf/m)	Not Applied
Fuel Pump Delivery Valve		M14x15	22 - 25 lb-ft (29.4 - 34.3 N·m, 3.0 - 3.5 kgf/m)	Not Applied
High-Pressure Fuel Injection Line Nuts			2.74 - 3.25 lb-ft (26.9 - 31.9 N·m, 20 - 24 kgf/m)	Not Applied
Fuel Injection Pump Mounting Nuts		3-M6x1.0	87 - 104 lb-in. (9.8 - 11.8 N·m, 1.0 - 1.2 kgf/m)	Not Applied
Fuel Injection Pump Inspection WIndow Plate Nut		3-M6x1.0	87 - 104 lb-in. (9.8 - 11.8 N·m, 1.0 - 1.2 kgf/m)	Not Applied
Fuel Limiter Mounting Nut			215 - 218 lb-in. (24.2 - 24.6 N·m, 24.7 - 25.1kgf/m)	Not Applied
Fuel Injector Nozzle Case Nut		1-0.605-40UNS-2B	29 - 33 lb-ft (39.2 - 44.1 N·m, 4.0 - 4.5 kgf/m)	Not Applied
Fuel Injector Nozzle Nuts		2-M6x1.0	87 - 104 lb-in. (9.8 - 11.8 N·m, 1.0 - 1.2 kgf/m)	Not Applied

See Tightening Torques for Standard Bolts and Nuts on page 4-33 for standard hardware torque values.

SPECIAL SERVICE TOOLS

<table>
<tr><th>No.</th><th>Tool Name</th><th colspan="5">Applicable Model and Tool Size</th><th>Illustration</th></tr>
<tr><td>1</td><td>Flywheel Holder Wrench (For Removing and Installing the Flywheel)</td><td colspan="5">Yanmar Part No.
114250-92101</td><td> 
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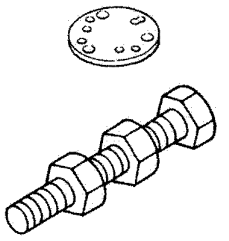
<tr><td rowspan="4">2</td><td rowspan="4">Flywheel Puller (For Removing the Flywheel)</td><td colspan="5">Yanmar Part No. 114250-92121</td><td rowspan="4"> 
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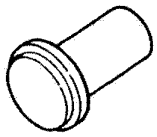
<tr><td>Model</td><td>Bolt</td><td>Qty. Used</td><td>Nut</td><td>Qty. Used</td></tr>
<tr><td>L48V, L70V</td><td rowspan="2">26116-060454</td><td>3</td><td rowspan="2">26716-060002</td><td>6</td></tr>
<tr><td>L100V</td><td>4</td><td>8</td></tr>
<tr><td rowspan="4">3</td><td rowspan="4">Oil Seal Installer (For Installing the Crankshaft and Camshaft Oil Seals)</td><td>Model</td><td colspan="2">Cylinder Block (Crankshaft) - Yanmar Part No.</td><td colspan="2">Crankcase Cover (Crankshaft and Camshaft) - Yanmar Part No.</td><td rowspan="4"> 
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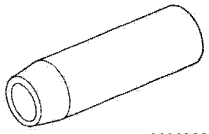
<tr><td>L100V</td><td colspan="2">014650-92311</td><td colspan="2">014650-92311</td></tr>
<tr><td rowspan="4">4</td><td rowspan="4">Oil Seal Protector (For Installing the Crankcase Cover)</td><td>Model</td><td colspan="4">Yanmar Part No.</td><td rowspan="4"> 
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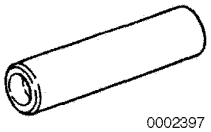
<tr><td>L70V</td><td colspan="4">114268-92300</td></tr>
<tr><td>L100V</td><td colspan="4">114268-92300</td></tr>
<tr><td rowspan="4">5</td><td rowspan="4">Valve Stem Seal Installer (For Installing Valve Stem Seals to the Correct Height)</td><td>Model</td><td colspan="4">Yanmar Part No.</td><td rowspan="4"> 
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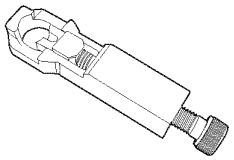
<tr><td>L48V</td><td colspan="4">114250-92350</td></tr>
<tr><td>L70V</td><td colspan="4">114350-92350</td></tr>
<tr><td>L100V</td><td colspan="4">114650-92350</td></tr>
<tr><td>6</td><td>Throttle Shaft Pin Removal Tool (L70V and L100V Models)</td><td colspan="5">Yanmar Part No. 114310-92000</td><td> 
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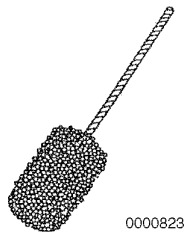
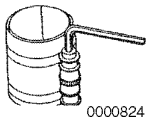
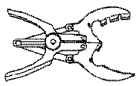
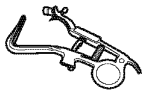
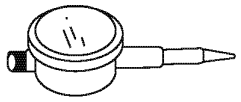
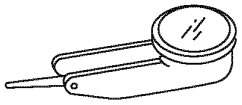
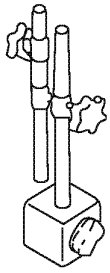
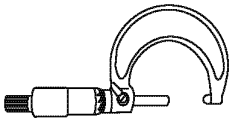
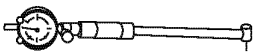
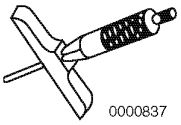
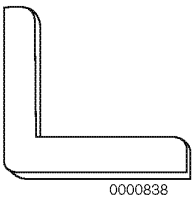
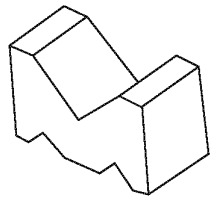
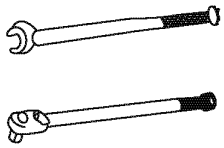
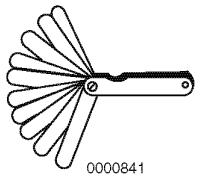
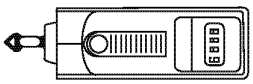
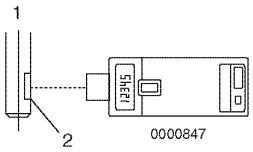
No.	Tool Name	Applicable Model and Tool Size			Illustration
7	Flex-Hone (For Honing of Cylinder Bore)	Model	Part No.	Cylinder Bore	 0000823
		L48V	129400-92400	3.071 - 3.307 in. (70 - 84 mm)	
		L70V	129400-92420	3.071 - 3.307 in. (78 - 84 mm)	
		L100V	129400-92430	3.268 - 3.740 in. (86 - 95 mm)	
8	Piston Ring Compressor (For Installing Piston)	Yanmar Part No. 95550-002476 The piston ring compressor is applicable for 2.362 - 4.921 in. (60 - 125 mm) diameter pistons			 0000824
9	Piston Ring Expander (For Removal/ Installation of Piston Rings)	Available Locally			 0000825
10	Piston Ring Groove Cleaning Tool	Available Locally			 0002897

MEASURING INSTRUMENTS

No.	Instrument Name	Application	Illustration
1	Dial Indicator (Available Locally)	Measurements of shaft bending, and strain and gap of surfaces	 0000831
2	Test Indicator (Available Locally)	Measurements of narrow or deep portions that cannot be measured by dial gauge	 0000832
3	Magnetic Stand (Available Locally)	For holding the dial gauge when measuring	 0000833
4	Micrometer (Available Locally)	For measuring the outside diameters of crankshaft, piston, piston pins, etc.	 0000834
5	Cylinder Bore Gauge (Available Locally)	For measuring the inside diameters of cylinder liners, rod metal, etc.	 0000835
6	Calipers (Available Locally)	For measuring outside diameters, depth, thickness and width	 0000836
7	Depth Micrometer (Available Locally)	For measuring amount of valve sink	 0000837
8	Square (Available Locally)	For measuring valve spring inclination and straightness of parts	 0000838

No.	Instrument Name		Application	Illustration
9	Straight Edge (Available Locally)		For measuring cylinder head distortion and straightness of parts	 0003594
10	V-Block (Available Locally)		For measuring shaft bend	 0000839
11	Torque Wrench (Available Locally)		For tightening nuts and bolts to the specified torque	 0000840
12	Feeler Gauge (Available Locally)		For measuring gaps between ring and ring groove, valve clearance and shaft joints during assembly	 0000841
13	Tachometer (Available Locally)	Contact Type	For measuring revolution by contacting the mortise in the revolving shaft	 0000846
		Photoelectric Type	For measuring revolution by sensing the reflecting mark on the outer periphery of the revolving shaft 1 — Revolving Shaft 2 — Reflection Mark	 0000847

CYLINDER HEAD

Removal of Cylinder Head

L48V Models

1. Remove the air cleaner assembly.
2. Remove the fuel tank and fuel tank support brackets.
3. Remove the muffler assembly.

L70V and L100V Models

1. Remove the cylinder head upper cooling cover.
2. Remove the cylinder head side cooling cover.
3. Remove the air cleaner assembly.
4. Remove the fuel tank and fuel tank support brackets.
5. Remove the muffler assembly.

All Models

1. Disconnect the external compression release linkage (if equipped) from the rocker arm cover.
2. Remove the rocker arm (valve) cover.
3. Remove the rocker arm shaft assembly **(Figure 8-2)**, by first removing the two bolts that secure the rocker arm shaft assembly to the cylinder head.

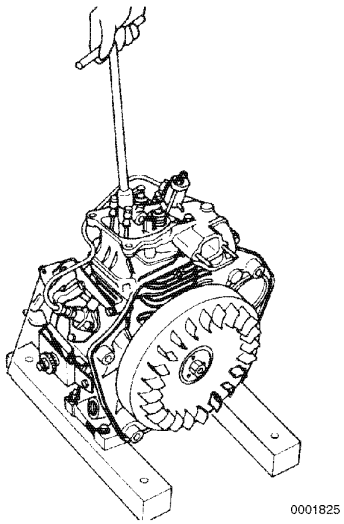


Figure 8-2

Note: Mark the push rods so they can be reinstalled in their original locations.

4. Remove the push rods.

Note: When loosening or tightening the high-pressure fuel line nuts, use a “line” or “flare nut” wrench to prevent rounding of the nuts.

5. Remove the high-pressure fuel injection line, fuel return line and the fuel injector. *See Removal of Fuel Injection Pump on page 9-17.*
6. Remove the two cylinder head nuts and two bolts and remove the cylinder head **(Figure 8-3)**. Discard the cylinder head gasket. Place the cylinder head on a protected work surface to prevent damage to the combustion surface.

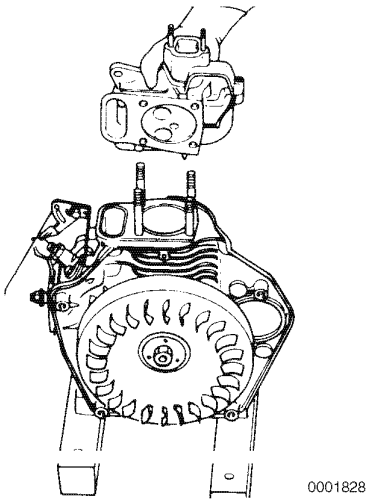


Figure 8-3

Disassembly of Cylinder Head

NOTICE: Arrange and mark all components so they can be installed in their original locations.

NOTICE: Remove the fuel injector before placing the cylinder head on a work surface. Failure to do so may result in damage to the fuel injector nozzle. See Removal of Fuel Injector on page 9-23.

1. Place the cylinder head on a work bench with the combustion side down.
2. Remove the valve stem caps **(Figure 8-4, (5))**.
3. Use an appropriate valve spring compressor tool to compress the valve springs.
4. Remove the valve keepers **(Figure 8-4, (6))**.
5. Slowly release the tension on the valve spring **(Figure 8-4, (8)).**
6. Remove the spring retainer **(Figure 8-4, (7))**, valve spring **(Figure 8-4, (8))** and washer **(Figure 8-4, (10))**.
7. Repeat the procedure with the remaining valve.
8. Remove the intake **(Figure 8-4, (11))** and exhaust **(Figure 8-4, (12))** valves from the cylinder head.
9. Remove the valve stem seals **(Figure 8-4, (9))**.
10. Remove the snap ring **(Figure 8-4, (1))** from each end of the rocker arm shaft. Remove the rocker arms **(Figure 8-4, (4))**. Identify the rocker arms so they can be installed in their original locations.
11. If necessary, remove the locknut **(Figure 8-4, (2))** and adjusting screw **(Figure 8-4, (3))** from each rocker arm.

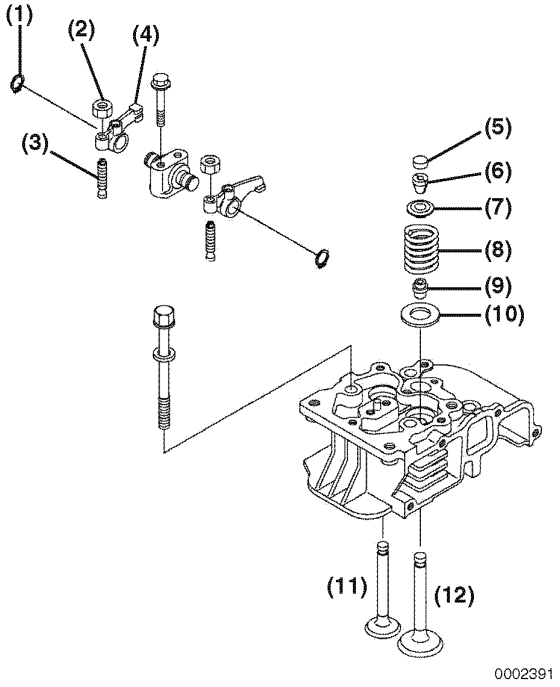


Figure 8-4

Inspection of Cylinder Head Components

Thoroughly clean all components using a non-metallic brush and an appropriate solvent. Each part must be free of carbon, metal filings and other debris. *NOTICE: Any part which is found defective as a result of inspection or any part whose measured value does not satisfy the standard or limit must be replaced. NEVER use diesel fuel as a cleaning agent.*

Visually inspect all parts. Replace any parts that are obviously discolored, heavily pitted, worn or otherwise damaged. Discard any parts that do not meet the specified limit.

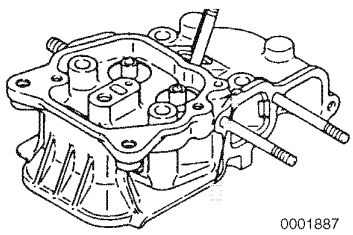


Figure 8-5

EGR Passage

The L48V does not require EGR passage inspection, as this model does not incorporate this feature.

The L70V and L100V model engines incorporate a drilled passage **(Figure 8-6, (1))** between the intake and exhaust valve pockets. The valves must be removed from the cylinder head to inspect the EGR passage. This passage allows some exhaust gases to flow back into the intake air and be re-burned in engine combustion to reduce emissions.

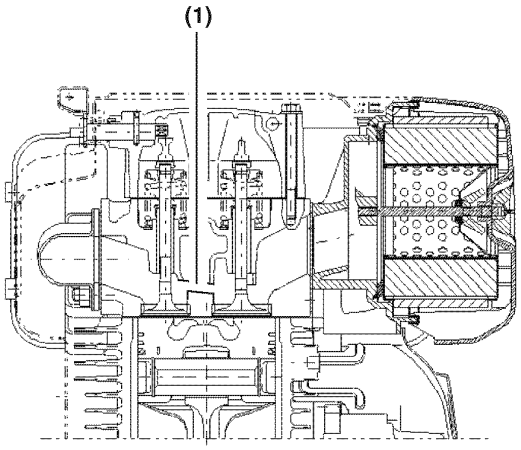


Figure 8-6

If this passage becomes restricted (possibly due to carbon build-up), the engine may not conform to EPA emissions regulations. It is important that this passage be inspected, measured and cleaned to allow the engine to operate within EPA emissions regulations.

The EGR passage can be measured with a common drill bit to determine if the passage is open to the standard dimension. Clean the passage as needed, however do not remove cylinder head material (metal) during the cleaning process.

Engine Model	EGR Passage Standard Dimension
L100V	4.0 mm (0/+0.1 mm)
L70V	3.4 mm (0/+0.1 mm)

Valve Face and Valve Seat

Always check the clearance between the valve and valve guide before grinding or lapping the valve seats. *See Intake / Exhaust Valves, Guides and Seals on page 8-5 for the service limit.* If the clearance exceeds the limit, replace the valve and / or cylinder head to bring the clearance within the limit.

Roughness or burrs will cause poor seating of a valve. Visually inspect the seating surfaces of each valve and valve seat to determine if lapping or grinding is needed.

Visually inspect all valve faces and valve seats for pitting, distortion, cracking or evidence of overheating. Usually the valves and the valve seats can be lapped or ground to return them to serviceable condition. Severely worn or damaged components will require replacement.

Coat the valve seat with a thin coat of bluing compound. Install the valve and rotate it to distribute bluing onto the valve face. The contact pattern should be centered on the valve face **(Figure 8-7, (1))** and even in width.

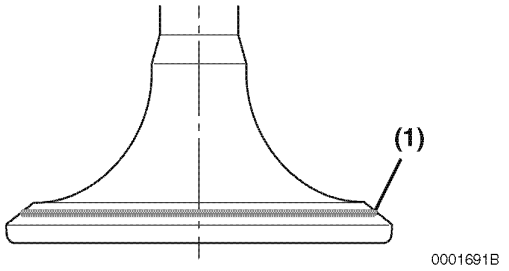


Figure 8-7

Also visually inspect the valve seat for even contact.

Light cutting can be performed by the use of a hand-operated cutter **(Figure 8-8, (3))**.

The valve seat **(Figure 8-8, (2))** diameter can be adjusted by top-grinding with a 150° stone to make the seat diameter smaller, and bottom-grinding using a 40° stone to make the seat diameter larger. Once the seat location has been corrected, grind and lap the seat angle **(Figure 8-8, (1))** to specification. *See Cylinder Head on page 8-4 for specifications.*

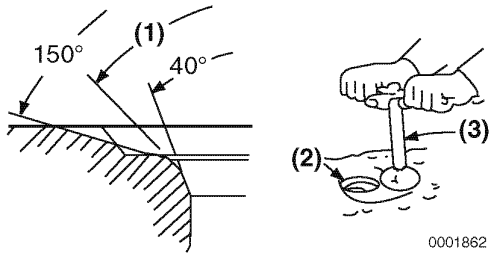


Figure 8-8

Grind the valve face and / or valve seat only enough to return them to serviceable condition. Grinding is needed if the valve and the valve seat do not contact correctly. *See Valve Recession on page 8-25.*

If the valve or seat require grinding, lap the valve after grinding. Lap the valve face to the valve seat using a mixture of valve lapping compound and engine oil.

Be sure to thoroughly wash all parts to remove all grinding powder or compound.

Valve Recession

Insert the valves into their original locations until they are fully seated. Use a depth micrometer to measure the distance **(Figure 8-9, (2))** between the cylinder head surface **(Figure 8-9, (1))** and the combustion surface of each exhaust and intake valve. *See Cylinder Head on page 8-4* for the service limit. Record the measurement.

Note: If the valve seats are worn or damaged beyond specification, the cylinder head must be replaced. The valve seats are not replaceable parts.

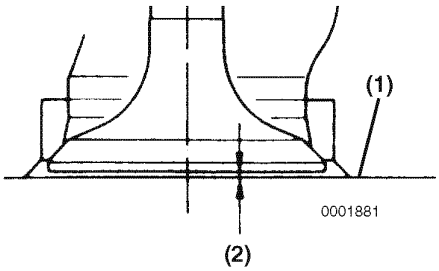


Figure 8-9

Valves and Valve Guides

Visually inspect the intake and exhaust valves. Replace any valves that are obviously discolored, heavily pitted or otherwise damaged.

Valve Stem Diameter

Use a micrometer to measure the valve stem diameter. Measure the valve stem near the combustion end and near the opposite end **(Figure 8-10, (1))**. *See Intake / Exhaust Valves, Guides and Seals on page 8-5* for the service limit. Record the measurements.

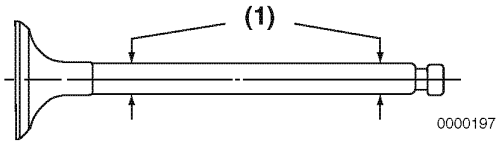


Figure 8-10

Valve Guides

Visually inspect the valve guides for distortions, scoring or other damage.

Use a telescoping gauge and micrometer to measure the inside diameter of the valve guide. Measure in three places and 90° apart **(Figure 8-11)**. See *"Intake / Exhaust Valves, Guides and Seals" on page 8-5* for the service limit. Replace valve guides if not within specification. Record the measurements.

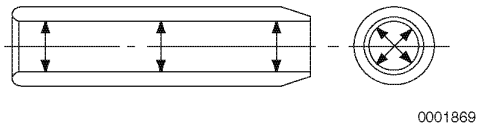


Figure 8-11

Valve Stem Bend

Place the valve stem on a flat inspection block or layout bed. Roll the valve until a gap can be observed between a portion of the valve stem and the surface of the block or bed. Use a feeler gauge to measure the gap **(Figure 8-12)**.
See Intake / Exhaust Valves, Guides and Seals on page 8-5 for the service limit. Record the measurement.

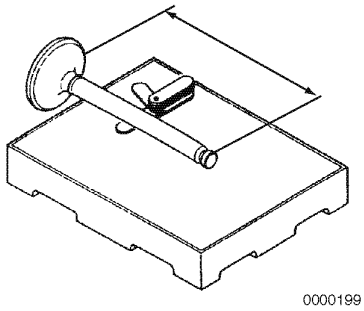


Figure 8-12

Valve Springs

Inspect the valve springs. If damage or corrosion is seen, or if measurements exceed the specified limits, replace the springs. Record all measurements.

Fractures

Check for fractures on the inside and outside portions of the springs. If the valve spring is fractured, replace the valve spring.

Corrosion

Check for corrosion of the spring material caused by oxidation.

Squareness

Use a flat surface and a square to check each spring for squareness **(Figure 8-13)**. *See Valve Spring on page 8-6* for the service limit.

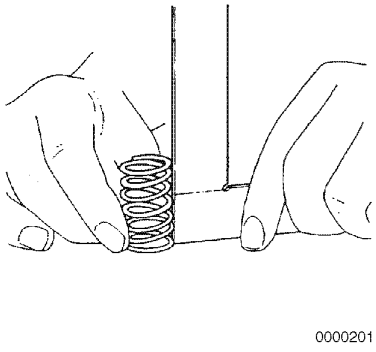
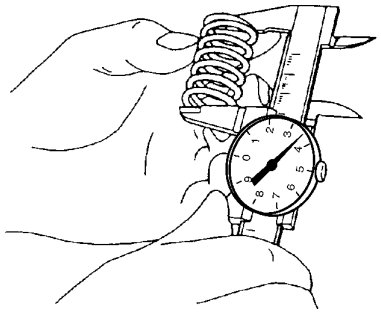


Figure 8-13

Free Length

Use a caliper to measure the length of the spring **(Figure 8-14)**. *See Valve Spring on page 8-6* for the service limit.



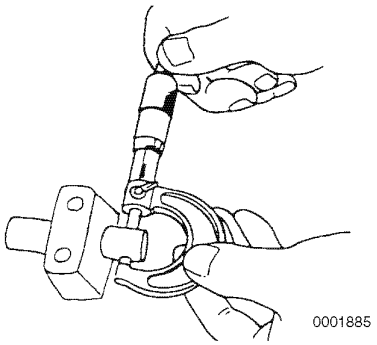
0000200

Figure 8-14

Rocker Arms and Push Rods

Rocker Arm Shaft Outside Diameter

Use a micrometer to measure the rocker arm shaft diameter. Measure at each rocker arm location in two directions, 90° apart **(Figure 8-15)**. *See Rocker Arm and Shaft on page 8-6* for the service limit. Record the measurements.



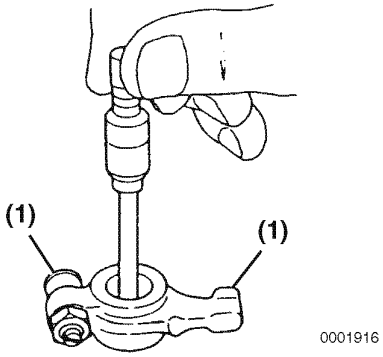
0001885

Figure 8-15

Rocker Arm

Use a telescoping gauge and micrometer to measure the inside diameter of the rocker arms **(Figure 8-16)**. *See Rocker Arm and Shaft on page 8-6* for the service limit. Record the measurements.

Inspect the contact areas **(Figure 8-16, (1))** for excessive wear or damage.



0001916

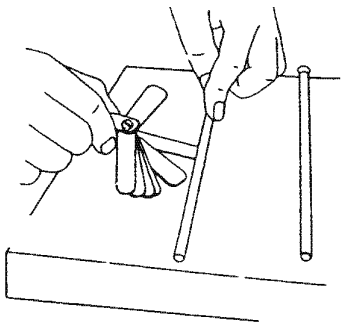
Figure 8-16

Push Rod Bend

Determine if the bend of the push rods are within the specified limit.

1. Place the push rods on a flat inspection block or layout bed.
2. Roll the push rods until a gap can be observed between a portion of the push rod and the surface of the block or layout bed.

Use a feeler gauge to measure the gap **(Figure 8-17)**. *See Push Rod on page 8-5* for the service limit. Record the measurement.



0000204

Figure 8-17

Cylinder Head Distortion

Place the cylinder head flat and inverted (combustion side up) on the bench. Use a straightedge and a feeler gauge to measure cylinder head distortion **(Figure 8-18)**. Measure diagonally and along each side. *See Cylinder Head on page 8-4* for the service limit. Record the measurements.

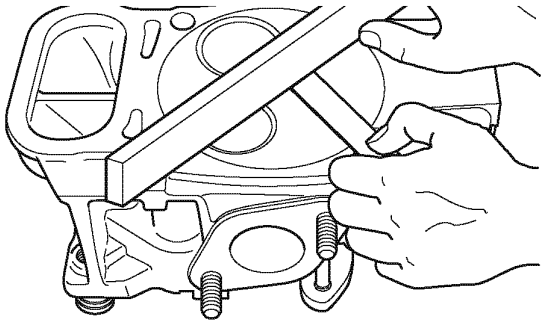


Figure 8-18

If distortion exceeds the service limit, resurface or replace the cylinder head. Remove only enough material to make the cylinder head flat, but do not remove more than 0.008 in. (0.20 mm).

Reassembly of Cylinder Head

Reassembly of Intake / Exhaust Valves

NOTICE: Always install new valve stem seals. The exhaust stem seals can be identified by having yellow paint. Ensure they are installed in the correct locations.

1. Oil the lip of the valve stem seal **(Figure 8-19, (2))**. Using a valve stem seal installation tool **(Figure 8-19, (1))**, install a new valve stem seal on each of the valve guides **(Figure 8-19, (3))**.

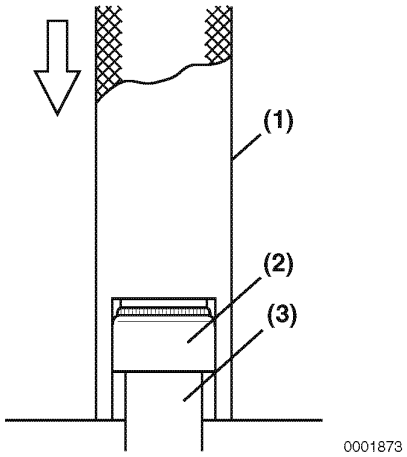


Figure 8-19

Note: Be sure the valve-spring washer is not installed on the cylinder head.

2. Measure the distance **(Figure 8-20, (1))** from the machined spring seat surface of the cylinder head to the top of the valve stem seal to ensure there is proper clearance **(Figure 8-20, (2))** between the guide and the seal. *See Intake / Exhaust Valves, Guides and Seals on page 8-5* for Valve Seal Installed Height Specifications.

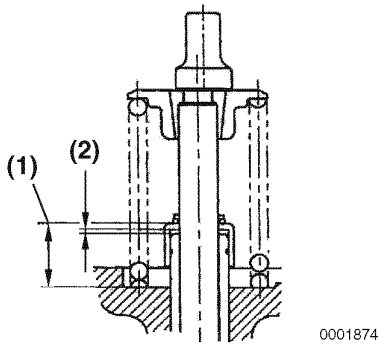


Figure 8-20

3. Place the valves **(Figure 8-22, (11, 12))** in their proper locations in the cylinder head. NOTICE: L100V models: Position the white paint mark ***(Figure 8-21,* (1))** on the valve spring toward the cylinder head during assembly.

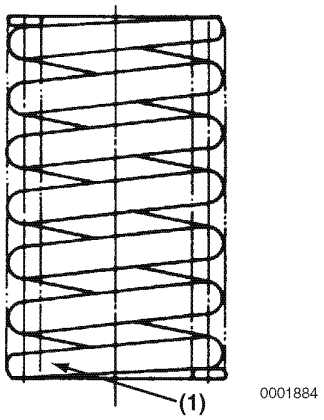


Figure 8-21

4. Place the cylinder head on the workbench with the combustion side down. Install the washer **(Figure 8-22, (10))**, valve spring **(Figure 8-22, (8))** and spring retainer **(Figure 8-22, (7))**.

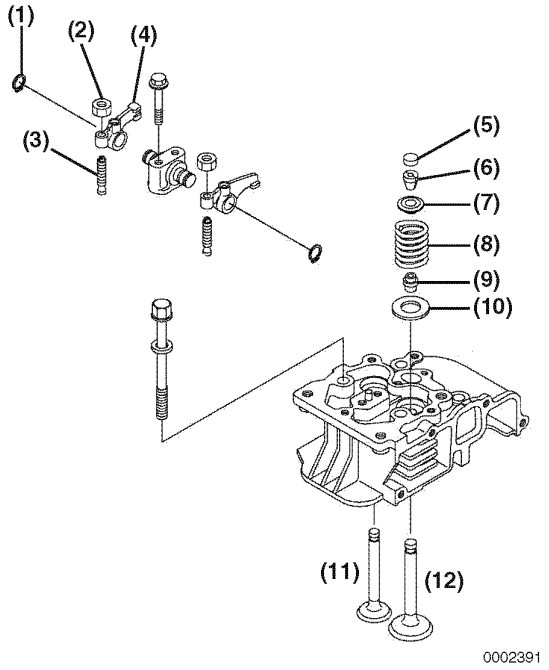


Figure 8-22

5. Using an appropriate valve spring compressor tool, compress the valve spring.
6. Insert the valve keepers **(Figure 8-22, (6))** and slowly release the tension on the valve spring. Install the valve cap **(Figure 8-22, (5))**. Repeat the steps on the remaining valve.
7. Install the rocker arms **(Figure 8-22, (4))** on the rocker shaft. Secure with a snap ring **(Figure 8-22, (1))** on each end. If removed, install the adjuster screws **(Figure 8-22, (3))** and locknuts **(Figure 8-22, (2))** in each rocker arm.

Installation of Cylinder Head

1. Carefully clean the gasket surfaces of the cylinder head and the cylinder block.
2. Install a new push rod cavity O-ring.
3. Select and install a cylinder head gasket. *See Calculating Cylinder Head Gasket Thickness on page 8-30*.
4. Install the cylinder head.

Note: Install the cap nuts **(Figure 8-23, (2))** on the studs that will be covered by the rocker arm cover.

5. Lightly oil the threads of the cylinder head studs. Install the washers **(Figure 8-23, (1))** and nuts. Tighten to the specified torque in two steps as shown in the chart below. Tighten in an "X" pattern. *See Special Torque Specifications on page 8-16* for torque values.

First Step	1/2 of final torque
Second Step	Final torque

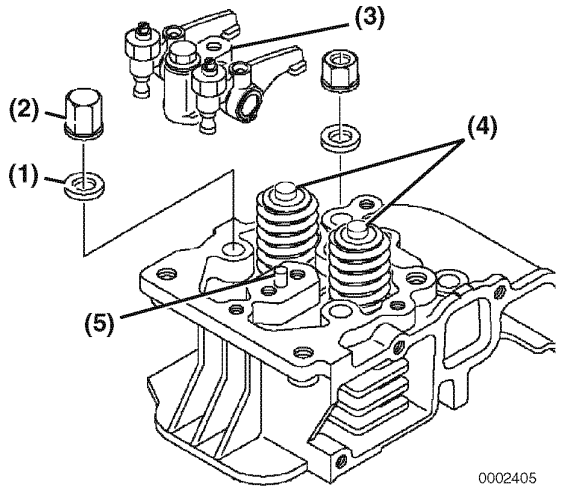


Figure 8-23

6. Insert the push rods in their respective positions. Ensure the push rods are seated in the tappets.
7. Place the valve caps **(Figure 8-23, (4))** on the valve stem tips.
8. Install the rocker arm shaft assembly **(Figure 8-23, (3))**. Be sure the alignment pin **(Figure 8-23, (5))** is in place.
9. Install and tighten the rocker arm shaft bolts to the specified torque. *See Special Torque Specifications on page 8-16* for torque values.

Calculating Cylinder Head Gasket Thickness

1. Rotate the flywheel until the TDC (Top Dead Center) mark on the flywheel **(Figure 8-24, (2))** aligns with the left-hand edge of the timing reference "notch" on the cylinder cooling fin **(Figure 8-24, (1))**.

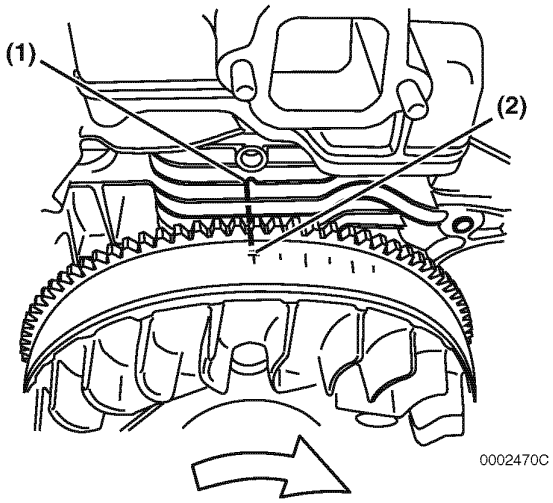


Figure 8-24

2. Place a wooden wedge between the flywheel and crankcase to hold the flywheel and crankshaft stationary.
3. Use a depth micrometer to measure the distance **(h)** from the cylinder block surface **(Figure 8-25, (2))** to the top of the piston **(Figure 8-25, (1))**. Be careful to avoid the valve relief pockets and any marks stamped on the piston. Take the average of two measurements, 180° apart and in line with the piston wrist pin and record the measurement **(h)**.

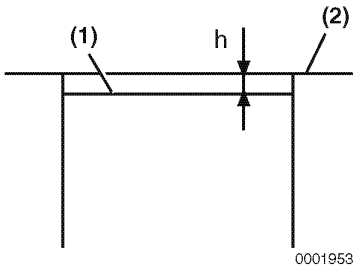


Figure 8-25

4. Subtract the measured value **(h)** from both the minimum and maximum values in the chart below for the engine model being serviced.

Model	Minimum	Maximum
L48V	0.0215 in. (0.546 mm)	0.0235 in. (0.596 mm)
L70V	0.0218 in. (0.553 mm)	0.0239 in. (0.603 mm)
L100V	0.0222 in. (0.563 mm)	0.0241 in. (0.613 mm)

5. Choose a gasket thickness from the chart that is between the two calculated values:

   Example: If the average of the two measurements is **(h)** = 0.006 in. (0.157 mm) for a model L70V, the calculations would look like this:

   - English Calculation:
     Minimum - (0.0218 - 0.006 = 0.0158 in.)
     Maximum - (0.0239 - 0.006 = 0.0179 in.)
   - Metric Calculation:
     Minimum - (0.553 - 0.157 = 0.396 mm)
     Maximum - (0.607 - 0.157 = 0.450 mm)
   - In this case, the head gasket required must be between 0.0158 and 0.0179 in. (0.396 mm and 0.450 mm) in thickness. The gasket to use would be the gasket that is 0.016 in. (0.40 mm) in thickness and would have an identification mark of 40.

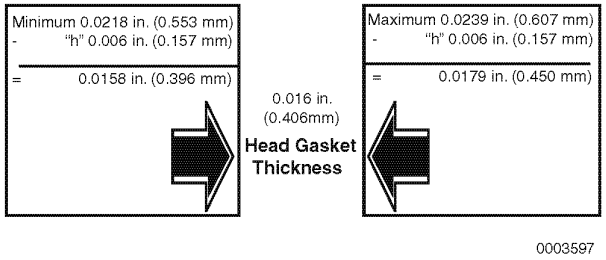


Figure 8-26

Note: If your calculation indicates the need for a thinner head gasket than those available, this would be an indication of damage to the connecting rod (bent) or connecting rod bearing (worn).

Available Cylinder Head Gasket Sets
(The cylinder head gaskets are sold in sets of five (5) gaskets, one of each thickness.)
The identification number is marked on each head gasket.

Cylinder Head Gasket Set Part Number		Thickness Identification Mark				
L48V	114771-01330	0.016 in. (0.40 mm)	0.018 in. (0.45 mm)	0.020 in. (0.50 mm)	0.022 in. (0.55 mm)	0.024 in. (0.60 mm)
L70V	114871-01330					
L100V	114651-01330	ID 40	ID 45	ID 50	ID 55	ID 60

Checking Actual Piston TDC (Top Dead Center)

Due to variations in machined and cast parts and assembly procedures, the TDC timing mark on the flywheel may not always align accurately with piston TDC mark on the cooling fin, misrepresenting true TDC piston position.

Indexing the flywheel to the actual piston TDC, provides an accurate measurement of the piston position in the cylinder to the TDC timing mark on the flywheel.

It is recommended that the flywheel be indexed any time the flywheel is removed from the crankshaft and before adjusting fuel Injection timing.
See Adjusting Fuel Injection Timing on page 9-14.

Indexing the flywheel to true TDC involves using the engine intake valve as a piston stop to rotate the piston against, in both directions of rotation. At each rotational stop, a mark is placed on the cooling fin where the TDC mark on the flywheel stops. This will provide two new marks on the cooling fin, one on each side of the existing TDC mark. The mid point between the two new marks is true TDC.

1. Close all fuel supply valves to the fuel injeciton pump. NOTICE: *Always use a wrench to hold the fuel injection pump fuel delivery valve to prevent loosening of the delivery valve when loosening or tightening the high-pressure fuel injection lines.*

Note: To prevent “rounding” the fuel line nuts, always use a “line” or “flare nut” wrench.

2. To prevent accidental engine starting, loosen the high-pressure fuel injection line nuts at each fuel injector and the fuel injection pump to drain fuel from the lines.

Note: Some fuel may drain from the fuel injection pump during this process. Make provisions to contain spills.

3. Remove the rocker arm (valve) cover bolts, valve cover and gasket. Discard the gasket.
4. Remove the intake valve adjustment screw lock nut from the intake valve rocker arm **(Figure 8-27, (3))** of No. 1 cylinder, and back out the adjustment screw **(Figure 8-27, (2))** enough to remove the push rod.

Note: The use of a “bridge” tool is needed to support the valve adjustment screw and open the valve. Use a suitable tool that allows adjustment of the valve adjustment screw. An 8 to 10 mm hex wrench is shown as an example in **(Figure 8-27, (1))**.

5. Insert the bridge tool across the top surface of the cylinder head to support the valve adjustment screw.

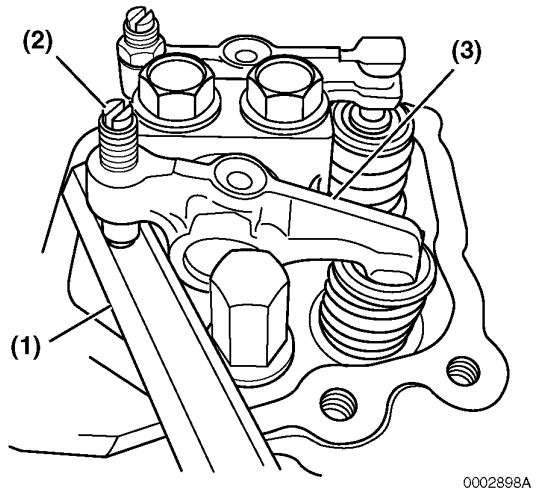


Figure 8-27

6. Rotate the flywheel to position the existing TDC mark at approximately 90°BTDC **(Figure 8-28)**.

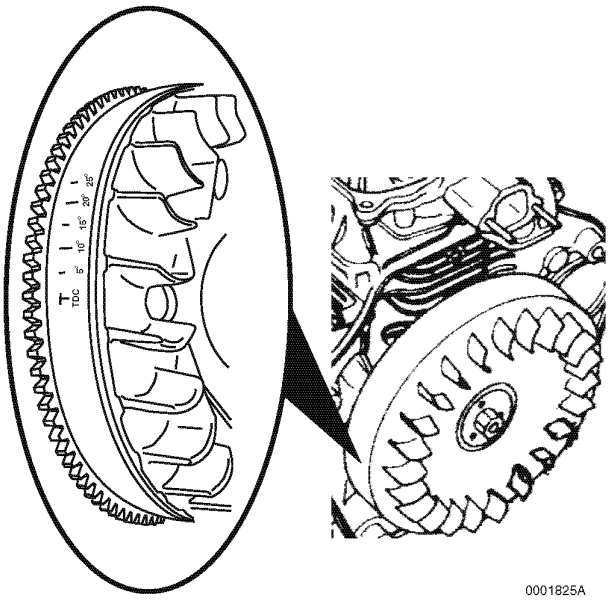


Figure 8-28

7. Turn the valve adjustment screw in against the bridge tool to open the intake valve into the cylinder to act as a piston stop.
8. Carefully rotate the flywheel in a clockwise **(Figure 8-29, (5))** direction to allow the piston to contact the intake valve. Measure the distance from the existing TDC mark **(Figure 8-29, (1))** on the cooling fin to the TDC mark on the flywheel **(Figure 8-29, (3))** (where the flywheel stopped).

   The valve should contact the piston approximately 30 - 40 mm BTDC.
9. If the valve does not contact the piston within the range, carefully rotate the flywheel counterclockwise away from the valve, readjust the screw to bring the contact distance into range and rotate the flywheel clockwise again to stop the piston at the valve. Recheck the measurement and repeat as necessary to bring the measurement within the range.
10. With the piston in contact with the intake valve, use a straightedge **(Figure 8-29, (4))** and scribe or fine point marker to transfer the position of the flywheel TDC mark **(Figure 8-29, (2))** to the cooling fin.

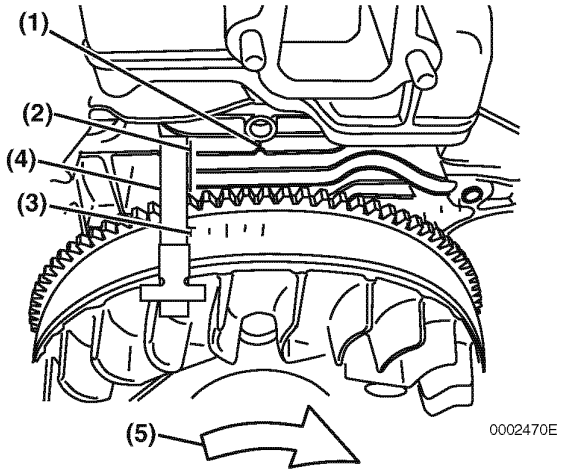


Figure 8-29

11. Carefully rotate the flywheel counterclockwise **(Figure 8-30, (1))** completely around to allow the piston to contact the valve from the other side.
12. With the piston in contact with the intake valve, use a straightedge **(Figure 8-30, (4))** and scribe or fine point marker to transfer the position of the flywheel TDC mark **(Figure 8-30, (3))** to the cooling fin **(Figure 8-30, (2))**.

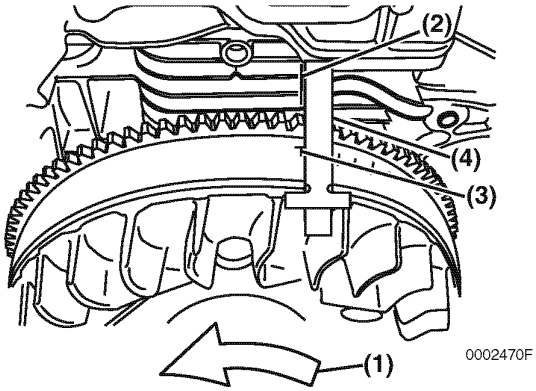
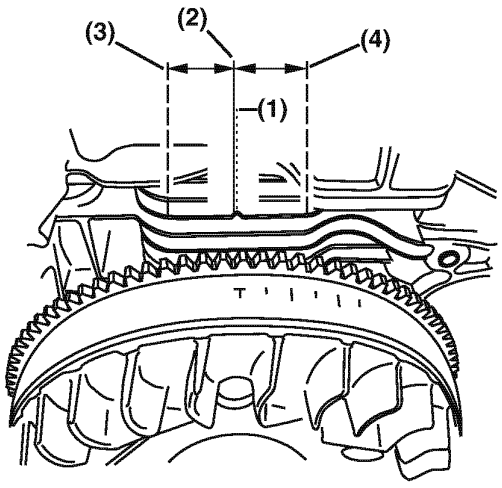


Figure 8-30

13. Using a caliper, measure the distance between the two new marks on the cooling fin **(Figure 8-30, (3, 4))**.

14. The mid-point **(Figure 8-31, (2))** (divide the distance by 2) of the distance measured is the new TDC cooling fin mark. Use a scribe or fine point marker to mark this position on the cooling fin as the new true piston TDC. **Figure 8-31** illustrates an example.



1 – Original TDC Timing Mark
2 – New TDC Timing Mark
3 – Left Piston Stop Timing Mark
4 – Right Piston Stop Timing Mark

Figure 8-31

15. Loosen the valve adjustment screw and remove the bridge tool.
16. Install the intake valve push rod.
17. Install the intake valve adjustment screw lock nut on the adjustment screw.
18. Adjust the valve clearance. *See Measuring and Adjusting Valve Clearance on page 8-35.*
19. Install a new rocker arm (valve) cover gasket.
20. Install the rocker arm (valve) cover and bolts.
21. Tighten the high pressure fuel injection line nuts on each fuel injector and on the fuel injection pump to specification. *See Special Torque Specifications on page 8-16.*
22. Open all fuel supply valves to the fuel injeciton pump.
23. Prime the fuel system. *See Priming the Fuel System on page 4-19.*

Measuring and Adjusting Valve Clearance

Note: The engine should be cold before adjusting valve clearance.

To adjust valve clearance, the piston must be at or near TDC of the compression stroke. When the piston is at TDC of the compression stroke, both the intake and exhaust valves will be closed and both rocker arms will be loose.

If the cooling fan housing is removed, the TDC mark on the flywheel can be aligned with the TDC mark on the cooling fin to locate piston TDC of the compression stroke.

If the cooling fan housing is not removed, piston TDC of the compression stroke may be found by rotating the flywheel and watching each valve open and close. Rotate the flywheel clockwise, allowing the exhaust valve to open then close, and then the intake valve to open and close. After the intake valve has closed, rotate the flywheel clockwise an additional 1/4 turn. At this position the piston will be on the compression stroke and both valves will be closed allowing valve clearance adjustment to be completed.

1. Remove the rocker arm (valve) cover bolts, valve cover and gasket. Discard the gasket.
2. Rotate the crankshaft to piston TDC of the compression stroke.
3. Check the valve clearance **(Figure 8-32, (1))** using a feeler gauge. If adjustment is required, proceed to the next step. *See Valve Clearance on page 8-4* for the specification.
4. Loosen the adjusting screw locknut **(Figure 8-32,** (3)). Turn the valve adjustment screw **(Figure 8-32, (2))** to adjust the valve clearance so there is a slight “drag” on the feeler gauge when sliding it between the rocker arm and the valve cap. Hold the adjusting screw while tightening the valve adjusting screw locknut. Recheck the clearance.

Standard Intake/Exhaust Valve Clearance - All Models
0.006 ± 0.002 in. (0.15 ± 0.05 mm)

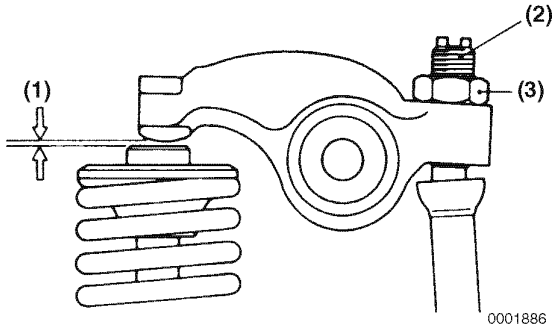


Figure 8-32

Note: There is a tendency for the clearance to decrease slightly when the locknut is tightened. It is suggested that you make the initial clearance adjustment slightly on the "loose" side before tightening the locknut. Recheck the clearance after tightening the locknut.

5. Apply oil to the contact surface between the adjusting screw and push rod.
6. Install a new rocker arm (valve) cover gasket.
7. Install the rocker arm (valve) cover and bolts.

ENGINE

Removal of Engine

Prepare a clean, flat work surface on a workbench large enough to accommodate the engine components.

1. Disconnect the battery cables (if equipped), negative (-) cable first.
2. Drain the engine oil. *See Replace Engine Oil on page 5-10.*
3. Turn off any fuel valves. Disconnect the fuel supply and fuel return lines at the engine.
4. Disconnect the throttle cable, any external engine shut-off linkage, external compression release linkage and any external wire connectors.
5. Remove all engine mount fasteners and remove the engine from the machine. Secure the engine to a solid base. **WARNING! ALWAYS secure the engine solidly to prevent injury or damage to parts due to the engine falling during work on the engine.**
6. Clean the engine by washing with solvent, air or steam cleaning. Cover or plug any open connectors, hoses or fittings to prevent any foreign matter from entering the engine during cleaning.
7. Remove the engine-mounted fuel tank (if equipped) **(Figure 8-33)**.

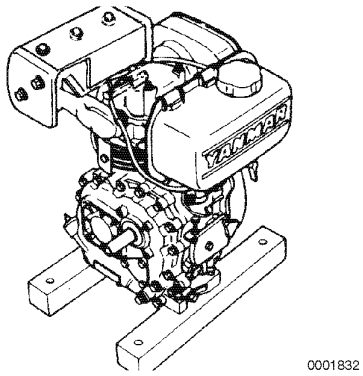


Figure 8-33

8. Remove the exhaust muffler **(Figure 8-34)**.

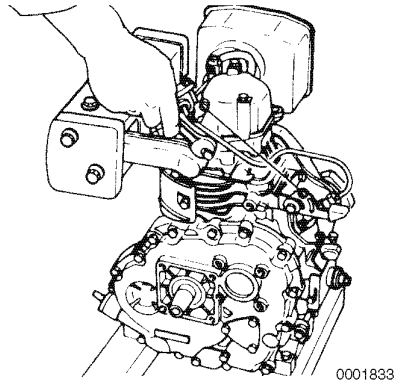


Figure 8-34

9. Remove the air cleaner cover.
10. Remove the filter element **(Figure 8-35)**.
11. Remove the air cleaner housing.

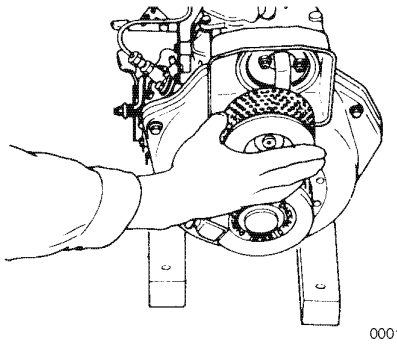


Figure 8-35

12. Remove the recoil starter and starter pulley. (The recoil starter and cooling fan may be removed as an assembly if the recoil assembly does not require service.)
13. Remove the cooling fan housing.
14. Remove the starter pulley from the flywheel **(Figure 8-36, (1))**.

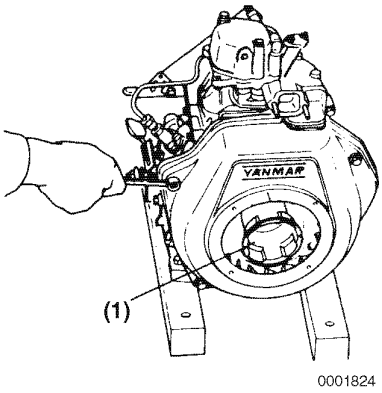


Figure 8-36

15. Remove the air intake manifold **(Figure 8-37)**.

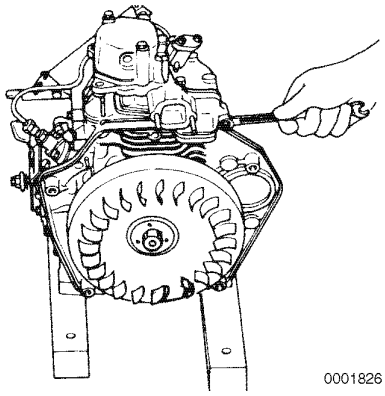


Figure 8-37

16. Remove the starter motor (if equipped).

    NOTICE: Mark all valve train components so they can be installed in their original locations.

17. Remove the cylinder head assembly.
    See Removal of Cylinder Head on page 8-22.
18. Remove the fuel injection pump **(Figure 8-38)**.
    See Removal of Fuel Injection Pump on page 9-17.

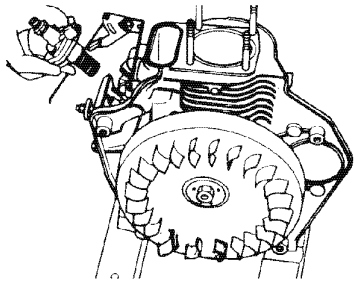


Figure 8-38

Disassembly of Engine

Note: Before performing any of the following procedures, first perform procedures in, *"Removal of Engine" on page 8-36*.

1. If not already completed, remove the cylinder head assembly. *See Removal of Cylinder Head on page 8-22*. If the cylinder head requires service, it should be done at this time. *See Disassembly of Cylinder Head on page 8-23*.

   NOTICE: Discard all used gaskets, O-rings and seals during assembly.

Note: Record all measurements taken during disassembly.

2. Remove the flywheel and stator assembly. *See Removal of Stator on page 11-15*.
3. Remove the crankcase cover **(Figure 8-39)** and oil pump assembly.

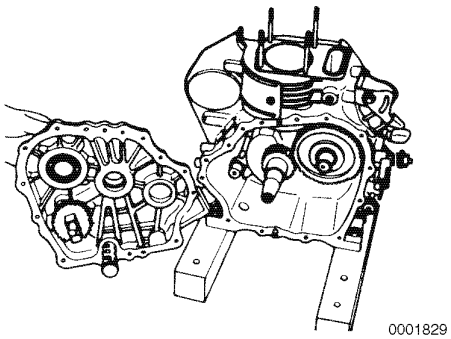


Figure 8-39

4. Position the engine with the open crankcase end facing up.

Note: Before removing the camshaft, rotate the camshaft at least two turns to "bump" any sticking tappets away from the camshaft.

Note: Identify the location of the camshaft gear and crankshaft gear alignment marks **(Figure 8-40)**. These marks are important for reassembly.

5. Remove the camshaft by pulling it straight up and out of the crankcase.

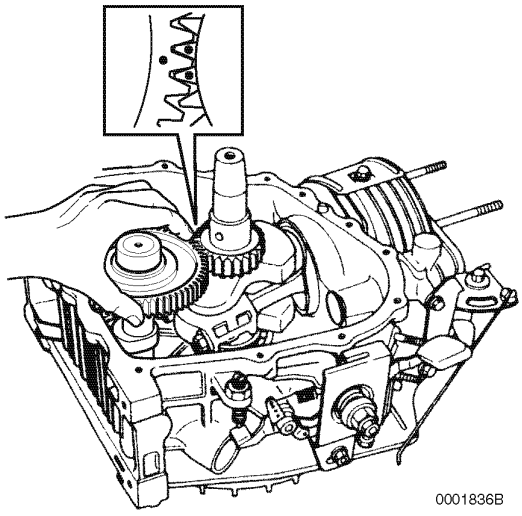


Figure 8-40

Note: The tappets are "mushroom" shaped and must be removed from inside the engine crankcase.

6. Remove the tappets. Mark the tappets so they can be reinstalled in the same location.
7. Remove the balancer **(Figure 8-41)** shaft by pulling it up and out of the crankcase, rotating as necessary for clearance. As with the camshaft, note the alignment marks where the balancer shaft gear meshes with the crankshaft gear.

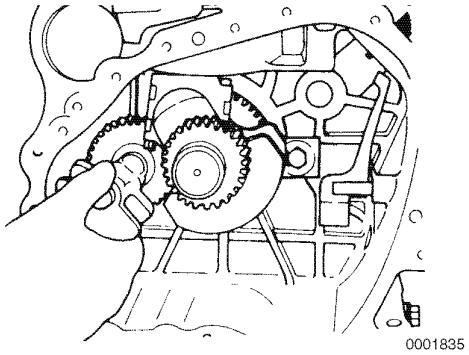


Figure 8-41

8. Measure bearing oil clearance prior to removing the piston and connecting rod to determine the extent of wear. Record the measurements.
   (a) Remove the bearing cap. Do not remove the bearing inserts at this time.
   (b) Wipe oil from the bearing insert and crankshaft journal surfaces.
   (c) Place a piece of PLASTIGAGE® **(Figure 8-42, (1))** along the full width of the bearing insert.

   NOTICE: Do not rotate the crankshaft when using PLASTIGAGE. A false reading may result.

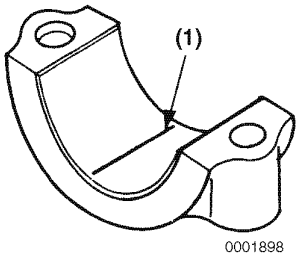


Figure 8-42

   (d) Install the bearing cap and tighten to specification. *See Special Torque Specifications on page 8-16.*
   (e) Remove the bearing cap.

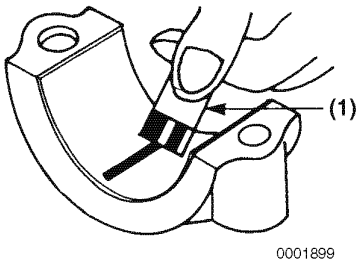


Figure 8-43

   (f) Compare the width of the flattened PLASTIGAGE to the graduation marks on the package **(Figure 8-43, (1))**. The mark that most closely matches the width of the flattened PLASTIGAGE will indicate the bearing oil clearance. *See Crankshaft, Balancer Shaft, Piston and Connecting Rod on page 8-7* for the wear limit.

   NOTICE: The piston can fall from the cylinder block if the engine is inverted. Position the engine so the connecting rod is horizontal before removing the connecting rod cap.

   Do not allow the connecting rod to contact the crankshaft journal during piston removal. Damage to the bearing journal may result.

   High hour engines may have carbon buildup or a ridge near the top of the cylinder that will catch the piston rings and make it impossible to remove the piston from the top of the cylinder block. Use a suitable ridge reamer to remove ridges and carbon prior to removing the piston.

9. Remove the connecting rod bolts **(Figure 8-44)**.
10. Remove the connecting rod cap.

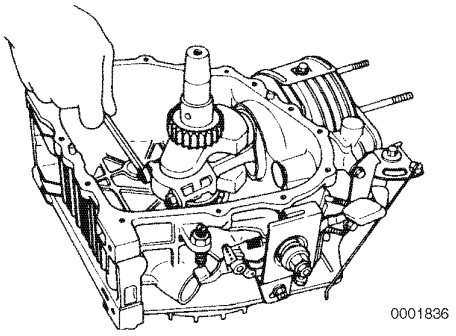


Figure 8-44

11. Rotate the crankshaft to the top of the stroke and push the piston and connecting rod out the top of the cylinder.
12. Remove the compression rings **(Figure 8-45, (1, 2))** from the piston using a piston ring expander.
13. Remove the oil ring **(Figure 8-45, (3))** and oil ring expander **(Figure 8-45, (4))** from the piston using a piston ring expander.

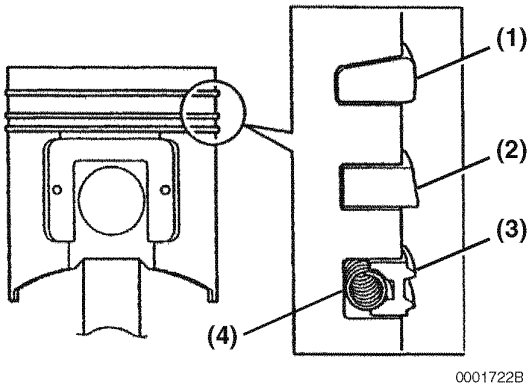


Figure 8-45

14. Remove the wrist pin circlips **(Figure 8-46, (1))** from the piston.

Note: The wrist pin is a light press-fit in the piston and may require driving out. If heating of the piston is necessary, heat the piston in an oven or in hot oil to 158° - 176°F (70° - 80°C). Support the piston to prevent damage to the piston as the wrist pin is driven out.

15. Support the piston **(Figure 8-46, (3))** and drive the wrist pin **(Figure 8-46, (4))** from the piston. Use a soft-faced hammer and a suitable driving tool that has a smaller diameter than the inside diameter of the wrist pin bore. Remove the connecting rod **(Figure 8-46, (2)** from the piston.

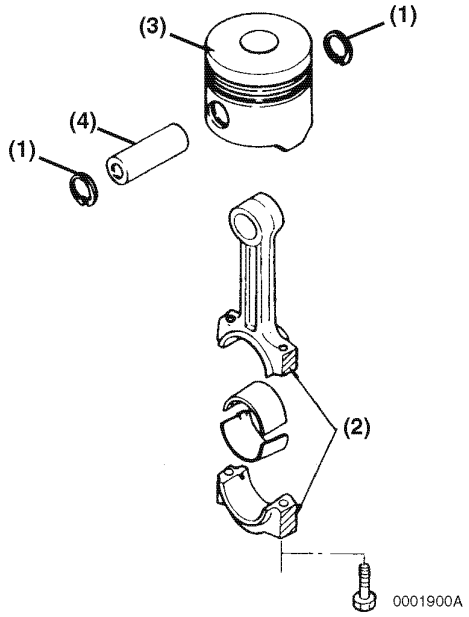


Figure 8-46

16. Remove the crankshaft bearing retainer fastener and bearing retainer **(Figure 8-47,** (1)) from inside the crankcase.

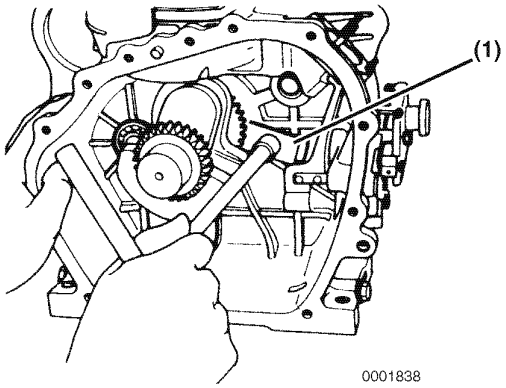


Figure 8-47

17. Remove the crankshaft from the open end of the crankcase. It will be necessary to use a heavy soft-faced hammer to drive the crankshaft out of the crankcase and drive the large main bearing out. Reinstall the flywheel nut to protect crankshaft threads while driving crankshaft and large bearing out. Keep crankshaft aligned as it is driven out by supporting the opposite crankshaft end **(Figure 8-48)**.

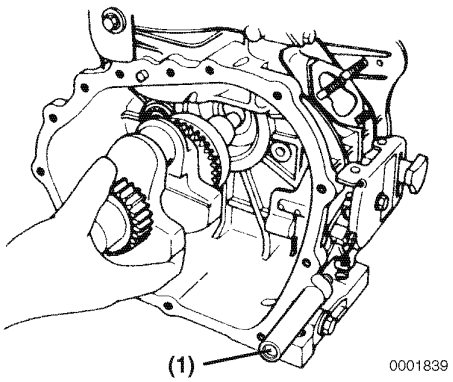


Figure 8-48

18. *NOTICE: Do not attempt to adjust or remove the fuel limiter* ***(Figure 8-48,*** **(1))** *assembly from the crankcase.*
19. Remove the governor and speed control mechanism only if necessary. If governor components or seal must be replaced. *See Replacement of Throttle Shaft Seal - L48V models on page 8-51* and *"Replacement of Throttle Shaft Seal - L70V and L100V models" on page 8-52*.

Inspection of Engine Components

Piston, Piston Rings and Wrist Pin

Note:

- On an engine with low hours, the piston and piston rings may be reused if they are found to be within specifications.
- On an engine with high hours, the piston rings should be replaced and the cylinder honed (*See Honing and Boring on page 8-47)* or replaced. The piston should be replaced as necessary.

1. Clean piston ring grooves using a piston ring groove cleaning tool. Follow manufacturer's instructions for correct operation.
2. Wash the piston in an appropriate solvent using a soft brush.
3. Visually inspect the piston for cracks. Pay particular attention to the ring lands between the piston ring grooves.
4. Measure the diameter of the piston skirt at 90° to the wrist pin bore as shown **(Figure 8-49)**. Measurements must be taken at a specified distance **(Figure 8-49, (1))** from the bottom of the piston, based on engine model. Record the measurements. *See Piston on page 8-9* for specifications.

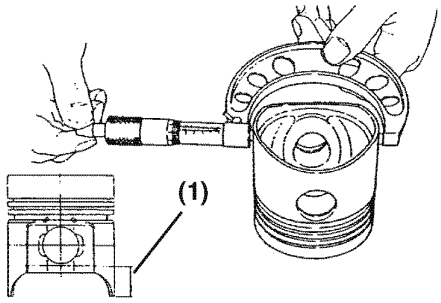


Figure 8-49

5. Subtract the piston measurement from the greatest measurement acquired during cylinder inspection (*See Cylinder Bore on page 8-47*) to obtain piston-to-cylinder clearance. Record the measurements. *See Piston on page 8-9* for specifications.
6. Measure the diameter of the wrist pin bore on both sides of the piston **(Figure 8-50)**. *See Piston on page 8-9* for specifications. Record the measurements.

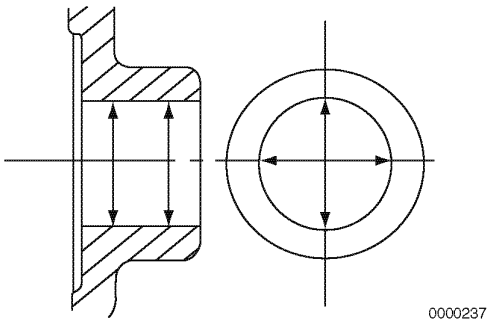


Figure 8-50

7. Measure the outside diameter of the wrist pin in three places and at 90° **(Figure 8-51)**. *See Piston on page 8-9* for specifications. Record the measurements.

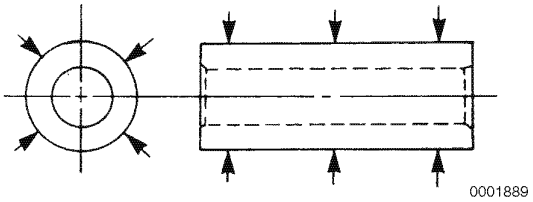


Figure 8-51

8. Using a micrometer, measure the thickness of each piston ring. *See Piston Ring on page 8-10* for specifications. Record the measurements.

Note:

- On an engine with low hours, the piston, piston rings and cylinder may be reused if they are found to be within specifications.
- On an engine with high hours, the piston rings should be replaced and the cylinder honed (*See Honing and Boring on page 8-47*) or replaced. The piston should be replaced as necessary.

9. Place each compression piston ring in the groove as shown **(Figure 8-52)**. Use a feeler gauge to measure the clearance between the piston ring and the piston ring land. Record the measurements. *See Piston Ring on page 8-10* for specifications. Replace the piston if not within specification.

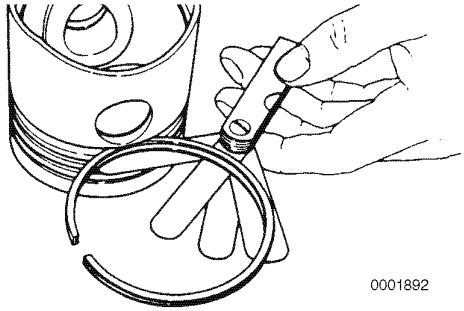


Figure 8-52

10. To measure piston ring end gap, insert each compression piston ring **(Figure 8-53, (1))**, one at a time, into the cylinder. Use a piston with the piston rings removed to slide the ring into the cylinder bore until it is approximately 1.18 in. (30 mm) **(Figure 8-53, (2))** from the bottom of the bore.
11. Remove the piston. Measure the end gap **(Figure 8-53, (3))** of each piston ring. Record the measurements. *See Piston Ring on page 8-10* for specifications.

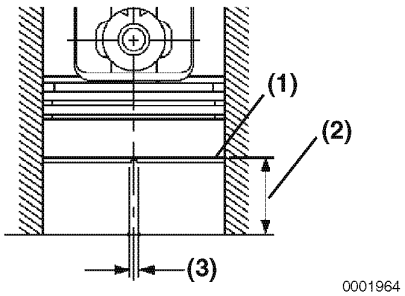


Figure 8-53

Note: Always check the piston ring end gap when installing new piston rings. *See Piston Ring on page 8-10* for specifications. Use a piston ring end gap filing tool to adjust the piston ring end gap on new piston rings.

Connecting Rod

1. Measure the wrist pin bushing bore using a bore gauge **(Figure 8-54, (1))**. Record the measurement. Replace the bushing if not within specifications. If the bushing has been removed, measure the inside diameter of the connecting rod small end **(Figure 8-54, (2))**. *See Connecting Rod on page 8-12* for specifications.

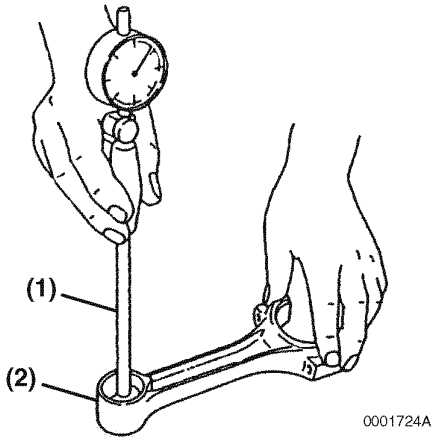


Figure 8-54

2. Inspect the bearing insert for separation or damage **(Figure 8-55)**.

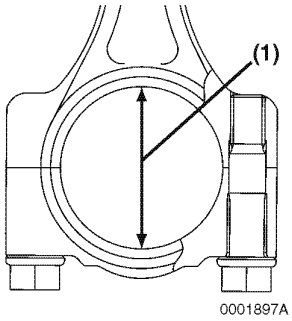


Figure 8-55

3. Place the connecting rod bearing inserts into the connecting rod and connecting rod cap. Install the rod cap and tighten the bolts to the specified torque.
4. Measure the inside diameter **(Figure 8-55, (1))**. Record the measurement. Compare the measurement with crankshaft rod journal outside diameter to calculate oil clearance. See *See Crankshaft on page 8-7* and *Piston* on page *8-9* for specifications.
5. Check for twist **(Figure 8-56, (1))** and bend **(Figure 8-56, (2))**. *See Connecting Rod on page 8-12* for the service limit. Record all measurements.

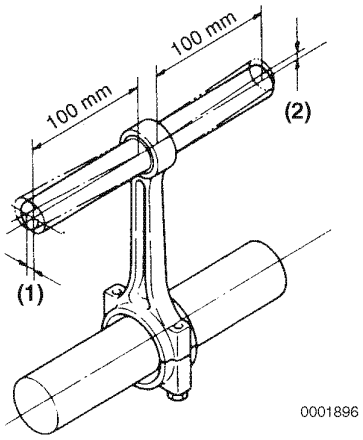


Figure 8-56

Crankshaft, Main Bearing and Flywheel

Clean the cylinder block and crankcase cover. Clean out each oil passage.

Do not remove plugs from the cylinder block or crankcase cover unless they are damaged or show evidence of leakage.

Replacement of Flywheel Ring Gear

Inspect the ring gear teeth for excessive wear or damage. Replace if necessary.

1. Drive a chisel between two ring gear teeth to split the ring gear. Remove the ring gear from the flywheel. **CAUTION! ALWAYS wear eye protection when servicing the engine.**
2. Carefully support the flywheel on cooling fan side **(Figure 8-57, (5))**. Heat the new ring gear to approximately 356°F (180°C).
3. Place the heated ring gear **(Figure 8-57, (2))** onto the flywheel **(Figure 8-57, (3))** with the chamfer on the teeth **(Figure 8-57, (1))** facing toward the engine **(Figure 8-57, (4))**. Tap lightly with a hammer to ensure it is fully seated.
4. Allow the assembly to slowly cool.

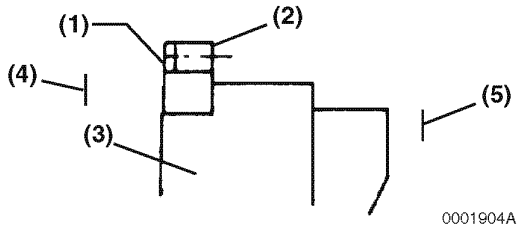
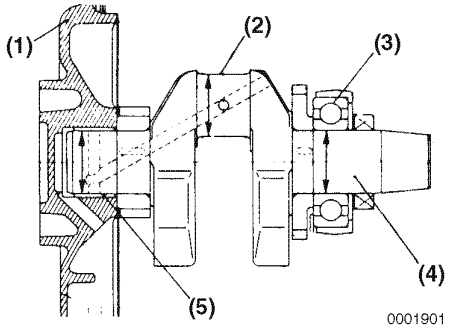


Figure 8-57

Crankshaft

1. Inspect the crankshaft for fractures using either the colorcheck method or the MAGNAFLUX® method. Replace the crankshaft if evidence of fractures are found.
2. Measure the outside diameter of the crankpin **(Figure 8-58, (2))** and main bearing journals. Take measurements at several places around each bearing surface. If not within specification, grind the journal(s) and install undersize bearings, or replace the crankshaft. *See Crankshaft on page 8-7* for the service limit. Record the measurements.

Note: The ball bearing **(Figure 8-58, (3))** on the flywheel end is press-fit onto the crankshaft **(Figure 8-58, (4))**. Replace the crankshaft if the bearing fit is loose.



1 – Crankcase Cover
2 – Crankpin
3 – Ball Bearing
4 – Crankshaft
5 – Plain Bearing

Figure 8-58

3. Roll the ball bearing and check for roughness.

Bearings

Inspect the main bearing **(Figure 8-59, (1))** for discoloration, separation or other damage.

Also inspect the balancer and cam bearings for wear and damage.

1. Measure the inside diameter of the main bearing insert **(Figure 8-59, (1))** in the crankcase cover. *See Crankshaft on page 8-7* for the service limit. Record the measurements.

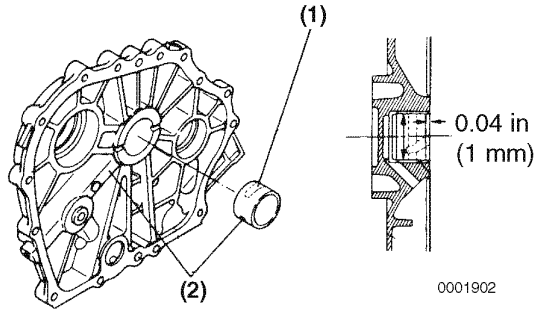


Figure 8-59

2. If the measurements are not within specifications, replace the bearing insert.
   (a) Remove the bearing insert using an appropriate tool.
   (b) When installing the new bearing insert, make sure the oil groove **(Figure 8-59, (1))** is facing up and that the oil hole is facing the oil port **(Figure 8-59, (2))**. Install to a depth of 0.04 in. (1 mm) from the thrust surface **(Figure 8-59)**.

Camshaft and Tappet

Camshaft

1. Measure the installed depth **(Figure 8-60, (1))** of the camshaft needle bearing on the cylinder block side. Record the measurement.

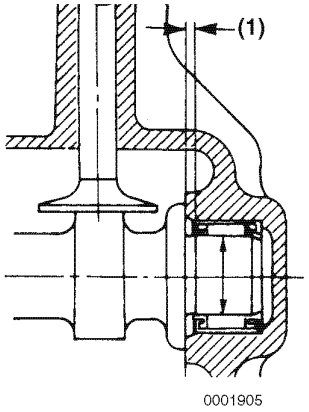


Figure 8-60

2. Visually inspect the needle bearing for evidence of wear or corrosion. Replace if damaged.
3. Press the new needle bearing to a depth of 0.055 - 0.059 in. (1.4 - 1.5 mm) **(Figure 8-60, (1))**.
4. Measure the camshaft bearing bore diameter in the crankcase cover. *See Camshaft on page 8-13* for the service limit. Record the measurement. The bearing surface is machined directly into the crankcase cover. If the bore is not within specification, the entire crankcase cover must be replaced.
5. Measure the camshaft journal outer diameter at each end. Record the measurements. Inspect the journal surfaces for damage or roughness. Replace the camshaft if it is damaged or not within specifications. *See Camshaft on page 8-13* for the service limit.

Tappet

1. Inspect the tappet contact surfaces for abnormal wear **(Figure 8-61, (1))**. Normal wear will be even as shown in **(Figure 8-61, (2)).** Slight surface defects can be corrected using an oilstone.

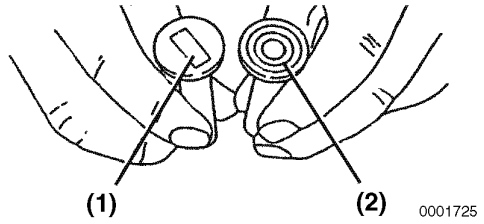


Figure 8-61

2. Measure the outside diameter of the tappet stem **(Figure 8-62, (1))**. See *"Tappet" on page 8-13 for the service limit.*

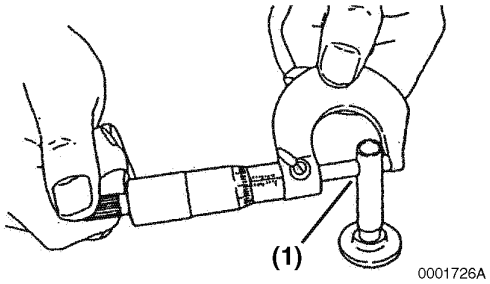


Figure 8-62

3. Measure the tappet bores in the cylinder block. See *"Tappet" on page 8-13 for the service limit.* Record the measurements.

Balancer Shaft

Check the balancer shaft for wear or damage to the gear **(Figure 8-63, (1))**. Measure and inspect the bearing support ends **(Figure 8-63, (2))** of the balancer shaft and bearings for wear and damage. Replace the balancer shaft and bearings if specifications are not within limits or damage is evident. See *"Balancer Shaft" on page 8-8* for the service limit.

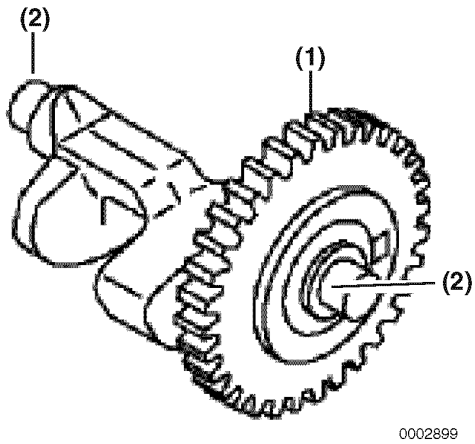


Figure 8-63

Timing Gears

Check the cam gear **(Figure 8-64, (1))**, the oil pump / governor drive gear **(Figure 8-64, (2))**, the crankshaft gear **(Figure 8-64, (3))** and the balancer gear **(Figure 8-64, (4))** for damage or wear. Replace any that are damaged or worn.

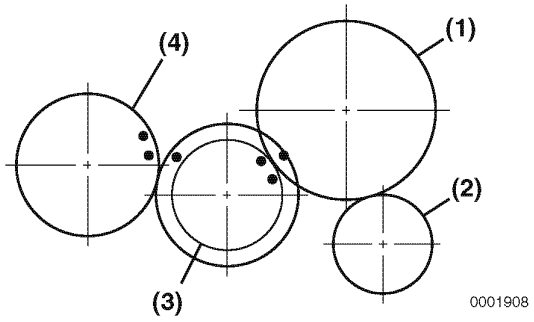


Figure 8-64

Cylinder Bore

The cylinder sleeve is cast into the aluminum cylinder block and is not replaceable. If it is damaged or worn beyond specifications, it can be bored oversize and an oversized piston and piston rings can be installed. See the parts catalog for available oversized parts.

1. Ensure that oil passages are clear and unobstructed.
2. Check for discoloration or evidence of cracks. If a fracture is suspected, use the colorcheck method or the MAGNAFLUX method to determine if the cylinder block is fractured.
3. Inspect the cylinder for roundness, taper or evidence of scoring. Collect and record the measurements. Consider honing, re-boring or replacing the cylinder block if the measurements are not within specification.
   - Take measurements at three places **(Figure 8-65, (a, b, c))** and in two directions **(Figure 8-65, (d, e))** in each cylinder.
   - See *"Cylinder Block" on page 8-14 for the service limit.* Record the measurements.

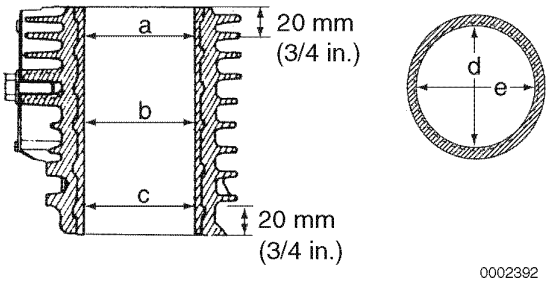


Figure 8-65

Honing and Boring

The piston must move freely in the cylinder while maintaining adequate compression and oil sealing. If the cylinder walls are scuffed, scored, out-of-round, or tapered beyond specifications, rebore and hone to restore cylinder to usable condition. Slight imperfections can be corrected by honing alone.

1. **Boring** - Significant cylinder damage may be corrected by boring the cylinder to an oversize dimension. Refer to the appropriate parts catalog for available oversize pistons and piston rings.
   - Boring a cylinder should always be done in a properly equipped machine shop.
   - A bored cylinder should always be finished with a hone to properly prepare the cylinder surface so the new piston rings will seat properly.
   - After the cylinder has been bored and honed, install the appropriate oversize piston and piston rings.
2. **Honing** - Minor cylinder imperfections may be corrected by using a rigid cylinder hone **(Figure 8-67, (1))**. Be sure not to exceed the maximum cylinder bore specification.

Deglazing - A used cylinder that did not require boring or honing, should always be deglazed with a ball hone **(Figure 8-66, (1))** before installing new piston rings. This will properly prepare the cylinder surface to allow new piston rings to seat properly.

Note: When honing a cylinder, with either a ridged hone or a ball hone **(Figure 8-67, (1))**, move the rotating hone up and down in the cylinder bore to accomplish a 30° to 40° crosshatch pattern **(Figure 8-66)**. This will provide the ideal surface for the proper seating of new piston rings.

NOTICE: NEVER allow the honing tool to operate in one position for any length of time. Damage to the cylinder wall will occur. Keep the tool in constant up-and-down motion.

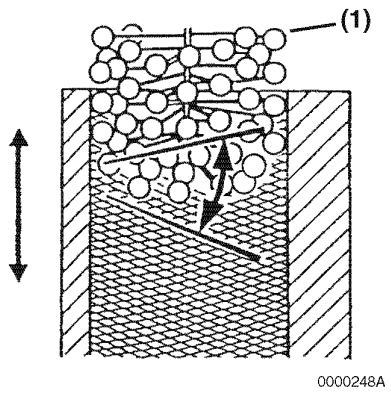


Figure 8-66

- Use a 50:50 mixture of diesel fuel and engine oil as a honing fluid.
- Use a 300-grit hone at 300 - 1200 rpm **(Figure 8-67)**.

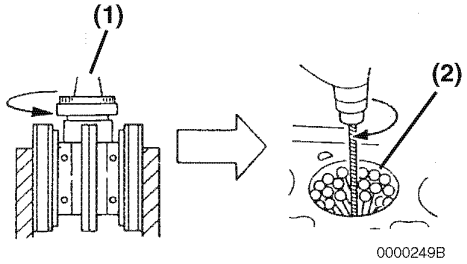


Figure 8-67

- *NOTICE: Solvents will not adequately remove honing residue, resulting in premature piston and ring wear. Always wash cylinders using hot, soapy water.* When honing is completed, wash the cylinder block with hot water and soap. The cylinder wall is adequately cleaned when a white rag wiped in cylinder comes out clean. Use brushes to clean all passages and crevices. Rinse with hot water and dry with compressed air. Apply clean engine oil to all steel surfaces to prevent rusting.

Inspection and Service of Engine Oil Pump

Disassembly and Inspection of Oil Pump

1. Remove and clean the oil filter **(Figure 8-69, (6))**. Inspect for damage. Do not remove the oil galley plugs **(Figure 8-69, (7))** unless they show evidence of leakage or the associated oil passages require cleaning.
2. Remove the oil pump cover **(Figure 8-69, (5))**.

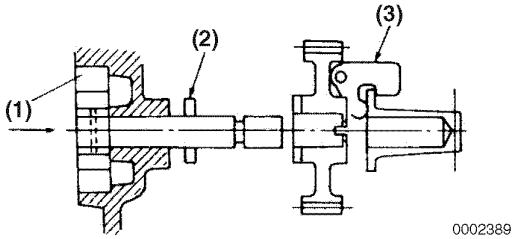
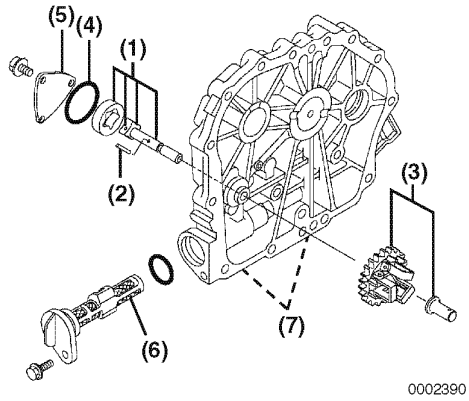


Figure 8-68



1 – Oil Pump Assembly
2 – Drive Pin
3 – Oil Pump / Governor Drive Gear and Spindle Assembly
4 – O-Ring
5 – Oil Pump Cover
6 – Oil Filter
7 – Plug (2 used)

Figure 8-69

3. Use a feeler gauge to measure the inner rotor-to-outer rotor clearance **(Figure 8-70)**. Record the measurement.

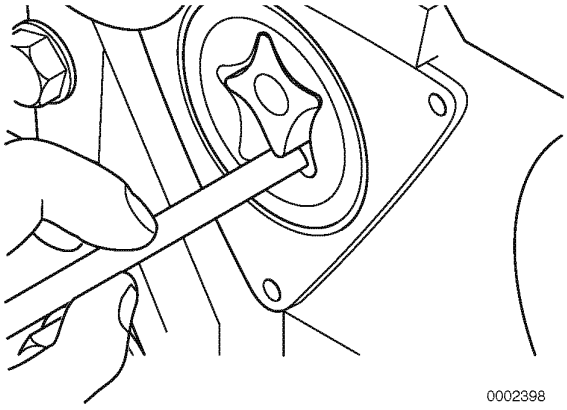


Figure 8-70

4. Use a feeler gauge to measure the outer rotor-to-housing clearance **(Figure 8-71)**. Record the measurement.

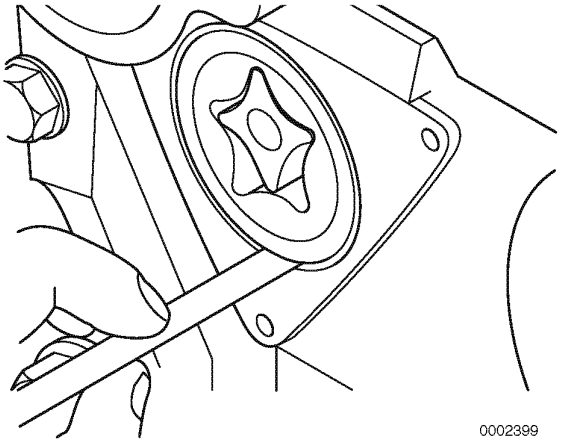


Figure 8-71

5. Measure the distance between the oil pump cover mounting surface and each rotor using a depth micrometer **(Figure 8-72)**. Record the measurement.

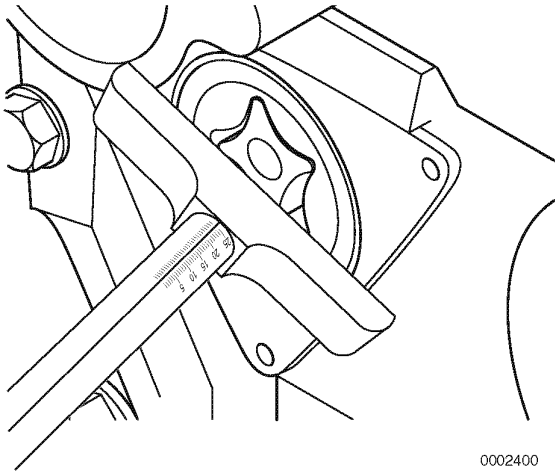


Figure 8-72

6. Use two screwdrivers to pry the oil pump / governor drive gear and spindle assembly **(Figure 8-73, (1))** off from the oil pump shaft. Inspect the gear teeth and drive pin groove for wear or damage.
7. Remove the drive pin **(Figure 8-73, (2))** from the oil pump shaft.

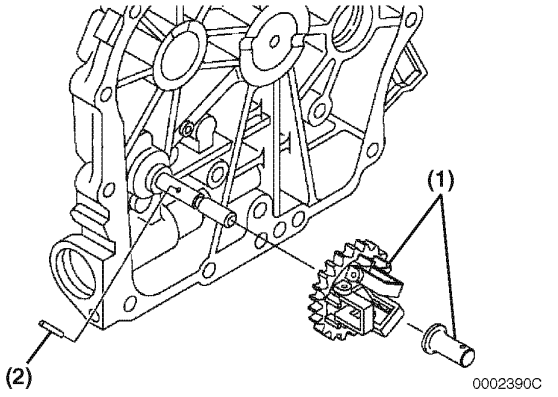


Figure 8-73

8. Remove the inner rotor, shaft assembly **(Figure 8-74, (1))** and outer **(Figure 8-74, (2))** rotor from the crankcase cover.

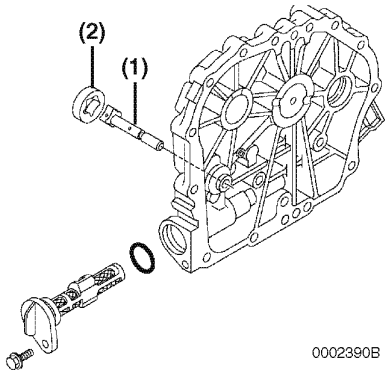


Figure 8-74

9. Inspect the pump cavity for deep scratches or excessive wear.
10. Measure the cavity inside diameter **(Figure 8-75, (1))**. Measure in at least two directions 90° apart. Record the measurements.
11. Measure the cavity depth **(Figure 8-75, (2))** using a depth micrometer. Record the measurement.

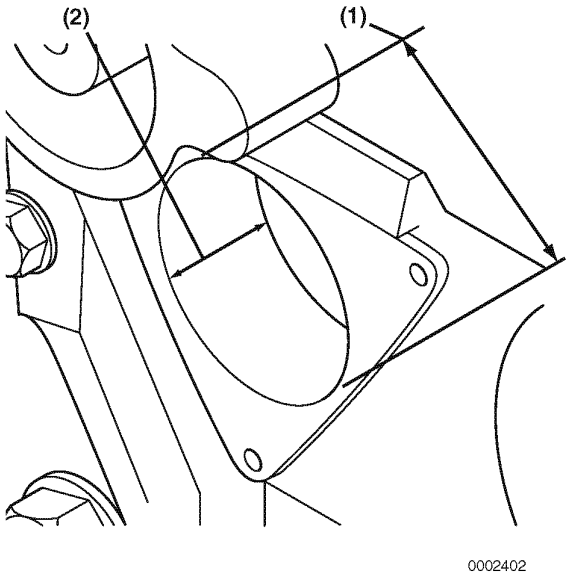


Figure 8-75

If any measurement is not within specification, replace all oil pump components, crankcase cover or both. *See Tappet on page 8-13* and *"Oil Pump (Trochoid Pump)" on page 8-16* for the service limits.

Reassembly of Oil Pump

1. Lubricate all components liberally with clean engine oil.
2. Install the inner rotor and shaft assembly **(Figure 8-76, (2))**. Install the outer rotor **(Figure 8-76, (1))** with the dot on the rotor facing up.

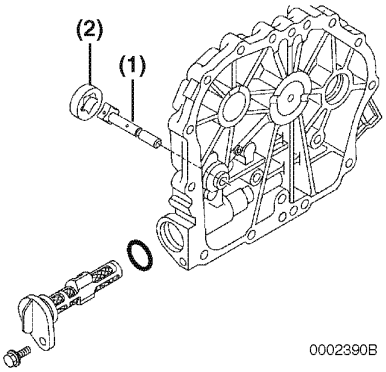


Figure 8-76

3. Install the drive pin **(Figure 8-77, (2))**. The pin must protrude evenly from either side of the shaft.

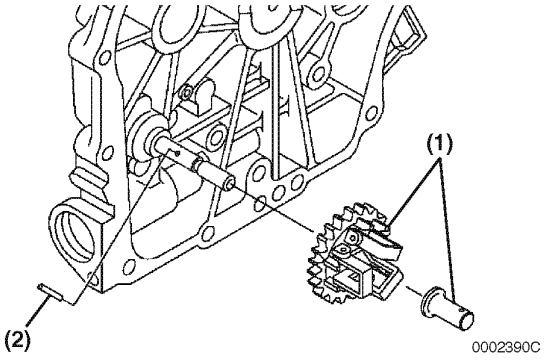


Figure 8-77

4. Install the oil pump cover and O-ring. Tighten to specification. *See Tightening Torques for Standard Bolts and Nuts on page 4-33.*

5. Install the oil pump / governor drive gear and spindle assembly **(Figure 8-77, (1))** onto the oil pump shaft. Ensure the gear is fully seated and the drive pin engages the drive grooves in the gear.

Reassembly of Engine

Note:

- Proceed slowly. make no forced assemblies unless a pressing operation is indicated. All parts must be perfectly clean and lightly lubricated when assembled.
- Use new gaskets, seals and o-rings during assembly.
- Apply clean engine oil or assembly lube liberally to all internal parts during assembly.
- Tighten all fasteners to a given torque. If a special torque is not provided in the *"Special Torque Specifications" on page 8-16*, tighten to standard torque specifications. *See Tightening Torques for Standard Bolts and Nuts on page 4-33*.

Replacement of Throttle Shaft Seal - L48V models

1. Remove the bolts **(Figure 8-78, (1))** that retain the speed control assembly.

Note: Speed controls vary in design based on engine usage. *See Speed Control Device on page 9-27* for more information.

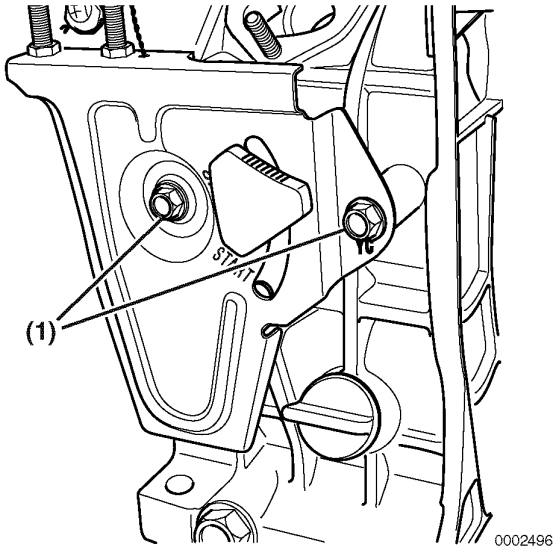


Figure 8-78

Note: Note the position of the governor springs. Use care not to distort or stretch them.

2. Pull the assembly away from the crankcase **(Figure 8-79, (1))** and mark the position of each spring end for reassembly. Carefully remove each spring.

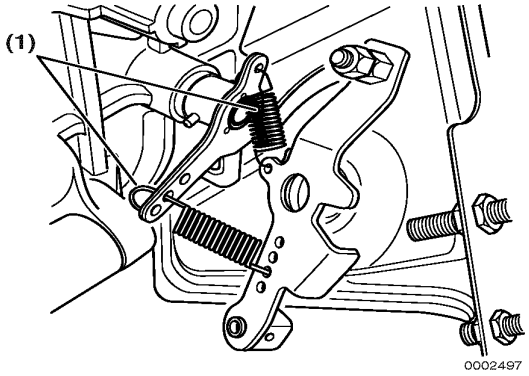


Figure 8-79

3. Remove the pin **(Figure 8-80, (1))** fastening the speed control lever to the throttle shaft. The pin is tapered and must be driven out in the correct direction. Use a pin punch to drive the tapered pin out. Use square solid blows because the pin is held very tightly in the hole.

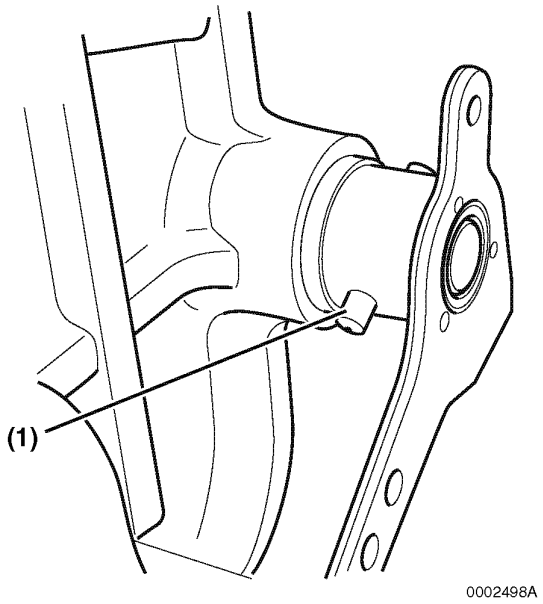


Figure 8-80

4. Remove the speed control lever and nylon washer.
5. Remove the throttle shaft and governor arm assembly **(Figure 8-81, (1))** along with the washer **(Figure 8-81, (2))**.
6. Carefully pry the seal **(Figure 8-81, (3))** out of the bore.

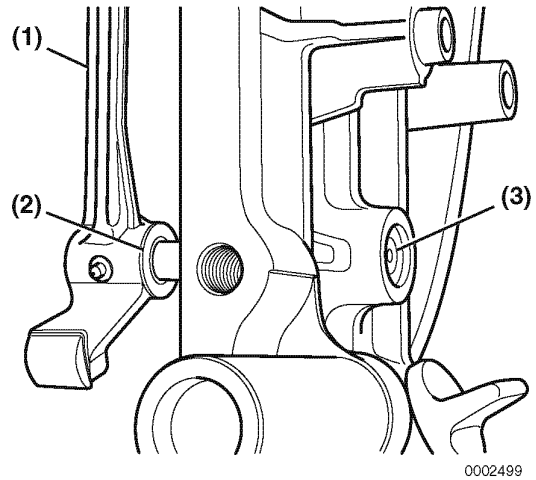


Figure 8-81

NOTICE: Damage or scratches on the throttle shaft can cause engine surging.

7. Inspect the throttle shaft for abnormal wear at the bearing area. Remove any burrs or scratches using fine emery cloth. Replace the throttle shaft and bearing if wear is excessive.
8. Install the new seal.
9. Reinstall the throttle shaft and governor lever assembly along with the washer.
10. Install the nylon washer and speed control lever on the throttle shaft.
11. Install the tapered pin in the opposite direction as it was removed. Use a pin punch to drive it securely into place.
12. Attach the governor springs in their original locations and install the speed control. See *"Speed Control Device" on page 9-27* for more information.

Replacement of Throttle Shaft Seal - L70V and L100V models

1. Remove the bolts **(Figure 8-82, (1))** that retain the speed control assembly.

Note: Speed controls vary in design based on engine usage. *See Speed Control Device on page 9-27* for more information.

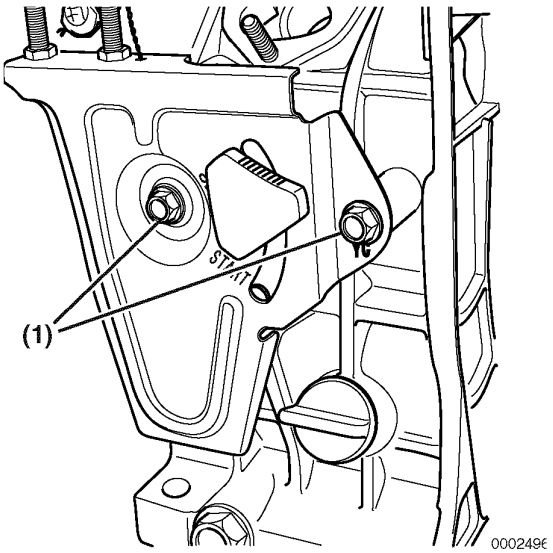


Figure 8-82

Note the position of the governor springs. Use care not to distort or stretch them.

2. Pull the assembly away from the crankcase **(Figure 8-83, (1))** and mark the position of each spring end for reassembly. Carefully remove each spring.

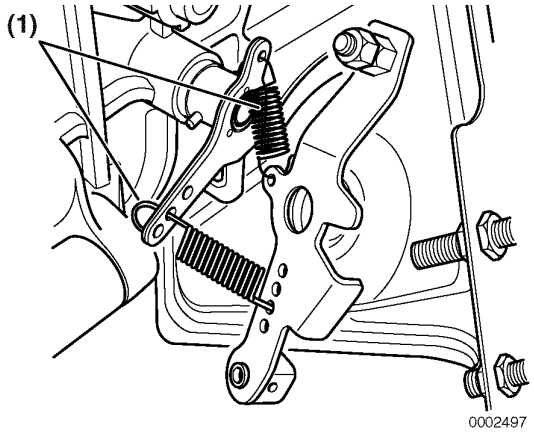


Figure 8-83

3. Remove the tapered pin **(Figure 8-84, (1))** that fastens the governor lever to the throttle shaft using the special throttle shaft pin removal tool **(Figure 8-84, (2))**. *See Special Service Tools on page 8-18* for the appropriate tool number.
4. Position the pin removal tool on the throttle shaft as shown **(Figure 8-84)**.

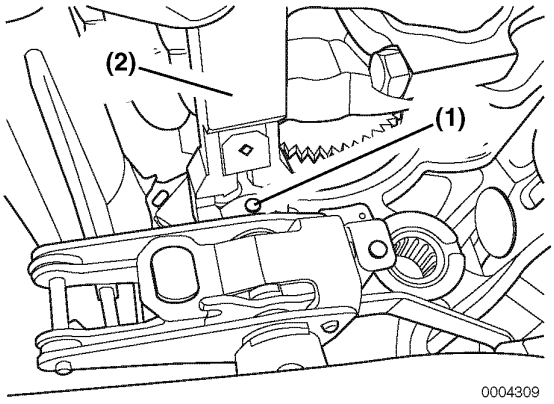


Figure 8-84

5. Tighten the hex cap screw **(Figure 8-85, (1))** on top of the tool to push the pin through the governor lever and throttle shaft to remove the pin.

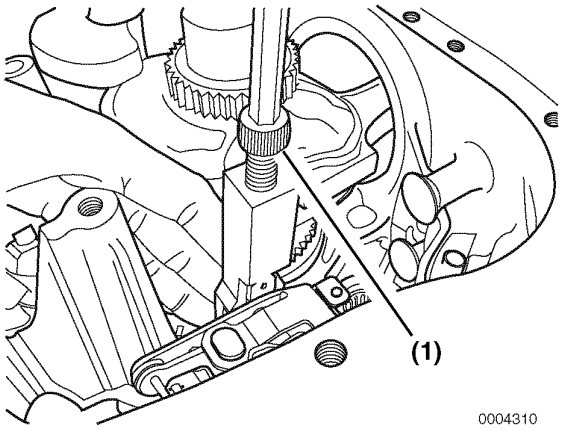


Figure 8-85

6. Remove the speed control lever, thrust washer, throttle shaft, inner washer and governor lever from the crankcase.
7. Carefully pry the seal **(Figure 8-86, (1))** out of the bore.

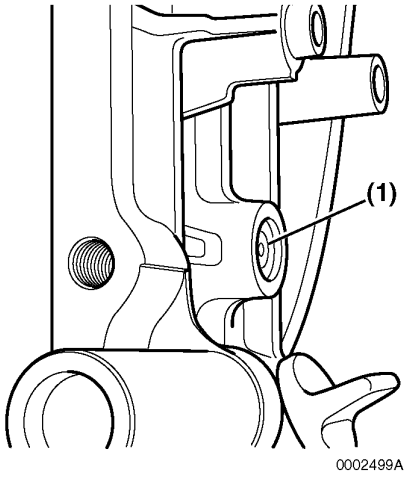


Figure 8-86

NOTICE: Damage or scratches on the throttle shaft can cause engine surging

8. Inspect the throttle shaft for abnormal wear at the bearing area. Remove any burrs or scratches using fine emery cloth. Replace the throttle shaft and bearing if wear is excessive.
9. Install the new seal.
10. Reinstall the speed control lever, thrust washer and throttle shaft through the crankcase inner washer and governor lever.
11. Install the tapered pin in the opposite direction as it was removed. Use a pin punch to drive it securely into place.
12. Attach the governor springs in their original locations and install the speed control. *See Speed Control Device on page 9-27* for more information.

replacement of crankshaft seals

1. Remove the seals from the crankcase and crankcase cover using an appropriate tool. Use care not to scratch or damage the seal mounting bores.
2. Use a seal installation tool to install the crankshaft oil seal **(Figure 8-87, (4))** into the crankcase cover **(Figure 8-87, (3))**. Install to a depth of 0.16 in. (4.0 mm) **(Figure 8-87, (5))** below the end of the crankcase bore. *See Special Service Tools on page 8-18* for the appropriate tool number.
3. Install the crankshaft oil seal **(Figure 8-87, (2))** into the cylinder block flush with the surface of the cylinder block **(Figure 8-87, (1))**.

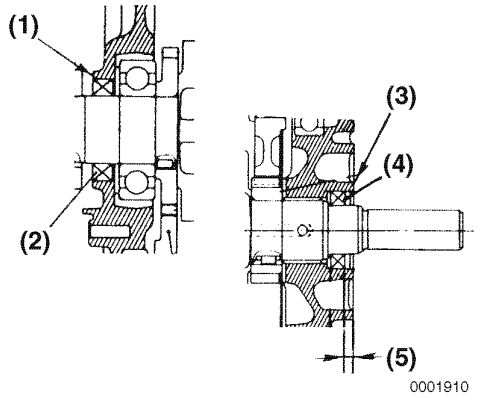


Figure 8-87

Reassembly of Piston, Piston Rings and Connection Rod

NOTICE: The piston and connecting rod must be assembled with the correct orientation. When correctly assembled, the identification mark ***(Figure 8-88, (1))*** *stamped into the top of the piston will be facing the same direction as the embossed mark* ***(Figure 8-88, (2))*** *cast into the beam of connecting rod, and the valve reliefs* ***(Figure 8-88, (4))*** *in the top of the piston will be facing in the same direction as the matching marks* ***(Figure 8-88, (3))*** *on the connecting rod and connecting rod cap.*

Note: The actual appearance of the match marks will vary but they will always be in the same locations **(Figure 8-88)**.

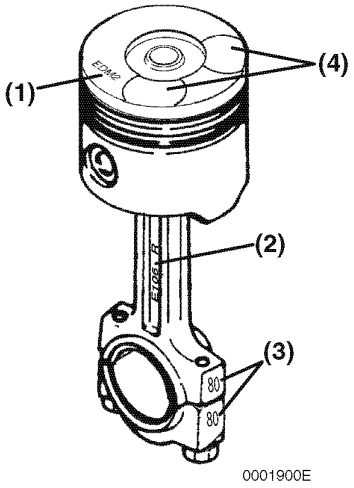


Figure 8-88

1. If removed, install a new wrist pin bushing in the connecting rod using a press and the appropriate tool. *NOTICE: Do not heat the piston directly with a flame.*

Note: The wrist pin is a light press-fit. If the wrist pin is difficult to install, heat the piston in an oven or oil to 158° - 176°f (70° - 80°c).

2. Place the connecting rod into the piston. the identification mark **(Figure 8-89, (1))** on the top of the piston and the embossed mark **(Figure 8-89, (2))** on the beam of the connecting rod will be facing in the same direction.

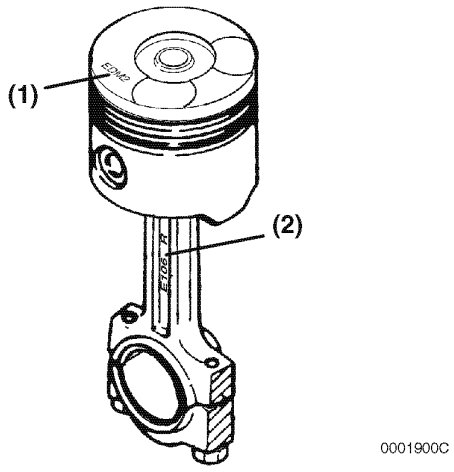


Figure 8-89

3. Lubricate the wrist pin **(Figure 8-90, (4))**. carefully support the piston **(Figure 8-90, (1))** to prevent damage while driving the wrist pin into place. Use a suitable tool slightly smaller than the inside diameter of the wrist pin bore to drive the wrist pin. Drive the wrist pin through the piston and connecting rod **(Figure 8-90, (3))** using a soft-faced hammer until it is centered between the circlip grooves in the wrist pin bore of the piston.
4. Install a circlip **(Figure 8-90, (2))** into each of the circlip grooves in the wrist pin bore. Be sure that the circlips are fully expanded in the grooves.

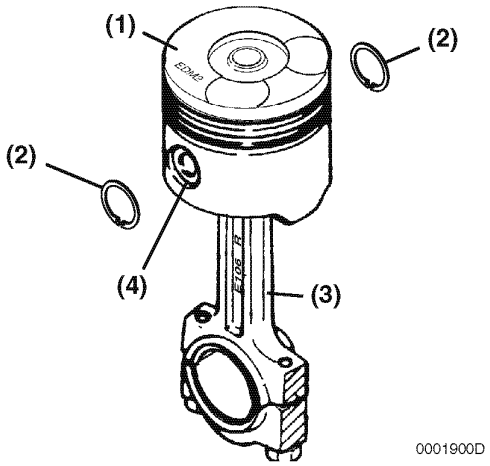


Figure 8-90

installation of piston rings

Note: If installing new piston rings the end gap must be checked and adjusted as necessary. *See Piston, Piston Rings and Wrist Pin on page 8-41.* Use a piston ring end gap filing tool to adjust the piston ring end gap on new piston rings.

Note: The top and second piston rings must be installed with the stamped “makers mark” **(Figure 8-91, (1))** facing the top of the piston. The “makers mark” may vary in appearance but will always be located on the top surface of the piston ring adjacent to the piston ring gap. The oil ring and oil ring expander can be installed either side up.

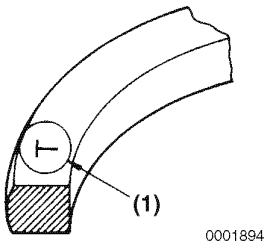


Figure 8-91

NOTICE: Always use a piston ring expander when installing piston rings. Never attempt to install piston rings by hand.

1. Install the oil ring expander **(Figure 8-92, (4))** and oil ring **(Figure 8-92, (3))** in the bottom piston ring groove. Install the oil ring with the end gap at 180° from the expander end gap.
2. Install the second compression ring **(Figure 8-92, (2))** into the middle piston ring groove. This ring is identified by its dark color and tapered face profile.
3. Install the top compression ring **(Figure 8-92, (1))** into the top piston ring groove. This ring is identified by its silver color and barrel-shaped face profile.

   *NOTICE: The oil ring expander **(Figure 8-92, (4))** end gap must be located 180° from the oil ring **(Figure 8-92, (3))** end gap.*

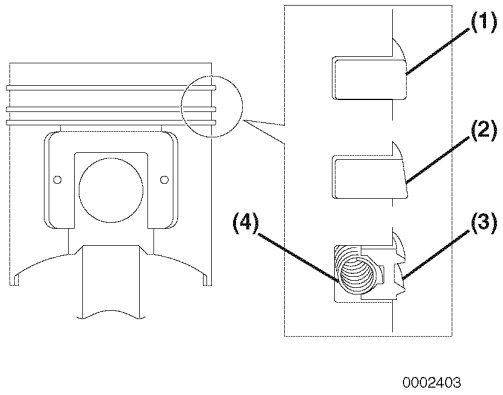


Figure 8-92

4. Stagger the piston ring end gaps at 120° intervals **(Figure 8-93, (1, 2, 3))**. Do not position the top piston ring end gap in line with the wrist pin.

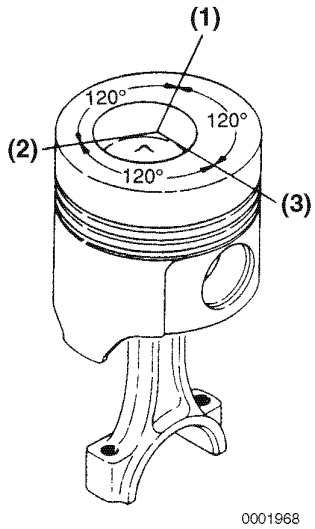


Figure 8-93

installation of crankshaft

1. Install the governor and speed control mechanism if it was removed.
   See Replacement of Throttle Shaft Seal - L48V models on page 8-51.
2. Apply multi-purpose grease to the lip of the oil seal in the crankcase.
3. Apply oil or assembly lube to the crankshaft bearings and journals.
4. Secure the crankcase to the workbench.
5. Place the crankshaft into the crankcase, making sure the rear main bearing is “square” with the bearing pocket in the rear of the crankcase.
6. Hold the crankshaft in alignment and use a heavy, soft-faced hammer to drive into place.

Note: Begin slowly, using light hammer taps, to ensure that the crankshaft bearing is properly aligned with the bearing pocket and the bearing has begun to move into the bearing pocket.

7. Make sure the crankshaft is inserted completely into the crankcase and the main bearing is fully seated. Rotate the crankshaft to make sure it rotates freely.

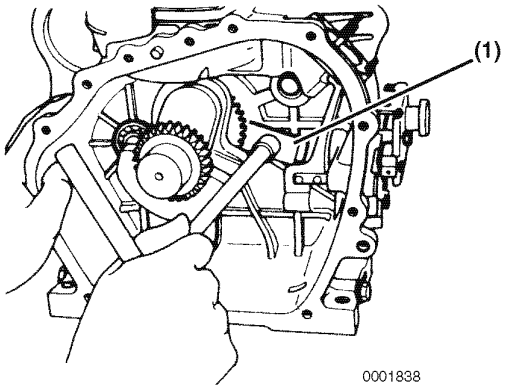


Figure 8-94

8. Position the bearing retainer plate **(Figure 8-94, (1))** in the crankcase.
9. Tighten the bearing retainer plate bolt.

installation of piston and connecting rod

1. Make sure connecting rod surface is clean and dry before installing the bearing inserts in the connecting rod and cap.
2. Lubricate the piston, piston rings and cylinder bore with clean engine oil or assembly lubricant.
3. Rotate the crankshaft so the crankpin for the piston is near bdc (bottom dead center).

   *NOTICE: Ensure the piston ring gaps are positioned correctly as shown in **(Figure 8-95)**.*

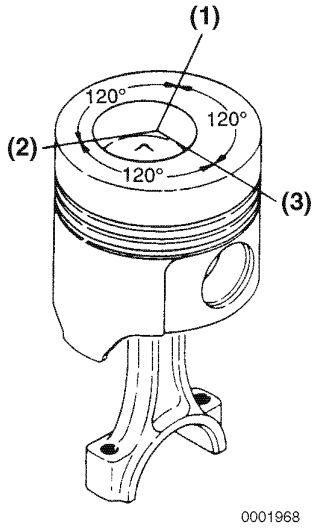


Figure 8-95

1 – top compression ring end gap
2 – second compression ring end gap
3 – oil ring end gap

4. Use a piston ring compressor to compress the piston rings.

   *NOTICE: The piston and connecting rod must be installed with the correct orientation. when installed correctly, the identification mark **(Figure 8-96, (1))** stamped into the top of the piston will face the open side of the crankcase. the connecting rod match marks, **(Figure 8-96, (3))** and the piston valve pockets will face the injection pump side of the engine.*

   Do not allow the connecting rod to contact the crankshaft journal during piston installation. Damage to the crankshaft bearing journal may result.

5. Carefully install the piston and rod assembly. The identification marks stamped into the top of the piston **(Figure 8-96, (1))** and connecting rod beam **(Figure 8-96, (2))** will be facing the open side of the crankcase. The connecting rod match marks **(Figure 8-96, (3))** and the piston valve pockets **(Figure 8-96, (4))** will face the injection pump side of the engine.

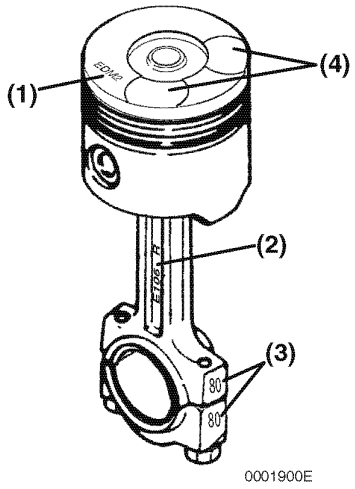


Figure 8-96

6. Apply a liberal coat of clean engine oil to the bearing inserts and crankshaft journal.
7. Apply a light coat of clean engine oil to the rod cap bolts. install the connecting rod cap. Tighten the connecting rod bolts **(Figure 8-97)** to the specified torque in two stages as shown in chart below. *See Special Torque Specifications on page 8-16* for specifications.

First Step	1/2 of final torque
Second Step	Final torque

8. Rotate the crankshaft to make sure all components move freely.

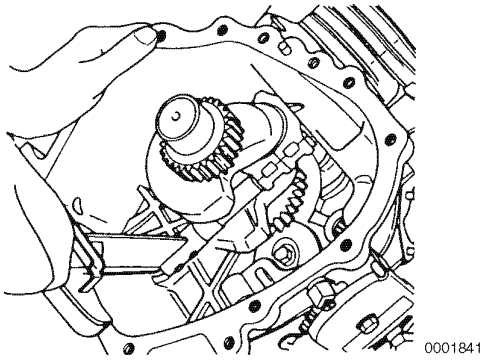


Figure 8-97

installation of camshaft and balancer shaft

1. Position the engine so the open crankcase is facing up.
2. Rotate the crankshaft to approximately 45° atdc (after top dead center).
3. Lubricate the balancer shaft bearings. insert the balancer shaft **(Figure 8-98)** into the cylinder block.

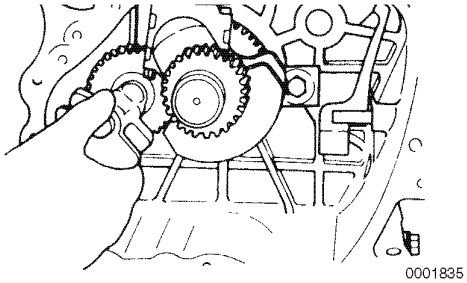
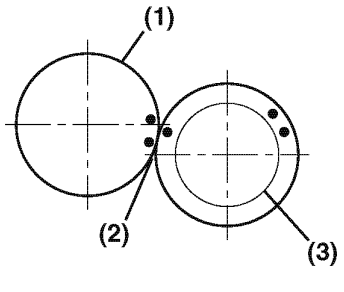


Figure 8-98

4. Align the timing marks **(Figure 8-99, (2))** on the balancer shaft gear **(Figure 8-99, (1))** and crankshaft gear **(Figure 8-99, (3))** as the balancer shaft is being installed.



1 – balancer shaft and gear
2 – balancer to crankshaft timing mark
3 – crankshaft gear

Figure 8-99

5. Lubricate the tappets. position the cylinder block so that gravity will keep the tappets in place and away from the camshaft lobes when the camshaft is reinstalled. Install the tappets in their respective locations in the cylinder block and push them fully into the tappet bores.
6. Rotate the crankshaft to approximately tdc (top dead center).

7. Lubricate the camshaft needle bearing in the cylinder block. Slowly insert the camshaft **(Figure 8-100)** into the cylinder block.

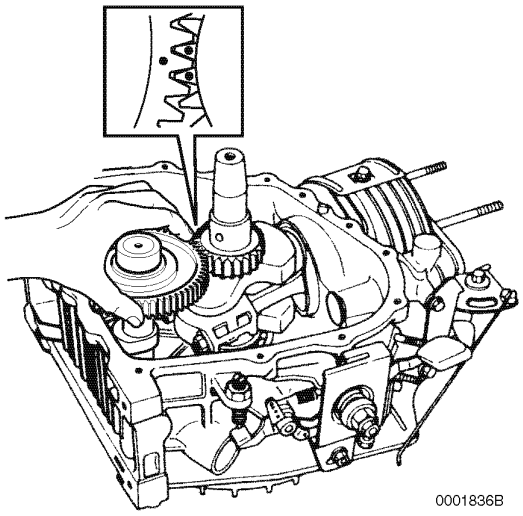
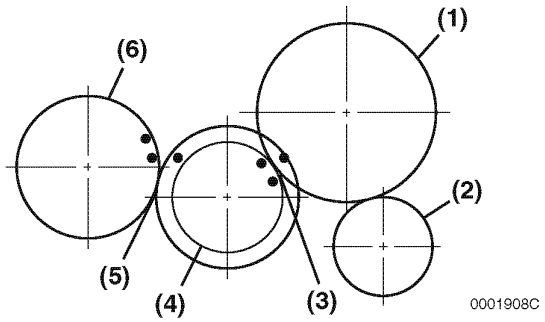


Figure 8-100

8. Align the timing marks **(Figure 8-101, (3))** on the camshaft gear and crankshaft gear as the camshaft is being installed.

Note: Balancer shaft gear marks **(Figure 8-101, (5))** and camshaft gear marks will not align at the same time with crankshaft gear marks as shown in **(Figure 8-101)**. The balancer shaft gear and camshaft gear marks must match to crankshaft gear marks independently.

9. Rotate crankshaft to ensure crankshaft timing marks align **(Figure 8-101)** to the balancer shaft and camshaft marks independently.



1 – cam gear
2 – governor gear
3 – cam to crankshaft timing mark
4 – crankshaft gear
5 – balancer to crankshaft timing mark
6 – balancer gear

Figure 8-101

installation of crankcase cover

1. Inspect oil pump assembly and service as needed, if not already completed.
2. Place a new aluminum gasket between the mating surfaces of the crankcase and the crankcase cover. Align gasket properly over two alignment pins on crankcase surface.
3. Apply multi-purpose grease to the lip of the oil seal in the crankcase cover.
4. Install an oil seal protector tool on the end of the crankshaft. *See Special Service Tools on page 8-18* for the appropriate tool number.
5. Install the crankcase cover **(Figure 8-102, (1))** while pushing down lightly on the crankcase cover. slowly turn the flywheel to allow the governor / oil pump drive gear to mesh with the camshaft gear. Maintain the light pressure while “wiggling” the cover slightly to align the balancer shaft bearing and the camshaft bearing with their respective pockets in the underside of the cover until the cover drops into place.
6. Tighten the crankcase cover bolts to the specified torque in two stages (1/2 then full torque) in the sequence shown **(Figure 8-102)**. *See Special Torque Specifications on page 8-16.*

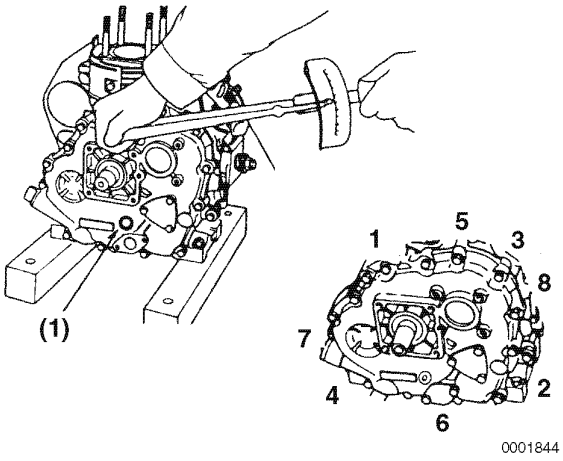


Figure 8-102

- Crankcase stiffener bolts are in the center of the crankcase on some model engines.
- Tighten the stiffener bolts after the bolts on the crankcase perimeter are tightened **(Figure 8-102)**. *See Special Torque Specifications on page 8-16.*

final engine assembly

1. Install the stator, lead retainer and flywheel. *See Installation of Stator on page 11-16.*
2. rotate the flywheel/crankshaft to make sure all parts rotate freely.
3. Install the cylinder head assembly. *See Installation of Cylinder Head on page 8-30.*
4. Install the fuel injection pump. *See Installation of Fuel Injection Pump on page 9-18.*
5. Make sure the nozzle gasket and spacer are in position. install the fuel injector, high pressure fuel injection line and return line. *See Installation of the Fuel Injector on page 9-26.*
6. Check actual piston tdc position. *See Checking Actual Piston TDC (Top Dead Center) on page 8-33.*
7. Check the fuel injection timing. *See Checking Fuel Injection Timing on page 9-11.*
8. Adjust valve clearance. *See Measuring and Adjusting Valve Clearance on page 8-35.*
9. Install the air intake manifold with a new gasket.
10. Install the starter pulley onto the flywheel.
11. Attach the rubber seal **(Figure 8-103, (1))** to the fan housing.
12. Install the fan housing rubber supports **(Figure 8-103, (2))** and sleeves **(Figure 8-103, (3))**.

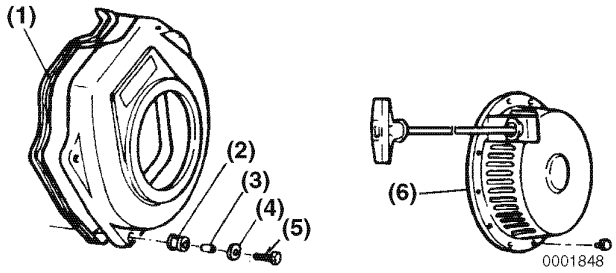


Figure 8-103

13. Install the cooling fan housing and secure with washers **(Figure 8-103, (4))** and bolts **(Figure 8-103, (5))**. Install the recoil starter **(Figure 8-103, (6))** if it has been removed.
14. Install the air filter housing and air filter element *See Clean Air Cleaner Element on page 5-13.*
15. Install the starter motor (if equipped).
16. Use the recoil or electric starter to rotate the flywheel/crankshaft to make sure all parts rotate freely.
17. For installation of engine into generator frame. *See Installation of Engine on page 6-7.*

Section 9

FUEL SYSTEM

Page

BEFORE YOU BEGIN SERVICING

Before performing any service procedures within this section, review the *Safety* section on page *3-1*.

INTRODUCTION

This section of the *Service Manual* describes the procedures necessary to remove, install and time the fuel injection pump, fuel injector and the associated system components.

SPECIFICATIONS

Test and Adjustment Specifications

Fuel Injector Pressure	Fuel Injection Timing
2843 psi (19.6 MPa, 200 kgf/cm^2)	*See Checking and Adjusting Fuel Injection Timing on page 9-11.*

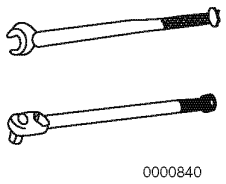
Note: Each 0.004 in. (0.1 mm) change in shim thickness in the fuel injector will result in approximately a 284 psi (1.96 MPa, 20 kgf/cm^2) pressure change. *See Adjusting Fuel Injector Pressure on page 9-25.*

Special Torque Specifications

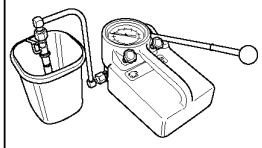
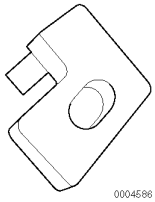
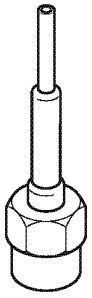
Component	Model	Thread Diameter and Pitch	Torque	Lubricating Oil Application (Thread Portion and Seat Surface)
Fuel Injector Retaining Nuts	All Models	2-M6x1.0	87 - 104 lb-in. (9.8 - 11.8 N·m, 1.0 - 1.2 kgf/m)	Not Applied
Fuel Pump Delivery Valve		M14x15	22 - 25 lb-ft (29.4 - 34.3 N·m, 3.0 - 3.5 kgf/m)	Not Applied
High-Pressure Fuel Injection Line Nuts			2.74 - 3.25 lb-ft (26.9 - 31.9 N·m, 20 - 24 kgf/m)	Not Applied
Fuel Injection Pump Mounting Nuts		3-M6x1.0	87 - 104 lb-in. (9.8 - 11.8 N·m, 1.0 - 1.2 kgf/m)	Not Applied
Fuel Injection Pump Inspection WIndow Plate Nut		3-M6x1.0	87 - 104 lb-in. (9.8 - 11.8 N·m, 1.0 - 1.2 kgf/m)	Not Applied
Fuel Limiter Mounting Nut			215 - 218 lb-in. (24.2 - 24.6 N·m, 24.7 - 25.1kgf/m)	Not Applied
Fuel Injector Nozzle Case Nut		1-0.605-40UNS-2B	29 - 33 lb-in. (39.2 - 44.1 N·m, 4.0 - 4.5 kgf/m)	Not Applied
Fuel Injector Nozzle Nuts		2-M6x1.0	87 - 104 lb-in. (9.8 - 11.8 N·m, 1.0 - 1.2 kgf/m)	Not Applied

Note: *See Tightening Torques for Standard Bolts and Nuts on page 4-33*, for standard hardware torque values.

SPECIAL SERVICE TOOLS

No.	Tool Name	Application	Illustration
1	Torque Wrench (Available Locally)	For tightening nuts and bolts to the specified torque	 0000840

MEASURING INSTRUMENTS

No.	Instrument Name		Application	Illustration
1	Fuel Injector Tester (Available Locally)		For observing injection spray pattern of fuel injection nozzle and measuring injection pressure	
2	Fuel Adjustment Jig (Yanmar P/N 114771-92310)		Used to adjust fuel injection timing and fuel limiter.	 0004586
3	Spill-Timing Tool	Locally Fabricated	Used to set fuel injection timing	

Make from a short piece of the end of a high-pressure fuel injection line, a high-pressure fuel injection line nut, and a short piece of clear plastic tubing (a thin nozzle from an aerosol spray can works well). Drill out the end of the fuel line to accept the nozzle. Use a small amount of silicone sealant to seal the nozzle into the fuel line.

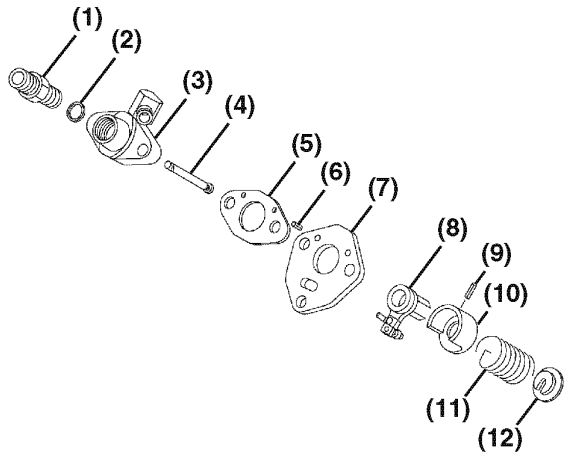
FUEL SYSTEM OPERATION

The following describes the operation of the fuel injection pump and fuel injector. *NOTICE: NEVER remove or attempt to remove the tamper-proof devices from the high-speed throttle limit screw. This adjustment has been made at the factory to meet all applicable emissions regulations and then sealed.*

Any alterations to this engine may affect the warranty coverage of this engine. See Yanmar Limited Warranty in Section 2.

Fuel Injection Pump

Note: Parts breakdown is for reference only.



1 – Fuel Delivery Valve
2 – O-Ring
3 – Body
4 – Fuel Plunger
5 – Gasket
6 – Alignment Pin
7 – Base Plate
8 – Fuel Control Lever
9 – Pin
10 – Spring Seat
11 – Spring
12 – Spring Retainer

Figure 9-1

Note: While the parts catalog shows the individual service parts for the fuel injection pump, the fuel injection pump is not intended to be serviceable. Do not disassemble the fuel pump. If the fuel injection pump is faulty, replace it with a new fuel injection pump assembly.

The fuel injection pump is a very important component of the engine. It is capable of making very precise fuel delivery adjustments according to the varied loads applied to the engine.

The fuel delivery valve **(Figure 9-2, (5))** connects to a high-pressure fuel injection line that is attached to the fuel injector. The plunger is activated by a tappet **(Figure 9-2, (6))** that rides on a special lobe **(Figure 9-2, (7)**) of the camshaft. The shape of the fuel injection lobe prevents the engine from operating in the reverse direction. A spring **(Figure 9-2, (2))** keeps the tappet in contact with the camshaft lobe. Proper fuel injection timing is adjusted by the thickness of a shim **(Figure 9-2, (8))** installed between the fuel injection pump and the crankcase mounting surface.

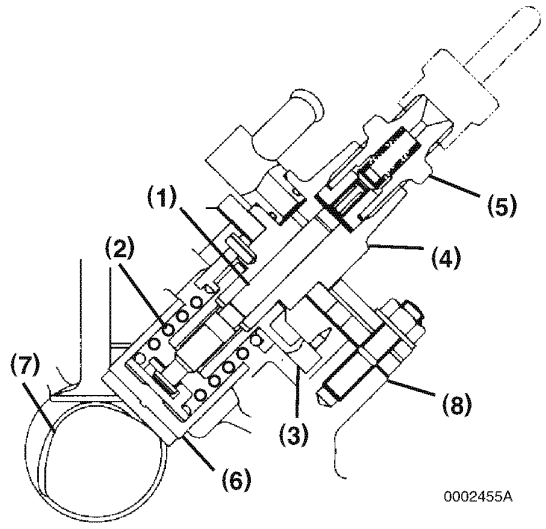
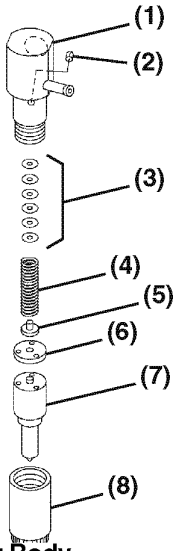


Figure 9-2

Fuel from the fuel tank to the fuel injection pump is delivered either by gravity or a low-pressure fuel pump. Engine speed is controlled by a centrifugally operated governor assembly that acts directly against the control lever **(Figure 9-2, (3))**.

Fuel to be injected into the cylinder is pressurized by the up and down motion of the camshaft-driven plunger **(Figure 9-2, (1))** within the body **(Figure 9-2, (4))**, through the fuel supply valve, and is then supplied by the high-pressure fuel injection line to the fuel injector.

Fuel Injector

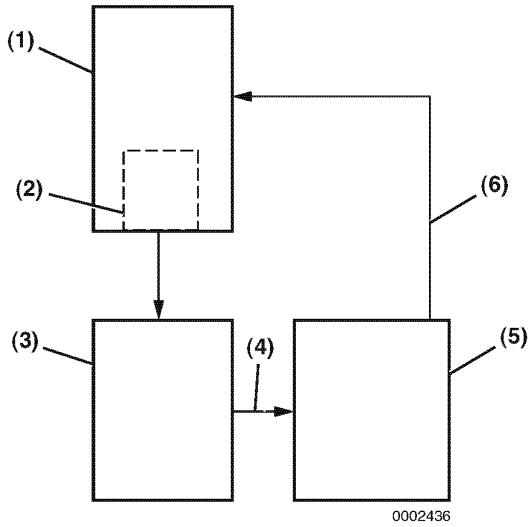


1 – Injector Body
2 – Alignment Pin
3 – Pressure Adjusting Shims
4 – Spring
5 – Spring Seat
6 – Valve Stop Spacer
7 – Nozzle Body and Valve
8 – Nozzle Case Nut

Figure 9-3

The fuel injector is essentially a spring-loaded valve. When fuel pressure from the fuel injection pump reaches a predetermined level, the pintle (valve) is forced off its seat and fuel is atomized as it passes between the pintle and seat. The timing and quantity of the fuel injected into the cylinder is controlled by the fuel injection pump and governor assembly.

FUEL SYSTEM DIAGRAM

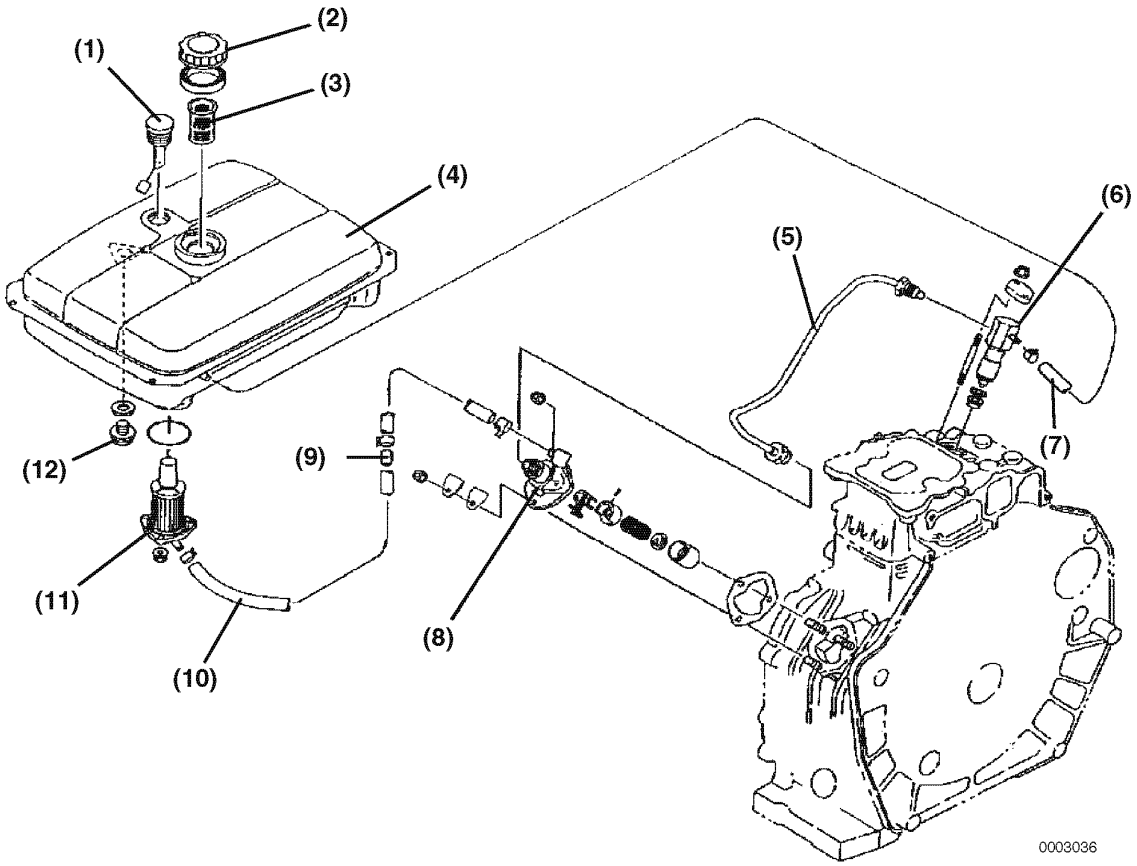


1 – Diesel Fuel Supply
2 – Fuel Filter
3 – Fuel Injection Pump
4 – High-Pressure Fuel Injection Line
5 – Fuel Injector
6 – Fuel Return from Fuel Injector

Figure 9-4

FUEL SYSTEM COMPONENTS

Typical (Components may vary by engine model and engine application)



1 – Fuel Gauge
2 – Filler Cap and Gasket
3 – Fuel Filler Strainer
4 – Fuel Tank
5 – High-Pressure Fuel Injection Line
6 – Fuel Injector
7 – Fuel Hose
8 – Fuel Injection Pump
9 – Air Separator
10 – Fuel Hose
11 – Fuel Filter
12 – Fuel Drain Plug

Figure 9-5

CHECKING AND ADJUSTING FUEL INJECTION TIMING

Checking Fuel Injection Timing

Note: Some fuel may drain from the fuel injection pump during this process. Make provisions to contain spills.

1. Verify actual piston TDC. *See Checking Actual Piston TDC (Top Dead Center) on page 8-33.*
2. Ensure the fuel injection pump is primed with fuel. *See Priming the Fuel System on page 4-19.*

Note: If the engine is removed from the equipment, attach a “temporary” fuel supply to the fuel injeciton pump inlet.

3. Remove the cooling fan housing and recoil starter.
4. Highlight the TDC timing mark on the cylinder cooling fin **(Figure 9-6, (1))**.
5. Highlight the TDC (Top Dead Center) **(Figure 9-6, (2))** and target timing **(Figure 9-6, (3))** marks BTDC (Before Top Dead Center) on the flywheel timing grid **(Figure 9-7)** based on the Fuel Injection Timing Chart.

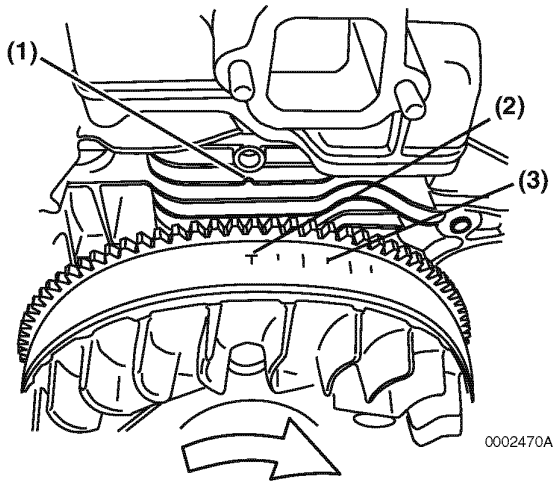


Figure 9-6

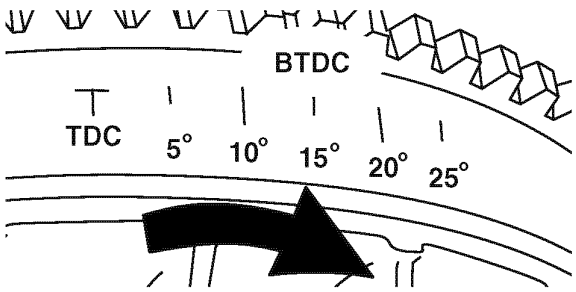


Figure 9-7

Fuel Injection Timing Chart

Engine	Injection Timing BTDC
L48V	17.5 ± 0.5°
L70V	16.0 ± 0.5°
L100V	15.5 ± 0.5°

6. Clean the areas around the fuel injection pump and fuel injector to prevent contamination when the fuel injection line is removed.

   NOTICE: Always use a wrench to hold the fuel injection pump fuel delivery valve to prevent loosening of the delivery valve when loosening or tightening the high-pressure fuel injection lines.

Note: To prevent “rounding” the fuel line nuts always use a “line” or “flare nut” wrench.

7. Remove the high-pressure fuel injection line.
8. Set the throttle control lever to the minimum speed position.

9. Remove the nut **(Figure 9-8, (2))** fastening the injection pump inspection window cover plate **(Figure 9-8, (1))**. Remove the inspection cover plate and gasket.

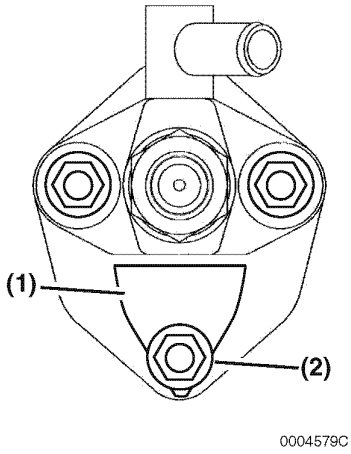


Figure 9-8

10. Install the fuel adjustment jig **(Figure 9-9, (2))**, Yanmar P/N 114771-92310, in the fuel injection pump inspection window. Using the inspection window cover plate nut, fasten the fuel adjustment jig aligning the upper left edge of the jig **(Figure 9-9, (4))** to the alignment mark scribed on the face of the fuel injection pump **(Figure 9-9, (1))** base plate **(Figure 9-9, (3))**.

Note: Be sure to keep the fuel adjustment jig parallel to the inspection window opening. **Figure 9-9** shows the alignment mark for clarity only. The edge of the jig should be directly on the mark when installed properly.)

Note: To assist in the alignment of the fuel adjustment jig, tighten the attaching nut to just hold the jig "lightly" in place. Then "lightly" tap the jig into the proper position. Once the jig is in position, tighten the attaching nut to hold the jig firmly in place.

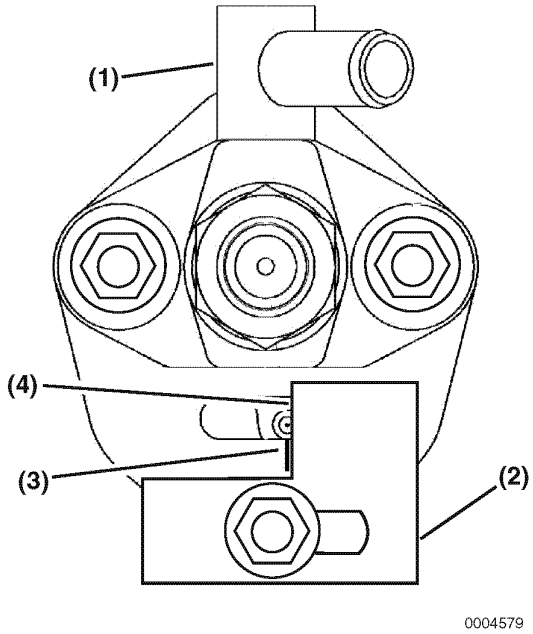


Figure 9-9

11. Set the throttle control lever to the maximum speed position.
12. Install the spill-timing tool **(Figure 9-10, (1))** onto the fuel delivery valve. *See Measuring Instruments on page 9-6*, for a description of the tool.

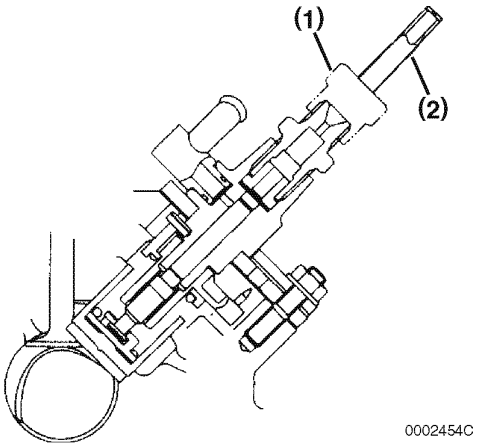


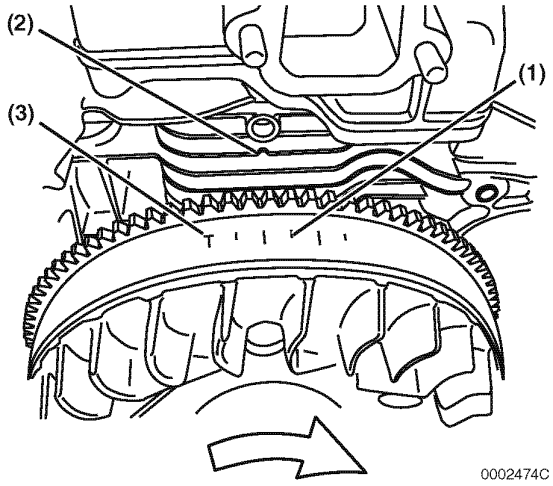
Figure 9-10

Note: If a timing tool is not available, timing can be checked by watching the fuel level movement in the delivery valve outlet.

13. Turn on the fuel supply to the fuel injection pump.
14. Rotate the flywheel / crankshaft clockwise until fuel is pumped from the nozzle of the spill-timing tool.

Note: The fuel injection pump pumps fuel to the fuel injector only once every two engine revolutions.

15. Slowly rotate the flywheel / crankshaft clockwise until the TDC mark on the flywheel is at approximately the 9 o'clock position.
16. Lightly "Flick" the timing tool nozzle with your finger to remove bubbles and establish a fuel level at approximately half the height of the nozzle **(Figure 9-10, (2))**.
17. Very slowly rotate the crankshaft clockwise until the fuel level in the nozzle of the spill-timing tool, or in the delivery valve, just begins to move. Immediately stop rotating the crankshaft. If no fuel movement is noticed, rotate the flywheel clockwise until the TDC mark is again at the 9 o'clock position and repeat the process.
18. Without moving the flywheel, insert a wooden wedge between the flywheel and the engine crankcase to hold the flywheel stationary.
19. Check the position of the flywheel target timing mark **(Figure 9-11, (1))** on the flywheel grid in relation to the TDC timing mark **(Figure 9-11, (2))** on the crankcase cooling fin.
    - If the two marks are aligned, the fuel injection timing is correct. Proceed to Step 21.
    - If the marks do not align, adjust the fuel injection timing. Do not rotate the flywheel and proceed to *"Adjusting Fuel Injection Timing" on page 9-14*. *NOTICE: Always turn the crankshaft in a clockwise direction when checking fuel injection timing.*



1 – Target Timing Mark
2 – TDC Timing Mark
3 – TDC -Top Dead Center

Figure 9-11

20. Repeat steps 15-20 two or three times to verify timing.
21. Remove the spill-timing tool.
22. Remove the wooden wedge.

    NOTICE: Always use a wrench to hold the fuel injection pump fuel delivery valve to prevent loosening of the delivery valve when loosening or tightening the high-pressure fuel injection lines.

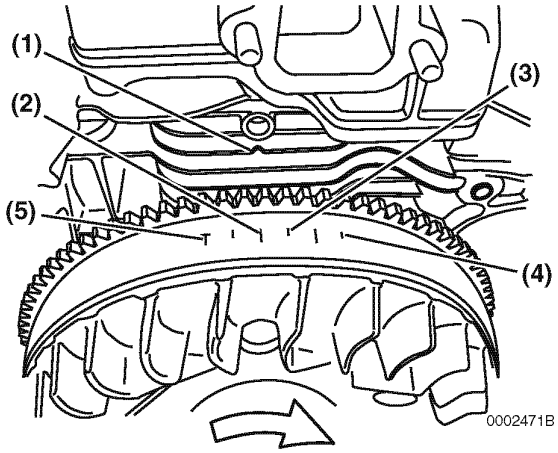
Note: To prevent "rounding" the fuel line nuts always use a "line" or "flare nut" wrench.

23. Install the high-pressure fuel injection line and tighten to specifications. *See Special Torque Specifications on page 9-5*.
24. Install the cooling fan housing and recoil.
25. Prime the fuel system. *See Priming the Fuel System on page 4-19*. Operate the engine and check for fuel leaks.

Adjusting Fuel Injection Timing

If the timing marks did not align when performing the *Checking Fuel Injection Timing* procedure on page *9-11*, perform the following steps to properly time the engine.

1. If not already completed, verify actual piston TDC, *See Checking Actual Piston TDC (Top Dead Center) on page 8-33*.
2. Leave the adjustment jig and the spill-timing tool installed on the fuel injection pump. Return the throttle control lever to the minimum speed position.
3. Ensure the wooden wedge is in place and the flywheel has not rotated since the timing check procedure.
4. Observe the difference between the "actual" timing setting and the "target" timing setting.
   - If the measured timing mark **(Figure 9-12, (2))** is closer to TDC **(Figure 9-12, (5))** than the target timing mark **(Figure 9-12, (3))**, the timing is “retarded” and must be advanced. To advance the timing, reduce shim thickness.
   - If the measured timing mark **(Figure 9-12, (4))** is further from TDC than the target timing mark **(Figure 9-12, (3))**, the timing is “advanced” and must be retarded. To retard the timing, increase shim thickness.



1 – TDC Timing Mark
2 – Measured Timing Mark (Timing Retarded)
3 – Target Timing Mark (15°)
4 – Measured Timing Mark (Timing Advanced)
5 – TDC -Top Dead Center

Figure 9-12

5. Calculate the amount of shim thickness that is required to correct the timing. Each 0.004 in. (0.1 mm) thickness change will result in 1° timing change.

Note: Shims are available in a set, including one each of the following thicknesses 0.008 in. (0.20 mm), 0.010 in. (0.25 mm), 0.012 in. (0.30 mm) and 0.014 in. (0.35 mm). You may use multiple shim sizes to reach the desired timing setting. The shims are not marked, so you will have to measure them with a micrometer.

6. Remove the fuel injection pump, *See Removal of Fuel Injection Pump on page 9-17* and the shim(s) from between the fuel injection pump and the engine crankcase. Measure and record the thickness of the existing shim(s).

   Example:

   Subject engine - L70V

   Target timing = 15° ± 0.5° BTDC

   Measured timing = 10° BTDC (5° retarded)

   Calculate the timing difference: 15° - 10° = 5°

Determine the difference in shim thickness:

Where: 0.004 in. (0.1 mm) = 1°

5° x 0.004 in.(0.1 mm) = 0.020 in. (0.5 mm)

In this case, the timing was "retarded" so the desired total shim(s) thickness needs to be 0.020 in. (0.5 mm) thinner than the original shim(s).

Measuring with a micrometer, if the existing shim(s) thickness is 0.048 in. (1.20 mm), the new thickness should be:

(0.048 in.- 0.020 in. = 0.028 in.) 2 x 0.014 in. shims = 0.028 in. total shims. (Equals 15 degrees BTDC)

or

(1.20 mm - 0.5 mm = 0.70 mm) 2 x 0.35 mm shims = 0.70 mm total shims. (Equals 15 degrees BTDC)

7. Install the calculated shim(s) **(Figure 9-13, (1))** over the injection pump mounting studs and onto the crankcase mounting surface.

Note: Do not use any sealant for this assembly.

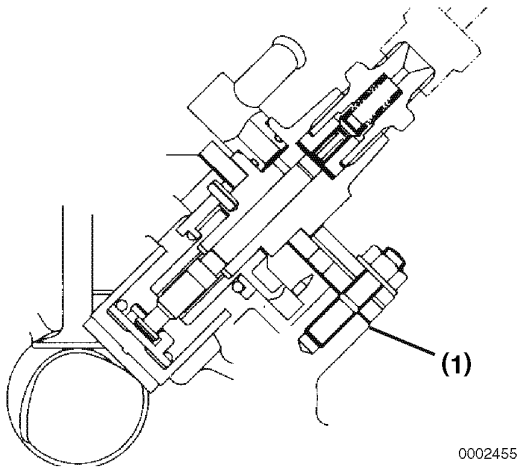


Figure 9-13

8. Install the fuel injection pump. Take up any slack in the mounting hardware by manually rotating the injection pump clockwise as you tighten the injection pump mounting nuts.
9. Tighten the fuel injection pump mounting nuts to specification. *See Special Torque Specifications on page 9-5*.
10. Remove the wooden wedge and repeat the timing procedures. *See Checking Fuel Injection Timing on page 9-11* and *Adjusting Fuel Injection Timing* on page *9-14* until fuel injection timing is correct.
11. When the timing is correctly set, remove the fuel adjustment jig and spill-timing tool and the wooden wedge.
12. Reinstall the injection pump inspection cover and gasket. Tighten the mounting nut to specification. *See Special Torque Specifications on page 9-5*.

    NOTICE: Always use a wrench to hold the fuel injection pump fuel delivery valve to prevent loosening of the delivery valve when loosening or tightening the high-pressure fuel injection lines.

Note: To prevent "rounding" the fuel line nuts, always use a "line" or "flare nut" wrench.

13. Install the high-pressure fuel injection line and tighten to specifications. *See Special Torque Specifications on page 9-5*.
14. Install the cooling fan housing and recoil.
15. Prime the fuel system. *See Priming the Fuel System on page 4-19*.
16. Operate the engine and check for fuel leaks.

FUEL TANK AND COMPONENTS

Removal of Fuel Tank

1. Disconnect the positive and negative battery cables from battery.

Note: *Always disconnect the (-) negative terminal (black) first and then the (+) positive terminal (red).*

2. Remove the drain plug **(Figure 9-14, (7))** and seal **(Figure 9-14, (8))** from tank and drain the fuel from tank into a suitable container. Do not allow any fuel to spill and clean any fuel that spills immediately.
3. Remove the outlet fuel clamp **(Figure 9-14, (2))** and hose **(Figure 9-14, (3)** from tank fuel filter **(Figure 9-14, (5))**.
4. Remove the four fuel tank screws and the fuel tank assembly from the frame.
5. Remove the three fuel filter housing nuts **(Figure 9-14, (4))** and pull out fuel tank filter together with the O-ring **(Figure 9-14, (6)**.

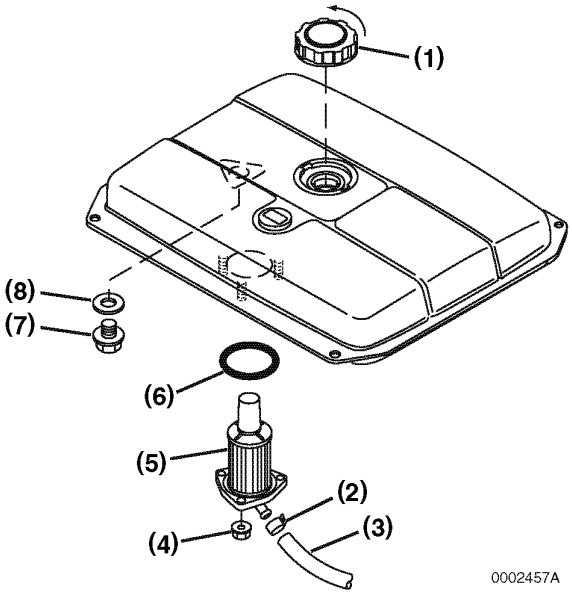


Figure 9-14

6. Remove the fuel gauge.
7. Remove the fuel cap **(Figure 9-15, (1)), seal (Figure 9-15, (2))** and inlet filter **(Figure 9-15, (3))**.

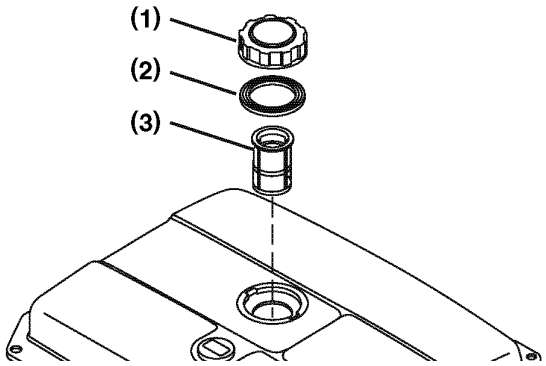


Figure 9-15

Inspection of Fuel Tank

Check the welded parts of the tank for cracks. Repair or replace tank as necessary.

Check the inside of the tank for residual fuel, debris and water. Clean all parts thoroughly.

Check all hoses for cracking and hardening. Replace as necessary.

Clean or replace all filters as necessary.

Inspect all O-rings and seals for leaking or damage and replace as necessary.

Check fuel gauge for proper operation and for leaking at seal area.

Installation of Fuel Tank

1. Install the fuel drain plug and new seal.
2. Install the fuel filter and O-ring with three nuts to fuel tank. Tighten the nuts securely.
3. Install the fuel gauge and new seal.
4. Install the fuel inlet filter, and fuel cap with new seal.
5. Install the fuel tank assembly to frame. Tighten the four fuel tank screws to specifications. *See Special Torque Specifications on page 9-5.*
6. Connect the fuel hose to filter assembly with clamp.

FUEL INJECTION PUMP

Removal of Fuel Injection Pump

Note: Be sure the speed control lever is set to the SLOW-IDLE position before removing the fuel injection pump.

1. Clean the areas around the fuel injection pump **(Figure 9-16, (6))** and fuel injector.
2. Close any fuel valves in the fuel supply line.

   NOTICE: Always use a wrench to hold the fuel injection pump fuel delivery valve to prevent loosening of the delivery valve when loosening or tightening the high-pressure fuel injection lines.

Note: To prevent "rounding" the fuel line nuts, always use a "line" or "flare nut" wrench.

3. Remove the high-pressure fuel injection line **(Figure 9-16, (1))**. Use care not to bend the line.
4. Remove the fuel supply line **(Figure 9-16, (2))**.
5. Plug or cap all openings to minimize leaks and prevent contamination.
6. Remove the three nuts **(Figure 9-16, (5))** fastening the fuel injection pump into the cylinder block.

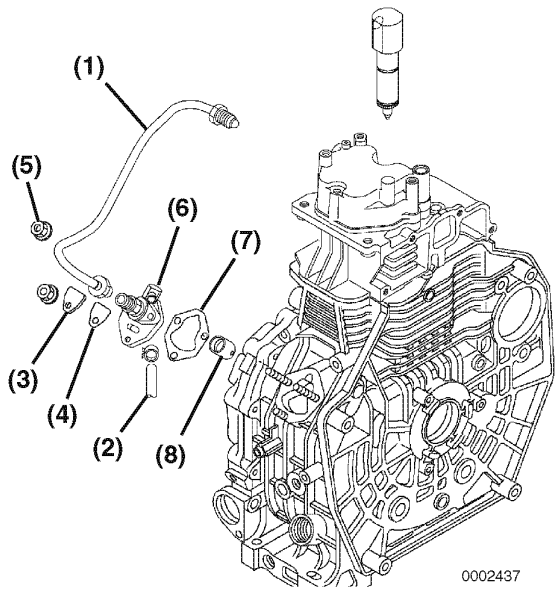


Figure 9-16

7. Remove the inspection cover **(Figure 9-16, (3))** and gasket **(Figure 9-16, (4)).**
8. Remove the fuel injection pump **(Figure 9-17)**.

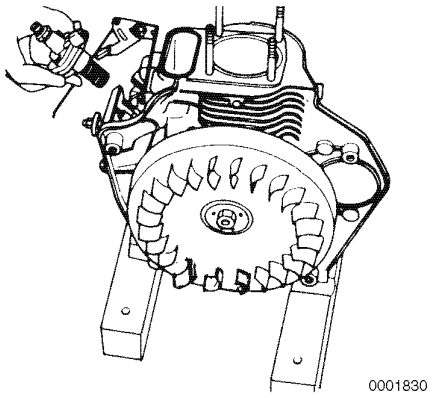


Figure 9-17

9. Remove the shim(s) **(Figure 9-16, (7))**. Use care not to bend or damage the shim(s).

Note: L48V model engines use a flat tappet and the L70V and L100V model engines use a roller tappet.

10. Remove the fuel injection pump tappet **(Figure 9-16, (8))** from the crankcase. The tappet may stay in the cylinder block. You can remove it with your finger. Inspect the face or roller end of the tappet for damage or abnormal wear. *See Tappet on page 8-13.*

Note: The fuel injeciton pump is not designed to be tested or serviced. Do not disassemble the fuel injection pump. If the fuel injection pump requires servicing, it must be replaced with a new fuel injection pump.

Installation of Fuel Injection Pump

1. Adjust the throttle control so the governor lever **(Figure 9-18, (1))** fork is positioned in the center of the fuel injection pump opening.

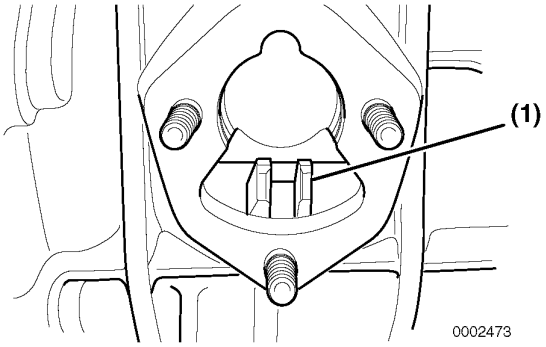


Figure 9-18

2. Install the fuel injection tappet.
3. Install the original fuel injection pump shim(s) **(Figure 9-20, (7)).**
4. Install the fuel injection pump **(Figure 9-20, (6))** into the crankcase, ensuring that the fuel injection pump lever pin **(Figure 9-19, (1))** is engaged in the governor lever fork **(Figure 9-19, (2))**.

   Hold the injection pump against the crankcase and move the speed control. Make sure the fuel injection pump control lever also moves.

   To reduce any play in the mounting hardware, manually rotate the fuel injection pump clockwise while tightening the mounting nuts.

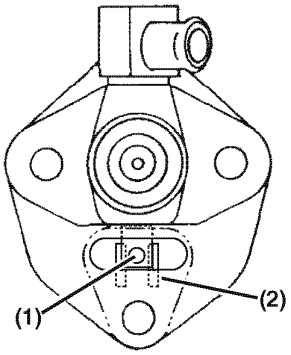


Figure 9-19

5. Install the two side mounting nuts **(Figure 9-20, (5))** and tighten to specification. *See Special Torque Specifications on page 9-5.*

Note: If the original fuel injection pump, camshaft and injection pump tappet **(Figure 9-20, (8))** are being reused, you do not need to recheck the fuel injection timing. If any of these components have been replaced, it will be necessary to check the fuel injection timing. *See Checking and Adjusting Fuel Injection Timing on page 9-11.*

6. Install the inspection cover **(Figure 9-19, (3))**, gasket **(Figure 9-20, (4))** and nut. Tighten to specification. *See Special Torque Specifications on page 9-5.*

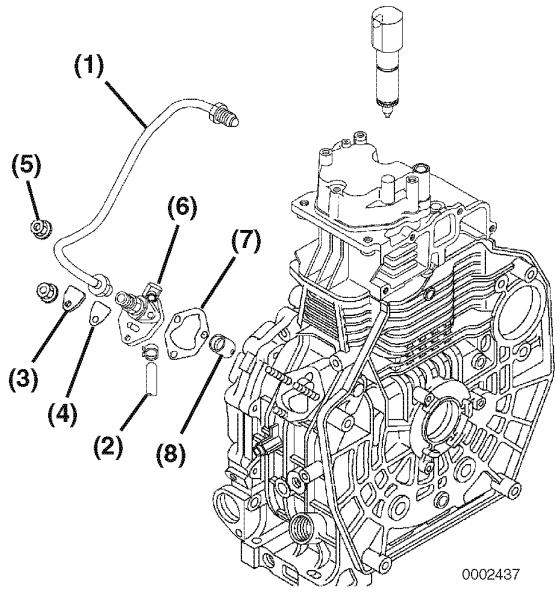


Figure 9-20

Note: To prevent “rounding” the fuel line nuts, always use a “line” or “flare nut” wrench.

7. Install the fuel injection high-pressure fuel injection line **(Figure 9-20, (1))**. Tighten the nuts to specification. *See Special Torque Specifications on page 9-5. NOTICE: Always use a wrench to hold the fuel injection pump fuel delivery valve to prevent loosening of the delivery valve when loosening or tightening the high-pressure fuel injection lines.*
8. Install the fuel supply line **(Figure 9-20, (2)).**
9. Prime the fuel system. *See Priming the Fuel System on page 4-19.*
10. Operate the engine and check for fuel leaks.

Replacement and/or Adjustment of the Fuel Limiter

If the fuel limiter **(Figure 9-21, (1))** is damaged, or it is obvious the fuel limiter adjustment has been tampered with, it will be necessary to replace and/or adjust the fuel limiter using the following procedure.

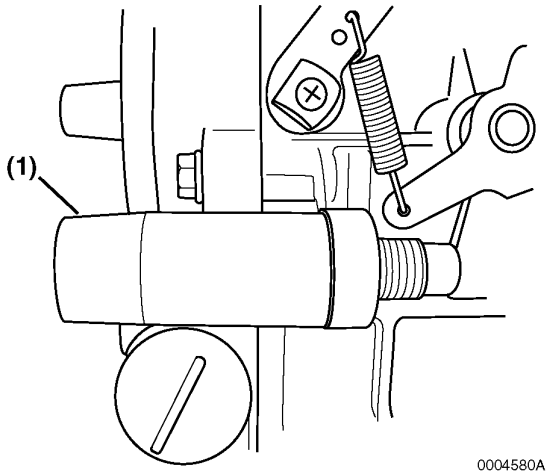


Figure 9-21

NOTICE: This is an emissions related procedure. Follow the procedure carefully to ensure emissions compliance. It is good service practice to always keep good service records.

If you are replacing the fuel injection pump, replace it before continuing with the fuel limiter replacement and/or adjustment procedure. See Installation of Fuel Injection Pump on page 9-18. Do not install the inspection window cover and gasket at this time.

1. Confirm that the fuel injection timing is correct. Adjust the fuel injection timing if needed. For the fuel injection timing procedure. *See Checking Fuel Injection Timing on page 9-11* and *“Adjusting Fuel Injection Timing” on page 9-14.*
2. Install the fuel adjustment jig **(Figure 9-22, (2))**, Yanmar P/N 114771-92310, in the fuel injection pump inspection window. Using the inspection window cover plate nut, fasten the fuel adjustment jig aligning the upper left edge of the jig **(Figure 9-22, (4))** to the alignment mark scribed on the face of the fuel injection pump **(Figure 9-22, (1))** base plate **(Figure 9-22, (3))**.

Note: Be sure to keep the fuel adjustment jig parallel to the inspection window opening. **Figure 9-22** shows the alignment mark for clarity only. The edge of the jig should be directly on the mark when installed properly.)

Note: To assist in the alignment of the fuel adjustment jig, tighten the attaching nut to just hold the jig "lightly" in place. Then "lightly" tap the jig into the proper position. Once the jig is in position, tighten the attaching nut to hold the jig firmly in place.

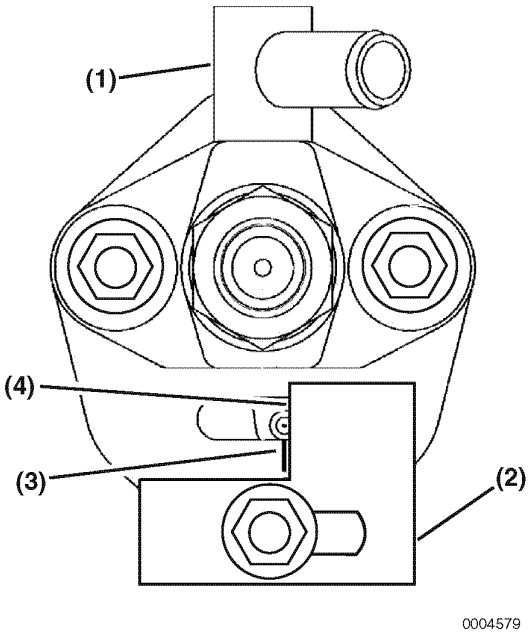


Figure 9-22

3. With the fuel adjustment jig in place, replacement or adjustment of the fuel limiter can continue.

Note: When replacing or adjusting the fuel limiter, a new fuel limiter tamper-proof cover and lock plate must be used. Using the correct parts catalog for the specific engine you are working on to order these parts.

4. To remove the tamper-proof cover from the fuel limiter, use a hacksaw or a cut-off wheel to carefully make a small slot **(Figure 9-23, (2))** in the side of the tamper-proof cover **(Figure 9-23, (1)).**

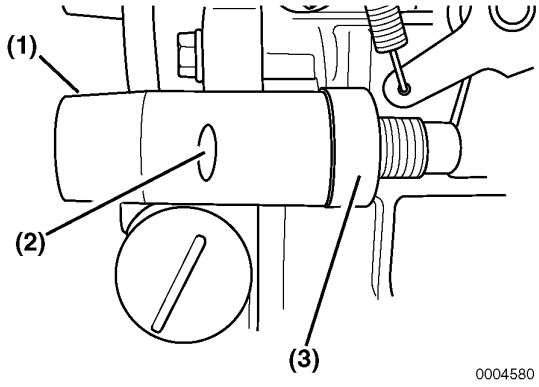


Figure 9-23

Note: Be careful not to damage the cylinder block boss **(Figure 9-23, (3))** when removing the tamper-resistant cover.

5. Use a hammer and metal chisel **(Figure 9-24, (2))** to drive off the tamper-resistant cover **(Figure 9-24, (1))**. The chisel should be held at about a 30° angle to the tamper-resistant cover, and engaged in the slot. Discard the old tamper-resistant cover.

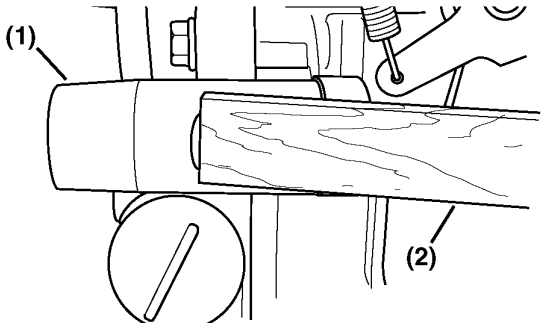


Figure 9-24

6. If installing a new fuel limiter, remove the original fuel limiter assembly from the threaded boss in the cylinder block. Disassemble the original fuel limiter assembly **(Figure 9-25)** and discard the fuel limiter **(Figure 9-25, (2))** and lock plate **(Figure 9-25, (1))**.

7. Reassemble the fuel limiter assembly with the new fuel limiter and the new lock plate.

Note: If the original fuel limiter is to be reused, the only part needing replacement is the lock plate.

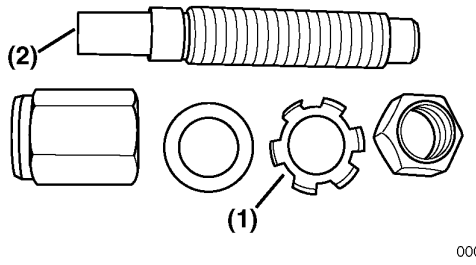


Figure 9-25

8. Assemble the new fuel limiter assembly **(Figure 9-26)** without the new tamper-resistant cover.

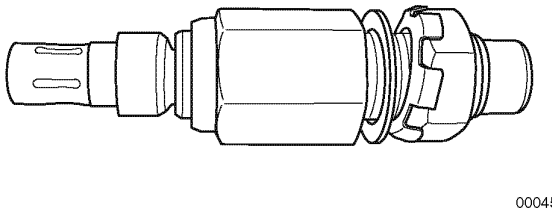


Figure 9-26

9. Thread the new fuel limiter assembly into the cylinder block boss until the threads on the fuel limiter extend about 0.250 in. (6.35 mm) past the surface of the cylinder block boss. Thread on the fuel limiter locking nuts, but do not tighten at this time.

Note: The fuel limiter is equipped with a "thermostat-like" wax pellet that contracts when cold, supplying more fuel for cold starting. When the engine reaches operating temperature, 86°F (30°C) or greater, the fuel limiter tip extends by 0.9 mm to return to the normal fuel setting. Do not use an open flame to heat the fuel limiter.

10. To adjust the fuel limiter, heat the rear portion of the fuel limiter with a hot air gun or hair dryer to assure that it is above 86°F (30°C), so the fuel limiter pin will be fully extended.

11. Rotate the speed control lever fully clockwise until it stops. Before proceeding, check that the tip of the fuel limiter is not touching the control lever **(Figure 9-27, (1))**.

L48V Models:

- Thread the fuel limiter into the crankcase boss until the fuel limiter pin just touches the control lever. Do not depress the fuel limiter pin.

L70V Models:

- Adjust the fuel limiter using the same procedure as the L48V above. Then move the speed control lever counter clockwise until the fuel limiter pin is no longer touching the control lever. Then turn the fuel limiter "in" an additional 1/3 turn.

L100V Models:

- Adjust the fuel limiter using the same procedure as the L48V above. Move the speed control lever counter clockwise away from the fuel limiter and then turn the fuel limiter "in" an additional 1/2 turn.

12. Without changing the adjustment of the fuel limiter, tighten the fuel limiter mounting nuts to specifications. *See Special Torque Specifications on page 9-5.*

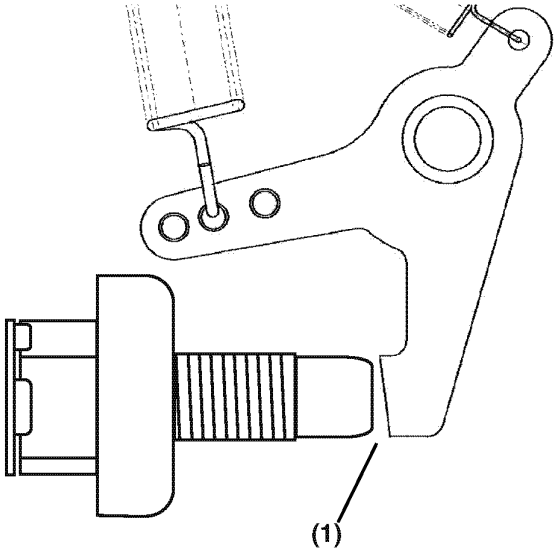


Figure 9-27

13. Remove the fuel adjustment jig from the fuel injection pump. Install the inspection window cover plate using a new gasket and tighten the nut to specifications. *See Special Torque Specifications on page 9-5.*
14. Install the new fuel limiter tamper resistant cover **(Figure 9-28, (1))**. Do not reuse the old cover. Use a soft-faced hammer to "tap" the tamper-resistant cover into place. When properly installed, there should not be a gap **(Figure 9-28, (2))** between the tamper-resistant cover and the cylinder block mounting boss **(Figure 9-28, (3)).**

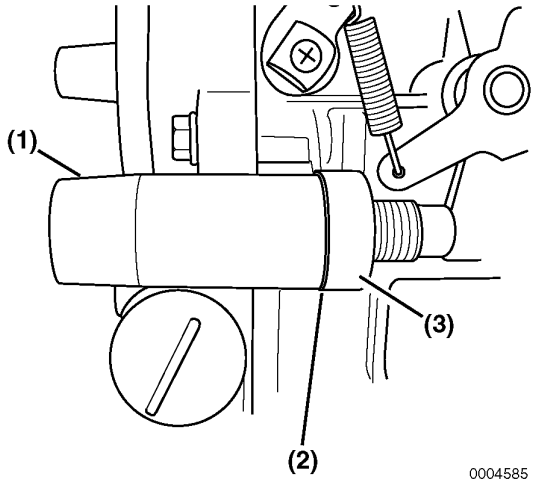


Figure 9-28

FUEL INJECTOR

Removal of Fuel Injector

1. Close any fuel valves in the fuel supply line.

   NOTICE: Always use a wrench to hold the fuel injection pump fuel delivery valve to prevent loosening of the delivery valve when loosening or tightening the high-pressure fuel injection lines.

Note: To prevent "rounding" the fuel line nuts, always use a "line" or "flare nut" wrench.

2. Remove the high-pressure fuel injection line.
3. Disconnect the fuel return hose from the fuel injector.
4. Remove the fuel injector retainer plate **(Figure 9-29, (1))**.
5. Remove the fuel injector from the cylinder head.

Note: If the fuel injector "sticks" in the cylinder head, reinstall the high-pressure fuel injection line and pry up on the fuel line nut.

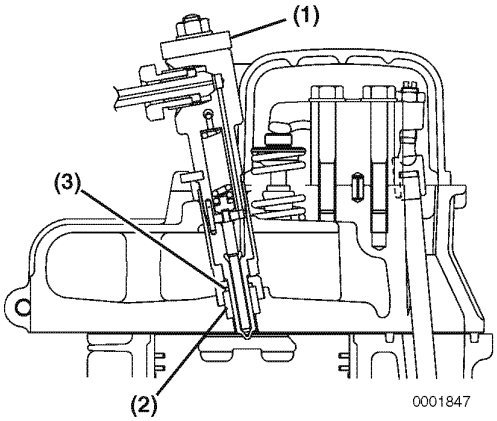


Figure 9-29

6. Remove the injector nozzle gasket **(Figure 9-29, (2))** and spacer **(Figure 9-29, (3))**. If the injector nozzle gasket and spacer remain in the cylinder head, remove them from the cylinder head by threading an 8 mm or 9 mm bolt, at least 200 mm long, into the gasket. Use the bolt as a puller. Discard the gasket.

Testing of Fuel Injector

NOTICE: Never use a steel wire brush to clean fuel injectors. Damage to the nozzle and other components is likely to result. Thoroughly clean the fuel injector nozzle using clean diesel fuel and a brass wire brush.

1. Visually inspect the fuel injector nozzle for deposits or damage. Clean, repair or replace as necessary.

Note: Test the fuel injector using an injection nozzle tester **(Figure 9-30)**. Operate the tester following the information provided by the tester manufacturer. Use clean, filtered fuel or FIE calibration fluid for the test.

2. Using the correct adapter, connect the fuel injector to a nozzle tester. Aim the fuel injector into a suitable container to contain the fuel spray. **DANGER! High-pressure fuel can penetrate your skin and result in serious injury. If you are exposed to high-pressure fuel spray, obtain prompt medical treatment. NEVER check for a fuel leak with your hands. ALWAYS use a piece of wood or cardboard.**

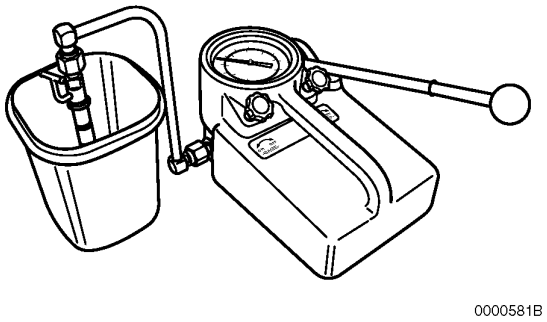


Figure 9-30

3. Pump the operating lever of the tester slowly, observing the pressure reading at the point where the fuel injector begins spraying fuel. *See Test and Adjustment Specifications on page 9-4*, for correct pressure readings.

Note: Opening pressure of a new fuel injector will be approximately 72.5 psi (0.5 MPa, 5 kgf/cm ^{2}) higher than one that has been operated for five hours or longer.

4. Pump the operating lever slowly to hold the pressure steady at a point just below the opening pressure and hold for five seconds. Observe the injector to see that it is sealing properly and is not "dripping." If fuel leaks from the return fuel line fitting, check that the nozzle case nut is tight. Repair or replace the fuel injector if fuel continues to leak from either the return line fitting or nozzle.
5. Pump the operating lever more rapidly to repeatedly "pop" the injector and observe the spray pattern. The pattern should be a very fine uniform spray **(Figure 9-31)**. If a dripping or an uneven pattern is seen **(Figure 9-32)**, service or replace the injector.

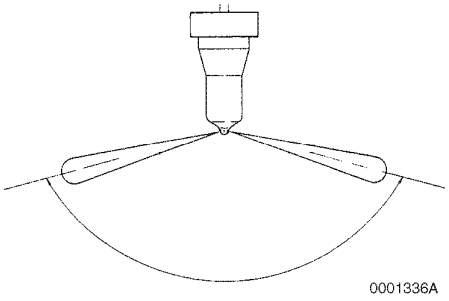


Figure 9-31

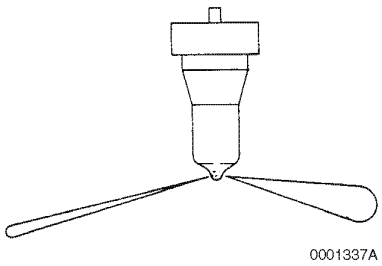
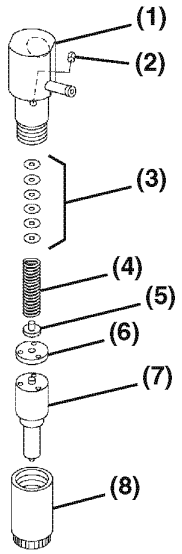


Figure 9-32

If the fuel injector fails any of these tests, it should be serviced or replaced as necessary. If the pressure is outside specified limits, adjust the pressure. *See Adjusting Fuel Injector Pressure on page 9-25.*

Disassembly and Inspection of Fuel Injector

1. Clean carbon from used injectors using clean diesel fuel. Hardened deposits or varnish can be cleaned using a brass wire brush. *NOTICE: NEVER use a steel wire brush to clean fuel injectors. Damage to the nozzle and other components is likely to result.*



1 – Injector Body
2 – Alignment Pin
3 – Pressure Adjusting Shims
4 – Spring
5 – Spring Seat
6 – Valve Stop Spacer
7 – Nozzle Body and Valve
8 – Nozzle Case Nut

Figure 9-33

2. Place the fuel injector in a soft-jawed vise with the nozzle pointing up.
3. Remove the nozzle case nut.
4. Carefully remove the injector from the vise.
5. Turn the injector over and remove the nozzle body, nozzle valve, valve stop spacer, nozzle spring seat, nozzle spring and shims.

6. Inspect the sealing surfaces **(Figure 9-34, (2))** between the valve stop spacer and nozzle body for nicks or scratches. Check the contact area between the valve stop spacer and the nozzle valve **(Figure 9-34, (1))** for scoring or pitting. Use a magnifying glass to inspect.

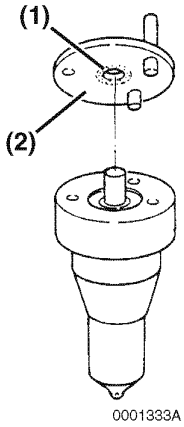


Figure 9-34

7. Perform a nozzle valve slide test:
   (a) Wash nozzle body and valve in clean diesel fuel.
   (b) While holding the nozzle body vertical, pull the nozzle valve about two-thirds of the way out **(Figure 9-35)**.
   (c) Manually move the nozzle valve up and down in the nozzle body. It should move smoothly with no binding.

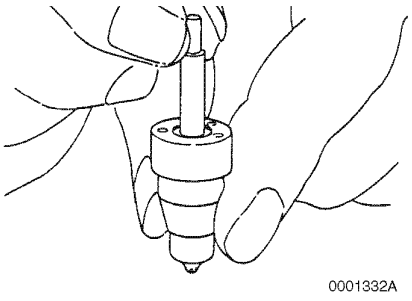
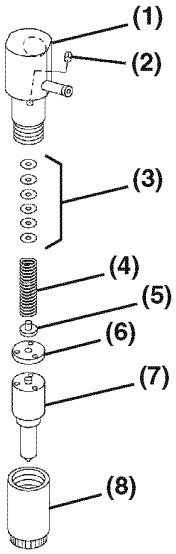


Figure 9-35

8. Replace the fuel injector assembly if it fails any inspection.

Adjusting Fuel Injector Pressure

The fuel injectors open when pressure reaches a predetermined pressure threshold. They close when the pressure is reduced below that threshold. The pressure threshold can be adjusted by adding or removing shims **(Figure 9-36, (3))**.



1 – Injector Body
2 – Alignment Pin
3 – Pressure Adjusting Shims
4 – Spring
5 – Spring Seat
6 – Valve Stop Spacer
7 – Nozzle Body and Valve
8 – Nozzle Case Nut

Figure 9-36

Note: The injection pressure will change by approximately 284 psi (1.96 MPa, 20 kgf/cm^2) for every 0.004 in. (0.1 mm) shim thickness. Add a shim(s) to increase the injector opening pressure. Remove a shim(s) to decrease injector opening pressure.

See the parts catalog for available shims.

1. Disassemble the fuel injector assembly. *See Disassembly and Inspection of Fuel Injector on page 9-24.*
2. Remove or add adjusting shims as needed.

3. Assemble the fuel injector assembly. *See Reassembly of Fuel Injector on page 9-26.*
4. Retest the fuel injector. *See Testing of Fuel Injector on page 9-23.* If the injector cannot be adjusted to the appropriate pressure, discard and replace the fuel injector.

Reassembly of Fuel Injector

1. Secure the fuel injector in a soft-jawed vise with the nozzle end up.
2. Install the shims, nozzle spring, nozzle spring seat, valve stop spacer, nozzle valve and nozzle body.
3. Install the nozzle case nut. Tighten it to specification. *See Special Torque Specifications on page 9-5.*

Installation of the Fuel Injector

1. Install a new nozzle spacer **(Figure 9-37, (3))** and gasket **(Figure 9-37, (2))** on the fuel injector.

   See the parts catalog for correct part number(s).

2. Install the fuel injector in the cylinder head. Align the alignment pin with the groove in the cylinder head and high-pressure outlet as shown, then push the fuel injector into place.

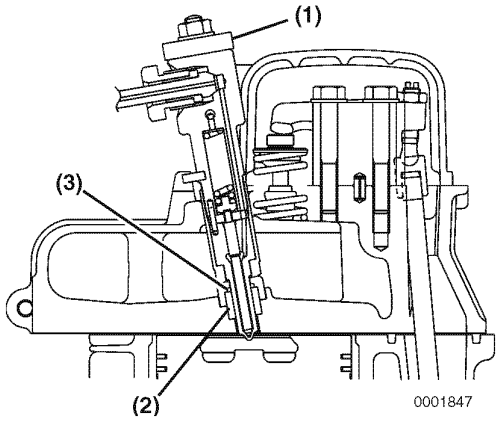


Figure 9-37

3. Install the injector retainer plate **(Figure 9-37, (1))** and tighten the nuts to specification. *See Special Torque Specifications on page 9-5.*

NOTICE: Always use a wrench to hold the fuel injection pump fuel delivery valve to prevent loosening of the delivery valve when loosening or tightening the high-pressure fuel injection lines.

Note: To prevent “rounding” the fuel line nuts, always use a “line” or “flare nut” wrench.

4. Install the high-pressure fuel injection line. Tighten to specifications. *See Special Torque Specifications on page 9-5.*
5. Install the return fuel hose.
6. Prime the fuel system. *See Priming the Fuel System on page 4-19.*
7. Operate the engine and check for fuel leaks.

SPEED CONTROL DEVICE

The YDG Models use a Constant Speed Type speed control device.

The position where the governor springs are installed differs depending on the rated rpm and the design of the speed control.

For removal and installation of the speed control device, *See Replacement of Throttle Shaft Seal - L70V and L100V models on page 8-52* or *See Replacement of Throttle Shaft Seal - L70V and L100V models on page 8-52*.

Use the following chart and graphics to determine the correct spring position for a given engine.

No Load Maximum Speed Control Adjustment

Before adjusting, mark the position of the governor spring on both the control lever and governor lever.

2700	3700	5500
Spring Location		
1-B	1-B	1-B

1. Set the speed control lever to the run position and start the engine.
2. Slightly loosen the bracket bolts and rotate the bracket slightly in either direction to obtain the specified no load maximum speed.

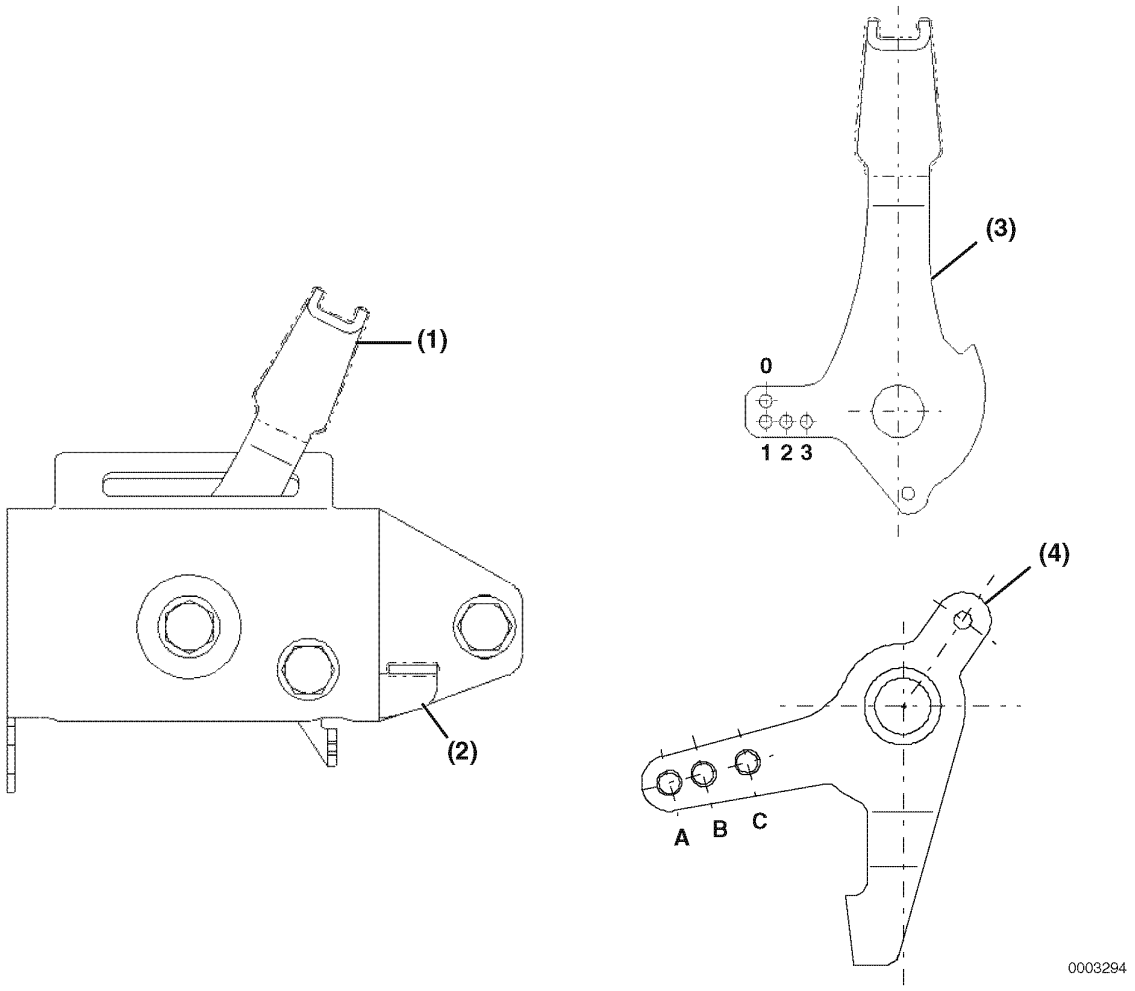
2700	3700	5500
3750 to 3800 RPM		

Note: Since the increase of magnetic current is enforced to the diesel generator when the no load maximum speed is lower than the standard, causing malfunctions to the AVR, in an attempt to decrease the engine load, always observe the standard maximum no load speed.

3. Hold the bracket while maintaining the specified speed and tighten bolts.

Constant Speed Type Device

The constant speed control device is used in applications where a constant engine rpm is wanted, such as generators. When moved to the full throttle position, the speed control lever “locks” at full throttle.



1 – Speed Control Lever
2 – Speed Control Release Lever
3 – Control Lever
4 – Governor Lever

Figure 9-38

Section 10

STARTER

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BEFORE YOU BEGIN SERVICING

Before performing any service procedures within this section, read the following safety information and review the *Safety* section on page *3-1*.

NOTICE

Make sure that the combined total resistance of the battery cable in both directions between the starter motor and the battery is within the value indicated on the wiring diagram. The starter motor will malfunction or break down if the resistance is higher than the specified value.

The starter motor is water-proofed according to JIS D 0203, R2 which protects the motor from rain or general cleaning. Do not use high-pressure wash or submerse the starter motor in water.

STARTER

INTRODUCTION

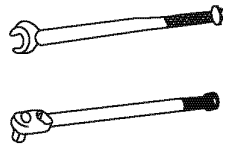
This section of the *Service Manual* covers the servicing of the recoil starter and electric starter motor (if equipped). Yanmar Electric starter motor, Part No. 114399-77010 is used in this section to show the service procedures for all starter motors. For specific part detail, see the *Yanmar Parts Catalog* for the engine being serviced.

SPECIFICATIONS

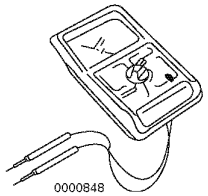
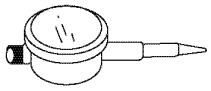
Engine Model			**L48V, L70V, L100V**
Type			Conventional
Hitachi Model Number			S114-414A
Yanmar Part Number			114399-77010
Nominal Output			12 VDC (0.8 kW)
Weight			7.9 lb (3.6 kg)
Rotation Direction (As Viewed From Pinion)			Counterclockwise
Engagement System			Magnetic Shift
No-load	Terminal Voltage / Current		11.5 VDC / 60 A (max)
	Revolution		7000 rpm (min)
Loaded	Terminal Voltage / Current		8 VDC / 200 A (max)
	Torque		27.7 lb-in. (0.32 kgf•m) (min)
Clutch System			Overrunning
Pinion Projection Voltage at 212°F (100°C)			8 VDC max
Pinion DP or Module / Number of Teeth			8
Brush	Spring Force		3.81 - 4.85 lbf (17 - 21.6 N, 1.8 - 2.2 kgf)
	Height	Standard	0.55 in. (14 mm)
		Limit	0.43 in. (11 mm)
Solenoid Switch	Pull-In Coil Resistance		0.33 Ω at 68°F (20°C)
	Hold-In Coil Resistance		1.13 Ω at 68°F (20°C)
Commutator	Outside Diameter	Standard	1.30 in. (33 mm)
		Limit	1.26 in. (32 mm)
	Runout	Standard	0 in. (0.05 mm)
		Limit	0.02 in. (0.4 mm)
	Insulation Depth	Standard	0.02 - 0.03 in. (0.5 - 0.8 mm)
		Limit	0.01 in. (0.2 mm)
Armature	Runout	Standard	0.002 in. (0.05 mm)
		Limit	0.016 in. (0.4 mm)

Bearings	Brush Side (shaft diameter)	0.4902 - 0.4909 in. (12.450 - 12.468 mm)
	Brush Side (bearing inside diameter)	0.4921 - 0.4928 in. (12.500 - 12.518 mm)
	Pinion Sliding Section (shaft diameter)	0.4921 - 0.4909 in. (12.450 - 12.468 mm)
	Pinion Sliding Section (bearing inside diameter)	0.493 - 0.494 in. (12.53 - 12.55)
	Pinion Side (shaft diameter)	0.4902 - 0.4909 in. (12.450 - 12.468 mm)
	Pinion Side (bearing inside diameter)	0.4921 - 0.4928 in. (12.500 - 12.518 mm)
Pinion Projection Length (Length L)		0.012 - 0.059 in. (0.3 - 2.5 mm)

SPECIAL SERVICE TOOLS

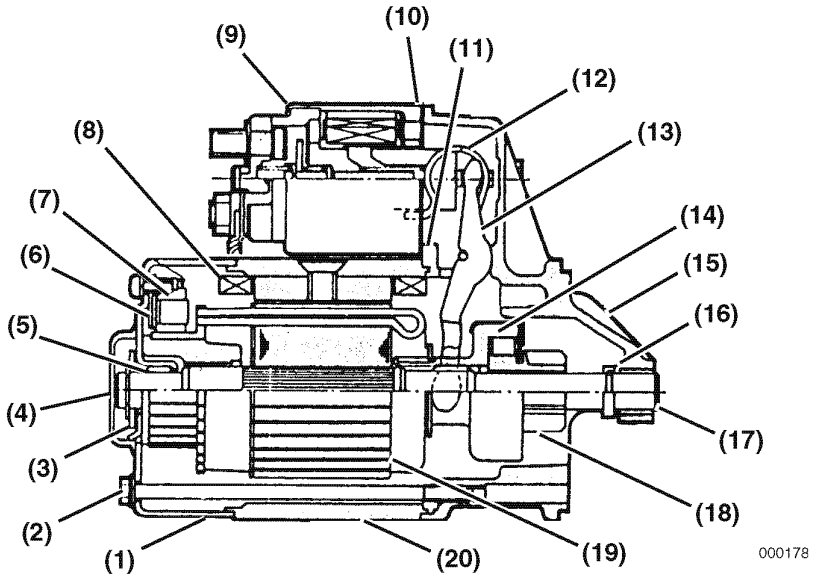
No.	Tool Name	Application	Illustration
1	Torque Wrench (Available Locally)	For tightening nuts and bolts to the specified torque	 0000840

MEASURING INSTRUMENTS

No.	Tool Name	Applicable Model and Tool Size	Illustration
1	Caliper	Locally available	 0000836
2	Multimeter	Locally available	 0000848
3	Dial Indicator	Locally available	 0000831
4	Force Gauge	Locally available	

Note: Tools not having Yanmar part numbers must be acquired locally.

ELECTRIC STARTER MOTOR COMPONENTS (STANDARD)



1 – Rear Cover
2 – Through-Bolt
3 – Thrust Washer
4 – Rear Dust Cover
5 – Rear Cover Bearing
6 – Brush Holder
7 – Brush
8 – Field Coil
9 – Solenoid Switch
10 – Dust Cover
11 – Dust Cover
12 – Torsion Spring
13 – Shift Lever
14 – Overrunning Clutch
15 – Gear Housing
16 – Pinion Stop
17 – Gear Housing Bearing
18 – Pinion
19 – Armature
20 – Field Housing

Figure 10-1

ELECTRIC STARTER MOTOR TROUBLESHOOTING

Step 1	Is starter motor operating?	No	See “B”
		Yes	See “E”
A	Are the pinion and ring gear meshing normal?	No	Adjust / pinion engagement length. Inspect shift lever for deformation, return spring for fatigue and pinion for sliding. Repair meshing between pinion and ring gear or replace as needed.
		Yes	Pinion roller clutch or reduction gear damaged.
B	Is the battery fully charged and terminals clean?	No	Charge or replace battery. Clean terminals.
		Yes	See “C”
C	Is the starter motor magnetic switch actuating sound heard?	No	Inspect and repair wiring up to magnetic switch, key switch, safety relay magnetic switch assembly and electrical connections as necessary.
		Yes	See “D”
D	Does starter motor operate with “M” terminal of starter motor connected directly to the battery?	No	Inspect brush and replace if worn. If brushes are not worn, replace armature assembly and/or starter motor assembly.
		Yes	Magnetic switch assembly contact defective. If starter motor becomes wet, replace magnetic switch assembly even if function is normal.
E	Does the starter motor crank the engine at normal speed?	No	See “B”
		Yes	See “A”

TESTING ELECTRIC STARTER MOTOR OPERATION (STANDARD)

Checking Pinion Projection Length

1. When the pinion is at the projected position, measure the gap **(Figure 10-2, (2))** between pinion and pinion stop. This measurement should be made with the pinion pressed back lightly **(Figure 10-2, (1))** to take up any play in engagement linkage. *See Specifications on page 10-4.*

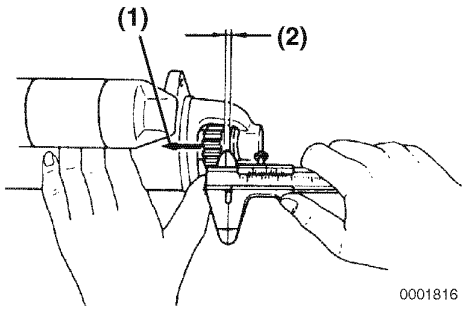


Figure 10-2

2. If the measured dimension **(Figure 10-2, (2))** is not within specifications, adjust the dust covers to obtain the standard range. Dust covers **(Figure 10-3, (1))** are available in 0.020 in (0.5 mm) and 0.031 in. (0.8 mm) thicknesses.

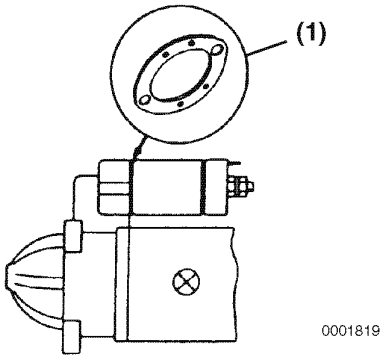


Figure 10-3

3. Check the distance between the flywheel ring gear **(Figure 10-4, (2))** and starter motor pinion **(Figure 10-4, (1))** in the rest position (mesh clearance) **(Figure 10-4, (3))**. The clearance must be 0.12 in. - 0.20 in. (3.0 mm - 5.0 mm).

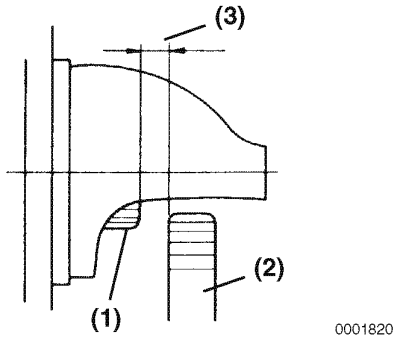


Figure 10-4

No-Load Test

Test the characteristics of the starter motor by performing a no-load test. *NOTICE: The starter motor can be damaged if operated continuously longer than 10 seconds while performing the no-load test.*

Secure the starting motor in a vise or other suitable fixture.

1. Connect an ammeter **(Figure 10-5, (1))** in series between the battery positive (+) terminal **(Figure 10-5, (2))** and the main positive (+) terminal **(Figure 10-5, (3))** on the starter motor.

Note: The ammeter and all wire leads used in this test must have a capacity equal to or greater than the amperage draw specification for the starter motor being tested.

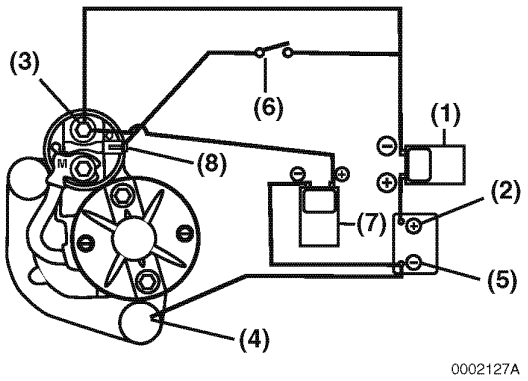


Figure 10-5

2. Connect a wire lead between the mounting base of the starter motor **(Figure 10-5, (4))** and the battery negative terminal **(Figure 10-5, (5))**.
3. Connect a voltmeter **(Figure 10-5, (7))** to the battery negative (-) terminal **(Figure 10-5, (5))** and the main positive (+) battery terminal on the starter motor **(Figure 10-5, (3))**.
4. Install a switch **(Figure 10-5, (6))** in a circuit between the battery positive (+) terminal **(Figure 10-5, (2))** and the starter solenoid switch terminal **(Figure 10-5, (8))** on the starter motor.
5. Use a suitable tachometer to monitor the rpm of the starter.
6. Turn the switch to the ON position to energize the solenoid and operate the starter. Monitor the rpm, amperage draw and voltage. *See Specifications on page 10-4* for the appropriate starter motor test specifications.

ELECTRIC STARTER MOTOR (STANDARD)

Disassembly of Electric Starter Motor

Note: While starter motor design varies between models, the basic repair procedures are the same. The following procedures are typical and may differ from the starter being serviced.

1. Disconnect the battery, negative (-) cable first.
2. Remove the wire from the solenoid switch. Remove the solenoid switch mounting bolt.
3. Remove the solenoid switch and dust covers **(Figure 10-6, (1)).**
4. Disconnect the solenoid plunger from the shift lever.
5. Remove the torsion spring (for reduction-type starter motor only) and pull the torsion spring out from the solenoid switch.

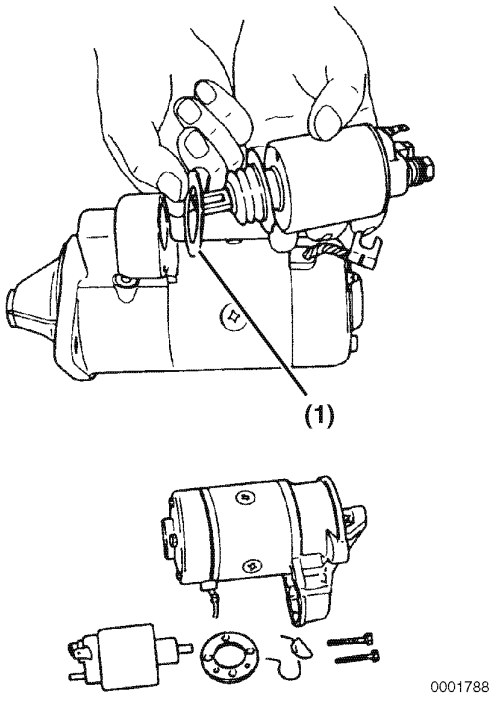


Figure 10-6

6. Remove the rear dust cover **(Figure 10-7, (1))**.

7. Remove the E-ring, and remove the thrust washer **(Figure 10-7)**.

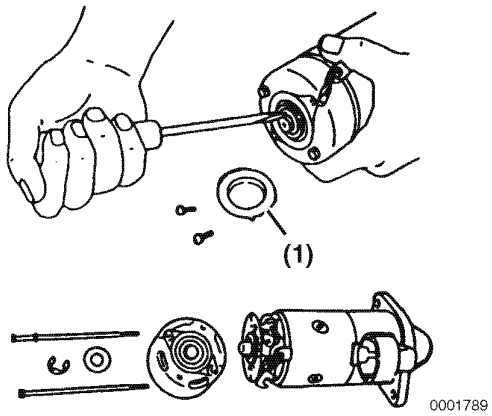


Figure 10-7

8. Remove the two through-bolts securing the rear cover and the two screws securing the brush holder.
9. Remove the rear cover.

Note: Make sure that the washer and shim are not damaged.

10. Pull up the brush springs using a brush spring puller **(Figure 10-8)**. On the negative (-) side, bring the brush spring into contact with the side of the brush for lifting from the commutator surface. On the positive (+) side, remove the brush from the brush holder assembly.

Note: There are two negative (-) brushes and one positive (+) brush.

11. Remove the brush holder assembly.

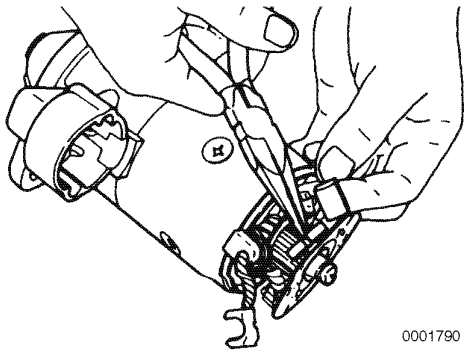


Figure 10-8

12. Pull off the field assembly from the armature assembly **(Figure 10-9)**.

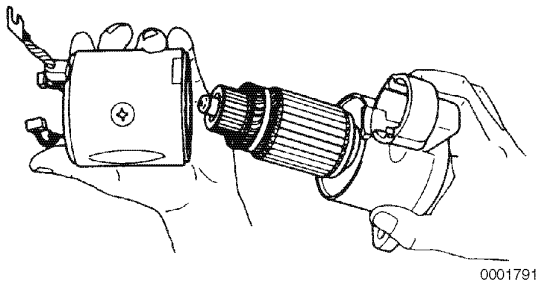


Figure 10-9

13. Pull out the armature assembly from the gear housing **(Figure 10-10)**.
14. Remove the shift lever.

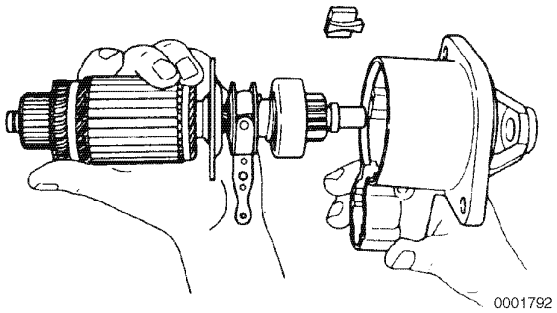


Figure 10-10

15. Pull down the pinion stop **(Figure 10-11, (1))** to expose the retaining ring. Using a flat-blade screwdriver, remove the retaining ring **(Figure 10-11, (2))** from the pinion shaft.

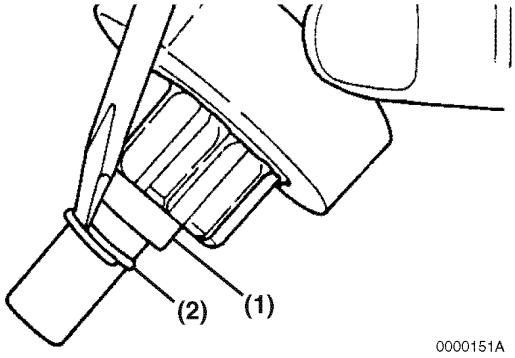


Figure 10-11

16. Remove the pinion stop, return spring (if equipped) and pinion clutch assembly from the pinion shaft **(Figure 10-12)**.

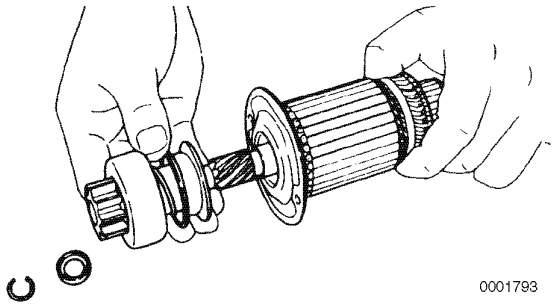


Figure 10-12

Inspection and Testing of Electric Starter Motor Components

Armature

Commutator Surface Inspection

If the commutator surface is rough, polish the surface with a #500 to #600 emery cloth **(Figure 10-13)**.

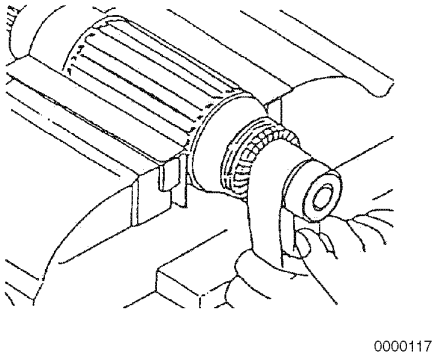


Figure 10-13

Measure Commutator Outside Diameter

Measure the commutator outside diameter **(Figure 10-14)**. Replace the armature if the measurement is less than the limit.

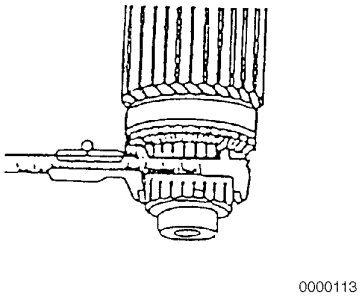


Figure 10-14

See Specifications on page 10-4 for the service limit.

Measure Commutator Insulation Depth

Measure the depth of the insulating material **(Figure 10-15, (1))** between commutator segments **(Figure 10-15, (2))**. If the depth measures less than the limit, use a hacksaw blade **(Figure 10-15, (3))** to remove the insulating material until the depth is within the limit.

A normal commutator condition is indicated in **(Figure 10-15, (4))**. An abnormal commutator condition is indicated in **(Figure 10-15, (5))**.

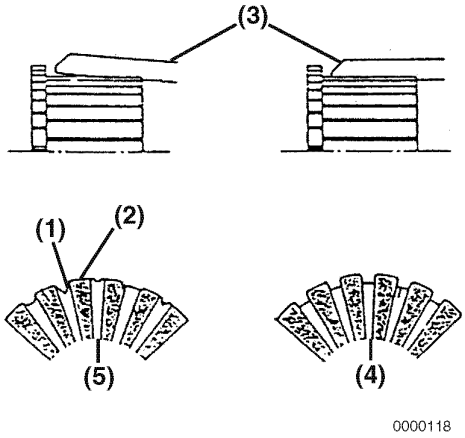


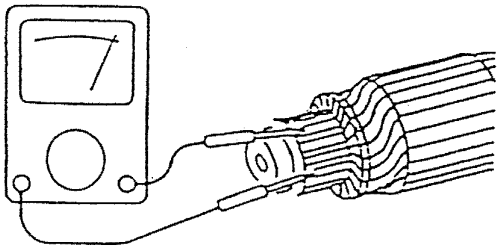
Figure 10-15

See Specifications on page 10-4 for the service limit.

Armature Coil Continuity Test

Check for continuity between the commutator segments using a multimeter **(Figure 10-16)**. The multimeter should indicate continuity.

If the multimeter does not indicate continuity, replace the armature.



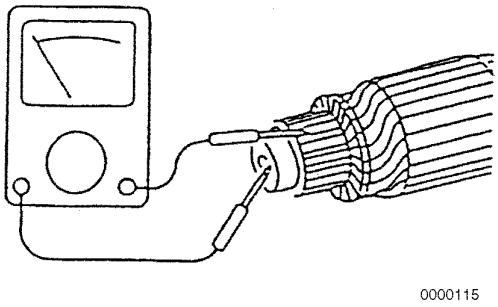
0000114

Figure 10-16

Armature Coil Insulation Test

Check for continuity between a commutator segment and the shaft or armature using a multimeter **(Figure 10-17)**. The multimeter should not indicate continuity.

If the multimeter indicates continuity, replace the armature.

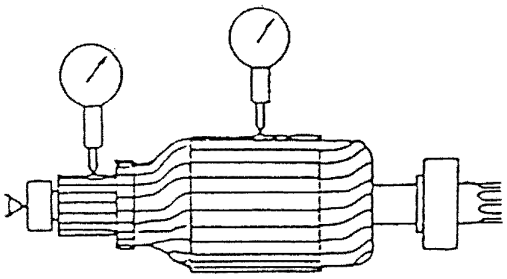


0000115

Figure 10-17

Measure Armature and Commutator Run-Out

Use a dial indicator to measure the armature core runout and the commutator runout **(Figure 10-18)**. Replace the armature if either of the measurements is not within specifications.



0000116

Figure 10-18

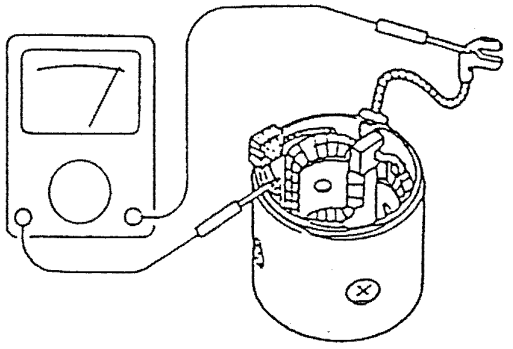
See Specifications on page 10-4 for the service limit.

Field Coil

Field Coil Continuity Test

Check for continuity between the field coil terminals using a multimeter **(Figure 10-19)**. The multimeter should indicate continuity.

If the multimeter does not indicate continuity, replace the field coil assembly.



0000119

Figure 10-19

Field Coil Insulation Test

Check for continuity between either field coil terminal and the yoke using a multimeter **(Figure 10-20)**. The multimeter should not indicate continuity.

If the multimeter indicates continuity, replace the field coil assembly.

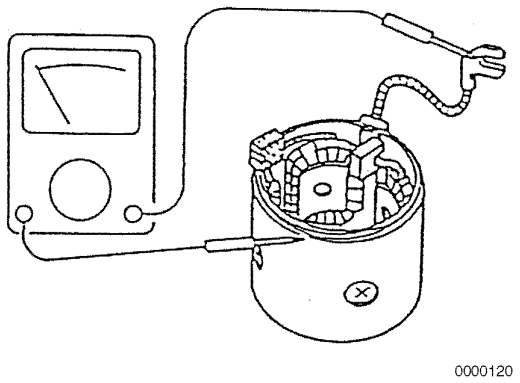


Figure 10-20

Measure Brush Length

Measure the length of the brush **(Figure 10-21)**. Replace the brush if the length is less than the limit.

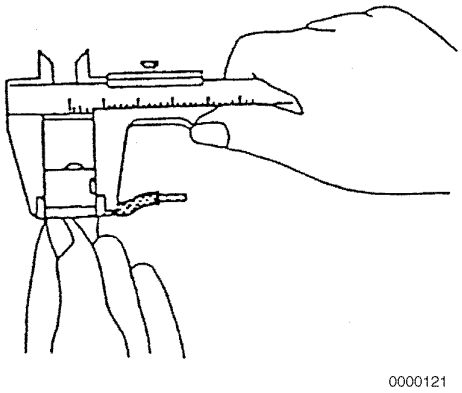


Figure 10-21

See Specifications on page 10-4 for the service limit.

Brush Holder

Brush Holder Insulation Test

Check for continuity between each brush holder and the base using a multimeter **(Figure 10-22)**. The multimeter should not indicate continuity.

If the multimeter indicates continuity, replace the brush holder.

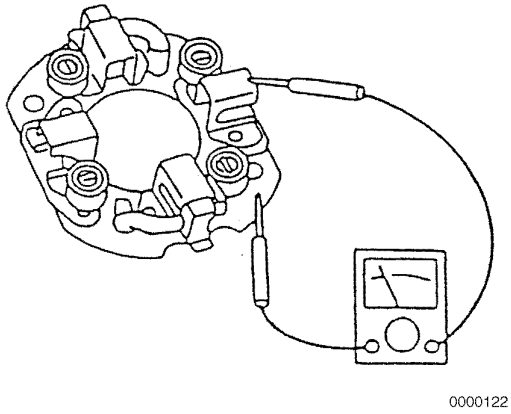


Figure 10-22

Brush Spring Test

Test the spring force for each brush spring **(Figure 10-23)**. Replace the brush spring if the force is not within the range.

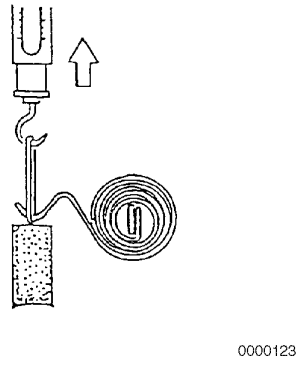


Figure 10-23

See Specifications on page 10-4 for the service limit.

Solenoid Switch

If the starter motor becomes wet, replace the solenoid switch even if the solenoid switch assembly function is normal.

Shunt Coil Continuity Test

Check for continuity between the "S" terminal and the switch body using a multimeter **(Figure 10-24)**. The multimeter should indicate continuity.

If the multimeter does not indicate continuity, replace the solenoid switch.

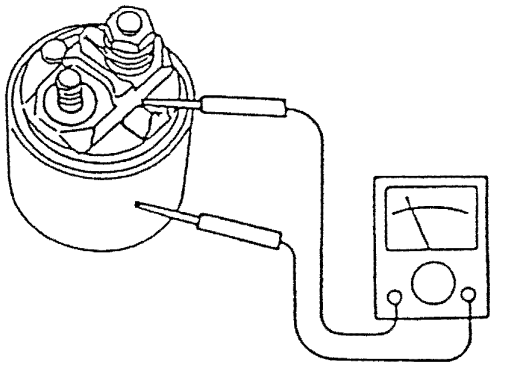


Figure 10-24

Series Coil Continuity Test

Check for continuity between the "S" and "M" terminals using a multimeter **(Figure 10-25)**. The multimeter should indicate continuity.

If the multimeter does not indicate continuity, replace the solenoid switch.

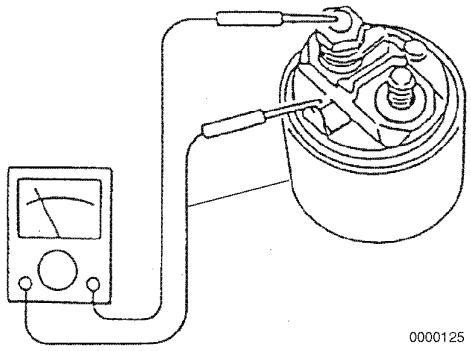


Figure 10-25

Coil Resistance Test

See Specifications on page 10-4 for the service limit.

Contact Continuity Test

Depress the plunger at the bottom of the solenoid switch. Check for continuity between the "B" and "M" terminals using a multimeter **(Figure 10-26)**. The multimeter should indicate continuity.

If the multimeter does not indicate continuity, replace the solenoid switch.

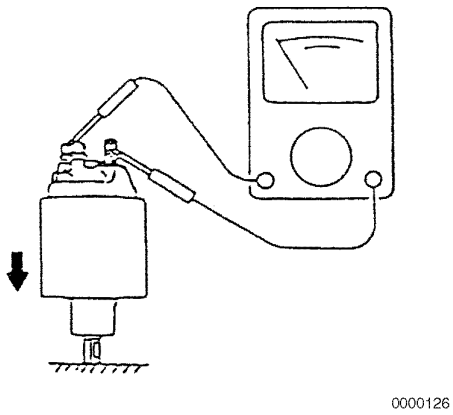


Figure 10-26

Measure Brush Length

Measure the length of the brush **(Figure 10-27)** and **(Figure 10-28)**. Replace the brush if the length is less than the limit.

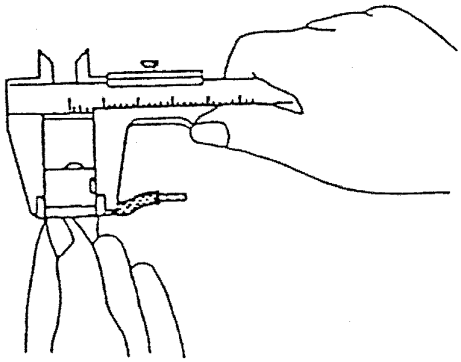


Figure 10-27

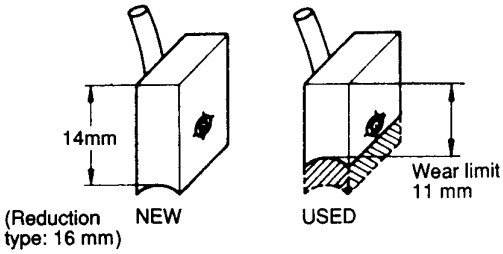


Figure 10-28

Brush Appearance and Brush Movement in Brush Holder

If the outside of the brush is damaged, replace it. If the movement of the brushes in the brush holder is hampered because the holder is rusted, repair or replace the holder.

Pinion

Pinion Teeth Inspection

Inspect the pinion teeth and replace the pinion if the teeth are worn or damaged.

Pinion Clutch Assembly Inspection

Manually rotate the pinion clutch assembly in the drive direction. It should rotate freely in the drive direction and be locked in the opposite direction **(Figure 10-29)**. Replace the pinion clutch assembly if the results are different.

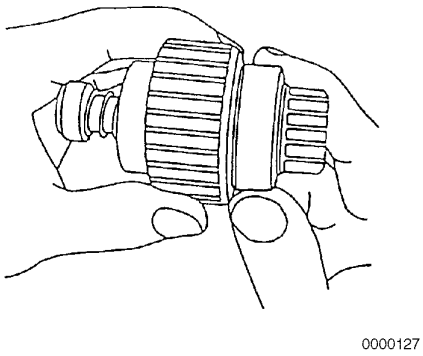


Figure 10-29

Slide the pinion clutch assembly on the shaft. It should slide smoothly on the shaft **(Figure 10-30)**. Rust, too much grease or damage could prevent the pinion clutch from sliding smoothly. If the pinion clutch assembly does not slide smoothly, clean the shaft and pinion clutch assembly or replace the damaged component.

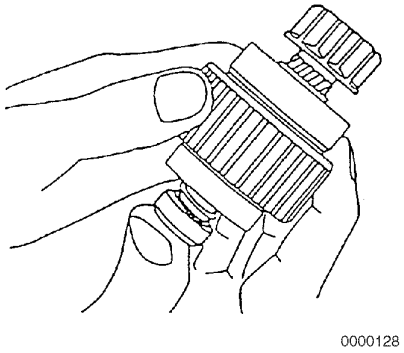


Figure 10-30

Pinion Spring Inspection

Inspect the pinion spring and replace if the spring is faulty.

Reassembly of Electric Starter Motor

1. Lightly grease pinion shaft with appropriate starter bendix grease (obtain locally).
2. Install the pinion assembly onto the shaft.
3. Install the retaining ring in groove in the shaft. Slide the pinion stop over the retaining ring **(Figure 10-31)**.

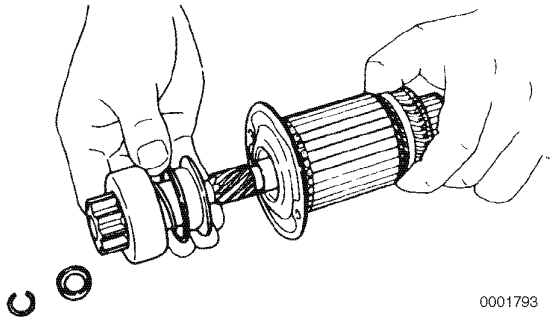


Figure 10-31

4. Apply a small amount of high temperature lithium grease (obtain locally) to the sliding portions of the shift lever. Install the shift lever. Be sure the shift lever properly engages the pinion.
5. Install the armature and pinion assembly into the pinion housing **(Figure 10-32)**.

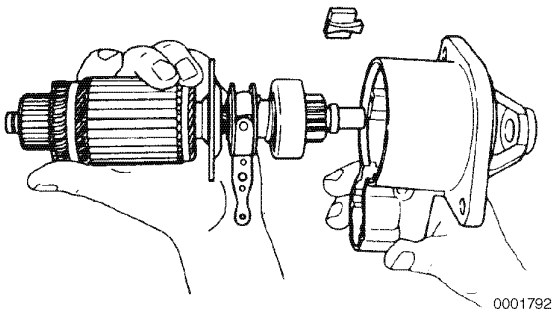


Figure 10-32

6. Install the field assembly over the armature assembly and align to the pinion housing **(Figure 10-33)**.

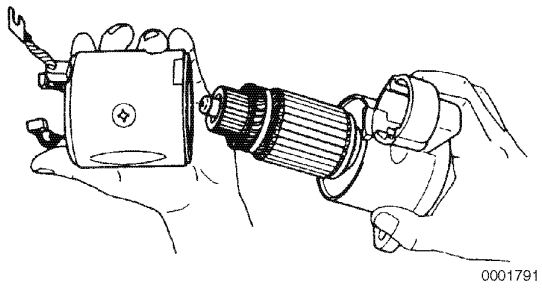


Figure 10-33

7. Install the brush holder assembly to the armature assembly.
8. Position the brush springs in brush holders. Install the brushes in the brush holders. Reversing the brushes will cause the starter motor to turn backwards **(Figure 10-34)**.

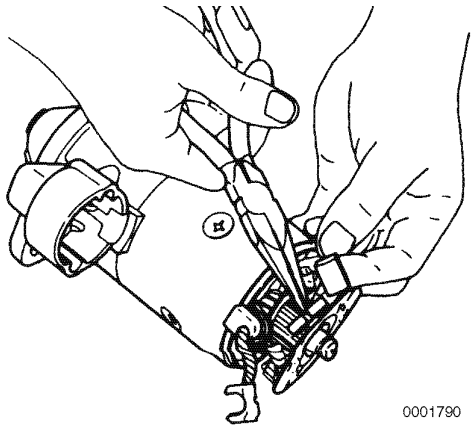


Figure 10-34

9. Install the rear cover.
10. Install and tighten the two through-bolts securely.
11. Install the thrust washer and E-ring.
12. Install the rear dust cover **(Figure 10-35, (1))**.

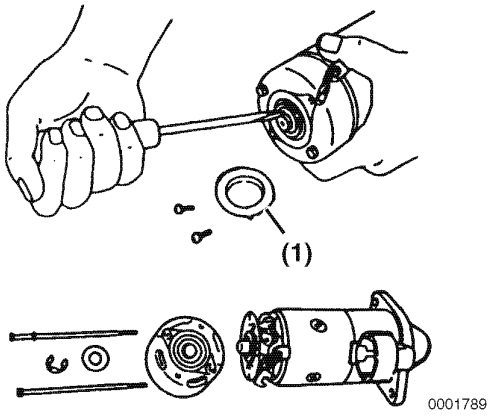


Figure 10-35

13. Apply a light coat of lithium grease to the surface of the plunger and the hole that engages the shift lever.
14. Install the plunger into the solenoid switch. Install the original dust covers **(Figure 10-36, (1))** and the return spring if equipped.
15. Install the solenoid switch assembly. Be sure the plunger properly engages the shift lever.

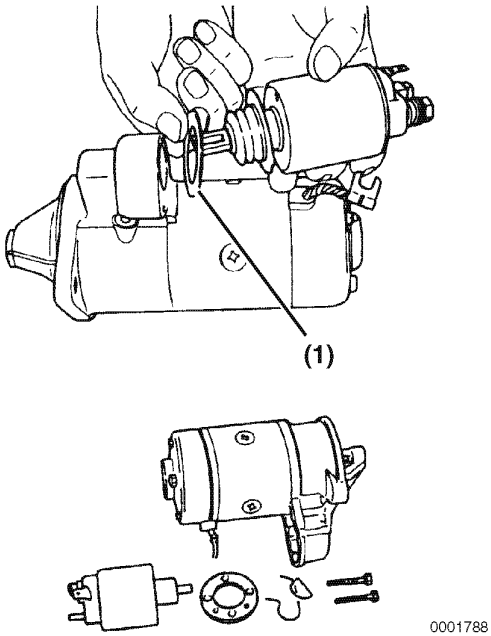


Figure 10-36

16. Connect the wire to the solenoid switch assembly. Tighten the nut **(Figure 10-37)**. Install the cover over the connection.

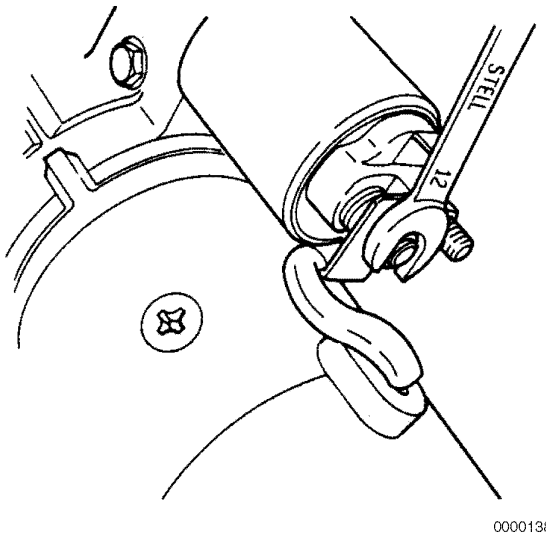


Figure 10-37

RECOIL STARTER

Disassembly of Recoil Starter

1. Remove the recoil starter assembly from the engine.

Note: Model L100V does not have a notch in the reel. The reel has sufficient clearance to allow the rope to move freely between the reel and starter housing.

2. Pull the starter rope out approximately 12 in. (30 cm) until the notch on the reel lines up with the starter rope. Hold the reel and use a screwdriver to pull the starter rope up **(Figure 10-38, (1))**.

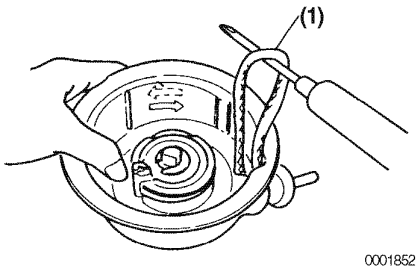
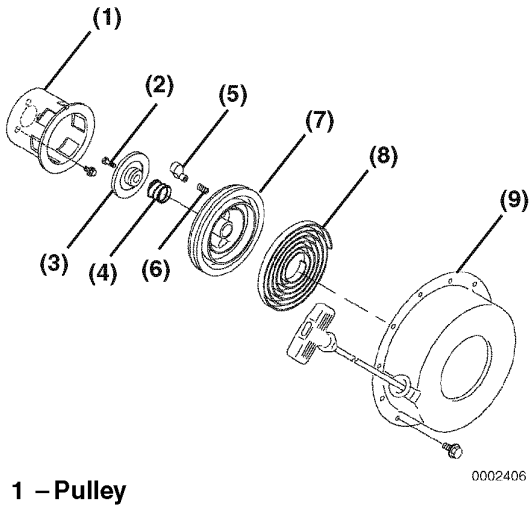


Figure 10-38

3. Allow the reel to slowly rotate backward until it stops. Remove the starter handle.
4. **Models L48V and L70V**: Remove the bolt **(Figure 10-39, (2))**.

   Model L100V: Remove retaining ring, washer and nylon washer **(Figure 10-40, (2, 3 and 4))**.

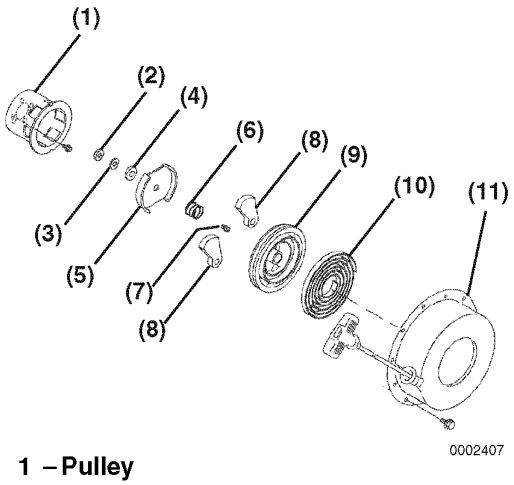
L48V and L70V



1 – Pulley
2 – Bolt
3 – Ratchet Cover
4 – Friction Spring
5 – Ratchet Pawl
6 – Ratchet Return Spring
7 – Rope Reel
8 – Recoil Spring
9 – Recoil Housing

Figure 10-39

L100V



1 – Pulley
2 – Retaining Ring
3 – Washer
4 – Nylon Washer
5 – Ratchet Cover
6 – Friction Spring
7 – Ratchet Return Spring
8 – Ratchet Pawls
9 – Rope Reel
10 – Recoil Spring
11 – Recoil Housing

Figure 10-40

5. Remove the ratchet cover and friction spring.
6. Remove the ratchet pawl and ratchet return spring. *NOTICE: The starter spring is under considerable tension when installing or removing it from the recoil housing and can unexpectedly come out of the housing. ALWAYS wear gloves and safety glasses when repairing the recoil starter.*
7. *NOTICE: If the reel is removed too quickly, the spring may unexpectedly come out of the housing.* Carefully remove the reel **(Figure 10-41, (3))** from the starter housing **(Figure 10-41, (1))** while turning it gently left and right to disconnect the boss from the spring **(Figure 10-41, (2))**.

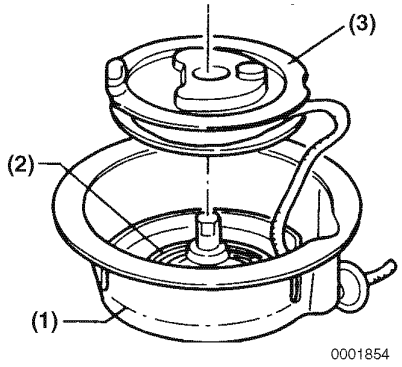


Figure 10-41

8. Carefully remove the recoil spring by winding it out of the housing.

Reassembly of Recoil Starter

1. Securely hook the spring end to the starter housing **(Figure 10-42, (1))**. Install the recoil spring by carefully winding it into the housing as shown **(Figure 10-42, (5))**. *NOTICE: NEVER allow the recoil handle to snap back against the engine. Return the handle to the starting position gently to prevent damage to the starter.*
2. Adjust the shape of the inner end **(Figure 10-42, (2))** of the spring so it is about 0.157 in (4 mm) **(Figure 10-42, (4))** from the starter spindle **(Figure 10-42, (3))**.

Note: Approximately 0.390 in. (10 mm) of the length of the inner end of the spring can be reshaped with pliers.

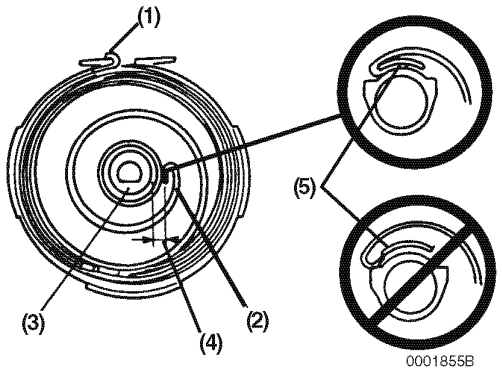


Figure 10-42

3. Lightly lubricate the spindle with lithium-based multipurpose grease.
4. Wind the starter rope 2-1/2 turns around the reel in the direction shown **(Figure 10-43)**.

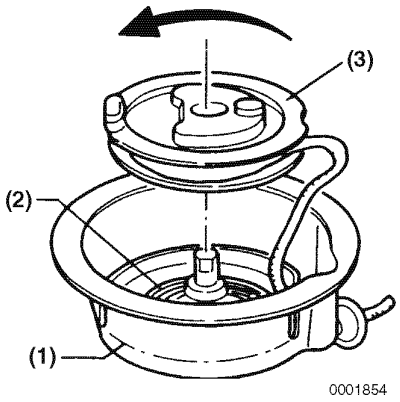
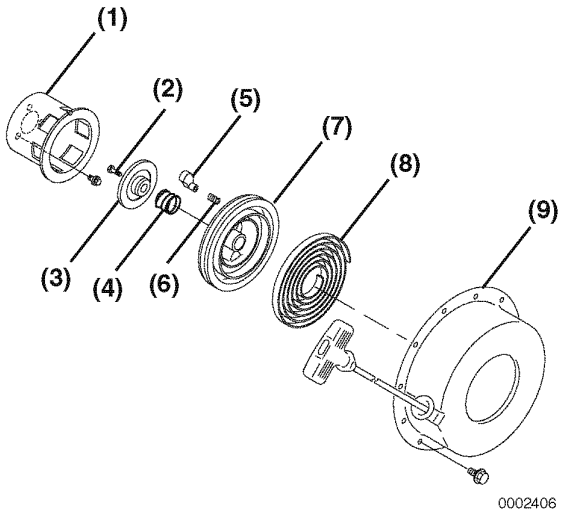


Figure 10-43

5. Place the reel **(Figure 10-43, (3))** into the housing **(Figure 10-43, (1))**. Be sure the boss **(Figure 10-42, (5))** on the reel **(Figure 10-42, (2))** engages the spring inner hook.
6. Thread the starter rope through the hole and tie a temporary knot to prevent the rope from being pulled back into the housing. Allow the reel to slowly rewind the rope until the knot is against the housing.
7. Install the ratchet, ratchet spring, friction spring and ratchet guide.
8. **Models L48V and L70V:** Install and tighten the bolt **(Figure 10-44, (2))**.

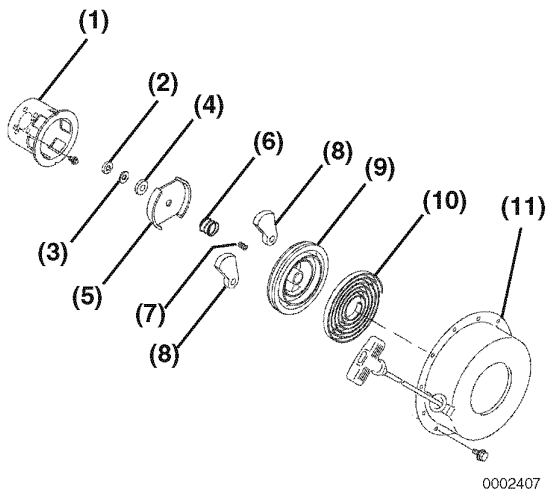


1 – Pulley
2 – Bolt
3 – Ratchet Cover
4 – Friction Spring
5 – Ratchet Pawl
6 – Ratchet Return Spring
7 – Rope Reel
8 – Recoil Spring
9 – Recoil Housing

Figure 10-44

9. **Model L100V:** Install the nylon washer, flat washer and retaining ring **(Figure 10-45, (4, 3, 2))**.

Note: Tighten the retaining ring using pliers.



1 – Pulley
2 – Retaining Ring
3 – Washer
4 – Nylon Washer
5 – Ratchet Guide
6 – Friction Spring
7 – Ratchet Return Spring
8 – Ratchet Pawls
9 – Rope Reel
10 – Recoil Spring
11 – Recoil Housing

Figure 10-45

Note: Model L100V does not have a notch in the reel. The reel has sufficient clearance to allow the rope to move freely between the reel and starter housing.

10. Wind the reel four turns in the direction shown **(Figure 10-46)** while holding the rope in the notch of the reel.

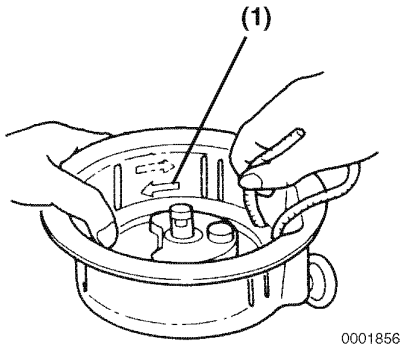


Figure 10-46

11. Install the handle and remove the temporary knot in the rope.

    NOTICE: Perform the following checks before operation

12. Pull the starter rope part way out two or three times.
    - If the resistance is too tight, make sure the parts are reassembled correctly.
    - If the ratchet does not move, check the friction spring.
13. Pull the starter rope out completely and allow the rope to return slowly.
    - If the starter rope does not come out of the reel completely, the return spring is wound too tightly. Remove one to two turns of tension from the rope.
    - If the starter rope returns slowly or does not return completely, rewind the starter rope one turn.

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Section 11

CHARGING SYSTEM

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BEFORE YOU BEGIN SERVICING

Before performing any service procedures within this section, read the following safety information and review the *Safety* section on page *3-1*.

NOTICE

Do not use a high-pressure wash directly on the alternator. Water will damage the alternator and result in inadequate charging.

Agricultural or other chemicals, especially those with a high sulfur content, can adhere to the IC regulator. This will corrode the conductor and result in battery over-charging (boiling) and charging malfunctions. Consult Yanmar before using the equipment in such an environment or the warranty is voided.

Do not reverse the positive (+) and negative (-) ends of the battery cable. The alternator diode and stator coil will be damaged.

INTRODUCTION

This section of the *Service Manual* describes servicing of the charging system/dynamo. Yanmar Part No. 114399-78730 dynamo is used in this section to show the service procedures for the representative dynamo. For specific part detail, see the *Parts Catalog* for the engine you are working on. The term Charging System will be used throughout this manual in reference to the Dynamo.

SPECIFICATIONS

General Specifications

Yanmar Part Number		114399-78730
Type		Rotating Permanent Magnet
Nominal Output		15 A @ 13 VDC
Revolution Direction		Clockwise or Counterclockwise
Battery Voltage		12 VDC
Rated rpm		3600 rpm
Grounding Characteristics		Negative (-) Side of Circuit
Regulated Voltage		14.5 ± 0.5 VDC
Wire Color	Wire Insulation	Green/White and Green/White
	Tube	White

Unregulated Output Test Specifications

Unregulated Output	
3750 rpm	**3220 rpm**
45.4 VDC	39 VDC

Values are approximate.

Regulated Output Test Specifications

Regulated Output @ 3600 rpm		Evaluation	Comment
Voltage	Amperage		
14 VDC or less	2 A or more	Normal	-
	13.5 A or more		
14-15 VDC	0.2 - 2.0 A	Normal	-
	0.3 - 13.5 A*		-
15 VDC or more	2 A or more	Abnormal	Replace faulty regulator / rectifier
	13.5 A or more		
15 VDC or less	0 A		Faulty wiring, flywheel magnets or regulator / rectifier
Low	Normal		Faulty battery

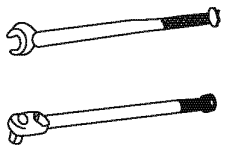
Measured value will vary depending on the charge state of the battery.

Special Torque Specifications

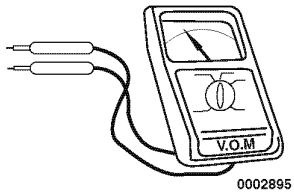
See Tightening Torques for Standard Bolts and Nuts on page 4-33 for standard hardware torque values.

Component	Model	Thread Diameter and Pitch	Torque	Lubricating Oil Application (Thread Portion and Seat Surface)
Flywheel Nut	L48V	M16 x 1.5 mm	101.5 - 108.7 lb-ft (137.3 - 147.1 N·m, 14.0 - 15.0 kgf/m)	Applied
	L70V	M16 x 1.5 mm	116 - 123.2 lb-ft (156.9 - 166.7 N·m, 16.0 - 17.0 kgf/m)	
	L100V	M18 x 1.5 mm	159 - 166 lb-ft (215.7 - 225.6 N·m, 22.0 - 23.0 kgf/m)	

SPECIAL SERVICE TOOLS

No.	Tool Name	Application	Illustration
1	Torque Wrench (Available Locally)	For tightening nuts and bolts to the specified torque	 0000840

MEASURING INSTRUMENTS

No.	Instrument Name	Application	Illustration
1	Multimeter	Electrical testing of voltage, resistance and amperage.	 0002895

CHARGING SYSTEM OPERATION

The charging system/dynamo consists of a series of permanent magnets that rotate around a stationary stator coil. The magnets are attached to the flywheel which is rotated via the engine crankshaft. The resultant output is an AC (alternating current) signal. The AC is converted to DC (direct current) in the regulator / rectifier. The regulator / rectifier outputs charging DC current to the battery.

Some models incorporate a rectifier only and no regulator. These models output a DC charging current with no regulation.

Some models have only AC lighting capabilities. These models have no rectifier or regulator and output an AC signal only.

CHARGING SYSTEM WIRING DIAGRAMS

12 V - 3 A and 12 V - 15 A System

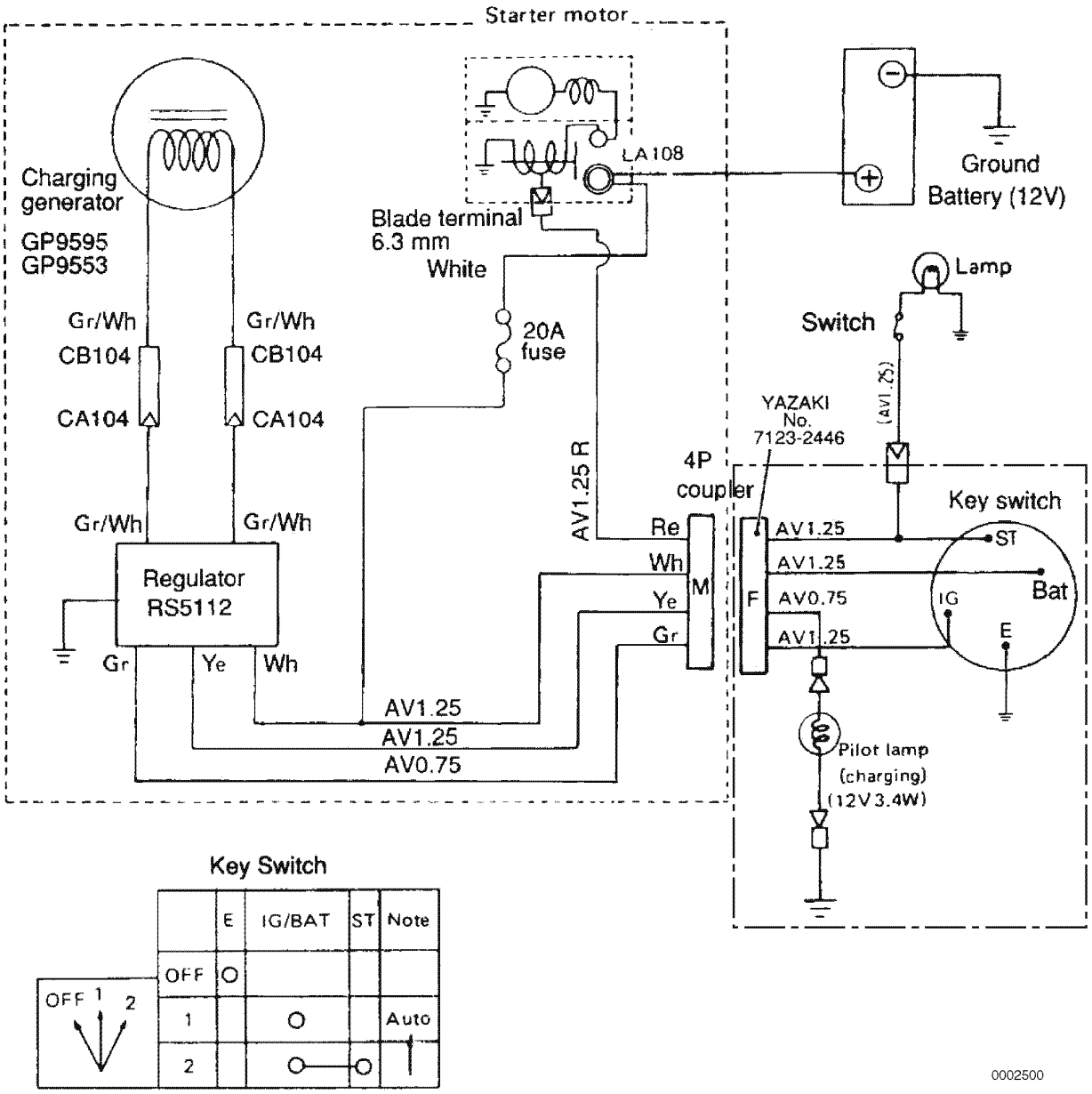


Figure 11-1

CHARGING SYSTEM

12 V - 1.7 A System

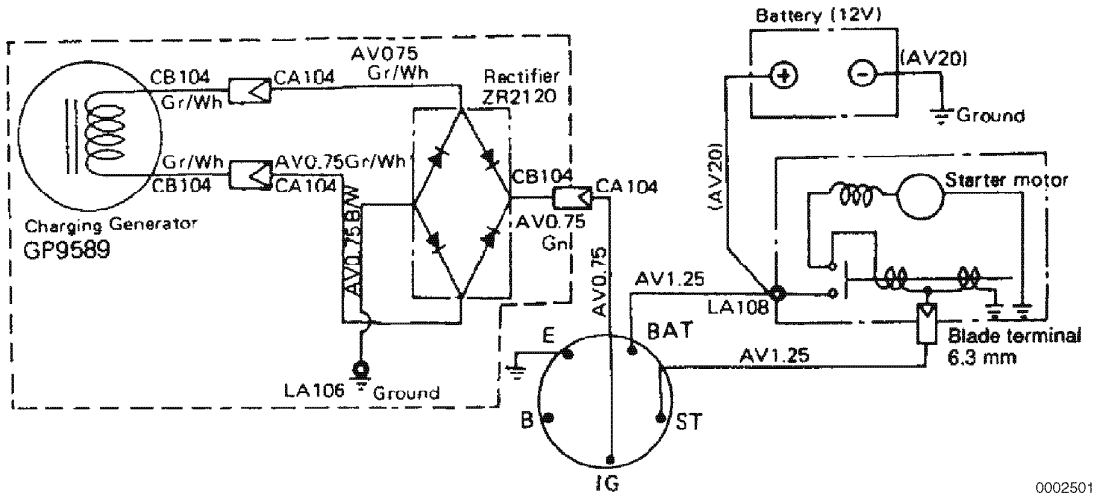


Figure 11-2

12 V - 1 A System

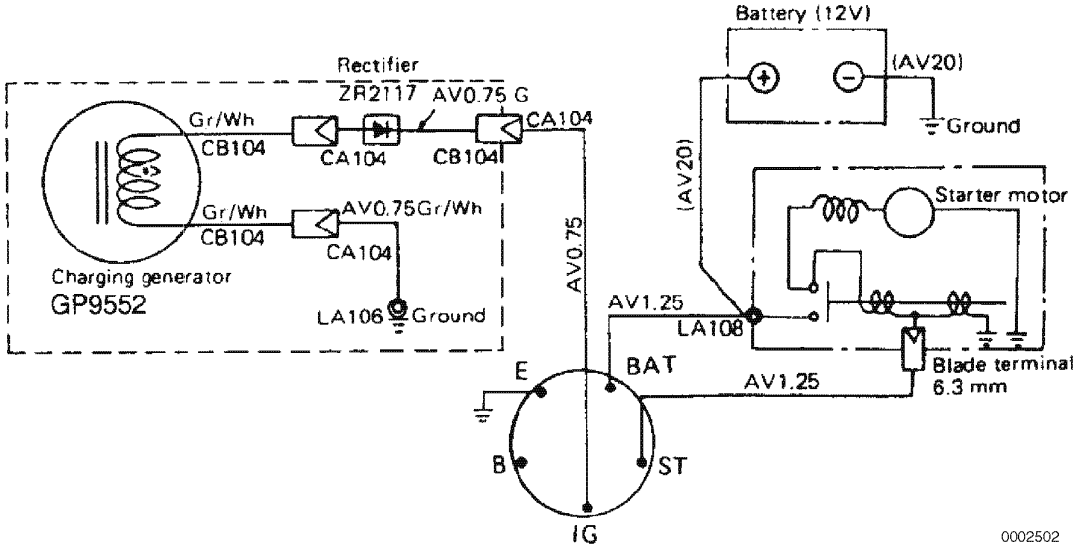
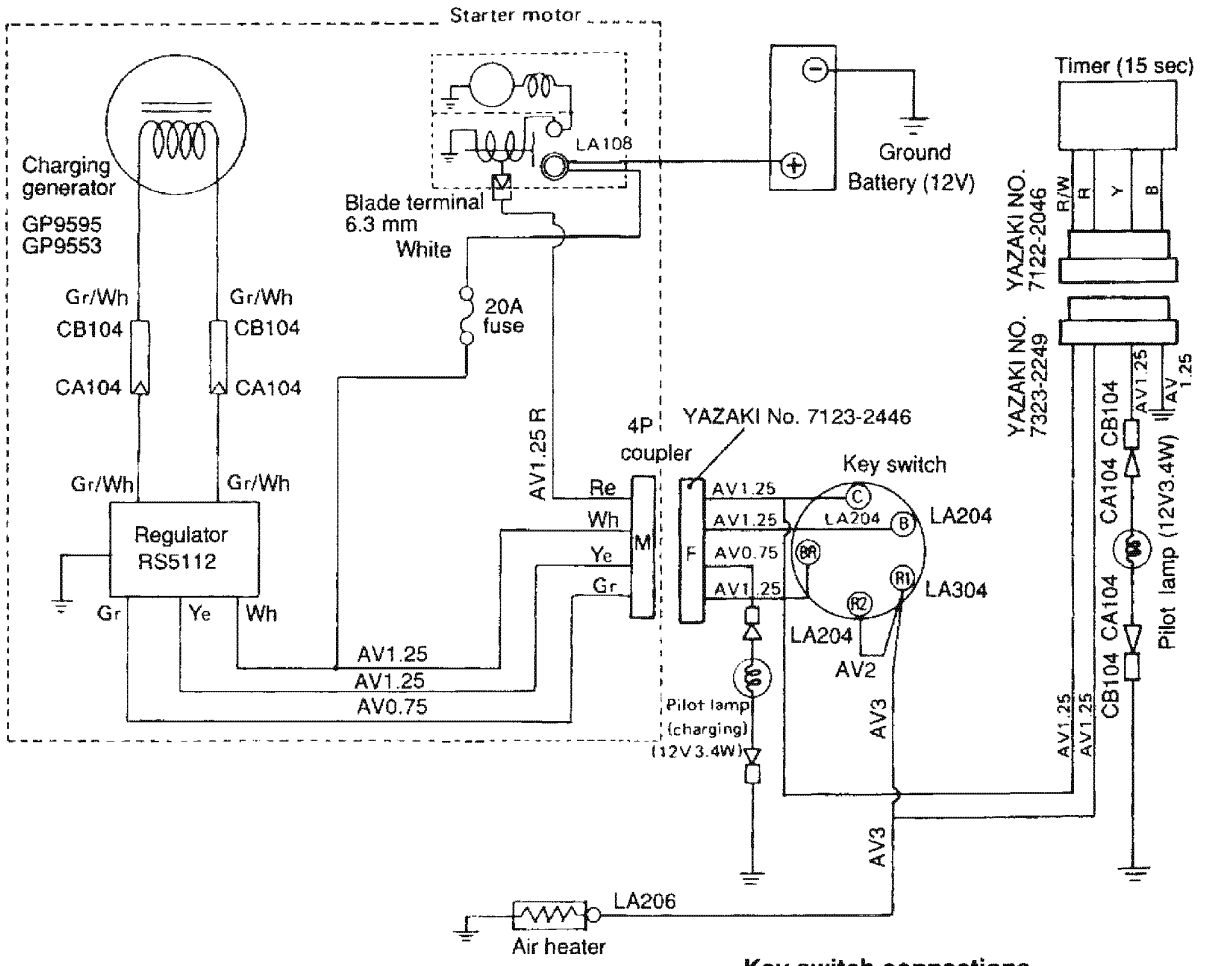


Figure 11-3

12 V - 3 A and 12 V - 15 A with Intake Air Heater and Timer



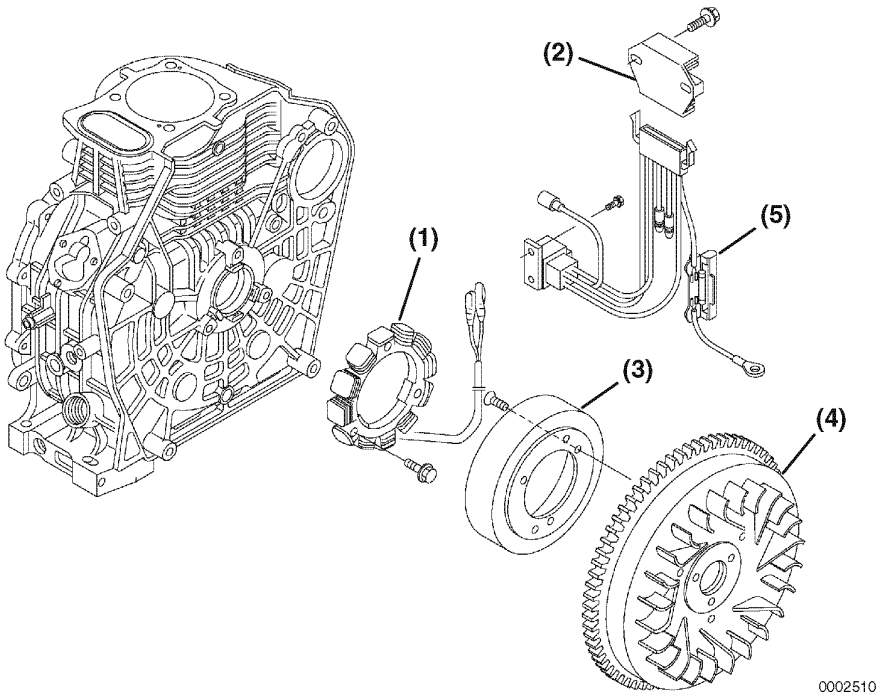
Key switch connections

	B	R1	R2	BR	C
Pre-heating	○	○		○	
OFF	○				
ON	○			○	
Starting	○		○	○	○

0002503

Figure 11-4

CHARGING SYSTEM COMPONENTS



1 – Stator Winding
2 – Voltage Regulator / Rectifier
3 – Magnet Assembly
4 – Flywheel
5 – 20 A Fuse[1]

1 Fuse is not used with all systems.

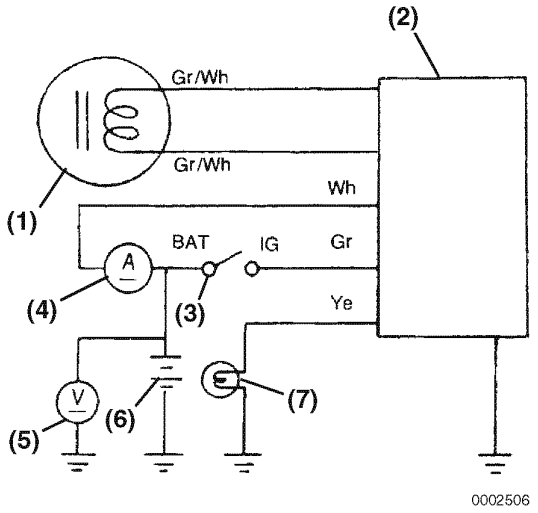
Figure 11-5

TESTING OF CHARGING SYSTEM AND COMPONENTS

Use a circuit tester or multimeter to perform the tests in this section.

Testing Regulated Output

1. Use a test voltmeter **(Figure 11-6, (5))** to test and record the battery **(Figure 11-6, (6))** voltage with the engine not running.
2. Connect a test ammeter **(Figure 11-6, (4))** between the regulator white output wire and the battery positive (+) terminal.
3. Start the engine and operate it at normal operating rpm. The charge lamp (if equipped) **(Figure 11-6, (7))** should glow.
4. Again, check the battery voltage with the engine running.
5. Check the amperage output.



1 – Stator
2 – Regulator / Rectifier
3 – Ignition Switch
4 – Test Ammeter
5 – Test Voltmeter
6 – Battery
7 – Charge Lamp

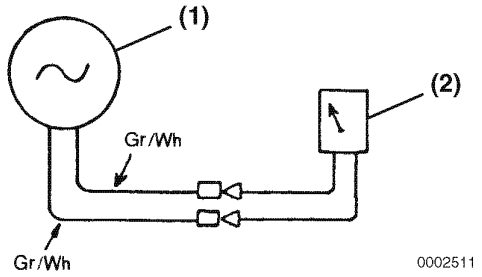
Figure 11-6

Results: The battery voltage must increase and remain within specification with the engine running. The amperage output must be within specification. *See Regulated Output Test Specifications on page 11-5.*

- If results are not correct, test the stator **(Figure 11-6, (1))** for continuity and shorts to the ground.
- *See Testing Stator Coil Continuity* and *Testing Stator Coil Short-to-Ground* on page *11-12.*
- Check the charging system wiring.
- Test the ignition switch **(Figure 11-6, (3))** for continuity between the BAT and IG terminals.
- Test the unregulated output. *See Testing Unregulated Output on page 11-11.*
- If no problems are found in the previous checks, replace the regulator / rectifier **(Figure 11-6, (2))**.

Testing Unregulated Output

1. Disconnect the stator wires from the regulator / rectifier.
2. Connect a test meter to the stator leads. Set the meter to read 100 volts AC **(Figure 11-7)**.
3. Start the engine and operate it at normal operating rpm.
4. Check the stator output with the engine running.



1 – Stator
2 – Test Meter

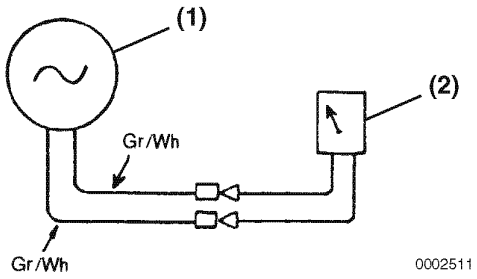
Figure 11-7

Results: The meter reading must be within specification. *See Unregulated Output Test Specifications on page 11-4.*

- If results are not correct, test the stator for continuity and shorts to the ground.
- Check for weak or loose flywheel magnets.

Testing Stator Coil Continuity

1. Disconnect the stator leads from the regulator / rectifier **(Figure 11-8)**.
2. Connect one meter lead to each of the stator wire terminals and read the meter.



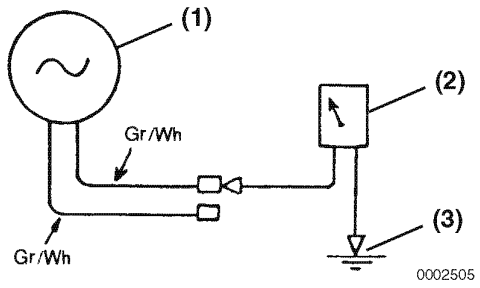
1 – Stator
2 – Test Meter

Figure 11-8

Results: The meter reading should indicate continuity. If continuity is not indicated, the windings are open and the stator must be replaced.

Testing Stator Coil Short-to-Ground

1. Disconnect the stator leads from the regulator / rectifier **(Figure 11-9)**.
2. Test the continuity between each stator wire terminal and engine ground.



1 – Stator
2 – Test Meter

Figure 11-9

Results: The meter reading should be infinity. If the meter reading indicates continuity, the windings are shorted to ground and the stator must be replaced.

Testing of Regulator / Rectifier

1. Disconnect the battery, negative (-) cable first.
2. Disconnect all wiring connectors from the regulator / rectifier.
3. Set the test meter to a range of 1-Ohm.
4. Measure the continuity between all terminals. Also test continuity between each terminal and the case.

Results: Compare the results with the following chart. If the results do not match the chart, replace the regulator / rectifier.

Note: **Yes** = continuity; **No** = no continuity.

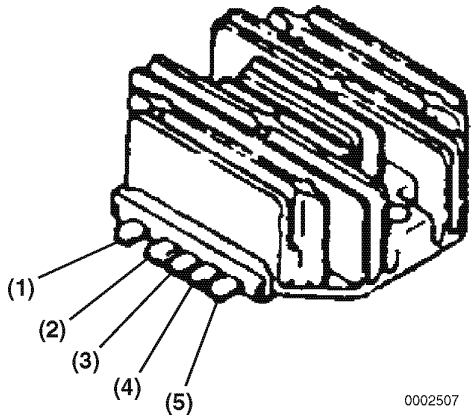


Figure 11-10

Regulator Number RS5112

		Meter Red Lead					
Meter Black Lead	Terminal Number	1	2	3	4	5	Case
	1	-	no	no	no	no	no
	2	yes	-	no	no	no	no
	3	yes	no	-	no	no	no
	4	no	no	no	-	no	no
	5	yes	yes	yes	no	-	yes
	Case	no	no	no	no	no	-

Regulator Number RS2190

	Meter Red Lead					
Meter Black Lead	Terminal Number	1	2	3	4	5
	1	-	yes	yes	no	yes
	2	no	-	no	no	yes
	3	no	no	-	no	yes
	4	no	no	no	-	no
	5	no	no	no	no	-

Testing of Rectifier

1. Disconnect the battery, negative (-) cable first.
2. Disconnect all wires from the rectifier.
3. Use an ohmmeter or continuity tester to check each diode. Refer to the following graphics and tables for test lead connections.

Results: Compare the results with the appropriate chart. If the results do not match the chart, replace the rectifier.

ZR2117 (Half-Wave Rectifier)

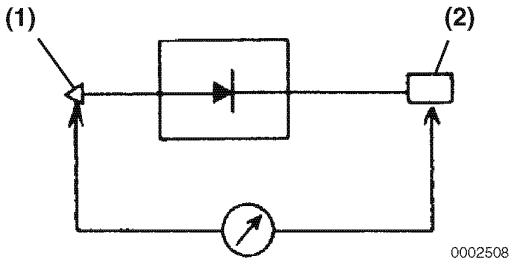


Figure 11-11

	Meter Red Lead		
Meter Black Lead	Terminal	1	2
	1	-	no
	2	yes	-

ZR2120 (Full-Wave Rectifier)

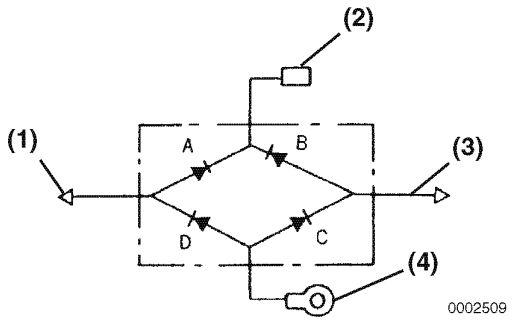


Figure 11-12

	Meter Red Lead				
Meter Black Lead	Terminal	1	2	3	4
	1	-	yes	-	no
	2	no	-	no	-
	3	-	yes	-	no
	4	yes	-	yes	-

STATOR

Removal of Stator

1. Disconnect the battery, negative (-) cable first.
2. Remove the recoil starter and starter pulley. (The recoil starter and cooling fan may be removed as an assembly if the recoil assembly does not require service.)
3. Remove the cooling fan housing **(Figure 11-13)**.

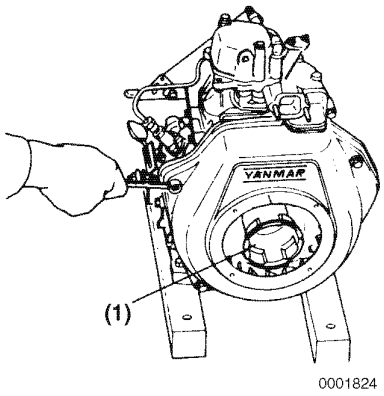


Figure 11-13

4. Remove the starter pulley **(Figure 11-13, (1))**.
5. Use the Yanmar flywheel holding wrench, or a standard strap wrench or ring gear holding tool (if electric start equipped) to hold the flywheel and remove the flywheel nut and washer.
6. Assemble the flywheel puller by threading one nut on each screw **(Figure 11-14, (2))** all the way to the screw head.
7. Insert each screw through the puller plate and thread a second nut on each screw on other side of puller plate.
8. Install the flywheel puller plate to flywheel with the three puller screw and nut assemblies, threading the screws into flywheel at least 0.5 in. (13 mm).
9. Thread down the lower nuts to the flywheel to keep each screw from moving.
10. Thread the upper nuts evenly to the plate keeping the flywheel puller plate parallel to flywheel.

Note: Support flywheel lightly to prevent flywheel damage as flywheel may “pop” off taper on crankshaft suddenly when using flywheel puller.

11. Tighten each upper nut **(Figure 11-14, (1))** evenly in a cross pattern to apply tension to flywheel, keeping puller plate parallel to flywheel. Alternately continue to tighten upper nuts until flywheel comes loose from crankshaft. If necessary, lightly tap on the center of the puller plate to assist in “popping” the flywheel loose from the crankshaft.

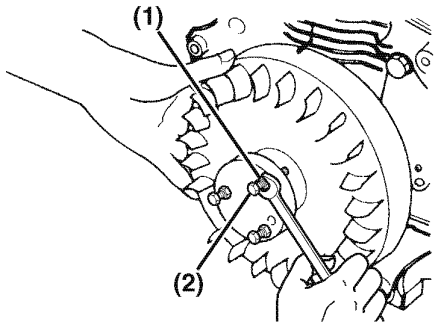


Figure 11-14

Note: Some charging systems use a rectifier only. AC lighting system stators are connected directly to the load and have neither a rectifier nor regulator / rectifier.

12. Disconnect the stator leads from the regulator / rectifier. Remove any wire retainer clamps.
13. Remove the three M6 bolts from the stator assembly.
14. Remove the stator assembly and lead retainer **(Figure 11-15, (1, 2))**.

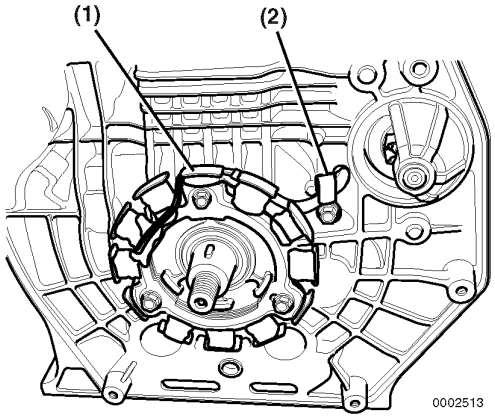


Figure 11-15

15. Inspect the flywheel magnets for damage or looseness. Replace the flywheel and/or magnet assembly if damage or looseness is evident.

Installation of Stator

1. Position the stator on the crankcase. Install three M6 bolts and tighten securely.
2. Route the stator lead to the regulator / rectifier and connect it.
3. Install any wire retainer clamps.
4. Install the flywheel. Install the washer and nut and tighten to specifications. *See Special Torque Specifications on page 11-5*.

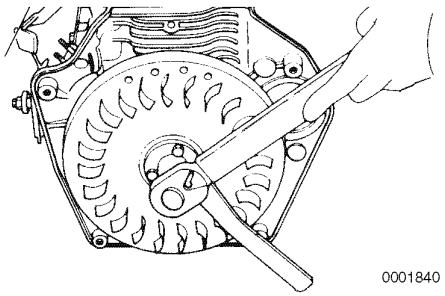


Figure 11-16

5. Install the cooling fan housing, starter pulley and recoil starter.
6. Start the engine. Listen for any unusual sounds from the flywheel area.
7. Verify that the charge lamp (if equipped) is ON while the engine is operating. If the charge indicator is not ON, repair the problem before operating the engine.

Section 12

ELECTRIC WIRING

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ELECTRIC WIRING PRECAUTIONS

Failure to follow these precautions may result in the failure of an electrical component and the loss of warranty coverage on that item as well as related items. Make sure that all users read and understand these precautions.

NOTICE

When the battery indicator goes out, it should not come on again. The battery indicator only comes on during operation if the alternator fails. However, if an LED is used in the battery indicator, the LED will shine faintly during normal operation

---

Make sure that the combined total resistance of the battery cable in both directions between the starter motor and the battery is within the value indicated in the Battery Cable Resistance chart in the Electric Wiring Section of this manual. The starter motor will malfunction and fail if the resistance is higher than the specified value.

Removing the battery cables or the battery while the engine is operating may cause damage to the current limiter depending on the electrical equipment being used. This situation could cause loss of control of output voltage. The continuous high voltage of 23-24 volts (for 5000 rpm dynamo) will damage the current limiter and other electrical equipment.

Reversing the battery cable connections at the battery or on the engine will destroy the SCR diode in the current limiter. This will cause the charging system to malfunction and may cause damage to the electrical harnesses.

ELECTRIC WIRING

Electrical Wire Resistance

AWG	Metric Nominal mm²	Ohms / Foot Resistance
20	0.5	0.009967
18	0.8	0.006340
16	1.25	0.004359
14	2	0.002685
12	3	0.001704
10	5	0.001073
8	8	0.000707
6	15	0.000421
4	20	0.000270
2	30	0.000158
1	40	0.000130
0 (1/0)	50	0.000103
00 (2/0)	60	0.000087
000 (3/0)	85	0.000066
0000 (4/0)	100	0.000051

Wiring voltage drop should not exceed 5% [0.05] x 12 Volts = 0.6 Volts.

Voltage Drop = Current [Amps] x Length of Wire [Feet] x Resistance per Foot [Ohms]

Example:

Current draw of 100 Amps x 3 feet of 4 AWG wire

100 Amps x 3 Feet x 0.000270 = 0.08 Volts [Voltage Drop]

BATTERY CABLE RESISTANCE (IF EQUIPPED)

AWG	mm²	Maximum Total Battery Cable Length (Positive Cable + Negative Cable + a*) 12 V Starter Motor Output			
		Less Than 2.68 hp (2 kW)		Greater Than 2.68 hp (2 kW)	
		m	ft	m	ft
6	15	1.5	4.75	N/A	N/A
4	20	2.3	7.4	N/A	N/A
2	30	3.8	12.6	2.3	7.5
1	40	4.6	15.3	2.8	9.2
0 (1/0)	50	5.9	19.5	3.5	11.6
00 (2/0)	60	7.0	22.8	4.2	13.7
000(3/0)	85	9.3	30.5	5.6	18.3
0000 (4/0)	100	11.9	39.0	7.1	23.4
00000 (5/0)	125	N/A	N/A	8.3	27.3
000000 (6/0)	150	N/A	N/A	10.1	33.3

Note: Total allowable resistance of the complete battery cable circuit (positive cable + negative cable + a*)
(a*: Resistance (Ω) of a battery switch or other electrical equipment having high resistance)

For starter motors of less than 2.68 hp (2 kW): The total resistance must be less than 0.002 Ω.

For starter motors of greater than 2.68 hp (2 kW): The total resistance must be less than 0.0012 Ω.

ELECTRICAL WIRE SIZES - VOLTAGE DROP

Total current on circuit in amps	Length of conductor from source of current to device and back to source—feet																		
	10	15	20	25	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170
12 Volts	Wire Size (AWG)																		
5	18	16	14	12	12	10	10	10	8	8	8	6	6	6	6	6	6	6	6
10	14	12	10	10	10	8	6	6	6	6	4	4	4	4	2	2	2	2	2
15	12	10	10	8	8	6	6	6	4	4	2	2	2	2	2	1	1	1	1
20	10	10	8	6	6	6	4	4	2	2	2	2	1	1	1	0	0	0	2/0
25	10	8	6	6	6	4	4	2	2	2	1	1	0	0	0	2/0	2/0	2/0	3/0
30	10	8	6	6	4	4	2	2	1	1	0	0	0	2/0	2/0	3/0	3/0	3/0	3/0
40	8	6	6	4	4	2	2	1	0	0	2/0	2/0	3/0	3/0	3/0	4/0	4/0	4/0	4/0
50	6	6	4	4	2	2	1	0	2/0	2/0	3/0	3/0	4/0	4/0	4/0				
60	6	4	4	2	2	1	0	2/0	3/0	3/0	4/0	4/0	4/0						
70	6	4	2	2	1	0	2/0	3/0	3/0	4/0	4/0								
80	6	4	2	2	1	0	3/0	3/0	4/0	4/0									
90	4	2	2	1	0	2/0	3/0	4/0	4/0										
100	4	2	2	1	0	2/0	3/0	4/0											
24 Volts																			
5	18	18	18	16	16	14	12	12	12	10	10	10	10	10	8	8	8	8	8
10	18	16	14	12	12	10	10	10	8	8	8	6	6	6	6	6	6	6	6
15	16	14	12	12	10	10	8	8	6	6	6	6	6	4	4	4	4	4	2
20	14	12	10	10	10	8	6	6	6	6	4	4	4	4	2	2	2	2	2
25	12	12	10	10	8	6	6	6	4	4	4	4	2	2	2	2	2	2	1
30	12	10	10	8	8	6	6	4	4	4	2	2	2	2	2	1	1	1	1
40	10	10	8	6	6	6	4	4	2	2	2	2	1	1	1	0	0	0	2/0
50	10	8	6	6	6	4	4	2	2	2	1	1	0	0	0	2/0	2/0	2/0	3/0
60	10	8	6	6	4	4	2	2	1	1	0	0	0	2/0	2/0	3/0	3/0	3/0	3/0
70	8	6	6	4	4	2	2	1	1	0	0	2/0	2/0	3/0	3/0	3/0	3/0	4/0	4/0
80	8	6	6	4	4	2	2	1	0	0	2/0	2/0	3/0	3/0	3/0	4/0	4/0	4/0	4/0
90	8	6	4	4	2	2	1	0	0	2/0	2/0	3/0	3/0	4/0	4/0	4/0	4/0	4/0	
100	6	6	4	4	2	2	1	0	2/0	2/0	3/0	3/0	4/0	4/0	4/0				

CONVERSION OF AWG TO EUROPEAN STANDARDS

Conductor Size (AWG)	Conductor Diameter (mm)	Conductor Cross-sectional Area (mm^2)
25	0.455	0.163
24	0.511	0.205
23	0.573	0.259
22	0.644	0.325
21	0.723	0.412
20	0.812	0.519
19	0.992	0.653
18	1.024	0.823
17	1.15	1.04
16	1.29	1.31
15	1.45	1.65
14	1.63	2.08
13	1.83	2.63
12	2.05	3.31
11	2.30	4.15
10	2.59	5.27
9	2.91	6.62
8	3.26	8.35
7	3.67	10.6
6	4.11	13.3
5	4.62	16.8
4	5.19	21.2
3	5.83	26.7
2	6.54	33.6
1	7.35	42.4
0 (1/0)	8.25	53.4
00 (2/0)	9.27	67.5
000(3/0)	10.40	85.0
0000 (4/0)	11.68	107.2
00000 (5/0)	13.12	135.1
000000 (6/0)	14.73	170.3
1.1 circular mil (CM) @ 0.0005067 mm^2		

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Section 13

TROUBLESHOOTING

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BEFORE YOU BEGIN SERVICING

Before performing any service procedures within this section, read the following safety information and review the *Safety* section on page *3-1*.

INTRODUCTION

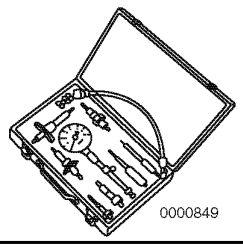
This section of the *Service Manual* describes troubleshooting procedures to assist in engine problem diagnosis and repair.

SPECIFICATIONS

Cylinder Compression Pressure

Compression Pressure (Standard)		Deviation Between Cylinders
Standard	Limit	
427 psi (2942 kPa, 30 kgf/cm^2)	356 psi (2452 kPa, 25 kgf/cm^2)	29 to 43 psi (0.2 to 0.3 MPa; 2 to 3 kgf/cm^2)

MEASURING INSTRUMENTS

Compression Gauge Kit or Compression gauge and compression adapters (available locally).	For measuring compression pressure Yanmar Gauge Set Code No. TOL-97190080	 0000849

TROUBLESHOOTING BY MEASURING COMPRESSION PRESSURE

Compression pressure drop is one of the major causes of increasing blow-by gas (engine oil contamination or increased engine oil consumption as a resultant phenomenon) or starting failure. The compression pressure is affected by the following factors:

- Degree of piston ring wear and the resultant increased end gap
- Damaged piston (possibly due to the use of starting fluid such as ether)
- Incorrect intake / exhaust valve clearance
- Poor sealing at the intake / exhaust valve seat due to burned or warped valves
- Gas leak from nozzle gasket or cylinder head gasket
- Bent connecting rod

The pressure will drop because of increased parts wear. Pressure drop reduces the durability of the engine.

A pressure drop may also be caused by scored cylinder or piston due to dust entrance from the dirty air cleaner element or worn or broken piston ring.

Measure the compression pressure to determine the condition of the engine.

Measuring Compression Pressure

1. Warm up the engine. **WARNING! NEVER touch hot engine surfaces such as the muffler, exhaust pipe, turbocharger (if equipped) and engine block during operation and shortly after you shut the engine down. These surfaces are extremely hot while the engine is operating and could cause serious burns.**
2. Stop the engine. Remove the fuel injector **(Figure 13-1, (3))** from the cylinder head. *See Removal of Fuel Injector on page 9-23.*

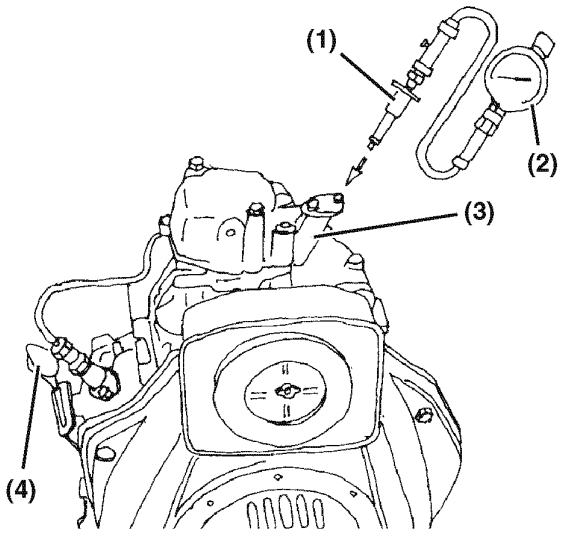


Figure 13-1

3. Crank the engine with the speed control **(Figure 13-1, (4))** at the stop position (no injection state) 5 to 6 compression strokes before installing the compression gauge adapter.
4. Install a gasket at the tip end of the compression gauge adapter **(Figure 13-1, (1))**. Install the compression gauge **(Figure 13-1, (2))** and the compression gauge adapter at the cylinder.
5. Crank the engine using the recoil or electric starter until the compression gauge reading is stabilized and at its maximum.

6. After performing the compression check remove the compression gauge and compression gauge adapter from the cylinder. Install the fuel injector and high pressure fuel injection line. *See Installation of the Fuel Injector on page 9-26.*

Low Compression Troubleshooting Chart

When the measured compression pressure is below the limit value, inspect each part in the chart below for a possible cause.

No.	Item	Cause	Corrective Action
1	Air Cleaner Element	Clogged element	Clean the element.
		Broken element	Replace the element.
		Defect at element seal portion	
2	Compression Release	Misadjusted, damaged or sticking	Repair or replace as necessary.
3	Valve Clearance	Excessive or no clearance	Adjust the valve clearance.
4	Cylinder Head Gasket	Gas leak from gasket	Replace the gasket.
			Retighten the cylinder head bolts to the specified torque.
5	Intake / Exhaust Valve	Warped or burned valves	Replace the intake / exhaust valve.
	Intake / Exhaust Valve	Sticking valve	Replace the intake / exhaust valve.
	Valve Seat	Gas leak due to worn valve seat or foreign matter trapped in valve	Lap the valve seat.
6	Piston Ring	Excessive end gap or broken	Replace piston rings with new.
	Piston	Damaged, scored, or cracked	Replace piston with new.
	Cylinder	Excessive wear or scoring	Perform honing and use oversized piston and rings.
7	Connecting Rod	Bent	Replace with new.

TROUBLESHOOTING QUICK REFERENCE CHARTS

The following charts summarize general trouble symptoms and their causes. *NOTICE: If any trouble symptoms occur, take corrective action immediately, to prevent engine damage and or personal injury.*

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ENGINE TROUBLESHOOTING CHART

Trouble Symptom / Cause		Starting Problem				Insufficient Engine Output			Poor Exhaust Color		High Knocking Sound During Combustion	Abnormal Engine Sound	Uneven Combustion Sound	Engine Surging		Excessive Engine Vibration	Difficulty in Returning to Low Speed	Excessive Fuel Consumption	Engine Oil				Excessive Blow-by Gas	Air Intake		Exhaust Temperature Rise	Corrective Action	Reference Page
		Engine Does Not Start.	Engine Starts But Stops Soon. Exhaust Smoke: None	Engine Starts But Stops Soon. Exhaust Smoke: Little	Engine Starts But Stops Soon. Exhaust Smoke: Much	Exhaust Color: Ordinary	Exhaust Color: White	Exhaust Color: Black	During Work: White	During Work: Black				During Idling	During Work Operation				Excessive Oil Consumption	Dilution by Diesel Fuel	Oil with Water	Low Oil Pressure		Pressure Drop	Pressure Rise			
Engine System	Improper Intake/Exhaust Valve Clearance	O	O			O						O											O		O	Adjust the Valve Clearance.	*See Checking Actual Piston TDC (Top Dead Center) on page 8-33.*
	Compression Leakage from Valve Seat					O		O		O		O						O					O	O		O	Lap the Valve Seat.	*See EGR Passage on page 8-24.*
	Intake/Exhaust Valve Seizure	O			O	O		O		O		O			O	O			O				O	O			Correct or Replace Intake/Exhaust Valve.	*See Valves and Valve Guides on page 8-25.*
	Cylinder Head Gasket Blowout					O															O						Replace the Gasket.	*See Inspection of Engine Components on page 8-41.*
	Seized or Broken Piston Ring	O			O		O		O			O		O		O			O	O			O			O	Replace the Piston Ring.	*See Reassembly of Piston, Piston Rings and Connection Rod on page 8-54.*
	Worn Piston Ring, Piston or Cylinder	O			O		O		O										O	O			O				Perform Honing and Use Oversize Parts.	*See Honing and Boring on page 8-47.*
	Seized Crankpin Metal or Bearing	O	O									O		O	O	O							O				Repair or Replace.	*See Crankshaft on page 8-7.*
	Improper Arrangement of Piston Ring Gaps		O				O												O				O				Correct the Ring Joint Positions.	*See Reassembly of Piston, Piston Rings and Connection Rod on page 8-54.*
	Reverse Assembly of Piston Rings						O		O										O				O				Reassemble Correctly.	*See Reassembly of Piston, Piston Rings and Connection Rod on page 8-54.*
	Worn Crankpin and Journal Bearing					O						O		O	O	O						O					Measure and Replace.	*See Crankshaft on page 8-7.*
	Loose Connecting Rod Bolt											O				O						O					Tighten to the Specified Torque.	*See Special Torque Specifications on page 8-16.*
	Foreign Matter Trapped in Combustion Chamber	O										O							O				O				Disassemble and Repair.	*See Inspection of Engine Components on page 8-41.*
	Worn Intake/Exhaust Valve Guide						O												O				O				Measure and Replace.	*See Intake / Exhaust Valves, Guides and Seals on page 8-5.*
	Governor Adjusted Incorrectly		O											O	O	O	O										Make Adjustment.	*See Check and Adjust Engine Speed Control on page 5-15.*
	Improper Open/Close Timing of Intake/ Exhaust Valves	O					O	O	O	O		O															Adjust the Valve Clearance.	*See Checking Actual Piston TDC (Top Dead Center) on page 8-33.*
	Bent Connecting Rod	O		O			O																				Replace Connecting Rod.	*See Removal of Engine on page 8-36.*

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ENGINE TROUBLESHOOTING CHART

Trouble Symptom / Cause		Starting Problem				Insufficient Engine Output			Poor Exhaust Color		High Knocking Sound During Combustion	Abnormal Engine Sound	Uneven Combustion Sound	Engine Surging		Excessive Engine Vibration	Difficulty in Returning to Low Speed	Excessive Fuel Consumption	Engine Oil				Excessive Blow-by Gas	Air Intake		Exhaust Temperature Rise	Corrective Action	Reference Page
			Engine Starts but Stops Soon.			Exhaust Color			During Work																			
			Exhaust Smoke																									
		Engine Does Not Start.	None	Little	Much	Ordinary	White	Black	White	Black				During Idling	During Work Operation				Excessive Oil Consumption	Dilution by Diesel Fuel	Oil with Water	Low Oil Pressure		Pressure Drop	Pressure Rise			
Engine Coolant System	Blocked Air Inlet or Passages							O																		O	Clean air intake screen, fan blades, and air passages.	-
	Damaged Cooling Fan							O																		O	Replace flywheel.	-
Engine Oil System	Incorrect Engine Oil	O	O			O													O			O	O				Use Correct Engine Oil.	*See Engine Oil on page 4-20.*
	Engine Oil System Leakage																		O			O					Repair.	*See Honing and Boring on page 8-47.*
	Insufficient Delivery Capacity of Trochoid Pump																					O					Check and Repair.	*See Honing and Boring on page 8-47.*
	Clogged Engine Oil Filter																					O	O				Clean or Replace.	*See Clean / Inspect Engine Oil Filter on page 5-11.*
	Insufficient Engine Oil Level		O																			O					Add Correct Engine Oil.	*See Adding Engine Oil on page 4-21.*
Fuel System	Too Early Timing of Fuel Injection Pump									O	O					O											Check and Adjust.	*See Checking and Adjusting Fuel Injection Timing on page 9-11.*
	Too Late Timing of Fuel Injection Pump						O		O									O								O	Check and Adjust.	*See Checking and Adjusting Fuel Injection Timing on page 9-11.*
	Incorrect Diesel Fuel					O	O	O	O	O			O															Use Correct Fuel Oil.	*See Diesel Fuel on page 4-17.*
	Water in Fuel System	O			O		O		O				O	O	O													Drain the Fuel Tank.	*See Drain the Fuel Tank and Replace Outlet Fuel Filter on page 5-16.*
	Clogged Fuel Filter	O	O			O																						Clean or Replace Outlet Fuel Filter.	*See Drain the Fuel Tank and Replace Outlet Fuel Filter on page 5-16.*

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ENGINE TROUBLESHOOTING CHART

	Trouble Symptom / Cause	Starting Problem: Engine Does Not Start.	Starting Problem: Engine Starts but Stops Soon. Exhaust Smoke: None	Starting Problem: Engine Starts but Stops Soon. Exhaust Smoke: Little	Starting Problem: Engine Starts but Stops Soon. Exhaust Smoke: Much	Insufficient Engine Output: Exhaust Color: Ordinary	Insufficient Engine Output: Exhaust Color: White	Insufficient Engine Output: Exhaust Color: Black	Poor Exhaust Color: During Work: White	Poor Exhaust Color: During Work: Black	High Knocking Sound During Combustion	Abnormal Engine Sound	Uneven Combustion Sound	Engine Surging: During Idling	Engine Surging: During Work Operation	Excessive Engine Vibration	Difficulty in Returning to Low Speed	Excessive Fuel Consumption	Engine Oil: Excessive Oil Consumption	Engine Oil: Dilution by Diesel Fuel	Engine Oil: Oil with Water	Engine Oil: Low Oil Pressure	Excessive Blow-by Gas	Air Intake: Pressure Drop	Air Intake: Pressure Rise	Exhaust Temperature Rise	Corrective Action	Reference Pages
Fuel System	Air in Fuel System	O	O			O																				Bleed the Air.	*See Priming the Fuel System on page 4-19.*
	Clogged or Cracked Fuel Line	O	O			O																				Clean or Replace.	*See Check and Replace Fuel Hoses on page 5-19.*
	Insufficient Fuel Supply to Fuel Injection Pump	O	O			O																				Check the Fuel Tank Cock, Fuel Filter, Fuel Line, and Fuel Feed Pump.	*See the appropriate procedure in Periodic Maintenance Schedule on page 5-6.*
	Uneven Injection Volume from Fuel Injection Pump						O	O	O	O			O	O	O	O									O	Check and Adjust.	*See Adjusting Fuel Injector Pressure on page 9-25.*
	Excessive Fuel Injection Volume									O								O	O				O		O	O	Check and Adjust.	*See Adjusting Fuel Injector Pressure on page 9-25.*
	Poor Spray Pattern from Fuel Injection Nozzle						O	O	O	O			O	O	O	O		O									Check and Adjust.	*See Adjusting Fuel Injector Pressure on page 9-25.*
	Priming Failure	O																								Foreign Matter Trapped in the Valve Inside the Priming Pump (Disassemble and Clean).	*See Fuel System Components on page 9-10.*
	Clogged Strainer at Feed Pump Inlet					O																				Clean the Strainer.	*See Drain the Fuel Tank and Replace Outlet Fuel Filter on page 5-16.*
Air/Exhaust Gas System	Clogged Air Filter				O			O		O			O											O			Clean Air Filter.	*See Clean Air Cleaner Element on page 5-13.*
	Engine Used at High Temperatures or at High Altitude							O		O								O						O			Study Output Drop and Load Matching.	-
	Clogged Exhaust Pipe							O		O			O													O	Clean Exhaust Pipe.	-
Electrical System	Starting Motor Defect	O																									Repair or Replace Stater Motor.	*See Testing Electric Starter Motor Operation (Standard) on page 10-8.*
	Dynamo Defect	O																									Repair or Replace Dynamo.	*See Testing of Charging System and Components on page 11-11.*
	Open-Circuit in Wiring	O																									Repair Open Circuit.	
	Battery Voltage Drop	O																									Inspect and Change the Battery.	*See Check Battery on page 5-8.*

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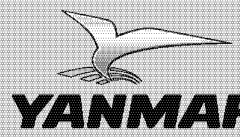

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