6LPA series

SERVICE MANUAL

6LPA-STP2
6LPA-STZP2

P/N: 0B6LP-U00100

YANMAR®

MARINE 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.

0707

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.

TABLE OF CONTENTS

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Section 1

INTRODUCTION

This manual gives specific instructions for the proper repair of Yanmar 6LPA-STP2/STZP2 series marine engines.

Please follow the procedures carefully to ensure quality service.

Yanmar recommends that you read this *Service Manual* completely before starting with repairs.

Along with standard tools, Yanmar recommends the use of special tools, necessary to perform repairs correctly.

Yanmar products are continuously undergoing improvement. This *Service Manual* has been checked carefully in order to avoid errors. However Yanmar is not liable, for any misrepresentations, errors of description or omissions. Contact an authorized Yanmar marine dealer or distributor for any questions you have regarding this *Service Manual.*

REVISION HISTORY

This manual is a living document. Periodic manual revisions are published to document product improvements and changes. This practice ensures the manual has the most current information.

As manual revisions become necessary, individual pages are prepared and sent to those who need the information. If a page, or number of pages should be replaced, the replacement information is sent along with a revised Revision Control Table. Discard the older, obsolete information.

At times, the revision involves inserting additional pages in one or more sections. Replace the Revision Control Table and insert the new pages.

This method of revision control represents the most cost-effective solution to providing current, updated information as needed.

Revision Control Table

Revision Date Revision Number	New Page Numbers Involved	Remarks	Initiating Dept.
Jun 2007 Rev. 0	ALL	Initial Release	YMI

Section 2

SAFETY

SAFETY STATEMENTS

Yanmar is concerned for your safety and the condition of your marine engine. Safety statements are one of the primary ways to call your attention to the potential hazards associated with Yanmar marine engines. 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 marine engine. Keep the decals 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 decal attached to it, make sure you order the new part and decal at the same time.

A 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 engine, personal property and / or the environment or cause the equipment to operate improperly.

SAFETY PRECAUTIONS

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.

⚠ DANGER

The safety messages that follow have DANGER level hazards. These safety messages describe a hazardous situation which, if not avoided, *will* result in death or serious injury.

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

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

Crush Hazard

NEVER stand under a hoisted engine. If the hoist mechanism fails, the engine will fall on you.

ALWAYS secure the engine solidly to prevent the engine from falling during maintenance.

⚠ WARNING

The safety messages that follow have WARNING level hazards. These safety messages describe a hazardous situation which, if not avoided, *could* result in death or serious injury.

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 and Explosion Hazard

Diesel fuel is flammable and explosive under certain conditions.

NEVER use a shop rag to catch the fuel.

Wipe up all spills immediately.

NEVER refuel with the engine running.

Store any containers containing fuel in a well-ventilated area, away from any combustibles or sources of ignition.

⚠ WARNING

Fire Hazard

Have appropriate safety equipment available. Have all fire extinguishers checked periodically for proper operation and / or readiness.

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

Undersized wiring systems can cause an electrical fire.

Entanglement Hazard

NEVER leave the key in the key switch when servicing the engine. Attach a “Do Not Operate” tag near the key switch while performing maintenance on the equipment.

ALWAYS stop the engine before beginning service.

If you must service the engine while it is operating, remove all jewelry, tie back long hair and keep your hands, other body parts and clothing away from moving / rotating parts.

Piercing Hazard

Avoid skin contact with high-pressure diesel fuel spray caused by a fuel system leak such as a broken fuel injection line. 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. Have your authorized Yanmar marine dealer or distributor repair the damage.

Flying Object Hazard

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

Coolant Hazard

Wear eye protection and rubber gloves when you handle Long Life engine coolant. If contact with the eyes or skin should occur, flush eyes and wash immediately with clean water.

⚠ WARNING

Sever Hazard

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.

The propeller may rotate during towing or if the engine is running at idle speed. NEVER service the engine while being towed or when the engine is running.

If the vessel has more than one engine, NEVER service a engine if either of the engines are running. In multi-engine configurations the propeller for an engine that is shut down may rotate if any of the other engines are running.

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 alternator 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 alternator and engine control unit prior to reconnecting the batteries.

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

NEVER turn off the battery switch (if equipped) or short the battery cables during operation. Damage to the electrical system will result

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Exhaust Hazard

All internal combustion engines create carbon monoxide gas during operation and special precautions are required to avoid carbon monoxide poisoning.

- NEVER block windows, vents, or other means of ventilation if the engine is operating in an enclosed area.
- ALWAYS ensure that all connections are tightened to specifications after repair is made to the exhaust system.

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.

⚠ WARNING

Sudden Movement Hazard

The engine lifting eyes are engineered to lift the weight of the marine engine only. ALWAYS use the engine lifting eyes when lifting the engine.

Lifting Hazard

Additional equipment is necessary to lift the marine engine and marine gear together. ALWAYS use lifting equipment with sufficient capacity to lift the marine engine.

If you need to transport an engine for repair have a helper assist you attach it to a hoist and load it on a truck.

Alcohol and Drug Hazard

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

Exposure Hazard

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

Tool Hazard

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

⚠ CAUTION

The safety messages that follow have CAUTION level hazards. These safety messages describe a hazardous situation which, if not avoided, *could* result in minor or moderate injury.

ALWAYS wear eye protection when servicing the engine 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.

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 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.

NEVER attempt to modify the engine design or safety features such as defeating the engine speed limit control or the diesel fuel injection quantity control.

NEVER attempt to adjust the low or high idle speed limit screw. This may impair the safety and performance of the engine and shorten its life. Modifications of this type may void the warranty. If adjustment is ever required, contact your authorized Yanmar marine dealer or distributor.

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.

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, stop the engine immediately. Determine the cause and repair the problem before you continue to operate the engine.

Make sure the engine is installed on a level surface. If a Yanmar Marine Engine is installed at an angle that exceeds the specifications stated in the Yanmar Marine Installation manuals, engine oil may enter the combustion chamber causing excessive engine speed, white exhaust smoke and serious engine damage. This applies to engines that run continuously or those that run for short periods of time.

Section 3

GENERAL SERVICE INFORMATION

Page

SAFETY PRECAUTIONS

Before you service the engine, read the following safety information and review the *Safety Section on page 2-1*.

LOCATION OF SAFETY DECALS

Figure 3-1 shows the location of safety decals on Yanmar 6LPA-STP2/STZP2 series marine engines.

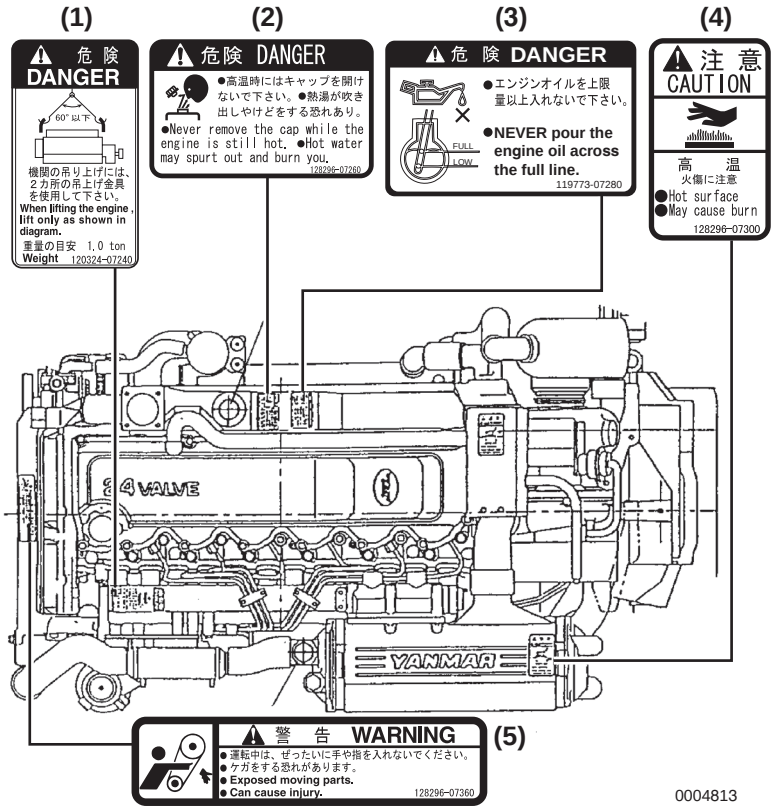

Figure 3-1

1 – Part Number: 120324-07240
2 – Part Number: 128296-07260
3 – Part Number: 119773-07280
4 – Part Number: 128296–07300
5 – Part Number: 128296–07360

Note: shows an overhead view of the engine.

COMPONENT IDENTIFICATION

Service Side (Left side as viewed from propeller)

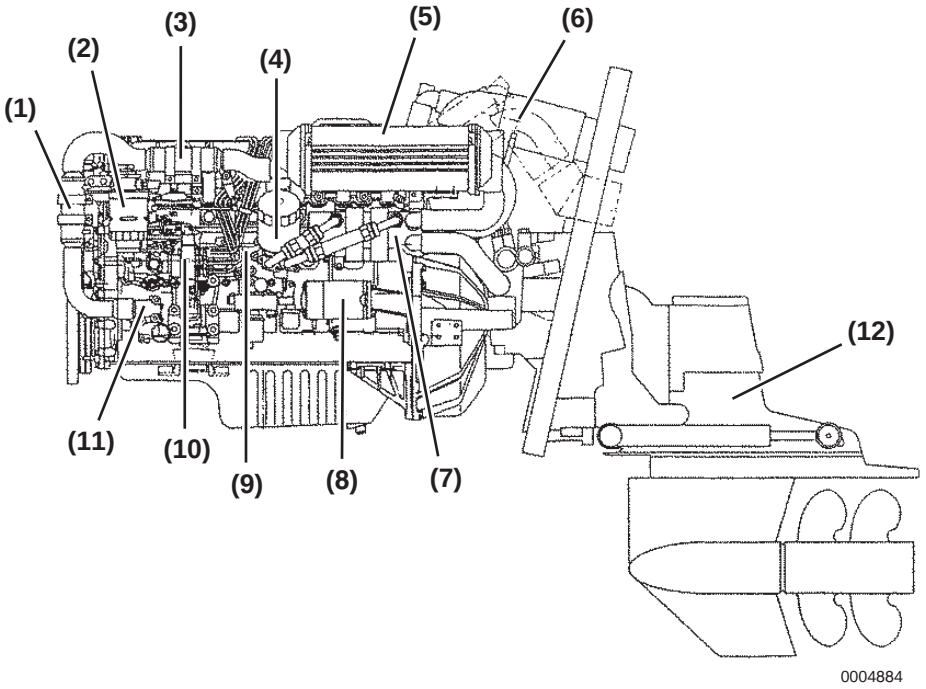

Figure 3-2

1 – Fuel Cooler
2 – Fuel Filter
3 – Power Steering Oil Cooler (6LPA-STZP2 Series Only)
4 – Engine Oil Filter
5 – Intercooler
6 – Mixing Elbow
7 – Engine Oil Cooler (2)
8 – Starter
9 – Engine Oil Cooler (1)
10 – Fuel Injection Pump
11 – Seawater Pump
12 – Stern Drive

Note: 6LPA-STZP2 Series with stern drive shown

Non-Service Side

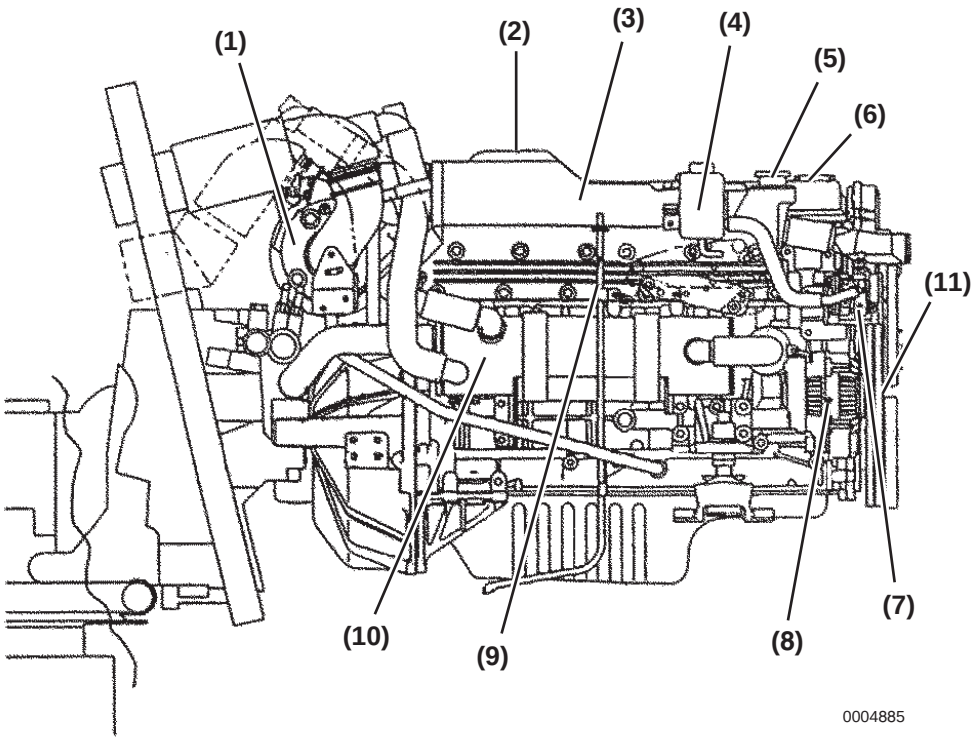

Figure 3-3

1 – **Turbocharger**
2 – **Engine Nameplate (on rocker arm cover)**
3 – **Freshwater Coolant Tank**
4 – **Power Steering Oil Tank (6LPA-STZP2 Series Only)**
5 – **Freshwater Filler Cap**
6 – **Engine Oil Filler Cap**
7 – **Power Steering Oil Pump (6LPA-STZP2 Series Only)**
8 – **Alternator**
9 – **Engine Oil Dipstick**
10 – **Freshwater Cooler**
11 – **V-Belt**

Note: 6LPA-STZP2 Series with stern drive shown

ENGINE PIPING DIAGRAMS

6LPA-STP2

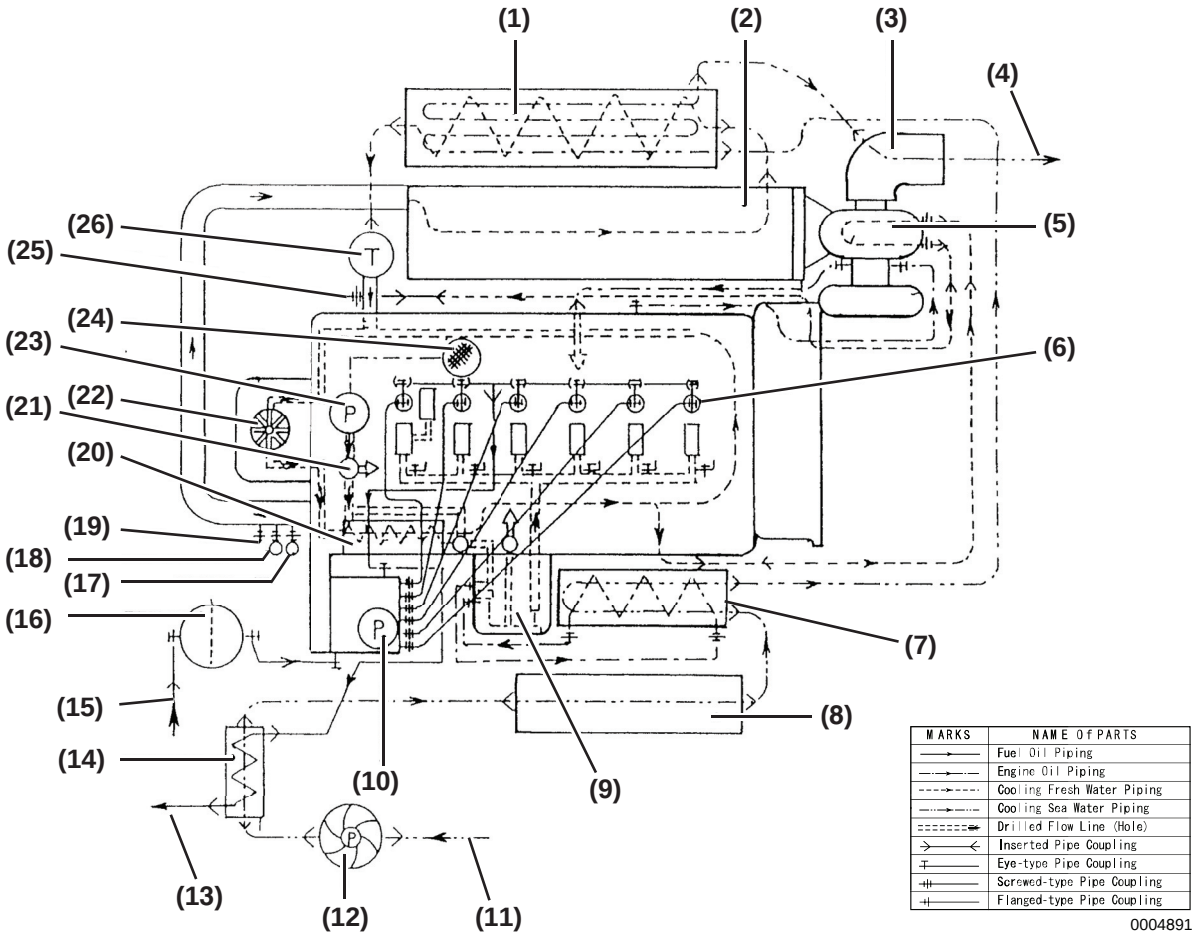

Figure 3-4

1 – Freshwater Cooler
2 – Exhaust Manifold
3 – Mixing Elbow
4 – Seawater Outlet
5 – Turbocharger
6 – Fuel Injection Valves
7 – Engine Oil Cooler
8 – Intercooler
9 – Engine Oil Filter
10 – Fuel Injection Pump
11 – Seawater Inlet
12 – Cooling Seawater Pump
13 – Fuel Return Pipe (To Fuel Tank)
14 – Diesel Fuel Cooler
15 – Diesel Fuel Inlet (From Fuel Tank)
16 – Diesel Fuel Filter
17 – Water Temperature Sender (Optional)
18 – Water Temperature Switch
19 – Water Outlet to Heater
20 – Engine Oil Cooler (Freshwater Cooling Relief Valves)
21 – Safety Valve
22 – Cooling Freshwater Pump
23 – Engine Oil Pump
24 – Engine Oil Inlet Filter
25 – Water Inlet From Heater
26 – Thermostat

6LPA-STZP2

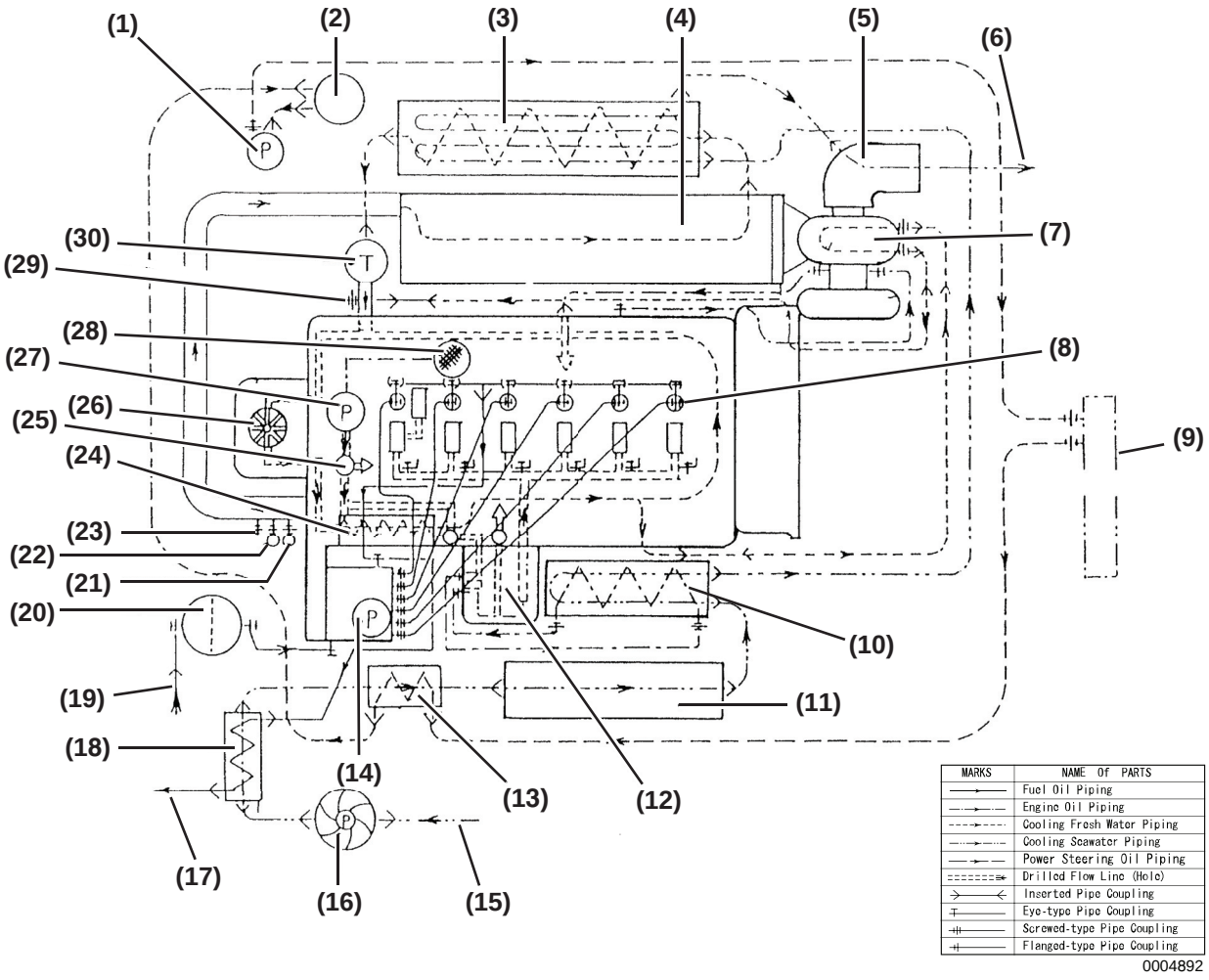

Figure 3-5

1 – Power Steering Oil Pump
2 – Power Steering Oil Tank
3 – Freshwater Cooler
4 – Exhaust Manifold
5 – Mixing Elbow
6 – Seawater Outlet
7 – Turbocharger
8 – Fuel Injection Valves
9 – Power Steering Cylinder Unit (Locally Supplied)
10 – Engine Oil Cooler
11 – Intercooler
12 – Engine Oil Filter
13 – Power Steering Oil Cooler
14 – Fuel Injection Pump
15 – Seawater Inlet
16 – Cooling Seawater Pump
17 – Fuel Return Pipe (To Fuel Tank)
18 – Diesel Fuel Cooler
19 – Fuel Inlet (From Fuel Tank)
20 – Diesel Fuel Filter
21 – Water Temperature Sender (Optional)
22 – Water Temperature Switch
23 – Water Outlet to Heater
24 – Engine Oil Cooler (Freshwater Cooling Relief Valves)
25 – Safety Valve
26 – Cooling Freshwater Pump
27 – Engine Oil Pump
28 – Engine Oil Inlet Filter
29 – Water Inlet From Heater
30 – Thermostat

EXTERNAL VIEWS

6LPA-STP2

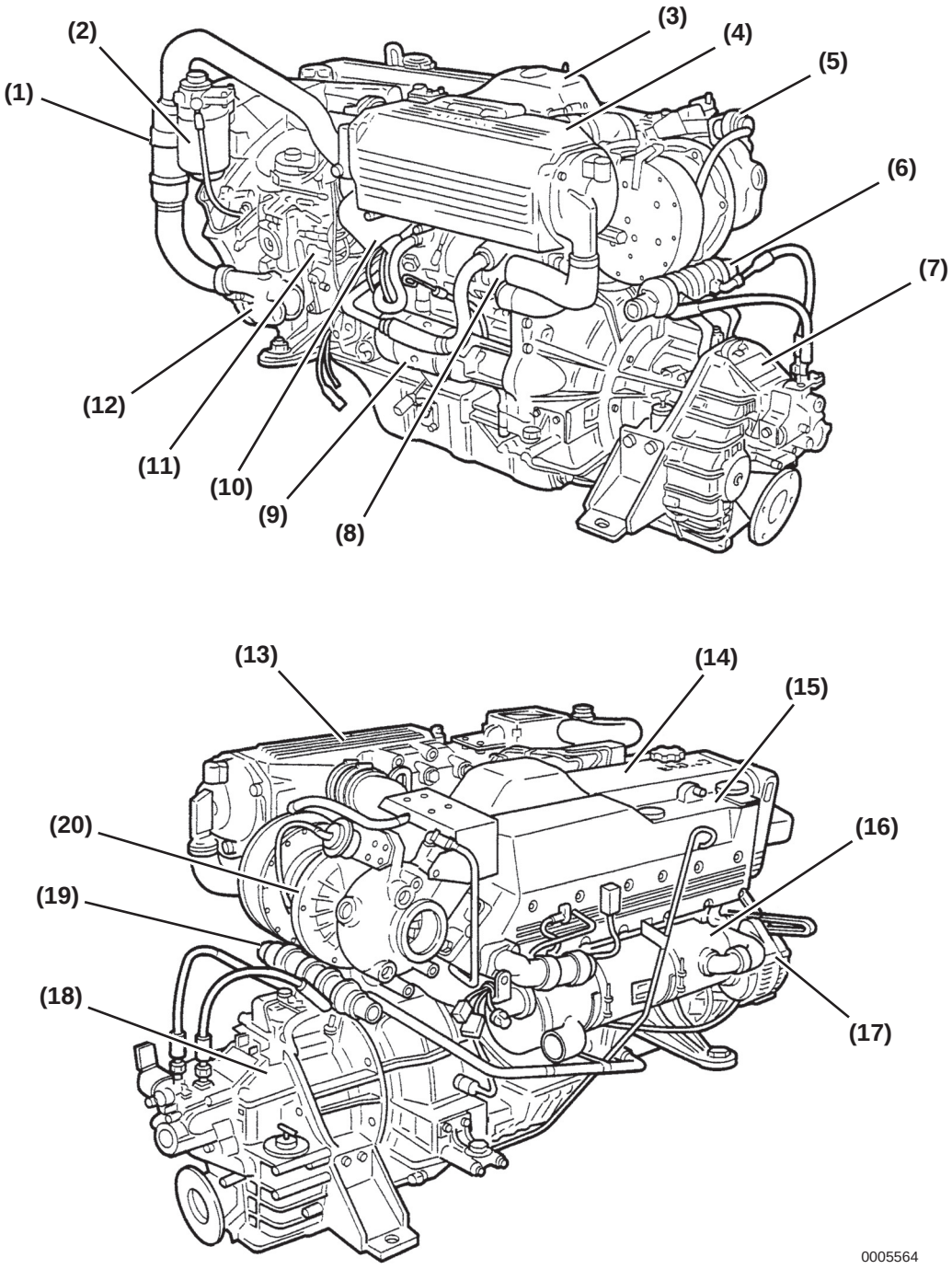

Figure 3-6

1 – Fuel Oil Cooler
2 – Fuel Filter
3 – Rocker Arm Cover
4 – Intercooler
5 – Turbocharger
6 – Lube Oil Cooler for Marine Gear
7 – Marine Gear
8 – Lube Oil Cooler (2)
9 – Starter
10 – Lube Oil Cooler (1)
11 – Fuel Injection Pump
12 – Seawater Pump
13 – Intercooler
14 – Rocker Arm Cover
15 – Freshwater Tank
16 – Freshwater Cooler
17 – Alternator
18 – Marine Gear
19 – Lube Oil Cooler for Marine Gear
20 – Turbocharger

ENGINE SENDER AND SWITCH LOCATIONS

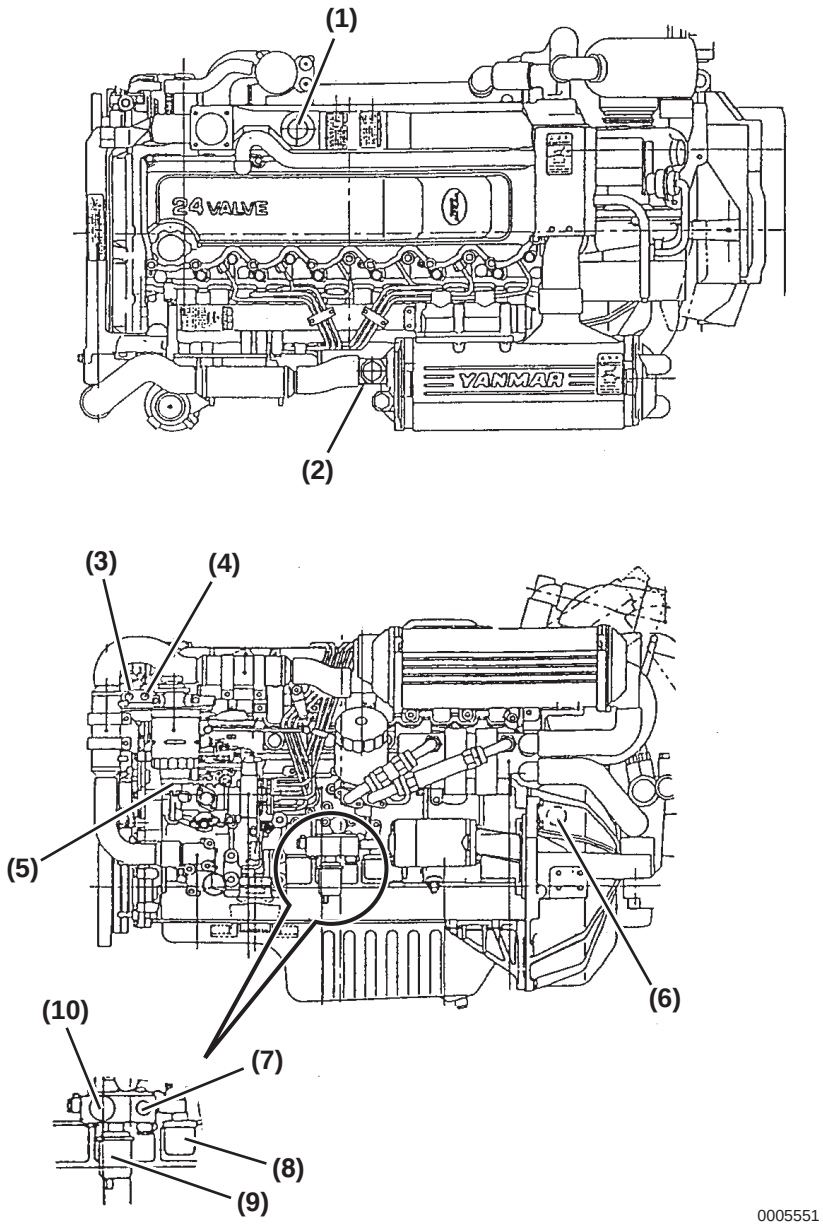

Figure 3-7

1 – Freshwater Level Switch
2 – Seawater Flow Switch
3 – Freshwater Temperature Switch
4 – Freshwater Temperature Sender
5 – Fuel Filter Switch
6 – Tachometer Sender
7 – Engine Oil Pressure Switch
8 – Engine Oil Pressure Sender
9 – Boost Sender
10 – Boost Switch

INSTRUMENT PANEL (OPTIONAL)

B-Type Panel (119773-91131)

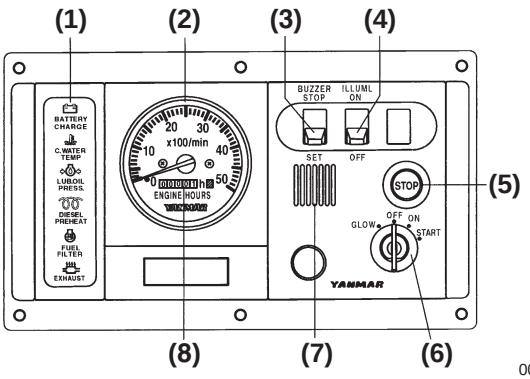

Figure 3-8

1 – Warning Lamp Unit - 6 Lamp Type
2 – Tachometer
3 – Buzzer Stop Switch
4 – Panel Illumination Switch
5 – Engine Stop Switch
6 – Key Switch
7 – Alarm Buzzer
8 – Hour Meter

C-Type Panel (119773-91162)

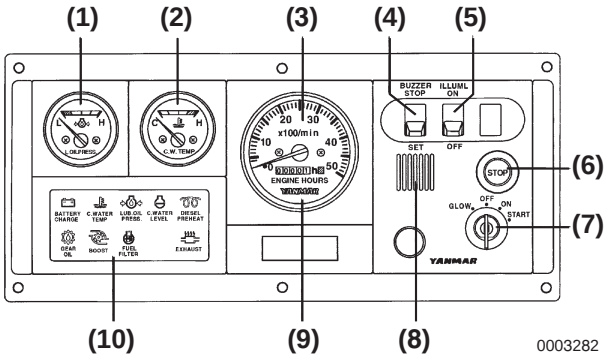

Figure 3-9

1 – Oil Pressure Meter
2 – CW Temperature Meter
3 – Tachometer
4 – Buzzer Stop Switch
5 – Panel Illumination Switch
6 – Engine Stop Switch
7 – Starter Key Switch
8 – Alarm Buzzer
9 – Hour Meter
10 – Warning Lamp Unit - 10 Lamp Type

D-Type Panel (119773-91192)

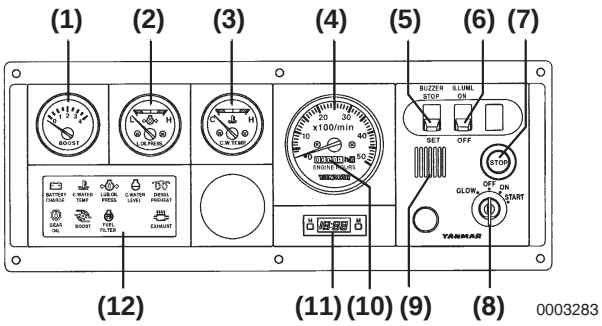

Figure 3-10

1 – Turbocharger Boost Pressure Meter
2 – Engine Oil Pressure Meter
3 – CW Temperature Meter
4 – Tachometer
5 – Buzzer Stop Switch
6 – Panel Illumination Switch
7 – Engine Stop Switch
8 – Starter Key Switch
9 – Alarm Buzzer
10 – Hour Meter
11 – Quartz Clock
12 – Warning Lamp Unit - 10 Lamp Type

PERFORMANCE CURVE CHARTS

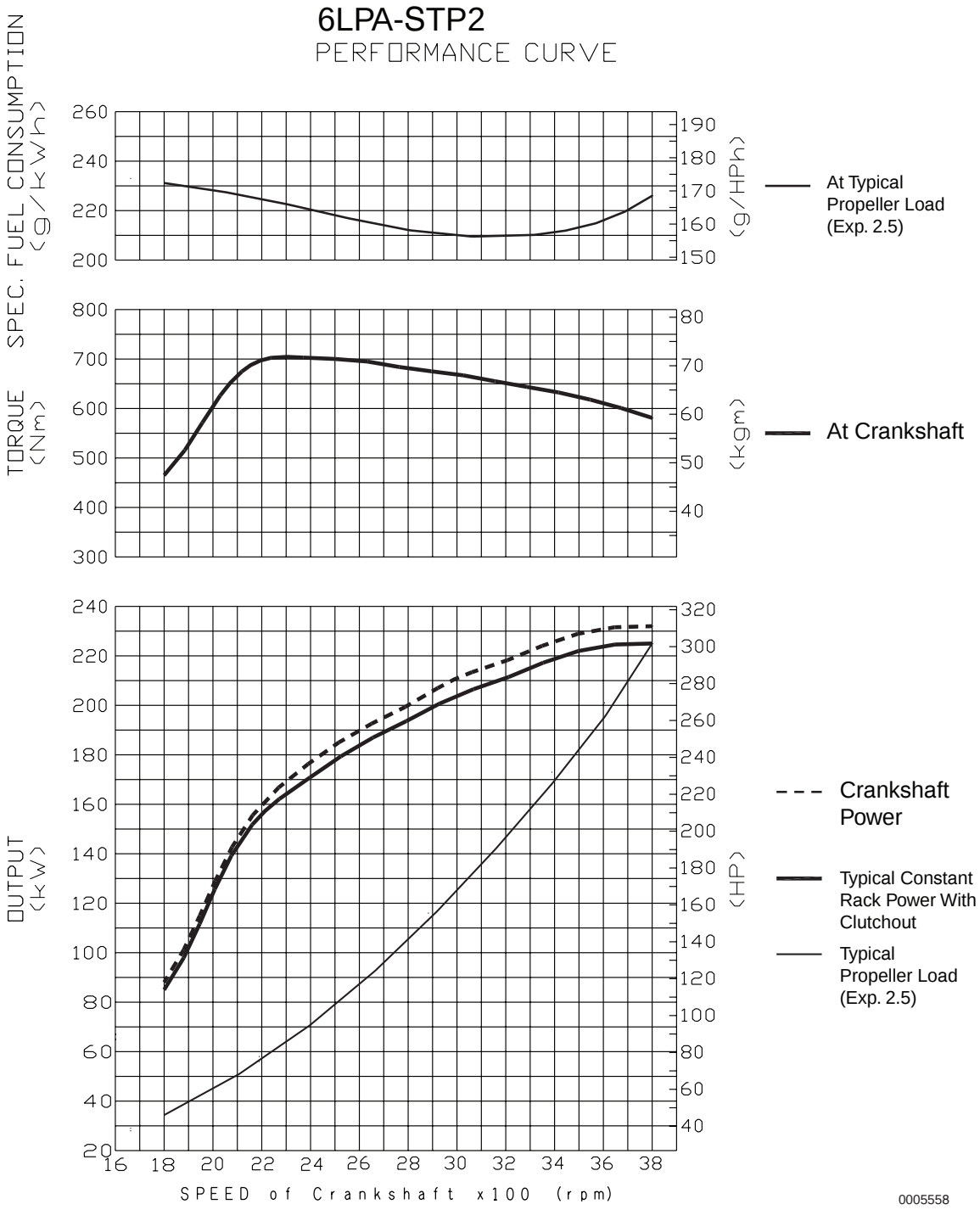

Figure 3-11

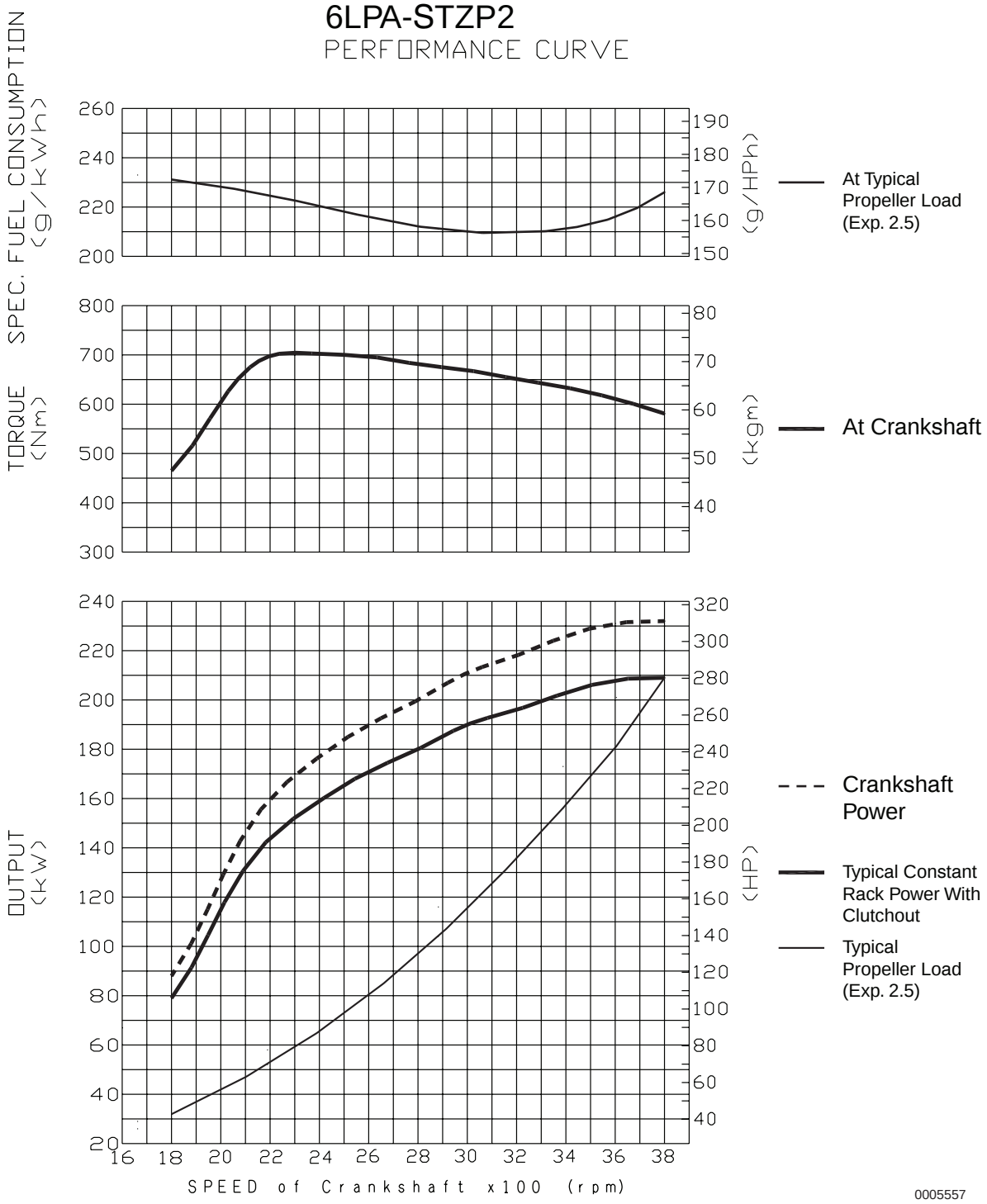

Figure 3-12

FRONT POWER TAKE-OFF (PTO) OUTPUT

Front PTO Diagram

Note: Use of PTO in other than "Method A" is prohibited. UP-pull drive is not allowed even in the case of "Method A."

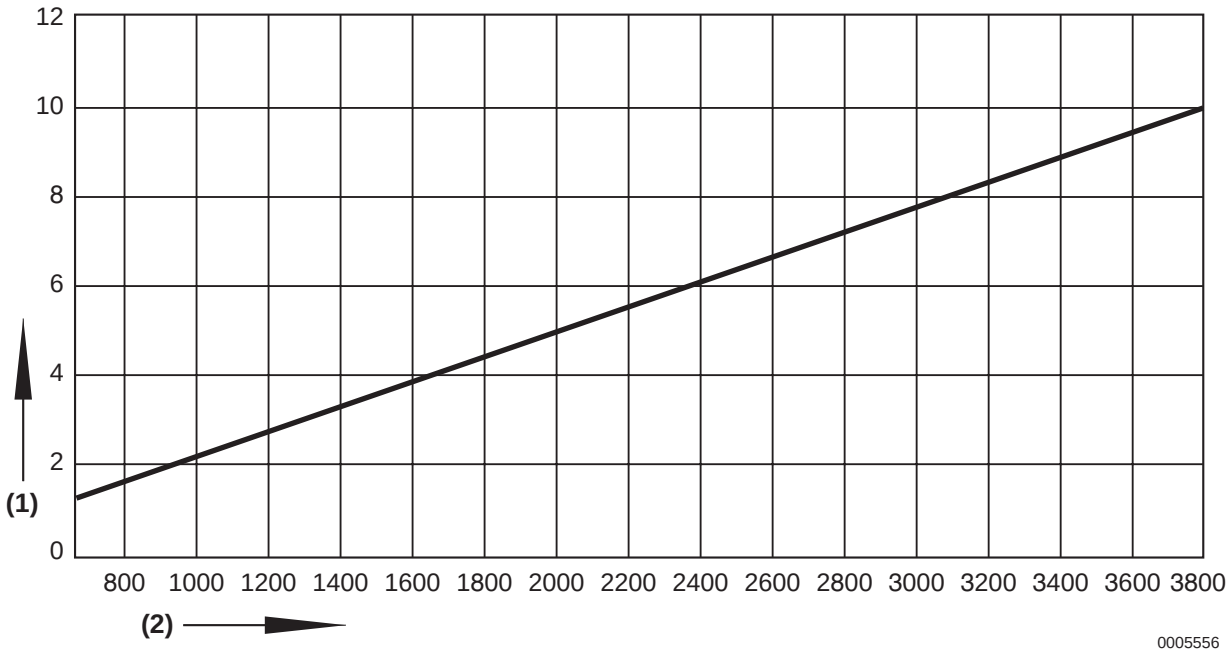

Figure 3-13

1 – Allowable Front PTO Output (hp)
2 – Engine Speed (rpm)

Method for Front PTO

1. Use type "A" (Belt drive with no outside bearing). NEVER use other types of PTO.
2. NEVER engage the UP-pull drive. Use the side pull belt drive.
3. Use a single V-drive, type "A."
4. The PTO pulley should be aluminum. The outside diameter should be maximum 170 mm (6.69 in.) and the overhang within 25 mm (0.98 in.).
5. Install the pulley to the exterior of the viscous damper and tighten the pulley and damper with the damper fixing bolts (M8 x (6 Qty.)) and the washers. (Torque: 3.8 ± 0.2 kg·m, 37.27 ± 1.96 N·m (27.4 ± 1.4 lb-ft))

Note: The crankshaft may break if the front PTO output exceeds the allowable output.

V-Pulley Overhang

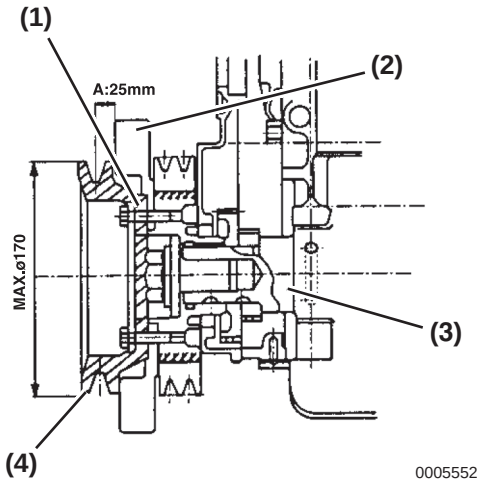

Figure 3-14

1 – Pulley Thickness Should be 10 mm (0.393 in.)
2 – Viscous Damper
3 – Crankshaft
4 – PTO Pulley (Aluminum)

V-Pulley Drawing

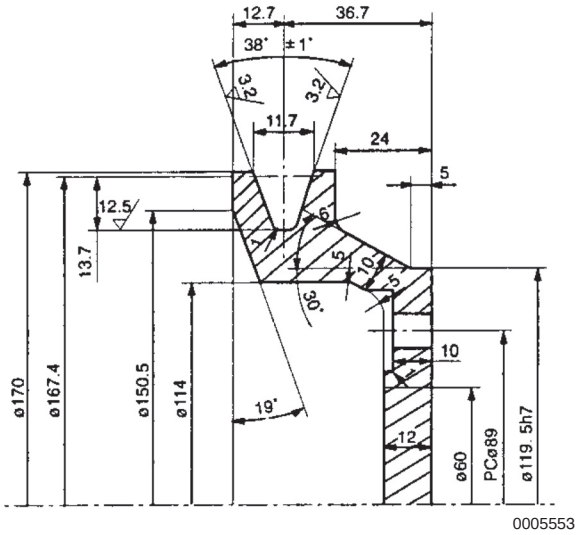

Figure 3-15

- "A"-Type V Belt Style: A Material: Aluminum equivalent inertia weight 0.065 kg·cm sec^2 (0.63 N·cm sec^2)

LOCATION OF NAMEPLATE

The nameplate of the Yanmar 6LPA series engines is shown in **Figure 3-16**. The nameplate is located on the engine rocker arm cover.

Engine Nameplate (Typical)

6LPA-STP2/STZP2 Engines

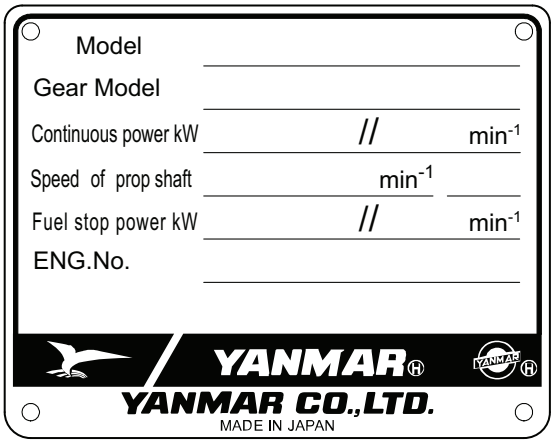

Figure 3-16

DIESEL FUEL

Diesel Fuel Specifications

CAUTION! ***Only use diesel fuels recommended by Yanmar for the best engine performance, to prevent engine damage and to comply with EPA warranty requirements. Only use clean diesel fuel.***

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

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.
- Water and sediment in the fuel should not exceed 0.05% by volume.
- Ash content not to exceed 0.01% by volume.
- Carbon residue content not to exceed 0.35% by volume. Less than 0.1% is preferred.
- Total aromatics content should not exceed 35% by volume. Less than 30% is preferred.
- PAH (polycyclic aromatic hydrocarbons) content should be below 10% by volume.
- NEVER mix kerosene, used engine oil, or residual fuels with the diesel fuel.
- NEVER use Biocide or mix winter and summer fuels.

- 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.

Handling Diesel Fuel

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 it. This prevents static electricity buildup which could cause sparks and ignite fuel vapors.***

- Keep the diesel fuel in a clean container. Store the container in a place away from rain and dirt as water and dust mixed in with the fuel cause engine failure.
- Keep the fuel container stationary for several hours to allow any dirt or water to settle to the bottom. Use a pump to extract the clear, filtered fuel from the top of the container for use.
- Pump out only half-way to avoid pumping out any contaminates or foreign matter in the bottom of the tank **(Figure 3-17)**.

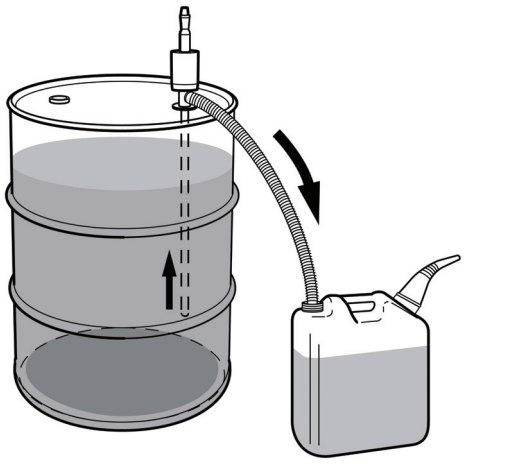

Figure 3-17

Diesel Fuel Lines

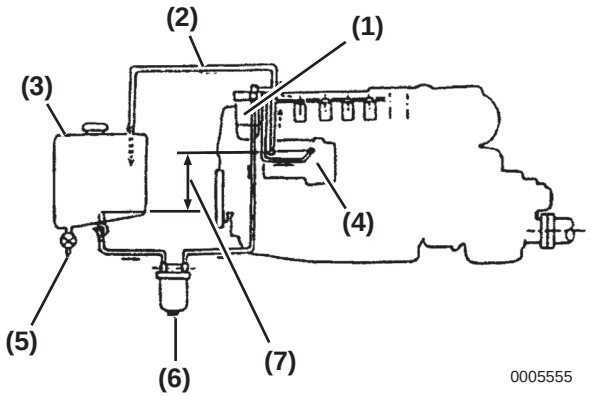

Figure 3-18

1 – Fuel Filter
2 – Fuel Return Pipe
3 – Fuel Tank
4 – Fuel Injection Pump
5 – Drain Cock
6 – Fuel Filter / Water Separator
7 – Suction Head 50 cm (19.6 in.) or Less

Install the lines between the fuel tank and the fuel injection pump.

Be sure to install a drain cock **(Figure 3-18, (5))** at the bottom of the fuel tank to remove water and contaminants.

Install a fuel filter / water separator **(Figure 3-18, (6))** and a fuel filter **(Figure 3-18, (1))** between the fuel tank and the fuel injection pump.

Fuel Tank

Note: Optional fuel tank style shown.

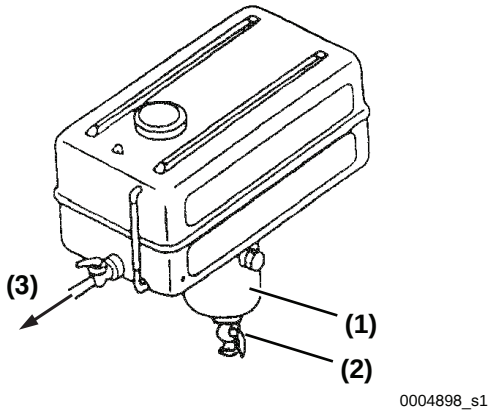

Figure 3-19

1 – Sediment Bowl
2 – Drain Cock
3 – Fuel Line to Engine

Install a drain cock **(Figure 3-19, (2))** at the bottom of the fuel tank to remove water and contaminants from the sediment bowl **(Figure 3-19, (1))**.

The fuel outlet should be positioned 20 to 30 mm (0.75 to 1.125 in.) above the bottom of the tank to ensure clean fuel is delivered to the engine.

Filling the Fuel Tank

1. Clean the area around the fuel cap. **DANGER!** ***Only fill the fuel tank with diesel fuel. Filling the fuel tank with gasoline may result in a fire and will damage the engine. NEVER refuel with the engine running.***
2. Remove the fuel cap from the fuel tank. **WARNING!** ***Wipe up all spills immediately. Keep sparks, open flames or any other form of ignition (match, cigarette, static electric source) well away when refueling.***
3. Stop fueling when the gauge shows the fuel tank is full. *NOTICE: NEVER overfill the fuel tank.*
4. Replace the fuel cap and hand-tighten. Over-tightening the fuel cap will damage it. **DANGER!** ***Store any containers containing fuel in a well-ventilated area, away from any combustibles or sources of ignition.***

Bleeding the Fuel System

Bleeding must be done if any fuel system maintenance has been performed (replacement of fuel filter, etc.) or if the engine does not start after several attempts.

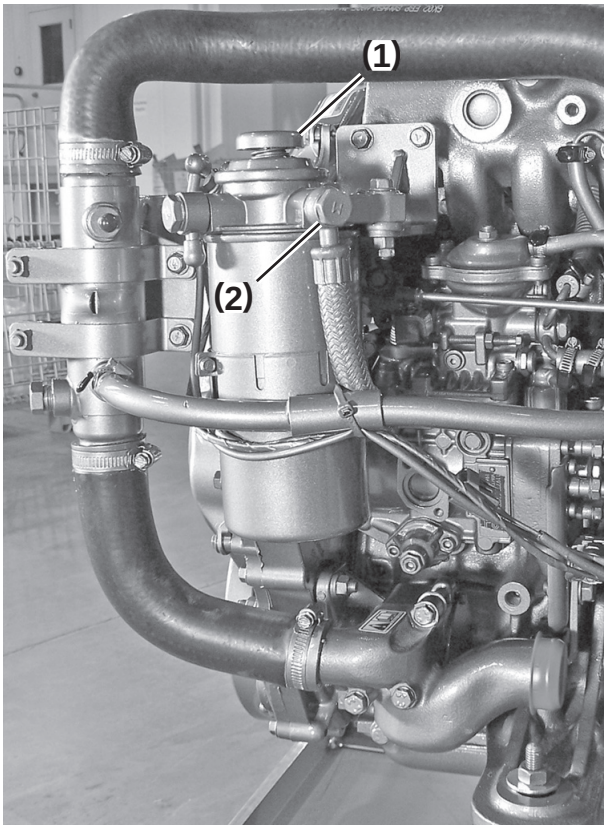

Figure 3-20

1. Check the fuel level in the fuel tank. Refill if necessary.
2. Open the fuel cock of the fuel tank. **WARNING! *ALWAYS wear safety glasses when bleeding the fuel system***.
3. Loosen the air bleed screw **(Figure 3-20, (2))** 2 to 3 turns.
4. Push up and down on the priming pump **(Figure 3-20, (1))** to release air out of the air bleed screw. **WARNING! *Ensure no fuel is leaking from the seals of the air bleed screw while pushing on the priming pump***.
5. Continue pumping until a solid stream of fuel with no air bubbles begins to flow.
6. Tighten the air bleed screw.

ENGINE OIL

Engine Oil Specifications

NOTICE: Only use the engine oil specified. Other engine oils may affect warranty coverage, cause internal engine components to seize or shorten engine life. NEVER mix different types of engine oil. This may adversely affect the lubricating properties of the engine oil.

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

API Service Categories CD or higher

Recommended SAE Oil Viscosity: 10W30 or 15W40

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)

NOTICE:

- Be sure the engine oil, engine oil storage containers, and engine oil filling equipment are free of sediment and water.
- Change the engine oil after the first 50 hours of operation and then every 125 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 3-21)**.
- 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 shown in the SAE Service Grade Viscosity Chart **(Figure 3-21)**.

SAE 15W40 is the recommended oil viscosity.

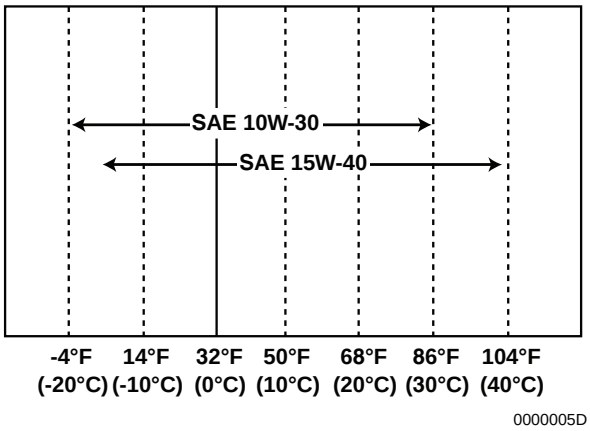

Figure 3-21

Handling Oil

- When handling or storing oil, never allow dust and water to contaminate the oil.
- Clean around the filler port before refilling.
- NEVER mix engine oils of different types or brands. Mixing oil may cause the chemical characteristics of the oil to change and lubricating performance to decrease, reducing the engine's life.
- Engine oil should be changed at the specified intervals, regardless if the engine has been operated

- Different oils are used for the engine and the marine drive unit. Always use the correct oil for each and store in separate clearly labeled containers

Checking the Engine Oil

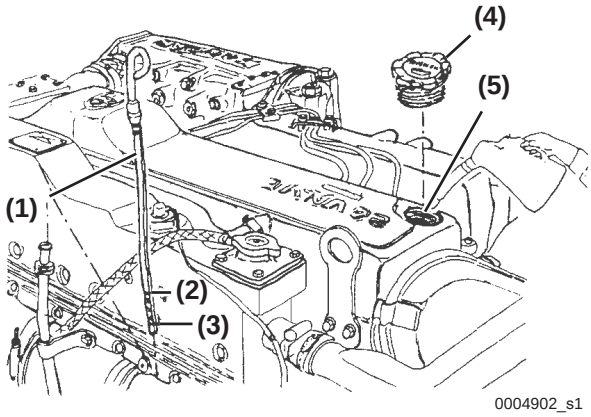

Figure 3-22

1 – Dipstick
2 – Upper Oil Level
3 – Lower Oil Level
4 – Filler Cap
5 – Oil Filler Port

1. Ensure the engine is level before checking the oil.
2. Remove the dipstick **(Figure 3-22, (1))** and wipe with a clean cloth.
3. Fully reinsert the dipstick.
4. Remove the dipstick. The oil level should be between the upper **(Figure 3-22, (2))** and lower **(Figure 3-22, (3))** lines on the dipstick.
5. Fully reinsert the dipstick.
6. Add engine oil if necessary.

Adding Engine Oil

1. *NOTICE: Prevent dirt and debris from contaminating engine oil. Carefully clean the dipstick and the surrounding area before you remove the cap.* Remove the oil filler port cap **(Figure 3-22, (4))** from filler port **(Figure 3-22, (5))** and fill with engine oil.
2. Fill with oil to the upper limit on the dipstick **(Figure 3-22, (2))**. *NOTICE: NEVER mix different types of engine oil. This may adversely affect the lubricating properties of the engine oil. NEVER overfill. Overfilling may result in white exhaust smoke, engine overspeed or internal damage.*
3. Insert the dipstick fully to check the level. *NOTICE: ALWAYS keep the oil level between upper and lower lines on the oil cap / dipstick.*
4. Tighten the filler port cap securely by hand.

MARINE DRIVE OIL

Note: Refer to the marine gear manufacturer's operation manual for oil specifications. Refer to the stern drive manufacturer's operation manual for stern drive oil specifications.

Mercruiser® Bravo Stern Drive Oil Specifications

Use marine gear oil that meets or exceeds the following guidelines and classifications:

Drive Oil

- QuickSilver® 1 High Performance Gear Lube

Power Steering Oil (6LPA-STZP2 Only)

- Quicksilver® Power Trim and Steering Fluid or Dextron-II

Power Trim Oil

- Quicksilver® Power Trim and Steering Fluid or SAE 10W-30 or 10W-40 Engine Oil

Checking and Adding Marine Drive Oil

Note: Refer to the manufacturer's operation manual for the proper procedure to check and fill the marine drive oil.

Checking and Adding Power Steering Oil (6LPA-STZP2 Models)

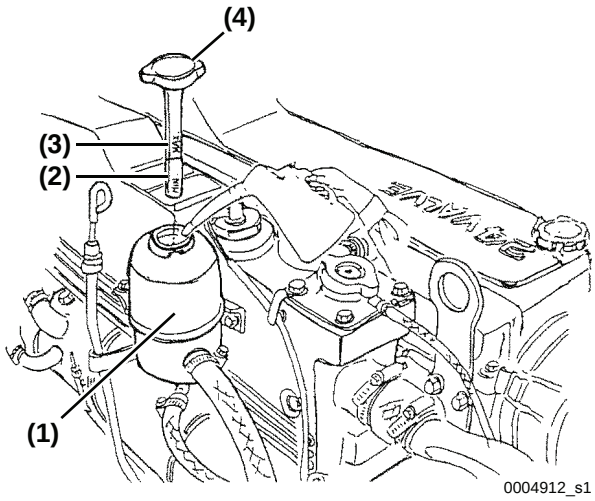

Figure 3-23

1 – Power Steering Oil Service Tank
2 – Lower Oil Level
3 – Upper Oil Level
4 – Filler Cap / Dipstick

1. Remove the filler cap / dipstick **(Figure 3-23, (4))** from the power steering oil service tank **(Figure 3-23, (1))** and wipe with a clean cloth.
2. Fully reinsert the dipstick.
3. Remove the dipstick. The oil level should be between upper **(Figure 3-23, (3))** and lower **(Figure 3-23, (2))** lines on the dipstick.
4. Fill with oil to the upper limit on the dipstick. *See Mercruiser® Bravo Stern Drive Oil Specifications on page 3-23. NOTICE: NEVER overfill the power steering system with oil.*
5. Fully reinsert the dipstick and hand tighten.

ENGINE COOLANT

Engine Coolant Specifications

- Texaco Long Life Coolant (LLC), both standard and premixed, product code 7997 and 7998
- Havoline Extended Life Antifreeze / Coolant, product code 7994

Note: In the U.S., LLC is required for the warranty to be valid.

NOTICE:

- Always add LLC to soft water - especially when operating in cold weather. Without LLC, cooling performance will decrease due to scale and rust in the cooling system. Water alone may freeze and form ice; it expands approximately 9% in volume.
- Use the proper amount of coolant concentrate for the ambient temperature as specified by the LLC manufacturer. LLC concentration should be a minimum of 30% to a maximum of 60%. Too much LLC will decrease the cooling efficiency also. NEVER mix different types or brands of LLC or a harmful sludge may form.
- NEVER use hard water. Water should be clean and free from sludge or particles.
- Following the manufacturer's recommendations, use a proper LLC which will not have any adverse effects on the materials (cast iron, aluminum, copper, etc.) of the engine's freshwater cooling system.
- Excessive use of antifreeze also lowers the cooling efficiency of the engine. Be sure to use the mixing ratios specified by the antifreeze manufacturer for the temperature range.
- Replace engine coolant periodically, according to the maintenance schedule.
- Remove scale from the cooling system periodically by flushing the system. NEVER mix different brands of antifreeze. Chemical reactions may make the antifreeze useless and engine problems may result.

Checking and Adding Engine Coolant

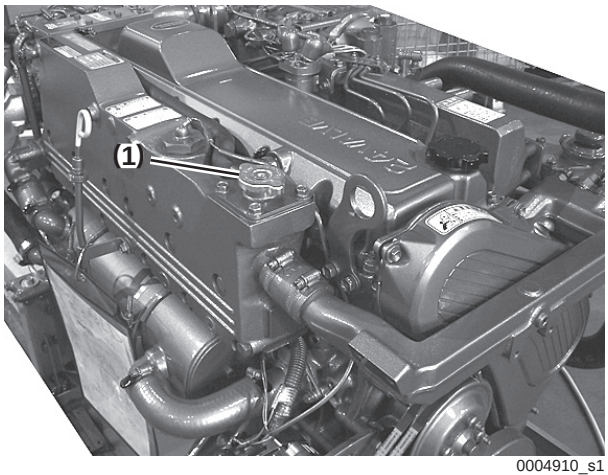

Figure 3-24

1 – Filler Cap

1. Ensure all drain cocks are closed.
2. Loosen the filler cap of the coolant tank to relieve the pressure, then remove the filler cap **(Figure 3-24, (1))**. **WARNING!** ***NEVER remove the filler cap while the engine is hot. Serious burns may result.***
3. Pour coolant slowly into the coolant tank to avoid air bubbles. Fill until coolant overflows from the filler port.
4. Align filler cap tabs with filler port notches and tighten filler cap. **WARNING!** ***ALWAYS tighten the filler cap. Steam or scalding water may spray out if it is not closed tightly.***

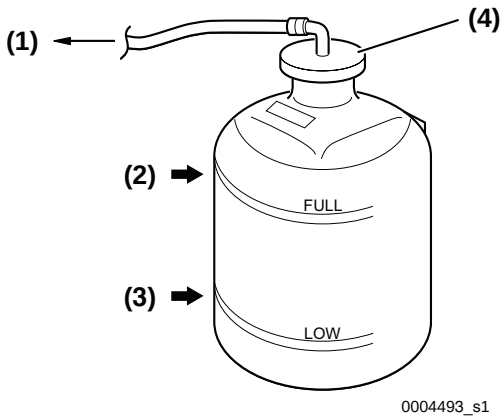

Figure 3-25

1 – Hose
2 – Full Mark
3 – Low Mark
4 – Coolant Recovery Tank Cap

5. Check the coolant level in the coolant recovery tank. The level should be at the FULL mark **(Figure 3-25, (2))**. Add coolant if necessary. *NOTICE: NEVER pour cold coolant into a hot engine.*
6. Remove the coolant recovery tank cap **(Figure 3-25, (4))** to add coolant if necessary. NEVER add water.
7. Replace the filler cap and tighten it firmly, failure to do so will cause water leakage.
8. Check the rubber hose **(Figure 3-25, (1))** connecting the coolant recovery tank to the coolant tank / heat exchanger. Replace if damaged.

   NOTICE: If the coolant runs low too often or only the coolant level in the coolant tank drops without any change in the level in the coolant recovery tank, there may be water or air leaks in the cooling system.

Draining the Freshwater and Seawater Cooling System

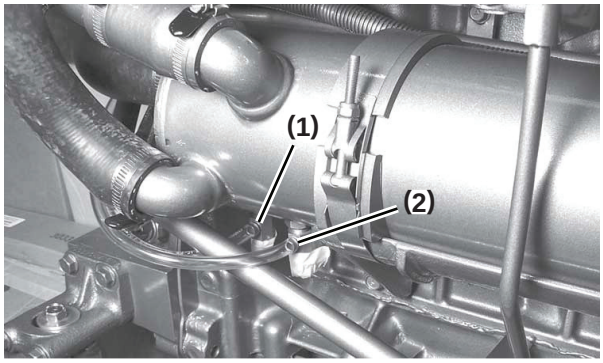

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Figure 3-26

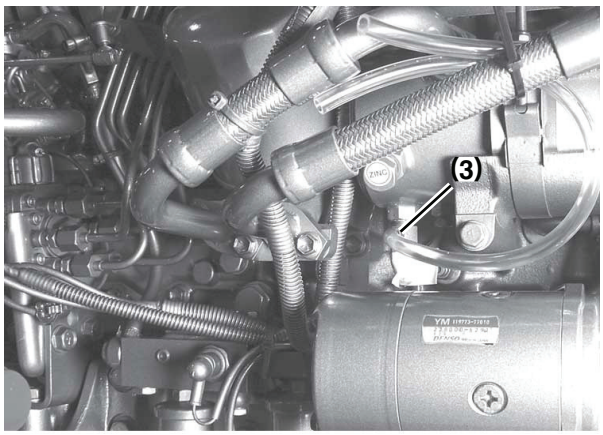

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Figure 3-27

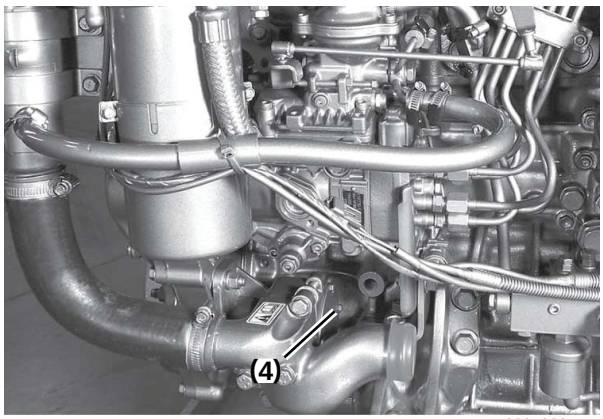

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Figure 3-28

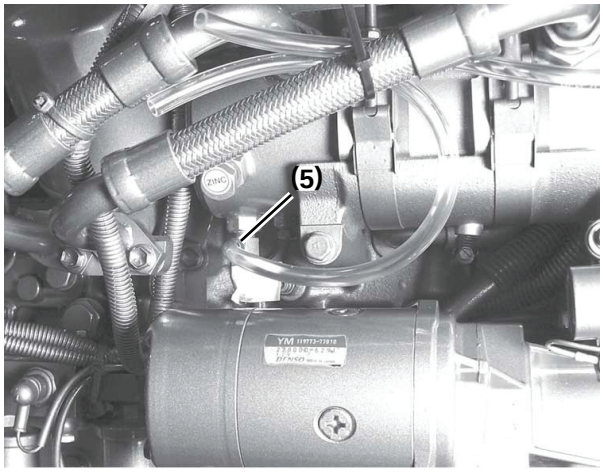

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Figure 3-29

1 – Seawater Drain Cock
2 – Freshwater Drain Cock
3 – Freshwater Drain Cock
4 – Seawater Pump Cover
5 – Seawater Drain Cock

Draining the Freshwater Cooling System

1. Open the freshwater drain cocks and drain the fresh water into an appropriate container.
2. Close the drain cocks after draining the water.
3. Dispose of waste properly

Draining Seawater Cooling System

NOTICE: If seawater is left inside, it may freeze and damage parts of the cooling system (freshwater cooler, seawater pump, etc.) when ambient temperature is below 0°C (32°F).

1. Close the seacock.
2. Open the seawater drain cocks and drain off the seawater.
3. Remove the four bolts attaching the seawater pump cover. Remove the cover and drain the seawater.
4. Install cover and tighten bolts.
5. Close all the drain cocks.

PRINCIPAL ENGINE SPECIFICATIONS

Engine Model		6LPA-STP2	6LPA-STZP2
Type		Vertical water cooled 4-cycle diesel engine	
No. of cylinders		6	
Bore x Stroke		94 mm x 100 mm (3.7 x 3.94 in.)	
Displacement		4.164 L (4.4 qt)	
Continuous power at crankshaft		211 kW (286 hp) / 3682 rpm	
Maximum Output Rating		232 kW (315 hp) / 3800 rpm*	
High idling		4280 ± 25	
Low idling		750 ± 25	
Combustion system		Direct injection	
Starting system		Electric starting (12V-2.5 kW)	
Charging system		Alternator with built in regulator DC12V-80A	
Cooling system		Constant high temperature freshwater cooling (2 systems: sea & freshwater)	
Lubrication system		Forced lubrication system with Trochoid gear pump	
Direction of rotation		Counter-clockwise (viewed from flywheel side)	
Engine oil capacity	Total	10.5 L (11.0 qt)	
	Oil pan	8.4 L (8.9 qt)	
Cooling water capacity		13.5 L (14.3 qt) Engine, 1.6 L (1.7 qt) Coolant Recovery Tank	
Turbocharger	Model	RHE62W (IHI made)	
	Type	Water cooled turbine housing	
Dimension (less gear)	L x W x H	1065 x 671 x 729 mm (41.9 x 26.4 x 28.7 in.)	1145 x 752 x 799 mm (45.1 x 29.6 x 28.7 in.)
Weight (less gear)		408 kg (899 lb)	428 kg (944 lb)
Recommended battery capacity		12 V x 120 Ah	
Recommended remote control handle		Single lever type only	
Engine installation		Flexible engine mount	

**Density of fuel: 0.840 g/cm3 at 15°C. Diesel fuel temperature 25°C at the inlet of the fuel injection pump. Rating condition: ISO 3046-1, 8665.*
Note: 1 hp = 0.7355 kW

Notation of Output Power

Specific Gravity	Fuel Temperature	
	25°C (77°F)	40°C (104°F)
0.860	323	306
0.840	315	299

Marine Gear (Optional)

Model	HURTH	KANZAKI	MERCRUISER		
	ZF063A1	KMH50A	Bravo X-1	Bravo X-2	Bravo X-3
Type	8° down Hydraulic	8° down Hydraulic	Stern drive		
Applicable engine	6LPA-STP2	6LPA-STP2	6LPA-STZP2		
Reduction ratio ZF63A1: Ahead/Astern Bravo X-1, 2, 3: Both Ahead and Astern	1.22/1.21	1.67/1.67	1.36	1.50	1.36
	1.56/1.58	2.13/2.13	1.50	1.65	1.50
	2.04/2.10	2.43/2.43	-	1.81	1.65
	2.52/2.53	-	-	2.00	1.81
See manufacturer's documentation for additional information.					

SPECIAL TORQUE CHART

Component		Specification
Fuel injection pump x Timing gear case		185 kgf/cm^2,18.14 N·m (13.6 lb-ft)
Fuel injection pump x Fuel injection pump stay		700 kgf/cm^2, 68.65 N·m (50.6 lb-ft)
Fuel injection pump drive gear x Fuel injection pump		1000 kgf/cm^2, 98.07 N·m (72.3 lb-ft)
Fuel injection pump stay x Cylinder block		700 kgf/cm^2, 68.65 N·m (50.6 lb-ft)
Fuel injection nozzle mounting bolt x Cylinder head		255 kgf/cm^2, 25.01 N·m (18.4 lb-ft)
No. 1 Camshaft timing pulley x Camshaft		1000 kgf/cm^2, 98.07 N·m (72.3 lb-ft)
No. 2 Camshaft timing pulley x Fuel injection pump drive gear		315 kgf/cm^2, 30.89 N·m (22.8 lb-ft)
Idler pulley x Timing gear cover		350 kgf/cm^2, 34.32 N·m (25.3 lb-ft)
Timing belt tensioner x Timing gear cover		130 kgf/cm^2, 12.75 N·m (9.4 lb-ft)
Idler gear x Cylinder block		694 kgf/cm^2, 68.06 N·m (50.2 lb-ft)
Timing gear cover, Cylinder block x Timing gear case		200 kgf/cm^2, 19.61 N·m (14.5 lb-ft)
Camshaft bearing cap x Cylinder head		250 kgf/cm^2, 24.52 N·m (18.08 lb-ft)
Camshaft oil seal retainer x Cylinder head		200 kgf/cm^2, 19.61 N·m (14.5 lb-ft)
Main bearing cap x Cylinder block	(12 pointed head)*	1050 kgf/cm^2, 102.97 N·m (75.9 lb-ft) (90° Retightening)
	(6 pointed head)	185 kgf/cm^2, 18.14 N·m (13.38 lb-ft)
Crankshaft pulley x Crankshaft		4400 kgf/cm^2, 431.50 N·m (318.3 lb-ft)
Flywheel x Crankshaft		1300 kgf/cm^2, 127.50 N·m (94 lb-ft)
Viscous damper x Crankshaft pulley		380 kgf/cm^2, 37.27 N·m (27.5 lb-ft)
Input shaft joint (rubber block) x Flywheel		400 kgf/cm^2, 39.23 N·m (28.9 lb-ft)
* Connecting rod cap x Connecting rod		375 kgf/cm^2, 36.77N·m (27.1 lb-ft) (90° Retightening)
* Cylinder head x Cylinder block		700 kgf/cm^2, 68.65 N·m (50.6 lb-ft) (90° Retightening)
Rocker cover x Cylinder head		65 kgf/cm^2, 6.37 N·m (56.4 lb-in.)
Intake manifold x Cylinder head		200 kgf/cm^2, 19.61 N·m (14.5 lb-ft)
Alternator bracket x Cylinder block		700 kgf/cm^2, 68.65 N·m (50.6 lb-ft)
Rear end plate x Cylinder block		185 kgf/cm^2, 18.14 N·m (13.4 lb-ft)
Engine mounting bracket x Cylinder block		700 kgf/cm^2, 68.65 N·m (50.6 lb-ft)
Rear oil seal case x Cylinder block		65 kgf/cm^2, 6.37 N·m (56.4 lb-in.)

* Apply oil to threads and seat before tightening.

TIGHTENING TORQUES FOR STANDARD BOLTS AND NUTS

Tightening Fasteners

Use the correct amount of torque when tightening the fasteners. 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 Standard Torque 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.

Hexagon Bolts and Nuts Torque

	Bolt diameter x pitch (mm)					
	M6 X 1.0	**M8 X 1.25**	**M10 X 1.5**	**M12 X 1.75**	**M14 X 1.5**	**M16 X 1.5**
N·m	11.0 ± 1.0	26.0 ± 3.0	50.0 ± 5.0	90.0 ± 10.0	140.0 ± 10.0	230.0 ± 10.0
kgf·m	1.1 ± 0.1	2.7 ± 0.3	5.1 ± 0.5	9.2 ± 1.0	14.3 ± 1.0	23.5 ± 1.0
lb-ft	-	19.0 ± 2.1	37 ± 3.6	66.0 ± 7.2	103 ± 7.2	170 ± 7.2
lb-in.	96 ± 9.0	-	-	-	-	-

ABBREVIATIONS AND SYMBOLS

Abbreviations

A	ampere
AC	alternating current
ACEA	Association des Constructeurs
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
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 (metric)
hr	hour
I.D.	inside diameter
ID	identification
IDI	indirect injection
in.	inch
in.Aq	inches Aqueous (water)
in.Hg	inches Mercury
in-lb	inch pound**
J	joule
JASO	Japanese Automobile
K	kelvin
kg	kilogram
kgf/cm²	kilogram force per square
kgf/m	kilogram force per meter
km	kilometers
kPa	kilopascal
kW	kilowatt
L	liter
L/hr	liter per hour
lb	pound
lbf	pound force
lb-ft	pound foot (Tightening Torque)
lb-in	pound inch (Tightening Torque)
m	meter
mL	milliliter
mm	millimeter
mmAq	millimeter Aqueous (water)
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
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

* Work torque such as engine torque
** Work torque such as starter motor torque

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	= ft-lb
kgf/m	x	86.8000	= in.-lb
kgf/m	x	9.8070	= N·m
N·m	x	0.7376	= ft-lb
N·m	x	8.8510	= in.-lb
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
in.Hg (60°)	x	0.0333	= bar
in.Hg (60°)	x	3.3770	= kPa
in.Hg (60°)	x	0.0344	= kg/cm^2
mmAq	x	0.0394	= in.Aq

Units of Power

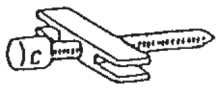
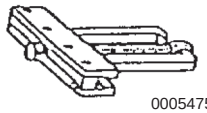
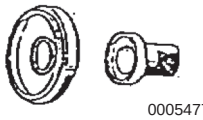
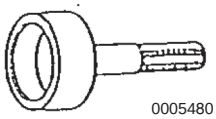
hp (metric or PS)	x	0.9863201	= hp SAE
hp (metric or PS)	x	0.7354988	= kW
hp SAE	x	1.0138697	= hp (metric or PS)
hp SAE	x	0.7456999	= kW
kW	x	1.3596216	= hp (metric or PS)
kW	x	1.3410221	= hp SAE

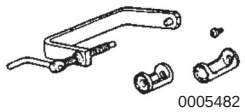
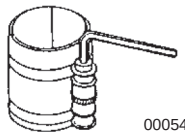
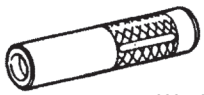
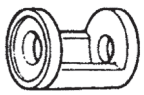
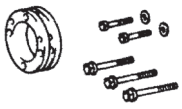
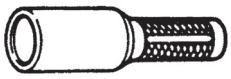
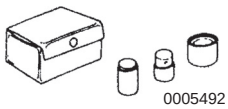
Units of Temperature

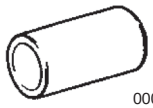
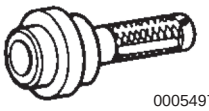
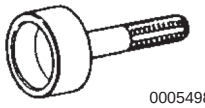
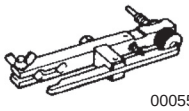
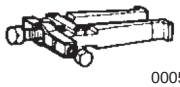
°F = (1.8 x °C) + 32
°C = 0.556 x (°F - 32)

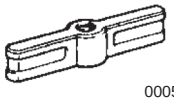
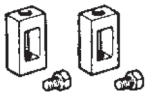
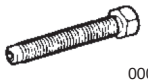
SPECIAL SERVICE TOOLS

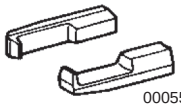
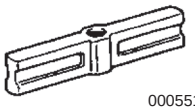
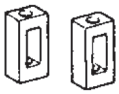
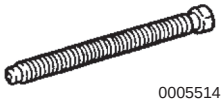
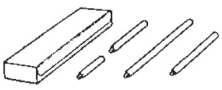
Note: The tool numbers used in this section are either Yanmar or Toyota part numbers. Yanmar part numbers are referred to as **Yanmar Part No.** Toyota part numbers are referred to as **Toyota Part No.** Tools not having part numbers must be obtained locally.

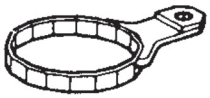
No.	Tool Name and Description	Tool P/N	Illustration
1	Seal cutter for removing oil pan	Yanmar Part No. 119770-01060 Toyota Part No. 09032-00110	 0005473
2	Puller for removing crankshaft pulley	Yanmar Part No. 119770-0107 Toyota Part No. 09213-00020	 0005474
3	Remover for removing drive gear, oil pump for removing	Yanmar Part No. 119770-01080 Toyota Part No. 09213-36020	 0005475
4	Tool for settling crankshaft pulley	Yanmar Part No. 119770-01090 Toyota Part No. 09213-58012	 0005476
5	Replacer for replacing the engine front oil seal	Yanmar Part No. 119770-01100 Toyota Part No. 09223-78010	 0005477
6	Tool for settling crankshaft pulley	Yanmar Part No. 119770-01120 Toyota Part No. 09330-00021	 0005479
7	Replacer, oil seal, for replacing the engine rear oil seal	Yanmar Part No. 119770-01130 Toyota Part No. 09223-56010	 0005480
8	Handle for removing crankshaft pulley	Yanmar Part No. 119770-01140 Toyota Part No. 09213-00030	 0005481

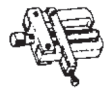
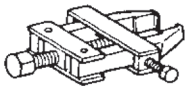
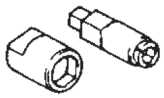
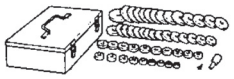
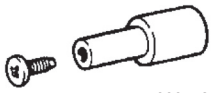
No.	Tool Name and Description	Tool P/N	Illustration
9	Compressor, valve spring for removing valve spring	Yanmar Part No. 119770-02000 Toyota Part No. 09202-70020	 0005482
10	Piston insertion for compressing piston ring	Yanmar Part No. 95550-002476	 0005483
11	Valve stem oil seal replacer	Toyota Part No. 09201-41020	 0005484
12	Attachment	Toyota Part No. 09202-00010	 0005486
13	Crankshaft pulley holding tool	Yanmar Part No. 119770-01090 Toyota Part No. 09213-58012	 0005487
14	Washer	Toyota Part No. 90201-08131	 0005488
15	Bolt	Toyota Part No. 91111-50845	 0005489
16	Crankshaft pulley & gear replacer for crankshaft pulley	Toyota Part No. 09214-60010	 0005490
17	Injection pump drive gear oil seal for injection pump drive gear bearing	Toyota Part No. 09214-76011	 0005491
18	Connecting rod bushing remover & replacer	Toyota Part No. 09222-17010	 0005492

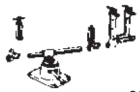
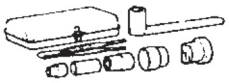
No.	Tool Name and Description	Tool P/N	Illustration
19	Remover & replacer	Toyota Part No. 09222-05020	 0005493
20	Guide	Toyota Part No. 09222-05030	 000549
21	Base	Toyota Part No. 09222-05040	 0005495
22	Cover & seal replacer for crankshaft timing gear or oil pump drive shaft gear	Toyota Part No. 09223-00010	 0005496
23	Crankshaft front oil seal replacer for camshaft oil seal	Toyota Part No. 09223-46011	 0005497
24	Crankshaft rear oil seal replacer	Yanmar Part No. 119770-01100 Toyota Part No. 09223-56010	 0005498
25	Crankshaft oil seal replacer for crankshaft front oil seal	Yanmar Part No. 119770-01100 Toyota Part No. 09223-78010	 0005499
26	Plunger stroke measuring tool	Toyota Part No. 09275-54011	 0005500
27	Oil seal puller for crankshaft front oil seal	Toyota Part No. 09308-10010	 0005501
28	Companion flange holding tool for crankshaft pulley	Yanmar Part No. 119770-01120 Toyota Part No. 09330-00021	 0005502

No.	Tool Name and Description	Tool P/N	Illustration
29	Puller B set	Toyota Part No. 09950-40010	 0005503
30	Hanger 150 for No. 1 camshaft timing pulley, oil pump drive shaft gear, crankshaft timing gear and injection pump drive gear bearing	Toyota Part No. 09951-04010	 0005504
31	Slide arm for No. 1 camshaft timing pulley, oil pump drive shaft gear, crankshaft timing gear and injection pump drive gear bearing	Toyota Part No. 09952-04010	 0005505
32	Center bolt 100 for oil pump drive shaft gear and crankshaft timing gear	Toyota Part No. 09953-04010	 0005506
33	Center bolt 150 for No. 1 camshaft timing pulley, oil pump drive shaft gear, crankshaft timing gear and injection pump drive gear bearing	Toyota Part No. 09953-04020	 0005507
34	Arm 25 for No. 1 camshaft timing pulley, oil pump drive shaft gear, crankshaft timing gear and injection pump drive gear bearing	Toyota Part No. 09954-04010	 0005508

No.	Tool Name and Description	Tool P/N	Illustration
35	Claw No. 6 for No. 1 camshaft timing pulley, oil pump drive shaft gear, crankshaft timing gear and injection pump drive gear bearing	Toyota Part No. 09955-04060	 0005509
36	Puller C Set	Toyota Part No. 09950-50010	 0005510
37	Hanger 150 for crankshaft pulley and injection pump drive gear	Toyota Part No. 09951-05010	 0005511
38	Slide arm for crankshaft pulley and injection pump drive gear	Toyota Part No. 09952-05010	 0005512
39	Center bolt 100 for crankshaft pulley and injection pump drive gear	Toyota Part No. 09953-05010	 0005513
40	Center bolt 150 for crankshaft pulley	Toyota Part No. 09953-05020	 0005514
41	Claw No. 2 for crankshaft pulley and injection pump drive gear	Toyota Part No. 09954-05020	 0005515
42	Handle set	Toyota Part No. 09950-70010	 0005516
43	Handle 100 for valve guide bushing	Toyota Part No. 09951-07100	 0005517

No.	Tool Name and Description	Tool P/N	Illustration
44	Variable pin wrench set	Toyota Part No. 09960-10010	 0005518
45	Variable pin wrench arm assembly for injection pump drive gear	Toyota Part No. 09962-01000	 0005519
46	Pin 7 for injection pump drive gear	Toyota Part No. 09963-00700	 0005520
47	Cylinder compression check gauge set	Toyota Part No. 09992-00024	 0005521
48	Oil pan seal cutter	Yanmar Part No. 119770-01060 Toyota Part No. 09032-00100	 0005522
49	Oil filter wrench	Toyota Part No. 09228-10002	 0005523
50	Fuel filter wrench	Toyota Part No. 09228-64010	 0005524
51	Water pump overhaul tool set	Toyota Part No. 09236-00101	 0005525
52	Injection pump camshaft bearing cone replacer for rotor rear bearing cover	Toyota Part No. 09285-76010	 0005526

No.	Tool Name and Description	Tool P/N	Illustration
53	Injection pump spline shaft puller for rectifier end frame	Toyota Part No. 09286-46011	 0005527
54	Alternator rear bearing puller	Toyota Part No. 09820-00021	 0005528
55	Alternator rear bearing replacer	Toyota Part No. 09820-00030	 0005529
56	Alternator pulley nut wrench set	Toyota Part No. 09820-63010	 0005530
57	Replacer set for rotor front bearing	Toyota Part No. 09950-60010	 0005531
58	Replacer 26	Toyota Part No. 09951-00260	 0005532
59	Replacer 50	Toyota Part No. 09951-00500	 0005533
60	Adapter	Toyota Part No. 09950-06010	 0005534
61	Gauge assembly	Toyota Part No. 09992-00211	 0005535

No.	Tool Name and Description	Tool P/N	Illustration
62	Attachment No. 7 for cylinder compression check	Toyota Part No. 09992-00400	 0005536
63	Shaft “C” for governor sleeve plug	Toyota Part No. 09237-00070	 0005537
64	Injection pump stand set	Toyota Part No. 09241-76022	 0005538
65	Injection pump stand arm	Toyota Part No. 09245-54010	 0005539
66	Injection pump tool set	Toyota Part No. 09260-54012	 0005540
67	Distributor head plug wrench	Toyota Part No. 09262-54010	 0005541
68	Socket 14 mm	Toyota Part No. 09269-54020	 0005542
69	Tweezers	Toyota Part No. 09269-54030	 0005543
70	Governor lever support bolt wrench	Toyota Part No. 09269-54040	 0005544
71	Regulator valve wrench	Toyota Part No. 09262-54020	 0005545

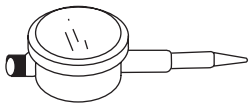
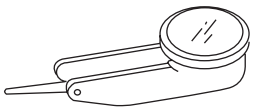
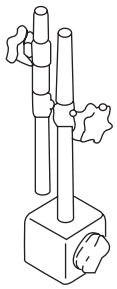
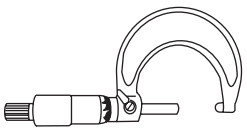
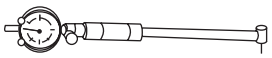
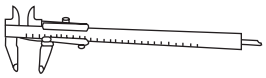
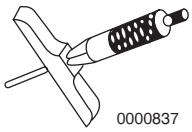
No.	Tool Name and Description	Tool P/N	Illustration
72	2 spring nozzle tool set	Toyota Part No. 09268-17010	 0005546
73	Attachment for injection pump	Toyota Part No. 09957-04010	 0005547
74	Toyota electrical tester set	Toyota Part No. 09082-00050	 0005548
75	Engine adjust kit	Toyota Part No. 09200-00010	 0005549
76	Hose plug set for plug for fuel hose	Toyota Part No. 09258-00030	 0005501

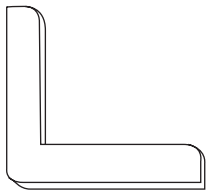
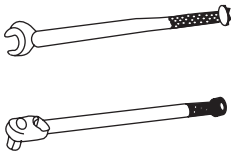
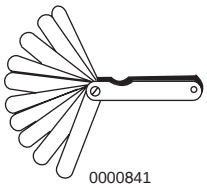
Equipment (Locally Available)

System	Equipment / Tool	Use
Engine	Caliper gauge	
	Connecting rod aligner	
	Cylinder gauge	
	Dial indicator	
	Dye penetrant	
	Engine tune up tester	
	Heater	
	Micrometer	
	Piston ring expander	
	Plastigage	
	Precision straight edge	
	Soft brush	
	Spring tester	Valve spring
	Steel square	Valve spring
	Thermometer	
	Torque wrench	
	Valve seat cutter	
	V-block	
	Vernier calipers	
Starter Motor	Dial indicator	Commutator
	Magnetic finger	
	Pull scale	Brush spring
	Sandpaper	Commutator
	Torque wrench	
	V-block	
	Vernier calipers	Commutator, Brush
Engine Oil Pump	Oil pressure gauge	
	Precision straight edge	
	Torque wrench	

System	Equipment / Tool	Use
Fuel System	Angle gauge	
	Brass brush	
	Dial indicator with magnetic base	
	Graduated cylinder	
	Injection nozzle tester	
	Injection pump tester	
	Inner pressure gauge	
	Micrometer	
	Steel square	
	Timer measuring device	
	Torque wrench	
	Vernier caliper	
	Wooden stick	

MEASURING INSTRUMENTS

No.	Instrument Name	Application	Illustration
1	Dial Indicator	Measure shaft bend and end play	 0000831
2	Test Indicator	Measurements of narrow or deep portions that cannot be measured by dial indicator	 0000832
3	Magnetic Stand	For holding the dial indicator when measuring	 0000833
4	Micrometer	For measuring the outside diameters of crankshaft, pistons, piston pins, etc.	 0000834
5	Cylinder Bore Gauge	For measuring the inside diameters of cylinder liners, bearing bores, etc.	 0000835
6	Calipers	For measuring outside diameters, depth, thickness and width	 0000836
7	Depth Micrometer	For measuring valve recession	 0000837

No.	Instrument Name	Application	Illustration
8	Square	For measuring valve spring inclination and straightness of parts	 0000838
9	Torque Wrench	For tightening nuts and bolts to the specified torque	 0000840
10	Feeler Gauge	For measuring piston ring gaps, piston ring clearance, fuel injector adjustment clearance, and valve adjustment clearance	 0000841

SPECIAL SERVICE MATERIALS (LOCALLY AVAILABLE)

Toyota P/N	Material	Location / Use
08826-00080	Seal packing, black or equivalent (FIPG - formed in place gasket)	Timing belt cover
		Timing gear cover
		Camshaft oil seal retainer
		Cylinder head semi-circular plug
		Cylinder head cover
		Main bearing cover
		Rear oil seal retainer
		Oil pump
		Oil pan
08826-00100	Seal packing 1282B, Three Bond 1282B or equivalent (FIPG - formed in place gasket)	Water temperature sender gauge
08833-00070	Adhesive 1344, Three Bond 1344, Loctite 242 or equivalent	Oil pressure sender gauge
		Taper screw plug on timing gear case

Special Service Materials Reference (Locally Available)

Material		Contents (Typical)	Features and Application
Liquid gasket	Three Bond® No. 1 TB1101	200 g (1 kg also available)	Non-drying liquid gasket; solventless type, easy to remove, superior seawater resistance, applicable to various mating surfaces
	Three Bond® No. 2 TB1102	200 g (1 kg also available)	Non-drying liquid gasket; easy to apply, superior water and oil resistance, especially superior gasoline/fuel resistance
	Three Bond® No. 3 TB1103	150 g	Drying film; low viscosity and forming of thin film, appropriate for mating surfaces of precision parts
	Three Bond® No. 4 TB1104	200 g (1 kg also available)	Semi-drying viscoelastic material, applicable for non-flat surfaces have indentions or protrusions, superior heat, water and oil resistance
	Three Bond® No. 10 TB1211	100 g	Solventless type silicone based sealant, applicable for high temperature areas -50 to 250°C (122 to 482°F)
	Three Bond® TB1212	100 g	Silicone based, non-fluid type, thick application possible
Adhesive	Loctite® TB1401	200 g	Prevention of loose fasteners, gasket leaks, and corrosion. Torque required to loosen fastener: 10 to 20% greater than tightened torque
	Loctite® Super TB1330B	50 g	Excellent adhesion strength, locks fastener semi-permanently
Pipe seal tape		5 m round tape	Sealing material for pipe threads. Ambient temperature range: -150 to -200°C (302 to 392°F)
O-ring kit		1.92-m diameter-1	O-ring of any size can be prepared as required. Including adhesives, release agents, cutters and jigs.
		2.42-m diameter-1	
		3.12-m diameter-1	
		3.52-m diameter-1	
		5.72-m diameter-1	
EP lubricant (molybdenum disulfate)	Lowcol Paste (Brand name)	50 g	For assembly of engine cylinders, pistons, metals, shafts, etc. Spray type application.
	Paste Spray (Brand name)	330 g	
	Molypaste (Brand name)	50 g	Prevention of seized threads at high temperatures. Applicable to exhaust and intake valves, stems, guides and face.

NOTICE: It is recommended that liquid gasket Three Bond® TB1212 should be used for service work. Before providing service, observe the cautions below:

1. Build up each sealant bead equally.
2. For bolt holes, apply liquid gasket to the inside surface of each hole.
3. Three Bond® TB1104 (Gray) or Three Bond® TB1102 (Yellow) is used with a gasket. The use of either of these sealant bonds without a gasket alone is not effecive.
4. If a gasket is used, do not use sealant TB1212.

WIRING DIAGRAMS

B-Type Instrument Panel

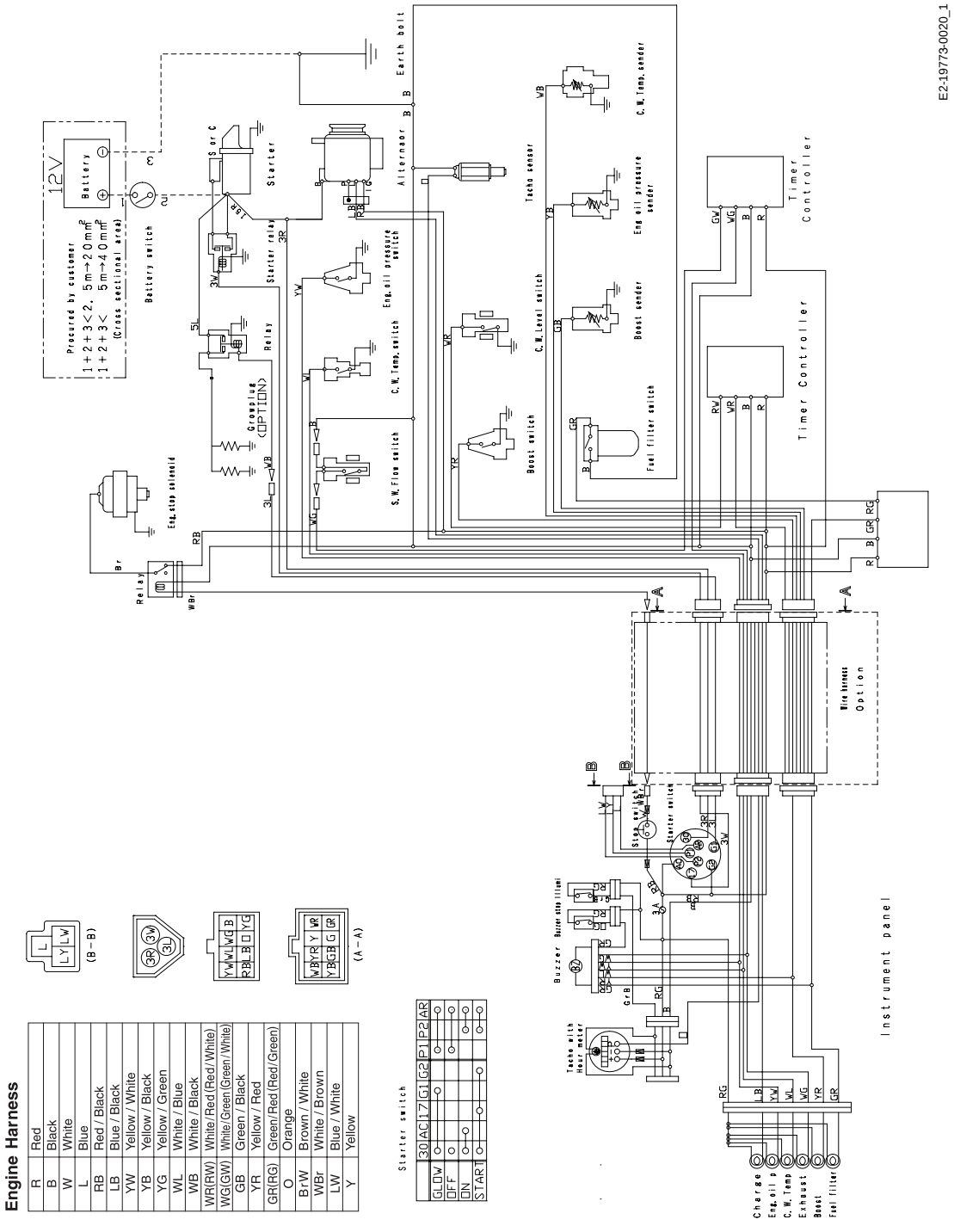


Figure 3-30

C/D-Type x B-Type Instrument Panel

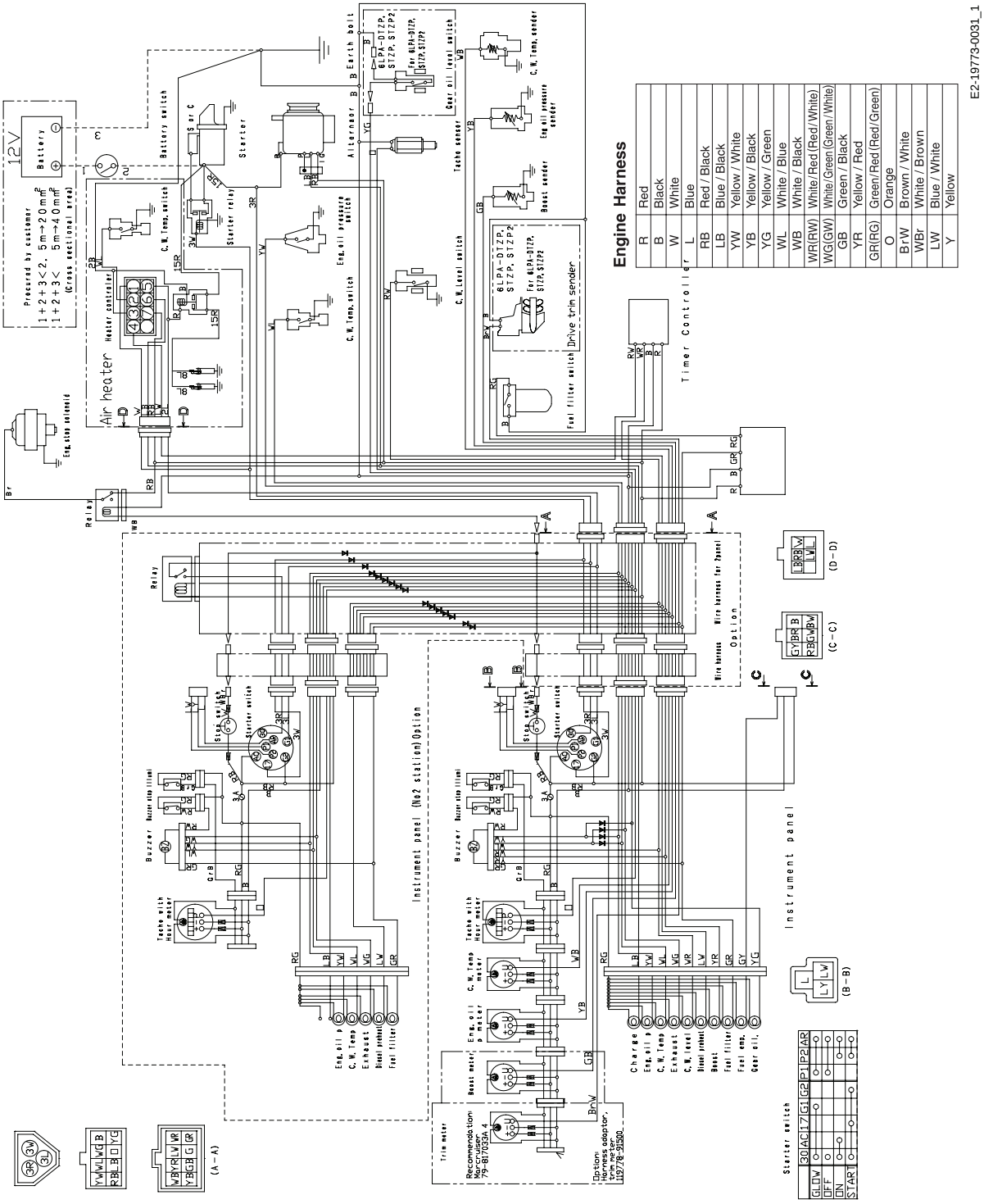


Figure 3-31

C/D-Type x C-Type Instrument Panel

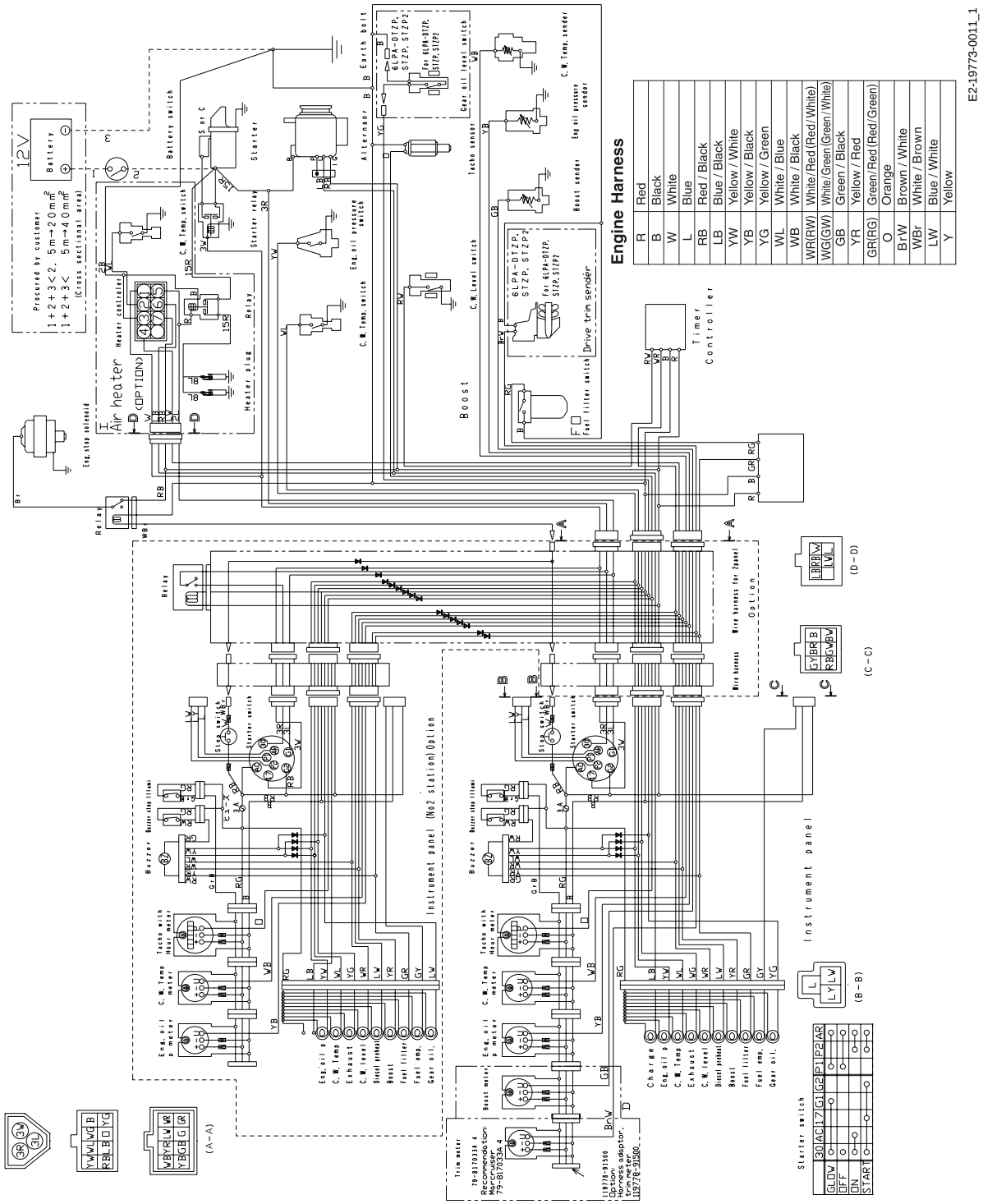


Figure 3-32

Section 4

PERIODIC MAINTENANCE

Page

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SAFETY PRECAUTIONS

Before you service the 6LPA-STP2/STZP2 marine engines, read the following safety information and review the *Safety Section on page 2-1*.

⚠ WARNING

The safety messages that follow have WARNING level hazards. These safety messages describe a hazardous situation which, if not avoided, *could* result in death or serious injury.

Exhaust Hazard

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.

Shock Hazard

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

Fire and Explosion Hazard

Diesel fuel is flammable and explosive under certain conditions.

NEVER use a shop rag to catch the fuel.

Wipe up all spills immediately.

Piercing Hazard

Avoid skin contact with high-pressure diesel fuel spray caused by a fuel system leak such as a broken fuel injection line. 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. Have your authorized Yanmar marine dealer or distributor repair the damage.

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.

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.

INTRODUCTION

This section of the *Service Manual* describes the procedures for proper care and maintenance of the engine.

The Importance of Periodic Maintenance

Engine deterioration and wear occurs in proportion to length of time the engine has been in service and the conditions the engine 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.

Performing Periodic Maintenance

WARNING! ***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. Accumulation of this gas within an enclosure could cause illness or even death. Make sure that all connections are tightened to specifications after repair is made to the exhaust system.***

Yanmar Replacement Parts

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

EPA REQUIREMENTS

To maintain optimum engine performance and compliance with the Environmental Protection Agency (EPA) Regulations for Engines, it is essential that you follow the *See Periodic Maintenance Schedule on page 4-6* and the *See Periodic Maintenance Procedures on page 4-9*.

EPA Requirements for USA and Other Applicable Countries

The EPA emission regulation is applicable only in the USA and other countries that have adapted the EPA requirements in part or in whole. Determine and follow the emission regulations in the country where your engine will be operating to assist you in specified compliance.

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

See *See Conditions to Ensure Compliance with EPA Emission Standards on page 4-5*. Clean or replace the air cleaner element if the air intake restriction exceeds the referenced specifications.

Conditions to Ensure Compliance with EPA Emission Standards

The following are the conditions that must be met in order to ensure that the emissions during operation meet the EPA standards.

The operating conditions should be as follows:

- Ambient temperature: -20 to 40°C (-4 to 104°F)
- Relative humidity: 80% or lower
- Permissible value for intake negative pressure: 2.0 kPa (204 mmAq) (8 in.Aq) or lower

The fuel and engine oil used should be as follows:

- Diesel fuel oil: ASTM D975 No. 1-D or No. 2-D, or equivalent (minimum of cetane No. 45)
- Engine Oil: Type API, Class CD of higher

Be sure to perform inspections as outlined in *Periodic Maintenance Procedures on page 4-9* and keep a record of the results.

Pay particular attention to these important points:

- Replacing the engine oil
- Replacing the oil filter
- Replacing the fuel filter
- Cleaning the intake silencer (air cleaner)

Note: Inspections are divided into two sections in accordance with who is responsible for performing the inspection: the user or the manufacturer.

Inspection and Maintenance

See Inspection and Maintenance of EPA Emission-Related Parts on page 4-8 for the EPA emission-related parts. Inspection and maintenance procedures not shown in the *Inspection and Maintenance of EPA Emission-Related Parts* section are covered in *Periodic Maintenance Schedule on page 4-6*.

This maintenance must be performed to keep the emission values of your engine in the standard values during the warranty period. The warranty period is determined by the age of the engine or the number of hours of operation.

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. **CAUTION!** ***Establish a periodic maintenance plan according to the engine application and make sure to perform the required periodic maintenance at intervals indicated. Failure to follow these guidelines will impair the engines safety and performance characteristics, shorten the engines life and may affect the warranty coverage of the engine.***

Note: The following procedures are considered normal maintenance and are performed at the owner's expense.

* For EPA requirements, see *Inspection and Maintenance of EPA Emission-Related Parts on page 4-8*.

○: Check or Clean ◇: Replace								
System	**Item**	**Periodic Maintenance Interval**						
		Daily	**Every 50 hours or one month whichever comes first**	**Every 125 hours or 6 months whichever comes first**	**Every 250 hours or one year whichever comes first**	**Every 500 hours or 2 years whichever comes first**	**Every 500 hours or 2 years whichever comes first**	**Every 1250 hours or 5 years whichever comes first**
Whole	Visual inspection of engine exterior	○						
Fuel System	Check the fuel level and refill if necessary	○						
	Drain water and sediment from the fuel tank		○					
	Drain the fuel / water separator		○					
	Replace the fuel filter element		◇ Initial 50		◇			
	Check the fuel injection timing						○	
	Check the fuel injector pressure and nozzle spray pattern*				○		◇	
Lubricating System	Check the engine oil level	○						
	Change the engine oil		◇ Initial 50	◇				
	Replace the engine oil filter element		◇ Initial 50	◇				
	Wash the engine oil cooler							○

○: Check or Clean ◇: Replace

System	Item	Periodic Maintenance Interval						
		Daily	Every 50 hours or one month whichever comes first	Every 125 hours or 6 months whichever comes first	Every 250 hours or one year whichever comes first	Every 500 hours or 2 years whichever comes first	Every 500 hours or 2 years whichever comes first	Every 1250 hours or 5 years whichever comes first
Marine Drive System	Check marine drive oil	○	Refer to the marine drive system operation manual					
	Check power steering oil	○						
	Check power trim oil	○						
	Check drive oil	○						
Freshwater Cooling System	Check coolant level	○						
	Change coolant				◇			
	Clean and check the cooling water passages							○
	Clean the cooling water system							○
Seawater Cooling System	Check seawater outlet discharge	○ During Operation						
	Check or replace the seawater pump impeller						◇	
	Check or replace zinc anodes				◇			
	Check and replace the seawater passages							◇
Piping	Clean or replace the exhaust / water mixing elbow					◇		
	Check or replace the fuel line and rubber hoses	○				◇		
Electrical System	Check the alarm indicators	○						
	Check the battery electrolyte level		○					
	Adjust the tension of the alternator V belt or replace the V belt					○		◇
Remote Control Handle	Check and lubricate the remote control cable operation	○						
	Adjust the remote control cable				○			
Intake and Exhaust System	Wash turbocharger blower				○			
	Clean air cleaner				○			
	Adjust the intake and exhaust valves				○ Initial 250		○	
	Lap the intake and exhaust valves						○	

○: Check or Clean ◇: Replace								
System	Item	Periodic Maintenance Interval						
		Daily	Every 50 hours or one month whichever comes first	Every 125 hours or 6 months whichever comes first	Every 250 hours or one year whichever comes first	Every 500 hours or 2 years whichever comes first	Every 500 hours or 2 years whichever comes first	Every 1250 hours or 5 years whichever comes first
Miscellaneous Items	Check and adjust the power steering oil pump belt (6LPA-STZP2 only)					○		
	Replace the timing belt							◇
	Replace the front rubber damper							◇

Inspection and Maintenance of EPA Emission-Related Parts

Parts	Interval
Clean fuel injection nozzle	1500 hours
Check fuel injection nozzle adjustment	3000 hours
Check fuel injection pump adjustment	
Check turbocharger adjustment	
Check electronic engine control unit (ECU) and its associated sensors and actuators	

Note: The inspection and maintenance items shown above are to be performed by a Yanmar Marine dealer.

PERIODIC MAINTENANCE PROCEDURES

After Initial 50 Hours of Operation

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

- **Changing the Engine Oil and Replacing the Engine Oil Filter Element**
- **Changing the Fuel Filter Element**

Changing the Engine Oil and Replacing the Engine Oil Filter Element

The engine oil on a new engine becomes contaminated from the initial break-in of internal parts. It is very important that the initial oil replacement is performed as scheduled.

It is easiest and most effective to drain the engine oil after operation while the engine is still warm. **WARNING!** ***If you must drain the engine oil while it is still hot, stay clear of the hot engine oil to avoid being burned. ALWAYS wear eye protection.***

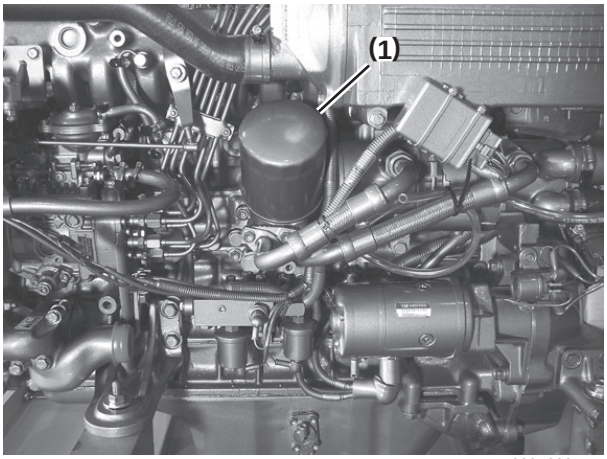

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Figure 4-1

1. Turn the engine OFF.
2. Remove the engine oil dipstick. Attach the oil drain pump (if equipped) and pump out the oil. For easier draining, remove the engine oil fill cap. *NOTICE: Prevent dirt and debris from contaminating engine oil. Carefully clean the dipstick and the surrounding area before you remove the dipstick.*
3. Turn the engine oil filter **(Figure 4-1, (1))** counterclockwise with a wrench.
4. Remove the engine oil filter.
5. Apply a small amount of engine oil to the seal of the new filter.
6. Install a new filter element and tighten by hand until the seal touches the housing.
7. Turn filter an additional 3/4 turn with a filter wrench.

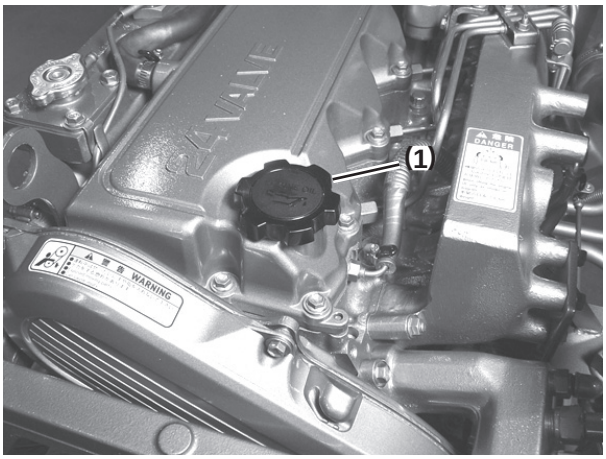

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Figure 4-2

8. Remove filler cap **(Figure 4-2, (1))** and fill with new engine oil through filler port. *See Adding Engine Oil on page 3-23*. *NOTICE: NEVER mix different types of engine oil. This may adversely affect the lubricating properties of the engine oil. NEVER overfill. Overfilling may result in white exhaust smoke, engine overspeed or internal damage.*
9. Perform a trial run and check for oil leaks.
10. Approximately 10 minutes after stopping the engine, remove the oil dipstick and check the oil level. Add oil if the level is too low.
11. Dispose of waste properly. *NOTICE: ALWAYS be environmentally responsible*.

Replacing the Fuel Filter Element

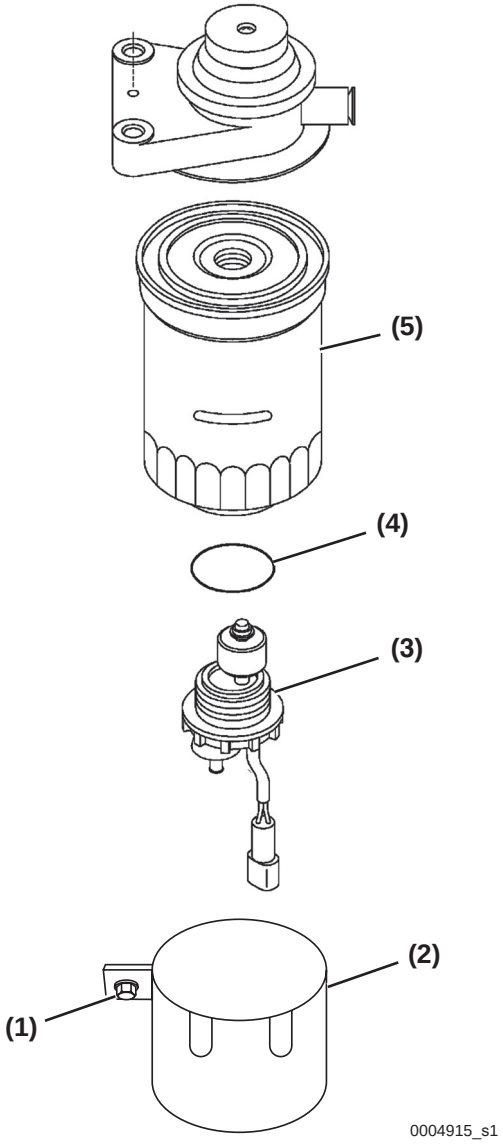

Figure 4-3

1 – Mounting Screw (2 used)
2 – Housing
3 – Alarm Switch
4 – O-Ring
5 – Filter Element

1. Close the fuel cock on the fuel tank.
2. Remove the two mounting screws **(Figure 4-3, (1))** and the housing **(Figure 4-3, (2))**.
3. Drain the fuel from the fuel drain cock on the bottom of the fuel / water separator.
4. Disconnect the alarm switch harness.
5. Remove the alarm switch **(Figure 4-3, (3))** with a wrench.
6. Remove the filter element **(Figure 4-3, (5))** with a filter wrench.

Component	Part No.
Fuel Filter Element	119773-55710

7. Install the alarm switch to the new fuel filter.
8. Apply a thin film of clean diesel fuel to the sealing surface of the new filter gasket.
9. Install the new filter and tighten hand-tight. Use a filter wrench and tighten to 14.7 to 19.6 N·m (130.1 to 173.5 lb-in.).
10. Install filter and tighten hand-tight.
11. Connect the alarm switch harness.
12. Install the housing and mounting screws.
13. Bleed the fuel system. *See Bleeding the Fuel System on page 3-21*.
14. Dispose of waste properly. *NOTICE: ALWAYS be environmentally responsible*.
15. Start engine and check for leaks. **WARNING! *NEVER check for fuel leaks with your hand.***

Every 50 Hours of Operation

After you complete the initial 50 hour maintenance procedures, perform the following procedures every 50 hours thereafter or monthly, whichever comes first

- **Draining Water from the Fuel Tank**
- **Draining Fuel Filter / Water Separator**
- **Checking Battery Electrolyte Level (Serviceable Batteries Only)**

Draining Water from the Fuel Tank

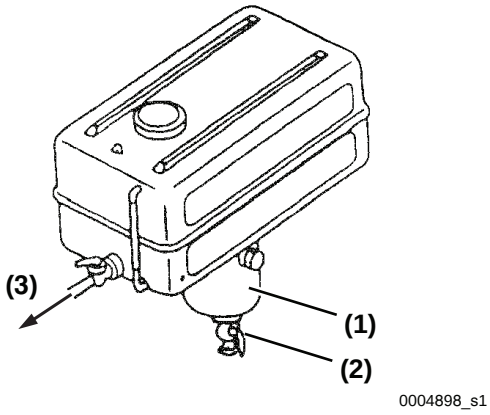

Figure 4-4

1 – Sediment Bowl
2 – Drain Cock
3 – Fuel Line to Engine

1. Put a pan under the drain cock **(Figure 4-4, (2))** to catch fuel.
2. Open the drain cock and drain water and sediment. Close the drain cock when the fuel is clean and free of air bubbles.
3. Dispose of waste properly. *NOTICE: ALWAYS be environmentally responsible*.

Draining Fuel Filter / Water Separator

Water and sediment can clog the fuel filter and impair the function of the fuel injection pump and valve. If heavy deposits of water and sediment are drained, also drain the fuel tank.

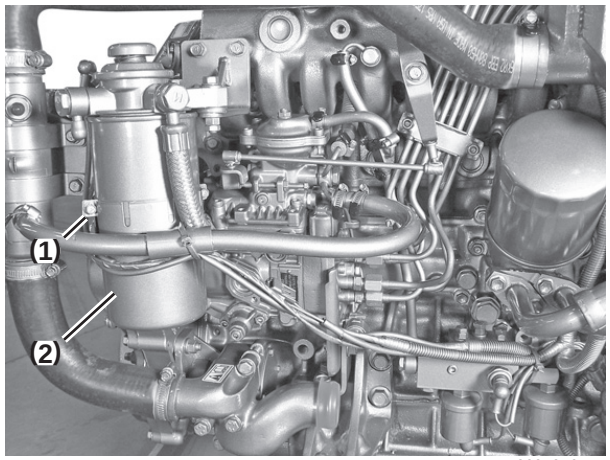

Figure 4-5

1. Close the fuel cock of the fuel tank.
2. Remove the two mounting screws **(Figure 4-5, (1))** and remove the housing **(Figure 4-5, (2))**.
3. Loosen the drain plug of the water separator and drain off any water or dirt collected inside.
4. Install housing and mounting screws.
5. Bleed air from the fuel system. *See Bleeding the Fuel System on page 3-21*.

Checking the Battery Electrolyte Level (Serviceable Batteries Only)

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.***

NOTICE: NEVER turn off the battery switch (if equipped) or short the battery cables during operation. Damage to the electric system will result.

Note: Battery fluid tends to evaporate in high temperatures, especially in summer. In such conditions, inspect the battery earlier than specified.

1. Turn the battery master switch to OFF (if equipped) or disconnect the negative (-) battery cable.
2. Remove the plugs and check the electrolyte level in all cells. *NOTICE: NEVER attempt to remove the covers or fill a maintenance-free battery*.
3. If the level is lower than the minimum fill level **(Figure 4-6)**, fill with distilled water **(Figure 4-6)** up to the upper limit **(Figure 4-6)** of the battery. **WARNING! *If operation continues with insufficient battery fluid, the battery life is shortened, and the battery may overheat and explode.***

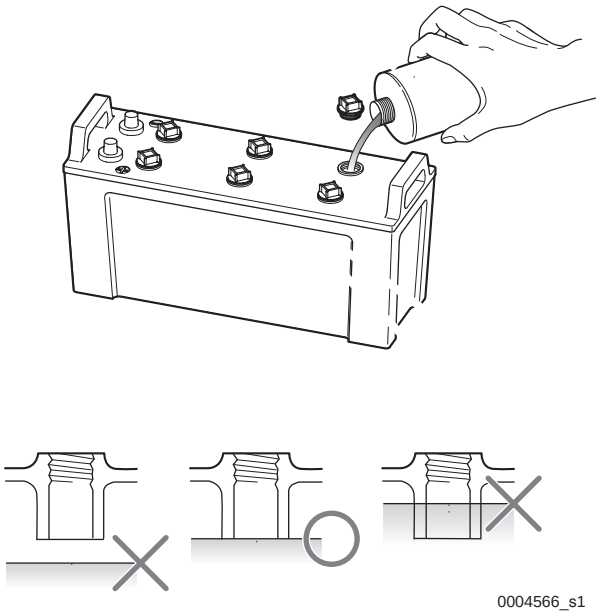

Figure 4-6

Every 125 Hours of Operation

Perform the following maintenance every 125 hours of operation or 6 months, whichever comes first.

- **Changing the Engine Oil and Replacing the Engine Oil Filter**

Changing the Engine Oil and Replacing the Engine Oil Filter

See Changing the Engine Oil and Replacing the Engine Oil Filter Element on page 4-9.

After Initial 250 Hours of Operation

Perform the following maintenance after the initial 250 hours of operation.

- **Checking the Fuel Injector Spray Pattern**
- **Inspecting and Adjusting Intake / Exhaust Valve Clearance**

Checking the Fuel Injector Spray Pattern

See Spray Test on page 6-15.

Inspecting and Adjusting Intake / 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 Valve Clearance Inspection and Adjustment on page 5-90*.

Every 250 Hours of Operation

Every 250 Hours of Operation Perform the following maintenance every 250 hours or one year of operation, whichever comes first.

- **Replacing the Fuel Filter Element**
- **Changing the Coolant**
- **Checking or Replacing the Zinc Anodes**
- **Checking and Adjusting the Remote Control Cable**
- **Cleaning the Turbocharger**
- **Cleaning the Air Cleaner**

Replacing the Fuel Filter Element

See Replacing the Fuel Filter Element on page 4-10.

Changing the Coolant

Replace the coolant every year.

Note: If Long Life coolant is used, replace coolant every 2 years. **WARNING! *Wear eye protection and rubber gloves when you handle Long Life engine coolant.***

1. Drain the freshwater cooling system. *See Draining the Freshwater Cooling System on page 3-26*.
2. Fill the cooling system with clean coolant. *See Checking and Adding Engine Coolant on page 3-25*.

Checking or Replacing Zinc Anodes

Inspect and replace the zinc anodes periodically. *NOTICE: If zinc anodes are not replaced periodically, corrosion and engine damage will result*.

1. Close the seacock.
2. Drain the seawater cooling system. *See Draining Seawater Cooling System on page 3-26*.

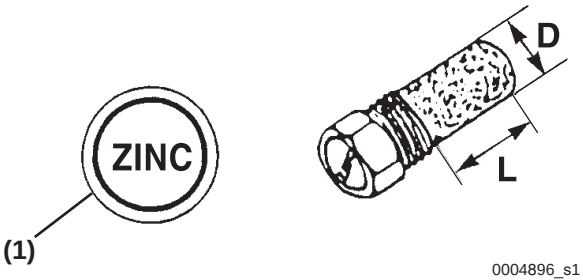

Figure 4-7

3. Remove all the plugs labeled ZINC **(Figure 4-7, (1))**.
   - Fuel Cooler **(Figure 4-8, (1))**
   - Freshwater Cooler **(Figure 4-9, (4))**
   - Intercooler **(Figure 4-11, (2))** and **(Figure 4-12, (2))**
   - Engine Oil Cooler **(Figure 4-11, (3))**
4. Measure the remaining zinc in the plug. Replace the zinc anode when it is less than one-half its original size. See chart for sizes.

Location	Part Number	Qty.	Dimensions D X L
Fuel Cooler	119574-44150	1	12.7 x 25.4 mm (0.5 x 1.0 in.)
Engine Oil Cooler		2	
Freshwater Cooler		2	
Intercooler	119574-18790	1	

Note: Some marine drives have additional zinc anodes. Check the manufacturer's documentation for location and other information.

5. Install a new zinc in a new plug. *NOTICE: NEVER use sealing tape to install the zinc anode. The anode must make metal-to-metal contact*.
6. Install plug.
7. Open the seacock and check for leaks.

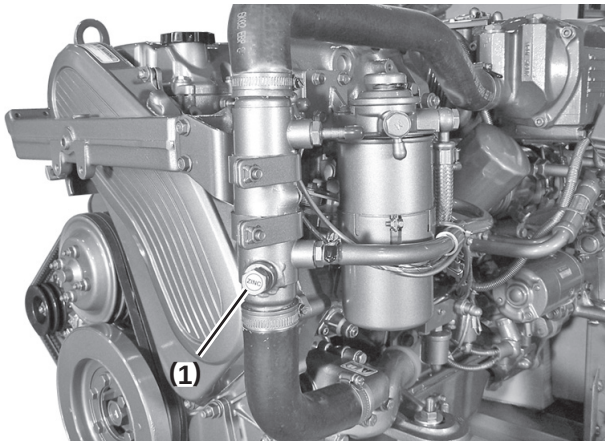

Figure 4-8

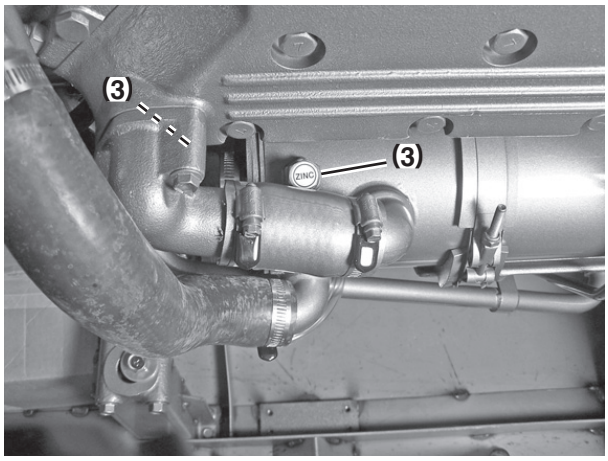

Figure 4-9

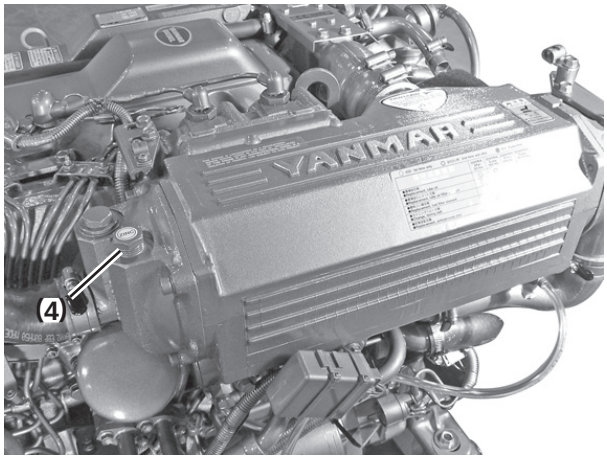

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Figure 4-10

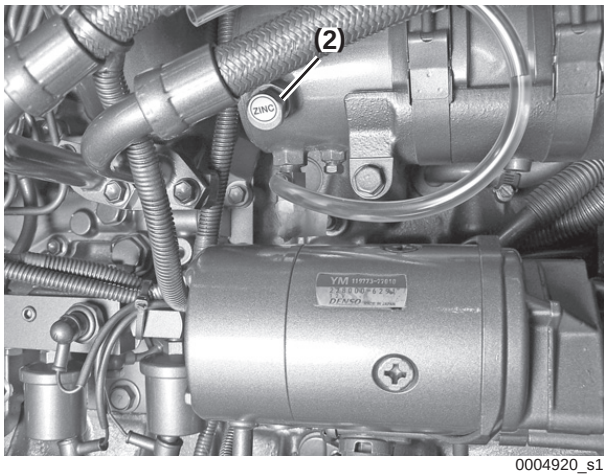

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Figure 4-11

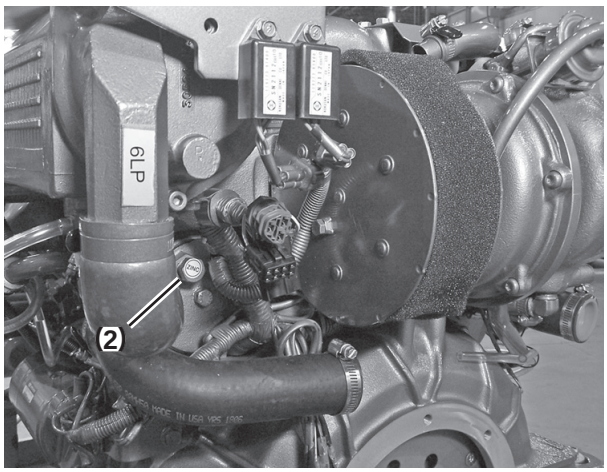

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Figure 4-12

Checking and Adjusting Remote Control Cables

Note: Never adjust the high speed stop bolt on the governor. This will void the engine warranty.

Adjusting Engine Speed (Governor) Remote Control Cable

Adjusting Clutch Remote Control Cable

Refer to the manufacturer's documentation.

Cleaning the Turbocharger

Contamination of the turbocharger causes revolutions to drop and engine output to fall.

If a significant drop in engine output is noted (10% or more), clean the turbocharger. See *Inspection and Cleaning on page 9-14*.

Cleaning the Air Cleaner

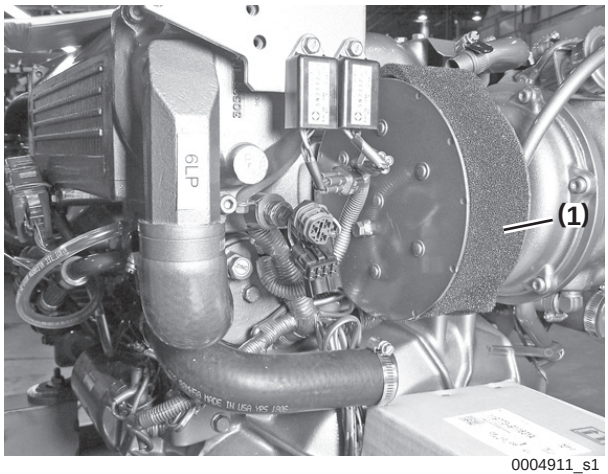

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Figure 4-13

1. Slide air cleaner **(Figure 4-13, (1))** off the air inlet.
2. Clean the air cleaner with detergent
3. Allow to air dry and install on the air inlet. *NOTICE: Replace the air cleaner if unable to clean or if damaged*.

Every 500 Hours of Operation

Perform the following maintenance every 500 hours or 2 years of operation, whichever comes first.

- **Cleaning or Replacing Exhaust / Water Mixing Elbow**
- **Replacing Fuel Line and Rubber Hoses**
- **Checking and Adjusting the Alternator V-Belt**
- **Checking and Adjusting the Power Steering Oil Pump Belt (6LPA-STZP2 Models)**

Cleaning or Replacing Exhaust / Water Mixing Elbow

Clean or replace the exhaust / water mixing elbow every 500 hours or 2 years, whichever comes first.

Replacing Fuel Line and Rubber Hoses

Replace fuel line and rubber hoses every 500 hours or 2 years, whichever comes first.

NOTICE: Replace rubberized fuel hoses every two years or every 500 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 500 hours of engine operation, whichever comes first.

Checking and Adjusting the Alternator V-Belt Tension

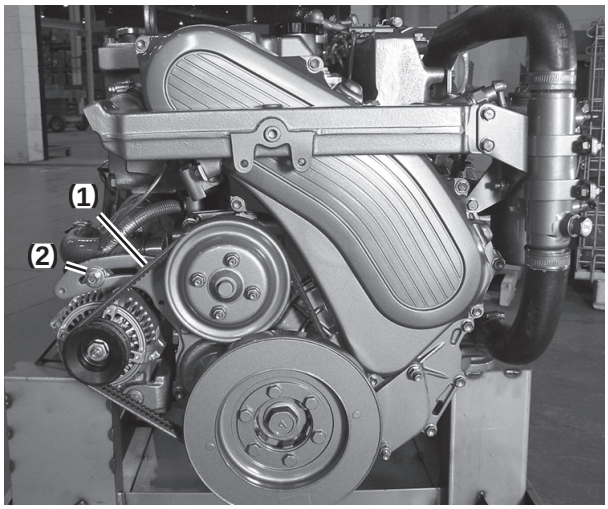

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Figure 4-14

NOTICE: NEVER allow oil on the belt(s). Oil on the belt causes slipping and stretching. Replace the belt if it is damaged. NEVER over-tighten the belt(s) or engine damage will result.

1. Check the belt by pushing on the middle of the belt **(Figure 4-14, (1))** with your finger. With proper tension, the belt should deflect 8 to 10 mm (approximately 3/8 in.).
2. Loosen the alternator bolt **(Figure 4-14, (2))** and move the alternator to adjust the V-belt tension.
3. Replace the V-belt if required.

Alternator V-Belt Part Number
119775–77260

Checking and Adjusting the Power Steering Oil Pump Belt (6LPA-STZP2 Models)

NOTICE: NEVER allow oil on the belt(s). Oil on the belt causes slipping and stretching. Replace the belt if it is damaged. NEVER over-tighten the belt(s) or engine damage will result.

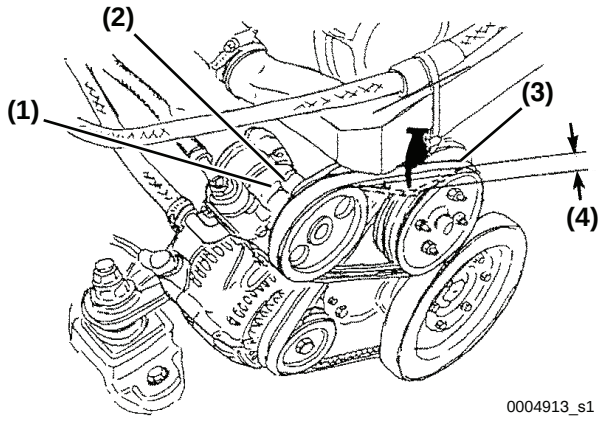


Figure 4-15

1. Check the belt by pushing on the middle of the belt **(Figure 4-15, (3))** with your finger. With proper tension, the belt should deflect 8 to 10 mm (approximately 3/8 in.) **(Figure 4-15, (4))**.
2. Loosen the power steering pump bolt **(Figure 4-15, (2))** and move the oil pump **(Figure 4-15, (1))** to adjust the belt tension.
3. Replace the belt if required.

Power Steering Oil Pump Belt Part Number (6LPA-STZP2 only)
119787–26540

Every 1000 Hours of Operation

Every 1000 Hours of Operation Perform the following maintenance every 1000 hours or 4 years of operation, whichever comes first.

- **Checking the Fuel Injection Timing**
- **Checking the Fuel Injector Pressure and Nozzle Spray Pattern**
- **Checking or Replacing the Seawater Pump Impeller**
- **Adjusting Intake and Exhaust Valve Clearances**
- **Lapping the Intake and Exhaust Valves**

Checking the Fuel Injection Timing

See Injection Timing Inspection and Adjustment on page 5-93.

Checking the Fuel Injector Pressure and Nozzle Spray Pattern

See Spray Test on page 6-15.

Checking or Replacing Seawater Pump Impeller

NOTICE: When turning the engine by hand, be sure to turn it in the correct direction. Turning it in the opposite direction damages the blades of the impeller.

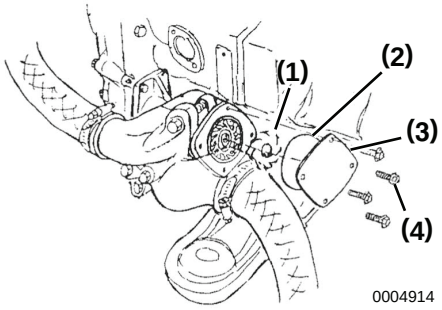


Figure 4-16

1 – Impeller
2 – O-Ring
3 – Cover
4 – Cover Bolts

1. Close the seacock. Drain the seawater cooling system. *See Draining Seawater Cooling System on page 3-26*.
2. Loosen the cover bolts and remove the cover and O-ring.
3. Inspect the inside of the seawater pump with a flashlight. If any of the following are found, disassembly and maintenance are required:
   - Impeller blades are cracked or nicked. Edges or surfaces of the blades are marred or scratched.
   - Wear plate is damaged.
4. If no damage is found when inspecting the inside of the pump, install the O-ring and cover.
5. If a large amount of water leaks continuously from the water drain line below the seawater pump during operation, replace the mechanical seal.

   NOTICE: Replace the seawater pump impeller every 1000 hours even if no damage is apparent.

Adjusting Intake / Exhaust Valve Clearance

See Valve Clearance Inspection and Adjustment on page 5-90.

Lapping the Intake and Exhaust Valve

See Valve Seat Inspection and Servicing on page 5-24.

Every 1250 Hours of Operation

Every 1250 Hours of Operation Perform the following maintenance procedures every 1250 hours of operation or 5 years, whichever comes first.

- **Cleaning the Cooling Water System**
- **Cleaning and Checking the Seawater Cooling Passage**
- **Cleaning and Checking the Freshwater Cooling Water Passage**
- **Adjusting the Tension of the Alternator V-Belt**
- **Replacing the Timing Belt**
- **Washing Engine Oil Cooler**

Cleaning the Cooling Water System

See Cooling System on page 7-1.

Cleaning and Checking the Seawater Cooling Passage

See Seawater Pump Disassembly on page 7-8.

Cleaning and Checking the Freshwater Cooling Water Passage

See Freshwater Pump Removal on page 7-5.

Adjusting the Tension of the Alternator V-Belt

See Checking and Adjusting the Alternator V-Belt Tension on page 4-16.

Replacing the Timing Belt

See Timing Belt Removal on page 5-69.

Washing Engine Oil Cooler

See Oil Cooler Removal on page 8-14.

Replacing the Front Rubber Damper

Replace the Front Rubber Damper.

Section 5

ENGINE

Page

SAFETY PRECAUTIONS

Before you service the engine, read the following safety information and review the *Safety Section on page 2-1*.

⚠ WARNING

This safety message that follows has a WARNING level hazard. The safety message describes a hazardous situation, which, if not avoided, *could* result in death or serious injury.

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.

NOTICE

NEVER attempt to adjust the low or high idle speed limit screw. This may impair the safety and performance of the engine and shorten its life. If adjustment is ever required, see your authorized Yanmar marine dealer or distributor.

INTRODUCTION

This section of the *Service Manual* describes the disassembly, inspection, and reassembly of the 6LPA-STP2/STZP2 engines.

SPECIFICATIONS

Principal Engine Specifications

See Principal Engine Specifications on page 3-27.

Engine Service Standards

Item	Description		Specification
Injection timing	Plunger stroke at aligning match mark between front pulley and timing cover		1.48 to 1.54 mm (0.058 to 0.061 in.)
Timing gear	Idler gear thrust clearance	Standard	0.05 to 0.15 mm (0.002 to 0.006 in.)
		Limit	0.3 mm (0.012 in.)
	Idler gear inside diameter		45.000 to 45.025 mm (1.771 to 1.773 in.)
	Idler gear shaft diameter		44.950 to 44.975 mm (1.769 to 1.770 in.)
	Idler gear oil clearance	Standard	0.025 to 0.075 mm (0.001 to 0.003 in.)
		Limit	0.20 mm (0.008 in.)
	Gear backlash	Standard	0.05 to 0.15 mm (0.002 to 0.006 in.)
		Limit	0.30 mm (0.012 in.)
Cylinder head	Combustion surface warpage	Limit	0.20 mm (0.008 in.)
	Valve seat re-facing	Intake	20°, 45°, 70°
		Exhaust	25°, 45°, 65°
	Valve seat contacting angle		45°
	Valve seat contacting width	Intake	1.4 to 1.8 mm (0.055 to 0.071 in.)
		Exhaust	1.6 to 2.0 mm (0.063 to 0.079 in.)
	Head bolt thread diameter	Standard	10.800 to 11.000 mm (0.425 to 0.433 in.)
		Limit	10.55 mm (0.415 in.)
Valve guide	Inside Diameter		7.010 to 7.030 mm (0.276 to 0.277 in.)

Item	Description		Specification
Valve	Valve overall length	Standard: Intake	126.85 to 127.45 mm (4.994 to 0.5.018 in.)
		Exhaust	126.43 to 127.03 mm (4.977 to 5.001 in.)
		Limit: Intake	126.85 mm (4.994 in.)
		Exhaust	126.43 mm (4.977 in.)
	Stem diameter	Intake	6.975 to 7.985 mm (0.275 to 0.314 in.)
		Exhaust	6.960 to 6.975 mm (0.274 to 0.275 in.)
	Stem oil clearance	Intake	0.020 to 0.055 mm (0.0008 to 0.0022 in.)
		Exhaust	0.020 to 0.055 mm (0.0008 to 0.0022 in.)
		Limit: Intake	0.08 mm (0.003 in.)
		Limit: Exhaust	0.10 mm (0.004 in.)
	Margin thickness	Standard: Intake	1.00 mm (0.040 in.)
		Exhaust	1.00 mm (0.040 in.)
		Limit: Intake	0.83 mm (0.033 in.)
		Limit: Exhaust	0.83 mm (0.033 in.)
Valve spring	Deviation	Limit	2.0 mm (0.080 in.)
	Free Length	Limit	49.6 mm (1.952 in.)
Valve rocker arm and shaft	Valve rocker arm inside diameter		20.012 to 20.033 mm (0.788 to 0.789 in.)
	Valve rocker arm shaft diameter		19.972 to 19.993 mm (0.786 to 0.787 in.)
	Oil clearance	Standard	0.019 to 0.061 mm (0.0007 to 0.0024 in.)
		Limit	0.10 mm (0.004 in.)

Item	Description		Specification
Camshaft	Thrust clearance	Standard	0.100 to 0.200 mm (0.004 to 0.008 in.)
		Limit	0.30 mm (0.012 in.)
	Journal oil clearance	Standard 1	0.022 to 0.074 mm (0.0009 to 0.0030 in.)
		Others	0.030 to 0.066 mm (0.001 to 0.003 in.)
		Limit	0.10 mm (0.004 in.)
	Journal diameter	1	34.969 to 34.985 mm (1.3767 to 1.3773 in.)
		Others	27.986 to 27.998 mm (1.1018 to 1.1022 in.)
	Circle runout	Limit	0.10 mm (0.004 in.)
	Cam lobe height - Standard	Intake	48.498 to 48.598 mm (1.9093 to 1.9133 in.)
		Exhaust	50.734 to 50.834 mm (1.997 to 2.0001 in.)
	Cam lobe height - Limit	Intake	47.998 mm (1.890 in.)
		Exhaust	50.234 mm (1.978 in.)
Cylinder block	Cylinder top surface warpage	Maximum	0.20 mm (0.008 in.)
	Cylinder bore diameter	Standard: Mark 1	94.000 to 94.010 mm (3.7007 to 3.7011 in.)
		Standard: Mark 2	94.010 to 94.020 mm (3.7011 to 3.7015 in.)
		Standard: Mark 3	94.020 to 94.030 mm (3.7015 to 3.7019 in.)
		Limit	94.23 mm (3.7098 in.)
	Main bearing cap bolt thread	Standard	11.800 to 12.000 mm (0.4645 to 0.4724 in.)
	Outside diameter	Minimum	11.50 mm (0.453 in.)

Item	Description		Specification
Piston and piston ring	Piston diameter	Standard: Mark 1	93.835 to 93.845 mm (3.694 to 3.695 in.)
		Standard: Mark 2	93.845 to 93.855 mm (3.6946 to 3.6950 in.)
		Standard: Mark 3	93.855 to 93.865 mm (3.6950 to 3.6954 in.)
	Piston oil clearance	Standard	0.145 to 0.165 mm (0.0057 to 0.0064 in.)
		Limit	0.215 mm (0.0084 in.)
	Piston ring groove clearance	Standard: No. 1	0.050 to 0.095 mm (0.002 to 0.004 in.)
		Standard: No. 2	0.060 to 0.100 mm (0.002 to 0.004 in.)
		Standard Oil	0.030 to 0.070 mm (0.001 to 0.003 in.)
		Limit	0.20 mm (0.008 in.)
	Piston ring end gap	Standard: No. 1	0.270 to 0.470 mm (0.011 to 0.018 in.)
		Standard: No. 2	0.400 to 0.650 mm (0.016 to 0.025 in.)
		Standard Oil	0.200 to 0.500 mm (0.008 to 0.020 in.)
		Limit: No. 1	0.85 mm (0.0334 in.)
		Limit: No. 2	0.90 mm (0.0354 in.)
		Limit Oil	0.88 mm (0.0346 in.)

Item	Description		Specification
Connecting Rod	Thrust clearance	Standard	0.100 to 0.200 mm (0.004 to 0.008 in.)
		Limit	0.30 mm (0.010 in.)
	Oil clearance	Standard	0.036 to 0.054 mm (0.001 to 0.002 in.)
		Limit	0.10 mm (0.004 in.)
	Crank pin bearing wall thickness	Standard Mark 2	1.486 to 1.489 mm (0.0585 to 0.0586 in.)
		Standard Mark 3	1.489 to 1.492 mm (0.0586 to 0.0587 in.)
		Standard Mark 4	1.492 to 1.495 mm (0.0587 to 0.0588 in.)
		Standard Mark 5	1.495 to 1.498 mm (0.0588 to 0.0589 in.)
		Standard Mark 6	1.498 to 1.501 mm (0.0589 to 0.0590 in)
	Rod Bend	Limit / 100 mm	0.03 mm (0.040 in.)
	Rod Twist	Limit / 100 mm	0.15 mm (0.045 in.)
	Piston pin bearing inside diameter		33.008 to 33.020 mm (1.2995 to 1.2999 in.)
	Piston pin diameter		33.000 to 33.012 mm (1.2992 to 1.2996 in.)
	Piston pin bearing oil clearance	Standard	0.004 to 0.012 mm (0.0001 to 0.0005 in.)
		Limit	0.03 mm (0.001 in.)
	Connecting rod bolt diameter of tension portions	Standard	8.300 to 8.400 mm (0.3267 to 0.3307 in.)
		Limit	7.95 mm (0.3129 in.)
Crankshaft	Thrust clearance	Standard	0.040 to 0.240 mm (0.0015 to 0.0094 in.)
		Limit	0.30 mm (0.019 in.)
	Thrust bearing thickness		2.930 to 2.980 mm (0.1153 to 0.1173 in.)
	Crank journal oil clearance	Standard	0.036 to 0.054 mm (0.0014 to 0.0021 in.)
		Limit	0.10 mm (0.004 in.)
	Crank journal diameter	Standard Mark 1	66.994 to 67.00 mm (2.6375 to 2.6377 in.)
		Standard Mark 2	66.988 to 66.994 mm (2.6373 to 2.6375 in.)
		Standard Mark 3	66.982 to 66.988 mm (2.6370 to 2.6373 in.)

Item	Description		Specification
Crankshaft	Crank journal bearing thickness	Standard Mark 2	1.979 to 1.982 mm (0.0779 to 0.0780 in.)
		Standard Mark 3	1.982 to 1.985 mm (0.0780 to 0.0781 in.)
		Standard Mark 4	1.985 to 1.988 mm (0.0781 to 0.0782 in.)
		Standard Mark 5	1.988 to 1.991 mm (0.0782 to 0.0783 in.)
		Standard Mark 6	1.991 to 1.994 mm (0.0783 to 0.0785 in.)
	Crank pin diameter	Standard Mark 1	58.994 to 59.000 mm (2.3225 to 2.3228 in.)
		Standard Mark 2	58.988 to 58.994 mm (2.3223 to 2.3225 in.)
		Standard Mark 3	58.982 to 58.988 mm (2.3221 to 2.3223 in.)
	Circle runout	Limit	0.06 mm (0.0023 in.)
	Journal taper and out-of-round	Limit	0.02 mm (0.0008 in.)
	Crank pin taper and out-of-round	Limit	0.02 mm (0.0008 in.)

Adjustment Specifications

No.	Item			Standard Specification	Remarks
1	Fuel injection timing - plunger stroke			1.51 ±0.03 mm (0.059 ±0.01 in.)	FID 12±0.5%TDC
2	FID			12 ± 0.5° BTDC	-
3	Fuel injection pressure		kgf/cm^2	250 +10 / -0 / (300 +10 / -0)	1st (2nd) stage
			MPa	24.52 +0.1 / -0 (29.42 +0.1 / -0)	
			psi	3555.8 +142.2 (4267 +142.2)	
4	Valve clearance		Intake	0.17 to 0.23 mm (0.007 to 0.009 in.)	Measured with engine cold / room temperature.
			Exhaust	0.47 to 0.53 mm (0.018 to 0.020 in.)	
5	Low idling		rpm	750 +25/0	-
6	High idling		rpm	4280 ±25	-
7	Valve timing - degrees	Intake	Open	BTDC:12	-
			Close	ABDC:24	-
		Exhaust	Open	BBDC:54	-
			Close	ATDC:12	-
8	Firing order			120° 120° 120° 120° 120° 120°	No. 1 cylinder is located opposite the flywheel side of the engine.
				1 - 4 - 2 - 6 - 3 - 5 - 1	
9	Oil pressure		kgf/cm^2	4.5	At 3800 rpm
			MPa	0.44	
			psi	64	
10	Oil capacity (oil pan)			8. 4L (8.8 qt) / 1. 4L (1.4 qt)	Full / Effective
11	Oil path capacity			2.1L (2.2 qt)	-
12	Freshwater capacity			13.5L (14.2 qt)	-
13	Freshwater thermostat			70 ±2°C (158 ±3°F)	Valve opening temp. °C
				10 mm (0.393 in.) or more	Lift at full open
14	Delivery capacity of seawater pump			135L (142.6 qt) or more	Pump shaft speed at 3800 rpm
					Total head: 10 m Aq, 98kPa (14.2 psi)

Special Torque Chart

Component		Specification
Fuel injection pump x Timing gear case		185 kgf/cm^2,18.14 N·m (13.6 lb-ft)
Fuel injection pump x Fuel injection pump stay		700 kgf/cm^2, 68.65 N·m (50.6 lb-ft)
Fuel injection pump drive gear x Fuel injection pump		1000 kgf/cm^2, 98.07 N·m (72.3 lb-ft)
Fuel injection pump stay x Cylinder block		700 kgf/cm^2, 68.65 N·m (50.6 lb-ft)
Fuel injection nozzle mounting bolt x Cylinder head		255 kgf/cm^2, 25.01 N·m (18.4 lb-ft)
No. 1 Camshaft timing pulley x Camshaft		1000 kgf/cm^2, 98.07 N·m (72.3 lb-ft)
No. 2 Camshaft timing pulley x Fuel injection pump drive gear		315 kgf/cm^2, 30.89 N·m (22.8 lb-ft)
Idler pulley x Timing gear cover		350 kgf/cm^2, 34.32 N·m (25.3 lb-ft)
Timing belt tensioner x Timing gear cover		130 kgf/cm^2, 12.75 N·m (9.4 lb-ft)
Idler gear x Cylinder block		694 kgf/cm^2, 68.06 N·m (50.2 lb-ft)
Timing gear cover, Cylinder block x Timing gear case		200 kgf/cm^2, 19.61 N·m (14.5 lb-ft)
Camshaft bearing cap x Cylinder head		250 kgf/cm^2, 24.52 N·m (18.08 lb-ft)
Camshaft oil seal retainer x Cylinder head		200 kgf/cm^2, 19.61 N·m (14.5 lb-ft)
Main bearing cap x Cylinder block	(12 pointed head)*	1050 kgf/cm^2, 102.97 N·m (75.9 lb-ft) (90° Retightening)
	(6 pointed head)	185 kgf/cm^2, 18.14 N·m (13.38 lb-ft)
Crankshaft pulley x Crankshaft		4400 kgf/cm^2, 431.50 N·m (318.3 lb-ft)
Flywheel x Crankshaft		1300 kgf/cm^2, 127.50 N·m (94 lb-ft)
Viscous damper x Crankshaft pulley		380 kgf/cm^2, 37.27 N·m (27.5 lb-ft)
Input shaft joint (rubber block) x Flywheel		400 kgf/cm^2, 39.23 N·m (28.9 lb-ft)
* Connecting rod cap x Connecting rod		375 kgf/cm^2, 36.77 N·m (27.1 lb-ft) (90° Retightening)
* Cylinder head x Cylinder block		700 kgf/cm^2, 68.65 N·m (50.6 lb-ft) (90° Retightening)
Rocker cover x Cylinder head		65 kgf/cm^2, 6.37 N·m (56.4 lb-in.)
Intake manifold x Cylinder head		200 kgf/cm^2, 19.61 N·m (14.5 lb-ft)
Alternator bracket x Cylinder block		700 kgf/cm^2, 68.65 N·m (50.6 lb-ft)
Rear end plate x Cylinder block		185 kgf/cm^2, 18.14 N·m (13.4 lb-ft)
Engine mounting bracket x Cylinder block		700 kgf/cm^2, 68.65 N·m (50.6 lb-ft)
Rear oil seal case x Cylinder block		65 kgf/cm^2, 6.37 N·m (56.4 lb-in.)

* Apply oil to threads and seat before tightening.

CYLINDER HEAD

NOTICE: AVOID placing the engine block directly on the floor, as the oil pan can be damaged.

Note: Cylinder number No. 1 and No. 2 are located starting from the gear case side.

Component Views

Cylinder Head and Camshaft

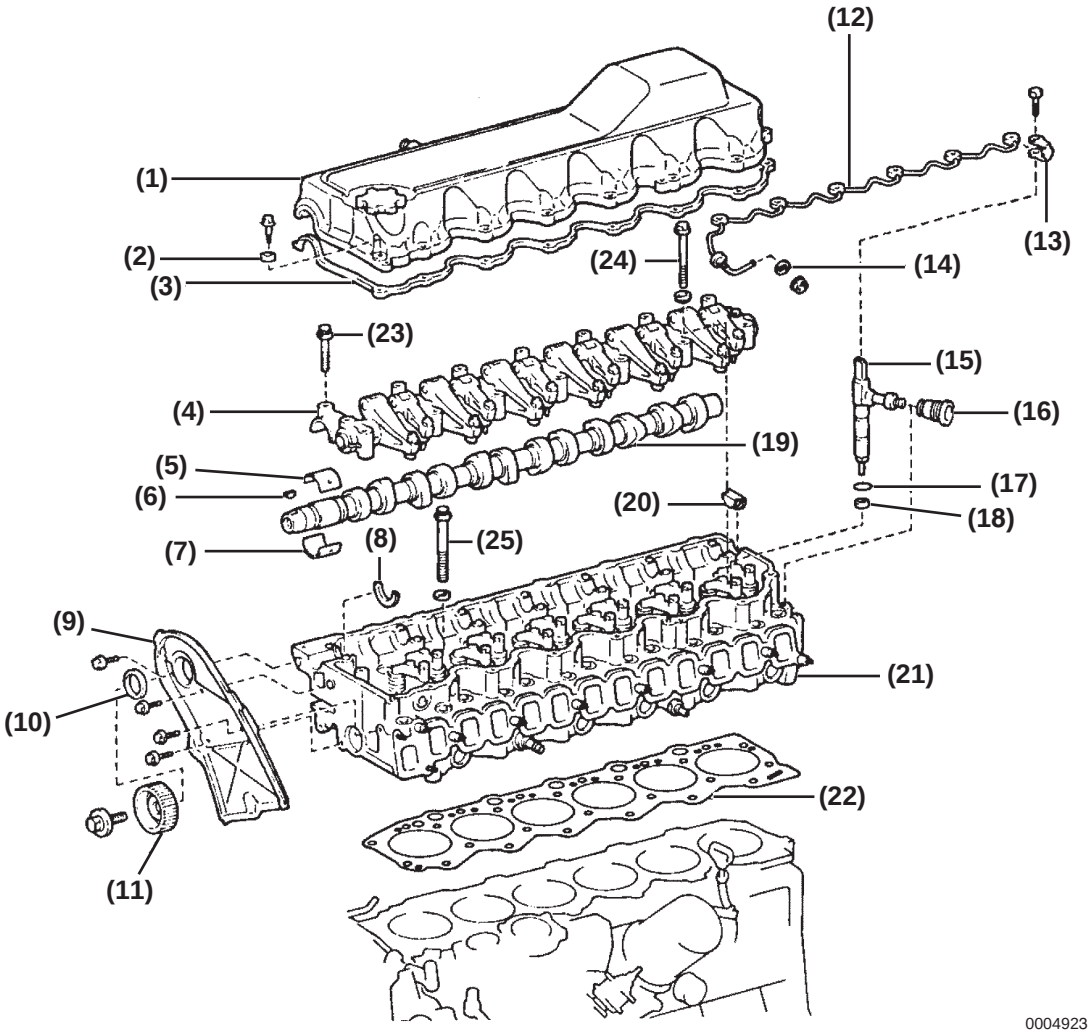


Figure 5-1

1 – Rocker Cover
2 – Seal Washer (Non-Reusable Part)
3 – Gasket
4 – Camshaft bearing cap, Valve rocker arm, Nozzle holder clamp, Rocker shaft assembly
5 – Camshaft Bearing
6 – Pulley Set Key
7 – Camshaft Bearing
8 – Thrust Plate
9 – Camshaft Oil Seal Retainer
10 – Camshaft Oil Seal (Non-Reusable Part)
11 – Camshaft Timing Pulley
12 – Fuel Return Pipe
13 – Gasket (Non-Reusable Part)
14 – Gasket (Non-Reusable Part)
15 – Fuel Injection Nozzle
16 – Nozzle Holder Seal (Non-Reusable Part)
17 – O-Ring (Non-Reusable Part)
18 – Nozzle Seat (Non-Reusable Part)
19 – Camshaft
20 – Semi Circular Plug
21 – Cylinder Head
22 – Cylinder Head Gasket (Non-Reusable Part)
23 – Rocker Arm Shaft Bolt (14 Qty.)
24 – Rocker Arm Shaft Bolt (6 Qty.)
25 – Cylinder Head Bolt (26 Qty.)

Camshaft Bearing Cap, Valve Rocker Arm, Nozzle Holder Clamp and Rocker Shaft Assembly

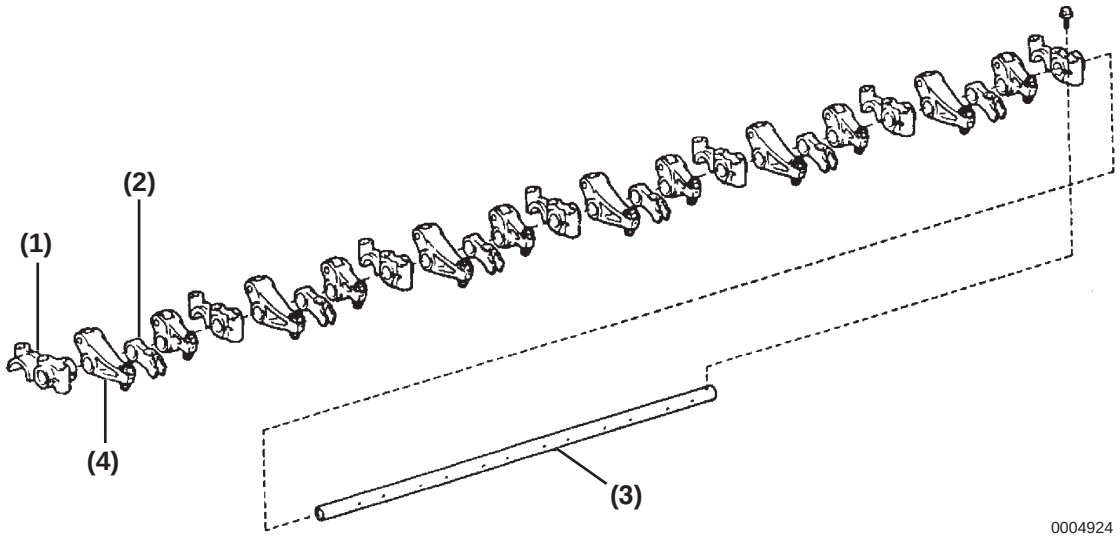


Figure 5-2

1 – Camshaft Bearing Cap
2 – Nozzle Holder Clamp
3 – Valve Rocker Shaft
4 – Valve Rocker Arm

Cylinder Head Assembly

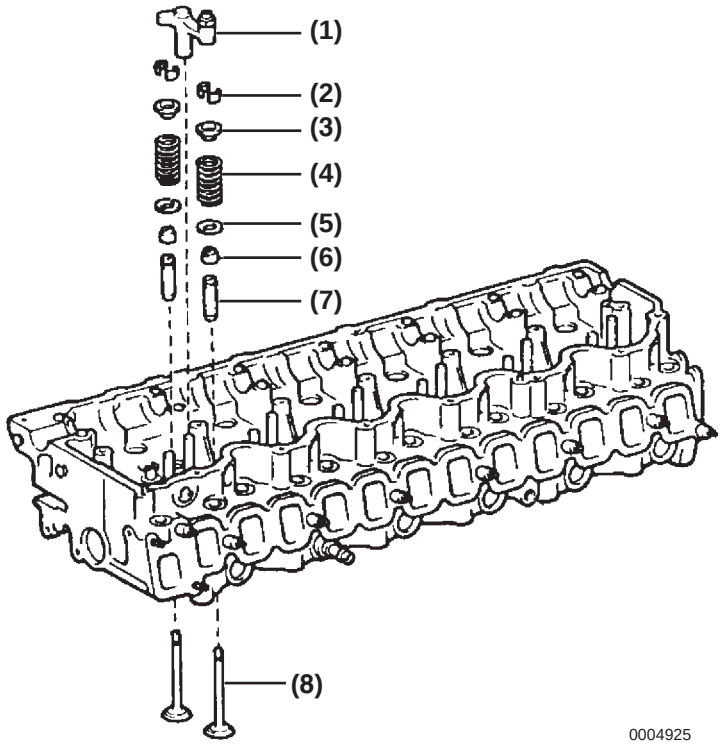


Figure 5-3

1 – Valve Bridge
2 – Cotter
3 – Spring Retainer
4 – Valve Spring
5 – Spring Seat
6 – Stem Seal (Non-Reusable Part)
7 – Valve Guide
8 – Valve

Cylinder Head Removal

Note: Before removal drain all cooling water from the freshwater and seawater systems.

1. Open the cooling water drain cocks as shown in **Figure 5-4**, **Figure 5-5** and **Figure 5-6**.
2. Drain all the cooling water and after draining, close all drain cocks.

Number of Drain Cocks		
Model	**Freshwater system**	**Seawater system**
6LPA Series	2	2

Draining Freshwater

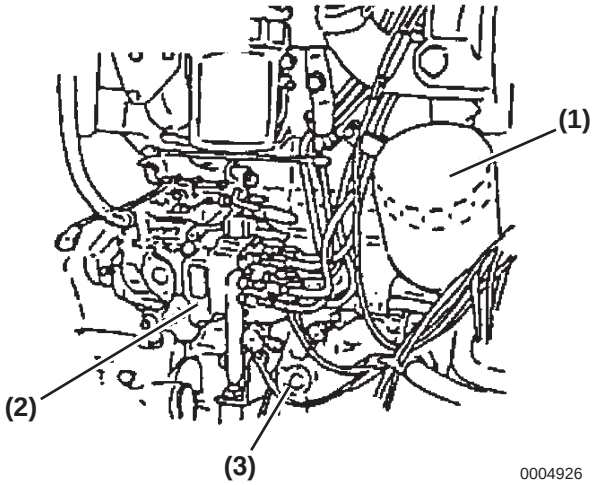


Figure 5-4

1 – Oil Filter
2 – Fuel Pump
3 – Freshwater Drain Cock

Draining Seawater

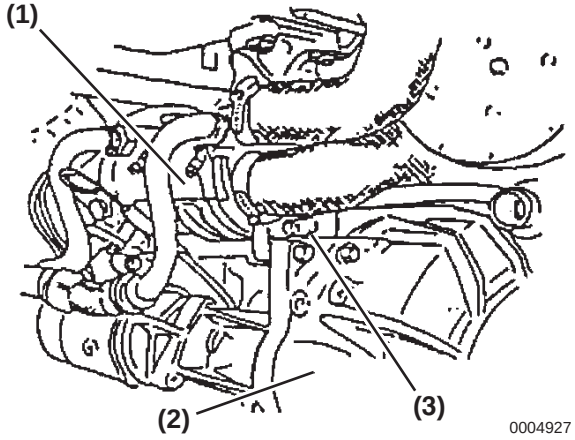


Figure 5-5

1 – Oil Cooler
2 – Flywheel Housing
3 – Seawater Drain Plug

Draining Fresh and Seawater

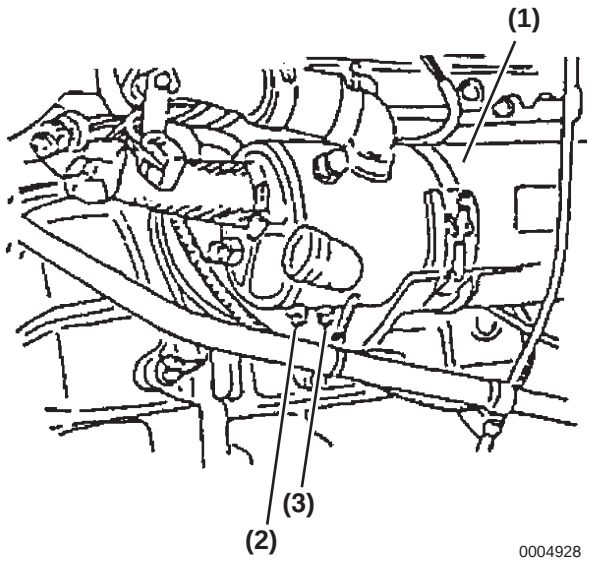


Figure 5-6

1 – Freshwater Cooler
2 – Seawater Drain Plug
3 – Freshwater Drain Plug

3. Remove the joint bolt under the oil pan and drain all the engine oil, then remove the oil dipstick.
4. Remove the turbocharger **(Figure 5-7, (1))**.

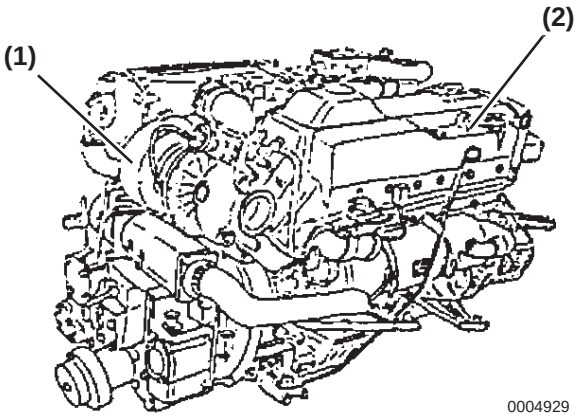


Figure 5-7

5. Remove the freshwater tank **(Figure 5-7, (2))**.
6. Remove the fuel filter **(Figure 5-8, (1))**.
7. Remove the intake manifold and intercooler **(Figure 5-8, (2))**.

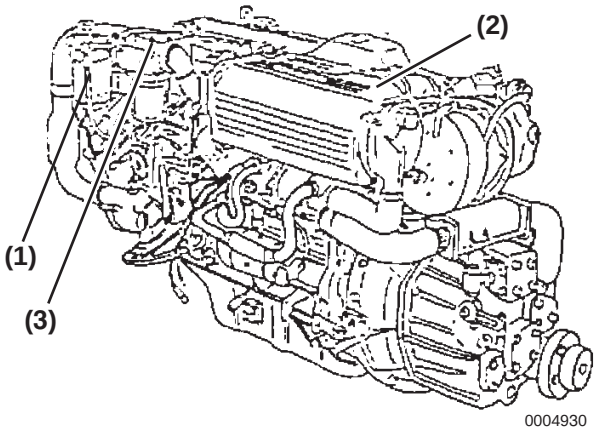


Figure 5-8

1 – Fuel Filter
2 – Intercooler
3 – Fuel Pump

8. Remove the 12 rocker cover bolts, seal washers, rocker cover and gasket **(Figure 5-9)**.

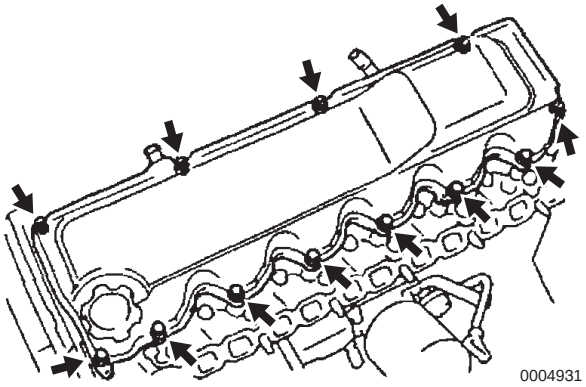


Figure 5-9

9. Remove the semi-circular plug **(Figure 5-1, (6))**.
10. Remove the timing belt and pulley **(Figure 5-10)**. *See Timing Belt Removal on page 5-69*.
11. Remove the 4 bolts and the oil seal retainer **(Figure 5-10)**.

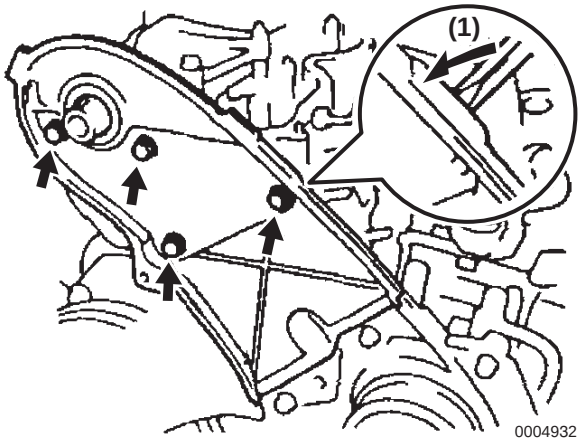


Figure 5-10

1 – Pry to Remove

12. Remove the fuel injection nozzle. *See Fuel Injection Nozzle Removal on page 6-14*.

13. Remove the camshaft bearing cap bolts and rocker arm bolts. Remove 7 bolts **(Figure 5-11, (A))** and loosen 14 bolts uniformly in sequence as shown in **Figure 5-11**.

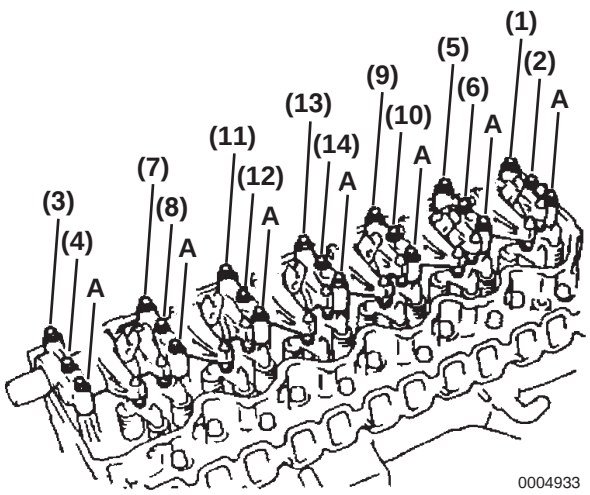


Figure 5-11

14. Remove the 7 bearing caps, 12 rocker arms, 6 holder clamps, rocker shaft assembly and the 7 upper camshaft bearings.

Note: Keep the bearings with the caps and the rocker arms and nozzle holder clamps installed with the rocker shaft, to ensure reassembly in the same order.

15. Remove the camshaft, thrust plate and 7 lower camshaft bearings.

Note: Keep the bearings together and in order as disassembled, to ensure reassembly in the same order.

16. Loosen and remove the 26 cylinder head bolts uniformly in sequence as shown in **Figure 5-12**. *NOTICE: NEVER remove the bolts at random or the head may warp or crack.*

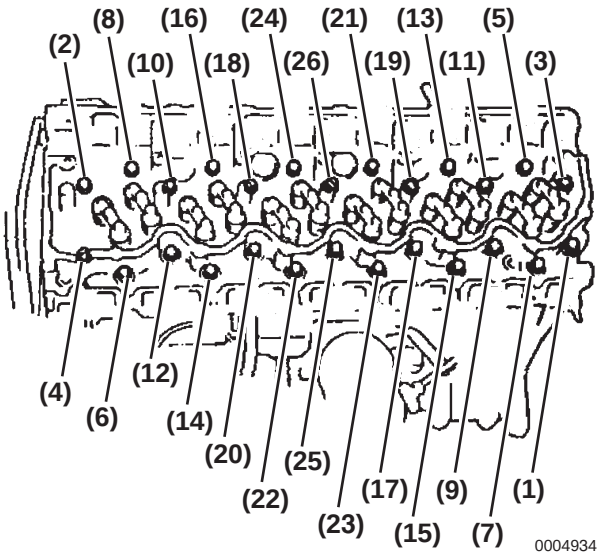


Figure 5-12

17. Lift the cylinder head from the cylinder block. If needed use a suitable tool to insert between the cylinder head and block to pry loose **(Figure 5-13, (1))**. *NOTICE: AVOID damaging the cylinder block and head surfaces when removing the cylinder head.*

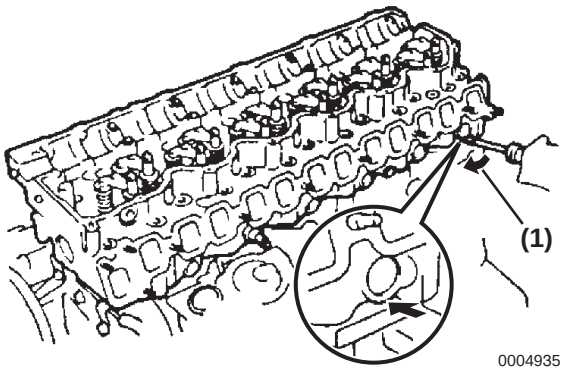


Figure 5-13

Cylinder Head Disassembly

1. Remove the valve bridge **(Figure 5-14)**.

Note: Keep the valve bridges together and in order by identifying and marking them by the cylinder number and intake or exhaust side.

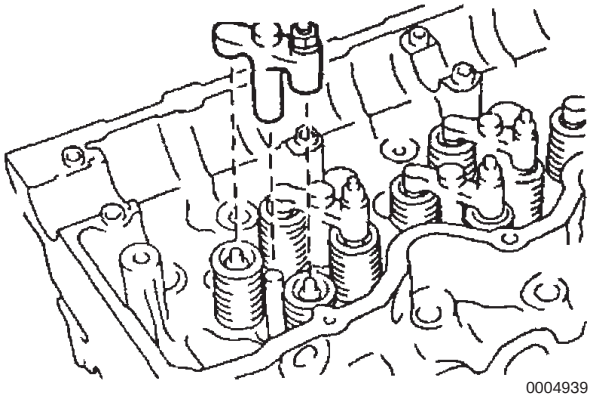


Figure 5-14

2. Compress the valve spring using special tool P/N 119770-02000 **(Figure 5-15, (1))** and remove 2 cotters. Perform for all valves.
3. Remove the spring retainer, valve spring, valve, and spring seat. Perform for all valves.

Note: Keep the valve, valve spring, spring seat and spring retainer together and in the order as disassembled, to ensure reassembly into their original positions.

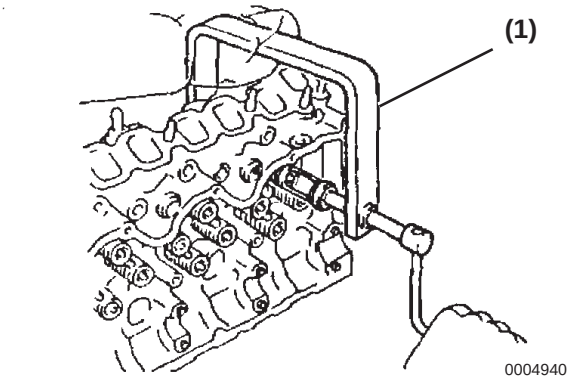


Figure 5-15

4. Remove the all stem seals using needle nose pliers **(Figure 5-16)**.

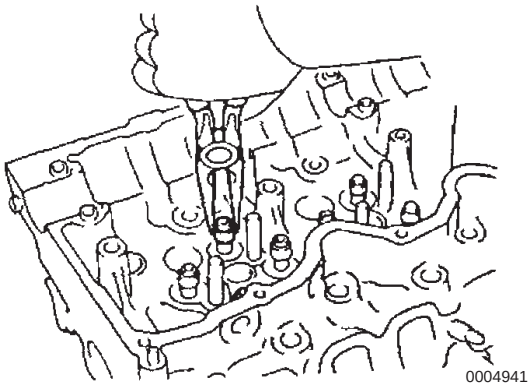


Figure 5-16

Cleaning, Inspection and Servicing

Cylinder Head Cleaning and Inspection

1. Turn the crankshaft to bring each piston to top dead center. Remove all carbon deposits from the piston tops using a scraper **(Figure 5-17)**.

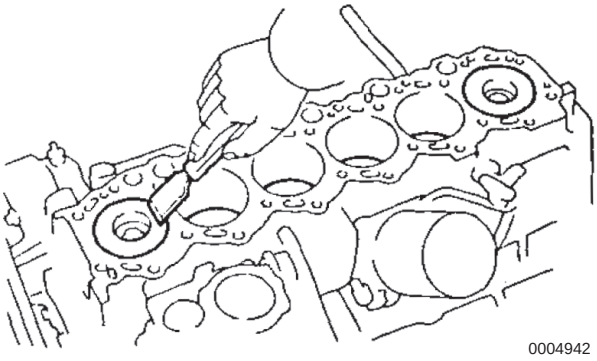


Figure 5-17

2. Remove all gasket materials from the top deck surface of cylinder block **(Figure 5-18)**. *NOTICE: AVOID damaging the cylinder block deck surface during cleaning.*

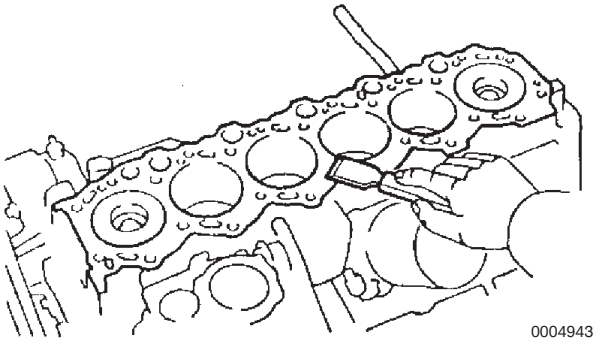


Figure 5-18

3. Using compressed air, clean out all carbon deposits and oil from the bolt holes. **WARNING! *ALWAYS wear protective goggles when using compressed air.***
4. Remove all gasket materials from the cylinder head deck surface, using a scraper **(Figure 5-19)**. *NOTICE: AVOID damaging the cylinder head deck surface during cleaning.*

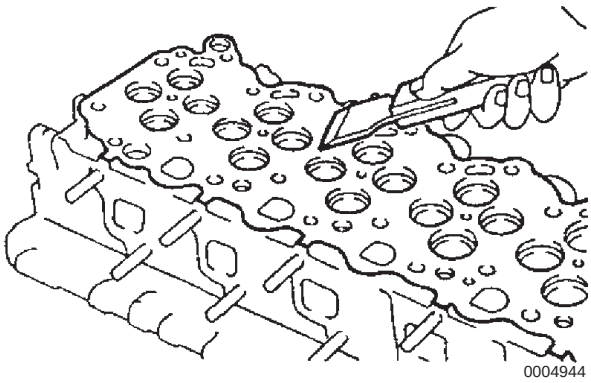


Figure 5-19

5. Remove all carbon deposits from the intake and exhaust valve seats, using a wire brush **(Figure 5-20)**. *NOTICE: AVOID damaging the valve seat surfaces during cleaning.*

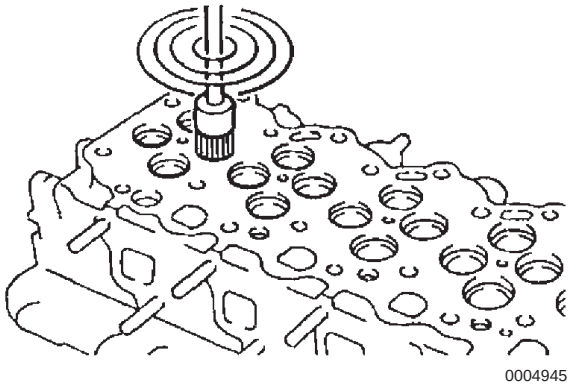


Figure 5-20

6. Clean all valve guide internal surfaces using a brush and solvent **(Figure 5-21)**.

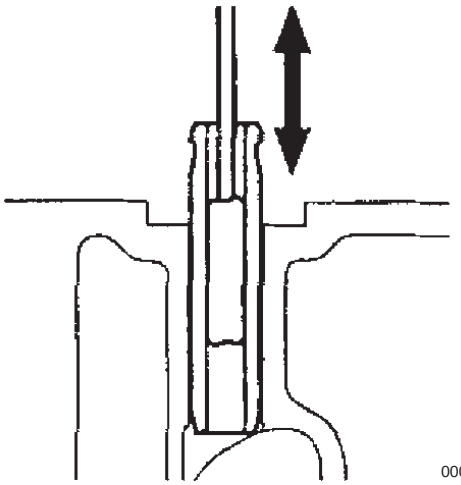


Figure 5-21

7. Thoroughly clean the cylinder head deck surface using a soft brush and solvent **(Figure 5-22)**.

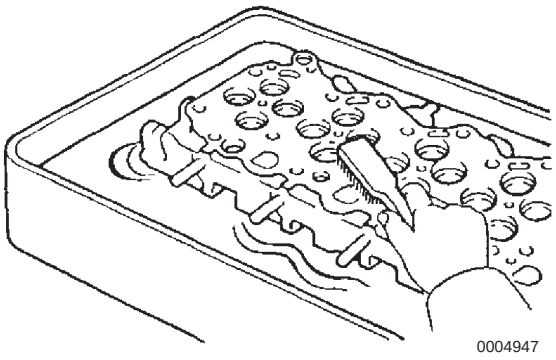


Figure 5-22

8. Measure the flatness of the cylinder head deck surface using a straight edge and feeler gauge **(Figure 5-23)**.
   - Maximum warpage: 0.20 mm

   If the measured warpage exceeds the specified maximum, replace the cylinder head.

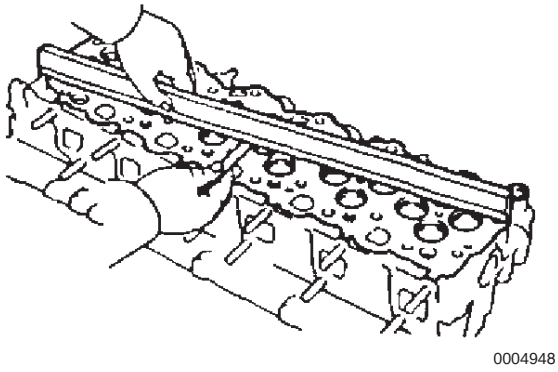


Figure 5-23

9. Check the intake and exhaust ports and the cylinder head deck surfaces for cracks, using a color check agent **(Figure 5-24)**. If any cracks are discovered, replace the cylinder head.

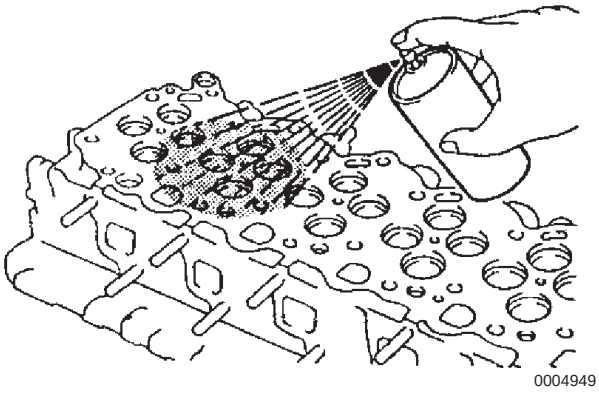


Figure 5-24

10. Measure the outside diameter of the cylinder head bolt threads using calipers **(Figure 5-25)**. Inspect the bolts for damaged threads.
    - Standard outside diameter: 10.80 to 11.00 mm (0.425 to 0.433 in.)
    - Minimum outside diameter: 10.55 mm (0.415 in.)

    If the measured value is less than the minimum outside diameter, or the bolt is damaged replace the bolt.

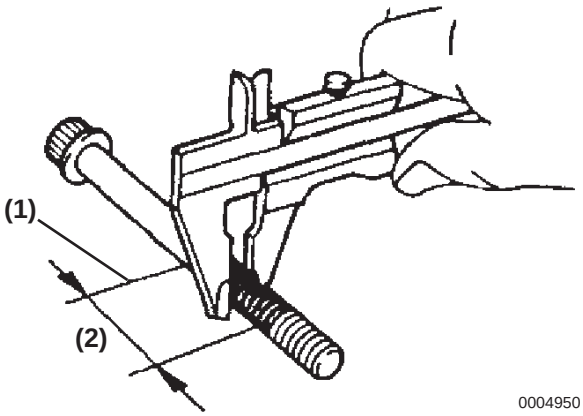


Figure 5-25

1 – Thread End
2 – 34 mm (1.3 in.)

Intake and Exhaust Valve Cleaning and Inspection

1. Remove all carbon deposits from the valves using a scraper and wire brush **(Figure 5-26)**.

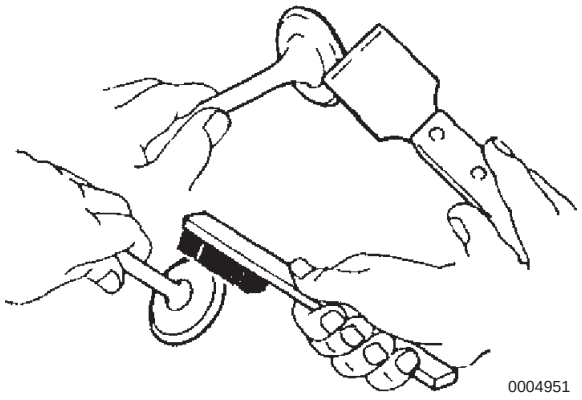


Figure 5-26

2. Measure the inside diameter of valve guides using a caliper gauge **(Figure 5-27)**.

   Valve guide inside diameter:
   - 7.010 to 7.030 mm (0.276 to 0.277 in.)

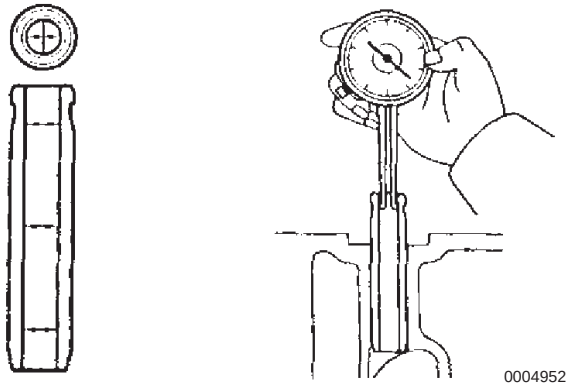


Figure 5-27

3. Measure the diameter of the valve stems using a micrometer **(Figure 5-28)**.

   Valve stem diameter:
   - Intake valve: 6.970 to 6.985 mm (0.274 to 0.275 in.)
   - Exhaust valve: 6.960 to 6.975 mm (0.274 to 0.275 in.)

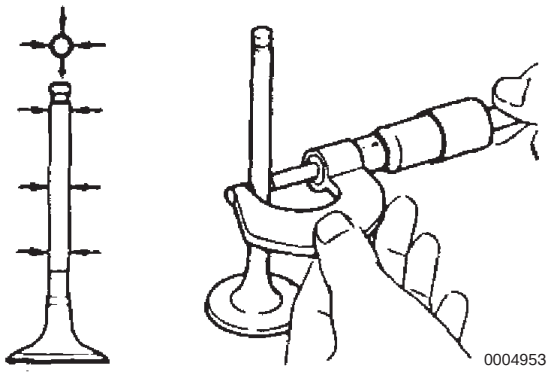


Figure 5-28

4. Subtract the valve stem diameter from the measured valve guide inner diameter.

   Standard oil clearance:

   - Intake valve: 0.025 to 0.060 mm (0.001 to 0.002 in.)
   - Exhaust valve: 0.035 to 0.070 mm (0.001 to 0.002 in.)

   Maximum oil clearance:

   - Intake valve: 0.08 mm (0.003 in.)
   - Exhaust valve: 0.10 mm (0.004 in.)

   If the measured clearance exceeds the specified maximum, replace the valve and cylinder head assembly.

5. Check the valve face for wear. If the valve face is worn, replace the valve.
6. Check the margin thickness of valve head **(Figure 5-29)**.
   - Standard margin thickness: 1.00 mm (0.014 in.)
   - Minimum margin thickness: 0.83 mm (0.033 in.)

   If the measured margin thickness is below the specified minimum, replace the valve.

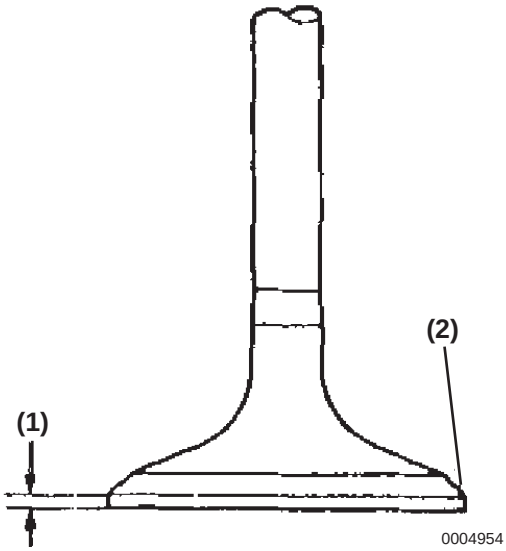


Figure 5-29

1 – Margin Thickness
2 – Valve Face

7. Check the overall length of the intake and exhaust valves **(Figure 5-30)**.

   Standard overall length:

   - Intake valve: 126.85 to 127.45 mm (4.994 to 5.017 in.)
   - Exhaust valve: 126.43 to 127.03 mm (4.977 to 5.001 in.)

   Minimum overall length:

   - Intake valve: 126.85 mm (4.994 in.)
   - Exhaust valve: 126.43 mm (4.997 in.)

   If the measured overall length is less than the specified minimum, replace the valve. Check the tip of valve stem for wear. If the valve stem tip is worn, replace the valve.

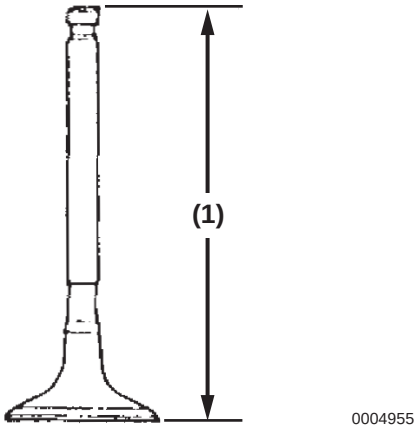


Figure 5-30

1 – Overall Length

Valve Seat Inspection and Servicing

1. Finish the valve seat surface using a 45° cemented carbide cutter **(Figure 5-31, (1))**. Only cut and remove the minimal amount of metal as necessary for cleaning.

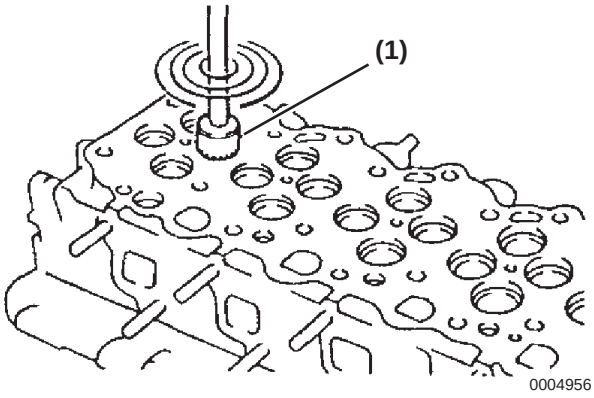


Figure 5-31

2. Check the valve seat for poor contact **(Figure 5-32)**. Apply a light coat of prussian blue (or white lead) on the valve face. Lightly press the valve onto the seat, without rotating the valve.
3. Check the valve face and seat as follows:
   - If the color adheres around 360° of the valve seat, the valve is concentric. If not concentric, replace the valve.
   - If the color adheres around 360° of the valve seat, the guide and face are concentric. If the color fails to adhere around 360°, refinish the valve seat.
   - Inspect the valve seat for proper contact width **(Figure 5-31, (1))** and proper location within the middle of valve face.

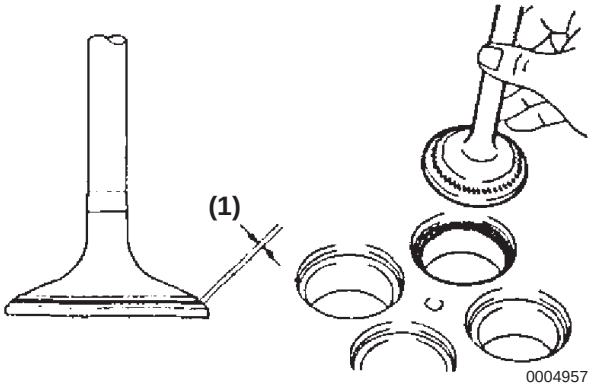


Figure 5-32

Contact width:

- Intake valve: 1.4 to 1.8 mm (0.055 to 0.071 in.)
- Exhaust valve: 1.6 to 2.0 mm (0.063 to 0.079 in.)

If contact is not in the middle of the valve face, correct the valve seat as follows **(Figure 5-33)**:

- If the seat position on the valve face is too low, refinish the seat using 25° and 45° cutters.

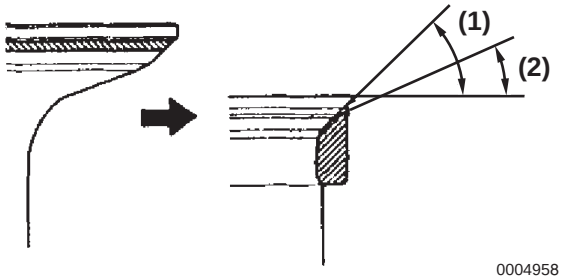


Figure 5-33

1 – 45° Angle
2 – 25° Angle

- If the seat position on the valve face is too high **(Figure 5-34)**, refinish the valve seat using cutters having angles as listed in the chart below and a 45° cutter.

Valve Seat Angle Chart	
Intake	**Exhaust**
70°	65°

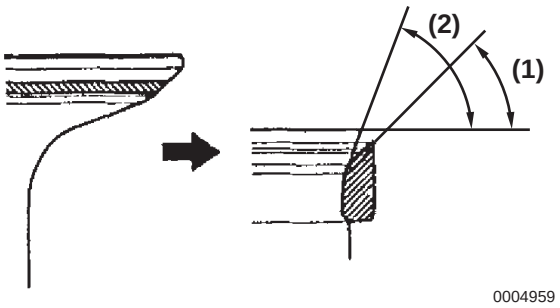


Figure 5-34

1 – 45° Angle
2 – (See Valve Seat Angle Chart)

4. Hand-lap the valve and valve seat using an abrasive compound **(Figure 5-35)**.

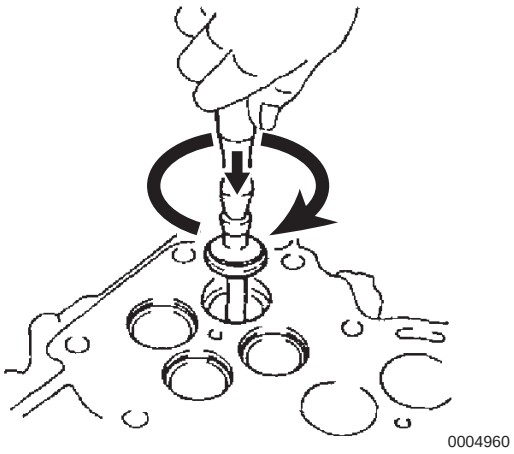


Figure 5-35

5. After lapping, clean the valve and valve seat.

Valve Spring Inspection

1. Measure the straightness of the valve spring using a square:
   - Maximum deviation: 2.0 mm (0.079 in.) **(Figure 5-36, (1))**

   If the measured deviation exceeds the specified maximum, replace the valve spring.

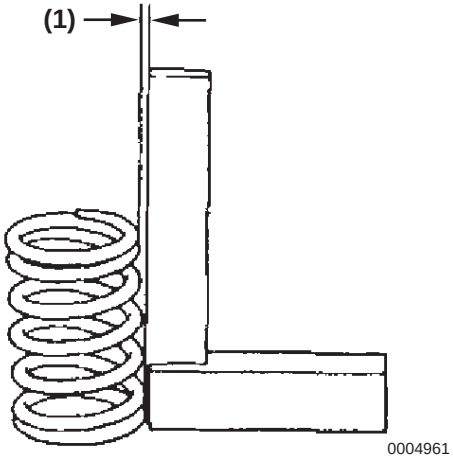


Figure 5-36

2. Measure the free length of the valve spring using calipers **(Figure 5-37)**.
   - Yellow Mark: 49.6 mm (1.953 in.)
   - Blue Mark: 49.6 mm (1.953 in.)

   If the measured free length is not within specifications, replace the valve spring.

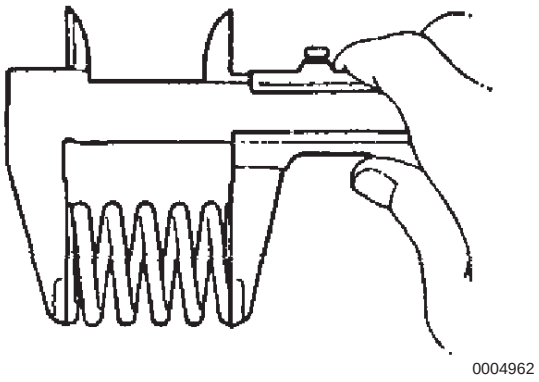


Figure 5-37

3. Measure the spring force after installing the spring at the specified length, using a spring tester **(Figure 5-38)**.

   Spring force:

   - 24.2 to 26.8 kgf, 237.32 to 262.82 N (53.3 to 59.1 lb-ft) at 39.5-mm (1.555 in.) position.

   If the spring force is not within the specified range, replace the valve spring.

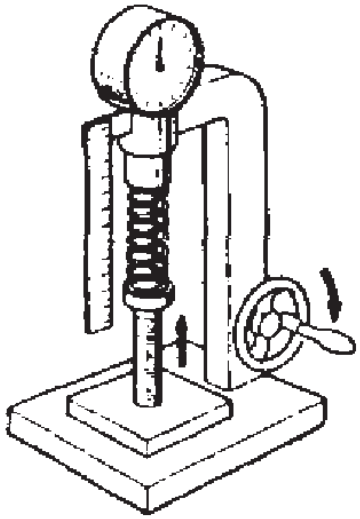


Figure 5-38

Valve Rocker Arm and Shaft Inspection

1. Inspect the rocker arms for smooth rotation **(Figure 5-39)**. If binding or hooking is felt, repair or replace.

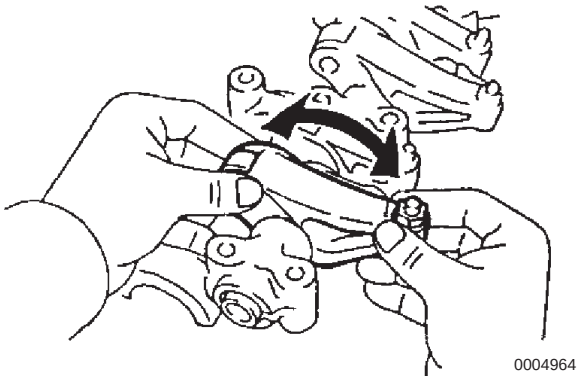


Figure 5-39

2. Remove rocker arm bolts and disassemble all parts as shown in **Figure 5-40**.

Note: Keep all parts together and in order as disassembled to ensure reassembly in the same order.

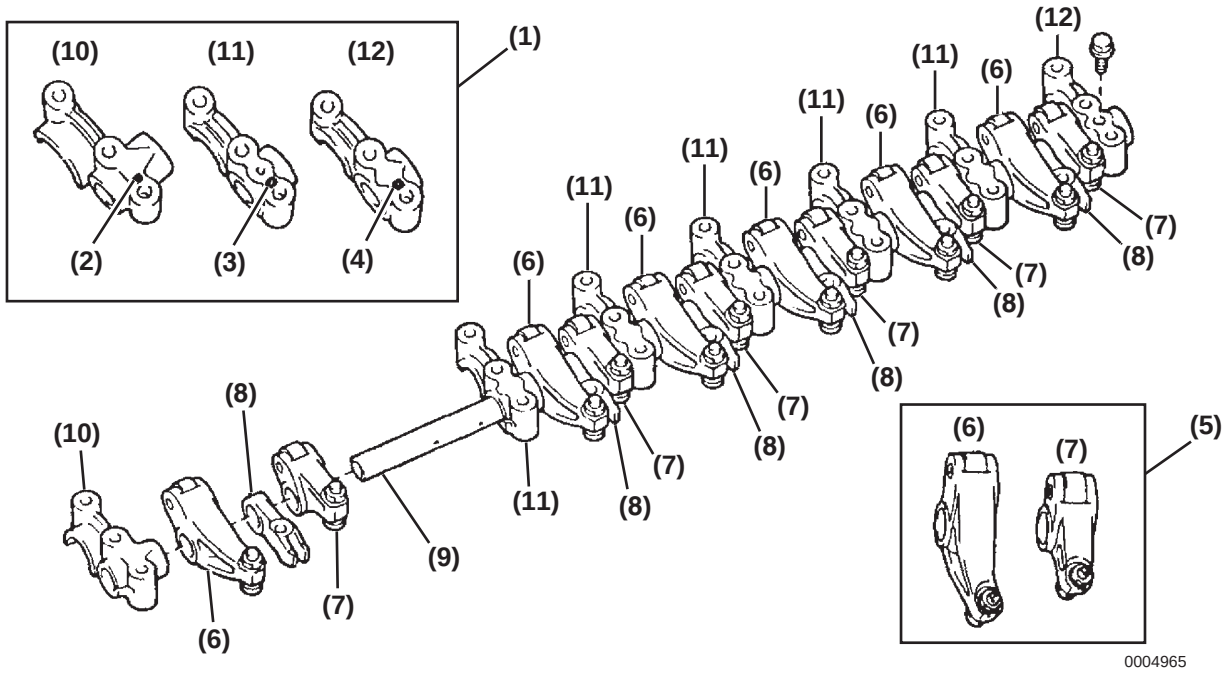


Figure 5-40

1 – Camshaft Bearing Caps
2 – Mark 1
3 – Mark 7
4 – Mark 2, 3, 4, 5, or 6
5 – Valve Rocker Arms
6 – Valve Rocker Arm (Intake Side)
7 – Valve Rocker Arm (Exhaust Side)
8 – Nozzle Holder Clamp
9 – Valve Rocker Shaft
10 – Camshaft Bearing Cap (With Mark 1)
11 – Camshaft Bearing Cap (With Mark 7)
12 – Camshaft Bearing Cap (With Mark 2, 3, 4, 5, or 6)

3. Measure the inside diameter of the rocker arm using a caliper gauge **(Figure 5-41)**.
   - Rocker arm inside diameter: 20.012 to 20.033 mm (0788 to 0.789 in.)

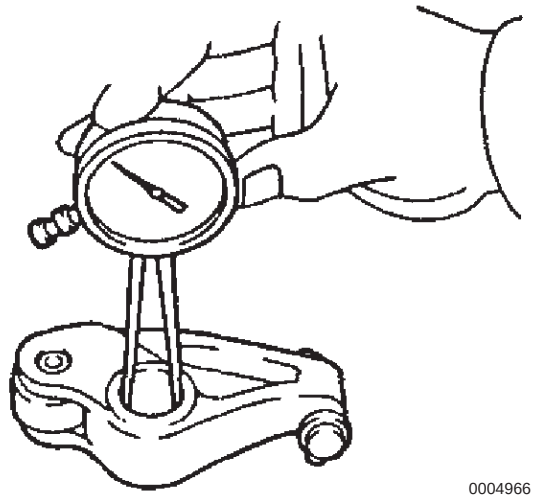


Figure 5-41

4. Measure the rocker arm shaft diameter using a micrometer **(Figure 5-42)**.
   - Shaft outside diameter: 19.972 to 19.993 mm (0.786 to 0.787 in.)

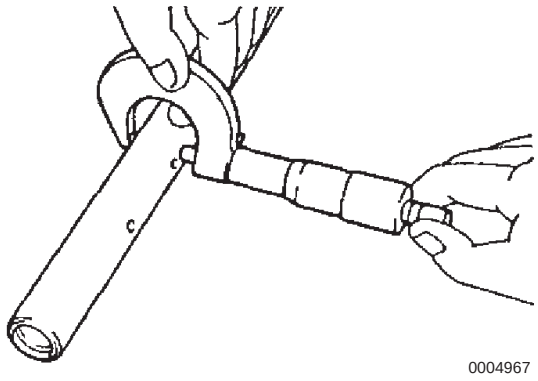


Figure 5-42

5. Subtract the rocker arm shaft diameter from the inside diameter of the rocker arm.
   - Standard oil clearance: 0.019 to 0.061 mm (0.007 to 0.0024 in.)
   - Maximum oil clearance: 0.10 mm (0.004 in.)

   If the measured oil clearance exceeds the specified maximum, replace the rocker arm shaft and rocker arm.

6. Assemble all parts as shown in **Figure 5-40**.

Camshaft and Bearing Inspection

1. Install the camshaft on a V-block to measure camshaft runout on the center journal. Use a dial indicator to measure runout while turning **(Figure 5-43)**.
   - Maximum circle runout: 0.10 mm (0.004 in.)

   If the measured runout exceeds the specified maximum, replace the camshaft.

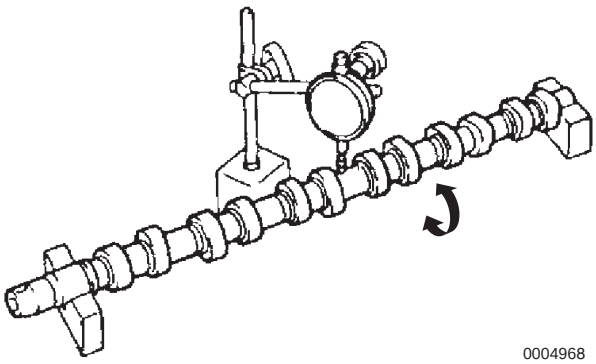


Figure 5-43

2. Measure the cam lobe height using a micrometer **(Figure 5-44)**.

   Standard cam lobe height:
   - Intake side: 48.498 to 48.598 mm (1.909 to 1.913 in.)
   - Exhaust side: 50.734 to 50.834 mm (1.997 to 2.001 in.)

   Minimum cam lobe height:
   - Intake side: 47.998 mm (1.887 in.)
   - Exhaust side: 50.234 mm (1.978 in.)

   If measured cam lobe height is less than the specified minimum, replace the camshaft.

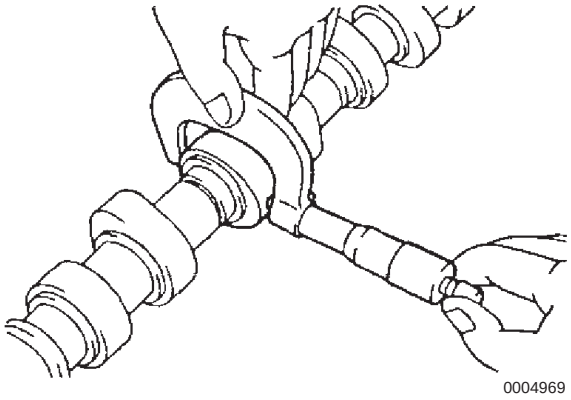


Figure 5-44

3. Measure the diameter of the camshaft journal using a micrometer **(Figure 5-45)**.

   Journal diameter:

   - No. 1: 34.969 to 34.985 mm (1.3767 to 1.3773 in.)
   - Others: 27.986 to 27.998 mm (1.1018 to 1.1022 in.)

   If the journal diameter is not within the specifications, check the oil clearance as shown in step 5.

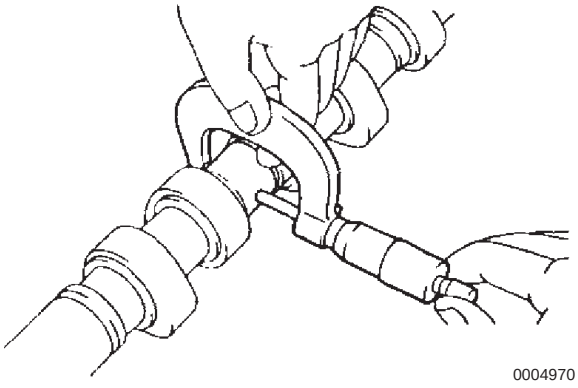


Figure 5-45

4. Check the camshaft bearings for flaking (peeling) or scoring (scratches) **(Figure 5-46)**. If the bearing is damaged, replace the bearing cap and cylinder head at the same time.

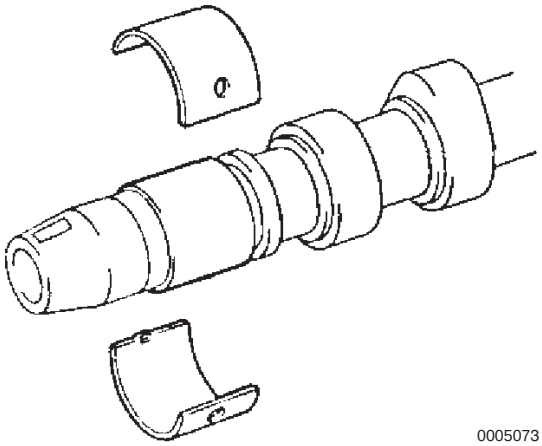


Figure 5-46

5. Inspect the oil clearance of the camshaft journal.
   (a) Remove the 7 bearing caps from the camshaft or valve rocker shaft.
   (b) Clean the bearing caps and camshaft journals.
   (c) Install the camshaft to the cylinder head.
   (d) Insert plastigage **(Figure 5-47, (1))** strips across the camshaft journals.

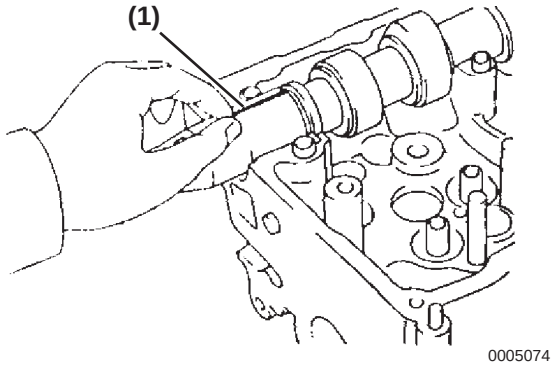


Figure 5-47

(e) Install the 7 bearing caps with 14 bolts. Tighten the 14 bolts in uniform steps in the sequence shown in **Figure 5-48**. Tightening torque: 250 kgf·cm, 24.52 N·m (18.08 lb-ft)

Note: NEVER turn the camshaft during tightening.

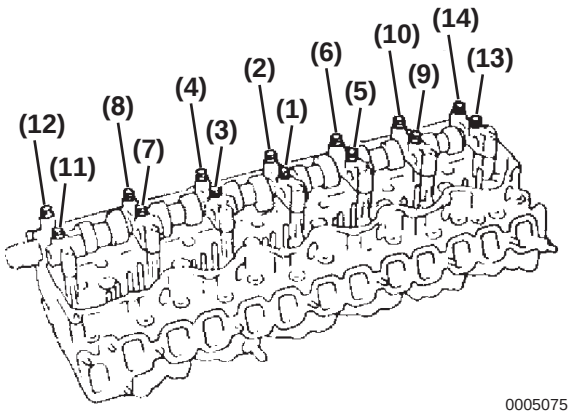


Figure 5-48

(f) Loosen the 14 bolts in uniform steps in the sequence shown in **Figure 5-49** and remove.

(g) Remove the 7 bearing caps.

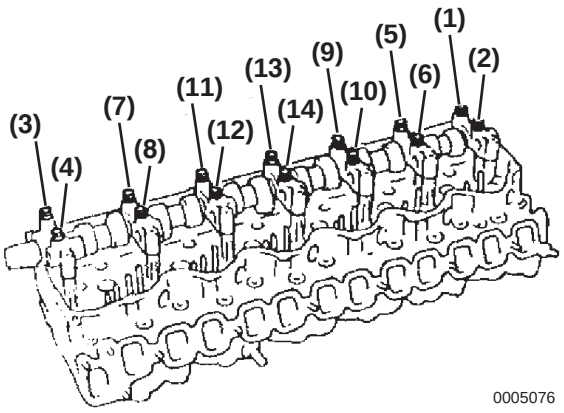


Figure 5-49

(h) Measure the plastigage at the widest point **(Figure 5-50)**.

If measured oil clearance is greater than the specified maximum, replace the camshaft, and inspect and replace the bearing caps and cylinder head as needed.

- Standard oil clearance:
  No. 1: 0.022 to 0.074 mm 0.0008 to 0.0029 in.)
  Others: 0.023 to 0.075 mm (0.0009 to 0.0030 in.)
- Maximum oil clearance: 0.10 mm (0.004 in.)

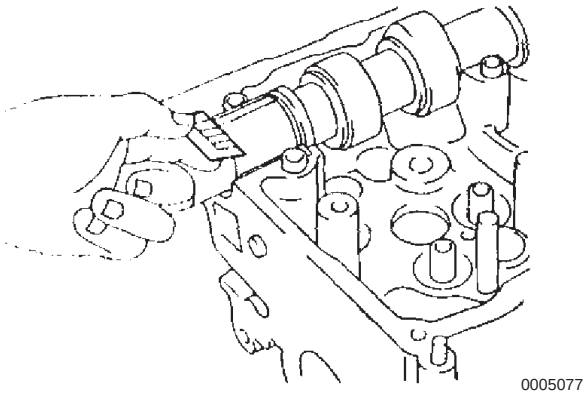


Figure 5-50

(i) Completely remove the plastigage.

(j) Install the 7 bearing caps to the valve rocker shaft.

6. To inspect the camshaft thrust clearance, install the camshaft and shown in step 5.

   Measure the thrust clearance using a dial gauge while moving the camshaft longitudinally **(Figure 5-51)**.

   - Standard thrust clearance: 0.100 to 0.200 mm (0.004 to 0.008 in.)
   - Maximum thrust clearance: 0.30 mm (0.012 in.)

   If the measured thrust clearance exceeds the maximum, replace the thrust plate. Replace the camshaft or the bearing cap and cylinder head as a set, as needed.

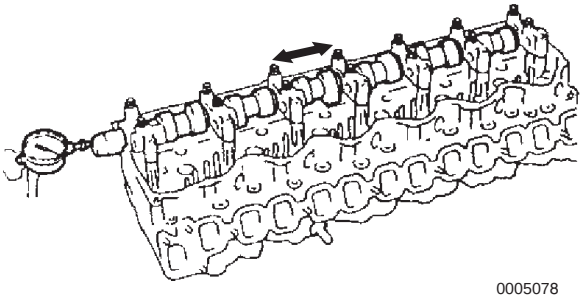


Figure 5-51

Camshaft Oil Seal Replacement

There are two methods for replacing the oil seal.

Method 1

Use this procedure when the camshaft oil seal retainer has been removed from the cylinder head.

1. Tap out the oil seal using a screwdriver and a hammer **(Figure 5-52)**.

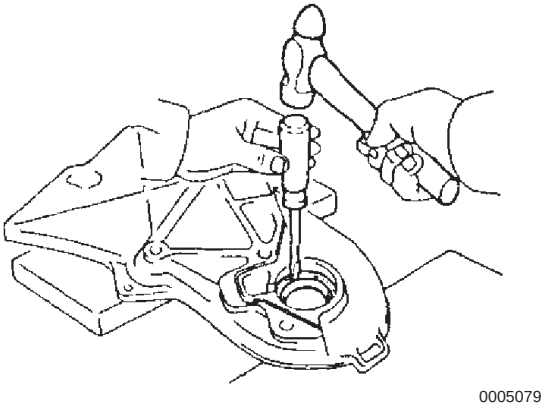


Figure 5-52

2. Apply grease to the oil seal lip.
3. Using a suitable tool **(Figure 5-53, (1))** tap in a new oil seal until its surface is level with the end surface of oil seal retainer.

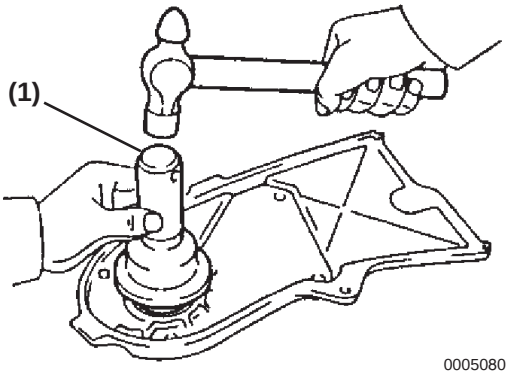


Figure 5-53

Method 2

Use this procedure when the camshaft oil seal retainer is installed to the cylinder head.

1. Cut off the oil seal lip using a knife **(Figure 5-54, (1))**.

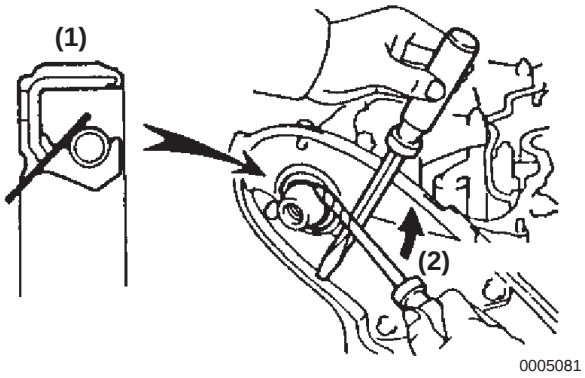


Figure 5-54

2. Remove the oil seal using two screwdrivers as a lever **(Figure 5-54, (2))**. *NOTICE: AVOID damaging the camshaft. Use tape on the screwdrivers tip to prevent damage.*
3. Apply grease to the new oil seal lip.
4. Using a suitable tool **(Figure 5-55, (1))** tap in a new oil seal until its surface is level with the end surface of oil seal retainer.

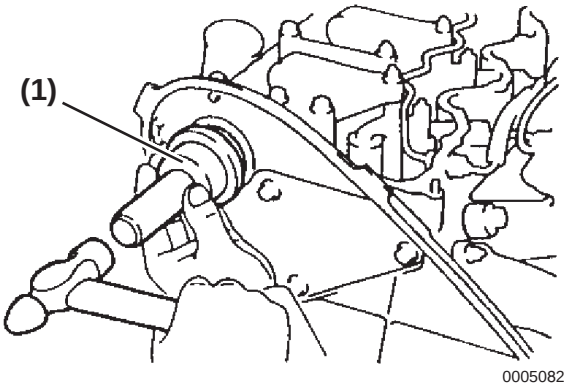


Figure 5-55

Cylinder Head Assembly

Note: Clean all parts to be assembled. Apply new engine oil to all sliding and rotating surfaces before assembling parts. Replace all gaskets and seals.

1. Using a suitable tool **(Figure 5-56, (1))** press new valve stem seals into the valve guides.

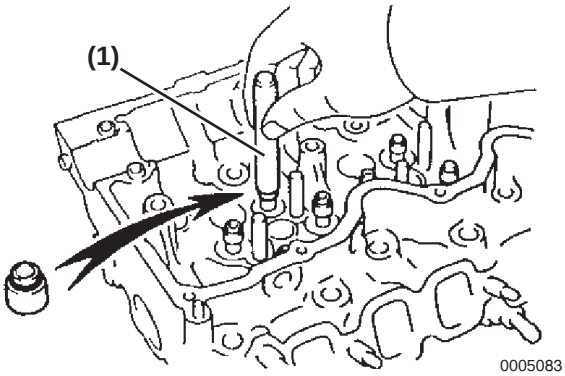


Figure 5-56

2. Install the following parts as shown in **Figure 5-57**.

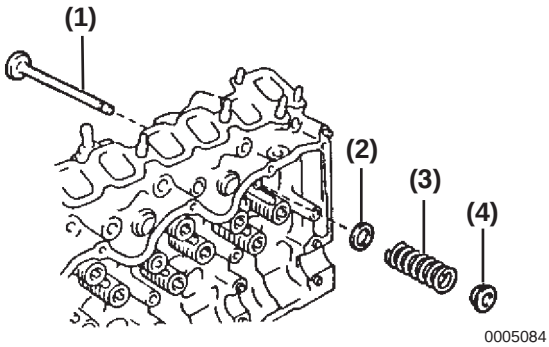


Figure 5-57

1 – Valve
2 – Spring Seat
3 – Valve Spring
4 – Spring Retainer

3. Using special tool P/N 119770-02000 **(Figure 5-58, (1))** compress the valve spring and install the spring retainer.

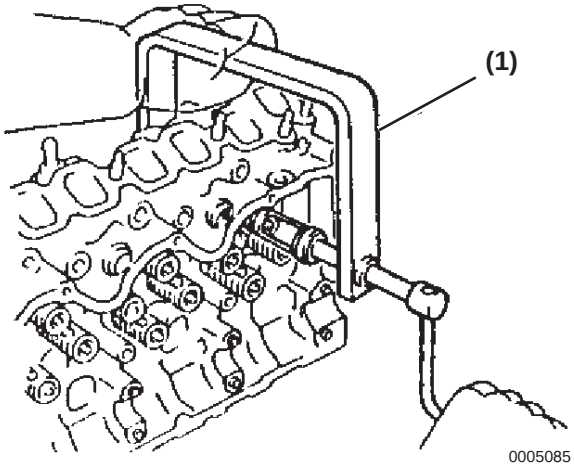


Figure 5-58

4. Tap the tip of the valve stem with a plastic hammer to seat the valve spring retainer **(Figure 5-59)**.

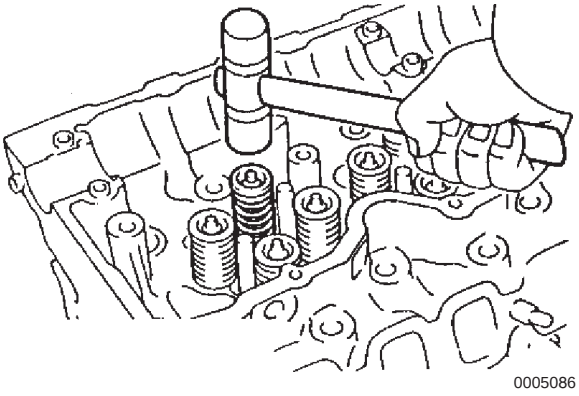


Figure 5-59

5. Install the valve bridge.
6. Inspect the valve bridge for smooth operation **(Figure 5-60)**.

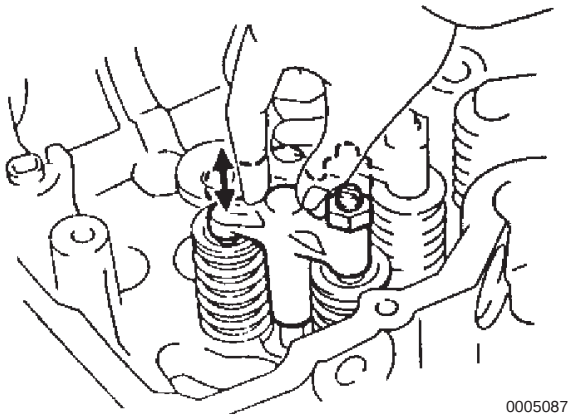


Figure 5-60

Cylinder Head Installation

Measure piston height to the top deck surface of the cylinder block for each cylinder to determine an appropriate cylinder head gasket.

1. Clean the top surface of cylinder block with solvent.
2. Set the piston of the cylinder for measurement just before top dead center.
3. Install a dial indicator on the cylinder block and adjust the dial indicator to zero.

Note: Use a dial indicator measuring tip **(Figure 5-61, (1))**. Always check that the measuring tip is parallel to the cylinder block gasket mounting surface and the piston head before reading the dial indicator.

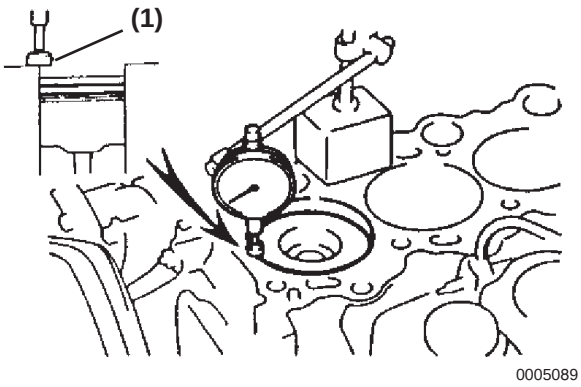


Figure 5-61

4. Determine the position where the piston head **(Figure 5-62, (1))** is at the upper-most position (TDC) by slowly turning the crankshaft clockwise and counter-clockwise **(Figure 5-62, (4))**.

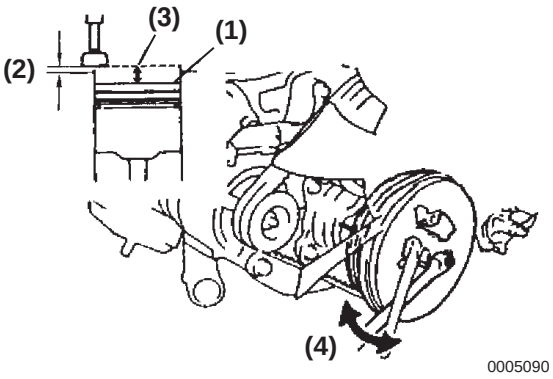


Figure 5-62

1 – Piston Head
2 – Piston Protrusion (P)
3 – Cylinder Block Top Surface
4 – Turning Crankshaft

5. Measure each cylinder at two points for a total of 12 points **(Figure 5-63, (1))**.
6. Record each measurement and determine the average of all.
   - Piston protrusion (P) **(Figure 5-62, (2))**: 0.175 to 0.425 mm (0.0068 to 0.0167 in.)

   If the measured value is not within the specified range, remove the piston and connecting rod assembly, and then reassemble and measure again. *See Cylinder Block Disassembly on page 5-42*.

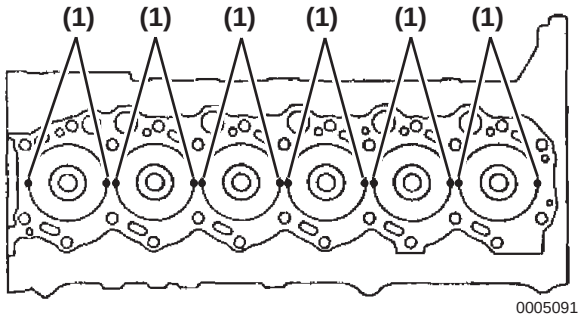


Figure 5-63

7. There are three thicknesses of service gaskets, (Mark No. 1, 3 and 5) **(Figure 5-64)**.

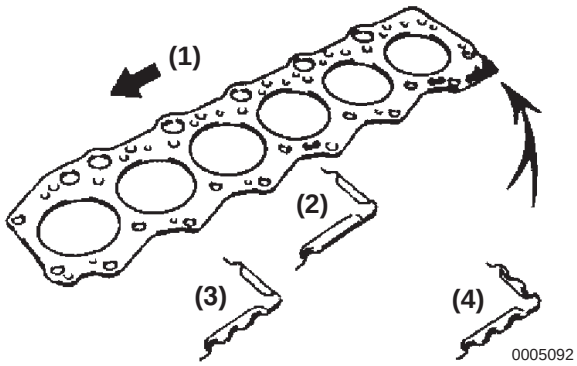


Figure 5-64

1 – Front
2 – Mark No. “1”
3 – Mark No. “3”
4 – Mark No. “5”

New Head Gasket Thickness	
Mark No. 1	0.85 to 0.95 mm (0.033 to 0.037 in.)
Mark No. 3	0.95 to 1.05 mm (0.037 to 0.041 in.)
Mark No. 5	1.05 to 1.15 mm (0.041 to 0.045 in.)

8. Select an appropriate gasket from the following charts, based on the piston protrusion measurement.

Piston protrusion (P)	Gasket size	Gasket P/N
0.225 mm (0.009 in.) or less	Use gasket “1.”	119771-00401
0.226 to 0.325 mm (0.009 to 0.013 in.)	Use gasket “3.”	119771-00411
0.326 mm (0.013 in.) or more	Use gasket “5.”	119771-00421

9. Set the No. 1 cylinder to BDC by turning the crankshaft pulley to align to the timing mark of No. 2 camshaft timing pulley, using the bottom dead center (BDC) mark of the timing gear cover **(Figure 5-65, (1))**.

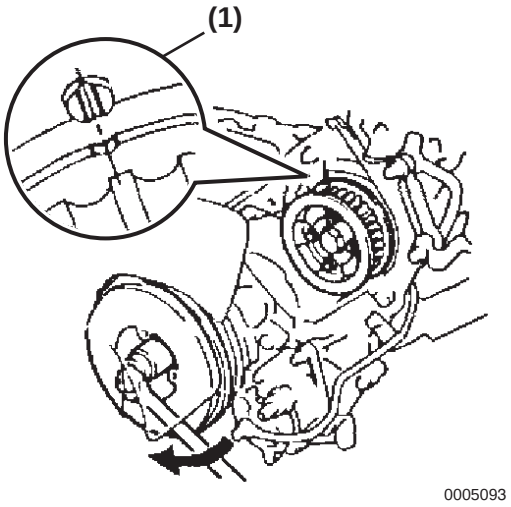


Figure 5-65

10. Install a new cylinder head gasket in position on the cylinder block **(Figure 5-66)**.

Note: Install the gasket in the correct position.

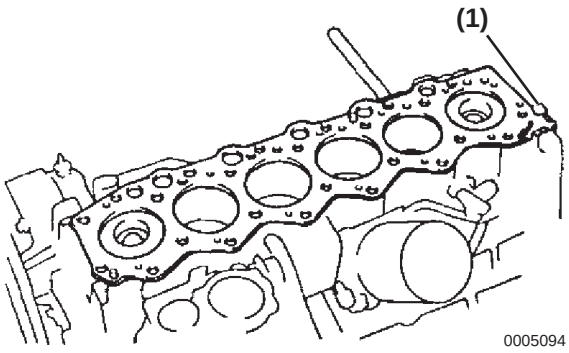


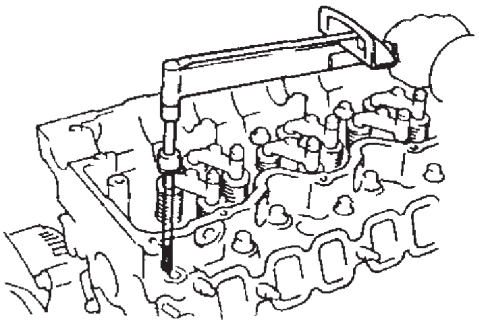
Figure 5-66

1 – Gasket Mark Number

11. Install the cylinder head correctly on the cylinder head gasket.
12. Lightly apply engine oil to the threads and cylinder head bolt seats and install the cylinder head bolts.

Note: Uniformly tighten the cylinder head bolts in 3 steps. If any bolts are damaged or deformed, replace with new bolts.

13. Tighten the 26 cylinder head bolts in uniform steps in the sequence shown in **Figure 5-67**. Torque the bolts to 700 kgf·cm, 68.65 N·m (50.6 lb-ft).
    - Bolt length:
      A. 121.5 mm (4.783 in.)
      B. 133.5 mm (5.256 in.)



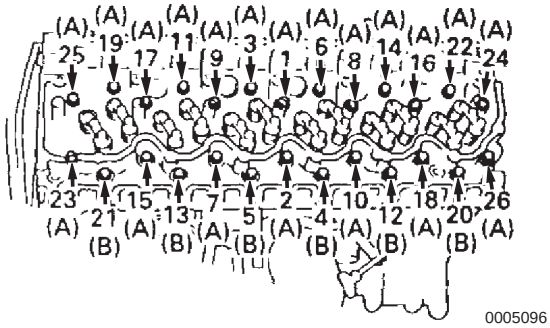


Figure 5-67

Note: If any one of the cylinder head bolts does not satisfy the specified torque, replace that bolt.

14. Mark the front side **(Figure 5-68, (1))** of each cylinder head bolt with paint **(Figure 5-68, (2))**.
15. Retighten the cylinder head bolts an additional 90° **(Figure 5-68, (3))**.
16. Retighten the cylinder head bolts again an additional 90° **(Figure 5-68, (4))**.

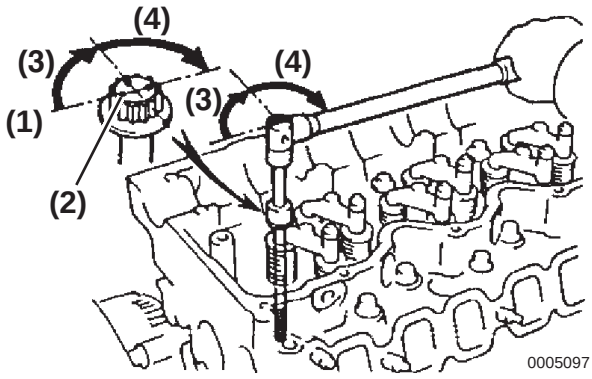


Figure 5-68

17. After tightening, check that the painted marks face 180° from the starting point.

Camshaft Installation

1. Install the thrust plate **(Figure 5-69, (1))**.

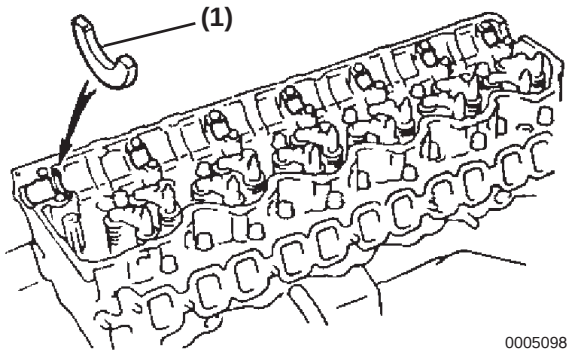


Figure 5-69

2. Install the 7 lower camshaft bearings.

Note: There are two types of camshaft bearings, one having a 20 mm (0.787 in.) **(Figure 5-70, (2))** width and the other, 29 mm (0.142 in.) **(Figure 5-70, (1))**.

Install the 29 mm (0.142 in.) bearing together with the camshaft bearing cap at the position of cylinder head journal No. 1.

Install the 20 mm (0.787 in.) bearing at the other position.

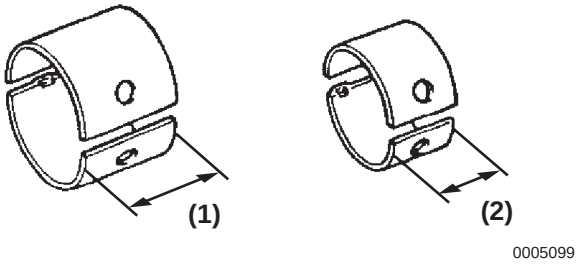


Figure 5-70

3. Install the camshaft on the cylinder head with the keyway groove **(Figure 5-71, (1))** facing up **(Figure 5-71, (2))**.

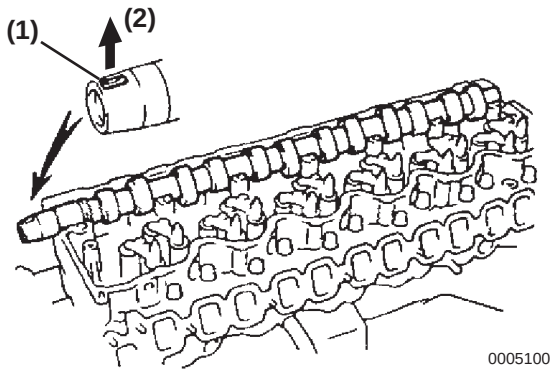


Figure 5-71

4. Install the upper camshaft bearing to the bearing cap.
5. Install the bearing cap and other parts.
6. Install 7 bearing caps, 12 rocker arms, 6 holder clamps and the rocker shaft assembly **(Figure 5-72)**.

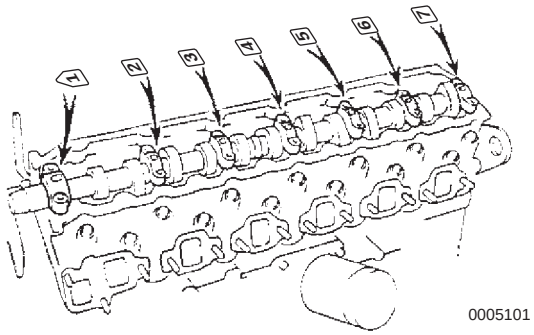


Figure 5-72

7. Uniformly tighten the 14 bearing cap bolts in steps in the order shown in **Figure 5-73**.
   - Torque (bearing cap, others A): 250 kgf·cm, 24.50 N·m (18.07 lb-ft) **(Figure 5-73)**.

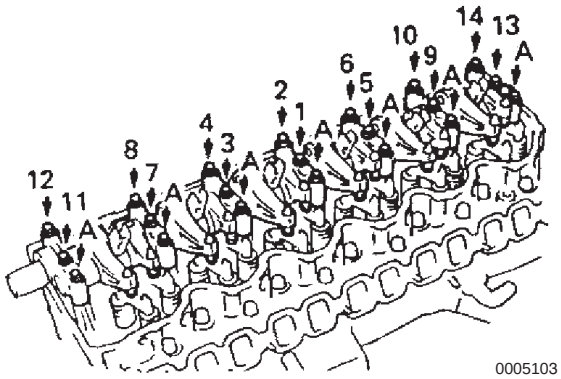


Figure 5-73

8. Install the fuel injection nozzle. *See Fuel Injection Nozzle Installation on page 6-25*.

Camshaft Oil Seal Retainer Installation

1. Completely remove the packing material remaining on the gasket surfaces and sealing groove using a razor and gasket scraper.
   - Clean all parts to thoroughly remove foreign matter.
   - Clean both seal surfaces using solvent.

Note: Avoid contaminating the oil seal retainer and cylinder head contacting surfaces with oil.

2. Apply seal packing to the oil seal retainer as shown in **Figure 5-74**.
   - Use a nozzle cut to a sealing width of 2 to 3 mm (0.078 to 0.118 in.) **(Figure 5-74, (1))**.

Note: Parts must be assembled within 5 minutes after seal packing is applied. Otherwise, the packing material must be removed and reapplied.

Note: Disconnect the nozzle from the tube immediately after use and protect it by sealing with a cap. (Seal packing: TOYOTA P/N 08826-00080 or equivalent)

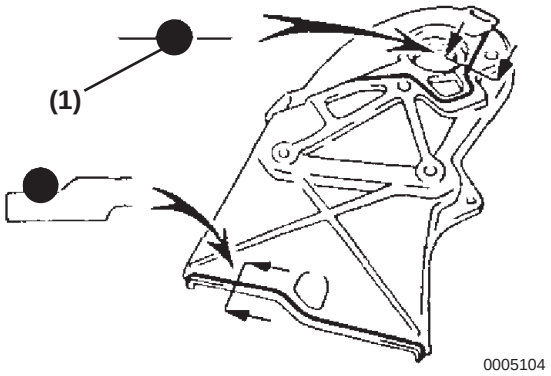


Figure 5-74

3. Install the oil seal retainer using 4 bolts **(Figure 5-75, (1))**. Tighten the bolts uniformly in steps and torque to 200 kgf·cm,19.61 N·m (14.5 lb-ft).

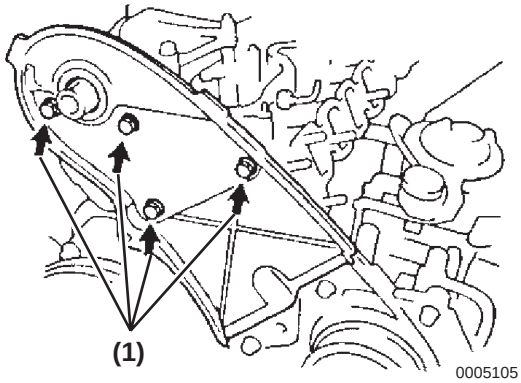


Figure 5-75

Final Assembly

1. Install the pulley and timing belt. *See Timing Belt Installation on page 5-73*.
2. Check and adjust the valve clearance. *See Valve Clearance Inspection and Adjustment on page 5-90*.

Install the Rocker Cover

1. Completely remove all packing material. from the semi-circular plug sealing area.
2. Apply seal packing **(Figure 5-76, (2))** to the semi-circular plug **(Figure 5-76, (1))**. (Seal packing: TOYOTA P/N 08826-00080 or equivalent)
3. Install the semi-circular plug to the cylinder head.

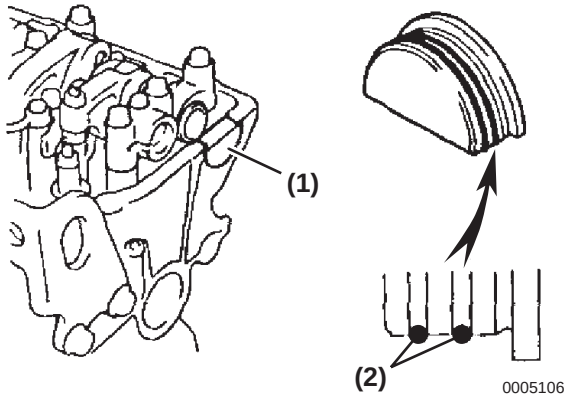


Figure 5-76

4. Completely remove all packing material from the rocker cover sealing area.
5. Apply seal packing to the cylinder head as shown in **Figure 5-77**. (Seal packing: TOYOTA P/N 08826-00080 or equivalent)

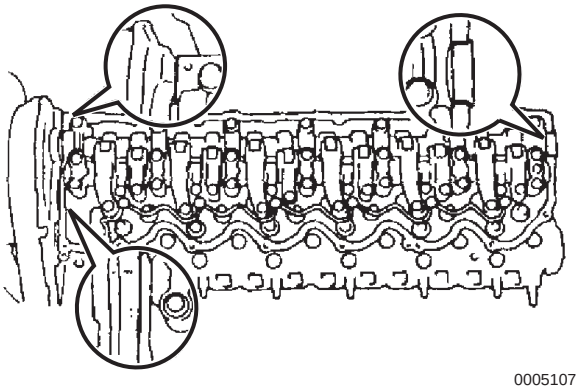


Figure 5-77

6. Install the gasket to the rocker cover.
7. Install the rocker cover using 12 new seal washers and 12 bolts. Uniformly tighten the bolts in steps and torque to 65 kgf·cm, 6.37 N·m (56.38 lb-in.).

CYLINDER BLOCK

Components

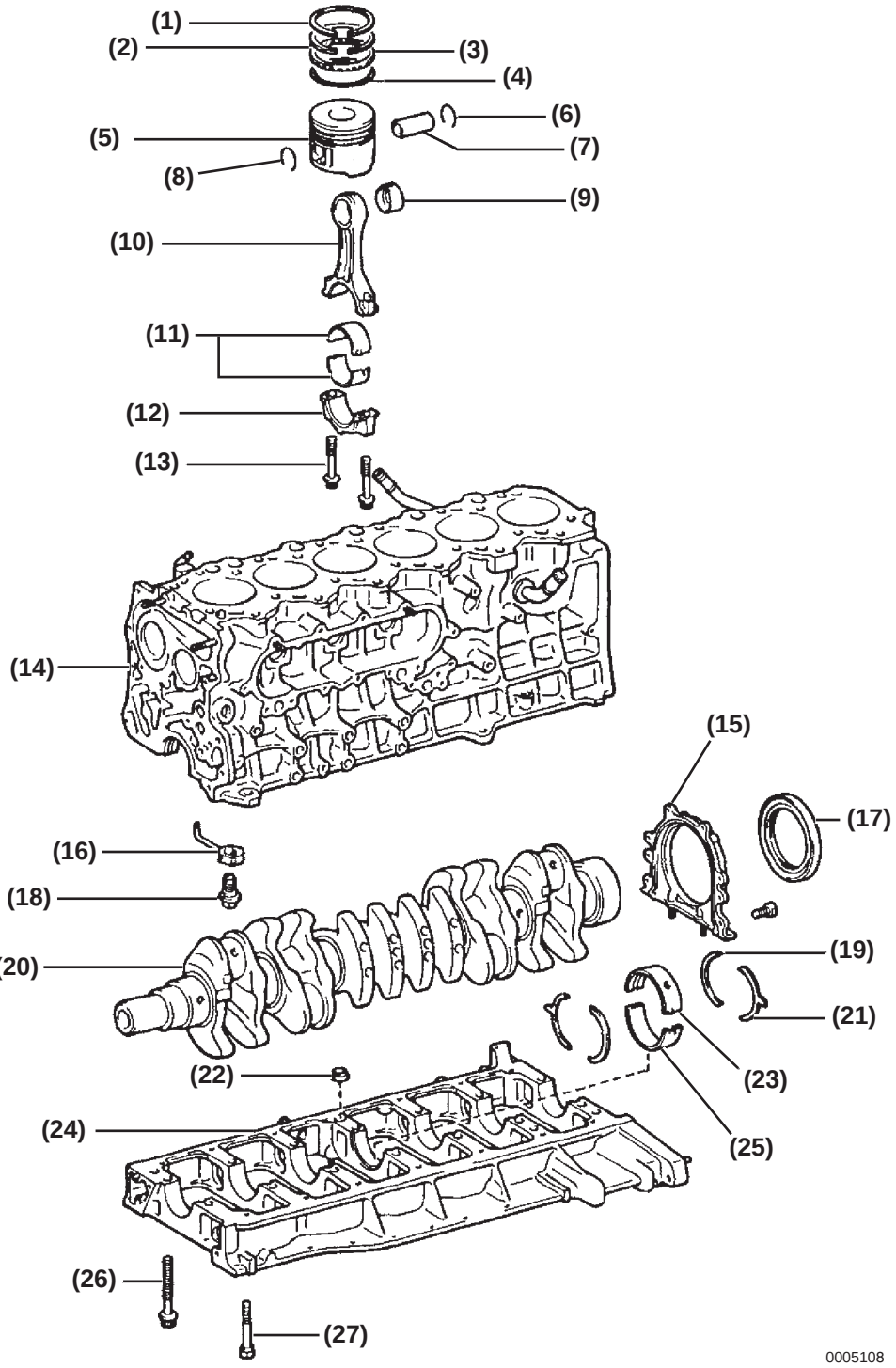


Figure 5-78

1 – No. 1 Piston Ring
2 – No. 2 Piston Ring
3 – Oil Ring
4 – Oil Ring (Coil)
5 – Piston
6 – Snap Ring (Non-Reusable Part)
7 – Piston Ring
8 – Snap Ring (Non-Reusable Part)
9 – Piston Pin Bearing
10 – Connecting Rod
11 – Crank Pin Bearing
12 – Connection Rod Cap
13 – Rod Bolt
14 – Cylinder Block
15 – Rear Oil Seal Case
16 – Oil Nozzle For Piston Cooling
17 – Crankshaft Oil Seal (Non-Reusable Part)
18 – Check Valve
19 – Crankshaft Oil Seal
20 – Crankshaft
21 – Crankshaft Thrust Bearing
22 – Cylinder Block Oil Hole Plug (Non-Reusable Part)
23 – Upper Main Bearing
24 – Main Bearing Cap
25 – Lower Main Bearing
26 – Main Bearing Cap Bolt (Inside)
27 – Main Bearing Cap Bolt (Outside)

Preparation for Disassembly

1. Remove the flywheel.
2. Install the engine on an engine stand.
3. Remove the timing belt and pulley. *See Timing Belt Removal on page 5-69*.
4. Remove the cylinder head. *See Cylinder Head Removal on page 5-16*.
5. Remove the freshwater pump and seawater pump *See Freshwater Pump Removal on page 7-5* and *See Seawater Pump Disassembly on page 7-8*.
6. Remove the alternator.
7. Remove the timing gear. *See Timing Gear Removal on page 5-80*.
8. Remove the fuel injection pump. *See Fuel Injection Pump Removal on page 6-29*.
9. Remove the oil pan and timing gear case. *See Oil Pump Removal on page 8-7*.
10. Remove the oil cooler. *See Oil Cooler Removal on page 8-14*.
11. Remove the engine mount.

Cylinder Block Disassembly

1. Remove the 6 rear oil seal case bolts.
2. Insert a screwdriver between the oil seal case and main bearing cap and pry **(Figure 5-79, (1))** to remove the oil seal case.

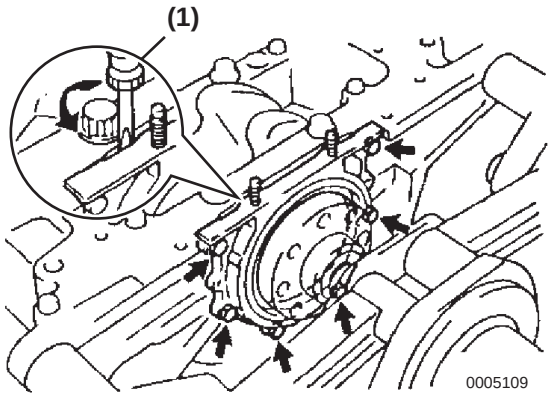


Figure 5-79

3. To check the connecting rod thrust clearance, move the connecting as shown in **Figure 5-80** to measure the thrust clearance using a dial gauge.
   - Standard thrust clearance: 0.100 to 0.200 mm (0.004 to 0.008 in.)
   - Maximum thrust clearance: 0.30 mm (0.011 in.)

   If the thrust clearance measured exceeds the maximum specification, replace the connecting rod assembly and inspect and replace the crankshaft if needed.

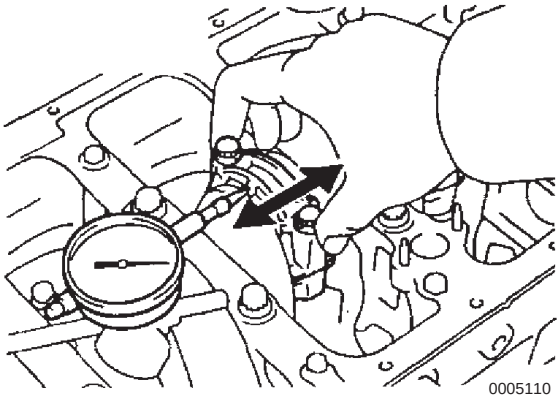


Figure 5-80

Note: Before removing the connecting rod caps, check the match marks **(Figure 5-81, (1))** on the connecting rod and cap to confirm that they match for reassembly.

4. To check connecting rod oil clearance, remove the two connecting rod cap bolts **(Figure 5-81, (2))**.

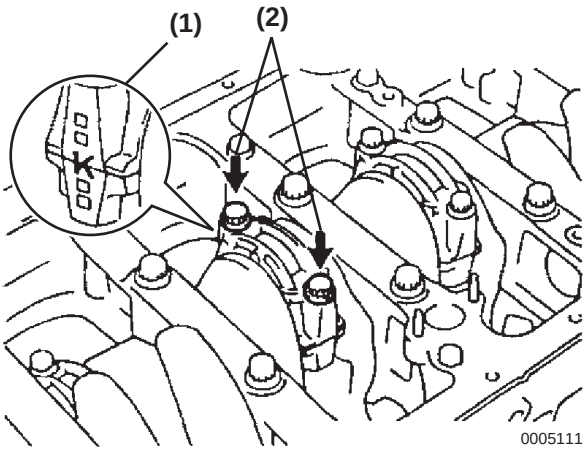


Figure 5-81

5. Move the connecting rod cap transversely **(Figure 5-82, (1))** using two removed connecting rod cap bolts, to remove the connecting rod cap.

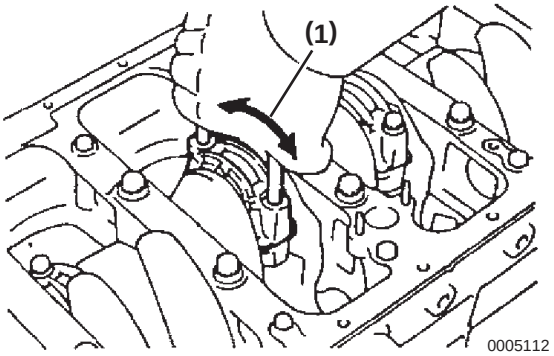


Figure 5-82

6. Insert the lower bearing to the connecting rod cap **(Figure 5-83)**.

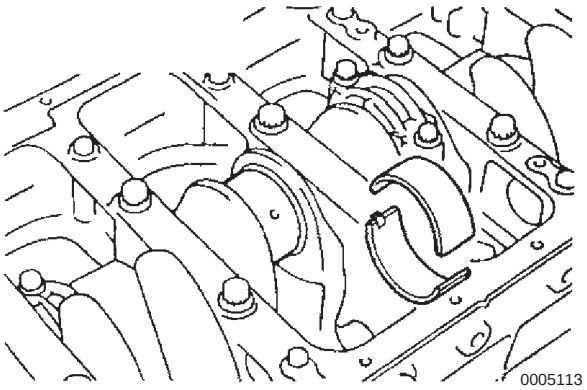


Figure 5-83

7. Check the crank pin and bearing for corrosion and scratches. If damage is present replace the bearing and grind or replace the crankshaft as necessary.
8. Attach a strip of the plastigage **(Figure 5-84, (1))** to the crank pin.

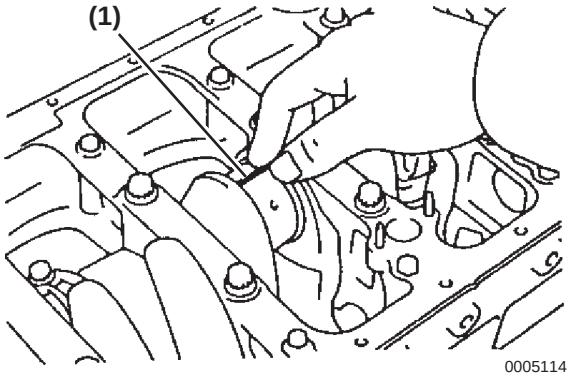


Figure 5-84

9. Install the connecting rod cap with 2 bolts **(Figure 5-85)**.

   Connecting rod cap torque:

   - First tightening: 375 kgf·cm, 37 N·m (27.2 lb-ft)
   - Second tightening: Turn additional 90°

Note: NEVER turn the crankshaft.

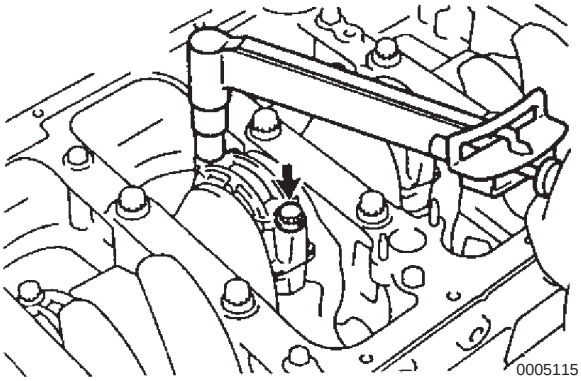


Figure 5-85

10. Remove the 2 bolts, connecting rod cap and lower bearing.
11. Measure the plastigage at the widest position **(Figure 5-86)**.
    - Standard oil clearance: 0.036 to 0.054 mm (0.001 to 0.002 in.)
    - Maximum oil clearance: 0.10 mm (0.004 in.)

    If the measured value exceeds the specified maximum, replace the bearing and grind or replace the crankshaft as necessary.

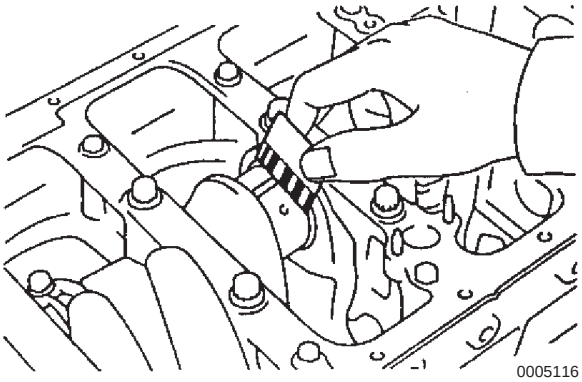


Figure 5-86

Note: Replace the old bearings with new bearings of the same number. If the bearing number is unknown, it may be determined by adding the numbers on the crankshaft with those on the connecting rod. There are five types of standard bearings, which are identified by marks “2”, “3”, “4”, “5” and “6” **(Figure 5-87)**.

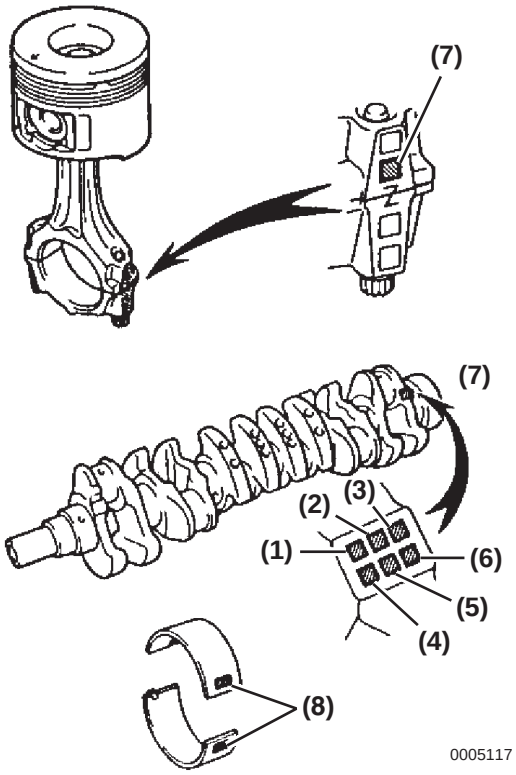


Figure 5-87

1 – No. 1 Mark
2 – No. 2 Mark
3 – No. 3 Mark
4 – No. 4 Mark
5 – No. 5 Mark
6 – No. 6 Mark
7 – Mark No. 1, 2 or 3
8 – Mark No. 2, 3, 4, 5, or 6

Crank Pin Bearing Selection Table									
	Mark No.								
Connecting Rod	1			2			3		
Crankshaft	1	2	3	1	2	3	1	2	3
Bearing	2	3	4	3	4	5	4	5	6

Example: If the marks on the connecting rod and crankshaft are (2) and (1), select bearing (3) as (2 + 1 = 3).

Inside Diameter of Larger End of Connecting Rod	
Mark “1”	62.014 to 62.020 mm (2.4414 to 2.4417 in.)
Mark “2”	62.020 to 62.026 mm (2.4417 to 2.4419 in.)
Mark “3”	62.026 to 62.032 mm (2.4419 to 2.4422 in.)

Diameter of Crankshaft Crank Pin	
Mark “1”	58.994 to 59.000 mm (2.3225 to 2.3228 in.)
Mark “2”	58.988 to 58.994 mm (2.3223 to 2.3226 in.)
Mark “3”	58.982 to 58.988 mm (2.3221 to 2.3223 in.)

Bearing Thickness		
Mark “2”	1.486 to 1.489 mm	P/N: 119770-00260
Mark “3”	1.489 to 1.492 mm (0.0585 to 0.0586 in.)	119770-01010
Mark “4”	1.492 to 1.495 mm (0.0586 to 0.0587 in.)	119770-01020
Mark “5”	1.495 to 1.498 mm (0.0587 to 0.0588 in.)	119770-01030
Mark “6”	1.498 to 1.501 mm (0.0589 to 0.0590 in.)	119770-01040

12. Completely remove the plastigage.

13. Before removing the pistons, remove all carbon deposits from the upper cylinder ridge areas **(Figure 5-88)**.

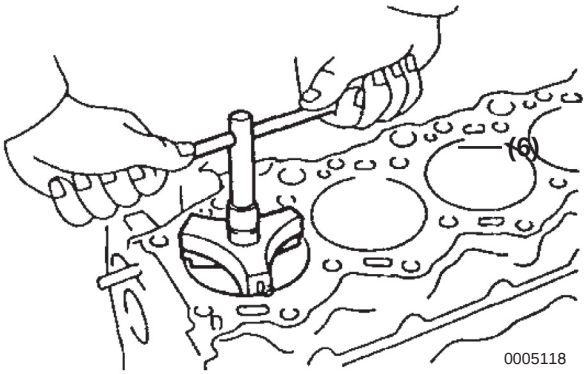


Figure 5-88

14. Remove all the piston and connecting rod assemblies from the cylinder block.

    Store each bearing, connecting rod and cap together as a set and mark each from the cylinder they were removed.

    Store the pistons and connecting rod assemblies together in sets marked by their cylinder number for correct reassembly.

15. Measure the crankshaft thrust clearance with a dial indicator by moving the crankshaft back and forth using a screwdriver **(Figure 5-89, (1))**.
    - Standard thrust clearance: 0.040 to 0.240 mm (0.001 to 0.009 in.)
    - Maximum thrust clearance: 0.30 mm (0.012 in.)

    If the measured value exceeds the specified maximum, replace the thrust bearing as a set.
    - Thrust bearing thickness: 2.930 to 2.980 mm (0.115 to 0.117 in.)

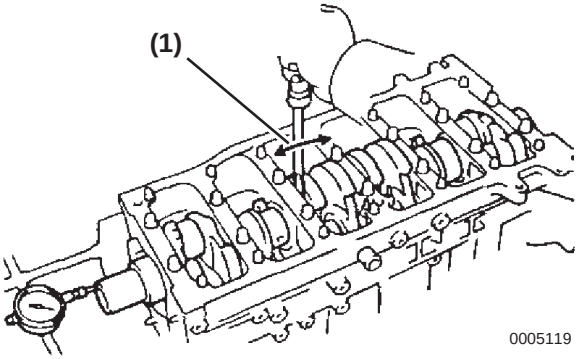


Figure 5-89

16. Remove the 15 main bearing cap bolts (6 pointed head) shown in **Figure 5-90**.

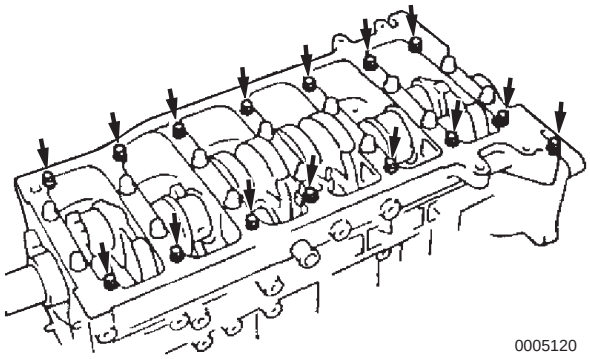


Figure 5-90

17. Uniformly loosen and remove the 14 main bearing cap bolts (12 pointed head) in the order shown in **Figure 5-91**.

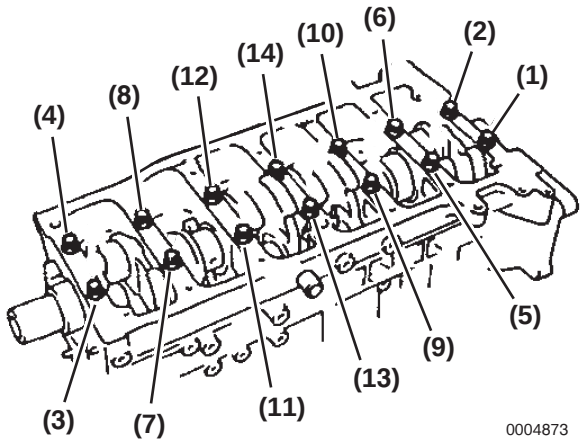


Figure 5-91

18. Insert the tip of a screwdriver **(Figure 5-92, (1))** between the main bearing cap and cylinder block and pry out the main bearing cap. Insert the lower bearing into the main bearing cap in preparation for reassembly.

Note: AVOID damaging the contact surfaces of the main bearing cap and cylinder block during disassembly.

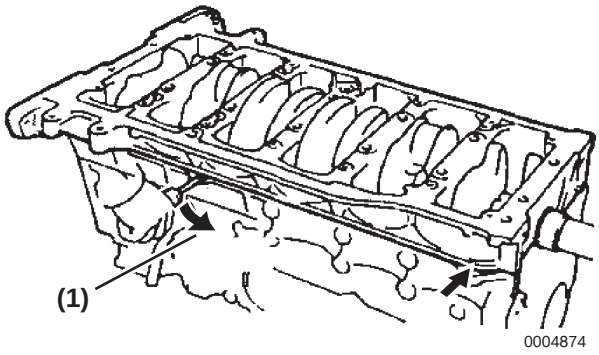


Figure 5-92

19. Lift and remove the crankshaft.
    - Insert the upper bearing into the cylinder block in preparation for reassembly.
    - Keep the thrust bearings in the correct order for reassembly.
20. Clean the main journals and bearings.

21. Check the main journals and bearings for damage. If damaged, replace the bearings and grind or replace the crankshaft as needed **(Figure 5-93)**.

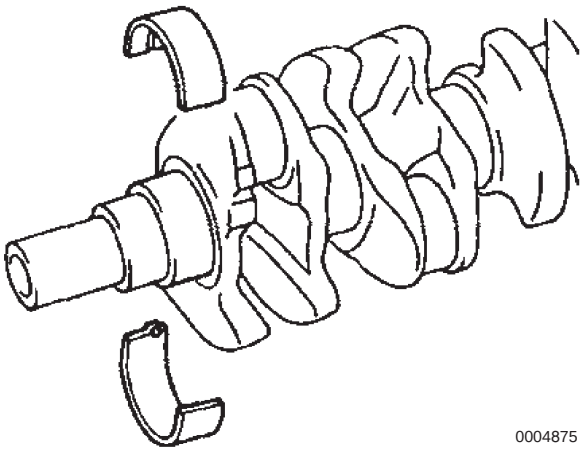


Figure 5-93

22. Install the crankshaft on the cylinder block.
23. Attach a strip of plastigage **(Figure 5-94, (1))** to each journal.

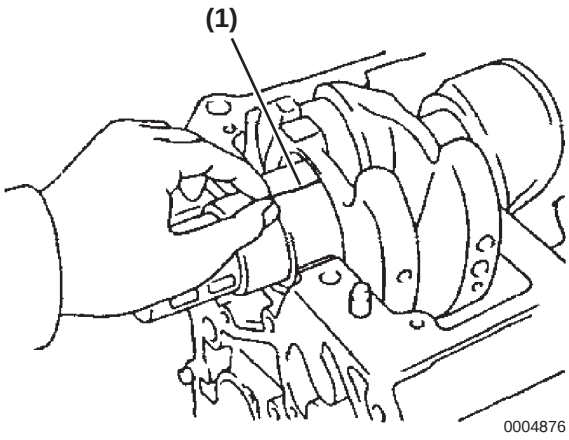


Figure 5-94

24. Install the main bearing cap with the 14 bolts (12 pointed head) **(Figure 5-95)**. See steps 13 to 18 starting at *Cylinder Block Assembly on page 5-63*. *NOTICE: NEVER turn the crankshaft.*

Tightening torque:

- First tightening: 1050 kgf·cm, 102.90 N·m (78.9 lb-ft).
- Second tightening: Turn by 90°

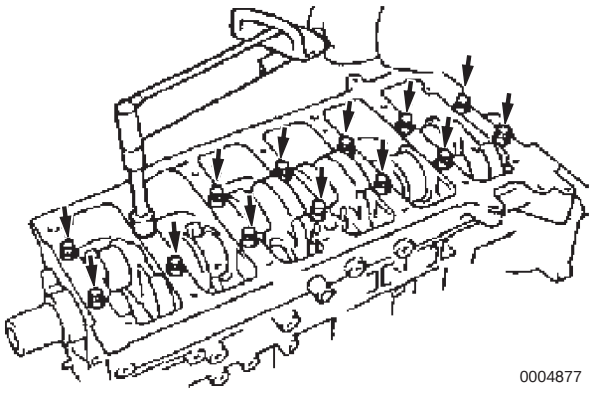


Figure 5-95

25. Remove the 14 bolts and main bearing caps.
26. Measure the plastigage at the widest point **(Figure 5-96)**.
    (a) Standard clearance: 0.036 to 0.054 mm (0.001 to 0.002 in.)
    (b) Maximum clearance: 0.10 mm (0.004 in.)

    If the measured oil clearance exceeds the specified maximum, replace the bearing and grind or replace the crankshaft as necessary.

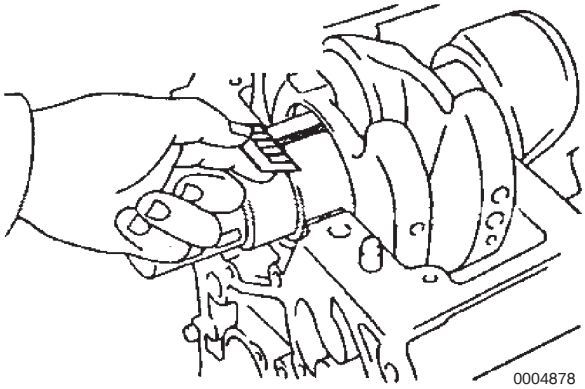


Figure 5-96

Note: Replace the old bearings with new bearings of the same number. If the bearing number is unknown, it may be determined by adding the numbers on the main bearing cap and crankshaft and select a bearing having a number equal to that obtained by addition. There are five types of standard bearings, which are identified by marks “2”, “3”, “4”, 5” and “6” **(Figure 5-97)**.

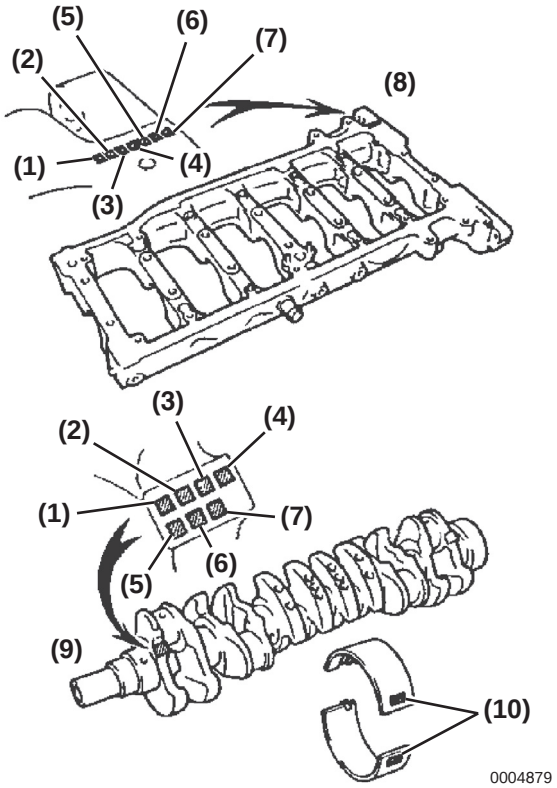


Figure 5-97

1 – No. 1
2 – No. 2
3 – No. 3
4 – No. 4
5 – No. 5
6 – No. 6
7 – No. 7
8 – Mark 1, 2, 3, 4 or 5
9 – Mark 1, 2 or 3
10 – Mark 2, 3, 4, 5 or 6

Crank Journal Bearing Selection Table									
	Mark No.								
Main bearing cap	1			2			3		
Crankshaft	1	2	3	1	2	3	1	2	3
Bearing	2	3	4	3	4	5	4	5	6

Example: If the numbers on the main bearing cap and crankshaft are (2) and (1), select bearing (3) as (2 + 1 = 3).

Cylinder Block Journal Bore Diameter	
Mark “1”	71.000 to 71.006 mm (2.7952 to 2.7955 in.)
Mark “2”	71.006 to 71.012 mm (2.7955 to 2.7957 in.)
Mark “3”	71.012 to 71.018 mm (2.7957 to 2.7959 in.)

Crankshaft Journal Diameter	
Mark “1”	66.994 to 67.000 mm (2.6375 to 2.6377 in.)
Mark “2”	66.988 to 66.994 mm (2.6377 to 2.6375 in.)
Mark “3”	66.982 to 66.988 mm (2.6370 to 2.6373 in.

Crank Journal Bearing Thickness and P/N		
Mark “2”	1.979 to 1.982 mm (0.0779 to 0.0780 in.)	-
Mark “3”	1.982 to 1.985 mm (0.0780 to 0.0781 in.)	P/N: 119770-00961
Mark “4”	1.985 to 1.988 mm (0.0781 to 0.0782 in.)	119770-00971
Mark “5”	1.988 to 1.991 mm 0.0782 to 0.0783 in.)	119770-00981
Mark “6”	1.991 to 1.994 mm (0.0783 to 0.0786 in.)	119770-00991
Mark “7”	1.994 to 1.997 mm (0.0785 to 0.0786 in.)	119770-01001
Mark “8”	1.997 to 2.000 mm (0.0786 to 0.0787 in.)	119770-01170

Crankshaft Bearing Identification Chart

Mark	Cylinder Block Main Journal Bore Diameter		Mark	Crankshaft Main Journal Diameter
A	70.999~71.00 mm (2.79522~2.79526 in.)		A	66.999~67.000 mm (2.63774~2.63778 in.)
B	70.998~70.999 mm (2.79518~2.79522 in.)		B	66.998~66.999 mm (2.63770~2.63744 in.)
C	70.997~70.998 mm (2.79514~2.79518 in.)		C	66.997~66.998 mm (2.63766~2.63770 in.)
D	70.996~70.997 mm (2.79511~2.79514 in.)		D	66.996~66.997 mm (2.63763~2.63766 in.)
E	70.995~70.996 mm (2.79507~2.79511 in.)		E	66.995~66.996 mm (2.63759~2.63763 in.)
H	70.994~70.995 mm (2.79503~2.79507 in.)		H	66.994~66.995 mm (2.63755~2.63759 in.)
4	70.993~70.994 mm (2.79499~2.79503 in.)		4	66.993~66.994 mm (2.63751~2.63755 in.)
5	70.992~70.993 mm (2.79495~2.79499 in.)		5	66.992~66.993 mm (2.63747~2.63751 in.)
6	70.991~70.992 mm (2.79491~2.79495 in.)		6	66.991~66.992 mm (2.63743~2.63747 in.)
7	70.990~70.991 mm (2.79487~2.79491 in.)		7	66.990~66.991 mm (2.63739~2.63743 in.)
8	70.989~70.990 mm (2.79483~2.79487 in.)		8	66.989~66.990 mm (2.63735~2.63739 in.)
9	70.988~70.989 mm (2.79479~2.79483 in.)		9	66.998~66.989 mm (2.63770~2.63735 in.)
L	70.987~70.988 mm (2.79475~2.79479 in.)		L	66.987~66.988 mm (2.63727~2.63713 in.)
M	70.986~70.987 mm (2.79471~2.79475 in.)		M	66.986~66.987 mm (2.63723~2.63727 in.)
R	70.985~70.986 mm (2.79467~2.79471 in.)		R	66.985~66.986 mm (2.63719~2.63723 in.)
S	70.984~70.985 mm (2.79463~2.79467 in.)		S	66.984~66.985 mm (2.63715~2.63719 in.)
U	70.983~70.984 mm (2.79459~2.79463 in.)		U	66.983~66.984 mm (2.63711~2.63715 in.)
X	70.982~70.983 mm (2.79455~2.79459 in.)		X	66.982~66.983 mm (2.63707~2.63711 in.)

		Crankshaft Main Journal Mark																	
		A	B	C	D	E	H	4	5	6	7	8	9	L	M	R	S	U	X
Cylinder Block Journal Mark	A	3	3	3	3	3	3	4	4	4	4	4	4	5	5	5	5	5	5
	B	3	3	3	3	3	4	4	4	4	4	4	5	5	5	5	5	5	6
	C	3	3	3	3	4	4	4	4	4	4	5	5	5	5	5	5	6	6
	D	3	3	3	4	4	4	4	4	4	5	5	5	5	5	5	6	6	6
	E	3	3	4	4	4	4	4	4	5	5	5	5	5	5	6	6	6	6
	H	3	4	4	4	4	4	4	5	5	5	5	5	5	6	6	6	6	6
	4	4	4	4	4	4	4	5	5	5	5	5	5	6	6	6	6	6	6
	5	4	4	4	4	4	5	5	5	5	5	5	6	6	6	6	6	6	7
	6	4	4	4	4	5	5	5	5	5	5	6	6	6	6	6	6	7	7
	7	4	4	4	5	5	5	5	5	5	6	6	6	6	6	6	7	7	7
	8	4	4	5	5	5	5	5	5	6	6	6	6	6	6	7	7	7	7
	9	4	5	5	5	5	5	5	6	6	6	6	6	6	7	7	7	7	7
	L	5	5	5	5	5	5	6	6	6	6	6	6	7	7	7	7	7	7
	M	5	5	5	5	5	6	6	6	6	6	6	7	7	7	7	7	7	8
	R	5	5	5	5	6	6	6	6	6	6	7	7	7	7	7	7	8	8
	S	5	5	5	6	6	6	6	6	6	7	7	7	7	7	7	8	8	8
	U	5	5	6	6	6	6	6	6	7	7	7	7	7	7	8	8	8	8
	X	5	6	6	6	6	6	6	7	7	7	7	7	7	8	8	8	8	8

27. Completely remove the plastigage.
28. Lift and remove the crankshaft **(Figure 5-98)**.

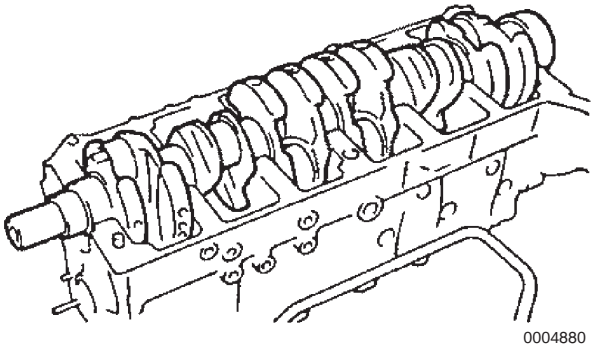


Figure 5-98

29. Remove the upper bearing and thrust bearing from the cylinder block.

    Keep the main bearing and thrust bearing together in order for reassembly.

30. Remove the check valve and oil nozzle (for piston cooling). *See Oil Nozzle Disassembly and Inspection on page 8-17*.

Cylinder Block Inspection

1. Use a scraper to remove any remaining gasket material from the top of the cylinder block **(Figure 5-99)**.

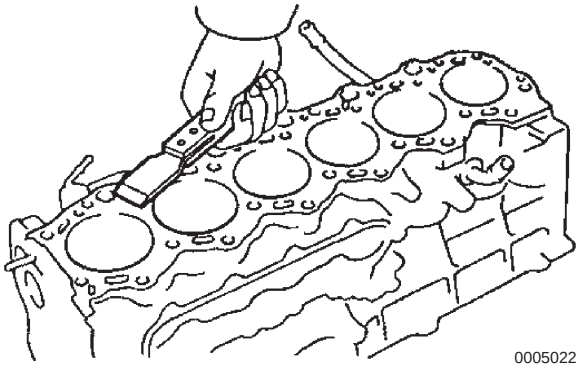


Figure 5-99

2. Thoroughly clean the cylinder block using a soft brush and solvent.
3. Measure the top deck surface of the cylinder block using a precision straight edge and feeler gauge **(Figure 5-100)**.
   - Maximum warpage is 0.20 mm (0.008 in.)

   If the measured warpage exceeds the maximum, replace the cylinder block.

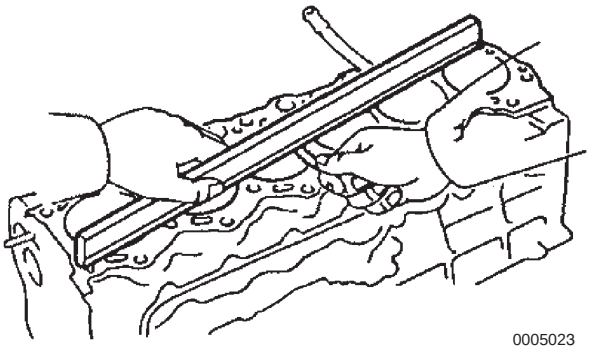


Figure 5-100

4. Visually check the cylinders for vertical scratches. If deep scratches are present, bore the cylinders or replace as needed **(Figure 5-101)**.

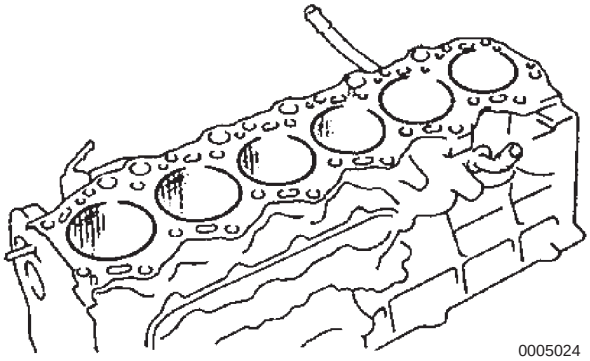


Figure 5-101

Note: There are three types of cylinders having different bore diameters, which are identified by markings of “1”, “2” and “3” in the upper portion of the cylinder block **(Figure 5-102)**.

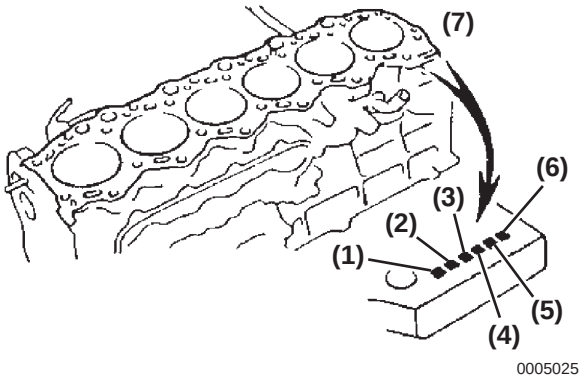


Figure 5-102

1 – No. 1
2 – No. 2
3 – No. 3
4 – No. 4
5 – No. 5
6 – No. 6
7 – Mark 1, 2 or 3

5. Measure the cylinder bore diameter at points A, B and C in the thrust **(Figure 5-103, (1))** and axial directions **(Figure 5-103, (2))**, using a cylinder gauge.

   Standard bore diameter:

   - Mark “1”: 94.000 to 94.010 mm (3.7007 to 3.7011 in.)
   - Mark “2”: 94.010 to 94.020 mm (3.7011 to 3.7015 in.)
   - Mark “3”: 94.020 to 94.030 mm (3.7015 in. to 3.7019 in.)

   Maximum bore diameter:

   - 94.23 mm (3.7098 in.)

   If the measured bore diameter exceeds the specified maximum, bore the cylinders or replace as needed.

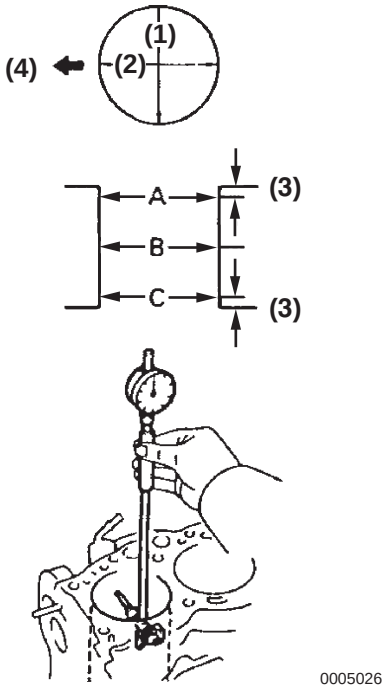


Figure 5-103

1 – Thrust Direction
2 – Axial Direction
3 – 10 mm (0.393 in.)
4 – Front

6. If the cylinder wear is less than 0.2 mm (0.008 in.), clean the cylinder ridge with a ridge reamer **(Figure 5-104)**.

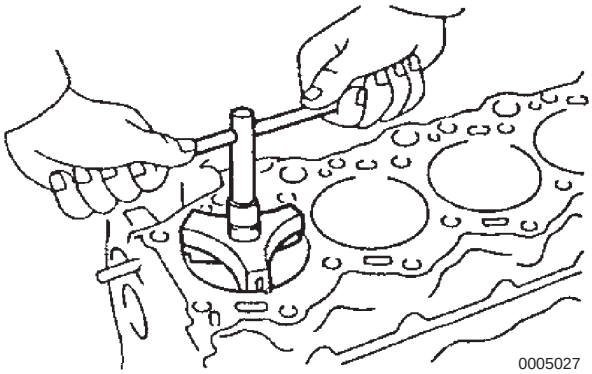


Figure 5-104

7. Measure the outside diameter of the main bearing cap bolt threads using calipers **(Figure 5-105)**. Check for damaged or seized threads.
   - Standard outside diameter: 11.800 to 12.000 mm (0.46 to 0.47 in.)
   - Minimum outside diameter: 11.50 mm (0.45 in.)

   If the measured outside diameter is below the specified minimum, replace the bolt(s).

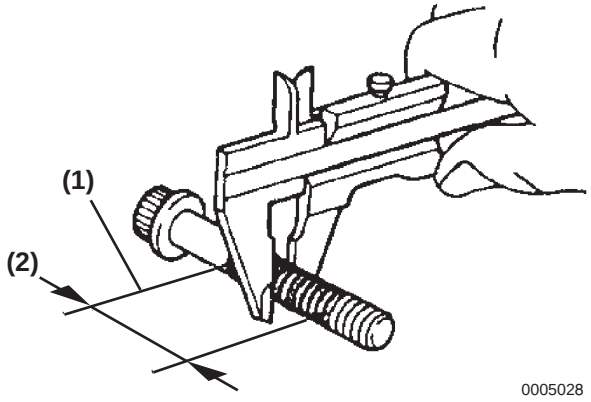


Figure 5-105

1 – Thread End
2 – 40 mm (1.57 in.)

Piston and Connecting Rod Disassembly

1. Check the piston to piston pin fit by moving the piston back and forth on the piston pin. If any movement is felt, replace the piston and piston pin as a set **(Figure 5-106)**.

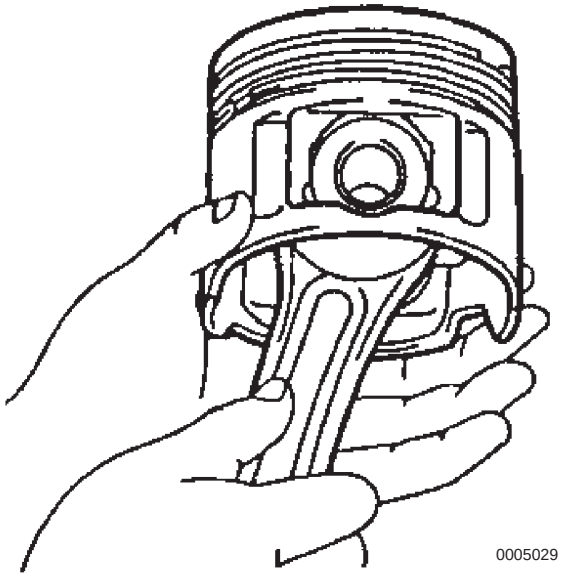


Figure 5-106

2. Remove the piston rings using the piston ring expander **(Figure 5-107)**.

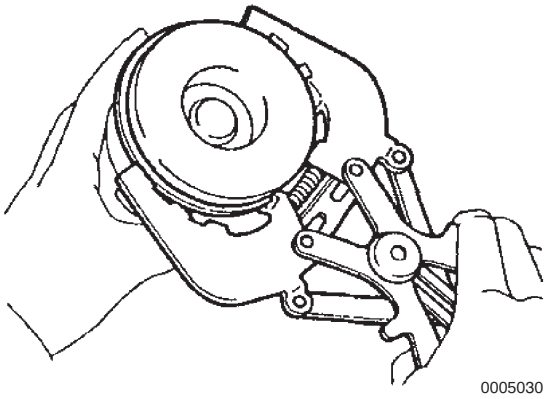


Figure 5-107

3. Manually remove the coil for the oil ring. Store the rings in the correct order for reassembly.

4. Pry out the snap ring using a small screwdriver to remove it from the piston **(Figure 5-108)**.

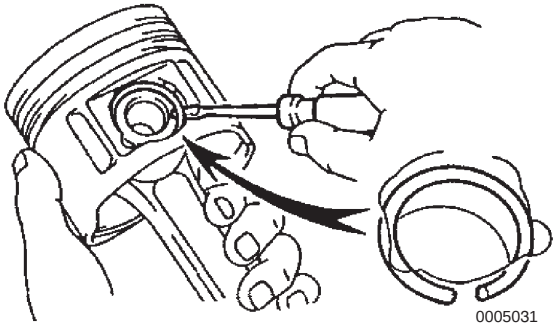


Figure 5-108

5. Slowly heat the piston to about 80°C (176°F) **(Figure 5-109)**.

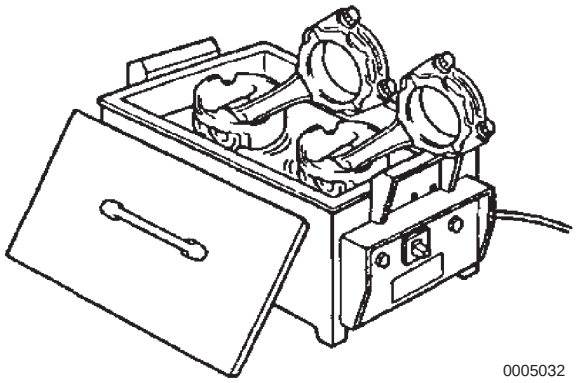


Figure 5-109

6. Lightly tap out the piston pin using a plastic hammer and copper bar to disconnect the connecting rod **(Figure 5-110)**.

   Store the piston and pin as a set. Store the pistons, pins, rings and connecting rods together in correct order for reassembly.

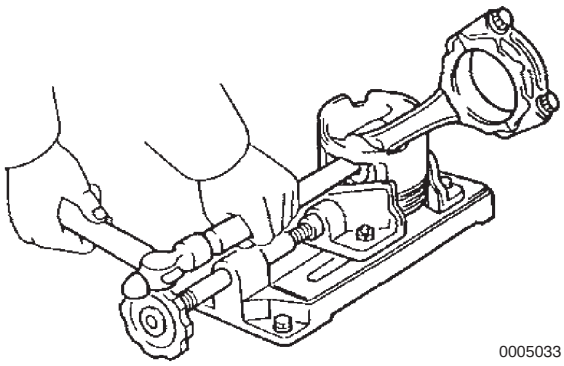


Figure 5-110

Piston and Connecting Rod Inspection

1. Clean the carbon deposits off the piston top using a scraper **(Figure 5-111)**.

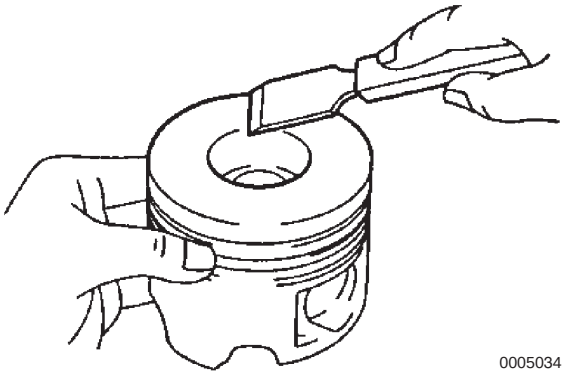


Figure 5-111

2. Clean the piston ring grooves using the groove cleaning tool or a damaged ring **(Figure 5-112)**.

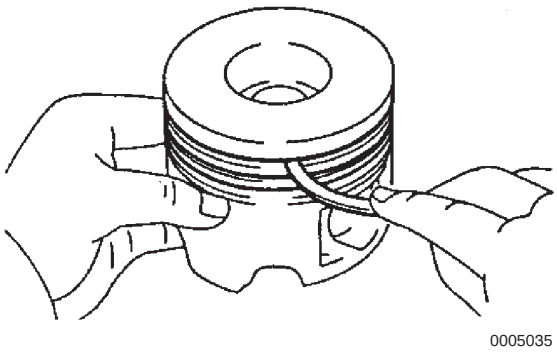


Figure 5-112

3. Completely clean the piston using a brush and solvent **(Figure 5-113)**.

Note: NEVER use a wire brush.

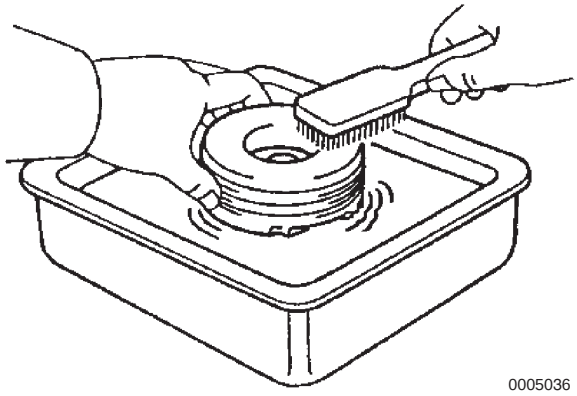


Figure 5-113

4. Measure the piston diameter and oil clearance. There are three types of pistons having different piston diameters, which are identified by marks “1”, “2” and “3”. The marks are stamped on the piston tops **(Figure 5-114, (1))**.

   Measure the piston diameter at right angle to the piston pin at the “L” position **(Figure 5-114, (3))** from the piston top, using a micrometer.

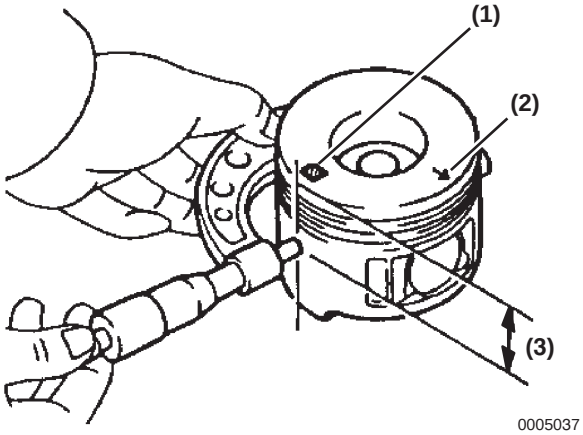
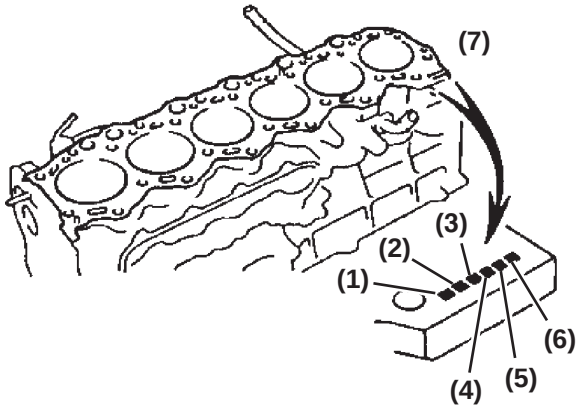


Figure 5-114

1 – SIze Mark
2 – Front Mark (Arrow)
3 – “L” Position

Piston Diameter	
Measurement position “L“	66.4 mm (2.6141 in.)
Mark “1”	93.835 to 93.845 mm (3.6942 to 3.6946 in.)
Mark “2”	93.845 to 93.855 mm (3.6946 to 3.6950 in.)
Mark “3”	93.855 to 93.865 mm (3.6950 to 3.6954 in.)

5. Measure the cylinder bore diameter in the thrust direction. See step 5 starting in *Cylinder Block Inspection on page 5-51*.



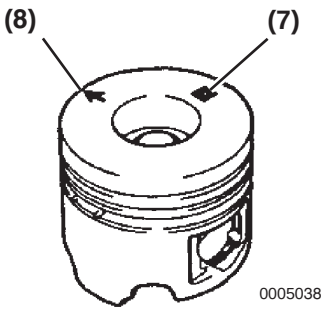


Figure 5-115

1 – No. 1
2 – No. 2
3 – No. 3
4 – No. 4
5 – No. 5
6 – No. 6
7 – Mark 1, 2 or 3
8 – Front Mark (Arrow)

6. Subtract the piston diameter from the cylinder bore diameter.
   - Standard oil clearance: 0.145 to 0.165 mm (0.0057 to 0.0065 in.)
   - Maximum oil clearance: 0.215 mm (0.0084 in.)

   If the measured oil clearance exceeds the specified maximum, replace all six pistons and bore all six cylinders. Replace the cylinder block as needed.

Note: When using a new cylinder block, make sure the number on the cylinder block and the number on the pistons are the same.

7. Measure the clearance of the piston ring.

   No. 1 ring (top ring):

   Install a new piston ring to the piston. Measure the clearance **(Figure 5-116, (1))** between the piston ring and ring groove using a thickness gauge.

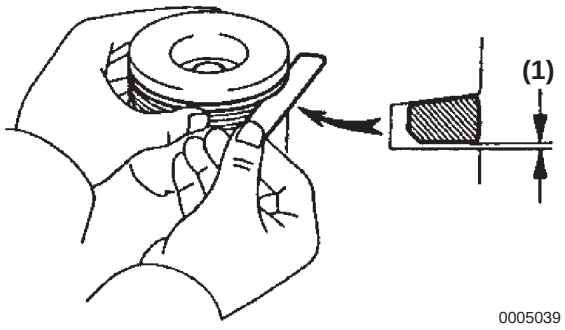


Figure 5-116

- Standard clearance: 0.050 to 0.095 mm (0.002 to 0.004 in.)
- Maximum clearance: 0.20 mm (0.008 in.)

If the measured clearance exceeds the specified maximum, replace the piston.

No. 2 ring (second ring) and oil ring:

Measure the clearance between the new piston ring and ring groove using a thickness gauge **(Figure 5-117)**.

- Standard clearance No. 2 ring: 0.060 to 0.100 mm (0.002 to 0.004 in.)

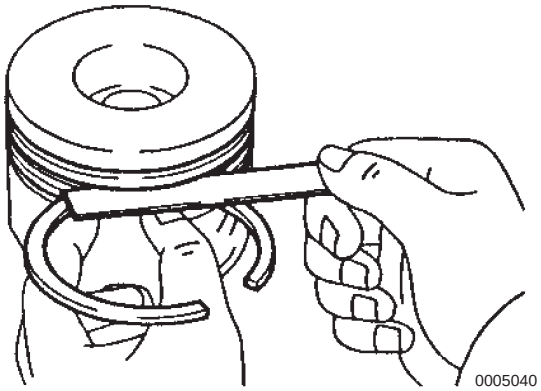


Figure 5-117

- Standard clearance of oil ring: 0.030 to 0.070 mm (0.001 to 0.003 in).
- Maximum clearance: 0.20 mm (0.008 in.)

If the measured clearance exceeds the specified maximum, replace the piston.

8. Measure the piston ring end gap.
   (a) Insert the piston ring in the cylinder.
   (b) Press in the piston ring to a position 130 mm (5.118 in.) **(Figure 5-118, (1))** from the cylinder block top surface **(Figure 5-118, (2))**, using the piston.

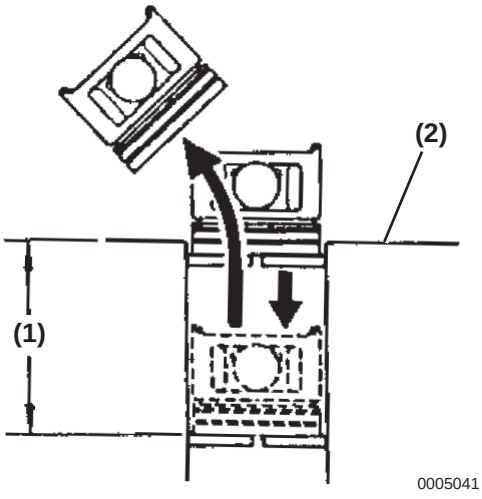


Figure 5-118

(c) Measure the end gap using a thickness gauge **(Figure 5-119)**.

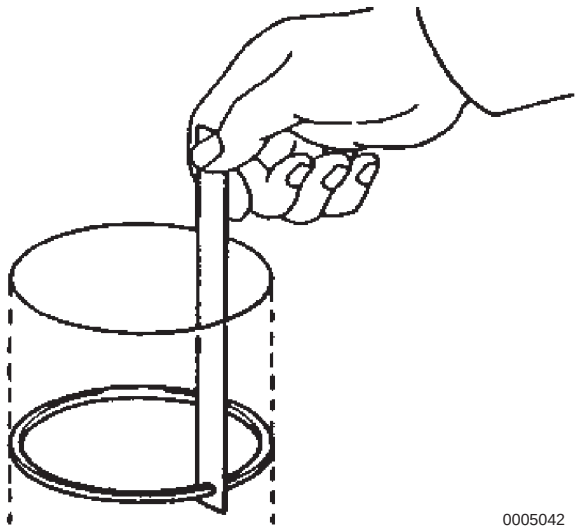


Figure 5-119

Standard end gap:

- No. 1 ring: 0.270 to 0.470 mm (0.011 to 0.018 in.)
- No. 2 ring: 0.400 to 0.650 mm (0.016 to 0.025 in.)
- Oil ring: 0.200 to 0.500 mm (0.025 to 0.020 in.)

Maximum end gap:

- No. 1 ring: 0.85 mm (0.0334 in.)
- No. 2 ring: 0.90 mm (0.0354 in.)
- Oil ring: 0.88 mm (0.0346 in.)

Note: If the end gap exceeds the specified maximum, replace the piston ring. If the end gap still exceeds the maximum even when a new piston ring is used, bore all six cylinders or replace the cylinder block.

9. Inspect the piston pin fit to the piston. If the piston pin can be pressed into the piston by hand after heating the piston to about 80°C, the fit is acceptable **(Figure 5-120)**.

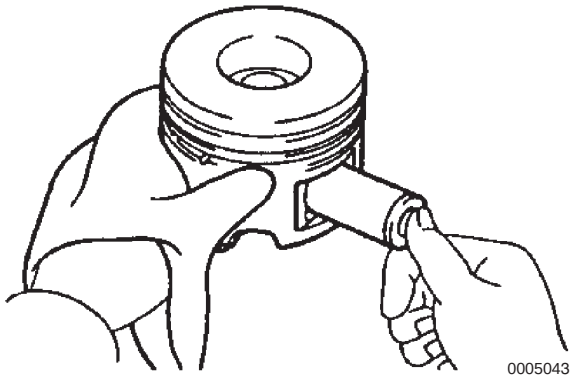


Figure 5-120

10. Measure the bend of the connecting rod using a rod aligner **(Figure 5-121, (1))** and thickness gauge.
    - Maximum bend: 0.03 mm (0.001 in.) per 100 mm (3.936 in.)

    If the measured bend exceeds the specified maximum, replace the connecting rod assembly.

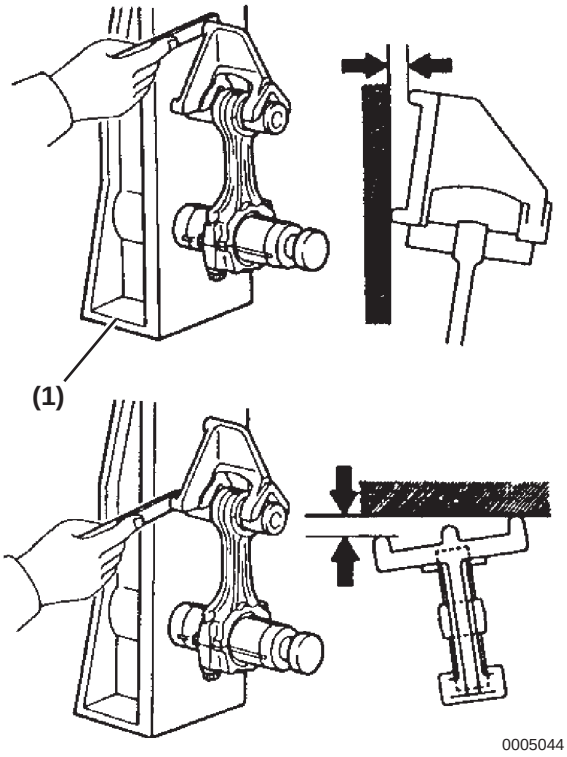


Figure 5-121

11. Measure the twist of the connecting rod.
    - Maximum twist: 0.15 mm (0.006 in.) per 100 mm (3.936 in.)

    If the measured twist exceeds the specified maximum, replace the connecting rod assembly.

12. Inspect the connecting rod bolt. Measure the tension portion diameter using calipers **(Figure 5-122)**.
    - Standard diameter: 8.300 to 8.400 mm (0.326 to 0.030 in.)
    - Minimum diameter: 7.95 mm (0.313 in.)

    If the measured diameter is less than the specified minimum, replace the connecting rod bolt.

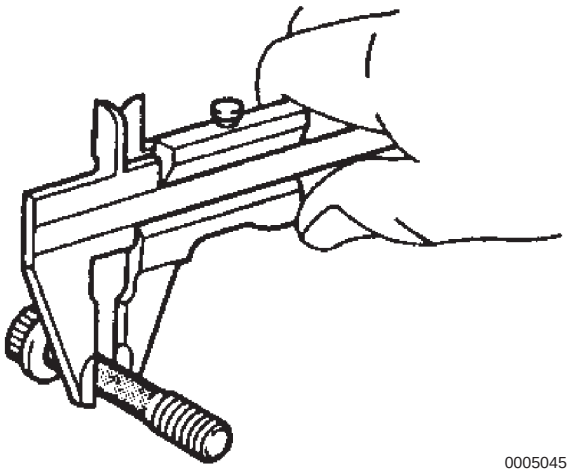


Figure 5-122

13. Inspect the oil clearance of the piston pin. Measure the inside diameter of the piston pin bearing using a caliper gauge **(Figure 5-123)**.
    - Inside diameter of piston pin bearing: 33.008 to 33.020 mm (1.2995 to 1.2999 in.)

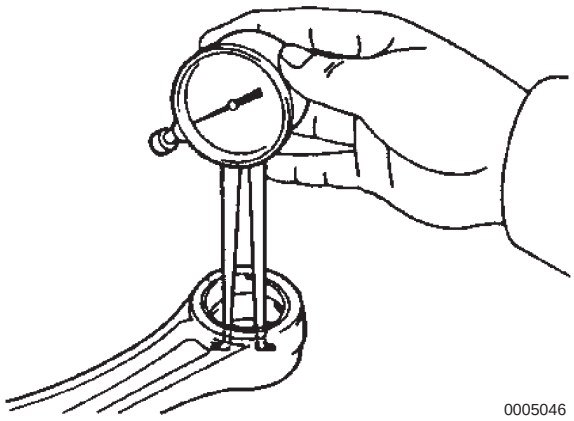


Figure 5-123

14. Measure the piston pin diameter using a micrometer **(Figure 5-124)**.
    - Piston pin diameter: 33.000 to 33.012 mm (1.2992 to 1.2996 in.)

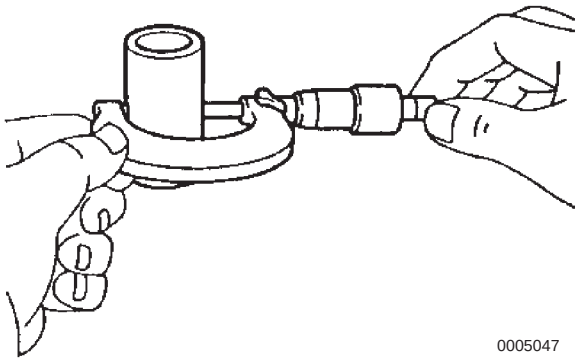


Figure 5-124

15. Subtract the measured piston pin diameter from the measured inside diameter of the piston pin bearing.
    - Standard oil clearance: 0.004 to 0.020 mm (0.0001 to 0.0008 in.)
    - Maximum oil clearance: 0.03 mm (0.001 in.)

    If measured oil clearance exceeds the specified maximum, replace the piston pin bearing. When necessary, replace the piston and piston pin as an assembly.

Note: If the piston pin bearing needs to be replaced, replace by the connecting rod assembly.

16. Check the piston pin engagement at room temperature. Apply engine oil to the piston pin and press it into the connecting rod by hand **(Figure 5-125)**.

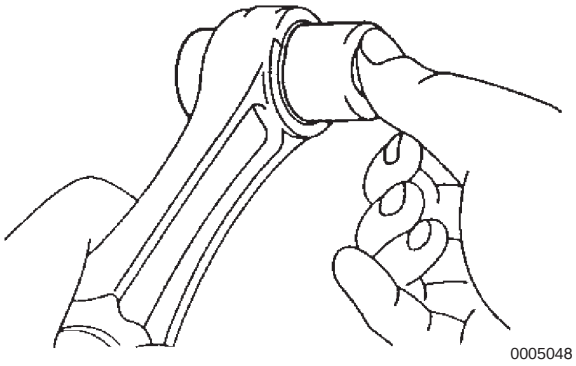


Figure 5-125

Inspection and Servicing of Crankshaft

1. To measure the circle runout of the crankshaft, set the crankshaft on a V-block. Measure circle runout of the center journal using a dial indicator while turning the crankshaft **(Figure 5-126, (1))**.
   - Maximum circle runout: 0.06 mm (0.002 in.)

   If the circle runout exceeds the specified maximum, replace the crankshaft.

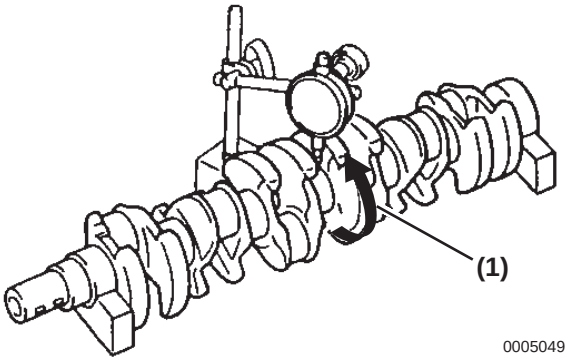


Figure 5-126

2. Inspect and measure diameters of each crank journal **(Figure 5-127, (1))** and crank pin **(Figure 5-127, (2))** using a micrometer.
   - Standard crank journal diameter: 66.982 to 67.000 mm (2.6370 to 2.6377 in.)
   - Standard crank pin diameter: 58.982 to 59.000 mm (2.3221 to 2.3228 in.)

   If the measured diameter is out of the specified range, check the oil clearance. Grind or replace the crankshaft as needed.

3. Measure the taper and out-of-round of the crank journal and crank pin.
   - Maximum taper and out-of-round: 0.020 mm (0.0008 in.)

   If the measured taper or out-of-round exceeds the specified maximum, replace the crankshaft.

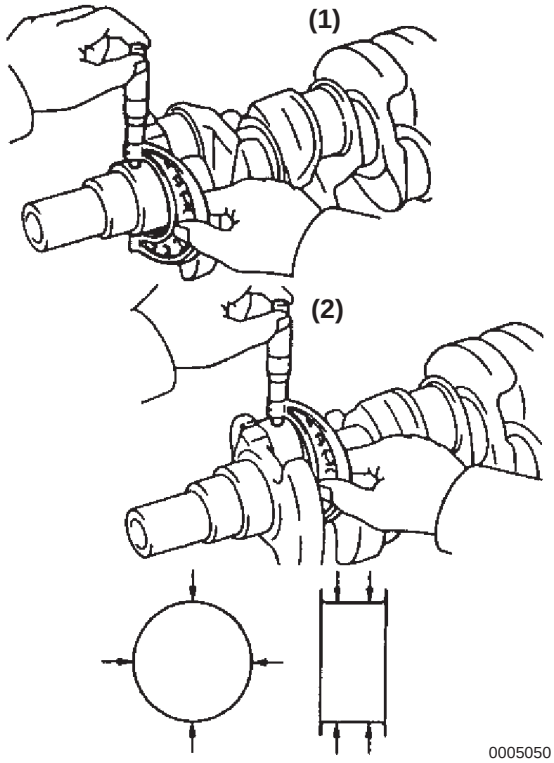


Figure 5-127

Crankshaft Oil Seal Replacement

There are 2 methods for oil seal replacement.

Method 1

When the rear oil seal case has been removed from the cylinder block:

1. Tap out the oil seal using a screwdriver and hammer **(Figure 5-128)**.

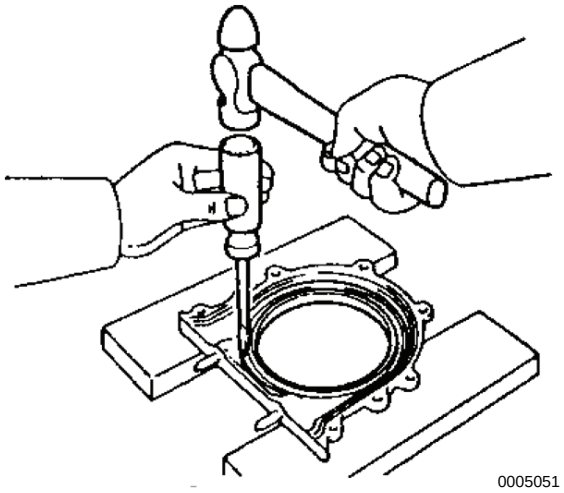


Figure 5-128

2. Using special tool P/N 119770-01130 **(Figure 5-129, (1))**, install a new oil seal until its surface is level with that of the rear oil seal case.

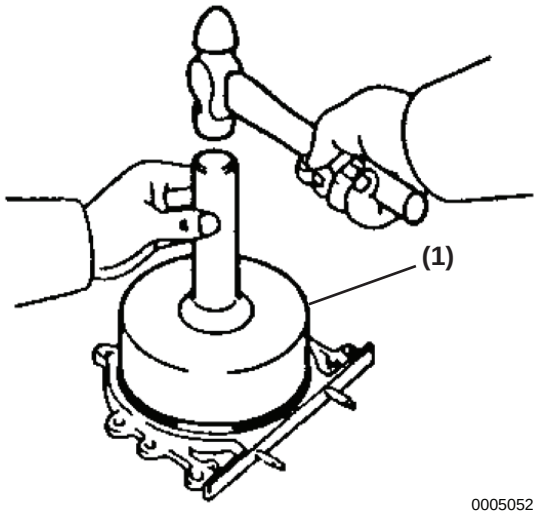


Figure 5-129

3. Apply grease to the oil seal lip.

Method 2

When the rear oil seal case is installed on the cylinder block:

1. Cut off the oil seal lip using a knife **(Figure 5-130, (1))**.
2. Pry out the oil seal using a screwdriver. *NOTICE:* AVOID damaging the crankshaft during removal. Use tape on the screwdriver tip to prevent scratches.

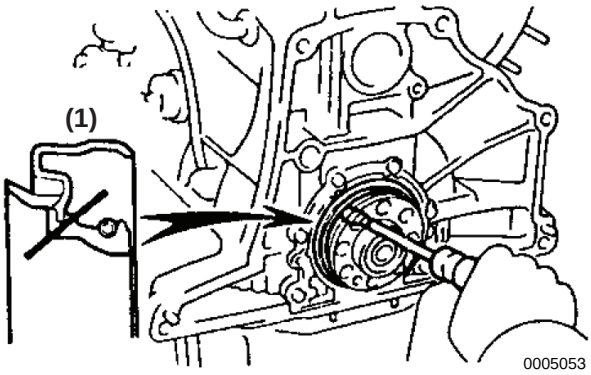


Figure 5-130

3. Apply grease to the new oil seal lip.
4. Using special tool P/N 119770-01130 **(Figure 5-131, (1))**, install the oil seal until its surface is level with that of the rear oil seal case.

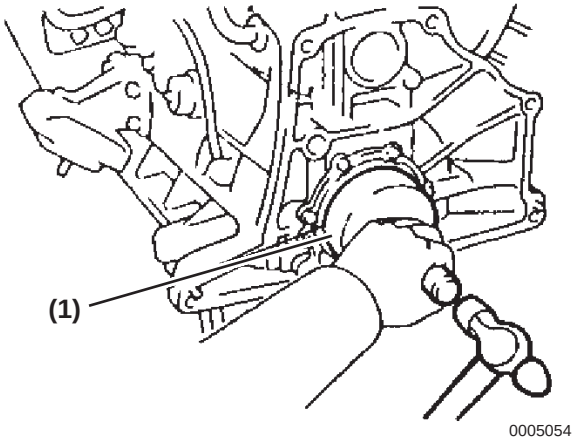


Figure 5-131

Piston and Connecting Rod Assembly

1. Install a new snap ring into one side of the piston pin snap ring grooves **(Figure 5-132, (1))**.

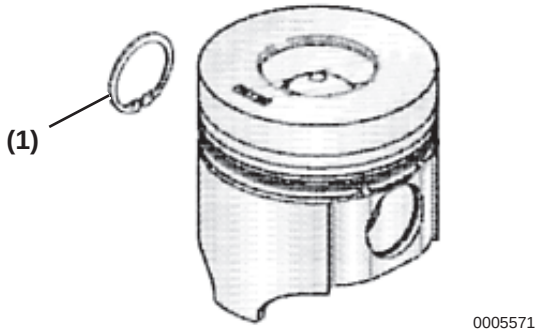


Figure 5-132

2. Slowly heat the piston to about 80°C (176°F) **(Figure 5-133)**.

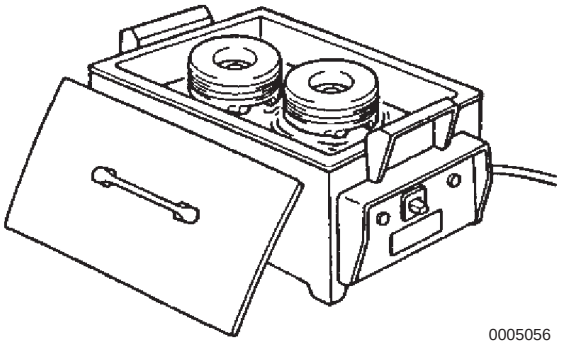


Figure 5-133

3. Apply engine oil to the piston pin.
4. Align the marks of the piston and connecting rod and press the piston pin in by hand **(Figure 5-134)**.

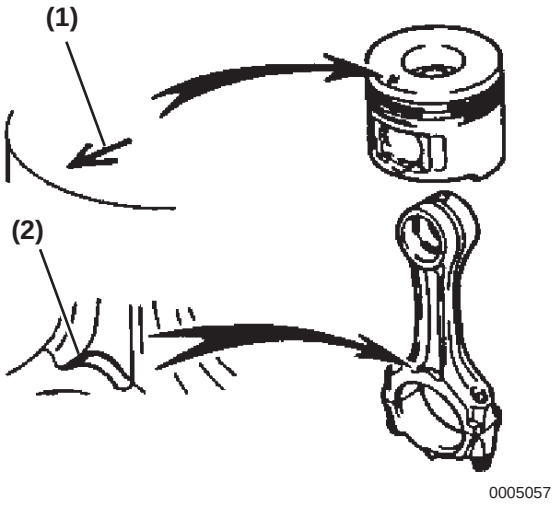


Figure 5-134

1 – Piston Front Mark (Arrow)
2 – Connecting Rod Front Mark

5. Install a new snap ring into the piston pin snap ring groove on the opposite side of the piston **(Figure 5-135, (1))**.

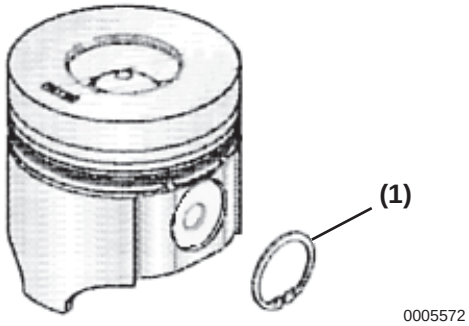


Figure 5-135

6. Manually install the coil for the oil piston ring **(Figure 5-136)**.

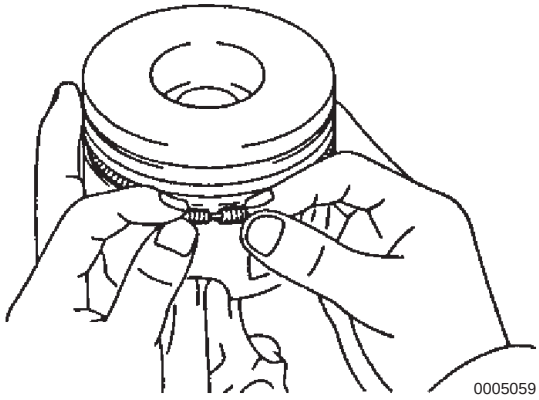


Figure 5-136

7. Using a piston ring expander, install the oil ring with the end gap **(Figure 5-137, (1))** facing the opposite side of the coil joint **(Figure 5-137, (2))**.

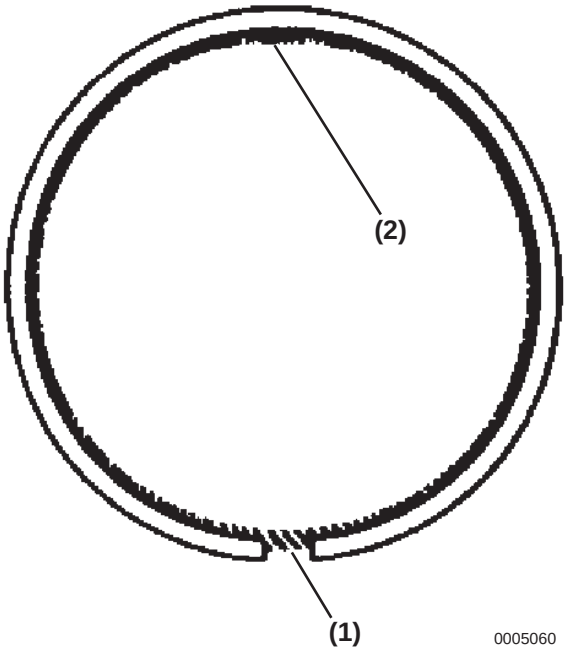


Figure 5-137

8. Using a piston ring expander, install the piston rings with the identification marks facing up **(Figure 5-138)**.

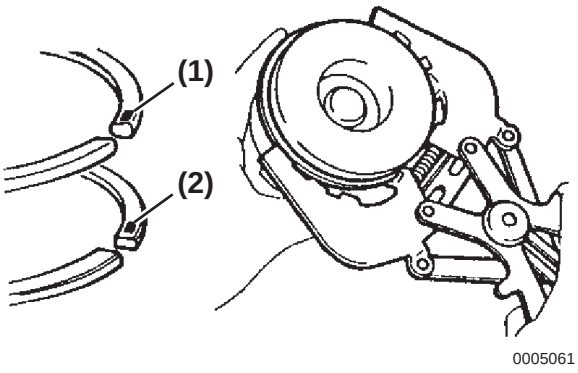


Figure 5-138

1 – No. 1 Piston Ring ID Mark
2 – No. 2 Piston Ring ID Mark

9. Install the piston rings with the ring end gaps as shown in **Figure 5-139**.

Note: NEVER allow ring end gaps to overlap at the same position.

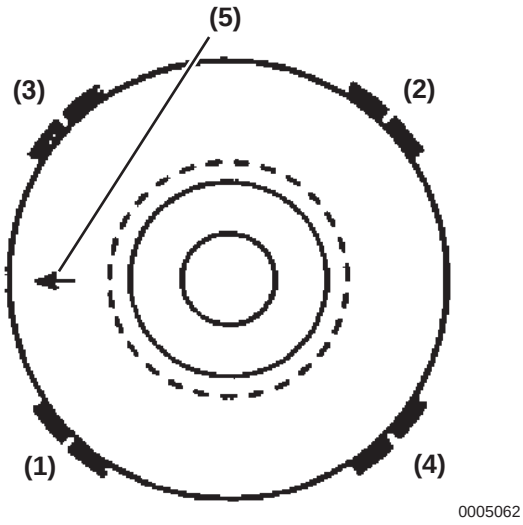


Figure 5-139

1 – No. 1 Piston Ring End Gap
2 – No. 2 Piston Ring End Gap
3 – Oil Piston Ring End Gap
4 – Oil Piston Coil Ring End Gap
5 – Piston Front Mark (Arrow)

10. Align the connecting rod bearing claw **(Figure 5-140, (1))** with the groove in connecting rod and connecting rod cap. Install all connecting rod bearings.

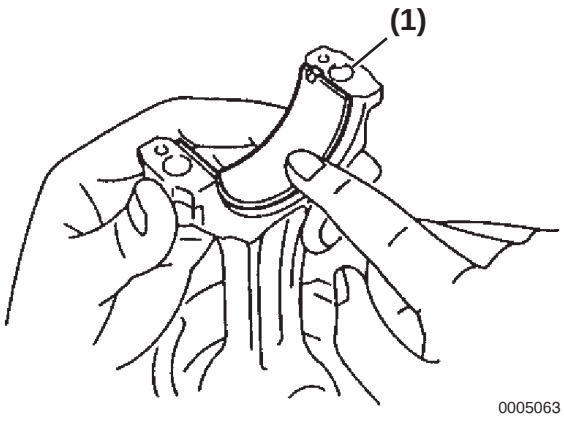


Figure 5-140

Cylinder Block Assembly

- Clean all parts before assembly.
- Apply new engine oil to all sliding and rotating surfaces before beginning assembly.
- Replace all gaskets, O-rings and oil seals.

1. Install the oil nozzle and check valve for piston cooling. *See Oil Nozzle Installation on page 8-17*.

Note: A oil groove and hole are provided to the upper main bearing, which are not provided to the lower main bearing.

2. Align the main bearing claws with the grooves in the cylinder block and press in seven upper bearings **(Figure 5-141)**.
3. Align the main bearing claws with the grooves in the main bearing caps and press in seven lower bearings.

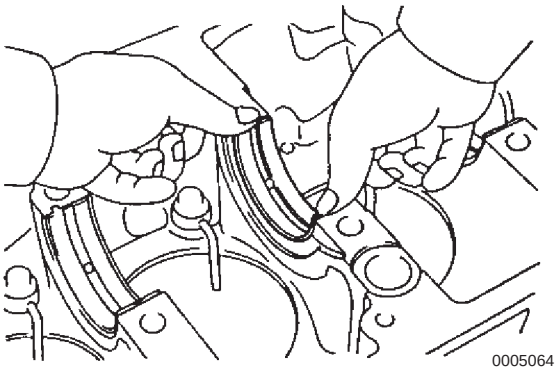


Figure 5-141

4. Place the crankshaft on the cylinder block **(Figure 5-142)**.

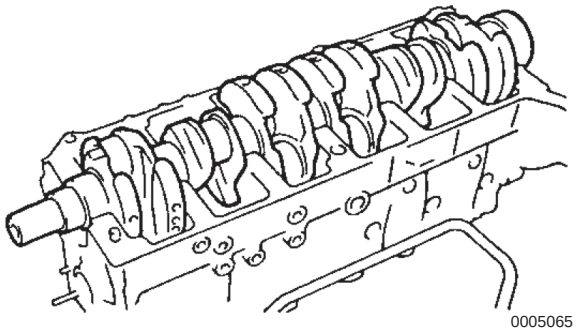


Figure 5-142

5. Push the crankshaft towards the front or rear of the cylinder block and install four thrust bearings to journal No. 4 of the cylinder block with the oil grooves facing outwards **(Figure 5-143)**.

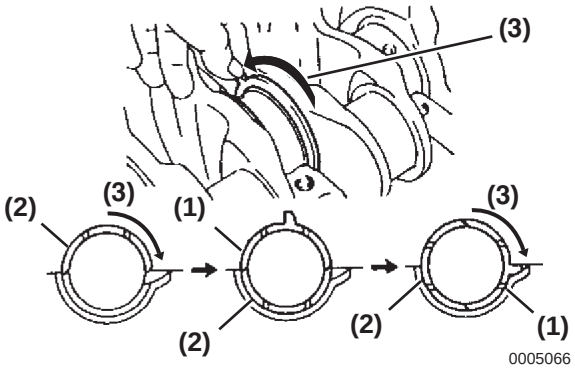


Figure 5-143

1 – No. 1
2 – No. 2
3 – Turn in direction of arrow.

6. Completely remove the packing material.

Note: Avoid contaminating the contact surfaces of the main bearing cap and cylinder block with oil.

7. Clean all components and remove all foreign matter.
8. Clean the sealing surface using clean solvent.

9. Apply seal packing (TOYOTA P/N 08826-00080 or equivalent) to the cylinder block **(Figure 5-144)**.

Note: Parts must be assembled within 5 minutes after the seal packing is applied or the packing material must be removed and then reapplied. Disconnect the nozzle from the tube immediately after use and cap the tube.

- Apply the seal packing in a width of 4 to 5 mm (0.157 to 0.197 in.) **(Figure 5-144, (1))**.

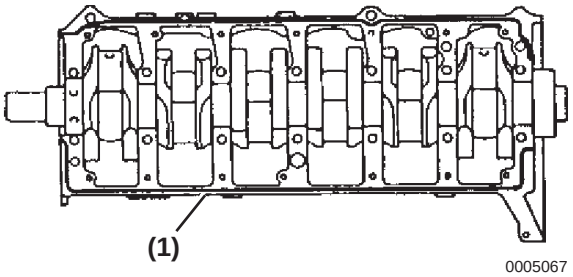


Figure 5-144

10. Install a new oil hole gasket **(Figure 5-145, (1))**.

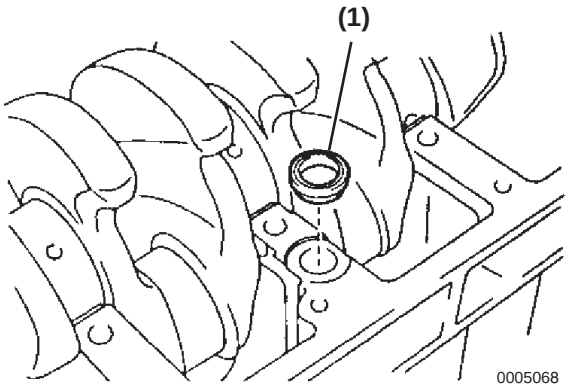


Figure 5-145

11. Place the main bearing cap on the cylinder block.
12. Apply engine oil to the threads and seat surfaces of the main bearing cap bolts.

Note: Replace any main bearing cap bolts that are broken, damaged or deformed.

13. Install the 14 main bearing cap bolts (12 pointed head), and tighten them uniformly in several passes in the sequence shown in **Figure 5-146**.
    - Torque: 1050 kgf·cm, 102.90 N·m (75.9 lb-ft)

Note: If any of the main bearing cap bolts fail to torque to the torque specification, replace the main bearing cap bolts.

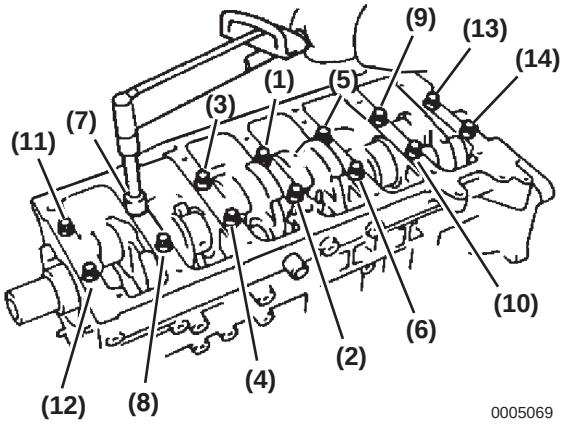


Figure 5-146

14. Make paint marks **(Figure 5-147, (1))** on the front **(Figure 5-147, (2))** of the main bearing cap bolt heads.
15. Retighten all bolts by 90° **(Figure 5-147, (3))** in the numerical order shown in **Figure 5-147**.

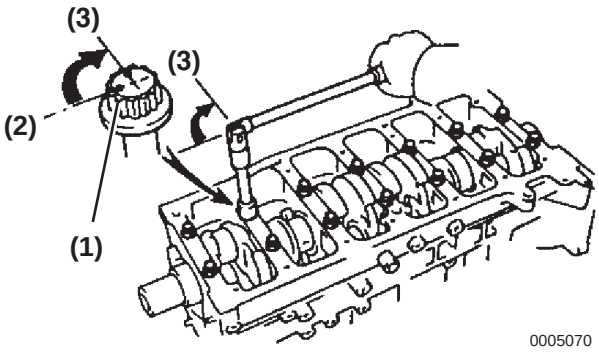


Figure 5-147

16. After all bolts have been retightened, check that all paint marks are facing 90° from the starting front point.
17. Check that the crankshaft rotates smoothly.

18. Install the outside 15 main bearing cap bolts (6 pointed head) **(Figure 5-148)**.
    - Torque: 185 kgf·cm, 18.13 N·m (13.3 lb-ft)

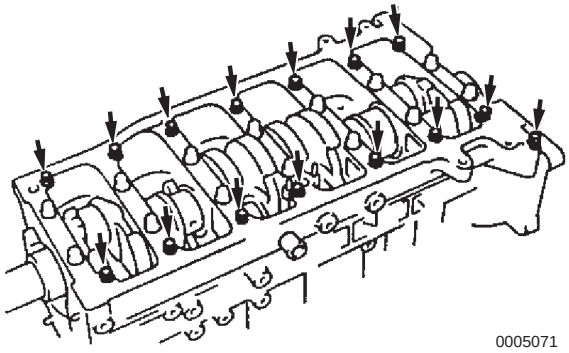


Figure 5-148

19. Inspect the thrust clearance of the crankshaft. See step 15 starting in *Cylinder Block Disassembly on page 5-42*.
20. Install each piston and connecting rod assembly into its corresponding cylinder, using the piston ring compressor (special tool P/N: 95550-002476) **(Figure 5-149, (1))**. Align the pistons with the front mark arrow **(Figure 5-149, (2))** facing the front.

Note: Position the cylinder block horizontally to allow easier installation of the piston and connecting rod assembly. Install the crankshaft pulley temporarily to keep the crankshaft from rotating freely. Use special tool P/N 119770-01090 and 119770-01120.

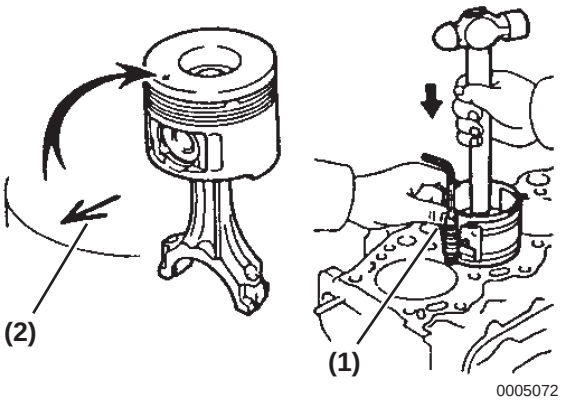


Figure 5-149

Over Size Piston		
Ring Set	719775-22100	Piston 0.5 mm (0.02 in.) over size CMP

21. Install the connecting rod caps to each connecting rod.

Note: Use the correct connecting rod cap corresponding to each cylinder and rod. Install the connecting rod cap with the front mark **(Figure 5-150, (1))** on the connecting rod cap facing to the front.

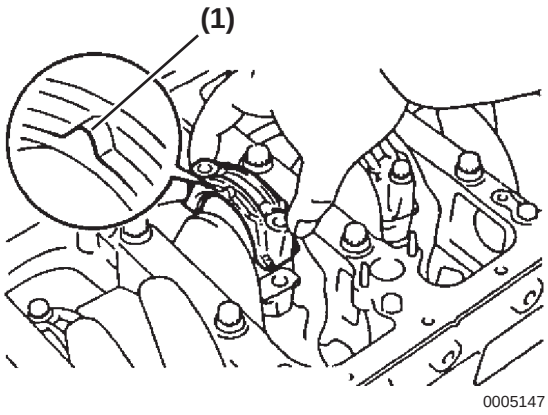


Figure 5-150

22. Apply engine oil to the threads and seats of the connecting rod cap bolts.
23. Install the connecting rod cap bolts and tighten them alternatively in several passes **(Figure 5-151)**.
    - Torque: 375 kgf·cm, 36.77 N·m (27.1 lb-ft)

Note: If any of the connecting rod cap bolts fails to satisfy the torque specification, replace the cap bolt.

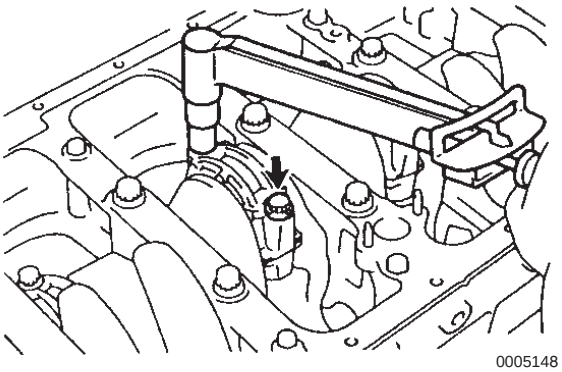


Figure 5-151

24. Make a paint mark **(Figure 5-152, (1))** at the front of each of the connecting rod cap bolt heads.
25. Retighten the connecting rod cap bolts by turning 90° **(Figure 5-152, (2))**.

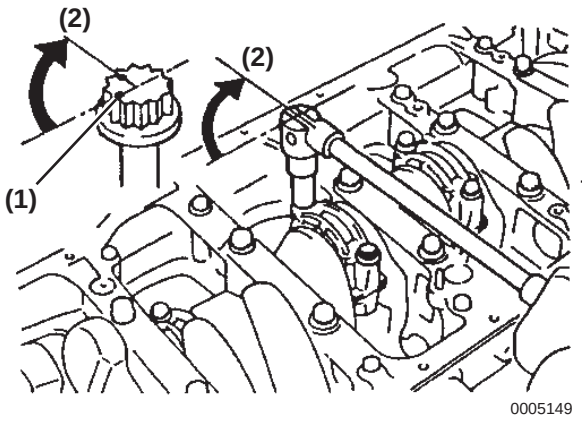


Figure 5-152

26. After tightening all bolts, check that the paint marks are 90° from the starting front point.
27. Check that the crankshaft rotates smoothly.
28. Check the connecting rod thrust clearance. See step 3 starting in *Cylinder Block Disassembly on page 5-42*.

Rear Crankshaft Oil Seal Installation

1. Completely remove the packing material from the case surface and seal groove using a razor blade and gasket scraper.

Note: Avoid contaminating the contact surface of the seal case and cylinder block with oil.

2. Clean all components and remove all foreign matter.
3. Clean both the sealing surfaces using solvent.
4. Apply seal packing (TOYOTA P/N 08826-00080 or equivalent) to the case as shown **(Figure 5-153)**. Apply the seal packing in a width of 2 to 3 mm (0.08 to 0.12 in.) **(Figure 5-153, (1))**.

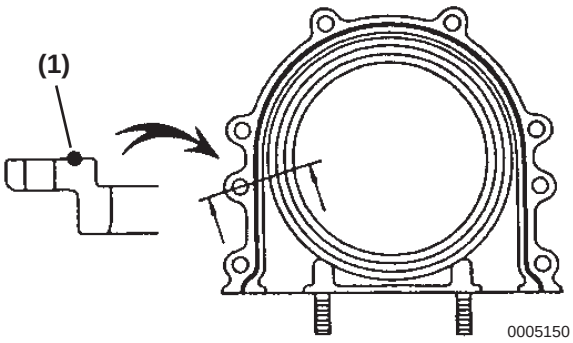


Figure 5-153

Note: Avoid using an excessive amount of seal packing. The parts must be assembled within 5 minutes after the seal packing is applied, or the packing material must be removed and reapplied. Always disconnect the nozzle from the tube immediately after use and cap the tube.

5. Install the case using 6 bolts and torque to 65 kgf·cm, 6.37 N·m (57.3 lb-in.) **(Figure 5-154)**.

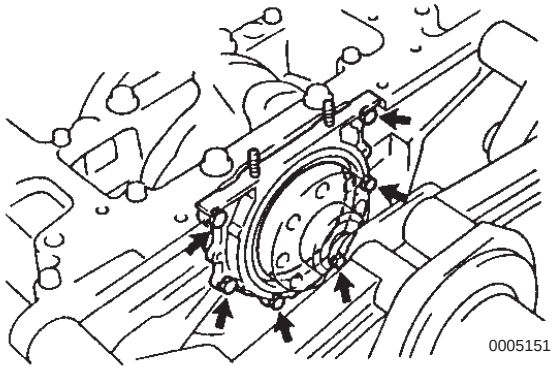


Figure 5-154

FINAL ENGINE ASSEMBLY AND ADJUSTMENTS

1. Install the engine mounting bracket and torque to [700 kgf·cm, 68.65 N·m (50.6 lb-ft) (M12)], [500 kgf·cm, 49.10 N·m (36.2 lb-ft) (M10)].
2. Install the timing gear case. *See Oil Pump Reassembly on page 8-9*.
3. Install the oil pan. See step 11 starting in *Oil Pump Installation on page 8-10*.
4. Install the rear end plate **(Figure 5-155, (1))** and torque to 185 kgf·cm, 18.14 N·m (13.3 lb-ft).

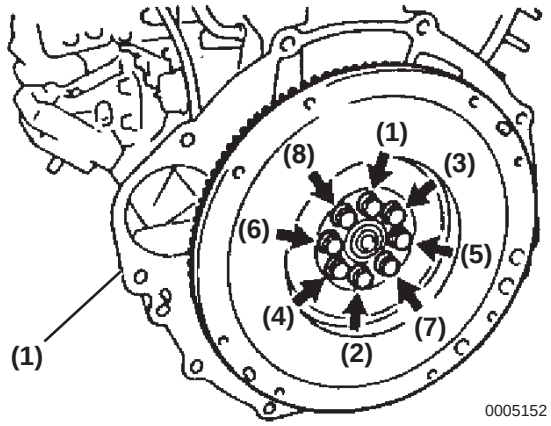


Figure 5-155

5. Install the flywheel and tighten the bolts uniformly in several passes using the sequence shown in **Figure 5-155**. Torque the bolts to 1300 kgf·cm, 127.40 N·m (93.9 lb-ft).
6. Install the flywheel housing set bolts and torque to 185 kgf·cm, 18.13 N·m (13.3 lb-ft).
7. Turn the engine upside down and mount to an engine stand.
8. Install the thermostat. *See Thermostat Installation on page 7-11*.
9. Install the alternator and bracket assembly. Torque bolts to 700 kgf·cm, 68.60 N·m (50.6 lb-ft).
10. Install the freshwater pump. *See Freshwater Pump Installation on page 7-6*.
11. Install the cylinder head. *See Cylinder Head Installation on page 5-33*.
12. Install the timing belt and pulley. *See Timing Belt Installation on page 5-73*.
13. Remove the engine from the engine stand.
14. Install the turbocharger oil pipe.
15. Install the oil cooler assembly, oil dipstick and guide. *See Oil Cooler Installation on page 8-15*.
16. Install the sender units and warning switches.
17. Install the fuel injection pump. *See Fuel Injection Pump Installation on page 6-34*.
18. Install the engine oil filter.

TIMING BELT

Components

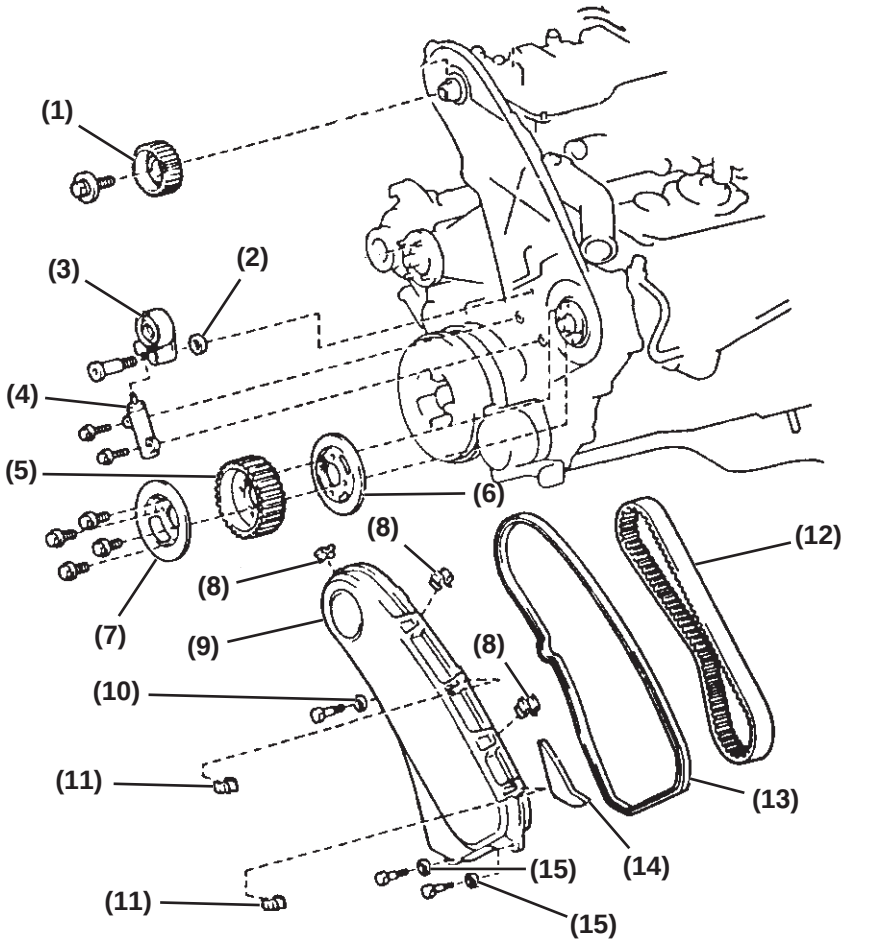


Figure 5-156

1 – No. 1 Camshaft Timing Pulley
2 – Plate Washer
3 – Idler Pulley
4 – Timing Belt Tensioner
5 – No. 2 Camshaft Timing Pulley
6 – No. 1 Flange
7 – No. 2 Flange
8 – Clip
9 – Timing Belt Cover
10 – Seal Washer
11 – Clamp
12 – Timing Belt
13 – Gasket
14 – Insulator
15 – Seal Washer

Timing Belt Removal

1. Remove the 3 timing belt cover clips **(Figure 5-157, (1))** and 2 clamps **(Figure 5-157, (2))**.
2. Remove the 3 bolts **(Figure 5-157, (3))**, 3 seal washers, timing belt cover, gasket and insulator.

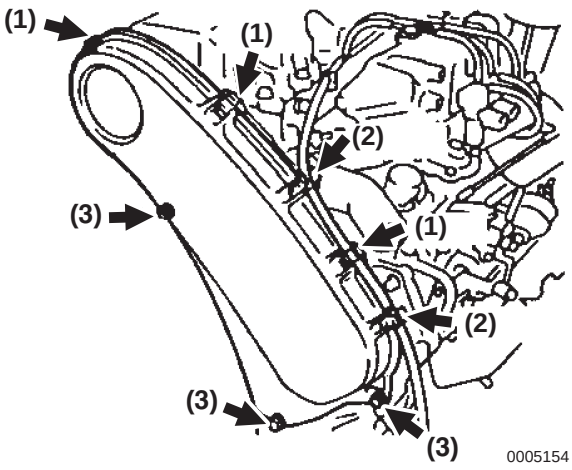


Figure 5-157

3. Turn the crankshaft pulley clockwise **(Figure 5-158, (1))** to align the timing marks of camshaft timing pulleys No. 1 and No. 2 with the BDC mark. *NOTICE: If the timing belt is disconnected and the crankshaft pulley is rotated, engine damage will result from the piston head and intake/exhaust valve heads contacting. NEVER turn the crankshaft with the timing belt disconnected and always make sure to set the crankshaft pulley at the correct angle when installing the belt.*

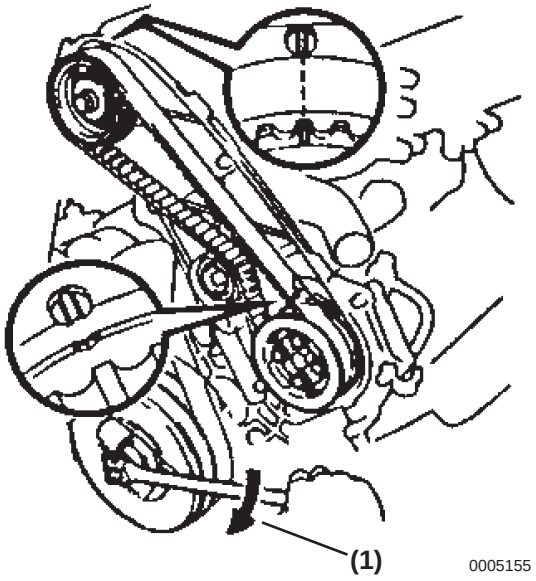


Figure 5-158

To remove the timing belt when the timing belt is reused:

- Draw an arrow mark **(Figure 5-159, (1))** on the timing belt, indicating the operation direction (engine revolution direction) and then match marks **(Figure 5-159, (2))** both on the timing pulley and timing belt.

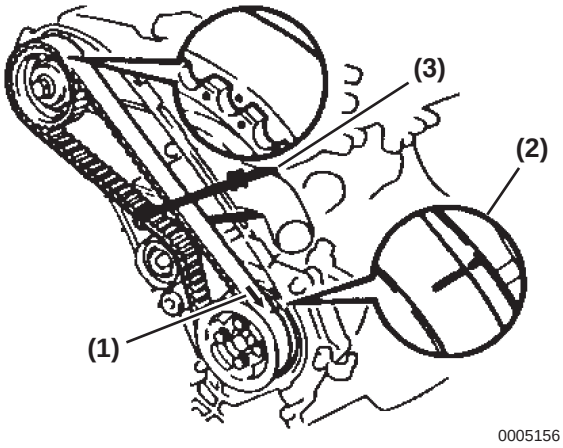


Figure 5-159

To remove the timing belt when replacing the timing belt tensioner only:

(a) Secure the belt by string **(Figure 5-159, (3))** so that the engagement between the timing pulley and timing belt will not be disconnected.

(b) Alternately loosen the two bolts **(Figure 5-160, (1))** to remove them, and then remove the timing belt tensioner.

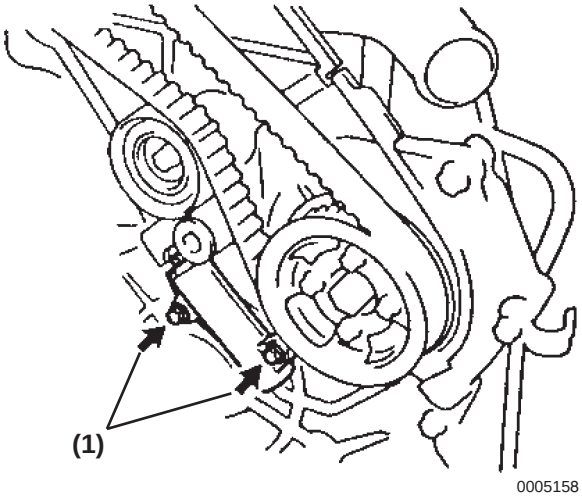


Figure 5-160

(c) Remove the timing belt.

4. Remove the pivot bolt, idler pulley **(Figure 5-161, (1))** and plate washer **(Figure 5-161, (2))** using an 8 mm hex / allen wrench **(Figure 5-161, (3))**.

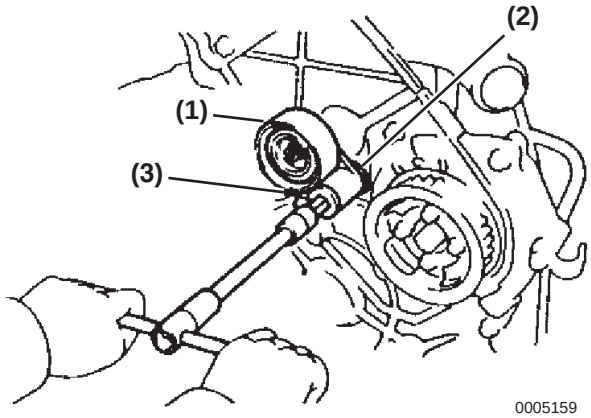


Figure 5-161

5. Remove the four bolts **(Figure 5-162, (1))**, No. 2 flange, timing pulley and No. 1 flange.

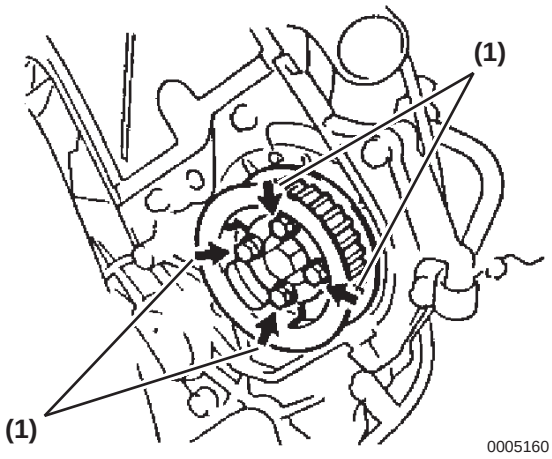


Figure 5-162

6. Remove the rocker cover. See step 8 starting in *Cylinder Head Removal on page 5-16*.

7. Slowly turn the camshaft timing pulley counter-clockwise to allow a wrench to align with the flats **(Figure 5-163, (1))** on the camshaft. Hold the camshaft with a wrench to remove the bolt **(Figure 5-163, (2))** and timing pulley.

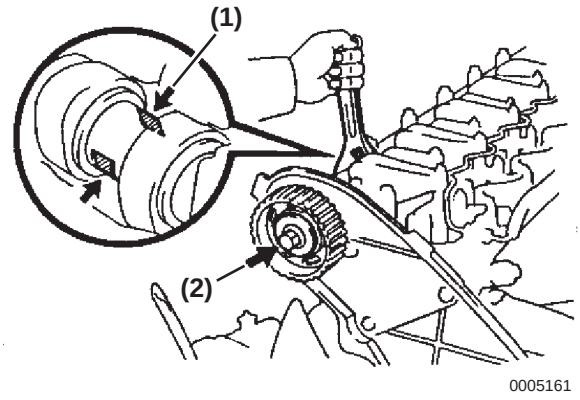


Figure 5-163

8. Remove the No. 1 timing pulley using a gear puller **(Figure 5-164, (1))**.

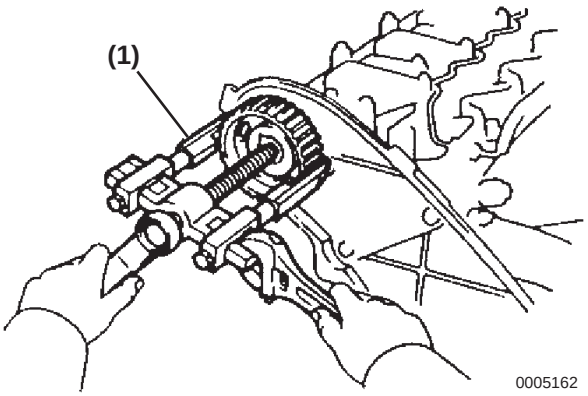


Figure 5-164

9. Remove the pulley key.

Timing Belt Inspection

Timing Belt

*NOTICE: NEVER bend, twist or turn the timing belt inside out. NEVER contaminate the timing belt with oil, water or steam **(Figure 5-165)**.*

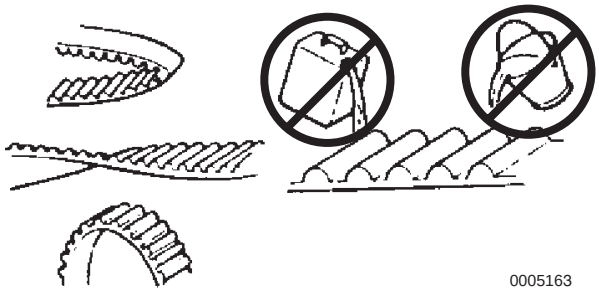


Figure 5-165

Inspect the belt for the following conditions, if any of the following conditions are present or the belt is damaged, replace the timing belt.

- Breaking or parting at the joints **(Figure 5-166)**.
  - Check the timing belt cover and gasket for damage and for correct installation.

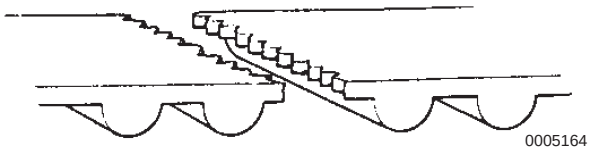


Figure 5-166

- If the belt teeth are cracked or damaged, check for a locked camshaft **(Figure 5-167)**.

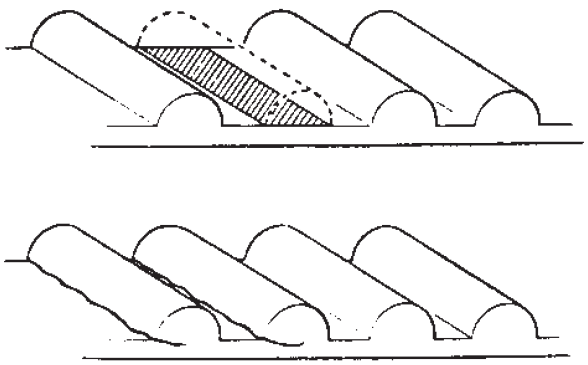


Figure 5-167

- If the belt face is cracked or worn, check the idler pulley for damage and sharp edges **(Figure 5-168)**.

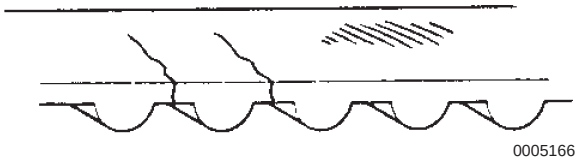


Figure 5-168

- If only one side of the belt is worn or damaged, check each timing pulley for wear or damage radially and axially **(Figure 5-169)**.

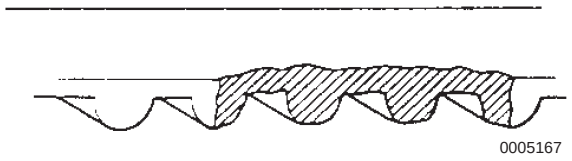


Figure 5-169

- If the belt teeth are worn, check the timing belt cover for damage and that the gasket is installed correctly. Also, check the pulley teeth for contamination with dust or debris **(Figure 5-170)**.

Figure 5-170

Idler Pulley

1. Visually check the seal of the idler pulley. If oil leakage is present replace the idler pulley **(Figure 5-171)**.

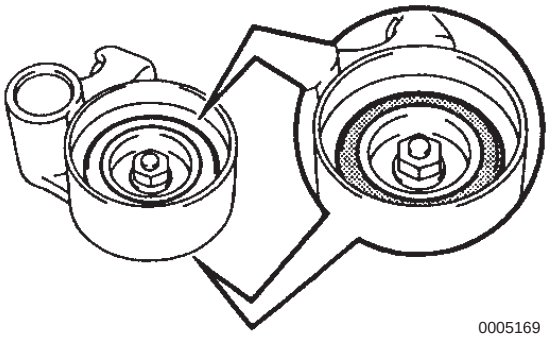


Figure 5-171

2. Inspect the idler pulley for smooth rotation. Replace the idler pulley as necessary **(Figure 5-172)**.

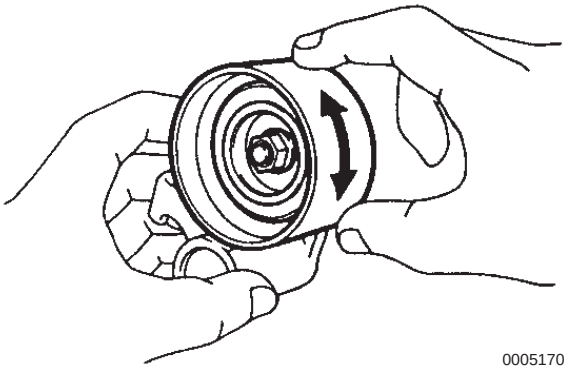


Figure 5-172

Tension Spring and Tensioner

1. Visually check the tensioner seal **(Figure 5-173, (1))** for oil leakage.
   - If oil is not present on the push rod side of the oil seal, the tensioner seal is in good condition.
   - If oil is present on the push rod side of the oil seal, replace the tensioner.

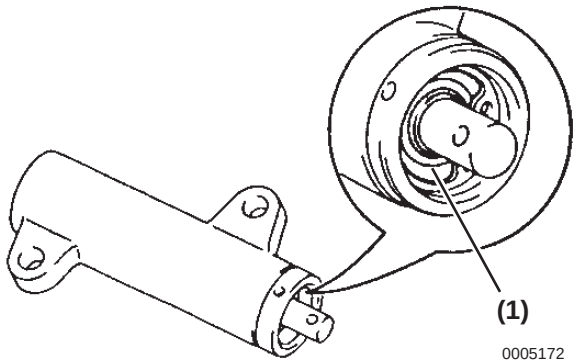


Figure 5-173

2. Hold the tensioner firmly and try to push the push rod in. The push rod should not move, if it moves, replace the tensioner **(Figure 5-174)**.

Note: NEVER hold the tensioner with the push rod facing down.

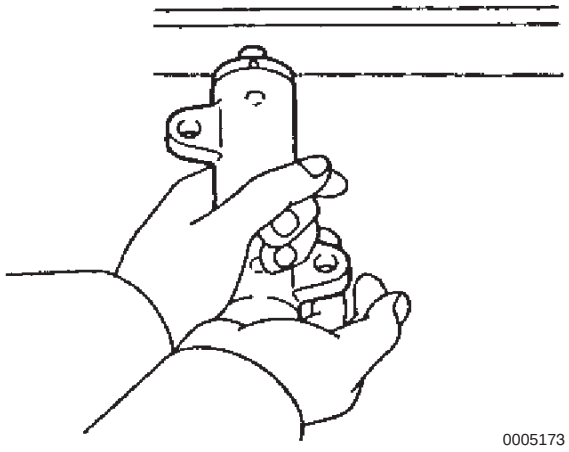


Figure 5-174

3. Measure the push rod protrusion **(Figure 5-175, (1))** from the end of housing.
   - Protrusion: 9.0 to 9.8 mm (0.354 to 0.386 in.)

If the measured value is not within specifications, replace the tensioner.

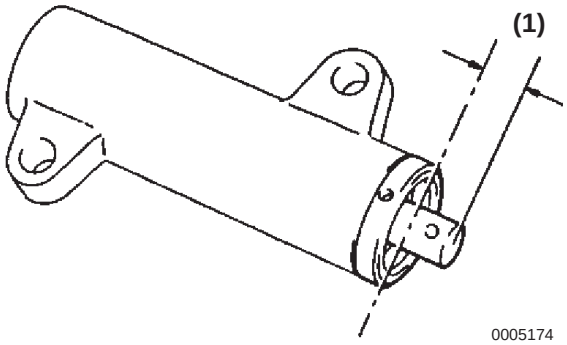


Figure 5-175

Timing Belt Installation

1. Install the pulley key into the key groove in the camshaft.
2. Press the No. 1 timing pulley onto the camshaft aligning to the key into the groove.
3. Hand tighten the pulley bolt.
4. Hold the camshaft with a hex wrench on the flats **(Figure 5-176, (1))** of the camshaft. Torque the pulley bolt to 1000 kgf·cm, 98.00 N·m (72.3 lb-ft) **(Figure 5-176)**.

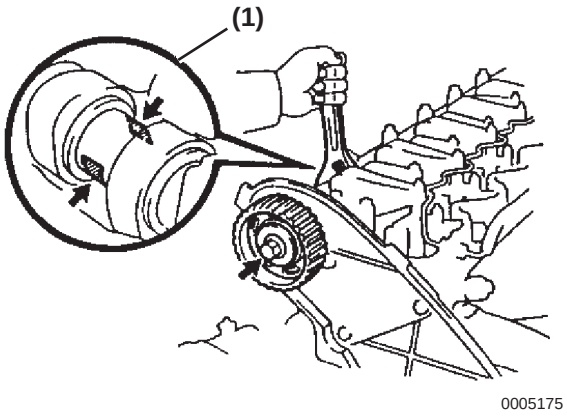


Figure 5-176

5. Remove all packing material from the rocker cover sealing surfaces.
6. Apply seal packing to 3 positions of the cylinder head.
7. Install the gasket to the rocker cover.

8. Install the rocker cover using new seal washers and bolts. Uniformly tighten the bolts in several passes and torque to 65 kgf·cm, 6.37 N·m (56.3 lb-in.) **(Figure 5-177)**.

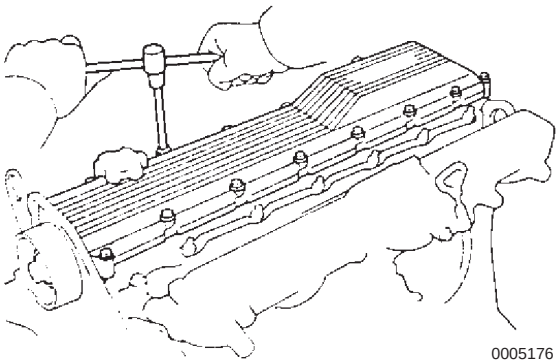


Figure 5-177

9. Align the knock pin **(Figure 5-178, (1))** on the injection pump drive gear with the knock pin hole of No. 1 flange timing pulley.
10. Install the No. 1 flange, timing pulley and No. 2 flange using four bolts **(Figure 5-178, (2))** and torque to 315 kgf·cm, 30.87 N·m (22.7 lb-ft).

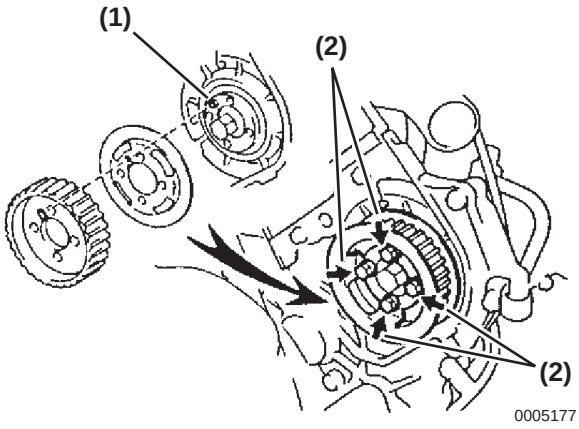


Figure 5-178

11. Install the plate washer **(Figure 5-179, (1))** and idler pulley **(Figure 5-179, (2))** by the pivot bolt, using an 8 mm allen / hex wrench **(Figure 5-179, (3))**.
    - Torque specification: 350 kgf·cm, 34.32 N·m (25.3 lb-ft).

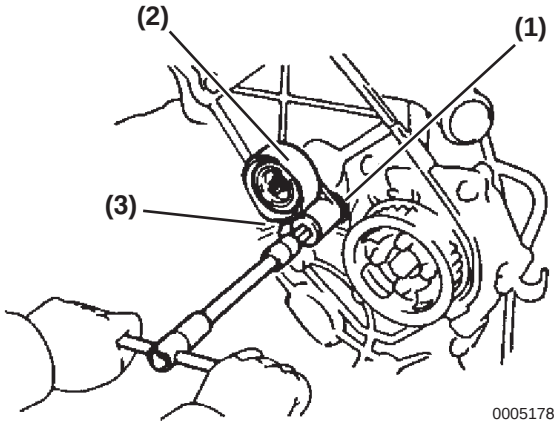


Figure 5-179

12. Check the pulley bracket for smooth movement.
13. Align the timing mark of the No. 2 camshaft timing pulley with the bottom dead center (BDC) mark **(Figure 5-180)**. *NOTICE: NEVER turn the camshaft pulley as the valve heads will contact the piston heads causing engine damage.*
14. Align the timing mark of No. 1 camshaft timing pulley to the bottom dead center (BDC) mark **(Figure 5-180)**.

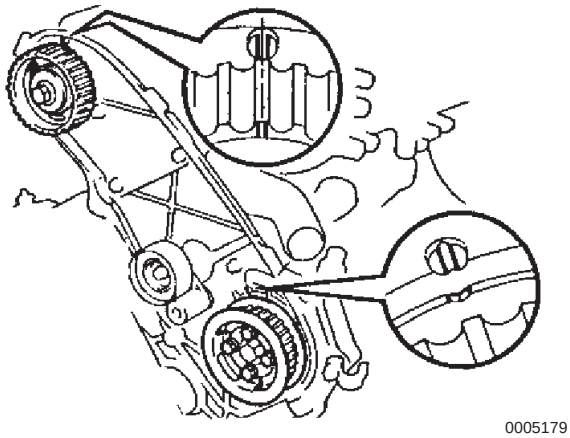


Figure 5-180

15. Prepare to install the timing belt. **WARNING! *ONLY install the timing belt when the engine is cool***.

- When reusing the timing belt, install the timing belt by aligning the mark **(Figure 5-181, (1))** marked before removal and the arrow mark **(Figure 5-181, (2))** to the engine revolution direction.

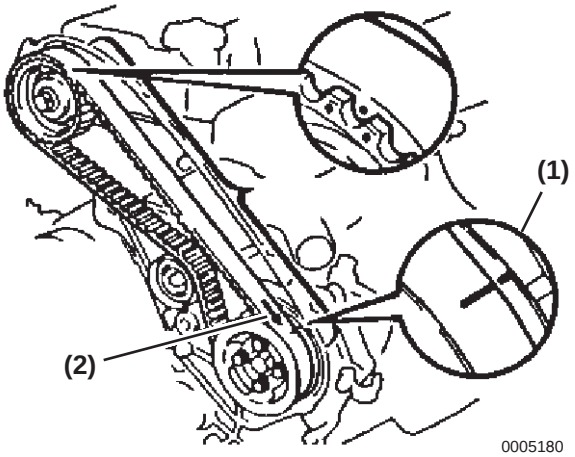


Figure 5-181

- Clean all oil and water off the pulleys and belt before installing.

Note: Never use cleaners or detergents, clean using a clean dry cloth.

- Install the idler pulley between No. 1 and No. 2 camshaft timing pulleys.

16. Tensioner Installation:

(a) Using a press, slowly press in the push rod by applying 100 to 1,000 kgf, 980.67 to 9806.65 N (220.4 to 2204.6 lbf).

(b) Align the push rod to the hole in the housing and carry out positioning of the push rod by passing a 1.5 mm allen / hex wrench **(Figure 5-182, (1))** through the hole.

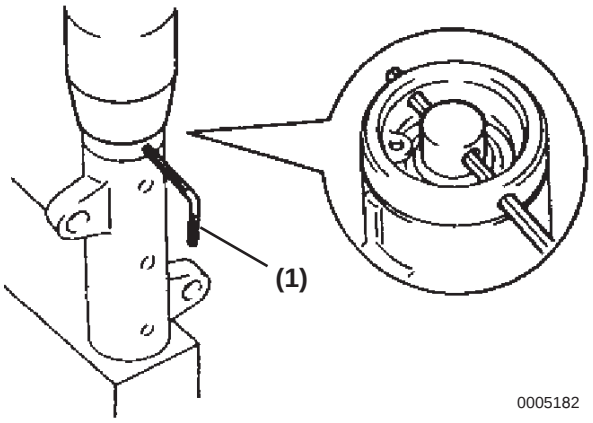


Figure 5-182

(c) Release the force.

(d) Temporarily secure the timing belt tensioner using 2 bolts **(Figure 5-183, (1))**, while pressing the idler pulley onto the timing belt.

(e) Alternately tighten the two bolts and torque to 130 kgf·cm, 12.74 N·m (112.7 lb-in.).

(f) Remove the 1.5 mm allen / hex wrench **(Figure 5-183, (2))** from the tensioner.

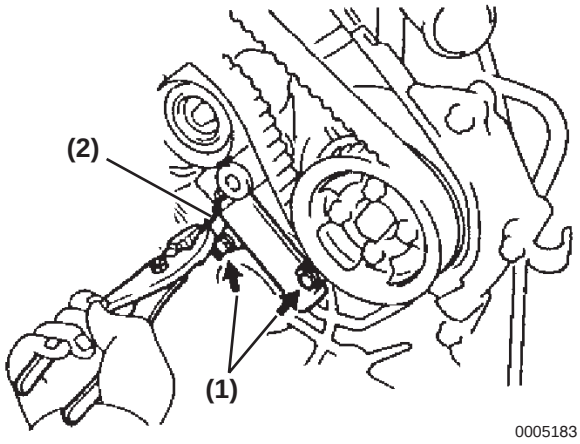


Figure 5-183

17. Turn **(Figure 5-184, (1))** the crankshaft pulley clockwise to check if each pulley timing mark **(Figure 5-184, (2))** matches with the top dead center (TDC) mark. If the timing marks never align disconnect the timing belt and reinstall it to with the correct alignment.

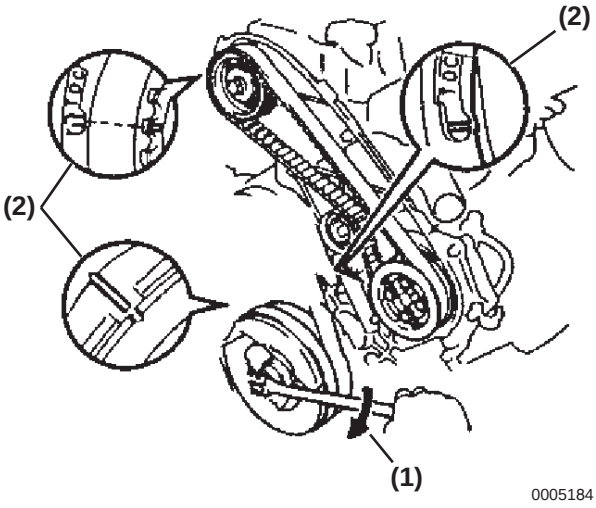


Figure 5-184

18. Remove all packing material from the timing cover sealing surfaces.
19. Apply seal packing (TOYOTA P/N 08826-00080 or equivalent) to the camshaft oil seal retainer and timing belt cover as shown in **Figure 5-185**.

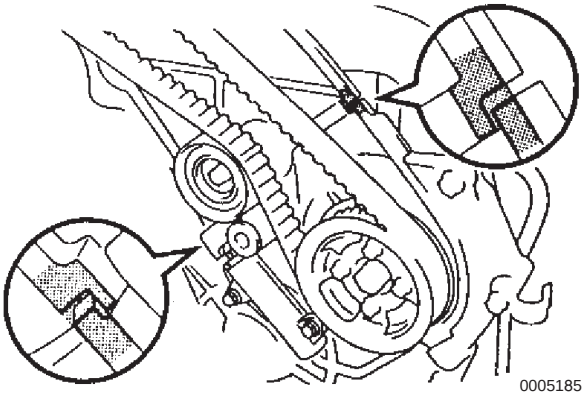


Figure 5-185

20. Install the insulator to the timing belt cover.
21. Install the gasket to the timing belt cover.
22. Install the timing belt cover **(Figure 5-186, (1))** with bolts and 3 seal washers **(Figure 5-186, (4))**, 2 clamps **(Figure 5-186, (2))** and 3 clips **(Figure 5-186, (3))**.

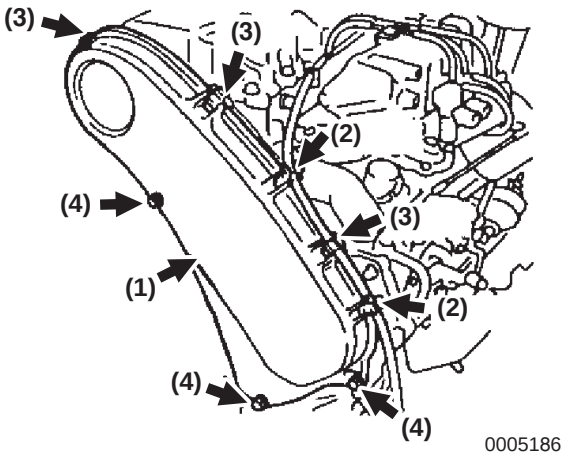


Figure 5-186

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TIMING GEAR

Components

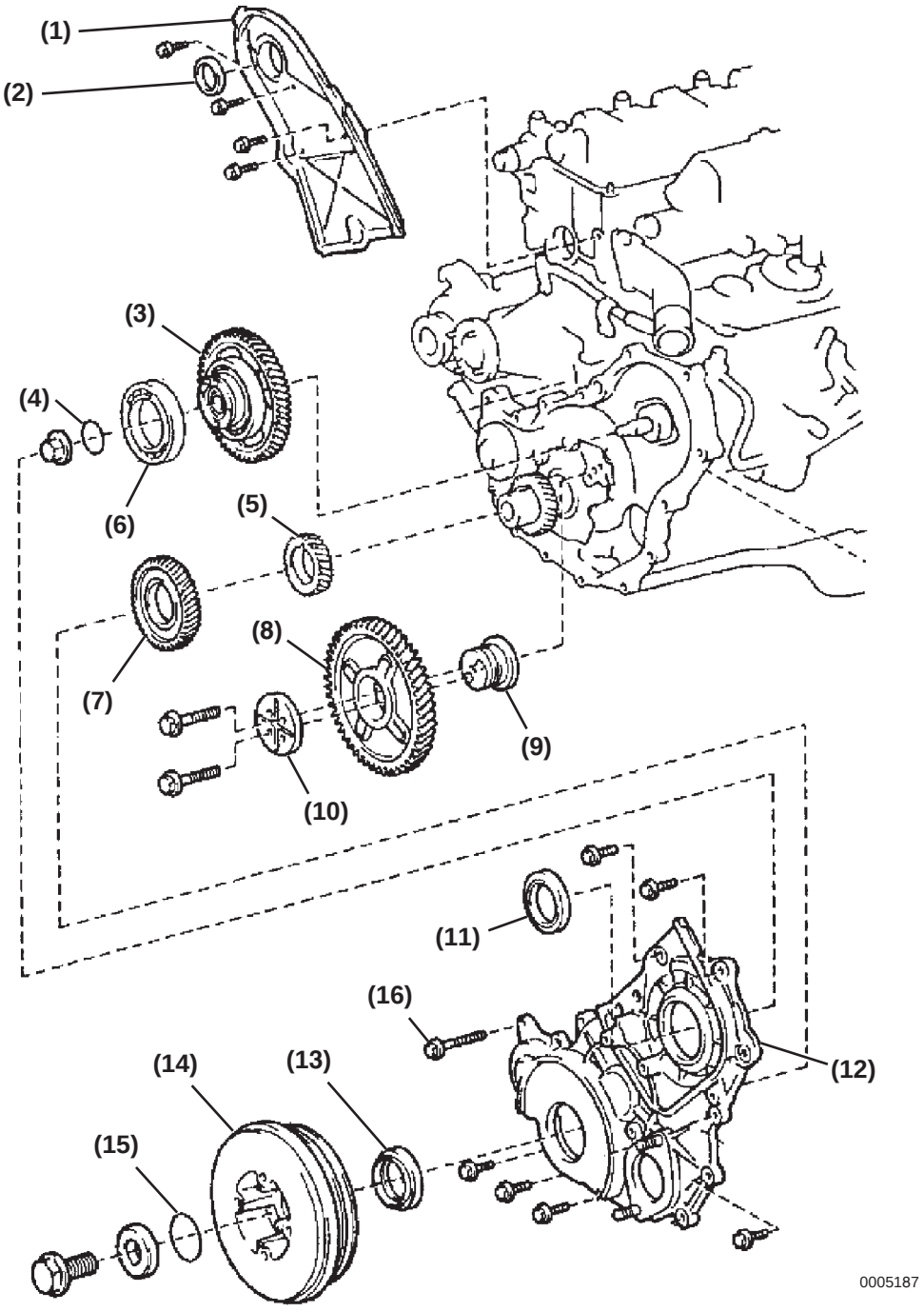

Figure 5-187

1 – Camshaft Oil Seal Retainer
2 – Camshaft Oil Seal (Non-Reusable Part)
3 – Fuel Injection Pump Drive Gear
4 – O-Ring (Non-Reusable Part)
5 – Camshaft Timing Gear
6 – Fuel Injection Pump Drive Gear Bearing
7 – Oil Pump Drive Shaft Gear
8 – Idler Gear
9 – Idler Gear Shaft
10 – Thrust Plate
11 – Fuel Injection Pump Drive Gear Oil Seal (Non-Reusable Part)
12 – Timing Gear Cover
13 – Crankshaft Front Oil Seal (Non-Reusable Part)
14 – Crankshaft Pulley
15 – O-Ring (Non-Reusable Part)
16 – Bolt - 6 Used

Timing Gear Removal

1. Remove the freshwater pump and alternator V-belt. *See Freshwater Pump Removal on page 7-5*.
2. Loosen the crankshaft pulley bolt using special tools P/N 119770-01090 **(Figure 5-188, (1))** and 119770-01120 **(Figure 5-188, (2))**.
   NOTICE: *NEVER rotate the camshaft timing pulley. If the timing belt is disconnected and the camshaft pulley is rotated, engine damage will result from the piston head and intake/exhaust valve heads contacting.*

   Use care when loosening the crank pulley bolt, as it is tightened to a high torque of 44 kgf·cm, 431.50 N·m (318.2 lb-ft).

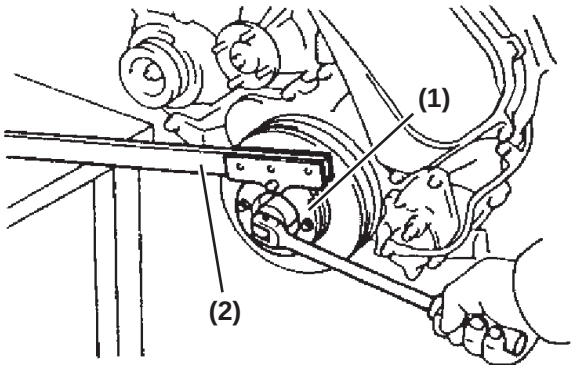

Figure 5-188

3. Remove the timing belt and pulley. *See Timing Belt Removal on page 5-69*.
4. Remove the camshaft oil seal retainer. See step 11 starting in *Cylinder Head Removal on page 5-16*.
5. Remove the viscous damper.
6. Remove the freshwater pump pulley.
7. Remove the pulley bolt and plate washer.
   NOTICE: NEVER rotate the crankshaft pulley. If the timing belt is disconnected and the crankshaft or camshaft pulley is rotated, engine damage will result from the piston head and intake or exhaust valve heads contacting the cylinder head.
8. Remove the crankshaft pulley using special tool P/N 119770-01070 **(Figure 5-189, (1))**.
9. Remove the O-ring from the crankshaft pulley.

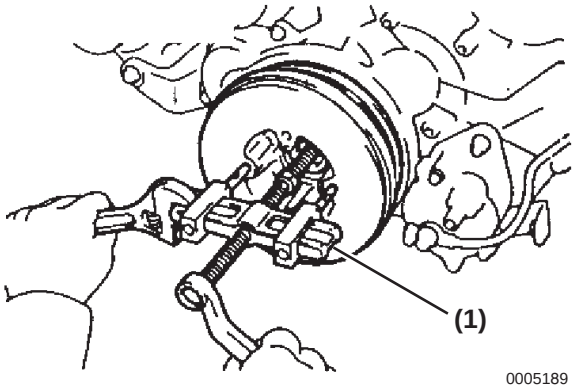

Figure 5-189

10. Remove the alternator adjusting bar.
11. Remove 14 bolts and pry **(Figure 5-190, (1))** out and remove the timing gear cover.

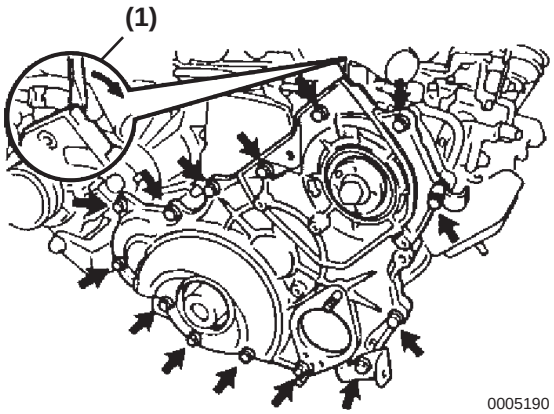

Figure 5-190

12. Remove the oil pump drive shaft gear from the crankshaft using special tool P/N 119770-01080 **(Figure 5-191, (1))**.

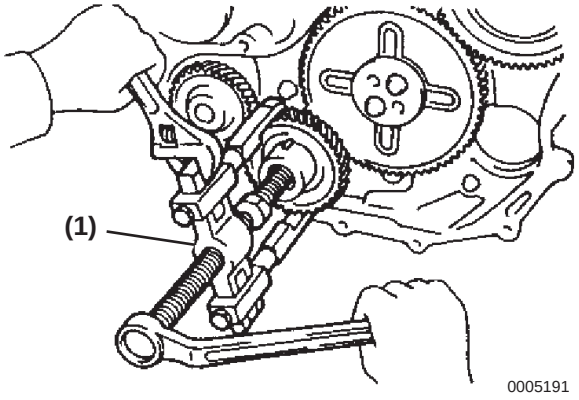

Figure 5-191

13. Measure the thrust clearance of the idler gear using a feeler gauge **(Figure 5-192, (1))**.
    - Standard thrust clearance: 0.05 to 0.15 mm (0.002 to 0.006 in.)
    - Maximum thrust clearance: 0.30 mm (0.011 in.)

    If the measured thrust clearance exceeds the maximum specification, replace the thrust plate. Inspect the idler gear and idler gear shaft and replace as necessary.

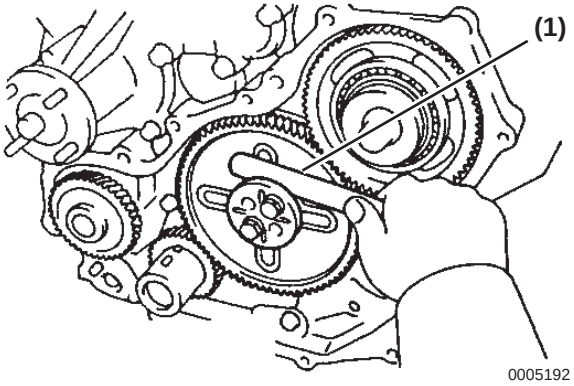

Figure 5-192

14. Remove the 2 bolts securing the idler gear and thrust plate.

15. Using a suitable tool **(Figure 5-193, (1))**, turn the fuel injection pump drive gear **(Figure 5-193, (2))**. in both directions to loosen and remove the idler gear **(Figure 5-193, (3))**.
16. Remove the idler gear shaft.

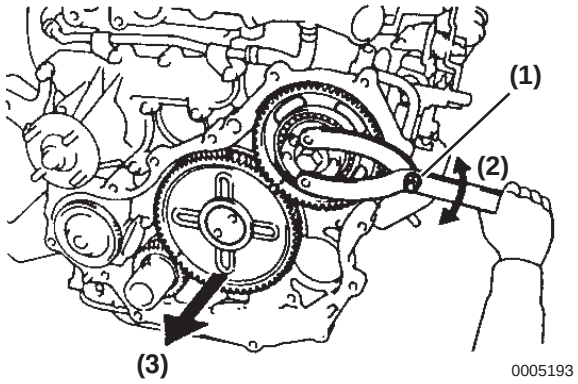

Figure 5-193

17. Using a suitable tool **(Figure 5-194, (1))** hold the fuel injection pump gear and loosen the gear nut.
18. Remove the gear nut together with the O-ring.

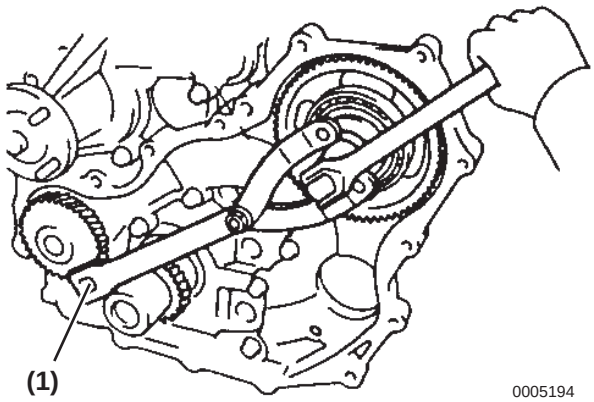

Figure 5-194

19. Remove the fuel injection pump drive gear using the special tool gear puller P/N 119770-01080 **(Figure 5-195, (1))**.

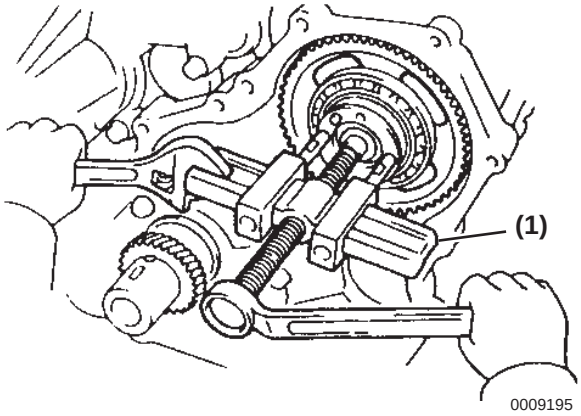

Figure 5-195

20. Remove the crankshaft timing gear using the special tool gear puller P/N 119770-01080 **(Figure 5-196, (1))**.

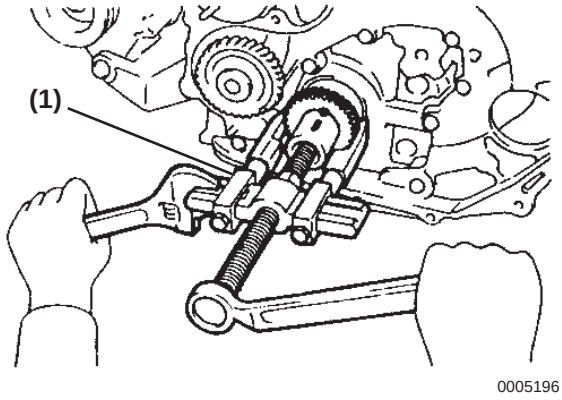

Figure 5-196

Timing Gear Inspection

1. Measure the inside diameter of the idler gear using a cylinder bore gauge **(Figure 5-197)**.
   - Inside diameter of idler gear: 45.000 to 45.025 mm (1.771 to 1.773 in.)

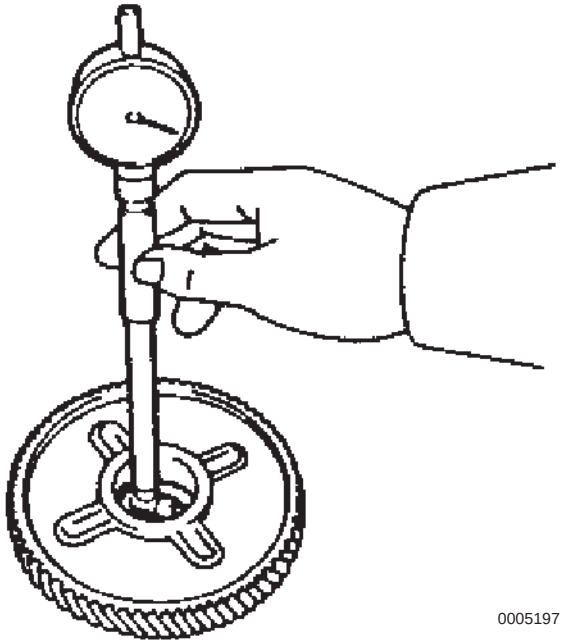

Figure 5-197

2. Measure the outside diameter of the idler gear shaft using a micrometer **(Figure 5-198)**.
   - Outside diameter of idle gear shaft: 44.950 to 44.975 mm (1.769 to 1.770 in.)

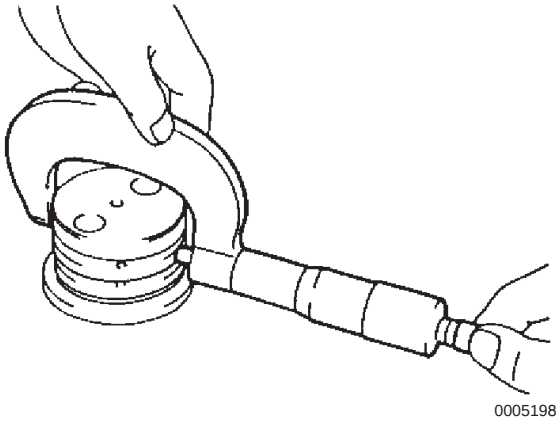

Figure 5-198

3. Subtract the outside diameter of idler gear shaft from the measured inside diameter of the idler gear.
   - Standard oil clearance: 0.025 to 0.075 mm (0.001 to 0.003 in.)
   - Maximum oil clearance: 0.20 mm (0.008 in.)

   If the measured value exceeds the maximum specification, replace the gear and shaft.

4. Check the fuel injection pump drive gear bearing for wear and excessive play **(Figure 5-199)**. Replace the fuel injection pump drive gear bearing as necessary.

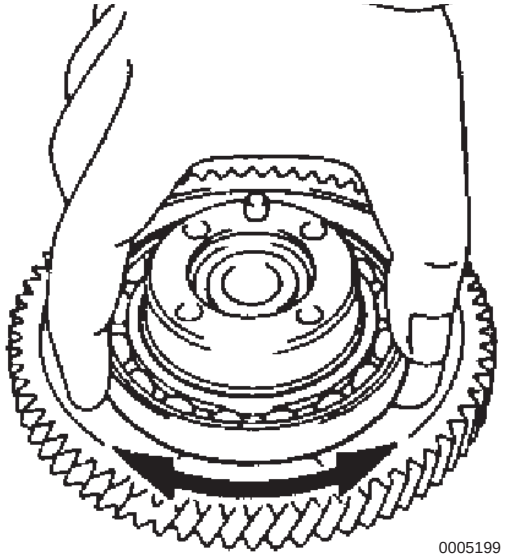

Figure 5-199

5. To replace the fuel injection pump drive gear bearing, remove the bearing using a suitable tool **(Figure 5-200, (1))**. Use the fuel injection pump drive gear nut **(Figure 5-200, (2))** as a pressing point for the puller.

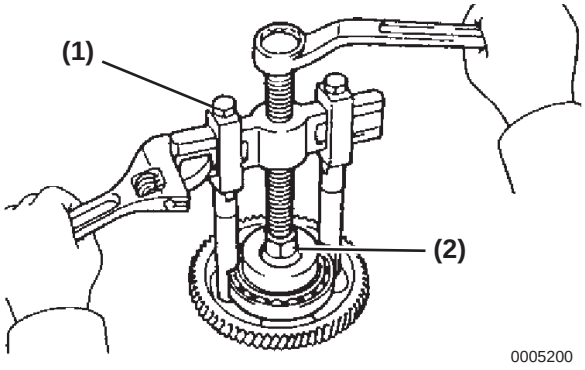

Figure 5-200

6. Press in a new bearing using a suitable tool **(Figure 5-201, (1))** and a press.

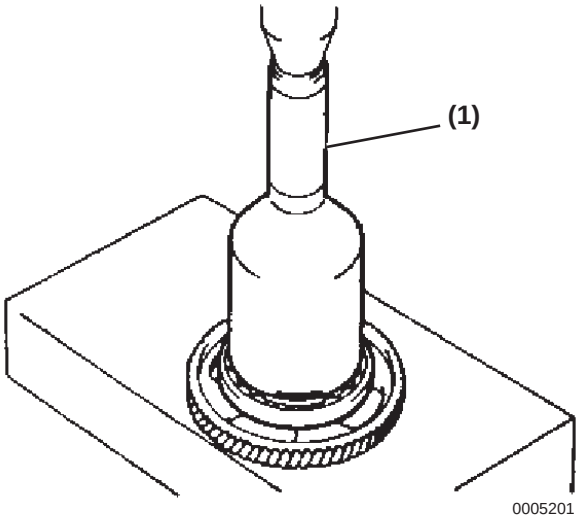

Figure 5-201

7. Install all the timing gears and measure the backlash using a dial indicator **(Figure 5-202)**.
   - Standard gear backlash: 0.05 to 0.15 mm (0.002 to 0.006 in.)
   - Maximum gear backlash: 0.30 mm (0.012 in.)

   If the measured gear backlash exceeds the maximum specification, replace all the gears as a set.

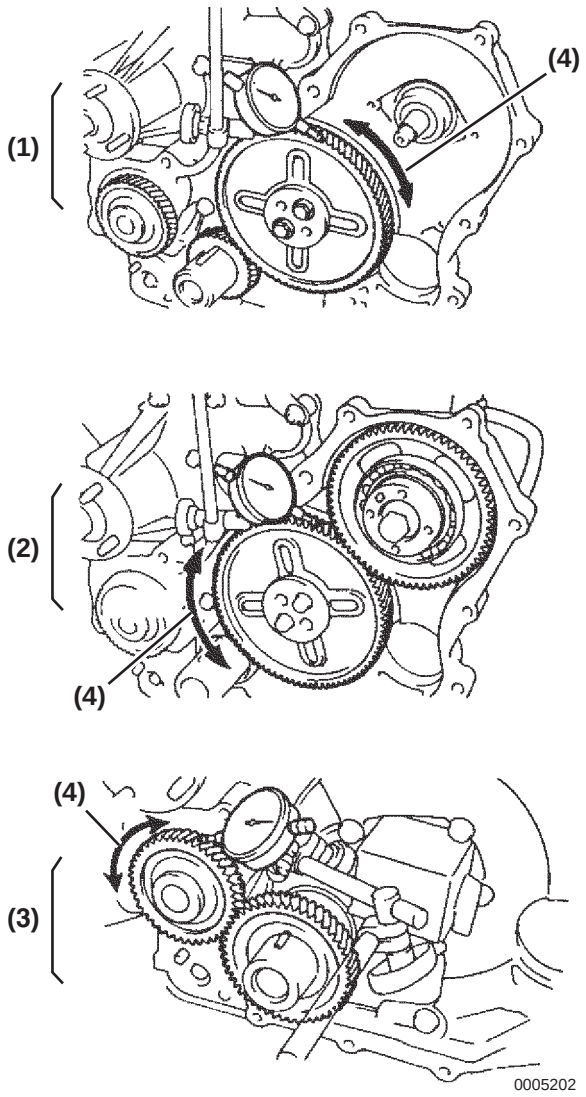

Figure 5-202

1 – Crankshaft Timing Gear to Idler Gear
2 – Fuel Injection Pump Drive Gear to Idler Gear
3 – Oil Pump Drive Shaft Gear to Oil Pump Gear
4 – Move in Both Directions

8. Remove the timing gears.

Front Crankshaft Oil Seal Replacement

There are two oil seal replacement methods.

Method 1

When the timing gear cover has been removed from the cylinder block:

1. Tap out the oil seal using a screwdriver and hammer **(Figure 5-203)**.

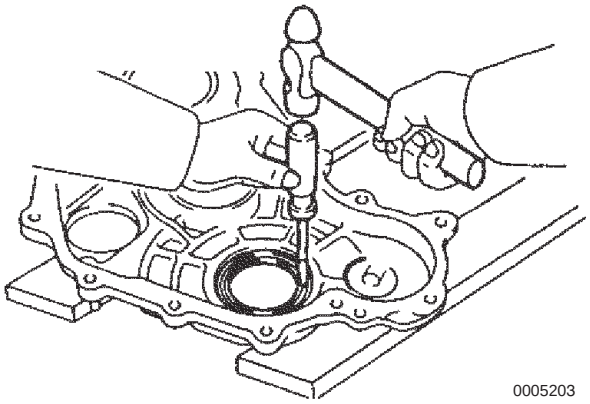

Figure 5-203

2. Tap in a new oil seal to install using special tool P/N 119770-01100 **(Figure 5-204, (1))**, until the surface is level with that of the timing gear cover.
3. Apply grease to the oil seal lip.

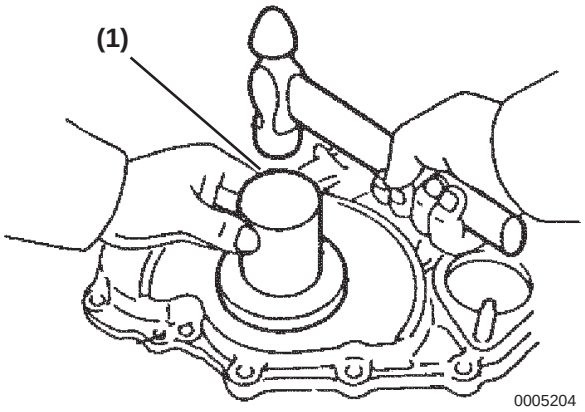

Figure 5-204

Method 2

When the timing gear cover is installed to the cylinder block:

1. Remove the oil seal using a suitable tool **(Figure 5-205, (1))**.

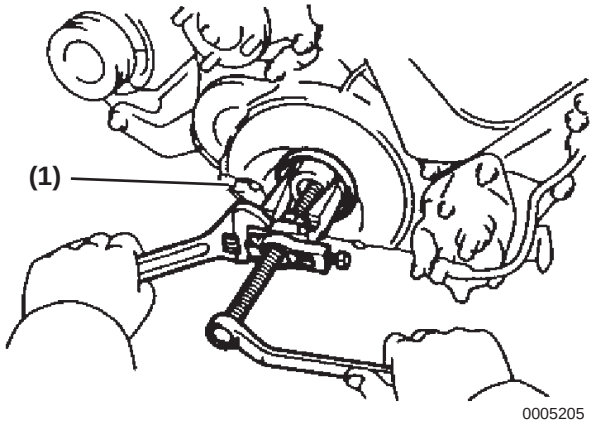

Figure 5-205

2. Apply grease to the lip of the new oil seal.
3. Tap in a new oil seal to install using special tool P/N 119770-01100 **(Figure 5-206, (1))**, until the surface is level with that of the timing gear cover.

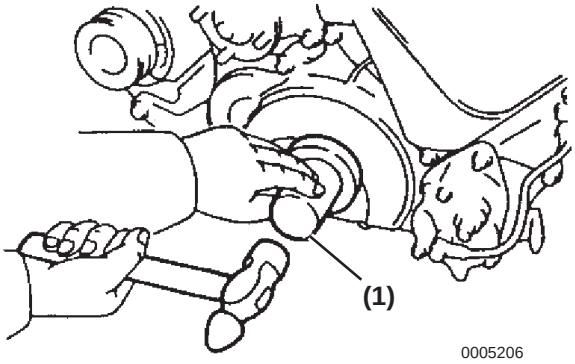

Figure 5-206

Fuel Injection Pump Drive Gear Oil Seal Replacement

There are two oil seal replacement methods:

Method 1

When the timing gear cover has been removed from the cylinder block:

1. Tap out of the oil seal using a screwdriver and hammer **(Figure 5-207)**.

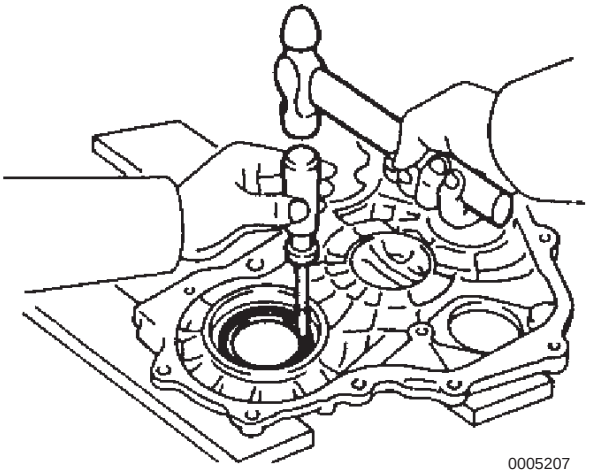

Figure 5-207

2. Tap in a new oil seal to install using a suitable tool **(Figure 5-208, (1))**, until the surface is level with that of the timing gear cover.

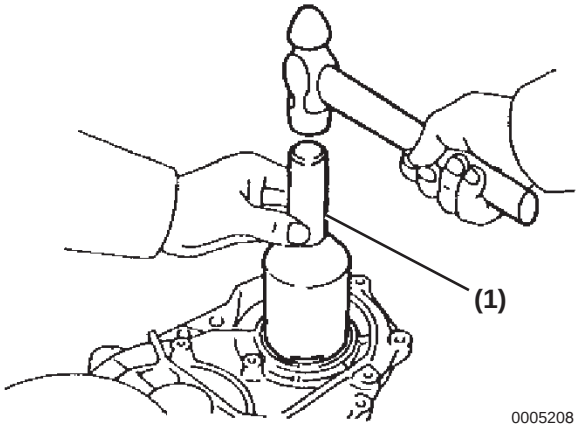

Figure 5-208

3. Apply grease to the oil seal lip.

Method 2

When the timing gear cover is installed to the cylinder block:

1. Cut off the oil seal lip using a knife **(Figure 5-209)**.
2. Pry the oil seal using a screwdriver **(Figure 5-209, (1))** to remove.

Note: AVOID damaging the fuel injection pump drive gear during removal. Use tape on the screwdriver tip to prevent scratches.

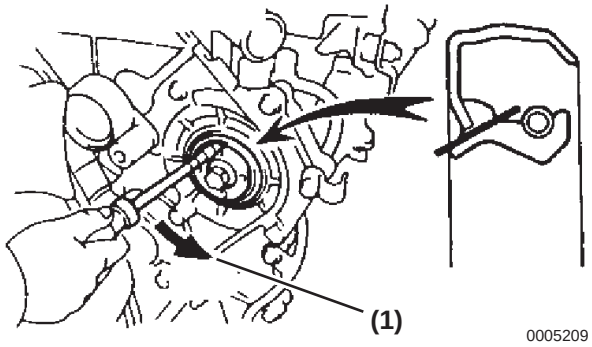

Figure 5-209

3. Apply grease to the lip of a new oil seal.
4. Tap in the new oil seal to install using a suitable tool **(Figure 5-210, (1))** until the seal surface is level with the timing gear cover.

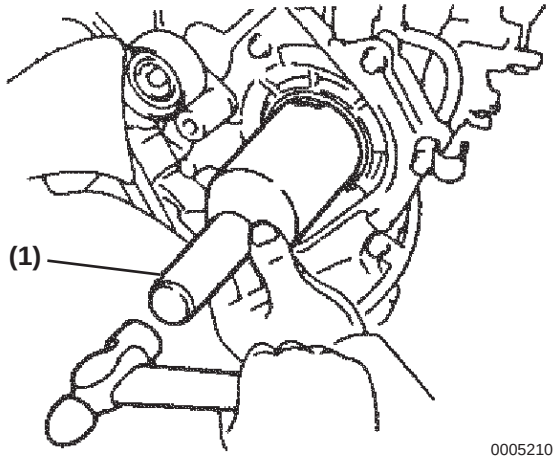

Figure 5-210

Timing Gear Installation

1. Install the timing gear with its timing mark **(Figure 5-211, (1))** facing to the front.
2. Align the gear key on the crankshaft to the key groove of timing gear.
3. Tap in the timing gear using a suitable tool **(Figure 5-211, (2))** to install.

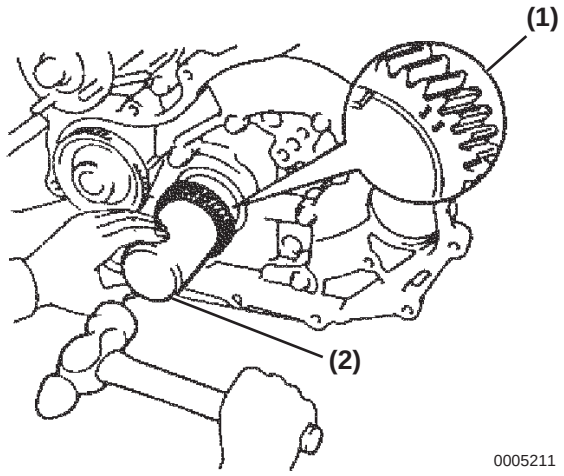

Figure 5-211

4. Install the fuel injection pump drive gear, aligning the key on the drive shaft to the key groove of the drive gear.
5. Install a new O-ring **(Figure 5-212, (1))** in the drive gear groove.
6. Install the gear nut.
7. Tighten the gear nut and torque to 1,000 kgf·cm, 98.07 N·m (72.3 lb-ft) **(Figure 5-212)**.

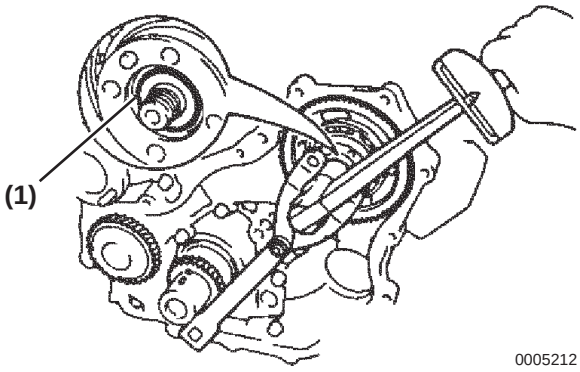

Figure 5-212

8. Install the idler gear shaft by aligning the bolt holes of the idler gear shaft to the bolt holes of the cylinder block.
9. Align timing marks "3" and "4" of the idler gear **(Figure 5-213, (1))** to the corresponding timing marks "3" **(Figure 5-213, (2))** of the crankshaft timing gear and timing mark "4" **(Figure 5-213, (3))** of the fuel injection pump drive gear by turning the fuel injection pump drive gear using a suitable tool **(Figure 5-213, (4))**.

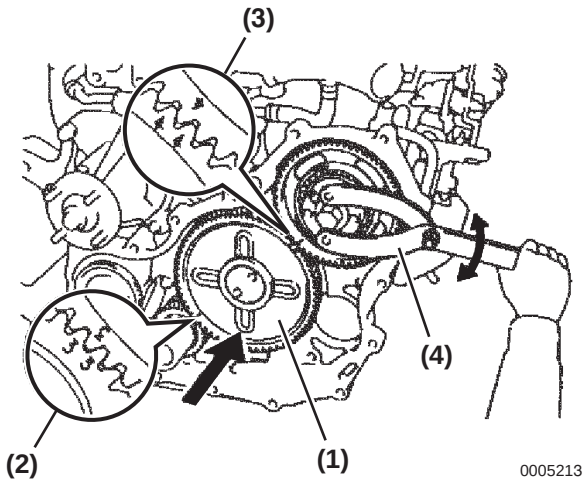

Figure 5-213

10. Install the thrust plate using 2 bolts **(Figure 5-214, (1))** and torque to 694 kgf·cm, 68.06 N·m (50.2 lb-ft).

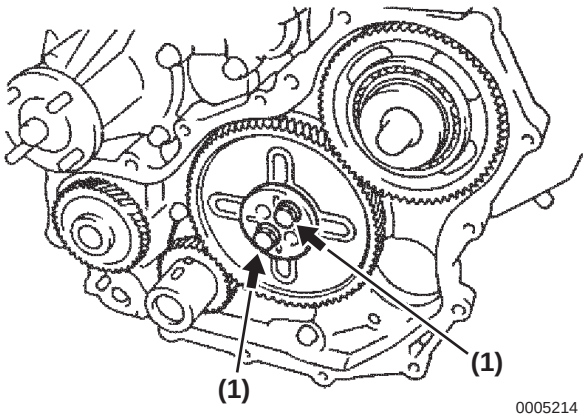

Figure 5-214

11. Align the key on the crankshaft to the key groove in the drive shaft gear.
12. Tap in the oil pump drive shaft gear, with the front **(Figure 5-215, (2))** facing out to install using a suitable tool **(Figure 5-215, (1))**.

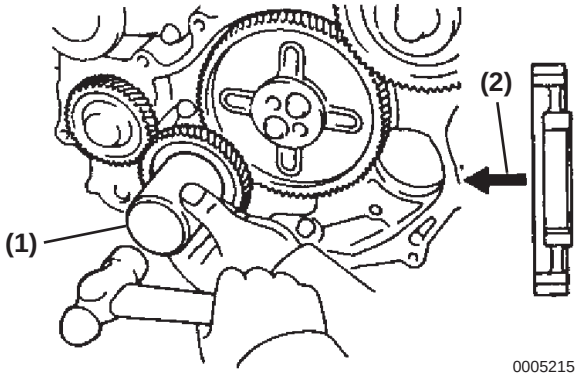

Figure 5-215

13. Remove the packing material from the timing gear cover.

Note: Avoid contaminating the timing gear cover and cylinder block sealing surfaces with oil.

- Completely remove the packing material remaining on the sealing surface and sealing groove.
- Clean all parts.
- Clean both sealing surfaces using solvent.

14. Apply the seal packing (TOYOTA P/N 08826-00080 or equivalent) to the timing gear cover as shown in **Figure 5-216**.
    - Attach a nozzle cut to a sealing width of 2 to 3 mm (0.078 to 0.118 in.) **(Figure 5-216, (1))**.

Note: Parts must be assembled within 5 minutes after the seal packing is applied or the seal material must be removed and reapplied. Disconnect the nozzle from the tube immediately after use and cap the tube.

15. Install the timing gear cover with 14 bolts and torque to 200 kgf·cm, 19.61 N·m (14.4 lb-ft).

Note: Use the correct bolts in the correct locations, as bolt lengths are different **(Figure 5-16)**.

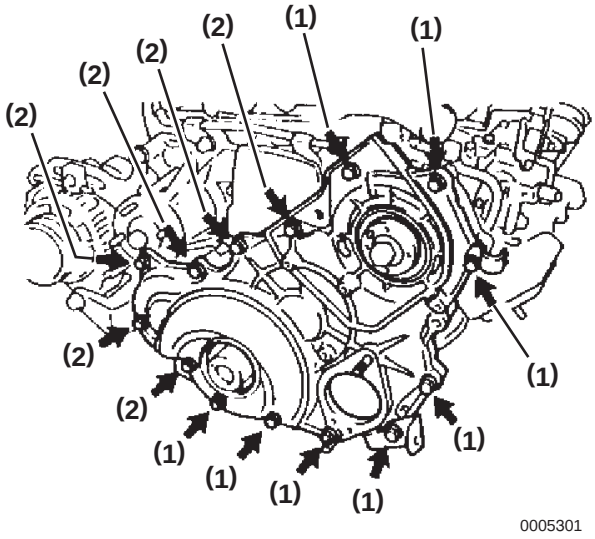

Figure 5-216

1 – Bolt Length 25 mm (0.984 in.)
2 – Bolt Length 50 mm (1.968 in.)

16. Install the alternator adjusting bar.

17. Install a new O-ring **(Figure 5-217, (1))** in the crankshaft pulley groove.
18. Align the key on the crankshaft to the key groove of the crankshaft pulley.
19. Tap in the crankshaft pulley to install using a suitable tool **(Figure 5-217, (2))**.
20. Hand tighten the plate washer and pulley nut. *NOTICE: NEVER turn the crankshaft pulley as the valve heads and piston head will contact causing engine damage.*

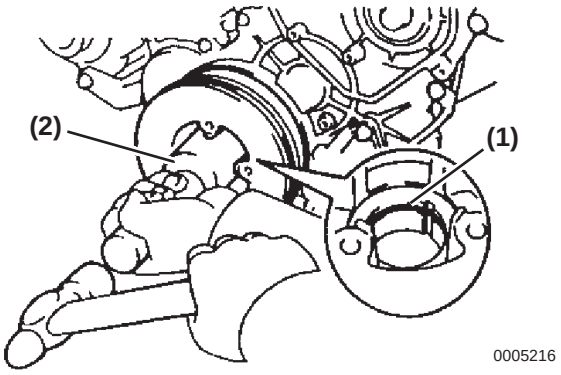

Figure 5-217

21. Install the camshaft oil seal retainer. *See Camshaft Oil Seal Retainer Installation on page 5-38*.
22. Install timing pulleys and timing belt. *See Timing Belt Installation on page 5-73*.
23. Tighten crankshaft pulley bolt and torque to 44 kgf·m, 431.50 N·m (318.2 lb-ft).
24. Install the freshwater pump pulley and viscous damper. Torque viscous damper bolts to 380 kgf·m, 37.27 N·m (27.5 lb-ft).
25. Install the freshwater pump, see *Freshwater Pump Installation on page 7-6* and alternator V-belt.

VALVE CLEARANCE INSPECTION AND ADJUSTMENT

NOTICE: Check and adjust the valve clearance when the engine is cooled down.

Valve Clearance Inspection

1. Remove the rocker cover. See step 8 starting in *Cylinder Head Removal on page 5-16*.
2. Turn **(Figure 5-218, (1))** the crankshaft pulley clockwise to align its groove to that of the timing gear cover **(Figure 5-218, (2))** and set No. 1 cylinder at TDC of the compression stroke.

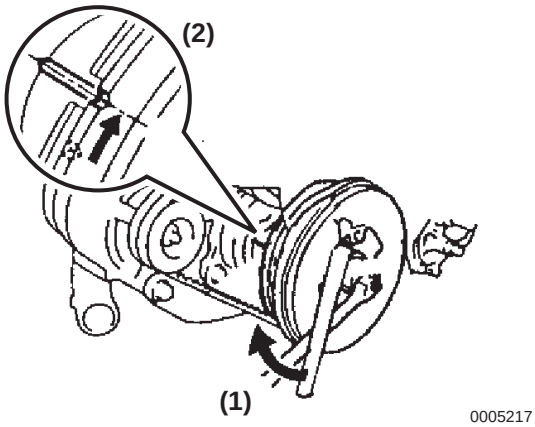

Figure 5-218

3. Check that the intake and exhaust valve rocker arm does not move when the crankshaft pulley is turned in the both directions (about 90°). If not, turn the crankshaft 360° and position the mark as shown **(Figure 5-218, (2))**.
4. Check only the valves indicated by arrows in **Figure 5-219**.
   - Measure the clearance between the adjusting screw on the valve rocker arm and valve bridge using a feeler gauge.

Measuring Valve Clearance at TDC of No. 1 Cylinder

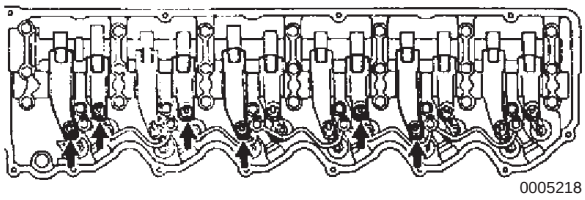

Figure 5-219

   - Record the measured valve clearance.

Valve Clearance (Engine Temperature = Cool)	
Intake	0.17 to 0.23 mm (0.007 to 0.009 in.)
Exhaust	0.47 to 0.53 mm (0.0185 to 0.0208 in.)

5. Turn the crankshaft pulley 360° and locate the mark as shown in **(Figure 5-218, (2))**.
6. Check only the valves indicated by arrow in **Figure 5-220**.
   - Record the measured valve clearance.

   - Measuring Valve Clearance at TDC of No. 6 Cylinder

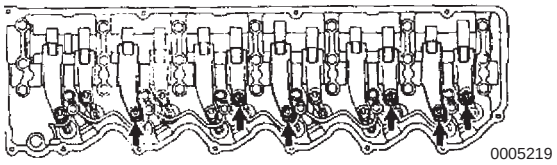

Figure 5-220

Valve Clearance Adjustment

1. Loosen **(Figure 5-221, (1))** the lock nut on the valve bridge **(Figure 5-221, (2))** and adjust the adjusting screw **(Figure 5-221, (3))** until the two bridge heads come into contact with the two valve stem heads.

Note: Secure the valve bridge using a wrench and loosen the lock nut. NEVER apply any torque to the valve bridge.

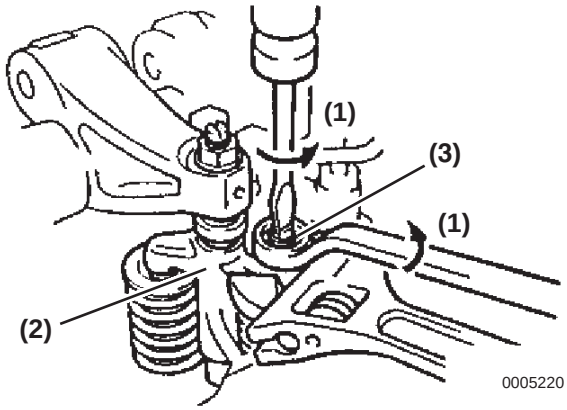

Figure 5-221

2. Loosen the lock nut on the valve rocker arm and then the adjusting screw.
3. Insert a 0.20 mm feeler gauge **(Figure 5-222, (1))** between the adjusting screw **(Figure 5-222, (2))** on the valve rocker arm **(Figure 5-222, (3))** and the valve bridge for the intake size and a 0.50 mm feeler gauge **(Figure 5-222, (1))** for the exhaust side.

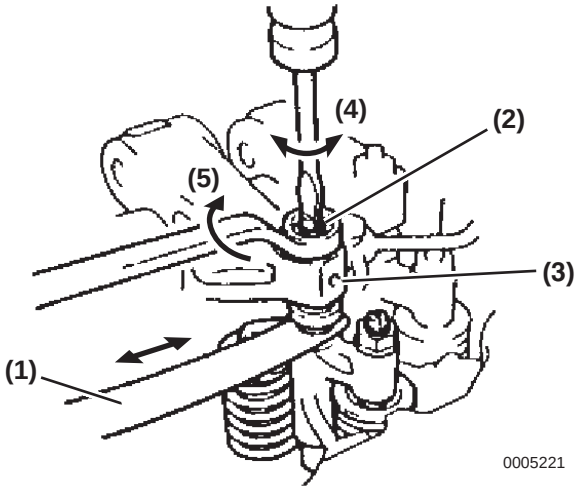

Figure 5-222

4. Turn the adjusting screw **(Figure 5-222, (4))** on the valve rocker arm, slightly slide the feeler gauge, and lock **(Figure 5-222, (5))** the adjusting screw by the lock nut.
5. Check that the resistance of the feeler gauge is the same when the feeler gauge is inserted and the adjusting screw on the valve bridge is loosened **(Figure 5-223)**. If not, readjust using the procedure in the following steps 7 to 9.

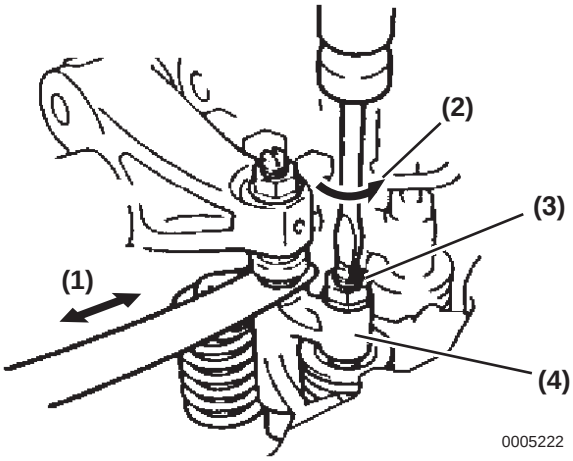

Figure 5-223

1 – Slide Feeler Gauge
2 – Loosen Adjusting Screw
3 – Adjusting Screw
4 – Valve Bridge

6. Tighten the adjusting screw on the valve bridge and lock the adjusting screw by the lock nut when resistance of the feeler gauge begins to increase **(Figure 5-224)**.

Note: Secure the valve bridge using a wrench and lock the adjusting screw with the lock nut. NEVER apply any torque to the valve bridge.

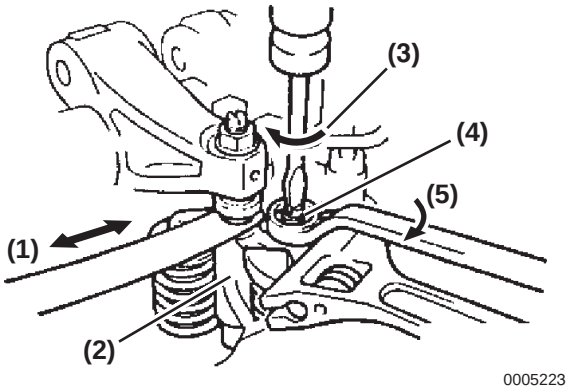

Figure 5-224

1 – Slide Feeler Gauge
2 – Valve Bridge
3 – Tighten Adjusting Screw
4 – Adjusting Screw
5 – Tighten Nut

7. Loosen the lock nut on the valve rocker arm.
8. Turn the adjusting screw on the valve rocker arm and lightly slide the feeler gauge in and lock the adjusting screw with the lock nut **(Figure 5-225)**.

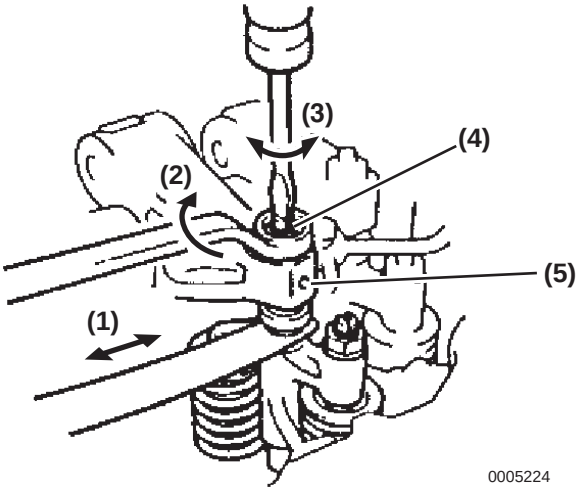

Figure 5-225

1 – Slide Feeler Gauge
2 – Lock Adjusting Screw Nut
3 – Turn Adjusting Screw
4 – Adjusting Screw
5 – Valve Rocker Arm

INJECTION TIMING INSPECTION AND ADJUSTMENT

Inspection of Injection Timing

1. Set the No. 1 or No. 6 cylinder at the top dead center (TDC) compression stroke.
2. Turn the crankshaft pulley clockwise to align its groove to that of the timing gear cover **(Figure 5-226)**.

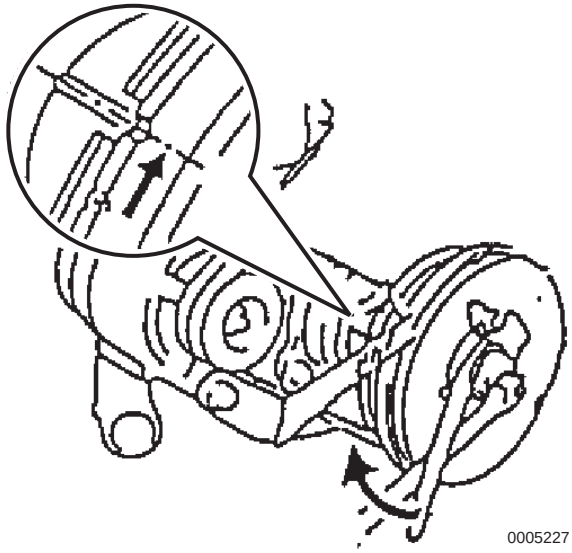

Figure 5-226

3. Loosen the two union nuts securing the fuel injection pump to No. 1 and No. 5 fuel injection pipes and position them out of the way **(Figure 5-227)**.

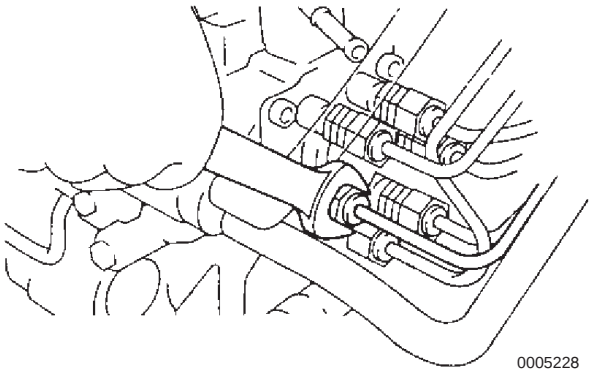

Figure 5-227

4. Remove the plug bolt **(Figure 5-228, (1))** and gasket **(Figure 5-228, (2))** from the distribution head plug of the fuel injection pump.
5. Install the plunger stroke measuring tool **(Figure 5-228, (3))** and dial indicator **(Figure 5-228, (4))** into the plug bolt hole of the distribution head plug.

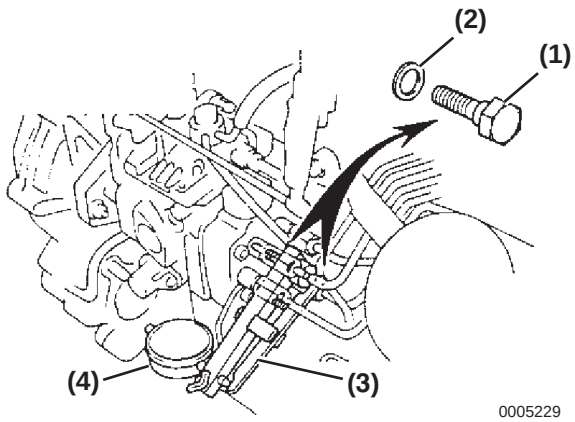

Figure 5-228

6. Slowly turn the crankshaft pulley counterclockwise and adjust the dial indicator to 0 mm (0 in.) when the dial indicator reading is at the minimum.

7. Turn the crankshaft clockwise **(Figure 5-229, (1))** and counterclockwise **(Figure 5-229, (2))** and check that the dial indicator reads the minimum. *NOTICE: Check that the minimum reading is zero 0 mm (0 in.)* ***(Figure 5-229, (3))***.

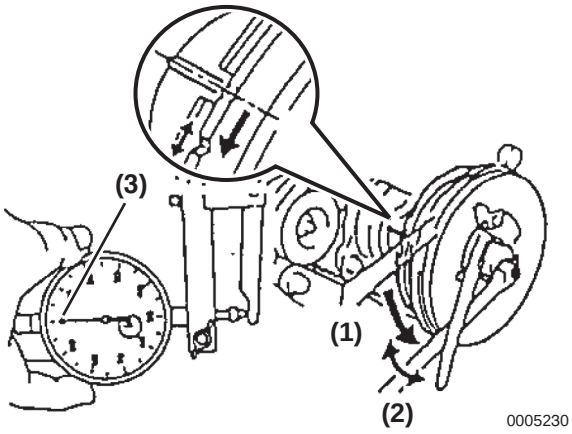

Figure 5-229

8. Slowly turn the crankshaft pulley clockwise **(Figure 5-230, (1))** to align its groove to that of the timing gear cover.

9. Measure the plunger stroke with the dial indicator.

   Plunger stroke:

   - 1.48 to 1.54 mm (0.058 to 0.060 in.)

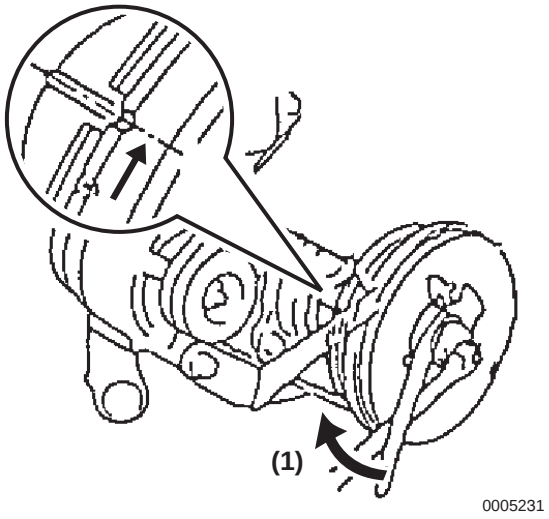

Figure 5-230

Adjustment of Injection Timing

1. Loosen the following nuts and bolts:
   (a) Remaining four union nuts **(Figure 5-231, (1))** securing the fuel injection pipe to the fuel injection pump
   (b) Two bolts **(Figure 5-231, (2))** securing the fuel injection pump to the fuel injection pump stay
   (c) Two nuts **(Figure 5-231, (3))** securing the fuel injection pump to the timing gear case.

Note: NEVER loosen the nuts over 90°.

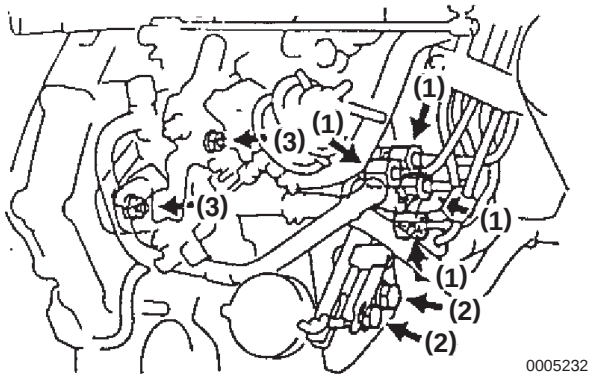

Figure 5-231

2. Slightly incline the injection pump to adjust the plunger stroke. If the stroke is less than the specification, incline the pump towards the engine **(Figure 5-232)**. If it is greater than the specification, incline the pump away from the engine.
   - Adjust gradually by tapping the pump flange using a brass bar and plastic hammer.
3. Install and torque the two nuts securing the fuel injection pump to the timing gear case to 185 kgf·cm, 18.14 N·m (13.3 lb-ft).
4. Install and torque the two bolts securing the fuel injection pump to the fuel injection pump to 700 kgf·cm, 68.65 N·m (50.6 lb-ft).
5. Re-check the plunger stroke using a dial indicator.

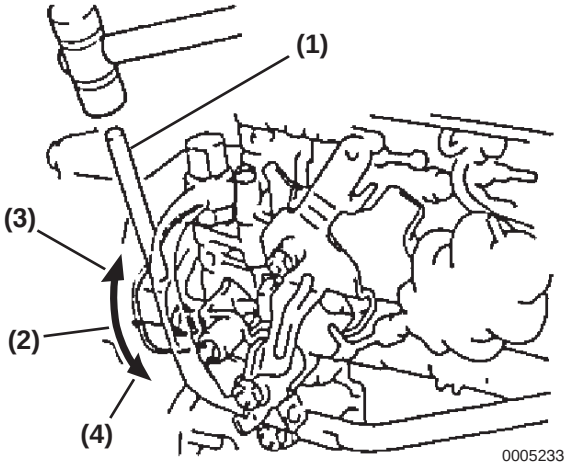

Figure 5-232

1 – Brass Bar
2 – Greater than specification
3 – Incline
4 – Less than specification

6. Install and torque the fuel injection pipe union nuts to 250 kgf·cm, 24.52 N·m (18 lb-ft).
7. Start the engine and check for fuel and oil leakage.

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Section 6

FUEL SYSTEM

Page

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SAFETY PRECAUTIONS

Before you service the fuel system, read the following safety information and review the *Safety Section on page 2-1*.

⚠ WARNING

The safety messages that follow have WARNING level hazards. These safety messages describe a hazardous situation which, if not avoided, *could* result in death or serious injury.

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 and Explosion Hazard

Diesel fuel is flammable and explosive under certain conditions.

NEVER use a shop rag to catch the fuel.

Wipe up all spills immediately.

NEVER refuel with the engine running.

Store any containers containing fuel in a well-ventilated area, away from any combustibles or sources of ignition.

Piercing Hazard

Avoid skin contact with high-pressure diesel fuel spray caused by a fuel system leak such as a broken fuel injection line. 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.

INTRODUCTION

This section of the *Service Manual* describes the procedures necessary to remove, install, and adjust the injectors and their associated system components as used on the Yanmar 6LPA-STP2/STZP2 engines.

SPECIFICATIONS

Test and Adjustment Specifications

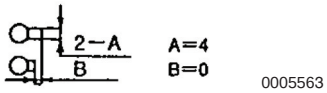
Part Name	Item	Specification	
Fuel injection nozzle	Nozzle type	DLLA150P979	
	Nozzle opening pressure No. 1	250 to 260 kgf/cm^2, 24.52 to 25.50 MPa (3556 to 3698 psi)	
	Nozzle opening pressure No. 2	300 to 310 kgf/cm^2, 29.42 to 30.40 MPa 4267 to 4409 psi)	
	Needle lift	0.33 to 0.38 mm (0.013 in.)	
	Adjusting shim thickness	1.900 to 2.000 mm (0.075 to 0.079 in.) (in 0.025 mm (0.001 in.) steps)	
	Pre-lift	0.08 to 0.10 mm (0.003 to 0.0004 in.)	
	No. 2 pressure spring seat thickness	3.09 to 3.27 mm (0.122 to 0.129 in.) (in 0.03 mm (0.001 in.) steps)	
	No. 2 opening pressure adjusting shim thickness	0.700 mm (0.027 in.)	1.425 mm (0.056 in.)
		0.850 mm (0.033 in.)	1.450 mm (0.057 in.)
		1.000 mm (0.039 in.)	1.575 mm (0.062 in.)
		1.025 mm (0.040 in.)	1.600 mm (0.063 in.)
		1.150 mm (0.045 in.)	1.725 mm (0.068 in.)
		1.175 mm (0.046 in.)	1.750 mm (0.069 in.)
		1.275 mm (0.050 in.)	1.900 mm (0.075 in.)
		1.300 mm (0.051 in.)	2.050 mm (0.081 in.)
	No. 1 opening pressure adjusting shim thickness	0.825 to 1.950 mm (0.032 to 0.077 in.) (0.075 mm (0.003 in.) steps) 2.000 to 2.100 mm (0.008 to 0.083 in.)	

Part Name	Item	Specification		
Fuel injection pump	Direction of rotation Injection order	Clockwise viewing from the drive side 1 4 2 6 3 5 (A-B-C-D-E-F)		
	Delivery valve opening pressure	75 to 85 kgf/cm^2, 7.36 to 8.34 MPa (1067 to 1209 psi)		
	Inclination of plunger spring free length	2.0 mm (0.08 in.)		
	Spring free length - Delivery valve spring	12.6 mm (0.5 in.)		
	Spring free length - Plunger spring	31.2 mm (1.29 in.)		
	Boost compensator spring free length	19.0 mm (0.7480 in.)		
	Roller height variation	0.02 mm (0.0009 in.)		
	Timer adjusting screw protrusion presetting	7.5 to 8.0 mm (0.30 to 0.31 in.)		
	Plunger spring shim thickness	0.5 mm (0.020 in.)	0.8 mm (0.315 in.)	1.0 mm (0.04 in.)
		1.2 mm (0.0472 in.)	1.5 mm (0.06 in.)	1.8 mm (0.71 in.)
		2.0 mm (0.080 in.)		
	Flyweight holder thrust clearance	0.15 to 0.35 mm (0.0006 to 0.0138 in.)		
	Governor gear adjusting washer thickness	1.05 mm (0.041 in.) 1.25 mm (0.050 in.)		
		1.45 mm (0.06 in.) 1.65 mm (0.065 in.)		
		1.85 mm (0.073 in.)		
	Governor shaft protrusion	0.5 to 2.0 mm (0.02 to 0.08 in.)		
	Plunger pre-stroke Adjusting shim thickness	0.23 to 0.27 mm (0.009 to 0.0106 in.) There are 131 types of shims having thickness from 1.90 to 3.20 mm (0.075 to 0.126 in.) in 0.01 mm (0.0004 in.) steps.		
	Boost compensator diaphragm adjusting shim thickness	There are 12 types of shims having thickness from 1.1 to 3.3 mm (0.043 to 0.130 in.) in 0.2 mm (0.0008 in.) steps.		

Special Torque Chart

Component	Specification
Fuel filter x fuel filter bracket	185 kgf·cm, 18.14 N·m (13.4 lb-ft)
Fuel hose clamp x fuel filter bracket	120 kgf·cm, 11.77 N·m (104.2 lb-in.)
Nozzle holder body x nozzle holder retaining nut	300 kgf·cm, 29.42 N·m (29.4 lb-ft)
Injection nozzle x cylinder head	255 kgf·cm, 25.01 N·m (18.4 lb-ft)
Injection pipe x injection nozzle and injection pump	250 kgf·cm, 24.52 N·m (18.1 lb-ft)
Injection pipe clamp x intake manifold and injection pipe clamp	65 kgf·cm, 6.37 N·m (56.4 lb-in.)
No. 1 fuel return pipe x cylinder head	186 kgf·cm, 18.24 N·m (13.4 lb-ft)
Delivery valve holder x distributive head	600 kgf·cm, 58.84 N·m (43.4 lb-ft)
Fuel inlet joint bolt x injection pump body	375 kgf·cm, 36.77 N·m (27.1 lb-ft)
Regulator valve x injection pump body	90 kgf·cm, 8.83 N·m (18.1 lb-in.)
Feed pump cover x injection pump body	31 kgf·cm, 3.04 N·m (27 lb-in.)
Timer cover and injection pump stay x injection pump body	85 kgf·cm, 8.34 N·m (74 lb-in.)
Timer adjusting screw x timer cover	145 kgf·cm, 14.22 N·m (14.2 lb-ft)
Governor link support x injection pump body	140 kgf·cm, 13.73 N·m (13.7 lb-ft)
Distribution head x injection pump body	120 kgf·cm, 11.77 N·m (104 lb-in.)
Governor shaft x injection pump body	275 kgf·cm, 26.97 N·m (19.9 lb-ft)
Overflow screw x governor cover	250 kgf·cm, 24.52 N·m (18.1 lb-ft)
Control lever x governor cover	70 kgf·cm, 6.86 N·m (61 lb-in.)
Governor cover x injection pump body	85 kgf·cm, 8.34 N·m (74 lb-in.)
Idle speed adjusting screw and lever x governor cover	70.4 kgf·cm, 6.90 N·m (61.1 lb-in.)
Governor lever x governor cover	85 kgf·cm, 8.34 N·m (74 lb-in.)
Distributive head plug x distributive head	900 kgf·cm, 88.2 N·m (65 lb-ft)
Diaphragm x push rod	75 kgf·cm, 7.35 N·m (65 lb-in.)
Diaphragm cover x governor cover	75 kgf·cm, 7.35 N·m (65 lb-in.)
Lever control spring x governor cover	115 kgf·cm, 11.28 N·m (100.0 lb-in.)
Fuel cut solenoid x distributive head	225 kgf·cm, 22.06 N·m (16.3 lb-ft)
Lead wire x fuel cut solenoid	17 kgf·cm, 1.67 N·m (14.8 lb-in.)
Cap x injection pump	115 kgf·cm, 11.28 N·m (99.8 lb-in.)
No. 2 fuel return pipe and fuel inlet pipe x injection pump	250 kgf·cm, 24.52 N·m (18.1 lb-ft)
Fuel inlet pipe x bracket	200 kgf·cm, 19.61 N·m (14.5 lb-ft)
Injection pump x timing gear case	185 kgf·cm, 18.14 N·m (13.4 lb-ft)
Pump stay x injection pump	700 kgf·cm, 68.65 N·m (50.1 lb-ft)
Injection pump drive gear x injection pump	1050 kgf·cm, 102.9 N·m (76 lb-ft)

Fuel Injection Pump Specifications

Pump Specification	Plunger diameter	12 mm (0.472 in.)
	Spill port shape	
	Cam profile	ND0283
	Cam lift	2.2 mm (0.086 in.)
	Statical diesel fuel rate	18.6 m^3/deg
	Pre-stroke	0.25 mm (0.01 in.)
	Governor type	AS
	Governor link	NAR
	Injection order	A B C D E F
	Direction of rotation	Clockwise viewing from drive side
	Valve	CPV
	Governor speed adjusting range	375 to 2140 rpm
Measurement Conditions	Nozzle type	DN12SD12
	Opening pressure	150 kgf/cm^2, 14.71 MPa (2133 psi)
	Injection pipe specification-diameter	2 x 6 x 840 mm (0.08 x 0.23 x 269.2 in.)
	Diesel fuel feed pressure	0.2 kgf/cm^2, 0.02 MPa (3 psi)
	Test oil	JIS No. 2 fuel oil
	Diesel fuel temperature	40°C (104°F) (at overflow portion)

Injection Characteristics

Note: [ ] marked figures are Boost Pressure PB (kPa).

( ) marked figures are Non-Uniform fuel injection quantity (mm^3/st)

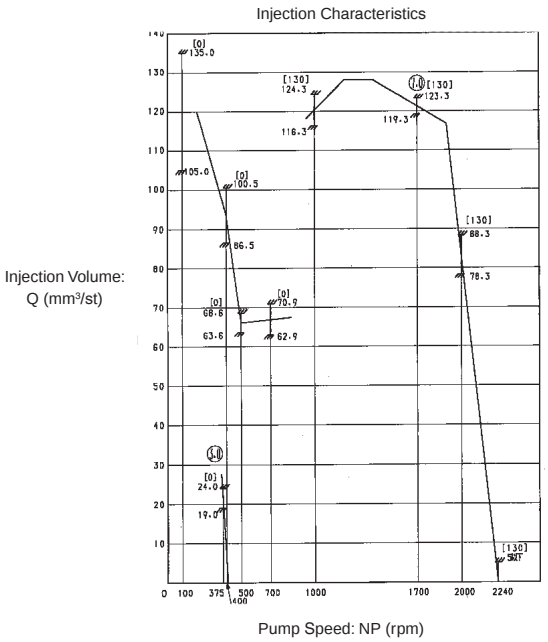


Figure 6-1

Timer Characteristics

Note: Values in [ ] indicate the injection timing advance (cam).)

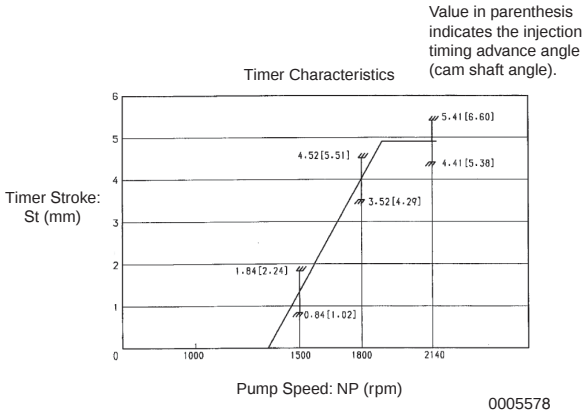


Figure 6-2

BCS Characteristics

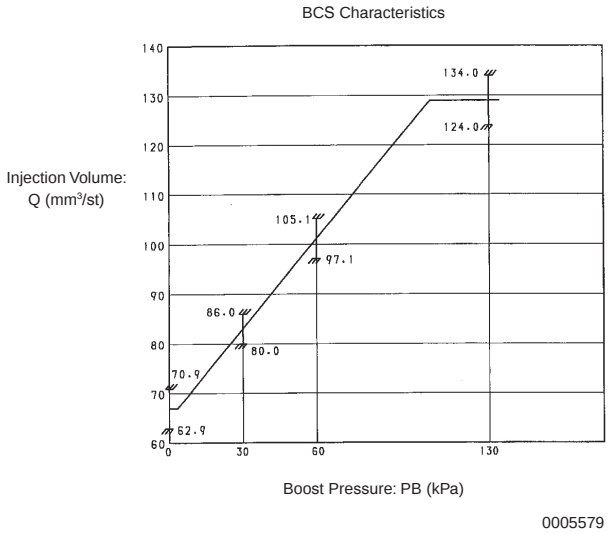


Figure 6-3

FUEL FILTER REPLACEMENT

1. Disconnect the water alarm switch connector from the fuel filter.
2. Close all the fuel tank cocks and then connect one end of a vinyl hose to the filter drain cock and the other end to an suitable fuel container.
3. Loosen the drain plug to drain the fuel and then remove the fuel filter using a fuel filter wrench **(Figure 6-4, (1))**.

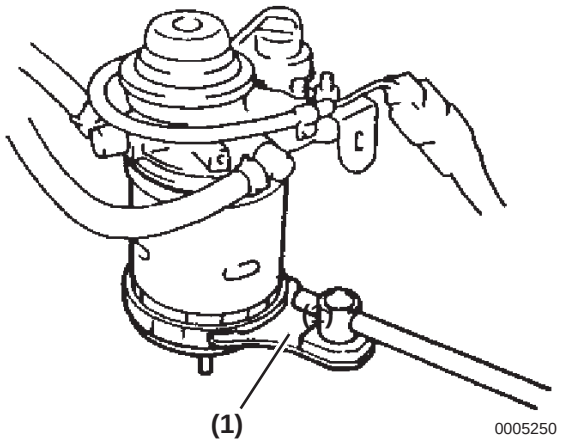


Figure 6-4

4. Remove the water alarm switch and O-ring from the fuel filter using pliers **(Figure 6-5, (1))**.
NOTICE: Avoid damaging the alarm switch during removal.

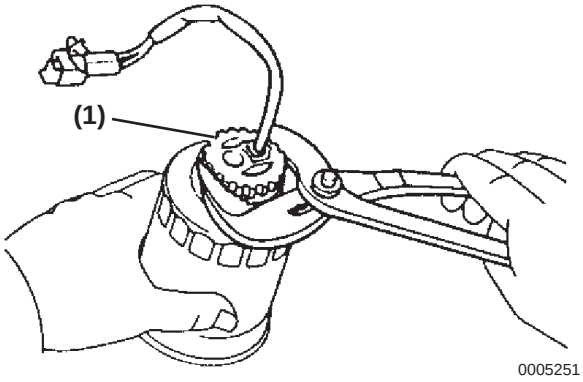


Figure 6-5

5. Lubricate a new alarm switch O-ring with clean diesel fuel and install the alarm switch and O-ring to the new fuel filter.
6. Inspect and clean the fuel filter mounting surface. Apply clean diesel fuel to the gasket of the new fuel filter and hand tighten the fuel filter until the gasket comes into contact with the seat then tighten the filter an additional 3/4 turn then torque to: 150 to 200 kgf·cm, 14.71 to 19.61 N·m (10.8 to 14.7 lb-ft) **(Figure 6-6)**.

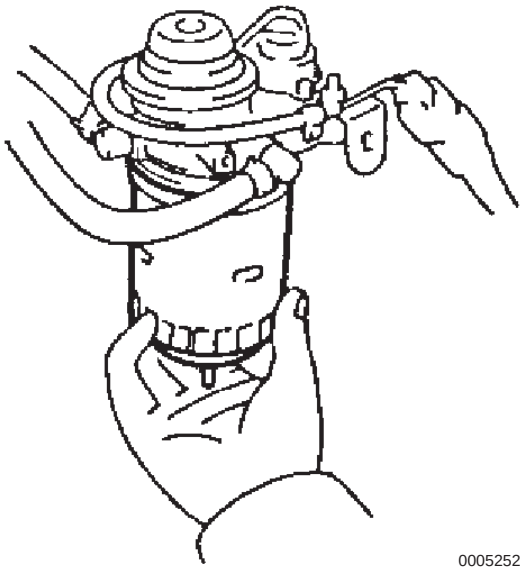


Figure 6-6

7. Reconnect the water alarm switch connector.

8. Open the fuel tank cock and operate the hand pump **(Figure 6-7, (1))** to fill the fuel filter with fuel and prime the fuel system.

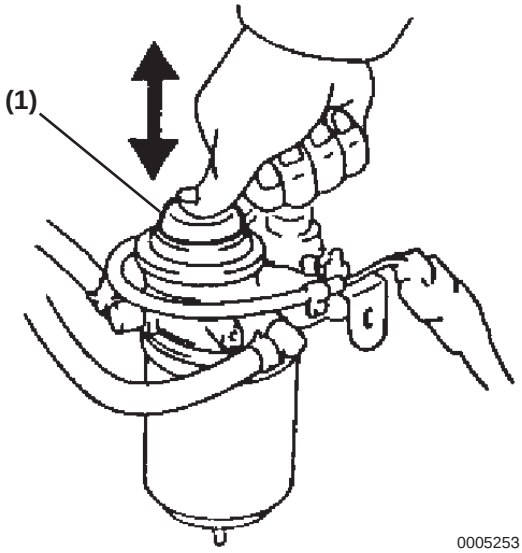


Figure 6-7

9. Start the engine to check for fuel leakage. Repair any leaks as necessary. **WARNING!** ***NEVER check for fuel leaks with your hand.***

FUEL INJECTION NOZZLE

Components

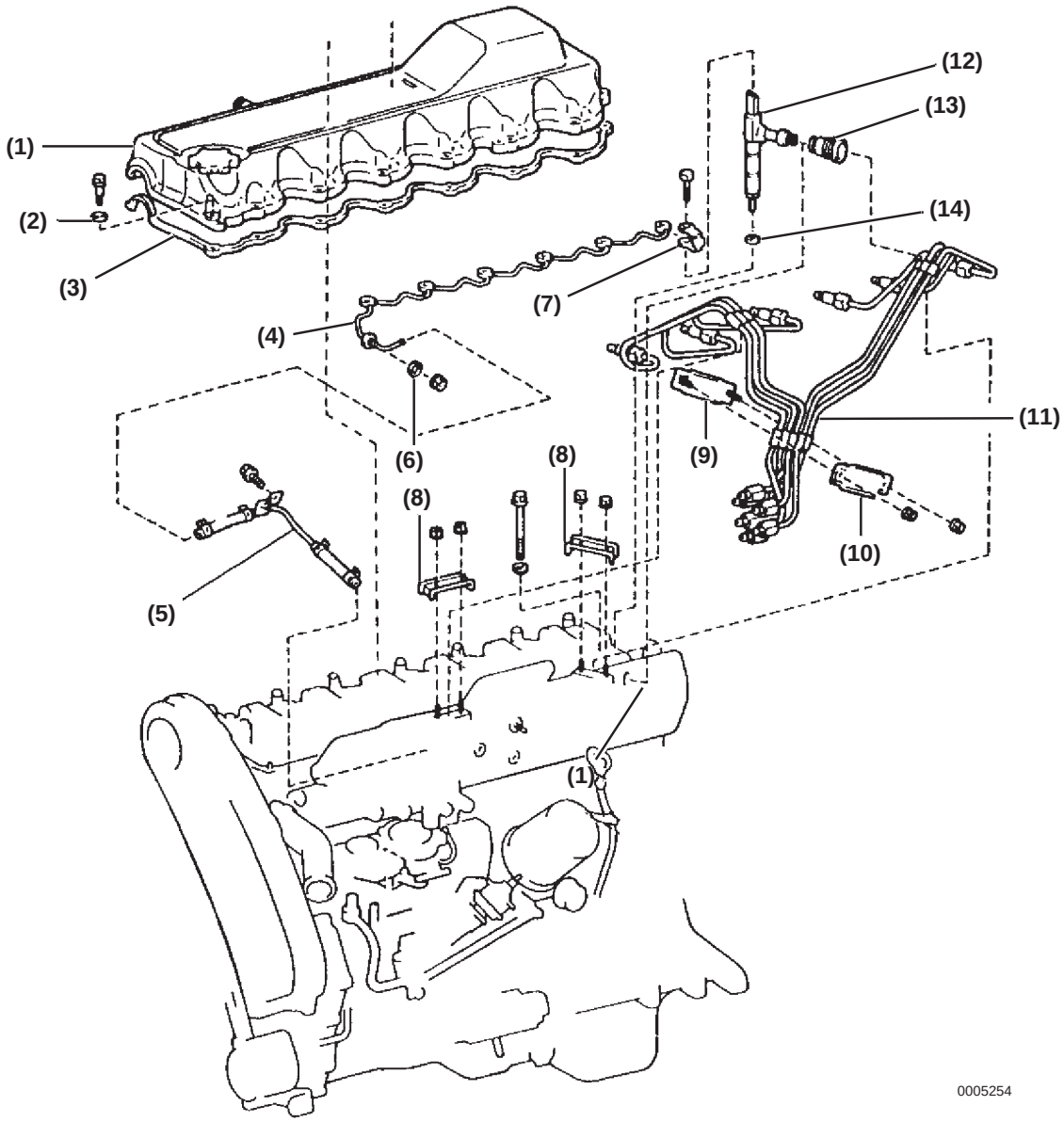


Figure 6-8

1 – Valve Cover
2 – Seal Washer (Non-Reusable)
3 – Gasket
4 – No. 1 Fuel Return Pipe
5 – No. 3 Fuel Return Pipe
6 – Gasket (Non-Reusable)
7 – Gasket (Non-Reusable)
8 – Clamp
9 – Clamp
10 – Clamp
11 – Injection Pipe
12 – Injection Nozzle
13 – Nozzle Holder Seal
14 – Nozzle Seat (Non-Reusable)

Fuel Injection Nozzle Removal

NOTICE: Consult a DENSO service shop when servicing the fuel injection pump and fuel injection nozzle. The following fuel injection nozzle service. The following fuel injection nozzle service procedure is described for reference only.

1. Remove the rocker cover. See step 8 starting in *Cylinder Head Removal on page 5-16*.
2. Remove the link unit from the fuel injection pump and intake manifold.
3. Remove the fuel return hose, 6 joint bolts, nut and 7 gaskets to remove the No. 1 fuel return pipe from the cylinder head **(Figure 6-9)**.

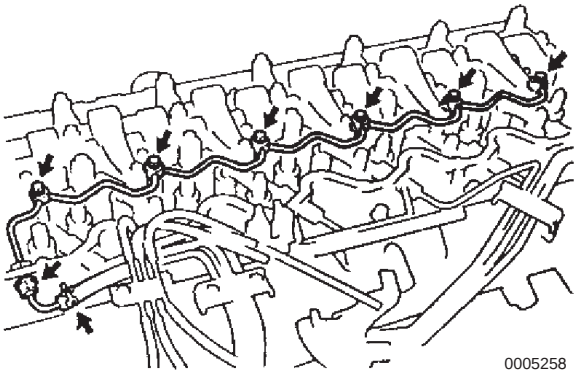


Figure 6-9

4. Remove the 4 nuts and 2 clamps from the intake manifold.
5. Remove the union nut of the fuel injection pipe from the fuel injection nozzle **(Figure 6-10)**.

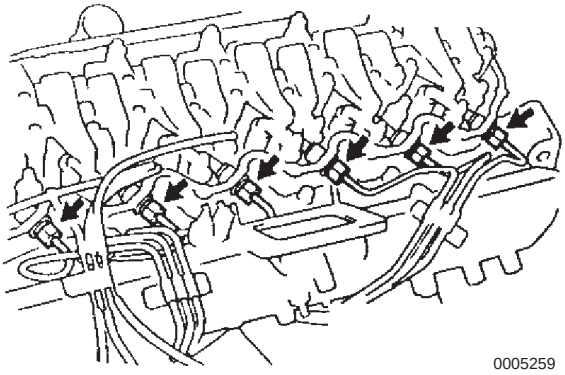


Figure 6-10

6. Remove the union nut of the fuel injection pipe from the fuel injection pump **(Figure 6-11)**.

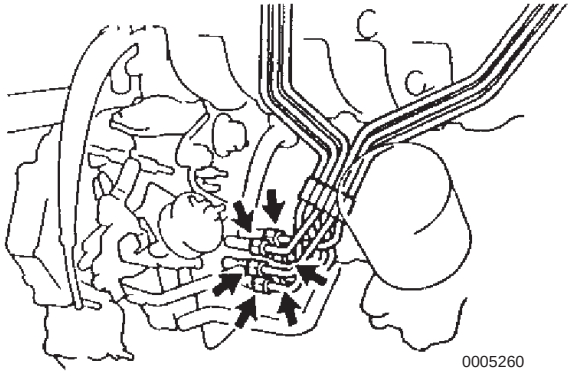


Figure 6-11

7. Remove the fuel injection pipe **(Figure 6-12)**.

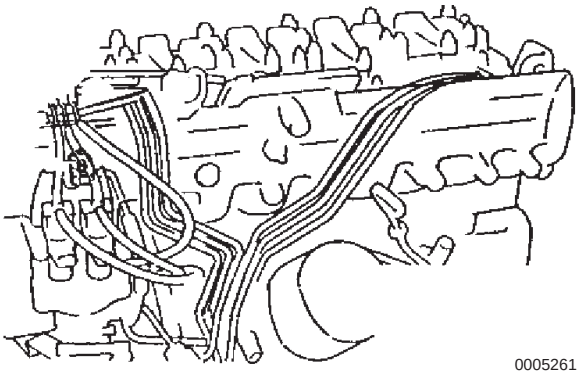


Figure 6-12

8. Remove the nozzle holder seal using a screwdriver to pry the nozzle holder from the cylinder head **(Figure 6-13)**.

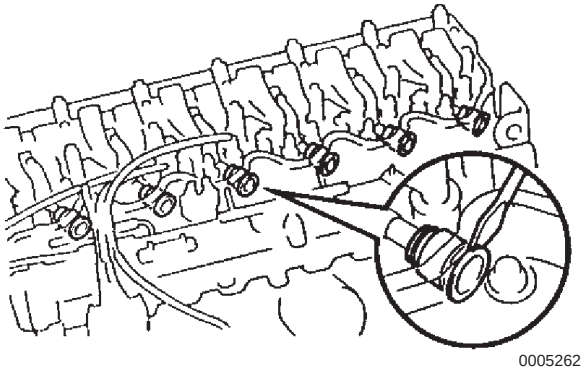


Figure 6-13

9. Remove the nozzle holder clamp from the cylinder head **(Figure 6-14)**.
10. Remove the fuel injection nozzle and seat from the cylinder head. Remove the O-ring from the fuel injection nozzle. Store fuel injection nozzle in orderly manner so that they can be reassembled to corresponding cylinders.

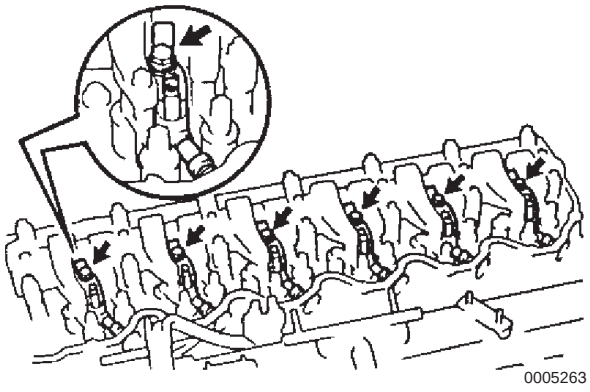


Figure 6-14

Fuel Injection Nozzle Testing

Leak Test

CAUTION! ***ALWAYS wear eye protection when servicing the engine.***

Increase the pressure to near the specified injection pressure of 10 to 20 kgf/cm^2, 0.98 to 1.96 MPa (142 to 284 psi). Check for oil leakage from the injection hole and around the retaining nut. There should be no leakage **(Figure 6-15, (1))**. If leakage occurs from the nozzle **(Figure 6-15, (2))**, replace, clean or repair the nozzle.

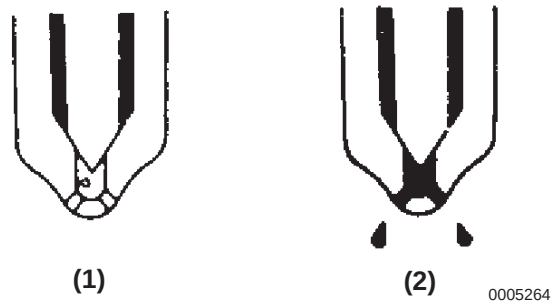


Figure 6-15

Spray Test

Check the spray condition for an even spray pattern **(Figure 6-16, (1))**. If the spray condition is improper **(Figure 6-16, (2))**, replace or clean the nozzle.

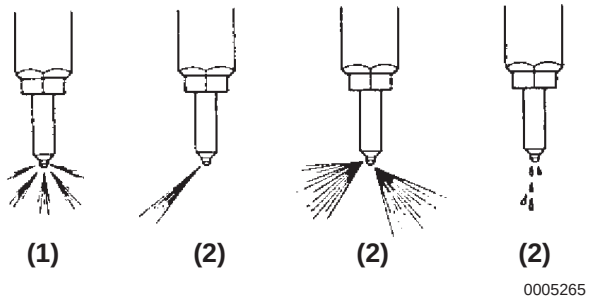


Figure 6-16

Fuel Injection Nozzle Components

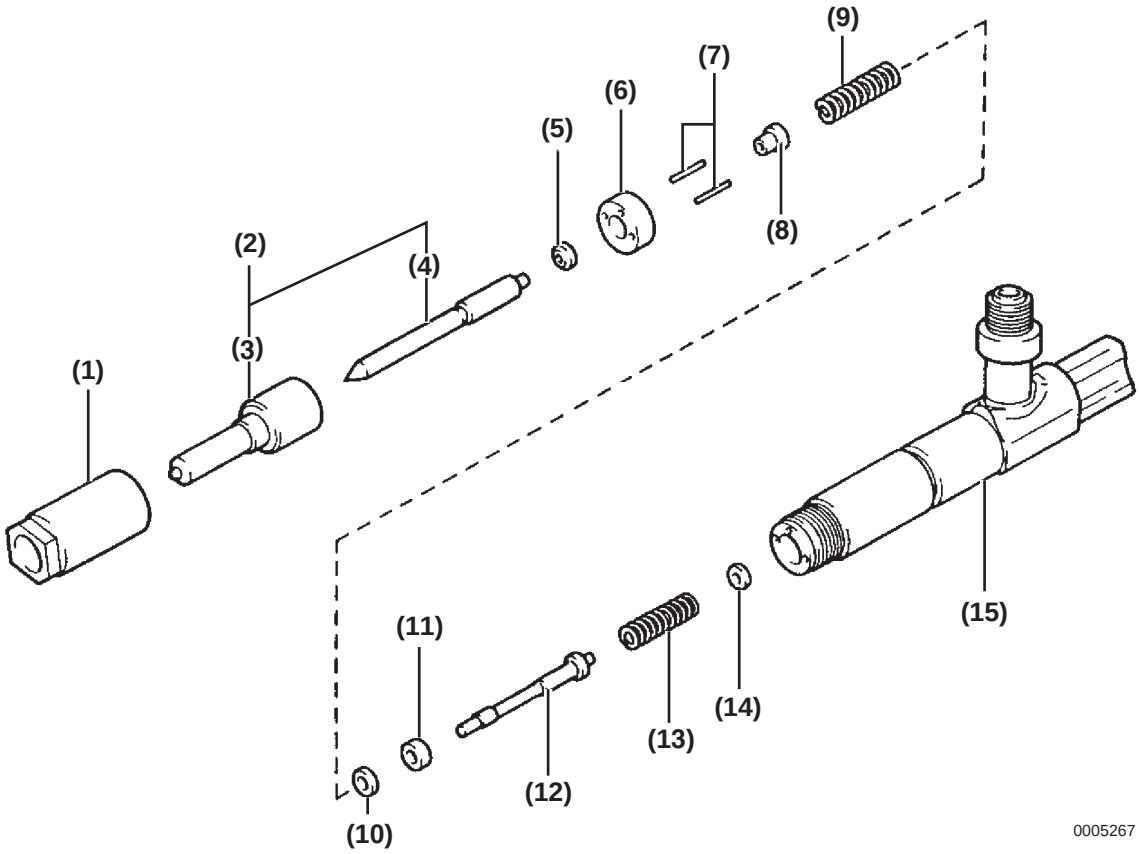


Figure 6-17

1 – Nozzle Holder Retaining Nut
2 – Nozzle Assembly
3 – Nozzle Body
4 – Needle Tip
5 – Adjusting Shim
6 – Tip Packing
7 – Straight Pins
8 – No. 2 Pressure Spring Seat
9 – No. 2 Pressure Spring
10 – Adjusting Shim
11 – No. 1 Pressure Spring Seat
12 – Pressure Pin
13 – No. 1 Pressure Spring
14 – Adjusting Shim
15 – Nozzle Holder Body

Fuel Injection Nozzle Disassembly and Inspection

1. Remove the nozzle holder retaining nut to disassemble the fuel injection nozzle **(Figure 6-18)**. Avoid dropping internal parts when disassembling the nozzle.

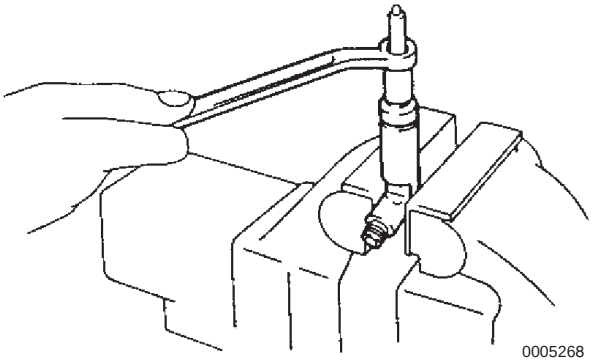


Figure 6-18

2. Remove carbon deposits from the nozzle tip **(Figure 6-19, (1))** with a wooden stick.

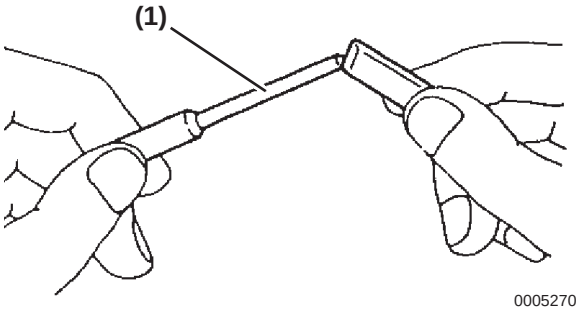


Figure 6-19

3. *NOTICE: Wash all parts with clean diesel fuel. NEVER touch the nozzle mating surfaces with bare hands*. Remove carbon deposits from the outside surface of nozzle body using a soft brass brush, except the lapped surface **(Figure 6-20, (1))**.

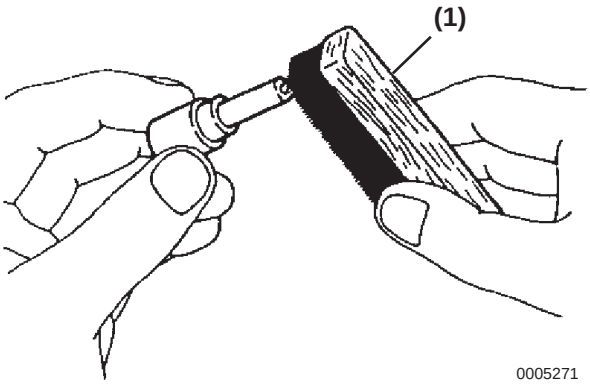


Figure 6-20

4. Check the nozzle body seat and needle tip for damage and corrosion. If damage or corrosion is present, replace the nozzle assembly **(Figure 6-21)**.

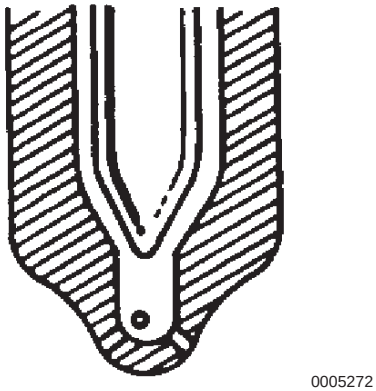


Figure 6-21

5. *NOTICE: Wash the nozzle in clean diesel fuel. NEVER touch the nozzle mating surfaces with bare hands.* Incline the nozzle body by about 60° **(Figure 6-22, (1))** and pull out the needle tip by about 1/3 of its overall length.

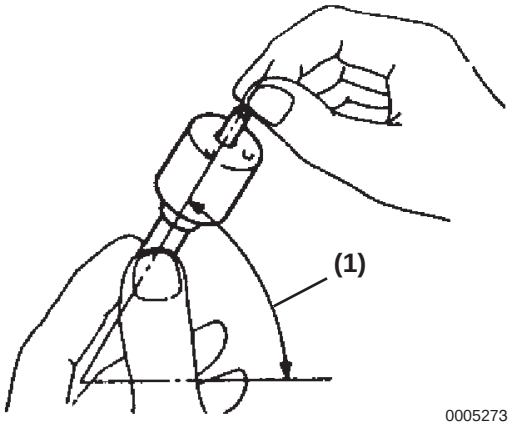


Figure 6-22

6. Check that the needle tip returns smoothly into the body by its own weight. Repeat the above test several times after turning the needle tip **(Figure 6-23)**. If the needle tip fails to return smoothly, replace the nozzle assembly.

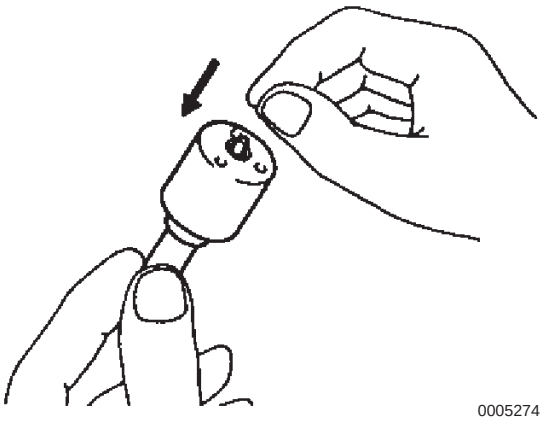


Figure 6-23

Fuel Injection Nozzle Adjustment

NOTICE: High precision is required for needle lift and pre-lift measurements. Thoroughly clean the parts and tools before measuring.

Pre-lift Adjustment

Needle Lift Adjustment

1. Attach the special tool to the dial indicator and adjust the stem to 3.0 mm (0.118 in.) or less **(Figure 6-24, (1))**.

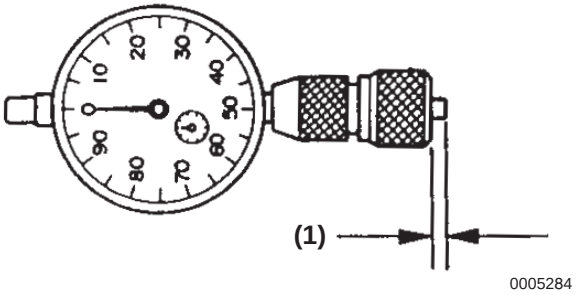


Figure 6-24

2. Adjust the dial indicator reading on the special tool or square block to zero, using the special tool **(Figure 6-25, (1))**.

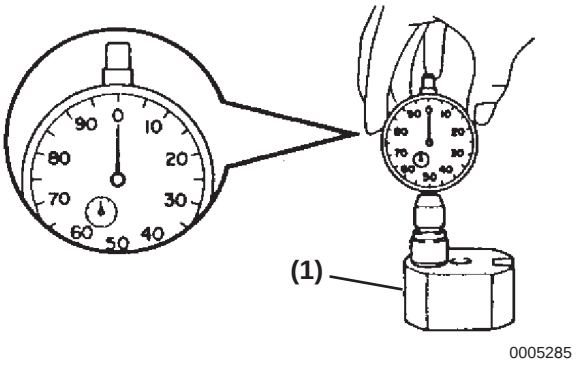


Figure 6-25

3. Measure dimension (t) of the No. 2 pressure spring seat **(Figure 6-26, (1))** using a micrometer.

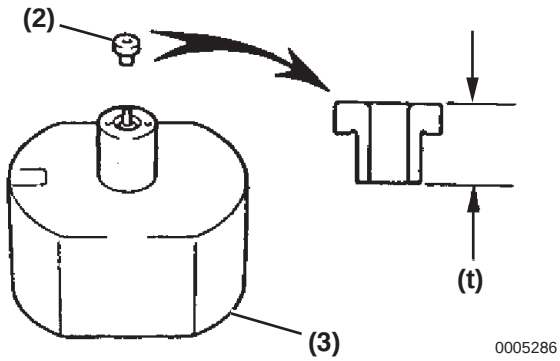
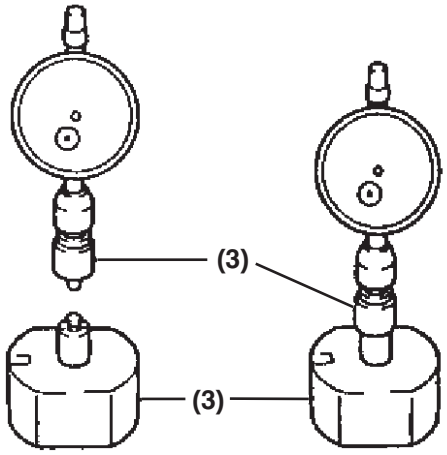


Figure 6-26

4. Install the nozzle assembly and No. 2 pressure spring seat on the special tool (B) **(Figure 6-26, (2))**.
5. Set the special tool **(Figure 6-27, (3))** on the nozzle and measure dimension (A).
   - Dimension (L1) = (t) - (A)
6. Remove the special tool and needle tip from the nozzle body.



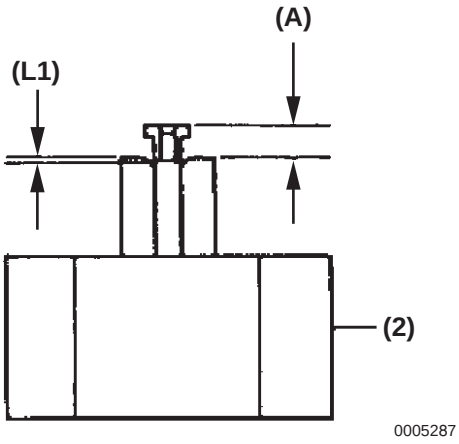


Figure 6-27

7. Install the tip packing and straight pins into the special tool as shown **(Figure 6-28)**.

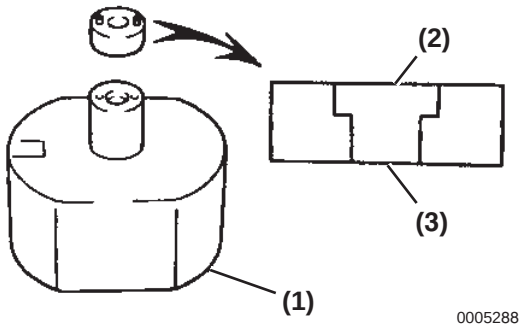


Figure 6-28

1 – Special Tool
2 – Top
3 – Bottom

8. Adjust the dial indicator reading to zero on the special tool or square block, using the special tool **(Figure 6-29, (1))**.
9. Install the straight pins into the tip packing and then into the holes in the special tool **(Figure 6-29, (1))** and then measure dimension (L2).

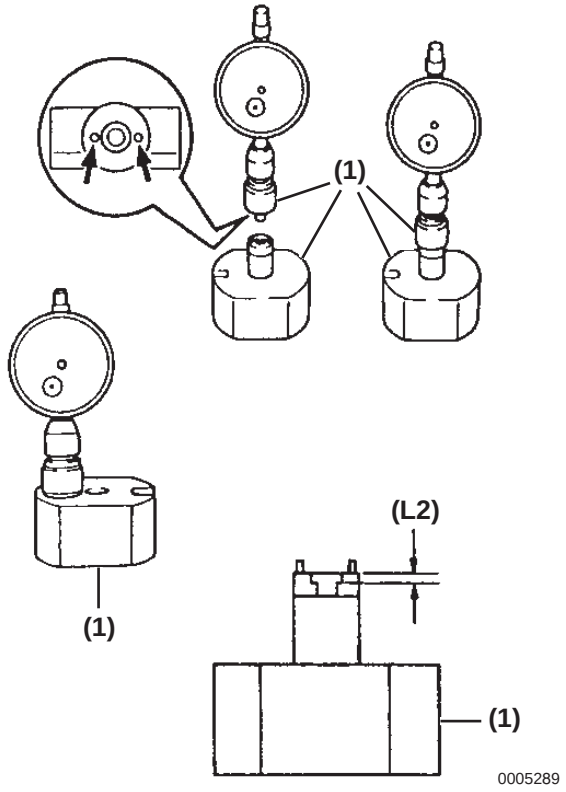


Figure 6-29

10. Measure dimension (L3) **(Figure 6-30)** of the adjusting shim, using a micrometer. If the measured needle lift is out of the specified range, change the adjusting shim. *NOTICE: Increasing the shim thickness reduces the needle lift.*
    - Needle lift = (L1+L2) - L3
    - Needle lift: 0.26 to 0.31 mm (0.0102 to 0.0122 in.)

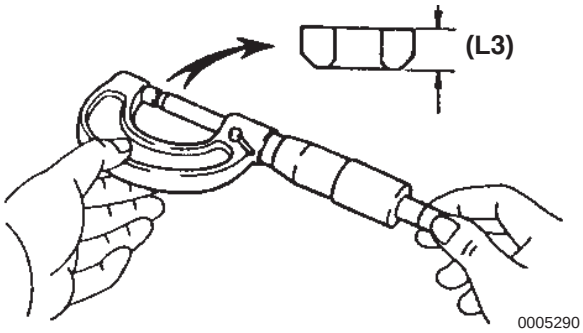


Figure 6-30

Adjusting Shim Thickness

1.900 mm (0.0748 in.)
1.925 mm (0.0757 in.)
1.950 mm (0.0767 in.)
1.975 mm (0.0797 in.)
2.000 mm (0.0787 in.)

Pre-lift Adjustment

1. Install the nozzle assembly, adjusting shim selected in step 1 above and No. 2 pressure spring seat on the special tool (B), using the special tool **(Figure 6-31)**.

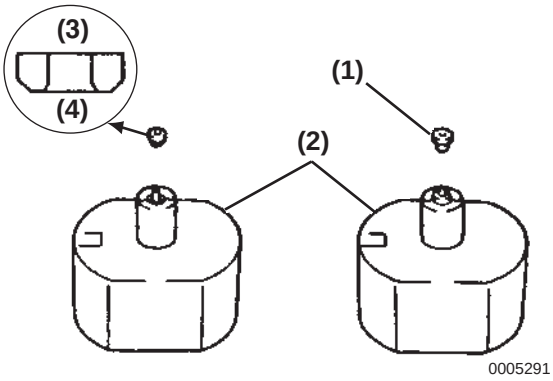
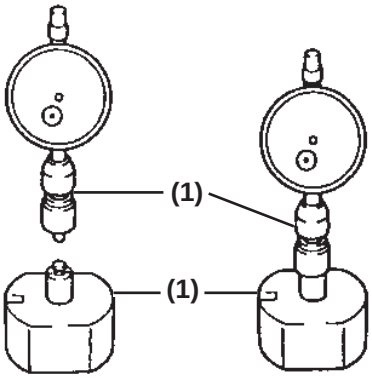


Figure 6-31

1 – No. 2 Pressure Spring Seat
2 – Special Tool (B)
3 – Top
4 – Bottom

2. Set the special tool on the nozzle and measure dimension (B).
   - Dimension (C) = (B) - (t)



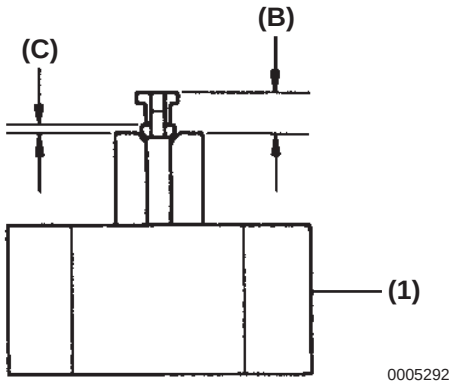


Figure 6-32

3. Measure dimension (D) of the tip packing using a micrometer **(Figure 6-33)**.
   - Dimension (L4) = (D) - (C)

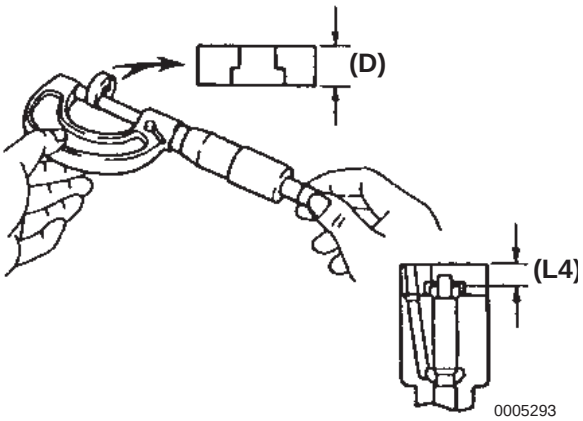


Figure 6-33

4. Measure dimension (E) of No. 2 pressure spring seat, using a micrometer. If the pre-lift length is out of the specified range, select a No. 2 pressure spring seat from the chart **(Figure 6-34)**. *NOTICE: Increasing the seat thickness reduces the pre-lift.*
   - Dimension (L5) = (t) - (E)
   - Pre-lift = (L4) - (L5)
   - Pre-lift standard: 0.08 to 0.10 mm (0.003 to 0.004 in.)

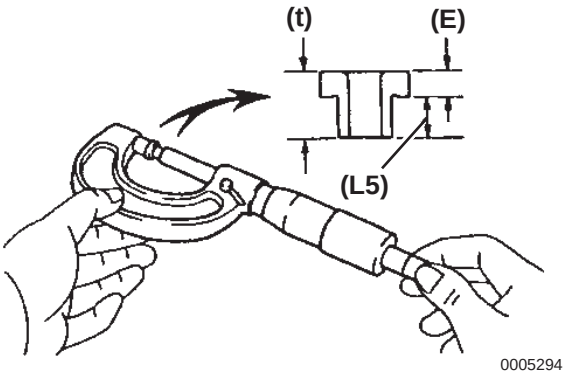


Figure 6-34

Thickness of No. 2

Pressure Spring Seat (t)

3.09 mm (0.122 in.)
3.12 mm (0.123 in.)
3.15 mm (0.124 in.)
3.18 mm (0.125 in.)
3.21 mm (0.126 in.)
3.24 mm (0.127 in.)
3.27 mm (0.129 in.)

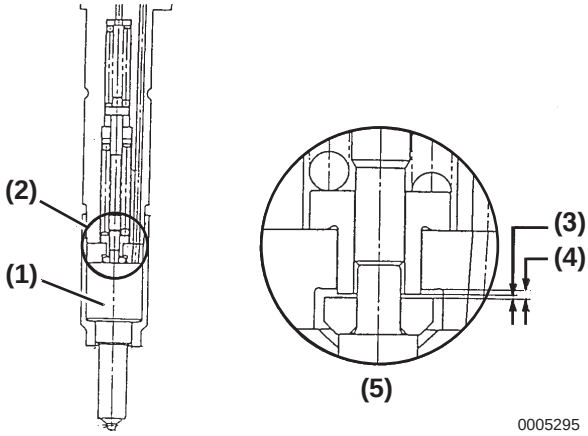


Figure 6-35

1 – Nozzle
2 – (E)
3 – Pre-lift
4 – Needle lift
5 – Detailed View of (E)

Checking No. 2 Opening Pressure

1. Assemble the nozzle assembly as shown in **Figure 6-36**. *NOTICE: Exclude the No. 1 pressure spring and pressure pin. Align the holes of the nozzle body, tip packing and nozzle holder body* ***(Figure 6-37)****.*

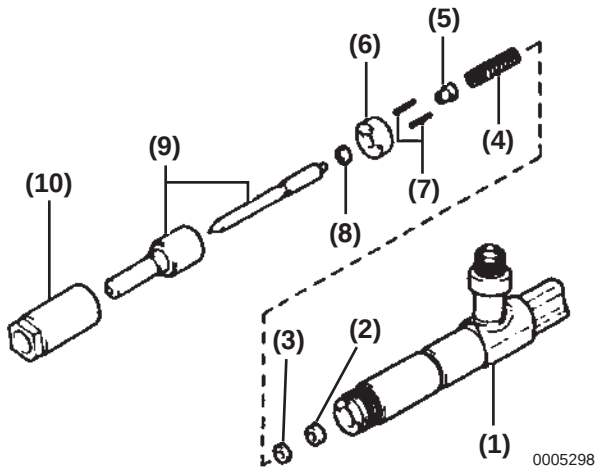


Figure 6-36

1 – Nozzle Holder Body
2 – No. 1 Pressure Spring Seat
3 – Adjusting Shim
4 – No. 2 Pressure Spring
5 – No. 2 Pressure Spring Seat
6 – Tip Packing
7 – Straight Pins
8 – Lift Adjusting Shim
9 – Nozzle Assembly
10 – Nozzle Holder Retaining Nut

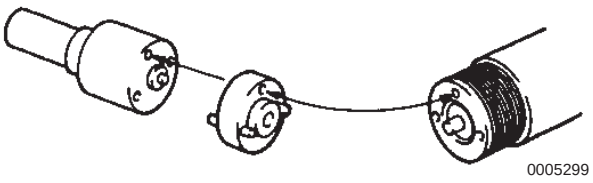


Figure 6-37

2. Tighten the nozzle holder retaining nut using a 14 mm socket **(Figure 6-38, (1))** torque to: 300 kgf·cm, 29.42 N·m (22 lb-ft).
NOTICE: NEVER tighten excessively. Otherwise, deformation, adhesion or other defects may occur.

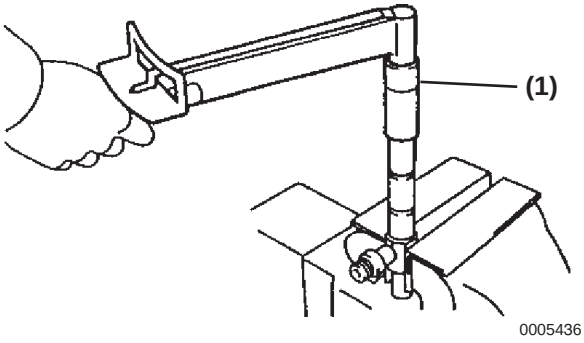


Figure 6-38

3. Install the fuel injection valve to the nozzle tester and bleed the air out from the union nut **(Figure 6-39)**. **WARNING!** ***Never put your hands over the nozzle injection hole.***

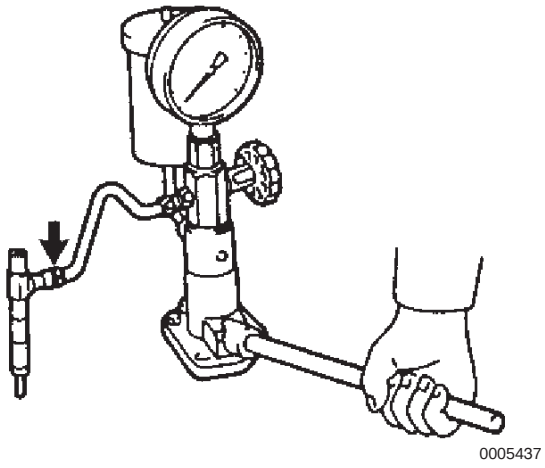


Figure 6-39

4. Pump the tester handle several times as quickly as possible to discharge foreign matter from the injection hole.

5. Slowly pump the tester handle and observe the pressure gauge **(Figure 6-40)**.
6. Read the pressure gauge when the injection pressure begins to decrease. *NOTICE: Judge if the nozzle operates normally or not by listening for the swishing sound.*
   - No. 2 opening pressure: 300 to 310 kgf/cm^2, 29.42 to 30.40 MPa (4267 to 4409 psi)

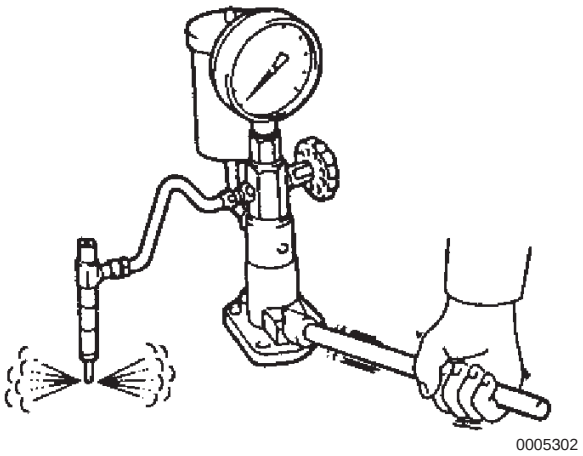


Figure 6-40

   - If No. 2 opening pressure is out of the specified range, disassemble the nozzle and select the appropriate adjusting shim from the chart and replace the shim located at the upper portion of the No. 2 pressure spring.

Adjusting Shim Thickness

0.700 mm (0.027 in.)	0.850 mm (0.033 in.)	1.000 mm (0.039 in.)
1.025 mm (0.040 in.)	1.150 mm (0.045 in.)	1.175 mm (0.046 in.)
1.275 mm (0.050 in.)	1.300 mm (0.051 in.)	1.425 mm (0.056 in.)
1.450 mm (0.057 in.)	1.575 mm (0.062 in.)	1.600 mm (0.0629 in.)
1.725 mm (0.0679 in.)	1.750 mm (0.0688 in.)	1.900 mm (0.0748 in.)
2.050 mm (0.080 in.)	-	-

Note: Changing the adjusting shim thickness by 0.025 mm changes the injection pressure by approximately 3.8 kgf/cm^2, 0.37 MPa (54 psi). Change only one adjusting shim (at the upper portion of No. 2 pressure spring).

7. After the injection test, check for leakage from from the injection hole **(Figure 6-41)**. There should be no leakage.

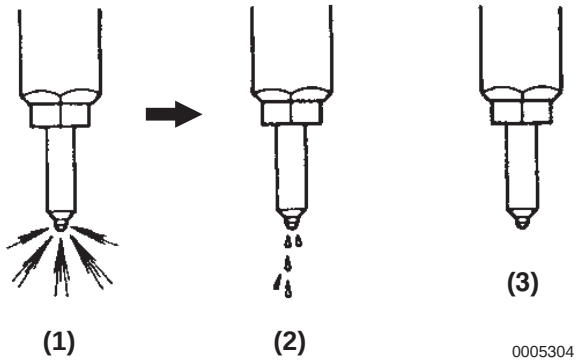


Figure 6-41

1 – Normal Spray During Operation
2 – Undesired - Leakage After Operation
3 – Normal - No leakage After Operation

8. Disassemble the nozzle after checking the No. 2 opening pressure.

Adjusting No. 1 Opening Pressure

1. Reassemble the fuel injection nozzle assembly to the operating condition as shown in **(Figure 6-17)**.
   - Align the holes of the nozzle holder body, tip packing and nozzle holder body.
   - If the adjusting shim thickness originally used is unknown, use a shim 1.5 mm (0.06 in.) thickness.
2. Install the assembly to the tester, pressurize and read the pressure gauge when the injection pressure begins to decrease. **CAUTION! *ALWAYS wear eye protection when servicing the engine.***
   - No. 1 opening pressure: 250 to 260 kgf/cm^2, 24.52 to 25.50 MPa (3556 to 3698 psi)
   - Determine if the nozzle operates normally or not by listening to the swishing sound. If the valve opening pressure is out of the specified range, disassemble the nozzle and select an appropriate adjusting shim to replace the shim at the upper portion of No. 1 pressure spring from the appropriate chart below.

Adjusting Shim Thickness

0.825 mm (0.032 in.)	0.900 mm (0.035 in.)	0.975 mm (0.038 in.)
1.050 mm (0.041 in.)	1.125 mm (0.044 in.)	1.200 mm (0.047 in.)
1.275 mm (0.050 in.)	1.350 mm (0.0531 in.)	1.425 mm (0.0561 in.)
1.500 mm (0.059 in.)	1.575 mm (0.062 in.)	1.650 mm (0.0649 in.)
1.725 mm (0.0679 in.)	1.800 mm (0.0708 in.)	1.875 mm (0.0738 in.)
1.950 mm (0.0767 in.)	2.000 mm (0.0787 in.)	2.100 mm (0.0826 in.)
2.175 mm (0.0856 in.)	-	-

Note: Changing the adjusting shim thickness by 0.025 mm changes the valve opening pressure by approximately 3.8 kgf/cm^2, 0.37 MPa (54 psi).

   - Change only one adjusting shim at the upper portion of No. 1 pressure spring.
3. After the injection test, check for leakage from from the injection hole. There should be no leakage.

Fuel Injection Nozzle Installation

1. Install a new O-ring onto the fuel injection nozzle.
2. Insert a new nozzle seat in the hole in the fuel injection nozzle of the cylinder head.
3. Install the fuel injection nozzle to the cylinder head, using the nozzle holder clamp, washer and bolt **(Figure 6-42)**. Torque to: 255 kgf·cm, 25.01 N·m (18.4 lb-ft)

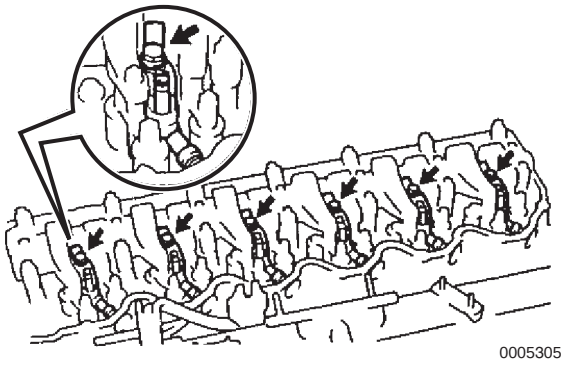


Figure 6-42

4. Install a new nozzle holder seal to the cylinder head **(Figure 6-43)**.

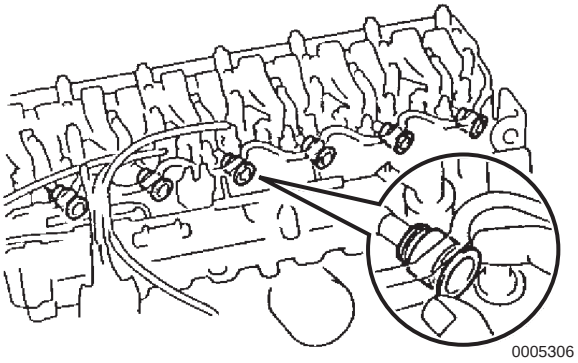


Figure 6-43

5. Install the fuel injection pipe to the fuel injection nozzle and fuel injection pump **(Figure 6-44)**.

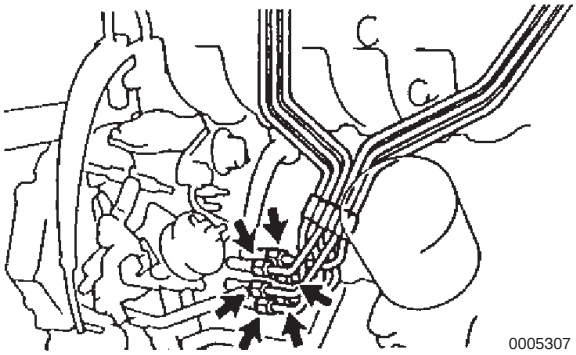


Figure 6-44

6. Tighten the union nut onto the fuel injection pump **(Figure 6-45)**. Torque to: 250 kgf·cm, 24.52 N·m (18 lb-ft).

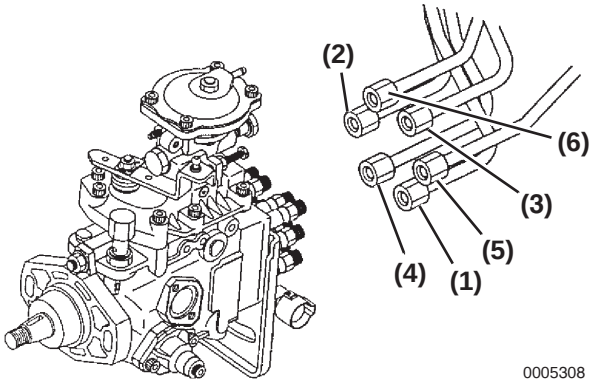


Figure 6-45

1 – No. 1
2 – No. 2
3 – No. 3
4 – No. 4
5 – No. 5
6 – No. 6

7. Tighten the union nut to the fuel injection nozzle and torque to: 250 kgf·cm, 24.52 N·m (18 lb-ft) **(Figure 6-46)**.

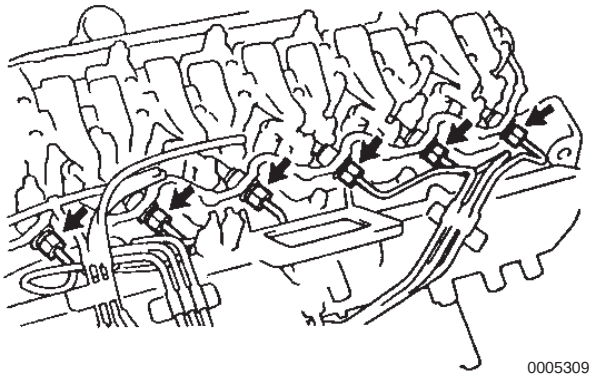


Figure 6-46

8. Install the 2 clamps with 2 nuts and torque to: 65 kgf·cm, 6.37 N·m (56 lb-in.).
9. Install 2 clamps with 4 nuts to the intake manifold **(Figure 6-47)**.

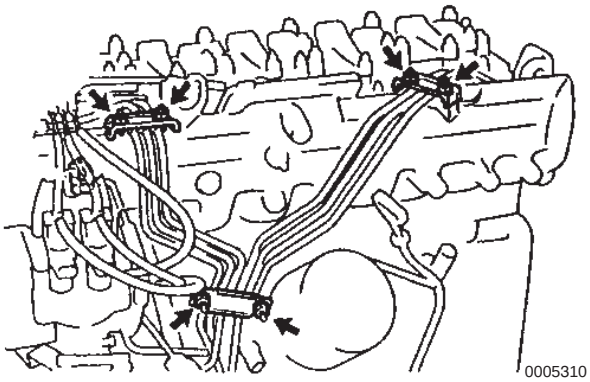


Figure 6-47

10. Install 7 new gaskets and No. 1 fuel return pipe to the cylinder head and fuel injection nozzle, using 6 joint bolts and nuts. Torque the joint bolt to: 176 kgf·cm, 17.26 N·m (12.7 lb-ft). Torque the nut to: 186 kgf·cm, 18.24 N·m (13.4 lb-ft).
    - Install gasket (A) so that its joint is located between pipes, as shown in **(Figure 6-48)**.

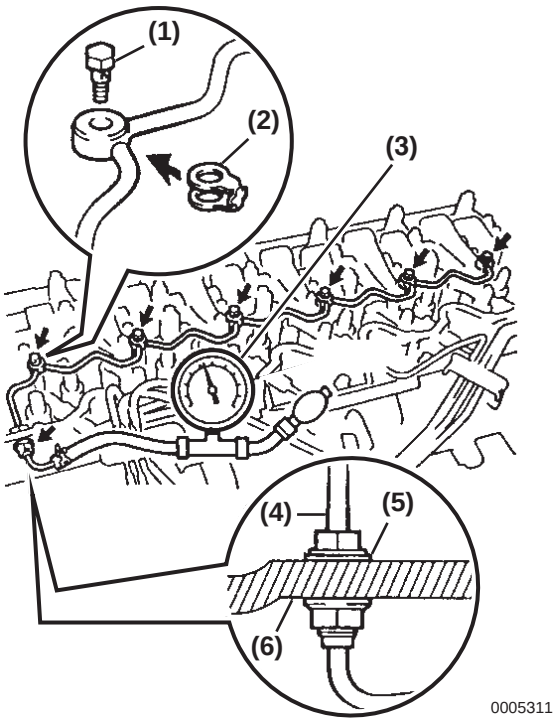


Figure 6-48

1 – Joint Bolt
2 – New Gasket (A)
3 – Turbocharger Pressure Gauge Tool
4 – No. 1 Nozzle Fuel Return Pipe
5 – New Gasket (B)
6 – Cylinder Head

11. Use the turbocharger pressure gauge as the tool. Connect the pressure gauge to the fuel return side of the No. 1 fuel return pipe, apply 0.5 kgf/cm^2, 0.05 MPa (7 psi) pressure continuously for 10 seconds and check for leakage.
12. Connect the fuel return hose to the No. 1 fuel return pipe.
13. Install the rocker cover. *See Install the Rocker Cover on page 5-39*.
14. Start the engine and check for fuel leakage. **WARNING! *NEVER check for a fuel leak with your hand.***

FUEL INJECTION PUMP

Components

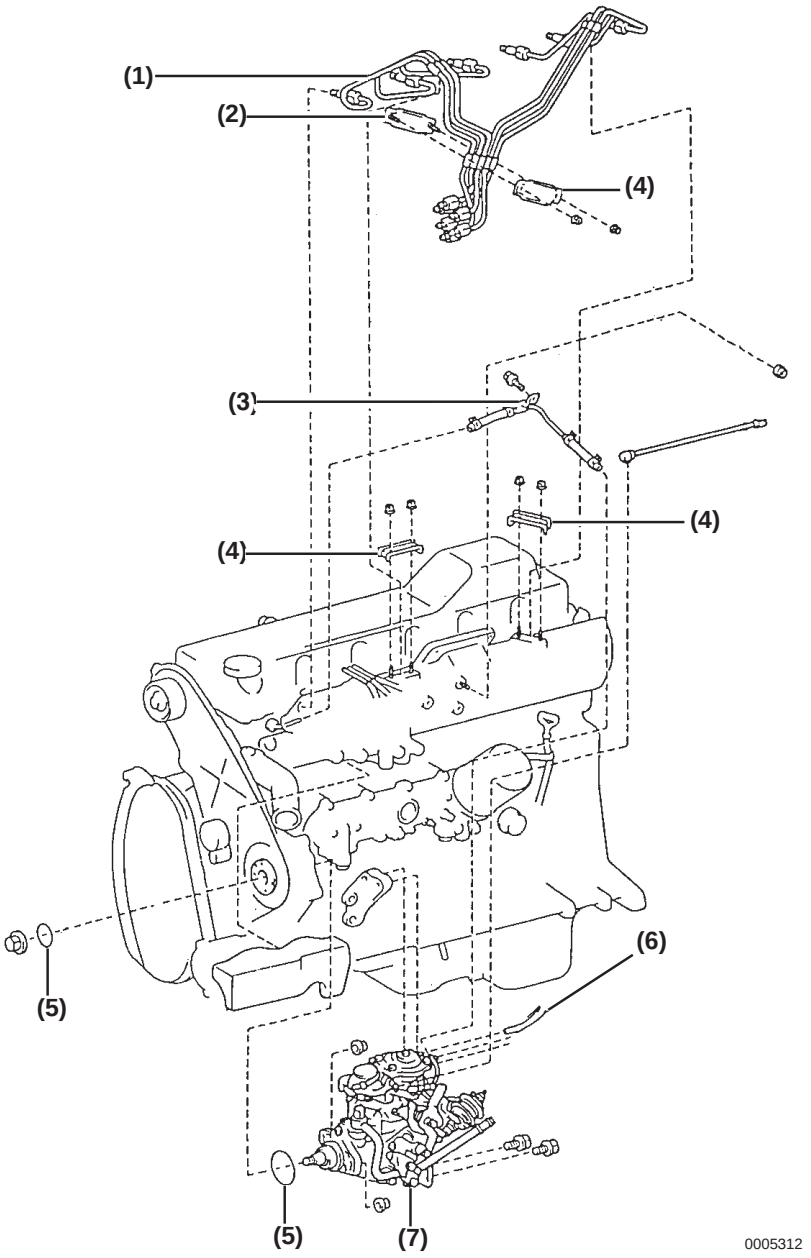


Figure 6-49

1 – Fuel Injection Pipe
2 – Clamp
3 – No. 3 Nozzle Return Pipe
4 – Clamp
5 – O-ring (Non-Reusable)
6 – Boost Compensator Hose
7 – Injection Pump

Fuel Injection Pump Removal

1. Drain the cooling water from the engine and disconnect the cooling pipe.
2. Remove the timing belt and No. 2 camshaft timing pulley. *See Timing Belt Removal on page 5-69*.
3. Remove the fuel injection pipe. *See Fuel Injection Nozzle Removal on page 6-14*.
4. Disconnect the boost compensator hose.
5. Remove the fuel injection pump drive gear set nut while securing the crankshaft pulley **(Figure 6-50, (1))**. *NOTICE: NEVER turn the crankshaft pulley. The valve heads and piston tops may be damaged by interference with each other.*

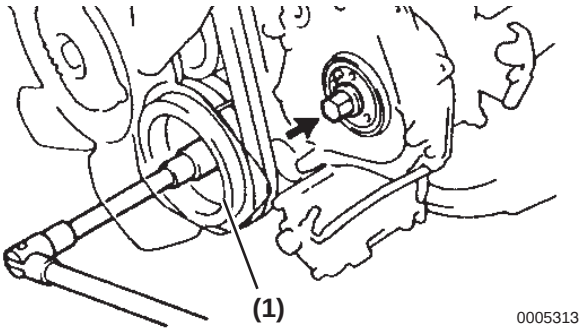


Figure 6-50

6. Remove the O-ring from the fuel injection pump drive gear.
7. Remove two fuel injection pump stay set bolts **(Figure 6-51, (1))**.

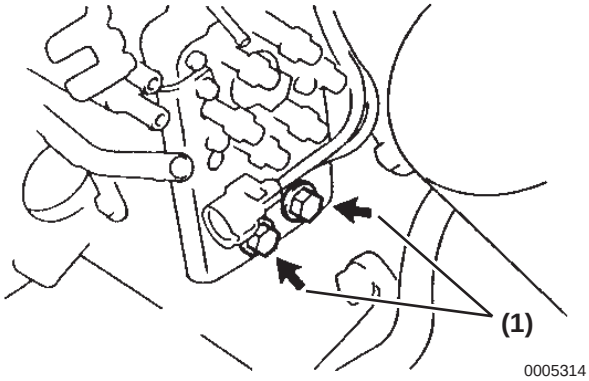


Figure 6-51

8. Check that match marks **(Figure 6-52, (1))** align before removing the fuel injection pump; if they do not have match marks, draw new match marks for reassembly.
9. Remove the two nuts securing the fuel injection pump to the timing gear case.

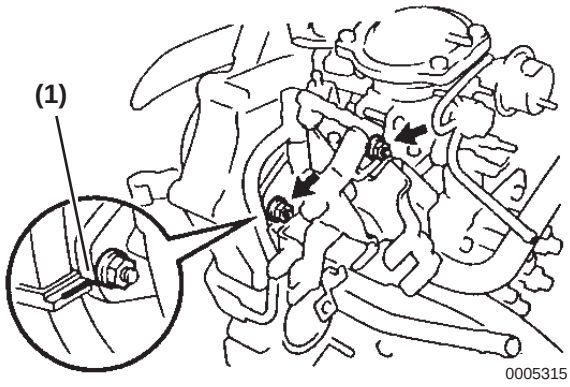


Figure 6-52

10. Remove the fuel injection pump using the special tool **(Figure 6-53)**. Tighten the two 8 mm puller bolts evenly. *NOTICE: NEVER grasp the adjustment lever for moving the fuel injection pump as the adjustment lever may be damaged. Never place the fuel injection pump at more than 45° from level.*

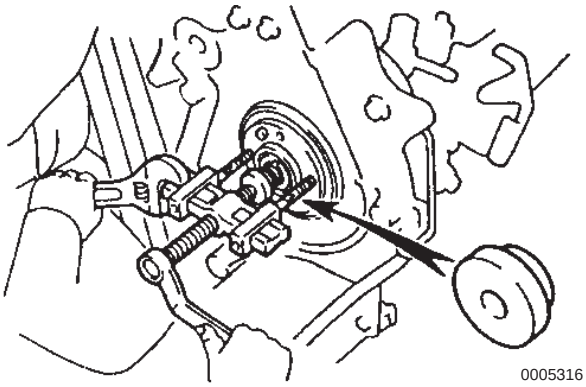


Figure 6-53

11. Remove the O-ring from the fuel injection pump.

Components

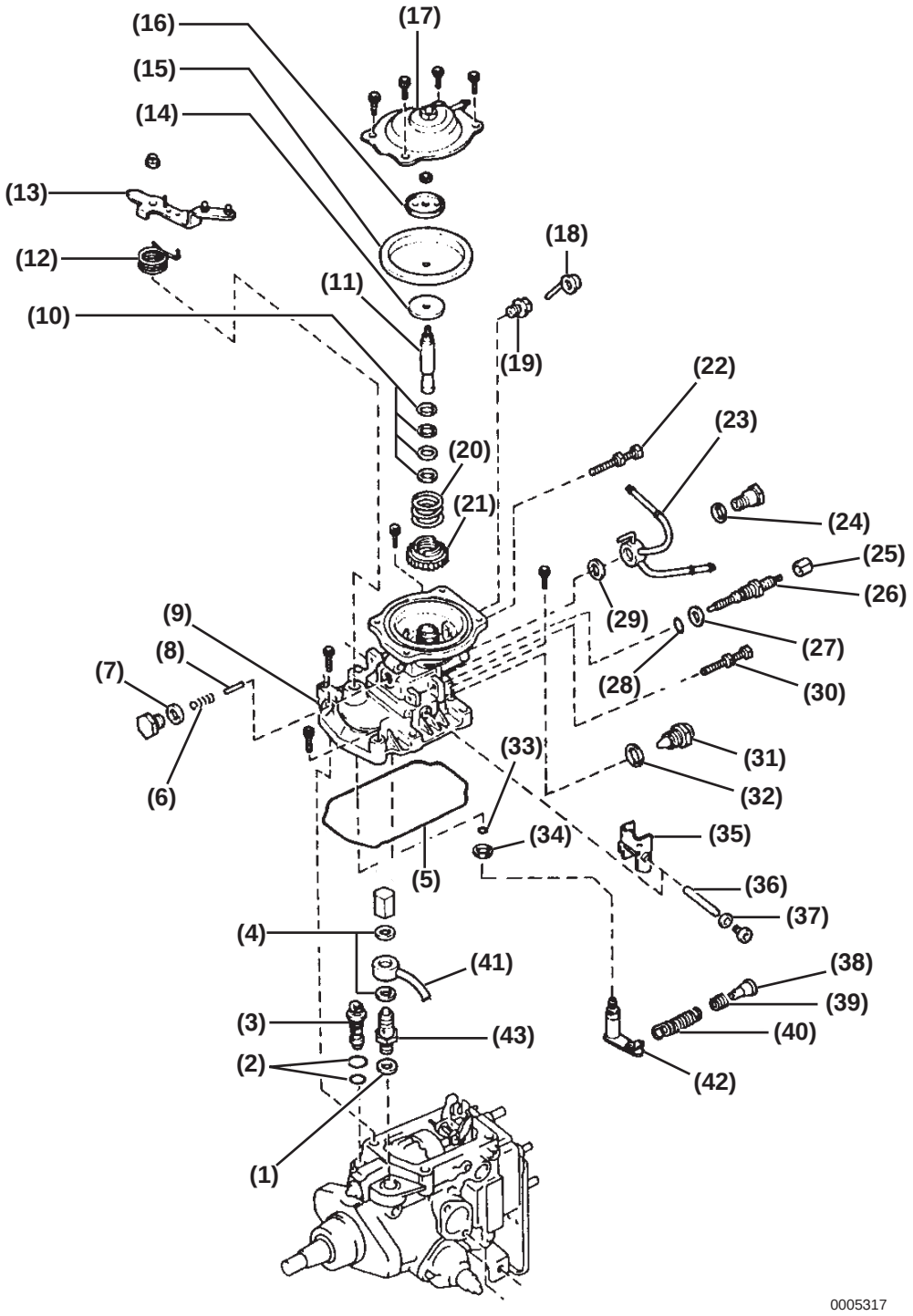


Figure 6-54

1 – Gasket (Non-Reusable)
2 – O-ring (Non-Reusable)
3 – Regulator Valve
4 – Gasket (Non-Reusable)
5 – Gasket (Non-Reusable)
6 – Lever Control Spring
7 – Gasket (Non-Reusable)
8 – Connecting Pin
9 – Governor Cover
10 – Shim
11 – Push Rod
12 – Lever Return Spring
13 – Governor Lever
14 – Spring Seat
15 – Diaphragm
16 – Spring Seat
17 – Diaphragm Cover
18 – Rubber Cap
19 – Overflow Screw
20 – Spring
21 – Guide Bushing
22 – Maximum Speed adjustment Screw
23 – No. 2 Fuel Return Pipe
24 – Gasket (Non-Reusable)
25 – Collar (Non-Reusable)
26 – Full Load Set Screw
27 – Gasket (Non-Reusable)
28 – O-ring
29 – Gasket (Non-Reusable)
30 – Idle Speed Adjustment Screw
31 – Cap
32 – Gasket (Non-Reusable)
33 – O-ring (Non-Reusable)
34 – Washer
35 – Control Lever
36 – Support Pin
37 – Gasket (Non-Reusable)
38 – Spring Seat
39 – Damper Spring
40 – Speed Control Spring
41 – Fuel Inlet Pipe
42 – Governor Lever Shaft
43 – Fuel Inlet Joint Bolt

Note: Since professional knowledge and special equipment are required for disassembly and adjustment of the fuel injection pump, consult DENSO.

COMPONENTS - Continued

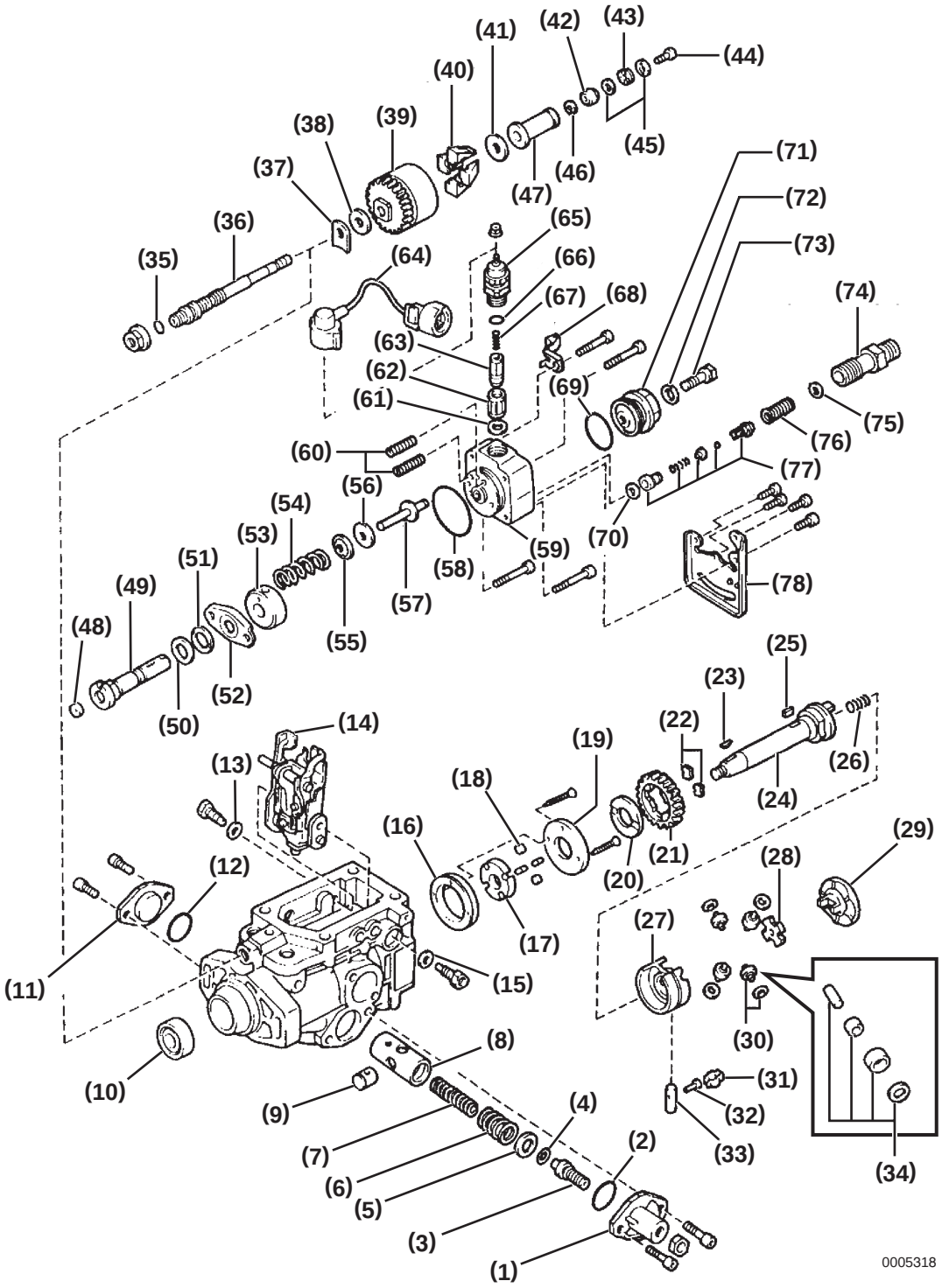


Figure 6-55

1 – LH Timer Cover
2 – O-ring (Non-Reusable)
3 – Timer Adjusting Screw
4 – O-ring (Non-Reusable)
5 – Timer Shim
6 – Timer Outer Spring
7 – Timer Inner Spring
8 – Timer Piston
9 – Timer sub-piston
10 – Oil Seal
11 – RH Timer Cover
12 – O-ring (Non-Reusable)
13 – Gasket (Non-Reusable)
14 – Governor Link
15 – Gasket (Non-Reusable)
16 – Fuel Pump Liner
17 – Fuel Pump Rotor
18 – Blade
19 – Feed Pump Cover
20 – Drive Shaft Washer
21 – Drive Gear
22 – Joint Rubber (Non-Reusable)
23 – Drive Pulley Set Key
24 – Drive Shaft
25 – Drive Shaft Set Key
26 – Coupling Spring
27 – Roller Ring
28 – Coupling
29 – Face Camplate
30 – Roller and Washer
31 – Clip
32 – Stopper Pin
33 – Slide Pin
34 – Roller and Washer
35 – O-ring (Non-Reusable)
36 – Governor Shaft
37 – Governor Gear Adjusting Washer
38 – No. 1 Flyweight Washer
39 – Flyweight Holder
40 – Flyweight
41 – No. 2 Flyweight Washer
42 – Stop Ring
43 – Bearing
44 – Sleeve Plug
45 – Bearing Retainer
46 – E-ring
47 – Governor SLeeve
48 – Plunger Adjusting shim
49 – Pump Plunger
50 – Lower Plunger Plate
51 – Upper Plunger Plate
52 – Lower Spring Seat
53 – Spill Ring
54 – Plunger Spring
55 – Upper Spring Seat
56 – Plunger Spring shim
57 – Plunger Spring guide
58 – O-ring (Non-Reusable)
59 – Distributive Head
60 – Lever Support Spring
61 – Wave Washer
62 – Strainer
63 – Valve
64 – Lead Wire
65 – Fuel Cut solenoid
66 – O-ring (Non-Reusable)
67 – Spring
68 – Wire Clamp
69 – O-ring (Non-Reusable)
70 – Gasket (Non-Reusable)
71 – Distributive Head Plug
72 – Gasket (Non-Reusable)
73 – Distributive Head Plug Bolt
74 – Delivery Valve Holder
75 – Spring Seat
76 – Spring
77 – Delivery Valve
78 – Fuel Injection Pump Stay

Fuel Injection Pump Installation

1. Install a new O-ring to the pump. *NOTICE: NEVER place the fuel injection pump at more than 45° from level.*
2. Lightly apply engine oil to the O-ring.
3. Align the set key on the drive shaft with the groove in the fuel injection pump drive gear **(Figure 6-56)**.

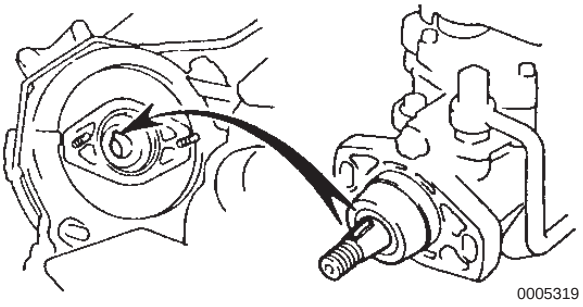


Figure 6-56

4. Align the match marks **(Figure 6-57, (1))** of the fuel injection pump and timing gear case.
5. Install the two nut securing the fuel injection pump to the timing gear case and torque to 185 kgf·cm, 18.14 N·m (13.4 lb-ft).

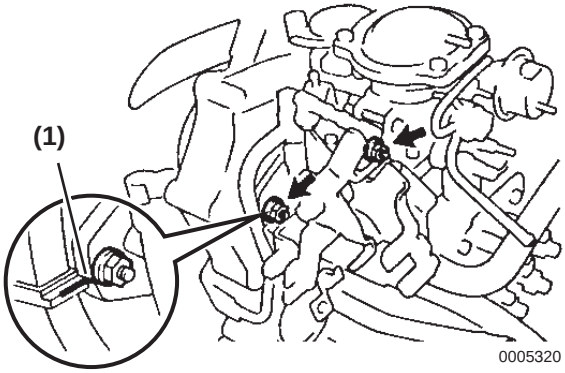


Figure 6-57

6. Install the fuel injection pump stay using two bolts **(Figure 6-58, (1))** and torque to 700 kgf·cm, 68.65 N·m (50.6 lb-ft). *NOTICE: Check that the pump stay is lifted to contact with the fuel injection pump before tightening to the specified torque. If there is a gap, loosen the bolt securing the pump stay to the cylinder block and lift the pump stay until it comes into contact with the fuel injection pump.*

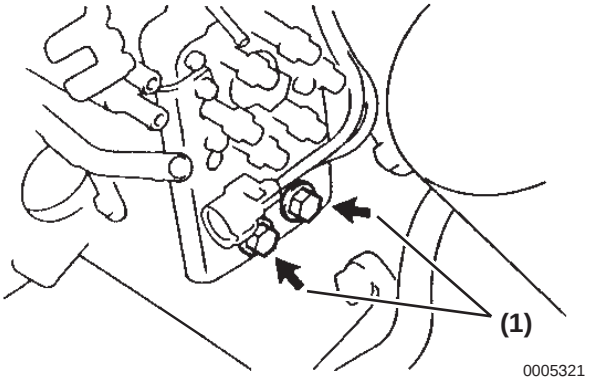


Figure 6-58

7. Install a new O-ring to the fuel injection pump drive gear.
8. Install the drive gear set nut of the fuel injection pump.
9. Tighten the set nut **(Figure 6-59, (1))** while securing the crankshaft pulley and torque to 1050 kgf·cm, 102.97 N·m (76 lb-ft). *NOTICE: NEVER turn the crankshaft pulley as damage will occur if the valve heads and piston tops contact.*

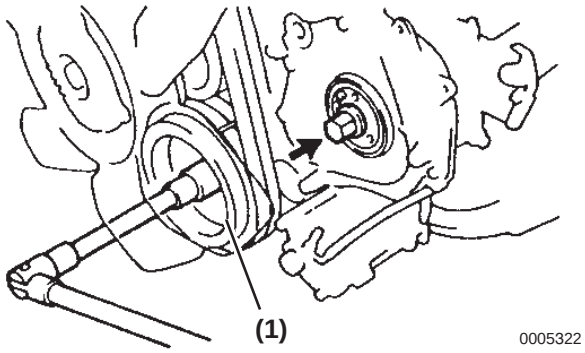


Figure 6-59

10. Check the thrust clearance of the fuel injection pump drive shaft.
11. Connect the boost compensator hose **(Figure 6-60, (1))** to the fuel injection pump.

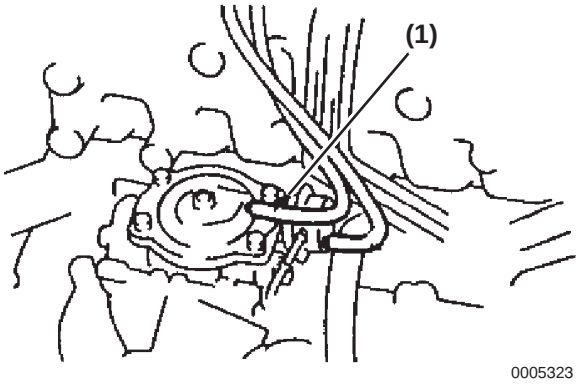


Figure 6-60

12. Install No. 2 camshaft timing pulley and the timing belt. *See Timing Belt Installation on page 5-73*.
13. Check the injection timing. *See Injection Timing Inspection and Adjustment on page 5-93*.
14. Fill the engine fresh water line with engine coolant.
15. Start the engine and check for fuel leakage. **WARNING! *NEVER check for a fuel leak with your hand.***

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Section 7

COOLING SYSTEM

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SAFETY PRECAUTIONS

Before you service the cooling system, read the following safety information and review the *Safety Section on page 2-1*.

⚠ CAUTION

The safety message that follows has CAUTION level hazards. The safety message describes a hazardous situation which, if not avoided, *could* result in minor or moderate injury.

Coolant Hazard

Wear eye protection and rubber gloves when you handle Long Life engine coolant. If contact with the eyes or skin should occur, flush eyes and wash immediately with clean water.

INTRODUCTION

This section of the *Service Manual* describes the procedures necessary to service the 6LPA-STP2/STZP2 marine engine cooling systems.

COOLING SYSTEM

Freshwater Pump Related Components

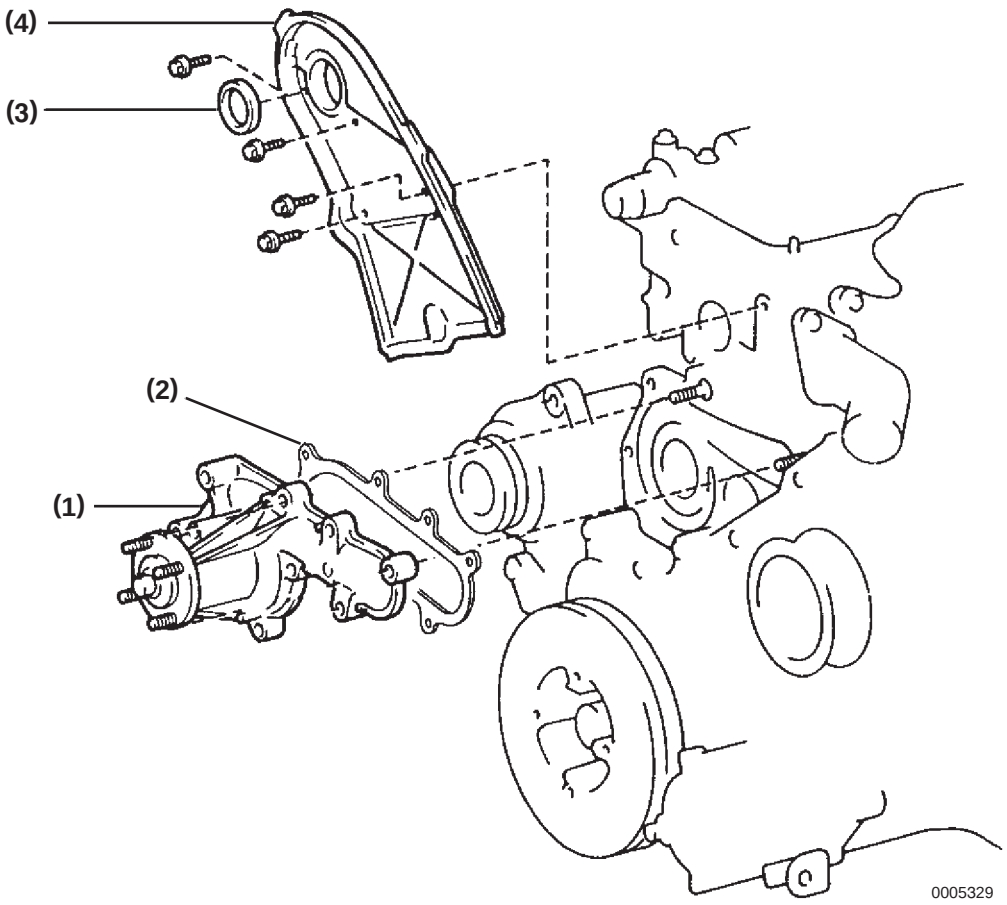

Figure 7-1

1 – Freshwater Pump
2 – Gasket (Non-Reusable Part)
3 – Camshaft Oil Seal (Non-Reusable Part)
4 – Camshaft Oil Seal Retainer

Freshwater Pump Removal

1. Drain the engine cooling water.
2. Loosen the six bolts for viscous damper and the four freshwater pump pulley nuts **(Figure 7-2)**.
3. Loosen the alternator pivot bolt and adjustment lock bolts and remove the two drive belts.

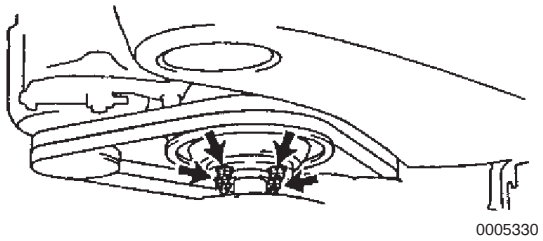

Figure 7-2

4. Remove the timing belt and idler pulley and No. 1 camshaft timing pulley. *See Timing Belt Removal on page 5-69*.
5. Remove the camshaft oil seal retainer. See step 11 starting in *Cylinder Head Removal on page 5-16*.
6. Remove the three bolts and alternator adjusting bar **(Figure 7-3, (1))**.
7. Remove the six bolts, two nuts, freshwater pump and gasket **(Figure 7-3)**.

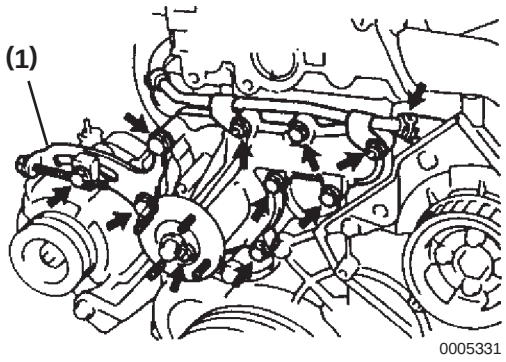

Figure 7-3

8. Inspect the freshwater pump by turning the pulley and checking that the freshwater pump rotates smoothly and the bearing has no play **(Figure 7-4)**. Replace the freshwater pump as needed.

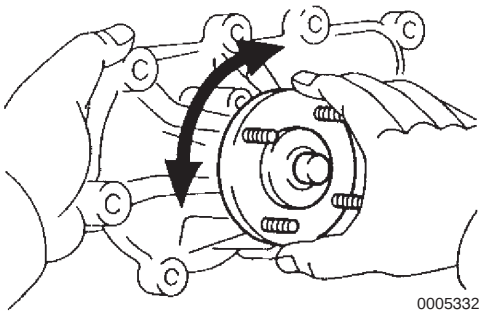

Figure 7-4

Freshwater Pump Installation

1. Temporarily secure a new gasket and pump using 6 bolts and 2 nuts.
2. Temporarily tighten the 3 bolts securing the alternator and adjusting bar **(Figure 7-5, (1))** then uniformly tighten the 7 bolts and 2 nuts securing the freshwater pump to the cylinder block **(Figure 7-5)**.

   Torque to: 12mm bolt head: 200 kgf·cm, 19.61 N·m (173.5 lb-in.)

   14mm bolt head: 400 kgf·cm, 39.23 N·m (347.2 lb-in.)

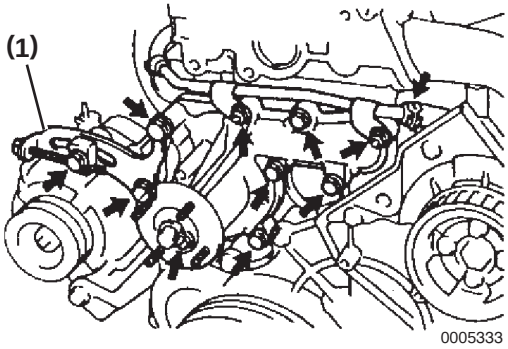

Figure 7-5

3. Install the camshaft oil seal retainer. *Camshaft Oil Seal Retainer Installation*.
4. Install No. 1 camshaft timing pulley, idler pulley and timing belt. *See Timing Belt Installation on page 5-73*.
5. Install the freshwater pump pulley, drive belt and viscous damper and torque to 65 kgf·cm, 6.37 N·m (56.3 lb-in.).
6. Install and adjust the drive belt. Tighten four freshwater pump pulley nuts **(Figure 7-6)**.
   Torque: 200 kgf·cm, 19.61 N·m (173.5 lb-in.)
   Torque: 380 kgf·cm, 37.27 N·m (329.8 lb-in.) for viscous damper.

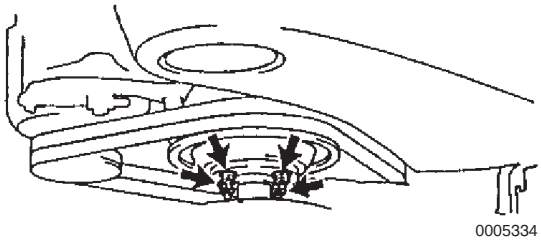

Figure 7-6

7. Fill with engine coolant (fresh water).
8. Start the engine and check for leakage.

SEAWATER PUMP COMPONENTS

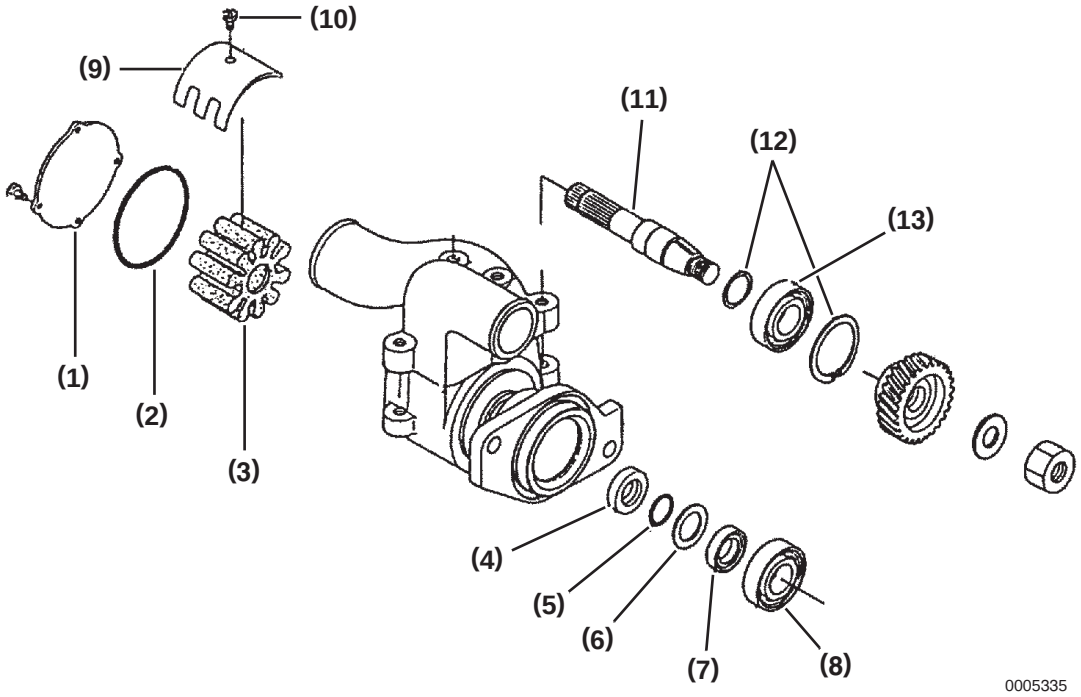

Figure 7-7

1 – End Plate
2 – O-ring
3 – Impeller
4 – Oil Seal
5 – O-ring
6 – Spacer
7 – Oil Seal
8 – Bearing
9 – Cam
10 – Set Screw
11 – Shaft
12 – Retaining Ring
13 – Bearing

Seawater Pump Disassembly

1. Disconnect the hose joint and remove the seawater pump.
2. Remove the end plate and pull out the impeller. The cam can be removed after removing the set screw.
3. Loosen the M16 nut on the drive side and pull out the gear the remove the retaining ring and pull out the shaft.
4. Check the impeller, inner sliding surface of the pump housing and the cam for excessive wear and damage. Replace as necessary.
5. Turn the shaft to check that it turns smoothly. Check the bearing for play. Replace as necessary.
6. If oil or water leakage is discovered at the hole of the pump bottom, replace the oil seal.

Seawater Pump Reassembly

1. Apply grease to the oil seal and bearing.
2. Insert the impeller while turning it in the operating direction (clockwise).

THERMOSTAT COMPONENTS

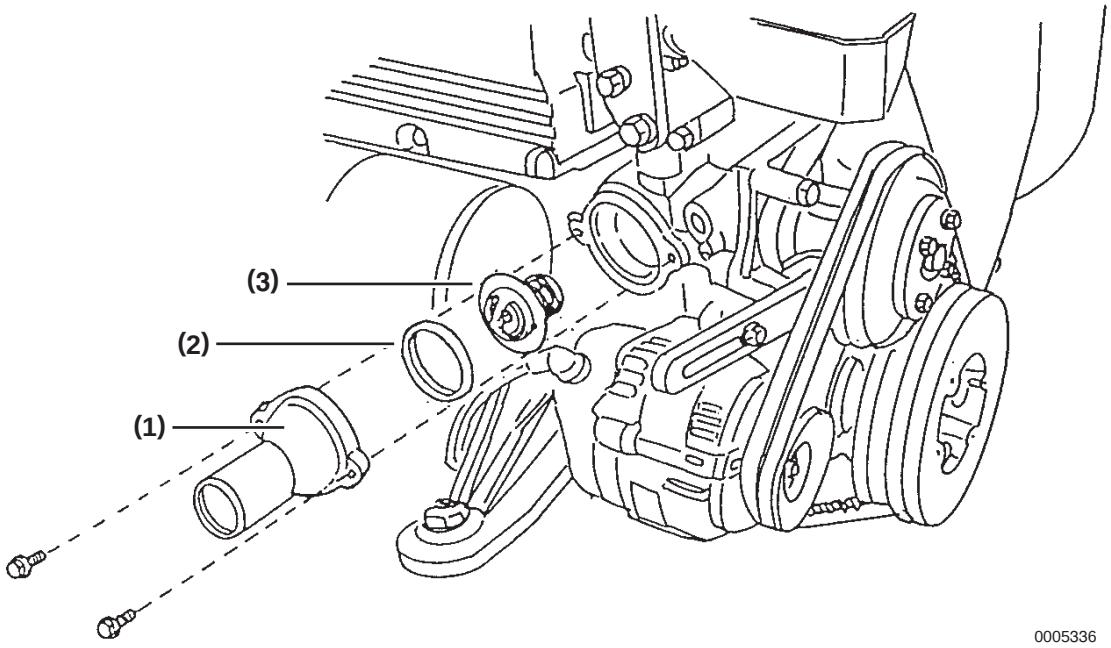

Figure 7-8

1 – Thermostat Cover
2 – Gasket
3 – Thermostat

Thermostat Removal

NOTICE: NEVER remove the thermostat. If the engine is operated with the thermostat removed, the engine will overheat and could be damaged.

1. Drain the freshwater from the freshwater cooler.
2. Remove the thermostat cover and thermostat.
3. Remove the rubber hose and hose band.
4. Remove the thermostat and the gasket from the thermostat **(Figure 7-9)**.

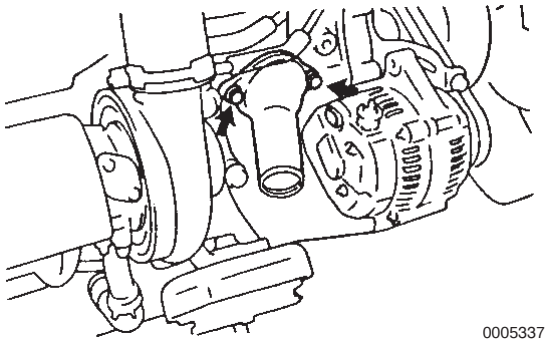

Figure 7-9

5. Inspect the thermostat for damage. Inspect the jiggle valve **(Figure 7-10, (1))** for damage. Replace as necessary.

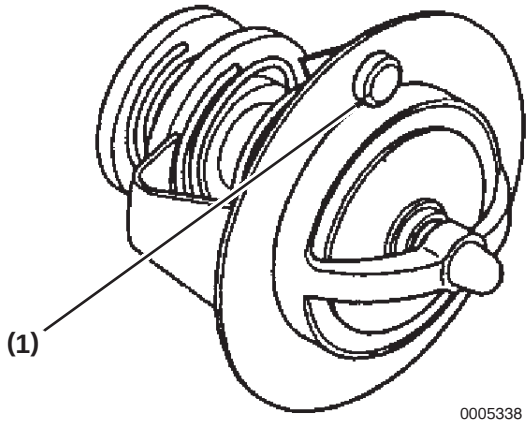

Figure 7-10

6. Immerse the thermostat in water and slowly heat it **(Figure 7-11)**. The valve opening temperature is indicated on the thermostat.
7. Check the valve opening temperature. The valve opening temperature range is 68 to 72°C (154 to 162°F). If the valve opening temperature does not satisfy the specification, replace the thermostat.

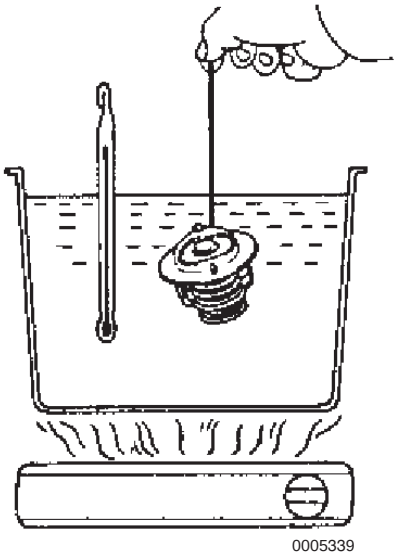

Figure 7-11

8. Check the valve lift **(Figure 7-12, (2))**. The valve lift must measure 10 mm (0.393 in.) or more at 90°C (194°F). If the valve lift does not satisfy the specification, replace the thermostat.

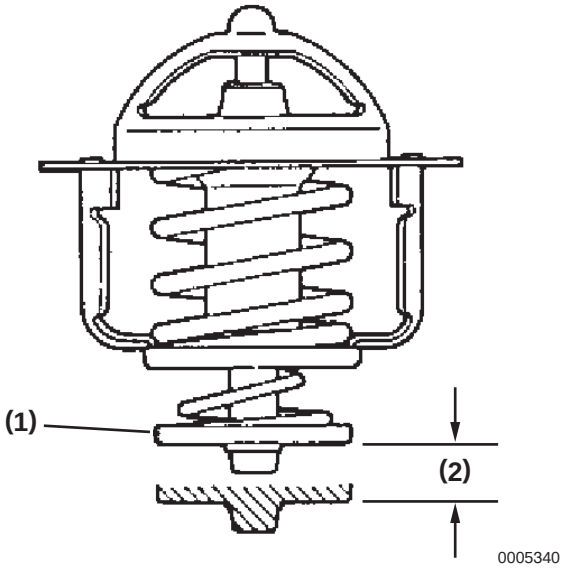

Figure 7-12

9. Check that the valve spring strongly presses the against the seat **(Figure 7-12, (1))** when the thermostat is closed completely. If not, replace the thermostat.

Thermostat Installation

1. Install the thermostat on the cylinder block.
2. Install a new gasket to the thermostat (P/N 119773-49570), ensure the jiggle valve **(Figure 7-13, (1))** faces upwards.

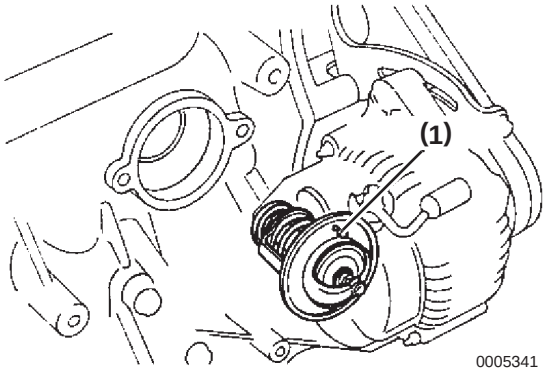

Figure 7-13

3. Install the thermostat cover **(Figure 7-14)**.

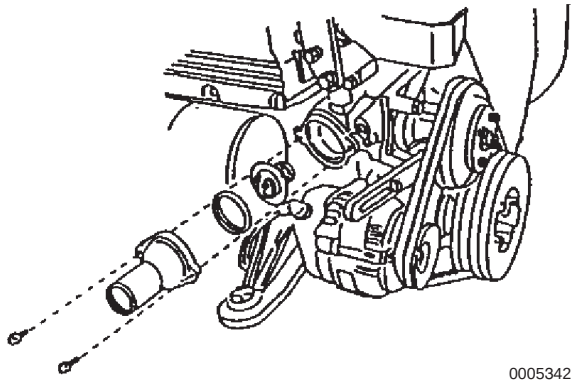

Figure 7-14

4. Secure the rubber hose with the hose band.
5. Fill with engine coolant (fresh water).
6. Start the engine and check for leakage.

COMPONENTS RELATED TO COOLING SYSTEM

Freshwater Tank

NOTICE: Prevent dirt and debris from contaminating the engine coolant. Carefully clean the pressure cap and the surrounding area before you remove the cap.

1. Remove the pressure cap **(Figure 7-15)**. **WARNING! *NEVER remove the pressure cap if the engine is hot. Steam and hot engine coolant will spray out and seriously burn you. Allow the engine to cool down before you attempt to remove the pressure cap.***

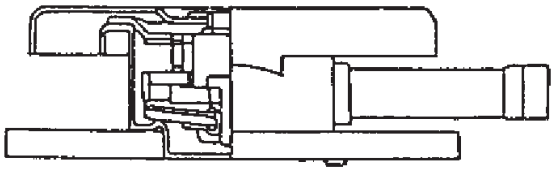

Figure 7-15

2. Check the pressure cap. *NOTICE: If the pressure cap **(Figure 7-16, (1))** is contaminated by foreign matter, wash with water. Measure the valve opening pressure by applying pressure to the tester, using the pressure cap tester **(Figure 7-16, (2))**.*
   - Standard valve opening pressure: 0.75 to 1.05 kgf/cm^2, 0.07 to 0.10 MPa (10.6 to 14.9 psi)
   - Minimum valve opening pressure: 0.6 kgf/cm^2, 0.06 MPa (8.5 psi)

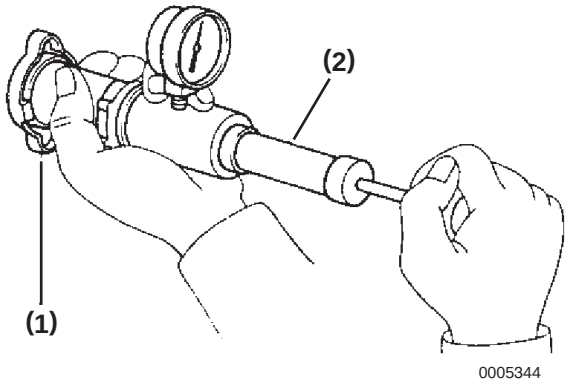

Figure 7-16

3. Use the maximum reading of the tester as the valve opening pressure. If the measured value is less than the specified minimum valve opening pressure, replace the pressure cap.
4. Check for the fresh water leakage. Fill the freshwater tank **(Figure 7-17, (1))** and engine with fresh water and bleed air from the freshwater path.

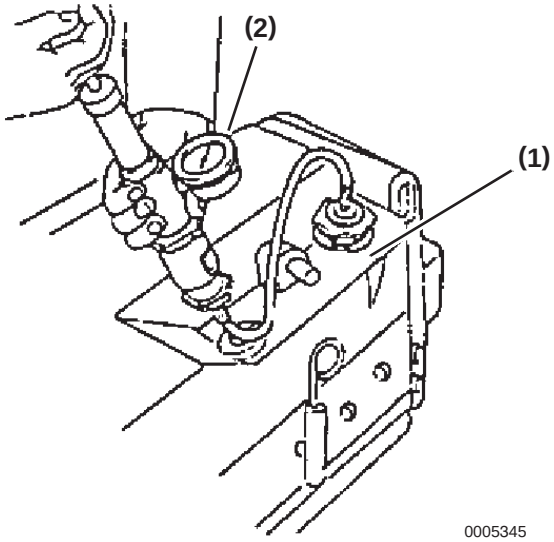

Figure 7-17

5. Attach the cap tester **(Figure 7-17, (2))** to the water filler. Increase the pressure to 1.2 kgf/cm^2 (17 psi) by the pressure cap tester and check that the pressure does not drop. If it does, check the hose, freshwater tank, cooler and freshwater pump for leakage. If no leakage is discovered from the outside, check the cylinder block and cylinder head.
6. Reinstall the pressure cap.

Freshwater Cooler

The freshwater cooler is the multi-pipe core type. The seawater flows inside the core while the fresh water flows outside the core to be cooled by the seawater.

1. Disconnect the rubber hose connected to the freshwater cooler **(Figure 7-18, (1))**.
2. Remove the freshwater cooler carefully, avoid hitting or damaging during removal.

   Check the rubber seat **(Figure 7-18, (2))** holding the freshwater cooler for collapse and cracks. Replace it before failures occur. Check the hose band **(Figure 7-18, (3))** for damage to the screw, nut and the plate. Replace as needed.

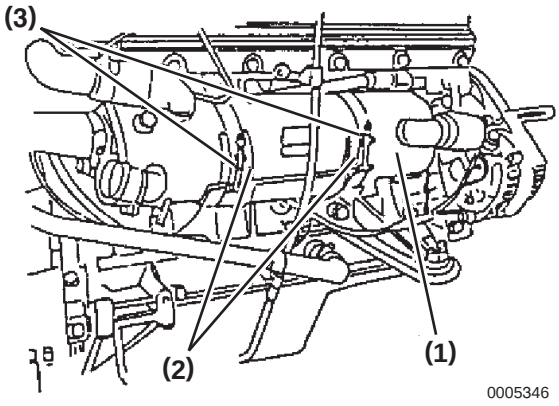

Figure 7-18

3. Remove the side cover from the freshwater cooler. Check the core for contamination by dust and foreign matter. If needed clean the core **(Figure 7-19, (1))** using a soft brush **(Figure 7-19, (2))** available locally.

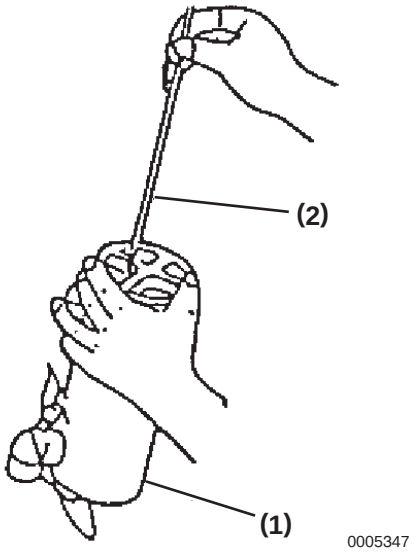

Figure 7-19

Coolant Recovery Tank

When the engine is operated, the fresh water temperature increases and fresh water expands to increase the freshwater tank pressure. When the pressure in the freshwater tank exceeds 0.9 kgf/cm^2, 0.09 MPa (12.8 psi), the pressure cap valve opens to release steam. If this steam is discharged to the atmosphere, the fresh water is consumed. In order to prevent the fresh water consumption, steam is discharged into the coolant recovery tank. Steam discharged into the coolant recovery tank condenses in the water, thus preventing discharge of fresh water to the atmosphere.

When the engine stops, the fresh water temperature decreases to drop the pressure in the freshwater tank. When the pressure in the freshwater tank drops, the negative pressure valve of the pressure cap activates to return the water from the coolant recovery tank to the freshwater tank. The water level in the coolant recovery tank rises during the operation (hot state) or lowers during stopping (cold state) **(Figure 7-20)**.

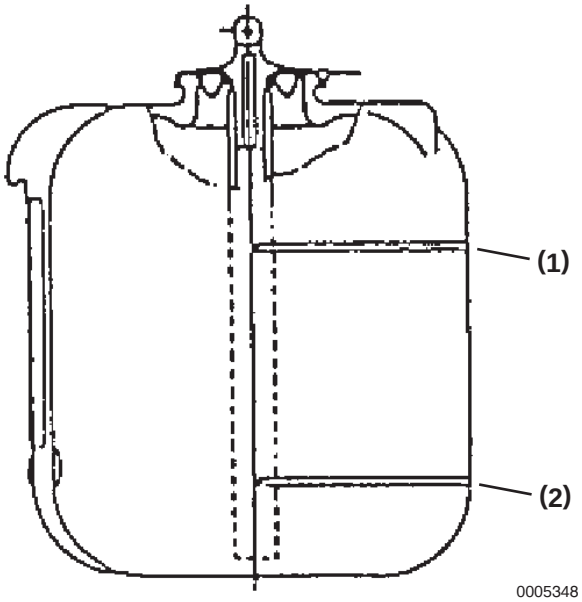

Figure 7-20

1 – Full Mark
2 – Low Mark

Coolant Recovery Tank Installation

1. Check the fresh water level on the coolant recovery tank **(Figure 7-21, (1))** daily. It is not required to remove the pressure cap.
2. Install the overflow pipe **(Figure 7-21, (2))** with a maximum length of 1000 mm (39.3 in.). Avoid bending the pipe.

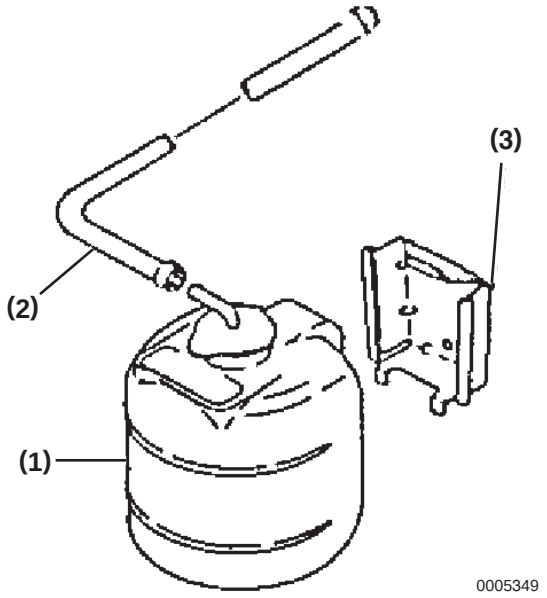

Figure 7-21

3. Check the fresh water level in the coolant recovery tank after the engine is cooled down. Replenish fresh water as needed to maintain the fresh water level between the LOW and FULL marks.
4. Periodically check the overflow pipe and mounting plate **(Figure 7-21, (3))** for cracks and replace as needed. Check the pipe for obstructions and clean as needed. Also, check for disconnected or loose pipe joints. If the coolant recovery tank leaks air the coolant recovery tank will not function correctly.

Seacock (Optional)

1. The seacock located on the bottom of the hull allows engine cooling seawater to be pumped from the sea to the engine. The seacock has a scoop strainer that prevents debris and foreign matter from being pulled into the cooling system.

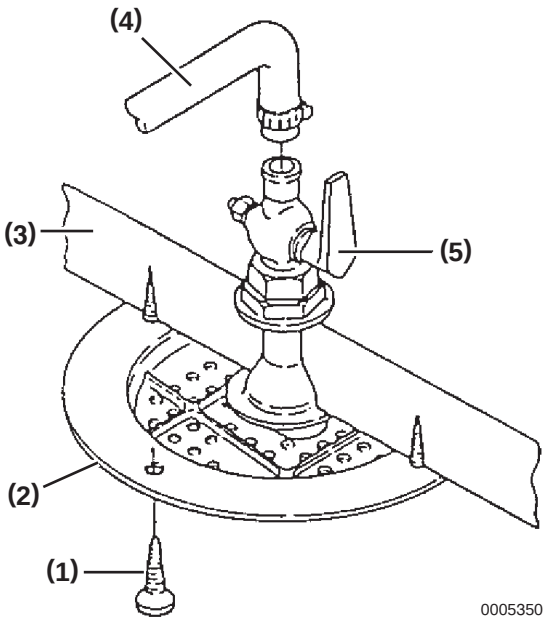

Figure 7-22

1 – Screw
2 – Seacock strainer
3 – Vessel Body
4 – Air Intake Pipe
5 – Seacock

NOTICE: The seacock should be closed after daily operation and opened before operation. If the seacock is open when the boat is not operating and a leak occurs in the seawater system, water will leak into the boat. If the boat is operated with the seacock closed, no seawater is fed to the engine and pump and will cause engine overheating or failure.

2. Inspect seawater delivery periodically. If the delivery level has dropped, check the seawater pump. If it is normal, lift the boat above the seawater and check the seacock for clogging. If seawater is leaking from the seacock, remove the seacock and check for wear. If so, repair or replace the seacock.

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Section 8

LUBRICATION

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SAFETY PRECAUTIONS

Before you service the 6LPA-STP2/STZP2 marine engine lubrication system, read the following safety information and review the *Safety Section on page 2-1*.

NOTICE

Only use 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.

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.

INTRODUCTION

This section of the *Service Manual* describes the procedures necessary to service the 6LPA-STP2/STZP2 marine engine lubrication systems.

SPECIFICATIONS

Note: All pressure specifications are with engine at normal operating temperature.

Test and Adjustment Specifications

Inspection Item		Specification
Oil Pressure		0.3 kgf/cm^2, 0.03 MPa (4.26 psi) or more at 800 rpm
		4.5 kgf/cm^2, 0.44 MPa (64 psi) at 3800 rpm
Oil Pump Rotor Tooth Tip Clearance	Standard	0.80 to 160 mm (0.031 to 6.29 in.)
	Maximum	0.21 mm (0.008 in.)
Oil Pump Body Clearance (Standard)	Standard	0.100 to 0.170 mm (0.003 to 0.006 in.)
	Maximum	0.20 mm (0.007 in.)
Oil Pump Side Clearance (Standard)	Standard	0.030 to 0.090 mm (0.011 to 0.035 in.)
	Maximum	0.15 mm (0.005 in.)

Special Torque Chart

Component	Specification
Drain Plug x Oil Pan	350 kgf·m, 34.32 N·m (303.7 lb-in.)
Relief Valve x Timing Gear Case	425 kgf·m, 41.68 N·m (368.8 lb-in.)
Oil Filter x Main Bearing Cap	90 kgf·m, 8.83 N·m (78.1 lb-in.)
Timing Gear Case x Cylinder Block and Main Bearing Cap	200 kgf·m, 19.61 N·m (173.5 lb-in.)
Injection Pump x Timing Gear Case	185 kgf·m, 18.14 N·m (160.5 lb-in.)
Oil Pan x Main Bearing Cap, Timing Gear Case and Rear Oil Seal Retainer	100 kgf·m, 9.81 N·m (86.8 lb-in.)
Oil Cooler Cover x Oil Cooler	160 kgf·m, 16.28 N·m (144.0 lb-in.)
Oil Cooler Cover and Oil Dipstick Guide x Cylinder Block	200 kgf·m, 19.26 N·m (170.4 lb-in.)
Relief Valve x Oil Cooler Cover	400 kgf·m, 39.23 N·m (347.2 lb-in.)
Check Valve x Oil Cooler Cover	275 kgf·m, 26.97 N·m (238.7 lb-in.)
Oil Nozzle x Cylinder Block	275 kgf·m, 26.97 N·m (238.7 lb-in.)

TESTING OIL PRESSURE

Visually check the oil for deterioration, mixture of water, discoloration or poor quality. If needed, replace the oil.

- Oil grade: Grade CD of API classification
- SAE viscosity: 10W30 or 15W40

1. Check the engine oil level. The oil level must be between the lower and upper limits of the oil dipstick. If it is lower than the lower limit, check for oil leaks and then add oil to the upper limit. *NOTICE: NEVER add oil exceeding the FULL mark and ALWAYS measure oil level when the engine is positioned horizontally.*
2. Remove the oil pressure sender unit and attach an oil pressure gauge **(Figure 8-1, (1))**.

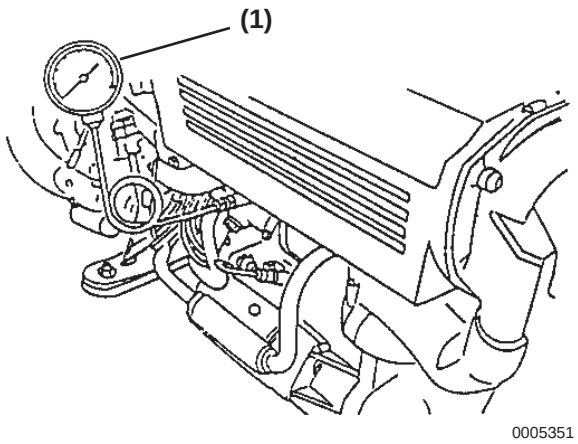


Figure 8-1

3. Start the engine and allow it to warm to normal operating temperature and read the pressure gauge:

Inspection Item	Test RPM	Specification
Oil Pressure	800	0.3 kgf/cm^2, 0.03 MPa or more (4.26 psi)
	3800	4.5 kgf/cm^2, 0.44 MPa (64 psi)

4. Remove the oil pressure gauge.
5. Apply THREE BOND 1344, LOCTITE 242 or equivalent **(Figure 8-2, (1))** to the threaded portion (2 to 3 threads) of the hydraulic sender unit **(Figure 8-2, (2))** and install the oil pressure sender unit.

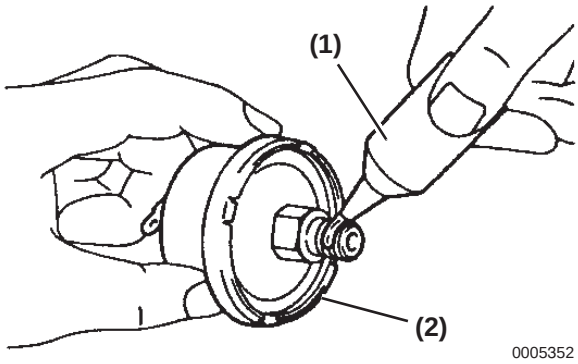


Figure 8-2

6. Start the engine and allow it to warm to normal operating temperature and check for oil leakage.

OIL PUMP

Components

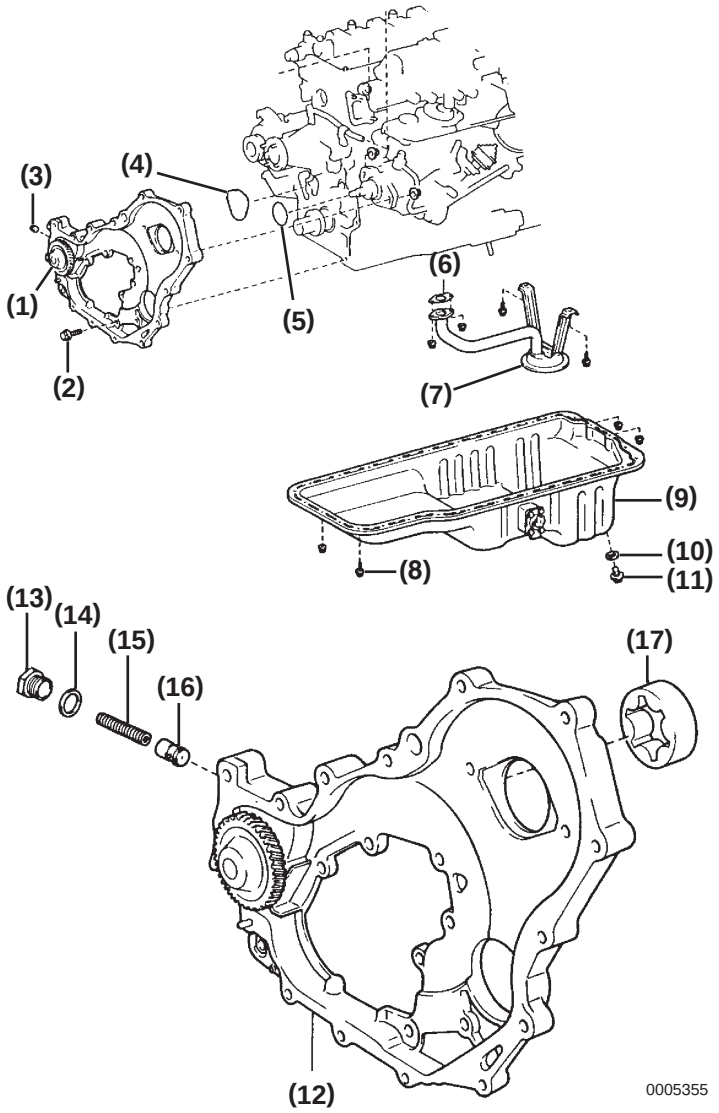


Figure 8-3

1 – Oil Pump Gear (Timing Gear Case)
2 – Bolt (7 used)
3 – Taper Screw (Pre-coated Part)
4 – Oil Pump Gasket (Non-Reusable)
5 – Injection Pump O-ring
6 – Gasket (Non-Reusable)
7 – Oil Strainer
8 – Bolt (27 used)
9 – Oil Pan
10 – Drain Plug Gasket (Non-Reusable)
11 – Drain Plug
12 – Timing Gear Case
13 – Plug
14 – Gasket (Non-Reusable)
15 – Spring
16 – Relief Valve
17 – Driven Rotor

Oil Pump Removal

Remove and clean the oil pan and oil strainer when repairing the oil pump.

1. Drain the engine fresh cooling water. *See Draining the Freshwater Cooling System on page 3-26*.
2. Drain the engine oil. *See Changing the Engine Oil and Replacing the Engine Oil Filter Element on page 4-9*.
3. Remove the timing gear. *See Timing Gear Removal on page 5-80*.
4. Remove the 27 oil pan nuts and bolts and insert an appropriate tool **(Figure 8-4, (1))** between the cylinder block and oil pan to cut off the seal and then remove the oil pan. *NOTICE: During removal avoid damaging the oil pan flange.*

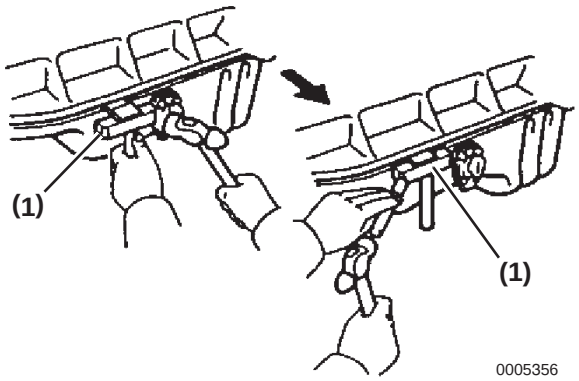


Figure 8-4

5. Remove the 2 nuts securing the fuel injection pump to the timing gear case.
6. Remove the 7 bolts securing the timing gear case to the cylinder block.
7. Insert a screwdriver **(Figure 8-5, (1))** between the oil pump and cylinder block and pry to remove the oil pump.

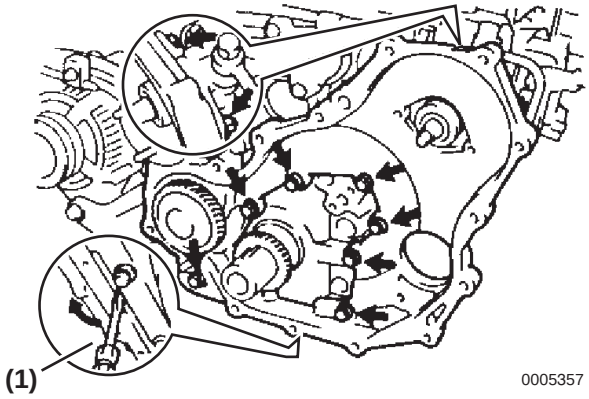


Figure 8-5

8. Remove the gasket and O-ring.
9. Remove the 2 bolts **(Figure 8-6, (1))** and 2 nuts **(Figure 8-6, (2))**, and the oil strainer and gasket.

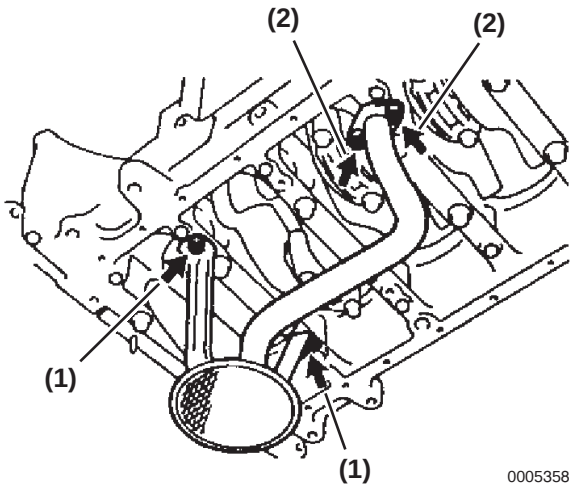


Figure 8-6

Oil Pump Disassembly and Inspection

1. Remove the driven rotor **(Figure 8-7, (1))**.

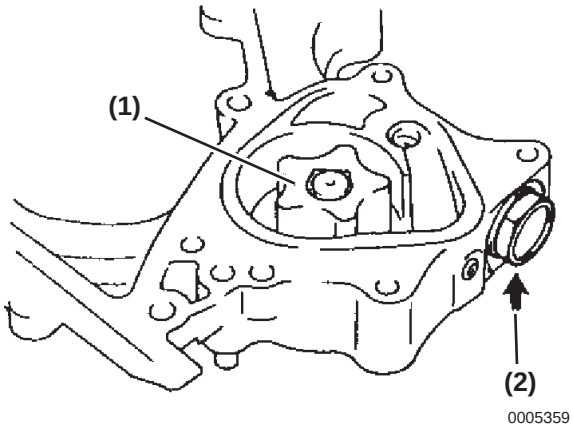


Figure 8-7

2. Remove the plug, gasket, spring and relief valve **(Figure 8-7, (1))**.
3. Inspect the relief valve **(Figure 8-8, (1))** by applying engine oil to the valve and check if it falls into the valve hole smoothly by its own weight. If not, replace the relief valve. If needed, replace the oil pump assembly.

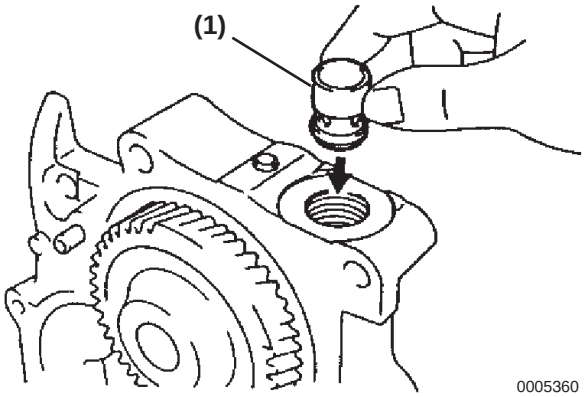


Figure 8-8

4. Check the drive shaft by turning the gear **(Figure 8-9)** and check if the drive shaft turns smoothly and the bearing has no play. If needed, replace the oil pump assembly.

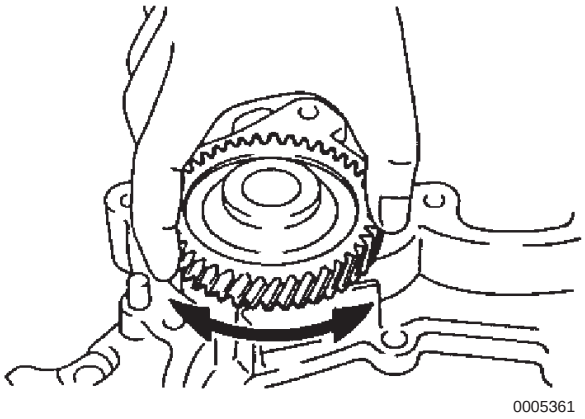


Figure 8-9

5. Check the clearance at the rotor tooth tip. Measure clearance at the tips of drive and driven rotors using a feeler gauge **(Figure 8-10)**. If the measured clearance exceeds the specified maximum, replace the oil pump assembly.

   Rotor tip tooth clearance:

   - Standard: 0.080 to 0.160 mm (0.031 to 6.29 in.)
   - Maximum: 0.21 mm (0.008 in.)

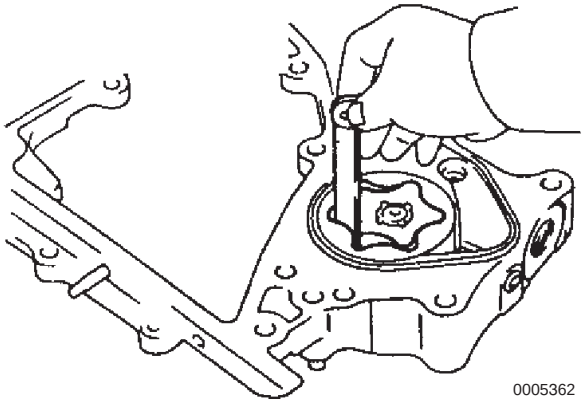


Figure 8-10

6. Check the clearance of the rotor body by measuring the clearance between the driven rotor and rotor body using a feeler gauge **(Figure 8-11)**. If the measured clearance exceeds the specified maximum, replace the oil pump assembly.

Rotor body clearance:

- Standard: 0.100 to 0.170 mm (0.003 to 0.006 in.)
- Maximum: 0.20 mm (0.007 in.)

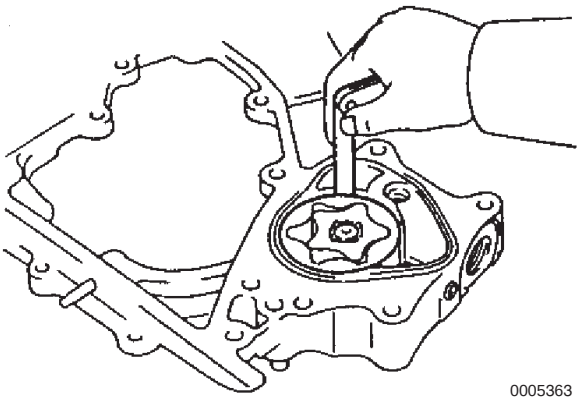


Figure 8-11

7. Check the clearance of the rotor assembly by measuring the clearance between the rotor and body end surface using a feeler gauge and a straight edge **(Figure 8-12)**. If the measured clearance exceeds the specified maximum, replace the oil pump assembly.

   Rotor side clearance:

   - Standard: 0.030 to 0.090 mm (0.011 to 0.035 in.)
   - Maximum: 0.15 mm (0.005 in.)

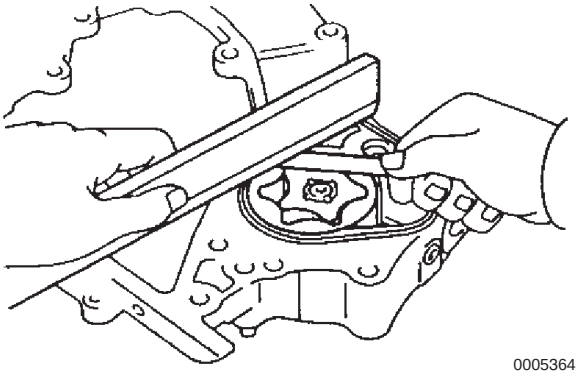


Figure 8-12

Oil Pump Reassembly

1. Install the relief valve and spring **(Figure 8-13, (1))** into the mounting holes in the timing gear case.
2. Using a new gasket install the plug and torque to 425 kgf·cm, 41.68 N·m (30.7 lb-ft).

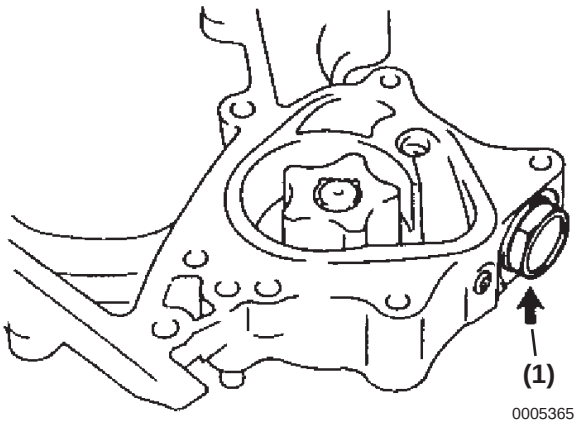


Figure 8-13

3. Install the drive and driven rotors aligning the mark **(Figure 8-14, (1))**.

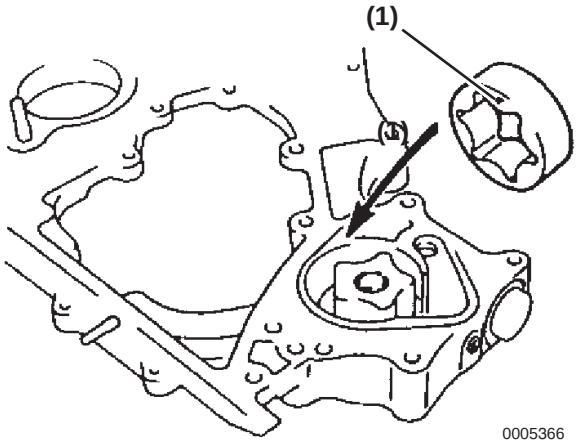


Figure 8-14

Oil Pump Installation

1. Using a new gasket install the oil strainer with the nuts **(Figure 8-15, (1))** and bolts **(Figure 8-15, (2))** and torque to 90 kgf·cm, 8.83 N·m (78.1 lb-in.).

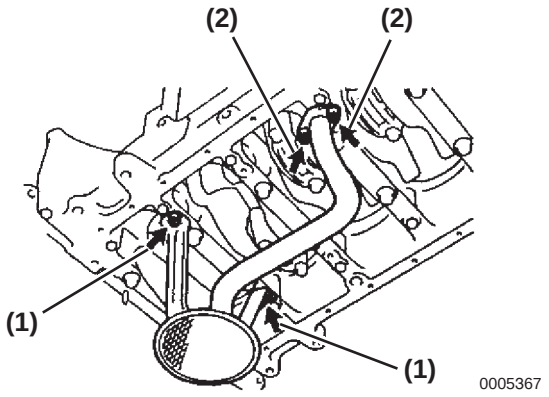


Figure 8-15

2. Remove all the old packing material from the gasket surface and seal groove using a gasket scraper. *NOTICE: Avoid contaminating the timing gear case and cylinder block mounting surfaces with oil.*

Note: Wash all parts and remove all old packing material chips and other foreign matter, then wash the sealing surfaces clean with solvent.

3. Apply new seal packing to the timing gear case using a 2 to 3 mm (0.078 to 0.118 in.) sealing width **(Figure 8-16, (1))**. *NOTICE: All parts must be assembled within 5 minutes after the seal packing is applied, otherwise the seal packing must be removed and reapplied. Remove the nozzle from the tube immediately after use and protect it with a cap.*

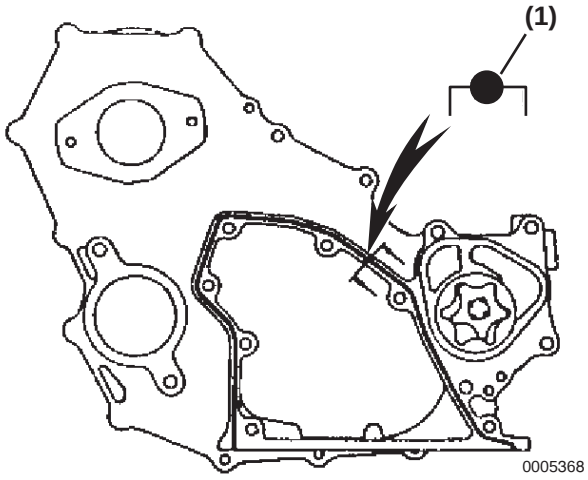


Figure 8-16

4. Install a new O-ring **(Figure 8-17, (1))** in the groove of the timing gear case. Use seal packing (TOYOTA P/N 08826-00080 or equivalent).

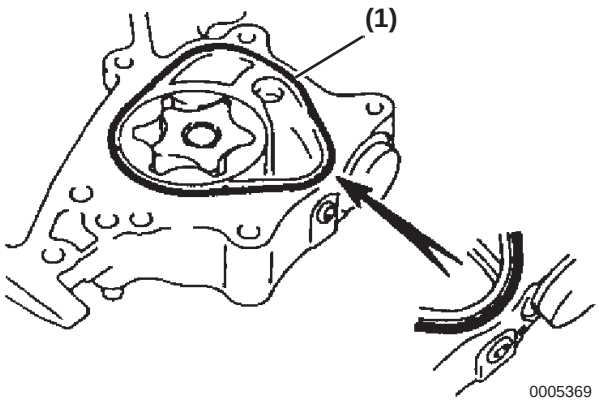


Figure 8-17

5. Install a new O-ring **(Figure 8-18, (1))** onto the fuel injection pump.

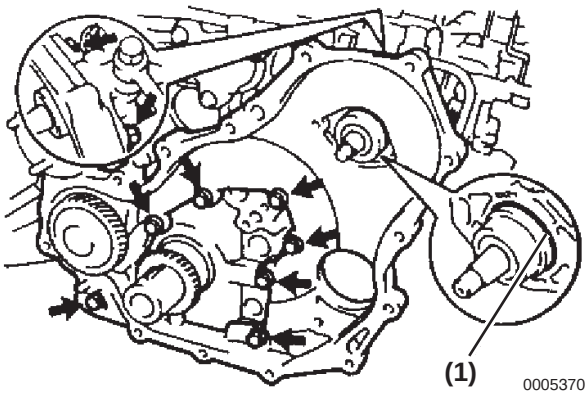


Figure 8-18

6. Install the timing gear case onto the cylinder block using 7 bolts. Uniformly tighten the bolts at several times to a final torque of 200 kgf·cm, 19.61 N·m (173.5 lb-in.).
7. Install the 2 nuts securing the injection pump to the timing gear case and torque to 185 kgf·cm, 18.14 N·m (160.5 lb-in.).
8. Remove the taper screw plug using a 5 mm hexagon wrench and pour in approximately 10 cc (0.3 oz) of engine oil into the oil pump **(Figure 8-19, (1))**.

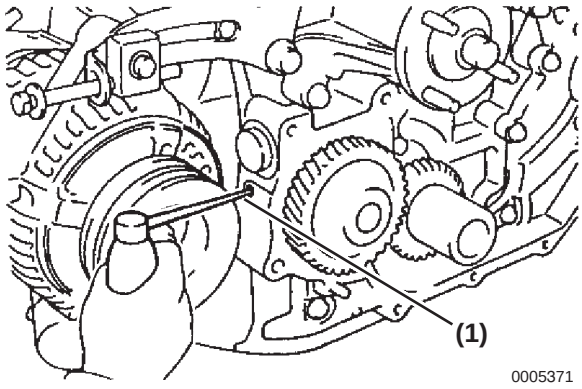


Figure 8-19

9. Apply TOYOTA P/N 08833-00070, THREE BOND 1344, LOCTITE 242 or equivalent adhesive **(Figure 8-20, (1))** to the threaded portion of taper screw plug (2 to 3 threads).

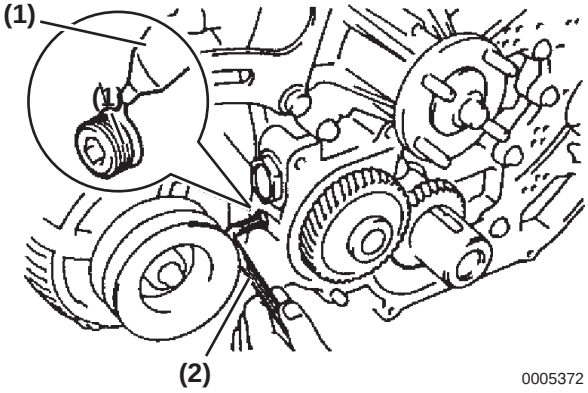


Figure 8-20

10. Tighten the taper screw plug using a 5 mm hexagon wrench **(Figure 8-20, (2))**. *NOTICE: Avoid contaminating the oil pan and cylinder block mounting surfaces with oil.*
11. Remove all the old packing material from the oil pan gasket surface and seal groove using a gasket scraper. *NOTICE: Use solvents that never damage painted surfaces. Wash all parts and remove all old packing material chips and other foreign matter and then wash the sealing surfaces with solvent.*
12. Apply new seal packing (TOYOTA P/N 08826-00080 or equivalent), to the oil pan using a 4 to 5 mm (0.157 to 0.196 in.) sealing width **(Figure 8-21, (1))**. *NOTICE: All parts must be assembled within 5 minutes after the seal packing is applied, otherwise the seal packing must be removed and reapplied. Remove the nozzle from the tube immediately after use and protect it with a cap.*

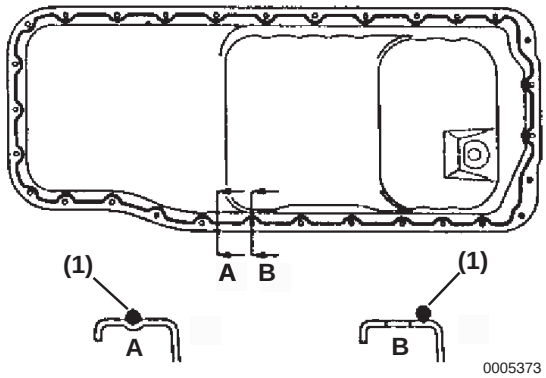
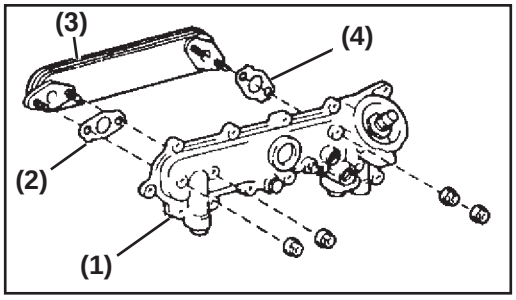


Figure 8-21

13. Install the oil pan using 27 bolts and 3 nuts. Uniformly tighten the nuts and bolts in several steps to a final torque of 100 kgf·cm, 9.81 N·m (86.8 lb-in.).
14. Install the timing gear. *See Timing Gear Installation on page 5-87*.
15. Fill with engine oil. *See Adding Engine Oil on page 3-23*.
16. Fill with engine coolant (fresh water). *See Checking and Adding Engine Coolant on page 3-25*.
17. Start the engine and check for oil leakage.
18. Check the oil level again, fill to the upper limit of the oil dipstick as needed.

OIL COOLER

Components



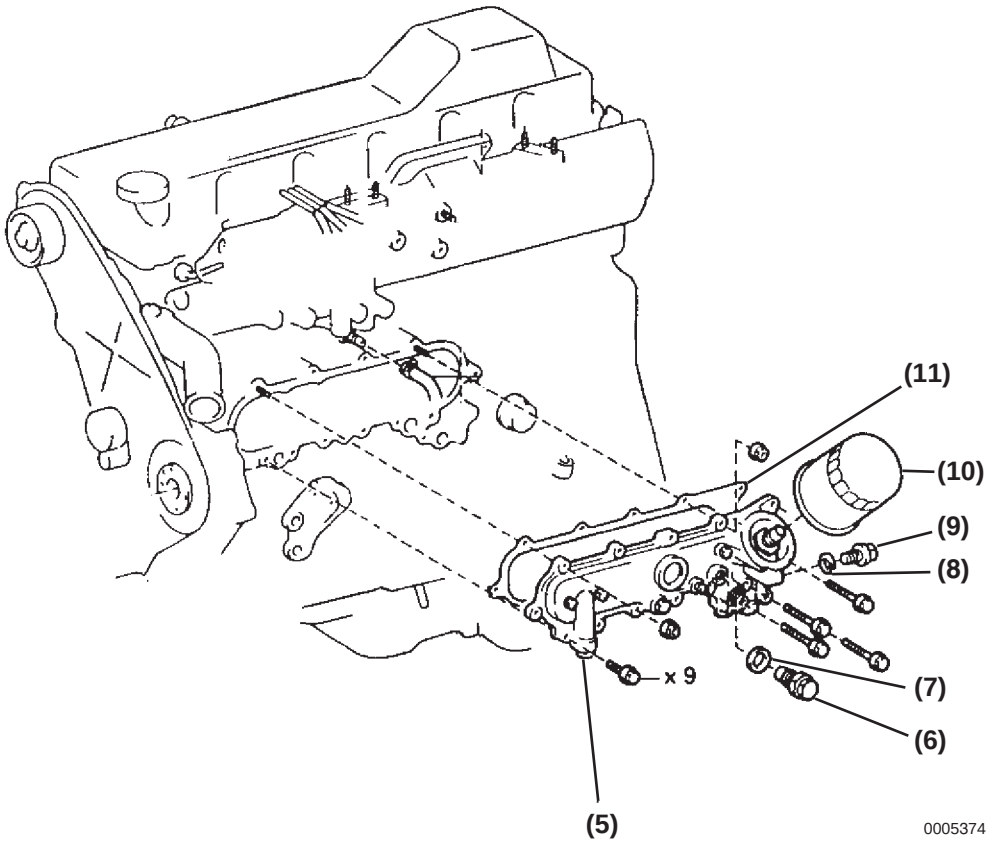


Figure 8-22

1 – Oil Cooler Cover
2 – Gasket (Non-Reusable part)
3 – Oil Cooler
4 – Gasket (Non-Reusable part)
5 – Oil Cooler Cover Assembly
6 – Relief Valve
7 – Gasket (Non-Reusable part)
8 – Gasket (Non-Reusable part)
9 – Check Valve
10 – Oil Filter
11 – Gasket

Oil Cooler Removal

1. Drain the engine coolant (fresh water). *See Draining the Freshwater Cooling System on page 3-26*.
2. Remove the timing belt and No. 2 camshaft timing pulley. *See Timing Belt Removal on page 5-69*.
3. Remove the fuel injection pipe and fuel injection pump. *See Fuel Injection Nozzle Removal on page 6-14* and *Fuel Injection Pump Removal on page 6-29*.
4. Remove the engine oil filter. See *Changing the Engine Oil and Replacing the Engine Oil Filter Element on page 4-9*.
5. Remove the relief valve **(Figure 8-23, (2))** and gasket.
6. Remove the check valve **(Figure 8-23, (1))** and gasket.

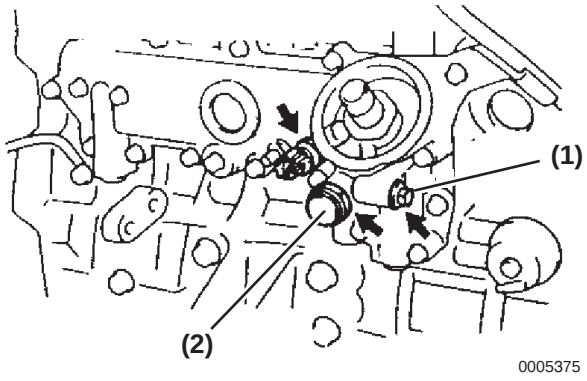


Figure 8-23

7. Remove 13 bolts, 2 nuts, oil cooler, cover assembly and gasket. Discard the gasket.

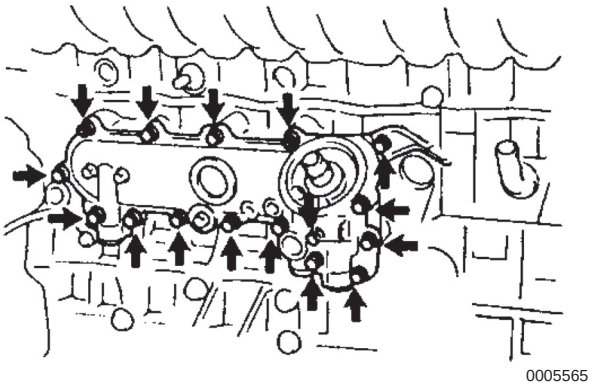


Figure 8-24

Oil Cooler Disassembly and Inspection

1. Inspect the relief valve by pressing **(Figure 8-25, (1))** the valve with a wooden stick to check for sticking. If the valve sticks, replace the relief valve.

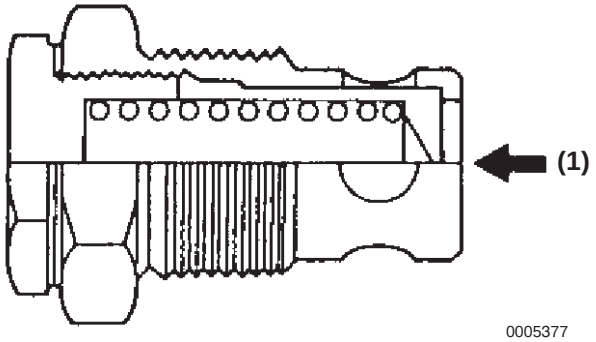


Figure 8-25

2. Inspect the check valve by pressing **(Figure 8-26, (1))** the valve with a wooden stick to check for sticking. If the valve sticks, replace the relief valve.

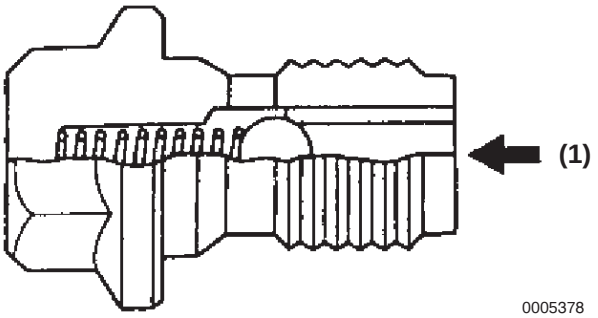


Figure 8-26

3. Inspect the oil cooler for damage and restrictions in the inlet **(Figure 8-27, (1))** and outlet **(Figure 8-27, (2))** ports. If needed, replace the oil cooler.

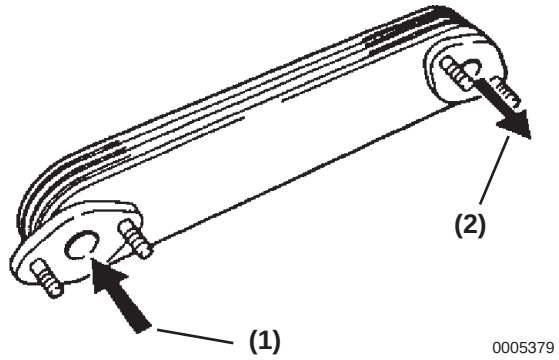


Figure 8-27

Oil Cooler Installation

1. Using 2 new gaskets install the oil cooler to the oil cooler cover using 4 nuts **(Figure 8-28, (1))**. Torque to: 160 kgf·cm, 15.69 N·m (144.0 lb-in.).

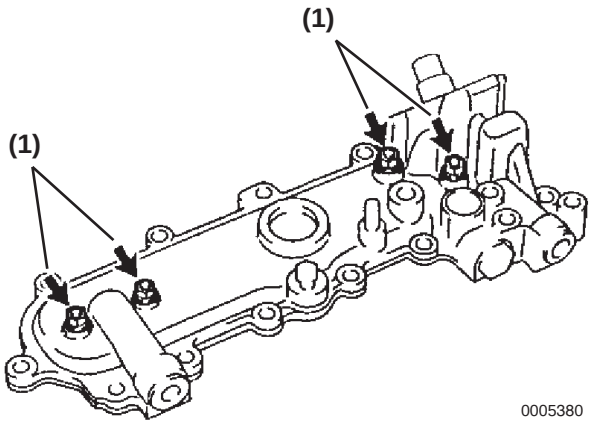


Figure 8-28

2. Install the new gaskets, oil cooler and cover assembly using 13 bolts and 2 nuts. Tighten the nuts and bolts uniformly several times to a final torque 200 kgf·cm, 19.61 N·m (170.4 lb-in.). Two lengths of bolts are used **(Figure 8-29)**:

   A: 20 mm (0.787 in.)
   B: 40 mm (1.57 in.)

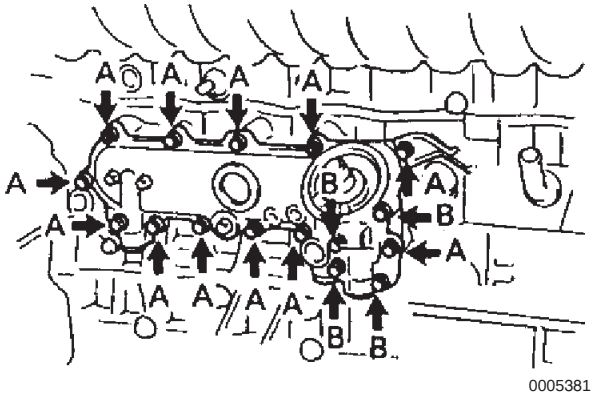


Figure 8-29

3. Using a new gasket install the relief valve **(Figure 8-30, (1))** and torque to 400 kgf·cm, 39.23 N·m (28.9 lb-ft).
4. Using a new gasket install the check valve **(Figure 8-30, (2))** and torque to: 275 kgf·cm, 26.97 N·m (19.8 lb-ft).

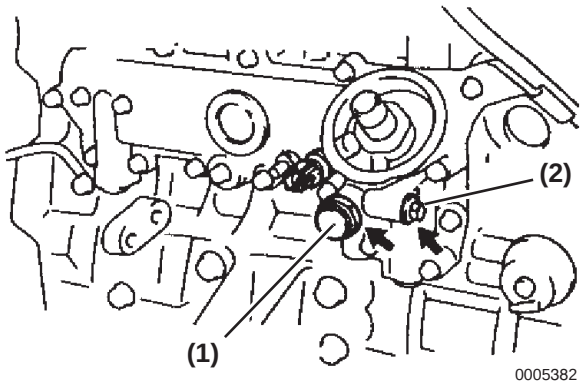


Figure 8-30

5. Install the engine oil filter. See *Changing the Engine Oil and Replacing the Engine Oil Filter Element on page 4-9*.
6. install the fuel injection pump. *See Fuel Injection Pump Installation on page 6-34*.
7. Install the fuel injection pipe. *See Fuel Injection Nozzle Installation on page 6-25*.
8. Install No. 2 camshaft timing pulley and timing belt. *See Timing Belt Installation on page 5-73*.
9. Fill with engine coolant (fresh water).
10. Start the engine and check for oil leakage.
11. Check the engine oil level again, if needed fill to the upper limit of the oil dipstick.

PISTON COOLING OIL NOZZLE

Components

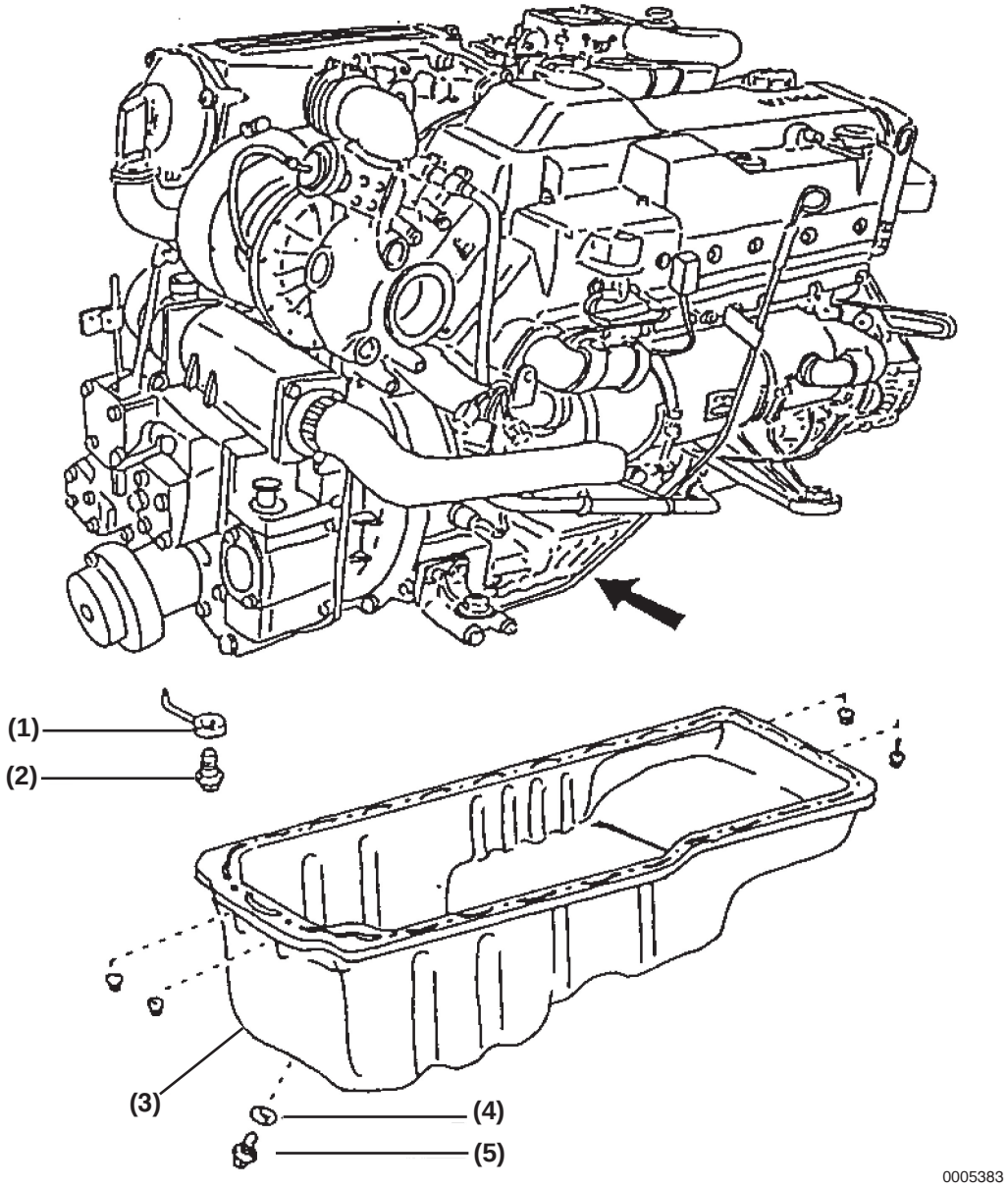


Figure 8-31

1 – Piston Cooling Oil Nozzle
2 – Check Valve
3 – Oil Pan
4 – Gasket (Non-Reusable part)
5 – Drain Plug

Oil Nozzle Disassembly and Inspection

1. Remove the oil pan. See step 4 starting in *Oil Pump Removal on page 8-7*.
2. Remove the check valve and oil nozzle Remove the 6 check valves and 6 oil nozzles.

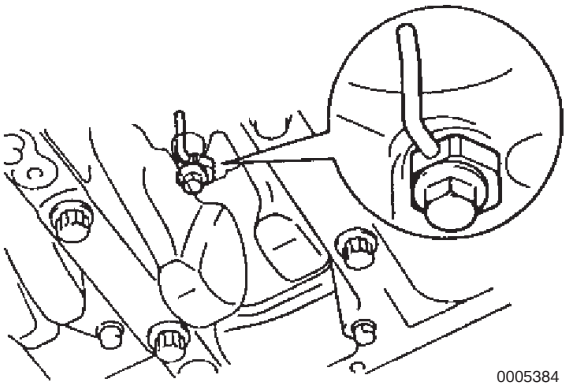


Figure 8-32

3. Inspect the check valve by pressing **(Figure 8-33, (1))** the valve with a wooden stick and check the valve for sticking. If the valve sticks, replace the check valve.

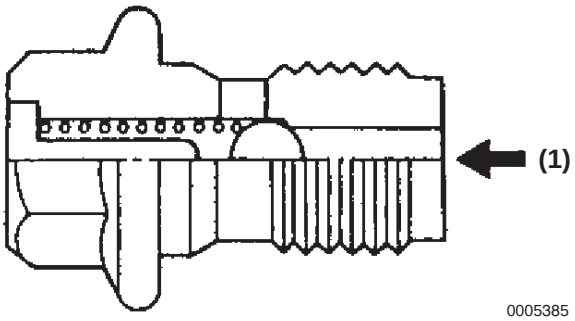


Figure 8-33

4. Inspect the oil nozzle **(Figure 8-34)** for damage, restrictions and clogs. If needed, replace the oil nozzle.

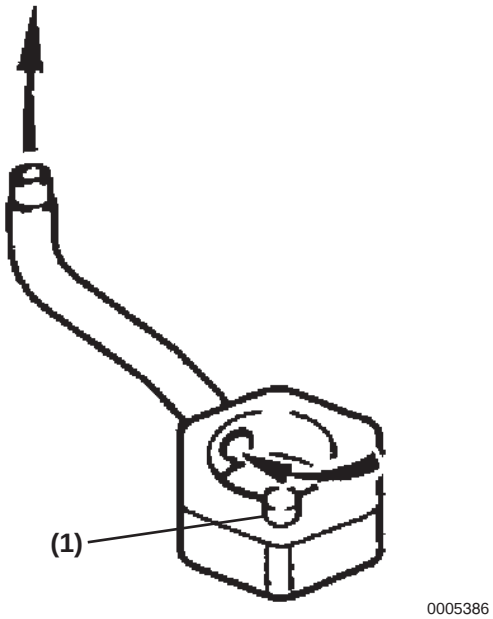


Figure 8-34

Oil Nozzle Installation

1. Align the oil nozzle pin **(Figure 8-34, (1))** with the pin hole in the cylinder block.
2. Install the oil nozzle together with the check valve **(Figure 8-35)**. Install 6 oil nozzles and check valves and torque to 175 kgf·cm, 17.16 N·m (151.8 lb-in.).

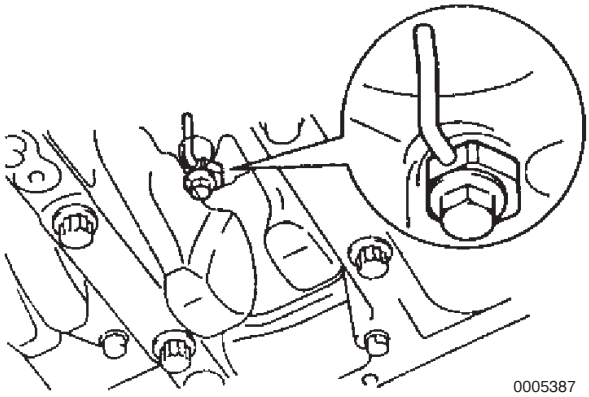


Figure 8-35

3. Install the oil pan. See step 11 starting in *Oil Pump Installation on page 8-10*.

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Section 9

TURBOCHARGER

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SAFETY PRECAUTIONS

Before you service the engine turbocharger, review the *Safety Section on page 2-1*.

INTRODUCTION

This section of the *Service Manual* describes the procedures necessary to service the 6LPA-STP2/STZP2 marine engine turbocharger.

TURBOCHARGER

Components and Operation

Turbine

Exhaust gas coming out of the engine is accelerated as it flows through the nozzle of the turbine housing and blown against the turbine wheel rotate the turbine shaft. This is called the turbine, in which the seal rings and thermal insulation plate are integrated to prevent failure of the bearings from the heated exhaust gas.

Blower

The compressor impeller mounted on the turbine shaft rotates with the turbine shaft in a separate plenum to compress the intake air to be fed to the air intake pipe and into the engine. This is called the compressor or blower.

Thrust Bearing

Thrust force is continuously applied to the turbine shaft. The thrust bearing is designed to prevent the shaft from movement due to the thrust.

Radial Bearing

The radial bearing is a floating bearing type, as it has double oil film layers on the inside and outside surfaces of the bearing. This causes the bearing to rotate together with the shaft. The slippage speed of bearing is lower than the turbine shaft revolution, thereby, the dynamic stability is improved, when compared with the normal type bearing.

Sealing Structure at Blower Side

Dual-wall structure is adopted into the rear of the compressor housing to prevent leakage of intake air and oil. A seal ring and oil defensive plate are also used to seal intake air and oil.

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Sectional View (RHE6W Model)

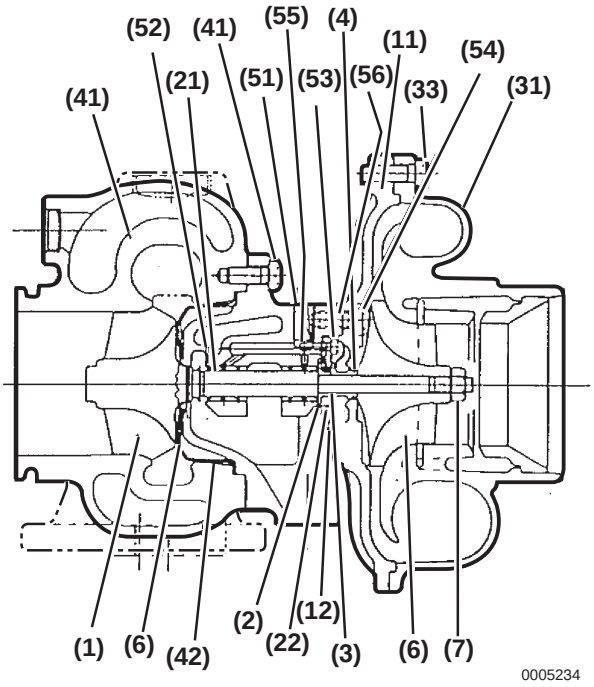


Figure 9-1

Components (RHE6W Turbocharger)

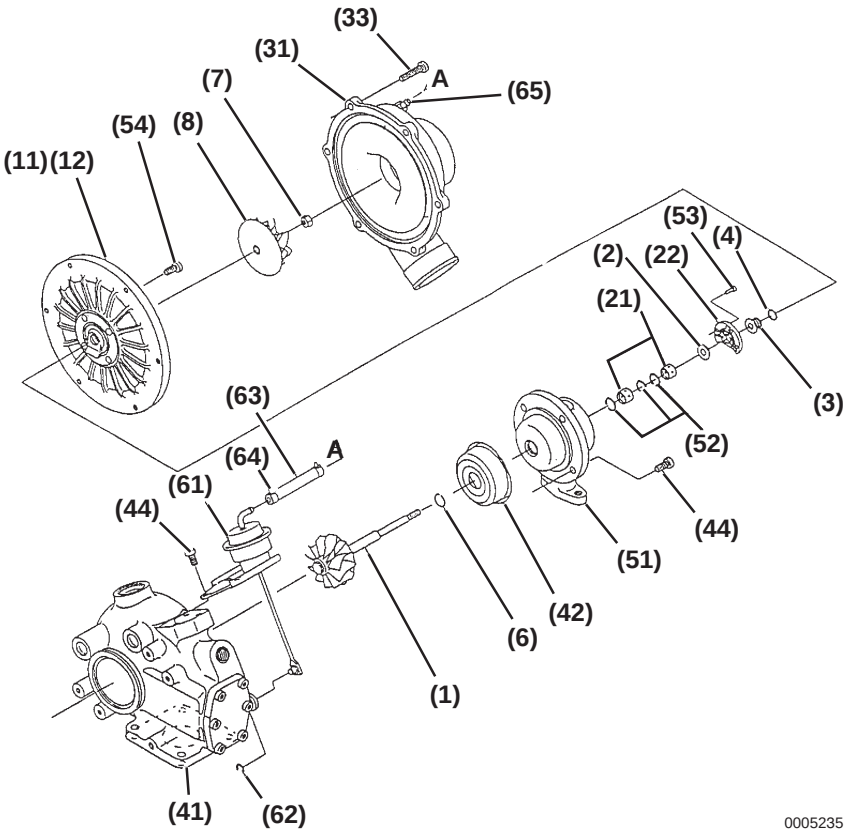


Figure 9-2

Components and Sectional View Identification List (RHE6W Model)

No.	Components	Notes	Qty
1	Turbine shaft	-	1
1	Thrust bearing	-	1
3	Oil thrower	-	1
4	Compressor side seal ring	-	1
6	Turbine side seal ring	-	1
7	Shaft end nut	Torque: 80 ± 0.5 kgf·m, 7.8 ± 0.5 N·m (69 ± 4 lb-in.)	1
8	Compressor impeller	-	1
11	Seal plate	-	1
12	Oil defensive plate	-	1
21	Floating bearing	-	2
22	Thrust bearing	-	1
31	Compressor housing	-	1
33	TORX T screw bolt	Torque: 230 ± 10 kgf·m, 23 ± 1 N·m (17 ± 0.7 lb-ft)	6
41	Turbine housing	-	1
42	Thermal housing plate	-	1
44	TORX T screw bolt	Torque: 285 ± 10 kgf·m, 28 ± 1 N·m (20.7 ± 0.7 lb-ft)	13
51	Bearing housing	-	1
52	Retaining ring	-	3
53	TORX T screw bolt	Torque: 38 ± 3 kgf·m, 3.7 ± 0.3 N·m (32.7 ± 3 lb-in.)	3
54	TORX T screw bolt	Torque: 230 ± 10 kgf·m, 23 ± 1 N·m (17 ± 0.7 lb-ft)	4
55	Liquid gasket	Apply Loctite No. 242	-
56	Liquid gasket	Apply liquid gasket	-
61	Waste gate actuator	-	1
62	E-Type retaining ring	-	1
63	Boost hose	-	1
64	Hose clip	-	2
65	Boost pipe	-	1

Service Specifications

Service Standards

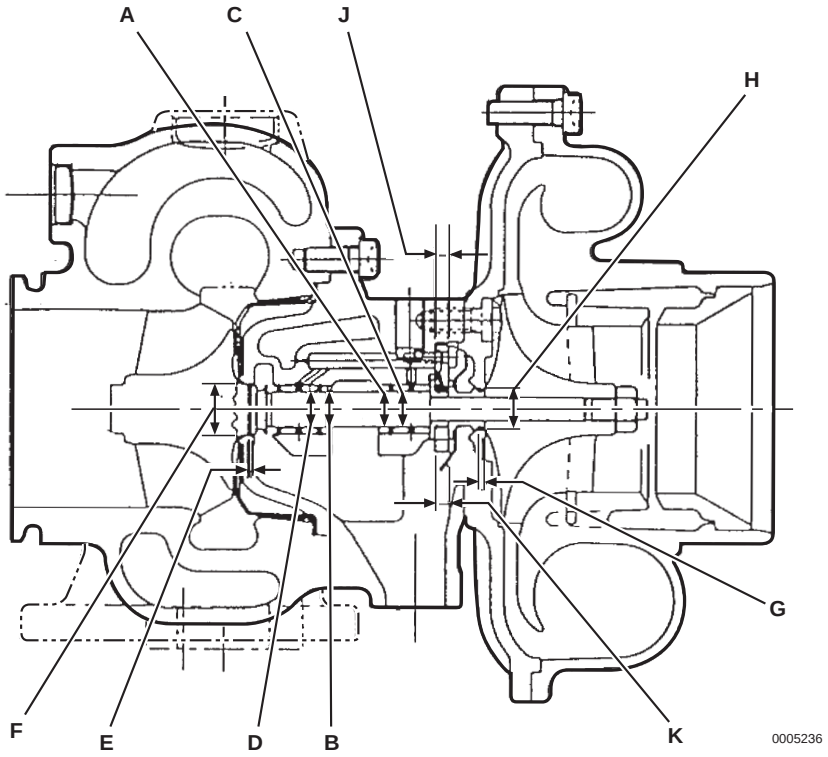


Figure 9-3

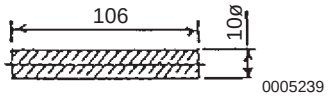
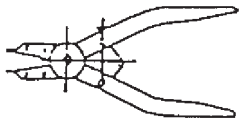
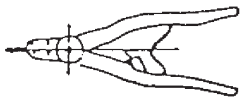
Inspection Item			Usable limit	Remarks
Turbine shaft	A	Turbine shaft journal outside diameter	11.380 mm (0.448 in.)	-
	E	Turbine side seal ring groove width	1.330 mm (0.052 in.)	-
	G	Compressor side seal ring groove width	1.520 mm (0.060 in.)	-
	-	Turbine shaft runout	0.011 mm (0.0004 in.)	-
	-	Turbine shaft play in axial direction	0.110 mm (0.004 in.)	Service Standard: 0.06 to 0.09 mm (0.002 to 0.004 in.)
	-	Turbine shaft play in radial direction	0.205 mm (0.008 in.)	Service Standard: 0.10 to 0.17 mm (0.004 to 0.007 in.)
Bearing	C	Floating bearing inside diameter	11.460 mm (0.451 in.)	-
	D	Floating bearing outside diameter	15.980v (0.629 in.)	-
	B	Bearing case inside diameter	16.110 mm (0.634 in.)	-
Thrust bearing	J	Thrust bearing width	4.280 mm (0.168 in.)	-
	K	Thrust bushing groove to groove distance	4.480 mm (0.176 in.)	-
Seal ring inserting area	F	Turbine side (bearing wheel chamber)	17.030 mm (0.670 in.)	-
	H	Compressor side (seal plate)	14.050 mm (0.553 in.)	-

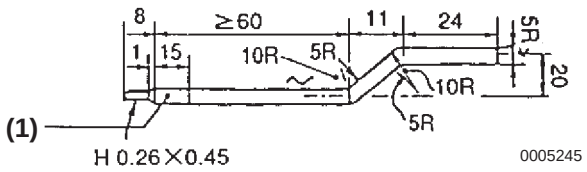
Special Torque Chart

Component	Specification
Turbine housing set bolt (M8)	285 ± 10 kgf·cm, 28 ± 1 N·m (20.7 ± 0.7 lb-ft)
Compressor housing set bolt (M8)	230 ± 10 kgf·cm, 23 ± 1 N·m (17 ± 0.7 lb-ft)
Thrust bearing set bolt (M4)	38 ± 3 kgf·cm, 3.7 ± 0.3 N·m (32.7 ± 3 lb-in.)
Seal plate set bolt (M8)	230 ± 10 kgf·cm, 23 ± 1 N·m (17 ± 0.7 lb-ft)
Compressor impeller set nut (M7) (left-handed thread)	80 ± 5 kgf·cm, 7.8 ± 0.5 N·m (69 ± 4 lb-in.)
Actuator set bolt (M8)	285 ± 10 kgf·cm, 28 ± 1 N·m (20.7 ± 0.7 lb-ft)
Valve case cover set bolt (M8)	285 ± 10 kgf·cm, 28 ± 1 N·m (20.7 ± 0.7 lb-ft)

Special Tools

In addition to the general tools, the following special tools are required for disassembling and reassembling the turbocharger.

Tool Name	Use	Illustration
Bar	For removing thrust bearing and thrust bushing (Material: copper or brass)	 0005239
Pliers	For removing and installing floating bearing retaining ring	 0005240
Pliers	For removing and installing seal ring	 0005241
Torque screwdriver for TORX bolt (TORX TT20 or equivalent Universal Type) 5 to 50 kgf·cm, 0.49 to 4.90 N·m (4.3 to 43.3 lb-in.)	For installing thrust bearing, for M4: 13 kgf·cm, 1.27± 0.1 N·m (11.2 ± 0.8 lb-in.) Available Locally	 0005242
Torque wrench for TORX bolt (TORX TT40 or equivalent Universal type)	For installing turbine housing for M8: 285 kgf·cm, 28 ± 1 N·m (20.7 ± 0.7 lb-ft) For installing compressor housing for M8: 230 kgf·cm, 23 ± 1 N·m (17 ± 0.7 lb-ft) For installing seal plate for M8: 230 kgf·cm, 23 ± 1 N·m (17 ± 0.7 lb-ft) Available Locally	-

Tool Name	Use	Illustration
Torque wrench (single purpose type)	For tightening shaft end nut for M7: 80 kgf·cm, 7.84 N·m (69.3 lb-in.)	 0005243
Box spanner wrench	For fixing turbine shaft (14mm x 12 pointed head) (Box part alone may be used.)	 0005244
Probe	For measuring play in axial and radial directions (To be attached to a dial indicator) (1) To be knurled here (rolette)	-
	 0005245	

Periodic Inspection

Inspection Intervals

Periodically inspect the turbocharger for damage and overall condition. The inspection interval may vary due to operating conditions. Refer to the table below as guideline when operating under normal conditions.

Inspection Item	Inspection Interval		
	Every 6 months or 1,500 hours	Every 12 months or 3,000 hours	Every 24 months or 6,000 hours
Rotation of turbine shaft	O		
Play of turbine shaft		O	
Overhaul and inspection			O

Inspection Procedure

Running of Turbine Shaft

Inspect the turbine shaft operation by listening for any abnormal sounds during operation. Use a listening bar to help diagnose any potential problems. Solidly position the end tip of the bar against the turbocharger case and raise the engine speed gradually. If high pitch sounds are generated at intervals of 2 to 3 seconds, abnormal operation is evident and a rotational problem may be present. The bearing or rotor may be defective, and cause for turbocharger replacement or overhaul.

Inspection of Turbine Shaft Play

Remove the turbocharger from the engine and inspect the turbine shaft axial and radial play following the procedures below.

After removing the turbocharger from the engine, always cover the oil inlet and outlet ports with tape.

- **Turbine Shaft Axial Play**
  - Service Standard: 0.06 to 0.09 mm (0.002 to 0.004 in.)
  - Wear Limit: 0.11 mm (0.004 in.)

Note: Move the turbine shaft in an axial direction **(Figure 9-4, (5))**.

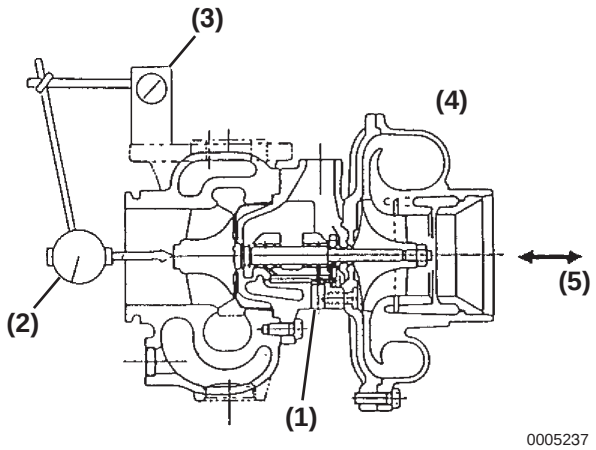


Figure 9-4

1 – Oil Inlet
2 – Dial Indicator
3 – Magnet Base
4 – Turbine Wheel Chamber

- **Turbine Shaft Radial Play**
  - Service Standard: 0.10 to 0.17 mm (0.004 to 0.007 in.)
  - Wear Limit: 0.205 mm (0.008 in.)

Note: Move the turbine shaft in a radial direction while moving simultaneously to the left and right sides **(Figure 9-5, (4))**.

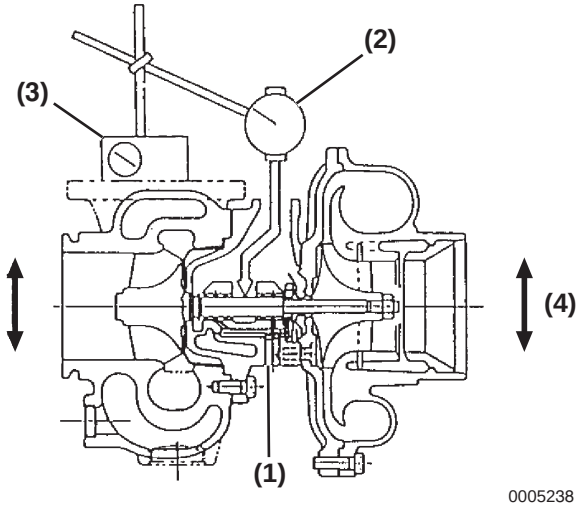


Figure 9-5

1 – Oil Inlet
2 – Dial Indicator
3 – Magnet Base

Disassembly

Component Identification (RHE6W Turbocharger)

Inspection Before Disassembly

Before disassembly check the turbine and compressor impellers for interference with their housings. The turbine shaft should rotate smoothly.

Measure the turbine shaft play. *See Inspection of Turbine Shaft Play on page 9-11*.

Turbine shaft axial play	Turbine shaft radial play
Wear limit: 0.110 mm (0.004 in.)	Wear limit: 0.205 mm (0.008 in.)

Disassembly

NOTICE: As mounting angles of the turbine housing, bearing housing and compressor housing of the turbocharger are determined according to their mounting status on the engine, make match marks before beginning disassembly.

1. Move the hose clip **(Figure 9-2, (64))** to the center of the boost hose **(Figure 9-2, (63))**.
2. Disconnect the boost hose **(Figure 9-2, (63))** from the compressor housing **(Figure 9-2, (31))** and waste gate actuator **(Figure 9-2, (61))**.
3. Remove the M8 TORX T screw bolt **(Figure 9-2, (33))** using a torque wrench (TT40).
4. Remove the compressor housing **(Figure 9-2, (31))**.

Note: Liquid gasket is applied to the compressor housing **(Figure 9-2, (31))** and seal plate **(Figure 9-2, (11))** mounting surfaces.

Note: Avoid damaging the compressor impellers when disassembling the compressor housing.

5. Attach the box spanner wrench (14 mm) to the shaft end of the turbine shaft **(Figure 9-2, (1))** on the turbine side and remove the shaft end nut **(Figure 9-2, (7))**. *NOTICE:* Pay attention to the loosening direction as the shaft and nut have left-handed threads.
6. Remove the compressor impeller **(Figure 9-2, (8))**.
7. Loosen the M8 TORX T screw bolt **(Figure 9-2, (54))** securing the seal plate, using a torque wrench (TT40).
8. Remove the seal plate **(Figure 9-2, (11))**.

Note: Lightly tap the bearing housing side of the seal plate with a wood or plastic hammer.

Note: Liquid gasket is applied to the seal plate and bearing wheel mounting surfaces.

9. Remove the oil thrower **(Figure 9-2, (3))** from the seal plate.
10. Remove the M8 TORX T screw bolt **(Figure 9-2, (44))** using a torque wrench (TT40).
11. Remove the turbine housing **(Figure 9-2, (41))**.
12. Carefully secure the heat insulation plate **(Figure 9-2, (42))** by hand and pull off turbine shaft **(Figure 9-2, (1))**.

Note: If the turbine shaft is tight, lightly tap the shaft end on the blower side with a wood or plastic hammer.

13. Remove the heat insulation plate **(Figure 9-2, (42))**.
14. Loosen the M4 TORX T screw bolt **(Figure 9-2, (53))** securing the thrust bearing, using a screwdriver (TT20).
15. Remove the thrust bearing **(Figure 9-2, (22))** and thrust brushing **(Figure 9-2, (2))** using a copper bar.
16. Remove the floating bearing **(Figure 9-2, (21))** on the compressor side from the bearing housing **(Figure 9-2, (51))**.
17. Remove the retaining ring **(Figure 9-2, (52))** on the turbine side from bearing housing **(Figure 9-2, (51))**, using retaining ring pliers.
18. Remove the floating bearing **(Figure 9-2, (21))** on the turbine side from the bearing housing **(Figure 9-2, (51))**.
19. Remove the far-side retaining rings **(Figure 9-2, (52))** of the turbine and compressor sides from the bearing housing **(Figure 9-2, (51))**, using retaining ring pliers.
20. Remove the seal ring **(Figure 9-2, (6))** on the turbine side from the turbine shaft **(Figure 9-2, (1))**.
21. Remove the seal ring **(Figure 9-2, (4))** on the compressor side from oil thrower **(Figure 9-2, (3))**.

Inspection and Cleaning

Component Identification (RHE6W Turbocharger)

Cleaning

Before cleaning, visually check each part for any trace of damage, seizure, wear, foreign matter or carbon deposits. Whenever the turbocharger is disassembled, always inspect all parts thoroughly for damage or wear.

Component Inspection Before Cleaning		
Condition	**Order**	**Component**
Carbon deposits	1	Turbine side seal ring of turbine shaft **(Figure 9-2, (1))** and turbine wheel backside.
	2	Mounting locations for bearing housing **(Figure 9-2, (51))** and thermal insulation plate **(Figure 9-2, (42))** and inner wall of bearing housing.
Lubrication status (wear, seizure, discoloration, etc.)	1	Journal of turbine shaft **(Figure 9-2, (1))**, thrust bushing **(Figure 9-2, (2))** and oil thrower **(Figure 9-2, (3))**.
	2	Floating bearing **(Figure 9-2, (21))** and thrust bearing **(Figure 9-2, (22))**.
	3	Internal circumference of bearing case and bearing housing **(Figure 9-2, (51))**.
Oil leakage	1	Inner wall of turbine housing **(Figure 9-2, (41))**.
	2	Outer surface of bearing housing **(Figure 9-2, (51))** and thermal insulation plate **(Figure 9-2, (42))** mounting area.
	3	Turbine side seal ring **(Figure 9-2, (6))** of turbine shaft **(Figure 9-2, (1))** and turbine wheel backside.
	4	Inner wall of compressor housing **(Figure 9-2, (31))**.
	5	Backside of compressor impeller **(Figure 9-2, (8))**.
	6	Surface of seal plate **(Figure 9-2, (11))** and seal ring **(Figure 9-2, (4))** inserting area.

Cleaning Procedures				
Part	**Tools**	**Detergent**	**Procedure**	**Notes**
Turbine Shaft and Housing	1. Wash Solvent Tank 2. Heat Source (Steam or Gas Burner) 3. Plastic Brush and Scraper	General carbon removing agent (Available locally)	Immerse the turbine shaft in heated wash solvent tank, until the carbon and other deposits are softened.	Only use a plastic scraper to remove carbon deposits. NEVER use a wire brush.
				NEVER strike the blades to remove carbon deposits.
				Avoid damaging the bearing surface and seal ring groove of the turbine shaft during cleaning.
				Clean all carbon deposits from the shaft. Deposits left on the turbine shaft may cause vibration and damage due to the shaft being out of balance.
Blower Impeller Housing	1. Wash Solvent Tank 2. Plastic Brush and Scraper	General carbon removing agent (Available locally)	Immerse in wash solvent tank until the carbon and other deposits are softened.	Only use a plastic scraper to remove carbon deposits. NEVER use a wire brush.
All other parts	-	Diesel Fuel	Clean all other parts with diesel oil.	Avoid damaging parts while cleaning. Lightly coat parts with oil to prevent corrosion until assembled.
			Clean all lubricating oil passages and dry with compressed air.	

Component Inspection

Compressor Housing

Check the compressor housing **(Figure 9-2, (31))** for any contact traces with the compressor impeller, damage, dents or cracks at the mating surfaces. Replace the housing if necessary.

Turbine Housing

Check for any damage or contact traces with the turbine wheel, damage from corrosion to the case surface, thermal deformation or cracks. Replace the turbine housing **(Figure 9-2, (41))** if necessary.

Compressor Impeller

Check for any damage, contact traces, chipping, corrosion or deformation. Replace the compressor impeller **(Figure 9-2, (8))** if necessary.

Turbine Shaft

1. Check for any damage, contact traces, chipping, thermal discoloration or deformation at the turbine wheel. Check the turbine shaft **(Figure 9-2, (1))** for straightness, the journal for thermal discoloration or abnormal wear, and the seal ring groove for surface defect or wear. Replace the turbine shaft if necessary.
2. Measure the outside diameter **(Figure 9-3, (A))** and seal ring groove width **(Figure 9-3, (E))** of the turbine shaft journal. Replace the turbine shaft if measurements are beyond the wear limit.
   - Wear limit of journal outside diameter **(Figure 9-3, (A))** is 11.38 mm (0.448 in.)
   - Wear limit of seal ring groove width **(Figure 9-3, (E))** is 1.33 mm (0.052 in.)
3. Measure the runout of the turbine shaft. Replace the turbine shaft if the measured runout exceeds 0.011 mm (0.0004 in.).

Thermal Insulation Plate

Check the thermal insulation plate **(Figure 9-2, (42))** for damage, contact traces, thermal deformation or corrosion. Replace the thermal insulation plate if necessary.

Thrust Bushing, Oil Thrower and Thrust Bearing

Check each part for damage, wear, surface defects and discoloration. Replace the component if needed, even if dimensions **(Figure 9-6, (G))** and **(Figure 9-6, (K))** are within the wear limit.

1. Thrust Bushing **(Figure 9-2, (2))**
   Measure the seal ring groove width **(Figure 9-6, (K))** of the thrust busing. Replace the thrust bushing if the measured value exceeds the wear limit.
   - Wear limit: 4.48 mm (0.176 in.)
2. Oil Thrower **(Figure 9-2, (3))**
   Measure the seal ring groove width **(Figure 9-6, (G))**. Replace with a new one if the measured value exceeds the wear limit.
   - Wear limit: 1.52 mm (0.059 in.)
3. Thrust Bearing **(Figure 9-2, (22))**
   Measure the thrust bearing width **(Figure 9-3, (J))**. Replace with a new one if the measured value exceeds the wear limit.
   - Wear limit: 4.28 mm (0.168 in.)

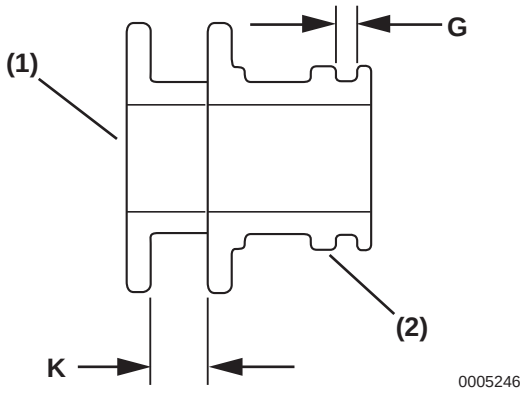


Figure 9-6

Floating Bearing

1. Check the floating bearing **(Figure 9-2, (21))** for damage, abnormal wear, discoloration or surface defects. Replace the floating bearing if necessary.

2. Measure the inside diameter **(Figure 9-3, (C))** and outside diameter **(Figure 9-3, (D))** of the bearing. If measurements exceed the wear limit, replace the floating bearing.
   - Wear limit: Outside diameter: 15.98 mm (0.629 in.)
   - Wear limit: Inside diameter: 11.46 mm (0.451 in.)

Bearing Housing

1. Check the casting surfaces for damage, separation, dents and cracks caused by corrosion. Replace the bearing housing **(Figure 9-2, (51))** if necessary.
2. Check the retaining ring **(Figure 9-2, (52))** for breakage and cracks. Replace the retaining ring if necessary.
3. Measure dimensions **(Figure 9-7, (B))** and **(Figure 9-7, (F))** of the bearing housing. Replace the bearing housing if either measured value exceeds the wear limit.
   - Bearing housing inside diameter **(Figure 9-7, (B))** Wear limit: 16.11 mm (0.634 in.)
   - Seal ring insertion hole on turbine side **(Figure 9-7, (F))** Wear limit: 17.03 mm (0.670 in.)

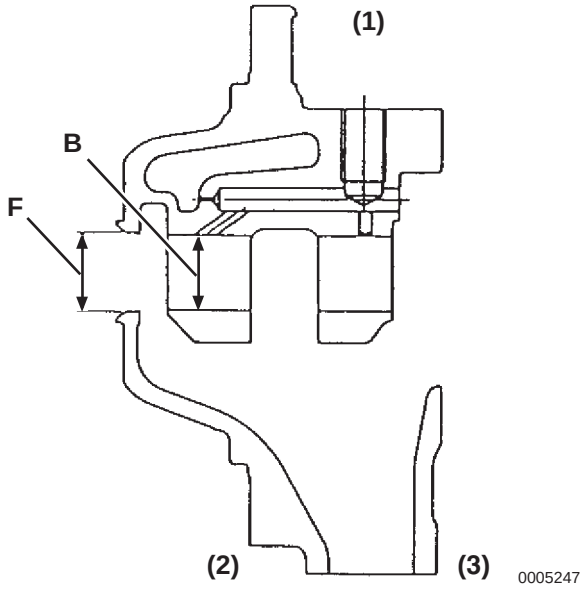


Figure 9-7

1 – Wheel Chamber
2 – Turbine Side
3 – Compressor Side

Seal Plate

1. Check the seal plate **(Figure 9-2, (11))** for any damage, contact traces, defects, dents or cracks of the mating surfaces. Replace the seal plate if necessary.
2. Measure the seal ring insertion hole **(Figure 9-8, (H))** on the compressor side. Replace the seal ring if the measured value exceeds the wear limit.
   - Wear limit: 14.05 mm (0.553 in.)

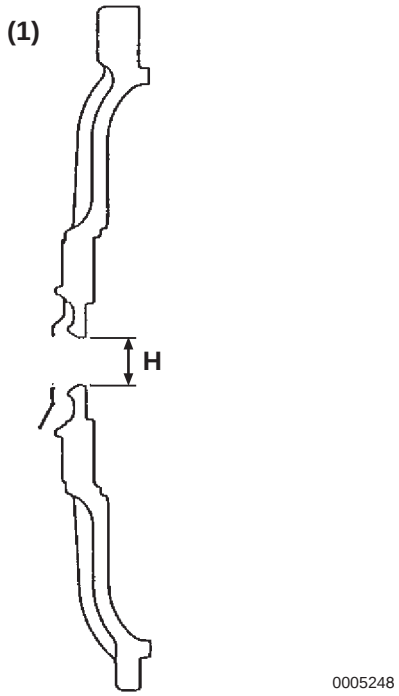


Figure 9-8

1 – Seal Plate

Seal Rings

Seal rings **(Figure 9-2, (4, 6))** should not be re-used. Replace the seal rings during reassembly.

Fasteners and Other Components

Inspect all fasteners and related components in addition to components listed. Inspect for damage, corrosion and replace any component or fastener as necessary. *NOTICE: ALWAYS replace the M4 and M8 TORX T screw bolt **(Figure 9-2, (54))** and **(Figure 9-2, (53))** during reassembly.*

Reassembly

Component Identification (RHE6W Turbocharger)

Obtain general tools, special tools, liquid gasket (Three Bond No. 1207) and LOCTITE No. 242 before reassembling the turbocharger.

NOTICE: Always replace the following parts with new ones.

- Turbine side seal ring **(Figure 9-2, (6))** (1 pc.)
- Compressor side seal ring **(Figure 9-2, (4))** (1 pc.)
- M4 pan head small screw **(Figure 9-2, (53))** (3 pcs.)
- M8 pan head small screw **(Figure 9-2, (54))** (4 pcs).

1. Install the retaining rings **(Figure 9-2, (52))** to the bearing housing **(Figure 9-2, (51))** using retaining ring pliers.
2. Install the turbine side floating bearing **(Figure 9-2, (21))** to the bearing housing **(Figure 9-2, (51))**.
3. Install the turbine side retaining ring **(Figure 9-2, (52))** to the bearing housing **(Figure 9-2, (51))** using retaining ring pliers.
4. Install the compressor side floating bearing **(Figure 9-2, (21))** to the bearing housing **(Figure 9-2, (51))**.

Note: The rounded surface of the retaining ring is installed facing the bearing. Apply engine oil to the floating bearing before reassembly.

5. Fit the seal ring **(Figure 9-2, (6))** onto the turbine shaft **(Figure 9-2, (1))**.
6. Install the thermal insulation plate **(Figure 9-2, (42))** to the bearing housing **(Figure 9-2, (51))** on the turbine side.

7. Apply engine oil to the journal of the turbine shaft and insert the shaft from the turbine side of the bearing housing **(Figure 9-2, (51))**.

   NOTICE: Avoid damaging the floating bearing during assembly to the turbine shaft. Position the seal ring end on the engine oil inlet side after centering with the turbine shaft.

8. Install the thrust bearing **(Figure 9-2, (2))** on the turbine shaft **(Figure 9-2, (1))**.
9. Apply engine oil to the thrust bearing **(Figure 9-2, (22))** and install it into the bearing housing **(Figure 9-2, (51))**.
10. Apply Loctite on the threaded portion of M4 TORX T thrust bearing bolt **(Figure 9-2, (53))** and torque to: 38 ± 3 kgf·cm, 3.73 ± 0.3 N·m (32.7 ± 3 lb-in.).
11. Install the bearing housing **(Figure 9-2, (51))** to the turbine housing **(Figure 9-2, (41))**, aligning match marks made before disassembly.

Note: When using new replacement bearing or turbine housing parts, verify alignment of the oil inlet, oil outlet and exhaust gas inlet locations during assembly.

12. Torque the M8 TORX bolt **(Figure 9-2, (44))** to 285 ±10 kgf·cm, 27.95 ± 1 N·m (20.7 ± 0.7 lb-ft).
13. Install the seal ring **(Figure 9-2, (4))** to the oil thrower **(Figure 9-2, (3))**.
14. Insert the oil thrower **(Figure 9-2, (3))** into seal plate **(Figure 9-2, (11))**.

Note: Position the seal ring end on the oil inlet side.

15. Apply liquid gasket (Three Bond No. 1207) on the flange surface of seal plate **(Figure 9-2, (11))** on the turbine side.
    - Liquid gasket thickness: 0.1 to 0.2 mm (0.004 to 0.008 in.)

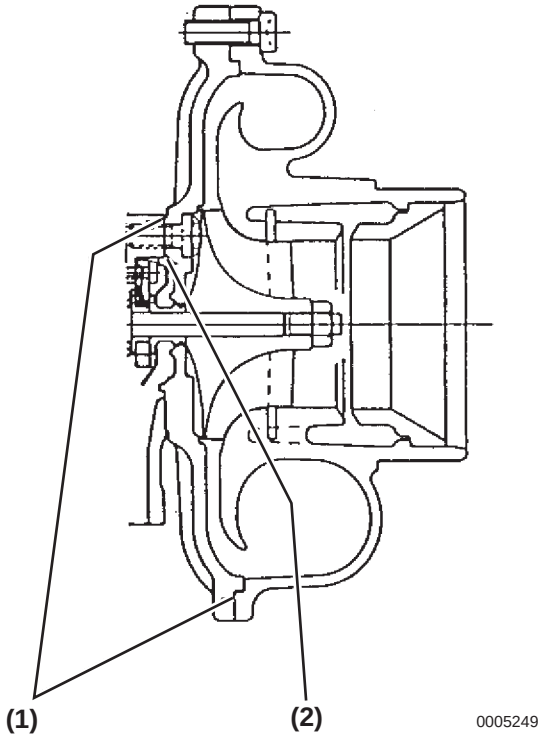


Figure 9-9

1 – Apply liquid gasket at this location.
2 – Avoid liquid gasket from leaking from this location.

16. Install the seal plate **(Figure 9-2, (11))** to bearing housing **(Figure 9-2, (51))**.
17. Apply Loctite on the threaded portion of M8 TORX bolt **(Figure 9-2, (54))** for seal plate mounting, and torque to 230±10 kgf·cm, 22.56 ± 1 N·m (17 ± 0.7 lb-ft).
18. Install the compressor impeller onto the turbine shaft **(Figure 9-2, (1))**.
19. Using a box spanner wrench (14 mm) on the turbine side end of the turbine shaft **(Figure 9-2, (1))** torque the shaft end nut **(Figure 9-2, (7))** to 80 ± 5 kgf·cm, 7.84 ± 0.5 N·m (69 ± 4 lb-in.).

Note: The shaft end nut uses left-handed threads.

20. Apply liquid gasket (Three Bond No. 1207) to the compressor side flange surface of seal plate **(Figure 9-2, (11))**.
    - Liquid gasket thickness: 0.1 to 0.2 mm (0.004 to 0.008 in.)
21. Assemble the compressor housing **(Figure 9-2, (31))** to the bearing housing **(Figure 9-2, (51))**, aligning the match marks made before disassembly. *NOTICE: When using new replacement bearing or compressor housing parts, verify alignment of the oil inlet, oil outlet and exhaust gas inlet locations during assembly.*
22. Tighten the M8 TORX bolt **(Figure 9-2, (33))** to 230 ±10 kgf·cm, 22.56 ± 1 N·m (17 ± 0.7 lb-ft).
23. Install the hose clip **(Figure 9-2, (64))** on the center of boost hose **(Figure 9-2, (63))**.
24. Install the boost hose **(Figure 9-2, (63))** to the compressor housing **(Figure 9-2, (31))** and waste gate actuator **(Figure 9-2,** (**(61))**.
25. Move the hose clip **(Figure 9-2, (64))** to the nipple of the compressor housing **(Figure 9-2, (31))** and waste gate actuator **(Figure 9-2, (61))**, to prevent the boost hose **(Figure 9-2, (63))** from disconnecting.
26. Measure the turbine shaft end play. See *Inspection of Turbine Shaft Play on page 9-11*, if turbine shaft play is not within specifications, identify the cause of the excessive movement and correct the problem.
    - Turbine shaft axial play: Service standard: 0.06 to 0.09 mm (0.002 to 0.004 in.)
    - Turbine shaft radial play: Service standard: 0.10 to 0.17 mm (0.004 to 0.007 in.)

Installation

NOTICE: When installing the turbocharger on the engine or handling the turbocharger after installation, follow all instructions below. NEVER allow debris or foreign matter into the turbocharger.

Lubrication path

1. Add new engine oil through the oil inlet port before installation on the engine, then manually turn the turbine shaft to lubricate the floating and thrust bearings.
2. Flush the oil inlet pipe from the engine and outlet pipe, and check for damage to the pipe or dirt, foreign matter or restrictions in the pipes.
3. Connect the pipes securely to avoid oil leaks at the joints.

Intake path

1. Check the intake line for foreign matter or dirt.
2. Connect securely to prevent air leaks at the joints with the intake duct and air cleaner.

Exhaust path

1. Check the exhaust system for dirt and foreign matter.

Note: Heat resistant steel nuts and bolts are used for the turbocharger installation, never use ordinary nuts and bolts. Always apply an anti-seizure compound to the threads before tightening. Use only heat resistant bolts for the turbine housing.

2. Connect the exhaust pipes securely to prevent exhaust gas leaks at each pipe joint.

Troubleshooting

Sufficient turbocharger performance and required engine output cannot be obtained if there is any damage or problems with the turbocharger. When troubleshooting, first inspect the engine and components for faults then inspect the turbocharger and follow the troubleshooting guidelines below.

Excessively Dense Exhaust Smoke (Insufficient Intake Air Amount)	
Possible Cause	**Corrective Action**
1. Clogged air cleaner element	Replace or wash the element.
2. Blocked air intake port	Remove obstruction.
3. Leak from a joint in intake line	Inspect and repair.

Excessively Dense Exhaust Smoke (Turbocharger Operation Failure)		
Possible Cause		**Corrective Action**
1. Carbon or other deposits on the turbine side seal, preventing smooth turbine shaft rotation		• Turbocharger overhaul (disassembly and cleaning) and engine oil replacement
2. Bearing seizure	• Insufficient lubrication or clogged lubrication passages • Excessively high oil temperature • Unbalanced rotating part • Insufficient warm up or sudden stop from loaded operation (no-load operation)	• Turbocharger overhaul (disassembly and repair) Inspect the oil system of the engine and repair faulty parts and replace the engine oil. • Replace or wash the faulty rotating part. • Strictly observe instructions in the operation manual.
3. Contact or breakdown of turbine wheel or compressor impeller	• Over speed • Excessive exhaust temperature rise • Foreign debris ingestion • Worn bearing • Faulty assembly	• Inspect and repair faulty engine parts. • Completely remove foreign debris after disassembling. Inspect the air cleaner and engine parts and repair as needed. • Disassemble turbocharger for repair. • Reassemble

Excessively Dense Exhaust Smoke (Influence of Exhaust Resistance)	
Possible Cause	**Corrective Action**
1. Exhaust gas leak before the turbocharger causing a decrease in speed	Check the connections and repair as needed.
2. Exhaust piping is deformed or clogged causing turbocharger speed to not increase	Repair the pipe to the normal operating condition.

White Exhaust Gas Color	
Possible Cause	**Corrective Action**
1. Oil flowing to the compressor or turbine side out due to a clogged oil return pipe	Repair or replace the piping.
2. Abnormal wear or damage to seal ring by excessive wear of bearing	Disassemble and repair the turbocharger.

Excessive Engine Oil Consumption	
Possible Cause	**Corrective Action**
1. Abnormal wear or breakage of seal ring by excessive wear of bearing	Disassemble and repair the turbocharger.

Engine Output Drop	
Possible Cause	**Corrective Action**
1. Exhaust gas leak	Check connections and repair.
2. Air leak from discharge side of compressor	
3. Clogged air cleaner element	Wash or replace the element.
4. Dirty or damaged turbocharger	Disassemble and repair or replace the turbocharger.

Poor (slow) Response (starting) of Turbocharger	
Possible Cause	**Corrective Action**
1. Hard carbon deposits on the turbine side (wheel sealing) preventing smooth turbine shaft rotation	Replace engine oil and wash the turbocharger after disassembly.
2. Incomplete combustion	Check the engine combustion system and take corrective action if needed to restore performance.

Abnormal Sound	
Possible Cause	**Corrective Action**
1. Restricted exhaust gas path caused from a clogged nozzle in turbine housing or reverse flow of blower discharge during acceleration (generally called surging)	Disassemble and wash the turbocharger.
2. Rotating parts contacting	Disassemble and repair or replace the turbocharger.

Abnormal Vibration	
Possible Cause	**Corrective Action**
1. Loose intake, exhaust or oil pipe connection to the turbocharger	Check pipe connections of the turbocharger and repair as needed.
2. Damage on the turbine wheel or compressor impeller caused by contact between rotating parts and adjacent parts due to damaged bearings or ingestion of foreign debris	Disassemble and repair or replace the turbocharger. If foreign debris is present completely remove it.
3. Unbalanced rotating part	Repair or replace the rotating part.

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Section 10

STARTER MOTOR

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SAFETY PRECAUTIONS

Before you service the starter motor, read the following safety information and review the *Safety Section on page 2-1*.

⚠ WARNING

These safety messages that follow have warning level hazards. These safety messages describe a hazardous situation, which, if not avoided, *could* result in death or serious injury.

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

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

NOTICE

NEVER engage the starter motor while the engine is running. Damage to the starter motor pinion and / or ring gear will result.

INTRODUCTION

This section of the *Service Manual* describes the procedures necessary to service the 6LPA-STP2/STZP2 marine engine starter motor.

STARTER SPECIFICATIONS

Special Torque Chart

Component	Specification
Starter housing, magnetic switch	95 kgf·cm, 9.32 N·m (82.4 lb-in.)
End cover, starter housing	95 kgf·cm, 9.32 N·m (82.4 lb-in.)
Lead wire, terminal 50	41 kgf·cm, 4.02 N·m (35.5 lb-in.)
Lead wire, terminal C	215 kgf·cm, 21.08 N·m (186.5 lb-in.)

STARTER

Components

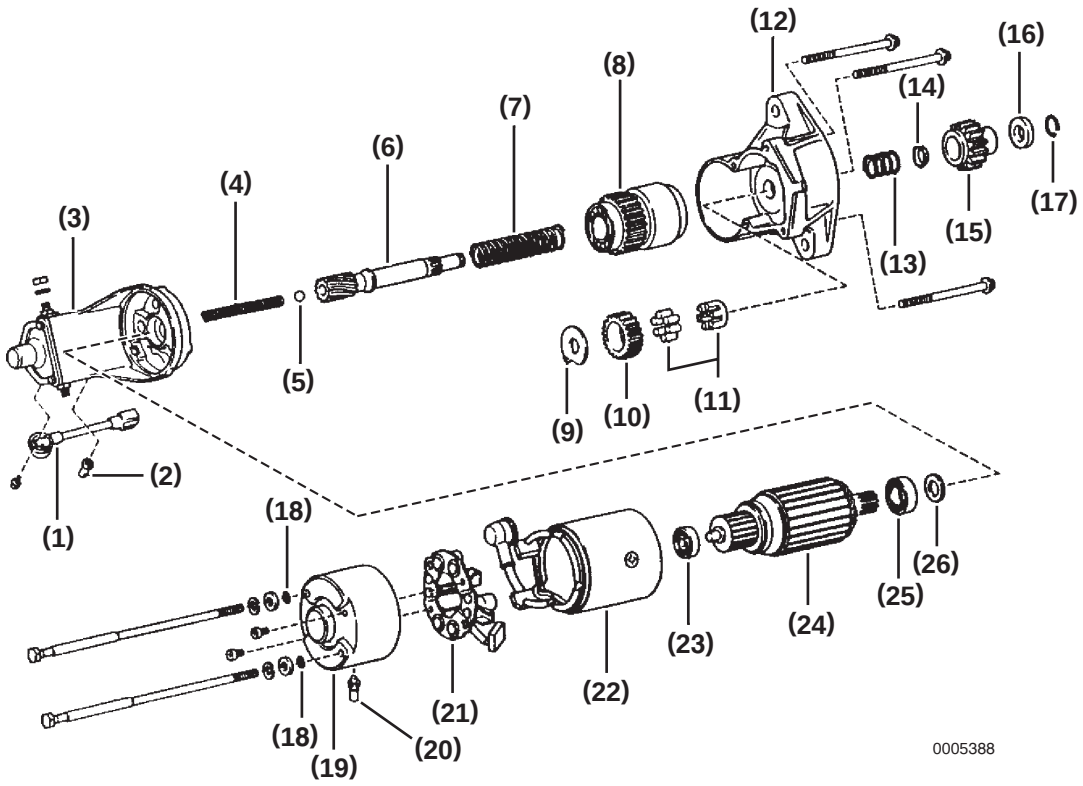

Figure 10-1

1 – Lead Wire
2 – Dust Protector
3 – Magnetic Switch
4 – Return Spring
5 – Steel Ball
6 – Clutch Shaft
7 – Compression Spring
8 – Starter Clutch
9 – Plate Washer
10 – Idle Gear
11 – Bearing
12 – Starter Housing
13 – Compression Spring
14 – Retainer
15 – Pinion Gear
16 – Stop Collar
17 – Snap Ring
18 – O-ring (Non-Reusable part)
19 – End Cover
20 – Dust Protector
21 – Brush Holder
22 – Field Coil Frame
23 – Front Bearing
24 – Armature
25 – Rear Bearing
26 – Felt Washer

Starter Disassembly

1. Remove the terminal nut and disconnect the lead wire from the magnetic switch terminal **(Figure 10-2)**.

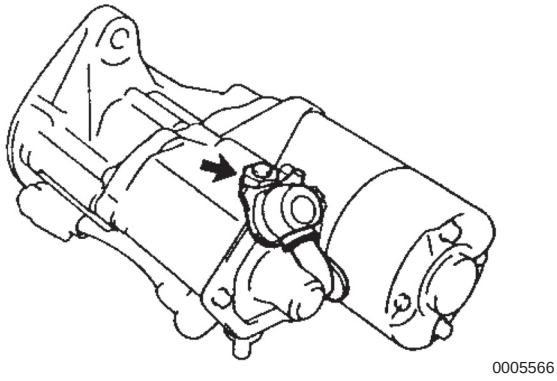

Figure 10-2

2. Remove the screw, washer and lead wire from terminal 50 **(Figure 10-3, (1))**.

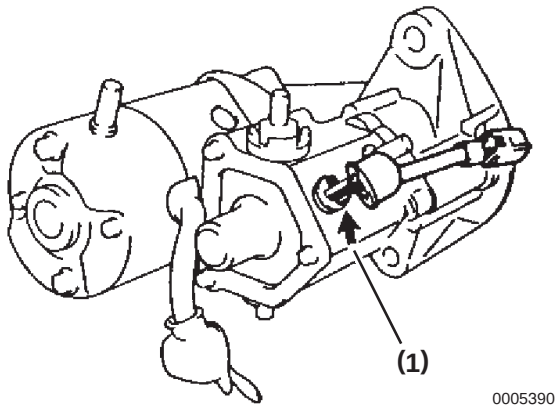

Figure 10-3

3. Remove the 2 through bolts **(Figure 10-4, (1))** and spring washers then pull the field coil frame from the magnetic switch, together with the armature and remove the felt washer from the rear bearing.

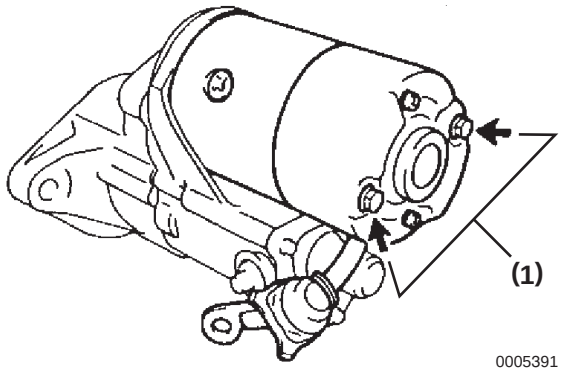

Figure 10-4

4. Remove the 3 screws **(Figure 10-5, (1))** from the starter housing and then remove the starter housing and clutch assembly, return spring, plate washer, bearing and idler gear from the magnetic switch assembly **(Figure 10-6)**.

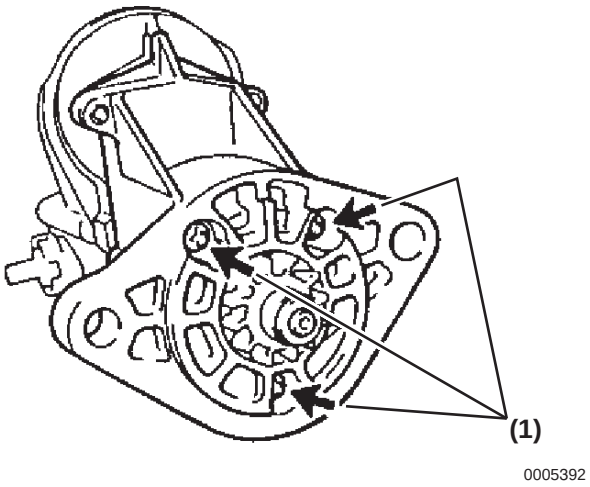

Figure 10-5

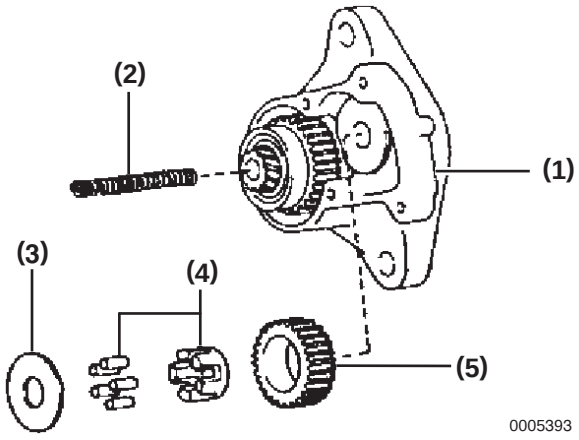

Figure 10-6

1 – Starter Housing and Clutch Assembly
2 – Return Spring
3 – Plate Washer
4 – Bearing
5 – Idler Gear

5. Remove the steel ball through the clutch shaft hole using a magnet **(Figure 10-7)**.

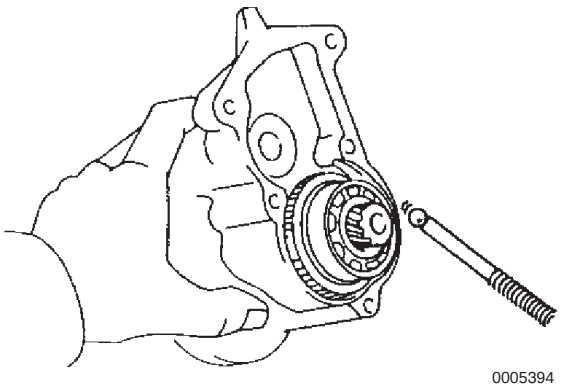

Figure 10-7

6. Remove the 2 screws **(Figure 10-8, (1))** and end cover from the field frame.

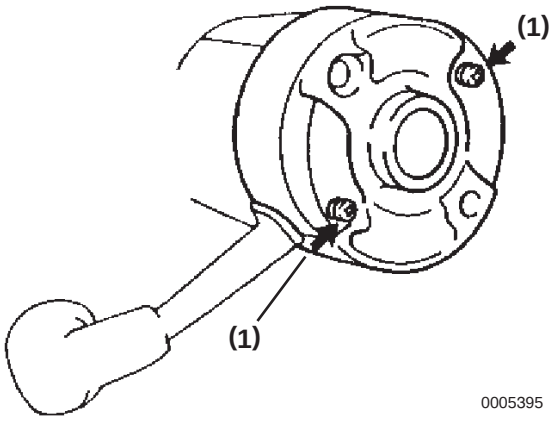

Figure 10-8

7. Secure the rear of the spring tang using a screwdriver **(Figure 10-9)** and remove the brush from the brush holder. Remove the 4 brushes and then the brush holder.

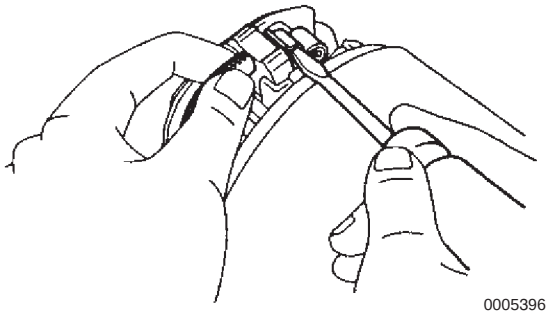

Figure 10-9

8. Remove the armature **(Figure 10-1, (24))** from the field coil frame **(Figure 10-1, (22))**.

Starter Inspection and Testing

Armature

1. Using an ohmmeter **(Figure 10-10, (1))** check the commutator for continuity between the commutator segments. If segments are electrically open, replace the armature.

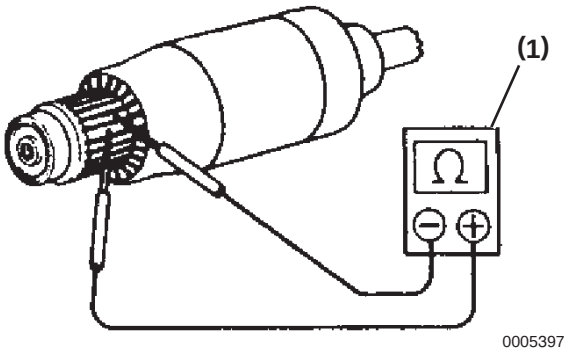

Figure 10-10

2. Using an ohmmeter **(Figure 10-11, (1))** check the commutator for continuity between the commutator and armature coil. If electrical continuity is measured, replace the armature.

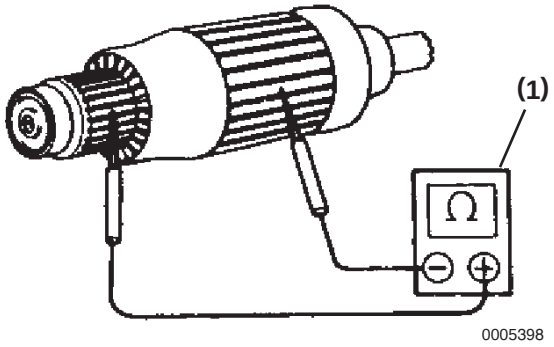

Figure 10-11

3. Inspect the commutator surface for damage, dirt and burning. If the commutator surface is lightly damaged, imperfections may be corrected with #400 emery cloth or by turning on a lathe.
4. Inspect the commutator for radial runout by mounting the commutator on a V-block to measure runout using a dial indicator **(Figure 10-12)**.

   Commutator radial runout:

   - Maximum: 0.05 mm (0.001 in.)

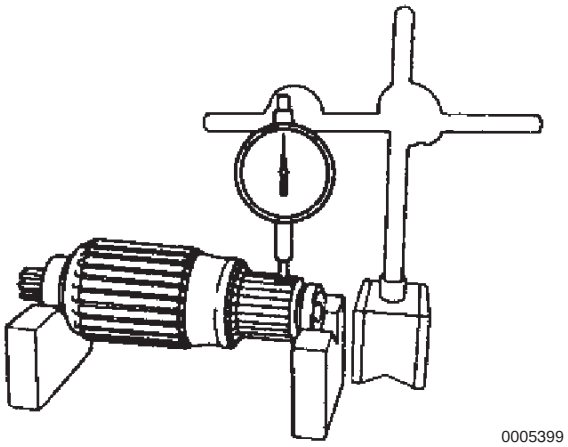

Figure 10-12

5. If the measured value exceeds the specified maximum, correct using a lathe if possible or replace the armature.
6. Measure commutator diameter using calipers **(Figure 10-13)**. If the measured value is less than the specified minimum, replace the armature.

   Commutator diameter:

   - Standard 36.0 mm (1.41 in.)
   - Minimum 35.0 mm (1.37 in.)

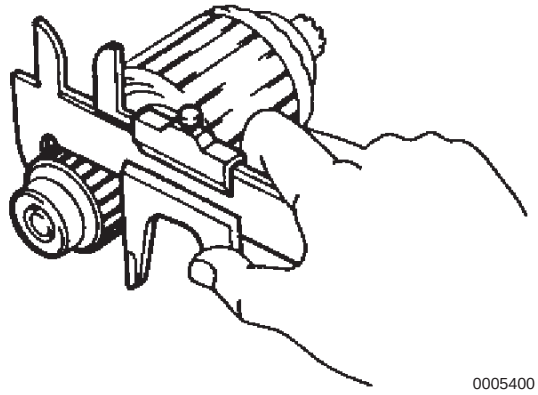

Figure 10-13

7. Check the undercut depth **(Figure 10-14, (1))** for entanglement of foreign matter, if necessary smooth the edges. If the measured undercut depth is less than the specified minimum, correct it with hack saw blade or replace the armature.

   Commutator undercut depth:

   - Standard 0.7 to 0.9 mm (0.027 to 0.035 in.)
   - Minimum 0.2 mm (0.007 in.)

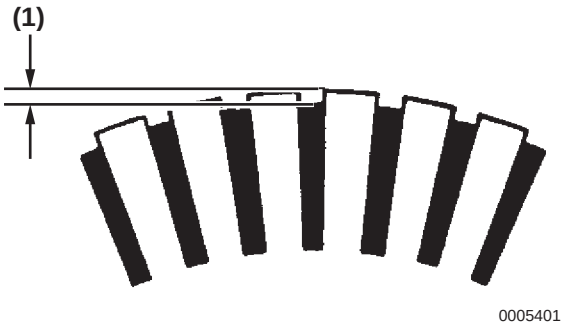

Figure 10-14

Field Coil Frame

1. Using an ohmmeter **(Figure 10-15, (1))** check the field coil frame for continuity between the lead wire and field coil brush. If the circuit is electrically open, replace the field coil frame.

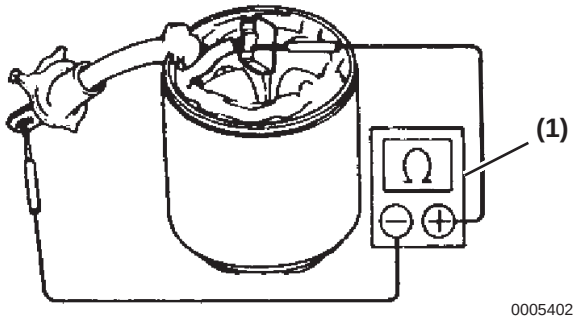

Figure 10-15

2. Using an ohmmeter **(Figure 10-16, (1))** check the field coil frame for continuity between the field coil end and the field coil frame. If continuity is measured, repair or replace the field coil frame.

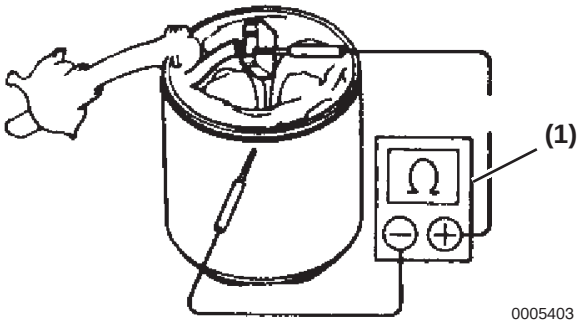

Figure 10-16

Brushes

1. Measure the brush length using calipers **(Figure 10-17)**. If the measured value is less than the specified minimum, replace the brush holder and field coil frame.

   Brush length:

   - Standard 20.5 to 21.0 mm (0.807 to 0.826 in.)
   - Minimum 13.0 mm (0.511 in.)

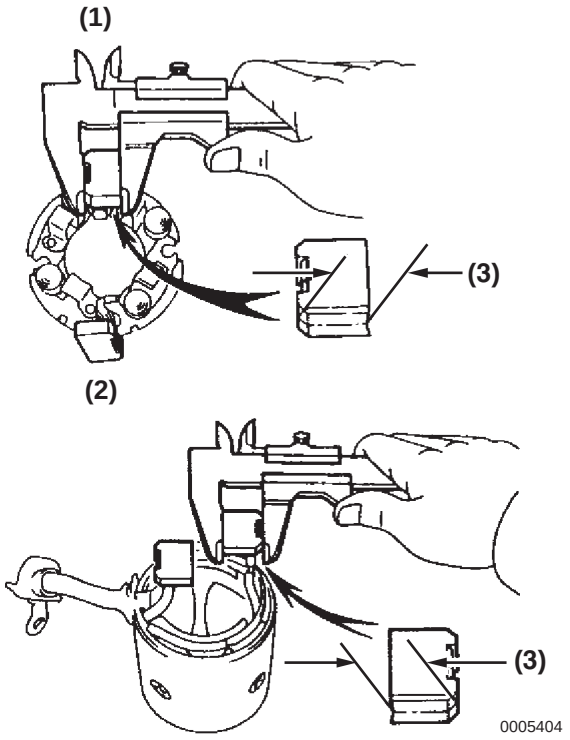

Figure 10-17

1 – Brush Holder Side
2 – Field Coil Frame Side
3 – Brush Coil Length

2. Using a scale check the brush spring load **(Figure 10-18)**. Read the scale when the brush spring just leaves the brush. If the measured mounting load is out of the specified range, replace the brush spring.

   Brush spring mounting load:

   - 1.9 to 3.6 kgf, 18.63 to 35.30 N (4.1 lbf to 7.9 lbf)

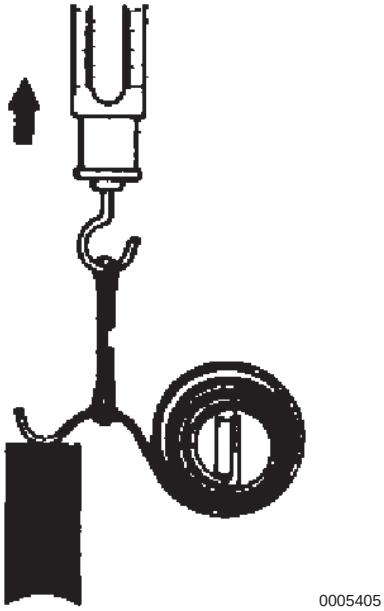

Figure 10-18

3. Using an ohmmeter **(Figure 10-19, (1))** check the brush holder insulation. The circuit between the brush holder positive (+) and negative (-) should not have electrical continuity. If continuity is measured, repair or replace the brush holder.

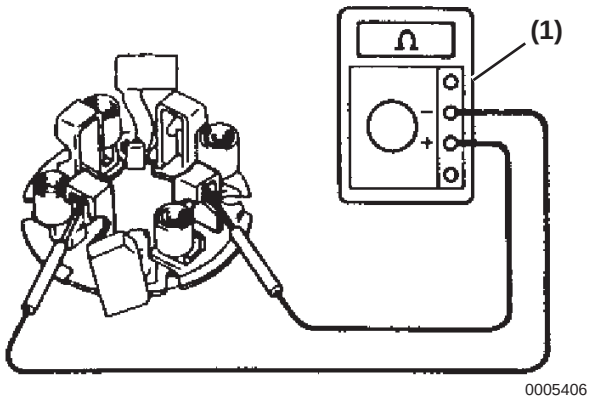

Figure 10-19

Clutch and Gear

1. Inspect the outside tooth surfaces of the pinion gear, idler gear and clutch for damage and wear. If they are damaged, replace the gear or clutch assembly. If any damage is discovered, also check the flywheel ring gear on the engine for damage.
2. Check the clutch pinion gear by securing the starter clutch and turning the pinion gear clockwise **(Figure 10-20, (1))** to check if it turns smoothly. Turn the pinion gear counterclockwise **(Figure 10-20, (2))** to ensure that it is locked. If needed, replace the clutch assembly.

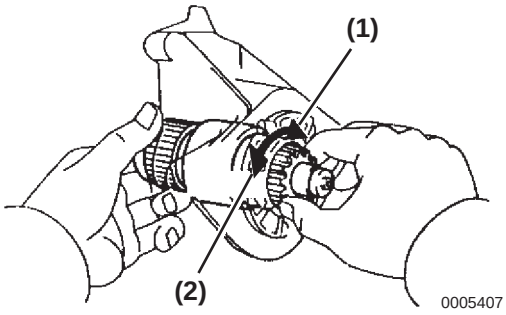

Figure 10-20

Clutch Assembly Replacement

1. Press down the pinion gear and starter housing and tap in the stop collar with a plastic hammer **(Figure 10-21)**.

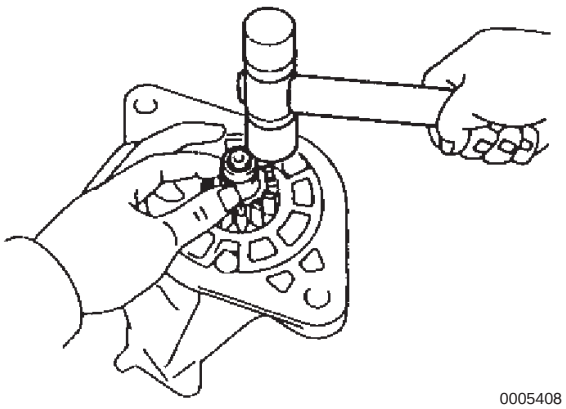

Figure 10-21

2. Pry the snap ring off using a screwdriver **(Figure 10-22)** and then disassemble the starter housing and clutch assembly.

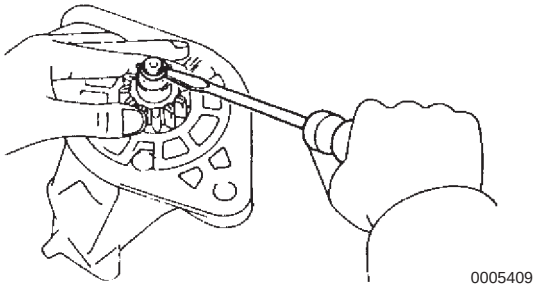

Figure 10-22

3. Remove the stop collar, pinion gear, retainer, spring, starter housing, starter clutch, compression spring and clutch shaft from the starter housing and clutch assembly **(Figure 10-23)**.

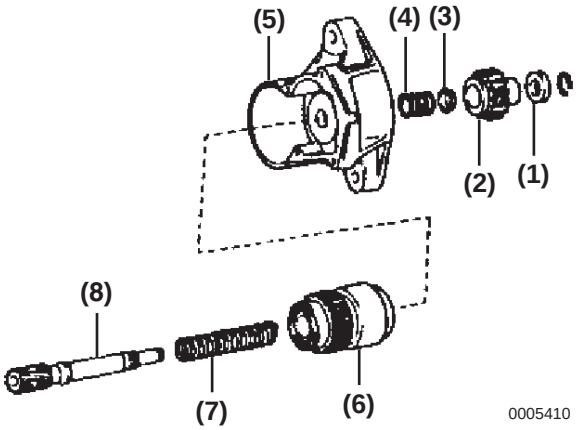

Figure 10-23

1 – Stop Collar
2 – Pinion Gear
3 – Retainer
4 – Spring
5 – Starter Housing
6 – Starter Clutch
7 – Compression Spring
8 – Clutch Shaft

4. Reassemble the starter housing and clutch assembly by assembling the clutch shaft, spring and starter clutch **(Figure 10-24)**.

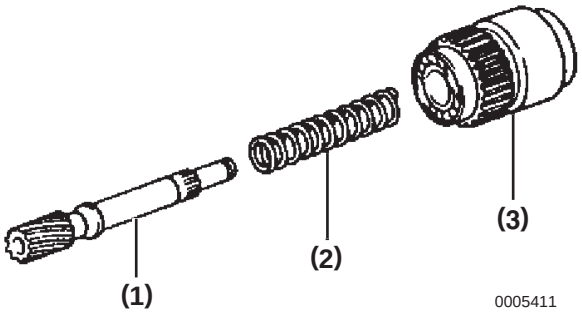

Figure 10-24

1 – Clutch Shaft
2 – Spring
3 – Starter Clutch

5. Reassemble the clutch shaft and starter clutch assembly, starter housing, compression spring, retainer, pinion gear and stop collar **(Figure 10-25)**.

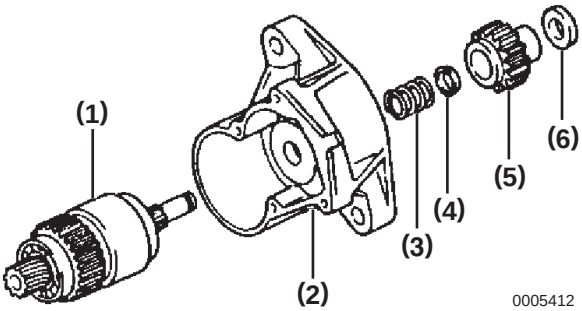

Figure 10-25

1 – Clutch Shaft and Starter Clutch
2 – Starter Housing
3 – Compression Spring
4 – Retainer
5 – Pinion Gear
6 – Stop Collar

6. While pressing down the pinion gear and starter housing, install the new snap ring using snap ring pliers. Check that the snap ring is installed completely in position **(Figure 10-26)**.

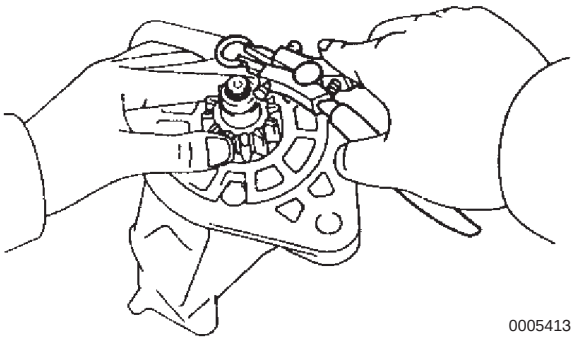

Figure 10-26

7. Tap in the clutch shaft with a plastic hammer and install the stop collar onto the snap ring **(Figure 10-27)**.

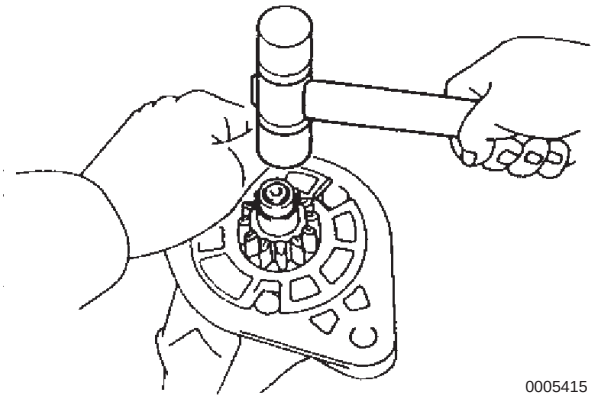

Figure 10-27

Bearing

1. Inspect the bearing by manually turning **(Figure 10-28)** the bearing while applying an inwards force. If you feel resistance or play in the bearing, replace the bearing.

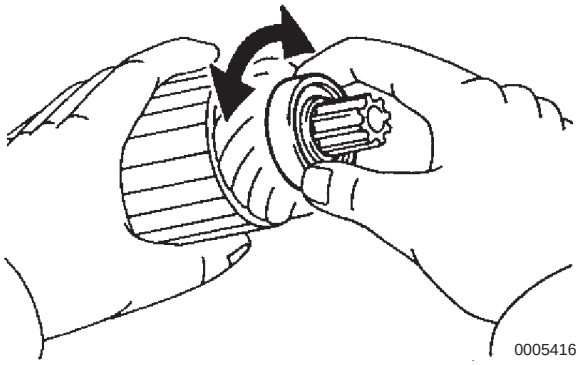

Figure 10-28

Replacing Bearing

1. Remove the front and rear bearings using a special tool **(Figure 10-29)**.

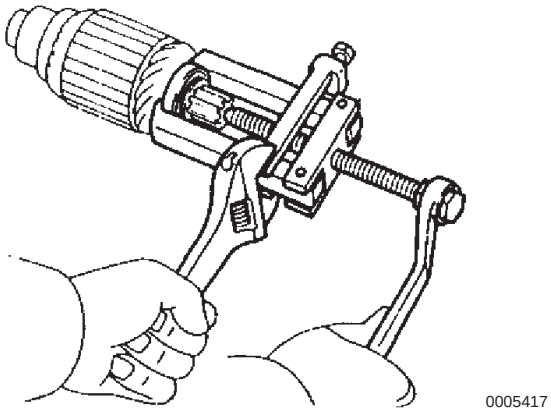

Figure 10-29

2. Press in a new front and rear bearing using the a press **(Figure 10-30)**.

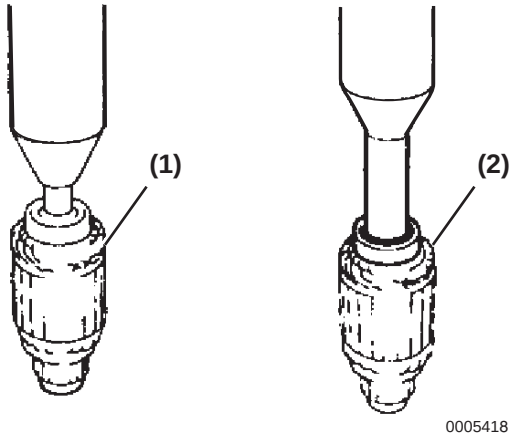

Figure 10-30

1 – Front Bearing
2 – Rear Bearing

Magnetic Switch

1. Using an ohmmeter **(Figure 10-31, (1))** check the continuity of the pull-in coil circuit between terminals 50 **(Figure 10-31, (2))** and C **(Figure 10-31, (3))**. If no electrical continuity is measured, replace the magnetic switch.

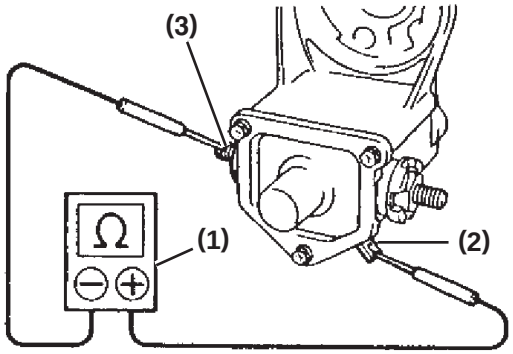

Figure 10-31

2. Using an ohmmeter **(Figure 10-32, (1))** check the continuity between terminals 50 **(Figure 10-32, (2))** and the switch body **(Figure 10-32, (3))**. If no electrical continuity is measured, replace the magnetic switch.

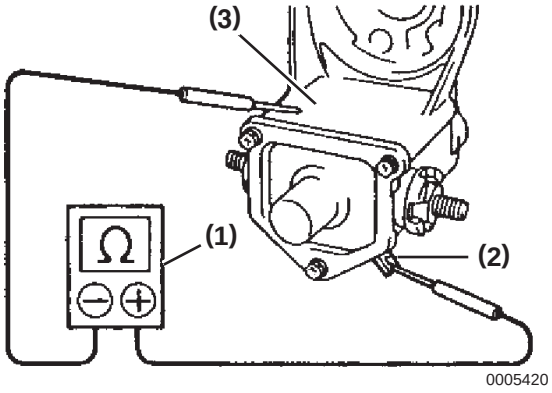

Figure 10-32

Starter Reassembly

1. Apply grease to the armature bearing and install the armature in the field frame **(Figure 10-33)**.

Note: Use high-temperature grease for lubrication of the bearing and gear when reassembling the starter.

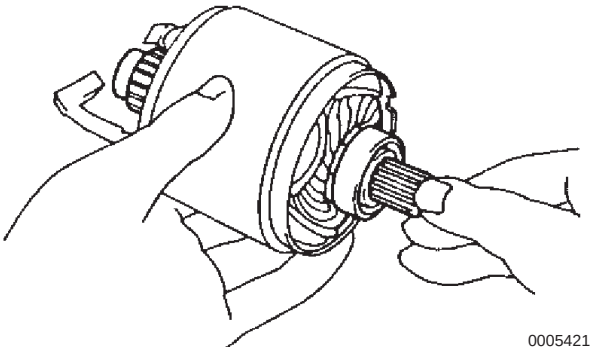

Figure 10-33

2. Install the brush holder to the armature.
3. Install the brush to the brush holder while securing the rear of the brush spring with a screwdriver **(Figure 10-34)**. Connect all four brushes in the same manner.
   NOTICE: Make sure that the positive (+) lead wire is not grounded.

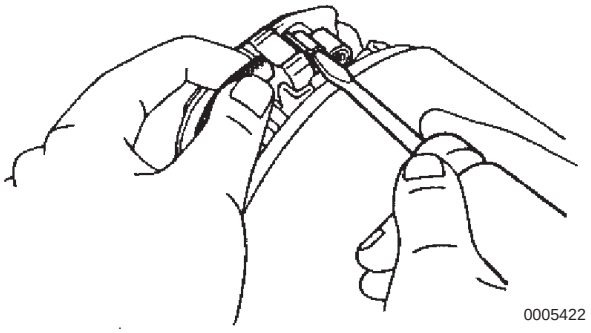

Figure 10-34

4. Install the end cover to the field coil frame using two screws **(Figure 10-35, (1))**.

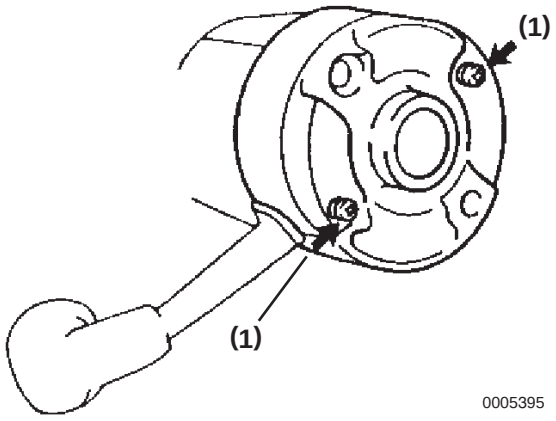

Figure 10-35

5. Apply grease to the steel ball and insert the steel ball into the clutch shaft hole.
6. Apply grease to the return spring and insert the return spring **(Figure 10-36, (1))** into the magnetic switch hole.
7. Install the plate washer **(Figure 10-36, (2))** to the magnetic switch.

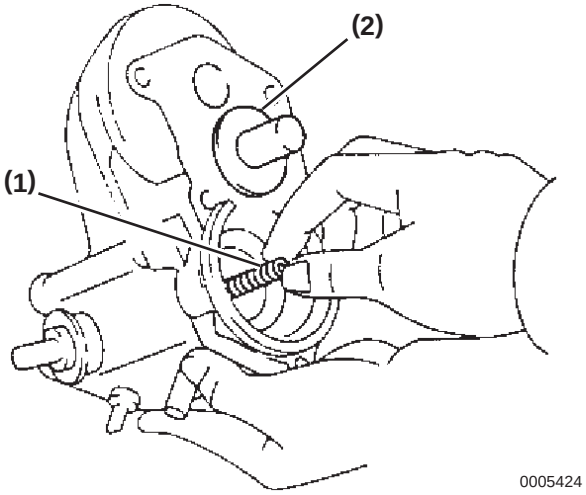

Figure 10-36

8. Install the idler gear **(Figure 10-37, (1))** and bearing **(Figure 10-37, (2))** to the starter housing.

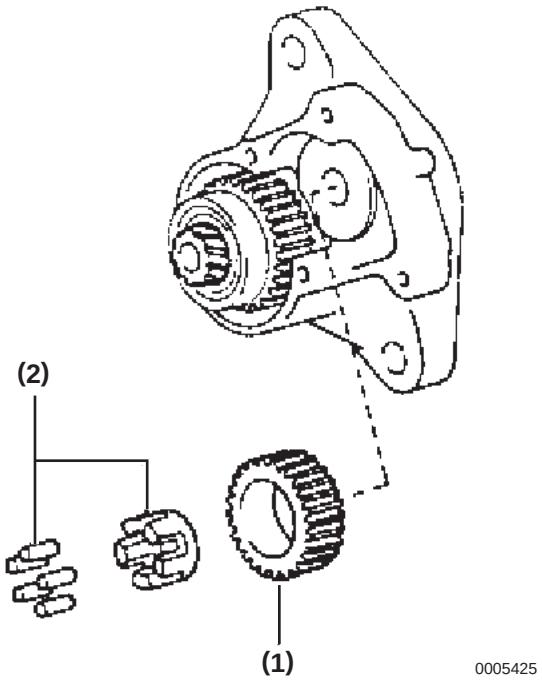

Figure 10-37

9. Assemble the starter housing and magnetic switch assembly, using 3 screws **(Figure 10-38)**.

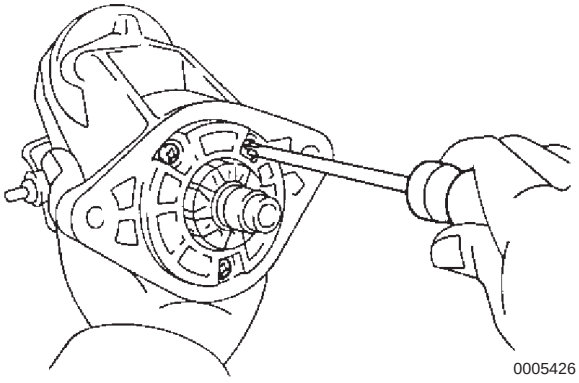

Figure 10-38

10. Install a new felt washer **(Figure 10-39, (1))** to the armature.

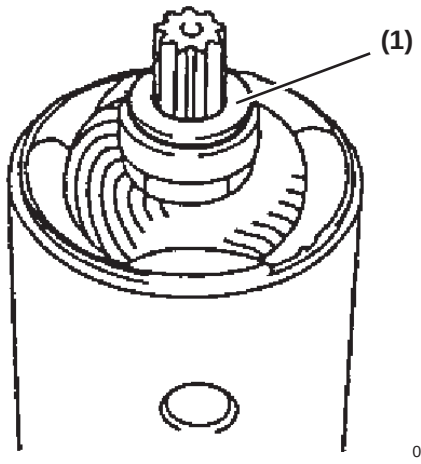

Figure 10-39

11. Align the projection of the field coil frame with the cutout in the magnetic switch **(Figure 10-40)**.

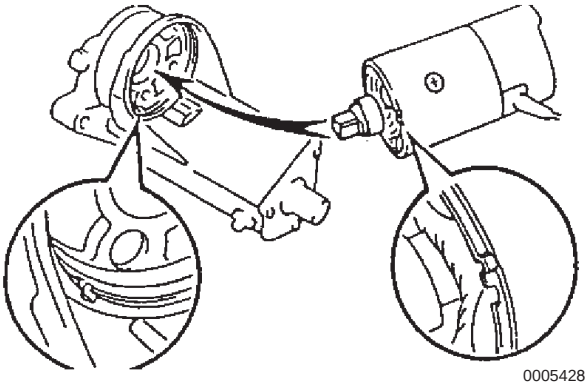

Figure 10-40

12. Assemble the field coil frame and armature assembly using two through bolts **(Figure 10-41, (1))** and torque to 95 kgf·cm, 9.32 N·m (82.4 lb-in.).

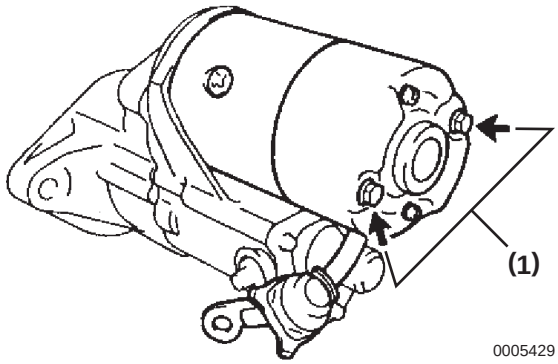

Figure 10-41

13. Connect the lead wire to terminal 50 **(Figure 10-42, (1))** using a screw and washer and torque to 41 kgf·cm, 4.02 N·m (35.5 lb-in.).

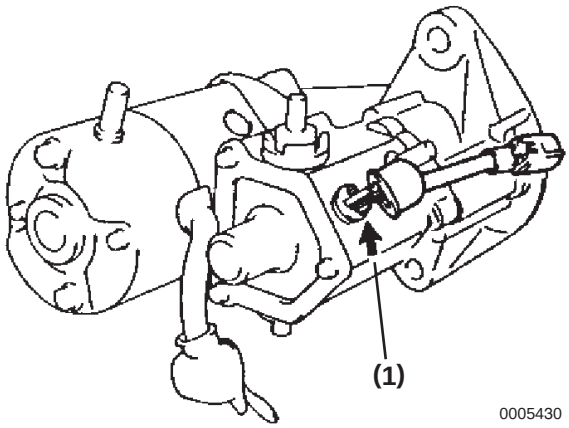

Figure 10-42

14. Connect the lead wire to terminal C **(Figure 10-43, (1))** and install the nut and torque to 215 kgf·cm, 21.08 N·m (186.5 lb-in.).

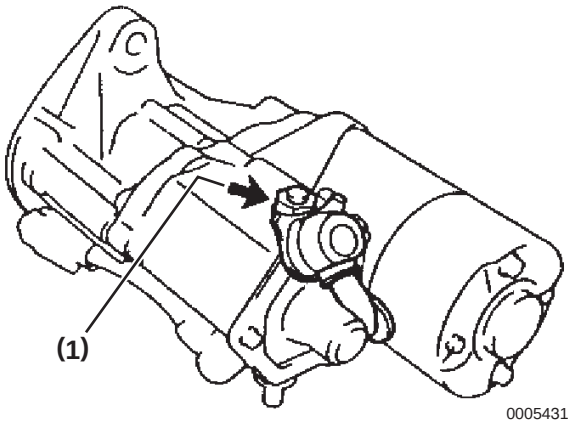

Figure 10-43

Performance Testing

Note: Complete testing within 3 to 5 seconds to avoid burning of the coil.

Pull In Test

1. Disconnect the field coil lead wire **(Figure 10-44, (1))** from terminal C **(Figure 10-44, (2))**.

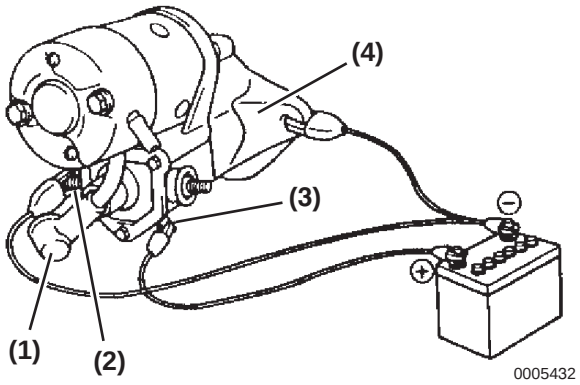

Figure 10-44

2. Connect the battery (+) to the magnetic switch terminal 50 **(Figure 10-44, (3))**. Connect the battery negative (-) lead to the grounded housing **(Figure 10-44, (4))**. Check that the clutch pinion gear moves outwards. If the clutch pinion gear does not move, replace the magnetic switch assembly.

Hold In Test

Under the above condition where the clutch pinion gear is located outside and the battery is connected, disconnect the negative (-) lead **(Figure 10-45, (1))** from terminal C **(Figure 10-45, (2))**. Check that the pinion gear is at the outside. If it has returned to the inside, replace the magnetic switch assembly.

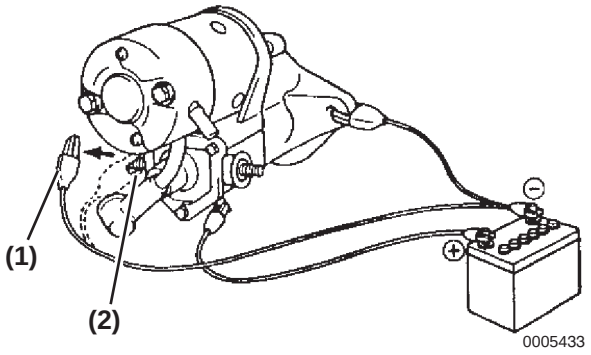

Figure 10-45

Check Return of the Clutch Pinion Gear

Disconnect the negative (-) lead from the switch body **(Figure 10-46, (1))**. Check that the clutch pinion gear returns to the inside. If the clutch pinion gear does not return to the inside, replace the magnetic switch assembly.

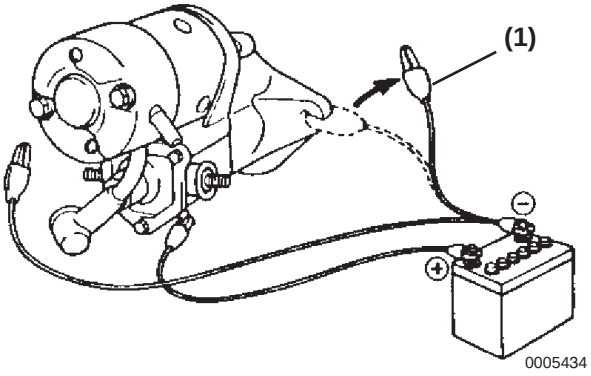

Figure 10-46

No Load Performance Test

1. Connect the battery **(Figure 10-47, (1))** and ammeter **(Figure 10-47, (2))** to the starter.
2. Check that the starter rotates smoothly and that the pinion gear moves outwards.
3. Check current using ammeter. If ammeter reading is not within specifications, check for mechanical drag or component damage of failure.

   Standard no load current:

   - 12V Type - 180A or less at 11.0V
   - 24V Type - 90A or less at 24.0V

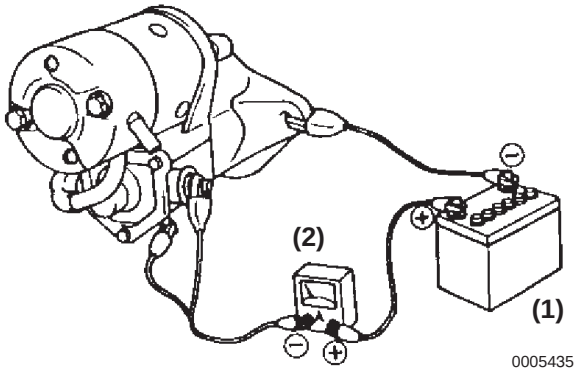

Figure 10-47

Section 11

ALTERNATOR

Page

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SAFETY PRECAUTIONS

Before you service the alternator, read the following safety information and review the *Safety Section on page 2-1*.

⚠ WARNING

These safety messages that follow have WARNING level hazards. These safety messages describe a hazardous situation which, if not avoided, *could* result in death or serious injury.

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

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

NOTICE

NEVER operate the engine if the alternator is producing unusual sounds. Damage to the alternator will result.

NEVER turn the battery switch OFF or disconnect the battery leads from the battery while the engine is operating. Damage to the alternator will result.

NEVER reverse the positive (+) and negative (-) ends of the battery cable when connecting battery cables. The alternator will be damaged.

NEVER use a high-pressure wash directly on the alternator. Water will damage the alternator and result in inadequate charging.

ALWAYS disconnect the battery cables from the battery when charging the battery.

NEVER use a high voltage insulation resistance tester for tests.

INTRODUCTION

This section of the *Service Manual* describes the procedures necessary to service the 6LPA-STP2/STZP2 marine engine alternator.

SPECIFICATIONS

Special Torque Chart

Component	(80A) Specification	(100A) Specification
Alternator Pulley to Rotor	1.125 kgf·cm, 110.32 N·m (81.3 lb-ft)	
Rectifier End Frame to Drive Shaft End Frame	46 kgf·cm, 4.51 N·m (39.9 lb-in.)	
Rectifier Holder to Coil Lead on Rectifier Frame	30 kgf·cm, 2.94 N·m (26.0 lb-in.)	
Rear End Cover to Rectifier Holder	45 kgf·cm, 4.41 N·m (39.0 lb-in.)	46 kgf·cm, 4.51 N·m (40.0 lb-in.)
Plate Terminal to Rectifier Holder	39 kgf·cm, 3.82 N·m (33.8 lb-in.)	
Terminal Insulator to Rectifier Holder	41.5 kgf·cm 4.07 N·m (36.0 lb-in.)	66 kgf·cm 6.47 N·m (57.2 lb-in.)

COMPONENTS

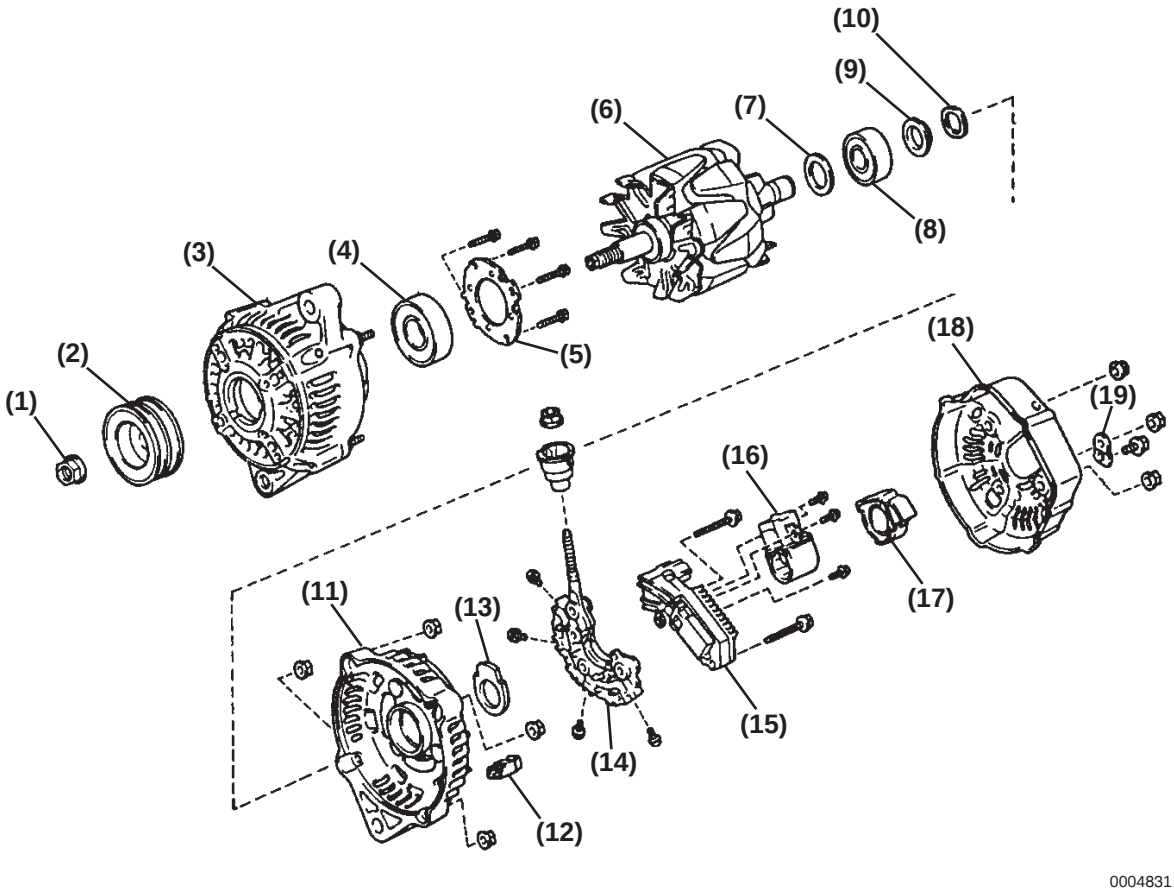

Figure 11-1

1 – Pulley Nut
2 – Pulley
3 – Stator Drive End Frame
4 – Front Bearing
5 – Bearing Retainer
6 – Rotor
7 – Bearing Cover A
8 – Rear Bearing
9 – Bearing Cover B
10 – Alternator Washer
11 – Rectifier End Frame
12 – Rubber Insulator (4 used)
13 – Seal Plate
14 – Terminal Insulator
15 – IC Regulator
16 – Brush Holder
17 – Brush Holder Cover
18 – Rear End Cover
19 – Plate Terminal

WIRING DIAGRAM

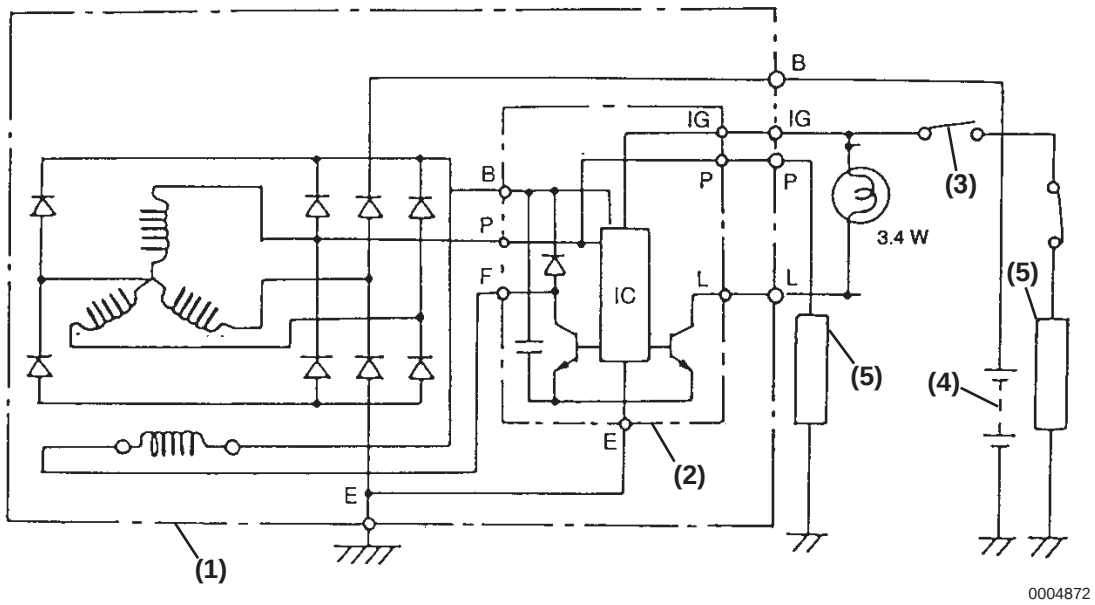

Figure 11-2

1 – Alternator Assembly (Including Regulator)
2 – Regulator Assembly
3 – Key Switch
4 – Battery
5 – Load

TEST AND INSPECTION

Drive Belt Inspection

1. Visually check for cracks, oil on surface, wear and damage. The belt should not contact the bottom of the pulley groove **(Figure 11-3)**. Replace the belt as necessary.

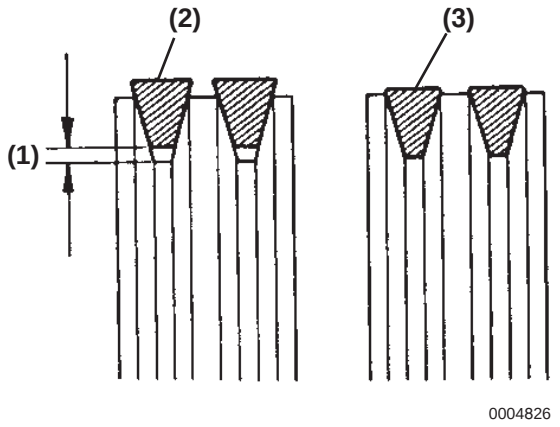

Figure 11-3

1 – Clearance - Pulley to Belt
2 – Correct Belt Running Height
3 – Incorrect Belt Running Height

2. Check drive belt tension by pressing on the drive belt as shown in **(Figure 11-4)** with 10 kgf·cm, 98 N·m (22.0 lbf) of force to check the deflection of the drive belt.

   Drive belt deflection:

   - New Drive Belt (Belt that has less than 5 minutes of usage) 6 to 8 mm (0.236 to 0.314 in.)
   - Used Drive Belt (Belt that has more than 5 minutes of usage) 8 to 11 mm (0.314 to 0.433 in.)

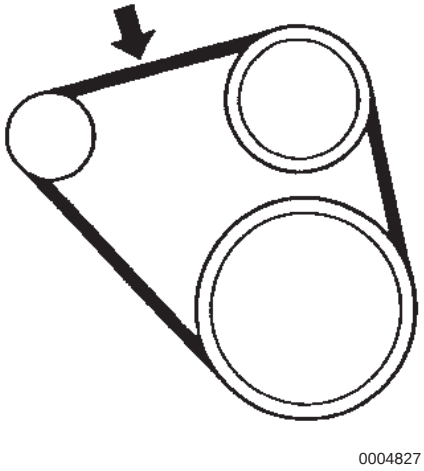

Figure 11-4

3. Adjust or replace the belt if necessary. Operate the engine for 5 minutes and then re-check belt deflection and adjust as needed.

General Inspection

1. Visually check the wiring for damage, proper routing and for loose terminals **(Figure 11-5)**.

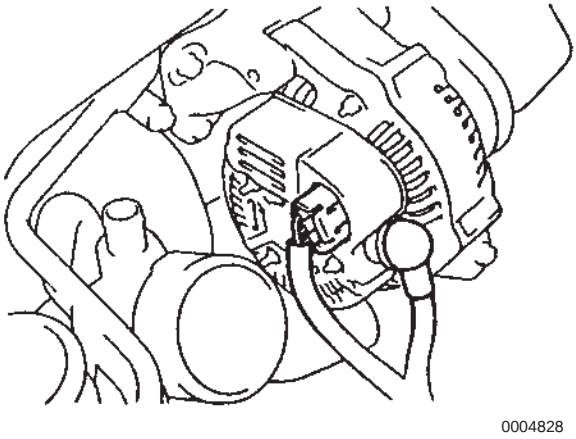

Figure 11-5

2. Check for abnormal sounds generated from the alternator while the engine is running.

Check Discharge Warning Light Circuit

1. Set the start switch to ON and check that the discharge warning light turns on.
2. Start the engine and check that the discharge warning light turns off. If the light fails to operate, repair as necessary.

Check Charging Circuit Under No Load

1. Connect a voltmeter and ammeter to the charging circuit as illustrated in **(Figure 11-6)**. *NOTICE: NEVER operate the engine with the batteries disconnected. Damage to the alternator will result.*

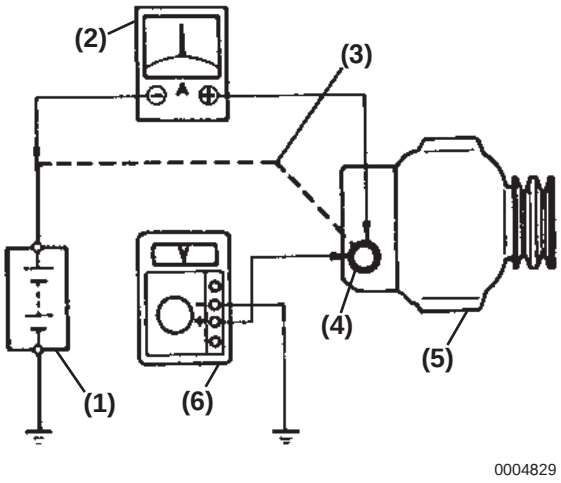

Figure 11-6

1 – Battery
2 – Ammeter
3 – Disconnect lead from terminal B at this point
4 – Terminal B
5 – Alternator
6 – Voltmeter

2. Disconnect the lead from alternator terminal B and connect to the negative (-) lead of ammeter.
3. Connect the positive (+) lead of ammeter to the alternator terminal B.
4. Connect the positive (+) lead of voltmeter to the alternator terminal B.
5. Connect the negative (-) lead of voltmeter to the ground.
6. Start the engine and let it run for a few minutes before carrying out the test.
7. Increase the engine speed to 2000 rpm, and record voltage and current output readings.

   No load:

   - Standard Current - 10A or less
   - Standard Voltage - 14.0 to 15.0V at 25°C (77°F) - 13.5 to 14.3V at 115°C (239°F)
   - If the voltmeter reading exceeds the standard value, replace the IC regulator.
   - If the voltmeter reading is below the specified value, check the IC regulator and alternator as instructed in step 8.
8. Ground terminal F **(Figure 11-7, (1))**, start the engine and check the voltmeter reading at terminal B.
   - If the voltmeter reading exceeds the standard value, replace the IC regulator.
   - If the voltmeter reading is below the specified value, check the alternator.

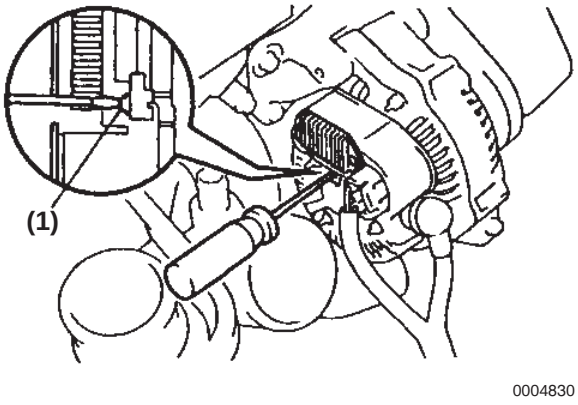

Figure 11-7

Check Charging Circuit Under Load

1. Operate the engine speed at 2000 rpm. Apply a load to the charging circuit.
2. Check the ammeter reading.
3. If the ammeter reading is below the specified value, repair the alternator.

   Standard current under load:

   - 12V 80A to 30A or more
   - 12V 100A to 40A or more

Note: When the battery is in the fully charged state, the indication is below the standard value.

ALTERNATOR SERVICE

Disassembly

1. Remove the terminal nuts and insulator **(Figure 11-8, (1))**.

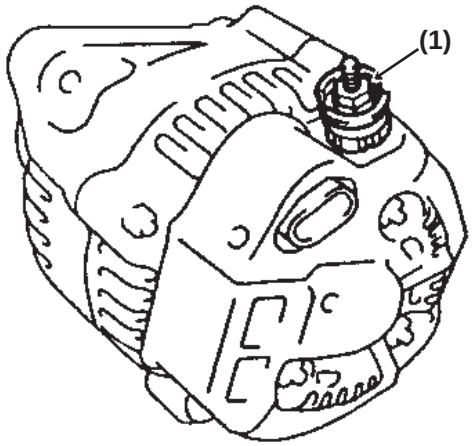

Figure 11-8

2. Remove the 3 nuts **(Figure 11-9, (1))**, bolt **(Figure 11-9, (2))** and plate terminal **(Figure 11-9, (3))** and then remove the rear end cover **(Figure 11-9, (4))**.

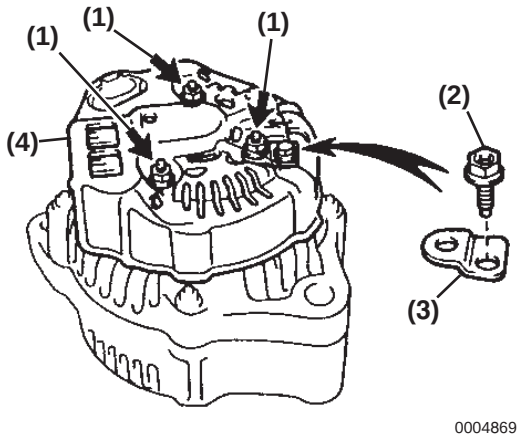

Figure 11-9

3. Remove the brush holder cover and the 5 brush holder screws **(Figure 11-10, (1))**.
4. Remove the IC regulator **(Figure 11-10, (2))**.

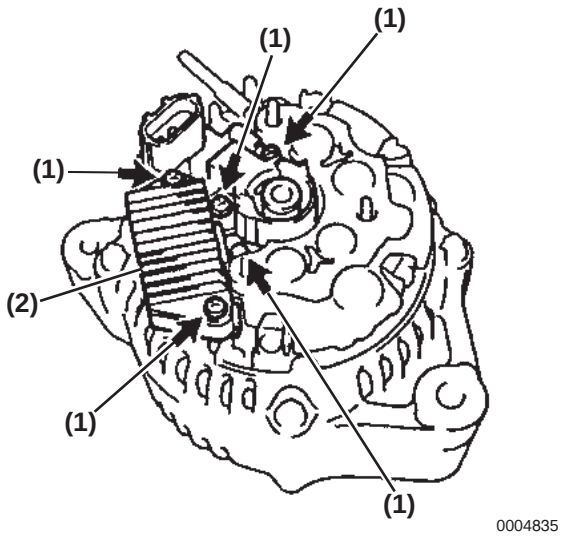

Figure 11-10

5. Remove the seal plate **(Figure 11-11, (1))** from the rectifier end frame.

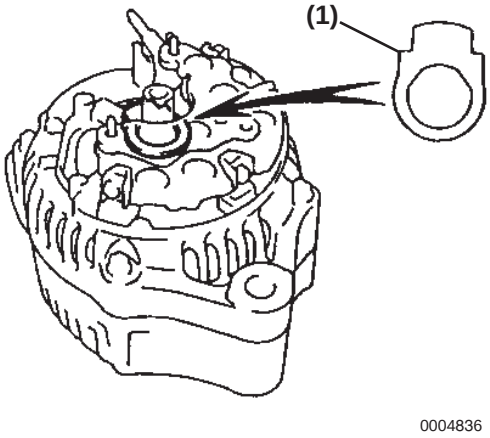

Figure 11-11

6. Remove the 4 rectifier holder screws **(Figure 11-12, (1))** and rectifier holder **(Figure 11-12, (2))**.

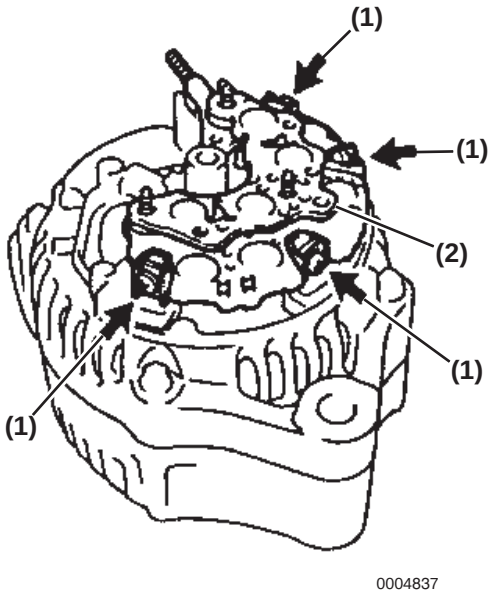

Figure 11-12

7. Remove the 4 rubber insulators **(Figure 11-13, (1))**.

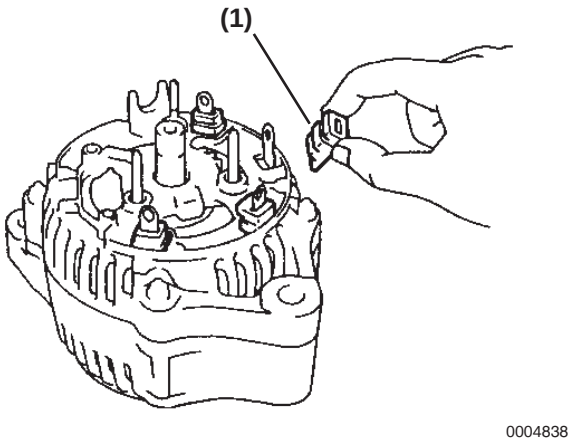

Figure 11-13

8. Install the special pulley nut tool **(Figure 11-14, (1))** in a vise. Using special pulley nut tool **(Figure 11-14, (2))** turn the tool in the direction shown by arrow to loosen the pulley nut.

Note: NEVER loosen the rotor shaft over 1/4 of a turn to prevent damage to the rotor shaft.

9. Remove the pulley nut and pulley.

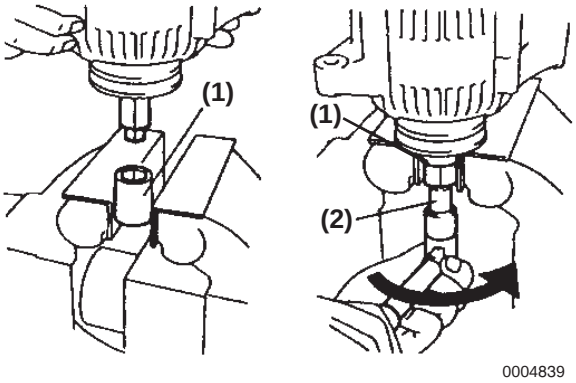

Figure 11-14

10. Remove the 4 rectifier end frame nuts **(Figure 11-15, (1))**.

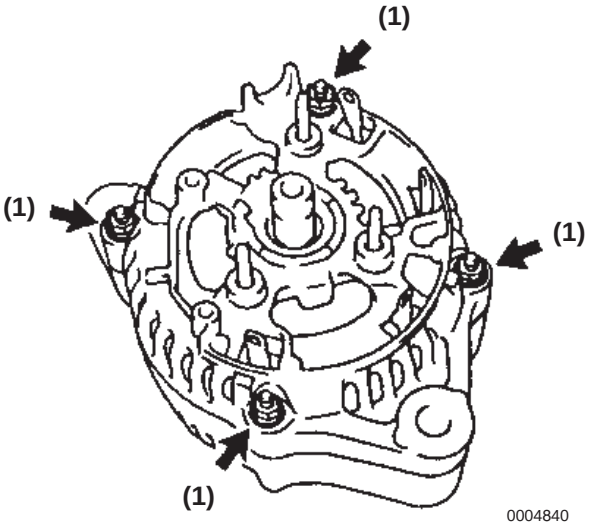

Figure 11-15

11. Using a special two-jaw puller tool **(Figure 11-16, (1))**, remove rectifier end frame.

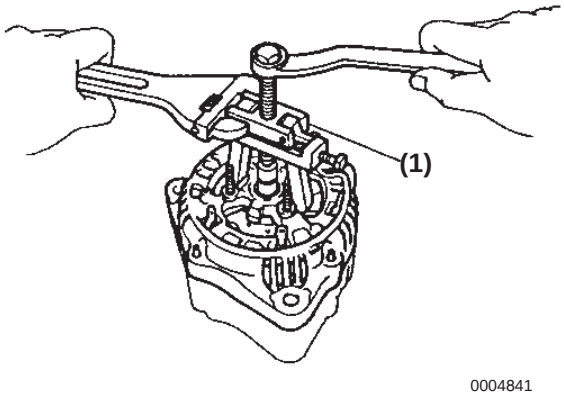

Figure 11-16

12. Remove the alternator washer **(Figure 11-17)**.

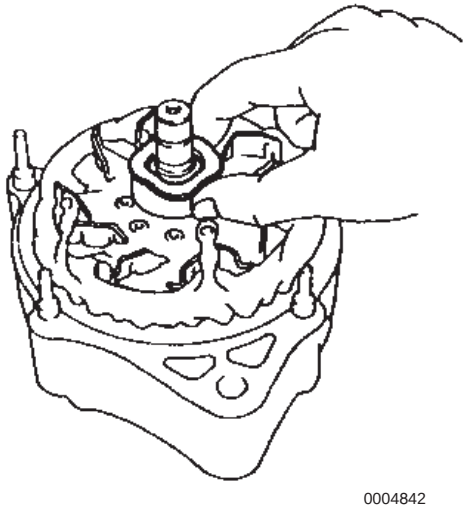

Figure 11-17

13. Remove the rotor from the drive frame.

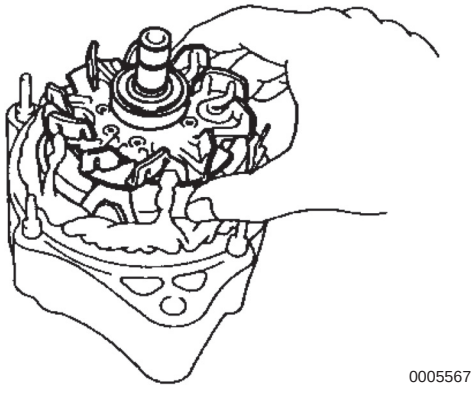

Figure 11-18

Inspection and Testing

Rotor Circuit and Slip Rings

1. Using an ohmmeter **(Figure 11-19, (1))** check the rotor circuit resistance. The rotor circuit should have continuity between the slip rings. If the resistance is not within specifications or there is no continuity replace the rotor.

   Rotor resistance:

   - Standard resistance at 20°C (68°F) is 2.9 ohms

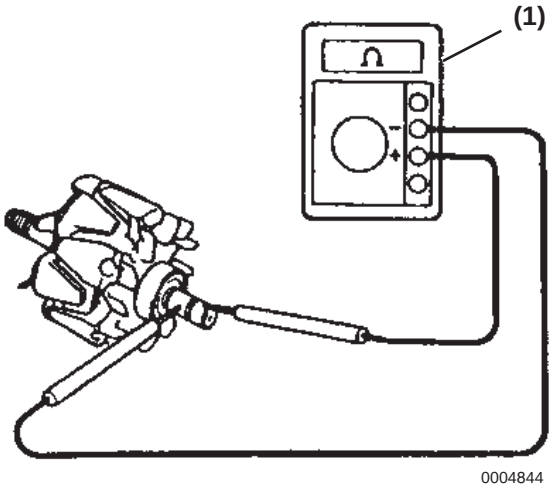

Figure 11-19

2. Using an ohmmeter **(Figure 11-20, (1))** check the rotor circuit for grounds. The rotor circuit between the slip rings and rotor should have no electrical continuity. If continuity is measured, replace the rotor.

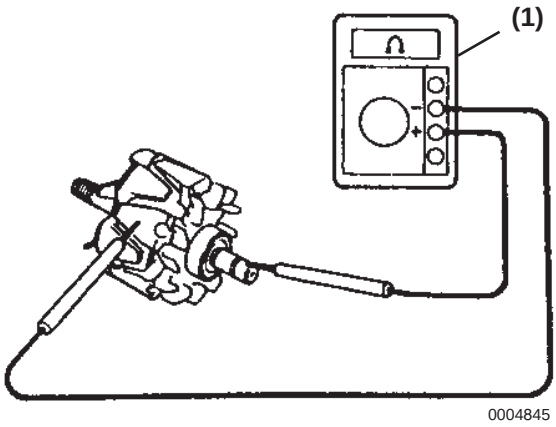

Figure 11-20

3. Inspect the slip rings for damage or scratches on the surface. If the surface is damaged or scratched, replace the rotor.
4. Measure the slip ring diameter using calipers **(Figure 11-21)**. If the slip ring diameter is not within specifications, replace the rotor

   Slip ring diameter:

   - Standard Diameter - 14.2 to 14.4 mm (0.559 to 0.566 in.)
   - Minimum Diameter - 12.8 mm (0.503 in.)

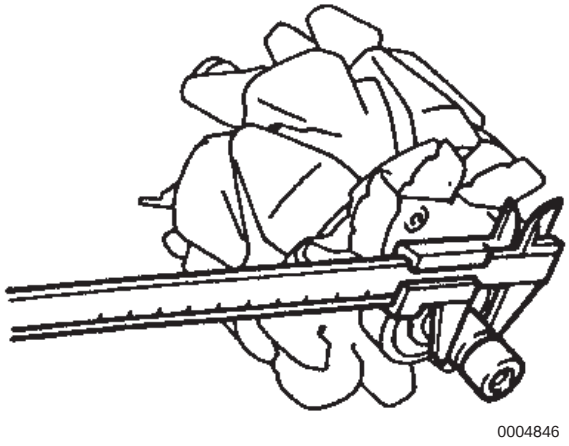

Figure 11-21

Stator Drive End Frame

1. Using an ohmmeter **(Figure 11-22, (1))** check the continuity of the stator drive end frame circuit. The stator circuit should have electrical continuity between the coil leads. If continuity is not measured, replace the drive end frame assembly.

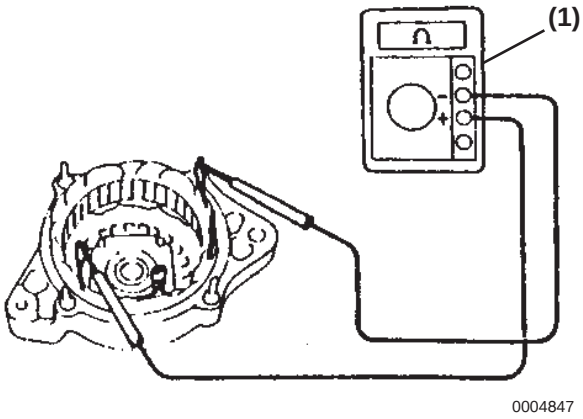

Figure 11-22

2. Using an ohmmeter **(Figure 11-23, (1))** check the stator for shorts to ground. The stator circuit when measured between the coil leads and drive end frame should have no continuity. If continuity is measured, replace the drive end frame assembly.

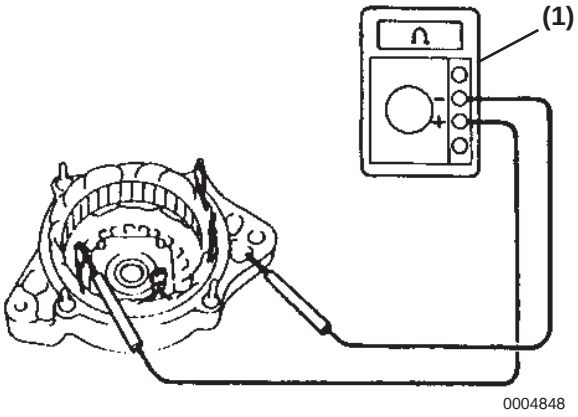

Figure 11-23

Brushes

1. Check the exposed brush length using calipers **(Figure 11-24)**. If the measured length is below the specified minimum, replace the brush holder.

   Brush length:

   - Brush Length (Standard) 10.5 mm (0.413 in.)
   - Brush Length (Minimum) 1.5 mm (0.059 in.)

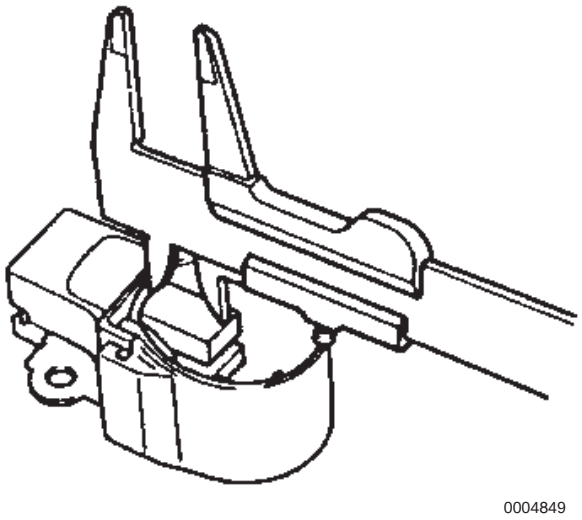

Figure 11-24

Rectifier

1. Check the positive rectifier. Connect one of tester probes of an ohmmeter to the positive (+) terminal **(Figure 11-25, (1))** and the other probe to the rectifier terminal **(Figure 11-25, (2))**.

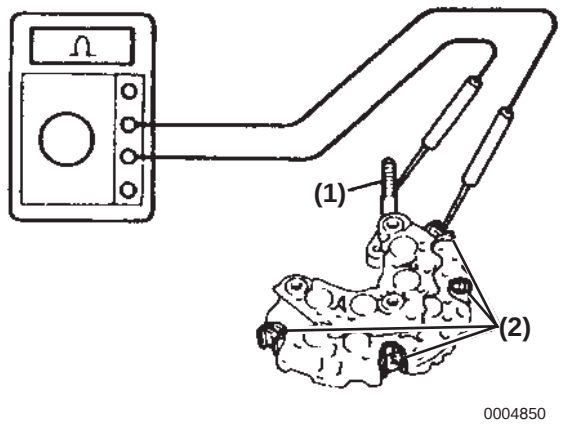

Figure 11-25

2. Reverse polarities of the probes and repeat the procedure.
3. Check that one of continuity shows the state while the other connection results in no continuity state. If the continuity check results are not as described above, replace the rectifier.
4. Check the negative rectifier. Connect one of tester probes of an ohmmeter to the negative (-) terminal **(Figure 11-26, (1))** and the other probe to the rectifier terminal **(Figure 11-26, (2))**.

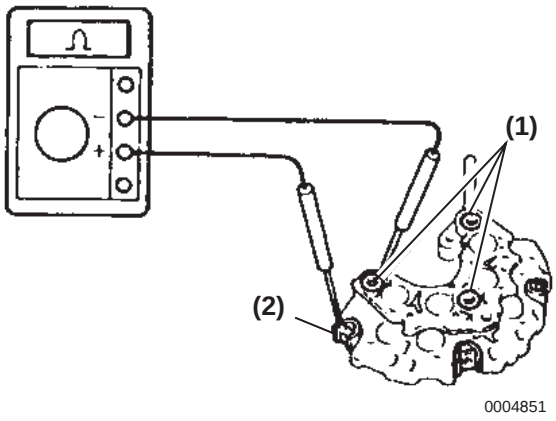

Figure 11-26

5. Reverse polarities of the probes and repeat the procedure.
6. Check that one of connections shows the continuity state while the other connection results in no continuity state. If the continuity check results are not as described above, replace the rectifier holder.

Bearing Service

1. Inspect the front bearing for wear and damage. If necessary replace the front bearing.
2. Remove the 4 bearing retainer screws and bearing retainer **(Figure 11-27)**.

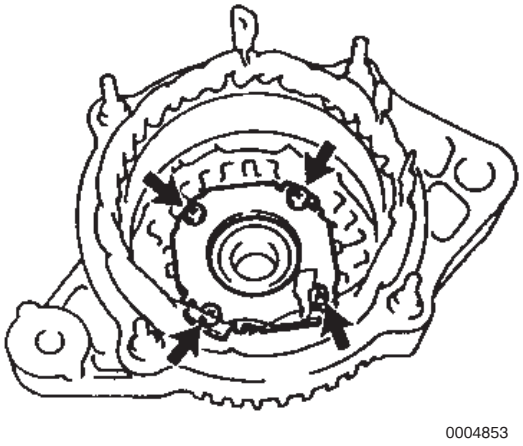

Figure 11-27

3. Press out the old front bearing using the special tool **(Figure 11-28, (1))** and a press.

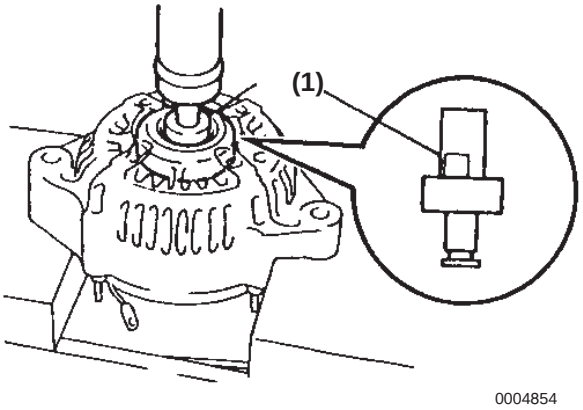

Figure 11-28

4. Press in a new bearing using the special tool **(Figure 11-29, (1))** in the same manner and then install the 4 bearing retainer screws.

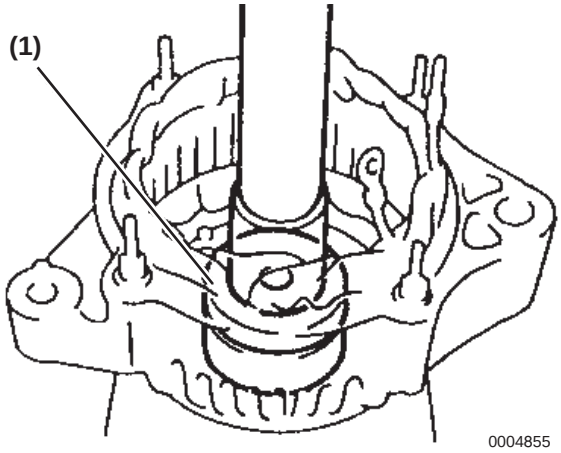

Figure 11-29

5. Rotate and inspect the rear bearing for wear and damage. If necessary replace the rear bearing **(Figure 11-30)**.

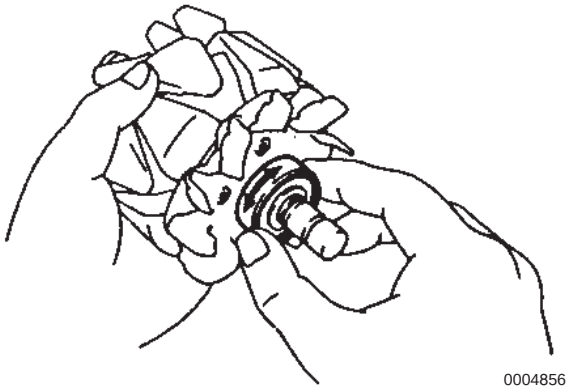

Figure 11-30

6. Remove the rear bearing cover B and remove the bearing using a special two-jaw puller tool **(Figure 11-31, (1))**. *NOTICE: Avoid damaging the fan during bearing removal.*

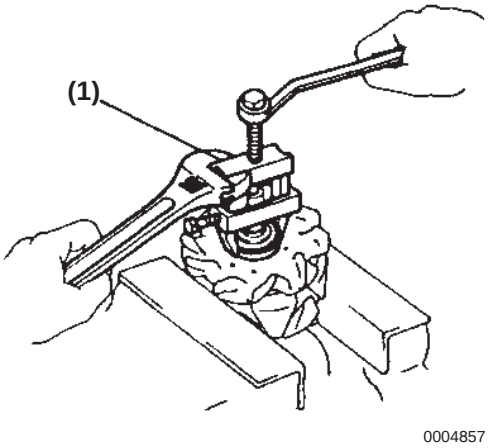

Figure 11-31

7. Remove the rear bearing cover A and inspect and replace if necessary.

8. Install the rear bearing cover A **(Figure 11-32, (1))**.

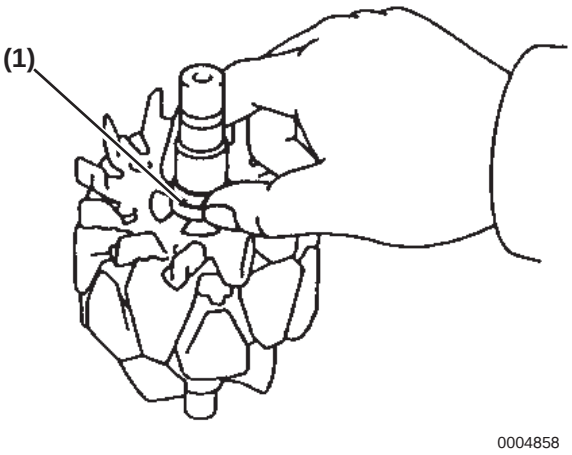

Figure 11-32

9. Press in a new bearing using the special tool **(Figure 11-33, (1))** and a press.

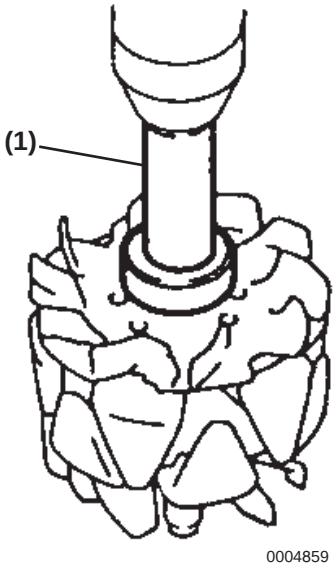

Figure 11-33

10. Install bearing cover B using the special tool **(Figure 11-34, (1))**.

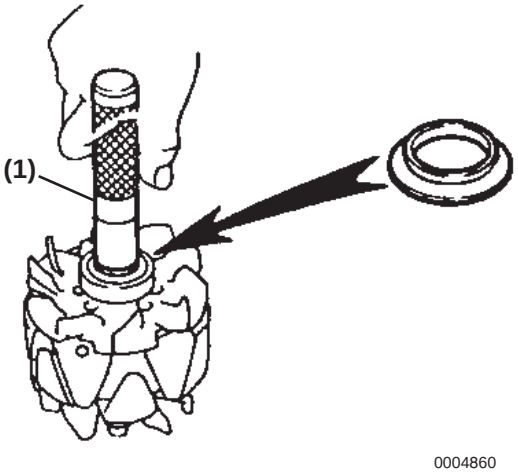

Figure 11-34

Assembly

1. Install the rotor assembly into the drive end frame and install the pulley to the shaft **(Figure 11-35)**.

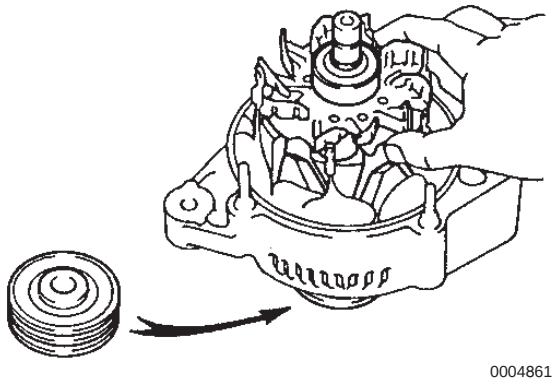

Figure 11-35

2. Install the rectifier end frame onto the rotor and drive end frame then install the alternator washer **(Figure 11-36, (1))** above the rotor.

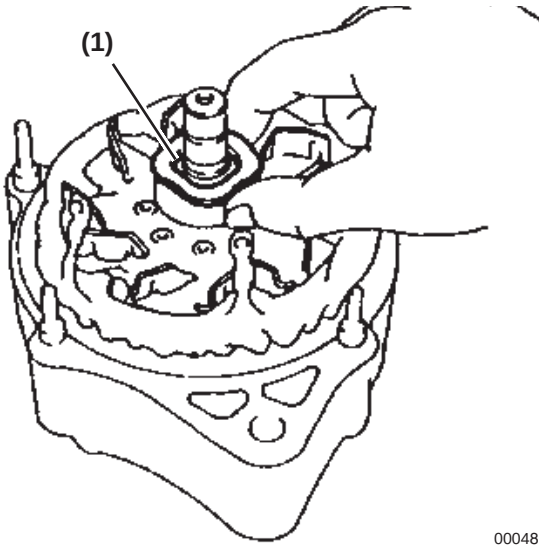

Figure 11-36

3. Slowly press on the rectifier end frame using a 29 mm socket wrench and a press **(Figure 11-37, (1))**.

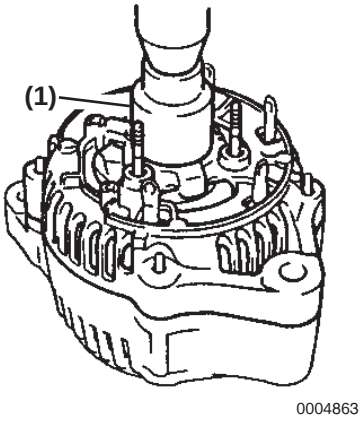

Figure 11-37

4. Install the 4 nuts **(Figure 11-38, (1))** and torque to: 46 kgf·cm, 4.51 N·m (39.9 lb-in.).

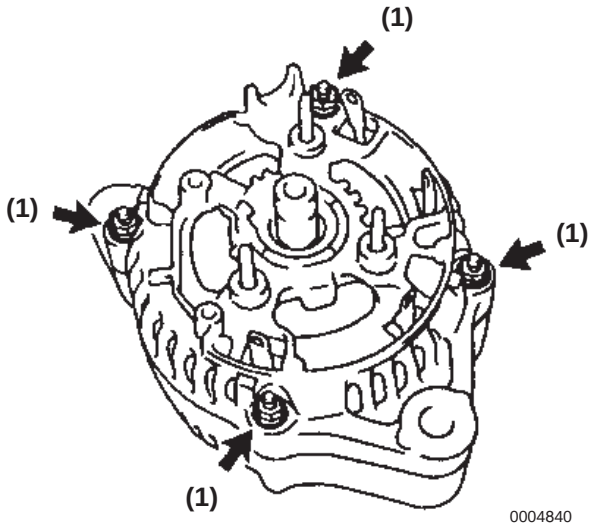

Figure 11-38

5. Manually tighten the pulley nut to secure the pulley to the rotor shaft.

6. Using the special nut holder tool **(Figure 11-39, ((1))** installed into a vice, torque the pulley nut **with special tool (Figure 11-39, (2))** to: 1.125 kgf·cm, 110.32 N·m (81.3 lb-ft).

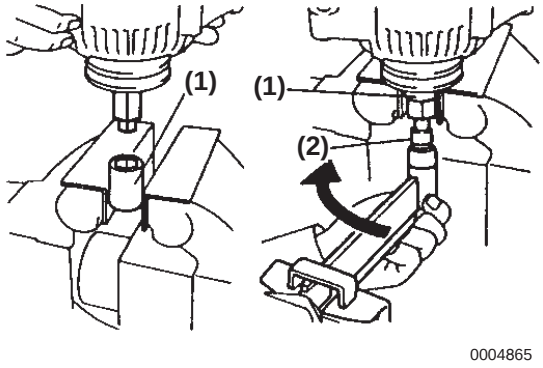

Figure 11-39

7. Install the rectifier holder and 4 rubber insulators **(Figure 11-40, (1))** above lead wires.

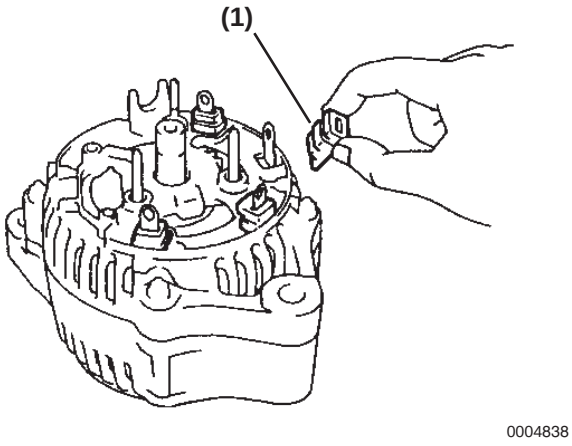

Figure 11-40

8. Install the rectifier holder **(Figure 11-41, (2))** with 4 bolts **(Figure 11-41, (1))** while pushing it downwards. Torque bolts to: 30 kgf·cm, 2.94 N·m (26.0 lb-in.).

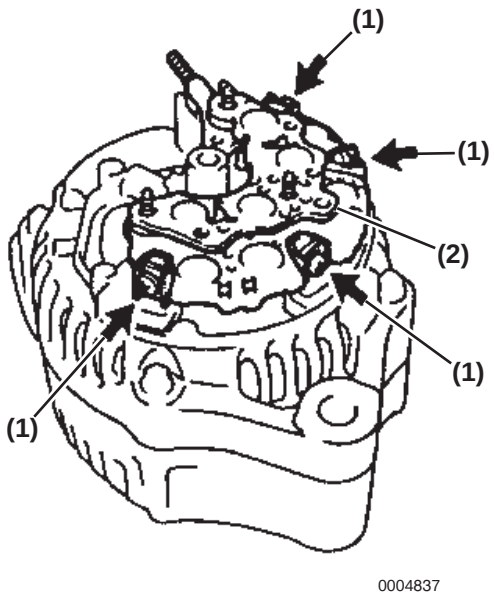

Figure 11-41

9. Install the seal plate on the rectifier end frame and then the IC regulator and brush holder in an upward direction **(Figure 11-42)**.
10. Tighten the 5 bolts and then install the brush holder cover above the brush holder.

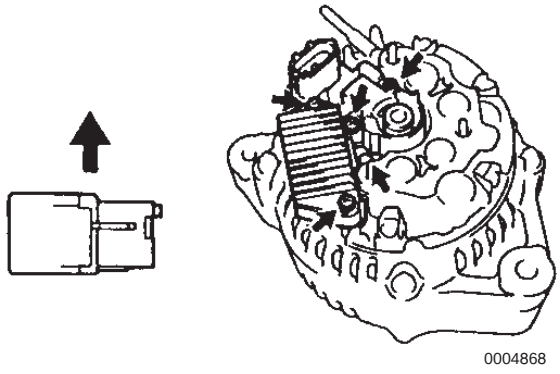

Figure 11-42

11. Install the rear cover **(Figure 11-43, (4))** and plate terminal **(Figure 11-43, (3))** using 3 nuts **(Figure 11-43, (1))** and a bolt **(Figure 11-43, (2))**.
    Torque the bolt to:
    39 kgf·cm, 3.82 N·m (33.8 lb-in.).

    Torque the nuts to:
    80A Models: 45 kgf·cm, 4.41 N·m (39.0 lb-in.)
    100A Models: 46 kgf·cm, 4.51 N·m (40.0 lb-in.)

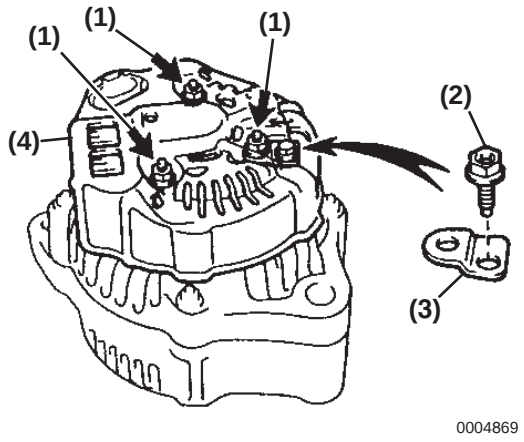

Figure 11-43

12. Install the terminal insulator and nut **(Figure 11-44, (1))**.
    Torque the nut to:
    80A Models: 41.5 kgf·cm, 4.07 N·m (36.0 lb-in.)
    100A Models: 66 kgf·cm, 6.47 N·m (57.2 lb-in.)

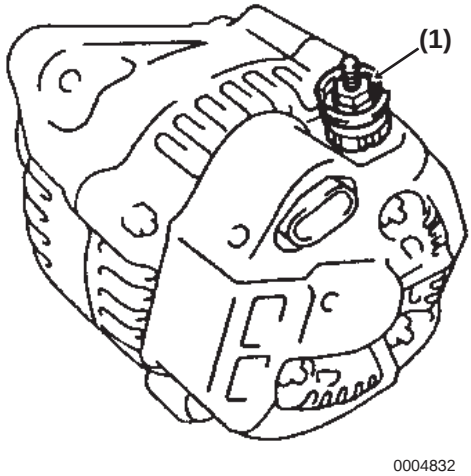

Figure 11-44

13. After final assembly, rotate the rotor pulley to ensure the rotor rotates smoothly **(Figure 11-45)**.

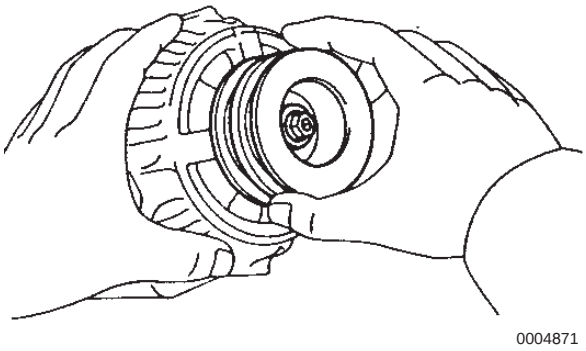

Figure 11-45

Section 12

TROUBLESHOOTING

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SAFETY PRECAUTIONS

Before you service the 6LPA-STP2/STZP2 marine engines, read the following safety information and review the *Safety Section on page 2-1*.

⚠ WARNING

The safety messages that follow have WARNING level hazards. These safety messages describe a hazardous situation which, if not avoided, *could* result in death or serious injury.

Exhaust Hazard

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.

Shock Hazard

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

Fire and Explosion Hazard

Diesel fuel is flammable and explosive under certain conditions.

NEVER use a shop rag to catch the fuel.

Wipe up all spills immediately.

Piercing Hazard

Avoid skin contact with high-pressure diesel fuel spray caused by a fuel system leak such as a broken fuel injection line. 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. Have your authorized Yanmar marine dealer or distributor repair the damage.

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.

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.

INTRODUCTION

This section contains information and diagnostic troubleshooting charts to accurately diagnose and engine, starter, or alternator problem.

TROUBLESHOOTING CHART

Symptom	Probable Cause	Measure
Engine does not start or starts with difficulty:		
Pinion gear does not engage	Loose terminal of battery / engage magnet	Tighten
	Poor contact of starting switch	Correct with sandpaper or replace
	Open coil of magnet switch	Replace
	Rough operation of shifter	Correct with sandpaper and apply grease
	Burr at gear tooth tip	Correct
	Poor clearance between pinion and ring gear	Correct
	Damaged starter bearing	Replace
Pinion gear is engaged with ring gear, but does not rotate	Loose battery / starter terminal	Tighten
	Poor contact of engage magnet switch	Correct with sandpaper
	Worn brush	Replace
	Dirty or rough surface of rectifier	Correct with sandpaper #500 to #600
	Open circuit of starter coil	Replace
	Worn rectifier	Replace
	Slippage of starter / clutch	Replace
	Excessive resistance of cable between battery and starter	Increase the cable size or shorten
	Insufficient battery charge	Charge
No fuel injection	Incomplete priming of fuel system	Carry out sufficient priming
	Fuel shut-off by faulty speed adjusting system	Re-adjust
	Clogged fuel inlet filter	Replace
	Fuel level in fuel tank is low	Add fuel
	Closed cock of fuel tank	Open cock
	Clogged fuel pipe	Clean
	Failure of fuel feed pump	Overhaul or replace
Failure of fuel injection valve	Faulty valve seat	Replace
	Sticking of nozzle	Replace
	Worn nozzle	Replace
	Clogged injection hole	Replace
	Drop in injection pressure	Re-adjust

Symptom	Probable Cause	Measure
Failure of fuel injection pump	Worn plunger	Replace both plunger and barrel (need to be replaced as a set)
	Broken plunger spring	Replace
	Sticking plunger	Overhaul or replace
	Oil leak from delivery valve	Lap valve
	Air trapped in pump	Bleed air from pump
	Broken delivery valve spring	Replace
Failure in fuel injection system	Incorrect injection timing of fuel injection pump	Re-adjust
	Loose fuel injection pipe joint	Tighten
	Broken fuel injection pipe	Replace
	Air trapped in fuel injection pipe	Bleed air from pipe
Engine compressed air leak	Air leak from exhaust valve	Carry out fitting of valve and seat
	No valve clearance	Re-adjust
	Faulty gasket / packing	Replace
	Worn upper portion of cylinder liner	Replace
	Worn piston ring	Replace
	Sticking piston ring	Overhaul or replace
	Insufficient tightening of head bolt	Re-tighten set bolts uniformly
	Broken valve spring	Replace
Other	Improper thickness of gasket / packing	Replace with a part of appropriate size
	Poor mounting of link or lever of speed control system	Re-adjust
	Location of speed control handle stopping position	Move the speed control handle towards higher speed
	Failure of engine starting system	Inspect and conduct servicing
	Clogged intake or exhaust pipe	Clean
Engine is not running smoothly:		
Operation failure of injection valve	Nozzle operation failure	Replace
	Broken valve spring	Replace
Uneven fuel injection quantities	Faulty operation of fuel pump plunger	Clean
	Damaged fuel pump plunger	Replace
	Broken plunger spring	Replace
	Incomplete mounting of fuel injection pump	Mount pump correctly
	Clogged fuel filter	Replace
	Faulty operation of regulator valve	Replace
	Air trapped in fuel injection system	Bleed air from system and prime system
	Faulty operation of fuel feed pump	Repair
	Faulty operation of fuel injection pump timer	Re-adjust

Symptom	Probable Cause	Measure
Failure of governor	Damaged governor bearing	Replace
	Faulty operation of governor link	Repair
	Sticking governor sleeve	Clean
	Fuel control sleeve failure	Disassemble, clean and service
Other	Overload operation	Reduce load
	Moving parts seized	Disassemble, inspect and conduct servicing
	Slippage of clutch	Inspect and repair
Engine stops suddenly:		
No fuel feed	Fuel level in fuel tank is low	Add fuel and prime
	Air trapped in fuel system or fuel injection	Bleed air
	Water trapped in fuel tank	Drain water from drain cock and fuel pipe, conduct priming
	Fuel cock closed	Inspect and repair as necessary
	Clogged fuel filter	Replace
	Broken fuel pipe	Replace
	Failure of fuel feed pump	Replace
Faulty operation of governor	Broken governor spring	Replace
	Sticking governor sleeve	Inspect and repair
Actuated emergency stop system (NOTE: this section is not related to the engine)	Loose lubrication oil pressure adjusting valve	Tighten valve
	Clogged lubrication oil filter	Clean
	Leak from safety valve of lubrication oil pump	Tighten safety valve
	Failure of lubrication oil pump	Disassemble and repair, or replace
	Actuated low lubricant pressure relay	Return to the original operating condition
	Actuated over speed relay	Return to the original operating condition
	Actuated water shut-off relay	Return to the original operating condition
Other	Moving parts seized	Disassemble and repair, or replace
	Overheating caused by insufficient seawater	Overhaul seawater pump and check for clogged seawater path

Symptom	Probable Cause	Measure
Abnormal exhaust color:		
Fuel injection pump failure	Faulty operation of plunger	Disassemble and correct, or replace
	Worn plunger	Replace
	Faulty delivery valve	Disassemble and correct, or replace
	Uneven injection quantities	Re-adjust
	Improper injection timing	Re-adjust
Fuel injection valve failure	Clogged injection nozzle	Replace
	Sticking needle valve	Replace
	Reduction in injection pressure	Re-adjust
	Poor atomization	Replace
	Carbon deposit	Clean
Turbocharger failure	Clogged filter	Clean
	Dirty compressor side	Clean
	Clogged turbine side	Clean
	Damaged bearing	Replace
Other	Overload operation	Reduce load
	Lubricant level too high	Lower the oil level
	Accumulated carbon deposit at intake / exhaust valve	Clean
	Dirty air cooler	Clean
	Poor fuel quality	Replace fuel
	Clogged intake / exhaust valve	Clean
Insufficient output:		
Insufficient fuel injection by fuel injection pump	Worn plunger	Replace
	Sticking plunger	Overhaul or replace
	Oil leak from delivery valve	Lap the valve
	Oil leak from fuel injection pipe joint	Tighten
	Faulty operation of regulator valve	Re-adjust
	Faulty position of governor lever	Re-adjust
	Clogged fuel filter	Replace
	Clogged fuel pipe	Clean
	Broken delivery valve spring	Replace
	Faulty fuel feed pump	Repair
Insufficient injection by fuel injection nozzle	Clogged injection hole	Replace
	Faulty valve seat	Replace
	Sticking nozzle	Replace
	Loose fuel injection pipe joint	Tighten
	Worn nozzle	Replace

Symptom	Probable Cause	Measure
Governor failure	Damaged governor bearing	Replace
	Improper length of governor link	Correct
Compressed gas leak in the engine cylinder	Gas leak from intake / exhaust valve	Conduct fitting of the valve
	Valve clearance too small	Re-adjust
	Worn upper portion of cylinder bore	Lap or replace
	Worn piston ring	Replace
	Sticking piston ring	Overhaul or replace
Improper fuel injection timing	Injection timing too advanced	Retard the injection timing
	Injection timing too retarded	Advance the injection timing
Turbocharger failure	Clogged air filter	Clean
	Dirty compressor side	Clean
	Clogged turbine nozzle	Clean
	Damaged bearing	Replace
Other	Improper fuel	Replace with correct fuel
	Clogged exhaust duct	Clean
	Seized or overheated moving parts	Disassemble and conduct servicing
	Insufficient seawater	Inspect seawater pump
	Insufficient feed of lubrication oil	Disassemble and clean lubrication oil pump and filter
Output for each cylinder is not uniform:		
Uneven fuel injection quantities	Air trapped in fuel injection pump	Bleed
	Faulty operation of plunger	Disassemble and clean
	Broken plunger spring	Replace
	Faulty delivery valve	Repair or replace
	Damaged delivery valve gasket	Replace
	Faulty operation of regulator valve	Overhaul or replace
	Faulty operation of fuel injection pump timer	Overhaul or replace
Failure of fuel injection nozzle	Oil leak from fuel injection system	Inspect and repair
	Broken valve spring	Replace
	Uneven injection pressures of injection valves	Re-adjust
	Improper injection timing	Re-adjust
	Clogged injection valve	Clean
Knocking:		
Fuel injection nozzle failure	Reduction in injection pressure	Adjust for higher injection pressure
	Broken fuel valve spring	Replace
	Sticking nozzle	Disassemble and lap
	Poor spray pattern	Overhaul
Fuel injection pump failure	Faulty operation of fuel injection pump timer	Repair
	Faulty operation of regulator valve	Repair

Symptom	Probable Cause	Measure
Excessive quantity of fuel is injected	Excessive delivery from fuel injection pump	Re-adjust fuel injection pump
Other	Insufficient seawater	Replace seawater pump impeller
	Piston clearance excessive	Replace
	Bearing clearance excessive	Replace
	Improper fuel	Replace with correct fuel
	Water trapped in fuel	Replace fuel
	Poor compression	Inspect and service
Breakdown of turbocharger:		
Drop in intake pressure	Dirty air filter	Clean
	Dirty guide vane at outlet of compressor	Clean
	Leak from intake piping	Repair
	Leak of exhaust gas	Repair
	High intake air temperature	Complete thermal insulation of exhaust pipe
		Ensure intake air path is unrestricted from outside air.
		Clean air cleaner
	Drop in air pressure in engine room	Ensure intake air path is unrestricted from outside air.
	Broken seal ring	Replace
	Broken turbine impeller	Replace
	Broken nozzle ring	Replace
	Dirty turbine impeller	Clean
	Clogged nozzle	Clean
	Clogged exhaust pipe	Clean
	Incorrect reading of pressure gage	Replace
Increased intake pressure	Exhaust gas leak	Re-mount of turbocharger
	Failure in fuel injection system	Inspect and adjust the injection timing
		Overhaul injection pump, repair or replace any defective parts
		Disassemble and inspect injection valve, repair or replace any defective parts
	Deformed turbine nozzle	Replace
	Dirty turbine side	Clean
	Increase in load (overloading)	Reduce load
	Incorrect reading of pressure gage	Replace

Symptom	Probable Cause	Measure
Abnormal vibration	Broken turbine impeller	Replace
	Broken compressor impeller	Replace
	Deposit of carbon or oxides on turbine	Remove and repair or replace
	Broken bearing	Replace
	Bent turbine shaft	Replace
	Loose parts or fasteners	Tighten
Noise	Damaged bearing	Replace
	Contact by revolving parts	Repair or replace
	Dirty or carbon deposit on turbine and compressor	Clean
	Entrapment of foreign matter (at turbine entrance)	Repair or replace
	Rapid change in load (surging)	Stabilize the load or replace turbine nozzle
Quick contamination of lubrication oil	Gas trapped in bearing housing	Repair
	Clogged seal air path	Clean
	Damaged seal ring	Replace
	Clogged pressure balance path	Clean
Pulsation of intake air pressure	Uneven cylinder combustion	Adjust for uniform combustion
	Rapid change in load	Operate correctly
	Excessively dirty compressor side	Clean
	Intake temperature too high	Clean cooling fin
		Complete thermal insulation of exhaust pipe
		Ensure intake air path is unrestricted from outside air
Other	Bearing seizure	Replace
	Water leak from exhaust opening	Replace
	Corrosion in compressor / turbine impeller or bearing housing	Increase the coolant temperature
Other malfunctions:		
Noise generation	Loose flywheel set bolts	Tighten bolts
	Loose connecting rod bolts	Tighten bolts
	Worn crank pin	Replace
	Excessive gear backlash	Inspect the gear; replace worn gear, shaft, and/or bushing with new ones

Symptom	Probable Cause	Measure
Low lubrication oil pressure	Clogged engine oil filter	Replace
	Engine oil temperature too high	Check the seawater level
	Failure of oil pump	Overhaul or replace
	Faulty operation of oil pump relief valve	Tighten the adjust valve
		Replace the safety valve
	Low viscosity of engine oil used	Replace the engine oil
	Insufficient engine oil quantity	Add oil
	Faulty pressure gauge or sender unit	Replace
Engine oil temperature too high	Insufficient seawater flow rate	Replace seawater pump impeller
	Overloaded operation	Decrease the load
Fresh water coolant temperature too high	Insufficient seawater	Replace seawater pump impeller
	Faulty thermostat	Replace
	Loose drive belt of freshwater pump	Adjust the belt tension
	Overloaded operation	Decrease the load

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