

SERVICE MANUAL

**MITSUBISHI  
DIESEL ENGINES  
L-SERIES**

**L2A, L2C, L2E  
L3A, L3C, L3E**

**March 2006**



**MITSUBISHI**  
HEAVY INDUSTRIES, LTD.

# INTRODUCTION

This service manual describes the specifications of the Mitsubishi Diesel Engine and the maintenance and adjustment procedures.

To maintain the performance of the engine for many years and to ensure safe operation, it is important to use the engine correctly and conduct regular inspection and maintenance, and also to take necessary measures which involves the disassembly, inspection, repair and reassembly of the engine and engine parts.

Read this manual carefully and understand the work procedures fully before disassembling, inspecting, repairing or reassembling the engine.

The contents of the manual are based on the engine models that are being produced at the time of publication. Due to improvements made thereafter, the actual engine that you work on may differ partially from the one described in this manual.

# How to Use This Manual

In this service manual, the Mitsubishi Diesel Engine (standard model) specifications, maintenance standards and adjustment procedure as well as service procedures such as disassembly, inspection, repair and reassembly are arranged in groups for quick reference.

A short summary of each Group is given in the General Contents, and there is also a table of contents at the beginning of each Group.

Regarding engine operation and periodical maintenance, refer to the Operation & Maintenance Manual. For component parts and ordering of service parts, refer to the Parts Catalogue. Structure and function of the engine are described in various training manuals.

There are separate manuals for the fuel injection pump, governor and turbocharger.

## Methods of Indication

- (1) Parts shown in illustrations and described in text are numbered to correspond with the sequence of disassembly.
- (2) Inspections to be conducted during disassembly are indicated in a box in disassembled views.
- (3) Maintenance standards for inspection and repair are specified in text where they are relevant and listed in No. 2 of each Group as well.
- (4) The sequence in which parts are to be assembled is summarized below each assembled view. Such as: 5 → 4 → 3 → 2 → 1.
- (5) Tightening torque under wet conditions is indicated as "[Wet]". When so indicated, apply engine oil to the threaded portion of the fastener. Unless indicated as such, the tightening torque is to be assumed in the dry condition.
- (6) The following marks are used in this manual to emphasize important safety cautions.



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



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



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



Indicates a potentially hazardous situation which, if not avoided, can result in property damage.

**Note:** Indicates important information or information which is useful for engine operation or maintenance.

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## Terms Used in This Manual

### Nominal value

Indicates the standard dimension of a part to be measured.

### Standard

Indicates the dimension of a part, the clearance between parts, or the standard performance. Since the value is indicated in a range needed for inspection, it is different from the design value.

### Limit

A part must be repaired or replaced with a new part when it reaches the limit value.

## Abbreviations, Standards, Etc.

- BTDC = Before Top Dead Center
- ATDC = After Top Dead Center
- BBDC = Before Bottom Dead Center
- ABDC = After Bottom Dead Center
- TIR = Total Indicated Reading
- API = American Petroleum Institute
- ASTM = American Society for Testing and Materials
- JIS = Japanese Industrial Standards
- LLC = Long Life Coolant
- MIL = Military Specifications and Standards (U.S.)
- MSDS = Material Safety Data Sheet
- SAE = Society of Automotive Engineers (U.S.)

## Units of Measurement

Measurements are based on the International System of Units (SI), and their converted metric values are indicated in parentheses. For metric conversion, the following rates are used.

- Pressure: 1 MPa = 10.197 kgf/cm<sup>2</sup>
- Torque: 1 N·m = 0.10197 kgf·m
- Force: 1 N = 0.10197 kgf
- Horsepower: 1 kW = 1.341 HP = 1.3596 PS
- Meter of mercury: 1 kPa = 0.7 cmHg
- Meter of water: 1 kPa = 10.197 cmH<sub>2</sub>O (cmAq)
- Rotational speed: 1 min<sup>-1</sup> = 1 rpm

## Safety Cautions

### **Warning Fire and Explosion**

#### **Keep flames away**

Store fuel and engine oil in a well-ventilated designated area.

Make sure that the caps of fuel and engine oil containers are tightly closed.

Do not use flames, do not smoke, or do not work near heater or other fire hazards where fuel or oil is handled or when cleaning solvent is being used for washing parts.

Wipe off spilled fuel, oil and LLC immediately and thoroughly. Spilled fuel, oil and LLC may ignite and cause a fire.



#### **Keep engine and surrounding area clean**

Do not store combustible (such as fuel, engine oil and LLC), explosive or dangerous materials near the engine. Those substances can cause a fire or explosion. Keep the engine and the surrounding area free of dust, dirt and foreign materials, since they can cause fire or the engine to overheat.

Clean the top surface of the battery after performing maintenance work. Dust on the battery may cause a short-circuit.

The engine must be used at least 1 m [3.3 ft.] away from buildings and other equipment to prevent possible fire caused by engine heat.

#### **Never open crankcase when engine is hot**

If the cover is opened while the engine is still hot, fresh air enters crankcase and oil mist can ignite due to engine heat and may result in the explosion of the engine. Never open the engine crankcase cover while the engine is hot. Wait at least 10 minutes after the engine has stopped. Open the cover after the engine becomes cool.

#### **Check for fuel, oil and exhaust gas leaks**

Inspect fuel, oil and exhaust pipes regularly for damage and loose.

If a fuel, oil and exhaust gas leak is found, repair the leakage immediately.

Spilled fuel or oil on a hot surface of the engine, or exhaust gas discharged directly to a combustible material may cause a fire and result in personal injury and/or damage to equipment.

#### **Use flameproof light**

When inspecting fuel, engine oil, coolant, battery electrolyte, etc., use a flameproof light. An ordinary light, if it accidentally broken, may ignite and cause an explosion.

#### **Do not short electrical wires**

Before inspecting or servicing any electrical component, disconnect the ground cable from the (-) negative battery terminal to prevent a short-circuit and a risk of fire.

Loose terminals or damaged cables/wires can cause a short-circuit that may result in fire. Before operating the engine, inspect the cables and wires, and repair or replace if necessary.

#### **Keep fire extinguishers and first-aid kit handy**

Keep fire extinguishers handy, and be familiarized with their usage.

Keep first-aid kits at the designated place with easy access by anyone at any time.

Establish response procedures to follow in the event of fire or accident. Provide emergency evacuation route and contact points and means of communication in case of emergency.



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## **Warning Stay Clear of All Rotating and Moving Parts**

### **Install protective covers around rotating parts**

Make sure the protective covers of the engine are correctly installed. Repair any damaged or loose covers.

When the engine is coupled to the radiator or other equipment, install protective covers around the exposed connecting belt and coupling.

Never remove protective covers of rotating parts such as the damper cover, camshaft cover or rocker cover while the engine is operating.

### **Check work area for safety**

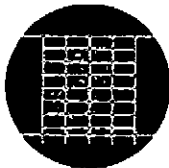
Before starting the engine, check to make sure that no one is near the engine, no tools are left behind on the floor or on the engine. Verbally notify persons around the engine or in the work area when starting the engine. When the starter device is posted with a sign that prohibits startup operation, do not operate the engine.

### **Watch out for rotating and moving parts while engine is in operation**

Do not touch or come close to rotating and moving parts (output shaft, flywheel, fan belts and pulleys) of the engine while the engine is running.

Keep flappy and loose objects away from rotating parts to avoid entanglement.

Entanglement of your body or tools in rotating and moving parts will result in serious injury.



### **Lock out and tag out**

Before starting inspection or maintenance work, be sure to lock out and tag out the engine.

Lockout and tagout are effective methods of cutting off machines and equipment from energy sources.

To lock out and tag out, pull out the key from the starter switch, turn off the battery switch, and post a "Do Not Operate" tag on the starter switch.

The starter key switch should be kept by the person performing the inspection and maintenance.

For the air starter system, close the main valve of the air tank, and post a "Do Not Open the Valve" tag.

### **Always stop engine before inspection and maintenance**

Be sure to stop the engine before proceeding with inspection and maintenance work. Never attempt to adjust the engine parts while the engine is running. Attempting any work on running engine can cause a severe accident.

### **Always remove turning tools from the engine**

Be sure to remove all turning tools used during maintenance and inspection work.

If the engine is started with turning tools or gears left on the engine, it can cause a severe accident and result in not only engine damage but also personal injury or death.

## **Warning Be Careful of Burns**

### **Do not touch engine during operation or immediately after operation**

Do not touch any parts of the engine during operation or immediately after operation to avoid burns.

To conduct maintenance and inspection work, wait until the engine has cooled sufficiently by checking the temperature gage.



### **Do not open radiator filler cap when the engine is hot**

Never open the radiator filler cap while the engine is running or immediately after the engine is stopped. The engine coolant is hot during engine operation and immediately after operation.

If the radiator filler cap is opened when the coolant is at operating temperature, steam and hot coolant may blow out and result in burns.

When opening the cap, stop the engine and allow the coolant temperature to lower sufficiently. Cover the cap with a cloth or use thick rubber glove, and then slowly open the cap. When closing the cap, be sure to tighten securely.

### **Add coolant only after coolant temperature is lowered**

Do not add coolant immediately after the engine stops. Wait until the coolant temperature lowers sufficiently to avoid a risk of burns.

### **Do not remove heat protection covers**

The high-temperature exhaust components are installed with heat protection covers. Do not remove these heat protection covers. If the covers must be removed during inspection and maintenance work, be sure to reinstall them after the inspection and maintenance work is completed.

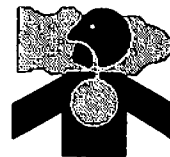
## **Warning Be Careful of Exhaust Fume Poisoning**

### **Perform engine operation in a well-ventilated area**

Exhaust gas from the engine contains carbon monoxide and other toxic substances.

Do not operate the engine in an enclosed area (inside a warehouse, tunnel, etc.) or in an area where all sides are blocked, as exhaust gas is hazardous. If the engine must be operated in an enclosed area, discharge the exhaust gas to the outside and provide adequate ventilation.

Connect exhaust duct to the exhaust pipe to discharge exhaust gas to the outside, and make sure exhaust gas does not leak from the duct joints. Make sure the exhaust gas is not discharged directly to surrounding buildings, plants or living passersby.



## **Warning Protect Ears from Noises**

### **Wear earmuff**

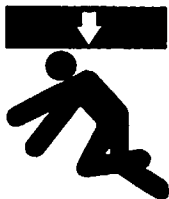
Be sure to wear earmuff or earplugs when entering the engine room. The earmuff or earplugs can be quite useful to protect ears from various engine noises.



## **Warning Be Careful of Falling Down**

### **Lift engine carefully**

To lift the engine, use slings capable of supporting the weight of the engine. Attach appropriate slings to the hangers on the engine. Keep the engine balanced during lifting by considering the center of gravity of the engine.



Keep the angle formed by slings attached to hangers within 60°. If the angle exceeds this limit, excessive load is imposed on the hangers and may damage the hangers and result in a serious accident.

If slings come in contact with the engine, place a cloth or other soft padding to avoid damage to the engine and slings.

### **Do not climb onto engine**

Never climb onto the engine. To work on parts located on the upper part of the engine, use a ladder, stand, or other stable platform.

Climbing on the engine may not only damage engine parts but also cause parts to fall off and result in personal injury.

### **Always prepare secure platform**

Use a stable work platform to stand on when working on the upper part of the engine and other hard-to-reach places.

Standing on a feeble stand or parts box may result in personal injury. Do not put obstacles on the platform.



## **Caution Be Careful of Handling Fuel, Engine Oil and LLC**

### **Use only specified fuel, engine oil and coolant (LLC)**

Use fuel, oil and LLC specified in this manual, and handle them carefully.

Use of any other fuel, oil or LLC, and improper handling may cause various engine problems and malfunctions. Obtain the MSDSs issued by the fuel, oil and LLC suppliers, and follow the directions in the MSDSs for proper handling.

### **Handle LLC carefully**

Wear safety mask and rubber gloves when handling LLC. Avoid contact with skin and eyes to prevent personal injury.

If LLC is accidentally swallowed, induce vomiting immediately and seek medical attention at once.

If LLC enter eyes, flush immediately with plenty of water and seek medical attention at once. If LLC is spilled on skin or clothes, wash immediately with plenty of water.

Keep flammable materials away from LLC to prevent a risk of fire. Never use open flames or generate sparks near LLC, as they can cause a fire.

Coolant containing LLC is a hazardous material. For disposal of the coolant, observe applicable law or regulations, or contact your Mitsubishi dealer.

### **Properly dispose of drained oil and LLC**

Do not discharge engine oil, used cleaning oil or LLC into conventional sewage.

Prepare drip pan or other containers to receive oil and LLC drained from the engine. Do not discharge them directly in the ground.

For disposal of used oil and LLC, observe applicable law or regulations, or contact your Mitsubishi dealer.

## **Caution Service Battery**

### **Handle battery carefully**

- Batteries release flammable hydrogen gas and oxygen. Never use open flames or generate sparks near the battery since open flames or sparks can cause an explosion.
- Do not use the battery when the fluid surface is lower than the minimum required level. Using a battery with a low electrolyte level may result in an explosion.
- Do not short the battery terminals with a tool or other metal object.
- When disconnecting battery cables, remove the cable from the (-) negative terminal first. When reconnecting cables, attach the cable to the (+) positive terminal first.
- Charge the battery in a well-ventilated area, with all filling hole plugs removed.
- Make sure the cable clamps are securely installed on the battery terminals. A loose cable clamp can cause sparks that may result in an explosion.
- Before servicing electrical components or conducting electric welding, set the battery switch to the [OFF] position or disconnect the cable from the (-) negative battery terminal to cut off the electrical current.
- Battery electrolyte contains dilute sulfuric acid. Careless handling of the battery may result in loss of sight and burns.
- Wear safety goggles and rubber gloves when working with the battery (filling of fluid, charging, etc.)
- If battery electrolyte is spilled on skin or clothes, wash immediately with lots of water. Then, use soap to clean thoroughly.
- If battery electrolyte enters eyes, flush immediately with lots of fresh water and seek medical attention at once.
- If battery electrolyte is accidentally swallowed, gargle with plenty of water, and then drink lots of water. Seek medical attention at once.



## **Caution When Abnormality Occurs**

### **If engine overheats, conduct cooling operation before stopping engine**

If the engine overheats, do not stop the engine immediately. Abrupt stopping of an overheated engine may cause the coolant temperature to rise and result in seizing of the engine. If the engine overheats, operate the engine at low idling speed (cooling operation), and stop the engine after the coolant temperature lowers sufficiently.

Do not add coolant immediately after stopping the engine. Adding coolant to a hot engine may cause damage to the cylinder head due to sudden change in temperature. Add coolant gradually after the engine cools to the room temperature.

### **If engine stops due to abnormality, exercise caution when restarting**

If the engine stops due to an abnormality, do not restart the engine immediately. If the engine stops with an alarm, check and correct the cause of the problem before restarting. Operating the engine without correcting the problem may result in serious engine problems.

### **If engine oil pressure drops, stop engine immediately**

If the engine oil pressure decreases, stop the engine immediately, and inspect the lubricating system including the oil level and pump. Operating the engine with low oil pressure may cause seizing of bearings and other parts.

### **If V-belt breaks, stop engine immediately**

If V-belt breaks, stop the engine immediately. Continued operation of the engine without V-belt in place causes an engine overheating and could be result in burns due to blowout of steam from reserve tank or radiator.

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## **Caution Other Cautions**

### **Never modify engine**

Unauthorized modification of the engine will void the manufacturer's warranty.

Modification of the engine may not only cause engine damage but may result in personal injury as well.

If there is a need to modify the engine, contact your Mitsubishi dealer.

### **Never break seals**

To ensure proper engine operation, the fuel control links are sealed to prevent accidental change of the injection volume and rotation speed settings. Operating the engine without these seals in place can cause problems described below, and also invalidates the warranty.

- Rapid wear of sliding and rotating parts
- Engine damage such as seizing of engine parts
- Considerably increased consumption of fuel and lubricating oil
- Degradation of engine performance due to improper balance between fuel injection volume and governor operation or overrun of engine which will be result in serious accident.

### **Perform all specified pre-operation inspections and periodic inspections**

Conduct the pre-operation inspections and periodic inspections as described in this manual.

Failure to conduct the specified inspections may cause various engine problems, damage to parts, and serious accidents.

### **Perform engine break-in**

To break in a new engine, operate the engine at a speed lower than rated speed under light load during the first 50 hours of operation.

Operating a new engine under heavy load or severe conditions during the break-in period will shorten the service life of the engine.

### **Warm up engine before use**

When starting auxiliary devices such as water heater and engine oil priming pump is not installed, let the engine idle for 5 to 10 minutes before operating the engine for work. Warm-up operation circulates lubricants in the engine and contributes to a longer service life and economical operation. Do not conduct warm-up operation for prolonged period of time.

Prolonged warm-up operation causes carbon build-up in the cylinders that lead to incomplete combustion.

### **Never operate engine under overload condition**

If the engine shows an overload condition such as back exhaust smoke, reduce the load immediately to operate the engine at appropriate output and load. Overloading causes not only high fuel consumption but also excessive carbon deposits inside the engine. Carbon deposits cause various problems and will shorten the service life of the engine.

### **Conduct cooling operation before stopping engine**

Before stopping the engine, let it idle at low speed for 5 to 6 minutes to cool down.

Stopping the engine immediately after high-load operation will cause engine parts to heat up and shorten the service life of the engine.

During cooling operation, check the engine for abnormalities.

### **Do not splash water on engine**

Do not allow water such as rain to enter the engine through the air inlet or exhaust openings.

Do not wash the engine while it is in operation, as the water enters the engine.

If the engine is started with water inside the combustion chambers, water hammering occurs and damages the engine, and may result in serious accidents.

### **Conduct proper maintenance of pre-cleaner**

The major cause of abnormal wear on engine parts is due to the dust from intake air. Worn parts result in an increase of oil consumption, decrease of output, and starting difficulties. Conduct maintenance of the pre-cleaner as described below to ensure optimum air filtering performance.

- Do not conduct maintenance of the air cleaner or pre-cleaner while the engine is in operation. Without the turbocharger can suck foreign particles into the engine and it could result in serious accidents.
- When removing the use care to prevent dust trapped in the air cleaner from entering the engine.

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**Observe safety rules at workplace**

Observe the safety rules established at your workplace when operating and maintaining the engine.

Do not operate the engine if you are feeling ill.

Operation of the engine with reduced awareness may cause improper operations that could result in accidents. In such a case, inform your supervisor of your condition.

When working in a team of two or more persons, use specified hand signals to communicate among the workers.

**Wear proper work clothes and protective gear**

Wear a hardhat, face shield, safety shoes, dust protective mask, gloves and other protective gear as needed.

When handling compressed air, wear safety goggles, a hardhat, gloves and other necessary protective gears. Without the proper protective gear, the compressed air may cause personal injury.

**Use appropriate tools for maintenance work**

Use appropriate tools according to the type of maintenance work, and use them correctly.

If a tool is damaged, replace with a new one.

**Do not operate starter for prolonged time**

Do not use the starter for more than 10 seconds at a time. If the engine does not start, wait for at least 30 seconds before cranking again.

Continuous operation of the starter will cause the battery to discharge as well as the starter to seize.

**Keep battery switch ON when engine is in operation**

If the battery switch is turned OFF when the engine is running, not only various meters will stop working but also the alternator may have its diode and transistor deteriorated.

**Cautions concerning transportation**

When transporting the engine using a truck, consider the engine weight, width and height to ensure safety. Abide by the pertinent laws and regulations.

**Do not operate engine continuously under low load**

When operating the engine with a 30 % load or lower, limit each operation to 10 minutes. Operating the engine under low load tends to result in unburned fuel, which can adhere on internal engine parts to cause malfunctions and shorten the engine service life.

**Ventilate the engine room sufficiently**

Be sure to provide sufficient ventilation in the engine room. Insufficient air in the room can cause the engine temperature to rise and the output power and performance to lower.

It is highly recommended to calculate the required amount of air supply to the engine and install an appropriate ventilation system before installing an engine.

**Do not touch high-pressure injection fuel**

Should injected fuel leak from a fuel injection pipe, do not touch the spurting fuel.

Fuel in the fuel injection pipes is under high pressure. Touching high-pressure fuel can cause the fuel to penetrate the skin and result in gangrene.

## Caution About Warning Labels

### Maintain and inspect warning labels

Make sure all warning labels are legible.

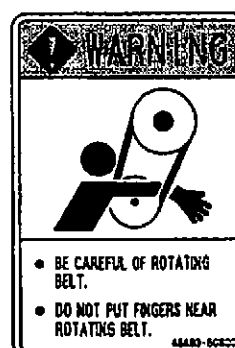
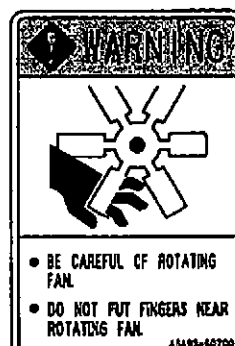
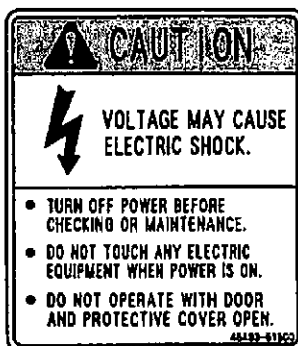
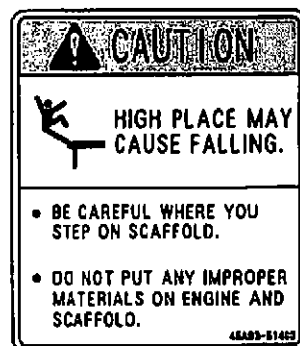
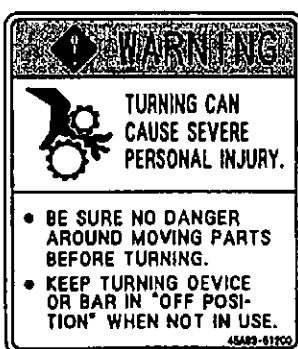
If the description and/or illustration on a warning label is illegible, clean or replace the label.

To clean warning labels, use a cloth, water and soap. Do not use solvents, gasoline or other chemicals to clean warning labels, as chemicals may cause the labels to peel off.

If warning labels are damaged or missing, install new labels.

If a part of the engine with warning label is replaced with a new part, also install the new warning label to the new part.

To obtain replacement warning labels, contact your Mitsubishi dealer.



Warning labels

# GENERAL CONTENTS

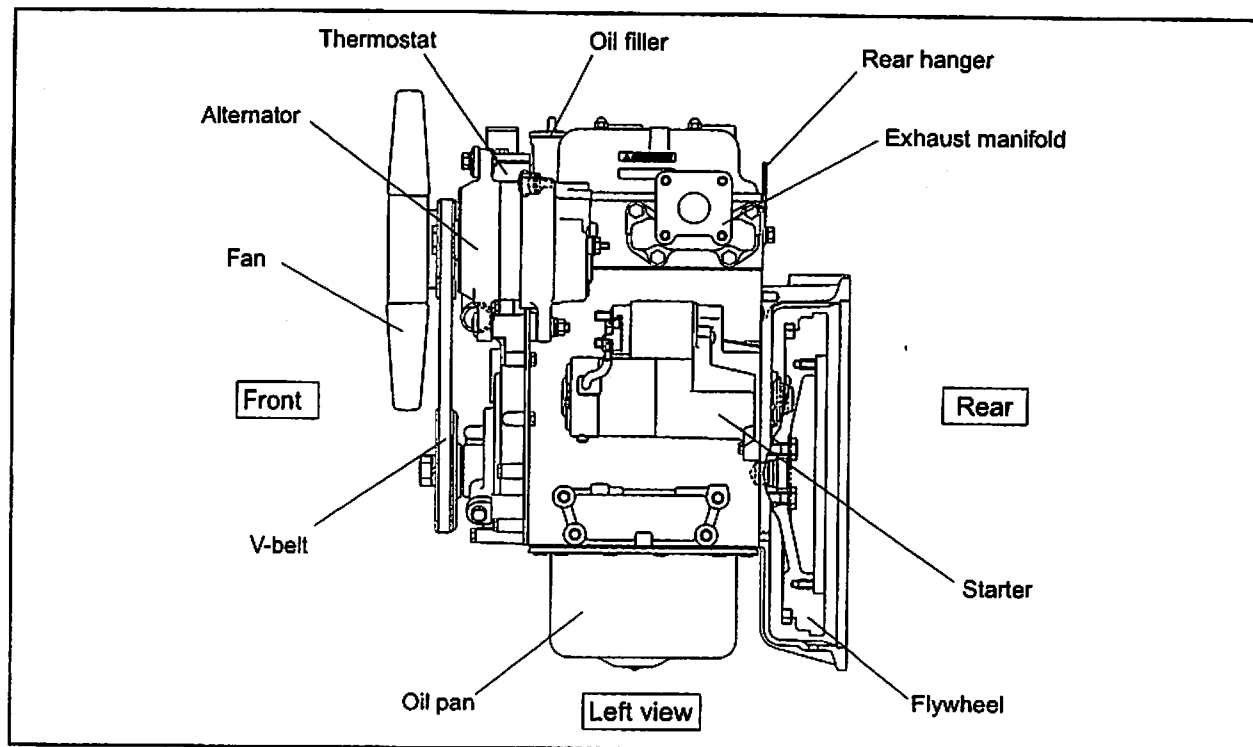
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# GENERAL

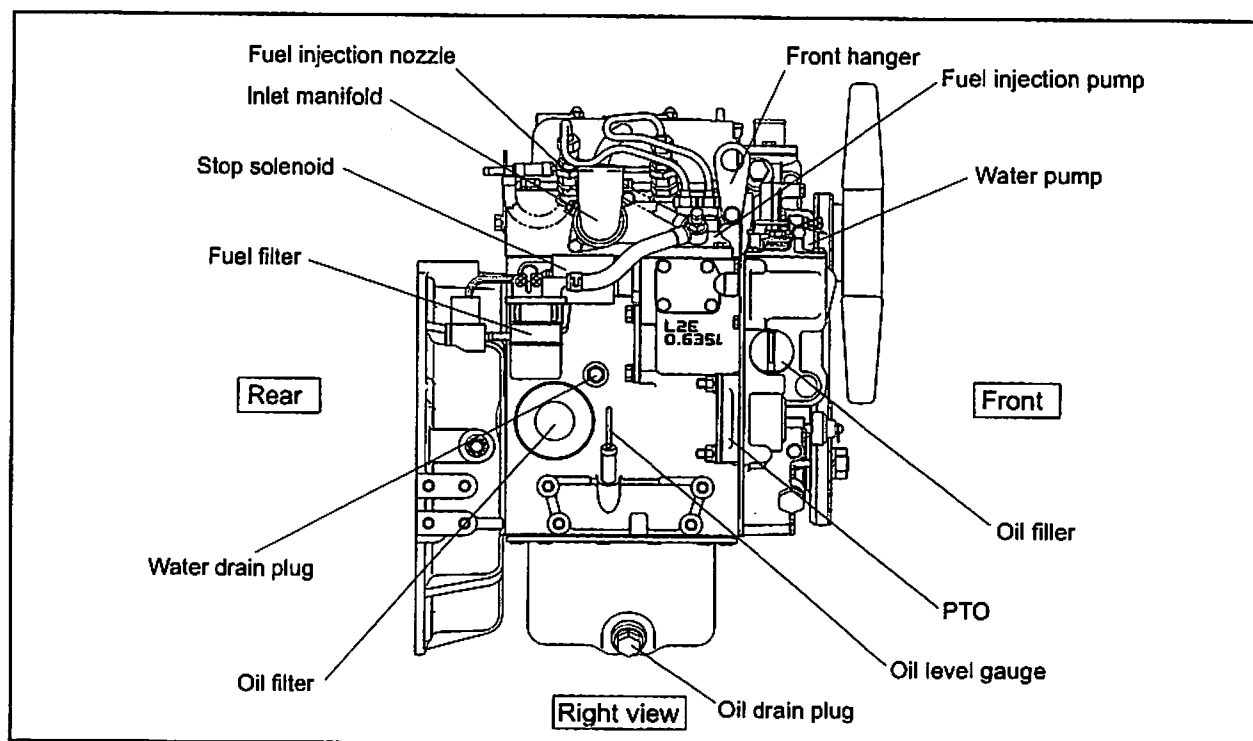
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## 1. Outside drawing

### 1.1 Outside drawing of L2A, L2C and L2E

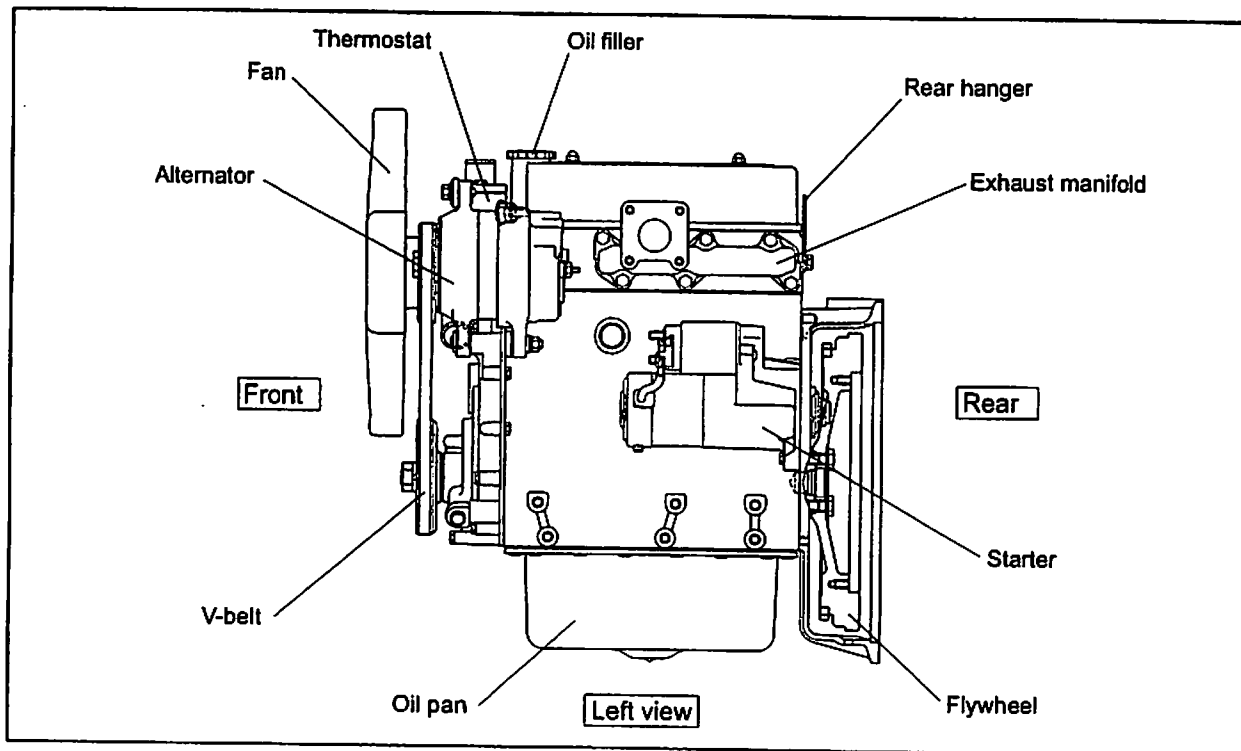


Left side view of engine

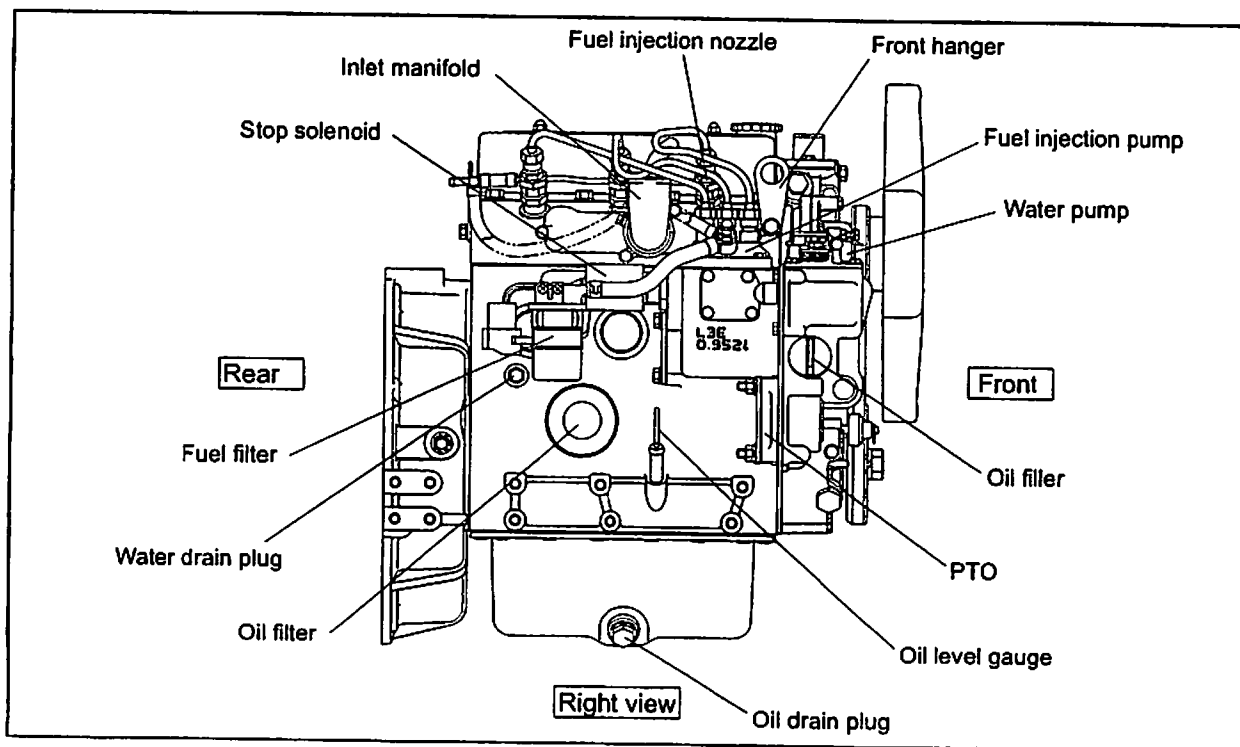


Right side view of engine

## 1.2 Outside drawing of L3A, L3C and L3E



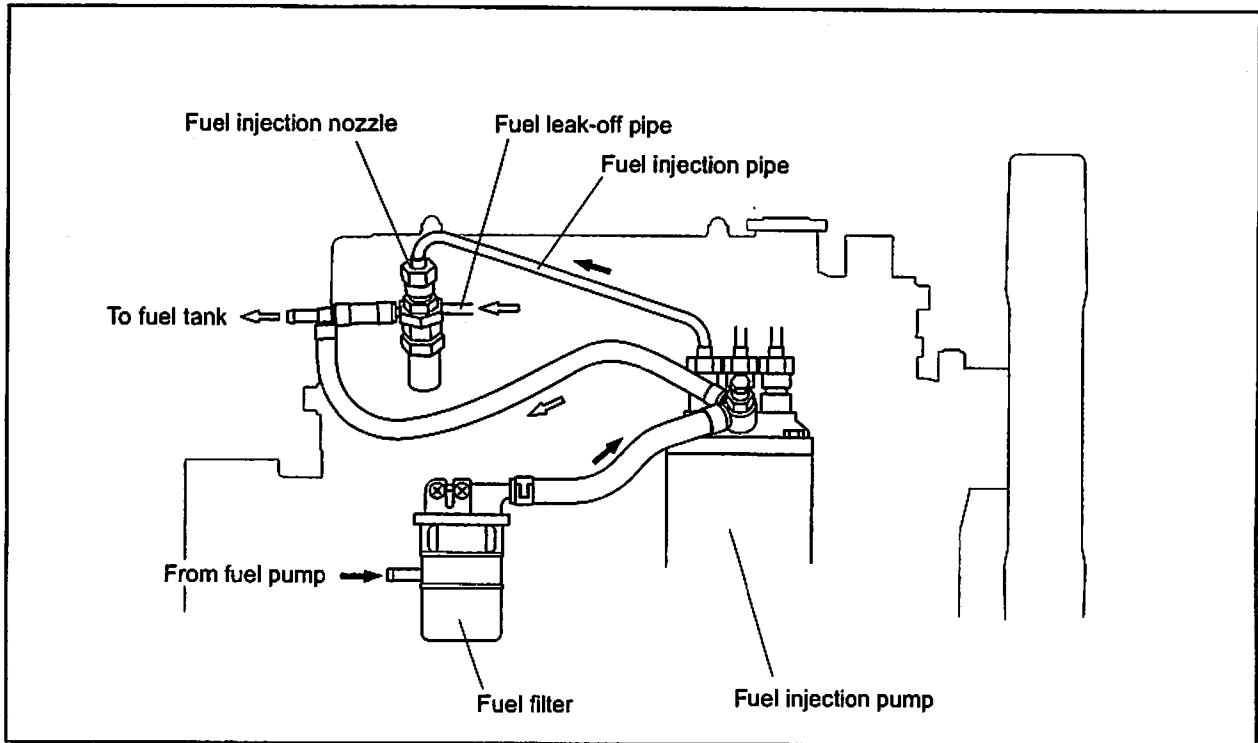
Left side view of engine



Right side view of engine

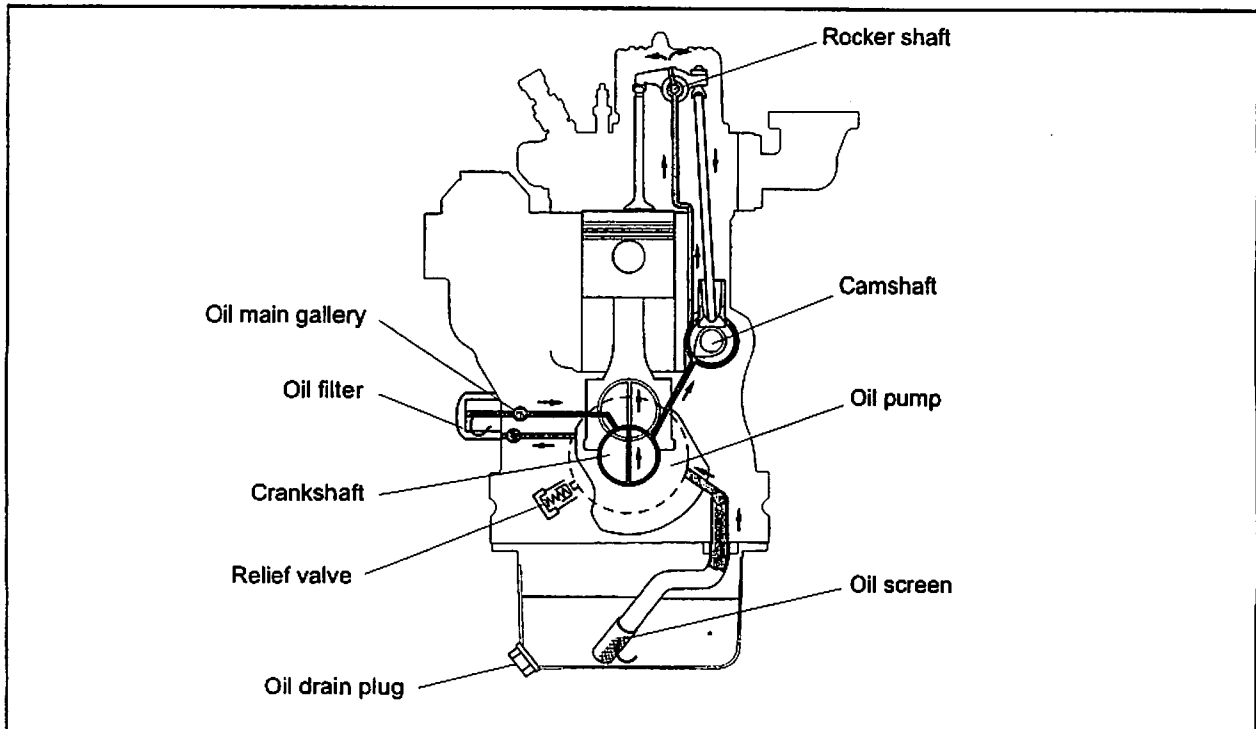
## 2. Outline of systems

### 2.1 Outline of fuel system



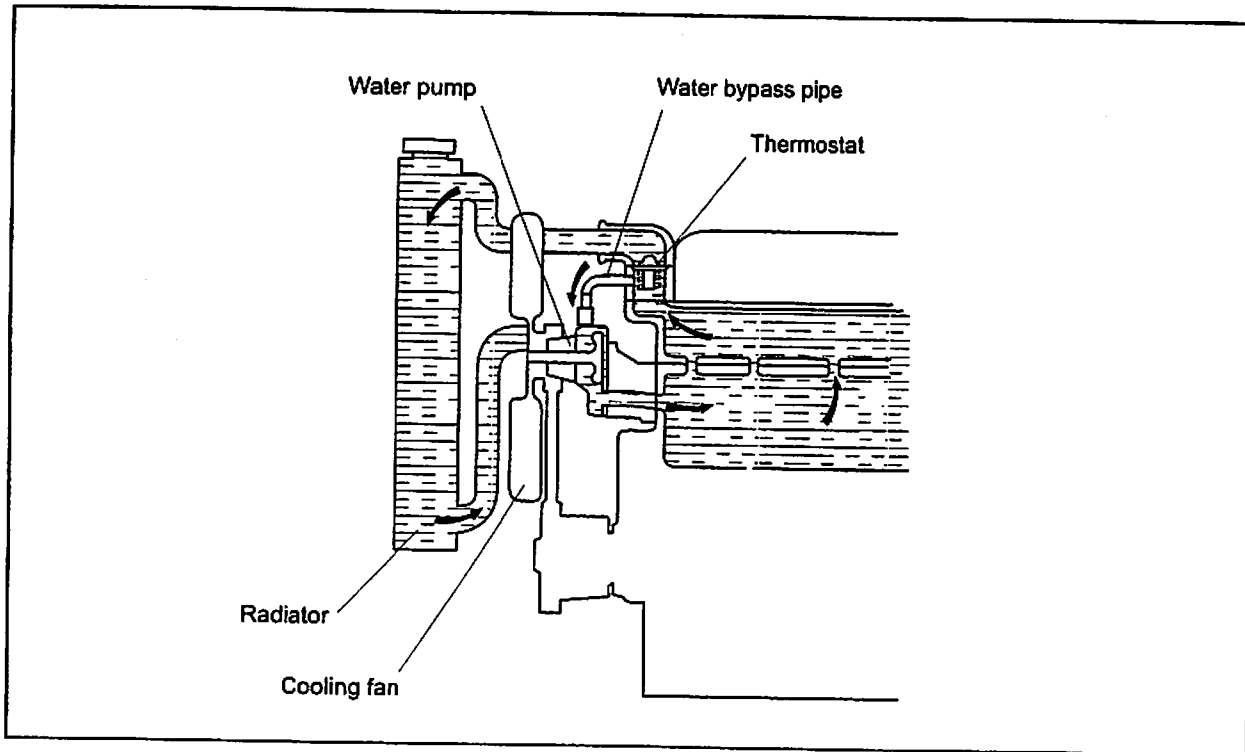
Outline of fuel system

### 2.2 Outline of lubrication system



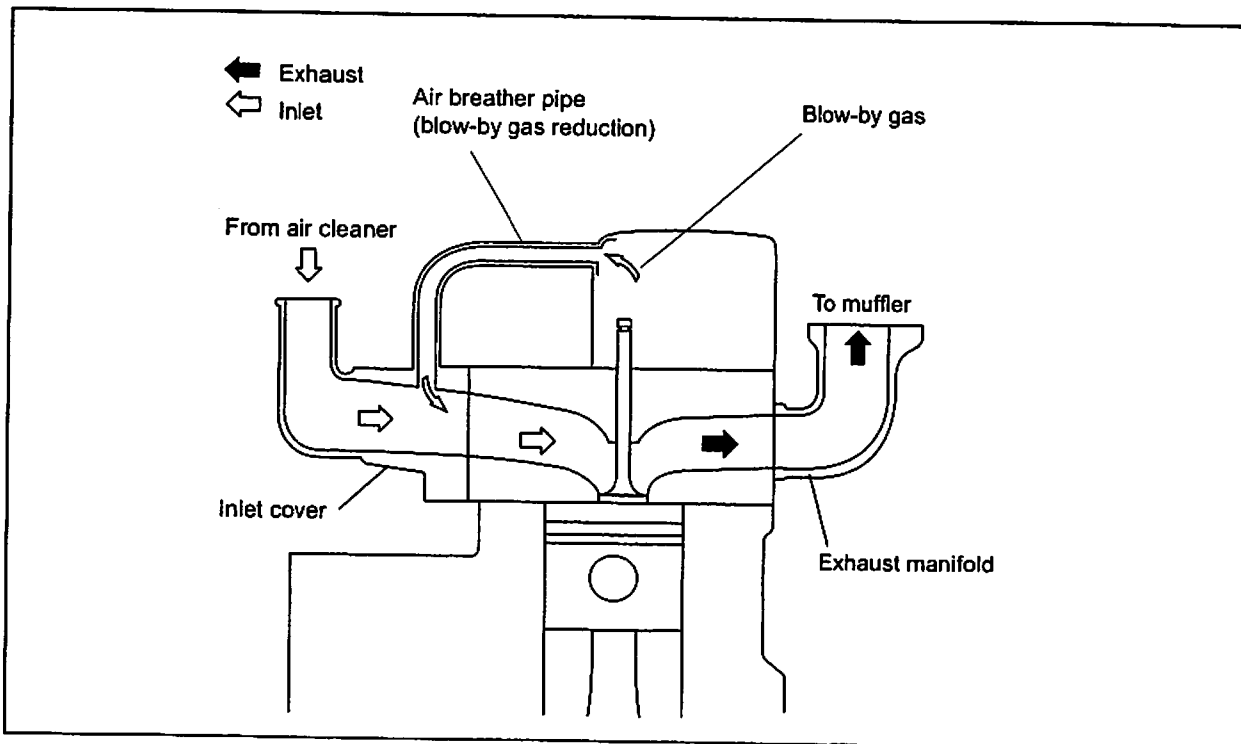
Outline of lubrication system

### 2.3 Outline of cooling system



Outline of cooling system

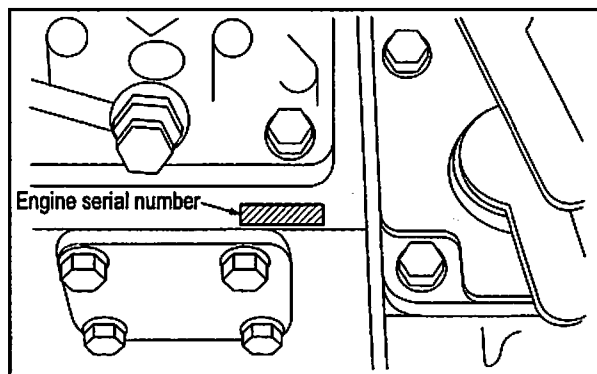
### 2.4 Outline of inlet and exhaust systems



Outline of inlet and exhaust systems

### 3. Engine serial number

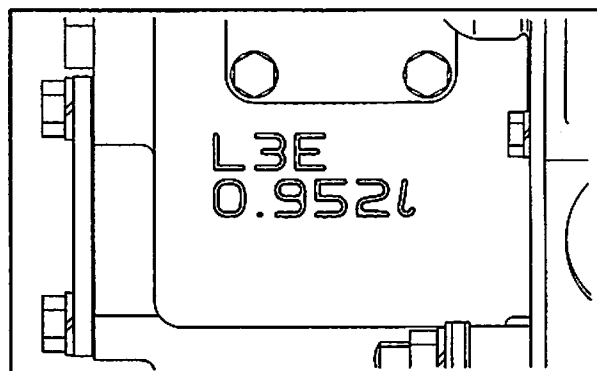
The engine serial number is stamped on the injection pump mount (upper side of tie rod cover) of the cylinder block.



Stamping position of engine serial number

### 4. Indication of engine model and total displacement

The engine type and displacement are stamped on the side of the injection pump mount of the cylinder block.



Engine model and cylinder capacity

## 5. Specifications

### 5.1 Specifications of L2A, L2C and L2E

Table 1-1 Specifications of L2A, L2C and L2E (1 / 4)

Engine model				L2A	L2C	L2E
Main specifications	Type			Vertical type, water-cooled, 4 cycle diesel		
	No. of cylinders			2		
	Combustion type			Swirl chamber type		
	Valve mechanism			Overhead valve type		
	Cylinder bore×stroke			65×70 mm [2.56×2.76 in.]	70×70 mm [2.76×2.76 in.]	76×70 mm [2.97×2.76 in.]
	Total displacement			0.464 L [0.126 U.S. gal.]	0.538 L [0.142 U.S. gal.]	0.635 L [0.168 U.S. gal.]
	Compression ratio			23:1		
	Fuel used			Diesel oil (JIS K2204 Special No. 1 - Special No. 3)		
	Order of ignition			1-2		
	Direction of rotation			Counterclockwise as viewed from flywheel side		
	Dry mass			61 kg [134 lb.]		
Main unit of engine	Piston ring	Number		Compression ring: 2 Oil ring (with expander): 1		
	Valve timing (when warm)	Inlet valve	Open	BTDC 18°		
			Close	ABDC 46°		
		Exhaust valve	Open	BBDC 46°		
			Close	ATDC 18°		
Starting system			Electric starting			
Fuel system	Fuel injection pump	Type		ND-PFR type		
		Manufacturer		DENSO CORPORATION		
		Plunger diameter		ø6.0 mm [0.24 in.]		
		MS retard (crank angle)		4°		
		Cam lift		6 mm [0.24 in.]		
	Governor	Speed governing type		Centrifugal weight system		
	Fuel injection nozzle	Type		Throttle type		
		Manufacturer		DENSO CORPORATION		
		Spray angle		15°		
		Valve opening pressure		13.73 <sup>+1.0</sup> <sub>0</sub> MPa [140 <sup>+10</sup> <sub>0</sub> kgf/cm <sup>2</sup> ] [1992 <sup>+142</sup> <sub>0</sub> psi]		
	Fuel filter	Type		Paper-element cartridge or paper-element switch cock		
	Fuel pump (option)	1	Type	Electromagnetic diaphragm		
			Discharge rate	0.3 L [0.08 U.S. gal.]/min or more (at 12 V-1.3 A)		
		2	Type	Electromagnetic plunger type		
			Discharge rate	1 L [0.26 U.S. gal.]/min or more (at 12 V-1.5 A)		
3		Type	Electromagnetic plunger type			
		Discharge rate	1.4 L [0.37 U.S.gal.]/min or more (at 24 V-1.5 A)			
4		Type	Electromagnetic plunger type (compact type)			
		Discharge rate	0.4 L [0.11 U.S. gal.]/min or more (at 12 V-1.5 A)			

Table 1-1 Specifications of L2A, L2C and L2E (2 / 4)

Engine model			L2A	L2C	L2E
Lubrication system	Lubrication system		Pressure feed, full flow filter system		
	Engine oil	Specification	API service category CD and CF		
		Capacity (engine total)	Upper limit: 2.4 L [0.63 U.S. gal]/Lower limit: 1.4 L [0.37 U.S. gal] (Upper limit: 2.9 L [0.77 U.S. gal]/Lower limit: 1.9 L [0.50 U.S. gal])		
	Oil pump	Type	Gear type (internal and external teeth engagement), built into gear case		
		Discharge rate	3 L [0.79 U.S. gal]/min or more (at 1000 min <sup>-1</sup> )		
	Relief valve	Type	Plunger valve type		
		Valve opening pressure	0.29±0.029 MPa (3.0±0.3 kgf/cm <sup>2</sup> ) [42.68±4.3 psi] (1000 min <sup>-1</sup> )		
	Oil filter	Type	Paper-element cartridge		
Cooling system	Cooling system		Forced-feed circulation type		
	Coolant capacity (main unit of engine)		1.2 L [0.32 U.S. gal]		
	Water pump	Type	Centrifugal volute type		
		Discharge rate	50 L [13.21 U.S. gal]/min (at pump rotation of 4500 min <sup>-1</sup> )		
	Thermostat	Type	Wax pellet		
		Valve opening pressure	76.5±1.5°C [169.7±2.7°F]		
	Cooling fan	Type	Suction (PP fan)		
		No. of blades/Outside diameter	4 variable pitch blades/260 mm [10.24 in.]		
Inlet system	Air cleaner	Type	Paper element		

Table 1-1 Specifications of L2A, L2C and L2E (3 / 4)

Engine model		L2A	L2C	L2E
Electrical system	Voltage - polarity	12 V - negative (-) ground, 24 V - negative (-) ground		
	Starter (1)	Type	M000T60481	
		Manufacturer	Mitsubishi Electric Corporation	
		Pinion engagement type	Pinion shift (reduction type)	
		Output	12 V - 1.2 kW	
		Number	1	
		Pinion/ring gear ratio	14/106	
	Starter (2)	Type	M001T68381	
		Manufacturer	Mitsubishi Electric Corporation	
		Pinion engagement type	Pinion shift (reduction type)	
		Output	12 V - 1.7 kW	
		Number	1	
		Pinion/ring gear ratio	14/106	
	Starter (3)	Type	M002T66071	
		Manufacturer	Mitsubishi Electric Corporation	
		Pinion engagement type	Pinion shift (reduction type)	
		Output	24 V - 3.2 kW	
		Number	1	
		Pinion/ring gear ratio	15/106	
	Alternator (1)	Type	A007TA0171B	
		Type	Three-phase current generator, integral with IC regulator	
		Manufacturer	Mitsubishi Electric Corporation	
		Output V-A	12 V-40 A	
		Rated voltage generating speed	5000 min <sup>-1</sup> (at 13.5 V, 37 A, when hot)	
		Regulator adjusting voltage	14.7±0.3 V	
	Alternator (2)	Type	A007TA8271A	
		Type	Three-phase current generator, integral with IC regulator	
		Manufacturer	Mitsubishi Electric Corporation	
		Output	24 V-25 A	
		Rated voltage generating speed	5000 min <sup>-1</sup> (at 27.0 V, 22 A, when hot)	
		Regulator adjusting voltage	28.5±0.5 V	
	Glow plug (1)	Type	Sheathed	
		Rated voltage-current	10.5 V-9.7 A±1.0 A (30-second duration)	
	Glow plug (2)	Type	Sheathed	
		Rated voltage-current	22.5 V-4.8 A±0.5 A (30-second duration)	

Table 1-1 Specifications of L2A, L2C and L2E (4 / 4)

Engine model		L2A	L2C	L2E
Electrical system	Stop solenoid (1)	Working voltage	12 V-ETR: 8 V or less	
		Insulation resistance	100 M $\Omega$ or more at DC 500 V megger (normal temperature, normal relative humidity)	
		Stroke	13.5 $\pm$ 0.5 mm [0.53 $\pm$ 0.02 in.]	
		Ambient temperature for use	-40 to 120°C [-40 to 248°F]	
	Stop solenoid (2)	Working voltage	12 V-ETS: 10 V - 15 V	
		Insulation resistance	100 M $\Omega$ or more at DC 500 V megger (normal temperature, normal relative humidity)	
		Stroke	10 $\pm$ 0.5 mm [0.39 $\pm$ 0.02 in.]	
		Ambient temperature for use	-30 to 120°C [-22 to 248°F]	
	Stop solenoid (3)	Working voltage	24 V-ETR: 16 V or less	
		Insulation resistance	100 M $\Omega$ or more at DC 500 V megger (normal temperature, normal relative humidity)	
		Stroke	13.5 $\pm$ 0.5 mm [0.53 $\pm$ 0.02 in.]	
		Ambient temperature for use	-40 to 120°C [-40 to 248°F]	
	Stop solenoid (4)	Working voltage	24 V-ETS: 20 V - 30 V	
		Insulation resistance	100 M $\Omega$ or more at DC 500 V megger (normal temperature, normal relative humidity)	
		Stroke	10 $\pm$ 0.5 mm [0.39 $\pm$ 0.02 in.]	
		Ambient temperature for use	-30 to 120°C [-22 to 248°F]	

## 5.2 Specifications of L3A, L3C and L3E

Table 1-2 Specifications of L3A, L3C, L3E (1 / 4)

Engine model				L3A	L3C	L3E	
Main specifications	Type			Vertical type, water-cooled, 4 cycle diesel			
	No. of cylinders			3			
	Combustion type			Swirl chamber type			
	Valve mechanism			Overhead valve type			
	Cylinder borexstroke			65×70 mm [2.56 ×2.76 in.]	70×70 mm [2.76 ×2.76 in.]	76×70 mm [2.99 ×2.76 in.]	
	Total displacement			0.696 L [0.184 U.S. gal.]	0.808 L [0.213 U.S. gal.]	0.952 L [0.251 U.S. gal.]	
	Compression ratio			23:1			
	Fuel used			Diesel oil (JIS K2204 Special No. 1 - Special No. 3)			
	Order of ignition			1-3-2			
	Direction of rotation			Counterclockwise as viewed from flywheel side			
	Dry mass			75 kg [165 lb.]			
Main unit of engine	Piston ring	Number		Compression ring: 2 Oil rings(with expander): 1			
	Valve timing (when warm)	Inlet valve	Open	BTDC 18°			
			Close	ABDC 46°			
		Exhaust valve	Open	BBDC 46°			
			Close	ATDC 18°			
	Starting system			Electric starting			
Fuel system	Fuel injection pump	Type	ND-PFR type				
		Manufacturer	DENSO CORPORATION				
		Plunger diameter	ø6.0 mm [0.24 in.]				
		MS retard (crank angle)	4°				
		Cam lift	6 mm [0.24 in.]				
	Governor	Speed governing type		Centrifugal weight system			
	Fuel injection nozzle	Type	Throttle type				
		Manufacturer	DENSO CORPORATION				
		Spray angle	15°				
		Valve opening pressure	13.73 <sup>+1.0</sup> <sub>0</sub> MPa[ 140 <sup>+10</sup> <sub>0</sub> kgf/cm <sup>2</sup> ] {1992 <sup>+142</sup> <sub>0</sub> psi}				
	Fuel filter	Type		Paper-element cartridge or paper-element switch cock			
	Fuel pump (option)	1	Type	Electromagnetic diaphragm			
			Discharge rate	0.3 L [0.08 U.S. gal.]/min or more (at 12 V-1.3 A)			
		2	Type	Electromagnetic plunger type			
			Discharge rate	1 L [0.26 U.S. gal.]/min or more (at 12 V-1.5 A)			
		3	Type	Electromagnetic plunger type			
Discharge rate			1.4 L [0.57 U.S. gal.]/min or more (at 24 V-1.5 A)				
4		Type	Electromagnetic plunger type (compact type)				
		Discharge rate	0.4 L [0.11 U.S. gal.]/min or more (at 12 V-1.5 A)				

Table 1-2 Specifications of L3A, L3C, L3E (2 / 4)

Engine model			L3A	L3C	L3E
Lubrication system	Lubrication system		Pressure feed, full flow filter system		
	Engine oil	Speci fication	API service category CF		
		Capacity (engine total)	Upper limit: 3.0 L [0.79 U.S. gal]/Lower limit: 1.5 L [0.40 U.S. gal] (Upper limit: 3.5 L [0.92 U.S. gal]/Lower limit: 2.0 L [0.53 U.S. gal])		
			Upper limit: 3.6 L [0.95 U.S. gal]/Lower limit: 1.8 L [0.48 U.S. gal] (Upper limit: 4.1 L [1.08 U.S. gal]/Lower limit: 0.61 L		
			Upper limit: 4.8 L [1.27 U.S. gal]/Lower limit: 3.0 L [0.79 U.S. gal] (Upper limit: 5.3 L [1.40 U.S. gal]/Lower limit: 3.5 L [0.92 U.S. gal])		
	Oil pump	Type	Gear type (internal and external teeth engagement), built into gear case		
		Discharge rate	3 L [0.79 U.S. gal]/min or more (at 1000 min <sup>-1</sup> )		
	Relief valve	Type	Plunger valve type		
		Valve opening pressure	0.29±0.029 MPa (3.0±0.3 kgf/cm <sup>2</sup> ) [42.68±4.3 psi] (1000 min <sup>-1</sup> )		
	Oil filter	Type	Paper-element cartridge		
Cooling system	Cooling system		Forced-feed circulation type		
	Coolant capacity (main unit of engine)		1.8 L [0.48 U.S. gal]		
	Water pump	Type	Centrifugal volute type		
		Discharge rate	50 L [13.21 U.S. gal]/min (at pump rotation of 4500 min <sup>-1</sup> )		
	Thermostat	Type	Wax pellet		
		Valve opening pressure	76.5±1.5°C [169.7±34.7°F]		
	Cooling fan	Type	Suction (PP fan)		
		No. of blades/Outside diameter	4 variable pitch blades/290mm [11.42 in.]		
Inlet system	Air cleaner	Type	Paper element		

Table 1-2 Specifications of L3A, L3C, L3E (3 / 4)

Engine model		L3A	L3C	L3E
Electrical system	Voltage - polarity	12 V - negative (-) ground, 24 V - negative (-) ground		
	Starter (1)	Type	M000T60481	
		Manufacturer	Mitsubishi Electric Corporation	
		Pinion engagement type	Pinion shift (reduction type)	
		Output	12 V - 1.2 kW	
		Number	1	
		Pinion/ring gear ratio	14/106	
	Starter (2)	Type	M001T68381	
		Manufacturer	Mitsubishi Electric Corporation	
		Pinion engagement type	Pinion shift (reduction type)	
		Output	12 V - 1.7 kW	
		Number	1	
		Pinion/ring gear ratio	14/106	
	Starter (3)	Type	M002T66071	
		Manufacturer	Mitsubishi Electric Corporation	
		Pinion engagement type	Pinion shift (reduction type)	
		Output	24 V - 3.2 kW	
		Number	1	
		Pinion/ring gear ratio	15/106	
	Alternator (1)	Type	A007TA0171B	
		Type	Three-phase current generator, integral with IC regulator	
		Manufacturer	Mitsubishi Electric Corporation	
		Output	12 V-40 A	
		Rated voltage generating speed	5000 min <sup>-1</sup> (at 13.5 V, 37 A, when hot)	
		Regulator adjusting voltage	14.7±0.3 V	
	Alternator (2)	Type	A007TA8271A	
		Type	Three-phase current generator, integral with IC regulator	
		Manufacturer	Mitsubishi Electric Corporation	
		Output	24 V-25 A	
		Rated voltage generating speed	5000 min <sup>-1</sup> (at 27.0 V, 22 A, when hot)	
		Regulator adjusting voltage	28.5±0.5 V	
	Glow plug (1)	Type	Sheathed	
		Rated voltage - current	10.5 V - 9.7 A±1.0 A (30-second duration)	
	Glow plug (2)	Type	Sheathed	
		Rated voltage - current	22.5 V - 4.8 A±0.5 A (30-second duration)	

Table 1-2 Specifications of L3A, L3C, L3E (4 / 4)

Engine model		L3A	L3C	L3E
Electrical system	Stop solenoid (1)	Working voltage	12 V-ETR: 8 V or less	
		Insulation resistance	100 M $\Omega$ or more at DC 500 V megger (normal temperature, normal relative humidity)	
		Stroke	13.5 $\pm$ 0.5 mm [0.53 $\pm$ 0.02 in.]	
		Ambient temperature for use	-40 to 120°C [-40 to 248°F]	
	Stop solenoid (2)	Working voltage	12 V-ETS: 10 V to 15 V	
		Insulation resistance	100 M $\Omega$ or more at DC 500 V megger (normal temperature, normal relative humidity)	
		Stroke	10 $\pm$ 0.5 mm [0.39 $\pm$ 0.02 in.]	
		Ambient temperature for use	-30 to 120°C [-22 to 248°F]	
	Stop solenoid (3)	Working voltage	24 V-ETR: 16 V or less	
		Insulation resistance	100 M $\Omega$ or more at DC 500 V megger (normal temperature, normal relative humidity)	
		Stroke	13.5 $\pm$ 0.5 mm [0.53 $\pm$ 0.02 in.]	
		Ambient temperature for use	-40 to 120°C [-40 to 248°F]	
	Stop solenoid (4)	Working voltage	24 V-ETS: 20 V - 30 V	
		Insulation resistance	100 M $\Omega$ or more at DC 500 V megger (normal temperature, normal relative humidity)	
		Stroke	10 $\pm$ 0.5 mm [0.39 $\pm$ 0.02 in.]	
		Ambient temperature for use	-30 to 120°C [-22 to 248°F]	

## **6. Tips on disassembling and reassembling**

This service manual covers recommended procedures to be followed when servicing Mitsubishi engines. The manual also contains special tools required and basic safety precautions.

It should be noted that this manual does not exhaustively cover potential hazards that could occur during maintenance, inspection and service work of engine.

When working on an engine, follow the relevant directions given in this manual and observe the following instructions:

### **6.1 Disassembling**

- (1) Use correct tools and instruments. Serious injury or damage to the engine will result from using the wrong tools and instruments.
- (2) Use an overhaul stand or work bench if necessary, and follow the disassembling procedures described in this manual.
- (3) Keep the engine parts in order of removal to prevent losing them.
- (4) Pay attention to assembling marks. Put your marks on the parts, if necessary, to ensure correct reassembling.
- (5) Carefully check each part for defects during disassembling or cleaning. Do not miss symptoms which can not be detected after disassembling or cleaning.
- (6) When lifting or carrying heavy parts, exercise utmost caution to ensure safety. Pay attention to balance of heavy parts when handling. (Get help, and use jacks, chain blocks and guide bolts as necessary.))

### **6.2 Reassembling**

- (1) Wash all engine parts, except such parts as oil seals, O-rings and rubber sheets, in cleaning oil and dry them with compressed air.
- (2) Use correct tools and instruments.
- (3) Use only high-quality lubricating oils and greases of appropriate types. Be sure to apply oil, grease or adhesive to the part wherever specified.  
Refer to "List of Sealant and Lubricant."
- (4) Use a torque wrench to tighten parts correctly when their tightening torques are specified.  
Refer to "List of Tightening Torque."
- (5) Replace all gaskets and packings with new ones unless specified otherwise. Apply adhesive if necessary. Use only the proper amount of adhesive.

# MAINTENANCE STANDARDS

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# 1. List of maintenance standards

## 1.1 Engine general

Table 2-1 List of maintenance standards Engine General

Unit mm [in.]

Inspection point			Nominal	Standard	Limit	Remark
Maximum rotation speed (rated rotation speed used as reference)			(Varies depending on specification of destination)			Adjust governor setting.
Minimum rotation speed						
Compression pressure (at 280 min <sup>-1</sup> )				2.7 MPa (28 kgf/cm <sup>2</sup> ) [398 psi]	Not acceptable at or below 2.2 MPa (22 kgf/cm <sup>2</sup> ) [313 psi]	When oil and water temperatures at 20 to 30 °C [68 to 86 °F]
Lubricating oil pressure	Rotated speed			0.29 to 0.39 MPa (3 to 4 kgf/cm <sup>2</sup> ) [42.7 to 56.9 psi]		Oil temperature at 60 to 70 °C [140 to 158 °F]
	Low idling			0.10 MPa (1.0kgf/cm <sup>2</sup> ) [14.2 psi]		
Valve timing		Inlet open		BTDC 18°		Values for checking valve timing Different from actual valve opening and closing timing
		Inlet open		ABDC 46°		
		Exhaust open		BBDC 46°		
		Exhaust open		ATDC 18°		
Valve clearance		Inlet		0.25 [0.01]		When engine is cold
		Exhaust		0.25 [0.01]		
Fuel injection timing (before TDC)				(Varies depending on specification)		

## 1.2 Main unit of engine

Table 2-2 List of maintenance standards Main unit of engine (1 / 4)

Unit mm [in.]

Inspection point			Nominal	Standard	Limit	Remark
Rocker arm	Rocker arm inside diameter		ø 12 [0.47]	12.013 to 12.035 [0.47295 to 0.47382]		
	Rocker shaft outside diameter		ø 12 [0.47]	11.470 to 11.984 [0.45157 to 0.47181]		
	Clearance between rocker arm and rocker shaft			0.029 to 0.065 [0.00114 to 0.00256]	0.2 [0.00788]	Replace rocker arm
Valve	Valve stem outside diameter	Inlet	ø 6.6 [0.26]	6.565 to 6.580 [0.25866 to 0.25925]	6.500 [0.25610]	
		Exhaust	ø 6.6 [0.26]	6.530 to 6.550 [0.25728 to 0.25807]	6.500 [0.25610]	
	Valve guide inside diameter	Inlet	ø6.6 [0.26]	6.600 to 6.615 [0.26004 to 0.26063]		
		Exhaust				
	Clearance between valve stem and valve guide	Inlet		0.020 to 0.050 [0.00079 to 0.00197]	0.10 [0.00394]	Replace valve and valve guide
		Exhaust		0.050 to 0.085 [0.00197 to 0.00335]	0.15 [0.00591]	

Table 2-2 List of maintenance standards Main unit of engine (2 / 4)

Unit mm [in.]

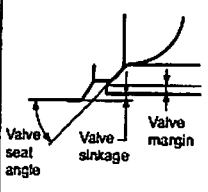
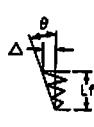
Inspection point			Nominal	Standard	Limit	Remark
Valve seat and valve	Valve seat angle		44°			
	Valve sinkage		0.5 [0.01970]	0.4 to 0.6 [0.01576 to 0.02364]		
	Valve margin			1.0 [0.03940]	0.5 [0.01970]	
	Valve guide mounting length		14 [0.55160]	13.5 to 14.5 [0.53190 to 0.55160]		
Valve spring	Free length		40		38.8	
	Squareness			 $\theta = 2^\circ$ $\Delta = 1.4$ [0.055] $L_f = 40$ [1.57]	$\Delta = 2.0$ [0.079] over entire length	
	Mounting length/load			35.5/61.1 to 71.0 N {6.54 to 7.24 kgf} [1.40/47.30 to 52.37 lbf] 28/170.7 to 189.4 N (17.41 to 19.31 kgf) [1.10/38.38 to 42.57 lbf]	-15%	
Cylinder	Pushrod	Runout		0.3 or less [0.012]	0.3 [0.012]	TIR, Replace
	Cylinder head	Distortion of cylinder head bottom surface		0.05 [0.020] or less	0.10 [0.039]	Repair
	Distortion of block top surface			0.05 [0.020] or less	0.10 [0.039]	Repair
	Cylinder inside diameter	L2A, L3A	$\phi$ 65 [2.56]	65.00 to 65.03 [2.55905 to 2.56023]	+0.7 [+0.027]	Repair limit is +0.2 [+0.00788]
		L2C, L3C	$\phi$ 70 [2.76]	70.00 to 70.03 [2.75590 to 2.75708]		
		L2E, L3E	$\phi$ 76 [2.99]	76.00 to 76.03 [2.99212 to 2.99330]		
Cylindricity			0.01 [0.039] or less			

Table 2-2 List of maintenance standards Main unit of engine (3 / 4)

Unit mm [in.]

Inspection point				Nominal	Standard	Limit	Remark
Piston	Out-side diameter	L2A L3A	STD	ø 65 [2.56]	64.919 to 64.939 [2.55586 to 2.55665]		
			0.25 OS	ø 65.25 [2.57]	65.169 to 65.189 [2.56570 to 2.56649]		
			0.50 OS	ø 65.50 [2.58]	65.419 to 65.439 [2.57555 to 2.57633]		
		L2C L3C	STD	ø 70 [2.76]	69.913 to 69.933 [2.75247 to 2.75326]		
			0.25 OS	ø 70.25 [2.77]	70.163 to 70.183 [2.76232 to 2.76310]		
			0.50 OS	ø 70.50 [2.78]	70.413 to 70.433 [2.77216 to 2.77295]		
		L2E L3E	STD	ø 76 [2.99]	75.906 to 75.926 [2.98842 to 2.98921]		
			0.25 OS	ø 76.25 [3.00]	76.156 to 76.176 [2.99826 to 2.99905]		
			0.50 OS	ø 76.50 [3.01]	76.406 to 76.426 [3.00810 to 3.00889]		
	Piston pin outside diameter		L2A, L3A L2C,L3C	ø 18 [0.71]	18.001 to 18.007 [0.70870 to 0.70894]		
			L2E, L3E	ø 21 [0.83]	21.002 to 21.005 [0.82685 to 0.82697]		
	Clearance between piston pin bore and piston pin		L2A, L3A L2C,L3C		0.006 to 0.018 [0.00024 to 0.00071]	0.08 [0.003]	
			L2E, L3E		0.007 to 0.015 [0.00028 to 0.00059]		
	Clearance between piston and cylinder (clearance)		L2A, L3A		0.061 to 0.111 [0.00240 to 0.00437]	0.2 [0.00788]	Repair to oversize or replace
			L2C, L3C		0.067 to 0.117 [0.00264 to 0.00461]		
			L2E, L3E		0.074 to 0.124 [0.00292 to 0.00489]		
Piston ring	Clearance between ring and ring groove	No. 1 ring		—	0.3 [0.01182]	Replace	
		No. 2 ring		0.05 to 0.09 [0.00197 to 0.00355]	0.2 [0.00788]		
		Oil ring		0.03 to 0.07 [0.00118 to 0.00276]	0.2 [0.00788]		
	Closed gap of ring	No. 1 ring		0.15 to 0.30 [0.00591 to 0.01182]	1.5 [0.05910]	Replace	
		No. 2 ring		0.15 to 0.30 [0.00591 to 0.01182]			
		Oil ring		0.15 to 0.35 [0.00591 to 0.01379]			
Connecting rod	Bend and torsion			0.05/100 [0.0197/3.93700] or less	0.15/100 [0.00591/3.93700]		
	End play			0.10 to 0.35 [0.03937 to 0.01379]	0.5 [0.0197]		

Table 2-2 List of maintenance standards Main unit of engine (4 / 4)

Unit mm [in.]

Inspection point		Nominal	Standard	Limit	Remark
Crankshaft	Journal outside diameter (STD)	ø 43 [1.69]	42.965 to 42.980 [1.69153 to 1.69212]	-0.70 [-0.02758]	Repair limit is -0.15 [-0.00591]
	Pin outside diameter (STD)	ø 40 [1.57]	39.965 to 39.980 [1.57342 to 1.57401]		
	Runout		0.06 [0.00236] or less		TIR
	Clearance between main bearing and crankshaft		0.030 to 0.075 [0.01182 to 0.00296]	0.10 [0.0039]	
	Clearance between connecting rod bearings		0.028 to 0.071 [0.00110 to 0.00280]	0.150 [0.0059]	
	End play		0.050 to 0.175 [0.00197 to 0.00690]	0.500 [0.0197]	
Timing gear backlash	Between crank gear and idler gear		0.010 to 0.141 [0.00039 to 0.00556]	0.3 [0.01182]	Replace
	Between idler gear and valve camshaft gear		0.010 to 0.136 [0.00039 to 0.00536]		
	Between idler gear and pump camshaft gear				
	Between valve camshaft gear and PTO gear		0.010 to 0.220 [0.00039 to 0.00867]		
Cam height of camshaft (major axis)		27.37 [1.08]	27.27 to 27.47 [1.07756 to 1.08149]	26.37 [1.03819]	
Cam height of fuel injection pump camshaft (major axis)		30 [1.18]	29.9 to 30.1 [1.17716 to 1.18504]	29 [1.14173]	Replace
Flywheel flatness			0.08 [0.00315] or less		
Clearance between tappet and cylinder block bore		ø 19 [0.75]	0.007 to 0.049 [0.00028 to 0.00193]	0.15 [0.00591]	Replace tappet.
Clearance between camshaft journal and cylinder block bore			0.050 to 0.100 [0.00197 to 0.00394]	0.15 [0.00591]	Replace camshaft or cylinder block
Clearance between idler gear bushing and idler shaft		ø 20 [0.79]	0.030 to 0.066 [0.01187 to 0.00260]	0.2 [0.00788]	

**1.3 Fuel system**
**Table 2-3 List of maintenance standards Fuel system**

Unit mm [in.]

Inspection point	Nominal	Standard	Limit	Remark
Fuel injection nozzle injection starting pressure	13.73 MPa (140 kgf/cm <sup>2</sup> ) [1992 psi]	13.73 to 14.73 MPa (140 to 150 kgf/cm <sup>2</sup> ) [1992 to 2134 psi]		Adjust with washers.

**1.4 Lubrication system**
**Table 2-4 List of maintenance standards Oil system**

Unit mm [in.]

Inspection point		Nominal	Standard	Limit	Remark
Oil pump	Clearance between oil pump housing inside diameter and oil pump outer gear outside diameter	ø 75.5 [2.97]	0.100 to 0.196 [0.00394 to 0.00772]	0.3 [0.01182]	Replace
	Clearance between oil pump outer gear width and oil pump housing	10 [0.039]	0.040 to 0.100 [0.00158 to 0.00394]	0.25 [0.00985]	Replace
Relief valve opening pressure (1000 min <sup>-1</sup> )			0.29±0.029 MPa {3.0±0.3 kgf/cm <sup>2</sup> } [43±4.3 psi]		Replace
Oil pressure at which oil pressure switch illuminates			0.05±0.01 MPa {0.5±0.1 kgf/cm <sup>2</sup> } [7±0.7 psi]		Replace

**1.5 Cooling system**
**Table 2-5 List of maintenance standards Cooling system**

Unit mm [in.]

Inspection point	Nominal	Standard	Limit	Remark
Thermo-stat	Temperature at which valve starts opening	76.5±1.5 °C [169.7±2.7 °F]		Replace
	Temperature at which valve lift becomes 6 mm [0.2364] or more	90 °C [194 °F]		
Thermo-switch	At 111±3.5°C [231.8±38.3°F]	30 mΩ (in oil of 120 °C [248 °F])		
Deflection amount of belt (when it is pushed between crankshaft pulley and alternator pulley with a force of approx. 98 N (10 kgf) [22.0459 lbf])		Approx. 10 mm [0.39]		

**1.6 Inlet/Exhaust system**
**Table 2-6 List of maintenance standards Inlet/Exhaust system**

Unit mm [in.]

Inspection point	Nominal	Standard	Limit	Remark
Distortion on mounting surfaces of intake cover and exhaust manifold			0.15 [0.00591]	Repair by grinding or replace

# 1.7 Electrical system

Table 2-7 List of maintenance standards Electrical system (1 / 3)

Unit mm [in.]

Inspection point		Nominal	Standard	Limit	Remark
Starter M000T60481 (12 V-1.2 kW)	Pinion clearance		0.5 to 2.0 [0.0197 to 0.0788]		
	Brush length		16.5 [0.65]	10 [0.39]	
	Brush spring load	20.58 N (2.10 kgf) [4.6 lbf]	17.5 to 23.7 N (1.78 to 2.42 kgf) [3.9 to 5.3 lbf]	6.86 N (0.70 kgf)	
	Commutator radial runout			0.1 [0.00394]	
	Commutator outside diameter		ø 29.4 [1.157]	ø 28.8 [1.134]	
	Depth of undercuts between segments	0.75 [0.030]	0.5 to 1.0 [0.0197 to 0.0394]	0.2 [0.00788] or less	
	No-load characteristics	Terminal voltage	11 V		
		Current	90 A or less		
		Rotation speed	2500 min <sup>-1</sup> or more		
Starter M001T68381 (12 V-1.7 kW)	Pinion clearance		0.5 to 2.0 [0.0197 to 0.0788]		
	Brush length		16.5 [0.65]	10 [0.39]	
	Brush spring load	20.58 N (2.10 kgf) [4.6 lbf]	17.5 to 23.7 N (1.78 to 2.42 kgf) [3.9 to 5.3 lbf]	6.86 N (0.70 kgf) [1.5 lbf]	
	Commutator radial runout			0.1 [0.00394]	
	Commutator outside diameter		ø 29.4 [1.157]	ø 28.8 [1.134]	
	Depth of undercuts between segments	0.75 [0.030]	0.5 to 1.0 [0.0197 to 0.0394]	0.2 [0.00788] or less	
	No-load characteristics	Terminal voltage	11 V		
		Current	110 A or less		
		Rotation speed	2400 min <sup>-1</sup> or more		

Table 2-7 List of maintenance standards Electrical system (2 / 3)

Unit mm [in.]

Inspection point				Nominal	Standard	Limit	Remark
Starter M002T66071 (24 V-3.2 kW)	Pinion shaft end play				0.5 [0.0197]		
	Pinion clearance				0.5 to 2.0 [0.0197 to 0.0788]		
	Brush length				18 [0.709]	11 [0.4331]	
	Brush spring load			34 N {3.47 kgf} [2 lbf]	28.9 to 39.1 N {2.95 to 3.99 kgf} [7 to 9 lbf]	20 N {2.04 kgf} [4 lbf]	
	Commutator radial runout					0.1 [0.00394]	
	Commutator outside diameter				ø 32 [1.2598]	ø 31.4 [1.23622]	
	Depth of undercuts between segments			0.5 [0.020]	0.4 to 0.6 [0.01576 to 0.02364]	0.2 [0.00788] or less	
	No-load charac- teristics	Terminal voltage			23 V		
		Current			80 A or less		
Rotation speed			3400 min <sup>-1</sup> or more				
Alternator A007TA0171B (12 V-40 A)	Brush spring load				4.8 to 6.0 N {0.49 to 0.61 kgf} [1.1 to 1.3 lbf]	2.2 N {0.22 kgf} [0.5 lbf]	
	Brush length				18.5 [0.7283]		
	Resistance between slip rings			2.95 Ω	2.7 to 3.2 Ω		
	Slip ring outside diameter				ø 22.7 [0.8937]	ø 22.1 [0.8701]	
	Output charac- teristics (when hot)	2500 min <sup>-1</sup>	Terminal voltage		13.5 V		
			Current		21 A or more		
		5000 min <sup>-1</sup>	Terminal voltage		13.5 V		
			Current		37 A or more		
	IC regulator adjusting voltage (at 20° [68°F] )				14.7±0.3 V		

Table 2-7 List of maintenance standards Electrical system (3 / 3)

Unit mm [in.]

Inspection point				Nominal	Standard	Limit	Remark
Alternator A007TA8271A (24 V-25 A)	Brush spring load				4.8 to 6.0 N {0.49 to 0.61 kgf} [1.1 to 1.3 lbf]	2.2 N {0.22 kgf} [0.5 lbf]	
	Brush length				18.5 [0.7283]	5 [0.197]	
	Resistance between slip rings			12.4 Ω	11.4 to 13.4 Ω		
	Slip ring outside diameter				ø 22.7 [0.8937]	ø 22.1 [0.8701]	
	Output characteristics (when hot)	2500 min <sup>-1</sup>	Terminal voltage		27.0 V		
			Current		18 A or more		
		5000 min <sup>-1</sup>	Terminal voltage		27.0 V		
			Current		22 A or more		
IC regulator adjusting voltage (at 20°C [68°F] )				28.5±0.5 V			
Clearance of stop solenoid to plunger rack					ETR	ETS	
					0.3 to 0.7 [0.01182 to 0.02758]	0.15 to 0.20 [0.00591 to 0.00788]	
Resistance value of glow plug			12 V		0.2 Ω		
			24 V		4.5 Ω		

## 2. List of tightening torque

### 2.1 Tightening torque of main bolts and nuts

Table 2-8 List of tightening torque of main bolts and nuts


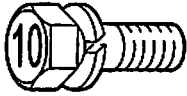
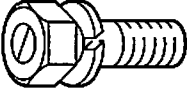
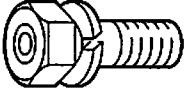
Description	Threads (mm) Diameter x Pitch	Torque			Remark	
		N·m	kgf·m	lbf·ft		
Main unit of engine						
Cylinder head bolt	Main	M10x1.25	73.5 to 83.4	7.5 to 8.5	54.2 to 61.5	
	Sub	M8x1.25	19.6 to 29.4	2.0 to 3.0	14.5 to 21.7	
Rocker cover nut		M6x1.0	4.9 to 6.9	0.5 to 0.7	3.6 to 5.1	
Rocker stay bolt		M8x1.25	14.7 to 21.6	1.5 to 2.2	10.8 to 15.9	
Main bearing cap bolt		M10x1.25	49.0 to 53.9	5.0 to 5.5	36.2 to 39.8	
Connecting rod cap nut		M8x1.0	31.4 to 34.3	3.2 to 3.5	23.1 to 25.3	
Flywheel bolt		M10x1.25	83.4 to 93.2	8.5 to 9.5	61.5 to 68.7	
Crankshaft pulley nut		M16x1.5	98.1 to 117.7	10 to 12	72.3 to 86.8	
Fuel system						
Hollow screw (fuel injection pump)		M10x1.0	9.8 to 14.7	1.0 to 1.5	7.2 to 10.8	
Delivery valve holder (fuel injection pump)			34.3 to 38.2	3.5 to 3.9	25.3 to 28.2	
Air-bleeding plug (fuel injection pump)			4.9 to 6.9	0.5 to 0.7	3.6 to 5.1	
Lock plate (fuel injection pump)			3.2 to 4.0	0.3 to 0.4	2.2 to 2.9	
Stop wire bracket (fuel injection pump)			3.2 to 4.0	0.3 to 0.4	2.2 to 2.9	
Fuel injection nozzle retaining nut		M16x0.75	34.3 to 39.2	3.5 to 4.0	25.3 to 28.9	
Fuel injection nozzle holder		M20x1.5	49.0 to 68.6	5.0 to 7.0	36.2 to 50.6	
Fuel injection pipe nuts		M12x1.5	24.5 to 29.4	2.5 to 3.0	18.1 to 21.7	
Fuel return pipe nut		M12x1.5	20.6 to 24.5	2.1 to 2.5	15.2 to 18.1	
Nut for setting torque spring		M12x1.0	14.7 to 24.5	1.5 to 2.5	10.8 to 18.1	
Adjusting screw nut for setting torque spring		M8x1	7.8 to 11.8	0.8 to 1.2	5.8 to 8.7	
Lubrication system						
Oil relief valve		M18x1.5	39.2 to 49.0	4.0 to 5.0	28.9 to 36.2	
Oil pan drain plug		M18x1.5	49.0 to 58.8	5.0 to 6.0	36.2 to 43.4	
Oil pressure switch		PT1/8	7.85 to 11.8	0.8 to 1.2	5.8 to 8.7	
Oil pump		M6x1.0	7.8 to 9.8	0.8 to 1.0	5.8 to 7.2	
Cooling system						
Thermoswitch		M16x1.5	19.6 to 29.4	2.0 to 3.0	14.5 to 21.7	
Thermostat cover bolt		M6x1.0	8 to 10	0.8 to 1.0	5.8 to 7.2	
Hole plug for thermoswitch		M16x1.5	19.6 to 24.5	2.0 to 2.5	14.5 to 18.1	
Inlet/Exhaust system						
Intake cover bolt		M6x1.0	7.8 to 9.8	0.8 to 1.0	5.8 to 7.2	
Exhaust manifold bolt		M8x1.25	14.7 to 21.6	1.5 to 2.2	10.8 to 15.9	
Electrical system						
Starter through bolt			4.4 to 7.1	0.45 to 0.72	3.3 to 5.2	
Starter brush holder tightening screw			2.4 to 4.4	0.24 to 0.45	1.7 to 3.3	
Starter magnet switch screw			4.1 to 7.6	0.42 to 0.77	3.0 to 5.6	

Table 2-8 List of tightening torque of main bolts and nuts

Description	Threads (mm) Diameter x Pitch	Torque			Remark
		N·m	kgf·m	lbf·ft	
Starter terminal M		8.8 to 12.7	0.90 to 1.30	6.5 to 9.4	
Starter terminal B	M8×1.25	7.8 to 11.8	0.8 to 1.2	5.8 to 8.7	
Stop solenoid fixing nut	M30×1.5	39.2 to 49.0	4.0 to 5.0	28.9 to 36.2	
Blind plug for stop solenoid	M30×1.5	39.2 to 49.0	4.0 to 5.0	28.9 to 36.2	
Glow plug	M10×1.25	14.7 to 19.6	1.5 to 2.5	10.8 to 18.1	
Glow plug lead wire nut	M4×0.7	0.98 to 1.47	0.10 to 0.15	0.72 to 1.1	
Alternator terminal B	M5×0.8	2.9 to 4.9	0.3 to 0.5	2.2 to 3.6	

## 2.2 Standard bolt and nut tightening torque

Table 2-9 Standard bolt and nut tightening torque

Description	Thread Dia×Pitch (mm)	Width across flats (mm) [in.]	Strength classification					
			7.8			10.9		
Metric automobile screw thread								
			N-m	kgf-m	lbf-ft	N-m	kgf-m	lbf-ft
	M8×1.25	12 [0.47]	17	1.7	12	30	3.1	22
	M10×1.25	14 [0.55]	33	3.4	25	60	6.1	44
	M12×1.25	17 [0.67]	60	6.1	44	108	11.0	80
	M14×1.5	22 [0.87]	97	9.9	72	176	17.9	129
	M16×1.5	24 [0.94]	145	14.8	107	262	26.7	193
	M18×1.5	27 [1.06]	210	21.4	155	378	38.5	278
	M20×1.5	30 [1.18]	291	29.7	215	524	53.4	386
	M22×1.5	32 [1.26]	385	39.3	284	694	70.8	512
	M24×1.5	36 [1.42]	487	49.7	359	878	89.5	647
	M27×3	41 [1.61]	738	75.3	544	1328	135.5	980
Metric course screw thread								
			N-m	kgf-m	lbf-ft	N-m	kgf-m	lbf-ft
	M10×1.5	14 [0.55]	32	3.3	24	58	5.9	43
	M12×1.75	17 [0.67]	57	5.8	42	102	10.4	75
	M14×2	22 [0.87]	93	9.5	69	167	17.0	123
	M16×2	24 [0.94]	139	14.2	103	251	25.6	185
	M18×2.5	27 [1.06]	194	19.8	143	350	35.7	258
	M20×2.5	30 [1.18]	30	27.7	200	489	49.9	361
	M22×2.5	32 [1.26]	363	37.0	268	653	66.6	482
	M24×3	36 [1.42]	468	47.7	345	843	86.0	622
	M27×3	41 [1.61]	686	70.0	506	1236	126.0	911

Note: (a) This table lists the tightening torque for standard bolts and nuts.

(b) The numerical values in the table are for fasteners with spring washers.

(c) The table shows the standard values with a maximum tolerance value of  $\pm 10\%$ .

(d) Use the tightening torque in this table unless otherwise specified.

(e) Do not apply oil to threaded sections. (Dry)

### 2.3 Standard eyebolt tightening torque

Table 2-10 Standard eyebolt tightening torque

Threads Dia×Pitch (mm)	Width across flats (mm) [in.]	Strength classification		
		4T		
		N·m	kgf·m	lbf·ft
M8×1.25	12 [0.47]	8±1	0.8±0.1	5.8±0.7
M10×1.25	14 [0.55]	15±2	1.5±0.2	11±1.5
M12×1.25	17 [0.67]	25±3	2.5±0.3	18±2.2
M14×1.5	19 [0.75]	34±4	3.5±0.4	25±2.9
M16×1.5	22 [0.87]	44±5	4.5±0.5	33±3.6
M18×1.5	24 [0.94]	74±5	7.5±0.5	54±3.6
M20×1.5	27 [1.06]	98±10	10.0±1.0	72±7.2
M24×1.5	32 [1.26]	147±15	15.0±1.5	109±11
M27×1.5	41 [1.61]	226±20	23.0±2.0	166±15

(Dry)

### 2.4 Standard union nut tightening torque

Table 2-11 Standard union nut tightening torque

Nominal diameter	Cap nut size M (mm)	Width across flats (mm) [in.]	N·m	kgf·m	lbf·ft
63	M14×1.5	19 [0.75]	39	4	29
80	M16×1.5	22 [0.87]	49	5	36
100	M20×1.5	27 [1.06]	78	8	58
120	M22×1.5	30 [1.18]	98	10	72
150	M27×1.5	32 [1.26]	157	16	116
180	M30×1.5	36 [1.42]	196	20	145
200	M30×1.5	36 [1.42]	196	20	145
220	M33×1.5	41 [1.61]	245	25	181
254	M36×1.5	41 [1.61]	294	30	217

(Maximum tolerance value: ± 10%, dry)

### 2.5 High-pressure fuel injection pipe tightening torque

Table 2-12 High-pressure fuel injection pipe tightening torque

Cap nut size (mm)	N·m	kgf·m	lbf·ft
M12×1.5	39±5	4±0.5	29±3.6
M14×1.5	49±5	5±0.5	36±3.6
M18×1.5	59±1	6±1.0	43±7.2

(Dry)

### 3. List of sealant and lubricant

Table 2-13 List of sealant and lubricant

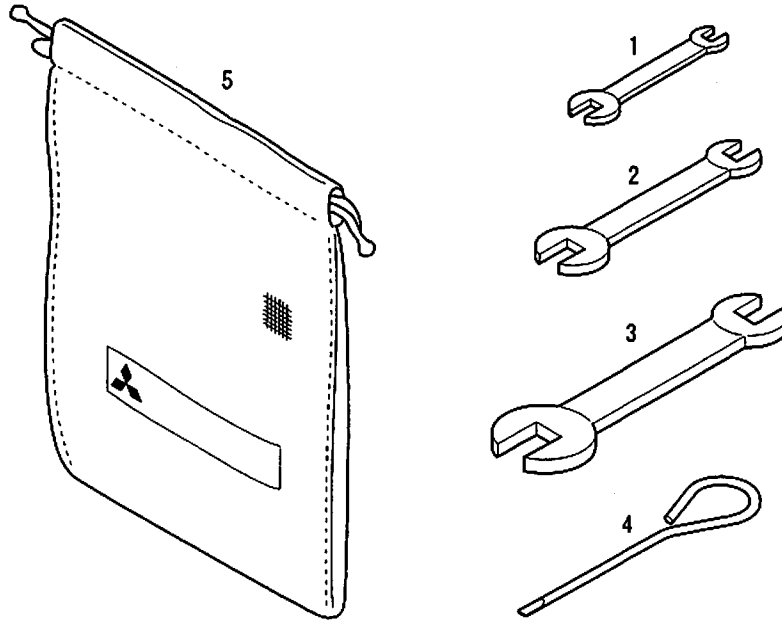
	Description	Sealant	Mating part	Application point
Threaded parts	Stop solenoid	THREEBOND 1212 or 1211	Cylinder block	Apply to effective threads.
	Water drain joint	Hermeseal or THREEBOND 1344N	Cylinder block	
	Oil pressure switch			
	Torque spring set	THREEBOND 1212 or 1211	Governor case	
Press-fit parts	Sealing cap	Hermeseal 52B	Cylinder block	Apply to cylinder head and cylinder block holes.
			Cylinder head	
			Cylinder head, cylinder block	
	Expansion plug		Cylinder block	
	Oil level gage guide			
Others	Side seal	THREEBOND 1212 or 1211	Cylinder block main bearing cap	Apply to circumference.
	Main bearing cap (front, rear)		Cylinder block	Apply to contact surface with cylinder block.

# LIST OF TOOLS

1. Basic tools.....3-2

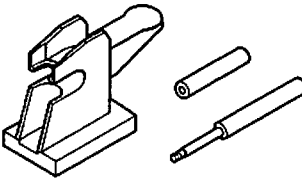
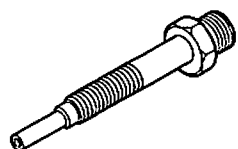
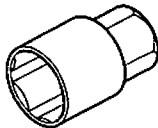
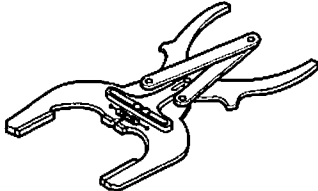
2. Special tools.....3-3

## 1. Basic tools



No.	Tool name	Part No.	Remark
-	Tool set	MM413-900	Includes 1 to 5
1	Spanner	MK96008010	Width across flats (8 mm×10 mm) [0.32×0.39 in.]
2	Spanner	MK96012014	Width across flats (12 mm×14 mm) [0.47×0.55 in.]
3	Spanner	MK96017019	Width across flats (17 mm×19 mm) [0.69×0.75 in.]
4	Screwdriver	MM300110	(-)
5	Tool bag	MM300783	

## 2. Special tools

Tool name	Part No.	Shape	Remark
Piston pin setting tool	30L91-00030 (L2A, L3A)		For pulling out and press fitting piston pins
	30L91-00020 (L2C, L3C)		
	30L91-10010 (L2E, L3E)		
Compression gage adapter	ST332270		For measuring compression
Oil pressure switch socket wrench (26)	MD998054		For removing and installing oil pressure switch
Piston ring pliers	31391-12900		Range applicable for removing and installing piston rings: 60 to 95 mm [2.36 to 3.74 in.]

# OVERHAUL DETERMINATION

1. Determining overhaul timing .....4-2
2. Testing compression pressure .....4-3

### 1. Determining overhaul timing

In most cases, the engine should be overhauled when the compression pressure of the engine becomes low. And increase in engine oil consumption and blow-by gas are also considered to evaluate the engine condition. Besides, such items as the decrease in output, increase in fuel consumption, decrease in oil pressure, difficulty of engine starting and increase in noise are also considered for judging the overhaul timing. However, these are largely affected by other causes, and are not always effective to judge the overhaul timing. Decreased compression pressure shows a variety of symptoms and engine conditions, thus making it difficult to accurately determine when the engine needs an overhaul. The following shows typical problems caused by reduced compression pressure.

- (1) Decreased output power
- (2) Increased fuel consumption
- (3) Increased engine oil consumption
- (4) Increased blow-by gas through the breather due to worn cylinder liners and piston rings (Visually check the blow-by amount)
- (5) Increased gas leakage due to poor seating of inlet and exhaust valves
- (6) Difficulty in starting
- (7) Increased noise from engine parts
- (8) Abnormal exhaust color after warm-up operation

The engine can exhibit these conditions in various combinations. Some of these problems are directly caused by worn engine parts, while others are not. Phenomena described in items (2) and (6) will result from improper fuel injection volume, fuel injection timing, worn plunger, faulty nozzles and also faulty conditions of electrical devices such as battery and starter. The most valid reason to overhaul an engine is a decrease in compression pressure due to worn cylinder liners and pistons, as described in item (4). In addition to this item, it is reasonable to take other problems into consideration for making the total judgment.

## 2. Testing compression pressure

### CAUTION

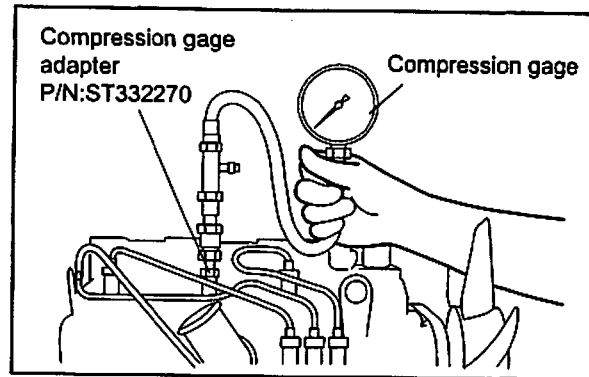
Measure all cylinders for compression pressure. Do not measure only one cylinder and make assumption about the other cylinders as it will lead to a wrong conclusion.

Compression pressure varies depending on the engine speed. When measuring the compression pressure, be sure to measure the engine speed as well.

It is important to regularly check the compression pressure so that you can tell the change with time. New or overhauled engines have slightly higher compression pressure.

The compression pressure settles to the standard value after the piston rings and valve seats running-in. The compression pressure decreases as the wear of parts progresses further.

- (1) Move the control lever to the STOP position.
- (2) Remove the glow plugs from all cylinders.  
Install the special tool gage adapter and a compression gage onto the cylinder to be measured.
- (3) While cranking the engine with the starter, read the compression gage. Note the reading at which the gage needle is stabilized.
- (4) If the measured value is at the limit or below, overhaul the engine.



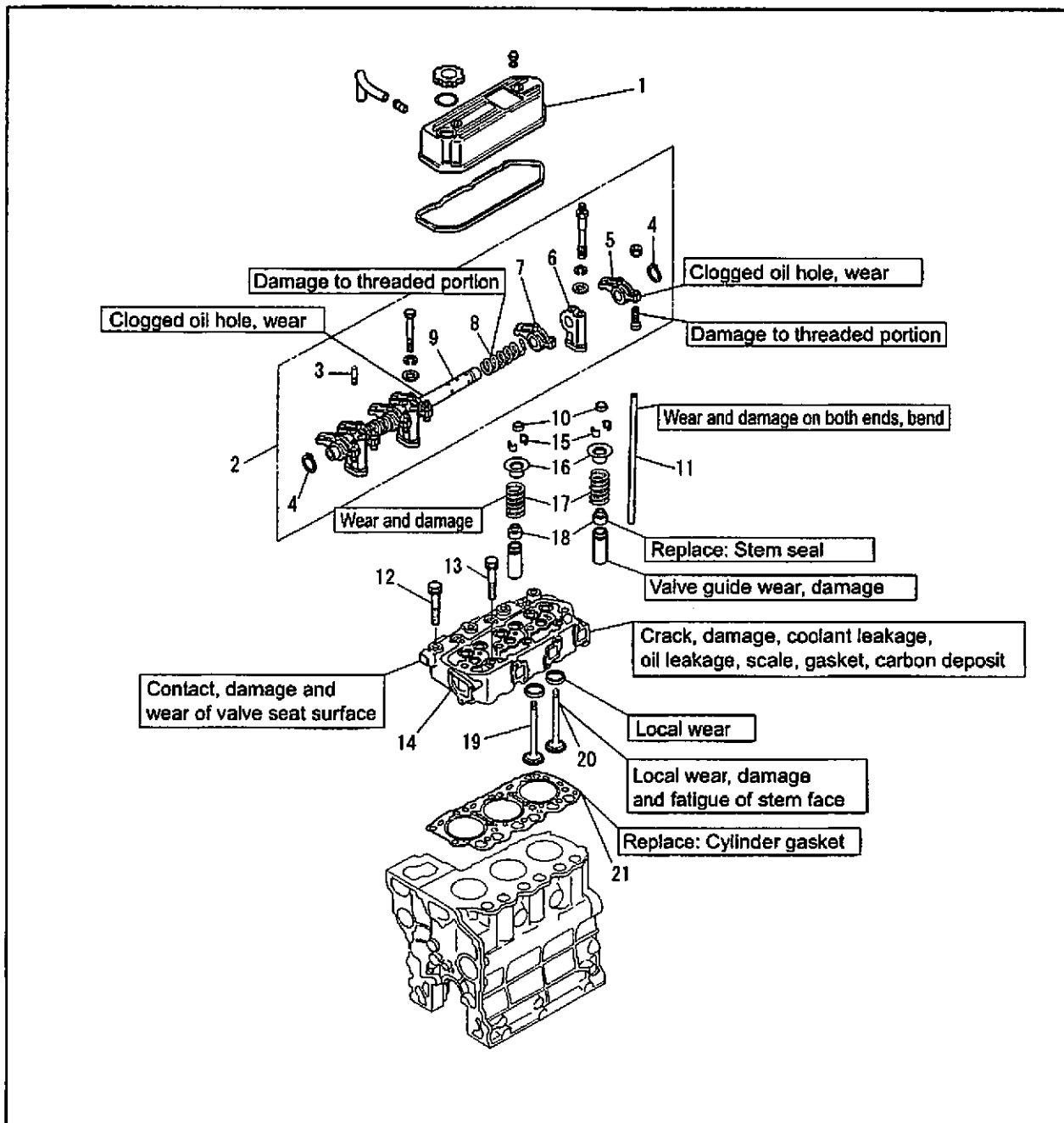
Testing compression pressure

Item	Standard	Limit
Engine speed	280 min <sup>-1</sup>	
Compression pressure	2.7MPa {28kgf/cm <sup>2</sup> } [398 psi]	Not acceptable at or below 2.2 MPa {22 kgf/cm <sup>2</sup> } [313 psi]
Difference between each cylinder	Within 0.25 MPa (2.5 kgf/cm <sup>2</sup> ) [36 psi]	

# DISASSEMBLING ENGINE MAIN PARTS

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# 1. Disassembling and inspecting cylinder head and valve mechanism



Disassembling and inspecting cylinder head and valve mechanism

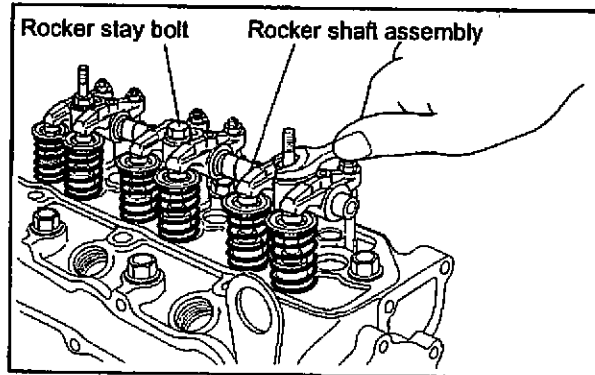
## Disassembling sequence

- |  |                              |                         |
|--|------------------------------|-------------------------|
| 1 Rocker cover                           | 8 Rocker shaft spring        | 15 Valve lock           |
| 2 Rocker shaft assembly (includes 3 - 9) | 9 Rocker shaft               | 16 Retainer             |
| 3 Grooved pin                            | 10 Valve cap                 | 17 Valve spring         |
| 4 Snap ring                              | 11 Pushrod                   | 18 Valve stem seal      |
| 5 Exhaust rocker arm                     | 12 Cylinder head bolt (main) | 19 Intake valve         |
| 6 Rocker stay                            | 13 Cylinder head bolt (sub)  | 20 Exhaust valve        |
| 7 Intake rocker arm                      | 14 Cylinder head             | 21 Cylinder head gasket |

### 1.1 Removing rocker shaft assembly

- (1) Loosen the rocker arm adjusting screw by about one turn.
- (2) Loosen rocker stay bolts and remove rocker shaft assembly.

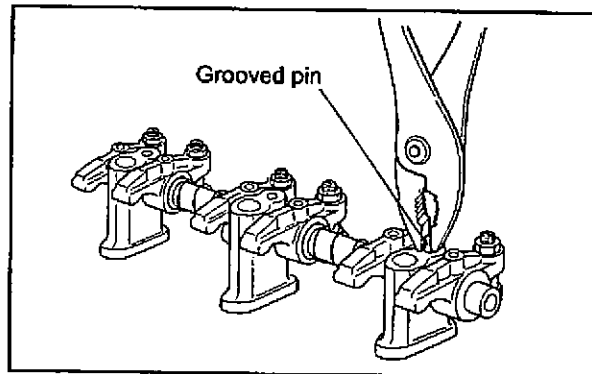
Note: When removing rocker shaft assembly, remove with the rocker stay bolts attached to it and keep them together for reassembling.



Removing rocker shaft assembly

### 1.2 Disassembling rocker shaft assembly

- (1) Pull out the grooved pin with a pair of pliers.

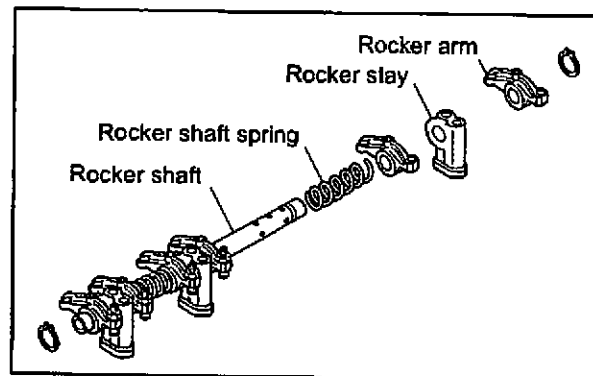


Removing grooved pin

- (2) Remove snap rings from both ends of the rocker shaft. Separate the rocker shaft assembly into the rocker arms, rocker stays, rocker shaft springs and rocker shaft.

Note: Be sure to arrange the component parts of rocker shaft assembly in the order of disassembling for correct reassembly.

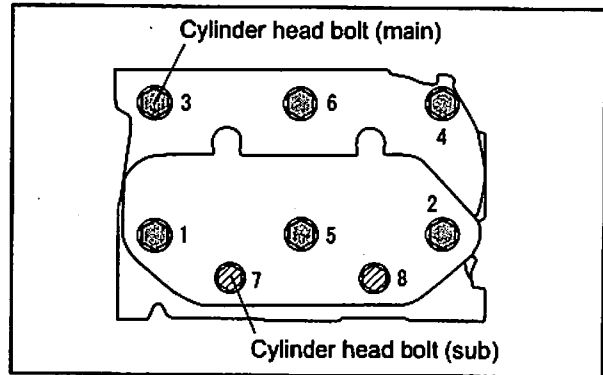
Reassemble the rocker shaft parts to make the original combinations before disassembling so that the clearances between the rocker shaft and arms can be restored.



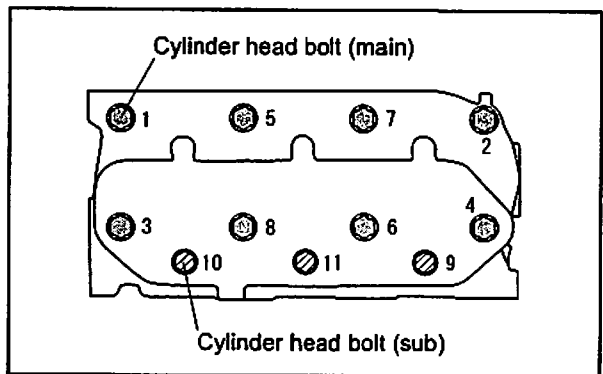
Disassembling rocker shaft assembly

### 1.3 Removing cylinder head bolt.

Loosen cylinder head bolts in the numerical order as shown in the illustration.



Loosening order of cylinder head bolt (L2)



Loosening order of cylinder head bolt (L3)

### 1.4 Removing cylinder head assembly

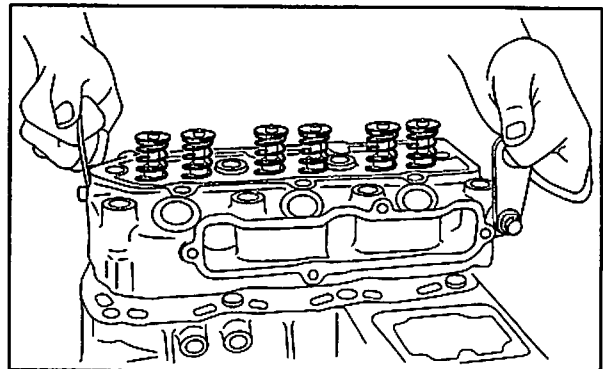
(1) Lift up the cylinder head assembly to remove.

Note: If the cylinder head assembly cannot be removed due to crimping of the cylinder head gasket, tap the thick area on the side of the cylinder head to give a shock.

(2) Remove the gasket from the cylinder head.

Note: (a) Be careful not to damage the fitting surfaces of the gasket when removing the gasket from the cylinder head.

(b) Before removing the cylinder head bolts, check the cylinder head components for any defects or faults. If any of them is faulty or defective, check the bolts for tightness with a torque wrench.



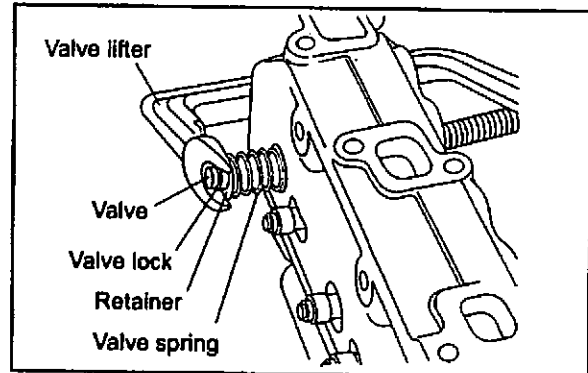
Removing cylinder head assembly

### 1.5 Removing valves and valve spring

(1) Use the valve lifter to compress the valve spring and remove the valve lock.

(2) Remove the retainer, valve spring and valve.

Note: Put match marks for easy identification of the installing position if the valve is to be reused. When reassembling, do not change the combination of the valve and valve seat.

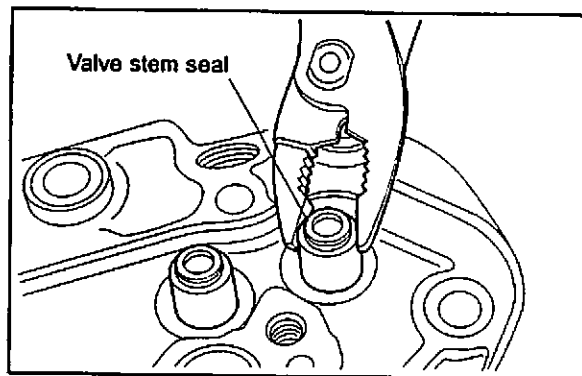


Removing valve

### 1.6 Removing valve stem seal

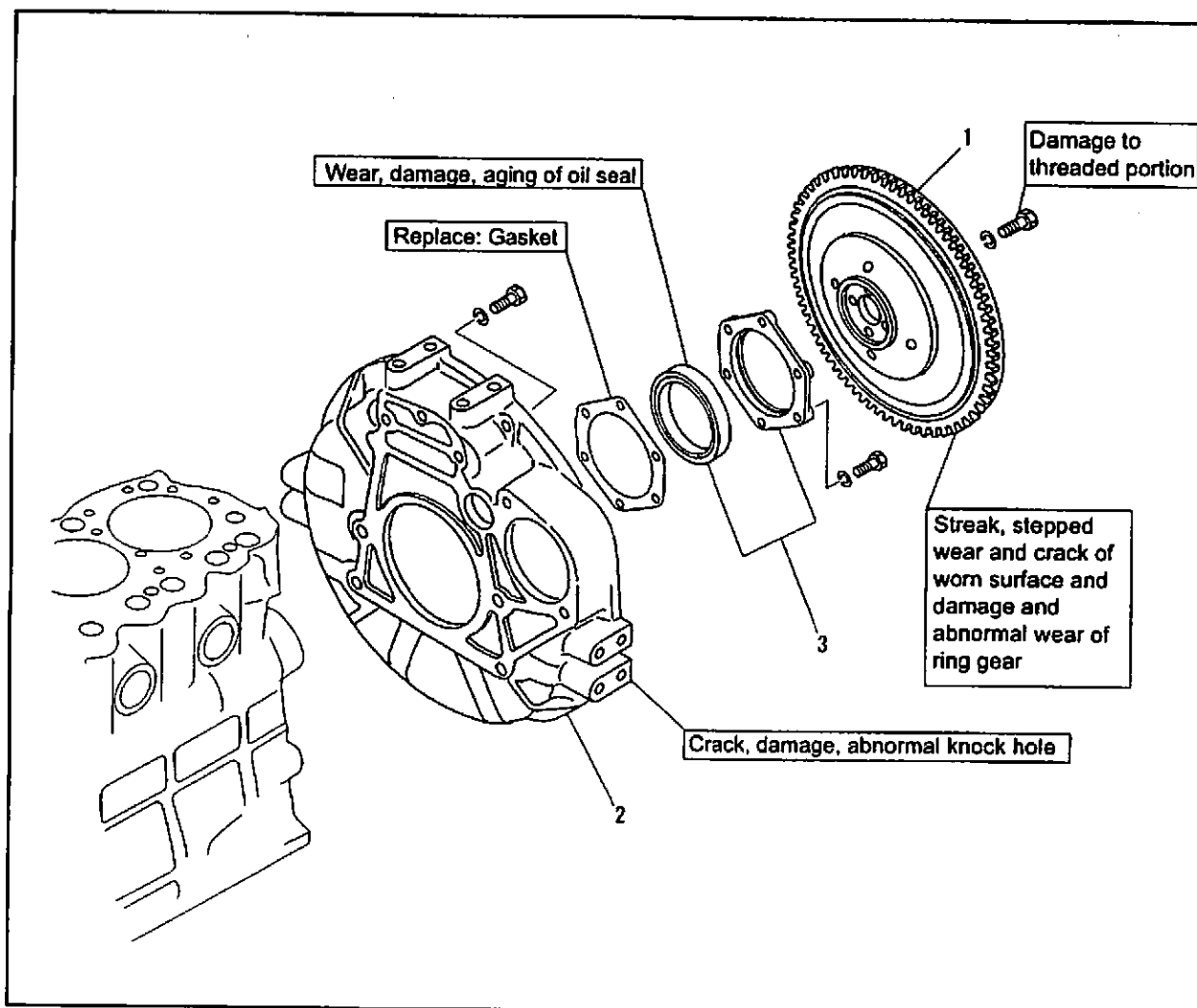
Grab the stem seal with pliers and remove.

Note: Be sure to replace the stem seal when reassembling the valve and valve spring.



Removing valve stem seal

## 2. Disassembling and inspecting flywheel



Disassembling and inspecting flywheel

### Disassembly sequence

- |                    |                           |
|--------------------|---------------------------|
| 1 Flywheel         | 3 Oil seal case, oil seal |
| 2 Flywheel housing |                           |

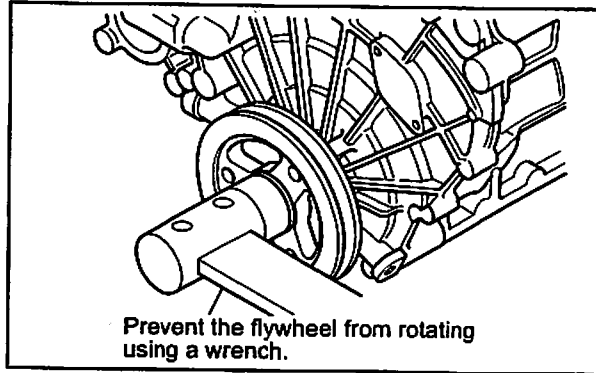
## 2.1 Removing flywheel

### CAUTION

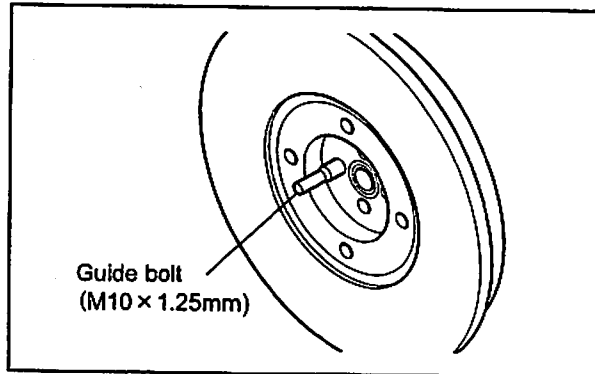
- (a) Be careful not to cut your hand with the ring gear when pulling out the flywheel.  
Be careful not to drop or hit the flywheel to avoid damage when removing it.
- (b) The personnel who holds the pulley must pay due attention to safety.  
Also, personnel must stay in close contact with each other during work.

- (1) One personnel must firmly hold the pulley with a wrench to prevent the flywheel from turning.
- (2) Remove one bolt from the flywheel.
- (3) Screw a guide bolt into the threaded hole from which a bolt is removed.
- (4) Remove remaining bolts from the flywheel.
- (5) Hold the flywheel firmly with both hands. Shake it back and forth to pull it out straight.

Note: The ring gear is shrink fitted to the flywheel. Do not remove it unless defective.



Detent of flywheel



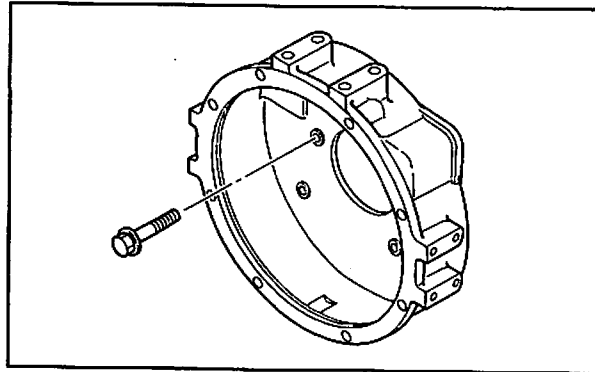
Removing flywheel

## 2.2 Removing flywheel housing

### CAUTION

Be careful not to damage the oil seal.

- (1) Remove bolts from the flywheel housing.
- (2) Remove the flywheel housing.



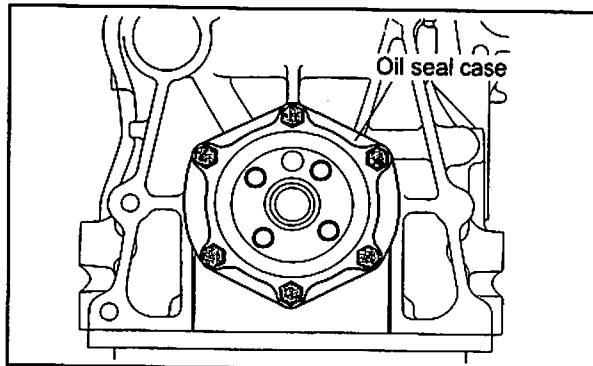
Removing flywheel housing

## 2.3 Removing oil seal case

### CAUTION

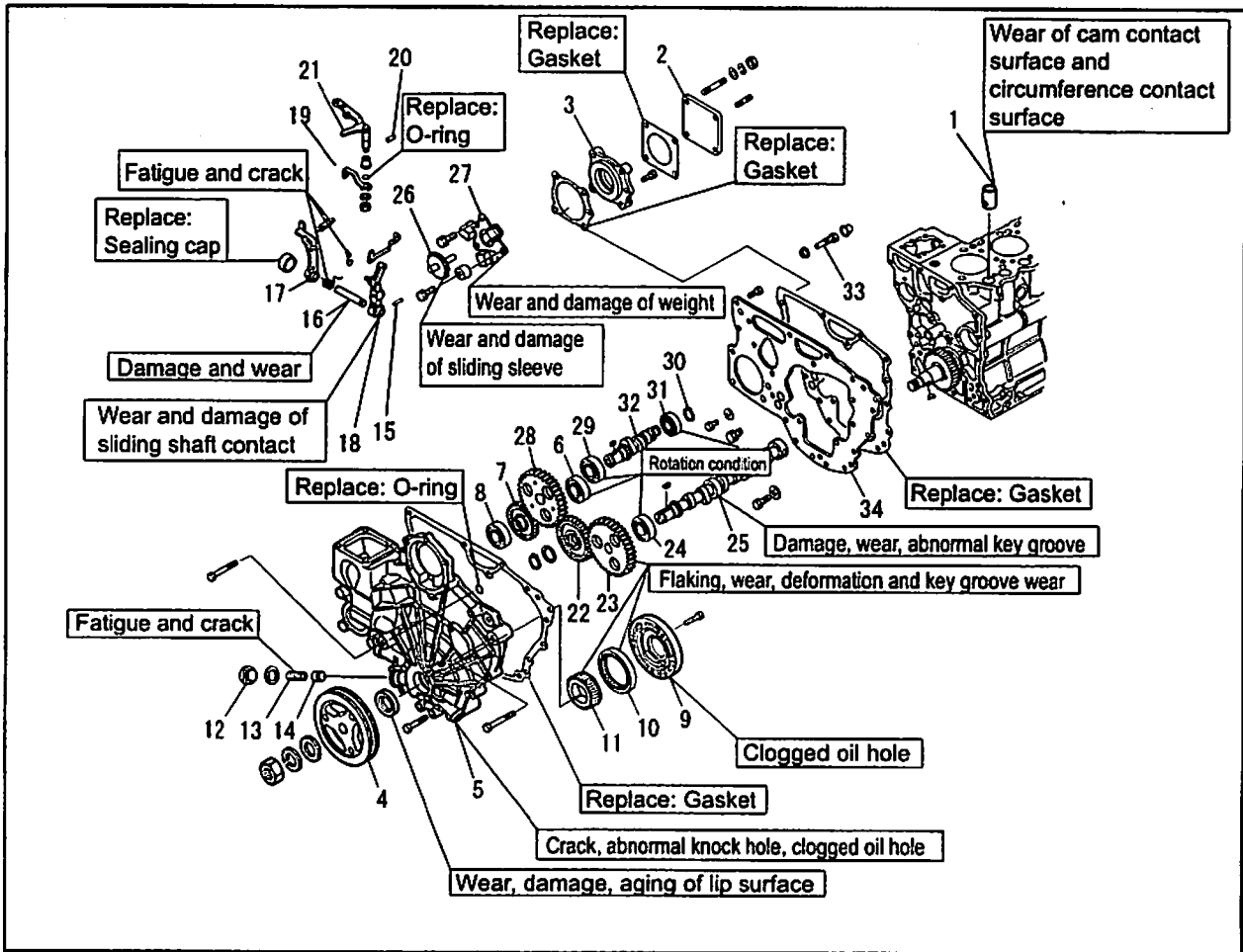
Be very careful not to damage the oil seal.

- (1) Remove bolts from the oil seal case.
- (2) Pry the oil seal case from the cylinder block using a screwdriver.



Removing oil seal case

### 3. Disassembling and inspecting gear case, timing gears and camshaft



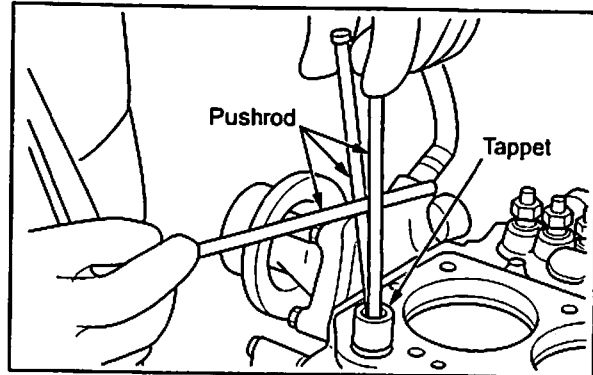
Disassembling and inspecting gear case, timing gears and camshaft

#### Disassembling sequence

- |   |                          |  |
|---|--------------------------|--|
| 1 Tappet  | 13 Relief spring         | 25 Camshaft<br>(Remove parts 23 to 25 as a unit)                     |
| 2 Oil pump cover                                  | 14 Relief plunger        |  |
| 3 Gear pump housing                               | 15 Grooved pin           | 26 Sliding shaft   |
| 4 Crankshaft pulley                               | 16 Governor shaft        | 27 Governor weight   |
| 5 Gear case                                       | 17 Tension lever         | 28 Fuel injection pump camshaft gears                                |
| 6 Ball bearing                                    | 18 Governor lever        | 29 Ball bearing  |
| 7 PTO gear  | 19 Governor spring lever | 30 Snap ring   |
| 8 Ball bearing<br>(Remove parts 6 to 8 as a unit) | 20 Grooved pin           | 31 Ball bearing  |
| 9 Oil pump housing                                | 21 Speed control lever   | 32 Fuel injection pump camshaft<br>(Remove parts 28 to 32 as a unit) |
| 10 Oil pump outer gear                            | 22 Idler gear            | 33 Torque spring set   |
| 11 Oil pump inner gear                            | 23 Camshaft gear         | 34 Front plate   |
| 12 Plug   | 24 Ball bearing          |  |

### 3.1 Removing tappet

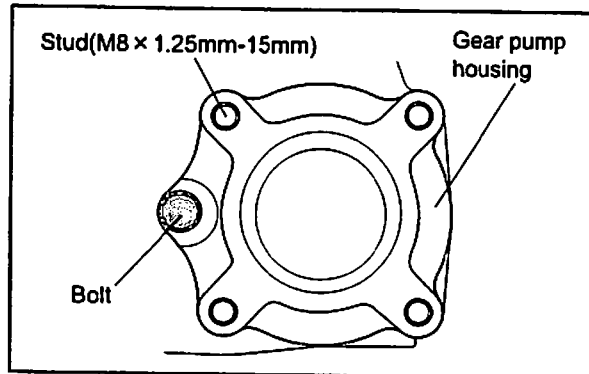
Use the pushrods to take out the tappet.



Removing tappet

### 3.2 Removing gear pump housing

- (1) Remove the bolts and one stud (M8×1.25mm-15mm) shown in the illustration from the gear pump housing.
- (2) Screw a jack bolt into the stud threaded hole and remove the gear pump housing.



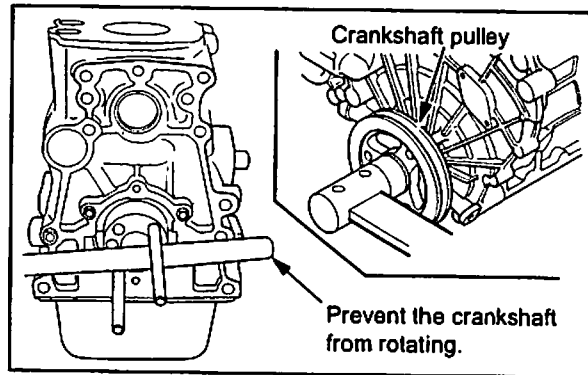
Removing gear pump housing

### 3.3 Removing crankshaft puley

#### CAUTION

The bar serving as a stopper of the crankshaft may come off. Pay due attention to safety.

- (1) Screw two guide bolts into the threaded holes at the rear end of the crankshaft. Use these bolts and a bar placed across them to prevent the crankshaft from rotating.
- (2) Remove the crankshaft pulley.
- (3) Take out the woodruff key of the crankshaft.



Removing crankshaft pulley

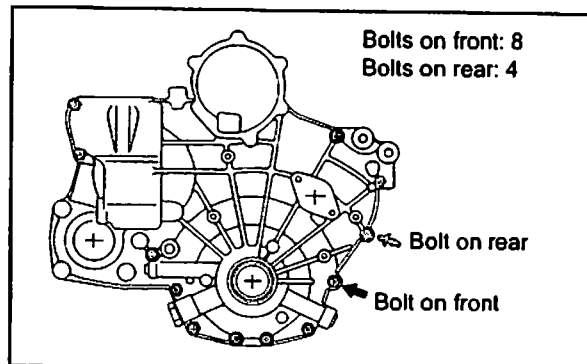
### 3.4 Removing timing gear case

#### CAUTION

The front plate is bolted to the crankcase from inside the gear case. Do not attempt to remove the front plate by tapping it with the gear case.

- (1) Remove bolts from the timing gear case.
- (2) Remove the timing gear case.

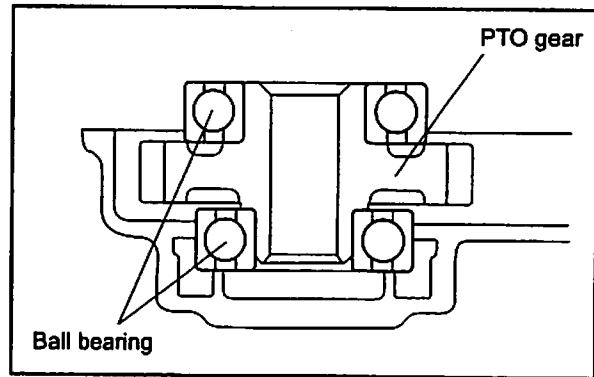
Note: Bolts have different lengths. Pay attention to the positions of bolts to ensure correct reassembling.



Removing gear case

## 3.5 removing PTO gear

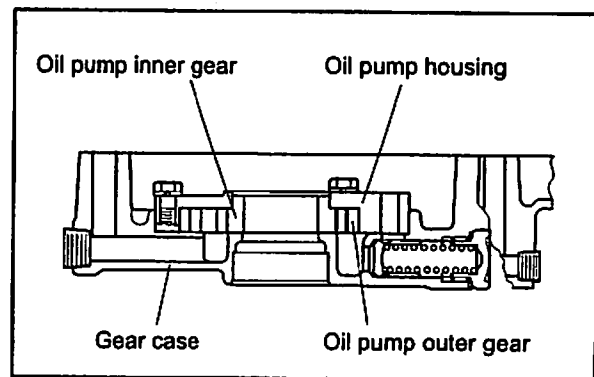
Pull out the PTO gear with two ball bearings as a unit from the gear case.



Removing PTO gear

## 3.6 Removing oil pump

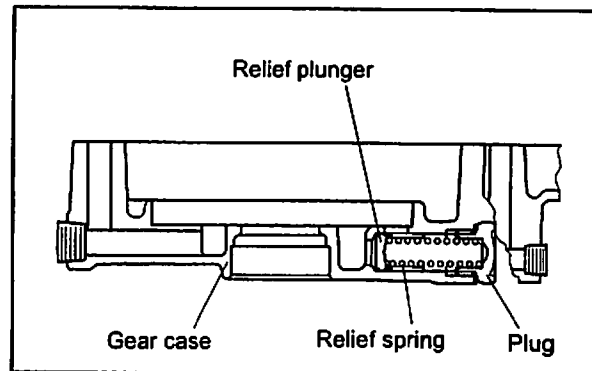
Remove the oil pump housing from the gear case and then, remove the oil pump outer gear and oil pump inner gear.



Removing oil pump

## 3.7 Removing relief valve

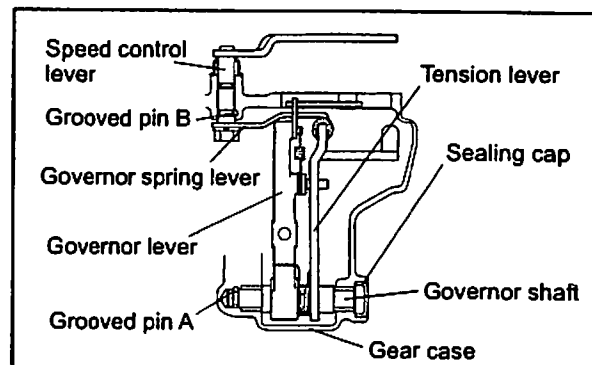
- (1) Remove the plug from the gear case.
- (2) Remove the oil relief spring and relief plunger.



Removing relief valve

## 3.8 Removing governor shaft and speed control lever

- (1) Remove the sealing cap from the side of the gear case.
- (2) Pull out the grooved pin A.
- (3) Remove the governor shaft.
- (4) Remove the tension lever and governor lever.
- (5) Remove the governor spring lever.
- (6) Remove the grooved pin B.
- (7) Remove the speed control lever.
- (8) Remove the governor cover.



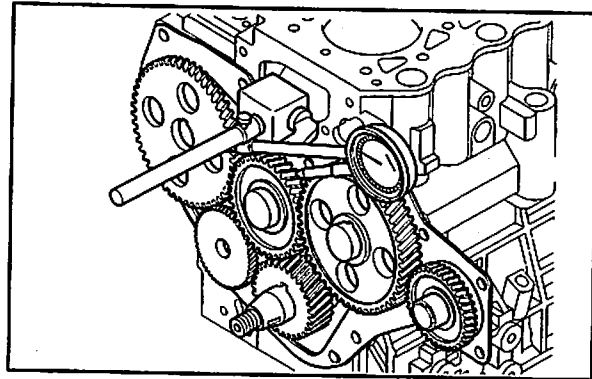
Removing governor shaft and speed control lever

### 3.9 Measuring backlash of timing gears

To measure backlash, apply a dial gauge to the gear shaft circle at the right angle to the shaft, or insert thickness gauges into the meshing between two gears.

Replace the gear if the limit is exceeded.

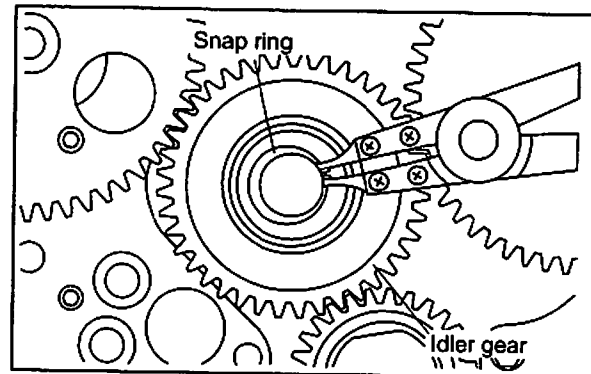
Measurement item		Standard	Limit
Timing gear backlash	Between crankshaft gear and idler gear	0.010 to 0.141 mm [0.00039 to 0.00555 in.]	0.30 mm [0.01182 in.]
	Between idler gear and valve camshaft gear	0.010 to 0.136 mm [0.00039 to 0.00536 in.]	
	Between idler gear and pump camshaft gear	0.010 to 0.136 mm [0.00039 to 0.00536 in.]	
	Between valve camshaft gear and PTO gear	0.010 to 0.220 mm [0.00039 to 0.00867 in.]	



Measuring backlash of timing gears

### 3.10 Removing idler gear

- (1) Remove the snap ring.
- (2) Remove the idler gear.



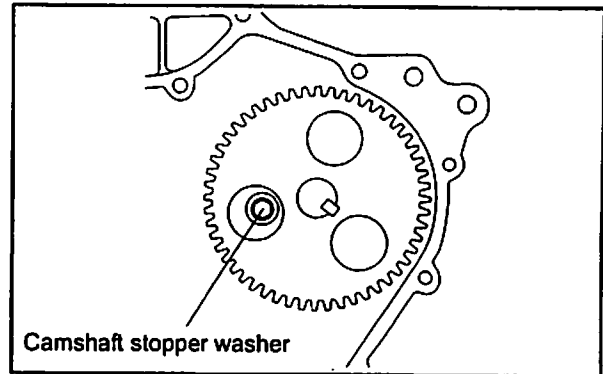
Removing idler gear

### 3.11 Removing camshaft

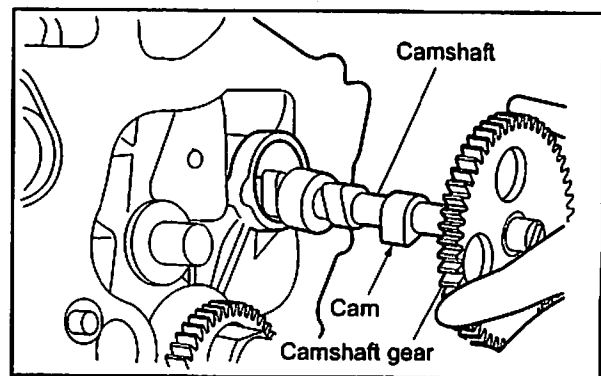
#### CAUTION

When pulling out the camshaft, be careful not to cause damage to the cam lobe of the camshaft and the cam shaft hole of the cylinder block.

- (1) Remove camshaft stopper washer.
- (2) Pull out the camshaft with camshaft gear ball bearings as a unit.



Removing camshaft (1)



Removing camshaft (2)

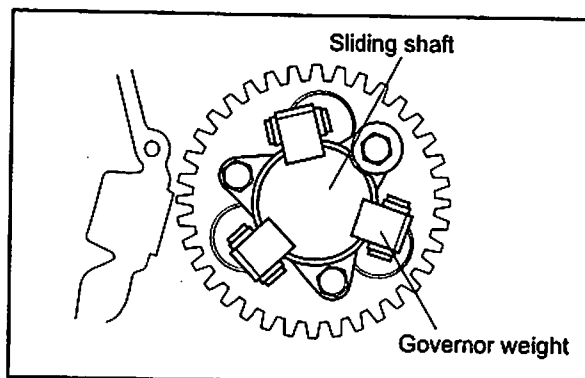
### 3.12 Removing fuel injection pump camshaft

#### CAUTION

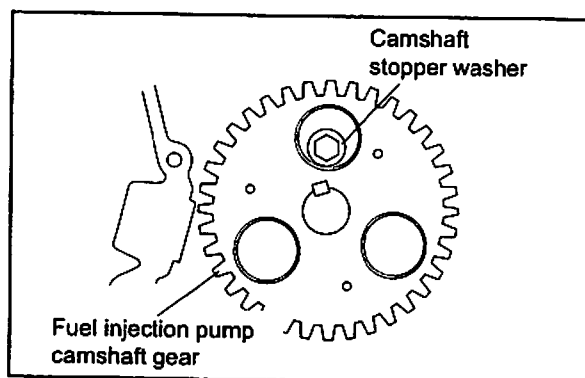
When pulling out the fuel injection pump camshaft, be careful not to cause damage to the cam portion of the fuel injection pump camshaft and the cam hole of the cylinder block.

(1) Remove the sliding shaft and governor weight.

(2) Remove camshaft stopper washer.

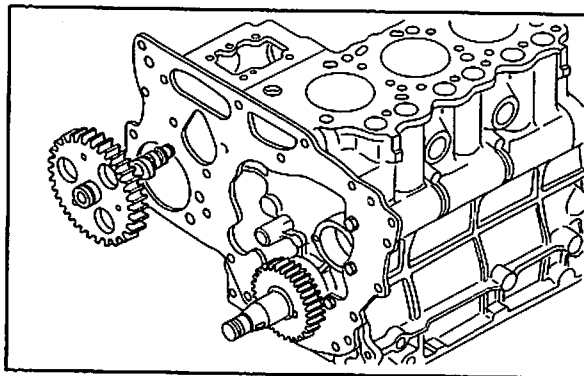


Removing sliding shaft and governor weight



Removing fuel injection pump camshaft (1)

(3) Remove the fuel injection pump camshaft with the fuel injection pump camshaft gear and ball bearings as a unit.

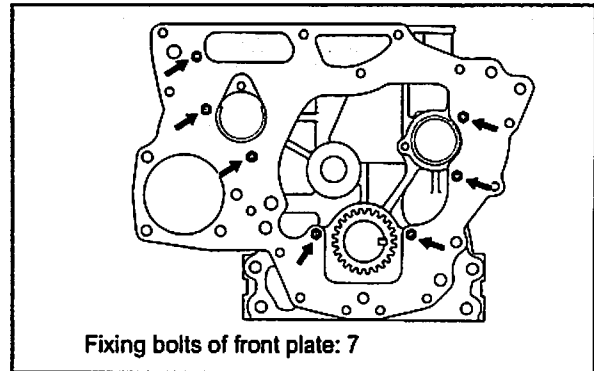


Removing fuel injection pump camshaft (2)

### 3.13 Removing front plate

- (1) Remove the front plate bolts.
- (2) Remove the front plate from the crankcase.

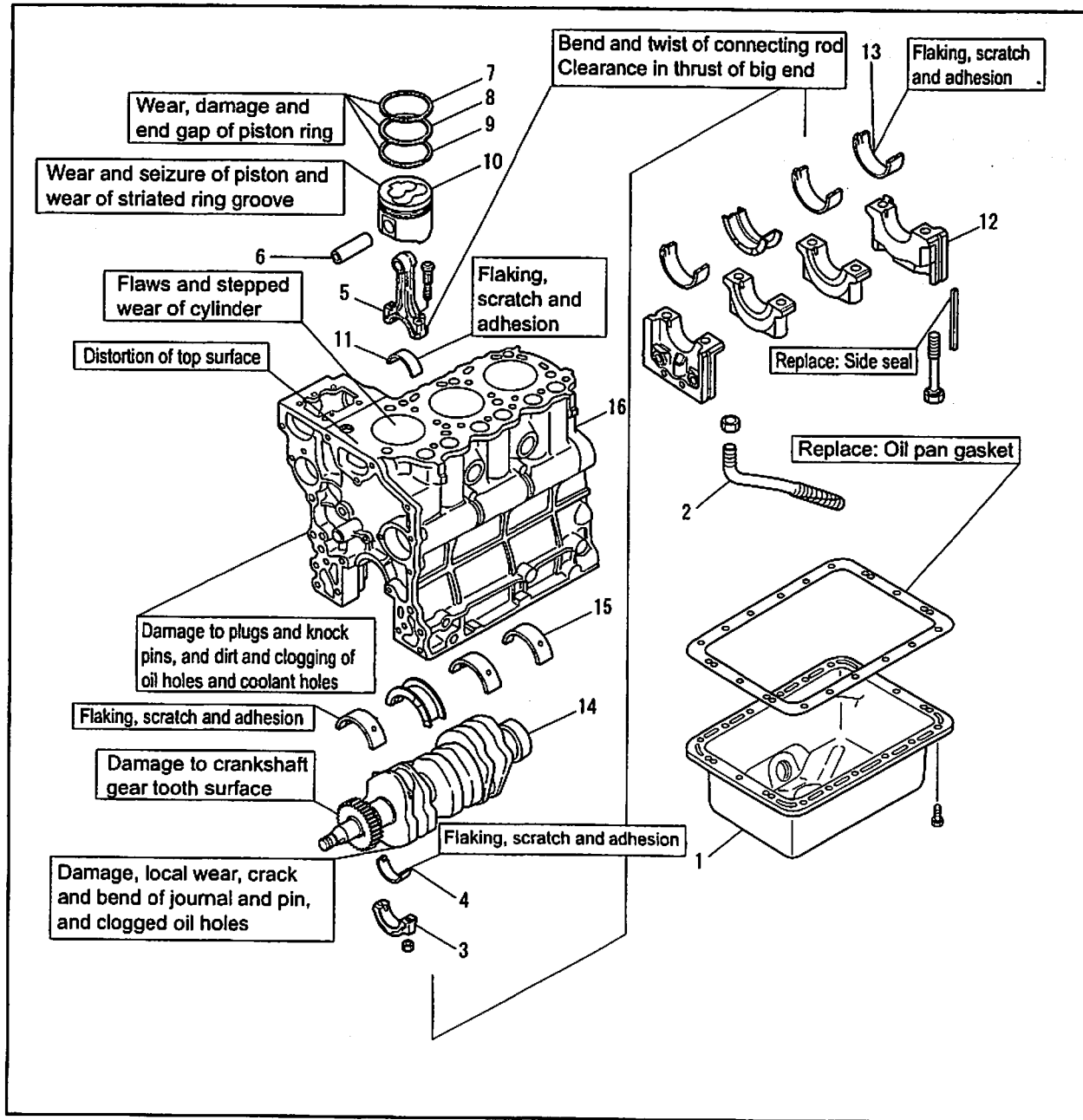
Note: If it is difficult to remove the front plate, lightly tap it with a plastic hammer.



Fixing bolts of front plate: 7

Removing front plate

#### 4. Disassembling and inspecting cylinder block, crankshaft, piston and oil pan



Disassembling and inspecting cylinder block, crankshaft, piston and oil pan

##### Disassembly sequence

- |                                |   |                       |
|--------------------------------|---|-----------------------|
| 1 Oil pan                      | 7 No. 1 ring                                  | 12 Main bearing cap   |
| 2 Oil screen                   | 8 No. 2 ring                                  | 13 Lower main bearing |
| 3 Connecting rod cap           | 9 Oil ring                                    | 14 Crankshaft         |
| 4 Lower connecting rod bearing | 10 Piston<br>(Remove parts 5 to 10 as a unit) | 15 Upper main bearing |
| 5 Connecting rod               | 11 Upper connecting rod bearing               | 16 Cylinder block     |
| 6 Piston pin                   |   |                       |

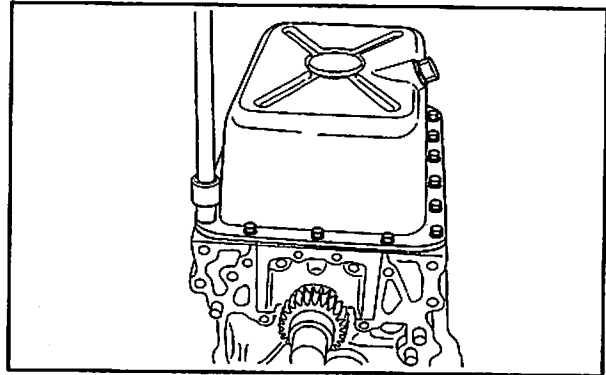
Note: When replacing the crankcase, carefully remove parts (relief valve, etc.) mounted on the non-reusable crankcase so that they can be reused.

### 4.1 Removing oil pan

#### CAUTION

Do not insert a chisel or screwdriver between the oil pan and crankcase to remove the oil pan. It will deform the oil pan flange.

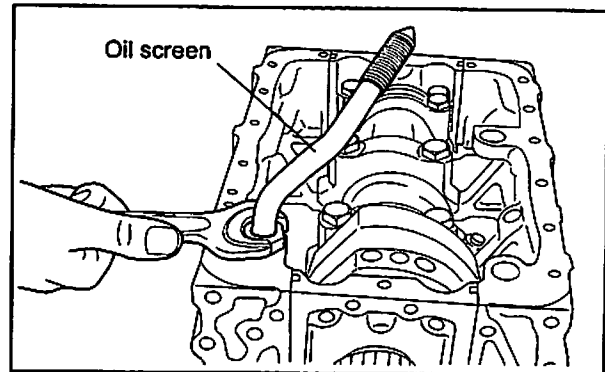
- (1) Turn the engine around.
- (2) Remove bolts from the oil pan.
- (3) To remove oil pan, tap bottom corners of the oil pan with a plastic hammer.



Removing oil pan

### 4.2 Removing oil screen

Loosen the nut to remove the oil screen.

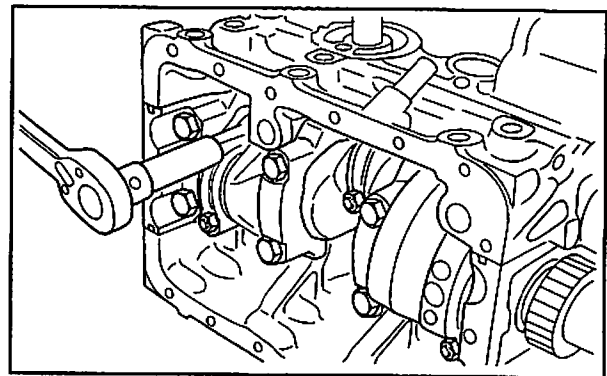


Removing oil screen

### 4.3 Removing connecting rod cap

- (1) Overturn the engine.
- (2) Mark the cylinder number on the connecting rod and connecting rod cap so that their combination is not changed when reassembling.
- (3) Remove the connecting rod caps.

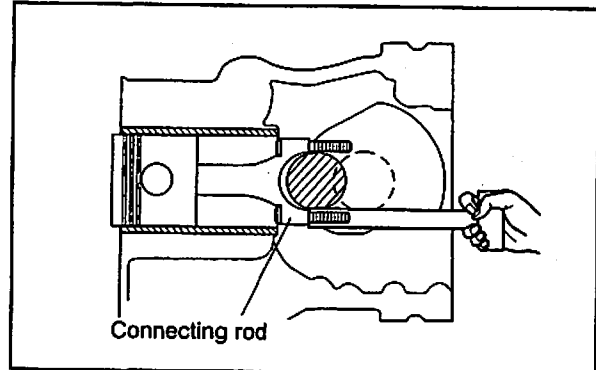
Note: Mark the cylinder No. and upper/lower on connecting rod bearings to ensure correct reassembling.



Removing connecting rod cap

#### 4.4 Pulling out piston

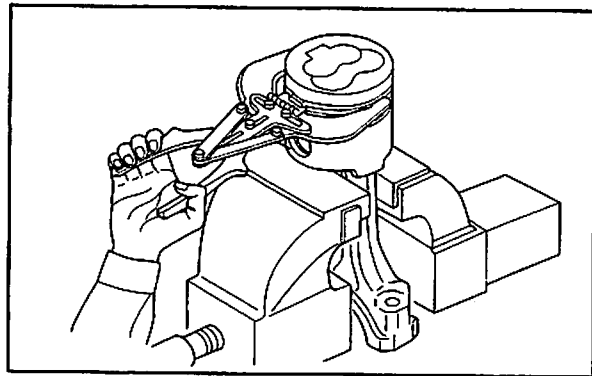
- (1) Turn the crankshaft and place the piston to top dead center.
- (2) Push the mating surface of the connecting rod cap with a piece of wood such a handle of a hammer and push out the piston and connecting rod upward of the cylinder.



Pulling out piston

#### 4.5 Removing piston ring

Remove the piston rings using piston ring pliers.



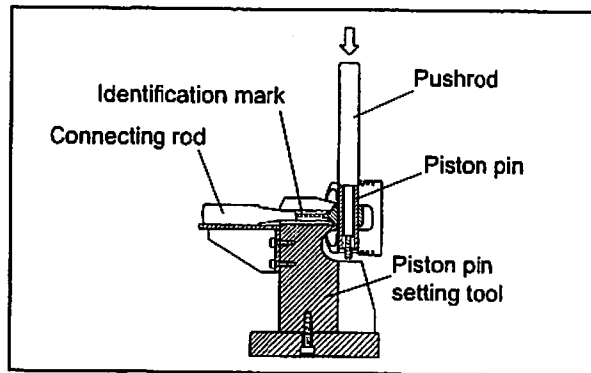
Removing piston ring

#### 4.6 Removing piston pin

Remove the piston pin using the piston pin setting tool.

Special name		Part No.
Piston pin setting tool	For L2A, L3A	30L91-00030
	For L2C, L3C	30L91-00020
	For L2E, L3E	30L91-10010

Note: An identification mark showing the diameter is stamped on the end face of the push rod.



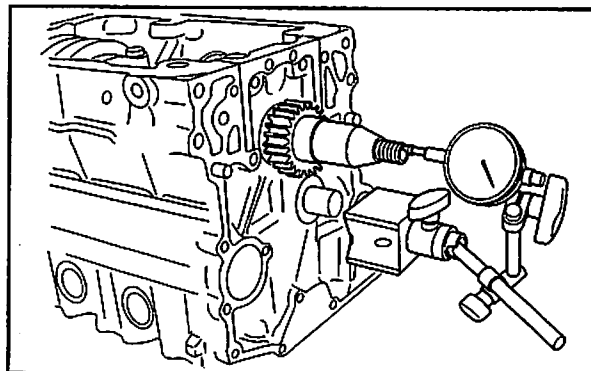
Removing piston pin

Part scription	Identification mark	Applicable model
Pushrod	D18	For $\phi$ 18mm [0.70868 in.] piston pin
	D21	For $\phi$ 21mm [0.82677 in.] Piston pin

## 4.7 Measuring crankshaft end play

Apply the dial gage to the tip of crankshaft to measure the end play. Replace the No. 2 bearings with collar if the limit is exceeded.

Measurement item	Standard	Limit
Crankshaft end play	0.050 to 0.175mm [0.00197 to 0.00690 in.]	0.500mm [0.00197 in.]



Measuring crankshaft end play

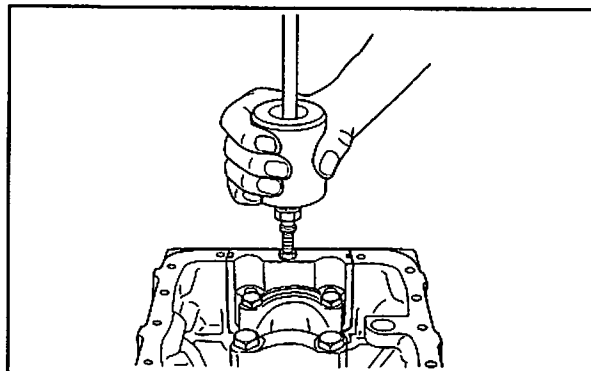
## 4.8 Removing main bearing cap

- (1) Remove main bearing cap bolts.
- (2) Remove main bearing caps together with lower main bearings.

Use a sliding hammer to remove main bearing caps on the front and rear ends.

Note: (a) Be careful not to damage main bearings.

(b) Mark each main bearing to the cylinder No.



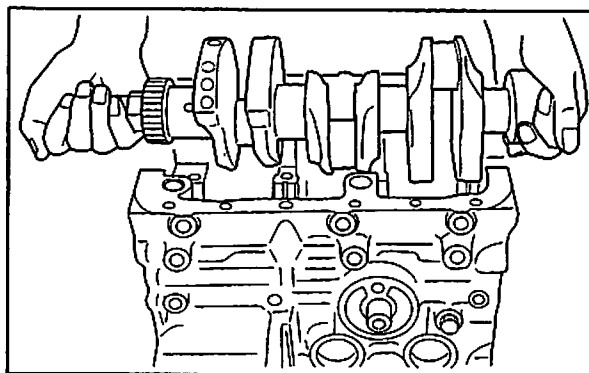
Removing main bearing cap

## 4.9 Removing crankshaft

### CAUTION

Be careful not to damage bearings when removing the crankshaft.

- (1) Slowly lift the crankshaft vertically above to remove.
- (2) Lay the removed bearings in disassembling order so that their original positions are restored when reassembling.



Removing crankshaft

# INSPECTING AND REPAIRING ENGINE MAIN PARTS

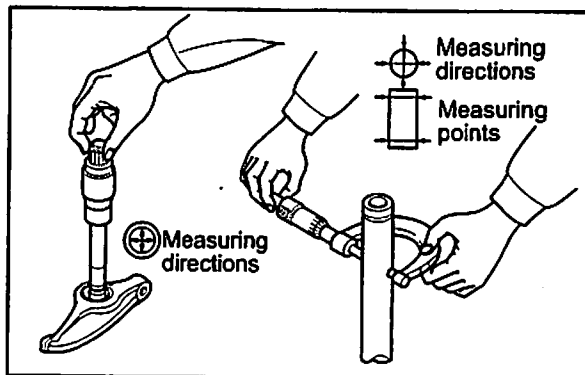
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## 1. Inspecting and repairing cylinder head and valve mechanism

### 1.1 Measuring rocker arm inside diameter and rocker shaft diameter

Measure the rocker arm inside diameter and rocker shaft diameter. If the limit is exceeded, replace with new parts.

Measurement item	Nominal	Standard	Limit
Rocker arm inside diameter	ø 12 mm [0.47 in.]	12.013 to 12.035 mm [0.47295 to 0.47381 in.]	-
Rocker shaft outside diameter	ø 12 mm [0.47 in.]	11.470 to 11.984 mm [0.45157 to 0.47181 in.]	-
Clearance between rocker arm and shaft	-	0.029 to 0.065 mm [0.00114 to 0.00256 in.]	0.200 mm [0.00787 in.]

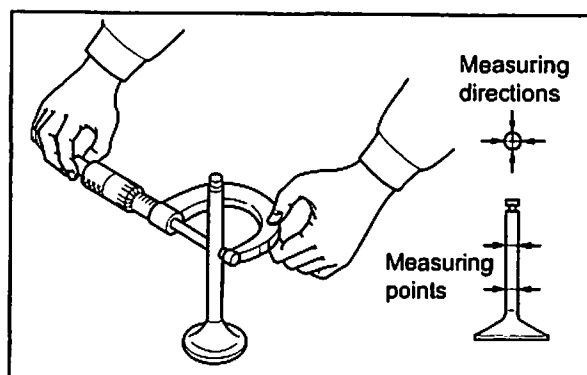


Measuring rocker arm inside diameter and rocker shaft outside diameter

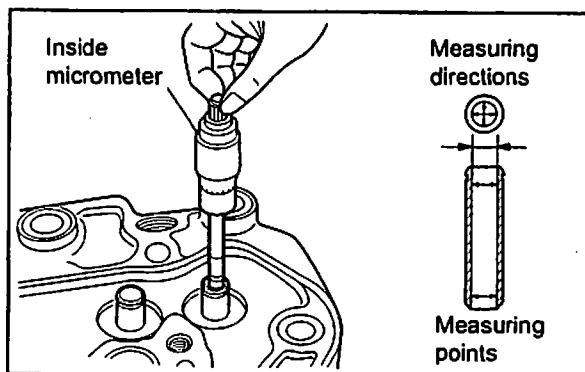
### 1.2 Measuring valve stem outside diameter and valve guide inside diameter

Measure the diameter at the top and bottom ends at right angles to the outer and inner surfaces, since valve stems and valve guides are subject to wear at both ends. Replace if the outside diameter is less than the limit or the clearance exceeds the limit.

Measurement item		Nominal value	Standard	Limit
Valve stem outside diameter	Inlet	ø 6.6 mm [0.260 in.]	6.565 to 6.580 mm [0.25846 to 0.25905 in.]	6.500 mm [0.25591 in.]
	Exhaust	ø 6.6 mm [0.260 in.]	6.530 to 6.550 mm [0.25709 to 0.25787 in.]	6.500 mm [0.25591 in.]
Clearance between valve stem and valve guide	Inlet	-	0.020 to 0.050 mm [0.00079 to 0.00197 in.]	0.100 mm [0.00394 in.]
	Exhaust	-	0.050 to 0.085 mm [0.00197 to 0.00335 in.]	0.150 mm [0.00591 in.]
Valve guide inside diameter	Inlet	ø 6.6 mm [0.260 in.]	6.600 to 6.615 mm [0.25984 to 0.26043 in.]	-
	Exhaust	ø 6.6 mm [0.260 in.]		



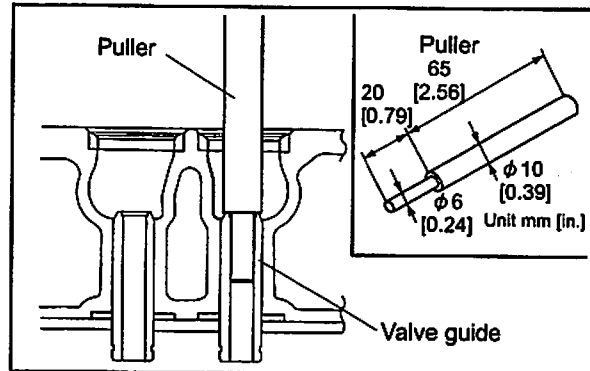
Measuring valve stem outside diameter



Measuring valve guide inside diameter

### 1.3 Replacing valve guide

- (1) Pull out the valve guide from the bottom to the top face of the cylinder head with a press using a blanking tool.

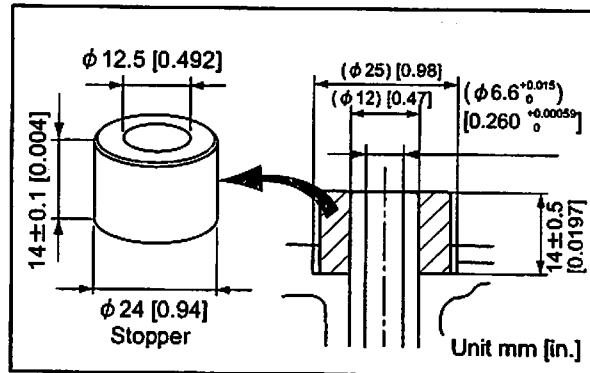


Pulling out valve guide

- (2) Using a stopper, press-fit the new valve guide from the top surface of cylinder head.

After press-fitting, make sure the dimensions of valve position are as shown in the illustration.

- (3) After press-fitting the guide, insert new valve and make sure that it slides.
- (4) Check contact between the valve and valve seat.



Press fitting valve guide

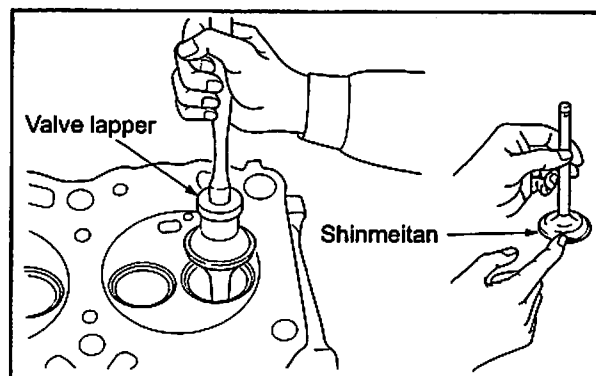
## 1.4 Checking valve face

Apply a thin coat of lapping/coloring past (lead-free) on the valve face, and check its contact with the valve seat using a valve lapper. Repair or replace the valve if the contact surface is not even and any abnormality is found, and the contact is less than the limit.

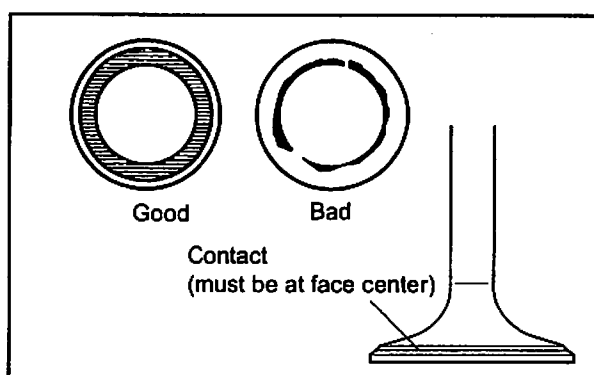
Note: (a) Check the valve faces after checking or replacing the valve guides.

(b) Do not rotate the valve coated with lapping/coloring past (lead-free) when pressing it against the valve seat.

(c) Be sure to lap the valve and valve seat whenever the valve is repaired or replaced.

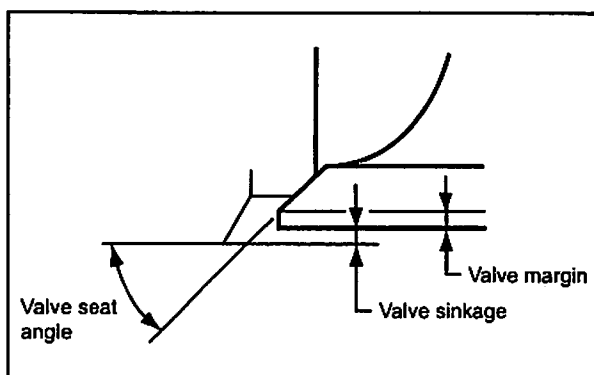


Checking valve face



Valve-to-valve seat contact

Measurement item		Standard	Limit
Valve seat	Valve seat angle	44°	
	Valve sinkage	0.4 to 0.6 mm [0.016 to 0.024 in.]	
Valve margin		1.0 mm [0.039 in.]	0.5 mm [0.020 in.]



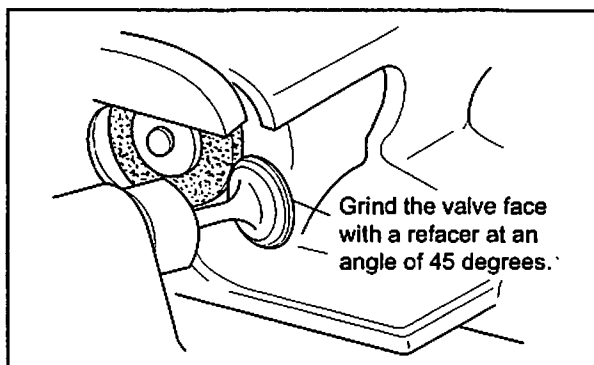
Valve-to-valve seat contact position

## 1.5 Retouching valve face

Grind remarkably worn valve faces with a valve refacer.

Note: (a) Grind the valve face with a refacer at the specified angle.

(b) Secure the valve margin width equal to or greater than the limit. Replace valves with new ones if their dimensions after refacing do not meet the standard.

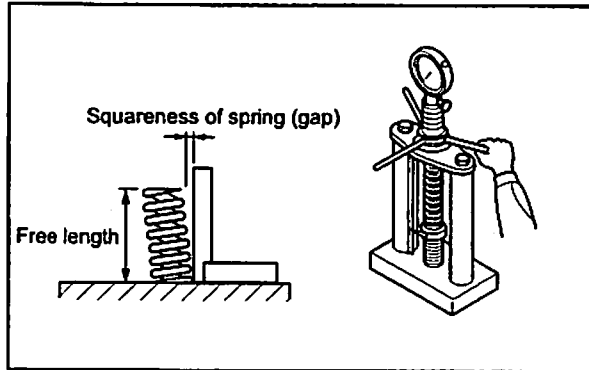


Retouching valve face

### 1.6 Measuring valve spring perpendicularity and free length

Measure the perpendicularity and free length of each valve spring and if the limit is exceeded, replace the spring.

Measure-ment item	Standard	Limit
Free length	40 mm [1.57 in.]	38.5 mm [1.516 in.]
Perpendicularity	$\theta = 2.0^\circ$ or less $\Delta$ (gap) = 1.4 mm [0.055 in.] or less $L_f = 40$ mm [1.57 in.]	total length 2.0 mm [0.079 in.]
Setting length /load	35.5 mm/64.1 to 71.0 N {6.54 to 7.24 kgf} [1.40 in./14.42 to 15.96 lbf]	-15%
	28 mm/170.1 to 189.4 N {17.41 to 19.31 kgf} [1.10 in./38.38 to 42.57 lbf]	



Squareness and free length of spring

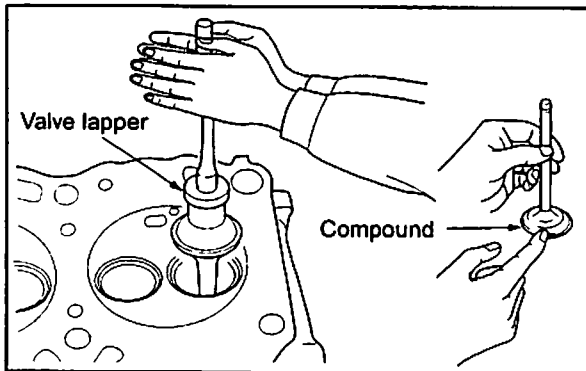
### 1.7 Lapping valve against valve seat

Be sure to lap the valves in the valve seats after the seats have been refaced or replaced.

- (1) Coat the seat contact surface of the valve face with a lapping compound lightly and evenly.

Note: (a) Do not allow the compound to adhere on the valve stem.

- (b) Mix a small amount of engine oil with the compound for smooth and even application.
  - (c) Use a medium compound (120 to 150 mesh) for initial lapping, and use a fine compound (200 mesh or finer) for finishing.
- (2) Use a special tool, valve lapper, to lap the valve in the seat. To lap, strike the valve against the valve seat while rotating the valve a little at a time.
  - (3) Wash off the compound with diesel fuel.
  - (4) Coat the seat contact surface of the valve face with engine oil, then lap the valve again.
  - (5) Inspect the valve face for contact.

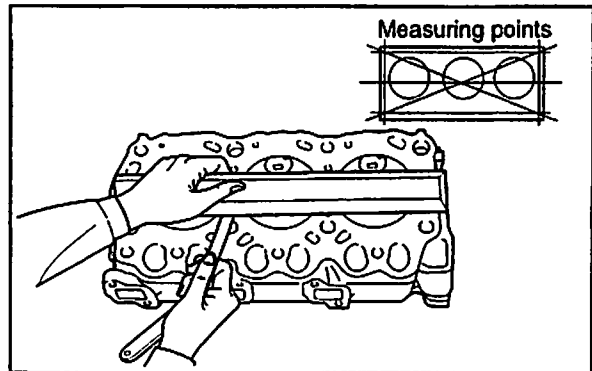


Lapping valve and valve seat

## 1.8 Measuring distortion of cylinder head bottom face

Apply a straight edge to the bottom face of the cylinder head and measure its distortion with thickness gages. If the distortion exceeds the limit, grind the cylinder head with a surface grinder.

Measurement item	Standard	Limit
Distortion of head bottom surface	0.05 mm [0.0020 in.]	0.10 mm [0.0039 in.]

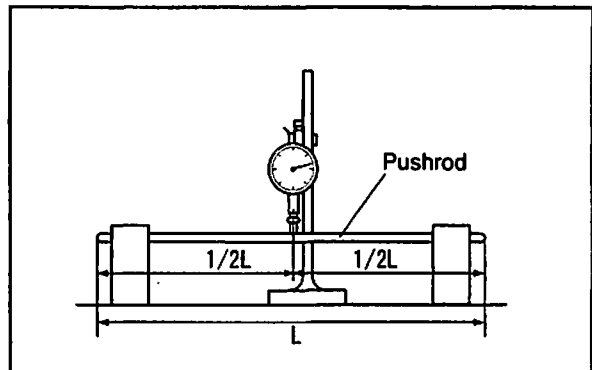


Measuring distortion of cylinder head bottom surface

## 1.9 Measuring runout of pushrod

Measure the runout of each pushrod. Replace if the limit is exceeded.

Measurement item	Standard	Limit	Remark
Runout of pushrod	Less than 0.3 mm [0.012 in.]	0.3 mm [0.012 in.]	Total Indicated Reading (TIR)



Measuring runout of pushrod

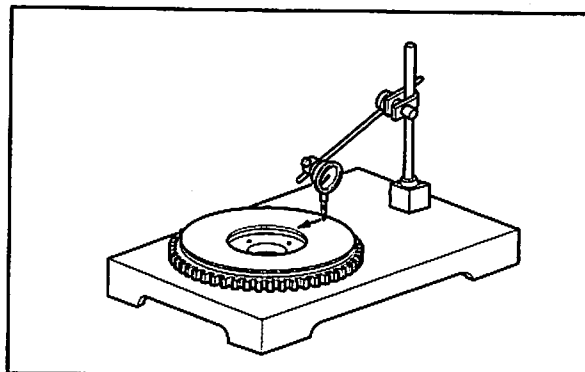
## 2. Inspecting and repairing flywheel

### 2.1 Measuring flatness of flywheel

Place the flywheel on a surface plate and move a dial gage applying to the friction surface of the flywheel to measure the flatness.

Grind the friction surface of the flywheel if the limit is exceeded.

Measurement item	Standard	Limit
Flywheel flatness	0.08 mm [0.0031 in.] or less	0.50 mm [0.0197 in.]



Measuring flatness of flywheel

### 2.2 Checking ring gear

Replace the ring gear if missing or abnormally worn teeth are found by inspection.

### 2.3 Replacing ring gear

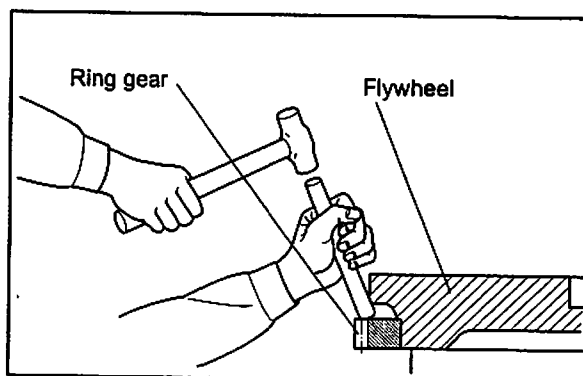
#### 2.3.1 Removing ring gear

- (1) Heat the ring gear evenly with an acetylene torch or other appropriate heat source.
- (2) Remove the ring gear by striking it evenly around the periphery with a hammer through a rod.

#### 2.3.2 Installing ring gear

- (1) Heat the ring gear evenly up to approx. 100°C [212°F] with an appropriate heater.
- (2) Install the ring gear onto the flywheel with the no-gear-chamfering side facing to the flywheel.

Note: Do not heat the ring gear excessively.



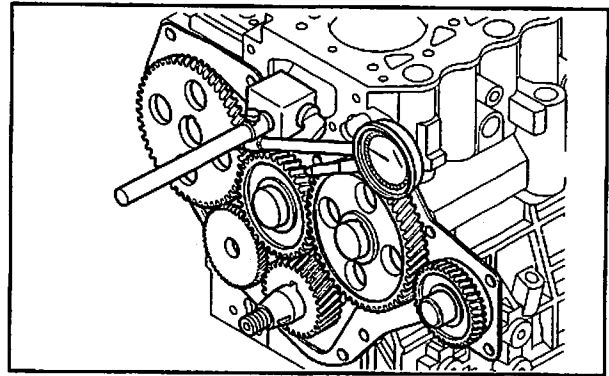
Removing ring gear

### 3. Inspecting and repairing gear case, timing gears and camshaft

#### 3.1 Measuring backlash of timing gear

To measure backlash of the timing gears, apply a dial gauge to the shaft on the pitch circumference of the gear at the right angle or insert thickness gauges into the meshing area of gears. Replace the gear if the limit is exceeded.

Measurement item		Standard	Limit
Timing gear backlash	Between crankshaft gear and idler gear	0.010 to 0.141 mm [0.00039 to 0.00555 in.]	0.30 mm [0.01182 in.]
	Between idler gear and valve camshaft gear	0.010 to 0.136 mm [0.00039 to 0.00536 in.]	
	Between idler gear and pump camshaft gear	0.010 to 0.220 mm [0.00039 to 0.00867 in.]	
	Between valve camshaft gear and PTO gear	0.010 to 0.220 mm [0.00039 to 0.00867 in.]	

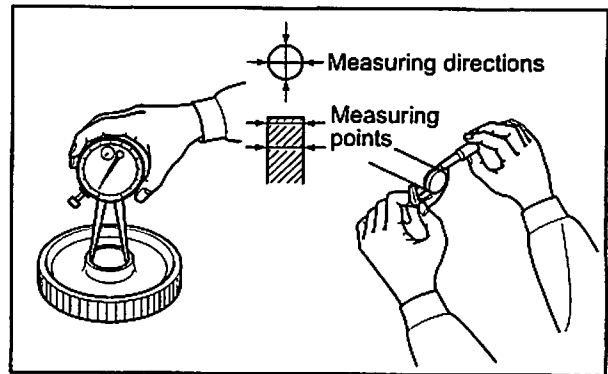


Measuring backlash of timing gears

#### 3.2 Measuring idler gear inside diameter and idler shaft outside diameter

Measure the inside diameter of the idler gear and outside diameter of the idler shaft. Replace the idler gear or idler shaft if the clearance exceeds the limit.

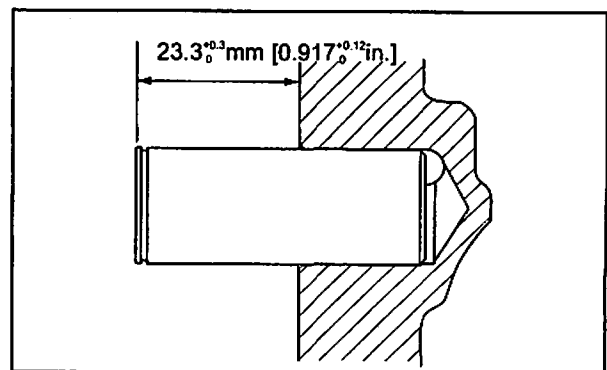
Measurement item	Standard	Limit
Clearance between idler gear and idler shaft	0.030 to 0.066 mm [0.00118 to 0.00260 in.]	0.200 mm [0.00787 in.]



Measuring idler gear inside diameter and idler shaft outside diameter

#### 3.3 Replacing idler shaft

Press-fit the idler shaft into the cylinder block to the dimension in the illustration.



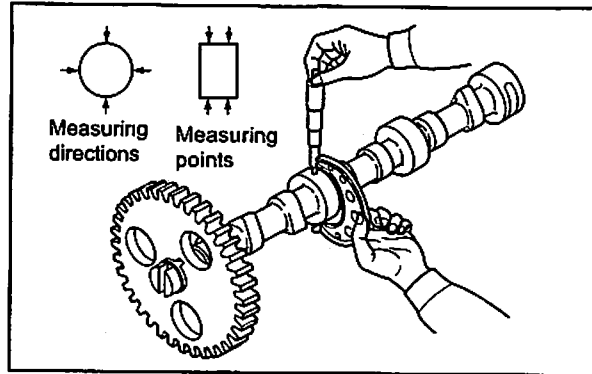
Replacing idler shaft

### 3.4 Measuring clearance between camshaft journal and cylinder block bore

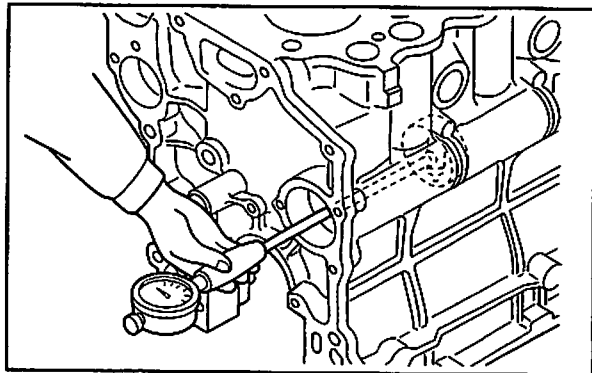
Calculate the clearance between the outside diameter of the camshaft journal and inside diameter of the cylinder block bore. Replace the camshaft or cylinder block if the clearance exceeds the limit.

Note: Start measurement from the No. 2 camshaft hole because the No. 1 camshaft hole is for ball bearings.

Measurement item	Standard	Limit
Clearance between camshaft journal and cylinder block bore	0.050 to 0.100 mm [0.00197 to 0.00394 in.]	0.150 mm [0.00591 in.]



Measuring outside diameter of camshaft journal

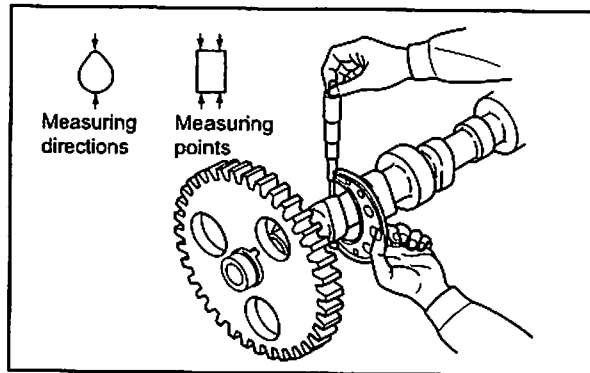


Measuring inside diameter of cylinder block camshaft holes

### 3.5 Measuring cam height

Measure the longer and shorter diameters of each cam with a micrometer to determine the cam height. If less than the limit, replace with a new part.

Measurement item	Standard	Limit
Cam height of camshaft (longer diameter)	27.27 to 27.47 mm [1.0736 to 1.0815 in.]	26.37 mm [1.0382 in.]

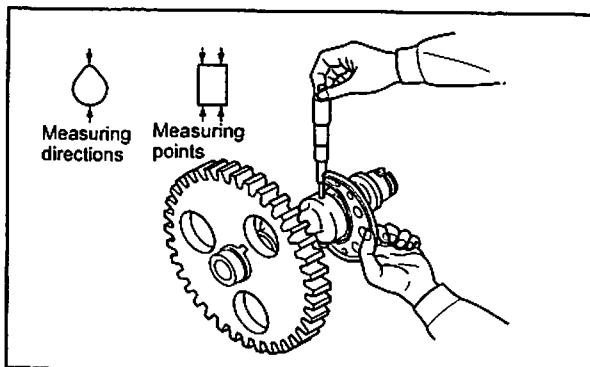


Measuring cam height of camshaft

### 3.6 Measuring cam height of fuel injection pump camshaft

Measure the cam height. Replace the camshaft if the height is less than the limit.

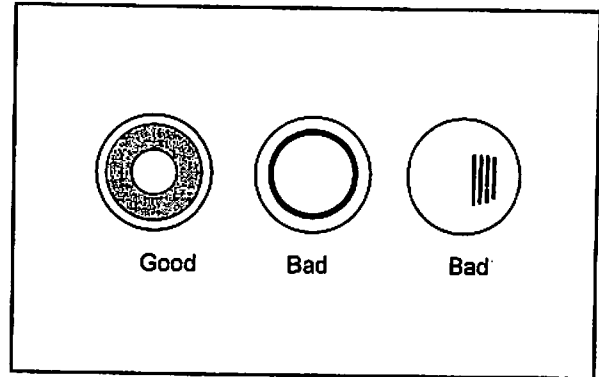
Measurement item	Standard	Limit
Cam height of fuel injection pump camshaft (longer diameter)	29.9 to 30.1 mm [1.177 to 1.185 in.]	29 mm [1.14 in.]



Measuring cam height of fuel injection pump camshaft

## 3.7 Inspecting tappet

Check the camshaft contact face of each tappet for wear. If the surface is unevenly worn, replace the tappet.

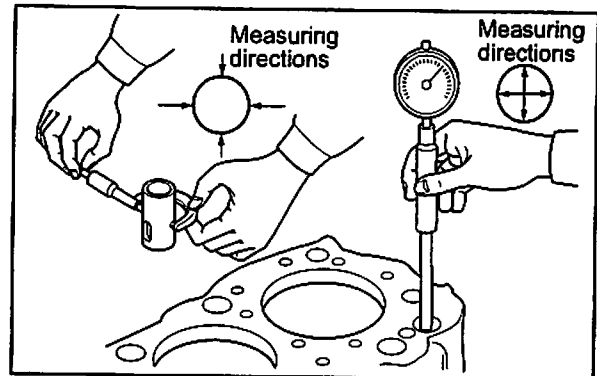


Inspecting tappets

## 3.8 Measuring clearance between tappet and tappet guide hole

Measure clearance between the tappet and tappet hole. Replace if the limit is exceeded.

Measurement item	Standard	Limit
Clearance between camshaft journal and cylinder block bore	0.007 to 0.049 mm [0.0003 to 0.0019 in.]	0.150 mm [0.00591 in.]



Measuring clearance between tappet and tappet guide hole

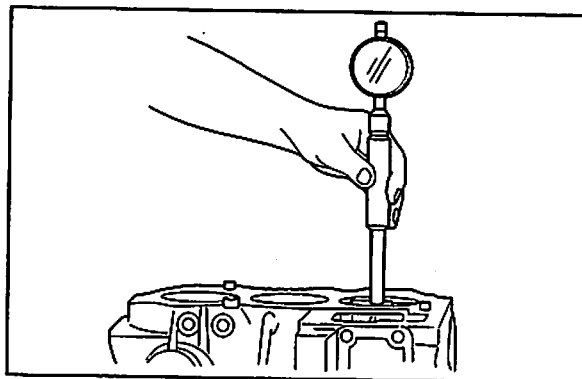
#### 4. Inspecting and repairing cylinder block, crankshaft, piston and oil pan

##### 4.1 Measuring cylinder inside diameter

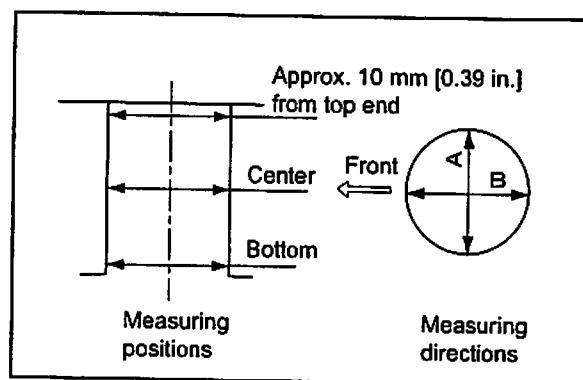
Use a cylinder gage to measure the inside diameter and cylindricity of the cylinder at three locations in the A and B directions as shown in the illustration.

If any one of the cylinders exceeds the repair limit, bore all the cylinders and replace the pistons and piston rings with oversize ones.

Replace the cylinder block if the limit is exceeded.



Measuring cylinder inside diameter



Measuring position of cylinder inside diameter

Measurement item		Nominal	Standard	Limit	Remark
Cylinder inside diameter	L2A, L3A	ø 65 mm [2.56 in.]	65.00 to 65.03 [2.5591 to 2.5602 in.]	+0.7 mm [+0.028 in.]	Repair limit is +0.2 mm [+0.008 in.]
	L2C, L3C	ø 70 mm [2.76 in.]	70.00 to 70.03 [2.7559 to 2.7571 in.]		
	L2E, L3E	ø 76 mm [2.99 in.]	76.00 to 76.03 [2.9921 to 2.9933 in.]		
Cylindricity of cylinder		-	0.01 mm [0.0004 in.] or less	-	-

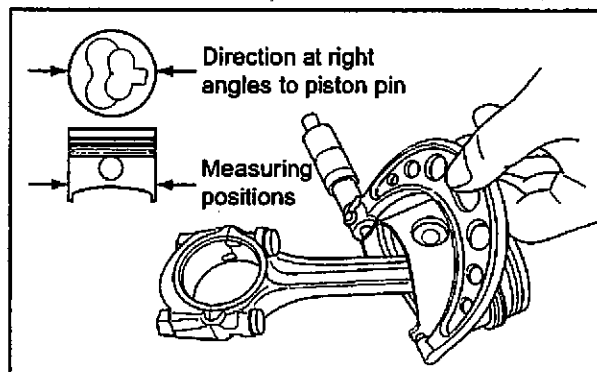
## 4.2 Boring cylinder

Bore cylinders in the following procedure.

### 4.2.1 Measuring piston outside diameter

Measure the piston's skirt portion diameter with a micrometer in the direction at right angles to the piston pin as shown in the illustration.

Measurement item	Nominal	Standard
L2A L3A	STD ø 65 mm [2.559 in.]	64.919 to 64.939 mm [2.5559 to 2.5566 in.]
	0.25 OS ø 65.25 mm [2.569 in.]	65.169 to 65.189 mm [2.5657 to 2.5665 in.]
	0.50 OS ø 65.50 mm [2.579 in.]	65.419 to 65.439 mm [2.5755 to 2.5763 in.]
L2C L3C	STD ø 70 mm [2.756 in.]	69.913 to 69.933 mm [2.7525 to 2.7533 in.]
	0.25 OS ø 70.25 mm [2.766 in.]	70.163 to 70.183 mm [2.7623 to 2.7631 in.]
	0.50 OS ø 70.50 mm [2.776 in.]	70.413 to 70.433 mm [2.7722 to 2.7729 in.]
L2E L3E	STD ø 76 mm [2.992 in.]	75.906 to 75.926 mm [2.9884 to 2.9892 in.]
	0.25 OS ø 76.25 mm [3.002 in.]	75.156 to 76.176 mm [2.9983 to 2.9990 in.]
	0.50 OS ø 76.50 mm [3.012 in.]	76.406 to 76.426 mm [3.0081 to 3.0089 in.]



Measuring piston outside diameter

### 4.2.2 Boring finish dimension

= [piston diameter] + [clearance] - [honing allowance (0.02 mm (0.0008 in.))]

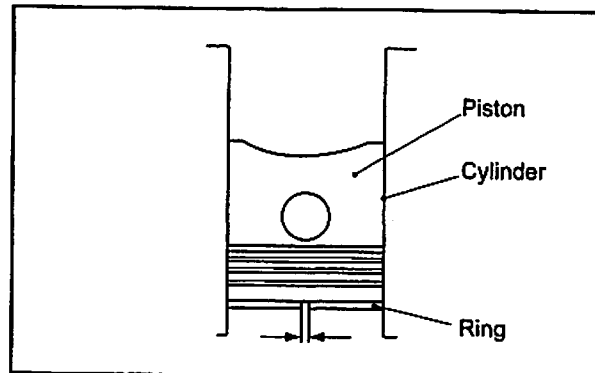
Measurement item	Standard	Limit	Remark
Clearance (clearance between piston and cylinder)	L2A, L3A 0.061 to 0.111 mm [0.00240 to 0.00437 in.]	0.2 mm [0.008 in.]	Repair to oversize or replace
	L2C, L3C 0.067 to 0.117 mm [0.00264 to 0.0046 in.]		
	L2E, L3E 0.074 to 0.124 mm [0.00291 to 0.00488 in.]		

### 4.3 Measuring piston ring end gap

#### CAUTION

- (a) When replacing rings without boring (honing), measure the end gap at the bottom of the cylinder where the wear is minimum.
- (b) When replacing the ring, use the ring of the same size as the piston.

Insert the piston ring into the cylinder bore and push it with the piston to achieve squareness. Then measure the end gap with thickness gages. Replace the piston ring if the limit is exceeded.



Measuring piston ring end gap

Measurement item		Standard	Limit
End gap of ring	No. 1 ring	0.15 to 0.30 mm [0.0059 to 0.0118 in.]	1.5 mm [0.059 in.]
	No. 2 ring	0.15 to 0.30 mm [0.0059 to 0.0118 in.]	
	Oil ring	0.15 to 0.35 mm [0.0059 to 0.0138 in.]	

### 4.4 Inspecting piston ring groove

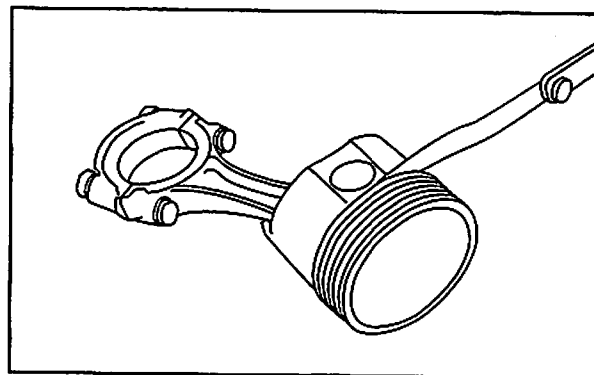
#### CAUTION

Remove carbon and check piston.

- (1) Remove deposits such as carbon from each ring groove.
- (2) Check each ring groove for wear or damage. If faulty, replace the ring.

Insert the piston ring, which thickness has been measured, into the piston ring groove. Apply a straight edge and insert thickness gauges to measure the clearance between ring and ring groove.

Replace if the limit is exceeded.



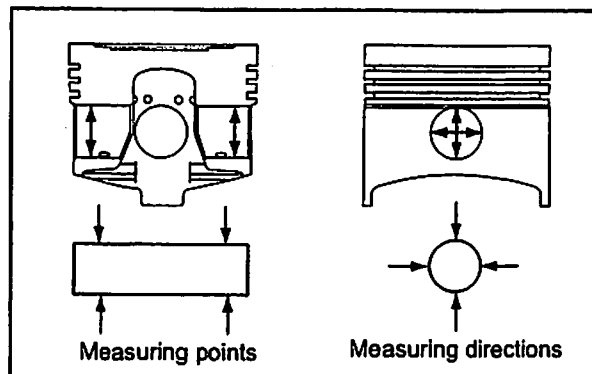
Measuring piston ring groove

Measurement item		Standard	Limit
Clearance between ring and ring groove	No. 1 ring	-	0.3 mm [0.012 in.]
	No. 2 ring	0.05 to 0.09 mm [0.0020 to 0.0035 in.]	0.2 mm [0.008 in.]
	Oil ring	0.03 to 0.07 mm [0.0012 to 0.0028 in.]	0.2 mm [0.008 in.]

#### 4.5 Measuring piston pin bore and piston pin diameter

Measure the piston pin bore diameter and piston pin outside diameter. Replace if the limit is exceeded.

Measurement item	Nominal	Standard	Limit
Outside diameter of piston pin	L2A,L3A L2C,L3C	ø 18 mm [0.71 in.]	18.001 to 18.007 mm [0.70870 to 0.70894 in.]
	L2E,L3E	ø 21 mm [0.83 in.]	21.002 to 21.005 mm [0.82685 to 0.82697 in.]
Clearance between piston pin bore and piston pin outside diameter	L2A,L3A L2C,L3C	-	0.006 to 0.018 mm [0.00024 to 0.00071 in.]
	L2E,L3E	-	0.007 to 0.015 mm [0.00028 to 0.00059 in.]
			0.08 mm [0.0031 in.]

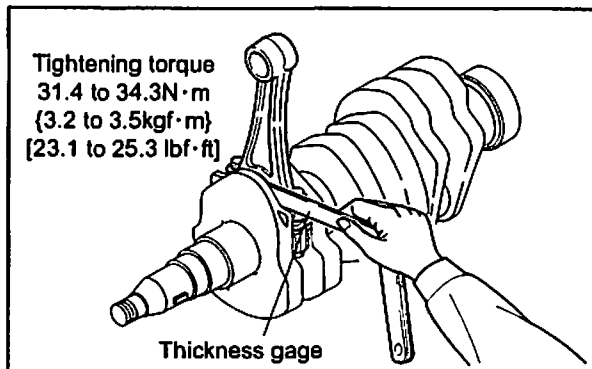


Measuring piston pin bore and piston pin outside diameter

#### 4.6 Measuring connecting rod end play

- (1) Install the connecting rod to its crank pin and tighten cap bolts to the specified torque.
- (2) Measure the clearance (end play) to the crank arm with thickness gages.
- (3) Replace the connecting rod if the limit is exceeded.

Measurement item	Standard	Limit
End play of connecting rods	0.10 to 0.35 mm [0.0039 to 0.0138 in.]	0.5 mm [0.0197 in.]

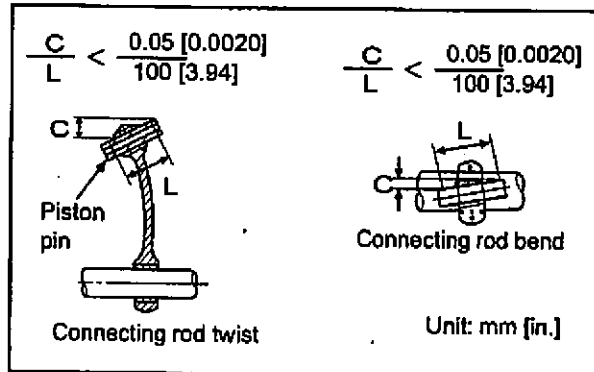


Measuring end play of connecting rod

#### 4.7 Checking bend and twist of connecting rods

- (1) Measure values of C and L as shown in the illustration to check the bend and twist of the connecting rod. Repair the connecting rod with a press to meet the standard value.

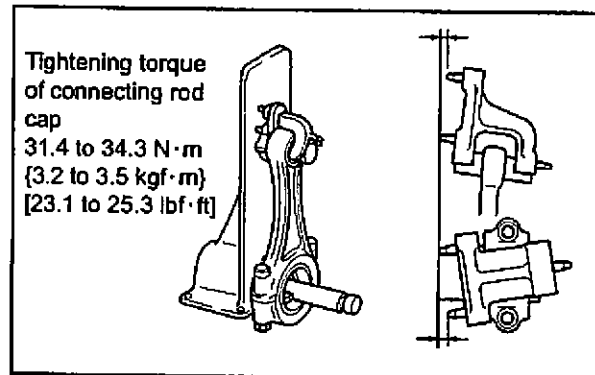
Replace if the limit is exceeded.



Checking bend and twist of connecting rods

- (2) A connecting rod aligner is generally used to check the bend and twist.

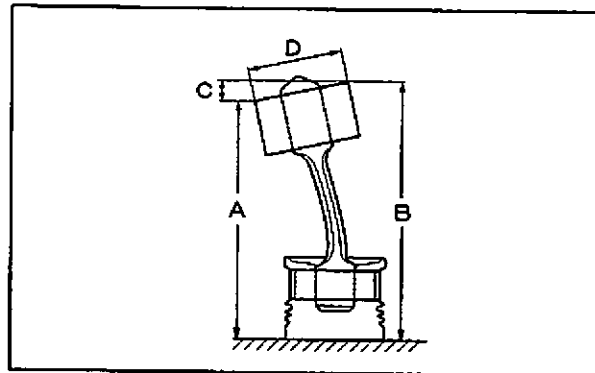
Note: Tighten the connecting rod cap to the specified torque before checking the bend.



Measurement with connecting rod aligner

- (3) When measuring bend and twist of the connecting rod with the piston installed, lay the piston upside down on a surface plate, insert a rod of a diameter equivalent to the crank pin diameter into the piston and connecting rod, and measure the height of the surface of the rod with a dial gage.

Measurement item	Standard	Limit
Bend and twist of connecting rod	0.05/100 mm [0.0020/3.94 in.] or less	0.15/100 mm [0.0059/3.94 in.]



Measuring bend of connecting rod

#### 4.8 Measuring clearance between connecting rod bearing and crank pin

##### CAUTION

When grinding crank pins, be sure to grind all the pins to the same size.

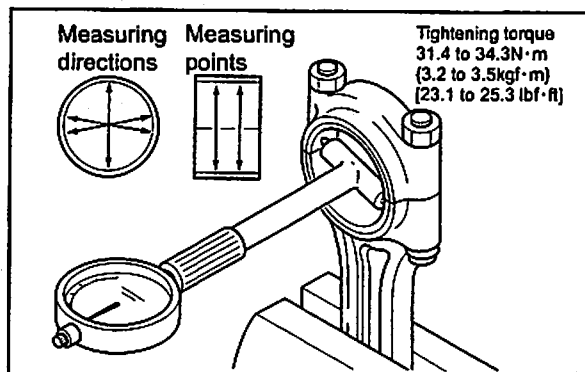
Finish the fillet radius to the specified dimension.

- (1) Reassemble the bearing into the big end of the connecting rod.
- (2) Tighten the connecting rod cap bolts to the specified torque.
- (3) Measure the inside diameter of the connecting rod bearing.
- (4) Measure the outside diameter of the crank pin.
- (5) Calculate the clearance from the difference between the inside diameter of the connecting rod bearing and outside diameter of the crank pin.
- (6) Replace the connecting rod bearing if the clearance exceeds the limit.
- (7) Measure the clearance between the connecting rod bearing and the crank pin again. Use the undersize bearing if the limit is exceeded.
- (8) If an undersize bearing is used, grind the crank pin to the specified undersize.

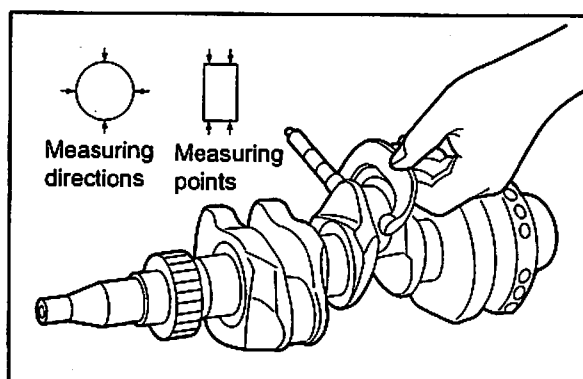
Measurement item	Nominal	Standard	Limit
Outside diameter of crankshaft pin (STD)	$\phi 40$ mm [1.57 in.]	39.965 to 39.980 mm [1.57342 to 1.57401 in.]	-0.70 mm [-0.0276 in.]
Clearance between connecting rod bearing and crankshaft pin		0.028 to 0.071 mm [0.00110 to 0.00280 in.]	0.150 mm [0.0059 in.]

##### Undersize grinding dimensions of crankshaft

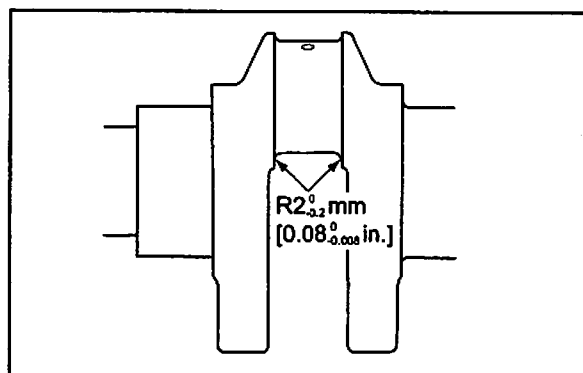
Measurement item	Undersize	Finish dimension
Crank pin undersize	0.25 mm [0.0098 in.]	$\phi 39.75^{+0.020}_{-0.035}$ mm [1.5650 <sup>+0.00079</sup> <sub>-0.00138</sub> in.]
	0.50 mm [0.0197 in.]	$\phi 39.50^{+0.020}_{-0.035}$ mm [1.5551 <sup>+0.00079</sup> <sub>-0.00138</sub> in.]



Measuring inside diameter of connecting rod bearing



Measuring crank pin outside diameter



Finish dimension of fillet radius

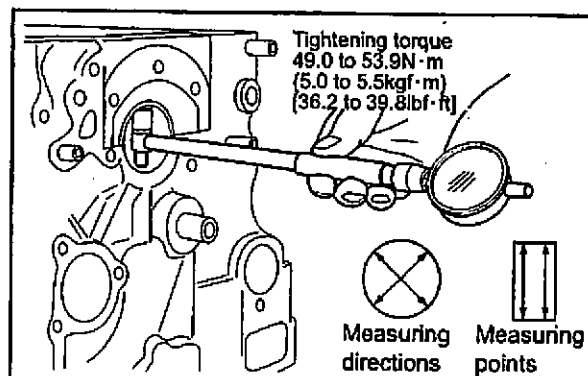
#### 4.9 Clearance between main bearing and crank journal

##### CAUTION

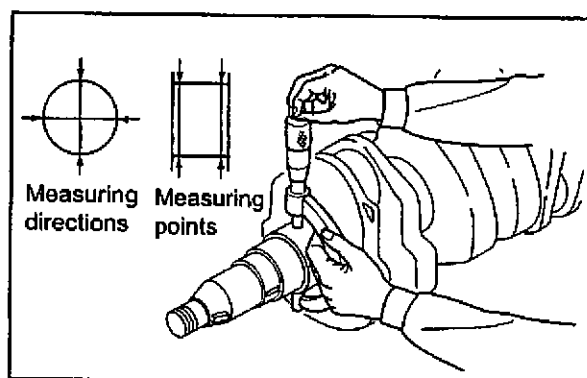
- When grinding crank journals, be sure to grind all the journals to the same size.
  - Finish the fillet radius to the specified dimension.
- Reassemble main bearings.
  - Tighten the main bearing caps to the specified torque.
  - Measure the inside diameter of the main bearings.
  - Measure the outside diameter of the crank journal.
  - Calculate the clearance between the inside diameter of the main bearing and outside diameter of the crank journal.
  - Replace the main bearing if the clearance exceeds the limit.
  - Measure the clearance between the main bearing cap and the crank journal again. Use the undersize bearing if the limit is exceeded.
  - If an undersize bearing is used, grind the crank journal to the specified undersize.

Measurement item	Nominal	Standard	Limit
Outside diameter of crankshaft journal (STD)	ø 43 mm [1.69 in.]	42.965 to 42.980 mm [1.69153 to 1.69212 in.]	-
Clearance between main bearing and crankshaft journal	-	0.030 to 0.075 mm [0.00118 to 0.00295 in.]	0.10 mm [0.0039 in.]

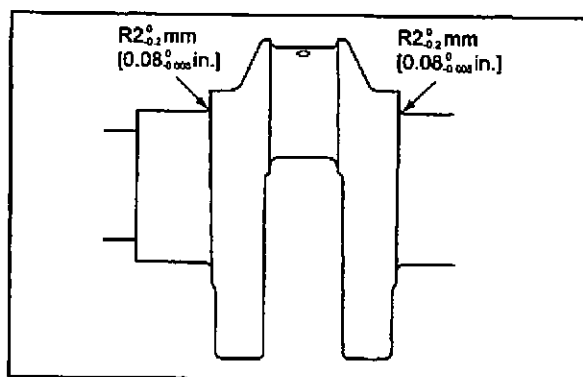
Undersize grinding dimensions of crankshaft		
Measurement item	Undersize	Finish dimension
Crank journal undersize	0.25 mm [0.0098 in.]	ø 42.75 <sup>+0.020</sup> <sub>-0.015</sub> mm [1.6831 <sup>+0.00079</sup> <sub>-0.00138</sub> in.]
	0.50 mm [0.0197 in.]	ø 42.50 <sup>+0.020</sup> <sub>-0.015</sub> mm [1.6732 <sup>+0.00079</sup> <sub>-0.00138</sub> in.]



Measuring inside diameter of lower hole of main bearing



Measuring crank journal outside diameter

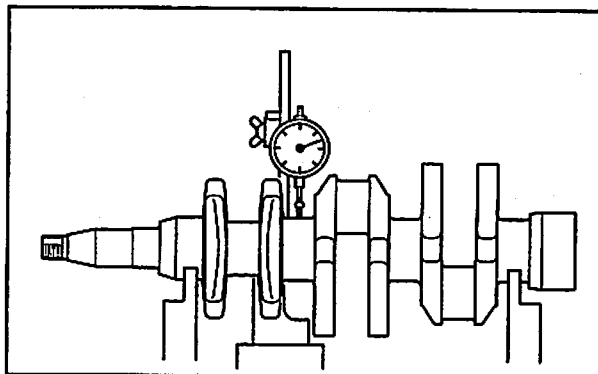


Finish dimension of fillet radius

#### 4.10 Measuring runout of crankshaft

Support the front and rear journals of the crankshaft with V-blocks. Measure runout of the center journal with a dial gage. If the limit is exceeded, replace with new one.

Measurement item	Standard	Remark
Runout of crankshaft	0.06 mm [0.0024 in.]	TIR



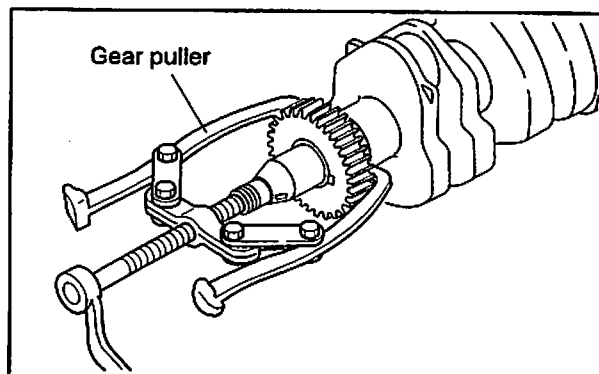
Measuring bend of crankshaft

#### 4.11 Replacing crankshaft gear

##### 4.11.1 Removing crankshaft gear

Using the gear puller, remove the gear from the crankshaft.

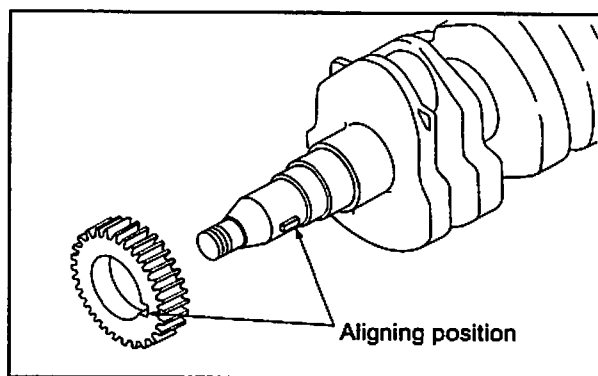
Note: Do not remove the gear by hitting it with a hammer.



Removing crankshaft gear

##### 4.11.2 Installing crankshaft gear

- (1) Install the key on the crankshaft.
- (2) Press-fit the gear fully in alignment with the key.



Installing crankshaft gear

#### 4.12 Measuring distortion of cylinder block top face

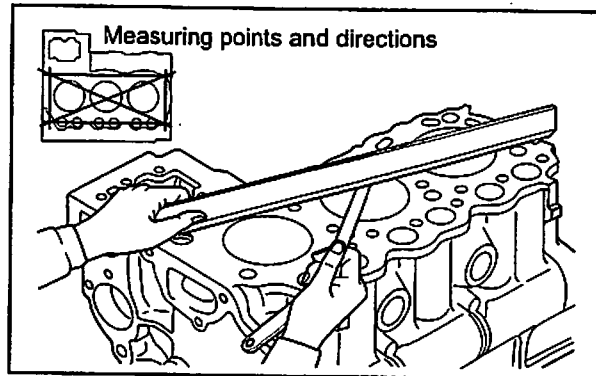
**CAUTION**

Do not grind more than 0.2 mm [0.008 in.] in combination with the cylinder head to be reassembled.

Apply a straight edge to the top surface of the cylinder block and measure its distortion with a thickness gage.

If the distortion exceeds the limit, grind the cylinder block with a surface grinder.

Measurement item	Standard	Limit
Distortion of cylinder block top surface	0.05 mm [0.0020 in.] or less	0.10 mm [0.0039 in.]



Measuring distortion of cylinder block top surface

# REASSEMBLING ENGINE MAIN PARTS

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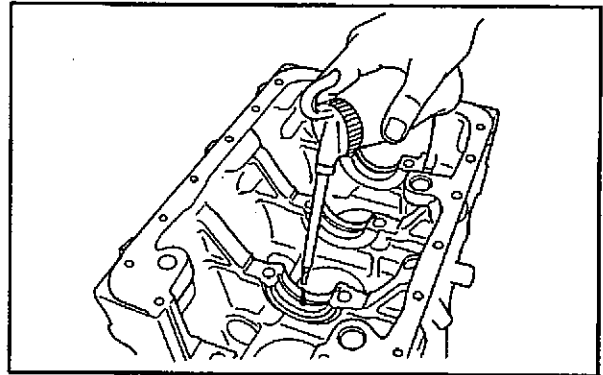
## 1. Cylinder block, crankshaft, piston and oil pan

### 1.1 Installing main bearing

- (1) Place the upper main bearing by aligning the lug to the lug groove on the crankcase and push to install.

**Note:** The oil hole of the main bearing is aligned with the oil hole of the crankcase by pushing the upper main bearing in alignment with the lug groove.

- (2) Apply a small quantity of engine oil to the inner surface of each main bearing.
- (3) With the oil grooves facing outside, install the thrust plate to the rear of the cylinder block.



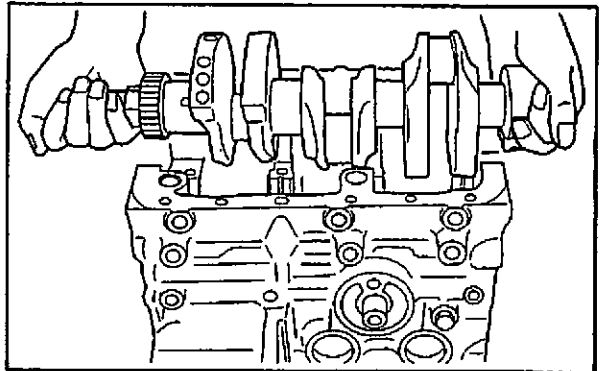
Installing main bearing

### 1.2 Installing crankshaft

- (1) Wash the crankshaft thoroughly in cleaning oil and dry it completely by compressed air.

**Note:** When washing the crankshaft, clean the inside of the oil holes completely and make sure that no foreign substances or dirt is present.

- (2) Hold the crankshaft horizontally and slowly install it to the cylinder block.
- (3) Apply a small quantity of engine oil to the crankshaft journals.



Installing crankshaft

### 1.3 Installing main bearing cap

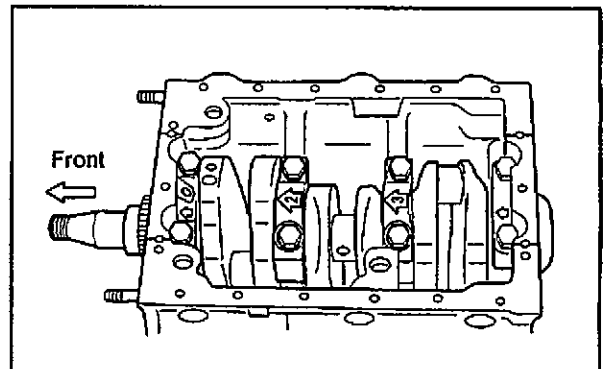
#### CAUTION

Install the foremost and rearmost caps so that they are flush with the cylinder block surface.

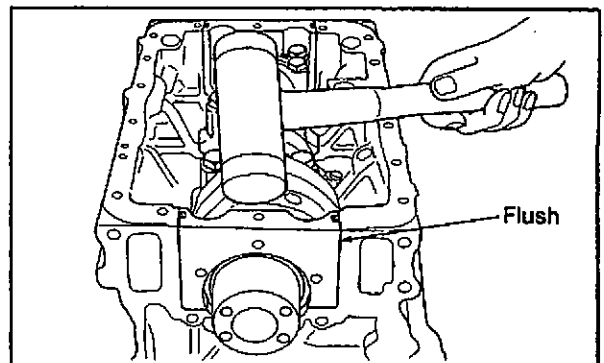
- (1) Apply sealant to the mating surface of the foremost and rearmost caps and the cylinder block mating faces before installing the main bearing caps.

Sealant or lubricant	THREEBOND 1212 or 1211
----------------------	------------------------

- (2) Install the main bearing caps so that their front marks (arrow) and cap numbers are in numerical order from the front of the engine.
- (3) Temporarily tighten bolts.



Reassembled position of main bearing cap



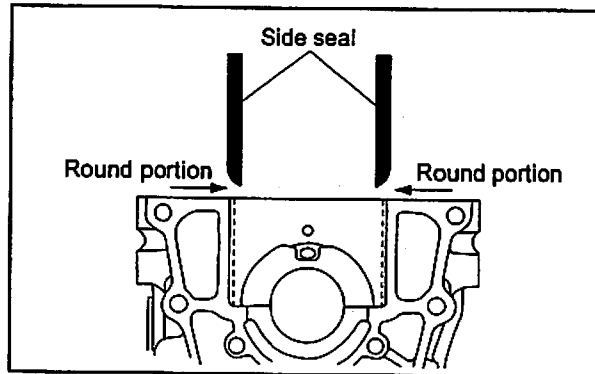
Installing main bearing cap

#### 1.4 Inserting side seal

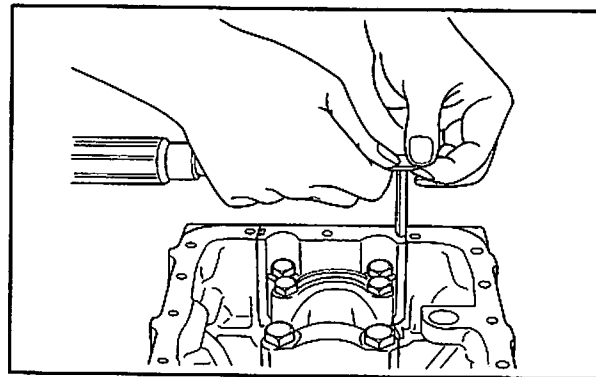
- (1) Apply a sealant to the circumference of new side seals.

Sealant	THREEBOND 1212 or 1211
---------	------------------------

- (2) With roundings of the side seals facing outward, push them in the front and rear caps to some extent by hands.
- (3) When the side seals are pushed-in to some extent, use a tool with flat surface such as flat-head screwdriver to completely push them in, taking care not to bend them.



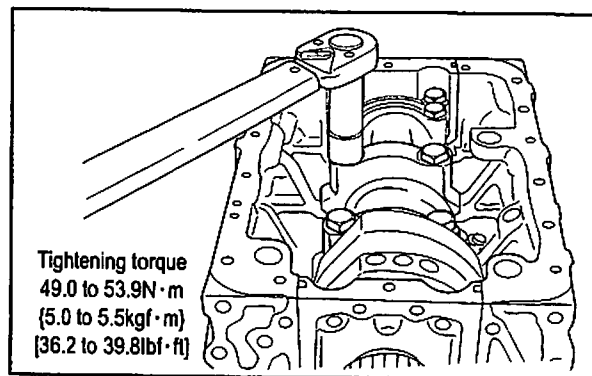
Installed direction of side seal



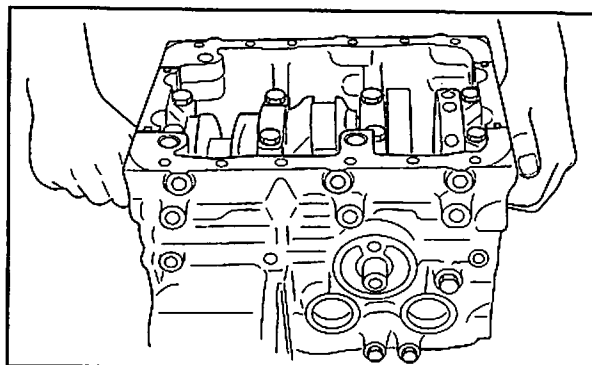
Inserting side seal

#### 1.5 Installing main bearing cap bolt

- (1) Tighten the main bearing cap bolts alternately and progressively to the specified torque.
- (2) Make sure that the crankshaft rotates smoothly.



Tightening main bearing cap bolt



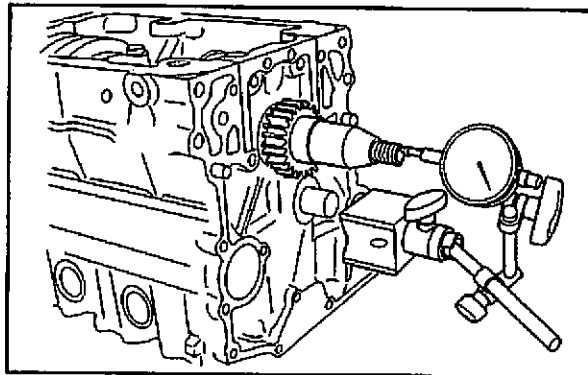
Checking crankshaft for rotation

## 1.6 Measuring crankshaft end play

Apply a dial gage to the tip of the crankshaft to measure the end play.

If the end play is out of the standard value, loosen the main bearing cap bolts and tighten them again

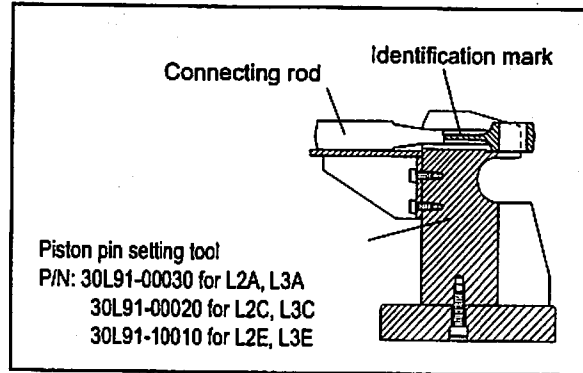
Measurement item	Standard	Limit
Measuring crankshaft end play	0.050 to 0.175 mm (0.00197 to 0.00689 in.)	0.500 mm (0.01969 in.)



Measuring crankshaft end play

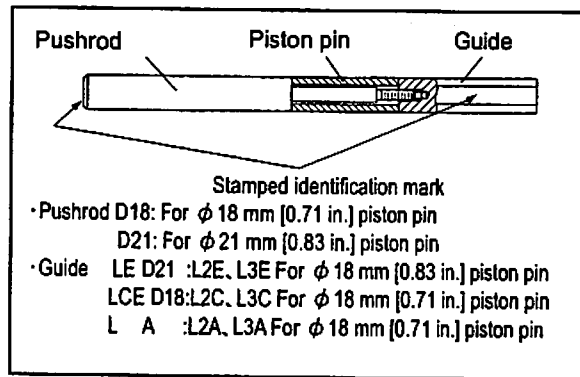
### 1.7 Reassembling piston and connecting rod

- (1) With the identification mark of connecting rod facing upward, place the rod on the piston pin setting tool.



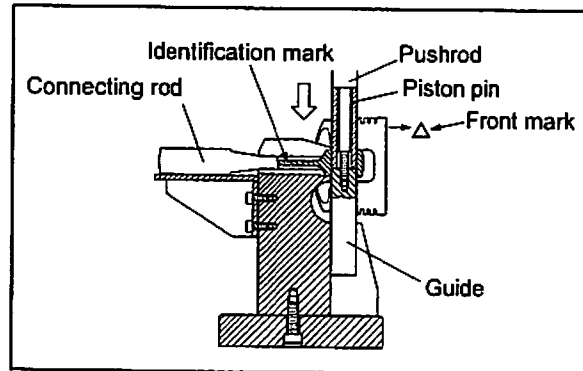
Reassembling piston connecting rod (1)

- (2) Set the piston pin push rod and guide to the piston pin.



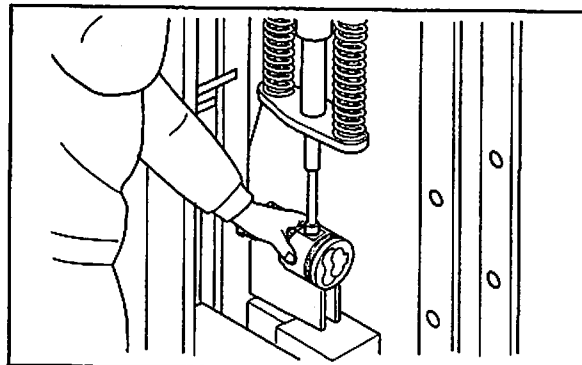
Reassembling piston connecting rod (2)

- (3) Reassemble the piston to the connecting rod with the front mark (  $\Delta$  ) on the piston top and the identification mark of the connecting rod facing upward. Install the piston pin from the piston pin guide.



Reassembling piston connecting rod (3)

- (4) Press-in the piston pin with the push rod using hydraulic press (pin press-in load  $9807 \pm 4903$  N [ $1000 \pm 500$  kgf] [ $2205 \pm 1102$  lbf]) until the guide contacts the piston setting tool.
- (5) After reassembling, make sure that the piston and the connecting rod move lightly on the piston pin.



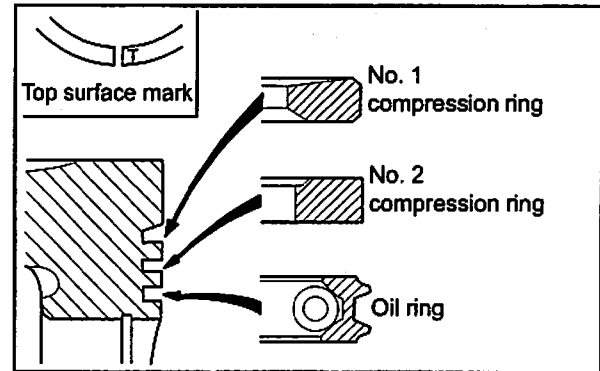
Reassembling piston connecting rod (4)

## 1.8 Installing piston rings

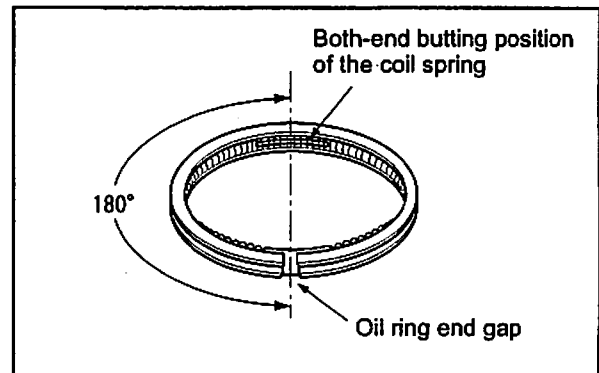
### CAUTION

- (a) A marking such as "R", is stamped near the end gap to show the top face of piston ring. Install all piston rings with the mark facing upward.
- (b) If piston rings are assembled upside down, it will cause malfunctions such as increase of oil consumption or engine seizure.

- (1) Install the piston rings to the piston with a ring expander.
- (2) Install the oil ring spring so that its joint is 180° away from the ring end gap as shown in the illustration.



Reassembling pistons and piston rings



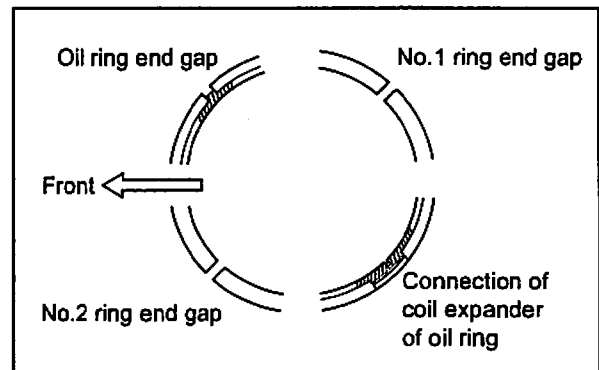
Reassembling oil rings

## 1.9 Installing piston and connecting rod

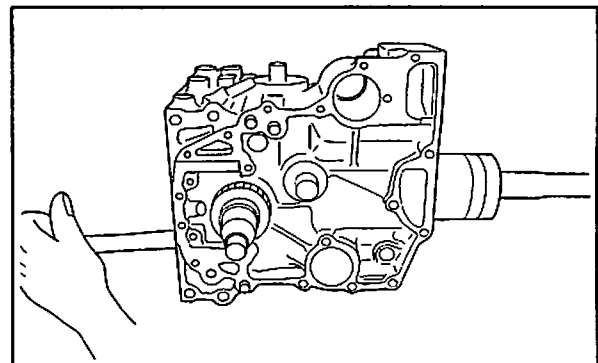
### CAUTION

Do not drive in the piston strongly. It may cause damage to the piston rings and crank pin.

- (1) Apply engine oil to the circumference of the piston and piston rings.
- (2) Place the ring end gaps in diagonal positions avoiding the piston pin direction and its right angle direction.
- (3) Fit the connecting rod bearing (upper) to the connecting rod aligning the lug and lug groove.
- (4) Turn the crankshaft to place the crank pin of the assembling cylinder to the top dead center.
- (5) Face the front mark (arrow) stamped on the piston top toward the timing gear case side (forward of the engine).
- (6) Insert the piston from the top face of cylinder block using a piston guide (commercially available).



Orienting piston ring end gaps



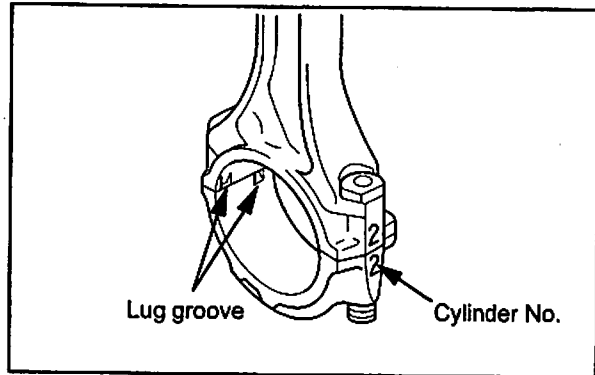
Installing pistons and connecting rods

### 1.10 Installing connecting rod cap

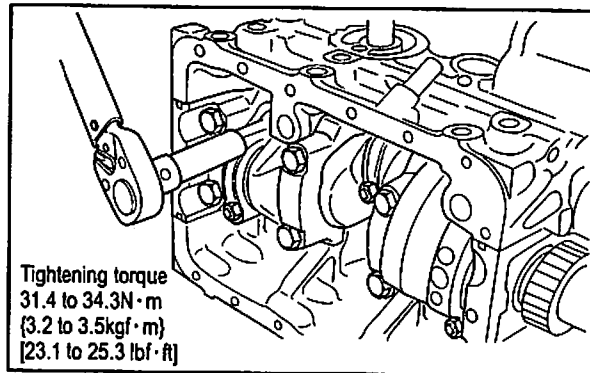
- (1) When the big end of the connecting rod comes into close contact with the crank pin, turn the crankshaft 180° while pressing the piston head.
- (2) Adjust the lower connecting rod bearing to the lug groove on the connecting rod and reassemble it.
- (3) Reassemble the bearing cap into the connecting rod in alignment with the mark put during disassembly.

Note: In the case of new connecting rods with no mating marks, reassemble so that lug grooves on the detent of the bearing are on the same side as shown in the illustration.

- (4) Tighten the connecting rod cap nuts alternately and progressively to the specified torque.



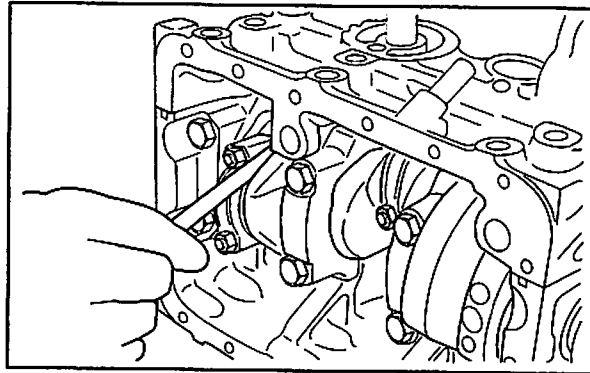
Installing connecting rod caps



Tightening connecting rod cap nuts

- (5) Inspect end play of the connecting rods. Loosen the cap nuts and retighten them if end play is small.

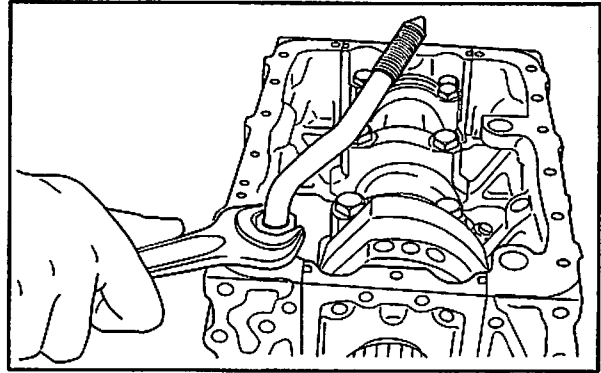
Measurement item	Standard	Limit
End play of connecting rod	0.10 to 0.35 mm [0.0039 to 0.0138 in.]	0.5 mm [0.020 in.]



Measuring end play of connecting rod

### 1.11 Installing oil screen

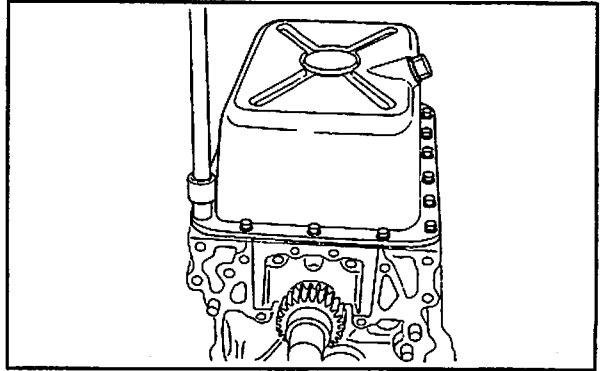
- (1) Turn the engine upside down to face up the oil pan mounting surface.
- (2) Install the oil screen so that the tip of the screen does not contact the oil pan.



Installing oil screen

### 1.12 Installing oil pan

- (1) Install new oil pan gasket.
- (2) Tighten oil pan bolts evenly and diagonally.

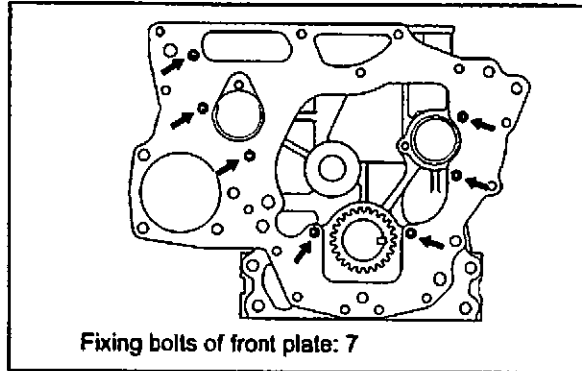


Installing oil pan

## 2. Gear case, timing gear and camshaft

### 2.1 Installing front plate

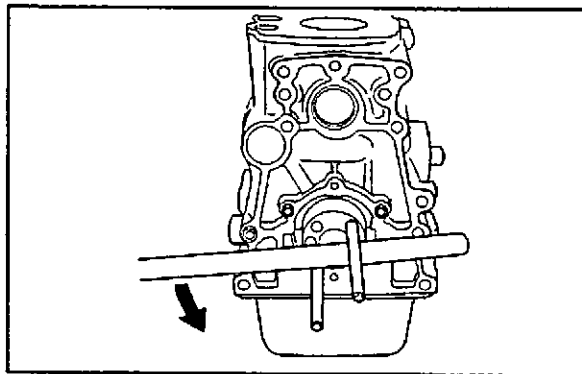
- (1) Clean the mounting surface of the gasket.
- (2) Apply sealant to prevent the gasket from falling off.
- (3) Install the gasket.
- (4) Install the front plate with bolts.



Installing front plate

### 2.2 Turning engine

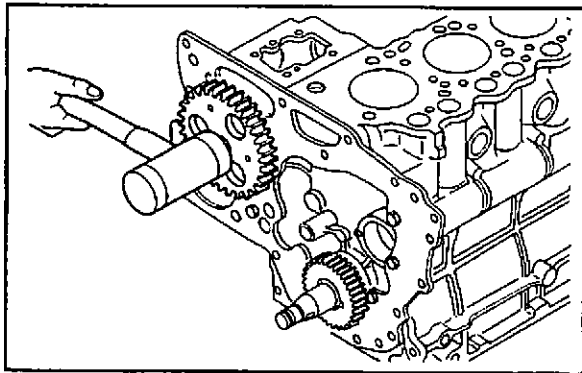
- (1) Install two bolts in the flywheel mounting holes of the crankshaft.
- (2) Turn the crankshaft with a bar using the bolts to place the No. 1 cylinder at the top dead center.



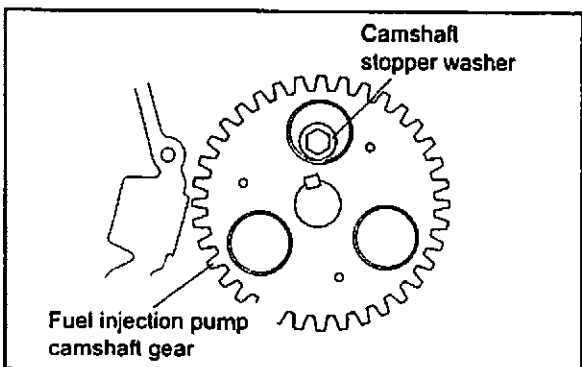
Turning engine

### 2.3 Installing fuel injection pump camshaft

- (1) Insert the fuel injection pump camshaft (with the bearing and gear) into the cylinder block hole.
- (2) Drive the bearing into the cylinder block hole completely by tapping the gear with a plastic hammer.
- (3) Make sure that the fuel injection pump camshaft rotates lightly.
- (4) Tighten the camshaft stopper bolts.



Driving in fuel injection pump camshaft



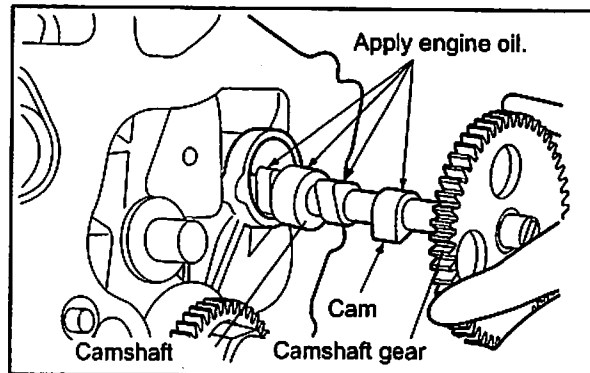
Installing camshaft stopper washers

### 2.4 Installing camshaft

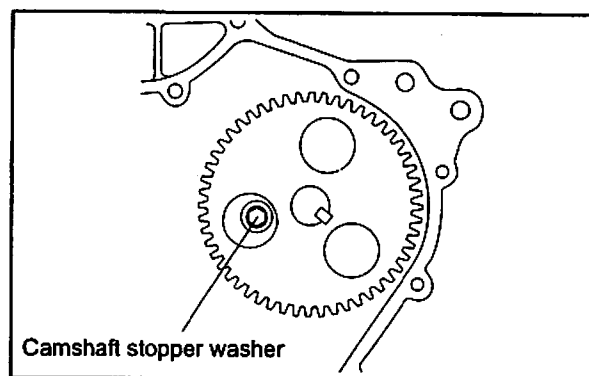
#### CAUTION

Be careful not to damage camshaft journals, cams and camshaft holes during insertion.

- (1) Apply engine oil to the camshaft journals and cams.
- (2) Slowly insert the camshaft assembly.
- (3) Install the camshaft stopper.
- (4) Make sure that the camshaft rotates lightly.  
Move the camshaft gear back and forth, and make sure there is end play.



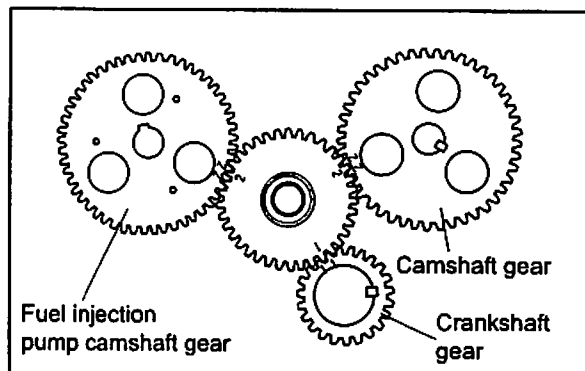
Installing camshaft



Installing camshaft stoppers

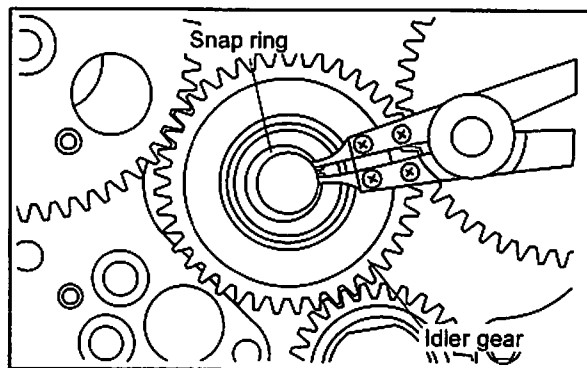
### 2.5 Installing idler gear

- (1) Apply engine oil to the idler gear shaft.
- (2) Install the idler gear while aligning all match marks on it and the other gears.



Align the timing marks.

- (3) Fix the idler gear shaft with a snap ring.
- (4) Move the idler gear back and forth, and make sure there is end play.



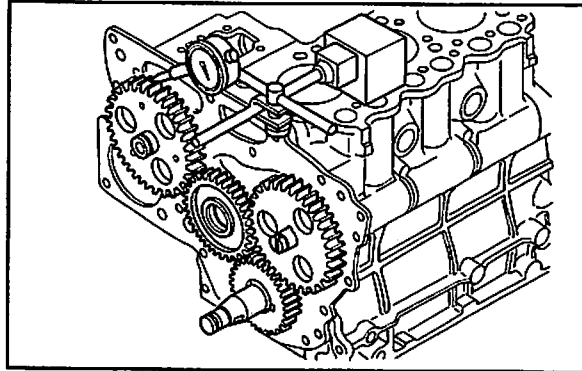
Installing idler gear

## 2.6 Check and adjustment after installing timing gear

Be sure to check and adjust as follows whenever the timing gears are disassembled and reassembled.

### 2.6.1 Inspecting backlash

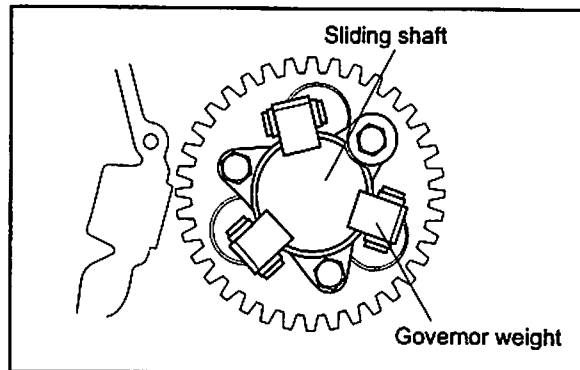
Check backlash between each gear after installing the timing gears.



Measuring backlash of timing gear

## 2.7 Installing governor weights and sliding shaft

Install the governor weights and sliding shaft on the fuel injection pump camshaft gear.

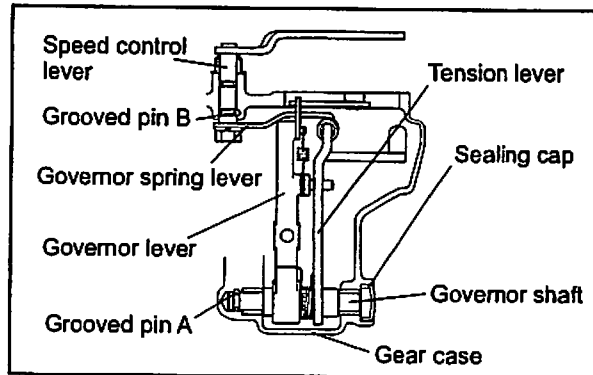


Installing governor weight and sliding shaft

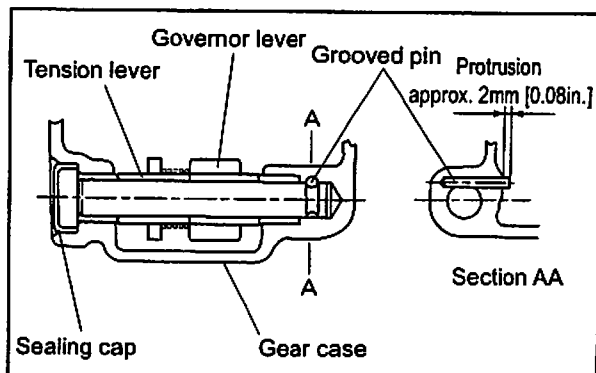
## 2.8 Installing speed control lever and governor shaft

- (1) Insert the governor shaft into the gear case while placing the governor lever and the tension lever.
- (2) Drive the grooved pin into the gear case.
- (3) Drive new sealing cap into the gear case.
- (4) Thoroughly apply Alvania Grease #2 or #3 to the governor shaft cover.
- (5) Install new O-ring on the speed control lever and insert it into the gear case through the governor shaft.
- (6) Drive the grooved pin into the gear case.
- (7) Install the governor spring lever.

Note: Install the governor spring lever to the speed control lever with the minimum assembling angle.



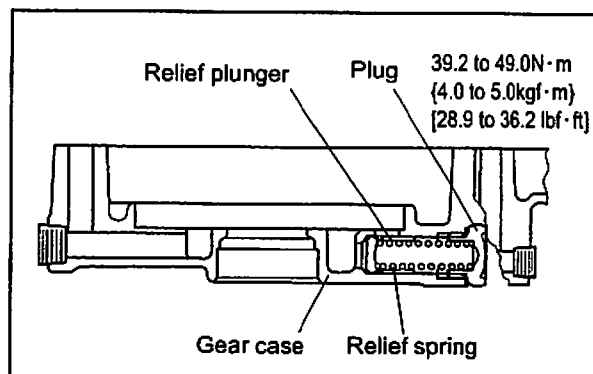
Installing speed control lever and governor shaft



Reassembling speed control lever

## 2.9 Installing relief valve

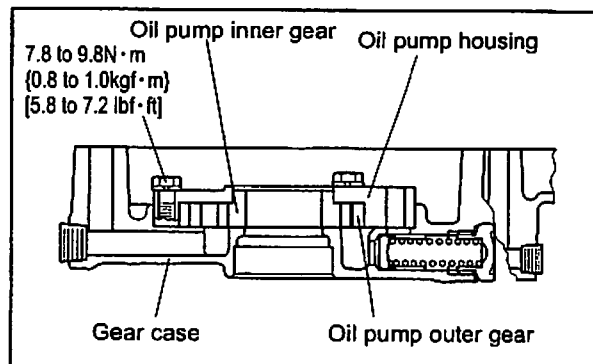
Insert the relief plunger and relief spring into the gear case and tighten the plug to the specified torque.



Installing relief valve

## 2.10 Installing oil pump

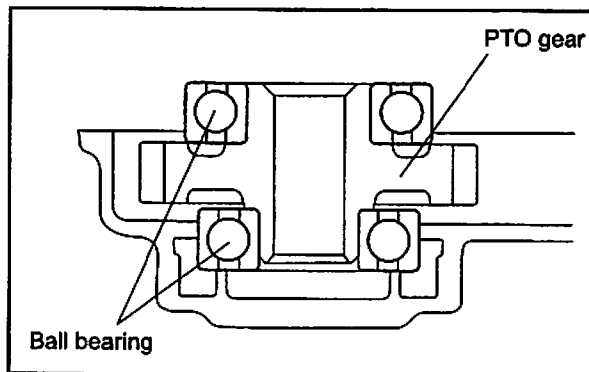
Install the oil pump inner gear, oil pump outer gear and oil pump housing, and tighten the bolts to the specified torque.



Installing oil pump

### 2.11 Installing PTO gear

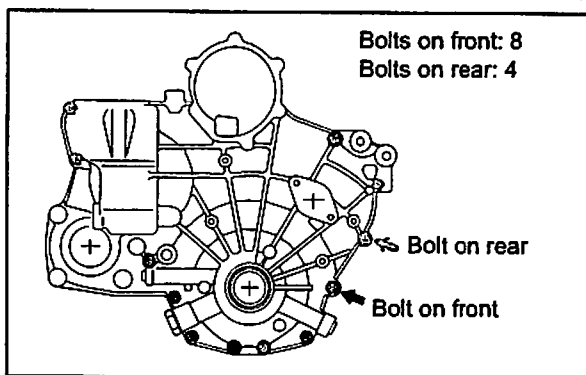
Install ball bearings on both sides of PTO gear and drive the PTO gear into the gear case.



Installing PTO gear

### 2.12 Installing timing gear case

- (1) Apply sealant to the gasket to prevent it from displacing and install the gasket on the front plate.
- (2) Apply engine oil to the oil seal lip.
- (3) Install the timing gear case and tighten the bolts.



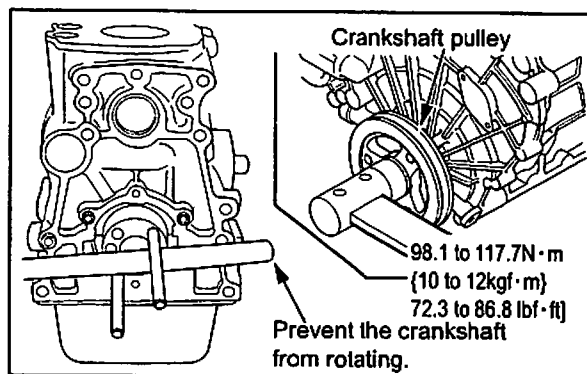
Installing gear case

### 2.13 Installing crankshaft pulley

#### **CAUTION**

The bar may come off. Be very careful.

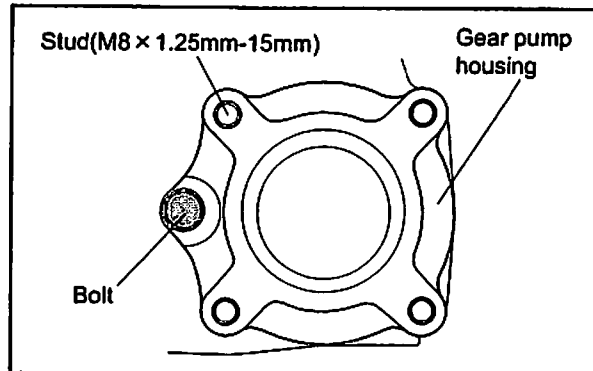
- (1) Screw two guide bolts into the threaded holes at the rear end of the crankshaft. Use these bolts and a bar placed across them to prevent the crankshaft from rotating.
- (2) Install the woodruff key on the crankshaft.
- (3) Install the crankshaft pulley and tighten the nuts to the specified torque.



Installing crankshaft pulley

### 2.14 Installing gear pump housing

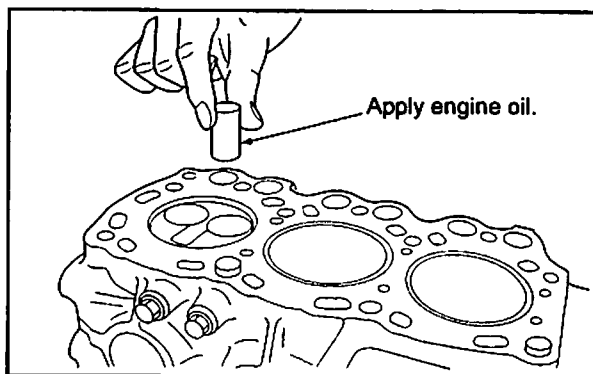
- (1) Install the gear pump housing to the stud bolts on the gear case.
- (2) Tighten the gear pump housing bolt.
- (3) Install the last stud bolt to the gear pump housing.



Installing gear pump housing

### 2.15 Installing tappet

- (1) Apply engine oil to the circumference of the tappet.
- (2) Install tappet to the tappet hole and slowly seat the tappet on the camshaft.



Inserting tappet

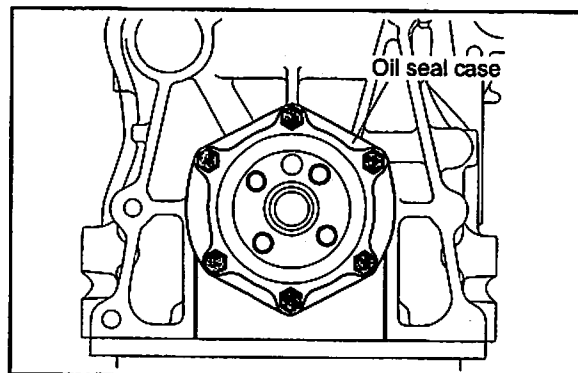
### 3. Flywheel

#### 3.1 Installing oil seal case

##### CAUTION

Be careful not to damage the oil seal.

- (1) Install the new oil seal gasket.
- (2) After applying engine oil to the whole circle of the oil seal lips, install the oil seal case on the cylinder block.

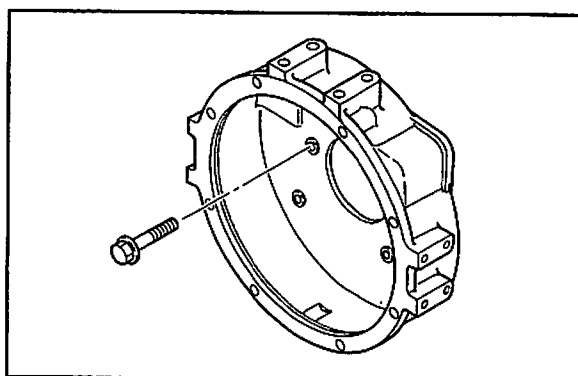


Installing oil seal case

#### 3.2 Installing flywheel housing

- (1) Clean the mounting surface of the gasket.
- (2) Apply sealant to prevent the gasket from falling off.
- (3) Install the gasket.
- (4) Install the flywheel housing aligning its dowel pin holes and dowel pins, then tighten the bolts.

Note: When the dowel pins are worn or the flywheel housing is replaced, replace the dowel pins.



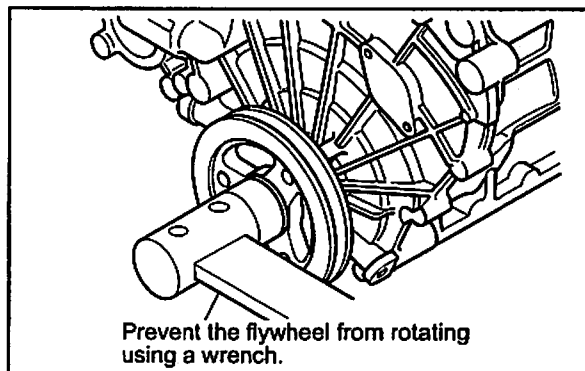
Installing flywheel housing

### 3.3 Installing flywheel

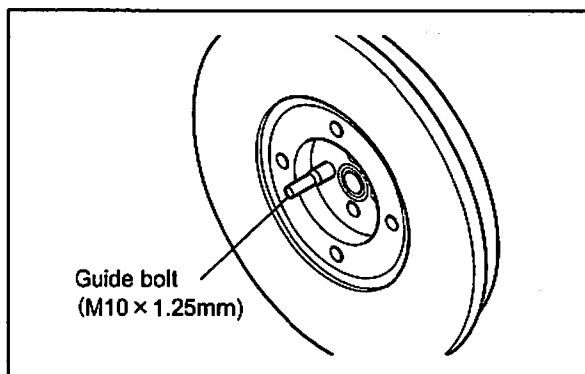
#### **CAUTION**

The person who holds the pulley must be very careful to assure safety by keeping close contact with the person who is installing the flywheel.

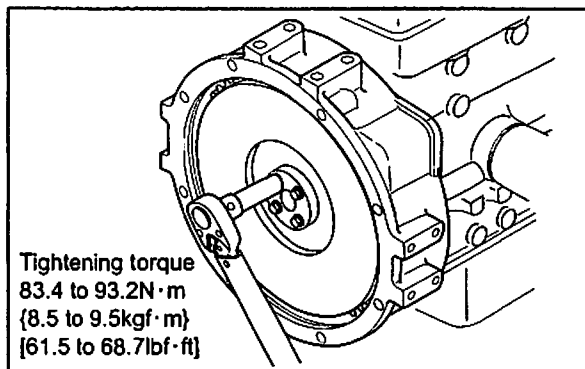
- (1) One person must firmly hold the pulley with a wrench to prevent the crankshaft from turning.
- (2) Screw the guide bolt into the rear end of the crankshaft.
- (3) Align the bolt hole of flywheel with the guide bolt and install the flywheel to the crankshaft.
- (4) Temporarily tighten bolts.
- (5) Remove the guide bolt and temporarily tighten the last bolt.
- (6) Tighten the flywheel bolts to the specified torque.



Detent of flywheel



Installing flywheel



Tightening flywheel bolts

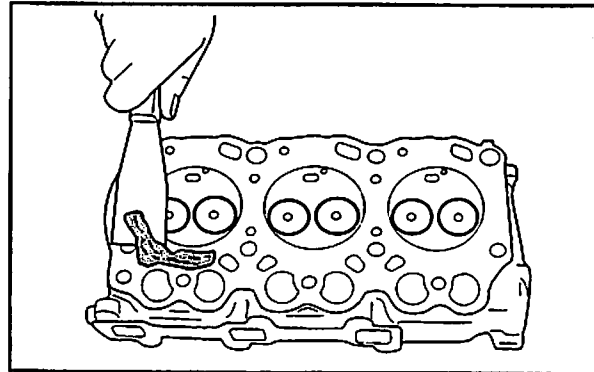
## 4. Reassembling cylinder head and valve mechanism

Reassemble the cylinder head and valve mechanisms in the reverse order of the disassembly procedures.

### 4.1 Cleaning cylinder head bottom surface

Taking care not to damage the cylinder head bottom surface, remove gasket residue.

Note: First, using a scraper, roughly scrape off the residue. Then using an engine-oil immersed oil stone, grind off remaining residue.



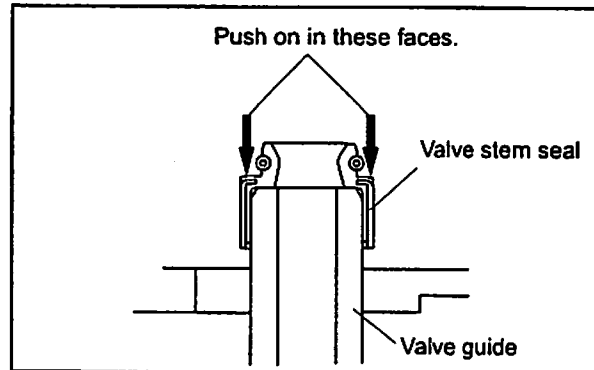
Scraping gasket

### 4.2 Installing valve stem seal

#### CAUTION

Do not apply oil or liquid gasket to the stem seal inside that comes in contact with the valve guide.

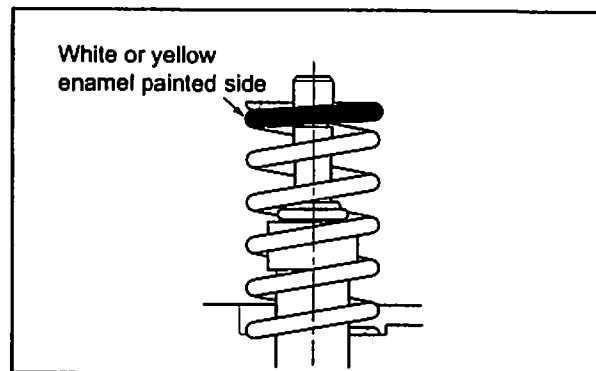
- (1) Apply engine oil to the lip of the valve stem seal.
- (2) Push the shoulder of the valve stem seal and fit it on the valve guide.
- (3) Make sure the valve guide is fully inserted into the valve stem seal.



Installing valve stem seal

### 4.3 Installing valve spring

Install the valve spring with its white or yellow enamel painted side faced upward.



Installing valve spring

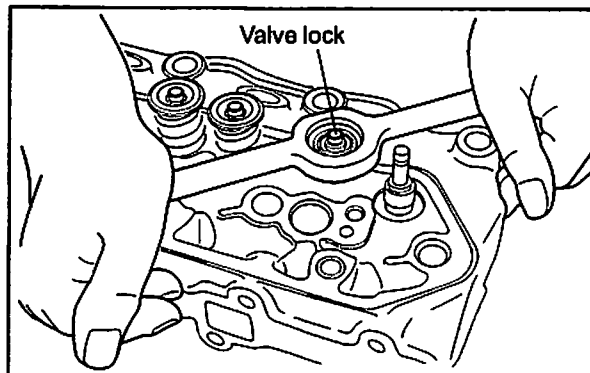
### 4.4 Installing valve lock

#### CAUTION

If valve spring is overcompressed, the lower end of the retainer will contact the stem seal and damage the stem seal.

Install the retainer on the valve spring.

Compressing the valve spring with a valve lifter, install the valve locks.



Installing valve lock

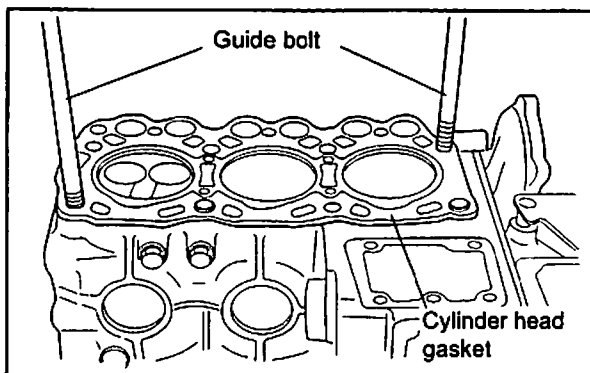
### 4.5 Installing cylinder head gasket

#### CAUTION

Do not use liquid gasket.

- (1) Make sure that there is no dirt or dents on the top surfaces of the cylinder block and pistons.
- (2) Screw in two guide bolts in the bolt holes of the block.
- (3) Place the new cylinder head gasket on the cylinder block using the guide bolts as a guide.

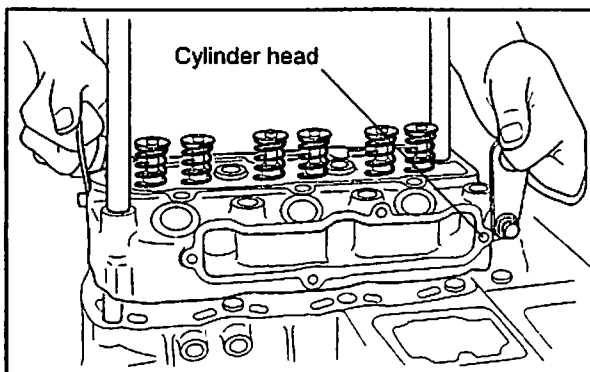
Note: The model name is stamped on the front top face of the gasket so that it is not confused with one for other model.



Installing cylinder head gasket

### 4.6 Installing cylinder head assembly

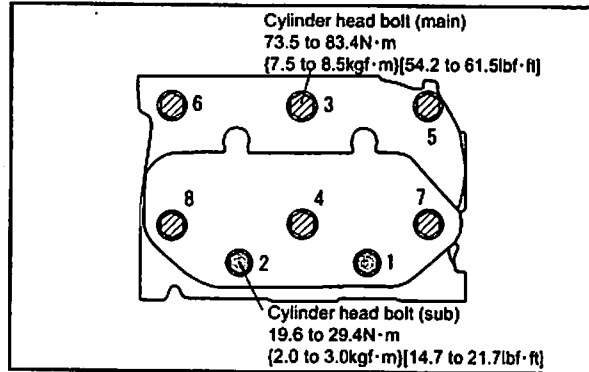
Install the cylinder head through the locating guide bolts as a guide.



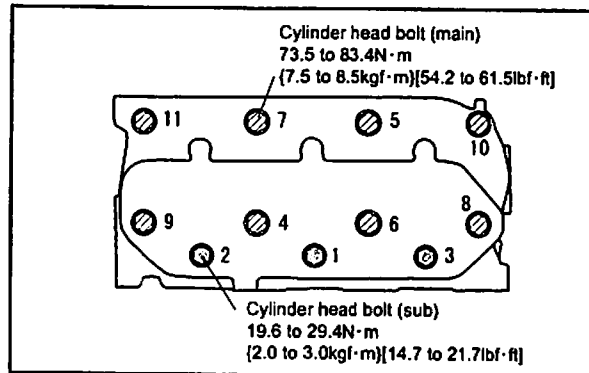
Installing cylinder head assembly

#### 4.7 Tightening cylinder head bolts

In the numerical order as shown in the illustration, tighten cylinder head bolts progressively to the specified torque.



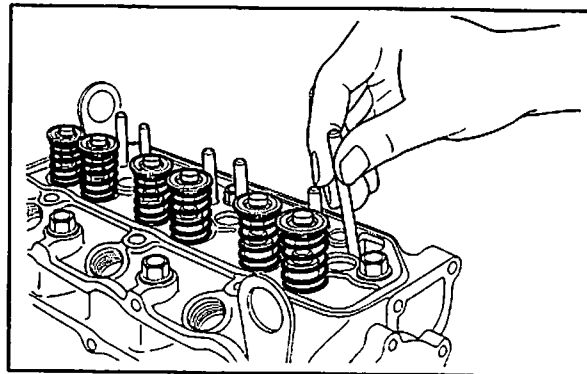
Tightening order of cylinder head bolts (L2)



Tightening order of cylinder head bolts (L3)

#### 4.8 Inserting pushrod

- (1) Insert each pushrod into its hole in the cylinder head.
- (2) Make sure that the ball end of each pushrod is placed correctly on the tappet cup.



Inserting pushrods

### 4.9 Reassembling rocker shaft assembly

Reassemble the rocker shaft assembly in the reverse order of the disassembly sequence.

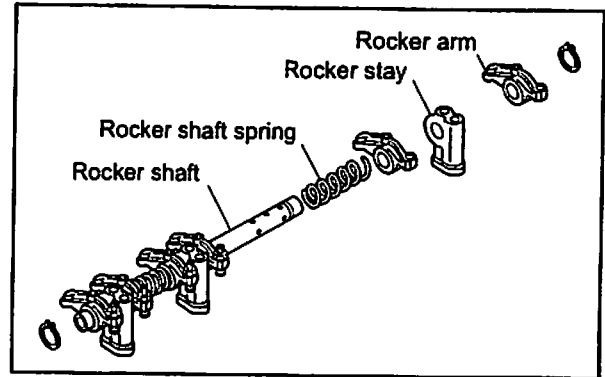
- (1) Apply engine oil to the rocker shaft.
- (2) Reassemble the rocker shaft assembly in the same position as installed before disassembly.

Note: If the position is different from the original position, the clearance becomes different, and it may result in a defect such as wear increase.

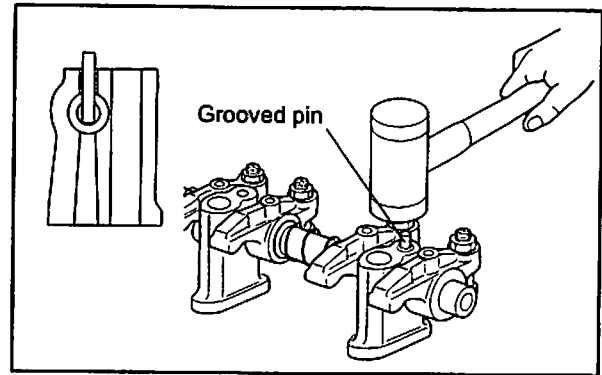
- (3) Align oil holes of the rocker shaft with those of the rocker stay and drive a grooved pin into the front rocker stay.

Note: Drive in the grooved pin until it contacts the inside of the rocker shaft.

- (4) After reassembling, make sure the rocker arms move lightly.



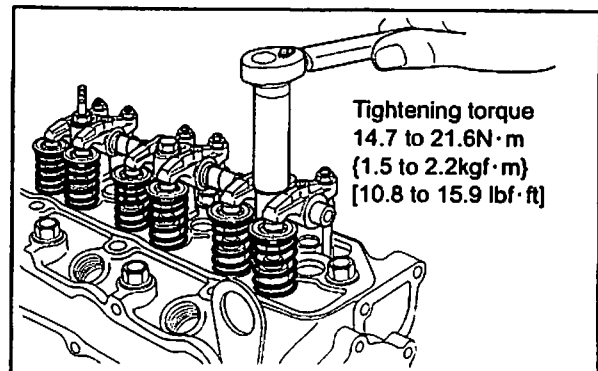
Reassembling rocker shaft assembly



Driving in grooved pin

### 4.10 Installing rocker shaft assembly

- (1) Install the valve caps on the valve heads.
- (2) Tighten the long bolts of the rocker bracket to the specified torque.
- (3) Tighten the short bolts of the rocker bracket.

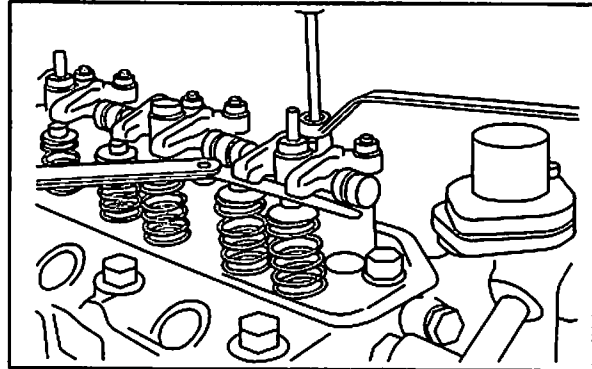


Installing rocker shaft assembly

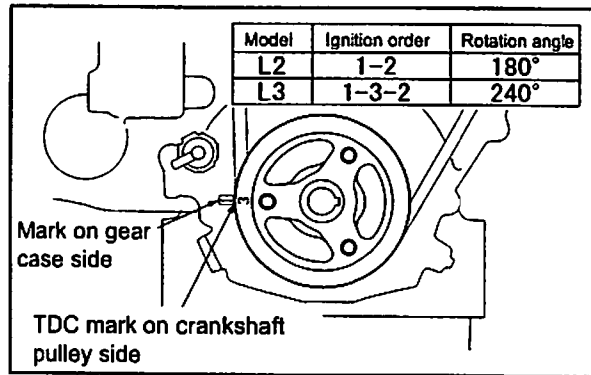
#### 4.11 Adjusting valve clearance

Adjust the valve clearance.

For adjusting procedures, refer to "Adjusting Engine, Inspecting and Adjusting Valve Clearance."



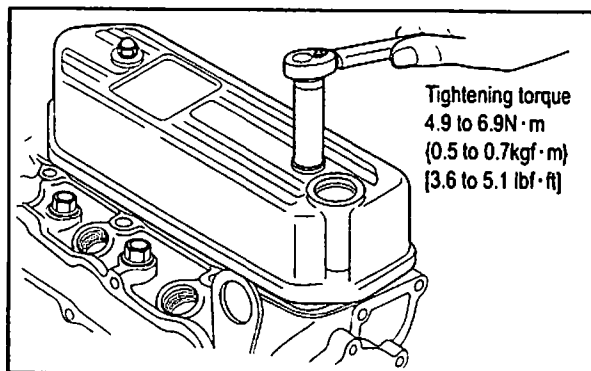
Adjusting valve clearance



Timing mark

#### 4.12 Installing rocker cover

- (1) Make sure that the gasket is correctly reassembled to the rocker cover.
- (2) Tighten the rocker cover mounting nuts to the specified torque.



Installing rocker cover

#### 4.13 Installing torque spring set

For installing procedures of the torque spring set, refer to item "Installing Fuel System."

# FUEL SYSTEM

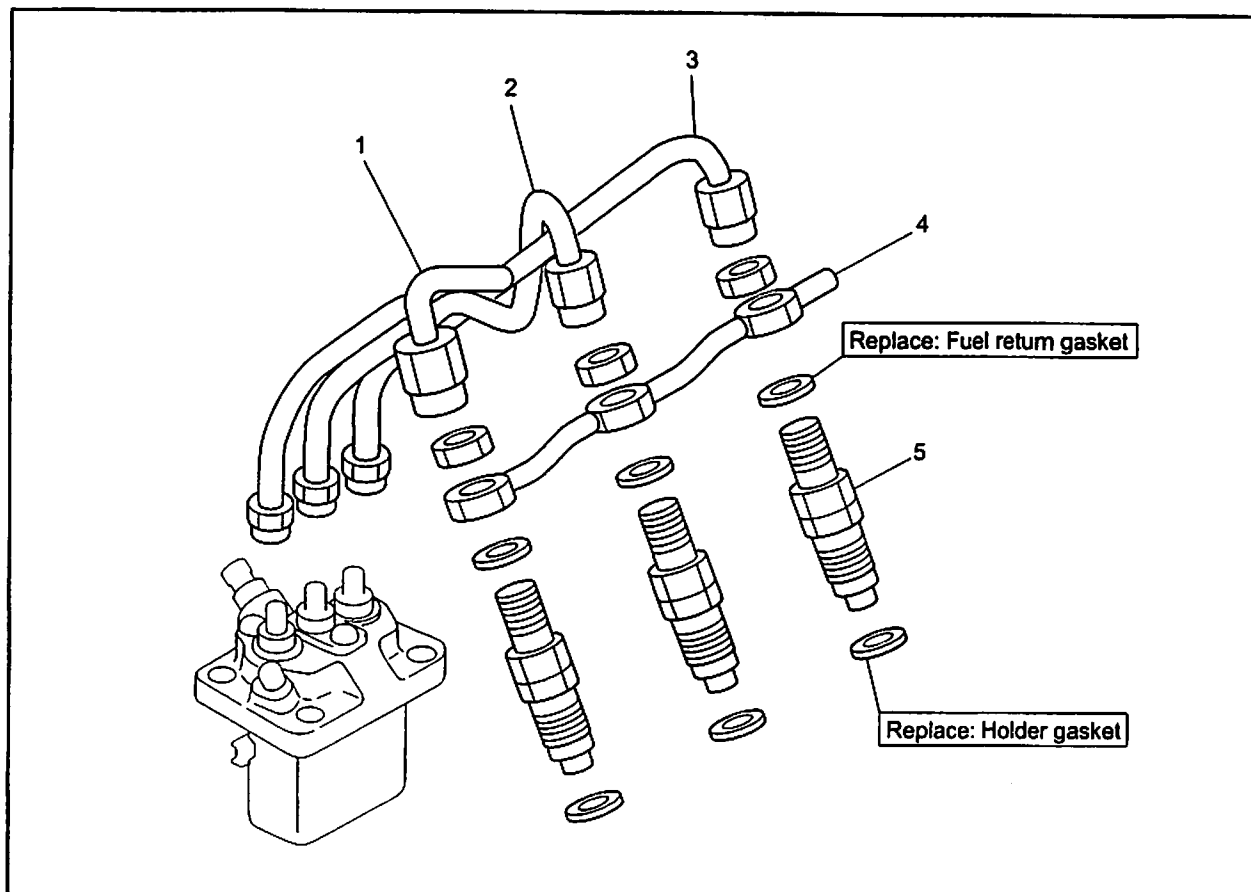
<p><b>1. Removing fuel system ..... 8-2</b></p> <p>1.1 Removing fuel pipe and fuel injection nozzle..... 8-2</p> <p>1.1.1 Removing fuel injection pipe .....8-3</p> <p>1.1.2 Removing fuel injection nozzle.....8-3</p> <p>1.2 Removing fuel filter ..... 8-4</p> <p>1.3 Removing governor..... 8-5</p> <p>1.3.1 Disconnecting tie rod from control rack.....8-6</p> <p>1.3.2 Removing governor shaft and speed control lever.....8-6</p> <p>1.4 Removing fuel injection pump..... 8-7</p> <p><b>2. Disassembling, inspecting and reassembling fuel system..... 8-8</b></p> <p>2.1 Disassembling and inspecting fuel injection nozzles..... 8-8</p> <p>2.1.1 Checking nozzle opening pressure .....8-9</p> <p>2.1.2 Checking fuel spray pattern from fuel injection nozzle.....8-10</p> <p>2.1.3 Cleaning or replacing when spray is poor 8-10</p> <p>2.2 Reassembling fuel injection nozzles ..... 8-11</p> <p>2.3 Inspecting fuel injection pump on engine8-12</p> <p>2.4 Disassembling and inspecting fuel injection pump ..... 8-12</p> <p>2.4.1 Removing swivel nipple.....8-13</p> <p>2.4.2 Removing tappets .....8-13</p> <p>2.4.3 Removing plunger .....8-13</p> <p>2.5 Reassembling fuel injection pump ..... 8-15</p> <p>2.5.1 Installing plunger barrel .....8-15</p> <p>2.5.2 Assembling delivery valve .....8-16</p> <p>2.5.3 Assembling control sleeve .....8-16</p> <p>2.5.4 Assembling plunger.....8-16</p> <p>2.5.5 Installing tappet .....8-17</p> <p>2.5.6 Installing control rack .....8-17</p> <p>2.5.7 Tightening delivery valve holder.....8-18</p> <p>2.5.8 Checking sliding of control rack .....8-18</p> <p>2.5.9 Installing lock plate .....8-18</p> <p>2.5.10 Installing swivel nipple.....8-18</p> <p>2.6 Disassembling and inspecting governor cover ..... 8-19</p> <p>2.7 Reassembling governor cover ..... 8-19</p> <p>2.8 Disassembling and inspecting torque spring set ..... 8-20</p> <p>2.9 Reassembling torque spring set ..... 8-20</p> <p>2.9.1 Torque spring set, single spring type .....8-21</p> <p>2.9.2 Torque spring set, double spring type .....8-22</p> <p>2.10 Inspecting fuel pump..... 8-23</p> <p>2.11 Disassembling, inspecting and reassembling fuel filter (cock switch type)..... 8-24</p>	<p>2.12 Inspecting fuel filter (cartridge type) ..... 8-24</p> <p><b>3. Installing fuel system ..... 8-25</b></p> <p>3.1 Fuel injection pump..... 8-25</p> <p>3.2 governor..... 8-26</p> <p>3.3 fuel filter..... 8-29</p> <p>3.4 Installing fuel pipe and fuel injection nozzles ..... 8-30</p>
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## 1. Removing fuel system

### CAUTION

Cover the openings on the injection pipe, nozzle inlet connector and injection pipe to prevent dust from entering the fuel system.

### 1.1 Removing fuel pipe and fuel injection nozzle



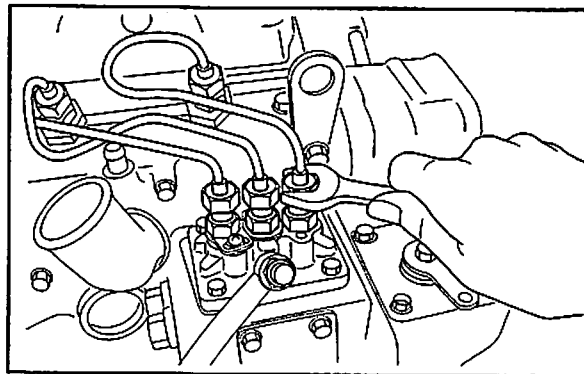
Removing fuel pipe and fuel injection nozzle

#### Removing sequence

- |                             |                         |
|-----------------------------|-------------------------|
| 1 No. 1 fuel injection pipe | 4 Fuel return pipe      |
| 2 No. 2 fuel injection pipe | 5 Fuel injection nozzle |
| 3 No. 3 fuel injection pipe |                         |

### 1.1.1 Removing fuel injection pipe

Remove the fuel injection pipe and fuel return pipe.

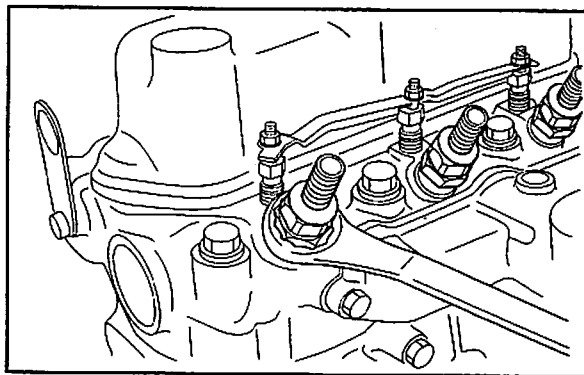


Removing fuel injection pipe

### 1.1.2 Removing fuel injection nozzle

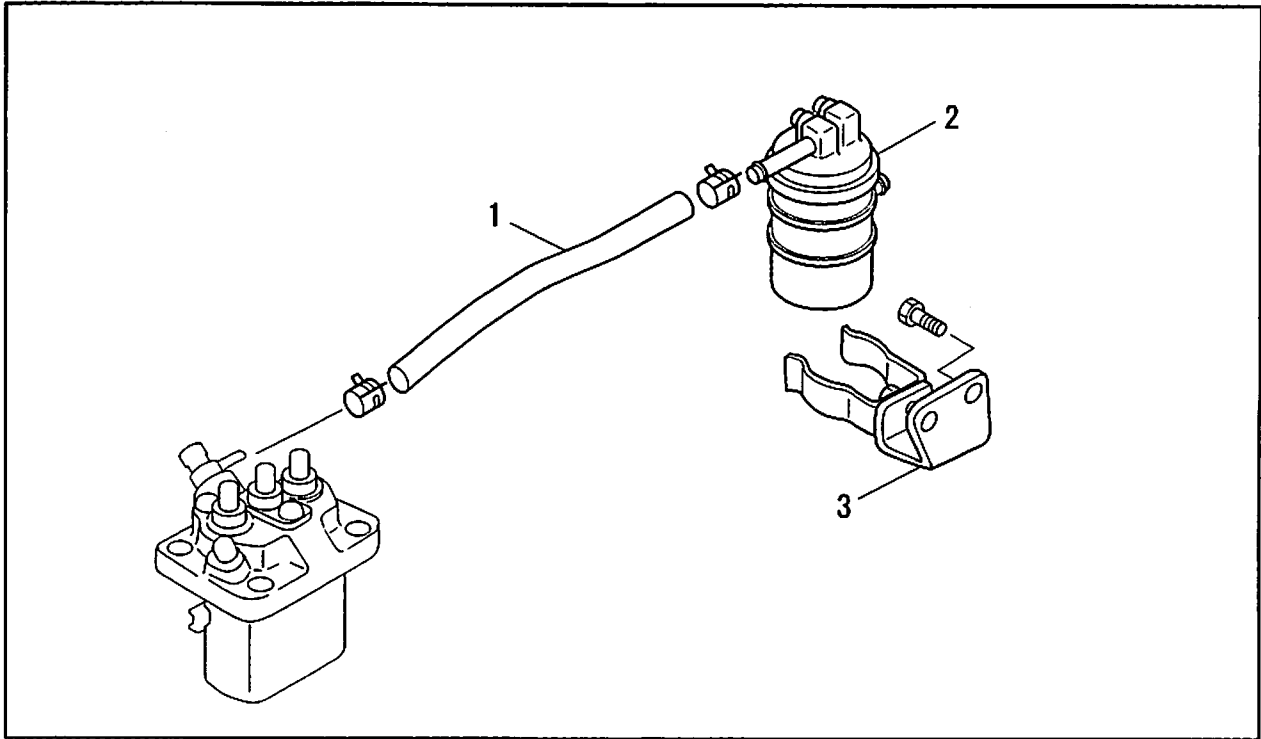
Using a wrench, loosen the nozzle, and remove the fuel injection nozzle and holder gasket.

Note: Using a wire or screwdriver remove the holder gasket.



Removing fuel injection nozzle

## 1.2 Removing fuel filter



Removing fuel filter

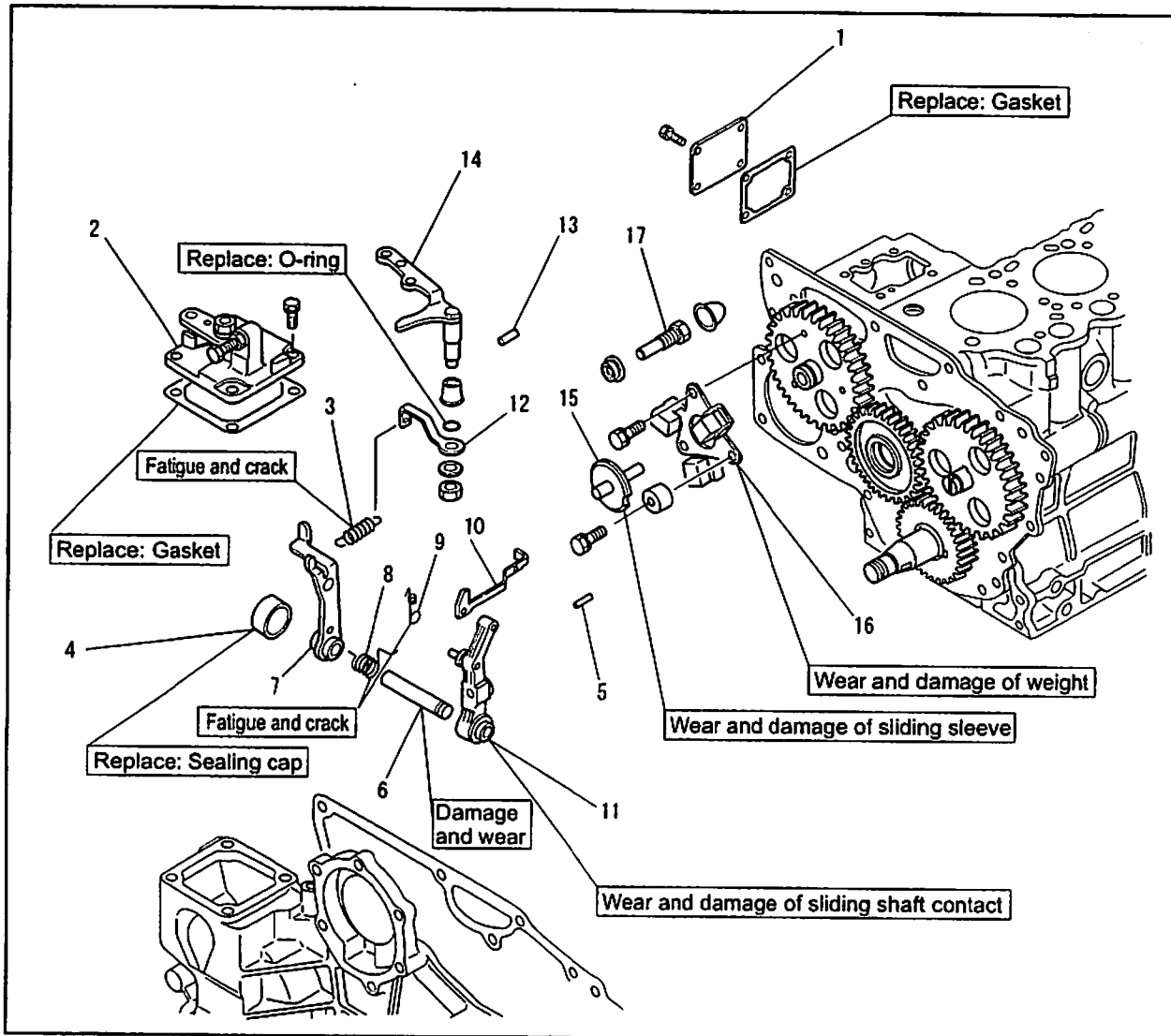
### Removing sequence

1 Fuel hose

2 Fuel filter

3 Fuel filter support

## 1.3 Removing governor



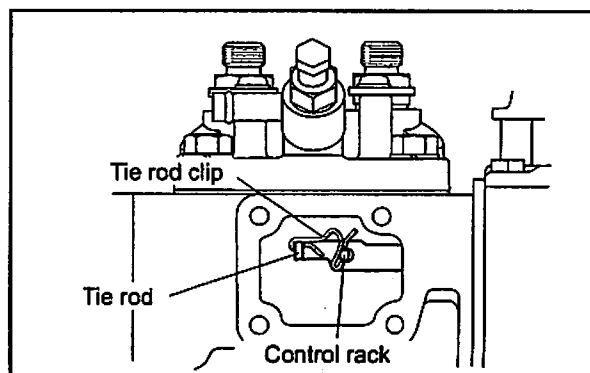
Removing governor

## Removing sequence

- |                   |                   |                        |
|-------------------|-------------------|------------------------|
| 1 Tie rod cover   | 7 Tension lever   | 13 Grooved pin         |
| 2 Governor cover  | 8 Start spring    | 14 Speed control lever |
| 3 Governor spring | 9 Tie rod spring  | 15 Sliding shaft       |
| 4 Sealing cap     | 10 Tie rod        | 16 Governor weight     |
| 5 Grooved pin     | 11 Governor lever | 17 Torque spring set   |
| 6 Governor shaft  | 12 Governor lever |                        |

## 1.3.1 Disconnecting tie rod from control rack

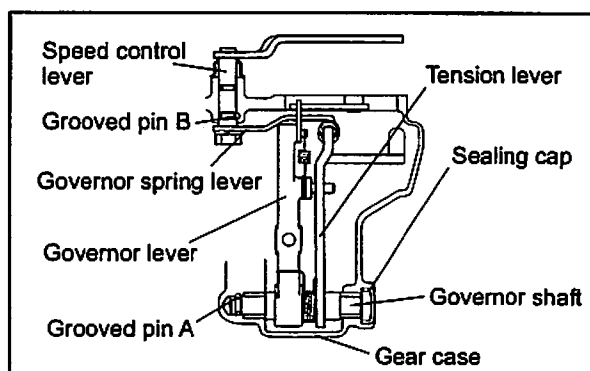
- (1) Remove the tie rod cover.
- (2) Remove the tie rod clip and disconnect the tie rod from the control rack.



Disconnecting tie rod from control rack

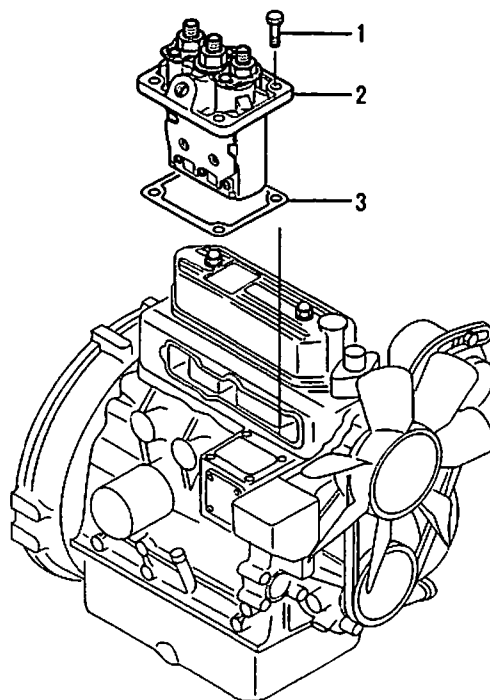
## 1.3.2 Removing governor shaft and speed control lever

- (1) Remove the sealing cap from the side of the gear case.
- (2) Pull out the grooved pin A.
- (3) Remove the governor shaft, and remove tension lever and governor lever.
- (4) Remove the governor spring lever.
- (5) Remove the grooved pin B and remove speed control lever.
- (6) Remove the governor cover.



Removing governor shaft and speed control lever

## 1.4 Removing fuel injection pump



Removing fuel injection pump

### CAUTION

Check thickness of the fuel injection timing adjusting shim.

#### Removing sequence

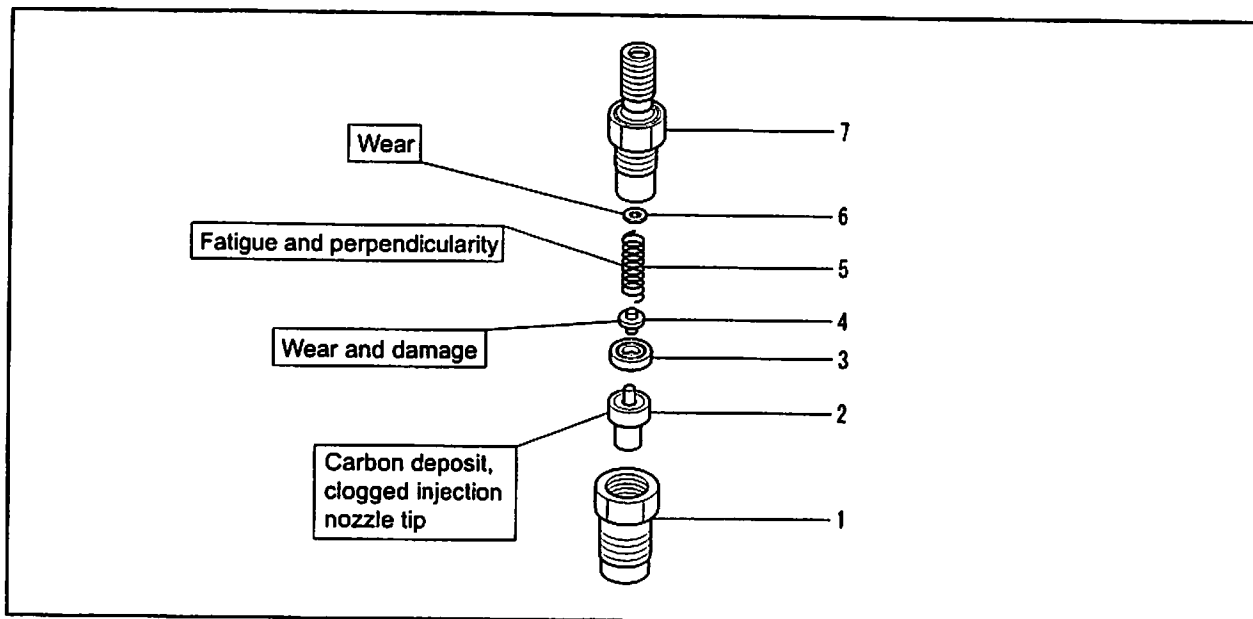
1 Bolt

2 Fuel injection pump

3 Shim

## 2. Disassembling, inspecting and reassembling fuel system

### 2.1 Disassembling and inspecting fuel injection nozzles



Disassembling and inspecting fuel injection nozzles

#### Disassembling sequence

- |                        |          |                 |
|------------------------|----------|-----------------|
| 1 Nozzle retaining nut | 4 Pin    | 7 Nozzle holder |
| 2 Nozzle tip assembly  | 5 Spring |                 |
| 3 Piece                | 6 Washer |                 |

### 2.1.1 Checking nozzle opening pressure

#### **CAUTION**

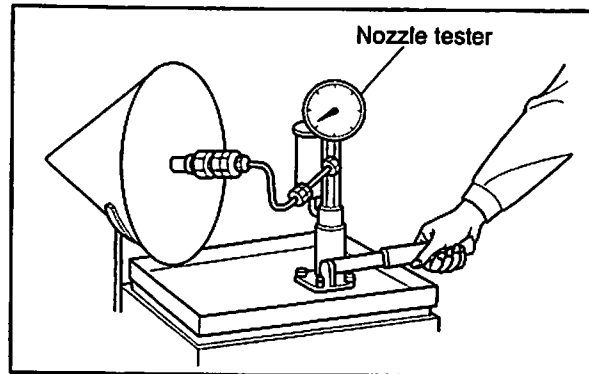
Never touch the spray hole during injection.

- (1) Install the fuel injection nozzle to the nozzle tester. Pump the tester handle up and down to bleed air.
- (2) Pump the tester handle at a rate of approx one cycle per second while observing the pressure at which injection starts.

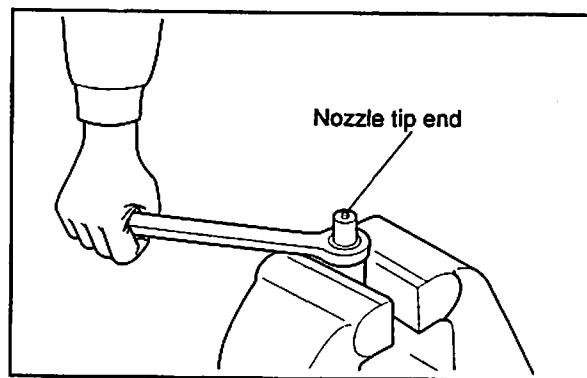
Note: The pointer should rise slowly and, during fuel injection, should vibrate. The pressure at which the pointer starts to vibrate is the valve opening pressure.

- (3) If the measured pressure does not conform to the standard value, disassemble the nozzle and adjust the pressure by changing the thickness of the washers.

Note: Change in washer thickness by 0.1 mm [0.004 in.] results in a pressure change of 1.0 MPa (10 kgf/cm<sup>2</sup>) [142 psi]. Washers are available in 10 different thicknesses at intervals of 0.05 mm [0.0020 in.] in the range between 1.25 and 1.70 mm [0.0492 to 0.0669 in.].



Checking valve opening pressure

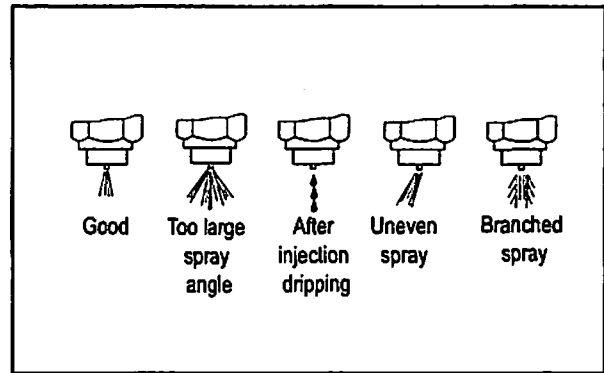


Replacing fuel injection nozzle tips

Measurement item	Standard
Nozzle opening pressure	13.73 to 14.73 MPa (140 to 150 kgf/cm <sup>2</sup> ) [199] to 2134 psi]

## 2.1.2 Checking fuel spray pattern from fuel injection nozzle

- (1) When adjusting the nozzle opening pressure using the nozzle tester, also check for such items as nozzle hole condition and fuel spray pattern.
- (2) Checking points of fuel spray are as follows:
  - Fuel is injected from all spray holes simultaneously.
  - Fuel is injected conically at the specified spray angle.
  - Injected fuel does not contain large particles and becomes fine spray.
  - After injection, no fuel droplets remain at the spray hole.
- (3) If spray is defective, clean or replace the nozzle tip.



Checking fuel spray pattern from fuel injection nozzle

## 2.1.3 Cleaning or replacing when spray is poor

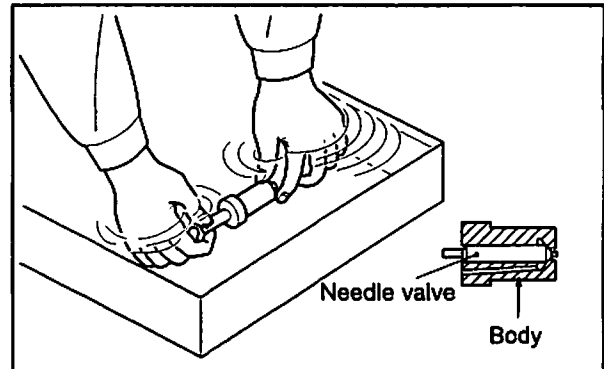
### CAUTION

When removing the nozzle tip assembly, never tap on the tip end of the assembly.

- (1) Loosen the nozzle retaining nut and remove the nozzle tip assembly. Clean the needle valve and the nozzle tip body.
  - (2) Wash the needle valve and the nozzle tip body in clean wash oil. Reassemble them in clean diesel oil.
- Note: The needle valve and the nozzle tip body are precision-machined parts. Handle them carefully and never change their combination.
- (3) Assemble the fuel injection nozzle, and tighten the nozzle retaining nut to the specified torque.
  - (4) If the fuel spray pattern is still poor, replace the nozzle tip.

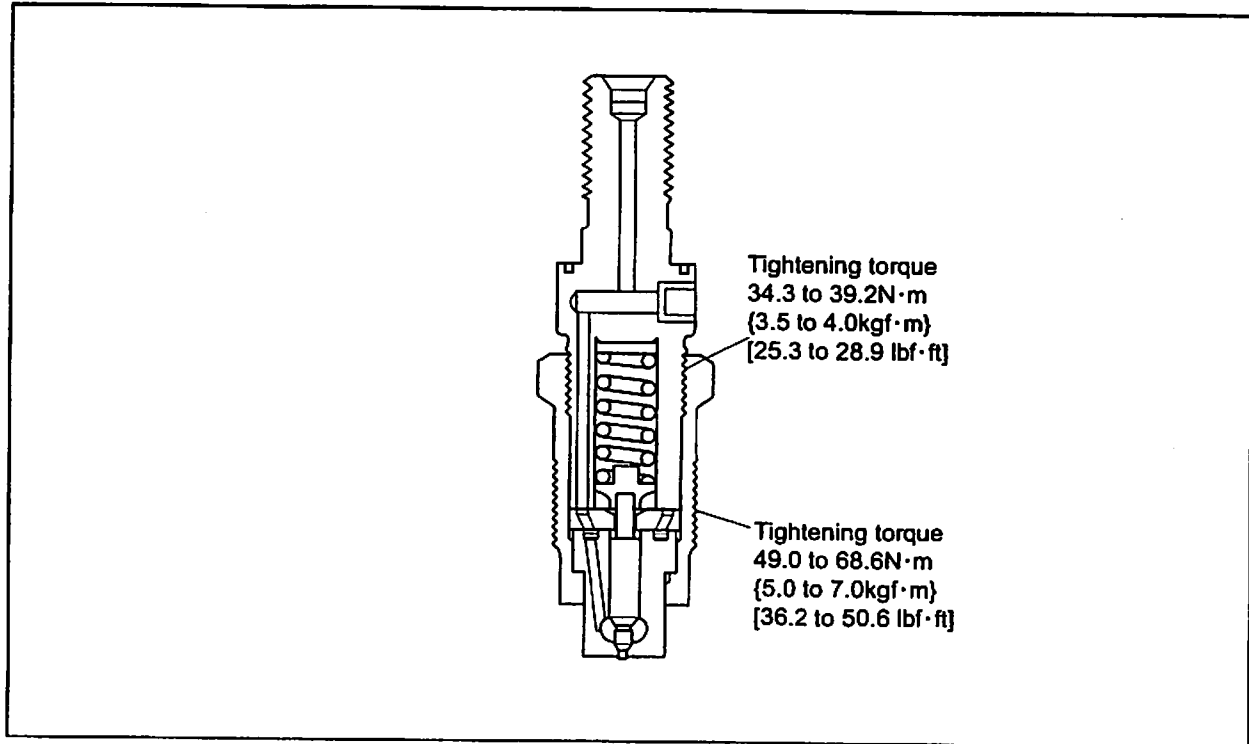
Note: (a) Never touch the sliding surface of the needle valve with your hand.

- (b) When replacing nozzle tip assembly, remove the seal peel (synthetic resin film) from the new nozzle tip assembly, and slide the nozzle and needle valve in clean wash oil to remove the anti-corrosive agent completely.



Cleaning nozzle tip assembly

## 2.2 Reassembling fuel injection nozzles



Reassembling fuel injection nozzles

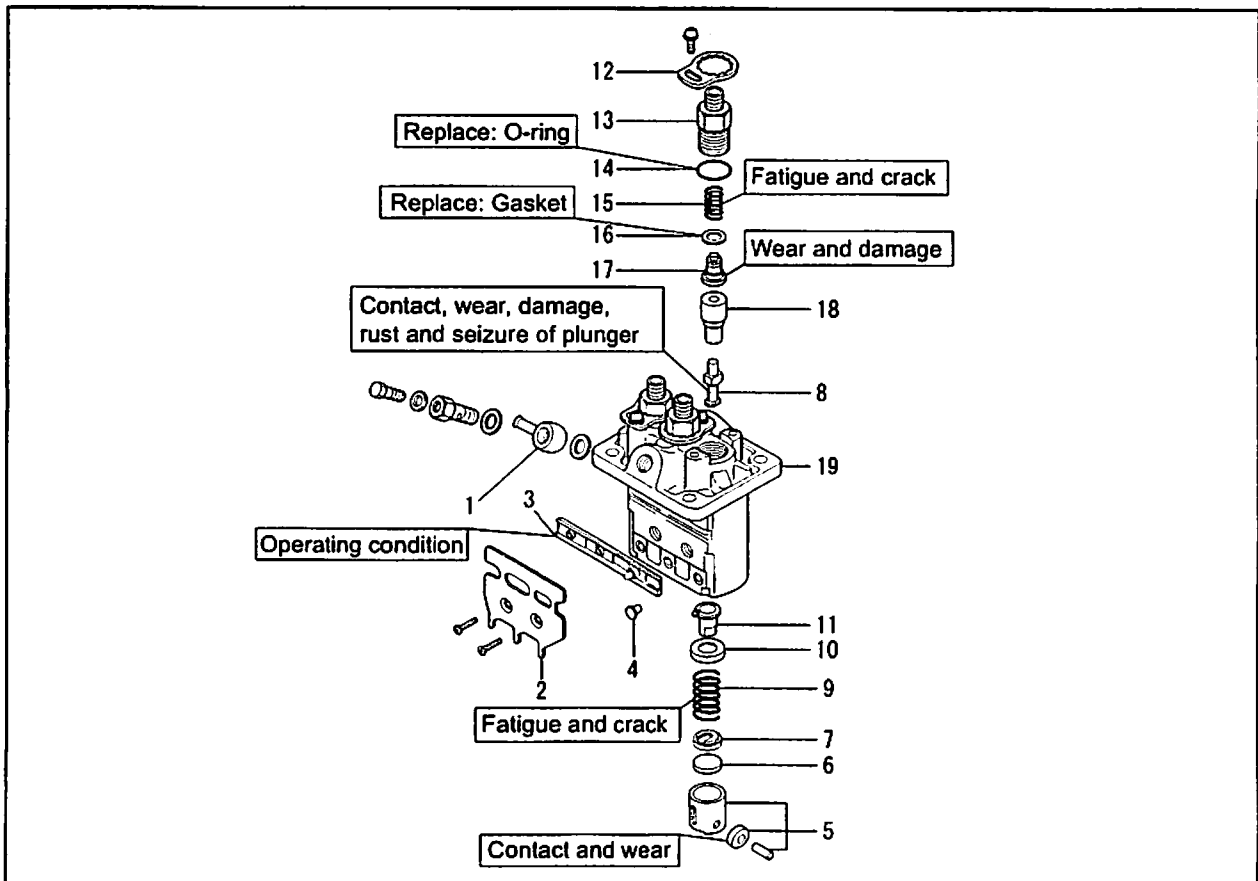
## 2.3 Inspecting fuel injection pump on engine

Do not disassemble the fuel injection pump unless it is absolutely necessary.

If faulty, it is desirable to replace it as an assembly.

Inspection item	Inspection procedure	Judgment
Low idling	Judgment by rotation speed	(Varies depending on specification)
Exhaust color	1) Observe exhaust color during sudden acceleration under no load. 2) Observe exhaust color under load.	No remarkable black smoke is emitted.
Nozzle injection condition	Remove the nozzle and reassemble them so that spray holes face outward. Rotate the starter to carefully observe the spray pattern.	The spray pattern must be good.

## 2.4 Disassembling and inspecting fuel injection pump



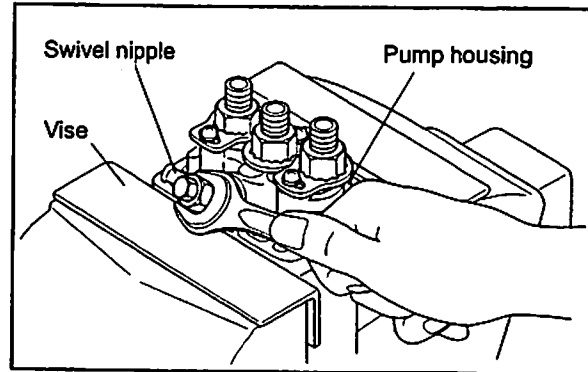
Disassembling and inspecting fuel injection pump

### Disassembling sequence

- |                     |                          |                          |
|---------------------|--------------------------|--------------------------|
| 1 Swivel nipple     | 8 Plunger                | 15 Delivery valve spring |
| 2 Stop wire bracket | 9 Plunger spring         | 16 Delivery valve gasket |
| 3 Control rack      | 10 Spring upper seat     | 17 Delivery valve        |
| 4 Tappet guide pin  | 11 Control sleeve        | 18 Plunger barrel        |
| 5 Tappet            | 12 Lock plates           | 19 Pump housing          |
| 6 Tappet shim plate | 13 Delivery valve holder |                          |
| 7 Spring lower seat | 14 O-rings               |                          |

### 2.4.1 Removing swivel nipple

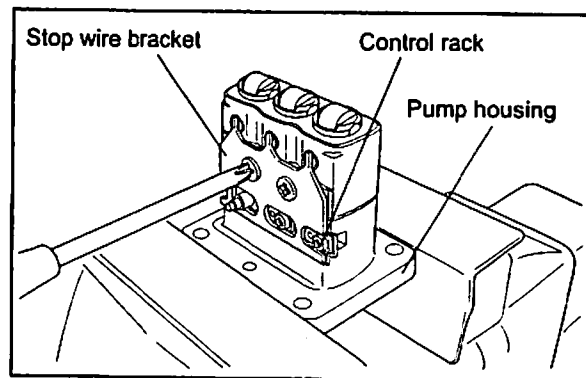
- (1) Grab the plunger of the pump housing with a vise.
- (2) Remove the swivel nipple from the pump housing.



Removing swivel nipple

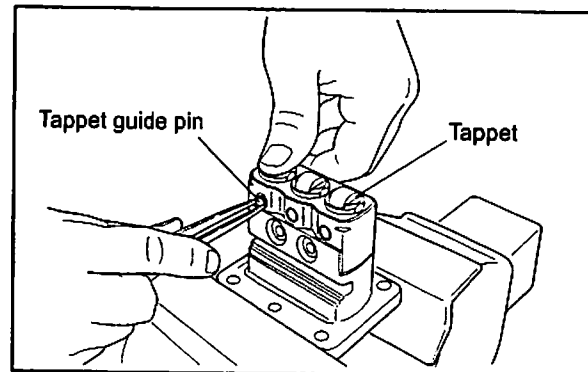
### 2.4.2 Removing tappets

- (1) Turn the pump housing upside down and grab the housing with a vise.
- (2) Remove the stop wire bracket and remove the control rack.



Removing stop wire bracket

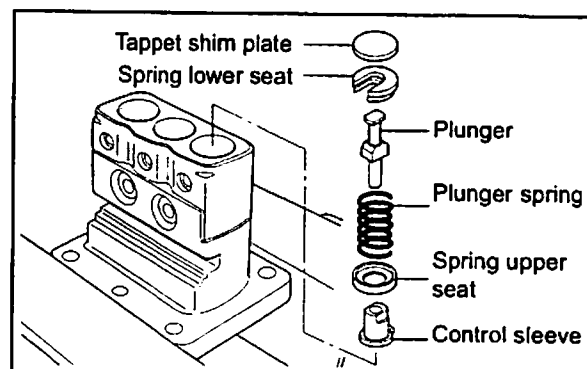
- (3) Push in the tappet and, pull out the tappet guide pin with tweezers.
- (4) Remove the tappet.



Removing tappet guide pin

### 2.4.3 Removing plunger

Using tweezers, remove the tappet shim plate, spring lower seat, plunger, plunger spring, spring upper seat and control sleeve from the pump housing.



Removing plunger

## 2.4.4 Removing delivery valve

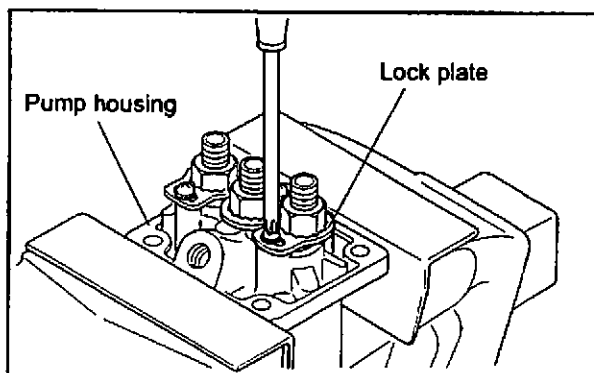
### CAUTION

- (a) The delivery valve, plunger and plunger barrel are precision-machined parts. Do not smear or scratch them.
- (b) Keep the combination of the plunger barrel and plunger for each cylinder when removing. Do not mix the plunger barrel with the plunger of a different cylinder.

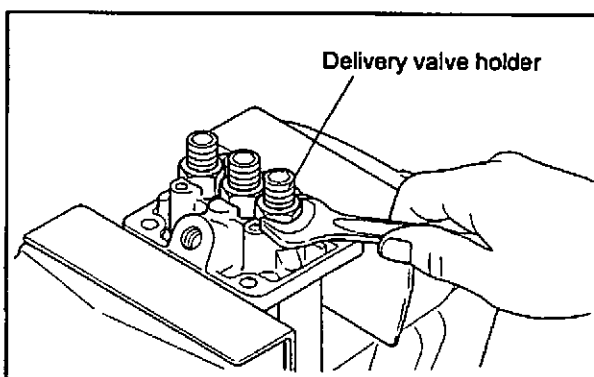
- (1) With pump housing faced up, grab the housing with a vise.
- (2) Remove outside lock plates first and remove center lock plate at the last.
- (3) Remove the delivery valve holder.

- (4) Remove the delivery valve spring.

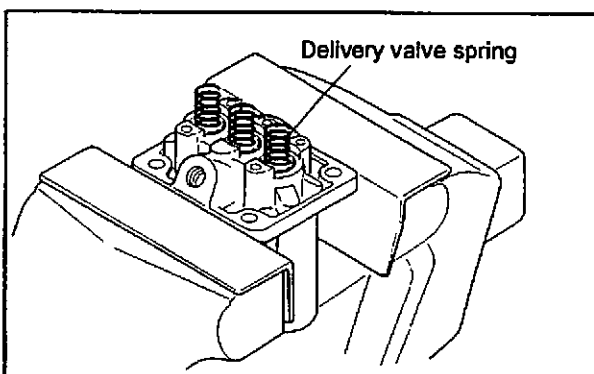
- (5) Using tweezers, remove the delivery valve gasket, delivery valve and plunger barrel from the pump housing.



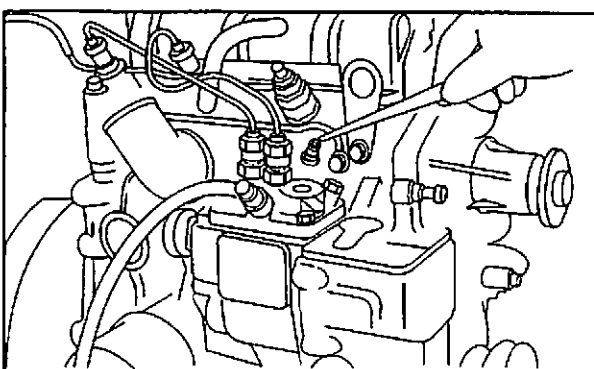
Removing lock plate



Removing delivery valve holder

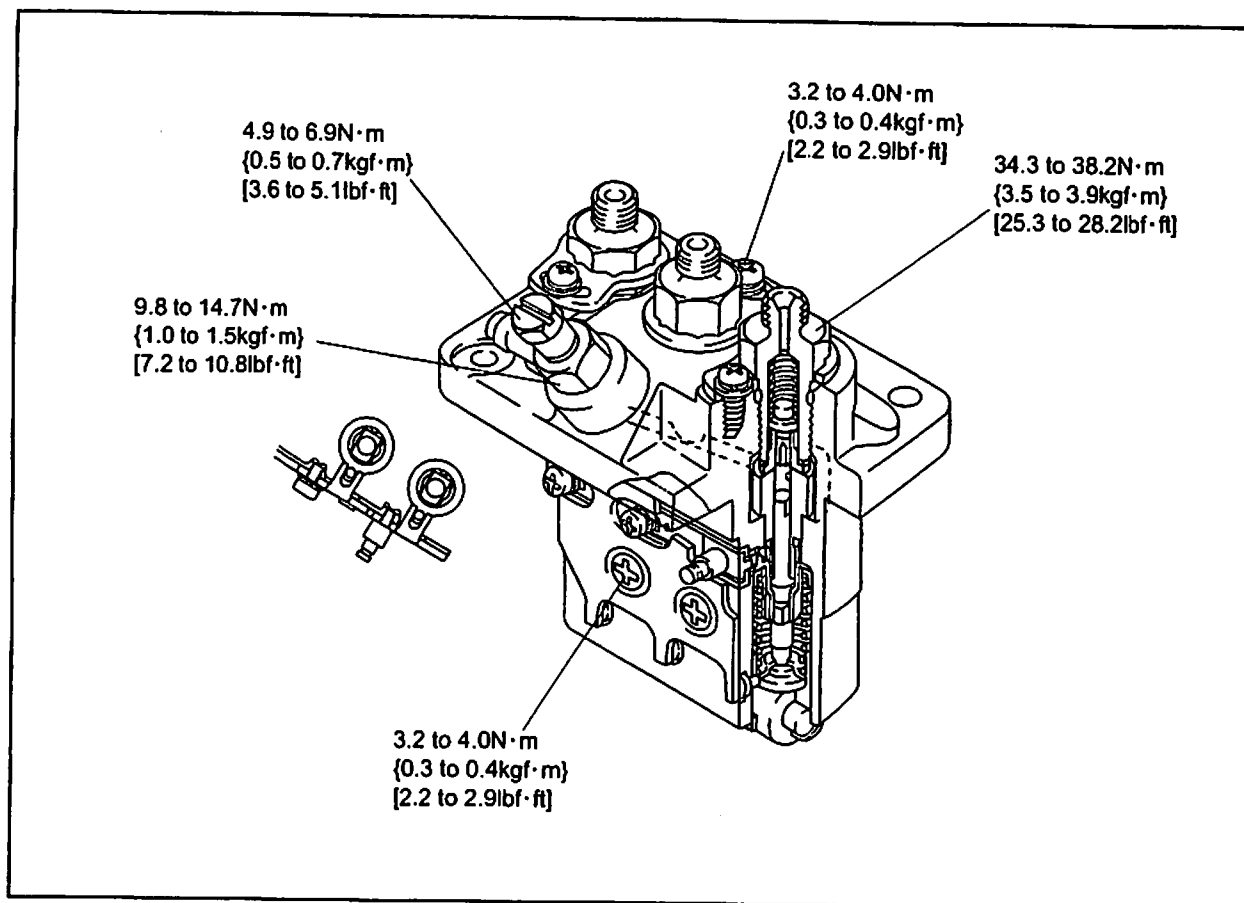


Removing delivery valve spring



Removing delivery valve

## 2.5 Reassembling fuel injection pump

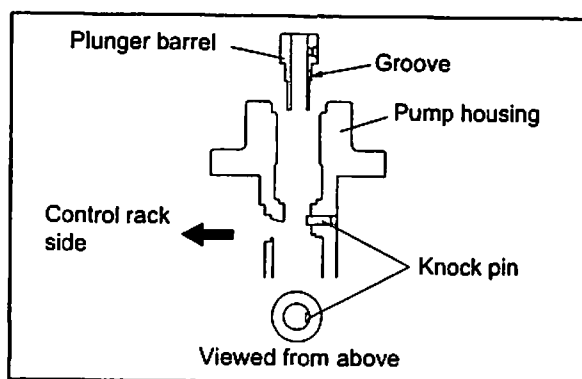


Reassembling fuel injection pump

### 2.5.1 Installing plunger barrel

Align the plunger barrel groove with the knock pin of the pump housing, and insert the plunger barrel into the pump housing..

Note: If the knock pin is not aligned with the plunger barrel groove, the plunger barrel will not be installed correctly. Make sure that O-ring is not protruded from the pump housing when the delivery valve holder is snugly tightened.



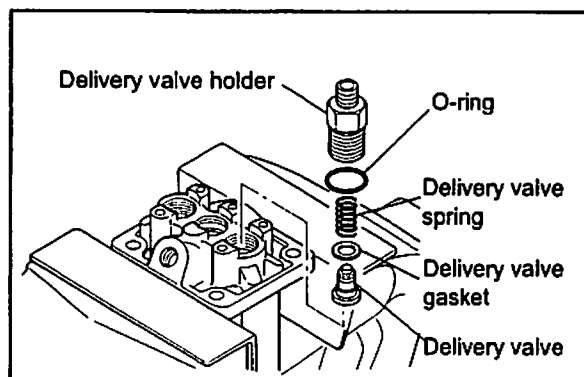
Inserting plunger barrel

## 2.5.2 Assembling delivery valve

### CAUTION

- (a) Do not reuse the O-ring.
- (b) Install a new O-ring so that it is not cut with threads of the valve holder.

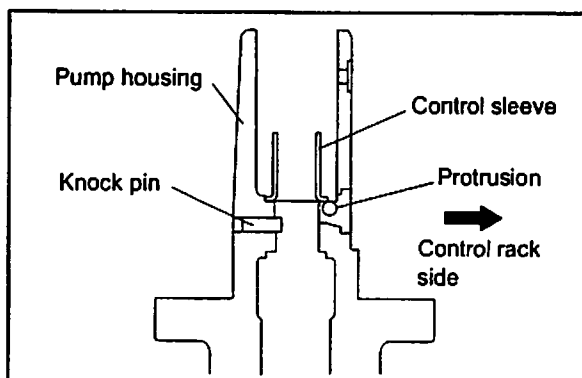
Assemble the delivery valve, delivery valve gasket and delivery valve spring. Then with the O-ring installed, temporarily tighten the delivery valve holder.



Assembling delivery valve

## 2.5.3 Assembling control sleeve

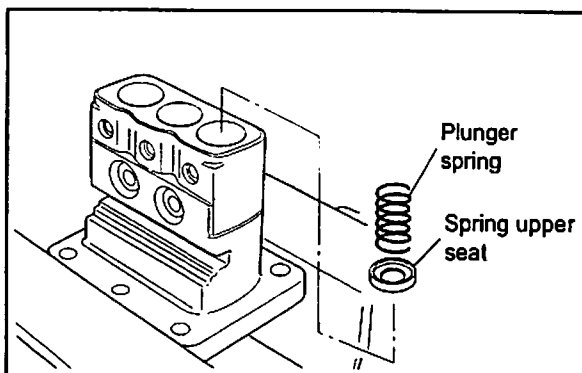
- (1) Reverse the pump housing and grab the housing with a vise.
- (2) Install the sleeve with the protrusion of the control sleeve the control rack side (opposite side to the knock pin). The protrusion can be seen through the housing hole.



Assembling control sleeve

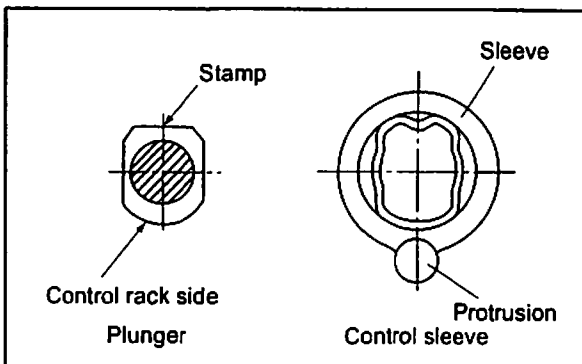
## 2.5.4 Assembling plunger

- (1) Assemble the spring upper seat and plunger spring.



Assembling plunger spring

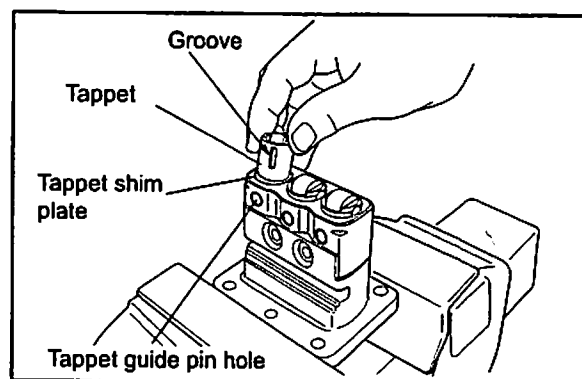
- (2) Place the stamped side of the collar of the plunger to the opposite side to the protrusion of the control sleeve (opposite side to the control rack side). Assemble the spring lower seat to the plunger and insert the plunger into the control sleeve.



Assembling direction of plunger

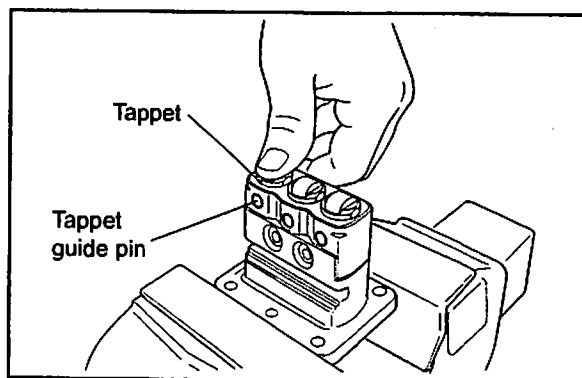
### 2.5.5 Installing tappet

- (1) Install the tappet shim plate.
- (2) Install the tappet so that its groove is positioned to face the tappet guide pin hole.



Installing tappet

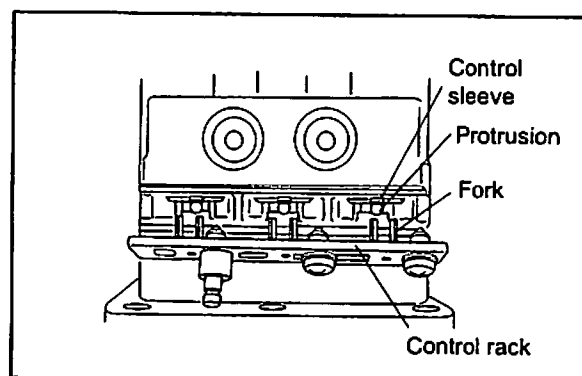
- (3) Push down the tappet, and install the tappet guide pin.



Installing tappet guide pin

### 2.5.6 Installing control rack

- (1) Align the control sleeve position so that the protrusion of the control sleeve fits into the fork of the control rack.
- (2) Install the control rack.



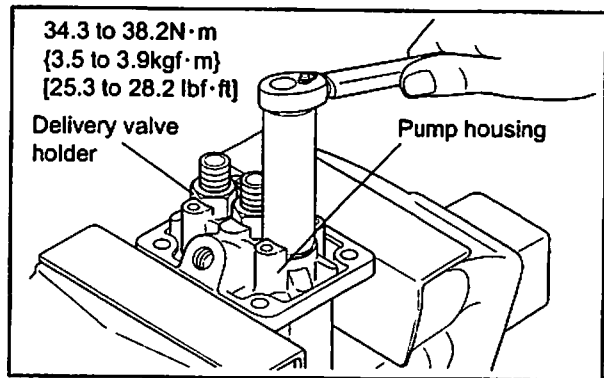
Installing control rack

- (3) Install the stop wire bracket.
- (4) Tighten the countersunk head screws to the specified torque.

Note: When reusing the countersunk head screws, apply adhesive to the threaded portion.

### 2.5.7 Tightening delivery valve holder

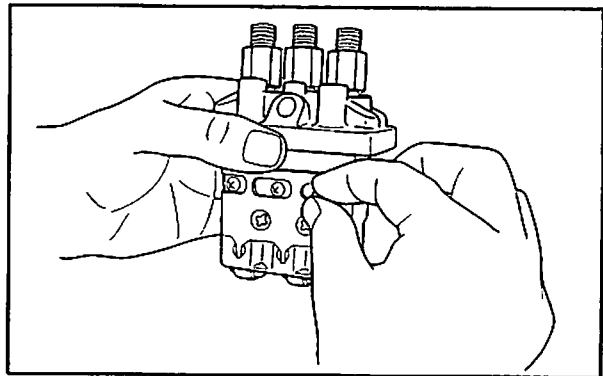
- (1) Place the pump housing upright, and grab the housing with a vise.
- (2) Tighten the delivery valve holder to the specified torque.



Tightening delivery valve holder

### 2.5.8 Checking sliding of control rack

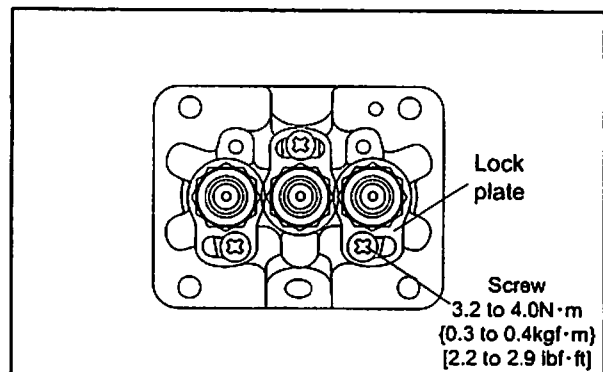
- (1) Remove the pump housing from the vise and check the control rack for smooth movement.  
If the movement is not smooth, the following defects are suspected:
  - Sliding of the element is poor.
  - A foreign substance is present in the teeth of rack or sleeve.
  - The valve holder is overtightened.
- (2) Check the injection timing.



Checking sliding of control rack

### 2.5.9 Installing lock plate

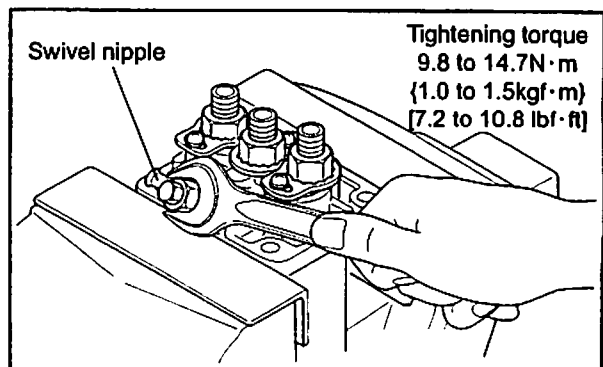
- (1) Grab the pump housing with a vise.
- (2) Install the center lock plate first and then side lock plates later.
- (3) Tighten the screws to the specified torque.



Installing lock plate

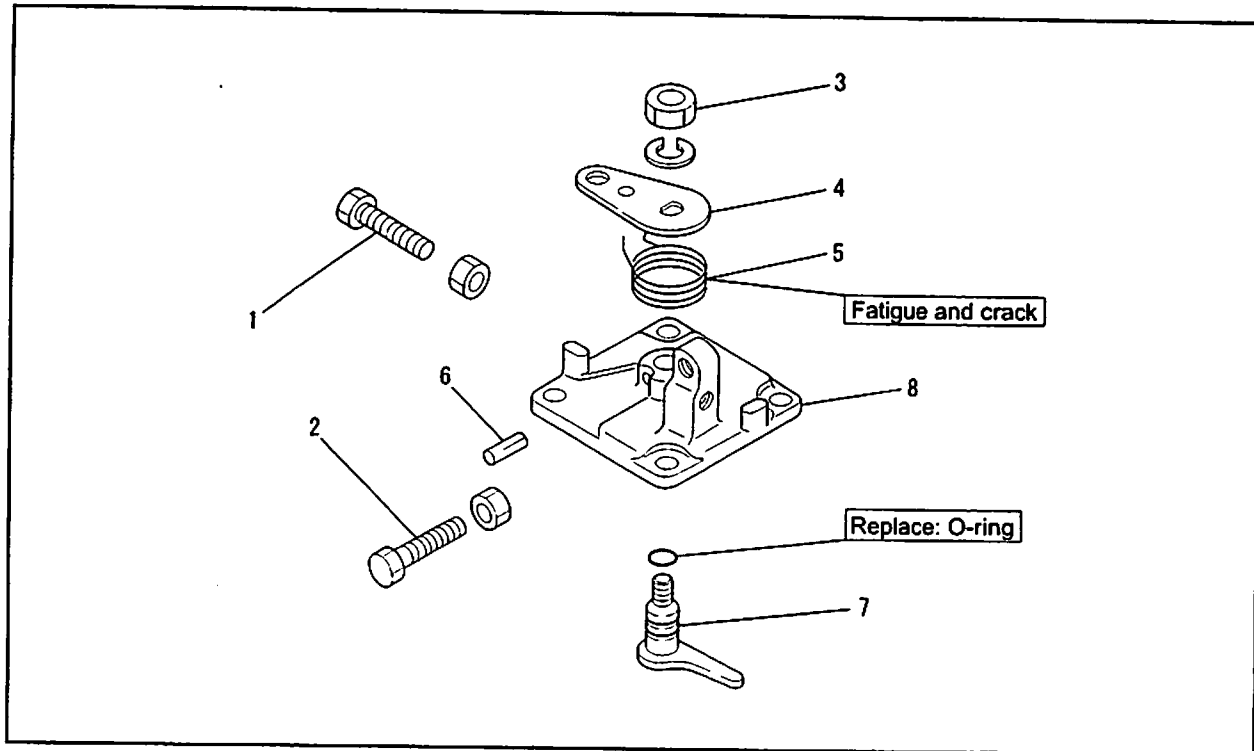
### 2.5.10 Installing swivel nipple

- (1) Install the swivel nipple on the pump housing
- (2) Tighten the hollow screw to the specified torque.



Installing swivel nipple

## 2.6 Disassembling and inspecting governor cover

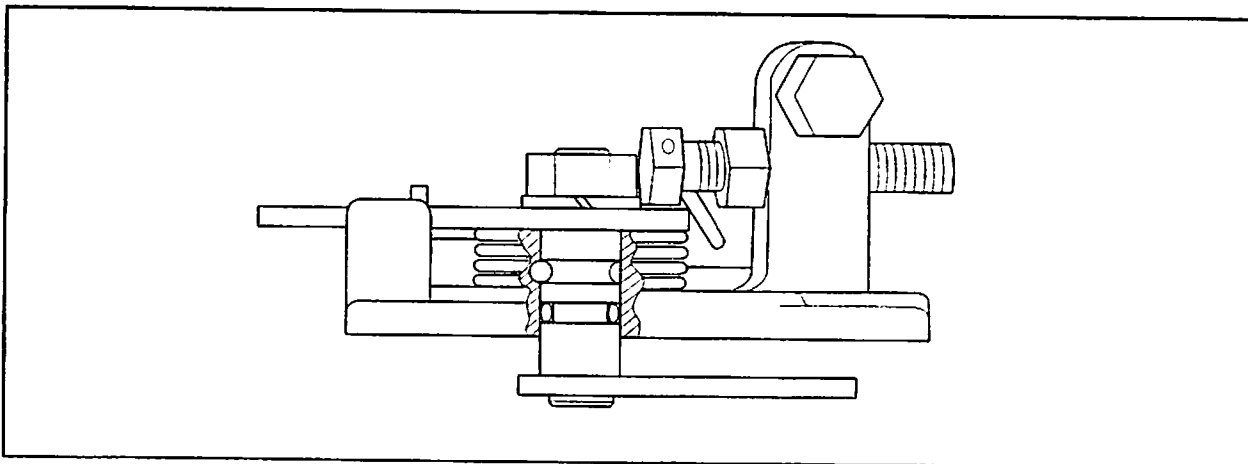


Disassembling and inspecting governor cover

### Disassembling sequence

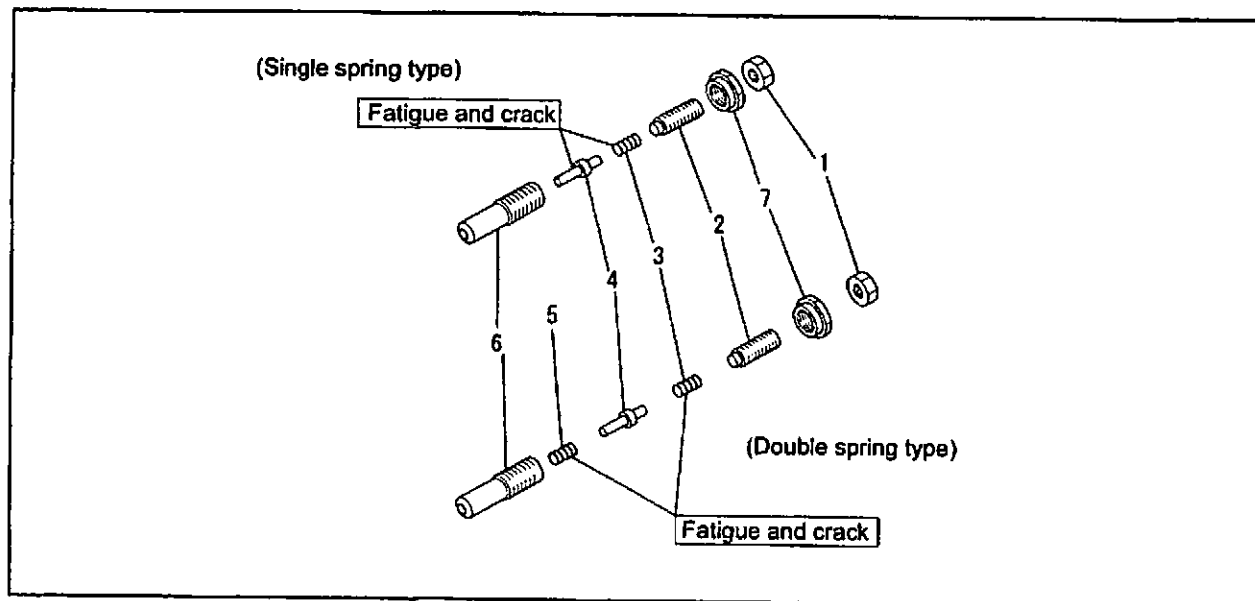
- |            |                 |                  |
|------------|-----------------|------------------|
| 1 Set bolt | 4 Stop lever    | 7 Lever          |
| 2 Set bolt | 5 Return spring | 8 Governor lever |
| 3 Jam nut  | 6 Grooved pin   |                  |

## 2.7 Reassembling governor cover



Reassembling governor cover

## 2.8 Disassembling and inspecting torque spring set

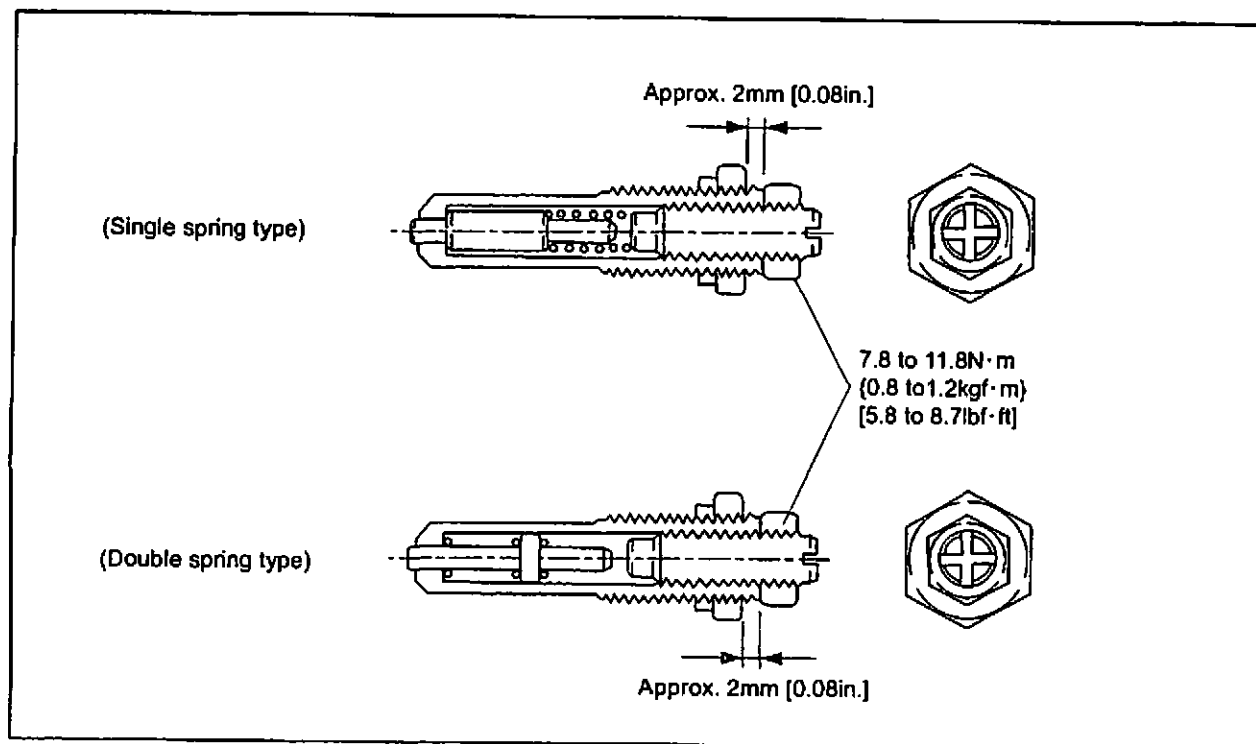


Disassembling and inspecting torque spring set

### Disassembling sequence

- |                   |                                 |
|-------------------|---------------------------------|
| 1 Locknut         | 4 Spring stopper                |
| 2 Adjusting screw | 5 Torque spring (2 spring type) |
| 3 Torque spring   | 6 Torque spring case            |

## 2.9 Reassembling torque spring set



Reassembling torque spring set

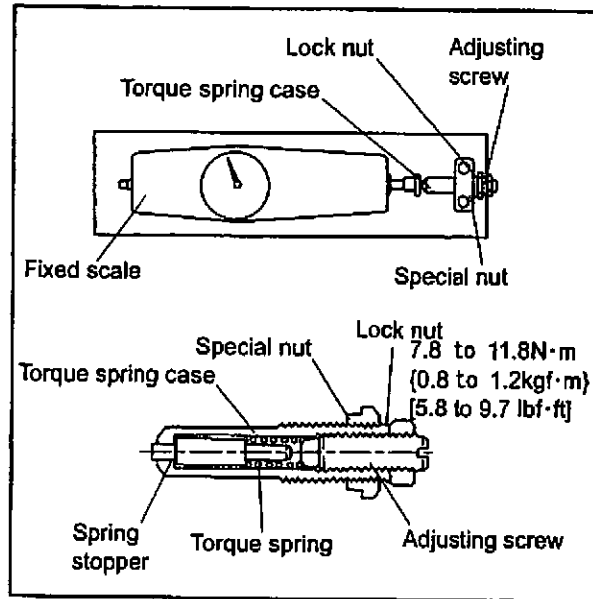
### 2.9.1 Torque spring set, single spring type

Reassemble the torque spring set of the single spring type as described in the following:

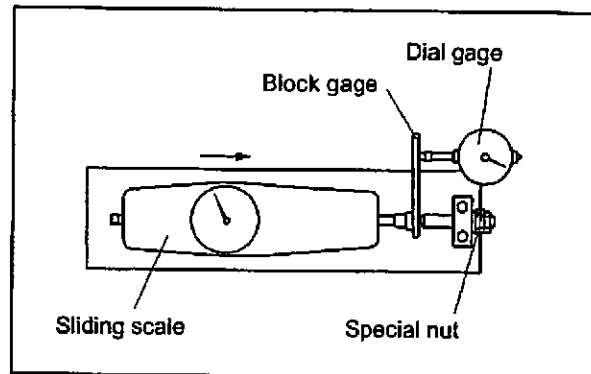
- (1) To lightly tighten adjusting screw, turn the adjusting screw with a screwdriver until you feel resistance. At the position where you feel resistance, secure the adjusting screw lightly using lock nut.
- (2) Set the scale to zero. Turn the torque spring case until the scale reading reaches the load value "A" g in the table below. At this position, secure the adjusting screw using the special nut.
- (3) Temporarily loose the adjusting screw until "A" g load decreases by approx. 200 g [7.05 oz.] and then tighten the adjusting screw again until the load reaches "B" g in the table below. At this position, tighten the lock nut to the specified torque to secure the adjusting screw.
- (4) To check that the torque spring set is adjusted to the appropriate load, place the torque spring set as shown in the illustration. Slowly push the scale to the torque spring set until the spring stopper moves or the pointer of the dial gage swings. Check the load against the torque spring at that moment is equal to "C" g of the table below.

A	B	C	Color
570 <sup>+10</sup> <sub>0</sub> g [20.11 <sup>+0.35</sup> <sub>0</sub> oz.]	570 <sup>+10</sup> <sub>0</sub> g [20.11 <sup>+0.35</sup> <sub>0</sub> oz.]	570 <sup>+20</sup> <sub>-30</sub> g [19.40 <sup>+0.71</sup> <sub>-1.06</sub> oz.]	Green
1520 <sup>+10</sup> <sub>0</sub> g [53.62 <sup>+0.35</sup> <sub>0</sub> oz.]	1520 <sup>+10</sup> <sub>-10</sub> g [53.62 <sup>+0.35</sup> <sub>-0.35</sub> oz.]	1500 <sup>+20</sup> <sub>-30</sub> g [52.91 <sup>+0.71</sup> <sub>-1.06</sub> oz.]	Red
970 <sup>+10</sup> <sub>0</sub> g [34.22 <sup>+0.35</sup> <sub>0</sub> oz.]	970 <sup>+10</sup> <sub>-10</sub> g [34.22 <sup>+0.35</sup> <sub>-0.35</sub> oz.]	950 <sup>+20</sup> <sub>-30</sub> g [33.51 <sup>+0.71</sup> <sub>-1.06</sub> oz.]	Yellow
1270 <sup>+10</sup> <sub>0</sub> g [44.80 <sup>+0.35</sup> <sub>0</sub> oz.]	1270 <sup>+10</sup> <sub>-10</sub> g [44.80 <sup>+0.35</sup> <sub>-0.35</sub> oz.]	1250 <sup>+20</sup> <sub>-30</sub> g [44.09 <sup>+0.71</sup> <sub>-1.06</sub> oz.]	Purple

Note: Load values (A, B and C) vary based on models.



Setting of torque spring of single spring type



Inspecting torque spring of single spring type

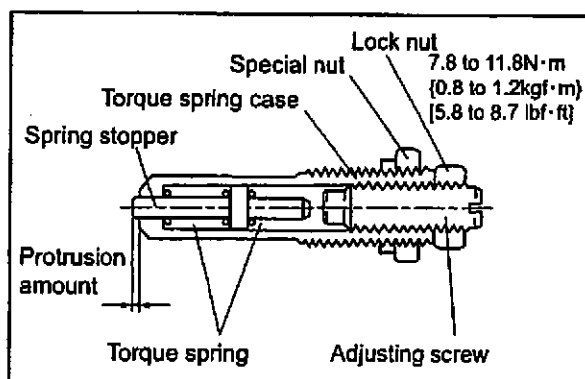
### 2.9.2 Torque spring set, double spring type

Reassemble the torque spring set of the double spring type as described in the following:

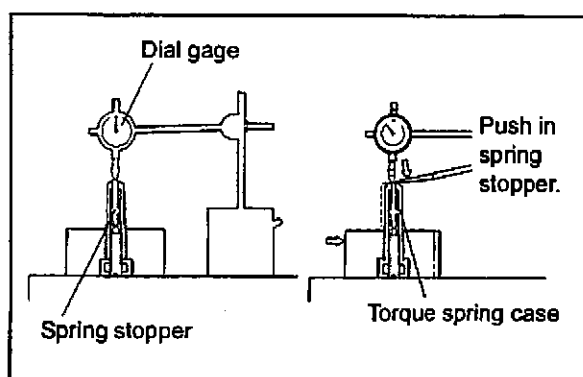
- (1) Screw in the adjusting screw so that the end of the spring stopper protrudes from the torque spring case as the protrusion table below. Then, tighten the locknut to the specified torque to secure the adjusting screw.
- (2) With the spring stopper pushed in as described above (1), make sure the spring stopper moves smoothly and is properly retracted to the end face of the torque spring case.

Protrusion mm [0.008 to 0.012 in.]	Color
0.2 to 0.3 mm [0.008 to 0.012 in.]	None
0 to 0.4 mm [0 to 0.016 in.]	White
0.3 to 0.4 mm [0.012 to 0.016 in.]	Blue
0.4 to 0.5 mm [0.016 to 0.020 in.]	Black
0.6 to 0.7 mm [0.024 to 0.028 in.]	Pink
0.5 to 0.6 mm [0.020 to 0.024 in.]	Orange

- (3) To check the protrusion of the spring stopper is correctly adjusted, place the torque spring set as shown in the illustration. Apply a dial gage to the end of the spring stopper and set the pointer to zero. Then, push in the spring stopper and slightly displace the torque spring set to the side. Read extension of the dial gage to the end of the torque spring case.



Setting of torque spring of double spring type



Measuring protrusion of spring stopper of double spring type

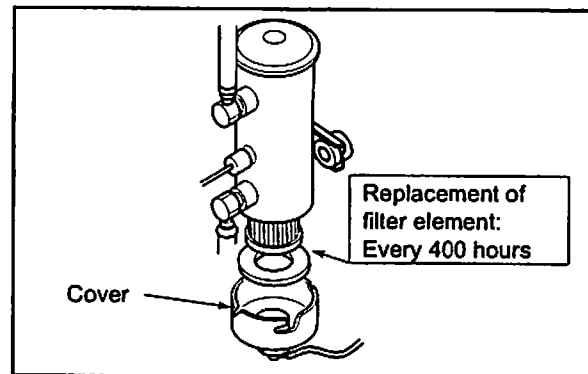
## 2.10 Inspecting fuel pump

The fuel pump is available in 3 types and the type differs based on engine specifications.

### (1) Electromagnetic plunger-type fuel pump

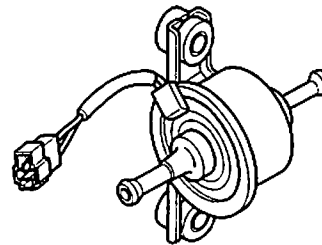
For this pump, a large-sized pump of normal type with a filter element and a small-sized pump of compact type without a filter element are available. In either type, apply the specified voltage, and check for operation and fuel leakage.

For the type with filter element, remove the cover and clean or replace the filter element.



Electromagnetic plunger-type fuel pump (normal type)

Check for damage on external surfaces and fuel leakage.

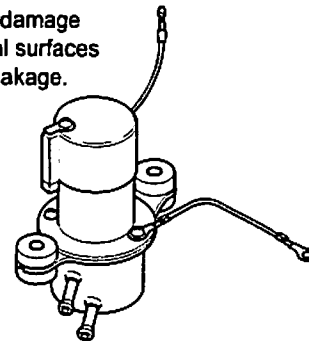


Electromagnetic plunger-type fuel pump type (compact type)

### (2) Electromagnetic diaphragm-type fuel pump

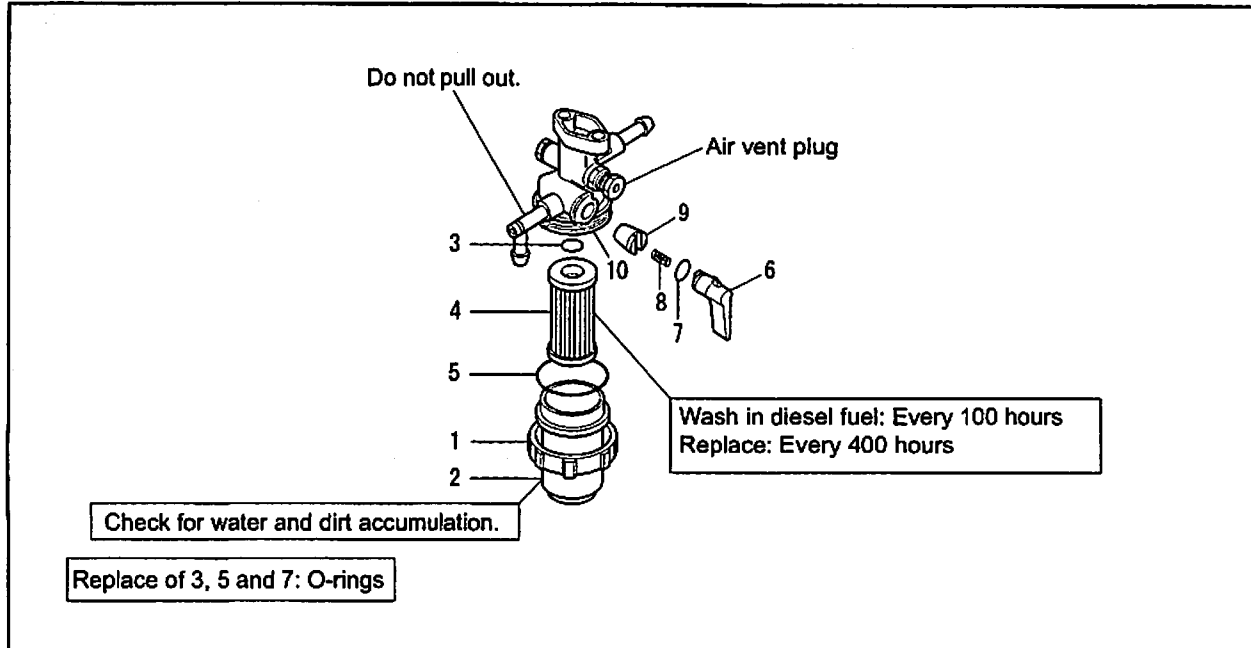
Do not disassemble this pump. Apply the specified voltage, and check for operation and fuel leakage.

Check for damage on external surfaces and fuel leakage.



Electromagnetic diaphragm-type fuel pump

## 2.11 Disassembling, inspecting and reassembling fuel filter (cock switch type)



Disassembling, inspecting and reassembling fuel filter

### Disassembling sequence

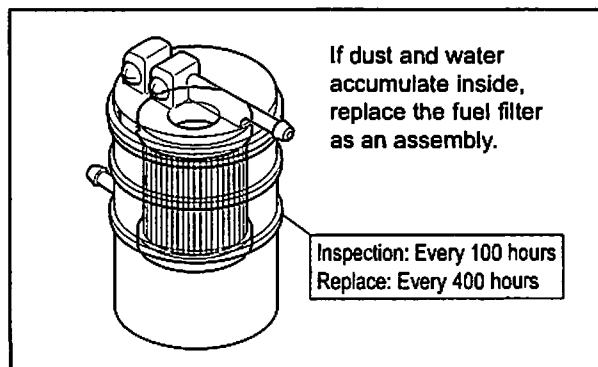
- |            |              |                |
|------------|--------------|----------------|
| 1 Ring nut | 5 O-rings    | 9 Valve        |
| 2 Cup      | 6 Cock lever | 10 Filter body |
| 3 O-rings  | 7 O-rings    |                |
| 4 Element  | 8 Spring     |                |

Note: (a) Disassemble the fuel filter only when removing the element. Do not disassemble the cock lever unless absolutely necessary.

(b) When removing the cock lever and reassembling it after cleaning, apply silicon oil to the O-ring of the lever.

## 2.12 Inspecting fuel filter (cartridge type)

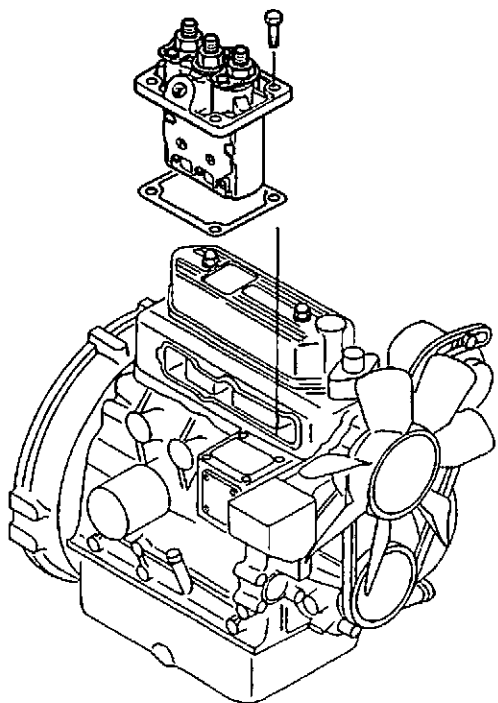
When dust or water is accumulated at the case bottom or in the element, replace the filter as an assembly. Replace the fuel filter every 400 hours. Check the filter every 100 hours. If defective, replace the filter regardless of the replacement interval.



Inspecting fuel filter

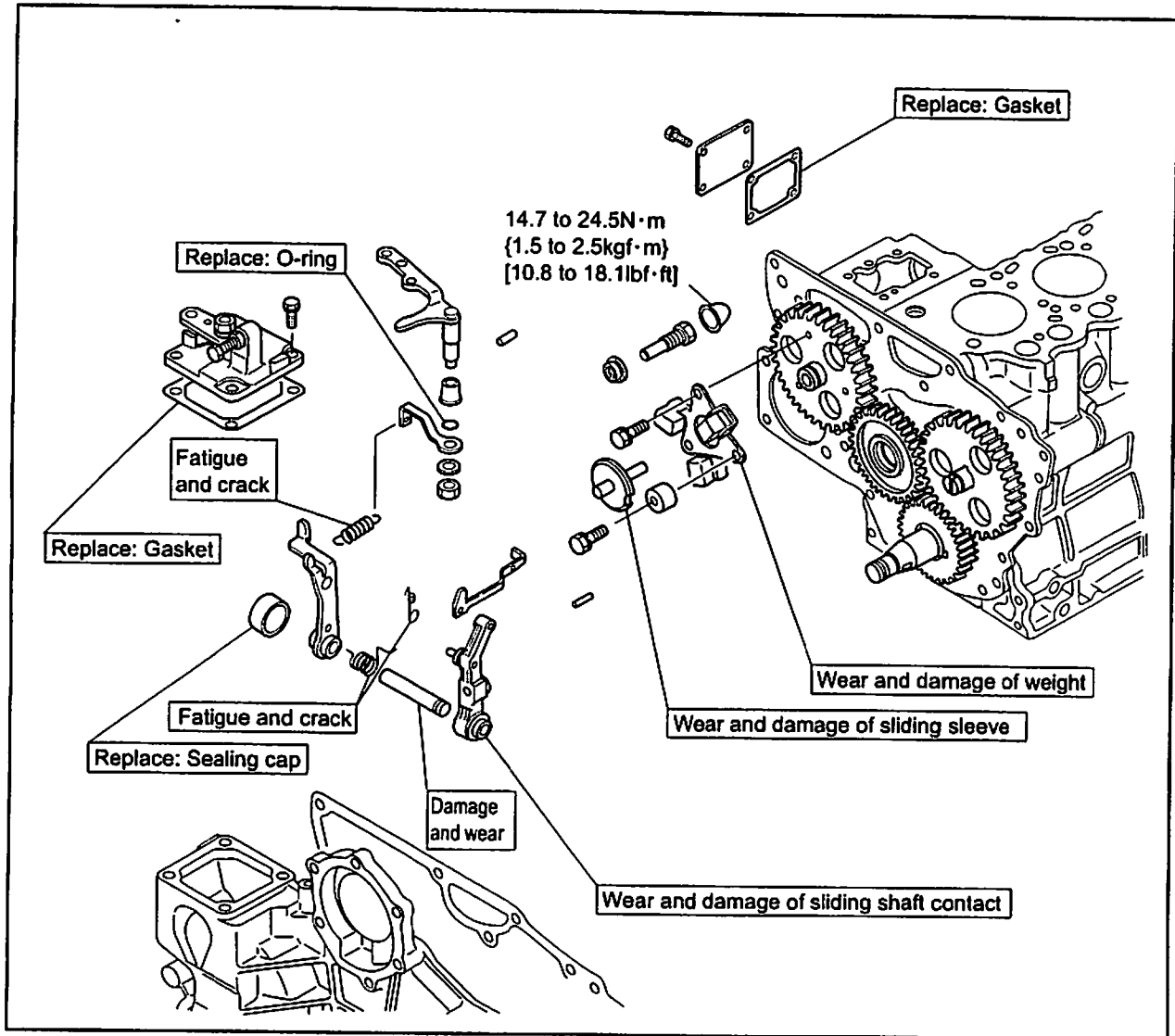
### 3. Installing fuel system

#### 3.1 Fuel injection pump



Installing fuel injection pump

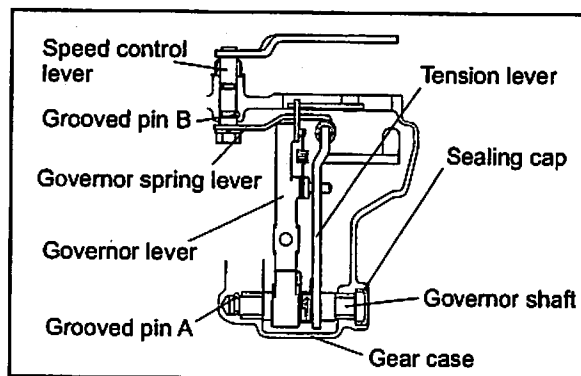
### 3.2 governor



Installing governor

### 3.2.1 Installing speed control lever and governor shaft

- (1) Insert the governor shaft into the gear case while placing the governor lever and the tension lever.
- (2) Drive the grooved pin A into the gear case.
- (3) Drive new sealing cap into the gear case.
- (4) Thoroughly apply Alvania Grease #2 or #3 to the governor shaft cover.
- (5) With governor shaft cover installed on speed control lever, install a new O-ring on the speed control lever and insert it into the gear case.

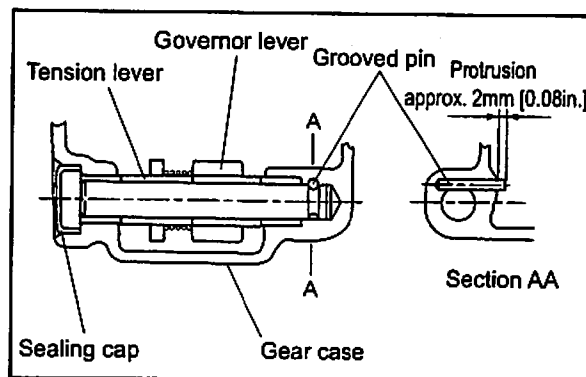


Installing speed control lever and governor shaft

- (6) Drive the grooved pin B into the gear case.

- (7) Install the governor spring lever.

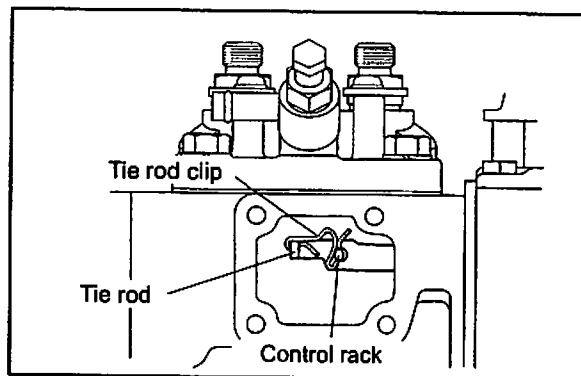
Note: Assemble the speed control lever and the governor spring lever with the minimum assembling angle.



Reassembling speed control lever

### 3.2.2 Connecting tie rod

Connect the tie rod to the control rack of fuel injection pump and fix them with the tie rod clip.



Connecting tie rod

### 3.2.3 Installing torque spring set

#### CAUTION

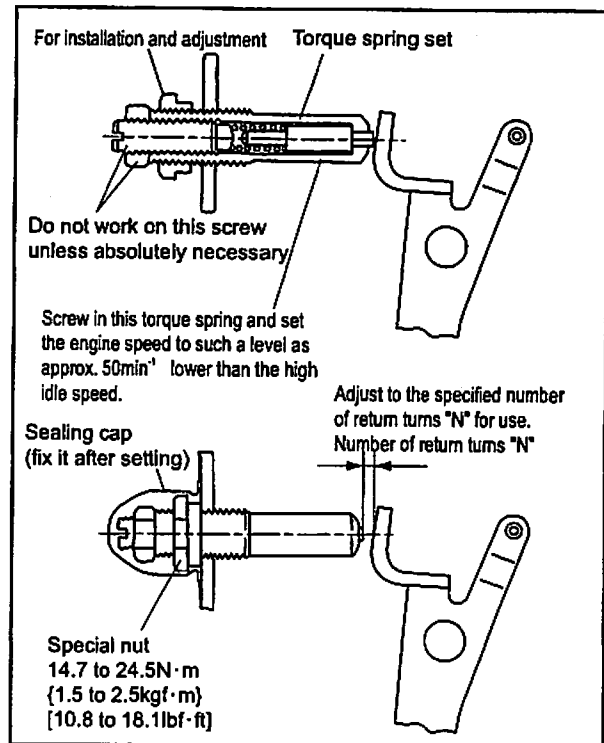
Torque spring set comes in 2 types: single type and double type. These torque spring sets are properly adjusted at the factory before shipment. Do not work on the adjusting screw unless absolutely necessary.

Adjust and reassemble the torque spring set as described in the following.

- (1) Adjust the speed control lever with the high speed set bolt and set it to the high idle speed.
- (2) Screw in the torque spring set and check the position at which the engine speed drops approx. 50 min<sup>-1</sup> lower than the high idle speed.
- (3) In this condition loosen the torque spring set by the specified number of turns (N) and fix it with the special nut.

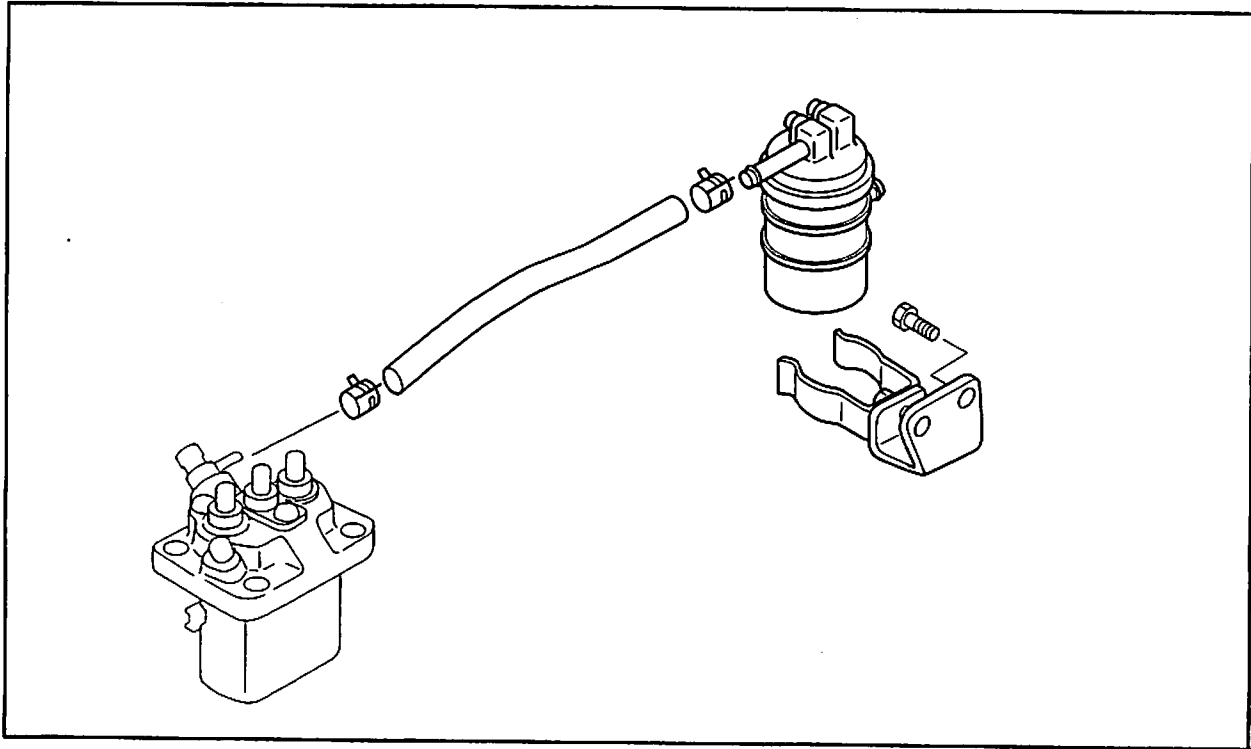
Note: The number of return turns (N) differs depending on specifications. Consult your dealer.

- (4) Put a torque spring sealing cap on the torque spring and firmly tighten the sealing cap to prevent it from becoming loose.



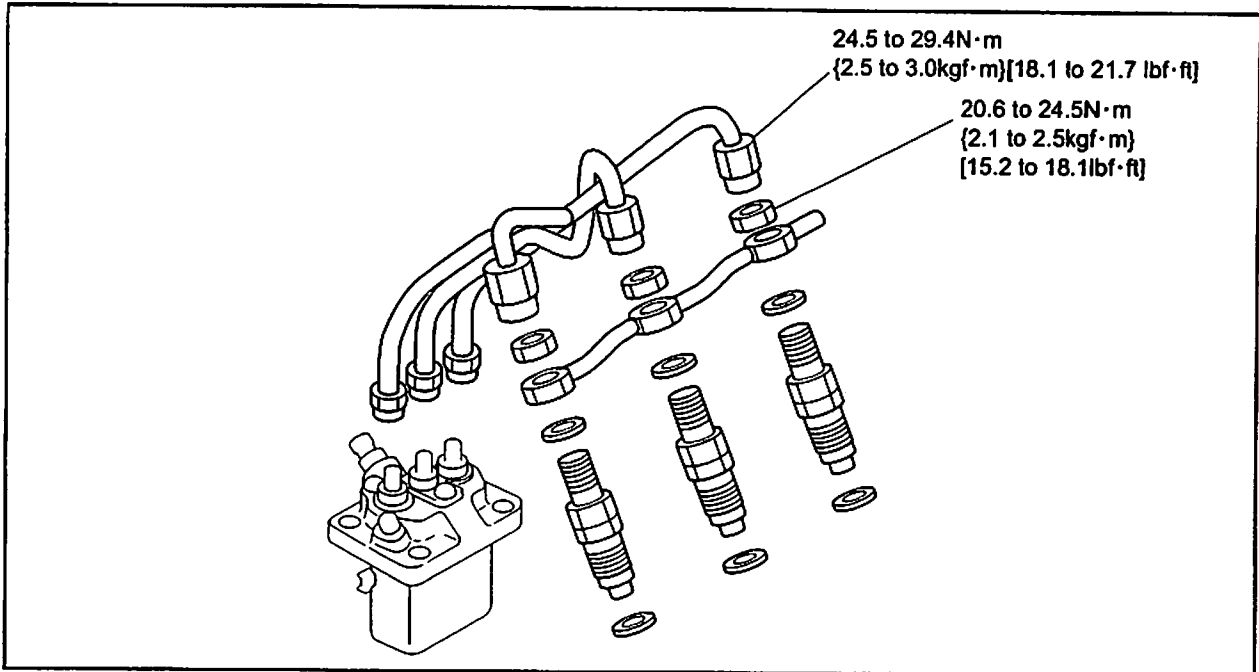
Installing torque spring set

### 3.3 fuel filter



Installing fuel filter

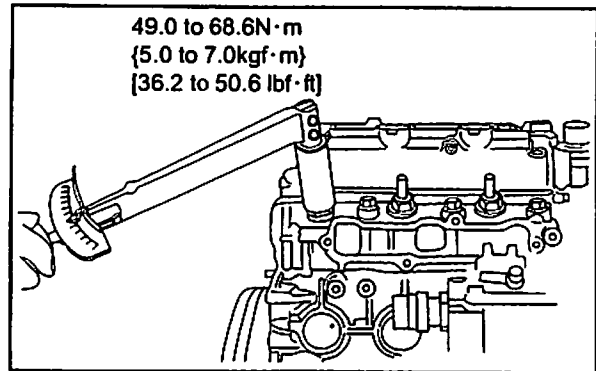
### 3.4 Installing fuel pipe and fuel injection nozzles



Installing fuel pipe and fuel injection nozzles

#### 3.4.1 Installing fuel injection nozzle

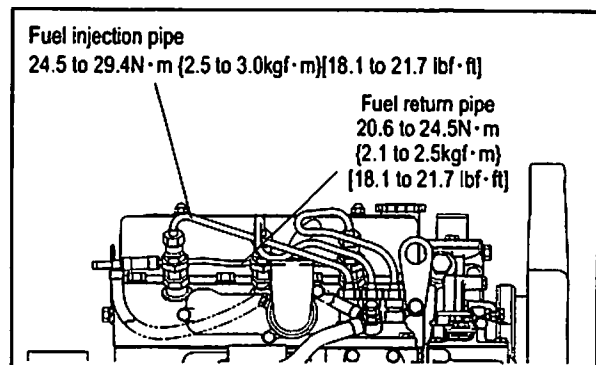
- (1) Clean the nozzle holder hole of cylinder head.
- (2) Install the gasket to the nozzle tip and tighten the fuel injection pump.



Installing fuel injection nozzles

#### 3.4.2 Installing fuel return pipe and fuel injection pipe

Install the fuel return pipe and fuel injection pipe.



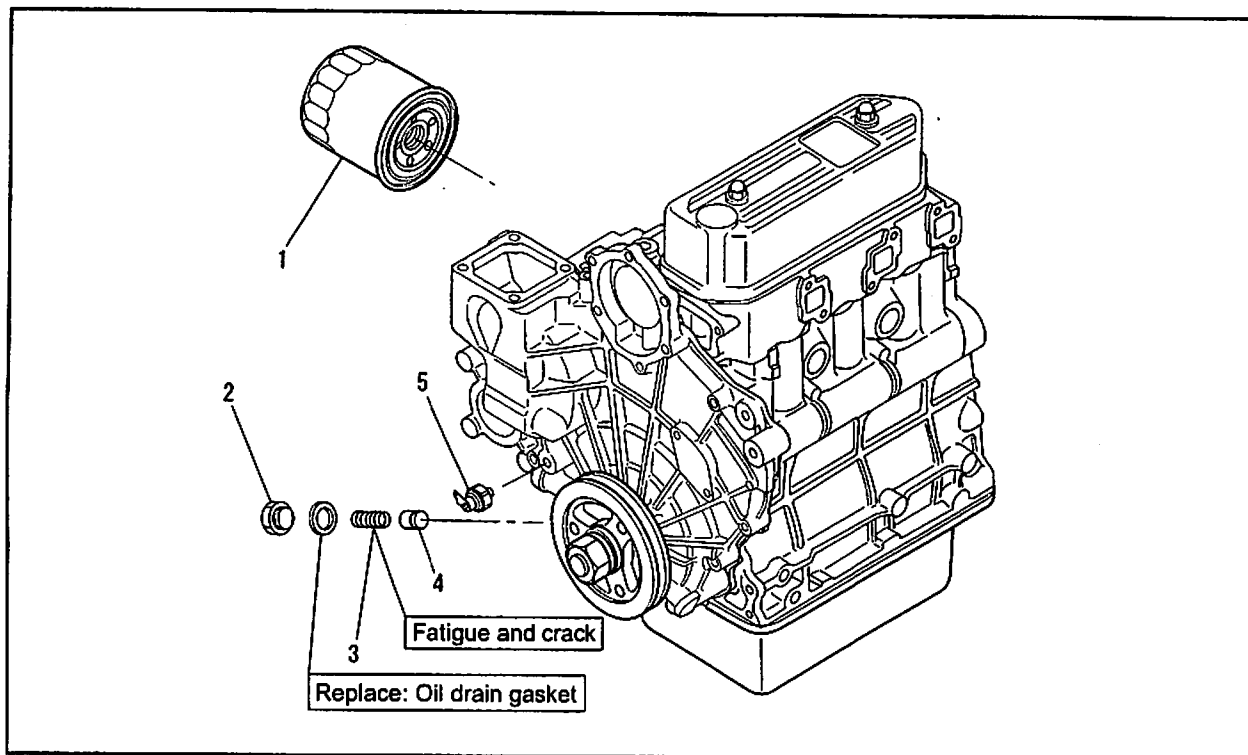
Installing fuel return pipe and fuel injection pipe

# LUBRICATION SYSTEM

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## 1. Removing lubrication system

### 1.1 Removing oil filter, relief valve and oil pressure switch



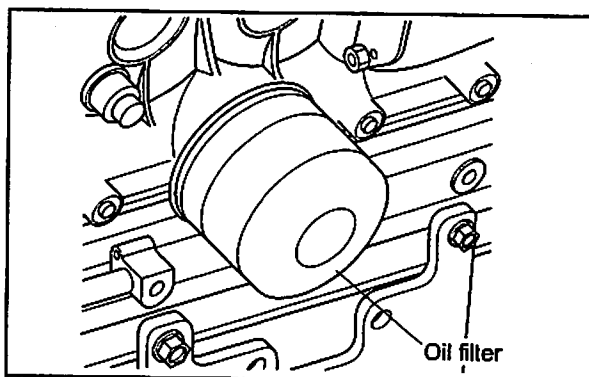
Removing oil filter, relief valve and oil pressure switch

#### Removal sequence

- |              |                  |                       |
|--------------|------------------|-----------------------|
| 1 Oil filter | 3 Relief spring  | 5 Oil pressure switch |
| 2 Plug       | 4 Relief plunger |                       |

### 1.1.1 Removing oil filter

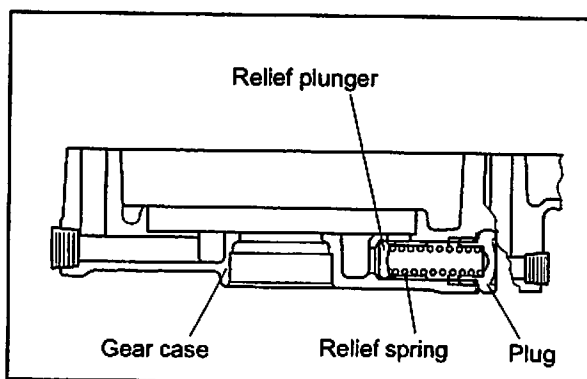
- (1) Place a drip pan under the oil filter.
- (2) Remove the oil filter using a filter wrench.



Removing oil filter

### 1.1.2 Removing relief valve

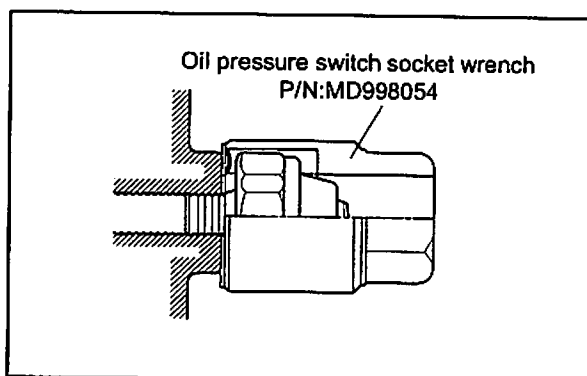
Remove the plug from the gear case and take out the relief spring and relief plunger.



Removing relief valve

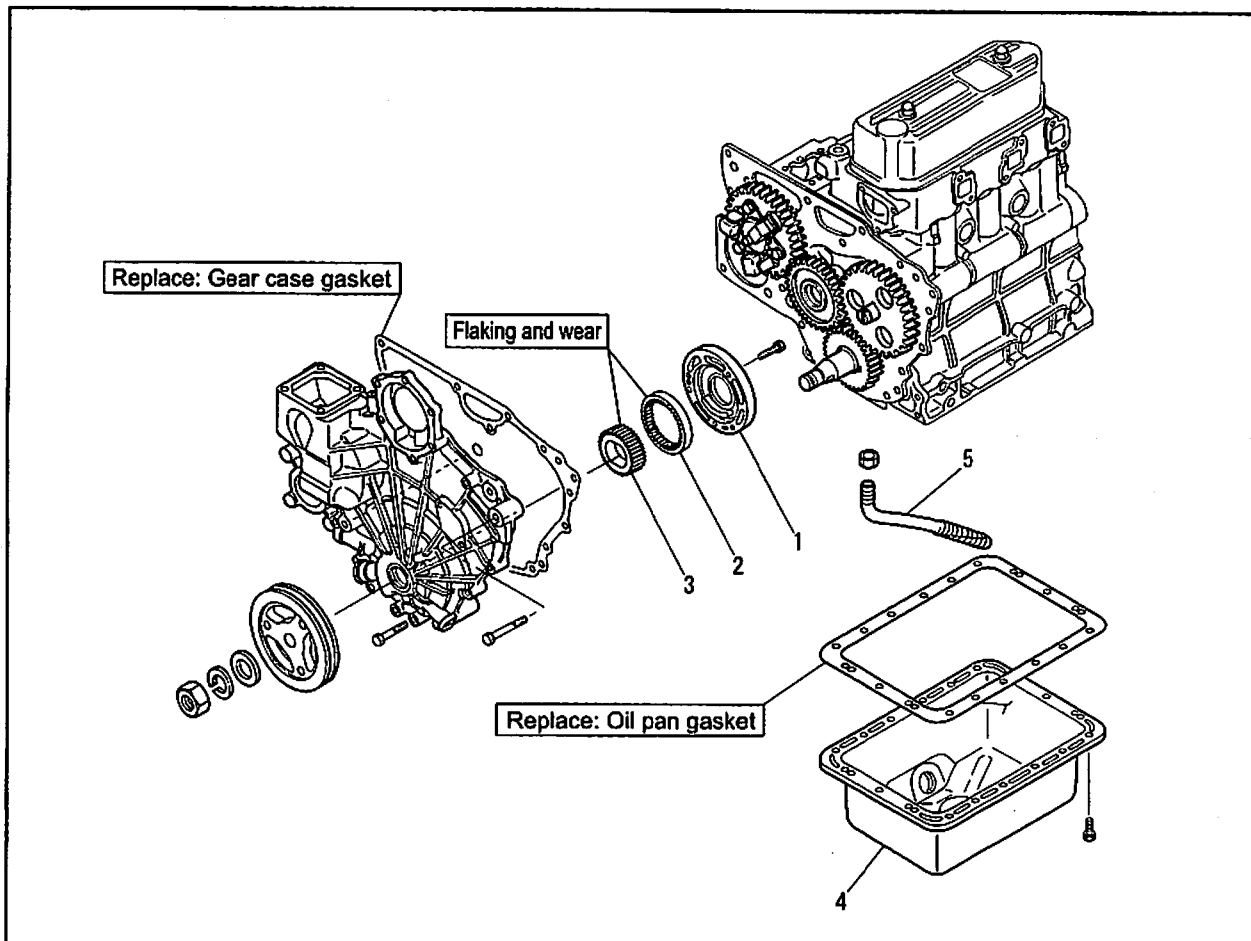
### 1.1.3 Removing oil pressure switch

Using oil pressure switch socket wrench, remove oil pressure switch.



Removing oil pressure switch

## 1.2 Removing oil pump, oil pan and oil screen



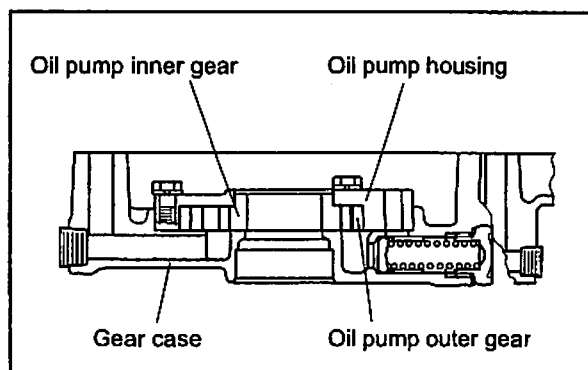
Removing oil pump, oil pan and oil screen

### Removal sequence

- |                       |                       |              |
|-----------------------|-----------------------|--------------|
| 1 Oil pump housing    | 3 Oil pump inner gear | 5 Oil screen |
| 2 Oil pump outer gear | 4 Oil pan             |              |

### 1.2.1 Removing oil pump

- (1) Remove the oil pump housing from the gear case.
- (2) Remove the oil pump outer gear and oil pump inner gear from the oil pump housing.



Removing oil pump

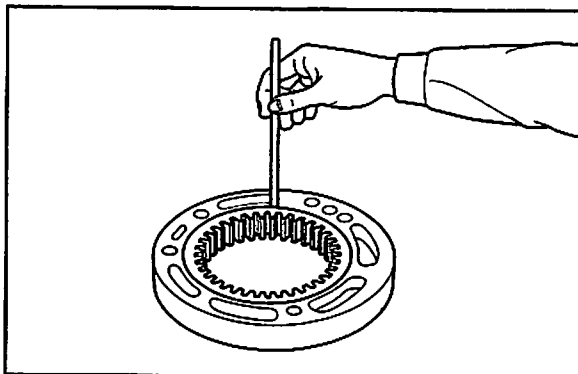
## 2. Disassembling, inspecting and reassembling lubrication system

### 2.1 Inspecting oil pump

#### 2.1.1 Measuring clearance between oil pump housing inside diameter and oil pump outer gear outside diameter

Measure the clearance using thickness gauges. Replace the gear or housing if the limit is exceeded.

Measurement item	Standard	Limit
Clearance between oil pump housing inside diameter and oil pump outer gear outside diameter	0.100 to 0.196mm [0.0039 to 0.00772 in.]	0.3mm [0.0118 in.]

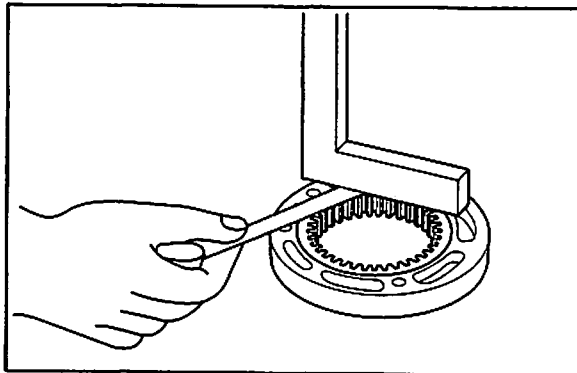


Measuring clearance between oil pump housing inside diameter and oil pump outer gear outside diameter

#### 2.1.2 Measuring the difference between oil pump outer gear width and oil pump housing width

Measure the clearance using thickness gauges. Replace the gear or housing if the limit is exceeded.

Measurement item	Standard	Limit
Difference between oil pump outer gear width and oil pump housing width	0.040 to 0.100mm [0.0016 to 0.0039 in.]	0.25mm [0.0099 in.]



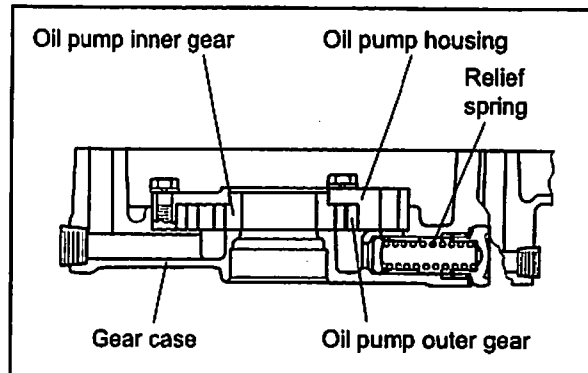
Measuring the difference between oil pump outer gear width and oil pump housing

## 2.2 Inspecting relief valve

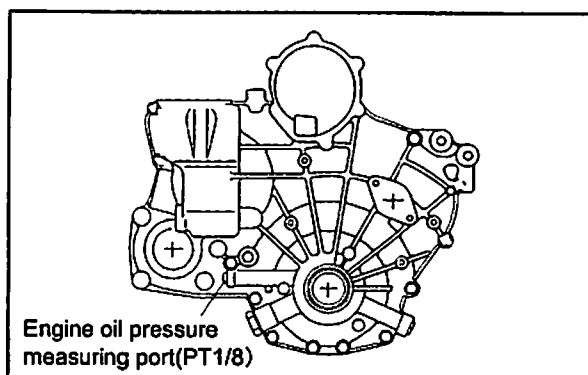
- (1) Check the relief valve and its seat for contact. Check the spring for fatigue and damage. If faulty, replace them.
- (2) Measure the relief valve opening pressure. If the pressure is not within the standard range, replace the spring.

Measurement item	Standard
Relief valve opening pressure	$0.29 \pm 0.029 \text{ MPa}$ $\{3.0 \pm 0.3 \text{ kgf/cm}^2\}$ $[42.68 \pm 4.27]$

Note: Measure the engine oil pressure at the engine front side (gear case).



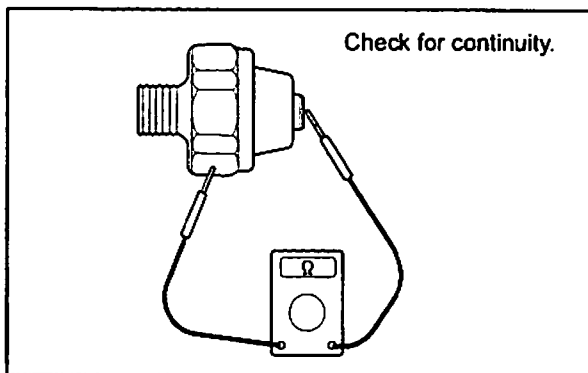
Inspecting relief valve



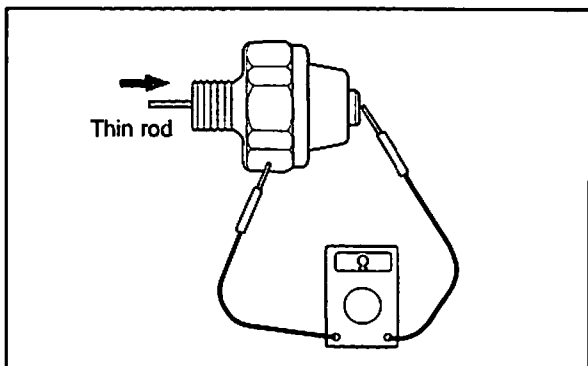
Engine oil pressure measuring port

## 2.3 Inspecting oil pressure switch

- (1) Connect a tester (ohm range) between the terminal and body to check for continuity. The switch is normal if there is continuity between them. If there is no continuity, replace the switch.
- (2) Insert a thin rod from the oil hole and lightly push it. The switch is normal if there is no continuity between them. Push the bar. If there is continuity, replace the switch.
- (3) When air pressure of  $0.05 \text{ MPa}$   $\{0.5 \text{ kgf/cm}^2\}$   $[7.1 \text{ psi}]$  is applied from the oil hole, the switch is normal if there is no continuity. Check air leaks at the same time. If there are air leaks, the diaphragm is damaged. Replace the switch.



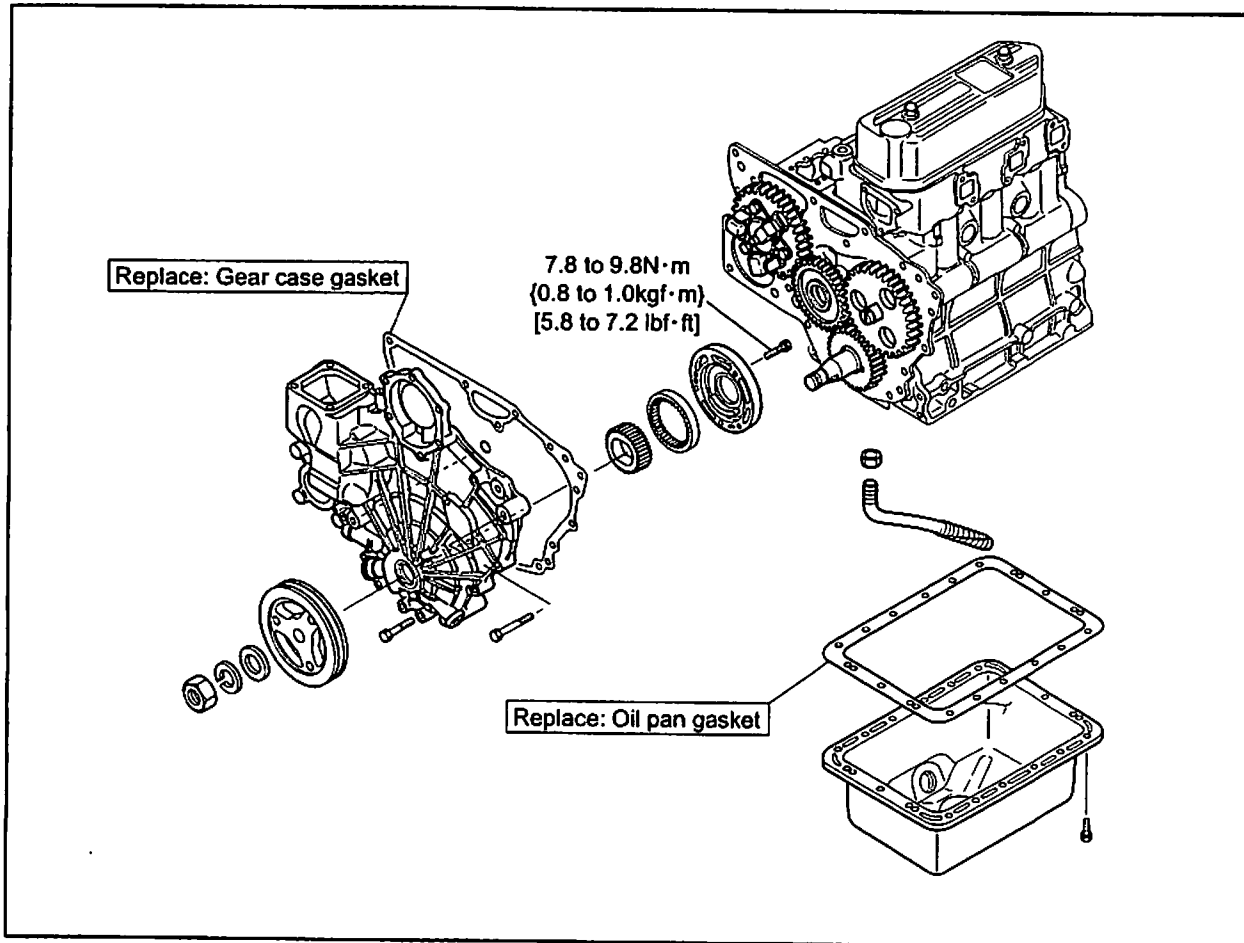
Inspecting oil pressure switch (1)



Inspecting oil pressure switch (2)

### 3. Installing lubrication system

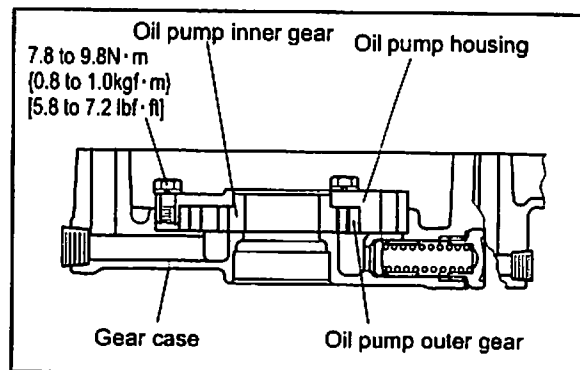
#### 3.1 Installing oil pump, oil pan and oil screen



Installing oil pump, oil pan and oil screen

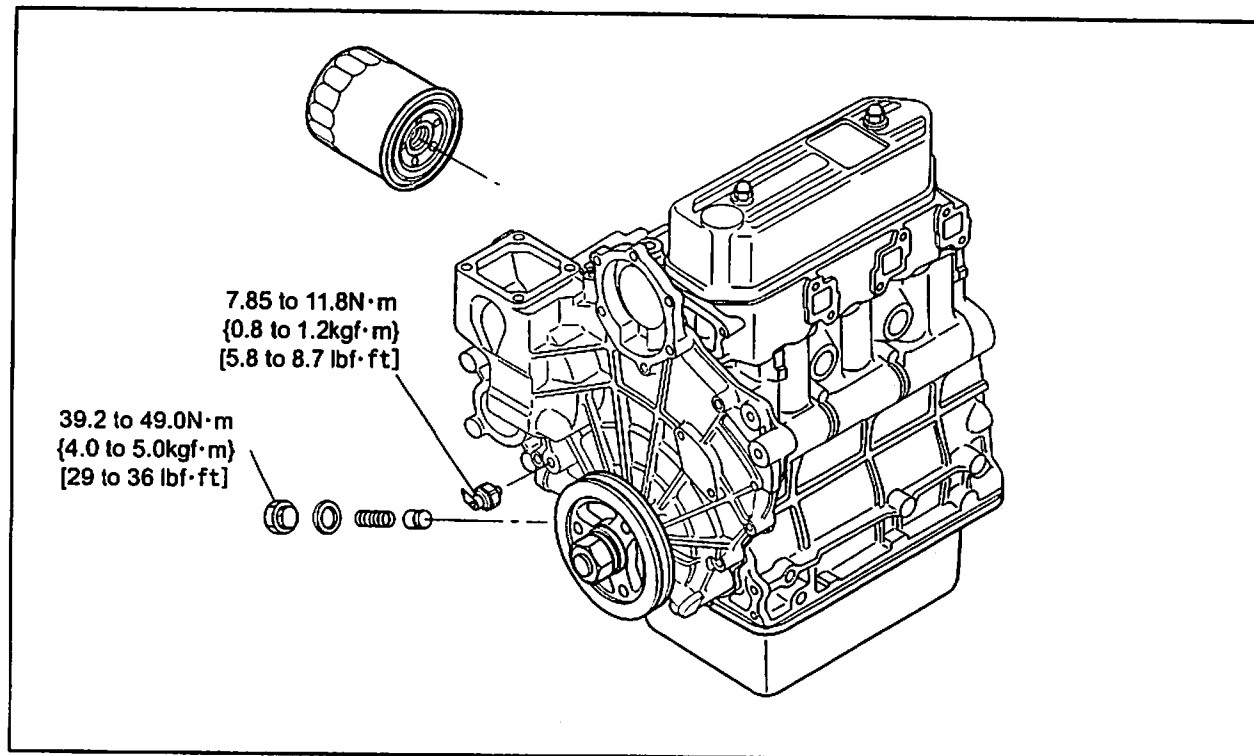
##### 3.1.1 Installing oil pump

Install the oil pump inner gear, oil pump outer gear and oil pump housing, and tighten the bolts to the specified torque.



Installing oil pump

## 3.2 Installing oil filter, relief valve and oil pressure



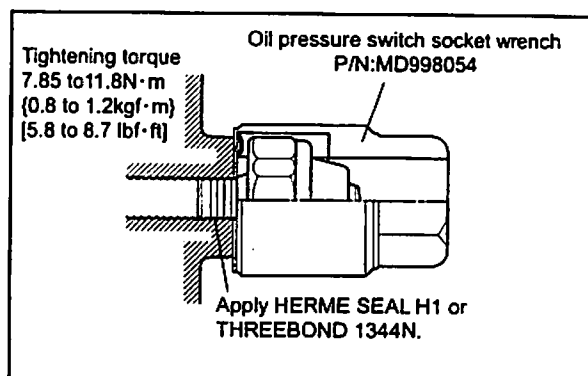
Installing oil filter, relief valve and oil pressure

### 3.2.1 Installing oil pressure switch

#### CAUTION

Do not allow sealant to squeeze out at the thread end.  
Do not overtighten.

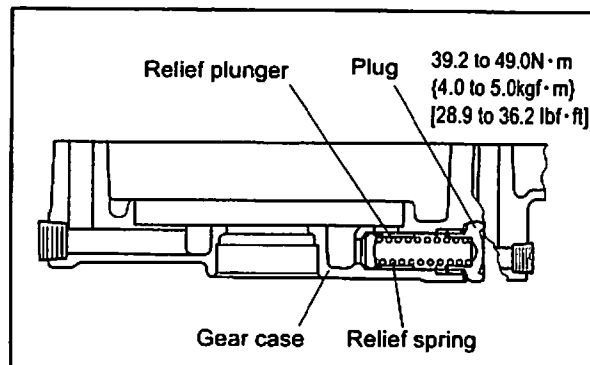
- (1) Using an oil pressure switch socket wrench, tighten the oil pressure switch to the specified torque.
- (2) Apply a sealant to the threaded portion when installing the switch.



Installing oil pressure switch

### 3.2.2 Installing relief valve

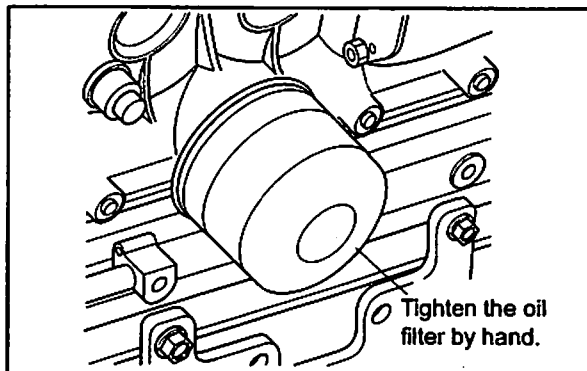
Insert the relief plunger and relief spring into the gear case and tighten the plug to the specified torque.



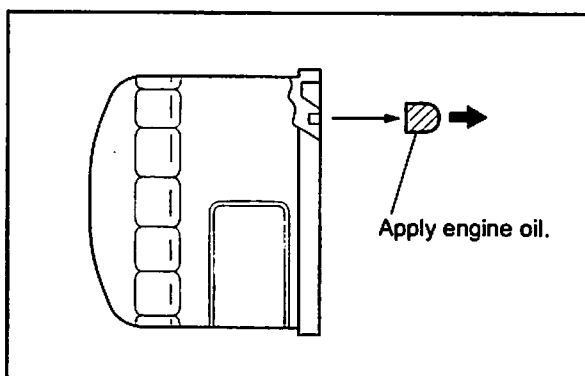
Installing relief valve

### 3.2.3 Installing oil filter

- (1) Apply a light coating of engine oil to the gasket of the filter.
- (2) Screw in the filter by hand. When the gasket contacts the mounting surface, tighten it one more turn.



Installing oil filter (1)



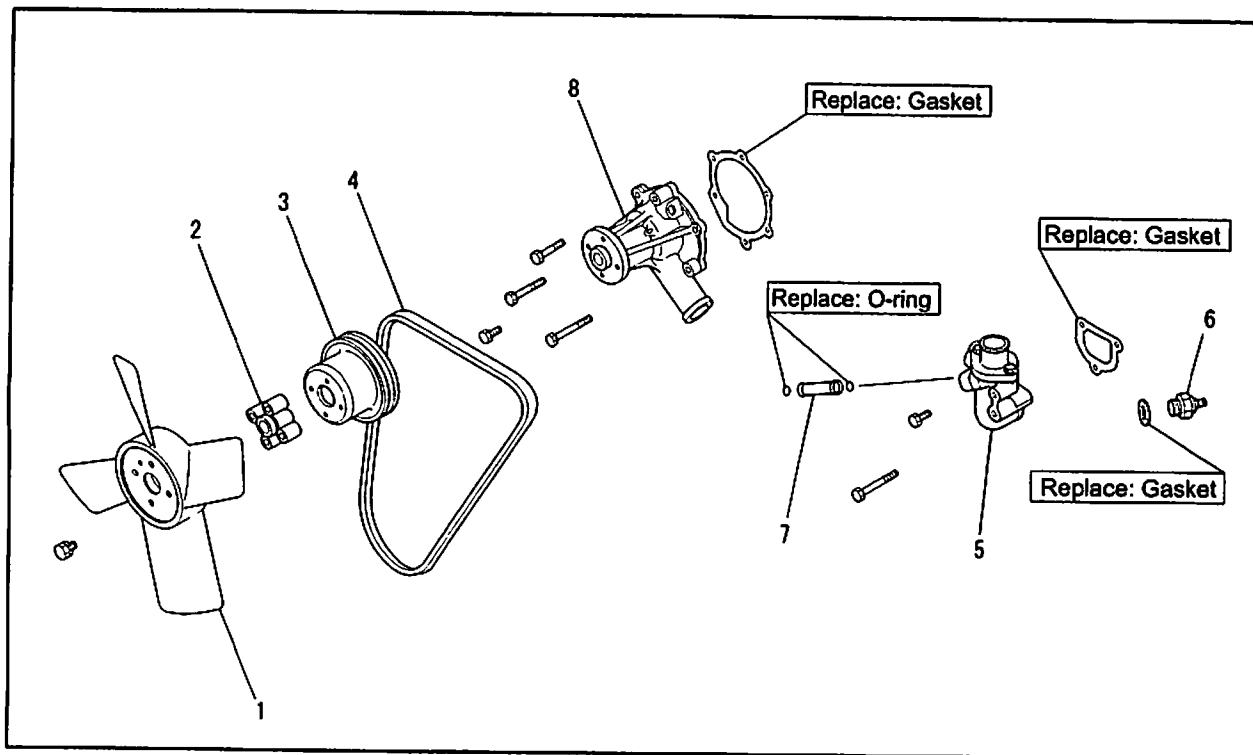
Installing oil filter (2)

# COOLING SYSTEM

- 1. Removing cooling system ..... 10-2
  - 1.1 Removing cooling fan, fan pulley, V-belt, thermostat, thermoswitch and water pump 10-2
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  - 3.1 Installing cooling fan, fan pulley, V-belt, thermostat, thermoswitch and water pump..... 10-5
  - 3.2 Adjusting V-belt tension ..... 10-5

## 1. Removing cooling system

### 1.1 Removing cooling fan, fan pulley, V-belt, thermostat, thermoswitch and water pump



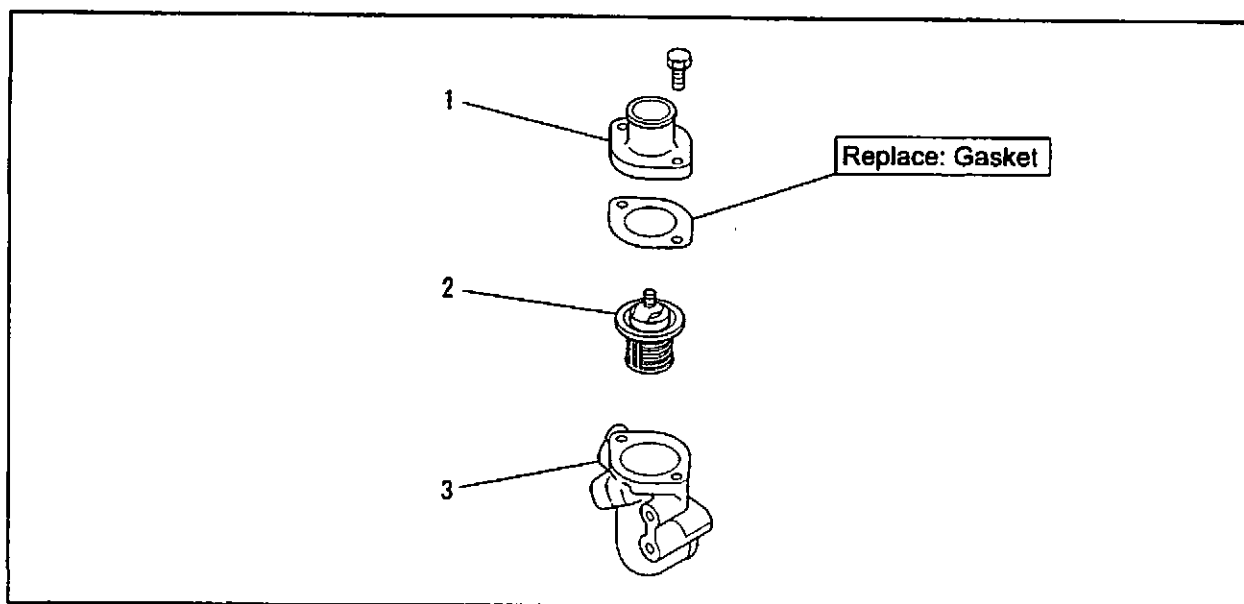
Removing cooling fan, fan pulley, V-belt, thermostat, thermoswitch and water pump

#### Removal sequence

- |              |                   |              |
|--------------|-------------------|--------------|
| 1 Fan        | 4 V-belt          | 7 Pipe       |
| 2 Fan spacer | 5 Thermostat case | 8 Water pump |
| 3 Fan pulley | 6 Thermoswitch    |              |

## 2. Disassembling, inspecting and reassembling cooling system

### 2.1 Disassembling and inspecting thermostat



Disassembling and inspecting thermostat

Disassembly sequence

1 Thermostat cover

2 Thermostat

3 Thermostat case

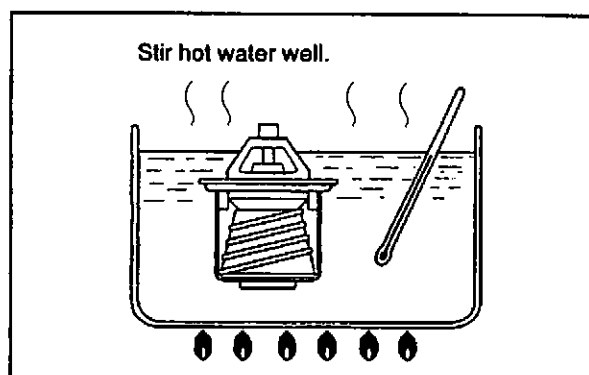
### 2.2 Inspecting thermostat

#### **CAUTION**

Both water and the thermostat become hot. Be careful of burns and fire.

To test the operation of the thermostat, immerse the thermostat in a deep pan filled with water. Heat the water while measuring the water temperature. Record the temperature at which the valve starts opening and the temperature at which the valve lift becomes the standard value. If either of the temperatures is not within the standard range, replace the thermostat.

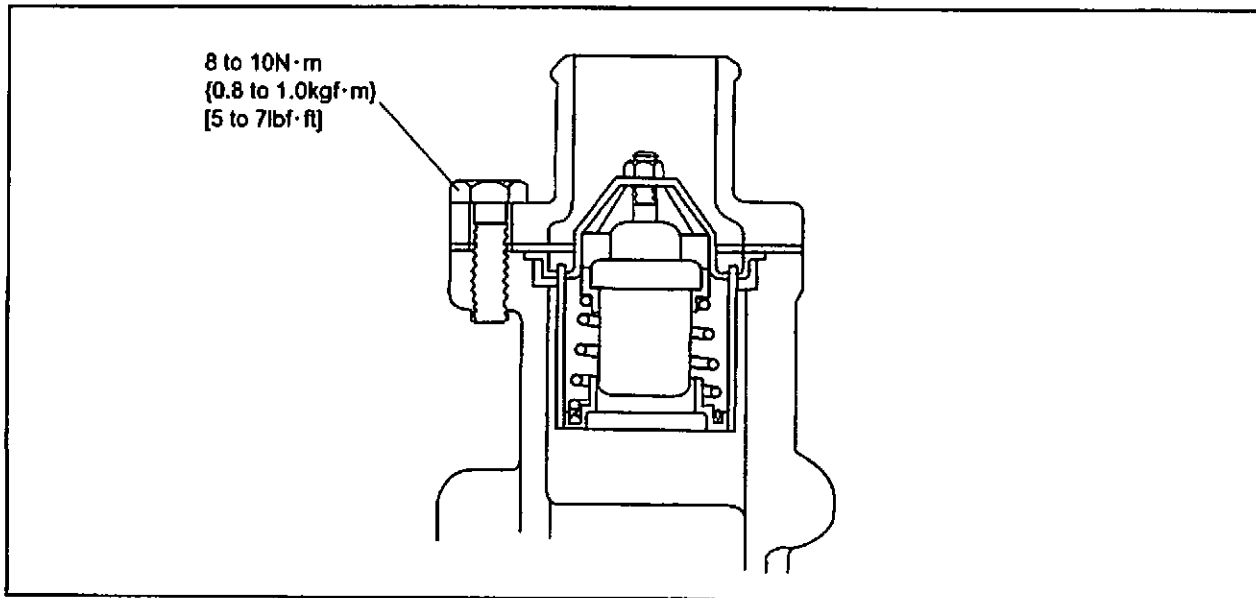
Note: Stir the water in the container with a stick to ensure uniform temperature distribution.



Inspecting thermostat

Measuringpoint	Standard
Temperature at which valve starts opening	76.5±1.5°C [169.7±2.7°F]
Temperature at which valve lift becomes 6 mm [0.24 in.] or more	90°C [194°F]

## 2.3 Reassembling thermostat



Reassembling thermostat

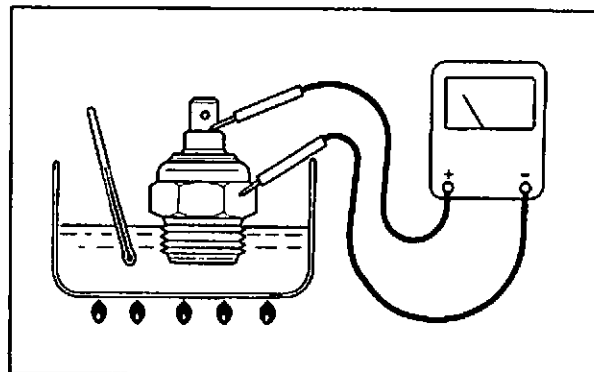
## 2.4 Inspecting thermostat

### CAUTION

Both water and the thermostat become hot. Pay attention to prevent burn and fire.

Immerse the temperature-sensor in oil and measure the resistance while raising the oil temperature. If the resistance extremely deviates from the standard, replace the thermostat.

Temperature	Standard
120°C [248°F]	30 mΩ

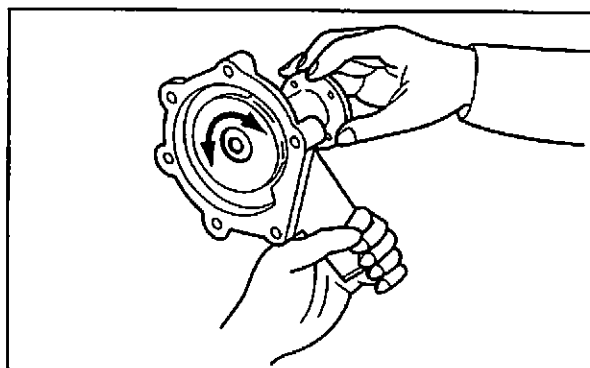


Inspecting thermostat

## 2.5 Inspecting water pump

### 2.5.1 Checking water pump for smooth rotation

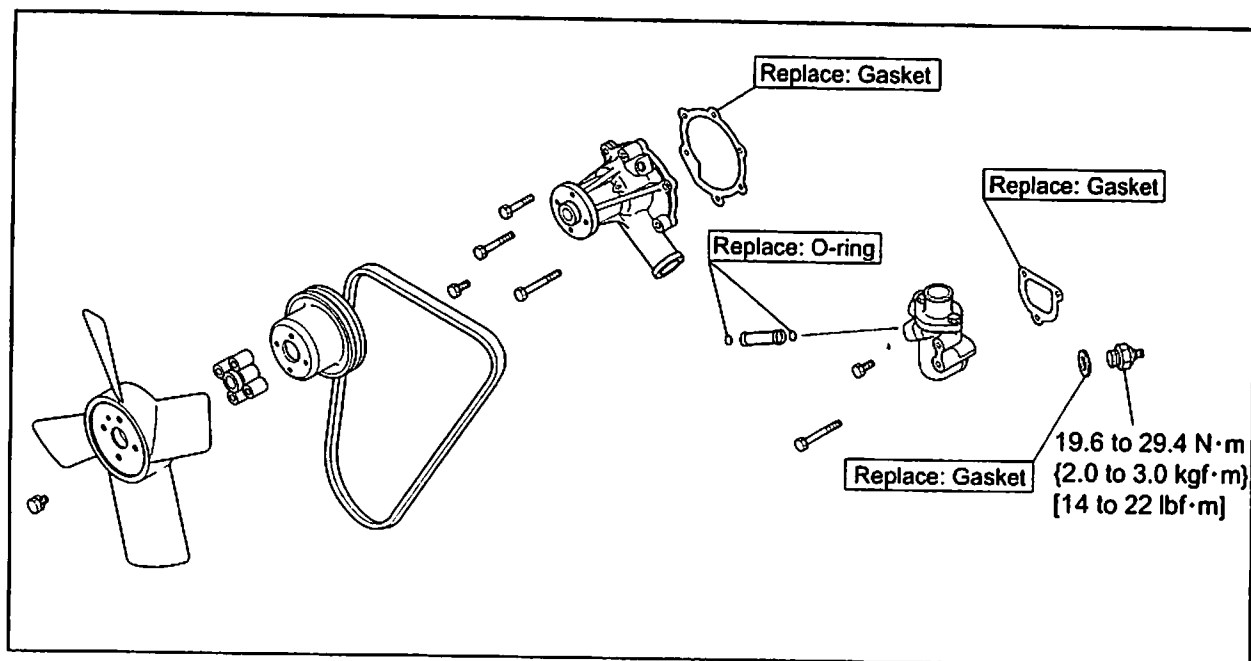
Check the water pump for smooth rotation of the impeller and shaft without noise and irregularities. If faulty, replace the water pump assembly.



Checking impeller and shaft for smooth rotation

### 3. Installing cooling system

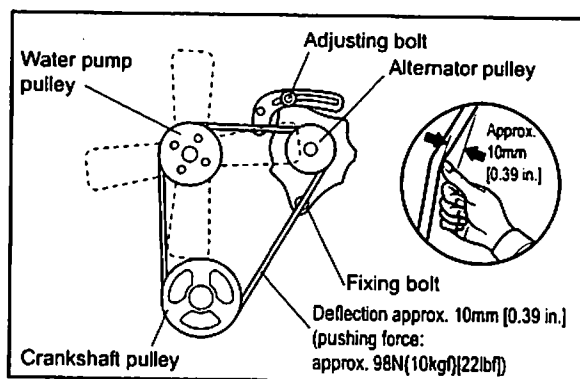
#### 3.1 Installing cooling fan, fan pulley, V-belt, thermostat, thermoswitch and water pump



Installing cooling fan, fan pulley, V-belt, thermostat, thermoswitch and water pump

#### 3.2 Adjusting V-belt tension

- (1) Loosen the adjusting bolt and fixing bolt of the alternator. Loop the V-belt over the water pump pulley, alternator pulley and crankshaft pulley.
- (2) With the alternator pushed toward the V-belt tension side, tighten the adjusting bolt at an appropriate position.
- (3) Inspect the V-belt tension to make sure it is within the specified value.



Adjusting deflection of V-belt

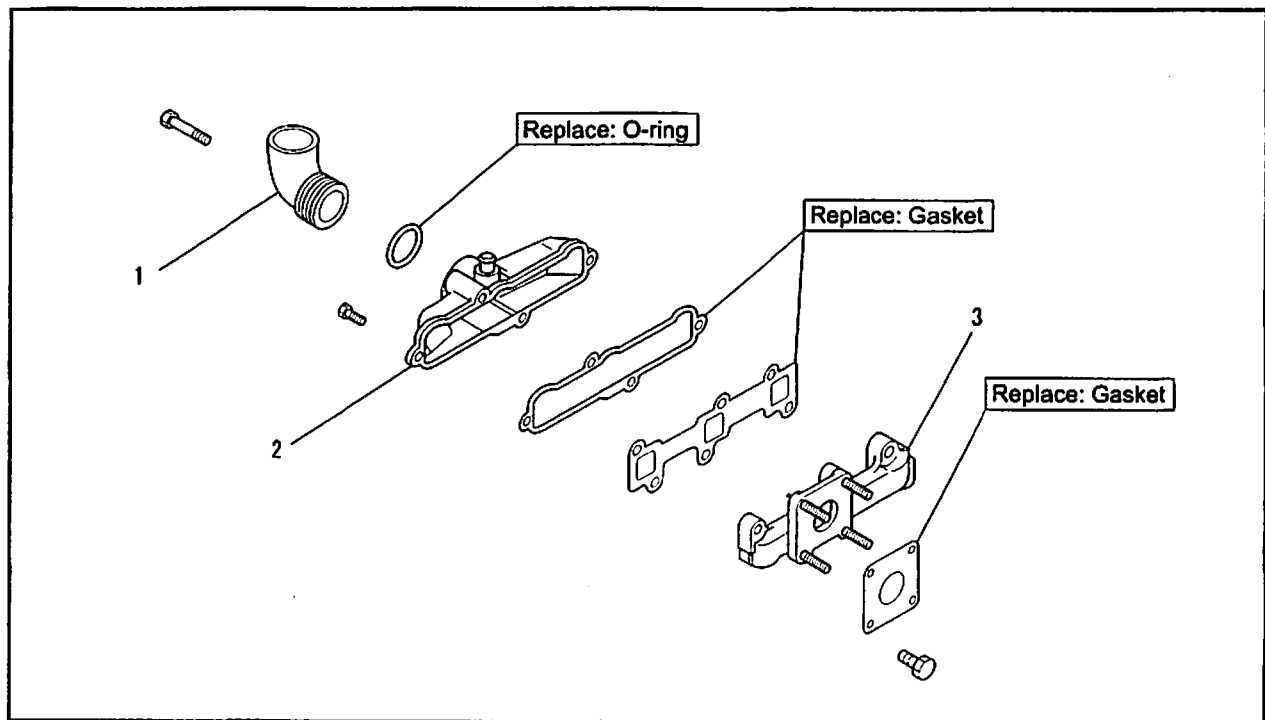
Belt tension (with pushing force of approx. 98 N [10 kgf] [22 lbf])	Approx. 10mm [0.39 in.]
--	----------------------------

# INLET AND EXHAUST SYSTEMS

1. Removing inlet and exhaust systems ..... 11-2
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2. Disassembling, inspecting and reassembling inlet and exhaust systems ..... 11-3
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  - 2.2 Measuring distortion of inlet cover and exhaust manifold ..... 11-3
3. Installing inlet and exhaust systems ..... 11-4
  - 3.1 Installing intake cover and exhaust manifold ..... 11-4

## 1. Removing inlet and exhaust systems

### 1.1 Removing intake cover and exhaust manifold



Removing intake cover and exhaust manifold

#### Removal sequence

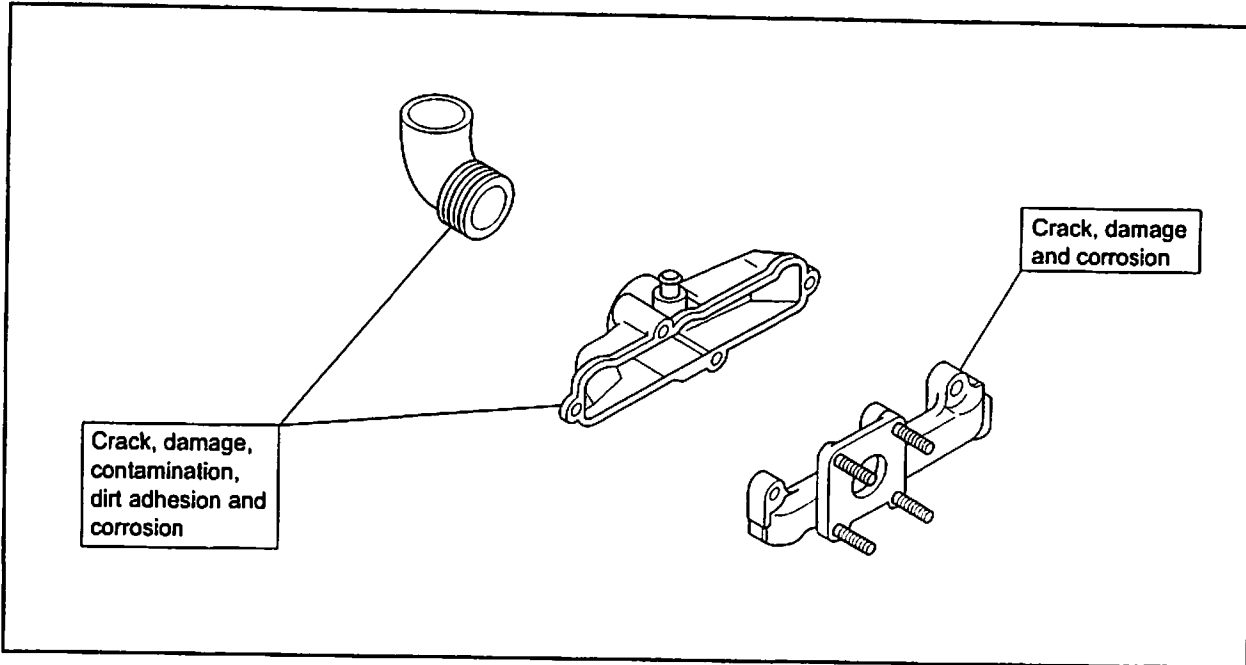
1 Intake pipe

2 Intake cover

3 Exhaust manifold

## 2. Disassembling, inspecting and reassembling inlet and exhaust systems

### 2.1 Inspecting intake cover and exhaust manifold

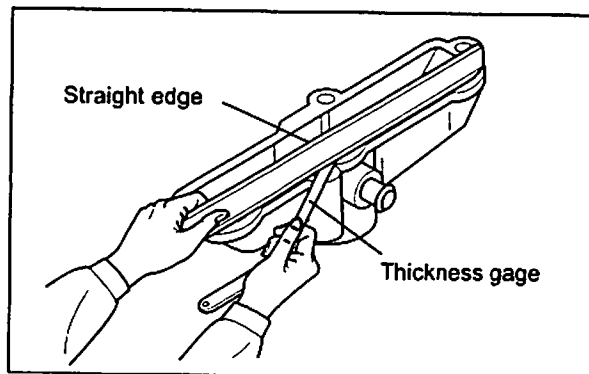


Inspecting intake cover and exhaust manifold

### 2.2 Measuring distortion of inlet cover and exhaust manifold

Using a straight edge and thickness gages, measure distortion across the cylinder head mounting surfaces of the inlet cover and exhaust manifold. If the measured distortion exceeds the limit, correct by grinding or replace the part.

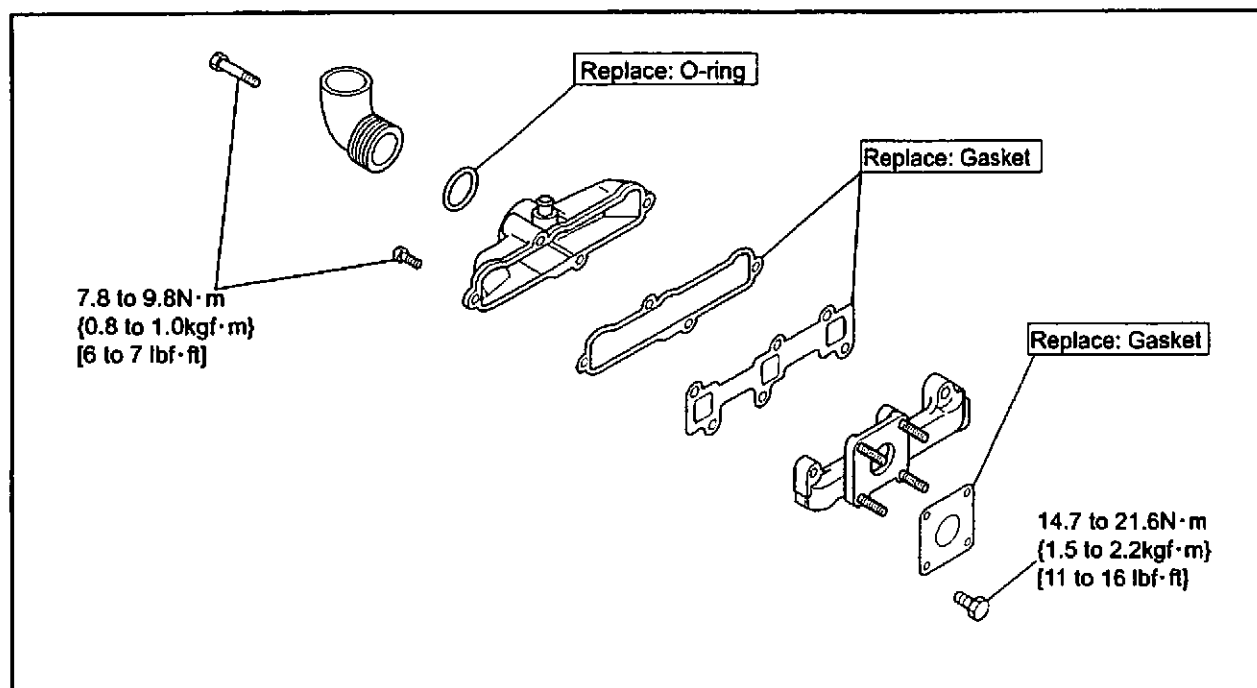
Measurement item	Limit
Distortion on mounting surfaces of intake cover and exhaust manifold	0.15mm [0.0059 in.]



Measuring distortion on intake cover

### 3. Installing inlet and exhaust systems

#### 3.1 Installing intake cover and exhaust manifold



Installing intake cover and exhaust manifold

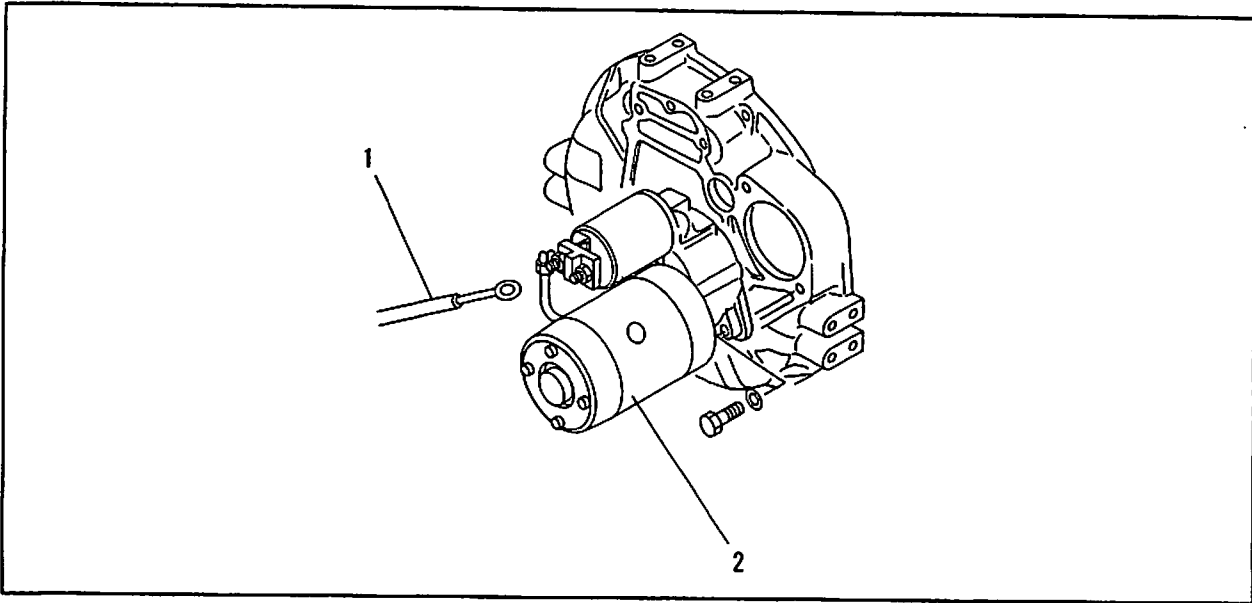
# ELECTRICAL SYSTEM

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## 1. Removing electrical system

### 1.1 Removing starter



Removing sequence

Removing starter

1 Harness

2 Starter

**1.2 Inspection before removing alternator (A007TA0171B (12V-40A), A007TA8271A (24V-25A))****1.2.1 Checking alternator operation**

Locate the cause of faulty charging from malfunctions described below. Do not remove the alternator for inspection and repair unless inspection cannot be performed with the alternator installed on the engine.

Overcharge.	Adjusted value of voltage regulator is high.
	Faulty battery.
Over dis-charge.	Low adjusted value of voltage relay.
	Faulty alternator output.
	Electric power consumption is extremely high.
	Special load is used.
	Faulty wiring.

**1.2.2 Handling precaution**

Improper handling could cause damage or failure to the alternator.

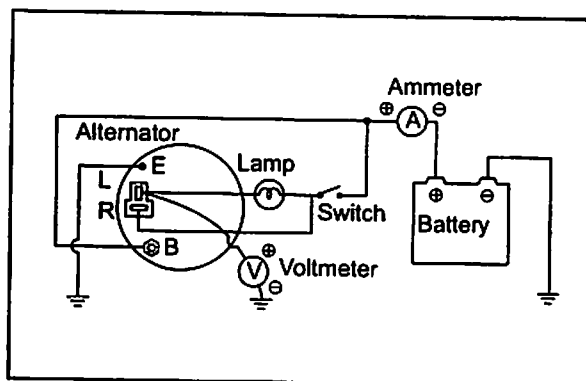
- (1) Connect right battery cables to the right terminals. The (-) cable is for grounding.
- (2) Do not use any high voltage tester such as megger.
- (3) Disconnect battery cables when recharged.
- (4) Do not disconnect lead wire from B terminal of the alternator when the engine is running.
- (5) Battery voltage is constantly applied to B terminal of the alternator. Do not ground at this terminal.
- (6) Do not short circuit or ground at L terminal. (Built-in IC regulator type)
- (7) When a steam cleaner is used, do not let the steam directly contact the alternator.

### 1.2.3 Inspecting regulated voltage (IC regulator integral type)

- (1) Disconnect (+) battery terminal and connect an ammeter across the line.
- (2) Connect a voltmeter between terminal L and ground.
- (3) The indication of the voltmeter must be 0 when the starter switch is OFF.

The indication of the voltmeter must be considerably lower than the battery voltage when the starter switch is ON (engine OFF).

- (4) Start the engine with the ammeter terminals shorted.
- (5) Read the voltmeter (regulated voltage) while the ammeter reading is 5 A or lower, 2500min<sup>-1</sup>, and lamp switches OFF.

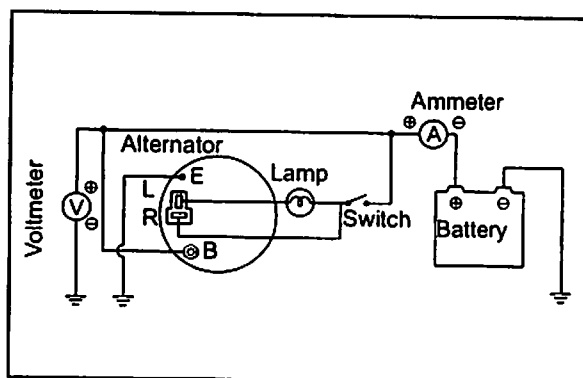


Checking regulated voltage

Measurement item		Standard	V-A
Regulated voltage (at 20 °C ) [68°F]	A007TA0171B	14.7±0.3 V	12-40
	A 007TA8271A	28.5±0.5 V	24-25

### 1.2.4 Checking output (Integrated IC regulator type)

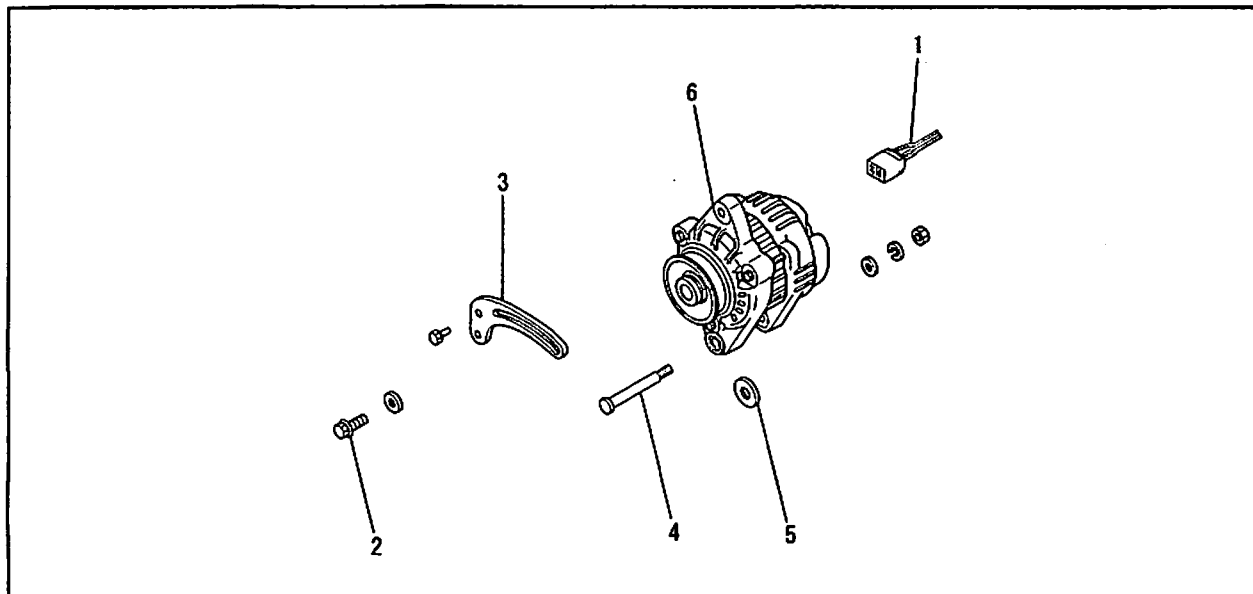
- (1) Disconnect the battery ground cable.
- (2) Connect terminal B of the alternator to the ammeter, then connect the voltmeter between terminal B and ground.
- (3) Connect the battery ground cable.
- (4) Start the engine.
- (5) Immediately apply all loads such as lamps.
- (6) Increase the engine speed and measure the maximum output current at the specified alternator rotation speed with the voltmeter indicated the specified value.
- (7) The output is normal if the measured value meets the standard.



Checking regulated voltage

Measurement item		Standard	
		Terminal voltage/current	Alternator rotation speed
Output characteristics (when hot)	A007TA0171B	13.5 V/21 A or higher	2500 min <sup>-1</sup>
		13.5 V/37 A or higher	5000 min <sup>-1</sup>
	A007TA8271A	27.0 V/18 A or higher	2500 min <sup>-1</sup>
		27.0 V/22 A or higher	5000 min <sup>-1</sup>

### 1.3 Removing alternator

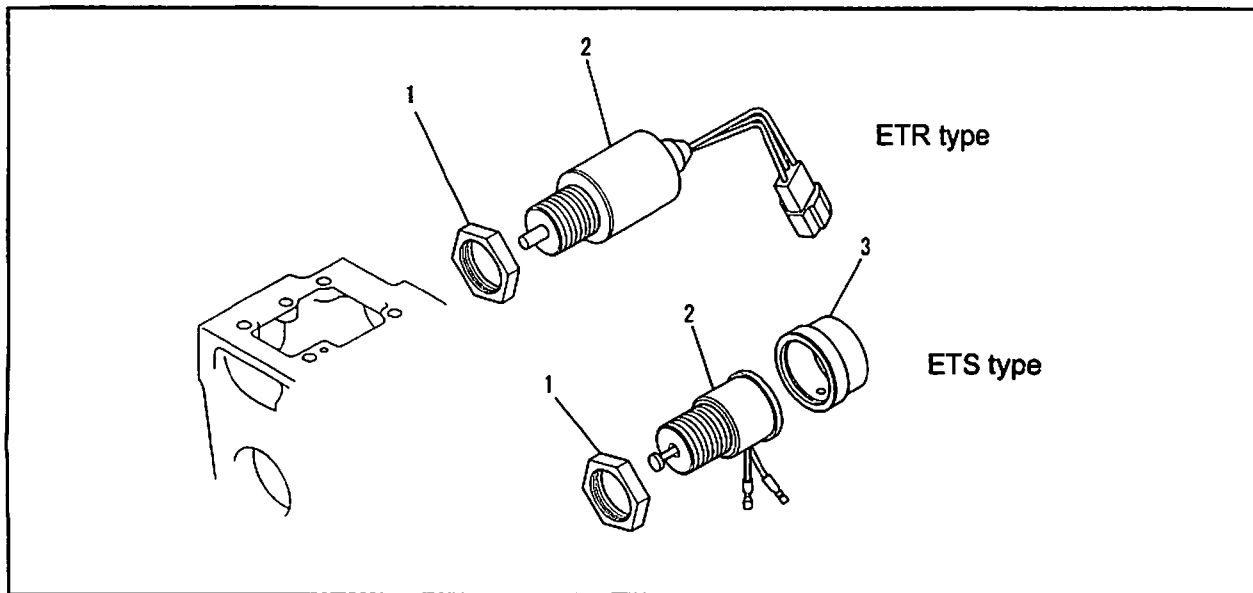


Removing alternator

#### Removing sequence

- |               |                   |              |
|---------------|-------------------|--------------|
| 1 Harness     | 3 Generator brace | 5 Washer     |
| 2 Flange bolt | 4 Bolt            | 6 Alternator |

### 1.4 Removing stop solenoid

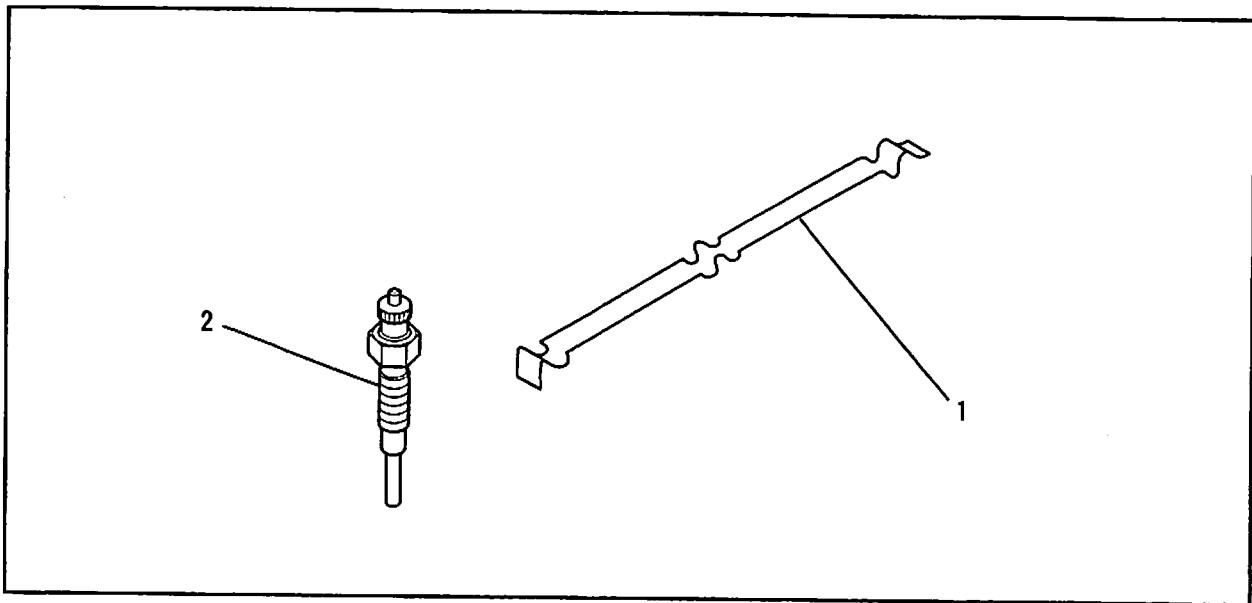


Removing stop solenoid

#### Removing sequence

- |       |                 |                         |
|-------|-----------------|-------------------------|
| 1 Nut | 2 Stop solenoid | 3 Rubber cap (ETS type) |
|-------|-----------------|-------------------------|

### 1.5 Removing glow plug



Removing sequence

Removing glow plug

1 Glow plug plate

2 Glow plug .

## 2. Disassembling, inspecting and reassembling electrical system

### 2.1 Inspection before disassembling starter (M000T60481(12 V-1.2 kW, M001T68381(12 V-1.7 kW))

#### 2.1.1 Inspecting pinion clearance

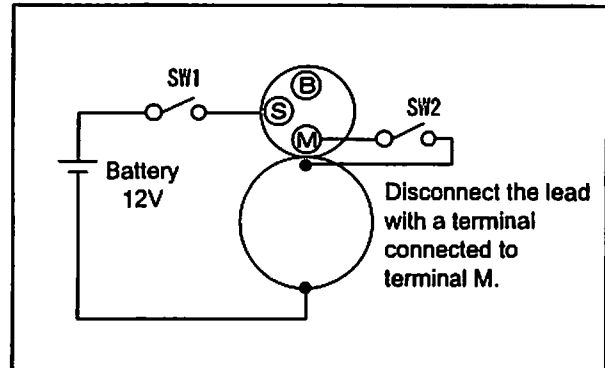
##### CAUTION

Do not apply current continuously for 10 seconds or longer.

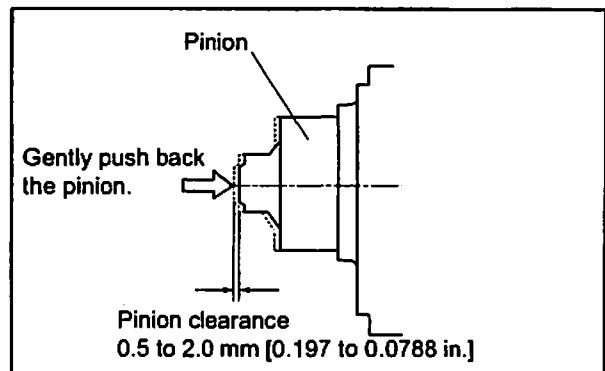
- (1) Connect the starter to the circuit as shown in the illustration.
- (2) When the switches SW1 and SW2 are turned ON, the pinion springs out to the cranking position and the armature rotates.
- (3) Turn the switch SW2 OFF to stop the rotation of the armature.
- (4) Gently push back the pinion in the out position with a finger and measure the distance over which the pinion has returned (movement amount).
- (5) If the measured value is out of the standard, increase or decrease the number of packings between the magnet switch and the front bracket for adjustment, or replace the lever with a new one.

Note: When the number of packings is increased, the pinion clearance becomes small.

Measurement item	Standard
Pinion clearance	0.5 to 2.0mm [0.0197 to 0.0788 in.]



Wiring during inspection of pinion clearance



Inspecting pinion clearance

#### 2.1.2 Inspecting magnet switch

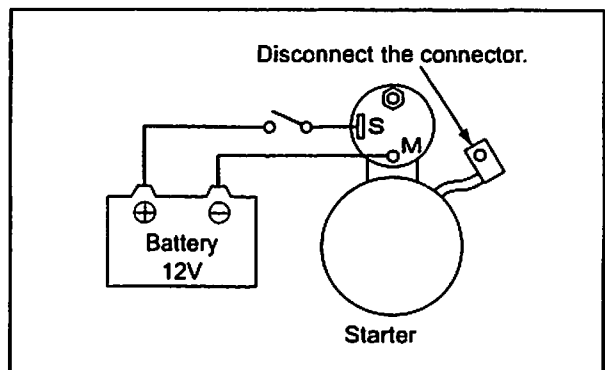
Perform the following inspection. If faulty, replace the magnet switch.

##### CAUTION

Do not apply current continuously for 10 seconds or longer.

- (1) Disconnect the connector of terminal M.
- (2) Pull-in test

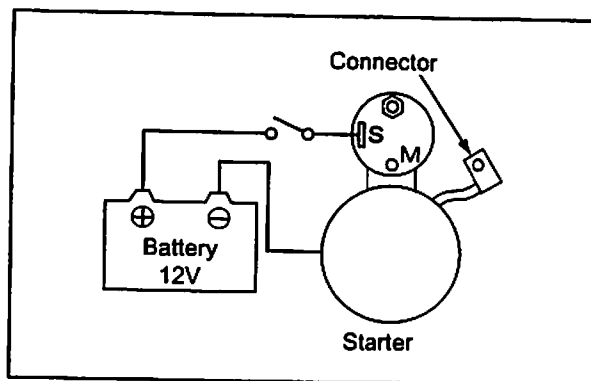
Connect the starter to the illustrated circuit. The magnet switch is normal if the pinion springs out when the switch is turned ON.



Pull-in test

**(3) Holding test**

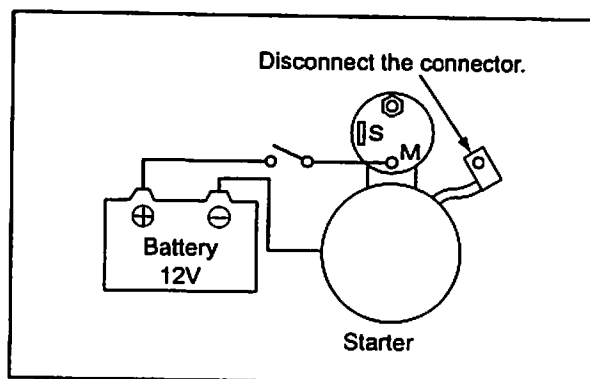
Connect the starter to the illustrated circuit. Pull out the pinion fully by hand. The magnet switch is normal if the pinion does not return when it is released.



Holding test

**(4) Return test**

Connect the starter to the illustrated circuit. Pull out the pinion fully by hand. The magnet switch is normal if the pinion returns immediately when it is released.



Return test

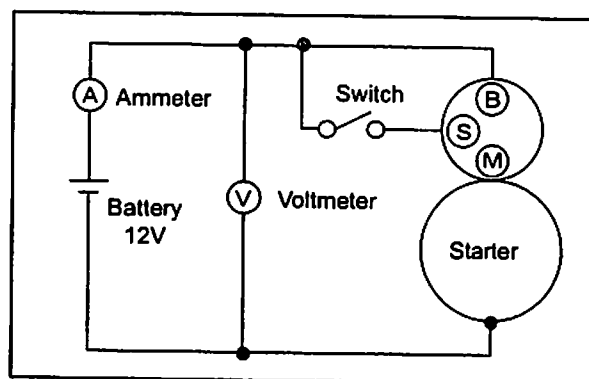
**2.1.3 No load test****CAUTION**

Use as thick a wire as possible and firmly tighten each terminal.

When detecting the rotation at the tip of the pinion, be careful that the pinion springs out during operation.

- (1) Connect the starter to the circuit as shown in the illustration.
- (2) The starter is normal if the pinion jumps out when the switch is turned ON and the starter rotates at or above the specified rotation speed.

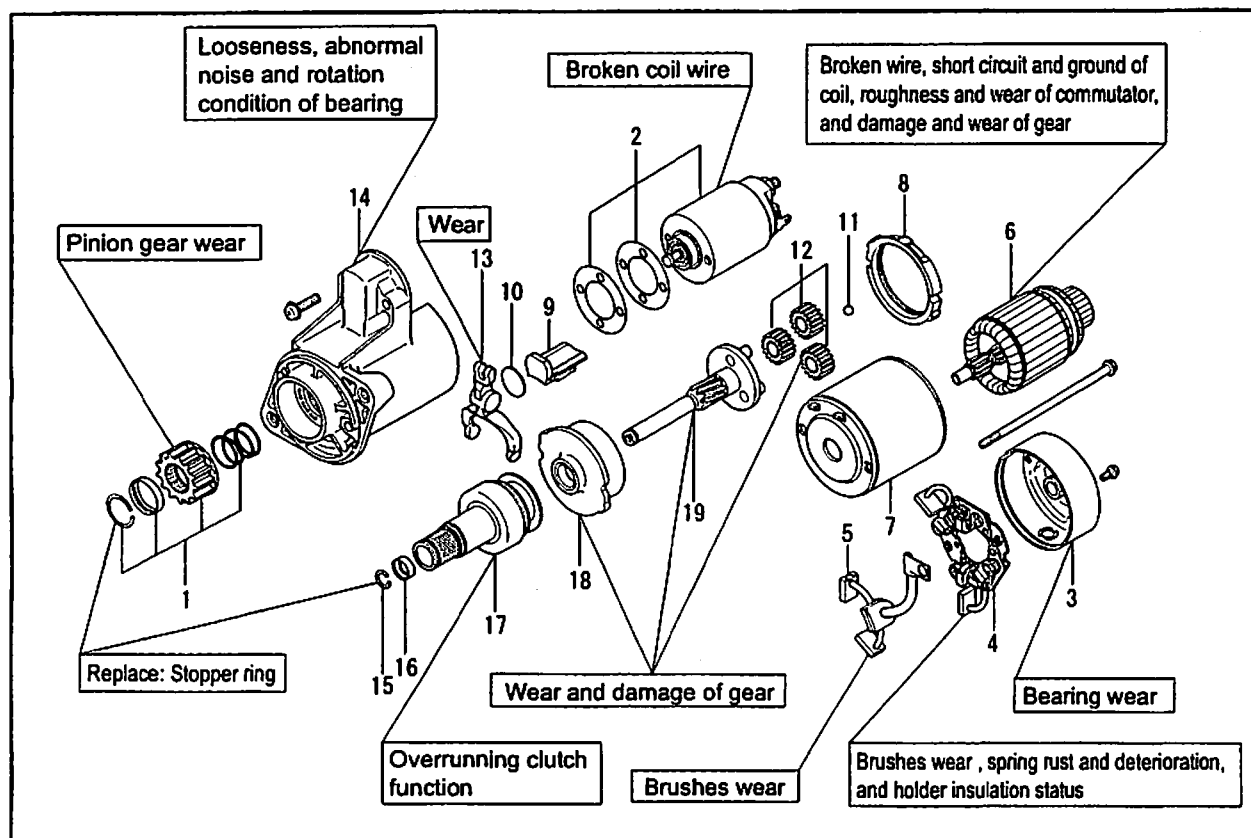
Disassemble, inspect and repair the starter if the terminal voltage, current or rotation speed does not meet the standard.



Test at no load

Item		Standard	
Starter model name		M000T60481	M001T68381
Nominal output V·kW		12·1.2	12·1.7
No-load characteristics	Terminal voltage V	11	11
	Current A	90 or less	110 or less
	Rotation speed min <sup>-1</sup>	2500 or more	2400 or more

## 2.2 Disassembling and inspecting starter (M000T60481(12 V-1.2 kW), M001T68381(12 V-1.7 kW))



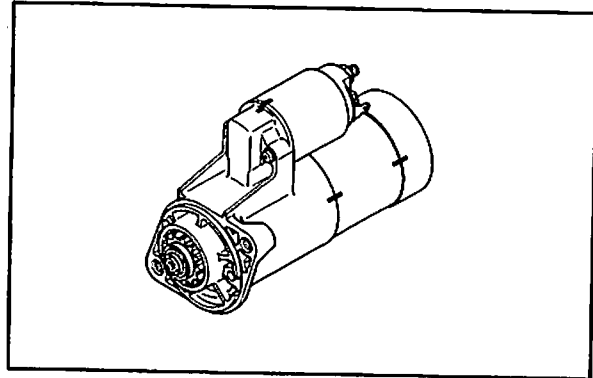
Disassembling and inspecting starter (M000T60481(12 V-1.2 kW), M001T68381(12 V-1.7 kW))

### Disassembly sequence

- |                  |                   |                       |
|------------------|-------------------|-----------------------|
| 1 Pinion set     | 8 Packing         | 15 Snap ring          |
| 2 Magnet switch  | 9 Packing         | 16 Stopper            |
| 3 Rear bracket   | 10 Plate          | 17 Overrunning clutch |
| 4 Brush holder   | 11 Ball           | 18 Internal gear      |
| 5 Brush assembly | 12 Planetary gear | 19 Gear shaft         |
| 6 Armature       | 13 Lever          |                       |
| 7 Yoke           | 14 Front bracket  |                       |

### 2.3 Preparation before disassembling

Mark the mating marks on magnet switch, front bracket, center bracket, yoke and rear bracket to each other for reassembly.



Preparatory work before disassembly

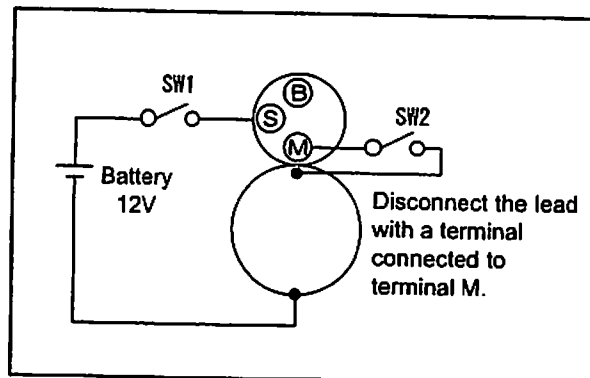
#### 2.3.1 Removing pinion set

##### CAUTION

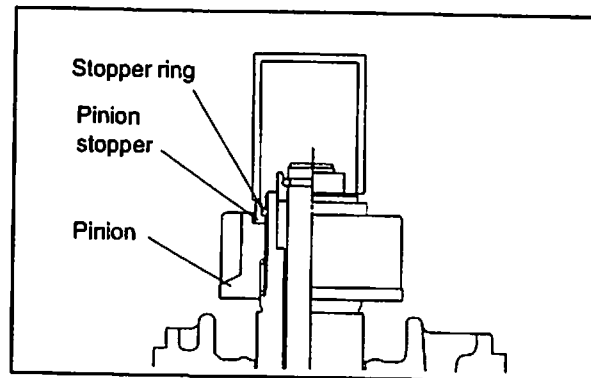
The starter generates heat if it is left with current applied. Remove the pinion within 10 seconds.

- (1) Connect the starter to the circuit as shown in the illustration.
- (2) Turn the switches SW1 and SW2 ON to move the pinion out and then turn the SW2 OFF to stop the rotation of the armature and the pinion.
- (3) Place an appropriate tube on the pinion stopper.  
Tap the tube with a hammer to drop the pinion stopper to the clutch side. This will expose the stopper ring.
- (4) Remove the stopper ring with a plier and remove the pinion.

Note: Do not reuse the stopper ring for reassembly.



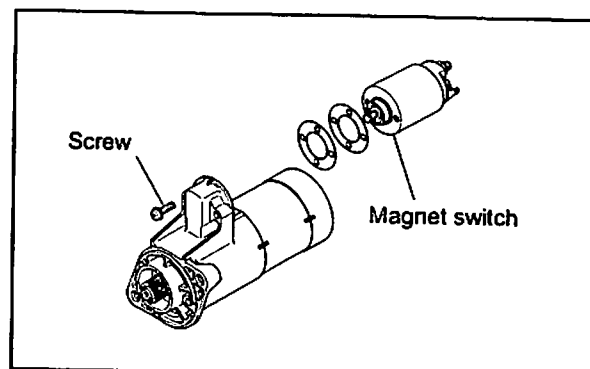
Connection to move the pinion forward



Removing pinion

#### 2.3.2 Removing magnet switch

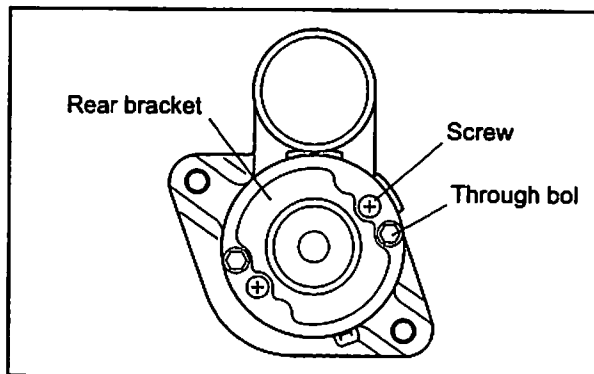
Remove the lead, and remove the magnet switch.



Removing magnet switch

## 2.3.3 Removing rear bracket

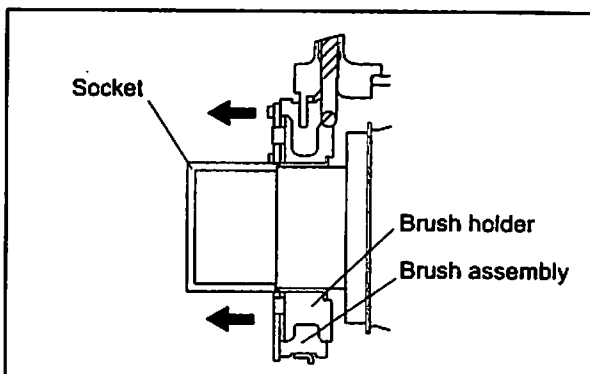
Remove the through bolts and screws of the brush holder, and then remove the rear bracket.



Removing rear bracket

## 2.3.4 Removing brush holder and brush assembly

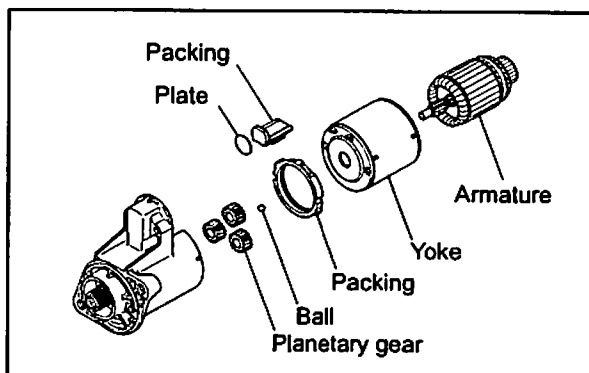
Apply a socket (of the same diameter as the commutator) to the commutator of the armature. Remove the brush holder and brush assembly by sliding on the socket.



Removing brush holder and brush assembly

## 2.3.5 Removing armature and yoke

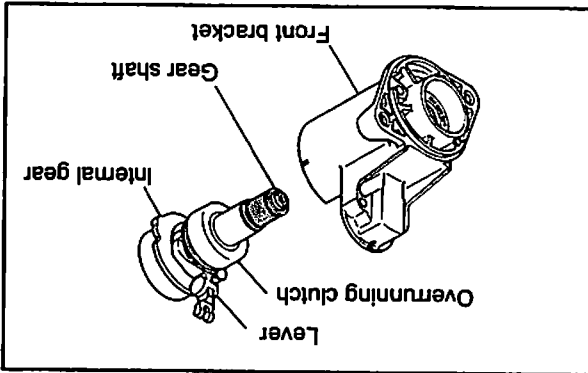
- (1) Remove the armature and the yoke.
- (2) Remove the packing from the internal gear.
- (3) Remove the packing and plate on the lever support.
- (4) Remove the ball from the internal gear.
- (5) Remove the planetary gears.



Removing armature and yoke

2.3.6 Removing overrunning clutch

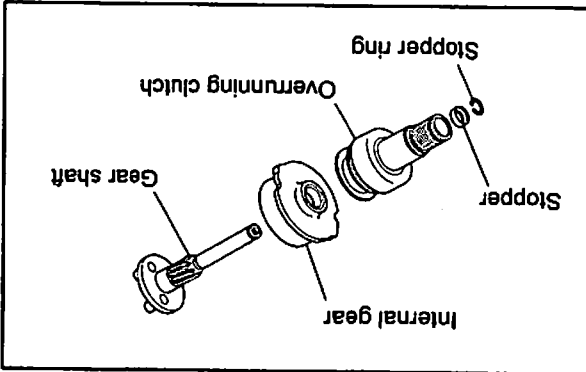
Pull out the internal gear, gear shaft, overrunning clutch and lever as a unit from the front bracket, and remove the lever.



Removing overrunning clutch

2.3.7 Removing gear shaft

- (1) Remove the stopper ring and then the stopper.
- (2) Separate the overrunning clutch, internal gear and gear shaft.



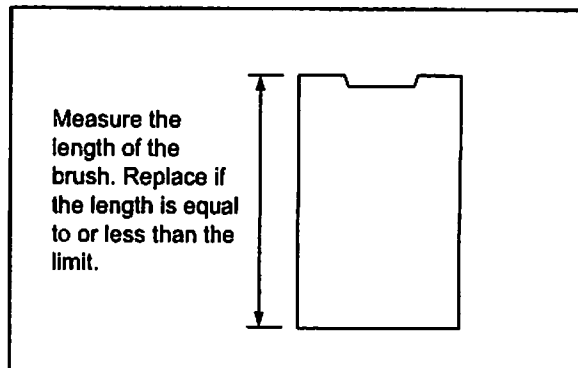
Removing gear shaft

## 2.4 Inspecting and repairing starter (M000T60481(12 V-1.2 kW), M001T68381(12 V-1.7 kW))

### 2.4.1 Inspecting brushes for wear

Measure the length of the brushes. If the measured value is less than the limit, replace both the brush holder assembly and the brush assembly.

Measurement item	Standard	Limit
Brush length	16.5mm [0.64961 in.]	10.0mm [0.3937 in.]

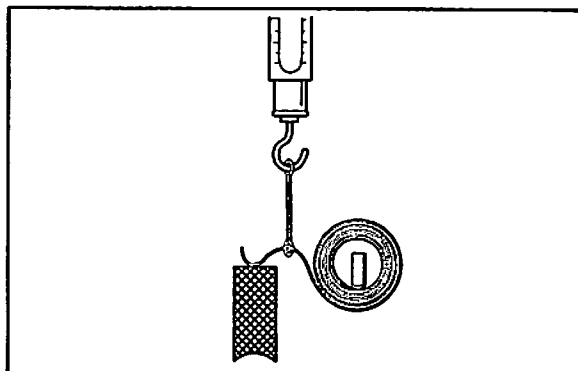


Inspecting brushes for wear

### 2.4.2 Measuring brush spring load

Using a new brush, measure the spring load at which the spring lifts from the brush. If the measured value is less than the limit, replace the spring.

Measurement item	Standard	Limit
Brush spring load	17.5 to 23.7N (1.78 to 2.42kgf) [39.24 to 5.34 lbf]	6.86N (0.70kgf) [1.54 lbf]

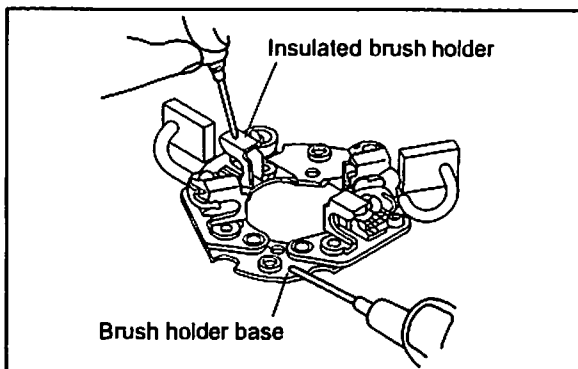


Measuring brush spring load

### 2.4.3 Checking brush holder for insulation

Check for continuity between each brush holder and the brush holder base, which must be insulated from each other. If continuity is indicated, replace the whole brush holder assembly.

Check the brush holders for looseness.

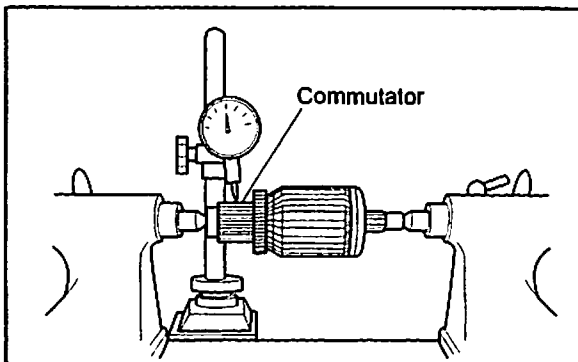


Checking brush holder for grounding

### 2.4.4 Inspecting commutator radial runout

- (1) Inspect the commutator surface. Polish it with 400 to 600 grit sandpaper if it is rough.
- (2) Measure the radial runout with a dial gage. Replace the commutator if the limit is exceeded.

Measurement item	Standard	Limit
Commutator radial runout	0.03mm [0.0012 in.]	0.10mm [0.0039 in.]



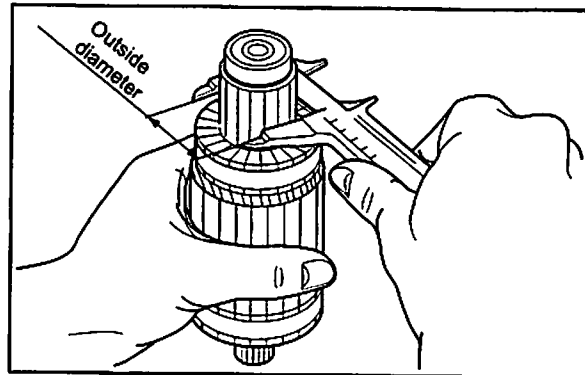
Measuring commutator radial runout

#### 2.4.5 Measuring commutator outside diameter

Measure the commutator outside diameter.

If less than the limit, replace with a new part.

Measurement item	Standard	Limit
Commutator outside diameter	29.4mm [1.1575 in.]	28.8mm [1.1339 in.]



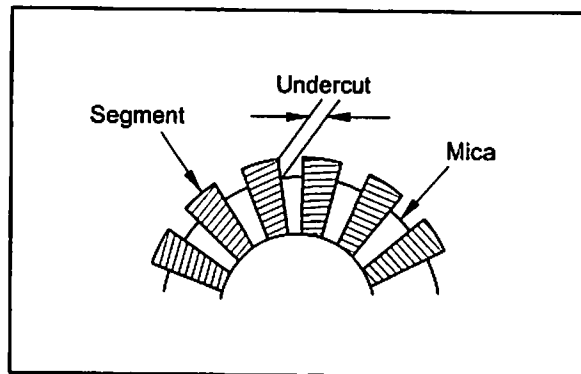
Measuring commutator outside diameter

#### 2.4.6 Measuring undercutting depth between segments

Measure the depth of undercutting between the commutator segments.

If less than the limit, repair or replace with a new part.

Measurement item	Standard	Limit
Undercutting depth	0.5 to 1.0mm [0.0197 to 0.0394 in.]	0.2mm [0.00788 in.]

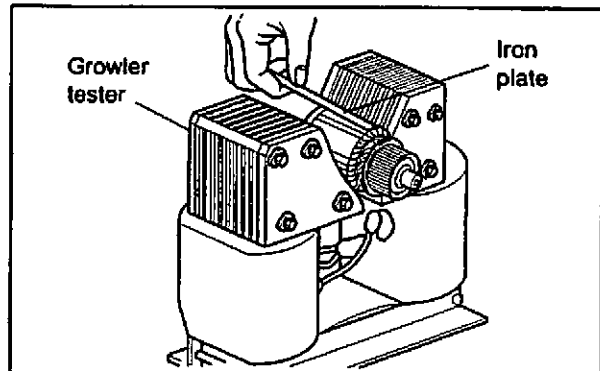


Measuring undercutting depth between segments

### 2.4.7 Checking armature coil

- (1) Inspect the armature coil using a growler.

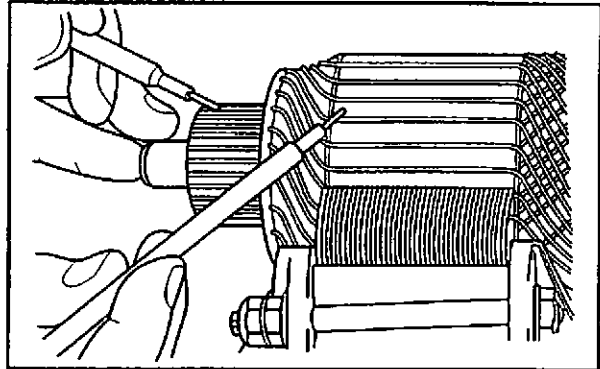
Apply a iron plate to the armature core. Replace the armature if the iron plate vibrates.



Checking armature coil for short circuit

- (2) Using a tester, make sure that there is no continuity between the commutator and the shaft.

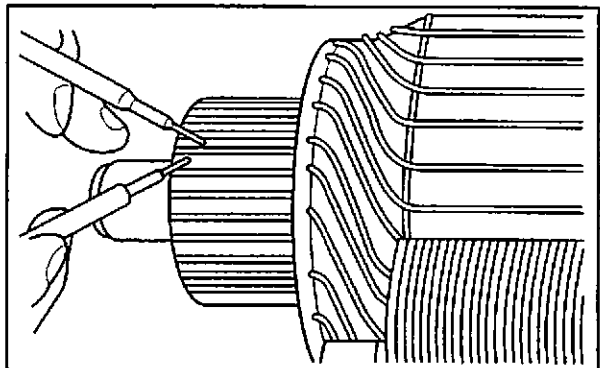
Replace the armature if continuity is indicated between the commutator and the shaft.



Checking armature coil for grounding

- (3) Using a tester, make sure that there is continuity between each segment.

Replace the armature if no continuity is indicated between each segment.



Checking armature coil for breaks

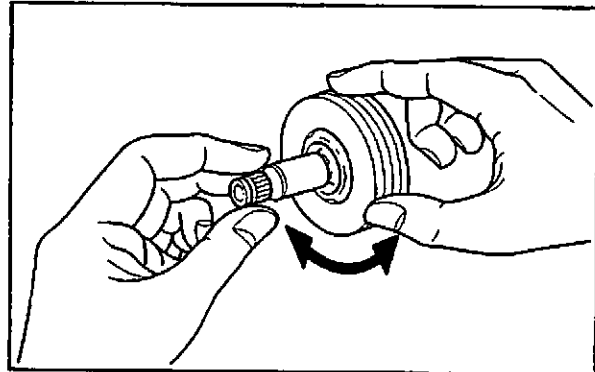
### 2.4.8 Inspecting rear bracket

Replace the rear bracket if the bearing is worn.

**2.4.9 Inspecting overrunning clutch****CAUTION**

**Do not wash the overrunning clutch in wash oil.**

Make sure that the overrunning clutch locks when the shaft rotates in one direction and that it rotates smoothly when the shaft rotates in the reverse direction.



Inspecting overrunning clutch

**2.4.10 Inspecting pinion**

Check the pinion for wear and damage.

If faulty, replace the pinion.

**2.4.11 Inspecting front bracket**

The ball bearing should rotate smoothly without abnormal noise. If faulty, replace the whole front bracket.

**2.4.12 Inspecting gears of starter**

Check gears of the starter for wear or damage. If faulty, replace the starter.

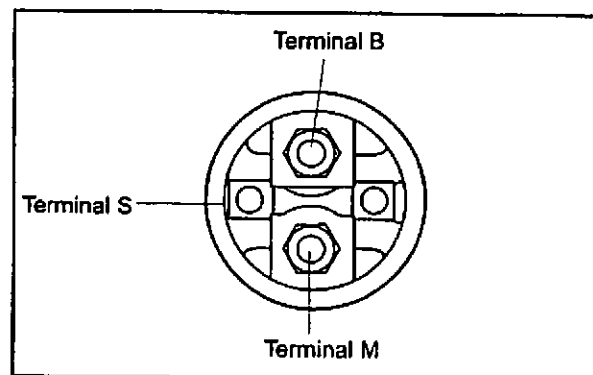
**2.4.13 Checking magnet switch for continuity**

Check for continuity between terminal M and the body.

Replace the magnet switch if no continuity is indicated.

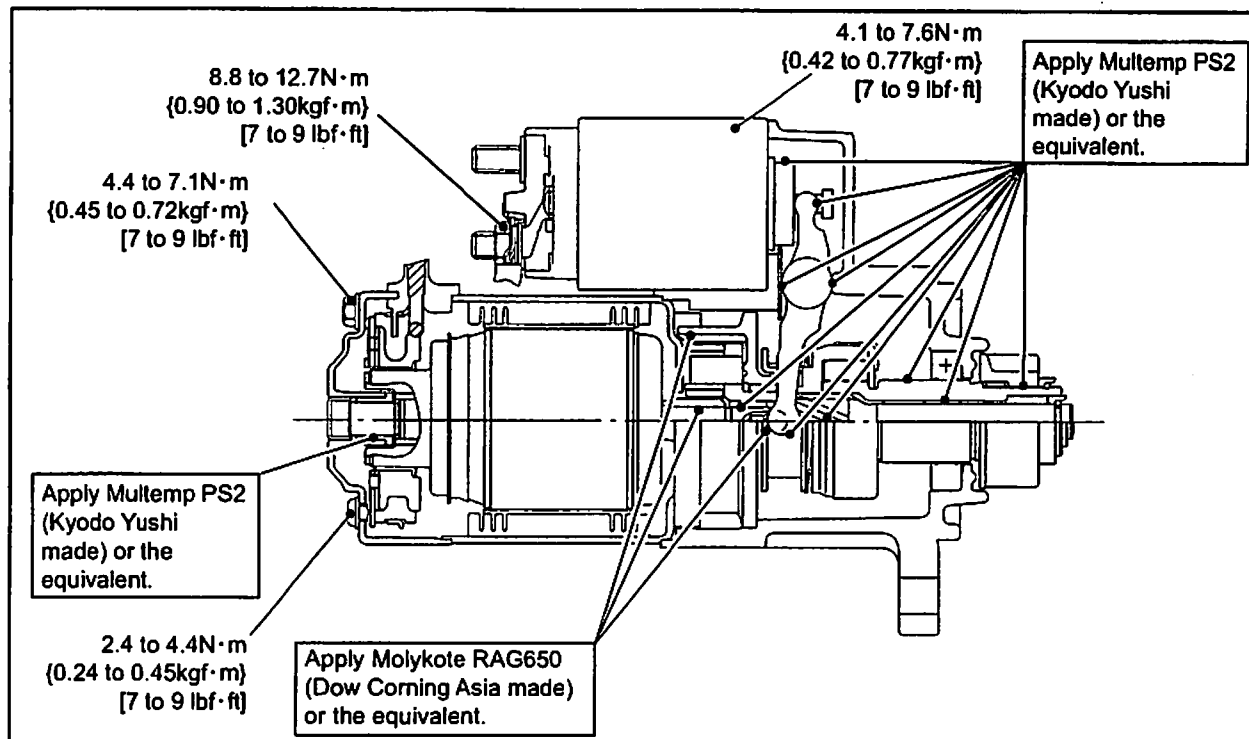
Check for continuity between terminal B and terminal M.

Replace the magnet switch if continuity is indicated.



Inspecting magnet switch

## 2.5 Reassembling starter (M000T60481(12 V-1.2 kW), M001T68381(12 V-1.7 kW))



Reassembling starter (M000T60481(12 V-1.2 kW), M001T68381(12 V-1.7 kW))

### 2.5.1 Applying grease

#### CAUTION

To avoid mixing of different greases, remove old grease before applying new grease.

Make sure that the starter mounting surface, brushes, commutator and other electric current conducting components are free from grease.

When overhauling the starter, apply grease to the following sliding surfaces, gears and bearings.

(1) Areas to which Multitemp PS2 (Kyodo Yushi made) or the equivalent is applied

Plunger surface (a small amount)

Shaft sliding area of overrunning clutch

Gear shaft

Pinion gear fitting surface

Spline of gear shaft

Sliding area between lever and overrunning clutch

Bearing of gear shaft

Rear bearing

(2) Areas to which Molykote RAG650 (Dow Corning Asia made) or the equivalent is applied

Ball

Gear shaft, gear and internal gear of armature

### 2.5.2 Installing pinion

#### CAUTION

Before assembling, apply grease to the inner race groove of the front bracket bearing.

Be sure to use a new stopper ring. Do not reuse the stopper ring that has been removed.

- (1) Put the overrunning clutch through the front bracket.
- (2) Fit the internal gear into the gear shaft.
- (3) Put the gear shaft through the overrunning clutch and install the stopper on it.
- (4) Fit the stopper ring into the groove of the stopper ring and firmly pinch it.
- (5) Using a gear puller, firmly draw the pinion and fit the stopper into the stopper ring.

Note: The adjustment of play in the axial direction of the gear shaft is not necessary because its required amount is automatically secured.

### 2.5.3 Installing gear shaft

#### CAUTION

Be sure to use a new stopper ring. Do not reuse a removed one.

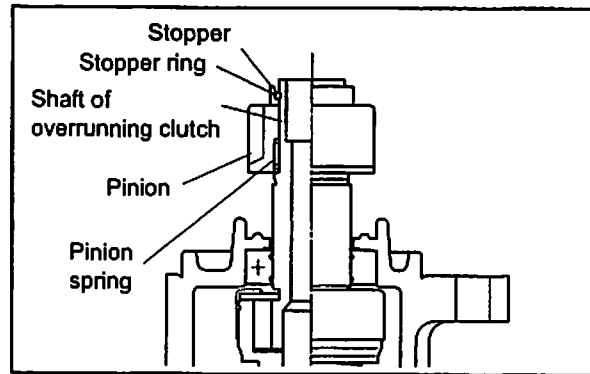
- (1) Reassemble the lever to the overrunning clutch.
- (2) Fit the internal gear into the gear shaft.
- (3) Put the gear shaft through the overrunning clutch and install the stopper on it.
- (4) Fit the stopper ring into the groove of the stopper ring and firmly pinch it.
- (5) Using a gear puller, firmly pull the pinion and fit the stopper into the stopper ring.

Note: The adjustment of play in the axial direction of the gear shaft is not necessary because its required amount is automatically secured.

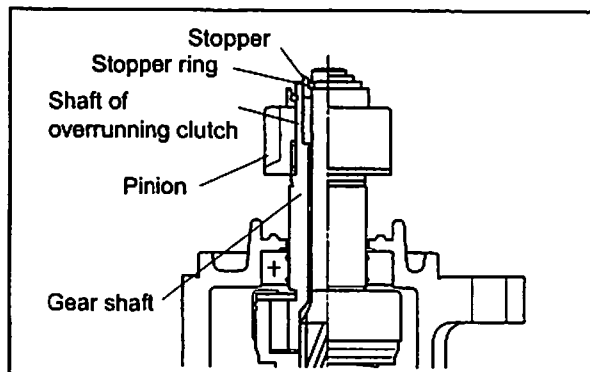
### 2.5.4 Installing yoke and armature

- (1) Install the planetary gears on the gear shaft.
- (2) Install the packing on the internal gear.
- (3) Install the plate and packing.
- (4) Install the yoke on the front bracket.
- (5) Apply grease to the tip of the armature and install a ball on it.
- (6) Install the armature.

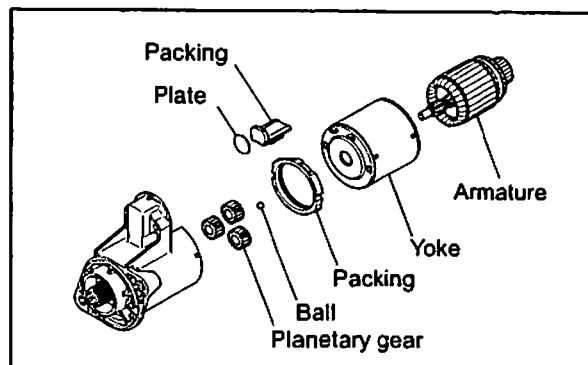
Note: The adjustment of play in the axial direction of the armature shaft is not necessary.



Installing pinion



Installing gear shaft

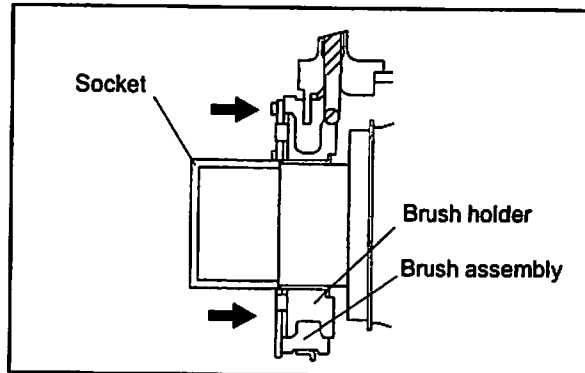


Installing yoke and armature

## 2.5.5 Installing brush holder and brush assembly

Hold the socket to the commutator of the armature.

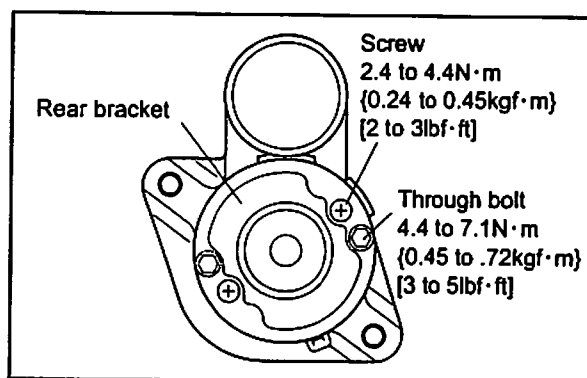
While sliding the brushes on the socket, install the brush holder and brush assembly on the armature.



Installing brush holder and brush assembly

## 2.5.6 Installing rear bracket

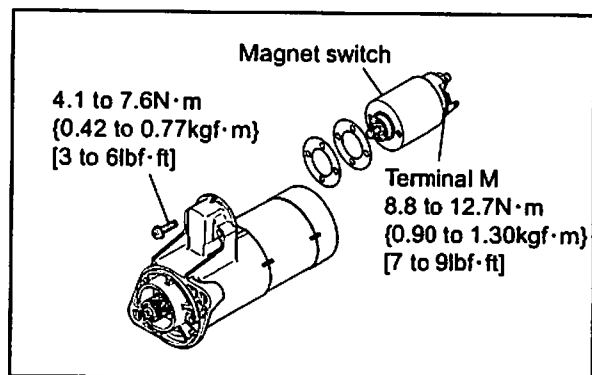
Install the rear bracket to the yoke and tighten the through bolt and screws of the brush holder.



Installing rear bracket

## 2.5.7 Installing magnet switch

- (1) Install the magnet switch and tighten the screws.
- (2) Connect terminal M and tighten fixing nuts.



Installing magnet switch

### 2.5.8 Inspecting pinion clearance

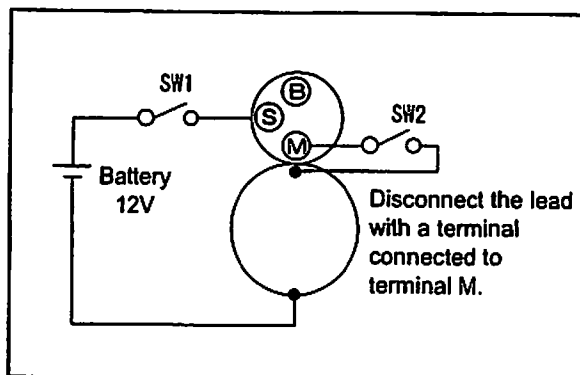
#### CAUTION

Do not apply current continuously for 10 seconds or longer.

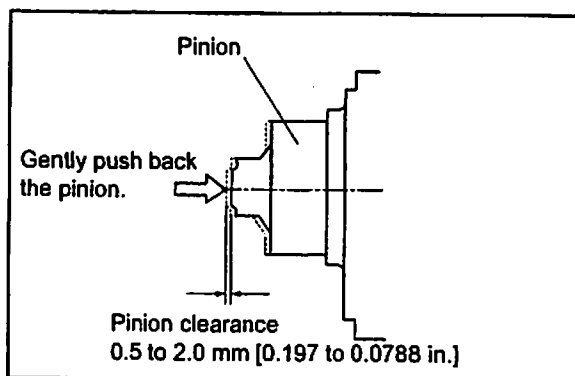
- (1) Connect the starter to the circuit as shown in the illustration.
- (2) When the switches SW1 and SW2 are turned ON, the pinion springs out to the cranking position and the armature rotates.
- (3) Turn the switch SW2 OFF to stop the rotation of the armature.
- (4) Gently push back the pinion in the out position with a finger and measure the distance over which the pinion has returned (movement amount).
- (5) If the measured value is out of the standard, increase or decrease the number of packings between the magnet switch and the front bracket for adjustment, or replace the lever with a new one.

Note: When the number of packings is increased, the pinion clearance becomes small.

Measurement item	Standard
Pinion clearance	0.5 to 2.0mm (0.0197 to 0.0788 in.)



Wiring during inspection of pinion clearance



Inspecting pinion clearance

## 2.6 Inspection before disassembling starter (M002T66071(24 V-3.2 kW))

### 2.6.1 Inspecting pinion clearance

#### CAUTION

Do not apply current continuously for 10 seconds or longer.

- (1) Connect the starter to the circuit as shown in the illustration.
- (2) When the switches SW1 and SW2 are turned ON, the pinion springs out to the cranking position and the armature rotates.
- (3) Turn the switch SW2 OFF to stop the rotation of the armature.
- (4) Gently push back the pinion in the out position with a finger and measure the distance over which the pinion has returned (movement amount).
- (5) If the measured value is out of the standard, increase or decrease the number of packings between the magnet switch and the front bracket for adjustment, or replace the lever with a new one.

Note: When the number of packings is increased, the pinion clearance becomes small.

Measurement item	Standard
Pinion clearance	0.5 to 2.0mm [0.0197 to 0.0788 in.]

### 2.6.2 Inspecting magnet switch

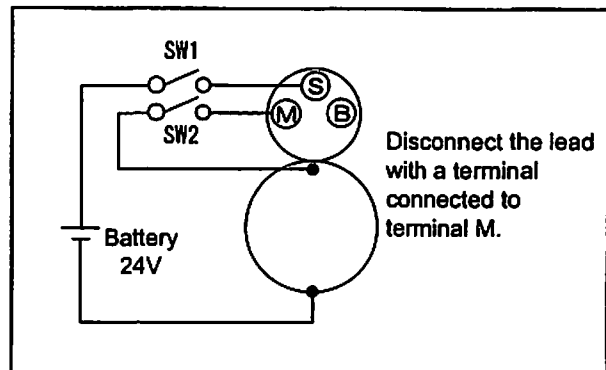
Perform the following inspection. If faulty, replace the magnet switch.

#### CAUTION

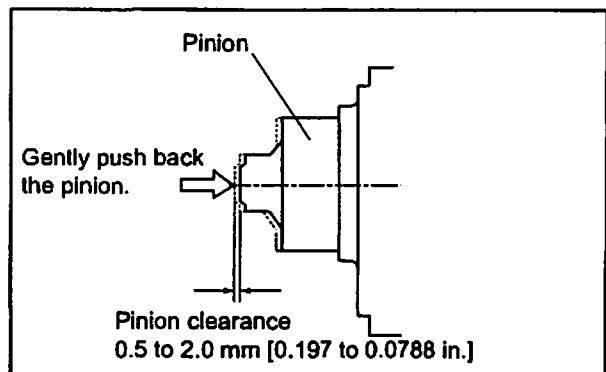
Do not apply current continuously for 10 seconds or longer.

- (1) Disconnect the connector of terminal M.
- (2) Pull-in test

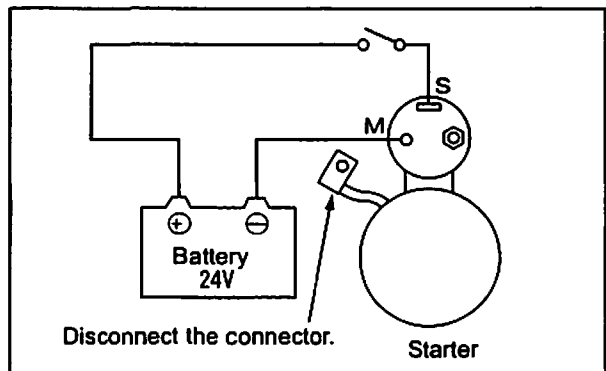
Connect the starter to the illustrated circuit. The magnet switch is normal if the pinion springs out when the switch is turned ON.



Wiring during inspection of pinion clearance



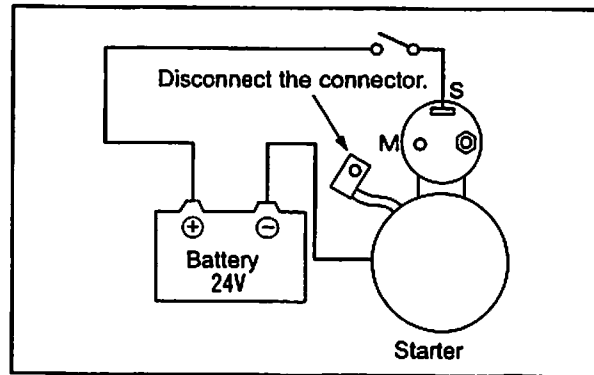
Inspecting pinion clearance



Pull-in test

**(3) Holding test**

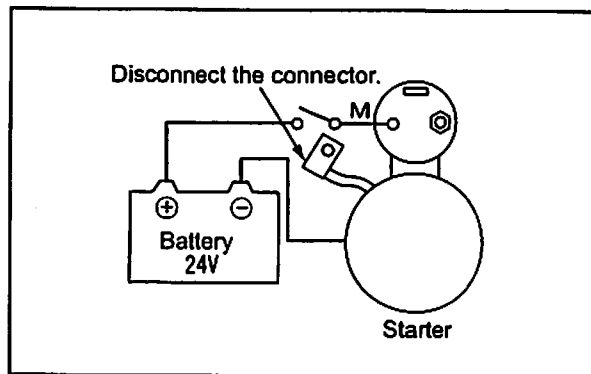
Connect the starter to the illustrated circuit. Pull out the pinion fully by hand. The magnet switch is normal if the pinion does not return when it is released.



Holding test

**(4) Return test**

Connect the starter to the illustrated circuit. Pull out the pinion fully by hand. The magnet switch is normal if the pinion returns immediately when it is released.



Return test

**2.6.3 No load test****CAUTION**

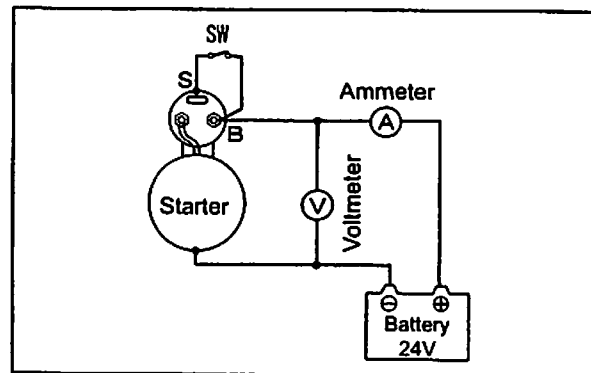
Use as thick a wire as possible and firmly tighten each terminal.

When detecting the rotation at the tip of the pinion, be careful that the pinion springs out during operation.

(1) Connect the starter to the circuit as shown in the illustration.

(2) The starter is normal if the pinion jumps out when the switch is turned ON and the starter rotates at or above the specified rotation speed.

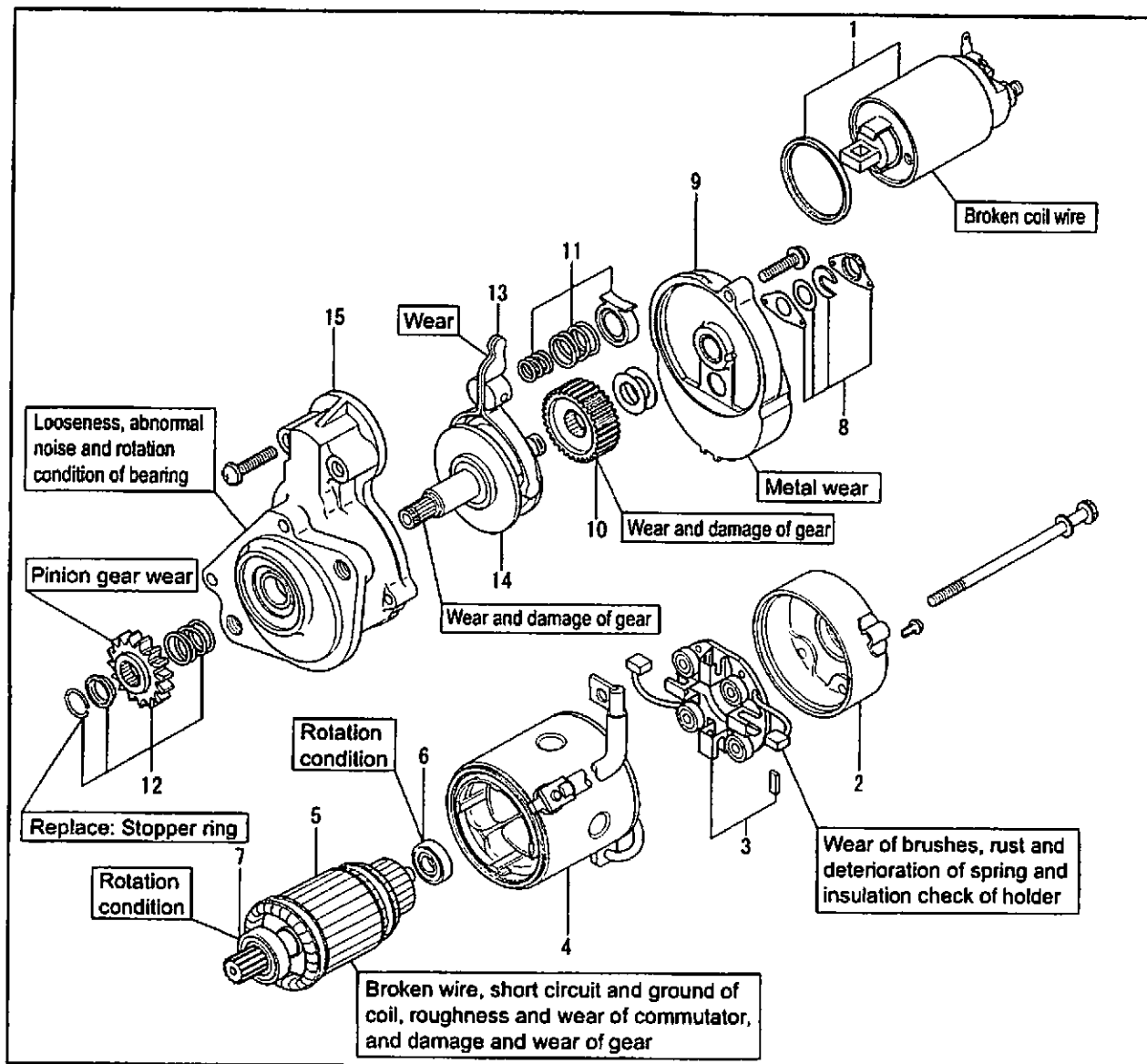
Disassemble, inspect and repair the starter if the terminal voltage, current or rotation speed does not meet the standard.



Test at no load

Item		Standard
Starter model		M002T66071
Nominal output V-kW		24-3.2
No-load characteristics	Terminal voltage V	23
	Current A	80 or less
	Rotation speed min <sup>-1</sup>	3400 or more

## 2.7 Disassembling and inspecting starter (M002T66071(24 V-3.2 kW))



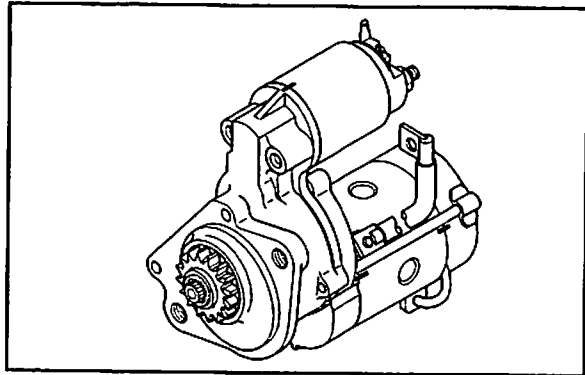
Disassembling and inspecting starter (M002T66071(24 V-3.2 kW))

## Disassembly sequence

- |                          |                   |                  |
|--------------------------|-------------------|------------------|
| 1 Magnet switch          | 6 Rear bearing    | 11 Spring set    |
| 2 Rear bracket           | 7 Front bearing   | 12 Pinion set    |
| 3 Brush and brush holder | 8 Cover set       | 13 Lever         |
| 4 Yoke                   | 9 Center bracket  | 14 Pinion shaft  |
| 5 Armature               | 10 Reduction gear | 15 Front bracket |

### 2.7.1 Preparation before disassembling

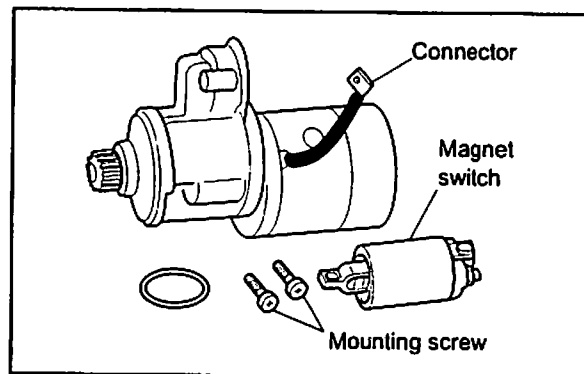
Mark the mating marks on magnet switch, front bracket, center bracket, yoke and rear bracket to each other for reassembly.



Preparation before disassembling

### 2.7.2 Removing magnet switch

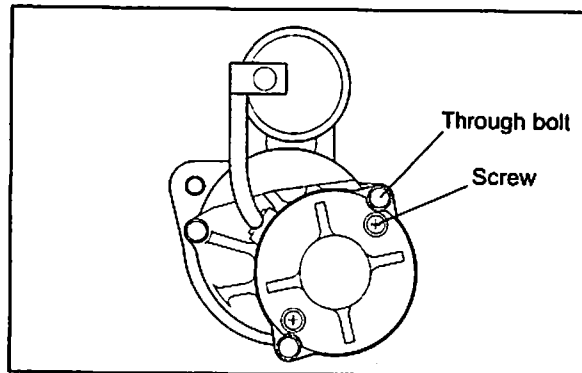
Remove the lead, and remove the magnet switch.



Removing magnet switch

### 2.7.3 Removing rear bracket

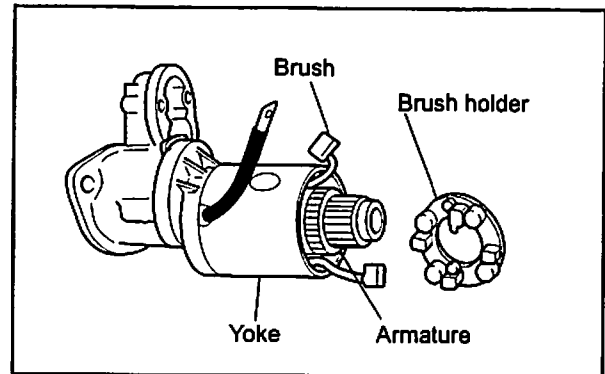
Remove the through bolts and screws of the brush holder, and then remove the rear bracket.



Removing rear bracket

### 2.7.4 Removing brushes, brush holder, yoke and armature

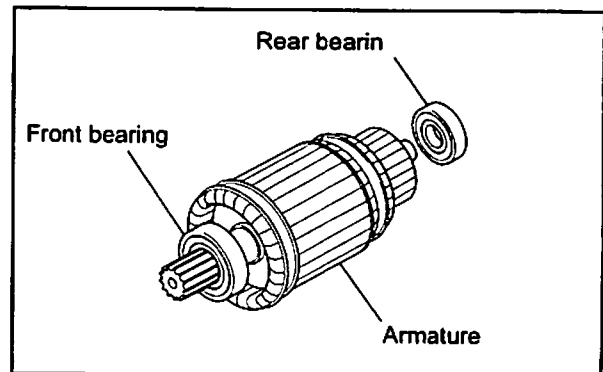
While lifting the two brushes, remove the yoke and brush holder assembly. Then, pull out the armature.



Removing brushes, brush holder, yoke and armature

### 2.7.5 Removing ball bearing

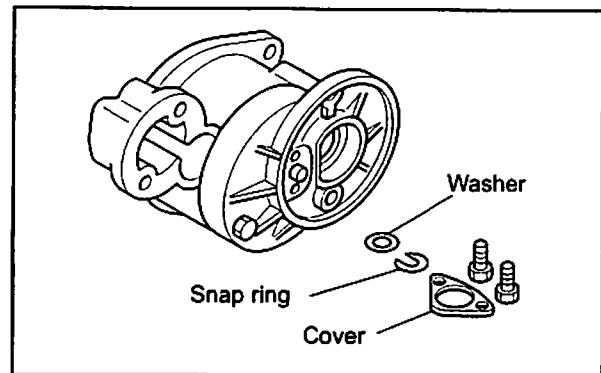
Remove the bearings from both ends of the armature with a puller.



Removing ball bearings

### 2.7.6 Removing cover set

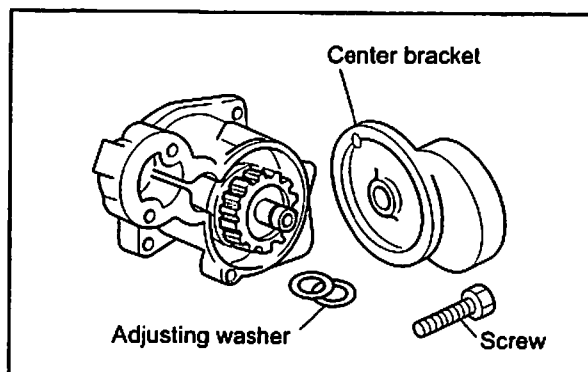
Remove the cover, and pull out the snap ring and the washer.



Removing cover

### 2.7.7 Removing center bracket

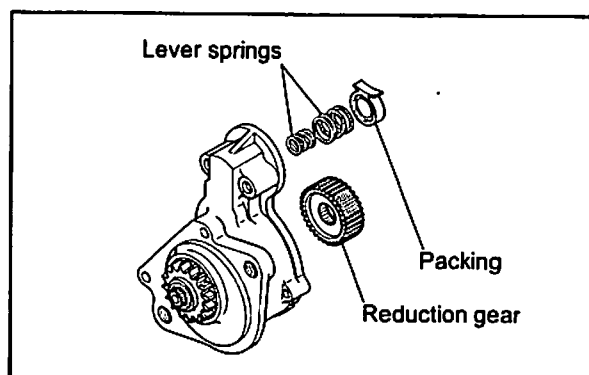
Remove the screw and then the center bracket. Removing center bracket will remove the adjusting washer for the pinion shaft end play.



Removing center bracket

### 2.7.8 Removing reduction gear and spring set

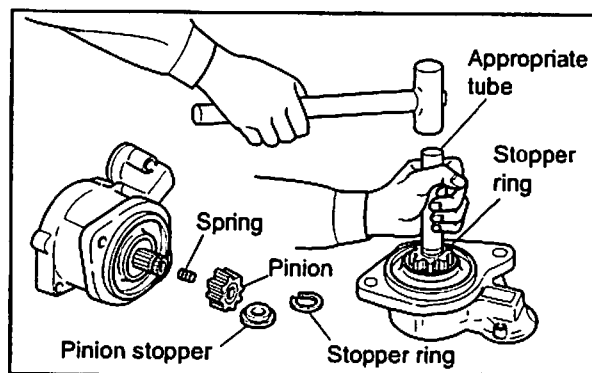
- (1) Remove the reduction gear from the pinion shaft.
- (2) Remove the packing and lever spring from the lever.



Removing reduction gear and spring set

### 2.7.9 Removing pinion set

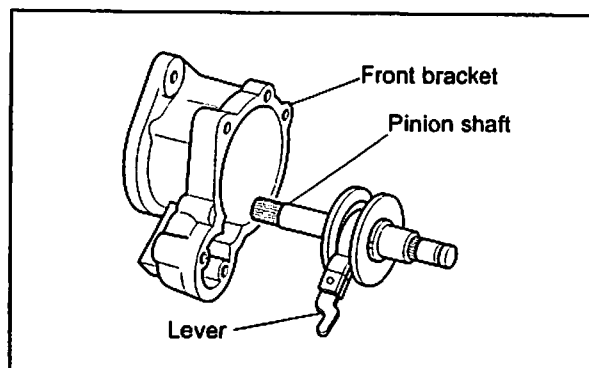
- (1) Place an appropriate tube on the pinion stopper. Tap the tube with a hammer to drop the pinion stopper to the clutch side. This will expose the stopper ring.
  - (2) Ply out the stopper ring, and remove the pinion.
- Note: Do not reuse the stopper ring for reassembly.



Removing pinion

### 2.7.10 Removing lever and pinion shaft

Pull out the lever and pinion shaft from the front bracket.



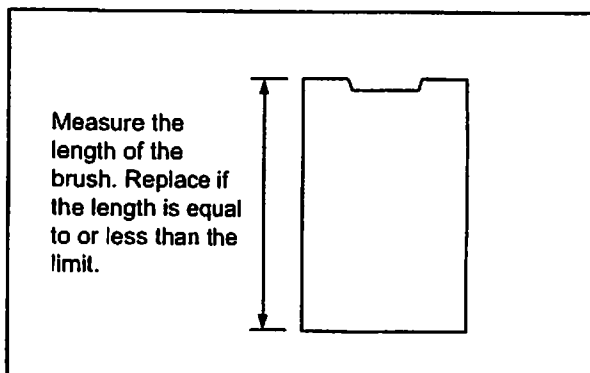
Removing pinion shaft

## 2.8 Inspecting and repairing starter (M002T66071(24 V-3.2 kW))

### 2.8.1 Inspecting brushes for wear

Measure the length of the brushes. If the measured value is less than the limit, replace both the brush holder assembly and the brush assembly.

Measurement item	Standard	Limit
Brush length	18mm [0.70866 in.]	11mm [0.43307 in.]

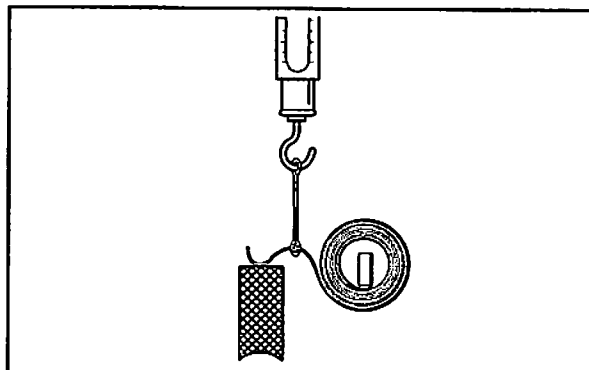


Inspecting brushes for wear

### 2.8.2 Measuring brush spring load

Using a new brush, measure the spring load at which the spring lifts from the brush. If the measured value is less than the limit, replace the spring.

Measurement item	Standard	Limit
Brush spring load	28.9 to 31.9N (2.95 to 3.99kgf) [6.50354 to 8.79631 lbf]	20N (2.04kgf) [4.49736 lbf]

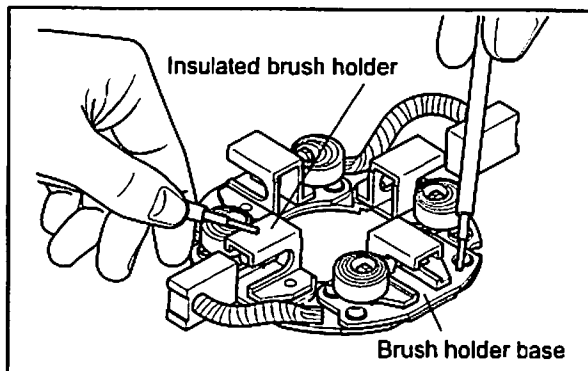


Measuring brush spring load

### 2.8.3 Checking brush holder for insulation

Check for continuity between each brush holder and the brush holder base, which must be insulated from each other. If continuity is indicated, replace the whole brush holder assembly.

Check the brush holders for looseness.

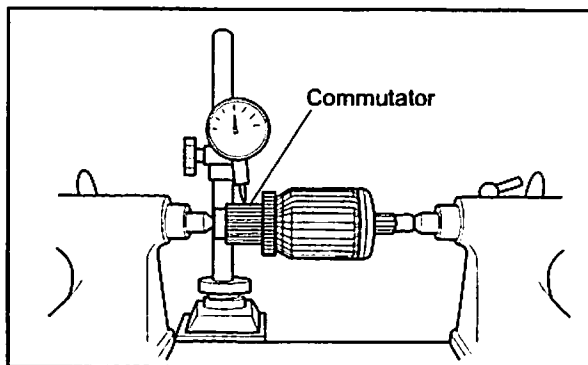


Checking brush holder for grounding

### 2.8.4 Inspecting commutator radial runout

- (1) Inspect the commutator surface. Polish it with 400 to 600 grit sandpaper if it is rough.
- (2) Measure the radial runout with a dial gage. Replace the commutator if the limit is exceeded.

Measurement item	Standard	Limit
Commutator radial runout	0.03mm [0.0012 in.]	0.10mm [0.0039 in.]



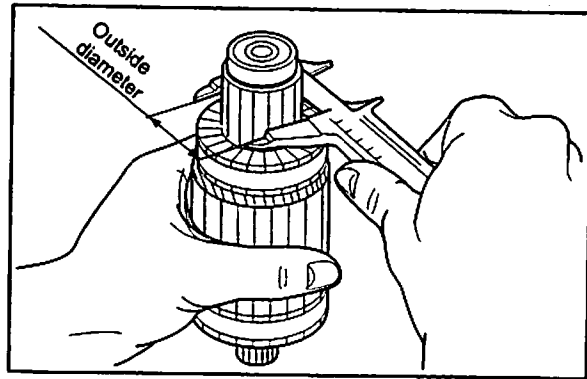
Measuring commutator radial runout

### 2.8.5 Measuring commutator outside diameter

Measure the commutator outside diameter.

If less than the limit, replace with a new part.

Measurement item	Standard	Limit
Commutator outside diameter	32.0mm [1.26 in.]	31.4mm [1.2362 in.]



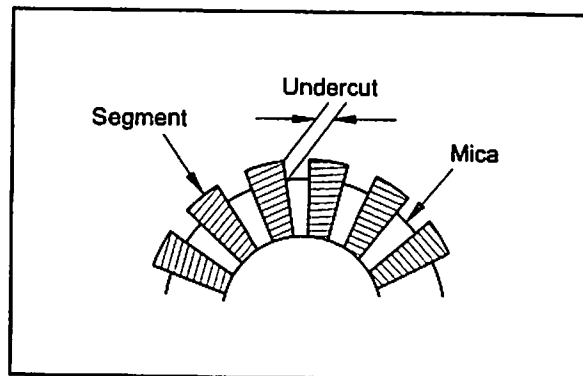
Measuring commutator outside diameter

### 2.8.6 Measuring undercutting depth between segments

Measure the depth of undercutting between the commutator segments.

If less than the limit, repair or replace with a new part.

Measurement item	Standard	Limit
Undercutting depth	0.5 to 1.0mm [0.0197 to 0.0394 in.]	0.2mm [0.00788 in.]

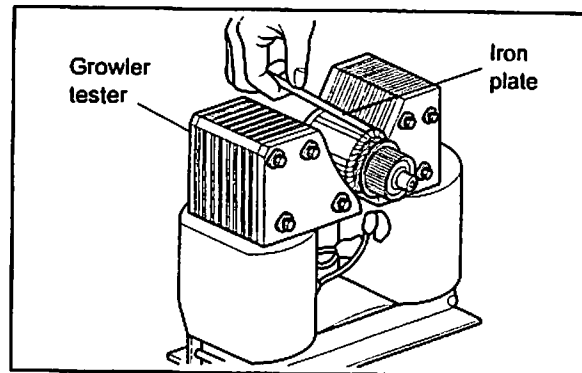


Measuring undercutting depth between segments

### 2.8.7 Checking armature coil

- (1) Inspect the armature coil using a growler.

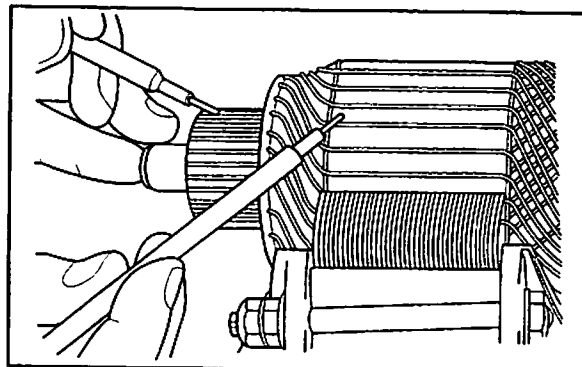
Apply an iron plate to the armature core. Replace the armature if the iron plate vibrates.



Checking armature coil for short circuit

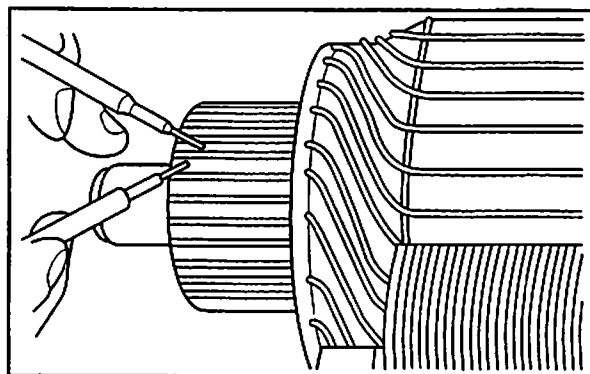
- (2) Using a tester, make sure that there is no continuity between the commutator and the shaft.

Replace the armature if continuity is indicated between the commutator and the shaft.



Checking armature coil for grounding

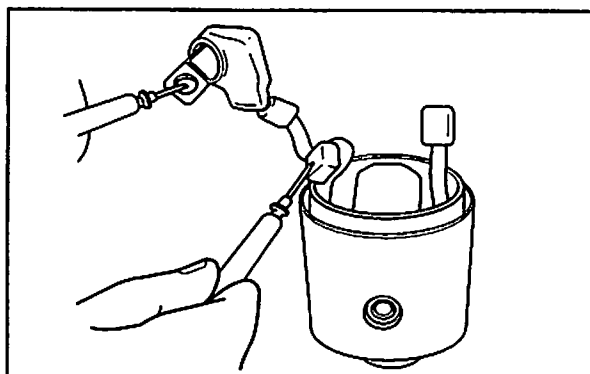
- (3) Using a tester, make sure that there is continuity between each segment.  
Replace the armature if no continuity is indicated between each segment.



Testing breaks of armature coil

### 2.8.8 Checking field coil for open circuit

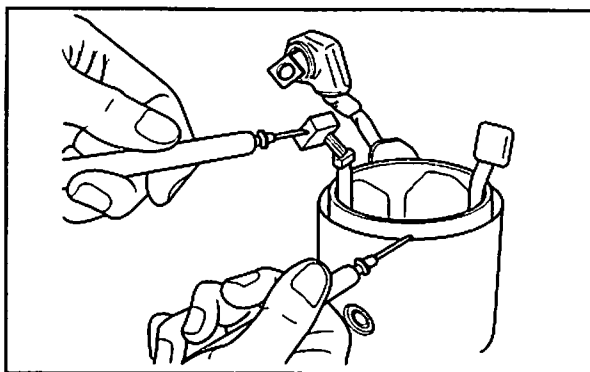
Check for continuity between the terminal lead wire and the brush (+). Replace the yoke assembly if no continuity (open circuit) is indicated.



Checking field coils for breaks

### 2.8.9 Checking field coil for insulation

Check for insulation between the yoke body and the brush (+). If there is continuity, the field coils are short-circuited. Check the insulation condition. If repair is impossible, replace the yoke assembly.



Checking field coils for grounding

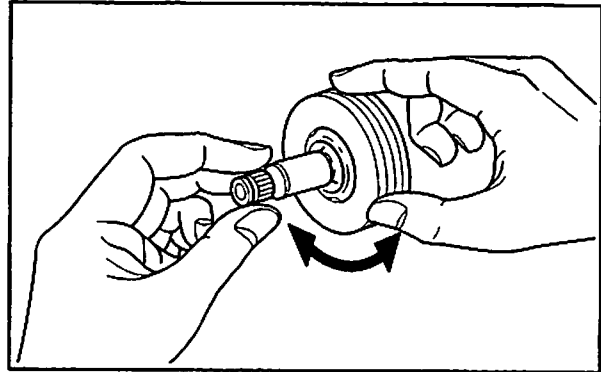
### 2.8.10 Inspecting center bracket

Check the bearing. Replace the center bracket if the bearing is worn.

**2.8.11 Inspecting overrunning clutch****CAUTION**

Do not wash the overrunning clutch in wash oil.

Make sure that the overrunning clutch locks when the shaft rotates in one direction and that it rotates smoothly when the shaft rotates in the reverse direction.



Inspecting overrunning clutch

**2.8.12 Inspecting pinion**

Check the pinion for wear and damage.

If faulty, replace the pinion.

**2.8.13 Inspecting front bracket**

The ball bearing should rotate smoothly without abnormal noise. If faulty, replace the whole front bracket.

**2.8.14 Inspecting gears of starter**

Check gears of the starter for wear or damage. If faulty, replace the starter.

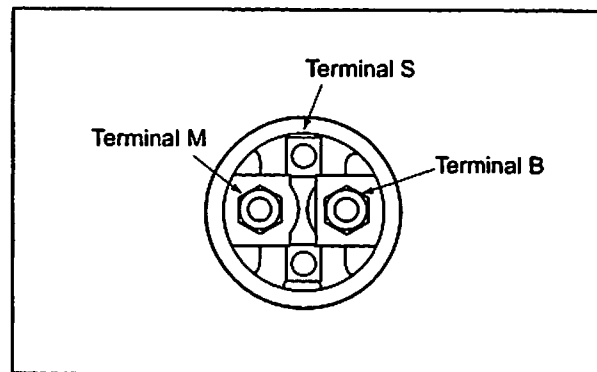
**2.8.15 Checking magnet switch for continuity**

Check for continuity between terminal M and the body.

Replace the magnet switch if no continuity is indicated.

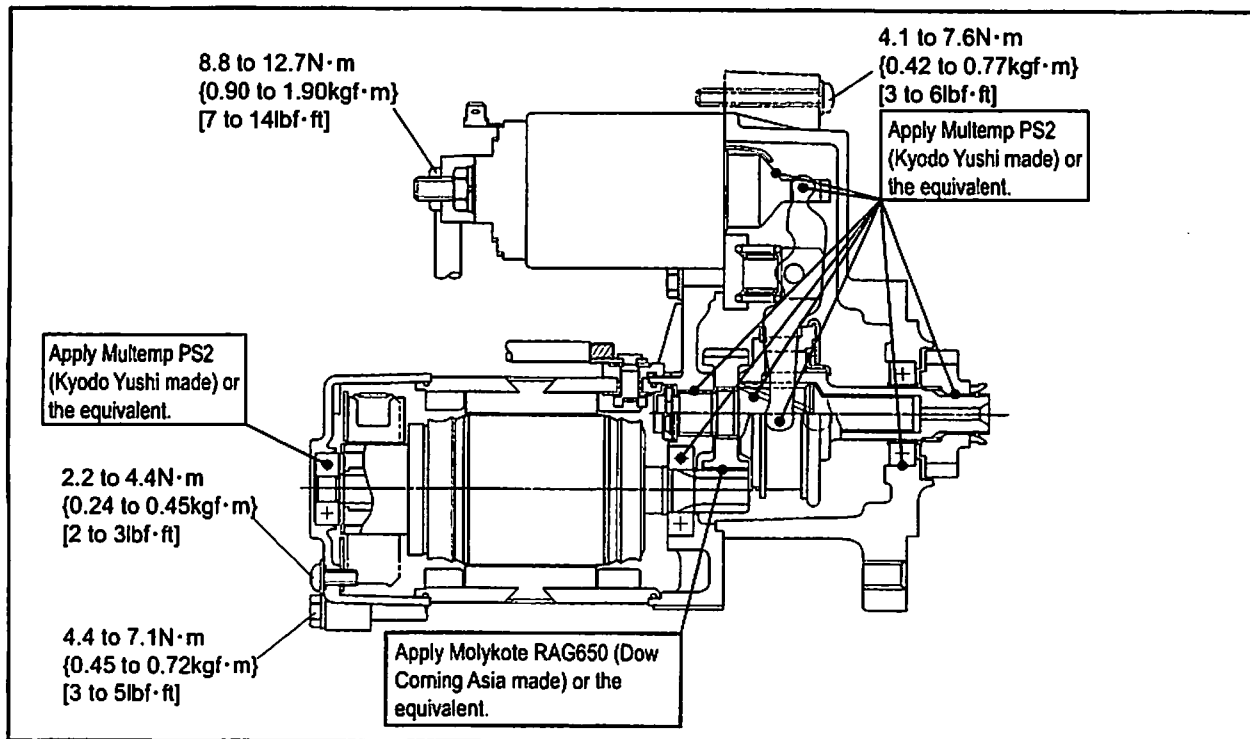
Check for continuity between terminal B and terminal M.

Replace the magnet switch if continuity is indicated.



Checking magnet switch for continuity

## 2.9 Reassembling starter (M002T66071(24 V-3.2 kW))



Reassembling starter (M002T66071(24 V-3.2 kW))

### 2.9.1 Applying grease

#### CAUTION

- To avoid mixing of different greases, remove old grease before applying new grease.
- Make sure that the starter mounting surface, brushes, commutator and other electric current conducting components are free from grease.

When overhauling the starter, apply grease to sliding surfaces, gears and bearings in the following:

#### (1) Parts or areas to which Multemp PS2 (Kyodo Yushi made) or the equivalent is applied

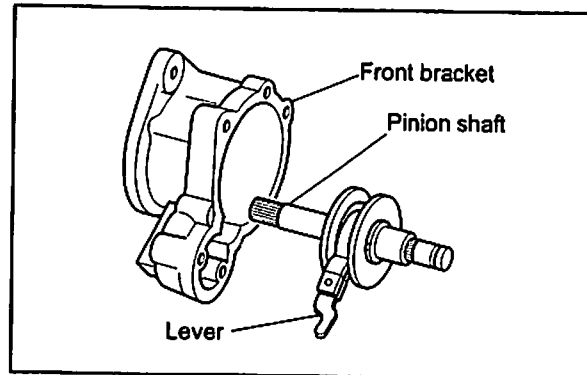
Plunger surface (a small amount)	Sliding area between lever and pinion shaft
Lever (at the point of contact with plunger and point of support)	Front bearing of armature shaft
Shaft sliding area of pinion shaft	Rear bearing of armature shaft
Pinion gear fitting surface	Center bracket bearing
Pinion shaft spline	

#### (2) Parts to which Molykote RAG650 (Dow Corning Asia made) or the equivalent is applied

Gear shaft, gear and internal gear of armature

### 2.9.2 Installing lever and pinion shaft

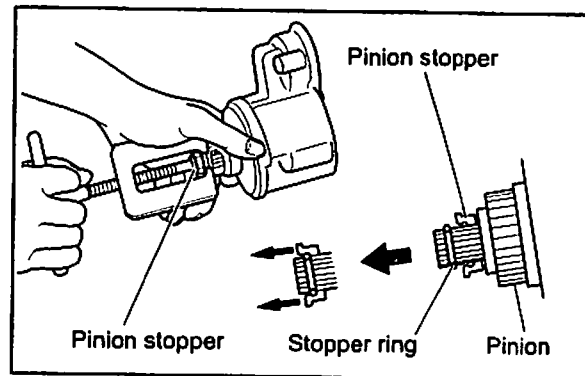
Reassemble the lever to the pinion shaft and insert them into the front bracket.



Installing pinion shaft

### 2.9.3 Installing pinion

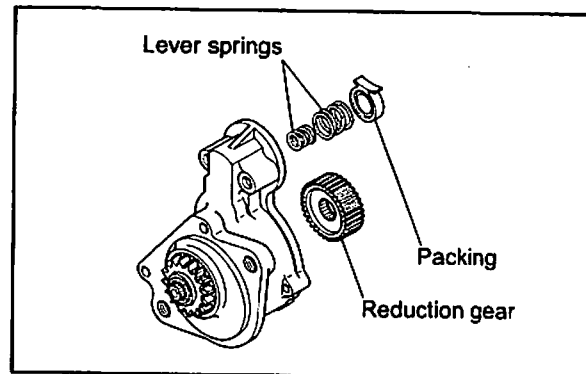
- (1) Install the spring, pinion and pinion stopper on the pinion shaft.
- (2) Install a stopper ring into the ring groove on the pinion shaft. Using a puller, pull the pinion stopper until its groove engages with the stopper ring.



Installing pinion

### 2.9.4 Installing spring set and reduction gear

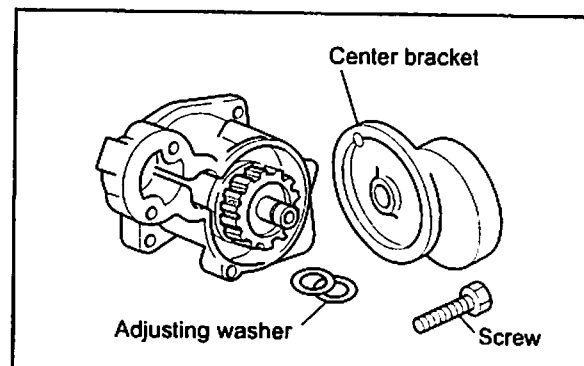
- (1) Install the two lever springs and packing on the lever.
- (2) Install the reduction gear on the pinion shaft.



Installing spring set and reduction gear

### 2.9.5 Installing center bracket

Install adjusting washers on the pinion shaft and secure the center bracket with a screw.

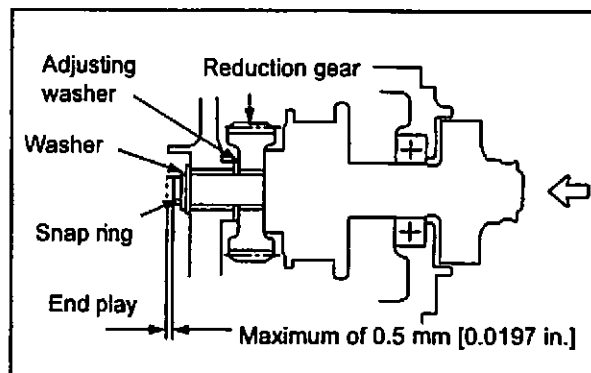


Installing center bracket

### 2.9.6 Adjusting pinion shaft end play

Adjust the end play (thrust gap) to 0.5 mm [0.0197 in.] or less by inserting adjusting washers between the center bracket and reduction gear.

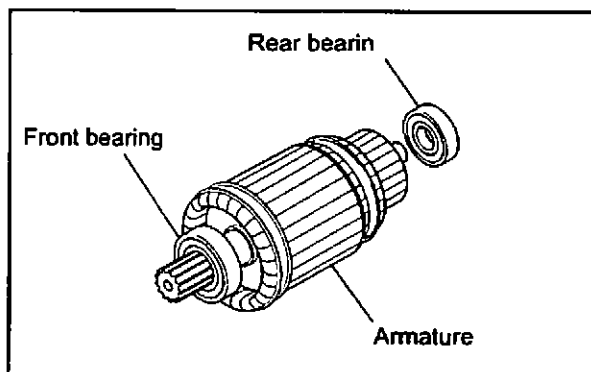
- (1) Install the pinion shaft, reduction gear, washer and snap ring onto the center bracket.
- (2) Measure the pinion shaft end play by moving the shaft in the axial direction.  
If the end play measurement exceeds 0.5 mm [0.0197 in.], make an adjustment by adding adjusting washer(s).



Adjusting pinion shaft end play

### 2.9.7 Installing bearing

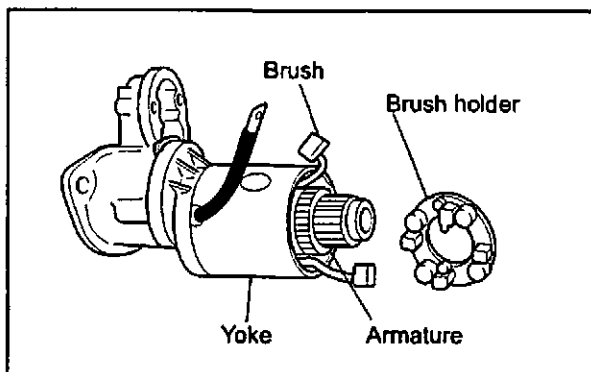
Install the bearings on both ends of the armature.



Installing bearings

### 2.9.8 Installing armature, yoke, brushes and holder

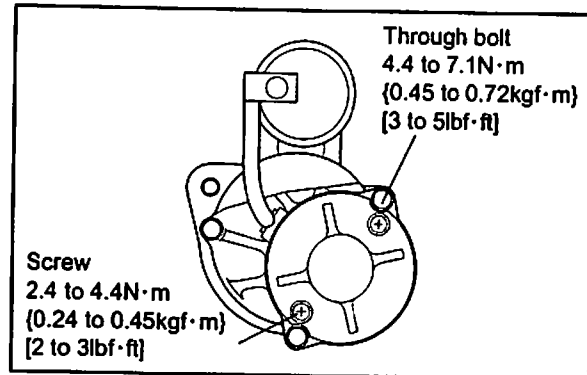
- (1) Align the knock pin with the center bracket and reassemble the armature to the yoke.
- (2) Reassemble the brush holder and brushes.



Installing brush holder

### 2.9.9 Installing rear bracket

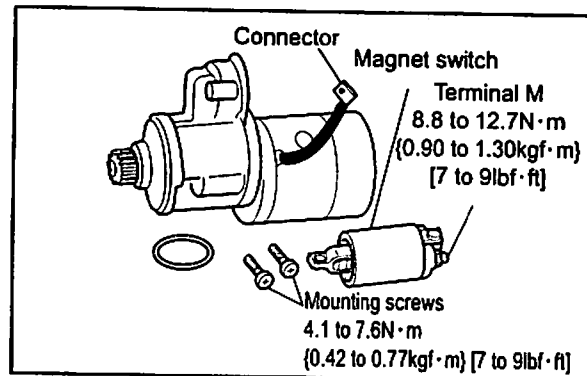
Install the rear bracket to the yoke and tighten the through bolt and screws of the brush holder.



Installing rear bracket

### 2.9.10 Installing magnet switch

- (1) Install the magnet switch and tighten the screws.
- (2) Connect terminal M and tighten fixing nuts.



Installing magnet switch

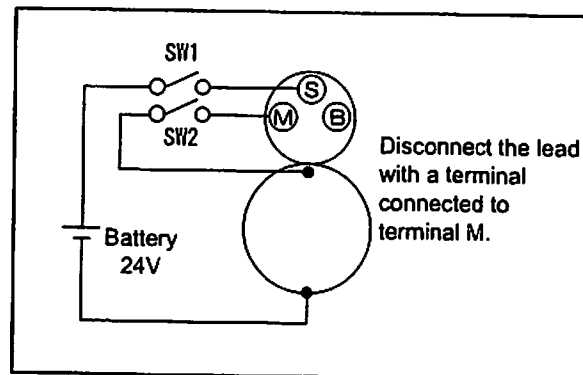
### 2.9.11 Inspecting pinion clearance

#### CAUTION

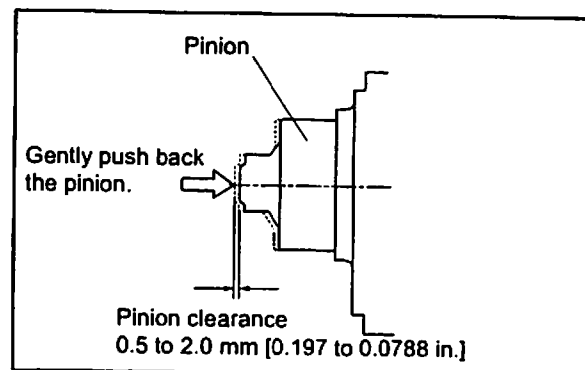
Do not apply current continuously for 10 seconds or longer.

- (1) Connect the starter to the circuit as shown in the illustration.
- (2) When the switches SW1 and SW2 are turned ON, the pinion springs out to the cranking position and the armature rotates.
- (3) Turn the switch SW2 OFF to stop the rotation of the armature.
- (4) Gently push back the pinion in the out position with a finger and measure the distance over which the pinion has returned (movement amount).
- (5) If the measured value is out of the standard, increase or decrease the number of packings between the magnet switch and the front bracket for adjustment, or replace the lever with a new one.

Note: When the number of packings is increased, the pinion clearance becomes small.



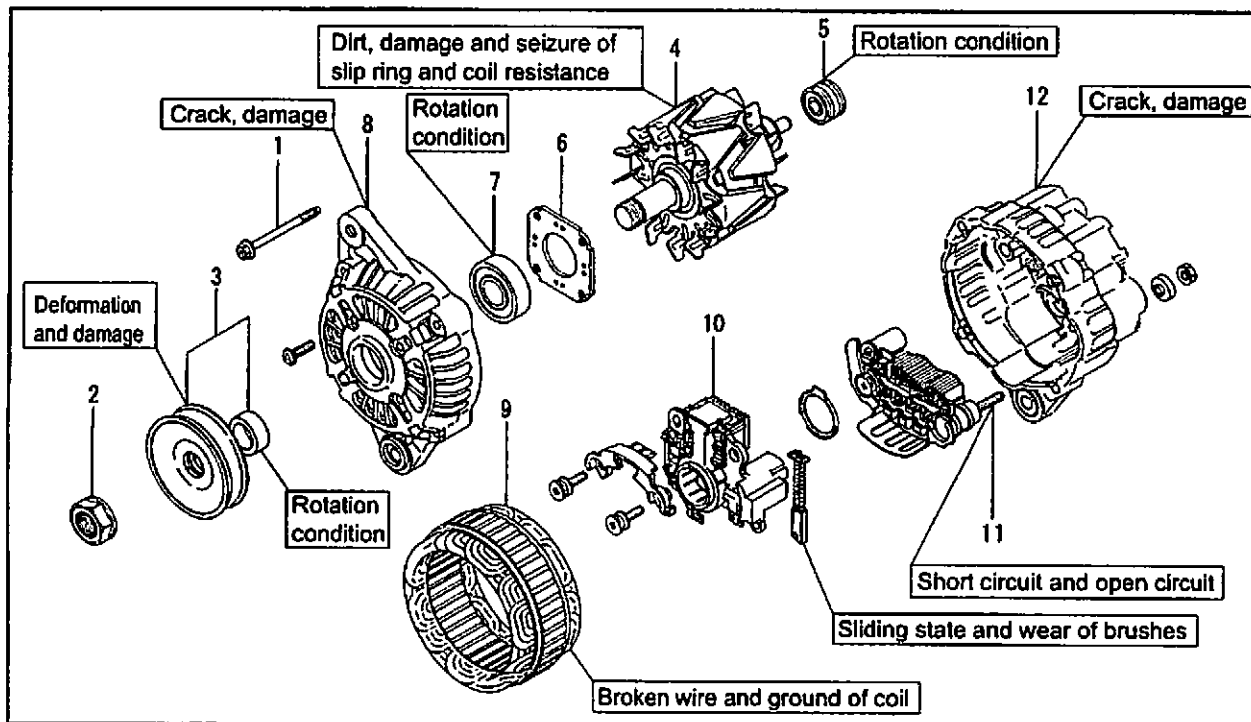
Wiring during inspection of pinion clearance



Inspecting pinion clearance

Measurement item	Standard
Pinion clearance	0.5 to 2.0mm [0.0197 to 0.0788 in.]

## 2.10 Disassembling and inspecting alternator



Disassembling and inspecting alternator

### Disassembling sequence

- |                  |                    |                       |
|------------------|--------------------|-----------------------|
| 1 Through bolt   | 5 Rear bearing     | 9 Stator              |
| 2 Nut            | 6 Bearing retainer | 10 Regulator assembly |
| 3 Pulley, spacer | 7 Front bearing    | 11 Rectifier assembly |
| 4 Rotor          | 8 Front bracket    | 12 Rear bracket       |

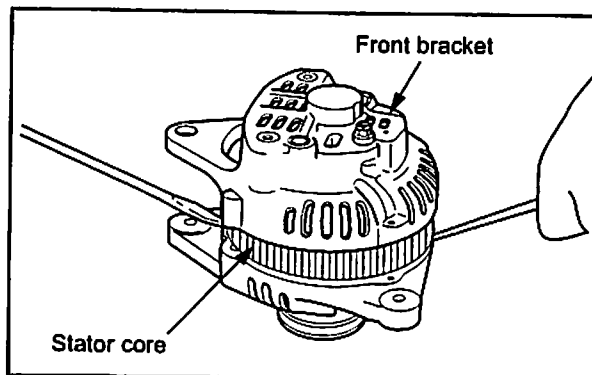
### 2.10.1 Separating front bracket from stator

#### CAUTION

Disassemble the alternator only when the repair is required.

Do not insert the screwdrivers too deep; it can damage the stator.

- (1) Remove the through bolts.
- (2) With two flat-head screwdrivers inserted between the front bracket and stator, pry and move them away from each other.



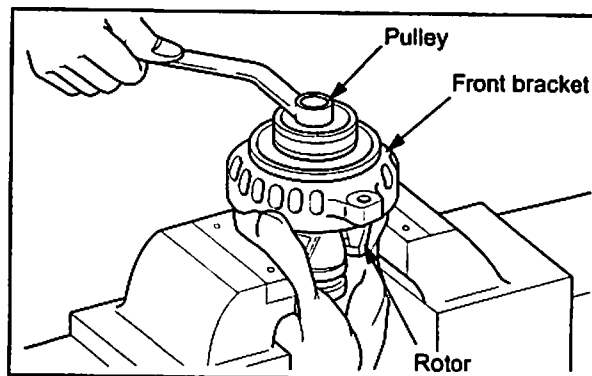
Separating front bracket from stator

### 2.10.2 Removing pulley

#### CAUTION

When securing the rotor with a vise, be sure to hold the base of the rotor claw. Holding the rotor claw will cause damage.

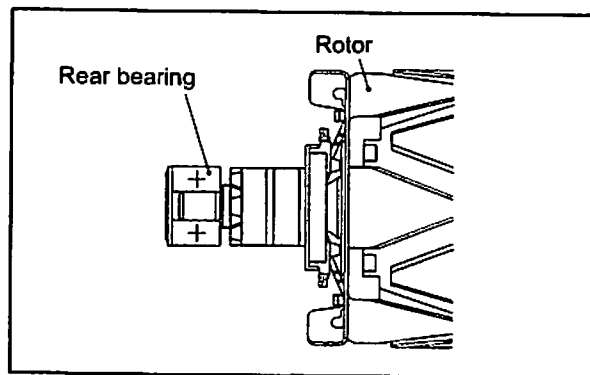
- (1) Apply a cloth to the rotor and secure it with a vise.
- (2) Remove the pulley nut and then pull out the pulley.



Removing pulley

### 2.10.3 Removing rear bearing

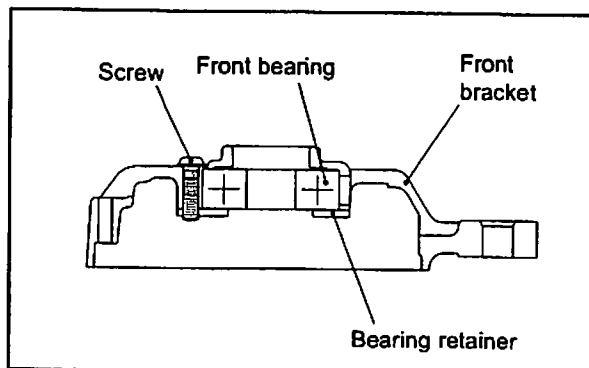
Remove the rear bearing from the rotor using a bearing puller.



Removing rear bearing

### 2.10.4 Removing front bearing

Remove the screw, and then remove the bearing retainer and front bearing from the front bracket.



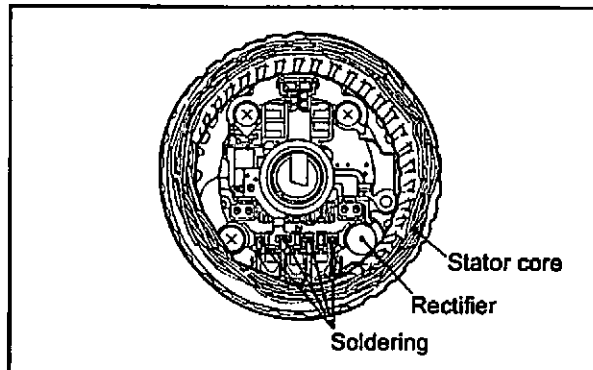
Removing front bearing

### 2.10.5 Removing stator

#### CAUTION

Unsoldering must be finished as quickly as possible.  
Extended heating will damage the diodes.

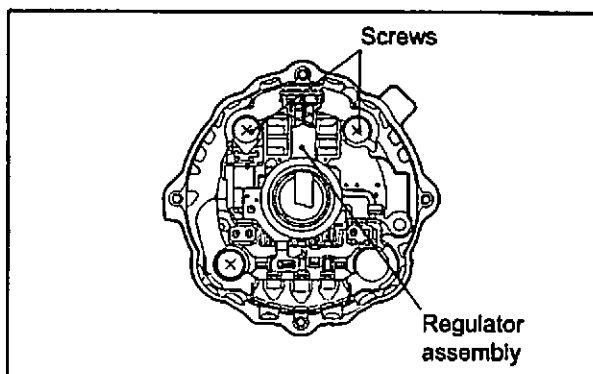
Cut off the joint of the stator and remove the stator from the rectifier.



Removing stator

### 2.10.6 Removing regulator assembly

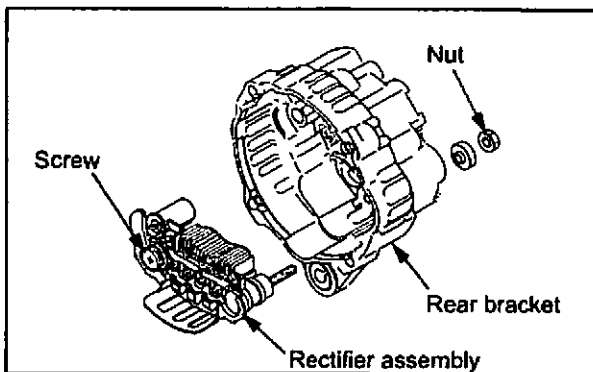
Remove the screws of the regulator assembly and then remove the regulator assembly.



Removing regulator assembly

### 2.10.7 Removing rectifier assembly

Remove the screw and nuts of the rectifier and then remove the rectifier assembly.



Removing rectifier assembly

## 2.11 Inspecting and repairing alternator

### 2.11.1 Checking rectifier

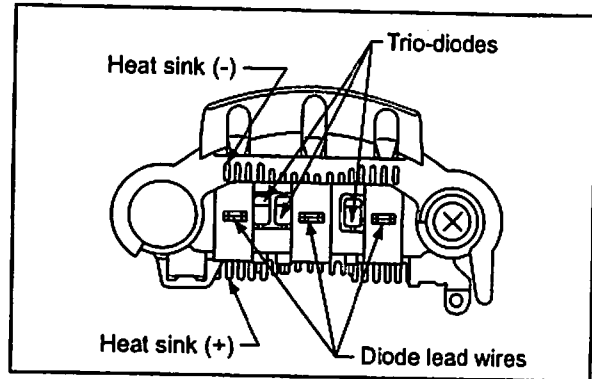
Test each of the rectifier diodes for continuity as follows:

- (1) Check for continuity between the diode lead terminal and the casing of that diode with a tester.

Check the continuity by alternating positive (+) and negative (-) of tester. A large resistance should be indicated in one direction and a small resistance in the opposite direction when it is normal.

- (2) If the same level of resistance is indicated in both directions, replace the rectifier.

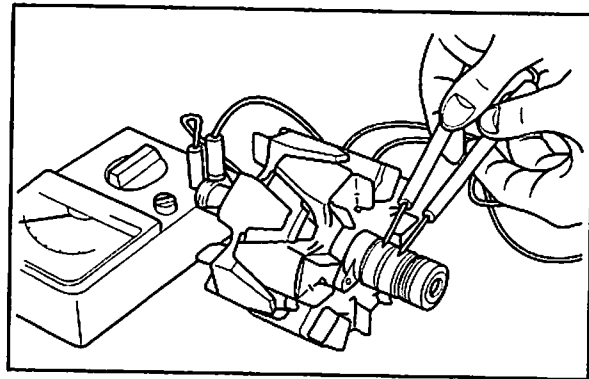
Perform this test on all diodes.



Checking rectifier

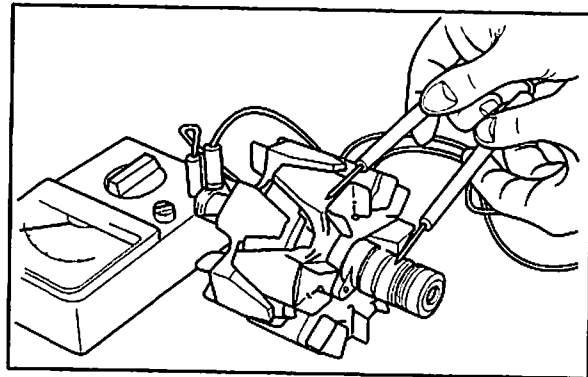
### 2.11.2 Checking field coil

- (1) Check for continuity between the slip rings. Replace the field coil if no continuity (open circuit) is indicated.



Checking field coils for continuity

- (2) Check for continuity between each slip ring and the shaft (or the core). Replace the field coil if continuity is indicated.



Checking field coils for grounding

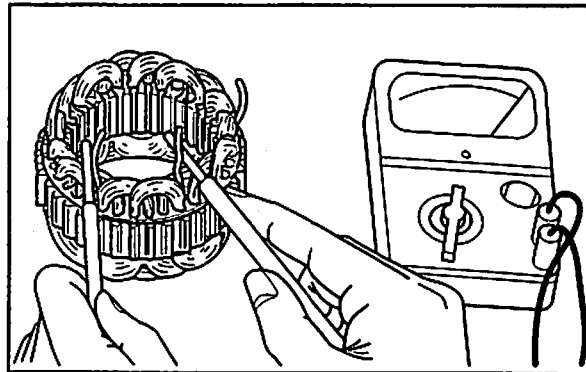
## 2.11.3 Checking stator

### (1) Checking for continuity between leads

Continuity should be indicated between a pair of lead wires.

No continuity should be indicated between leads.

Replace the stator if any abnormality is found.

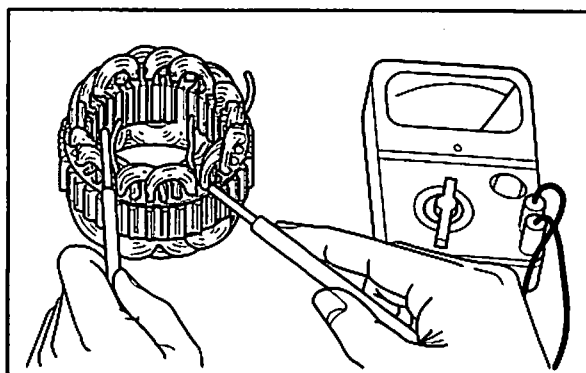


Checking for continuity between leads

### (2) Checking for insulation between the leads and the core

Check for insulation between each lead and the stator core. Replace the stator if continuity is indicated.

Note: The core cannot be replaced as a discrete unit.

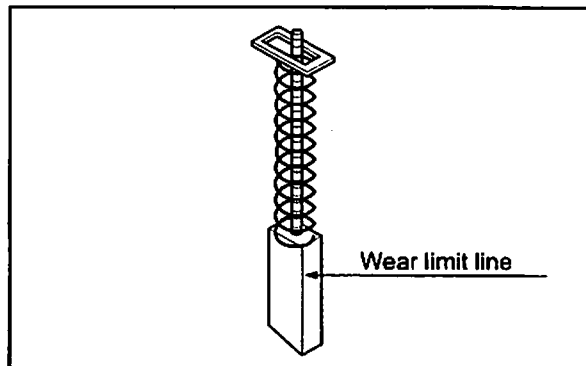


Checking for grounding between the leads and the core

## 2.11.4 Inspecting brushes for wear

Measure the length of the brushes. If the measured value is less than the limit, replace both the brush holder assembly and the brush assembly.

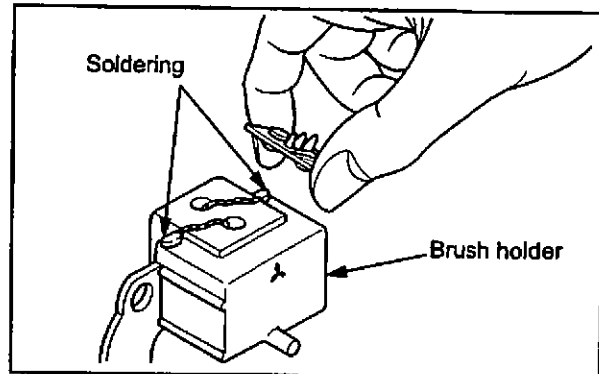
Measurement item	Standard	Limit
Brush length	18.5mm [0.728 in.]	5mm [0.197 in.]



Inspecting brushes

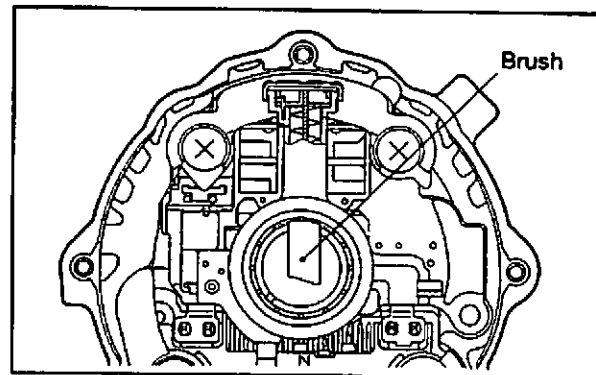
### 2.11.5 Replacing brushes

- (1) To remove the brush and the spring, unsolder the brush lead.



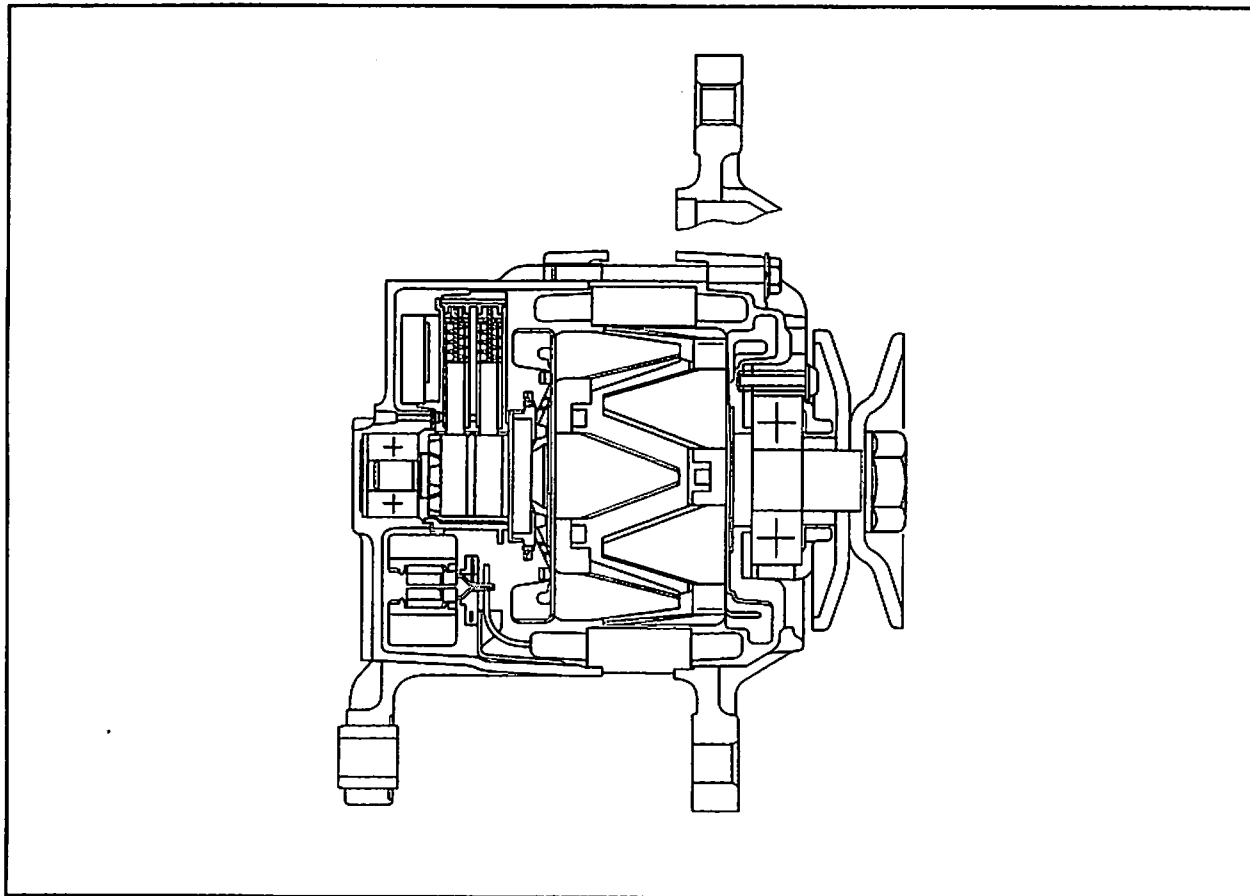
Replacing brushes

- (2) To install a new brush, push the brush into the brush holder as shown in the illustration, and then solder the lead to the brush.



Installing brushes

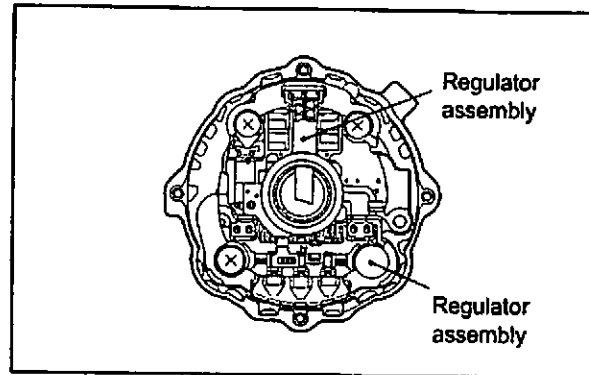
## 2.12 Reassembling alternator



Reassembling alternator

### 2.12.1 Installing rectifier assembly and regulator assembly

Install the rectifier assembly and regulator assembly on the rear bracket.



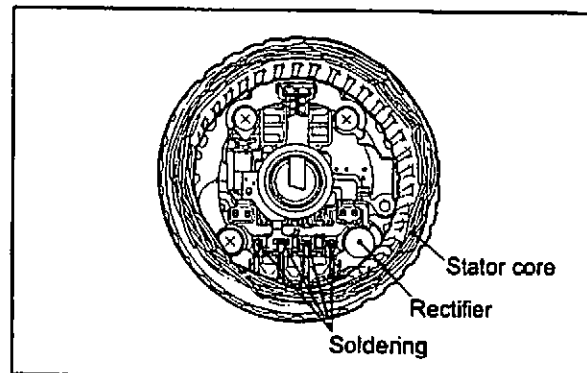
Installing rectifier assembly and regulator assembly

### 2.12.2 Installing stator

#### CAUTION

Soldering must be finished as quickly as possible.  
Extended heating will damage the diodes.

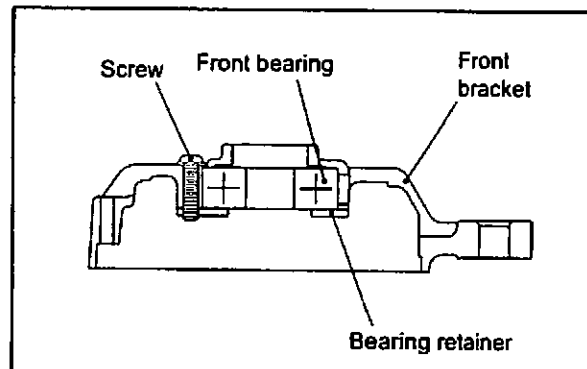
Install the stator and solder the leads of the stator to the rectifier.



Installing stator

### 2.12.3 Installing front bearing

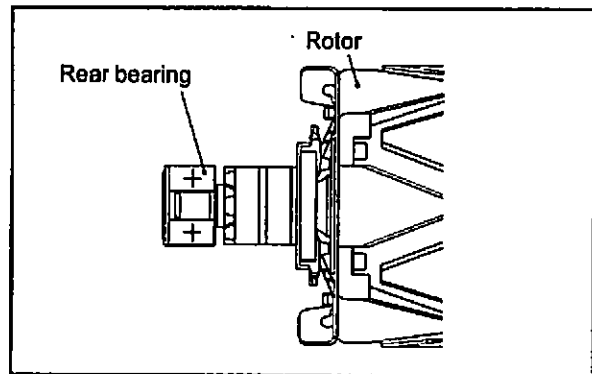
Drive the front bearing into the front bracket and secure the bearing retainer with a screw.



Installing front bearing

### 2.12.4 Installing rear bearing

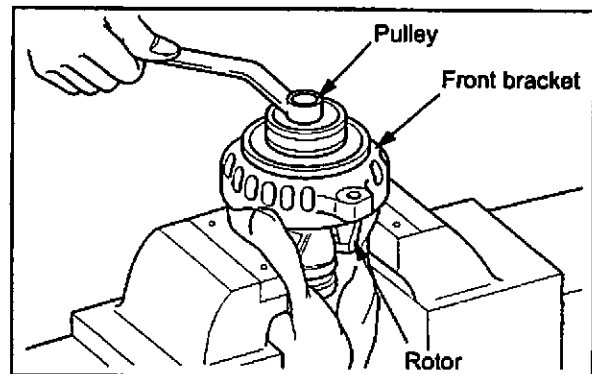
Press-fin the rear bearing to the rotor.



Installing rear bearing

### 2.12.5 Installing pulley

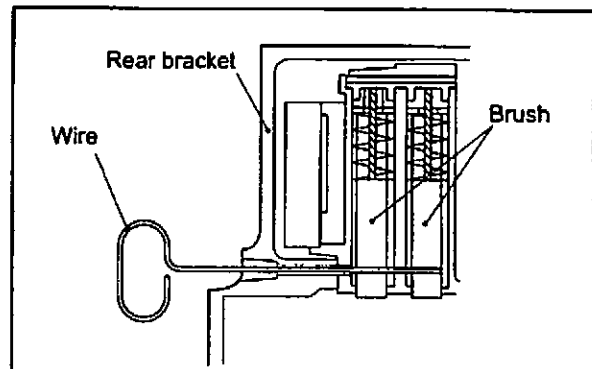
- (1) Insert the rotor into the front bracket.  
Apply a cloth to the rotor and secure it with a vise.
- (2) Install the spacer and pulley and secure the pulley with a nut.



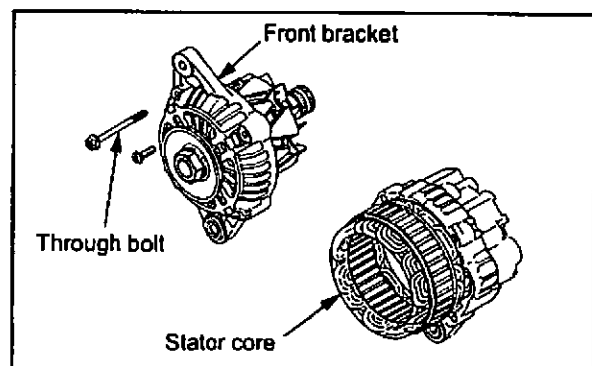
Installing pulley

### 2.12.6 Assembling stator and front bracket

- (1) When installing the rotor into the rear bracket, lift the brushes with a piece of wire inserted through the small hole in the bracket. After installation, remove the wire.
- (2) Assemble the front bracket, stator and rear bracket and secure them with through bolts.



Securing brushes

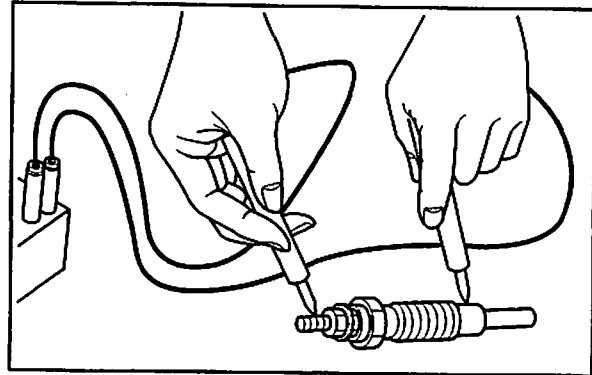


Joining stator and front bracket

### 2.13 Checking glow plug

Check for continuity between the terminal and body as shown in the illustration. Replace the glow plug if no continuity is indicated or the resistance is large.

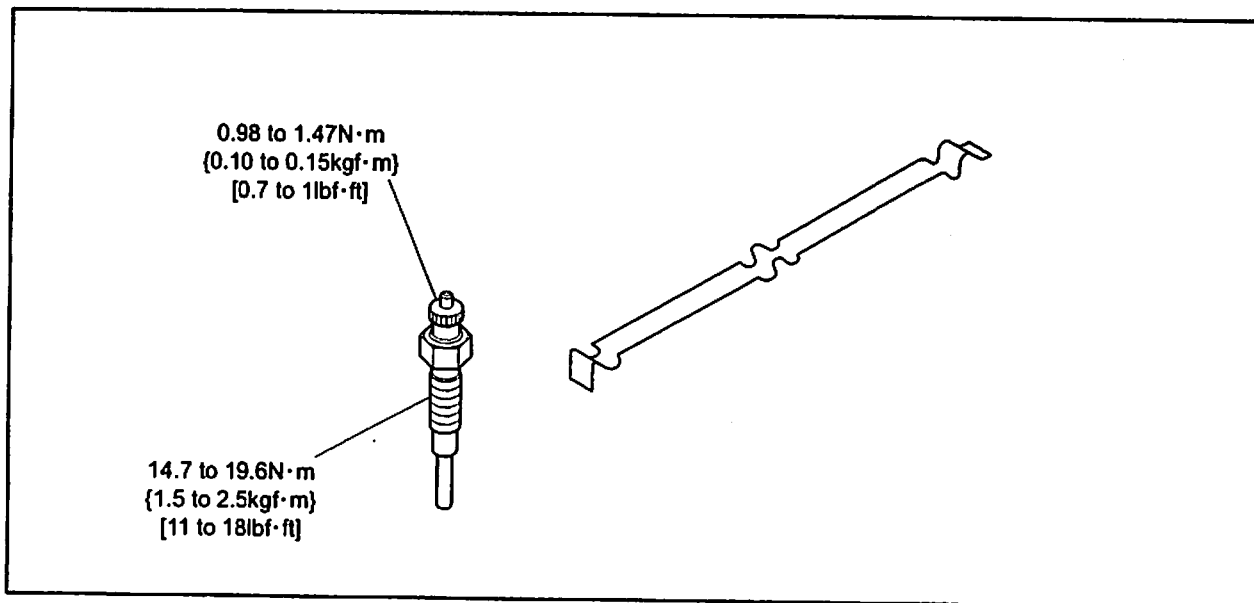
Measurement item		Standard
Resistance value	12 V	0.2 $\Omega$
	24 V	4.5 $\Omega$



Inspecting glow plug

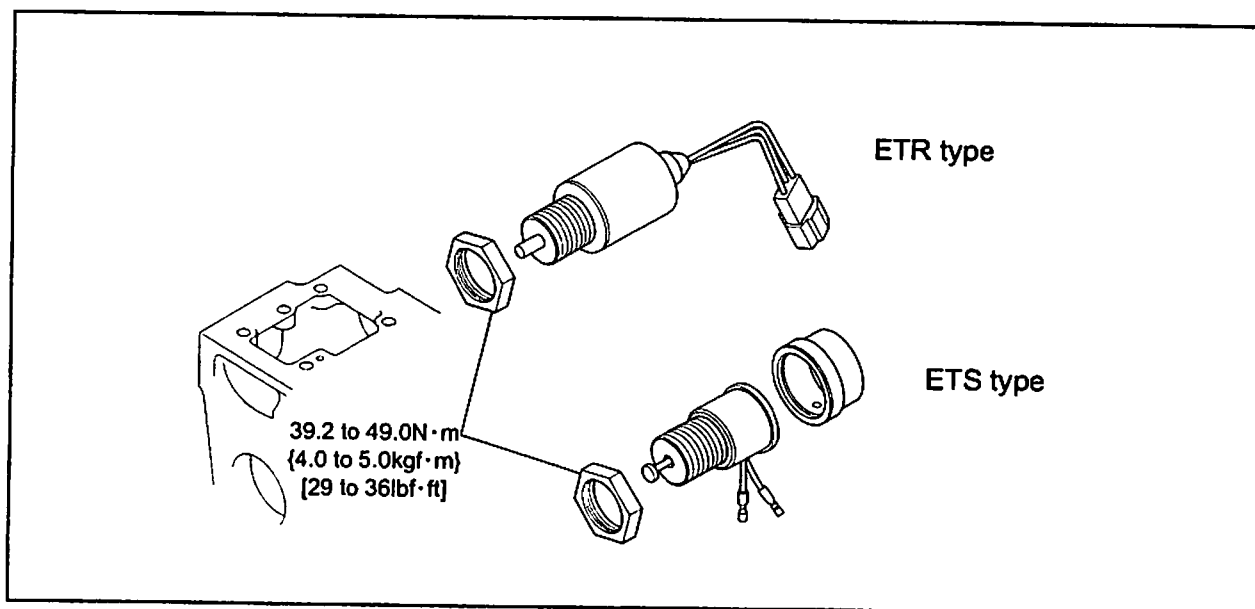
### 3. Installing electrical system

#### 3.1 Installing glow plug



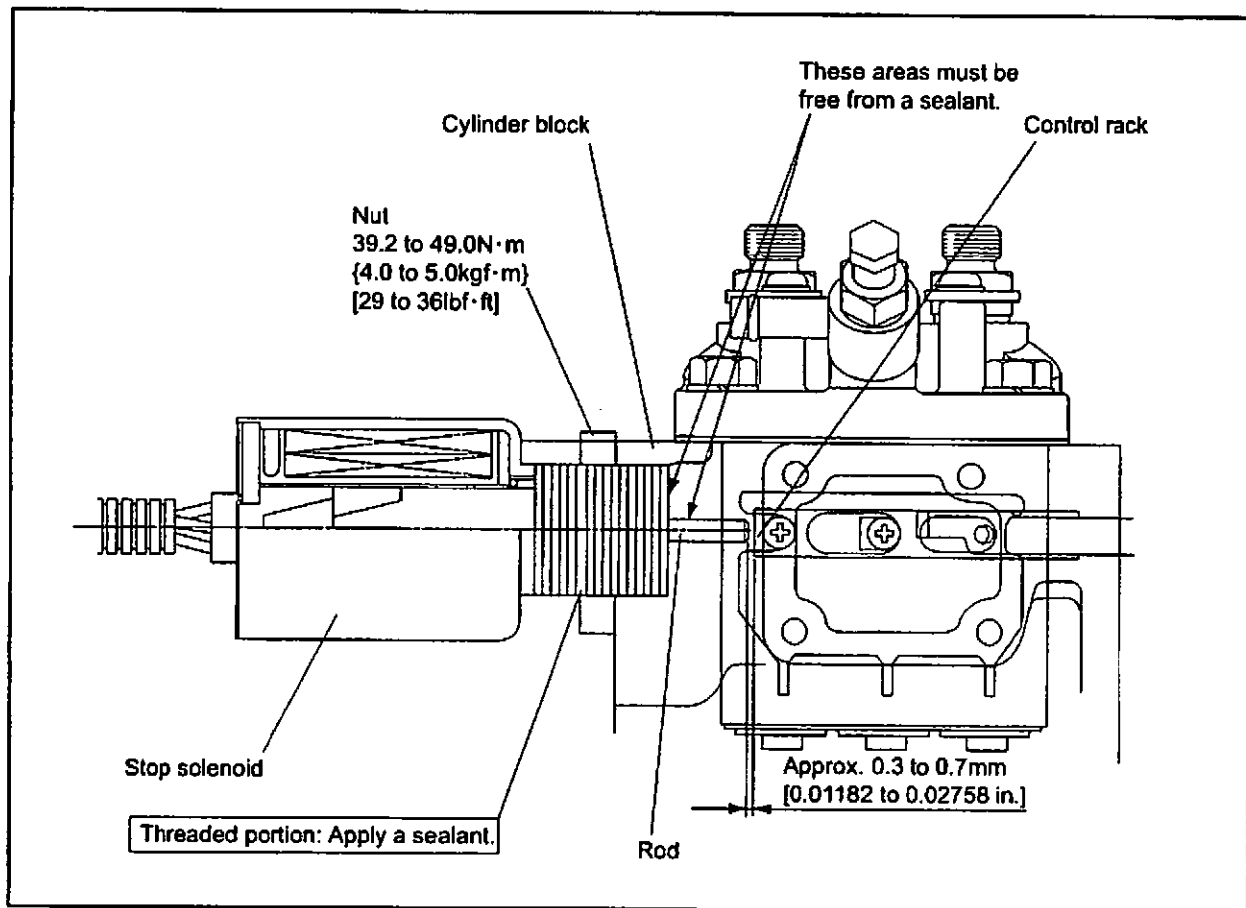
Installing glow plug

#### 3.2 Installing stop solenoid



Installing stop solenoid

### 3.3 Installing stop solenoid (ETR type)



Installing stop solenoid (ETR type)

#### 3.3.1 Procedure for installing stop solenoid (ETR type)

(1) Apply a sealant to the threaded portion of the stop solenoid.

Note: Apply the sealant up to the position where the stop solenoid is screwed into the cylinder block.

Sealant or lubricant	THREEBOND 1212 or 1211
----------------------	------------------------

(2) Temporarily reassemble the stop solenoid and the nut to the cylinder block.

(3) Move the control rack of the fuel injection pump fully in the stop direction.

(4) Screw in the stop solenoid until the rod contacts the control rack.

(5) Turn the stop solenoid in the reverse direction by 90 to 180° from the above condition and temporarily tighten the nut.

(6) Move the control rack side by side and make sure that there is play of approx. 0.3 to 0.7 mm [0.01182 to 0.02758 in.].

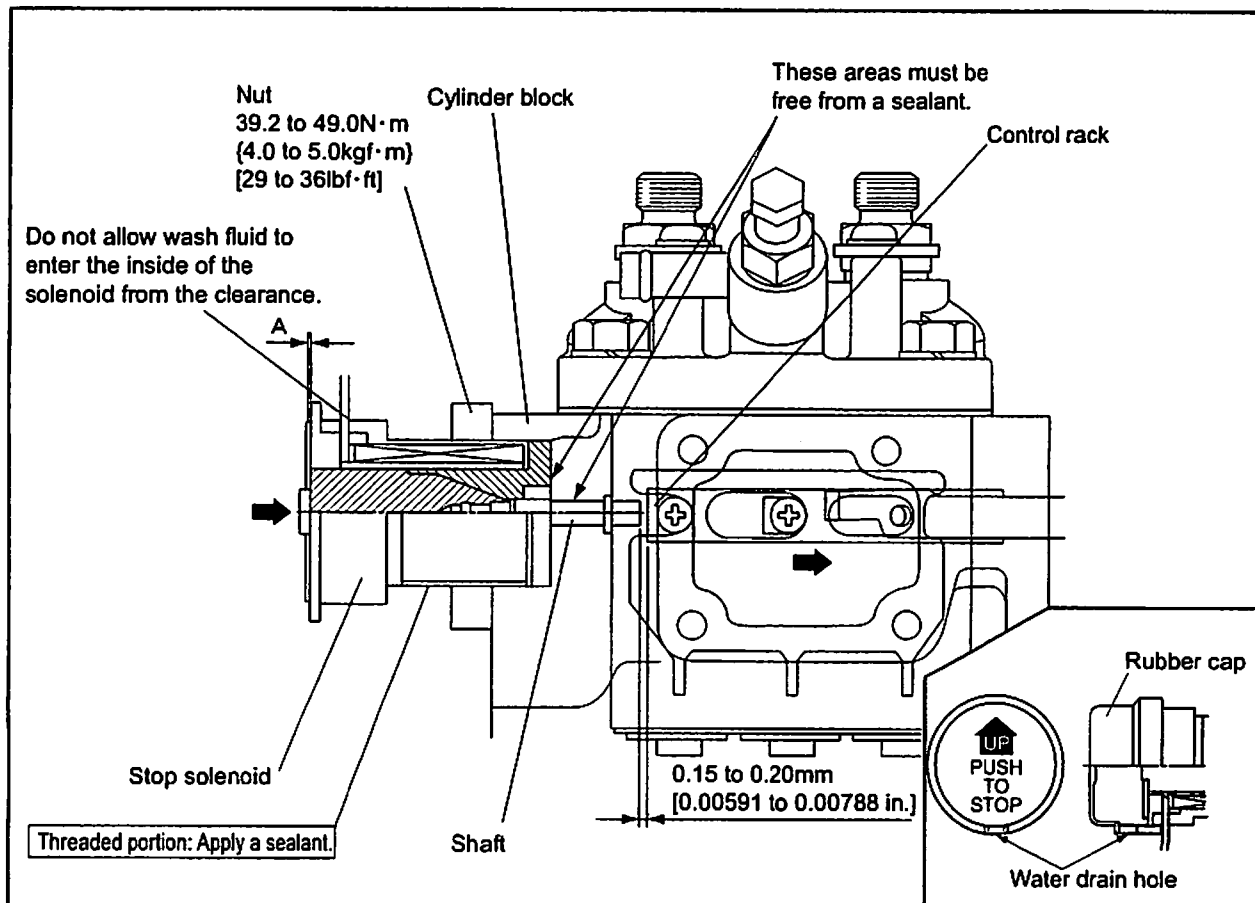
(7) Tighten the nut to the specified torque.

#### 3.3.2 Verification after reassembling (ETR type)

(1) After starting the engine, turn the starter switch key to the OFF position and make sure that the stop solenoid operates and the engine stops.

(2) After starting the engine, make a short circuit between the terminal of the oil pressure switch and the switch body and make sure that the engine stops.

### 3.4 Installing stop solenoid (ETS type)



Installing stop solenoid (ETS type)

#### 3.4.1 Procedure for installing stop solenoid (ETS type)

##### CAUTION

Do not allow wash fluid to enter the terminal and the inside (cord and shaft) of the solenoid.

(1) Apply a sealant to the threaded portion of the stop solenoid.

Note: Apply the sealant up to the position where the stop solenoid is screwed into the cylinder block.

Sealant or lubricant	THREEBOND 1212 or 1211
----------------------	------------------------

(2) Temporarily reassemble the stop solenoid and the nut to the cylinder block.

(3) Move the control rack of the fuel injection pump fully in the stop direction.

(4) Screw in the stop solenoid while pushing in the plunger until the shaft contacts the control rack.

At this time the clearance of A should be 0 mm [0 in.] (position where the plunger is also turned by screwing in the stop solenoid).

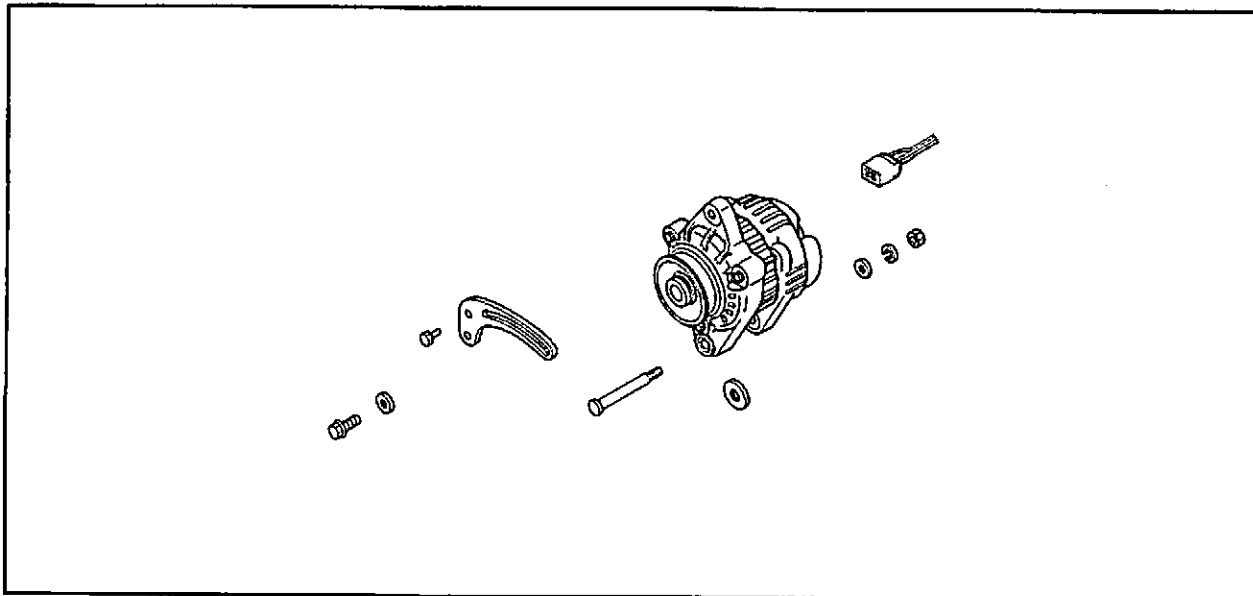
(5) Turn the stop solenoid in the reverse direction by 30 to 45° from the above condition (at this time the clearance between the control rack and shaft is 0.15 to 0.20 mm [0.00591 to 0.00788 in.]) and tighten the nut to the specified torque.

(6) Finally, reassemble the rubber cap with the arrow facing upward (water drain hole facing downward) as illustrated.

#### **3.4.2 Verification after reassembly (ETS type)**

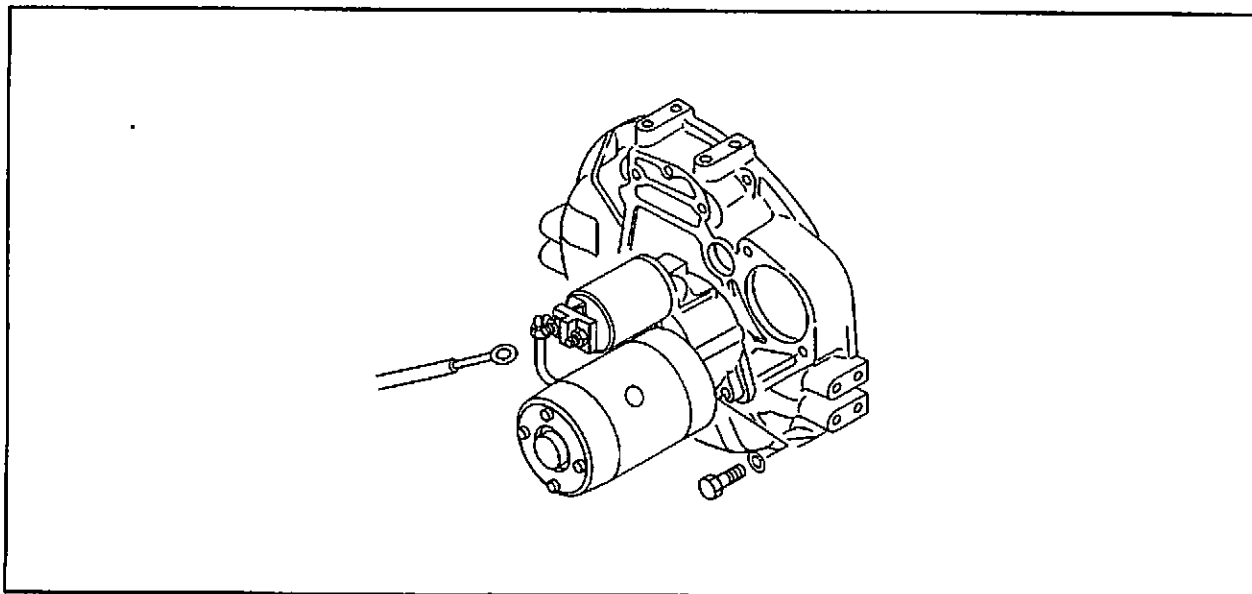
- (1) After starting the engine, turn the starter switch key to the OFF position and make sure that the solenoid operates and that the engine stops.
- (2) During engine start, turn the starter switch key to the ON position and make sure that the solenoid operates and that the engine enters a stopped state.
- (3) When turning the starter switch key from the OFF position to ON to START, make sure that the solenoid operates once with the key turned to ON and that the operation of the solenoid instantly finishes with the key turned to START.

### 3.5 Installing alternator



Installing alternator

### 3.6 Installing starter



Installing starter

# ENGINE ADJUSTMENT, BREAK-IN OPERATION AND PERFORMANCE TEST

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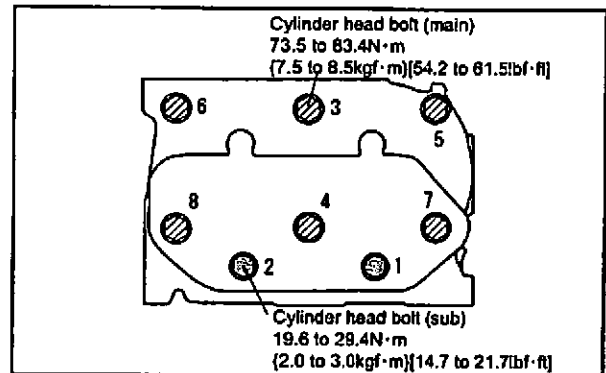
## 1. Inspection and adjustment of engine

### 1.1 Inspecting and adjusting valve clearance

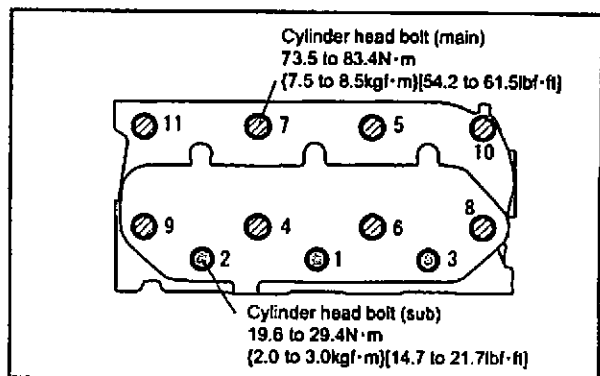
#### 1.1.1 Preparation of valve clearance inspection

- (1) Inspect and adjust the valve clearance when the engine is cold.
- (2) Slightly loosen cylinder head bolts and tighten them to the specified torque in the order as shown in the illustration.

Note: Be careful that the tightening torque of cylinder head bolts is different between main bolts and sub bolts.



Tightening order of cylinder head bolts (L2)



Tightening order of cylinder head bolts (L3)

### 1.1.2 Inspecting valve clearance

- (1) Set No. 1 cylinder to the top dead center in compression stroke.

This position is where the TDC mark on the crankshaft pulley aligns with the mark on the gear case.

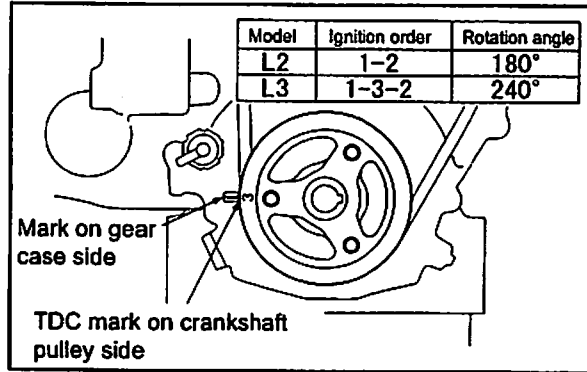
**Note:** The compression top is where the rocker arm does not move when the crankshaft is rotated in the forward and backward direction by both 20° approx.

If the rocker arm moves, it is the top dead center in exhaust stroke. Rotate the crankshaft another full turn to set the No. 1 cylinder to the top dead center in compression stroke.

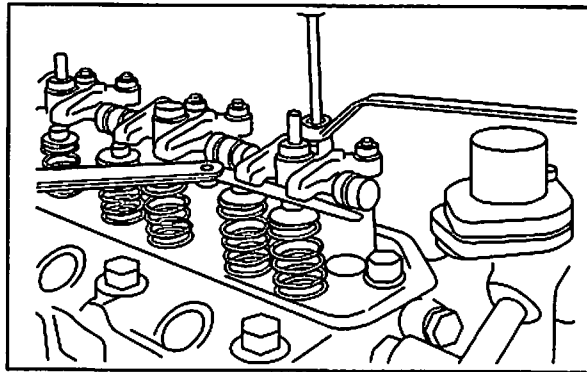
- (2) Start adjusting the valve clearance from the No. 1 cylinder and adjust the valve clearance of other cylinders according to the ignition order.

**Note:** To set the next cylinder to the compression top after adjustment of No. 1 cylinder, rotate the crankshaft in the forward direction (clockwise toward the timing gear case) by the angle corresponding to the number of cylinders.

- (3) Insert a thickness gauge between the rocker arm and bridge cap. Turn the adjusting screw while measuring the clearance, and adjust the clearance so that the thickness gauge can move with slight stiffness.
- (4) After adjustment, tighten the lock nut firmly. Then, check the clearance again.



Timing mark



Adjusting valve clearance

Measurement item		Standard
Valve clearance	Inlet	0.25mm [0.0099 in.]
	Exhaust	0.25mm [0.0099 in.]

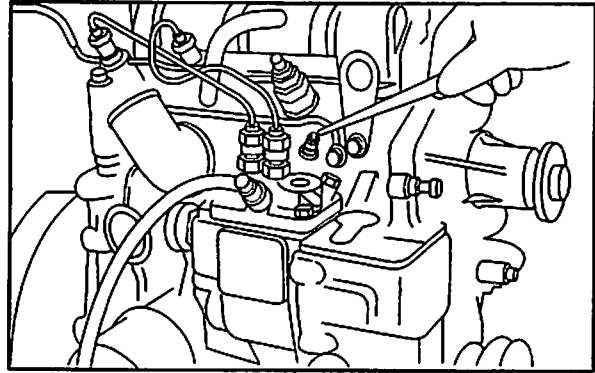
## 1.2 Inspecting fuel injection timing

### CAUTION

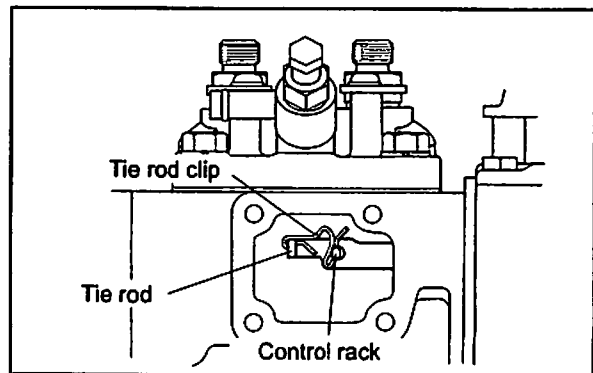
To prevent fuel leakage, stop the fuel supply before removing the delivery valve.

The fuel injection timing varies with the output, speed and other engine specifications. Be sure to check the engine's specification sheet.

- (1) Remove the No. 1 fuel injection pipe.
- (2) Remove the No. 1 delivery valve of the fuel injection pump, and install the holder again.
- (3) Remove the tie rod cover.  
Remove the tie rod clip and disconnect tie rod from the control rack.
- (4) Set the control rack to the medium position of the operating range.
- (5) Feed fuel from the fuel hose and check that the fuel flows out from the delivery holder.
- (6) Rotate the crankshaft forward (clockwise). The fuel injection timing is the moment when the fuel stops flowing from the delivery valve holder outlet.



Removing delivery valve



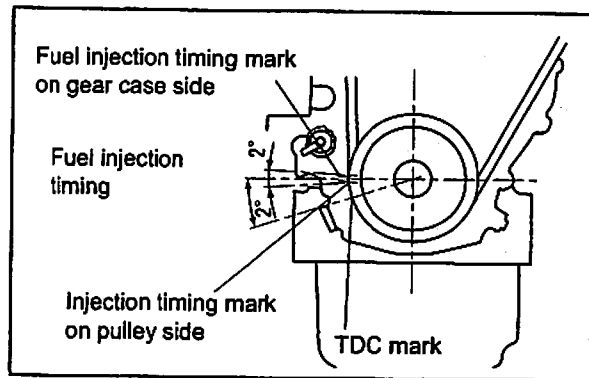
Connecting and disconnecting tie rod

### 1.3 Adjusting fuel injection timing

- (1) Check that the fuel injection timing meets the specified fuel injection timing at the position where the injection timing mark on the crank pulley is aligned with the mark on the gear case.
- (2) If the fuel injection timing does not meet the specified value, increase or decrease the thickness of the fuel injection pump adjusting shim to adjust timing.

Note: A change in thickness of the shim by 0.1 mm [0.00394 in.] results in a change in the fuel injection timing by approx 1°.

There are nine kinds of shims from 0.2 mm to 1.0 mm [0.00788 to 0.0394 in.].



Fuel injection timing

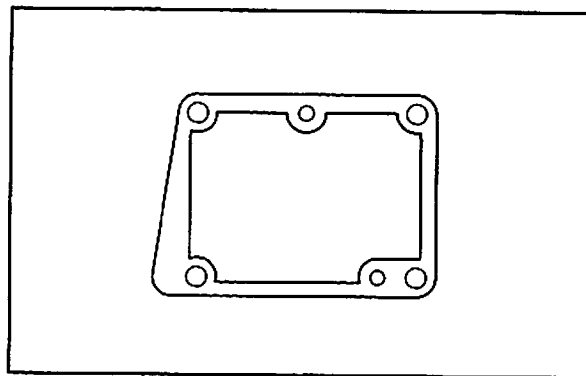
Adjusting value	Standard value $\pm 1.5^\circ$
-----------------	--------------------------------

- (3) Check the fuel injection timing in the following procedure with the delivery valve installed.

Note: If the delivery valve gets dirty or the engine is dirty, when the delivery valve is taken out, dirt may enter the fuel injection pump.

- (4) Remove the tie rod cover and disconnect the tie rod from the control rack.
- (5) Set the control rack to the medium position in the operating range and then remove the No. 1 fuel injection pipe on the nozzle side.

When the crankshaft is gradually rotated, fuel begins to swell at the tip of the pipe. This timing is the fuel injection timing. In this case, the timing is delayed by 1° as compared to the normal fuel injection timing.



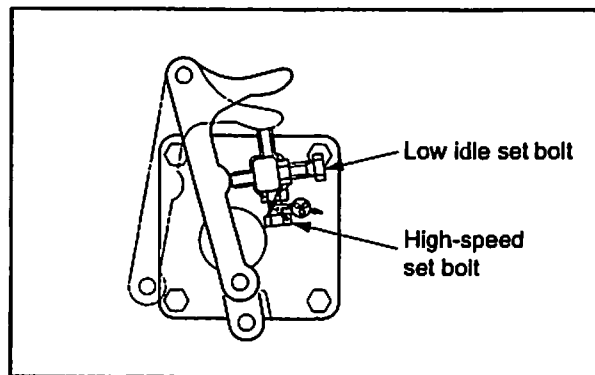
Adjusting shim

### 1.4 Checking and adjusting low idle speed and high idle speed

Adjust the speed after an engine warm-up (coolant temperature of 60 °C [140°F] or higher).

To adjust the engine speed, remove the cooling fan and pay attention to the rotating part.

- (1) During engine operation for speed adjustment, check for leakages of gas, water, oil and fuel.
- (2) Adjust the high idling speed with the high-speed set bolt. The high-speed set bolt is sealed at the factory before shipment. Do not make an adjustment unless absolutely necessary. Do not remove the torque spring set from the front plate unless necessary.
- (3) Adjust the engine low idling speed with the low idle set bolt.
- (4) Do not remove the sealing cap to adjust the torque spring set.
- (5) After adjustment, perform an acceleration and deceleration test to check for hunting and smoke condition.



Adjusting engine speed

## 1.5 Bleeding fuel system

### ⚠ WARNING

Completely wipe off any spilled fuel from the air vent screws with a cloth or the like. They can cause fire.

Bleeding of the fuel system must be started from the place closest to the fuel tank: the fuel filter the first and the fuel injection pump the last.

### 1.5.1 Bleeding fuel filter

#### (1) Cartridge type paper element

Loosen the air vent screw with stamp mark "1." Tighten the air vent screw when fuel does not show air bubbles.

Loosen the air vent screw with stamp mark "2." Tighten the air vent screw when fuel does not show air bubbles.

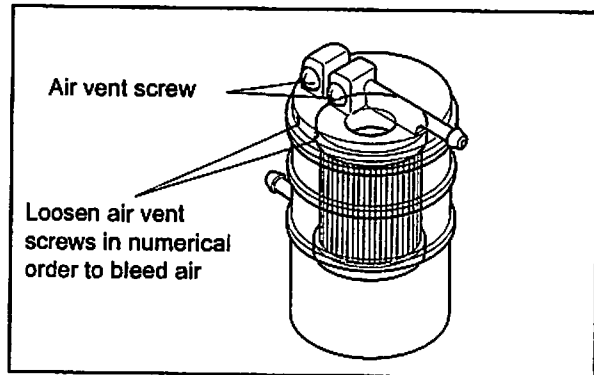
Note: Place the starter key in the ON position for the fuel pump type.

When the fuel supply is gravity type, fuel will flow into the filter by itself.

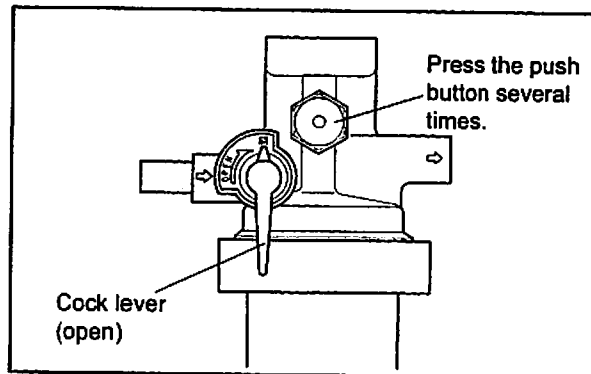
#### (2) Switch-cock type paper element

Place the fuel filter cock lever in the OPEN position and push the button several times to bleed the filter.

Note: When the fuel supply is gravity type, fuel will drop by itself, and when the fuel supply is the pump type, fuel and air in the filter will flow out with the starter key positioned ON.



Bleeding fuel filter (cartridge type)

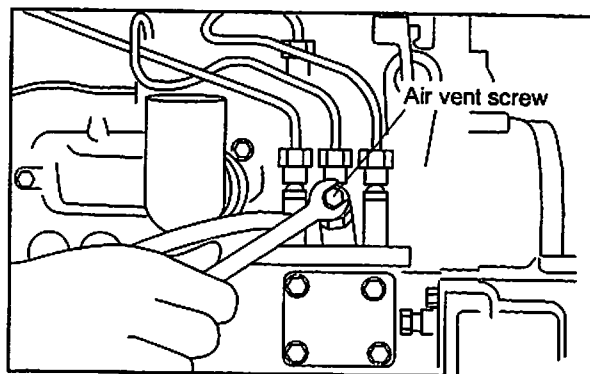


Bleeding fuel filter (switch cock type)

### 1.5.2 Bleeding fuel injection pump

Loosen the air vent screw of pump to discharge air in the fuel pipe and fuel injection pump.

Note: Air in the fuel injection pipe and fuel injection nozzle is automatically discharged by cranking of the engine.



Bleeding fuel injection pump

## 2. Break-in operation

Whenever the engine is overhauled, attach a dynamometer and operate the engine for break-in and inspection.

### 2.1 Starting up

- (1) Before starting the engine, check the levels of coolant, engine oil and fuel.  
Bleed the fuel and cooling systems.
- (2) Stop the fuel supply, and crank the engine with the starter for about 10 seconds to lubricate the engine.
- (3) Move the control lever slightly in the fuel increase direction (but not to the "full injection" position), and then turn the starter switch key to the [START] position to start the engine.
- (4) After the engine has started, adjust the control lever to let the engine operate at a minimum no-load speed (low idle speed).
- (5) Turn the starter switch key to the [OFF] position and make sure that the engine stops.

### 2.2 Inspecting engine condition after starting up

During the break-in operation, check the following.

If any abnormality is found, stop the engine, investigate the cause, and take appropriate measures.

- (1) The oil pressure must be within the specified value.
- (2) The coolant temperature must be within the specified value.
- (3) The engine must be free from any leakages such as oil, coolant and fuel. Pay special attention to oil leakage from the fitting face of turbocharger lube oil pipe.
- (4) Check for an abnormal noise.

Note: Knocking noise will disappear as the coolant temperature rises.

- (5) Check for the color of smoke and odors.

### 2.3 Break-in operation time

Perform break-in operations according to the table below.

Break-in operation time				
	Engine speed (min <sup>-1</sup> )		Load (kw)	Duration (min)
1	Low rotation speed	600 to 900	No-load	5
2	Medium rotation speed	1000 to 1200	No-load	5
3	High rotation speed	1400 to rated rotation speed	No-load	10
4	Rotated speed		25%	10
5			50%	10
6			75%	30
7			100%	20

Note: Be sure to perform break-in operation after overhaul or installation.

### 2.4 Inspection and adjustment after break-in operation

- (1) Adjustment of valve clearance
- (2) Inspection of fuel injection timing
- (3) Check of exterior bolt and nut tightness

### **3. Performance test (JIS standard)**

The following describes the procedures specified in "Earth moving machinery - Engines - Part 1: Test code of net power (JIS D0006-1)" and "Earth moving machinery - Engines - Part 2: Standard format of specifications and testing methods of diesel engines (JIS D0006-2)."

Other test items may be required in some applications. All test results should be evaluated comprehensively in order to determine the engine performance.

#### **3.1 Engine equipment condition**

The engine must be equipped with standard auxiliary devices such as cooling fan, air cleaner and alternator.

#### **3.2 Test items and purposes**

##### **3.2.1 Operation load test**

Conduct this test to evaluate the engine output, torque, fuel consumption rate and governor performance under various load conditions.

##### **3.2.2 Continuous load test**

Operate the engine continuously for 10 hours at 90% load (continuous load application) of nominal net brake power while the engine speed is maintained at revolutions corresponding to the nominal brake power. In this test, evaluate the fuel consumption rate and operating condition, and confirm that the engine is capable of continuous operation.

##### **3.2.3 Low idle test**

Conduct this test to confirm that the engine can operate stably at the specified low idle speed.

#### **3.3 Other inspections**

Check for leakage of gases, coolant and oil; abnormal odors; and hunting. Make adjustment as needed.

#### **3.4 Engine output adjustment**

Diesel engine output is affected by atmospheric pressure, temperature and humidity. Therefore, correction calculations must be performed to obtain the value of engine output under the standard atmospheric conditions.

##### **3.4.1 Standard atmospheric conditions:**

Base temperature: 298 K (25°C) [77°F]

Total pressure: 100 kPa (750 mmHg)

Dry pressure: 99 kPa [743 mmHg]

### 3.4.2 Calculation of corrected power

Multiply the measured brake power or torque by the calculated diesel engine correction factor to obtain a corrected value.

If the applicable range of the correction formula is exceeded, indicate the corrected values and record the test conditions on the test record.

Collected output = Correction factor ( $\alpha_c$ ) × Measured axle output

• Atmospheric conditions during test

Temperature( $T$ ): 283K (10°C) [50°F]  $\leq T \leq$  313K (40°C) [104°F]

Dry atmospheric pressure( $P_d$ ): 80kPa (600mmHg)  $\leq P_d \leq$  110kPa (825mmHg)

$\alpha_c = (f_a)^{f_m}$   $f_a$ : Atmospheric factor  $f_m$ : Engine factor

• Range of correction equation use

The range of correction factor ( $\alpha_c$ ) is as follows:

$0.9 \leq \alpha_c \leq 1.1$ .

Calculation of Atmospheric factor ( $f_a$ )

• Naturally aspirated engine and engine with mechanically changed engine

$$f_a = \left( \frac{99}{P_d} \right) \cdot \left( \frac{T}{298} \right)^{0.7}$$

• Turbocharged engine without air cooler or with air-to-air cooler

$$f_a = \left( \frac{99}{P_d} \right)^{0.7} \cdot \left( \frac{T}{298} \right)^{1.2}$$

• Turbocharged engine with air-to-liquid cooler

$$f_a = \left( \frac{99}{P_d} \right)^{0.7} \cdot \left( \frac{T}{298} \right)^{0.7}$$

Calculation of engine factor ( $f_m$ )

$$f_m = 0.036q_c - 1.14$$

$q_c$ : Corrected fuel supply volume

$$q_c = \frac{q}{r}$$

$$q = \frac{(z) \times (\text{Fuel flow rate g/s})}{(\text{Stroke volume l}) \times (\text{Engine speed min}^{-1})}$$

$z = 120000$  (4-cycle engine)

$r$ : Ratio between pressure at turbocharger or air cooler outlet and atmospheric pressure ( $r=1$  for Naturally aspirated engine)

• Applicable range of engine factor ( $f_m$ )

$37.2 \leq q_c \leq 65 \text{ mg/(l-cycle)}$

•  $q_c \leq 37.2 \text{ mg/(l-cycle)}$  :  $f_m = 0.2$  (constant)

•  $65 \text{ mg/(l-cycle)} \leq q_c$  :  $f_m = 1.2$  (constant)

# TROUBLESHOOTING

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### 1. Troubleshooting

#### 1.1 Before troubleshooting

##### CAUTION

- (a) For the fuel injection pump, the injection quantity of each cylinder can be measured only with a pump tester. Do not adjust or disassemble the fuel injection pump even during troubleshooting unless absolutely necessary.
- (b) To inspect the combustion state of each cylinder, loosen the fuel injection pipe of any cylinder to stop injection, and compare the extent of a drop in the engine speed with that of other cylinders

- (1) Troubles of the diesel engine often occur in combination of various problem causes, and therefore it is often very difficult to determine the defect from a problem phenomenon.

Especially a similar phenomenon occurs in troubles of the fuel injection pump, fuel injection nozzles and compression pressure. It is, therefore, necessary to conduct a careful study to determine the cause.

From the reason above, troubleshooting described in this section is summarized as the inspecting order from items which are more likely to cause problems or items easy to inspect in sequence.

- (2) The diesel engine has the following characteristics from its structure and combustion system. It is necessary to fully understand these characteristics before performing troubleshooting.

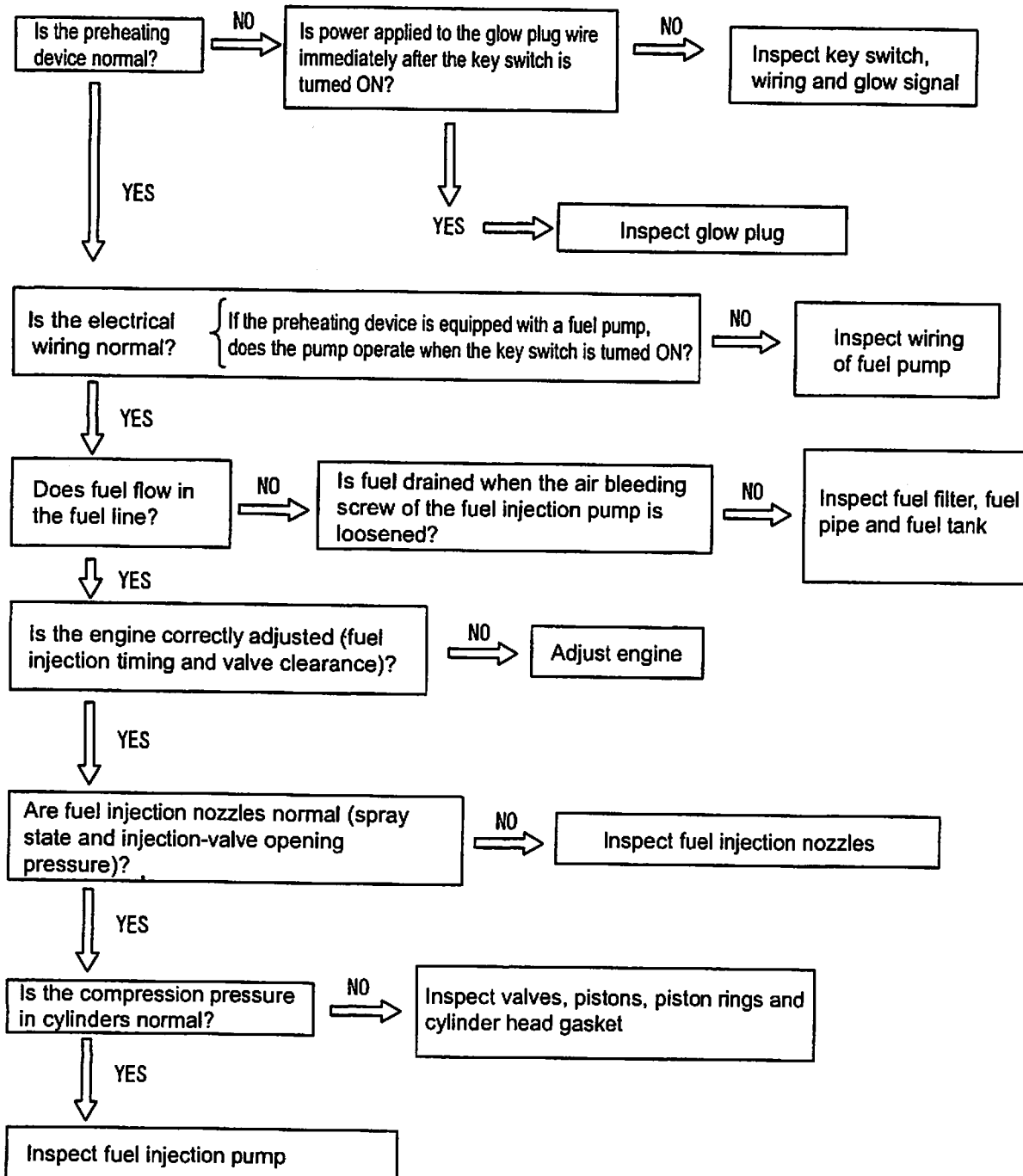
- The engine produces unique combustion noise (diesel knock) in the normal condition.
- The engine discharges slight black smoke at heavy load.
- High compression and high torque cause vibration on a single unit of the engine.
- Slight hunting is caused during acceleration and deceleration.

## 1.2 Starting trouble

### 1.2.1 Check items before troubleshooting

- (1) Clogging of air cleaner element
- (2) Coagulation of engine oil
- (3) Use of poor quality fuel
- (4) Drop in cranking speed

### 1.2.2 Problem: Starting trouble



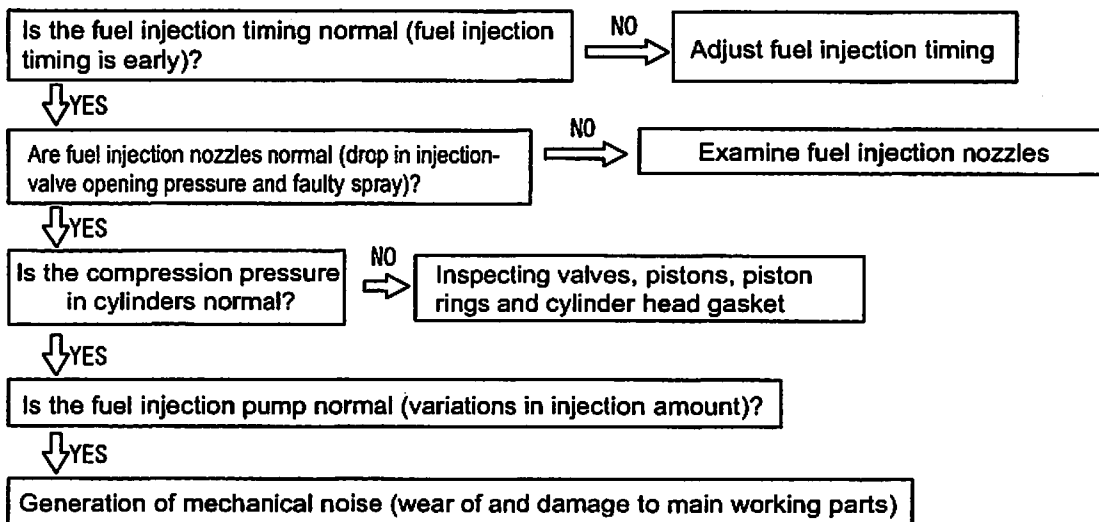
### 1.3 Knocking

The diesel engine rotates producing unique combustion noise (diesel knock) due to its combustion system. This knock noise is normal unless it is especially loud.

#### 1.3.1 Check items before troubleshooting

- (1) Clogging of air cleaner element
- (2) Use of poor quality fuel (low cetane number fuel such as kerosene)

#### 1.3.2 Problem: Knocking



## 1.4 Overheating

### 1.4.1 Check items before troubleshooting

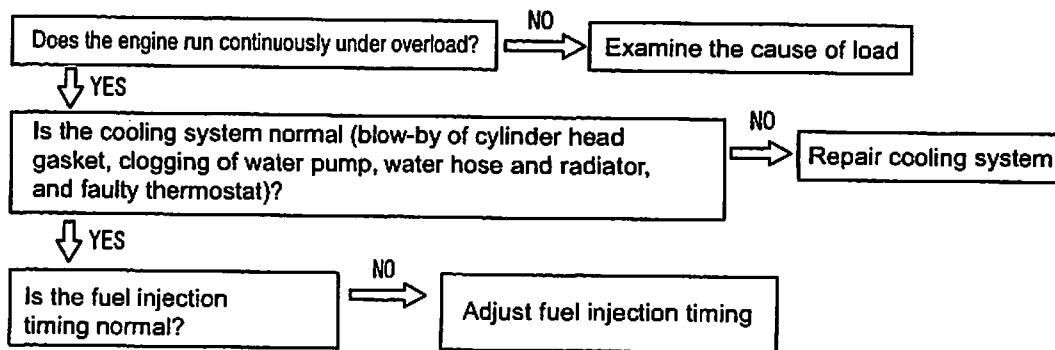
- (1) Quantity and leakage of coolant
- (2) Loosening of fan belt
- (3) Clogging of radiator fins
- (4) Concentration of LLC
- (5) Clogging of muffler
- (6) Quantity and degradation of engine oil
- (7) Swirling of cooling air
- (8) Thermostat malfunction

### 1.4.2 Problem: Overheating

Overheat often occurs by engine load mismatching when the engine is set up.

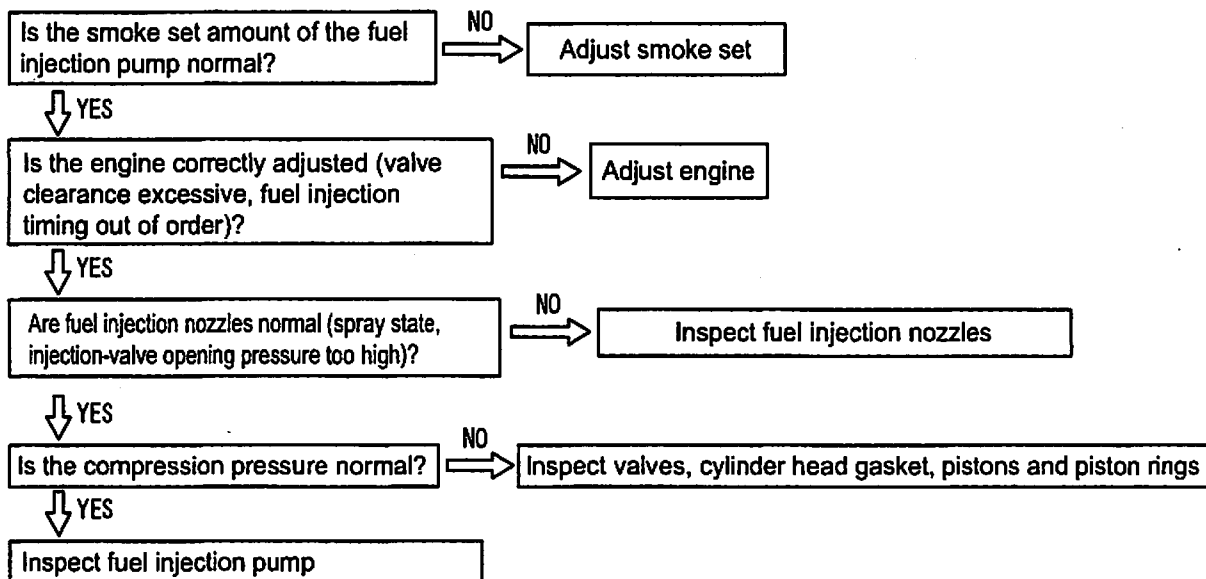
If the engine itself is normal and overheat occurs, measure the ambient and coolant temperatures in the loaded condition (thermostat full open).

If the temperature difference is greater than 60°C [140°F], the investigation into other components as well as the engine is suggested.

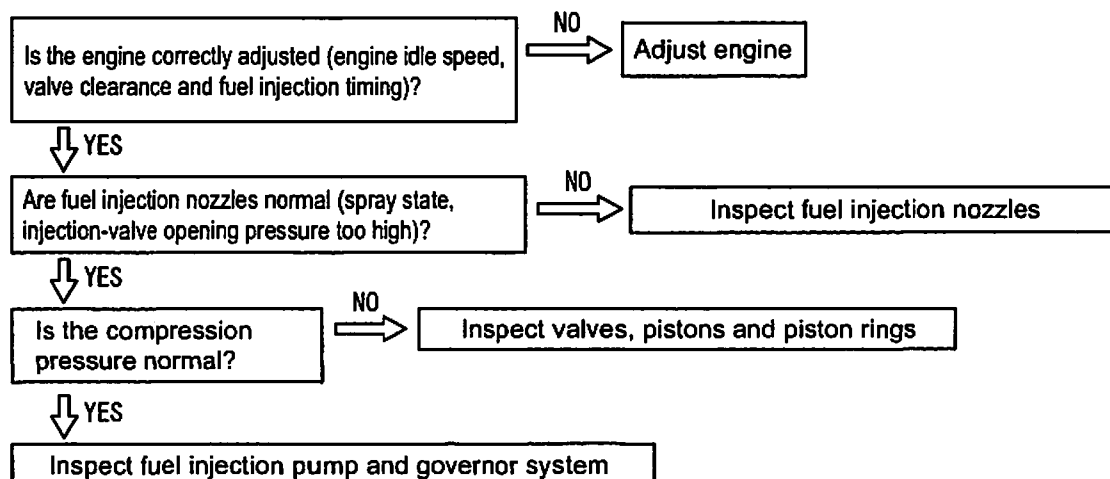


**1.5 Excessive black smoke.****1.5.1 Check items before troubleshooting**

- (1) Clogging of air cleaner element
- (2) Use of poor quality fuel
- (3) Overload

**1.5.2 Problem: Excessive black smoke****1.6 Idling malfunction****1.6.1 Check items before troubleshooting**

- (1) Engine control system malfunction
- (2) Viscosity of engine oil too high
- (3) Use of poor quality fuel

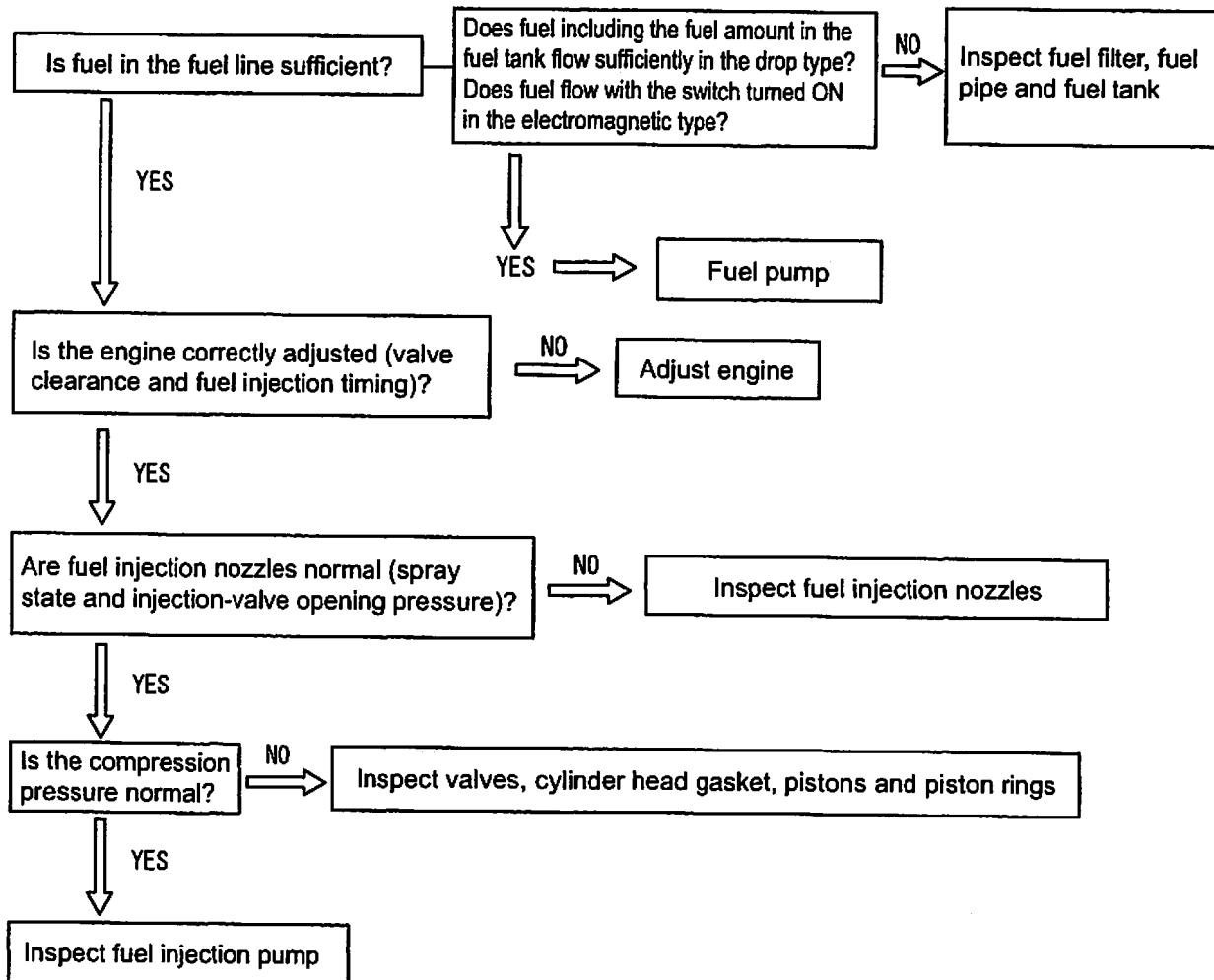
**1.6.2 Problem: Unstable idling**

## 1.7 Low output

### 1.7.1 Check items before troubleshooting

- (1) Seizure of engine moving parts
- (2) Viscosity of engine oil too high
- (3) Use of poor quality fuel
- (4) Clogging of air cleaner element
- (5) Clogging of muffler
- (6) Powertrain malfunction

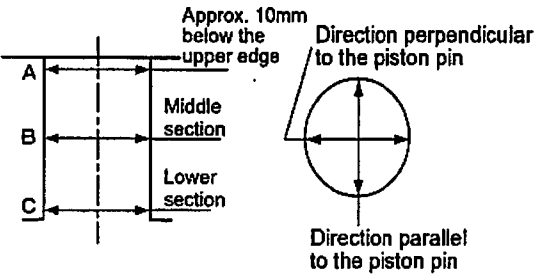
### 1.7.2 Problem: Low output



# SUPPLEMENT INSPECTION RECORD SHEET (L-SERIES)

No.1	Measurement of Cylinder Inside Diameter.....	Supplement- 2
No.2	Measurement of Valve Guide Inside Diameter and Valve Stem Outside Diameter.....	Supplement- 3
No.3	Measurement of Valve Seat Angle, Valve Sinkage and Valve Margin.....	Supplement- 4
No.4	Measurement of Distortion of Cylinder Head Bottom Surfaces.....	Supplement- 5
No.5	Measurement of Clearance Between Connecting Rod Bearing Inside Diameter and Crankshaft Pin Outside .....	Supplement- 6
No.6	Measurement of Rocker Arm Inside Diameter and Rocker Shaft Outside Diameter.....	Supplement- 7
No.7	Measurement of Piston Pin Bore Diameter and Piston Pin Outside Diameter .....	Supplement- 8
No.8	Measurement of Valve Clearance .....	Supplement- 9
No.9	Measurement of Valve Opening Pressure of Fuel Injection Nozzle .....	Supplement-10
No.10	Measurement of Camshaft Journal Outside Diameter to Cylinder Block Camshaft Bore Clearance (L2) .....	Supplement-11
No.11	Measurement of Camshaft Journal Outside Diameter to Cylinder Block Camshaft Bore Clearance (L3) .....	Supplement-12
No.12	Measurement of Crankshaft End Play .....	Supplement-13

**INSPECTION RECORD SHEET**

Company		Engine Model	Date	L																																					
		Serial No.																																							
Inspection Point	Measurement of Cylinder Inside Diameter		Unit	mm [in.]																																					
<p><b>Measuring Positions</b></p>  <p style="margin-left: 100px;">Approx. 10mm below the upper edge</p> <p style="margin-left: 100px;">Direction perpendicular to the piston pin</p> <p style="margin-left: 100px;">Middle section</p> <p style="margin-left: 100px;">Lower section</p> <p style="margin-left: 100px;">Direction parallel to the piston pin</p>																																									
<p><b>Standard</b></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2"></th> <th style="text-align: center;">Nominal Value</th> <th style="text-align: center;">Standard</th> <th style="text-align: center;">Limit</th> <th style="text-align: center;">Remarks</th> </tr> </thead> <tbody> <tr> <td rowspan="3" style="text-align: center;">Cylinder Inside Diameter</td> <td style="text-align: center;">L2A, L3A</td> <td style="text-align: center;"><math>\phi 65</math> [2.56]</td> <td style="text-align: center;">65.00 to 65.03 [2.5591 to 2.5602]</td> <td rowspan="3" style="text-align: center;">+0.7 [0.028]</td> <td rowspan="3" style="text-align: center;">Repair. limit: +0.20 [0.008]</td> </tr> <tr> <td style="text-align: center;">L2C, L3C</td> <td style="text-align: center;"><math>\phi 70</math> [2.76]</td> <td style="text-align: center;">70.00 to 70.03 [2.7559 to 2.7571]</td> </tr> <tr> <td style="text-align: center;">L2E, L3E</td> <td style="text-align: center;"><math>\phi 76</math> [2.99]</td> <td style="text-align: center;">76.00 to 76.03 [2.9921 to 2.9933]</td> </tr> </tbody> </table>							Nominal Value	Standard	Limit	Remarks	Cylinder Inside Diameter	L2A, L3A	$\phi 65$ [2.56]	65.00 to 65.03 [2.5591 to 2.5602]	+0.7 [0.028]	Repair. limit: +0.20 [0.008]	L2C, L3C	$\phi 70$ [2.76]	70.00 to 70.03 [2.7559 to 2.7571]	L2E, L3E	$\phi 76$ [2.99]	76.00 to 76.03 [2.9921 to 2.9933]																			
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<p><b>Measured Values</b></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2" style="text-align: center;">Part Name</th> <th colspan="3" style="text-align: center;">Cylinder Inside Diameter</th> </tr> <tr> <th style="text-align: center;">No.</th> <th style="text-align: center;">Position</th> <th style="text-align: center;">A</th> <th style="text-align: center;">B</th> <th style="text-align: center;">C</th> </tr> </thead> <tbody> <tr> <td rowspan="2" style="text-align: center;">1</td> <td style="text-align: center;">X</td> <td></td> <td></td> <td></td> </tr> <tr> <td style="text-align: center;">Y</td> <td></td> <td></td> <td></td> </tr> <tr> <td rowspan="2" style="text-align: center;">2</td> <td style="text-align: center;">X</td> <td></td> <td></td> <td></td> </tr> <tr> <td style="text-align: center;">Y</td> <td></td> <td></td> <td></td> </tr> <tr> <td rowspan="2" style="text-align: center;">3</td> <td style="text-align: center;">X</td> <td></td> <td></td> <td></td> </tr> <tr> <td style="text-align: center;">Y</td> <td></td> <td></td> <td></td> </tr> </tbody> </table>					Part Name		Cylinder Inside Diameter			No.	Position	A	B	C	1	X				Y				2	X				Y				3	X				Y			
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# INSPECTION RECORD SHEET

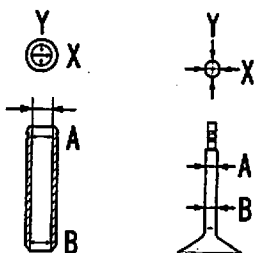
No.2

L

Company		Engine Model		Date	
		Serial No.			
Inspection Point	Measurement of Valve Guide Inside Diameter and Valve Stem Outside Diameter			Unit	mm [in.]

Measuring Positions

Standard



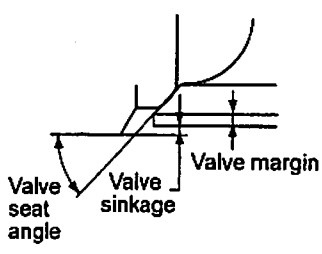
		Nominal Value	Standard	Limit
Valve Guide Inside Diameter	Inlet	φ6.6 [0.260]	6.600 to 6.615 [0.2598 to 0.2604]	—
	Exhaust	φ6.6 [0.260]	6.600 to 6.615 [0.2598 to 0.2604]	—
Valve Stem Outside Diameter	Inlet	φ6.6 [0.260]	6.565 to 6.580 [0.2585 to 0.2621]	6.500 [0.2559]
	Exhaust	φ6.6 [0.260]	6.530 to 6.550 [0.2571 to 0.2579]	6.500 [0.2559]
Clearance between Valve Stem and Valve Guide	Inlet	—	0.020 to 0.050 [0.0008 to 0.0020]	0.100 [0.0039]
	Exhaust	—	0.050 to 0.085 [0.0020 to 0.0033]	0.150 [0.0059]

Measured Values

Part Name		Valve Guide Inside Diameter				Valve Stem Outside Diameter				Clearance			
No.	Position	A		B		A		B		A		B	
		X	Y	X	Y	X	Y	X	Y	Max.	Min.	Max.	Min.
1	Inlet												
	Exhaust												
2	Inlet												
	Exhaust												
3	Inlet												
	Exhaust												

Remark	Approved by	Checked by	Measured by

INSPECTION RECORD SHEET

Company			Engine Model		Date	L																																		
			Serial No.																																					
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Part Name			Valve Seat Angle	Valve Sinkage	Valve Margin																																			
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Remark					Approved by	Checked by	Measured by																																	

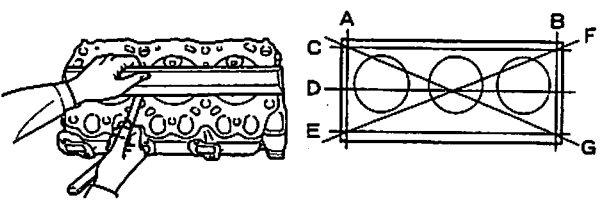
# INSPECTION RECORD SHEET

No.4

L					
Company	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; padding: 5px;">Engine Model</td> <td style="width: 50%; padding: 5px;"></td> </tr> <tr> <td style="width: 50%; padding: 5px;">Serial No.</td> <td style="width: 50%; padding: 5px;"></td> </tr> </table>	Engine Model		Serial No.	
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Serial No.					
Date					
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	mm [in.]				

**Measuring Positions**



**Standard**

	Standard	Limit
Distortion of Cylinder Head Bottom Surfaces	0.05 or less [0.0020]	0.10 [0.0039]

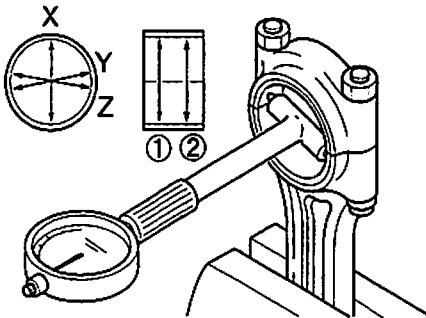
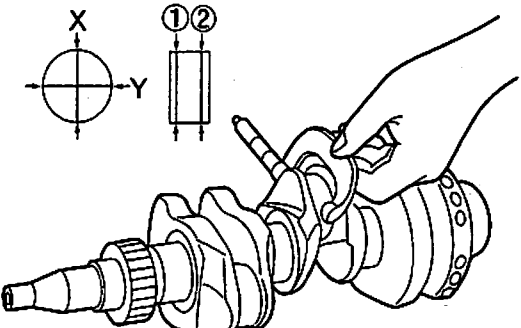
**Measured Values**

Part Name	Distortion of Cylinder Head Bottom Surfaces						
No.	A	B	C	D	E	F	G
1							
2							
3							

Remark	Approved by	Checked by	Measured by

INSPECTION RECORD SHEET

L																																																																										
Company		Engine Model		Date																																																																						
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# INSPECTION RECORD SHEET

No.6

Company		Engine Model	Date		L
		Serial No.			
Inspection Point	Measurement of Rocker Arm Inside Diameter and Rocker Shaft Outside Diameter			Unit	mm [in.]

**Measuring Positions**

**Standard**

	Nominal Value	Standard	Limit
Rocker Arm Inside Diameter	φ12 [0.47]	12.013 to 12.035 [0.4730 to 0.4738]	-
Rocker Shaft Outside Diameter	φ12 [0.47]	11.470 to 11.984 [0.4516 to 0.4718]	-
Clearance between Rocker Arm and Shaft	-	0.029 to 0.065 [0.0011 to 0.0026]	0.200 [0.0079]

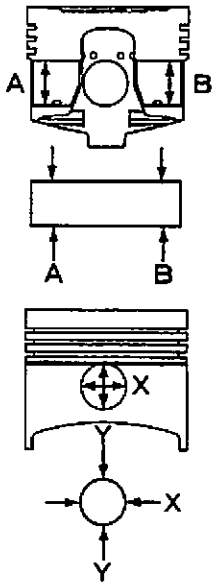
**Measured Values**

Part Name		Rocker Arm Inside Diameter		Rocker Shaft Outside Diameter		Clearance	
No.	Position	X	Y	X	Y	Max.	Min.
1	Inlet						
	Exhaust						
2	Inlet						
	Exhaust						
3	Inlet						
	Exhaust						

Remark	Approved by	Checked by	Measured by

INSPECTION RECORD SHEET

				L																																																														
Company	Engine Model		Date																																																															
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Remark					Approved by	Checked by	Measured by																																																											

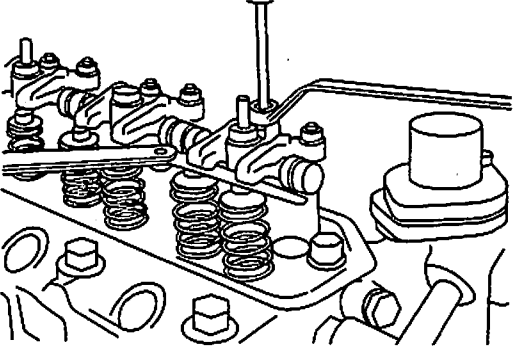
# INSPECTION RECORD SHEET

No.8

L					
Company	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; padding: 5px;">Engine Model</td> <td style="width: 50%; padding: 5px;"></td> </tr> <tr> <td style="padding: 5px;">Serial No.</td> <td style="padding: 5px;"></td> </tr> </table>	Engine Model		Serial No.	
Engine Model					
Serial No.					
Date					
Inspection Point	Measurement of Valve Clearance				
Unit	mm [in.]				

**Measuring Positions**



**Standard**

		Standard
Valve Clearance (Cold Setting)	Inlet	0.25 [0.0098]
	Exhaust	0.25 [0.0098]

**Measured Values**

No.		Valve Clearance	
		Inlet	Exhaust
1	Before Adjustment		
	After Adjustment		
2	Before Adjustment		
	After Adjustment		
3	Before Adjustment		
	After Adjustment		

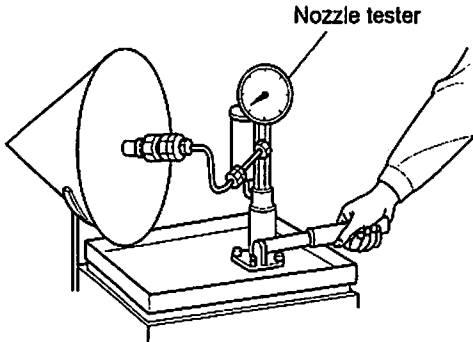
Remark	Approved by	Checked by	Measured by

INSPECTION RECORD SHEET

			<b>L</b>	
<b>Company</b>		<b>Engine Model</b>		<b>Date</b>
		<b>Serial No.</b>		
<b>Inspection Point</b>	<b>Measurement of Valve Opening Pressure of Fuel Injection Nozzle</b>	<b>Unit</b>	<b>MPa (kg/cm<sup>2</sup>) [psi]</b>	

**Measuring Positions**



**Standard**

	Nominal Value	Standard
Valve Opening Pressure	13.73 {140} [1995]	13.73 to 14.73 {140 to 150} [1995 to 2135]

**Measured Values**

No.	Valve Opening Pressure	Service Hours (h)	Valve Opening Pressure
	Before Adjustment		After Adjustment
1			
2			
3			

<b>Remark</b>	<b>Approved by</b>	<b>Checked by</b>	<b>Measured by</b>

# INSPECTION RECORD SHEET

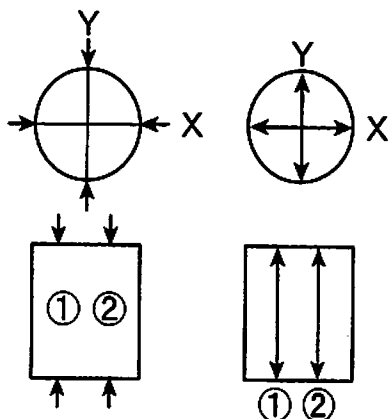
No.10

L

Company		Engine Model		Date	
		Serial No.			
Inspection Point	Measurement of Camshaft Journal Outside Diameter to Cylinder Block Camshaft Bore Clearance (L2)			Unit	mm [in.]

Measuring Positions

Standard



		Nominal Value	Standard	Limit
Camshaft Journal Outside Diameter	No.2	φ34 [1.34]	33.925 to 33.950 [1.3356 to 1.336]	-
	No.3	φ33 [1.30]	32.925 to 32.950 [1.2963 to 1.2972]	-
Cylinder Block Camshaft Bore Inside Diameter	No.2	φ34 [1.34]	34.000 to 34.025 [1.3386 to 1.3396]	-
	No.3	φ33 [1.30]	33.000 to 33.025 [1.2992 to 1.3002]	-
Camshaft Journal Outside Diameter to Cylinder Block Camshaft Bore Clearance		No.2 No.3	- 0.050 to 0.100 [0.0020 to 0.0039]	0.150 [0.0059]

Measured Values

Part Name		Camshaft Journal Outside Diameter		Cylinder Block Camshaft Bore Inside Diameter		Clearance	
No.	Position	X	Y	X	Y	Max.	Min.
2	①						
	②						
3	①						
	②						

Remark	Approved by	Checked by	Measured by

INSPECTION RECORD SHEET

Company		Engine Model	Date		L
		Serial No.			
Inspection Point	Measurement of Camshaft Journal Outside Diameter to Cylinder Block Camshaft Bore Clearance (L3)			Unit	mm [in.]

**Measuring Positions**

**Standard**

		Nominal Value	Standard	Limit	
Camshaft Journal Outside Diameter	No.2	φ34 [1.34]	33.925 to 33.950 [1.3356 to 1.336]	-	
	No.3 No.4	φ33 [1.30]	32.925 to 32.950 [1.2963 to 1.2972]	-	
Cylinder Block Camshaft Bore Inside Diameter	No.2	φ34 [1.34]	34.000 to 34.025 [1.3396 to 1.3396]	-	
	No.3 No.4	φ33 [1.30]	33.000 to 33.025 [1.2992 to 1.3002]	-	
Camshaft Journal Outside Diameter to Cylinder Block Camshaft Bore Clearance		No.2 No.3 No.4	-	0.050 to 0.100 [0.0020 to 0.0039]	0.150 [0.0059]

**Measured Values**

Part Name		Camshaft Journal Outside Diameter		Cylinder Block Camshaft Bore Inside Diameter		Clearance	
No.	Position	X	Y	X	Y	Max.	Min.
2	①						
	②						
3	①						
	②						
4	①						
	②						

Remark	Approved by	Checked by	Measured by

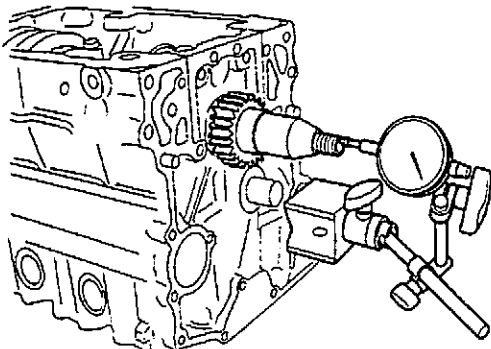
# INSPECTION RECORD SHEET

No.12

				<b>L</b>
Company		Engine Model		Date
		Serial No.		
Inspection Point	Measurement of Crankshaft End Play			Unit
				mm [in.]

**Measuring Positions**



**Standard**

	Standard	Limit
Crankshaft End Play	0.050 to 0.175 [0.0020 to 0.0069]	0.500 [0.020]

**Measured Values**

Disassembling	During Reassembling

Remark	Approved by	Checked by	Measured by

