ENGINE BASE

SERVICE MANUAL

MITSUBISHI
S4S, S6S

HYUNDAI

REFERENCE ONLY

- EXCAVATOR(16-18TON, -7SERIES)
- FORK LIFT(HDF35-70, -7SERIES)

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 reassembling, 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.

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How to Use This Manual

In this service manual, the Mitsubishi Diesel Engine (standard model for land use) 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.
There are separate manuals for the fuel injection pump, governor and turbocharger.

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.

1. 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 described in text where they are relevant, are also listed in Group 1 in the General Contents.

(4) The sequence in which parts are to be assembled is summarized below each assembled view.
Such as: ⑤→②→④→③→①.

(5) The following marks are used in this manual to emphasize important safety cautions.

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

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

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

CAUTION ···· 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.

(6) 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.

2. 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.

3. 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.)

4. 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^2
- 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_2O (cmAq)
- Rotational speed: 1 min^{-1} = 1 rpm

GENERAL CONTENTS

SAFETY CAUTIONS

⚠ WARNING Danger of Fire and Explosion

● Keep flames away

Do not use flames or smoke at a site where fuel or engine oil is handled or cleaning solvent is used for washing parts.
Flames can ignite such materials and result in a dangerous situation.
Spilled fuel and oil should be wiped immediately and thoroughly. Spilled fuel and oil can ignite and cause fire.
When storing fuel or engine oil, make sure that the storage area is well ventilated and the caps of containers are tightly closed.

● Keep surrounding area neat and clean

Do not leave combustible or explosive materials, such as fuel and engine oil, near the engine. They can cause fire or explosion.
Remove dust, dirt and other foreign materials accumulated on or near the engine. They can cause fire or engine overheating. Be sure to remove dust from the top side of the battery after maintenance. Dust can cause a short-circuit.
The engine must be positioned at least 1 m [3.28 ft] away from buildings and other equipment to prevent possible fire caused by engine heat.

● Do not open crankcase until engine cools

After the engine stops operation, let the engine cool for at least 10 minutes before opening the side cover of the crankcase.
Inflow of fresh air into the crankcase of a hot engine can cause oil mist to ignite and explode.

● Check for fuel and oil leaks

When fuel or oil leaks are found, repair the leakage immediately.
Fuel or engine oil spilled on a hot surface of the engine can cause fire and result in personal injury or equipment damage.

● Use shatterproof light

Use a shatterproof light when inspecting the fuel system, lubrication system, cooling system or battery fluid level.
A non-shatterproof light may catch fire and explode.

● Do not short-circuit electrical wires

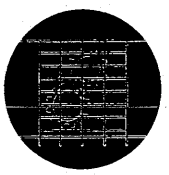
Do not inspect or repair the electrical system with the battery cables connected to the battery, since it can cause accidental short-circuiting and lead to fire. Be sure to disconnect the negative (-) battery cable from the battery before conducting work.
Loose terminals and damaged cables/wires can result in a short-circuit and cause fire. Inspect the terminals, cables and wires before servicing, and repair or replace when damage is found.

● Keep fire extinguishers and first aid kit nearby

Always keep fire extinguishers nearby, and be familiarized with their usage.
Keep a first aid kit at a designated place, and make sure it is easily accessible whenever needed.
Also, establish emergency response procedures to follow in the event of a fire or accident, and post emergency contact locations and contact methods.

⚠ WARNING Danger of Entanglement

● Install protective covers on rotating parts



Make sure the protective covers of the engine are installed correctly at rotating parts.
If protective covers are loose or damaged, repair.
Never remove the covers guarding rotating parts, such as the camshaft cover and rocker covers, when the engine is operating.
When the engine is coupled to other equipment or connected to a radiator, be sure to install covers on the exposed connecting belt and coupling.
Never remove protective covers.

● Check surrounding area for safety before starting engine

Before starting the engine, check to make sure no one is near the generator and tools are not left on or near the engine. Always verbally notify people within the immediate area when starting the engine.
When the starter switch is posted with a sign that prohibits startup operation, do not operate the engine.

● Stay clear of rotating parts while engine is in operation

Do not approach rotating parts while the engine is in operation.
Keep items that can be easily entangled away from rotating parts.
Rotating parts can entangle a persons' body or tools to cause serious.

● Lock out and tag out

Be sure to lock out and tag out before starting inspection and maintenance.
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 or a similar sign on the starter switch.
The starter switch key should be kept by the person performing the inspection and maintenance.
If the engine is installed with an air starter system, close the main valve of the air tank, and post a "Do Not Open" tag on the main valve.

● Always stop engine before inspection and maintenance

Before inspection and maintenance, be sure to stop the engine. Never attempt to adjust the belt tension while the engine is operating. Operating belt can entangle your body and result in serious injury.

● Always return turning tools to original position after use

Be sure to remove all turning tools used in inspection and maintenance. Return the turning gear in the original position before starting the engine.
Starting the engine with the turning tools inserted or turning gear engaged may not only cause engine damage but personal injury as well.

⚠ WARNING Danger of Burns

● Do not touch engine in operation or immediately after operation

Do not touch any part of the engine while the engine is operating or immediately after it stops operation. Touching the engine in operation or immediately after operation can cause burns.
When conducting inspection and maintenance, check the water temperature gage to make sure the engine has cooled sufficiently.

● Open radiator filler cap carefully

Never open the radiator filler cap while the engine is operating or immediately after it stops operation. Open the cap only after the engine stops and the coolant temperature drops sufficiently.
When opening the cap, slowly turn the cap to release internal pressure. To prevent burns caused by spurting steam, wear thick rubber gloves or cover the cap with a cloth.
When closing the cap, make sure to tighten it securely.
If the radiator filler cap is opened when the coolant is at operating temperature, steam and hot coolant may blow out, causing skin burns as a result.

● Add coolant after coolant temperature drops sufficiently

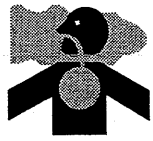
Do not add coolant immediately after the engine stops, wait until the coolant temperature drops sufficiently. Otherwise, it will result to burns.

● Do not remove heat shields

The exhaust system, which becomes extremely hot while the engine is operating, is installed with heat shields. Never remove these heat shields. If they must be removed for inspection and maintenance, be sure to reinstall the heat shields after inspection and maintenance.

⚠ WARNING Beware of Exhaust Gas Poisoning

● Operate engine in well-ventilated area



If the engine is installed in an enclosed area and an exhaust duct is used to discharge the exhaust gas to the outside, inspect the duct joints to make sure there is no exhaust gas leak from duct joints.
When the engine is used as a movable generator, do not use the engine in an enclosed area (inside a warehouse, tunnel, etc.) or at a site where all sides are blocked for poor ventilation. If the engine must be operated in an enclosed area, discharge the exhaust gas to the outside and provide adequate ventilation. Make sure the exhaust gas does not blow in the direction of plants or animals.
Exhaust gas from the engine contains carbon monoxide and other harmful substances. Operating the engine in an ill-ventilated area can cause gas poisoning.

⚠ WARNING Danger of Hearing Problems

● Wear ear plugs

Always wear ear plugs when entering the machine room (engine room).
Combustion sound and mechanical noise generated by the engine can cause hearing problems.

⚠ WARNING Beware of Falling Equipment

● Lift engine carefully

When lifting the engine, use wire ropes capable of supporting the entire weight of the engine.
Attach appropriate slings to the hangers provided on the engine to lift the engine.
Keep the engine balanced during lifting by considering center of gravity of the engine.
Keep the angle formed by wire ropes within 60°. If the angle exceeds this limit, excessive load is applied on the hangers and may damage the hangers.
If wire ropes contact the engine directly, place a cloth or other soft padding to prevent damage to the engine and wire ropes.

● Do not climb onto engine

Do not climb onto the engine, or set a foot on any part located on the side of the engine.
To work on parts located on the upper section, use a ladder, stand, etc., and be careful not to fall.
Climbing on the engine can damage engine parts, and a person may fall and get injured.

● Watch footing when conducting maintenance

When working on the upper part of the engine and other hard-to-reach places, use a stable work platform.
Standing on a decrepit stand or parts box may result in personal injury.
Do not place any item on a work platform.

⚠ CAUTION Cautions Regarding Engine Oil and LLC

● Use only specified fuel, engine oil and coolant

Use fuel, engine oil and coolant specified in this manual, and handle them carefully.
Use of other fuel, oil or coolant, and improper handling may cause various engine problems and malfunctions.
Obtain the MSDSs (Material Safety Data Sheets) issued by the fuel, oil and coolant manufacturers, and follow the directions on the MSDSs for proper handling.

● Handle LLC (long life coolant) carefully

LLC contains strong alkali. Do not swallow or allow it to contact eyes.
Since drained coolant (containing LLC) is harmful, do not dispose of it into conventional sewage. Abide by the applicable law and regulations when discarding drained coolant.

● Properly disposed of drained oil and coolant

Do not disposed of drained engine oil or coolant into conventional sewage.
Laws and regulations prohibit disposal of oil and coolant into ordinary sewage systems.
When disposing oil waste, coolant and other environmentally hazardous waste, abide by the law and regulations.

⚠ CAUTION Cautions Regarding Battery

● Handle battery carefully

- Never use flames or allow sparks near the battery. The battery releases flammable hydrogen gas and oxygen gas. These gases can be ignited by flames and cause an explosion.
- Do not use the battery when the fluid surface is lower than the minimum level. Using a battery with a low electrolytic level can result in an explosion.
- Do not short the battery terminals with a tool or other metal object.
- When disconnecting battery cables, always 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 [Open/OFF] position or disconnect the cable from the negative (-) battery terminal to cut off the electrical current.
- Electrolyte (battery fluid) contains dilute sulfuric acid. Careless handling of the battery can lead to the loss of sight and/or skin burns. Also, do not swallow electrolyte.
- Wear protective goggles and rubber gloves when maintaining and inspecting the battery (when adding water, charging, etc.).
- If electrolyte is spilled onto the skin or clothes, immediately wash with lots of water and thoroughly clean with soap.
- If electrolyte gets into eyes, immediately flush with lots of clean fresh water, and seek immediate medical attention.
- Should accidentally swallow electrolyte, gargle with plenty of water, then drink lots of water, and seek immediate medical attention.

⚠ CAUTION Response to Abnormalities

● If engine overheats, conduct heating operation before stopping engine

If the engine overheats, do not stop the engine immediately. Abruptly stopping an overheated engine may cause the coolant temperature to rise, resulting 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 heads due to sudden change in temperature. Add coolant after the engine cools to 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 oil pressure drops, stop engine immediately

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

● If fan belt breaks, stop engine immediately

If the fan belt breaks, stop the engine immediately. Continued operation of the engine without the fan belt causes coolant to change into steam and blow out from the reservoir and radiator, thus resulting in burns.

⚠ 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 also result in personal injury.

● Never break seals

To ensure proper engine operation, the fuel control link is attached with seals that prevent change of the fuel injection volume and rotation speed settings. Operating the engine without these seals in place can result in the following problems, and also invalidates the warranty.

- Rapid wear of moving and rotating parts
- Engine malfunctions including engine damage and seizing of engine parts
- Increased consumption of fuel and lubricating oil
- Degradation of engine performance due to improper balance between fuel injection volume and governor operation

● Always perform 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 pre-operation inspections or periodic inspections may cause various engine problems and damage to parts, as well as serious accidents.

● Break in new engine

Break in a new engine by operating it with a light load during the first 50 hours of operation. Operating a new engine under high load or severe condition during the break-in period can shorten the service life of the engine.

● Conduct warm-up operation

After the engine starts, let it idle at low speed for 5 to 10 minutes before using the engine for work.
Warm-up operation circulates lubricants in the engine, thus prolonging the service life and contributing to high-performance and economical operation.
Do not conduct warm-up operation for an extended period of time. Prolonged warm-up operation causes carbon build-up in the cylinders that leads to incomplete combustion.

● Never operate engine under overload condition

Do not operate the engine if the exhaust smoke is black.
Overloading the engine (indicated by black smoke) causes not only high fuel consumption but also excessive carbon deposits inside the engine that leads to engine problems and shortens the service life of the engine.

● Conduct cooling operation before stopping engine

Before stopping the engine, conduct cooling operation (operating at low speed) for 5 to 6 minutes.
Abruptly stopping the engine immediately after high-load operation can cause partial overheating 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 rain water to enter the engine through the air inlet or exhaust openings.
Do not wash the engine while it is operating. Cleaning fluid (water) can be sucked into the engine.
If water enters the combustion chambers of the engine, starting the engine can cause water hammer action, and may result in internal engine damage and serious accidents.

● Conduct proper maintenance of air cleaner

The major cause of abnormal wear on engine parts is dust entering with intake air. Worn parts result in many problems such as an increase of oil consumption, decrease of output, and starting difficulties. For effective removal of dust from intake air, conduct maintenance of the air cleaner according to the following directions.

- Do not conduct maintenance of the air cleaner while the engine is operating.
- When removing the air cleaner, do not allow dust attached on the air clear to fall into the outlet side of the air cleaner.
- If equipped with a dust indicator, conduct maintenance only when the clog warning sign appears. Unnecessary maintenance may cause dust to enter the engine when removing the filter element, or result in element damage or deformation.

● Observe safety rules at workplace

Observe the safety rules established at workplace when operating and maintaining the engine.
When feeling ill, do not operate the engine, and inform supervisor of condition.
Operation of the engine with reduced awareness may cause operation errors that may result in accidents.
When working in a group, use specified hand signals to communicate among the workers.

● Wear proper work clothes and protective gear

Wear a hardhat, face shield, safety shoes, dust mask and other protective gear, as needed.
When handling compressed air, wear safety goggles, hardhat, gloves and other necessary protective gear.
Conducting work without proper protective gear may result in serious injury.

● Use appropriate tools for maintenance work

To conduct maintenance work, use tools appropriate for the type of work to be performed, and use them correctly.
If tools are damaged, replace with new tools.

● Do not operate starter for prolonged time

Do not operate the starter for more than 10 seconds at a time if the engine does not start and wait for at least 30 seconds before cranking again.
Continuous operation of the starter will drain the battery power and cause seizing of the starter.

● Do not turn off battery switch while engine is operating

Do not turn off the batter switch while the engine is in operation.
Turning off the battery switch while the engine is in operation not only stops the instrument operations but also damages the diodes and transistors inside the alternator.

● Cautions in transporting engine

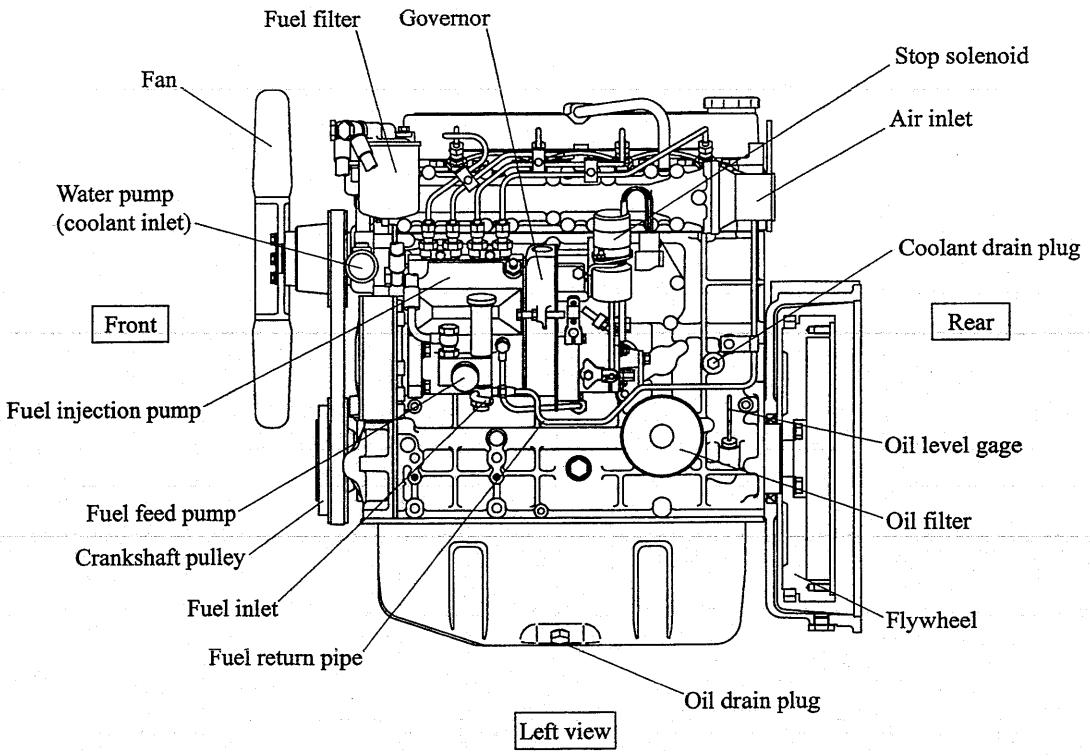
When transporting the engine on a truck, consider the generator weight, width and height to ensure safety, and also abide by the traffic law, road trucking vehicle law, vehicle restriction ordinance and other pertinent laws.

GENERAL

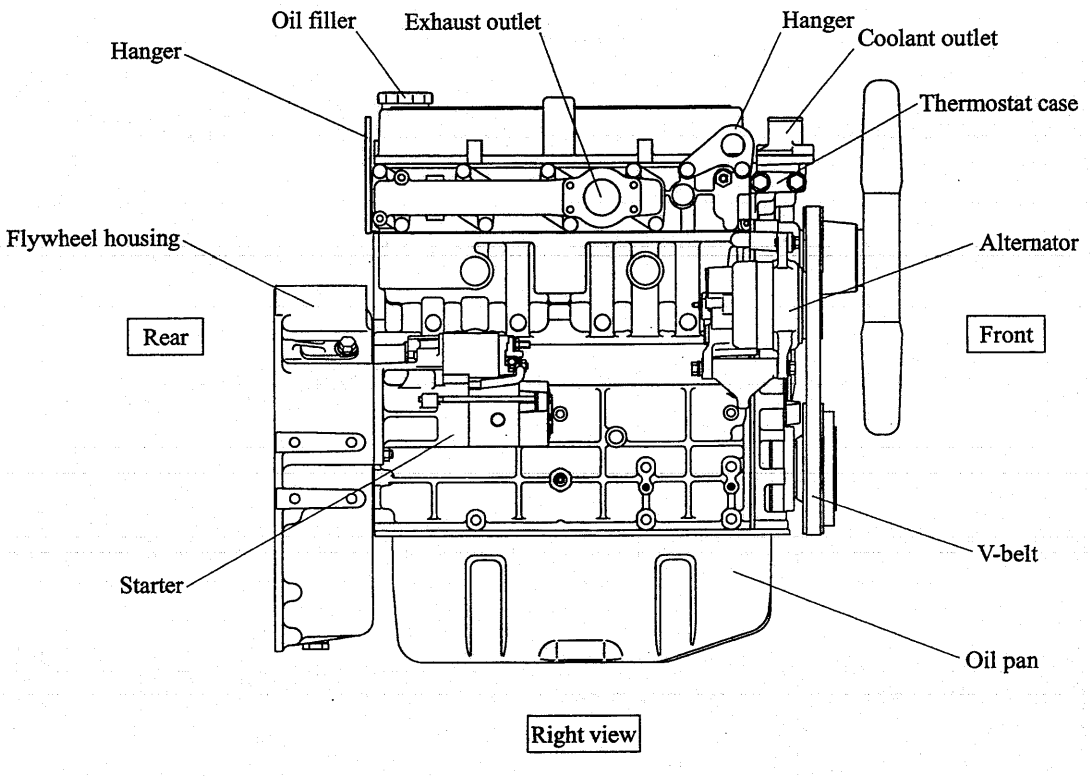
1. Outline

1.1 External View (In-line Fuel Injection Pump and Distributor-type Fuel Injection Pump)

(1) S4S in-line fuel injection pump specification

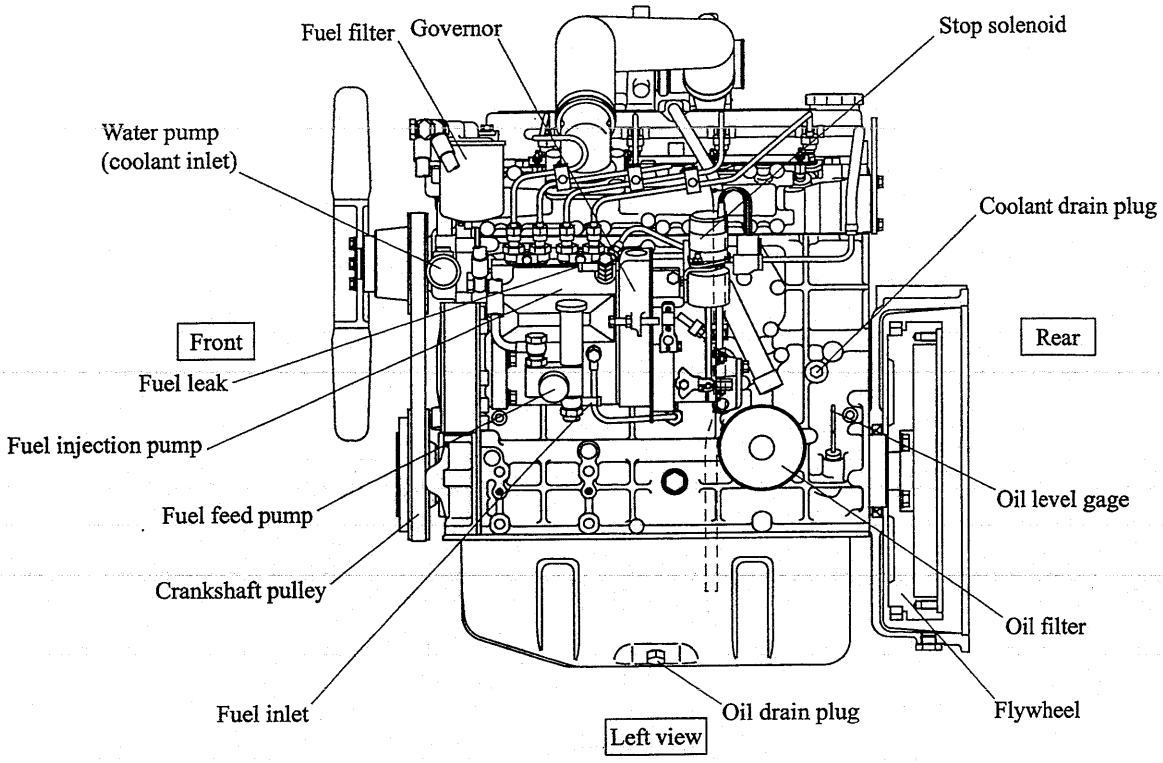


Left view of engine

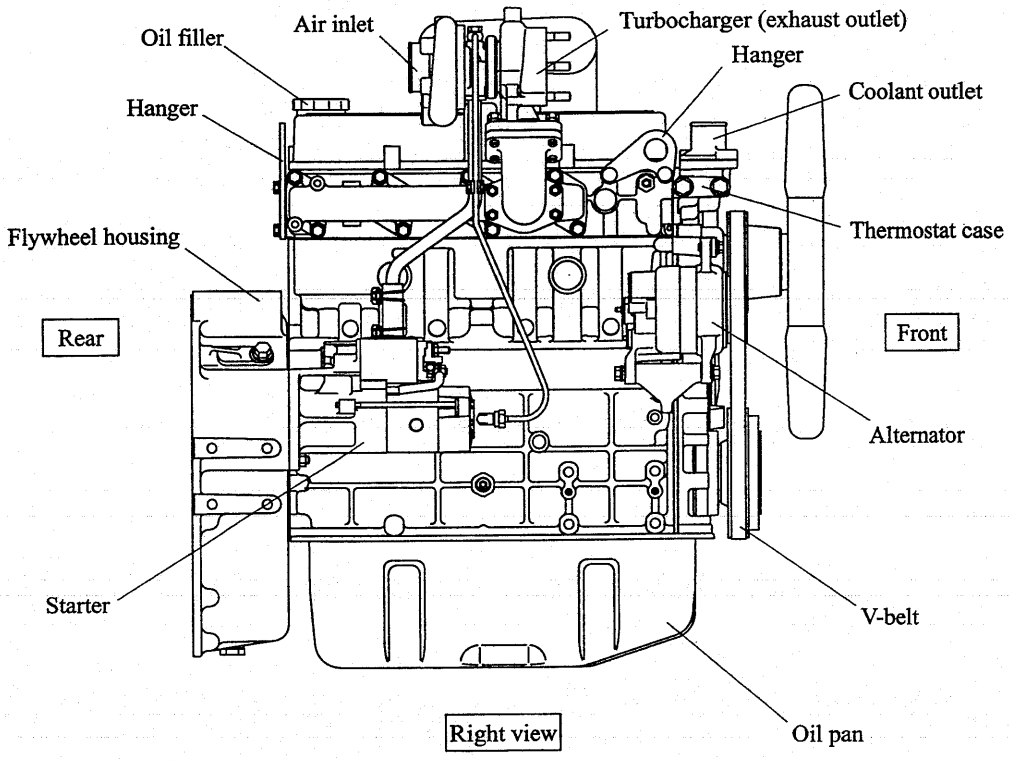


Right view of engine

(2) S4S-DT in-line fuel injection pump specification

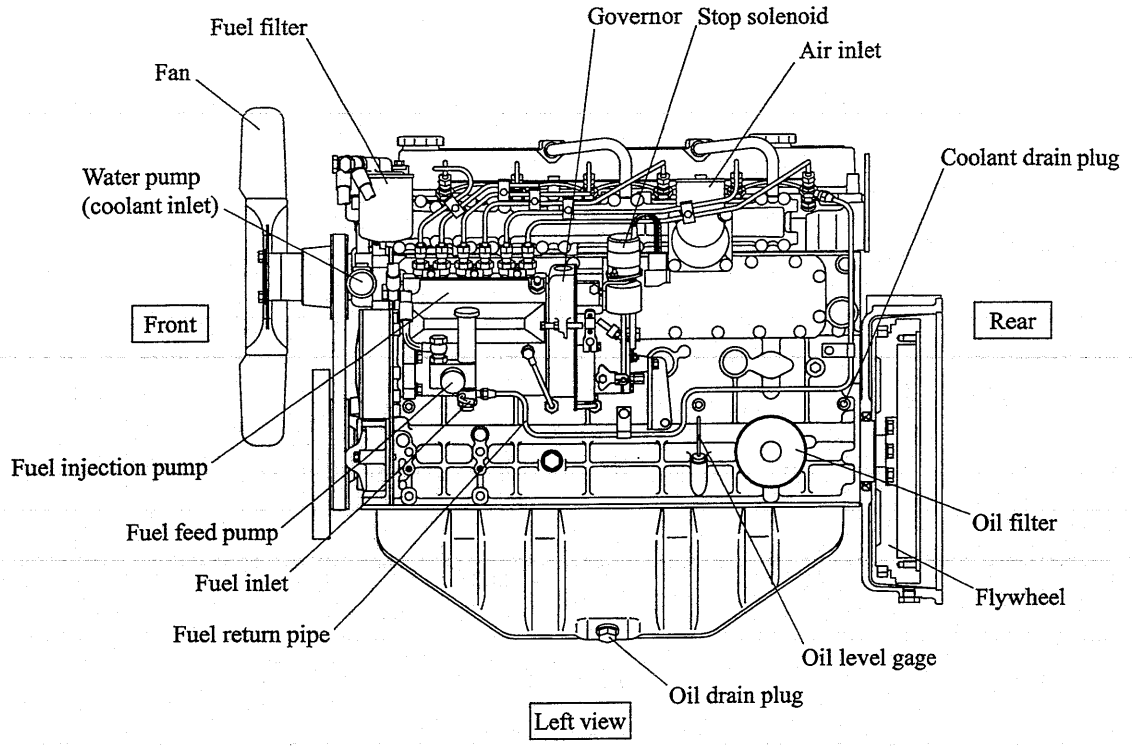


Left view of engine

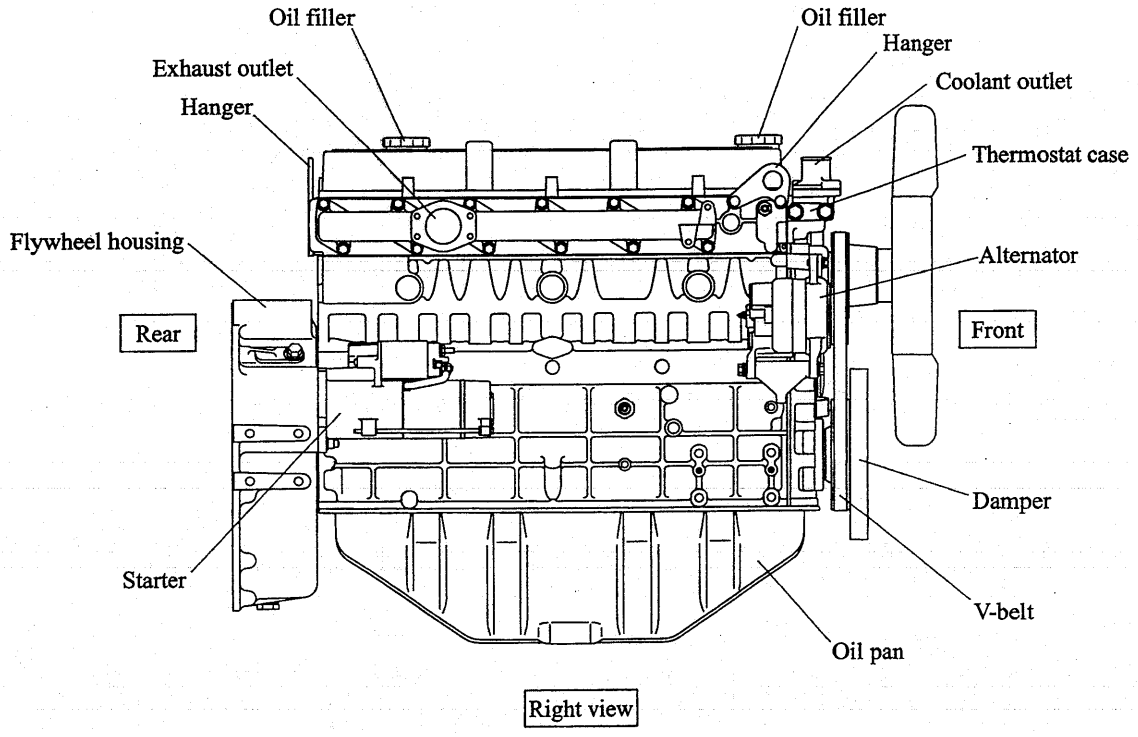


Right view of engine

(3) S6S in-line fuel injection pump specification

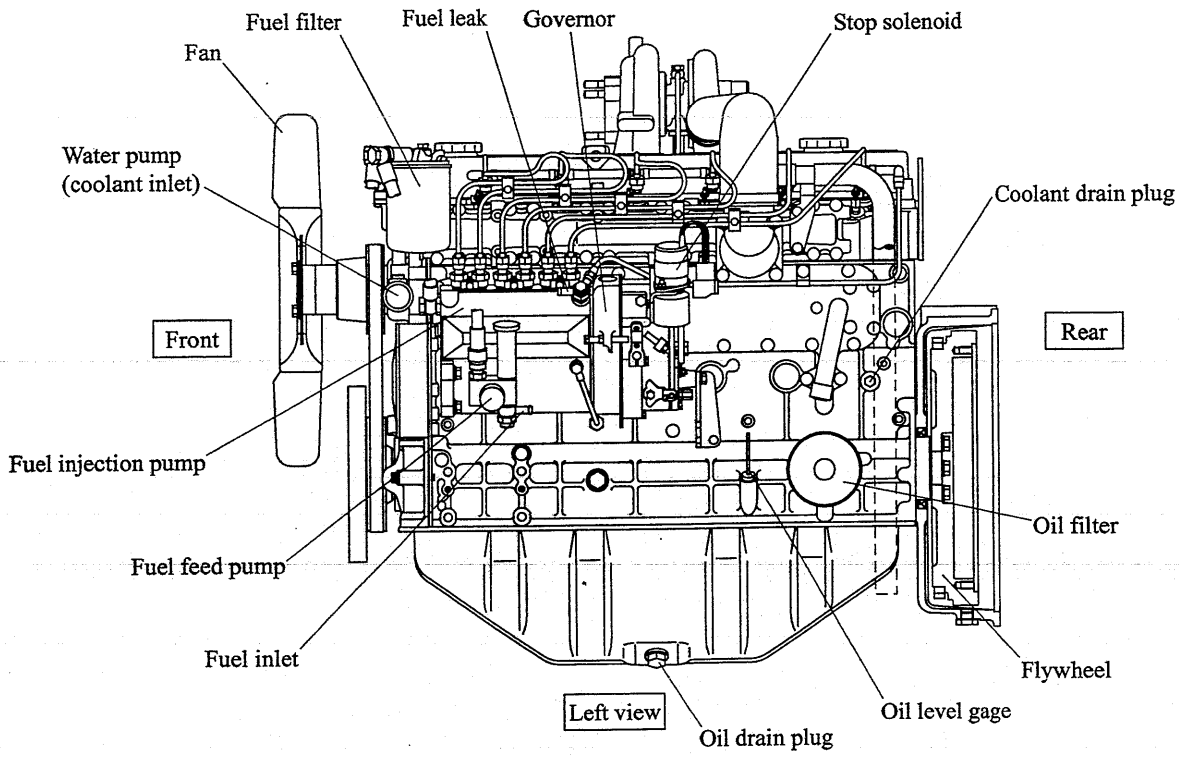


Left view of engine

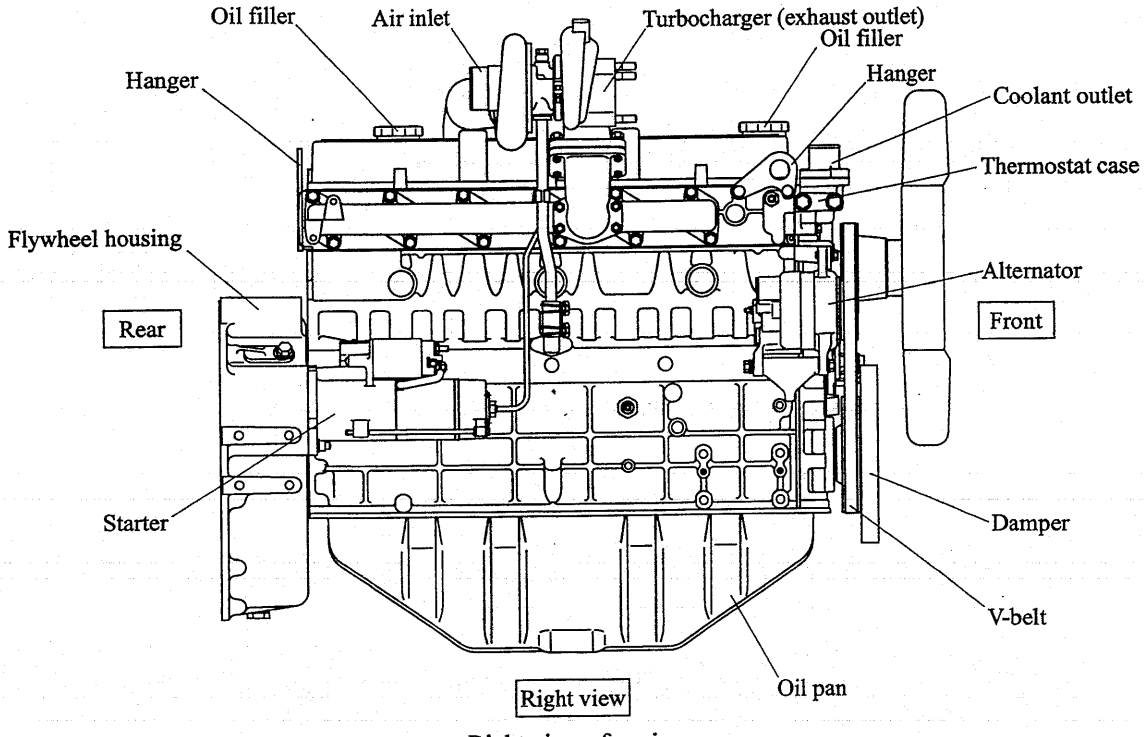


Right view of engine

(4) S6S-DT in-line fuel injection pump specification

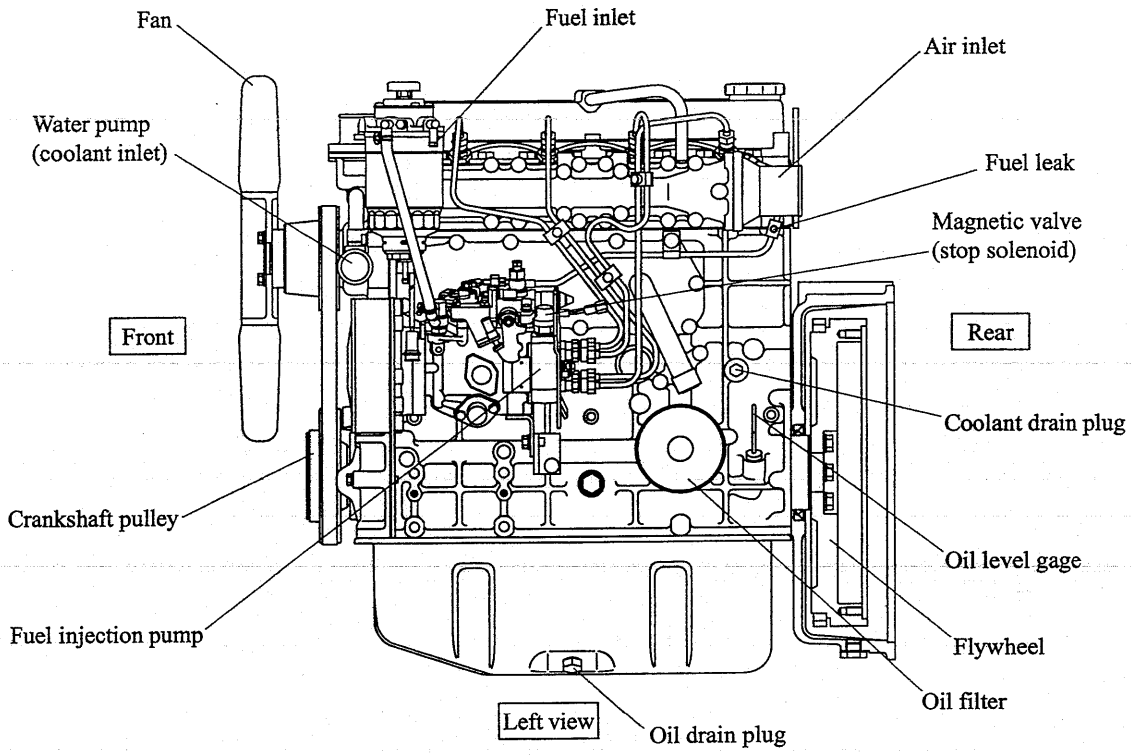


Left view of engine

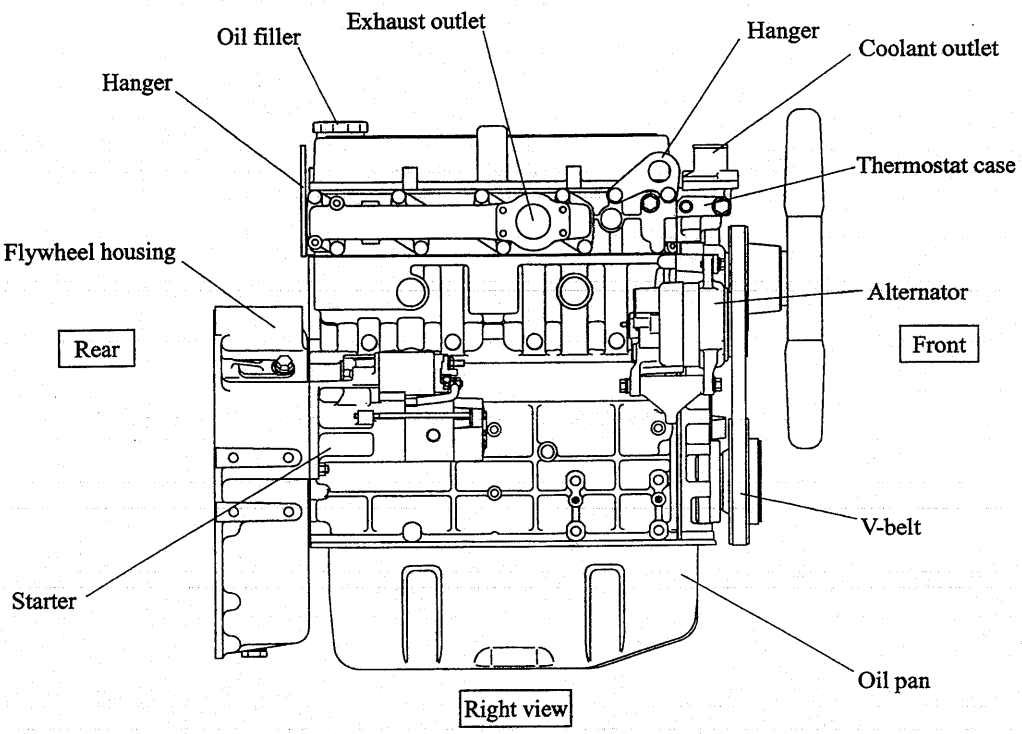


Right view of engine

(5) S4S distributor-type fuel injection pump specification

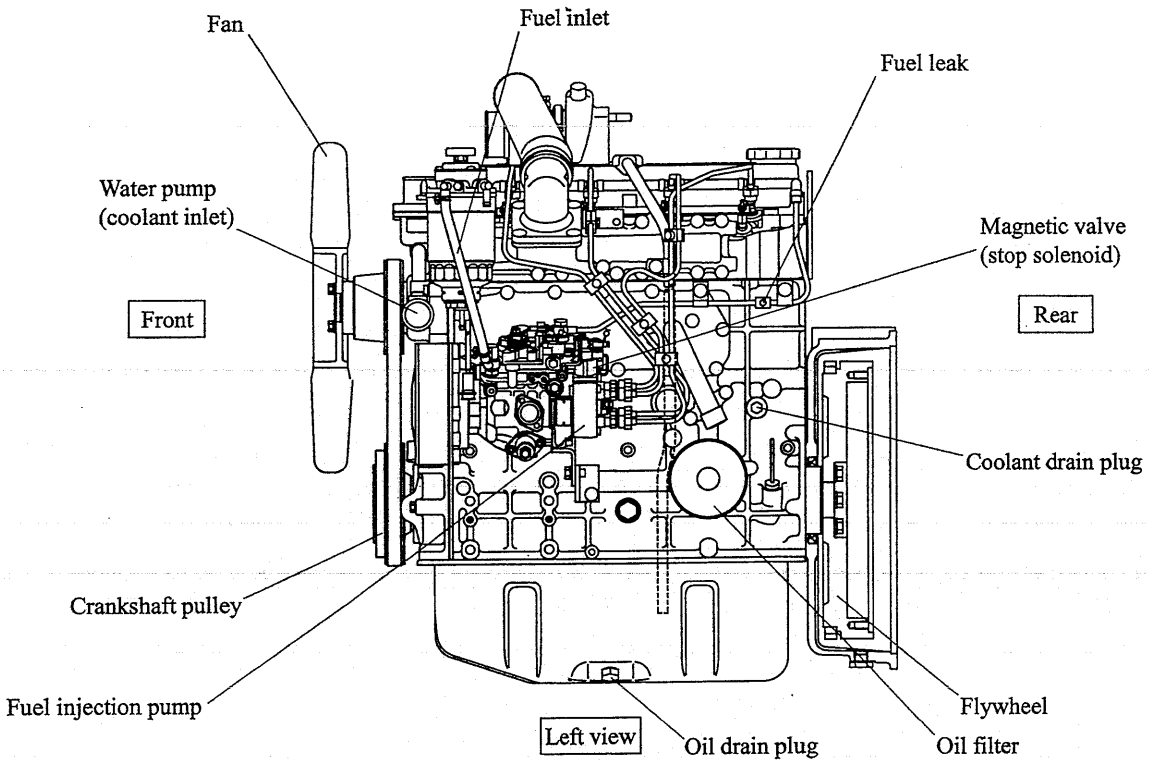


Left view of engine

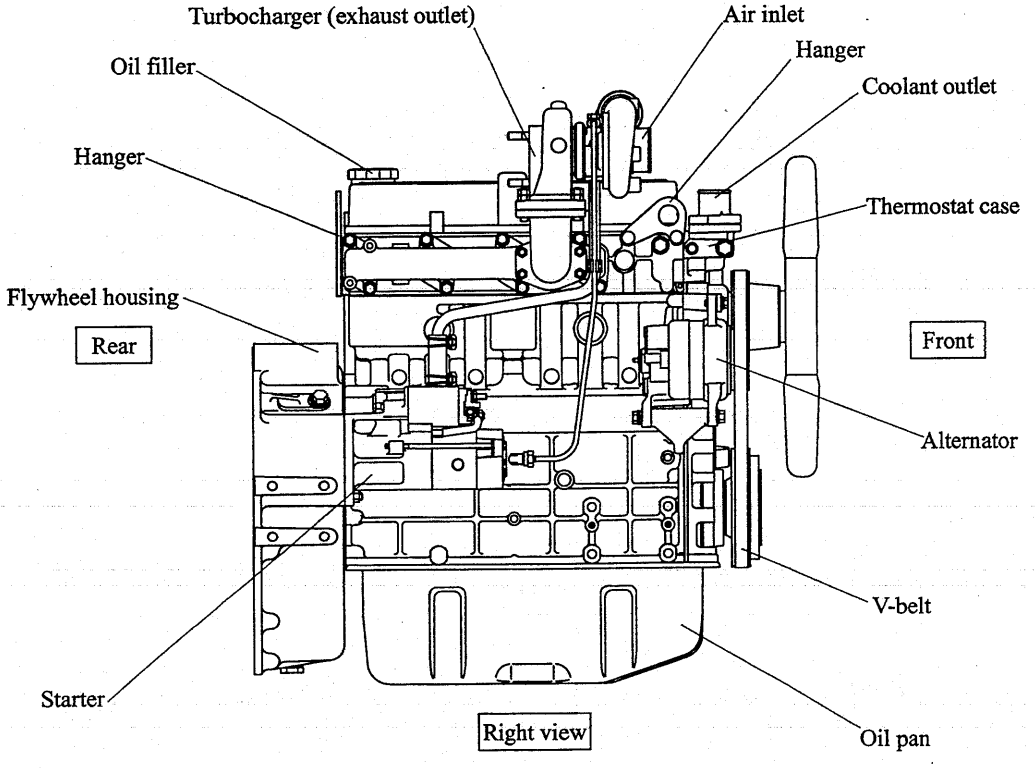


Right view of engine

(6) S4S-DT distributor-type fuel injection pump specification

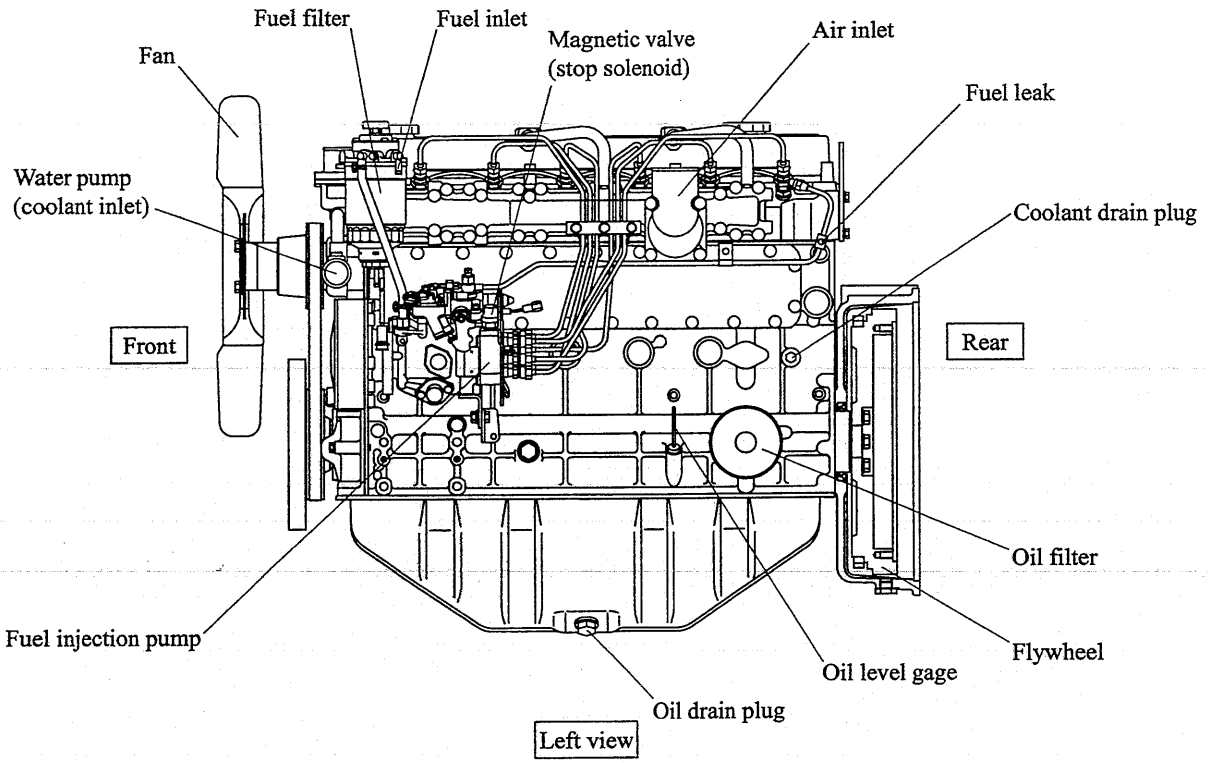


Left view of engine

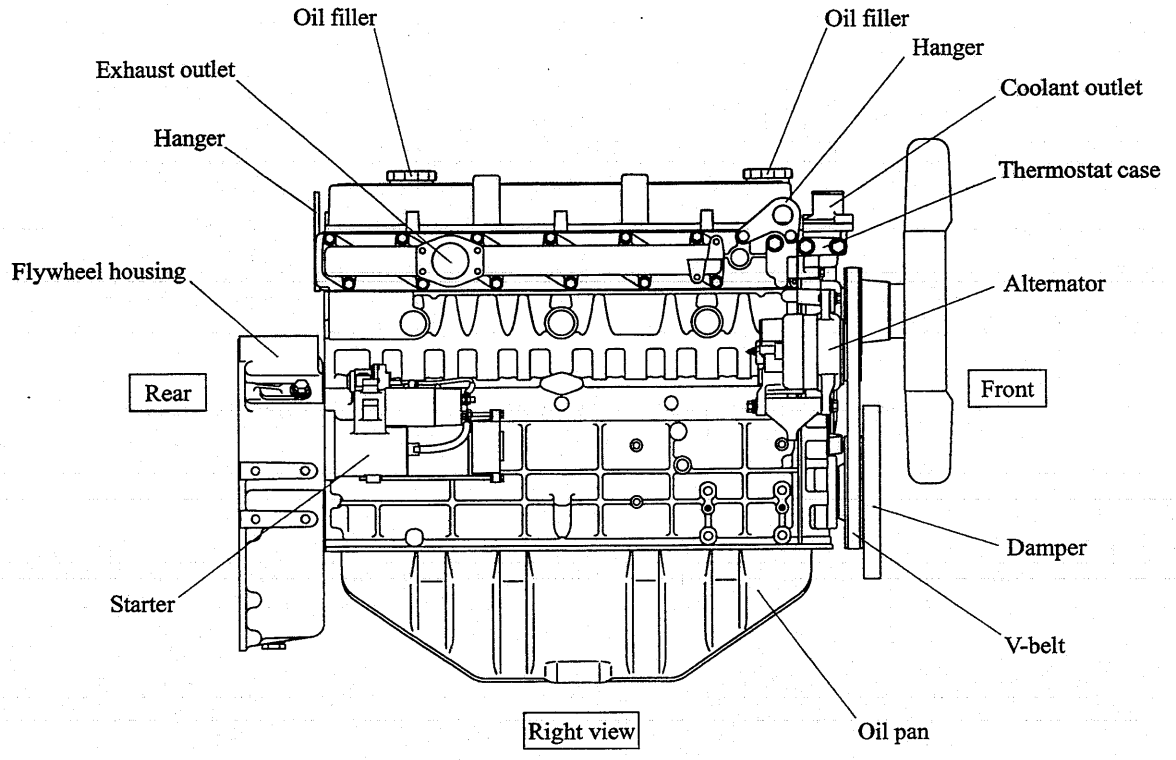


Right view of engine

(7) S6S distributor-type fuel injection pump specification

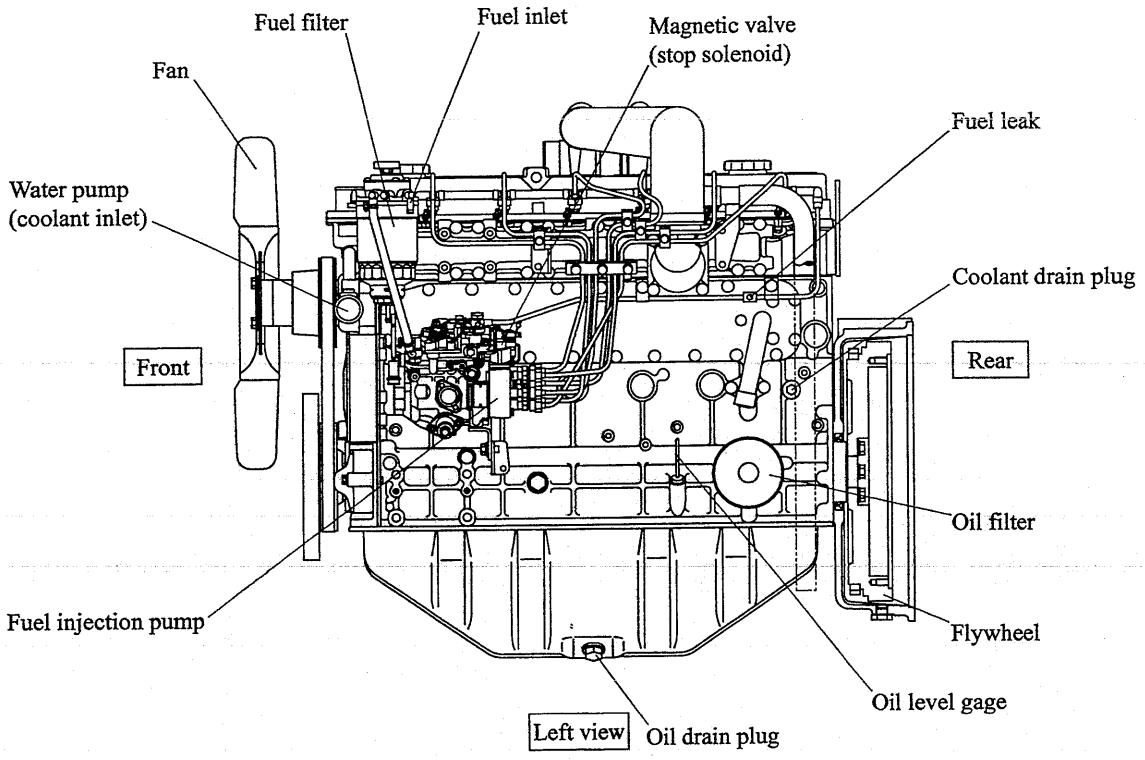


Left view of engine

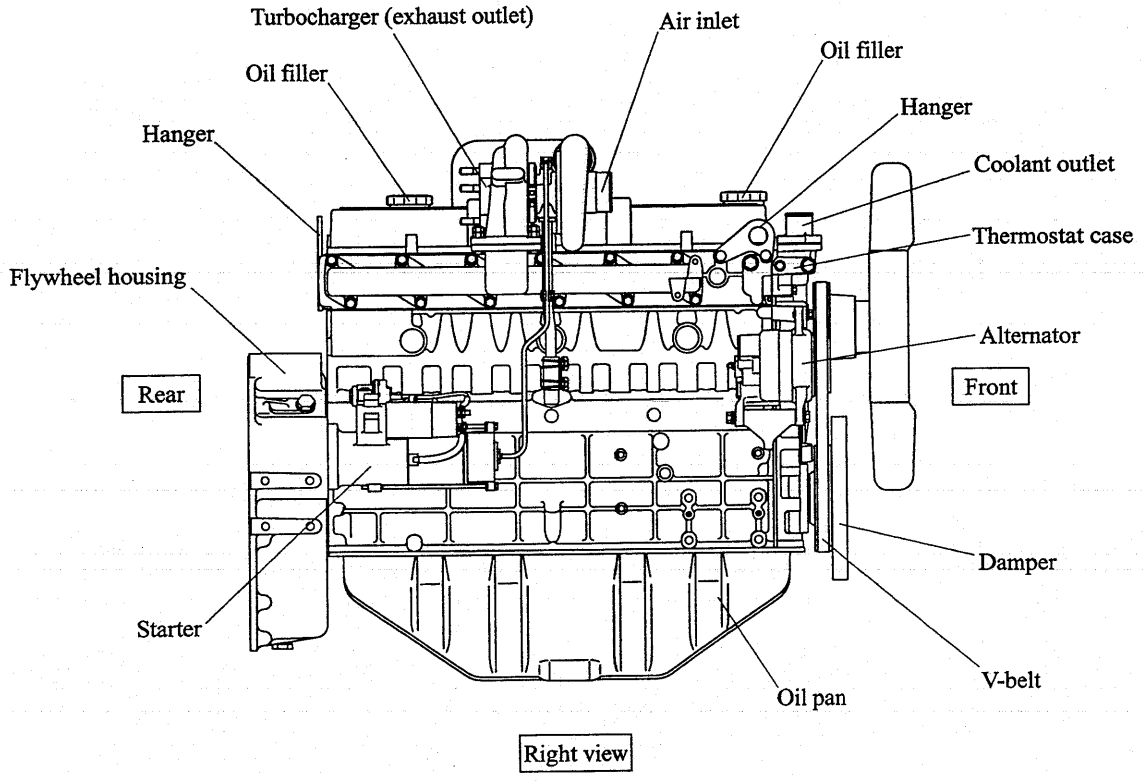


Right view of engine

(8) S6S-DT distributor-type fuel injection pump specification



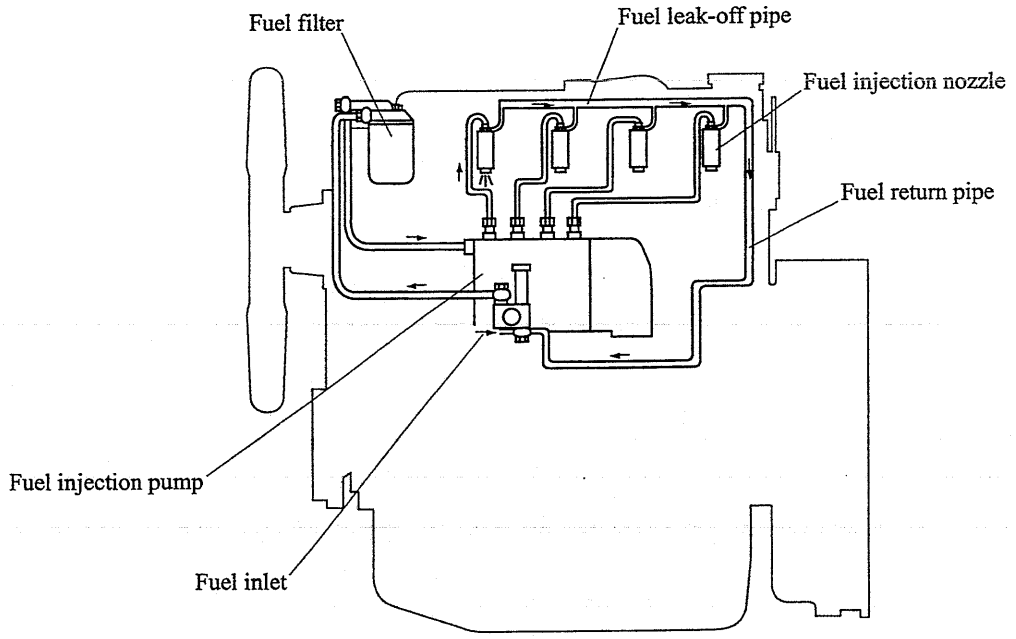
Left view of engine



Right view of engine

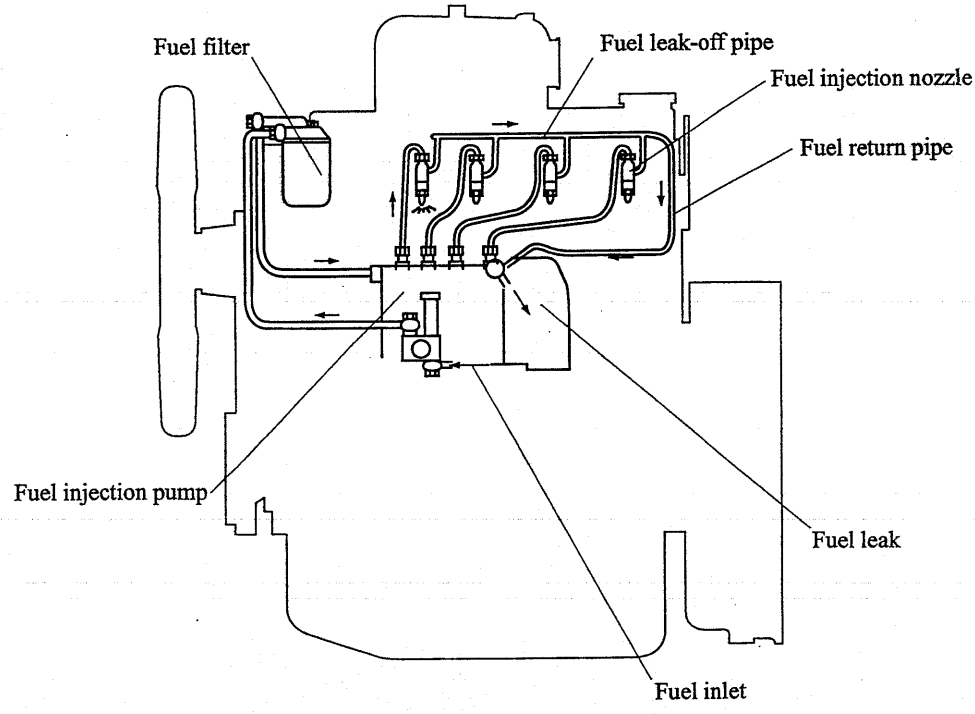
1.2 Outline of Fuel System

(1) S4S in-line fuel injection pump (swirl chamber) specification



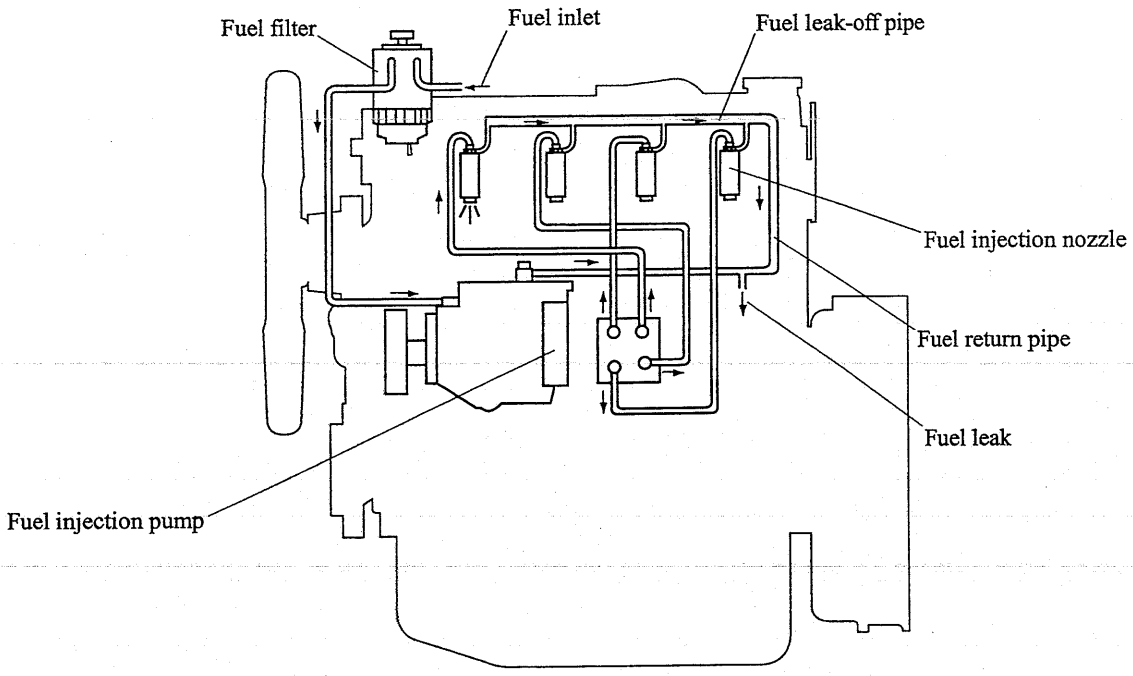
Outline of fuel system

(2) S4S-DT in-line fuel injection pump (direct injection) specification



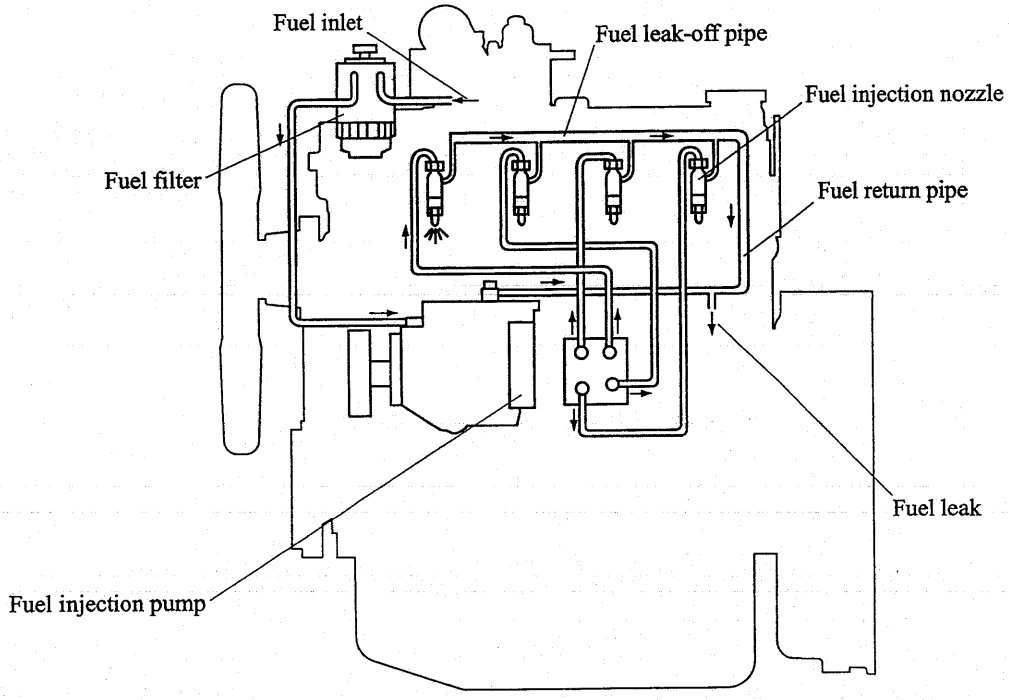
Outline of fuel system

(3) S4S distributor-type fuel injection pump (swirl chamber) specification



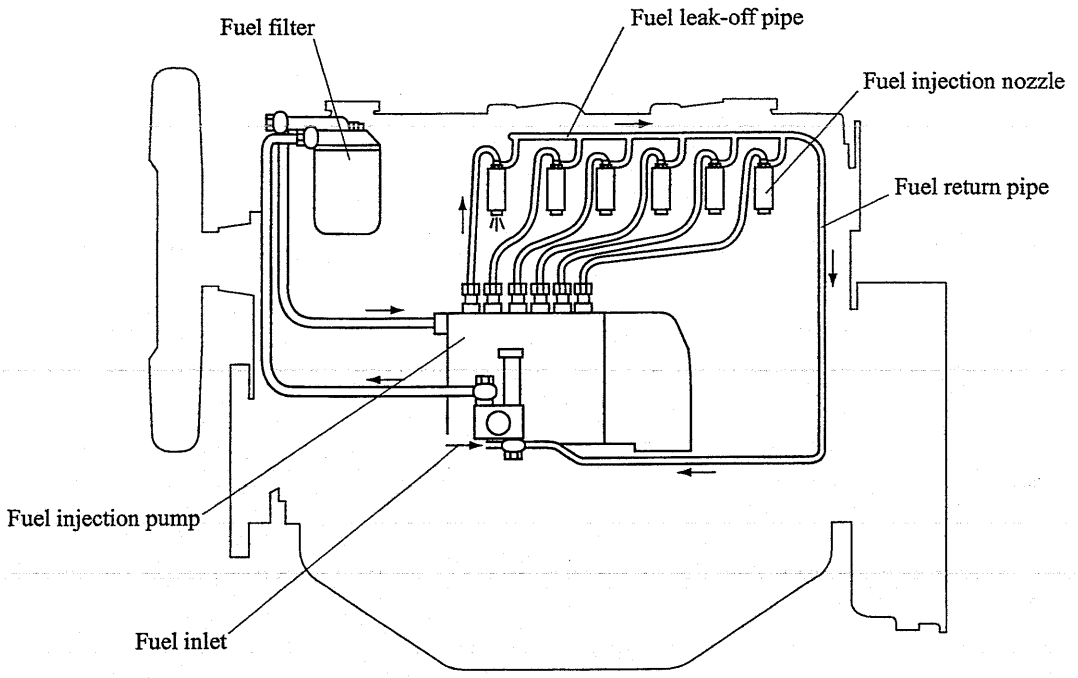
Outline of fuel system

(4) S4S-DT distributor-type fuel injection pump (direct injection) specification



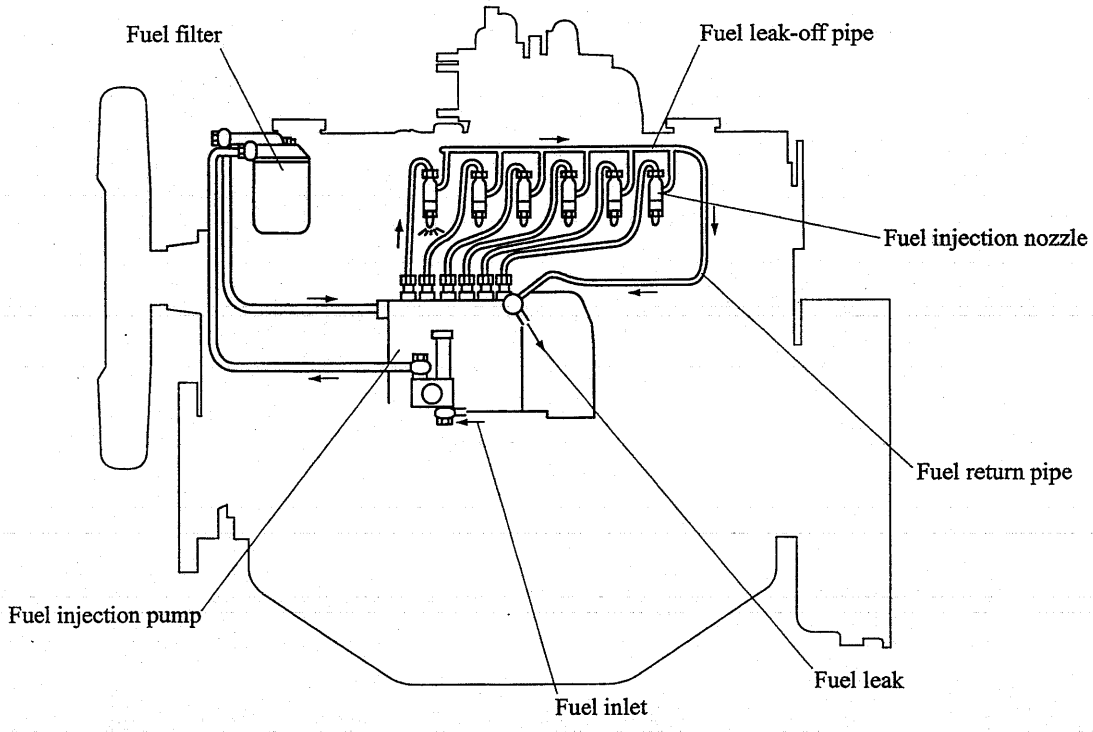
Outline of fuel system

(5) S6S in-line fuel injection pump (swirl chamber) specification



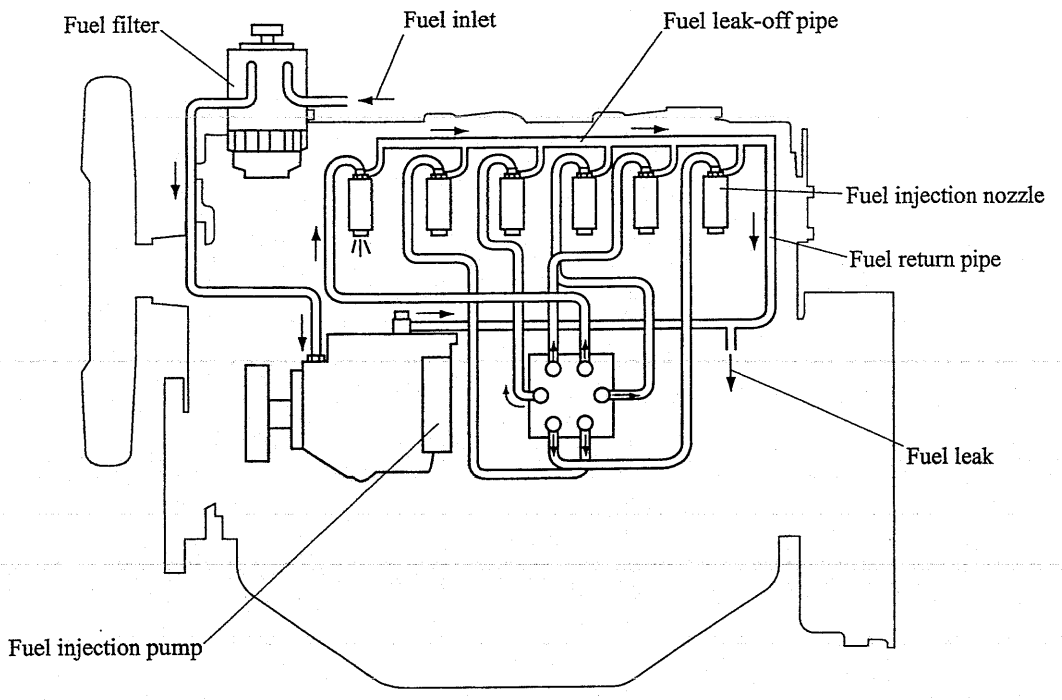
Outline of fuel system

(6) S6S-DT in-line fuel injection pump (direct injection) specification



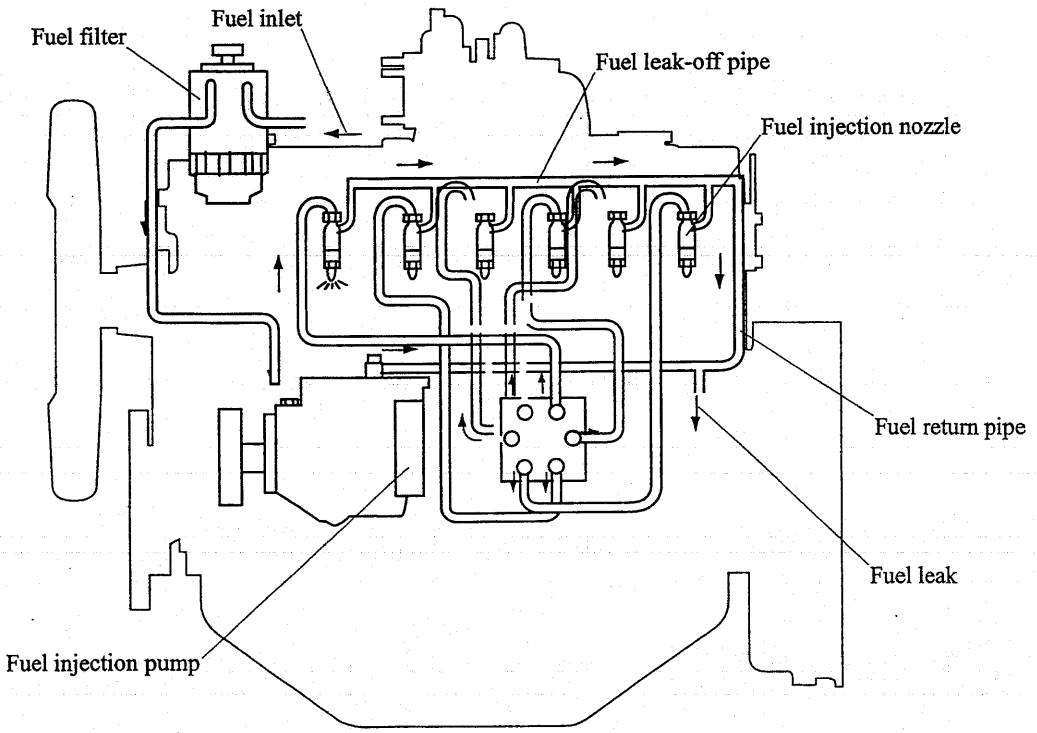
Outline of fuel system

(7) S6S distributor-type fuel injection pump (swirl chamber) specification



Outline of fuel system

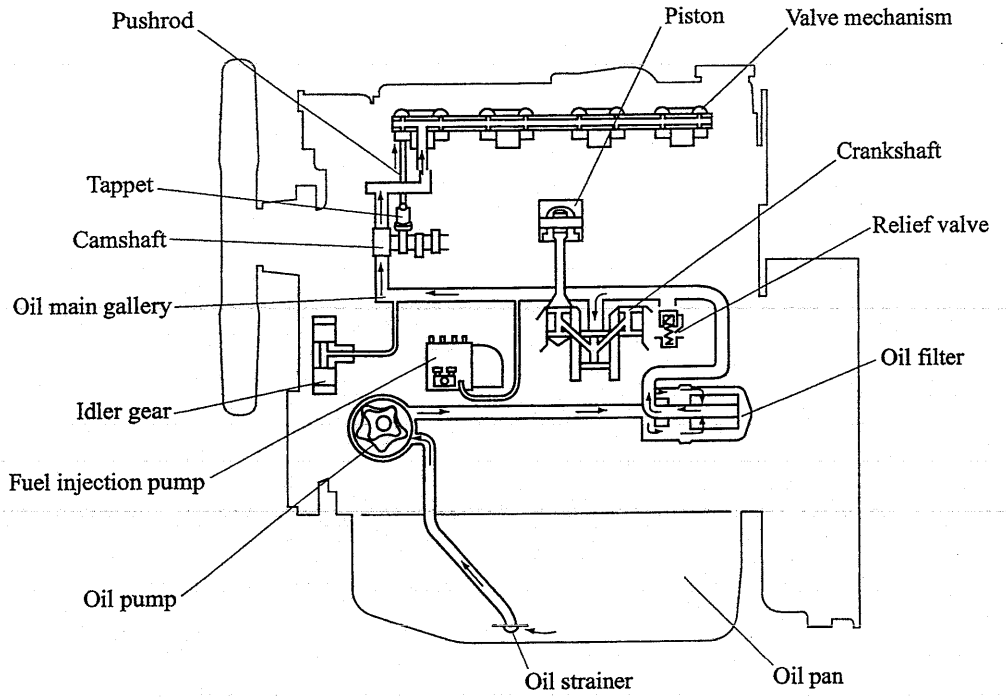
(8) S6S-DT distributor-type fuel injection pump (direct injection) specification



Outline of fuel system

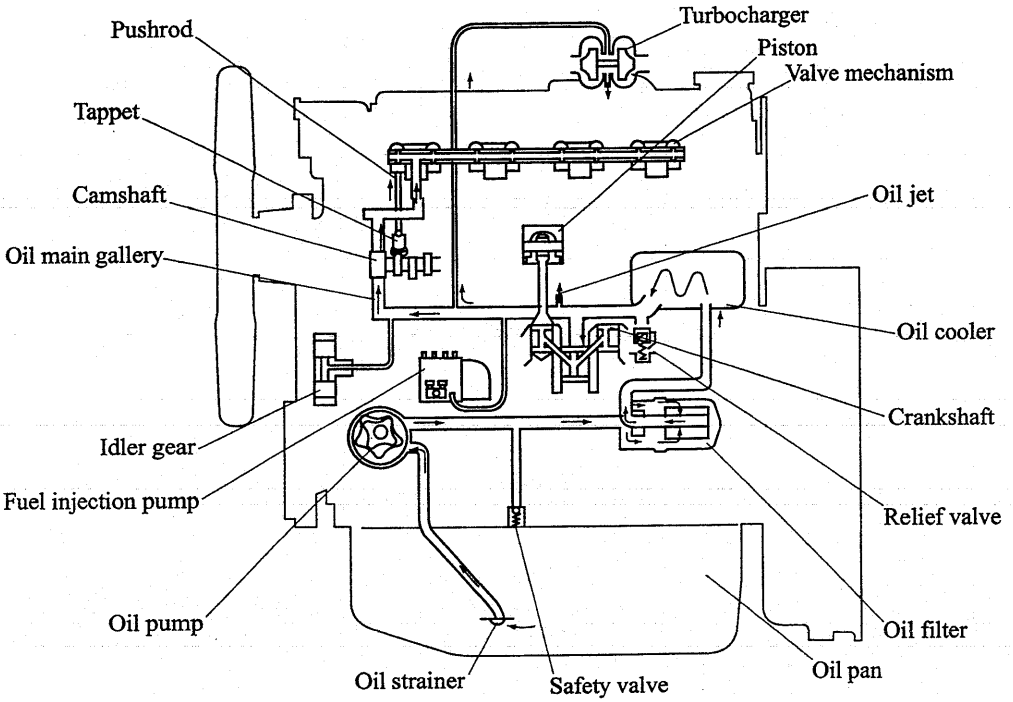
1.3 Outline of Lubrication System

(1) S4S in-line fuel injection pump specification



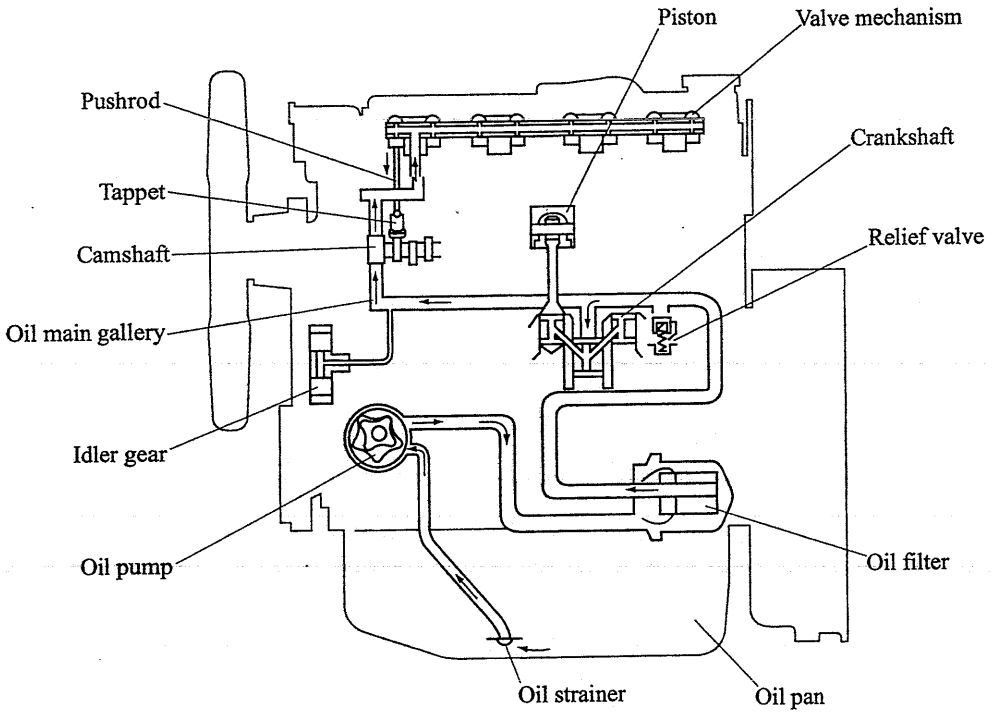
Outline of lubrication system

(2) S4S-DT in-line fuel injection pump specification



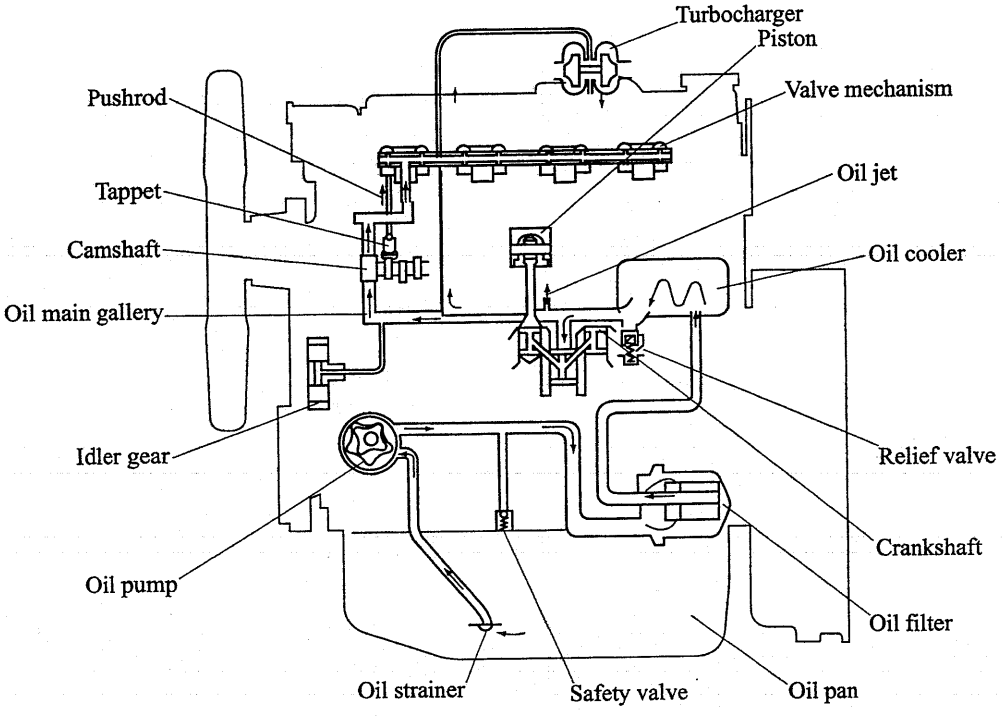
Outline of lubrication system

(3) S4S distributor-type fuel injection pump specification



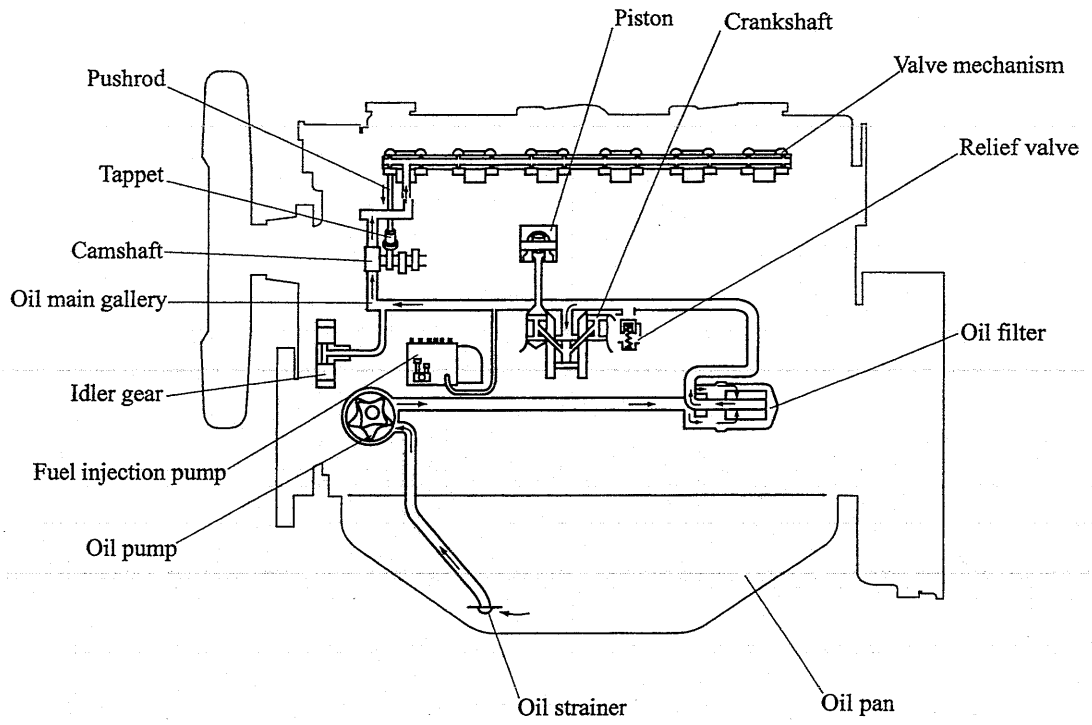
Outline of lubrication system

(4) S4S-DT distributor-type fuel injection pump specification



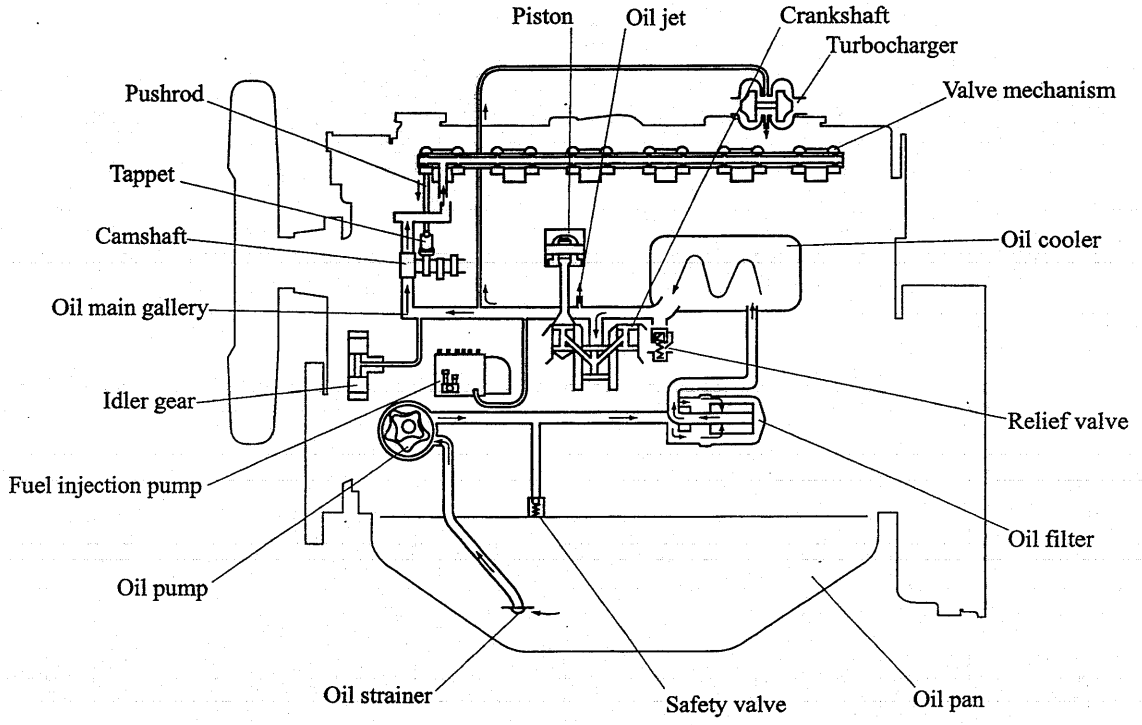
Outline of lubrication system

(5) S6S in-line fuel injection pump specification



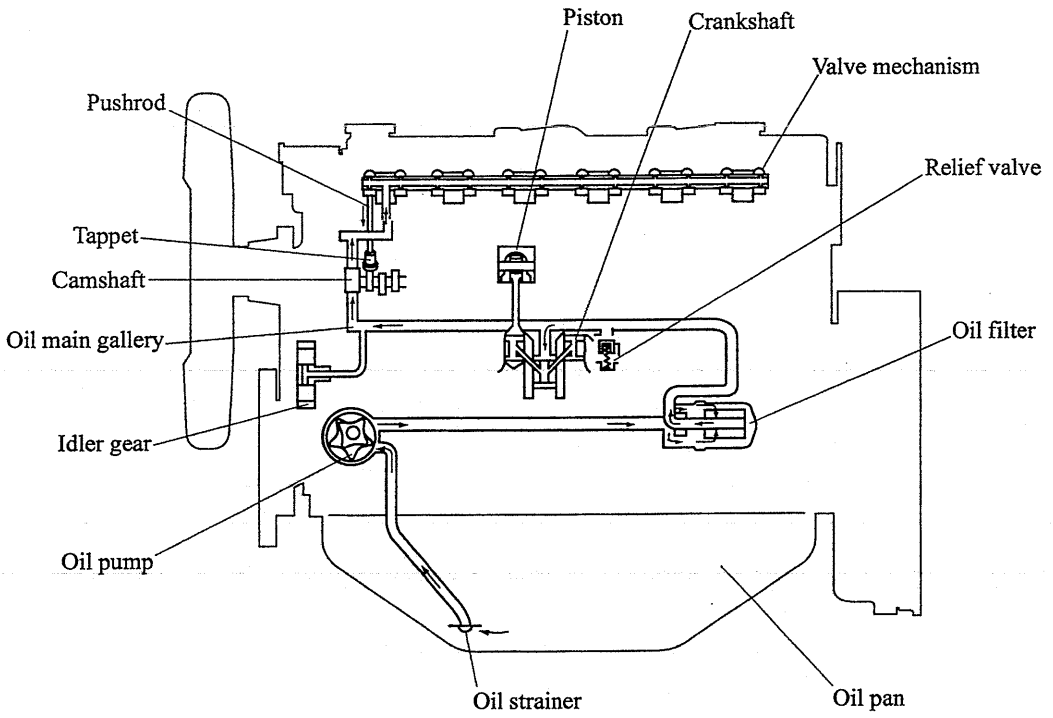
Outline of lubrication system

(6) S6S-DT in-line fuel injection pump specification



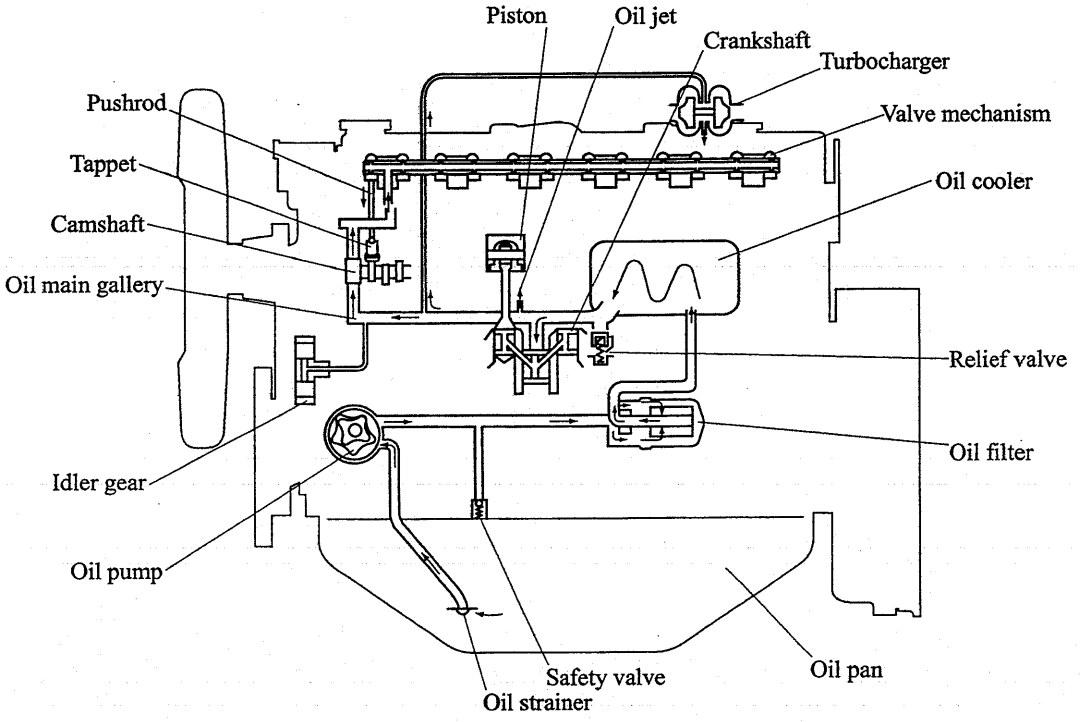
Outline of lubrication system

(7) S6S distributor-type fuel injection pump specification



Outline of lubrication system

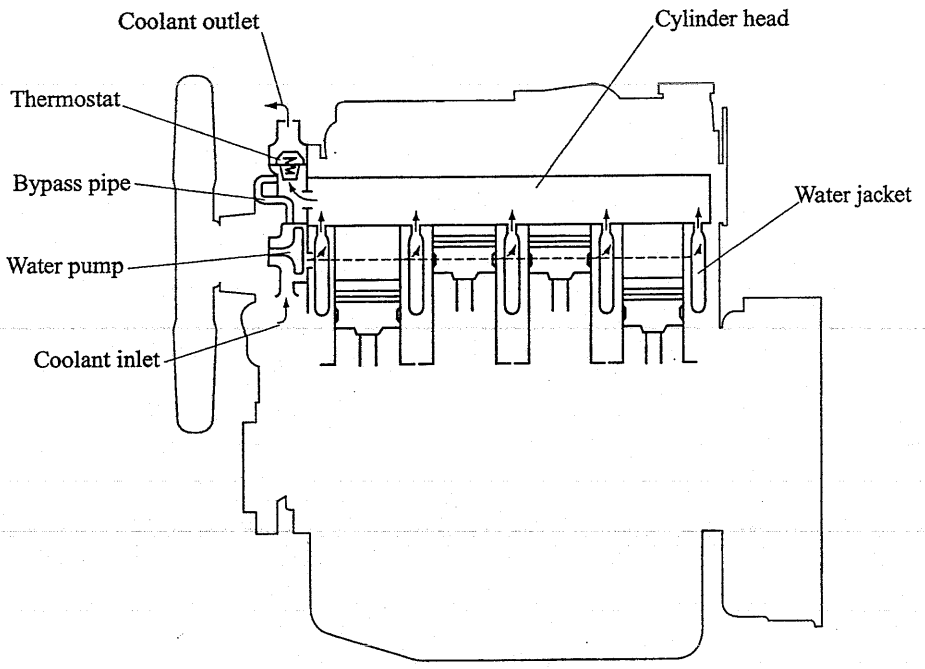
(8) S6S-DT distributor-type fuel injection pump specification



Outline of lubrication system

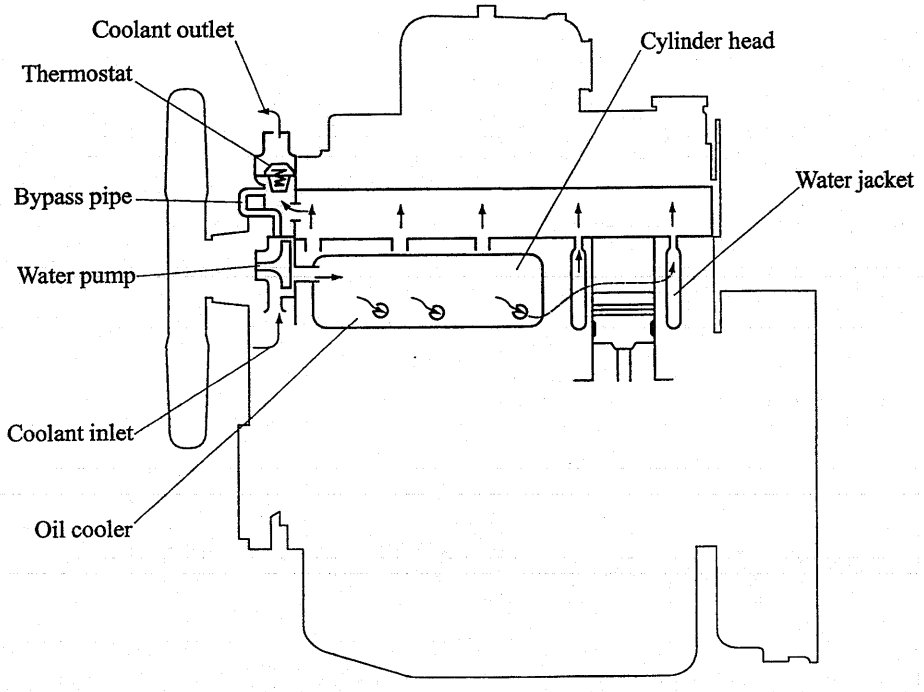
1.4 Outline of Cooling System

(1) S4S



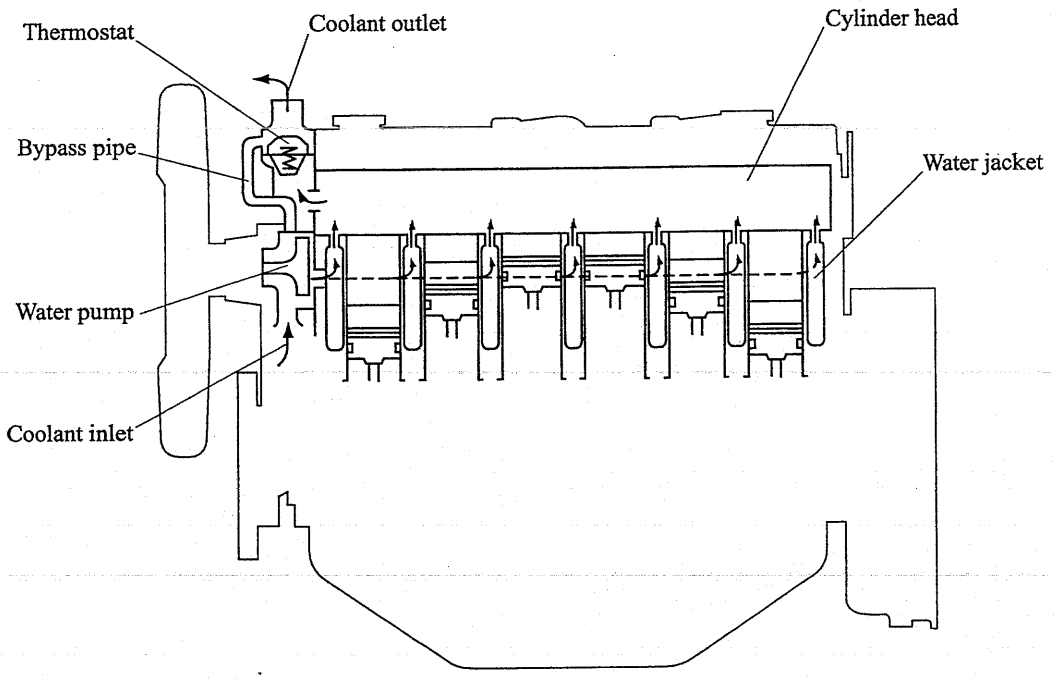
Outline of cooling system

(2) S4S-DT



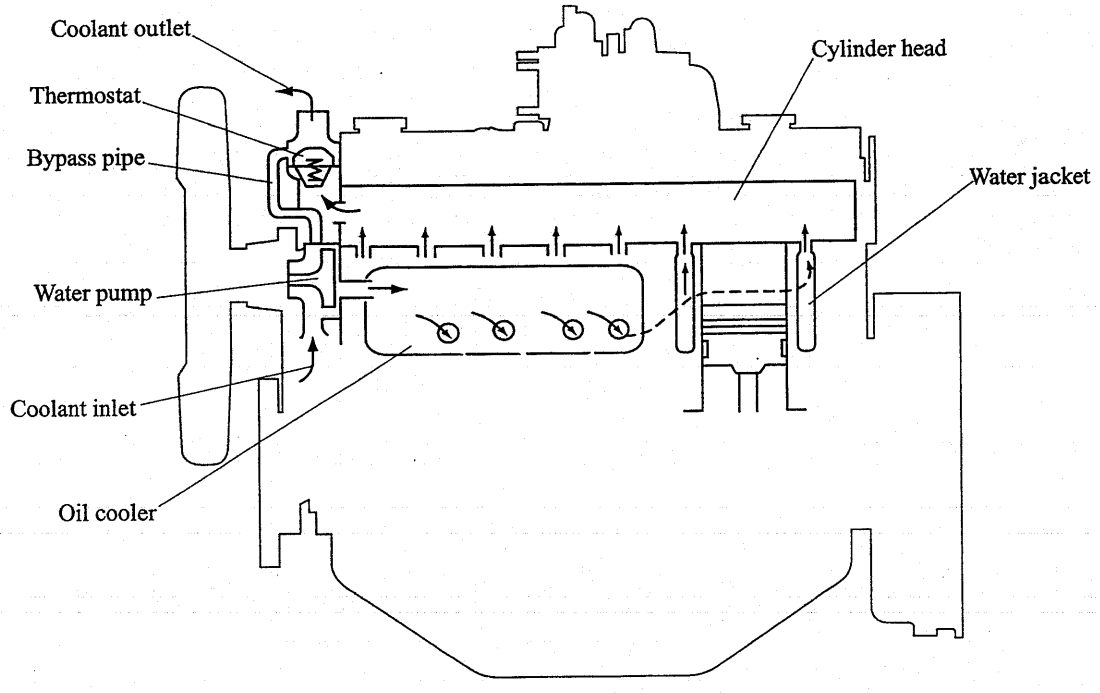
Outline of cooling system

(3) S6S



Outline of cooling system

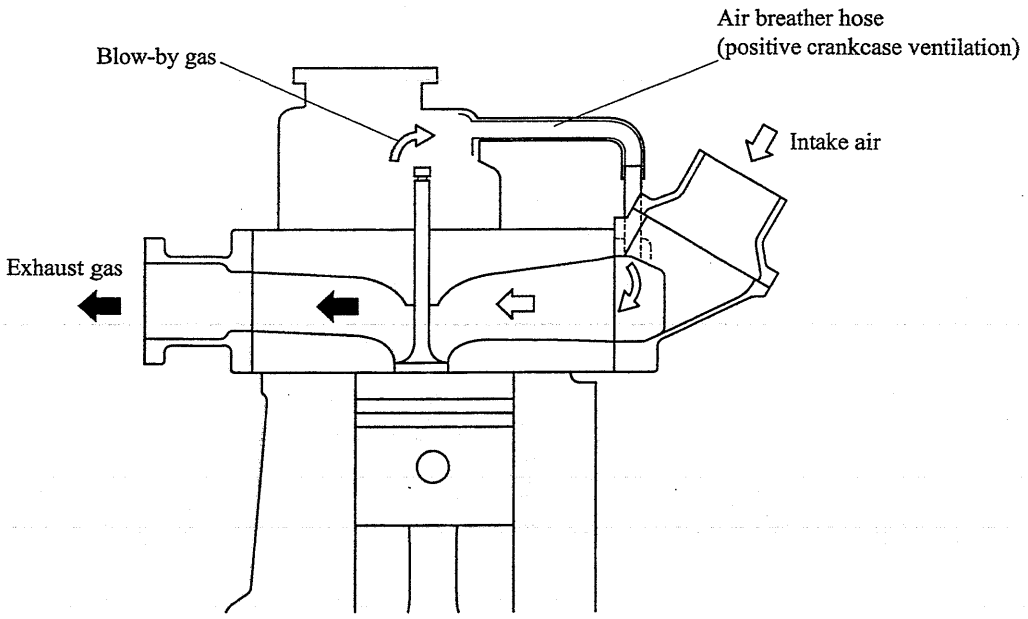
(4) S6S-DT



Outline of cooling system

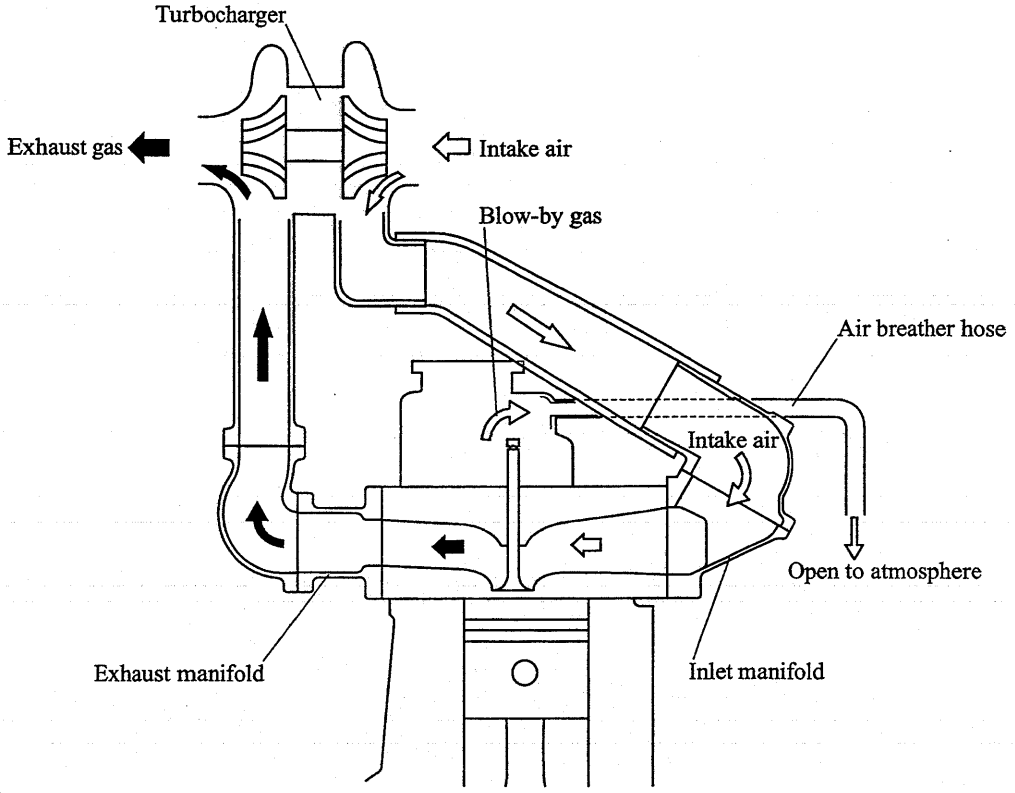
1.5 Outline of Inlet and Exhaust Systems

(1) Non-turbocharged engine



Outline of inlet and exhaust systems

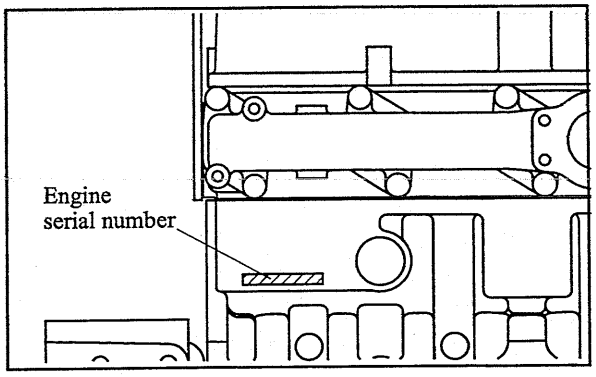
(2) Turbocharged engine



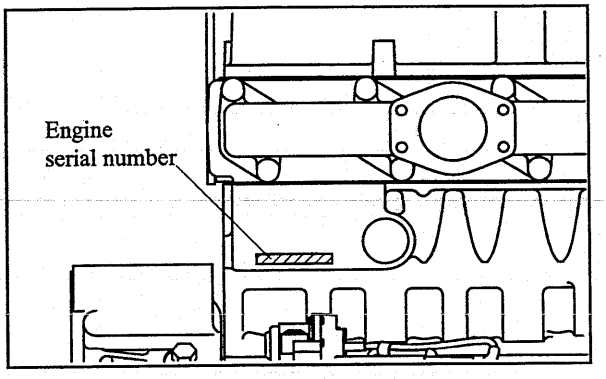
Outline of inlet and exhaust systems

1.6 Engine Serial Number

The engine serial number is stamped on the side of the crankcase.

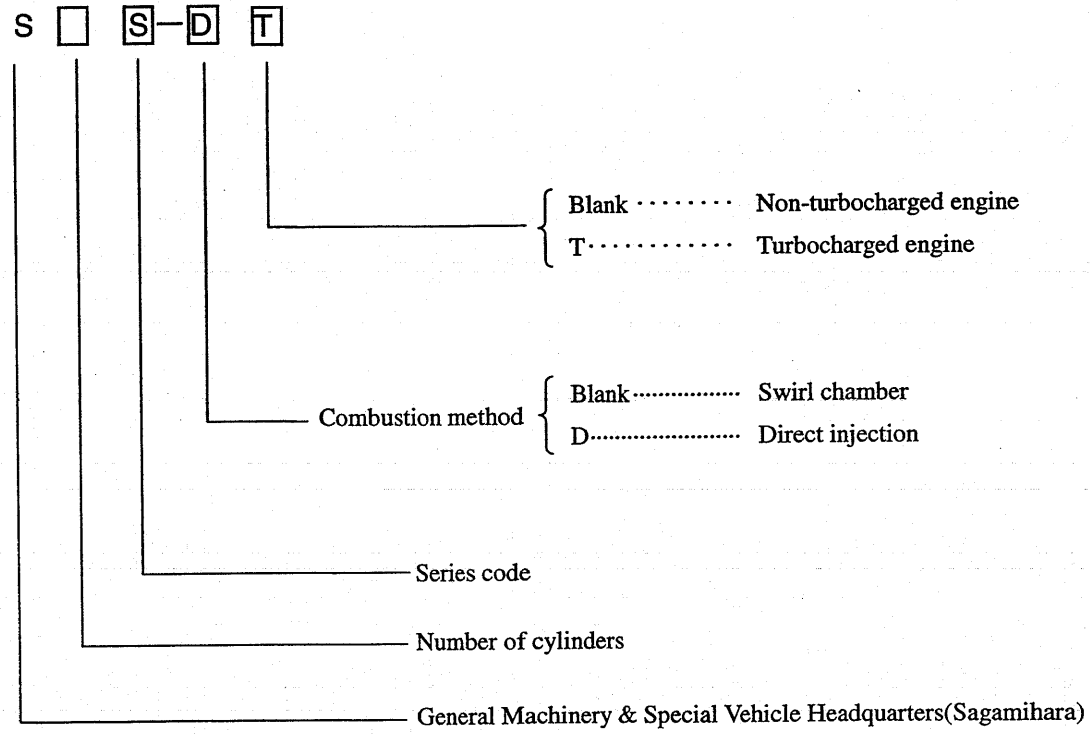


S4S engine serial number location



S6S engine serial number location

1.7 Engine Model and Application Code



2. Specifications

2.1 S4S in-line fuel injection pump specification (may differ in detail)

Engine type				S4S	S4S-DT
Main specifications	Type			Mitsubishi diesel engine	
	Cooling method			Water cooling	
	No. of strokes			4-stroke cycle	
	No. of cylinders - cylinder arrangement			4 in-line	
	Combustion method			Swirl chamber	Direct injection
	Valve mechanism			Overhead	
	Cylinder bore × stroke mm [in.]			94 × 120 [3.701 × 4.724]	
	Total displacement ℓ [cu in.]			3.331 [203]	
	Compression ratio			22:1	17:1
	Fuel			Diesel fuel (JIS No. 2 equivalent)	
	Firing order			1-3-4-2	
	Rotational direction			Counterclockwise as viewed from flywheel side	
	Dimension (with fan)	Overall length mm [in.]		781 [30.7]	
		Overall width mm [in.]		567 [22.3]	
		Overall height mm [in.]		717 [28.2]	815 [32.1]
	Dry weight kg [lb.]			245 [540]	250 [551]
Engine main parts	Cylinder sleeve	Type		Dry (integral with cylinder block)	
	Piston ring	No. of rings		Compression ring: 2	
				Oil ring (with expander): 1	
	Valve timing	Inlet valve	Open	BTDC 30°	BTDC 18°
			Close	ABDC 50°	ABDC 54°
		Exhaust valve	Open	BBDC 74°	BBDC 66°
			Close	ATDC 30°	ATDC 22°
	Starting system			Electric starter	
	Starting aid			Glow plug	
Fuel system	Injection pump	Type		In-line (Bosch Type A)	
		Plunger diameter mm [in.]		ϕ7 [0.28]	ϕ9 [0.35]
	Feed pump	Type		Piston pump (Bosch)	
	Governor	Speed control system		Centrifugal	
		Type		Bosch Type RSV	
	Injection nozzle	Type		Throttle nozzle (Bosch)	Hole nozzle (Bosch)
		No. of spray holes		1	4
		Spray hole diameter mm [in.]		ϕ1.0 [0.039]	ϕ0.28 [0.011]
		Spray angle		0°	155°
		Valve opening pressure MPa (kgf/cm²) [psi]		11.77 (120) [1707]	17.65 (180) [2561]
	Fuel filter	Type		Paper-element cartridge	

Engine type			S4S	S4S-DT
Lubrication system	Lubricating method		Forced circulation (oil pump pressure feed)	
	Engine oil	Grade (API service classification)	Class CF (SAE30 equivalent)	
		Capacity ℓ [U.S.gal]	Entire engine: 10 [2.64], Oil pan: Maximum of 9 [2.38], oil filter: 1 [0.26]	
	Oil pump	Type	Trochoid	
		Speed ratio to crankshaft	0.74	
		Discharge capacity ℓ [U.S.gal] / min	28.6 [7.6] at 0.3MPa (3 kgf/cm^2) [43 psi] discharge pressure of pump running at 2230min^{-1}	
	Relief valve	Type	Piston valve	
		Valve opening pressure MPa (kgf/cm^2) [psi]	0.35±0.05 (3.6±0.5) [51±7]	
	Safety valve	Valve opening pressure MPa (kgf/cm^2) [psi]	—	1.1 (11) [156]
	Oil cooler	Type	—	Water-cooled, multi-plate
	Oil filter	Type	Paper-element cartridge	
Cooling system	Cooling method		Water-cooled, forced circulation	
	Coolant capacity (engine water jacket) ℓ [U.S.gal]		5.5 [1.45]	5 [1.32]
	Water pump	Type	Centrifugal volute pump	
		Speed ratio to crankshaft	1.3	
		Discharge capacity ℓ [U.S.gal] / min	160 [42.3] at 0.75 MPa (7.5 kgf/cm^2) [107 psi] discharge pressure of pump running at 3600min^{-1}	
	Cooling fan	Type	Pusher (PP fan)	
		No. of blades	6	
		Outside diameter mm [in.]	ϕ440 [17.3]	
	V-belt	Type	Raw-edge cog V-belt Type B × 1	
	Thermostat	Type	Wax	
		Valve opening temperature °C [°F]	76.5±1.5 [169.7±2.7] (Approx.90 [194] when fully opened)	
Inlet / exhaust system	Air cleaner	Type	Paper element	
	Turbocharger	Type	—	TD04H

Engine type				S4S	S4S-DT
Electrical system	Voltage - polarity			12 V - negative (–) ground	24 V - negative (–) ground
	Starter	Type		M8T75171	M2TS5071
		Pinion mesh type		Pinion shift	
		Output V-kW		12-2.2	24-3.2
		Pinion/ring gear ratio		10/122	
	Alternator	Type		3-phase alternating-current generator, built-in rectifier	
		Output V-A		12-50	24-25
		Working speed min^{-1}		1000 to 18000	
		Rated output generating speed min^{-1}		5000	
		Maximum permissible speed min^{-1}		22000	
		Speed ratio to crankshaft		2.0	
	Glow plug	Type		Sheathed	
		Rated voltage - current V-A		10.5-9.7 (30-second application)	23-3.0 (30-second application)
	Stop solenoid (option)	Type ETS (RUN-OFF)	Operating voltage V	8 to 14 (for 12 V)	16 to 27 (for 24 V)
			Operating temperature °C [°F]	–30 to 90 [–22 to 194]	
			Rated time sec	10 or less	
			Rated current A	22.6 or less	11.7 or less
		Type ETR (RUN-ON)	Rated voltage V	12	24
			Rated temperature °C [°F]	20 [68]	
			Rated absorbing current A	55	29
			Rated hold current A	1.1	0.6

2.2 S6S in-line fuel injection pump specification (may differ in detail)

Engine type				S6S	S6S-DT
Main specifications	Type			Mitsubishi diesel engine	
	Cooling method			Water cooling	
	No. of strokes			4-stroke cycle	
	No. of cylinders - cylinder arrangement			6 in-line	
	Combustion method			Swirl chamber	Direct injection
	Valve mechanism			Overhead	
	Cylinder bore × stroke mm [in.]			94 × 120 [3.701 × 4.724]	
	Total displacement ℓ [cu in.]			4.996 [305]	
	Compression ratio			22:1	17:1
	Fuel			Diesel fuel (JIS No. 2 equivalent)	
	Firing order			1-5-3-6-2-4	
	Rotational direction			Counterclockwise as viewed from flywheel side	
	Dimension	Overall length mm [in.]		1033 [40.7]	
		Overall width mm [in.]		579 [22.8]	
		Overall height mm [in.]		748 [29.4]	839 [33.0]
	Dry weight kg [lb.]			345 [761]	355 [783]
Engine main parts	Cylinder sleeve	Type		Dry (integral with cylinder block)	
	Piston ring	No. of rings		Compression ring: 2	
				Oil ring (with expander): 1	
	Valve timing	Inlet valve	Open	BTDC 30°	BTDC 18°
			Close	ABDC 50°	ABDC 54°
		Exhaust valve	Open	BBDC 74°	BBDC 66°
			Close	ATDC 30°	ATDC 22°
	Starting system			Electric starter	
	Starting aid			Glow plug	
Fuel system	Injection pump	Type		In-line (Bosch Type A)	
		Plunger diameter mm [in.]		ϕ7 [0.28]	ϕ9 [0.35]
	Feed pump	Type		Piston pump (Bosch)	
	Governor	Speed control system		Centrifugal	
		Type		Bosch Type RSV	
	Injection nozzle	Type		Throttle nozzle (Bosch)	Hole nozzle (Bosch)
		No. of spray holes		1	4
		Spray hole diameter mm [in.]		ϕ1.0 [0.039]	ϕ0.28 [0.011]
		Spray angle		0°	155°
		Valve opening pressure MPa (kgf/cm²) [psi]		11.77 (120) [1707]	17.65 (180) [2561]
	Fuel filter	Type		Paper-element cartridge	

Engine type			S6S	S6S-DT
Lubrication system	Lubricating method		Forced circulation (oil pump pressure feed)	
	Engine oil	Grade (API service classification)	Class CF (SAE30 equivalent)	
		Capacity ℓ [U.S.gal]	Entire engine: 12.5 [3.30], Oil pan: Maximum of 11.5 [3.04], oil filter: 1 [0.26]	
	Oil pump	Type	Trochoid	
		Speed ratio to crankshaft	0.74	
		Discharge capacity ℓ [U.S.gal] / min	38.7 [10.2] at 0.3MPa (3 kgf/cm^2) [43 psi] discharge pressure of pump running at 2230min^{-1}	
	Relief valve	Type	Piston valve	
		Valve opening pressure MPa (kgf/cm^2) [psi]	0.35±0.05 (3.6±0.5) [51±7]	
	Safety valve	Valve opening pressure MPa (kgf/cm^2) [psi]	—	1.1 (11) [156]
	Oil cooler	Type	—	Water-cooled, multi-plate
	Oil filter	Type	Paper-element cartridge	
Cooling system	Cooling method		Water-cooled, forced circulation	
	Coolant capacity (engine water jacket) ℓ [U.S.gal]		9 [2.4]	8 [2.1]
	Water pump	Type	Centrifugal volute pump	
		Speed ratio to crankshaft	1.3	
		Discharge capacity ℓ [U.S.gal] / min	160 [42.3] at 0.75 MPa (7.5 kgf/cm^2) [107 psi] discharge pressure of pump running at 3600min^{-1}	
	Cooling fan	Type	Pusher (PP fan)	
		No. of blades	7	
		Outside diameter mm [in.]	ϕ500 [19.7]	
	V-belt	Type	Raw-edge cog V-belt Type B × 1	
	Thermostat	Type	Wax	
		Valve opening temperature °C [°F]	76.5±1.5 [169.7±2.7] (Approx.90 [194] when fully opened)	
Inlet / exhaust system	Air cleaner	Type	Paper element	
	Turbocharger	Type	—	TE06H

Engine type				S6S	S6S-DT
Electrical system	Voltage - polarity			12 V - negative (–) ground	24 V - negative (–) ground
	Starter	Type		M3T67671	M8T60373
		Pinion mesh type		Pinion shift	
		Output V-kW		12-3	24-5
		Pinion/ring gear ratio		10/122	
	Alternator	Type		3-phase alternating-current generator, built-in rectifier	
		Output V-A		12-50	24-25
		Working speed min^{-1}		1000 to 18000	
		Rated output generating speed min^{-1}		5000	
		Maximum permissible speed min^{-1}		22000	
		Speed ratio to crankshaft		2.0	
	Glow plug	Type		Sheathed	
		Rated voltage - current V-A		10.5-9.7 (30-second application)	23-3.0 (30-second application)
	Stop solenoid (option)	Type ETS (RUN-OFF)	Operating voltage V	8 to 14 (for 12 V)	16 to 27 (for 24 V)
			Operating temperature °C [°F]	–30 to 90 [–22 to 194]	
			Rated time sec	10 or less	
			Rated current A	22.6 or less	11.7 or less
		Type ETR (RUN-ON)	Rated voltage V	12	24
			Rated temperature °C [°F]	20 [68]	
			Rated observing current A	55	29
			Rated hold current A	1.1	0.6

2.3 S4S distributor-type fuel injection pump specification (may differ in detail)

Engine type				S4S	S4S-DT
Main specifications	Type			Mitsubishi diesel engine	
	Cooling method			Water cooling	
	No. of strokes			4-stroke cycle	
	No. of cylinders - cylinder arrangement			4 in-line	
	Combustion method			Swirl chamber	Direct injection
	Valve mechanism			Overhead	
	Cylinder bore × stroke mm [in.]			94 × 120 [3.701 × 4.724]	
	Total displacement ℓ [cu in.]			3.331 [203]	
	Compression ratio			22:1	19:1
	Fuel			Diesel fuel (JIS No. 2 equivalent)	
	Firing order			1-3-4-2	
	Rotational direction			Counterclockwise as viewed from flywheel side	
	Dimension	Overall length mm [in.]		781 [30.7]	
		Overall width mm [in.]		567 [22.3]	
		Overall height mm [in.]		717 [28.2]	815 [32.1]
	Dry weight kg [lb.]			245 [540]	250 [551]
Engine main parts	Cylinder sleeve	Type		Dry (integral with cylinder block)	
	Piston ring	No. of rings		Compression ring: 2	
				Oil ring (with expander): 1	
	Valve timing	Inlet valve	Open	BTDC 30°	BTDC 18°
			Close	ABDC 50°	ABDC 54°
		Exhaust valve	Open	BBDC 74°	BBDC 66°
			Close	ATDC 30°	ATDC 22°
	Starting system			Electric starter	
	Starting aid			Glow plug	
Fuel system	Injection pump	Type		Distributor (Bosch Type VE)	
		Plunger diameter mm [in.]		ϕ 10 [0.39]	ϕ 11 [0.43]
	Feed pump	Type		Vane pump (Bosch)	
	Governor	Speed control system		Centrifugal	
		Type		All speed	
	Injection nozzle	Type		Throttle nozzle (Bosch)	Hole nozzle (Bosch)
		No. of spray holes		1	5
		Spray hole diameter mm [in.]		ϕ 1.0 [0.039]	ϕ 0.20 [0.008]
		Spray angle		0°	150° (varies with specification)
		Valve opening pressure MPa (kgf/cm²) [psi]		11.77 (120) [1707]	17.65 (180) [2561]
	Fuel filter	Type		Paper-element cartridge	

Engine type			S4S	S4S-DT
Lubrication system	Lubricating method		Forced circulation (oil pump pressure feed)	
	Engine oil	Grade (API service classification)	Class CF (SAE30 equivalent)	
		Capacity ℓ [U.S.gal]	Entire engine: 10 [2.64], Oil pan: Maximum of 9 [2.38], oil filter: 1 [0.26]	
	Oil pump	Type	Trochoid	
		Speed ratio to crankshaft	0.74	
		Discharge capacity ℓ [U.S.gal] / min	28.6 [7.6] at 0.3MPa (3 kgf/cm^2) [43 psi] discharge pressure of pump running at 2230min^{-1}	
	Relief valve	Type	Piston valve	
		Valve opening pressure MPa (kgf/cm^2) [psi]	0.35±0.05 (3.6±0.5) [51±7]	
	Safety valve	Valve opening pressure MPa (kgf/cm^2) [psi]	—	1.1 (11) [156]
	Oil cooler	Type	—	Water-cooled, multi-plate
	Oil filter	Type	Paper-element cartridge	
Cooling system	Cooling method		Water-cooled, forced circulation	
	Coolant capacity (engine water jacket) ℓ [U.S.gal]		5.5 [1.45]	5 [1.32]
	Water pump	Type	Centrifugal volute pump	
		Speed ratio to crankshaft	1.3	
		Discharge capacity ℓ [U.S.gal] / min	160 [42.3] at 0.75 MPa (7.5 kgf/cm^2) [107 psi] discharge pressure of pump running at 3600min^{-1}	
	Cooling fan	Type	Pusher (PP fan)	
		No. of blades	6	
		Outside diameter mm [in.]	ϕ440 [17.3]	
	V-belt	Type	Raw-edge cog V-belt Type B × 1	
	Thermostat	Type	Wax	
		Valve opening temperature °C [°F]	76.5±1.5 [169.7±2.7] (Approx.90 [194] when fully opened)	
Inlet / exhaust system	Air cleaner	Type	Paper element	
	Turbocharger	Type	—	TD04H

Engine type				S4S	S4S-DT
Electrical system	Voltage - polarity			12 V - negative (–) ground	24 V - negative (–) ground
	Starter	Type		M8T75171	M2TS5071
		Pinion mesh type		Pinion shift	
		Output V-kW		12-2.2	24-3.2
		Pinion/ring gear ratio		10/122	
	Alternator	Type		3-phase alternating-current generator, built-in rectifier	
		Output V-A		12-50	24-25
		Working speed min^{-1}		1000 to 18000	
		Rated output generating speed min^{-1}		5000	
		Maximum permissible speed min^{-1}		22000	
		Speed ratio to crankshaft		2.0	
	Glow plug	Type		Sheathed	
		Rated voltage - current V-A		10.5-9.7 (30-second application)	23-3.0 (30-second application)
	Stop solenoid	Type ETR (RUN-ON)	Rated voltage V	12	24
			Power consumption W	20	14
			Start voltage V	6.3 or less	13 or less
			Recovery voltage V	2.5 or more	5 or more
			Coil resistance Ω	8	37

2.4 S6S distributor-type fuel injection pump specification (may differ in detail)

Engine type				S6S	S6S-DT
Main specifications	Type			Mitsubishi diesel engine	
	Cooling method			Water cooling	
	No. of strokes			4-stroke cycle	
	No. of cylinders - cylinder arrangement			6 in-line	
	Combustion method			Swirl chamber	Direct injection
	Valve mechanism			Overhead	
	Cylinder bore × stroke mm [in.]			94 × 120 [3.701 × 4.724]	
	Total displacement ℓ [cu in.]			4.996 [305]	
	Compression ratio			22:1	19.5:1
	Fuel			Diesel fuel (JIS No. 2 equivalent)	
	Firing order			1-5-3-6-2-4	
	Rotational direction			Counterclockwise as viewed from flywheel side	
	Dimension	Overall length mm [in.]		1033 [40.7]	
		Overall width mm [in.]		579 [22.8]	
		Overall height mm [in.]		748 [29.4]	839 [33.0]
	Dry weight kg [lb.]			345 [761]	355 [783]
Engine main parts	Cylinder sleeve	Type		Dry (integral with cylinder block)	
	Piston ring	No. of rings		Compression ring: 2	
				Oil ring (with expander): 1	
	Valve timing	Inlet valve	Open	BTDC 30°	BTDC 18°
			Close	ABDC 50°	ABDC 54°
		Exhaust valve	Open	BBDC 74°	BBDC 66°
			Close	ATDC 30°	ATDC 22°
	Starting system			Electric starter	
	Starting aid			Glow plug	
Fuel system	Injection pump	Type		Distributor (Bosch Type VE)	
		Plunger diameter mm [in.]		ϕ10 [0.39]	ϕ11 [0.43]
	Feed pump	Type		Vane pump (Bosch)	
	Governor	Speed control system		Centrifugal	
		Type		All speed	
	Injection nozzle	Type		Throttle nozzle (Bosch)	Hole nozzle (Bosch)
		No. of spray holes		1	5
		Spray hole diameter mm [in.]		ϕ1.0 [0.039]	ϕ0.20 [0.008]
		Spray angle		0°	150°(varies with specification)
		Valve opening pressure MPa (kgf/cm²) [psi]		11.77 (120) [1707]	17.65 (180) [2561]
	Fuel filter	Type		Paper-element cartridge	

Engine type			S6S	S6S-DT
Lubrication system	Lubricating method		Forced circulation (oil pump pressure feed)	
	Engine oil	Grade (API service classification)	Class CF (SAE30 equivalent)	
		Capacity ℓ [U.S.gal]	Entire engine: 12.5 [3.30], Oil pan: Maximum of 11.5 [3.04], oil filter: 1 [0.26]	
	Oil pump	Type	Trochoid	
		Speed ratio to crankshaft	0.74	
		Discharge capacity ℓ [U.S.gal] / min	38.7 [10.2] at 0.3MPa (3 kgf/cm^2) [43 psi] discharge pressure of pump running at 2230min^{-1}	
	Relief valve	Type	Piston valve	
		Valve opening pressure MPa (kgf/cm^2) [psi]	0.35±0.05 (3.6±0.5) [51±7]	
	Safety valve	Valve opening pressure MPa (kgf/cm^2) [psi]	—	1.1 (11) [156]
	Oil cooler	Type	—	Water-cooled, multi-plate
	Oil filter	Type	Paper-element cartridge	
Cooling system	Cooling method		Water-cooled, forced circulation	
	Coolant capacity (engine water jacket) ℓ [U.S.gal]		9 [2.4]	8 [2.1]
	Water pump	Type	Centrifugal volute pump	
		Speed ratio to crankshaft	1.3	
		Discharge capacity ℓ [U.S.gal] / min	160 [42.3] at 0.75 MPa (7.5 kgf/cm^2) [107 psi] discharge pressure of pump running at 3600min^{-1}	
	Cooling fan	Type	Pusher (PP fan)	
		No. of blades	7	
		Outside diameter mm [in.]	ϕ500 [19.7]	
	V-belt	Type	Raw-edge cog V-belt Type B × 1	
	Thermostat	Type	Wax	
		Valve opening temperature °C [°F]	76.5±1.5 [169.7±2.7] (Approx.90 [194] when fully opened)	
Inlet / exhaust system	Air cleaner	Type	Paper element	
	Turbocharger	Type	—	TE06H

Engine type				S6S	S6S-DT
Electrical system	Voltage - polarity			12 V - negative (–) ground	24 V - negative (–) ground
	Starter	Type		M3T67671	M8T60373
		Pinion mesh type		Pinion shift	
		Output V-kW		12-3	24-5
		Pinion/ring gear ratio		10/122	
	Alternator	Type		3-phase alternating-current generator, built-in rectifier	
		Output V-A		12-50	24-25
		Working speed min^{-1}		1000 to 18000	
		Rated output generating speed min^{-1}		5000	
		Maximum permissible speed min^{-1}		22000	
		Speed ratio to crankshaft		2.0	
	Glow plug	Type		Sheathed	
		Rated voltage - current V-A		10.5-9.7 (30-second application)	23-3.0 (30-second application)
	Stop solenoid (option)	Type ETR (RUN-ON)	Rated voltage V	12	24
			Power consumption W	20	14
			Start voltage V	6.3 or less	13 or less
			Recovery voltage V	2.5 or more	5 or more
			Coil resistance Ω	8	37

3. Tips on Disassembly and Reassembly

This service manual describes service procedures recommended by Mitsubishi Heavy Industries Ltd., and also contains information of special tools and basic safety precautions.

It should be noted that the manual cannot cover all potential dangers in maintaining, inspecting and servicing an engine.

When working on the engine, follow the directions in this manual and pay close attention to the following cautions.

3.1 Disassembly

(1) Use correct tools and instruments.
(2) Arrange a work bench and boxes for placing removed parts, if necessary, and follow the specified disassembly sequence.
(3) Lay down disassembled parts neatly in order to prevent losing them.
(4) During disassembly, pay attention to alignment marks to ensure proper reassembly and if necessary, put additional marks on parts to aid reassembly.
(5) Carefully check each part for abnormalities before disassembly and also during removal and cleaning in order to discover any signs of abnormalities or defects that may not be found after cleaning.
(6) Exercise utmost caution to ensure safety, particularly for balancing removed parts and transporting heavy parts. (Use jacks and chain blocks when necessary.)

3.2 Reassembly

(1) Wash all engine parts, except for oil seals, O-rings, rubber sheets, etc., in cleaning oil and dry them with compressed air.
(2) Use correct tools and instruments.
(3) Use only high-quality lubricating oils and greases.
(4) Be sure to apply a coat of oil, grease or sealant to parts as specified.
(5) Use a torque wrench to tighten parts to specified tightening torque when tightening torque is indicated.
(6) Replace all gaskets, packings and O-rings with new ones unless specified otherwise.

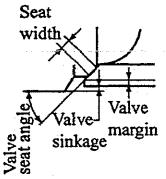
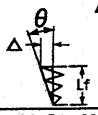
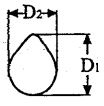
MAINTENANCE STANDARDS

1. Maintenance Standards Table

Unit: mm [in.]

Group	Inspection point		Nominal value	Standard	Limit	Remark
General	Maximum speed (no-load)		According to engine specification			Adjust governor setting.
	Minimum speed (no-load)					
	Compression pressure	Swirl chamber	3.23 MPa (33 kgf/cm²) [469 psi] (at 300 min⁻¹)		2.84 MPa (29 kgf/cm²) [412 psi]	Oil and water temperature at 20 to 30°C [68 to 86°F]
		Direct injection	2.94 MPa (30 kgf/cm²) [426 psi] (at 300 min⁻¹)		2.64 MPa (27 kgf/cm²) [384 psi]	
	Lubricating oil pressure	at 1500 min⁻¹	0.29 to 0.49 MPa (3 to 5 kgf/cm²) [42 to 71psi]		0.15 MPa (1.5 kgf/cm²) [21 psi]	Oil temperature at 70 to 90°C [158 to 194°F]
		Idling	0.1 MPa (1 kgf/cm²) [14.2 psi] or more		0.05 MPa (0.5 kgf/cm²) [7.1 psi]	
	Valve timing	Inlet valve open Inlet valve closed Exhaust valve open Exhaust valve closed	BTDC 30° ABDC 50° (Swirl BBDC 74° chamber) ATDC 30° ±3° (crank angle)	BTDC 18° ABDC 54° (Direct BBDC 60° injection) ATDC 22° ±3° (crank angle)		
	Valve clearance (Cold)			0.25 [0.009]		Both Inlet and Exhaust
	Fuel injection start timing		—			The timing for each model of engine varies according to its specification. Be sure to verify the timing by referring to the specifications of each model.
	V belt deflection			10 to 12 [0.39 to 0.47]		Deflection when pressed with thumb 98 N (10 kgf) [22 lbf].
Engine main parts	Rocker arm	Rocker bushing inside diameter	ϕ19 [0.7480]	19.010 to 19.030 [0.7484 to 0.7492]		
		Rocker shaft diameter	ϕ19 [0.7480]	18.980 to 19.000 [0.7472 to 0.7480]		
		Clearance between bushing and shaft		0.010 to 0.050 [0.0003 to 0.0020]	0.070 [0.0028]	
	Valve	Valve stem diameter — Inlet	ϕ8 [0.3150]	7.940 to 7.955 [0.3126 to 0.3132]	7.900 [0.3110]	
		Valve stem diameter — Exhaust	ϕ8 [0.3150]	7.920 to 7.940 [0.3118 to 0.3126]	7.850 [0.3091]	
		Valve stem - to - guide clearance — Inlet		0.065 to 0.095 [0.0026 to 0.0037]	0.150 [0.0059]	
		Valve stem - to - guide clearance — Exhasut		0.080 to 0.115 [0.0031 to 0.0045]	0.200 [0.0079]	
		Height to top of valve guide	14 [0.5511]	13.9 to 14.1 [0.5472 to 0.5551]		

Unit: mm [in.]

Group	Inspection point			Nominal value	Standard	Limit	Remark
Engine main parts	Valve seat and valve	Valve seat angle		30°			
		Valve sinkage	Inlet	0.4 [0.0157]	0.3 to 0.5 [0.0118 to 0.0197]	1.0 [0.0394]	
			Exhaust	0.5 [0.0197]	0.4 to 0.6 [0.0157 to 0.0236]	1.0 [0.0394]	
		Seat width		1.4 [0.0551]	1.26 to 1.54 [0.0496 to 0.0606]	1.8 [0.0709]	
		Valve margin			2.13 [0.0839]	Refacing permissible up to 1.83 [0.0720]	
	Valve spring	Free length			48.85 [1.92]	47.60 [1.87]	
		Perpendicularity			θ = 1.5° Δ = 1.3 [0.051] Lf = 48.85 [1.92] 	Δ = 1.5 [0.0591] over entire length	
		Installation length/load			43 [1.693]/176 to 196 N (18.0 to 20.0 kgf) [39.7 to 44.1 lbf]	43 [1.693]/147 (15.0 kgf) [33.1 lbf]	
	Cylinder head		Bottom face distortion		0.05 [0.002] or less	0.20 [0.0079]	Slightly reface
			Compressed thickness of gasket	1.2 [0.0472]	1.15 to 1.25 [0.0453 to 0.0492]		
	Push rod		Bend		0.3 [0.0118]or less		Runout (dial gage reading) when pushrod is supported along center line of spherical surface at either end.
	Flywheel		Flatness		0.15 [0.0059]or less	0.50 [0.197]	
			Face runout		0.15 [0.0059]or less	0.50 [0.197]	
	Timing gear	Backlash			0.050 to 0.150 [0.0020 to 0.0059]	0.250 [0.0098]	Replace gears.
		Idler gear end play		30 [1.181]	0.050 to 0.200 [0.0020 to 0.0079]	0.350 [0.0138]	Replace thrust plate.
		Camshaft gear end play		5 [0.197]	0.100 to 0.250 [0.0039 to 0.0098]	0.300 [0.0118]	Replace thrust plate.
	Camshaft	Cam lift (D_1 - D_2)	Inlet	6.684 [0.2631]	6.384 to 6.784 [0.2513 to 0.2671]	6.184 [0.2435]	
			Exhaust	6.720 [0.2646]	6.420 to 6.820 [0.2528 to 0.2685]	6.220 [0.2449]	
		Deflection			0.02 [0.0008] or less	0.05 [0.002]	Repair or replace
		Journal diameter 4S	No. 1, 2	ϕ 54 [2.126]	53.940 to 53.960 [2.1236 to 2.1244]	53.900 [2.1120]	
			No. 3	ϕ 53 [2.087]	52.940 to 52.960 [2.0842 to 2.0850]	52.900 [2.0827]	
		Journal diameter 6S	No. 1, 2, 3	ϕ 54 [2.126]	53.940 to 53.960 [2.1236 to 2.1244]	53.900 [2.1120]	
			No. 4	ϕ 53 [2.087]	52.940 to 52.960 [2.0842 to 2.0850]	52.900 [2.0827]	

Unit: mm [in.]

Group	Inspection point			Nominal value	Standard	Limit	Remark
Engine main parts	Camshaft bore	Clearance between camshaft journal and bore			0.070 to 0.110 [0.0028 to 0.0043]	0.150 [0.0059]	If it exceeds the repair limit, refinish bores and install bushings, or replace camshaft.
	Clearance between shaft and bushing				0.009 to 0.050 [0.0004 to 0.0020]	0.100 [0.0039]	
	Crankcase	Surface distortion			0.050 [0.0020] or less	0.200 [0.0079]	Slightly reface.
	Cylinder	Bore diameter		ϕ94 [3.7007]	94.000 to 94.035 [3.7007 to 3.7021]	94.200 [3.7087] (Repair) 94.700 [3.7283] (Replace)	Refinish cylinder to 0.25 [0.0098] or 0.50 [0.0197] oversize of nominal value by honing and use the same oversize pistons and piston rings.
		Circularity			0.01 [0.0004] or less		
		Taper			0.15 [0.0006] or less		
	Piston	Outside diameter (at piston skirt)	S.T.D	ϕ94 [3.7007]	93.955 to 93.985 [3.6990 to 3.7001]	93.770 [3.6917]	
			0.25 OS		94.205 to 94.235 [3.7089 to 3.7100]	94.020 [3.7016]	
			0.50 OS		94.455 to 94.485 [3.7187 to 3.7199]	94.270 [3.7114]	
		Protrusion from crankcase			0.05 to 0.45 [0.0020 to 0.0177]		Checking bearing clearance
	Piston ring	Clearance between ends	No. 1 ring		0.300 to 0.500 [0.0118 to 0.0197]	1.500 [0.0591]	
			No. 2 ring		0.500 to 0.700 [0.0197 to 0.0276]		
			Oil ring		0.300 to 0.500 [0.0118 to 0.0197]		
		Clearance between groove and ring	No. 1 ring		0.070 to 0.110 [0.0276 to 0.0043]	0.200 [0.0079]	
			No. 2 ring		0.045 to 0.085 [0.0018 to 0.0033]	0.150 [0.0059]	
			Oil ring		0.020 to 0.060 [0.0008 to 0.0024]	0.150 [0.0059]	
	Piston pin	Diameter		ϕ30 [1.1811]	29.994 to 30.000 [1.1809 to 1.1811]		
		Clearance between pin and bushing			0.000 to 0.016 [0.0000 to 0.0006]	0.050 [0.0020]	
	Crankpin diameter			ϕ58 [2.283]	57.955 to 57.970 [2.2817 to 2.2823]	57.800 [2.2756]	
	Clearance between crankpin and connecting rod bearing				0.030 to 0.090 [0.0012 to 0.0035]	0.200 [0.0079]	If worn beyond limit, replace rod bearings or regrind crankpins and replace undersize bearings (undersize)

Unit: mm [in.]

Group	Inspection point	Nominal value	Standard	Limit	Remark
Engine main parts	Bushing inside diameter	ϕ30 [1.1811]	30.020 to 30.045 [1.1811 to 1.1829]		
	Clearance between connecting rod and bushing		0.020 to 0.051 [0.0008 to 0.002]	0.080 [0.0031]	
	Connecting rod bend and twist		0.05 / 100 [0. 002 / 3.937] or less		
	End play	33 [1.299]	0.150 to 0.350 [0.0059 to 0.0138]	0.500 [0.020]	Replace connecting rod.
	Crank journal diameter	ϕ78 [3.071]	77.955 to 77.970 [3.0691 to 3.0697]	77.850 [3.0650] (Repair) 77.100 [3.035] (Replace)	
	Distance between centers of journal and crankpin	60 [2.362]	±0.04 [0.0016]		
	Parallelism between journal and crankpin		Deviation of 0.01 [0.0004] or less over entire pin length		
	Circularity of journal and crankpin		0.010 [0.0004] or less	0.030 [0.0012]	
	Taper of journal and crankpin		0.010 [0.0004] or less	0.030 [0.0012]	
	Fillet radius of journal and crankpin	R3 [0.118]	±0.2 [0.008]		
	End play (clearance between thrust bearing journal width of crankshaft)	31 [1.22]	0.100 to 0.264 [0.004 to 0.0104]	0.300 [0.0118]	Replace thrust bearings if worn down to limit. Use oversize thrust bearings if worn beyond limit. +0.15 [+0.0059] +0.30 [+0.0118]
	Deflection		0.020 [0.0008] or less	0.050 [0.002]	
	Main bearing: Clearance between bearing and journal		0.050 to 0.110 [0.0020 to 0.0043]	0.200 [0.008] (Repair) –0.9 [–0.035] as journal diameter which is 78 [3.07]	Replace main bearings if worn down to limit. Regrind crank journal and use undersize bearings. –0.25 [–0.006] –0.75 [–0.018] –0.50 [–0.012]
	Main bearing: Clearance between thrust bearings		0.100 to 0.264 [0.004 to 0.0104]	0.300 [0.0118]	Replace thrust bearings.
	Tappet bore: Inside diameter	ϕ14 [0.55118]	14.000 to 14.018 [0.55118 to 0.5519]	14.100 [0.5551]	
	Tappet bore: Clearance between tappet and bore		0.016 to 0.052 [0.0006 to 0.0020]	0.080 [0.0031]	Replace tappet.

Unit: mm [in.]

Group	Inspection point			Nominal value	Standard	Limit	Remark
Fuel system	Fuel injection nozzle	Valve opening pressure	Swirl chamber	11.77 MPa (120 kgf/cm²) [1707 psi]	11.77 to 12.75 MPa (120 to 130 kgf/cm²) [1707 to 1849 psi]		Make shim adjustment. Pressure varies by 1 (10) [142] per 0.1 mm [0.004 in.] thickness of shim.
			Direct injection	17.70 MPa (180 kgf/cm²) [2560 psi]	18.14 to 19.12 MPa (185 to 195 kgf/cm²) [2631 to 2773 psi]		
		Spray cone angle	Swirl chamber	0°			Test by means of hand tester, using diesel fuel, at 20°C [68°F]. If discharge pattern is bad even after nozzle is washed in clean diesel fuel, replace nozzle tip.
			Direct injection	155° (Varies depending on specification)			
		Oil tightness of needle valve seat		Seat shall hold a test pressure 1.96 MPa (20 kgf/cm²) [285 psi] lower than valve opening pressure for 10 seconds.			Wash or replace nozzle tip.
Lubrication system	Oil pump	Clearance between outer rotor and inner rotor			0.13 to 0.15 [0.0051 to 0.0059]	0.20 [0.0079]	Replace outer rotor and shaft assembly.
		End play between rotors and case			0.04 to 0.09 [0.0016 to 0.0035]	0.15 [0.0059]	Replace oil pump assembly.
		Clearance between outer rotor and case			0.20 to 0.30 [0.0079 to 0.0118]	0.50 [0.0197]	Replace oil pump assembly.
		Main shaft outside diameter (case side)		ϕ16 [0.630]	15.985 to 16.000 [0.629 to 0.630]		
		Clearance between main shaft and case			0.032 to 0.074 [0.0013 to 0.0029]	0.150 [0.0059]	Replace oil pump assembly.
		Main shaft outside diameter (Oil pump bushing side)		ϕ14 [0.551]	13.957 to 13.975 [0.5495 to 0.5502]		
		Clearance between main shaft and oil pump bushing			0.025 to 0.111 [0.0010 to 0.0044]	0.200 [0.0079]	Replace bushing or oil pump assembly.
		Inner rotor inside diameter		ϕ16 [0.630]	15.951 to 15.968 [0.628 to 0.629]		(Shrink fit onto main shaft)
	Relief valve		Valve opening pressure	0.35 MPa (3.6 kgf/cm²) [51.21 psi]	0.30 to 0.40 MPa (3.1 to 4.1 kgf/cm²) [44.09 to 58.32 psi]		
	Safety valve		Valve opening pressure		1.1 MPa (11 kgf/cm²) [156.4 psi]		
Cooling system	Thermostat		Temperature at which valve starts opening		76.5 ±2°C [169 ±35°F] (STD)		
			Temperature at which valve lift is 9 mm [0.354 in.] or more		90°C [194°F]		

Unit: mm [in.]

Group	Inspection point		Nominal value	Standard				Limit				Remark
Electrical system	Starter	Pinion clearance		0.5 to 2.0 [0.020 to 0.079]								Adjust with packing.
		No-load characteristics: Terminal voltage		M8T7 5171	M2TS 5071	M3T6 7671	M8T6 0373	—				Inspect
				11 V	23 V	11 V	23 V					
		No-load characteristics: Current		130 A or less	80 A or less	180 A or less	85 A or less	—				
		No-load characteristics: Rotation speed		3800 min^{-1}	2960 min^{-1}	3800 min^{-1}	3300 min^{-1}	—				
		Brush length		18.0 [0.71]	17.5 [0.69]	17.0 [0.67]	18.0 [0.71]	11.0 [0.43]				Replace
		Brush spring load N (kgf)		26.5 to 36.3 (2.7 to 3.7) [6.0 to 8.2]	26.7 to 36.1 (2.7 to 3.7) [6.0 to 8.2]	33.3 to 45.1 (3.4 to 4.6) [7.5 to 10.1]	29.4 to 39.2 (3.0 to 4.0) [6.6 to 8.8]	M8T7 5171 / M2TS 5071: 14.7 (1.5) [3.3]		M3T6 7671: 17.7 (1.8) [4.0]	M8T6 0373: 13.7 (1.4) [3.1]	Replace
		Commutator radial runout		—				0.10 [0.004]				Repair or replace
		Commutator diameter		32.0 [1.26]		38.7 [1.52]	32.0 [1.26]	31.4 [1.24]		38.1 [1.50]	31.4 [1.24]	Replace
		Under cutting depth		0.4 to 0.6 [0.016 to 0.024]				0.2 [0.008]				Repair
	Alternator	IC regulator controlled voltage (at 20°C [68°F])		A7TA0483A		A7TA8083A		—				
				14.7 ±0.3 V		28.5 ±0.5 V						
		Output characteristics (when hot): 2500 min^{-1} or less: Current		33 A above		18 A above		—				Inspect
								—				
		Output characteristics (when hot): 5000 min^{-1} or less: Current		47 A above		22 A above		—				
								—				
		Brush length		18.5				5.0				Replace
	Magnetic plug (resistance of stop solenoid ETR type (RUN-ON))		12 V	8 to 10.7 Ω				—				Replace
			24 V	33 to 43.4 Ω				—				

2. Tightening Torque Table

2.1 Important Bolts and Nuts

(1) Engine main parts

Description	Threads Diameter × Pitch mm	Width across flats (mm)	Torque			Remark
			N·m	kgf·m	lbf·ft	
Cylinder head	M12 × 1.75	19	113 to 123	11.5 to 12.5	83.2 to 90.4	
Cylinder head plug	M16 × 1.5	14	39.2 to 49.0	4.0 to 5.0	28.9 to 36.2	
Rocker case	M8 × 1.25	12	10.0 to 13.0	1.0 to 1.3	7.2 to 9.4	
Rocker shaft brackets (long)	M8 × 1.25	12	10.0 to 20.0	1.0 to 2.0	7.2 to 14.5	
Main bearing cap	M14 × 2.0	22	98 to 108	10.0 to 11.0	72.3 to 79.6	
Connecting rod nut cap	M10 × 1.0	14	49.0 to 59.0	5.0 to 6.0	36.2 to 43.4	
Flywheel	M12 × 1.25	17	78.5 to 88.3	8.0 to 9.0	57.9 to 65.1	
Camshaft thrust plate	M8 × 1.25	12	10.0 to 13.0	1.0 to 1.3	7.2 to 9.4	
Front plate	M8 × 1.25	12	10.0 to 13.0	1.0 to 1.3	7.2 to 9.4	
Timing gear case	M8 × 1.25	12	17.0 to 20.0	1.7 to 2.0	12.3 to 14.5	
Crankshaft pulley nut	M30 × 1.5	46	480 to 500	49 to 51	354.4 to 368.9	
Idler gear thrust plate	M10 × 1.25	14	29.0 to 39.0	3.0 to 4.0	21.7 to 28.9	
Coolant drain plug	1/4-18NPTF	14	35.3 to 43.1	3.6 to 4.4	26.0 to 31.8	

(2) Fuel system

Description	Threads Diameter × Pitch mm	Width across flats (mm)	Torque			Remark
			N·m	kgf·m	lbf·ft	
Fuel injection pump delivery valve holders		22	34.0 to 39.0	3.5 to 4.0	25.3 to 28.9	
Fuel injection pump gear nut (distributor type)	M14 × 1.5	22	76.5 to 86.3	7.8 to 8.8	56.4 to 63.6	
Fuel injection pump gear nut (in-line type, VE swirl chamber)	M12 × 1.75	19	58.8 to 68.6	6.0 to 7.0	43.4 to 50.6	
Fuel injection pump gear nut (in-line type, VE direct injection)	M14 × 1.5	22	83.4 to 98.0	8.5 to 10.0	61.5 to 72.3	
Fuel injection pipe nuts	M12 × 1.5	17	26.5 to 32.4	2.7 to 3.3	19.5 to 23.9	
Fuel return pipe nut	M10 × 1.25	14	17.7 to 21.6	1.8 to 2.2	13.0 to 15.9	
Fuel leak-off pipe nut	M12 × 1.5	17	20.6 to 24.5	2.1 to 2.5	15.2 to 18.1	
Fuel injection pump overflow valve		17	15.0 to 20.0	1.5 to 2.0	10.8 to 14.5	
Fuel injection pump eye bolt	M14 × 1.5	22	15.0 to 20.0	1.5 to 2.0	10.8 to 14.5	
Nozzle (swirl chamber)	M20 × 1.5	21	53.0 to 64.7	5.4 to 6.6	39.1 to 47.7	
Nozzle glands (direct injection)	M8 × 1.25	12	21.0 to 23.7	2.0 to 2.4	14.5 to 17.4	
Fuel filter element (in-line type)	M20 × 1.5		11.7 to 15.7	1.2 to 1.6	8.7 to 11.6	
Fuel filter air bleeder plug (in-line type)	M8 × 1.25	12	7.8 to 11.8	0.8 to 1.2	5.8 to 8.7	
Fuel filter element (distributor type)	M20 × 1.5		12.0 to 18.0	1.2 to 1.8	8.7 to 13.0	
Fuel filter level sensor (distributor type)	M20 × 1.5		4.0 to 6.0	0.4 to 0.6	2.9 to 4.3	
Fuel filter drain plug	M14 × 1.0		1.0 to 2.0	0.1 to 0.2	0.7 to 1.4	
Fuel filter air bleeder plug (distributor type)			2.0 to 4.0	0.2 to 0.4	1.4 to 2.9	

(3) Lubricating system

Description	Threads Diameter × Pitch mm	Width across flats (mm)	Torque			Remark
			N·m	kgf·m	lb·ft	
Oil pump gear	M10 × 1.25	14	28.0 to 38.0	2.9 to 3.9	21.0 to 28.2	
Oil pan	M8 × 1.25	12	10.0 to 13.0	1.0 to 1.3	7.2 to 9.4	Extruded
	M10 × 1.25	12	27.5 to 33.4	2.8 to 3.4	20.3 to 24.6	Casting
Oil pan drain plug	M14 × 1.5	227	34.0 to 44.0	3.5 to 4.5	25.3 to 32.5	
	M20 × 1.5	24	73.0 to 83.0	7.5 to 8.5	54.2 to 61.5	
Relief valve	M22 × 1.5	27	44.1 to 53.9	4.5 to 5.5	32.5 to 39.8	
Safety valve	M18 × 2.0	24	64.0 to 74.0	6.5 to 7.5	47.0 to 54.2	
Fuel injection pump oil supplied pipe (in-line type)	M12 × 1.0	17	16.0 to 23.0	1.6 to 2.3	11.6 to 16.6	
Turbocharger oil supplied eye bolt	M10 × 1.25	14	13.7 to 18.6	1.4 to 1.9	10.1 to 13.7	

(4) Cooling system

Description	Threads Diameter × Pitch mm	Width across flats (mm)	Torque			Remark
			N·m	kgf·m	lb·ft	
Thermostat case	M8 × 1.25	12	17.0 to 20.0	1.7 to 2.0	12.3 to 14.5	

(5) Inlet and exhaust systems

Description	Threads Diameter × Pitch mm	Width across flats (mm)	Torque			Remark
			N·m	kgf·m	lb·ft	
Exhaust manifold (bolt only)	M8 × 1.25	12	27.5 to 33.3	2.8 to 3.4	20.3 to 24.6	
Exhaust manifold (with spacer)	M8 × 1.25	12	15.0 to 22.0	1.5 to 2.2	10.8 to 15.9	
Turbocharger air hose plate clamp		7	3.0 to 5.0	0.3 to 0.5	2.2 to 3.6	

(6) Electrical system

Description	Threads Diameter × Pitch mm	Width across flats (mm)	Torque			Remark
			N·m	kgf·m	lb·ft	
Starter terminal B	M8 × 1.25	12	9.8 to 11.8	1.0 to 1.2	7.2 to 8.7	
Glow plug (swirl chamber)	M10 × 0.7	12	15.0 to 20.0	1.5 to 2.0	10.8 to 14.5	
Glow plug (direct injection)	M10 × 0.7	12	20.0 to 30.0	2.5 to 3.0	18.1 to 21.7	
Glow plug (terminal)	M4 × 0.7	8	1.0 to 1.5	0.10 to 0.15	0.7 to 1.1	

2.2 Standard Bolts and Nuts

Threads Diameter × Pitch mm	Strength classification					
	4T			7T		
	N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft
6 × 1.0	2.94 to 4.90	0.3 to 0.5	2.2 to 3.6	7.85 to 9.80	0.8 to 1.0	5.8 to 7.2
8 × 1.25	9.80 to 12.7	1.0 to 1.3	7.2 to 9.4	14.7 to 21.6	1.5 to 2.2	10.8 to 15.9
10 × 1.25	17.7 to 24.5	1.8 to 2.5	13.0 to 18.1	29.4 to 41.2	3.0 to 4.2	21.7 to 30.4
12 × 1.25	29.4 to 41.2	3.0 to 4.2	21.7 to 30.4	53.9 to 73.5	5.5 to 7.5	39.8 to 54.2

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 ±10 %.
(d) Use the tightening torque in this table unless otherwise specified.
(e) Do not apply oil to threaded sections. (Dry)

2.3 Standard Eye Bolts

Threads Diameter × Pitch mm	Width across flats (mm)	Strength classification		
		4T		
		N·m	kgf·m	lbf·ft
8 × 1.25	12	8 ±1	0.8 ±0.1	5.9 ±0.74
10 × 1.25	14	15 ±2	1.5 ±0.2	11.1 ±1.48
12 × 1.25	17	25 ±3	2.5 ±0.3	18.4 ±2.21
14 × 1.5	22	34 ±4	3.5 ±0.4	25.1 ±2.95
16 × 1.5	24	44 ±5	4.5 ±0.5	32.5 ±3.69
18 × 1.5	27	74 ±5	7.5 ±0.5	54.2 ±3.69
20 × 1.5	30	98 ±10	10.0 ±1.0	72.3 ±7.38
24 × 1.5	36	147 ±15	15.0 ±1.5	108.4 ±11.1
27 × 1.5	41	226 ±20	23.0 ±2.0	166.7 ±14.8

(Dry)

2.4 Standard Union Nuts

Nominal diameter	Cap nut size M (mm)	Width across flats (mm)	N·m	kgf·m	lbf·ft
63	14 × 1.5	19	39	4	29
80	16 × 1.5	22	49	5	36
100	20 × 1.5	27	78	8	58
120	22 × 1.5	30	98	10	72
150	27 × 1.5	32	157	16	116
180	30 × 1.5	36	196	20	145
200	30 × 1.5	36	196	20	145
220	33 × 1.5	41	245	25	181
254	36 × 1.5	41	294	30	217

(Maximum tolerance value: ±10 %, dry)

2.5 Standard Plugs

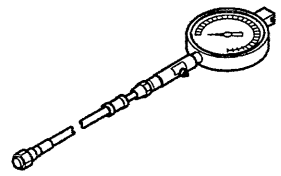
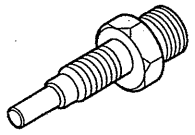
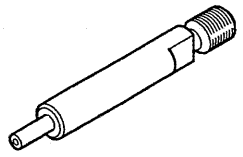
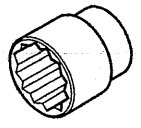
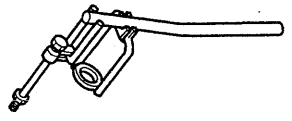
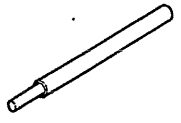
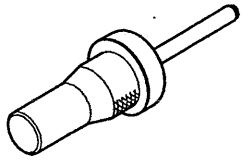
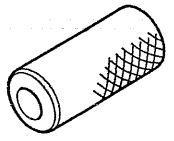
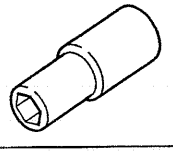
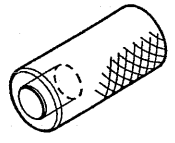
Thread Diameter	Torque for alminum materials			Torque for ferrous matirials		
	N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft
NPTF1/16	4.90 to 7.85	0.5 to 0.8	3.62 to 5.79	7.85 to 11.8	0.8 to 1.2	5.79 to 8.68
PT1/8	7.85 to 11.8	0.8 to 1.2	5.79 to 8.68	14.7 to 21.6	1.5 to 2.2	10.8 to 15.9
PT1/4, NPTF1/4	19.6 to 29.4	2.0 to 3.0	14.5 to 21.7	34.3 to 44.1	3.5 to 4.5	25.3 to 32.5
PT3/8	—	—	—	53.9 to 73.5	5.5 to 7.5	39.8 to 54.2

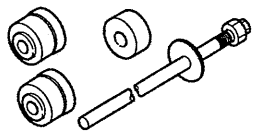
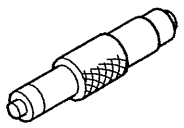
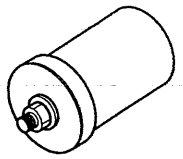
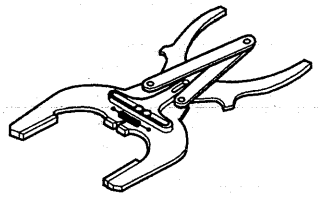
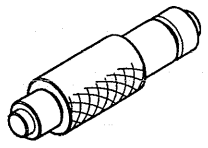
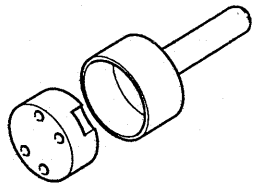
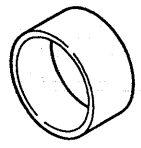
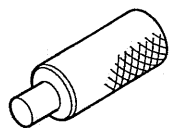
3. Sealants and Lubricants Table

Apply to	Mating part	Sealant or lubricant	How to use
Oil pan	Crankcase Timing gear case	Three Bond 1207C	Apply to inside circumference of oil pan mounting surface grooves and bolt holes.
Rear bearing cap seat on crankcase	No. 7 bearing cap	Three Bond 1212	Apply to corners before installing cap.
Side seal	Crankcase No. 7 bearing cap	Three Bond 1211	Apply to side seals.
Cylinder head coolant hole plug	Cylinder head	Three Bond 1386D	Apply to plug hole.
Crankcase coolant hole plug	Crankcase	Three Bond 1386D	Apply to plug hole.
Crankcase oil hole plug	Crankcase	Three Bond 1386D	Apply to plug hole.
Return oil hole blind plug or pipe of crankcase	Crankcase	Three Bond 1386D	Apply to blind plug or pipe.
Crankshaft threads	Crankshaft pulley nut	Three Bond 1212	Apply to crankshaft thread before tightening nut.

SPECIAL TOOLS

1. Special Tools

Application	Tool name/part No.	Shape	Use
Overhaul instruction	Compression gage 33391-02100		Testing the compression pressure 0 to 7 MPa (0 to 71.4 kgf/cm^2) [0 to 1015 psi]
	Gage adapter 30691-21100 (swirl chamber)		Testing the compression pressure
	Gage adapter 32A91-01100 (direct injection)		Testing the compression pressure
Engine main parts	Turning socket 58309-73100		Engine turning
Engine main parts / Cylinder heads and valve mechanisms	Valve spring pusher 30691-04500		Valve spring removal/installation
	Valve guide remove 32A91-00300		Valve guide removal
	Valve seat insert caulking tool Inlet valve: 36791-00200 Exhaust valve: 34491-03020		Valve seat installation
	Stem seal installer 32A91-10200		Valve stem installation
	Socket 34491-00300		Camshaft thrust plate and rocker bracket installation
	Valve guide installer 32A91-00100		Valve guide installation

Application		Tool name/part No.	Shape	Use
Engine main parts	Flywheel, timing gear and camshaft	Camshaft bushing installer set 30691-00010		Camshaft bushing removal/installation
		Idler bushing installer 30091-07300		Idler gear bushing removal
		Idler shaft puller MH061077		Idler gear shaft removal
	Piston, connecting rod, crankshaft, carankcase and tappet	Piston ring pliers 31391-12900		Piston ring removal/installation
		Connecting rod bushing puller 32A91-00500		Connecting rod bushing removal/installation
		Oil seal sleeve installer set 30691-13010		Crankshaft rear oil seal sleeve installation
		Piston installer 34491-00200		Piston installation
Lubrication system	Oil pump	Oil pump bushing installer 32A91-00400		Oil pump bushing installation

OVERHAUL INSTRUCTIONS

1. Determination of Overhaul Timing

In most cases, the engine should be overhauled when the compression pressure of the engine is low and decreased compression pressure results in a noticeable increase in engine oil consumption and blow-by gas and these symptoms can be used to evaluate the engine condition.

Reduced power output, increased fuel consumption, low oil pressure, difficulty in starting, and increased operating noise are also signs that suggest the need for an overhaul, however, since these problems can be caused by various factors, they do not serve as reliable sources for assessing the need for an overhaul.

Reduced compression pressure manifests 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.

(a) Decreased output power

(b) Increased fuel consumption

(c) Increased engine oil consumption

(d) Increased blow-by gas through the breather due to worn cylinder liners and piston rings

(e) Increase gas leakage due to poor seating of inlet and exhaust valves

(f) Difficulty in starting

(g) Increased noise from engine parts

(h) 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 (b) and (f) can result from improper fuel injection volume and timing of the fuel injection pump, worn plunger, faulty nozzles and also faulty conditions of electrical devices such as battery and starter.

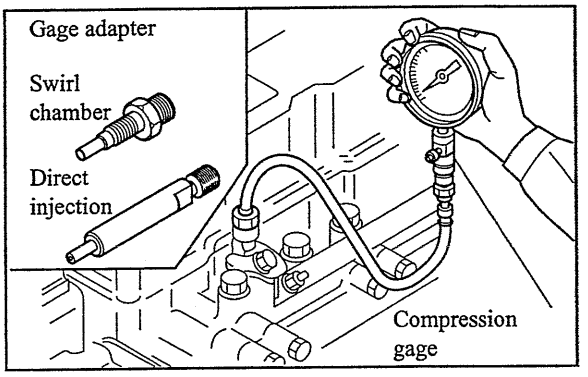
The most valid reason to overhaul an engine is a decrease in compression pressure due to worn cylinder liners and pistons, as described in item (d), and once this is determined, it is reasonable to take other problems into consideration for making the final judgment.

2. Testing Compression Pressure

(1) Move the control lever to STOP position.
(2) Remove the glow plugs from all cylinders. Install the special tool gage adapter and a compression gage onto the cylinder being measured.

Special tool	Part No.
Compression gage	33391-02100
Gage adapter	30691-21100 (Swirl chamber)
	32A91-01100 (Direct injection)

(3) While cranking the engine with the starter, read the compression gage. Note the reading at which the gage needle stabilizes.
(4) If the measured value is at or below the limit, overhaul the engine.



Testing the compression pressure

⚠ CAUTION

(a) Measure all cylinders for compression pressure. Do not measure only one cylinder and make assumption about the other cylinders as this will lead to a wrong conclusion.
(b) Compression pressure varies depending on the engine speed. Keep the specified engine speed when measuring the compression pressure.

		Standard	Limit
Engine speed		300 min^{-1}	
Compression pressure	Swirl chamber	3.23 MPa (33 kgf/cm^2) [469 psi]	2.84 MPa (29 kgf/cm^2) [413 psi]
	Direct injection	2.94 MPa (30 kgf/cm^2) [427 psi]	2.64 MPa (27 kgf/cm^2) [384 psi]

⚠ CAUTION

It is important to regularly check the compression pressure so that you can tell the difference.
- New or overhauled engines have slightly higher compression pressure.
- The compression pressure settles to the standard value as the piston rings and valve seats fit in.
- As wear progresses further, the compression pressure drops.

PREPARATION FOR DISASSEMBLY

1. Preparation

1.1 Cutting off Fuel Supply

⚠ CAUTION

Before disassembling the engine, close the main fuel supply valve, and drain fuel from the pipe completely.
If fuel is remaining in the pipe, serious accidents such as an explosion and fire may result.

1.2 Removing Electrical Wiring

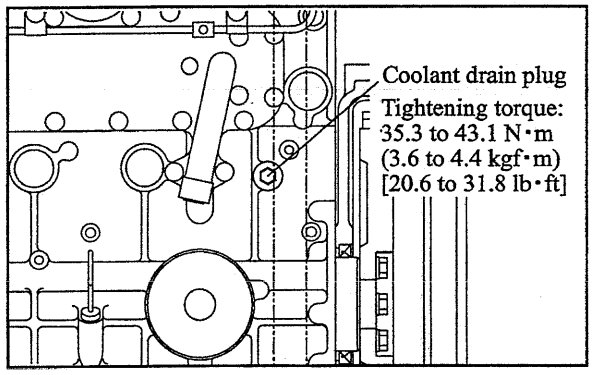
Remove the wiring harnesses from the following equipment.
Before removal, attach mating tags etc. onto the terminals to aid reassembly.

- Starter
- Switches

1.3 Draining Coolant

Remove the coolant drain plug on the left-hand rear of the crankcase to drain coolant from the engine.
Install and tighten the coolant drain plug to specified torque.

Amount of coolant	S4S	5.0 to 5.5 ℓ [1.32 to 1.45 U.S.gal]
	S6S	8.0 to 9.0 ℓ [2.11 to 2.37 U.S.gal]

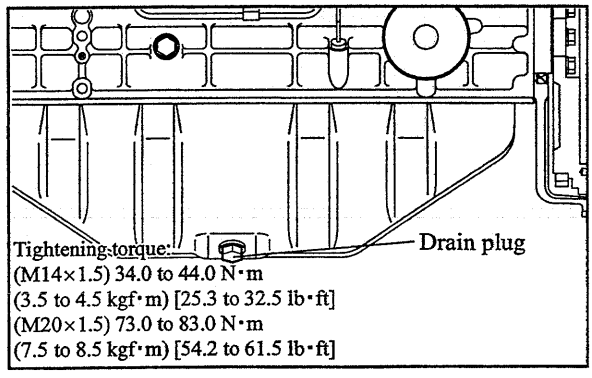


Draining coolant

1.4 Draining Engine Oil

Remove the engine oil drain plug at bottom of oil pan from the oil pan to drain the engine oil.
Install and tighten the drain plug to the specified torque.

Amount of engine oil	S4S	Oil pan capacity 9.0 ℓ [2.37 U.S.gal] Entire amount of engine oil Approx.10 ℓ [2.64 U.S.gal]
	S6S	Oil pan capacity 11.5 ℓ [3.03 U.S.gal] Entire amount of engine oil Approx.12.5 ℓ [3.30 U.S.gal]



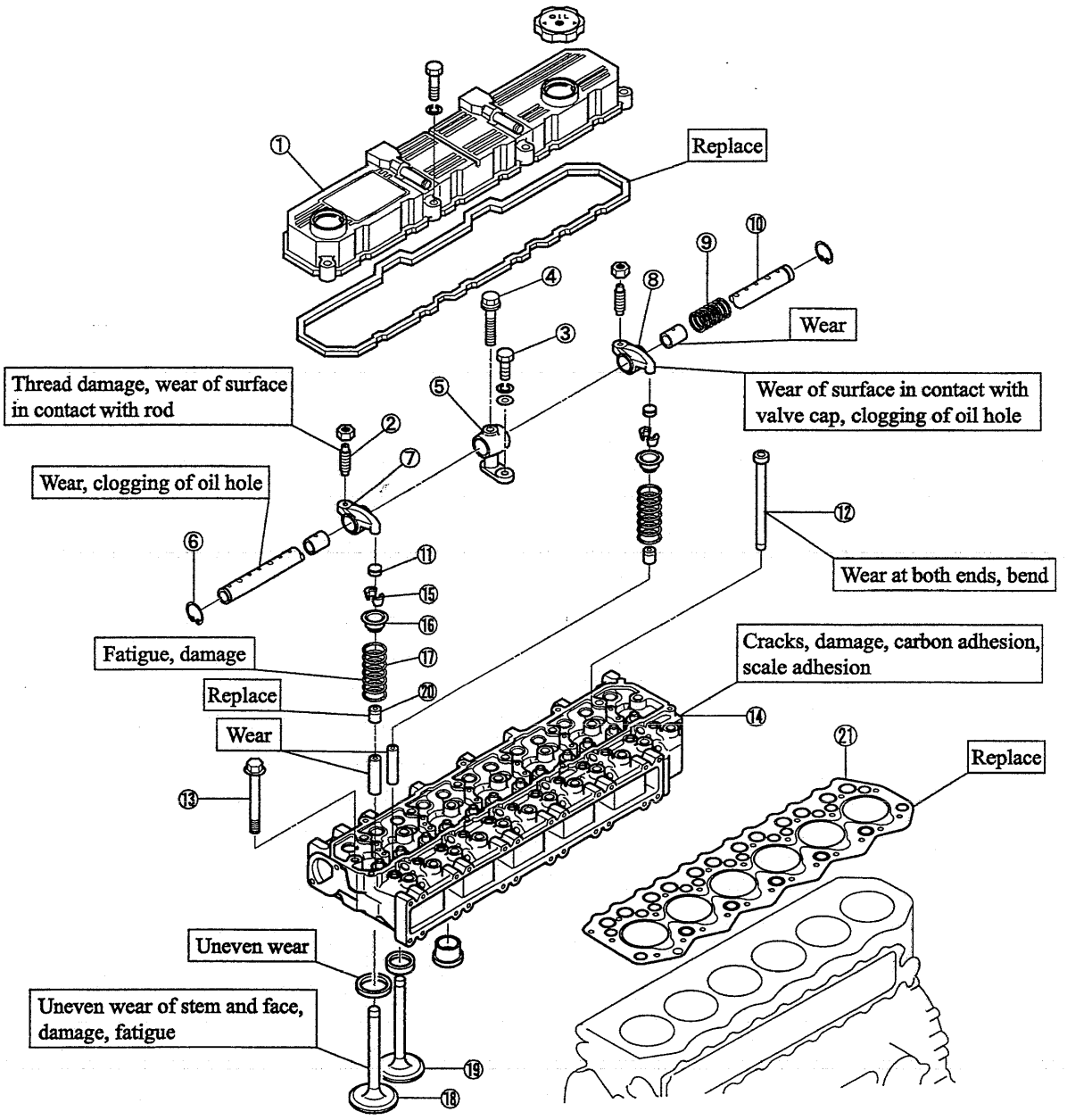
Draining engine oil

⚠ CAUTION

Do not touch the engine oil which may be extremely hot as it can cause burns.

DISASSEMBLY OF MAIN ENGINE PARTS

1. Cylinder Head and Valve Mechanism



Disassembly and inspection of cylinder head and valve mechanism

< Disassembly sequence >

① Rocker cover
② Adjusting screw
③ Bolt (short)
④ Bolt (long)
⑤ Rocker shaft bracket
⑥ Snap ring
⑦ Rocker arm
⑧ Rocker arm
⑨ Rocker shaft spring
⑩ Rocker shaft
⑪ Valve cap
⑫ Pushrod
⑬ Cylinder head bolt
⑭ Cylinder head
(Remove parts ⑭ to ⑳ as a unit.)
⑮ Valve cotter
⑯ Valve retainer
⑰ Valve spring
⑱ Valve (IN)
⑲ Valve (EX)
⑳ Valve stem seal
㉑ Cylinder head gasket

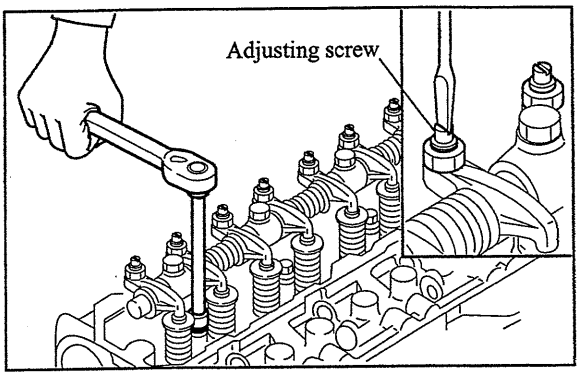
1.1 Removing Rocker Shaft Assembly

(1) Loosen the adjusting screw of the rocker by about one turn.

(2) Loosen the shorter bolt of the rocker shaft bracket first. Loosen the longer bolt, then. Remove the rocker shaft assembly from the cylinder head.

⚠ CAUTION

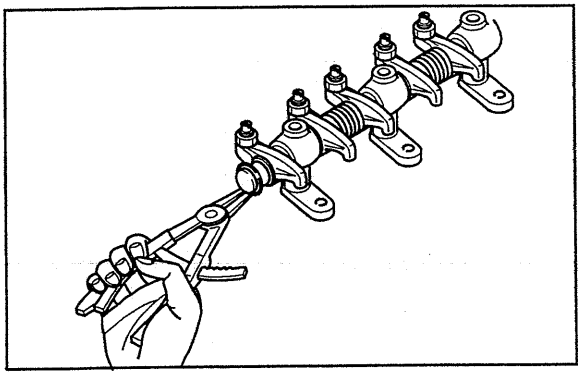
If these bolts are loosened in reverse order, the rocker shaft bracket may be damaged.



Removing rocker shaft assembly

1.2 Disassembling Rocker Shaft Assembly

In the course of disassembly, place removed rocker components neatly in the order of disassembly so that they can be reassembled back onto their original locations. Doing so, original clearances between the rocker arms and the rocker shaft are restored upon reassembly.

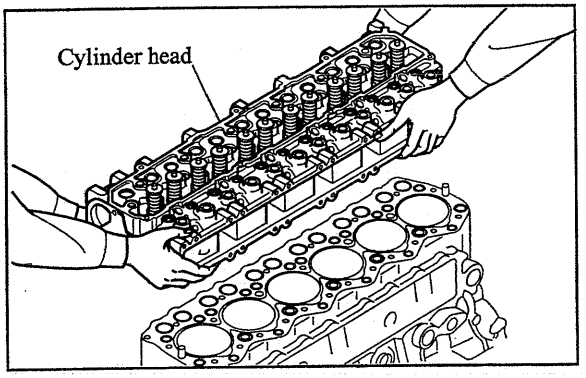


Disassembling rocker shaft assembly

1.3 Removing Cylinder Head Assembly

Remove the cylinder head bolts. Lift the cylinder head and remove it from the crankcase.

Note: Be careful not to damage the mount surfaces of the cylinder and crankcase when removing the gasket from the cylinder head.
Before removing the cylinder head bolts, check the cylinder head components for any defects or faults. If faulty or defective, check the bolts for tightness with a torque wrench.



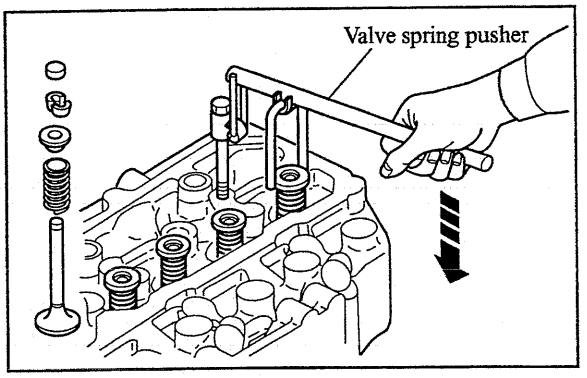
Removing cylinder head

1.4 Removing Valves and Valve Springs

Push the valve spring evenly using the valve spring pusher (special tool), and remove the valve cotter.

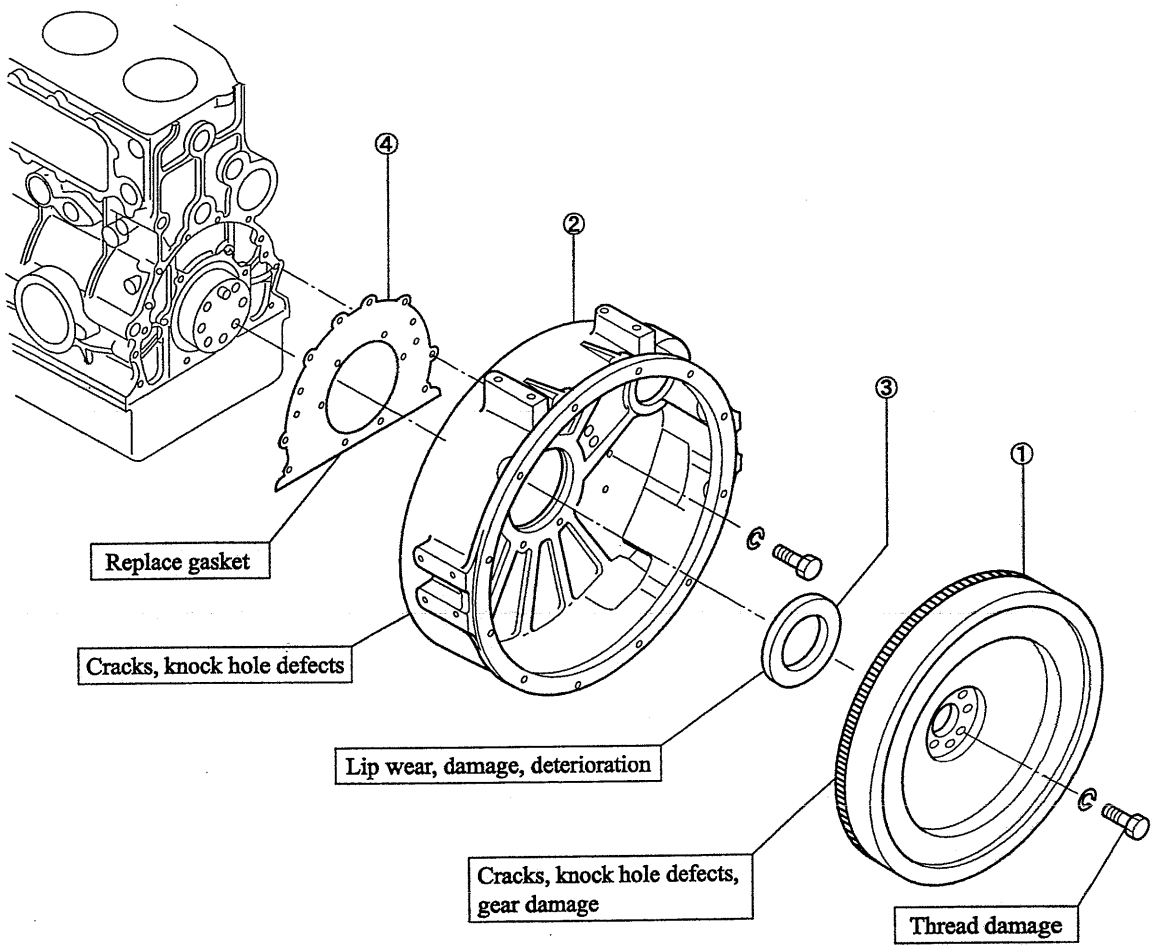
Special tool name	Part No.
Valve spring pusher	30691-04500

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



Removing valve and valve spring

2. Flywheel



Disassembly of flywheel

< Disassembly sequence >

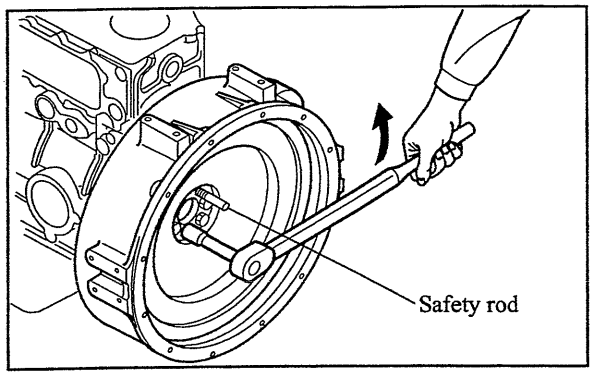
① Flywheel
② Flywheel housing
(Remove parts ② and ③ as a unit.)
③ Oil seal
④ Gasket

2.1 Removing Flywheel

(1) Remove one flywheel mounting bolt.
(2) Screw the safety rod (M12 × 1.25) into the threaded hole, from which the mounting bolt was removed above. Remove the remaining bolts and remove the lock washers.
(3) Hold the flywheel firmly with both hands. Shake it back and forth to pull it out straight.

⚠ CAUTION

Be very careful not to cut your hand with the ring gear when pulling out the flywheel.



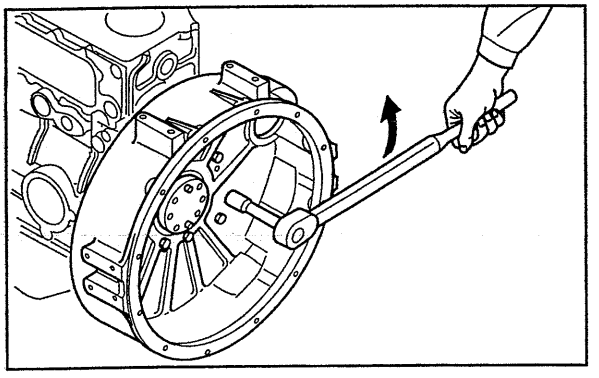
Removing flywheel

2.2 Removing Flywheel Housing

Remove the flywheel housing mounting bolts. Remove the flywheel housing.

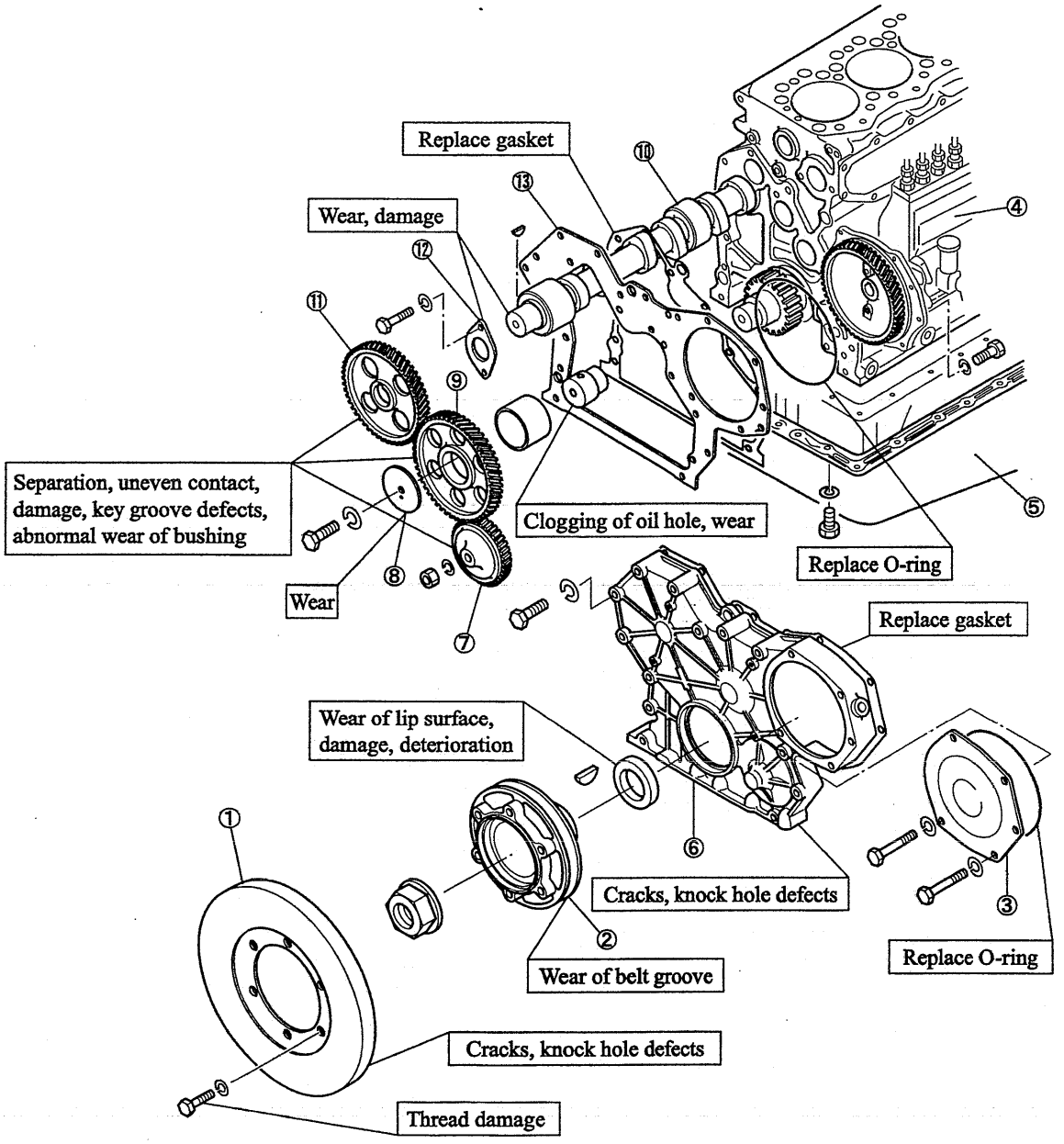
⚠ CAUTION

Be very careful not to damage the oil seal.



Removing flywheel housing

3. Damper, Timing Gears and Camshaft



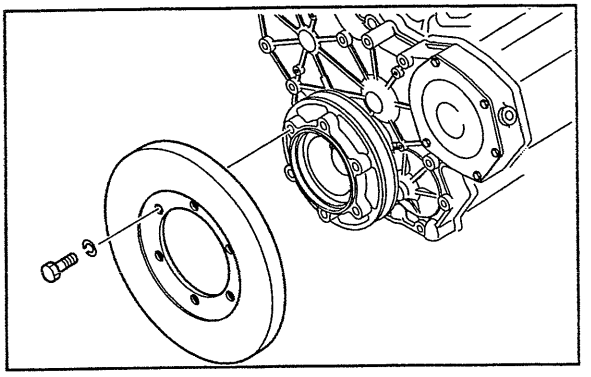
Disassembly of timing gears

< Disassembly sequence >

① Damper (S6S)
② Crankshaft pulley
③ Cover
④ Fuel injection pump
⑤ Oil pan
⑥ Timing gear case
⑦ Oil pump gear
⑧ Thrust plate
⑨ Idler gear
⑩ Camshaft
⑪ Camshaft gear
⑫ Thrust plate
(Remove parts ⑩ to ⑫ as a unit.)
⑬ Front plate

3.1 Removing Damper (S6S)

Remove the mounting bolts, and remove the damper.



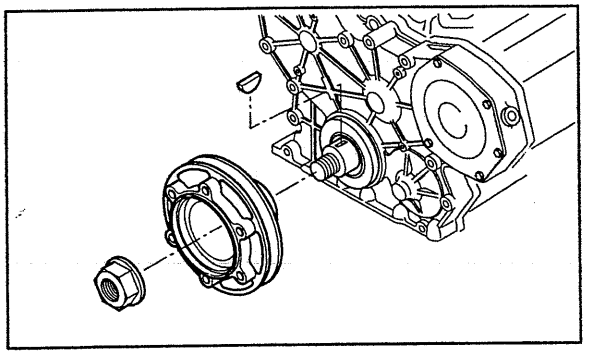
Removing damper

3.2 Removing Crankshaft Pulley

(1) Screw two bolts (M12 × 1.25) into the threaded holes at the rear end of the crankshaft. Prevent the crankshaft from rotating using a bar.
(2) Remove the nut, and remove the crankshaft pulley.

⚠ CAUTION

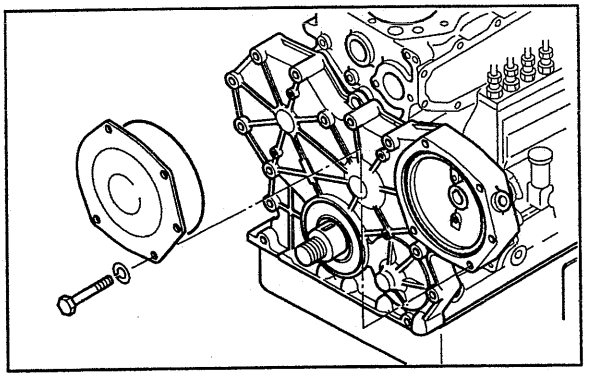
The bar may come off. Be very careful.



Removing crankshaft pulley

3.3 Removing Cover

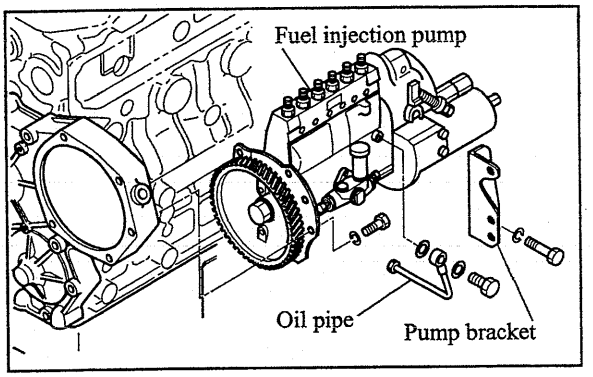
Remove the cover mounting bolts, and remove the cover.



Removing cover

3.4 Removing Fuel Injection Pump

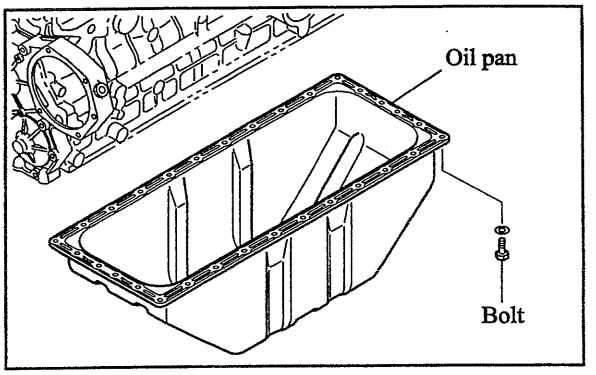
(1) Disconnect the oil pipe.
(2) Remove the pump bracket.
(3) Remove the fuel injection pump mounting bolts, and remove the fuel injection pump.



Removing fuel injection pump

3.5 Removing Oil Pan

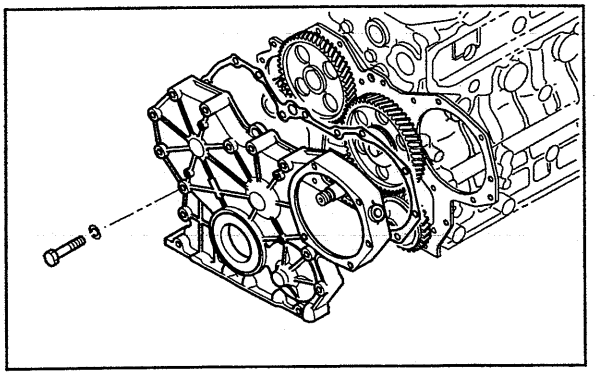
Remove the oil pan mounting bolts, and remove the oil pan.



Removing oil pan

3.6 Removing Timing Gear Case

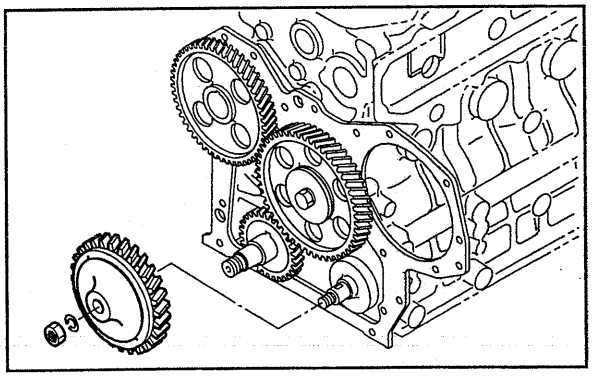
Remove the timing gear mounting bolts, and remove the timing gears.



Removing timing gear case

3.7 Removing Oil Pump Gear

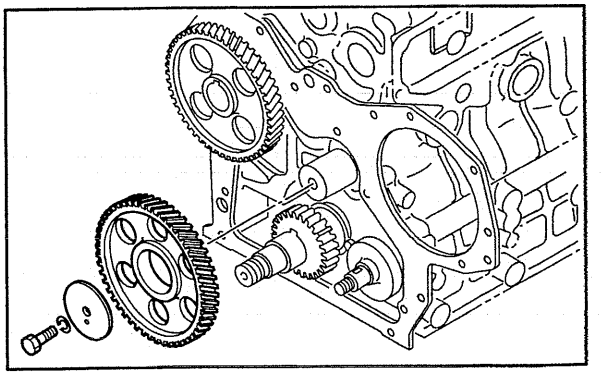
Remove the gear mounting nut, and remove the oil pump gear.



Removing oil pump gear

3.8 Removing Idler Gear

Remove the thrust plate mounting bolt, and remove the thrust plate and idler gear.



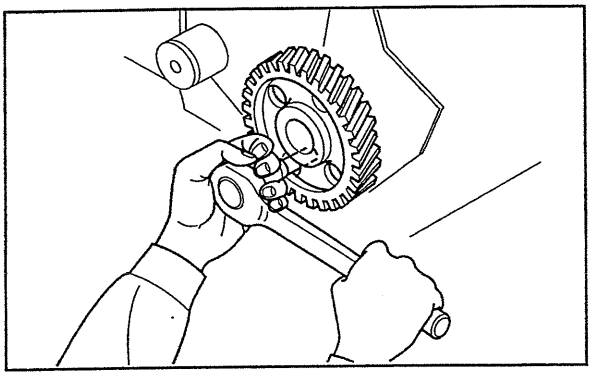
Removing idler gear

3.9 Removing Camshaft

(1) Reverse the crankcase.
(2) Face the lightening hole in the camshaft gear up and down. Remove the thrust plate tightening bolts, and remove the camshaft from the crankcase.

⚠ CAUTION

Be careful not to damage the cam of the camshaft and the camshaft bearing of the crankcase.

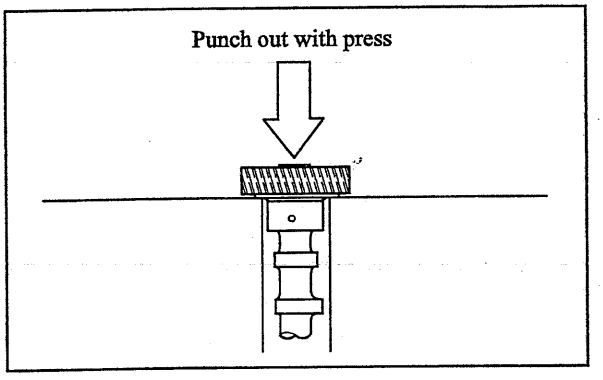


Removing camshaft

3.10 Separating Camshaft Gear

Punch out the camshaft gear from the camshaft using a hydraulic press.

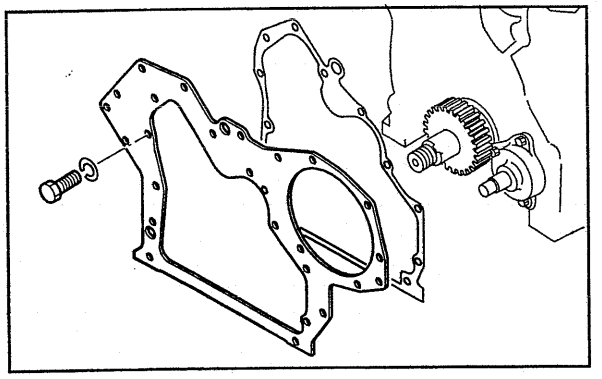
Note: The camshaft gear and thrust plate will not separate unless they are defective.



Separating camshaft gear

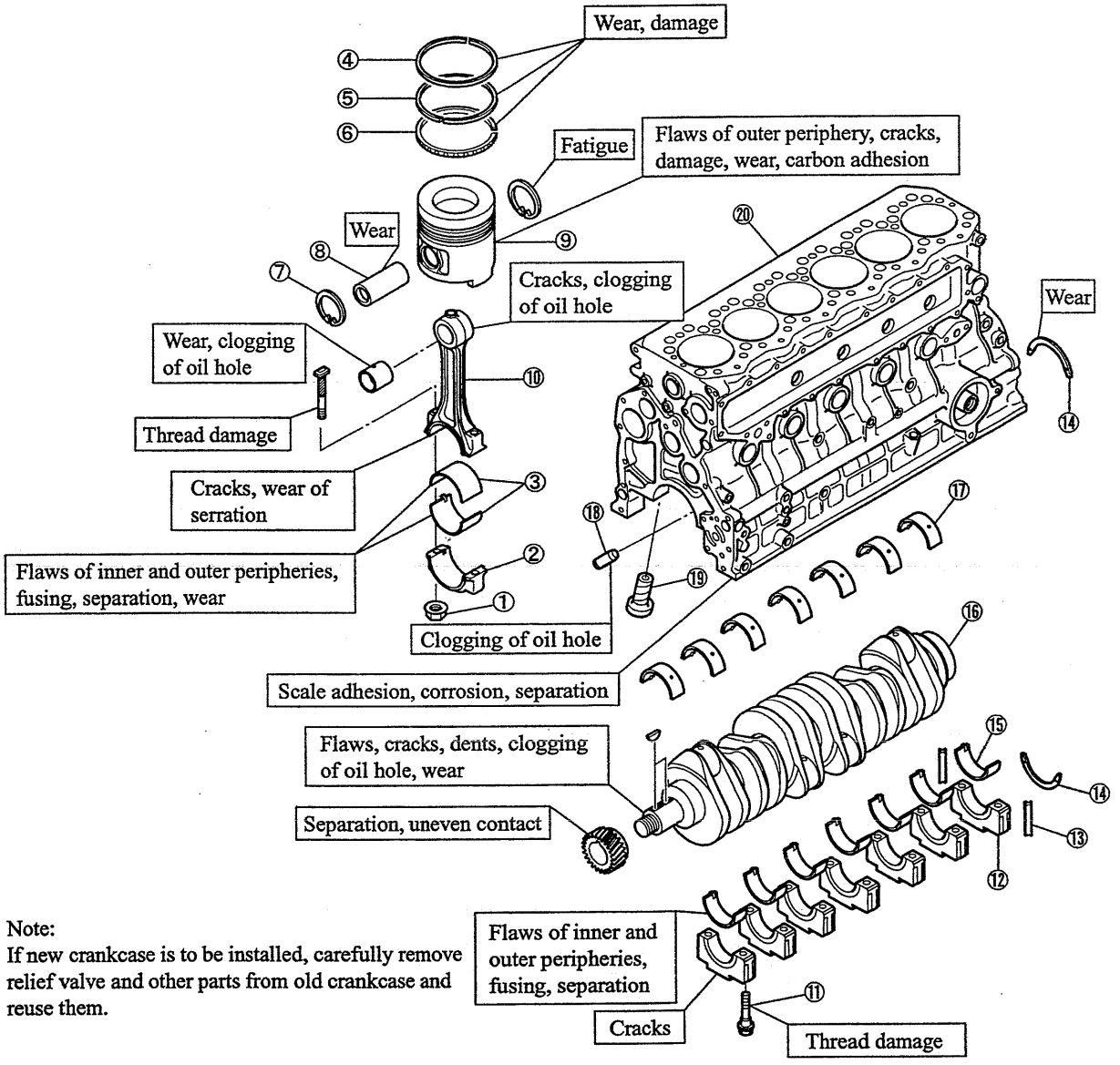
3.11 Removing Front Plate

Remove the front plate mounting bolts, and remove the front plate from the crankcase.



Removing front plate

4. Pistons, Connecting Rods, Crankshaft and Crankcase



Note:
If new crankcase is to be installed, carefully remove relief valve and other parts from old crankcase and reuse them.

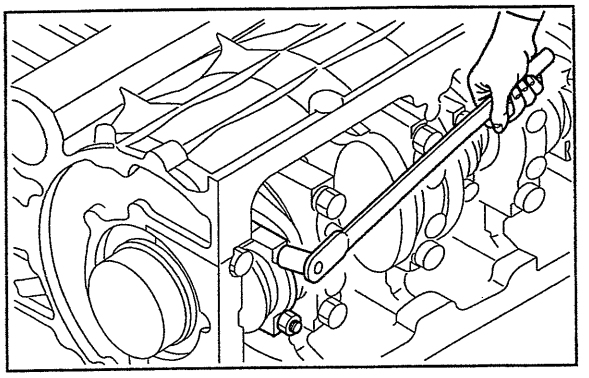
Disassembly of pistons, connecting rods, crankshaft and crankcase

< Disassembly sequence >

① Nut
② Connecting rod cap
③ Connecting rod bearing
④ No. 1 ring
⑤ No. 2 ring
⑥ Oil ring
⑦ Snap ring
⑧ Piston pin
⑨ Piston
⑩ Connecting rod
(Remove parts ④ to ⑩ as a unit.)
⑪ Bearing cap bolt
⑫ Main bearing cap
⑬ Side seal
⑭ Thrust plate
⑮ Lower main bearing
⑯ Crankshaft
⑰ Upper main bearing
⑱ Tappet
⑲ Crankcase

4.1 Removing Connecting Rod Caps

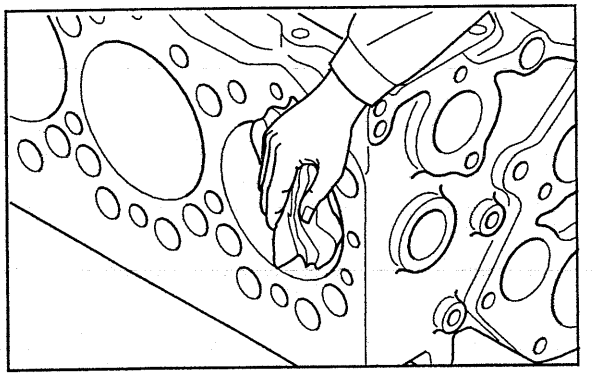
(1) Remove each connecting rod cap tightening nut, hit the tip of the tightening bolt evenly almost squarely with an iron hammer, and remove the cap when the cap-side reamer comes off.
(2) Clarify the cylinder number and the upper and lower parts of the removed connecting rod bearings.



Removing connecting rod cap

4.2 Preparation for Pulling Out Pistons

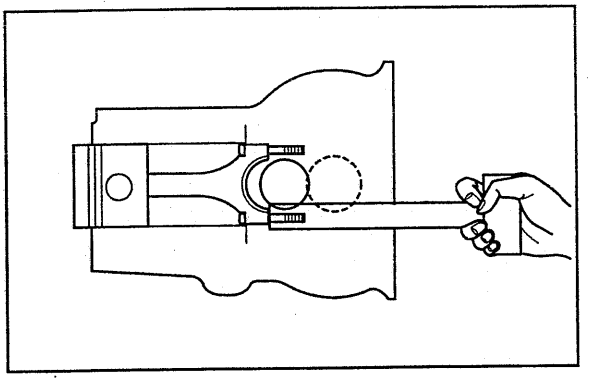
(1) Turn the crankcase on its side.
(2) If carbon adheres to the upper part of the cylinder, the piston may be difficult to draw up. Remove carbon with waste cloth or oil paper.



Preparation for pulling out pistons

4.3 Pulling Out Pistons

Move the connecting rod to the top, apply the hammer grip to the larger end of the connecting rod, and pull out the piston to above the crankcase.

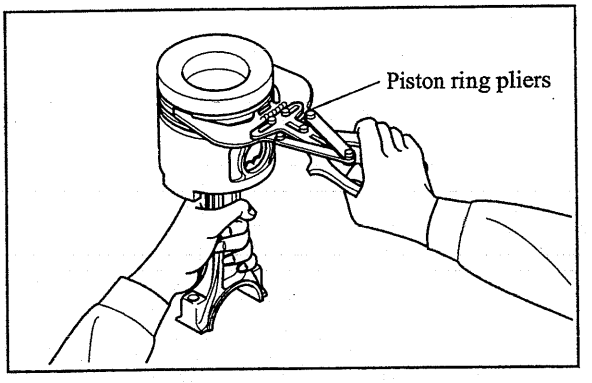


Pulling out piston

4.4 Removing Piston Rings

Remove the piston ring with the piston ring pliers (special tool).

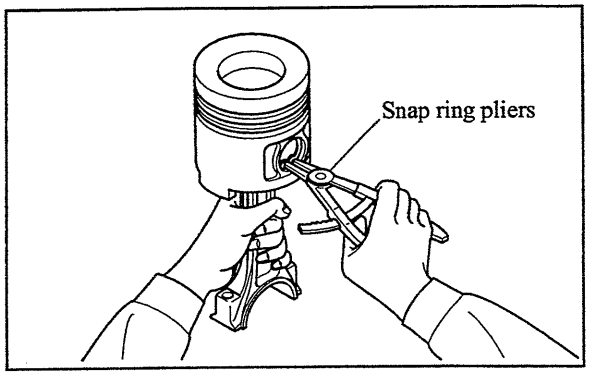
Special tool name	Part No.
Piston ring pliers	31391-12900



Removing piston ring

4.5 Removing Piston Pins

(1) Remove the snap ring using the snap ring pliers.
(2) Draw out the piston pin. Separate the piston from the connecting rod.
(3) Heat the piston with a piston heater or hot water if the piston pin is hard to draw out.

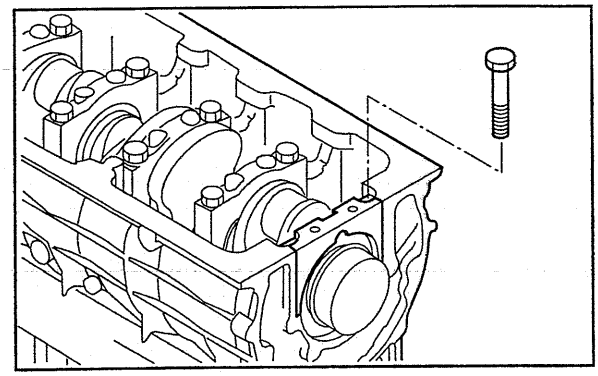


Removing piston pin

4.6 Removing Main Bearing Caps

Remove the main bearing cap tightening bolts, and remove the main bearing cap with the lower main bearing attached. Remove the rearmost main bearing cap using the drawing puller.

Note: Be careful not to damage each lower main bearing. Put the removed main bearings in order so as to reassemble them in the same positions.

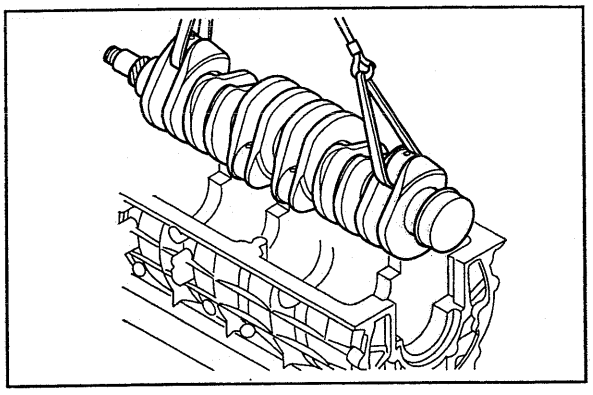


Removing main bearing cap

4.7 Removing Crankshaft

Attach a hoist to the crankshaft, host it horizontally, and remove the crankshaft upward slowly.

Note: Be careful not to damage each upper main bearing. Put the removed main bearings in order so as to reassemble them in the same positions.



Removing crankshaft

4.8 Removing Tappets

Remove the tappet.

Note: Put the removed tappets in order so as to reassemble them in the same positions.

INSPECTION AND REPAIR OF MAIN ENGINE PARTS

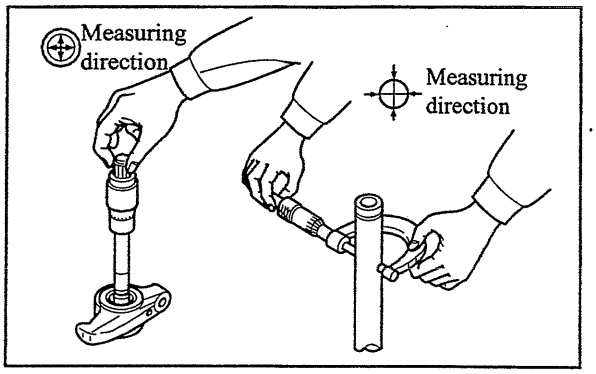
1. Cylinder Head and Valve Mechanisms

1.1 Measuring Rocker Bushing Inside Diameter and Rocker Shaft Outside Diameter

Measure the inside diameter of the rocker bushing and the outside diameter of the rocker shaft, and calculate the clearance between them.
Replace the rocker arm until the clearance reaches the limit. Also replace the rocker shaft if the clearance exceeds the limit.

Unit: mm [in.]

	Nominal	Standard	Limit
Rocker bushing inside diameter	ϕ19 [ϕ0.75]	19.010 to 19.030 [0.74843 to 0.74921]	
Rocker shaft outside diameter	ϕ19 [ϕ0.75]	18.980 to 19.000 [0.74724 to 0.74803]	
Clearance between rocker bushing and shaft	-	0.010 to 0.050 [0.00039 to 0.00197]	0.070 [0.00276]



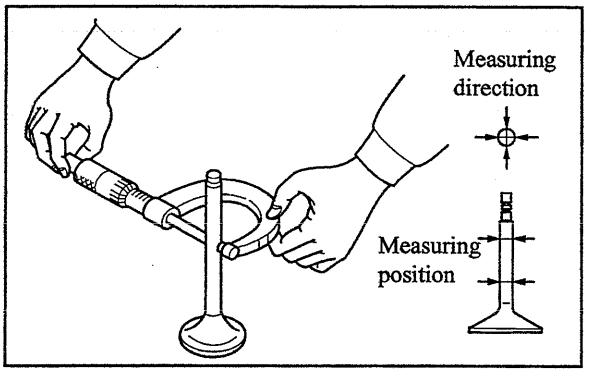
Measuring rocker bushing inside diameter and rocker shaft outside diameter

1.2 Measuring Valve Stem Outside Diameter

Measure the outside diameters of the valve stems. Replace the valve stems if the limit is exceeded. Also replace the valve stems with remarkable uneven wear.

Unit: mm [in.]

		Nominal	Standard	Limit
Valve stem outside diameter	Inlet	ϕ8 [ϕ0.31]	7.940 to 7.955 [0.31260 to 0.31319]	7.900 [0.31102]
	Exhaust	ϕ8 [ϕ0.31]	7.920 to 7.940 [0.31181 to 0.31260]	7.850 [0.30906]



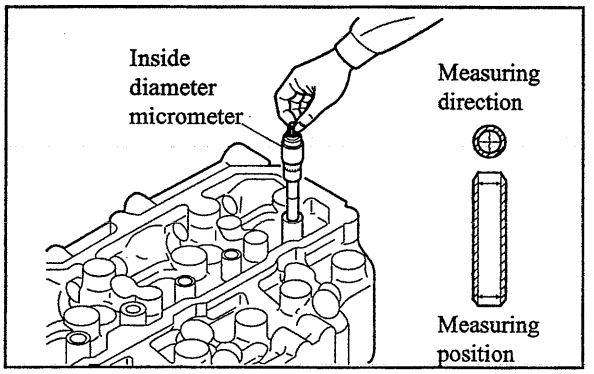
Measuring valve stem outside diameter

1.3 Measuring Clearance between Valve Stems and Valve Guides

Measure the inside diameters of the valve guides. It is necessary to measure the inside diameters at the top and bottom ends at right angles with the inner surface, since the valve guides are subject to wear at both ends.
Replace the valve guides when wear exceeds the limit.

Unit: mm [in.]

		Nominal	Standard	Limit
Clearance between valve stem and valve guide	Inlet	-	0.065 to 0.095 [0.00256 to 0.00374]	0.150 [0.00591]
	Exhaust	-	0.080 to 0.115 [0.00315 to 0.00453]	0.200 [0.00787]
Valve guide mounting length		14 [0.55]	13.9 to 14.1 [0.547 to 0.555]	-

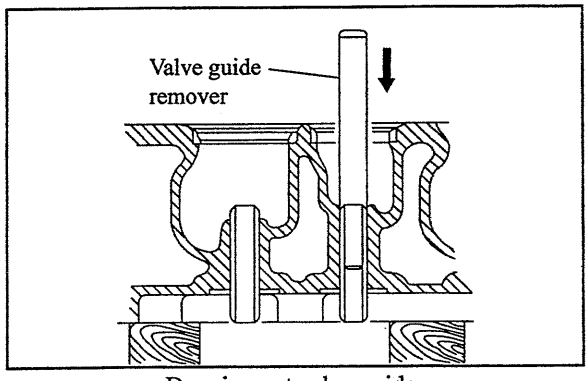


Measuring valve guide inside diameter

1.4 Replacing Valve Guides

(1) Use the valve guide remover (special tool) to draw out the valve guide.

Special tool name	Part No.
Valve guide remover	32A91-00300



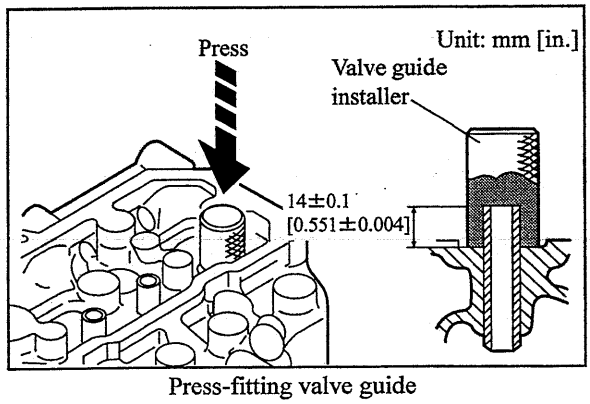
Drawing out valve guide

(2) Use the valve guide installer (special tool) to press-fit the valve guide.

Special tool name	Part No.
Valve guide installer	32A91-00100

⚠ CAUTION

The amount of press-fitting the valve guide is specified. Thus, be sure to use the valve guide installer.



Press-fitting valve guide

1.5 Checking Valve Faces

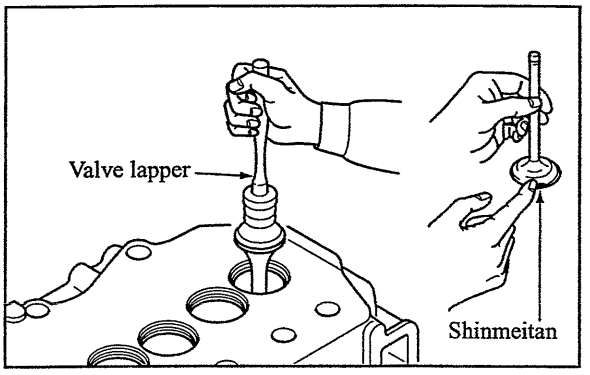
Apply a shinmeitan thinly on the valve faces, and check contact with the valve seats using the valve lapper. Repair or replace the valves and valve seats whose contact is not uniform all over the surface and some abnormality is detected or the limit is exceeded.

Note: (a) Check the valve faces after checking or replacing the valve guides.
(b) Do not rotate the valves with a shinmeitan applied when pressing them against the valve seats.
(c) Be sure to face up the valves and valve seats after repairing or replacing the valves or valve seats.

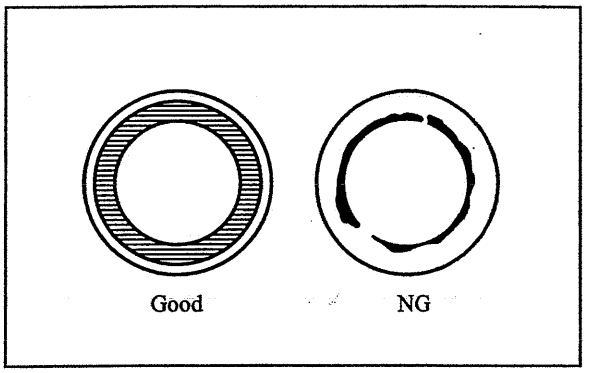
Contact of valves with valve seats

Unit: mm [in.]

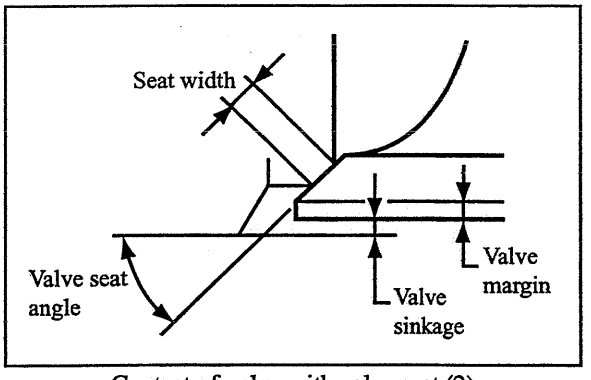
			Nominal	Standard	Limit
Valve seat	Valve seat angle		30°		
	Valve sinkage	Inlet	0.4 [0.016]	0.3 to 0.5 [0.012 to 0.020]	1.0 [0.039]
		Exhaust	0.5 [0.020]	0.4 to 0.6 [0.016 to 0.024]	
	Seat width		1.4 [0.055]	1.26 to 1.54 [0.0496 to 0.0606]	1.8 [0.071]
Valve margin			2.13 [0.0839]		Up to 1.83 [0.0720] when re-faced



Checking valve face



Contact of valve with valve seat (1)

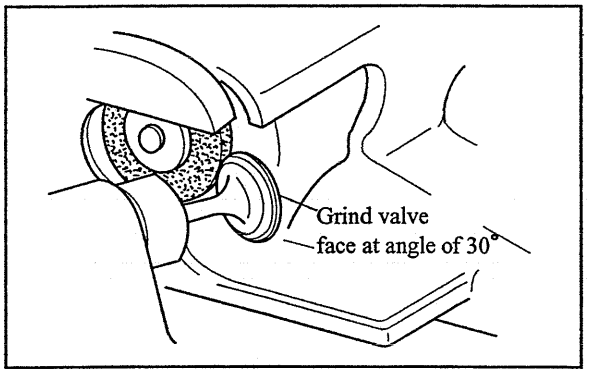


Contact of valve with valve seat (2)

1.6 Repairing Valve Faces

Repair remarkably worn valve faces with the valve re-facer.

Note: (a) Grind the valve face with the re-facer at an angle of 30 degrees.
(b) Keep the valve margin exceeding the limit.
Replace valves with new ones if their dimensions do not meet the standard.

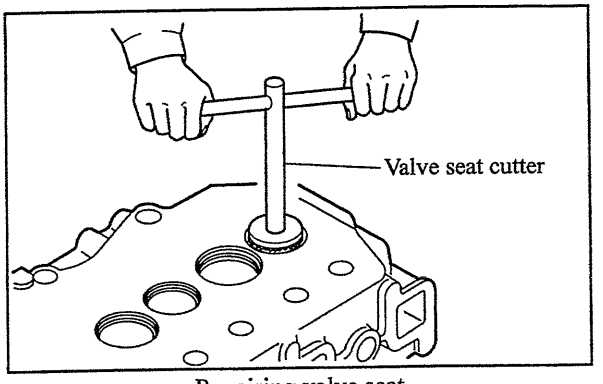


Correcting valve face

1.7 Repairing Valve Seats

Grind the valve seats with a valve seat cutter or valve seat grinder. After grinding, polish them with #400 or equivalent sandpaper placed between the cutter and valve seat.

Note: (a) Keep the degree of repair of the valve seats to a minimum.
(b) Replace the valve seats whose widths exceed the limit due to wear or repair.



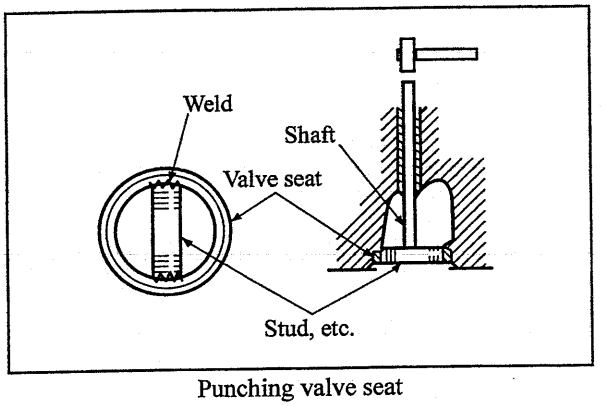
Repairing valve seat

1.8 Replacing Valve Seats

(1) Punching valve seats

Weld a stud or rod to a valve seat, insert the shaft into the valve guide hole from the top of the cylinder head, and press the tip against the welded stud to punch the valve seat.

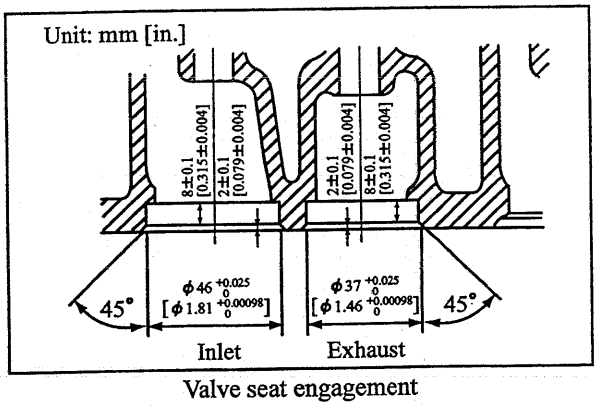
Note: Be careful not to allow spatters to adhere to the machined surface of the cylinder head during welding.



Punching valve seat

(2) Inserting valve seats

Measure the inside diameter of the valve seat engagement of the cylinder head to make sure that it is up to standard before inserting the valve seat.



Valve seat engagement

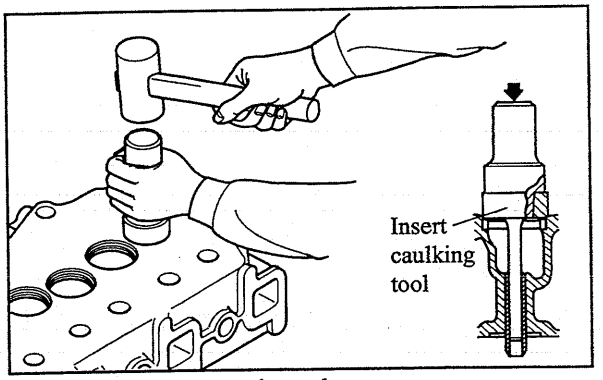
(3) Insert the valve seat into the cylinder head by cooling it with either of the methods shown below.

Cool the valve seat for four minutes or more in liquid nitrogen (at approximately -170°C [-274°F]) and then insert it, while keeping the cylinder head at room temperature.

Heat the cylinder head at 80 to 100°C [176 to 212°F]. Cool the valve seat sufficiently in ether or alcohol with dry ice, and then insert it.

Insert the valve seat cooled with an insert caulking tool into the cylinder head.

Special tool name	Part No.	
Valve insert caulking tool	Inlet	36791-00200
	Exhaust	34491-03020

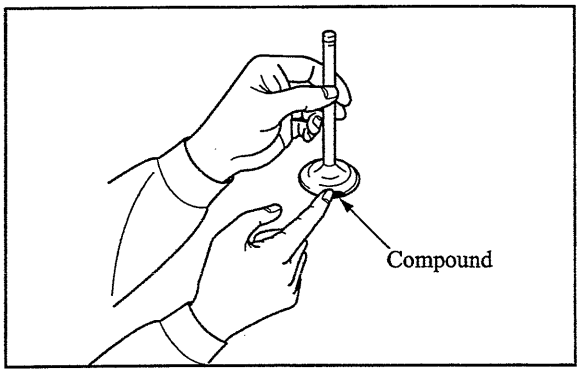


Inserting valve seat

1.9 Facing Up Valves and Valve Seats

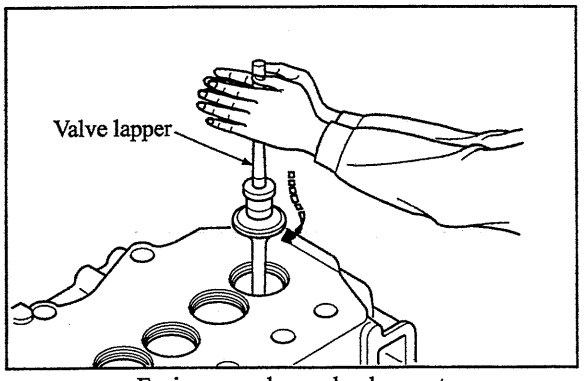
(1) Be sure to face up the valves and valve seats after repairing or replacing the valves or valve seats.
(2) Apply compound uniformly and thinly to the valve surface to be faced up.

Note: (a) Do not apply compound to the valve stem.
(b) Use medium-grain compound (120- to 150-mesh) first. Then, use fine-grain compound (200-mesh or finer) then.
(c) Compound spreads more evenly if it is mixed with a small amount of engine oil.



Applying compound

(3) Face up the valves and valve seats with the valve lapper. Hit the valve lapper against the valve seat while rotating the valve little by little.
(4) Remove compound with cleaning oil, etc.
(5) Apply engine oil to the contact surface and face it up with oil.
(6) Check the contact of the valve faces.

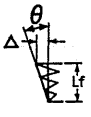


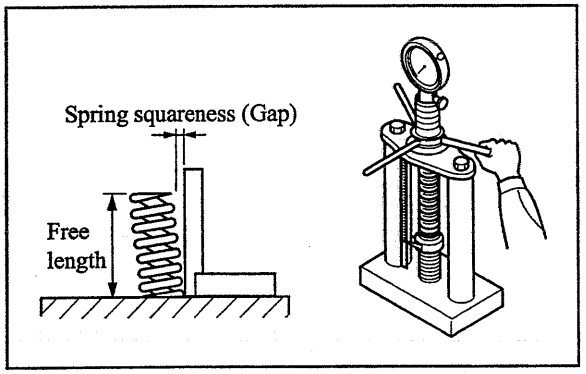
Facing up valve and valve seat

1.10 Measuring Tilt and Free Length of Valve Springs

Check the tilt and reduction of the free length of the valve springs. Replace the valve springs if the limits are exceeded.

Unit: mm [in.]

	Standard	Limit
Free length	48.85 [1.9232]	47.60 [1.8740]
Squareness	 θ = 1.5° or less Δ (gap) = 1.3 [0.051] or less Lf = 48.85 [1.9232]	Δ = 1.5 [0.059] all over length
Mounting length/load, mm/N (mm/kgf) [in./lbf]	43/176 to 196 (43/18 to 20) [1.69/40 to 44]	43/147 (43/15) [1.69/33]



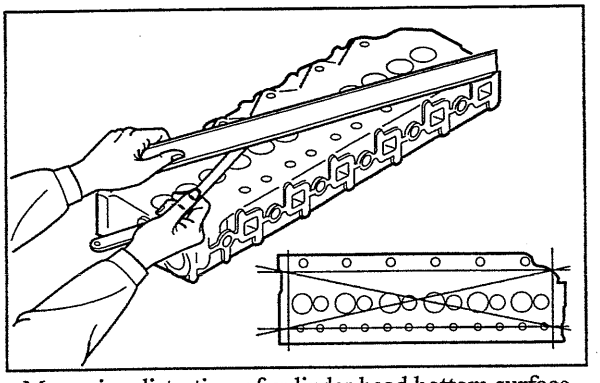
Measuring tilt and free length of valve spring

1.11 Measuring Distortion of Cylinder Head Bottom Surface

Apply the straight edge against the bottom of the cylinder head, and measure the distortion with the thickness gage. Grind the cylinder head with distortion exceeding the limit by a small quantity with the surface grinder.

Unit: mm [in.]

	Standard	Limit
Distortion of cylinder head bottom surface	0.05 [0.0020] or less	0.20 [0.0079]



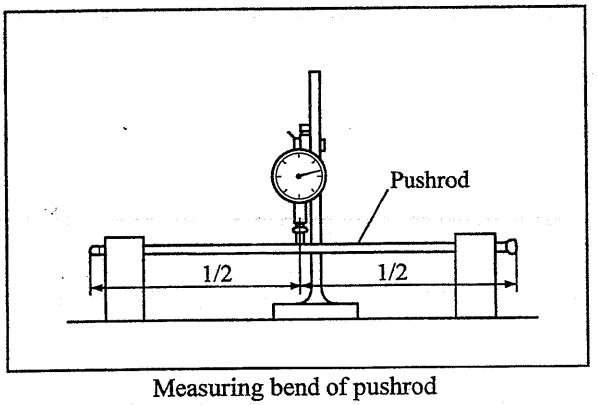
Measuring distortion of cylinder head bottom surface

1.12 Measuring Bend of Pushrods

Measure the bend of the pushrods. Replace the pushrods with the bend exceeding the limit with new parts.

Unit: mm [in.]

	Standard (Limit)
Bend of pushrod	0.3 [0.012] or less

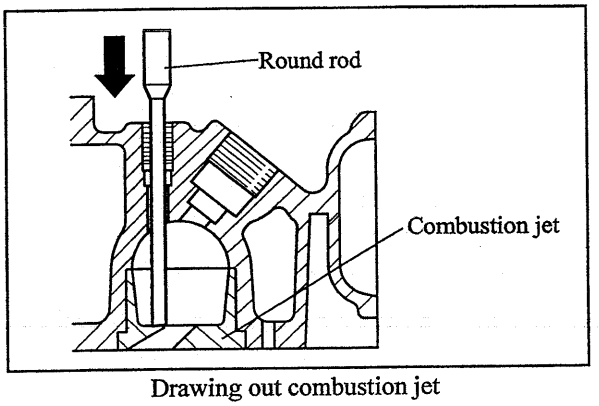


Measuring bend of pushrod

1.13 Replacing Combustion Jets

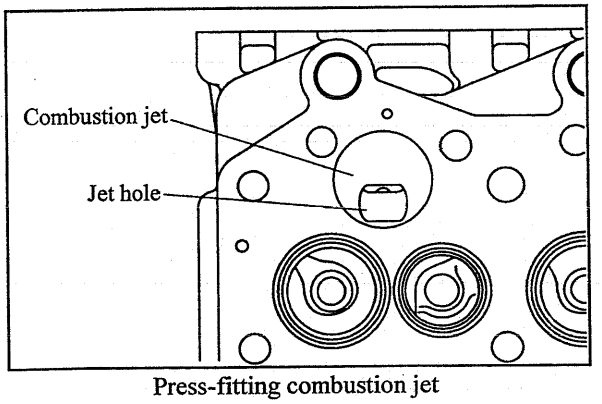
Replace the combustion jet only when it has cracks or other defects.

(1) To draw out the combustion jet, insert a round rod of approximately 6 mm [0.24 in.] in diameter through the glow plug mounting hole and hit the periphery of the inner surface of the jet lightly.



Drawing out combustion jet

(2) Place the combustion rod with the jet hole horizontally and hit it with a plastic hammer, etc.



Press-fitting combustion jet

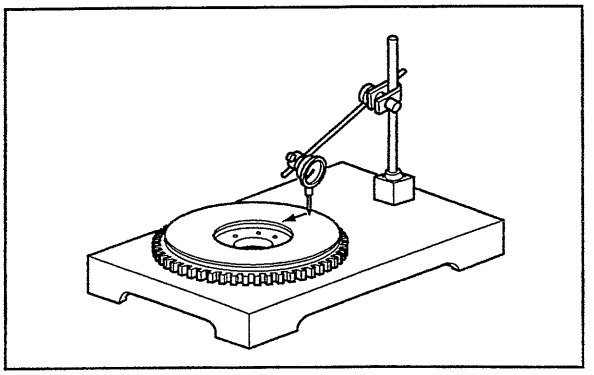
2. Flywheel, Camshaft and Timing Gears

2.1 Measuring Flatness of Flywheel

Place the flywheel on the level block. Move a dial gage on the friction surface of the flywheel to measure the flatness.
Grind the friction surface of the flywheel if the limit is exceeded.

Unit: mm [in.]

	Standard	Limit
Flywheel flatness	0.15 [0.0059] or less	0.50 [0.0197]



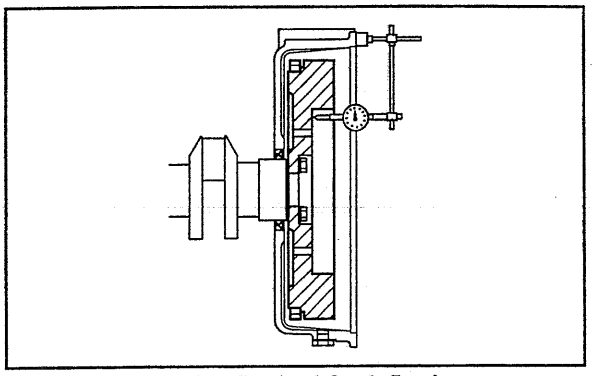
Measuring flatness of flywheel

2.2 Checking Flywheel for Deflection

Check deflection of the flywheel to see if it meets the standard.
Retighten the bolt if the deflection exceeds the limit.

Unit: mm [in.]

	Standard	Limit
Flywheel deflection	0.15 [0.0059] or less	0.50 [0.0197]



Checking flywheel for deflection

2.3 Checking Ring Gear

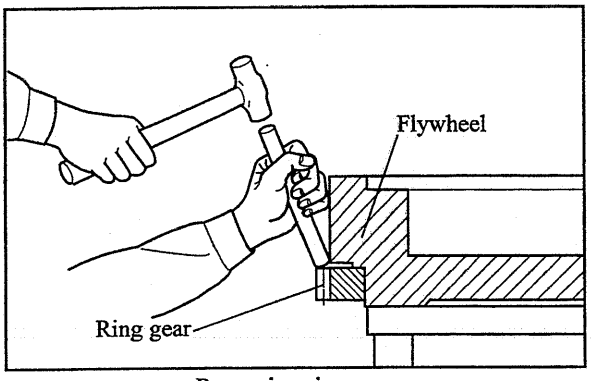
Check the ring gear. Replace the ring gear if the teeth are cracked or abnormally worn.

2.4 Replacing Ring Gear

(1) Removing ring gear
Heat the ring gear evenly with an acetylene torch, etc. Hit the ring gear evenly around the periphery with a hammer and a rod.

(2) Installing ring gear
Heat the ring gear with a heater, etc. up to approximately 100°C [212°F], and install it onto the flywheel from the side of the non-beveled gear teeth.

Note: Do not heat the ring gear excessively.



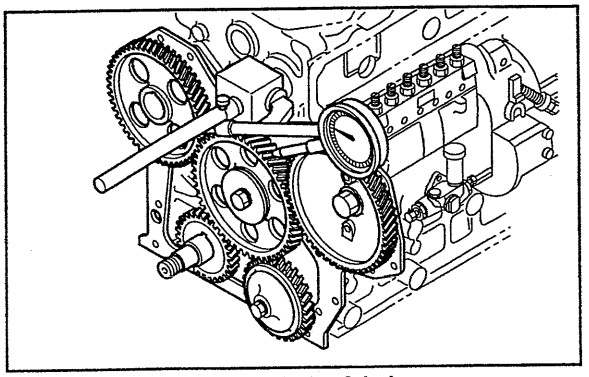
Removing ring gear

2.5 Measuring Backlash and End Play

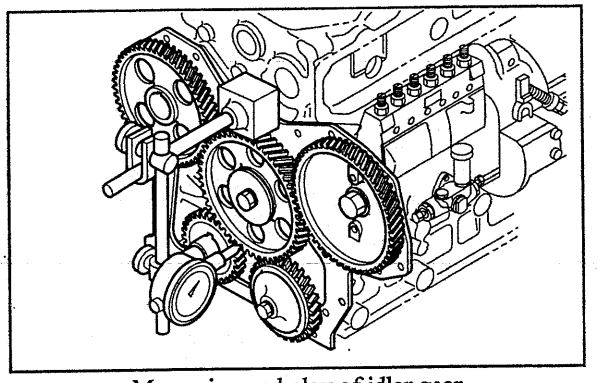
Measure the backlash and end play of each gear.
Replace all gears with new parts, in principle, if the measured backlash exceeds the limit.
Replace the thrust plates with new parts if the measured end play exceeds the limit.

Unit: mm [in.]

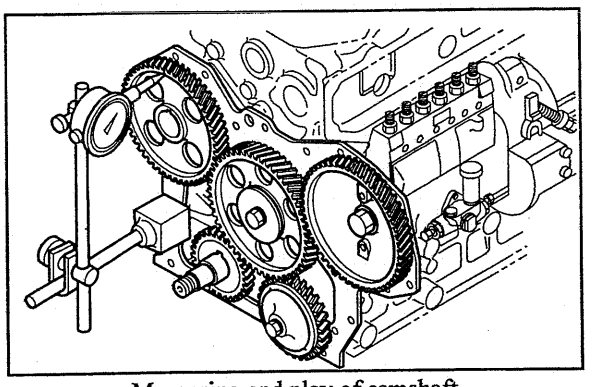
	Standard	Limit
Inter-gear backlash	0.050 to 0.150 [0.00197 to 0.00591]	0.250 [0.00984]
End play of idler gear	0.050 to 0.200 [0.00197 to 0.00787]	0.350 [0.01378]
End play of camshaft	0.100 to 0.250 [0.00394 to 0.00984]	0.300 [0.01181]



Measuring backlash of timing gear



Measuring end play of idler gear



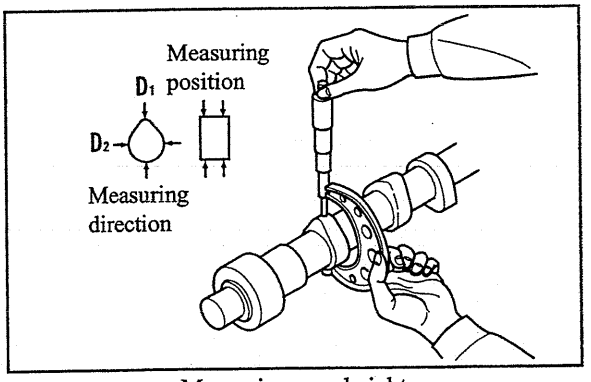
Measuring end play of camshaft

2.6 Measuring Cam Height

Measure the longer and shorter diameters of each cam with a micrometer. Replace the cams if the limit is exceeded.

Unit: mm [in.]

		Nominal	Standard	Limit
Cam profile (D1 - D2)	Inlet cam	6.684 [0.26315]	6.384 to 6.784 [0.25134 to 0.26709]	6.184 [0.24346]
	Exhaust cam	6.720 [0.26457]	6.420 to 6.820 [0.25276 to 0.26850]	6.220 [0.24488]



Measuring cam height

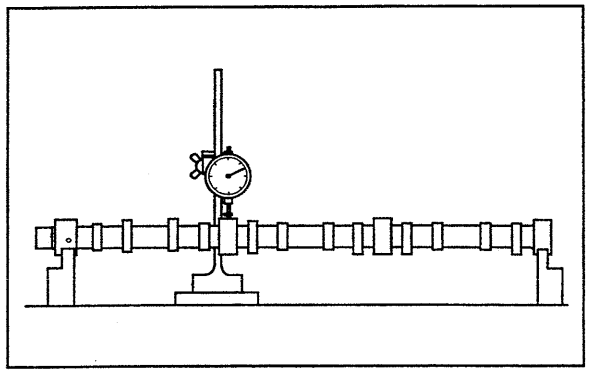
2.7 Measuring Bend of Camshaft

Measure the bend of the camshaft. Repair camshaft with bend exceeding the limit with a press or replace them.

Note: Apply a dial gage to the camshaft, rotate the camshaft by one turn and read shaking of the pointer. Half of the reading is bend.

Unit: mm [in.]

	Standard	Limit
Bend of camshaft	0.02 [0.0008] or less	0.05 [0.0020]



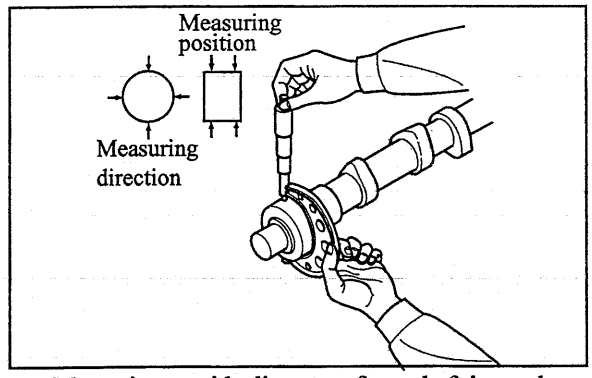
Measuring bend of camshaft

2.8 Measuring Camshaft Journal Outside Diameter and Camshaft Bore Diameter

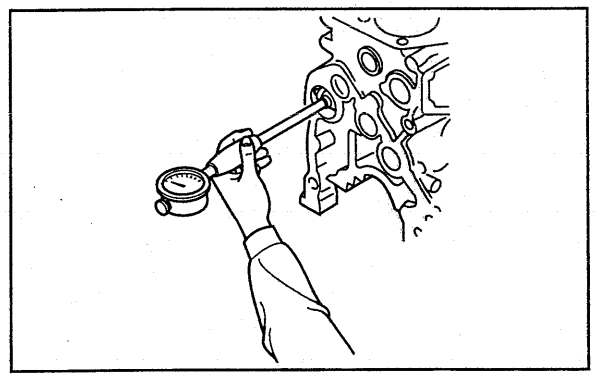
Measure the outside diameter of the camshaft journal. Replace the camshaft journal if the limit is exceeded.

Unit: mm [in.]

		Nominal	Standard	Limit
Camshaft journal outside diameter	No. 1, 2 (S4S)	φ54 [φ2.13]	53.94 to 53.96 [2.1236 to 2.1244]	53.90 [2.1220]
	No. 1, 2, 3 (S6S)			
	No. 3 (S4S)	φ53 [φ2.09]	52.94 to 52.96 [2.0843 to 2.0850]	52.90 [2.0827]
	No. 4 (S6S)			
Clearance between camshaft journal and camshaft bore			0.07 to 0.11 [0.0028 to 0.0043]	0.15 [0.0059]



Measuring outside diameter of camshaft journal



Measuring camshaft bore diameter

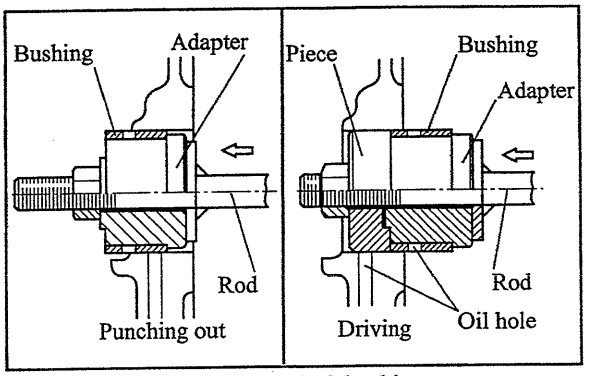
2.9 Driving Camshaft Bushing

(1) Bore the camshaft bore to the dimensions of 57-mm diameter, H6 $^{+0.019}_{0}$ $\frac{12.5S}{\nabla\nabla}$ and drive a bushing into it, if the clearance between the camshaft journal and camshaft bore exceeds the limit.

(2) Drive the camshaft bushing using the camshaft bushing installer set (special tool).

Special tool name	Part No.
Camshaft bushing installer set	30691-00010

(3) Adjust the oil hole from the oil gallery to the oil hole of the bushing when driving the bushing.



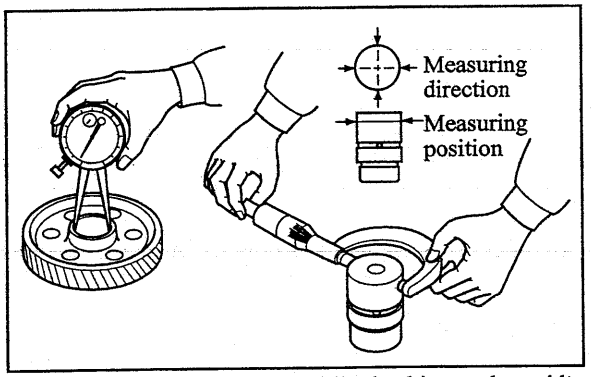
Driving camshaft bushing

2.10 Measuring Idler Bushing Inside Diameter and Shaft Outside Diameter

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

Unit: mm [in.]

	Standard	Limit
Clearance between idler bushing and shaft	0.009 to 0.050 [0.00035 to 0.00197]	0.100 [0.00394]

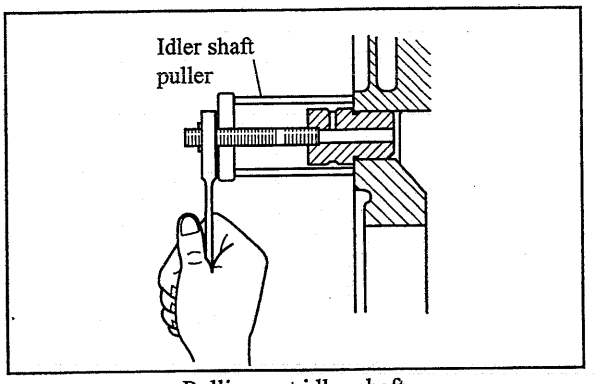


Measuring inside diameter of idler bushing and outside diameter of idler shaft

2.11 Replacing Idler Shaft

Pull out the idler shaft using the idler shaft puller.

Special tool name	Part No.
Idler shaft puller	MH061077



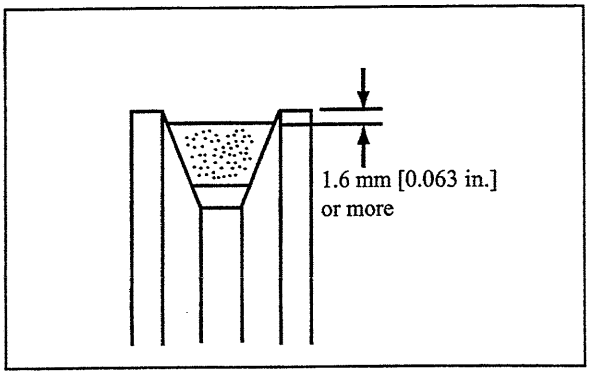
Pulling out idler shaft

2.12 Checking V-Belt Groove of Crankshaft Pulley for Wear

Check the pulley V-belt groove for wear. Attach a new V-belt around a worn pulley, apply higher tension to the belt, and check that the top surface of the belt is out of the pulley groove or inside it to check the degree of wear.

When the top of the V-belt is out of the pulley groove, it is normally considered that the pulley has sufficiently long service life.

If the belt top is 1.6 mm [0.063 in.] or more below the groove edge on the contrary, the pulley is not usable. Replace the pulley.



Checking wear of V-belt groove

2.13 Checking Damper (S6S)

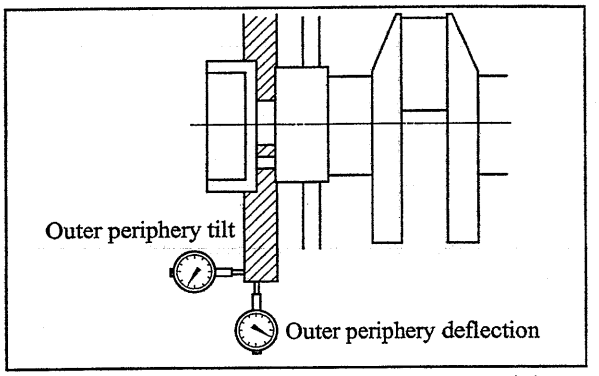
Check the damper for apparent cracks, swelling, cracks in the mirror plate, paint discoloration, separation due to overheating, etc.

Replace the damper with a new part when it has been used for 8000 hours or more, even if it is free from defects.

Measure the deflection and tilt of the outer periphery with the dial gage. Replace the damper if the limit is exceeded.

Unit: mm [in.]

	Standard	Limit	Remark
Outer periphery deflection	0.5 [0.020] or less	1.5 [0.059]	Replace with new parts after using for 8000 hours or more.
Outer periphery tilt	0.5 [0.020] or less	1.5 [0.059]	



Checking deflection and tilt of damper outer periphery

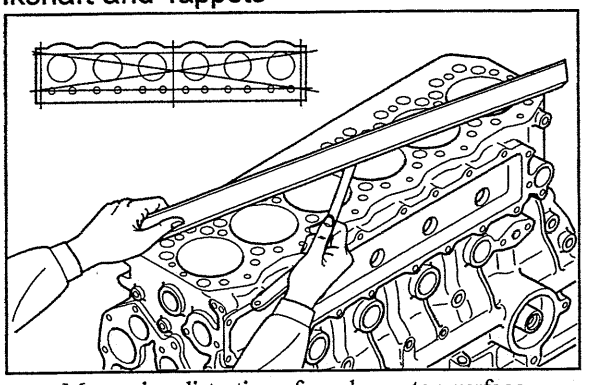
3. Crankcase, Pistons, Connecting Rods, Crankshaft and Tappets

3.1 Measuring Distortion of Crankcase Top Surface

Apply a straight edge to the top surface of the crankcase and measure the distortion with a thickness gage. If the distortion exceeds the limit, grind the crankcase with a surface grinder. Be careful not to grind it excessively.

Unit: mm [in.]

	Standard	Limit
Distortion of crankcase top surface	0.05 [0.0020] or less	0.20 [0.0079]



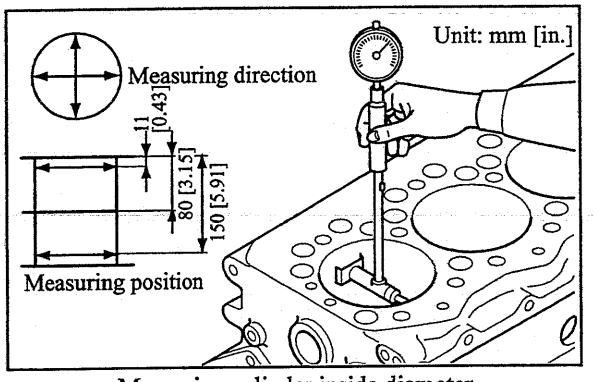
Measuring distortion of crankcase top surface

3.2 Measuring Cylinder Inside Diameter

(1) Measure the inside diameter of the cylinder at three points each, i.e., upper point (with much staggered wear), middle point, and lower point, in the direction of the crankshaft and the perpendicular direction.

Unit: mm [in.]

	Standard	Limit	
		Repair	Replace
Cylinder inside diameter	94.000 to 94.035 [3.70079 to 3.70217]	94.200 [3.70866]	94.700 [3.72835]
Roundness	0.01 [0.00039] or less		
Cylindricity	0.015 [0.00059] or less		



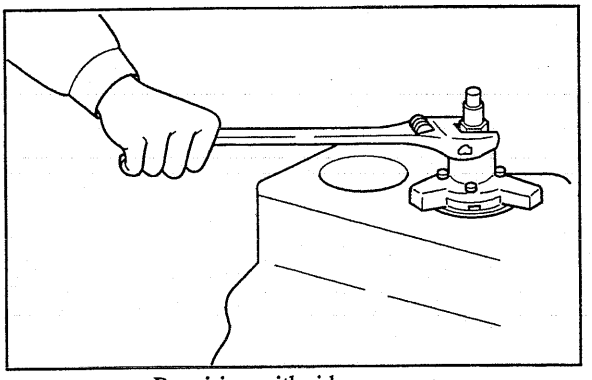
Measuring cylinder inside diameter

(2) Bore the cylinder to +0.25 mm [+0.0098 in.] or +0.5 mm [+0.0197 in.] oversize, if the measured value is between the repair limit and replacement limit. Hone-finish the bored cylinder to an accuracy of 0 to 0.035 mm [0.00138 in.].

(3) Use an oversized piston and piston rings to fit the oversized cylinder.

(4) If the cylinder is worn unevenly, take maximum wear into consideration and select an oversize that allows complete cylindricity.
All cylinders must have the same oversize, if one cylinder is oversized.

(5) If the cylinder has a slight amount of wear and is reused after replacing the piston rings only, scrape the staggered wear portion in the upper part of the cylinder with a ridge reamer, etc. Hone-finish it as necessity requires.



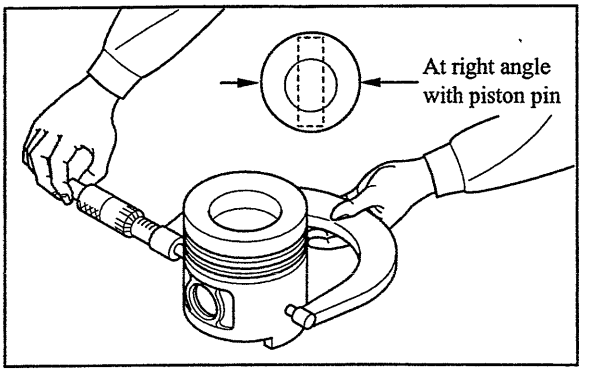
Repairing with ridge reamer

3.3 Measuring Piston Outside Diameter

Measure the piston skirt at a right angle to the piston pin with the micrometer.
Replace the piston with a new part if the limit is exceeded.

Unit: mm [in.]

		Standard	Limit
Piston outside diameter	S.T.D	93.955 to 93.985 [3.69902 to 3.70020]	93.770 [3.69173]
	0.25 O.S	94.205 to 94.235 [3.70886 to 3.71004]	94.020 [3.70157]
	0.50 O.S	94.455 to 94.485 [3.71870 to 3.71988]	94.270 [3.71141]



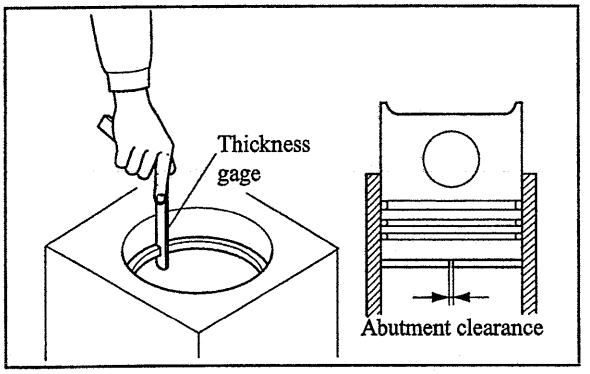
Measuring outside diameter of piston

3.4 Measuring Clearance of Piston Ring Abutments

Insert the piston ring into the gage or new crankcase, horizontally using a piston and measure the abutment.
Replace the piston ring set if the limit is exceeded.
Gage inside diameter: ϕ 94 +0.035/0 mm
[ϕ 3.70 +0.00138/0 in.]

Unit: mm [in.]

		Standard	Limit
Clearance of piston ring abutment	No. 1 ring and oil ring	0.300 to 0.500 [0.01181 to 0.01969]	1.500 [0.05906]
	No. 2 ring	0.500 to 0.700 [0.01969 to 0.02756]	



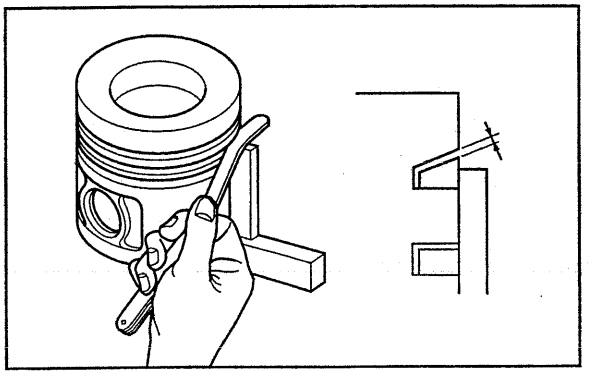
Measuring clearance of piston ring abutment

3.5 Measuring Piston Ring Grooves

Insert a piston ring with known thickness into the ring groove, apply the straight edge to it, and insert the thickness gage further to measure the ring groove of the piston. Replace the piston if the limit is exceeded.

Unit: mm [in.]

		Standard	Limit
Clearance between ring and ring groove	No. 1 ring	0.070 to 0.110 [0.00276 to 0.00433]	0.200 [0.00787]
	No. 2 ring	0.045 to 0.085 [0.00177 to 0.00335]	0.150 [0.00591]
	Oil ring	0.020 to 0.060 [0.00079 to 0.00236]	0.150 [0.00591]

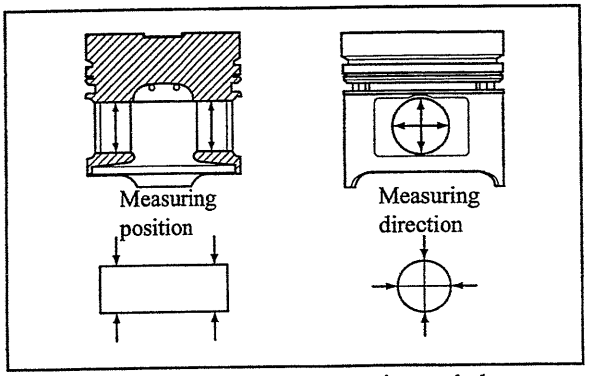

Measuring ring groove of piston

3.6 Measuring Piston Pin Bore Diameter and Piston Pin Outside Diameter

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

Unit: mm [in.]

	Nominal	Standard	Limit
Piston pin outside diameter	ϕ30 [ϕ1.18]	29.994 to 30.000 [1.18087 to 1.18110]	-
Clearance between piston pin bore and piston pin	-	0.000 to 0.016 [0.00000 to 0.00063]	0.050 [0.00197]



Measuring clearance between piston pin bore and piston pin

3.7 Measuring Piston Projection

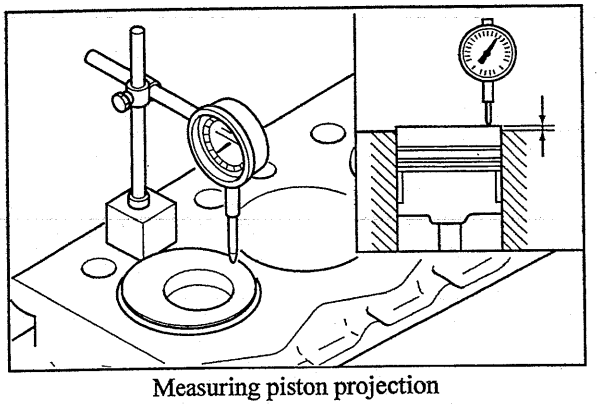
Measure the degree of projection of the piston as shown below. Check the clearance of each part if the measured value is below standard.

(1) Find the top dead center of the piston with the dial gage.

(2) Apply the dial gage to the top surface of the crankcase, and adjust the zero point.
Measure projections at three points on the top of the piston, and find the mean value. Subtract the projection from the gasket thickness in the condition where the cylinder head is tightened. The clearance between the piston top and cylinder head is known.

Unit: mm [in.]

	Standard
Projection of piston from crankcase	0.05 to 0.45 [0.0020 to 0.0177]
Thickness with gasket installed	1.2±0.05 [0.047±0.0020]



Measuring piston projection

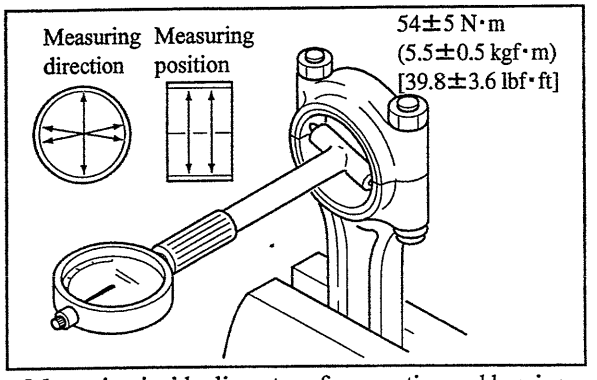
⚠ CAUTION

The projection of the piston has great influence upon engine performance. It must be as specified in order to prevent valve interference, too.

3.8 Measuring Clearance between Connecting Rod Bearings and Crank Pins

Measure the outside diameter of the crank pin and the inside diameter of the connecting rod bearing. Replace the bearing if the clearance exceeds the limit. If the crank pin has excessive wear or uneven wear, grind the crank pin and use an undersized bearing.
The connecting rod bearings are available in three undersizes: -0.25, -0.50 and -0.75 mm [-0.0098, -0.0197 and -0.0295 in.].

Note: When measuring the inside diameter of the bearing, be careful not to mistake the upper and lower sides of the bearing, install the bearing in the connecting rod, tighten the cap to the specified torque, and measure.



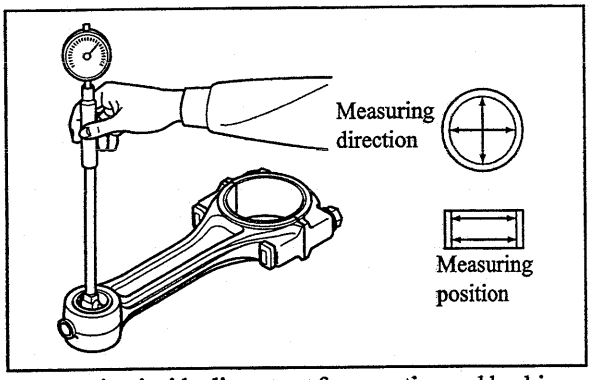
Measuring inside diameter of connecting rod bearing

Unit: mm [in.]

	Nominal	Standard	Limit
Crank pin outside diameter	ϕ58 [ϕ2.28]	57.955 to 57.970 [2.28169 to 2.28228]	57.800 [2.27559]
Clearance between crank pin and connecting rod bearing	-	0.030 to 0.090 [0.00118 to 0.00354]	0.200 [0.00787]

3.9 Measuring Clearance between Connecting Rod Bushings and Piston Pins

Measure the inside diameter of the connecting rod bushing and the outside diameter of the piston pin. Replace if the limit is exceeded.



Measuring inside diameter of connecting rod bushing

Unit: mm [in.]

	Nominal	Standard	Limit
Rod bushing inside diameter	ϕ30 [ϕ1.18]	30.020 to 30.045 [1.18189 to 1.18287]	-
Clearance between rod bushing and piston pin	-	0.020 to 0.051 [0.00079 to 0.00201]	0.080 [0.00315]

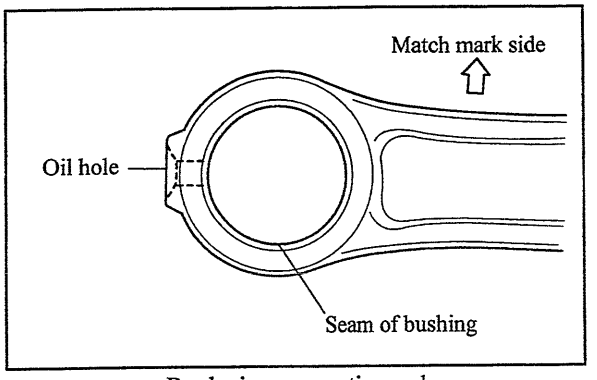
3.10 Replacing Connecting Rod Bushings

(1) Replace the connecting rod bushing using the connecting rod bushing puller (special tool).

Special tool name	Part No.
Connecting rod bushing puller	32A91-00500

(2) Adjust the oil hole of the bushing to that of the connecting rod. Locate the seam of the bushing in the position shown on the right.

(3) After press fitting, insert the piston pin and make sure that it slides smoothly, free from rattling.



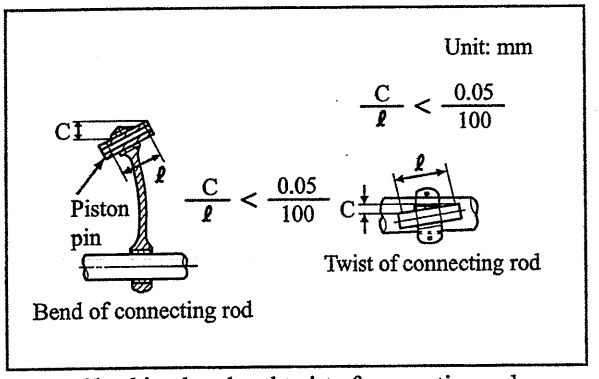
Replacing connecting rod

3.11 Checking Bend and Twist of Connecting Rods

(1) Measure the values "C" and "ℓ" shown on the right. Repair connecting rods below the standard using a press.

Unit: mm

	Standard	Limit
Bend and twist of connecting rod (C/ℓ)	0.05/100	0.15/100



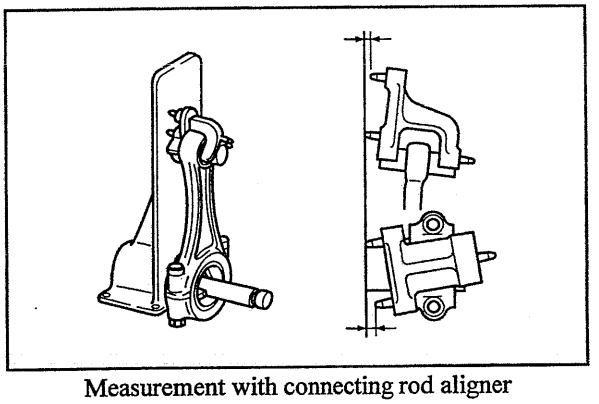
Checking bend and twist of connecting rod

(2) Use the connecting rod aligner, in general, to check the bend and twist of the connecting rod.

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

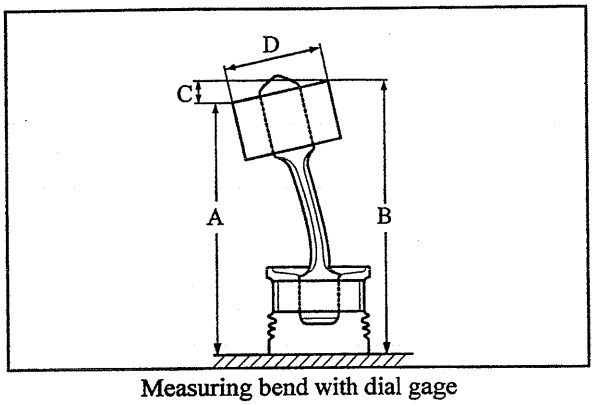
Unit: N·m (kgf·m) [lbf·ft]

Tightening torque	49.0 to 59.0 (5.0 to 6.0) [36.2 to 43.4]



Measurement with connecting rod aligner

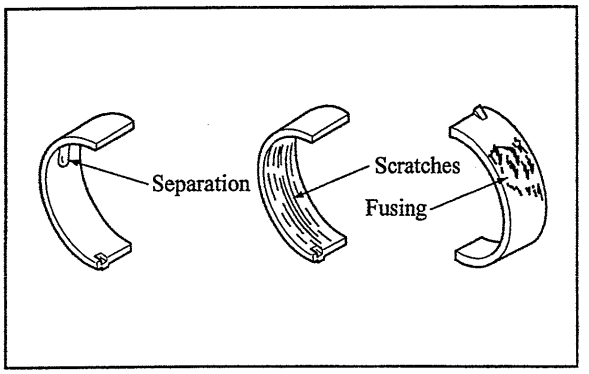
(3) When measuring the bend and twist with the piston installed, place the piston upside down on the level block, insert a round rod equivalent to the crank pin diameter, and measure the height of the round rod surface with the dial gage.



Measuring bend with dial gage

3.12 Checking Connecting Rod Bearings

Check the inner surfaces of the connecting rod bearings. Replace the connecting rod bearings with hit flaws, damage due to foreign matter, etc., on the surface with new parts.



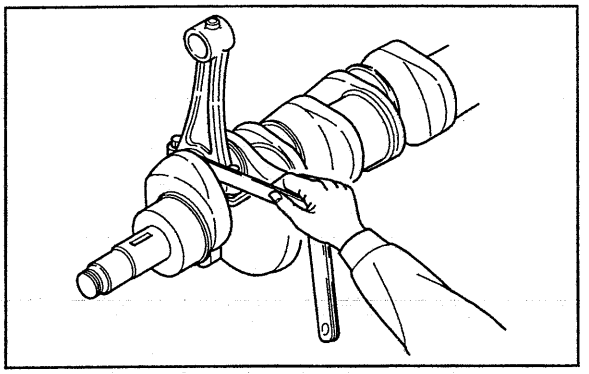
Checking connecting rod bearing

3.13 Measuring End Play of Connecting Rods

Install the connecting rod on the corresponding crank pin, tighten it to the specified torque, and measure the clearance between it and the crank arm (i.e., end play) with the thickness gages. Replace the connecting rod with a new part if the clearance exceeds the limit.

Unit: mm [in.]

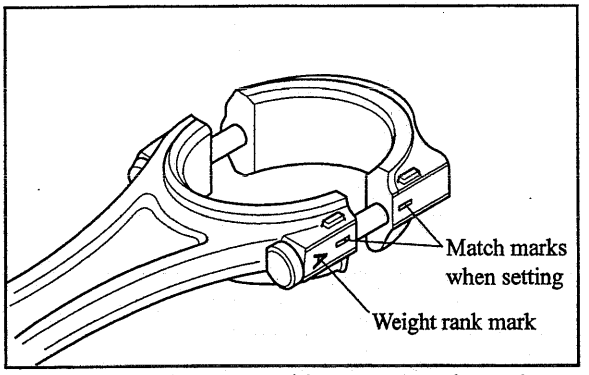
	Standard	Limit
End play	0.150 to 0.350 [0.00591 to 0.01378]	0.500 [0.01969]



Measuring end play of connecting rod

3.14 Replacing Connecting Rods

When replacing a connecting rod, use a rod having the same weight mark (stamped rank).



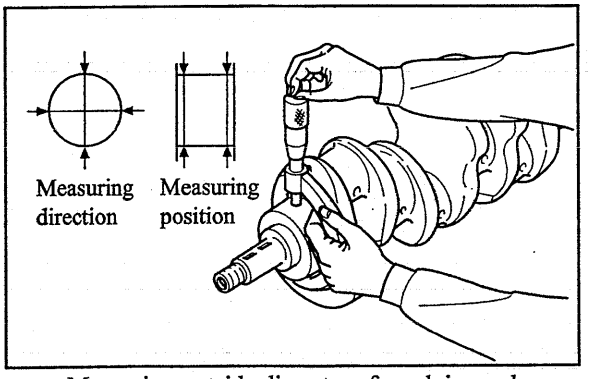
Weight rank stamp position on connecting rod

3.15 Measuring Crank Journal Outside Diameter

Measure the outside diameter of the crank journal with the micrometer in the vertical and horizontal directions, and check the roundness, cylindricity, and clearance from the bearing. Grind the crank journal to an undersize if the repair limit is exceeded. Replace the crank journal if the replacement limit is exceeded.

Unit: mm [in.]

		Nominal	Standard	Limit
Crank journal	Outside diameter	ϕ78 [ϕ3.07]	77.955 to 77.970 [3.06909 to 3.06969]	Repair: 77.850 [3.06496] Replace: 77.100 [3.03543]
	Roundness		0.010 [0.00039] or less	0.030 [0.00118]
	Cylindricity		0.010 [0.00039] or less	0.030 [0.00118]



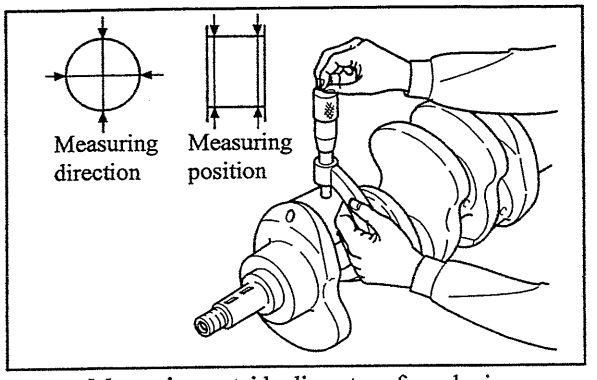
Measuring outside diameter of crank journal

3.16 Measuring Crank Pin Outside Diameter

Measure the outside diameter of the crank pin in the vertical and horizontal directions, and check the roundness, cylindricity, and clearance from the bearing. Grind the crank pin to an undersize or replace it with a new part if the limit is exceeded.

Unit: mm [in.]

		Nominal	Standard	Limit
Crank pin	Outside diameter	ϕ58 [ϕ2.28]	57.955 to 57.970 [2.28169 to 2.28228]	57.800 [2.27559]
	Roundness		0.010 [0.00039] or less	0.030 [0.00118]
	Cylindricity		0.010 [0.00039] or less	0.030 [0.00118]



Measuring outside diameter of crank pin

3.17 Grinding Crankshaft

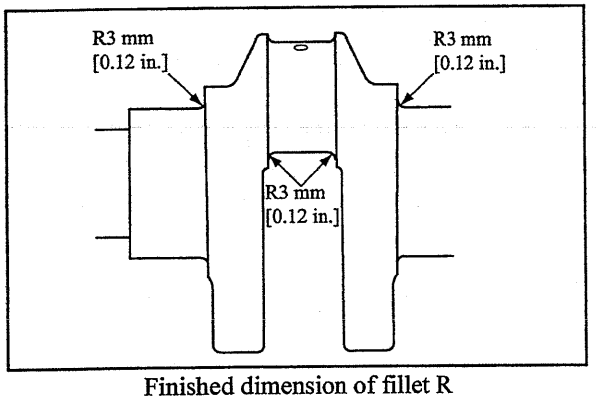
Grind the crankshaft to an undersize of the main bearing and connecting rod bearing.

In grinding, be careful not to change the fillet R and width. If the surface hardness of the crankshaft has reduced remarkably, re-quench and check it by means of magnetic-field inspection. The normal hardness is Vickers 620 or more.

Undersize grinding dimensions of crankshaft

Unit: mm [in.]

	Undersizing amount	Finished dimension
Crank journal	0.25 [0.0098]	77.705 to 77.720 [3.05925 to 3.05984]
	0.50 [0.0197]	77.455 to 77.470 [3.04941 to 3.05000]
	0.75 [0.0295]	77.205 to 77.220 [3.03957 to 3.04016]
Crank pin	0.25 [0.0098]	57.705 to 57.720 [2.27185 to 2.27244]
	0.50 [0.0197]	57.455 to 57.470 [2.26201 to 2.26260]
	0.75 [0.0295]	57.205 to 57.220 [2.25217 to 2.25276]



Finished dimension of fillet R

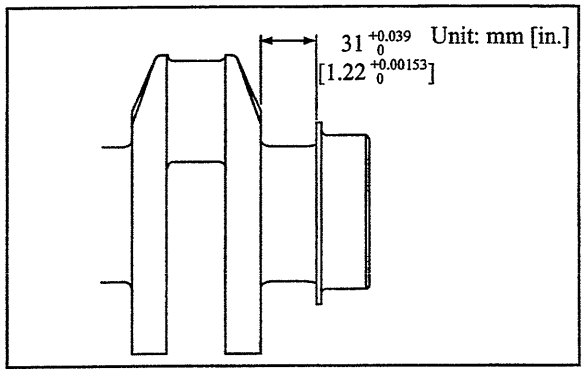
⚠ CAUTION

When grinding the journal or pin of the crankshaft, be sure to grind all journals or pins.
Finish the fillet R to R3 mm [0.12 in.].

3.18 Measuring End Play of Crankshaft

(1) Replace the thrust plate with a new part if the end play of the crankshaft exceeds the limit.

Note: The end play of the crankshaft means the difference between the width of the thrust receiver of the crankshaft and the width of the thrust plate installed in the bearing cap.



Width of thrust receiver of crankshaft

(2) Use oversized thrust plates when the limit is exceeded even if new thrust plates are inserted. Thrust plates are available in two oversizes: +0.15 and +0.30 mm [+0.0059 and +0.0118 in.].
In general, the purpose may be fulfilled in many cases if only the rear thrust plate is oversized.

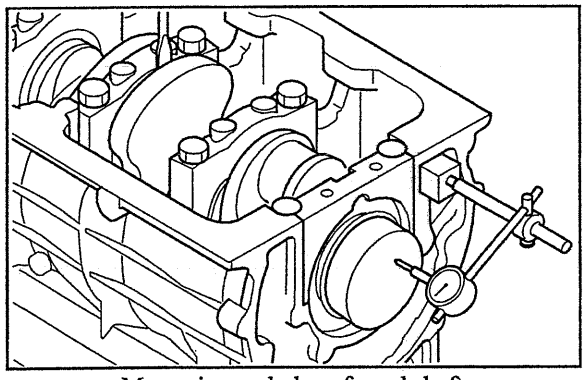
Unit: mm [in.]

	Standard	Limit
End play of crankshaft	0.100 to 0.264 [0.00394 to 0.01039]	0.300 [0.01181]

Unit: mm [in.]

	Single O. S.	Both O. S.	Tolerance
+0.15 O.S.	31.15 [1.2264]	31.30 [1.2323]	+0.039/0 [+0.00154/0]
+0.30 O.S.	31.30 [1.2323]	31.45 [1.2382]	
-	-	31.60 [1.2441]	

O. S.: Oversized



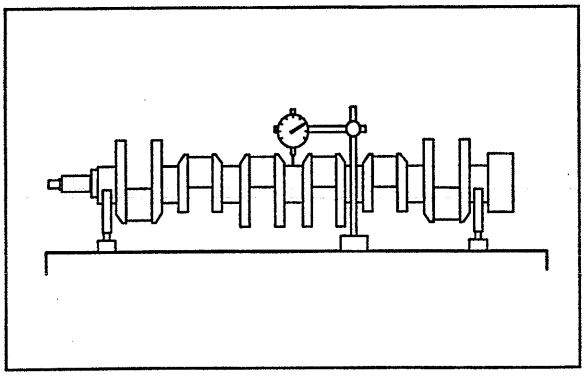
Measuring end play of crankshaft

3.19 Measuring Bend of Crankshaft

Support the front and rear journals of the crankshaft with V-blocks, and measure deflection (both-side deflection) of the center journal with the dial gage. Grind the crankshaft with light deflection in accordance with the standard. Repair the crankshaft with large deflection using a press, etc. Replace the crankshaft with remarkable deflection with a new part.

Unit: mm [in.]

	Standard	Limit
Bend of crankshaft	0.020 [0.00079] or less	0.050 [0.00197]

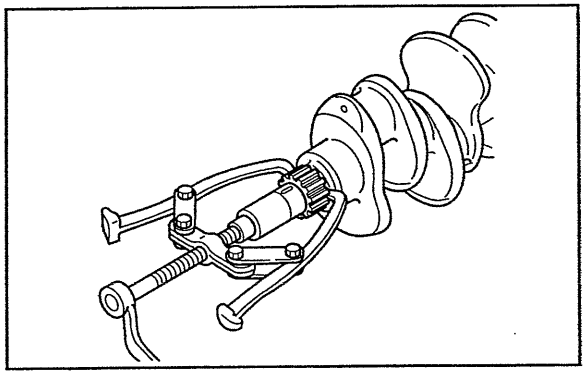


Measuring bend of crankshaft

3.20 Replacing Crankshaft Gear

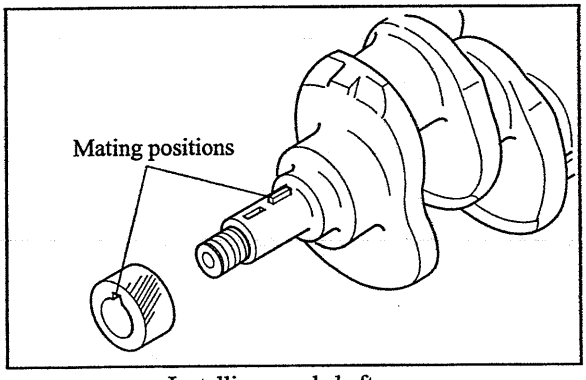
(1) Pull out the gear from the crankshaft using the gear puller.

Note: Do not hit the gear to pull it out.



Pulling out crankshaft gear

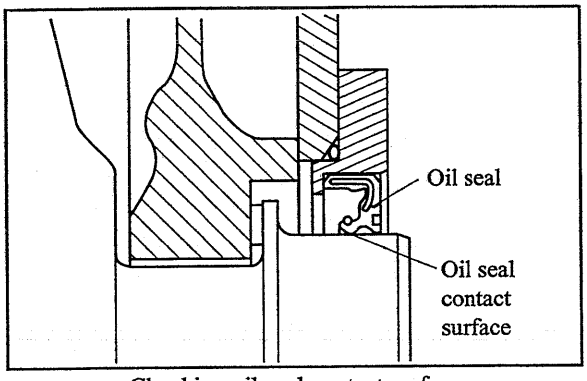
(2) Warm the gear up to approximately 100°C [212°F] with a gear heater, etc.
Adjust the position so that the key on the crankshaft is inserted into the notch of the gear, and hit the end face of the gear lightly with a copper hammer to engage the gear.



Installing crankshaft gear

3.21 Checking Oil Seal Contact Surface

Check the oil seal contact surface at the rear end of the crankshaft. Use spare oil seal and an oil seal sleeve if the crankshaft is worn by the oil seal.



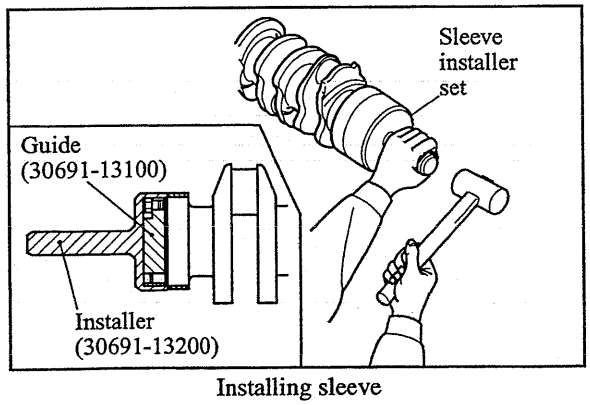
Checking oil seal contact surface

(1) Installing sleeve
Apply oil to the inner surface of the sleeve and drive in the sleeve using the oil seal sleeve installer set (special tool).

Special tool name	Part No.
Oil seal sleeve installer set	30691-13010

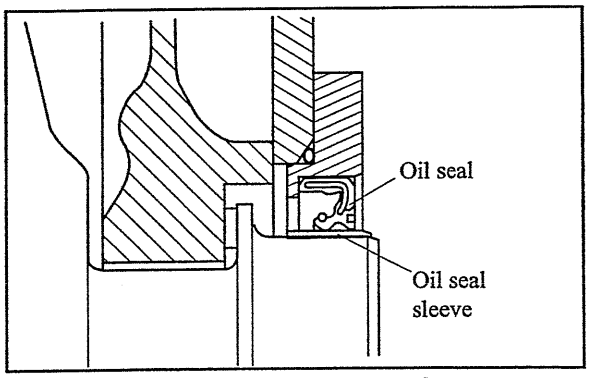
⚠ CAUTION

Be very careful not to make dents or flaws on the outer periphery of the sleeve.



Installing sleeve

If the oil seal sleeve gets worn when running the engine again, remove the sleeve in the procedures shown below and replace the oil seal and oil seal sleeve with new spare parts again.



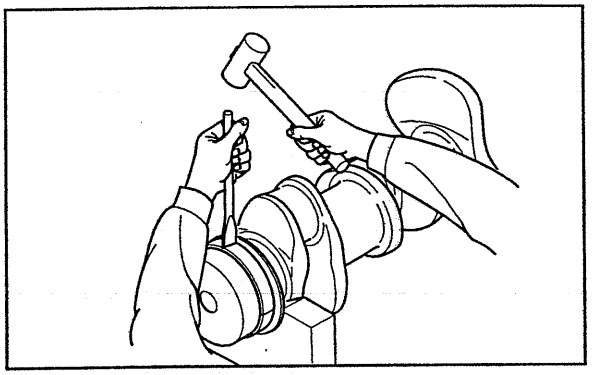
Checking oil seal contact surface

(2) Removing sleeve

Apply a graver to the end face of the sleeve at the right angle of three positions, hit it with a hammer, and remove the sleeve when the tension is reduced.
If the sleeve cannot be removed, apply the graver in the axial direction, hit it lightly to elongate the sleeve, and remove it when the tightening margin is reduced.

⚠ CAUTION

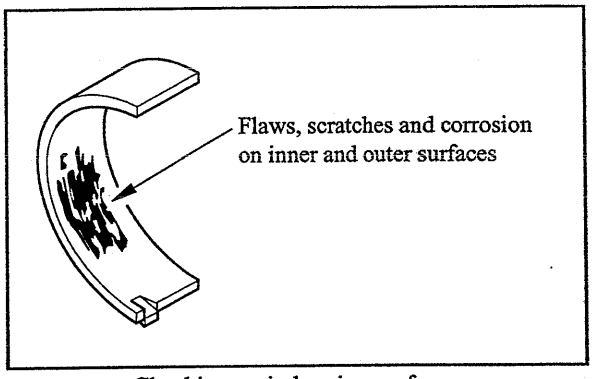
Be very careful not to damage the crankshaft with the graver when splitting the sleeve.



Removing sleeve

3.22 Checking Main Bearing Surfaces

Check the main bearings for contact on the crankshaft contact surface, scratches, and corrosion due to foreign matter, separation, etc. Also check the back bearing contact surfaces of the crankcase, main bearing caps, and bearings.



Checking main bearing surfaces

3.23 Measuring Clearance of Main Bearing

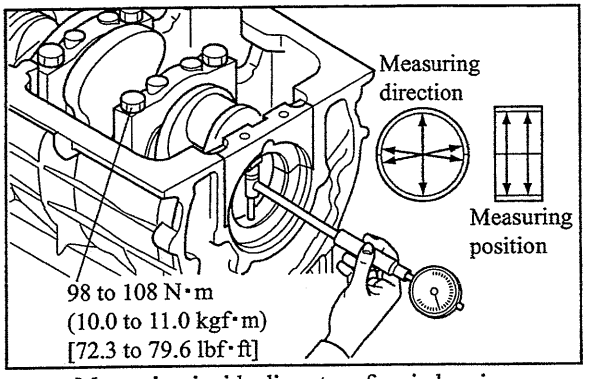
(1) To measure the clearance of the main bearing, assemble the main bearing with the crankcase and main bearing cap and tighten the main bearing cap to the specified torque. Measure the inside diameter of the bearing at two front and rear positions in the longitudinal direction of the crankshaft, find the mean value, and find the difference between the crankshaft journal and outside diameter.

Unit: mm [in.]

	Standard	Limit
Clearance between main bearing and crank journal	0.050 to 0.110 [0.00197 to 0.00433]	0.200 [0.00787]

(2) Replace the main bearing with a new part if the clearance between the main bearing and crank journal is below the limit. Re-grind the crankshaft and use an undersized bearing (-0.25, -0.50 or -0.75 mm [-0.0098, -0.0197 or -0.0295 in.]) if the clearance exceeds the limit.

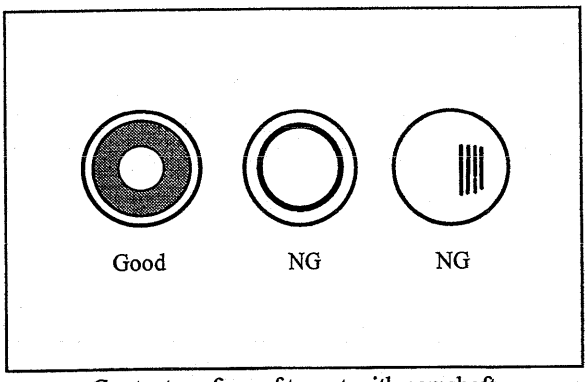
(3) If grinding is done to the specified dimension based on the main bearing hole, no facing up is needed after installation.



Measuring inside diameter of main bearing

3.24 Checking Contact Surfaces of Tappet Cams

Check the uneven wear of the tappet surfaces in contact with the camshaft. Replace defective tappets.



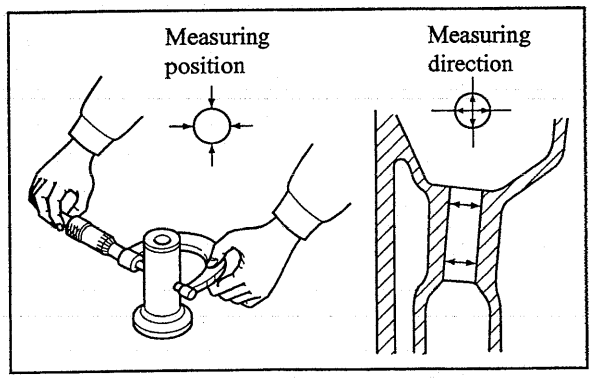
Contact surface of tappet with camshaft

3.25 Measuring Clearance between Tappets and Tappet Guide Holes

Replace the tappet with a new part if the clearance between the tappet and tappet guide hole exceeds the limit.

Unit: mm [in.]

	Nominal	Standard	Limit
Tappet hole diameter	ϕ14 [ϕ0.55]	14.000 to 14.018 [0.55118 to 0.55189]	14.100 [0.55512]
Clearance between tappet and tappet hole	-	0.016 to 0.052 [0.00063 to 0.00205]	0.08 [0.0031]



Measuring clearance between tappet and tappet guide hole

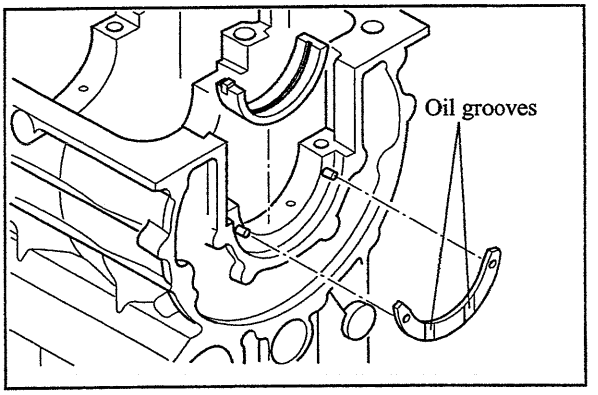
REASSEMBLY OF MAIN ENGINE PARTS

1. Crankcase, Tappets, Crankshaft, Pistons and Connecting Rods

Reassemble these parts in the reverse order of the disassembly procedures.

1.1 Installing Main Bearings, Thrust Plates and Tappets

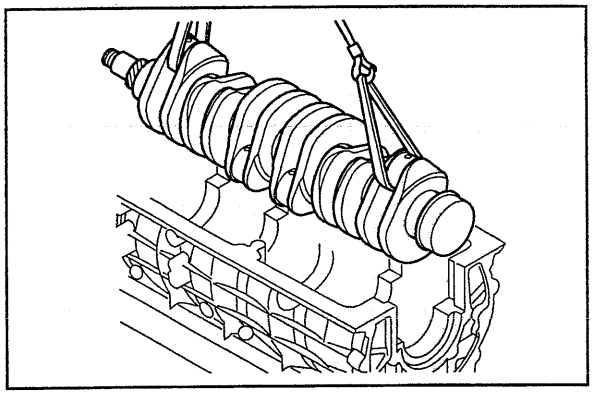
(1) Adjust the upper main bearing to the lug groove on the crankcase and push it.
The oil hole of the main bearing is aligned with the oil hole of the crankcase now.
(2) Apply a small quantity of engine oil to the inner surface of the main bearing.
(3) Install the thrust plate with the oil grooves facing outside to the back of the crankcase.
(4) Apply engine oil to the tappet and insert it into the crankcase.



Installing main bearing

1.2 Installing Crankshaft

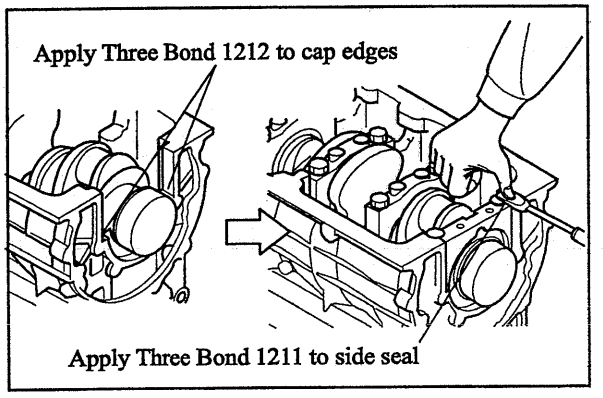
(1) Clean the crankshaft sufficiently with cleaning oil and blow compressed air onto it to clean.
(2) Hold the crankshaft horizontally and insert into the crankcase slowly.
(3) Apply a small quantity of engine oil to the crankshaft journal.



Installing crankshaft

1.3 Installing Main Bearing Caps

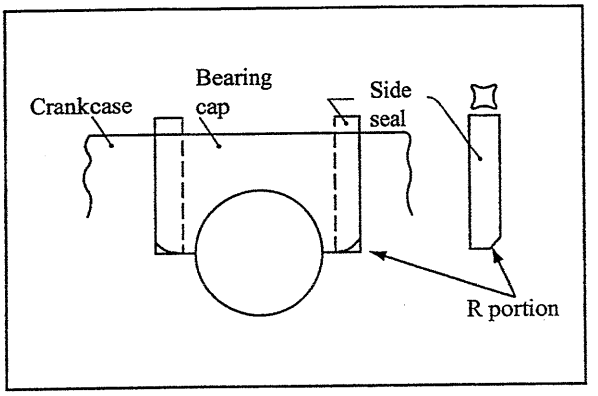
(1) Apply engine oil to each bearing and install the cap.
(2) Apply Three Bond 1212 to the edges of the rear cap before installing the main bearing cap.
(3) Install the main bearing cap so that the back of the crankcase is flush with the back of the main bearing cap.



Installing main bearing cap

(4) Apply Three Bond 1211 to the side seal and insert it into the main bearing cap groove.
Insert the side seal with the R portion outside. Press it by hand to some extent, and then press it completely using a flat jig taking care not to bend it.
(5) Apply Three Bond 1211 to the periphery of the side seal.

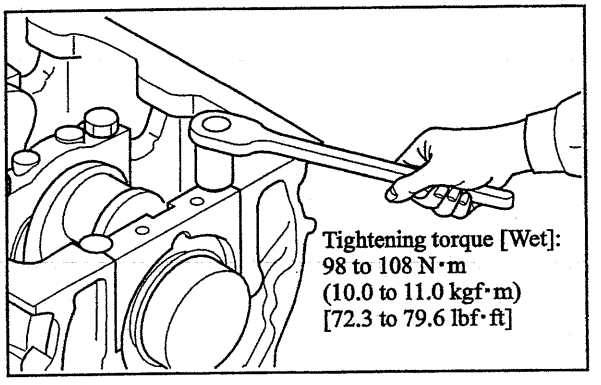
Note: Install the main bearing caps from the front side in the order of the numbers marked on them.



Inserting side seal

1.4 Installing Main Bearing Cap Bolts

(1) Tighten the main bearing cap bolts with engine oil and apply the specified torque.
(2) Make sure that the crankshaft rotates smoothly.



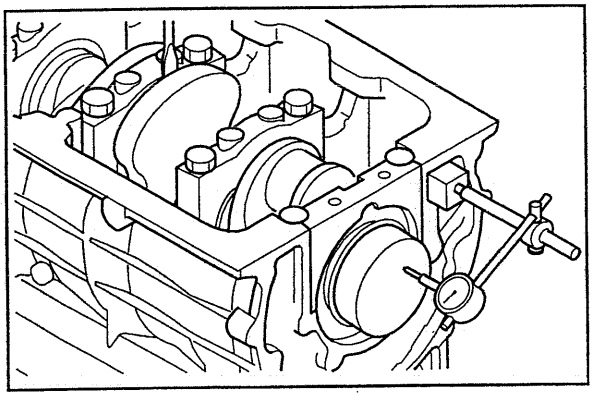
Installing main bearing cap bolt

1.5 Measuring Crankshaft End Play

After installing the main bearing caps, measure the end play of the crankshaft and make sure that its value is within the standard.

Unit: mm [in.]

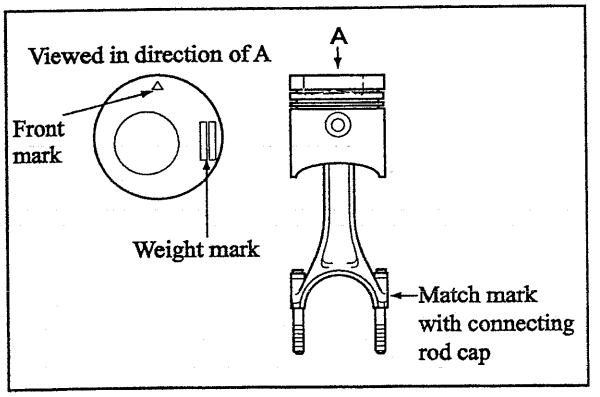
	Standard	Limit
Crankshaft end play	0.100 to 0.264 [0.00394 to 0.01039]	0.300 [0.01181]



Measuring crankshaft end play

1.6 Reassembling Pistons and Connecting Rods

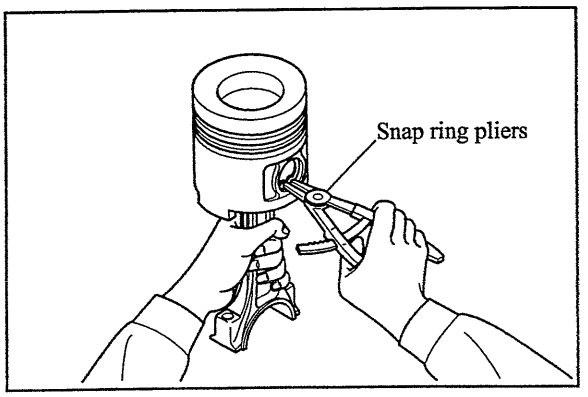
(1) Reassemble the piston and connecting rod so that the weight mark on the piston and the match mark on the connecting rod face the same side.
(2) Apply engine oil to the piston pin and insert the piston pin to join the piston with the connecting rod.



Reassembling piston and connecting rod

(3) Install the snap ring into the ring groove of the piston using the ring pliers.
Check the tension of the snap ring and the insertion condition in the groove.

Note: Adjust the splits of the snap ring toward the bottom of the piston.



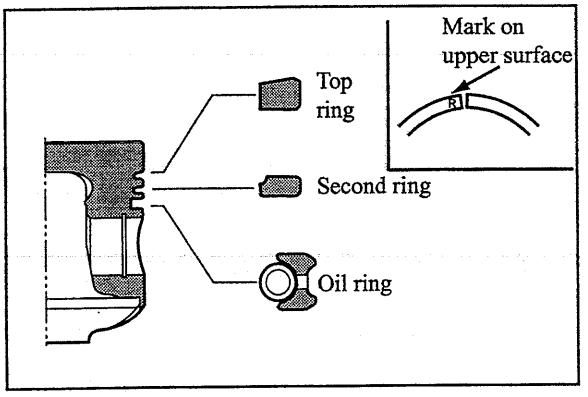
Installing snap ring

1.7 Installing Piston Rings

(1) Install the compression rings and oil ring to the piston using the piston ring pliers (special tool).

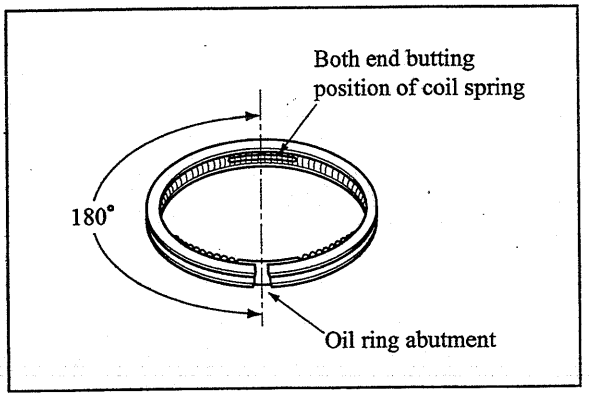
Special tool name	Part No.
Piston ring pliers	31391-12900

Note: Install the compression rings with the "T" mark on the top ring and the "2T" mark on the second ring on the upper side of the piston.
The oil ring may be installed in any direction.



Combination of piston and piston ring

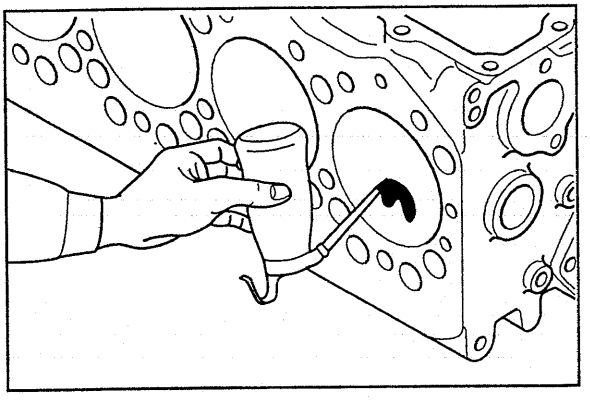
(2) Install the oil ring so that the abutment is located at the 180° position to the both-end butting position of the coil spring.



Abutment position on oil ring

1.8 Preparation for Installing Pistons

(1) Turn the crankcase on its side.
(2) Clean the cylinder inner surface with a waste cloth, and apply engine oil to it.

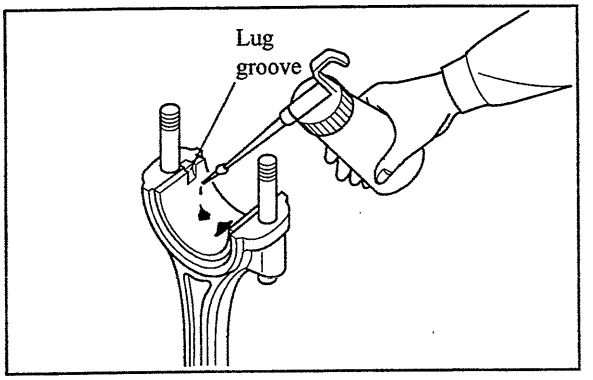


Preparation for installing pistons

1.9 Installing Connecting Rod Tightening Bolts and Bearings

(1) Insert the notch surface on the head of the connecting rod cap tightening bolt firmly before installing the bearing.

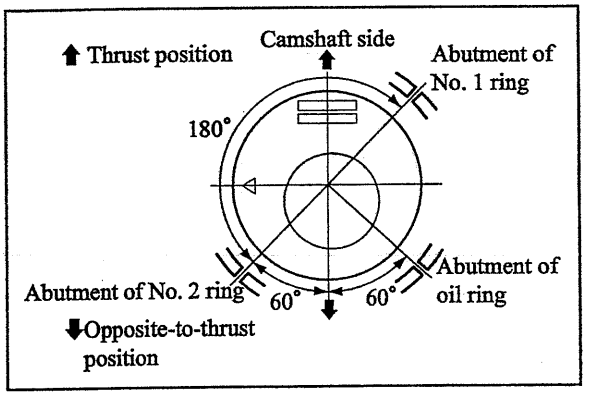
(2) Insert the rod bearing (upper) to the larger end of the connecting rod to fit into the lug groove, and apply engine oil to the inner surface.



Installing connecting rod tightening bolts and bearing

1.10 Orienting Piston Ring Abutments

Apply engine oil to the piston rings, and orient the abutments of the piston rings to the proper positions by avoiding the pin position, thrust position, and the position opposite to the thrust.



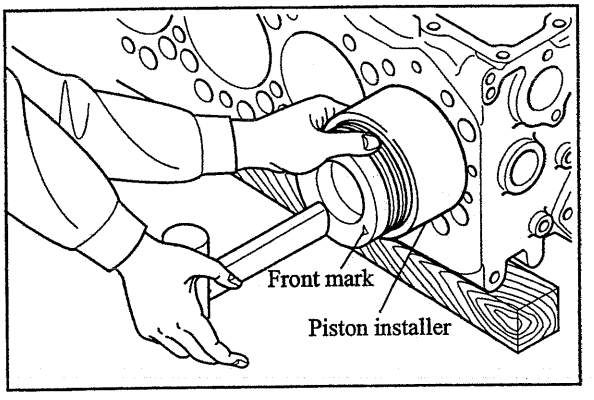
Orienting piston ring abutments

1.11 Installing Pistons

(1) Move the crank pin for installing the piston to the top position, turn the front mark (O) on the piston to the front of the engine, and insert the piston into the cylinder using the piston installer (special tool).

Special tool name	Part No.
Piston installer	34491-00200

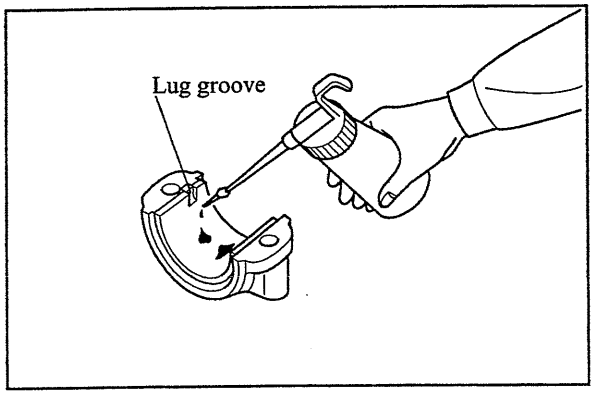
(2) When the larger end of the connecting rod is brought into close contact with the crank pin, turn the crankshaft 180° while pressing the piston head to the position where the cap may be installed easily.



Installing piston

1.12 Installing Connecting Rod Caps

(1) Fit the connecting rod bearing (lower) to the lug groove of the connecting rod cap, and apply engine oil to the inner surface.

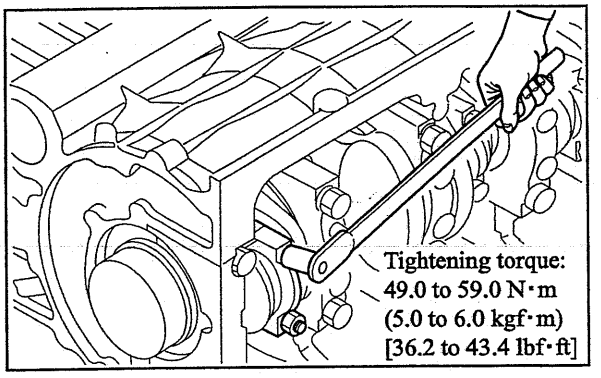


Installing connecting rod cap (1)

(2) Tighten the cap mounting nuts to the specified torque.

⚠ CAUTION

Make sure that the match mark on the cap is on the same side as the match mark on the connecting rod.



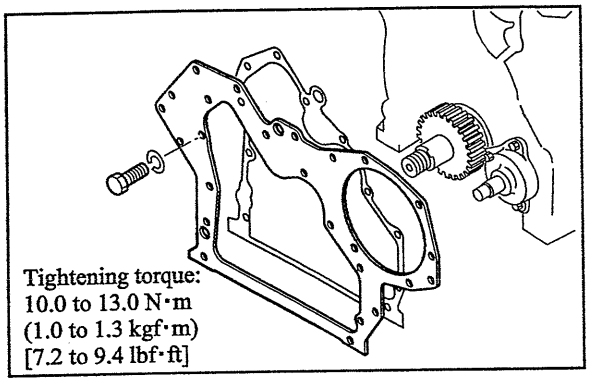
Installing connecting rod cap (2)

2. Timing Gears

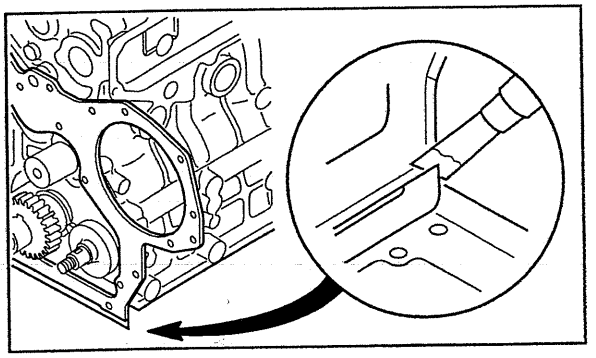
Reassemble the timing gears in the reverse order of the disassembly procedures.

2.1 Installing Front plate

(1) Install the gasket to fit the dowel pin of the crankcase.
(2) Tighten the front plate to the crankcase to the specified torque.
(3) Cut the excess portion of the gasket below the crankcase bottom entirely with a cutter.



Installing front plate (1)



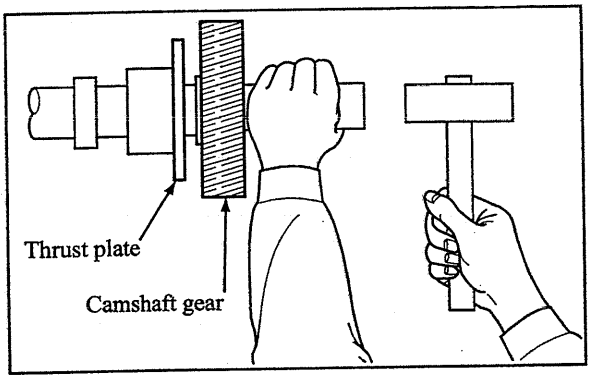
Installing front plate (2)

2.2 Installing Camshaft Gear and Thrust Plates

Warm the camshaft gear and insert the thrust plate without fail when installing the gear.

⚠ CAUTION

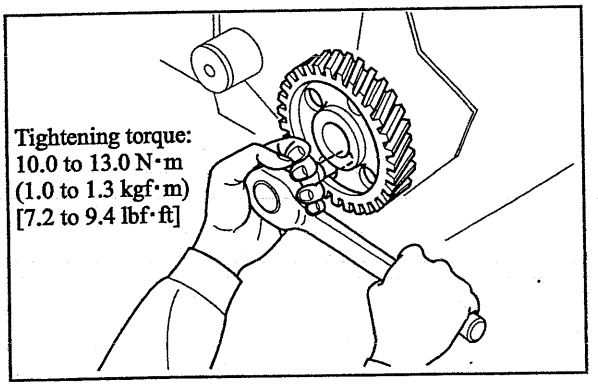
Be careful not to damage the cam of the camshaft and the bushing.



Installing camshaft gear and thrust plate

2.3 Installing Camshaft

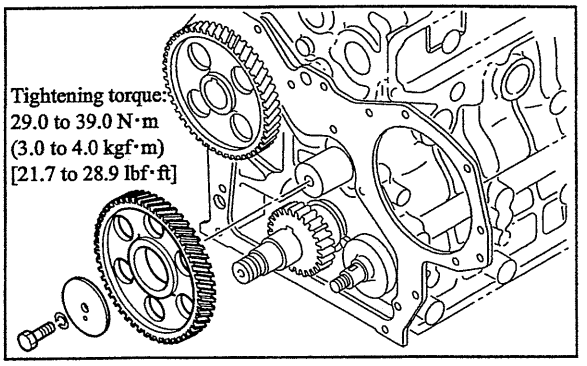
(1) Apply engine oil to the camshaft journal and cam.
(2) Insert the camshaft slowly into the crankcase.
(3) Tighten the thrust plate mounting bolts to the specified torque.



Installing camshaft

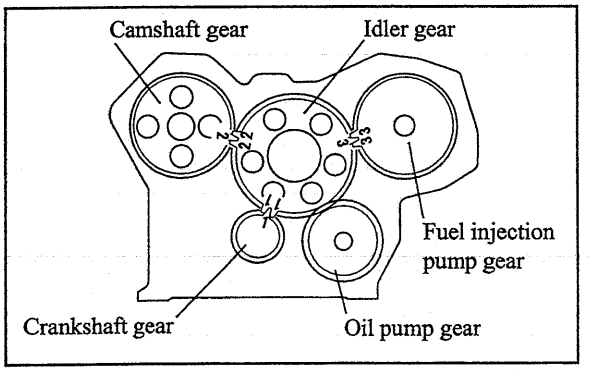
2.4 Installing Idler Gear

(1) Fit the match mark of each gear, and install the idler gear.
(2) Install the thrust plate, and tighten the bolt to the specified torque.



Installing idler gear

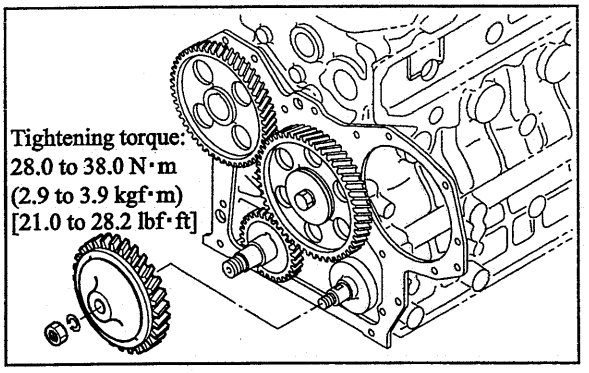
(3) The match mark positions of the gears fit each other as shown right at the top dead center of the No. 1 piston on the compression stroke.



Match marks of timing gears

2.5 Installing Oil Pump Gear

(1) Install the oil pump gear to the oil pump shaft.
(2) Tighten the jam nut to the specified torque.



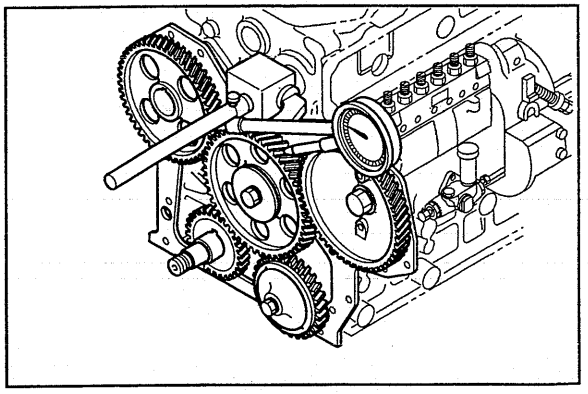
Installing oil pump gear

2.6 Check and Adjustment after Installing Timing Gears

Be sure to check and adjust the backlash and end play of each timing gear when the gear is disassembled and reassembled.

Unit: mm [in.]

	Standard	Limit
Inter-gear backlash	0.050 to 0.150 [0.00197 to 0.00591]	0.250 [0.00984]
Idler gear end play	0.050 to 0.200 [0.00197 to 0.00787]	0.350 [0.01378]
Camshaft end play	0.100 to 0.250 [0.00394 to 0.00984]	0.300 [0.01181]

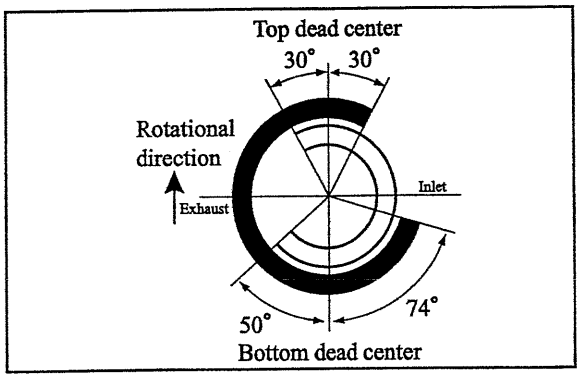


Checking timing gears for backlash

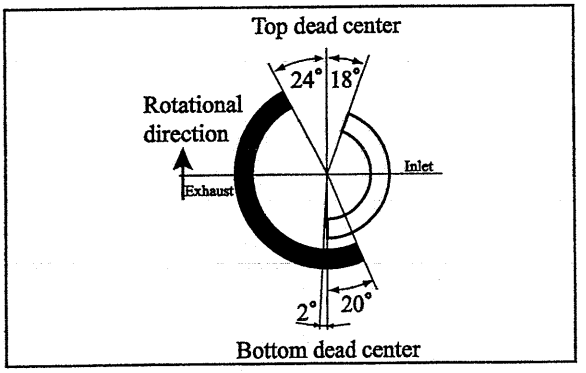
2.7 Checking Valve Timing

It is unnecessary to check the valve timing, in particular, if the gears are reassembled with the match marks aligned to each other. However, check the valve timing to make sure.

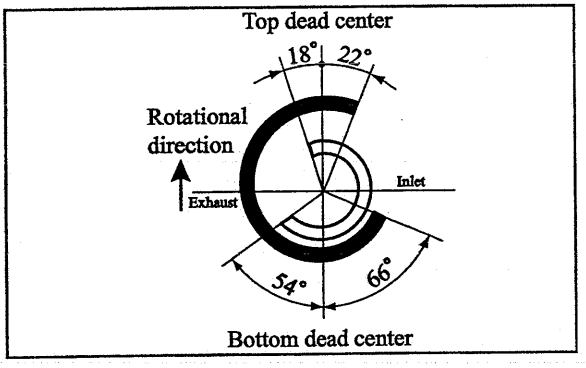
(1) Make the valve clearance between the inlet valve and exhaust valve of cylinder No. 1 using a flat 3-mm [0.118-in.] thick plate.
(2) Insert the thinnest thickness gage (0.05 mm [0.002 in.]) between the top face of the valve cap and rocker, and turn the crankshaft slowly.
(3) Find the position where the thickness gage is caught tight (i.e., the valve begins to open) and the position where the thickness gage begins to move (i.e., the valve is closed). Check that these positions coincide with the angle shown in the valve timing chart in the condition where there is a 3-mm [0.118-in.] clearance on the valve side.



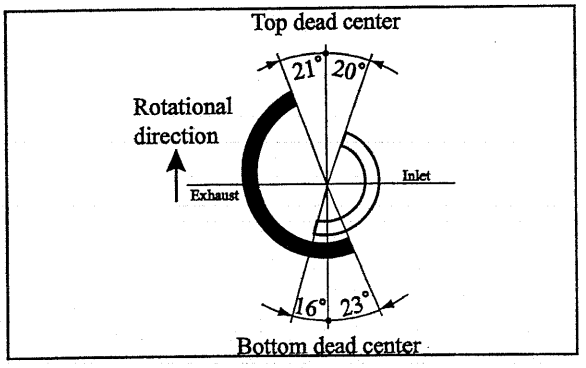
Valve timing chart (Swirl chamber)



Valve timing chart (Swirl chamber)
(with 3-mm [0.118-in.] clearance on valve side)



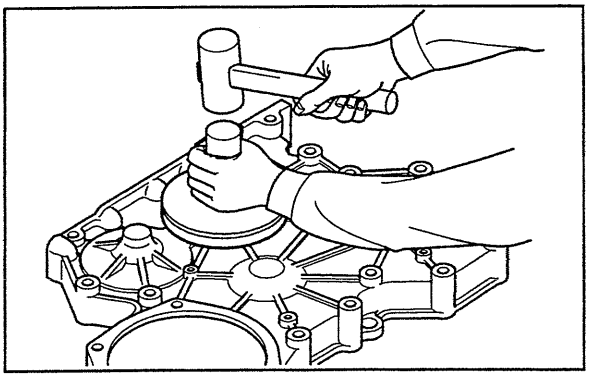
Valve timing chart (Direct injection)



Valve timing chart (Direct injection)
(with 3-mm [0.118-in.] clearance on valve side)

2.8 Installing Oil Seals

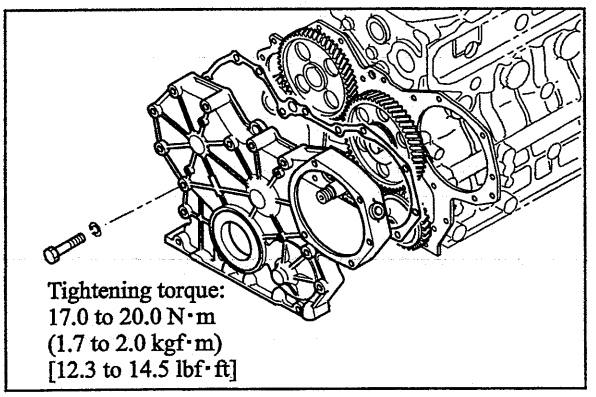
Apply a small quantity of oil to the oil seal. Drive it into the crank gear case using the installer.



Installing oil seal

2.9 Installing Timing Gear Case

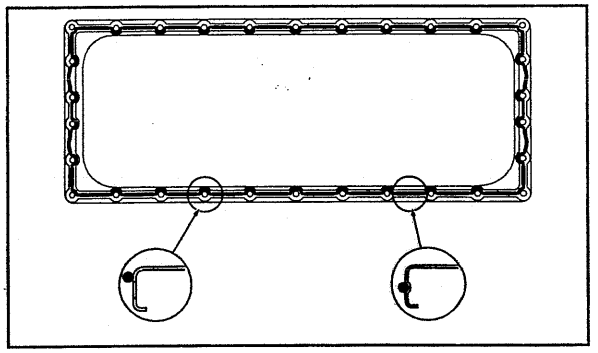
(1) Install the gasket to fit the crankcase dowel pin.
(2) Apply engine oil to the oil seal lip.
(3) Install the timing gear case and tighten the bolts to the specified torque.



Installing timing gear case

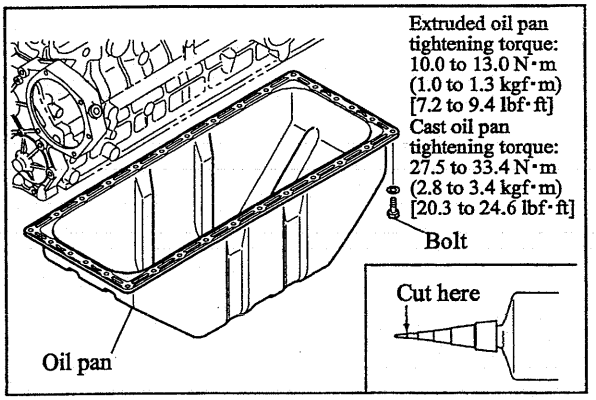
2.10 Installing Oil Pan

(1) Clean the mount surfaces of the crankcase, timing gear case, and oil pan.
(2) Squeeze Three Bond 1207C (32A91-05100: liquid gasket) in a 4-mm [0.16-in.] diameter bead all around the oil pan flange periphery, and spread it.
(3) Install the oil pan to the crankcase within five minutes of applying the liquid gasket.
(4) Tighten the mounting bolts to the specified torque.



Liquid gasket application position

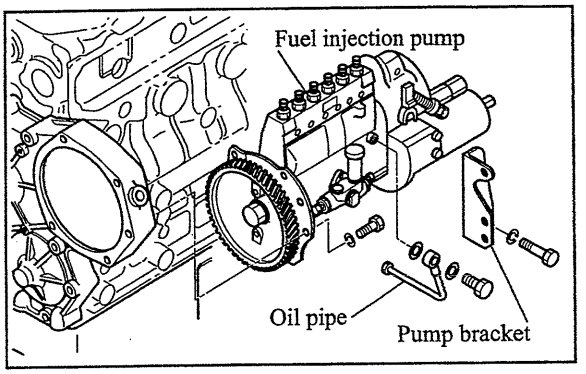
Note: (a) Cut the nozzle tip of the liquid gasket tube at the position shown on the right when squeezing the liquid gasket in a 4-mm [0.16-in.] diameter bead.
(b) Using the common gasket (32A13-03200) is also allowed if it is difficult to use liquid gasket.



Installing oil pan

2.11 Installing Fuel Injection Pump

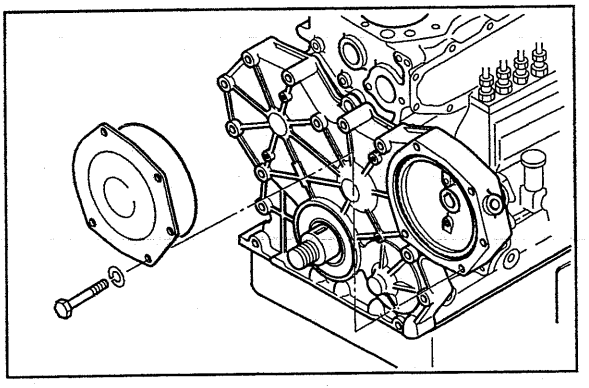
(1) Install the fuel injection pump, and tighten the bolts.
(2) Install the pump bracket.
(3) Install the oil pipe.



Installing fuel injection pump

2.12 Installing Cover

Install the cover, and tighten the bolts.



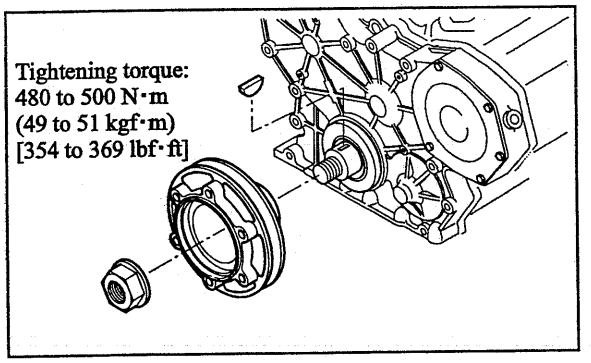
Installing cover

2.13 Installing Crankshaft Pulley

Screw two safety rods (M12 × 1.25) into the threaded holes at the rear end of the crankshaft, and prevent the crankshaft from rotating with a bar.
Tighten the crankshaft pulley to the specified torque.

⚠ CAUTION

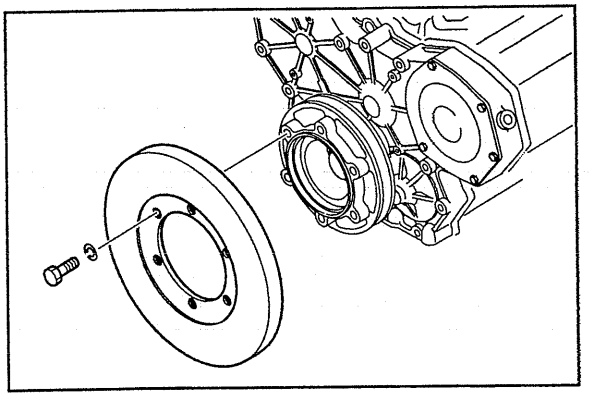
The bar may come off. Be very careful.



Installing crankshaft pulley

2.14 Installing Damper (S6S)

Install the damper, and tighten the bolts.



Installing damper

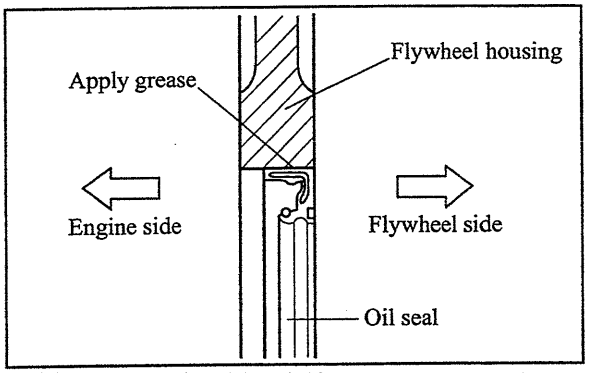
3. Flywheel

Reassemble the flywheel in the reverse order of the disassembly procedures.

3.1 Installing Oil Seals

Apply a small quantity of grease to the new oil seal, and install the oil seal to the flywheel housing.
Be careful of the oil seal installation direction.

Note: Use an oil seal with a sleeve if the oil seal-contacting surface of the crankshaft is worn.

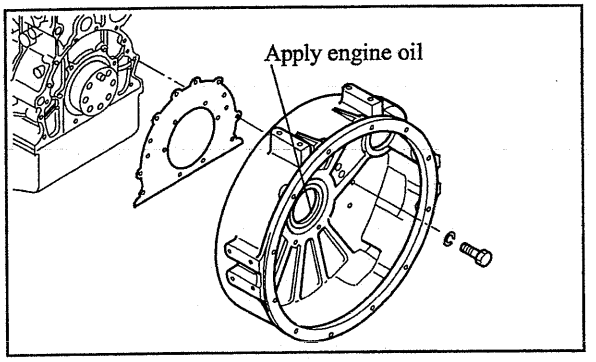


Installing oil seal

3.2 Installing Flywheel Housing

(1) Install a new rear gasket.
(2) Fit the flywheel housing to the crankcase dowel pin, and tighten the bolts.

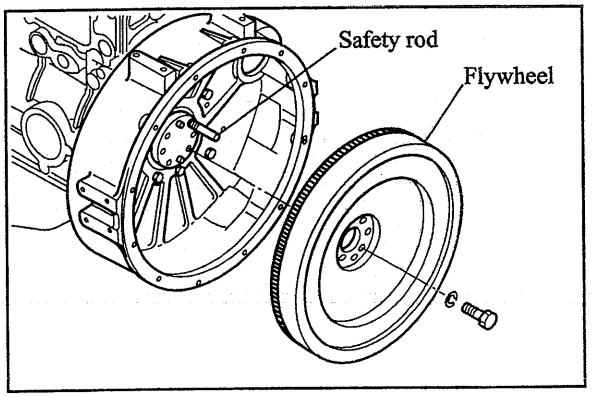
Note: If the starter is installed on the housing in advance, the post-work may be done easily.



Installing flywheel housing

3.3 Installing Flywheel

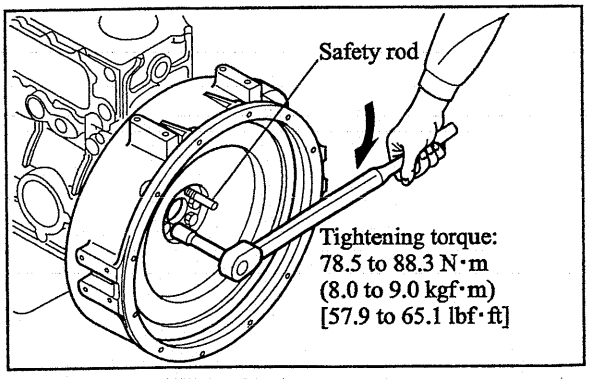
(1) Screw the safety rod (M12 × 1.25) into the rear end of the crankshaft.
(2) Install the flywheel to the crankshaft while fitting it to the safety rod.
(3) Tighten the bolts (five) temporarily.
(4) Unscrew the safety rod, and tighten the last bolt (one) temporarily.
(5) Prevent the crankshaft pulley nut from rotating with a torque wrench, etc.
(6) Tighten the flywheel mounting bolts to the specified torque.



Installing flywheel (1)

⚠ CAUTION

The person who holds the pulley should be very careful. Both persons should make signs mutually to proceed with the work.



Installing flywheel (2)

4. Cylinder Head and Valve Mechanisms

Reassemble these parts in the reverse order of the disassembly procedures.

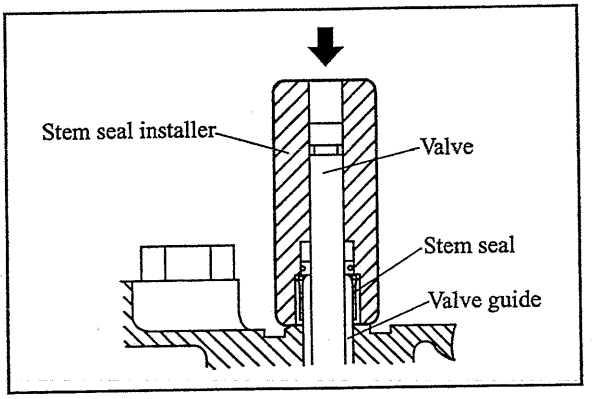
4.1 Installing Stem Seals

Install the stem seal to the valve guide using the stem seal installer (special tool) after installing the valve.

Special tool name	Part No.
Stem seal installer	32A91-10200

⚠ CAUTION

Do not apply liquid seal to the stem seal's engagement with the valve guide. Apply engine oil to the valve stem and install the stem seal in order to ensure the initial lubrication of the stem seal lip.
Do not draw out the valve after installing the stem seal in order not to damage the lip.

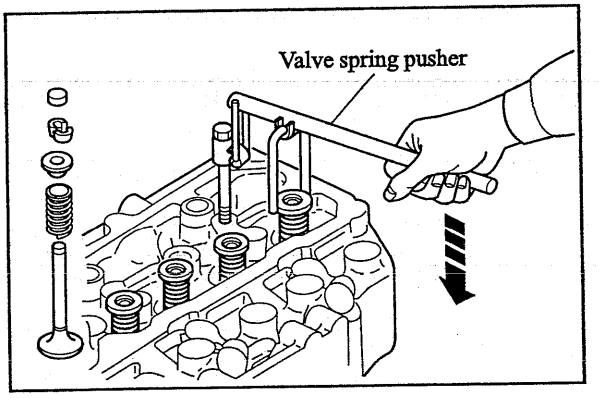


Installing stem seal

4.2 Installing Valves and Valve Springs

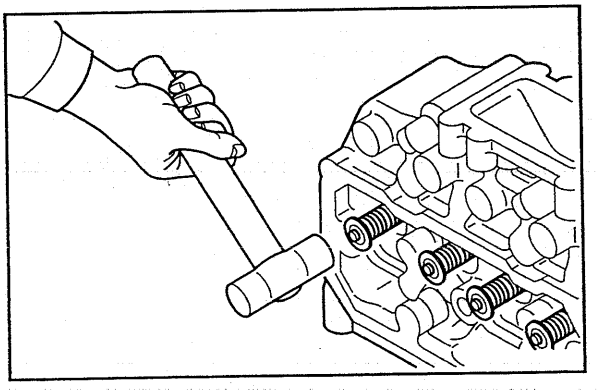
(1) Install the valve spring and retainer into the valve guide. Install the valve cotter using the valve spring pusher (special tool).

Special tool name	Part No.
Valve spring pusher	30691-04500



Installing valve and valve spring

(2) Hit the valve stem top lightly several times with a soft hammer to make sure that the valve spring and valve cotter are installed and seated firmly.



Checking valve cotter for installation

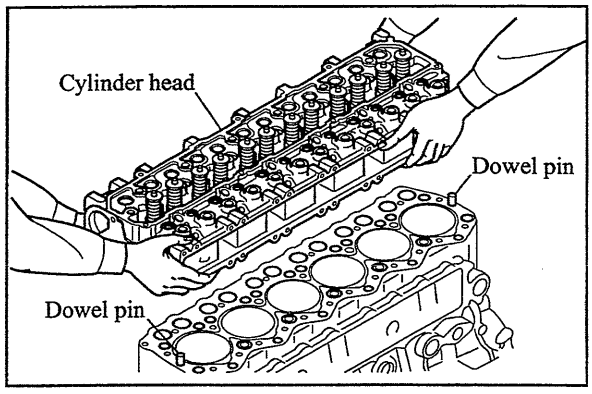
4.3 Installing Cylinder Head

(1) Fit the cylinder head gasket to two dowel pins on the top of the crankcase to prevent it from shifting.

(2) Install the cylinder head to fit the dowel pins, and tighten the cylinder head bolts.

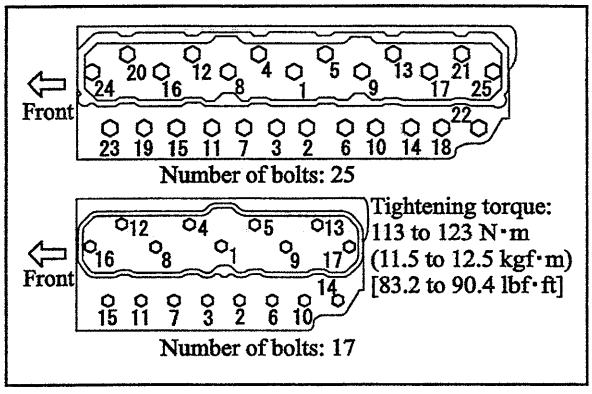
⚠ CAUTION

Do not use liquid packing. Make sure that there are no dents on the top surface of the crankcase.



Installing cylinder head

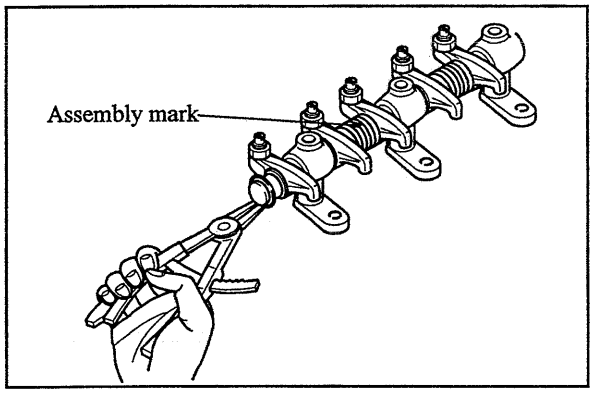
(3) Tighten the cylinder head bolts evenly to the specified torque in the order shown on the right.



Order of tightening cylinder head bolts

4.4 Reassembling Rocker Arms and Rocker Shaft Assembly

Face the reassembly marks on the shaft toward the front of the engine when reassembling the rocker arm. After reassembly, make sure that the rocker arm moves lightly.



Reassembling rocker shaft assembly

4.5 Inserting Pushrods

Insert the pushrod into the pushrod hole of the cylinder head.

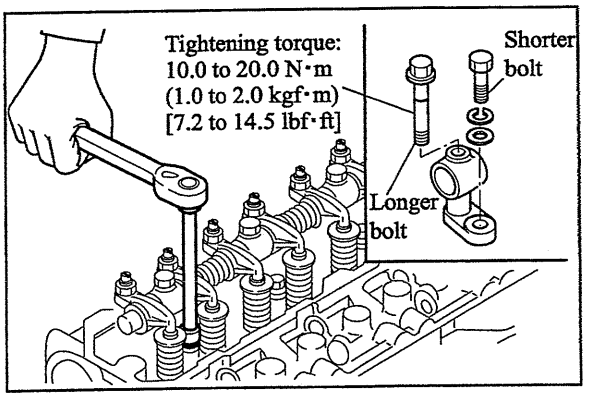
Make sure that the ball end of the pushrod is placed securely on the R portion of the tappet.

4.6 Installing Rocker Shaft Assembly

(1) Install the valve cap.

(2) Install the rocker shaft assembly to the cylinder head. Tighten the longer bolt to the specified torque.

Note: In reverse order of disassembly, tighten the longer of the rocker shaft bracket tightening bolts first, and then tighten the shorter bolt.



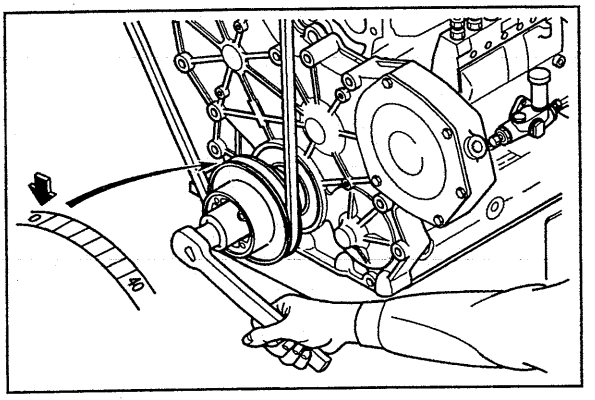
Installing rocker shaft assembly

4.7 Checking Top Dead Center of No. 1 Piston on Compression Stroke

(1) Engage the turning socket (special tool) with the nut of the crankshaft pulley and turn it in the forward direction of the engine (clockwise when viewed from the front of the engine).

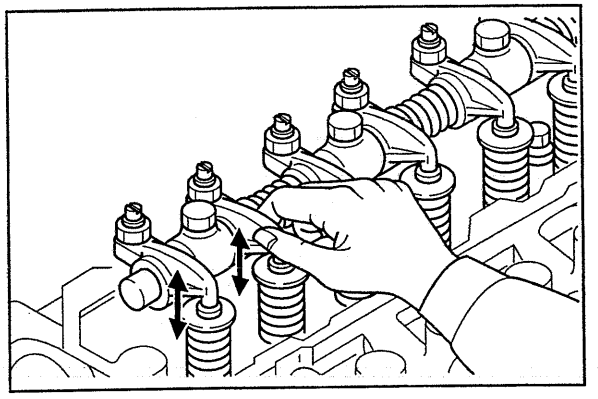
Special tool name	Part No.
Turning socket	58309-73100

(2) Stop turning the socket at the position where the "0" mark on the outer periphery of the crankshaft pulley is aligned with the pointer on the timing gear case.



Checking top dead center on compression stroke (1)

(3) Move the rocker arms of the inlet and exhaust valves of the No. 1 cylinder up and down to check that the pushrods do not push up the rocker arms. The position where the pushrods do not push up the rocker arms of the inlet and exhaust valves (i.e., there is a clearance) is the top dead center of the No. 1 piston on the compression stroke.
If the pushrods push up the rocker arms, rotate the crankshaft by another turn.



Checking top dead center on compression stroke (2)

4.8 Adjusting Valve Clearance

(1) Insert a thickness gage between the rocker arm and valve cap to check the clearance.

Unit: mm [in.]

		Standard
Valve clearance (when engine is cold)	Inlet	0.25 [0.0098]
	Exhaust	0.25 [0.0098]

(2) Loosen the lock nut. Tighten or loosen the adjusting screw, while measuring the clearance, until the thickness gage moves slightly stiff.

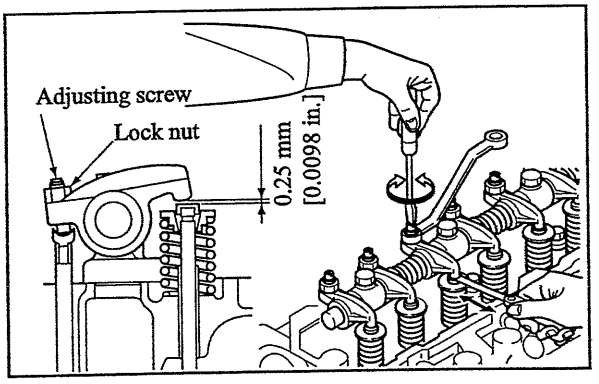
(3) After adjustment, tighten the lock nut firmly. Then, check the clearance again.

(4) Adjust the valve clearances of other cylinders while turning the engine.
The order and turning angle are as shown below.

Order (Cylinder Nos.)		Turning angle
S4S	1-3-4-2	180°
S6S	1-5-3-6-2-4	120°

⚠ CAUTION

When the valve clearance is adjusted after disassembly, rotate the crankshaft a couple of turns after the adjustment, and check again that the clearance is set to the standard.

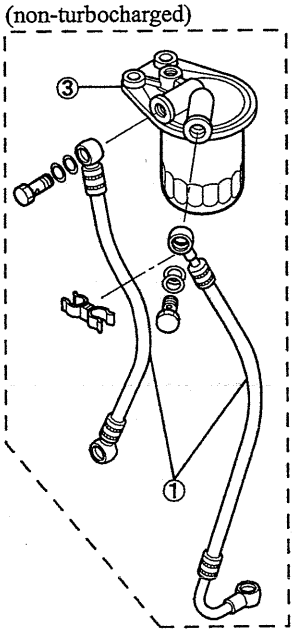


Adjusting valve clearance

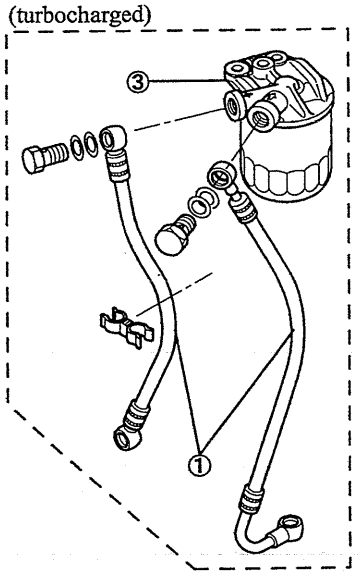
REMOVAL OF FUEL SYSTEM

1. Fuel Filter and Fuel Pipes

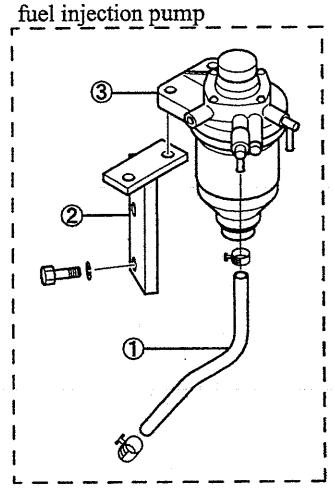
Filter for in-line fuel injection pump (non-turbocharged)

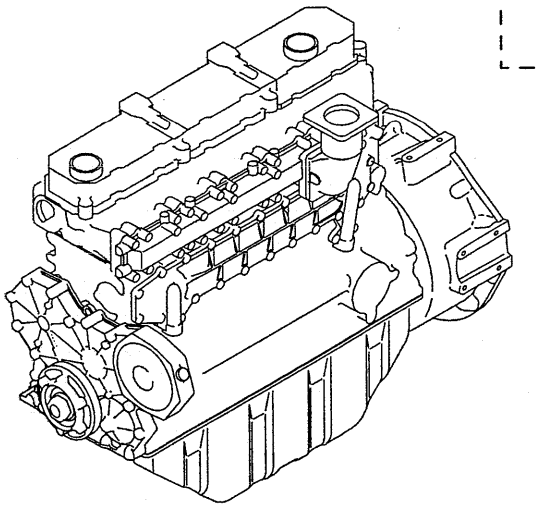


Filter for in-line fuel injection pump (turbocharged)



Filter for distributor-type fuel injection pump





Removal of fuel filter and fuel pipes

< Removal sequence >

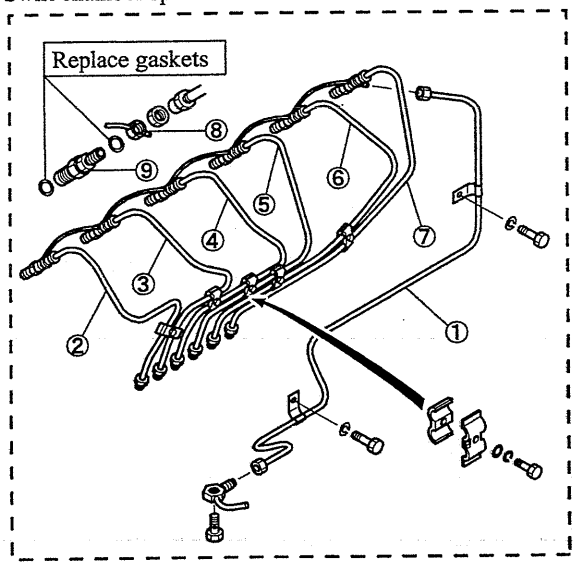
① Fuel hose

② Fuel filter bracket

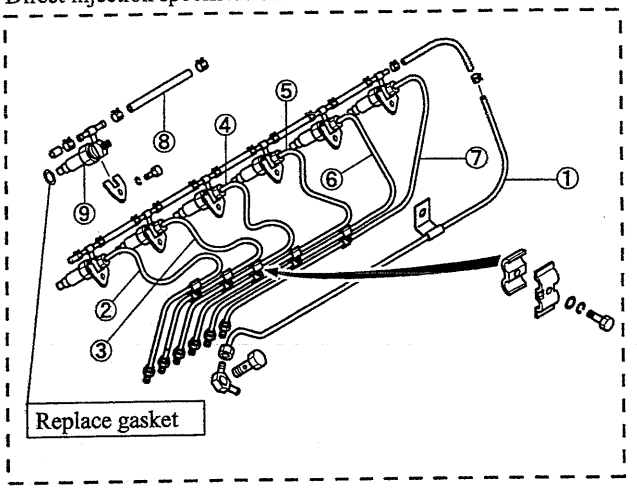
③ Fuel filter

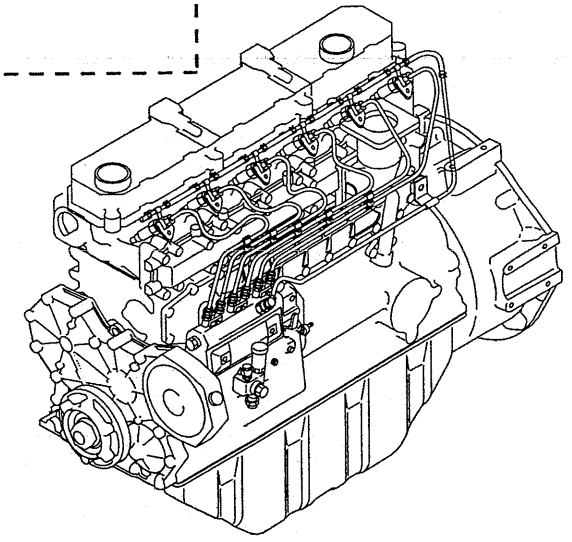
2. Fuel Injection Pipes, Fuel Leak-Off Pipes and Fuel Injection Nozzles (In-line fuel injection pump)

Swirl chamber specification



Direct injection specification





Removal of fuel injection pipes, fuel leak-off pipes and fuel injection nozzles (in-line fuel injection pump)

< Removal sequence >

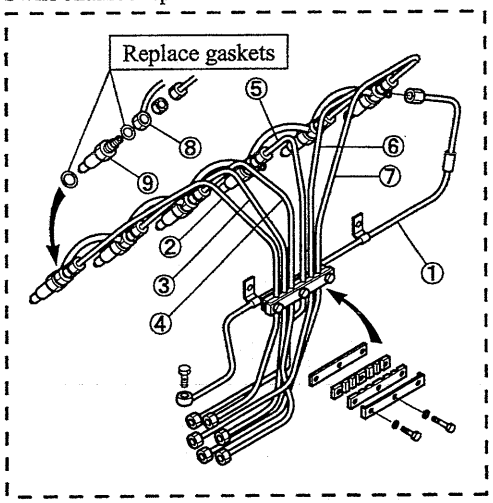
① Fuel return pipe
② No. 1 fuel injection pipe
③ No. 2 fuel injection pipe
④ No. 3 fuel injection pipe
⑤ No. 4 fuel injection pipe
⑥ No. 5 fuel injection pipe
⑦ No. 6 fuel injection pipe
⑧ Fuel leak-off pipe (swirl chamber specification)
Fuel hose (direct injection specification)
⑨ Fuel injection nozzle

⚠ CAUTION

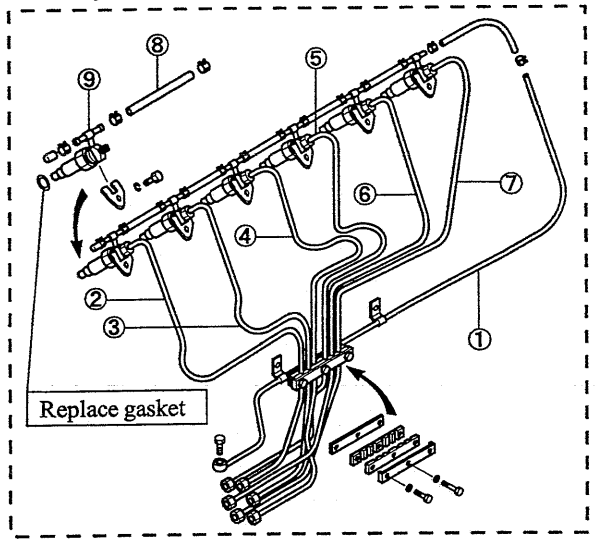
To prevent dust from entering the fuel system, cover all the openings in the injection pump, nozzle inlet connectors and injection pipes.

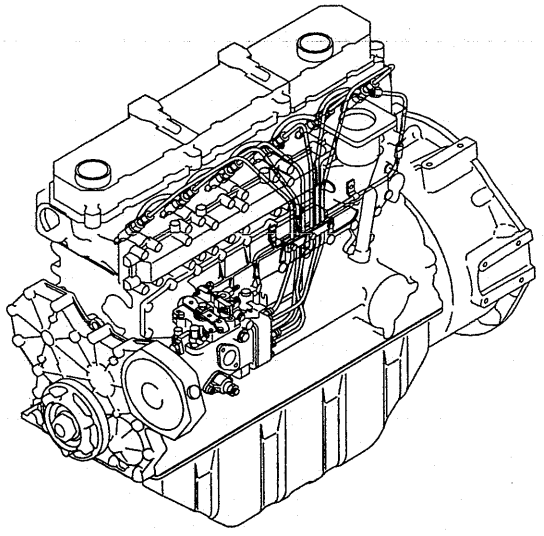
(Distributor-type fuel injection pump)

Swirl chamber specification



Direct injection specification





Removal of fuel injection pipes, fuel leak injection nozzles
(distributor-type fuel injection pump)

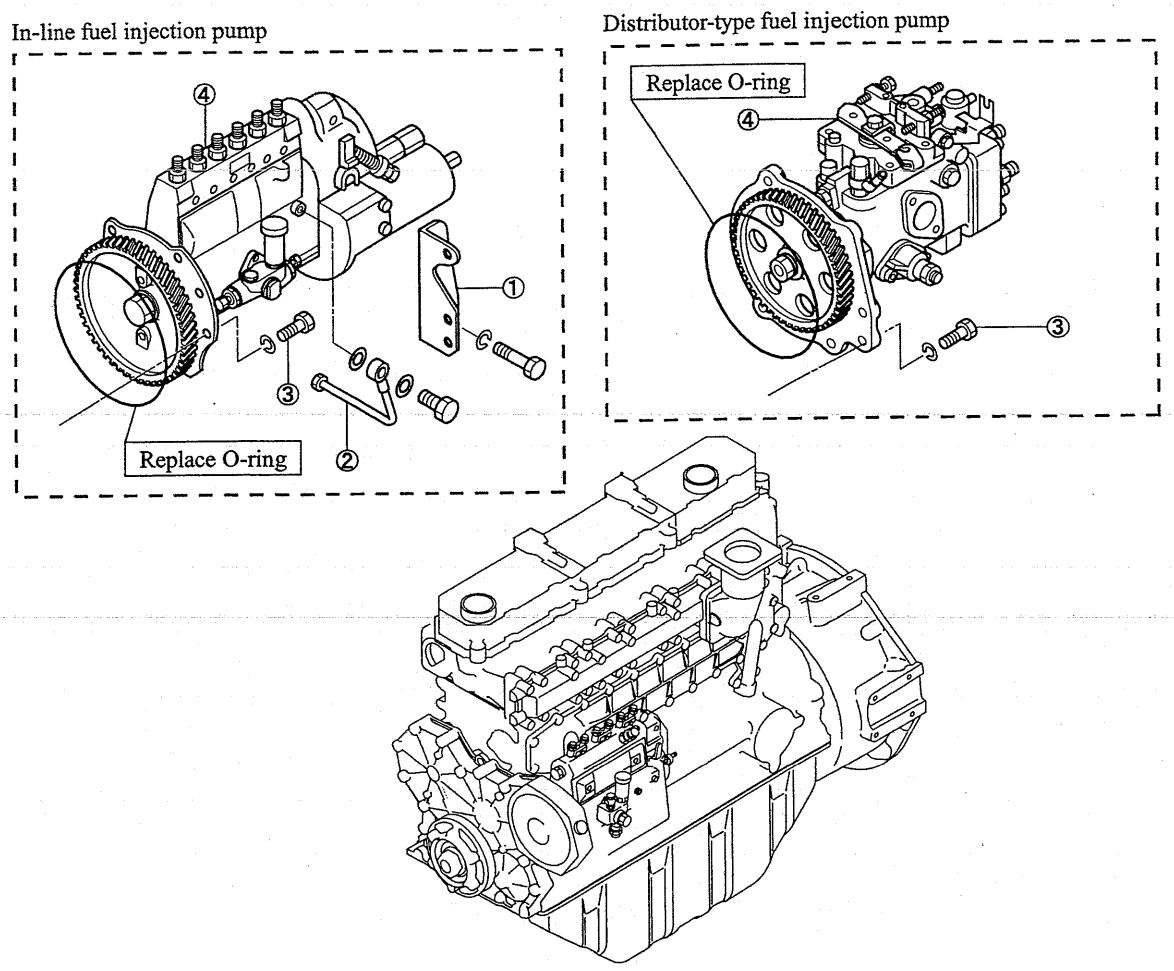
< Removal sequence >

① Fuel return pipe
② No. 1 fuel injection pipe
③ No. 2 fuel injection pipe
④ No. 3 fuel injection pipe
⑤ No. 4 fuel injection pipe
⑥ No. 5 fuel injection pipe
⑦ No. 6 fuel injection pipe
⑧ Fuel leak-off pipe (swirl chamber specification)
Fuel hose (direct injection specification)
⑨ Fuel injection nozzle

⚠ CAUTION

To prevent dust from entering the fuel system, cover all the openings in the injection pump, nozzle inlet connectors and injection pipes.

3. Fuel Injection Pump



Removal of fuel injection pump

(in-line and distributor-type fuel injection pumps)

< Removal sequence >

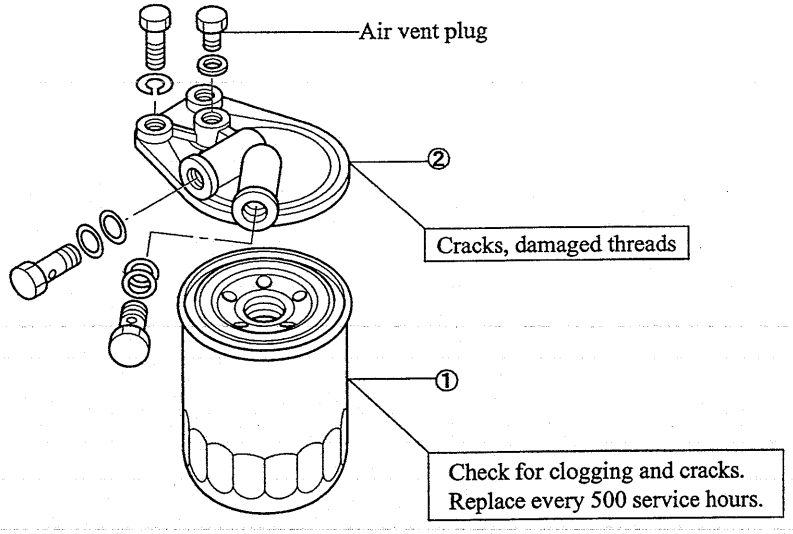
① Pump bracket
② Oil pipe
③ Mounting bolt
④ Fuel injection pump

DISASSEMBLY, INSPECTION AND REASSEMBLY OF FUEL SYSTEM

1. Fuel Filter

1.1 Disassembly and Inspection of Fuel Filter

(In-line fuel injection pump, non-turbocharged)



Disassembly and inspection of fuel filter

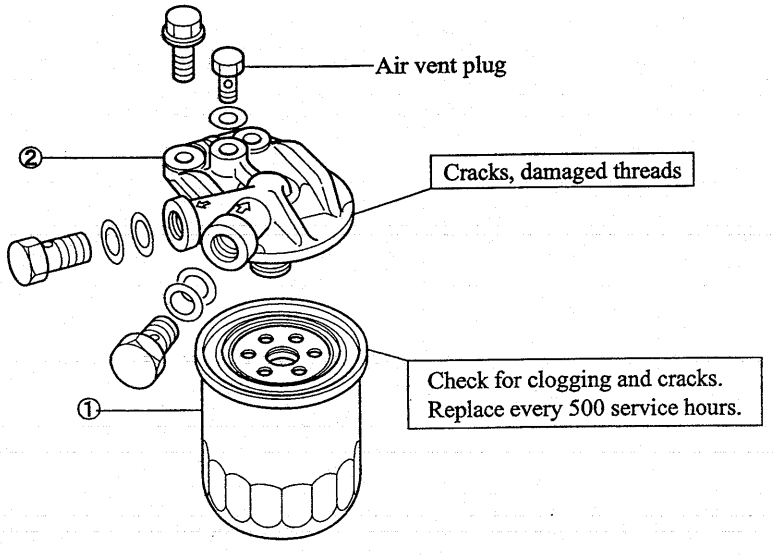
(in-line fuel injection pump, non-turbocharged)

< Disassembly sequence >

① Filter element

② Filter bracket

(In-line fuel injection pump, turbocharged)



Disassembly and Inspection of fuel filter

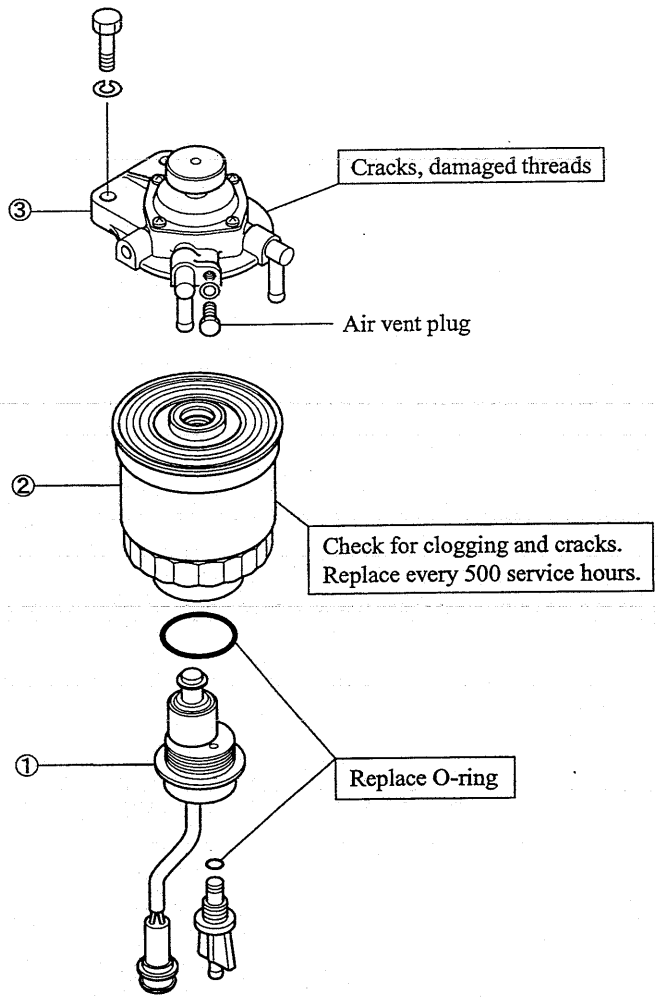
(in-line fuel injection pump, turbocharged)

< Disassembly sequence >

① Filter element

② Filter bracket

(Distributor-type fuel injection pump)



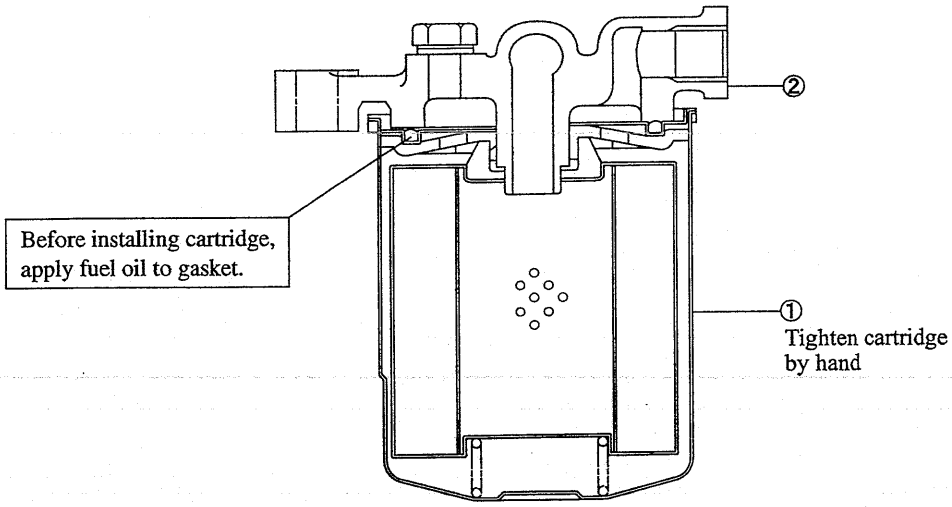
Disassembly and inspection of fuel filter
(distributor-type fuel injection pump)

< Disassembly sequence >

① Level sensor ② Filter element ③ Body

1.2 Reassembly of Fuel Filter

(In-line fuel injection pump, non-turbocharged)



Reassembly of fuel filter (in-line fuel injection pump, non-turbocharged)

< Reassembly sequence >

②→①

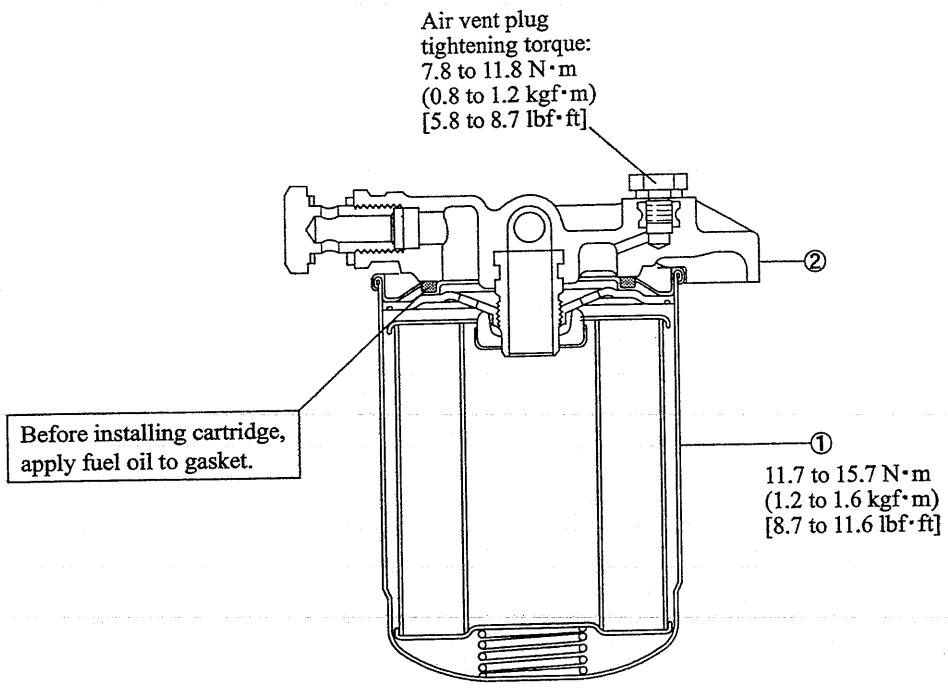
Before installing the cartridge, clean the mounting surface of the cartridge, coat the gasket with clean fuel oil. Screw in the cartridge until the gasket contacts the seal surface of the bracket, and then tighten it by hand. (Do not use a filter wrench for installation.)

Do not use a filter that has dents or scratches, since damaged filter can break during engine operation.

⚠ CAUTION

After installation, start the engine and check to make sure there is no fuel leak.

(In-line fuel injection pump, turbocharged)



Reassembly of fuel filter (in-line fuel injection pump, turbocharged)

< Reassembly sequence >

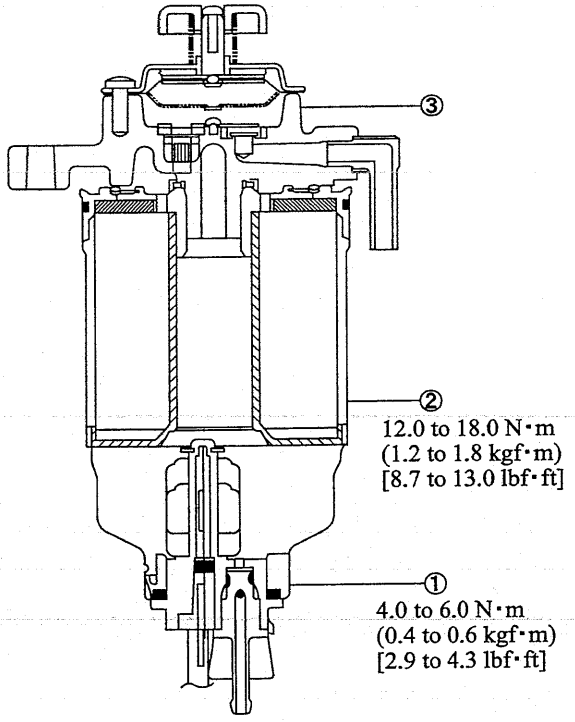
②→①

Before installing the cartridge, clean the mounting surface of the cartridge, coat the gasket with clean fuel oil. Screw in the cartridge until the gasket contacts the seal surface of the bracket, and then further rotate 3/4 to 1 turn by hand. (Do not use a filter wrench for installation.)
Do not use a filter that has dents or scratches, since damaged filter can break during engine operation.

⚠ CAUTION

After installation, start the engine and check to make sure there is no fuel leak.

(Distributor-type fuel injection pump)



Reassembly of fuel filter (distributor-type fuel injection pump)

< Reassembly sequence >

③→②→①

Do not use a filter that has dents or scratches, since damaged filter can break during engine operation.

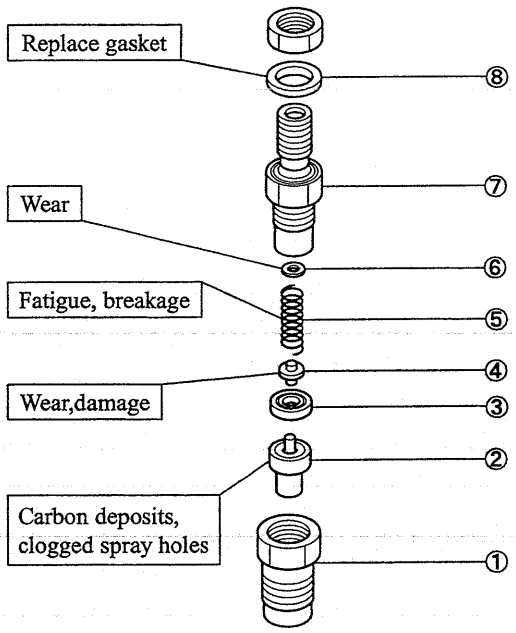
⚠ CAUTION

After installation, start the engine and check to make sure there is no fuel leak.

2. Fuel Injection Nozzles

2.1 Disassembly of Fuel Injection Nozzles

(Swirl chamber specification)

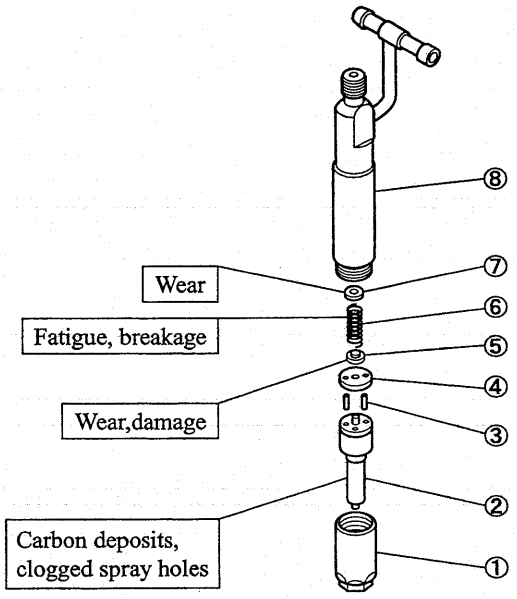


Disassembly of fuel injection nozzle (swirl chamber specification)

< Disassembly sequence >

① Nozzle	③ Piece	⑤ Spring	⑦ Nozzle holder
② Nozzle tip assembly	④ Pin	⑥ Washer	⑧ Gasket

(Direct injection specification)



Disassembly of fuel injection nozzle (direct injection specification)

< Disassembly sequence >

① Retaining nut	③ Straight pin	⑤ Pressure Pin	⑦ Shim
② Nozzle tip	④ Tip packing	⑥ Pressure spring	⑧ Nozzle body

2.2 Inspection of Fuel Injection Nozzles

Conduct the following inspections and,if faulty, repair or replace as required.

(1) Checking fuel injection nozzle for valve opening pressure

(a) Install the fuel injection nozzle onto the nozzle tester. Pump the tester handle up and down to bleed air.

(b) Pump the tester handle at a rate of approx. one cycle per second while observing the pointer of the tester.

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.

(c) If the measured pressure does not conform to the standard value, disassemble and adjust by changing the thickness of the washer.

Unit: MPa (kgf/cm^2) [psi]

		Standard
Valve opening pressure	Swirl chamber	11.77 to 12.75 (120 to 130) [1710 to 1850]
	Direct injection	18.14 to 19.12 (185 to 195) [2630 to 2770]

(d) Change in washer thickness by 0.1 mm (0.004 in.) results in a pressure change of 1.0 MPa (10 kgf/cm^2) [142 psi].
Washers are available in 10 different thicknesses at intervals of 0.05 mm (0.002 in.) in the range between 1.25 and 1.70 mm (0.049 and 0.067 in.).

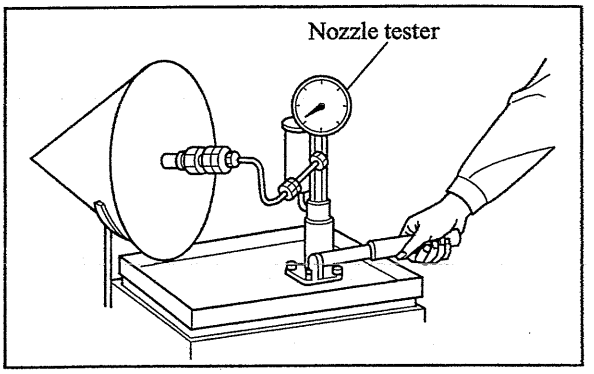
⚠ CAUTION

Never touch the spray of fuel from the fuel injection nozzle during inspection.

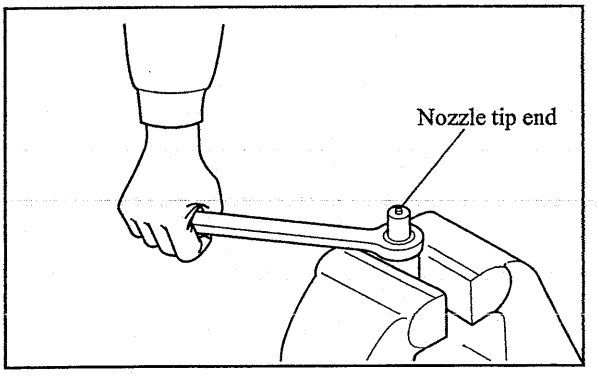
(2) Checking fuel spray pattern from fuel injection nozzle

(a) When checking the valve opening pressure using the nozzle tester, also check for such as clogged nozzle hole, fuel spray pattern and fuel leakage from the spray hole.

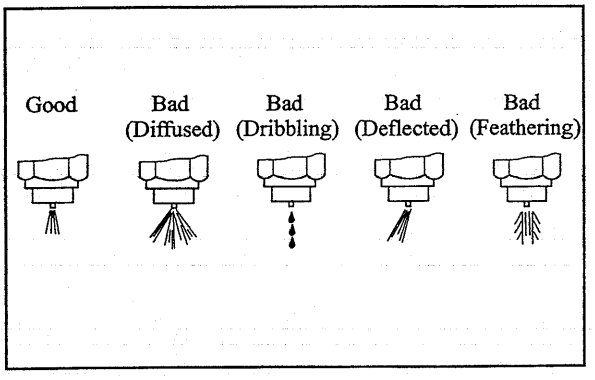
(b) When the tester handle is pumped at a rate of approx. one cycle per second, fuel should be sprayed in a fairly straight pattern.



Checking fuel injection nozzle for valve opening pressure



Replacing fuel injection nozzle tip assembly



Fuel spray patterns

(3) Cleaning or replacing when spraying badly

(a) Loosen the nozzle retaining nut to remove the nozzle tip assembly. Clean the needle valve and the nozzle tip body.

⚠ CAUTION

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

(b) Wash the needle valve and the nozzle tip body in clean wash oil. Reassemble them in clean light oil.

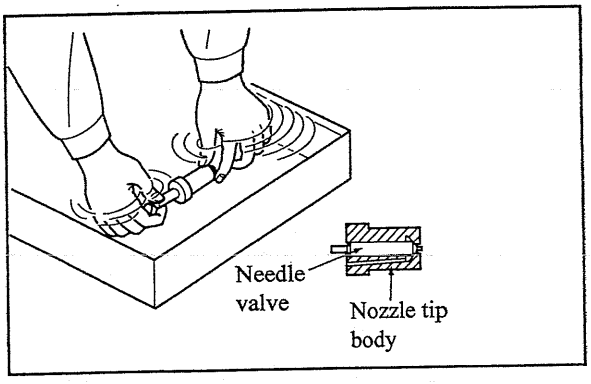
Note: The needle valve and the nozzle tip body are precision machined parts. Handle with care and never change their combination.

(c) Assemble the fuel injection nozzle, tightening the nozzle retaining nut to the specified torque.

(d) If the fuel spray pattern is still not good, replace the nozzle tip assembly.

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

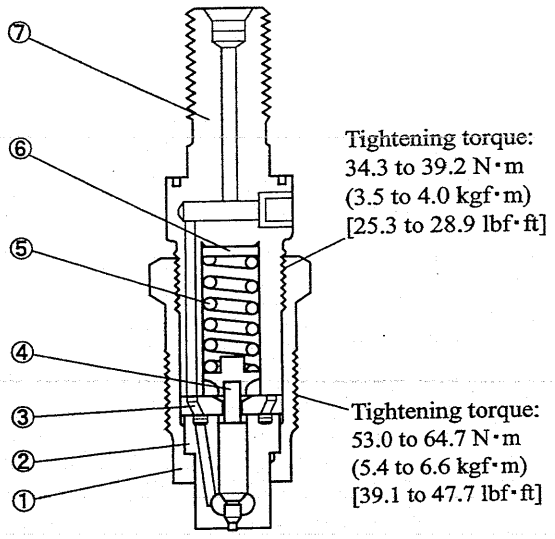
(b) If the nozzle tip assembly is to be replaced, remove the seal peel (synthetic resin film) from the new nozzle tip assembly, and slide the nozzle and needle valve in clean wash oil to remove the anti-corrosive agent completely.



Cleaning fuel injection nozzle tip components

2.3 Reassembly of Fuel Injection Nozzles

(Swirl chamber specification)

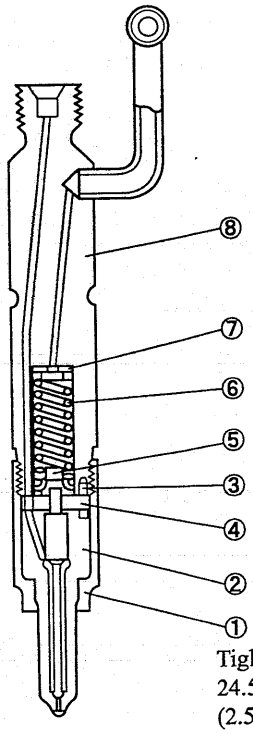


Reassembly of fuel injection nozzle (swirl chamber specification)

< Reassembly sequence >

⑦→⑥→⑤→④→③→②→①

(Direct injection specification)



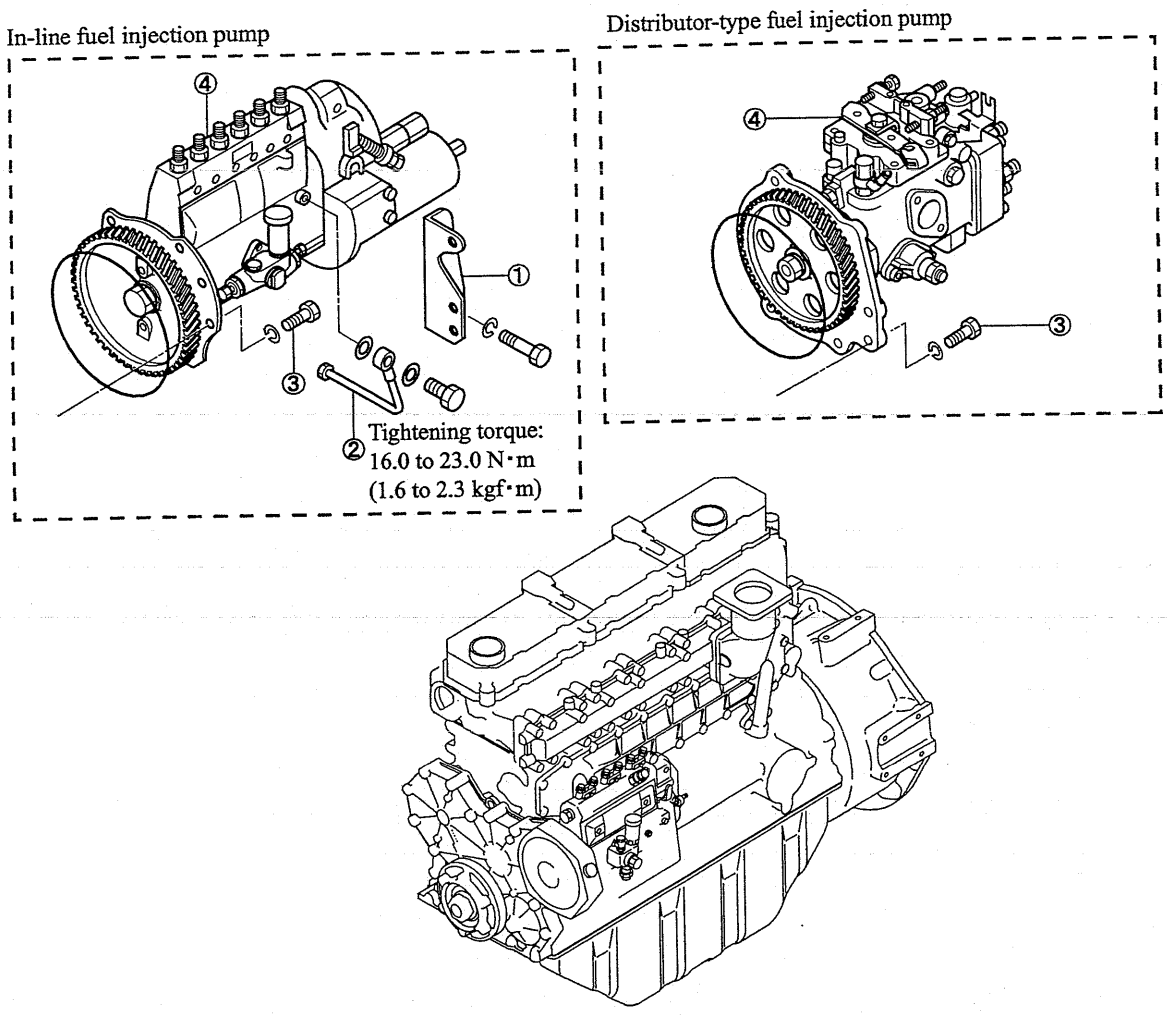
Reassembly of fuel injection nozzle (direct injection specification)

< Reassembly sequence >

⑧→⑦→⑥→⑤→④→③→②→①

INSTALLATION OF FUEL SYSTEM

1. Fuel Injection Pump

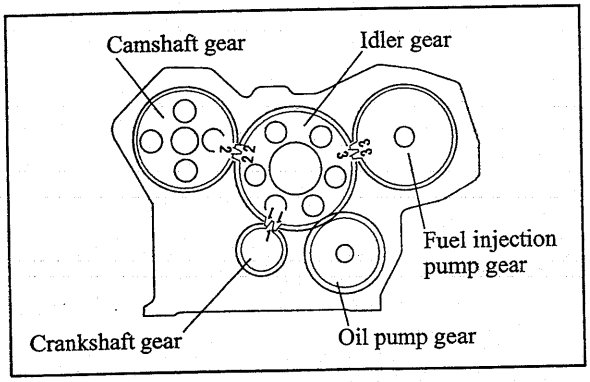


Installation of fuel injection pump
(in-line and distributor-type fuel injection pumps)

< Installation sequence >
④→③→②→①

Install the fuel injection pump after aligning its gear alignment mark with the idler gear alignment mark, and confirm that the alignment marks of the timing gears are as shown in the right diagram.

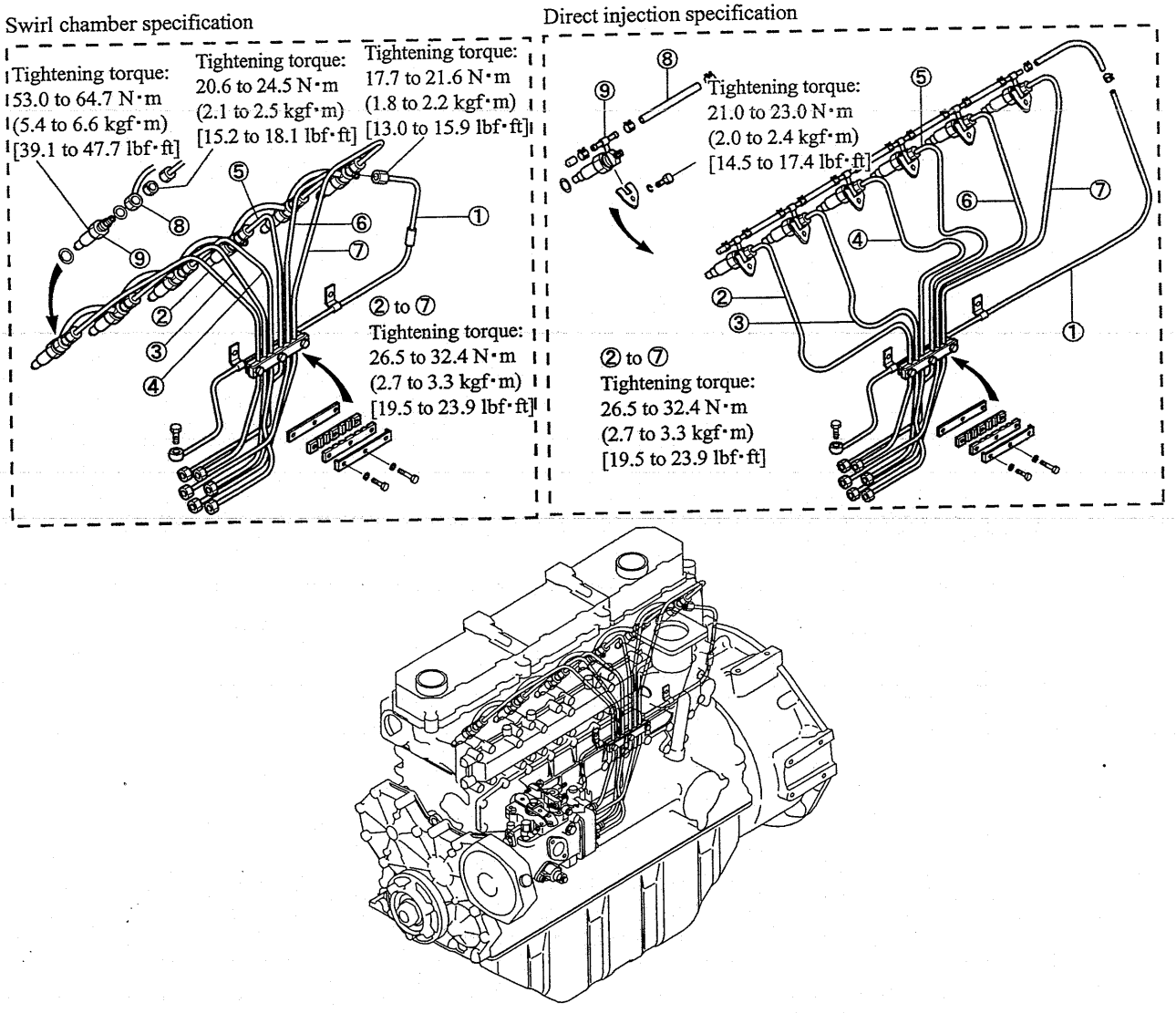
Note: When the alignment marks of the timing gears are as shown in the right diagram, the No.1 piston is positioned at the top dead center on the compression stroke.



Alignment marks of timing gears

2. Fuel Injection Pipes, Fuel Leak-Off Pipes and Fuel Injection Nozzles

(Distributor-type fuel injection pump)



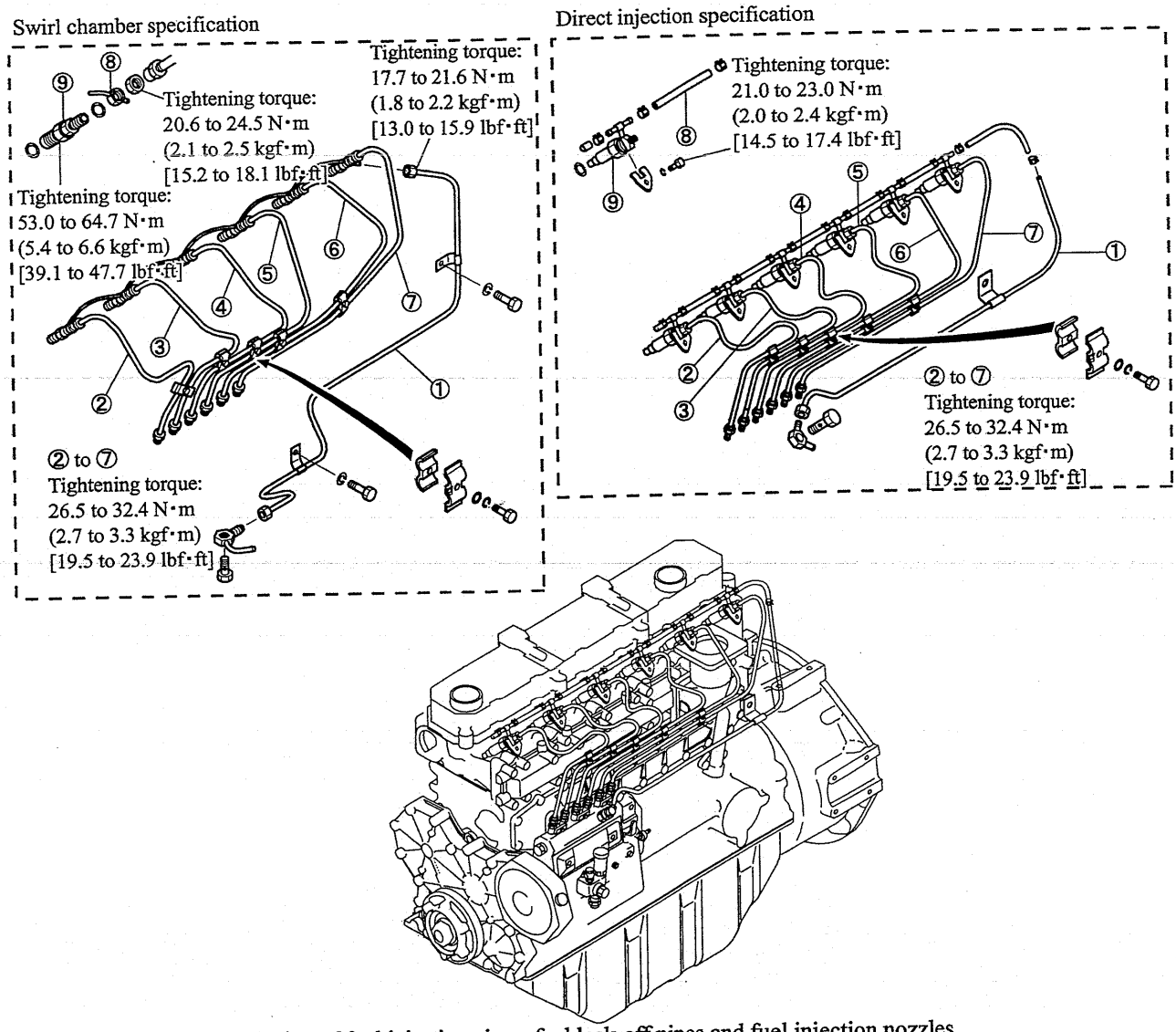
Installation of fuel injection pipes, fuel leak-off pipes and fuel injection nozzles

(distributor-type fuel injection pump)

< Installation sequence >

⑨→⑧→⑦→⑥→⑤→④→③→②→①

(In-line fuel injection pump)



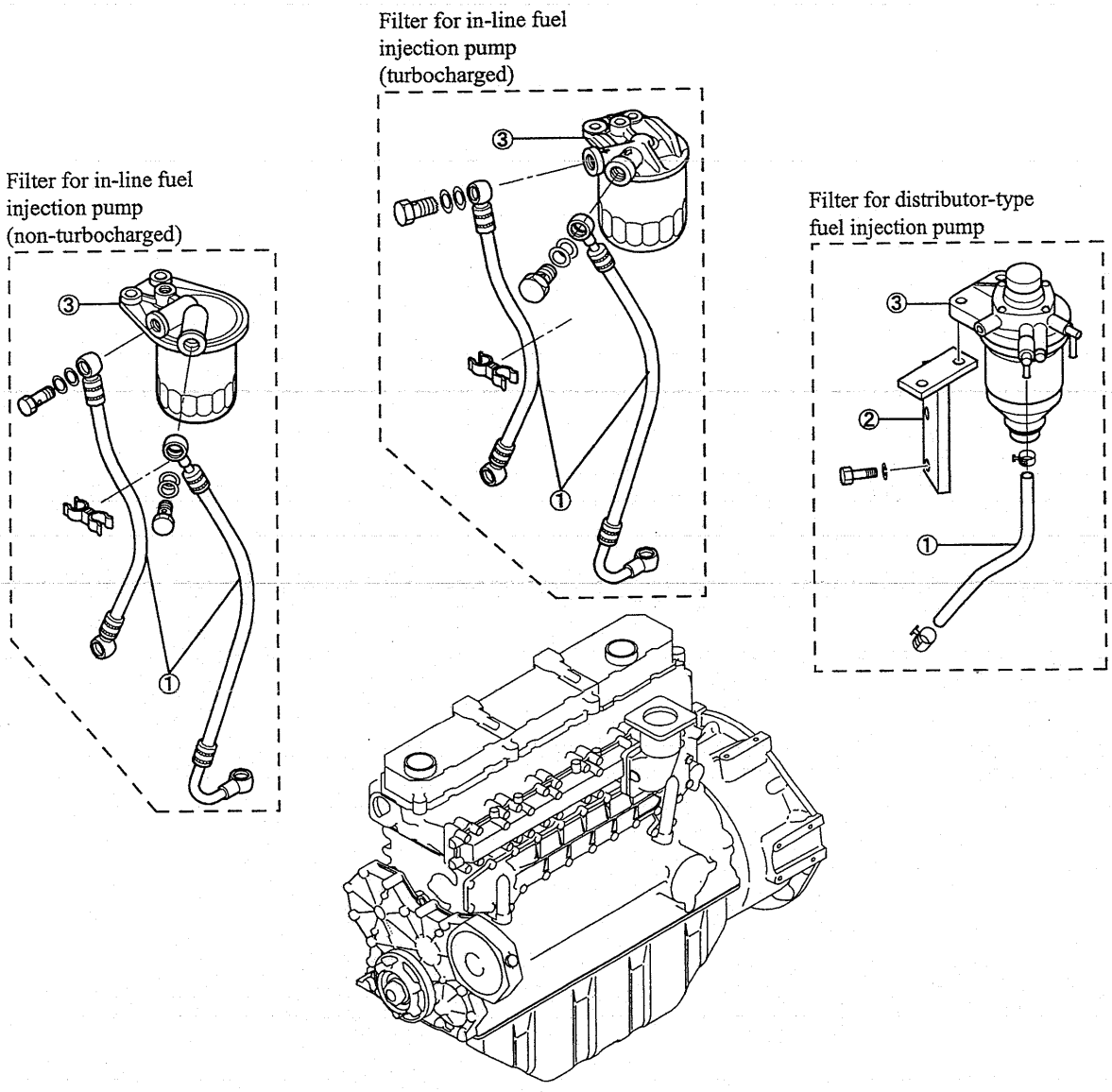
Installation of fuel injection pipes, fuel leak-off pipes and fuel injection nozzles

(in-line fuel injection pump)

< Installation sequence >

⑨→⑧→⑦→⑥→⑤→④→③→②→①

3. Fuel Filter and Fuel Pipes



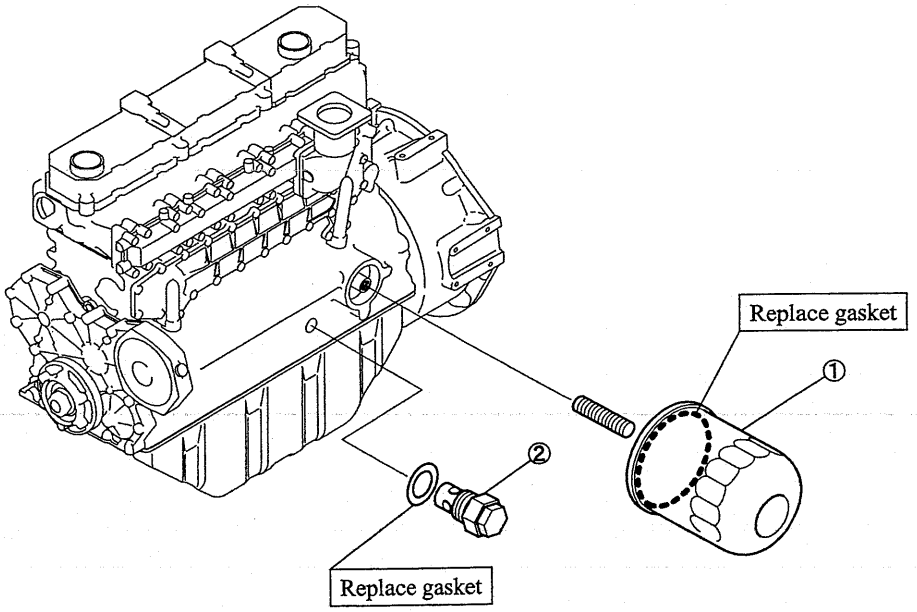
Installation of fuel filter and fuel pipes

< Installation sequence >

③→②→①

REMOVAL OF LUBRICATION SYSTEM

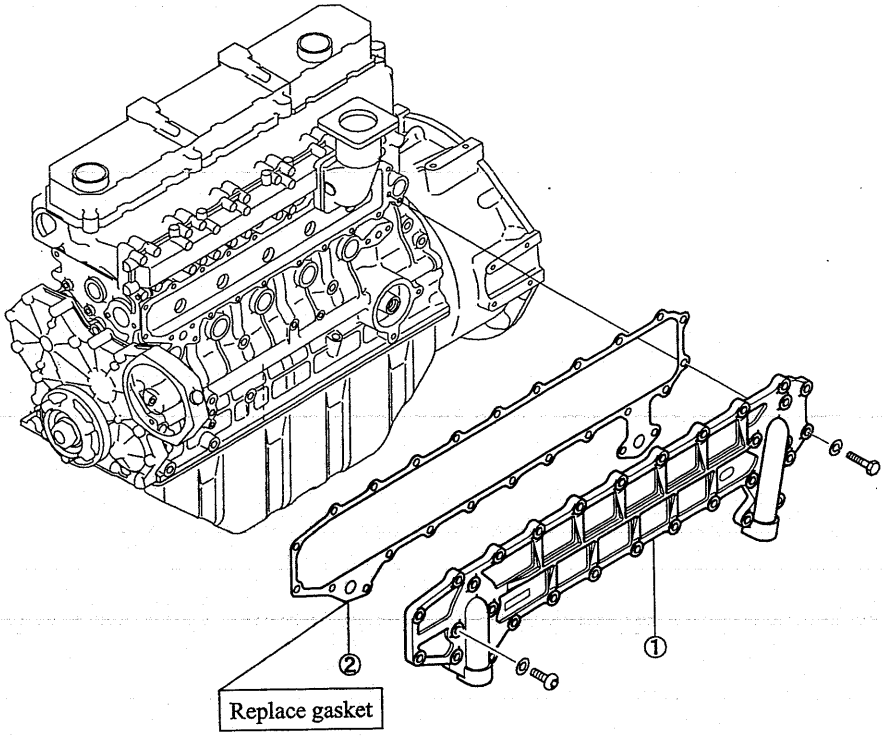
1. Oil Filter and Relief Valve



Removal of oil filter and relief valve

< Removal sequence >
① Oil filter
② Relief valve

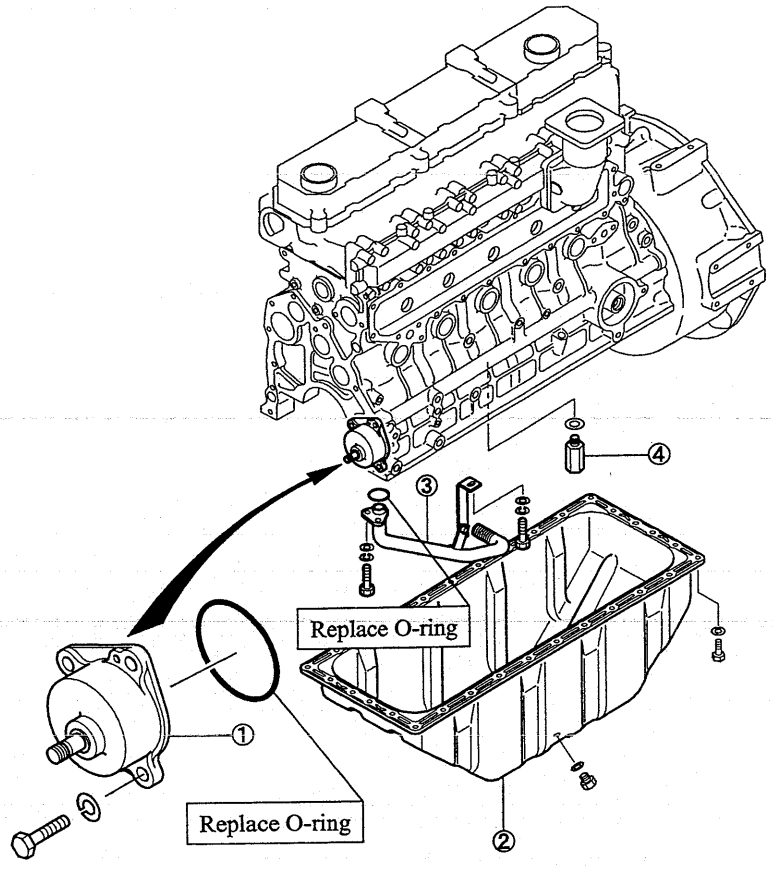
2. Oil Cooler



Removal of oil cooler

< Removal sequence >
① Oil cooler assembly
② Oil cooler gasket

3. Oil Pump, Oil Pan and Oil Strainer



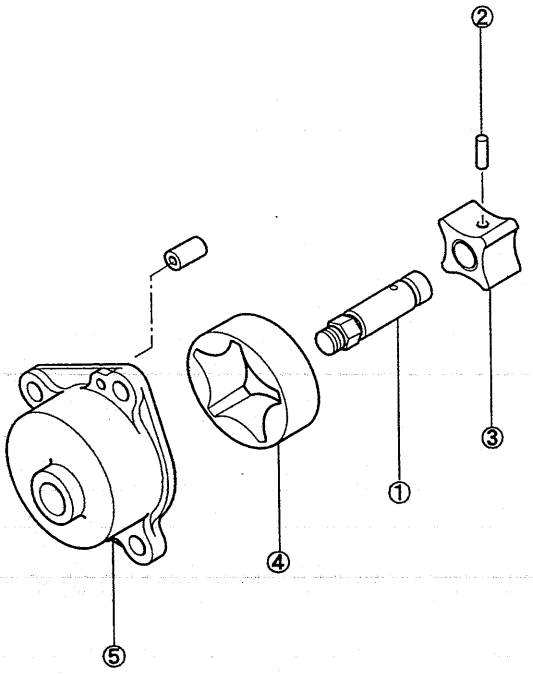
Removal of oil pump, oil pan and oil strainer

< Removal sequence >
① Oil pump
② Oil pan
③ Oil strainer
④ Safety valve

DISASSEMBLY, INSPECTION AND REASSEMBLY OF LUBRICATION SYSTEM

1. Oil Pump

1.1 Disassembly of Oil Pump



Disassembly of oil pump

< Disassembly sequence >
① Main shaft
② Pin
③ Inner rotor
④ Outer rotor
⑤ Pump case

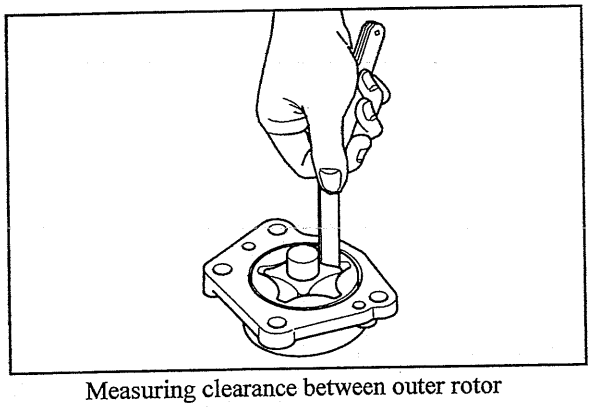
1.2 Inspection of Oil Pump

(1) Measuring clearance between outer rotor and inner rotor

Measure the clearance between the outer rotor and inner rotor. If the clearance exceeds the limit, replace the outer rotor together with the shaft assembly.

Unit: mm [in.]

	Standard	Limit
Clearance between outer rotor and inner rotor	0.13 to 0.15 [0.0051 to 0.0059]	0.20 [0.0079]



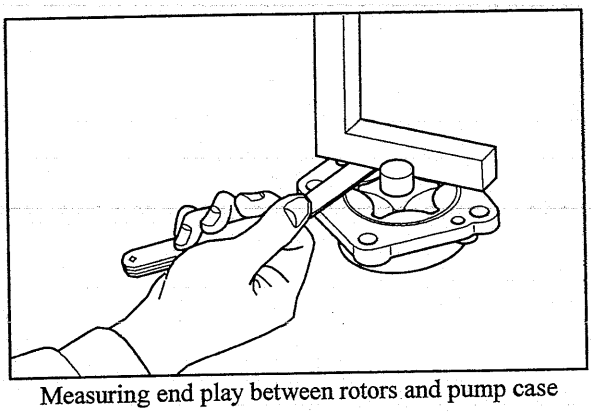
Measuring clearance between outer rotor and inner rotor

(2) Measuring end play between rotors and pump case

Measure the end play between the rotors and pump case. If the end play exceeds the limit, replace the oil pump.

Unit: mm [in.]

	Standard	Limit
End play between rotors and case.	0.04 to 0.09 [0.0016 to 0.0035]	0.15 [0.0059]



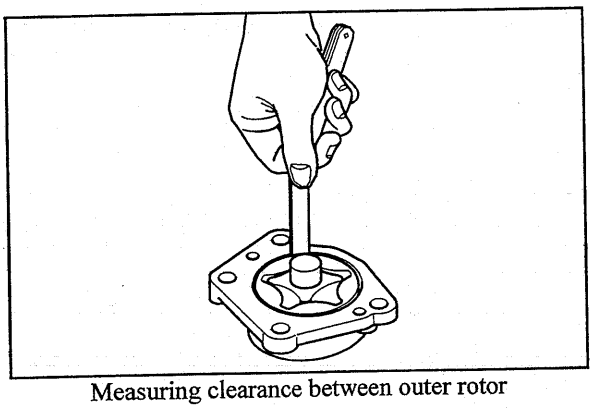
Measuring end play between rotors and pump case

(3) Measuring clearance between outer rotor and pump case

Measure the clearance between the outer rotor and pump case. If the clearance exceeds the limit, replace the oil pump.

Unit: mm [in.]

	Standard	Limit
Clearance between outer rotor and case	0.20 to 0.30 [0.0079 to 0.0118]	0.50 [0.0197]



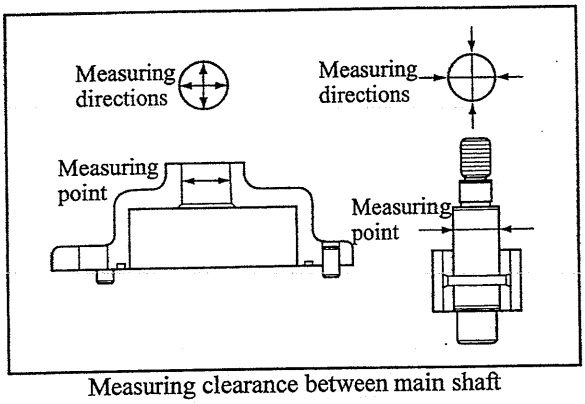
Measuring clearance between outer rotor and pump case

(4) Measuring clearance between main shaft and pump case

Measure the diameter of the main shaft and the inside diameter of the hole in the pump case to find the clearance between the two. If the clearance exceeds the limit, replace the entire oil pump assembly.

Unit: mm [in.]

	Standard	Limit
Diameter of shaft (case side)	15.985 to 16.000 [0.6293 to 0.6299]	—
Clearance between shaft and case	0.032 to 0.074 [0.0013 to 0.029]	0.150 [0.0059]



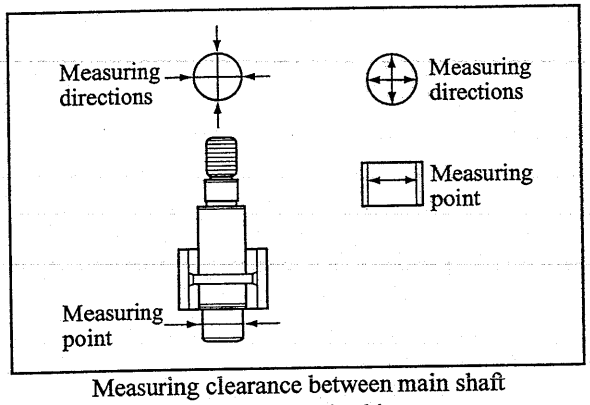
Measuring clearance between main shaft and pump case

(5) Measuring clearance between main shaft and oil pump bushing

Measure the diameter of the main shaft and the inside diameter of the oil pump bushing in the crankcase to find the clearance between the two. If the clearance exceeds the limit, replace the oil pump bushing or the entire oil pump assembly.

Unit: mm [in.]

	Standard	Limit
Diameter of shaft (bushing side)	13.957 to 13.975 [0.5495 to 0.5502]	—
Clearance between shaft and bushing	0.025 to 0.111 [0.0010 to 0.0044]	0.200 [0.0079]



Measuring clearance between main shaft and oil pump bushing

(6) Installing oil pump bushing

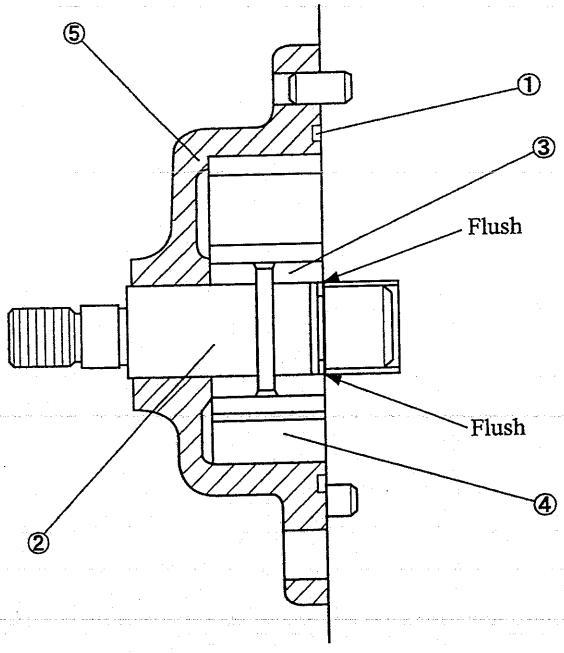
To install the oil pump bushing, use the specified oil pump bushing installer.

Name of special tool	Part No.
Oil pump bushing installer	32A91-00400

⚠ CAUTION

Install the oil pump bushing in the crankcase so that it is even with the front face of the crankcase.

1.3 Reassembly of Oil Pump

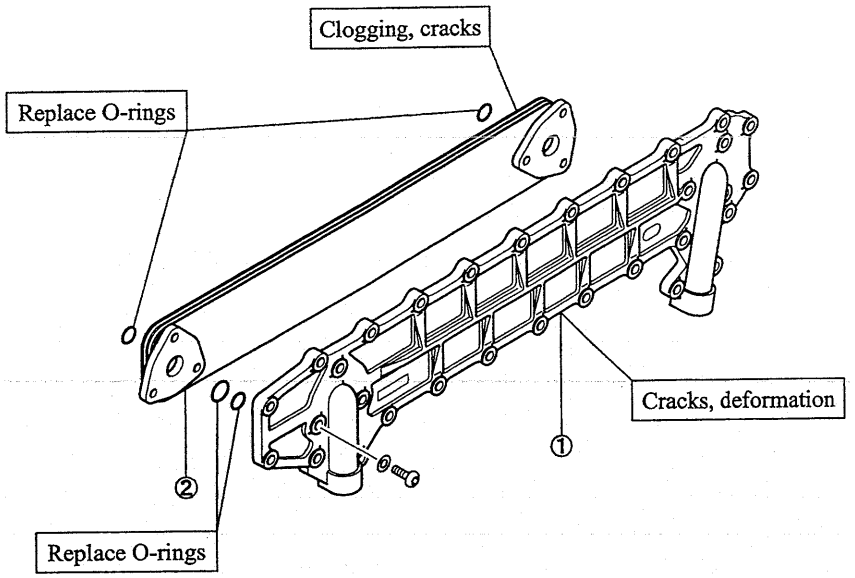


Reassembly of oil pump

< Reassembly sequence >
⑤→④→③→②→①

2. Oil Cooler

Disassembly and Inspection of Oil Cooler

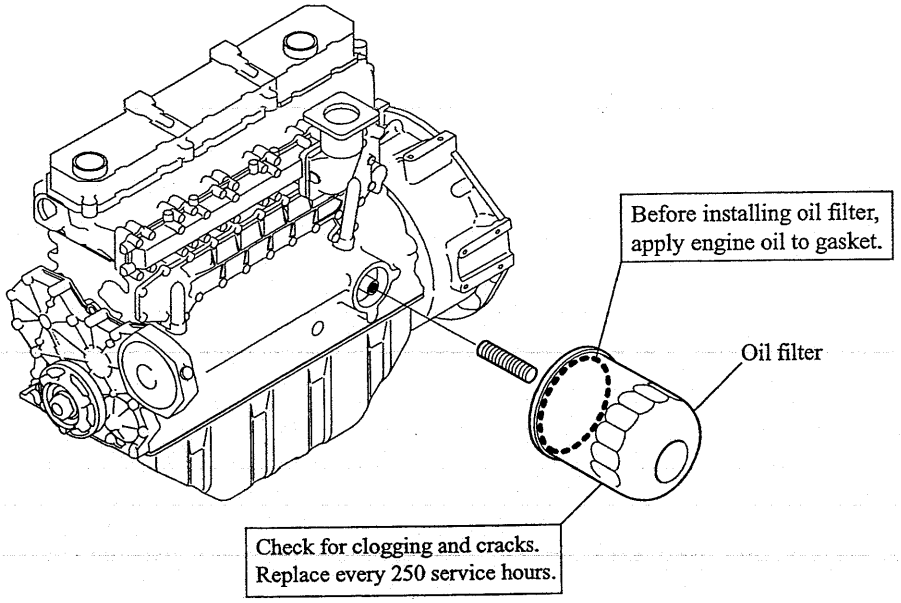


Disassembly and inspection of oil cooler

< Disassembly sequence >
① Oil cooler case
② Oil cooler element

3. Oil Filter

Inspection of Oil Filter



Inspection of oil filter

4. Relief Valve

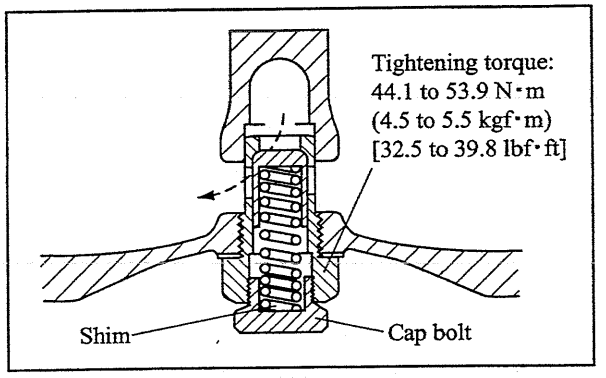
Inspection of Relief Valve

(1) Check the relief valve and its seat for contact. Check the spring for fatigue and damage.

(2) Measure the opening pressure. If the opening pressure is not correct, make a shim adjustment.

Unit: MPa (kgf/cm^2) [psi]

	Standard
Opening pressure	0.30 to 0.40 (3.1 to 4.1) [44 to 58]



Checking relief valve

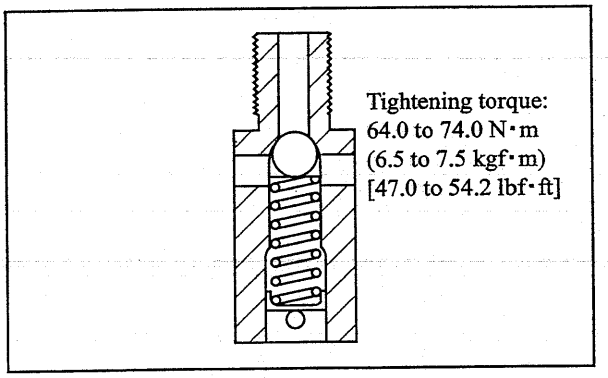
5. Safety Valve

Inspection of Safety Valve

Check the safety valve and its seat for contact. Check the spring for fatigue and damage.

Unit: MPa (kgf/cm^2) [psi]

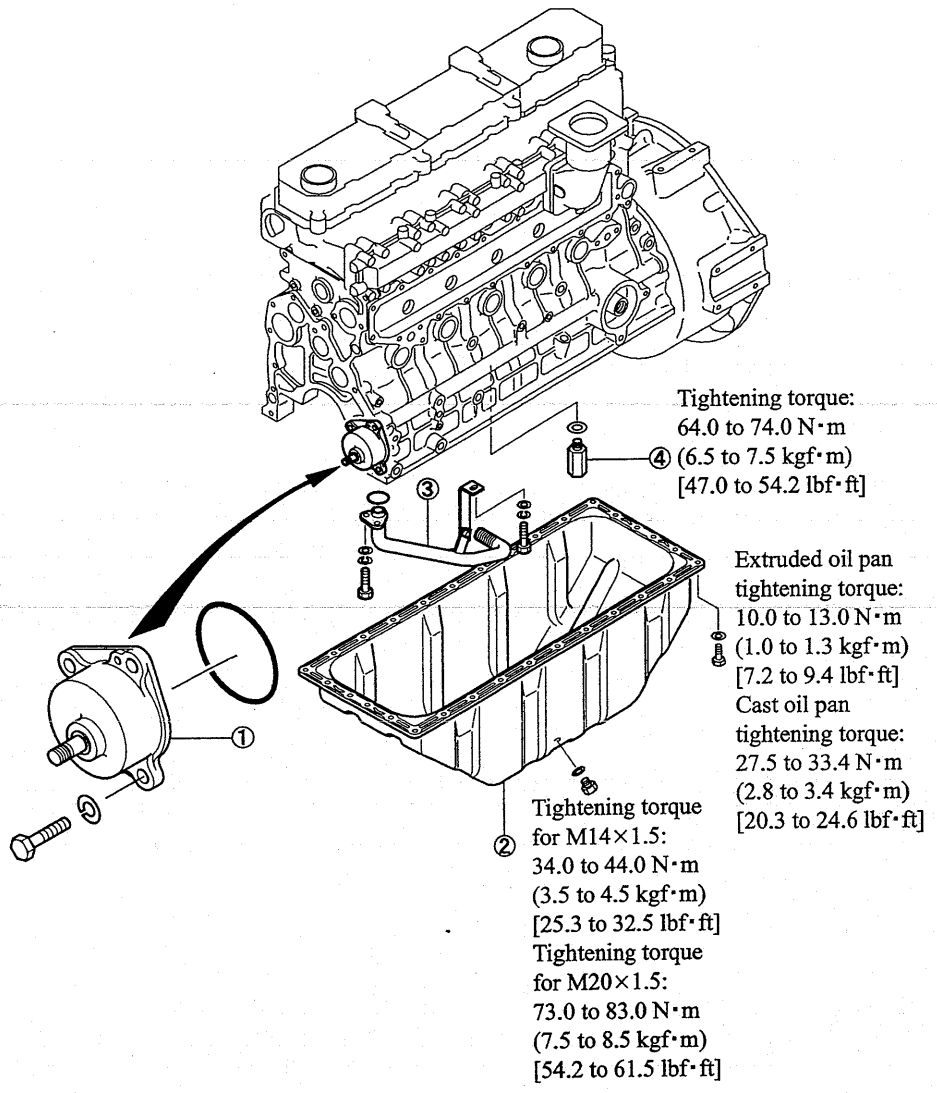
	Standard
Opening pressure	1.1 (11) [156]



Checking safety valve

INSTALLATION OF LUBRICATION SYSTEM

1. Oil Pump, Oil Pan and Oil Strainer

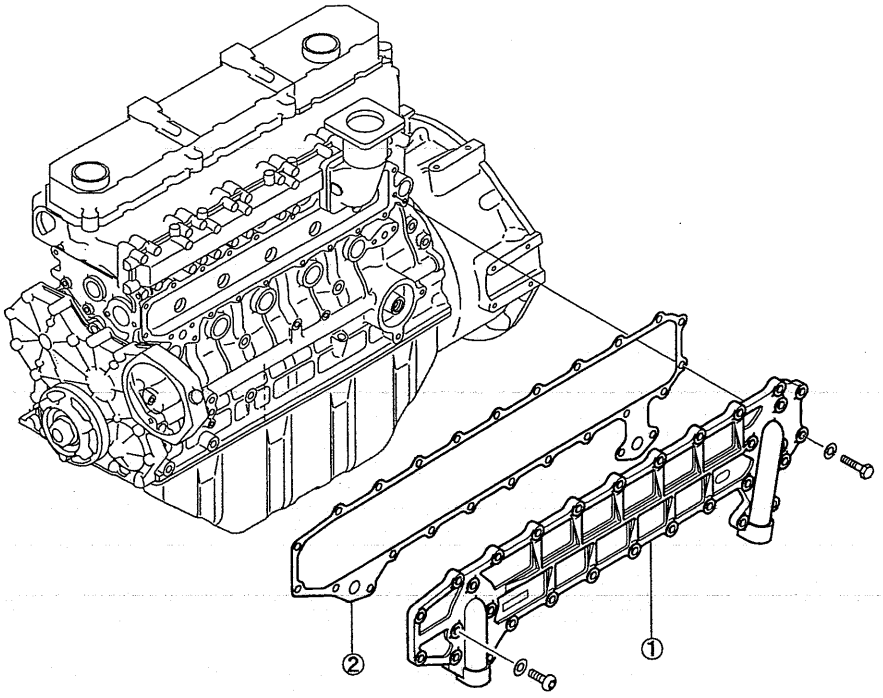


Installation of oil pump, oil pan and oil strainer

< Installation sequence >

④→③→②→①

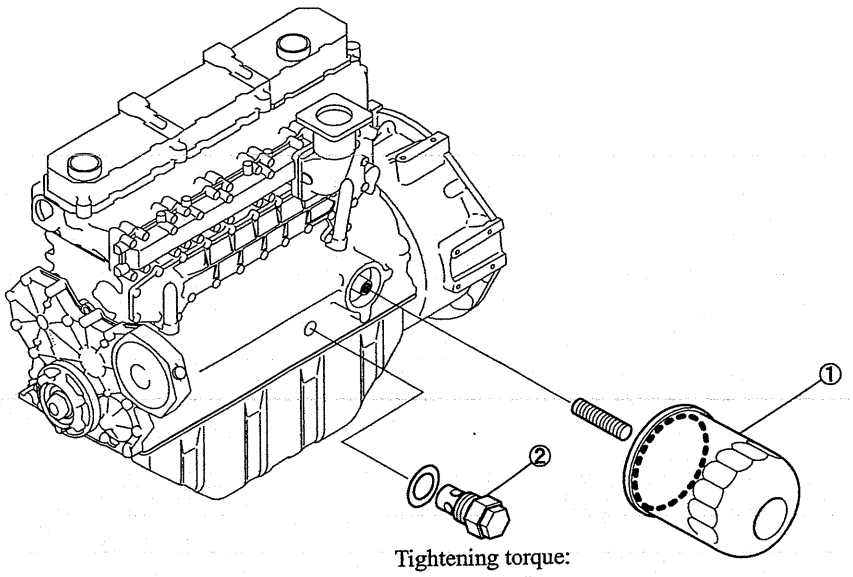
2. Oil Cooler



Installation of oil cooler

< Installation sequence >
②→①

3. Oil Filter and Relief Valve



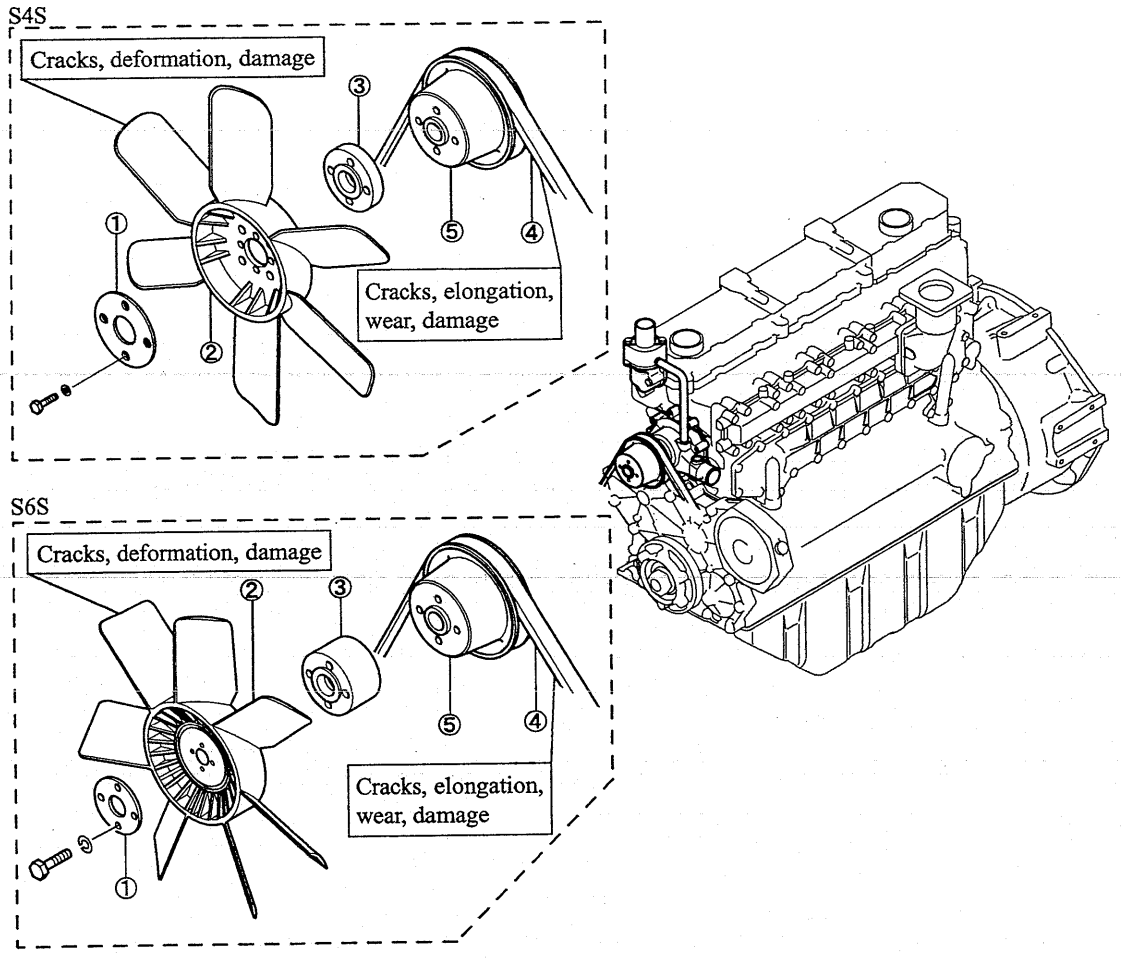
Installation of oil filter and relief valve

< Installation sequence >

②→①

REMOVAL OF COOLING SYSTEM

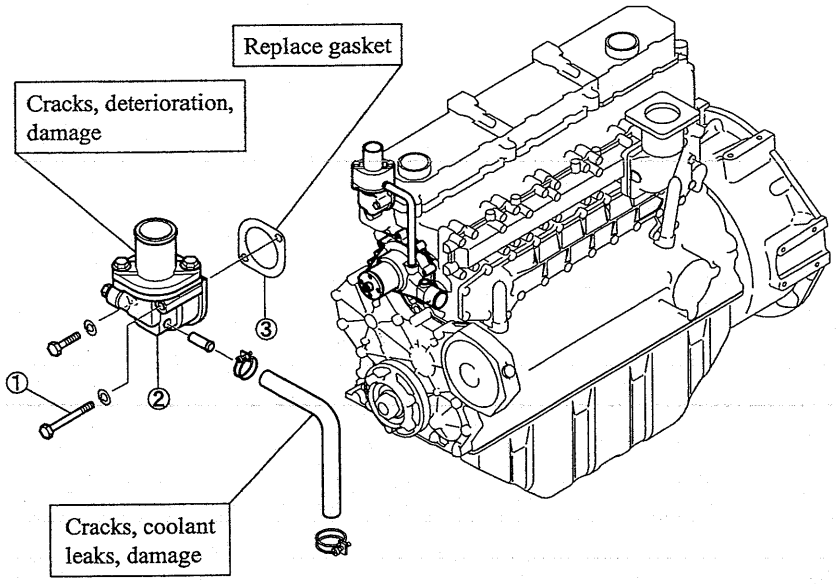
1. Cooling Fan, Fan Pulley and V-Belt



Removal of cooling fan, fan pulley and V-belt

< Removal sequence >
① Fan plate
② Cooling fan
③ Fan spacer
④ V-belt
⑤ Water pump pulley

2. Thermostat

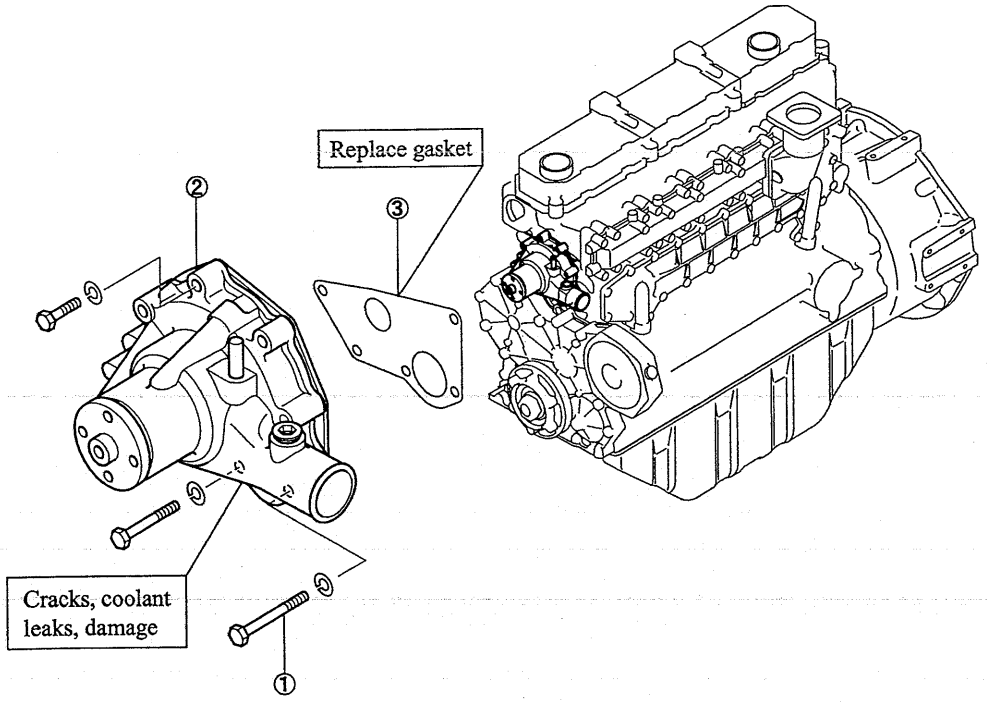


Removal of thermostat

< Removal sequence >

① Bolt ② Thermostat case ③ Gasket

3. Water Pump



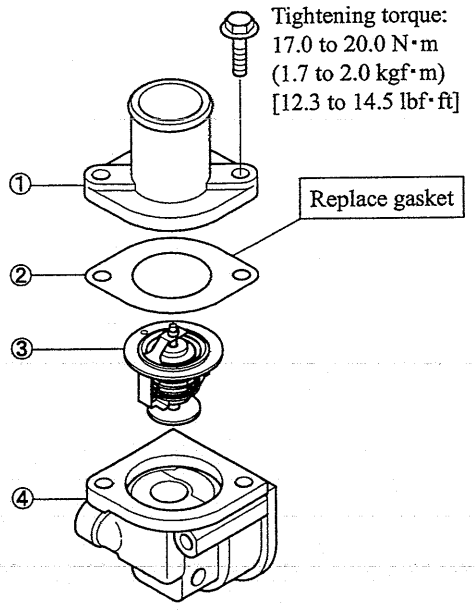
Removal of water pump

< Removal sequence >
① Bolt
② Water pump assembly
③ Gasket

DISASSEMBLY, INSPECTION AND REASSEMBLY OF COOLING SYSTEM

1. Thermostat

1.1 Disassembly of Thermostat



Disassembly of thermostat

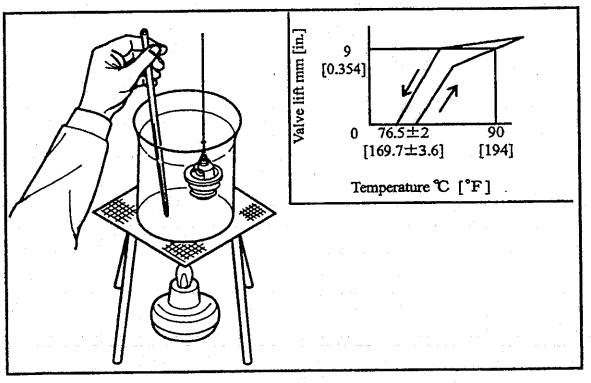
< Disassembly sequence >

① Thermostat cover
② Gasket
③ Thermostat
④ Thermostat case

1.2 Inspection of Thermostat

To test the thermostat operation, immerse the thermostat in a container 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 9 mm [0.354 in.] or more. If the temperatures are not within the standard range, replace the thermostat.

	Standard
Temperature at which valve starts opening	76.5 ± 2 °C [169.7 ± 3.6 °F]
Temperature at which valve lift becomes 9 mm [0.354 in.] or more	90 °C [194 °F]



Inspection of thermostat

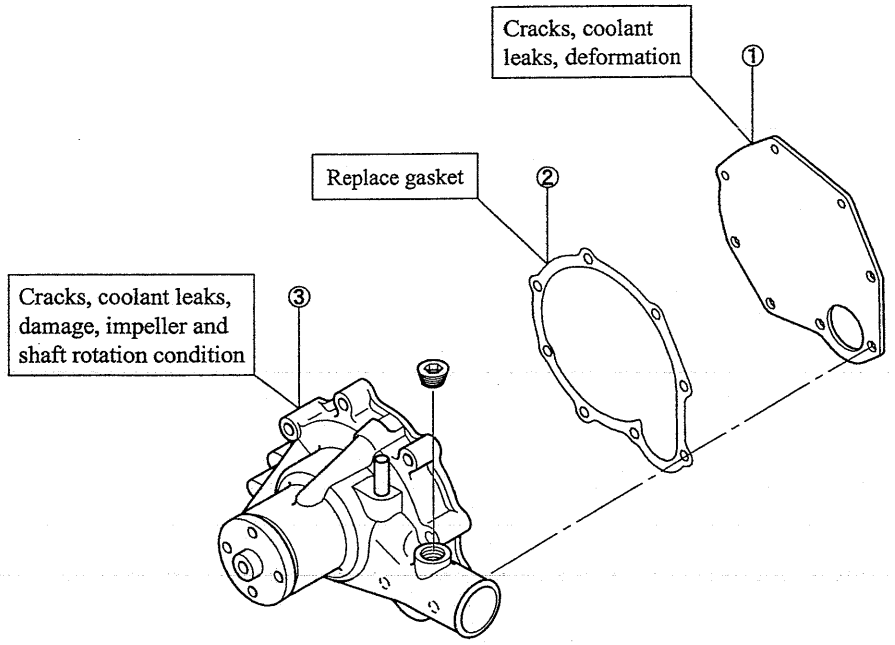
Note: (a) Stir the water in the container with a bar to ensure uniform temperature distribution.
(b) When installing the thermostat, be sure to check the valve opening temperature stamped on the thermostat mounting flange top.

⚠ CAUTION

This is a "hot" operation. Pay every attention to prevent burns and fire.

2. Water Pump

2.1 Disassembly of Water Pump



Disassembly of water pump

< Disassembly sequence >

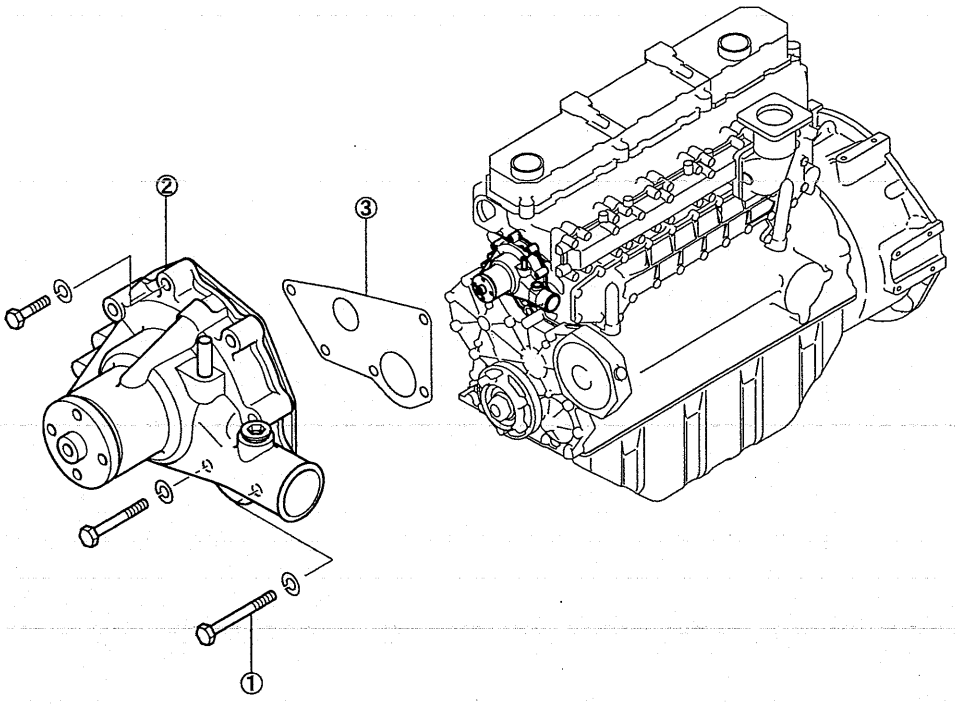
① Water pump cover ② Gasket ③ Water pump

2.2 Inspection of Water Pump

Rotate the impeller and shaft for any noise and binding. If faulty, replace the entire water pump assembly.

INSTALLATION OF COOLING SYSTEM

1. Water Pump

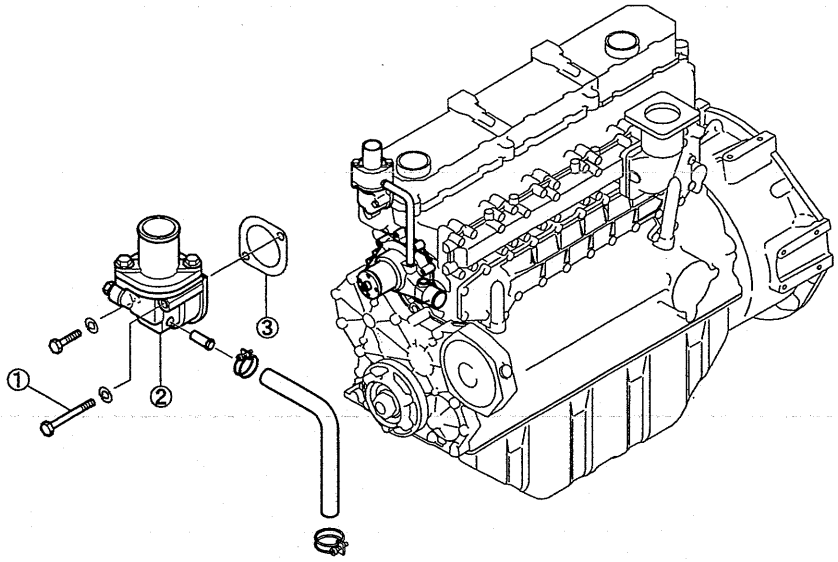


Installation of water pump

< Installation sequence >

③→②→①

2. Thermostat

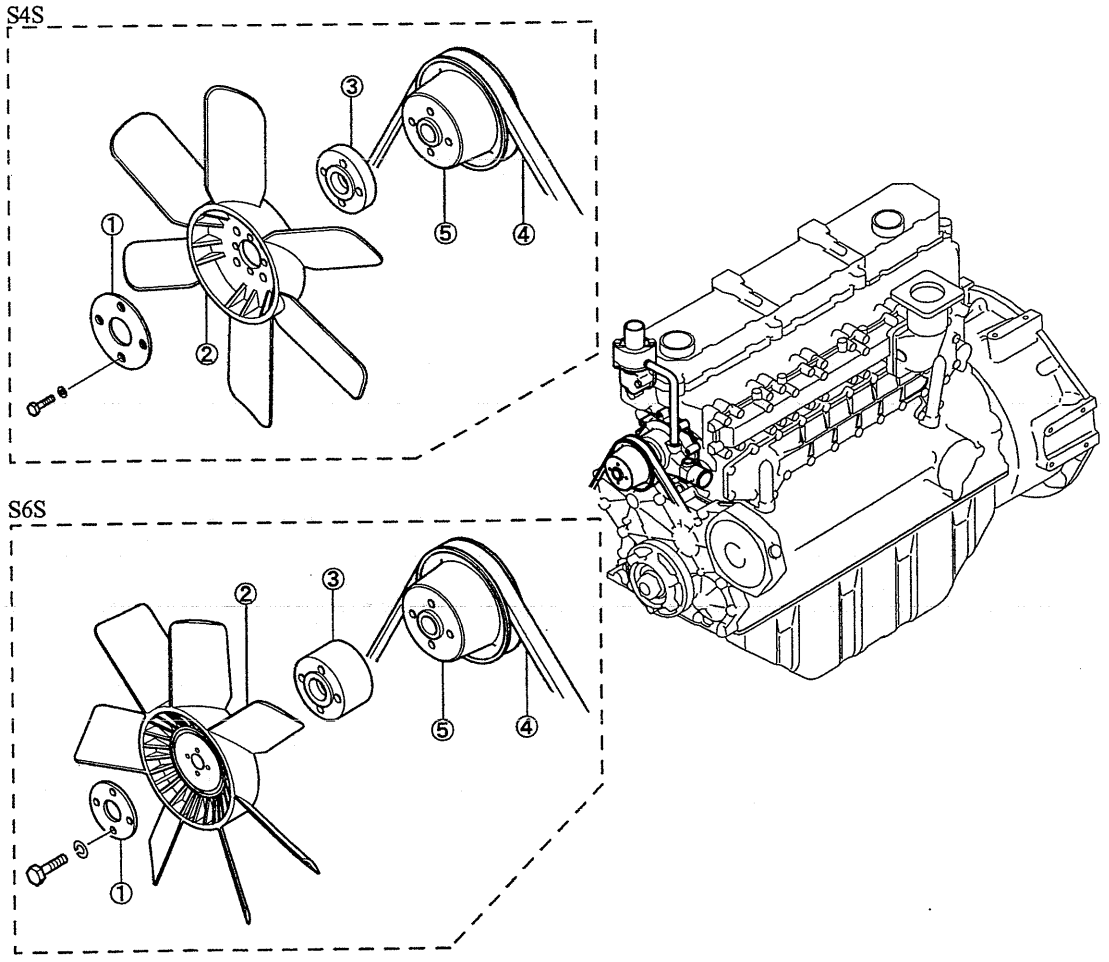


Installation of thermostat

< Installation sequence >

③→②→①

3. Cooling Fan, Fan Pulley and V-Belt



Installation of cooling fan, fan pulley and V-Belt

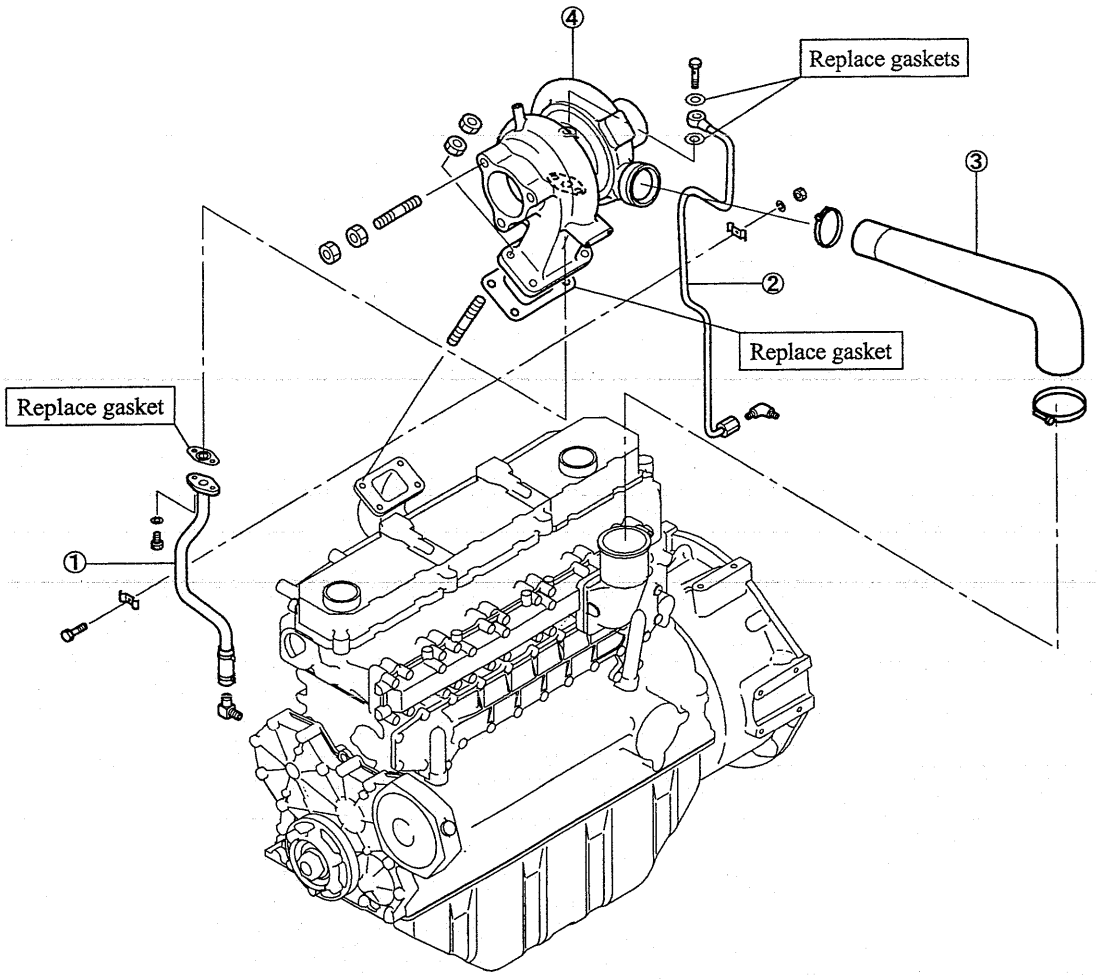
< Installation sequence >

⑤→④→③→②→①

REMOVAL OF INLET AND EXHAUST SYSTEMS

1. Turbocharger

(In-line fuel injection pump specification)

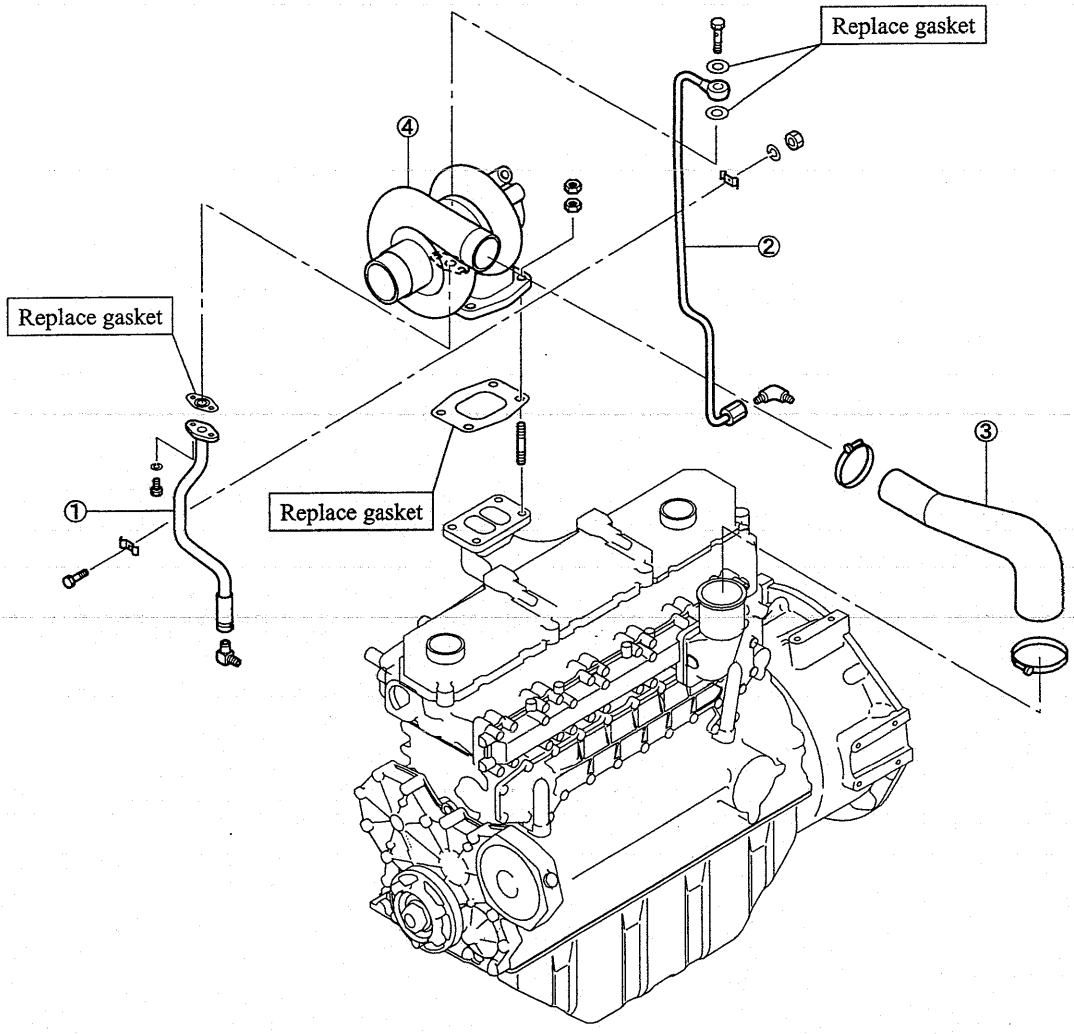


Removal of turbocharger (in-line fuel injection pump specification)

< Removal sequence >

① Oil pipe
② Oil pipe
③ Air hose
④ Turbocharger

(Distributor-type fuel injection pump specification)

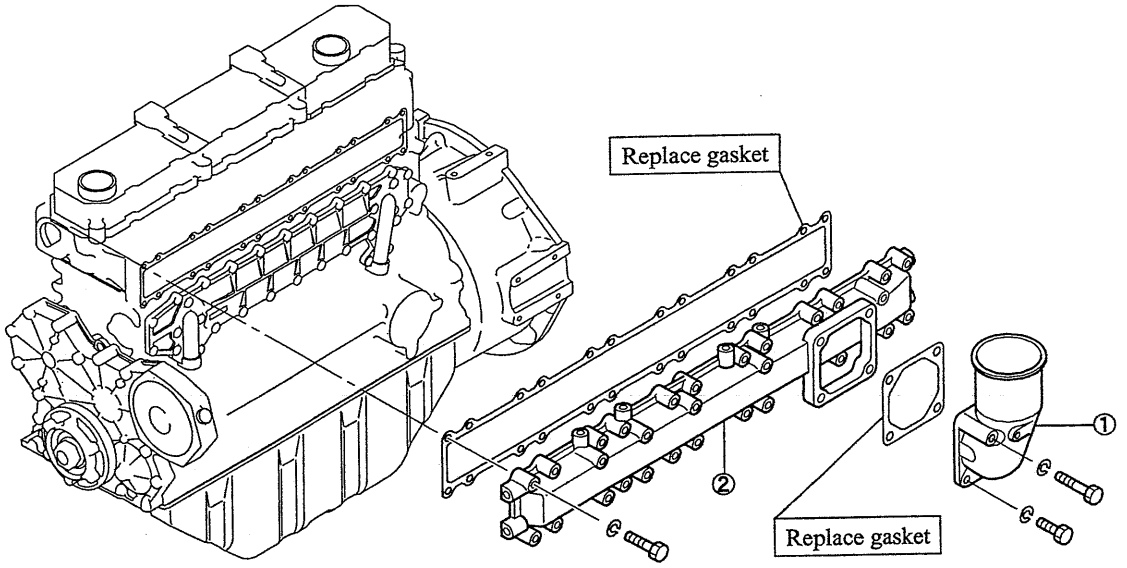


Removal of turbocharger (distributor-type fuel injection pump specification)

< Removal sequence >

① Oil pipe
② Oil pipe
③ Air hose
④ Turbocharger

2. Inlet Manifold

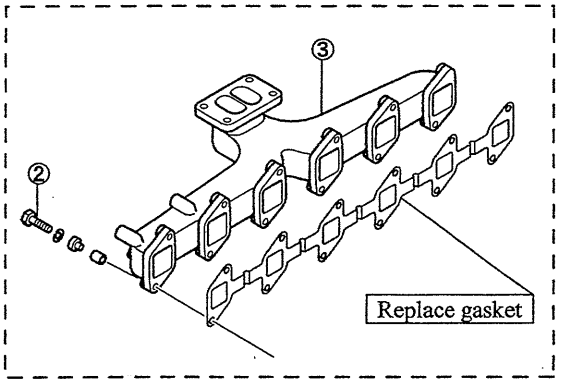


Removal of inlet manifold

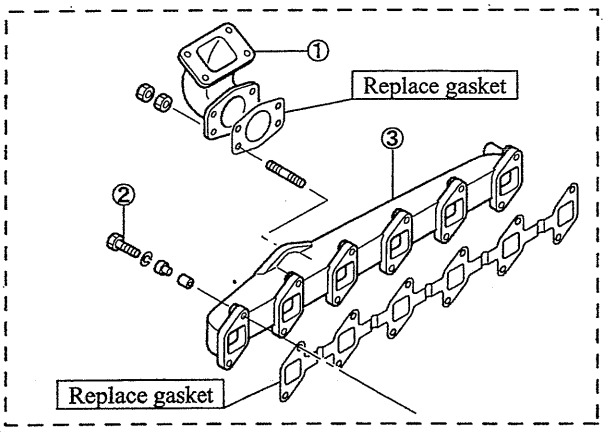
< Removal sequence >
① Air inlet elbow
② Inlet manifold

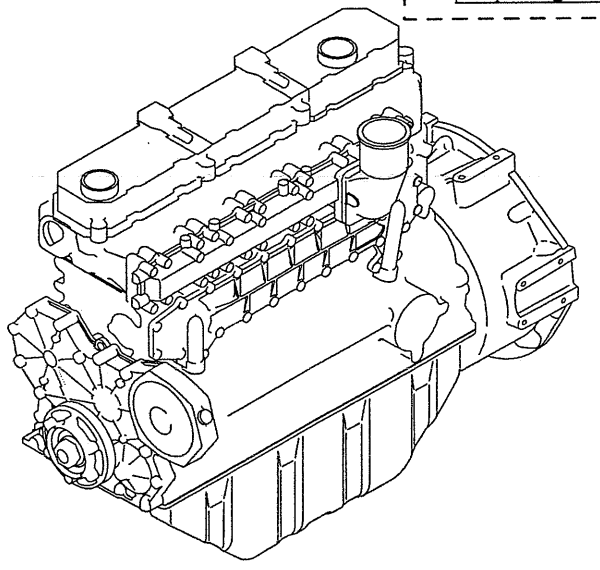
3. Exhaust Manifold

Distributor-type fuel injection pump specification



In-line fuel injection pump specification





Removal of exhaust manifold

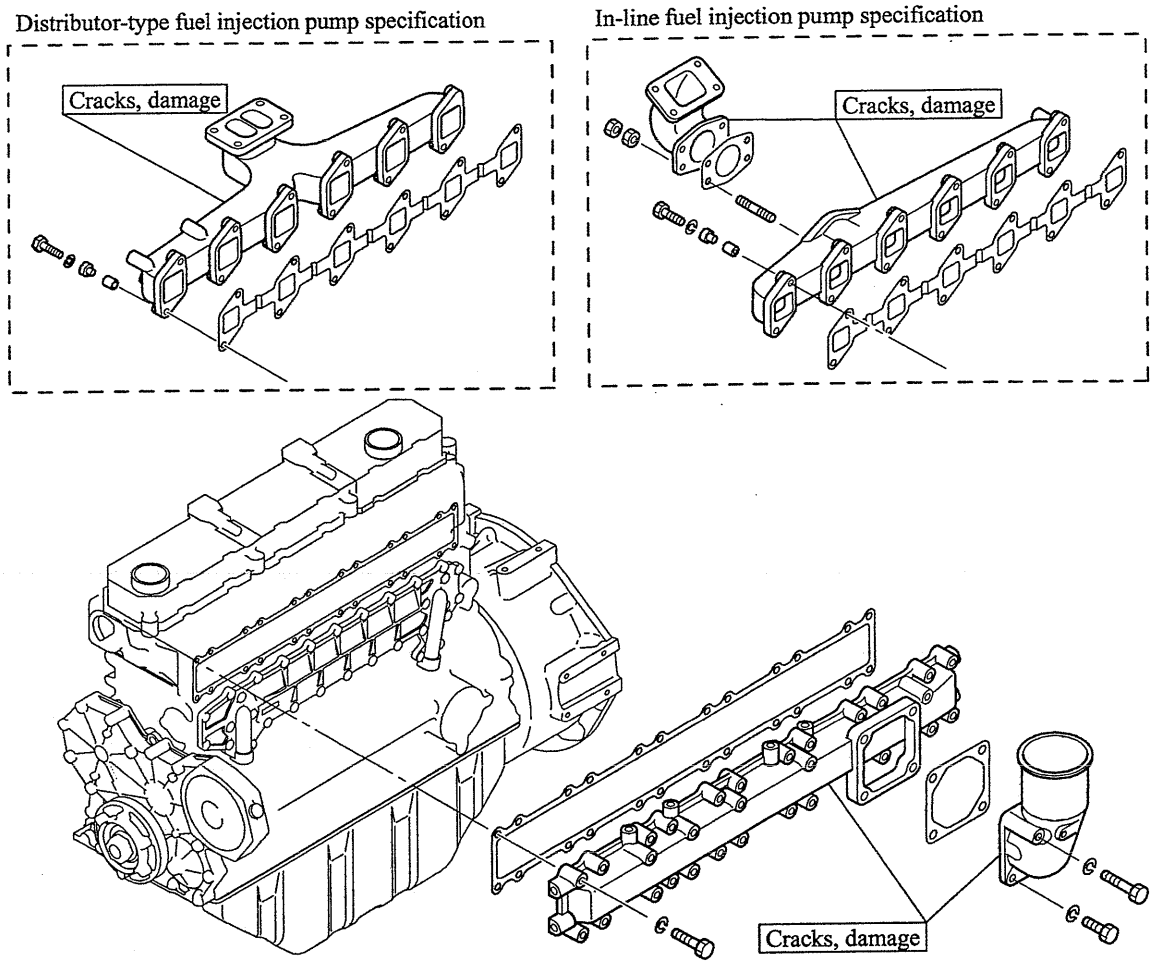
< Removal sequence>

① Exhaust pipe ② Bolt ③ Exhaust manifold

DISASSEMBLY, INSPECTION AND REASSEMBLY OF INLET AND EXHAUST SYSTEMS

1. Inlet and Exhaust Manifolds

1.1 Inspection of Inlet and Exhaust Manifolds



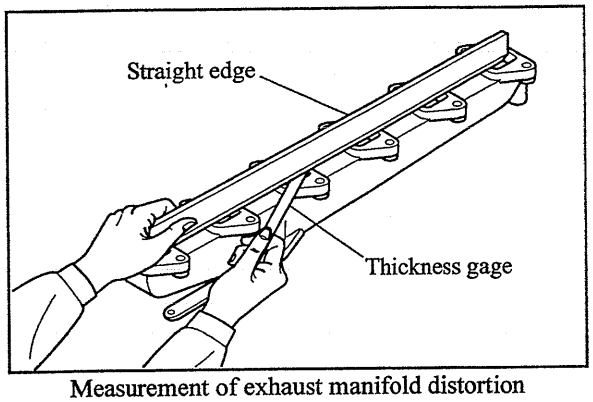
Inspection of inlet and exhaust manifolds

1.2 Measurement of Exhaust Manifold Distortion

Using a straight edge across the cylinder head mounting face of the exhaust manifold and a thickness gage, measure any distortion.
If the measured distortion exceeds the limit, correct by grinding or replace the manifold.

Unit: mm [in.]

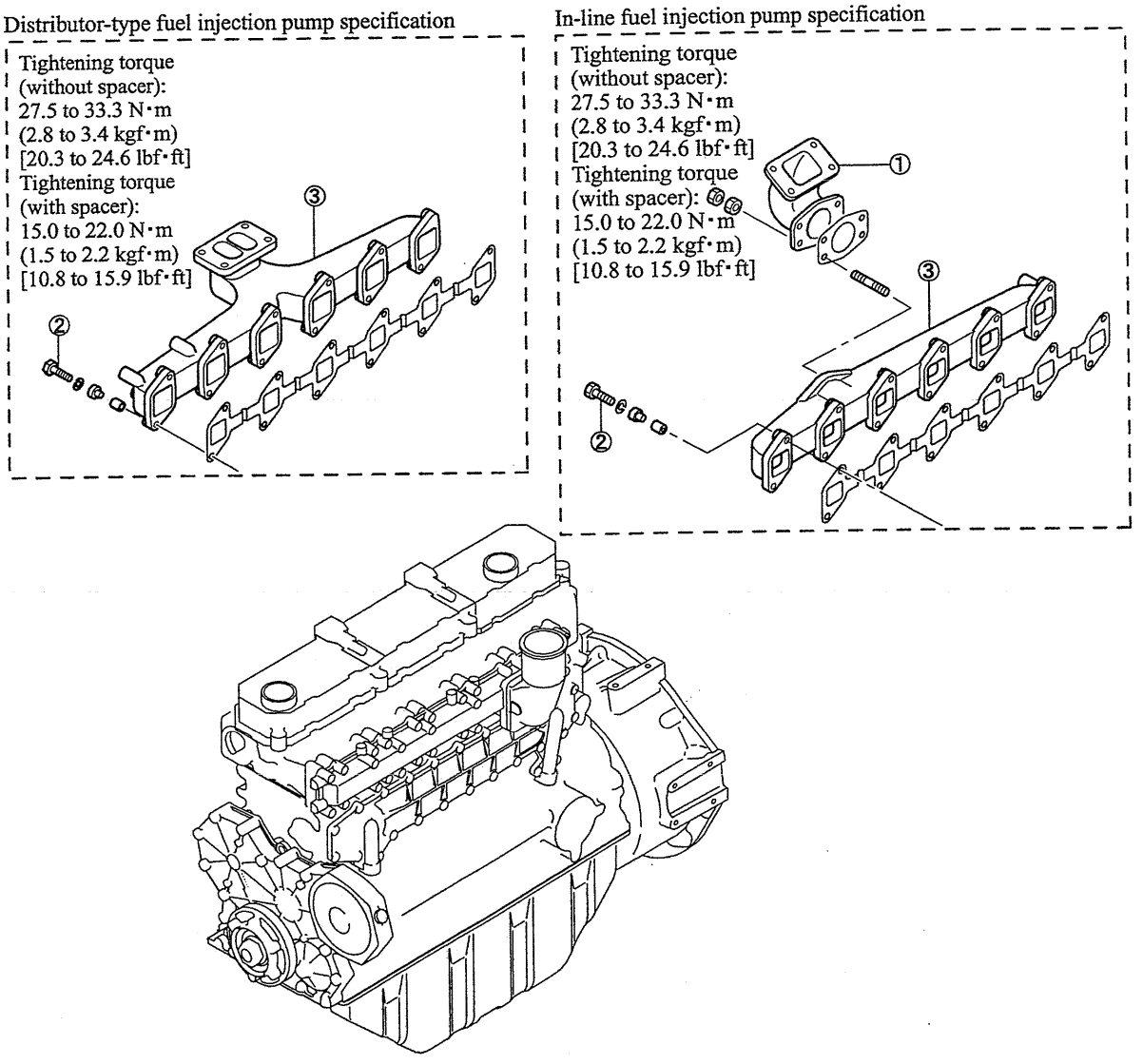
	Limit
Exhaust manifold distortion	0.15 [0.006] or less



Measurement of exhaust manifold distortion

INSTALLATION OF INLET AND EXHAUST SYSTEMS

1. Exhaust Manifold

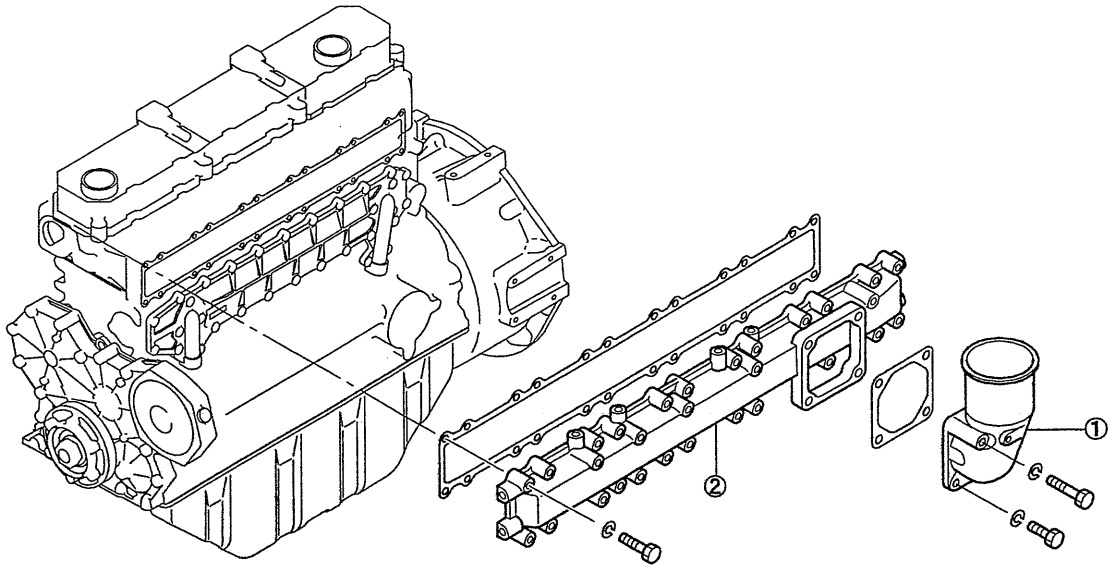


Installation of exhaust manifold

< Installation sequence >

③→②→①

2. Inlet Manifold



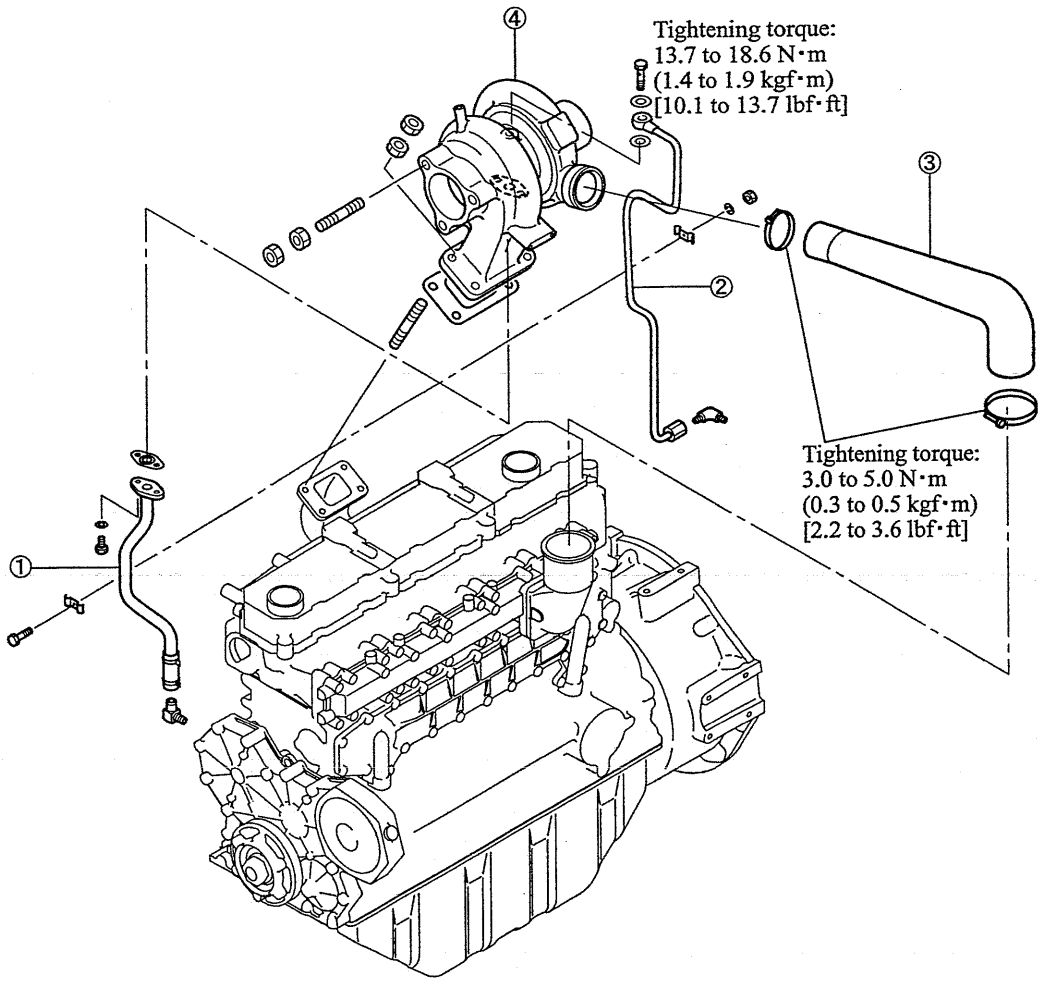
Installation of inlet manifold

< Installation sequence >

②→①

3. Turbocharger

(In-line fuel injection pump specification)

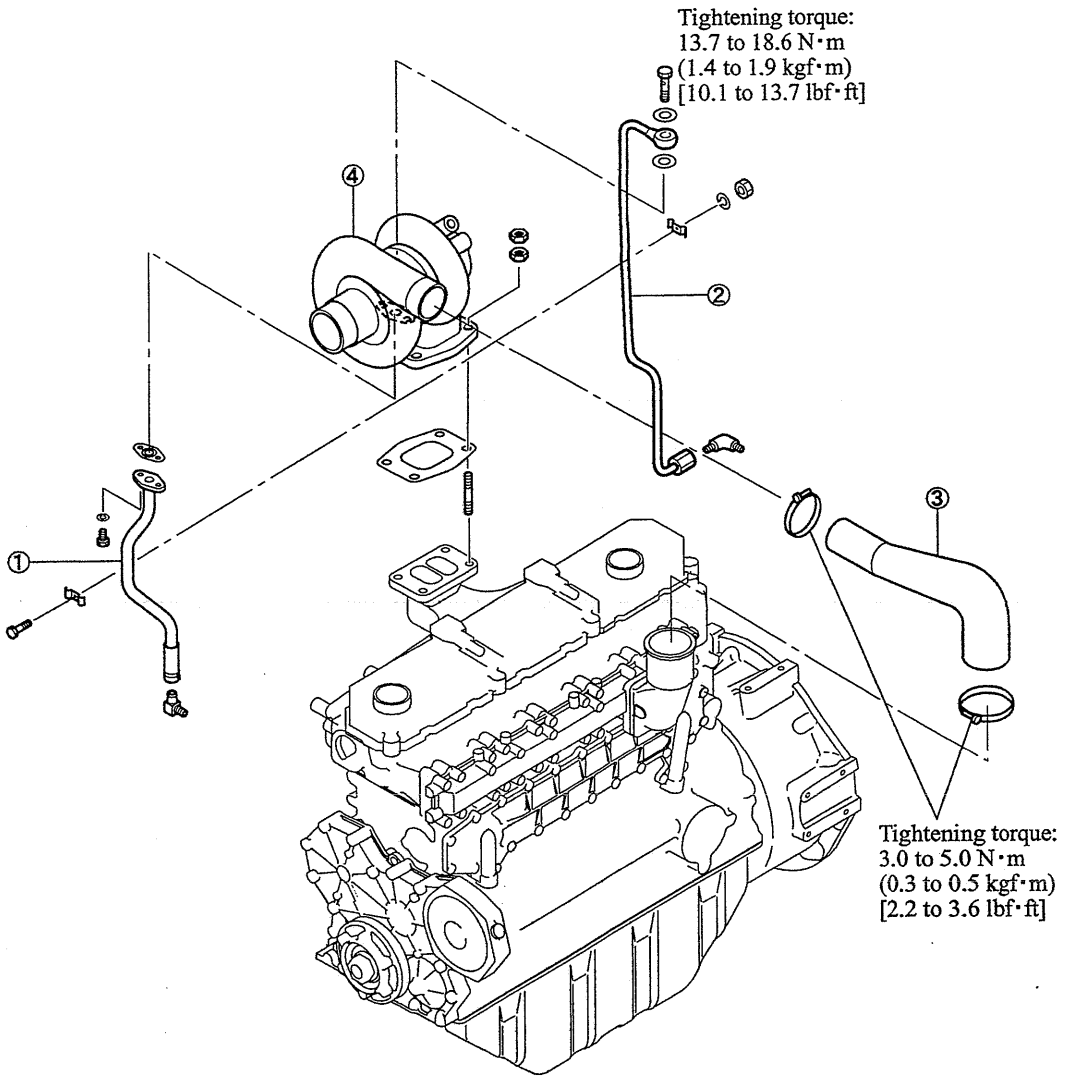


Installation of turbocharger (in-line fuel injection pump specification)

< Installation sequence >

④→③→②→①

(Distributor-type fuel injection pump specification)



Installation of turbocharger (distributor–type fuel injection pump specification)

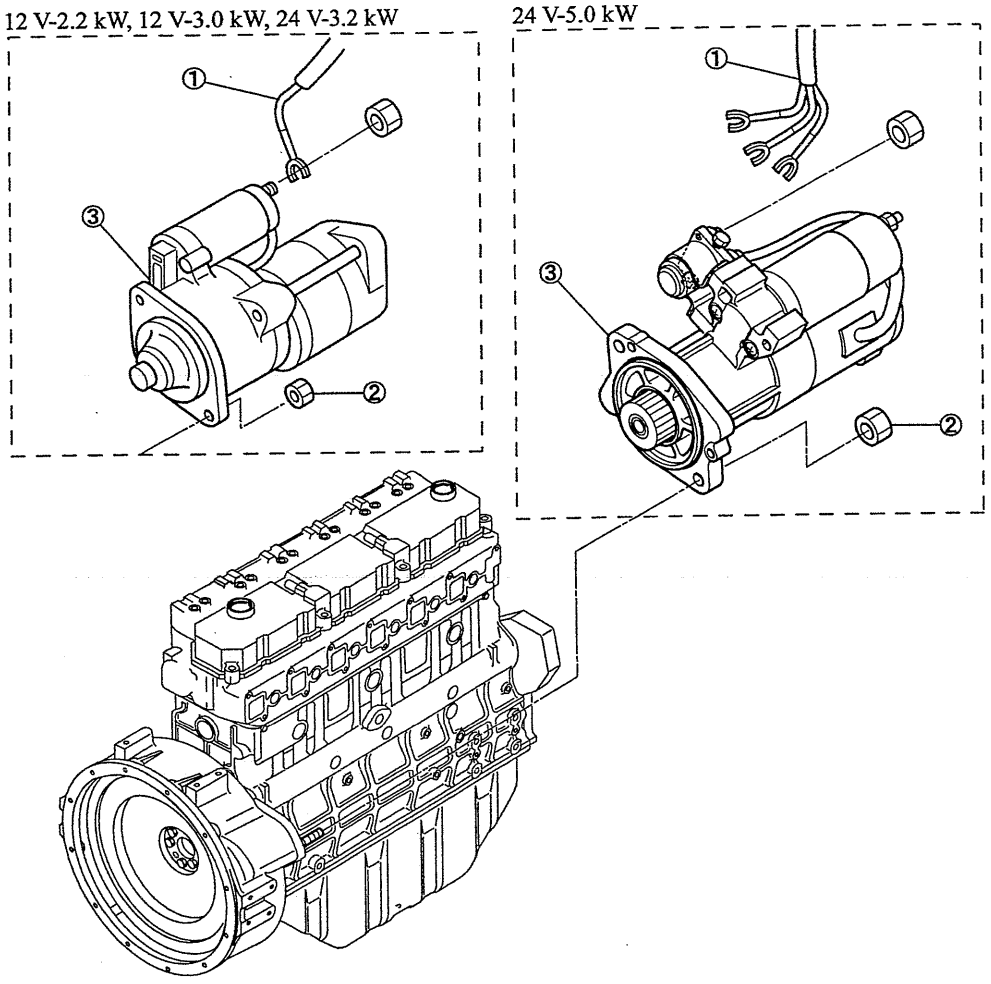
< Installation sequence >

④→③→②→①

REMOVAL OF ELECTRICAL SYSTEM

1. Starter

(12 V-2.2 kW, 12 V-3.0 kW, 24 V-3.2 kW, 24 V-5.0 kW)



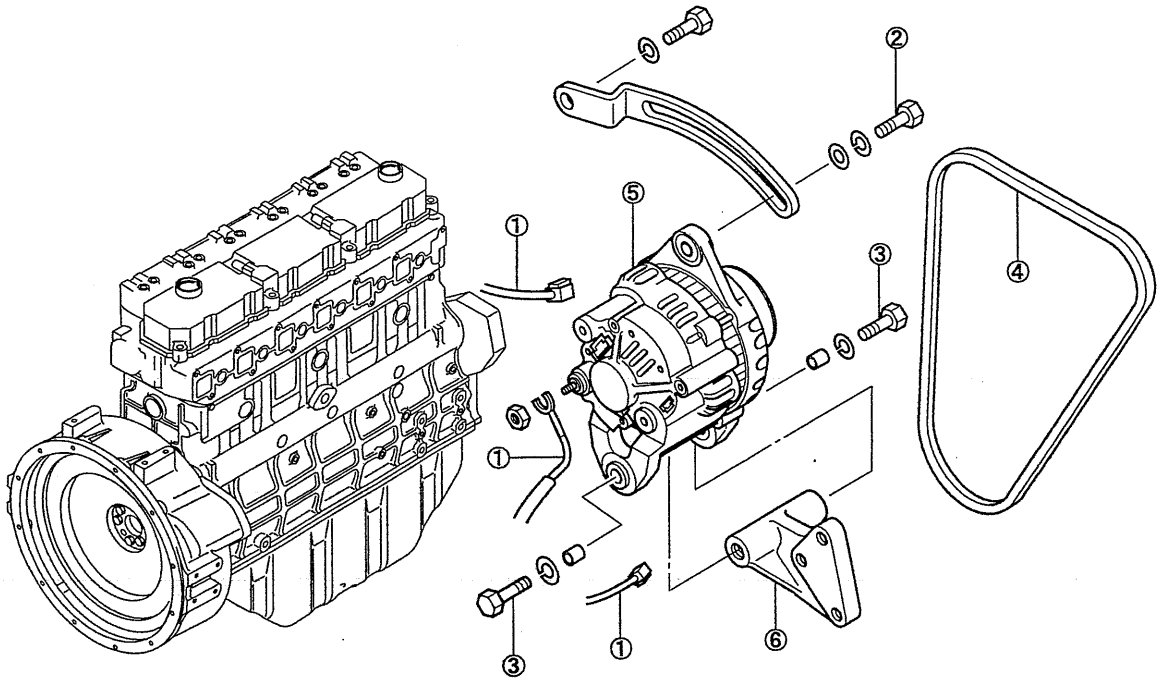
Removal of starter

< Removal sequence >

① Harness ② Nut ③ Starter

2. Alternator

(12 V-50 A, 24 V-25 A)



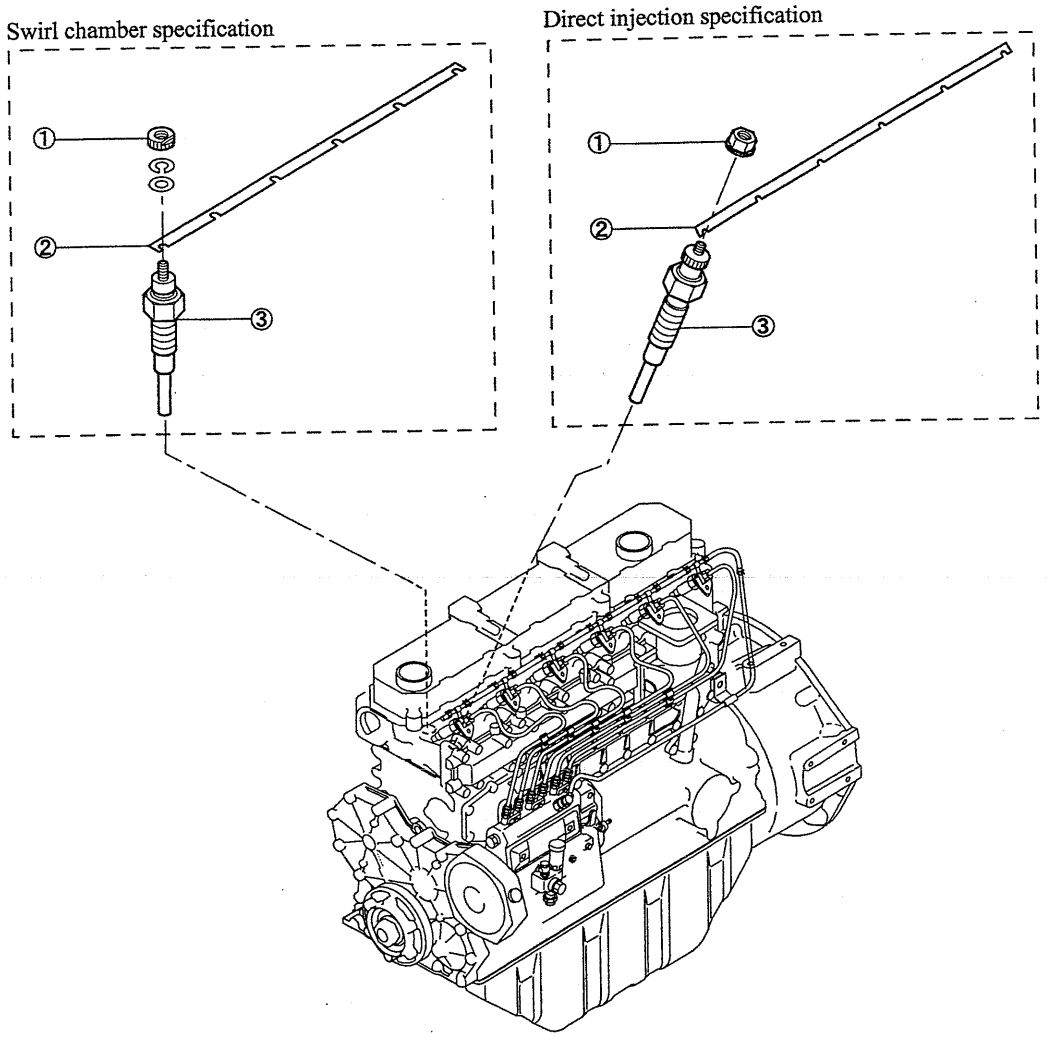
Removal of alternator

< Removal sequence >

① Harness, B terminal
② Adjusting bolt
③ Mounting bolt
④ V-belt
⑤ Alternator
⑥ Alternator bracket

3. Glow Plug

(12 V, 24 V)



Removal of glow plug

< Removal sequence >

① Nut

② Connection plate

③ Glow plug

DISASSEMBLY, INSPECTION AND REASSEMBLY OF ELECTRICAL SYSTEM

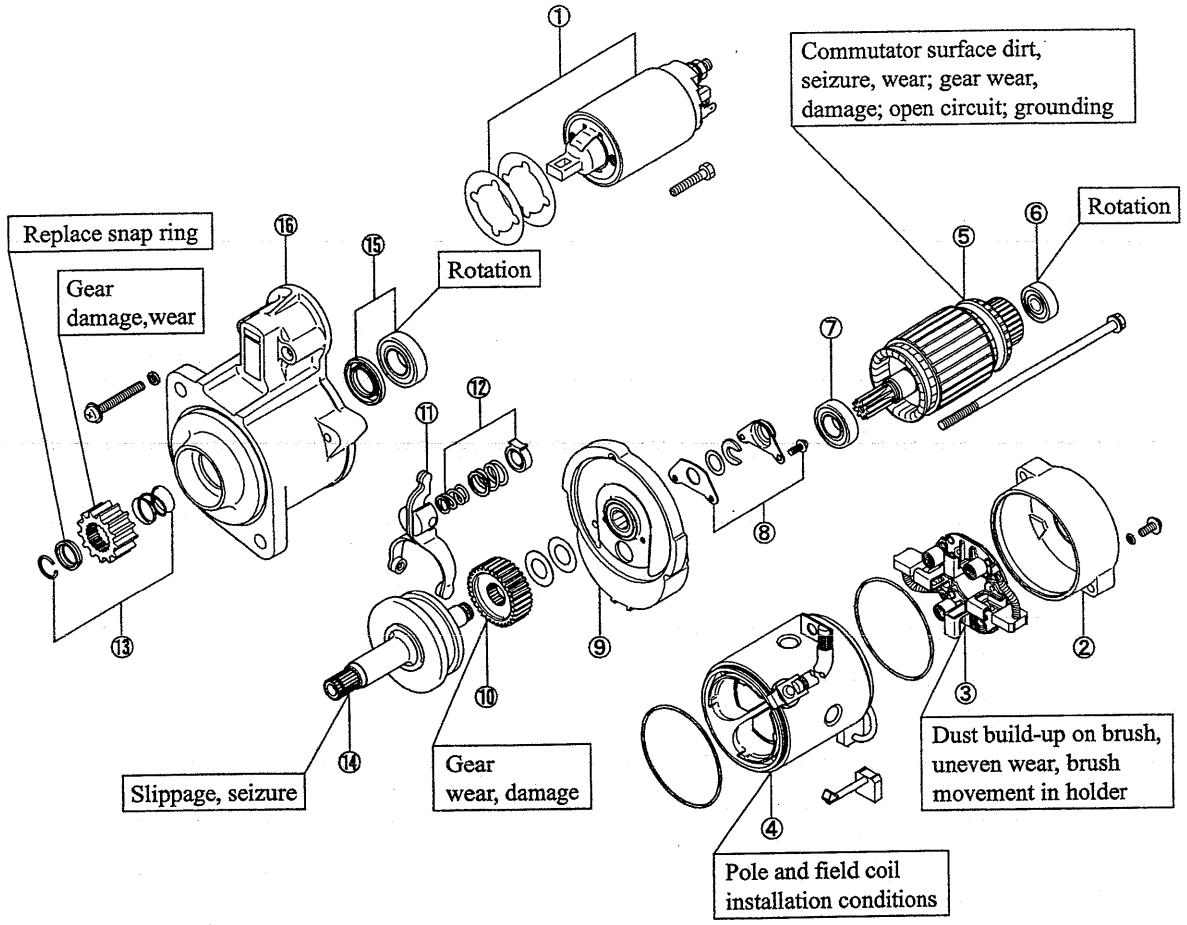
1. Starter

1.1 Disassembly of Starter

M2TS5071 (24 V-3.2 kW)

M3T67671 (12 V-3.0 kW)

M8T75171 (12 V-2.2 kW)

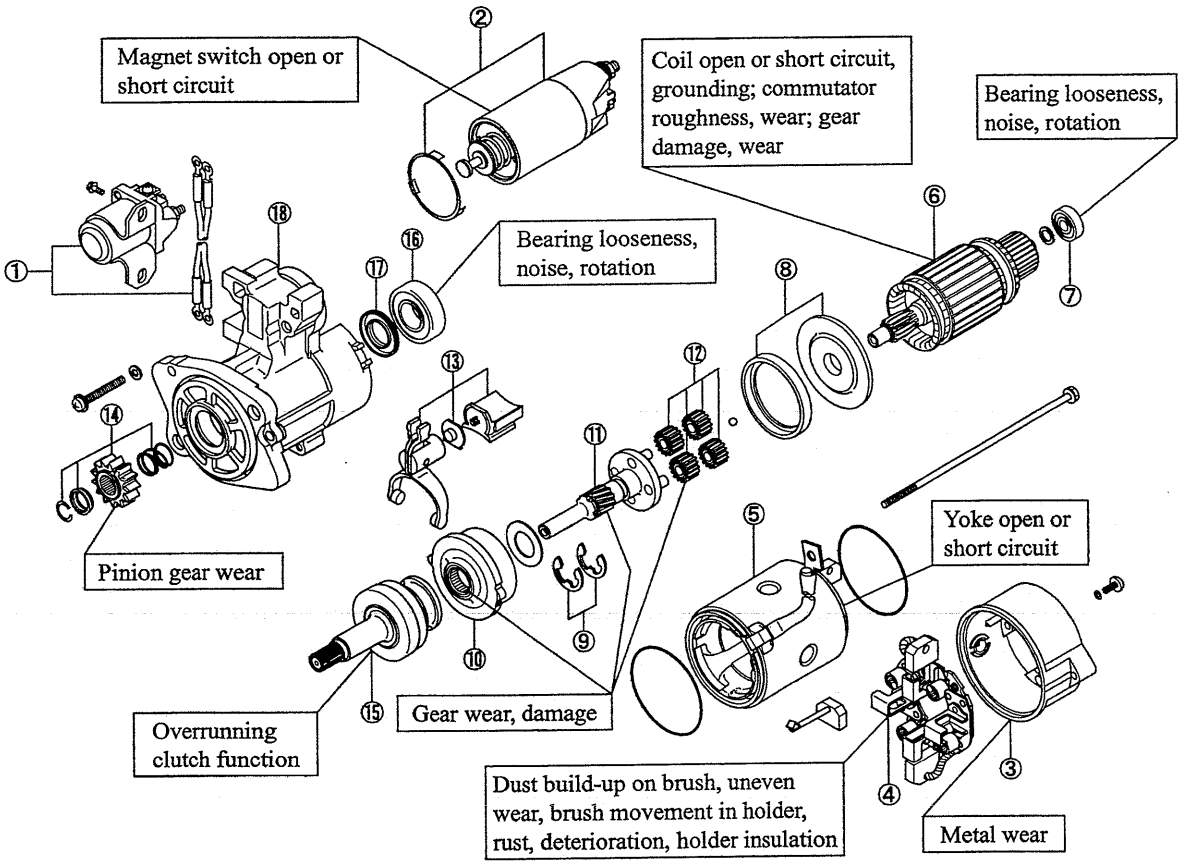


Disassembly of starter (12 V, 24 V)

< Disassembly sequence >

① Switch assembly
② Rear bracket
③ Brush holder assembly
④ Yoke assembly
⑤ Armature
⑥ Bearing
⑦ Ball bearing
⑧ Cover set
⑨ Center bracket assembly
⑩ Gear
⑪ Lever assembly
⑫ Spring set
⑬ Pinion set
⑭ Pinion shaft assembly
⑮ Sleeve bearing set
⑯ Front bracket assembly

M8T60373 (24 V-5 kW)



Disassembly of starter

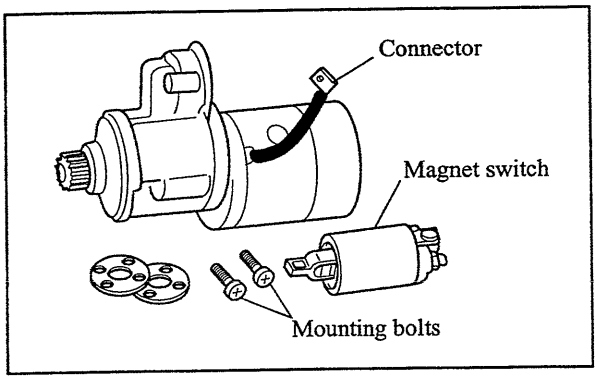
< Disassembly sequence >

① Auxiliary switch
② Magnet switch assembly
③ Rear bracket
④ Brush holder
⑤ Yoke assembly
⑥ Armature
⑦ Ball bearing
⑧ Packing set
⑨ Washer set
⑩ Internal gear
⑪ Gear shaft
⑫ Gear
⑬ Lever assembly
⑭ Pinion set
⑮ Overrunning clutch
⑯ Ball bearing
⑰ Oil seal
⑱ Front bracket

(1) Removing magnet switch

(a) Loosen the nut at terminal M, and disconnect the connector.

(b) Loosen the two magnet switch mounting bolts, and remove the magnet switch.

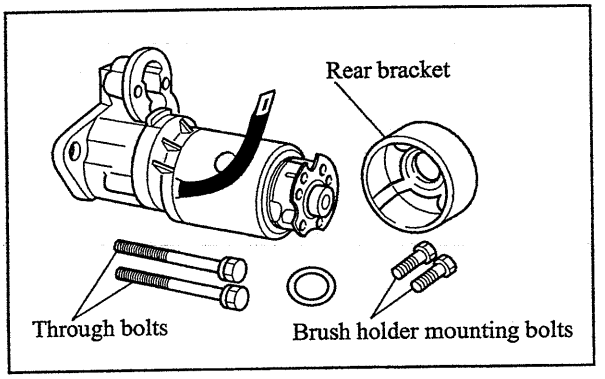


Removing magnet switch

(2) Removing rear bracket

Loosen the two through bolts and the two brush holder mounting bolts. Remove the rear bracket.

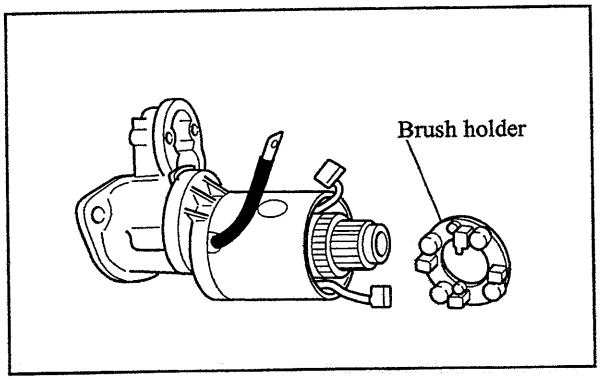
Note: There is an adjusting washer in the rear bracket. Do not lose it.



Removing rear bracket

(3) Removing brush holder

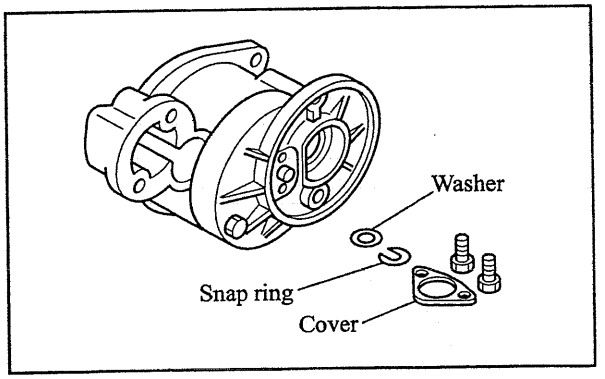
While lifting the two brushes, remove the yoke and brush holder assembly. Pull out the armature from the yoke.



Removing brush holder

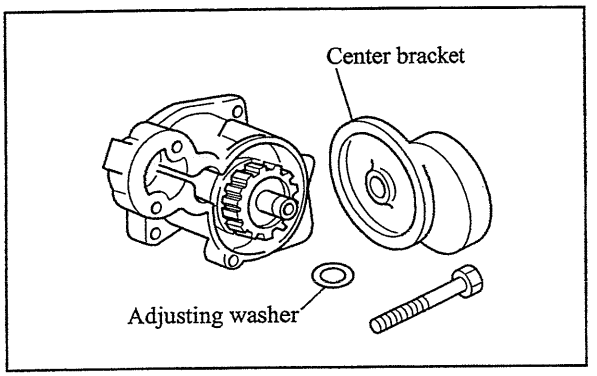
(4) Removing cover

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



Removing cover

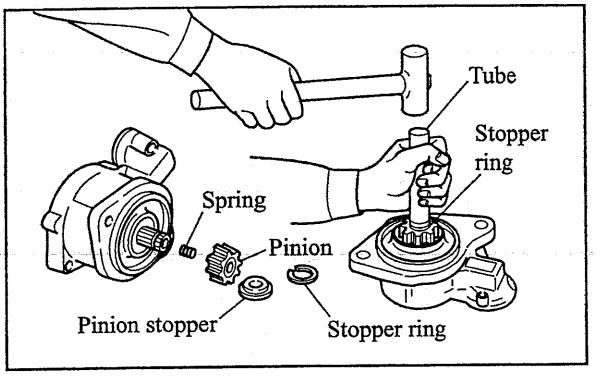
(5) Removing center bracket
Loosen the bolt, and remove the center bracket. This will also remove the washer for adjusting the pinion shaft end play.



Removing center bracket

(6) Removing pinion
(a) 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.
(b) Using a pair of pliers, remove the stopper ring to remove the pinion.

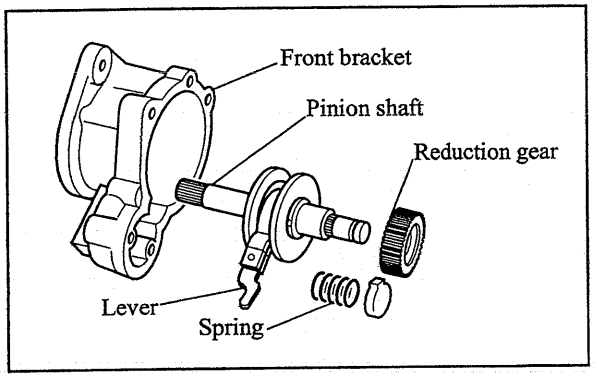
Note: The stopper ring should not be reused on reassembly.



Removing pinion

(7) Removing pinion shaft
Pull out the spring, lever, reduction gear, and pinion shaft from the front bracket.

Note: To facilitate reassembly, note the correct installations of the lever and the spring as they are removed.



Removing pinion shaft

(8) Removing ball bearings
Using a bearing puller or other similar tool, remove the ball bearings at both ends of the armature.
The ball bearing that has been press-fit into the front bracket cannot be replaced. If the ball bearing is worn or faulty, replace the entire front bracket assembly.

1.2 Inspection and Repair of Starter

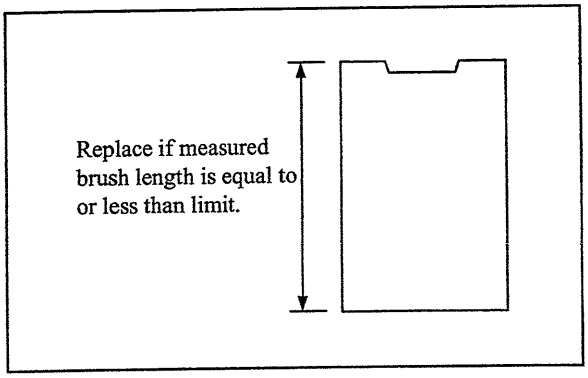
(1) Inspecting brushes

(a) Inspecting brushes for wear

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

Unit: mm [in.]

		Standard	Limit
Brush length	M8T75171	18.0 [0.71]	11.0 [0.43]
	M2TS5071	17.5 [0.69]	
	M3T67671	17.0 [0.67]	
	M8T60373	18.0 [0.71]	



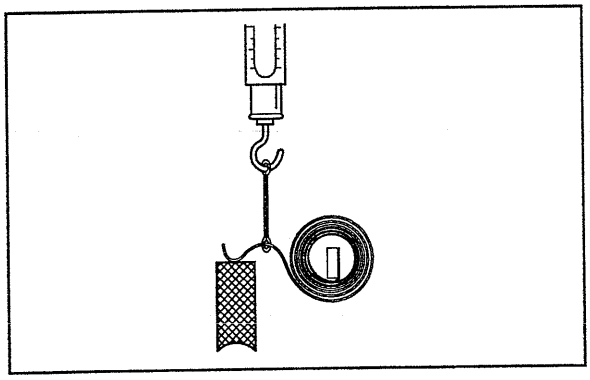
Inspecting brush

(b) Measuring brush spring load

Using a new brush and a spring balance as illustrated, measure the spring load at which the spring lifts from the brush. If the measured value is equal to or less than the limit, replace the spring.

Unit: N (kgf) [lbf]

		Standard	Limit
Brush spring load	M8T75171	26.5 to 36.3 (2.7 to 3.7) [6.0 to 8.2]	14.7 (1.5) [3.3]
	M2TS5071	26.7 to 36.1 (2.7 to 3.7) [6.0 to 8.2]	
	M3T67671	33.3 to 45.1 (3.4 to 4.6) [7.5 to 10.1]	17.7 (1.8) [4.0]
	M8T60373	29.4 to 39.2 (3.0 to 4.0) [6.6 to 8.8]	13.7 (1.4) [3.1]

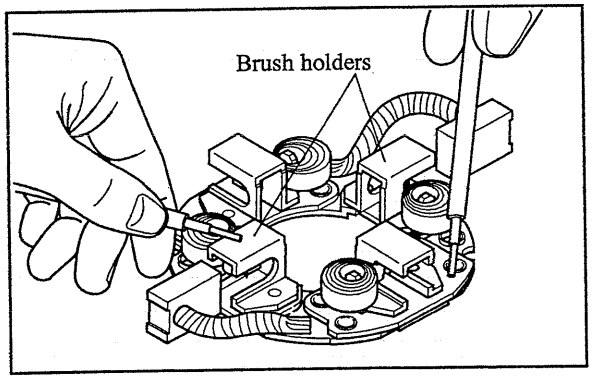


Measuring brush spring load

(c) Inspecting brush holders for grounding

Check for continuity between each brush holder and the brush holder base. If continuity is indicated, replace the entire brush holder assembly.

Check the brush holders for looseness.



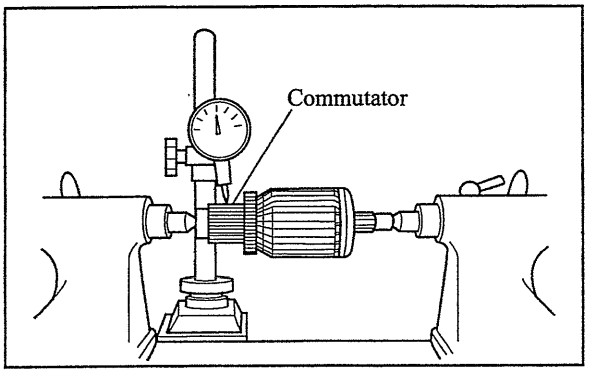
Inspecting brush holders for grounding

(2) Inspecting armature

(a) Using a dial gage, measure the commutator for radial runout. If the measure value is equal to or exceeds the limit, correct (within the outside diameter limit) or replace.

Unit: mm [in.]

		Limit
Commutator radial runout	M8T75171 M2TS5071 M3T67671 M8T60373	0.10 [0.004]

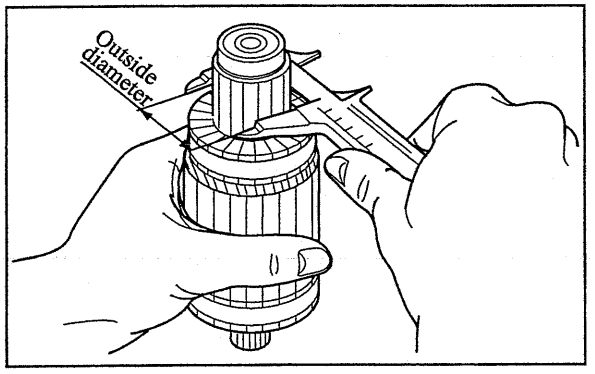


Measuring commutator radial runout

(b) Measure the commutator outside diameter. If the measured value is equal to or less than the limit, replace.

Unit: mm [in.]

		Standard	Limit
Commutator outside diameter	M8T75171	32.0 [1.26]	31.4 [1.24]
	M2TS5071		
	M3T67671	38.7 [1.52]	38.1 [1.50]
	M8T60373	32.0 [1.26]	31.4 [1.24]

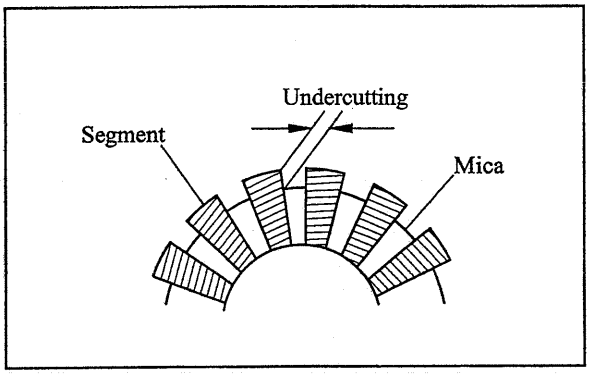


Measuring commutator outside diameter

(c) Measure the depth of undercutting between the commutator segments. If the measured value is equal to or less than the limit, correct or replace.

Unit: mm [in.]

		Standard	Limit
Mica undercutting depth	M8T75171 M2TS5071 M3T67671 M8T60373	0.4 to 0.6 [0.016 to 0.024]	0.2 [0.008]

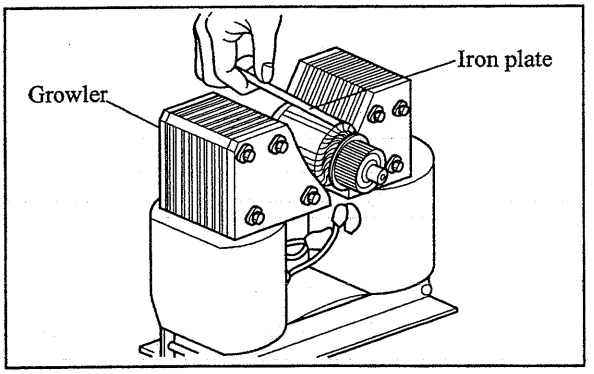


Measuring mica undercutting depth

(d) Testing armature coil for short circuit

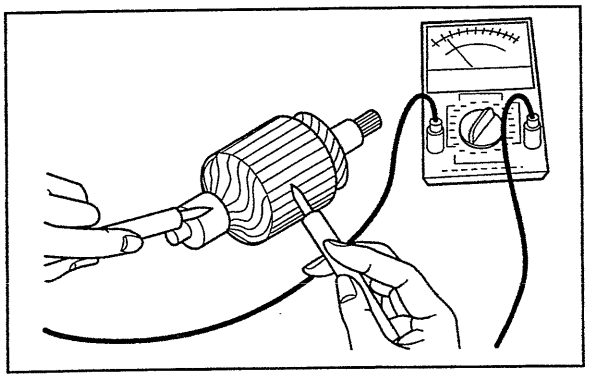
Using a growler, test the armature coil for short circuit. Replace if short circuit is indicated.

How to inspect: (Before inspection, remove any debris from the armature coil.) With a thin iron plate positioned parallel with the armature coil, slowly rotate the armature coil. While the coil is running, the iron plate should not be pulled onto the coil or vibrate.



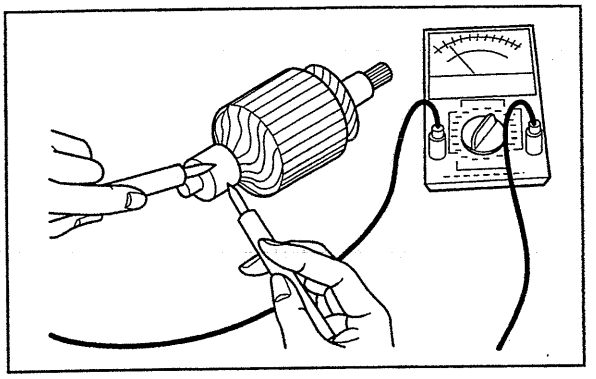
Testing armature coil for short circuit

(e) Testing armature coil for grounding
Check for continuity between the commutator segment and the armature coil. If continuity is indicated, replace the armature.



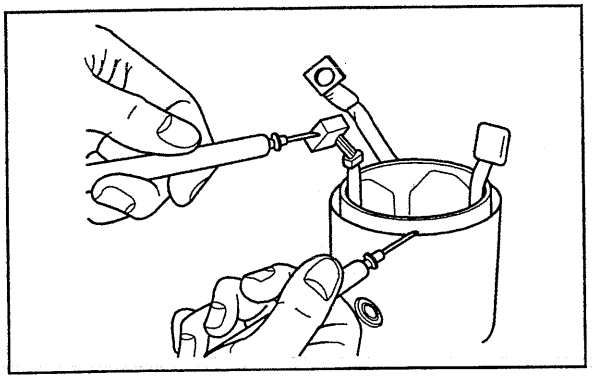
Testing armature coil for grounding

(f) Testing armature coil for open circuit
Check for continuity between the segments in various combinations. If no continuity is indicated, replace the armature.



Testing armature coil for open circuit

(3) Inspecting field coil
(a) There should be no continuity between each coil end (brush) and the yoke.
(b) There should be continuity between the coil ends (brushes).
(c) The pole-shoes and the coil should not be loose. If faulty, replace the yoke.



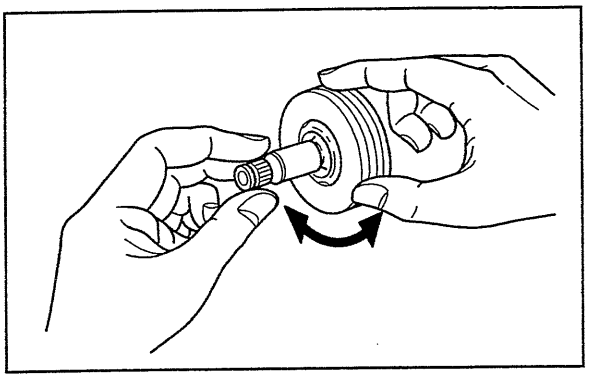
Inspecting field coil

(4) Inspecting bearings
Check that the bearings rotate smoothly without abnormal noise. If faulty, replace.

(5) Inspecting overrunning clutch

(a) Turn the pinion shaft by hand, and check the following items. If faulty, replace the overrunning clutch.
- The pinion shaft should rotate smoothly when turned clockwise.
- The pinion shaft should not rotate when turned counterclockwise.

(b) Check the pinion for wear or damage. If faulty, replace.



Inspecting overrunning clutch

⚠ CAUTION

Do not wash the overrunning clutch in wash oil.

(6) Inspecting front bracket
The ball bearing should rotate smoothly without abnormal noise. If faulty, replace the entire front bracket.

(7) Inspecting rear bracket
If the metal is worn, replace the rear bracket.

(8) Inspecting internal gear, planetary gears, and armature shaft gear
Replace if worn or damaged.

(9) Inspecting lever
As the lever's friction surface with the overrunning clutch wears, the pinion gap goes out of the standard value. If so, adjust or replace the lever.

(10) Inspecting magnet switch

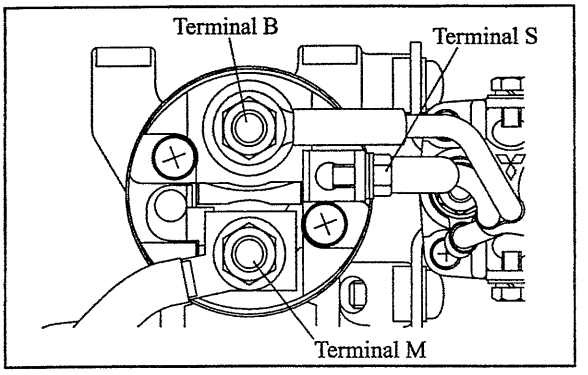
Inspect the magnet switch for the following items. When it is found to be faulty, replace it.

(a) Opening of coil

Check that there is continuity between the terminals S and M and between the terminal S and ground. If there is no continuity, replace the magnet switch.

(b) Welding of contacts

Check that there is no continuity between the terminals B and M. If there is, the contacts are welded closed. Replace the magnet switch.



Inspecting magnet switch

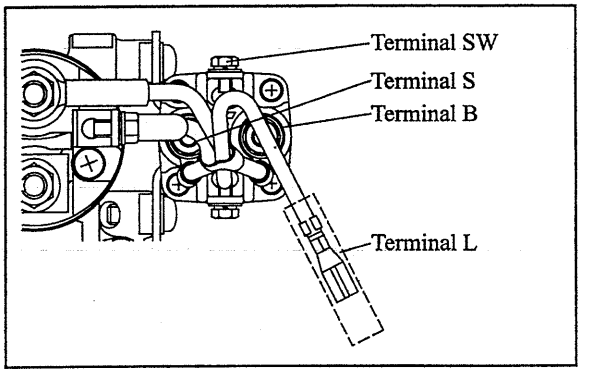
(11) Inspecting starter relay

(a) Opening of coil

Check that there is continuity between the terminals SW and L. If there is no continuity, replace the starter relay.

(b) Welding of contacts

Check that there is no continuity between the terminals S and B. If there is, the contacts are welded closed. Replace the starter relay.



Inspecting starter relay

1.3 Reassembly of Starter

To reassemble, follow the disassembly sequence in reverse and observe the following.

(1) Lubrication

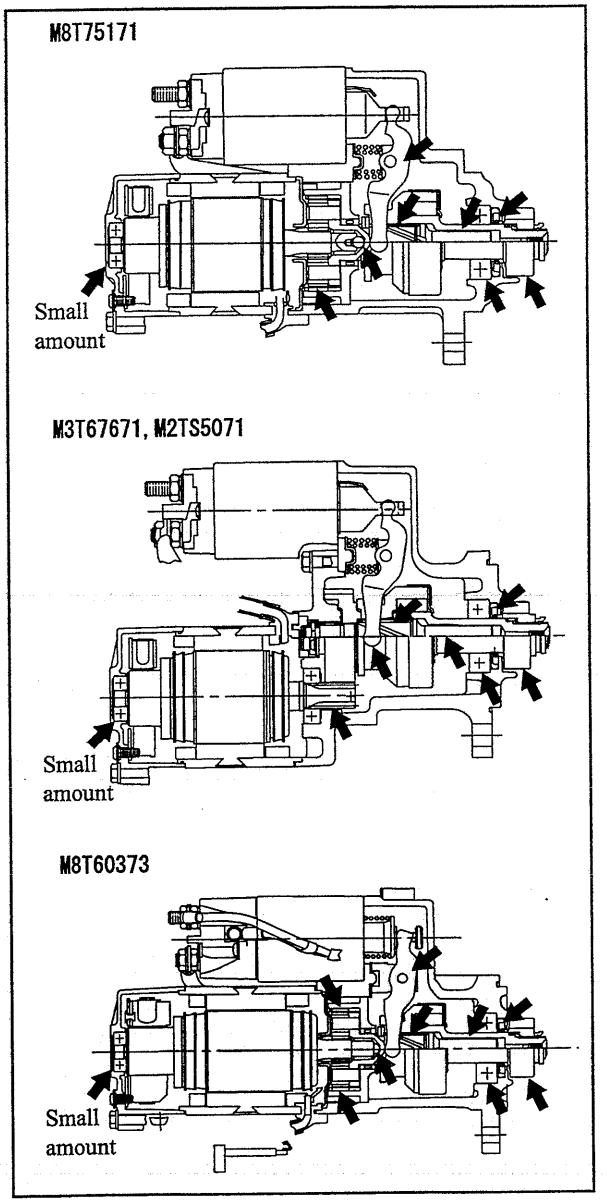
When the starter is overhauled, apply grease to the following sliding surfaces, gears and bearings.

Grease	Multemp PS2 (KYODO YUSHI CO.,LTD) or equivalent

(a) Armature shaft gear and reduction gear
(b) Bearings
(c) Pinion shaft washer and stopper ring
(d) Pinion
(e) Lever's sliding surfaces

⚠ CAUTION

Ensure that the starter mounting face, the brushes, the commutator and other current-carrying parts are not smeared with grease.

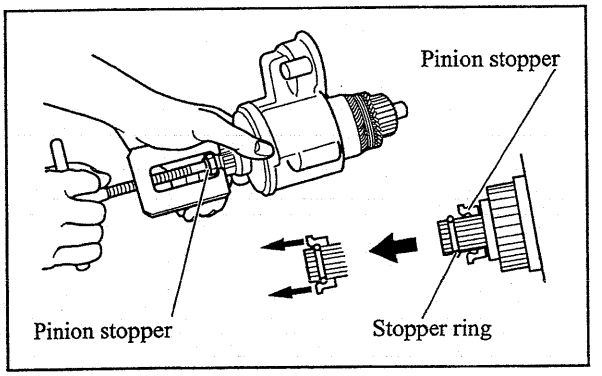


Applying grease

(2) Installing stopper ring

Install a new 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.

Note: On reassembly, use a new stopper ring.



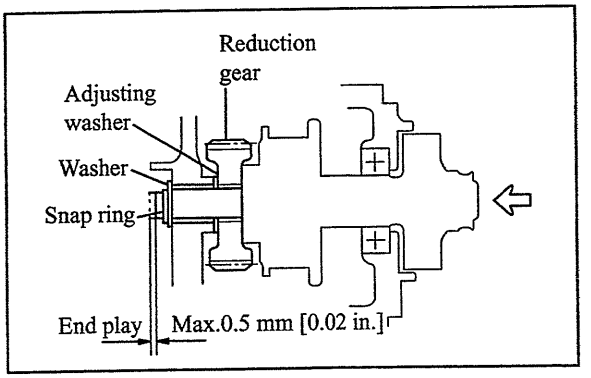
Installing stopper ring

(3) Adjusting pinion shaft end play

Adjust the end play (thrust gap) to 0.5 mm [0.02 in.] or less as illustrated by inserting an appropriate washer between the center bracket and the reduction gear.

(a) Install the pinion shaft complete with the reduction gear washer and snap ring onto the center bracket.

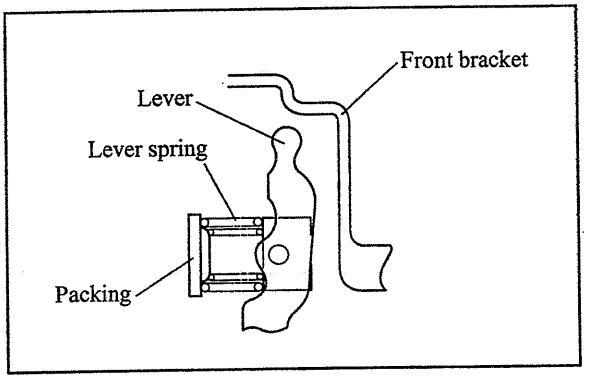
(b) Measure the pinion shaft end play by moving the shaft in the axial direction. If the measured value exceeds 0.5 mm [0.02 in.], correct by adding adjusting washers.



Adjusting pinion shaft end play

(4) Installing lever

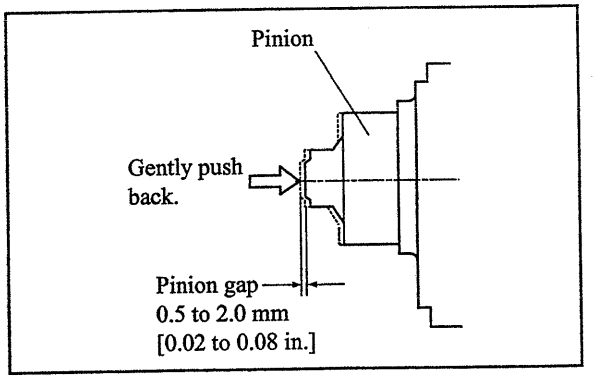
Install the lever in the correct orientation.



Installing lever

(5) Inspecting pinion gap

With the pinion fully pulled out to the rear, gently push back the end of the pinion with a finger and measure the distance that the pinion has moved back. If the measured distance is out of the 0.5 to 2.0 mm [0.02 to 0.08 in.] range, add or reduce the packings mounted at the magnetic switch. If the pinion gap is too great, add the packings. If the pinion gap is too small, reduce the packings.

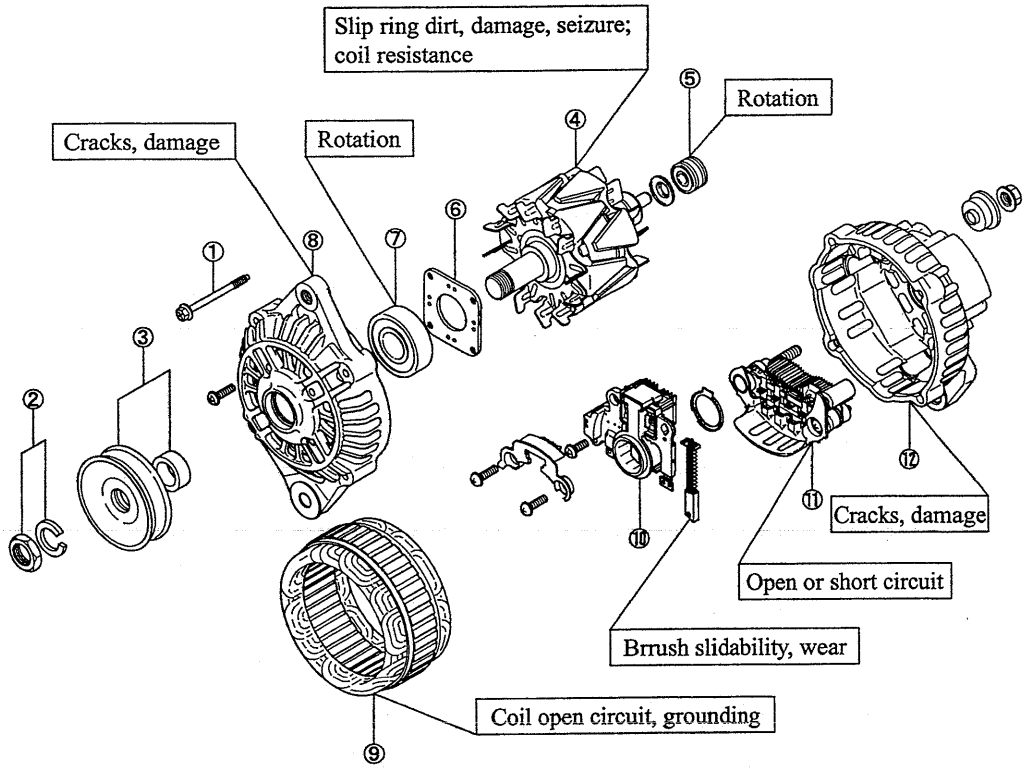


Adjusting pinion gap

2. Alternator

2.1 Disassembly of Alternator

(12 V-50 A, 24 V-25 A)



Disassembly of alternator

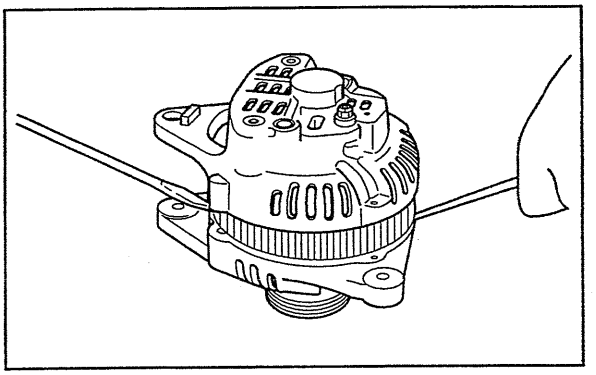
< Disassembly sequence >

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

(1) Separating front bracket from stator core
With flat-head screwdrivers positioned between the front bracket and the stator core, pry them away from each other.

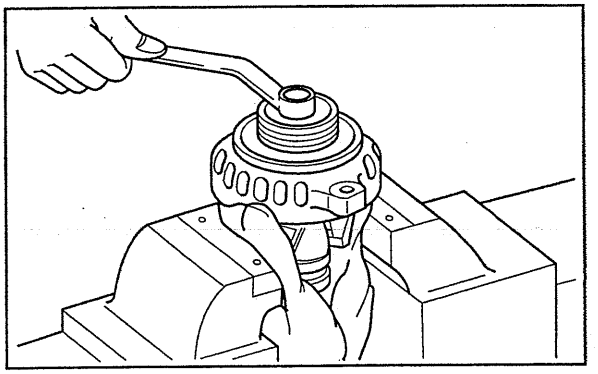
⚠ CAUTION

Do not insert the screwdrivers too deep, as it can damage the stator core.



Separating front bracket from stator core

(2) Removing pulley
(a) Protecting the rotor with a cloth, place the front bracket and rotor assembly in a vice. Remove the pulley nut, and then remove the pulley and spacer.
(b) Pull out the rotor from the front bracket.



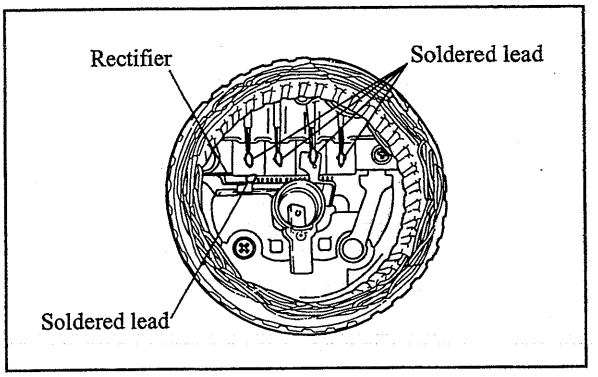
Removing pulley

(3) Removing stator core and rectifier
(a) Unsolder the stator core leads at the rectifier. Remove the stator core.

⚠ CAUTION

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

(b) Loosen the mounting screws, and remove the rectifier.

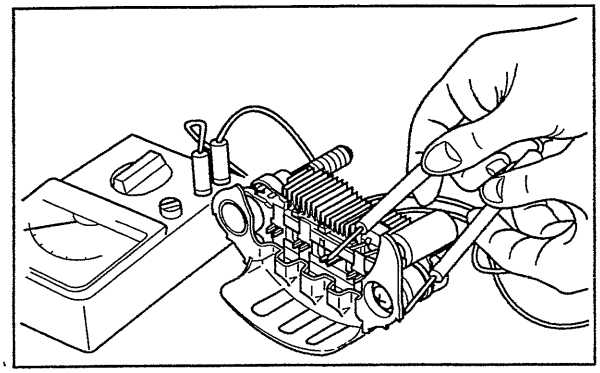


Removing stator core

2.2 Inspection and Repair of Alternator

(1) Inspecting diodes
Perform continuity test on each of the rectifier diodes in the following manner.

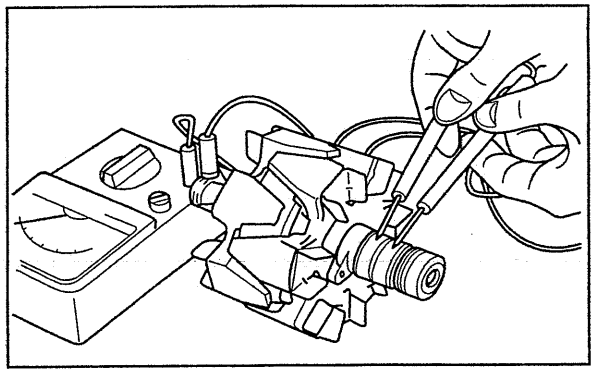
(a) Connect a tester between the diode lead terminal and the casing of that diode. A great resistance should be indicated in one direction and a small resistance in the opposite direction.
(b) If the same level of resistance is indicated in both directions, replace the rectifier.
Perform this test on all diodes.



Inspecting diodes

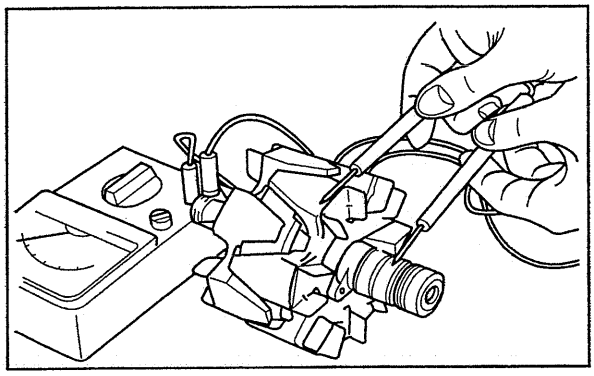
(2) Inspecting field coils

(a) Check for continuity between the slip rings. Replace if no continuity is indicated (open circuit).



Testing field coils for continuity

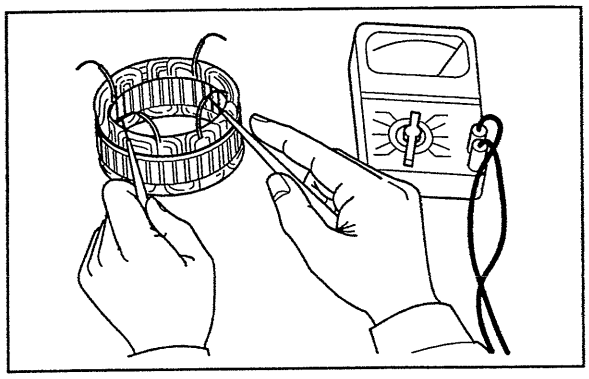
(b) Check for continuity between each slip ring and the shaft (or the core). Replace if continuity is indicated.



Testing field coils for grounding

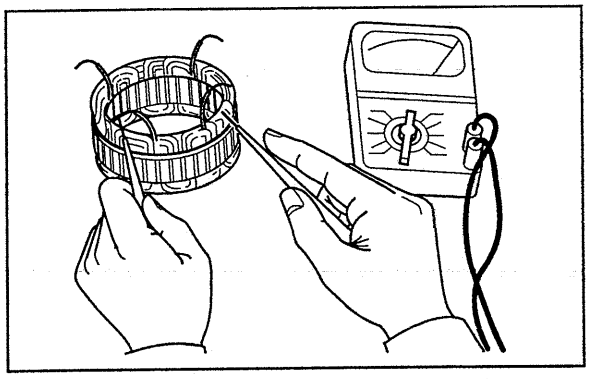
(3) Inspecting stator core

(a) Check for continuity between the stator leads in various combinations. Replace if no continuity is indicated (open circuit).



Testing stator core for continuity

(b) Check for continuity between each lead and the stator core. Replace if continuity is indicated.



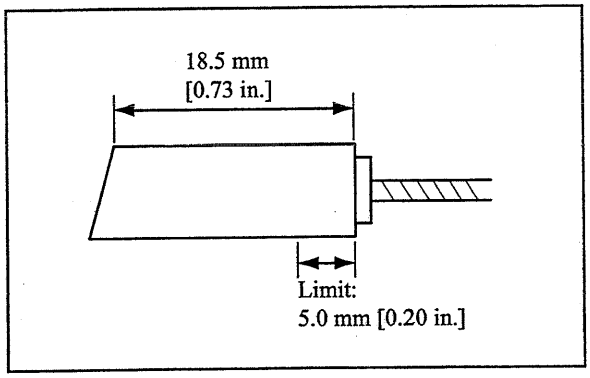
Testing stator core for grounding

(4) Inspecting brushes

(a) Measure the brush length. Replace if the measured value is equal to or less than the limit.

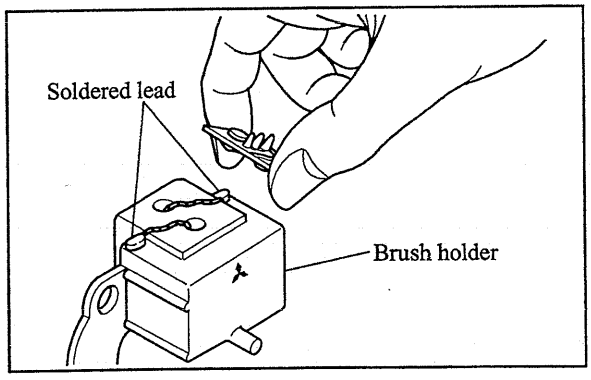
Unit: mm [in.]

	Standard	Limit
Brush length	18.5 [0.73]	5.0 [0.20]



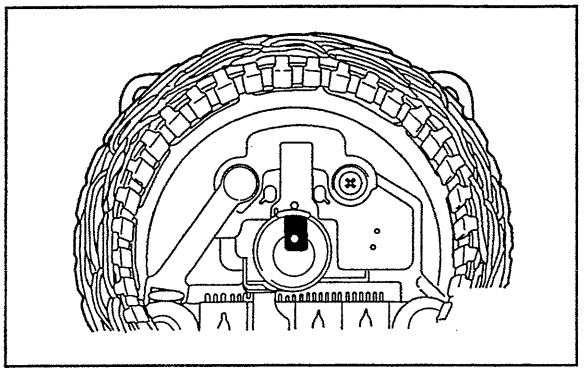
Inspecting brush

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



Removing brush

(c) Push a new brush into the brush holder, and solder the brush lead.

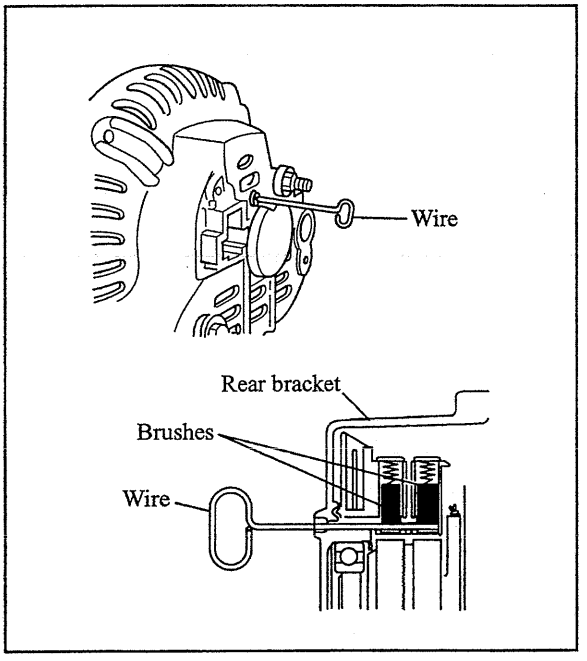


Installing new brush

2.3 Reassembly of Alternator

To reassemble, follow the disassembly sequence in reverse and observe the following.

(a) The rear bearing has an eccentric groove around the periphery. The deepest portion of this groove should be aligned with the lug on the snap ring.
(b) When replacing the rear bearing, a new bearing should be press-fitted so that the groove on its periphery is placed to the slip ring side.
(c) Heat the rear bracket before press-fitting the rear bearing into the bracket.
(d) When installing the rotor into the rear bracket, insert a wire through a small hole in the bracket to lift the brushes. After installation, remove the wire.



Reassembly of alternator

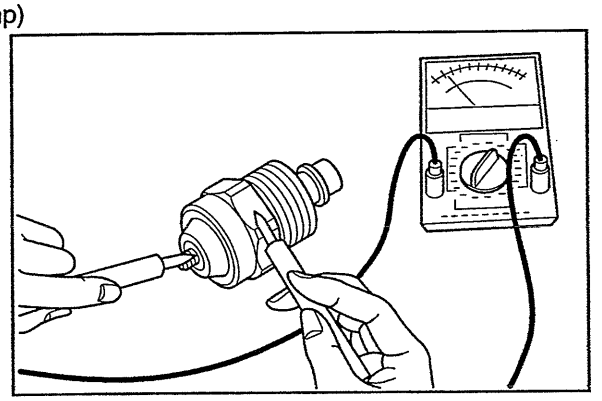
3. Magnetic Valve (Stop Solenoid)

(12 V or 24 V for Distributor-type Fuel Injection Pump)

3.1 Inspection of Magnetic Valve (Stop Solenoid)

(1) Check for continuity between each terminal and the body as shown left. If there is no continuity or the resistance is lower than the standard resistance value, replace the entire magnetic valve assembly.

		Standard
Resistance (at 20°C [68°F])	12 V	8 to 10.7 Ω
	24 V	33 to 43.4 Ω

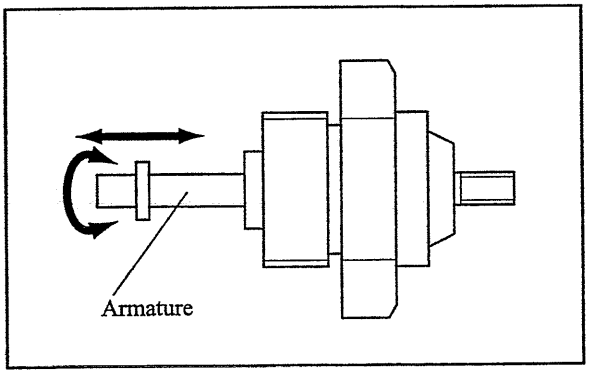


Inspection of magnetic valve (1)

(2) Check the rubber at the end of the armature for peeling or damage. Slide the armature by hand to check for jamming due to dust or other foreign matter.

Unit: N·m (kgf·m) [lbf·ft]

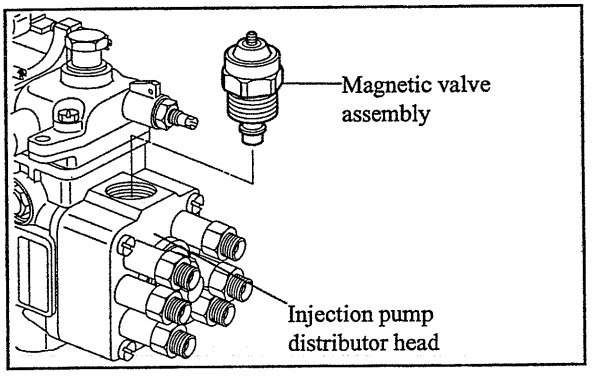
Tightening torque	15 to 25 (1.5 to 2.5) [10.8 to 18.1]



Inspection of magnetic valve (2)

3.2 Installation of Magnetic Valve (Stop Solenoid)

Install the magnetic valve assembly in the distributor with the specified torque.



Installation of magnetic valve

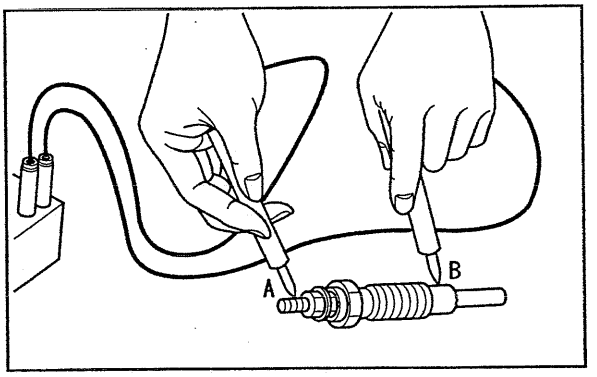
4. Glow Plug

(12 V, 24 V)

Inspection of Glow Plug

As shown left, connect the (+) wiring to the portion A, and ground the portion B. If the glow plug glows red hot, it is normal.

Rated voltage-current V-A	12 V	11-5.5, (direct injection), 30-second application
		10.5-9.7, (swirl chamber), 30-second application
	24 V	23-3.0, (direct injection), 30-second application
		22-4.4, (swirl chamber), 15-second application

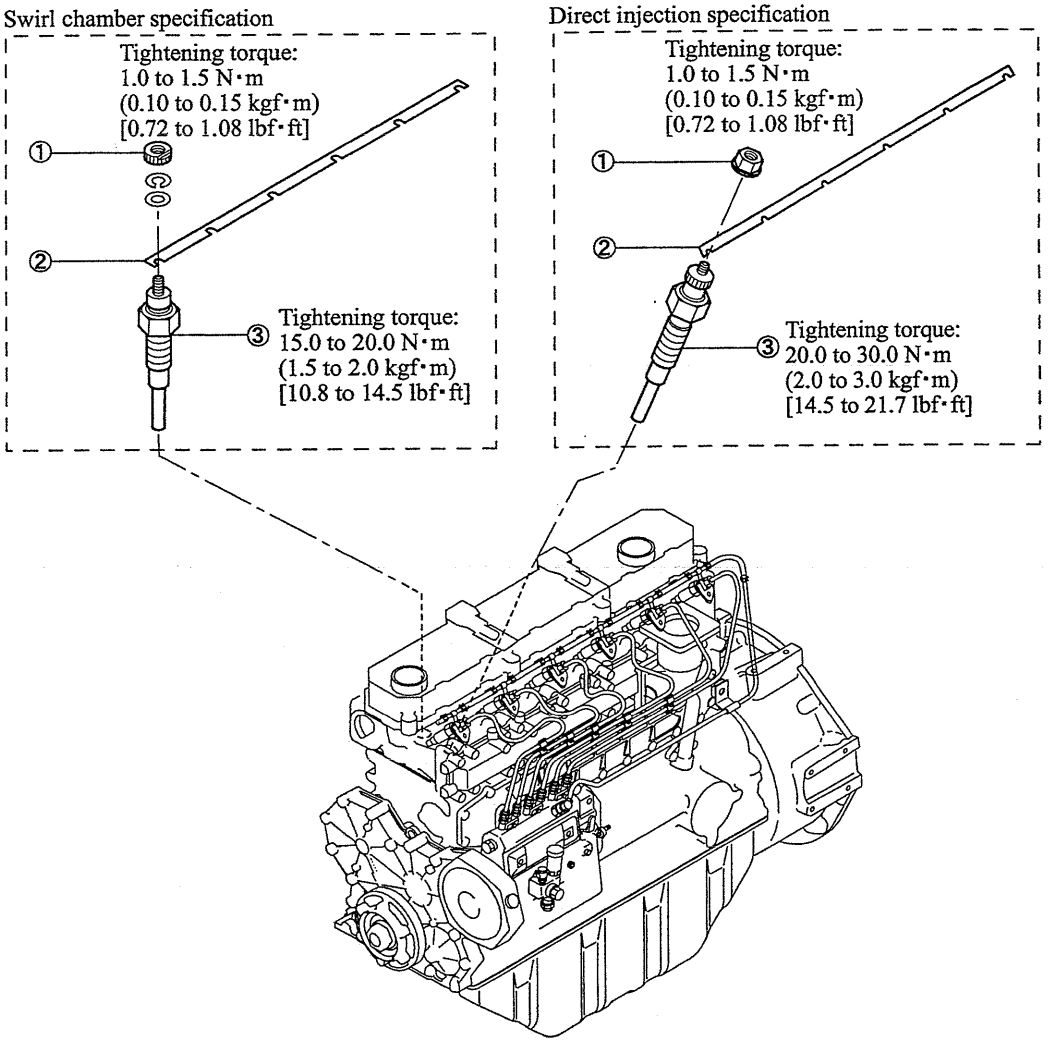


Inspection of glow plug

INSTALLATION OF ELECTRICAL SYSTEM

1. Glow Plug

(12 V, 24 V)



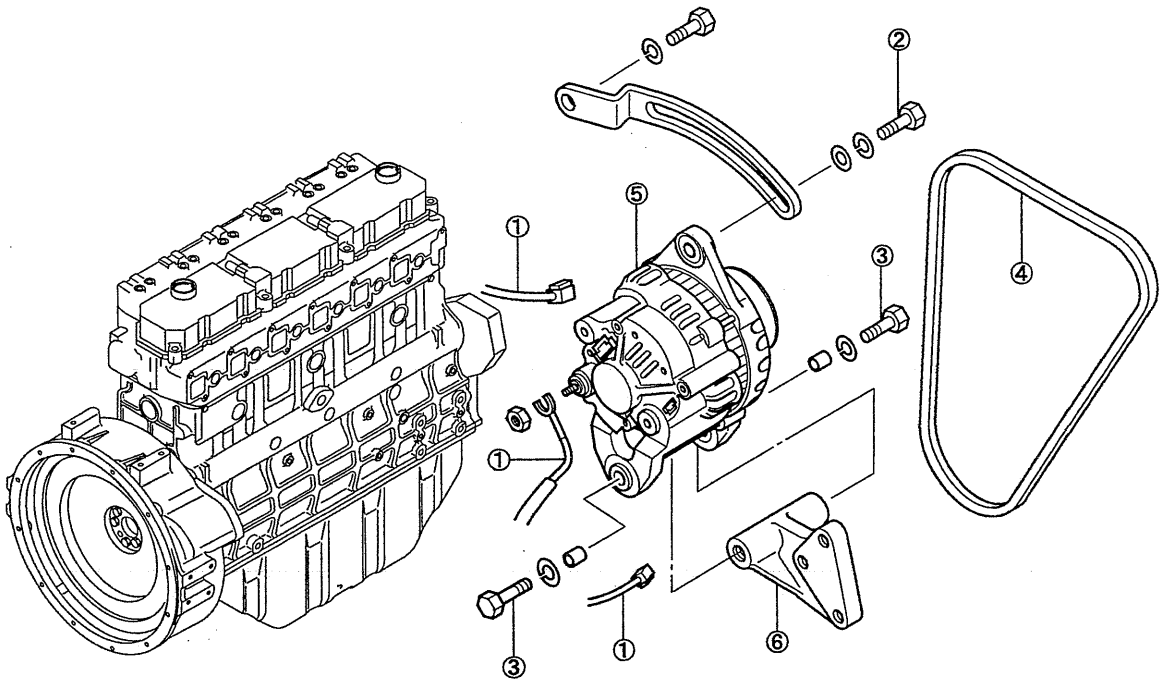
Installation of glow plug

< Installation sequence >

③→②→①

2. Alternator

(12 V-50 A, 24 V-25 A)



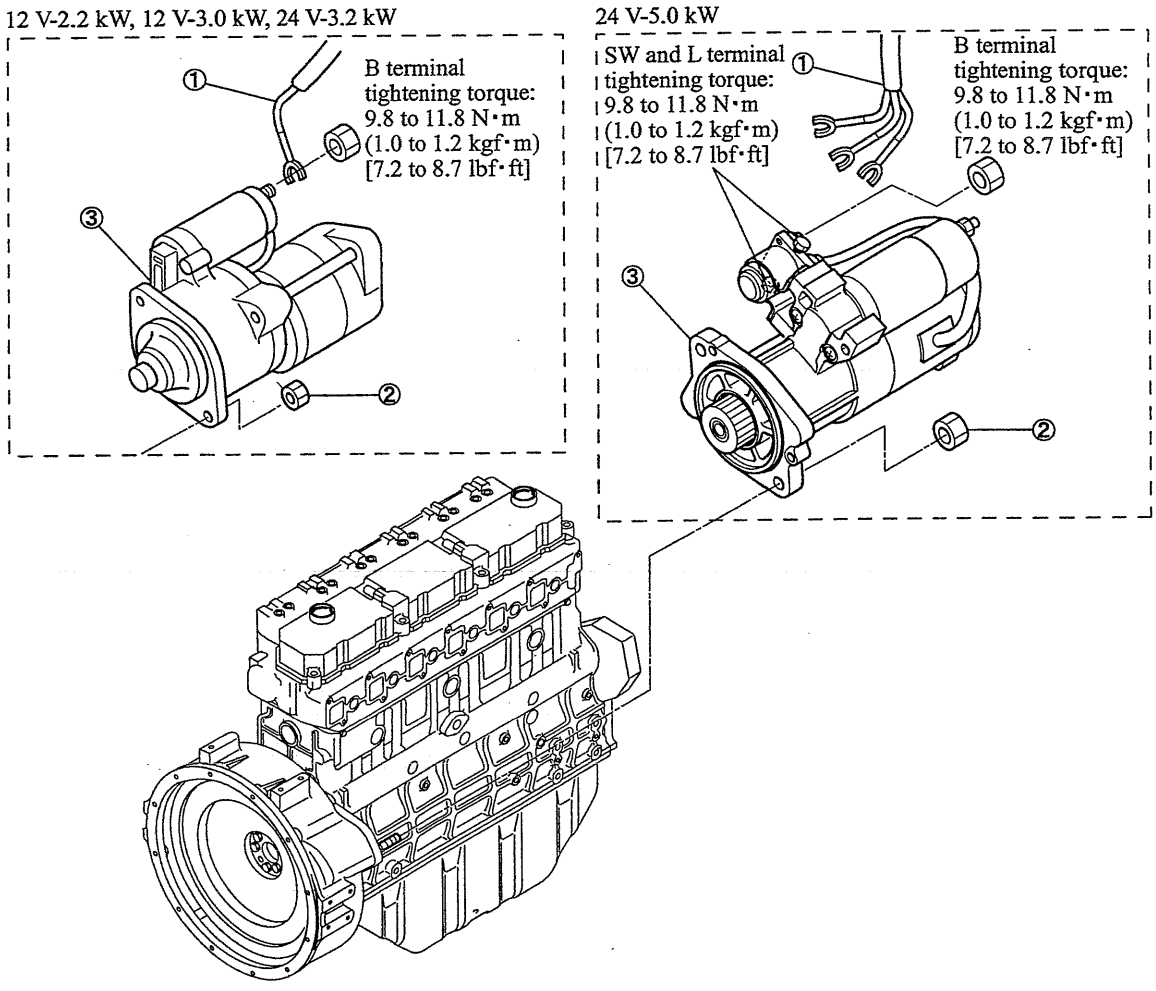
Installation of alternator

< Installation sequence >

⑥→⑤→④→③→②→①

3. Starter

(12 V-2.2 kW, 12 V-3.0 kW, 24 V-3.2 kW, 24 V-5.0 kW)



Installation of Starter

< Installation sequence >

③→②→①

INSPECTION, ADJUSTMENT, BREAK-IN OPERATION AND PERFORMANCE TESTS

1. Adjustment of Engine

1.1 Inspection and Adjustment of Valve Clearance

Inspect and adjust the valve clearance of the engine when the engine is cold.

Unit: mm [in.]

		Standard
Valve clearance (when engine is cold)	Inlet	0.25 [0.0098]
	Exhaust	

(1) Inspecting valve clearance

(a) Inspect the valve clearance in the firing order by turning the crankshaft 180° in the normal direction to bring each piston to the top dead center on the compression stroke.

Firing order

Cylinder No.		
	S4S	1-3-4-2
	S6S	1-5-3-6-2-4

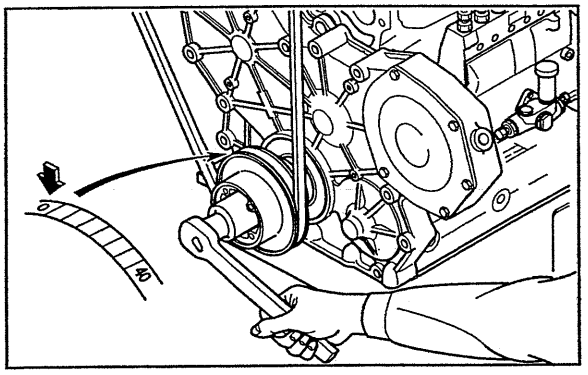
(b) Attach a socket and ratchet handle to the crankshaft pulley tightening nut, and turn the crankshaft.
(Turning socket: 58309-73100)

Unit: mm [in.]

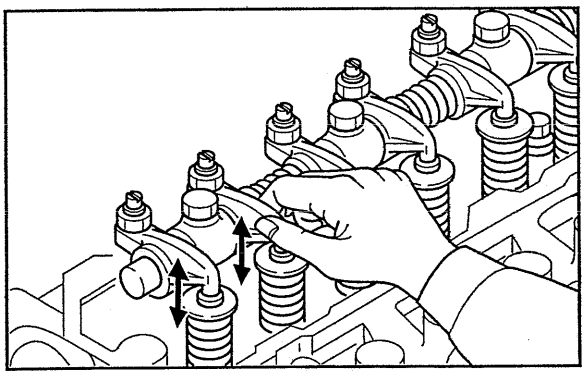
Width across flats of crankshaft pulley tightening nut	46 [1.81]

(c) When the No. 1 piston is at the top dead center on the compression stroke, the "0" line stamped on the circumference of the crankshaft pulley is aligned with the pointer of the timing gear case, and the inlet and exhaust valves are not lifted off their seats by the pushrods.

(d) Insert a feeler gage between the rocker arm and valve cap to inspect the clearance.



Checking top dead center of No. 1 piston on compression stroke (1)

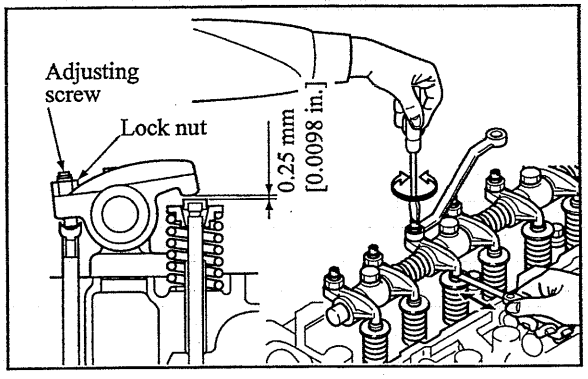


Checking top dead center of No. 1 piston on compression stroke (2)

(2) Adjusting valve clearance

(a) Loosen the lock nut, insert a feeler gage between the rocker arm and valve cap, and while measuring the clearance, tighten or loosen the adjusting screw until the feeler gage moves slightly tight.

(b) After adjusting the clearance, securely tighten the lock nut, and inspect the clearance again.

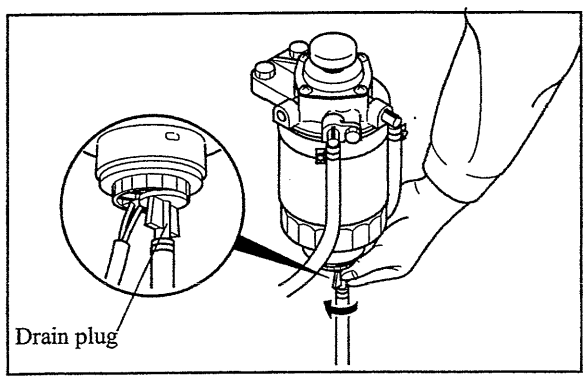


Adjusting valve clearance

1.2 Draining of Fuel System

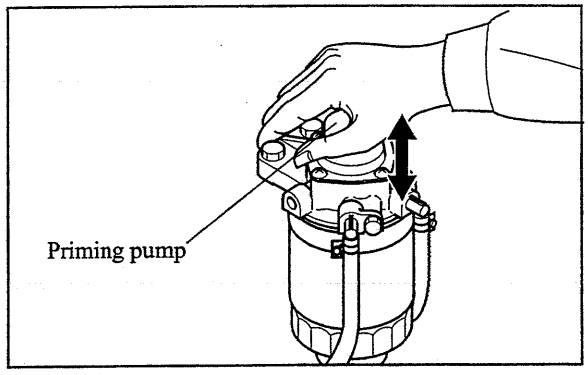
If water collects in an amount greater than the specified amount in the bottom of the fuel filter, it may enter the fuel system.
Drain the fuel system as described below.

(1) Fuel filter (distributor-type fuel injection pump)
  (a) Loosen the drain plug at the bottom of the fuel filter.



Draining of fuel filter (1)

  (b) Push the priming pump about seven times to feed the fuel rapidly to accelerate the draining of the fuel system.
  (c) After draining the fuel system, securely tighten the drain plug.
  (d) After draining the fuel system, be sure to bleed the fuel system.



Draining of fuel filter (2)

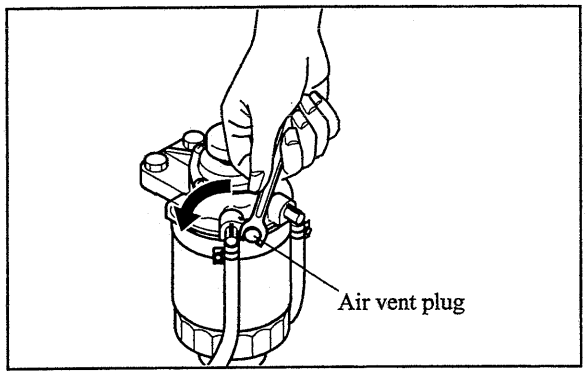
⚠ CAUTION

When the fuel system is drained, the fuel is discharged at the same time. Thoroughly wipe off any fuel spilled on the surrounding parts.

1.3 Bleeding of Fuel System

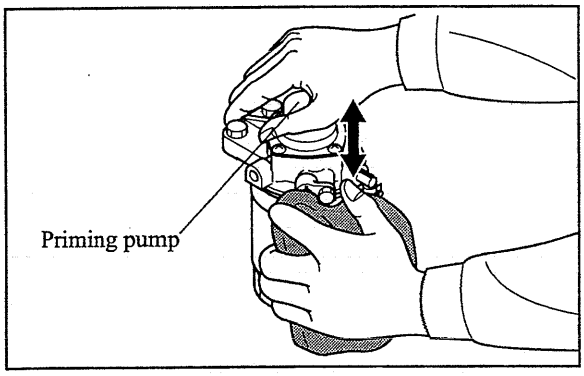
Start to bleed the fuel system from a location closest to the fuel tank, and move toward the engine in the order of the fuel filter and the fuel injection pump.

(1) Fuel filter (distributor-type fuel injection pump)
  (a) Loosen the air vent plug of the fuel filter with a wrench.



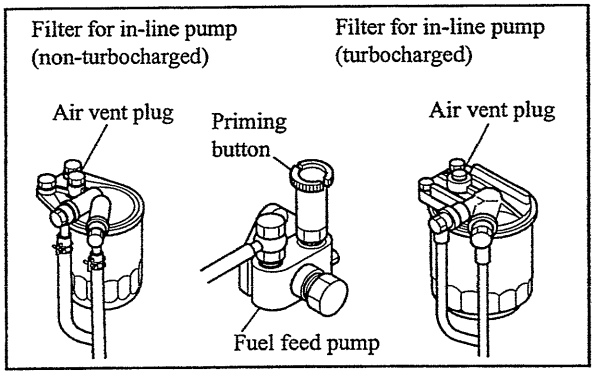
Bleeding of fuel filter (1)

  (b) Apply a cloth to the air vent plug, and repeatedly push the priming pump.
  The bleeding procedure is completed when no air bubbles appear in the fuel coming out of the air vent plug.
  (c) Securely tighten the air vent plug.



Bleeding of fuel filter (2)

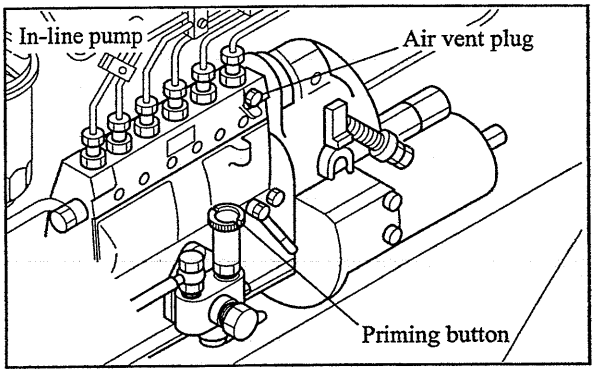
(2) Fuel filter (in-line fuel injection pump)
  (a) Loosen the air vent plug of the fuel filter by about 1.5 turns.
  (b) Loosen the priming pump cap of the fuel feed pump by turning it counterclockwise, and move it up and down.
  (c) Tighten the air vent plug when no air bubbles appear in the fuel coming out of it.



Bleeding fuel filter (in-line fuel injection pump)

(3) Fuel injection pump (in-line fuel injection pump)
  (a) Loosen the air vent plug of the fuel injection pump by about 1.5 turns.
  (b) Move up and down the priming pump cap.
  (c) Tighten the air vent plug when no air bubbles appear in the fuel coming out of it. Before tightening the last air vent plug, lock the priming pump cap of the fuel feed pump by turning it clockwise while pushing it down.
  (d) Bleed the right-hand fuel injection pump in the same way as the left-hand one.

Note: (a) If all of the vent plugs are tightened before the priming pump cap is locked, the fuel pressure acts on the fuel feed pump to make it impossible to return the priming pump cap to the original position.
  (b) Thoroughly wipe off any fuel spilled from the air vent plugs with a cloth or the like.



Bleeding fuel injection pump
(in-line fuel injection pump)

1.4 Inspection of Fuel Injection Timing (Distributor-type Fuel Injection Pump Specification)

The fuel injection timing varies with the output, speed and other engine specifications. Be sure to check it according to the specification sheet.

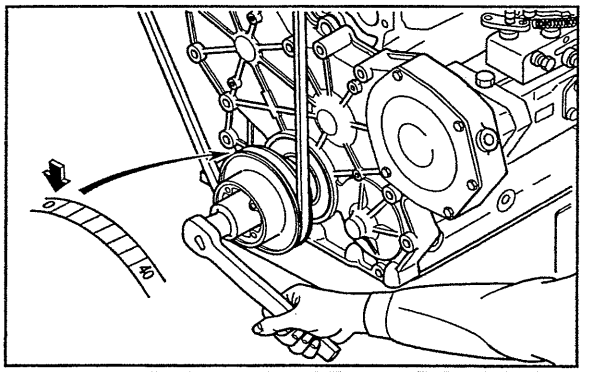
(1) Checking top dead center of No.1 piston on compression stroke

(a) Apply a special tool or turning socket to the crankshaft pulley tightening nut, and turn the crankshaft in the normal direction of engine rotation or clockwise when seen from the front of the engine.

Special tool name	Part No.
Turning socket	58309-73100

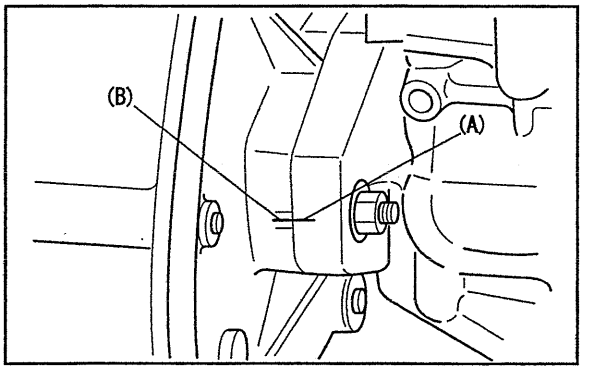
(b) Stop turning the crankshaft when the "0" line stamped on the circumference of the crankshaft pulley is aligned with the pointer of the timing gear case.

(c) Move the rocker arms of the inlet and exhaust valves of the No. 1 cylinder up and down to check that the pushrods are not lifting both of the inlet and exhaust valves off their seats or that the inlet and exhaust valves both have no clearance.



Checking top dead center of No. 1 piston on compression stroke

(2) Check that the alignment mark (A) of the fuel injection pump is aligned with the alignment mark (B) of the flange plate.



Alignment mark of fuel injection pump

1.5 Inspection of Fuel Injection Timing (In-line Fuel Injection Pump Specification)

The fuel injection timing varies with the output, speed and other engine specifications. Be sure to check it according to the specification sheet.

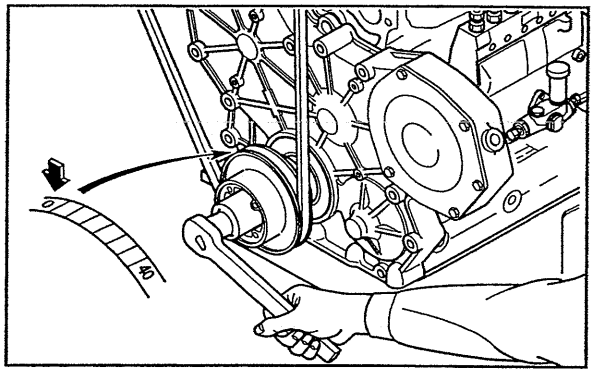
(1) Checking top dead center of No.1 piston on compression stroke

(a) Apply a special tool or turning socket to the crankshaft pulley tightening nut, and turn the crankshaft in the normal direction of engine rotation or clockwise when seen from the front of the engine.

Special tool name	Part No.
Turning socket	58309-73100

(b) Stop turning the crankshaft when the "0" line stamped on the circumference of the crankshaft pulley is aligned with the pointer of the timing gear case.

(c) Move the rocker arms of the inlet and exhaust valves of the No. 1 cylinder up and down to check that the pushrods are not lifting both of the inlet and exhaust valves off their seats or that the inlet and exhaust valves both have no clearance.



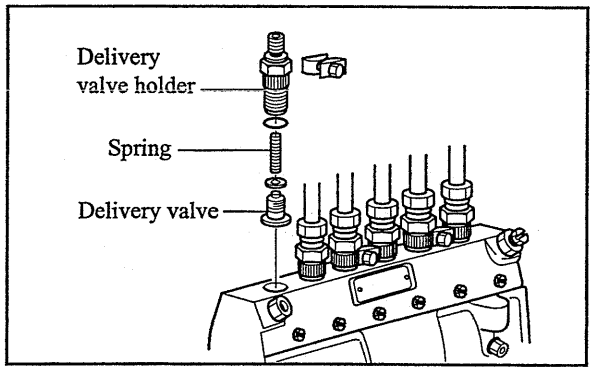
Checking top dead center of No. 1 piston on compression stroke

(2) Inspecting fuel injection timing

(a) Bring the piston to the top, and check the top dead center.
Remove the delivery valve holder from the No.1 plunger of the fuel injection pump, remove the delivery valve, spring and stopper, and install the delivery valve holder alone.

(b) Install the spare injection pipe to the No.1 plunger. Face the other end of the pipe downward so that the flow-out condition of the fuel can be clearly seen.

(c) Position the crankshaft at about 60° before the top dead center of the No.1 piston on the compression stroke.

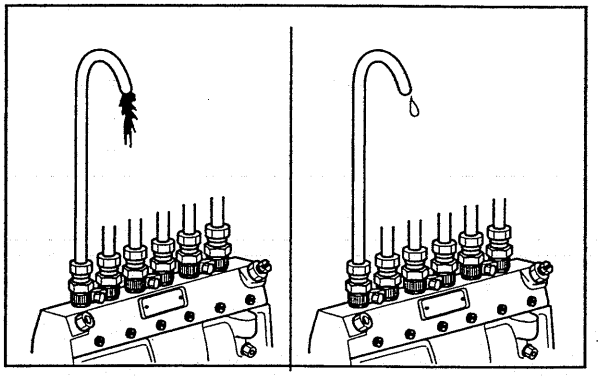


Inspecting fuel injection timing (1)

(d) Feed the fuel by the priming pump, and slowly turn the crankshaft in the normal direction while allowing the fuel to flow out of the injection pipe.

(e) Turn the crankshaft more slowly when the flow of the fuel out of the injection pipe is about to stop, and stop turning the crankshaft when the flow of the fuel out of the injection pipe is stopped.

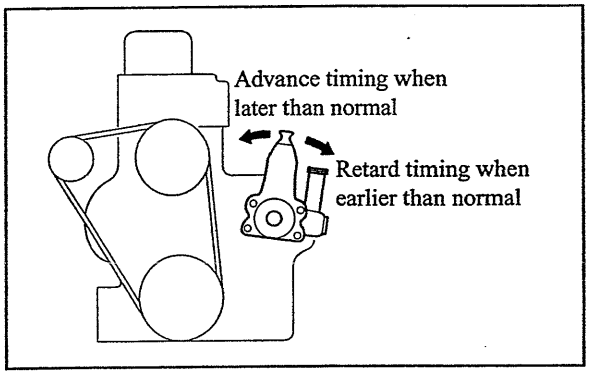
(f) Check that the line stamped on the crankshaft pulley and the pointer indicate the fuel injection timing.



Inspecting fuel injection timing (2)

1.6 Adjustment of Fuel Injection Timing

When the fuel is injected earlier than normal, turn the fuel injection pump away from the crankcase.
When the fuel is injected later than normal, turn the fuel injection pump toward the crankcase.



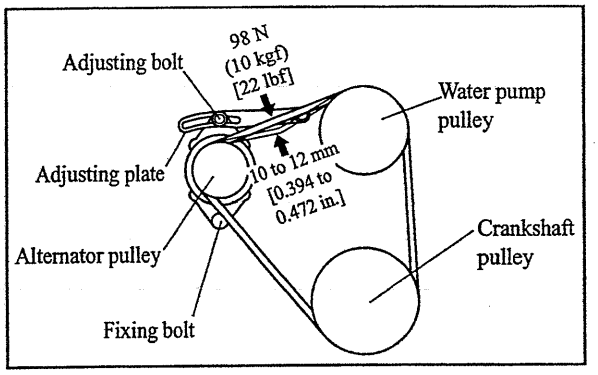
Adjustment of fuel injection timing

1.7 Inspection and Adjustment of V-belt Tension

Inspect the V-belt for the amount of deflection when it is strongly pressed down on with the thumb at the center of its span. Adjust the V-belt to proper tension by loosening all of the bolts securing the alternator and installing the alternator at an appropriate angle.

Unit: mm [in.]

	Standard
Deflection of V-belt	10 to 12 [0.394 to 0.472]



Inspection and adjustment of V-belt tension

1.8 Adjustment of Governor (Distributor-type Fuel Injection Pump Specification)

Inspection and adjustment of minimum no-load speed (low idle speed) and maximum no-load speed

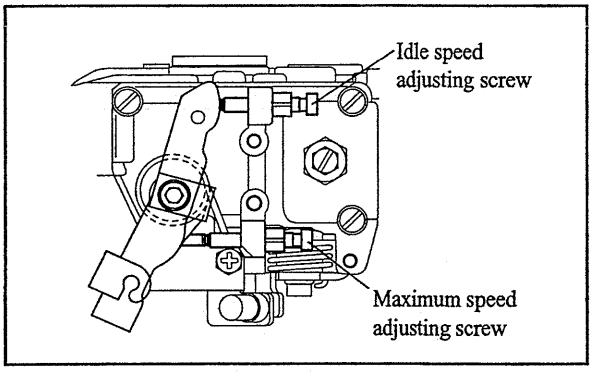
⚠ CAUTION

(a) Each engine has the minimum no-load speed (low idle speed) and maximum no-load speed checked on the test bench at the factory and has the setting bolts sealed. These settings can be inspected and adjusted at our designated service shop only.
(b) After the governor parts are adjusted, seal all external stoppers as done at the time of factory shipment.
(c) Whether the seals are intact or not has important bearing on the validity of claims under warranty. Be sure to seal all of the specified sections.
(d) When inspecting and adjusting the governor, be prepared to operate the engine stop lever manually in anticipation of the engine overrunning (running at an extremely high speed).

Inspect and adjust the governor after engine warm-up operation long enough for the water and oil temperatures to rise to 70°C [158°F].

(1) Starting engine
(a) Pull the speed control lever to the high-speed side, and operate the starter switch.
(b) The engine fires at a speed of about 150 min^{-1} and then increases in speed. Operate the speed control lever to maintain the engine speed at 800 to 1000 min^{-1}.
(c) When the engine speed has stabilized, return the speed control lever to the low idle speed position.

(2) Setting low idle speed (setting minimum no-load speed)
For the engine to run at the minimum no-load speed, fix the speed control lever, and turn the idle speed adjusting screw.



Adjusting engine

⚠ CAUTION

If there is the speed range over which torsional vibration is likely to occur, avoid the speed range.

(3) Setting governor (setting maximum speed)
(a) Hold the speed control lever in the specified maximum speed position.
(b) Adjust the maximum speed adjusting screw (maximum speed setting screw) to the specified speed

1.9 Adjustment of Governor (In-line Fuel Injection Pump Specification)

Inspection and adjustment of minimum no-load speed (low idle speed) and maximum no-load speed

⚠ CAUTION

(a) Each engine has the minimum no-load speed (low idle speed) and maximum no-load speed checked on the test bench at the factory and has the setting bolts sealed. These settings can be inspected and adjusted at our designated service shop only.
(b) After the governor parts are adjusted, seal all external stoppers as done at the time of factory shipment.
(c) Whether the seals are intact or not has important bearing on the validity of claims under warranty. Be sure to seal all of the specified sections.
(d) When inspecting and adjusting the governor, be prepared to operate the engine stop lever manually in anticipation of the engine overrunning (running at an extremely high speed).

Inspect and adjust the governor after engine warm-up operation long enough for the water and oil temperatures to rise to 70°C [158°F].

(1) Starting engine
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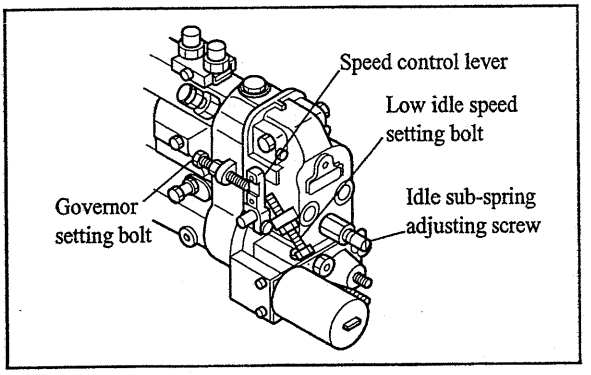
(b) The engine fires at a speed of about 150 min^{-1} and then increases in speed. Operate the speed control lever to maintain the engine speed at 800 to 1000 min^{-1}.
(c) When the engine speed has stabilized, return the speed control lever to the low idle speed position.



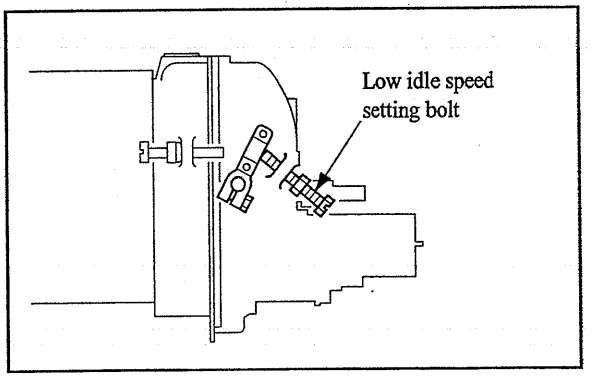
Starting engine

(2) Setting low idle speed (setting minimum no-load speed)
(a) For the engine to run at the minimum no-load speed, fix the speed control lever, and turn the low idle speed setting bolt.

⚠ CAUTION

If there is the speed range over which torsional vibration is likely to occur, avoid the speed range.

(b) Turn the low idle speed setting bolt clockwise to increase the speed.

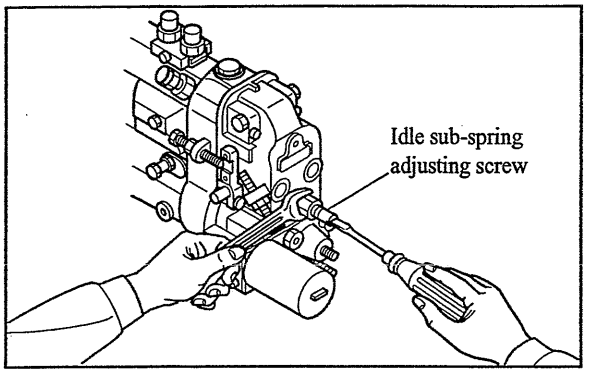


Setting low idle speed

(c) If the engine speed does not stabilize, turn the idle sub-spring adjusting screw clockwise to bring the idle sub-spring into light contact with the tension lever and to stabilize the engine speed.

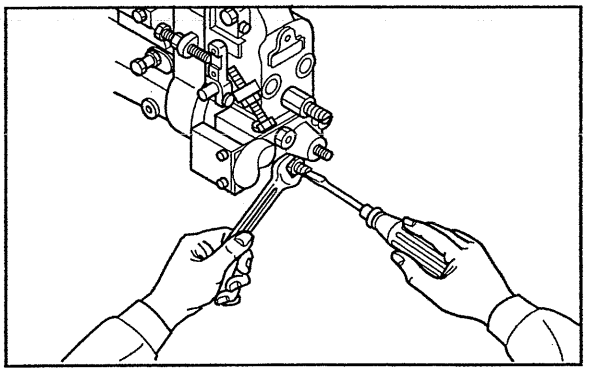
⚠ CAUTION

If the idle sub-spring is overtightened clockwise, the engine is likely to overrun during maximum no-load speed operation. Given this possibility, carefully adjust the engine speed stability.



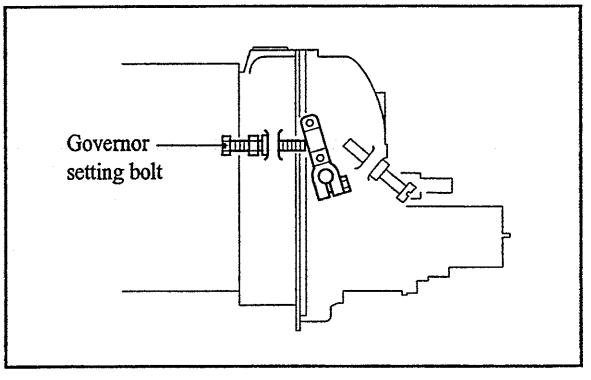
Adjusting engine speed stability

(3) Setting rack (setting maximum output)
(a) Free the torque spring adjusting screw. Hold the speed control lever at the specified engine output and speed.
(b) In this condition, check that the engine output and speed are stabilized.
(c) While maintaining the stabilized condition, adjust the full-load stopper bolt.
(d) Find the rated output position by tightening or loosening the full-load stopper bolt.
(e) When the rated output position is approximately determined, tighten the full-load stopper bolt, and then turn it counterclockwise by degrees. In the position where the engine speed is about to drop below the rated speed, fix the full-load stopper bolt, and securely tighten the lock nut.
(f) Check that the speed control lever is positioned on the high-speed side.
(g) The fuel injection (engine output) increases as the full-load stopper bolt is turned clockwise and decreases as the full-load stopper bolt is turned counterclockwise.



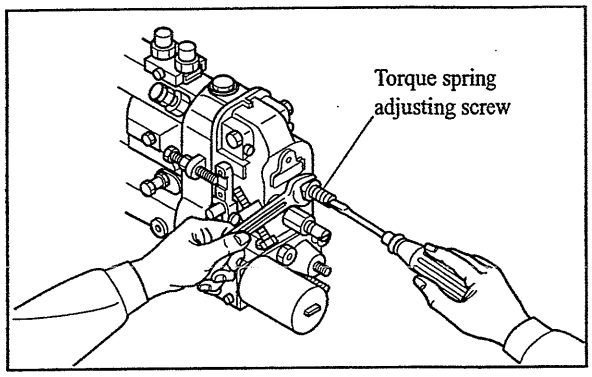
Setting rack

(4) Setting governor (setting maximum speed)
(a) While applying the full load to the engine, hold the speed control lever in the specified maximum speed position.
(b) Adjust the governor setting bolt (maximum speed setting bolt) to the specified speed position, and set it there.



Setting governor

(5) Setting torque spring (optional specification)
Set the speed control lever at the maximum speed, and apply the load to the engine. Turn the torque spring adjusting screw until the engine delivers the specified output at the specified speed. Fix the screw with the lock nut, and install a cap to the lock nut.



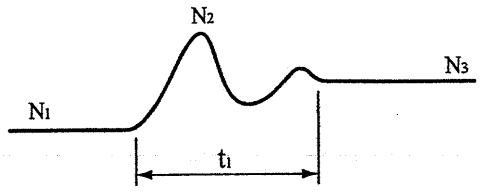
Setting torque spring

(6) Measuring speed variation
Measurement of speed variation at removal of load
(a) Operate the speed control lever to set the engine at the rated output and speed.
(b) From this condition, instantaneously remove the load to put the engine into the no-load condition. Operate the engine with the speed control lever fixed.
(c) The engine speed temporarily jumps up and then lowers and stabilizes. Record the momentary maximum speed, stabilized speed, and time from the removal of the load to the stabilization of the speed.

Measurement of speed variation at application of load
From the no-load condition, instantaneously apply the specified load to the engine. Record the momentary maximum speed, stabilized speed, and time from the application of the load to the stabilization of the speed.

Calculation of speed variation
Calculate the speed variation from the measured results. When the speed variation falls outside of the specified limits, adjust the governor notches.

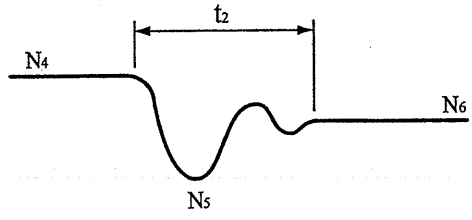
At removal of load



Momentary speed variation (%)	Permanent speed variation (%)
$\frac{N_2 - N_1}{N_1} \times 100$	$\frac{N_3 - N_1}{N_1} \times 100$

N_1 = Engine speed before removal of load (min^{-1})
N_2 = Engine speed at removal of load (min^{-1})
N_3 = Stabilized engine speed after removal of load (min^{-1})
t_1 = Stabilization time

At application of load

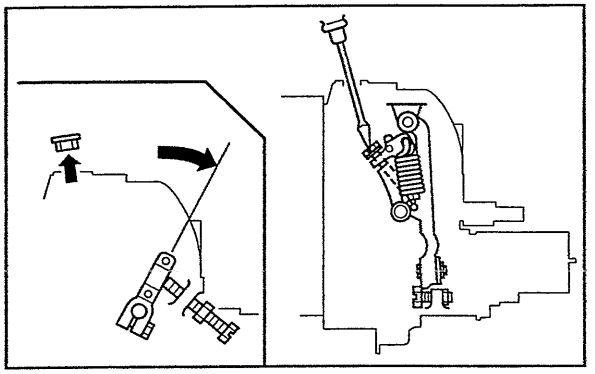


Momentary speed variation (%)	Permanent speed variation (%)
$\frac{N_4 - N_5}{N_4} \times 100$	$\frac{N_4 - N_6}{N_4} \times 100$

N_4 = Engine speed before application of load (min^{-1})
N_5 = Engine speed at application of load (min^{-1})
N_6 = Stabilized engine speed after application of load (min^{-1})
t_2 = Stabilization time

Measuring speed variation

(7) Adjusting speed variation (adjusting governor notches)
   (a) Adjust the speed variation by turning the adjusting screw of the swivel lever.
   (b) Remove the plug at the top of the governor, and set the speed control lever to the low idle speed position. The swivel lever turns up to reveal the head of the adjusting screw. Turn the adjusting screw with a flat-head screwdriver.
   (c) The speed variation decreases as the adjusting screw is tightened and increases as the adjusting screw is loosened. One notch equals a quarter turn of the adjusting screw and changes the engine speed by three to five revolutions.
   (d) Turning the adjusting screw changes the governor spring tension and hence the maximum speed. Readjust the governor setting bolt.
   (e) The maximum speed increases as the adjusting screw is tightened and decreases as the adjusting screw is loosened.



Adjusting speed variation

⚠ CAUTION

The adjusting screw can be loosened by 20 notches (or 5 turns) from the position where it is fully tightened. It is dangerous if the adjusting screw is loosened more.

(8) Sealing
   Seal each setting bolt.

2. Break-In Operation

When the engine is overhauled, it should be mounted on a dynamometer and operated for break-in and inspection.

2.1 Starting Up

(1) Before starting the engine, check the levels of coolant, engine oil and fuel, and bleed the fuel and cooling systems.
(2) With the fuel supply cut off, operate the starter and crank the engine for about 15 seconds to circulate engine oil.
(3) Move the speed control lever slightly in the direction for increased fuel (do not move it to "full injection" position), and then turn the starter switch key to the [START] position to start the engine.
(4) After the engine starts, let it operate at the minimum no-load speed (low idle speed) by moving the speed control lever.

2.2 Inspection after Starting Up

During the break-in operation, check the following. If an abnormality is found, stop the engine, investigate the cause, and take appropriate measures.

(1) Lubricating oil pressure should be 0.29 to 0.49 MPa (3 to 5 kgf/cm^2) [43 to 71 psi] at 1500 min^{-1} or over 0.1 MPa (1 kgf/cm^2) [14 psi] at 750 min^{-1}.
(2) Coolant temperature should be 75 to 85°C [167 to 185°F].
(3) Lubricating oil temperature should be 70 to 90°C [158 to 194°F].
(4) Check for leakage of oil, coolant and fuel.
(5) Knocking should stop when the coolant temperature rises. The engine should not produce any other abnormal noise.
(6) Check for exhaust color and abnormal odors.

2.3 Break-In Period

The following shows the relationship between the load in break-in operation and the operation time.

Break-in period

	Engine speed (min^{-1})	Load	Time (min)
1	1000	No load	30
2	1500	25%	30
3	Rated speed	25%	10
4	(2300)	50%	10
5		75%	30
6		100%	20

2.4 Inspection and Adjustment after Break-In Operation

(a) Check the bolts and nuts for looseness.
(b) Adjust the valve clearance.
(c) Inspect the fuel injection timing.

3. Performance Tests

There are various performance test procedures. 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

(1) Operation load test
Conduct this test to evaluate the engine output, torque, fuel consumption rate and governor performance under various load conditions.

(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) Minimum no-load engine speed test
Conduct this test to confirm that the engine can operate stably at the specified minimum no-load 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.

(1) Standard atmospheric conditions:
Base temperature: 298 K (25°C) [77°F]
Atmospheric pressure: 100 kPa [750 mmHg]
Dry atmospheric pressure: 99 kPa [743 mmHg]

(2) Calculation of corrected power
Multiply the measured brake power or torque by the calculated diesel engine correction factor to obtain a corrected value.

Corrected output=Correction factor (α_c)× Measured brake power

Atmospheric conditions during test

Temperature (T): 283 K (10°C) [50°F] $\leqq T \leqq$ 313 K (40°C) [104°F]

Dry atmospheric pressure(P): 80 kPa (600 mmHg) $\leqq P \leqq$ 110 kPa (825 mmHg)

(3) Calculation of correction factor (α_c)

$\alpha_c=(fa)^{fm}$ *fa*: Atmospheric factor *fm*: Engine factor

(a) Calculation of atmospheric factor (*fa*)

①Natural aspiration engine and engine with mechanically driven air charger

$$fa=\left(\frac{99}{Pd}\right)\cdot\left(\frac{T}{298}\right)^{0.7}$$

②Turbocharged engine without air cooler or with air-to-air cooler

$$fa=\left(\frac{99}{Pd}\right)^{0.7}\cdot\left(\frac{T}{298}\right)^{1.2}$$

③Turbocharged engine with air-to-liquid cooler

$$fa=\left(\frac{99}{Pd}\right)^{0.7}\cdot\left(\frac{T}{298}\right)^{0.7}$$

(b) Calculation of engine factor (*fm*)

$fm=0.036qc-1.14$

qc: Corrected fuel supply volume

①$qc=\dfrac{q}{r}$

$$q=\frac{(z)\times(\text{Fuel flow rate } g/s)}{(\text{Stroke volume } \ell)\times(\text{Engine speed } \text{min}^{-1})}$$

z=120000(4-stroke cycle engine)

r: Ratio between pressure at turbocharger or air cooler outlet and atmospheric pressure
(*r*=1 for natural aspiration engine)

②Applicable range of engine factor (*fm*)

$37.2 \leqq qc \leqq 65$ mg/(ℓ-cycle)

- $qc \leqq 37.2$ mg/(ℓ-cycle) : $fm=0.2$ (constant)
- 65 mg/(ℓ-cycle)$\leqq qc$: $fm=1.2$ (constant)

(c) Range of correction equation use

The range of correction factor (α_c) is as follows:

$0.9 \leqq \alpha_c \leqq 1.1$

If this range is exceeded, indicate the corrected values and record the test conditions on the test record.

OTHERS

1. Disassembly and Reassembly of General Parts

1.1 Oil Seals

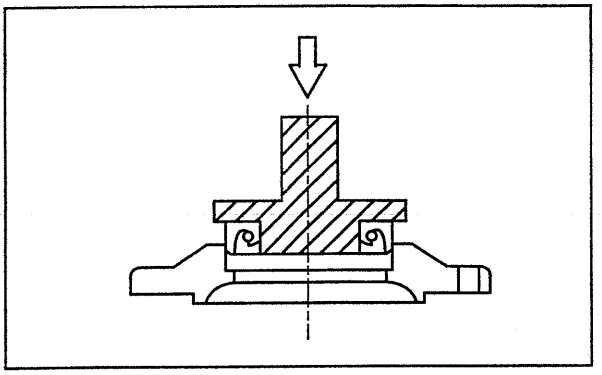
When installing oil seals, observe the following.

Installation of oil seals to housings

(a) Check the seal lip for scratches and damage, and be sure to position the lip correctly.

(b) Apply a small amount of grease to the periphery (housing contact surface) of the oil seal before installation.

(c) Use an oil seal driver that guides the seal lip and presses the seal periphery, as shown in the diagram on the right. Using such a tool, install the oil seal straight into the housing. Striking the oil seal directly with a hammer causes seal damage and results in oil leaks.

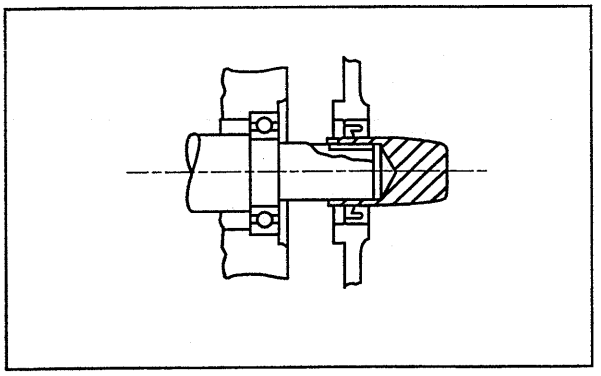


Oil seal driver

Installation of oil seals to shafts

(a) Apply grease to the oil seal lip.

(d) Use an oil seal guide similar to the one shown in the diagram when installing an oil seal over the stepped portion, splines, threads or key grooves.

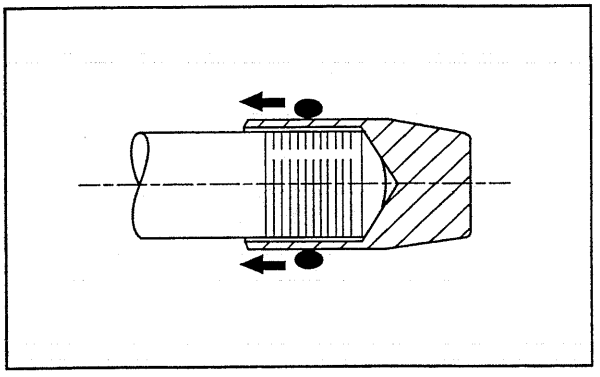


Oil seal guide

1.2 O-rings

Use an O-ring guide similar to the one shown in the diagram when installing an O-ring over the stepped portion, splines, threads or key grooves.

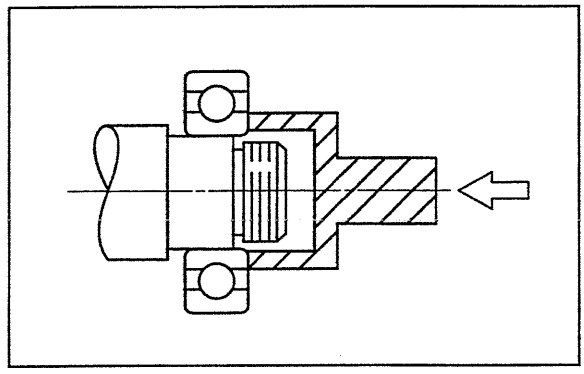
Be sure to apply a small amount of grease to the O-ring before installation.



O-ring guide

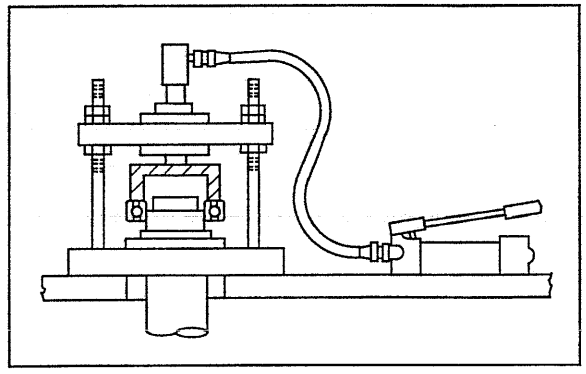
1.3 Bearings

(a) When installing a bearing, be sure to push the inner or outer race that fits into the installation position.
Be sure to use a bearing driver similar to the one shown in the diagram.



Bearing driver

(b) Use of a press minimizes the impact on the bearing and ensures proper installation.



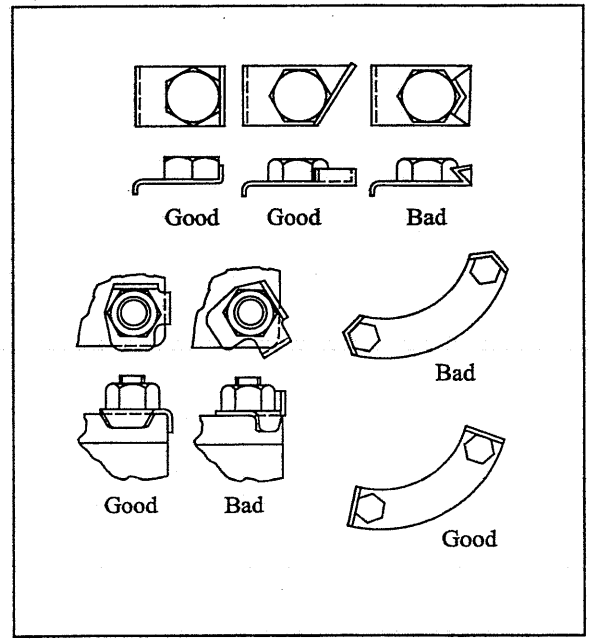
Using press for bearing installation

1.4 Lock Plates

Be sure to bend lock plates.
The diagram on the right shows the methods of bending representative lock plates.

1.5 Split Pins and Spring Pins

Generally, new split pins should be installed whenever split pins are removed.
Be sure to bend split pins.
Be sure to check spring pins for secure installation.



Bending lock plate

ENGINE INSPECTION RECORD SHEETS

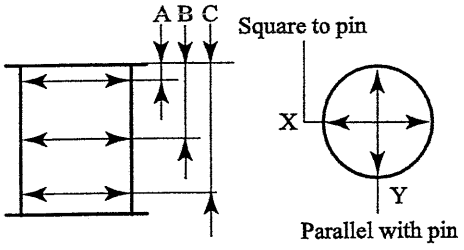
1. Measurement of Cylinder Inside Diameter
2. Measurement of Clearance between Valve Stem and Valve Guide and Outside Diameter of Valve Stem
3. Measurement of Valve Sinkage, Seat Width and Valve Margin
4. Measurement of Distortion of Cylinder Head Bottom Surfaces
5. Measurement of Oil Clearance of Connecting Rod Bearing
6. Measurement of Rocker Arm Inside Diameter and Rocker Shaft Outside Diameter
7. Measurement of Piston Pin Bore Diameter and Piston Pin Outside Diameter
8. Measurement of Valve Clearance
9. Measurement of Valve Opening Pressure of Fuel Injection Nozzle
10. Measurement of Camshaft Journal Inside Diameter and Camshaft Bushing Clearance
11. Measurement of Crankshaft End Play

INSPECTION RECORD SHEET

S4S, S6S

Company		Engine Model		Date	
		Serial No.			
Inspection Point	Measurement of Cylinder Inside Diameter			Unit	mm [in.]

Measuring Positions



Standard

	Nominal Value	Standard	Limit	
			Repair	Replace
Cylinder Inside Diameter	ϕ94 [ϕ3.70]	94.000 to 94.035 [3.70079 to 3.70217]	94.200 [3.70866]	94.700 [3.72835]

Measured Values

Part Name		Cylinder Inside Diameter		
No.	Position	A	B	C
1	X			
	Y			
2	X			
	Y			
3	X			
	Y			
4	X			
	Y			
5	X			
	Y			
6	X			
	Y			

Remark	Approved by	Checked by	Measured by

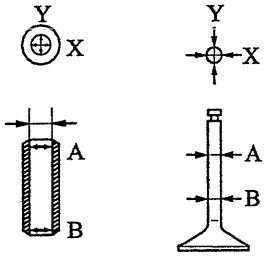
No.2

INSPECTION RECORD SHEET

S4S, S6S

Company		Engine Model		Date	
		Serial No.			
Inspection Point	Measurement of Clearance between valve Stem and Valve Guide and Outside Diameter of Valve Stem			Unit	mm [in.]

Measuring Positions



Standard

		Nominal Value	Standard	Limit
Valve Guide Inside Diameter	Inlet	ϕ8 [ϕ0.31]	8.020 to 8.035 [0.31575 to 0.31634]	–
	Exhaust	ϕ8 [ϕ0.31]	8.020 to 8.035 [0.31575 to 0.31634]	–
Valve Stem Outside Diameter	Inlet	ϕ8 [ϕ0.31]	7.940 to 7.955 [0.31260 to 0.31319]	7.900 [0.31102]
	Exhaust	ϕ8 [ϕ0.31]	7.920 to 7.940 [0.31181 to 0.31260]	7.850 [0.30906]
Clearance between Valve Stem and Valve Guide	Inlet	–	0.065 to 0.095 [0.00256 to 0.00374]	0.150 [0.00591]
	Exhaust	–	0.080 to 0.115 [0.00315 to 0.00453]	0.200 [0.00787]

Measured Values

Part Name		Valve Guide Inside Diameter				Valve Stem Outside Diameter				Clearance			
		A		B		A		B		A		B	
No.	Position	X	Y	X	Y	X	Y	X	Y	Max.	Min.	Max.	Min.
1	Inlet												
	Exhaust												
2	Inlet												
	Exhaust												
3	Inlet												
	Exhaust												
4	Inlet												
	Exhaust												
5	Inlet												
	Exhaust												
6	Inlet												
	Exhaust												

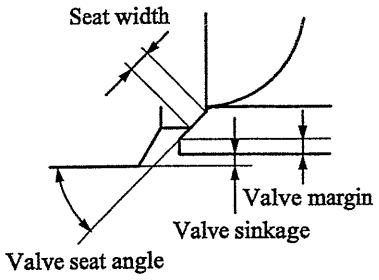
Remark	Approved by	Checked by	Measured by

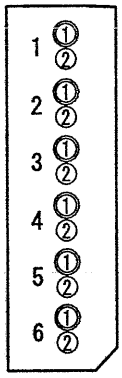
INSPECTION RECORD SHEET

S4S, S6S

Company		Engine Model		Date	
		Serial No.			
Inspection Point	Measurement of Valve Sinkage, Seat Width and Valve Margin			Unit	mm [in.]

Measuring Positions





Standard

			Nominal Value	Standard	Limit
Valve Seat	Valve Seat Angle		30°		
	Seat Width		1.4 [0.055]	1.26 to 1.54 [0.0496 to 0.0606]	1.6 [0.063]
	Valve Sinkage	Inlet	0.4 [0.016]	0.3 to 0.5 [0.012 to 0.020]	1.0 [0.039]
		Exhaust	0.5 [0.020]	0.4 to 0.6 [0.016 to 0.024]	
Valve Margin			2.13 [0.0839]		Refacing permissible up to 1.83 [0.0720]

Measured Values

Part Name No.	Valve		Valve Seat Angle	Seat Width	Valve Sinkage	Valve Margin
1	Inlet	①				
	Exhaust	②				
2	Inlet	①				
	Exhaust	②				
3	Inlet	①				
	Exhaust	②				
4	Inlet	①				
	Exhaust	②				
5	Inlet	①				
	Exhaust	②				
6	Inlet	①				
	Exhaust	②				

Remark	Approved by	Checked by	Measured by

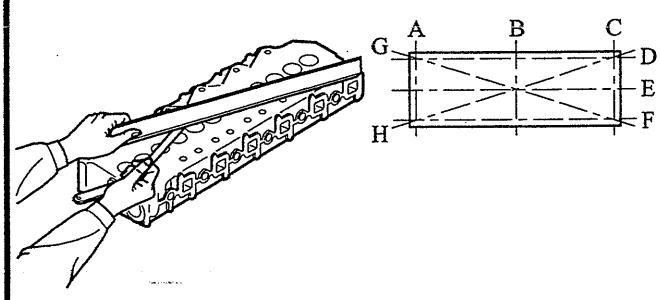
No.4

INSPECTION RECORD SHEET

S4S, S6S

Company		Engine Model		Date	
		Serial No.			
Inspection Point	Measurement of Distortion of Cylinder Head Bottom Surfaces			Unit	mm [in.]

Measuring Positions



Standard

	Standard	Limit
Distortion of Cylinder Head Bottom Surfaces	0.05 [0.0020] or less	0.20 [0.0079]

Measured Values

Part Name	Distortion of Cylinder Head Bottom Surfaces							
No.	A	B	C	D	E	F	G	H
1								
2								
3								
4								

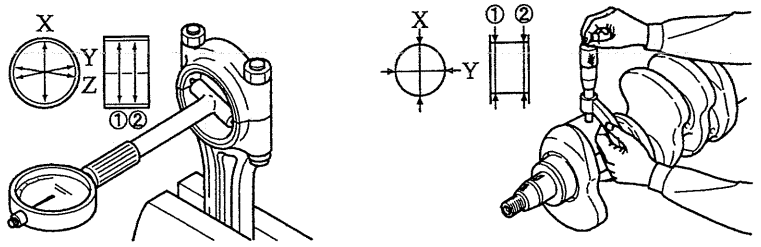
Remark	Approved by	Checked by	Measured by

INSPECTION RECORD SHEET

S4S, S6S

Company		Engine Model		Date	
		Serial No.			
Inspection Point	Measurement of Oil Clearance of Connecting Rod Bearing			Unit	mm [in.]

Measuring Positions



Standard

	Nominal Value	Standard	Limit
Connecting Rod Bearing Inside Diameter	ϕ58 [ϕ2.28]	57.985 to 58.060 [2.28287 to 2.28583]	–
Crankshaft Pin Outside Diameter	ϕ58 [ϕ2.28]	57.955 to 57.970 [2.28169 to 2.28228]	57.800 [2.27559]
Connecting Rod Bearing Oil Clearance	–	0.030 to 0.090 [0.00118 to 0.00354]	0.200 [0.00787]

Measured Values

Part Name		Connecting Rod Bearing Inside Diameter			Crankshaft Pin Outside Diameter		Oil Clearance
No.	Position	X	Y	Z	X	Y	
1	①						
	②						
2	①						
	②						
3	①						
	②						
4	①						
	②						
5	①						
	②						
6	①						
	②						

Remark	Approved by	Checked by	Measured by

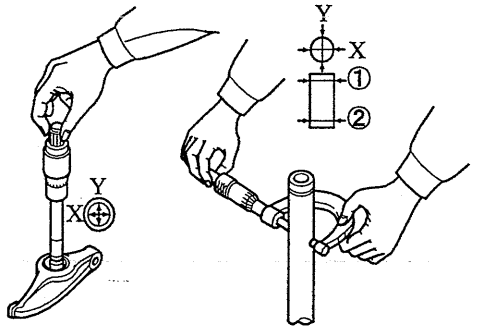
No.6

INSPECTION RECORD SHEET

S4S, S6S

Company		Engine Model		Date	
		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 (Bushing) Inside Diameter	ϕ19 [ϕ0.75]	19.010 to 19.030 [0.74843 to 0.74921]	–
Rocker Shaft Outside Diameter	ϕ19 [ϕ0.75]	18.980 to 19.000 [0.74724 to 0.74803]	–
Clearance between Rocker Arm (Bushing) and Shaft	–	0.010 to 0.050 [0.00039 to 0.00197]	0.070 [0.00276]

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						
4	Inlet						
	Exhaust						
5	Inlet						
	Exhaust						
6	Inlet						
	Exhaust						

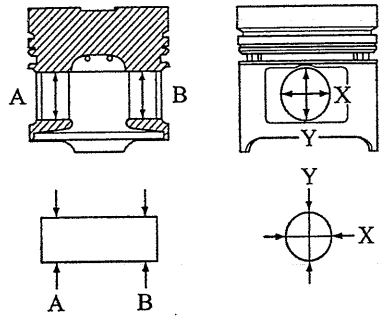
Remark	Approved by	Checked by	Measured by

INSPECTION RECORD SHEET

S4S, S6S

Company		Engine Model		Date	
		Serial No.			
Inspection Point	Measurement of Piston Pin Bore Diameter and Piston Pin Outside Diameter			Unit	mm [in.]

Measuring Positions



Standard

	Nominal Value	Standard	Limit
Piston Pin Bore Diameter	ϕ30 [ϕ1.18]	30.000 to 30.010 [1.18110 to 1.18150]	–
Piston Pin Outside Diameter	ϕ30 [ϕ1.18]	29.994 to 30.000 [1.18087 to 1.18110]	–
Clearance between Piston Pin Bore and Piston Pin	–	0.000 to 0.016 [0.00000 to 0.00063]	0.050 [0.00197]

Measured Values

Part Name		Piston Pin Bore Diameter		Piston Pin Outside Diameter		Clearance	
No.	Position	X	Y	X	Y	Max.	Min.
1	A						
	B						
2	A						
	B						
3	A						
	B						
4	A						
	B						
5	A						
	B						
6	A						
	B						

Remark	Approved by	Checked by	Measured by

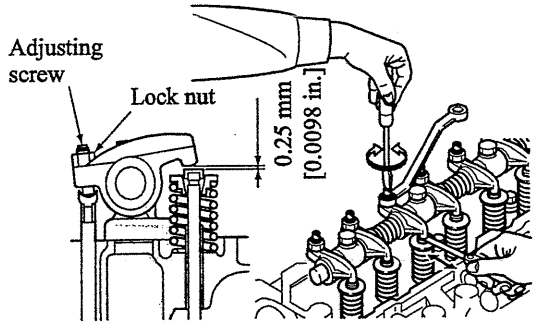
No.8

INSPECTION RECORD SHEET

S4S, S6S

Company		Engine Model		Date	
		Serial No.			
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		
4	Before Adjustment		
	After Adjustment		
5	Before Adjustment		
	After Adjustment		
6	Before Adjustment		
	After Adjustment		

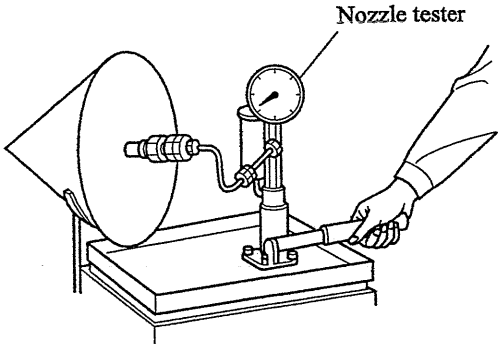
Remark	Approved by	Checked by	Measured by

INSPECTION RECORD SHEET

S4S, S6S

Company		Engine Model		Date	
		Serial No.			
Inspection Point	Measurement of Valve Opening Pressure of Fuel Injection Nozzle			Unit	MPa (kgf/cm^2) [psi]

Measuring Positions



Standard

	Nominal Value		Standard
Valve Opening Pressure	Swirl Chamber	11.77 (120) [1710]	11.77 to 12.75 (120 to 130) [1710 to 1850]
	Direct Injection	17.7 (180) [2560]	18.14 to 19.12 (185 to 195) [2630 to 2770]

Measured Values

No.	Valve Opening Pressure Before Adjustment	Service Hours (h)	Valve Opening Pressure After Adjustment
1			
2			
3			
4			
5			
6			

Remark	Approved by	Checked by	Measured by

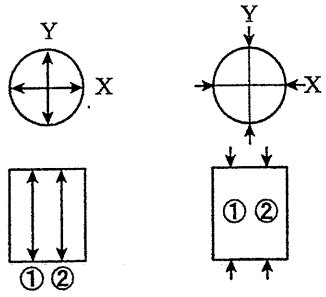
No.10

INSPECTION RECORD SHEET

S4S, S6S

Company		Engine Model		Date	
		Serial No.			
Inspection Point	Measurement of Camshaft Journal Inside Diameter and Camshaft Bushing Clearance			Unit	mm [in.]

Measuring Positions



Standard

			Nominal Value	Standard	Limit
Camshaft Journal Outside Diameter	S4S	No.1, 2	ϕ54 [ϕ2.13]	53.94 to 53.96 [2.1236 to 2.1244]	53.90 [2.1220]
	S6S	No.1, 2, 3			
	S4S	No.3	ϕ53 [ϕ2.09]	52.94 to 52.96 [2.0843 to 2.0850]	52.90 [2.0827]
	S6S	No.4			
Clearance between Camshaft Journal Outside Diameter and Crankcase Camshaft Bore Diameter			–	0.07 to 0.11 [0.0028 to 0.0043]	0.15 [0.0059]
Camshaft Bore Diameter	S4S	No.1, 2	ϕ54 [ϕ2.13]	54.030 to 54.050 [2.1272 to 2.1280]	–
	S6S	No.1, 2, 3			
	S4S	No.3	ϕ53 [ϕ2.09]	53.030 to 53.050 [2.0878 to 2.0886]	–
	S6S	No.4			

Measured Values

Part Name		Camshaft Bushing Inside Diameter		Camshaft Journal Outside Diameter		Clearance	
No.	Position	X	Y	X	Y	Max.	Min.
1	①						
	②						
2	①						
	②						
3	①						
	②						
4	①						
	②						

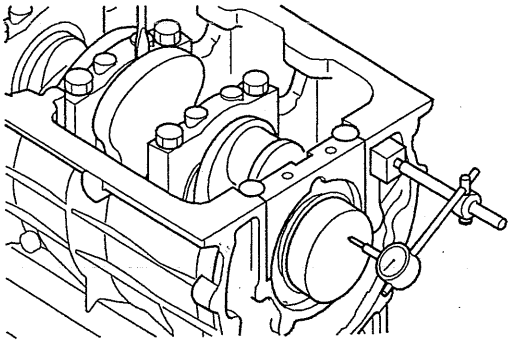
Remark	Approved by	Checked by	Measured by

INSPECTION RECORD SHEET

S4S, S6S

Company		Engine Model		Date	
		Serial No.			
Inspection Point	Measurement of Crankshaft End Play			Unit	mm [in.]

Measuring Positions



Standard

	Standard	Limit
Crankshaft End Play	0.100 to 0.264 [0.00394 to 0.01039]	0.300 [0.01181]

Measured Values

During Disassembly	After Reassembly

Remark	Approved by	Checked by	Measured by