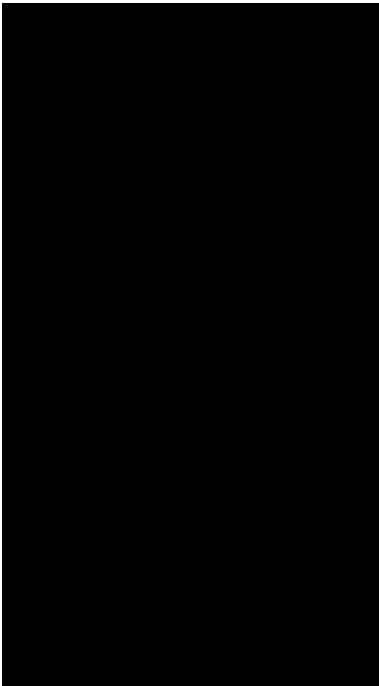


SERVICE MANUAL



MITSUBISHI DIESEL ENGINES S6R, S6R2

FOREWORD

This service manual describes the maintenance and adjustment procedures, and specifications for Mitsubishi diesel engines.

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 scheduled inspection and maintenance, and it may also be necessary to take appropriate measures which involve in disassembly, inspection, repair and assembly work of the engine and engine parts.

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

The contents of this manual are based on the engine model produced at the time of publication. Please note that the contents of this manual may change due to improvements made thereafter.

HOW TO USE THIS MANUAL

This service manual consists of several chapters, which will give you quick references to specifications, maintenance standards, adjustment and service procedures including practices to disassemble, inspect, repair and assemble the Mitsubishi diesel engines.

A short summary describing the contents of each chapter is given in the CHAPTER INDEX page, and there is also a detailed table of contents at the beginning of each chapter.

Regarding the procedures for operation and scheduled maintenance of the engine, refer to the Operation and Maintenance Manual. For information on the engine components and ordering of service parts, refer to the Parts Catalogue. Structure and function of the engine are described in the relevant training manuals.

If you have an inquiry, please check the engine model and serial number, and contact our service department.

Description format

- (1) Index numbers allotted to parts in exploded views are not only a call-out of part names listed in the text but also an indication of the sequence of disassembly.
- (2) Inspections to be conducted during disassembly process are indicated in boxes in the relevant exploded views.
- (3) Maintenance standards required for inspection and repair works are indicated in the appropriate positions in the text. They are also collectively indicated in the Chapter 2.
- (4) The tightening torque with engine oil applied on the thread, is specified [Wet]. Unless otherwise specified, the tightening torque is of dry condition.
- (5) In this manual, important safety or other cautionary instructions are emphasized with the following head marks.



DANGER

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



WARNING

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



CAUTION

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



CAUTION

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

Note

Emphasizes important matter, or indicates information useful for operation or maintenance of the engine.

Terms used in this manual

Nominal value

means the basic nominal size of a part to be measured.

Standard value

means the quantitative requirement for dimension of a part, clearance between parts and performance. The values are rounded off for the inspection job, and do not necessarily conform to the design values.

Limit value

means the limit value, which the measured value reaches, the part needs repair or replacement with a new one.

Abbreviations and Standards

- ♦BTDC : Before Top Dead Center
- ♦ATDC : After Top Dead Center
- ♦BBDC : Before Bottom Dead Center
- ♦ABDC : After Bottom Dead Center
- ♦TIR : Total Indicator 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.A.)
- ♦MSDS : Material Safety Data Sheet
- ♦SAE : Society of Automotive Engineers (U.S.A.)
- ♦P/N : Part Number

Unit of Measurement

Measurements are based on the International System of Units (SI), and their converted metric values are indicated in { } and U.S. customary values are in []. For metric conversion, the following rates are used.

- ♦Pressure : $1 \text{ MPa} = 10.197 \text{ kgf/cm}^2$
- ♦Torque : $1 \text{ N}\cdot\text{m} = 0.10197 \text{ kgf}\cdot\text{m}$
- ♦Force : $1 \text{ N} = 0.10197 \text{ kgf}$
- ♦Output power : $1 \text{ kW} = 1.341 \text{ HP} = 1.3596 \text{ PS}$
- ♦Pressure (mercury column) : $1 \text{ kPa} = 0.7 \text{ cmHg}$
- ♦Pressure (watercolumn) : $1 \text{ kPa} = 10.197 \text{ cmH}_2\text{O (cmAq)}$
- ♦Rotation speed: $1 \text{ min}^{-1} = 1 \text{ rpm}$

Safety Cautions

Fire and Explosion Precautions

WARNING

Keep Flames Away

Do not use flames near the engine (in the engine room). The flame is dangerous to ignite combustibles and cause a fire. Wipe off spilled fuel, oil and LLC immediately and thoroughly.



Spilled fuel, oil and LLC may ignite and cause a fire. Store the fuel and engine oil in a well ventilated area. Make sure that the fuel and engine oil container caps are tightly fastened.

Keep Engine Surrounding Area Tidy and Clean

Do not place combustible or explosive material, such as fuel, engine oil, LLC or explosive powder near the engine. Such substances can cause a fire or explosion. Thoroughly remove dust, dirt and other foreign material collected on the engine and the area around the engine. Such material can cause a fire or the engine to overheat. In particular, clean the top surface of the battery thoroughly. Dust can cause a short-circuit. Always place the engine at a position at least 1 m [3.28 ft.] apart from buildings and other equipment to prevent a possible fire caused by engine heat.

Do Not Open Side Covers Until Engine Cools

Do not try to open the side cover of crankcase before the engine cools down. Wait at least 10 minutes after stopping the engine. Opening the cover when the engine is hot allows fresh air to flow into the crankcase, which can cause oil mist to ignite and explode.

Pay Attention to Fuel, Oil and Exhaust Gas Leak

If any fuel, oil or exhaust gas leakage is found, immediately take corrective measures to stop it. Such leakages, if left uncorrected, can cause fuel or engine oil to reach hot engine surfaces or hot exhaust gas to contact flammable material, may results in a fire, personal injury and damage to the equipment.

Use Explosion-proof Light

When inspecting fuel, engine oil, coolant, battery electrolyte, etc., use an explosion-proof light. If the lighting is not an explosion-proof type, it may ignite and cause an explosion.

Prevent Electrical Wires From Short Circuit

Avoid inspecting or servicing the electrical system with the battery cable connected to the battery. Otherwise, a fire could result from short circuit. Be sure to disconnect the battery cable from the negative (-) terminal before starting work. A loose terminal and a damaged cable or wire may result in a short circuit and a fire. Inspect, and if any defect is found, repair or replace it before starting work.

Keep Fire Extinguishers and First-aid Kit Handy

Keep fire extinguishers handy, and become familiar with their usage. Keep a first-aid kit at the designated place to be ready for use in an emergency. Make counteract procedures against a fire or an accident. Provide the contact person and means of communication in case of emergency.



Stay Away From Rotating and Moving Parts



Install Protective Covers Over Rotating Parts After Inspection and Maintenance Work

Check the covers over engine rotating parts for correct installation. Repair any damaged or loosed covers. Never remove the protective covers over rotating parts during operation. When the engine is coupled to a radiator or other equipment, install protective covers over the exposed connecting belt and coupling.



Check Work Area for Safety Before Starting

Before starting the engine, make sure that no one is near the engine and that tools are not left on or near the engine. Verbally notify persons within the immediate area when starting the engine. When the starter device is tagged with the warning sign saying DO NOT RUN, never start the engine.

Stay Away From Moving Parts While Engine Operates

Keep away from the rotating parts during operation. Do not leave any objects that may get caught in rotating parts. If clothes or a tool gets caught in rotating parts, serious injury will result.



Lockout and Tagout

Be sure to lockout and tagout before starting inspection and maintenance. Lockout and tagout are effective methods of cutting off machines and equipment from energy sources. To accomplish the lockout/tagout, remove the starter switch key, set the battery switch to OFF position and attach a DO NOT RUN or equivalent caution tag to the starter switch. The starter switch key must be kept by the person who performs inspection and maintenance work.

Be Sure to Stop the Engine Before Inspection and Maintenance

Be sure to stop the engine before proceeding to inspection and maintenance work. Never try to make adjustments on the engine parts while the engine is running. Rotating parts such as belt can reel in your body and cause serious injuries.

Always Put Back Engine Turning Tool After Use

Be sure to remove the turning tool used for inspection and maintenance work. Make sure to pull back the turning gear to the engine running position before starting the engine. If the engine is started with a turning tool inserted or turning condition, it can not only cause damage to the engine, but also lead to a personal injury.

Be Careful of Exhaust Gas Poisoning

WARNING

Be Careful of Ventilation to Operate Engine

If the engine is installed in an enclosed area, and the exhaust gas is ducted outside, make sure that duct joints are free from gas leak. Exhaust gas from the engine contains harmful components such as carbon monoxide. Operating the engine in an ill-ventilated area can cause gas poisoning.



Be Careful of Hearing Loss

WARNING

Wear Ear Plugs

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



Be Careful of Falling

WARNING

Lift Engine Carefully

Use slings or wire ropes strong enough to lift the load considering the engine weight. To lift the engine, hitch the proper slings to the lifting hangers prepared on the engine. To lift the engine, keep the engine in a well-balanced position, thinking carefully of the engine center of gravity.



The hangers prepared on the engine are designed for lifting the weight of engine only. In the case where the generator, marine gear, and others are installed to the engine, consideration that the additional weight will not affect the hangers of the engine.

Keep the angle formed by slings attached to hangers within 60°. If the angle exceeds this limit, excessive load may be applied to the hangers and damage the hangers. If the wire rope contacts the engine directly, place a cloth or other soft pad to avoid damage to the engine and sling.

Do Not Climb Onto the Engine

Do not climb onto the engine, nor step on any engine parts on the engine sides. To work on parts located high on the engine, use a ladder, footing, and others to prevent from slipping and falling. Climbing onto the engine may result in engine part damage and your injury by falling down.

Always Prepare a Stable Footing

When working on the upper part of the engine and other hard-to-reach places, use a stable footing. Standing on an old footstool or parts box may result in personal injury. Do not put any unnecessary objects on a footing.



Be Careful When Handling Fuel, Engine Oil or LLC

WARNING

Use Specified Fuel, Engine Oil and Long-Life Coolant (LLC) Only

Use the fuel, oil and LLC specified in this manual only, and handle them carefully. Use of any other fuel, oil or LLC, or improper handling may cause various engine defects and malfunctions. Get the MSDS issued by the fuel, oil and LLC suppliers, and follow the directions in the MSDS for proper handling.

Handle LLC Carefully

When handling LLC, wear rubber gloves and a protective face mask. If LLC or coolant containing LLC comes into contact with your skin or eyes, or if it is swallowed, you would suffer from inflammation, irritation or poisoning. If LLC is accidentally swallowed, induce vomiting immediately and seek medical attention. If LLC enter your eyes, flush them immediately with plenty of water and seek medical attention. If LLC contact your skin or clothing, wash it away immediately with plenty of water. Keep flames away from LLC. LLC can catch flames and cause a fire. Drained coolant containing LLC is a hazardous material. Do not discard it in an unauthorized procedure. Practice the applicable law and regulations when discard drained coolant.

Proper Discarding of Waste Oil, LLC and Coolant

Do not discard waste engine oil, LLC and coolant in an unauthorized procedure. Such a way of disposal is strictly prohibited by laws and regulations. Discard waste oil, LLC, coolant and other environmentally hazardous waste in accordance with the applicable laws and regulations.

Be Careful of Burns

WARNING

Do Not Touch the Engine During or Immediately After Operation

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

You can get burned. Before starting the maintenance and inspection work,



check the water temperature meter to make sure that the engine is cooled down.

Be Careful to Open and Close the Radiator Cap

Never open the radiator cap while the engine is running or immediately after the engine stops. Stop the engine and give a sufficient time to allow the coolant to cool down before opening the cap. When opening the radiator cap, slowly open the cap so as to release internal pressure. To prevent hot steam scalds, wear thick rubber gloves or cover the cap with a cloth. When closing the radiator cap, tightly close the cap. Do not open the radiator cap during engine running or immediately after engine stop. Otherwise hot steam and coolant gush out and can cause burns.

Refill Coolant Only After the Coolant Temperature Dropped

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

Do Not Remove Heat Shields

The exhaust system, which becomes extremely hot while the engine is operating, is provided with various heat shields. Never remove the heat shields. If any of these heat shields were inevitably removed for the inspection and maintenance, be sure to install them after the work.

Be Careful of Burns When Changing Oil

Wear gloves when draining oil or changing oil filters. If your skin contacts hot oil or hot parts, you get burn injury.

Battery



CAUTION

Be Careful with Battery

- Never use flames or generate sparks near the battery. The battery gives off highly flammable hydrogen gas and oxygen gas. Any flame or spark near a battery may cause an explosion.
- Do not use the battery if its fluid level is below the lower limit line. Long use of the battery may result in an explosion.
- Do not short the battery terminals with a tool or other metal object.
- When disconnecting battery cables, always remove first from negative (-) terminal first. When reconnecting the cables, always connect first to the positive (+) terminal.
- Charge the battery in a well-ventilated area, with all battery plugs removed.
- Make sure the cable clamps are securely fastened to the battery terminals. A loose terminal 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 may lead to the loss of sight and/or skin burns. Also, do not swallow battery fluid.
- Wear protective goggles and rubber gloves when working with the battery (such as adding water or charging).
- If battery electrolyte is spilled onto the skin or clothing, immediately wash it away with lots of water. Use soap to clean thoroughly.
- Battery fluid can make you blind if splash into your eyes. Immediately flush it away with plenty of clean water, and seek immediate medical attention.
- If battery fluid is accidentally swallowed, gargle with plenty of water, then drink lots of water, and seek immediate medical attention.



When Abnormality Occurs



CAUTION

Do Not Add Coolant Immediately After a Sudden Stop Due to Overheating

If the engine stops suddenly due to overheating, or you suddenly stop the engine by any reason, do not add coolant immediately. If water is added immediately, parts such as cylinder heads can be damaged due to the sudden drop of temperature. Add coolant slowly after the engine becomes cool.

Be Careful to Restart After Abnormal Stop

If the engine stops abnormally, do not restart the engine immediately. If the engine stops giving an emergency alert, inspect the engine and correct the cause of the defect before restarting. If the engine is kept operating in such a condition, it can result in serious engine failure.

Immediately Stop the Engine When Engine Oil Pressure Drops

If the engine oil pressure drops significantly, stop the engine immediately, and inspect the lubrication system to find the cause. Continuous engine operation with low oil pressure may cause bearings and other parts to seize.

Stop the Engine Immediately When the Belt Break

If the belt breaks, stop the engine immediately. Continuous engine operation with the broken belt can cause the engine to overheat. Steam of boiled coolant may gush out from the reserve tank or radiator, and results in burns.

Other Cautions

CAUTION

Do Not Tamper

If tampered, the warranty is totally void even in the warranty period. Tampering with the engine can not only damage the engine but also may lead to personal injury.

Perform All Specified Pre-operation Inspections and Scheduled Inspections

Conduct the daily inspection and scheduled inspection/maintenance as described in this manual.

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

Wear Proper Work Clothing and Protective Gears

Wear a hard hat, face shield, safety shoes, dust mask, gloves and other protective gears as needed. When using compressed air, wear safety goggles, a hard hat, gloves and other necessary protective gear. Works without wearing proper protective gears may result in serious injury.

Never Break the Seals

To ensure the proper engine operation, the fuel control link is provided with seals that protect the fuel injection volume and rotation speed settings against tampering. If the seal is tampered, no guarantee will be provided. If the seal is tampered, the defects shown below can occur.

- ♦Rapid wear of moving and rotating parts
- ♦Engine troubles such as seizure and damage of engine parts
- ♦Sudden increase of fuel and lubricating oil consumption
- ♦Deterioration of engine performance due to improper balance between fuel injection volume and governor control, or a serious accident due to overrunning of the engine

Inspect the Engine After Operation

After the engine operation, inspect each part of engine once again. If any defect is found, correct immediately.

Break-in the Engine

To break-in a new engine or overhauled engine, operate the engine at a speed lower than the rated speed in a light load condition during the first 50 hours of operation. Operating a new engine or overhauled engine in a severe condition during the break-in period shortens the service life of the engine.

Warm-up the Engine Before Use

After starting the engine, run the engine at a low idling speed for 5 to 10 minutes for warming-up. Start the work after this operation is completed. Warm-up operation circulates lubricant in the engine, and works for the longer service life and economical operation. Do not continue the warm-up operation for a longer time than necessary. Long warm-up operation causes carbon deposits in the cylinders, and may lead to incomplete combustion.

Do Not Operate the Engine in an Overloaded Condition

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

Cool Down the Engine Before Stop

Cool down the engine at low idling for five to six minutes before stopping it. Stopping the engine immediately after high-load operation will cause local heat up of engine parts and shorten the service life of the engine. During the cooling operation, check the engine for abnormalities.

Do Not Continue Low Load Operation

Low load continuous operation (less than 30%) must be limited within one hour. Long warm-up operation causes carbon deposits in the cylinders, and may lead to incomplete combustion. Also, after low load operation for approx one hour, run the engine at a 30% or higher load for five minutes or more.

Use Care to Protect Engine From Water

Use care to protect engine from water such as rain entering through the air inlet or exhaust openings. Do not wash the engine while it is running. Cleaning fluid or water can be sucked into the engine. Starting the engine with water inside the combustion chambers can cause the water hammering, and may result in engine inner parts damage and serious accident.

Air Cleaner or

Pre-cleaner is to be Properly Maintained.

With foreign material in the intake air, excessive wear of the engine can result. Worn parts produce many problems such as increase of oil consumption, decrease of output and starting difficulties. For effective removal of dust from intake air, maintain the air cleaner/pre-cleaner according to the following instructions.

- ♦Never perform maintenance of the air cleaner or pre-cleaner during operation. Foreign material enters the turbocharger and may result in a serious failure.
- ♦When removing the air cleaner or pre-cleaner, be careful to prevent dust and foreign material collected on the cleaner from entering the engine. After removing the air cleaner or pre-cleaner, immediately cover the opening (inlet port of engine or turbocharger silencer) with plastic sheet or similar means to prevent foreign materials from entering the engine.
- ♦An air cleaner with a dust indicator gives an alarm when it is clogged. Conduct maintenance when the alarm is given.

Observe Safety Rules at Work Site

Observe the safety rules established at the workplace when operating and maintaining the engine. Do not operate the engine if you are in bad health. Consult your supervisor about your condition. Operation of the engine with decreased attention may cause improper operation and results in an accident. When working in a team of two or more people, use specified hand signals to communicate among workers.

Use Proper Tools for Maintenance Work

Always keep in mind to select most appropriate tools for the work and use them correctly. If a tool is damaged, replace with new tool.

Do Not Operate Starter for a Long Time

Do not use the starter for more than 10 seconds at a time. If the engine does not start, wait for at least 1 minute before starting again. Continuous operation of the starter to start a stubborn engine may lead to a flat battery or starter burning out.

Do Not Turn Off the Battery Switch During Operation

If the battery switch is turned OFF when the engine is running, not only various meters will stop working but also the diodes and transistors in the starter can be damaged.

Cautions for Engine Transportation

To road-transport the engine, consider the engine weight, width and height, and obey applicable laws and regulations such as road traffic laws, vehicle road acts and vehicle restriction ordinances.

Be Careful of Engine Room Ventilation

Always keep the engine room well-ventilated. Insufficient intake air amount of the engine can cause an increase in the engine temperature, and could result in a decrease in the output power and poor performance. It is highly recommended to calculate the required amount of air supply to the engine and install an adequate ventilation system before installing the engine.

Do Not Touch High Pressure Fuel Jet

Do not touch fuel jet leaked or sprayed from the high pressure injection pipe. Fuel in the fuel injection pipe has a high pressure and if the fuel impinges your skin, it goes through the skin and can cause serious injury.

Warning Labels



Maintenance of Warning Labels

Make sure all warning/caution labels are legible.

Clean or replace the warning or caution label when the description or illustration is not clear to read.

For cleaning the warning/caution labels, use a cloth, water and soap. Do not use cleaning solvent, gasoline or other chemicals to prevent the label from fading and peering.

Replace a damaged or missing label with a new one.

If any engine part stuck with a warning label is replaced with a new one, attach a new identical warning label to the new part.

To get new warning labels, contact our approved dealer.



Warning labels

Points on Disassembling and Assembling

This service manual contains the recommended practices to service the engine. The manual also contains dedicated special tools made for the work, and the basic safety cautions to obey when working. Note that this manual does not cover all potential hazards that could occur during maintenance, inspection and service works of the engine.

When working on the engine, follow the related instructions in this manual and also be careful of the following:

Points on Disassembling

- ♦ Use correct tools and instruments. Or serious damage or accident may result.
- ♦ Do not use jack bolts having sharp edge, as they may cause damage to the surface.
- ♦ Use a footing and workbench to place disassembled parts if necessary, and obey the disassembling procedures described in this manual. Do not place the parts on the floor directly. Place them on a workbench or the like.
- ♦ Place the engine parts in the order of removal to prevent from missing. Place the parts in the serial order for reassembling.
- ♦ When reusing the engine parts, unless there are special reasons, install them to their original positions.
- ♦ Pay attention to assembling marks. Put your marks on the parts, if necessary, to ensure correct assembling.
- ♦ Carefully check each part for defects during disassembling or cleaning. Do not miss symptoms which can not be found after disassembling or cleaning.
- ♦ Pay attention to the safety, especially for the balancing of disassembled parts and carrying of heavy parts. (Get help, and use jacks, chain blocks and guide bolts as necessary.)
- ♦ Use protective gloves when you touch overheated or frozen parts. Touching the part with a bare hand can cause burns.

Points on Assembling

- ♦ Wash all engine parts, except such parts as oil seals, O-rings and rubber seats, in cleaning oil and dry them with compressed air.
- ♦ Use correct tools and instruments.
- ♦ Use only high-quality lubricating oil and grease of the appropriate type. Be sure to apply oil, grease or adhesive to specified surfaces.
- ♦ Use a torque wrench to tighten parts correctly when their tightening torques are specified. Refer to "Tightening torque table."
- ♦ Replace Gaskets, packings and O-rings with new ones. Apply adhesive as required. Do not apply adhesive too much.
- ♦ Use protective gloves when you touch overheated or frozen parts. Touching the part with a bare hand can cause burns.

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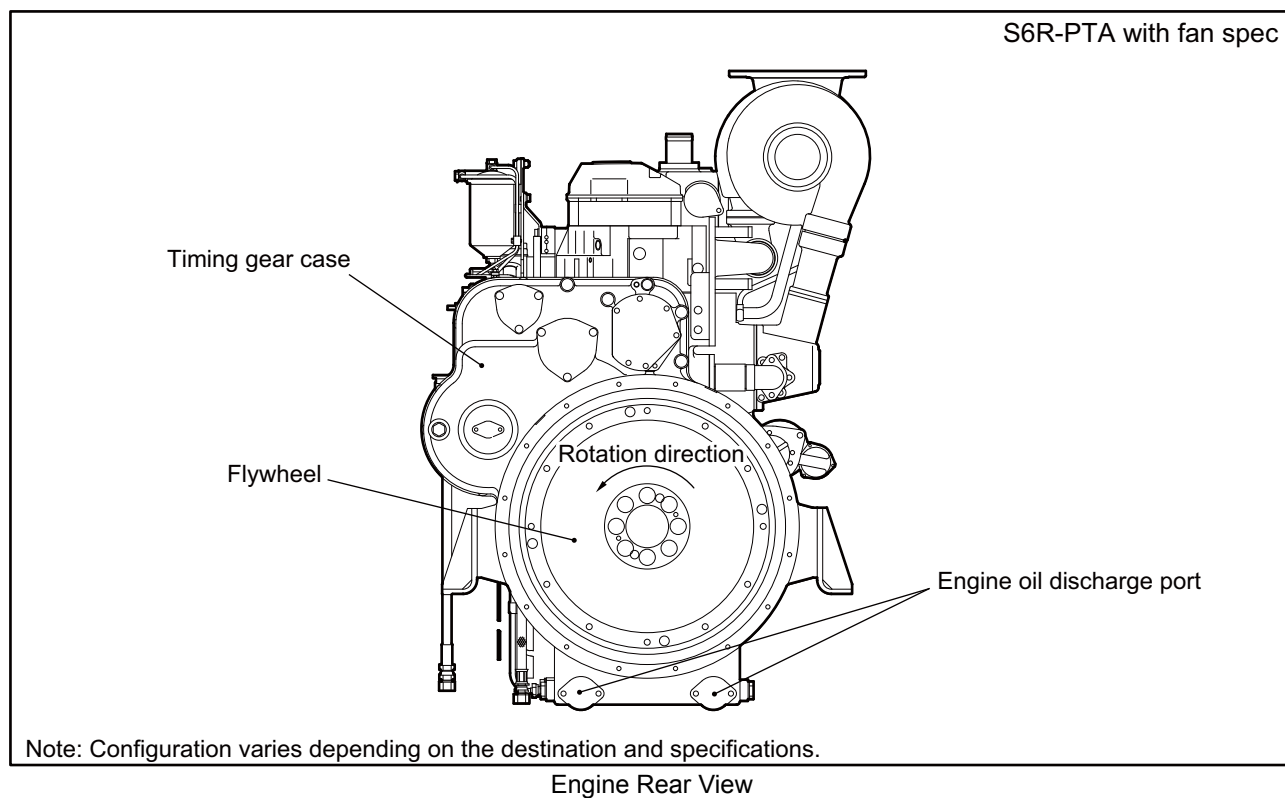
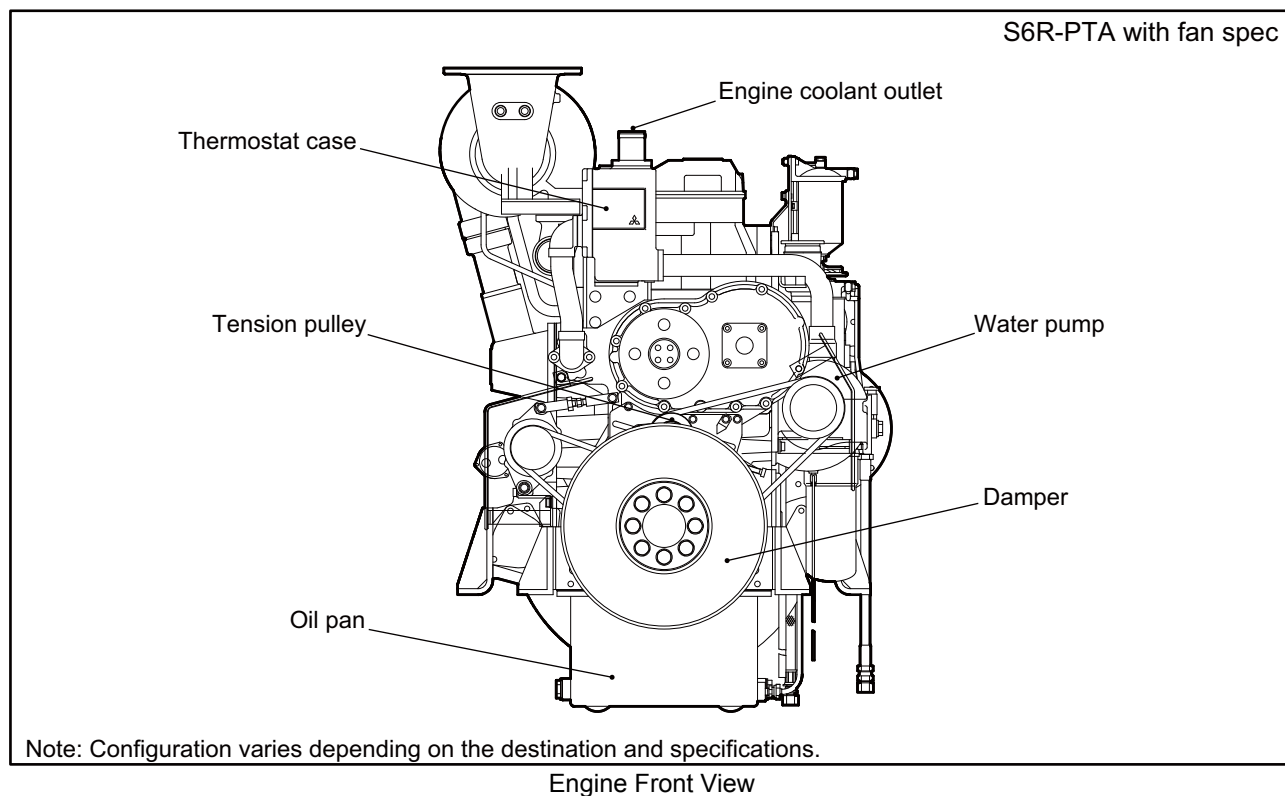
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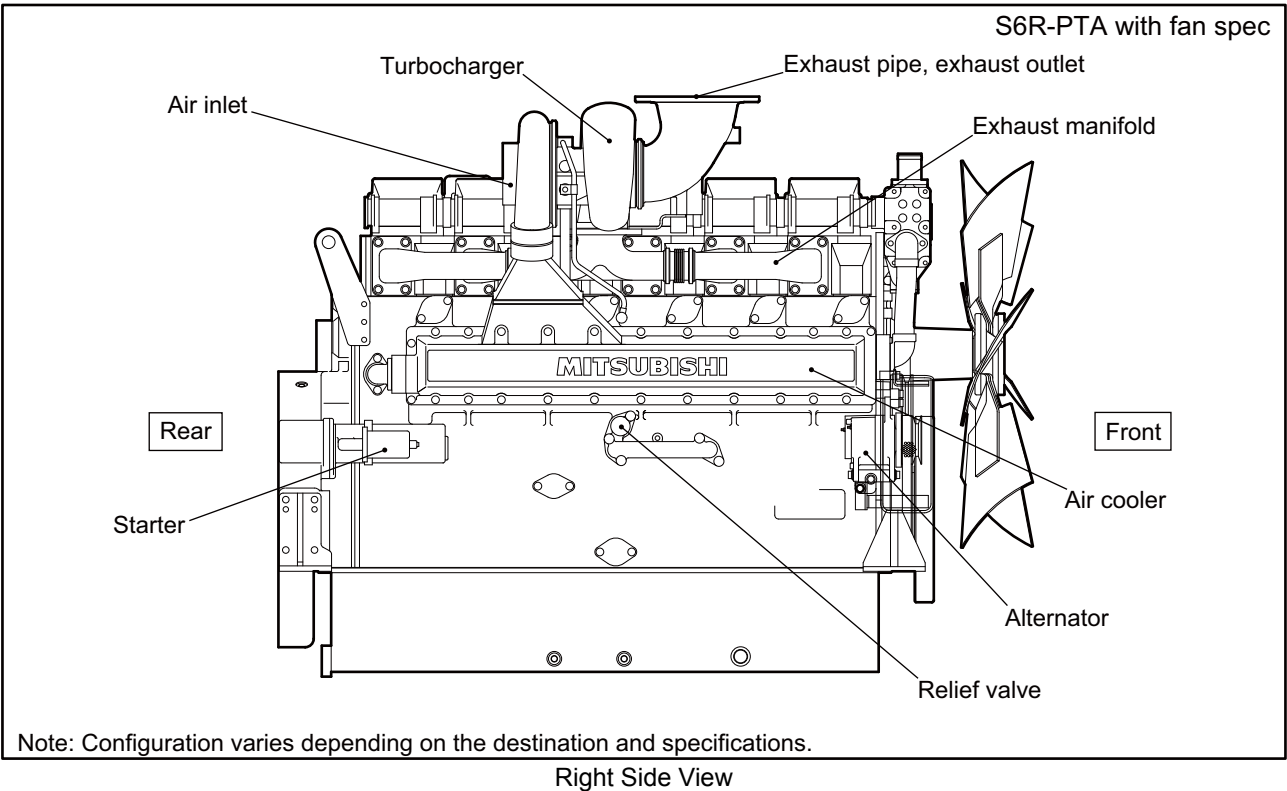
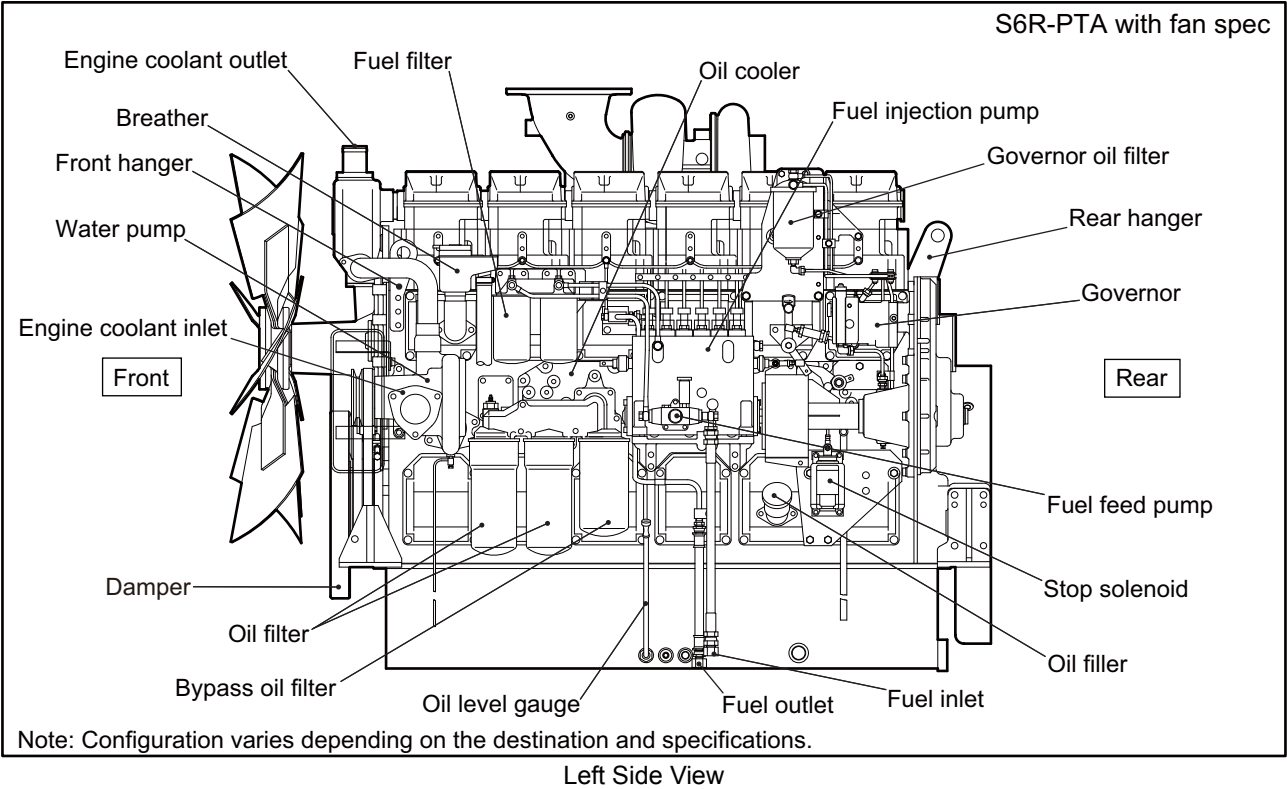
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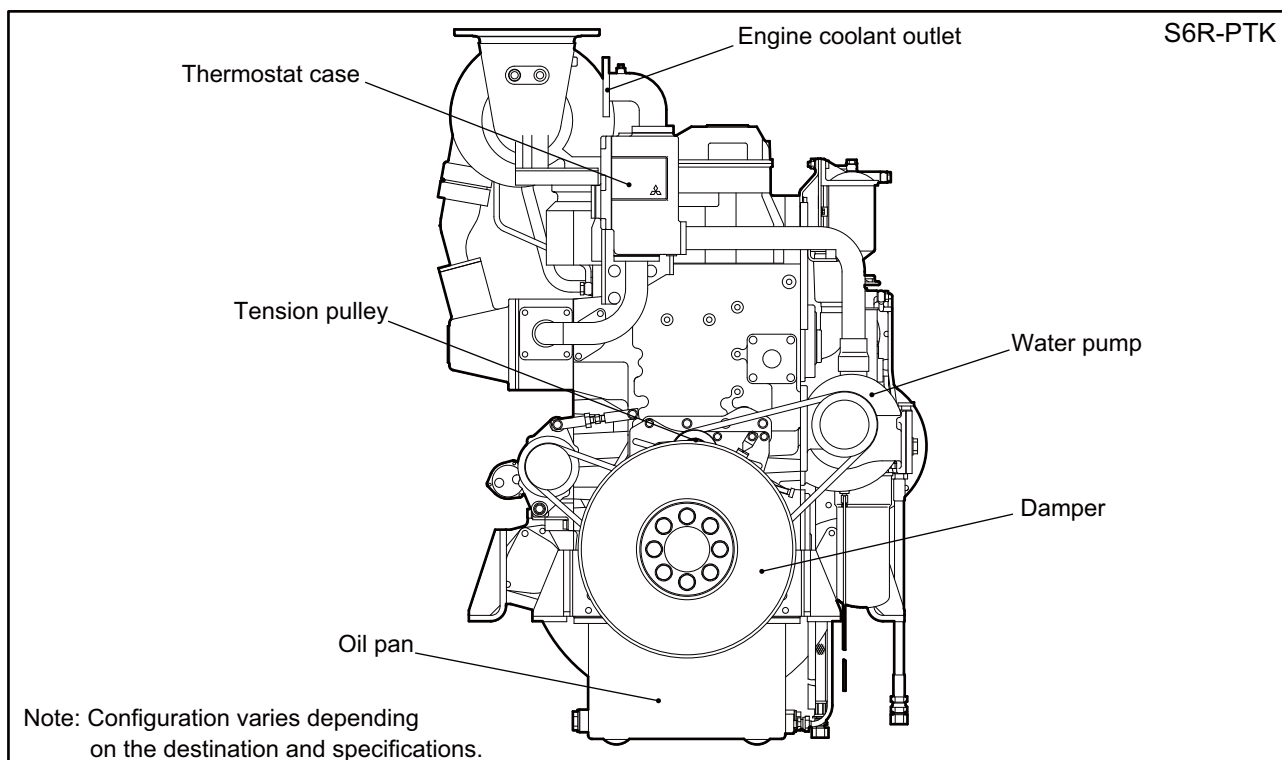
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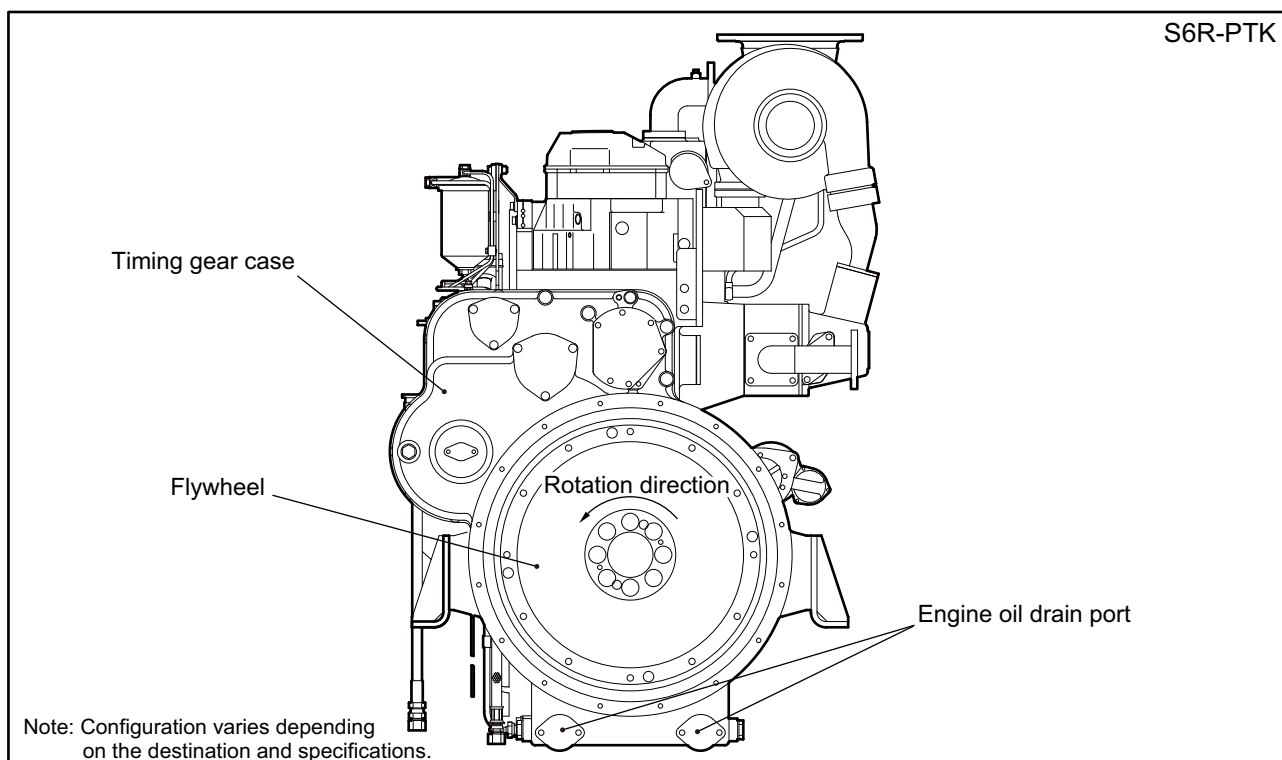
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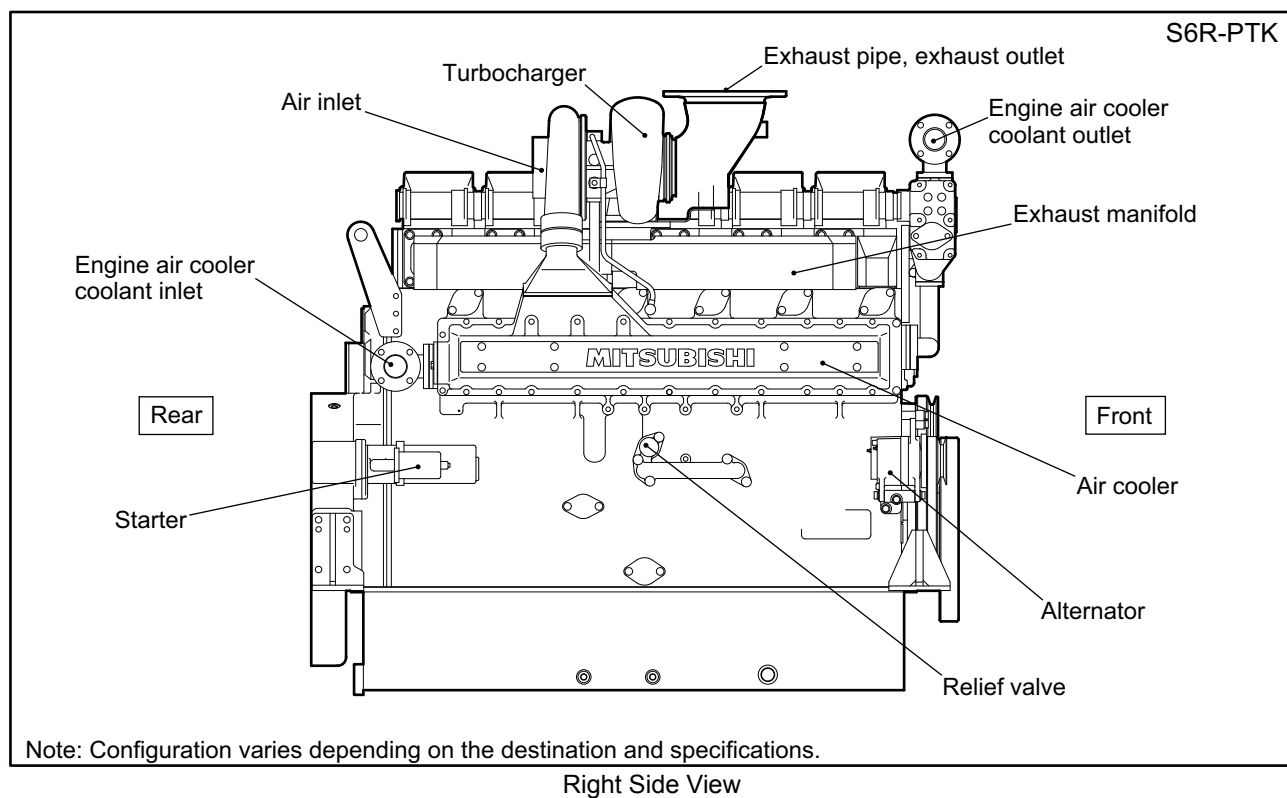
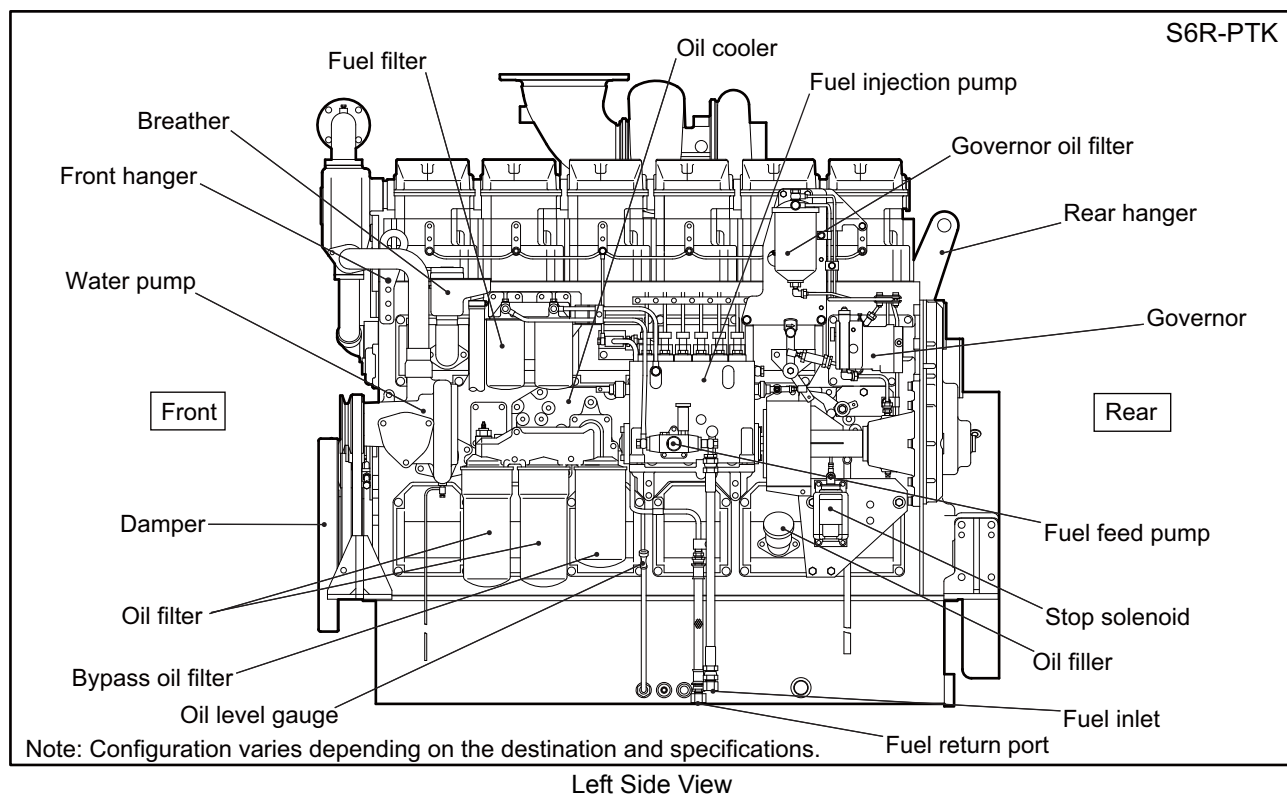


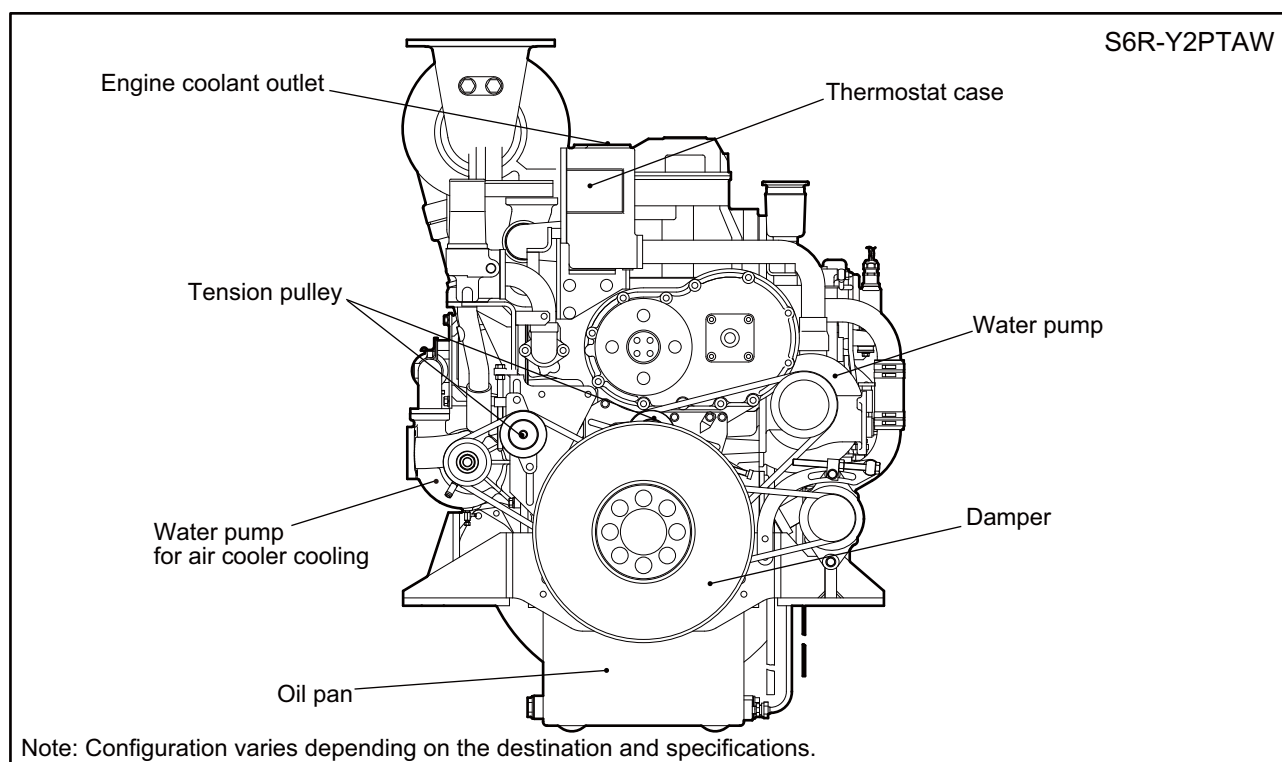


Engine Front View

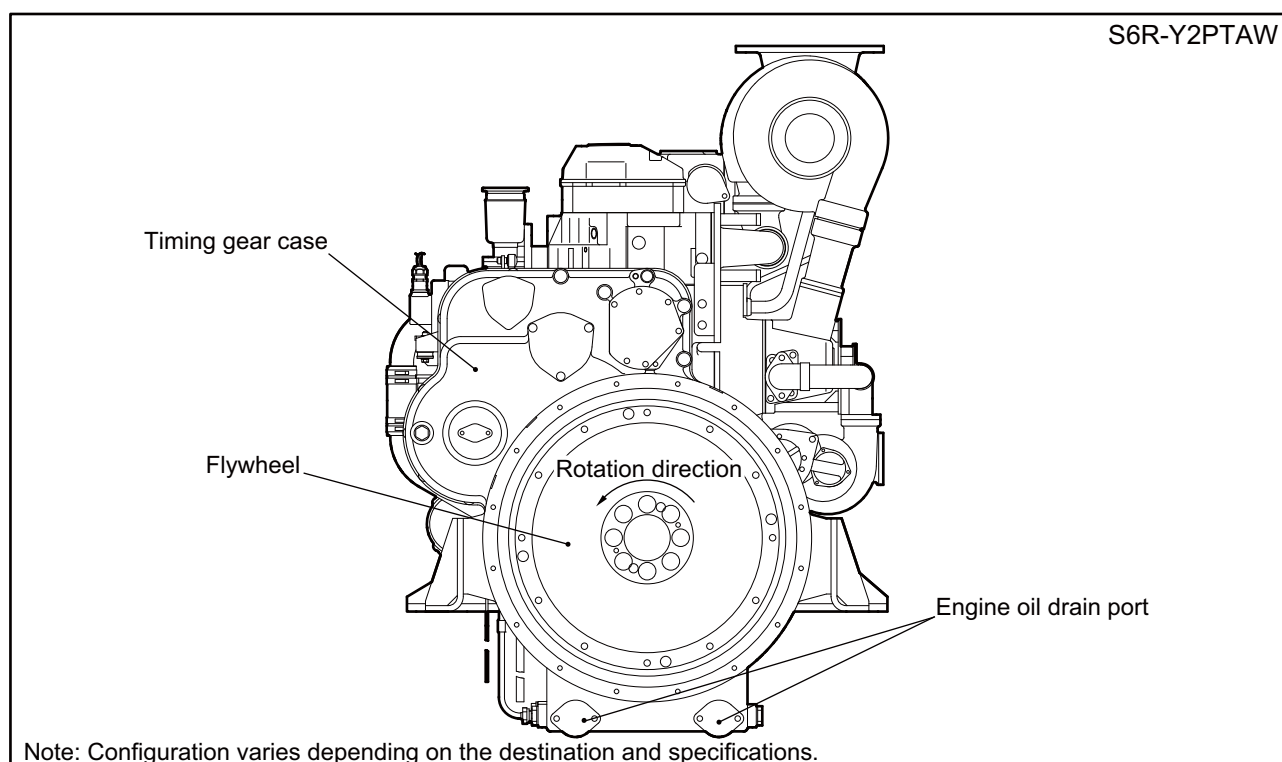


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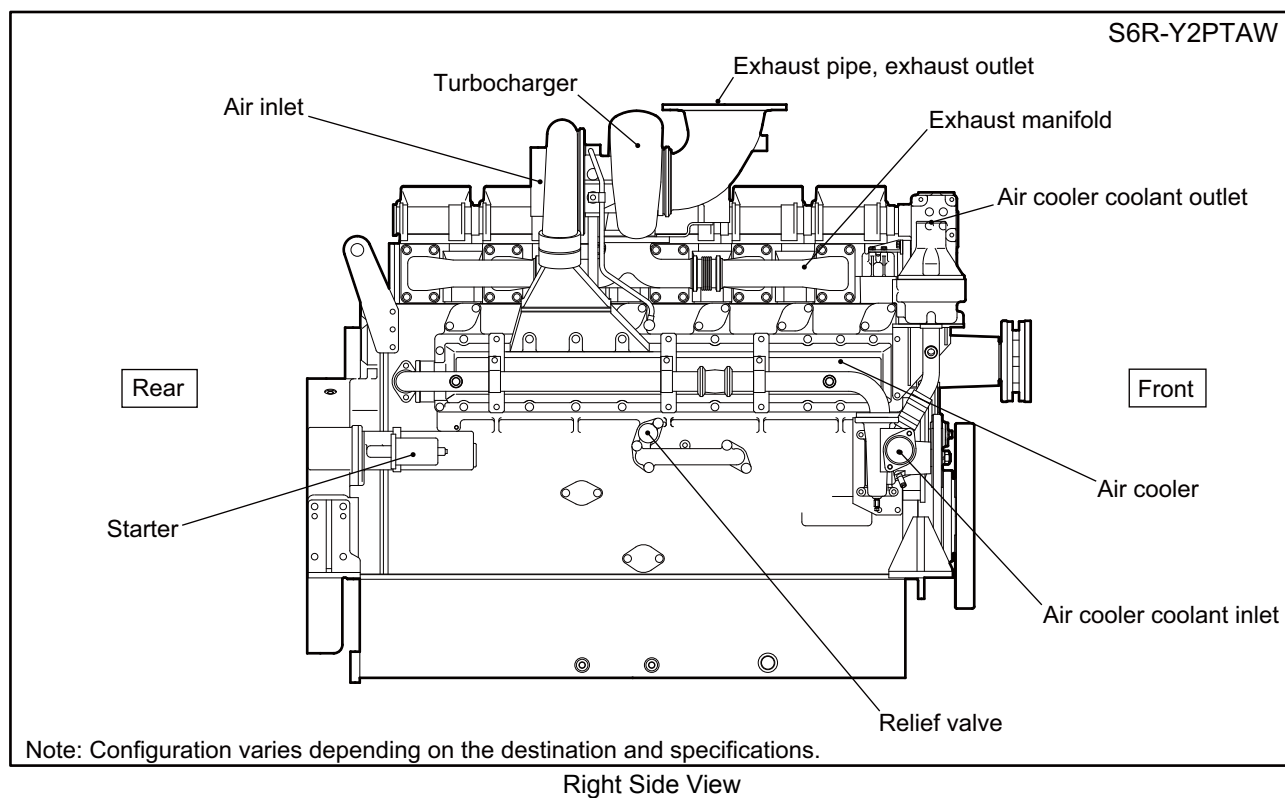
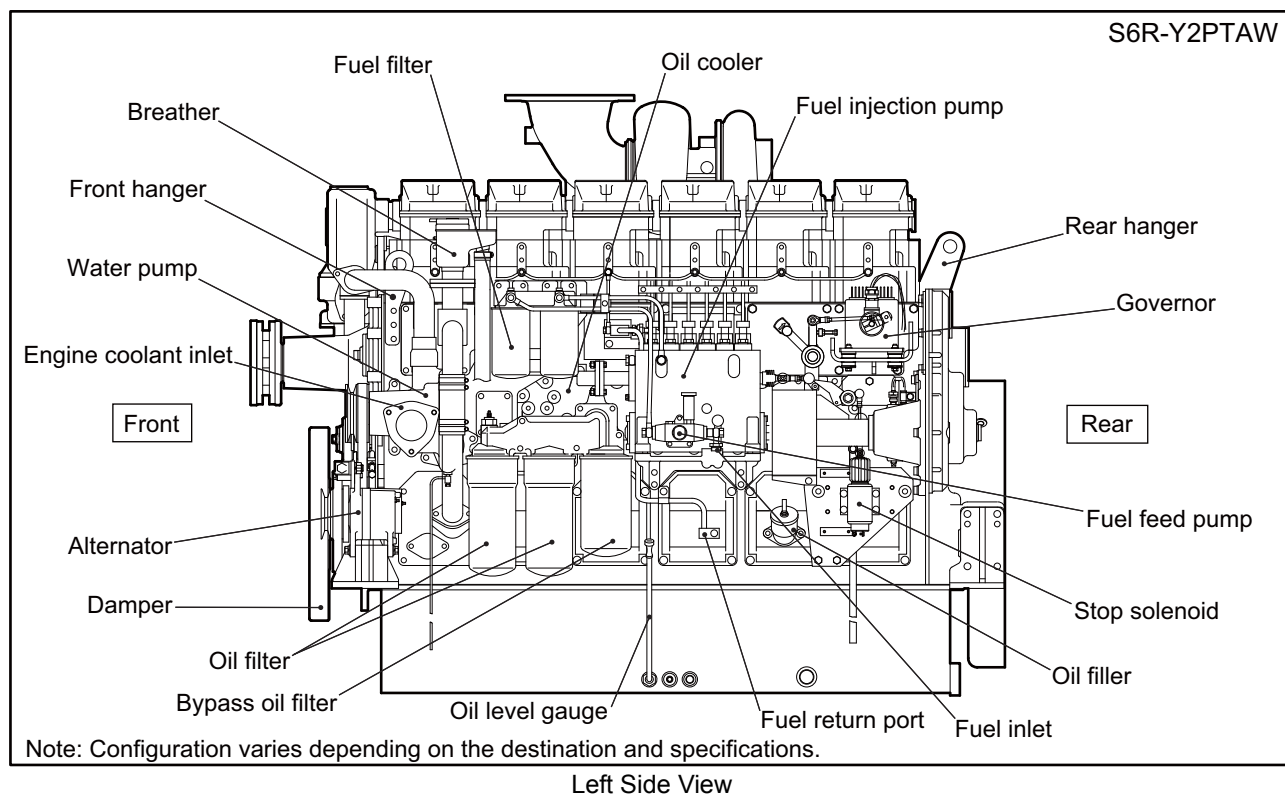


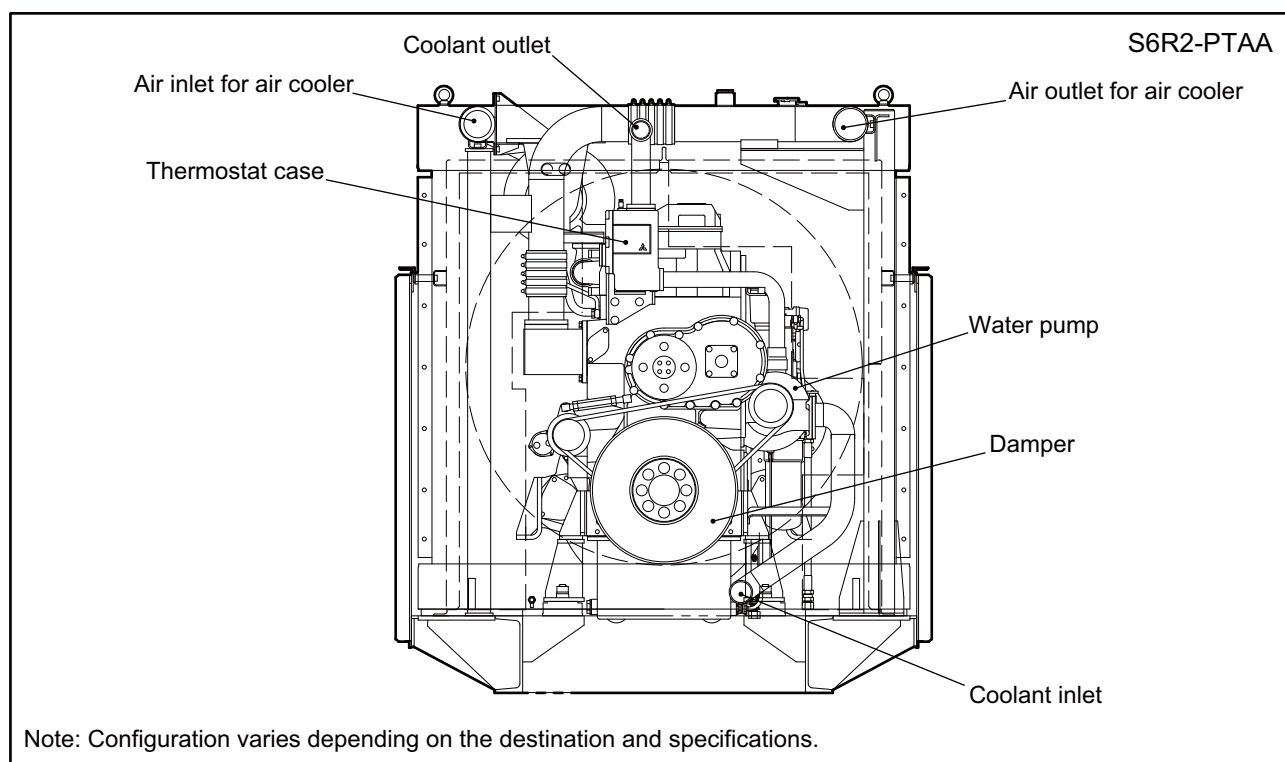


Engine Front View

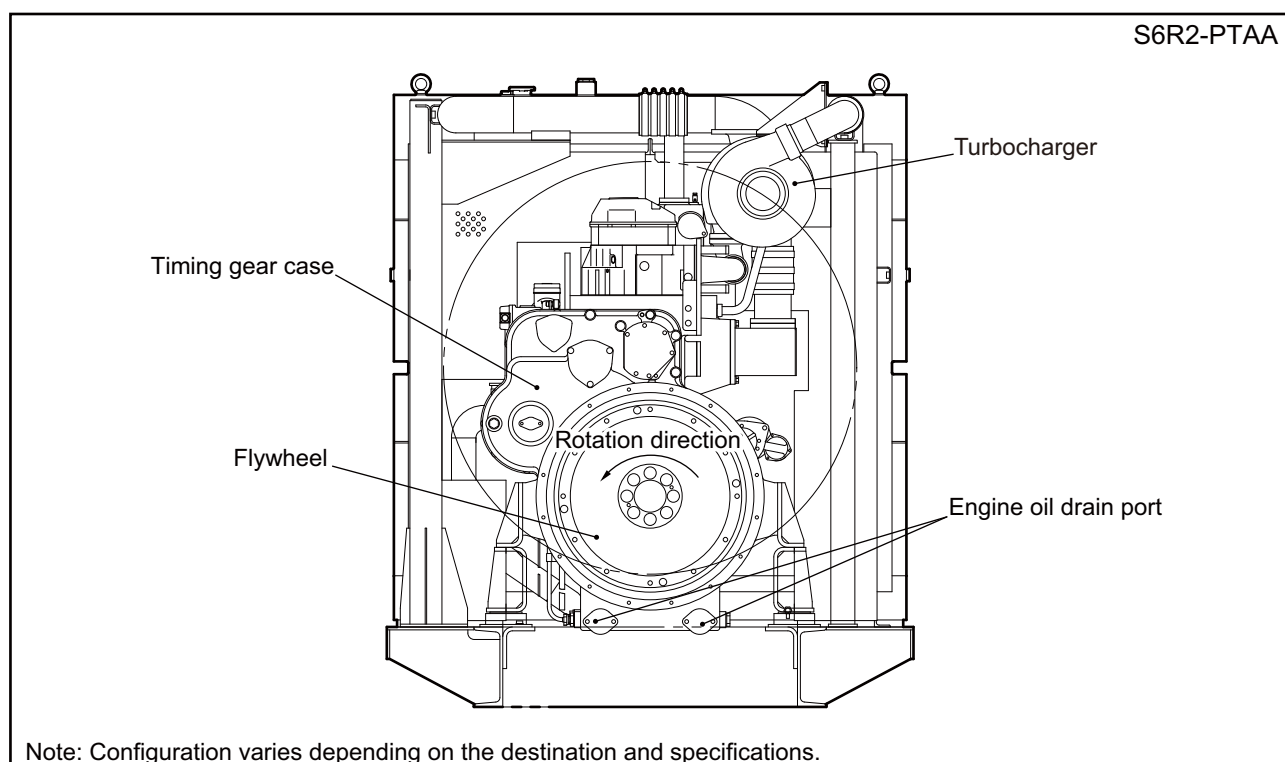


Engine Rear View

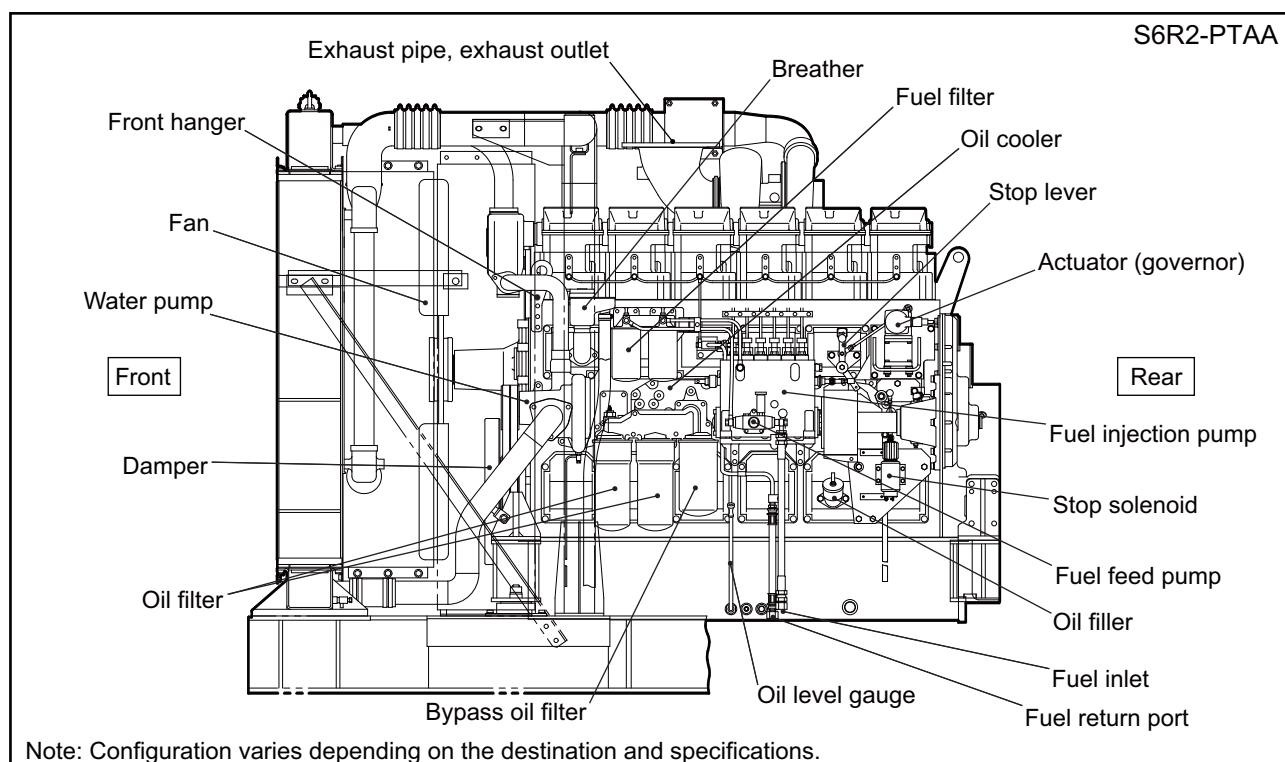




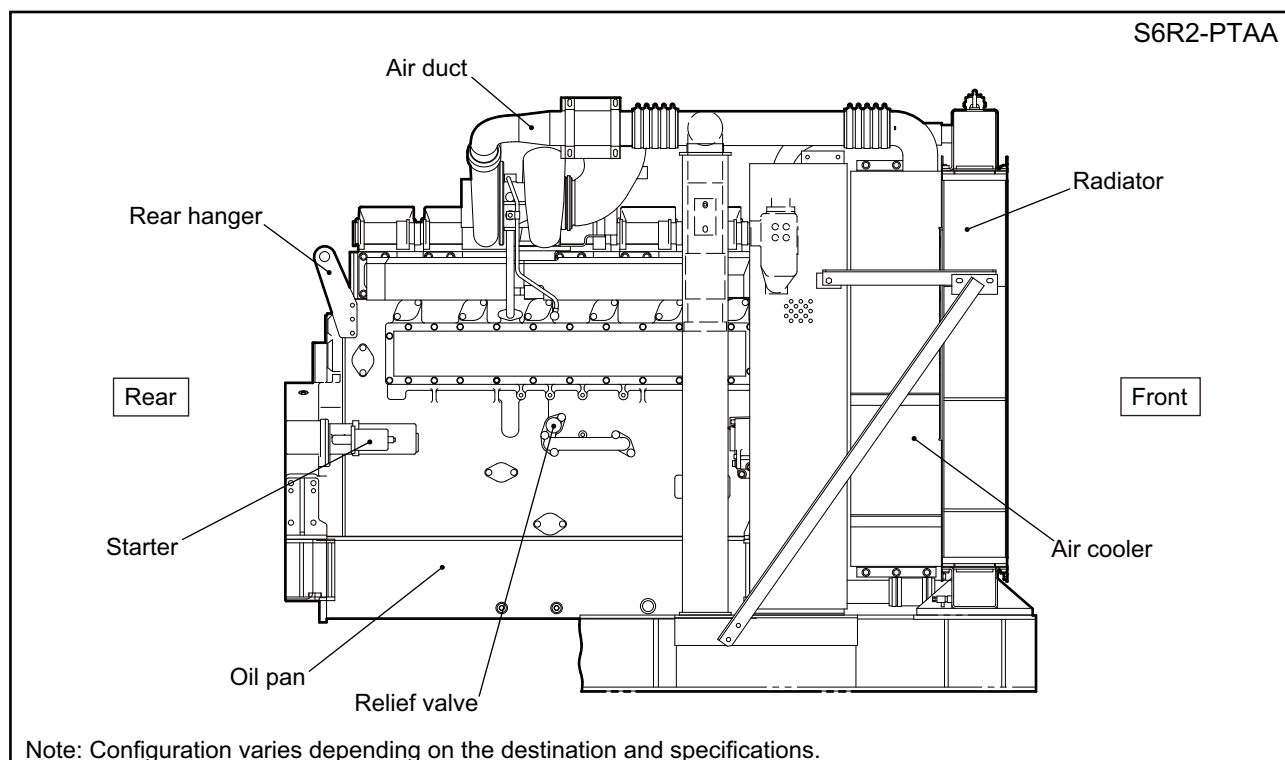
Engine Front View



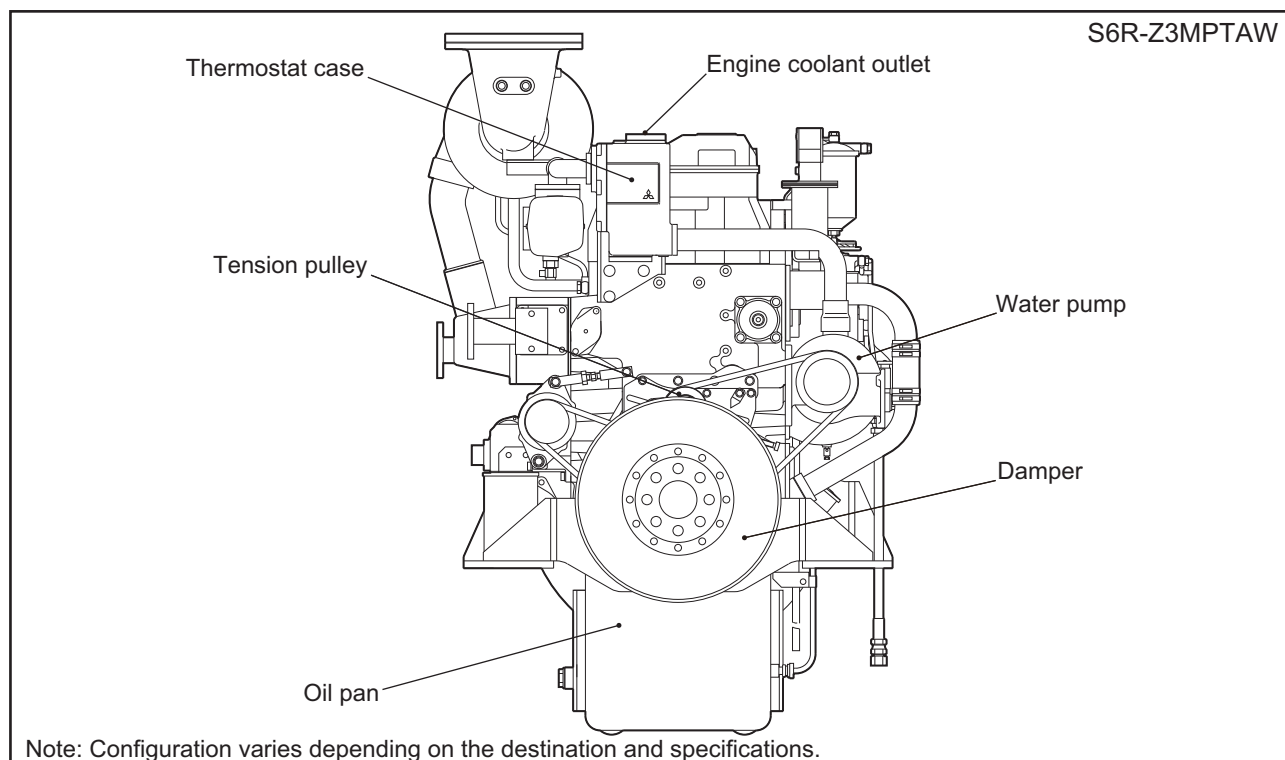
Engine Rear View



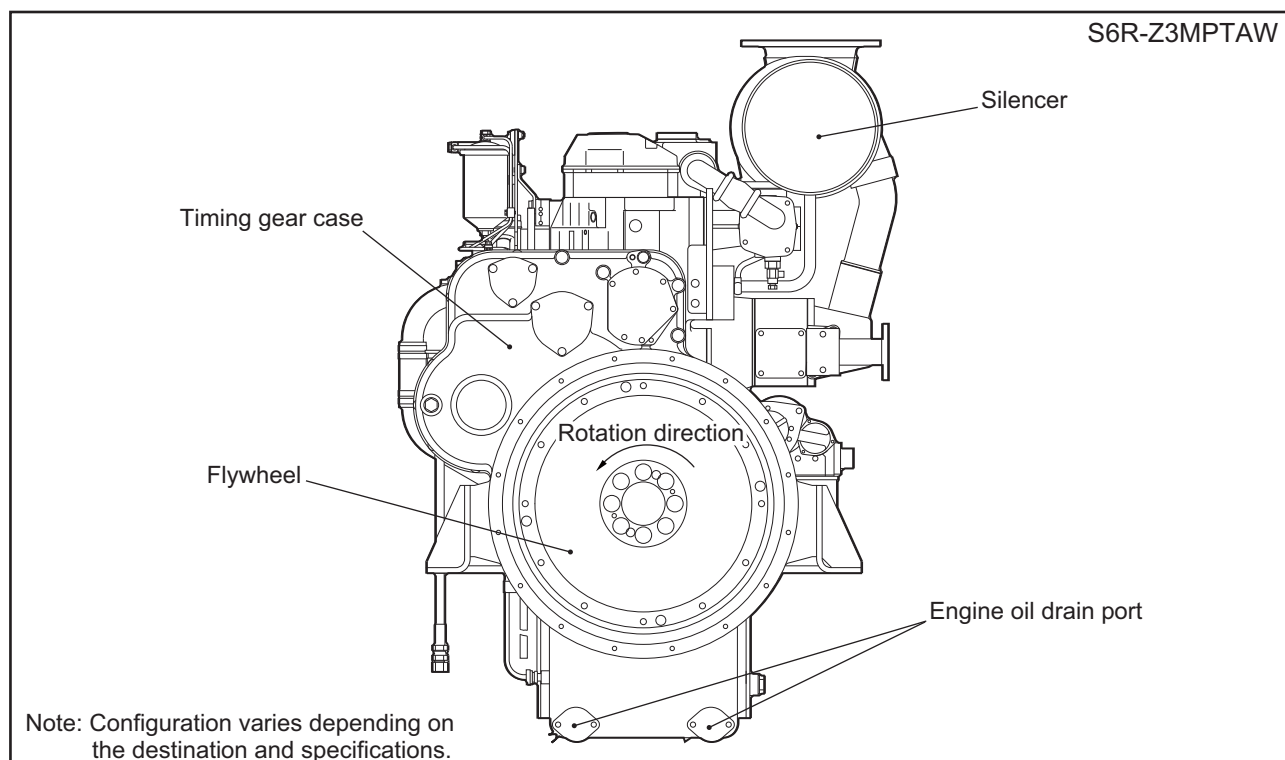
Left Side View



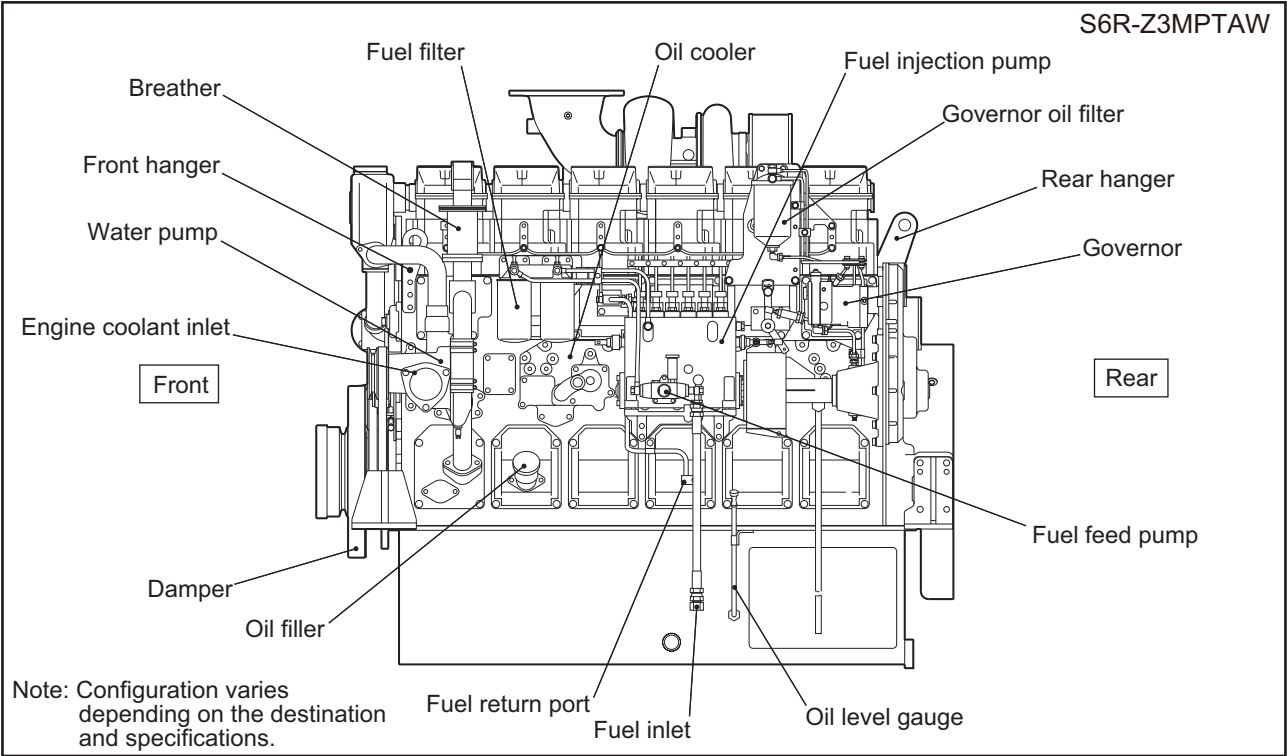
Right Side View



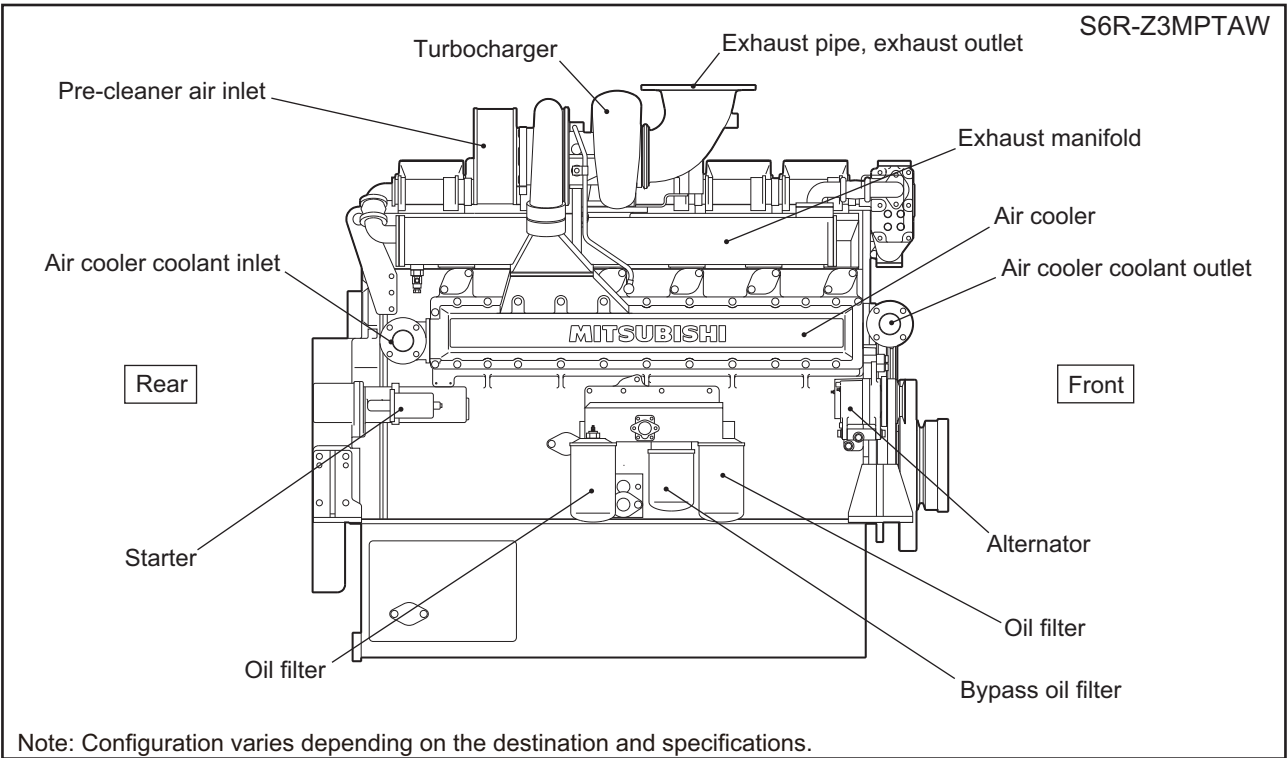
Engine Front View



Engine Rear View



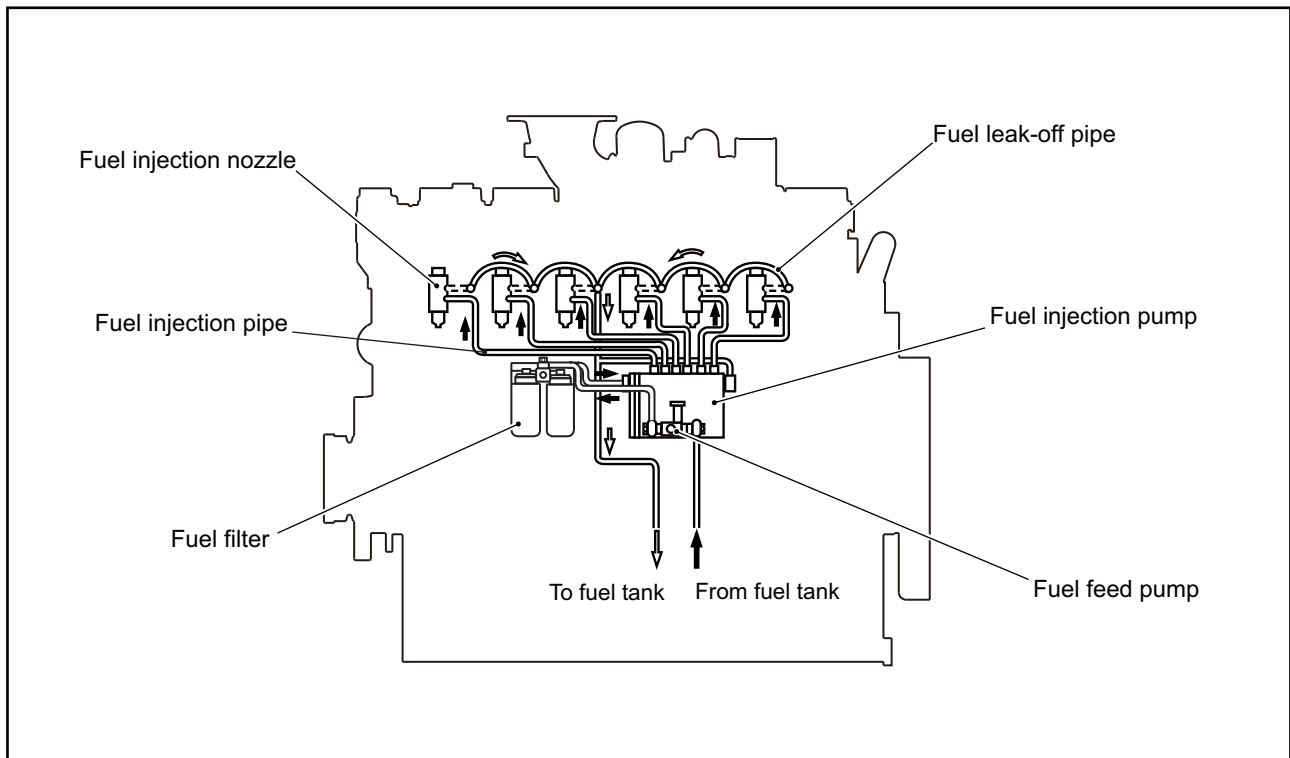
Left Side View



Right Side View

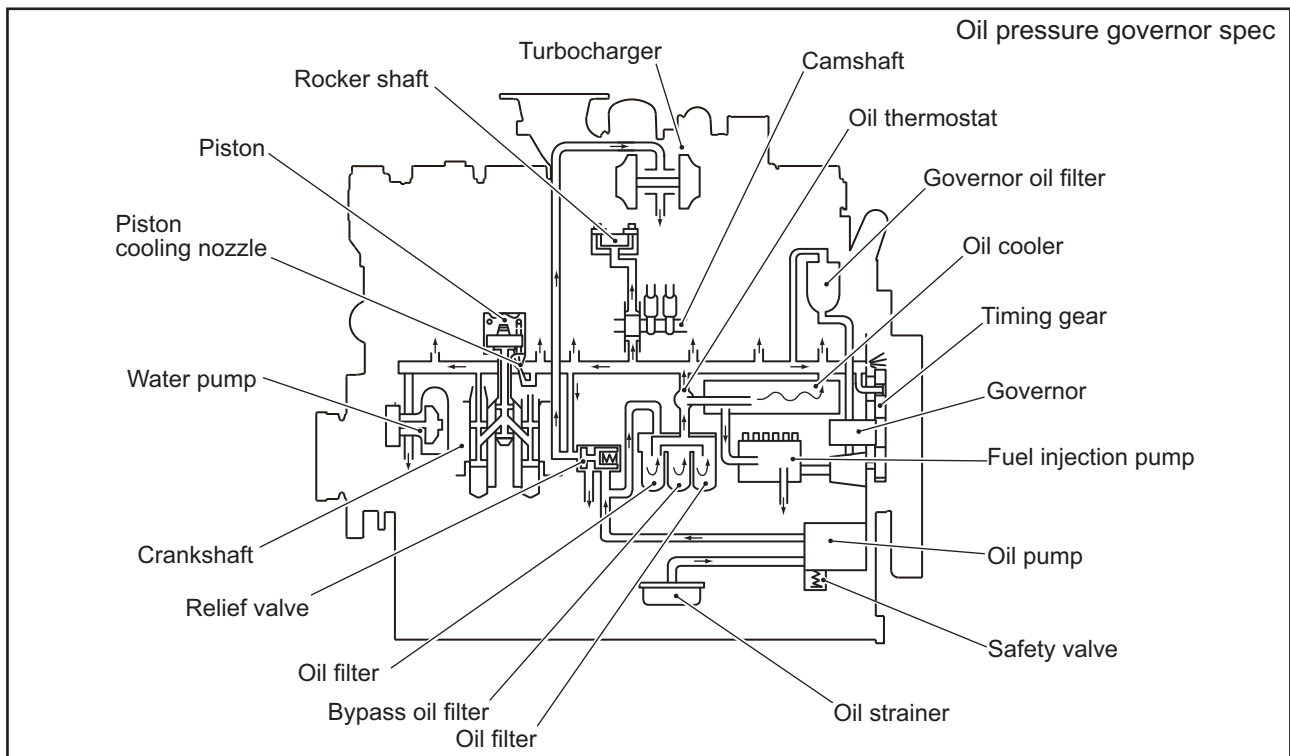
2. Outline of Systems

2.1 Outline of Fuel System

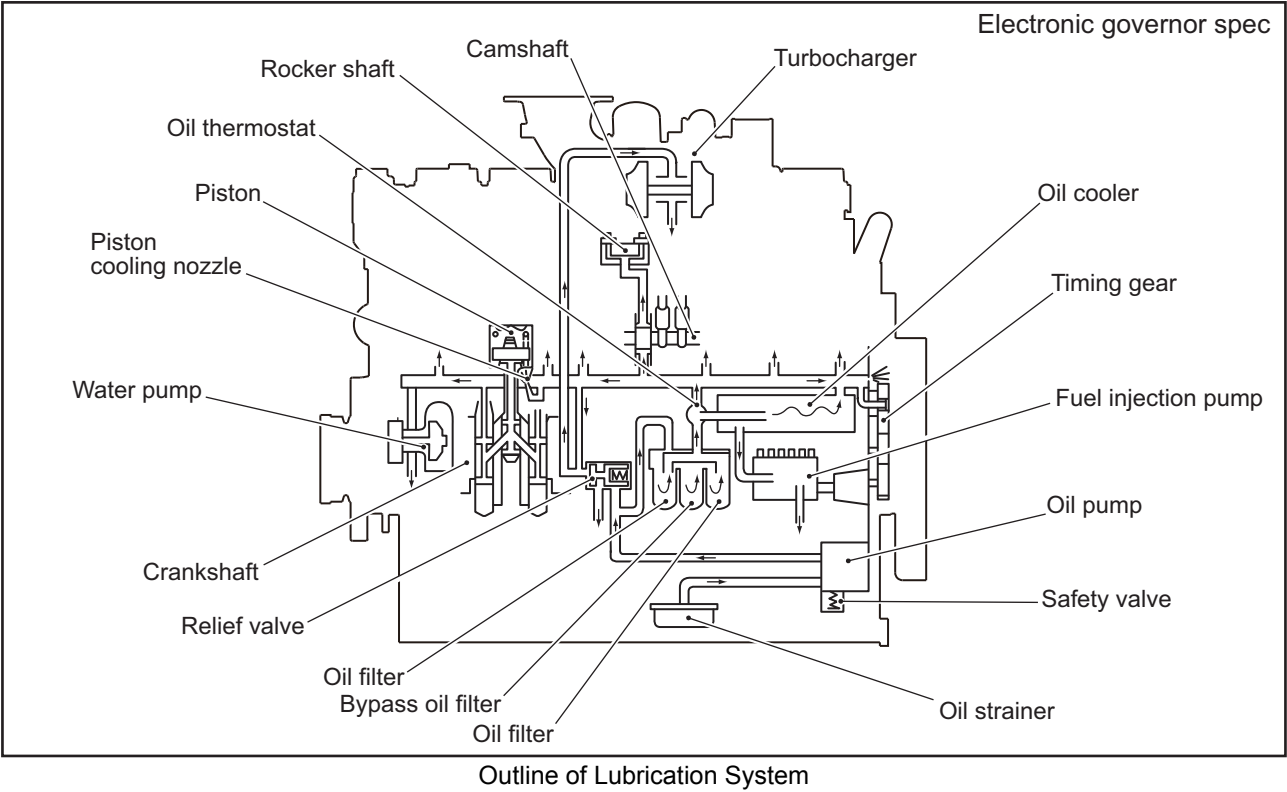


Outline of Fuel System

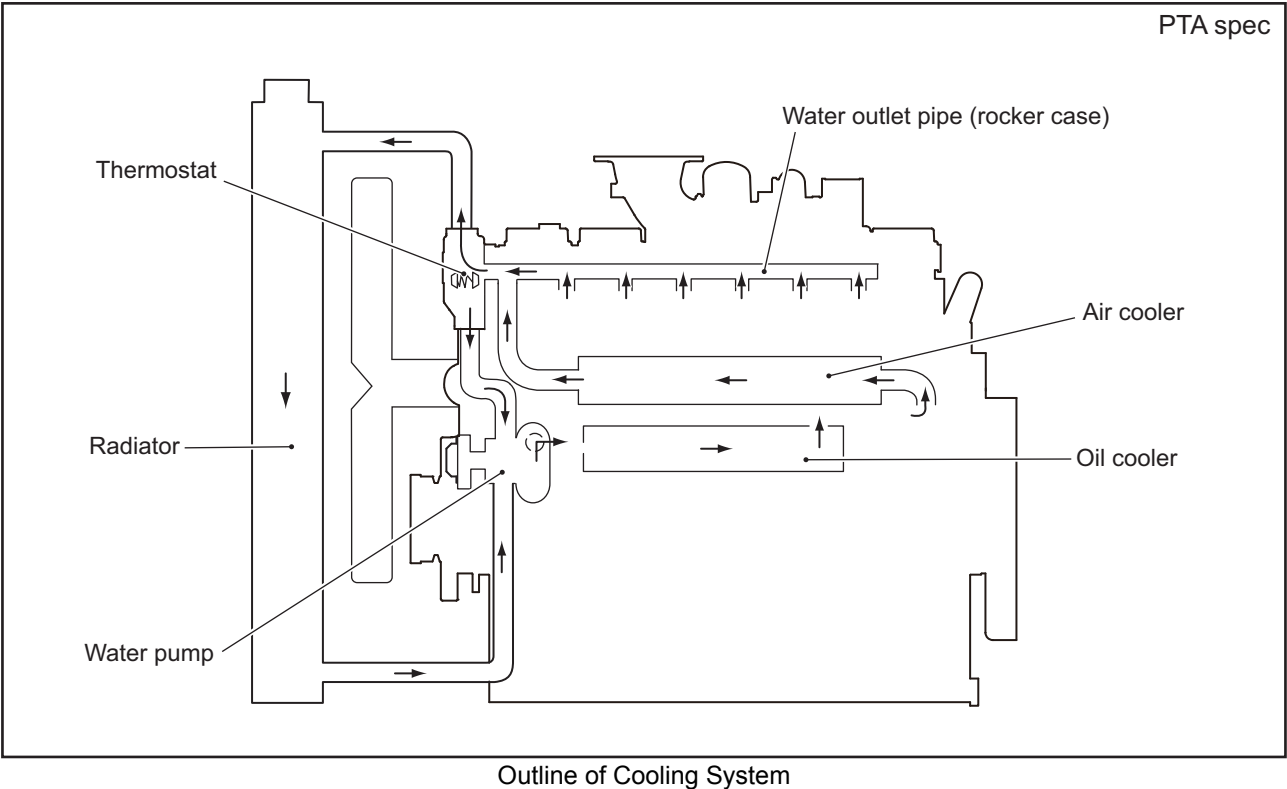
2.2 Outline of Lubrication System



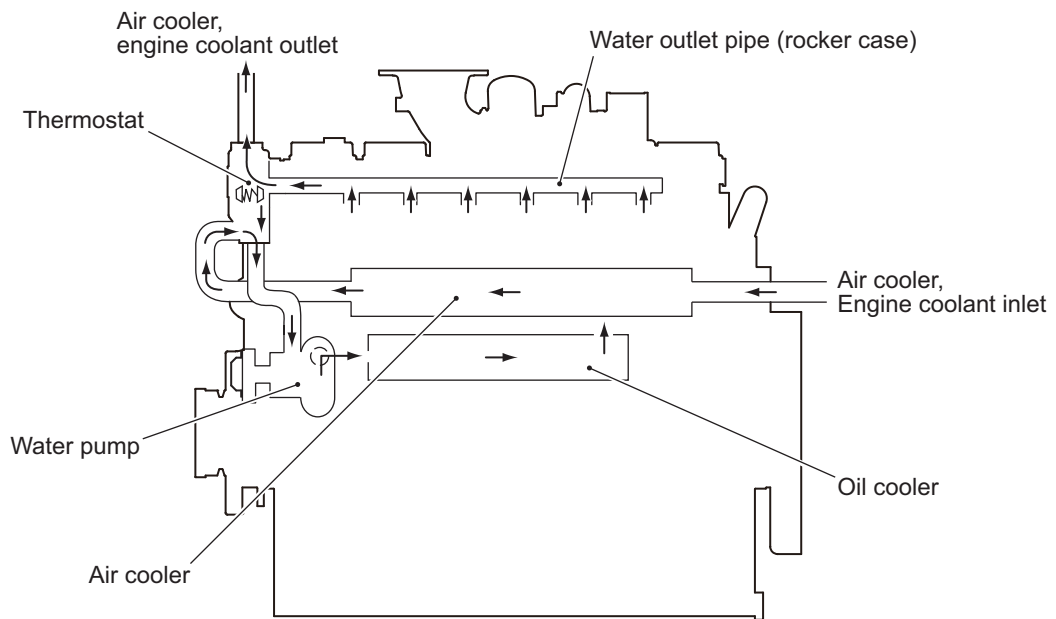
Outline of Lubrication System



2.3 Outline of Cooling System

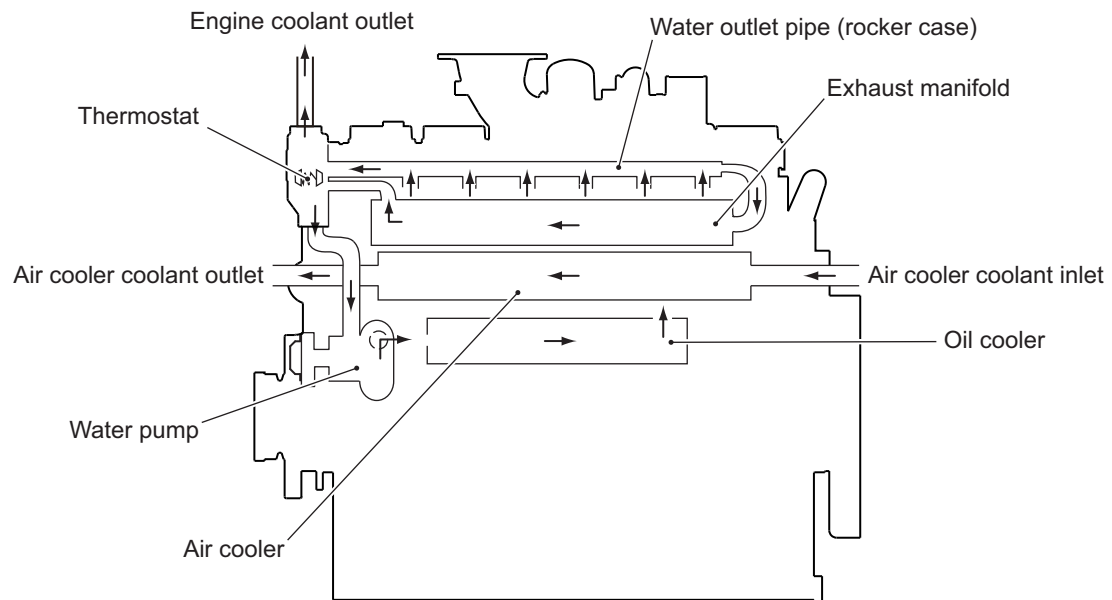


PTK spec

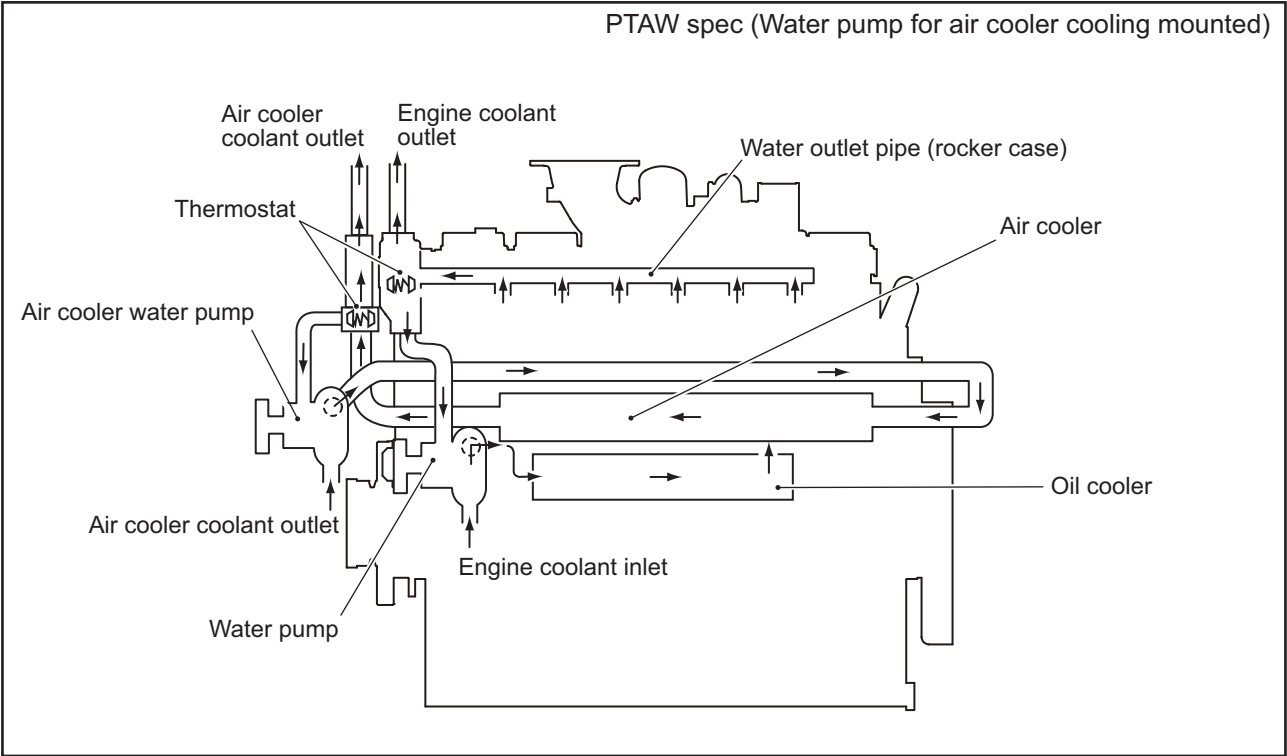


Outline of Cooling System

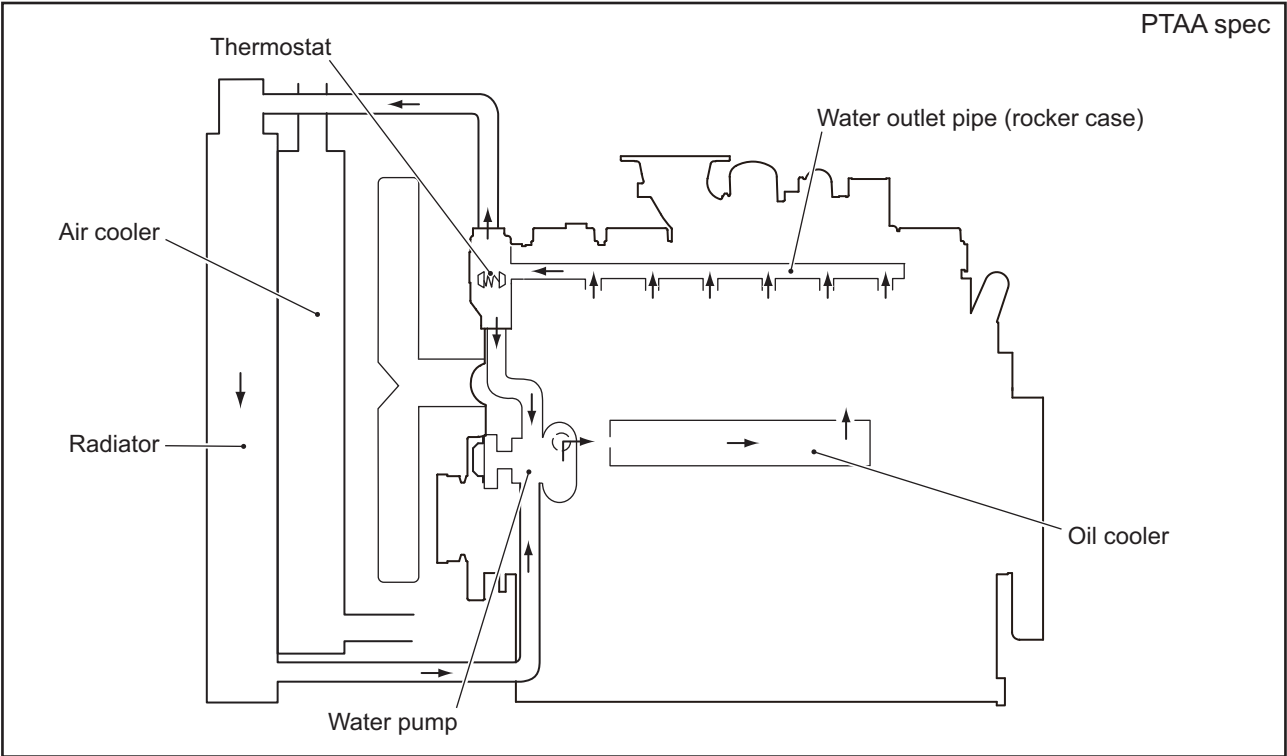
PTAW spec (Outside of water pump for air cooler cooling)



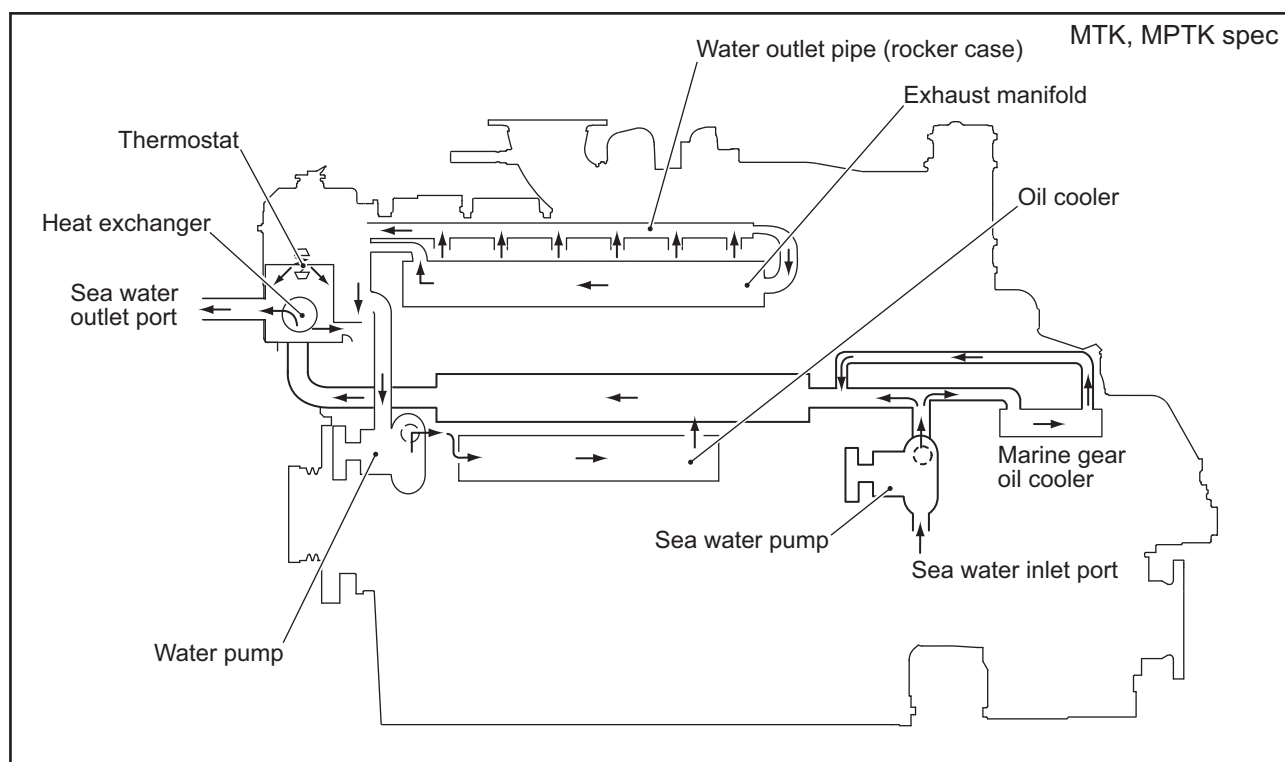
Outline of Cooling System



Outline of Cooling System

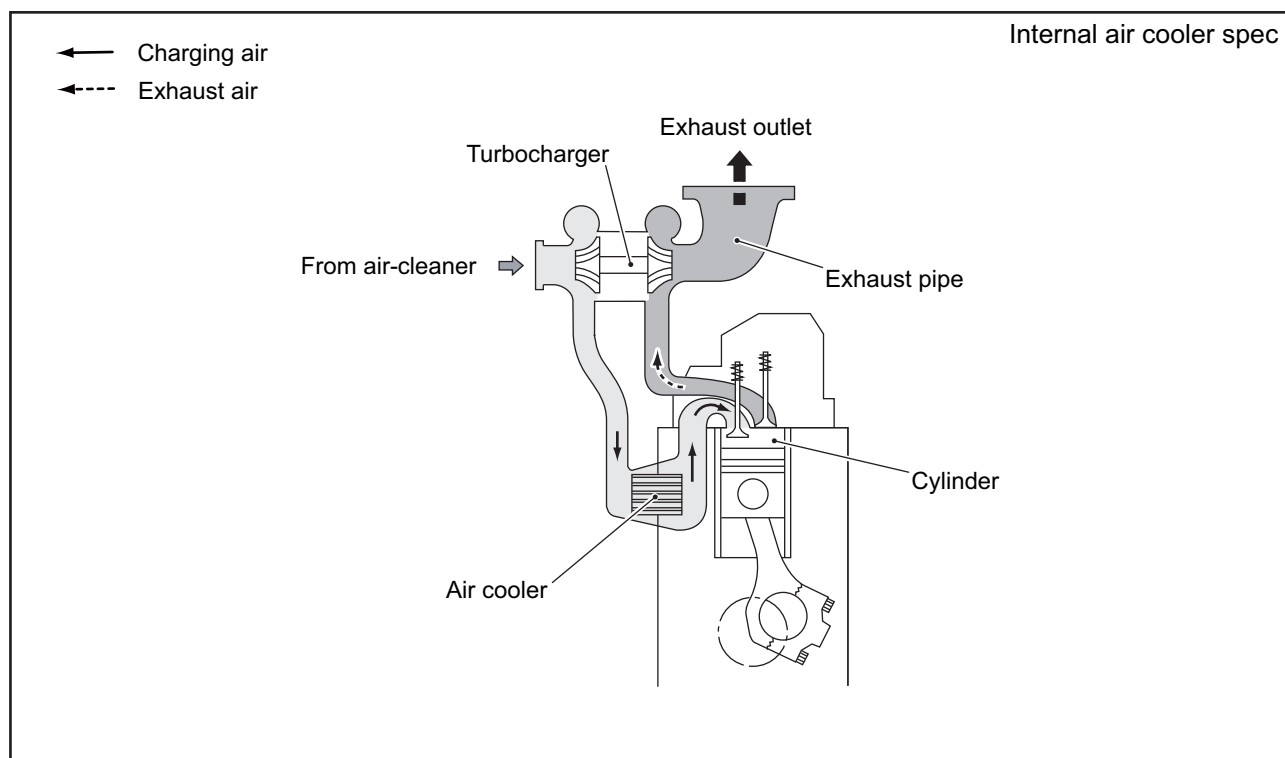


Outline of Cooling System

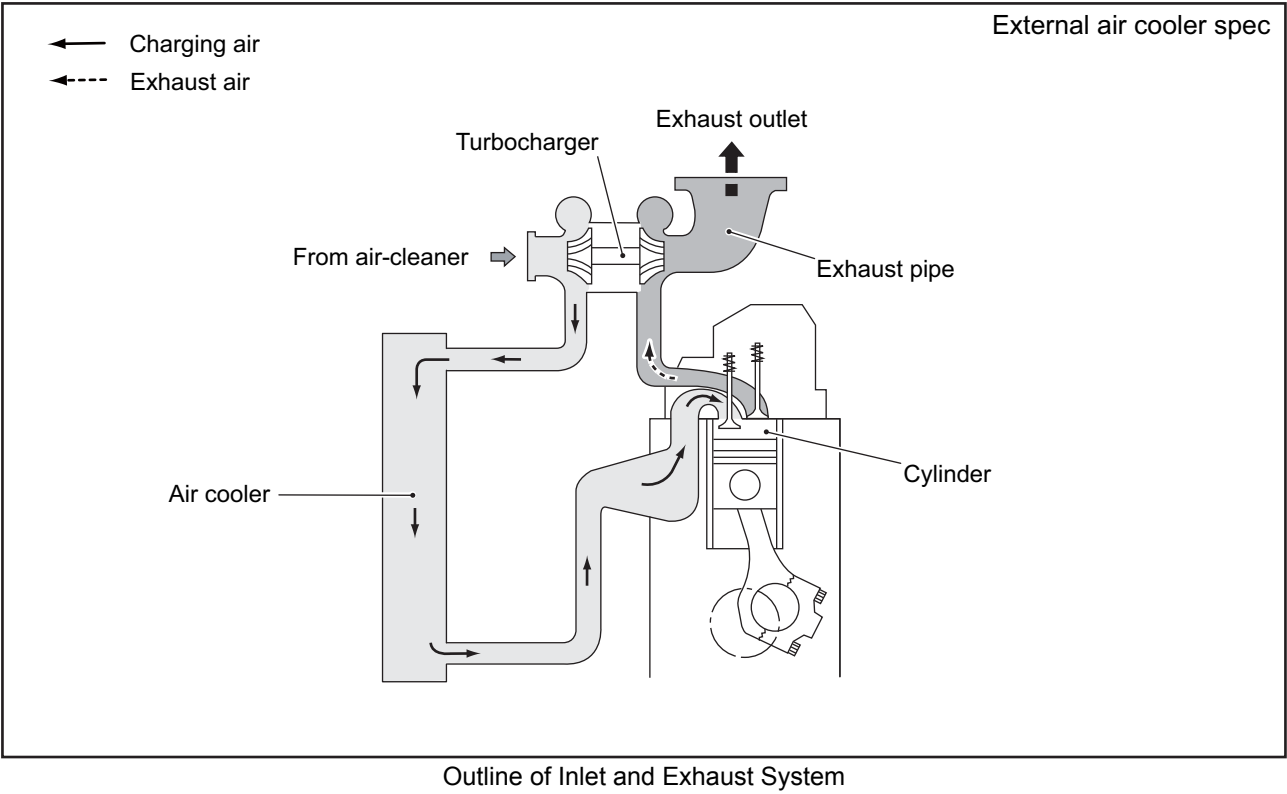


Outline of Cooling System

2.4 Outline of Inlet and Exhaust System



Outline of Inlet and Exhaust System

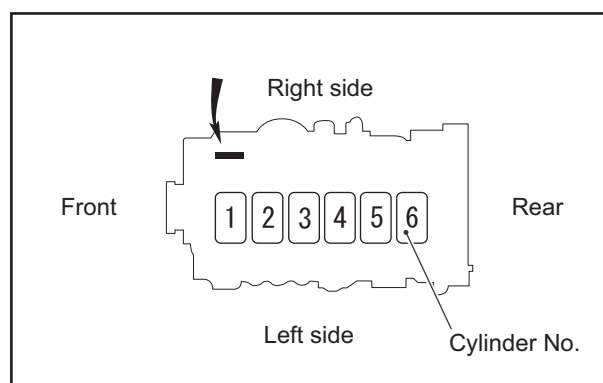


3. Contents of Plate and Label

3.1 Name Plate

The name plate is attached on the lateral side of the engine, and shows the following information:

- ♦Engine serial number
- ♦Manufactured date
- ♦Total displacement
- ♦Engine output
- ♦Rated speed

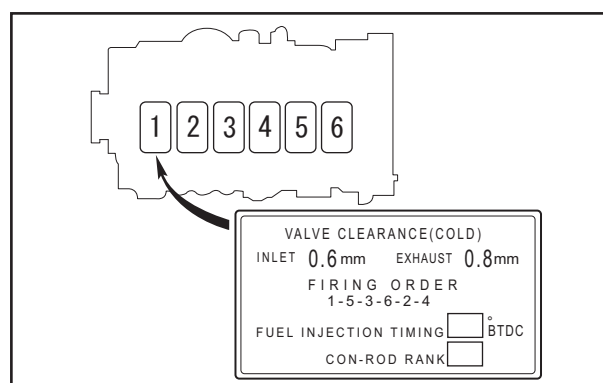


Name Plate

3.2 Caution Plate

The caution plate is attached to the top face of the rocker cover of No. 1 cylinder and shows the following information:

- ♦Valve clearance
- ♦Firing order
- ♦Fuel injection timing
- ♦Connecting rod weight rank



Caution Plate

3.3 Emissions Certification Label

The emission certification label that shows compliance with emission requirements is attached to the engine.

4. Specifications

Engine model	S6R	S6R2
Type	Water cooled, four stroke cycle diesel, turbo charged	
No. of cylinders - Arrangement	6 cylinders, in-line	
Combustion system	Direct injection system	
Valve mechanism	Overhead	
Cylinder bore × stroke	170×180 mm [6.69×7.09 in.]	170×220 mm [6.69×8.66 in.]
Total displacement	24.51 L [1495.9 cu in]	29.96 L [1828.5 cu in.]
Firing order	1-5-3-6-2-4	
Direction of rotation	Counterclockwise as viewed from flywheel side	
Engine oil	Class CF or CH-4 (API service classification)	

Specification table

The mark "o" in the table represents the installed equipment of each engine type.

Note:(a) This table shows the general information. The installation of equipment differs in accordance with the customization and specifications.

(b) The specification and part number may be changed with the design progress without prior notice.

Equipment name	Specification name	S6R														S6R2													
		PT	PTA	PTA-S	Y1PTA-4	Y1PTA-5	Y2PTAW	PTK	V2PTK-1	TA	MPTA	Z3MPTAW	Y1MPTA-3	MPTK	Y1MPTK-3	Y2MPTK-3	MPT	PT	PTA	PTAA	PTA-S	PTAA-S	PTK	MPTA	MPTK	MTK	MTK2	MTK3	MTK2L
Valve mechanism	Single spring (Inlet side)	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
	Double spring (Exhaust side)		o		o	o	o	o			o					o											o	o	o
Camshaft	Overlap 61° (37505-40100)	o	o	o			o		o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o				
	Overlap 93° (37505-34100)		o		o	o	o	o			o					o											o		o
	Overlap 93° advanced by 4° (37505-04300)																										o	o	
Cylinder liner	(37507-22700)	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o												
	(37507-55600)																	o	o	o	o	o	o	o	o	o	o	o	o
Piston cooling nozzle	One jet	o	o	o				o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
	Two jets		o		o	o	o																						
Oil pan	Standard oil pan (37513-60101)	o	o	o	o	o	o	o	o	o	o						o	o	o	o	o	o	o						
	Deep type oil pan (Hi 145L, Low114L) [38.3, 30.1 USgal] (37513-20602)		o					o			o	o	o	o	o	o	o		o			o	o	o	o	o	o	o	o
Connecting rod Rod	Bolt identification mark "AU""AL" (37519-31020)	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o												
	Bolt identification mark "2" (37519-75020 to 76010)																	o	o	o	o	o	o	o	o	o	o	o	o

Equipment name	Specification name	S6R													S6R2																
		PT	PTA	PTA-S	Y1PTA-4	Y1PTA-5	Y2PTAW	PTK	V2PTK-1	TA	MPTA	Z3MPTAW	Y1MPTA-3	MPTK	Y1MPTK-3	Y2MPTK-3	MPT	PT	PTA	PTAA	PTA-S	PTAA-S	PTK	MPTA	MPTK	MTK	MTK2	MTK3	MTK2L		
Piston	Overlap 61° Compression ratio 14 (37517-30101)	○	○	○				○		○	○		○	○	○		○														
	Overlap 93° Compression ratio 15 (37517-10401)		○		○	○		○	○																						
	Overlap 93° Compression ratio 14.5 (37517-00900)						○					○				○															
	Overlap 61° Compression ratio 14 (37517-25100)																	○	○	○	○	○	○	○	○	○					
	Overlap 91° Compression ratio 14 (37517-05300)																										○		○		
	Overlap 93° 4°advance, compression ratio14 (37517-05500)																											○	○		
Flywheel	Standard (37521-00012)	○	○	○	○	○	○	○	○									○	○	○	○	○	○								
	FCD spec (37521-00060)										○	○	○	○	○	○	○							○	○	○	○	○	○	○	
	Land clutch (37521-12012)									○																					
Front pulley, Crankshaft pulley	(37525-12201)	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
	(37525-04501)						○																								
	(37525-18800)										○						○														
	(37320-22600)		○					○	○																						
	(37525-28101)												○		○	○								○	○	○	○	○	○	○	
	(37525-18600)										○														○						
	(37525-02800)									○																					

Equipment name	Specification name	S6R												S6R2														
		PT	PTA	PTA-S	Y1PTA-4	Y1PTA-5	Y2PTAW	PTK	V2PTK-1	TA	MPTA	Z3MPTAW	Y1MPTA-3	MPTK	Y1MPTK-3	Y2MPTK-3	MPT	PT	PTA	PTAA	PTA-S	PTAA-S	PTK	MPTA	MPTK	MTK2	MTK3	MTK2L
Turbocharger	TD10L-42F-34																	○										
	TD10L-42F-43		○					○		○			○															
	TD13L-47F-40	○							○	○		○					○	○	○									
	TD13L-47F-47		○					○		○			○	○									○	○	○			
	TD13L-47F-55		○							○																		
	TD13L-54QRC-47							○	○																			
	TD13L-54QRC-47 Water cool exhaust manifold											○																
	TD13L-57V-55		○																									
	TD13M1-48QRC-40															○												
	TD15-50B-49										○			○										○		○		
	TD15-50B-54		○								○									○								
	TD15-55B-54													○										○	○			
	TD15-55B-54 Classification JG																								○			
	TD15-55B-54 Classification NK																								○			
	TD15-55B-59							○																	○			
	TD15-55B-66																						○					
	TF15L-60QV-49																				○							
	TF15M-60QV-49			○																		○	○		○			
	TF15M-60QVRC-49		○		○	○																						
	TF15M-67QVRC-49 (Flange connection type)																										○	○
	TF15M-67QVRC-54																										○	○
	TF15M1-67QVRC-49						○																					
	TF15M1-60QVRC-49 Water cool exhaust manifold											○																
Fan	D1010, PUSHER (46648-02300)	○	○	○	○				○	○						○	○	○		○			○					
	D1016, PUSHER (46648-22600)																		○		○							

Equipment name	Specification name	S6R												S6R2														
		PT	PTA	PTA-S	Y1PTA-4	Y1PTA-5	Y2PTAW	PTK	V2PTK-1	TA	MPTA	Z3MPTAW	Y1MPTA-3	MPTK	Y1MPTK-3	Y2MPTK-3	MPT	PT	PTA	PTAA	PTA-S	PTAA-S	PTK	MPTA	MPTK	MTK2	MTK3	MTK2L
Air cooler	Fresh water (internal cooling) air cool exhaust manifold (37555-30030)		○	○	○	○				○	○							○	○		○		○					
	Fresh water (external cooling) air cool exhaust manifold (37555-30040)							○	○													○						
	Fresh water (internal cooling) Water cool exhaust manifold (37555-10054)										○		○											○				
	Sea water (37555-30083)													○	○										○	○		
	Fresh water (internal cooling) air cool exhaust manifold Classification JG (37555-30J30)										○													○				
	Fresh water (two system) air cool exhaust manifold (37555-30030)						○																					
	Fresh water (two system) Water cool exhaust manifold (37555-00060)											○				○												
	MTK2(37555-33013)																									○		○
	MTK3(37555-05012)																									○	○	
	MPTK(37555-30083)																								○			
Fuel injection nozzle	T model, screw adjust opening pressure type (37560-35000)		○		○	○		○	○																			
	T model, screw adjust opening pressure type (37560-37000)		○	○				○														○				○		
	T model, screw adjust opening pressure type (37560-39000)		○					○		○	○		○	○	○				○	○	○	○	○	○	○	○		
	T model, screw adjust opening pressure type (37560-22010)																						○	○	○	○	○	
	T model, screw adjust opening pressure type (37560-41000)																				○							
	T model, screw adjust opening pressure type (37561-44000)	○	○					○			○		○			○	○	○					○	○	○			
	T model, shim adjust opening pressure type (37560-32000)																									○		
	TE model, screw adjust opening pressure type (37860-06000)						○					○																
	S model, screw adjust opening pressure type (37760-22001)															○												

Equipment name	Specification name	S6R												S6R2														
		PT	PTA	PTA-S	Y1PTA-4	Y1PTA-5	Y2PTAW	PTK	V2PTK-1	TA	MPTA	Z3MPTAW	Y1MPTA-3	MPTK	Y1MPTK-3	Y2MPTK-3	MPT	PT	PTA	PTAA	PTA-S	PTAA-S	PTK	MPTA	MPTK	MTK2	MTK3	MTK2L
Fuel filter	Diesel oil		○	○	○	○	○	○	○						○	○			○	○	○	○						
	Diesel oil, changover type										○	○		○										○	○			
	A diesel oil	○	○					○			○		○			○	○	○	○				○	○	○	○	○	○
	Diesel oil, changeover type										○		○											○	○			
	Primary filter										○						○							○				
	Changeover type (VOLVO)																							○	○			
Governor	Woodward make PSG type governor	○	○					○		○	○	○	○	○	○	○		○	○				○	○	○	○	○	○
	Woodward make SG type governor										○						○						○					
	TOHO SEISAKUSHO Co., LTD. SG4017 type actuator		○	○				○											○	○	○	○	○					
	Woodward make DYNA8000 type Actuator		○																○									
	Woodward make PROACT type Actuator		○		○	○	○																					
Starter	Land use self starter motor (37566-30200)	○	○	○	○	○	○	○	○									○	○	○	○	○	○					
	Land use self starter motor (37566-40300)×2																											
	Marine use self starter motor (37566-45200)										○	○	○	○	○	○	○							○	○	○	○	○
	Marine use self starter motor (37566-45200)×2																							○				
	Air motor (04065-61001)										○													○	○			
Alternator	30A (04343-38000)	○	○	○	○	○	○	○	○									○	○	○	○	○	○					
	35A, brushless (04343-35500)		○								○	○		○	○	○								○	○			
	35A, brushless, JG (04343-35600)										○		○	○										○	○			
	35A, JG (04344-05100)										○		○			○								○		○	○	○
	130A (04344-08001)										○																	
Stop solenoid	RUN-OFF	○	○					○		○	○	○	○	○	○	○	○	○	○				○	○	○	○	○	○
	RUN-ON		○	○	○	○	○	○	○										○	○	○	○	○					
Start restriction solenoid	RUN-OFF																									○		○

Chapter 2 SERVICE DATA

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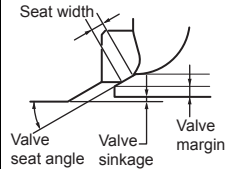
1. Maintenance Service Data

1.1 Maintenance Service Data of Engine General

Item				Nominal value	Standard value	Limit value	Remarks			
Compression pressure					1.8 MPa {18.5 kgf/cm ² } [263 psi]	1.27 MPa {13 kgf/cm ² } [189 psi]	Cranking (approx 120 min ⁻¹)			
Engine oil pressure		At rated			0.49 to 0.64 MPa {300 kgf/cm ² } [4267 psi]	0.29 MPa {300 kgf/cm ² } [4267 psi]	When oil temperature is 90 to 100° C [194 to 212°F]			
		When idling			0.20 to 0.29 MPa {300 kgf/cm ² } [4267 psi]	0.15 MPa {300 kgf/cm ² } [4267 psi]				
Valve timing	Overlap 61° camshaft P/N:37505-40100	Inlet	Open	BTDC 37°			Valve clearance 0 mm			
			Close	ABDC 44°						
		Exhaust	Open	BBDC 57°				±2°(Crank angle)		Valve clearance 2 mm [0.08 in.]
			Close	ATDC 24°						
		Inlet	Open	BTDC 2.5°						
			Close	BBDC 13°						
		Exhaust	Open	BBDC 26°						
			Close	BTDC 10.5°						
	Overlap 93° camshaft P/N:37505-34100	Inlet	Open	BTDC 53°			Valve clearance 0 mm			
			Close	ABDC 44°						
		Exhaust	Open	BBDC 57°				±2°(Crank angle)		Valve clearance 2 mm [0.08 in.]
			Close	ATDC 40°						
		Inlet	Open	BTDC 14°						
			Close	ABDC 12.5°						
		Exhaust	Open	BBDC 25.5°						
			Close	ATDC 1°						
	Overlap 93° advanced by 4° camshaft P/N:37505-04300	Inlet	Open	BBDC 57°			Valve clearance 0 mm			
			Close	ABDC 40°						
		Exhaust	Open	BBDC 61°				±2°(Crank angle)		Valve clearance 2 mm [0.08 in.]
			Close	ABDC 36°						
		Inlet	Open	BTDC 18°						
			Close	ABDC 8.5°						
		Exhaust	Open	BBDC 29.5°						
			Close	BTDC 3°						
Valve clearance (when cold)		Inlet			0.6 mm [0.024 in.]					
		Exhaust			0.8 mm [0.031 in.]					
Fuel injection timing							Check the caution plate on No. 1 rocker cover.			

1.2 Maintenance Service Data of Basic Engine

Unit: mm [in.]

Item				Nominal value	Standard value	Limit value	Remarks
Rockers	Rocker bushing inside diameter			ø36 [1.42]	36.000 to 36.040 [1.4173 to 1.4189]	36.090 [1.4209]	
	Rocker shaft outside diameter			ø36 [1.42]	35.966 to 35.991 [1.4160 to 1.4170]	35.940 [1.4150]	
Valve	Valve stem outside diameter			ø10 [0.39]	9.940 to 9.960 [0.3913 to 0.3921]	9.910 [0.3902]	Same for both inlet and exhaust valves.
	Valve guide inside diameter			ø10 [0.39]	10.000 to 10.015 [0.3937 to 0.3943]	10.060 [0.3961]	
	Clearance between the bot- tom face of valve bridge and top face of valve rotator	Intake side			2.1 [0.083]		Single valve spring spec only
		Exhaust side	Single valve spring spec		3.4 [0.134]		
	Double valve spring spec			2.1 [0.083]			
Valve seat and valve	Valve seat angle			30°			
	Valve sinkage			0	- 0.1 to 0.1 [-0.004 to 0.004]	1.0 [0.039]	
	Seat width			2.3 [0.091]	2.18 to 2.42 [0.0858 to 0.0953]	2.8 [0.110]	
	Valve margin			3.0 [0.118]	2.8 to 3.2 [0.110 to 0.126]	2.5 [0.098]	
	Inside diameter of valve seat counterbore				60.000 to 60.030 [2.3622 to 2.3634]	60.09 [2.3657]	
	Valve seat outside diameter	Standard			60.100 to 60.130 [2.3661 to 2.3673]		2 lines, brown
		0.03			60.130 to 60.160 [2.3673 to 2.3685]		3 lines, brown
		0.06			60.160 to 60.190 [2.3685 to 2.3697]		4 lines, brown
	Valve seat interference				0.070 to 0.130 [0.0028 to 0.0051]		
Single valve spring	P/N: 37504-10400	Free length			73 [2.87]	71 [2.80]	
		Squareness			A=1.5° or less B=1.9 [0.075] or less Lf=73 [2.87]	B=2.2 [0.087] over entire length	
		Installed length/load (mm [in.]/N {kgf} [lbf])			66.0 [2.60]/289 to 319 {29.45 to 32.55} [65 to 72]		
Double valve spring	P/N: 37504-10600	Inner spring	Free length		90.6 [3.567]	88.12 [3.469]	
			Squareness		A=2.0° or less B=3.2 [0.126] or less Lf=90.6 [3.567]	B=3.7 [0.146] over entire length	
			Set length / load (mm [in.]/N {kgf} [lbf])		56.0 [2.20]/137 to 152 {14 to 15.5} [31 to 34]		
	P/N: 37504-20500	Outer spring	Free length		96.57 [3.8020]	93.92 [3.698]	
			Squareness		A=2.5° or less B=4.2 [0.165] or less Lf=96.57 [3.8020]	B=4.9 [0.193] over entire length	
			Set length / load (mm [in.]/N {kgf} [lbf])		62.0 [2.44]/496 to 549 {50.6 to 56.0} [112 to 123]		
Push rod	Runout				0.50 [0.0197] or less		TIR

Unit: mm [in.]

Item			Nominal value	Standard value	Limit value	Remarks
Cylinder head	Distortion of bottom surface			0.03 [0.0012] or less	0.07 [0.003]	
	Height (reference)			154.9 to 155.1 [6.098 to 6.106]		
Cylinder liner	Inside diameter	P/N: 37507-22700 (S6R)	ø170 [6.69]	170.02 to 170.04 [6.6937 to 6.6945]	170.100 [6.6968]	
		P/N: 37507-55600 (S6R2)	ø170 [6.69]	170.00 to 170.04 [6.6929 to 6.6945]		
	Roundness			0.02 [0.0008] or less		
	Cylindricity			0.02 [0.0008] or less		
	Flange protrusion			0.11 to 0.20 [0.0043 to 0.0079]		
	Flange thickness			14.16 to 14.20 [0.5575 to 0.5591]		
	Top ridge height			0.16 to 0.24 [0.0063 to 0.0094]		
Piston	Outside diameter	P/N: 37517-30101 ("30101" stamp) 37517-10401 ("10401" stamp) 37517-00900 ("00900" stamp) 37517-25100 ("25100" stamp) 37517-05500 ("05500" stamp) 37517-05300 ("05300" stamp)	ø170 [6.69]	169.760 to 169.800 [6.6835 to 6.6850]	169.660 [6.6795]	Measure the outside diameter from lower end of piston at 40 mm [1.57 in.] with right angles to the piston pin.
		P/N: 37517-07800 ("07800" stamp) 37517-07900 ("07900" stamp)	ø170 [6.69]	169.739 to 169.779 [6.6826 to 6.6842]	169.639 [6.6787]	
		P/N: 37517-00800 ("00800" stamp)	ø170 [6.69]	169.760 to 169.780 [6.6835 to 6.6842]	169.660 [6.6795]	
	Weight difference per engine	P/N: 37517-30101 ("30101" stamp) 37517-10401 ("10401" stamp) 37517-00900 ("00900" stamp) 37517-25100 ("25100" stamp) 37517-05500 ("05500" stamp) 37517-05300 ("05300" stamp) 37517-07800 ("07800" stamp) 37517-07900 ("07900" stamp)		within 10 g [0.35 oz]		
		P/N: 37517-00800 ("00800" stamp)		within ±15 g [0.53 oz]		
	Piston pin bore inside diameter		ø70 [2.76]	70.002 to 70.015 [2.7560 to 2.7565]	70.040 [2.7575]	
	protrusion			0.04 to 0.64 [0.0016 to 0.0252]		
Cylinder head gasket	Thickness when tightened		1.8 [0.071]	1.77 to 1.83 [0.0697 to 0.0720]		
Piston cooling nozzle	Valve opening pressure	One jet spec		0.26 to 0.32 MPa {2.7 to 3.3 kgf/cm ² } [38 to 47 psi]		
		Two jet spec		0.10 to 0.15 MPa {1.0 to 1.5 kgf/cm ² } [14 to 21 psi]		
Piston and cylinder head	Top clearance			1.24 to 1.99 [0.0488 to 0.0783]		
Piston ring	End gap	No. 1 compression		0.6 to 0.8 [0.024 to 0.032]	1.0 [0.039]	
		No. 2 compression		0.6 to 0.8 [0.024 to 0.032]		
		Oil		0.3 to 0.45 [0.0118 to 0.0177]	0.6 [0.024]	

Unit: mm [in.]

Item			Nominal value	Standard value	Limit value	Remarks	
Piston pin	Outside diameter		ø70 [2.76]	69.987 to 70.000 [2.7554 to 2.7559]	69.970 [2.7547]		
Connect- ing rod	Inside diameter of connecting rod bushing		ø70 [2.76]	70.020 to 70.040 [2.7567 to 2.7575]	70.070 [2.7587]		
	Bend and twist			0.05/100 [0.0020/3.94] or less			
	End play			0.4 to 0.6 [0.016 to 0.024]	1.0 [0.039]		
	Inside diameter of big end bore		ø131 [5.16]	131.000 to 131.025 [5.1575 to 5.1585]	Minimum: 130.950 [5.1555]		
					Maximum: 131.050 [5.1594]		
	Roundness for inside diameter of big end bore				0.100 [0.0039]		
	Big end side (Width)			66.7 to 66.8 [2.626 to 2.620]			
Connect- ing rod rod bearing	Thickness at center	Standard	3.000 [0.1181]	2.957 to 2.970 [0.1164 to 0.1169]	2.930 [0.1154]		
		Under size	0.25	3.125 [0.1230]	3.082 to 3.095 [0.1213 to 0.1219]	3.055 [0.1203]	
			0.50	3.250 [0.1280]	3.207 to 3.220 [0.1263 to 0.1268]	3.180 [0.1252]	
			0.75	3.375 [0.1329]	3.332 to 3.345 [0.1312 to 0.1317]	3.305 [0.1301]	
			1.00	3.500 [0.1378]	3.457 to 3.470 [0.1361 to 0.1366]	3.430 [0.1350]	
Flywheel	Face runout (Reference)			0.285 [0.0112] or less			
	Radial runout (Reference)			0.127 [0.0050] or less			
Damper	Face runout (Reference)			0.5 [0.0197] or less			
	Radial runout (Reference)			0.5 [0.0197] or less			
Rear mech- anism	Backlash between crank gear and idler gear			0.11 to 0.28 [0.0043 to 0.0110]	0.50 [0.197]		
	Backlash between idler gear and camshaft gear			0.12 to 0.18 [0.0047 to 0.0071]	0.50 [0.197]		
	Backlash between idler gear and fuel injection pump gear			0.12 to 0.18 [0.0047 to 0.0071]	0.50 [0.197]		
	Idler bushing inside diameter		ø50 [1.97]	50.000 to 50.025 [1.9685 to 1.9695]	50.060 [1.9709]		
	Idler shaft outside diameter		ø50 [1.97]	49.950 to 49.975 [1.9665 to 1.9675]	49.900 [1.9646]		
	Idler gear end play			0.2 to 0.4 [0.008 to 0.016]	0.6 [0.0236]		
Camshaft	Cam lift (Major axis - minor axis)	37505-34100 (Overlap 93°)		9.207 to 9.287 [0.3625 to 0.3656]	8.45 [0.3327]		
		37505-40100 (Overlap 61°)		9.207 to 9.287 [0.3625 to 0.3656]	8.45 [0.3327]		
	Runout			0.05 [0.0020] or less	0.08 [0.0031]	TIR	
	Journal diameter		ø84 [3.30]	83.92 to 83.94 [3.3039 to 3.3047]	83.87 [3.3020]		
	Camshaft bushing inside diameter (As installed in crankcase)		ø84 [3.30]	84.020 to 84.095 [3.3079 to 3.3108]	84.100 [3.3110]		
	End play			0.10 to 0.25 [0.0039 to 0.0098]	0.40 [0.0157]		

Unit: mm [in.]

Item				Nominal value	Standard value	Limit value	Remarks
Crank shaft	Crankpin outside diameter	Standard		ø125 [4.92]	124.930 to 124.950 [4.9185 to 4.9193]	124.890 [4.9169]	
		Under size	0.25		124.680 to 124.700 [4.9084 to 4.9094]	124.640 [4.9071]	
			0.50		124.430 to 124.450 [4.8988 to 4.8996]	124.390 [4.8972]	
			0.75		124.180 to 124.200 [4.8890 to 4.8898]	124.140 [4.8874]	
			1.00		123.930 to 123.950 [4.8791 to 4.8799]	123.890 [4.8775]	
	Crank main journal outside diameter	Standard		ø140 [5.51]	139.930 to 139.950 [5.5090 to 5.5098]	139.890 [5.5075]	
		Under size	0.25		139.680 to 139.700 [5.4992 to 5.5000]	139.640 [5.4976]	
			0.50		139.430 to 139.450 [5.4894 to 5.4901]	139.390 [5.4878]	
			0.75		139.180 to 139.200 [5.4795 to 5.4803]	139.140 [5.4779]	
			1.00		138.930 to 138.950 [5.5090 to 5.5098]	138.890 [5.4681]	
	Parallelism of journal and crankpin				Deviation of 0.01 [0.0004] or less over entire pin length	0.03 [0.012]	
	Circularity of journal and crankpin				Diameter difference 0.01 [0.0004] or less	0.03 [0.012]	
	Cylindricity of journal and crankpin				Diameter difference 0.01 [0.0004] or less	0.03 [0.012]	
	Fillet radius of pin			R7 [0.28]	6.8 to 7.0 [0.268 to 0.276]		
	Fillet radius of journals			R7 [0.28]	6.8 to 7.0 [0.268 to 0.276]		
	Hardness of journals and crankpins				Hv > 620		
	Finishing surface roughness				Ra 0.2 µm [0.008 µin.]		
	Angular deviation between pins				±20'		
	Crankpin width			67 [2.64]	67.20 to 67.30 [2.6457 to 2.6496]		
	Rearmost crank main journal width	Standard		66 [2.60]	66.00 to 66.05 [2.5984 to 2.6004]		
		Over size	0.25		66.25 to 66.30 [2.6083 to 2.6102]		
			0.50		66.50 to 66.55 [2.6181 to 2.6201]		
			0.75		66.75 to 66.80 [2.6279 to 2.6299]		
			1.00		67.00 to 67.05 [2.6378 to 2.6398]		
			1.25		67.25 to 67.30 [2.6476 to 2.6496]		
			1.50		67.50 to 67.55 [2.6575 to 2.6594]		
	Runout				0.04 [0.0016] or less	0.10 [0.0039]	TIR
	End play (width between web and thrust bearing)				0.300 to 0.520 [0.0118 to 0.0205]	0.600 [0.0236]	

Unit: mm [in.]

Item				Nominal value	Standard value	Limit value	Remarks
Main bearing	Thickness at center	Standard		3.500 [0.1378]	3.467 to 3.480 [0.1365 to 0.1370]	3.425 [0.1348]	
		Under size	0.25	3.625 [0.1427]	3.592 to 3.605 [0.1414 to 0.1419]	3.550 [0.1398]	
			0.50	3.750 [0.1476]	3.717 to 3.730 [0.1463 to 0.1469]	3.675 [0.1447]	
			0.75	3.875 [0.1526]	3.842 to 3.855 [0.1513 to 0.1518]	3.800 [0.1496]	
			1.00	4.000 [0.1575]	3.967 to 3.980 [0.1562 to 0.1567]	3.925 [0.1545]	
Trust plate	Thickness	Standard		5.00 [0.1969]	4.78 to 4.85 [0.1882 to 0.1909]	4.71 [0.1854]	
		Over size	0.25	5.25 [0.2067]	5.03 to 5.10 [0.1980 to 0.2008]	4.96 [0.1953]	
			0.50	5.50 [0.2165]	5.28 to 5.35 [0.2079 to 0.2106]	5.21 [0.2051]	
			0.75	5.75 [0.2264]	5.53 to 5.60 [0.2177 to 0.2189]	5.46 [0.2150]	
Crankcase	Distortion of top surface				0.1 [0.004] or less	0.2 [0.008]	
	Inside diameter of main bearing bore			ø147 [5.79]	147.000 to 147.025 [5.7874 to 5.7884]	147.035 [5.7888]	
	Depth of counterbore in crankcase				14.00 to 14.05 [0.5512 to 0.5531]		
	Height from journal center to top face (Reference value)				549.45 to 549.55 [21.6318 to 21.6358]		

1.3 Maintenance Service Data of Fuel System

Unit: mm [in.]

Item			Nominal value	Standard value	Limit value	Remarks
Fuel injection nozzle	Free length of nozzle spring	P/N:37561-26400		30 [1.18]		
		P/N:48726-00402		26.8 [1.055]		
	Squareness of nozzle spring	P/N:37561-26400		0.6 [0.0236] or less		
		P/N:48726-00402		1.25° or less		
	Nozzle spring parallelism of top and bottom surfaces	P/N:37561-26400		0.1 [0.004] or less		
		P/N:48726-00402		0.65° or less		
	Fuel injection starting pressure	P/N: 37760-14001 37760-22001	30.40 MPa {310 kgf/cm ² } [4267 psi]	30.40 to 30.89 MPa {310 to 315 kgf/cm ² } [4409 to 4480 psi] (the value when it is new)		
		P/N: 37560-32000	34.32 MPa {350 kgf/cm ² } [4978 psi]	33.83 to 35.79 MPa {345 to 365 kgf/cm ² } [4907 to 5192 psi] (the value when it is new)		
		P/N: 37561-44000 37860-06000 37560-35000 37560-39000 37560-22010	34.32 MPa {350 kgf/cm ² } [4978 psi]	34.32 to 34.81 MPa {350 to 355 kgf/cm ² } [4978 to 5049 psi] (the value when it is new)		
	Orifice cone angle	P/N: 37561-44000 ("K" mark)	155°			
		P/N: 37860-06000 ("XX" mark) 37760-14001 ("SS" mark) 37760-22001 ("RS" mark)	158°			
		P/N: 37560-35000 ("M" mark) 37560-37000 ("F" mark) 37560-39000 ("H" mark) 37560-32000 ("N" mark) 37560-22010 ("N" mark)	160°			
	Orifice diameter	P/N: 37760-14001 ("SS" mark)	ø0.26 [0.012]			
		P/NP/N: 37860-06000 ("XX" mark)	ø0.27 [0.0106]			
		P/N: 37560-35000 ("M" mark) 37760-22001 ("RS" mark)	ø0.29 [0.0114]			
		P/N: 37560-32000 ("N" mark) 37561-44000 ("K" mark) 37560-22010 ("N" mark)	ø0.31 [0.0122]			
		P/N: 37560-39000 ("H" mark)	ø0.325 [0.0128]			
		P/N: 37560-37000 ("F" mark)	ø0.35 [0.0138]			
	Number of orifices	P/N: 37760-14001 ("SS" mark) 37760-22001 ("RS" mark)	9			
		P/N: 37860-06000 ("XX" mark) 37560-35000 ("M" mark) 37560-32000 ("N" mark) 37561-44000 ("K" mark) 37560-22010 ("N" mark) 37560-39000 ("H" mark) 37560-41000 ("P" mark) 37560-37000 ("F" mark)	10			

Unit: mm [in.]

Item				Nominal value	Standard value	Limit value	Remarks
Fuel injection pump accessory drive	Inside diameter of case bearing housing			ø90 [3.54]	89.987 to 90.022 [3.5428 to 3.5442]		
				ø100 [3.94]	99.987 to 100.022 [3.9365 to 3.9379]		
	For injection pump drive shaft bearing	outside diameter	Small	ø90 [3.54]	89.985 to 90.000 [3.5427 to 3.5433]		
			Large	ø100 [3.94]	99.985 to 100.000 [3.9364 to 3.9370]		
		Inside diameter	Small	ø45 [1.77]	44.988 to 45.000 [1.7712 to 1.7717]		
			Large	ø50 [1.97]	49.988 to 50.000 [1.9680 to 1.9685]		
	Outside diameter of drive shaft bearing fit			ø45 [1.77]	45.002 to 45.013 [1.7717 to 1.7722]		
				ø50 [1.97]	50.002 to 50.013 [1.9686 to 1.9690]		
Governor drive	Inside diameter of drive shaft case bearing housing			ø52 [2.05]	51.988 to 52.018 [2.0468 to 2.0479]		
	Drive shaft side bearing	outside diameter		ø52 [2.05]	51.987 to 52.000 [2.0467 to 2.0472]		
		Inside diameter		ø25 [0.98 in.]	24.990 to 25.000 [0.9839 to 0.9843]		
	Outside diameter of drive shaft bearing fit			ø25 [0.98 in.]	25.002 to 25.011 [0.9843 to 0.9847]		
	Outside diameter of drive shaft gear fit			ø26 [1.02]	26.035 to 26.048 [1.0250 to 1.0255]		
	Inside diameter of drive gear fit			ø26 [1.02]	26.000 to 26.013 [1.0236 to 1.0241]		
	Inside diameter of idler shaft case bearing housing			ø47 [1.85]	46.989 to 47.014 [1.8500 to 1.8509]		
	Idler shaft side bearing	outside diameter		ø47 [1.85]	46.989 to 47.000 [1.8500 to 1.8504]		
		Inside diameter		ø20 [0.79]	19.990 to 20.000 [0.7870 to 0.7874]		
	Outside diameter of idler shaft bearing fit			ø20 [0.79]	20.002 to 20.011 [0.7875 to 0.7878]		
	Outside diameter of idler shaft gear fit			ø24 [0.94]	24.035 to 24.048 [0.9463 to 0.9468]		
	Inside diameter of idler gear fit			ø24 [0.94]	24.000 to 24.013 [0.9449 to 0.9454]		
	backlash				0.12 to 0.18 [0.0047 to 0.0071]	0.4 [0.0157]	

1.4 Maintenance Service Data of Lubrication System

Unit: mm [in.]

Item		Nominal value	Standard value	Limit value	Remarks
Oil pump	Backlash between oil pump gear and idler gear		0.087 to 0.316 [0.0034 to 0.0124]	0.500 [0.0197]	
	Drive gear and driven gear backlash		0.100 to 0.200 [0.0039 to 0.0079]	0.400 [0.00157]	
	Top clearance between gear teeth and case		0.100 to 0.196 [0.0039 to 0.0077]	0.350 [0.0138]	
	Side clearance between gear width and case depth		0.050 to 0.114 [0.0020 to 0.0045]	0.250 [0.0098]	
	Drive shaft outside diameter	ø25 [0.98]	24.947 to 24.960 [0.9822 to 0.9827]	24.900 [0.9803]	
	Driven shaft outside diameter		24.947 to 24.960 [0.9822 to 0.9827]	24.900 [0.9803]	
	Bushing inside diameter		25.000 to 25.021 [0.9843 to 0.9851]	25.100 [0.9882]	
	Spindle outside diameter	ø25 [0.98]	24.949 to 24.960 [0.9822 to 0.9827]	24.900 [0.9803]	
	Idler gear bushing inside diameter		25.000 to 25.021 [0.9843 to 0.9851]	25.100 [0.9882]	
	Safety valve opening pressure		1.4 ± 0.1 MPa {14 ± 1 kgf/cm ² } [203 ± 14 psi]		
Oil filter alarm	Differential pressure for activation of alarm		0.15 to 0.18 MPa {1.5 to 1.8 kgf/cm ² } [21 to 26 psi]		
Relief valve	Spring free length		115 [4.53]		
Oil thermostat	Valve opening temperature		80 to 84°C [176 to 183.2°F]		
	Temperature at which valve lift becomes 11 [0.43] or more		95°C [203°F]		
Oil pump idler gear and crankshaft gear backlash			0.11 to 0.38 [0.0043 to 0.0150]		

1.5 Maintenance Service Data of Cooling System

Unit: mm [in.]

Item			Nominal value	Standard value	Limit value	Remarks
Tension pulley	Inside diameter of pulley bearing fit		ø52 [2.05]	51.970 to 52.000 [2.0461 to 2.0472]		
	Bearing	Outside diameter	ø52 [2.05]	51.987 to 52.000 [2.0467 to 2.0472]		
		Inside diameter	ø20 [0.79]	19.988 to 20.000 [0.7869 to 0.7874]		
	Outside diameter of bracket bearing fit		ø20 [0.79]	19.987 to 20.000 [0.7869 to 0.7874]		
Thermostat	P/A: 37546-21700 (For jacket water)	Valve opening temperature		69 to 73°C [156 to 163°F]		Valve open temperature stamp: 71°C [160°F]
		Temperature at which valve lift becomes 9 [0.35] or more		85°C [185°F]		
	P/A: 35C46-05200 (For air cooler)	Valve opening temperature		33 to 37°C [91.4 to 98.6°F]		Opening temperature stamp 35°C [95°F]
		Temperature at which valve lift becomes 10 [0.433] or more		50°C [122°F]		
	P/A: 37546-40700 (For air cooler)	Valve opening temperature		69 to 73°C [156 to 163°F]		Valve open temperature stamp: 71°C [160°F]
		Temperature at which valve lift becomes 11 [0.43] or more		85°C [185°F]		
Water pump	Outside diameter of case bearing housing		ø80 [3.15]	79.988 to 80.018 [3.1494 to 3.1503]	80.025 [3.1506]	
			ø90 [3.54]	89.987 to 90.022 [3.5428 to 3.5442]	90.025 [3.5443]	
	Bearing	Outside diameter	ø80 [3.15]	79.985 to 80.000 [3.1490 to 3.1496]		
			ø90 [3.54]	89.985 to 90.000 [3.5427 to 3.5433]		
		Inside diameter	ø40 [1.57]	39.988 to 40.000 [1.5743 to 1.5748]		
	Outside diameter of shaft fit to bearing		ø40 [1.57]	40.002 to 40.013 [1.5749 to 1.5753]	39.995 [1.5746]	
	Impeller front clearance		0.72 [0.0283]	0.14 to 1.30 [0.0055 to 0.0445]		
	Impeller water pump shaft interference		ø20 [0.79]	0.024 to 0.060 [0.0009 to 0.0024]		
For air cooler water pump	Case bearing inside diameter of counterbore	Pump case	ø62 [2.44]	61.988 to 62.018 [2.4405 to 2.4416]		
		Bearing cover	ø68 [2.6]	67.961 to 67.991 [2.6756 to 2.6768]		
	Bearing	Outside diameter	ø28 [1.10]	27.990 to 28.000 [1.1020 to 1.1024]		
		Inside diameter	ø68 [2.6]	67.987 to 68.000 [2.6766 to 2.6772]		
	Outside diameter of shaft fit to bearing		ø28 [1.10]	28.002 to 28.015 [1.1024 to 1.1030]		
	Impeller front clearance		0.8 [0.031]	0.5 to 1.1 [0.0197 to 0.0433]		

Unit: mm [in.]

Item			Nominal value	Standard value	Limit value	Remarks
Sea water pump for air cooler	Inside diameter of case bearing housing		ø90 [3.54]	89.9825 to 90.0175 [3.5426 to 3.5440]		
	Bearing	Outside diameter	ø90 [3.54]	90.000 to 90.015 [3.5433 to 3.5439]		
		Inside diameter	ø30 [1.18 in.]	29.990 to 30.000 [1.1807 to 1.1811]		
			ø40 [1.57]	39.988 to 40.000 [1.5743 to 1.5748]		
	Outside diameter of shaft fit to bearing		ø30 [1.18 in.]	30.002 to 30.018 [1.1812 to 1.1818]		
			ø40 [1.57]	40.002 to 40.018 [1.5743 to 1.5749]		
	Fan drive	Inside diameter of case bearing housing		ø100 [3.94]	99.987 to 100.022 [3.9365 to 3.9379]	
ø110 [4.33]				109.987 to 110.022 [4.3302 to 4.3316]		
Bearing		Outside diameter	ø100 [3.94]	99.985 to 100.000 [3.9364 to 3.9370]		
			ø110 [4.33]	109.985 to 110.000 [4.3301 to 4.3307]		
		Inside diameter	ø45 [1.77]	45.002 to 45.013 [1.7717 to 1.7722]		
			ø50 [1.97]	50.002 to 50.013 [1.9686 to 1.9690]		
Outside diameter of shaft fit to bearing		ø45 [1.77]	44.988 to 45.000 [1.7712 to 1.7717]			
		ø50 [1.97]	49.988 to 50.000 [1.9680 to 1.9685]			

1.6 Maintenance Service Data of Electrical System

Unit: mm [in.]

Item					Nominal value	Standard value	Limit value	Remarks
Starter	P/N: 37566-30200 (Single wire type) 37566-45200 (2-wire type)	Armature	Commutator	Dia		ø43 [1.69]	ø42 [1.65]	
				Runout		0.06 [0.0024]	0.1 [0.004]	
				Undercut depth		0.7 to 0.9 [0.028 to 0.035]	0.2 [0.008] or less	
			Shaft outside diameter	Front		ø20 [0.79]		
				Rear		ø10 [0.39]		
		Shaft	Front pinion metal	Outside diameter		ø19 [0.75]		
				Clearance between metal and shaft			0.25 [0.01]	
			Outside diameter of bearing to fit	Outside diameter		ø30 [1.18]		
		Metal	Front bracket	Inside diameter		ø19 [0.75]		
				Clearance between metal and shaft			0.25 [0.01]	
			Pinion	Inside diameter		ø19 [0.75]		
				Clearance between metal and shaft			0.25 [0.01]	
		Bearing outside diameter to fit	Internal shaft	Bearing inside diameter		ø55 [2.17]	ø55.1 [2.17]	
				Item name		6006		Replace if it does not rotate smoothly or an abnormal noise is generated.
			Armature front	Bearing inside diameter		ø47 [1.85]	ø47.1 [1.85]	
				Item name		6204		Replace if it does not rotate smoothly or an abnormal noise is generated.
			Armature rear	Bearing inside diameter		ø30 [1.18]	ø30.1 [1.19]	
				Item name		6200		Replace if it does not rotate smoothly or an abnormal noise is generated.
		Brush	Brush length			22 to 23 [0.87 to 0.91]	less than 13 [0.51] lefts	
			Brush spring load			4.5 [0.177]	less than 4.1 [0.161]	With brush installed
		Thrust cap	Armature	P/N: 37566-30200		0.15 to 0.75 [0.0059 to 0.0295]		Adjust with the adjust washer
				P/N: 37566-45200		0.2 to 0.7 [0.008 to 0.028]		
			Internal shaft			0.2 to 0.8 [0.008 to 0.032]		Adjust with the adjust washer

Unit: mm [in.]

Item						Nominal value	Standard value	Limit value	Remarks
Starter	P/N: 37566-30200 (Single wire type) 37566-45200 (2-wire type)	Magnetic switch	Coil resistance (Ω)	Pressure	P/N: 37566-30200		0.127 [0.0050]		(Reference at 20°C [68°F])
					P/N: 37566-45200		0.066 [0.0026]		
				Holding	P/N: 37566-30200		0.92 [0.0362]		(Reference at 20°C [68°F])
					P/N: 37566-45200		1.07 [0.0421]		
			Contactor deflection		P/N: 37566-30200		1.5 to 2.5 [0.06 to 0.1]	0.6 [0.023]	
					P/N: 37566-45200		1.35 to 2.05 [0.0531 to 0.0807]		
		Insulating resistance	Armature	Commutator to earth			100MΩ or higher (Room temperature and humidity at 500 V megger)	0.02MΩ or higher (Room temperature and humidity at 500 V megger)	
			Yoke assy	M terminal lead to earth			10MΩ or higher (Room temperature and humidity at 500 V megger)	0.02MΩ or higher (Room temperature and humidity at 500 V megger)	
			Brush holder	Positive brush box to holder ring			10MΩ or higher (Room temperature and humidity at 500 V megger)	0.02MΩ or higher (Room temperature and humidity at 500 V megger)	

Unit: mm [in.]

Item						Nominal value	Standard value	Limit value	Remarks
Alternator	P/N:04343-35500 04343-35600	Initial exciting type (brush-less)	Output current (at 27 V)	Rotation speed (min ⁻¹)	2500		30 A or more (when cold)		
					5000		35 A or more (when engine is hot)		
			Regulator adjusting voltage (Alternator 5000 min ⁻¹ , load at 5 A or lower)				28.5 ± 0.5 V		
			Field coil resistance (20 °C [68 °F])				7.3 to 8.5 Ω		
	P/N:04343-38000	Self exciting type (with brush)	Output current (at 27 V)	Rotation speed (min ⁻¹)	2500		26 A or more (when engine is hot)		
					5000		30 A or more (when engine is hot)		
			Regulator adjusting voltage (Alternator 5000 min ⁻¹ , load at 5 A or lower)				28.5 ± 0.5 V		
						33 [1.3]	32.8 to 33.2 [1.291 to 1.307]	32.4 [1.276]	
			Height of brushes			21.5		8.0 [0.36]	The part shows a limit line.
			Pressure of brush springs			3.7N {0.38kgf} [83.78 lbf]	3.1N to 4.3N {0.32 to 0.44kgf} [0.70 to 0.97 lbf]	1.8N {0.18kgf} [0.40 lbf]	
	Belt tension (cogged type)						10 to 15 [0.4 to 0.6]		When the center of the belt is pushed with a force of approx 98 to 147 N {10 to 15 kgf} [22 to 33 lbf]
Alternator	P/N:04343-38300	External exciting type (with brush)	Output current (at 27 V)	Rotation speed (min ⁻¹)	2500		29 A or more (when engine is hot)		
					5000		35 A or more (when engine is hot)		
			Regulator adjusting voltage (Alternator 5000 min ⁻¹ , load at 5 A or lower)				28.5 ± 0.5 V		
			Rotor slip ring outside diameter			33 [1.3]	32.8 to 33.2 [1.291 to 1.307]	32.4 [1.276]	
			Height of brushes			21.5 [0.847]		8.0 [0.36]	The part shows a limit line.
						3.7N {0.38kgf} [83.78 lbf]	3.1N to 4.3N {0.32 to 0.44kgf} [0.70 to 0.97 lbf]	1.8N {0.18kgf} [0.40 lbf]	
			Belt tension (ribbed type)						Refer to the table below

1.6.1 Belt tension

Unit N {kgf} [lbf]

Item	Number of ribs	Belt straight distance (mm) [in.]				
		300 [11.81] or below	more than 300 to 400 [11.81 to 15.75]	more than 400 to 500 [15.75 to 19.69]	more than 500 to 600 [16.69 to 23.62]	more than 600 [23.62]
When a new belt is installed:	3	74 {7.55} [16.64]	49 {5.00} [11.02]	37 {3.77} [8.32]	29 {2.96} [6.52]	25 {2.55} [5.62]
	4	88 {8.97} [19.78]	59 {6.02} [13.26]	44 {4.49} [9.89]	35 {3.57} [7.87]	29 {2.96} [6.52]
	5	103 {10.50} [23.16]	69 {7.04} [15.51]	51 {5.20} [11.47]	41 {4.18} [9.22]	34 {3.47} [7.64]
	6	118 {12.03} [26.53]	79 {8.06} [17.76]	59 {6.02} [13.26]	47 {4.79} [10.57]	39 {3.98} [8.77]
	7	132 {13.46} [29.67]	88 {8.97} [19.78]	66 {6.73} [14.84]	53 {5.40} [11.91]	44 {4.49} [9.89]
	8	147 {14.99} [33.05]	98 {9.99} [22.03]	74 {7.55} [16.64]	59 {6.02} [13.26]	49 {5.00} [11.02]
	9	162 {16.52} [36.42]	108 {11.01} [24.28]	81 {8.26} [18.21]	65 {6.63} [14.61]	54 {5.51} [12.14]
	10	176 {17.95} [39.57]	118 {12.03} [26.53]	88 {8.97} [19.78]	71 {7.24} [15.96]	59 {6.02} [13.26]
	11	191 {19.48} [42.94]	127 {12.95} [28.55]	96 {9.79} [21.58]	76 {7.75} [17.09]	64 {6.53} [14.39]
	12	206 {21.01} [46.31]	137 {13.97} [30.80]	103 {10.50} [23.16]	82 {8.36} [18.43]	69 {7.04} [15.51]
When re-adjusted:	3	51 {5.20} [11.47]	34 {3.47} [7.64]	26 {2.65} [5.85]	21 {2.14} [4.72]	17 {1.73} [3.82]
	4	62 {6.32} [13.94]	41 {4.18} [9.22]	31 {3.16} [6.97]	25 {2.55} [5.62]	21 {2.14} [4.72]
	5	72 {7.34} [16.19]	48 {4.89} [10.79]	36 {3.67} [8.09]	29 {2.96} [6.52]	24 {2.45} [5.40]
	6	82 {8.36} [18.43]	55 {5.61} [12.36]	41 {4.18} [9.22]	33 {3.37} [7.42]	27 {2.75} [6.07]
	7	93 {9.48} [20.91]	62 {6.32} [13.94]	46 {4.69} [10.34]	37 {3.77} [8.32]	31 {3.16} [6.97]
	8	103 {10.50} [23.16]	69 {7.04} [15.51]	51 {5.20} [11.47]	41 {4.18} [9.22]	34 {3.47} [7.64]
	9	113 {11.52} [25.40]	75 {7.65} [16.86]	57 {5.81} [12.81]	45 {4.59} [10.12]	38 {3.87} [8.54]
	10	123 {12.54} [27.65]	82 {8.36} [18.43]	62 {6.32} [13.94]	49 {5.00} [11.02]	41 {4.18} [9.22]
	11	134 {13.66} [30.12]	89 {9.08} [20.01]	67 {6.83} [15.06]	54 {5.51} [12.14]	45 {4.59} [10.12]
	12	144 {14.68} [32.37]	96 {9.79} [21.58]	72 {7.34} [16.19]	58 {5.91} [13.04]	48 {4.89} [10.79]

The force when the middle of belt straight line is pushed and deflected by 15 mm [0.5906 in.]

1.7 Air Start System

Unit: mm [in.]

Item		Nominal value	Standard value	Limit value	Remarks
Sterter valve	Clearance between valve and valve guide	ø15 [0.59]	0.016 to 0.052 [0.0006 to 0.0020]	0.100 [0.004]	
	Valve spring free length		36 [1.42]	34 [1.34]	
Distributor valve	Distributor valve height		21.85 to 21.95 [0.8602 to 0.8642]	21.75 [0.8563]	
	Clearance between shaft and bushing		0.050 to 0.091 [0.0020 to 0.0036]	0.150 [0.0059]	

2. Tightening Torque Table

2.1 Tightening Torque Spec for Basic Engine

Description		Dia x Pitch (M-thread)	Tightening torque			Remarks
			N·m	kgf·m	lbf·ft	
Cylinder head bolt		M 22 × 2.5	539 ± 27	55 ± 2.75	397.55 ± 19.91	[Wet] 2-time tightening method, Note (a)
Cylinder head nozzle gland (studs)		M 14 × 2.0	73.5 ± 4.5	7.5 ± 0.5	54.21 ± 3.31	Apply Loctite 272 to the internal screw thread of the cylinder head
Rocker case		M 12 × 1.25	108 ± 5.4	11 ± 0.55	79.66 ± 3.98	
Rocker shaft		M 14 × 2.0	147 ± 7.4	15 ± 0.75	108.42 ± 5.45	
Rocker arm (lock nut)		M 12 × 1.25	64 ± 3.2	6.5 ± 0.33	47.20 ± 2.36	
Bridge (lock nut)		M 10 × 1.25	55 ± 2.8	5.6 ± 0.28	40.57 ± 2.06	
Camshaft gear		M 14 × 1.5	176 ± 8.8	17.9 ± 0.9	129.81 ± 6.49	Use 12T bolt w/hard washer
Camshaft thrust plate		M 12 × 1.25	59 ± 5.9	6 ± 0.6	43.52 ± 4.35	
Main bearing cap		M 22 × 2.5	490 ± 24.5	50 ± 2.5	361.41 ± 18.07	[Wet], Note (b)
Hanger		M 12 × 1.25	108 ± 5.4	11 ± 0.55	79.66 ± 3.98	
Piston cooling nozzle		M 12 × 1.75	34 ± 1.7	3.5 ± 0.18	25.08 ± 1.25	Note (c)
Timing gear case		M 16 × 1.5	255 ± 12.8	26 ± 1.3	188.08 ± 9.44	Use hard washer
Rear plate		M 12 × 1.25	108 ± 5.4	11 ± 0.55	79.66 ± 3.98	
Front mounting bracket		M 12 × 1.25	108 ± 5.4	11 ± 0.55	79.66 ± 3.98	Front end lower bolt of right front mounting bracket only
Rear mounting bracket		M 16 × 1.5	216 ± 10.8	22 ± 1.1	159.31 ± 7.96	
Connecting rod cap		M 22 × 1.5	Note (e)			[Wet]
Flywheel		M 22 × 1.5	539 ± 27	55 ± 2.75	397.54 ± 19.91	[Wet]
Damper		M 22 × 1.5	490 ± 24.5	50 ± 2.5	361.40 ± 18.07	
Idler shaft		M 12 × 1.25	108 ± 5.4	11 ± 0.55	79.66 ± 3.98	Apply MOLYKOT
Idler shaft thrust collar (nut)		M 18 × 1.5	196 ± 9.8	20 ± 1.0	144.56 ± 7.22	
Fuel injection Accessory drive	Case	M 12 × 1.25	108 ± 5.4	11 ± 0.55	79.66 ± 3.98	
	Gear (nut)	M 30 × 1.5	490 ± 24.5	50 ± 2.5	361.40 ± 18.07	
Governor drive case		M 12 × 1.25	108 ± 5.4	11 ± 0.55	79.66 ± 3.98	

Note:(a) For torque-angle tightening method of cylinder head bolts, follow the steps in sequence given below:

- 1) Tighten the bolts with a snug torque of $294 \pm 14.7 \text{ N}\cdot\text{m}$ [$30 \pm 1.5 \text{ kgf}\cdot\text{m}$] [$217 \pm 11 \text{ lbf}\cdot\text{ft}$].
 - 2) Tighten to the angle $65 \pm 3^\circ$.
 - 3) Loosen all bolts, and then retighten them in the sequence shown in the above 1) and 2).(2-time tightening)
For tightening procedure, refer to "Cylinder Head Bolt - Tighten" of "ASSEMBLY OF BASIC ENGINE".
- (b) Tighten the main bearing cap bolt in specified sequence. Tighten them to the half of specified torque, then tighten them to the specified torque.
For tightening procedure, refer to "Main bearing cap - Install" of "ASSEMBLY OF BASIC ENGINE."
- (c) Tighten piston cooling nozzle check valves to the specified torque. Do not over-tighten. If the tightening torque exceeds the specified torque, it could cause the check valve to malfunction, which may result in piston seizure.
- (d) When [Wet] is indicated, apply engine oil to the threads and bolt seat surface.
- (e) Connecting rod cap bolts should be tightened as shown below.

Bolt mark	Torque method (2-time tightening method)	Angle controlled method (2-time tightening method)
2	$539 \pm 27 \text{ N}\cdot\text{m}$ [$55 \pm 2.75 \text{ kgf}\cdot\text{m}$] [$398 \pm 20 \text{ lbf}\cdot\text{ft}$]	Snug torque $245 \pm 12.3 \text{ N}\cdot\text{m}$ [$25 \pm 1.25 \text{ kgf}\cdot\text{m}$] [$180 \pm 9 \text{ lbf}\cdot\text{ft}$] → $60 \pm 3^\circ$
AU	$637 \pm 31.9 \text{ N}\cdot\text{m}$ [$65 \pm 3.25 \text{ kgf}\cdot\text{m}$] [$470 \pm 24 \text{ lbf}\cdot\text{ft}$]	Snug torque $294 \pm 14.7 \text{ N}\cdot\text{m}$ [$30 \pm 1.5 \text{ kgf}\cdot\text{m}$] [$217 \pm 11 \text{ lbf}\cdot\text{ft}$] → $60 \pm 3^\circ$
AL		

2.2 Tightening Torque Spec for Fuel System

Description			ThreadsDia - Pitch (mm)	Tightening torque			Remarks
				N·m	kgf·m	lbf·ft	
Fuel injection pump	Accessory drive case		M 12 × 1.25	108 ± 5.4	11 ± 0.55	79.66 ± 3.98	
	Accessory drive gear (nut)	Nut	M 30 × 1.5	490 ± 24.5	50 ± 2.5	361.40 ± 18.07	
		Speed pick-up	M 30 × 1.5	392 ± 19.6	40 ± 2.0	242.65 ± 14.46	
	Coupling shaft		M 14 × 1.5	172 ± 5	17.5 ± 0.5	126.86 ± 3.68	Tighten the slit portion.
	Laminated plate		M 14 × 1.5	118 ± 5	12 ± 0.5	87.03 ± 3.68	2-time tightening method
			M 12 × 1.25	108 ± 5	11 ± 0.5	79.66 ± 3.68	10T bolt + Nut with washer, 2-time tightening method
	Pump mounting bolt		M 12 × 1.25	108 ± 5.4	11 ± 0.55	79.66 ± 3.98	
	Bracket		M 12 × 1.25	108 ± 5.4	11 ± 0.55	79.66 ± 3.98	
	Flywheel (nut)		M 24 × 1.5	392 ± 19.6	40 ± 2.0	289.12 ± 14.45	
Air vent plug		M 8 × 1.25	15 ± 2	1.5 ± 0.2	11.06 ± 1.47		
Plunger assembly			M 12 × 1.25	80.5 ± 2.5	8.25 ± 0.25	59.37 ± 1.84	
Delivery valve holder			M 30 × 1.5	245 ± 10	25 ± 1	180.70 ± 7.38	
Fuel injection pipe (nozzle and pump side)			M 18 × 1.5	59 ± 10	6 ± 1	43.52 ± 7.38	
Fuel rack control lever			M 8 × 1.25	25 ± 1.25	2.5 ± 0.13	18.44 ± 0.92	2-time tightening method
Fuel filter air vent plug			M 8 × 1.25	9 ± 1	0.9 ± 0.1	6.64 ± 0.74	
Nozzle tip retaining nut			M 28 × 1.5	186.5 ± 9.5	19 ± 1	137.56 ± 7	T type, TE type
			M 28 × 1.5	127.5 ± 5.0	13 ± 0.5	94.04 ± 3.68	S type
Nozzle inlet connector			M 16 × 1.5	69 ± 5	7 ± 0.5	50.84 ± 3.68	
Nozzle holder cap nut			M 14 × 1.5	73.5 ± 4.5	7.5 ± 0.5	54.21 ± 3.32	
Nozzle holder set screw			M 10 × 1.5	39 ± 5	4 ± 0.5	28.76 ± 3.69	
Short plug			M 14 × 1	73.5 ± 4.9	7.5 ± 0.5	54.21 ± 3.61	
Nozzle gland (nut)			M 14 × 1.5	98 ± 4.9	10 ± 0.5	72.28 ± 3.61	

2.3 Tightening Torque Spec for Lubrication System

Description	Dia x Pitch (M-thread)	Tightening torque			Remarks
		N·m	kgf·m	lbf·ft	
Oil pump	M 12 × 1.25	108 ± 10.8	11 ± 1.1	79.66 ± 7.96	
Oil pump idler gear (nut)	M 12 × 1.25	69 ± 3.5	7 ± 0.35	50.89 ± 2.58	Apply Loctite 262 to threads
Oil pump cover	M 10 × 1.25	33 ± 6.7	3.4 ± 0.68	24.34 ± 4.94	
Governor oil filter air vent plug	M 8 × 1.25	9.8 ± 2.0	1 ± 0.2	7.23 ± 1.48	
Governor oil filter drain plug	M 8 × 1.25	9.8 ± 2.0	1 ± 0.2	7.23 ± 1.48	
Governor oil filter center bolt	M 14 × 1.5	34.3 ± 6.9	3.5 ± 0.7	25.30 ± 5.09	
Oil pan	M 12 × 1.25	59 ± 5.9	6 ± 0.6	43.52 ± 4.35	

2.4 Tightening Torque Spec for Cooling System

Description		Dia x Pitch (M-thread)	Tightening torque			Remarks
			N·m	kgf·m	lbf·ft	
Water pump	Pump	M 12 × 1.25	59 ± 5.9	6 ± 0.6	43.52 ± 4.35	
	Pump shaft pulley (nut)	M 24 × 1.5	245 ± 12.3	25 ± 1.25	180.70 ± 9.07	For alternator driving
	Pipe	-	22.5 ± 2.25	2.29 ± 0.23	16.59 ± 1.66	R 1/4
Water pump for air cooler cooling	Pump shaft pulley (nut)	M 20 × 1.5	112 ± 4.9	11.5 ± 0.5	82.61 ± 3.61	
	Pipe	-	22.5 ± 2.25	2.29 ± 0.23	16.59 ± 1.66	
Water pump for sea water pump	Pump	M 10 × 1.25	18.6 ± 2.95	1.9 ± 0.3	13.72 ± 2.18	
	Pump shaft pulley (nut)	M 24 × 2.0	220 ± 10	22.4 ± 1.0	162.26 ± 7.38	
Fan drive	Camshaft gear (front)	M 24 × 1.5	176 ± 8.8	17.9 ± 0.9	129.81 ± 6.49	
	Drive shaft gear (nut)	M 30 × 1.5	392 ± 19.6	40 ± 2.0	289.12 ± 14.46	
	Plate fan	M 12 × 1.25	108 ± 10.8	11 ± 1.1	79.66 ± 7.97	

2.5 Tightening Torque Spec for Inlet and Exhaust System

Description	Dia x Pitch (M-thread)	Tightening torque			Remarks
		N·m	kgf·m	lbf·ft	
Mounting nut for turbocharger	M 12 × 1.25	108 ± 5.4	11 ± 0.55	79.66 ± 7.97	
Exhaust pipe V clamp	1/4-28 UNF	9 ± 0.45	0.9 ± 0.04	11.80 ± 1.48	
Air cooler	M 12 × 1.25	108 ± 10.8	11 ± 1.1	79.66 ± 7.97	
Air cooler cover	M 8 × 1.25	16 ± 2	1.6 ± 0.2	11.80 ± 1.48	
Air cooler element	M 10 × 1.5	49 ± 5	5 ± 0.5	36.14 ± 3.69	

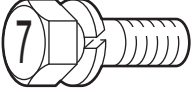
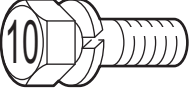
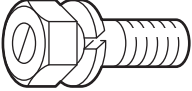
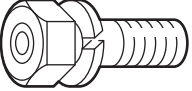
2.6 Tightening Torque Spec for Electrical System

Description			Dia x Pitch (M-thread)	Tightening torque			Remarks
				N·m	kgf·m	lbf·ft	
Starter	P/N: 37766-20200 (Single wire type) 37766-30300 (2-wire type)	Starter - Install	M 12 × 1.25	59 ± 5.9	6.0 ± 0.60	43.5 ± 4.35	
		Magnetic switch assembly	M 6 × 1.0	4.5 ± 0.6	0.46 ± 0.06	3.32 ± 0.44	
		Lever assembly	M 8 × 1.25	10.9 ± 1.3	1.1 ± 0.14	8.04 ± 0.96	
		Front bracket	M 6 × 1.0	5.85 ± 0.75	0.60 ± 0.07	4.31 ± 0.55	
		Safety switch	M 6 × 1.0	4.2 ± 0.3	0.43 ± 0.03	3.10 ± 0.22	
		Center bracket	M 8 × 1.25	14 ± 1.7	1.4 ± 0.17	10.3 ± 1.25	Hexagon socket bolt
		Brush holder	M 5 × 0.8	3.2 ± 0.4	0.33 ± 0.04	2.36 ± 0.30	
		Through bolt	M 6 × 1.0	8.7 ± 1.1	0.9 ± 0.11	6.42 ± 0.81	
		B terminal nut	M 10 × 1.25	17.7 ± 1.9	1.8 ± 0.19	13.05 ± 1.40	
		E terminal nut	M 10 × 1.25	22.6 ± 2.9	2.3 ± 0.3	16.67 ± 2.14	2- wire type only
Alternator	P/N: 04343-35500 04343-35600	Pulley nut	M 20 × 1.5	147 ± 15	14.99 ± 1.53	108.4 ± 11.1	
		Retainer tightening screw	M 5 × 0.8	3.9 ± 1	0.4 ± 0.1	2.88 ± 0.73	
		Through bolt	M 6 × 1.0	5.4 ± 1.5	0.55 ± 0.15	3.98 ± 1.11	
		Regulator assembly tightening screw	M 5 × 0.8	3.9 ± 1	0.4 ± 0.1	2.88 ± 0.73	
		Rectifier assembly tightening screw	M 5 × 0.8	3.9 ± 1	0.4 ± 0.1	2.88 ± 0.73	
		B terminal nut	M 5 × 0.8	6.9 ± 0.9	0.07 ± 0.09	5.09 ± 0.66	
		E terminal nut	M 5 × 0.8	6.9 ± 0.9	0.70 ± 0.09	5.09 ± 0.66	
		Coil assembly tightening screw	M 5 × 0.8	3.9 ± 1	0.4 ± 0.1	2.88 ± 0.73	
		Screw connecting field coil and regulator	M 5 × 0.8	3.9 ± 1	0.4 ± 0.1	2.88 ± 0.73	
		Connector assembly tightening bolt	M 6 × 1.0	5.4 ± 1.5	0.55 ± 0.15	3.98 ± 1.1	
	P/N: 04343-38000	Pulley nut	M 20 × 1.5	147 ± 29	14.99 ± 2.95	108.4 ± 21.4	
		Retainer tightening screw	M 5 × 0.8	3.9 ± 1	0.4 ± 0.1	2.88 ± 0.73	
		Through bolt	M 5 × 0.8	4.4 ± 1	0.45 ± 0.1	3.25 ± 0.73	
		Regulator assembly tightening screw	M 5 × 0.8	3.9 ± 1	0.4 ± 0.1	2.88 ± 0.73	
		Rectifier assembly tightening screw	M 5 × 0.8	3.9 ± 1	0.4 ± 0.1	2.88 ± 0.73	
		B terminal nut	M 5 × 0.8	6.9 ± 1.9	0.7 ± 0.19	5.09 ± 1.40	

2.7 Tightening Torque Spec for Air Start System

Description	Dia x Pitch (M-thread)	Tightening torque			Remarks
		N·m	kgf·m	lbf·ft	
Starter valve nut	M 8 × 1.25	19 ± 0.95	1.94 ± 0.09	14 ± 0.7	
Starter valve cap nut	M 36 × 1.5	117.6 ± 5.88	12 ± 0.6	86.7 ± 4.34	

2.8 Tightening Torque for Standard Bolts

Threads	Thread size Dia. x Pitch	Width across flats (mm)	Strength classification					
			7T			10.9		
Metric automobile screw thread								
			N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft
	M 8 × 1.25	12	17	1.7	12.5	30	3.1	22.1
	M 10 × 1.25	14	33	3.4	24.3	60	6.1	44.3
	M 12 × 1.25	17	60	6.1	44.3	108	11.0	79.7
	M 14 × 1.5	22	97	9.9	71.5	176	17.9	129.8
	M 16 × 1.5	24	145	14.8	106.9	262	26.7	193.2
	M 18 × 1.5	27	210	21.4	154.9	378	38.5	278.8
	M 20 × 1.5	30	291	29.7	214.6	524	53.4	386.5
	M 22 × 1.5	32	385	39.3	284.0	694	70.8	511.9
Metric course screw thread								
			N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft
	M 10 × 1.5	14	32	3.3	23.6	58	5.9	42.8
	M 12 × 1.75	17	57	5.8	42.0	102	10.4	75.2
	M 14 × 2	22	93	9.5	68.6	167	17.0	123.2
	M 16 × 2	24	139	14.2	102.5	251	25.6	185.1
	M 18 × 2.5	27	194	19.8	143.1	350	35.7	258.1
	M 20 × 2.5	30	272	27.7	200.6	489	49.9	360.7
	M 22 × 2.5	32	363	37.0	267.7	653	66.6	481.6
	M 24 × 3	36	468	47.7	345.2	843	86.0	621.8
	M 27 × 3	41	686	70.0	506.0	1236	126.0	911.6

Note: (a) The tightening torque listed in this table is for standard bolts and nuts.

(b) The numerical values in the table are the values when spring washers are used.

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

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

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

2.9 Tightening Torque for Standard Eyebolts

Thread size Dia. × Pitch (M-thread)	Width across flats (mm) [in.]	Strength classification		
		4T		
		N·m	kgf·m	lbf·ft
8 × 1.25	12 [0.47]	8 ± 1	0.8 ± 0.1	5.90 ± 0.73
10 × 1.25	14 [0.55]	15 ± 2	1.5 ± 0.2	11.06 ± 1.47
12 × 1.25	17 [0.67]	25 ± 3	2.5 ± 0.3	18.44 ± 2.21
14 × 1.5	19 [0.75]	34 ± 4	3.5 ± 0.4	25.08 ± 2.95
16 × 1.5	22 [0.87]	44 ± 5	4.5 ± 0.5	32.45 ± 3.68
18 × 1.5	24 [0.94]	74 ± 5	7.5 ± 0.5	54.58 ± 3.68
20 × 1.5	27 [1.06]	98 ± 10	10.0 ± 1.0	72.28 ± 7.37
24 × 1.5	32 [1.26]	147 ± 15	15.0 ± 1.5	108.42 ± 11.06
27 × 1.5	41 [1.61]	226 ± 20	23.0 ± 2.0	166.69 ± 14.75

(Dry)

2.10 Tightening Torque for Standard Union Nuts

Nominal	Cap nut thread size Dia. × Pitch (M-thread)	Width across flats (mm) [in.]	N·m	kgf·m	lbf·ft
63	14 × 1.5	19 [0.75]	39	4	28.76
80	16 × 1.5	22 [0.87]	49	5	36.14
100	20 × 1.5	27 [1.06]	78	8	57.53
120	22 × 1.5	30 [1.18]	98	10	72.28
150	27 × 1.5	32 [1.26]	157	16	115.80
180	30 × 1.5	36 [1.42]	196	20	144.56
200	30 × 1.5	36 [1.42]	196	20	144.56
220	33 × 1.5	41 [1.61]	245	25	180.70
254	36 × 1.5	41 [1.61]	294	30	216.84

(Maximum tolerance value: ±10%, dry condition)

2.11 Tightening Torque for Fuel Injection Pipe

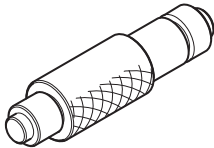
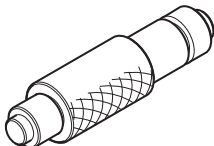
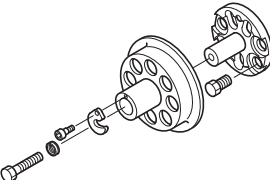
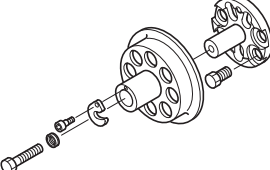
Cap nut thread size Dia. × Pitch	N·m	kgf·m	lbf·ft
12 × 1.5	39 ± 5	4 ± 0.5	28.8 ± 3.68
14 × 1.5	49 ± 5	5 ± 0.5	36.1 ± 3.68
18 × 1.5	59 ± 10	6 ± 1.0	43.5 ± 7.37

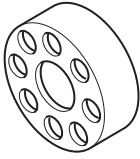
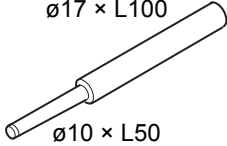
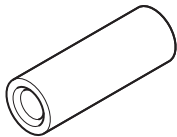
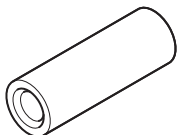
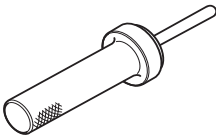
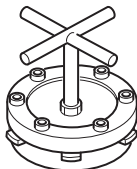
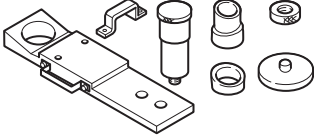
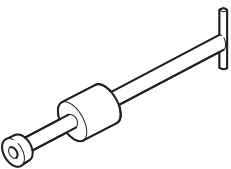
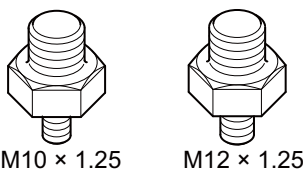
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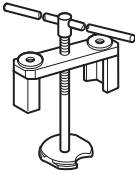
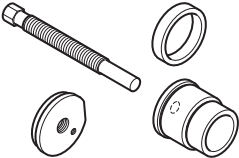
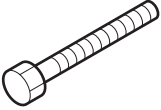
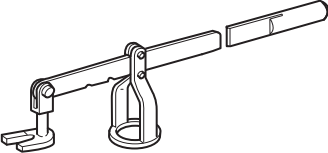
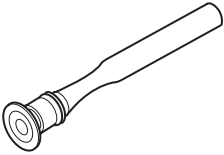
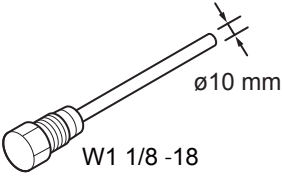
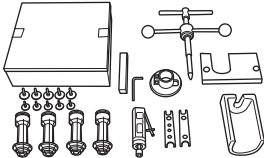
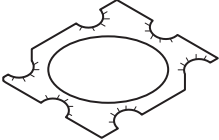
Chapter 3 SERVICE TOOLS

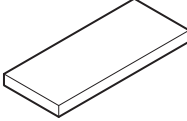
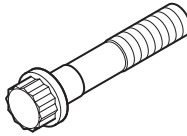
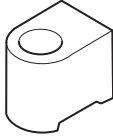
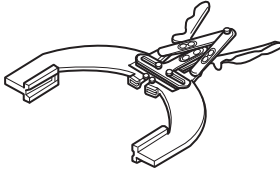
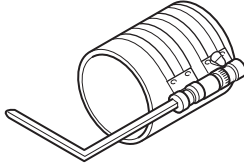
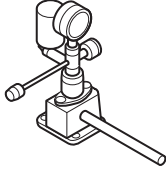
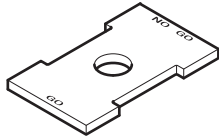
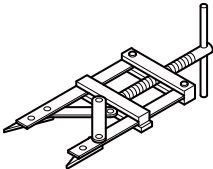
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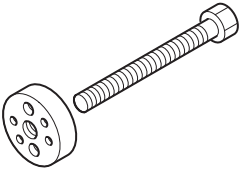
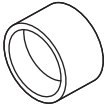
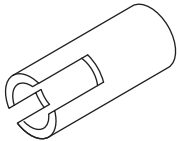
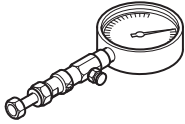
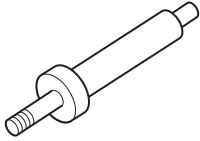
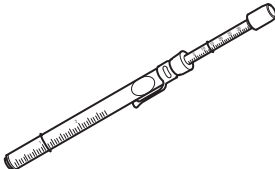
1. Special Tools

Maintenance item	Tool name	Part No.	Illustration	Usage
Basic engine	Rocker bushing tool	37591-02600		Rocker bushing - replace Bushing inside diam : $\phi 36 \times 40$ mm [1.38 $\times$ 1.57 in.]
	Idler bushing puller	32591-02500		Idler bushing - replace Bushing inside diam : $\phi 50 \times 55$ mm [1.97 $\times$ 2.17 in.]
	Eye bolt	37591-02500	 M10 $\times$ 1.25	Main bearing cap - remove
	Eye bolt	05930-00200	 M12 $\times$ 1.25	Gear case - lift
	Eye bolt	45815-32301	 M10 $\times$ 1.5	Piston - lift
	Eye nut	37591-02400	 M14 $\times$ 1.5	Cylinder head assembly - install/ remove
	Front seal Installer assembly	37591-05010		Front oil seal - install
	Rear seal installer assembly	37591-06010		Rear oil seal - install

Maintenance item	Tool name	Part No.	Illustration	Usage
Basic engine	Front slinger - insert	37591-03900		Front oil seal slinger installation
	Valve guide remover	33591-04300		Valve guide - remove Applicable valve guide inside/outside diam: $\varnothing 10 \times 18$ mm [0.39 $\times$ 0.71 in.]
	Guide and seal installer	37191-11500		Valve guide and stem seal - install Guide height: 31.5 mm [1.240 in.] Stem seal height: 34.3 mm [1.350 in.] Inlet and exhaust with single valve spring
	Guide and seal installer	37591-12300		Valve guide and stem seal - install Exhaust double valve spring spec
	Valve seat installer	37591-04010		Valve seat - press-in Big outside diam: $\varnothing 59$ mm [2.32 in.] Small outside diam: $\varnothing 48.5$ mm [1.9095 in.]
	Crankcase grinder	37591-07010		Crankcase counterbore depth - reface
	Connecting rod bushing installer	37591-01010		Connecting rod bushing - install and remove
	Nozzle remover	33591-10101		Fuel injection nozzle - remove
	Adapter set	37591-04400		Main bearing cap - remove $M10 \times 1.25$: 37591-04300 $M12 \times 1.25$: 37591-04411

Maintenance item	Tool name	Part No.	Illustration	Usage
Basic engine	Cylinder liner remover	37591-04100		Cylinder liner - remove Applicable cylinder liner inner diam: ø170 mm [6.69 in.]
	Cam bushing tool assembly	37591-08020		Cam bushing installation/removal
	Jack bolt	64362-68500	 M12 × 1.25-95mm	Water pump plate - remove
	Valve spring pusher	33591-04500		Valve spring - install/remove
	Valve lapper	Suction cup diam: ø35 mm [1.38 in.] 30091-07500 Suction cup diam: ø40 mm [1.57 in.] 30091-08800		Valve lapping
	Valve seat cutter	Shaft 37591-06400	 ø10 mm W1 1/8 -18	Valve seat - reface Width across flats: 32 mm [1.26 in.] Applicable seat inside/outside diameter: ø45 to 66 [1.77 to 2.60 in.]
		Cutter 37591-06430	 W1 1/8 -18 θ=30°	
	Valve seat puller	32591-04200		Valve seat - remove
	Head bolt plate	37598-08900		Cylinder head bolt - tighten with controlled angle

Maintenance item	Tool name	Part No.	Illustration	Usage
Basic engine	Projection plate	37598-09201		Depth of counterbore in crankcase - measure L230 × W50 × T15 mm [L9.06 × W1.97 × T0.59 in.]
	Bolt	37591-06300	 M22 × 2.5 - 115mm	Cylinder liner flange Protrusion - measure (Liner presser jig)
	Liner pusher	37591-06200		Cylinder liner flange protrusion - measure (Liner presser jig)
	Ring expander	37191-03200		Piston ring - install/remove Applicable diam: ø101.6 to 177.8 mm [4.00 to 7.00 in.]
	Piston installer	37191-07100		Piston- install Applicable piston diam: ø89 to 178 mm [3.50 to 7.01 in.]
Fuel system	Nozzle tester	83091-03301		Fuel injection nozzle opening pressure - measure
	Socket	58309-73100		Fuel injection Pump gear and water pump gear - install/remove
	Fuel injection pump coupling gauge	37591-06100		Fuel injection pump coupling clearance - adjust GO: 48.75 mm [1.9193 in.] NO GO: 49.25 mm [1.9390 in.]
Cooling system	Water pump pliers	37591-03100		Water pump cover Hole snap ring - install/removal Applicable diam: ø180 to 300 [7.09 to 11.81 in.]

Maintenance item	Tool name	Part No.	Illustration	Usage
Cooling system	Impeller remover	37591-03200		Water pump impeller - pull-out M18 × 1.5 mm
	Seal ring installer guide	45B91-02100		Water pump unit seal - install
	Mating ring installer guide	45B91-02200		Water pump mating ring - install
Inspection and measurement	Compression gauge	33A91-01700		Compression pressure - measure Measurement range: 0 to 7 MPa {0 to 71 kgf/cm ² } [0 to 1015 psi]
	Gauge adapter	37591-02200		Compression pressure - measure U5/8-18
	Belt gauge	32591-09100		Belt tension - measure

Chapter 4 OVERHAUL INSTRUCTIONS

1. Determining Overhaul Timing 4-3
2. Compression Pressure - Measure..... 4-4

1. Determining Overhaul Timing

In most cases, the engine should be overhauled when the compression pressure of the engine decrease. An increase in engine oil consumption and blow-by gas should be considered when evaluating the engine condition.

Such symptoms as the output decrease, fuel consumption increase, oil pressure decrease, engine starting difficulty and noise increase should be considered to evaluate overhaul timing, although these symptoms are often affected by various causes, and are not always effective to consider overhaul timing.

Decreased compression pressure shows a variety of symptoms and engine conditions, thus making it difficult to accurately determine when the engine needs an overhaul.

The following shows typical symptoms:

- (1) Output power decrease
- (2) Fuel consumption increase
- (3) Engine oil consumption increase
- (4) Combustion gas leak increase by cylinder liner and piston ring wear, and as a result, blow-by gas increase through the breather. (Visually check the blow-by amount.)
- (5) Gas leak increase due to poor seating of inlet and exhaust valves
- (6) Difficult starting
- (7) Noise increase from engine parts
- (8) Abnormal exhaust color after engine warm-up

The engine shows these symptoms in various combinations.

Some of these symptoms are directly caused by worn engine parts, while others are not.

Symptoms of items (2) and (6) are affected by 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 the compression pressure decrease due to worn cylinder liner and piston ring, as described in item (4). And once this symptom is shown, it is reasonable to take other symptoms into consideration for making the final decision.

2. Compression Pressure - Measure

CAUTION

- (a) Be sure to measure the compression pressure of all cylinders. It is not a clever way to measure the compression pressure of only two or three cylinders, and assume the compression pressure of all other cylinders. Cylinders are all independent.
- (b) Also be sure to check the engine speed when measuring the compression pressure, as the compression pressure varies depending on the engine speed.
- (c) It is important to measure the compression pressure at regular intervals, and know the change of the pressure.

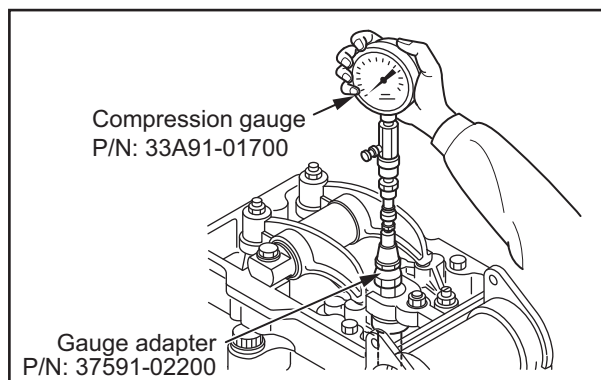
- (1) Remove the injection nozzle from the cylinder head where the compression pressure is to be measured.
- (2) Attach the compression gauge adapter to the fuel injection nozzle hole and connect the compression gauge.
- (3) Place the fuel injection pump rack at the no-injection position (rack "0" position), and crank the engine with the starter.

Read the engine speed and compression pressure while the engine is running at a stable speed.

Note: Ensure the battery being fully charged when cranking the engine with the starter.

If the battery voltage is low, the proper compression pressure can not be measured because of a low cranking speed.

- (4) If the measured value exceeds the limit, overhaul the engine.



Compression Pressure - Measure

Item	Standard value	Limit value	Basic Rotation speed
Compression pressure	1.8 MPa {18.5 kgf/cm ² } [263 psi]	1.27 MPa {13 kgf/cm ² } [189 psi]	120 min ⁻¹

Chapter 5 DISASSEMBLY OF BASIC ENGINE

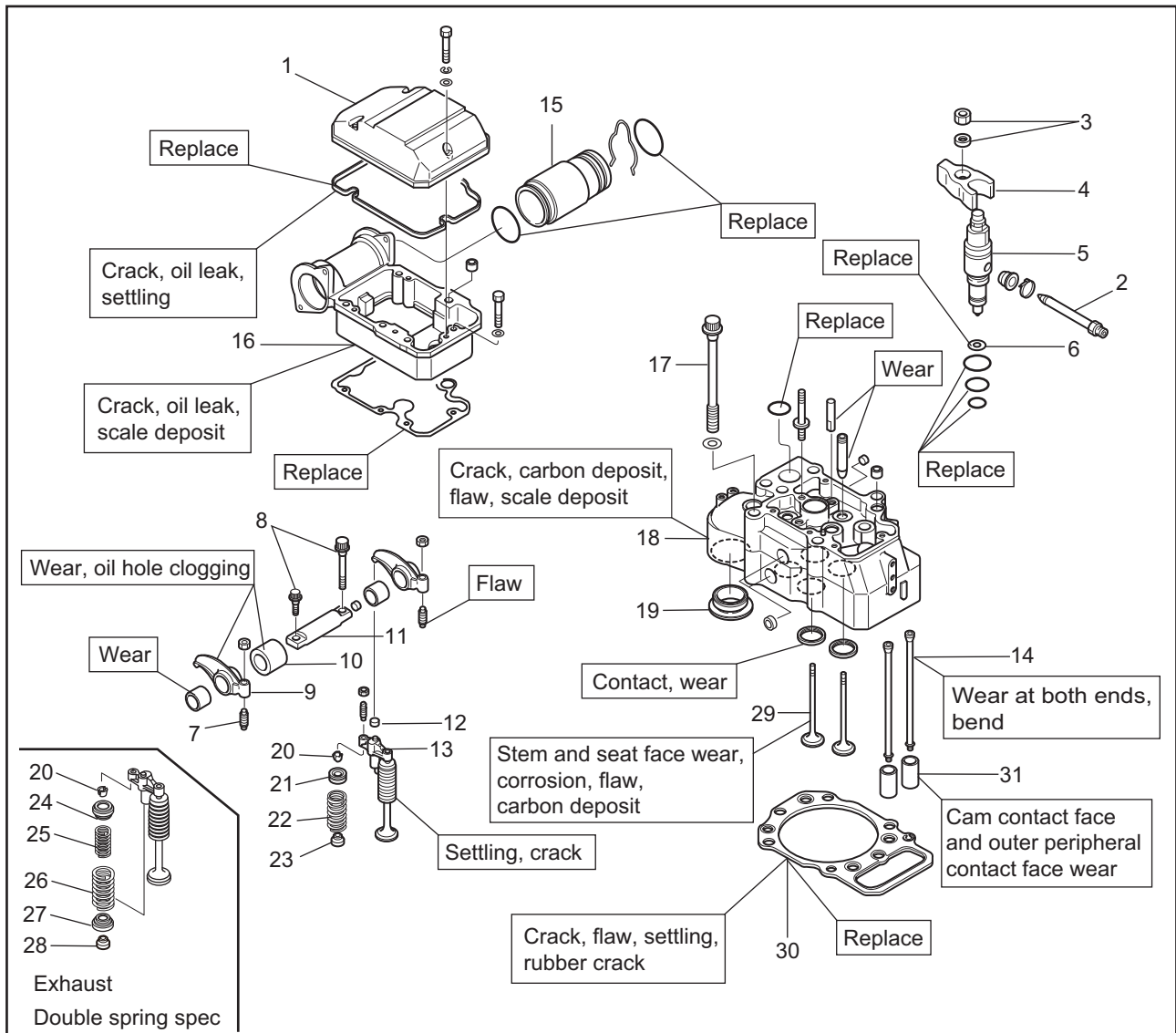
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1. Cylinder Heads and Valve Mechanisms - Disassemble and Inspect

Understanding of the current engine condition before disassembling is very important to know the cause of trouble and do the efficient work.

Depending on the maintenance work or purpose, it is desirable to inspect some of the following items before proceeding with any job.

- ♦ Valve Clearance - Inspect
- ♦ Fuel Injection Timing - Inspect
- ♦ Clearance Between Bottom Face of Valve Bridge and Top Face of Valve Rotator - Inspect
- ♦ Valve Sinkage - Measure



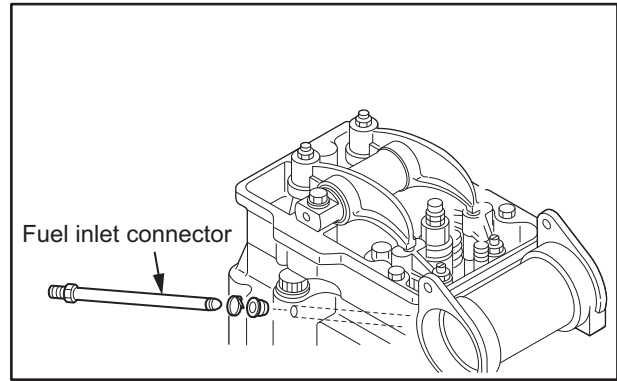
Cylinder Heads and Valve Mechanisms - Disassemble and Inspect

Disassembling Sequence

- | | | |
|-------------------------|---|---------------------------------------|
| 1 Rocker cover | 12 Bridge cap | 23 Stem seal |
| 2 Fuel inlet connector | 13 Valve bridge | 24 Valve rotator |
| 3 Washer, nut | 14 Push rod | (24 to 28 exhaust double spring spec) |
| 4 Nozzle gland | 15 Water outlet connector | 25 Inner valve spring |
| 5 Fuel injection nozzle | 16 Rocker case | 26 Outer valve spring |
| 6 Gasket | 17 Cylinder head bolt | 27 Lower retainer |
| 7 Adjusting screw | 18 Cylinder head (Approx 35 kg [77.2 lb]) | 28 Stem seal |
| 8 Bolt | 19 Inlet port packing | 29 Valve |
| 9 Rocker arm | 20 Valve cotter | 30 Cylinder head gasket |
| 10 Spacer | 21 Valve rotator | 31 Tappet |
| 11 Rocker shaft | 22 Valve spring | |

1.1 Fuel Inlet Connector - Remove

Remove the fuel inlet connector.



Fuel Inlet Connector - Remove

1.2 Nozzle Assembly - Remove

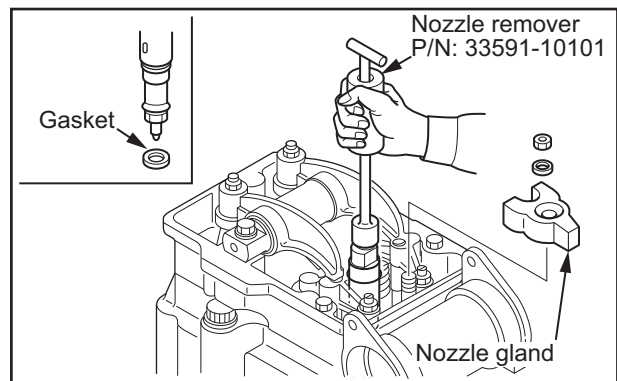
CAUTION

When removing the nozzle assembly with nozzle remover, be careful not to get caught your fingers between the nozzle remover weight, bar and plate.

CAUTION

Before removing the nozzle assembly, clean the nozzle assembly to prevent foreign material from getting into the cylinder head. Keep the nozzle and the fuel inlet connector as a set, and handle the nozzle with care to avoid damage to the nozzle tip.

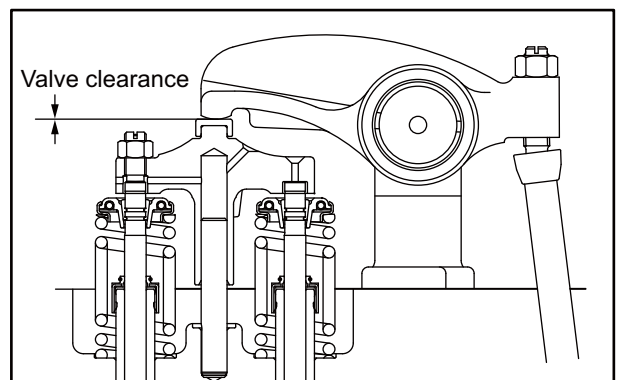
- (1) Remove the nozzle gland.
- (2) Remove the nozzle holder with nozzle remover.
- (3) Remove the gasket remained inside the cylinder head.



Nozzle Assembly - Remove

1.3 Valve Clearance - Inspect

Inspect the valve clearance, and know the current condition. For the inspection procedure, refer to "Valve Clearance - Inspect and Adjust" of "ASSEMBLY OF BASIC ENGINE."

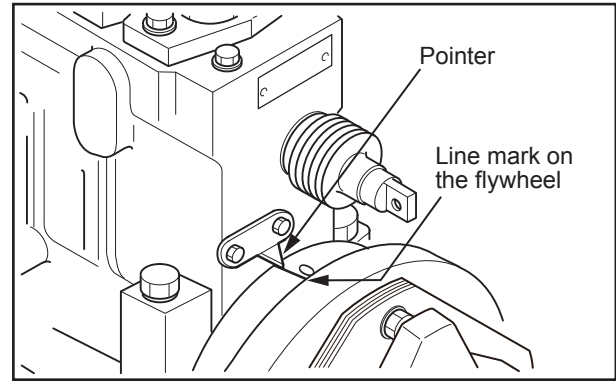


Valve Clearance - Inspect

1.4 Fuel Injection Timing - Inspect

Inspect the fuel injection timing, and know the current condition.

For the inspection procedures, refer to "Fuel Injection Timing - Check and Adjust" of "ASSEMBLY OF BASIC ENGINE. "



Fuel Injection Timing - Inspect

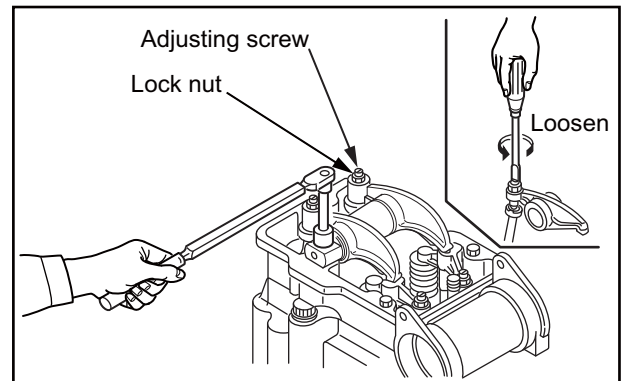
1.5 Rocker Shaft Assembly - Remove

(1) Loosen the adjusting screw of rocker arm.

(2) Remove the rocker shaft assembly from rocker case.

Note: Keep the removed rocker shaft assembly and bolts as a set.

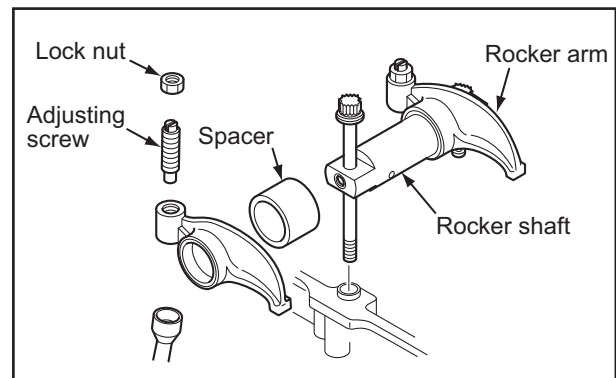
(3) Remove the push rod.



Rocker Shaft Assembly - Remove

(4) Disassemble the rocker shaft assembly.

Note: Do not remove the rocker bushing unless it is defective or its inside diameter exceeds the limit.

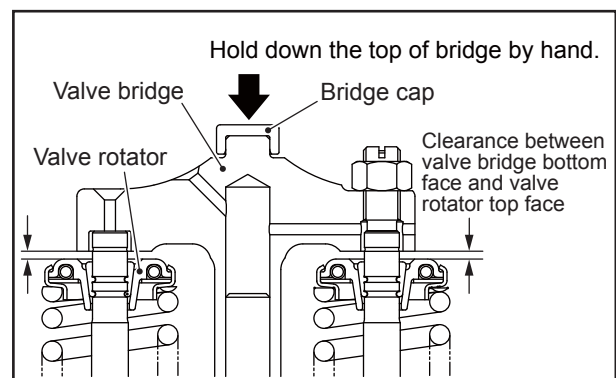


Rocker Shaft Assembly - Disassemble

1.6 Clearance Between Bottom Face of Valve Bridge and Top Face of Valve Rotator - Inspect

Inspect the clearance between the bottom face of valve bridge and the top face of valve rotator, and know the current condition.

For the inspection procedure, refer to "Clearance Between Bottom Face of Valve Bridge and Top Face of Valve Rotator - Measure" of "ASSEMBLY OF BASIC ENGINE. "

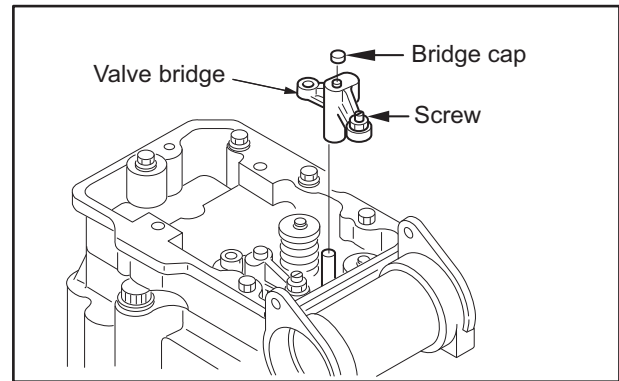


Clearance Between Valve Bridge Bottom Face and Rotator Top Face - Check

1.7 Valve Bridge - Remove

Remove the valve bridge and bridge cap.

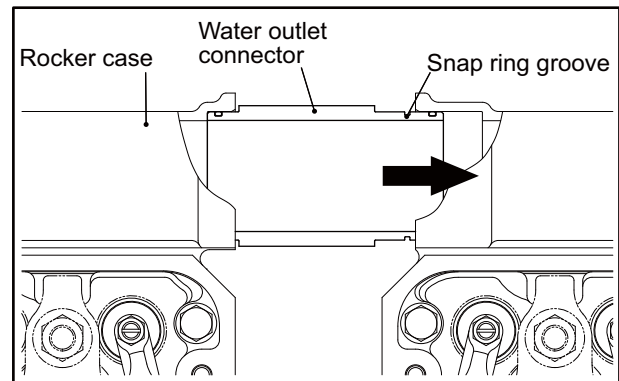
Note: Be careful not to drop the bridge cap into the cylinder head.



Valve Bridge - Remove

1.8 Rocker Case - Remove

- (1) Remove the snap ring of water outlet connector.
- (2) Slide the water outlet connector to the snap ring groove side, and separate it from the next rocker case.
- (3) Remove the rocker case from the cylinder head.



Rocker Case - Remove

1.9 Cylinder Head Assembly - Remove

CAUTION

When removing the cylinder head gasket, be careful not to damage the cylinder head or crankcase surface with a screwdriver or the like.

- (1) Remove the cylinder head bolt.
- (2) Remove the cylinder head by lifting it up using the sling.

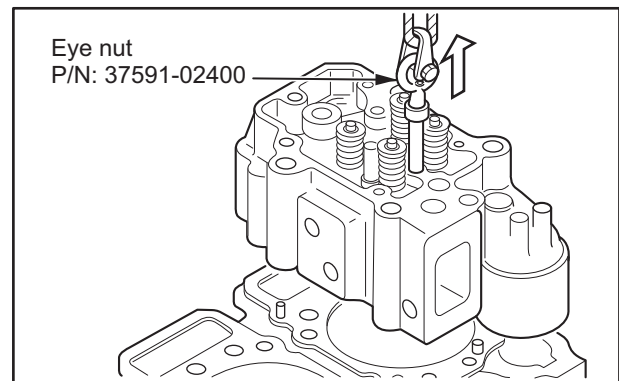
Note: Dowel pins are used to retain the cylinder head in a position. Therefore, pull the cylinder head vertical to the mounting surface to remove.

- (3) Remove the cylinder head gasket.

1.10 Valve Sinkage - Measure

Measure the valve sinkage, and know the current condition.

For the measurement procedure, refer to "Valve Sinkage - Measure" of "ASSEMBLY OF BASIC ENGINE."

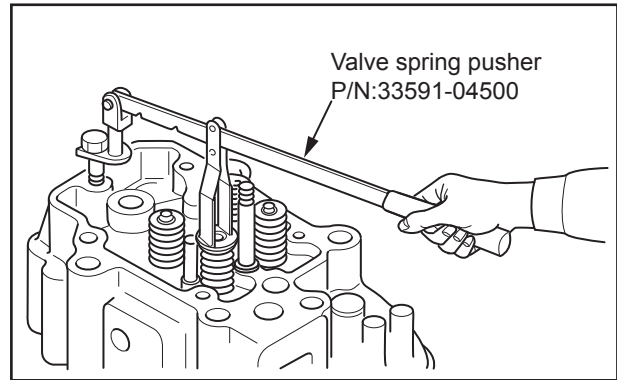


Cylinder Head Assembly - Remove

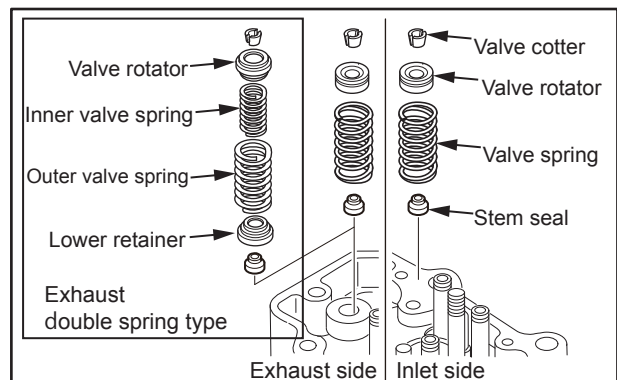
1.11 Valve and Valve Spring - Remove

Using a valve spring pusher, compress the valve spring evenly and remove the valve cotters.

Note: If valves are reusable, mark each valve seat and the mating valve to identify their original positions. Do not change the combination of the valve seat and the valve when reassembling.



Valve Spring - Compress

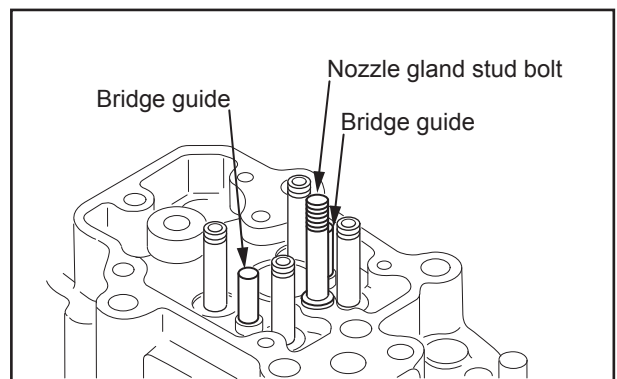


Valve and Valve Spring - Remove

1.12 Nozzle Gland Stud Bolt and Bridge Guide - Remove

Do not remove the nozzle gland stud bolt and the bridge guide from the cylinder head, unless they are defective.

If they are removed, see "Nozzle Gland Stud Bolt and Bridge Guide - Inspect and Replace" of "INSPECTION AND REPAIR OF BASIC ENGINE."



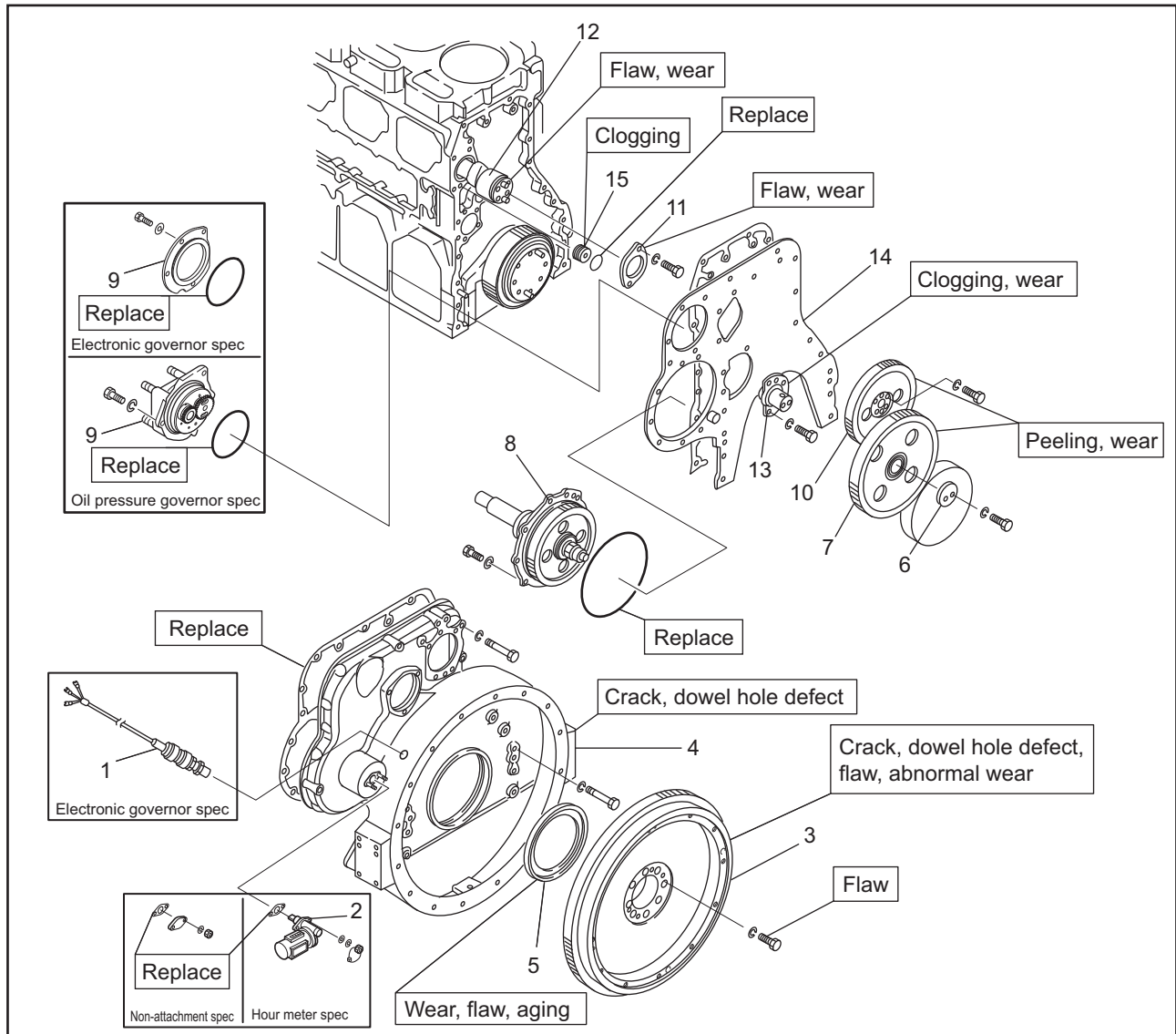
Nozzle Gland Stud Bolt and Bridge Guide - Remove

2. Rear Mechanism - Disassemble and Inspect

Understanding of the current engine condition before disassembling is very important to know the cause of trouble and do the efficient work.

Depending on the maintenance work or purpose, it is desirable to inspect some of the following items before proceeding with any job.

- ♦Flywheel Face and Radial Runout - Measure
- ♦Timing Gear Backlash - Measure
- ♦Idle Gear and Camshaft End Play - Measure



Rear Mechanism - Disassemble and Inspect

Disassembling Sequence

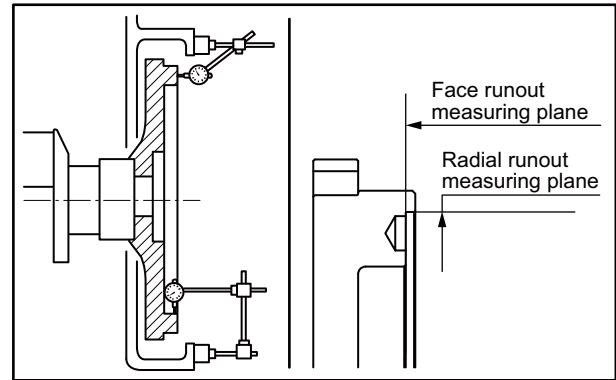
- | | |
|---|--|
| 1 Pick up (Electronic governor spec) | 9 Governor drive (Oil pressure governor spec) |
| 2 Hour meter (With hour meter spec) | (Refer to the chapter "FUEL SYSTEM" for disassembly, inspection and assembly.) |
| 3 Flywheel (Standard: approx 83 kg [183 lb])
(FCD spec: approx 42 kg [93 lb])
(Land clutch: approx 100 kg [220 lb]) | 10 Camshaft gear |
| 4 Timing gear case (Approx 88 kg [194 lb]) | 11 Thrust plate |
| 5 Oil seal | 12 Camshaft gear (Approx 32 kg [71 lb]) |
| 6 Thrust plate | 13 Idler shaft |
| 7 Idler gear | 14 Rear plate |
| 8 Accessory drive
(Refer to the chapter "FUEL SYSTEM" for disassembly, inspection and assembly.) | 15 Nozzle plate |

Note: The shape of flywheel differs in accordance with the customization and specification.

2.1 Flywheel Face and Radial Runout - Measure

Measure the face and radial runouts of the flywheel, and know the current condition.

For the measurement procedure, refer to "Flywheel Face and Radial Runout - Measure" of "ASSEMBLY OF BASIC ENGINE."



Flywheel Face and Radial Runout - Measure

2.2 Flywheel - Remove

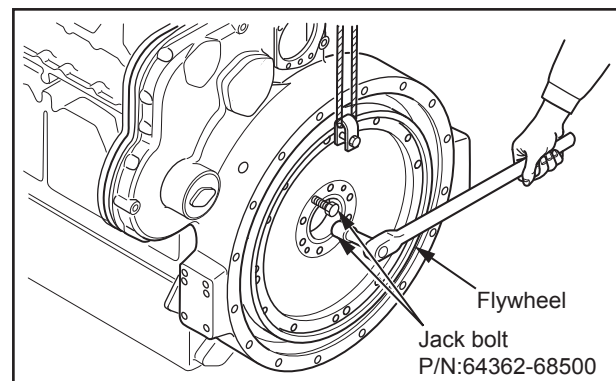
CAUTION

- (a) Be careful not to drop or bump the flywheel. It can, not only cause damage to parts, but also lead to personnel injury.
- (b) Be careful not to cut your hands with the ring gear when pulling-out the flywheel.

CAUTION

Be sure to remove the pickups before removing the flywheel.

- (1) Hitch a sling to the flywheel to prevent it from falling.
- (2) Screw two jack bolts evenly into the jack bolt holes, and remove the flywheel.



Flywheel - Remove

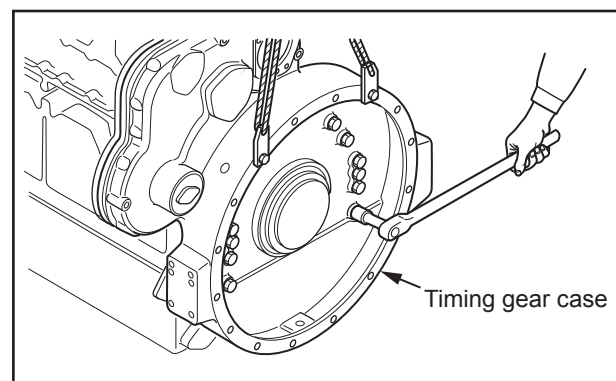
2.3 Timing Gear Case - Remove

CAUTION

Be careful not to drop or hit the timing gear case. It can, not only cause damage to parts, but also lead to personnel injury.

- (1) Hitch a sling to the timing gear case to prevent it from falling.
- (2) Lift the timing gear case to disengage the dowel pins, and remove the timing gear case.
- (3) Remove the oil seal from the timing gear case.

Note: Replace the removed oil seal with a new one. Oil seal can not be re-used.

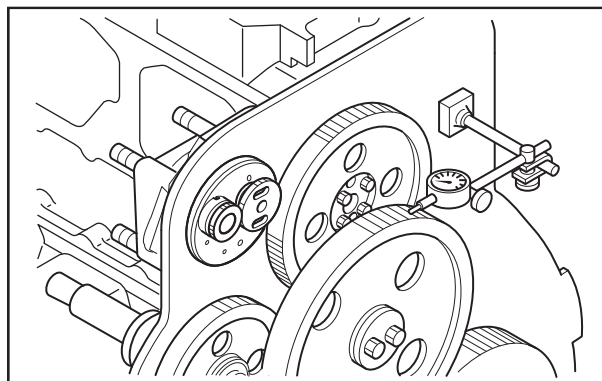


Timing Gear Case - Remove

2.4 Timing Gear Backlash - Measure

Measure the timing gear backlash, and know the current condition.

For the measurement procedure, refer to "Timing Gear Backlash - Measure" of "ASSEMBLY OF BASIC ENGINE."

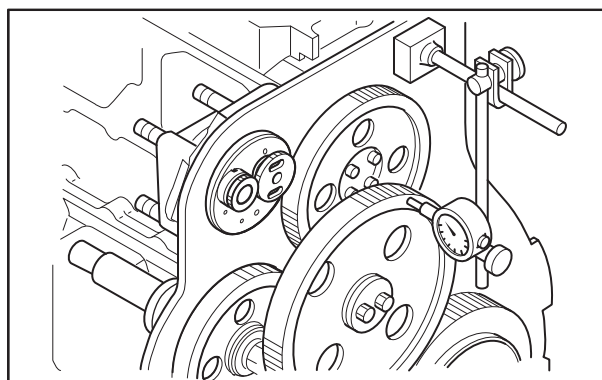


Timing Gear Backlash - Measure

2.5 Idler Gear End Play - Measure

Measure the idler gear end play, and know the current condition.

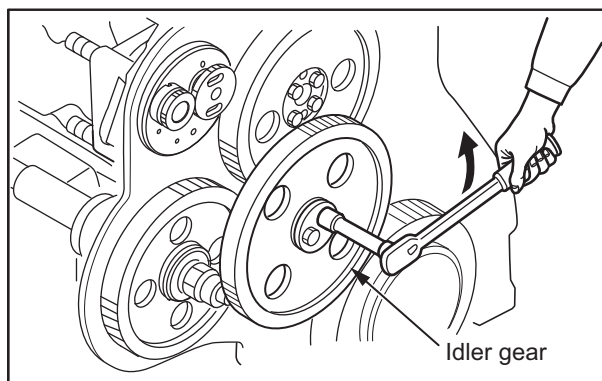
For the measurement procedure, refer to "Idler Gear End Play - Measure" of "ASSEMBLY OF BASIC ENGINE."



Idler Gear End Play - Measure

2.6 Idler Gear - Remove

- (1) Remove the thrust plate from the idler shaft.
- (2) Remove the idler gear from the idler shaft.

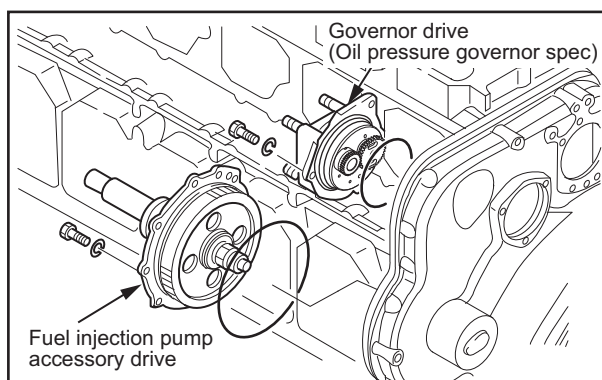


Idler Gear - Remove

2.7 Governor Drive and Fuel Injection Pump Accessory Drive - Remove

Remove the governor drive (oil pressure governor spec) and fuel injection pump accessory drive from the rear plate.

(Refer to the chapter "FUEL SYSTEM" for disassembly, inspection and assembly.)

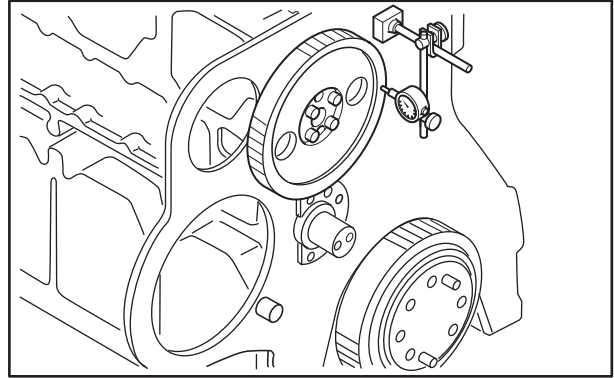


Governor Drive, Fuel Injection Pump and Accessory Drive - Remove

2.8 Camshaft End Play - Measure

Measure the camshaft end play, and know the current condition.

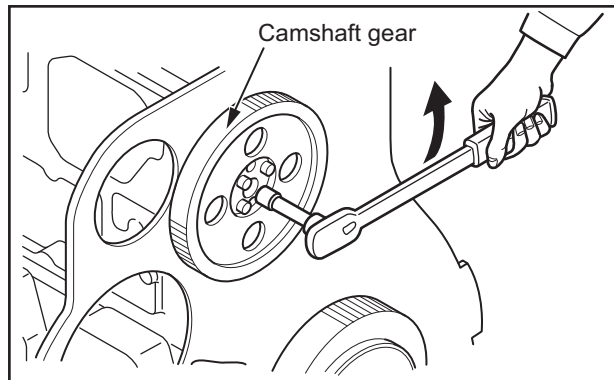
For the measurement procedure, refer to "Camshaft End Play - Measure" of "ASSEMBLY OF BASIC ENGINE."



Camshaft End Play - Measure

2.9 Camshaft Gear - Remove

Remove the camshaft gear from the camshaft.



Camshaft Gear - Remove

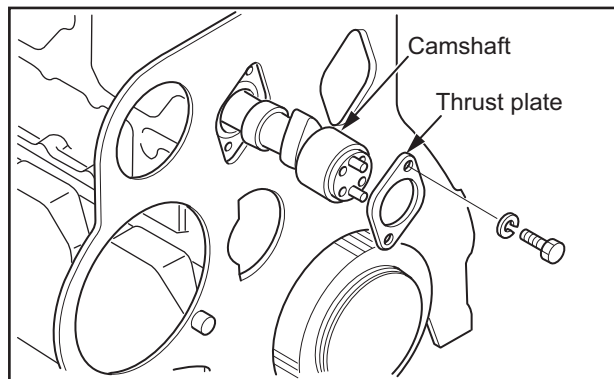
2.10 Camshaft - Remove

CAUTION

Support the camshaft with a wood stick or the like through the side cover. Remove the camshaft paying attention not to damage the crank case and camshaft bushing.

- (1) Remove the thrust plate.
- (2) Support the camshaft through the side cover opening, remove the camshaft from the crankcase.

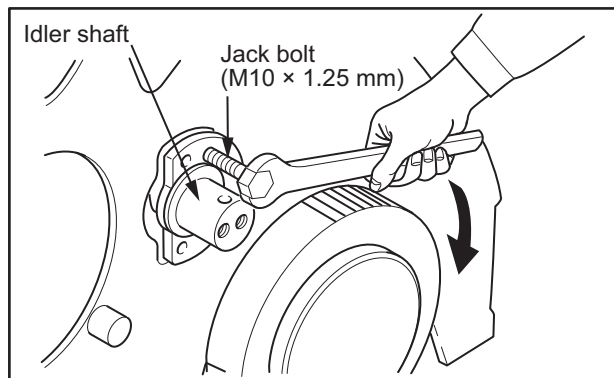
Note: Before removing camshaft, remove the oil seal case, oil seal and coupling from the cam shaft front end.



Camshaft - Remove

2.11 Idler Shaft - Remove

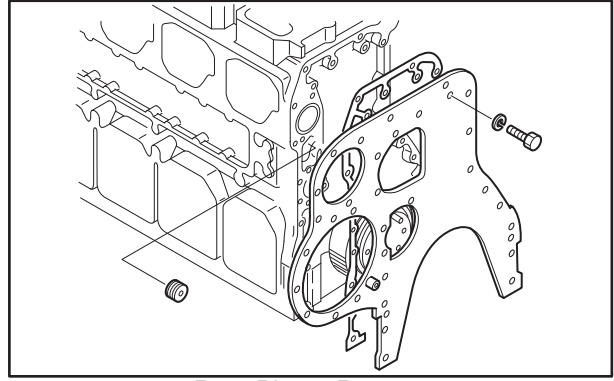
Screw two jack bolts evenly into the jack bolt holes, and remove the idler shaft.



Idler Shaft - Remove

2.12 Rear Plate - Remove

- (1) Remove the rear plate from the crankcase.
- (2) Remove the nozzle plate from the crankcase.



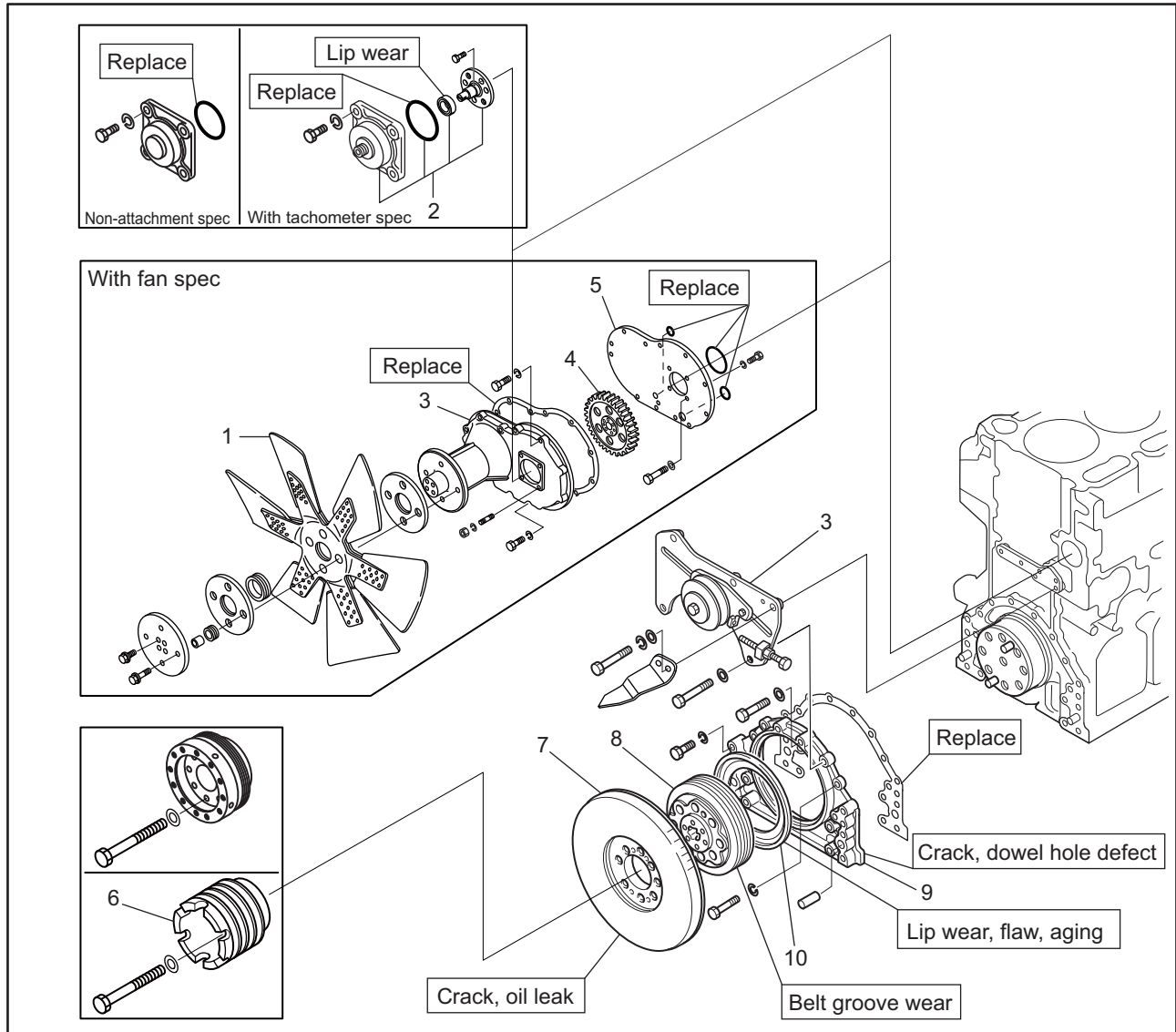
Rear Plate - Remove

3. Front Mechanism - Disassemble and Inspect

Understanding of the current engine condition before disassembling is very important to know the cause of trouble and do the efficient work.

Depending on the maintenance work or purpose, it is desirable to inspect some of the following items before proceeding with any job.

♦Damper Face and Radial Runout - Measure



Front Mechanism - Disassemble and Inspect

Disassembling Sequence

- | | |
|--|----------------------------------|
| 1 Fan (With fan spec) | 5 Fan plate (With fan spec) |
| 2 Oil seal case, coupling
(With tachometer spec) | 6 Front pulley |
| 3 Fan drive assembly (With fan spec)
(Refer to the chapter "COOLING SYSTEM" for
disassembly, inspection and assembly.) | 7 Damper (Approx 56 kg [123 lb]) |
| 4 Fan drive gear (With fan spec) | 8 Crankshaft pulley |
| | 9 Front cover |
| | 10 Oil seal case |

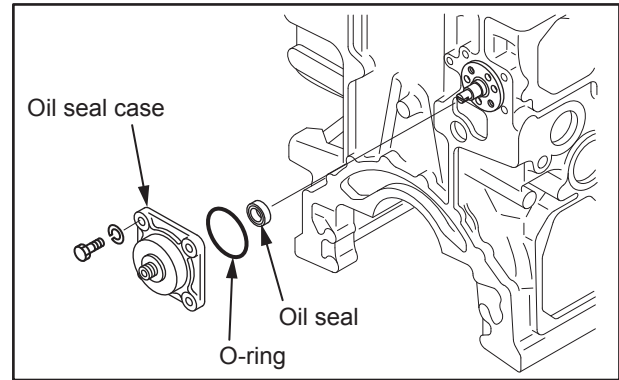
Note: The shape of front pulley differs in accordance with the customization and specification.

3.1 Coupling - Remove

(With tachometer spec)

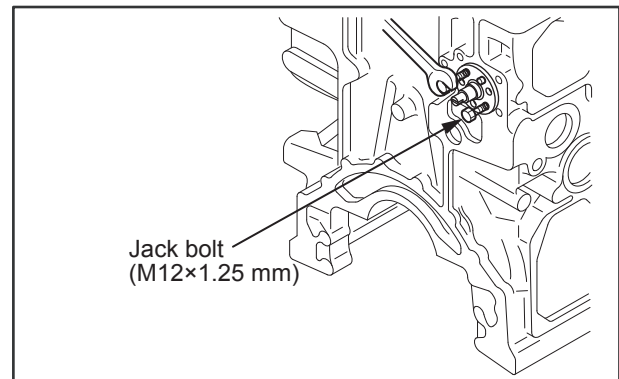
- (1) Remove the oil seal case and oil seal from the crank-case or fan drive case.

Note: Replace the removed oil seal with a new one. Oil seal can not be re-used.



Oil Seal Case - Remove

- (2) Screw two jack bolts evenly into the jack bolt holes, and remove the coupling from the camshaft.

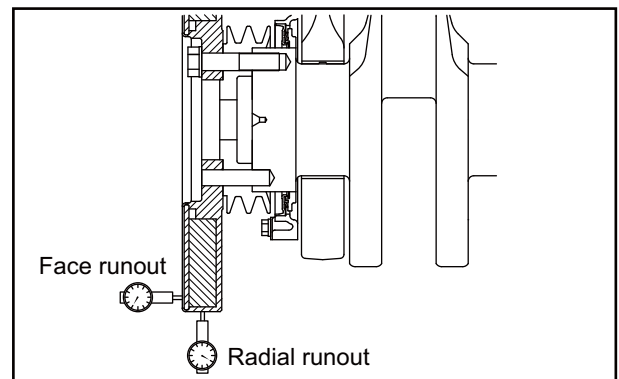


Coupling - Remove

3.2 Damper Face and Radial Runout - Measure

Measure the face and radial runout of the damper, and know the current condition.

For the measurement procedure, refer to "Damper Face and Radial Runout - Measure" of "ASSEMBLY OF BASIC ENGINE."



Damper Face and Radial Runout - Measure

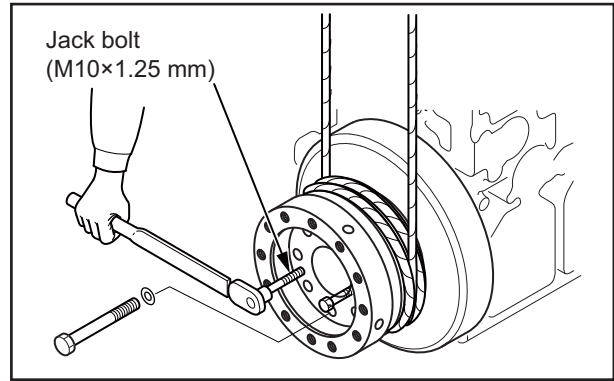
3.3 Front Pulley, Damper and Crankshaft Pulley - Remove



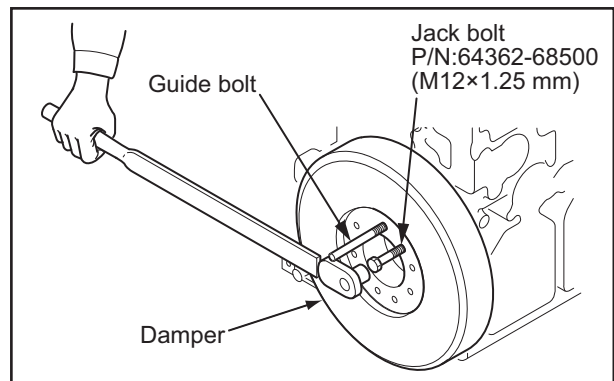
CAUTION

Be careful not to drop or bump the damper. It can, not only cause damage to parts, but also lead to personnel injury.

- (1) Install the guide bolt to damper mounting thread on the crankshaft.
- (2) Hitch a rope or the like to the groove of front pulley to support. Screw two jack bolts evenly into the jack bolt holes, and remove the pulley.
- (3) While supporting the damper with a sling, screw two jack bolts evenly into the jack bolt holes, and remove the damper.
- (4) Remove the crankshaft pulley from the crankshaft.



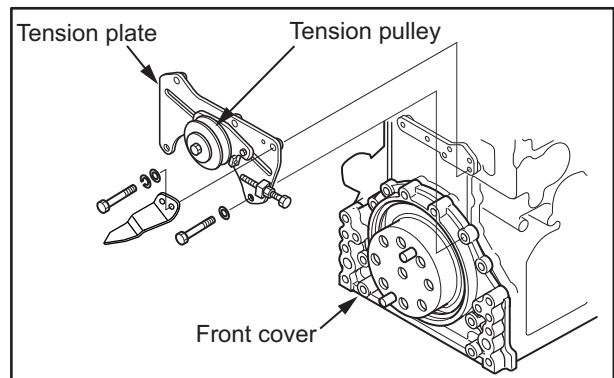
Front Pulley - Remove



Damper - Remove

3.4 Tension Pulley - Remove

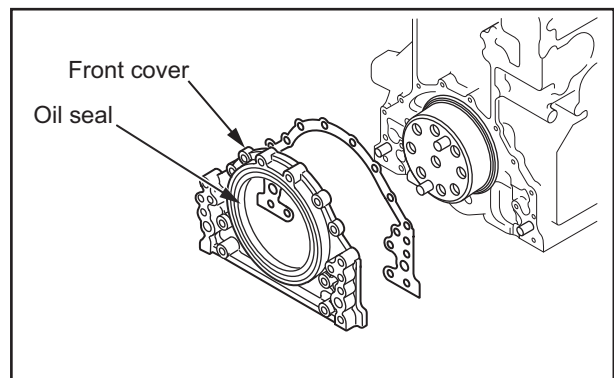
Remove the tension pulley and tension plate from the front cover and bracket.



Tension Pulley - Remove

3.5 Front Cover - Remove

- (1) Remove the front cover from the crankcase.
- (2) Remove the oil seal from the front cover.



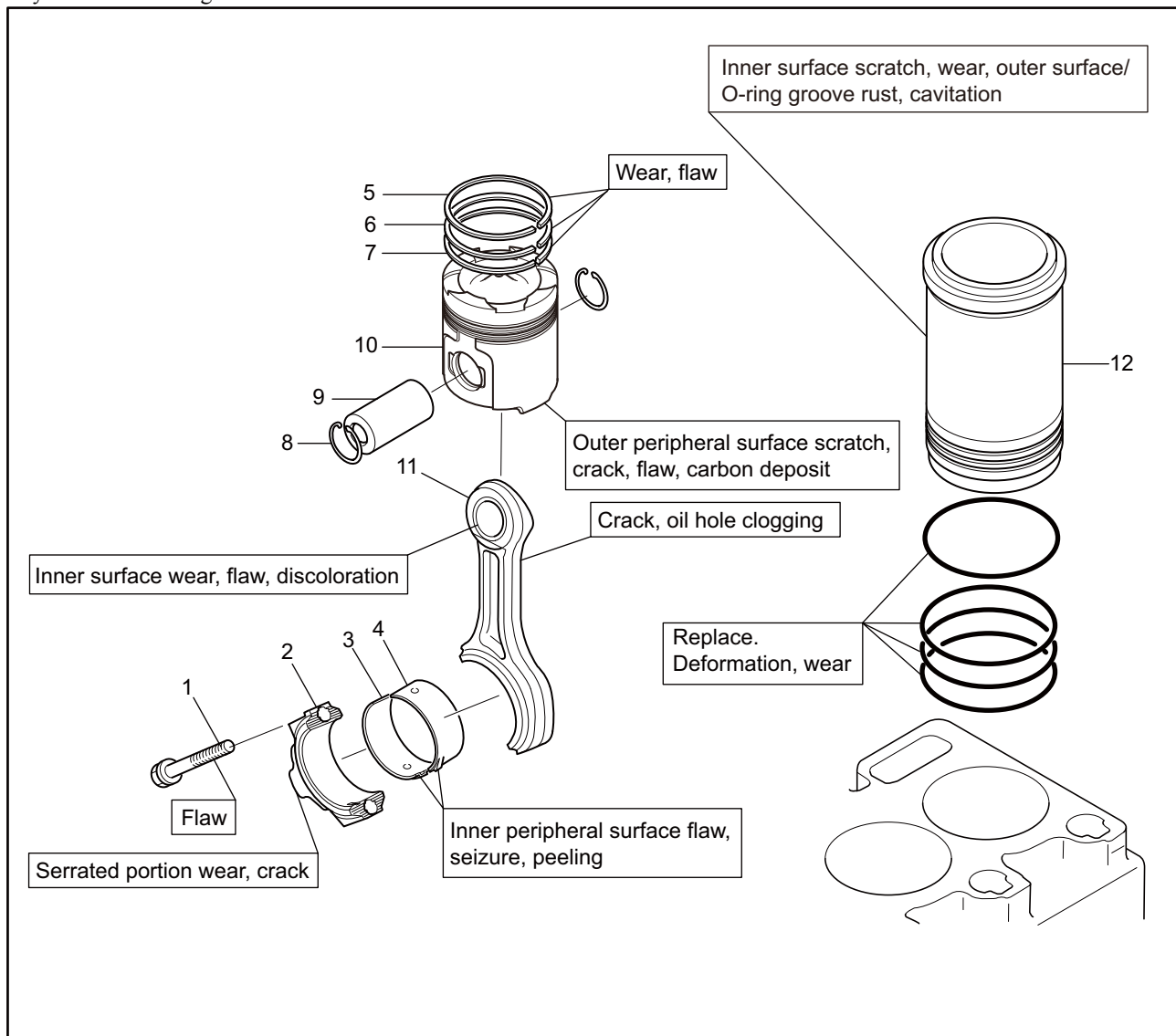
Front Cover - Remove

4. Cylinder Liner, Piston and Connecting Rod - Disassemble and Inspect

Understanding of the current engine condition before disassembling is very important to know the cause of trouble and do the efficient work.

Depending on the maintenance work or purpose, it is desirable to inspect some of the following items before proceeding with any job.

- ♦Piston Protrusion - Measure
- ♦Connecting Rod End Play - Measure
- ♦Cylinder Liner Inside Diameter - Measure
- ♦Cylinder Liner Flange Protrusion - Measure



Cylinder Liner, Piston and Connecting Rod - Disassemble and Inspect

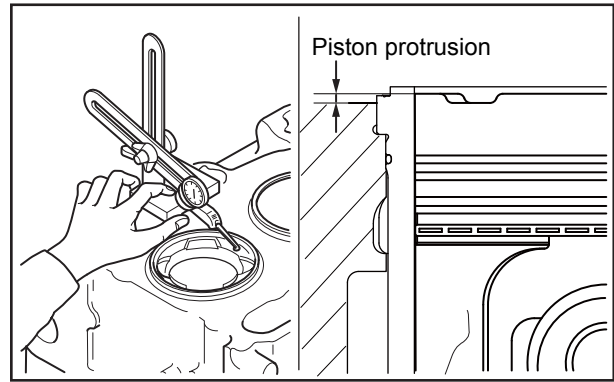
Disassembling Sequence

- | | |
|--------------------------------|---|
| 1 Connecting rod cap bolt | 8 Snap ring |
| 2 Connecting rod cap | 9 Piston pin |
| 3 Lower connecting rod bearing | 10 Piston |
| 4 Upper connecting rod bearing | 11 Connecting rod |
| 5 No. 1 compression ring | 12 Cylinder liner (S6R: approx 16 kg [35 lb]) |
| 6 No. 2 compression ring | (S6R2: approx 19 kg [42 lb]) |
| 7 Oil ring | |

4.1 Piston Protrusion - Measure

Measure the piston protrusion, and know the current condition.

For the measurement procedure, refer to "Piston Protrusion - Measure" of "ASSEMBLY OF BASIC ENGINE."

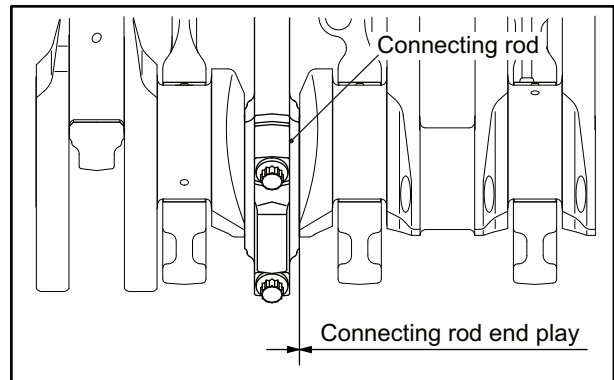


Piston Protrusion - Measure

4.2 Connecting Rod End Play - Measure

Measure the connecting rod end play, and know the current condition.

For the measurement procedure, refer to "Connecting Rod End Play - Measure" of "ASSEMBLY OF BASIC ENGINE."



Connecting Rod End Play - Measure

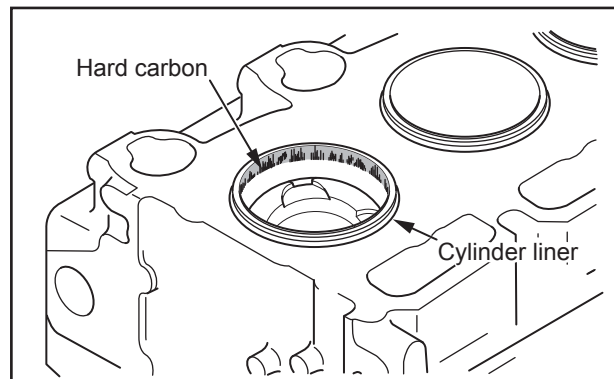
4.3 Hard Carbon Deposits on the Upper Part of Cylinder Liner - Remove

CAUTION

Be sure to remove hard carbon deposits from the upper part of the cylinder liner before pulling-out the piston. Hard carbon deposits, if not removed, cause damage to the piston and piston rings.

Remove hard carbon deposits from the upper part of cylinder liner with carbon remover (scraper, sandpaper, etc.)

Note: Be careful not to damage the inner surface of the cylinder liner.



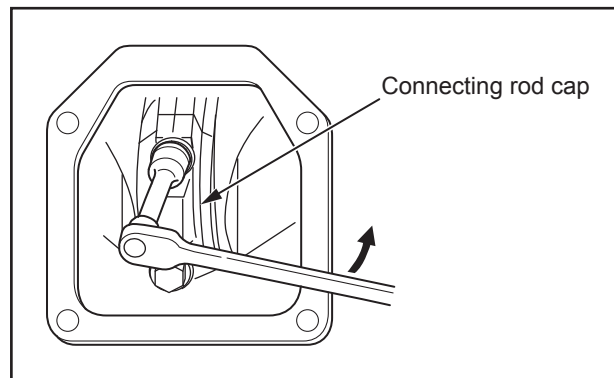
Hard Carbon Deposits on the Upper Part of Cylinder Liner - Remove

4.4 Connecting Rod Cap - Remove

Using a socket wrench, remove the connecting rod bolts through the inspection window on the side of the crankcase, and remove the connecting rod cap and connecting rod bearings.

Note:(a) Be careful not to damage the connecting rod bearings by dropping them into the oil pan.

(b) Make marks, such as cylinder number and upper or lower, on the removed connecting rod bearings to ensure the correct reassembly.



Connecting Rod Cap - Remove

4.5 Piston - Remove

CAUTION

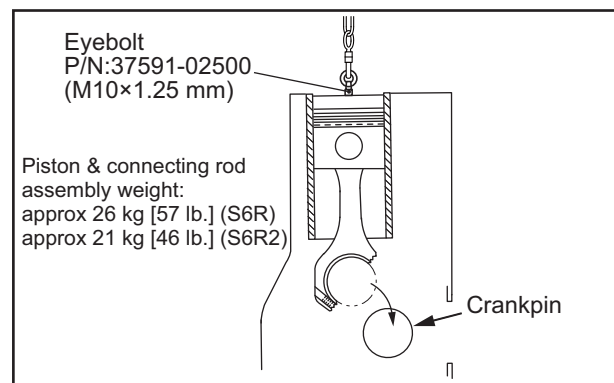
When holding the connecting rod with your hand to prevent it from swinging, be very careful, as you may suffer hand injuries from accidental movement of the connecting rod.

CAUTION

- (a) When pulling-out the piston, be careful not to drop the upper connecting rod bearing.
- (b) When removing piston, be careful not to damage cylinder liner by connecting rod runout.
- (c) When only a few pistons remain in the cylinders, the crankshaft tends to turn by weight imbalance. Be sure to hold the crankshaft to prevent it from rotating while removing pistons.
- (d) Make sure that the connecting rod does not interfere with the piston cooling nozzle when removing the piston.
- (e) When pulling the piston out of the cylinder liner, hold the piston by hand so that the piston does not rock. If the piston rocks the piston skirt will be damaged by the connecting rod.

4.5.1 Removing the Piston With Chain Block Lifting

- (1) Remove the connecting rod cap and rotate the crankshaft to bring the piston to the top dead center position.
- (2) Install the eye bolt to the threaded hole on the piston top, and support the piston to prevent it from falling down.
- (3) Rotate the crankshaft to place the crank pin slightly near to the inspection window so that the connecting rod big end does not contact the cylinder liner.
- (4) Carefully pull-out the piston by making sure that the connecting rod big end slides into the cylinder liner.



Removing the Piston With Chain Block Lifting

4.5.2 Removing the Piston With Pushing-up the Connecting Rod Big End

- (1) Remove the connecting rod cap and rotate the crankshaft to bring the piston to the top dead center position.
- (2) Install the eye bolt to the threaded hole on the piston top, and support the piston to prevent it from falling down.
- (3) Rotate the crankshaft carefully until the crankpin is displaced from the connecting rod and the lower bolt hole can be seen through the inspection window.
- (4) Insert a bar wrapped with cloth, and push up the bottom of connecting rod carefully, with the crankpin as a fulcrum.

Note: Protect the crankpin and connecting rod big end with cloth or rubber to prevent them from damage with the bar.

- (5) Push-up the connecting rod and piston while adjusting the supporting position.
When the oil ring is slid out of the cylinder liner, carefully put the piston on the top face of cylinder liner.
- (6) Lift the piston with eye bolt on the piston top, and pull out the piston from cylinder liner.

4.6 Piston Ring - Remove

CAUTION

When removing the piston ring, be careful not to be pinched your hand between the piston and connecting rod by piston swing.

CAUTION

A free swing of piston and its bump to connecting rod may result in piston damage.

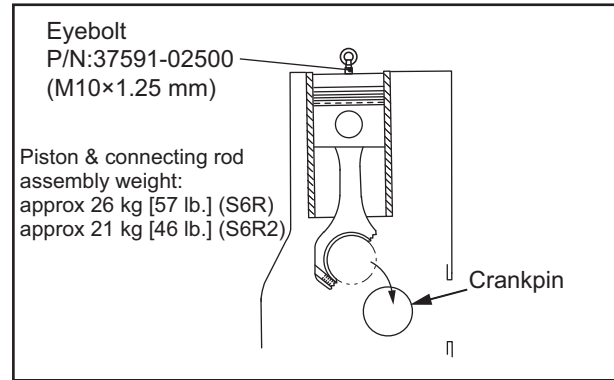
Hold the piston and connecting rod in a vise, and remove the piston rings with ring expander.

4.7 Piston Pin and Piston - Remove

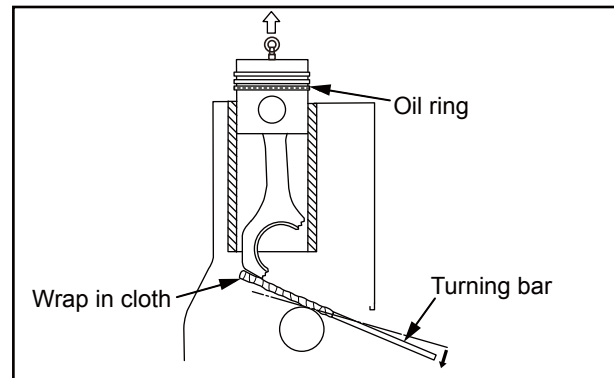
- (1) Remove the snap ring with ring pliers.
- (2) Place a piece of wood to piston pin end and lightly tap with hammer to remove the piston pin, and separate the piston from connecting rod.

Note:(a) Do not tap the piston pin directly with hammer.

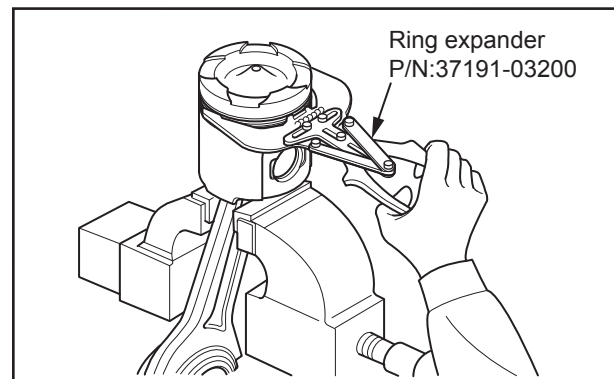
- (b) If the piston is stubborn, heat the piston with heater or in hot water.



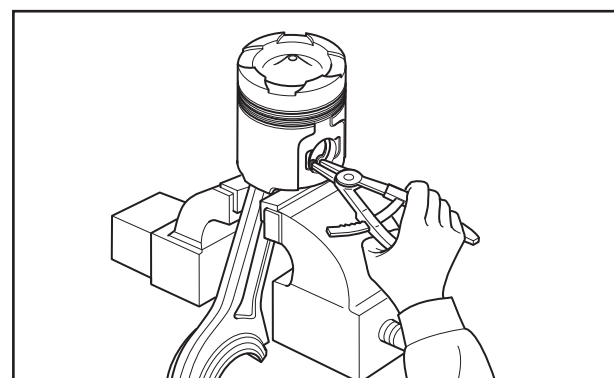
Crankshaft - Rotate



Connecting Rod Big End - Push-up



Piston Ring - Remove

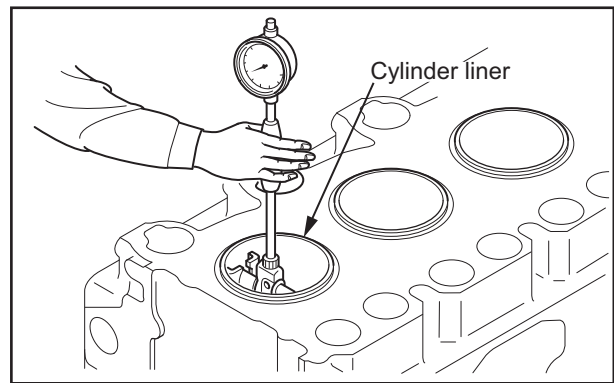


Piston Pin and Piston - Remove

4.8 Cylinder Liner Inside Diameter - Measure

Measure the cylinder liner inside diameter, and know the current condition.

For the measurement procedure, refer to "Cylinder Liner Inside Diameter - Measure" of "ASSEMBLY OF BASIC ENGINE."

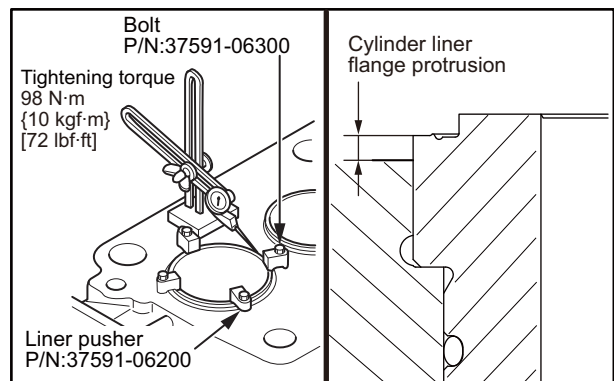


Cylinder Liner Inside Diameter - Measure

4.9 Cylinder Liner Flange Protrusion - Measure

Measure the cylinder liner flange protrusion, and know the current condition.

For the measurement procedure, refer to "Cylinder Liner Flange Protrusion - Measure" of "ASSEMBLY OF BASIC ENGINE."



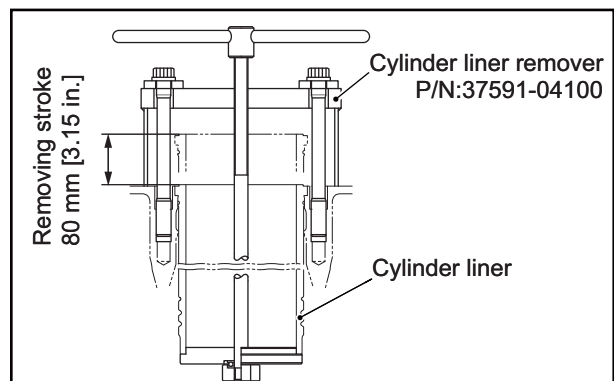
Cylinder Liner Flange Protrusion - Measure

4.10 Cylinder Liner - Remove

(1) Set the cylinder liner remover to the cylinder liner.

Note: Use care not to hit the piston cooling nozzle when setting the remover plate to the bottom of cylinder liner.

(2) Rotate the handle, and remove the cylinder liner.



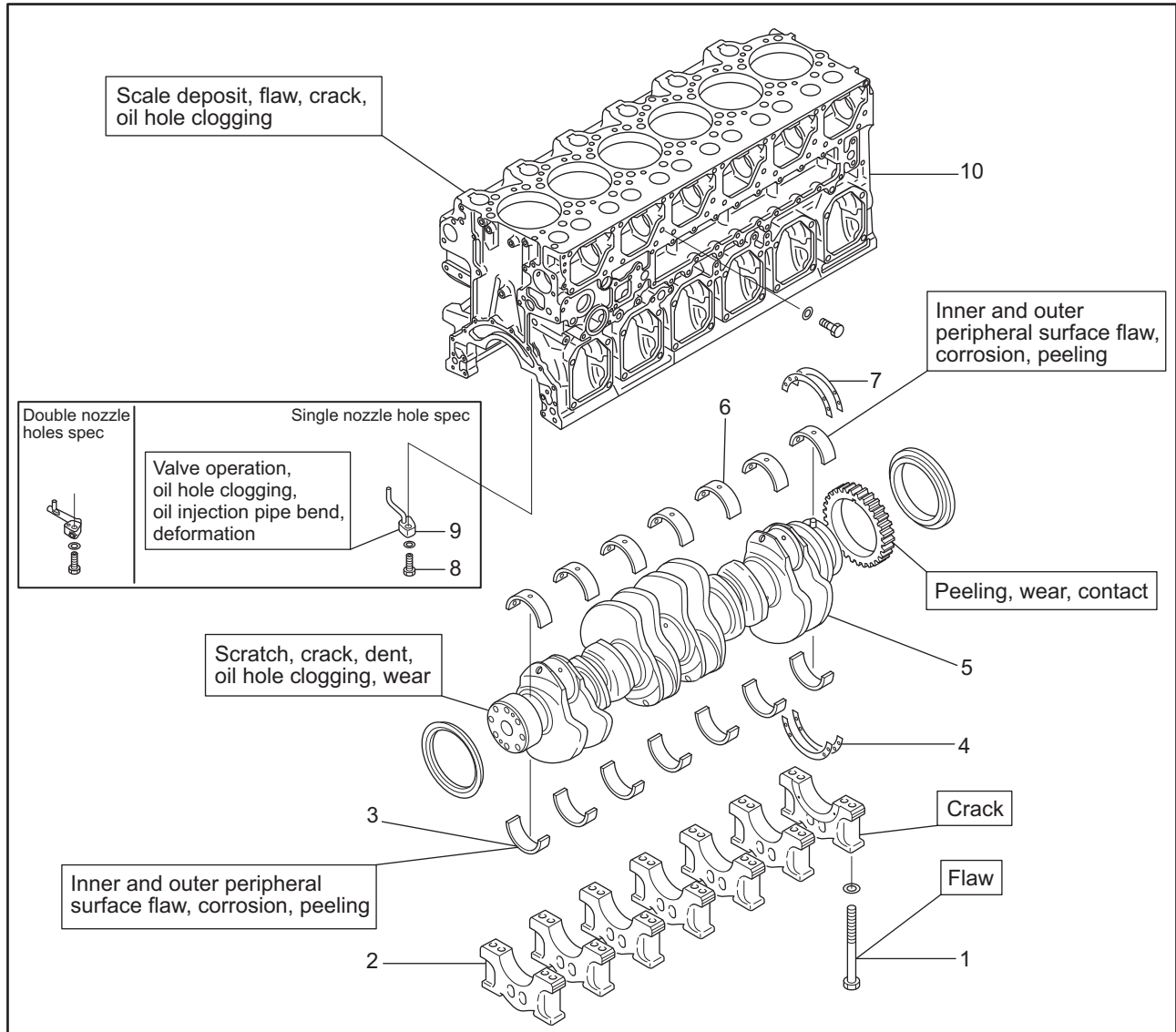
Cylinder Liner - Remove

5. Crankcase, Crankshaft and Main Bearing - Disassemble and Inspect

Understanding of the current engine condition before disassembling is very important to know the cause of trouble and do the efficient work.

Depending on the maintenance work or purpose, it is desirable to inspect some of the following items before proceeding with any job.

♦Crankshaft End Play - Measure



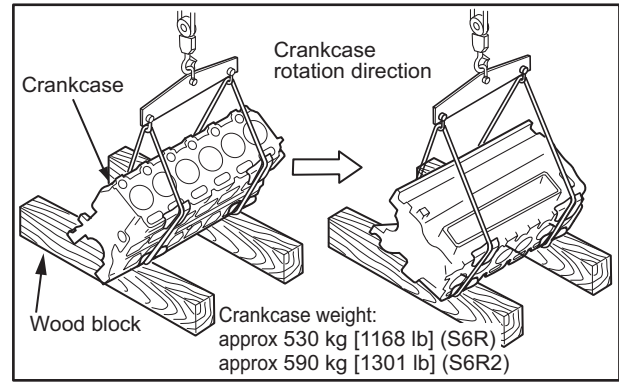
Crankcase, Crankshaft and Main Bearing - Disassemble and Inspect

Disassembling Sequence

- | | |
|--|--|
| 1 Main bearing cap bolt | 7 Upper thrust plate |
| 2 Main bearing cap | 8 Check valve (One jet hole spec)
Eye bolt (Two jet hole spec) |
| 3 Lower main bearing | 9 Piston cooling nozzle |
| 4 Lower thrust plate | 10 Crankcase (S6R: approx 530 kg [1168 lb])
(S6R2: approx 590 kg [1301 lb]) |
| 5 Crankshaft (S6R: approx 285 kg [628 lb])
(S6R2: approx 300 kg [661 lb]) | |
| 6 Upper main bearing | |

5.1 Crankcase - Turn Over (Upend)

Using a turnover machine, turn over the crankcase. When the turnover machine is not available, hitch slings to the crankcase using wood pieces and cloth pads, and raise the crankcase with a hoist or crane. Then lay it on the wooden block with its side facing downward. Then, change the positions of the slings, and turn over to upend the crankcase.

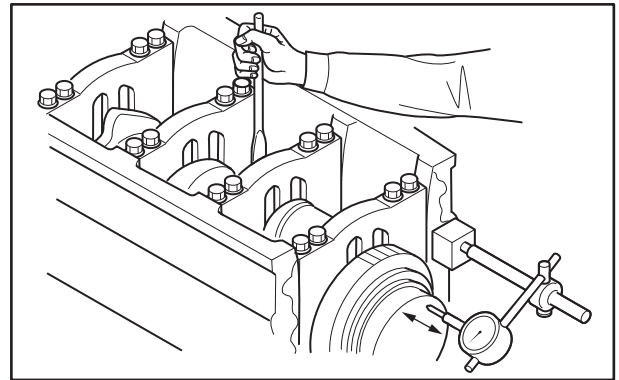


Crankcase - Turn Over (Upend)

5.2 Crankshaft End Play - Measure

Measure the crankshaft end play, and know the current condition.

For the measurement procedure, refer to "Crankshaft End Play - Measure" of "ASSEMBLY OF BASIC ENGINE."



Crankshaft End Play - Measure

5.3 Piston Cooling Nozzle - Remove

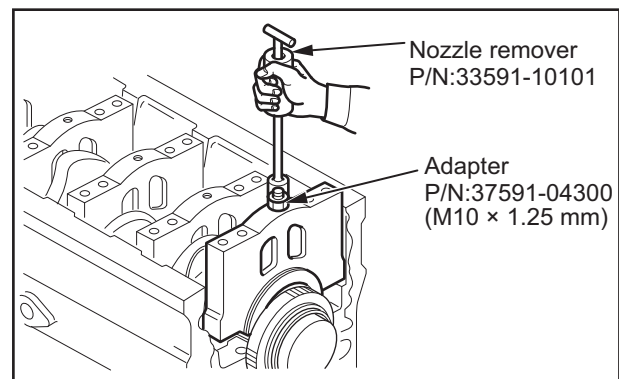
Remove the piston cooling nozzle from the crankcase.

5.4 Main Bearing Cap - Remove

CAUTION

When removing the main bearing cap, be careful not to damage the lower main bearing or the lower thrust plate attached to the cap. Also be careful not to drop those parts from the cap, which may result in crankshaft damage.

- (1) Remove the main bearing cap bolt.
- (2) Install the adapter to main bearing cap.
- (3) Install the nozzle remover to adapter.
- (4) Remove the main bearing cap from crankcase.
- (5) Remove the lower main bearing from the main bearing cap.
- (6) Remove the lower thrust plate from the rearmost main bearing cap.



Main Bearing Cap - Remove

5.5 Crankshaft - Remove

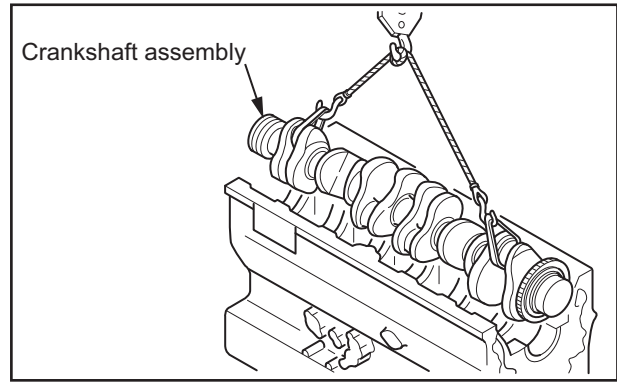
CAUTION

- (a) Before removing the crankshaft, remove the front side upper thrust plate first, and be careful not to drop it into crankcase.
- (b) When placing the crankshaft onto a pallet or other stands, be careful not to damage the crankshaft. Once placed on a pallet, place some support to prevent the crankshaft from moving.

- (1) Push a mating face of the front upper thrust plate, and rotate the thrust plate to remove.
- (2) Suspend the crankshaft in a horizontal position, and slowly lift the crankshaft upward.

Note: Do not hitch a chain directly onto crankshaft, as it could damage the crankshaft. Place cloth belts or pads in the positions before lifting crankshaft.

- (3) Remove the upper main bearing from crankcase, paying attention to the lug position, and remove the upper thrust plate on the rear side.



Crankshaft - Remove

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Chapter 6 INSPECTION AND REPAIR OF BASIC ENGINE

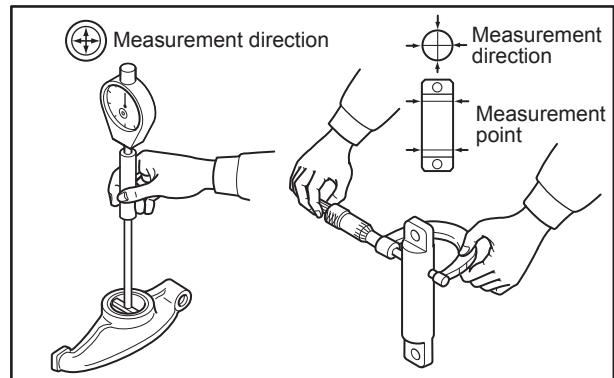
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1. Cylinder Head and Valve Mechanism - Inspect and Repair

1.1 Bushing Inside Diameter and Shaft Outside Diameter of Rocker - Measure

Measure the inside diameter of the rocker bushing and the outside diameter of the rocker shaft. If the measurement exceeds the limit, replace the rocker bushing or rocker shaft with a new one.

Item	Nominal value	Standard value	Limit value
Rocker bushing inside diameter	ø36 mm [1.4 in.]	36.000 to 36.040 mm [1.4173 to 1.4189 in.]	36.090 mm [1.4209 in.]
Rocker shaft outside diameter	ø36 mm [1.4 in.]	35.966 to 35.991 mm [1.4160 to 1.4170 in.]	35.940 mm [1.4150 in.]



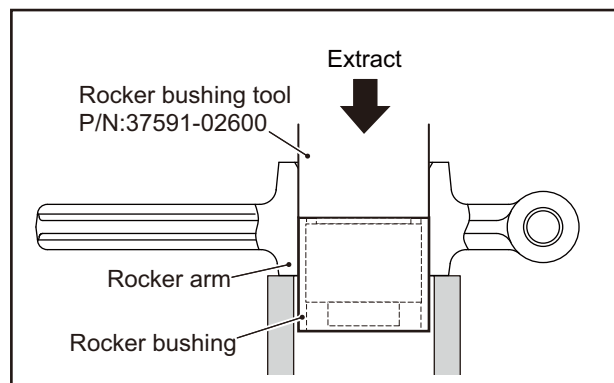
Bushing Inside Diameter and Shaft Outside Diameter of Rocker - Measure

1.2 Rocker Bushing - Replace

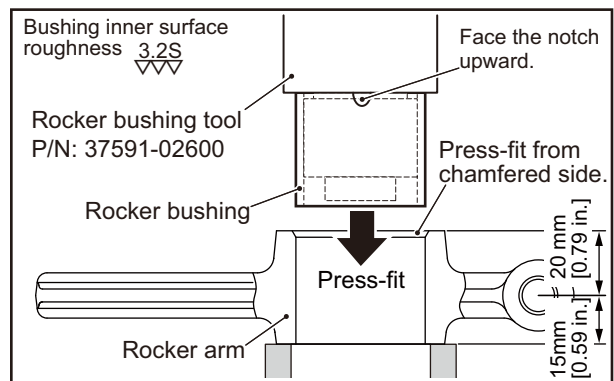
CAUTION

If rocker bushing notch is not aligned with center axis of screw hole, oil will not feed from rocker arm to valve, resulting in wear of rocker arm and bridge, or seizure of valve.

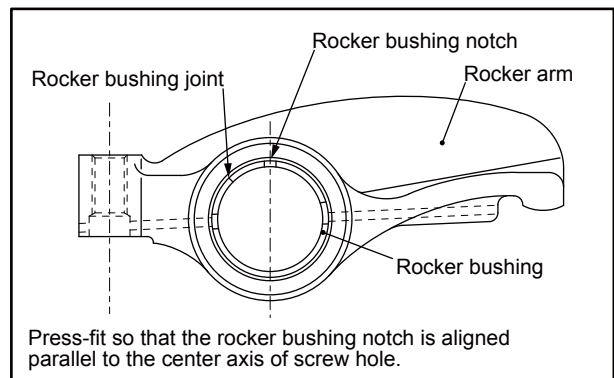
- (1) Pull-out the rocker bushing with rocker bushing tool.
- (2) Install the new rocker bushing with rocker bushing tool.
With the positioning notch (4mm wide) of rocker bushing facing upward, align the position as shown in illustration. Press-in the rocker bushing into chamfered side of rocker arm hole.
- (3) Check the alignment of the rocker arm and rocker bushing oil holes.
- (4) Measure the installed inside diameter of rocker bushing. If the value is smaller than the standard, ream the inside diameter to the standard.



Rocker Bushing - Remove



Rocker Bushing - Insert



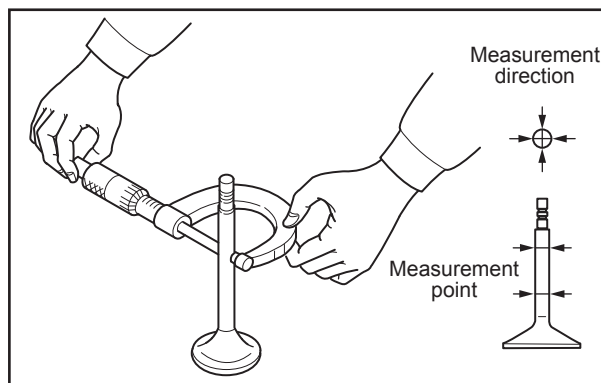
Rocker Bushing - Position

1.3 Valve Stem Outside Diameter and Valve Guide Inside Diameter - Measure

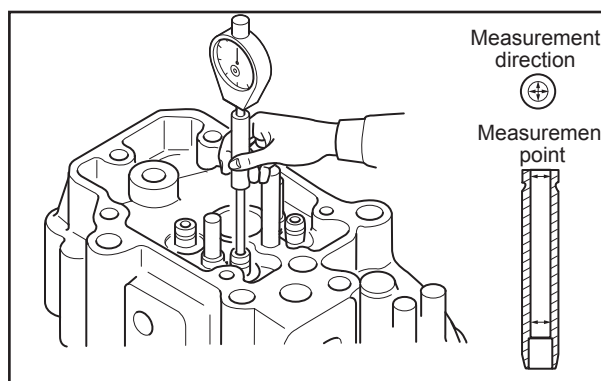
Measure the outside diameter of valve stem and the inside diameter of valve guide at the top and bottom sliding ends in right-angle directions as shown, as the sliding surface tends to wear at the top and bottom ends. If the measurement exceeds the limit, replace the valve guide or valve with a new one.

Note: Lap the valve and valve seat whenever new valve is installed.

Item	Nominal value	Standard value	Limit value
Valve stem outside diameter	ø10 mm [0.39 in.]	9.940 to 9.960 mm [0.0010 to 0.0044 in.]	9.910 mm [0.3902 in.]
Valve guide inside diameter	ø10 mm [0.39 in.]	10.000 to 10.015 mm [0.3937 to 0.3943 in.]	10.060 mm [0.3961 in.]



Valve Stem Outside Diameter - Measure



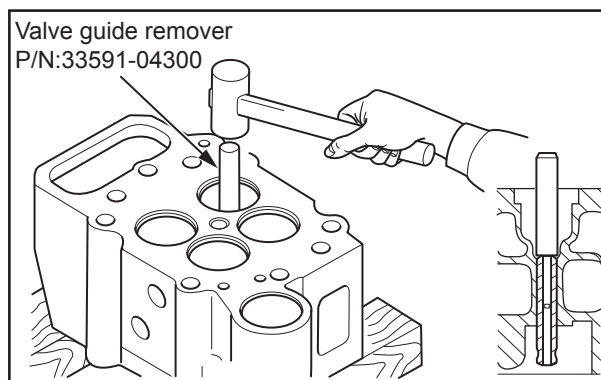
Valve Guide Inside Diameter - Measure

1.4 Valve Guide - Replace

CAUTION

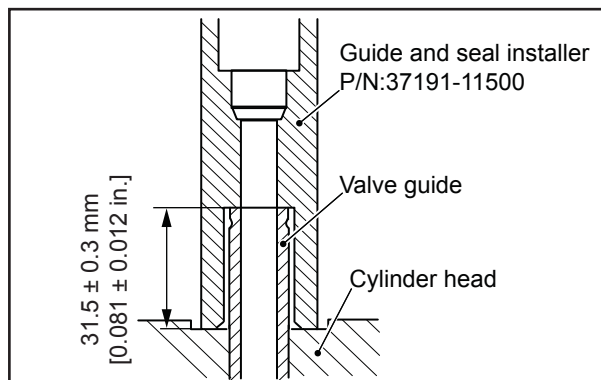
Be sure to use the guide and seal installer, and press-in the valve guide to the specified height.

(1) Remove the valve guide with valve guide remover.



Valve Guide - Remove

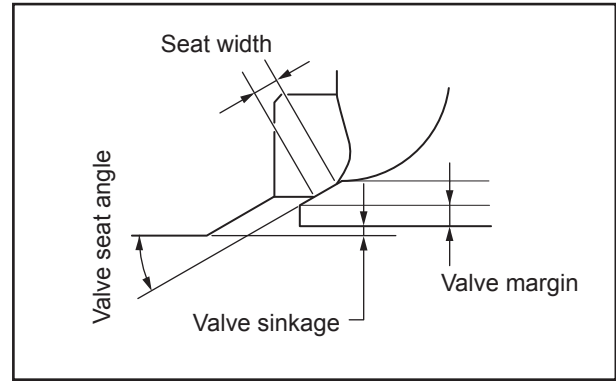
(2) With guide and seal installer, press-in the new valve guide slowly.



Valve Guide - Press-in

1.5 Valve Face - Inspect

Inspect the valve face after the valve guide is inspected or replaced. Lap the valve and valve seat whenever valve is refaced or replaced.



Valve Face - Inspect

1.5.1 Valve Margin - Inspect

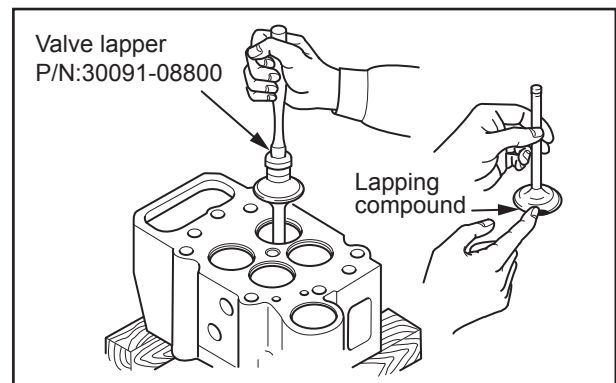
Measure the valve margin. If the value exceeds the limit, reface or replace the valve with a new one.

1.5.2 Seat Width - Inspect

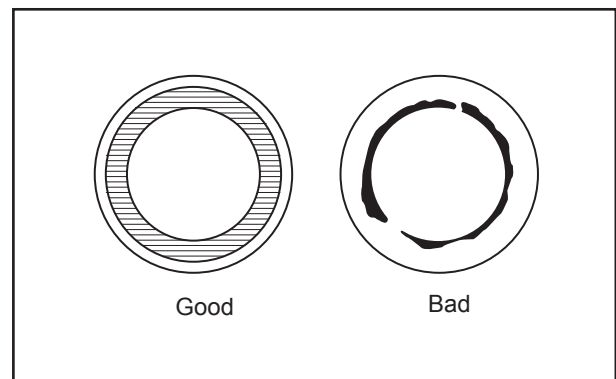
Apply a thin lead-free coloring paste on the valve face, and tap the valve face against valve seat with valve lapper to check the contact condition. If the contact is not even, or any defects are found, or if the value exceeds the specified limit, reface or replace the valve or valve seat.

Note: Do not rotate the valve when pressing valve face coated with lead-free coloring paste against valve seat.

Item		Nominal value	Standard value	Limit value
Valve seat	Valve seat angle	30°	-	-
	Seat width	2.3 mm [0.09 in.]	2.18 to 2.44 mm [0.0858 to 0.09 in.]	2.8 mm [0.1102 in.]
Valve margin		3.0 mm [0.12 in.]	2.8 to 3.2 mm [0.1102 to 0.1260 in.]	2.5 mm [0.098 in.]



Seat Width - Inspect



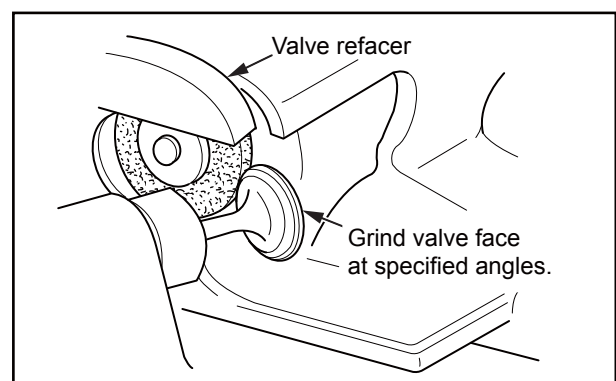
Contact Condition Between Valve Seat and Valve

1.6 Valve Face - Reface

When the valve is re-used by refacing, use valve refacer.

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

- (b) The valve margin is to be within the specified limit.
If the dimensions after refacing does not meet the specified values, replace the valve with a new one.



Valve Face - Reface

1.7 Valve Seat - Reface

If any damage or inclusions are found, grind the seat face.

- (1) Reface the valve seat with valve seat cutter or valve seat grinder. After refacing, insert sand paper of approx 400 grit between cutter and valve, and grind valve seat lightly.

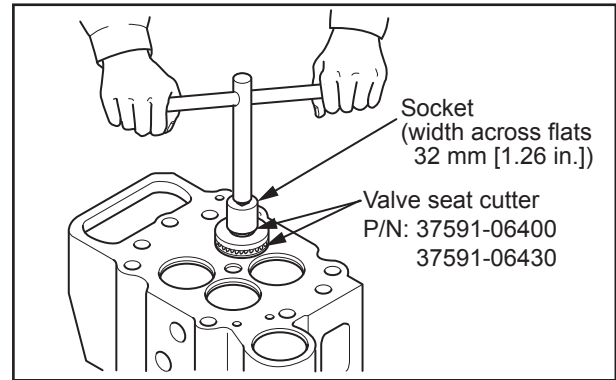
If the seat width exceeds the standard, grind the valve inner seat with 44°50' valve seat cutter.

- (2) Lap the valve and valve seat.

Note:(a) Valve seat refacing depth is to be minimal.

- (b) If the seat width cannot be repaired to the standard value, or line contact on valve seat outer periphery is shown, replace the valve seat with a new one.

- (c) If the valve sinkage exceeds the specified limit after refacing, replace the valve seat with a new one.



Valve Seat - Reface

1.8 Valve Seat - Replace

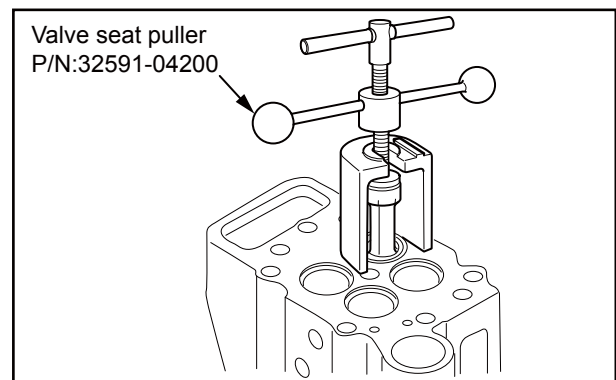
CAUTION

Select the valve seat with appropriate interference. Improper interference can result in dropping out of valve seat or crack in cylinder head.

Be careful not to damage the machined surface of cylinder head when removing the valve seat.

1.8.1 Valve Seat - Remove (With Valve Seat Puller)

Remove the valve seat with valve seat puller.

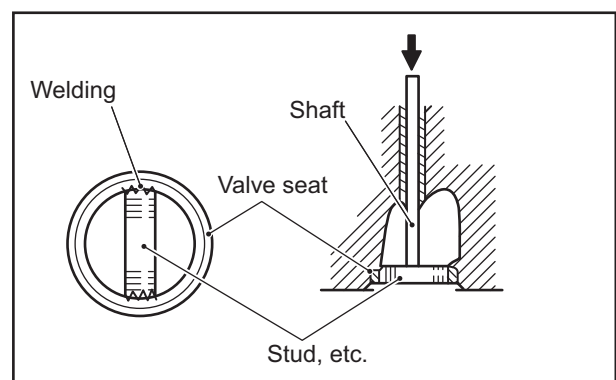


Valve Seat - Remove (With Valve Seat Puller)

1.8.2 Valve Seat - Remove (by Welding)

To remove the valve seat, weld a stud to valve seat as shown. Then, insert a shaft into valve guide hole from the top of cylinder head, and punch out the valve seat with shaft.

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



Valve Seat - Remove (by Welding)

1.8.3 Valve Seat - Install

- (1) Before installing the valve seat, measure the inside diameter of valve seat counterbore in cylinder head and the outside diameter of valve seat to make sure that the interference is within the range of standard value. If the value exceeds the standard, use the oversize valve seat.

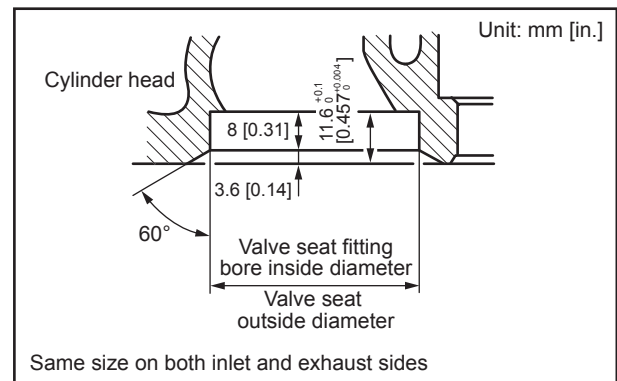
If the inside diameter of valve seat counterbore in cylinder head exceeds the limit, replace the cylinder head with a new one.

Note: Oversized valve seats are available in 0.03 and 0.06 mm [0.0012 and 0.0024 in.] sizes.

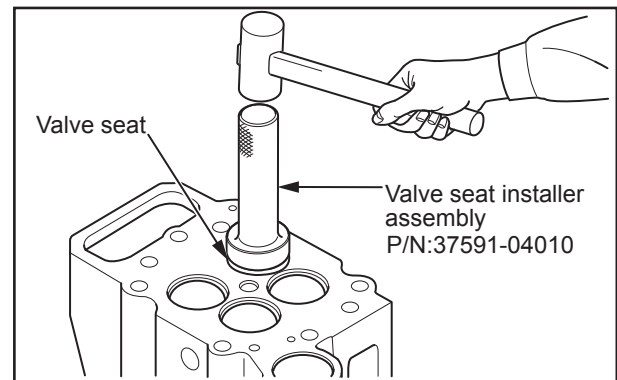
Item		Standard value	Limit value	Remarks
Valve seat inside diameter of counterbore		60.000 to 60.030 mm [2.3622 to 2.3634 in.]	60.09 mm [2.3657 in.]	-
Valve seat outside diameter	Standard	60.100 to 60.130 mm [2.3661 to 2.3673 in.]	-	2 lines, brown
	0.03 mm [0.0012 in.]	60.130 to 60.160 mm [2.3673 to 2.3685 in.]	-	3 lines, brown
	0.06 mm [0.0024 in.]	60.160 to 60.190 mm [2.3685 to 2.3697 in.]	-	4 lines, brown
Valve seat interference		0.070 to 0.130 mm [0.0028 to 0.0051 in.]	-	-

Inside diameter of valve seat counterbore	Applicable valve seat
60.03 mm [2.3634 in.] or less	Standard
More than 60.03 mm [2.3634 in.]	0.03 mm [0.0012 in.]
More than 60.06 mm [2.3646 in.]	0.06 mm [0.0024 in.]

- (2) Cool the valve seat at least for 4 minutes in liquid nitrogen and cool the cylinder head to a room temperature.
- (3) Install the valve seat into the cylinder head with valve seat caulking tool.



Valve Seat Counterbore



Valve Seat - Install

1.9 Valve and Valve Seat - Lap

Lap the valve and valve seat whenever valve seat is refaced or valve is replaced, or the contact surfaces fail to keep a pressure in the pressure test after assembling.

- (1) Apply a thin coat of lapping compound evenly to the valve face.

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

(b) Compound spreads more evenly when it is mixed with a small amount of engine oil.

(c) Use medium-grain compound (125 to 150 mesh) for initial lapping, then use fine-grain compound (200 mesh) for finishing.

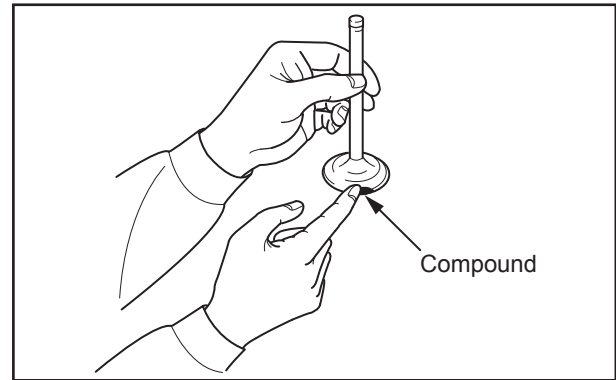
- (2) Use a valve lapper for lapping.

Tap the valve against valve seat while rotating the valve little by little.

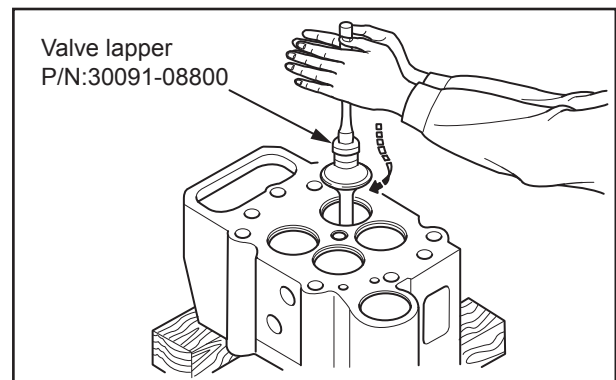
- (3) Clean off the compound using diesel oil.

- (4) Apply engine oil to the contact surface of valve, and finish the lapping.

- (5) Apply a thin lead-free coloring paste on the valve face, and tap the valve face against the valve seat using a valve lapper to check for contact condition.



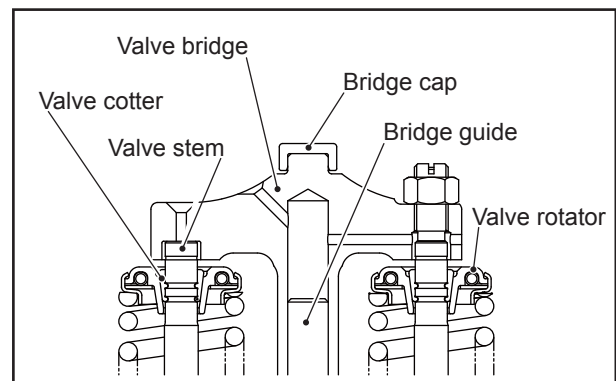
Compound - Apply



Valve and Valve Seat - Lap

1.10 Valve Bridge, Bridge Cap, Valve Cotter and Valve Rotator - Inspect

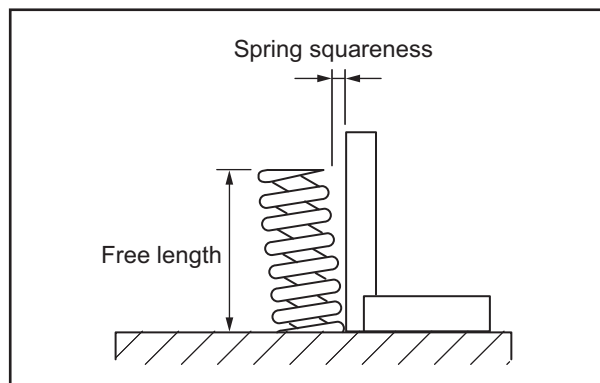
- (1) Inspect the contact surfaces between valve bridge and valve stem, and the sliding surface between valve bridge and bridge guide. If significant wear or uneven contact is found, replace them with new ones.
- (2) Check the bridge cap for wear. If significant wear is found, replace the bridge cap with a new one.
- (3) Check the valve rotator for rotation. If any defect is found, replace the valve rotator with a new one.
- (4) Inspect the contact surfaces between valve cotter and valve stem, and valve cotter and valve rotator. If significant uneven wear or dent is found, replace them with new ones.



Valve Bridge, Bridge Cap, Valve Cotter and Valve Rotator - Inspect

1.11 Squareness and Free Length of Valve Spring - Measure

Measure the squareness and free length of valve spring. If the free length or squareness exceeds the limit, replace the valve spring with a new one.

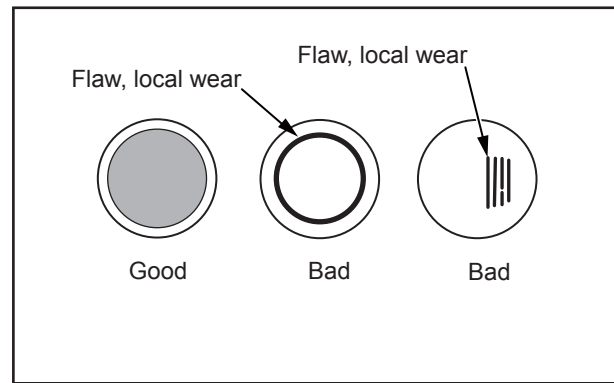


Squareness and Free Length of Spring - Measure

Item			Standard value		Limit value
Single valve spring		P/N: 37504-10400	Free length	73 mm [2.87 in.]	71 mm [2.80 in.]
			Squareness	A=1.5° or less B=1.9 mm [0.075 in.] or less Lf=73 mm [2.87 in.]	At full length B=2.2 mm [0.087 in.]
			Set length / load	66.0 mm [2.598 in.] / 289 to 319 N {29.45 to 32.55 kgf} [64.97 to 71.71 lbf]	-
Double valve spring	Inner spring	P/N: 37504-10600	Free length	90.6 mm [3.567 in.]	88.12 mm [3.4693 in.]
			Squareness	A=2.0° or less B=3.2 mm [0.126 in.] or less Lf=90.6 mm [3.567 in.]	At full length B=3.7 mm [0.146 in.]
			Set length / load	56.0 mm / 137 to 152 N {14 to 15.5 kgf} [30.80 to 34.17 lbf]	-
	Outer spring	P/N: 37504-20500	Free length	96.57 mm [3.8020 in.]	93.92 mm [3.6976 in.]
			Squareness	A=2.5° or less B=4.2 mm [0.165 in.] or less Lf=96.57 mm [3.8020 in.]	At full length B=4.2 mm [0.165 in.]
			Set length / load	62.0 mm / 496 to 549 N {50.6 to 56.0 kgf} [111.51 to 123.42 lbf]	-

1.12 Tappet - Inspect

Inspect the tappet sliding face to cam for even wear. If the surface is defective, replace the tappet with a new one.

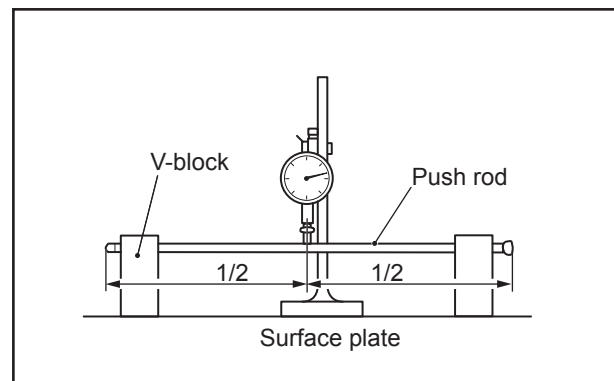


Tappet Sliding Face to Cam - Inspect

1.13 Pushrod Runout - Measure

Measure the runout of push rod at TIR. If the runout exceeds the standard, replace the push rod with a new one.

Item	Standard value	Remarks
Pushrod runout	0.50 mm [0.020 in.] or less	TIR



Pushrod Runout - Measure

1.14 Nozzle Gland Stud Bolt and Bridge Guide - Inspect and Replace

Inspect the nozzle gland stud bolt for bending or damage at threaded portion.

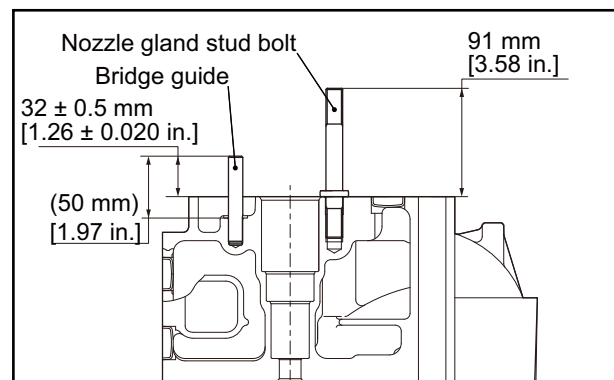
Inspect the bridge guide for uneven wear and damage on the sliding surface.

1.14.1 Nozzle Gland Stud - Install

Tighten the nozzle gland stud bolt until it comes to the bottom end.

1.14.2 Bridge Guide - Install

Press-in the bridge guide to the specified dimension.



Nozzle Gland Stud Bolt and Bridge Guide - Install

1.15 Distortion of Cylinder Head Bottom Surface - Measure

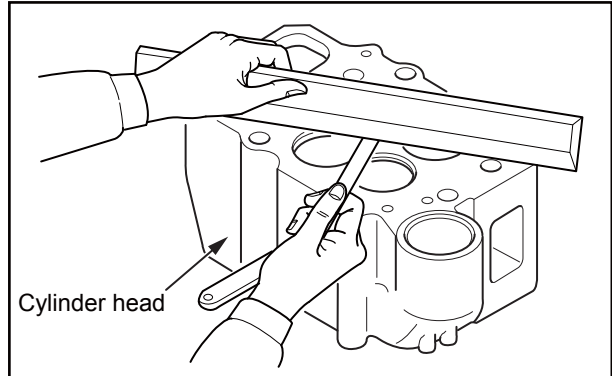
CAUTION

Refacing depth of cylinder head is to be minimum. Excessive grinding of the cylinder head may result in defects such as contact between piston and valve.

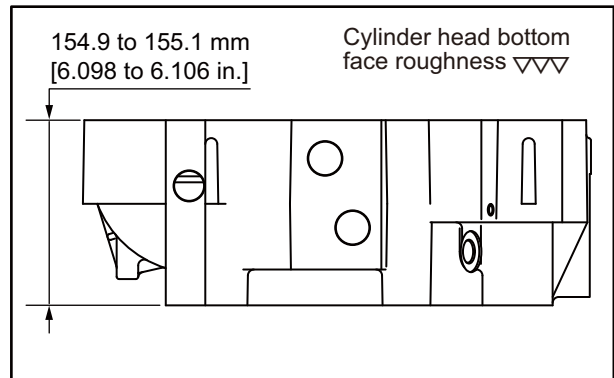
With a straight edge placed on the bottom face of cylinder head, measure the bottom face distortion with thickness gauges. If the value exceeds the limit, replace the cylinder head with a new one, or repair by grinding.

After grinding, record the maximum depth of grinding. Note that total grinding amount, which includes grinding depth of top face of crankcase, must be 0.50 mm [0.020 in.] or less.

Item	Standard value	Limit value
Distortion of cylinder head bottom surface	0.03 mm [0.0012 in.] or less	0.07 mm [0.0028 in.]
The height of cylinder head (reference value)	154.9 to 155.1 mm [6.098 to 6.106 in.]	-



Distortion of Cylinder Head Bottom Surface - Measure



Height of Cylinder Head - Measure

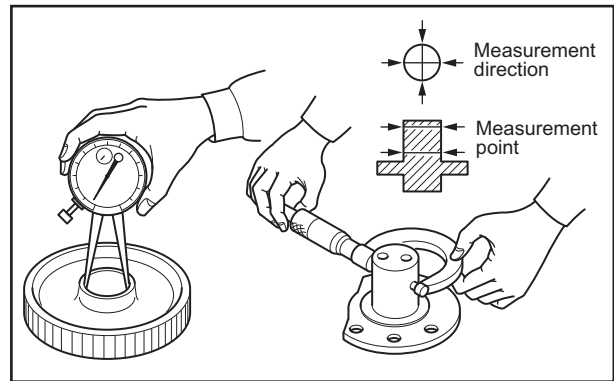
2. Rear Mechanism - Inspect and Repair

2.1 Idler Bushing Inside Diameter and Idler Shaft Outside Diameter - Measure

Measure the idler bushing inside diameter and the idler shaft outside diameter. If the value exceeds the limit, replace the idler gear assembly or the idler shaft with a new one.

Note: After replacing idler bushing, finish the bushing inside diameter by reaming.

Item	Nominal value	Standard value	Limit value
Idler bushing Inside diameter	ø50 mm [1.97 in.]	50.000 to 50.025 mm [1.9685 to 1.9695 in.]	50.060 mm [1.9708 in.]
Idler shaft outside diameter	ø50 mm [1.97 in.]	49.950 to 49.975 mm [1.9665 to 1.9675 in.]	49.900 mm [1.9646 in.]

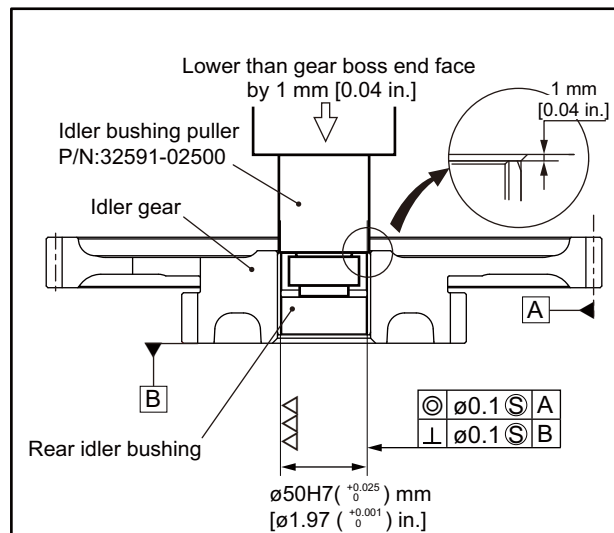


Idler Bushing Inside Diameter and Idler Shaft Outside Diameter - Measure

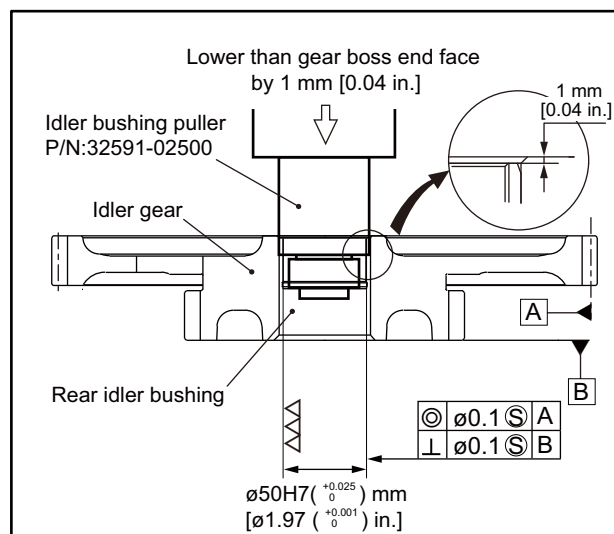
2.2 Idler Bushing - Replace

- (1) Using the removing side of the idler bushing puller, remove the idler bushing.
- (2) Using the installing side of the idler push puller, press-fit the idler bushing from the large gear side until it becomes flush with the end face of gear boss. Furthermore, using the removal side of the idler bushing puller, lower the idler bushing end face from end face of gear boss by 1 mm [0.04 in.]
- (3) After installing, ream the bore of idler bushing to the specified dimension shown.

Note: Reaming after press-fit is necessary, as the rear idler bushings are supplied in a semi-finished condition.



Idler Bushing - Replace

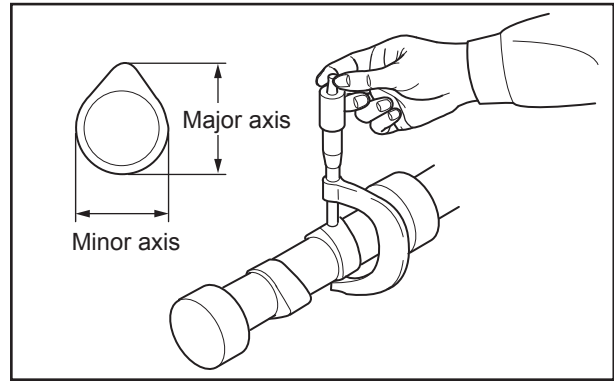


Idler Bushing - Replace (Y2PTAW spec)

2.3 Cam Lift of Cam Shaft Lobe - Measure

Measure the major diameter and minor diameter of cam lobe to know the cam lift. If the value exceeds the limit, replace the camshaft with a new one.

Item	Part No.	Standard value	Limit value
Cam lift (major diam - minor diam)	37505-34100 (Overlap 93°)	9.207 to 9.287 mm [0.3625 to 0.3656 in.]	8.45 mm [0.3327 in.]
	37505-40100 (Overlap 61°)		



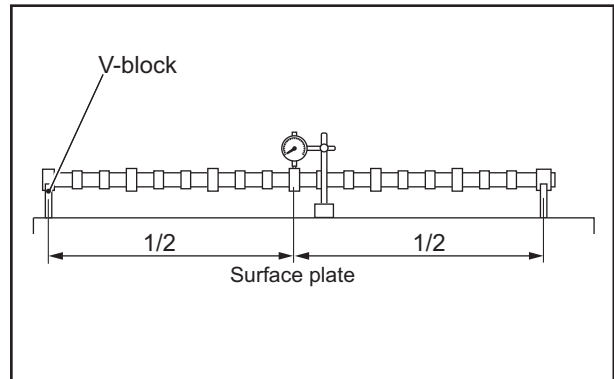
Cam Lift of Camshaft Lobe - Measure

2.4 Camshaft Runout - Measure

Measure the runout of camshaft at TIR. If the value exceeds the limit, correct the camshaft using a press, or replace the camshaft with a new one.

Note: With a dial gauge set on the camshaft, rotate the camshaft one turn and read the gauge indication.

Item	Standard value	Limit value	Remarks
Camshaft runout	0.05 mm [0.0020 in.] or less	0.08 mm [0.0031 in.]	TIR

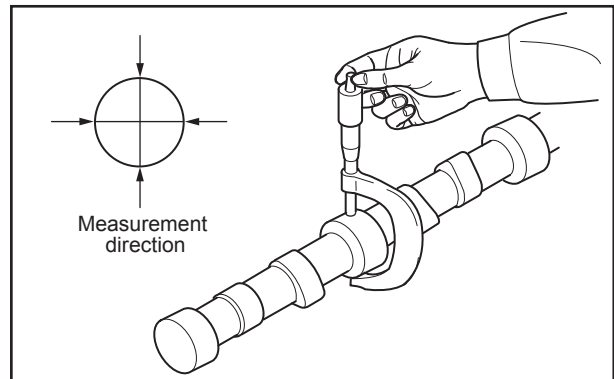


Camshaft Runout - Measure

2.5 Camshaft Journal Outside Diameter - Measure

Measure the diameter of each camshaft journal in two directions at right angles to each other. If the value exceeds the limit, replace the camshaft with a new one.

Item	Nominal value	Standard value	Limit value
Camshaft journal outside diameter	ø84 mm [3.31 in.]	83.92 to 83.94 mm [3.3039 to 3.3047 in.]	83.87 mm [3.3020 in.]



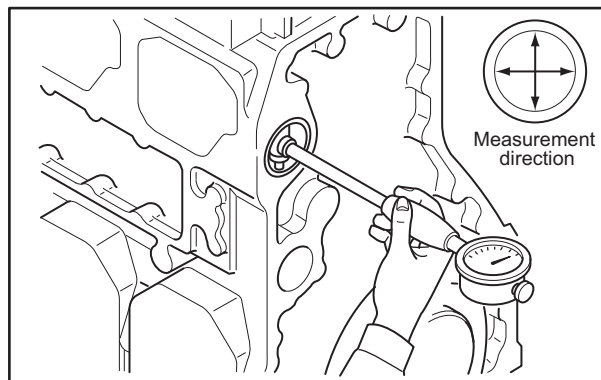
Camshaft Journal Outside Diameter - Measure

2.6 Camshaft Bushing - Inspect

- (1) Check the inside surface of each bushing for damage, corrosion, flaking and other abnormalities. If any defect is found, replace the camshaft bushing with a new one.
- (2) Measure the camshaft bushing inside diameter with bushing installed in the crankcase. If the measurement exceeds the limit, replace the bushing with a new one.

Note: Be careful not to damage the inner surface of camshaft bushing when measuring the inside diameter.

Item	Nominal value	Standard value	Limit value
Camshaft bushing inside diameter	ø84 mm [3.31 in.]	84.020 to 84.095 mm [3.3079 to 3.3108 in.]	84.100 mm [3.3110 in.]

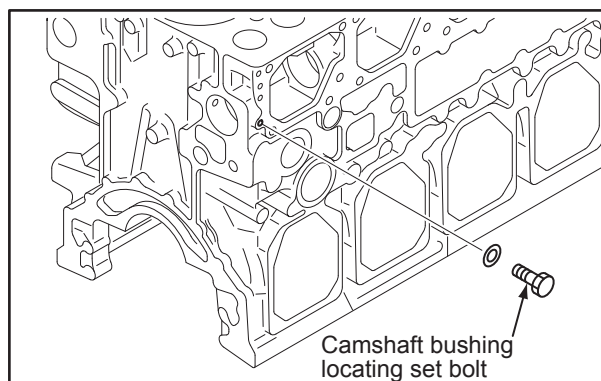


Camshaft Bushing Inside Diameter - Measure

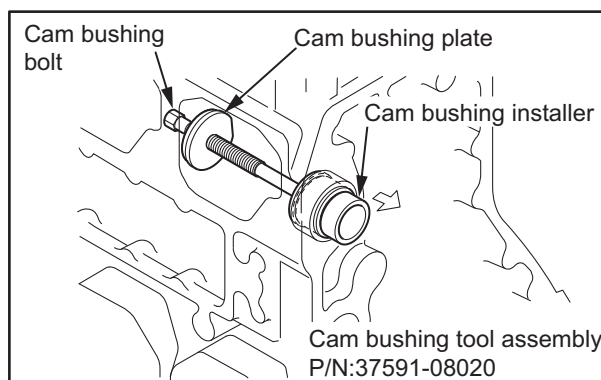
2.7 Camshaft Bushing - Replace

2.7.1 Camshaft Bushing - Remove

- (1) Remove the locating set bolt of camshaft bushing.
- (2) Set the cam bushing installer and cam bushing plate into camshaft bushing.
- (3) Set the cam bushing bolt by screwing it into cam bushing plate.
- (4) Apply molybdenum-disulfide base anti-seizure lubricant (ThreeBond 1910 or equivalent) to the tip of cam bushing bolt (the position that will touch cam bushing installer).
- (5) Screw in the cam bushing bolt and push the cam bushing installer to pull out the camshaft bushing.



Locating Set Bolt of Camshaft Bushing

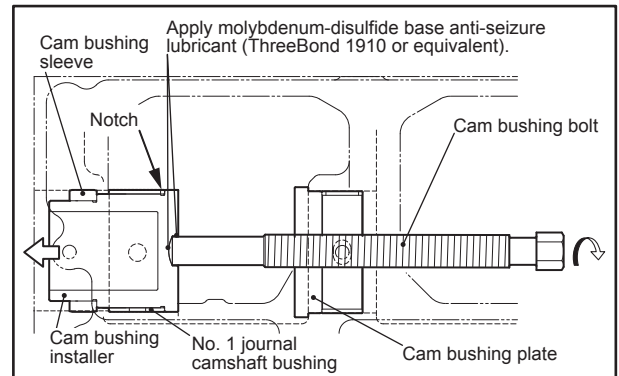


Camshaft Bushing - Remove

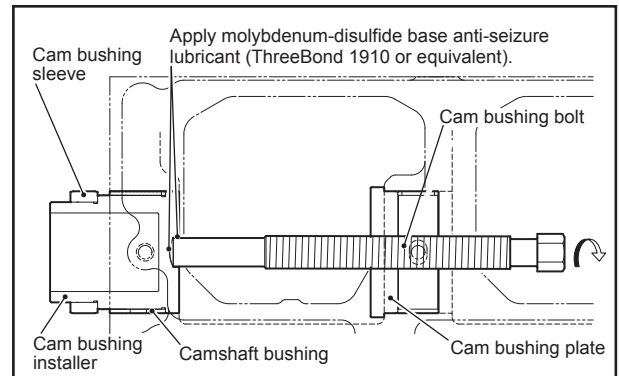
2.7.2 Camshaft Bushing - Install

- (1) Insert the camshaft bushing installer into camshaft bushing and install the cam bushing sleeve.
- (2) Face the cut of the camshaft bushing upward and set the camshaft bushing in camshaft fitting bore of crankcase while aligning the oil hole in camshaft bushing with oil hole in crankcase.
Orient the notch of camshaft bushing of No. 1 journal to No 2 cylinder.
Place the locating bolt hole of camshaft bushing of No. 7 journal to No 6 cylinder side.

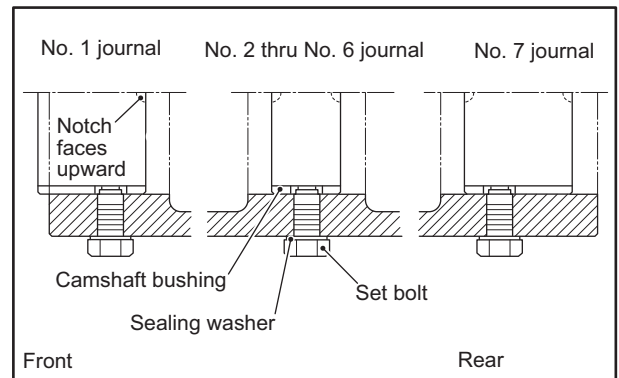
- (3) Set the cam bushing plate and cam bushing bolt.
 - (4) Apply molybdenum-disulfide base anti-seizure lubricant (ThreeBond 1910 or equivalent) to the tip of cam bushing bolt (the position that will touch cam bushing installer).
 - (5) Screw in the cam bushing bolt and push the cam bushing installer to press-fit the camshaft bushing.
- Note: Press-fit the camshaft bushing while aligning the oil hole in crankcase and oil hole in camshaft bushing.
- (6) Install the sealing washer and set bolt to fix the camshaft bushing.



Camshaft Bushing (Beginning of Pressing) - Press-Fit



Camshaft Bushing (Set) - Press-Fit

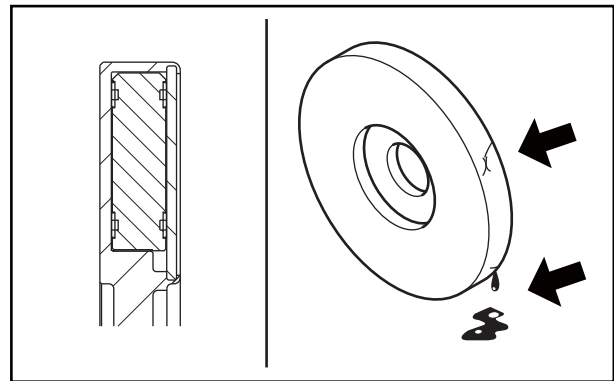


Camshaft Bushing Types on Journals

3. Front Mechanism - Inspect and Repair

3.1 Damper - Inspect Visually

Check the damper for cracks around outer periphery, swelling in end plate, silicone oil leakage, and discoloration and separation of coating due to overheating. If any defect is found, replace the damper with a new one.

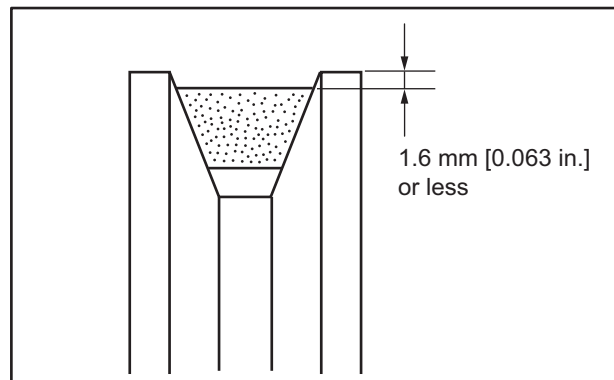


Damper - Inspect Visually

3.2 Pulley - Inspect

Check the belt groove of pulley for wear.

- (1) Check the sinkage of belt.
- (2) Fit a new belt tightly in pulley groove.
- (3) If the belt sinks 1.6 mm [0.063 in.] or more below pulley rim, replace the pulley with a new one.

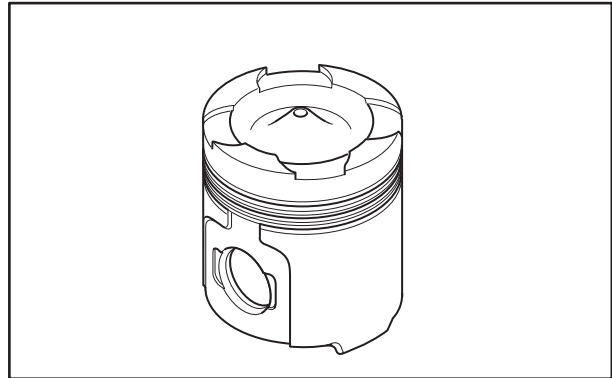


Pulley Wear - Inspect

4. Piston and Connecting Rod - Inspect and Repair

4.1 Piston - Inspect Visually

Check the combustion surface, piston pin bore, ring groove, sliding surface and bottom surface of piston. If any defect are found, replace the piston with a new one.



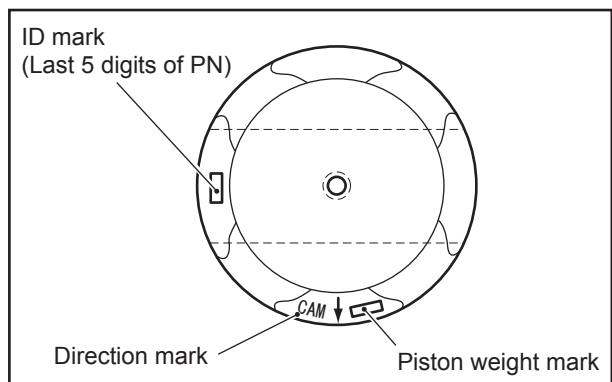
Piston - Inspect Visually

4.2 Piston Weight

Check the piston weight on the top face of piston.

When replacing pistons, be sure that the weight difference per engine is within permissible range.

Item	Part No.	ID stamp	Compression ratio	Standard value
Piston weight difference	37517-30101	30101	14	within 10 g [0.35 oz]
	37517-10401	10401	15	
	37517-00900	00900	14.5	
	37517-25100	25100	14	
	37517-05500	05500	14	
	37517-05300	05300	14	
	37517-07800	07800	14	
	37517-07900	07900	15	
	37517-00800	00800	14	within 15 g [0.53 oz]

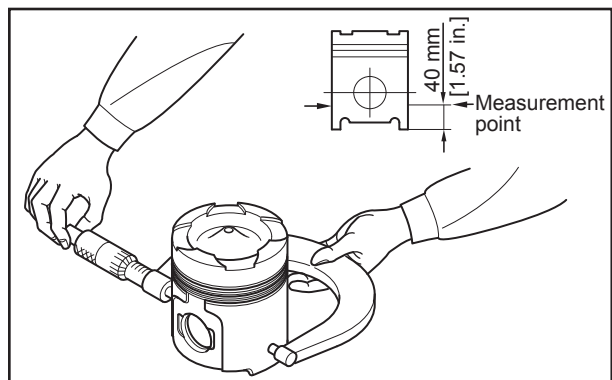


Piston Weight Stamp

4.3 Piston Outside Diameter - Measure

Measure the piston outside diameter of piston skirt at right angle to piston pin. If the value exceeds the limit, replace the piston with a new one.

Item	Part No.	Nominal value	Standard value	Limit value
Piston outside diameter	37517-30101	ø170 mm [6.69 in.]	169.760 to 169.800 mm [6.6835 to 6.6850 in.]	169.660 mm [6.6795 in.]
	37517-10401			
	37517-00900			
	37517-25100			
	37517-05500			
	37517-05300			
	37517-07800	ø170 mm [6.69 in.]	169.739 to 169.779 mm [6.6826 to 6.6842 in.]	169.639 mm [6.6787 in.]
	37517-07900			
	37517-00800	ø170 mm [6.69 in.]	169.760 to 169.780 mm [6.6835 to 6.6842 in.]	169.660 mm [6.6795 in.]



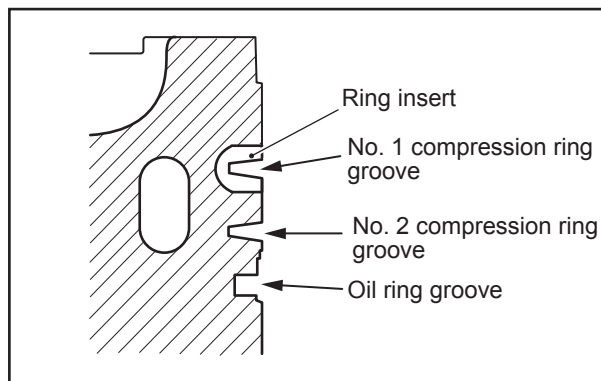
Piston Outside Diameter - Measure

4.4 Piston Ring Groove - Inspect

CAUTION

Remove carbon deposits from piston and inspect the entire circumference of piston.

- (1) Remove all deposits such as carbon from each ring groove.
- (2) Visually check each ring groove for wear or damage. If faulty, replace the piston with a new one. Inspect the ring insert of No. 1 compression ring groove by dye penetration test for cracks and separation.

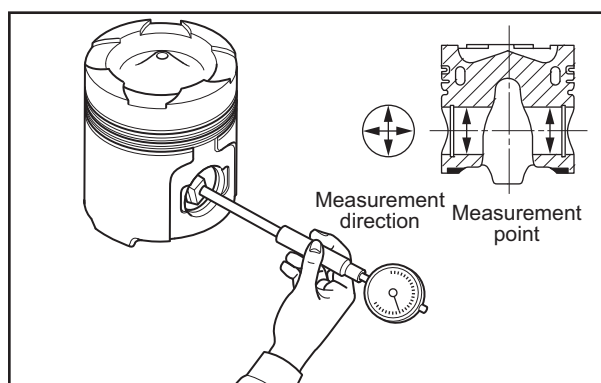


Piston Ring Groove - Inspect

4.5 Piston Pin Bore Inside Diameter - Measure

Measure the piston pin bore inside diameter. If the value exceeds the limit, replace the piston with a new one.

Item	Nominal value	Standard value	Limit value
Piston pin bore inside diameter	ø70 mm [2.76 in.]	70.002 to 70.015 mm [2.7560 to 2.7565 in.]	70.040 mm [2.7575 in.]



Piston Pin Bore Inside Diameter - Measure

4.6 Piston Ring - Inspect Visually

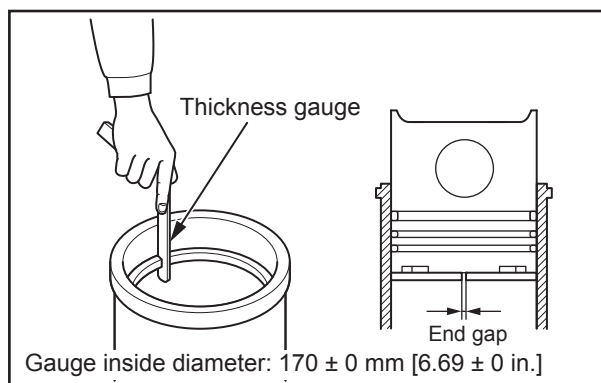
Check the sliding surface and top and bottom surfaces for seizing, abnormal wear, foreign material inclusion and plating flaking. If any defects are found, replace the piston rings with new ones.

4.7 Piston Ring End Gap - Measure

Place the piston ring in the gauge or a new cylinder liner, and measure the end gap. If the value exceeds the limit, replace piston rings with a new set of rings.

Note: Using a piston, push the piston ring squarely into gauge or cylinder liner.

Item	Standard value	Limit value
Piston ring end gap	No.1 compression 0.6 to 0.8 mm [0.024 to 0.032 in.]	1.0 mm [0.040 in.]
	No.2 compression 0.6 to 0.8 mm [0.024 to 0.032 in.]	
	Oil 0.3 to 0.45 mm [0.012 to 0.0177 in.]	0.6 mm [0.024 in.]



Gauge inside diameter: 170 ± 0 mm [6.69 ± 0 in.]

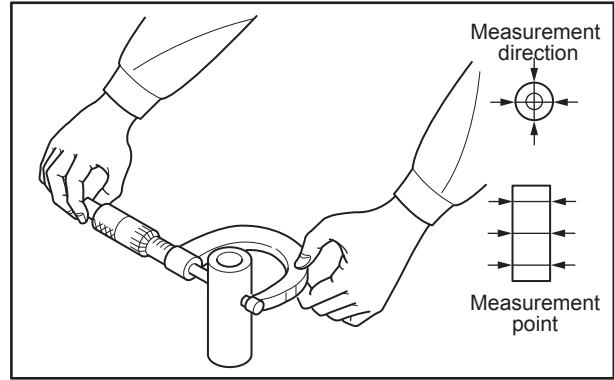
Piston Ring End Gap - Measure

4.8 Piston Pin Outside Diameter - Measure

Measure the piston pin outside diameter.

If the value exceeds the limit, replace the piston pin with a new one.

Item	Nominal value	Standard value	Limit value
Piston pin outside diameter	ø70 mm [2.76 in.]	69.987 to 70.000 mm [2.7554 to 2.7559 in.]	69.970 mm [2.7547 in.]



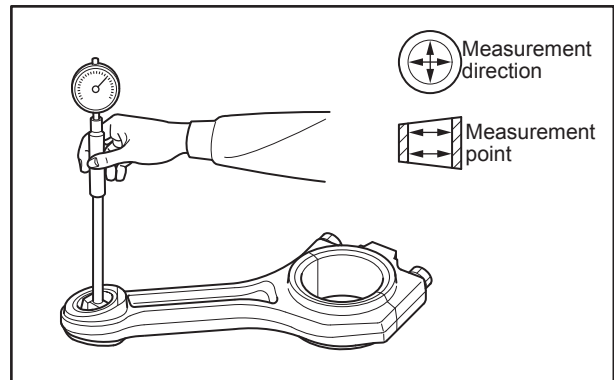
Piston Pin Outside Diameter - Measure

4.9 Connecting Rod Bushing Inside Diameter - Measure

Measure the inside diameter of the connecting rod bushing.

If the value exceed the limit, replace the connecting rod bushing with a new one.

Item	Nominal value	Standard value	Limit value
Inside diameter of connecting rod bushing	ø70 mm [2.76 in.]	70.020 to 70.040 mm [2.7567 to 2.7575 in.]	70.070 mm [2.7587 in.]



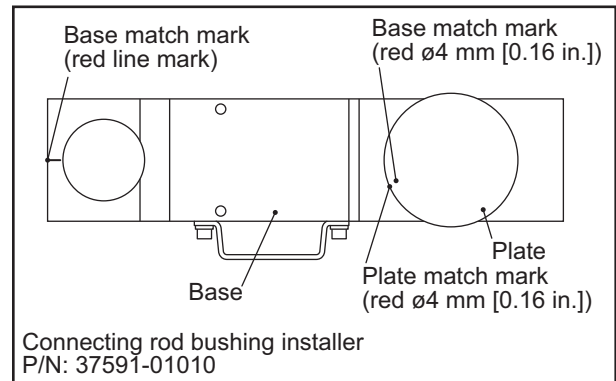
Connecting Rod Bushing Inside Diameter - Measure

4.10 Connecting Rod Bushing - Replace

Using the connecting rod bushing installer, replace the connecting rod bushing.

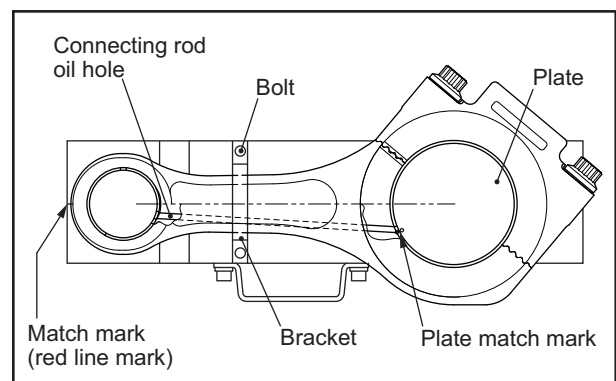
4.10.1 Installer Base and Connecting Rod - Fix

- (1) Align the match mark on base with match mark on plate, and install the plate.



Connecting Rod Bushing Installer - Use (1)

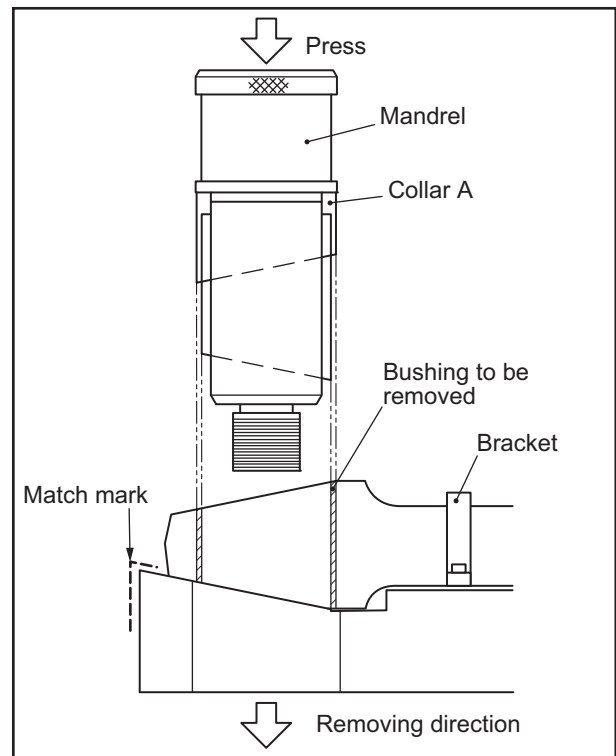
- (2) With the connecting rod bearing removed from the connecting rod, install the connecting rod cap to plate.
- (3) Align the match mark, and install the connecting rod to plate.
- (4) Tighten the connecting rod bolts to the specified torque.
- (5) Fix the connecting rod in place with bracket.



Connecting Rod Bushing Installer - Use (2)

4.10.2 Connecting Rod Bushing - Remove

- (1) Apply engine oil to inner surface of connecting rod bushing.
- (2) Attach the collar A to mandrel and insert the mandrel into connecting rod bushing while aligning the match mark (red line) on collar A with mark on the base.
- (3) With pressing machine, apply pressure slowly on mandrel head to push-out the connecting rod bushing.



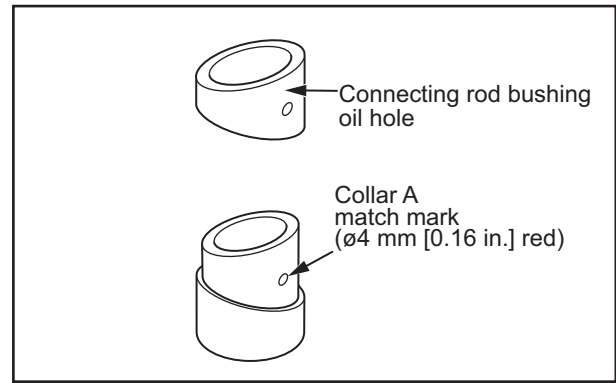
Connecting Rod Bushing Installer - Use (3)

4.10.3 Connecting Rod Bushing - Press-In

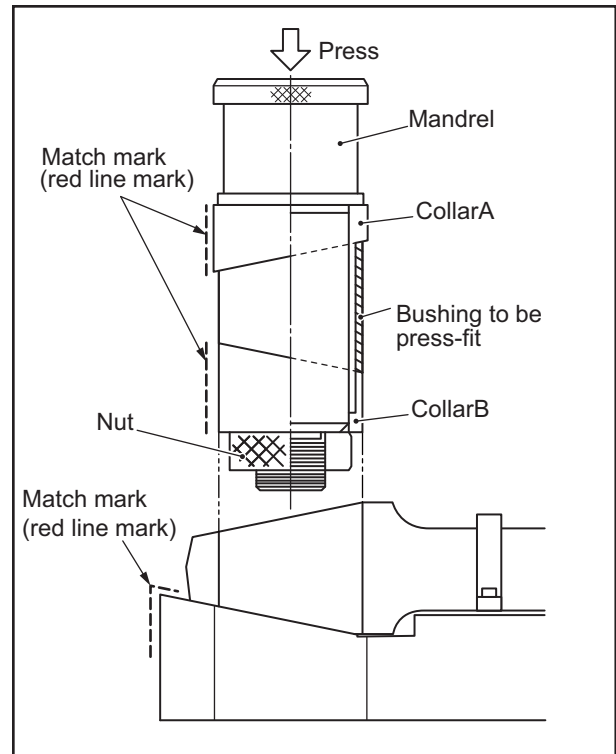
CAUTION

- (a) Make sure that the match marks (red lines) on collars A and B are aligned.
- (b) Make sure that the oil hole of connecting rod bushing is in alignment with match mark (red $\phi 4$ mm [0.16 in.]) on collar A.

- (1) Align the oil hole with match mark on collar A ($\phi 4$ mm [0.16 in.] red), and install a new connecting rod bushing on collar A.
- (2) Install the combination of collar A and collar B to mandrel, and fix them with nut.

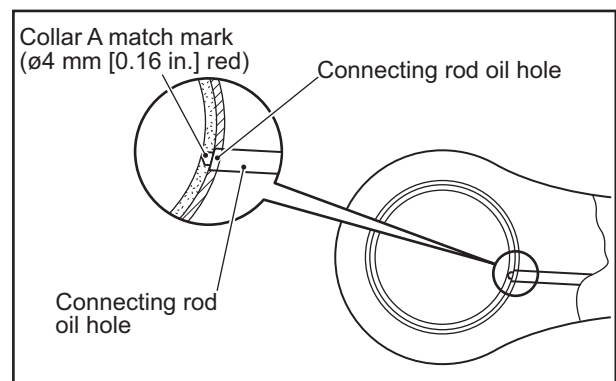


Connecting Rod Bushing Installer - Use (4)



Connecting Rod Bushing Installer - Use (5)

- (3) Apply engine oil to outer surface of connecting rod bushing. Align the match mark (red line) on collar A with mark of collar B to align the oil hole of connecting rod bushing and oil hole of connecting rod. Press-in the bushing into connecting rod with pressing machine.

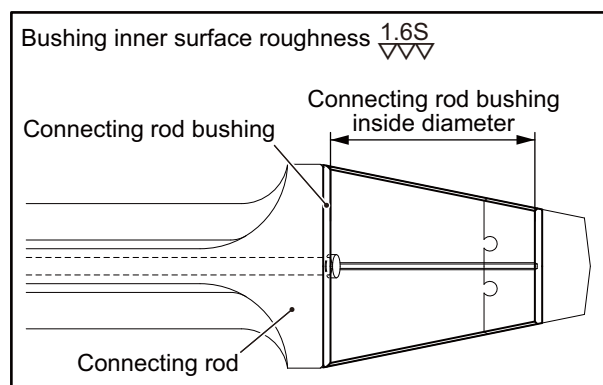


Connecting Rod Bushing Installer - Use (6)

- (4) Measure the inside diameter of the connecting rod bushing.

If the value is out of the standard, ream the inside diameter to the standard.

Item	Standard value
Inside diameter of connecting rod bushing	70.020 to 70.040 mm [2.7567 to 2.7575 in.]



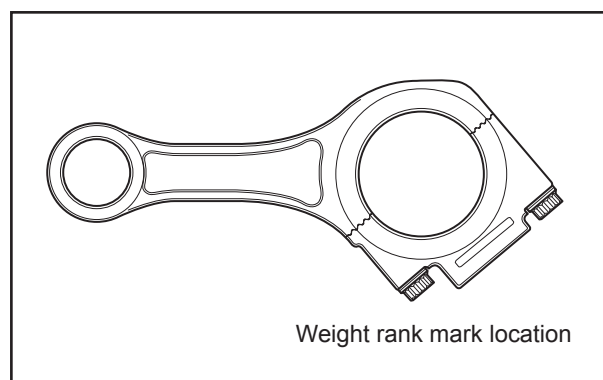
Connecting Rod Bushing Inside Diameter - Measure

4.11 Connecting Rod Assembly Weight Rank

When replacing a connecting rod, be sure to check the weight rank of connecting rod. In one engine, all the connecting rods must be of the same weight rank.

Weight rank list			
Part No.	Weight rank	Weight	Allowable value
37519-75020	A	14900 g [525.58 oz]	±30 g [±1.05 oz]
37519-75030	B	15000 g [529.11 oz]	
37519-75040	C	15100 g [532.64 oz]	
37519-75050	D	15200 g [536.16 oz]	
37519-75060	E	15300 g [539.69 oz]	
37519-75070	F	15400 g [543.22 oz]	
37519-75080	G	15500 g [546.75 oz]	
37519-75090	H	15600 g [550.27 oz]	
37519-76010	I	15700 g [553.8 oz]	
37519-31020	M	16150 g [569.68 oz]	

Note: The weight rank of connecting rod assembled in engine is also stamped on caution plate.



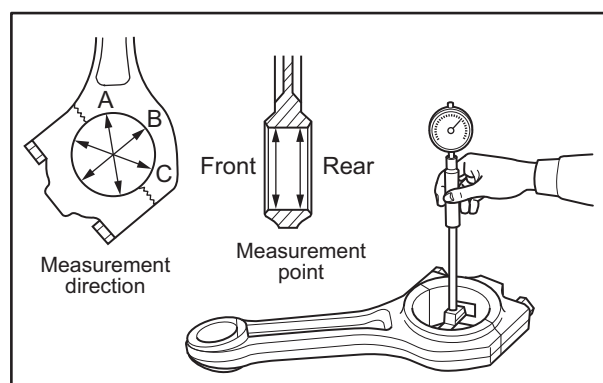
Connecting Rod Weight Rank Mark Location

4.12 Bore Diameter and Roundness of Connecting Rod Big End - Measure

Measure the connecting rod bore diameter at front and rear ends respectively in the directions A, B and C as shown in illustration. The roundness is determined by subtracting the minimum value from the maximum value among measurements of A, B and C.

If the value exceeds the limit, replace the connecting rod with a new one.

Item	Nominal value	Standard value	Limit value	Roundness limit
Connecting rod big end bore diameter	ø131 mm [5.16 in.]	131.000 to 131.025 mm [5.1575 to 5.1585 in.]	Minimum: 130.950 mm [5.1554 in.] Maximum: 131.050 mm [5.1593 in.]	0.100 mm [0.0039 in.]

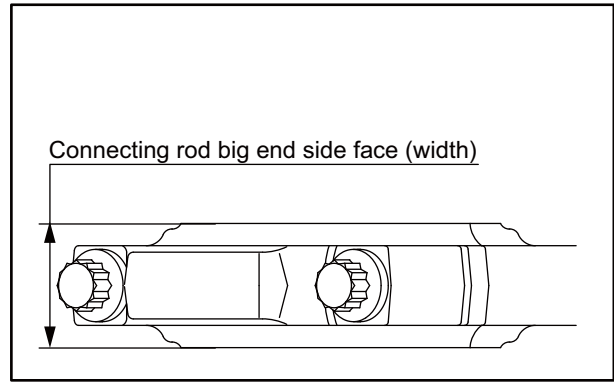


Connecting Rod Big End Bore Diameter - Measure

4.13 Side Face Width of Connecting Rod Big End - Measure

- (1) Inspect the side face of connecting rod big end visually.
If there is any defect such as wear or flaw, replace the connecting rod with a new one.
- (2) Measure the side face width of connecting rod big end.
If the value exceeds the limit, replace the connecting rod with a new one.

Item	Standard value
Side face width of connecting rod big end	66.7 to 66.8 mm [2.6260 to 2.6299 in.]



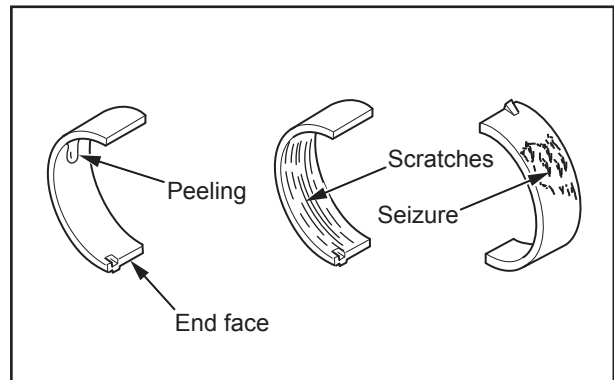
Side Face Width of Connecting Rod Big End - Measure

4.14 Connecting Rod Big End Serration and Bolt Holes - Inspect

Inspect the connecting rod big end serration and bolt holes with magnetic particle inspection. If there is any defect such as cracks, fretting and foreign material inclusion, replace the connecting rod with a new one.

4.15 Connecting Rod Bearing - Inspect

Inspect the sliding surface, back surface and end surface of connecting rod bearing. If there is any defect such as local contact, sliding scratches, corrosion and foreign material inclusion, replace the bearing with a new one.



Connecting Rod Bearing - Inspect

4.16 Connecting Rod Bearing Thickness - Measure

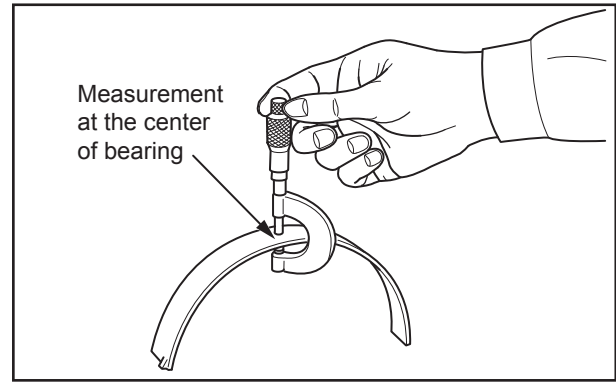
Measure the thickness of connecting rod at its center.

If the value exceeds the limit, replace both upper and lower connecting rod bearing shells with new ones as a set.

When the crankshaft is re-ground due to wear of crank pin, use the undersize bearing.

For the crankshaft grinding procedure, refer to "Crankpin and Crank Journal - Grind" of "INSPECTION AND REPAIR OF BASIC ENGINE."

Note: Replacement shells for undersized connecting rod bearing are available in sizes of 0.25, 0.50, 0.75 and 1.00 mm [0.0098, 0.0197, 0.0295 and 0.0394 in.]



Connecting Rod Bearing Thickness - Measure

Item	Size		Nominal value	Standard value	Limit value
Connecting rod bearing thickness at center	Standard		3.000 mm [0.1181 in.]	2.957 to 2.970 mm [0.1164 to 0.1169 in.]	2.930 mm [0.1154 in.]
	Under size	0.25 mm [0.0098 in.]	3.125 mm [0.1230 in.]	3.082 to 3.095 mm [0.1213 to 0.1219 in.]	3.055 mm [0.1203 in.]
		0.50 mm [0.0197 in.]	3.250 mm [0.1280 in.]	3.207 to 3.220 mm [0.1263 to 0.1268 in.]	3.180 mm [0.1252 in.]
		0.75 mm [0.0295 in.]	3.375 mm [0.1329 in.]	3.332 to 3.345 mm [0.1312 to 0.1317 in.]	3.305 mm [0.1301 in.]
		1.00 mm [0.0394 in.]	3.500 mm [0.1378 in.]	3.457 to 3.470 mm [0.1361 to 0.1366 in.]	3.430 mm [0.1350 in.]

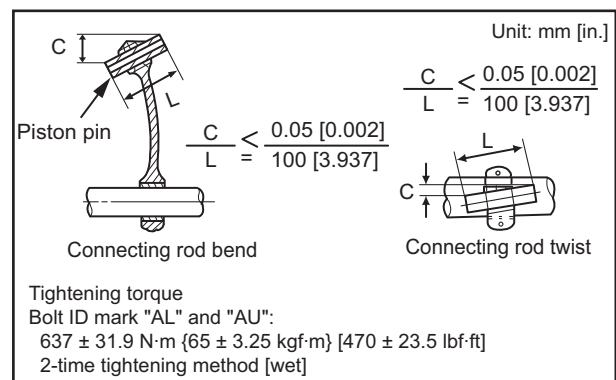
4.17 Connecting Rod Bend and Twist - Inspect

(1) Measure the dimensions of C and L as shown in illustration to check the bend and twist of connecting rod. Straighten the connecting rod with a press so that the measurement value meets the standard.

If the value exceeds the limit, replace the connecting rod with a new one.

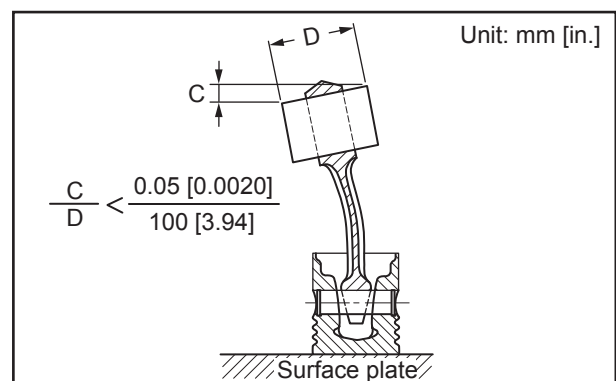
Note: Tighten the connecting rod cap to the specified torque and check the bend and twist.

(2) To inspect the connecting rod with the piston installed, turn the piston upside down and place it on a surface plate. Insert a round bar having the same diameter as the crankpin into the big-end bore, and measure the height of the bar with dial gauge.



Connecting Rod Bend and Twist - Inspect

Item	Standard value
Connecting rod bend and twist (C/L, C/D)	0.05/100 mm [0.0020/3.94 in.] or less



Deflection of Connecting Rod - Measure

5. Crankcase and Crankshaft - Inspect and Repair

5.1 Crankcase Top Surface Distortion - Measure

CAUTION

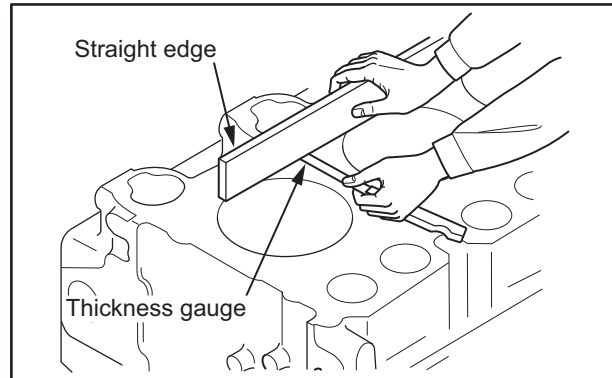
Refacing depth of crankcase is to be minimum.

Excessive grinding of the crankcase may result in defects such as defective combustion and stamping between piston and valve.

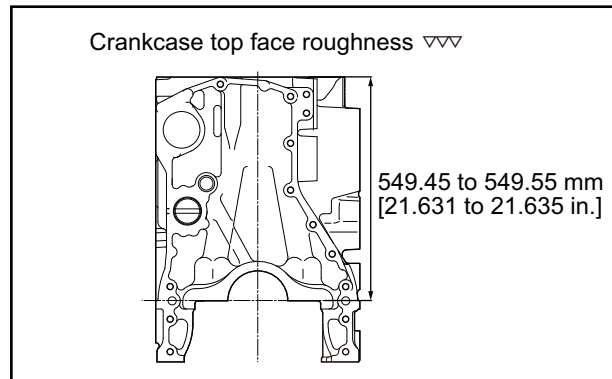
Apply a straight edge to the top surface of the crankcase and measure its distortion with thickness gauges. If the value exceeds the limit, replace the cylinder head with a new one, or repair by grinding.

After grinding, record the maximum depth of grinding. Note that the total grinding amount, which includes the grinding depth of bottom surface of cylinder head, must be 0.50 mm [0.020 in.] or less.

Item	Standard value	Limit value
Crankcase top surface distortion	0.1 mm [0.004] or less	0.2 mm [0.008 in.]
Height from the crank journal center to Crankcase top surface (reference value)	549.45 to 549.55 mm [21.6318 to 21.6358 in.]	-



Crankcase Top Surface Distortion - Measure



Height From Crank Journal Center to Crankcase Top Surface

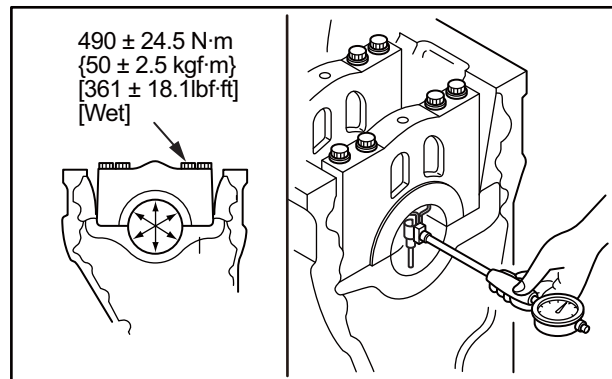
5.2 Inside Diameter of Main Bearing Housing Bore - Measure

- (1) Assemble the main bearing cap in crankcase in accordance with the specified method.

Note: For tightening procedure of main bearing cap, refer to "Main Bearing Cap - Install" of "ASSEMBLY OF BASIC ENGINE."

- (2) Measure the housing diameter in vertical and two diagonal directions.

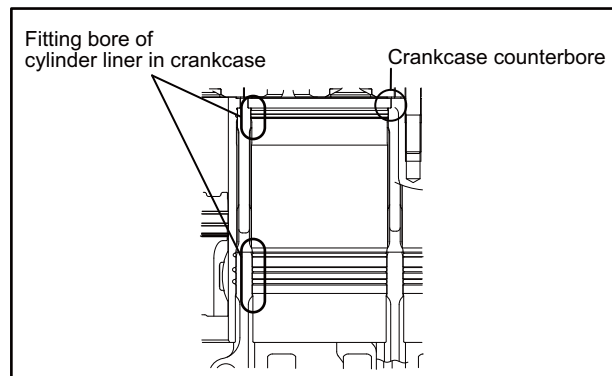
Item	Nominal value	Standard value	Limit value
Inside diameter of main bearing bore	ø147 mm [5.79 in.]	147.000 to 147.025 [5.7874 to 5.7884 in.]	147.035 [5.7888 in.]



Inside Diameter of Main Bearing Housing Bore - Measure

5.3 Cylinder Liner Fitting Bore in Crankcase - Inspect

- (1) Inspect the counterbore in crankcase. Check for cracks in edges, uneven contact between counterbore and bottom face of cylinder liner flange. If any defect is found, reface the counterbore in crankcase.
- (2) Inspect the cylinder liner fitting section in crankcase. Check for the defects such as fretting and corrosion.

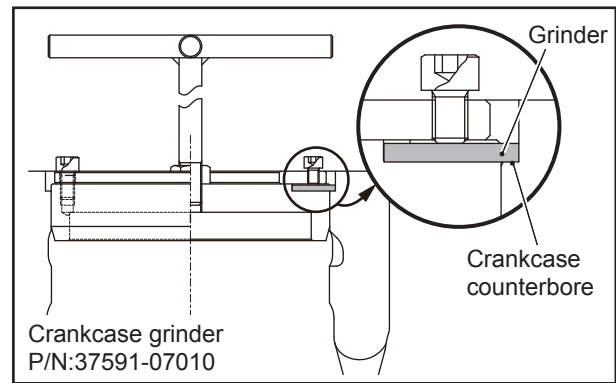


Cylinder Liner Fitting Bore in Crankcase - Inspect

5.4 Counterbore in Crankcase - Repair

If local contact is shown on counterbore in crankcase, grind and repair. Grind the counterbore with crankcase grinder to correct the difference in depth at four directions in circumference to be less than 0.05 mm [0.0020 in.]

After the grinding of counterbore in crankcase is completed, measure the cylinder liner flange protrusion.



Counterbore in Crankcase - Repair

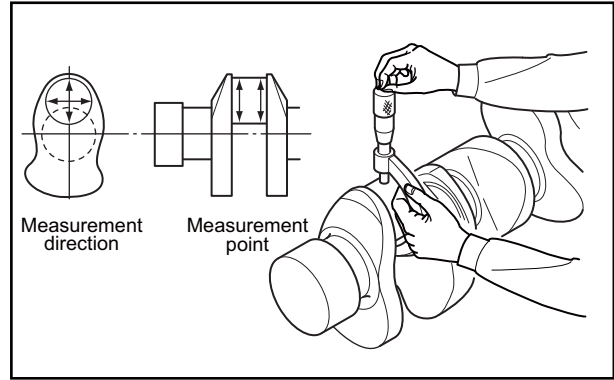
5.5 Crankpin and Journal Outside Diameters - Measure

- (1) Measure the outside diameter of crankpins and crank journals.

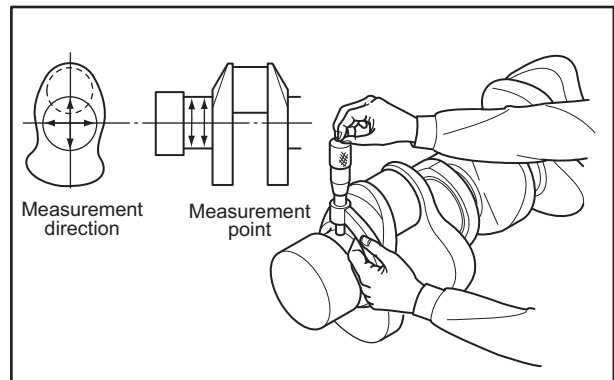
If the value exceeds the limit, use an undersize bearing, and grind the crankshaft for use with undersized bearing.

If the specified limit is exceeded even if the -1.00 mm [-0.0394 in.] undersize bearing is used, replace the crankshaft with a new one.

- (2) know the roundness and cylindricity based on measured values.



Crankpin Outside Diameter - Measure



Crank Journal Outside Diameter - Measure

5.5.1 Crankpin and Crank Journal - Grind

When using the undersize bearing, grind to the standard value corresponding to undersize bearing to be used.

Do not change the fillet radius and bearing journal width when grinding. Quench the crankshaft if its surface hardness is significantly decreased, and after quenching do the magnetic particle inspection.

After grinding, measure the width of crankpin journals and rearmost crank main journal.

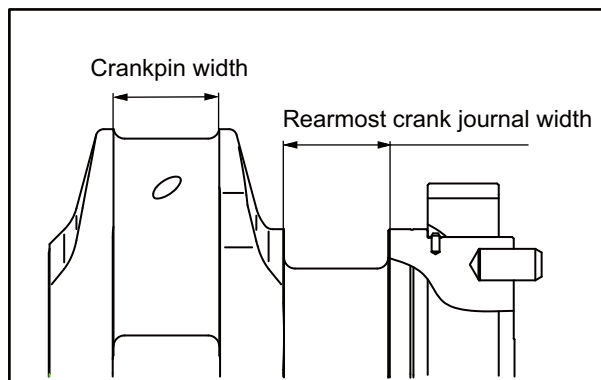
Item		Nominal value	Size		Standard value	Limit value
Crankpin outside diameter		ø125 mm [4.92 in.]	Standard		124.930 to 124.950 mm [4.9185 to 4.9193 in.]	124.890 mm [4.9169 in.]
			Under Size	0.25 mm [0.0098 in.]	124.680 to 124.700 mm [4.9087 to 4.9094 in.]	124.640 mm [4.9071 in.]
				0.50 mm [0.0197 in.]	124.430 to 124.450 mm [4.8988 to 4.8996 in.]	124.390 mm [4.8972 in.]
				0.75 mm [0.0295 in.]	124.180 to 124.200 mm [4.8890 to 4.8898 in.]	124.140 mm [4.8874 in.]
				1.00 mm [0.0394 in.]	123.930 to 123.950 mm [4.8791 to 4.8799 in.]	123.890 mm [4.8775 in.]
Crankshaft main journal outside diameter		ø140 mm [5.51 in.]	Standard		139.930 to 139.950 mm [5.5090 to 5.5098 in.]	139.890 mm [5.5075 in.]
			Under Size	0.25 mm [0.0098 in.]	139.680 to 139.700 mm [5.4492 to 5.5000 in.]	139.640 mm [5.4976 in.]
				0.50 mm [0.0197 in.]	139.430 to 139.450 mm [5.4894 to 5.4901 in.]	139.390 mm [5.4878 in.]
				0.75 mm [0.0295 in.]	139.180 to 139.200 mm [5.4795 to 5.4803 in.]	139.140 mm [5.4779 in.]
				1.00 mm [0.0394 in.]	138.930 to 138.950 mm [5.4697 to 5.4705 in.]	138.890 mm [5.4681 in.]
Pin and journal	Parallelism	-	-	-	Pin deflection at pin length: 0.01 [0.0004] or less 0.01 mm [0.0004] or less	0.03 mm [0.0012 in.]
	Roundness	-	-	-	Diameter difference: 0.01 mm [0.0004 in.] or less	0.03 mm [0.0012 in.]
	Cylindricity	-	-	-	Diameter difference: 0.01 mm [0.0004 in.] or less	0.03 mm [0.0012 in.]
	Fillet radius	Pin	R7 [0.28 in.]	-	6.8 to 7.0 mm [0.268 to 0.276 in.]	-
		Main journal	R7 [0.28 in.]	-	6.8 to 7.0 mm [0.268 to 0.276 in.]	-
	Hardness	-	-	-	Hv > 620	-
	Surface roughness	-	-	-	Ra 0.2 µm [0.008 µin.]	-
Angular deviation between pins		-	-	-	±20'	-

5.6 Width of Crankpin and Rearmost Crank Main Journal - Measure

(1) Inspect the ends of crankshaft for harmful flaw and wear.

(2) Measure the crankpin and rearmost crank main journal width.

When using oversize thrust plate due to wear of rearmost crank journal width, grind the crankshaft for use with oversize thrust plate.



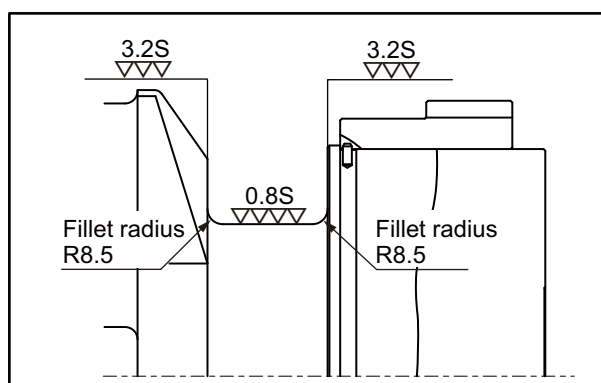
Width of Crankpin and Rearmost Crank Main Journal - Measure

5.6.1 Rearmost Crank Main Journal Width - Grind

When using the oversize thrust plate, grind the rearmost crank journal width for use with oversize thrust plate.

Do not change the fillet radius when grinding. Quench the crankshaft if its surface hardness is significantly decreased, and after quenching do the magnetic particle inspection. Ensure that the finishing surface roughness after grinding is in the standard value.

Note: The difference of thickness between front and rear thrust plates must be 0.25 mm [0.0098 in.] or less.



Rearmost Crank Main Journal Width - Grind

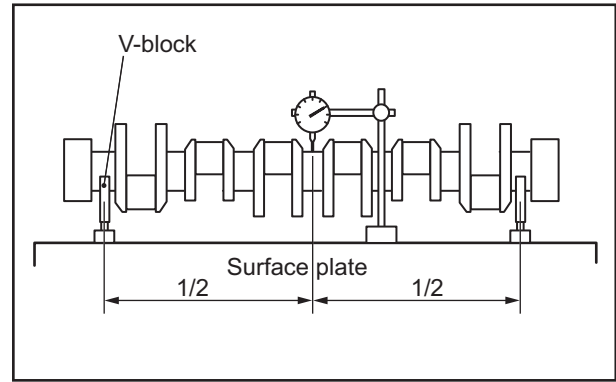
Item	Nominal value	Size		Standard value
Crankpin width	67 mm [2.64 in.]	-		67.20 to 67.30 mm [2.6457 to 2.6496 in.]
Rearmost crank journal width	66 mm [2.60 in.]	Standard		66.00 to 66.05 mm [2.598 to 2.600 in.]
		Over size	0.25 mm [0.0098 in.]	66.25 to 66.30 mm [2.6083 to 2.6102 in.]
			0.50 mm [0.0197 in.]	66.50 to 66.55 mm [2.6181 to 2.6201 in.]
			0.75 mm [0.0295 in.]	66.75 to 66.80 mm [2.6279 to 2.6299 in.]
			1.00 mm [0.0394 in.]	67.00 to 67.05 mm [2.6378 to 2.6398 in.]
			1.25 mm [0.0492 in.]	67.25 to 67.30 mm [2.6476 to 2.6496 in.]
			1.50 mm [0.0591 in.]	67.50 to 67.55 mm [2.6575 to 2.6594 in.]

5.7 Crankshaft Runout - Measure

Support the crankshaft at front and rear main journals with V-blocks, and measure the crankshaft runout at the center main journal with dial gauge. If the runout deviates slightly from the standard, correct the crankshaft by grinding. If the value exceeds the standard considerably, straighten the crankshaft with pressing machine.

If the value exceeds the limit, replace the crankshaft with a new one.

If the crankshaft is repaired by grinding or pressing, inspect the crankshaft for cracks and other harmful damage with magnetic particle inspection.



Crankshaft Runout - Measure

Item	Standard value	Limit value	Remarks
Crankshaft runout	0.04 mm [0.0016 in.] or less	0.10 mm [0.0039 in.]	TIR

5.8 Crankshaft Gear - Inspect

If there is any defect on the crankshaft gear teeth, such as flaking, wear, or local contact, replace the crankshaft gear with a new one.

5.9 Crankshaft Gear - Replace

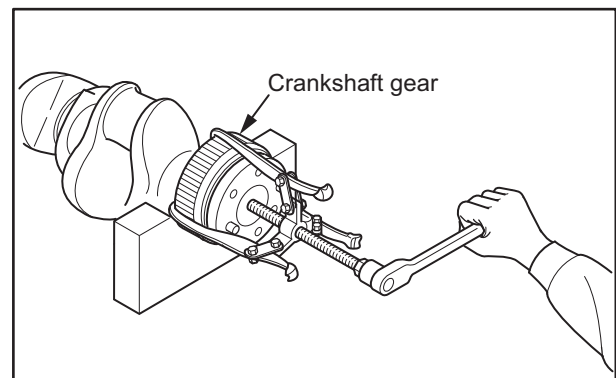
CAUTION

Use protective gloves when you touch hot parts.
Handling with bare hands could result in burns.

5.9.1 Crankshaft Gear - Remove

Using a gear puller, remove the gear from crankshaft.

Note: When removing the crankshaft gear by heating, the heating temperature is 180°C [356°F] or less.



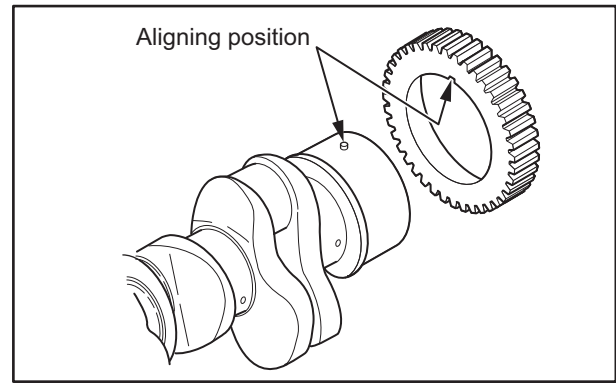
Crankshaft Gear - Remove

5.9.2 Crankshaft Gear - Install

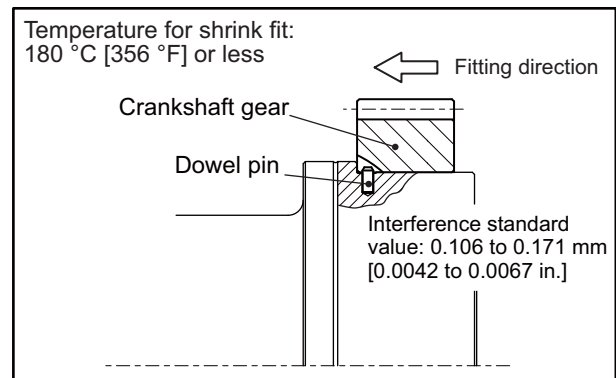
CAUTION

- Check the correct installing direction and position of crankshaft gear.
- To shrinkage-fit the crankshaft gear to crankshaft, heat the crankshaft gear evenly to the specified temperature.

- Measure the outside diameter of crankshaft and inside diameter of crankshaft gear, and check the interference.
- Heat the crankshaft gear evenly to the specified temperature. After checking gear direction and position, install the crankshaft gear.



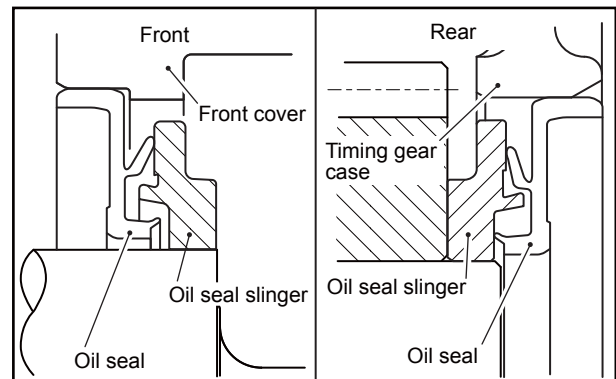
Crankshaft Gear - Install



Crankshaft Gear Installation Direction

5.10 Oil Seal Slinger - Inspect

If any defect such as dent, damage, wear and looseness that can lead to oil leakage is found, replace the oil seal slinger with a new one.



Oil Seal Slinger - Inspect

5.11 Oil Seal Slinger - Replace

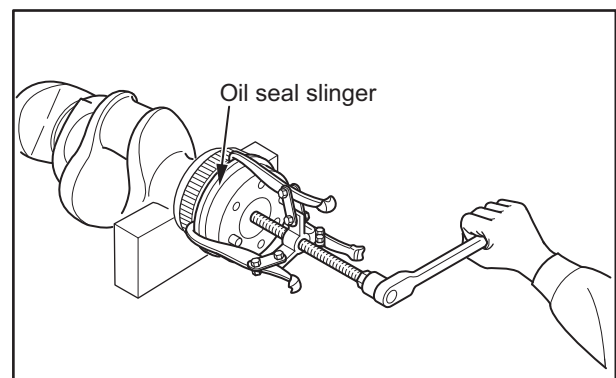
CAUTION

Use protective gloves when you touch hot parts. Handling with bare hands could result in burns.

5.11.1 Oil Seal Slinger - Remove

Using a gear puller, pull out the oil seal slinger from crankshaft.

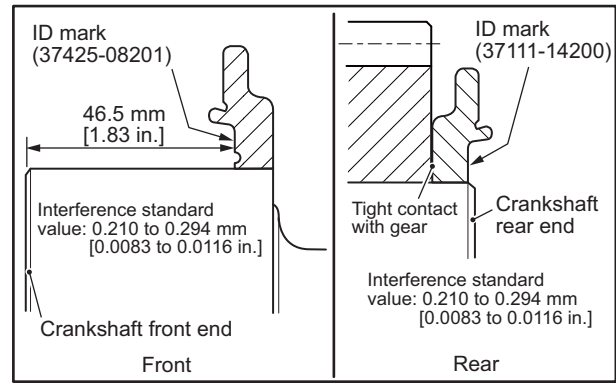
Note: When removing the oil seal slinger by heating, the heating temperature is 100°C [212°F] or less.



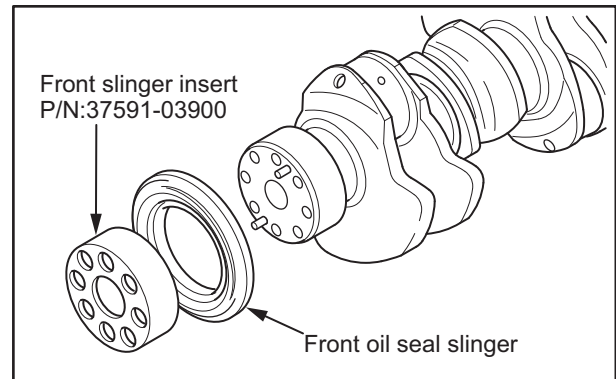
Oil Seal Slinger - Remove

5.11.2 Oil Seal Slinger - Install

- (1) Measure the outside diameter of crankshaft and inside diameter of oil seal slinger, and check the interference.
- (2) Heat the oil seal slinger evenly to the temperature of 110°C [230°F] or less. After checking the correct direction and position of slinger, install the slinger.



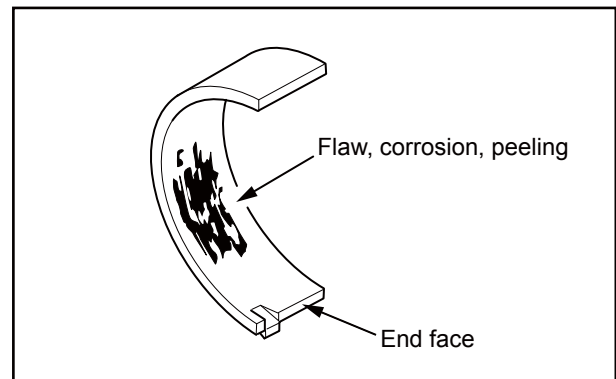
Oil Seal Slinger - Install



Front Oil Seal Slinger - Install

5.12 Main Bearing - Inspect

Inspect the sliding surface, back surface and end surface of main bearing. If any defect such as local contact, sliding scratches, corrosion and foreign material inclusion is found, replace the main bearing with a new one.



Main Bearing - Inspect

5.13 Thickness of Main Bearing Shell - Measure

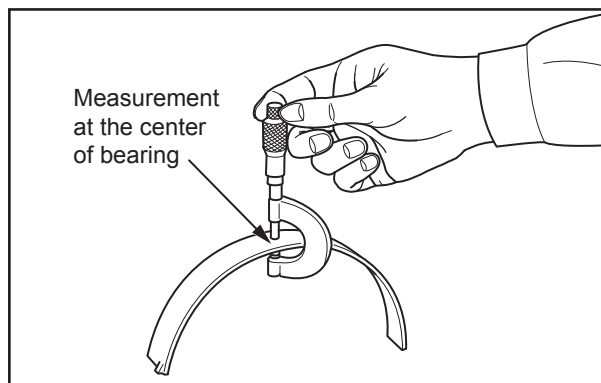
Measure the thickness of main bearing shell at its center.

If the value exceeds the limit, replace both upper and lower main bearing shells with new ones as a set.

When the crankshaft is re-ground due to wear of crank journal, use the undersize bearing.

For the crankshaft grinding procedure, refer to "Crankpin and Crank Journal - Grind" of "INSPECTION AND REPAIR OF BASIC ENGINE."

Note: Replacement shells for undersized main bearing are available in sizes of 0.25, 0.50, 0.75 and 1.00 mm [0.0098, 0.0197, 0.0295 and 0.0394 in.]

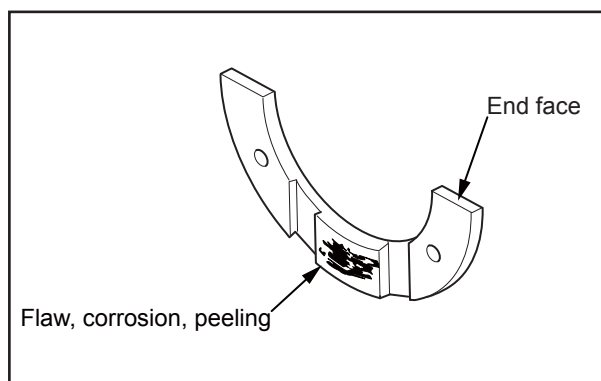


Thickness of Main Bearing Shell - Measure

Item	Size		Nominal value	Standard value	Limit value
Main bearing thickness at center	Standard		3.500 mm [0.1378 in.]	3.467 to 3.480 mm [0.1365 to 0.1370 in.]	3.425 mm [0.1348 in.]
	Under size	0.25 mm [0.0098 in.]	3.625 mm [0.1427 in.]	3.592 to 3.605 mm [0.1419 to in.]	3.550 mm [0.1398 in.]
		0.50 mm [0.0197 in.]	3.750 mm [0.1476 in.]	3.717 to 3.730 mm [0.1463 to 0.1469 in.]	3.675 mm [0.1447 in.]
		0.75 mm [0.0295 in.]	3.875 mm [0.1526 in.]	3.842 to 3.855 mm [0.1513 to 0.1518 in.]	3.800 mm [0.1496 in.]
		1.00 mm [0.0394 in.]	4.000 mm [0.1575 in.]	3.967 to 3.980 mm [0.1562 to 0.1567 in.]	3.925 mm [0.1545 in.]

5.14 Thrust Plate - Inspect

Inspect the sliding surface, back surface and end surface of thrust plate. If any defect such as local contact, sliding scratches, corrosion and foreign material inclusion is found, replace the thrust plate with a new one.



Thrust Plate - Inspect

5.15 Thickness of Thrust Plate - Measure

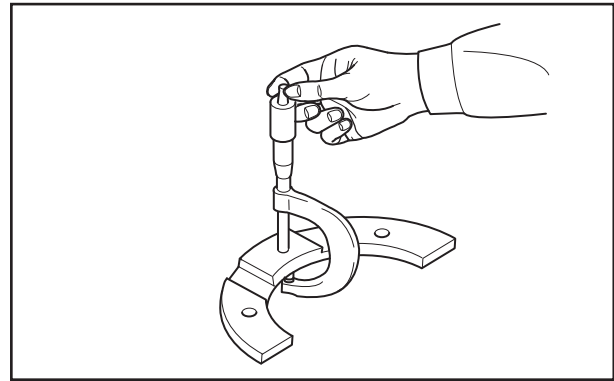
Measure the thickness of thrust plate.

If the value exceeds the limit, replace the thrust plate with a new one. When the crankshaft is re-ground due to wear, use the oversize thrust plate.

For the crankshaft grinding procedure, refer to "Rearmost Crank Journal Width - Grind" of "INSPECTION AND REPAIR OF BASIC ENGINE."

Note:(a) Replacement thrust plates are available in three oversizes of 0.25, 0.50, 0.75 mm [0.0098, 0.0197, 0.0295 in.]

(b) Because the oversize thrust plate can be used in only one side (a set of upper and lower), the end play can be adjusted with a minimum crankshaft grinding.



Thickness of Thrust Plate - Measure

Item	Size		Nominal value	Standard value	Limit value
Thickness of thrust plate	Standard		5.00 mm [0.1969 in.]	4.78 to 4.85 mm [0.1882 to 0.1909 in.]	4.71 mm [0.1854 in.]
	Over size	0.25 mm [0.0098 in.]	5.25 mm [0.2067 in.]	5.03 to 5.10 mm [0.1980 to 0.2008 in.]	4.96 mm [0.1953 in.]
		0.50 mm [0.0197 in.]	5.50 mm [0.2165 in.]	5.28 to 5.35 mm [0.2079 to 0.2106 in.]	5.21 mm [0.2051 in.]
		0.75 mm [0.0295 in.]	5.75 mm [0.2264 in.]	5.53 to 5.60 mm [0.2177 to 0.2205 in.]	5.46 mm [0.2150 in.]

5.16 Piston Cooling Nozzle - Inspect

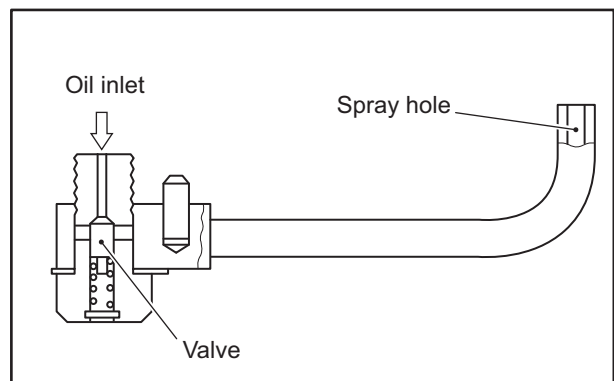
CAUTION

If oil jet pipe of piston cooling nozzle is bent or deformed, it will reduce the cooling performance, and can lead to piston seizure.

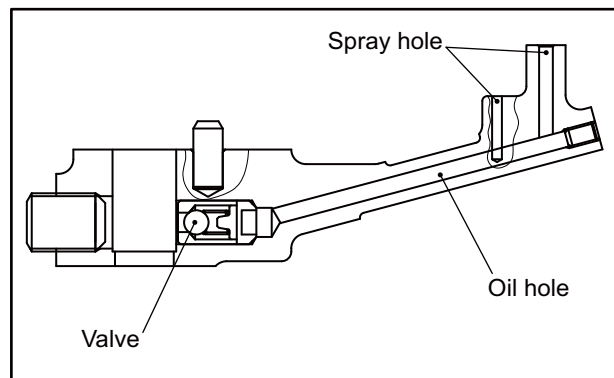
Inspect the piston cooling nozzle.

If there is any defect such as valve malfunction and oil hole clogging, replace the piston cooling nozzle with a new one.

Item	Standard value	
Piston cooling nozzle valve opening pressure	One jet spec	0.26 to 0.32 MPa {2.7 to 3.3 kgf/cm ² } [38 to 47 psi]
	Two jet spec	0.10 to 0.15 MPa {1.0 to 1.5 kgf/cm ² } [14 to 21 psi]



Piston Cooling Nozzle (One Jet Spec) - Inspect



Piston Cooling Nozzle (Two Jet Spec) - Inspect

Chapter 7 ASSEMBLY OF BASIC ENGINE

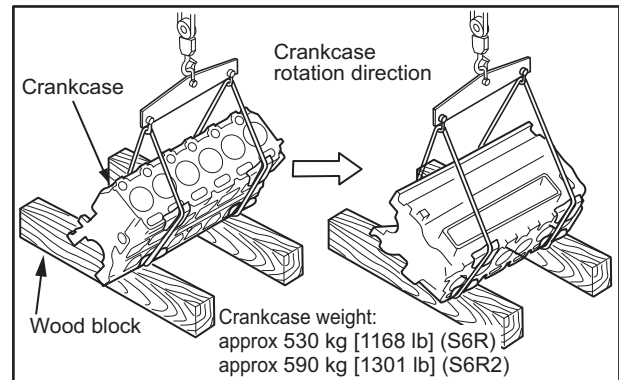
1. Crankshaft and Main Bearing - Install	7-3
1.1 Crankcase - Turn Over (Upend)	7-3
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1.3 Upper Main Bearing - Install	7-4
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1. Crankshaft and Main Bearing - Install

1.1 Crankcase - Turn Over (Upend)

Using a turnover machine, turn over the crankcase. When the turnover machine is not available, hitch slings to the crankcase using wood pieces and cloth pads, and raise the crankcase with a hoist or crane. Then lay it on the wooden block with its side facing downward. Then, change the positions of the slings, and turn over to upend the crankcase.



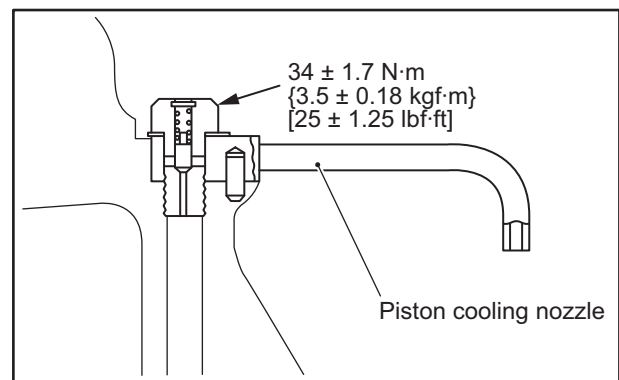
Crankcase - Turn Over (Upend)

1.2 Piston Cooling Nozzle - Install

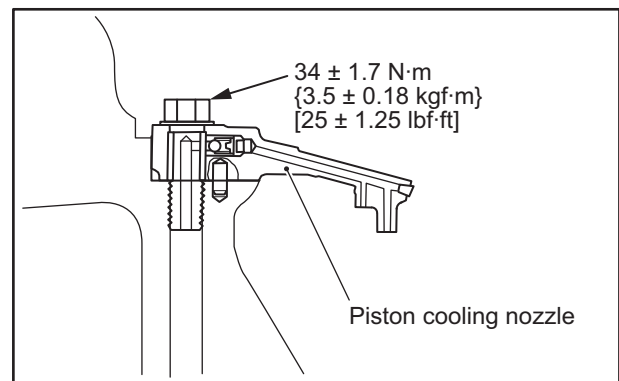
CAUTION

Be sure to tighten the piston cooling nozzle to the specified torque using a torque wrench. If the nozzle is over-tightened, it may cause the valve malfunction, and lead to piston seizure.

Install the piston cooling nozzle into the crankcase and tighten the eye bolt or check valve to the specified torque.



Piston Cooling Nozzle - Install (One Jet Spec)



Piston Cooling Nozzle - Install (Two Jet Spec)

1.3 Upper Main Bearing - Install

CAUTION

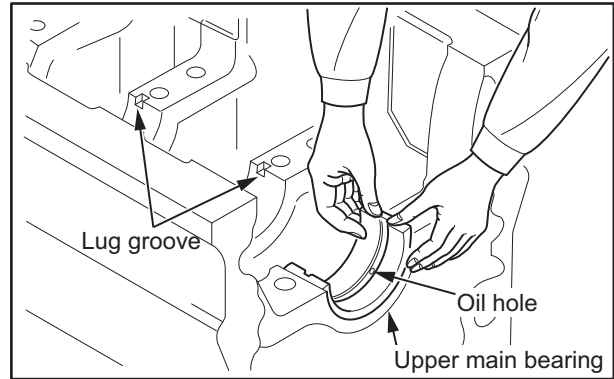
- (a) Do not apply engine oil to the back face of the main bearing shell and main bearing fitting bore in the crankcase when installing the main bearing. Install the main bearing only after cleaning off foreign material, oil and grease from these surface using cleaning solvent.
- (b) When installing main bearings, be careful not to confuse the upper shell with lower shell.
The upper main bearing shell is identified by machined oil hole. The lower main bearing shell has no oil hole nor groove. Be careful not to install the main bearing upside down.
- (c) Be careful not to damage the bearing when installing.

- (1) Clean the main bearing fitting bore and main bearing cap mating surfaces using cleaning solvent, and make sure that these surfaces are free from any foreign material.
- (2) Make sure that the main bearing is free from damage and contamination.
- (3) Fit the upper main bearing shell in the crankcase bore aligning the lug on the shell with the lug slot in the crankcase.

Note:(a) Make the main bearing crush heights even at both ends.

- (b) The oil hole in the upper main bearing shell is aligned with the oil hole in the crankcase by aligning the lug on upper shell with the lug slot in the crankcase.

- (4) Apply an even coat of clean engine oil to the sliding surface of upper main bearing shell.



Upper Main Bearing - Install

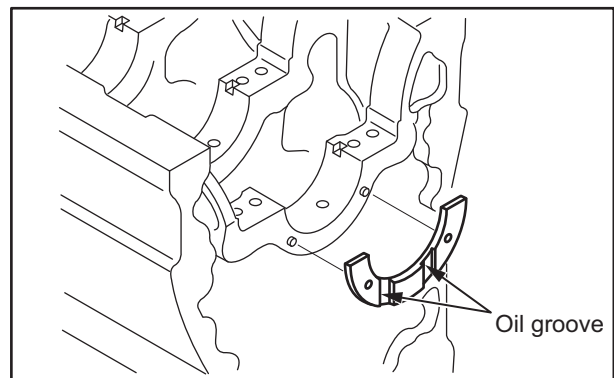
1.4 Rear Upper Thrust Plate - Install

CAUTION

Be careful not to damage the thrust plate when installing.

- (1) With the oil grooves of the thrust plate facing outside, install the rear upper thrust plate to the dowel pins on the crankcase rearmost main journal.
- (2) Apply engine oil evenly to the sliding surface.

Note: Front upper thrust plate is to be installed after the crankshaft installation.



Rear Upper Thrust Plate - Install

1.5 Crankshaft - Install

(1) Make sure that the sliding surfaces of the upper main bearing shells installed in the crankcase are evenly coated with clean engine oil.

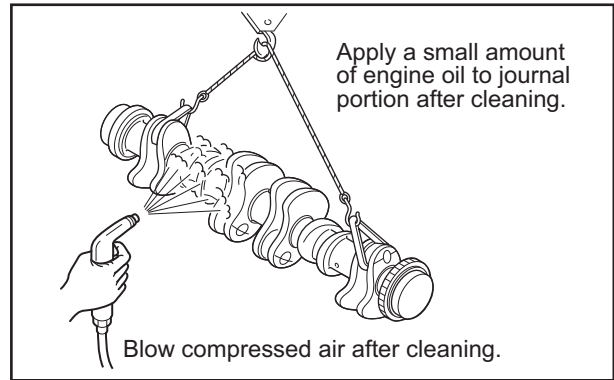
(2) Thoroughly clean the crankshaft with cleaning oil, and blow off the oil with compressed air. Then, apply an even coat of clean engine oil to the crankshaft journals.

Note: When cleaning crankshaft, be sure to thoroughly clean the crank journals, crankpins, and oil holes and make sure that the crankshaft is free from foreign material such as machining chips and dirt. Make sure that oil holes are free from burrs.

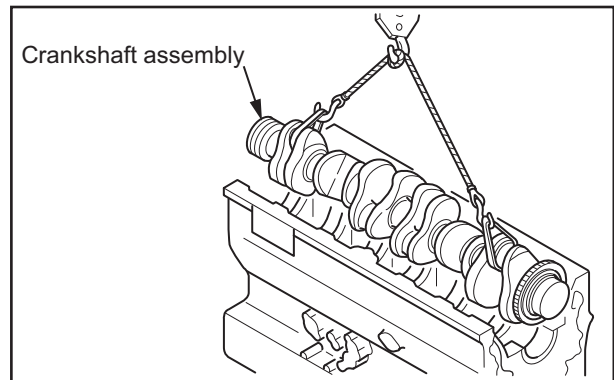
(3) Lift the crankshaft keeping in a horizontal attitude, and slowly install into the crankcase.

Note: When lifting the crankshaft, use fiber slings or pads to avoid any damage to the crankshaft.

(4) Slowly rotate the crankshaft to verify smooth rotation of the crankshaft.



Crankshaft - Clean



Crankshaft - Install

1.6 Front Upper Thrust Plate - Install

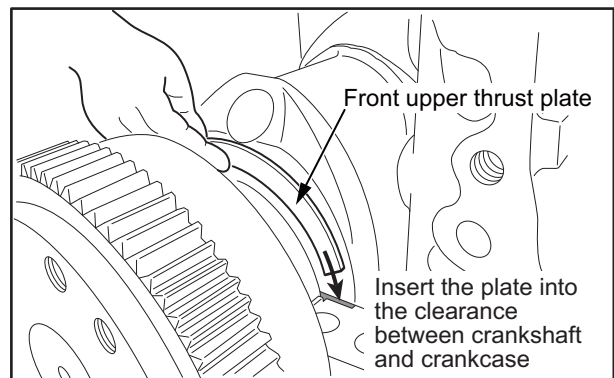
CAUTION

Be careful not to damage the front upper thrust plate when installing.

(1) Push the installed crankshaft softly toward the engine front direction to contact the installed rear upper thrust plate with the crank journal web face.

(2) With the oil grooves on the front upper thrust plate facing outside, insert the front upper thrust plate into the clearance between the crankshaft and crankcase.

(3) Move the crankshaft back and forth to verify the proper end play.



Front Upper Thrust Plate - Install

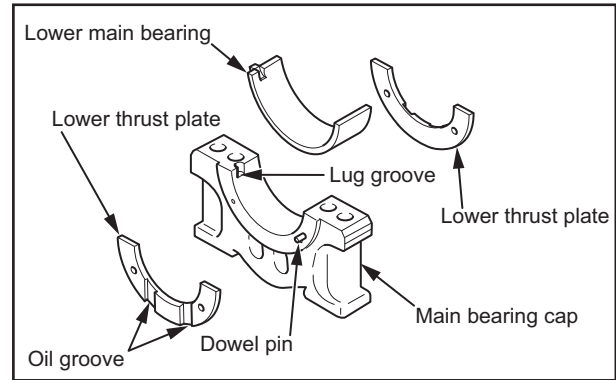
1.7 Lower Main Bearing Shell and Lower Thrust Plate - Install

- (1) Install the lower main bearing shell, aligning the lug with the lug slot in the main bearing cap.

Note: Make the crush heights even.

- (2) Apply an even coat of clean engine oil to the sliding surfaces of lower main bearing shells.
- (3) Install the lower thrust plates aligning with the dowel pins to the rearmost main bearing cap.

Note: Install the lower thrust plates so that the oil groove faces outer side of the cap.



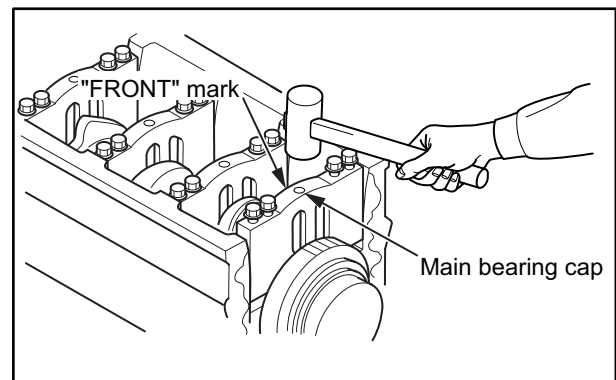
Lower Main Bearing and lower Thrust Plates - Install

1.8 Main Bearing Cap - Install

CAUTION

Be sure to tighten the bolts in the specified sequence when installing the main bearing cap bolts.

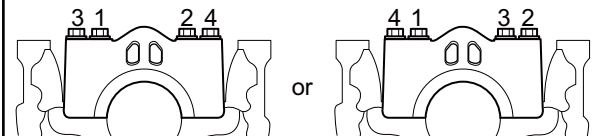
- (1) Make sure that the main bearings and thrust plates installed to main bearing caps are evenly coated with clean engine oil.
- (2) Install the main bearing caps so that their stamp numbers are arranged in numerical order from engine front to rear, and all lugs are aligned on the same side, which shows the embossed mark of "FRONT" faces toward the engine front.
- (3) Apply oil to the main bearing cap bolts and washers and hand tighten them.
- (4) Tap the main bearing caps with a soft-head hammer evenly to install them in position.
- (5) Tighten temporary the main bearing cap bolt except for rearmost one to the half of specified torque in the illustrated order.
- (6) Tighten the main bearing cap bolts and side bolts except the rearmost ones to the specified torque in the specified sequence shown in the illustration.
- (7) Hand tighten the rearmost cap bolts and side bolts to make the rearmost main bearing be lightly seated. Measure the crankshaft end play in this condition.



Main Bearing Cap - Install

Tighten to the specified torque in the numerical order in two steps. [Wet]

First time:	Second time:
245 ± 12.3 N·m	490 ± 24.5 N·m
{25 ± 1.25 kgf·m}	{50 ± 2.5 kgf·m}
[181 ± 9.1 lbf·ft]	[361 ± 18.1 lbf·ft]



Tightening Sequence of Main Bearing Cap Bolts

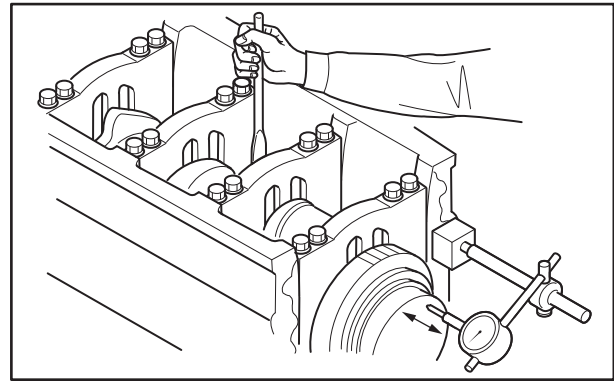
1.9 Crankshaft End Play - Measure

- (1) Verify the smooth rotation of the crankshaft.
- (2) Apply a dial gauge probe to the rear end face of crankshaft.
- (3) Using a bar, move the crankshaft fully to the front and rear to read the each measurement. The end play is the difference between the front and rear measurements.
If the value exceeds the standard value, inspect the thrust plates and the crankshaft.
If the end play is less than the standard value, loosen the rear most bearing cap bolts and move the crankshaft back and forth, and measure the end play again.
- (4) After tightening the rearmost main bearing cap to the specified torque, measure the end play again to verify.
- (5) Again, verify the crankshaft smooth rotation.
- (6) Check that the all main bearing cap bolts are correctly tightened.

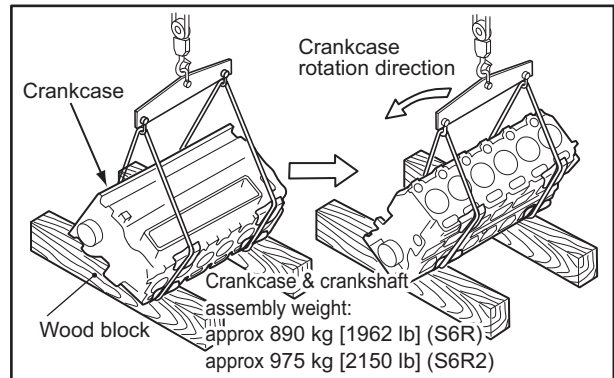
Item	Standard value	Limit value
Crankshaft end play	0.300 to 0.520 mm [0.012 to 0.21 in.]	0.600 mm [0.24 in.]

1.10 Crankcase - Turn Over

Using a turnover machine, turn over the crankcase. When the turnover machine is not available, hitch slings to the crankcase using wood pieces and cloth pads, and raise the crankcase with a hoist or crane. Then lay it on the wooden block with its side facing downward. Then, change the sling positions. Turn over the crankcase on the wooden blocks to turn it to the normal position.



Crankshaft End Play - Measure



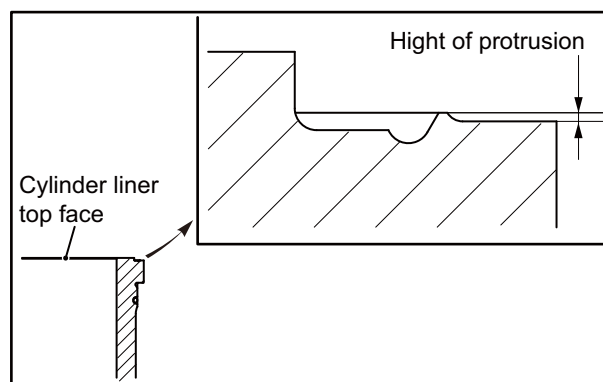
Crankcase - Turn Over

2. Cylinder Liner, Piston and Connecting Rod - Assemble

2.1 Cylinder Liner Protrusion - Measure

- (1) Place the dial gauge probe on the top surface of cylinder liner flange, and adjust the dial gauge to zero.
- (2) Slide the probe to measure the protrusion of the cylinder liner at four places.
- (3) If the value exceeds the limit, or if the ridge is cracked, replace the cylinder liner with a new one.

Item	Standard value
Cylinder liner protrusion	0.16 to 0.24 mm [0.0063 to 0.0094 in.]



Cylinder Liner Protrusion - Measure

2.2 Cylinder Liner Flange Protrusion - Calculate (When Cylinder Liner Not Installed)

CAUTION

If the amount of protrusion is not enough, the contact pressure of cylinder head gasket is low, and it can result in gas and water leakage.

- (1) Inspect the cylinder liner contact surface on the crankcase. If uneven contact is shown, reface the counterbore with the crankcase grinder to correct the depth difference at four places in circumference to be less than 0.05 mm [0.0020 in.]

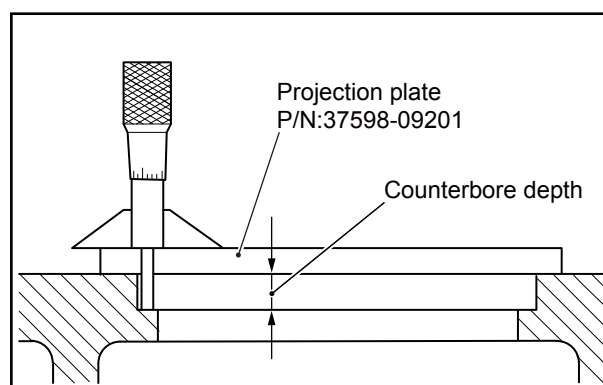
For repair procedure, refer to "Counterbore in Crankcase - Repair" of "INSPECTION AND REPAIR OF BASIC ENGINE."

- (2) Make sure that the top and bottom faces of cylinder liner flange, the top surface of crankcase and the fitting surfaces of cylinder liner are clean before measurement.
- (3) Measure the depth of counterbore in crankcase.

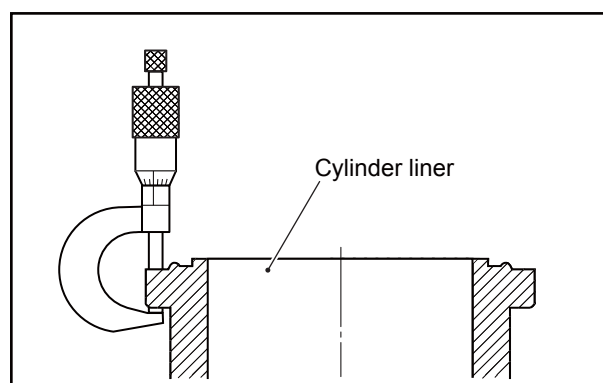
Item	Standard value
Depth of counterbore in crankcase	14.00 to 14.05 mm [0.5512 to 0.5531 in.]

- (4) Measure the thickness of cylinder liner flange.

Item	Standard value
Thickness of cylinder liner flange	14.16 to 14.20 mm [0.5575 to 0.5591 in.]



Depth of Counterbore in Crankcase - Measure



Thickness of Cylinder Liner Flange

- (5) Calculate the cylinder liner flange protrusion by subtracting the depth of counterbore in crankcase from the thickness of the cylinder liner flange.

If the value exceeds the limit, insert a shim under the cylinder liner flange. Select a shim which makes the cylinder liner flange protrusion the largest within the tolerance of the standard.

Note:(a) Shims are available in 3 sizes: 0.05, 0.10 and 0.15 mm [0.0020, 0.0039 and 0.0059 in.]

(b) Do not double the shims.

Item	Standard value
Cylinder liner flange protrusion	0.11 to 0.20 mm [0.0043 to 0.0079 in.]

Shim thickness	Part No.
0.05 ± 0.02 mm [0.0020 ± 0.0008 in.]	37507-12510
0.10 ± 0.02 mm [0.0039 ± 0.0008 in.]	37507-12500
0.15 ± 0.02 mm [0.0059 ± 0.0008 in.]	37507-12520

2.3 Cylinder Liner - Install

CAUTION

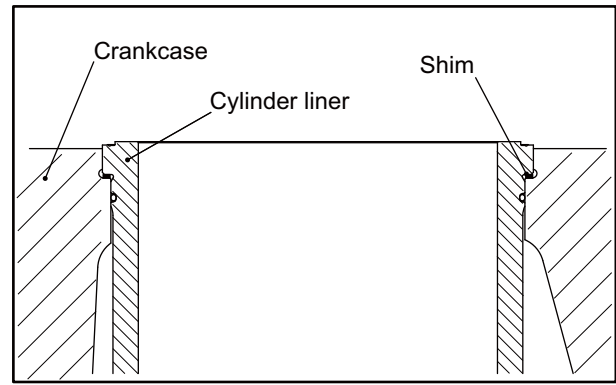
Apply engine oil to the O-ring sliding surfaces to prevent O-rings from twisting.

Do not apply engine oil to the O-ring grooves on cylinder liner.

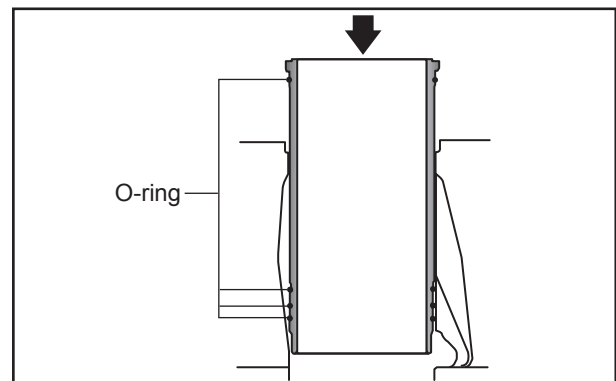
- (1) Install the O-rings to the cylinder liner.
- (2) Insert the shim to the cylinder which needs the adjustment of cylinder liner flange protrusion.
- (3) Apply engine oil to the O-ring fitting bore in Crankcase and cylinder liner O-ring sliding surfaces.

- (4) Slowly insert the cylinder liner into the bore in the crankcase. With a correct cylinder liner installer, lightly tap the cylinder liner until its flange contacts snugly on the seating surface of the crankcase. Then, lightly tap the liner several times to verify the stable seating.

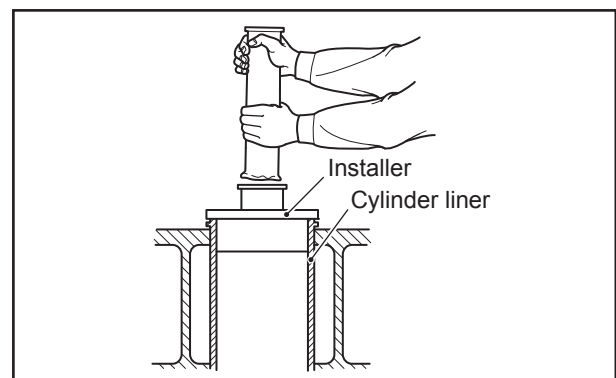
Note: To verify the correct O-rings installation, measure the roundness of inside diameter of the cylinder liner (especially O-ring installing position.)



Shim - Insert



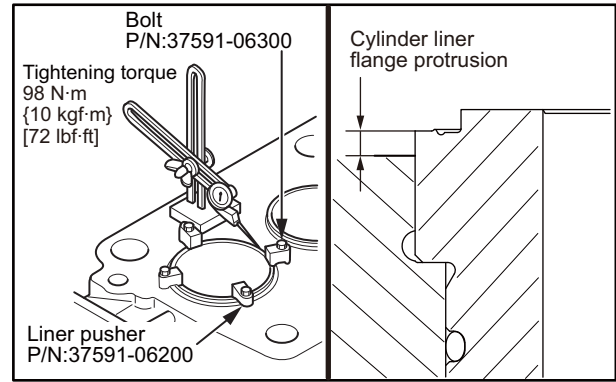
Cylinder Liner O-Rings - Install



Cylinder Liner - Install

2.4 Cylinder Liner Flange Protrusion - Measure (When Cylinder Liner Installed)

- (1) Remove dust and dirt from the crankcase top face and the cylinder liner top end face to measure.
- (2) Place the liner pusher on equally spaced 4 positions of the cylinder liner upper rim and tighten the pusher bolts evenly to make a close contact of the cylinder liner and the crankcase.
- (3) Apply a dial gauge probe to the top face of the crankcase, and the dial gauge to zero.
- (4) Slide the probe to measure the flange protrusion at four places on the top of the cylinder liner, and calculate the mean value.
- (5) If the mean value of the protrusion is smaller than the standard, insert a shim under the cylinder liner flange.
For shim and standard value, refer to "Cylinder Liner Flange Protrusion - Calculate (When Cylinder Liner Not Installed)" of "ASSEMBLY OF BASIC ENGINE."



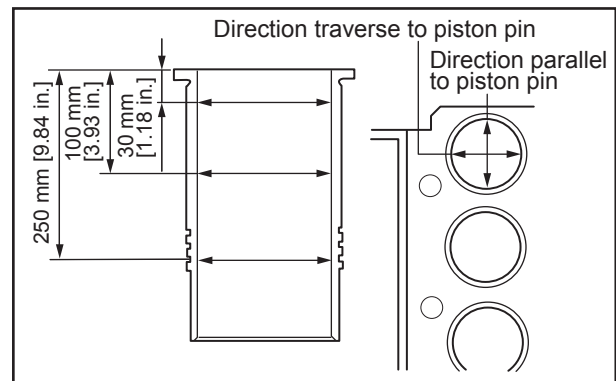
Cylinder Liner Flange Protrusion - Measure

2.5 Cylinder Liner Inside Diameter - Measure

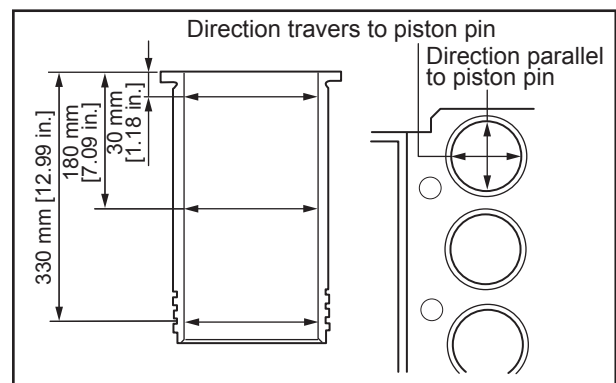
Measure the inside diameter of the cylinder liner at three levels, i.e., upper (position of No.1 compression ring when piston is at the top dead center), liner middle position, and O-ring installed position, in both parallel and perpendicular directions to the piston pin direction.

Replace the cylinder liner if the value exceeds the limit. If the liner is distorted, pull-out the liner and re-install paying attention to O-rings.

Item	Part No.	Nominal value	Standard value	Limit value
Inside diameter	37507-22700 (S6R)	ø170 mm [6.69 in.]	170.02 to 170.04 mm [6.6937 to 6.6945 in.]	170.100 mm [6.697 in.]
	37507-55600 (S6R2)	ø170 mm [6.69 in.]	170.00 to 170.04 mm [6.6926 to 6.6945 in.]	
Roundness	-	-	0.02 mm [0.0008 in.] or less	-
Cylindricity	-	-	0.02 mm [0.0008 in.] or less	-



Cylinder Liner Dimension Measuring Position (S6R)



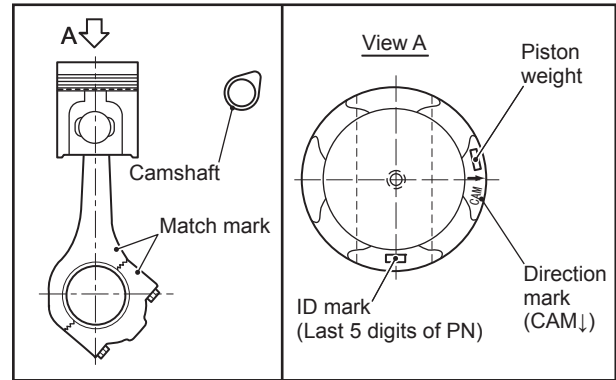
Cylinder Liner Dimension Measuring Position (S6R2)

2.6 Piston and Connecting Rod - Assemble

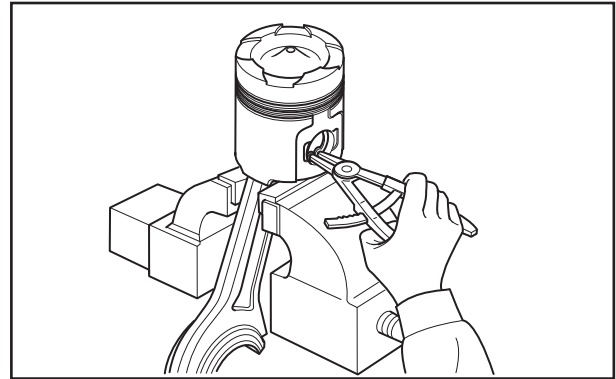
- (1) Apply engine oil to the piston pin, and assemble the piston and the connecting rod. The orientation of piston and connecting rod is shown in the illustration.

Note: The piston and piston pin are made for a clearance fit. However, the piston pin is more easily inserted into the piston if the piston is warmed up with a heater or with hot water.

- (2) Install the snap ring with ring pliers. Make sure that the snap ring is fully inserted into the ring groove.



Assembling Orientation of Piston and Connecting Rod



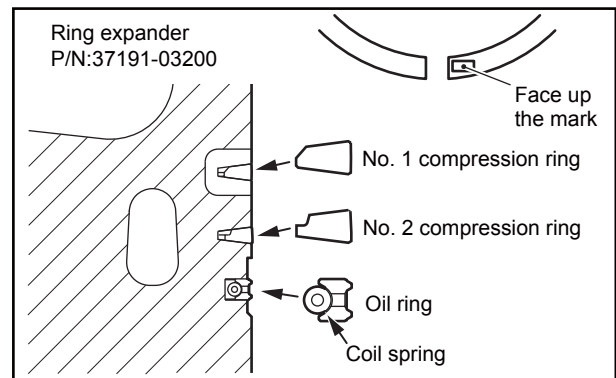
Piston and Connecting Rod - Assemble

2.7 Piston Ring - Install

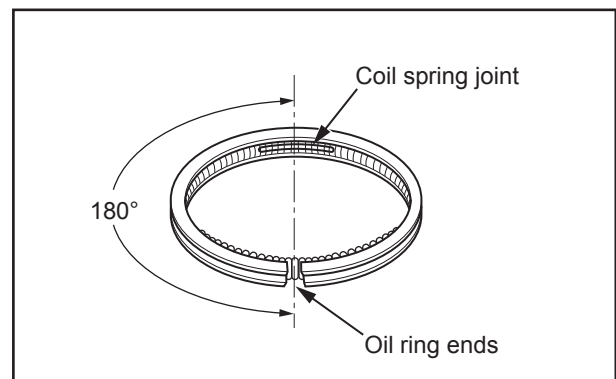
CAUTION

Every piston ring has a top mark near the end gap. Install piston rings with the marks facing upward. Be careful not to install piston rings upside down. If piston rings are assembled incorrectly, it results in defects such as engine seizure.

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



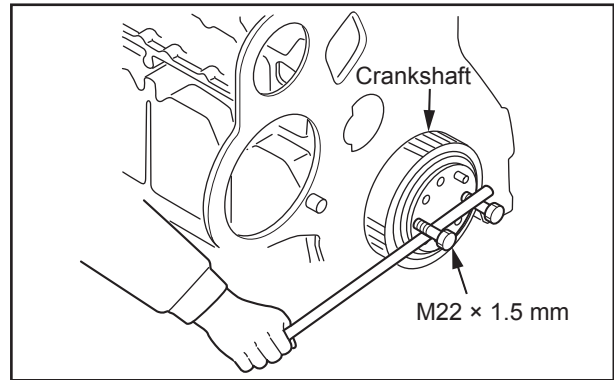
Piston and Piston Ring - Install



Oil Ring and Coil Spring Assembling

2.8 Crankshaft - Turn

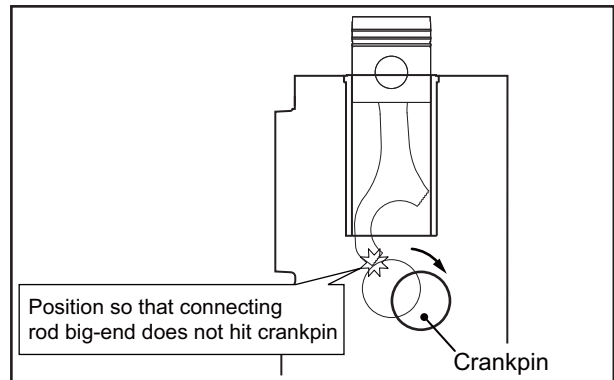
- (1) Install two bolts to the flywheel mounting holes of the crankshaft.
- (2) Using the bolts, turn the crankshaft with a bar.



Crankshaft - Turn

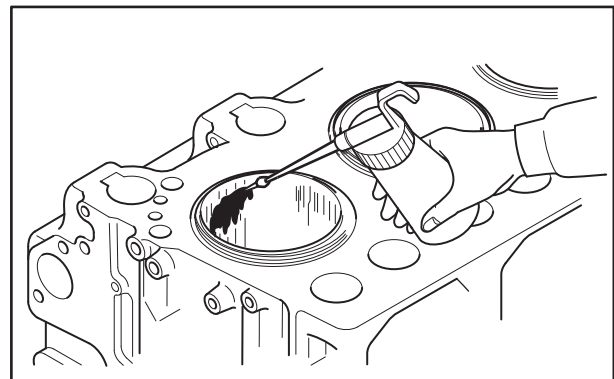
2.9 Piston Installation - Prepare

- (1) Turn the crankshaft to a position where the connecting rod big end does not hit the crankpin on the piston installing.



Position of Crankpin - Adjust

- (2) Clean the cylinder liner inner surface and the crankpin, and apply engine oil to the cylinder liner.



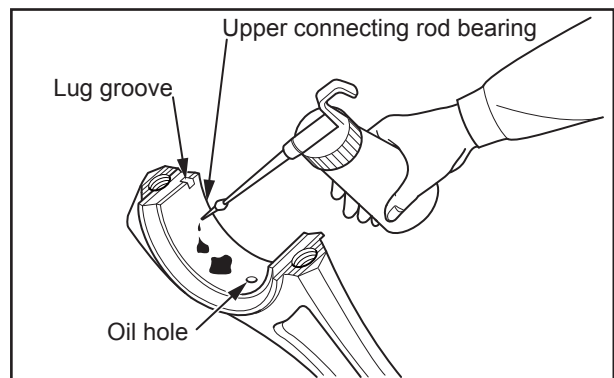
Piston Installation - Prepare

2.10 Upper Connecting Rod Bearing - Install

CAUTION

Be careful not to put engine oil on the back face of upper connecting rod bearing.

Install the upper connecting rod bearing into connecting rod big end aligning the lug and lug slot. Apply engine oil to the sliding surface. Verify the alignment of the oil hole of connecting rod and the oil hole of bearing.



Upper Connecting Rod Bearing - Install

2.11 Piston - Install

CAUTION

When installing the piston, install the eye bolt to the threaded hole on the piston top, and lift the piston with chain block. When the installation work is done by hand, be sure to take preventive measures so that piston does not falling down, and be very careful not to hurt your hands and fingers or not to damage the parts.

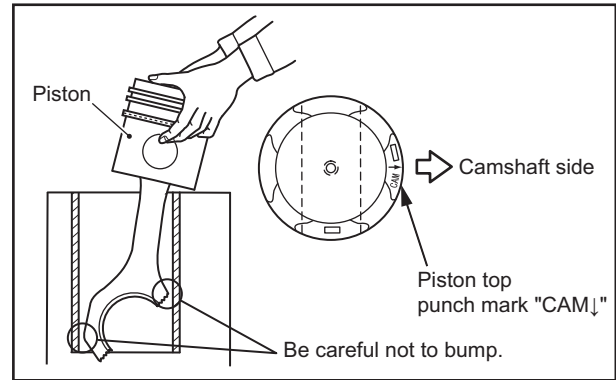
CAUTION

- (a) Make sure that the punch mark on the piston top faces the camshaft side.
- (b) Checking through the inspection window on the side of crankcase, make sure that the connecting rod does not hit the piston cooling nozzle when installing piston.
- (c) To prevent the oil ring from impact damaging, slowly insert the piston.

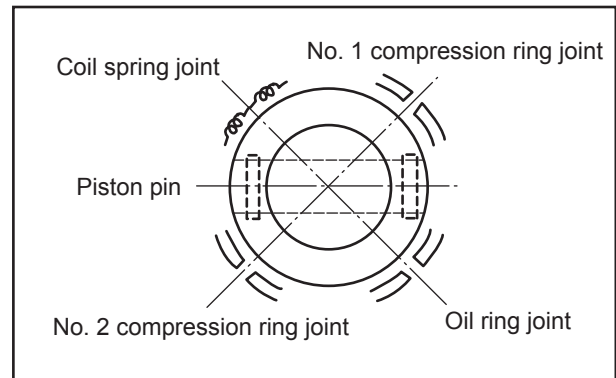
- (1) Insert the connecting rod into the cylinder liner carefully not to damage the liner, and slowly lower the piston to the upper surface of crankcase.
- (2) Apply engine oil to the piston rings.
Place the end gaps equally spaced each other, avoiding piston pin and thrust/anti-thrust directions.
- (3) Hold the compression ring position of piston with hands, and slowly insert the piston skirt into cylinder liner.

- (4) Verify again the positions of piston ring gaps.
Apply engine oil to the piston rings.
Apply engine oil to the inner surface of piston installer.
Verify the oil ring placed in the groove. Then, compress the piston rings with piston installer.

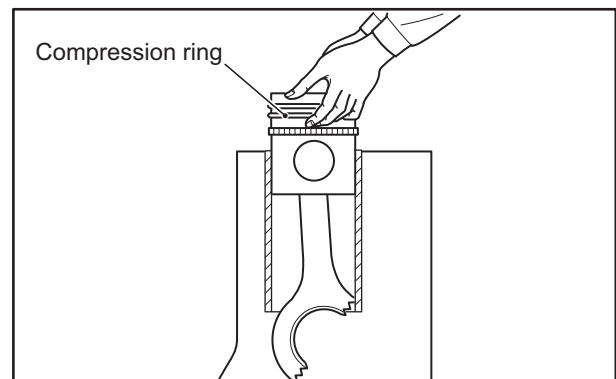
Note: For piston ring placing, see above (2).



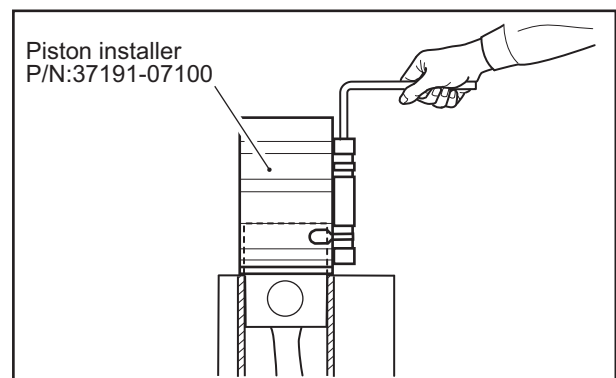
Piston and Connecting Rod - Install



Piston Ring End Gaps - Place



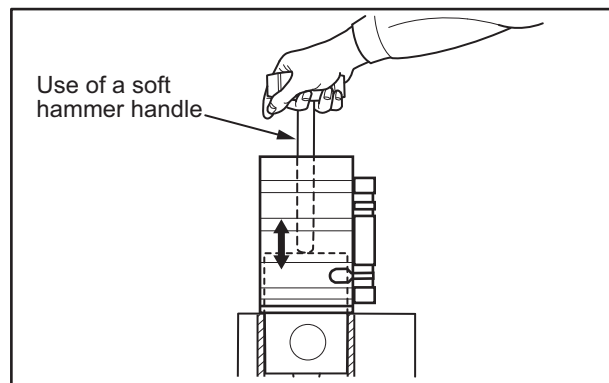
Piston Skirt - Insert



Piston Ring - Compress

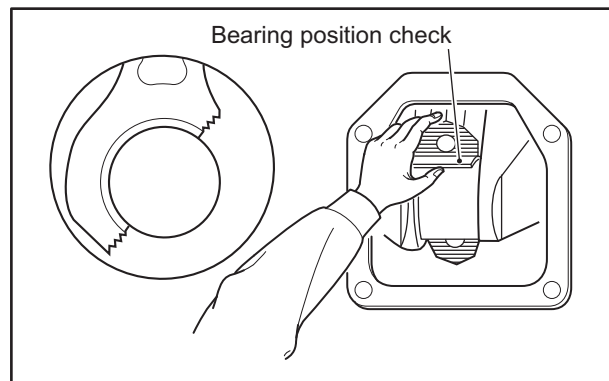
- (5) Install piston into cylinder liner by tapping the piston head with soft-head hammer.

Note: Make sure that the piston is not caught in the cylinder liner, or the connecting rod big end does not hit the crank pin.



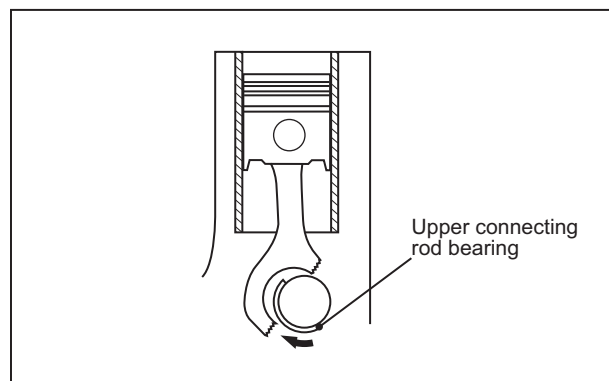
Piston- Install

- (6) Verify the proper placing of upper connecting rod bearing shell through the inspection window on crankcase side. If the bearing shell is not placed properly, push the bearing upward with your hand to correct the position.



Connecting Rod Bearing - Installation Check

- (7) If the upper connecting rod bearing is displaced from connecting rod big end, rotate the crankshaft to make a space between the connecting rod big end and crankpin. Then, insert the connecting rod bearing, sliding on the crankpin, and make sure that the lug on the bearing shell is correctly positioned in the lug slot of the rod.



Lug Groove - Align

2.12 Connecting Rod Cap - Install

CAUTION

- (a) Make sure that the matching numbers on the connecting rod and the connecting rod cap are on the same side and in alignment.
- (b) Make sure that the installing position of connecting rod bolt with the identification mark.
- (c) When installing the connecting rod cap, make sure that dust or metal particles are not caught in the serrations, bolt seating surfaces and the bolt threads.

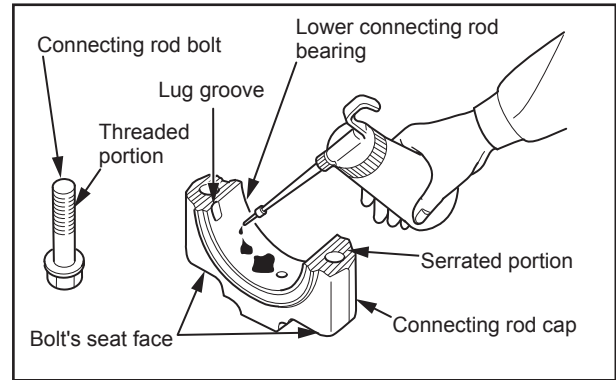
- (1) Install the lower connecting rod bearing, aligning its lug with the lug slot of the connecting rod bearing cap.
- (2) Apply engine oil to the connecting rod bolt threads and seating surface, and the sliding surface of the lower connecting rod bearing shell.
- (3) Install the connecting rod cap to the connecting rod so that the matching numbers on the connecting rod cap and the connecting rod are the same and on the same side.
- (4) Hand tighten the connecting rod bolts.

Note: Bolt identification mark

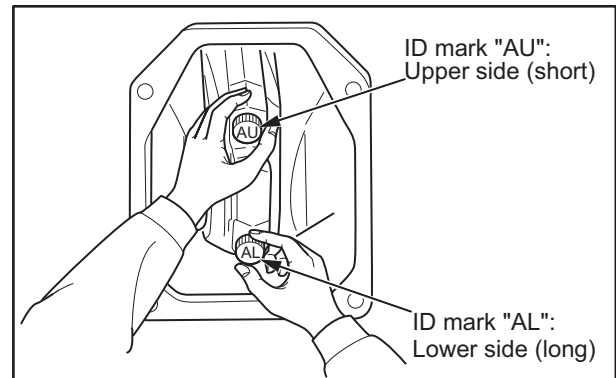
"AU": Upper (short) (P/N: 37519-21300)

"AL": Lower (long) (P/N: 37519-11400)

"2": No differentiation between upper and lower (P/N: 37519-20301)

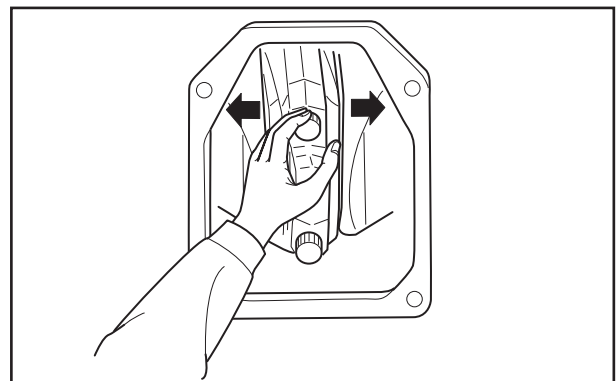


Connecting Rod Cap - Install (1)



Connecting Rod Cap - Install (2)

- (5) Align the connecting rod and rod cap side faces to ensure the rod end play.



Connecting Rod Cap - Install (3)

- (6) Measure the connecting rod end play, and adjust the end play to the range of the standard value.
- (7) Tighten the connecting rod bolts to the specified torque. After tightening to the specified torque, loosen the bolts completely and tighten again to the specified torque. Measure the end play again.

Note: To tighten the connecting rod bolts with the angle control tightening, follow the steps below.

(a) Tighten the bolts to the snug torque.

Bolt Position	Bolt Identification mark	Snug torque	Part No.
Upper	AU	245 ± 12.3 N·m {25 ± 1.25 kgf·m} [180 ± 9 lbf·ft]	37519-21300
Lower	AL	294 ± 14.7 N·m {30 ± 1.5 kgf·m} [217 ± 11 lbf·ft]	37519-11400
-	2	245 ± 12.3 N·m {25 ± 1.25 kgf·m} [180 ± 9 lbf·ft]	37519-20301

(b) Tighten the bolt by 60±3° further.

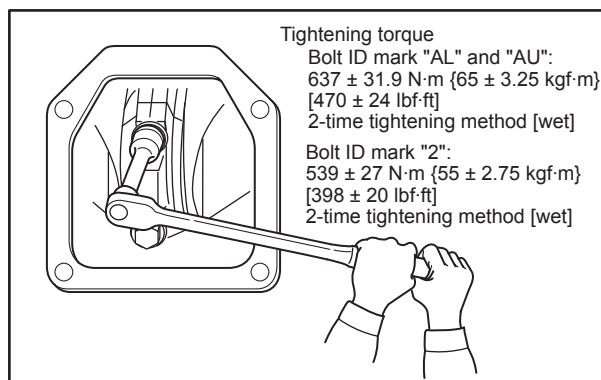
(c) Loosen all bolts, and then angle controlled tighten them again. (2-time tightening method)

2.13 Connecting Rod End Play - Measure

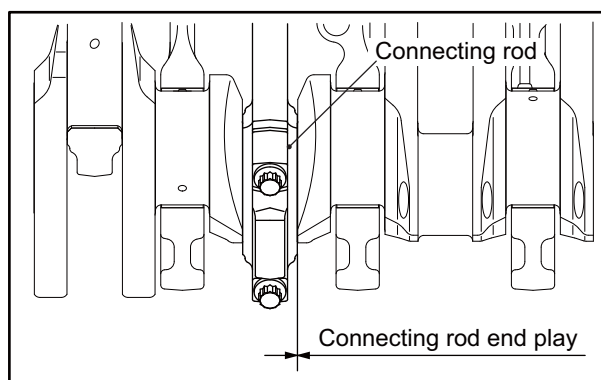
Measure the end play of the connecting rod.

If the value exceeds the limit, find the causal parts, and replace them with new ones.

Item	Standard value	Limit value
Connecting rod end play	0.4 to 0.6 mm [0.0157 to 0.0236 in.]	1.0 mm [0.040 in.]



Connecting Rod Cap - Install (4)



Connecting Rod End Play - Measure

2.14 Piston Protrusion - Measure

CAUTION

Piston protrusion must always meet the standard, as the amount of protrusion not only influences engine performance, but it also prevents valve from stamping.

Measure the protrusion of each piston, following the instructions below. If the value exceeds the limit, inspect the clearances between various parts involved.

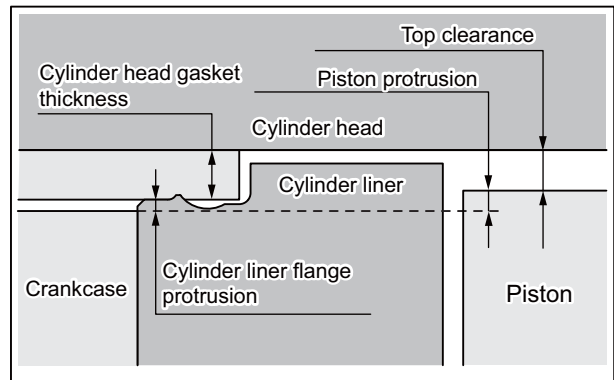
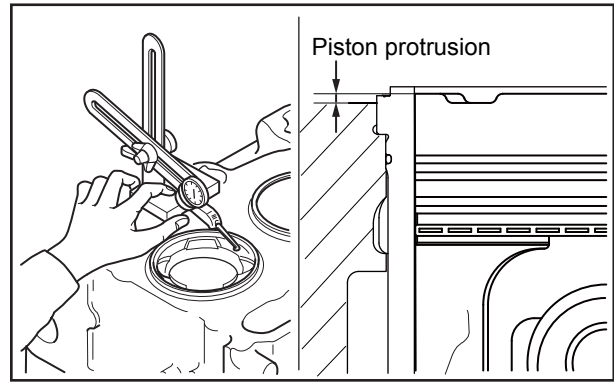
- (1) Move the piston to the top dead center.
- (2) Apply the dial gauge probe to the top face of crankcase, and adjust the dial gauge to zero.
- (3) Move the dial gauge to the top face of piston, measure the maximum protrusion by turning the crankshaft near top dead center.

Note: The crankshaft position that indicates the maximum protrusion is defined as the correct top dead center.

- (4) Measure the protrusion at four places on the piston top face, and calculate the mean value.

Note: The top clearance (clearance between the piston top and cylinder head) can be calculated by the piston protrusion, cylinder liner flange protrusion and cylinder head gasket thickness.

Top clearance = Cylinder head gasket thickness + Cylinder liner flange protrusion - Piston protrusion

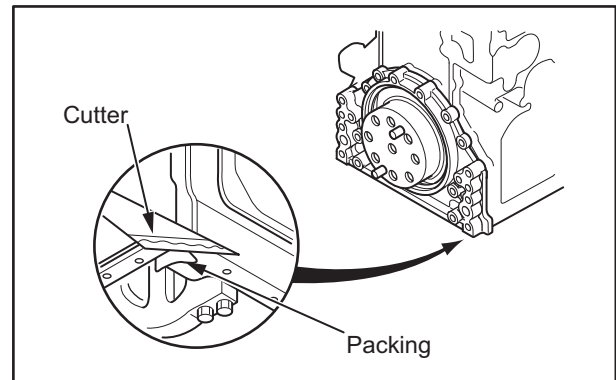


Item	Standard value
Piston protrusion	0.04 to 0.64 mm [0.0016 to 0.0252 in.]
Cylinder liner flange protrusion	0.11 to 0.20 mm [0.0043 to 0.0079 in.]
Thickness of cylinder head gasket	1.77 to 1.83 mm [0.0697 to 0.0720 in.]
Top clearance	1.24 to 1.99 mm [0.0488 to 0.0783 in.]

3. Front Mechanism - Assemble

3.1 Front Cover - Install

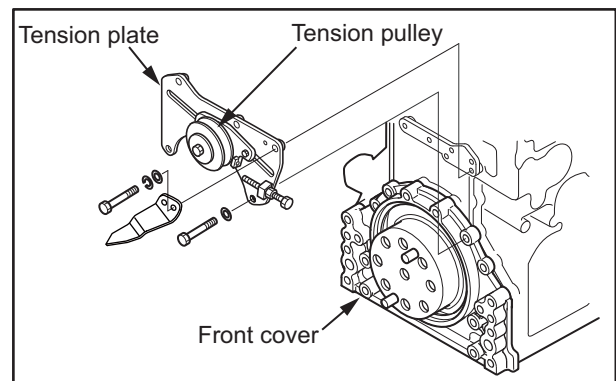
- (1) Apply sealant (ThreeBond 1211) to the packing mounting surface of the crankcase, and install the packing.
- (2) Apply sealant (ThreeBond 1211) to the packing for front cover mounting surface, and install the front cover.
- (3) Tighten the bolt.
- (4) Check that the lower face of front cover is flush with the bottom of crankcase.
Cut off any excessive packing neatly.



Front Cover - Install

3.2 Tension Pulley - Install

- (1) Install the tension pulley to tension plate, then tighten the bolts.
- (2) Install the tension plate to front cover and bracket.

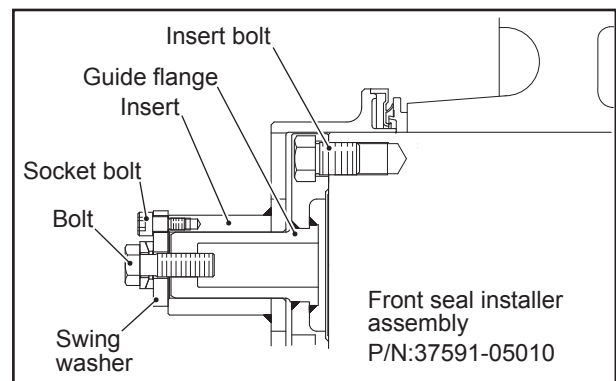


Tension Pulley - Install

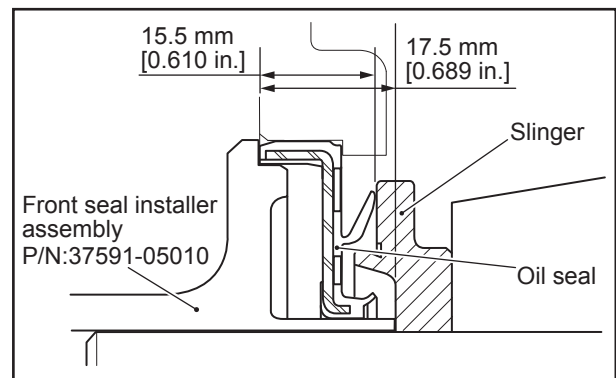
3.3 Front Oil Seal - Install

With the front seal installer assembly, install the front oil seal.

- (1) Apply clean engine oil evenly to the oil seal lip.
Note: Pay attention to the installing side of oil seal, and be careful not to damage the oil seal.
- (2) Install the guide flange to the crankshaft front end, and secure it with the insert bolts.
- (3) Set the oil seal to insert and install it to the guide flange.
- (4) Tighten the bolt on guide flange to insert the oil seal into the front cover.
- (5) Remove the installer assembly.



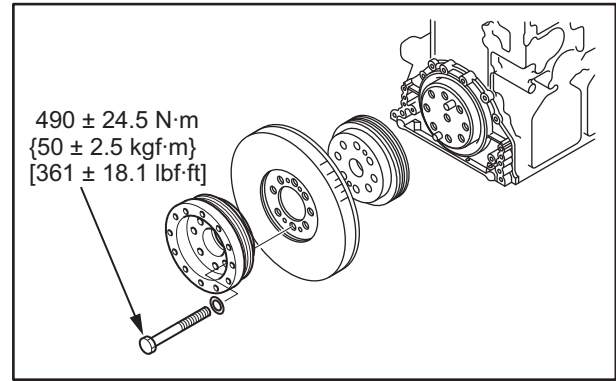
Front Oil Seal - Install (1)



Front Oil Seal - Install (2)

3.4 Crankshaft Pulley, Damper and Front Pulley - Install

- (1) Install the guide bolt to damper mounting thread on the crankshaft.
- (2) Put the crankshaft pulley, belt and damper to the guide bolt, and install them aligning with the dowel pin.
- (3) Tighten the bolts to the specified torque.



Crankshaft Pulley, Damper and Front Pulley - Install

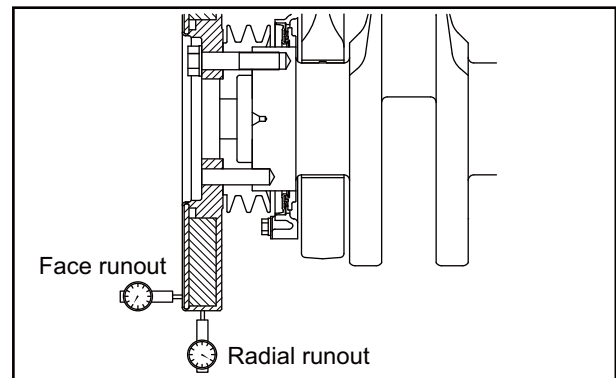
3.5 Damper Face and Radial Runout - Measure

Measure the face and radial runouts of damper.

If the value exceeds the limit, check the assembling condition such as loose bolt or foreign material collection on the mounting faces.

Note: For measurement, avoid the punch mark position.

Item	Standard value
Face runout (reference)	0.5 mm [0.020 in.] or less
Radial runout (reference)	0.5 mm [0.020 in.] or less

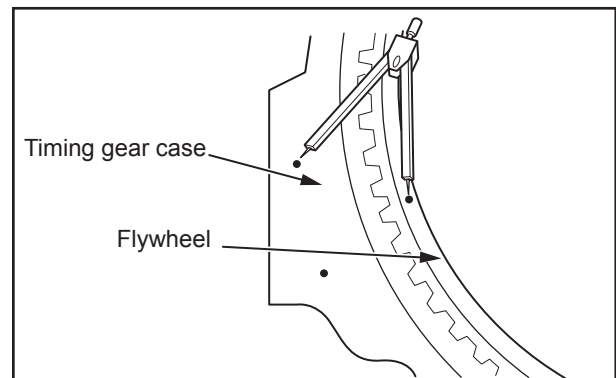


Damper Face and Radial Runout - Measure

3.6 Pointer - Install and Adjust

- (1) Install the pointer to the tension plate.
- (2) Turn the crankshaft to the top dead center of No. 1 cylinder. Align the stamped line of top dead center of No. 1 cylinder on the periphery of damper with the pointer.
- (3) To make sure the No.1 cylinder top dead center, measure the flywheel punch mark positioning at the same distance from the two punch marks stamped on the timing gear case.

Note: For checking procedure of the top dead center by piston movement, refer to "Piston Protrusion - Measure" of "ASSEMBLY OF BASIC ENGINE."

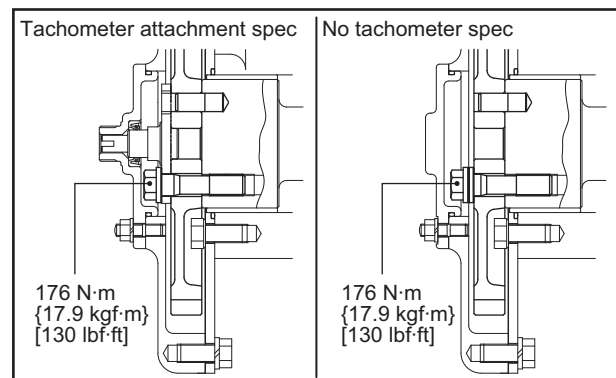


Top Dead Center of Punch Marks - Check

3.7 Fan Drive Gear - Install

(With fan spec)

- (1) Install the fan drive plate to crankcase.
- (2) Install the fan drive gear to camshaft, and tighten the bolts to the specified torque.



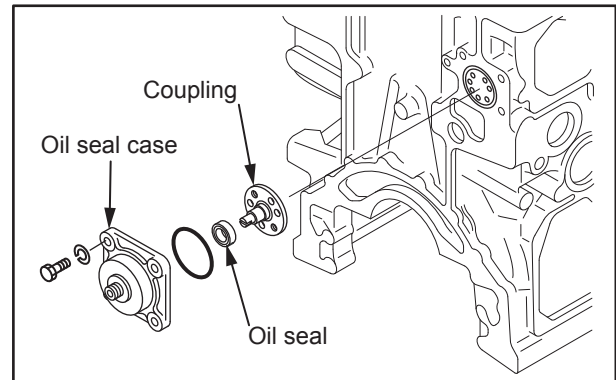
Fan Drive Gear - Install

3.8 Coupling - Install

(With tachometer spec)

- (1) Install the coupling aligning the dowel pin on the camshaft front end, and tighten the bolt.
- (2) Install the oil seal and O-ring to oil seal case, and tighten the bolt.

Note:(a) Apply grease to the oil seal lip and the entire circumference of O-ring.
(b) Install the camshaft, then install coupling, oil seal and oil seal case.

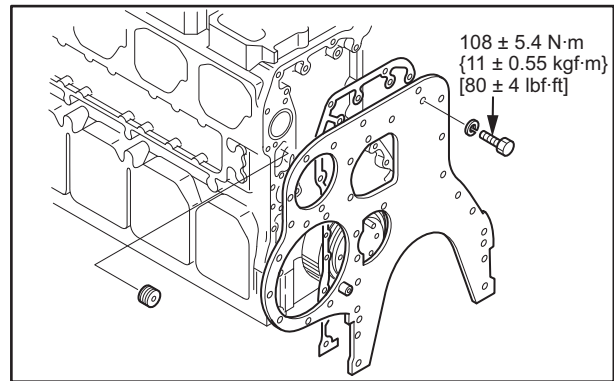


Coupling - Install

4. Rear Mechanism - Assemble

4.1 Rear Plate - Install

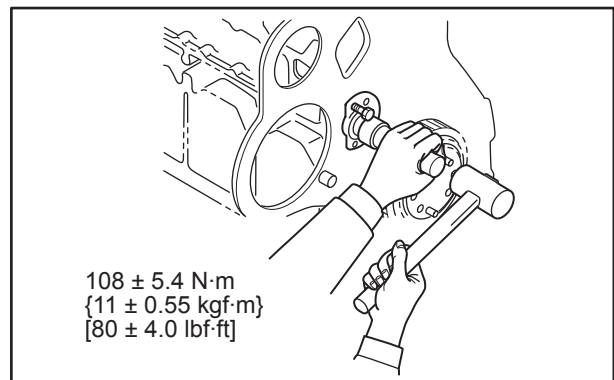
- (1) Install the nozzle plates.
- (2) Apply sealant (ThreeBond 1211) to the rear plate packing mounting surface of the crankcase, and install the packing.
- (3) Apply the same sealant (ThreeBond 1211) to the packing, and then install the rear plate.
- (4) Tighten the bolts to the specified torque.
- (5) Make sure that the bottom face of the rear plate is flush with the bottom face of the crankcase. Cut off excessive packing carefully.



Rear Plate - Install

4.2 Idler Shaft - Install

- (1) Tap-in the idler shaft into position using a bolt as guide.
- (2) Tighten the bolts to the specified torque.



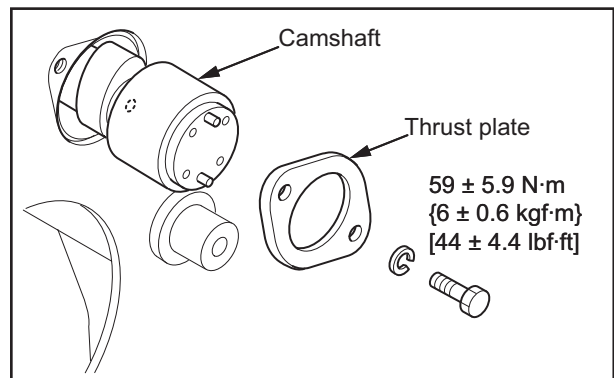
Idler Shaft - Install

4.3 Camshaft - Install

CAUTION

Install the camshaft while supporting it with a protective pad through the crankcase window. Be careful not to bump the camshaft to avoid the damage to cam lobe and bushing.

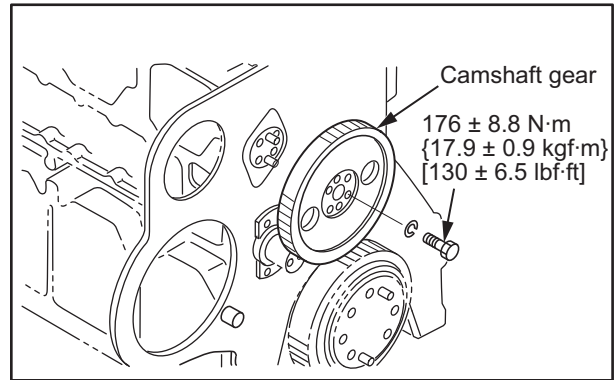
- (1) Apply engine oil to the inner surface of camshaft bushing.
- (2) Apply engine oil to the camshaft oil galleries, journals and lobes.
- (3) Support the camshaft with pad, and slowly insert the camshaft into crankcase.
- (4) Install the thrust plate, and tighten the bolts to the specified torque.
- (5) Make sure that the camshaft rotates.



Camshaft - Install

4.4 Camshaft Gear - Install

- (1) Install the camshaft gear by aligning its hole with the dowel pins on camshaft.
- (2) Tighten the bolts to the specified torque.
- (3) Verify the camshaft smooth rotation.

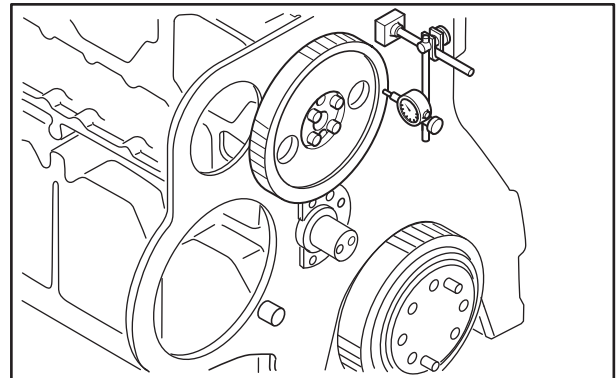


Camshaft Gear - Install

4.5 Camshaft End Play - Measure

Measure the camshaft end play. If the value exceeds the limit, find the causal parts, and replace them with new ones.

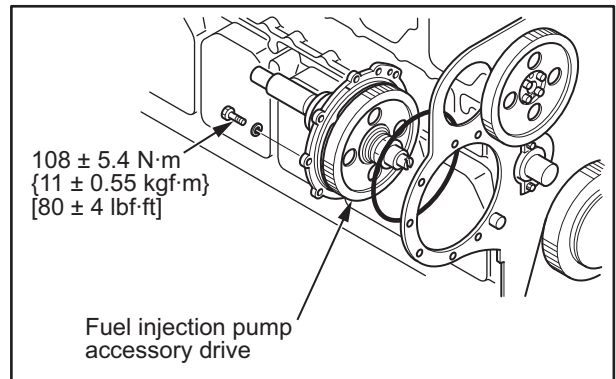
Item	Standard value	Limit value
Camshaft end play	0.10 to 0.25 mm [0.0039 to 0.0098 in.]	0.40 mm [0.0157 in.]



Camshaft End Play - Measure

4.6 Fuel Injection Pump Accessory Drive - Install

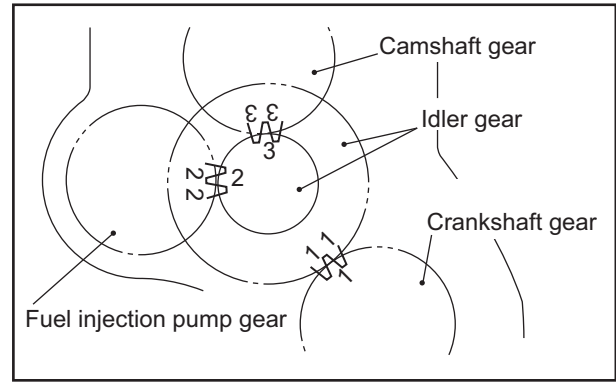
- (1) Install the O-ring to the mounting surface of the fuel injection pump accessory drive case. Apply a thin coat of ThreeBond 1212 to the flange.
- (2) Install the fuel injection pump accessory drive to the rear plate.
- (3) Tighten the bolts to the specified torque.



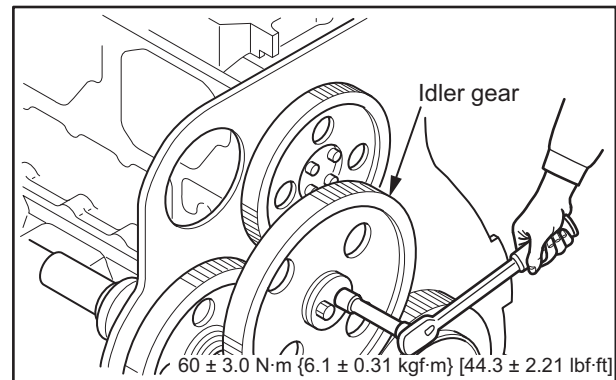
Fuel Injection Pump Accessory Drive
- Install

4.7 Idler Gear - Install

- (1) Turn the crankshaft to move the No. 1 cylinder to the top dead center.
- (2) Apply engine oil to the idler shaft.
- (3) Install the idler gear, aligning it with the match marks.
- (4) Install the thrust plate to the idler shaft.
- (5) Tighten the bolts to the specified torque.
- (6) Make sure that the match marks on timing gears are properly aligned as shown in the illustration.



Timing Gear Train

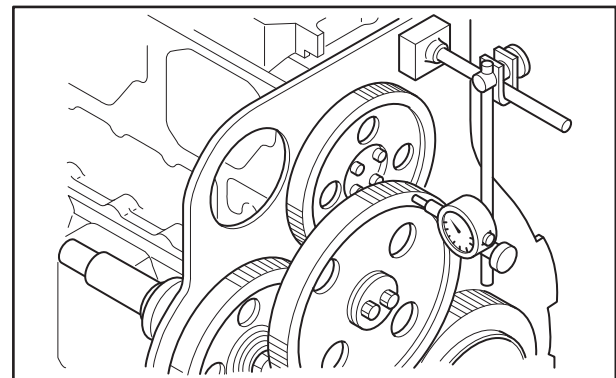


Idler Gear - Install

4.8 Idler Gear End Play - Measure

Measure the end play of the idler gear. If the value exceeds the limit, find the causal parts, and replace them with new ones.

Item	Standard value	Limit value
Idler gear end play	0.2 to 0.4 mm [0.008 to 0.016 in.]	0.6 mm [0.024 in.]

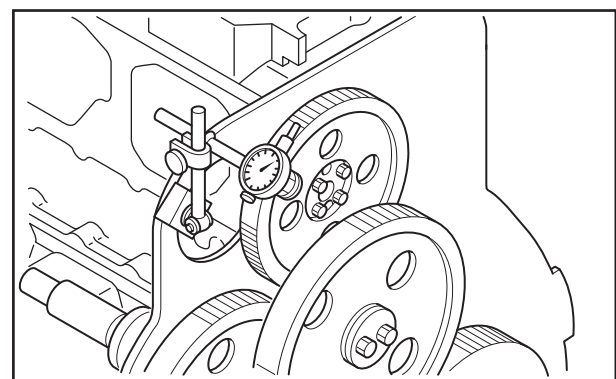


Idler Gear End Play - Measure

4.9 Timing Gear Backlash - Measure

Measure the backlash of timing gears using either method: measure the gear backlash with a dial gauge applying its probe to a tooth flank on the pitch circle at a right angle to the tooth axis, or measure the clearance between gears by inserting thickness gauges between the engaging gear teeth. If the value exceeds the limit, replace the gears with new ones.

Item	Standard value	Limit value
Backlash between crank gear and idler gear	0.11 to 0.28 mm [0.0043 to 0.0110 in.]	0.50 mm [0.0197 in.]
Backlash between idler gear and camshaft gear	0.12 to 0.18 mm [0.0047 to 0.0071 in.]	0.50 mm [0.0197 in.]
Backlash between idler gear and fuel injection pump gear	0.12 to 0.18 mm [0.0047 to 0.0071 in.]	0.50 mm [0.0197 in.]



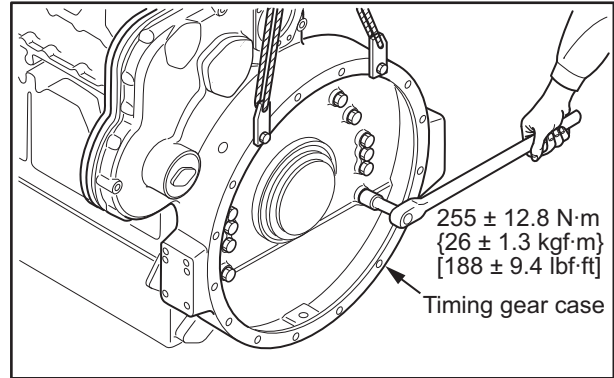
Timing Gear Backlash - Measure

4.10 Timing Gear Case - Install

CAUTION

Be careful not to drop or bump the timing gear case. It will result in personnel injury as well as damage of the timing gear case.

- (1) Apply sealant (ThreeBond 1211) to the rare plate packing mating surface, and install the packing.
- (2) Apply sealant (ThreeBond 1211) to the packing mating surface to timing gear case.
- (3) Set the eye bolt to timing gear case, align it with the dowel pins, and install the timing gear case.
- (4) Tighten the bolts to the specified torque.
- (5) Cut off excessive packing carefully from the bottom of crankcase.

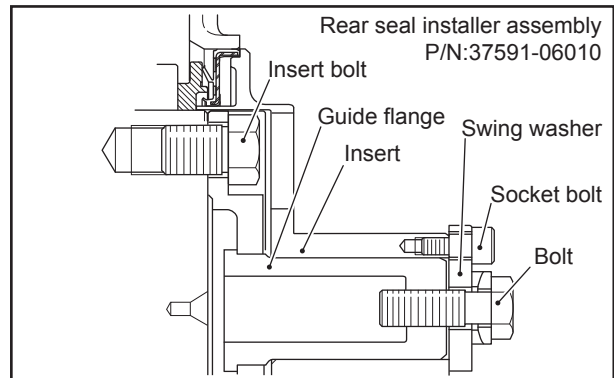


Timing Gear Case - Install

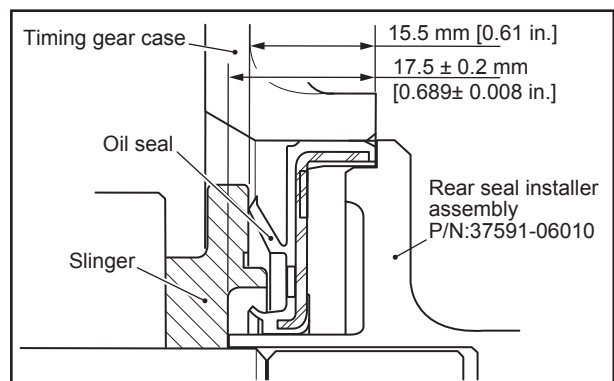
4.11 Rear Oil Seal - Install

Use the rear seal installer assembly to install the rear oil seal.

- (1) Apply clean engine oil evenly to the oil seal lip.
Note: Pay attention to the installing side of oil seal, and be careful not to damage the oil seal.
- (2) Install the guide flange to the crankshaft rear end face, and fix it with insert bolts.
- (3) Set the oil seal to insert and install it to the guide flange.
- (4) Tighten the bolt on the guide flange to insert the oil seal into timing gear case.
- (5) Remove the installer assembly.



Rear Oil Seal - Install (1)



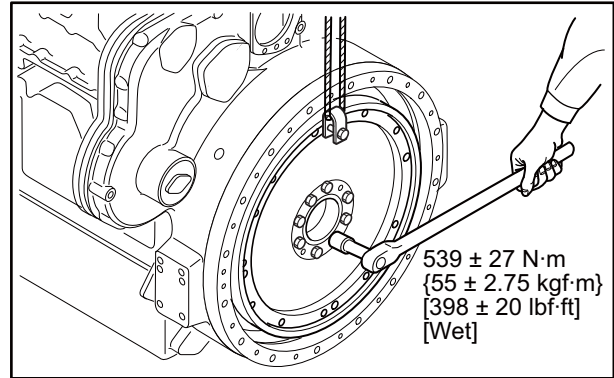
Rear Oil Seal - Install (2)

4.12 Flywheel - Install

CAUTION

Be careful not to drop or bump the flywheel. It will result in personnel injury as well as damage of the flywheel.

- (1) Check the mounting surfaces of flywheel and crankshaft to make sure that they are free from any foreign material or damage.
- (2) Hitch a sling to the flywheel.
- (3) Install the flywheel by aligning its hole with dowel pin on crankshaft.
- (4) Apply engine oil to the bolt threads and bolt seat surfaces, then tighten the bolts to the specified torque.

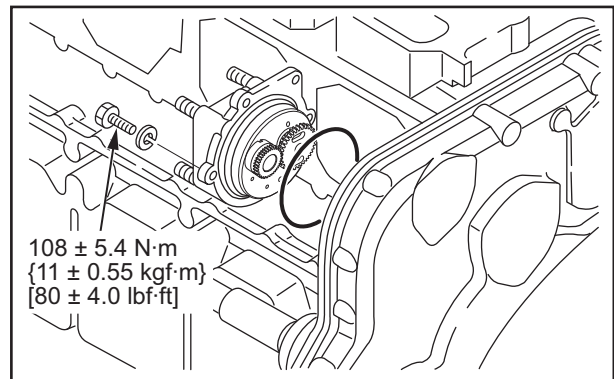


Flywheel - Install

4.13 Governor Drive - Install

(Oil pressure governor spec)

- (1) Install the O-ring to governor drive.
- (2) Install the governor drive to rear plate.
- (3) Tighten the bolts to the specified torque.



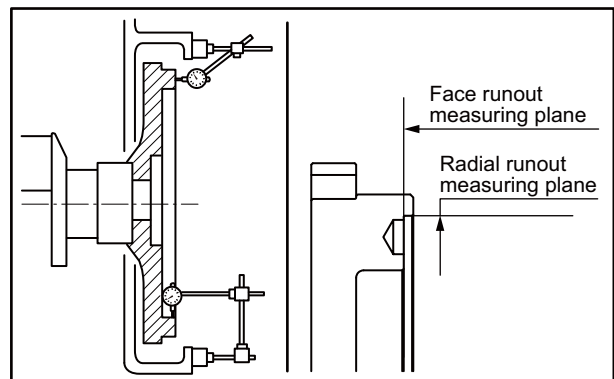
Governor Drive - Install

4.14 Flywheel Face and Radial Runout - Measure

Measure the face and radial runouts of the flywheel.

If the measured value extremely deviates from the standard, check the assembling condition such as loose bolt or foreign material collection on mounting faces.

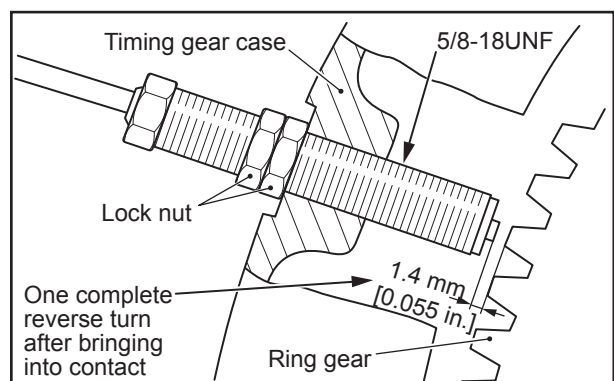
Item	Standard value
Face runout (reference)	0.285 mm [0.0112 in.] or less
Radial runout (reference)	0.127 mm [0.0050 in.] or less



Flywheel Face and Radial Runout - Measure

4.15 Pickup - Install

- (1) Turn the crankshaft to move the ring gear teeth top to the center line of pickup installing hole.
- (2) Insert the pickup into the hole slowly and carefully by hand.
- (3) When the tip of pickup contacts with the ring gear tooth top, loosen the pickup to adjust the clearance to standard value.
- (4) Fix the pickup with lock nut.



Pickup - Install

5. Cylinder Head and Valve Mechanism - Assemble

5.1 Cylinder Head - Assemble

CAUTION

- Be careful when inserting the valve through stem seal, as the edge of stem can cause damage to the stem seal lip.
- Do not apply oil or liquid sealant to the fitting faces between stem seal and valve guide.
- Always replace the stem seal with a new one. Stem seal can not be re-used.
- For the double spring exhaust valve, first place the lower retainer, then install the stem seal.

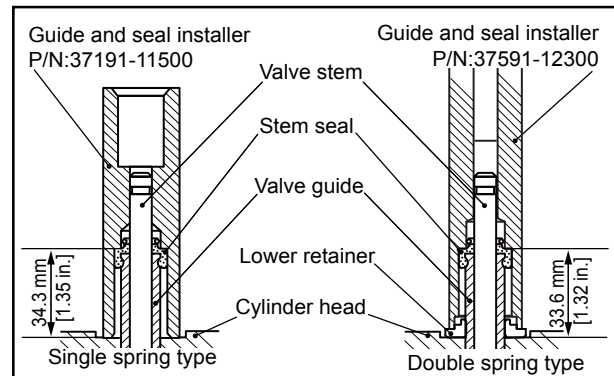
- Apply engine oil to the valve stem, and insert valve into valve guide.
- Install the lower retainer to valve guide on exhaust side. (Exhaust double spring spec only)
- Install the stem seal to valve guide with guide and seal installer.

Note: Place the valve in valve guide before installing the stem seal. The valve stem seal is centered with valve stem.

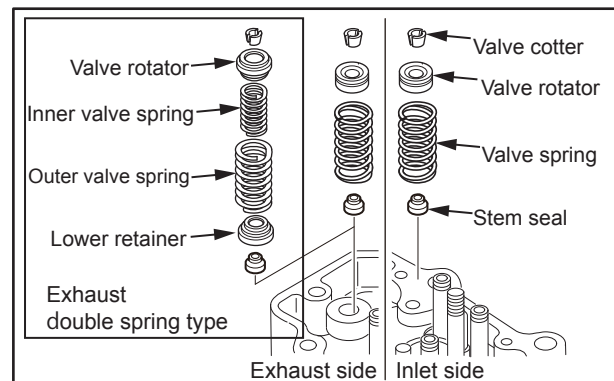
- Apply engine oil to the lip of stem seal.
- Install the retainer, valve spring and rotator to valve guide, and install the valve cotters with valve spring pusher.

Note: In case of the double spring spec, parts are different between inlet and exhaust valves. Make sure that correct parts are assembled.

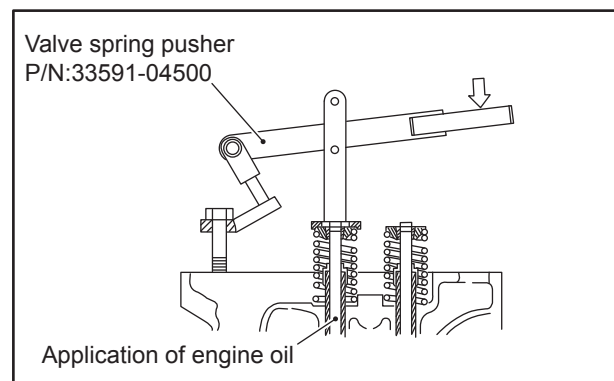
- Tap the top of valve stem lightly several times with a soft-head hammer to slightly open the valve, and make sure that the valve spring and valve cotters are properly installed and seated firmly.



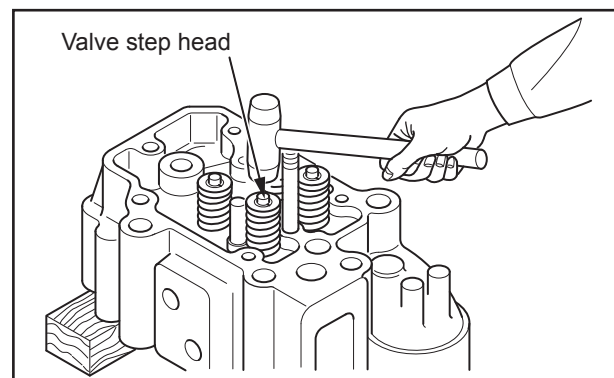
Stem Seal - Install



Valve and Valve Spring - Install



Valve Cotter - Install



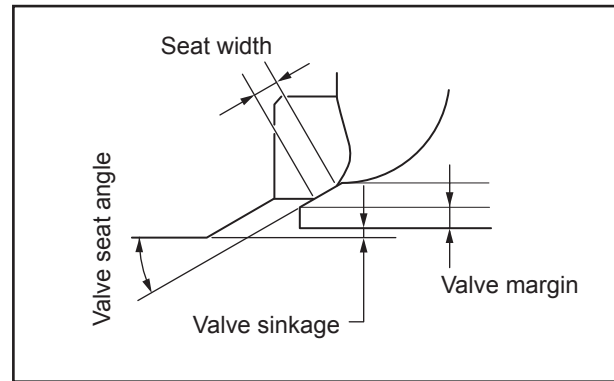
Valve - Install

5.2 Valve Sinkage - Measure

Measure the valve sinkage.

If the value exceeds the limit, replace the valve or valve seat with a new one. Lap the valve and valve seat whenever valve or valve seat is refaced or replaced.

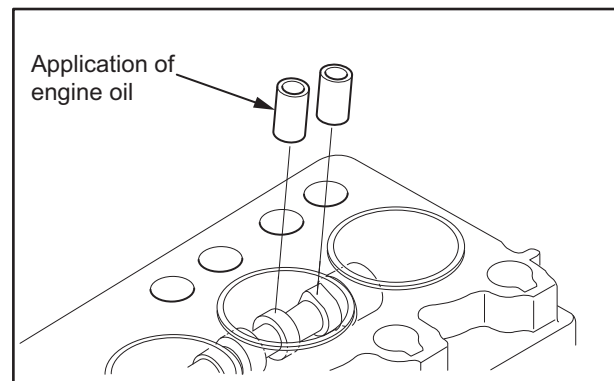
Item	Standard value	Limit value
Valve sinkage	-0.1 to 0.1 mm [-0.004 to 0.004 in.]	1.0 mm [0.040 in.]



Valve Sinkage - Measure

5.3 Tappet - Install

Apply engine oil to the tappet outside face, insert tappet into tappet hole and place the tappet softly on camshaft.



Tappet - Install

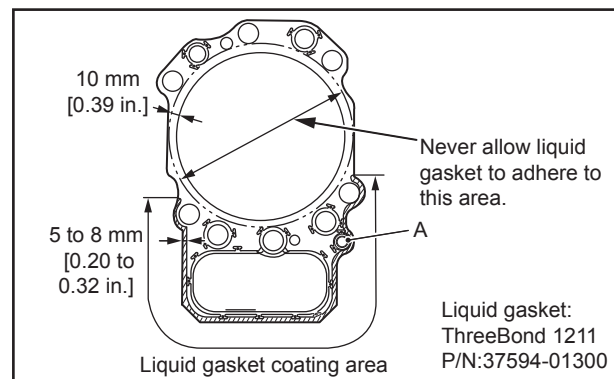
5.4 Liquid Gasket - Apply

CAUTION

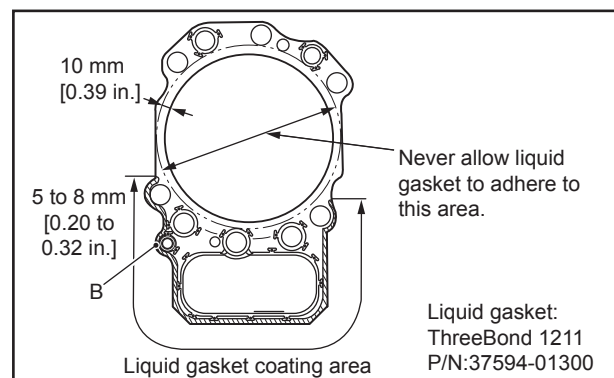
- (a) Do not apply liquid gasket excessively. It results in O-ring deformation. Be careful to apply gasket to portions A and B. The space to O-ring is very narrow.
- (b) Do not apply liquid gasket around the periphery of cylinder bore. It results in gas leakage.

- (1) Wipe off oil, grease and other contamination from the cylinder head gasket, cylinder head bottom surface and crankcase top surface.
- (2) Apply a thin coat of liquid gasket to both sides of cylinder head gasket around tappet holes and oil passages. Beads of liquid gasket is 5 to 8 mm [0.20 to 0.31 in.] from the cylinder head gasket outer edge with a thickness of 0.2 to 0.5 mm [0.008 to 0.020 in.] The area of application is shown on the right.

Note: After the application of liquid gasket to cylinder head gasket install the cylinder head before liquid gasket dries.



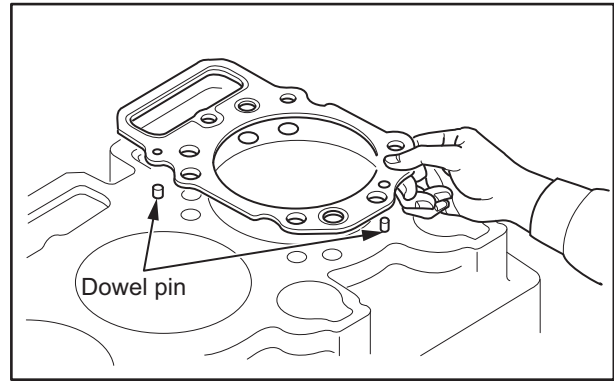
Liquid Gasket - Area of Application (Head Side)



Liquid Gasket - Area of Application (Crankcase Side)

5.5 Cylinder Head Gasket - Install

- (1) Wipe off oil, grease and other contamination from the cylinder head bottom surface and crankcase top surface.
- (2) Install the cylinder head gasket coated with liquid gasket onto crankcase with dowel pin and hole in alignment.



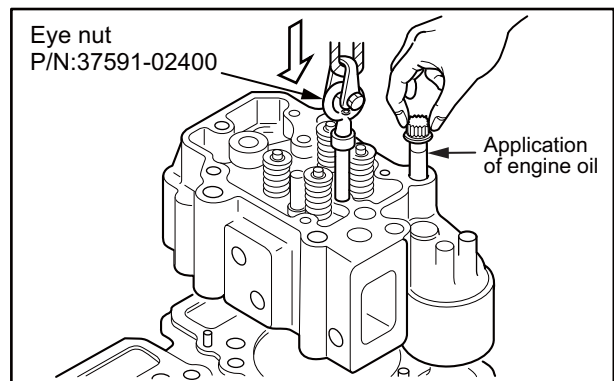
Cylinder Head Gasket - Install

5.6 Cylinder Head Assembly - Install

- (1) Apply engine oil to the cylinder head bolt threads, bolt seats and washer surfaces.

Note: Do not apply excessive amount of engine oil. Remove the excess before assembling.

- (2) Install the eye nut to stud bolt, and lift the cylinder head assembly.
- (3) Slowly lower the cylinder head, and install the cylinder head aligning dowel pins with holes. Make sure that the dowel pins are inserted in the holes, hand tighten the cylinder head bolts.



Cylinder Head Assembly - Install

5.7 Cylinder Head Bolt - Tighten

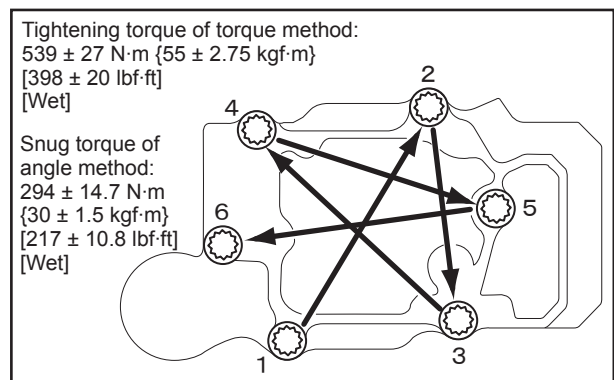
Two methods of cylinder head bolt tightening, torque tightening and angle controlled tightening, are available.

5.7.1 Torque Tightening Method

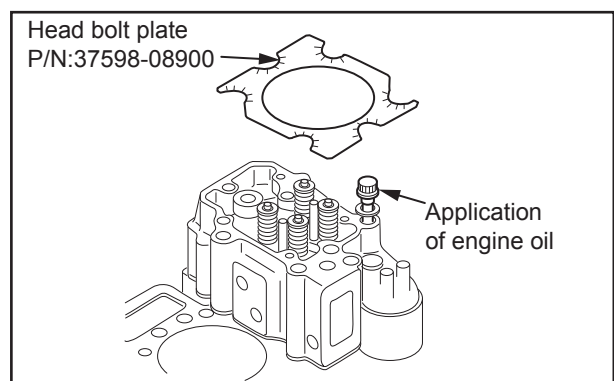
- (1) Tighten the cylinder head bolts progressively to the specified torque in the sequence shown in illustration.
- (2) Tighten all the bolts, and then loosen them, and tighten them again according to this torque method. (2-time tightening method)

5.7.2 Angle Controlled Tightening Method

- (1) Tighten the cylinder head bolts to the specified snug torque in the sequence shown the illustration.
- (2) Place the head bolt plate on the top of cylinder head.
- (3) Put a mark to the cylinder head bolt.
- (4) Tighten bolts by turning $65 \pm 3^\circ$ in the specified sequence.
- (5) Loosen all bolts, and then angle controlled tighten them again. (2-time tightening method)



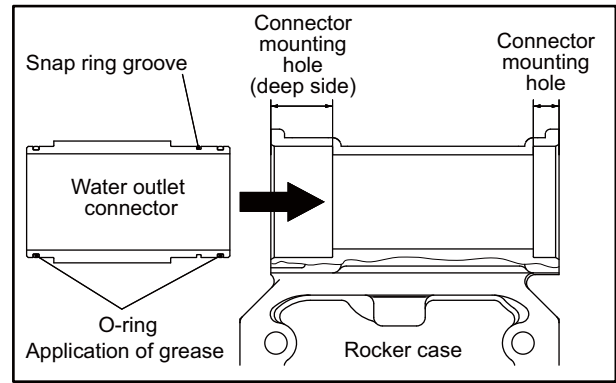
Cylinder Head Bolts - Tightening Sequence



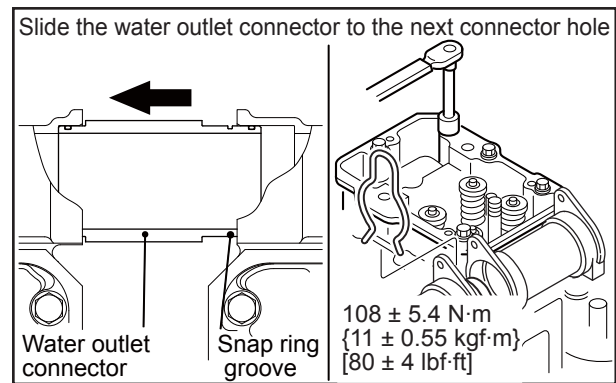
Cylinder Head Bolt - Angle Controlled Tightening Method

5.8 Rocker Case - Install

- (1) Install O-rings on water outlet connector. Apply grease to the O-ring sliding surface.
- (2) Apply grease to connector mounting hole of rocker case.
- (3) Install the snap ring groove end of water outlet connector to the deeper connector mounting hole of rocker case, and fully insert the water outlet connector.
- (4) Install the rocker case aligning its holes with the dowel pins.
- (5) Tighten the bolts to the specified torque.
- (6) Slide the water outlet connector into the adjacent connector mounting hole of rocker case.
- (7) Install the snap ring to snap ring groove on water outlet connector.



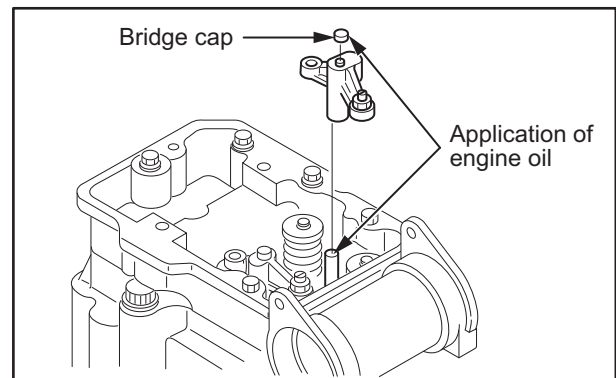
Water Outlet Connector - Install



Rocker Case - Install

5.9 Bridges and Bridge Caps - Install

- (1) Apply engine oil to the bridge guide.
- (2) Install the bridge on bridge guide. Place the screw-fitted end of bridge to exhaust manifold side.
- (3) Apply engine oil to the bridge contact area of bridge cap, and install the bridge cap. Be careful not to drop the bridge cap inside crankcase through push rod hole.

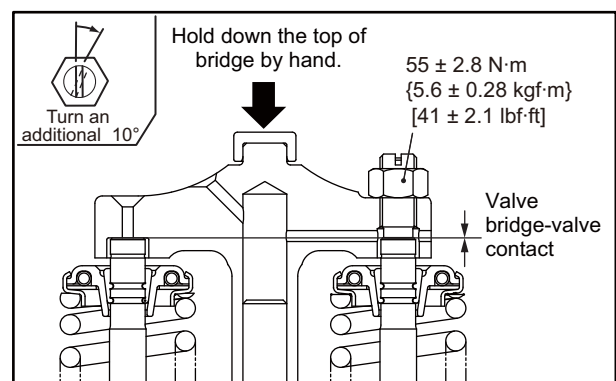


Bridges and Bridge Caps - Install

5.10 Valve Bridge and Adjusting Screw - Adjust

Adjust the contact of valve stem top faces to ensure bridge smooth sliding on bridge guide and balanced pushing to valves.

- (1) Loosen the adjusting screw so that its top face protrudes from top face of nut by 6 to 7 mm [0.23 to 0.27 in.]
- (2) Press the top of bridge by hand so that the top face of valve stem on bridge plane end contacts closely to the bridge pushing face.
- (3) Turn the adjusting screw slowly until screw contacts the top face of valve stem. Then, turn the screw further by 10°, and tighten lock nut to the specified torque.



Valve Bridge and Adjusting Screw - Adjust

5.11 Clearance Between Bottom Face of Valve Bridge and Top Face of Valve Rotator - Inspect

CAUTION

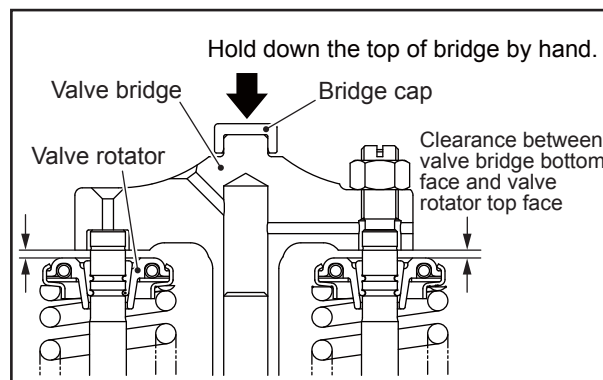
Be sure to keep the standard clearance between valve bridge and valve rotator. If the clearance is smaller than the standard, the valve cotter may come off or get damage.

Push the valve bridge by hand to make close contact of the top end face of valve stem. Then, check the clearance between bottom face of valve bridge and top face of valve rotator. If the value deviates from the standard, find the causal parts, and replace them with new ones.

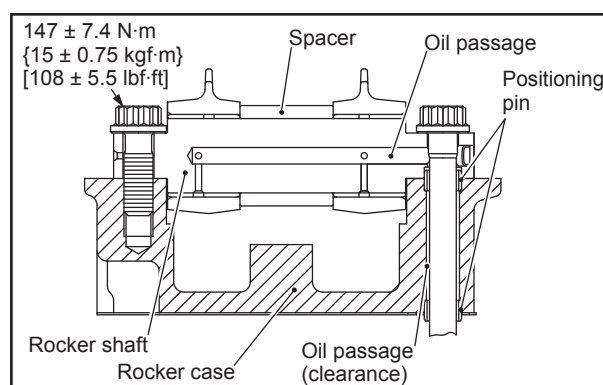
Item			Standard value
Valve bridge bottom face and valve rotator top face clearance	Intake side		2.1 mm [0.083 in.]
	Exhaust side	Single valve spring spec	3.4 mm [0.134 in.]
		Double valve spring spec	2.1 mm [0.083 in.]

5.12 Rocker Shaft Assembly - Install

- (1) Install the spacer to the rocker shaft, and install the rocker arms on both sides.
- (2) Align the dowel pin hole of rocker shaft with dowel pin, and install the rocker shaft assembly to rocker case.
- (3) Tighten the bolts to the specified torque.



Clearance Between Bottom Face of Valve Bridge and Top Face of Valve Rotator - Inspect



Rocker Shaft Assembly - Install

5.13 Valve Clearance - Check and Adjust

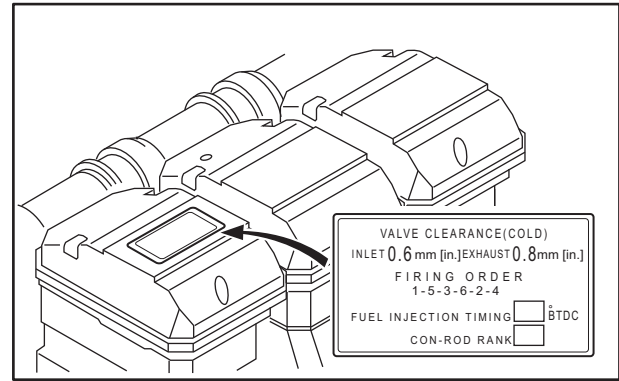
Adjust the valve clearance when the engine is cold.

Note:(a) The inlet valves are on the left side and exhaust valves are on the right when the cylinder head is viewed from camshaft side.

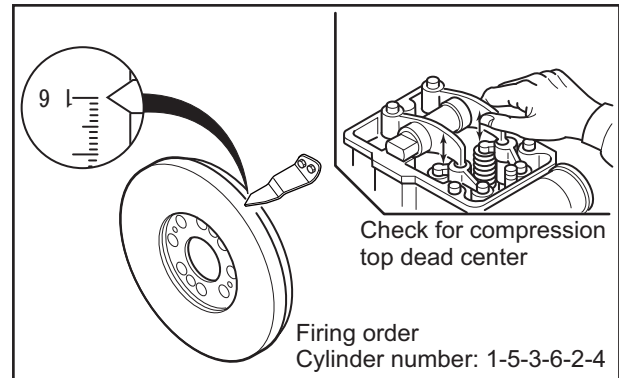
(b) The valve clearance standard values are shown on the caution plate on the No. 1 cylinder rocker cover.

Item		Standard value
Valve clearance	Inlet	0.6 mm [0.024 in.]
	Exhaust	0.8 mm [0.031 in.]

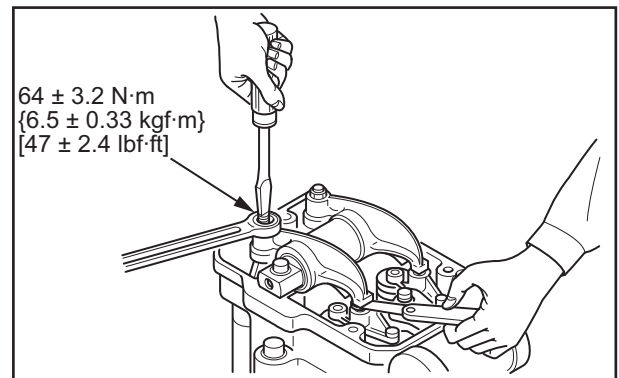
- (1) Adjust the valve clearance in the firing order at TDC of compression stroke by turning crankshaft in the normal direction.
- (2) On each cylinder, the piston is at the top dead center on compression stroke, when corresponding cylinder number stamped on damper is aligned with pointer, and inlet valves and exhaust valves are not pushed with push rod.
- (3) Insert a thickness gauge between rocker arm and bridge cap to measure the clearance. Tighten or loosen the screw to adjust the clearance where the movement of thickness gauge becomes slightly restricted.
- (4) After the adjustment tighten the lock nut firmly to the specified torque. Then, check the clearance again.



Valve Clearance Label - Location



No. 1 Cylinder Compression Top Dead Center - Check

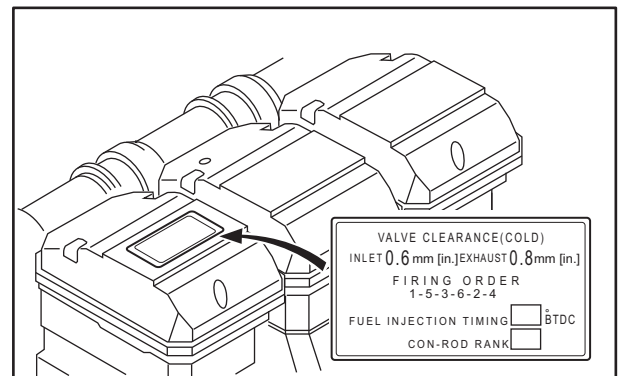


Valve Clearance - Adjust

5.14 Fuel Injection Timing - Check and Adjust

5.14.1 Specified Value of Fuel Injection Timing - Check

The fuel injection timing varies depending on the engine output, speed and specifications. Be sure to check the plate on the No. 1 rocker cover for the fuel injection timing.



Specified Value of Fuel Injection Timing - Check

5.14.2 Fuel Injection Timing - Check

- (1) Turn the crankshaft in normal direction, and stop the turning when the No. 1 cylinder is positioned at approx 10° before the specified fuel injection timing.

Check that the "0" stamped line of fuel injection pump flywheel indicates before the pointer.

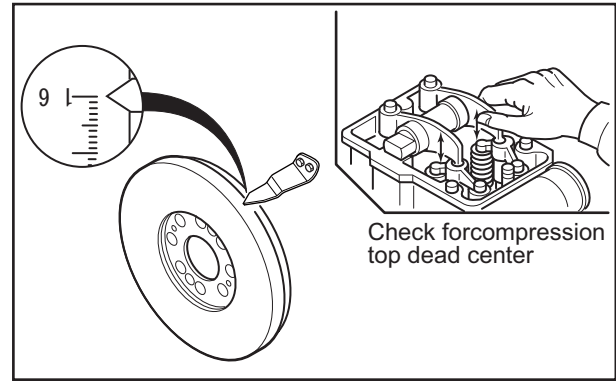
Note: In this condition, the clearances of inlet and exhaust valves are as specified, and valves are not pushed down.

In case of the exhaust stroke top dead center, valves are pushed down.

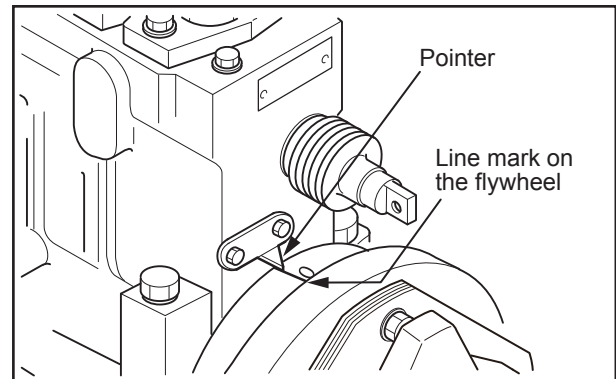
- (2) Turn the crankshaft to the normal direction progressively, align the fuel injection timing mark on damper with engine pointer.

If the "0" line mark of fuel injection pump flywheel aligns with pointer, the fuel injection timing is adjusted to the specified timing.

If the "0" line mark does not align with pointer, adjust the fuel injection timing.



TDC for Cylinder No.1 - Positioning



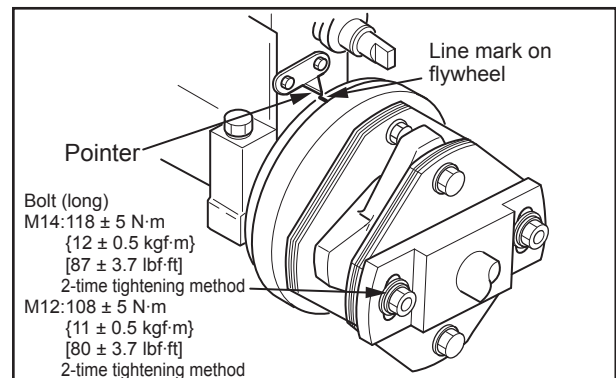
Fuel Injection Timing - Check

5.14.3 Fuel Injection Timing - Adjust

- (1) Turn the crankshaft to the normal direction progressively, align the fuel injection timing mark on damper with engine pointer.
- (2) Loosen the bolts (long) of driving coupling, and rotate the fuel injection pump only. Adjust the "0" line mark to pointer, then tighten the bolts (long.)
- (3) From the specified fuel injection timing, turn the crankshaft in the reverse direction by approx 10°.
- (4) Turning the crankshaft to the normal direction progressively again, align the line mark of fuel injection timing with the pointer.

In this condition, check the "0" line mark of fuel injection pump flywheel aligns with the pointer.

Repeat the step (2) until the proper alignment is made.



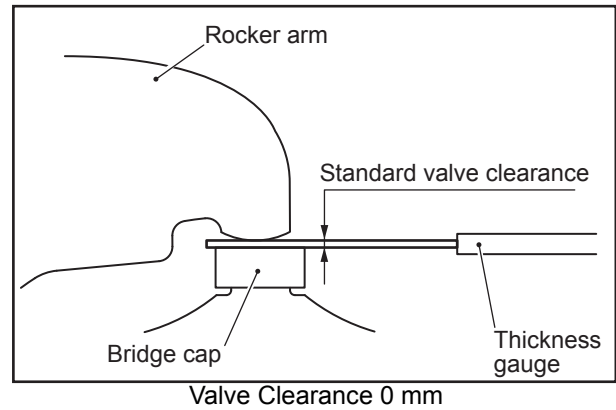
Fuel Injection Timing - Adjust

5.15 Valve Timing - Inspect

The specified valve timing is automatically made, when gears are assembled by aligning match marks and valve clearance is adjusted to the specified value. To make sure, check the valve timing as follows:

5.15.1 Valve Timing at Normal Valve Clearance (No Thickness Gauge Insertion)

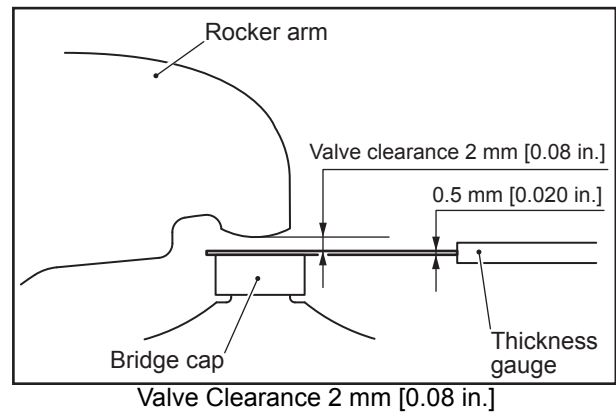
- (1) Check that the valve clearance is adjusted to the specification.
- (2) Insert the thickness gauge, which has the same thickness as the specified valve clearance, between bridge cap and rocker arm. (valve clearance 0 mm)
- (3) Turn the crankshaft in the normal direction little by little, and find a position where thickness gauge is tightly gripped (valve open position) and a position where thickness gauge is released (valve closed position.)
- (4) Verify the value to the specification.



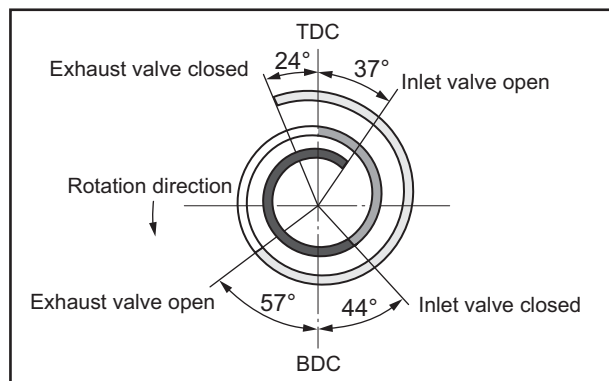
5.15.2 Valve Timing When Valve Clearance is 2 mm [0.08 in.] Valve Timing

Adjust the clearance to 2.5 mm [0.098 in.] for reliable inspection, where the valve motion changes rapidly.

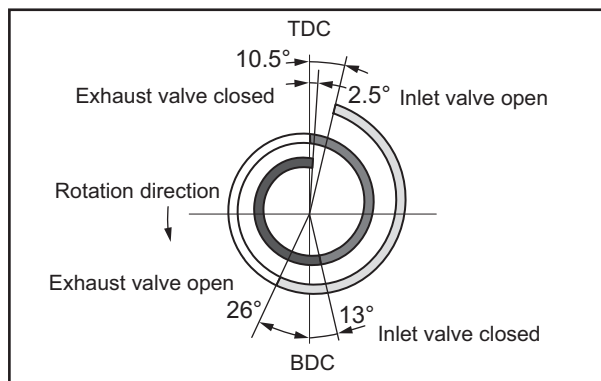
- (1) Insert a thickness gauge of 0.5 mm [0.020 in.] between bridge cap and rocker arm. (Valve clearance 2 mm [0.08 in.]
- (2) Turn the crankshaft in the normal direction little by little, and find a position where thickness gauge is tightly gripped (valve open position) and a position where thickness gauge is released (valve closed position.)
- (3) Verify the value to the specification.
- (4) Readjust valve clearance to the correct value.



Overlap 61° spec



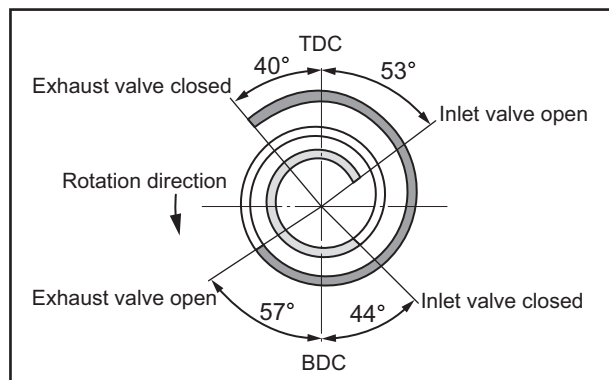
Overlap 61° Spec
Valve Timing When Valve Clearance is 0 mm



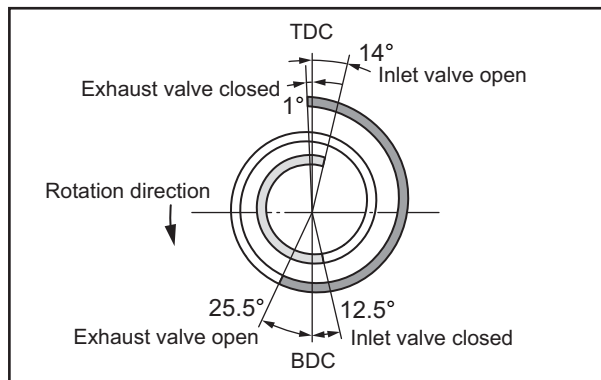
Overlap 61° Spec
Valve Timing When Valve Clearance is 2 mm [0.08 in.]

Item	Specification	Valve clearance	Item	Nominal value	Standard value
Valve timing	Overlap 61° Camshaft P/N: 37505-40100	0 mm [0.00 in.]	Inlet	Open BTDC 37°	-
				Close ABDC 44°	
			Exhaust	Open BBDC 57°	
				Close ATDC 24°	
		2 mm [0.08 in.]	Inlet	Open BTDC 2.5°	±2°
				Close ABDC 13°	
			Exhaust	Open BBDC 26°	
				Close BTDC 10.5°	

Overlap 93° spec



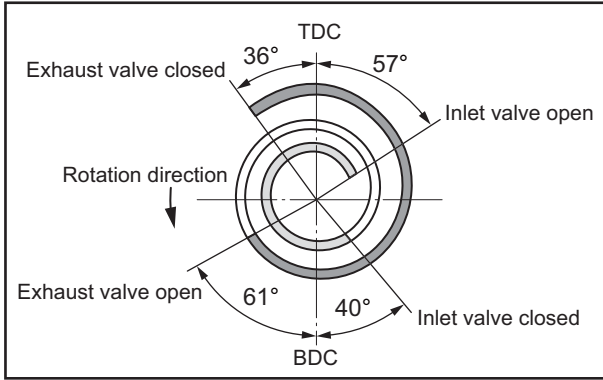
Overlap 93° Spec
Valve Timing When Valve Clearance is 0 mm



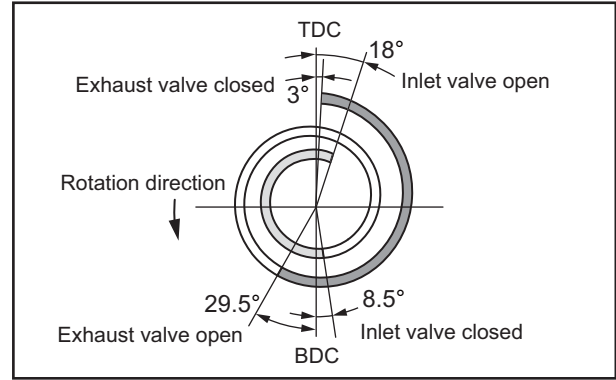
Overlap 93° Spec
Valve Timing When Valve Clearance is 2 mm [0.08 in.]

Item	Specification	Valve clearance	Item	Nominal value	Standard value
Valve timing	Overlap 93° Camshaft P/N: 37505-34100	0 mm [0.00 in.]	Inlet	Open BTDC 53°	-
				Close ABDC 44°	
			Exhaust	Open BBDC 57°	
				Close ATDC 40°	
		2 mm [0.08 in.]	Inlet	Open BTDC 14°	±2°
				Close ABDC 12.5°	
			Exhaust	Open BBDC 25.5°	
				Close ATDC 1°	

Overlap 93° advanced by 4° spec



Overlap 93° Advanced by 4° Spec
Valve Timing When Valve Clearance is 0 mm



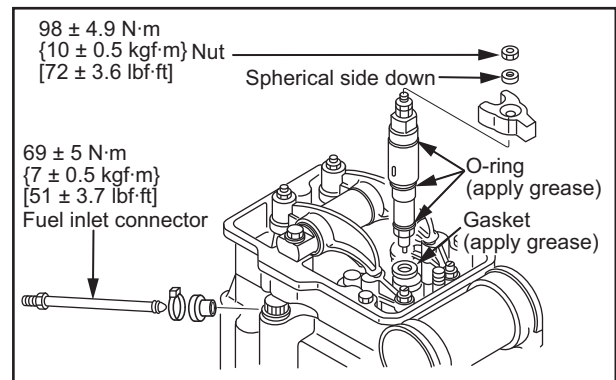
Overlap 93° Advanced by 4° Spec
Valve Timing When Valve Clearance is 2 mm [0.08 in.]

Item	Specification	Valve clearance	Item	Nominal value	Standard value
Valve timing	Overlap 93° Advanced by 4° Camshaft P/N: 37505-04300	0 mm [0.00 in.]	Inlet	Open BBDC 57°	-
				Close ABDC 40°	
			Exhaust	Open BBDC 61°	
				Close ABDC 36°	
		2 mm [0.08 in.]	Inlet	Open BTDC 18°	±2°
				Close ABDC 8.5°	
			Exhaust	Open BBDC 29.5°	
				Close BTDC 3°	

5.16 Fuel Injection Nozzle Assembly - Install

- (1) Remove the fuel inlet connector from fuel injection nozzle assembly.
- (2) Install three O-rings to fuel injection nozzle, and apply grease to the surface.
- (3) Apply a thin coat of grease to the gasket and install it to fuel injection nozzle.
- (4) Insert fuel injection nozzle to cylinder head so that cylinder head aligns with the mounting hole of fuel inlet connector for fuel injection nozzle. Then tighten it temporarily.
- (5) Tighten the nut to the specified torque and fix the nozzle gland.
- (6) Install the sleeve to space between inlet connector and cylinder head hole.
- (7) Tighten the fuel inlet connector to the specified torque.
- (8) Install the sleeve securely, and fix it with the band.

Note: Do not forget to install the gasket when installing fuel injection nozzle assembly.



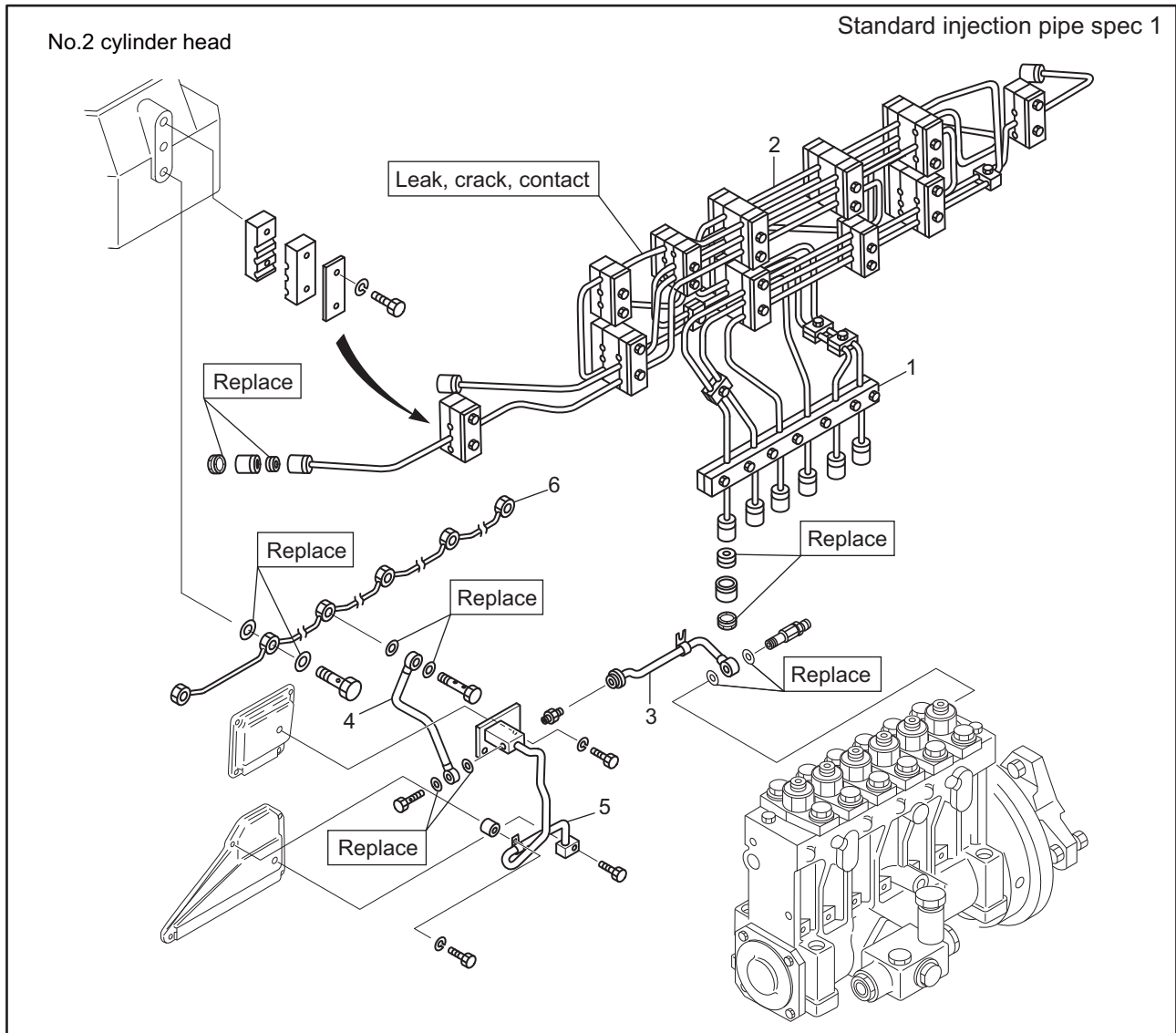
Fuel Injection Nozzle - Install

Chapter 8 FUEL SYSTEM

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1. Fuel System - Remove and Inspect

1.1 Fuel Injection Pipe and Fuel Leak-off Pipe - Remove and Inspect



Fuel Injection Pipe and Fuel Leak-off Pipe - Remove and Inspect

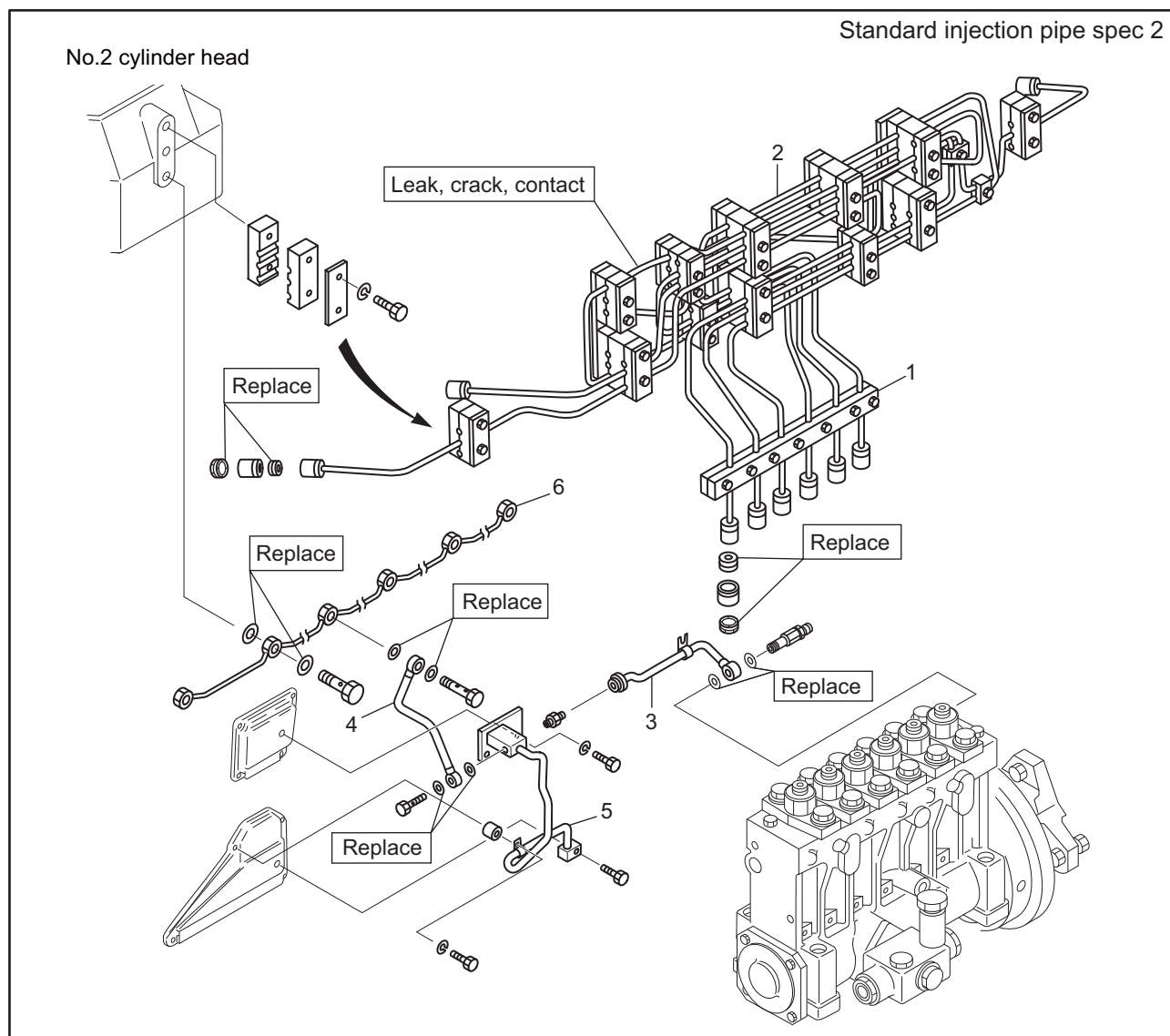
Removing Sequence

- | | |
|---------------------------------|---------------------|
| 1 Clamp | 4 Leak-off pipe |
| 2 No.1 to 6 fuel injection pipe | 5 Leak-off end pipe |
| 3 Leak-off pipe | 6 Leak-off pipe |

CAUTION

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

Note: The consisting parts at fuel inlet and outlet differ depending on the customization and specification.



Fuel Injection Pipe and Fuel Leak-off Pipe - Remove and Inspect

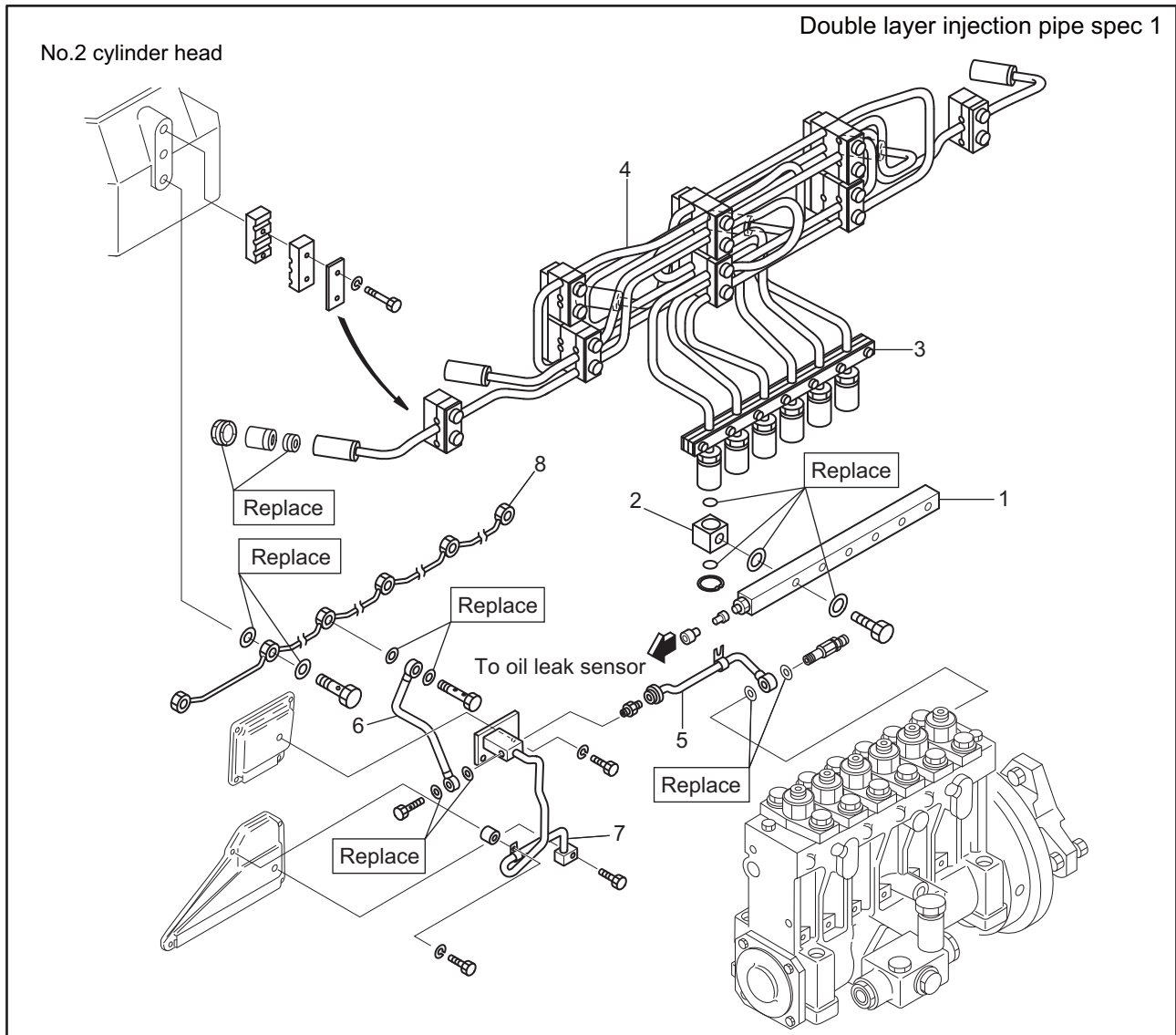
Removing Sequence

- | | |
|---------------------------------|---------------------|
| 1 Clamp | 4 Leak-off pipe |
| 2 No.1 to 6 fuel injection pipe | 5 Leak-off end pipe |
| 3 Leak-off pipe | 6 Leak-off pipe |

CAUTION

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

Note: The consisting parts at fuel inlet and outlet differ depending on the customization and specification.



Fuel Injection Pipe and Fuel Leak-off Pipe - Remove and Inspect

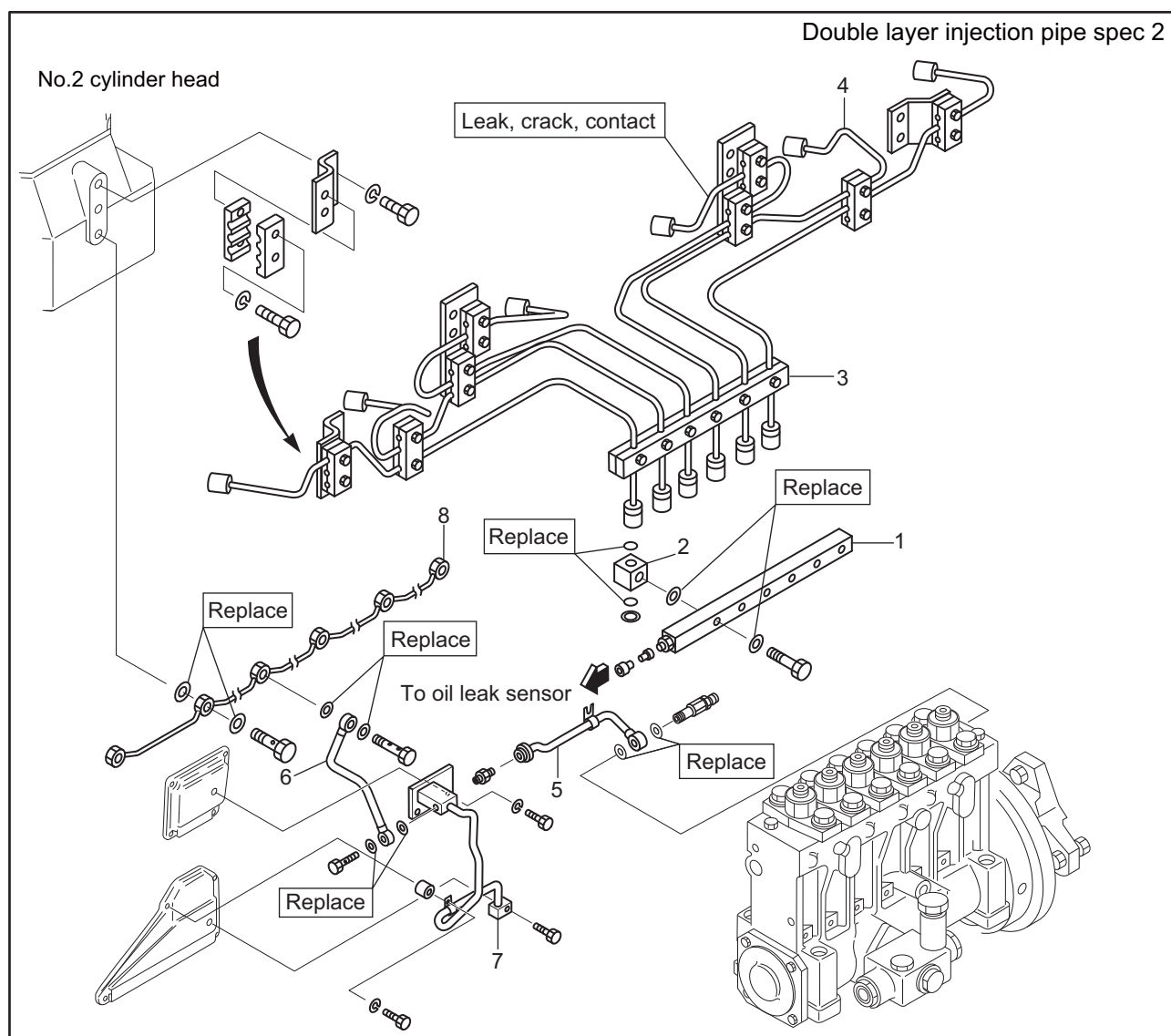
Removing Sequence

- | | |
|---------------------------------|---------------------|
| 1 Leak-off pipe | 5 Leak-off pipe |
| 2 Leak connector | 6 Leak-off pipe |
| 3 Clamp | 7 Leak-off end pipe |
| 4 No.1 to 6 fuel injection pipe | 8 Leak-off pipe |

CAUTION

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

Note: The consisting parts at fuel inlet and outlet differ depending on the customization and specification.



Fuel Injection Pipe and Fuel Leak-off Pipe - Remove and Inspect

Removing Sequence

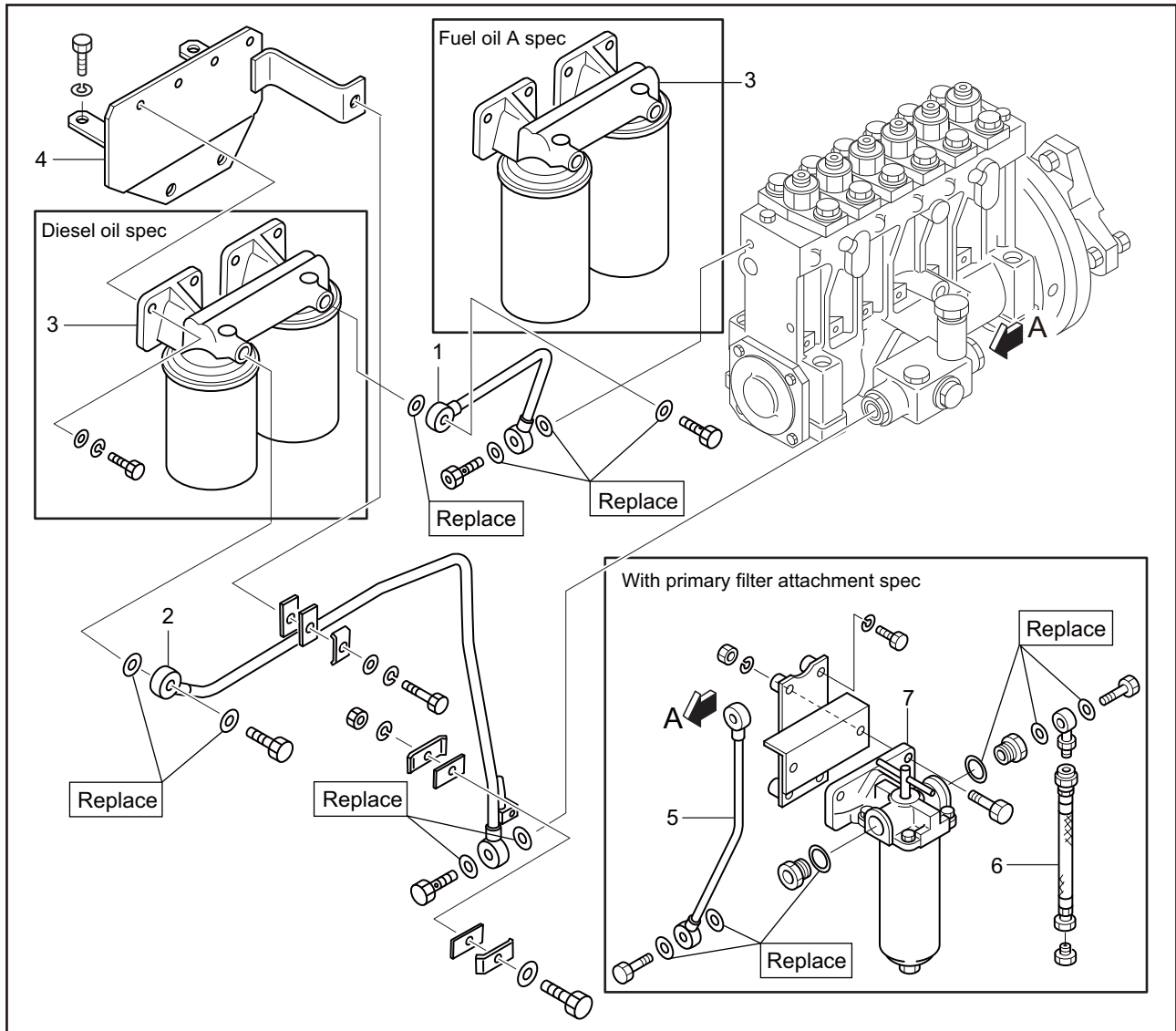
- | | |
|---------------------------------|---------------------|
| 1 Leak-off pipe | 5 Leak-off pipe |
| 2 Leak connector | 6 Leak-off pipe |
| 3 Clamp | 7 Leak-off end pipe |
| 4 No.1 to 6 fuel injection pipe | 8 Leak-off pipe |

CAUTION

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

Note: The consisting parts at fuel inlet and outlet differ depending on the customization and specification.

1.2 Fuel Filter and Fuel Pipe - Remove and Inspect

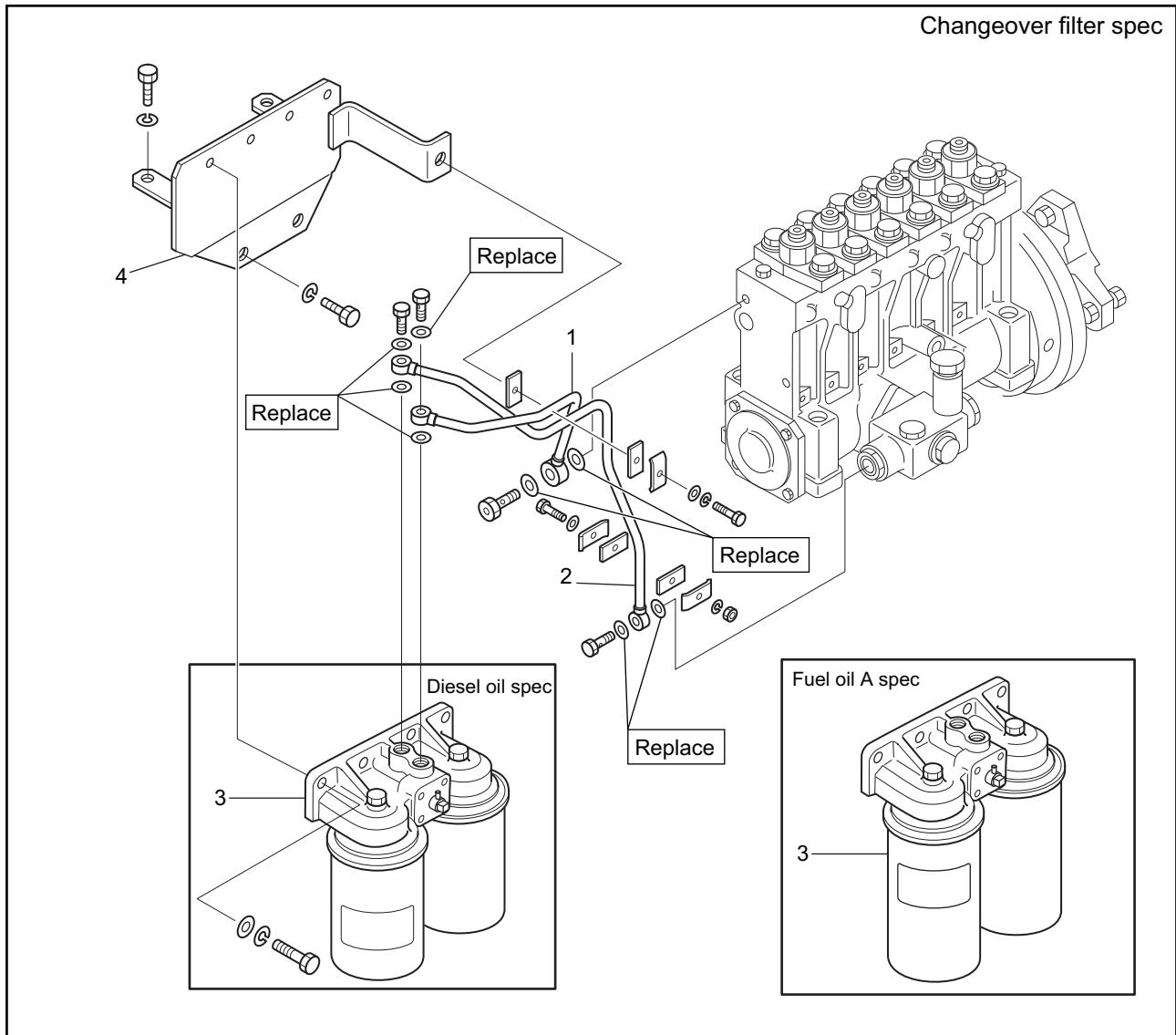


Fuel Filter and Fuel Pipe - Remove and Inspect

Removing Sequence

- | | | |
|---------------|-----------------|---------------------------------------|
| 1 Fuel pipe | 4 Bracket | 7 Fuel filter
(for primary filter) |
| 2 Fuel pipe | 5 Fuel pipe | |
| 3 Fuel filter | 6 Flexible pipe | |

Note: The consisting parts at fuel inlet and outlet differ depending on the customization and specification.



Fuel Filter and Fuel Pipe - Remove and Inspect

Removing Sequence

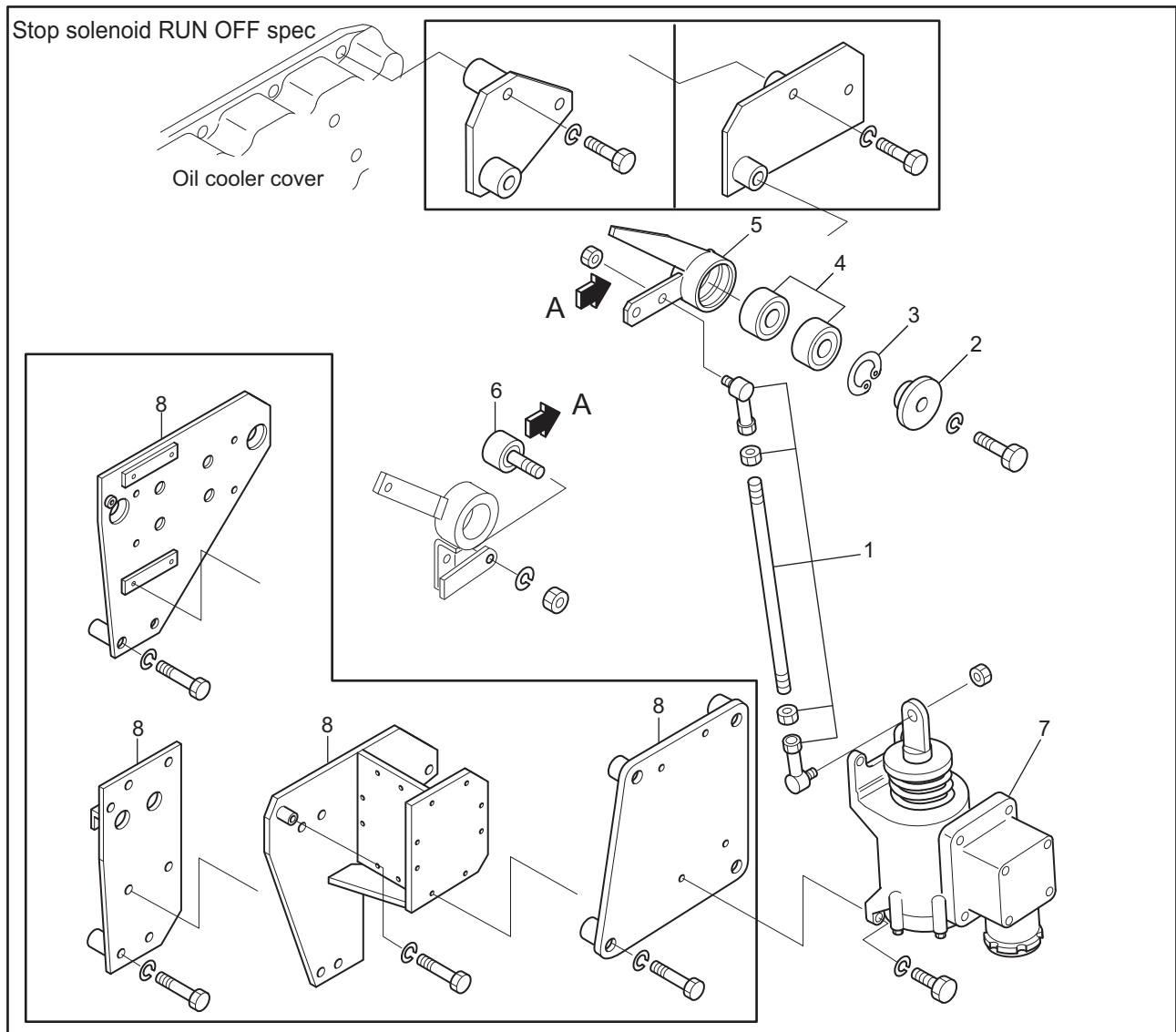
- 1 Fuel pipe
- 2 Fuel pipe

3 Fuel filter

4 Bracket

Note: The consisting parts at fuel inlet and outlet differ depending on the customization and specification.

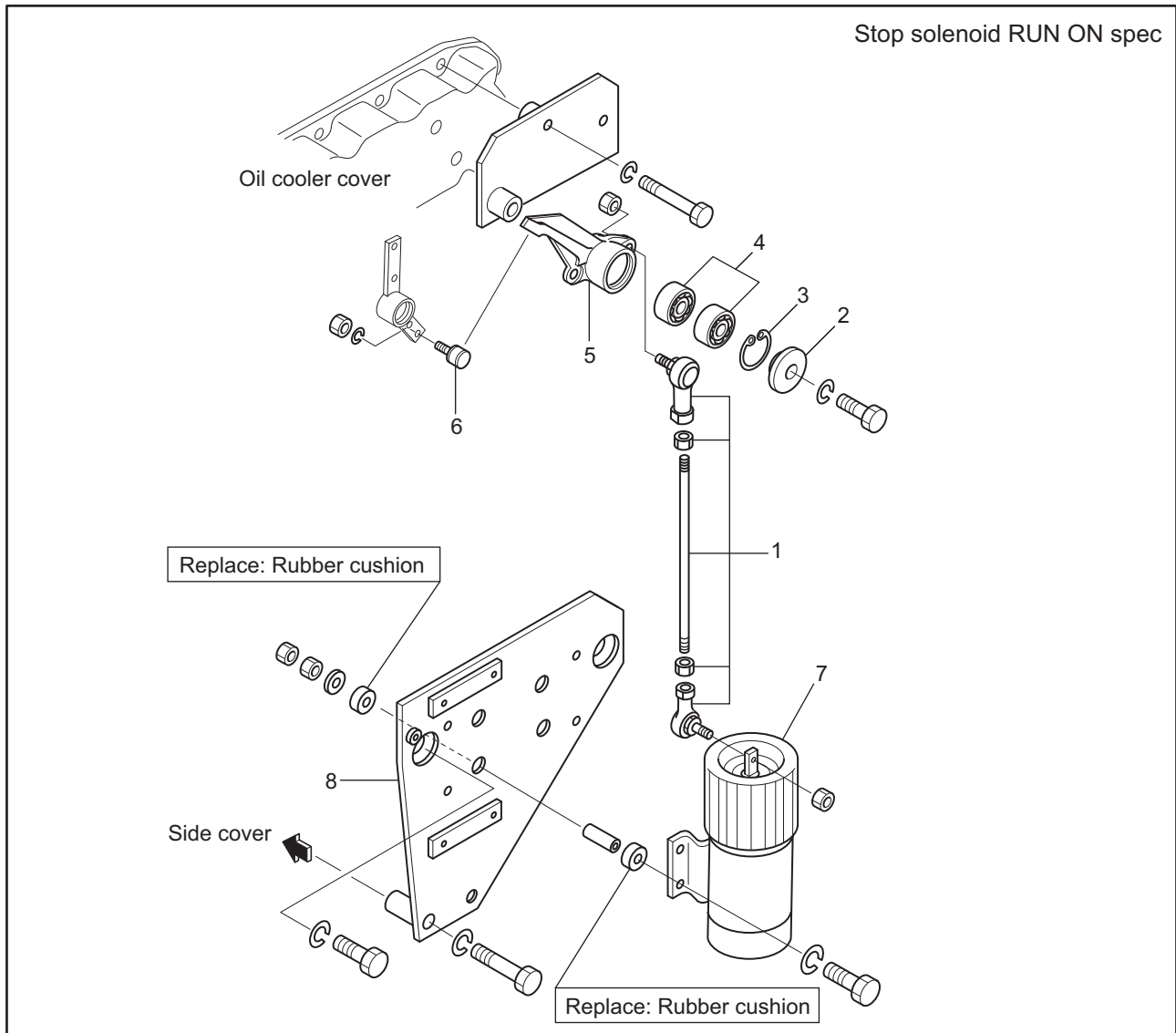
1.3 Stop Solenoid - Remove and Inspect



Stop Solenoid - Remove and Inspect

Removing Sequence

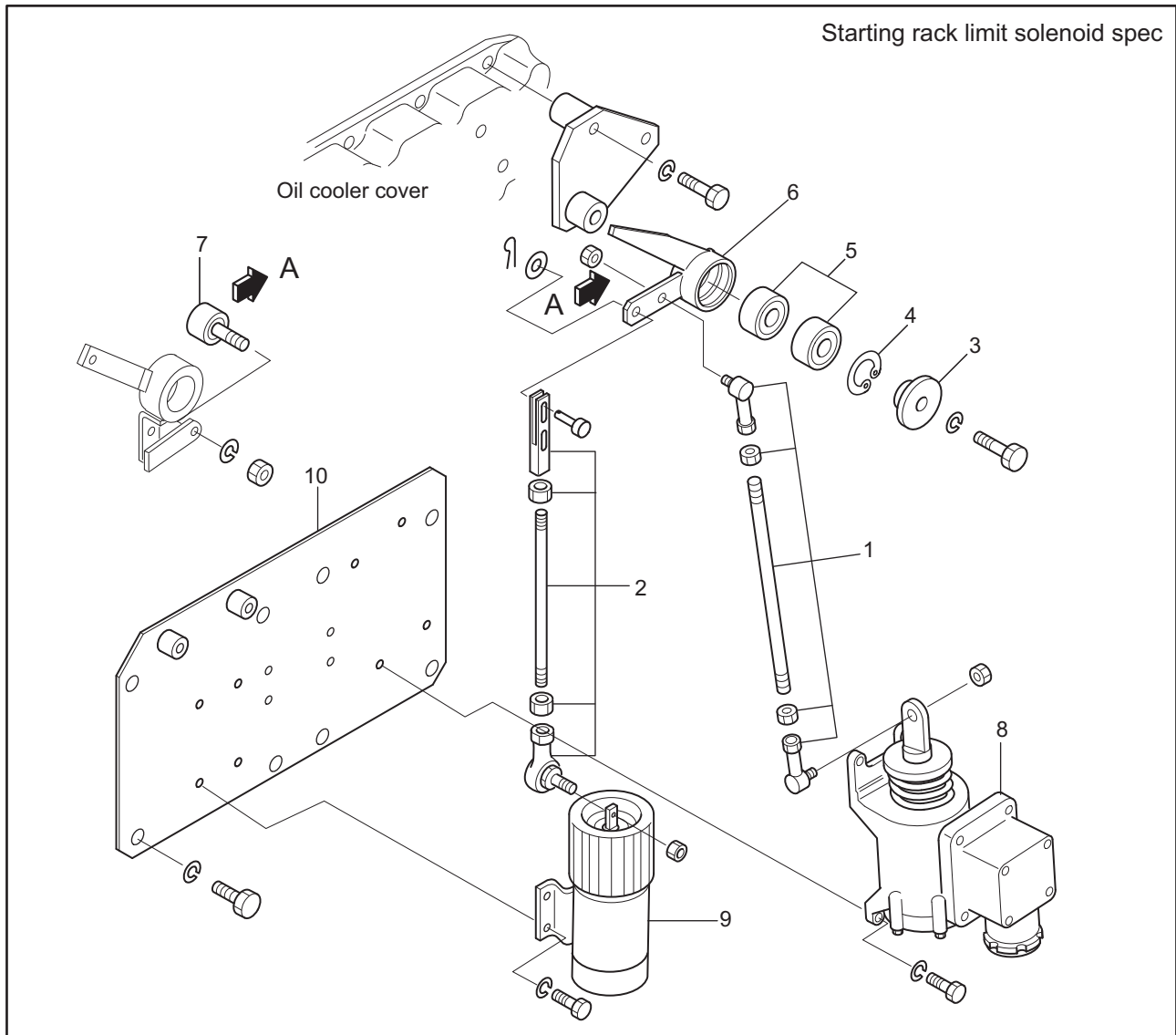
- | | | |
|-------------|----------------|-----------------|
| 1 Link | 4 Ball bearing | 7 Stop solenoid |
| 2 End plate | 5 Stop lever | 8 Bracket |
| 3 Snap ring | 6 Follower | |



Stop Solenoid - Remove and Inspect

Removing Sequence

- | | | |
|-------------|----------------|-----------------|
| 1 Link | 4 Ball bearing | 7 Stop solenoid |
| 2 End plate | 5 Stop lever | 8 Bracket |
| 3 Snap ring | 6 Follower | |

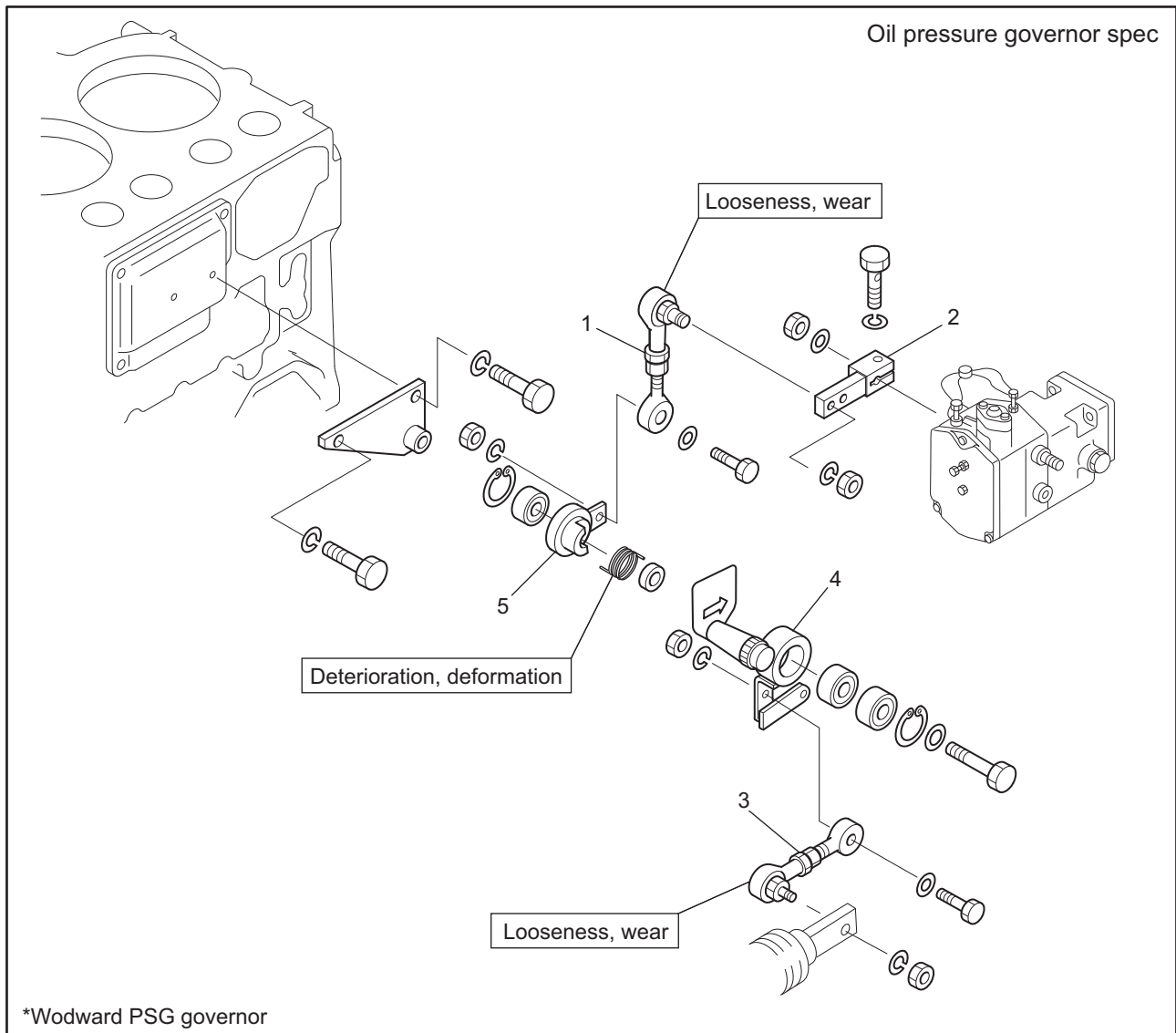


Stop Solenoid - Remove and Inspect

Removing Sequence

- | | | |
|-------------|-----------------|--------------------------------|
| 1 Link | 5 Ball bearing | 9 Start rack restrict solenoid |
| 2 Link | 6 Stop lever | 10 Bracket |
| 3 End plate | 7 Follower | |
| 4 Snap ring | 8 Stop solenoid | |

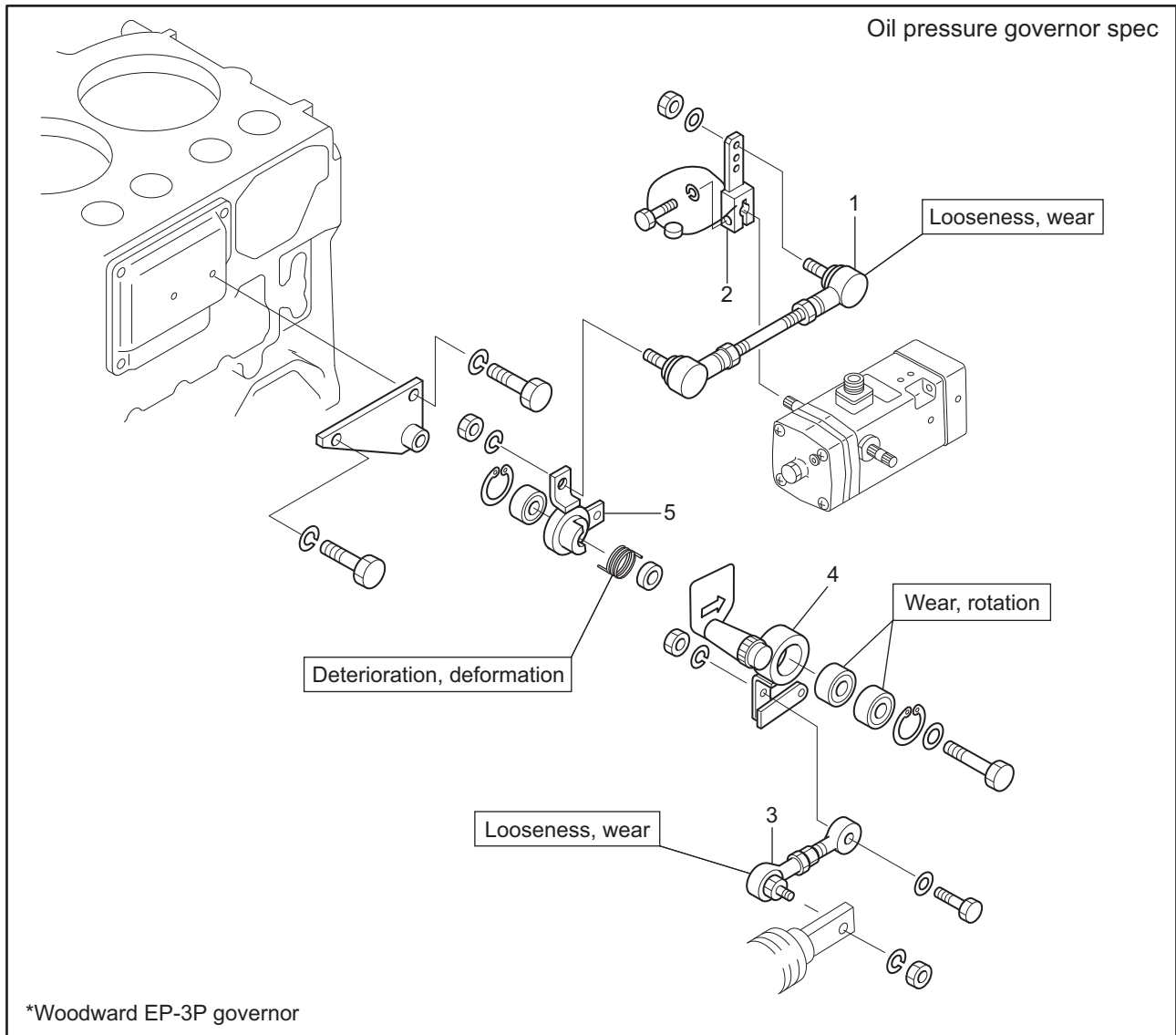
1.4 Fuel Control Link - Remove and Inspect



Fuel Control Link - Remove and Inspect

Removing Sequence

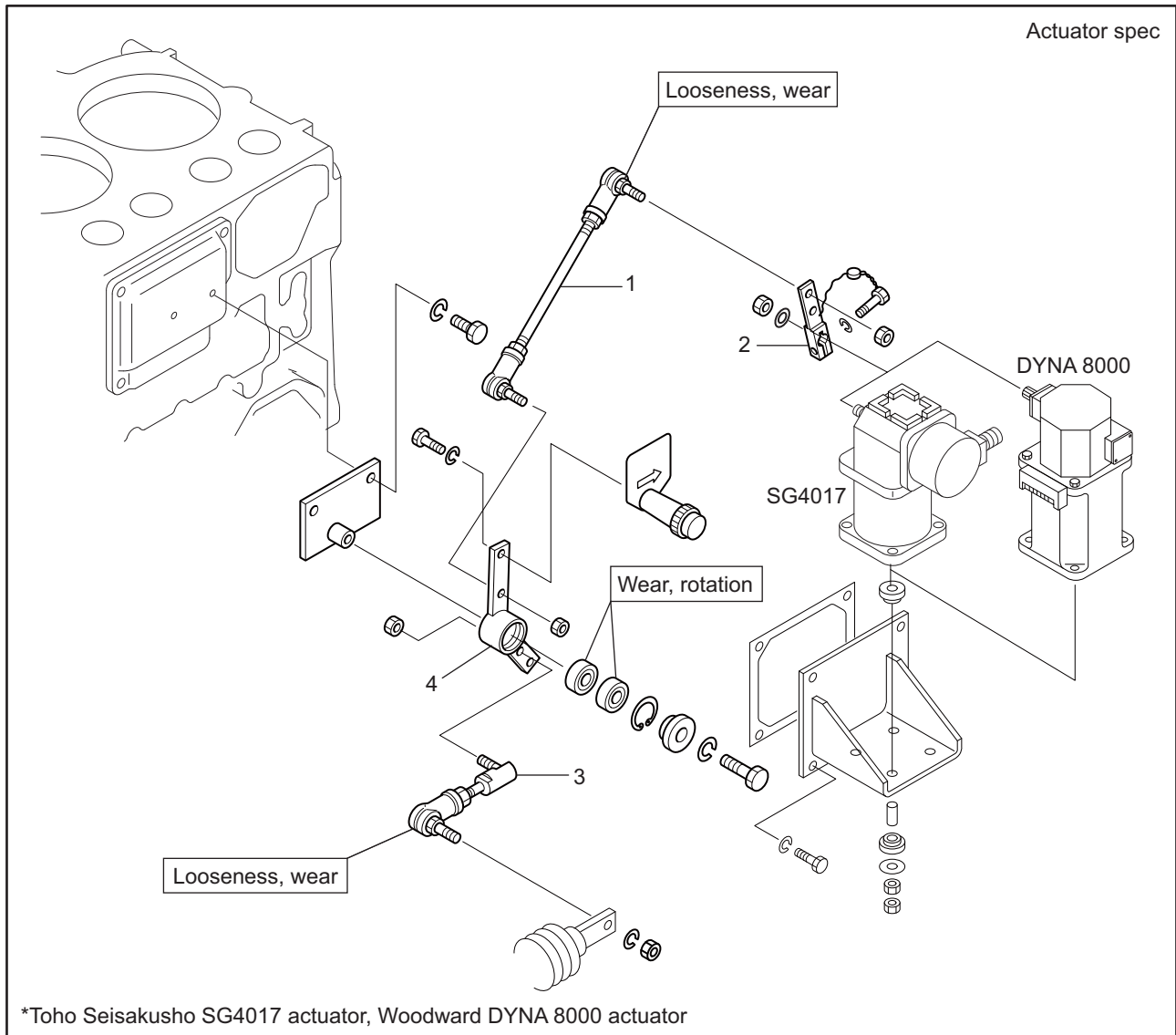
- | | | |
|------------------|--------------|---------|
| 1 Link | 3 Link | 5 Lever |
| 2 Governor lever | 4 Stop lever | |



Fuel Control Link - Remove and Inspect

Removing Sequence

- | | | |
|------------------|--------------|---------|
| 1 Link | 3 Link | 5 Lever |
| 2 Governor lever | 4 Stop lever | |



Fuel Control Link - Remove and Inspect

Removing Sequence

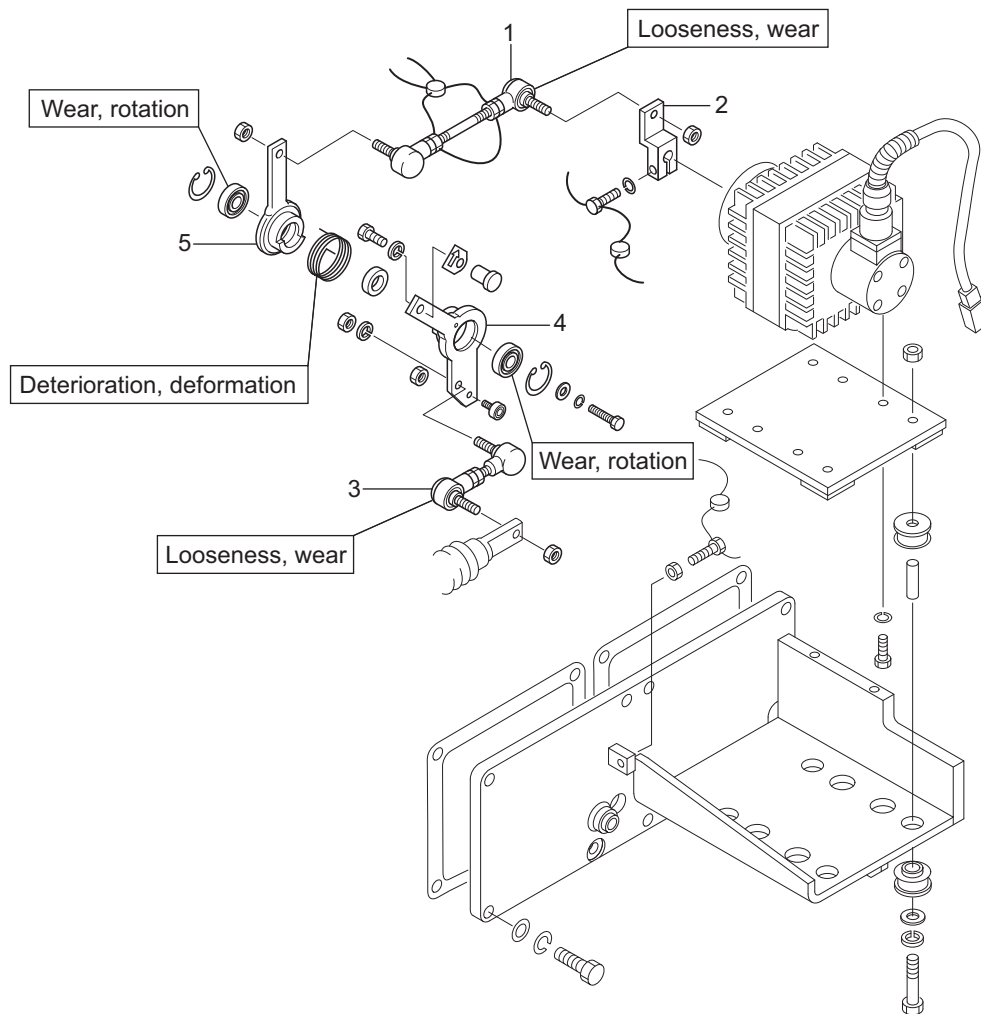
1 Link

2 Governor lever

3 Link

4 Stop lever

Actuator spec



*Woodward ProAct actuator

Fuel Control Link - Remove and Inspect

Removing Sequence

1 Link

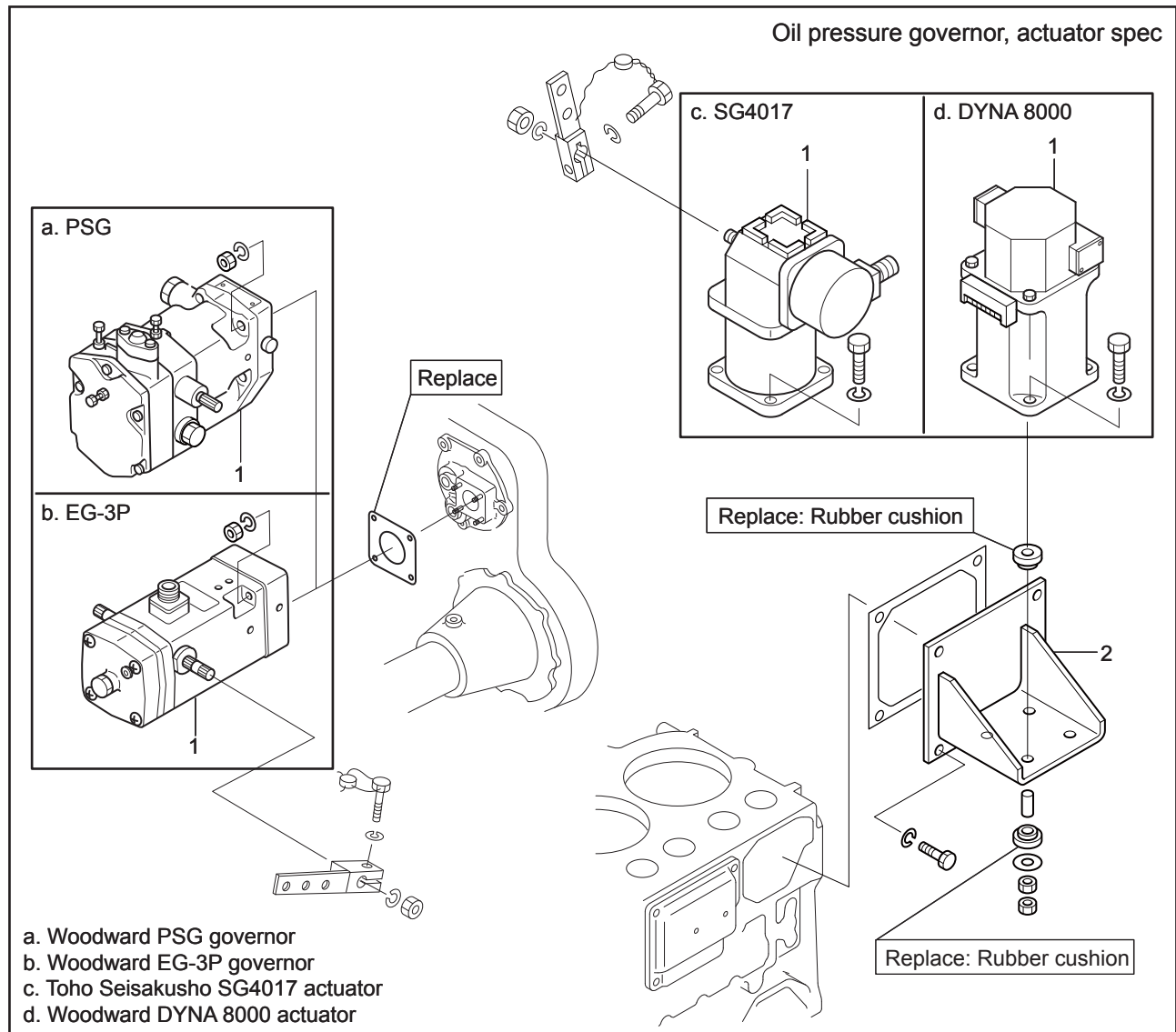
2 Governor lever

3 Link

4 Stop lever

5 Lever

1.5 Governor and Actuator - Remove and Inspect

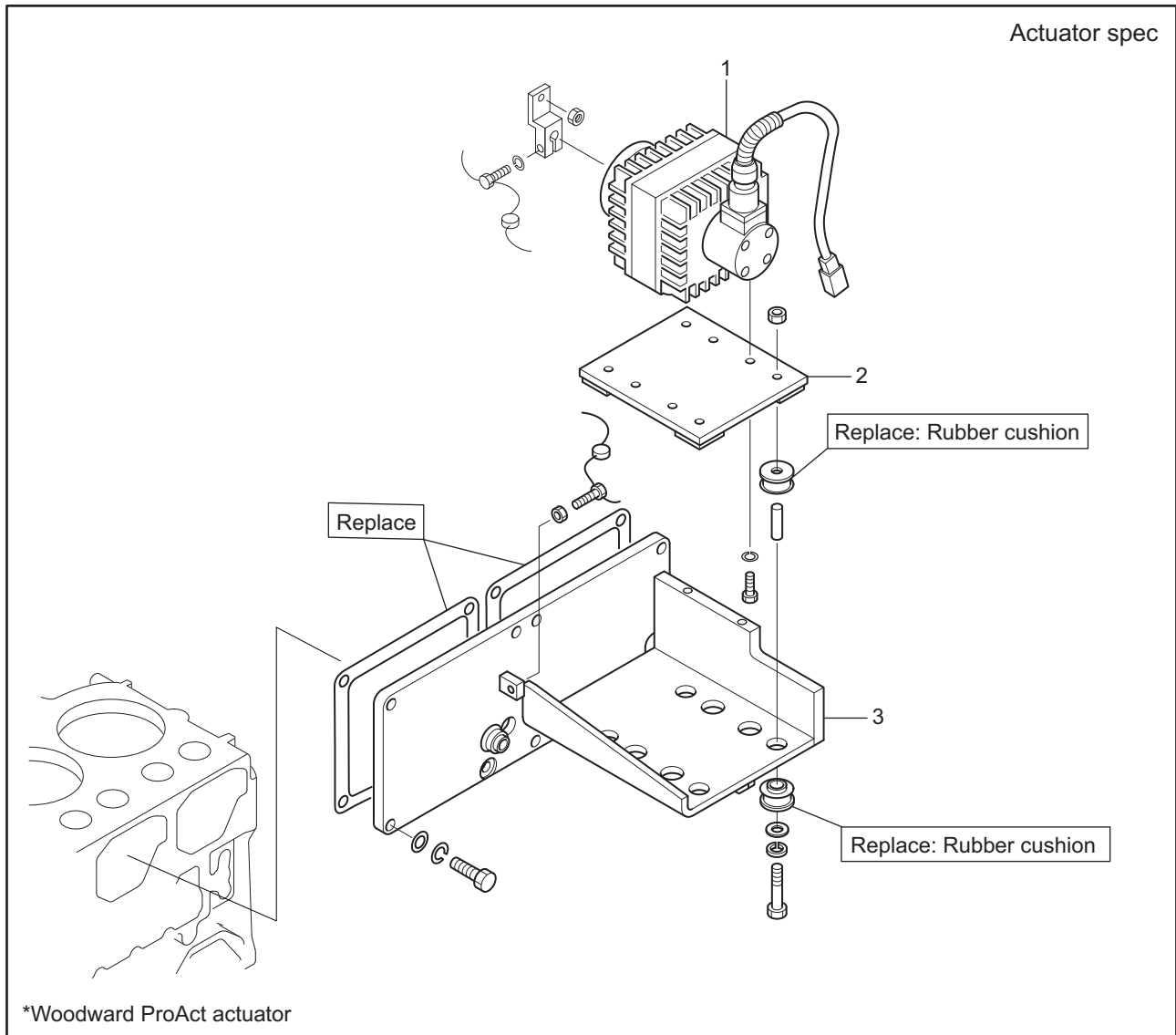


Governor and Actuator - Remove and Inspect

Removing Sequence

1 Governor, actuator

2 Bracket



Actuator - Remove and Inspect

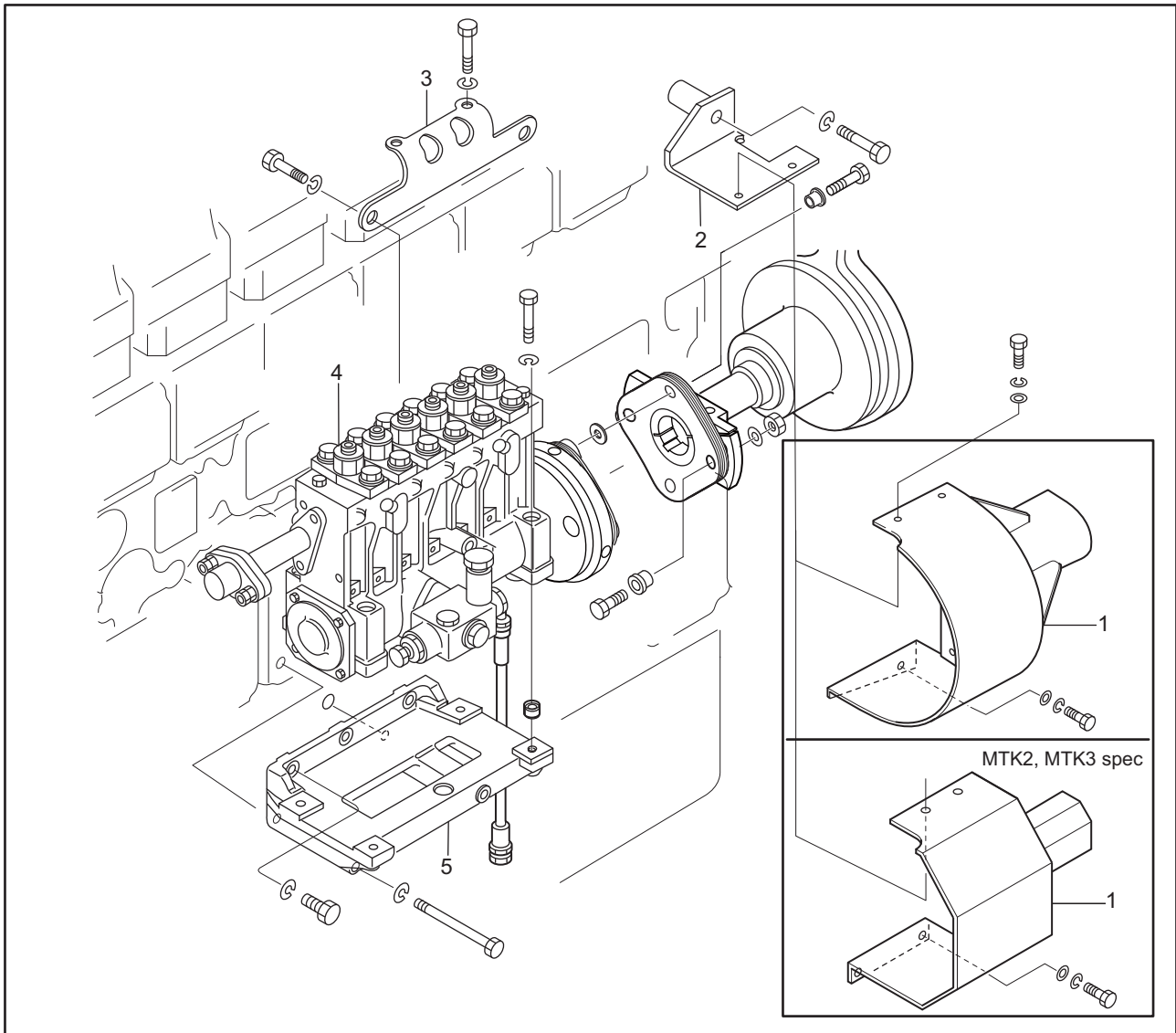
Removing Sequence

1 Actuator

2 Plate

3 Actuator bracket

1.6 Fuel Injection Pump - Remove and Inspect



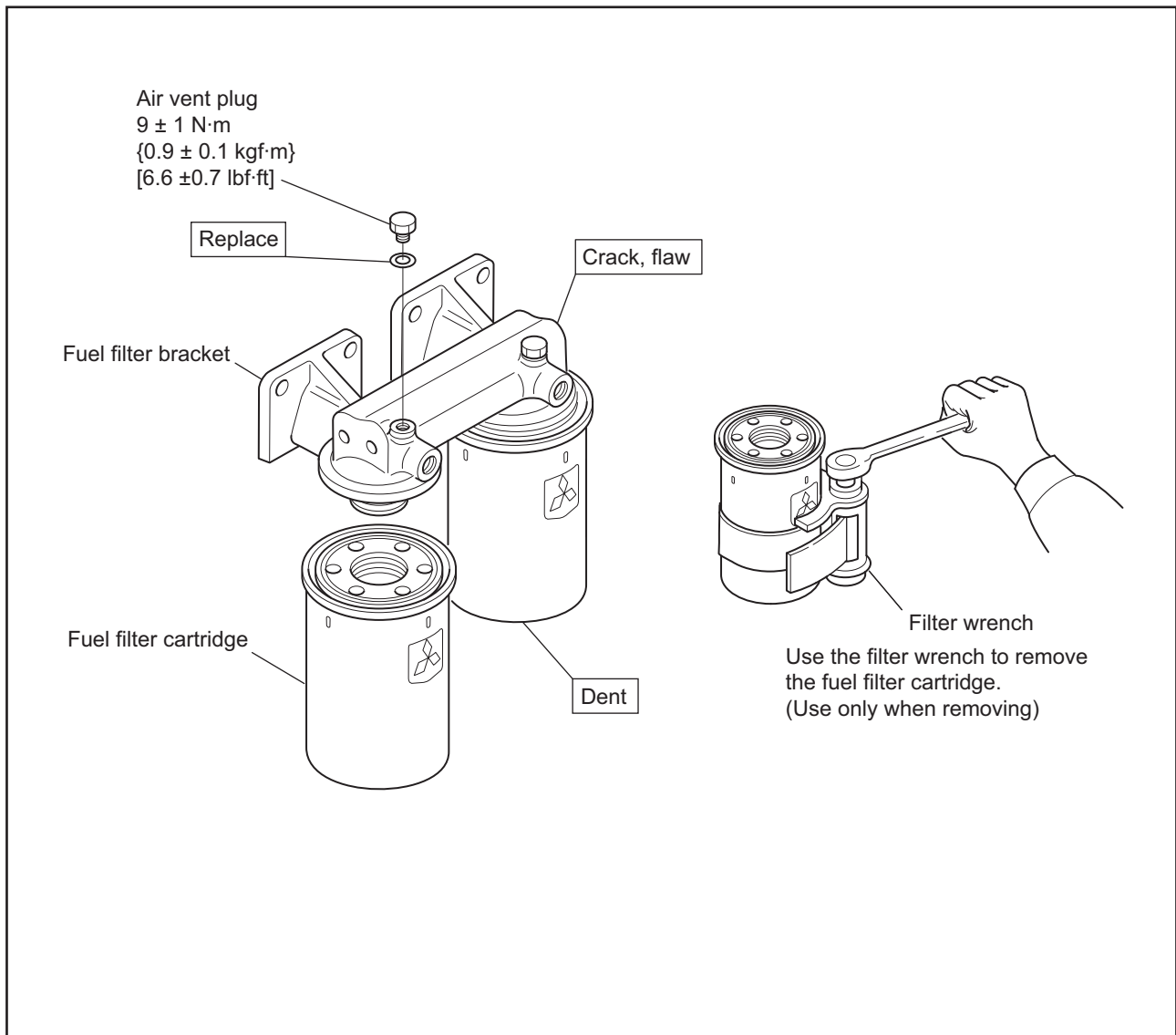
Fuel Injection Pump - Remove and Inspect

Removing Sequence

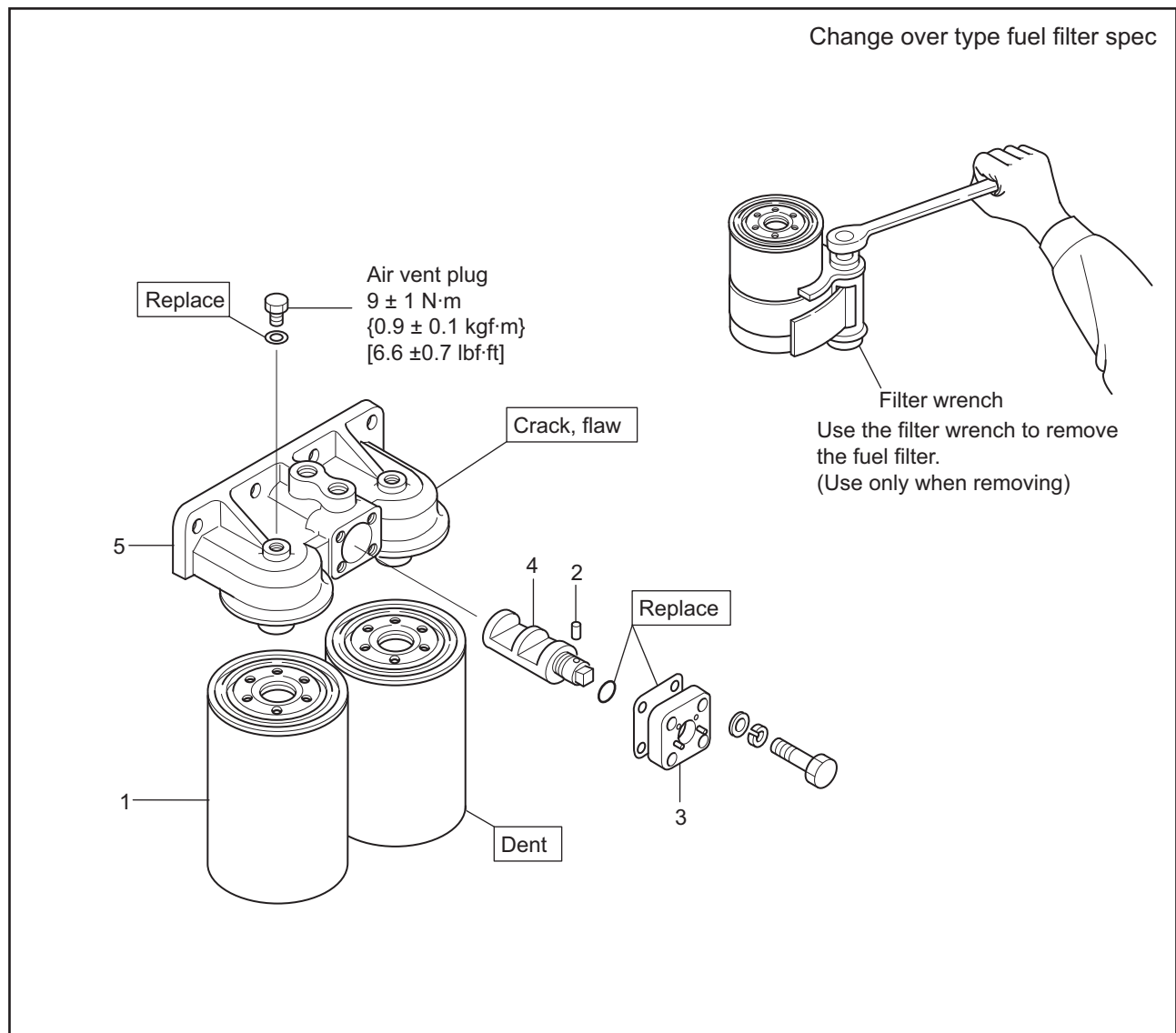
- | | |
|------------------|---|
| 1 Coupling cover | 4 Fuel injection pump (Approx 56 kg [123 lb]) |
| 2 Bracket | 5 Bracket |
| 3 Bracket | |

2. Fuel System - Disassemble, Inspect and Assemble

2.1 Fuel Filter (Paper Element) - Disassemble, Inspect and Assemble



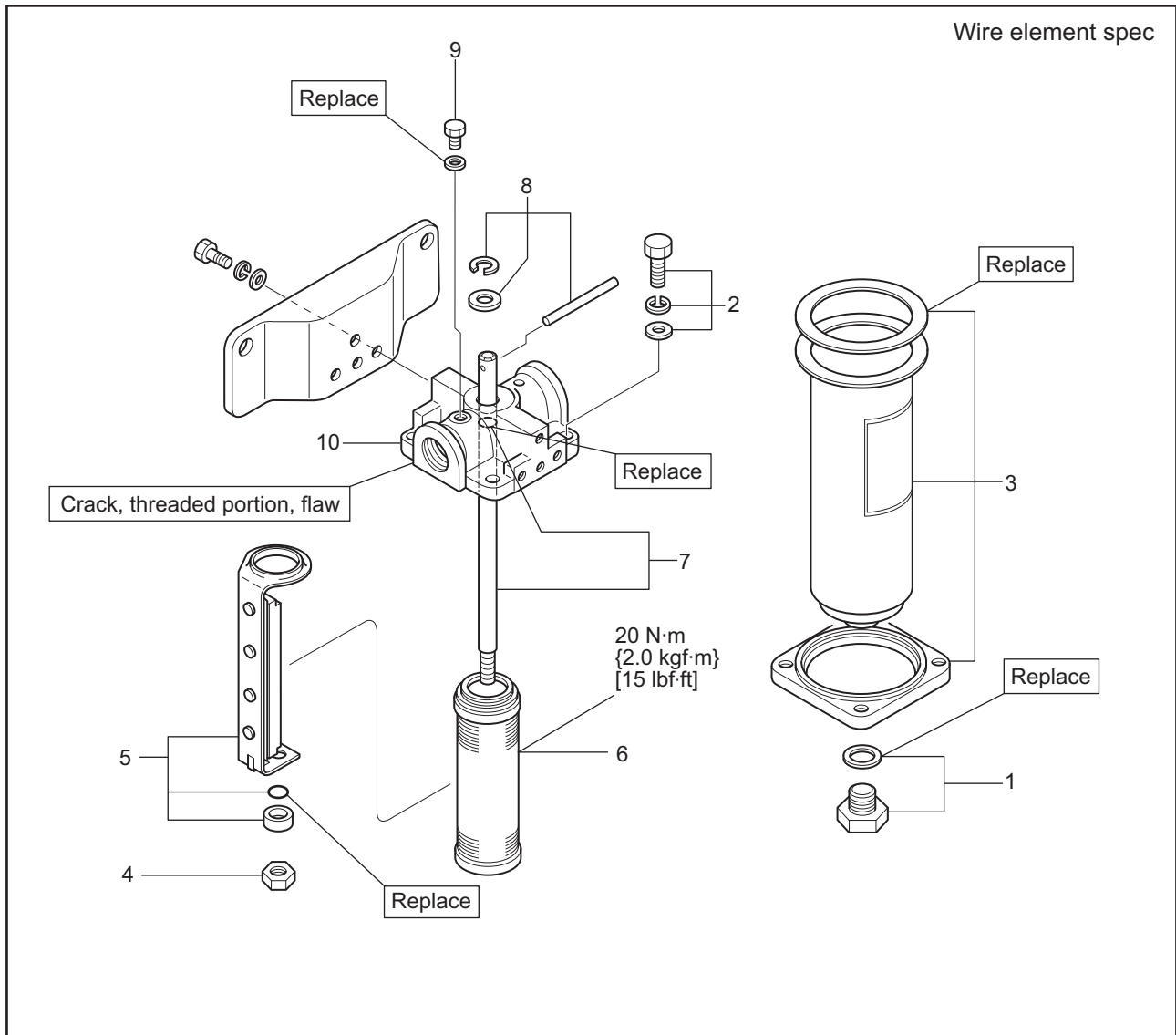
Fuel Filter (Paper Element) - Disassemble, Inspect and Assemble



Fuel Filter (Paper Element) - Disassemble, Inspect and Assemble

Disassembling Sequence

- | | |
|-------------------------|-----------------------|
| 1 Fuel filter cartridge | 4 Cock |
| 2 Pin | 5 Fuel filter bracket |
| 3 Cover | |



Fuel Filter (Wire Element) - Disassemble, Inspect and Assemble

Disassembling Sequence

- | | |
|-------------------------------------|-----------------------------|
| 1 Plug, packing | 6 Element |
| 2 Bolt, spring washer, plain washer | 7 Rod, O-ring |
| 3 Flange, lower case, packing | 8 Snap ring, washer, handle |
| 4 Nut | 9 Air vent plug |
| 5 Plate, scraper, collar, O-ring | 10 Cover |

2.1.1 Fuel Filter Cartridge - Install



WARNING

- (a) Make sure that there is no flame around the area before handling fuel.
- (b) Wipe any spilled fuel to prevent a fire.
- (c) Do not use the fuel filter cartridge that has a dent on the case. If the case has a dented, it can cause damage to the fuel filter cartridge, leading to fuel leaks during operation, and results in a fire.

CAUTION

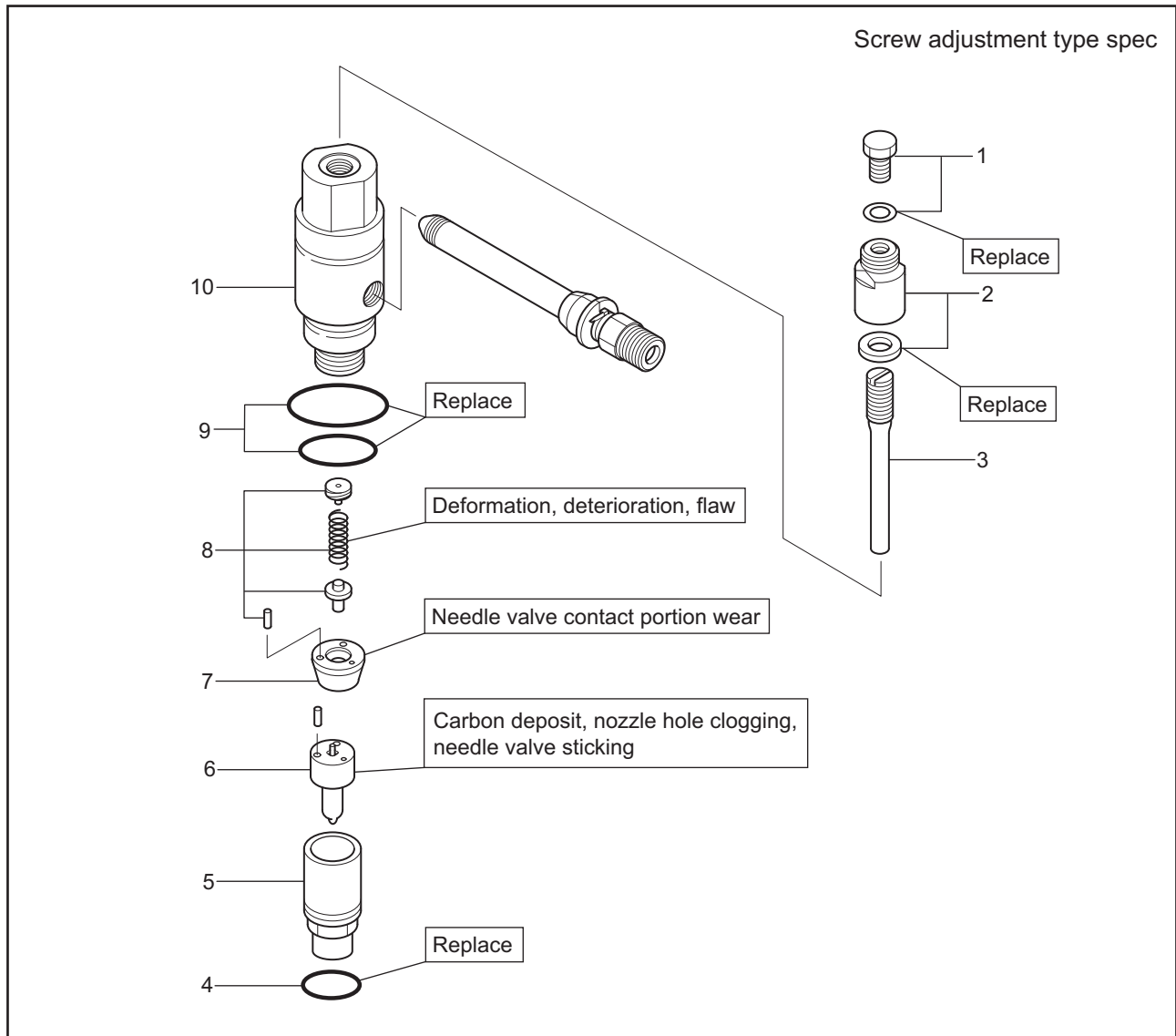
- (a) When installing the fuel filter cartridge, do not use a filter wrench. Tighten it with your hand.
 - (b) Be careful not to dent or damage the surface of fuel filter cartridge.
-
- (1) Remove dust and contaminants on the filter cartridge mating face.
 - (2) Apply clean fuel on the fuel filter gasket.
 - (3) After the fuel filter gasket comes into contact with the base, tighten the cartridge by 3/4 to 1 turn by hand.
- Note: After the installation bleed air from the fuel system.
- (4) Start the engine, and make sure that there is no fuel leaks.

2.2 Fuel Injection Nozzle - Disassemble and Inspect

Understanding of the current engine condition before disassembling is very important to know the cause of trouble and do the efficient work.

Depending on the maintenance work or purpose, it is desirable to inspect some of the following items before proceeding with any job.

- ♦Fuel Injection Start Pressure - Inspect
- ♦Fuel Injection Nozzle Spray - Inspect

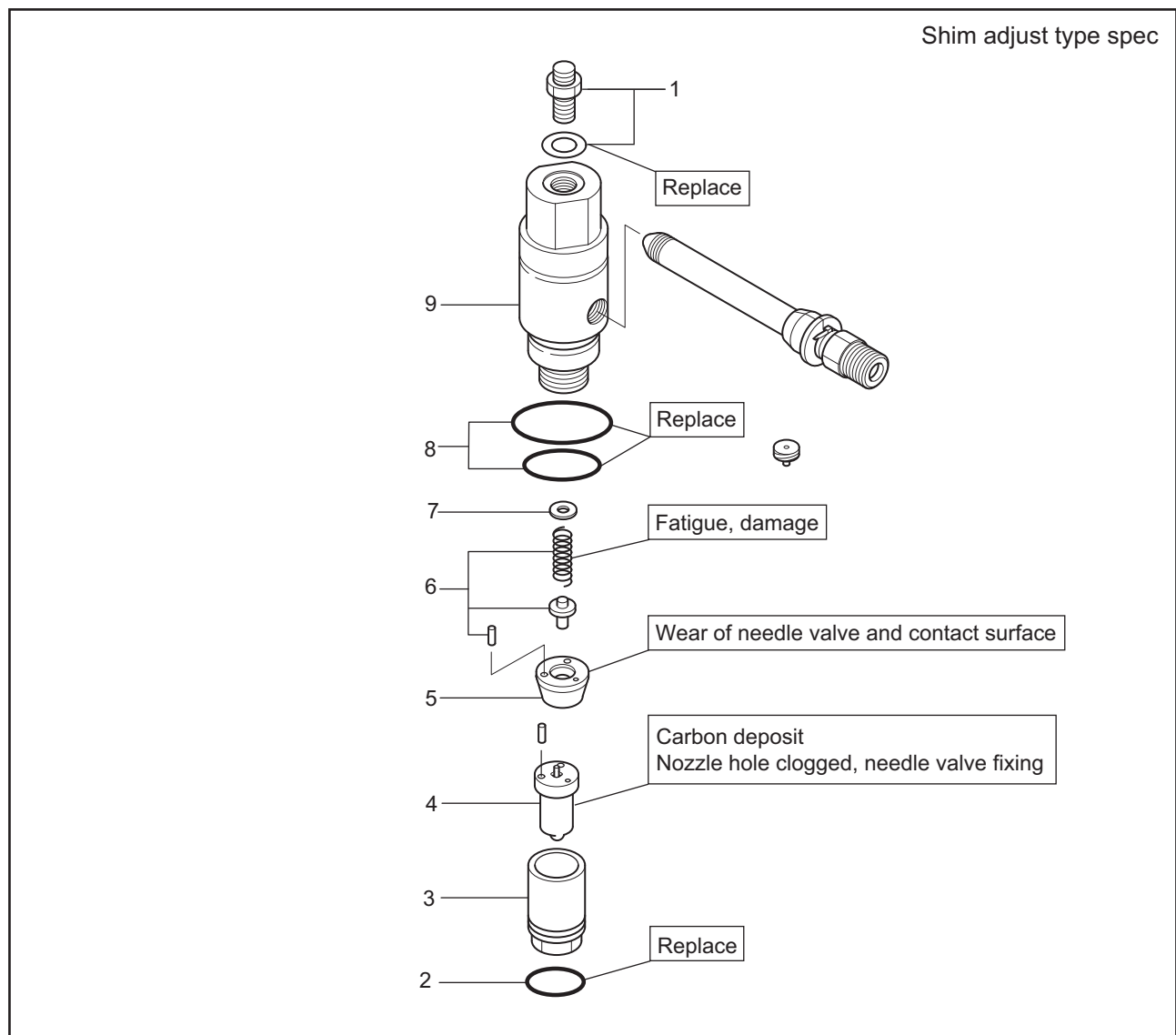


Fuel Injection Nozzle - Disassemble and Inspect

Disassembling Sequence

- | | |
|-----------------------------|--|
| 1 Set screw, sealing washer | 6 Nozzle tip |
| 2 Cap nut, sealing washer | 7 Spacer |
| 3 Adjusting screw | 8 Push rod, nozzle spring, spring seat |
| 4 O-ring | 9 O-ring |
| 5 Retaining nut | 10 Nozzle holder |

Note: Nozzle tip, spacer, and nozzle spring must be replaced with new ones as a set.



Fuel Injection Nozzle - Disassemble and Inspect

Disassembling Sequence

- | | |
|-----------------|---------------------------|
| 1 Short plug | 6 Push rod, nozzle spring |
| 2 O-ring | 7 Shim |
| 3 Retaining nut | 8 O-ring |
| 4 Nozzle tip | 9 Nozzle holder |
| 5 Spacer | |

Note: Nozzle tip, spacer, and nozzle spring must be replaced with new ones as a set.

2.3 Fuel Injection Nozzle - Inspect and Adjust

2.3.1 Fuel Injection Start Pressure - Inspect and Adjust



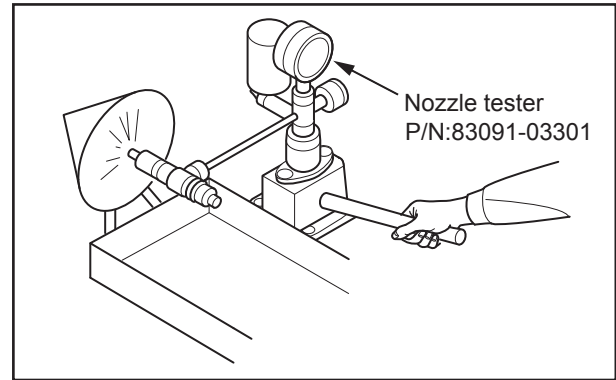
CAUTION

Never touch the fuel injection nozzle orifice during nozzle injection test.

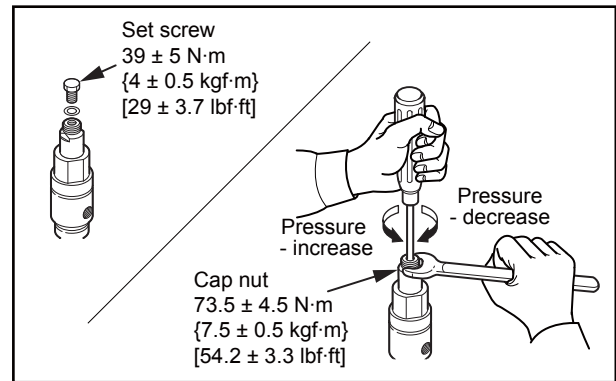
(Screw adjust type)

- (1) Install the fuel injection nozzle to the nozzle tester.
- (2) Push down the handle at a speed of one stroke a second and measure the pressure when injection starts. If the pressure is out of the standard, adjust it to the standard.
- (3) To adjust the injection start pressure, remove the set screw on the nozzle holder, loosen the cap nut and turn the adjusting screw with a screwdriver.
- (4) After adjustment, tighten the cap nut and set screw to the specified torque.
- (5) After tightening the set screw, inspect the injection start pressure again to make sure it is within the standard value.

Item	Nominal value	Standard value
37560-22010		
37560-35000	34.32 MPa	34.32 to 34.81 MPa
37560-39000	{350 kgf/cm ² }	{350 to 355 kgf/cm ² }
37561-44000	[4978 psi]	[5049 psi]
37860-06000		(the value when it is new)
37760-14001	30.40 MPa	30.40 to 30.89 MPa
37760-22001	{300 kgf/cm ² }	{310 to 315 kgf/cm ² }
	[4267 psi]	[4480 psi]
		(the value when it is new)



Fuel Injection Start Pressure - Inspect

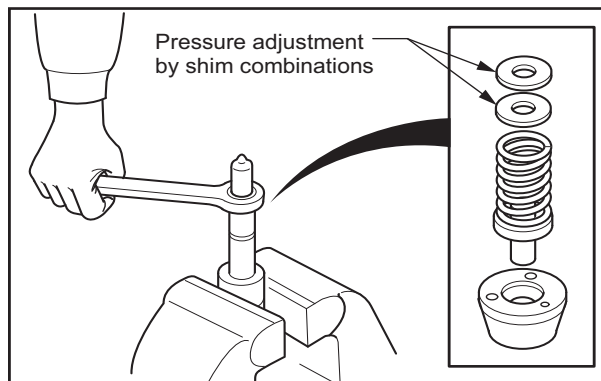


Fuel Injection Start Pressure - Adjust

(Shim adjust type)

- (1) Install the fuel injection nozzle to the nozzle tester.
- (2) Push down the handle at a speed of one stroke a second and measure the pressure when injection starts. If the pressure is out of the standard, adjust it to the standard.
- (3) Adjust the injection start pressure by increasing or decreasing the number of shims. Shims are available in 9 types from 0.40 to 1.2 mm [0.0157 to 0.0472 in.] Refer to the table below for adjustment.
- (4) After the adjustment, tighten the retaining nut to the specified torque of $186.5 \pm 9.5 \text{ N}\cdot\text{m}$ $\{19 \pm 1 \text{ kgf}\cdot\text{m}\}$ $[137.55 \pm 7.01 \text{ lbf}\cdot\text{ft}]$.
- (5) After tightening the retaining nut to the specified torque, inspect again the injection start pressure to see that it is as specified.

Item		Nominal value	Standard value
Fuel injection starting pressure	37560-32000	34.32 MPa {350 kgf/cm ² } [4978 psi]	33.83 to 35.79 MPa {345 to 365 kgf/cm ² } [5192 psi] (the value when it is new)



Valve Opening Pressure of Fuel Injection Nozzle - Adjust

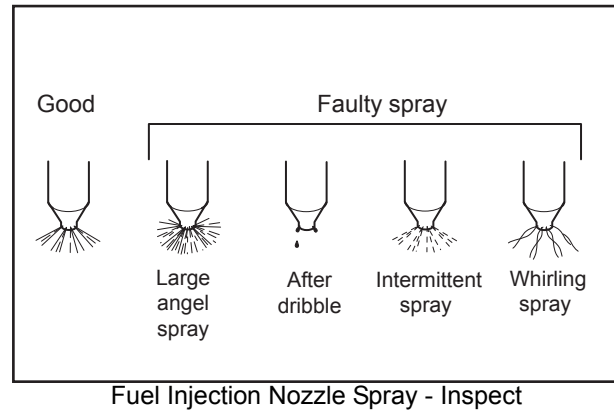
Shim part number	Shim thickness	Valve opening pressure	
48742-00311	0.40 mm [0.0157 in.]	-6.66 MPa	-68.0 kgf/cm ² [-967 psi]
48742-00321	0.50 mm [0.0197 in.]	-5.33 MPa	-54.4 kgf/cm ² [-774 psi]
48742-00331	0.60 mm [0.0236 in.]	-4.00 MPa	-40.8 kgf/cm ² [-580 psi]
48742-00341	0.70 mm [0.276 in.]	-2.67 MPa	-27.2 kgf/cm ² [-387 psi]
48742-00351	0.80 mm [0.0315 in.]	-1.33 MPa	-13.6 kgf/cm ² [-193 psi]
48742-00361	0.90 mm [0.0354 in.]	0.0 (Standard)	0.0 (Standard)
48742-00371	1.00 mm [0.0394 in.]	1.33 MPa	13.6 kgf/cm ² [193 psi]
48742-00381	1.10 mm [0.0433 in.]	2.67 MPa	27.2 kgf/cm ² [387 psi]
48742-00391	1.20 mm [.0472]	4.00 MPa	40.8 kgf/cm ² [580 psi]

2.3.2 Fuel Injection Nozzle Spray - Inspect

When adjusting the nozzle opening pressure with the nozzle tester, inspect for nozzle orifice clogging, fuel spray pattern and dripping. If spray condition is faulty, clean or replace the nozzle tip.

Checking points of fuel spray are as follows:

- ♦ Injection spray is straight.
- ♦ The spray is of fine fuel droplets without big drops.
- ♦ No dripping is shown after injection.

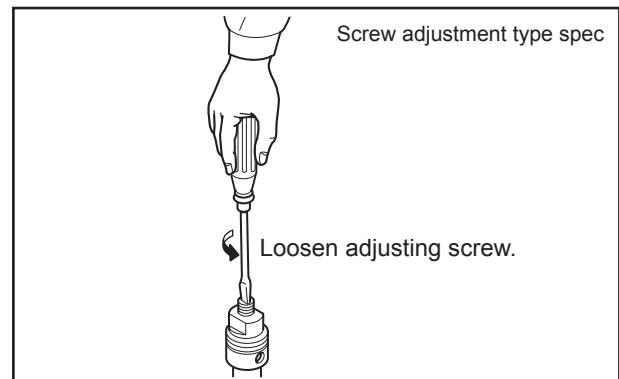


2.3.3 Nozzle Tip - Clean and Replace

CAUTION

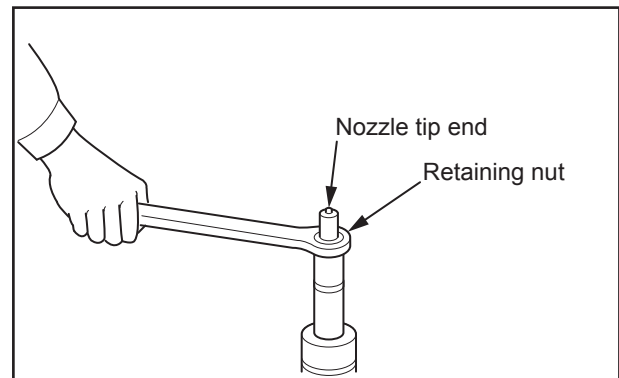
- (a) Be careful not to hit the nozzle tip.
- (b) The needle valve and body are precision parts.
Handle them carefully, and do not change the original valve and body combination.

- (1) Remove the retaining nut.
- (2) Remove the nozzle tip.



Nozzle Tip - Remove

- (3) Clean the needle valve and body of nozzle tip.
When cleaning the needle valve and nozzle tip body, use clean wash oil. Assemble the needle valve and body in clean diesel fuel after cleaning.
- (4) Tighten the nozzle tip retaining nut to the specified torque.
- (5) If the spray pattern is still faulty after cleaning and adjusting, replace the nozzle tip with a new one.
New nozzle tips are coated with anti-corrosive agent. Wash the nozzle tips before use. First wash them in wash oil, and wash it again with clean diesel fuel before installation.

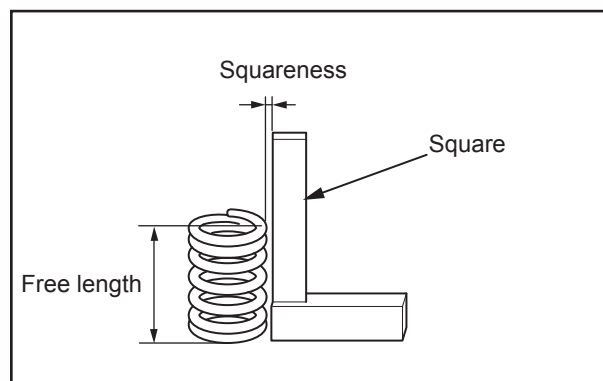


Nozzle Tip - Clean

2.3.4 Squareness, Free Length of Nozzle Spring, Parallelism of Top and Bottom Faces - Measure
Measure the squareness, free length and parallelism of top and bottom surfaces of nozzle spring.

Item	Spring part No.	Standard value
Free length	37561-26400	30 mm [1.18 in.]
	48726-00402	26.8 mm [1.055 in.]
Squareness	37561-26400	0.6 mm [0.024 in.] or less
	48726-00402	1.25° or less
Parallelism of top and bottom surfaces	37561-26400	0.1 mm [0.004 in.] or less
	48726-00402	0.65° or less

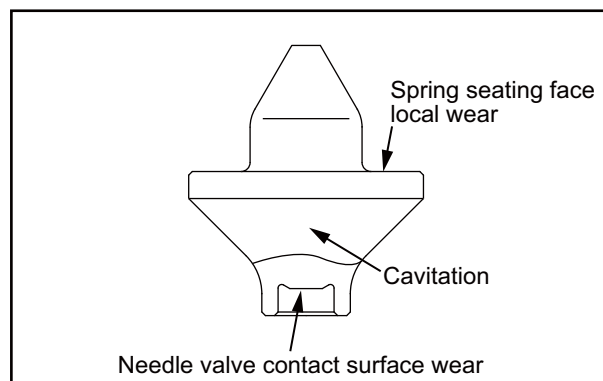
Note: When the nozzle tip is replaced, replace the spacer and nozzle spring with new ones.



Squareness, Free Length of Nozzle Spring, Parallelism of Top and Bottom Faces - Measure

2.3.5 Push Rod - Inspect

Inspect the push rod visually. If its spring seat wears unevenly, or its needle valve contact surface wears remarkably, or the cavitation occurs on its tapered area, replace the push rod with a new one.

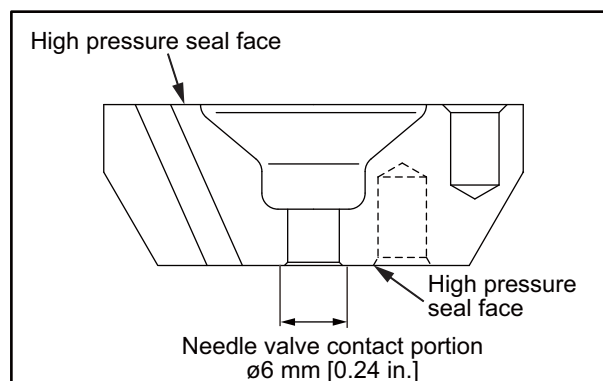


Push Rod - Inspect

2.3.6 Spacer - Inspect

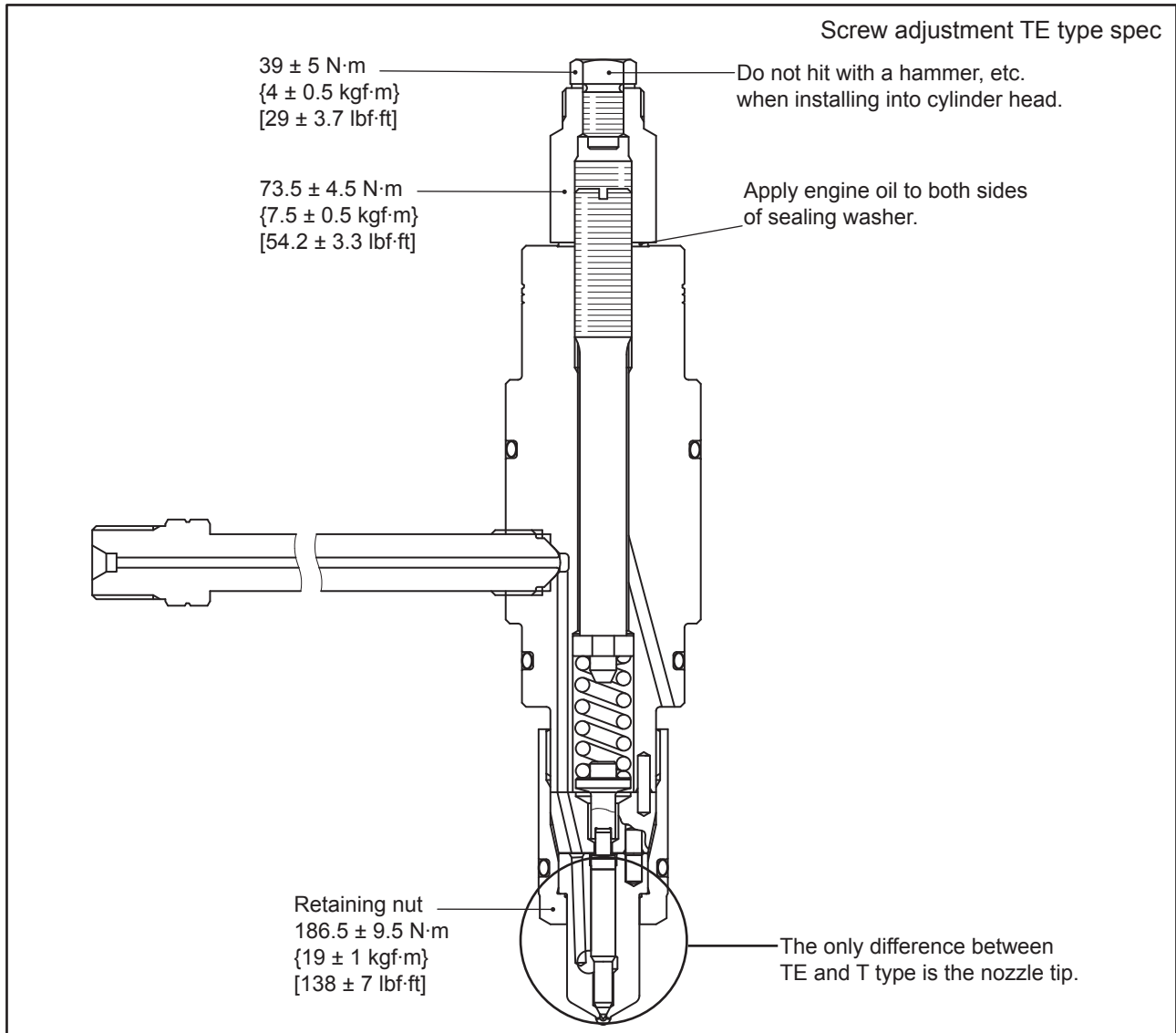
Inspect the spacer visually. If its needle valve contact surface or high pressure seal surface wears remarkably, replace the spacer with a new one.

Note: When the nozzle tip is replaced, replace the spacer and nozzle spring with new ones.



Spacer - Inspect

2.4 Fuel Injection Nozzle - Assemble

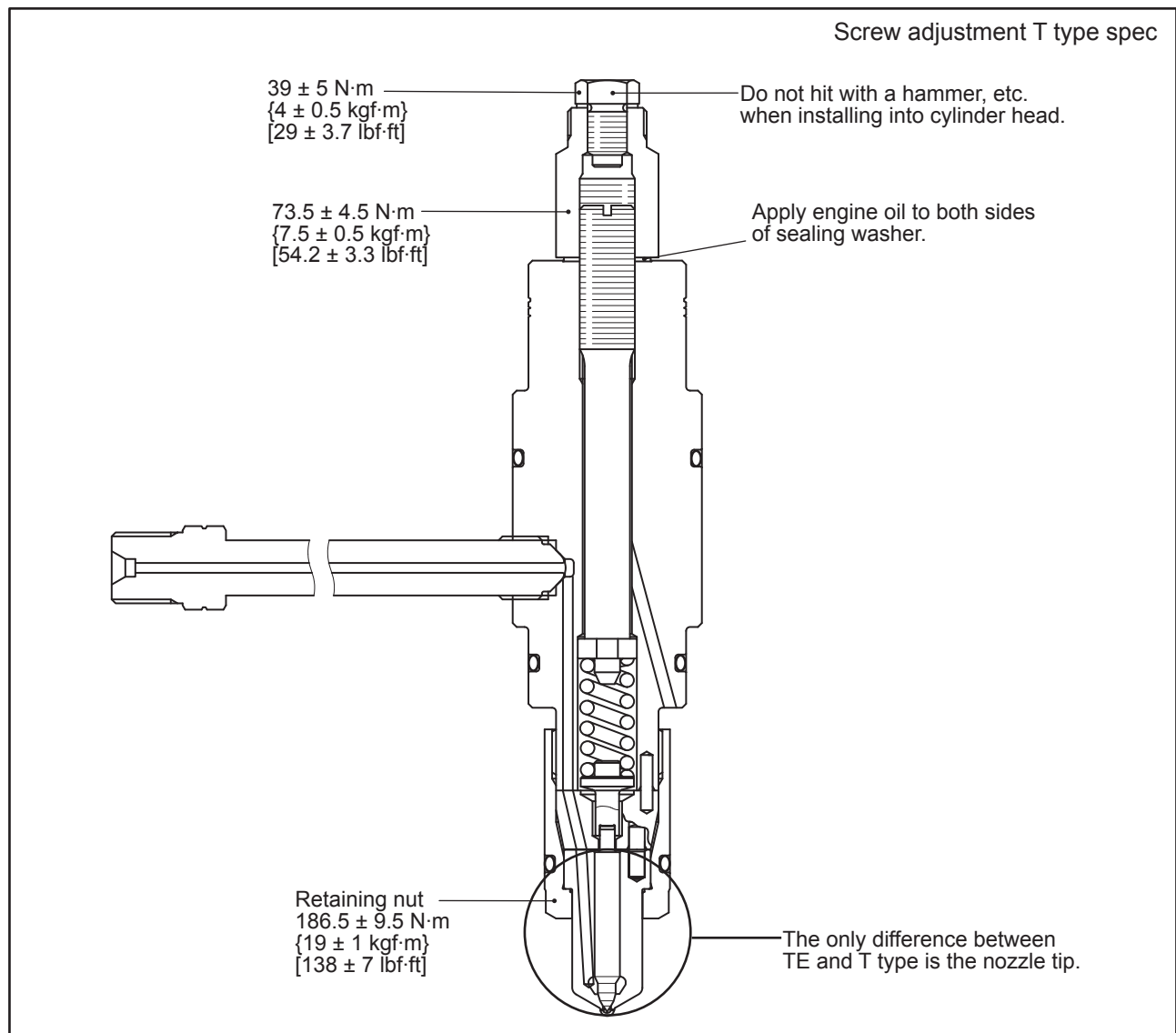


Fuel Injection Nozzle - Assemble

CAUTION

Be sure to tighten the retaining nut to the specified torque. Excessive tightening of retaining nut can harm smooth movement of the needle valve and result in abnormal exhaust smoke or needle valve sticking.

Note: When assembling the nozzle tip on the nozzle holder, make sure to align the nozzle tip knock pin with the nozzle holder hole.

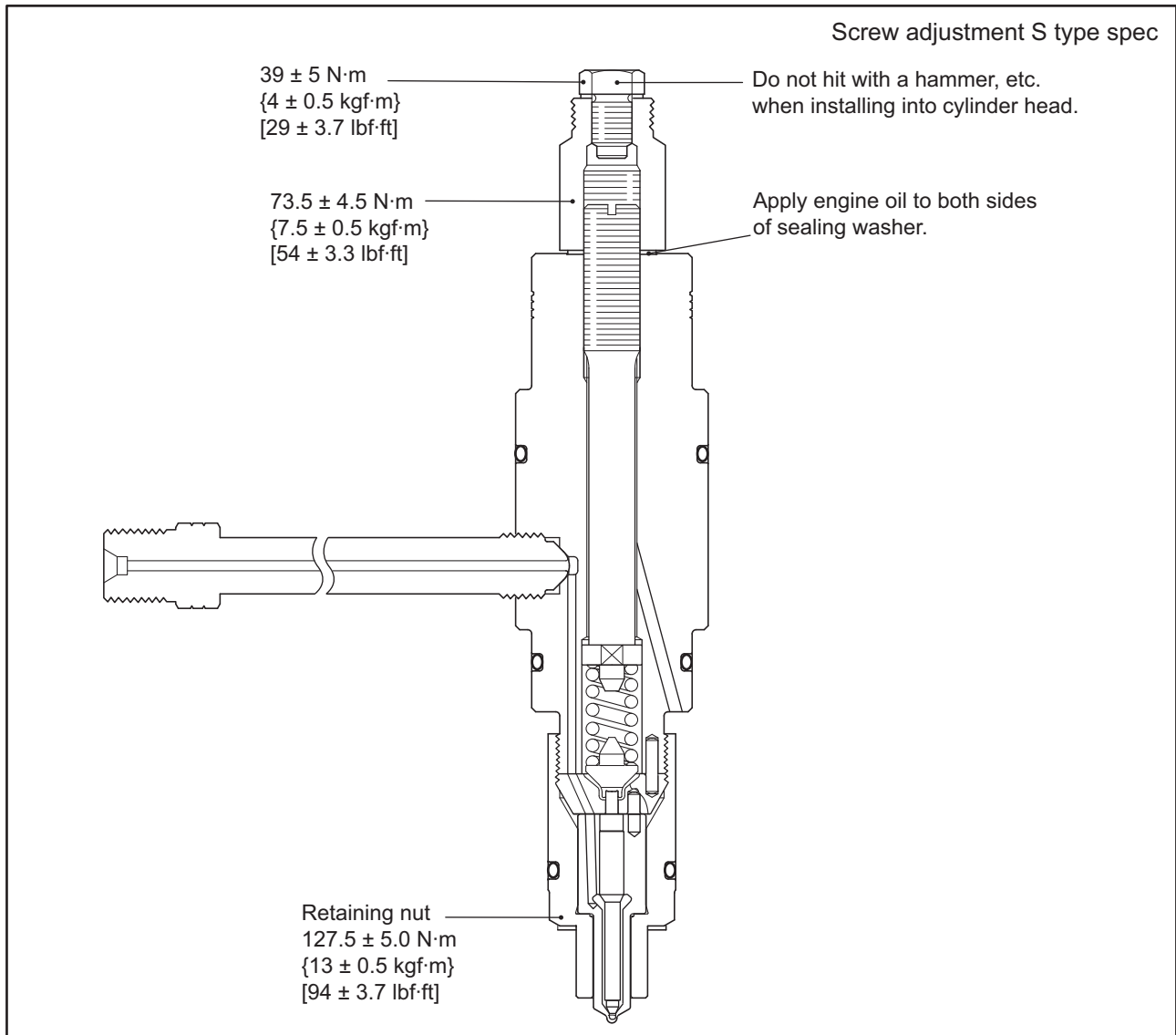


Fuel Injection Nozzle - Assemble

CAUTION

Be sure to tighten the retaining nut to the specified torque. Excessive tightening of retaining nut can harm smooth movement of the needle valve and result in abnormal exhaust smoke or needle valve sticking.

Note: When assembling the nozzle tip on the nozzle holder, make sure to align the nozzle tip knock pin with the nozzle holder hole.

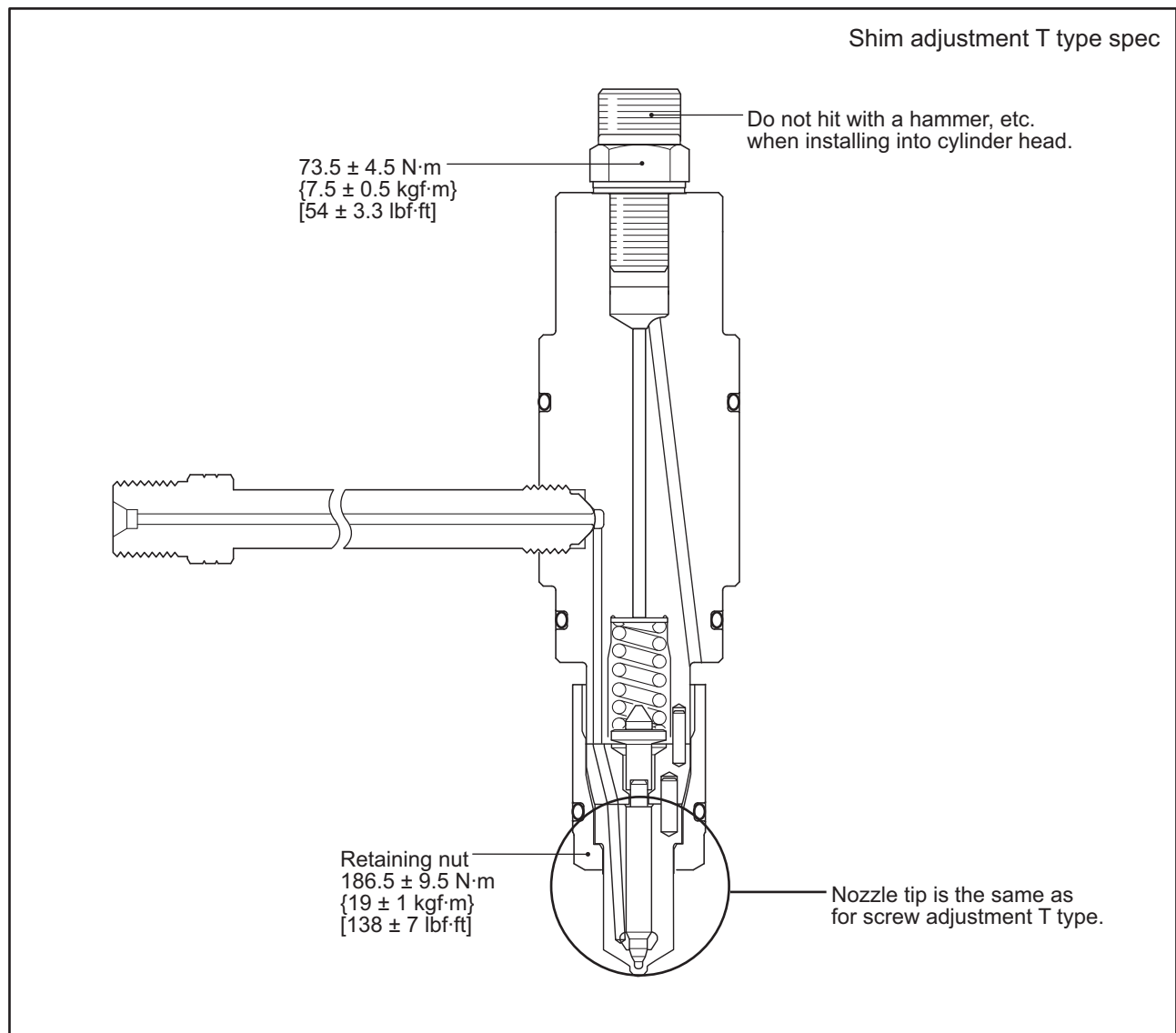


Fuel Injection Nozzle - Assemble

CAUTION

Be sure to tighten the retaining nut to the specified torque. Excessive tightening of retaining nut can harm smooth movement of the needle valve and result in abnormal exhaust smoke or needle valve sticking.

Note: When assembling the nozzle tip on the nozzle holder, make sure to align the nozzle tip knock pin with the nozzle holder hole.



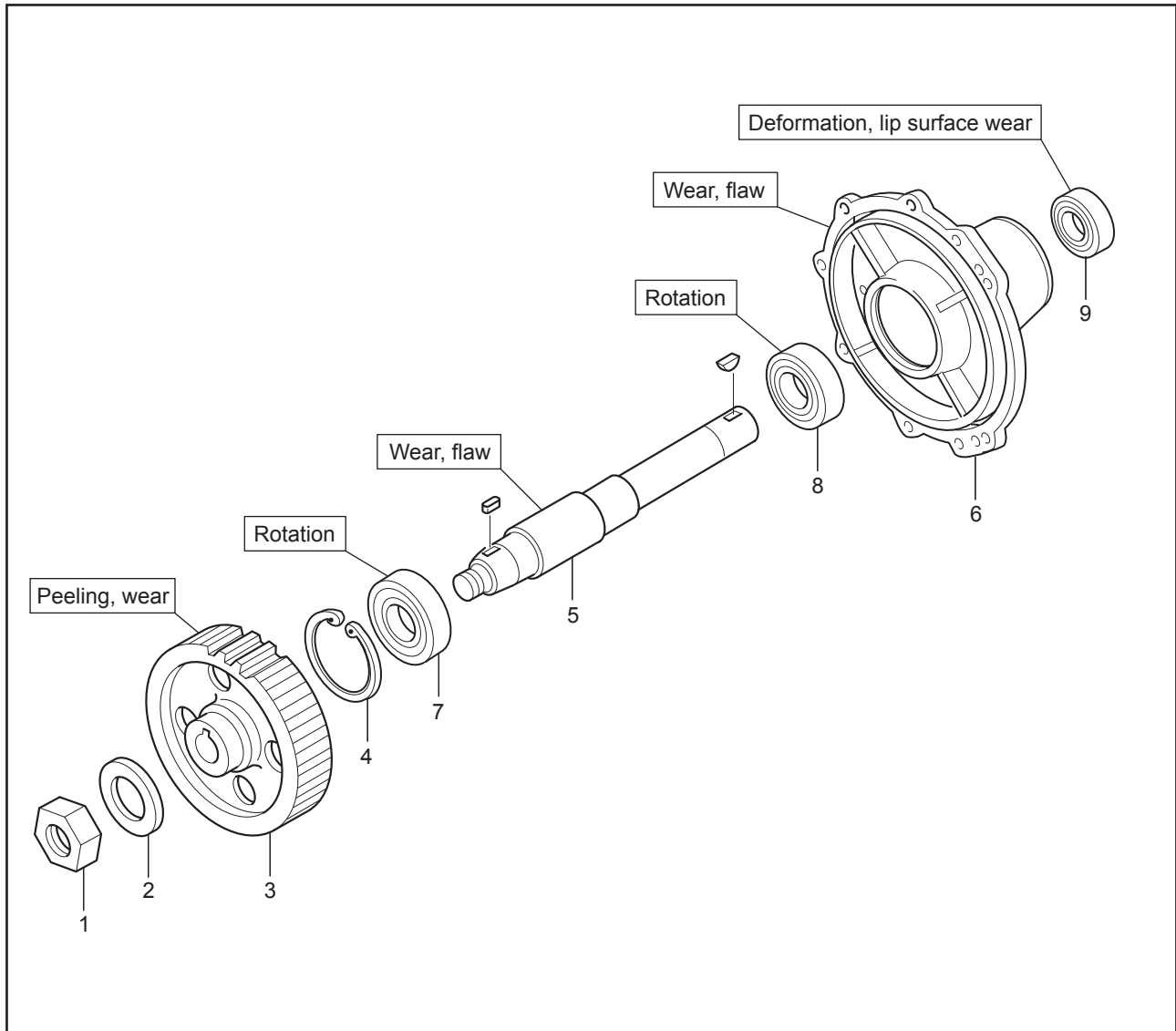
Fuel Injection Nozzle - Assemble

CAUTION

Be sure to tighten the retaining nut to the specified torque. Excessive tightening of retaining nut can harm smooth movement of the needle valve and result in abnormal exhaust smoke or needle valve sticking.

Note: When assembling the nozzle tip on the nozzle holder, make sure to align the nozzle tip knock pin with the nozzle holder hole.

2.5 Fuel Injection Pump Accessory Drive - Disassemble and Inspect



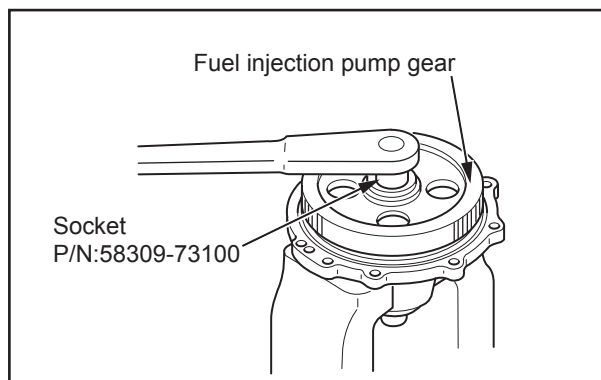
Fuel Injection Pump Accessory Drive - Disassemble and Inspect

Disassembling Sequence

- | | | |
|----------------------------|---------------|------------|
| 1 Nut | 4 Snap ring | 7 Bearing |
| 2 Washer | 5 Drive shaft | 8 Bearing |
| 3 Fuel injection pump gear | 6 Drive case | 9 Oil seal |

2.6 Outside Diameter and Inside Diameter of Accessory Drive Bearing Fit - Inspect

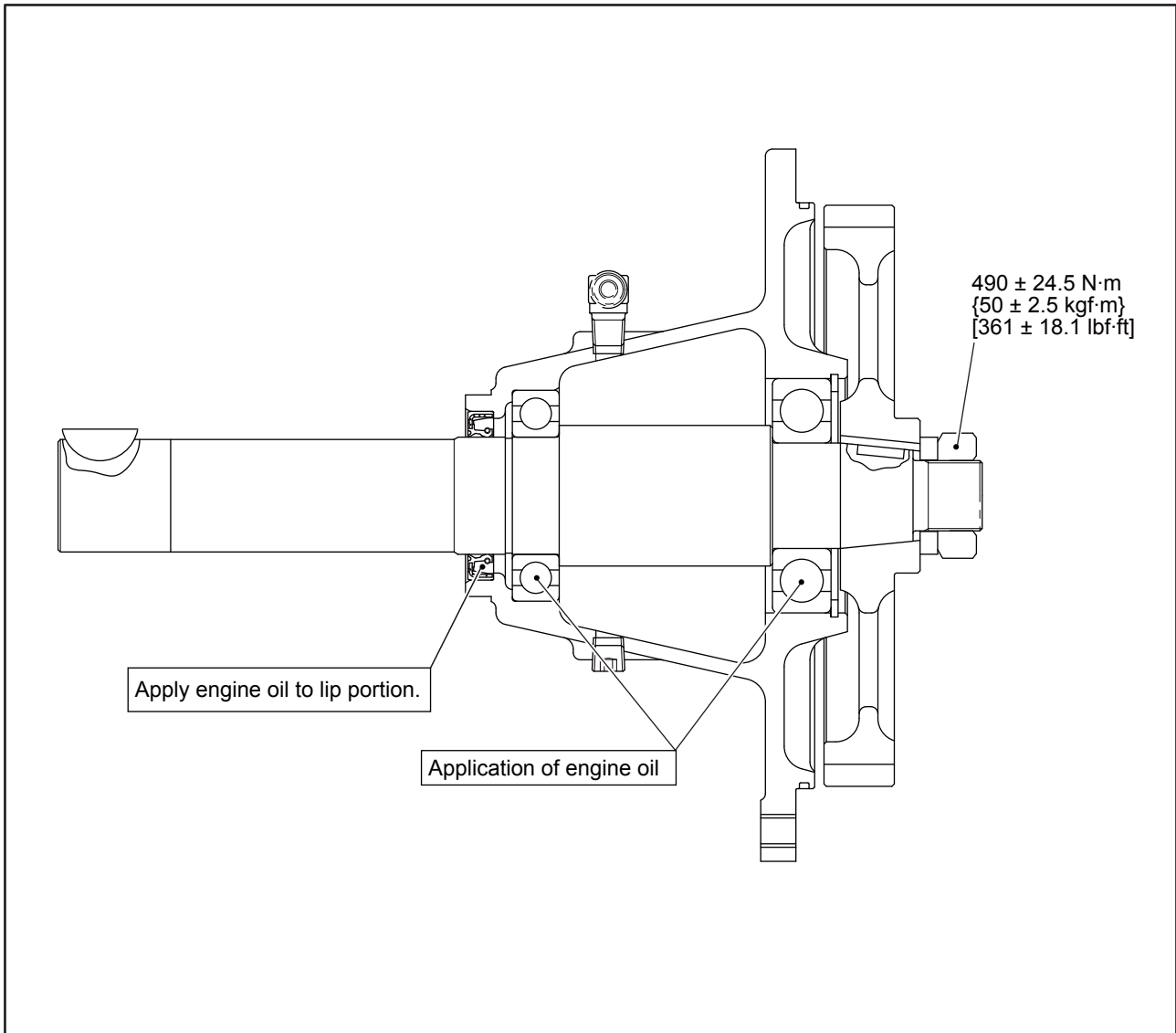
- (1) Rotate the bearing and if the rotation is not smooth, replace the bearing with a new one.
- (2) Inspect the fit of drive shaft and bearing. If significant wear is found, replace them with new ones.
- (3) Inspect the fit of drive case and bearing. If significant wear is found, replace them with new ones.
- (4) Inspect the drive shaft and oil seal, and if any defect is found, replace them with new one.



Fuel Injection Pump Gear - Remove

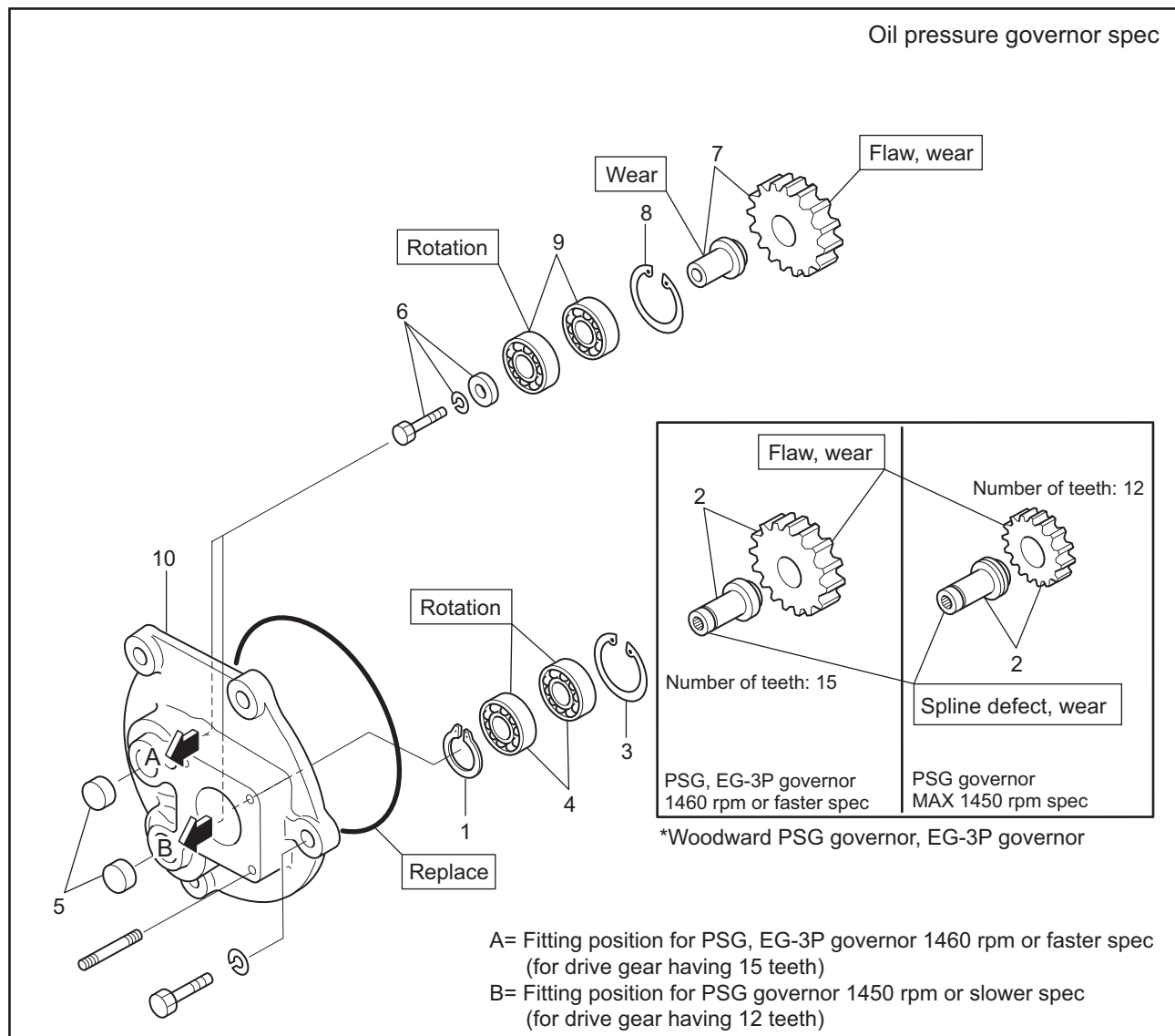
Item			Nominal value	Standard value
Inside diameter of case bearing housing			ø90 mm [3.54 in.]	89.987 to 90.022 mm [3.5428 to 3.5442 in.]
			ø100 mm [3.94 in.]	99.987 to 100.022 mm [3.9365 to 3.9379 in.]
Fuel injection pump drive shaft bearing	outside diameter	Small	ø90 mm [3.54 in.]	89.985 to 90.000 mm [3.5427 to 3.5433 in.]
		Large	ø100 mm [3.94 in.]	99.985 to 100.000 mm [3.9364 to 3.9370 in.]
	Inside diameter	Small	ø45 mm [1.77 in.]	44.988 to 45.000 mm [1.7712 to 1.7717 in.]
		Large	ø50 mm [1.97 in.]	49.988 to 50.000 mm [1.9680 to 1.9685 in.]
Outside diameter of drive shaft bearing fit			ø45 mm [1.77 in.]	45.002 to 45.013 mm [1.7717 to 1.7722 in.]
			ø50 mm [1.97 in.]	50.002 to 50.013 mm [1.9686 to 1.9690 in.]

2.7 Fuel Injection Pump Accessory Drive - Assemble



Fuel Injection Pump Accessory Drive - Assemble

2.8 Governor Drive - Disassemble and Inspect



Governor Drive - Disassemble and Inspect

Disassembling Sequence

- | | | |
|---------------------------|---------------------------|---------------|
| 1 Snap ring | 5 Sealing cap | 9 Bearing |
| 2 Drive gear, drive shaft | 6 Bolt, washer | 10 Drive case |
| 3 Snap ring | 7 Idler gear, idler shaft | |
| 4 Bearing | 8 Snap ring | |

Note: Do not disassemble the drive gear, drive shaft, idler gear and idler shaft unless it is absolutely necessary.

2.9 Outside Diameter and Inside Diameter of Bearing Fit

(Oil pressure governor spec)

Rotate the bearing and if the rotation is not smooth, replace the bearing with a new one.

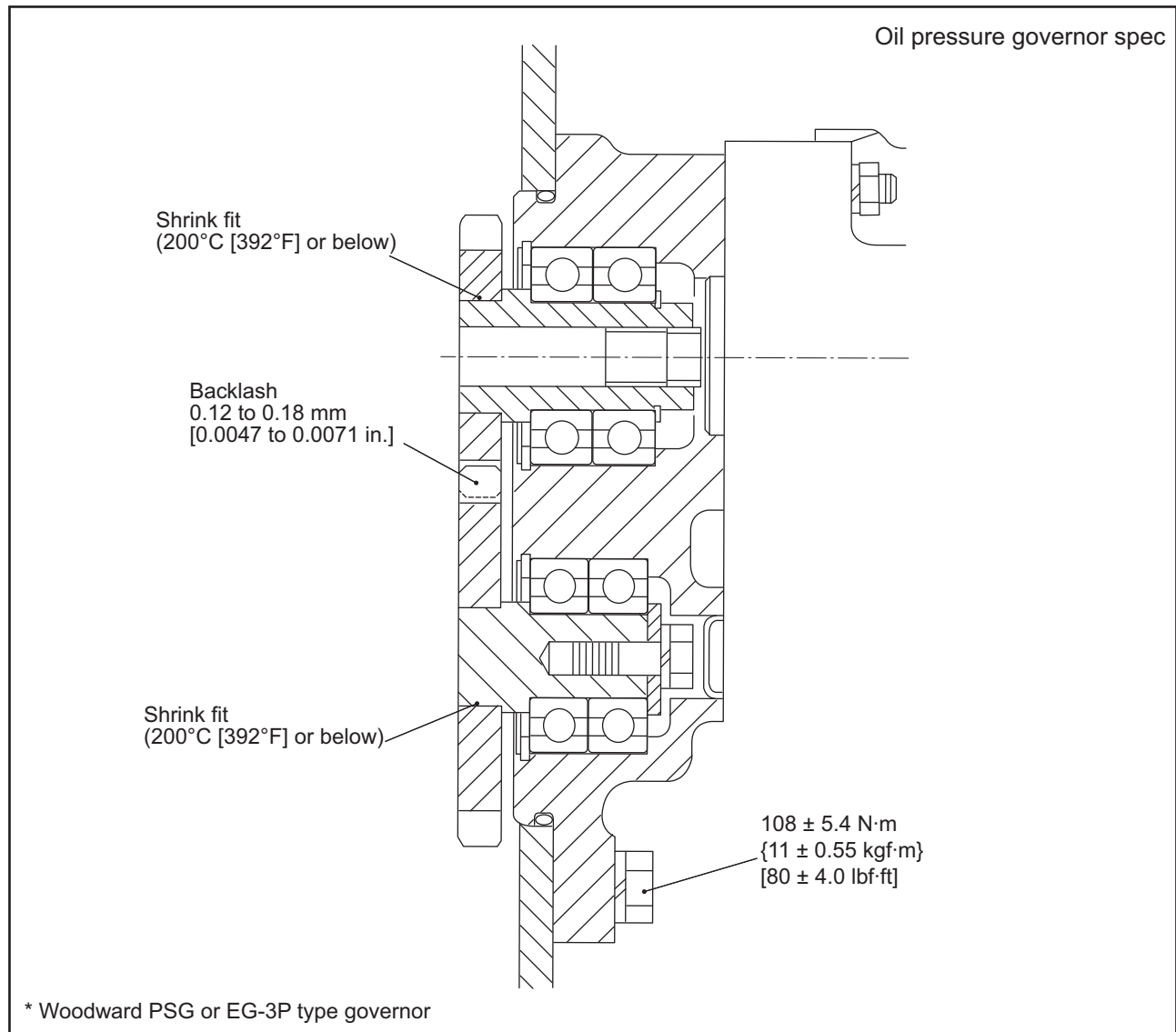
Inspect the fit of drive shaft, idler shaft and bearing. If significant wear is found, replace them with new ones.

Inspect the fit of drive case and bearing. If significant wear is found, replace them with new ones.

Item		Nominal value	Standard value
Outside diameter and inside diameter of bearing fit	Inside diameter of drive shaft case bearing housing	ø52 mm [2.05 in.]	51.988 to 52.018 mm [2.0468 to 2.0480 in.]
	Drive shaft side bearing	outside diameter	51.987 to 52.000 mm [2.0467 to 2.0472 in.]
		Inside diameter	24.990 to 25.000 mm [0.9839 to 0.9843 in.]
	Outside diameter of drive shaft bearing fit		25.002 to 25.011 mm [0.9843 to 0.9847 in.]
	Outside diameter of drive shaft gear fit		ø26 mm [1.02 in.] 26.035 to 26.048 mm [1.0250 to 1.0255 in.]
	Inside diameter of drive gear fit		ø26 mm [1.02 in.] 26.000 to 26.013 mm [1.0236 to 1.0241 in.]
	Inside diameter of idler shaft case bearing housing		ø47 mm [1.85 in.] 46.989 to 47.014 mm [1.8500 to 1.8509 in.]
	Idler shaft side bearing	outside diameter	46.989 to 47.000 mm [1.8500 to 1.8504 in.]
		Inside diameter	19.990 to 20.000 mm [0.7870 to 0.7874 in.]
	Outside diameter of idler shaft bearing fit		ø20 mm [0.79 in.] 20.002 to 20.011 mm [0.7875 to 0.7878 in.]
	Outside diameter of idler shaft gear fit		ø24 mm [0.94 in.] 24.035 mm 24.048 mm [0.9463 to 0.9468 in.]
	Inside diameter of idler gear fit		ø24 mm [0.94 in.] 24.000 to 24.013 mm [0.9449 to 0.9454 in.]

* Woodward PSG type governor and EG-3P type governor

2.10 Governor Drive - Assemble



Governor Drive - Assemble

2.10.1 Drive Gear and Idler Gear Backlash - Measure

Measure the drive gear and idler gear backlash. If the value exceeds the limit, replace the drive gear or idler gear with a new one.

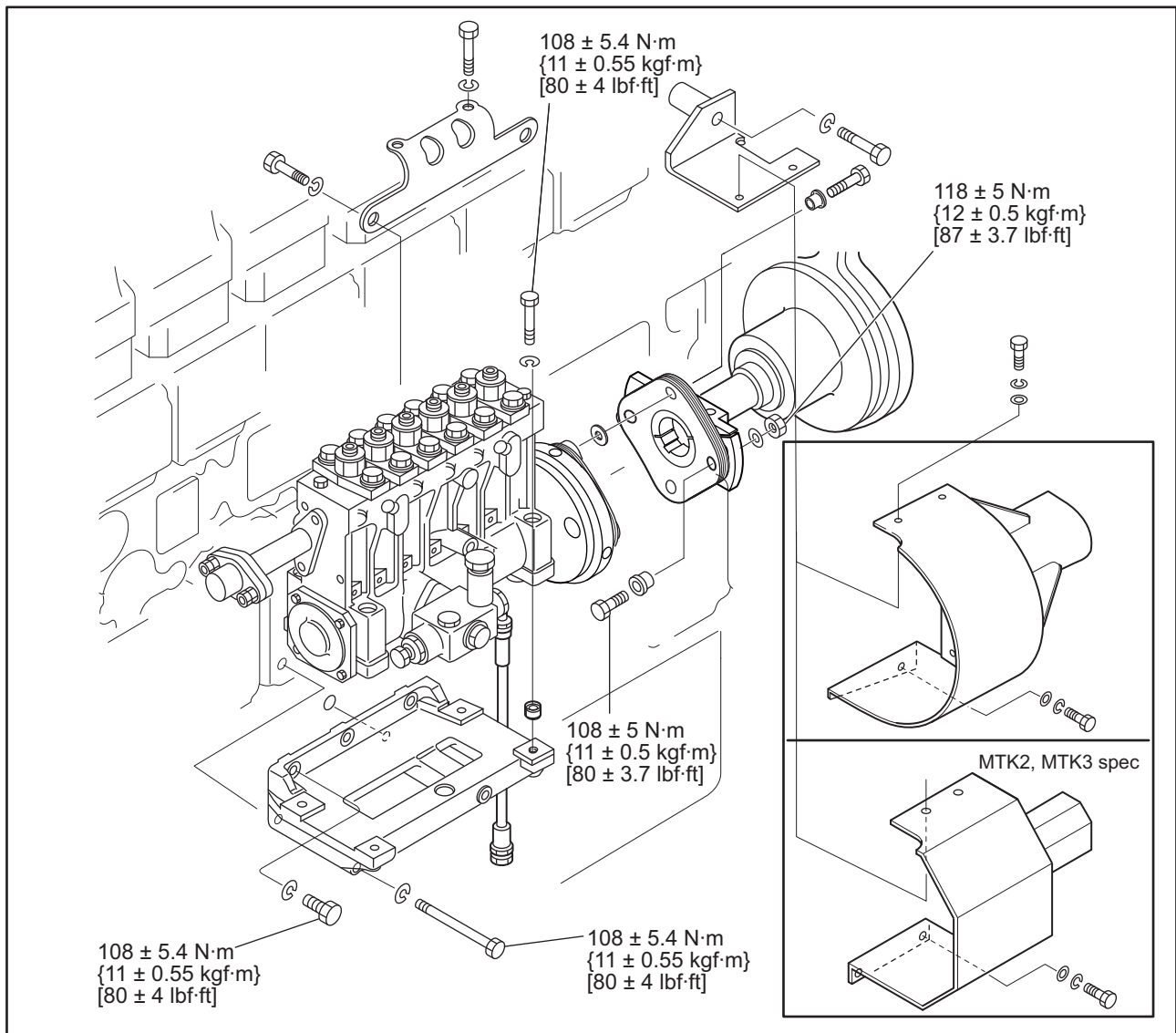
Item	Standard value	Limit value
Backlash between drive gear and idler gear	0.12 to 0.18 mm [0.0047 to 0.0071 in.]	0.4 mm [0.016 in.]

3. Fuel System - Install

Install the parts in the reverse order of the disassemble sequence. (Refer to the illustration for disassembling.)

Clean and dry well the fuel passage.

3.1 Fuel Injection Pump - Install



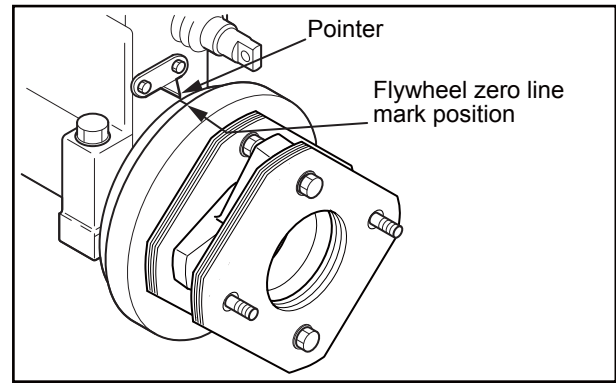
Fuel Injection Pump - Install

3.1.1 Checking Before Installing Fuel Injection Pump

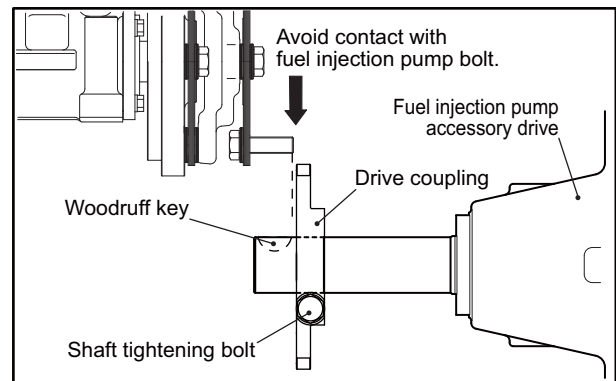
CAUTION

Ensure the correct mounting position of drive coupling. If it is installed 180 degrees out of position, the fuel injection timing cannot be adjusted.

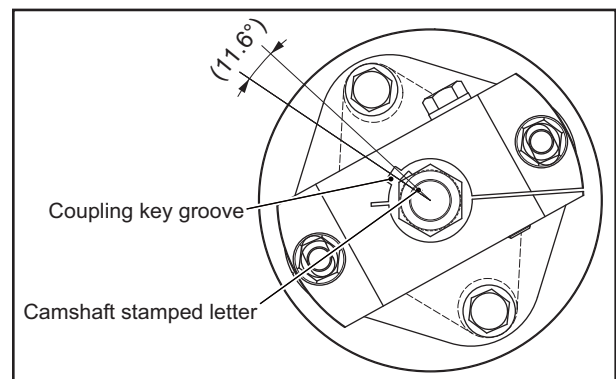
- (1) Rotate the crankshaft to the No. 1 compression top dead center.
- (2) Install drive coupling temporary attached to the fuel injection pump to the accessory driving shaft with the woodruff key. Adjust the position so that the driving coupling is not interfered with the bolt for fuel injection pump. The shaft tightening bolt should be loosened at this time.
- (3) Align the "0" line mark on the fuel injection pump flywheel with the pointer. (Injection start timing of cylinder No. 1)
- (4) Make sure that the camshaft stamped letter and the coupling key groove are oriented as shown in the illustration.



Pointer and Line Mark - Align



Drive Coupling - Install



Fuel Injection Pump Assembling Position of Camshaft and Driving Coupling (View From Rear (Drive Side))

3.1.2 Fuel Injection Pump - Install

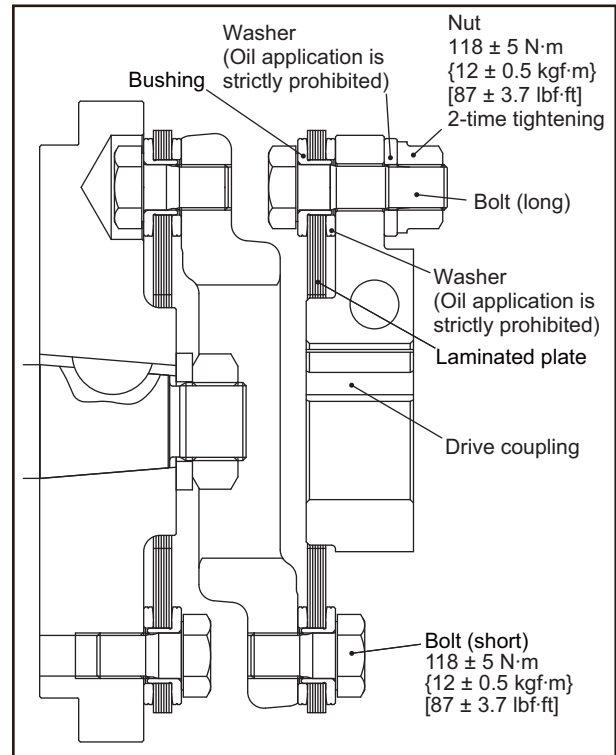
CAUTION

- (a) First, tighten the bolts (long) to connect the drive coupling and laminated plates to the specified torque, and then loosen the bolts. Tighten again to the specified torque. (2-time tightening)
- (b) Wash the bolt, bushing and washer before using. Foreign material on the contact surface of drive coupling and laminated plates can cause the slipping or damage of coupling.
- (c) After tightening the coupling, retighten the coupling if the laminated plate is distorted.

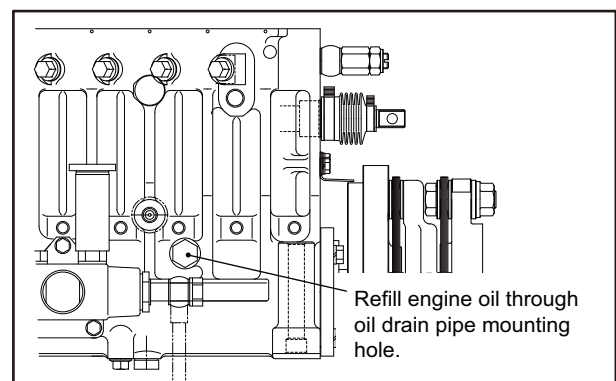
- (1) Lift the fuel injection pump. Slowly lower the fuel injection pump, and install the pump aligning with the dowel pin on bracket.
- (2) Connect the laminated plates and drive coupling, and hand tighten the bolt.
Check that the "0" stamped line of fuel injection pump flywheel of the No. 1 compression top dead center indicates near the pointer.

Note: When installing coupling connecting bolts, be careful not to forget bushings and washers, and also pay attention to the mounting direction.

- (3) Adjust the clearance between the drive coupling and flywheel to the standard.
For the adjusting procedures, refer to "Clearance Between Fuel Injection Pump Flywheel and Driving Coupling - Adjust" of "FUEL SYSTEM."
- (4) Tighten all bolts and nuts installed to the couplings to the specified torque.
- (5) Recheck the clearance between couplings and the tightening condition of bolts and nuts.
- (6) Install the stay between fuel injection pump case and crankcase.
- (7) Refill engine oil through the oil drain pipe mounting hole of cam chamber.
- (8) Install the oil pipe and fuel pipe.



Drive Coupling and Laminated Plates - Connect

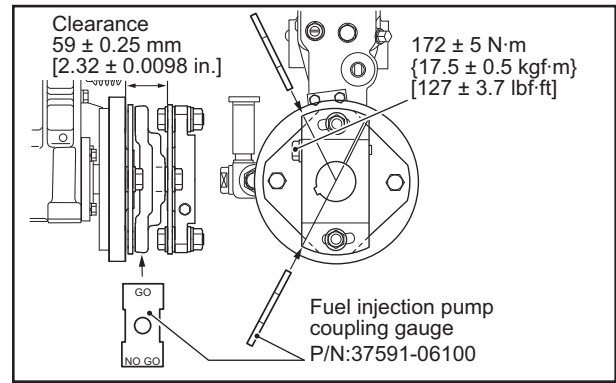


Engine Oil - Refill

3.1.3 Clearance Between Fuel Injection Pump Flywheel and Drive Coupling - Adjust

Adjust the clearance between the fuel injection pump flywheel and the drive coupling with the fuel injection pump coupling gauge as follows:

- (1) Insert the GO side of gauge into the clearance between fuel injection pump flywheel and drive coupling. And adjust the clearance.
- (2) Tighten the bolts to the specified torque.
- (3) Make sure that the NO GO side of gauge cannot be inserted in the clearance while the GO side can be inserted. In this condition, the clearance between the fuel injection pump flywheel and drive coupling is adjusted to the set value.
- (4) If the set value cannot be made by inserting the gauge, loosen the bolts, and readjust the clearance.



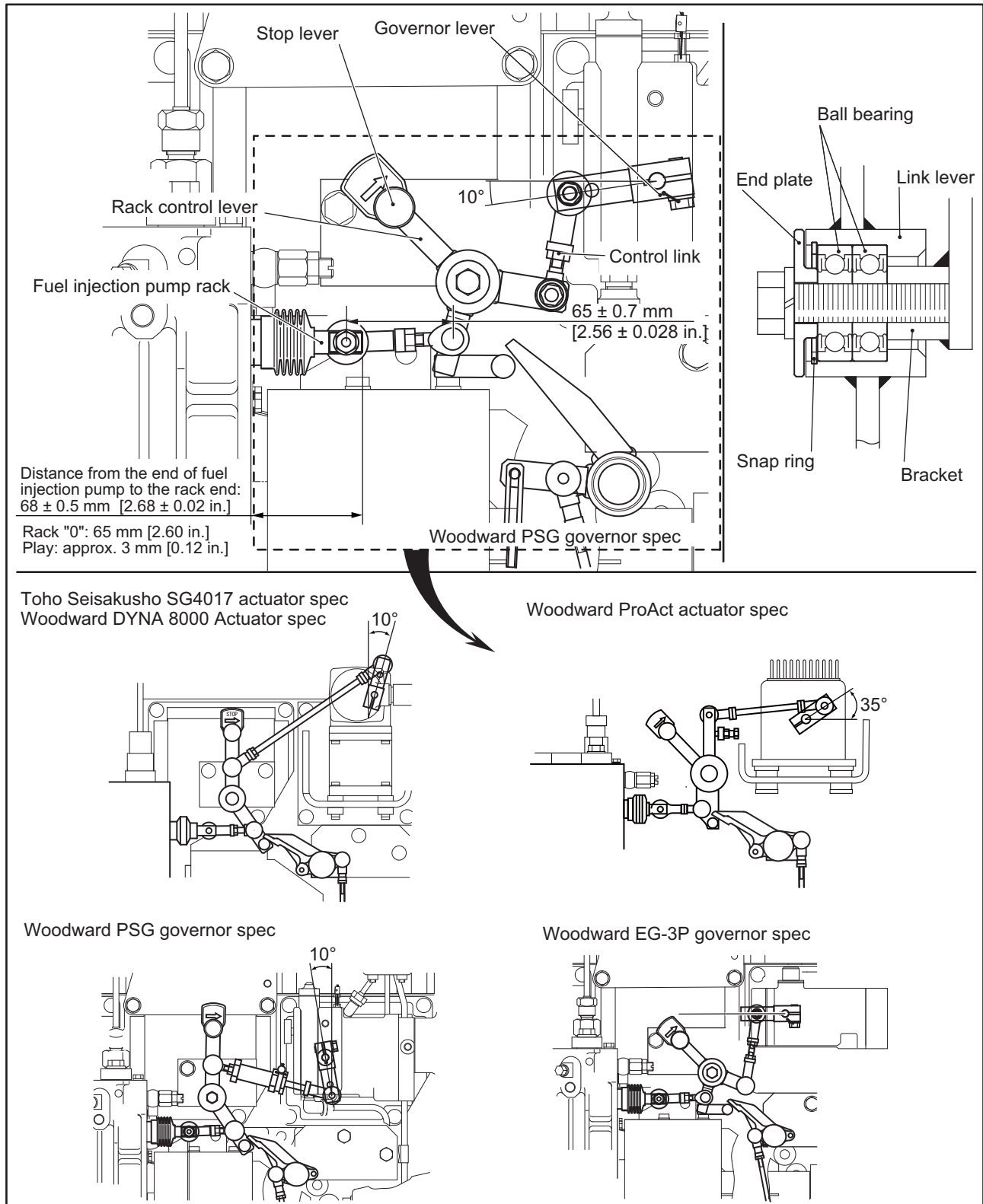
Clearance Between Fuel Injection Pump Flywheel and Drive Coupling - Adjust

3.2 Fuel Control Link - Install

3.2.1 Control Link Lever - Install

- (1) Install the link lever with ball bearing, snap ring and end plate to the bracket.
- (2) Set the governor output shaft at "0" angle (fuel decreasing side) and the specified angle of governor lever, then engage the serrated portion of the shaft.

3.2.2 Fuel Control Link - Install and Adjust



Fuel Control Link - Install and Adjust

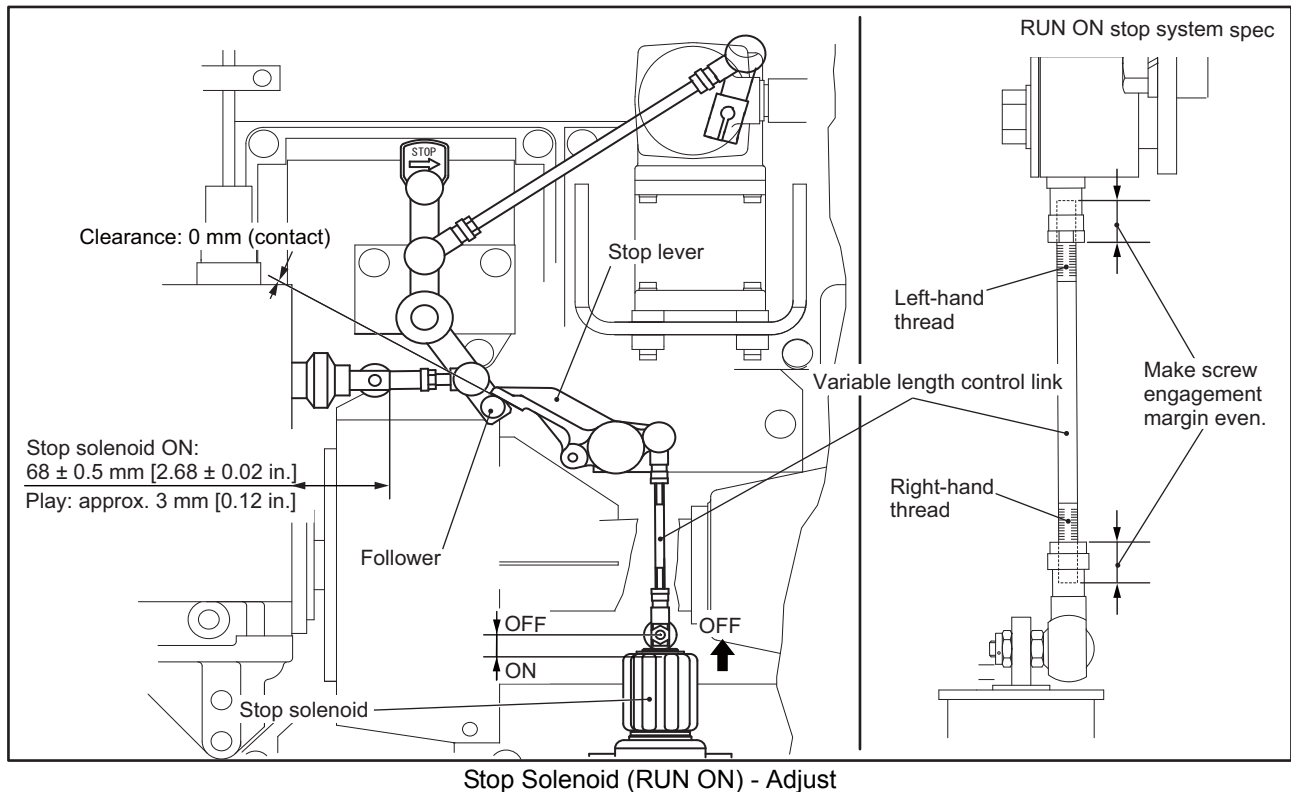
- (1) Adjust the link between the fuel injection pump rack and rack control lever to 65 ± 0.7 mm [2.56 ± 0.028 in.], and install the fuel control link.
- (2) Install the control link between the rack control lever and governor lever.
- (3) Adjust the length of control link so that the distance between the end face of fuel injection pump and the end of rack becomes 68 ± 0.5 mm [2.67 ± 0.02 in.].

Note: Make sure that the length of thread engagement between the rod and ball joint screw is 8 mm [0.32 in.] or more.

- (4) Verify the distance between the end of fuel injection pump and fuel injection pump rack is 65 mm [2.56 in.] and the play is 3 mm [0.12 in.] when the stop lever is fully pulled to the stop position.

3.3 Stop Solenoid - Install

3.3.1 Stop Solenoid (RUN ON) - Adjust

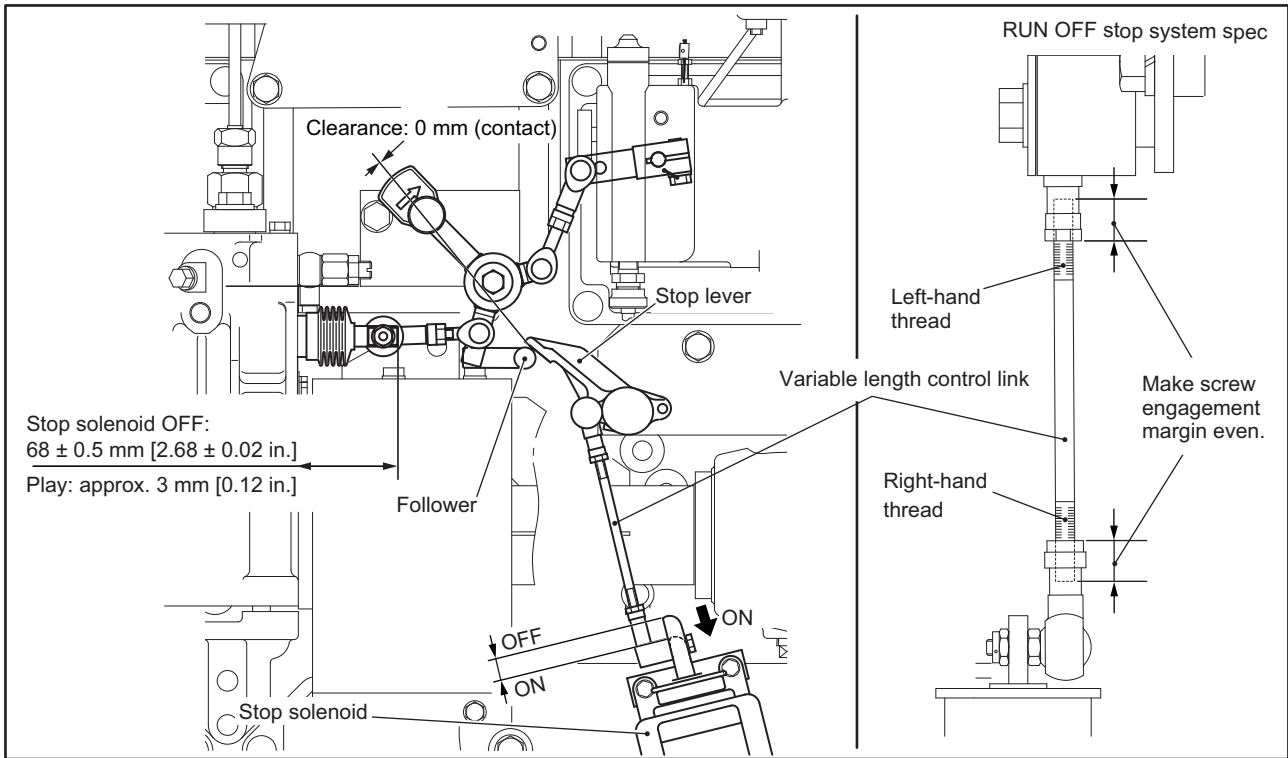


- (1) Turn off the stop solenoid (engine stop).
- (2) Fine adjust the flexible length control link so that the distance between the end face of the fuel injection pump and the end of the control rack becomes 68 ± 0.5 mm [2.68 ± 0.02 in.] (stop position.)

Note:(a) Secure approx 3 mm [0.12 in.] play when the stop solenoid is in OFF condition so that the control rack does not move to the "0" position.

- (b) Adjust the engagement lengths even and 8 mm [0.32 in.] or more on right and left-handed threads of the variable-length control link.

3.3.2 Stop Solenoid (RUN OFF) - Adjust



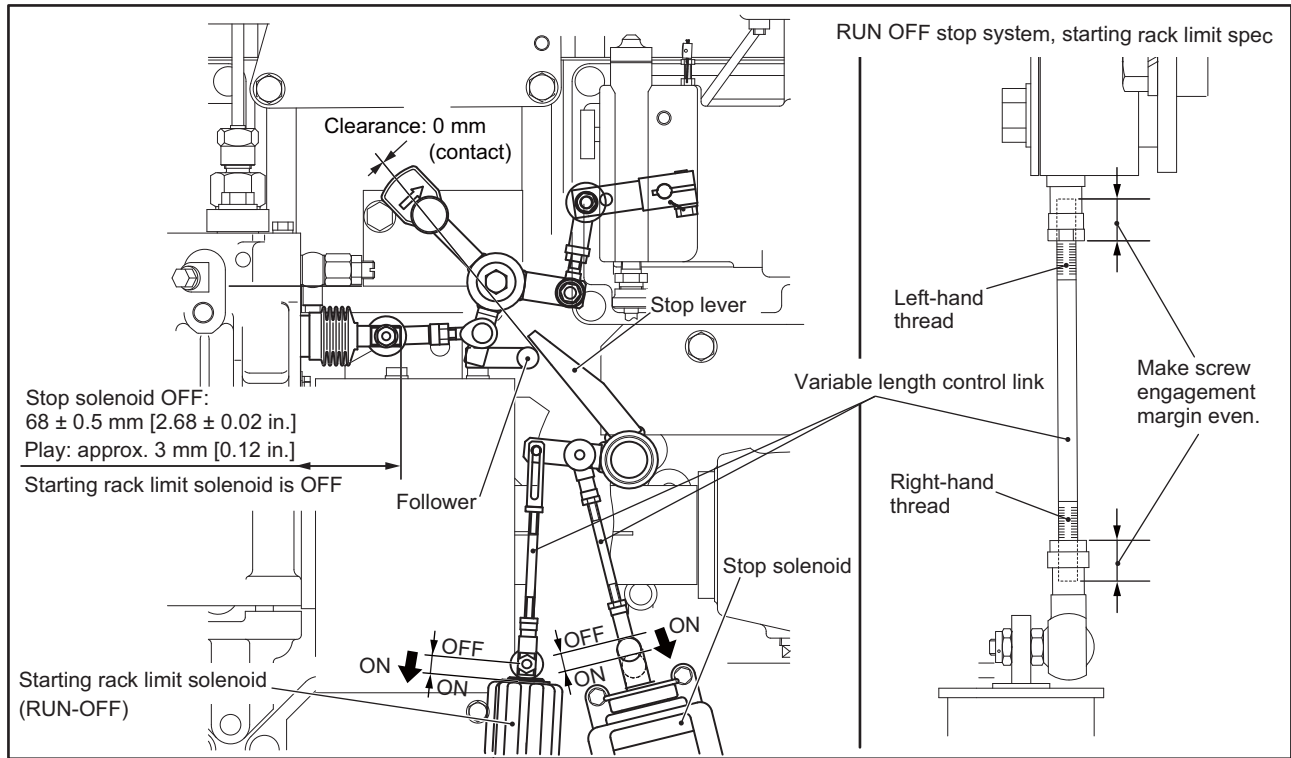
Stop Solenoid (RUN OFF) - Adjust

- (1) Push the stop solenoid manually to the stop solenoid ON position (engine stop.)
- (2) Fine adjust the flexible length control link so that the distance between the end face of the fuel injection pump and the end of the control rack becomes $68 \pm 0.5 \text{ mm}$ [$2.68 \pm 0.02 \text{ in.}$] (stop position.)

Note:(a) Secure approx 3 mm [0.12 in.] play when the stop solenoid is in ON condition so that the control rack does not move to the "0" position.

- (b) Adjust the engagement lengths even and 8 mm [0.32 in.] or more on right and left-handed threads of the variable-length control link.

3.3.3 Stop Solenoid (RUN OFF), Start Rack Restrict Solenoid (RUN OFF) - Adjust



Stop Solenoid (RUN OFF), Start Rack Restrict Solenoid (RUN OFF) - Adjust

- (1) Push the stop solenoid manually to the stop solenoid ON position (engine stop.)
 - (2) Adjust the variable-length control link so that the distance between the follower and stop lever is 0 mm (contact).
- Note: When the power of governor actuator is OFF, the fuel injection pump rack is at the no injection (engine stop) position. In this condition, the distance between the fuel injection pump case end face and the fuel injection pump rack end is 68 ± 0.5 mm [2.68 ± 0.019 in.]
- (3) Push the start rack restrict solenoid manually to the stop solenoid ON position (engine stop.)
 - (4) Adjust the variable-length control link so that the distance between the end face of fuel injection pump and the end of control rack is 68 ± 0.5 mm [2.68 ± 0.02 in.], and the stop lever and follower contact.

3.3.4 Solenoid Function - Verify

Make sure the solenoid functions of start, running and emergency stop of the engine and check the fuel injection pump rack positions.

Stop solenoid

Specification	Item	Engine starting	Engine running	Engine emergency stop
Stop solenoid RUN ON	Plunger position (spring condition)	Compressed		Stretched
	Activation	ON		OFF
	Distance from the fuel injection pump end face to control rack end	-		68±0.5 mm [2.68±0.019 in.]
Stop solenoid RUN OFF	Plunger position (spring condition)	Stretched		Compressed
	Activation	OFF		ON
	Distance from the fuel injection pump end face to control rack end	-		68±0.5 mm [2.68±0.019 in.]

Note:(a) If the distance for the fuel rack end of fuel injection pump is 68.5 mm [2.697 in.] (3.5 mm [0.138 in.] play to the rack) or more, the engine may not be stopped.

(b) If the distance of fuel injection pump rack end is 66 mm [2.60 in.], fuel injection pump rack stopper may be damaged.
Ensure the correct play of 2 to 3 mm [0.08 to 0.12 in.]

Start rack restrict solenoid RUN OFF

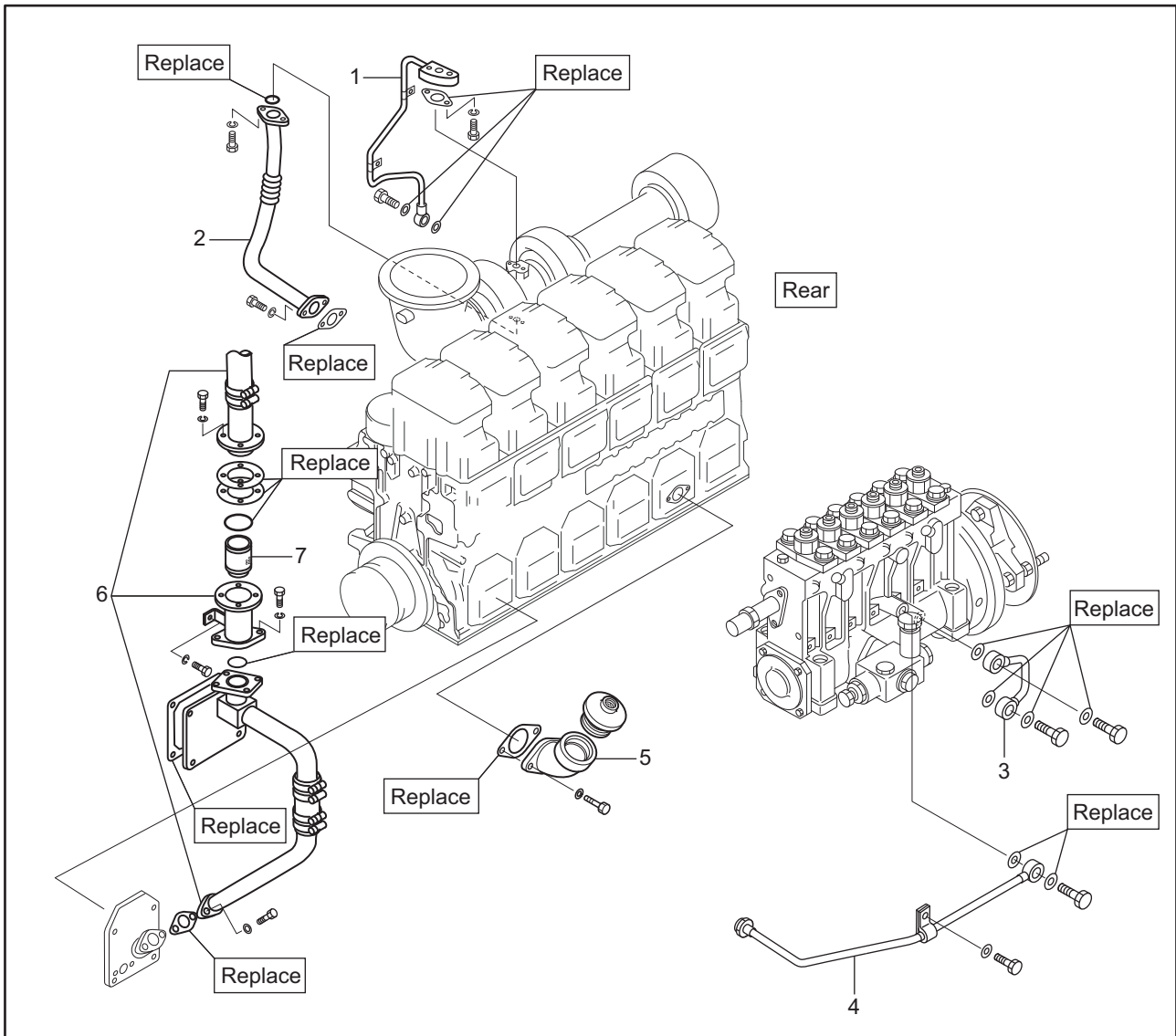
Specification	Item	Engine starting	Engine running	Engine emergency stop	
Start rack restrict solenoid RUN OFF	Plunger position (spring condition)	Compressed	Stretched	Stretched	Compressed
	Activation	ON	OFF	ON	OFF
	Distance from the fuel injection pump end face to control rack end	-	FULL	68±0.5 mm [2.68±0.019 in.]	

Chapter 9 LUBRICATION SYSTEM

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1. Lubrication System - Remove and Inspect

1.1 Lubrication System - Remove and Inspect (1)

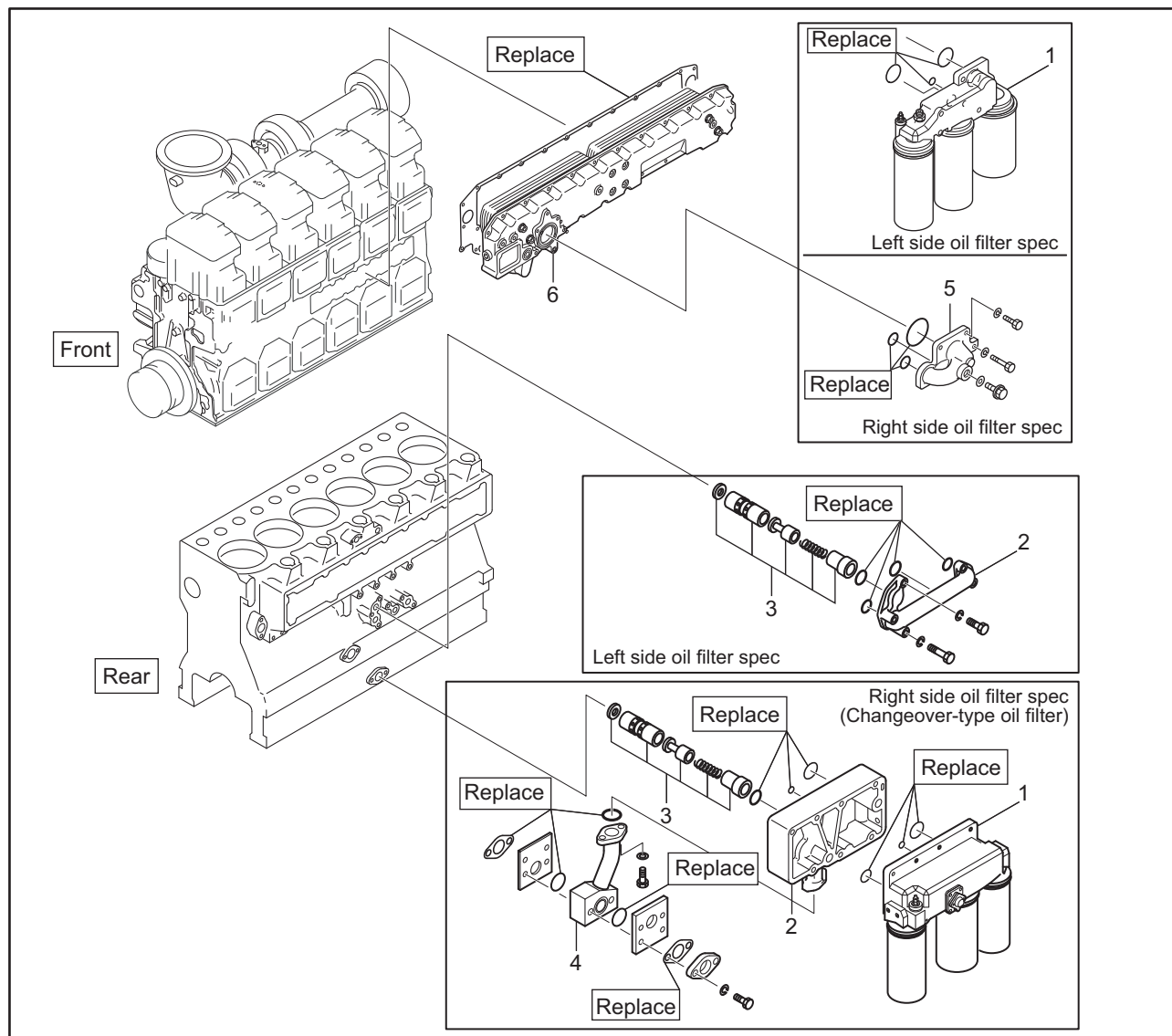


Lubrication System - Remove and Inspect (1)

Removing Sequence

- | | | |
|------------|--------------|--------------------|
| 1 Oil pipe | 4 Oil pipe | 6 Breather |
| 2 Oil pipe | 5 Oil filler | 7 Breather element |
| 3 Oil pipe | | |

1.2 Lubrication System - Remove and Inspect (2)

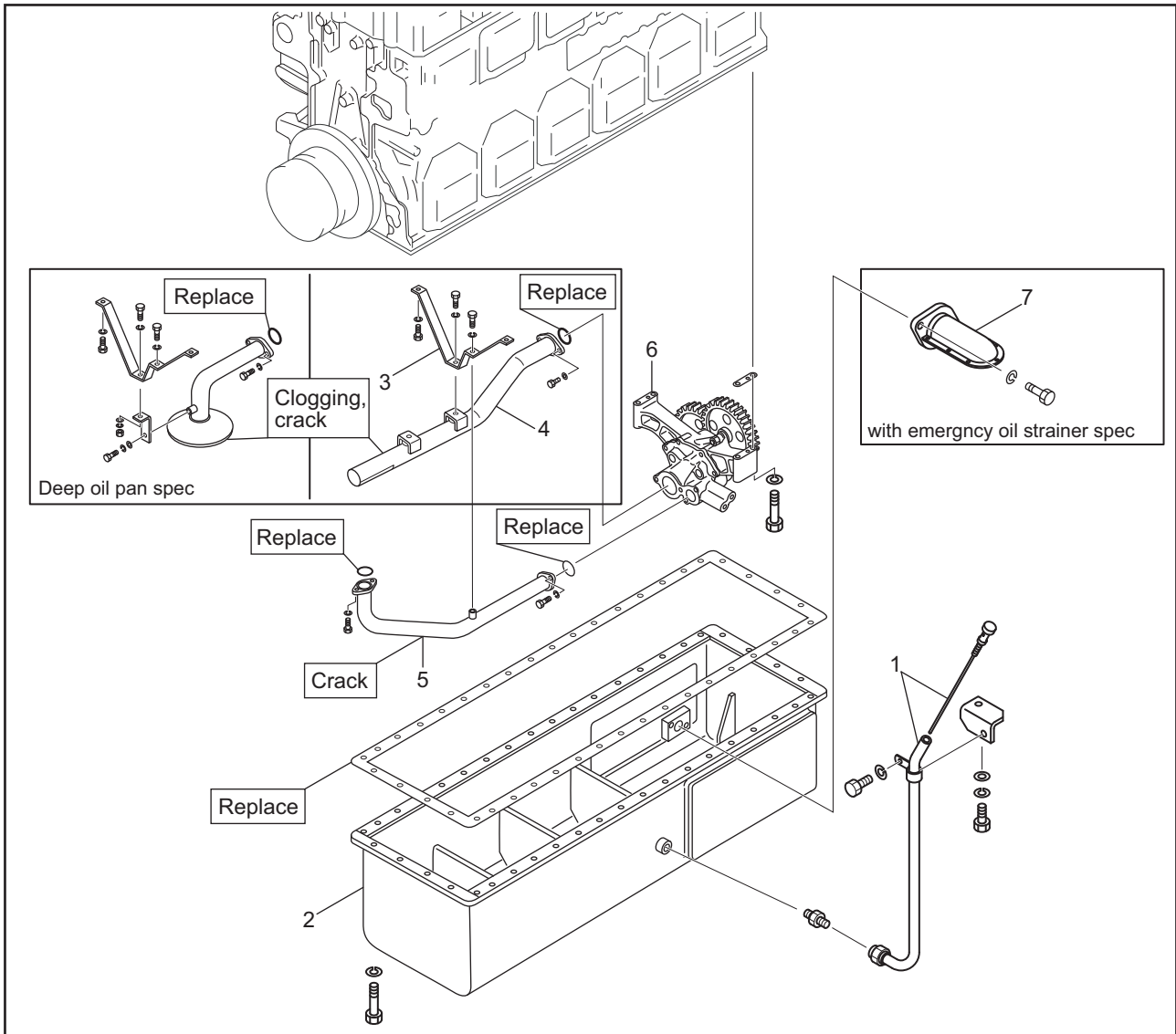


Lubrication System - Remove and Inspect (2)

Removing Sequence

- | | |
|------------------------------|-------------------------------------|
| 1 Oil filter | 4 Emergency oil pipe |
| 2 Relief valve pipe | (Right side oil filter spec) |
| Oil filter adapter | 5 Oil cooler cover |
| (Right side oil filter spec) | (Left side oil filter spec) |
| 3 Relief valve | 6 Oil cooler (Approx 19 kg [42 lb]) |

1.3 Lubrication System - Remove and Inspect (3)



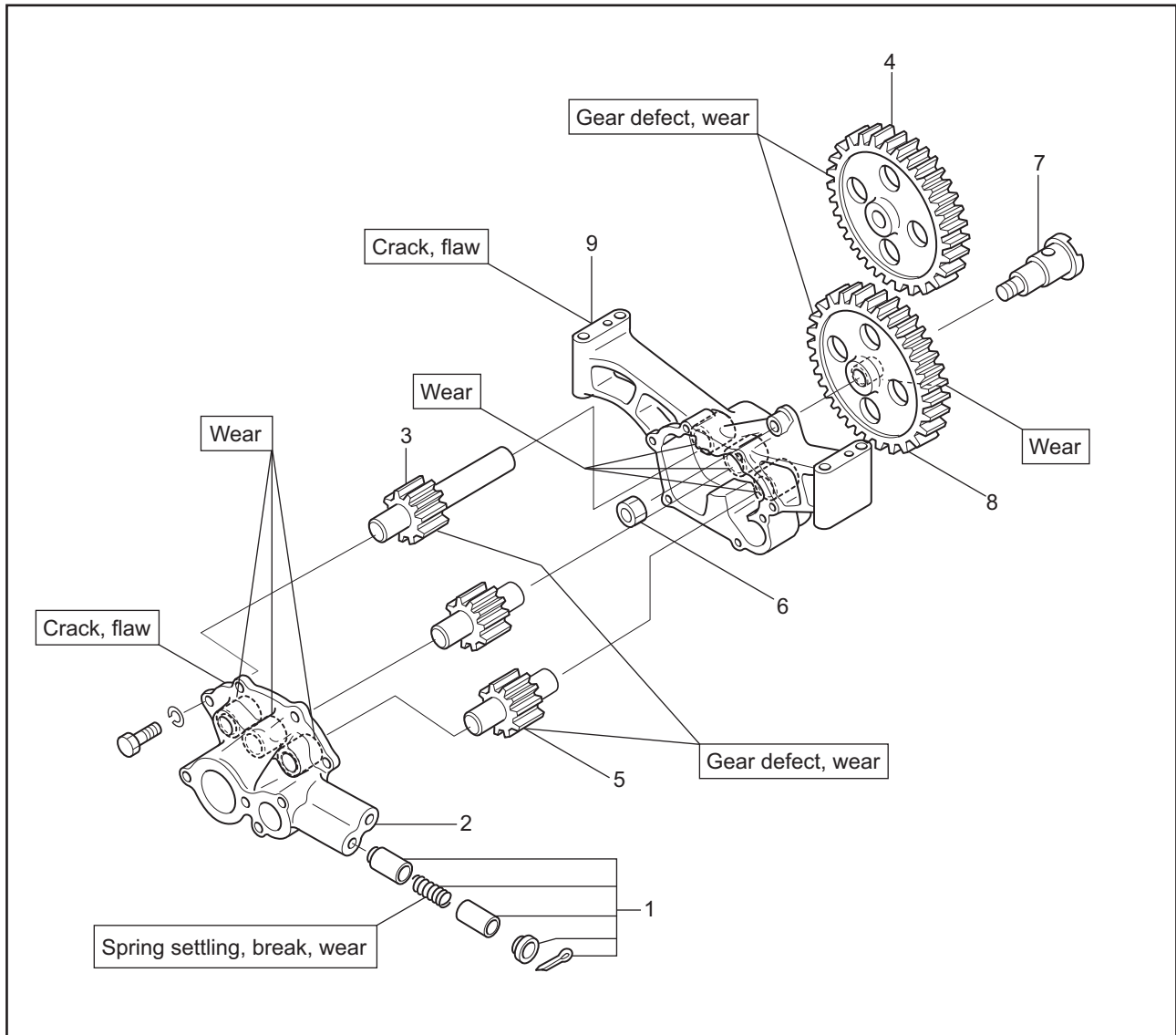
Lubrication System - Remove and Inspect (3)

Removing Sequence

- | | |
|--|---|
| 1 Oil level gauge | 5 Oil pipe |
| 2 Oil pan (Standard: approx 55 kg [121 lb]
(Deep type: approx 110 kg [243 lb])) | 6 Oil pump |
| 3 Oil pump support | 7 Oil strainer (With emergency oil strainer spec) |
| 4 Oil strainer | |

2. Lubrication System - Disassemble, Inspect and Assemble

2.1 Oil Pump and Safety Valve - Disassemble and Inspect



Oil Pump and Safety Valve - Disassemble and Inspect

Disassembling Sequence

- | | | |
|----------------|-----------------|--------------|
| 1 Safety valve | 4 Oil pump gear | 7 Spindle |
| 2 Pump cover | 5 Driven gear | 8 Idler gear |
| 3 Drive gear | 6 Nut | 9 Pump case |

2.2 Oil Pump and Safety Valve - Inspect

2.2.1 Backlash Between Oil Pump Gear and Idler Gear - Measure

Measure the backlash between oil pump gear and idler gear. If the value exceeds the limit, replace the gears with new ones.

Item	Standard value	Limit value
Backlash between oil pump gear and idler gear	0.087 to 0.316 mm [0.0034 to 0.0124 in.]	0.500 mm [0.0197 in.]

2.2.2 Drive Gear and Driven Gear Backlash - Measure

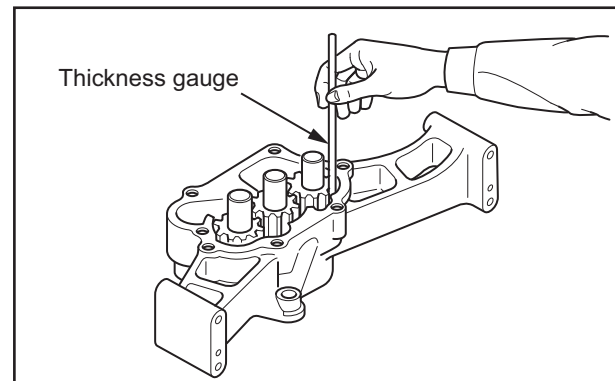
Measure the backlash between drive gear and driven gear. If the value exceeds the limit, replace the gears with new ones.

Item	Standard value	Limit value
Drive gear and driven gear backlash	0.100 to 0.200 mm [0.0039 to 0.0079 in.]	0.400 mm [0.0157 in.]

2.2.3 Clearance Between the Gear Teeth and Case - Measure

Measure the top clearance between drive/driven gear teeth and case housing. If the value exceeds the limit, replace the gear or case with a new one.

Item	Standard value	Limit value
Top clearance between gear teeth and case	0.100 to 0.196 mm [0.0039 to 0.0077 in.]	0.350 mm [0.0138 in.]

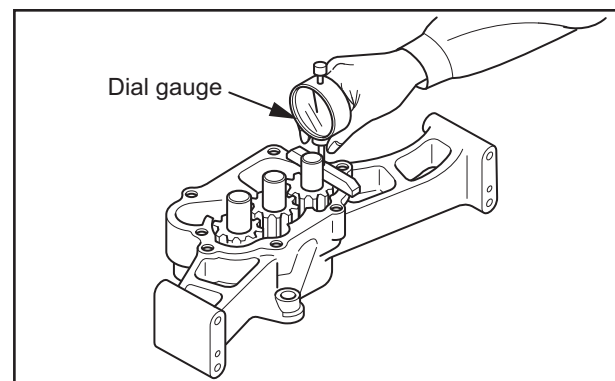


Clearance Between the Gear Teeth and Case
- Measure

2.2.4 Side Clearance Between Gear Width and Case - Measure

Measure the side clearance between the gear width and case depth. If the value exceeds the limit, replace the gear or case with a new one.

Item	Standard value	Limit value
Side clearance between gear width and case depth	0.050 to 0.114 mm [0.0020 to 0.0045 in.]	0.250 mm [0.0098 in.]



Side Clearance Between Gear Width and Case -
Measure

2.2.5 Drive/Driven Gear Shaft Outside Diameters and Bushing Inside Diameters - Measure

- (1) Check the gear teeth. If any defect is found, replace the gear with a new one.
- (2) Measure the drive/driven gear shaft outside diameters and bushing inside diameters. If any of the gear or bushing exceeds the limit, replace them as a set with new ones.

Item	Nominal value	Standard value	Limit value
Drive shaft outside diameter	ø25 mm [0.98 in.]	24.947 to 24.960 mm [0.9822 to 0.9827 in.]	24.900 mm [0.9803 in.]
Driven shaft outside diameter		24.947 to 24.960 mm [0.9822 to 0.9827 in.]	24.900 mm [0.9803 in.]
Bushing inside diameter		25.000 to 25.021 mm [0.9843 to 0.9851 in.]	25.100 mm [0.9882 in.]

2.2.6 Spindle Outside Diameter and Idler Gear Bushing Inside Diameter - Measure

Bushing Inside Diameter - Measure

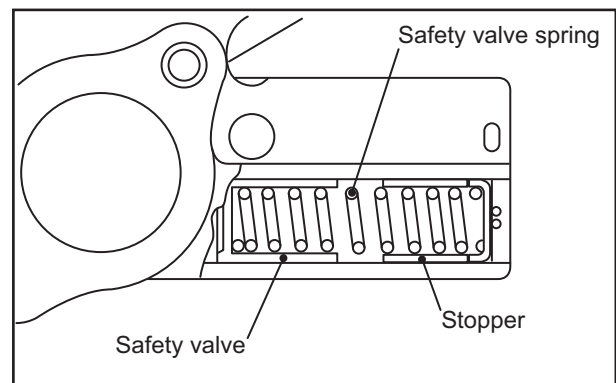
Measure the spindle outside diameter and idler gear bushing inside diameter. If the limit is exceeded, replace them as a set with new ones.

Item	Nominal value	Standard value	Limit value
Spindle outside diameter	ø25 mm [0.98 in.]	24.949 to 24.960 mm [0.9822 to 0.9827 in.]	24.900 mm [0.9803 in.]
Idler gear bushing inside diameter		25.000 to 25.021 mm [0.9843 to 0.9851 in.]	25.100 mm [0.9882 in.]

2.2.7 Oil Pump Safety Valve - Inspect

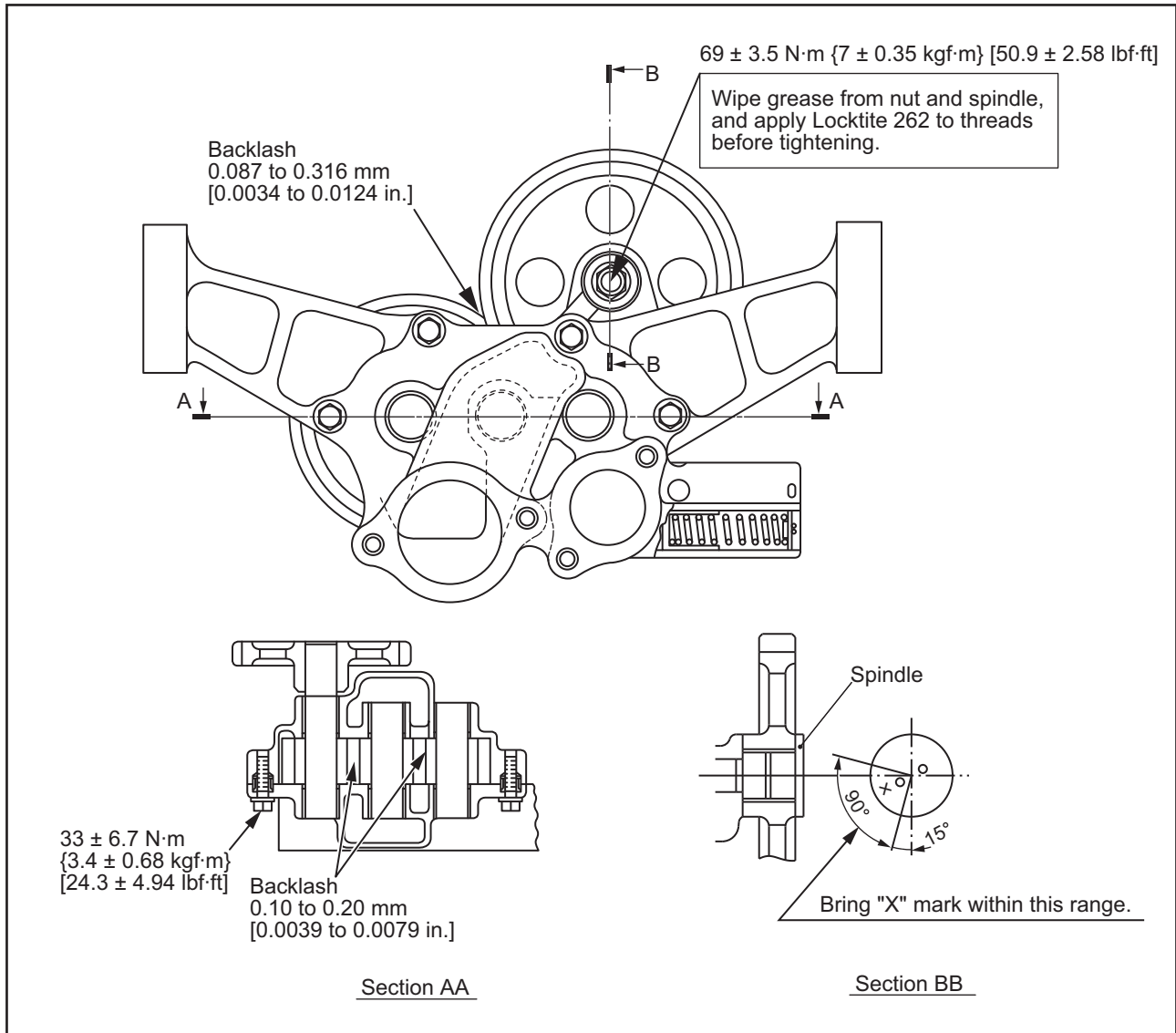
Item	Standard value
Safety valve opening pressure	1.4 ± 0.1 MPa { 14 ± 1 kgf/cm ² } [203 ± 14 psi]

- (1) Inspect the oil pump safety valve spring, and if any deformation, wear, or damage is found, or if the measured value exceeds the limit, replace it with a new one.
- (2) Inspect the valve and stopper. If significant wear or malfunction of sliding parts is found, replace them with new ones.



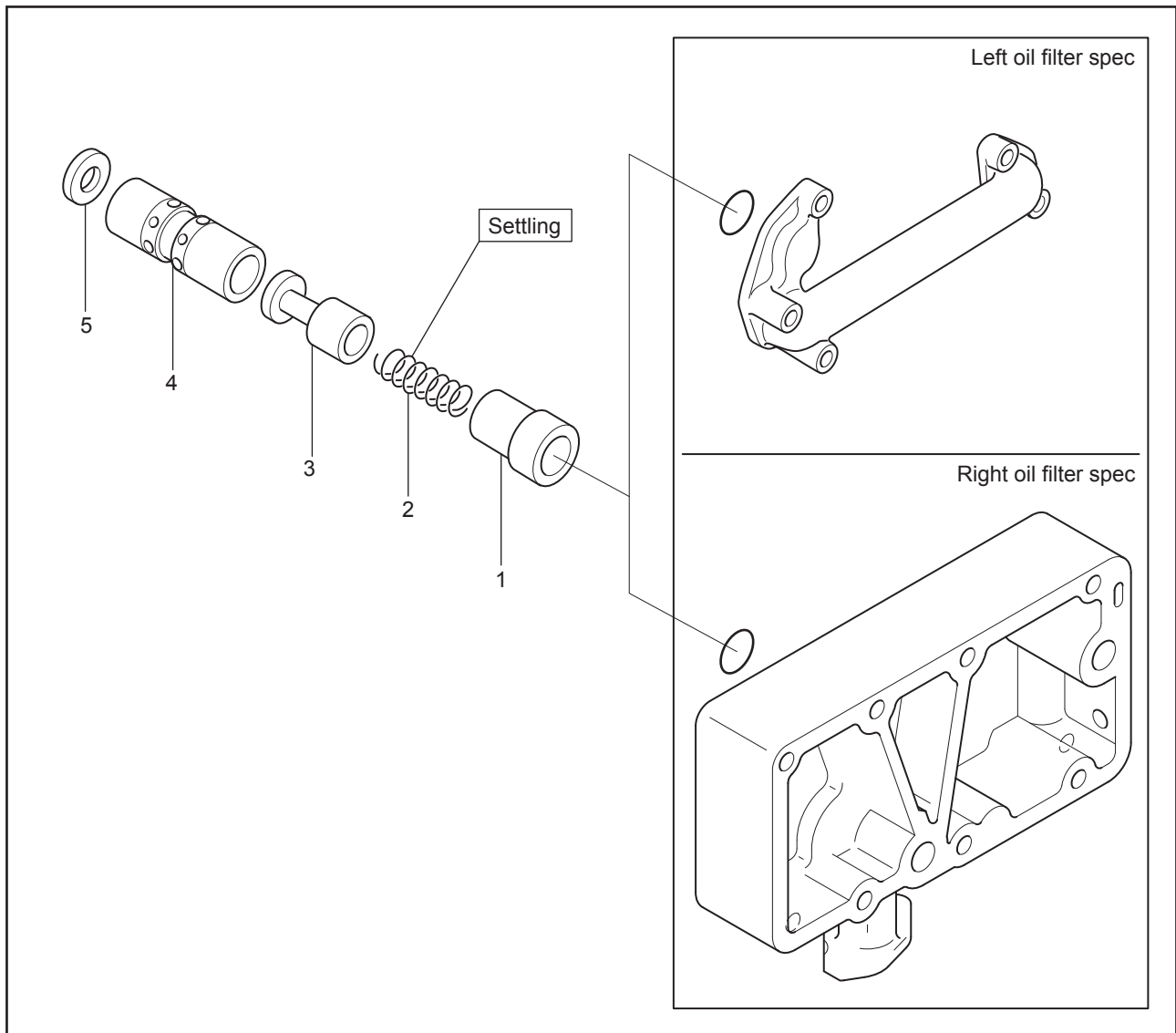
Safety Valve - Inspect

2.3 Oil Pump and Safety Valve - Assemble



Oil Pump and Safety Valve - Assemble

2.4 Relief Valve - Disassemble and Inspect



Relief Valve - Disassemble and Inspect

Disassembling Sequence

- 1 Stopper
- 2 Spring

- 3 Relief valve
- 4 Sleeve

- 5 Plate

2.5 Relief Valve - Inspect

- (1) Inspect the relief valve spring, and if any deformation, wear or damage is found, replace the spring with a new one.

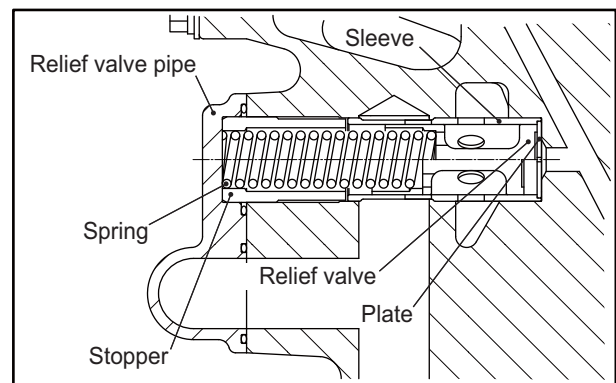
Item	Standard value
Relief valve Spring free length	115 mm [4.53 in.]

- (2) Inspect the valve, and if any wear, scratch, or slide malfunctions are found, replace the valve with a new one.

2.6 Relief Valve - Assemble

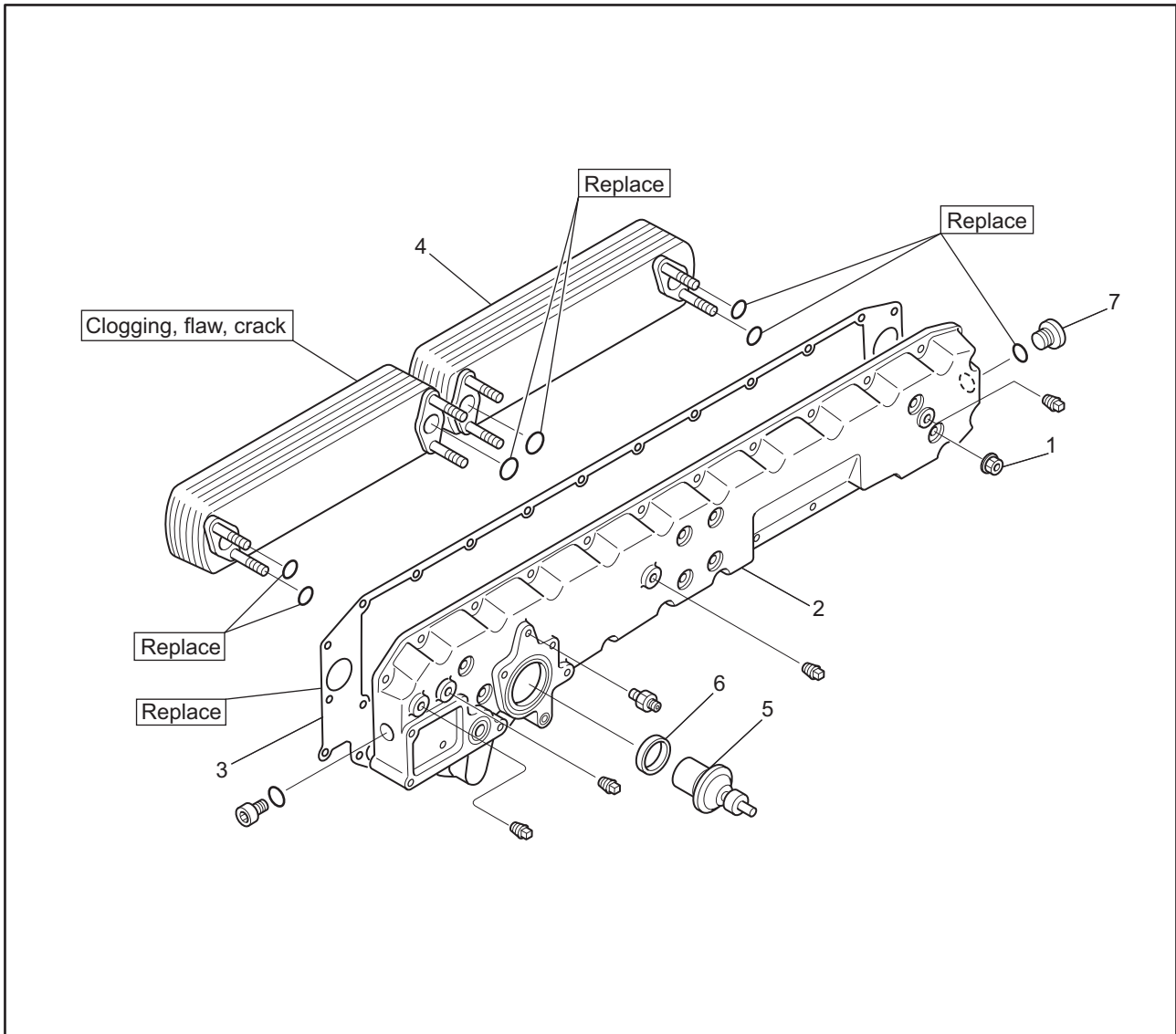
To assemble, follow the disassembly sequence in reverse.

Use new O-rings to assemble.



Relief Valve - Assemble

2.7 Oil Cooler and Oil Thermostat - Disassemble



Oil Cooler and Oil Thermostat - Disassemble

Disassembling Sequence

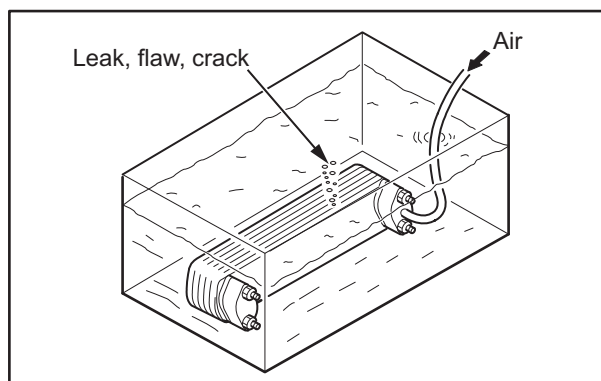
- | | | |
|--------------------|------------------|-----------|
| 1 Nut | 4 Element | 6 Sealing |
| 2 Oil cooler cover | 5 Oil thermostat | 7 Plug |
| 3 Packing | | |

CAUTION

Replace packings and O-rings with new ones when assembling.

2.7.1 Oil Cooler - Inspect

Check the oil passages of element for flaws or cracks by applying compressed air of 1.5 MPa {15 kgf/cm²} [217 psi]. If any leakage or damage is found, replace the element with a new one.

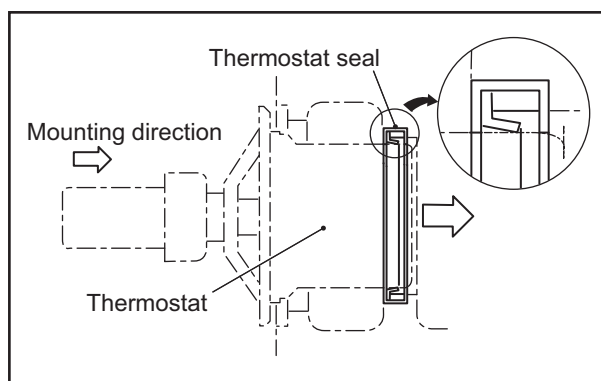


Oil Cooler - Inspect

2.8 Oil Thermostat - Inspect

2.8.1 Oil Thermostat Seal - Inspect

- (1) Inspect the oil thermostat seal for deterioration and cracks. If defects are found, replace the seal with a new one.
- (2) Refer to the illustration for correct orientation of seal installation.



Oil Thermostat Seal - Install

2.8.2 Oil Thermostat Operation - Inspect



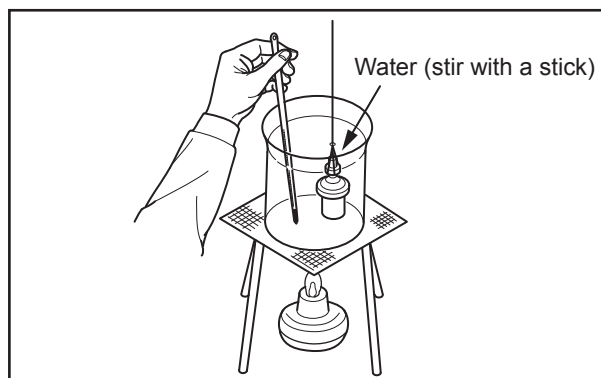
CAUTION

Be very careful with hot water and flames.
Or, you may get burned or cause a fire.

- (1) Put the oil thermostat fully into water in a container.
- (2) Heat the water while measuring water temperature. Record the temperature at which valve start to open, and at which valve lift becomes to the standard value. Replace the thermostat if a deviation from the standard temperature is unusual.

Note:(a) Stir the water to maintain uniform temperature during the test.

- (b) At assembling, be sure to check the valve opening temperature marked on the side of thermostat valve.



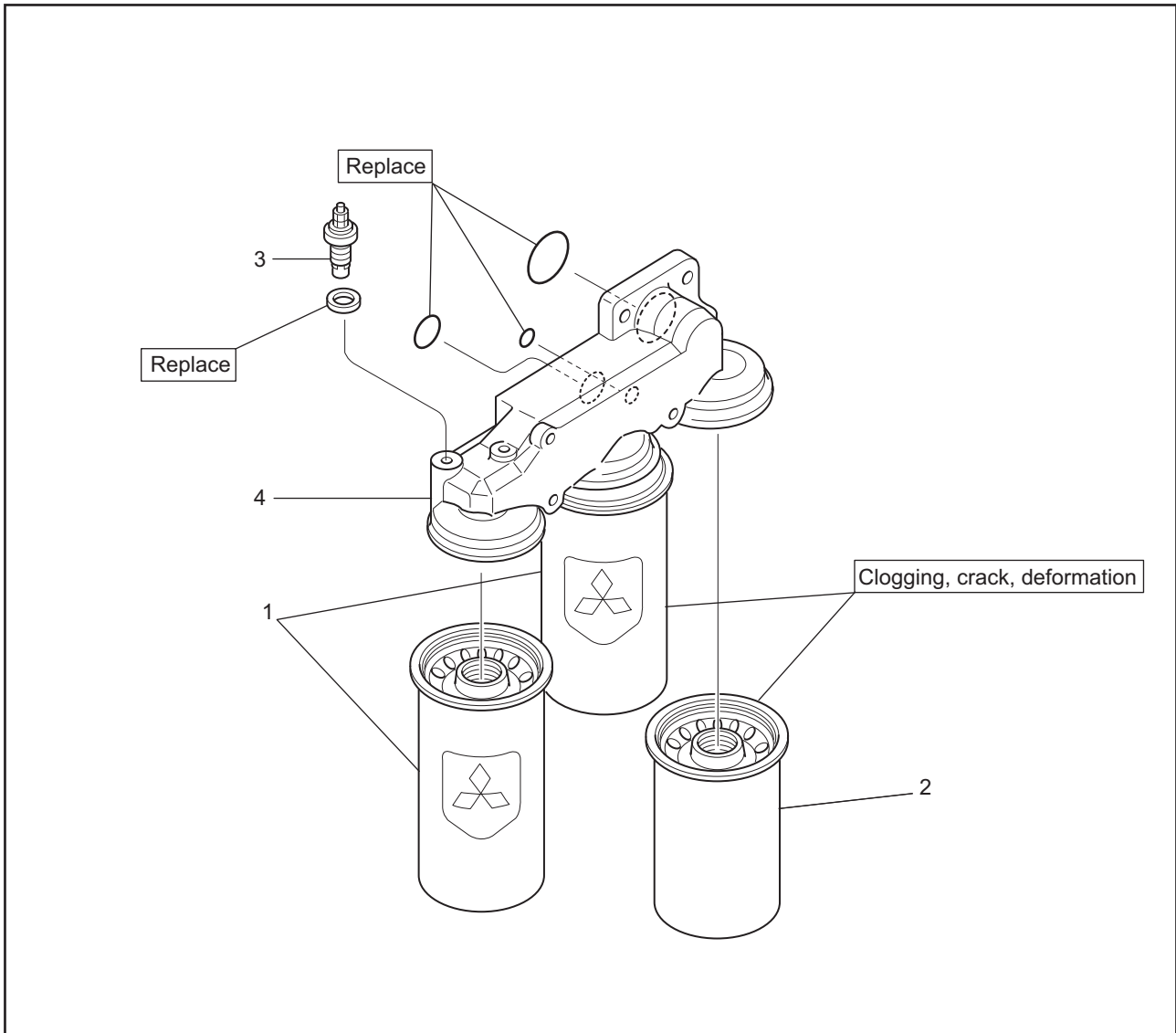
Oil Thermostat Operation - Inspect

Item	Standard value
Valve opening temperature	80 to 84°C [176 to 183.2°F]
Temperature at which valve lift becomes 11 mm [0.43 in.] or more	95°C [203°F]

2.9 Oil Cooler and Oil Thermostat - Assemble

To assemble, follow the disassembly sequence in reverse. Thoroughly clean oil passages with wash oil, and dry the cleaned parts with compressed air.

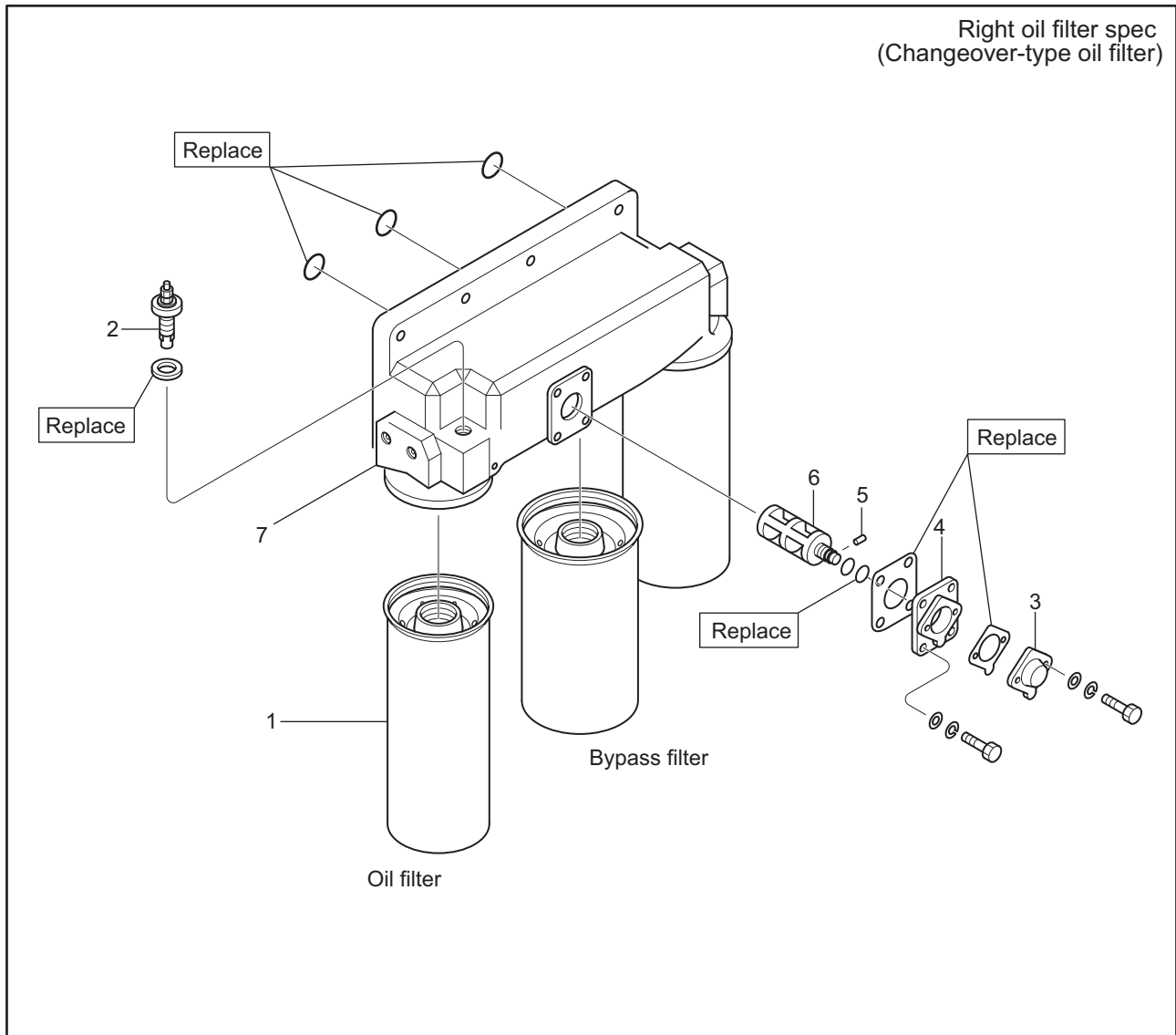
2.10 Oil Filter - Disassemble and Inspect



Oil Filter - Disassemble and Inspect

Disassembling Sequence

- | | |
|---------------------|--------------------|
| 1 Oil filter | 3 Oil filter alarm |
| 2 Bypass oil filter | 4 Bracket |



Oil Filter - Disassemble and Inspect

Disassembling Sequence

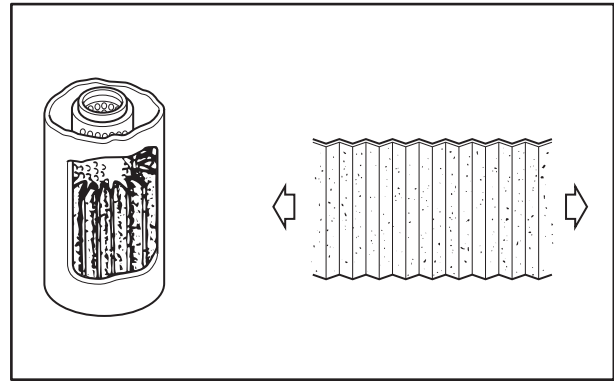
- 1 Oil filter (Cartridge type)
- 2 Oil filter alarm
- 3 Cover

- 4 Cover
- 5 Pin

- 6 Cock
- 7 Filter bracket

2.11 Oil Filter - Inspect

When replacing the oil filter, sample the oil (500 ml [0.13 U.S. gal]) and check for metal and other particles. If metal or other particles are found, cut and unfold the element, and inspect the color and shape of metal particles trapped in element to identify the cause.

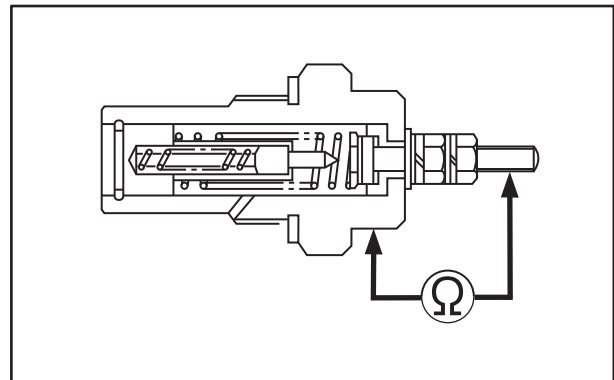


Oil Filter - Inspect

2.12 Oil Filter Alarm - Inspect

- (1) Use a tester to check the alarm for insulation and continuity. If the alarm is defective, disassemble and repair. If the bakelite or rubber insulations are deteriorated or damaged, replace the alarm.
- (2) If the filter alarm activation pressure is out of the standard, replace the alarm with a new one.

Item	Standard value
Oil filter alarm differential pressure for activation of alarm	0.15 to 0.18 MPa {1.5 to 1.8 kgf/cm ² } [217.6 to 261.1 psi]



Oil Filter Alarm - Inspect

2.13 Oil Filter - Assemble

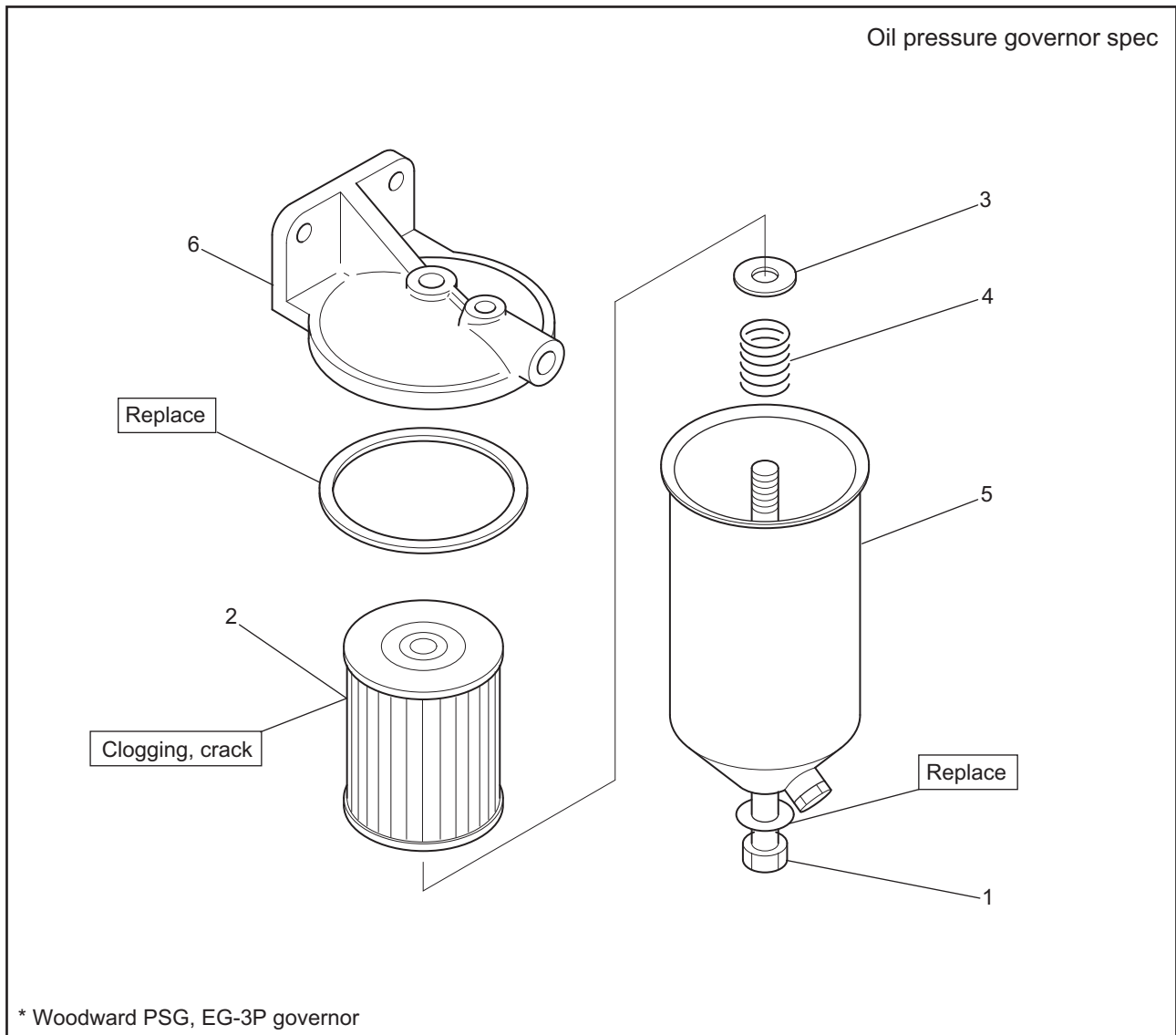
To assemble, follow the disassembly sequence in reverse. Thoroughly clean oil passages with wash oil, and dry the cleaned parts with compressed air.

2.14 Oil Filter Cartridge - Install

CAUTION

- (a) When installing oil filter cartridge, tighten it by hand. (Do not use filter wrench.)
 - (b) Be careful not to dent or damage the surface of cartridge.
- (1) Remove dust and contamination on oil filter cartridge mating face.
 - (2) Apply clean engine oil on oil filter gasket.
 - (3) After the oil filter gasket contacts with base surface, tighten the cartridge by 3/4 to 1 turn by hand.
 - (4) Start the engine, and make sure that there is no fuel leaks.

2.15 Governor Oil Filter - Disassemble and Inspect



Governor Oil Filter - Disassemble and Inspect

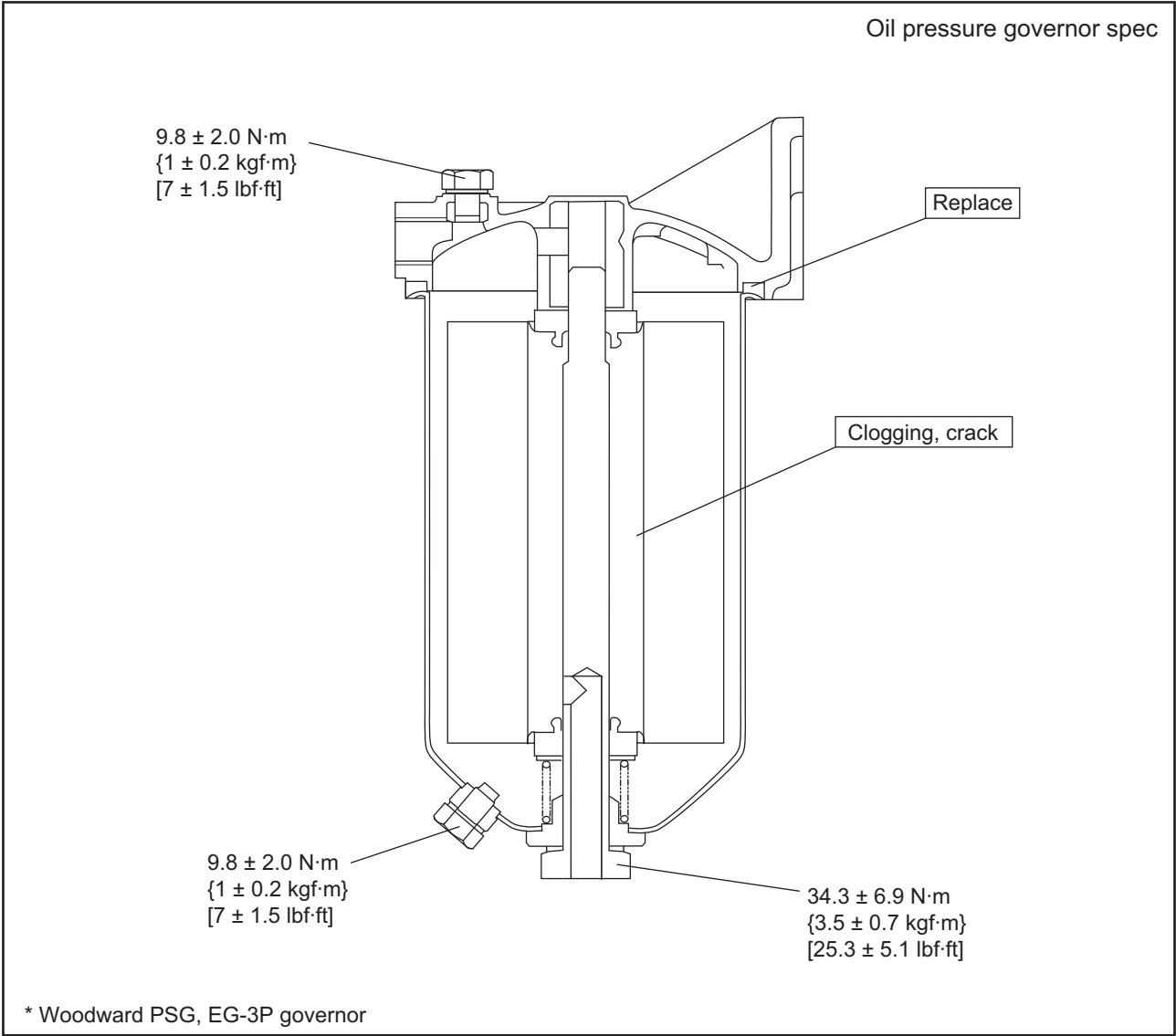
Disassembling Sequence

- 1 Center bolt
- 2 Element

- 3 Spring seat
- 4 Spring

- 5 Case
- 6 Cover

2.16 Governor Oil Filter - Assemble



Governor Oil Filter - Assemble

3. Lubrication System - Install

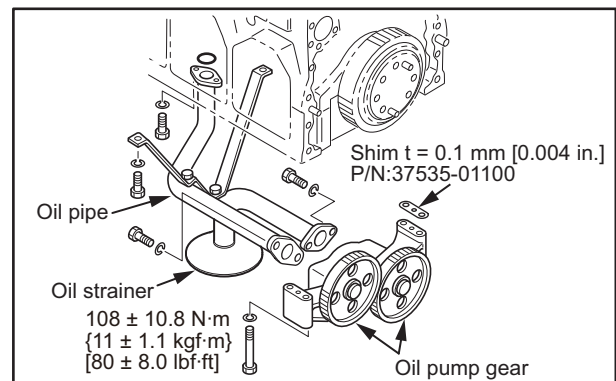
- ♦Install the parts in the reverse order of the disassemble sequence. (Refer to the illustration for disassembling.)
- ♦Thoroughly clean and dry the oil passage.

3.1 Oil Pump - Install

After installing the oil pump to crankcase, measure the backlash of crankshaft gear and oil pump gear.

If the backlash is out of the standard, insert shims to oil pump mounting portion to adjust the backlash.

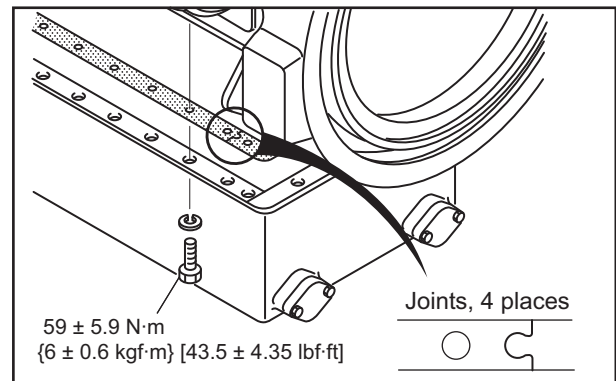
Item	Standard value
Backlash between oil pump gear and crankshaft gear	0.11 to 0.38 mm [0.0043 to 0.0150 in.]



Backlash When Installing Oil Pump - Adjust

3.2 Oil Pan - Install

- (1) Apply sealant (Heldite) to four places on both surfaces of oil pan packing joints, and attach the packing to the oil pan.
- (2) Install two guide bolts into the crankcase, and install the oil pan.
- (3) Tighten the mounting bolts to the specified torque.



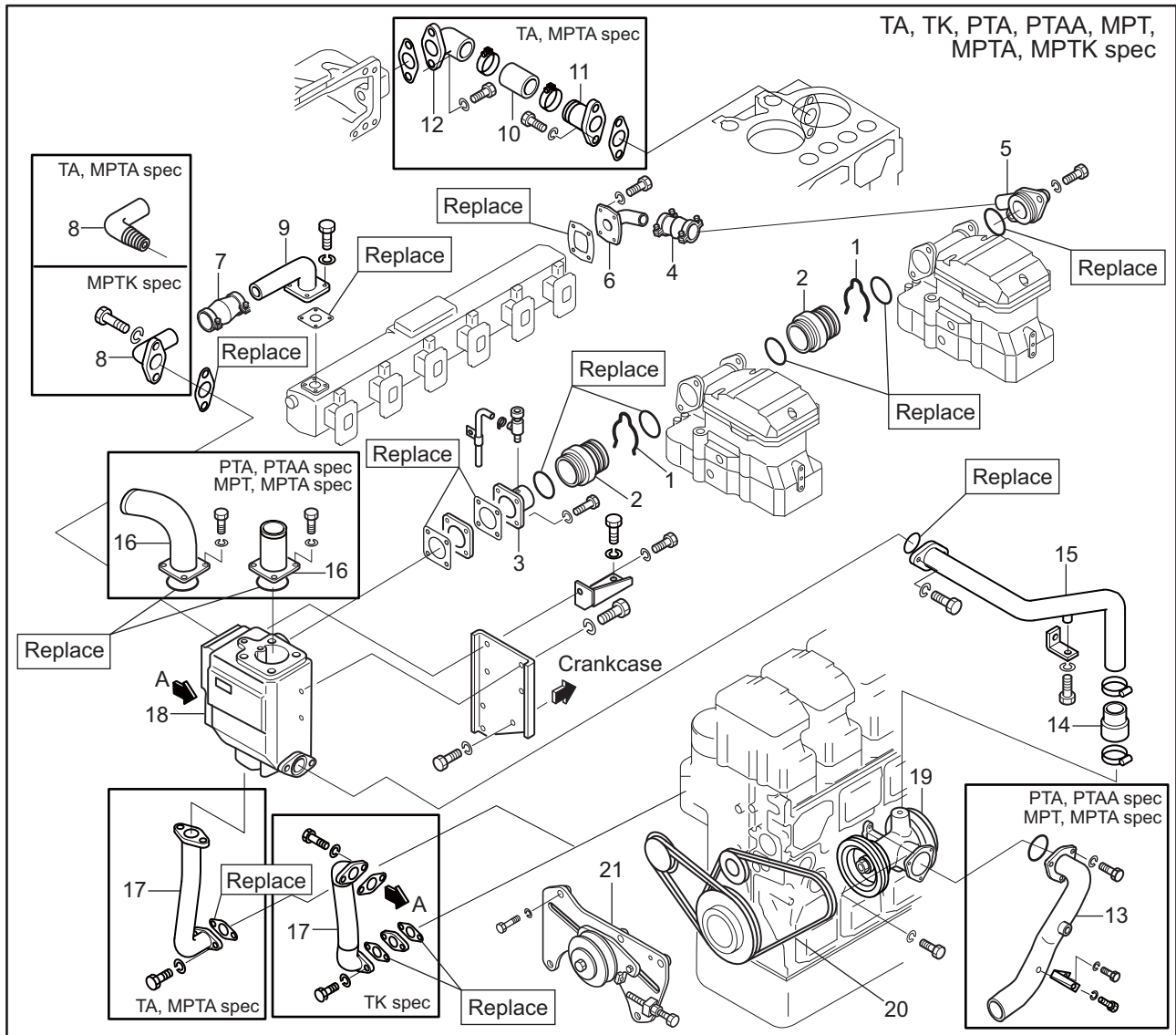
Oil Pan - Install

Chapter 10 COOLING SYSTEM

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1. Cooling System - Remove and Inspect

1.1 Water Pump, Thermostat and Water Pipe - Remove and Inspect

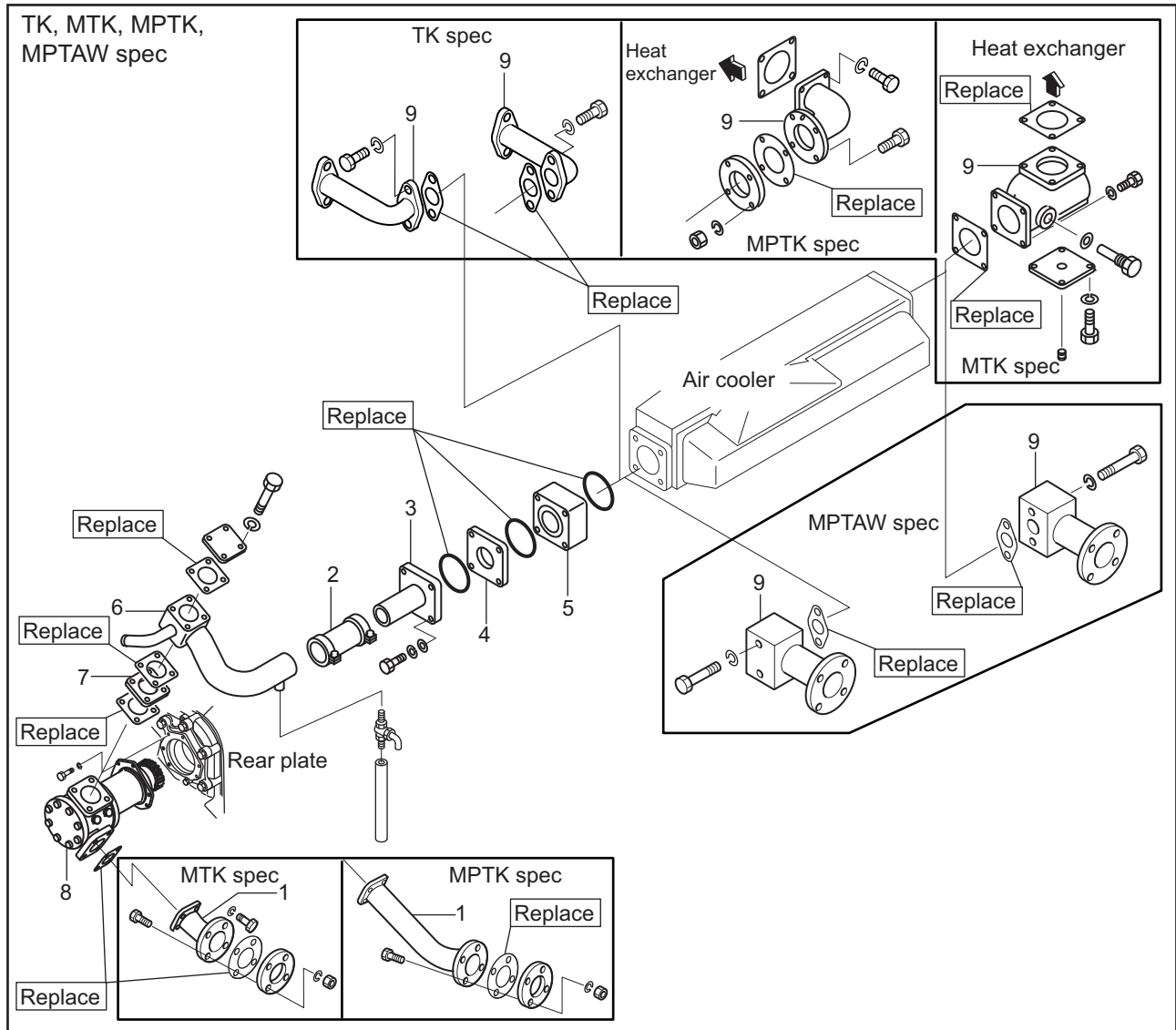


Water Pump, Thermostat and Water Pipe - Remove and Inspect

Removing Sequence

- | | | |
|--------------|----------------|--------------------------------------|
| 1 Snap ring | 8 Water pipe | 15 Water pipe |
| 2 Connector | 9 Water pipe | 16 Water pipe |
| 3 Water pipe | 10 Rubber hose | 17 Water pipe |
| 4 Coupling | 11 Water pipe | 18 Thermostat |
| 5 Water pipe | 12 Water pipe | 19 Water pump (Approx 24 kg [53 lb]) |
| 6 Water pipe | 13 Water pipe | 20 Belt |
| 7 Coupling | 14 Rubber hose | 21 Tension pulley |

1.3 Sea Water Pump and Water Pipe - Remove and Inspect

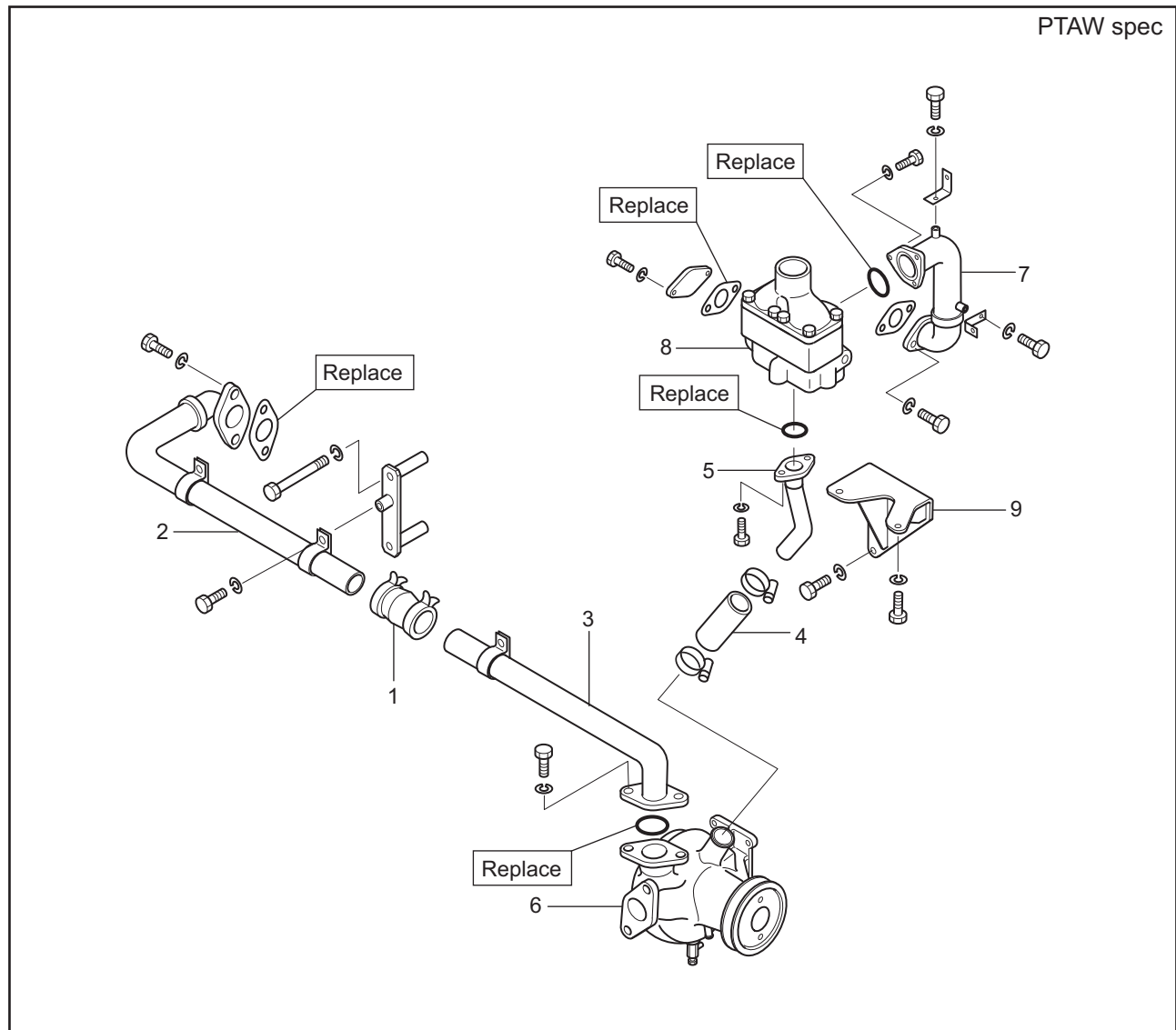


Sea Water Pump and Water Pipe - Remove and Inspect

Removing Sequence

- | | | |
|--------------|--------------|------------------|
| 1 Water pipe | 4 Orifice | 7 Plate |
| 2 Coupling | 5 Connector | 8 Sea water pump |
| 3 Water pipe | 6 Water pipe | 9 Water pipe |

1.4 Air Cooler Coolant Pump, Thermostat and Water Pipe - Remove and Insp



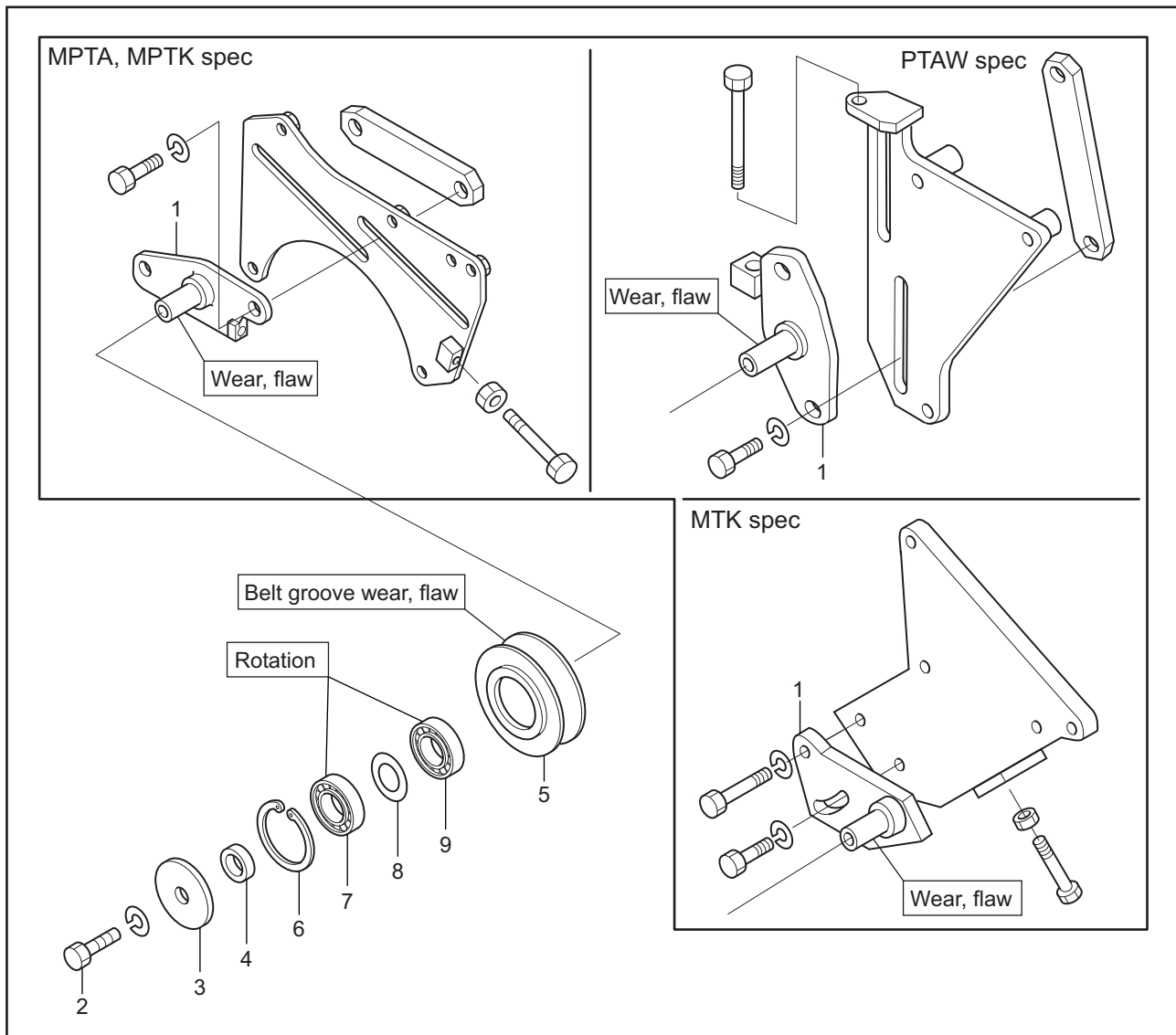
Air Cooler Coolant Pump, Thermostat and Water Pipe - Remove and Inspect

Removing Sequence

- | | | |
|--------------|-----------------------------|--------------|
| 1 Coupling | 4 Rubber hose | 7 Water pipe |
| 2 Water pipe | 5 Water pipe | 8 Thermostat |
| 3 Water pipe | 6 Water pump for air cooler | 9 Bracket |

2. Cooling System - Disassemble, Inspect and Assemble

2.1 Tension Pulley - Disassemble and Inspect



Tension Pulley - Disassemble and Inspect

Disassembling Sequence

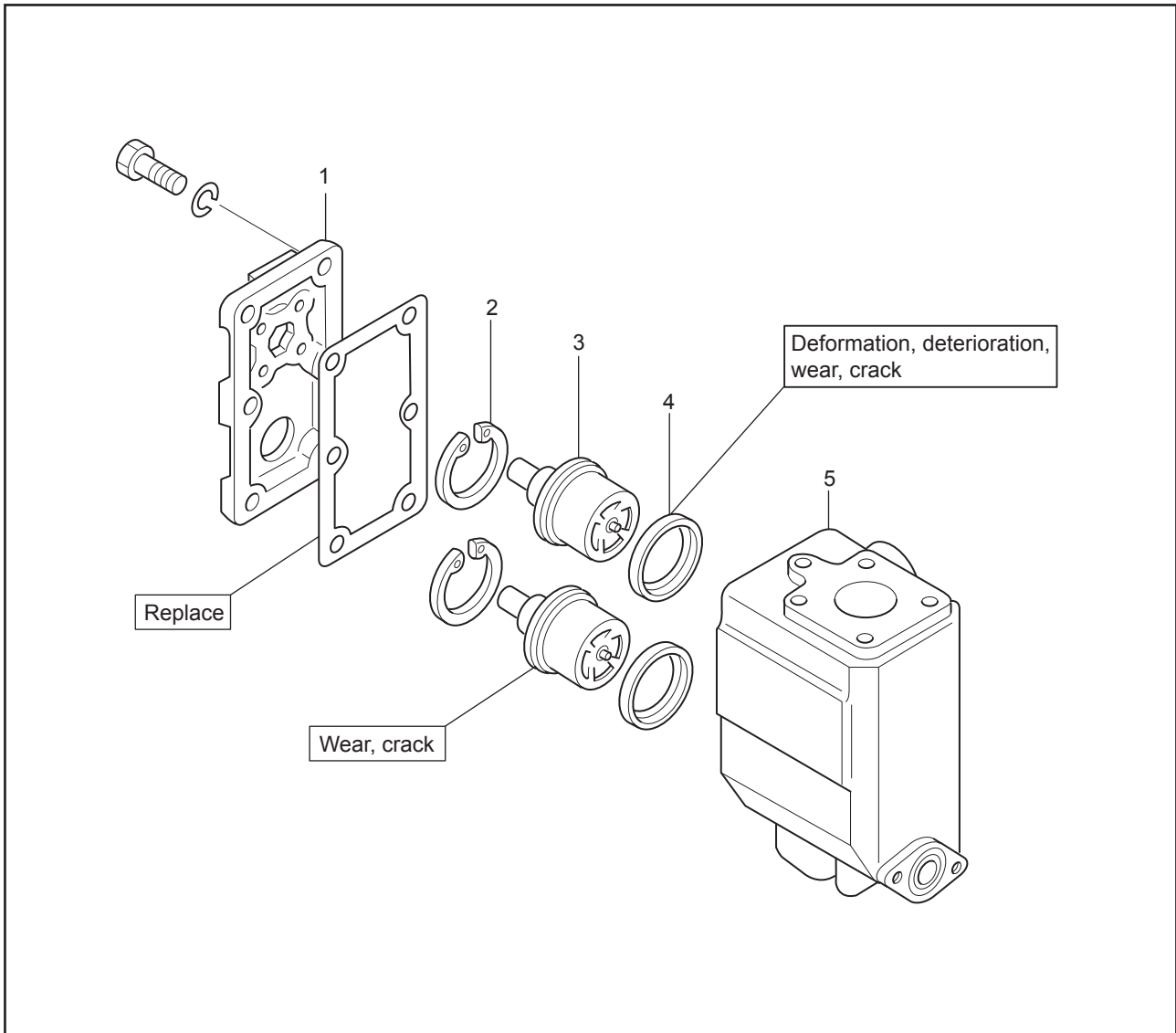
- | | | |
|-------------------|------------------|-----------|
| 1 Tension bracket | 4 Spacer | 7 Bearing |
| 2 Bolt | 5 Tension pulley | 8 Spacer |
| 3 Thrust plate | 6 Snap ring | 9 Bearing |

2.1.1 Tension Pulley - Inspect

Measure the bearing fit in tension pulley and on shaft. If abnormal wear or damage is shown, replace the bearing, pulley or tension bracket.

Item		Nominal value	Standard value
Inside diameter of tension pulley bearing fit		ø52 [2.05]	51.970 to 52.000 mm [2.0461 to 2.0472 in.]
Bearing	Inside diameter	ø20 [0.79]	19.988 to 20.000 mm [0.7869 to 0.7874 in.]
	outside diameter	ø52 [2.05]	51.987 to 52.000 mm [2.0467 to 2.0472 in.]
Outside diameter of bracket bearing fit		ø20 [0.79]	19.987 to 20.000 mm [0.7869 to 0.7874 in.]

2.2 Thermostat - Disassemble and Inspect



Thermostat - Disassemble and Inspect

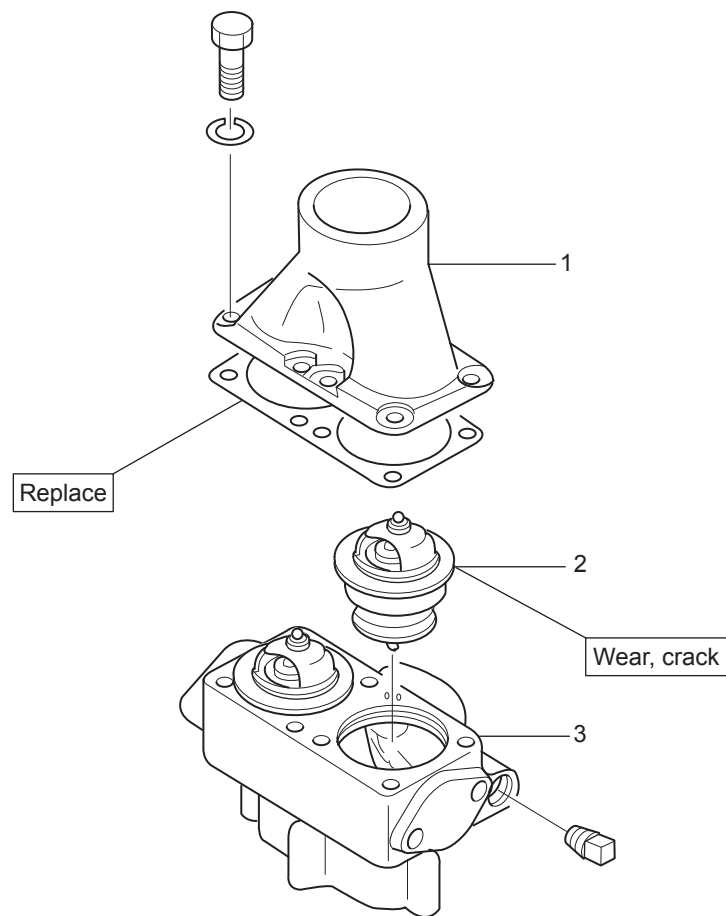
Disassembling Sequence

- 1 Thermostat cover
- 2 Snap ring

- 3 Thermostat
- 4 Thermostat seal

- 5 Thermostat case

PTAW spec



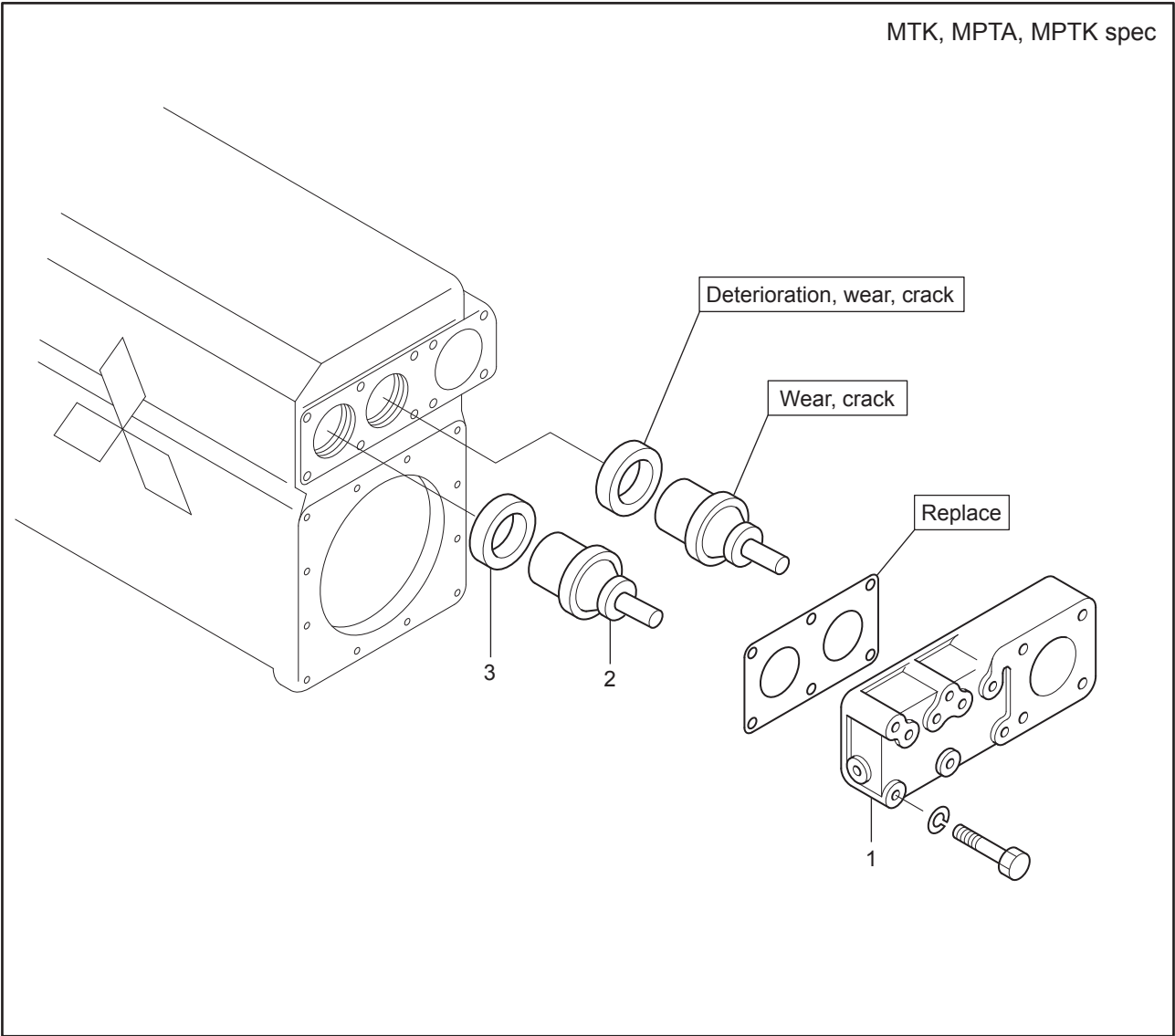
Thermostat - Disassemble and Inspect

Disassembling Sequence

1 Thermostat cover

2 Thermostat

3 Thermostat case



Thermostat - Disassemble and Inspect

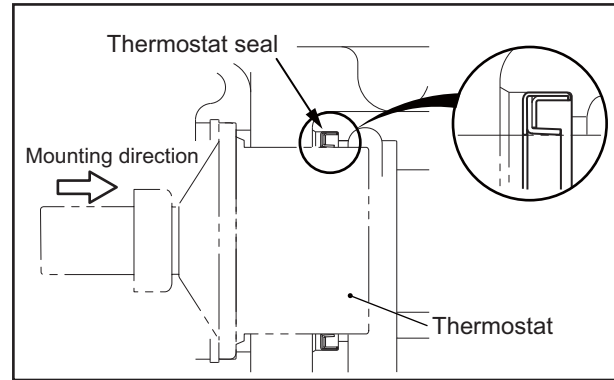
Disassembling Sequence

- 1 Thermostat cover
- 2 Thermostat
- 3 Thermostat seal

2.3 Thermostat for Jacket Water and Air Cooler - Inspect

2.3.1 Thermostat Seal - Inspect

- (1) Inspect the thermostat seal for deterioration and cracks.
If defects are found, replace the seal with a new one.
- (2) Refer to the illustration for correct orientation of seal installation.



Thermostat Seal - Install

2.3.2 For Water Jacket and Air Cooler Thermostat Operation - Inspect

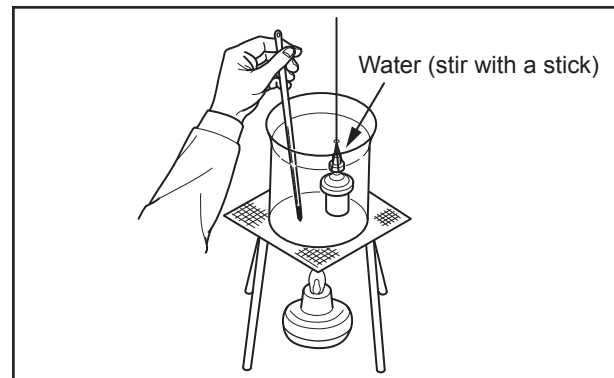
CAUTION

Be very careful with hot water and flames.
Or, you may get burned or cause a fire.

- (1) Immerse the thermostat in a container filled with water.
- (2) Heat the water while measuring water temperature.
Record the temperature at which valve start to open, and at which valve lift becomes to the standard value.
Replace the thermostat if a deviation from the standard temperature is unusual.

Note:(a) Stir the water to maintain uniform temperature during the test.

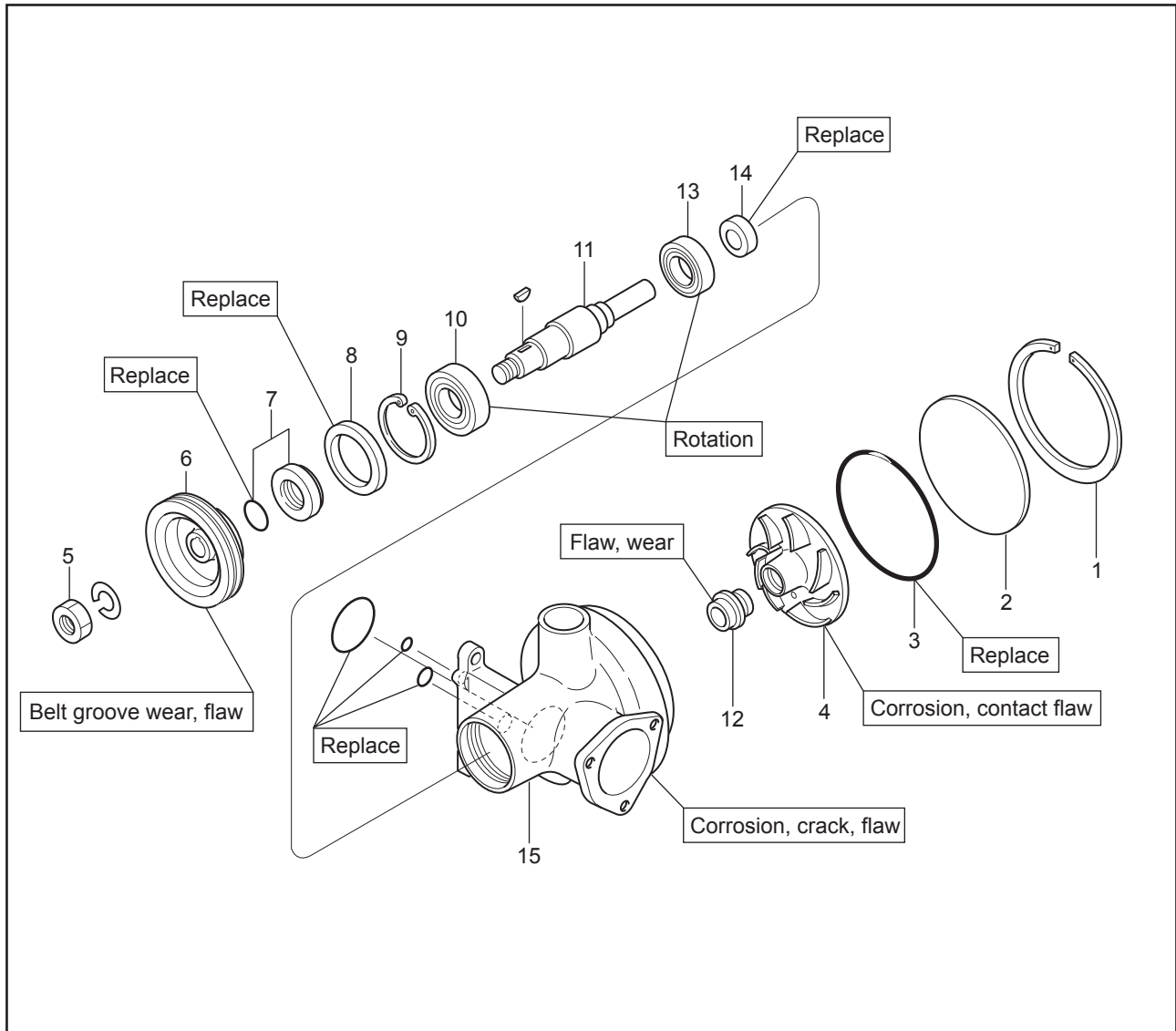
- (b) At assembling, be sure to check the valve opening temperature marked on the side of thermostat valve.



Thermostat Operation - Inspect

Part No.	Item	Standard value	Remarks
For jacket water	37546-21700	Valve opening temperature 69 to 73 °C [157 to 163 °F]	Opening temperature stamp 71 °C [160 °F]
		Temperature at which valve lift becomes 9 mm [0.35 in.] or more 85 °C [185 °F]	
For air cooler	35C46-05200	Valve opening temperature 33 to 37°C [91.4 to 98.6 °F]	Opening temperature stamp 35 °C [95 °F]
		Temperature at which valve lift becomes 10 mm [0.35 in.] or more 50°C [122 °F]	
	37546-40700	Valve opening temperature 69 to 73 °C [157 to 163 °F]	Opening temperature stamp 71 °C [160 °F]
		Temperature at which valve lift becomes 11 mm [0.43 in.] or more 85 °C [185 °F]	

2.5 Water Pump - Disassemble and Inspect



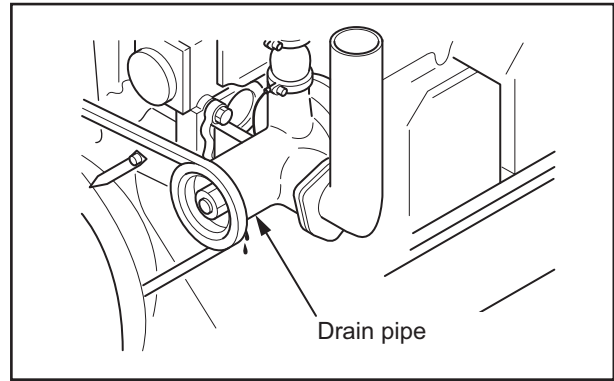
Water Pump - Disassemble and Inspect

Disassembling Sequence

- | | | |
|-------------|---------------------|-------------------------------------|
| 1 Snap ring | 6 Water pump pulley | 11 Water pump shaft |
| 2 Cover | 7 Spacer, O-ring | 12 Unit seal |
| 3 O-ring | 8 Oil seal | 13 Bearing |
| 4 Impeller | 9 Snap ring | 14 Oil seal |
| 5 Nut | 10 Bearing | 15 Pump case (Approx 15 kg [33 lb]) |

2.5.1 Water Pump Mounted on Engine - Inspect

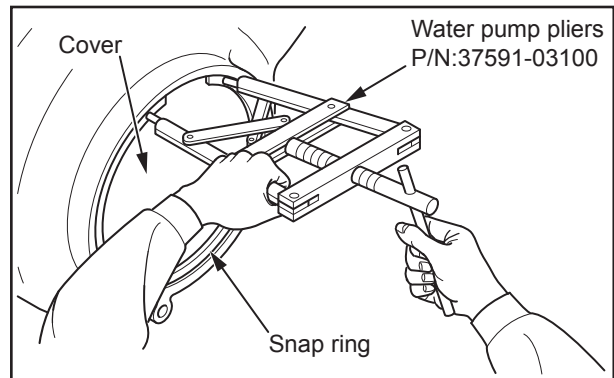
Visually check the drain port at the bottom center of water pump case with a finger. If water is oozing out, the unit seal is defective, and if oil is oozing out, the oil seal is defective.



Water Pump Mounted on Engine - Inspect

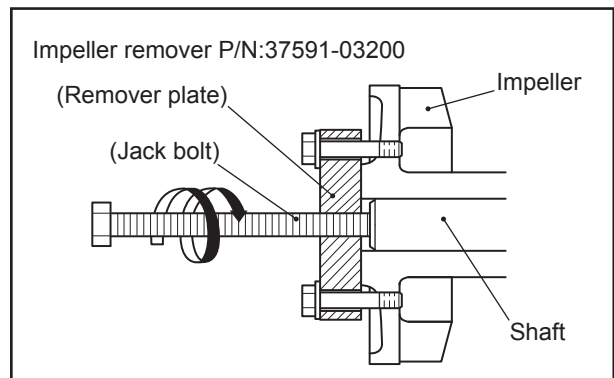
2.5.2 Impeller - Remove

(1) Remove the snap ring that holds the cover with water pump pliers, and remove the cover.



Water Pump Cover - Remove

(2) Remove the impeller with impeller remover.



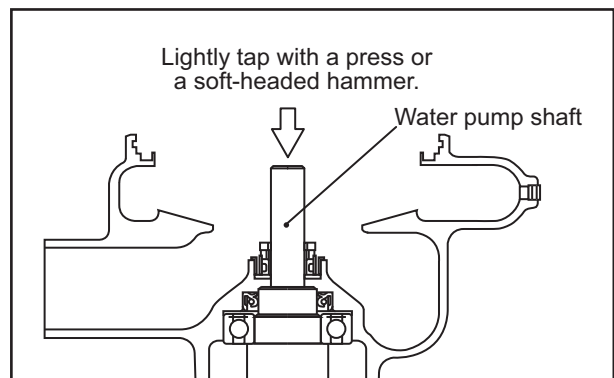
Impeller - Remove

2.5.3 Water Pump Shaft - Remove

CAUTION

When removing the impeller from water pump shaft, take care not to damage the water pump shaft and impeller.

Remove the snap ring on pulley side, with press tool or tapping with soft-headed hammer, remove the water pump shaft together with bearing.



Water Pump Shaft - Remove

2.6 Water Pump - Inspect

Measure the inside diameter of water pump case fit to bearing, and the outside diameter of shaft fit to bearing, and the inside and outside diameters of bearing. If any of the measurements is out of the standard, replace the part with a new one.

Item		Nominal value	Standard value	Limit value
Inside diameter of pump case fit to bearing		ø80 mm [3.15 in.]	79.988 to 80.018 mm [3.1491 to 3.1502 in.]	80.025 mm [3.1506 in.]
		ø90 mm [3.54 in.]	89.987 to 90.022 mm [3.5428 to 3.5442 in.]	90.025 mm [3.5443 in.]
Bearing	outside diameter	ø80 mm [3.15 in.]	79.985 to 80.000 mm [3.149 to 3.1496 in.]	-
		ø90 mm [3.54 in.]	89.985 to 90.000 mm [3.5427 to 3.5433 in.]	-
	Inside diameter	ø40 mm [1.57 in.]	39.988 to 40.000 mm [1.5743 to 1.5748 in.]	-
Outside diameter of shaft fit to bearing		ø40 mm [1.57 in.]	40.002 to 40.013 mm [1.5748 to 1.5753 in.]	39.995 mm [1.5746 in.]
Impeller front clearance		0.72 mm [0.0311 in.]	0.14 to 1.30 mm [0.006 to 0.0512 in.]	-

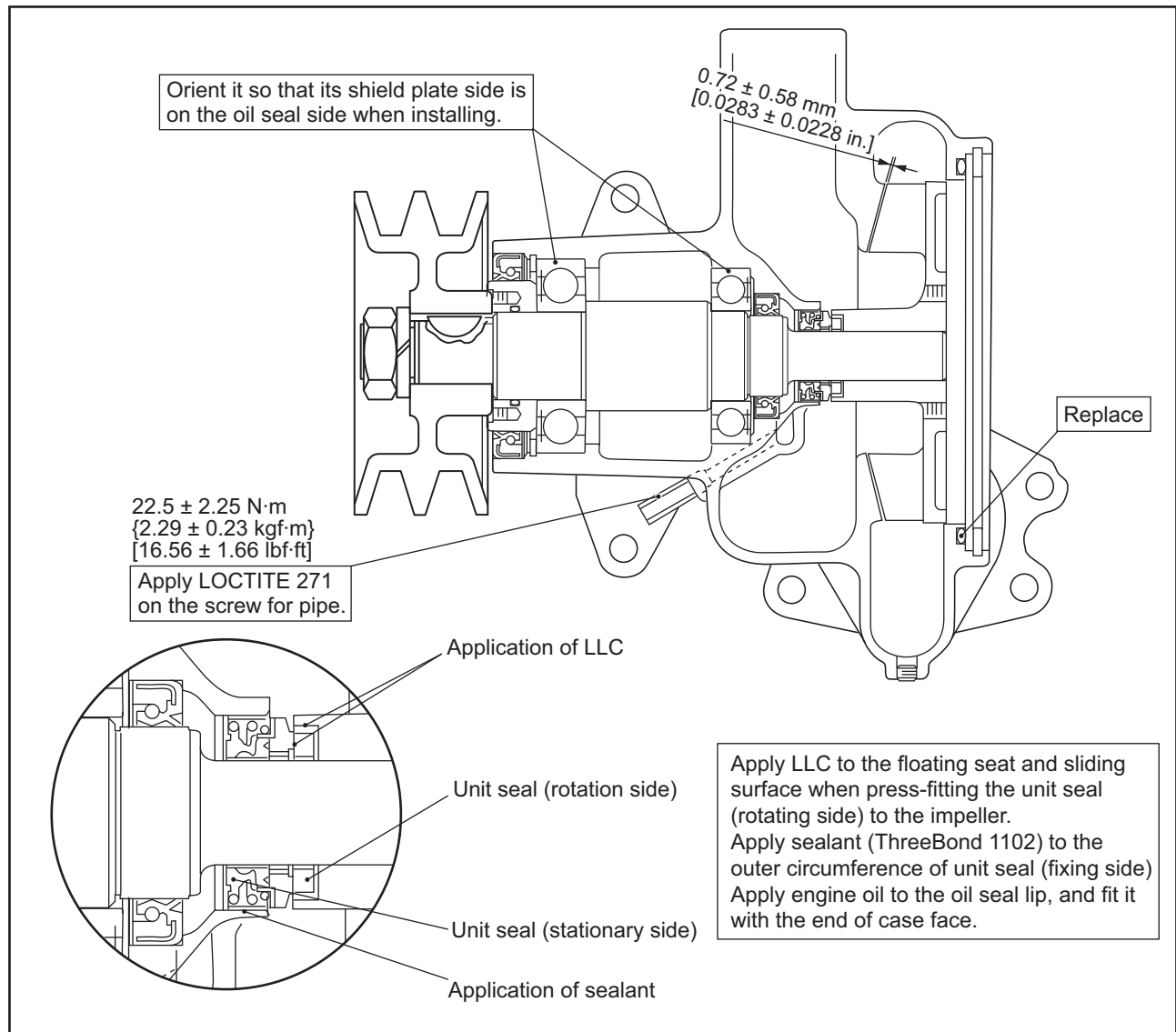
2.7 Water Pump Shaft - Inspect

When the flange and impeller are removed from water pump shaft, interference may become deficient.

If the interference is less than the specified standard value, replace either impeller or water pump shaft.

Item	Nominal value	Standard value
Interference between impeller and water pump shaft	ø20 mm [0.79 in.]	0.024 to 0.060 mm [0.0009 to 0.0024 in.]

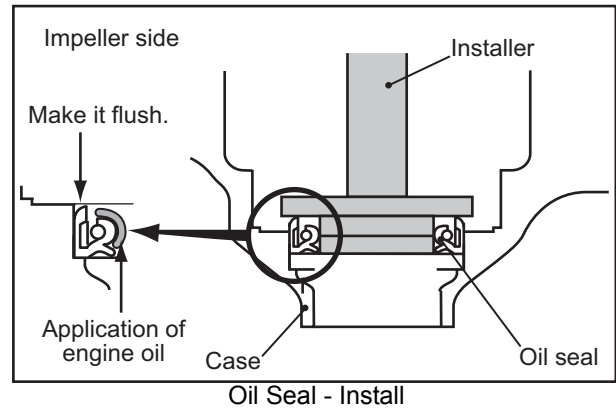
2.8 Water Pump - Assemble



Water Pump - Assemble

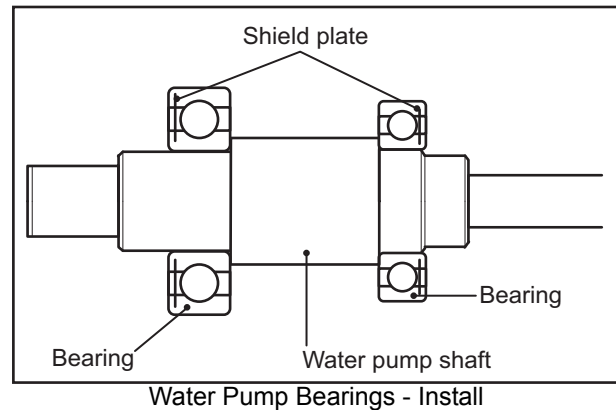
2.8.1 Oil Seal - Install

- (1) Tap-in the oil seal with installer making sure that oil seal surface is flush with water pump housing face.
- (2) Apply engine oil to the oil seal lip.



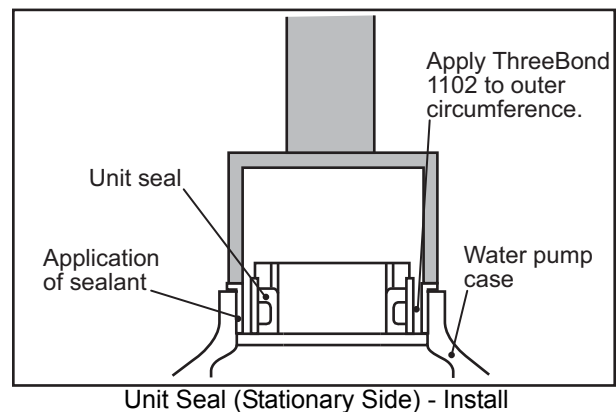
2.8.2 Water Pump Bearings - Install

Install the bearing to water pump shaft. Orient each bearing so that its shield plate faces to oil seal side when installing the bearing to shaft.



2.8.3 Unit Seal (Stationary Side) - Install

- (1) Apply sealant (ThreeBond 1102) to the outer circumference of unit seal (stationary side.)
- (2) Tap-in the unit seal into water pump case with unit seal installer.

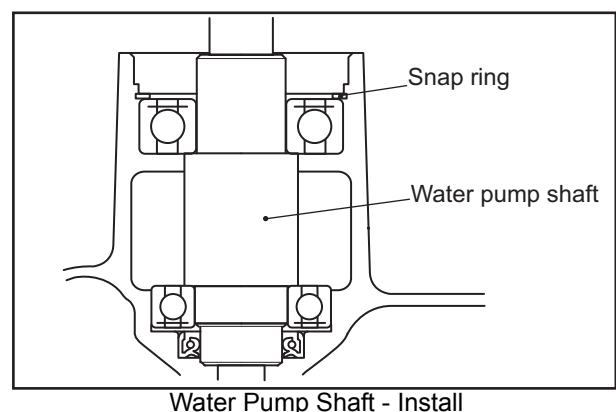


2.8.4 Water Pump Shaft - Install

CAUTION

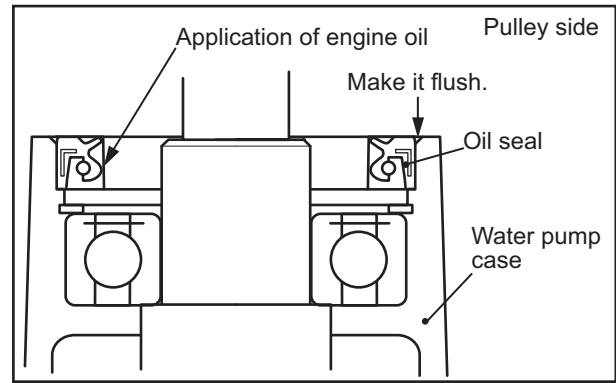
Be careful not to damage the water pump shaft by oil seal and unit seal (fixing side) when press-fitting the water pump shaft.

- (1) Press-in the water pump shaft slowly into pump case until the end of ball bearing comes into contact with pump case.
- (2) Securely install the snap ring to groove.



2.8.5 Water Pump Oil Seal - Install

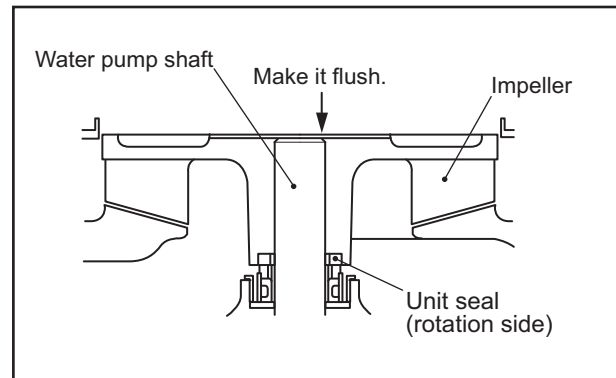
- (1) Tap-in the oil seal with installer making sure that oil seal surface is flush with water pump housing face.
- (2) Apply engine oil to the oil seal lip.



Water Pump Oil Seal - Install

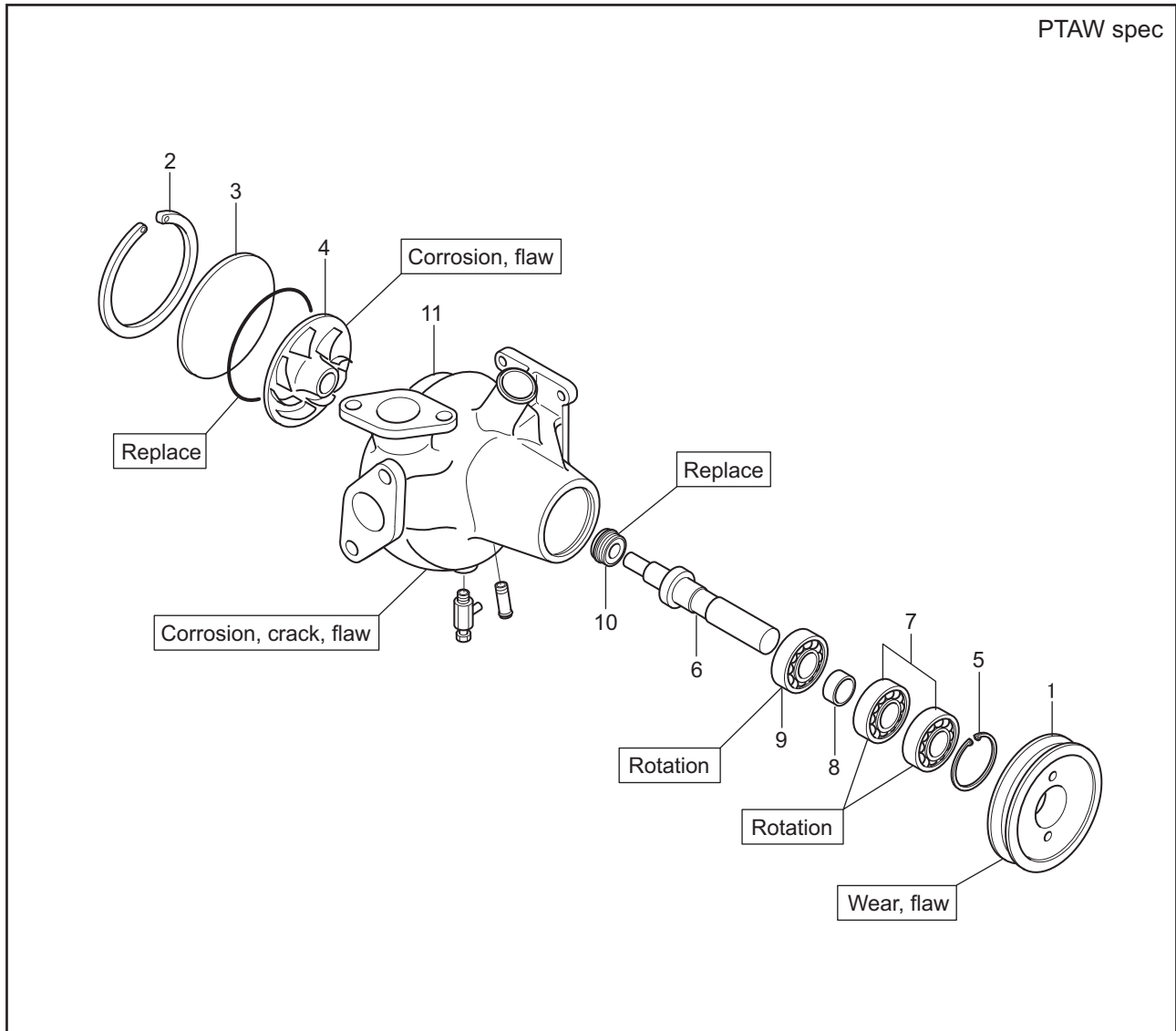
2.8.6 Unit Seal (Rotating Side) and Impeller - Install

- (1) Install the unit seal (rotating side) to impeller.
- (2) Apply LLC to the unit seal (rotating side).
- (3) Press-in the water pump impeller with press tool. Place the water pump impeller boss face to be flush with the end face of pump shaft.



Unit Seal (Rotating Side) and Impeller - Install

2.9 Air Cooler Water Pump - Disassemble and Inspect



Air Cooler Water Pump - Disassemble and Inspect

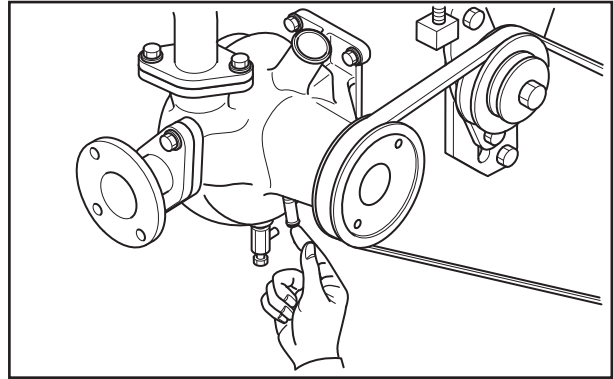
Disassembling Sequence

- | | | |
|---------------------|--------------------|---|
| 1 Water pump pulley | 5 Snap ring | 9 Ball bearing |
| 2 Snap ring | 6 Water pump shaft | 10 Unit seal |
| 3 Cover | 7 Ball bearing | 11 Water pump case (Approx 15 kg [33 lb]) |
| 4 Impeller | 8 Spacer | |

2.9.1 Air Cooler Water Pump Mounted on Engine

- Inspect

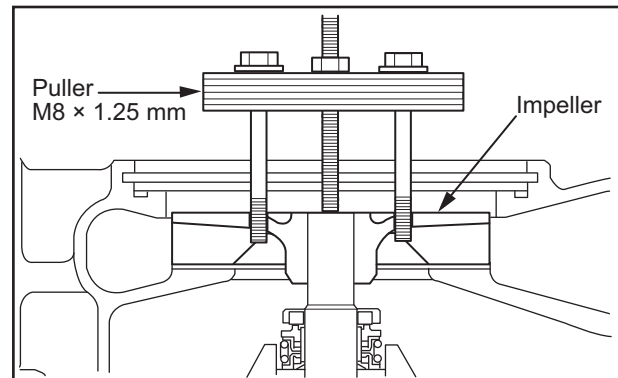
Touch the drain port at the bottom center of water pump case with a finger. If water or oil is oozing out, the unit seal is defective.



Air Cooler Water Pump Mounted on Engine - Inspect

2.9.2 Impeller - Remove

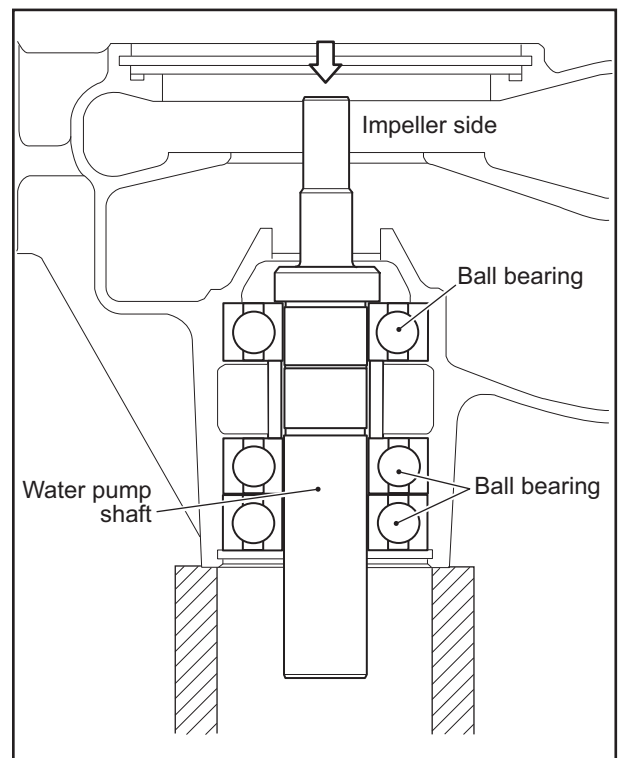
Install a puller to impeller pul-out holes, and remove the impeller.



Impeller - Remove

2.9.3 Water Pump Shaft - Remove

Remove the shaft and ball bearings as a set by pushing the impeller end face of water pump shaft with hand press or the like.



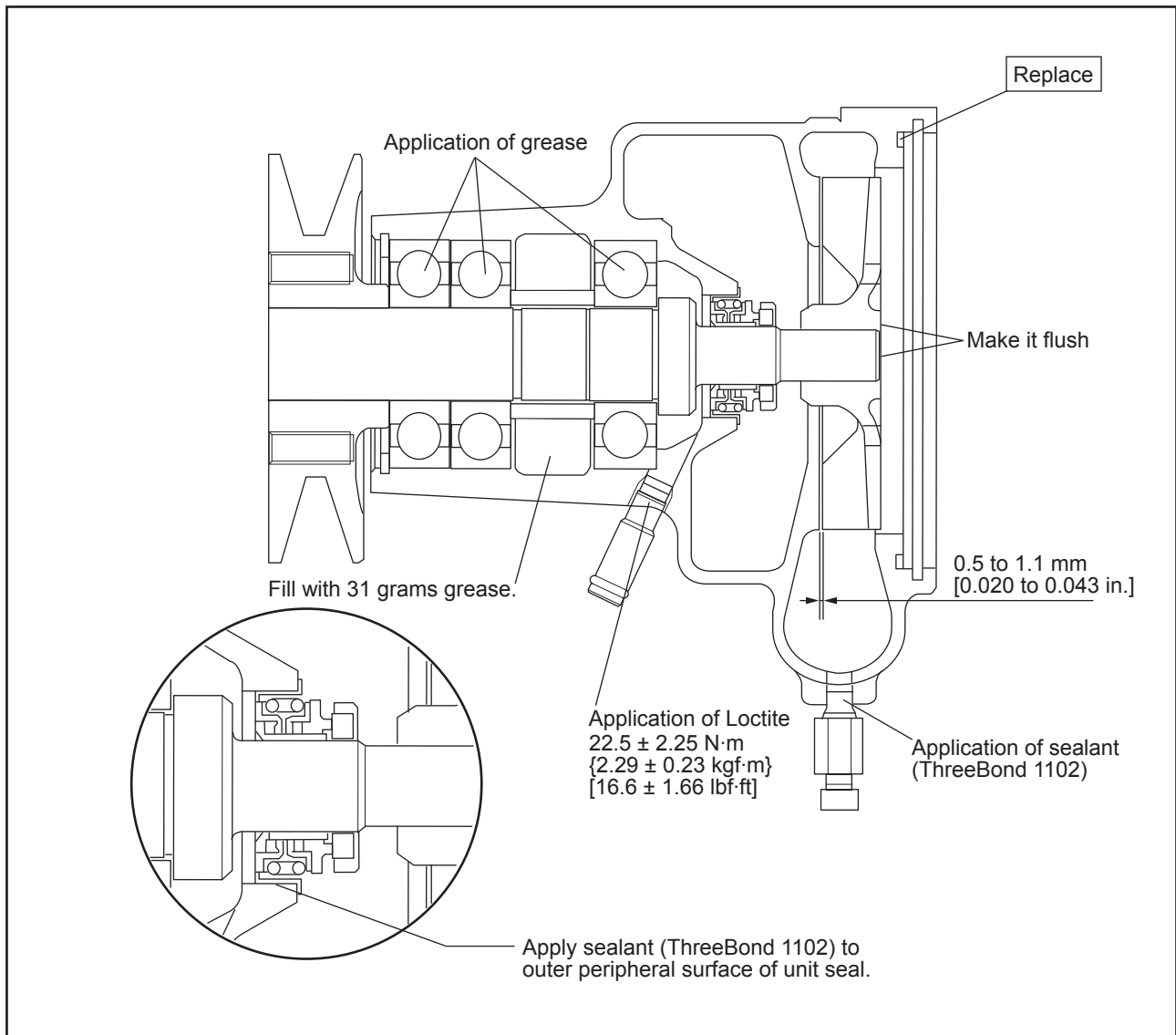
Water Pump Shaft - Remove

2.9.4 Air Cooler Water Pump - Inspect

Measure the bearing fit diameters of water pump bearing housing and shaft, and the inside and outside diameters of bearing. If any of the measurements is out of the standard, replace the part with a new one.

Item		Nominal value	Standard value
Inside diameter of bearing fit	Pump case	ø62 mm [2.44 in.]	61.988 to 62.018 mm [2.4404 to 2.4416 in.]
	Bearing cover	ø68 mm ([2.68 in.]	67.961 to 67.991 mm [2.6760 to 2.6768 in.]
Bearing	Inside diameter	ø28 mm [1.1024 in.]	27.990 to 28.000 mm [1.1020 to 1.1024 in.]
	Outside diameter	ø68 mm ([2.68 in.]	67.987 to 68.000 mm [2.677 to 2.6772 in.]
Outside diameter of shaft fit to bearing		ø28 mm [1.1024 in.]	28.002 to 28.015 mm [1.1024 to 1.1034 in.]
Impeller front clearance		0.8 mm [0.031 in.]	0.5 to 1.1 mm [0.020 to 0.043 in.]

2.10 Air Cooler Coolant Pump - Assemble

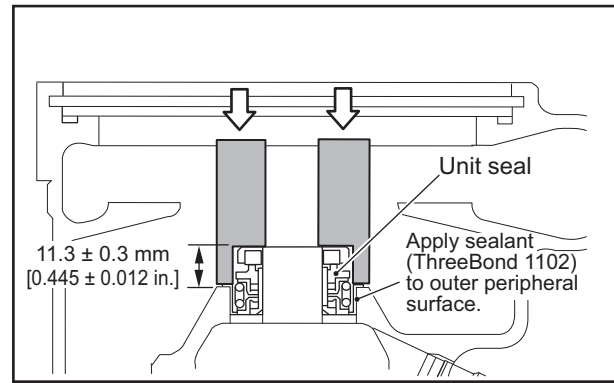


Air Cooler Coolant Pump - Assemble

2.10.1 Unit Seal - Install

- (1) Apply sealant (ThreeBond 1102) to the circumference of the unit seal.
- (2) Press-in the unit seal into water pump case with unit seal installer.

Note: Replace the unit seal with a new one whenever it is removed from water pump case.



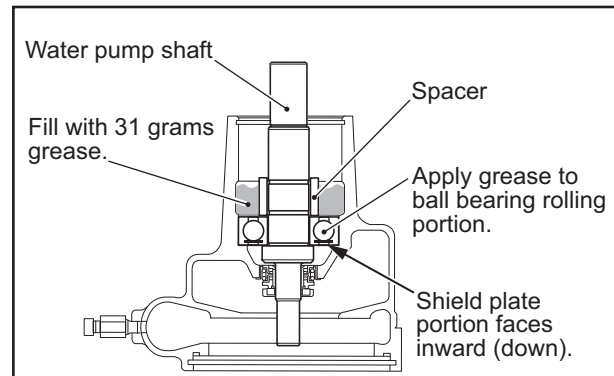
Unit Seal - Install

2.10.2 Water Pump Shaft - Install

CAUTION

Be careful not to damage the water pump shaft by oil seal and unit seal when press-fitting the water pump shaft.

- (1) Press-in the water pump shaft slowly into pump case until the end face of ball bearing comes into contact with pump case.
- (2) Install the spacer to water pump shaft.
- (3) Apply grease on ball bearing rolling faces.
- (4) Fill grease of 31g [1.09 oz] into space among spacer, ball bearing and pump case.



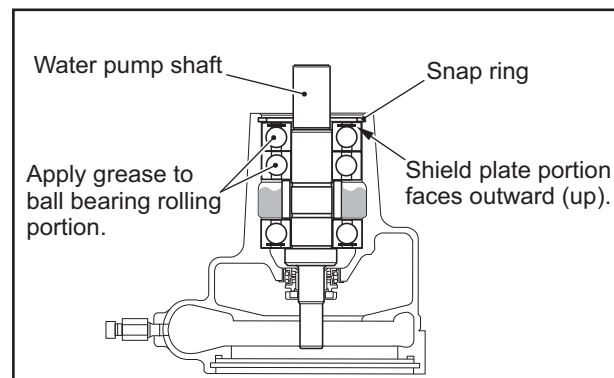
Water Pump Shaft - Install

2.10.3 Ball Bearing - Install

- (1) Apply grease on ball bearing rolling faces and press fit the bearing to Water pump shaft.

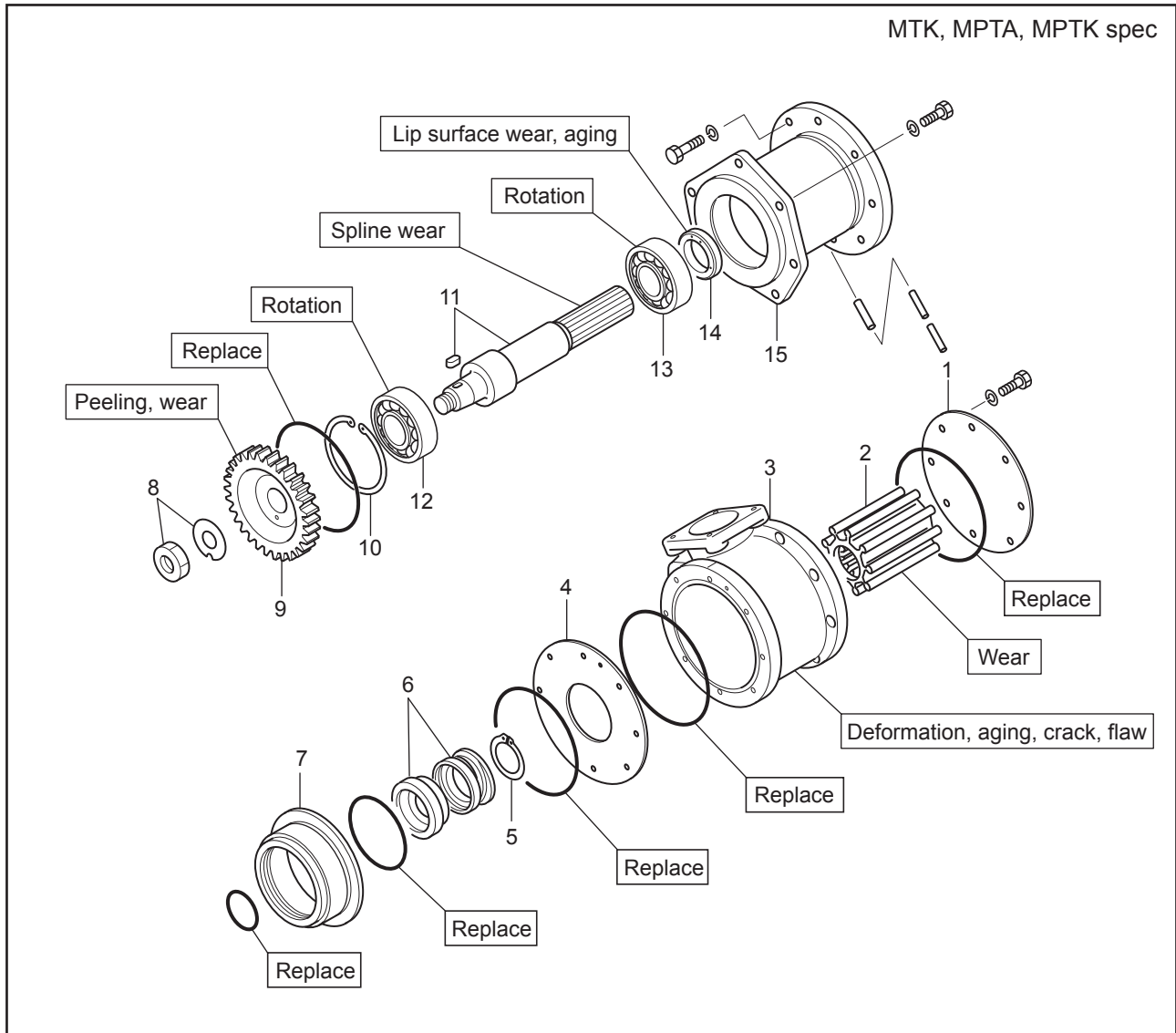
Note: Place the sealed plate outside to fit the outer bearing to the shaft.

- (2) Securely install the snap ring to pump case groove.



Ball Bearing - Install

2.11 Sea Water Pump - Disassemble and Inspect



Sea Water Pump - Disassemble and Inspect

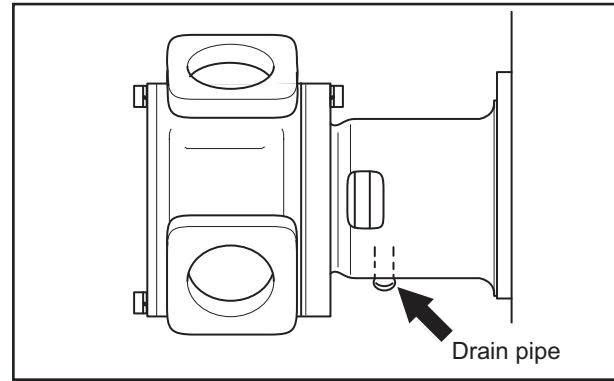
Disassembling Sequence

- | | | |
|-----------------------|-------------------|---------------------|
| 1 Cover | 6 Unit seal | 11 Water pump shaft |
| 2 Water pump impeller | 7 Housing | 12 Bearing |
| 3 Case | 8 Nut, washer | 13 Bearing |
| 4 Plate | 9 Water pump gear | 14 Oil seal |
| 5 Snap ring | 10 Snap ring | 15 Bearing case |

2.11.1 Sea Water Pump Assembled to Engine - Inspect

With fingers, touch the drain port at pump holder bottom. If water is oozing out, the unit seal is defective.

Clean the pipe inside with fine stick or the like, in case of clogging with deposition salt.



Sea Water Pump Assembled to Engine - Inspect

2.11.2 Outside Diameter and Inside Diameter of Bearing Fit - Inspect

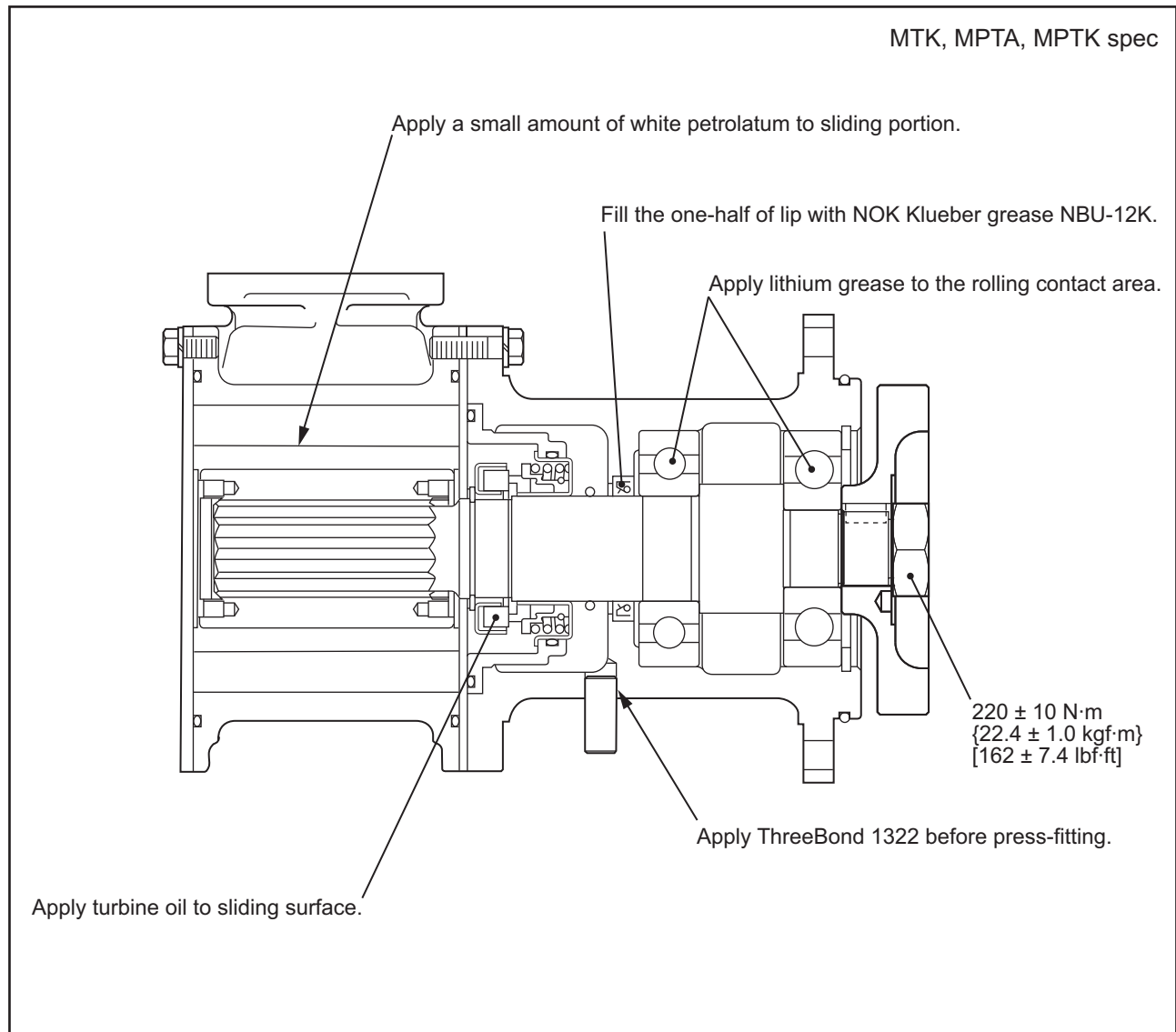
Turn the bearing and if turning is not smooth, replace the bearing with a new one. Inspect the fit of bearing case and bearing. If heavy wear is found, replace them with new ones. Inspect the fit of shaft and bearing. If heavy wear is found, replace them with new ones.

Item		Nominal value	Standard value
Inside diameter of case bearing housing		ø90 mm [3.54 in.]	89.9825 to 90.0175 mm [3.5430 to 3.5440 in.]
Bearing	outside diameter	ø90 mm [3.54 in.]	90.000 to 90.015 mm [3.5430 to 3.5439 in.]
	Inside diameter	ø30 mm [1.18 in.]	29.990 to 30.000 mm [1.1807 to 1.1811 in.]
		ø40 mm [1.57 in.]	39.988 to 40.000 mm [1.5743 to 1.5748 in.]
Outside diameter of shaft fit to bearing		ø30 mm [1.18 in.]	30.002 to 30.018 mm [1.1810 to 1.1818 in.]
		ø40 mm [1.57 in.]	40.002 to 40.018 mm [1.5749 to 1.5755 in.]

2.11.3 Drive Gear - Inspect

Inspect the drive gear teeth. Replace the gear if flaking or wear is unusual.

2.12 Sea Water Pump - Assemble



Sea Water Pump - Assemble

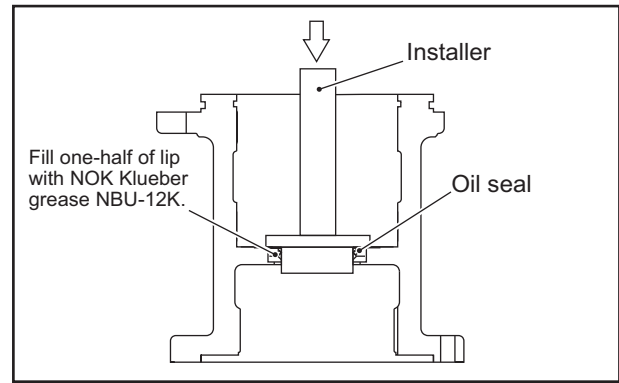
2.12.1 Oil Seal - Install

- (1) Press-fit the oil seal to the bearing case with the installer.

Note: Always replace the oil seal with a new one.

Place the lip to face to bearing.

- (2) Apply grease to the oil seal groove and lips.



Oil Seal - Install

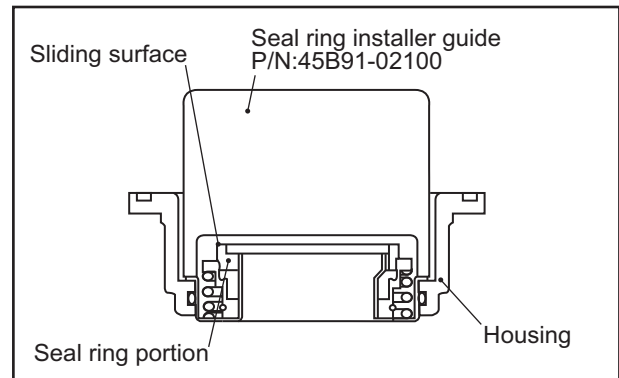
2.12.2 Unit Seal Ring - Install

Insert the unit seal ring slowly into housing by hand using unit seal ring installer.

Note:(a) Always replace the unit seal with a new one whenever it is removed from pump case.

(b) Do not use a hammer or mallet to install.

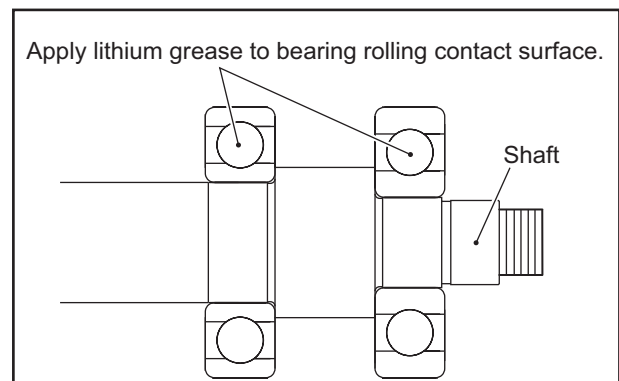
(c) Do not damage the sliding surface of the unit seal.



Unit Seal Ring - Install

2.12.3 Bearing - Install

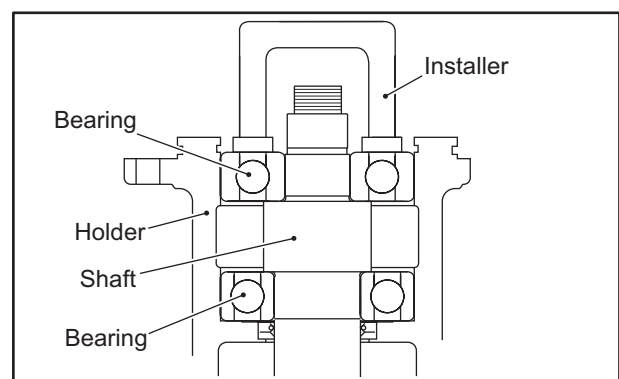
- (1) Tap-in the bearing squarely along the shaft center line.
- (2) Apply grease on bearing rolling faces.



Bearing - Install

2.12.4 Shaft and Bearing - Install

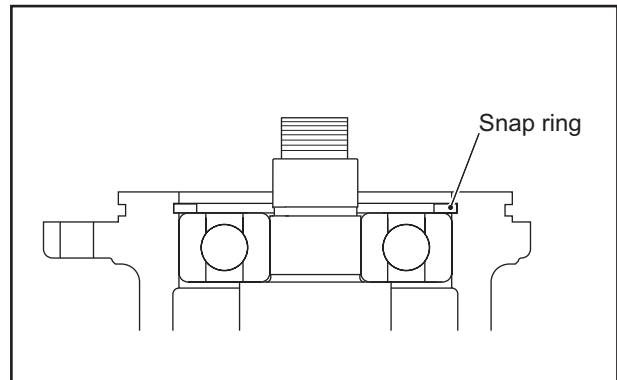
- (1) Press-fit the ball bearing and water pump shaft to the holder with the installer.
- (2) Press-fit the ball bearing to the water pump shaft with the installer.



Shaft and Bearing - Install

2.12.5 Snap Ring - Install

Fit the snap ring to the bearing case.

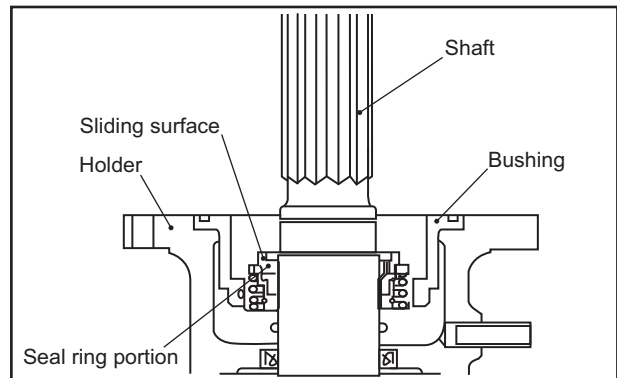


Snap Ring - Install

2.12.6 Housing - Install

- (1) Install O-ring to shaft.
- (2) Install housing and unit seal assembly to bearing case.
Clean the sliding faces of seal ring with ethyl alcohol, and apply turbine oil.

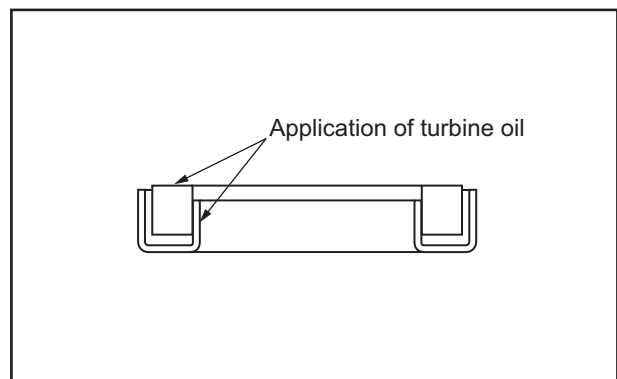
Note: Finally, check the sliding surfaces for flaw or dust.



Housing - Install

2.12.7 Unit Seal Mating Ring - Install

- (1) Clean the mating ring sliding face and inside face of unit seal with ethyl alcohol, and apply turbine oil.



Unit Seal Mating Ring - Install (1)

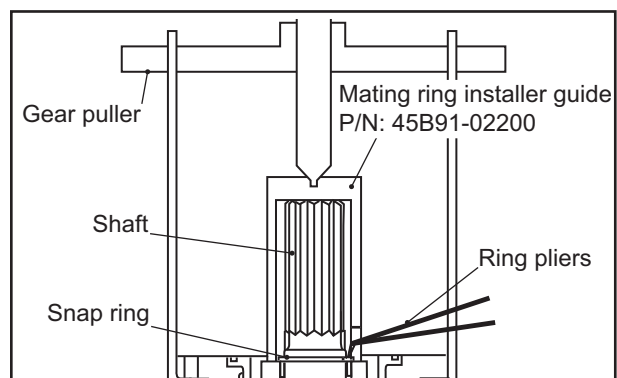
- (2) Install mating ring and snap ring to shaft.
- (3) Using the mating ring installer guide and gear coupler, slowly install the mating ring.

Note: Check the ring for square installation. If the ring is slanted, the snap ring can not be assembled or it can cause water leak.

- (4) Insert the mating ring until the installer guide contacts to shaft end face, fix with snap ring.

Note:(a) Do not over-tighten the gear puller.

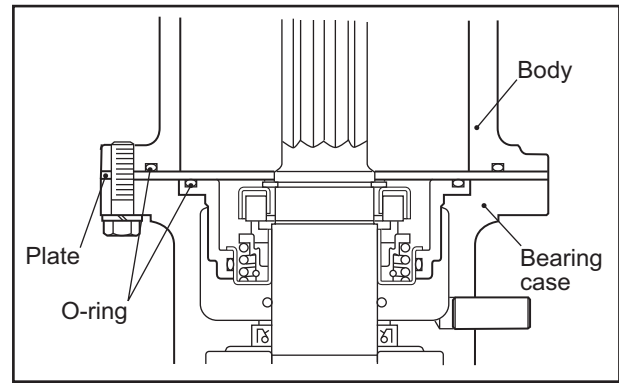
- (b) Use the ring prier through mating ring installer guide notch.



Unit Seal Mating Ring - Install (2)

2.12.8 Body - Install

- (1) Apply grease to the O-ring and install it to bearing case and body.
- (2) Attach the plate to bearing and install the body.

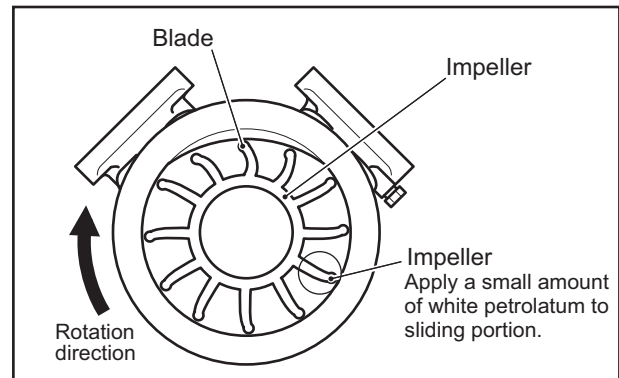


Body - Install

2.12.9 Impeller - Install

- (1) Tap-in the impeller to shaft.

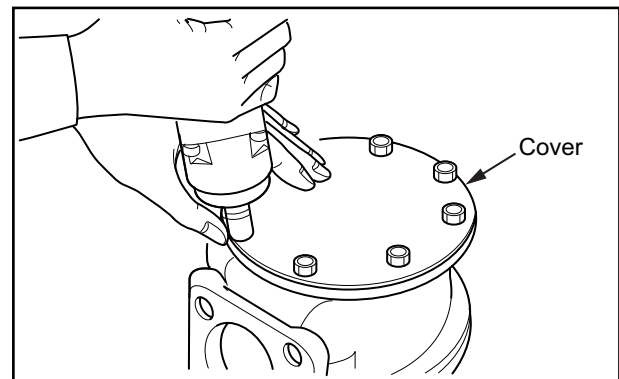
Note: The bend of impeller is as shown in the illustration.



Impeller - Install

2.12.10 Cover - Install

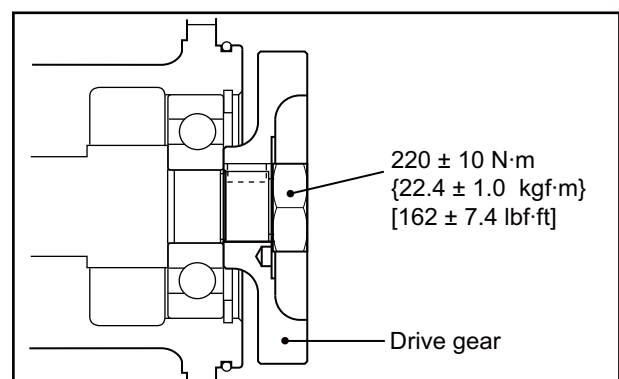
Install the O-ring to body and install the cover.



Cover - Install

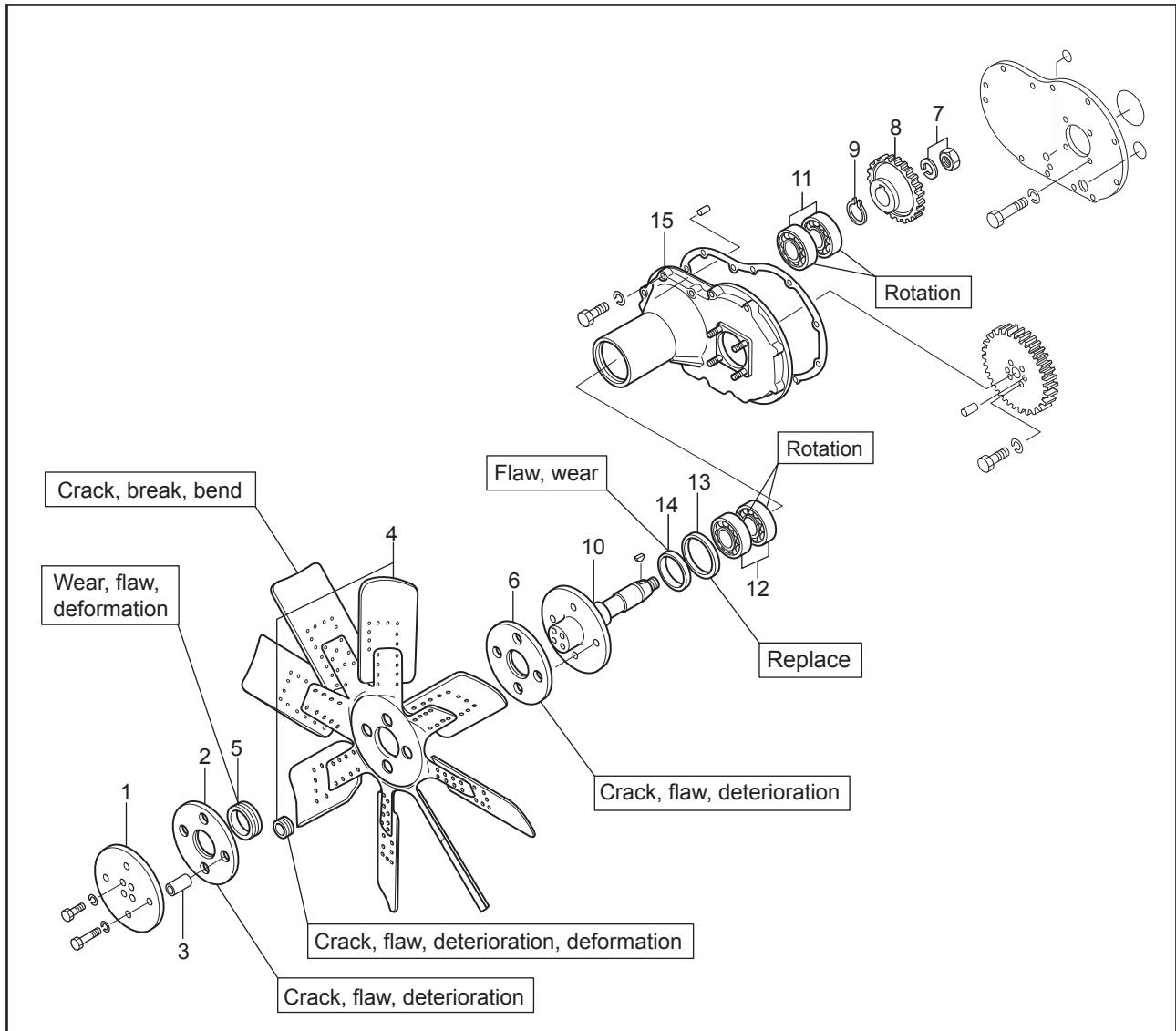
2.12.11 Gear - Install

Install the drive gear and tighten the nut to the specified torque. Bend the washer to rock.



Gear - Install

2.13 Fan Drive Assembly - Disassemble and Inspect



Fan Drive Assembly - Disassemble and Inspect

Disassembling Sequence

- | | | |
|-------------------|-------------------|--------------------|
| 1 Fan plate | 6 Friction rubber | 11 Ball bearing |
| 2 Friction rubber | 7 Nut, washer | 12 Ball bearing |
| 3 Spacer | 8 Fan drive gear | 13 Oil seal |
| 4 Fan, grommet | 9 Snap ring | 14 Oil seal sleeve |
| 5 Bushing ring | 10 Drive shaft | 15 Fan drive case |

CAUTION

If one blade of fan is damaged, the opposite side blade will vibrate, resulting in damages such as breakage or bend. Replace the fan with a new one.

2.14 Fan Drive - Inspect

Inspect the fit between the fan drive shaft and fan drive case bearing, and if unusual wear is found, replace with new one.

Item		Nominal value	Standard value
Inside diameter of case bearing housing		ø100 mm [3.94 in.]	99.987 to 100.022 mm [3.9365 to 3.9379 in.]
		ø110 mm [4.33 in.]	109.987 to 110.022 mm [4.3302 to 4.3316 in.]
Bearing	outside diameter	ø100 mm [3.94 in.]	99.985 to 110.000 mm [3.9364 to 4.3307 in.]
		ø110 mm [4.33 in.]	109.985 to 110.000 mm [4.3301 to 4.3307 in.]
	Inside diameter	ø45 mm [1.77 in.]	45.002 to 45.013 mm [1.7717 to 1.7722 in.]
		ø50 mm [1.97 in.]	50.002 to 50.013 mm [1.9686 to 1.9690 in.]
		Outside diameter of shaft fit to bearing	
ø50 mm [1.97 in.]	49.988 to 50.000 mm [1.9680 to 1.9685 in.]		

2.15 Bushing Ring, Friction Rubber and Grommet - Inspect

Inspect the bushing ring, friction rubber, and grommet, and if any defect is found, replace the part with a new one.

2.16 Oil Seal Sleeve - Inspect

If any defects such as dents, scars, wear and looseness that can lead to oil leakage are found, replace the oil seal sleeve with a new one.

2.17 Oil Seal Sleeve - Replace



CAUTION

Use protective gloves when you touch hot parts.
Handling with bare hands could result in burns.

2.17.1 Oil Seal Sleeve - Remove

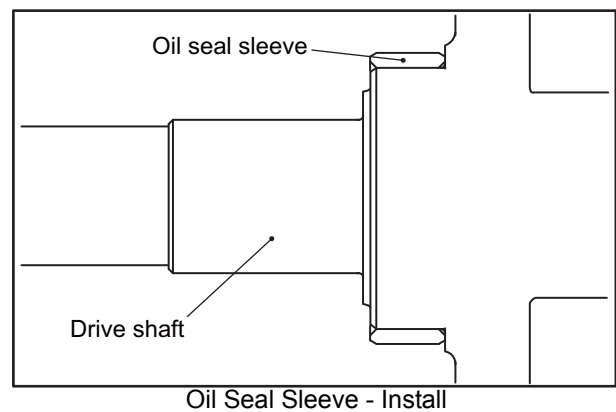
Place a chisel vertically to the sleeve end face and tap three places with a hammer. When the sleeve is loosened, remove the sleeve.

If the sleeve can not be removed by the above procedure, hold the chisel against the sleeve in the axial direction and tap on it lightly to make the sleeve expand. Once the interference between crankshaft and sleeve is reduced, the sleeve will be removed easily.

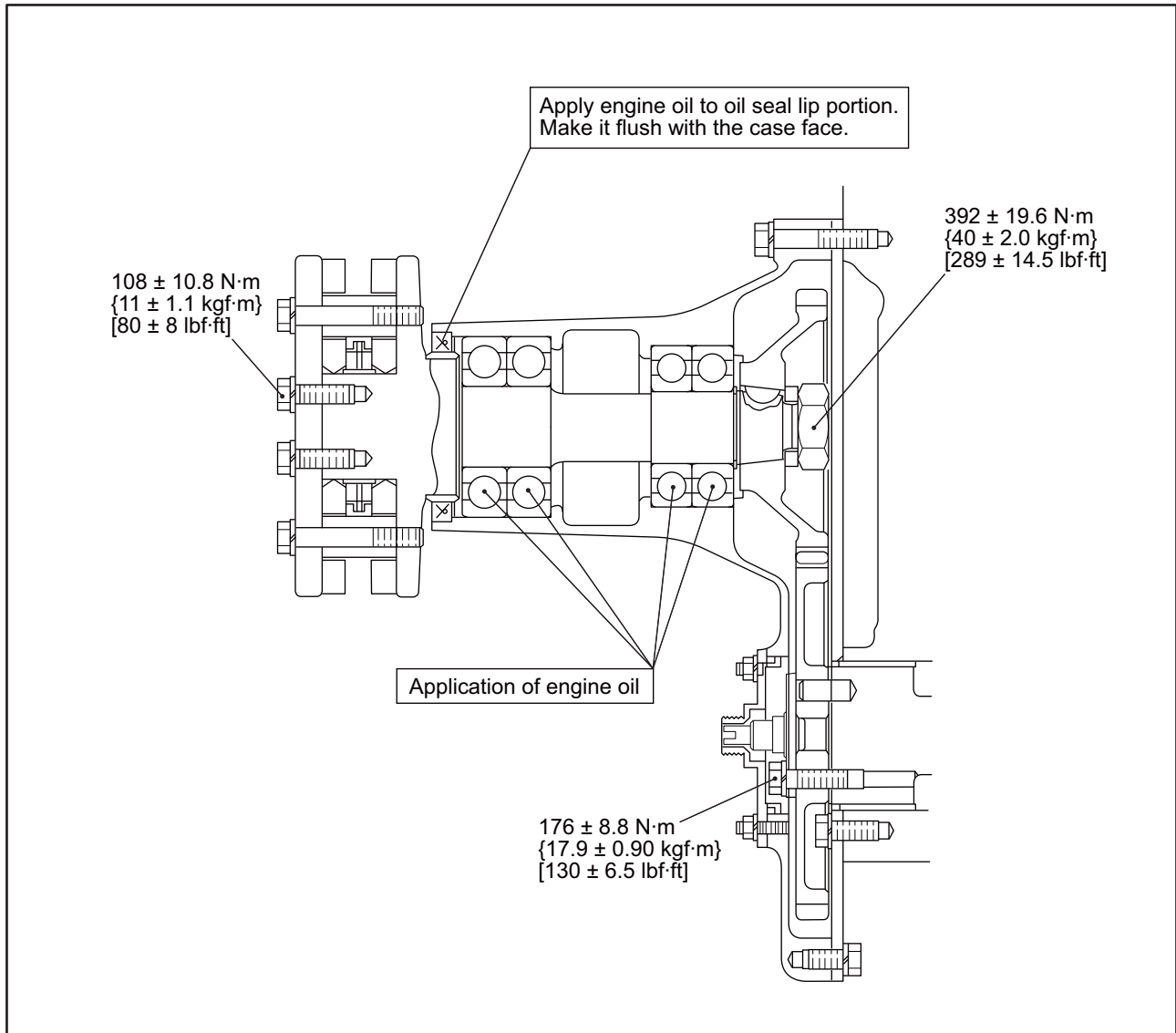
2.17.2 Oil Seal Sleeve - Install

Heat the oil seal sleeve to a temperature of 180 to 200 °C [356 to 392 °F] with a heater.

Insert the oil seal sleeve to drive shaft.



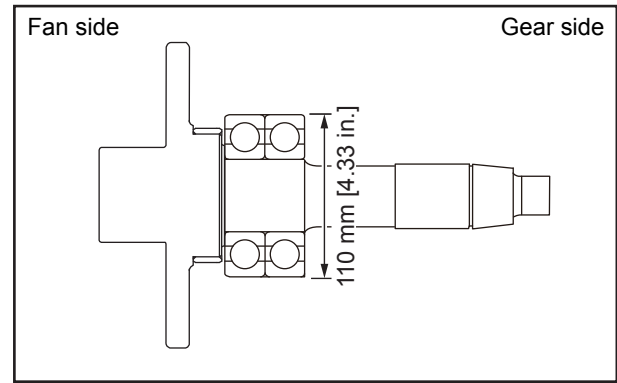
2.18 Fan Drive - Assemble



Fan Drive - Assemble

2.18.1 Fan Drive Gear Case - Assemble

(1) Press-in the bearing to drive shaft with bearing installer.

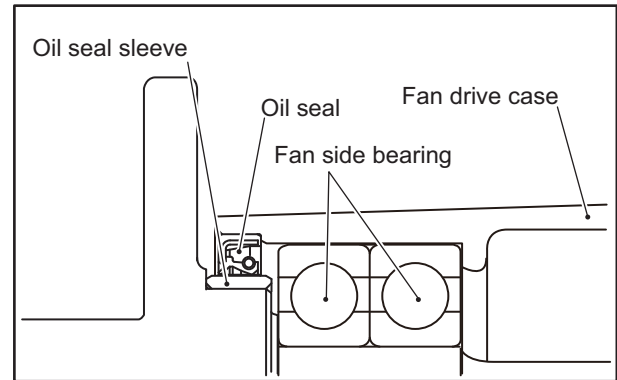


Ball Bearing - Install

(2) Install the oil seal to fan drive case with installer.

(3) Apply clean engine oil evenly to the oil seal lip.

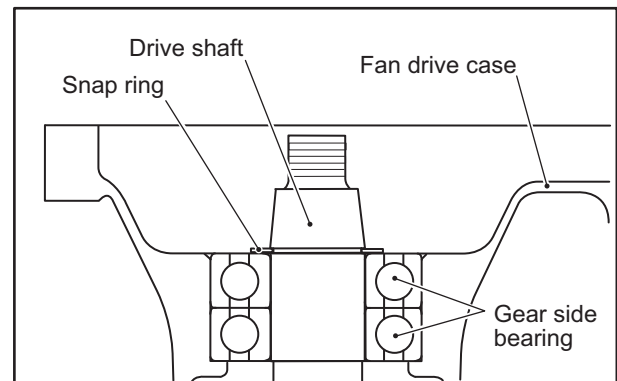
(4) Install the drive shaft to fan drive case.



Oil Seal - Install

(5) Press-in the bearing to drive shaft with bearing installer.

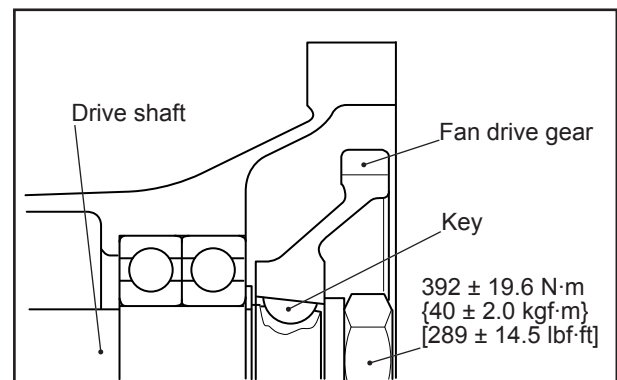
(6) Install the snap ring.



Gear Side Bearing - Install

(7) Install the key to gear end of drive shaft.

(8) Install the fan drive gear while aligning it to drive shaft key, and tighten the nut to the specified torque.



Fan Drive Gear - Install

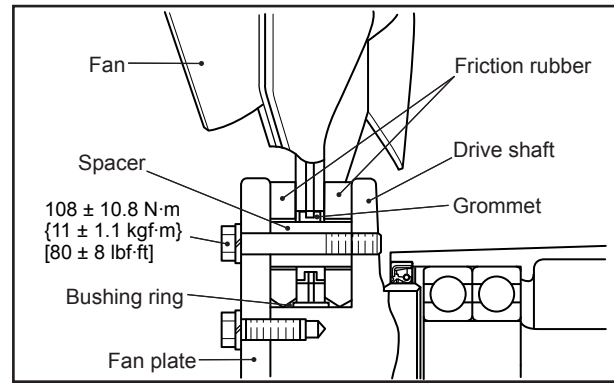
2.18.2 Fan - Assemble

Installation the fan at the final step of assembling work.

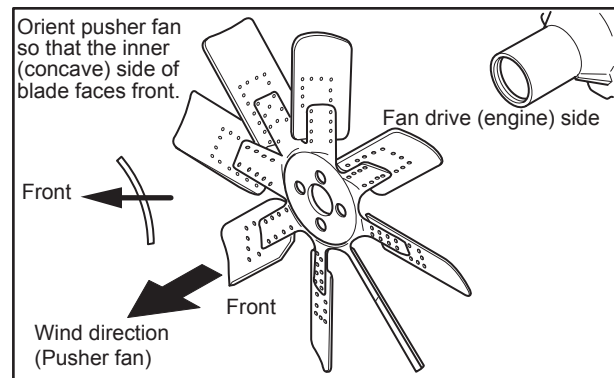
- (1) Install the friction rubber to drive shaft.
- (2) Install the bushing ring to drive shaft.
- (3) Install the fan to bushing ring.

Note: Ensure the proper fan orientation (wind direction: pusher) when installing.

- (4) Install the grommet to fan.
- (5) Insert the spacer to grommet and friction rubber.
- (6) Install the friction rubber to fan hub.
- (7) Install the fan plate to fan hub, and tighten the bolts to the specified torque.



Fan - Assemble (1)



Fan - Assemble (2)

3. Cooling System - Install

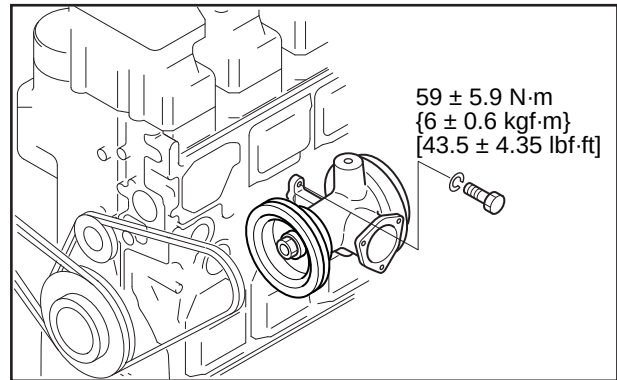
- Install the parts in the reverse order of the disassemble sequence. (Refer to the illustration for disassembling.)
- Clean and dry well the coolant passage.

3.1 Water Pipe (Air Cooler) - Install

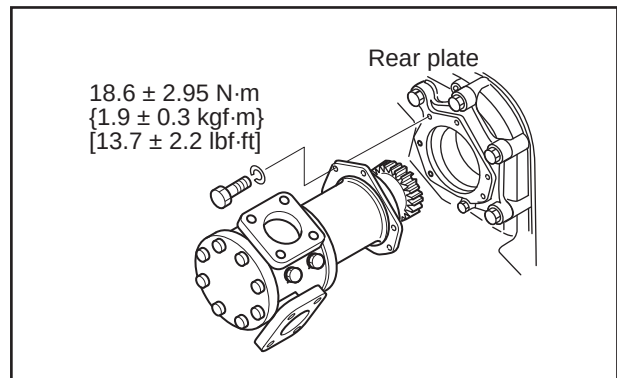
Apply silicone sealant to the both sides of packings between air cooler in/out connectors and water pipes.

3.2 Water Pump and Sea Water Pump - Install

Tighten the mounting nuts to the specified torque.



Water Pump - Install



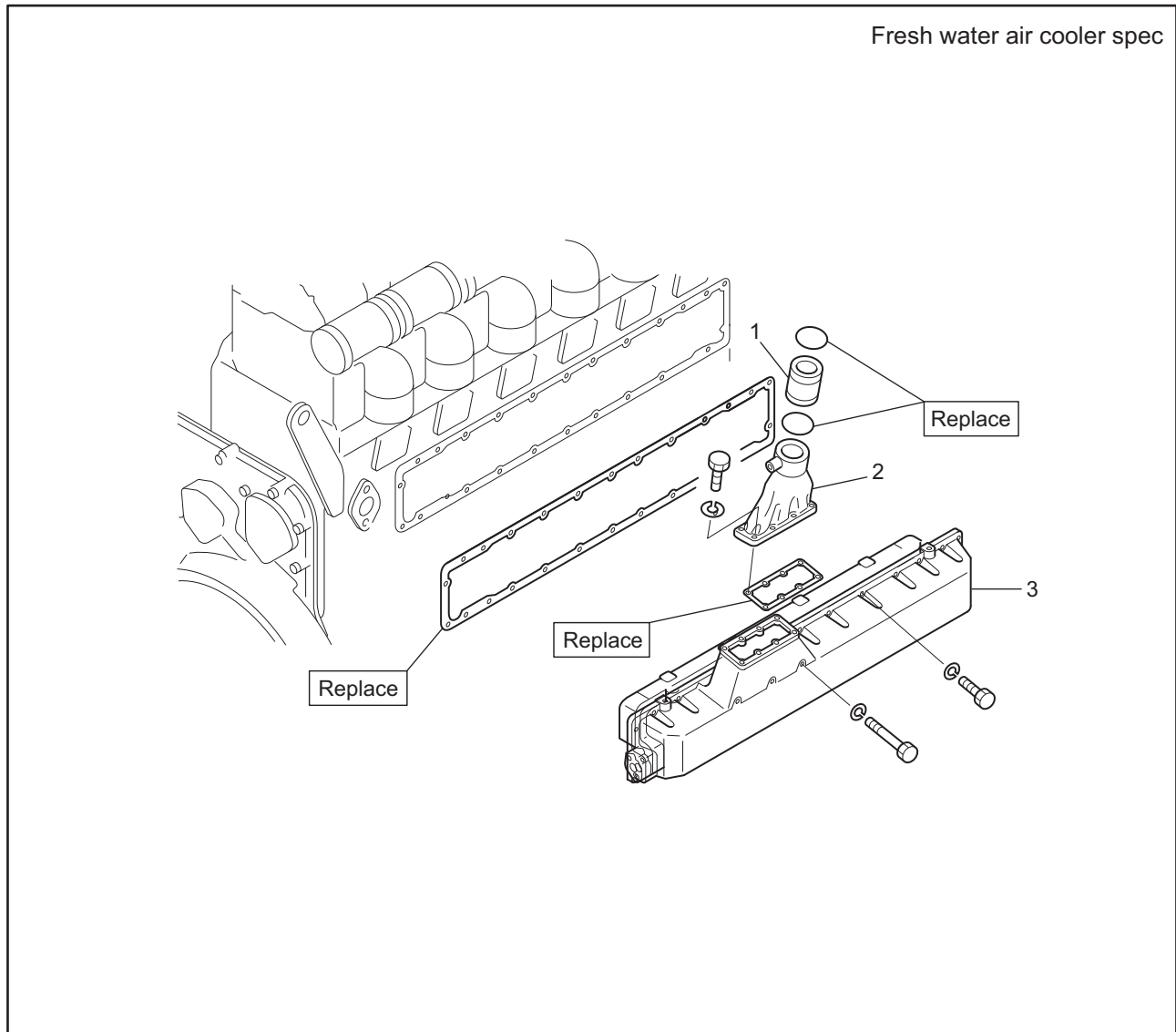
Sea Water Pump - Install

Chapter 11 INLET AND EXHAUST SYSTEMS

1. Inlet and Exhaust Systems - Remove and Inspect.....	11-3
1.1 Inlet Ststem - Remove and Inspect.....	11-3
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1. Inlet and Exhaust Systems - Remove and Inspect

1.1 Inlet Ststem - Remove and Inspect



Inlet System - Remove and Inspect

Removing Sequence

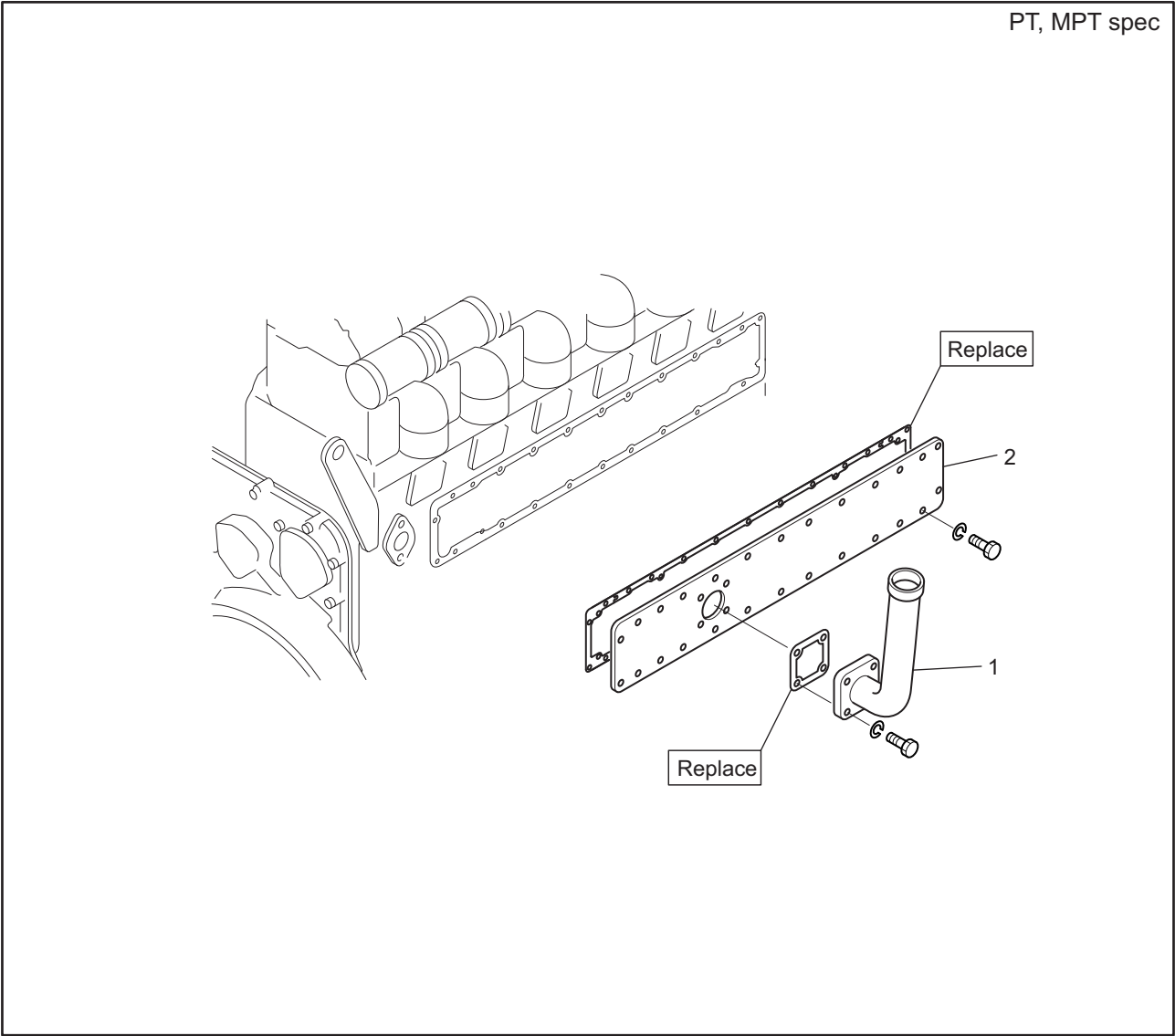
- 1 Connector
- 2 Duct
- 3 Air cooler (Fresh water air cooler internal cooling
water cool exhaust manifold spec: approx 51 kg [112 lb])
(Fresh water air cooler external cooling
water cool exhaust manifold spec: approx 55 kg [121 lb])

This diagram illustrates the assembly of a vehicle's front end, specifically focusing on the replacement of several key components. The main assembly is shown in a perspective view, with various parts labeled with numbers and 'Replace' instructions.

- Component 1:** A long, rectangular metal bracket or frame, likely for the headlight or fog light assembly. It is shown with several mounting points and a central cutout.
- Component 2:** A small, cylindrical part, possibly a bush or a spacer, located near the top of the main assembly.
- Component 3:** A small, cylindrical part, possibly a bush or a spacer, located near the top of the main assembly.
- Component 4:** A small, cylindrical part, possibly a bush or a spacer, located near the bottom of the main assembly.
- Replace:** A label indicating that the component should be replaced. It is used for components 2, 3, and 4.

The diagram shows the main assembly with a large, rectangular metal bracket (1) and a smaller, cylindrical component (2) and (3) being replaced. A fourth component (4) is also shown being replaced. The main assembly is shown in a perspective view, with the components being replaced shown in an exploded view.

Removing Sequence

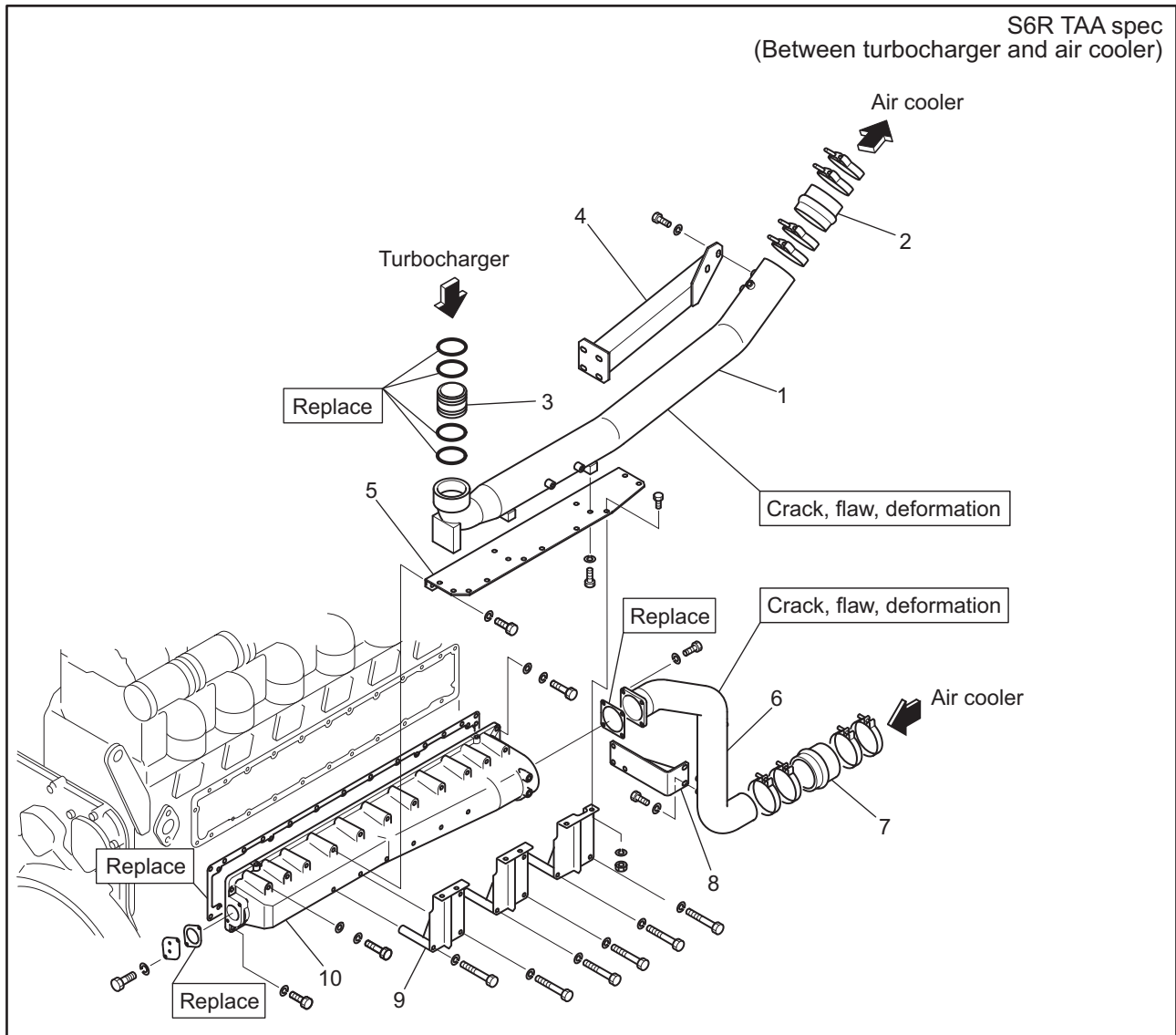


Inlet System - Remove and Inspect

Removing Sequence

1 Duct

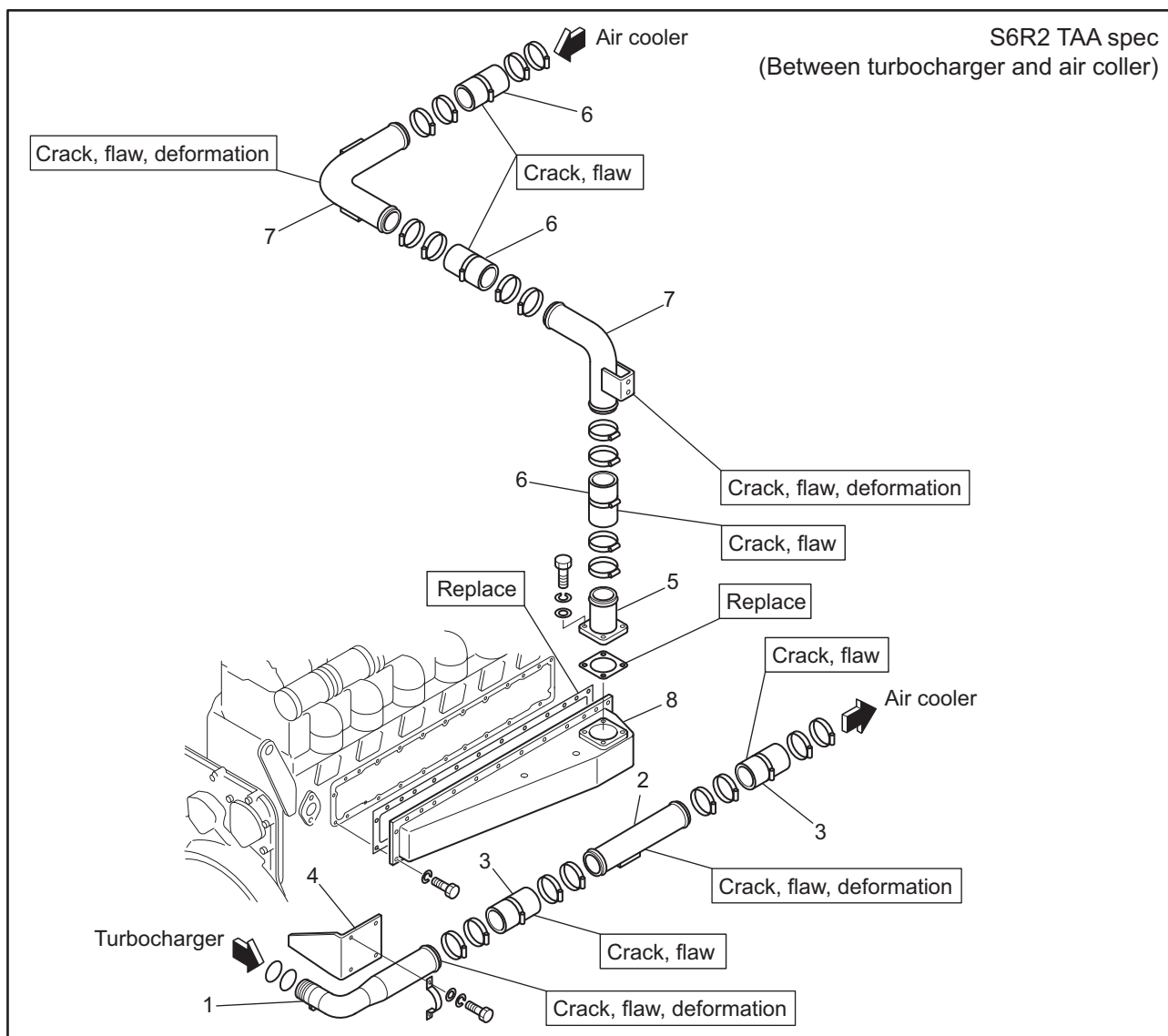
2 Cover



Inlet System - Remove and Inspect

Removing Sequence

- | | | |
|-----------------|-----------------|--------------------|
| 1 Air duct | 5 Air duct stay | 9 Air duct stay |
| 2 Rubber hose | 6 Air duct | 10 Air cooler case |
| 3 Connector | 7 Rubber hose | |
| 4 Air duct stay | 8 Air duct stay | |

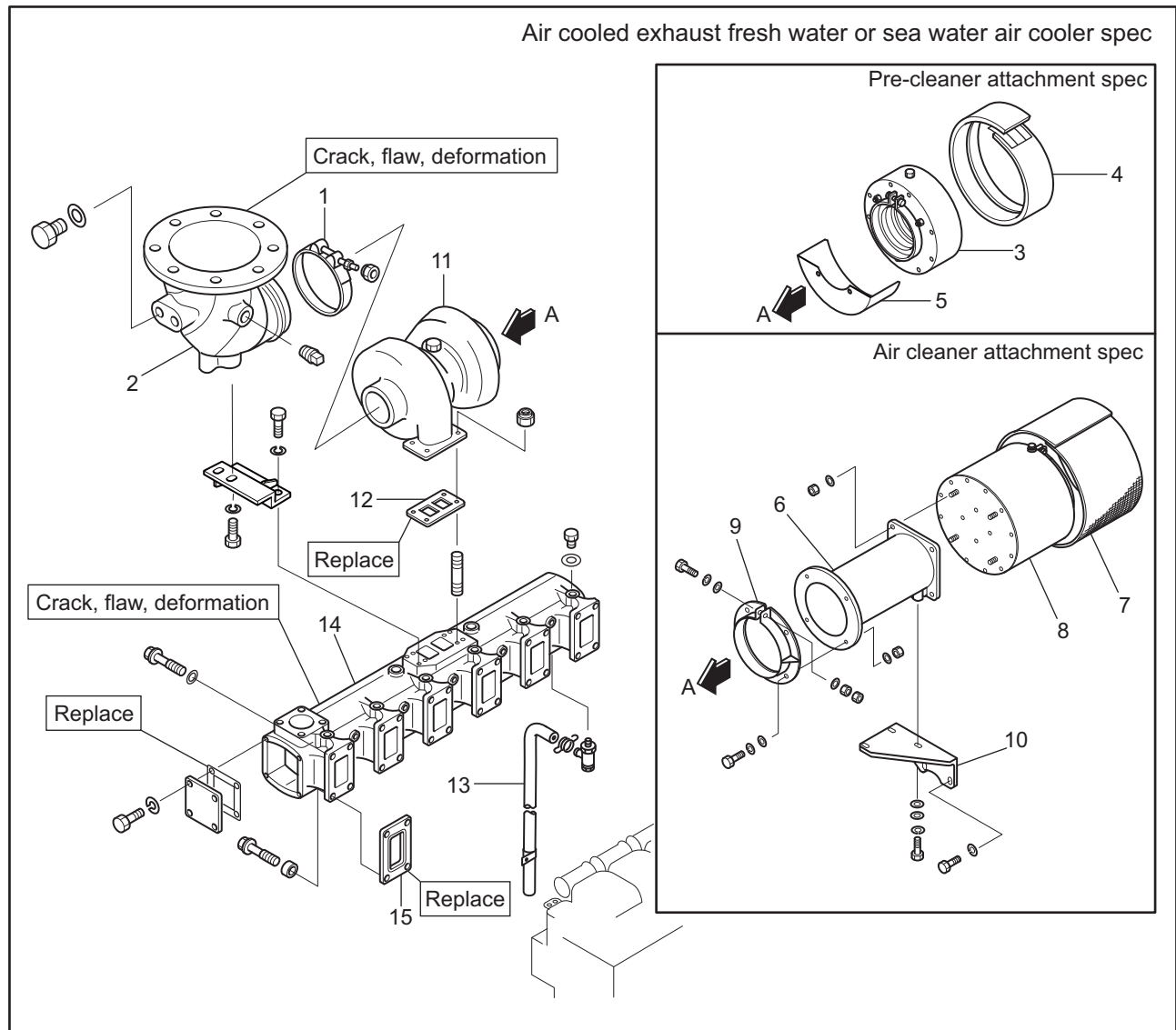


Inlet System - Remove and Inspect

Removing Sequence

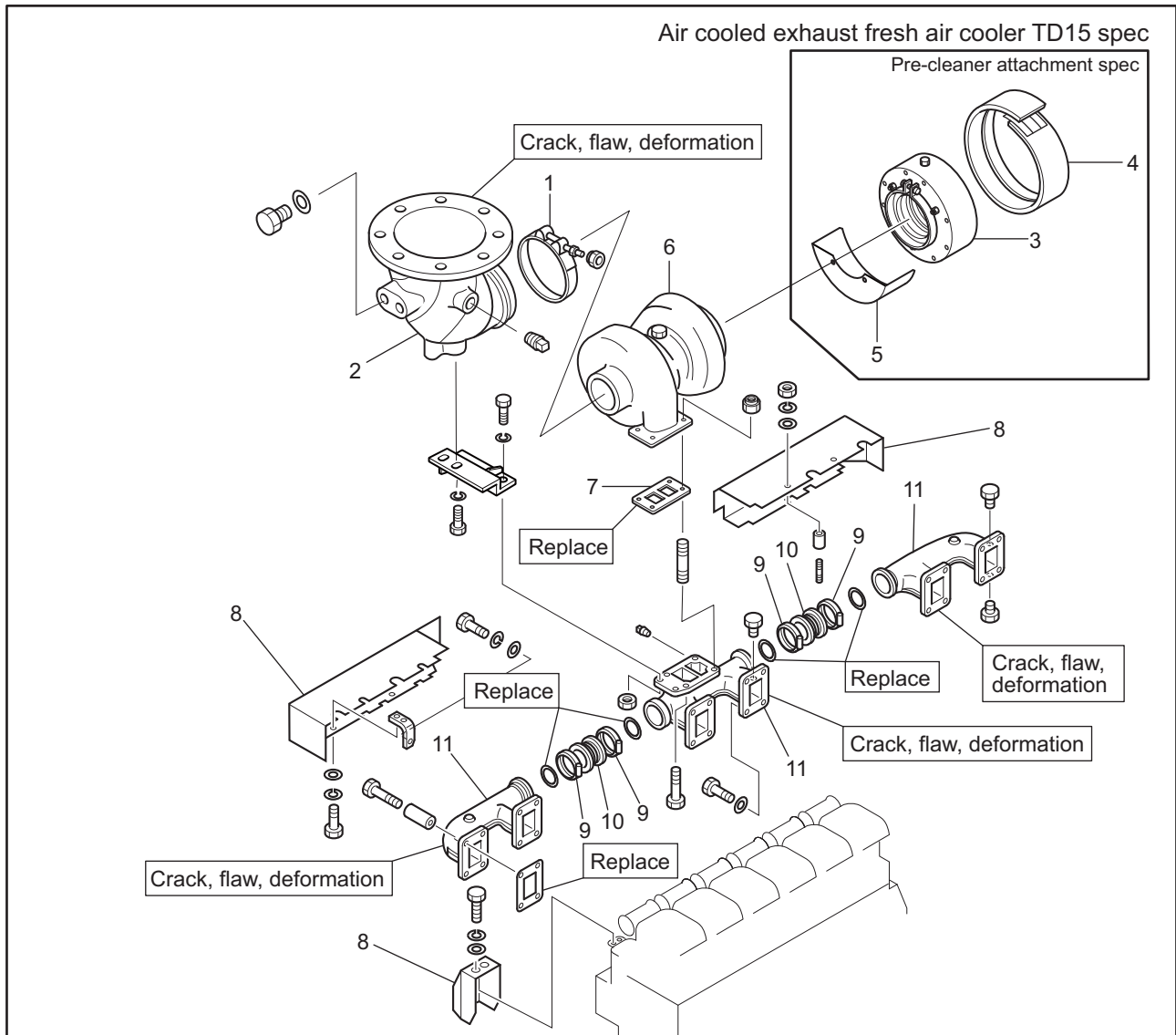
- | | | |
|---------------|-----------------|----------------------|
| 1 Air duct | 4 Air duct stay | 7 Air duct |
| 2 Air duct | 5 Air duct | 8 Inter cooler cover |
| 3 Rubber hose | 6 Rubber hose | |

1.2 Exhaust System - Remove and Inspect



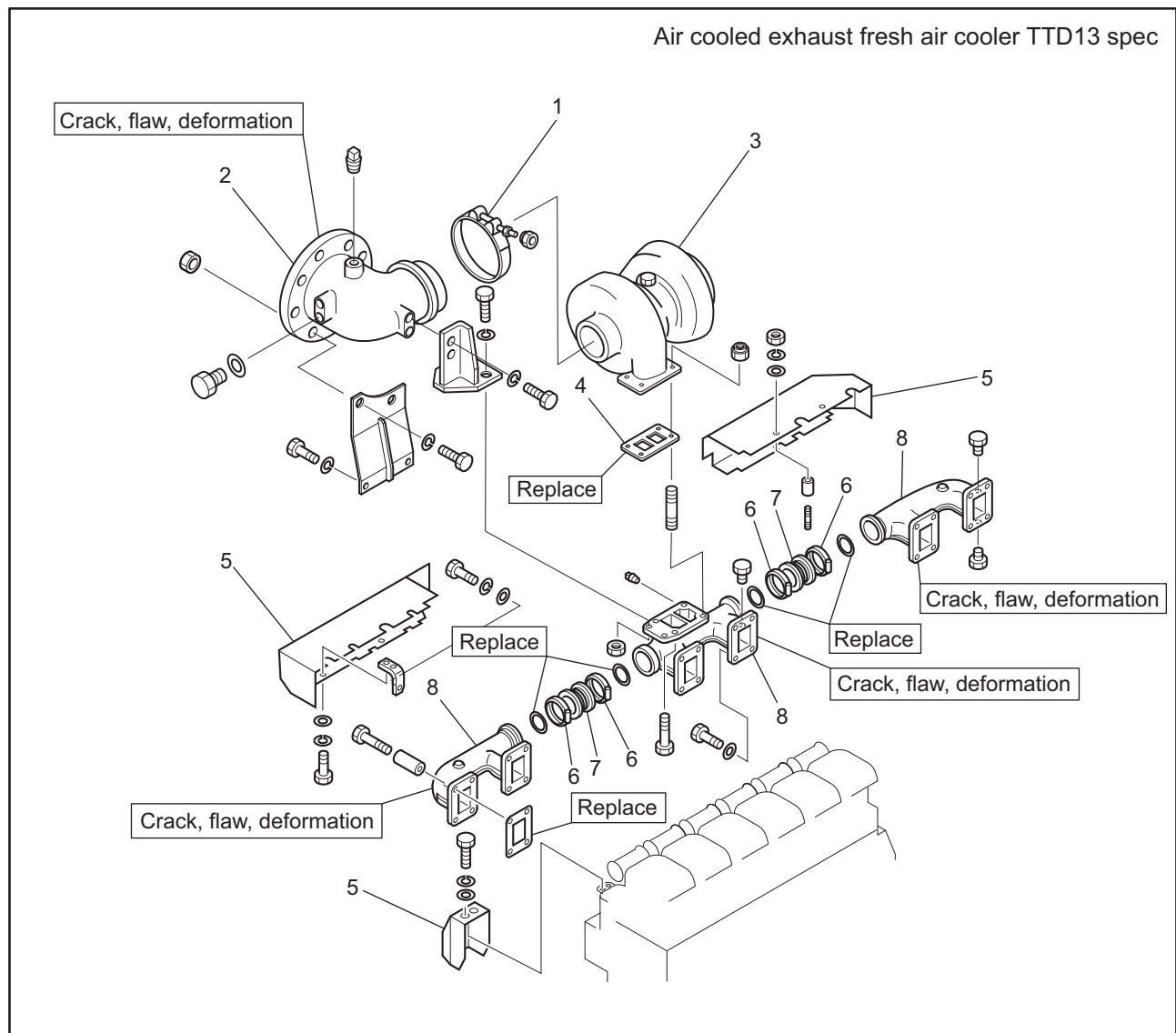
Removing Sequence

- | | |
|------------------------------|---|
| 1 V-clamp | 9 Band |
| 2 Exhaust pipe | 10 Duct stay |
| 3 Silencer | 11 Turbocharger (Approx 50 kg [110 lb]) |
| 4 Air cleaner or pre-cleaner | 12 Gasket |
| 5 Silencer cover | 13 Drain pipe |
| 6 Silencer duct | 14 Exhaust manifold (Approx 75 kg [165 lb]) |
| 7 Silencer cover | 15 Gasket |
| 8 Silencer | |



Removing Sequence

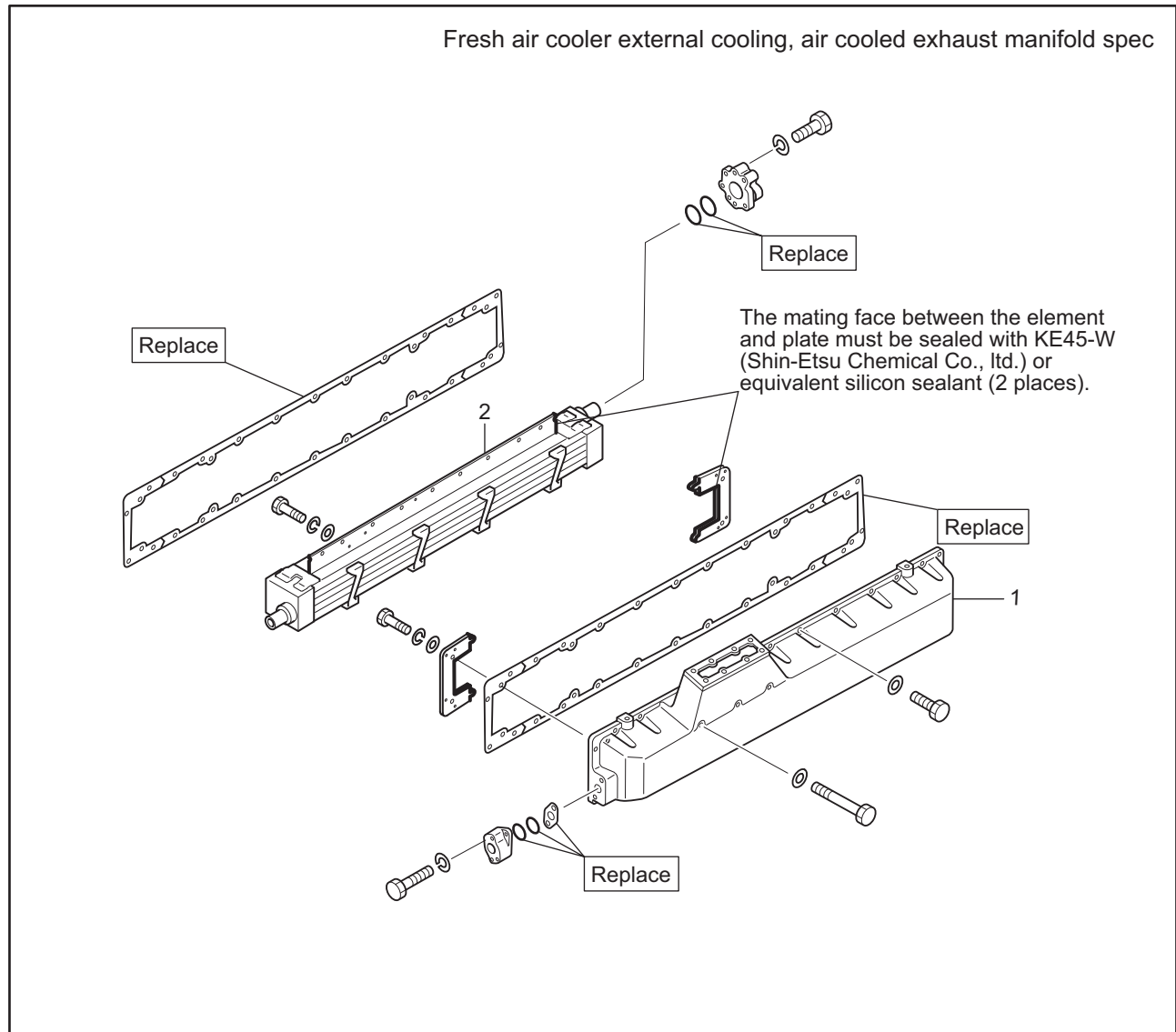
- | | |
|--|---------------------|
| 1 V-clamp | 7 Gasket |
| 2 Exhaust pipe | 8 Insulator |
| 3 Silencer | 9 Coupling |
| 4 Air cleaner or pre-cleaner | 10 Flexible joint |
| 5 Silencer cover | 11 Exhaust manifold |
| 6 Turbocharger (Approx 50 kg [110 lb]) | |



Exhaust System - Remove and Inspect

Removing Sequence

- | | |
|--|--------------------|
| 1 V-clamp | 5 Insulator |
| 2 Exhaust pipe | 6 Coupling |
| 3 Turbocharger (Approx 50 kg [110 lb]) | 7 Flexible joint |
| 4 Gasket | 8 Exhaust manifold |

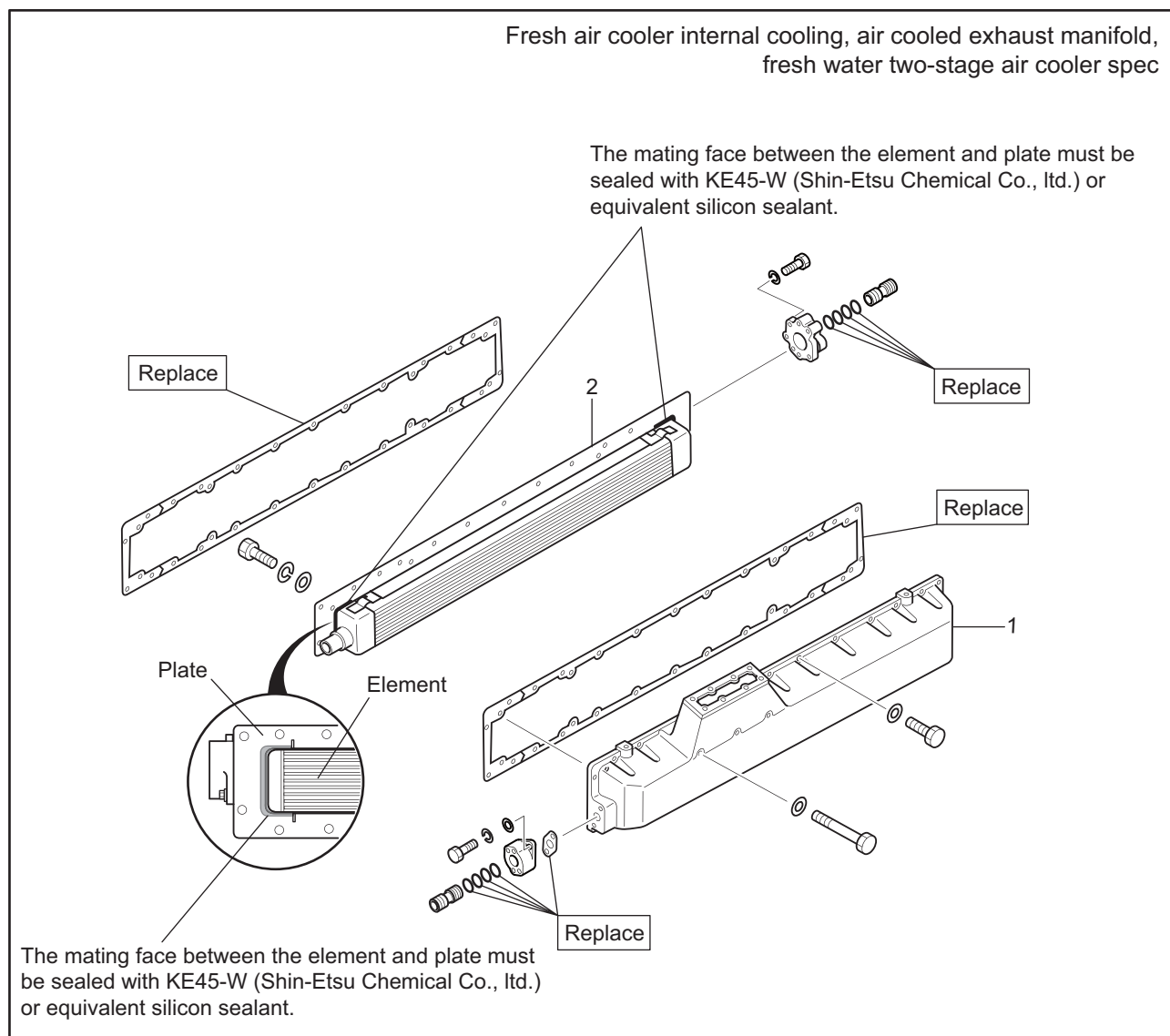


Air Cooler - Disassemble, Inspect and Assemble

Disassembling Sequence

1 Air cooler cover

2 Air cooler element (Approx 40 kg [88 lb])

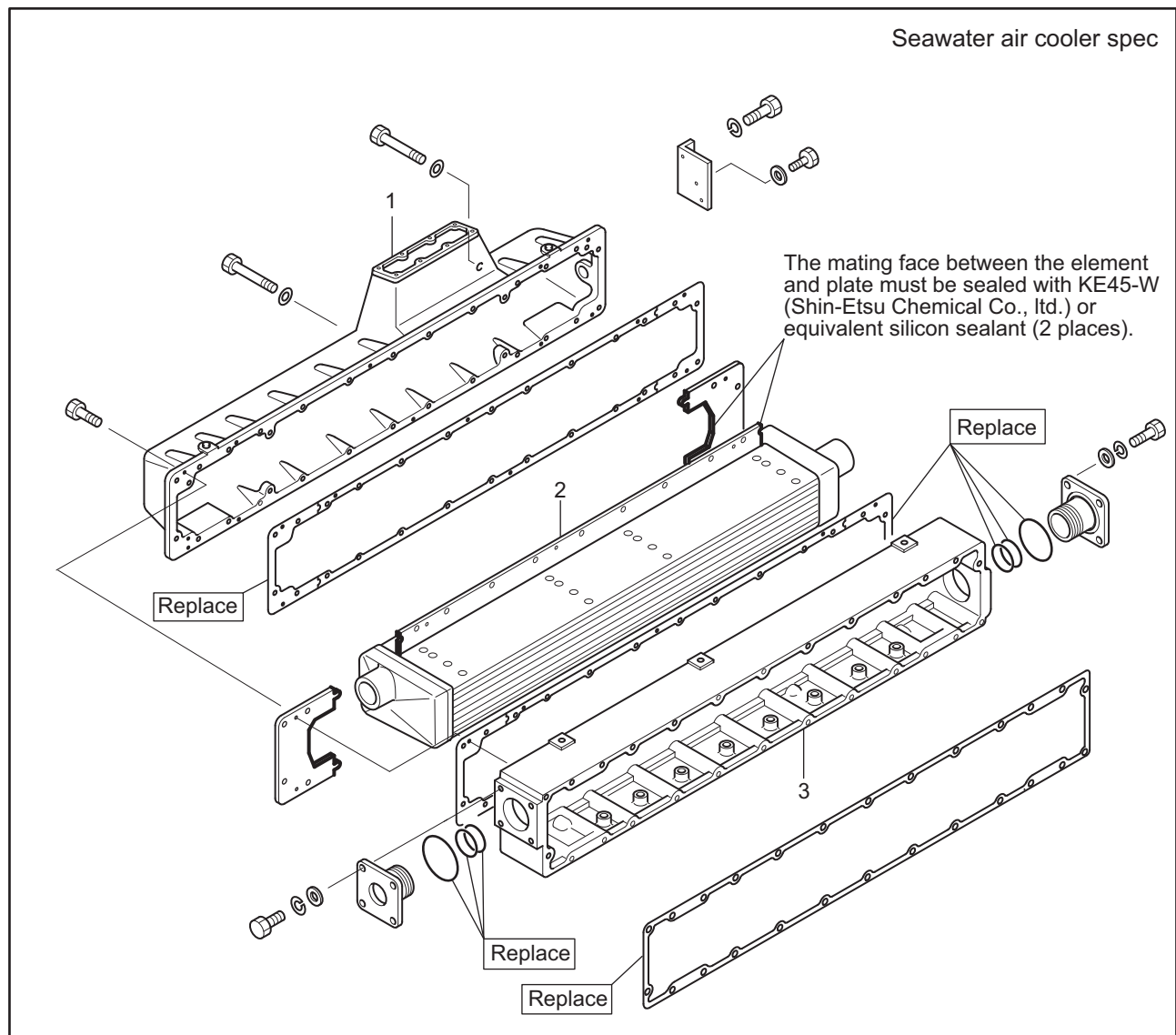


Air Cooler - Disassemble, Inspect and Assemble

Disassembling Sequence

1 Air cooler cover

2 Air cooler element (Approx 46 kg [101 lb])



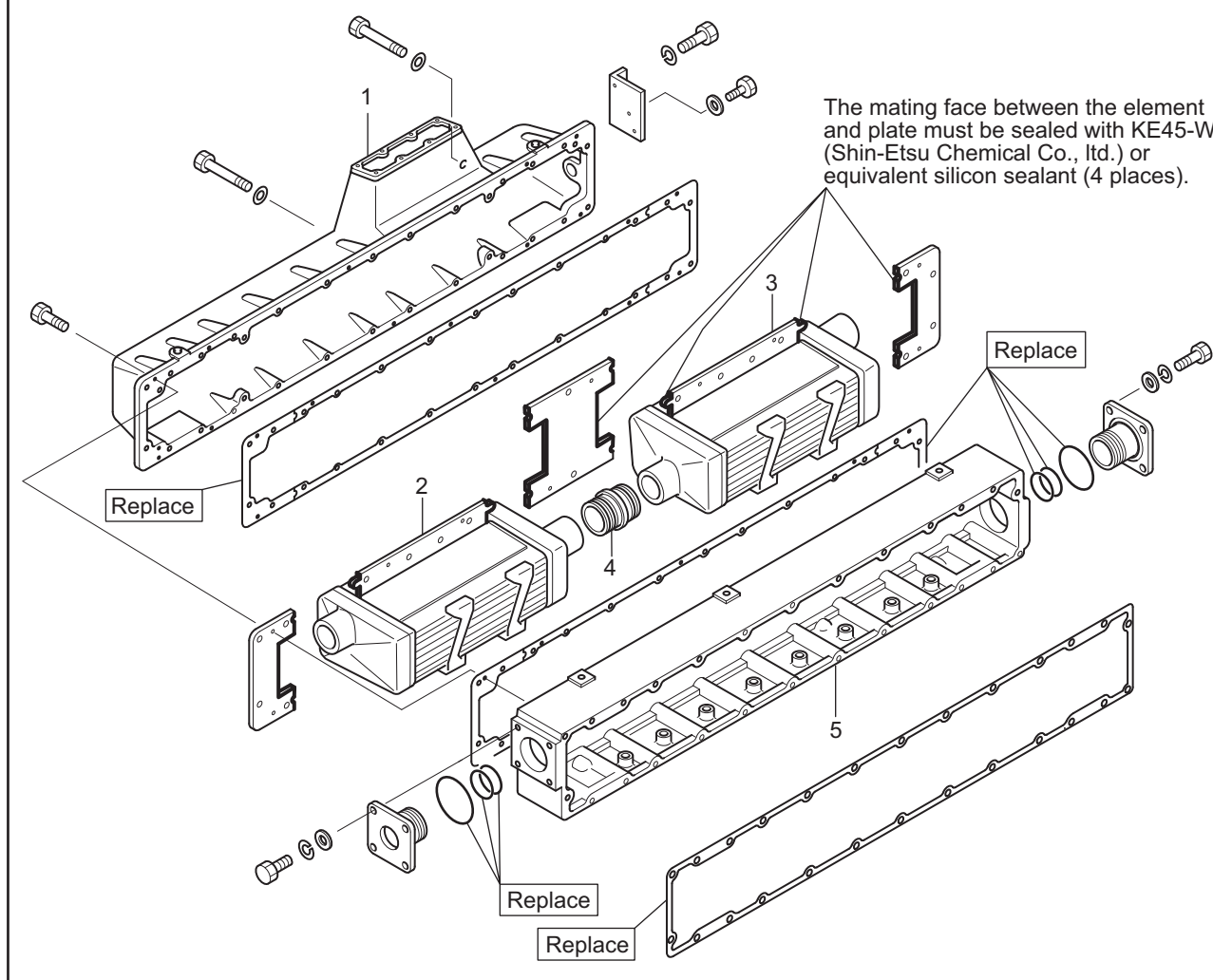
Air Cooler - Disassemble, Inspect and Assemble

Disassembling Sequence

- 1 Air cooler cover
- 2 Air cooler element (Approx 53 kg [117 lb])

- 3 Air cooler case

S6R2-MTK2 spec



Air Cooler - Disassemble, Inspect and Assemble

Disassembling Sequence

- | | |
|---|-------------------|
| 1 Air cooler cover | 4 Joint |
| 2 Air cooler element (Right) (Approx 29 kg [64 lb]) | 5 Air cooler case |
| 3 Air cooler element (Left) (Approx 29 kg [64 lb]) | |

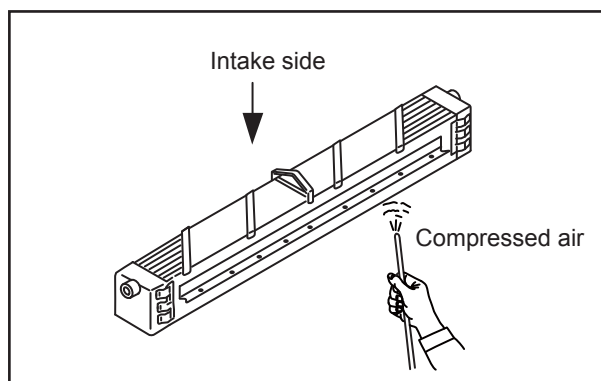
2.1.1 Air Cooler - Inspect

CAUTION

The air cooler differs in material and structure depending on the application (fresh water or seawater). Pay attention to the difference when handling the air cooler. This cooler is for fresh water.

2.1.2 Air Cooler - Clean

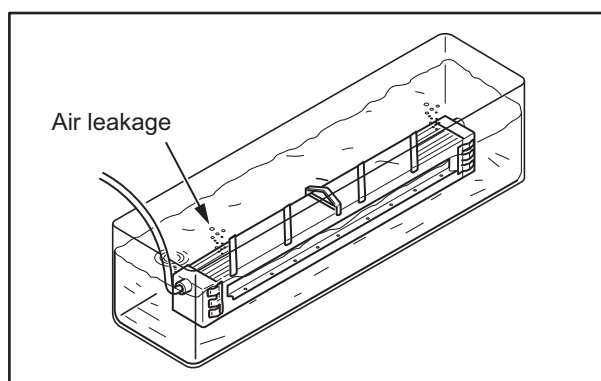
Blow compressed air (at a pressure of 0.29 to 0.49 MPa {3 to 5 kgf/cm²} [43 to 71 psi] or less) through the air cooler in the opposite direction to the normal air flow to remove the accumulation of dust and dirt. Then, inspect for corrosion and cracks.



Air Cooler - Clean

2.1.3 Air Cooler - Inspect for Leakage

Immerse the air cooler in water. In this condition, blow compressed air (at a pressure of 0.39 MPa {4 kgf/cm²} [57 psi]) to the coolant passage to check for air leakage.



Air Cooler - Inspect for Leakage

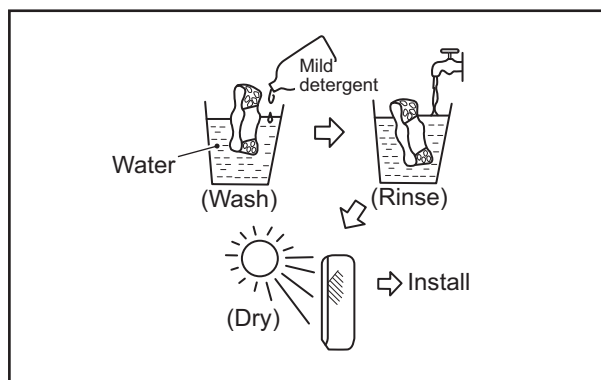
2.1.4 Air Cooler - Assemble

To assemble, follow the disassembly sequence in reverse. Seal the clearance between the element and plate with KE45-W (Shin-Etsu Chemical Co., Ltd.) or equivalent silicone sealant.

2.2 Pre-cleaner - Clean

- (1) Remove the pre-cleaner from the silencer, and hand-wash the pre-cleaner using neutral detergent.
- (2) Rinse with fresh water.
- (3) Dry it thoroughly, and install it to the silencer.

Note: If the pre-cleaner is damaged or torn, replace it with a new one.



Pre-cleaner - Clean

3. Inlet and Exhaust Systems - Install

3.1 Exhaust Pipe and Exhaust Manifold - Install

Install the parts in the reverse order of the disassemble sequence. (Refer to the illustration for disassembling.)

Thoroughly clean and dry the inlet and exhaust passages.

3.1.1 Exhaust Manifold Coupling - Tighten

CAUTION

Do not distort the exhaust manifold coupling.

- (1) Apply MOLYKOTE (molybdenum disulfide anti-seize) or equivalent to the bolt.
- (2) Tighten the nuts to the specified torque.
- (3) Lightly shake the outer circumference of exhaust manifold coupling to make a snug contact between exhaust manifold mating face and exhaust manifold coupling taper face.
- (4) Tighten the nuts to the specified torque.
- (5) Lightly shake again to verify the snug fitting.

3.1.2 V-clamp - Tighten

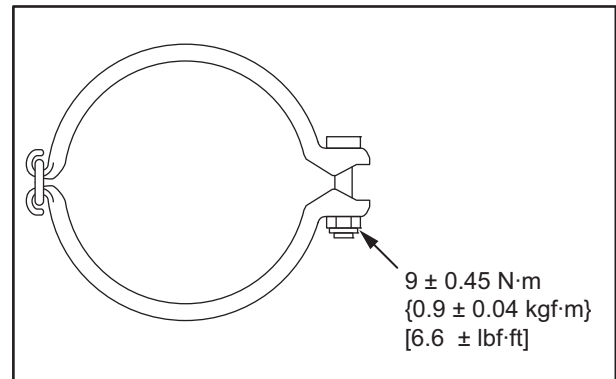
CAUTION

Do not deform the V-clamp. This results in the decrease of tightening force.

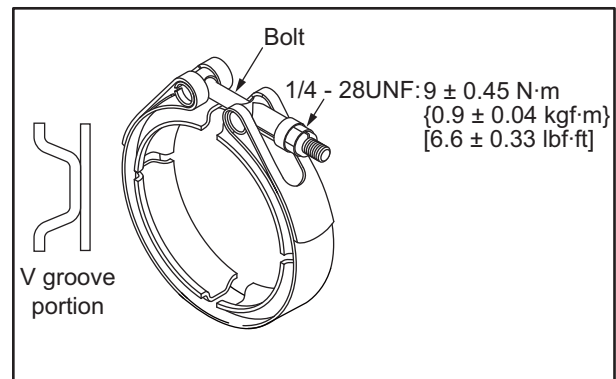
- (1) Apply MOLYKOTE (molybdenum disulfide anti-seize) or equivalent to the bolt.
- (2) Tighten the nuts to the specified torque.
- (3) Lightly tap the outer circumference of V-clamp to make a snug contact between exhaust manifold mating face and V-clamp tapered face.
- (4) Tighten the nuts to the specified torque.
- (5) Lightly shake again to verify the snug fitting.

3.2 Air Cooler - Install

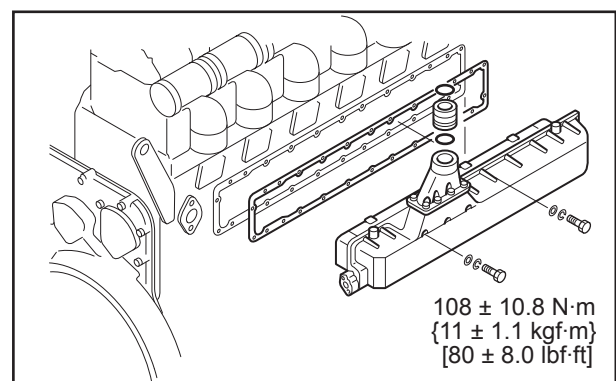
Install the Air cooler to the crank case, and tighten bolts to the specified torque.



Exhaust Manifold Coupling - Tighten



V-clamp - Tighten



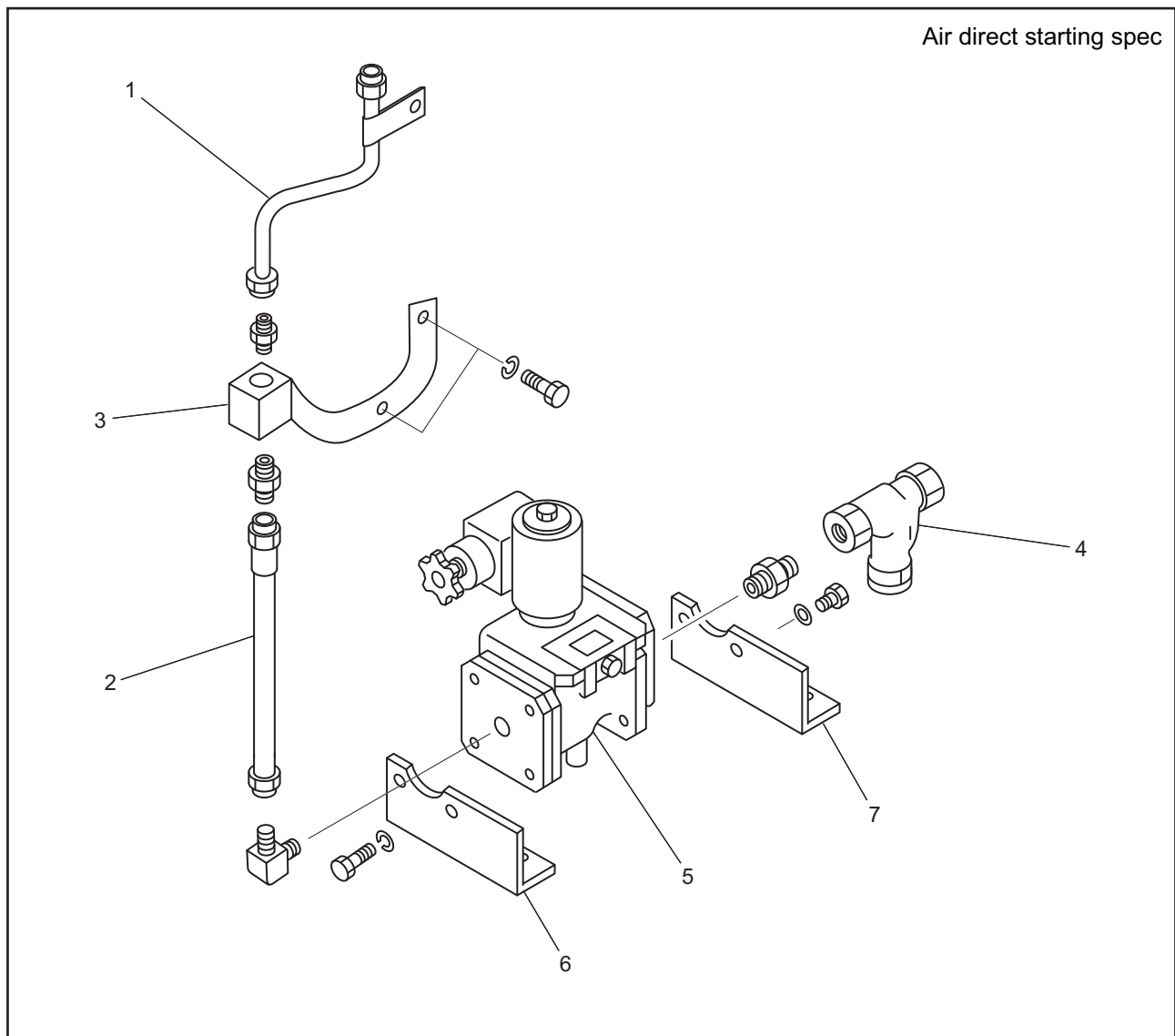
Air Cooler - Install

Chapter 12 AIR START SYSTEM

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2.8 Distributer Valve - Assemble	12-13
3. Air Start System - Install	12-13

1. Air Start System - Remove and Inspect

1.1 Magnetic Valve - Remove and Inspect

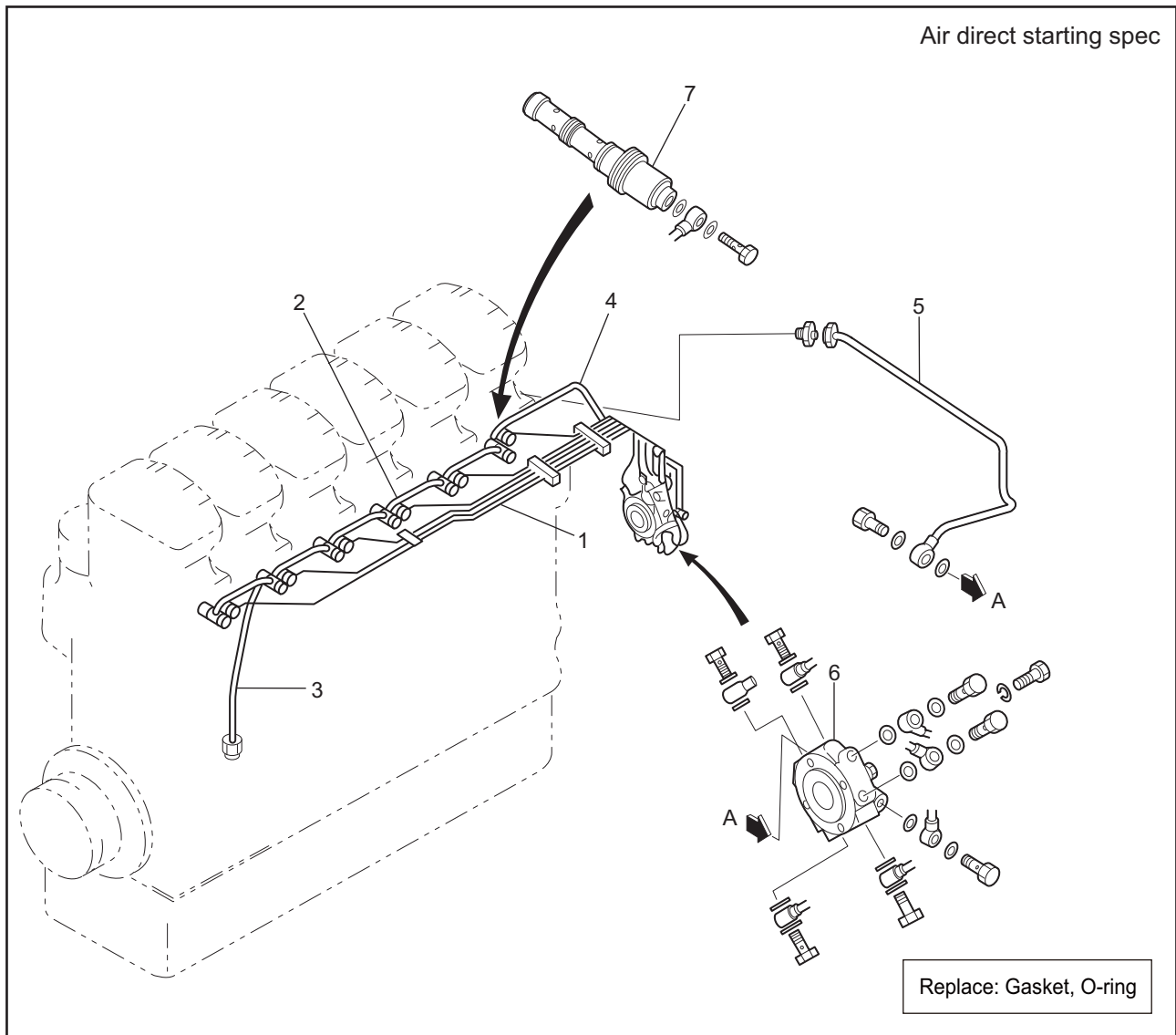


Magnetic Valve - Remove and Inspect

Removing Sequence

- | | |
|-----------------|------------------|
| 1 Air pipe | 5 Magnetic valve |
| 2 Flexible pipe | 6 Stay |
| 3 Stay | 7 Stay |
| 4 Air strainer | |

1.2 Air Pipe, Starter Valve and Distributor Valve - Inspect

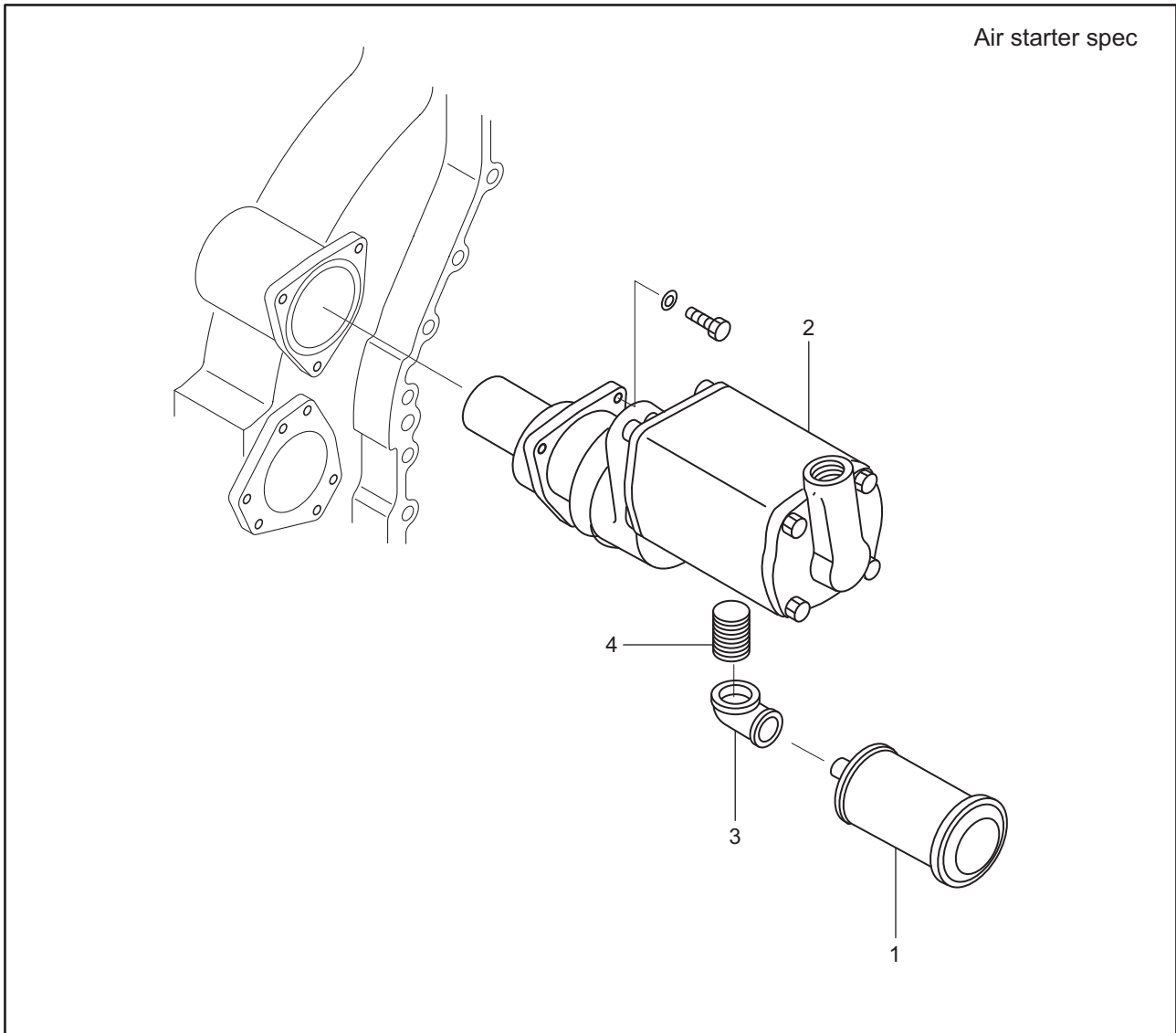


Air Pipe, Starter Valve and Distributor Valve - Remove

Removing Sequence

- | | |
|-------------------------------|-----------------|
| 1 No.1 thru 6 pilot air pipes | 5 Oil pipe |
| 2 Main air pipe | 6 Distributor |
| 3 Main air pipe | 7 Starter valve |
| 4 Main air pipe | |

1.3 Air Starter - Remove and Inspect



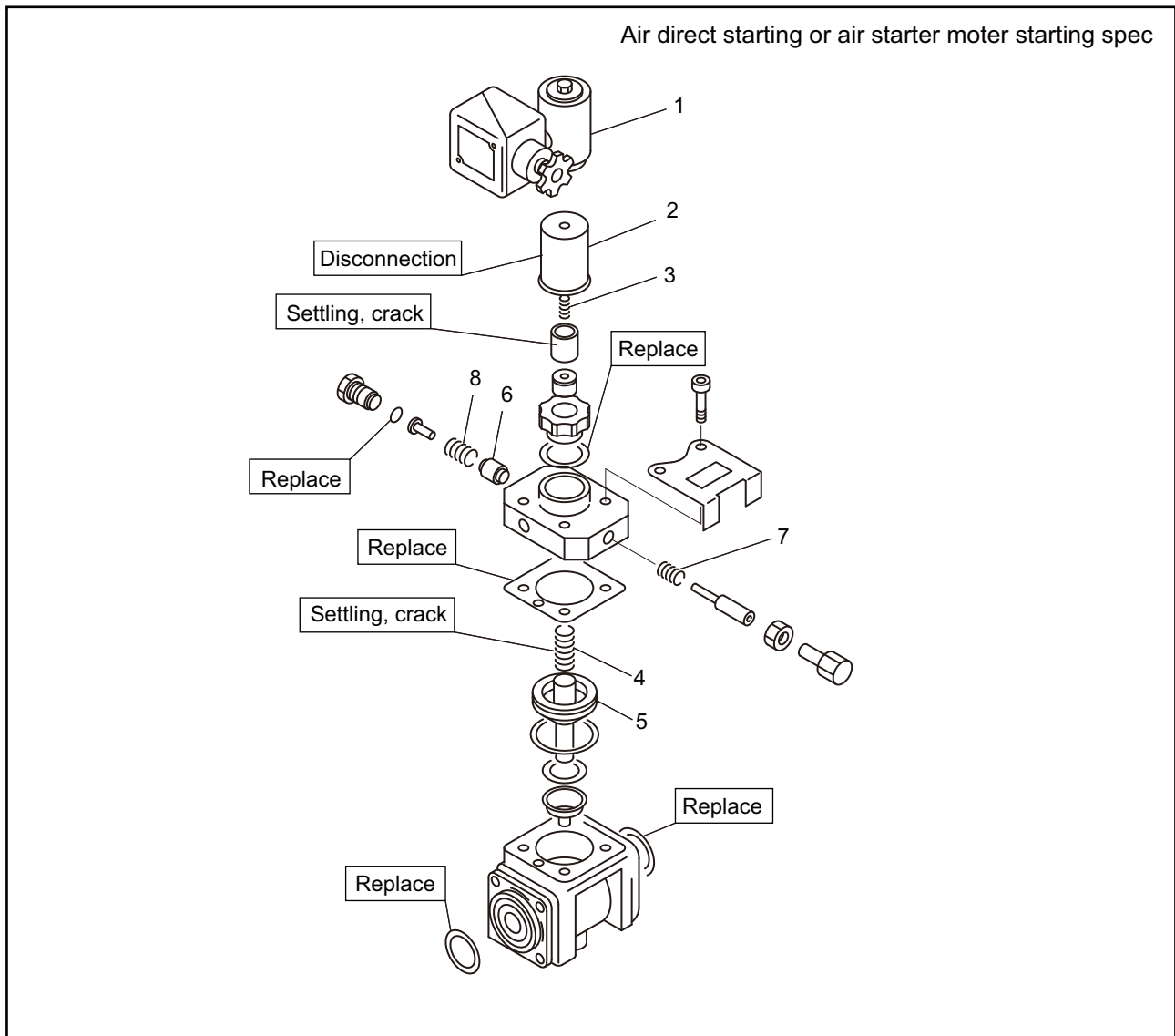
Air Starter - Remove and Inspect

Removing Sequence

- | | |
|--|-----------------|
| 1 Auto-muffler | 3 Elbow |
| 2 Air motor (Weight: approx 30 kg [66 lb]) | 4 Barrel nipple |

2. Air Start System - Disassemble, Inspect and Assemble

2.1 Magnetic Valve - Disassemble and Inspect



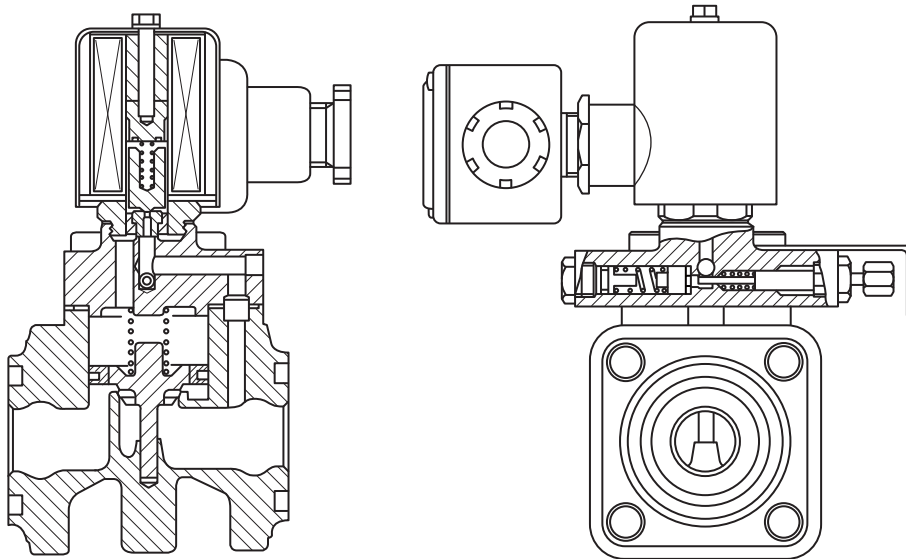
Magnetic Valve - Disassemble and Inspect

Removing Sequence

- | | |
|------------------|-------------------|
| 1 Magnetic valve | 5 Piston assembly |
| 2 Coil | 6 Valve |
| 3 Plunger spring | 7 Return spring |
| 4 Piston spring | 8 Valve spring |

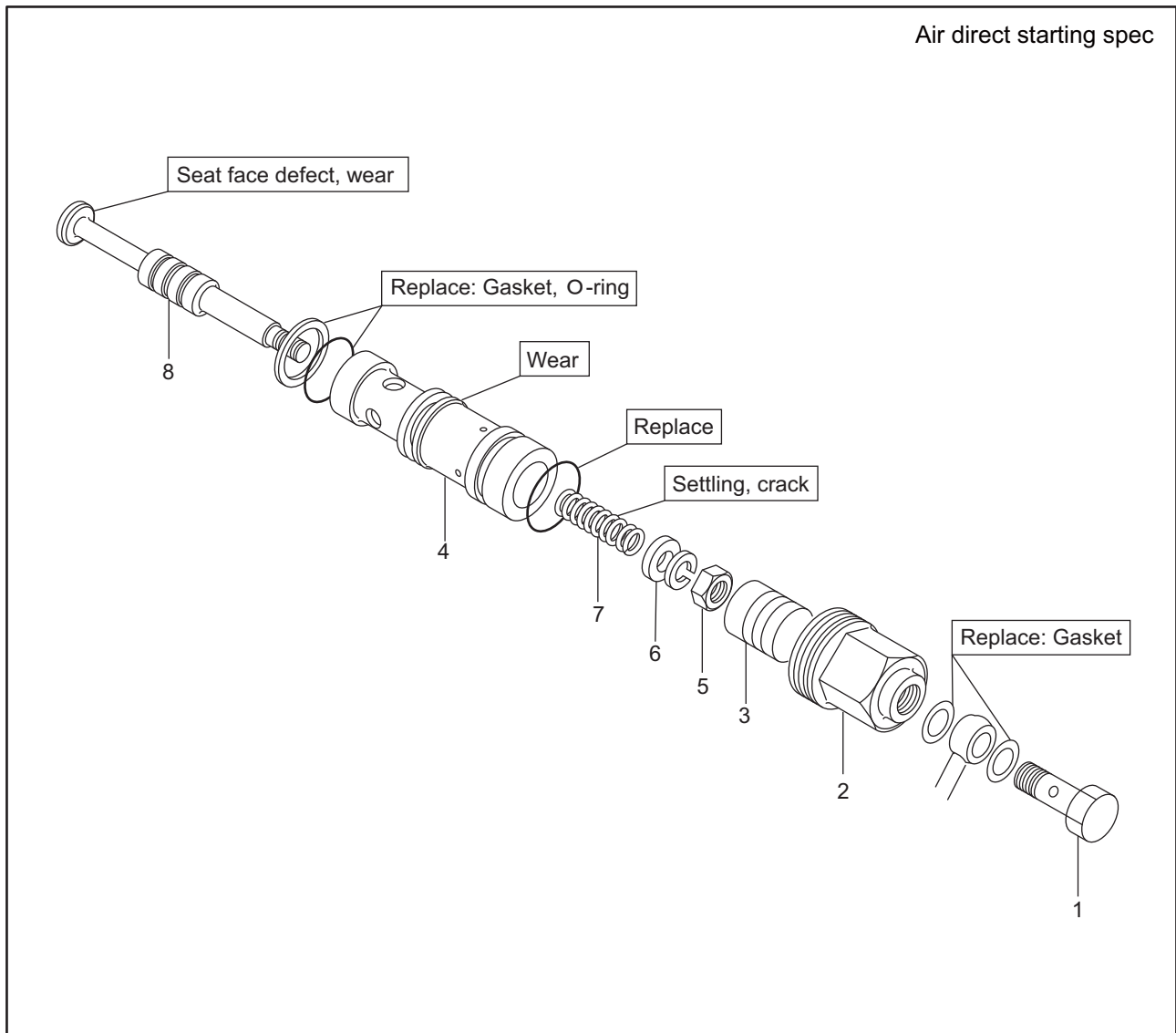
2.2 Magnetic Valve - Assemble

Air direct starting or air starter motoer starting spec



Magnetic Valve - Assemble

2.3 Starter Valve - Disassemble and Inspect



Starter Valve - Disassemble and Inspect

Removing Sequence

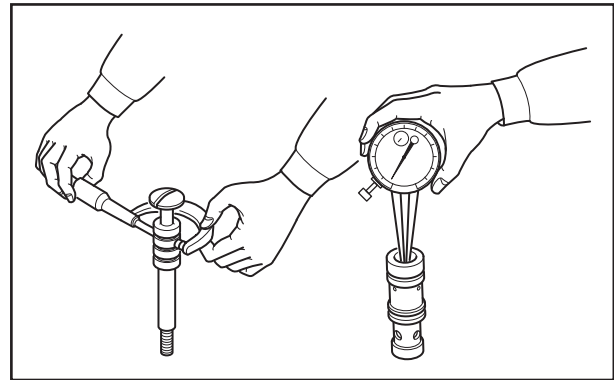
- | | |
|------------------------|-----------------|
| 1 Eye bolt | 5 Nut |
| 2 Cap nut | 6 Retainer |
| 3 Starter valve piston | 7 Spring |
| 4 Starter valve guide | 8 Startor valve |

2.4 Starter Valve - Inspect

2.4.1 Clearance Between Starter Valve and Starter Valve Guide - Measure

Measure the clearance between the starter valve and valve guide. If the value exceeds the limit, replace the starter valve or starter valve guide with a new one.

Item	Nominal value	Standard value	Limit value
Valve and valve guide guide clearance	-	0.016 to 0.052 mm [0.0006 to 0.0020 in.]	0.100 mm [0.0039 in.]



Clearance Between Starter Valve and Starter Valve Guide - Measure

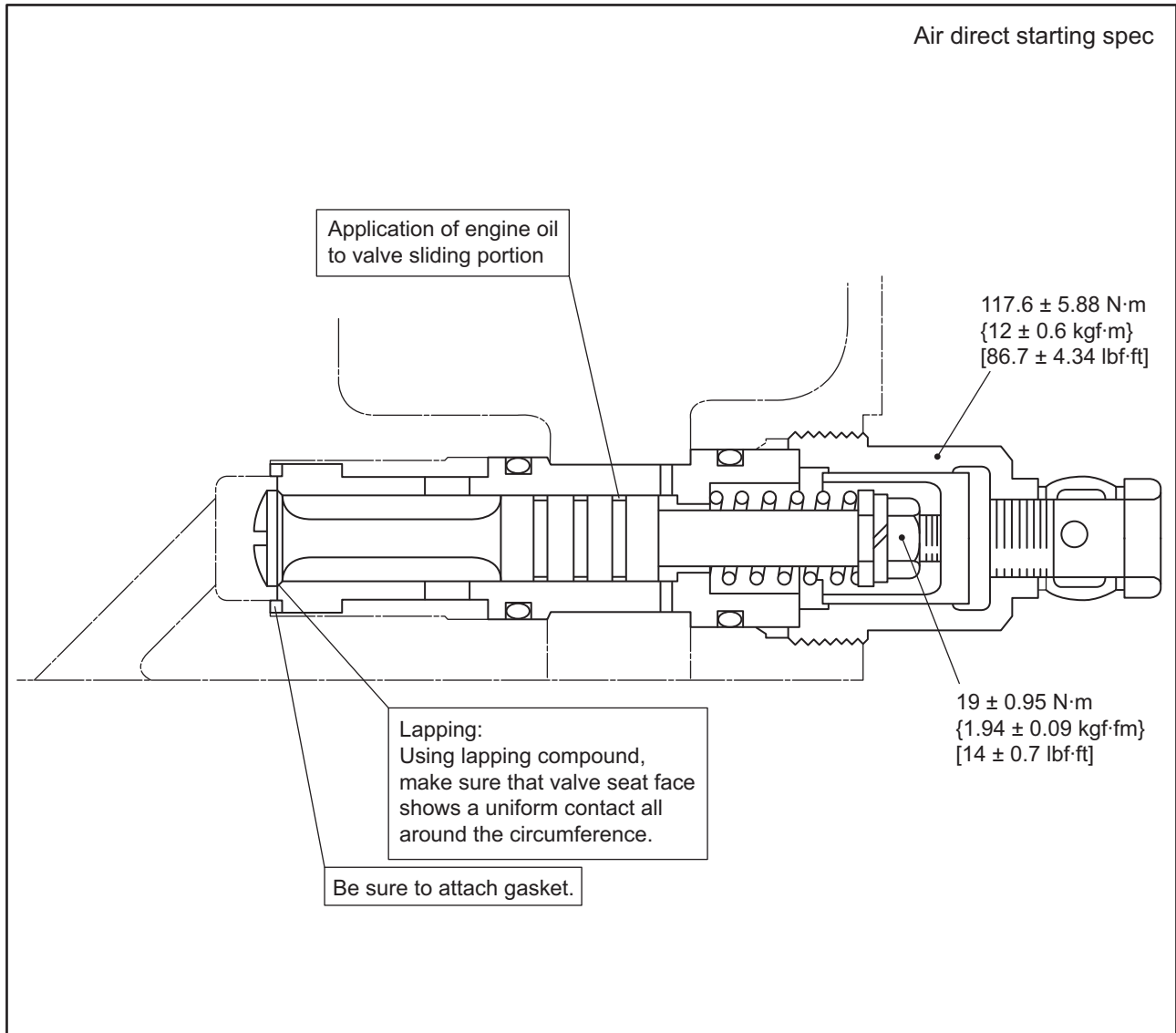
2.4.2 Free Length of Valve Spring - Measure

Measure the free length of valve spring.

If the value exceeds the limit, replace the valve spring with a new one.

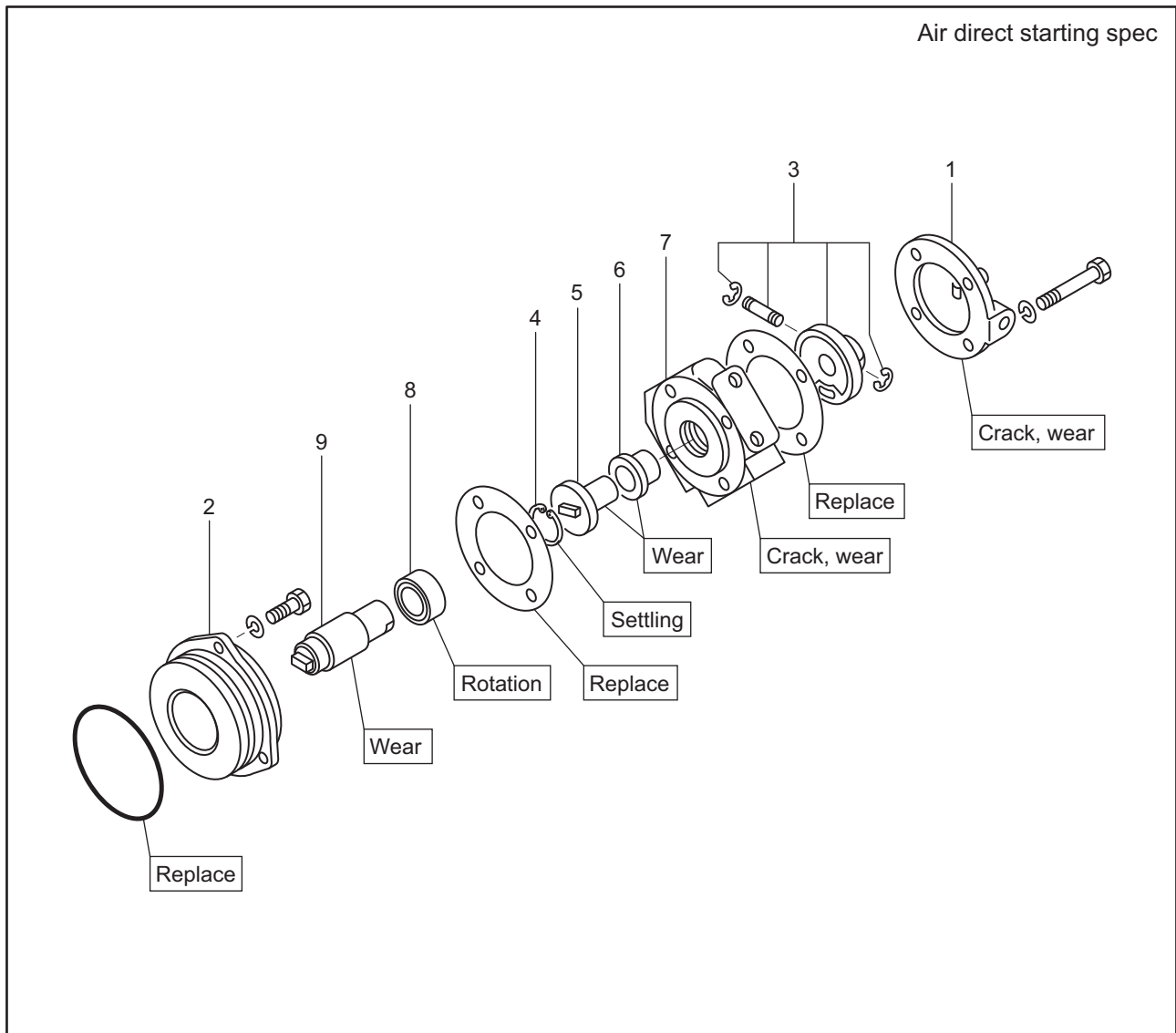
Item	Standard value	Limit value
Valve spring free length	36 mm [1.42 in.]	34 mm [1.34 in.]

2.5 Starter Valve - Assemble



Starter Valve - Assemble

2.6 Distributer Valve - Disassemble and Inspect



Distributer Valve - Disassemble and Inspect

Removing Sequence

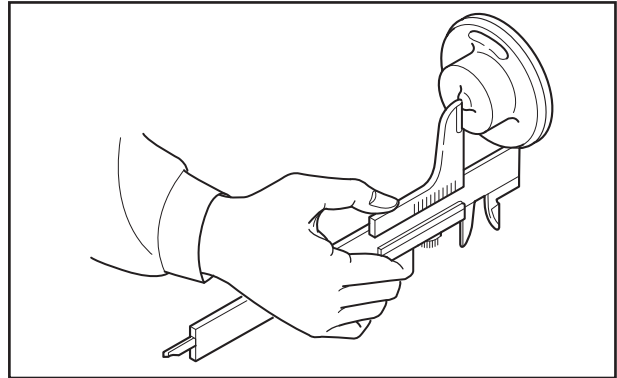
- | | |
|---------------------------------------|---------------------|
| 1 Case cover | 6 Bushing |
| 2 Distributer spacer | 7 Distributer valve |
| 3 Distributer valve, lock pin, E-ring | 8 Ball bearing |
| 4 Snap ring | 9 Drive shaft |
| 5 Shaft | |

2.7 Distributer Valve - Inspect

2.7.1 Distributer Valve Height - Measure

Measure the distributor valve height. If the value exceeds the limit, replace the valve with a new one.

Item	Standard value	Limit value
Distributor valve height	21.85 to 21.95 mm [0.8602 to 0.8642 in.]	21.75 mm [0.8563 in.]

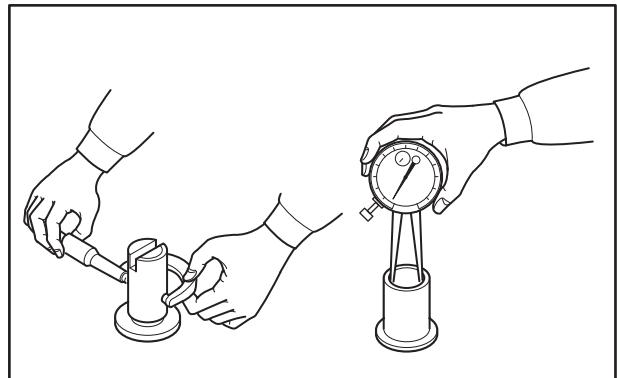


Distributor Valve Height - Measure

2.7.2 Clearance Between Distributer Shaft and Bushing - Measure

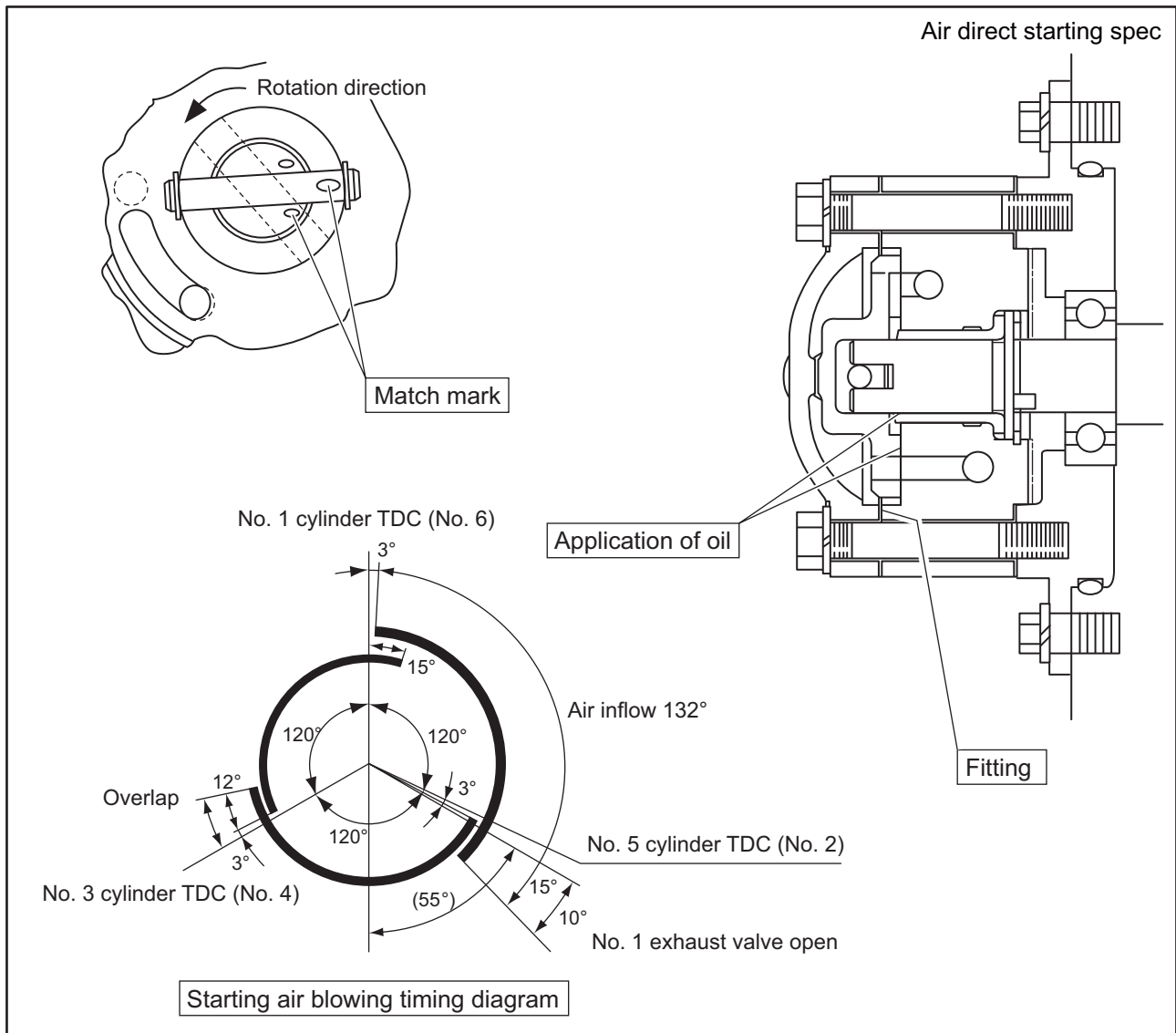
Measure the clearance between the distributor shaft and bushing. If the value exceeds the limit, replace the distributor shaft or bushing with a new one.

Item	Standard value	Limit value
Clearance between shaft and bushing	0.050 to 0.091 mm [0.0020 to 0.0036 in.]	0.150 mm [0.0059 in.]



Clearance Between Distributer Shaft and Bushing
- Measure

2.8 Distributer Valve - Assemble



Distributer Valve - Assemble

Note: Align the match marks to assemble the distributor. The wrong assembling results in 360° timing error of air blow and the engine will not start.

3. Air Start System - Install

Install the parts in the reverse order of the disassemble sequence. (Refer to the illustration for disassembling.)

Chapter 13 ADJUSTMENT AND OPERATION

1. Engine - Adjust	13-3
1.1 Turning Gear - Use	13-3
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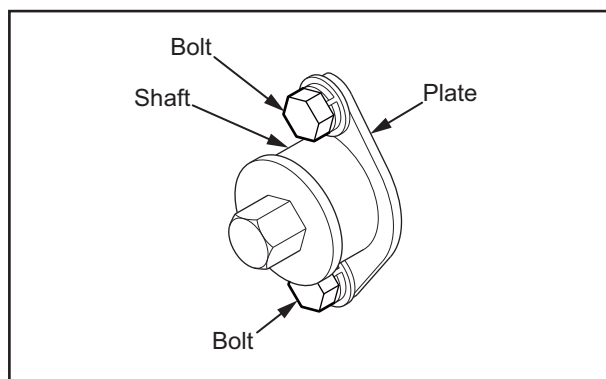
1. Engine - Adjust

1.1 Turning Gear - Use

WARNING

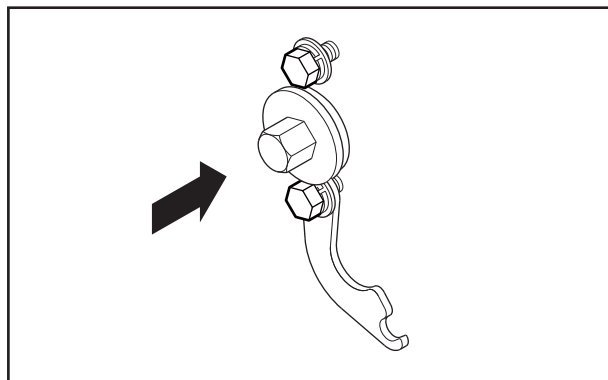
Before starting the engine, make sure that the turning gear is in the engine running position. If the engine is started with the turning gear engaged (pushed-in position), it will result in personal injury as well as damage to ring gear.

- (1) Loosen two bolts, and remove the plate from slot of shaft.



Turning Gear - Use (for Engine Running)

- (2) Push-in the shaft all the way so that it engages with ring gear.

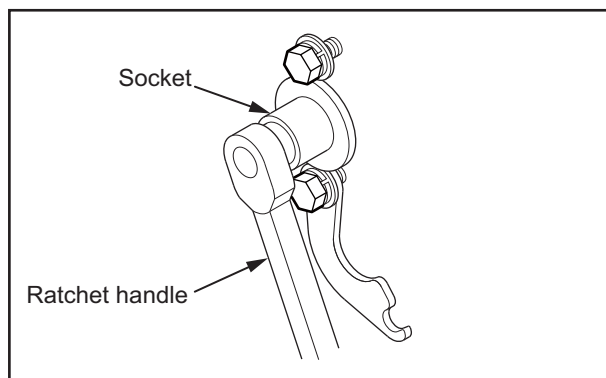


Turning Gear - Use (Push-in)

- (3) Using a socket and ratchet handle, rotate the shaft for turning crankshaft.
 (4) After the turning, pull-out the shaft, insert the plate into slot of shaft, and tighten the bolts.

CAUTION

Make sure that the plate is firmly fitted in slot of shaft.



Turning Gear - Use (for Turning)

1.2 Valve Bridge and Adjusting Screw - Check

Check the adjustment of valve bridge and adjusting screw. If it is not adjusted, adjust it to the standard value.

For the adjusting procedure, refer to "Valve Bridge and Adjusting Screw - Adjust" of "ASSEMBLY OF BASIC ENGINE."

1.3 Valve Clearance - Check

Check the valve clearance.

If it is not adjusted, adjust it to the standard value.

For the adjusting procedures, refer to "Valve Clearance - Inspect and Adjust" of "ASSEMBLY OF BASIC ENGINE."

1.4 Fuel Injection Timing - Check

Check the fuel injection timing.

If it is not adjusted, adjust the timing to the specified value.

For the adjusting procedures, refer to "Fuel Injection Timing - Check and Adjust" of "ASSEMBLY OF BASIC ENGINE."

1.5 Fuel System - Bleed Air

WARNING

- Thoroughly wipe off fuel spilled out of air vent plug to prevent a fire.
- After air bleeding, ensure the lock of priming pump cap. If locking is insufficient, it could cause damage to the priming pump and result in fuel leak and a fire.

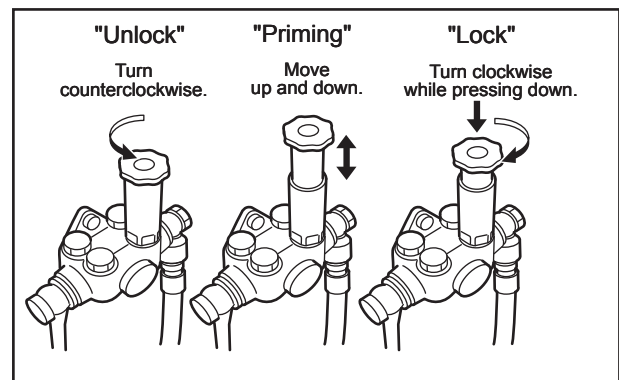
To bleed air from fuel system, start air bleeding at the place nearest to fuel tank, from fuel filter to injection pump, while feeding fuel with priming pump.

1.5.1 Fuel Filter (Paper Element) - Bleed Air

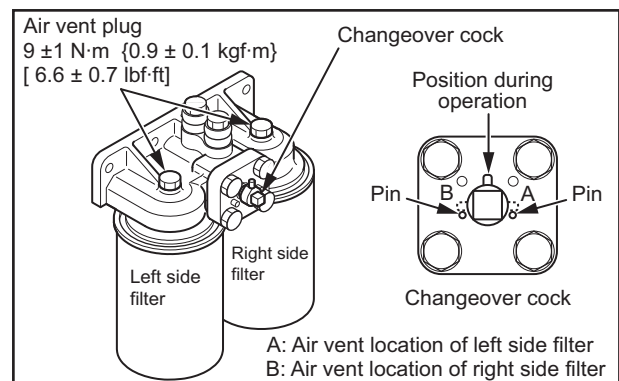
CAUTION

If the air vent plugs, threads of bracket or sealing washers are damaged, replace them with new ones.

- Loosen the air vent plug of fuel filter by approx 1.5 turns.
- Feed fuel by moving the priming pump up and down.
- When fuel flowing from vent holes no longer contains air bubbles, tighten the air vent plugs to the specified torque.



Priming Pump - Operate



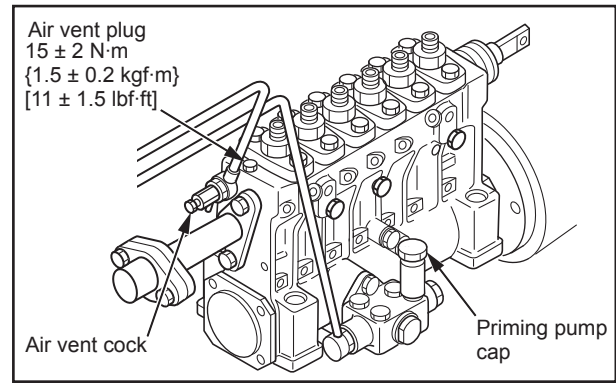
Fuel Filter (Paper Element) - Bleed Air

1.5.2 Fuel Injection Pump - Bleed Air

- (1) Loosen the air vent plugs of fuel injection pump by approx 1.5 turns.
- (2) Feed fuel by moving the priming pump up and down.
- (3) When fuel flowing from vent holes no longer contains air bubbles, tighten a air vent plug leaving one plug un-tightened. Lock the priming pump by turning the cap clockwise while pushing it down. Then tighten the last air vent plug.

Note:(a) To check the function of check valve, tighten the all air vent plugs, then lock the priming pump cap. The priming pump cap resists the push-in, but the check valve opening pressure is stabilized and the valve function is verified with this procedure.

- (b) Thoroughly wipe off fuel spilled out of air vent plug.



Fuel Injection Pump - Bleed Air

1.5.3 Priming Pump Cap - Lock

CAUTION

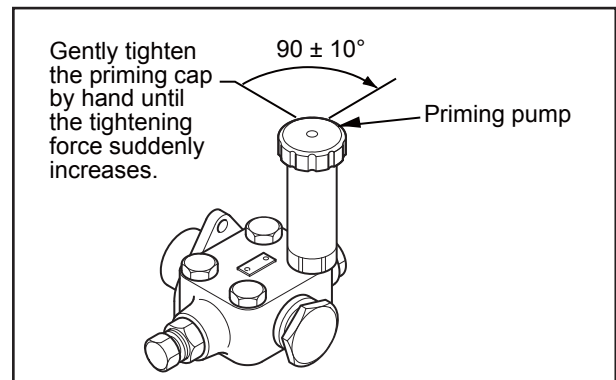
If the priming pump cap is not locked sufficiently, the screw in cap wears due to engine vibration, which can result in the priming pump cap to pop-off and fuel to leak.

If it is over-tightened, the head of priming pump can be damaged. Make sure to tighten the cap to the correct angle.

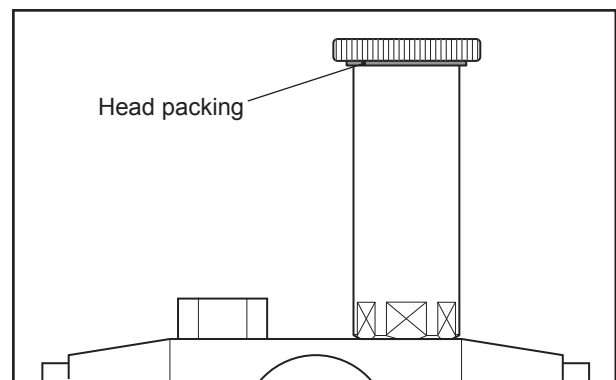
CAUTION

Check the head packing of priming pump for deformation and damage. If any deformation or damage is found, replace the priming pump with a new one.

- (1) Gently tighten the priming pump cap by hand until the tightening force suddenly increases.
- (2) Using a wrench, further tighten the priming pump cap by $90 \pm 10^\circ$ from the mark position.
- (3) Check the mounting condition of head packing. If any defects such as deformation or dent are found, replace the priming pump with a new one.



Priming Pump Cap - Lock



Priming Pump Cap Packing

1.6 Belt and Belt Tension - Inspect and Adjust

CAUTION

If any defects such as cuts or surface separations are found during inspection, replace the belt with a new one.

Keep the belt free from oil and grease. Oil or grease causes the belt to slip and shorten the service life.

Excessive belt tension can cause rapid wear of alternator bearing and shorten the service life of belt. Adjust the belt tension correct following the procedures below:

1.6.1 Belt - Inspect

(1) Inspect the belt visually for separation or damage. If any defect is found, replace the belt with a new one.

(2) Inspect the tension (deflection) and pressing force of belt.

V-belt

Inspect the V-belt deflection by pressing it with approx 98 to 147 N {10 to 15 kgf} [22 to 33 lbf] force at the center of its span.

The belt deflection of 10 to 15 mm [0.39 to 0.59 in.] is normal.

If the deflection is out of standard, adjust the belt tension.

Ribbed belt

Refer to the table below. If the pressing force is not meet the standard, when pushing in the middle of pulleys with the gauge and the belt deflexion is 15 mm, adjust the belt tension.

1.6.2 Belt Tension (Water Pump, Air cooler and Water Pump) - Adjust

(1) Remove the belt cover.

(2) Loosen all the fixing bolts of tension pulley.

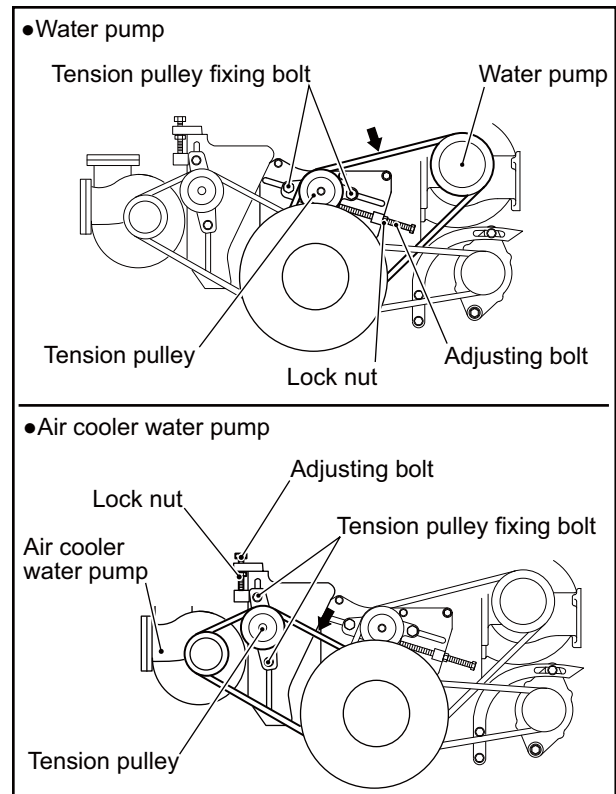
(3) Loosen the lock nut of adjusting bolt.

(4) Adjust the belt tension by turning the adjusting bolt.

(5) After the tension adjustment is completed, fix the lock nut of adjusting bolt.

(6) Tighten all the fixing bolts of tension pulley.

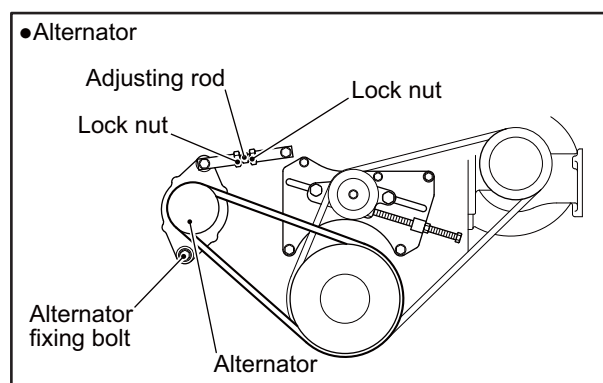
(7) Install the belt cover.



Belt Tension (Water Pump, Air Cooler and Water Pump) - Adjust

1.6.3 Belt Tension (Alternator) - Adjust

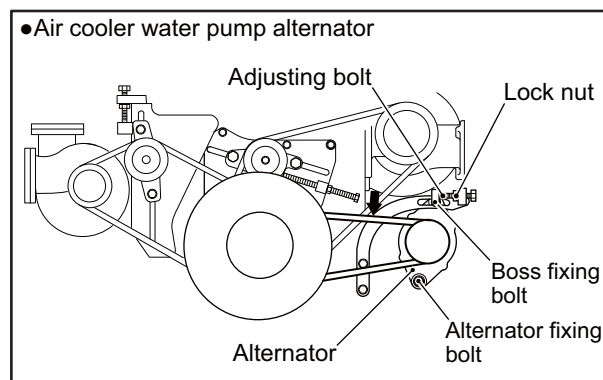
- (1) Remove the belt cover.
- (2) Loosen all the fixing bolts of alternator.
- (3) Turn the adjusting rod to adjust the belt tension.
- (4) Tighten all the fixing bolts of alternator.
- (5) Install the belt cover.



Belt Tension (Alternator) - Adjust

1.6.4 Belt Tension (Air Cooler Water Pump Alternator Side) - Adjust

- (1) Remove the belt cover.
- (2) Loosen fixing bolts of alternator and boss.
- (3) Loosen the lock nut, and adjust the belt tension by turning the adjusting bolt.
- (4) Tighten all lock nuts.
- (5) Tighten fixing bolts of alternator and boss.
- (6) Install the belt cover.



Belt Tension (Air Cooler Water Pump Alternator Side) - Adjust

Ribbed belt tension (N) table

Item	Number of ribs	Belt straight distance (mm) [in.]				
		300 [11.81] or below	more than 300 to 400 [11.81 to 15.75]	more than 400 to 500 [15.75 to 19.69]	more than 500 to 600 [16.69 to 23.62]	more than 600 [23.62]
When a new belt is installed:	3	74 N {7.55 kgf} [16.64 lbf]	49 N {5.00 kgf} [11.02 lbf]	37 N {3.77 kgf} [8.32 lbf]	29 N {2.96 kgf} [6.52 lbf]	25 N {2.55 kgf} [5.62 lbf]
	4	88 N {8.97 kgf} [19.78 lbf]	59 N {6.02 kgf} [19.78 lbf]	44 N {4.49 kgf} [13.26 lbf]	35 N {3.57 kgf} [7.87 lbf]	29 N {2.96 kgf} [6.52 lbf]
	5	103 N {10.50 kgf} [23.16 lbf]	69 N {7.04 kgf} [15.51 lbf]	51 N {5.20 kgf} [11.47 lbf]	41 N {4.18 kgf} [9.22 lbf]	34 N {3.47 kgf} [7.64 lbf]
	6	118 N {12.03 kgf} [26.53 lbf]	79 N {8.06 kgf} [17.76 lbf]	59 N {6.02 kgf} [13.26 lbf]	47 N {4.79 kgf} [10.57 lbf]	39 N {3.98 kgf} [8.77 lbf]
	7	132 N {13.46 kgf} [29.67 lbf]	88 N {8.97 kgf} [19.78 lbf]	66 N {6.73 kgf} [14.84 lbf]	53 N {5.40 kgf} [11.91 lbf]	44 N {4.49 kgf} [9.89 lbf]
	8	147 N {14.99 kgf} [33.05 lbf]	98 N {9.99 kgf} [22.03 lbf]	74 N {7.55 kgf} [16.64 lbf]	59 N {6.02 kgf} [13.26 lbf]	49 N {5.00 kgf} [11.02 lbf]
	9	162 N {16.52 kgf} [36.42 lbf]	108 N {11.01 kgf} [24.28 lbf]	81 N {8.26 kgf} [18.21 lbf]	65 N {6.63 kgf} [14.61 lbf]	54 N {5.51 kgf} [12.14 lbf]
	10	176 N {17.95 kgf} [39.57 lbf]	118 N {12.03 kgf} [26.53 lbf]	88 N {8.97 kgf} [19.78 lbf]	71 N {7.24 kgf} [14.96 lbf]	59 N {6.02 kgf} [13.26 lbf]
	11	191 N {19.48 kgf} [42.94 lbf]	127 N {12.95 kgf} [28.55 lbf]	96 N {9.79 kgf} [21.58 lbf]	76 N {7.75 kgf} [17.09 lbf]	64 N {6.53 kgf} [14.39 lbf]
	12	206 N {21.01 kgf} [46.31 lbf]	137 N {13.97 kgf} [30.80 lbf]	103 N {10.50 kgf} [23.16 lbf]	82 N {8.36 kgf} [18.43 lbf]	69 N {7.04 kgf} [15.15 lbf]

Ribbed belt tension (N) table

Item	Number of ribs	Belt straight distance (mm) [in.]				
		300 [11.81] or below	more than 300 to 400 [11.81 to 15.75]	more than 400 to 500 [15.75 to 19.69]	more than 500 to 600 [16.69 to 23.62]	more than 600 [23.62]
When re-adjusted:	3	51 N {5.20 kgf} [11.47 lbf]	34 N {3.47 kgf} [7.64 lbf]	26 N {2.65 kgf} [5.85 lbf]	21 N {2.14 kgf} [4.72 lbf]	17 N {1.73 kgf} [3.82 lbf]
	4	62 N {6.32 kgf} [7.19 lbf]	41 N {4.18 kgf} [9.22 lbf]	31 N {3.16 kgf} [6.97 lbf]	25 N {2.55 kgf} [5.62 lbf]	21 N {2.14 kgf} [4.72 lbf]
	5	72 N {7.34 kgf} [16.19 lbf]	48 N {4.89 kgf} [10.79 lbf]	36 N {3.67 kgf} [8.09 lbf]	29 N {2.96 kgf} [6.52 lbf]	24 N {2.45 kgf} [5.40 lbf]
	6	82 N {8.36 kgf} [18.43 lbf]	55 N {5.61 kgf} [12.36 lbf]	41 N {4.18 kgf} [9.22 lbf]	33 N {3.37 kgf} [7.42 lbf]	27 N {2.75 kgf} [6.07 lbf]
	7	93 N {9.48 kgf} [20.91 lbf]	62 N {6.32 kgf} [13.94 lbf]	46 N {4.69 kgf} [10.34 lbf]	37 N {3.77 kgf} [8.32 lbf]	31 N {3.16 kgf} [6.97 lbf]
	8	103 N {10.50 kgf} [23.16 lbf]	69 N {7.04 kgf} [15.51 lbf]	51 N {5.20 kgf} [11.47 lbf]	41 N {4.18 kgf} [9.22 lbf]	34 N {3.47 kgf} [7.64 lbf]
	9	113 N {11.52 kgf} [25.40 lbf]	75 N {7.65 kgf} [16.86 lbf]	57 N {5.81 kgf} [12.81 lbf]	45 N {4.59 kgf} [10.12 lbf]	38 N {3.87 kgf} [8.54 lbf]
	10	123 N {12.54 kgf} [27.65 lbf]	82 N {8.36 kgf} [18.43 lbf]	62 N {6.32 kgf} [13.94 lbf]	49 N {5.00 kgf} [11.02 lbf]	41 N {4.18 kgf} [9.22 lbf]
	11	134 N {13.66 kgf} [30.12 lbf]	89 N {9.08 kgf} [20.01 lbf]	67 N {6.83 kgf} [15.06 lbf]	54 N {5.51 kgf} [12.14 lbf]	45 N {4.59 kgf} [10.12 lbf]
	12	144 N {14.68 kgf} [32.37 lbf]	96 N {9.79 kgf} [21.58 lbf]	72 N {7.34 kgf} [16.19 lbf]	58 N {5.91 kgf} [13.04 lbf]	48 N {4.89 kgf} [10.79 lbf]

The force when the middle of belt straight line is pushed and deflected by 15 mm [0.5906 in.]

2. Break-in Operation

2.1 Preparation Before Engine Starting

- ♦ Check the levels of fuel, engine oil, and coolant, and also bleed air from fuel system and cooling system.
- ♦ Inspect the link between governor output lever and the fuel injection pump rack. Check that the fuel control rack is at the no-injection position when the engine is stopped. Check that the control rack is at the "0" position when the stop lever is pulled.
- ♦ Check the wiring of electrical system (sensor, meter alarm panel, starter, alternator, stop solenoid, and battery). Turn ON the controller main switch to check for abnormality.

Set the governor speed lever so that the engine may run at a low idling speed after start-up.

- ♦ Operate the stop solenoid, and make sure that the fuel injection pump rack moves to the no injection position.
- ♦ Install the pressure gauge, thermometer and flow meter as required.

2.2 Engine Start-up

- (1) Pull the stop lever to the no injection position, and crank for approx 10 seconds with starter to circulate engine oil in the engine. Repeat this 2 or 3 times with one minute intervals between them.

Check that there is no defect such as abnormal noise or rotation speed fluctuation.

- (2) Start the engine in the normal procedure.

Check that the engine can run at a low idling speed after start-up.

- (3) Check that the oil pressure increases immediately, and the coolant circulates.

- (4) Check for leakage of oil, coolant, fuel and gas (air), and abnormal noise and vibration.

- (5) After checking the engine low idling without any problem, turn the key switch to OFF position, and make sure that the engine stops.

2.3 Break-in Operation

CAUTION

Be prepared to activate the emergency stop for unexpected trouble of engine operation.

2.3.1 Break-in Operation Load and Time

The load during break-in operation is to be increased progressively as shown in the table.

Note that the time shown in the table is the minimum time required to check the engine in a stable condition.

Break-in Operation				
	Rotating speed (min ⁻¹)		Loading factor	Time (min)
1	Low rotating speed	600 to 900	No-load	20
2	Medium rotating speed	1000 to 1200	No-load	10
3	High rotating speed	1400 to rated speed	No-load	10
4	Marine partial load rotation speed	Equivalent to 25 % output	25 %	20
5		Equivalent to 50 % output	50 %	20
6		Equivalent to 75 % output	75 %	30
7	Rated speed		100 %	20

2.3.2 Inspection while the Engine is Running

During the break-in operation, pay attention to followings and make sure that there is no abnormality.

- ♦Oil pressure and oil temperature
- ♦Coolant temperature and level
- ♦Leakage of oil, water, fuel and gas; especially oil from turbocharger pipe connection of lubricating oil.
- ♦Noise and vibration
- ♦Intake air pressure and temperature
- ♦Exhaust color and odor
- ♦Exhaust temperature
- ♦Differences between right and left banks
- ♦Blow-by gas (amount and color)
- ♦Rotational fluctuation
- ♦Face and radial runouts of rotating parts
- ♦Indication and operation of meter and alarm

2.3.3 Inspection and Adjustment After Break-in Operation

- ♦Valve clearance
- ♦Fuel injection timing
- ♦Bolts and nuts around the engine - retighten
- ♦Belt tension
- ♦Defects such as oil leakage - inspect and repair

3. Engine-Test and Adjustment

CAUTION

- (a) Engine test, adjustment and seal shall be performed at the certified maintenance shop only.
When the seal of engine is to be done at a service shop other than the certified shops, ask a certified shop for the presence of qualified person for the test, adjustment and seal.
- (b) Performance check and adjustment of the engine shall be conducted when the water and oil temperatures become stable after sufficient warm-up operation.

After the break-in operation is completed, and the engine runs normally, check and adjust the performance and functions of the engine.

Record the test results referring to the engine data of delivery time.

3.1 Engine Performance Test

Fuel consumption rate, various temperatures and pressures, and exhaust color

3.2 Emission Gas Test

Exhaust gas analyses

3.3 Governor Performance Test

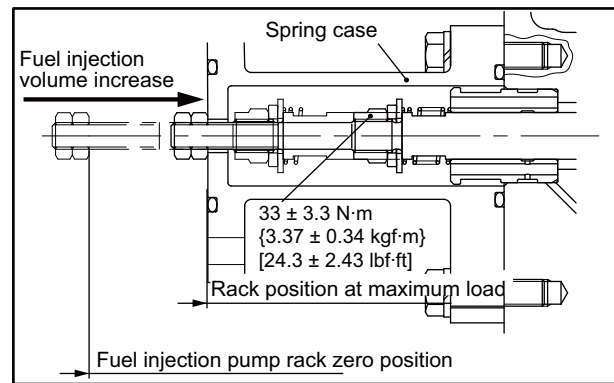
- ♦Minimum speed at no-load (low idle) - set
- ♦Maximum speed at no-load (high idle) - set
- ♦Load sudden application and rejection tests
- ♦Governor droop, hunting, and rotational fluctuation - check
- ♦Setting conditions of governor controller and others - check

3.4 Alarm Action and Emergency Stop Tests

Oil pressure decrease, water temperature increase, and overspeed

3.5 Maximum Fuel Injection Volume - Set

- (1) Remove the rack set cap at the front end of fuel injection pump, and apply the rated (maximum) load.
- (2) Secure the double nuts when the nuts at the rack end comes into contact with the spring case end face.



Maximum Fuel Injection Volume - Set

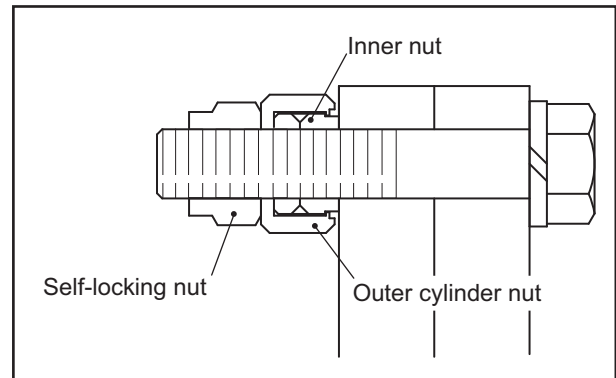
3.6 Seal

After all performance tests and adjustments are completed, stop the engine, and seal the specified part between governor actuator and fuel injection pump rack.

3.6.1 Tamper Proof - Remove

Tamper proof nut is composed of double structure, and cannot be removed by rotating.

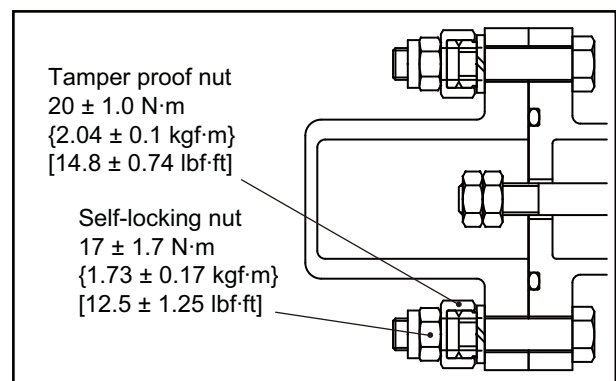
To remove, cut the outer cylinder nut and remove the inner nut.



Tamper Proof - Remove

3.6.2 Tamper Proof - Install

Tighten the tamper proof nut to the specified torque, and make sure that the inner nut is separated.



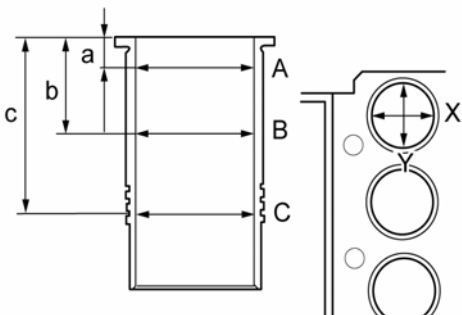
Tamper Proof - Install

Engine inspection record sheet (SR series)

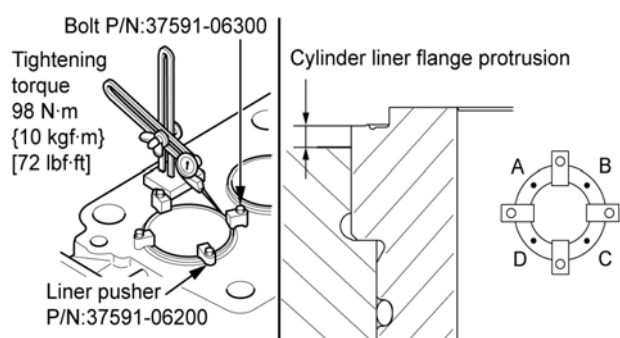
- No. 1 Cylinder liner bore inside diameter - measure
- No. 2 Cylinder liner flange protrusion - measure
- No. 3 Valve guide inside diameter and Valve stem diameter - measure
- No. 4 Cylinder head valve sinkage, seat width, and valve margin - measure
- No. 5 Cylinder head bottom face distortion - measure
- No. 6 Connecting rod bushing inside diameter and connecting rod big-end bore diameter
- measure
- No. 7 Rocker bushing inside diameter and rocker shaft outside diameter - measure
- No. 8 Piston pin bore inside diameter and piston pin outside diameter - measure
- No. 9 Valve clearance - measure
- No. 10 Fuel injection nozzle injection pressure - measure
- No. 11 Camshaft bushing inside diameter and camshaft journal outside diameter (right
side) - measure
- No. 12 Camshaft bushing inside diameter and camshaft journal outside diameter (left side)
- measure
- No. 13 Crankshaft end play - measure

INSPECTION RECORD SHEET

No.1

				SR																																																																																																																																																																					
Customer			Engine Model		Date																																																																																																																																																																				
			Serial No.																																																																																																																																																																						
Item	Cylinder liner bore inside diameter - measure				Unit mm[in.]																																																																																																																																																																				
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INSPECTION RECORD SHEET

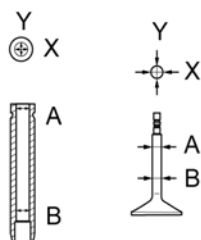
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INSPECTION RECORD SHEET

No.3(1/3)

		SR	
Customer		Engine Model	
		Serial No.	
Item	Valve guide inside diameter and Valve stem diameter - measure (1/3)	Unit	mm[in.]

Measuring location



Standard

Item to be measured	Nominal	Standard	Limit
Valve guide inside diameter (same for inlet and exhaust)	$\phi 10$ [0.39]	10.000 to 10.015 [0.3937 to 0.3943]	10.060 [0.3961]
Valve stem outside diameter (same for inlet and exhaust)	$\phi 10$ [0.39]	9.940 to 9.960 [0.3913 to 0.3921]	9.910 [0.3902]

Measured value

Item		Valve guide inside diameter				Valve stem outside diameter				Clearance			
No.	Location	A		B		A		B		A		B	
		X	Y	X	Y	X	Y	X	Y	Max.	Min.	Max.	Min.
1	Inlet	a											
		b											
	Exhaust	a											
		b											
2	Inlet	a											
		b											
	Exhaust	a											
		b											
3	Inlet	a											
		b											
	Exhaust	a											
		b											
4	Inlet	a											
		b											
	Exhaust	a											
		b											
5	Inlet	a											
		b											
	Exhaust	a											
		b											
6	Inlet	a											
		b											
	Exhaust	a											
		b											

Remark

Approved by Checked by Measured by

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INSPECTION RECORD SHEET

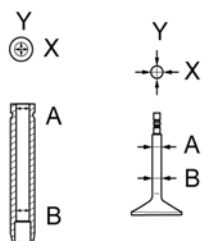
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Customer		Engine Model				Date																	
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Item		Valve guide inside diameter and Valve stem diameter - measure (2/3)						Unit		mm[in.]													
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No.	Location	A		B		A		B		A		B											
		X	Y	X	Y	X	Y	X	Y	Max.	Min.	Max.	Min.										
7	Inlet	a																					
		b																					
	Exhaust	a																					
		b																					
8	Inlet	a																					
		b																					
	Exhaust	a																					
		b																					
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		b																					
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		b																					
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		b																					
12	Inlet	a																					
		b																					
	Exhaust	a																					
		b																					
Remark										Approved by		Checked by		Measured by									

INSPECTION RECORD SHEET

No.3(3/3)

		SR	
Customer		Engine Model	
		Serial No.	
Item	Valve guide inside diameter and Valve stem diameter - measure (3/3)	Unit	mm[in.]

Measuring location



Standard

Item to be measured	Nominal	Standard	Limit
Valve guide inside diameter (same for inlet and exhaust)	$\phi 10$ [0.39]	10.000 to 10.015 [0.3937 to 0.3943]	10.060 [0.3961]
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Measured value

Item		Valve guide inside diameter				Valve stem outside diameter				Clearance			
No.	Location	A		B		A		B		A		B	
		X	Y	X	Y	X	Y	X	Y	Max.	Min.	Max.	Min.
13	Inlet	a											
		b											
	Exhaust	a											
		b											
14	Inlet	a											
		b											
	Exhaust	a											
		b											
15	Inlet	a											
		b											
	Exhaust	a											
		b											
16	Inlet	a											
		b											
	Exhaust	a											
		b											

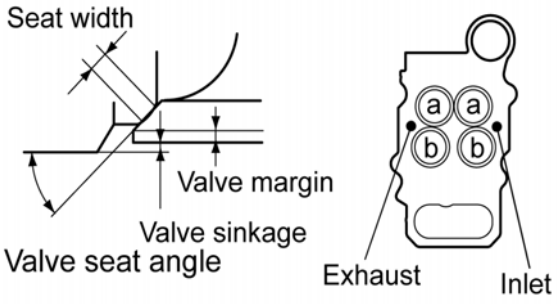
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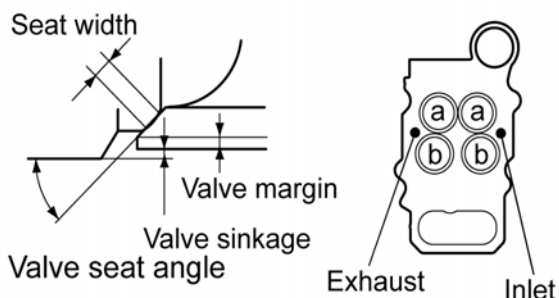
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INSPECTION RECORD SHEET

No.4(2/2)

				SR	
Customer		Engine Model		Date	
		Serial No.			
Item	Cylinder head valve sinkage, seat sidth, and valve margin - measure (2/2)			Unit	mm[in.]

Measuring location



Standard

Item to be measured		Standard	Limit
Valve seat (Same for inlet, exhaust)	Valve seat angle	30°	-
	Valve sinkage	-0.1 to 0.1 [-0.039 to 0.039]	1.0 [0.039]
	Seat width	2.18 to 2.42 [0.0862 to 0.0953]	2.8 [0.110]
	Valve margin	2.8 to 3.2 [0.110 to 0.126]	Reface up to 2.5[0.098]

Measured value

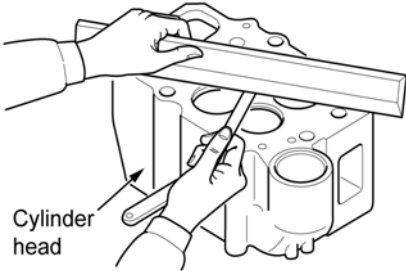
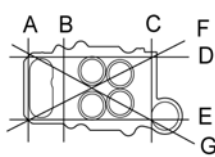
Item			Valve seat angle	Valve sinkage	Seat width	Item			Valve seat angle	Valve sinkage	Seat width
No.	Valve					No.	Valve				
1	Inlet	a				5	Inlet	a			
		b						b			
	Exhaust	a					Exhaust	a			
		b						b			
2	Inlet	a				6	Inlet	a			
		b						b			
	Exhaust	a					Exhaust	a			
		b						b			
3	Inlet	a				7	Inlet	a			
		b						b			
	Exhaust	a					Exhaust	a			
		b						b			
4	Inlet	a				8	Inlet	a			
		b						b			
	Exhaust	a					Exhaust	a			
		b						b			

Remark

Approved by Checked by Measured by

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INSPECTION RECORD SHEET

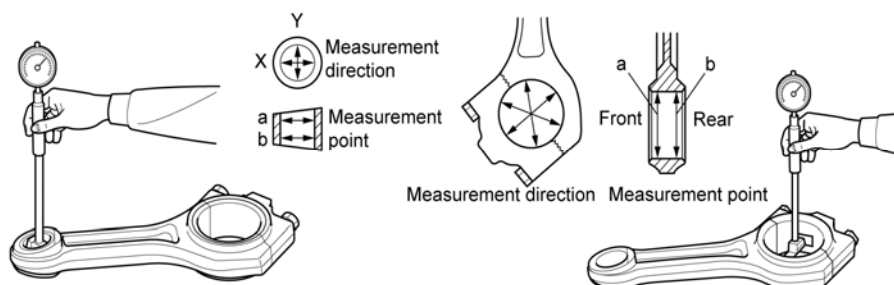
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INSPECTION RECORD SHEET

No. 6(1/2)

				SR	
Customer			Engine Model		Date
			Serial No.		
Item	Connecting rod bushing inside diameter and connecting rod big-end bore diameter - measure (1/2)				Unit mm[in.]

Measuring location



Standard

Item to be measured	Nominal	Standard	Limit	Roundness
Connecting rod bushing inside diameter	ϕ 70 [2.76]	70.020 to 70.040 [2.7567 to 2.7575]	70.070[2.7587]	-
Connecting rod big end bore diameter	ϕ 131 [5.16]	131.000 to 131.025 [5.1575 to 5.1585]	Minimum:130.950[5.1555] Maximum:131.050[5.1594]	0.100 [0.0039]

Measured value

Item		Connecting rod bushing inside diameter		Connecting rod big-end bore diameter		
No.	Direction	X	Y	A	B	C
1	a					
	b					
2	a					
	b					
3	a					
	b					
4	a					
	b					
5	a					
	b					
6	a					
	b					
7	a					
	b					
8	a					
	b					

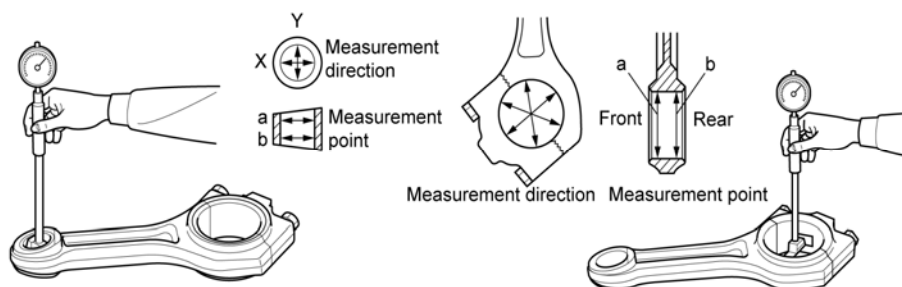
Remark

Approved by

Checked by

Measured by

INSPECTION RECORD SHEET

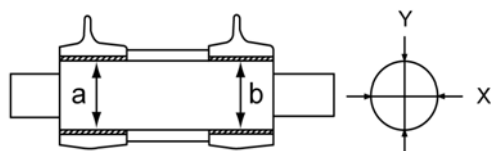
					SR		
Customer			Engine Model			Date	
			Serial No.				
Item	Connecting rod bushing inside diameter and connecting rod big-end bore diameter - measure (2/2)					Unit	mm[in.]
Measuring location  The diagrams illustrate the correct setup for measuring the connecting rod bushing and big-end bore diameter. The left diagram shows the bushing measurement with 'X' and 'Y' measurement directions and 'a' and 'b' measurement points. The right diagram shows the big-end bore measurement with 'Front' and 'Rear' measurement directions and 'a' and 'b' measurement points.							
Standard							
Item to be measured		Nominal	Standard		Limit	Roundness	
Connecting rod bushing inside diameter		ϕ 70 [2.76]	70.020 to 70.040 [2.7567 to 2.7575]		70.070[2.7587]	-	
Connecting rod big end bore diameter		ϕ 131 [5.16]	131.000 to 131.025 [5.1575 to 5.1585]		Minimum:130.950[5.1555] Maximum:131.050[5.1594]	0.100 [0.0039]	
Measured value							
Item		Connecting rod bushing inside diameter		Connecting rod big-end bore diameter			
No.	Direction	X	Y	A	B	C	
1	a						
	b						
2	a						
	b						
3	a						
	b						
4	a						
	b						
5	a						
	b						
6	a						
	b						
7	a						
	b						
8	a						
	b						
Remark				Approved by	Checked by	Measured by	

INSPECTION RECORD SHEET

No. 7(1/2)

				SR	
Customer			Engine Model		Date
			Serial No.		
Item	Rocker bushing inside diameter and rocker shaft outside diameter - measure (1/2)			Unit	mm[in.]

Measuring location



Standard

Item to be measured	Nominal	Standard	Limit
Rocker bushing inside diameter	ϕ 36 [1.42]	36.000 to 36.040 [1.4173 to 1.4189]	36.09 [1.4209]
Rocker shaft outside diameter	ϕ 36 [1.42]	35.966 to 35.991 [1.4160 to 1.4170]	35.940 [1.4150]

Measured value

Item		Rocker bushing inside diameter		Rocker shaft outside diameter		Clearance	
No.	Direction	X	Y	X	Y	Maximum	Minimum
1	a						
	b						
2	a						
	b						
3	a						
	b						
4	a						
	b						
5	a						
	b						
6	a						
	b						
7	a						
	b						
8	a						
	b						

Remark

Approved by Checked by Measured by

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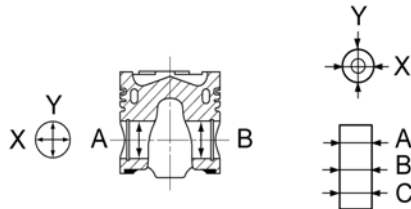
				SR													
Customer		Engine Model		Date													
		Serial No.															
Item	Rocker bushing inside diameter and rocker shaft outside diameter - measure (2/2)			Unit	mm[in.]												
Measuring location		Standard															
		<table border="1"> <thead> <tr> <th>Item to be measured</th> <th>Nominal</th> <th>Standard</th> <th>Limit</th> </tr> </thead> <tbody> <tr> <td>Rocker bushing inside diameter</td> <td>φ 36 [1.42]</td> <td>36.000 to 36.040 [1.4173 to 1.4189]</td> <td>36.09 [1.4209]</td> </tr> <tr> <td>Rocker shaft outside diameter</td> <td>φ 36 [1.42]</td> <td>35.966 to 35.991 [1.4160 to 1.4170]</td> <td>35.940 [1.4150]</td> </tr> </tbody> </table>				Item to be measured	Nominal	Standard	Limit	Rocker bushing inside diameter	φ 36 [1.42]	36.000 to 36.040 [1.4173 to 1.4189]	36.09 [1.4209]	Rocker shaft outside diameter	φ 36 [1.42]	35.966 to 35.991 [1.4160 to 1.4170]	35.940 [1.4150]
Item to be measured	Nominal	Standard	Limit														
Rocker bushing inside diameter	φ 36 [1.42]	36.000 to 36.040 [1.4173 to 1.4189]	36.09 [1.4209]														
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Measured value																	
Item		Rocker bushing inside diameter		Rocker shaft outside diameter		Clearance											
No.	Direction	X	Y	X	Y	Maximum	Minimum										
9	a																
	b																
10	a																
	b																
11	a																
	b																
12	a																
	b																
13	a																
	b																
14	a																
	b																
15	a																
	b																
16	a																
	b																
Remark					Approved by		Checked by	Measured by									

INSPECTION RECORD SHEET

No. 8(1/2)

		SR	
Customer		Engine Model	
		Serial No.	
Item	Piston pin bore inside diameter and piston pin outside diameter - measure (1/2)	Unit	mm[in.]

Measuring location



Standard

Item to be measured	Nominal	Standard	Limit
Piston pin bore inside diameter	$\phi 70$ [2.76]	70.002 to 70.015 [2.7560 to 2.7565]	70.040 [2.7575]
Piston pin outside diameter	$\phi 70$ [2.76]	69.987 to 70.000 [2.7554 to 2.7559]	69.970 [2.7547]

Measured value

Item		Piston pin bore diameter		Piston pin outside diameter		Clearance	
No.	Location	X	Y	X	Y	Maximum	Minimum
1	A						
	B						
	C	-	-			-	-
2	A						
	B						
	C	-	-			-	-
3	A						
	B						
	C	-	-			-	-
4	A						
	B						
	C	-	-			-	-
5	A						
	B						
	C	-	-			-	-
6	A						
	B						
	C	-	-			-	-
7	A						
	B						
	C	-	-			-	-
8	A						
	B						
	C	-	-			-	-

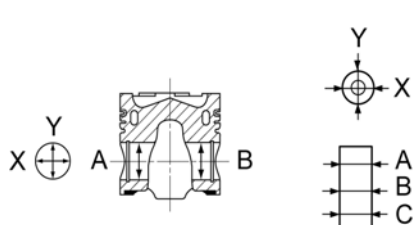
Remark

Approved by

Checked by

Measured by

INSPECTION RECORD SHEET

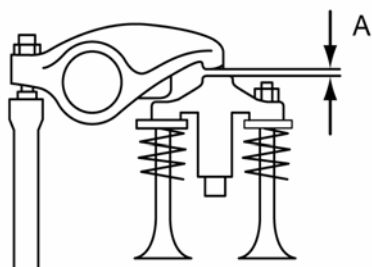
					SR													
Customer			Engine Model			Date												
			Serial No.															
Item	Piston pin bore inside diameter and piston pin outside diameter - measure (2/2)					Unit	mm[in.]											
Measuring location			Standard															
			<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Item to be measured</th> <th>Nominal</th> <th>Standard</th> <th>Limit</th> </tr> </thead> <tbody> <tr> <td>Piston pin bore inside diameter</td> <td>$\phi 70$ [2.76]</td> <td>70.002 to 70.015 [2.7560 to 2.7565]</td> <td>70.040 [2.7575]</td> </tr> <tr> <td>Piston pin outside diameter</td> <td>$\phi 70$ [2.76]</td> <td>69.987 to 70.000 [2.7554 to 2.7559]</td> <td>69.970 [2.7547]</td> </tr> </tbody> </table>				Item to be measured	Nominal	Standard	Limit	Piston pin bore inside diameter	$\phi 70$ [2.76]	70.002 to 70.015 [2.7560 to 2.7565]	70.040 [2.7575]	Piston pin outside diameter	$\phi 70$ [2.76]	69.987 to 70.000 [2.7554 to 2.7559]	69.970 [2.7547]
			Item to be measured	Nominal	Standard	Limit												
Piston pin bore inside diameter	$\phi 70$ [2.76]	70.002 to 70.015 [2.7560 to 2.7565]	70.040 [2.7575]															
Piston pin outside diameter	$\phi 70$ [2.76]	69.987 to 70.000 [2.7554 to 2.7559]	69.970 [2.7547]															
Measured value																		
Item		Piston pin bore diameter		Piston pin outside diameter		Clearance												
No.	Location	X	Y	X	Y	Maximum	Minimum											
9	A																	
	B																	
	C	-	-			-	-											
10	A																	
	B																	
	C	-	-			-	-											
11	A																	
	B																	
	C	-	-			-	-											
12	A																	
	B																	
	C	-	-			-	-											
13	A																	
	B																	
	C	-	-			-	-											
14	A																	
	B																	
	C	-	-			-	-											
15	A																	
	B																	
	C	-	-			-	-											
16	A																	
	B																	
	C	-	-			-	-											
Remark					Approved by	Checked by	Measured by											

INSPECTION RECORD SHEET

No. 9

				SR	
Customer			Engine Model		Date
			Serial No.		
Item	Valve clearance - measure				Unit mm[in.]

Measuring location



Standard

Item to be measured		Standard
Valve clearance (A)	Inlet	0.6[0.024]
	Exhaust	0.8[0.031]

Measured value

No.		Valve clearance		No.		Valve clearance	
		Inlet	Exhaust			Inlet	Exhaust
1	Before adjustment			9	Before adjustment		
	After adjustment				After adjustment		
	adjustment				adjustment		
2	Before adjustment			10	Before adjustment		
	After adjustment				After adjustment		
	adjustment				adjustment		
3	Before adjustment			11	Before adjustment		
	After adjustment				After adjustment		
	adjustment				adjustment		
4	Before adjustment			12	Before adjustment		
	After adjustment				After adjustment		
	adjustment				adjustment		
5	Before adjustment			13	Before adjustment		
	After adjustment				After adjustment		
	adjustment				adjustment		
6	Before adjustment			14	Before adjustment		
	After adjustment				After adjustment		
	adjustment				adjustment		
7	Before adjustment			15	Before adjustment		
	After adjustment				After adjustment		
	adjustment				adjustment		
8	Before adjustment			16	Before adjustment		
	After adjustment				After adjustment		
	adjustment				adjustment		

Remark

Approved by

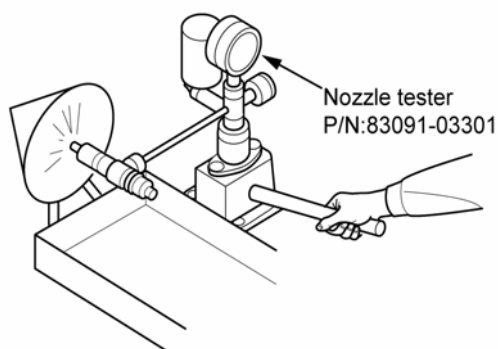
Checked by

Measured by

INSPECTION RECORD SHEET

				SR	
Customer			Engine Model		
			Serial No.		
Date					
Item	Fuel injection nozzle injection pressure - measure				Unit
					MPa{kgf/cm ² }[psi]

Measuring location



Standard

Item to be measured			Part No.	Nominal	Standard
Valve opening pressure	S6R,S6R2	Screw adjust type	37560-22010	34.32 {350} [4978]	34.32 to 34.81 {350 to 355} [4978 to 5049]
			37560-35000		
			37560-39000		
			37561-44000		
			37860-06000	30.40 {310}[4409]	30.40 to 30.89 {310 to 315}[4409 to 4480]
			37760-14001		
			37760-22001		
	S12R,S16R	Shim adjust type	37560-32000	34.32 {350}[4978]	33.83 to 35.79 {345 to 365}[4907 to 5191]
		Screw adjust type	-	34.32 {350}[4978]	34.32 to 34.81 {350 to 355}[4978 to 5049]

Measured value

No.	Injection pressure	Service hours (h)	Injection pressure	No.	Injection pressure	Service hours (h)	Injection pressure
	Before adjustment		After adjustment		Before adjustment		After adjustment
1				9			
2				10			
3				11			
4				12			
5				13			
6				14			
7				15			
8				16			

Remark

Approved by

Checked by

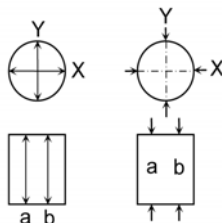
Measured by

INSPECTION RECORD SHEET

No. 11

			SR		
Customer		Engine Model		Date	
		Serial No.			
Item	Camshaft bushing inside diameter and camshaft journal outside diameter (right side) - measure			Unit	mm[in.]

Measuring location



Standard

Item to be measured		Nominal	Standard	Limit
Camshaft bushing inside diameter	S6R,S6R2	$\phi 84[3.31]$	84.020 to 84.095 [3.3079 to 3.3108]	84.100 [3.3110]
	S12R,S16R	$\phi 84[3.31]$	84.000 to 84.035 [3.3071 to 3.3085]	84.100 [3.3110]
Camshaft journal bore outside diameter		$\phi 84[3.31]$	83.920 to 83.940 [3.3039 to 3.3047]	83.870 [3.3020]

Measured value

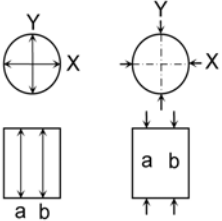
Item		Camshaft bushing inside diameter		Camshaft journal outside diameter		Clearance	
No.	Location	X	Y	X	Y	Minimum	Maximum
1	a						
	b						
2	a						
	b						
3	a						
	b						
4	a						
	b						
5	a						
	b						
6	a						
	b						
7	a						
	b						
8	a						
	b						
9	a						
	b						

Remark

Approved by Checked by Measured by

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INSPECTION RECORD SHEET

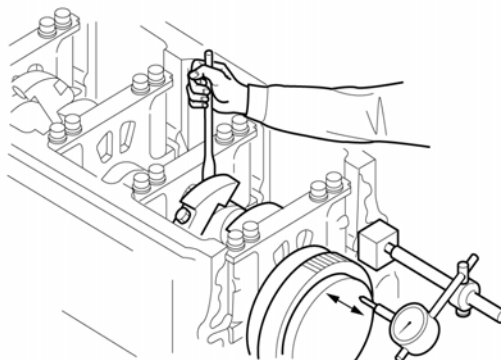
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INSPECTION RECORD SHEET

No.13

				SR	
Customer			Engine Model		Date
			Serial No.		
Item	Crankshaft end play - measure				Unit mm[in.]

Measuring location



Standard

Item to be measured		Part No.	Standard	Limit
Crankshaft end play	S6R,S6R2	-	0.300 to 0.520 [0.0118 to 0.0205]	0.600 [0.0236]
	S12R	-	0.200 to 0.400 [0.0079 to 0.0157]	0.500 [0.0197]
	S16R	37820-10103	0.200 to 0.400 [0.0079 to 0.0157]	0.500 [0.0197]
		37820-03100	0.200 to 0.420 [0.0079 to 0.0165]	0.500 [0.0197]

Measured value

Before disassembly	After reassembly

Remark	Approved by	Checked by	Measured by