

**MITSUBISHI  
DIESEL ENGINE**

**S16R  
S16R2**

# **SERVICE MANUAL**

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# 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 disassembly, inspection, repair and assembly works 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.

### Brief Summary of the System Used in Compiling This Service Manual:

- (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 as [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.



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



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



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



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 or standard performance of engine. The values are rounded off for the inspection job, and do not necessarily conform to the design values.

### Limit value

means the 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.)
- ♦SDS: 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 the conversion, the following rates are used.

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

## Safety Precautions

### Fire and Explosion Protection


**WARNING**

#### Keep Flames Away

Do not use flames near the engine (in the engine room). The flame is dangerous as it ignites 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.

#### Tidy Up Around the Engine

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 accumulated 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.

#### Be Alert for Leaking Fuel, Oil, or Exhaust Gas

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 result 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.

#### Prevention of Electric 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



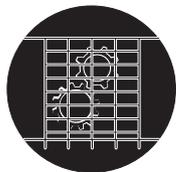
against a fire or an accident. Provide the contact person and means of communication in case of emergency.

## Stay Away From Rotating and Moving Parts

### WARNING

#### 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 around 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 During Operation

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 the 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 Engine Before Inspection/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 Turning Tool Back in Place 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 a damage to the engine, but also lead to a personal injury.

## Prevention of Exhaust Gas Poisoning

### WARNING

#### Pay Attention to Ventilation When Operating 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 sometimes contains harmful components. Operating the engine in an ill-ventilated area can cause gas poisoning.



## Prevention 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.



## Fall Prevention

### WARNING

#### Lift Engine Carefully

Use slings or wire ropes strong enough to lift the load considering the engine weight. To lift the engine, attach 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, consider 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 part directly, place a cloth or other soft pad to avoid damage to the part and wire rope. Remove the engine part if necessary. Remove the engine part if necessary.

#### 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 Coolant

### WARNING

#### Use Specified Fuel, Engine Oil and Coolant Only

Use the fuel, oil and coolant specified in this manual only, and handle them carefully. Use of material other than the specified one, or improper handling may cause various engine defects and malfunctions. Get the SDS issued from the fuel, oil and coolant suppliers, and follow the directions in the SDS for proper handling.

#### Be Careful with Coolant

When handling coolant, wear rubber gloves and a protective face mask. If the coolant contacts your skin, or get into your eyes or mouth, it may cause injury of skin or eyes, or poisoning. If coolant is accidentally swallowed, induce vomiting immediately and seek medical attention. If coolant enters your eyes, flush them immediately with plenty of water and seek medical attention. If coolant contacts your skin or clothing, wash it away immediately with plenty of water. Keep flames away from coolant. Coolant can catch flames and cause a fire. Drained coolant is a hazardous material. Do not discard it in an unauthorized procedure. Practice the applicable law and regulations when discard drained coolant.

#### Proper Procedure to Discard Waste Oil and Coolant

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

## Burn Protection

### 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 scald, 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

Refill the coolant after the coolant temperature drops to a room temperature. Replacement job immediately after the engine stop may cause burns.

#### Do Not Remove Heat Shields

The exhaust system, which becomes extremely hot while the engine is running, 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.

#### Burn Prevention 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 Safety Precautions

### CAUTION

#### Be Careful When Handling 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 cables 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 coolant 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 When Starting After an Abnormal Stop

If the engine stops abnormally, do not restart the engine immediately. If the engine stops or is stopped, inspect the engine to clarify the cause of the defect and correct the cause 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 Precautions



### Do Not Tamper

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

### Performance of Pre-Operation Inspection and Periodic Inspections

Conduct the daily inspection and periodic 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, a face shield, safety shoes, a dust mask, gloves, ear plugs and other protective gears as needed. When using compressed air, wear ear plugs, safety goggles, a hard hat, gloves and other necessary protective gears. Works without wearing proper protective gears may result in serious injury.

### Never Break the Seals

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

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

### Check the Engine After Operation

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

### Engine Break-in

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 Operation

Start the engine and warm it up at rated speed and no load. Start the work after the coolant temperature rises. 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. Carbon build-up in the cylinders and incomplete combustion may result.

### 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 Stopping

Cool down the engine for 5 to 6 minutes (rated speed, no load) before stopping. Stopping the engine immediately after a 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.

### Prohibition of Continuous 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 a continuous low load operation, run the engine at a load of 50% or higher for 30 minutes or more to prevent carbon from accumulating.

**Do Not Splash Water on Engine**

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.

**Use Care to Maintain the Air Cleaner or Pre-cleaner**

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 the maintenance when the alarm is given.

**Obey 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 Continuously**

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**

Do Not Turn Off the Battery Switch During Operation. If the battery switch is turned OFF when the engine is running, not only various indicators will stop working but also the diodes and transistors in the starter can be damaged.

**Engine Transportation Precautions**

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 Spray**

Do not touch fuel jet leaked or sprayed from the high pressure injection pipe. Fuel in the fuel injection pipe is under 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 your MHIET dealer.



Common 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 the safety cautions in this manual does not cover all potential hazards that could occur during maintenance and inspection work. During maintenance and inspection work, follow the instructions in this manual and keep the following in mind.

### Points on Disassembling

- ♦Use correct tools and instruments. Otherwise, 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 or workbench to place disassembled parts as required, and obey the disassembly procedure 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 good order 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 disassembly or cleaning. Do not miss the chance to find symptoms which cannot be found after disassembly or cleaning.
- ♦Pay attention to the safety, especially for the balancing of disassembled parts and carrying of heavy parts. (Get the 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 on 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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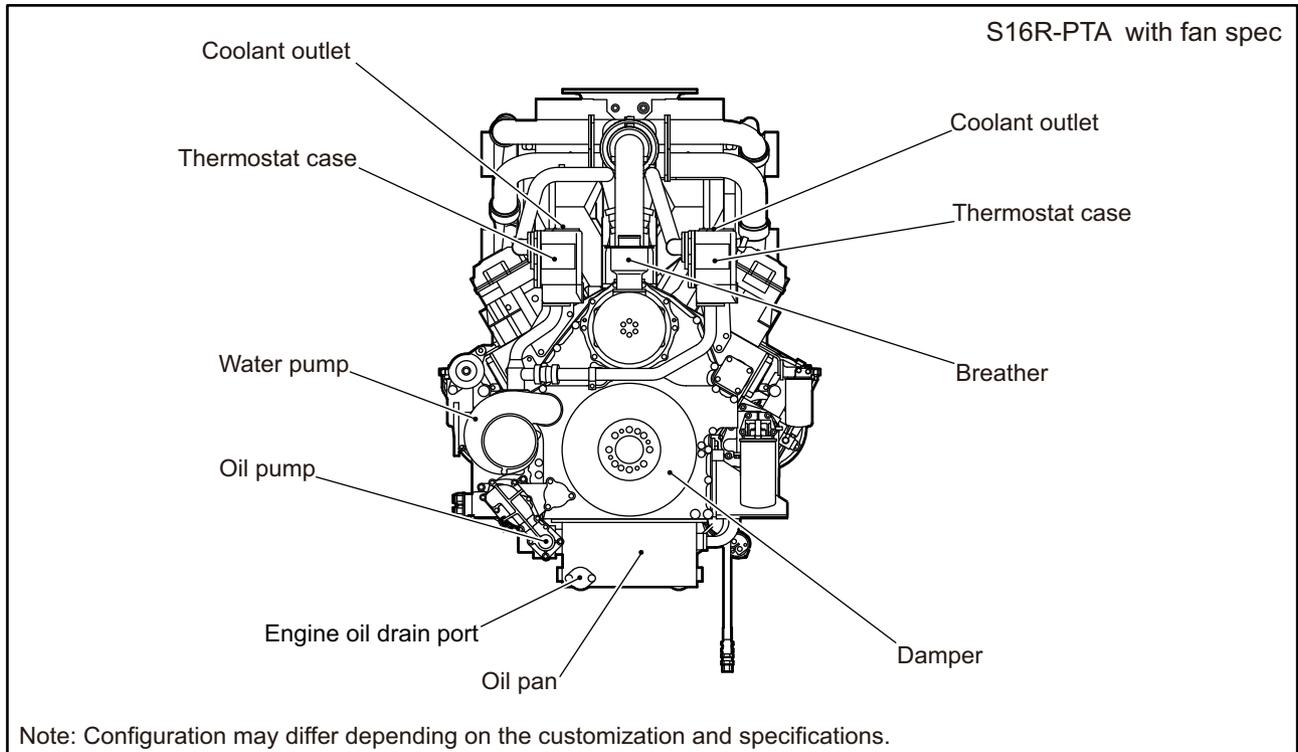
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# Chapter 1 GENERAL

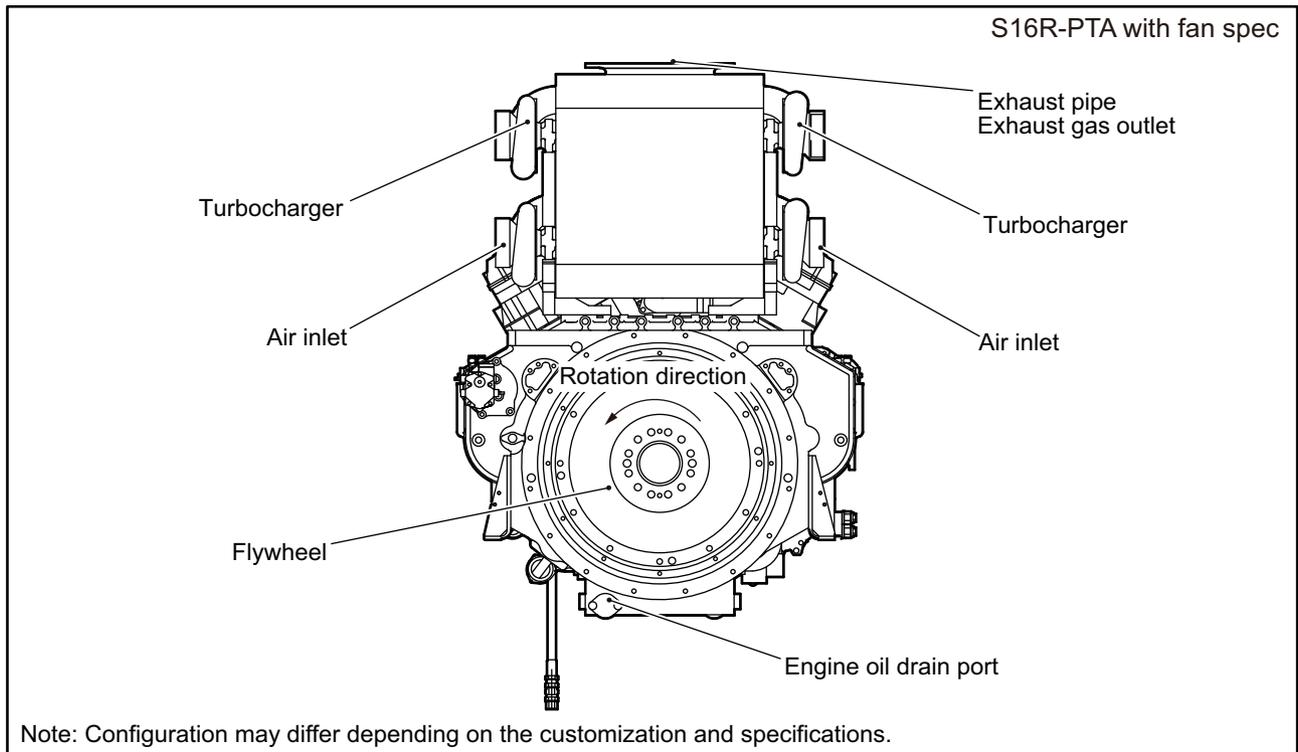
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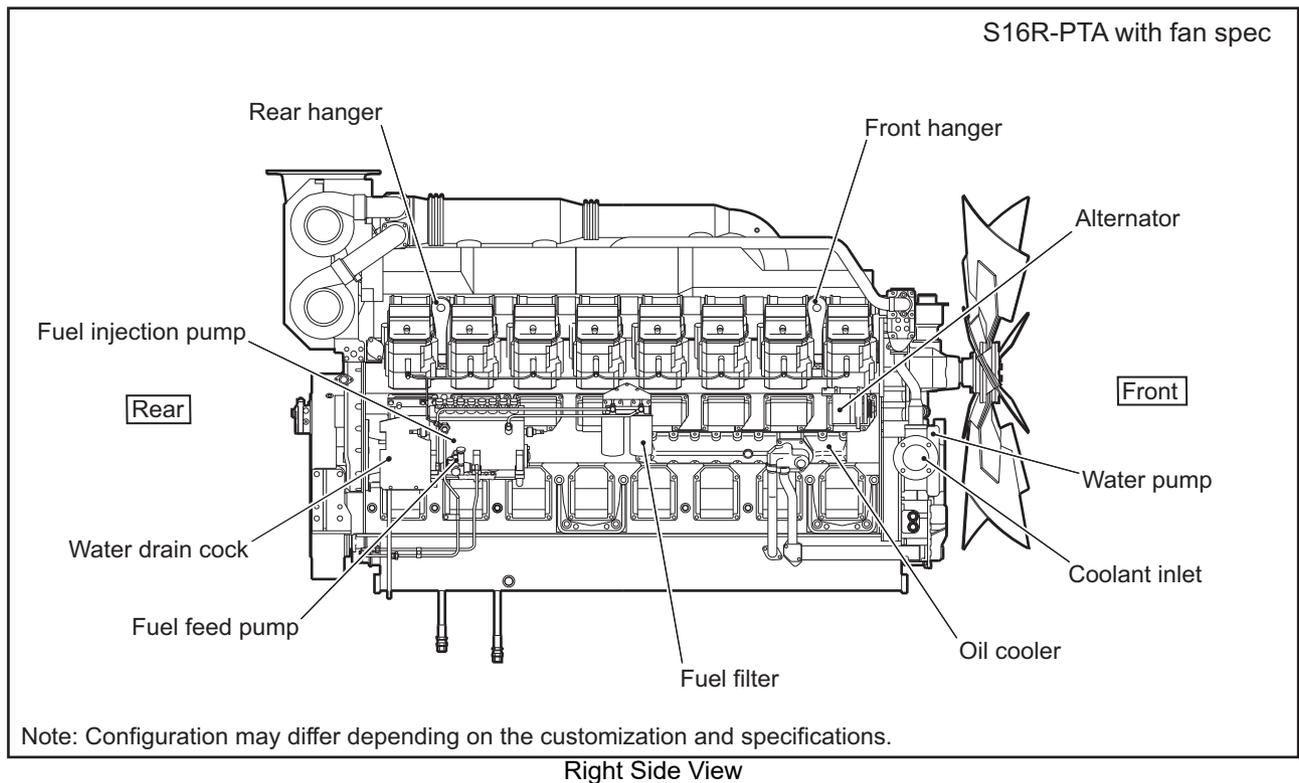
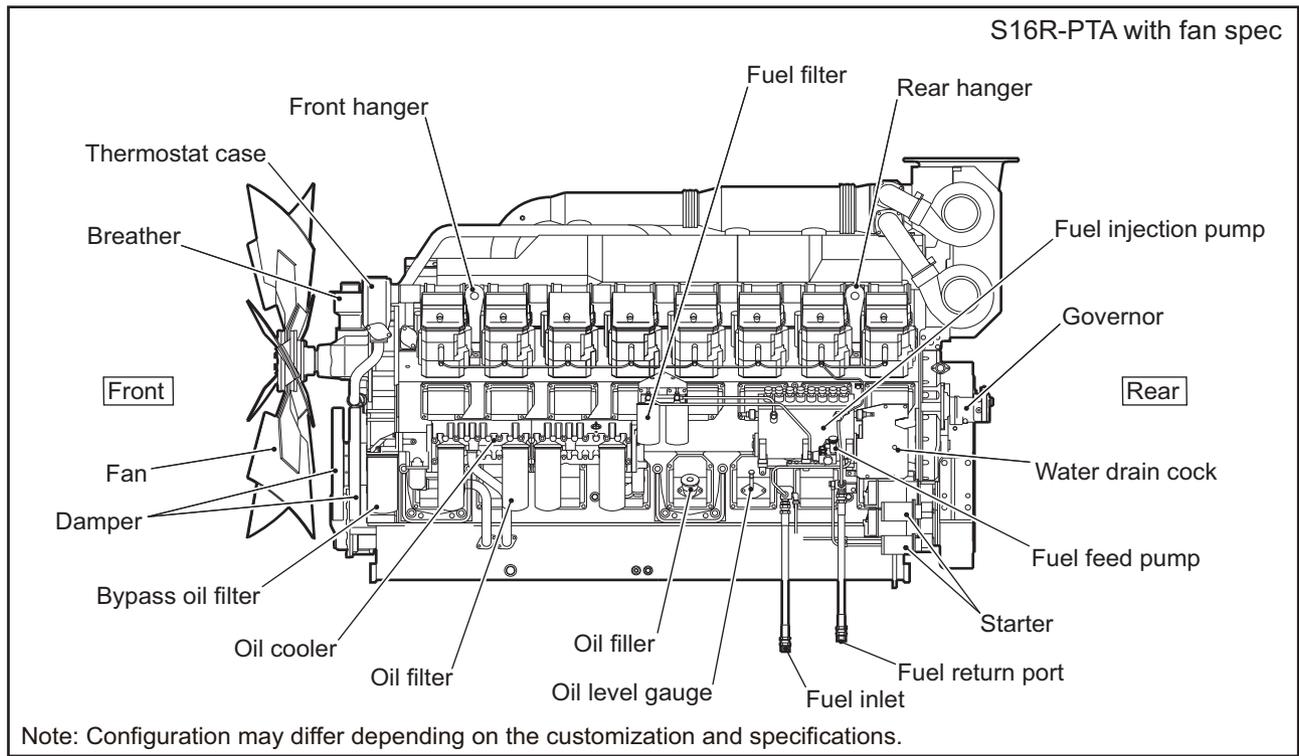
1. External View



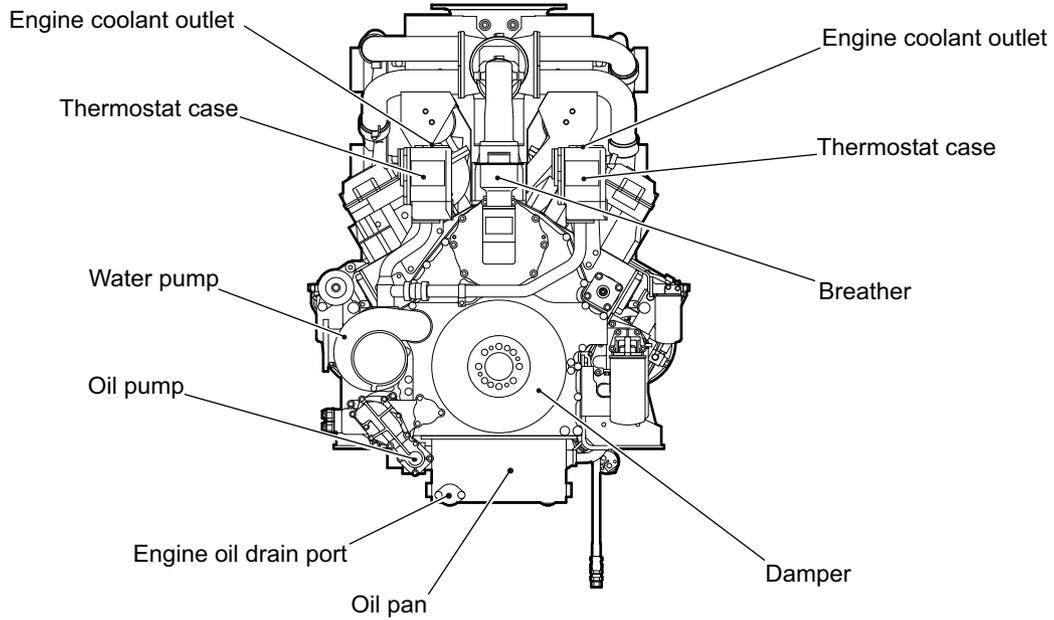
Engine Front View



Engine Rear View



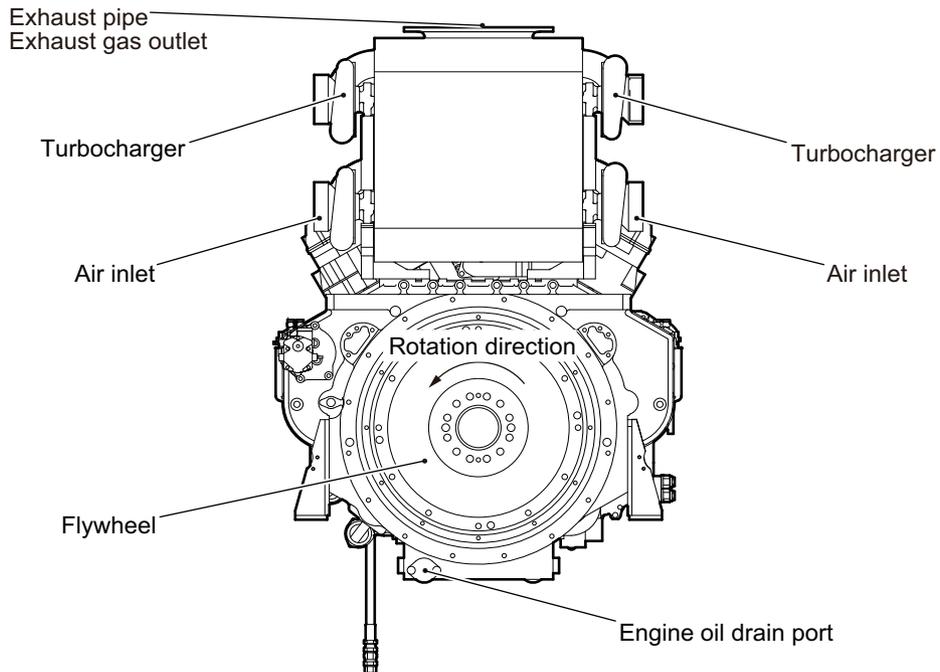
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Note: Configuration may differ depending on the customization and specifications.

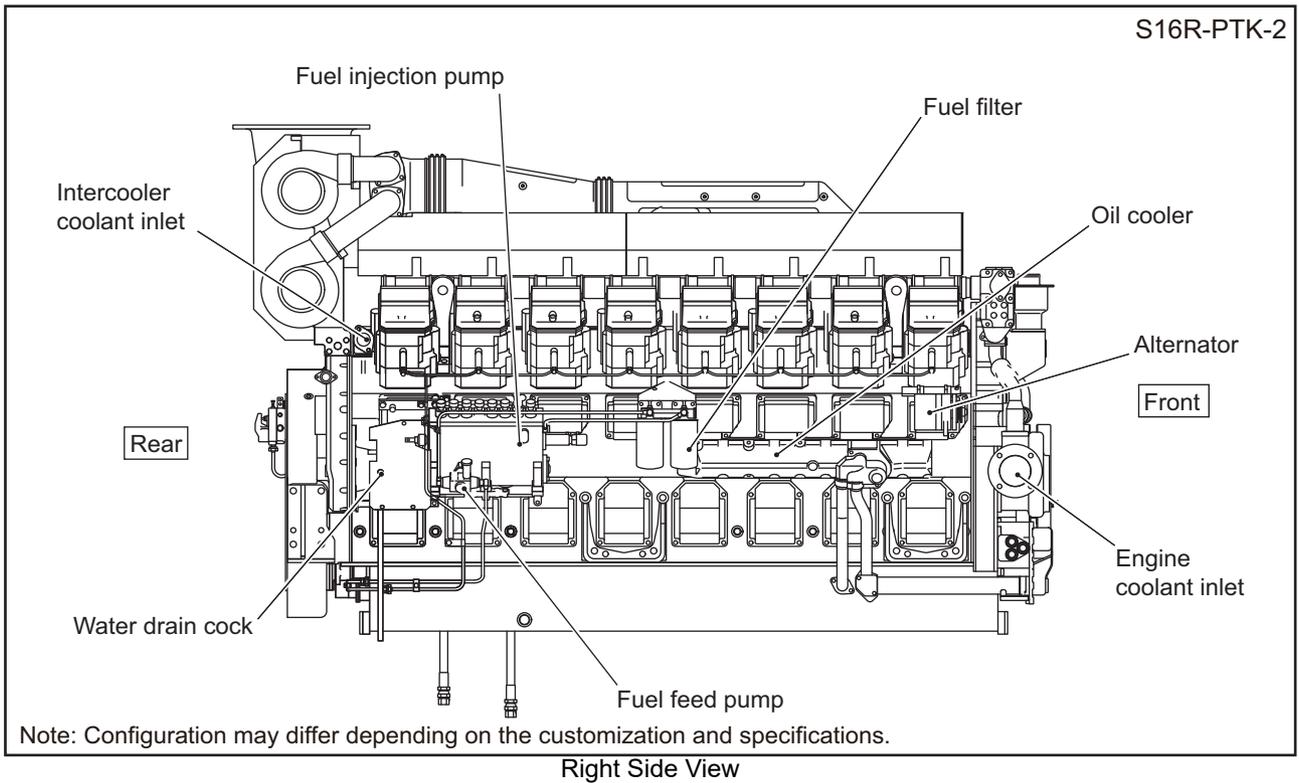
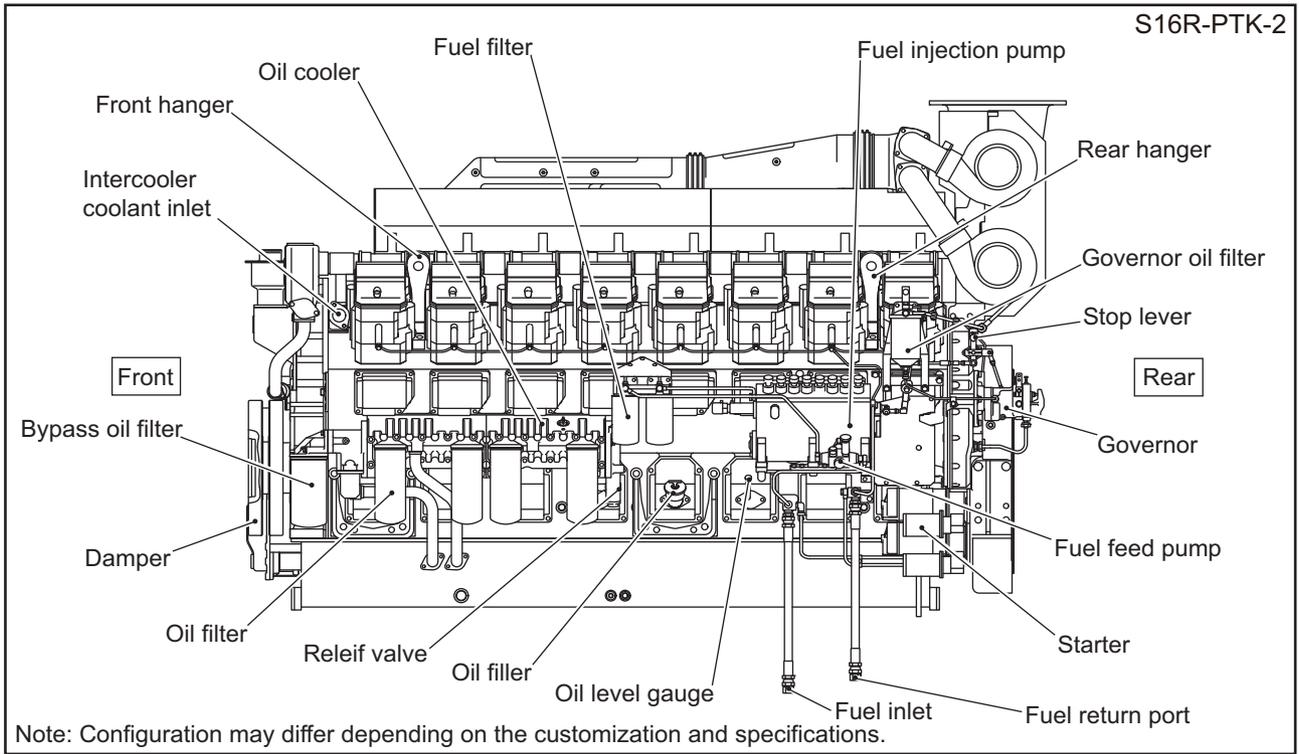
Engine Front View

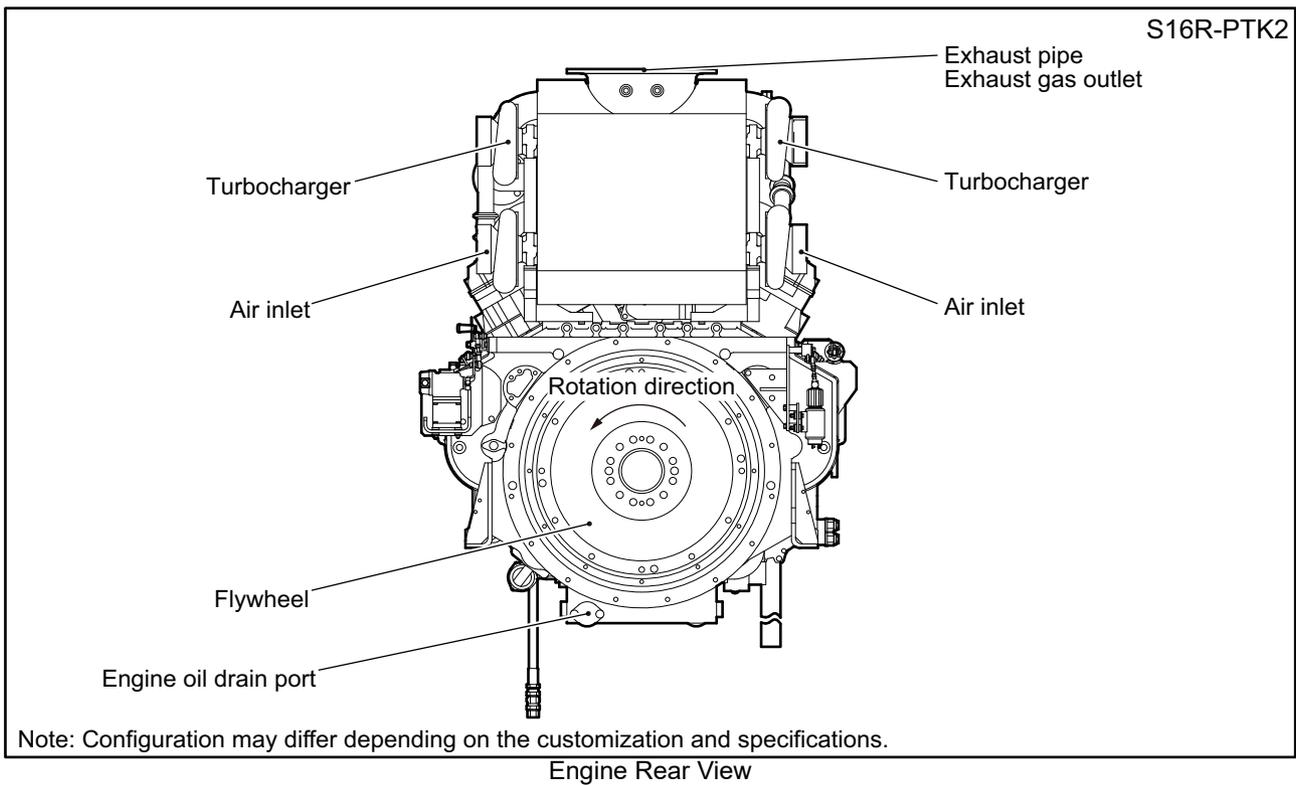
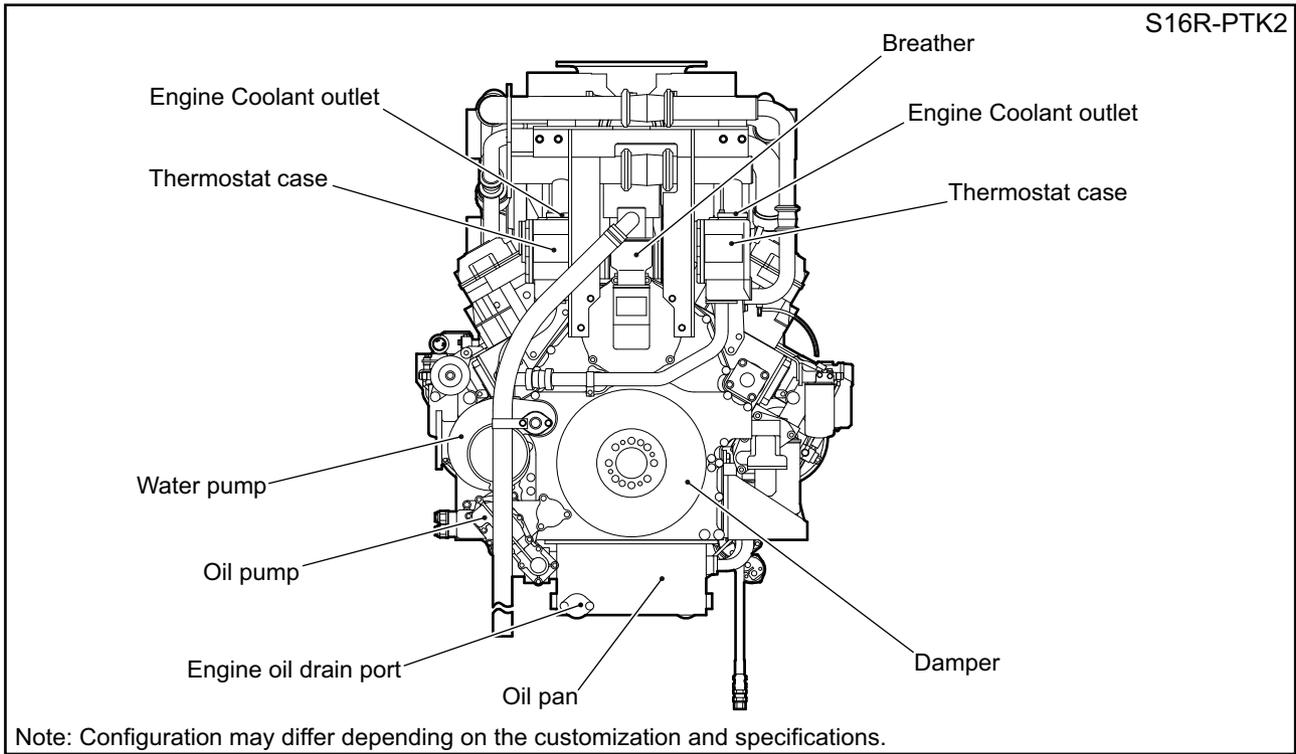
S16R-PTK-2

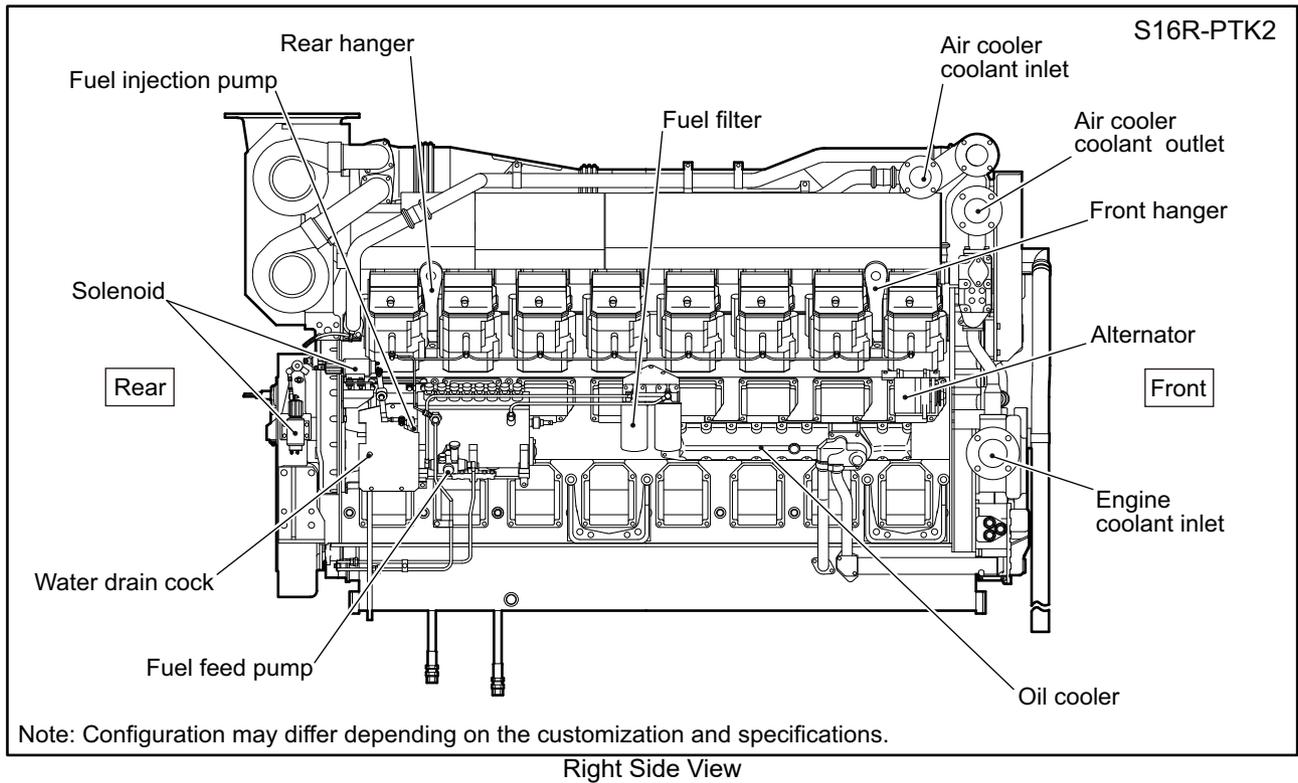
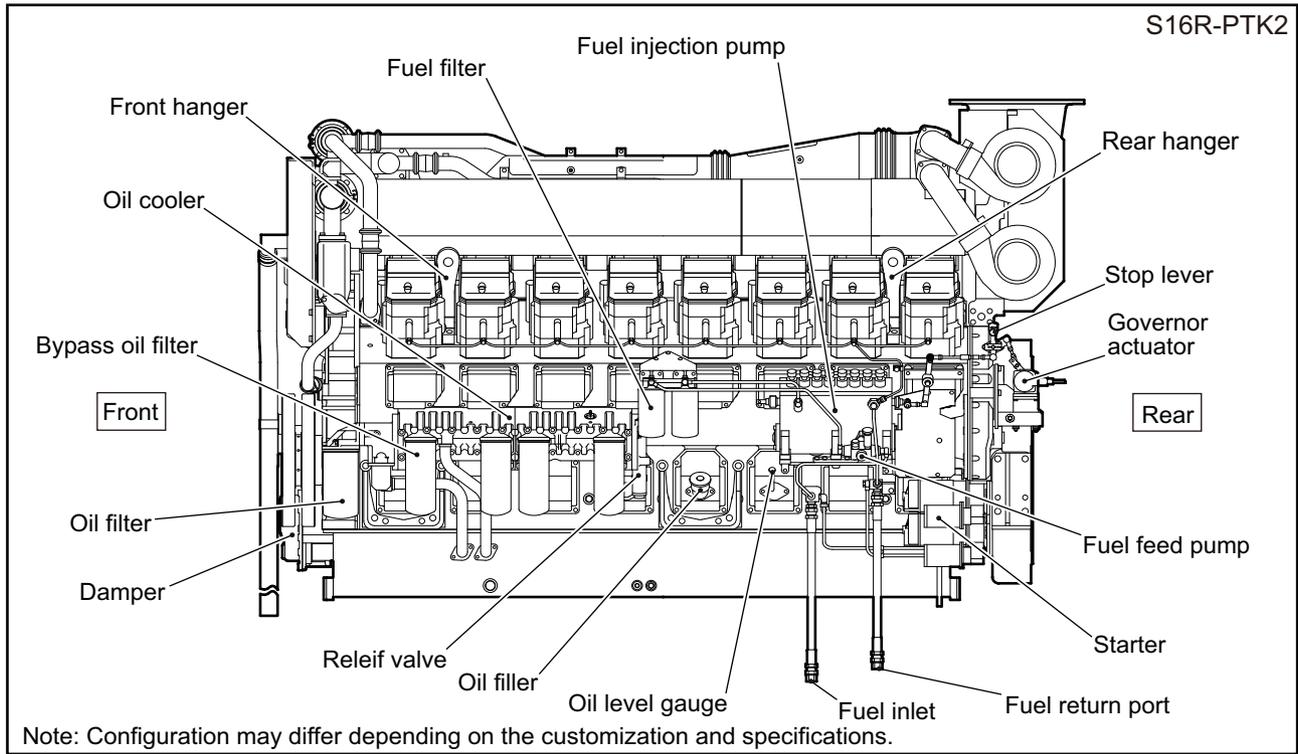


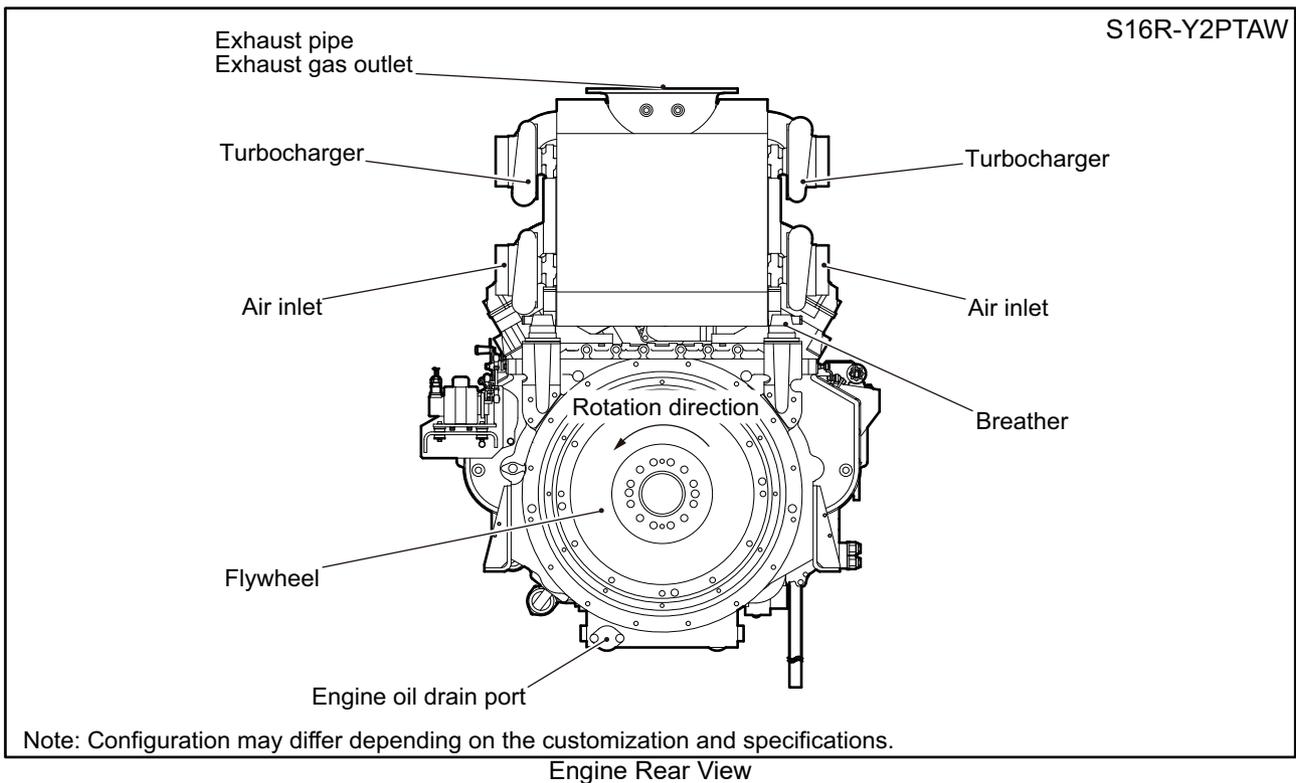
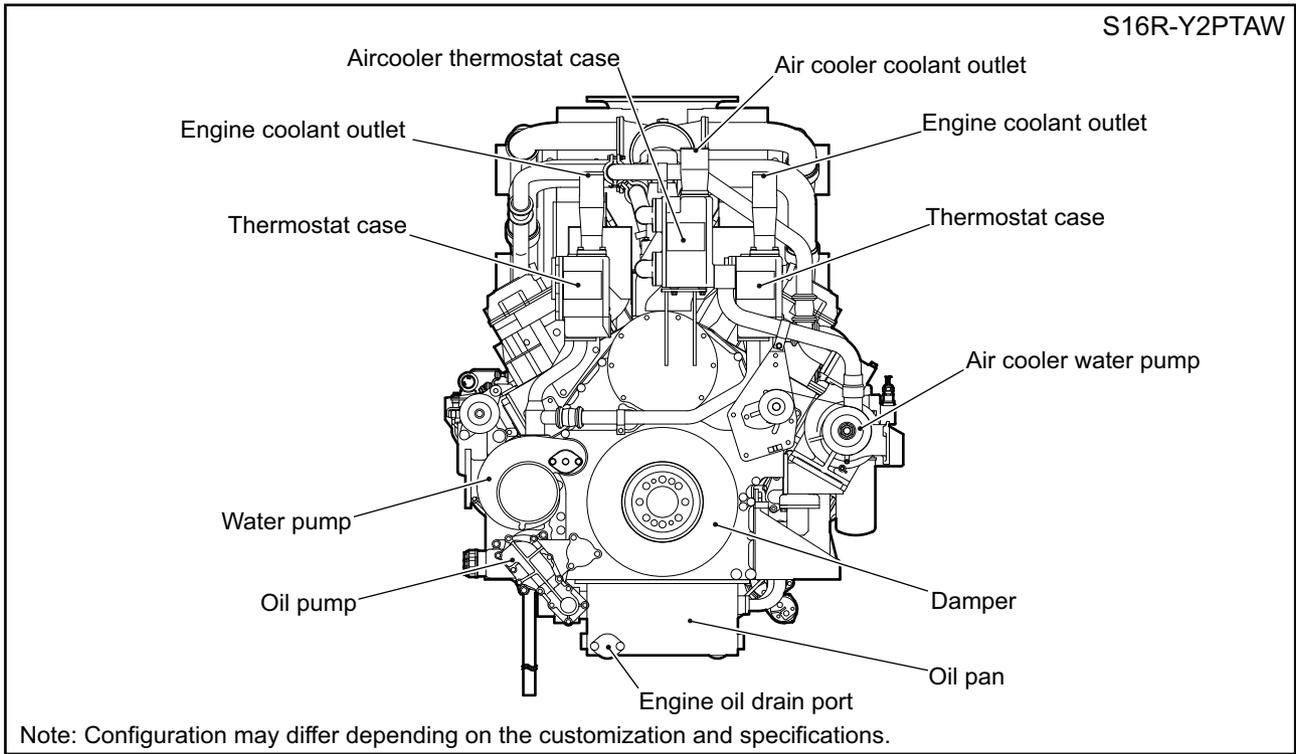
Note: Configuration may differ depending on the customization and specifications.

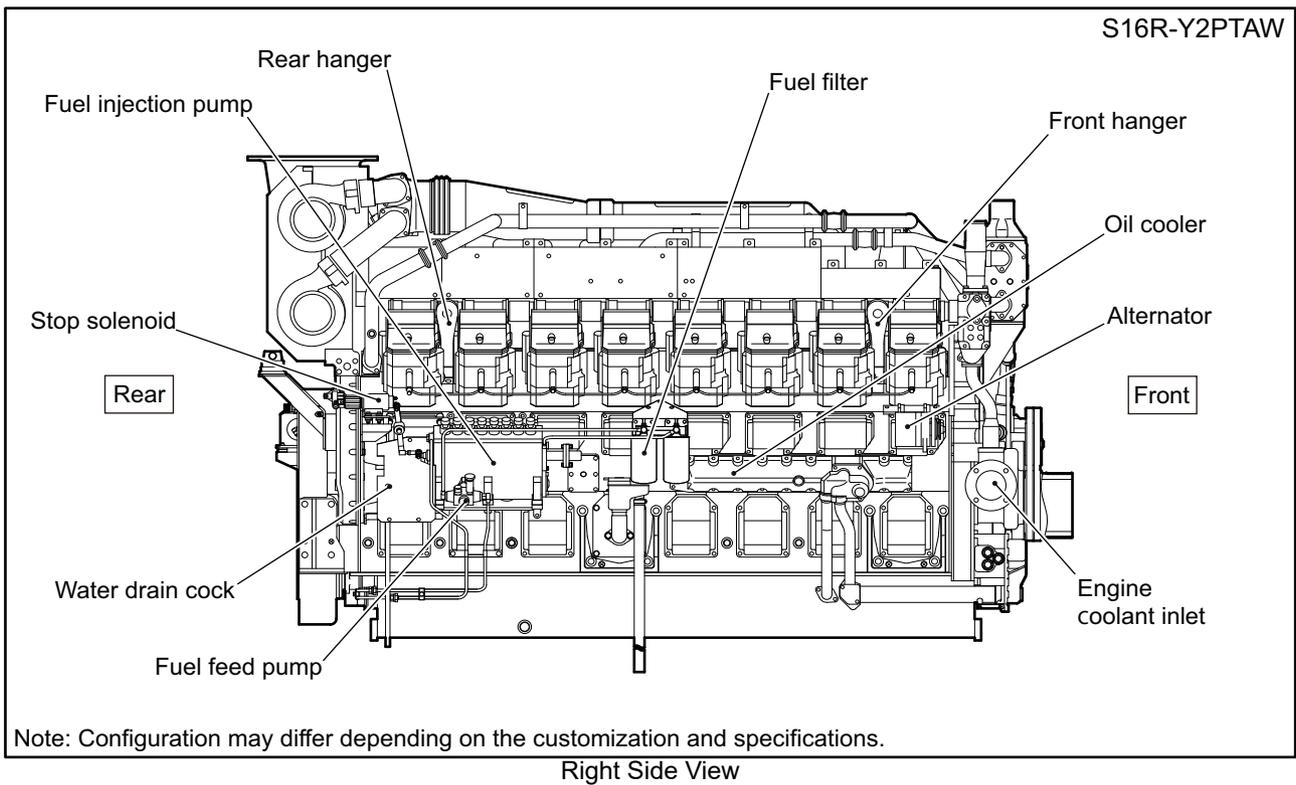
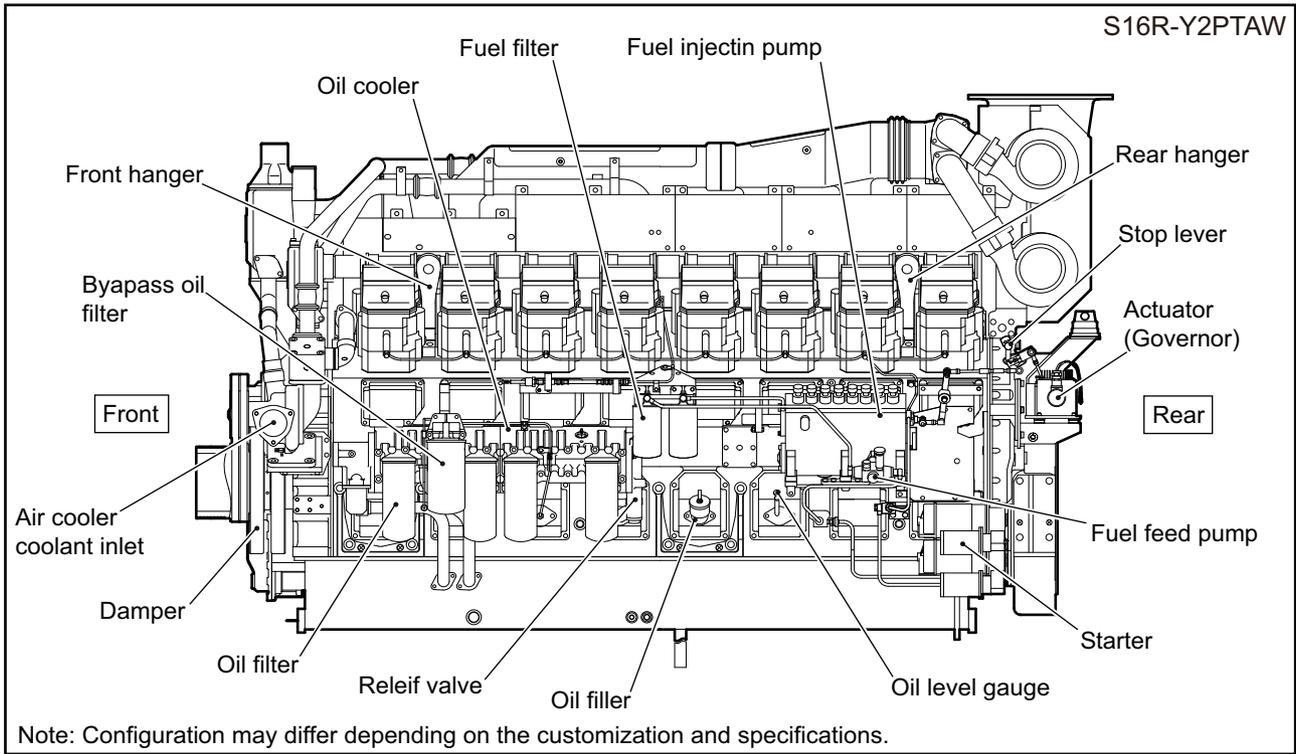
Engine Rear View

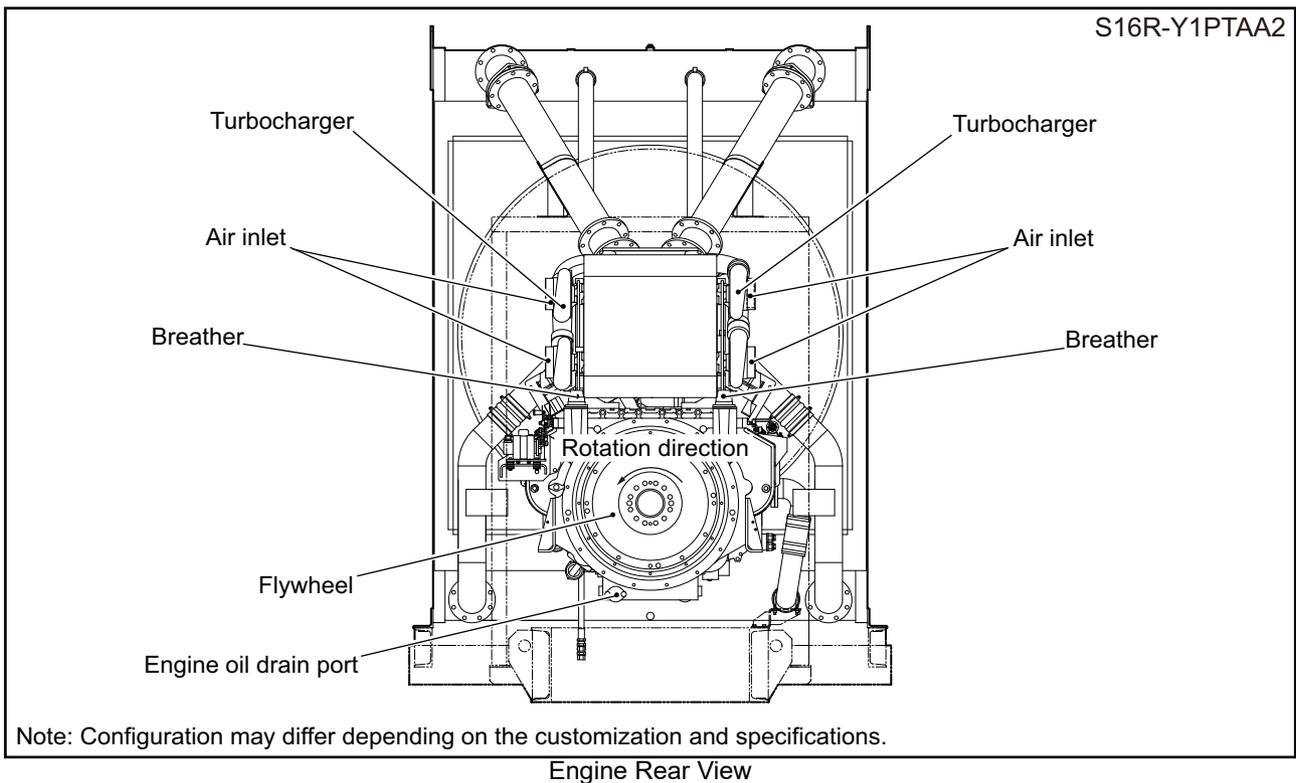
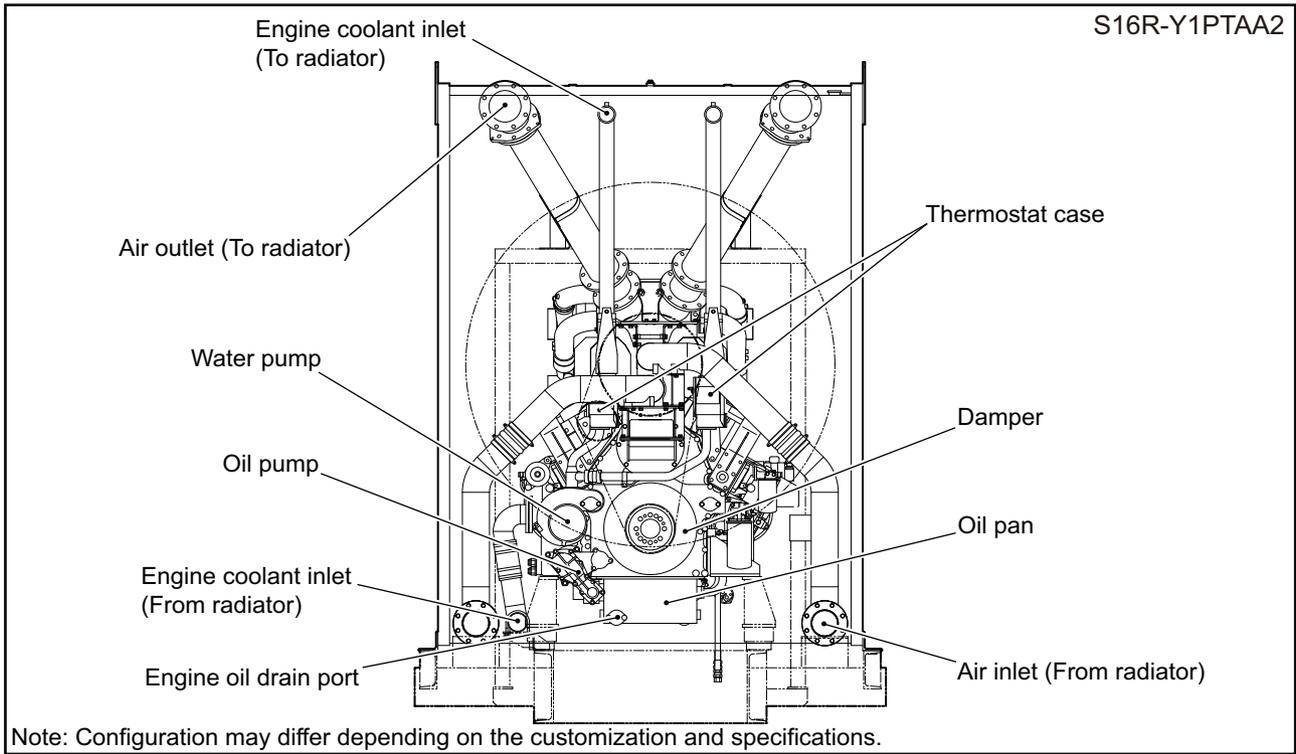


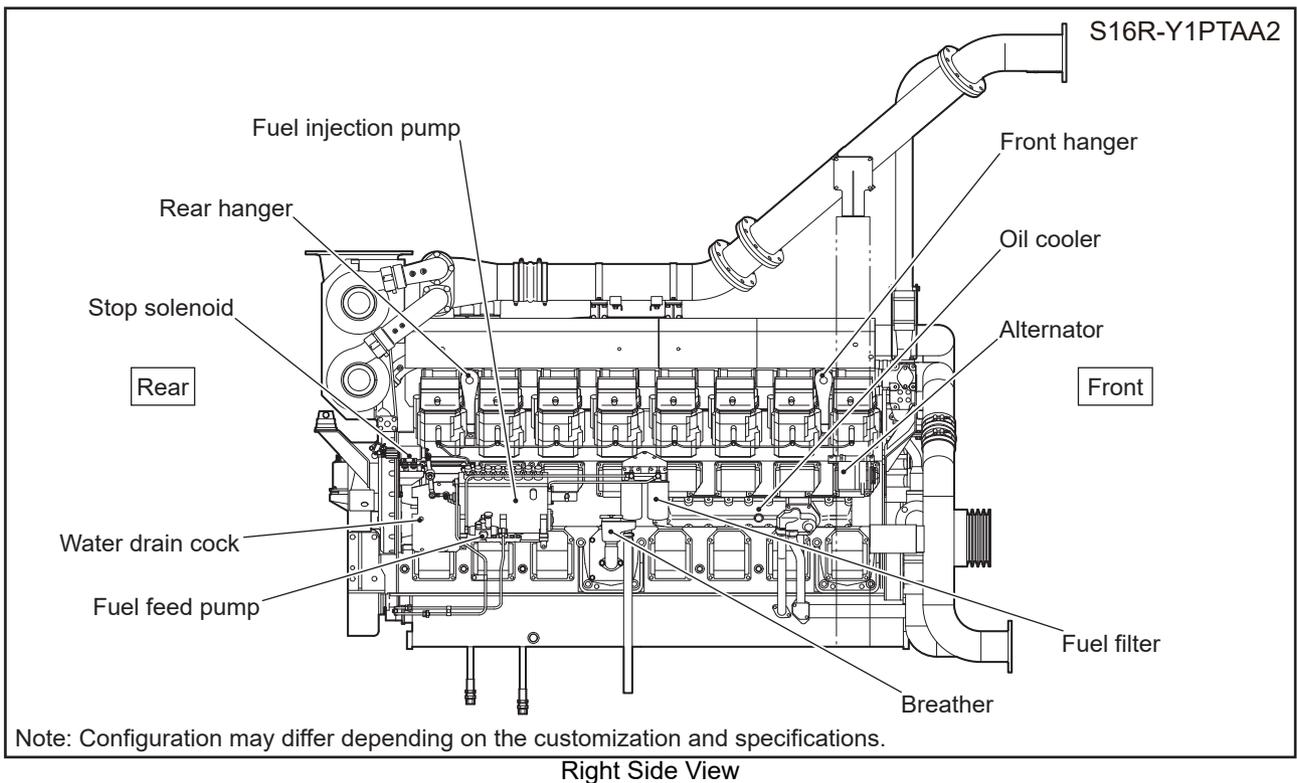
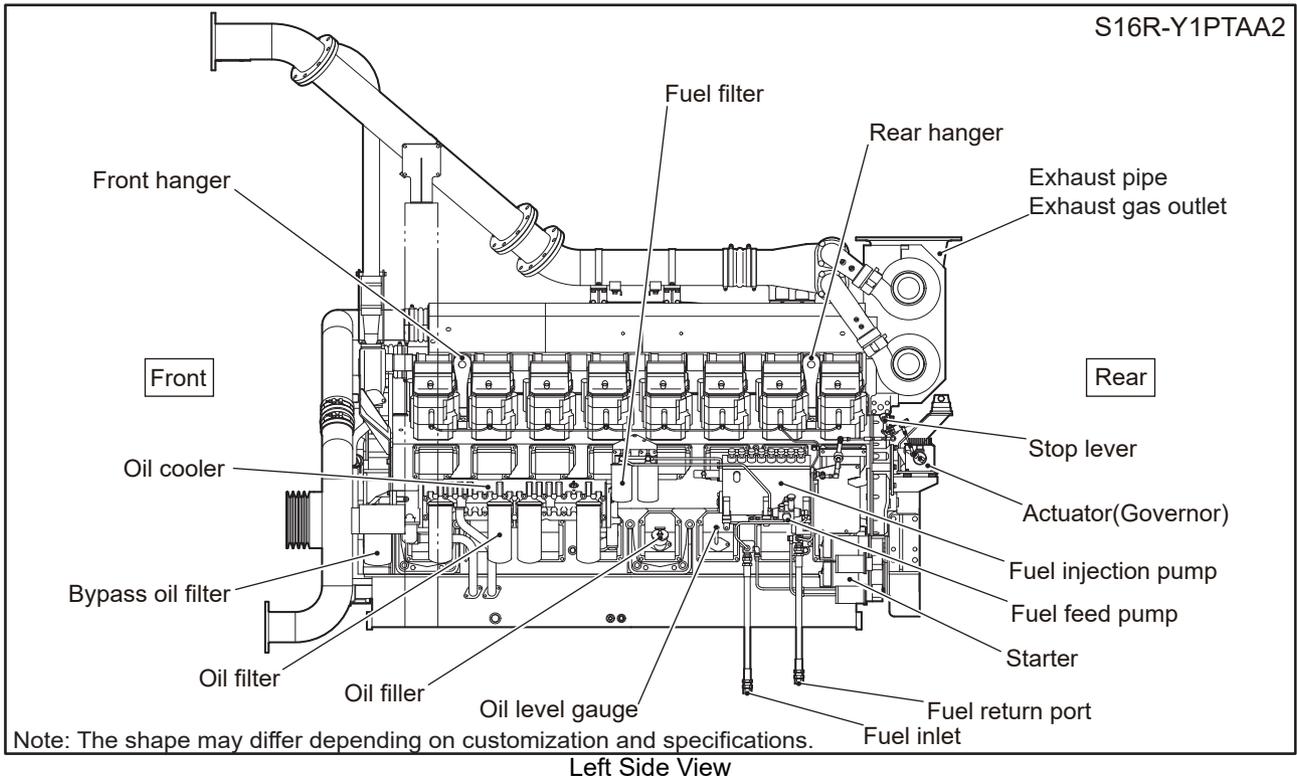




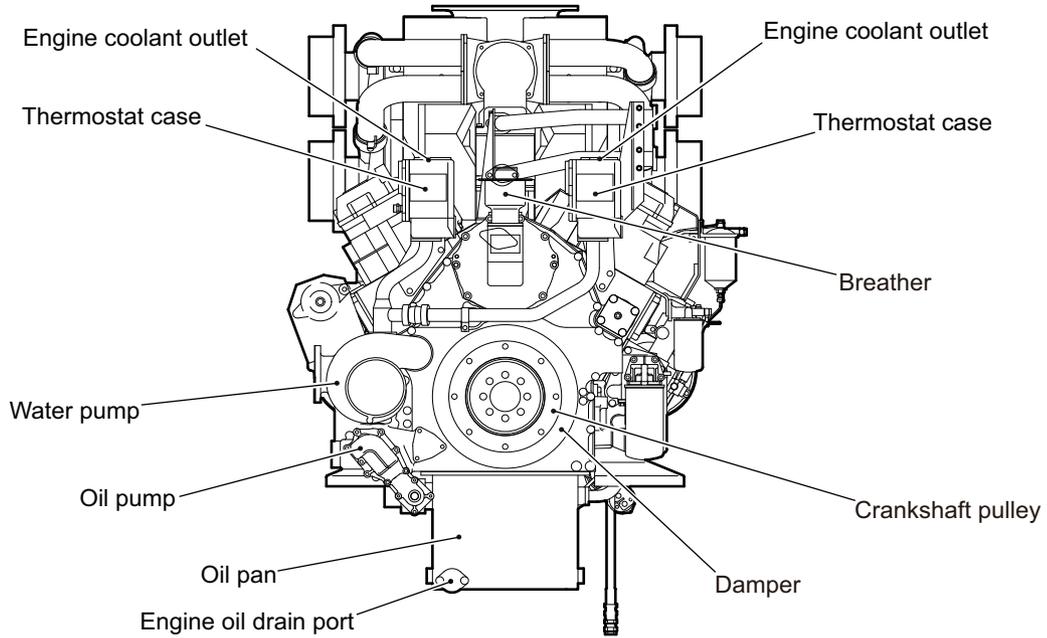








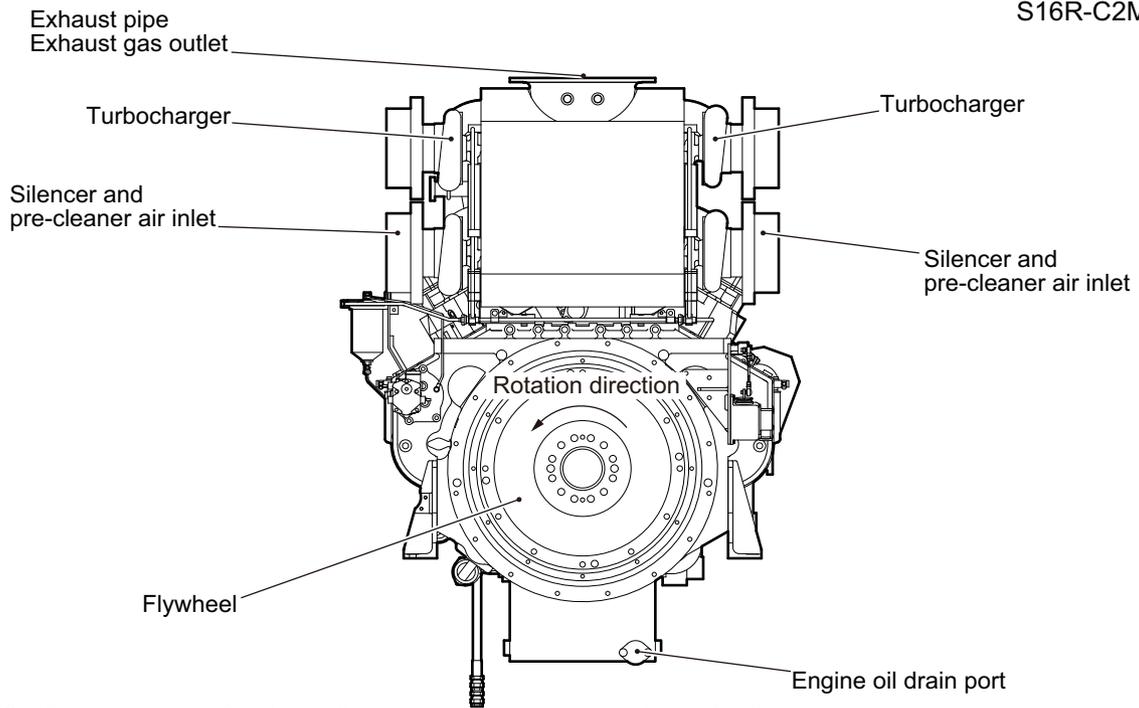
S16R-C2MPTK



Note: Configuration may differ depending on the customization and specifications.

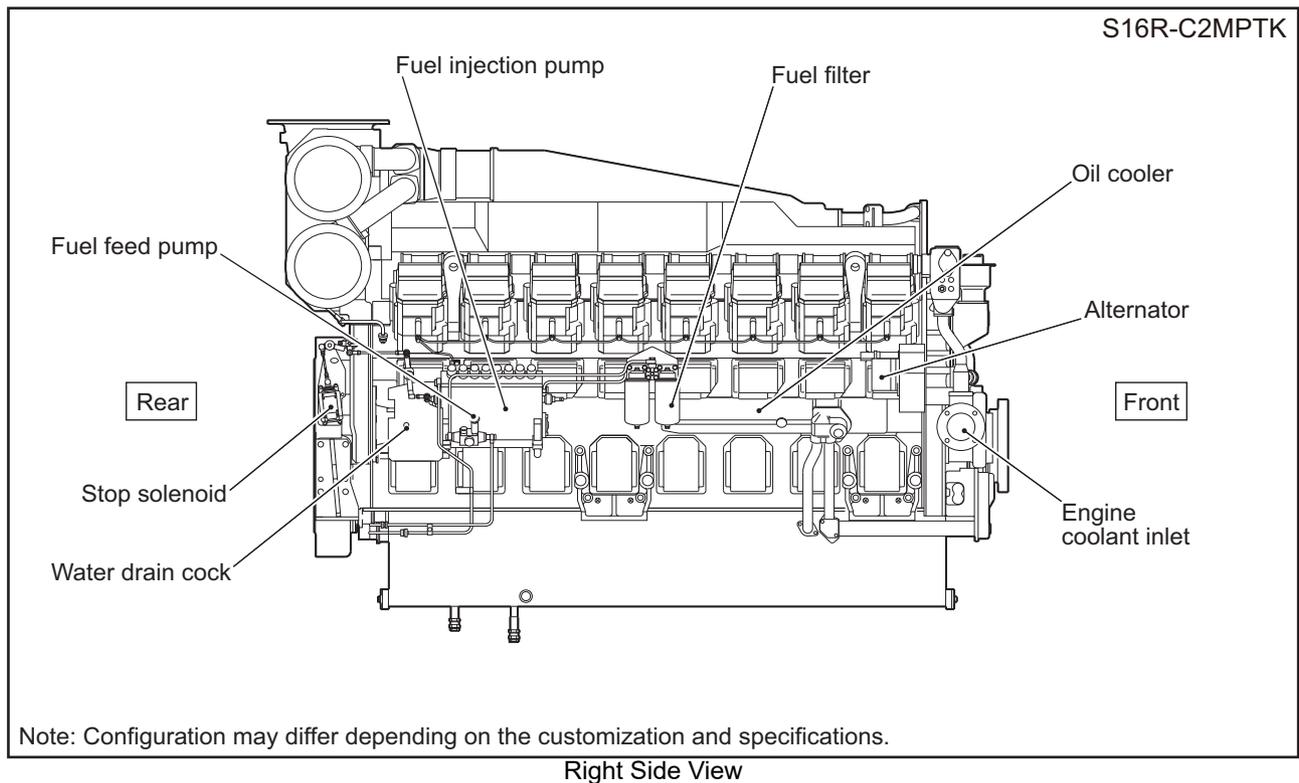
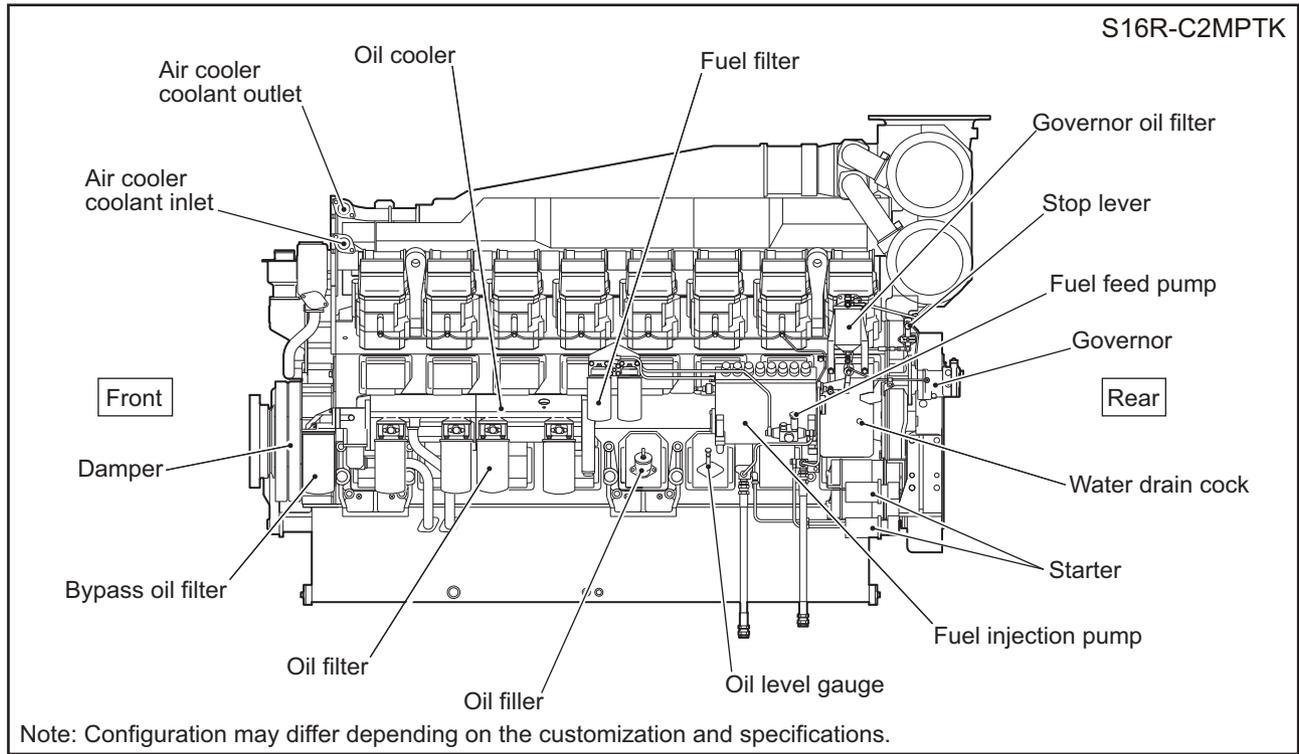
Engine Front View

S16R-C2MPTK

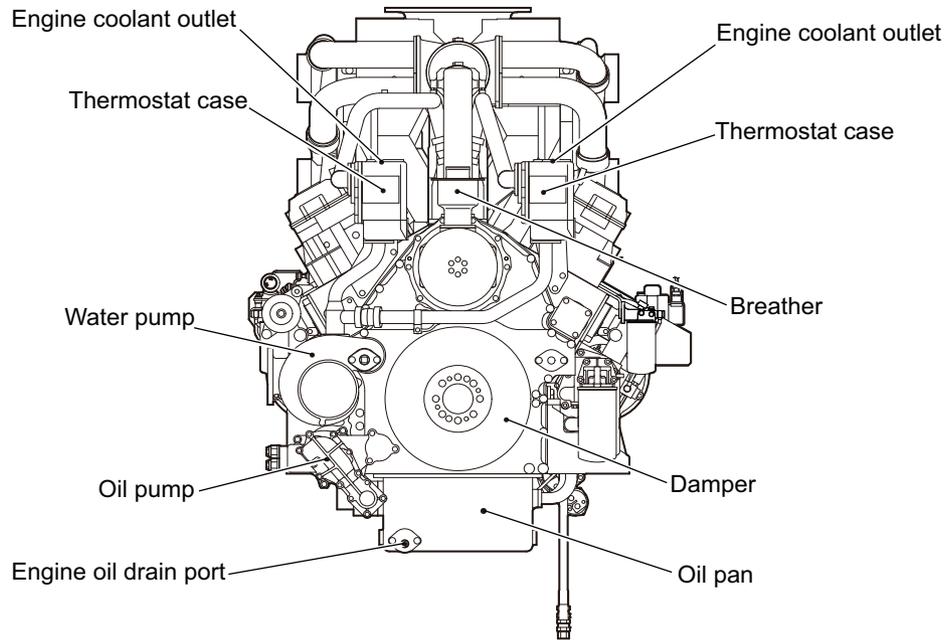


Note: Configuration may differ depending on the customization and specifications.

Engine Rear View



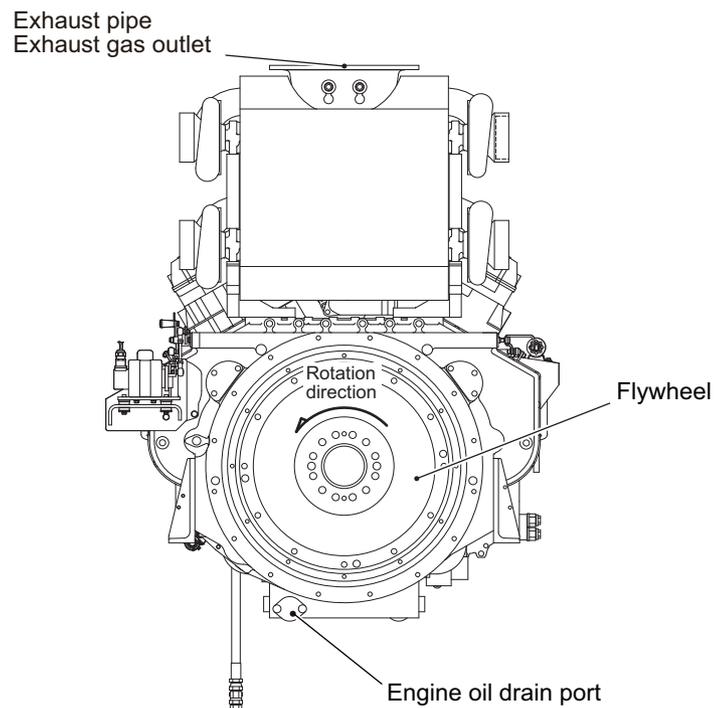
S16R-PTAH



Note: Configuration may differ depending on the customization and specifications.

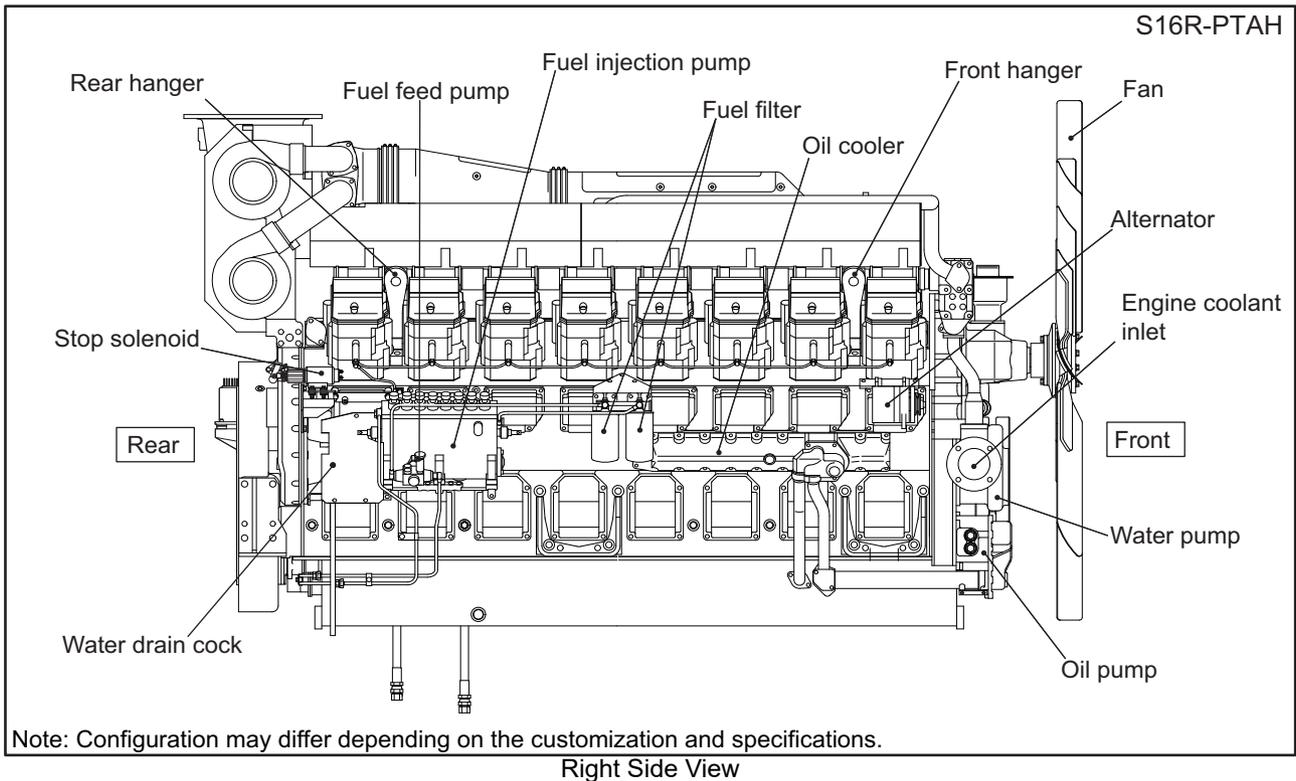
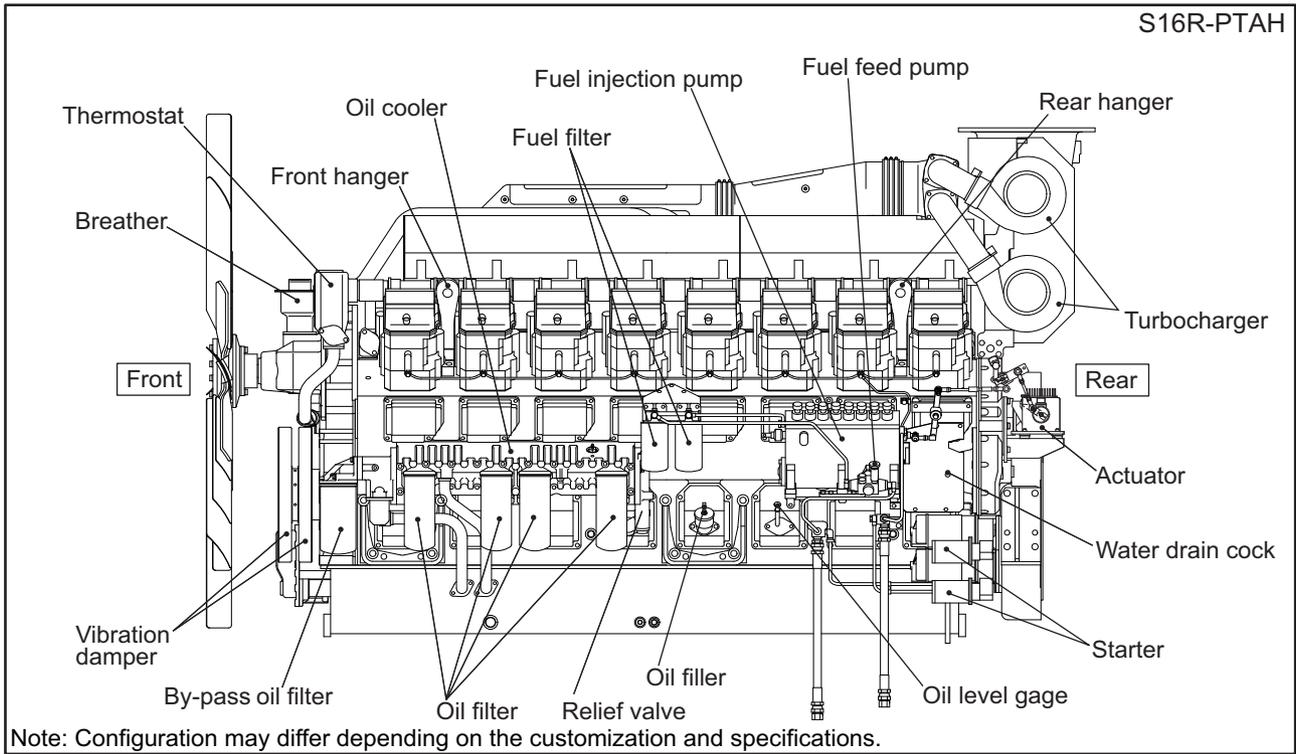
Engine Front View

S16R-PTAH

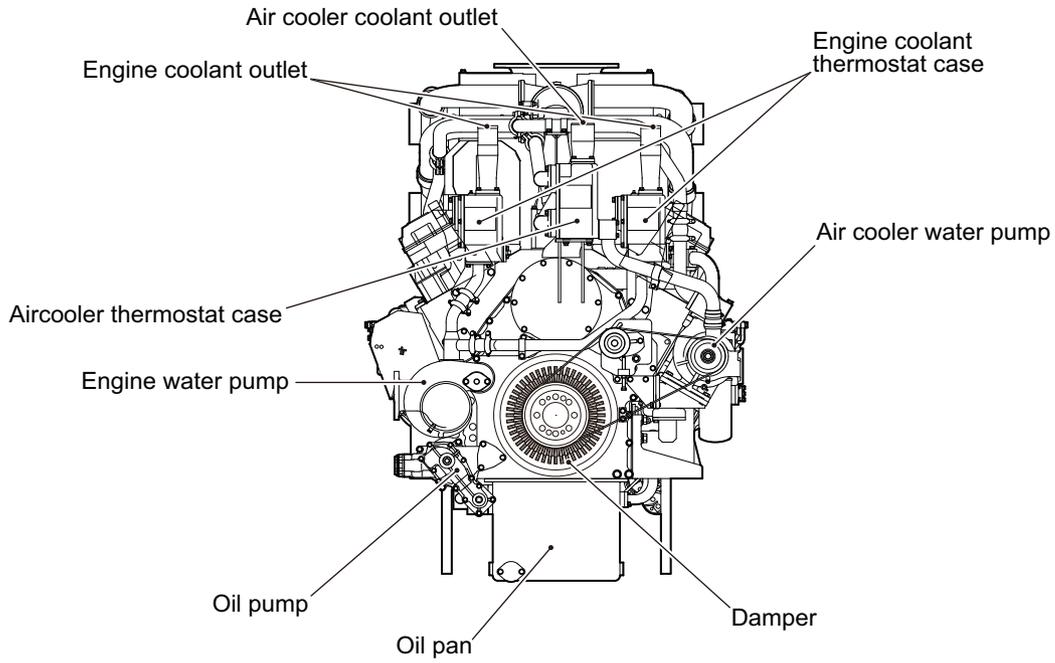


Note: Configuration may differ depending on the customization and specifications.

Engine Rear View



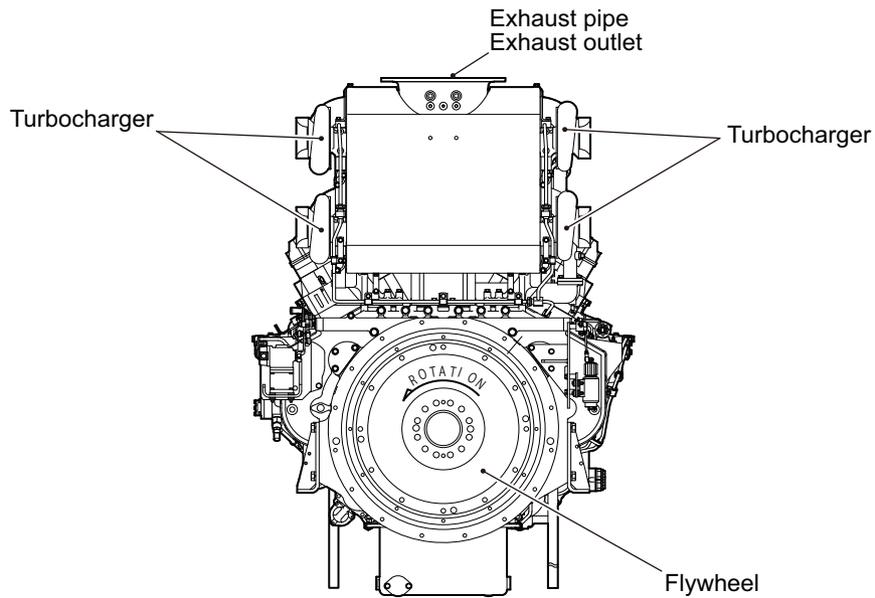
S16R2-PTAW



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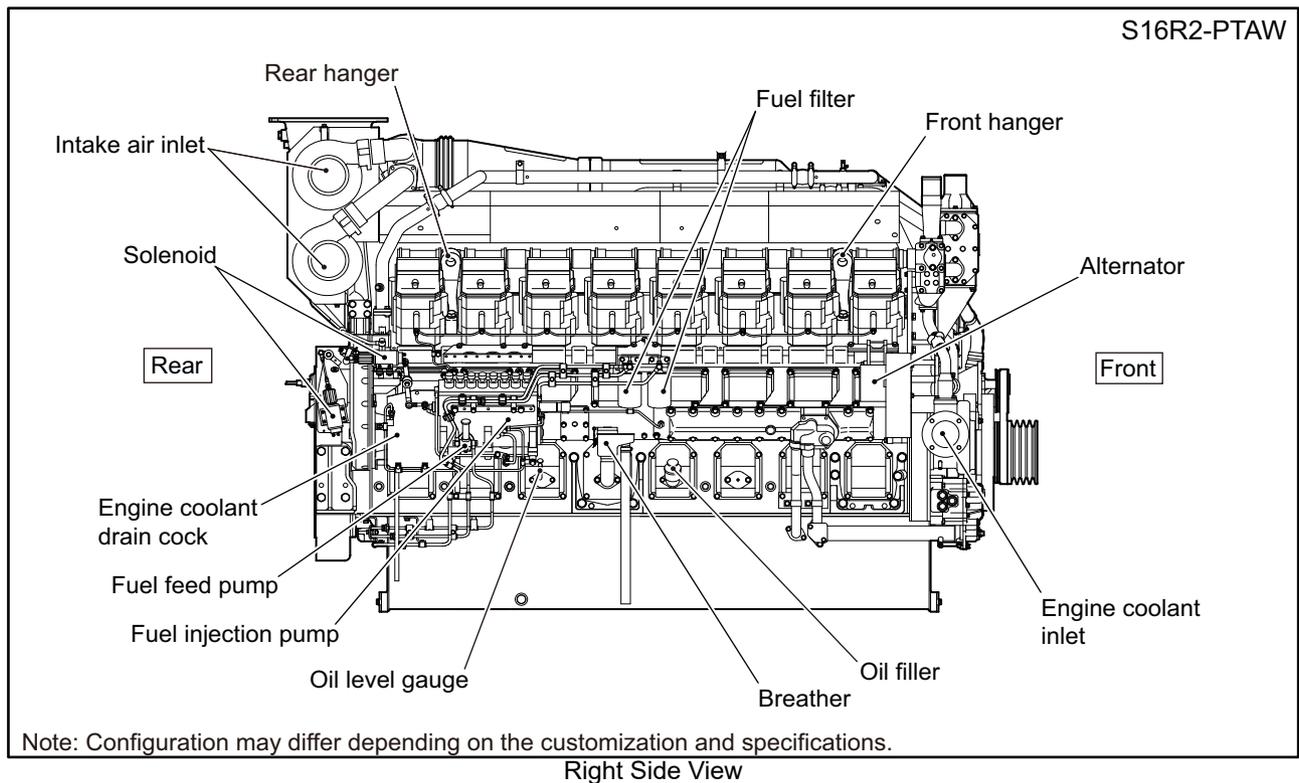
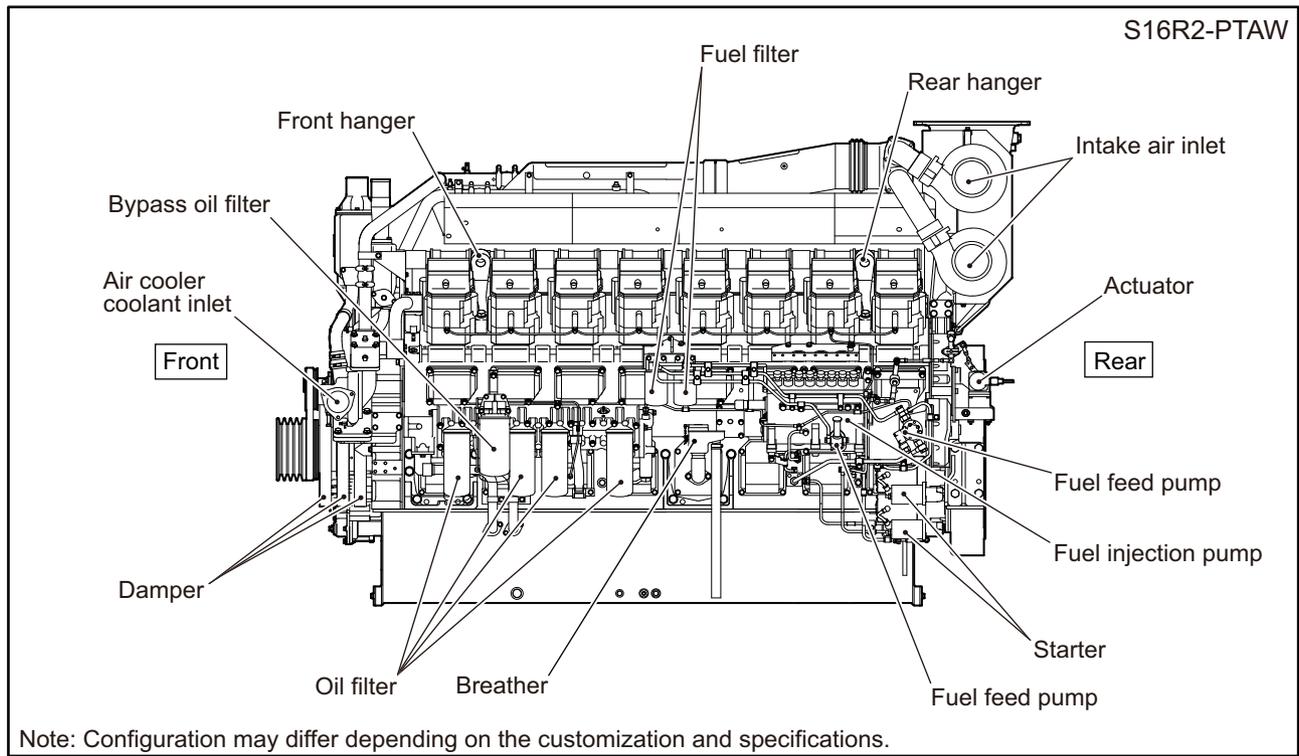
Engine Front View

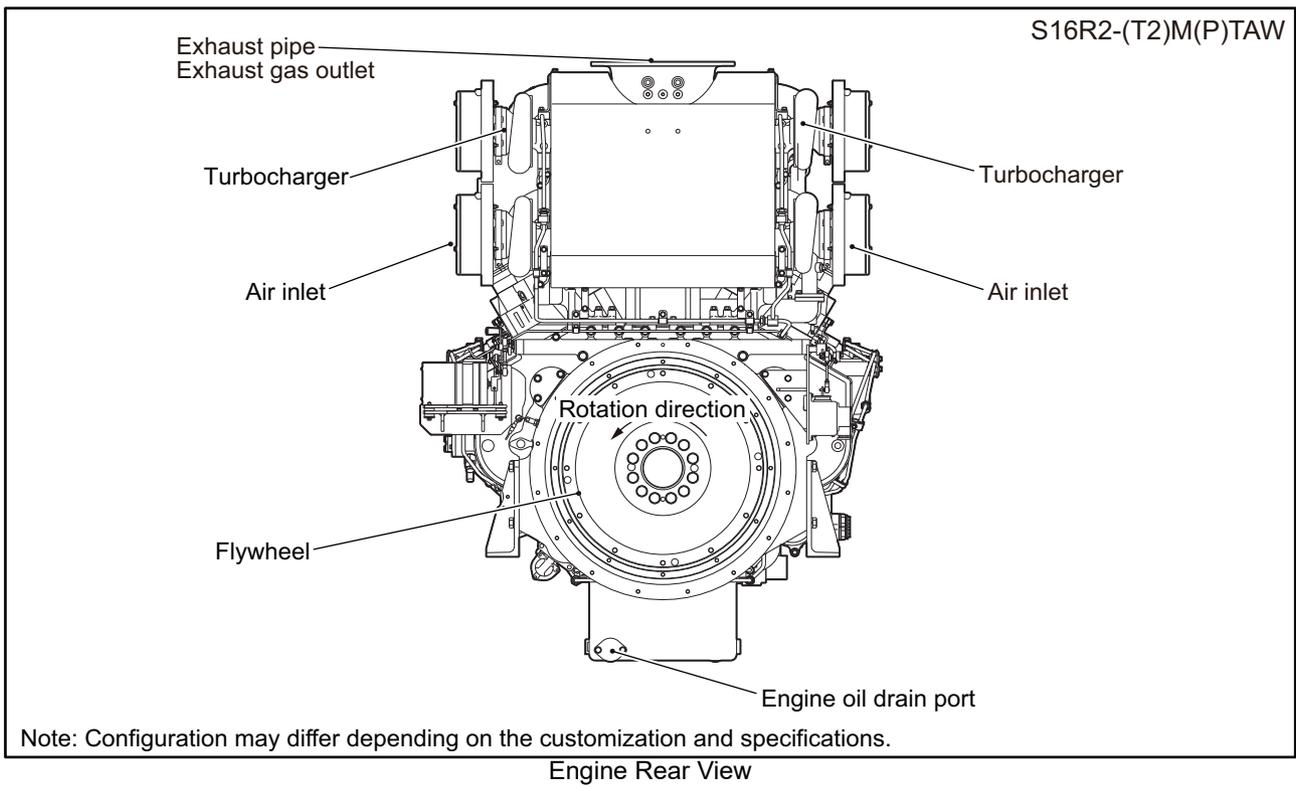
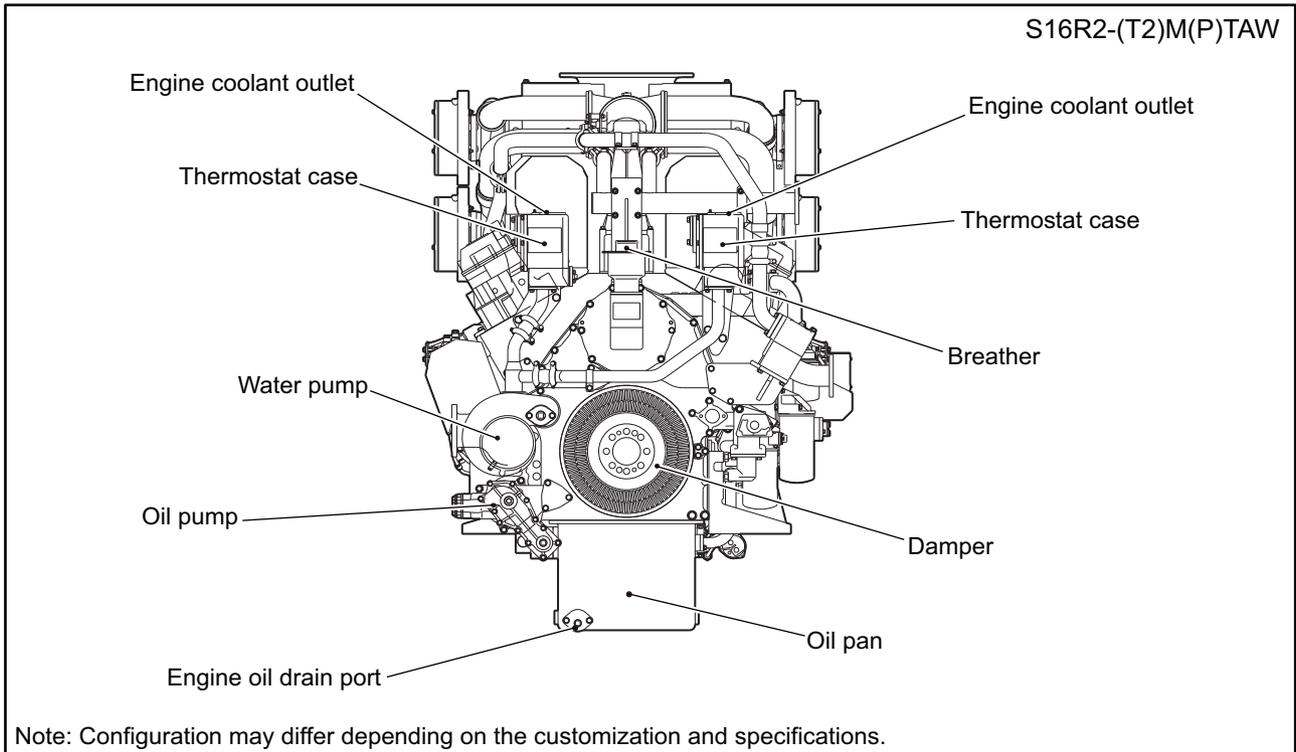
S16R2-PTAW

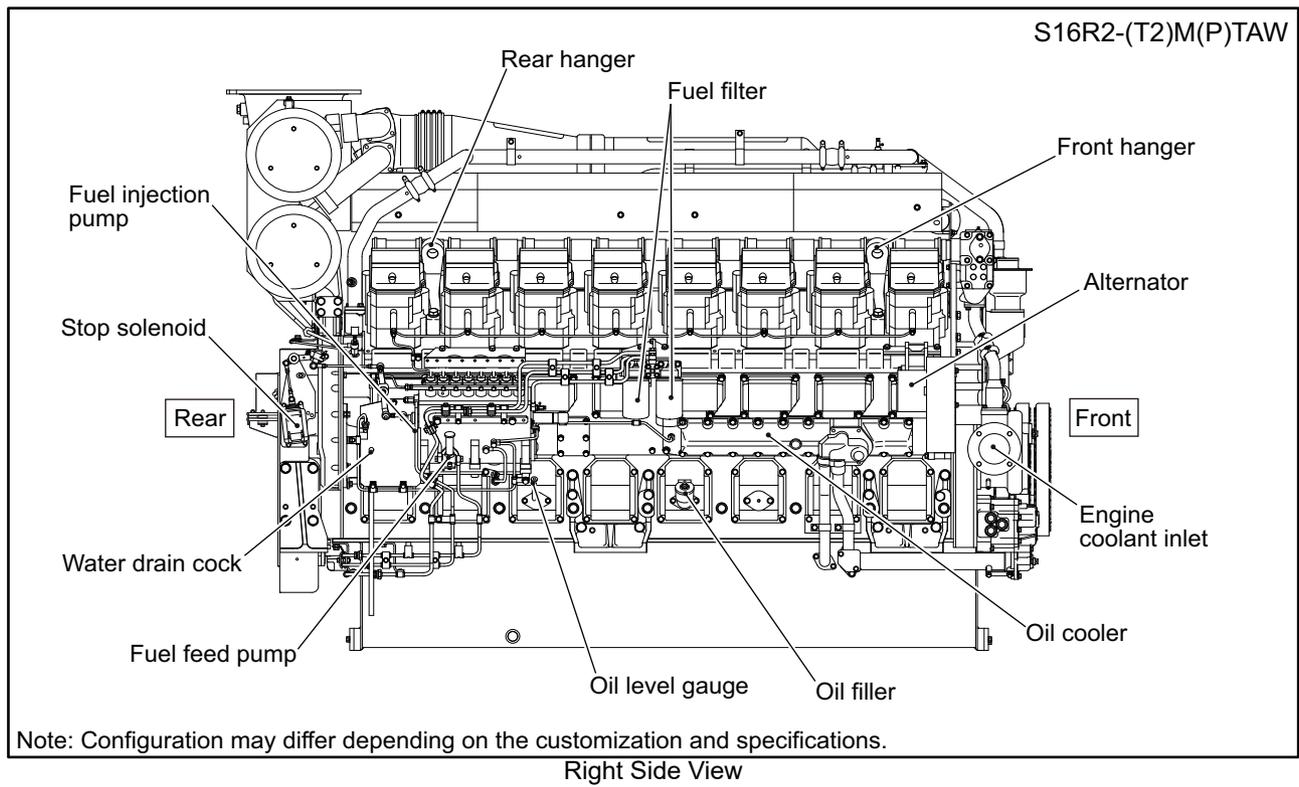
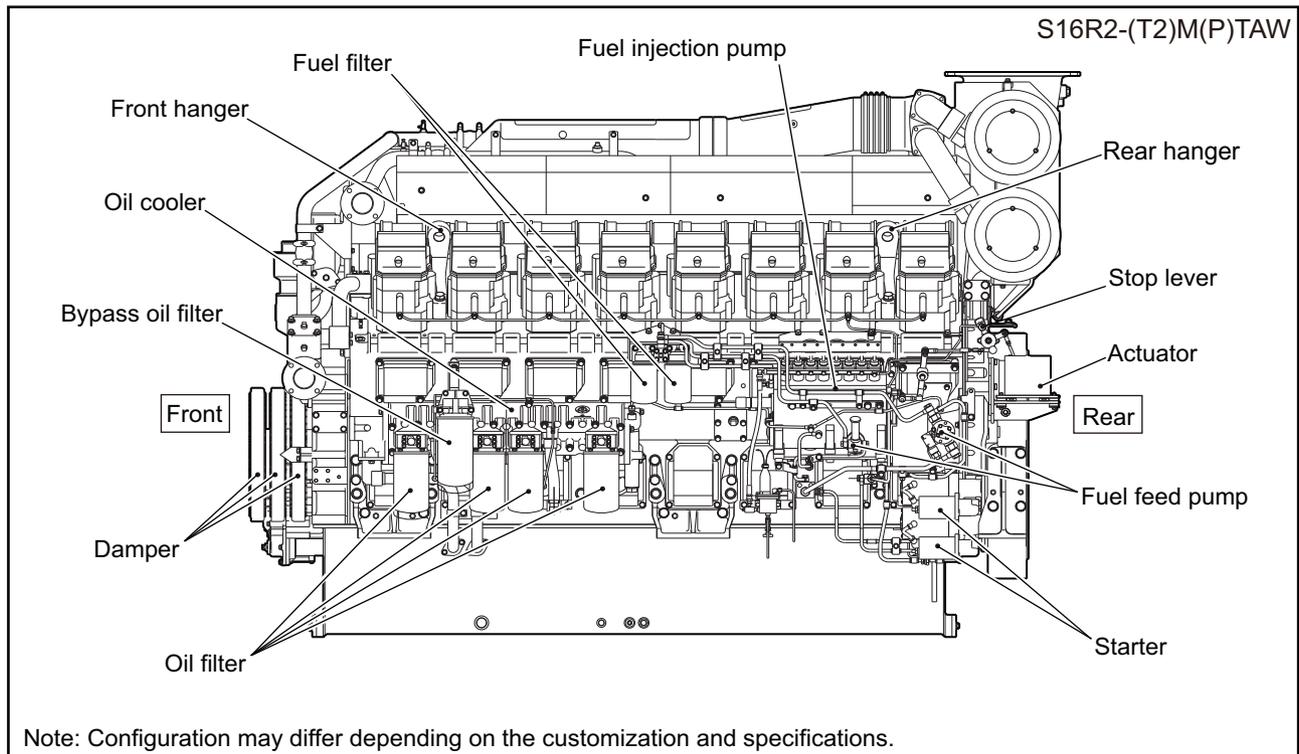


Note: Configuration may differ depending on the customization and specifications.

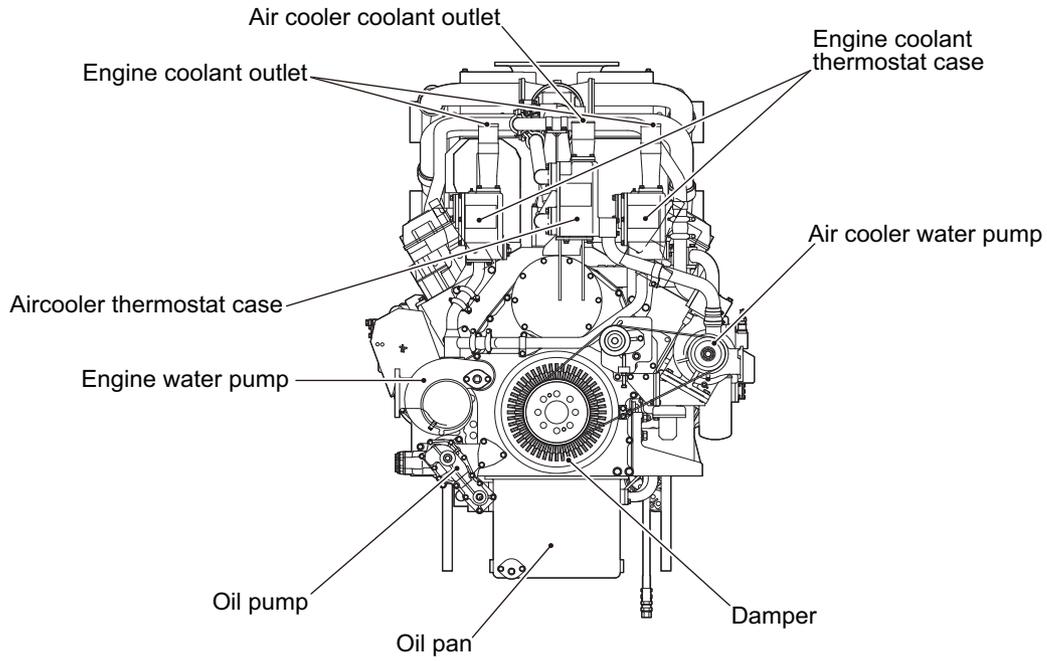
Engine Rear View







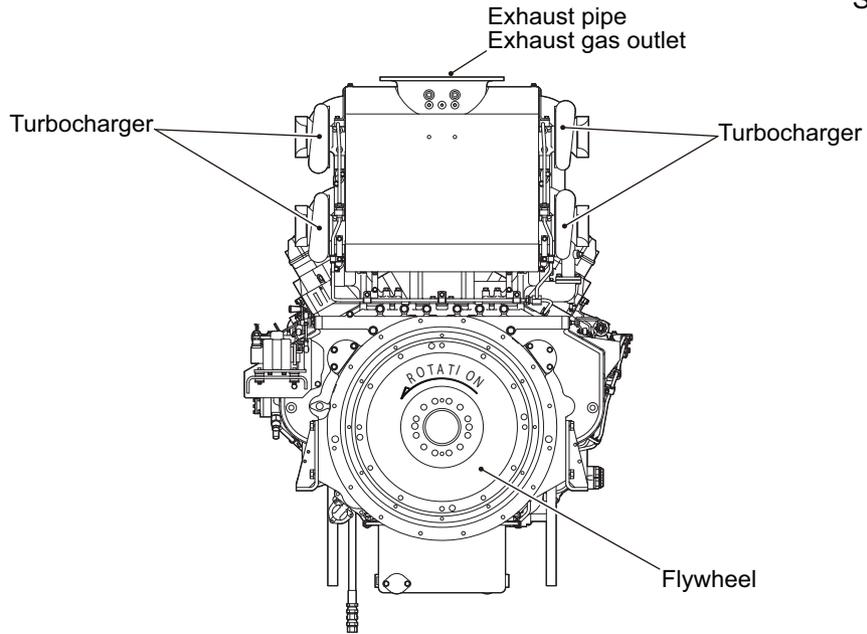
S16R2-PTAW(2)-E



Note: Configuration may differ depending on the customization and specifications.

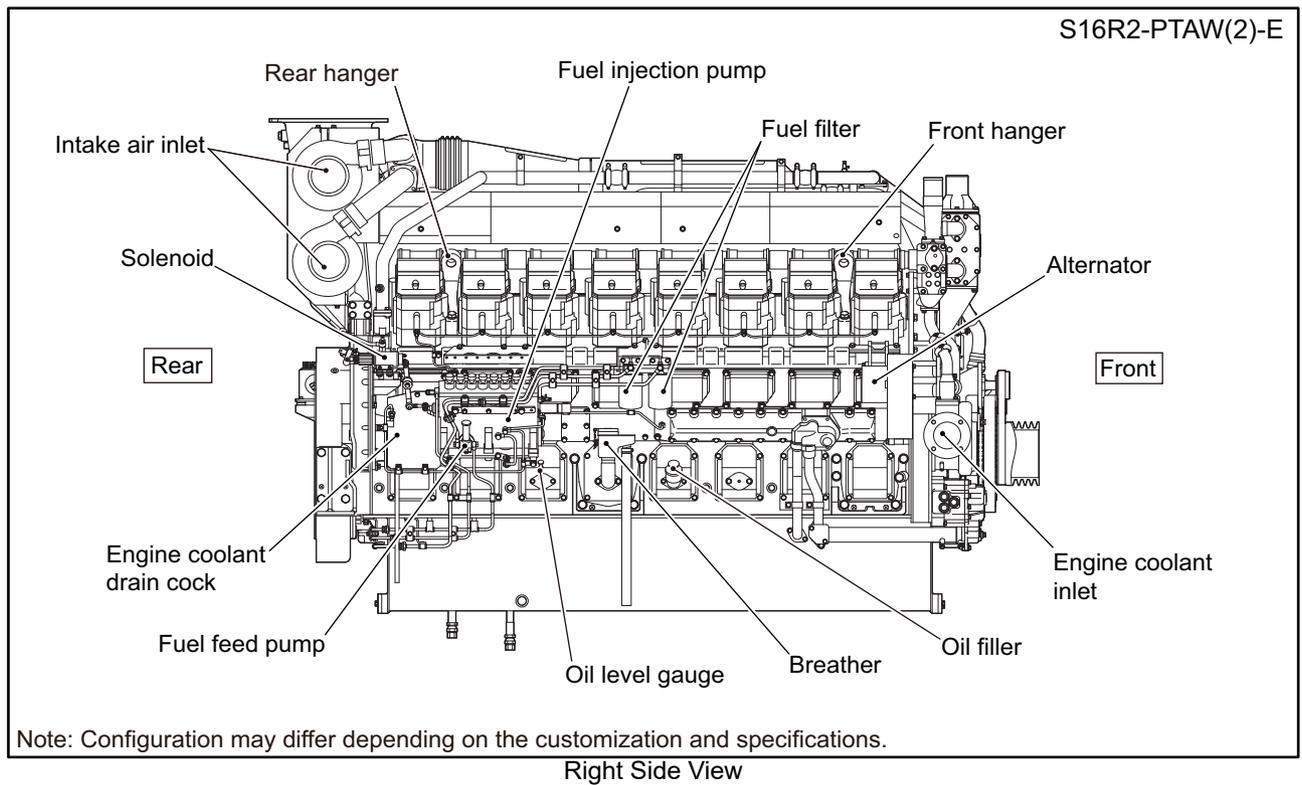
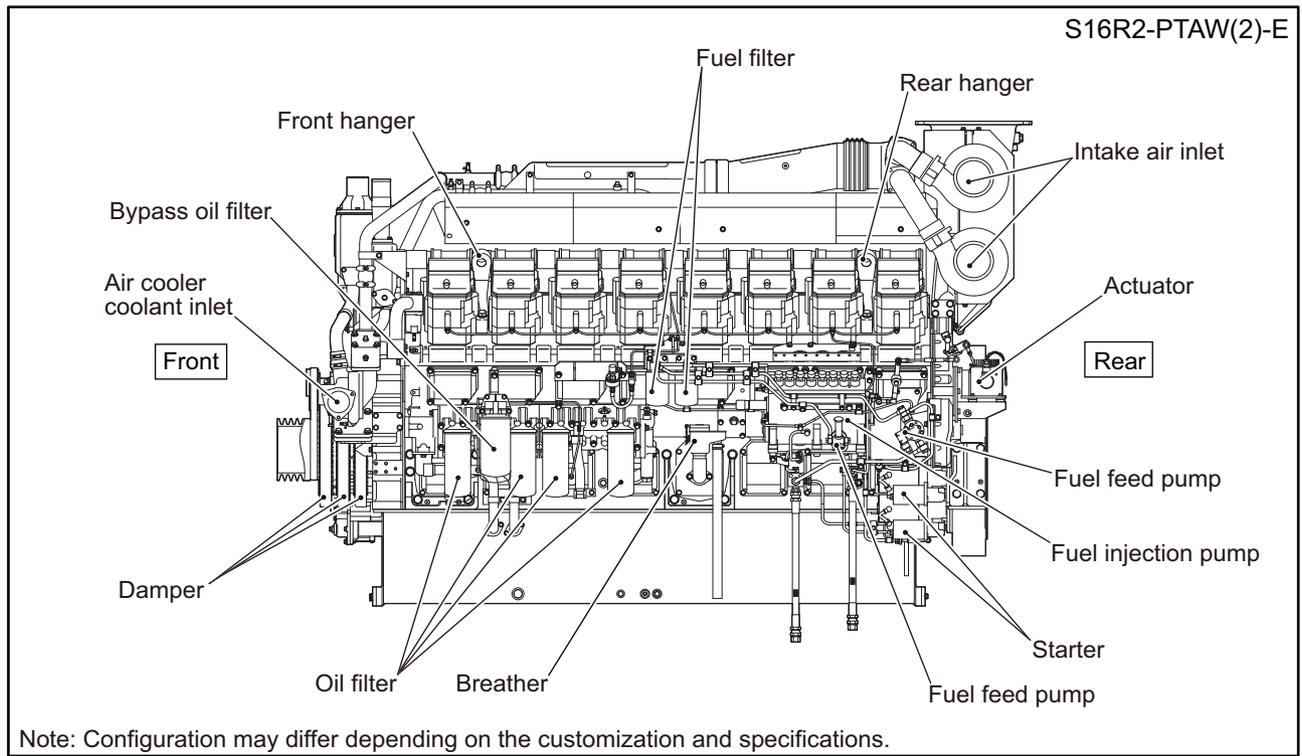
Engine Front View

S16R2-PTAW(2)-E

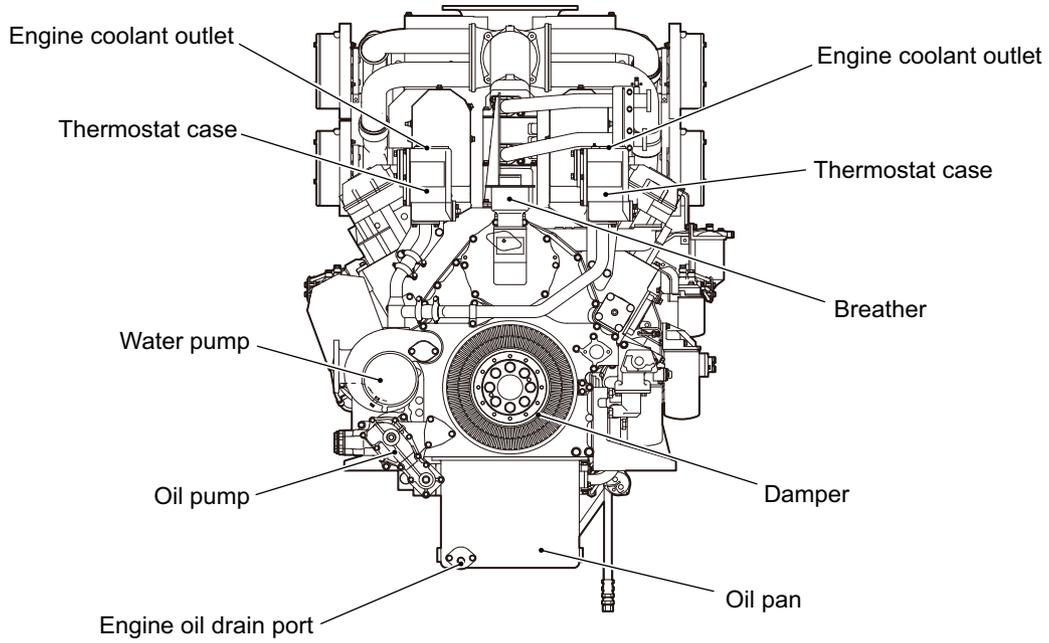


Note: Configuration may differ depending on the customization and specifications.

Engine Rear View



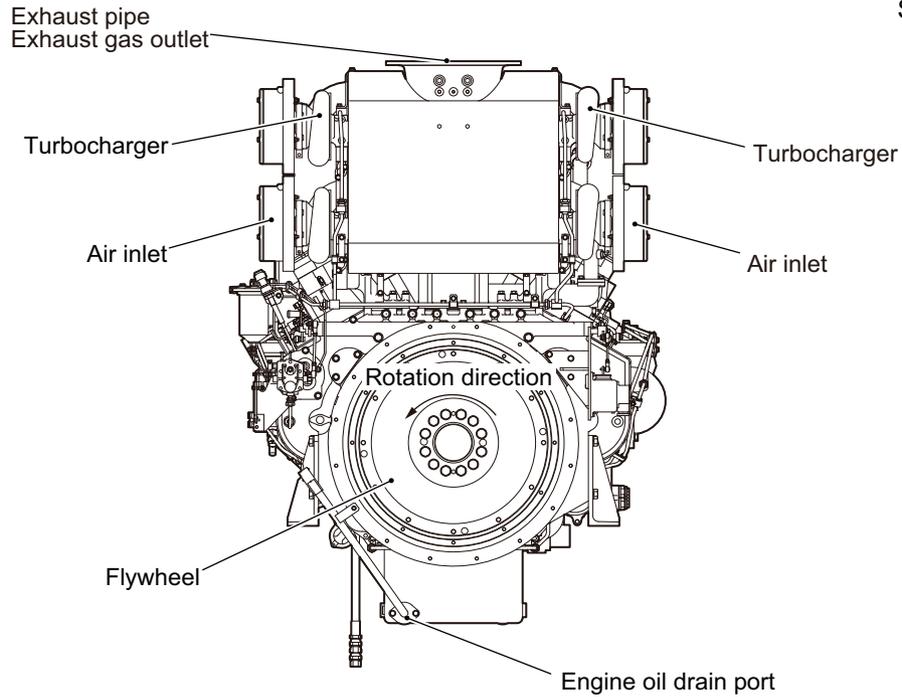
S16R2-MPTK2



Note: Configuration may differ depending on the customization and specifications.

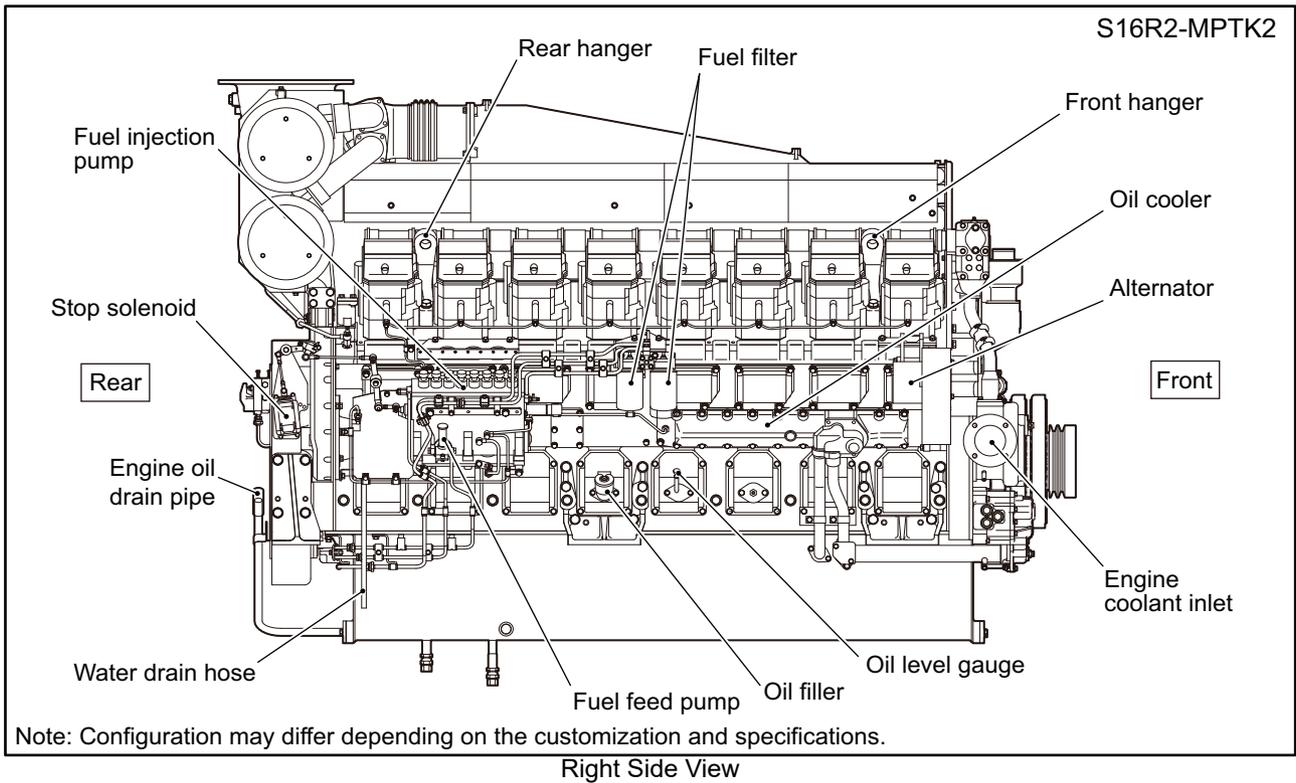
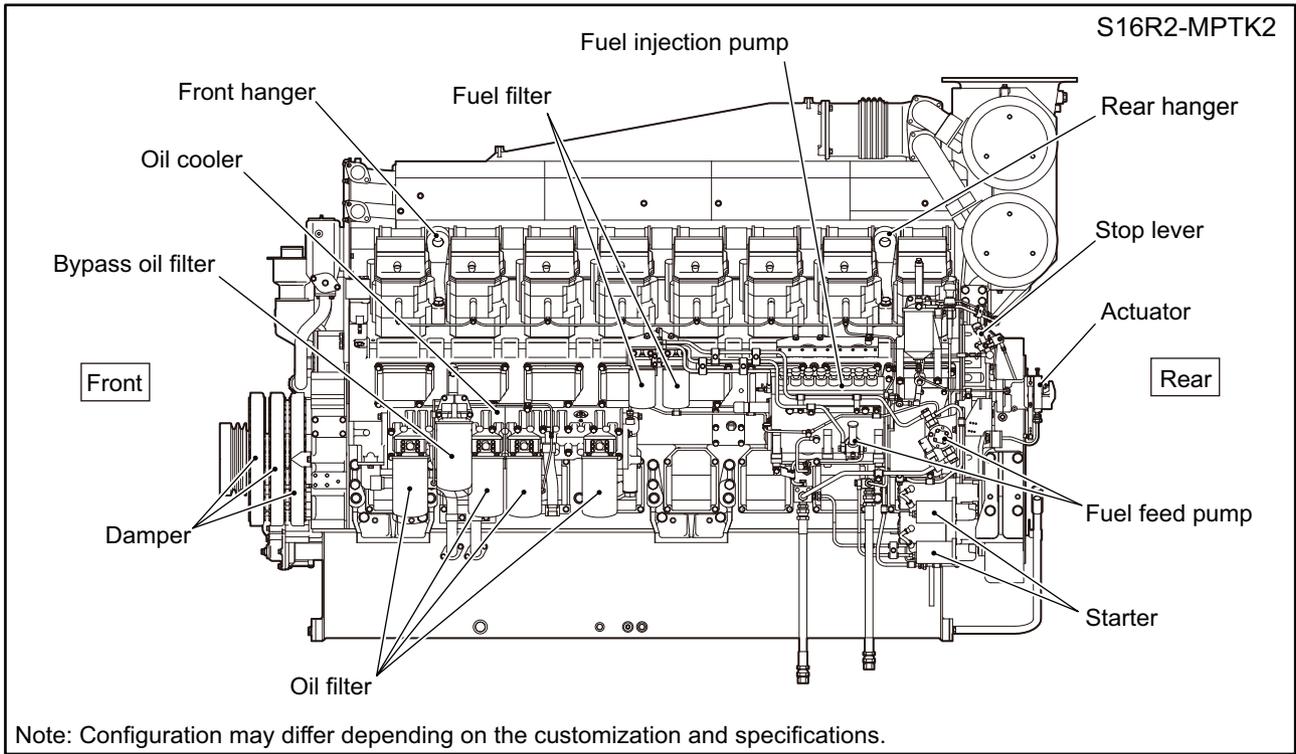
Engine Front View

S16R2-MPTK2



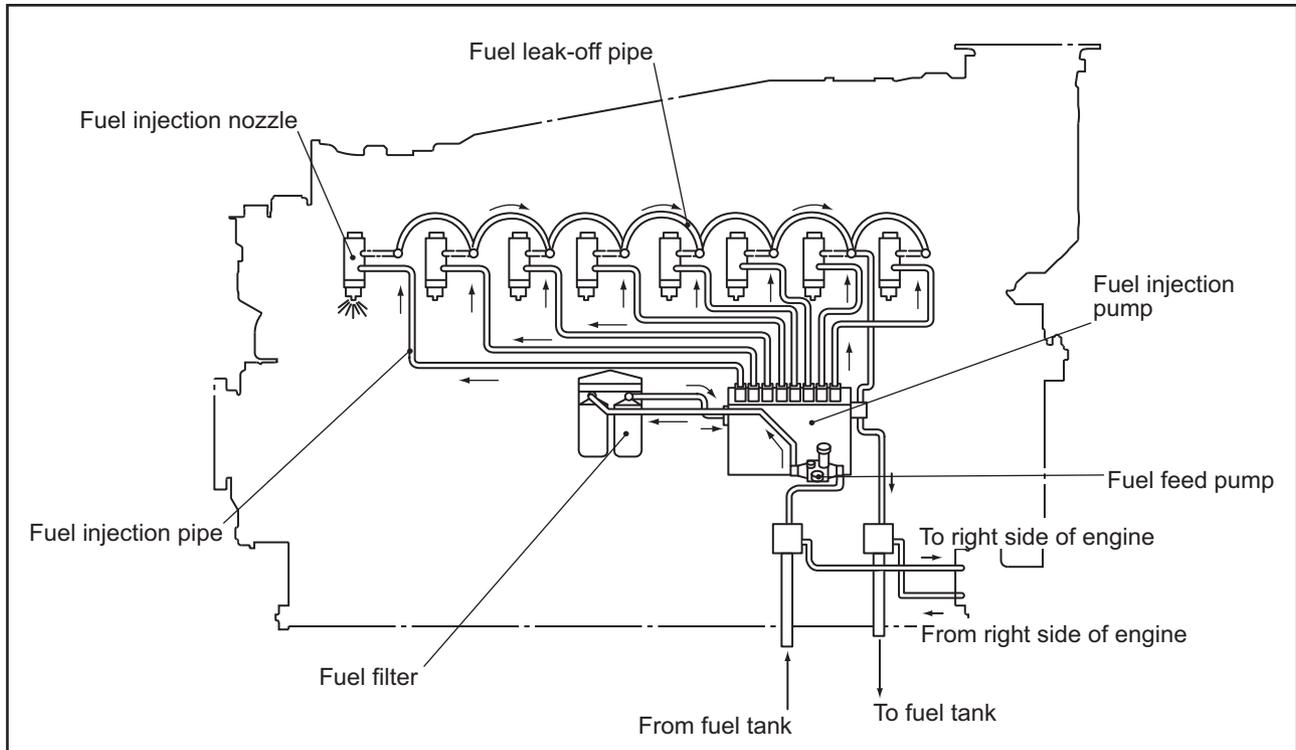
Note: Configuration may differ depending on the customization and specifications.

Engine Rear View

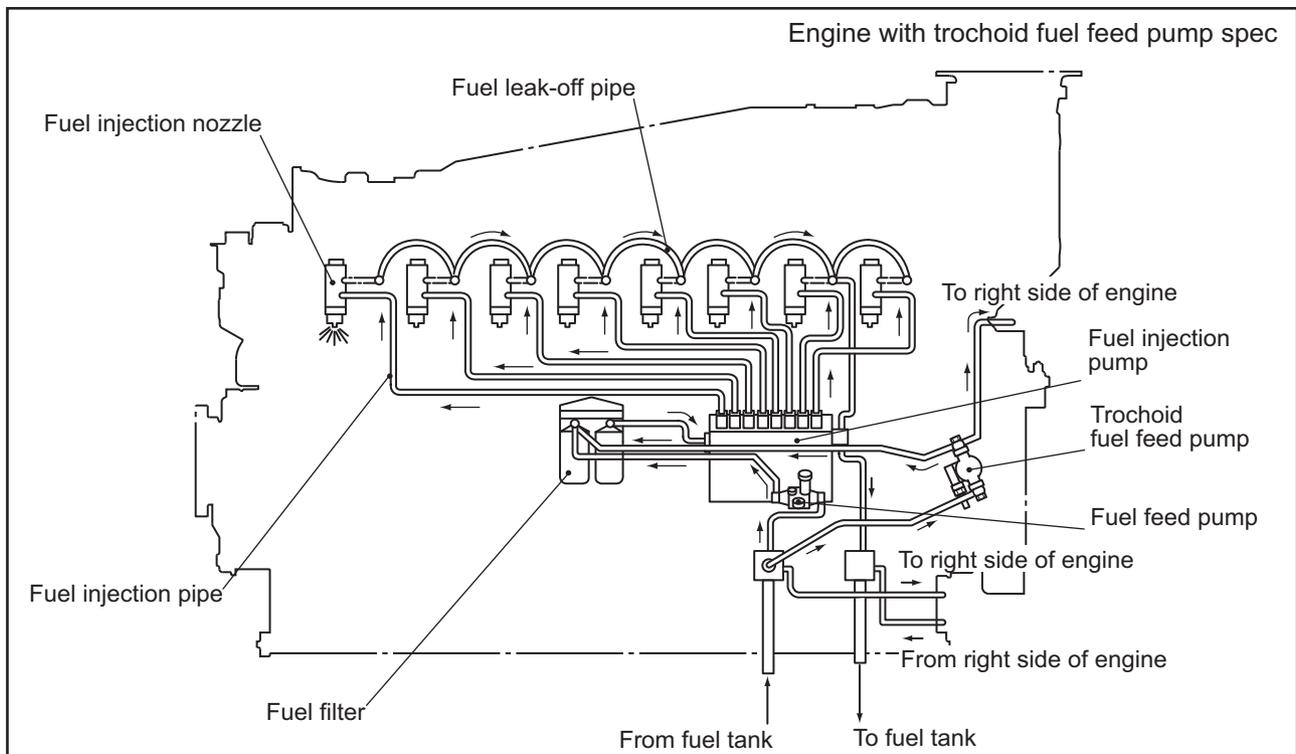


## 2. Outline of Systems

### 2.1 Outline of Fuel System

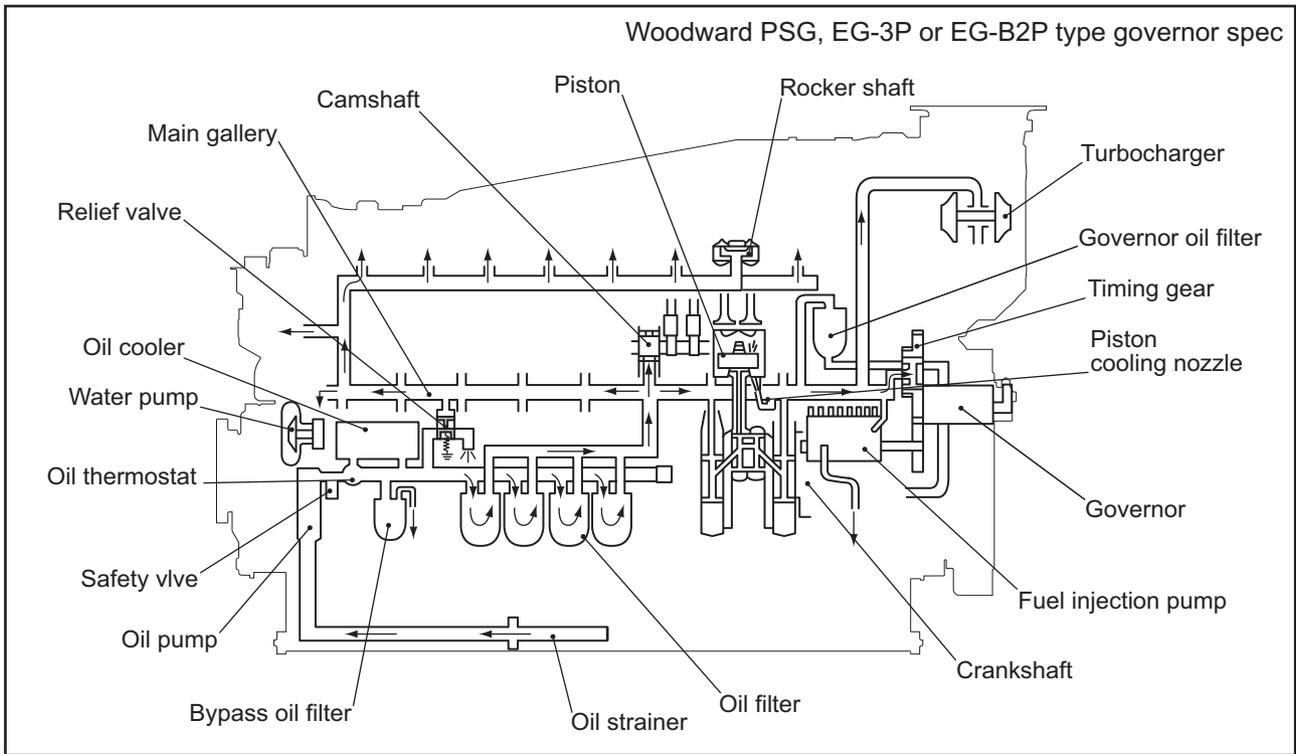


Outline of Fuel System

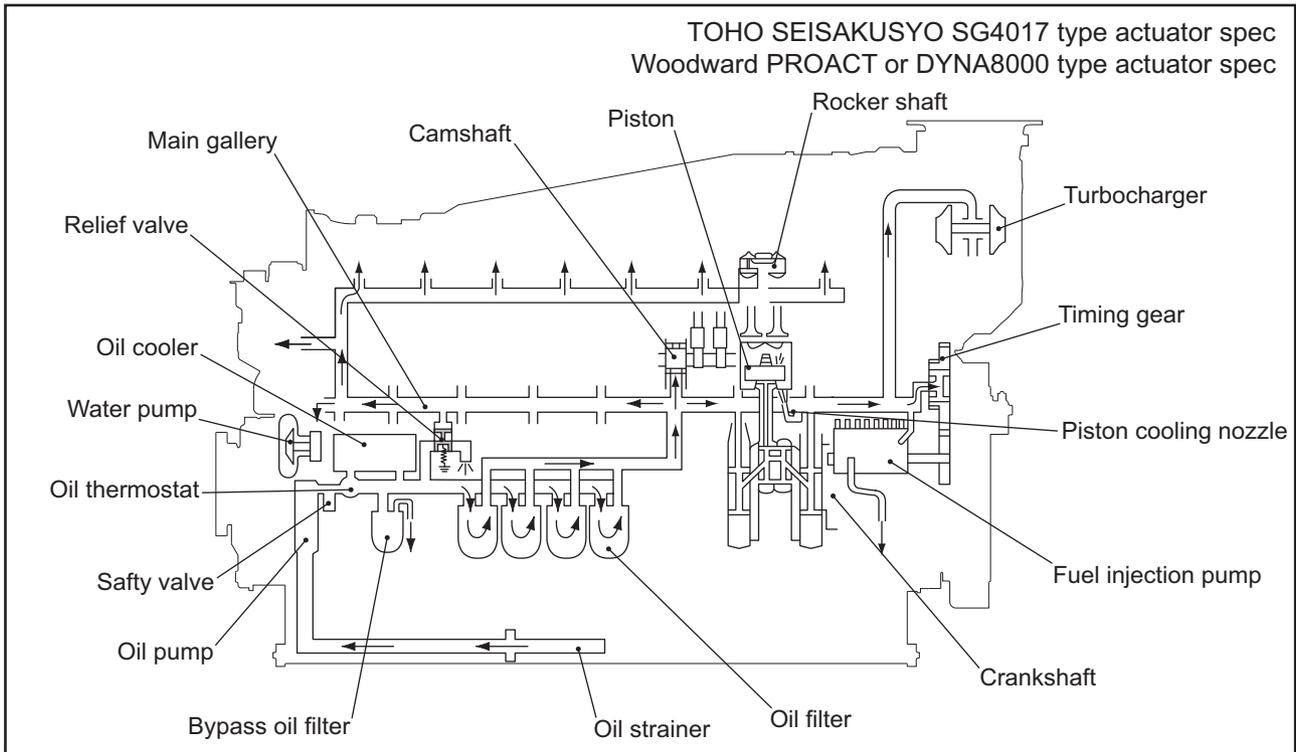


Outline of Fuel System

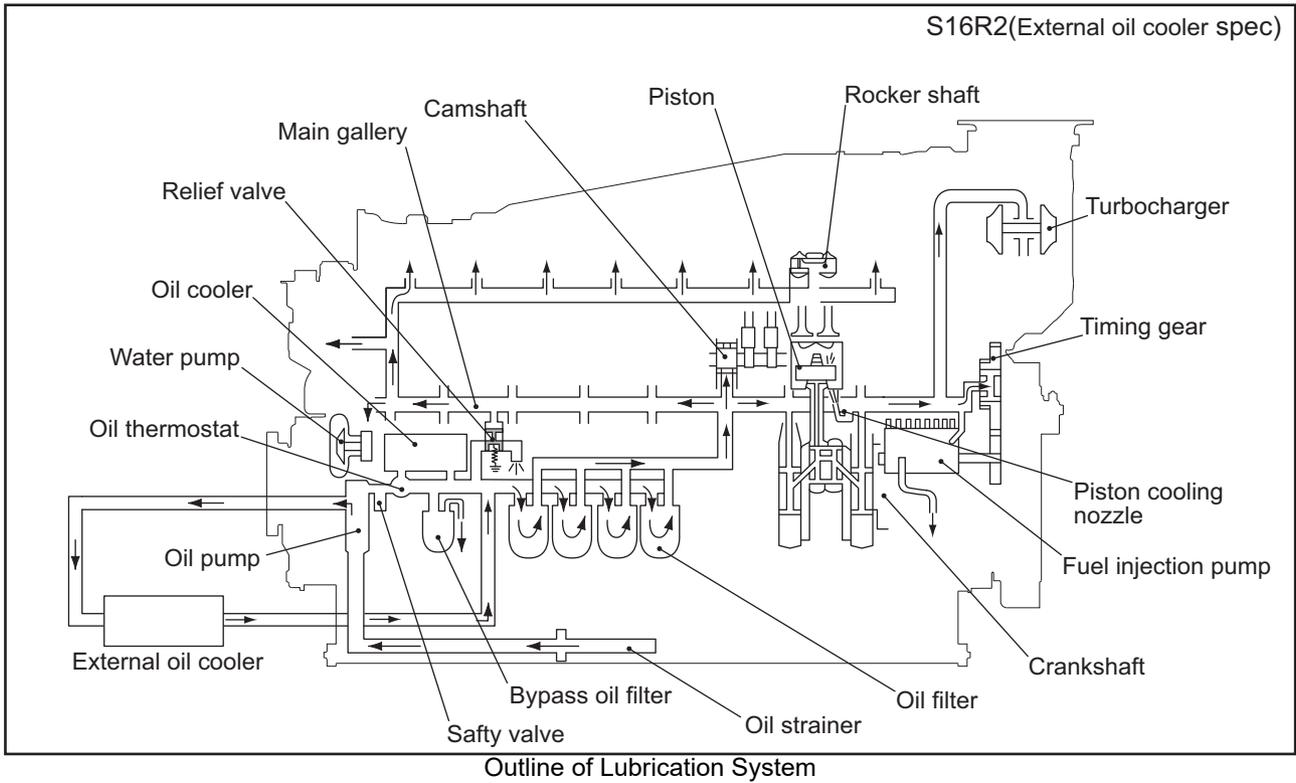
2.2 Outline of Lubrication System



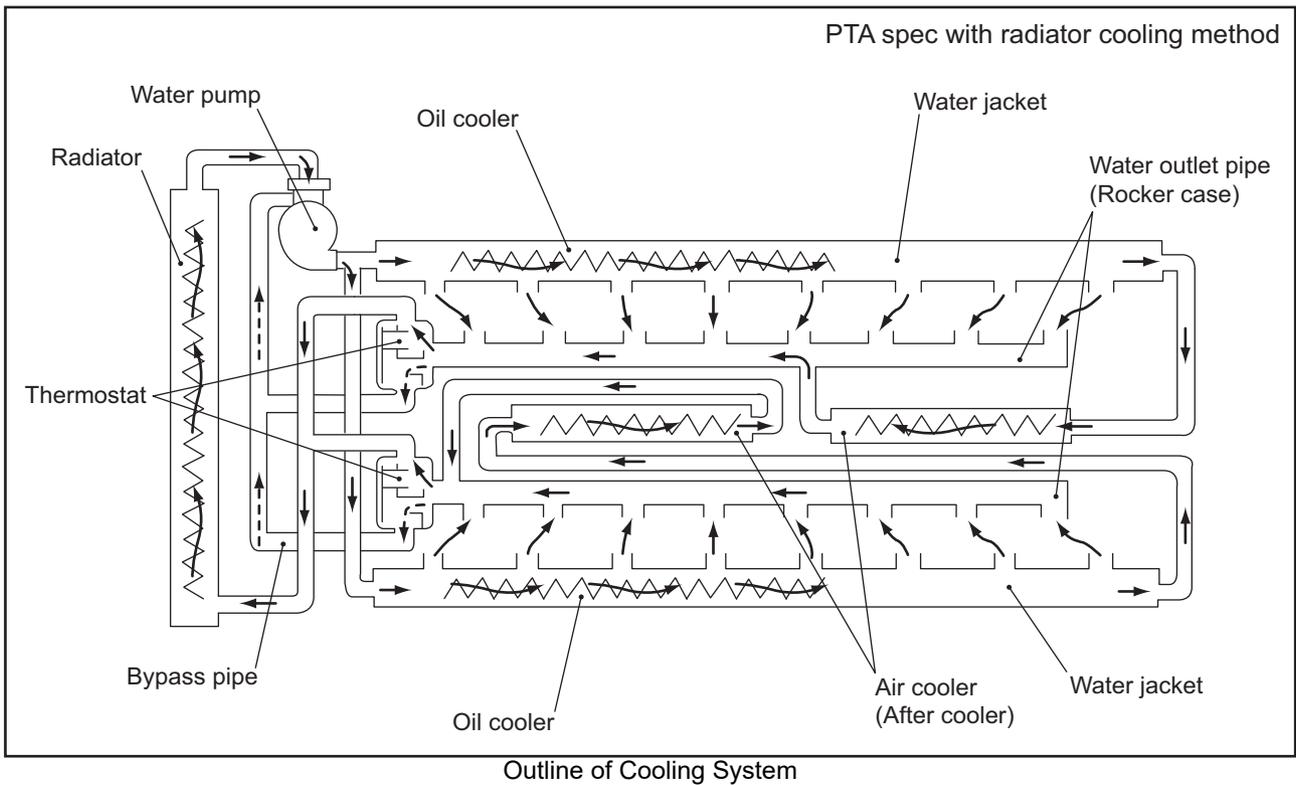
Outline of Lubrication System

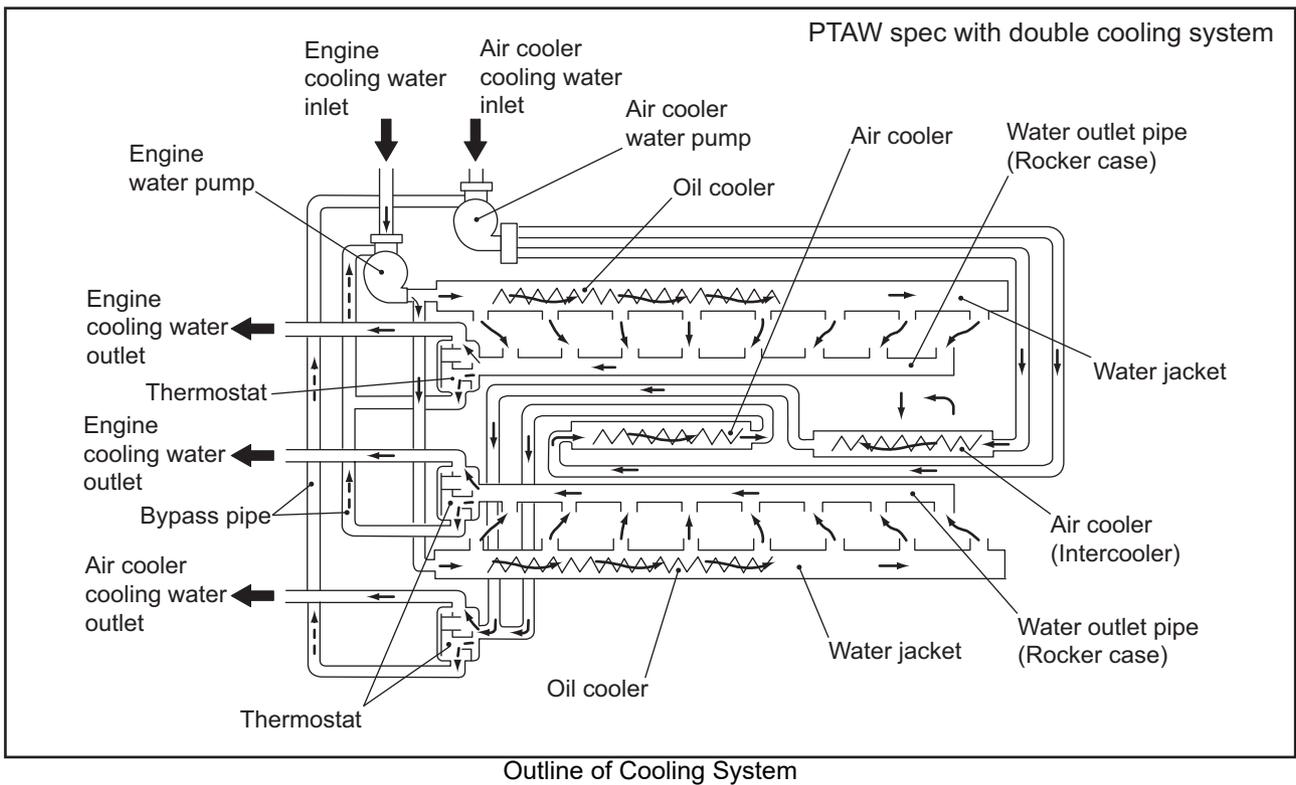
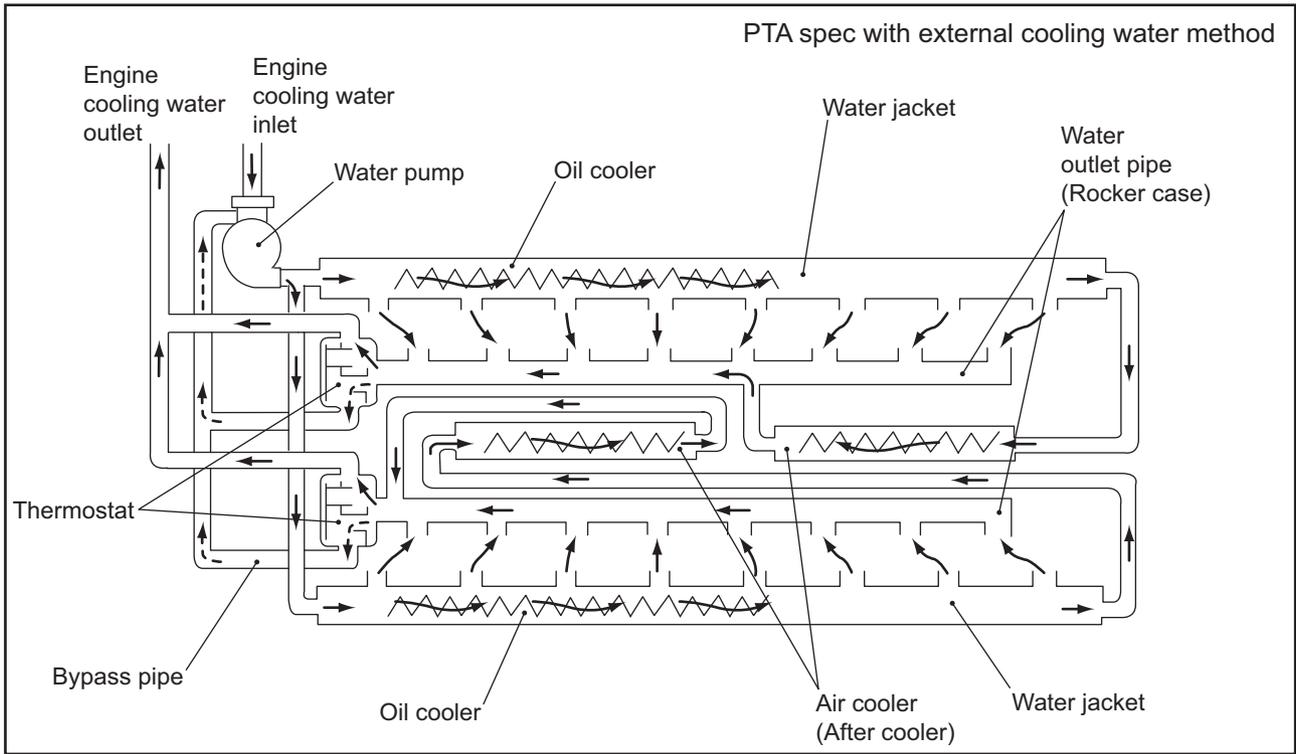


Outline of Lubrication System

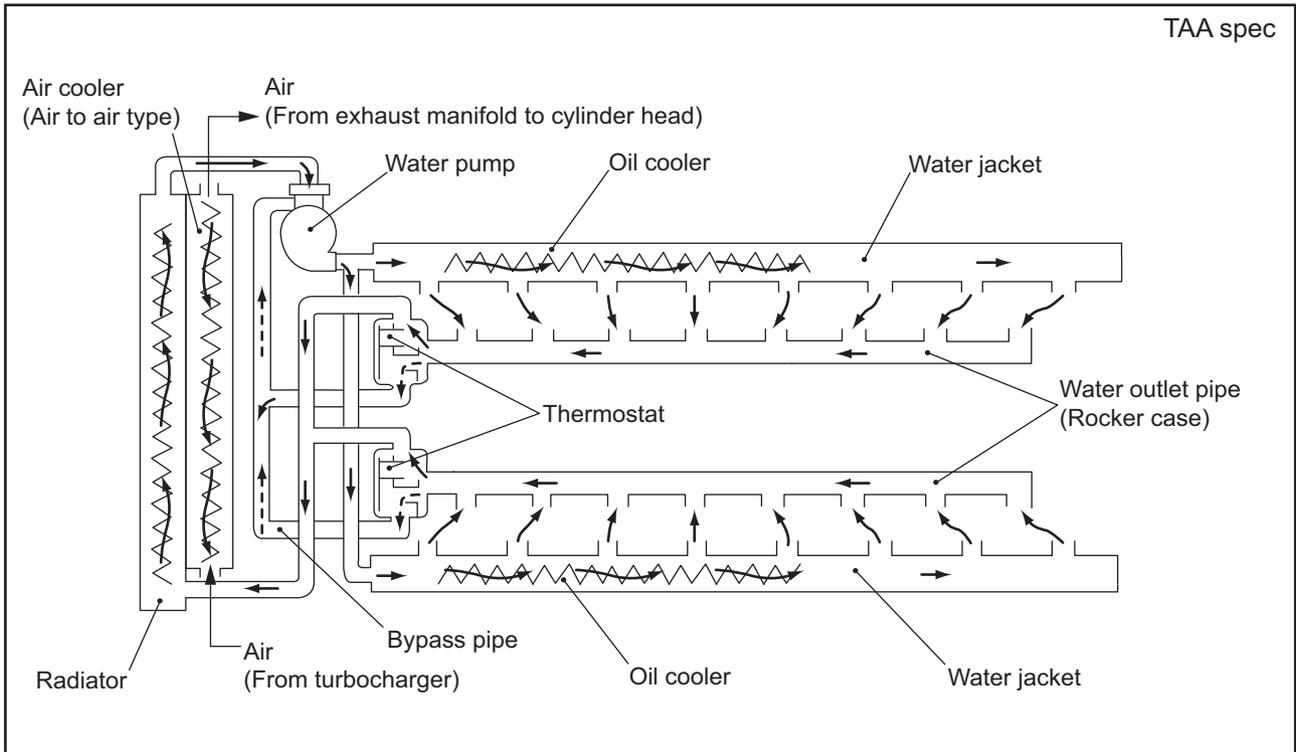


2.3 Outline of Cooling System

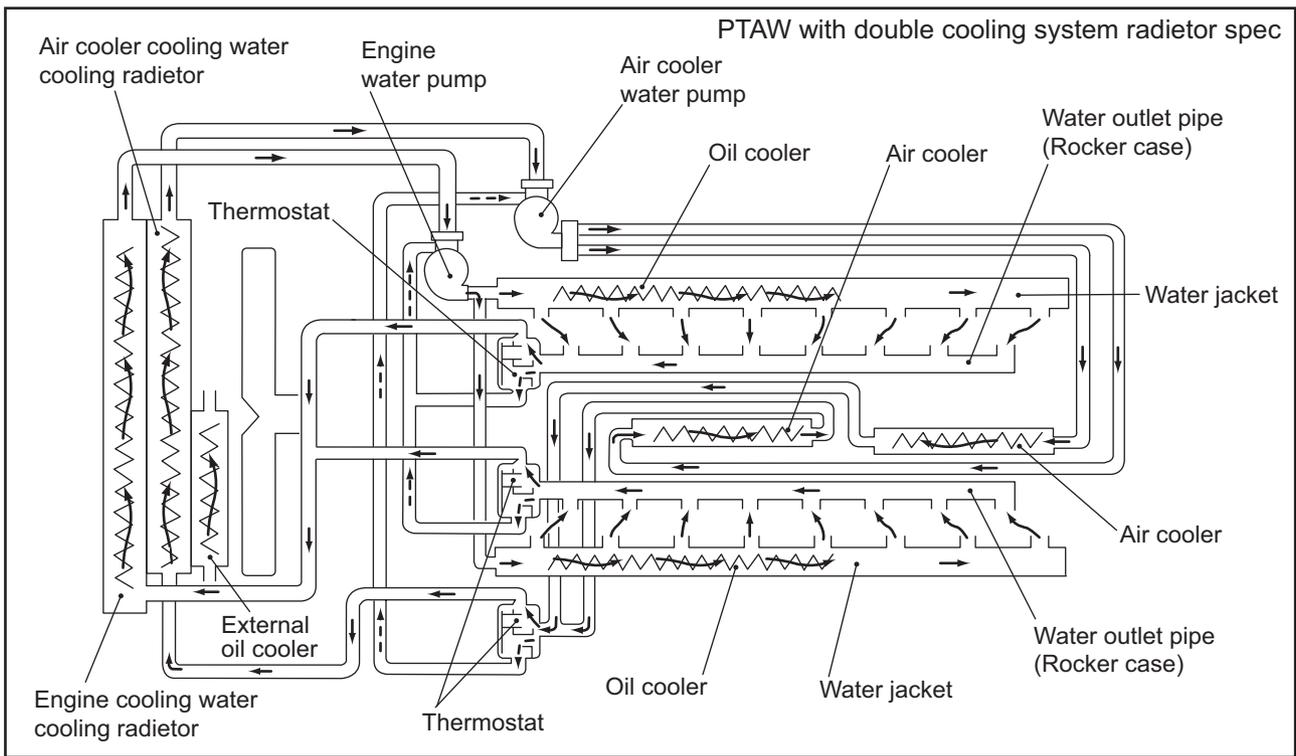




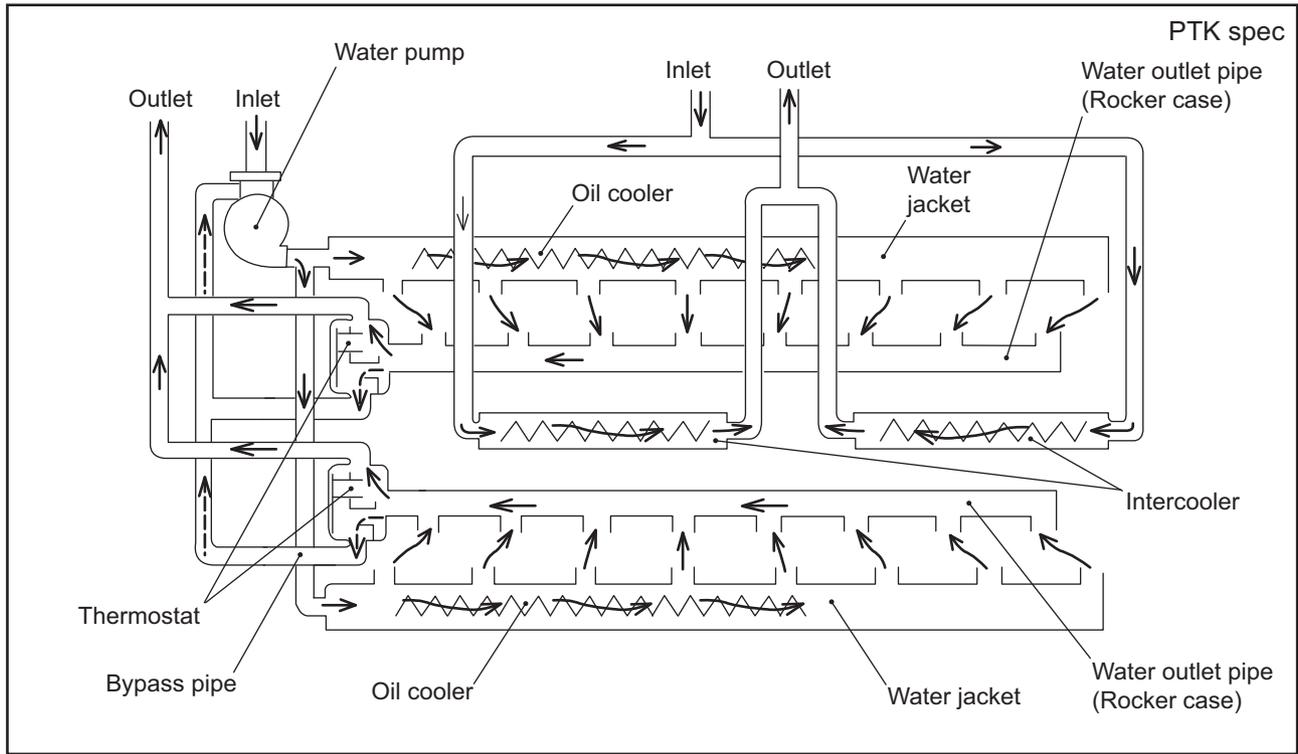
TAA spec



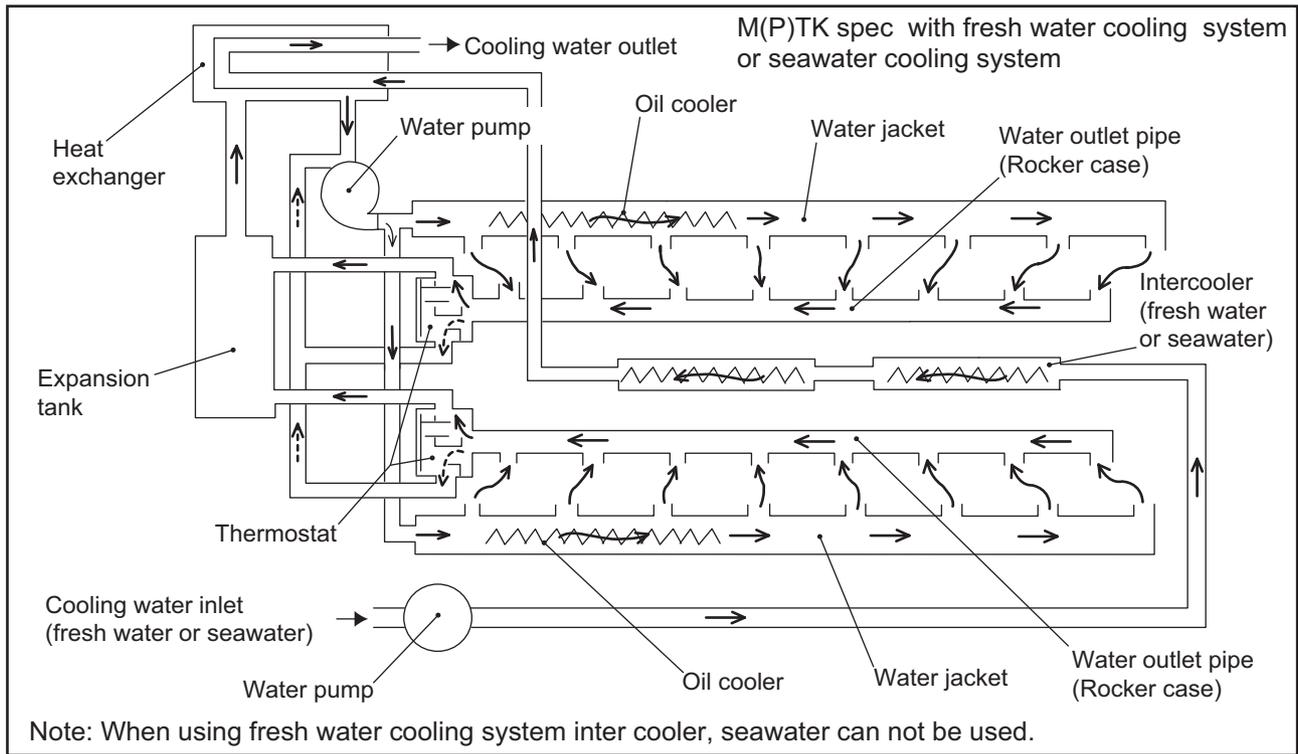
Outline of Cooling System



Outline of Cooling System



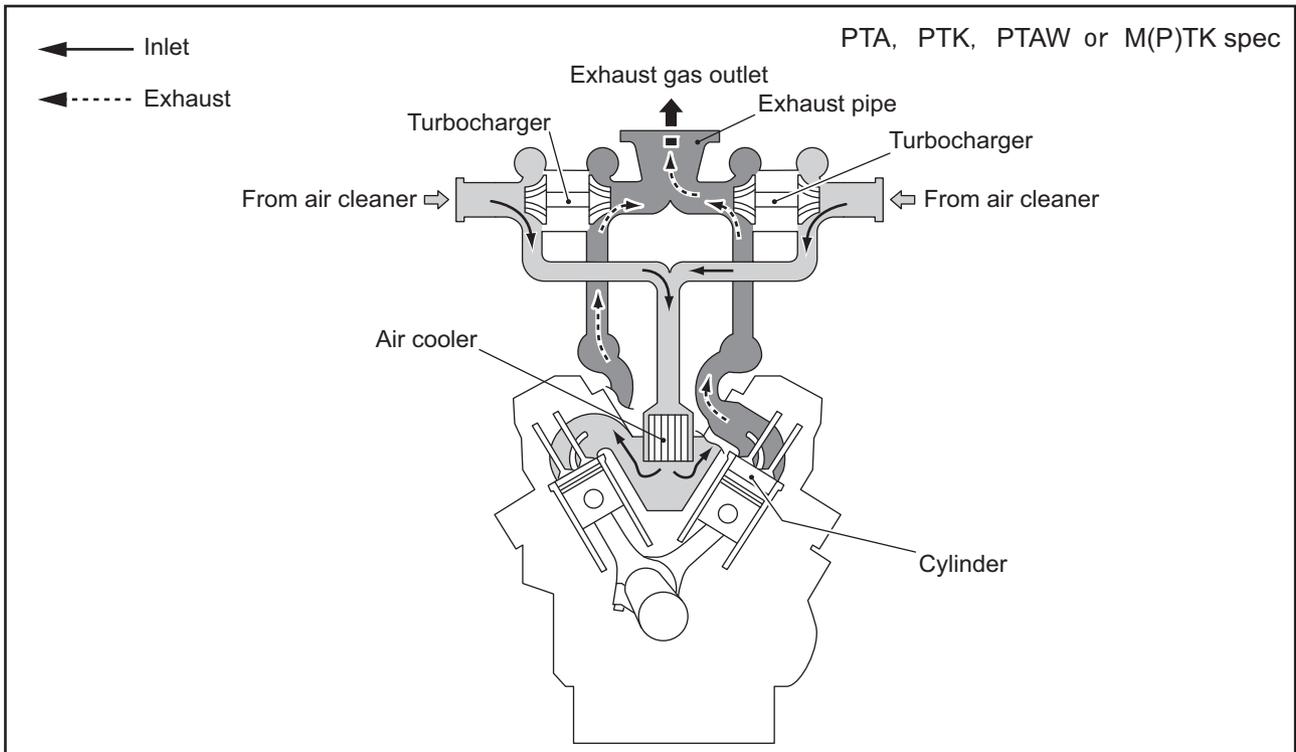
Outline of Cooling System



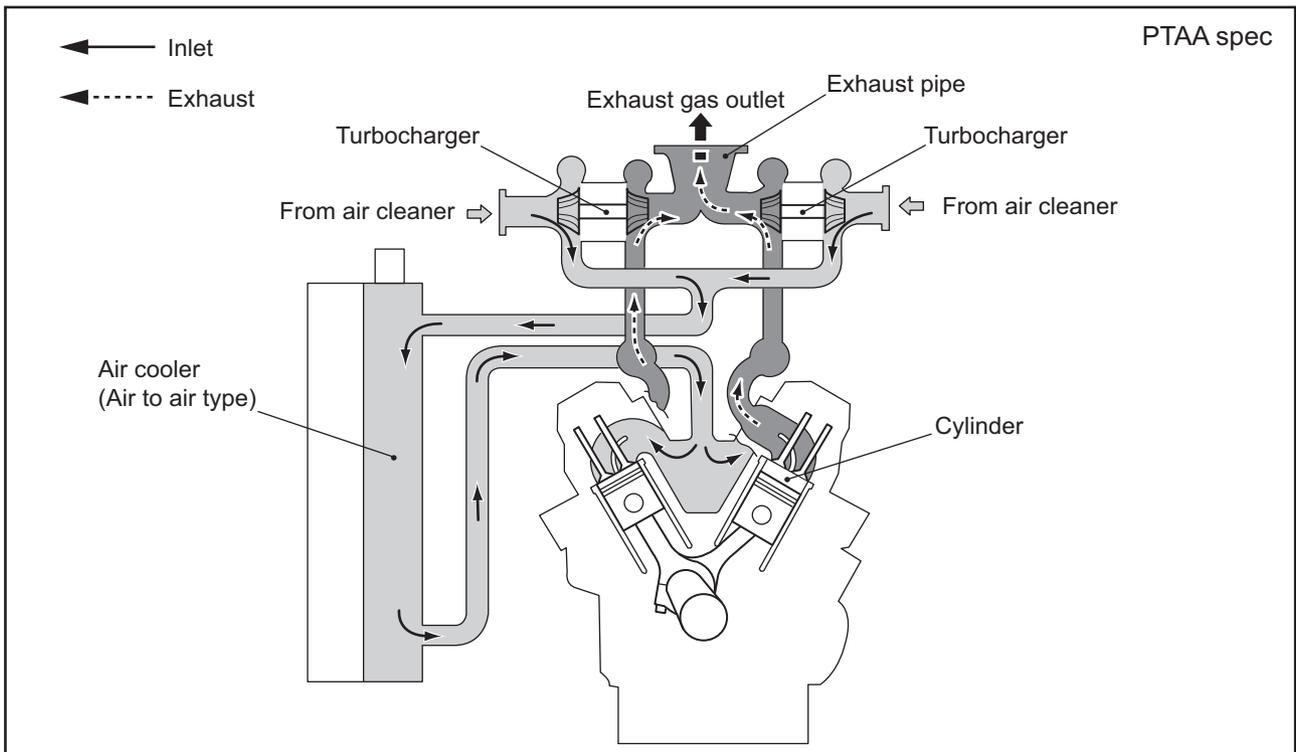
Note: When using fresh water cooling system inter cooler, seawater can not be used.

Outline of Cooling System

2.4 Outline of Inlet and Exhaust System



Outline of Inlet and Exhaust System



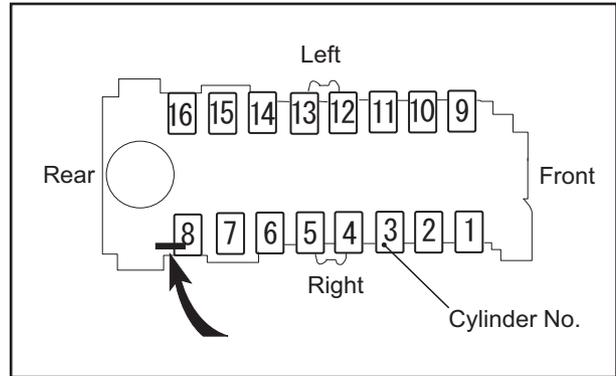
Outline of Inlet and Exhaust System

### 3. Indications of Plate and Label

#### 3.1 Name Plate

The name plate is located on the lateral side of the engine, and indicates the following information:

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

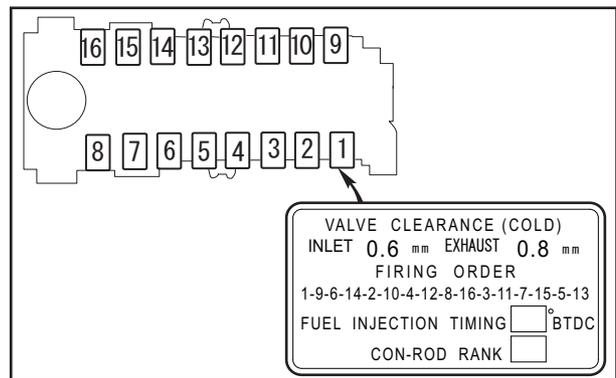


Name Plate

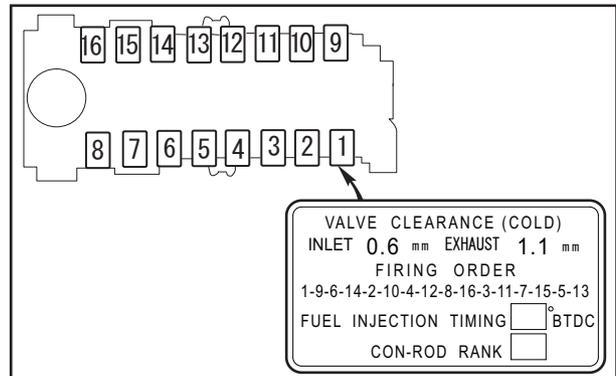
#### 3.2 Caution Plate

The caution plate is located on the top face of the rocker cover of No. 1 cylinder and indicates the following information:

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



Caution Plate (1)



Caution Plate (2)

(S16R2-T2MPTAW-11 and Sand Pump Ship for Pump Drive of S16R2-MPTK2 for China)

#### 3.3 Emission Certification Label

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

## 4. Specifications

Engine model	S16R	S16R2
Type	Water cooled, four stroke cycle diesel, turbo charged	
No. of cylinders - Arrangement	16-V	
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	65.37 L [3989.725 cubic in.]	79.90L [4876.534 cubic in.]
Firing order	1-9-6-14-2-10-4-12-8-16-3-11-7-15-5-13	
Direction of rotation	Counterclockwise as viewed from flywheel side	
Engine oil	Class CF or CH-4 (API service classification)	

## Specification table

The mark "Y" 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	S16R																							
		A2PTAW	C2MPTK	MPTA	MPTK	MTK	PTA	PTA2	PTAA2	PTAH	PTK	PTK2	T2M(P)TK	T2MPTAW	Y1MPTA-3	Y1PTA-1	Y1PTA-2	Y1PTA-4	Y1PTAA2-1	Y1PTAA2-3	Y2PTAW-1	Y2PTAW2-1	Y3MPTAW-3	Z3MPTAW	
Valve mechanism	Single spring			Y	Y	Y	Y	Y	Y	Y	Y	Y			Y	Y			Y						
	Double spring	Y	Y						Y			Y	Y			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cam shaft	Overlap 61° (Right 37805-□110□) (Left 37805-□120□)			Y	Y	Y	Y				Y				Y										
	Overlap 93° (Right 37N05-□130□) (Left 37N05-□140□)							Y	Y		Y						Y	Y							
	Overlap 108° (Right 37805-□070□) (Left 37805-□080□)	Y	Y						Y			Y	Y		Y				Y	Y	Y	Y	Y	Y	Y
Cylinder liner	Standard (37507-□260□)	Y			Y	Y	Y	Y	Y	Y	Y	Y			Y	Y	Y	Y	Y	Y	Y	Y	Y		
	High-power (37507-□270□)		Y	Y	Y								Y	Y											Y
Oil pan	Shallow (200 L [52.84 US gal]) (37813-□010□)	Y					Y	Y	Y	Y	Y				Y	Y	Y	Y	Y	Y	Y	Y			
	Deep (260 L [68.70 US gal]) (37813-□220□)		Y	Y	Y	Y						Y	Y	Y										Y	Y

Equipment name	Specification name	S16R																								
		A2PTAW	C2MPTK	MPTA	MPTK	MTK	PTA	PTA2	PTAA2	PTAH	PTK	PTK2	T2M(P)TK	T2MPTAW	Y1MPTA-3	Y1PTA-1	Y1PTA-2	Y1PTA-4	Y1PTAA2-1	Y1PTAA2-3	Y2PTAW-1	Y2PTAW2-1	Y3MPTAW-3	Z3MPTAW		
Piston	Overlap 61° Compression ratio 14 (37517-□010□)				Y	Y	Y				Y															
	Overlap 93° Compression ratio 13.5 (37517-□770□)							Y	Y			Y														
	Overlap 108° Compression ratio 14 (37517-□060□)									Y									Y	Y		Y				
	Overlap 108° Compression ratio 15 (37517-□040□)															Y	Y	Y								
	Overlap 108° Compression ratio 14.5 (37517-□450□)																							Y		
	Overlap 108° Compression ratio 14.5 (37517-□090□)	Y	Y										Y	Y								Y			Y	
	Overlap 61° Compression ratio 14 Outside diameter deviation reduction (37517-□080□)				Y	Y																				
Crank shaft	Standard (37820-□319□)	Y			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
	NV Classification (37820-□010□)		Y	Y	Y								Y												Y	
Crank shaft pulley	PTAW fan drive (Ribbed belt) (37720-□360□)																				Y	Y				
	NV classification pulley (37720-□350□)			Y	Y																			Y		
	LR classification pulley (45325-□180□)			Y	Y																					
	PTAW ribbed belt pulley (37720-□380□)	Y																								
	PTAW fan drive (V belt) (37720-□420□)	Y																								
Stub shaft (37725-□430□)																Y	Y	Y								
Flywheel	Standard (37721-□006□)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
	Light weight type (37721-□701□)						Y																			
Damper	Double damper		Y	Y	Y	Y																				
	Double damper with spacer	Y					Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Fuel injection pipe	Standard pipe	Y			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
	Double pipe		Y	Y	Y								Y												Y	

Equipment name	Specification name	S16R																							
		A2PTAW	C2MPTK	MPTA	MPTK	MTK	PTA	PTA2	PTAA2	PTAH	PTK	PTK2	T2M(P)TK	T2MPTAW	Y1MPTA-3	Y1PTA-1	Y1PTA-2	Y1PTA-4	Y1PTAA2-1	Y1PTAA2-3	Y2PTAW-1	Y2PTAW2-1	Y3MPTAW-3	Z3MPTAW	
Fuel injection nozzle	T type (37560-□700□)				Y		Y	Y	Y		Y	Y													
	T type (37560-□500□)															Y	Y								
	T type (37560-□201□)															Y									
	T type (37560-□100□)																		Y	Y		Y			
	T type (37560-□900□)			Y	Y	Y	Y				Y				Y										
	TE type (37860-□600□)		Y										Y	Y								Y			Y
	TE type (37860-□500□)	Y								Y													Y		
	TE type (37860-□800□)	Y																							
	S type (37760-□400□)																								Y
Fuel filter	Diesel oil	Y					Y	Y	Y	Y		Y			Y	Y	Y	Y	Y	Y	Y	Y	Y		
	A diesel oil				Y		Y	Y	Y		Y	Y	Y												
	Diesel oil, change over type		Y	Y	Y									Y										Y	
	A diesel oil, change over type					Y																			
	Diesel oil with trochoid	Y																							
	Diesel oil, change over type (English)															Y								Y	
Governor	Woodward make PSG type governor			Y	Y	Y						Y	Y	Y									Y	Y	
	Woodward make EG-3P type governor											Y													
	Woodward make DYNA8000 type actuator						Y	Y	Y																
	TOHO SEISAKUSHO Co., LTD. SG4017 type actuator						Y	Y	Y		Y	Y													
	Woodward make PROACT2 type actuator	Y								Y						Y	Y	Y	Y	Y	Y	Y	Y		
Trochoid fuel feed pump type	Trochoid fuel feed pump																					Y			
Solenoid	Stop: RUN OFF		Y	Y	Y	Y						Y	Y	Y	Y								Y	Y	
	Stop: RUN ON	Y					Y	Y	Y	Y	Y	Y				Y	Y	Y	Y	Y	Y	Y			
	Start rack control: RUN OFF							Y	Y			Y													
Exhaust manifold	ø60 exhaust pipe	Y	Y	Y	Y	Y	Y			Y				Y		Y	Y				Y		Y	Y	
	ø60 exhaust pipe Seawater air cooler											Y													
	ø60 exhaust pipe 2 Turbo												Y												
	ø80 exhaust pipe									Y									Y	Y		Y			
	ø120 exhaust															Y									
	ø150 exhaust							Y				Y													
	ø150 exhaust (PTAA2)								Y																

Equipment name	Specification name	S16R																							
		A2PTAW	C2MPTK	MPTA	MPTK	MTK	PTA	PTA2	PTAA2	PTAH	PTK	PTK2	T2M(P)TK	T2MPTAW	Y1MPTA-3	Y1PTA-1	Y1PTA-2	Y1PTA-4	Y1PTAA2-1	Y1PTAA2-3	Y2PTAW-1	Y2PTAW2-1	Y3MPTAW-3	Z3MPTAW	
Turbocharger	TD13-36F(34)				Y					Y															
	TD13-36F(29)						Y																		
	TD13M-40Q(24)										Y														
	TD13M-37Q22V(26.3)							Y																	
	TD13M-37Q22VRC								Y																
	TD13M-43QRC(29)																		Y				Y		
	TD13M-45Q22VRC(29) With RCC cover																						Y		
	TD13M1-43QH20.8VRC(29) With RCC cover	Y																							
	TD13M1-45QH20.8VRC(29) With RCC cover											Y													
	TD13M1-48QH20.8VRC(34) With RCC cover																						Y		
	TD13L-40Q23.5VRC(27.5)							Y																	
	TD13L-43QRC(30)											Y													
	TD13L-43Q23.5VRC								Y																
	TD13L-48QRC(40)						Y						Y												
	TD10-36F(28)	Y		Y	Y		Y				Y				Y										
	TD10L-45VRC(28)															Y									
	TD10L-45VRC(23)																Y								
TD10L-40MRC(23)																	Y								
TD10L-40V(28)				Y																					
TD10L-40QRC(23)																				Y					
TD10L2-40MRC(23)																							Y		
TD10L2-51VRC(28)																				Y					
TD10L2-45VRC(28)									Y			Y												Y	
Air cooler	(37N55-□100□)	Y		Y			Y			Y				Y	Y	Y	Y				Y				
	Fresh water (big size) (37N55-□800□)	Y						Y			Y											Y			
	Fresh water two stages (37855-□005□)		Y										Y										Y	Y	
	Sea water (37855-□003□)				Y	Y						Y													
	Built-in radiator (37847-□130□)									Y									Y						
Fan	D1530, PUSHER (37848-□350□)						Y	Y							Y	Y									
	D1828, PUSHER (46648-□640□)						Y	Y		Y															
Heat exchanger	Heat exchanger (45R52-□000□)				Y																				
	Heat exchanger (45R52-□100□)				Y							Y													
	Expansion tank (45346-□810□)			Y																					

Equipment name	Specification name	S16R																						
		A2PTAW	C2MPTK	MPTA	MPTK	MTK	PTA	PTA2	PTAA2	PTAH	PTK	PTK2	T2M(P)TK	T2MPTAW	Y1MPTA-3	Y1PTA-1	Y1PTA-2	Y1PTA-4	Y1PTAA2-1	Y1PTAA2-3	Y2PTAW-1	Y2PTAW2-1	Y3MPTAW-3	Z3MPTAW
Air cooler cooling water pump	PTAW (Centrifugal) (37753-□001□)																				Y	Y		
	PTAW (Centrifugal) (37753-□004□)	Y																						
	MPTK spec (Mono flex) (45353-□460□)				Y							Y												
Oil pump	Discharge 240 L/min [63.41 U.S.gal/min] (37735-□003□)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Discharge 275 L/min [72.66 U.S.gal/min] (37735-□301□)												Y											
Starter	Land use starter (37766-□020□) × 2	Y					Y	Y	Y	Y	Y	Y				Y	Y	Y	Y	Y	Y	Y		
	Air starter (04065-□200□) × 1																							
	Marine starter (37766-□030□) × 2		Y	Y	Y	Y						Y	Y	Y									Y	Y
Alternator	30A, JG (04343-□800□)						Y	Y	Y	Y	Y	Y			Y	Y	Y	Y	Y	Y		Y		
	35A, JG (04343-□560□)			Y	Y	Y						Y												
	35A, Ribbed belt (04343-□830□)	Y																			Y	Y		
	35A (04343-□550□)		Y	Y	Y									Y	Y									Y

Equipment name	Specification name	S16R2									
		A2PTAW-1	F1PTAW-1	MPTK2	PTA	PTAW	PTAW2-E	PTAW-E	T2MPTAW	T2MPTAW-11	T2MPTK
Valve mechanism	Double spring	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cam shaft	Overlap 93° (Right 37N05-□130□) (Left 37N05-□140□)			Y							Y
	Overlap 108° (Right 37805-□070□) (Left 37805-□080□)	Y	Y		Y	Y		Y	Y		Y
	Overlap 108° (Right 37805-□410□) (Left 37805-□420□)						Y				
Cylinder liner	High-power (37807-□410□)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Oil pan	Deep (260 L [68.70 US gal]) Marine (37813-□530□)			Y					Y	Y	Y
	Deep (260 L [68.70 US gal]) Land use (37813-□520□)	Y	Y		Y	Y	Y	Y			
Piston	Overlap 93° Compression ratio 14.4 (37517-□460□)			Y							Y
	Overlap 108° Compression ratio 14 (37517-□550□)	Y	Y		Y	Y	Y	Y	Y		
	Overlap 108° Compression ratio 14 ABS Classification (37517-□55A□)										Y
Crank shaft	JG Classification (37820-□5J1□)									Y	
	NV Classification (37820-□55Y□)								Y		
	ABS Classification (37820-□55A□)										Y
	Standard (37820-□559□)	Y	Y	Y	Y	Y	Y	Y			
Crank shaft pulley	Front pulley (V-belt) (45R25-□010□)			Y							
	PTAW Ribbed belt pulley (37720-□390□)	Y									
	PTAW pulley (V-belt) (37820-□560□)		Y		Y	Y					
Flywheel	Standard (37721-□006□)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Damper	Triple damper with spacer	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Fuel injection pipe	Standard pipe	Y	Y		Y	Y	Y	Y			
	Double pipe			Y					Y	Y	
	ABS Classification Double pipe										Y

Equipment name	Specification name	S16R2										
		A2PTAW-1	F1PTAW-1	MPTK2	PTA	PTAW	PTAW2-E	PTAW-E	T2MPTAW	T2MPTAW-11	T2MPTK	
Fuel injection nozzle	TE type (37860-□600□)			Y								
	TE type (37860-□500□)									Y		
	TE type (37860-□800□)	Y	Y		Y	Y	Y	Y	Y		Y	
Fuel filter	Diesel oil					Y						
	Diesel oil with trochoid	Y	Y		Y		Y	Y				
	Diesel oil, change over type (English)			Y					Y	Y	Y	
Governor	Woodward make PSG type Governor			Y					Y		Y	
	TOHO SEISAKUSHO Co., LTD. SG4017 type Actuator				Y	Y						
	Woodward make PROACT2 type Actuator	Y	Y				Y	Y				
	Woodward make PROACT type Digital actuator								Y	Y	Y	
Trochoid Fuel feed pump type	Trochoid Fuel Feed pump	Y	Y	Y	Y	Y	Y	Y		Y		
Solenoid	Stop: RUN OFF			Y		Y			Y	Y	Y	
	Stop: RUN ON	Y					Y	Y				
	Start rack control: RUN OFF		Y		Y	Y						
Exhaust manifold	ø80 exhaust pipe	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Turbocharger	TD13M1-40QRC(34)					Y						
	TD13M1-43QH20.8VRC(29) With RCC cover		Y									
	TD13M1-43QH 20.8VRCN(34)								Y			
	TD13M1-43QH23.5VRCN (34)With RCC cover				Y							
	TD13M1-45QH20.8VRC(29) With RCC cover											Y
	TD13M1-45QH20.8VRC(34) With RCC cover				Y		Y					
	TD13M1-48QH 20.8VRCN(34)	Y		Y				Y				
	TD10L2-40MRC(28)								Y	Y		

Equipment name	Specification name	S16R2									
		A2PTAW-1	F1PTAW-1	MPTK2	PTA	PTAW	PTAW2-E	PTAW-E	T2MPTAW	T2MPTAW-11	T2MPTK
Air cooler	Fresh water (big size) (37N55-□800□)					Y					
	Fresh water (big size) (37855-□401□)	Y	Y		Y	Y	Y	Y	Y	Y	
	Fresh water two stages (37855-□007□)			Y							
	ABS Classification (37755-□2A1□)										Y
Air cooler cooling water pump	PTAW (Centrifugal) (37753-□004□)	Y	Y			Y	Y	Y			
Oil pump	Discharge 275 L/min [72.66 U.S.gal/min] (37735-□301□)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Starter	Land use starter (37766-□020□) × 2	Y	Y		Y	Y	Y	Y			
	Marine starter (37766-□030□) × 2			Y					Y	Y	Y
Alternator	35A, JG (04343-□560□)			Y							
	35A, ribbed belt (04343-□830□)	Y	Y		Y	Y	Y	Y			
	35A (04343-□550□)								Y	Y	Y

# Chapter 2 SERVICE DATA

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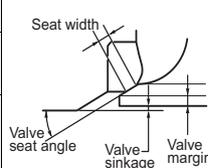
## 1. Maintenance Service Data

## 1.1 General Maintenance Service Data of Engine

Item		Nominal value	Standard value	Limit value	Remarks	
Compression pressure			1.8 MPa {18.5 kgf/cm <sup>2</sup> } [263 psi]	1.27 MPa {13 kgf/cm <sup>2</sup> } [184.2 psi]	Cranking (approx. 120 min <sup>-1</sup> )	
Engine oil pressure		Rated	0.49 to 0.64 MPa {5 to 6.5 kgf/cm <sup>2</sup> } [71.1 to 92.8 psi]	0.29 MPa {3 kgf/cm <sup>2</sup> } [42.1 psi]	When oil temp is at 90 to 100°C [194 to 212 °F]	
		Idling	0.20 to 0.29 MPa {2 to 3 kgf/cm <sup>2</sup> } [29 to 42.1 psi]	0.15 MPa {1.5 kgf/cm <sup>2</sup> } [21.8 psi]		
Valve timing	Overlap 61° Camshaft P/N: Right: 37805-□110□ (Part No. stamp, Green paint color) Left: 37805-□120□ (Part No. stamp, Green paint color)	Inlet	Open	BTDC 37°	±2° (Crank angle)	Valve clearance 0 mm [0.00 in.] (Standard value)
			Close	ABDC 44°		
		Exhaust	Open	BBDC 57°		
			Close	ATDC 24°		
	Overlap 93° Camshaft P/N: Right: 37N05-□130□ (Part No. stamp) Right: 37805-□130□ (Part No. stamp, White paint color) Left: 37N05-□140□ (Part No. stamp) Left: 37805-□140□ (Part No. stamp, White paint color)	Inlet	Open	BTDC 2.5°	±2° (Crank angle)	Valve clearance 2 mm [0.08 in.]
			Close	ABDC 13°		
		Exhaust	Open	BBDC 26°		
			Close	BTDC 10.5°		
	Overlap 108° Camshaft P/N: Right: 37N05-□130□ (Part No. stamp) Right: 37805-□130□ (Part No. stamp, White paint color) Left: 37N05-□140□ (Part No. stamp) Left: 37805-□140□ (Part No. stamp, White paint color)	Inlet	Open	BTDC 53°	±2° (Crank angle)	Valve clearance 0 mm [0.00 in.] (Standard value)
			Close	ABDC 44°		
		Exhaust	Open	BBDC 57°		
			Close	ATDC 40°		
	Overlap 108° Camshaft P/N: Right: 37805-□070□ (108H stamp) Left: 37805-□080□ (108H stamp)	Inlet	Open	BTDC 14°	±2° (Crank angle)	Valve clearance 2 mm [0.08 in.]
			Close	ABDC 12.5°		
		Exhaust	Open	BBDC 25.5°		
			Close	ATDC 1°		
Overlap 108° Camshaft P/N: Right: 37805-□410□ (Part No. stamp) left: 37805-□420□ (Part No. stamp)	Inlet	Open	BTDC 63°	±2° (Crank angle)	Valve clearance 0 mm [0.00 in.] (Standard value)	
		Close	ABDC 35°			
	Exhaust	Open	BBDC 53°			
		Close	ATDC 45°			
Overlap 108° Camshaft P/N: Right: 37805-□410□ (Part No. stamp) left: 37805-□420□ (Part No. stamp)	Inlet	Open	BTDC 25°	±2° (Crank angle)	Valve clearance 2 mm [0.08 in.]	
		Close	ABDC 3°			
	Exhaust	Open	BBDC 21°			
		Close	ATDC 7°			
Valve clearance (when cold)		Inlet		0.6 mm [0.024 in.]		
		Exhaust		0.8 mm [0.031 in.]		
		Exhaust		1.1 mm [0.043 in.]	S16R2-T2MPTAW-11 and sand pump ship for pump drive of S16R2-MPTK2 for China	
Fuel injection timing					Check the caution plate on No. 1 rocker cover.	

1.2 Maintenance Service Data of Main Engine Unit

Unit: mm [in.]

Item		Nominal value	Standard value	Limit value	Remarks	
Rocker	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 bottom face of valve bridge and the top face of valve rotator	Intake side		2.1 [0.083]		Single valve spring spec only
		Exhaust side		3.4 [0.134]		
Valve seat and valve	Valve seat angle	30°				
	Valve sinkage	0	- 0.1 to 0.1 [-0.004 to 0.004]	1.0 [0.040]		
	Seat width	2.3 [0.091]	2.19 to 2.42 [0.0862 to 0.0953]	2.8 [0.110]		
	Valve margin	3.0 [0.118]	2.80 to 3.26 [0.1102 to 0.1283]	Refacing permissible up to 2.5 [0.098]		
	Inside diameter of valve seat counterbore		60.000 to 60.030 [2.3622 to 2.3634]	60.090 [2.3657]		
	Valve seat outside diameter	Standard		60.100 to 60.130 [2.3661 to 2.3673]		3pcs, brown
		0.03 [0.0012]		60.130 to 60.160 [2.3673 to 2.3685]		4pcs, brown
		0.06 [0.0024]		60.160 to 60.190 [2.3685 to 2.3697]		5pcs, brown
	Valve seat interference		0.070 to 0.130 [0.0028 to 0.0051]			
	Single valve spring	P/N: 37504-□040□	Free length			73 [2.87]
Squareness				A = 1.5° or less B = less than 1.9 [0.075] Lf = 73 [2.87]	B = 2.2 [0.087] over entire length	
Installed length/load (mm [in.]/N {kgf} [lbf])				66.0 [2.598]/ 289 to 319 {29.45 to 32.55} [64.97 to 71.71]		

Unit: mm [in.]

Item			Nominal value	Standard value	Limit value	Remarks	
Double valve spring	P/N: 37504-□060□	Inner spring	Free length		90.6 [3.567]	88.12 [3.4693]	
			Squareness		A = 2.0° or less B = less than 3.2 [0.126] Lf = 90.6 [3.567]	B=3.7 [0.146] over entire length	
			Set length / load (mm [in.]/N {kgf} [lbf])		56.0 [2.205]/137 to 152 {14 to 15.5} [30.80 to 34.17]		
	P/N: 37504-□050□	Outer spring	Free length		96.57 [3.8020]	93.92 [3.6976]	
			Squareness		A = 2.5° or less B = less than 4.2 [0.165] Lf = 96.57 [3.8020]	B=4.9 [0.193] over entire length	
			Set length / load (mm [in.]/N {kgf} [lbf])		62.0 [2.441]/496 to 549 {50.6 to 56.0} [111.51 to 123.42]		
Push rod	Runout			0.50 [0.0197] or less		TIR	
Cylinder head	Distortion of bottom surface			0.03 [0.0012] or less	0.07 [0.0028]		
	Height (reference)			155±0.1 [6.1024±0.0039]			
Cylinder liner	Inside diameter	Standard	P/N: 37507-□260□	ø170 [6.69]	170.000 to 170.040 [6.6929 to 6.6945]	170.100 [6.6988]	
		High-power spec	P/N: 37507-□270□ P/N: 37807-□570□	ø170 [6.69]	170.020 to 170.040 [6.6937 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]		

Item		Nominal value	Standard value	Limit value	Remarks	
Piston	Outside diameter	P/N: 37517-□010□ ("□010□" stamp) 37517-□060□ ("□060□" stamp) 37517-□040□ ("□040□" stamp) 37517-□080□ ("□080□" stamp) 37517-□090□ ("□090□" stamp) 37517-□450□ ("□450□" stamp) 37517-□460□ ("□460□" stamp) 37517-□550□ ("□550□" stamp) 37517-□55A□ ("□55A□" 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 [1.57] with right angles to the piston pin.
		P/N: 37517-□770□ ("□770□" stamp)	ø170 [6.69]	169.739 to 169.779 [6.6826 to 6.6842]	169.639 [6.6787]	
		P/N: 37817-□710□ ("□710□" stamp)	ø170 [6.69]	169.760 to 169.780 [6.6835 to 6.6842]	169.660 [6.6795]	
	Weight tolerance	P/N: 37517-□010□ ("□010□" stamp) 37517-□060□ ("□060□" stamp) 37517-□040□ ("□040□" stamp) 37517-□080□ ("□080□" stamp) 37517-□090□ ("□090□" stamp) 37517-□450□ ("□450□" stamp) 37517-□460□ ("□460□" stamp) 37517-□550□ ("□550□" stamp) 37517-□55A□ ("□55A□" stamp) 37517-□770□ ("□770□" stamp) 37817-□710□ ("□710□" stamp)		Within ±25 g [0.88 oz.]		
	Piston pin bore inside diameter		ø70 [2.76]	70.002 to 70.015 [2.7560 to 2.7565]	70.040 [2.7575]	
	Protrusion			0.03 to 0.63 [0.0012 to 0.0248]		
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		0.10 to 0.15 MPa {1.0 to 1.5 kgf/cm <sup>2</sup> } [14 to 21 psi]			
Piston and cylinder head	Top clearance		1.25 to 2.00 [0.0492 to 0.0787]			
Piston ring	End gap	No. 1 compression		0.6 to 0.8 [0.024 to 0.031]	2.0 [0.078]	
		No. 2 compression		0.6 to 0.8 [0.024 to 0.031]		
		Oil	S16R			0.3 to 0.45 [0.012 to 0.0177]
			S16R2			0.3 to 0.5 [0.012 to 0.020]
Piston pin	Outside diameter	ø70 [2.76]	69.987 to 70.000 [2.7554 to 2.7559]	69.970 [2.7547]		

Unit: mm [in.]

Item		Nominal value	Standard value	Limit value	Remarks		
Connecting 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			0.6 to 0.9 [0.024 to 0.035]	1.4 [0.055]		
	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)			59.7 to 59.8 [2.350 to 2.354]			
Connecting 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 [0.0098]	3.125 [0.1230]	3.082 to 3.095 [0.1213 to 0.1219]	3.055 [0.1203]	
			0.50 [0.0197]	3.250 [0.1280]	3.207 to 3.220 [0.1263 to 3.22]	3.180 [0.1252]	
			0.75 [0.0295]	3.375 [0.1329]	3.332 to 3.345 [0.1312 to 0.1317]	3.305 [0.1301]	
			1.00 [0.0394]	3.500 [0.1378]	3.457 to 3.470 [0.1361 to 0.1366]	3.430 [0.1350]	
Flywheel	Face runout (Reference)			0.336 [0.0132] or less			
	Radial runout (Reference)			0.130 [0.0051] or less			
Oil pump drive	Inside diameter of bearing fit on oil pump bearing cover		ø110 [4.33]	110.000 to 110.035 [4.3307 to 4.3321]			
	Inside diameter of bearing fit on pump plate		ø110 [4.33]	109.987 to 110.022 [4.3302 to 4.3316]			
	Bearing	Outside diameter		ø110 [4.33]	109.985 to 110.000 [4.3301 to 4.3307]		
		Inside diameter		ø50 [1.97]	49.988 to 50.000 [1.9680 to 1.9682]		
	Outside diameter of bearing fit on oil pump gear		ø50 [1.97]	49.993 to 50.013 [1.9682 to 1.9690]			
Fan drive idler gear	Backlash between crank gear and idler gear			0.11 to 0.30 [0.0043 to 0.0118]	0.50 [0.0197]		
	Backlash between idler gear and fan drive gear			0.12 to 0.18 [0.0047 to 0.0071]	0.50 [0.0197]		
	Inside diameter of idler bushing		ø50 [1.97]	50.000 to 50.025 [1.9685 to 1.9695]	50.060 [1.9709]		
	Outside diameter of idler shaft		ø50 [1.97]	49.950 to 49.975 [1.9665 to 1.9675]	49.900 [1.9646]		
	End play of idler gear			0.40 to 1.10 [0.0157 to 0.0433]	1.20 [0.047]		

Item		Nominal value	Standard value	Limit value	Remarks	
Front mechanism	Backlash between crank gear and front idler gear		0.11 to 0.28 [0.0043 to 0.0110]	0.50 [0.0197]		
	Backlash between front idler gear and water pump gear		0.12 to 0.18 [0.0047 to 0.0071]			
	Backlash between water pump gear and oil pump gear		0.12 to 0.18 [0.0047 to 0.0071]			
	Inside diameter of front idler bushing		ø50 [1.97]	50.000 to 50.025 [1.9685 to 1.9695]	50.060 [1.9709]	
	Outside diameter of front idler shaft		ø50 [1.97]	49.950 to 49.975 [1.9665 to 1.9675]	49.900 [1.9646]	
	End play of front idler gear			0.20 to 0.40 [0.0079 to 0.0157]	0.60 [0.0236]	
Rear mechanism	Backlash between crank gear and rear idler gear		0.11 to 0.30 [0.0043 to 0.0118]	0.50 [0.0197]		
	Backlash between idler gear and camshaft gear					
	Backlash between idler gear and injection pump gear					
	Inside diameter of rear idler bushing		ø65 [2.56]	65.000 to 65.030 [2.5591 to 2.5602]	65.060 [2.5614]	
	Outside diameter of rear idler shaft		ø65 [2.56]	64.951 to 64.970 [2.5571 to 2.5579]	64.900 [2.5551]	
	End play of rear idler gear			0.30 to 0.50 [0.0118 to 0.0197]	1.00 [0.0394]	
Camshaft	Cam lift (Major axis - Minor axis)	Right : 37805-□110□ Left : 37805-□120□ (Overlap 61°)		9.207 to 9.287 [0.3625 to 0.3656]	8.931 [0.3516]	
		Right : 37805-□130□ Left : 37805-□140□ (Overlap 93°)				
		Right : 37805-□070□ Left : 37805-□080□ (Overlap 108°)		9.260 to 9.340 [0.3646 to 0.3677]	9.021 [0.3552]	
		Intake side	Right : 37805-□410□ Left : 37805-□420□ (Overlap 108°)		8.544 to 8.634 [0.3364 to 0.3399]	8.687 [0.3420]
	Exhaust side				9.260 to 9.340 [0.3646 to 0.3677]	9.021 [0.3552]
	Runout			0.1 [0.004] or less	0.16 [0.0063]	TIR
	Outside diameter of journal		ø84 [3.30]	83.920 to 83.940 [3.3039 to 3.3047]	83.870 [3.3020]	
	Inside diameter of camshaft bushing (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]		
Crank shaft	Outside diameter of crankpin	Standard		124.930 to 124.950 [4.9185 to 4.9193]	124.890 [4.9169]	
		Under size	0.25 [0.0098]		124.680 to 124.700 [4.9087 to 4.9094]	124.640 [4.9071]
			0.50 [0.0197]		124.430 to 124.450 [4.8988 to 4.8996]	124.390 [4.8972]
			0.75 [0.0295]		124.180 to 124.200 [4.8890 to 4.8898]	124.140 [4.8874]
			1.00 [0.0394]		123.930 to 123.950 [4.8791 to 4.8799]	123.890 [4.8775]

Unit: mm [in.]

Item			Nominal value	Standard value	Limit value	Remarks	
Crank shaft	Outside diameter of crank main journal	Standard	ø170 [6.69]	169.920 to 169.940 [6.6898 to 6.6905]	169.880 [6.6882]		
		Under size		0.25 [0.0098]	169.670 to 169.690 [6.6799 to 6.6807]	169.630 [6.6783]	
				0.50 [0.0197]	169.420 to 169.440 [6.6701 to 6.6709]	169.380 [6.6685]	
				0.75 [0.0295]	169.170 to 169.190 [6.6602 to 6.6610]	169.130 [6.6586]	
				1.00 [0.0394]	168.920 to 168.940 [6.6504 to 6.6512]	168.880 [6.6488]	
	Parallelism of journal and crankpin				Deviation of 0.01 [0.0004] or less overentire pin length	0.03 [0.0012]	
	Circularity of journal and crankpin				Diameter difference 0.01 [0.0004] or less	0.03 [0.0012]	
	Cylindricity of journal and crankpin				Diameter difference 0.01 [0.0004] or less	0.03 [0.0012]	
	Fillet radius of pin			R7 [0.28]	6.8 to 7.0 [0.268 to 0.276]		
	Fillet radius of journals			R8.5 [0.335]	8.3 to 8.5 [0.327 to 0.335]		
Hardness of journals and crankpins				Hv > 590			
Finishing surface roughness				Ra 0.2 µm [0.008 µin.]			
Angular deviation between pins				±20'			
Crankpin width			120 [4.72]	120.20 to 120.30 [4.7323 to 4.7362]			
Crank shaft	Width of rearmost crank journal	Standard	P/N: 37820-□010□	67 [2.64]	67.00 to 67.03 [2.6378 to 2.6390]		
		Over size			0.25 [0.0098]	67.25 to 67.28 [2.6476 to 2.6488]	
					0.50 [0.0197]	67.50 to 67.53 [2.6575 to 2.6587]	
					0.75 [0.0295]	67.75 to 67.78 [2.6673 to 2.6685]	
					1.00 [0.0394]	68.00 to 68.03 [2.6772 to 2.6783]	
					1.25 [0.0492]	68.25 to 68.28 [2.6870 to 2.6882]	
					1.50 [0.0591]	68.50 to 68.53 [2.6968 to 2.6980]	
	Standard	P/N: 37820-□310□ 37820-□550□ (ALFING make)	67 [2.64]	67.00 to 67.05 [2.6378 to 2.6398]			
	Over size			0.25 [0.0098]	67.25 to 67.30 [2.6476 to 2.6496]		
				0.50 [0.0197]	67.50 to 67.55 [2.6575 to 2.6594]		
				0.75 [0.0295]	67.75 to 67.80 [2.6673 to 2.6693]		
				1.00 [0.0394]	68.00 to 68.05 [2.6772 to 2.6791]		
				1.25 [0.0492]	68.25 to 68.30 [2.6870 to 2.6890]		
				1.50 [0.0591]	68.50 to 68.55 [2.6968 to 2.6988]		
	Runout				0.04 [0.002] or less	0.10 [0.0039]	TIR
End play (width between webs and thrust bearings)				0.200 to 0.500 [0.0079 to 0.0197]	0.600 [0.0236]		

Item		Nominal value	Standard value	Limit value	Remarks		
Main bearing	Thickness at center	Standard	4.500 [0.1772]	4.467 to 4.480 [0.1759 to 0.1764]	4.425 [0.1742]		
		Under size	0.25 [0.0098]	4.625 [0.1821]	4.592 to 4.605 [0.1808 to 0.1813]	4.550 [0.1791]	
			0.50 [0.0197]	4.750 [0.1870]	4.717 to 4.730 [0.1857 to 0.1862]	4.675 [0.1841]	
			0.75 [0.0295]	4.875 [0.1919]	4.842 to 4.855 [0.1906 to 0.1911]	4.800 [0.1890]	
			1.00 [0.0394]	5.000 [0.1969]	4.967 to 4.980 [0.1956 to 0.1961]	4.925 [0.1939]	
Trust plate	Thickness	Standard	5.00 [0.1969]	4.78 to 4.85 [0.1882 to 0.1909]	4.76 [0.1874]		
		Over size	0.25 [0.0098]	5.25 [0.2067]	5.03 to 5.10 [0.1980 to 0.2008]	5.01 [0.1972]	
			0.50 [0.0197]	5.50 [0.2165]	5.28 to 5.35 [0.2079 to 0.2106]	5.26 [0.2071]	
			0.75 [0.0295]	5.75 [0.2264]	5.53 to 5.60 [0.2177 to 0.2205]	5.51 [0.2169]	
Crank-case	Distortion of top surface			0.1 [0.004] or less	0.2 [0.008]		
	Inside diameter of main bearing bore		ø179 [7.05]	179.000 to 179.025 [7.0472 to 7.0482]	179.045 [7.0490]		
	Depth of counterbore in crankcase			14.00 to 14.05 [0.5512 to 0.5531]			
	Height from journal center to top face (Reference)			549.45 to 549.55 [21.6318 to 21.6358]			

## 1.3 Maintenance Service Data for Fuel System

Unit: mm [in.]

Item		Nominal value	Standard value	Limit value	Remarks	
Fuel injection nozzle	Free length of nozzle spring		30 [1.18]			
	Squareness of nozzle spring		0.6 [0.0236] or less			
	Parallelism of top and bottom nozzle spring		0.1 [0.0039] or less			
	Starting pressure of fuel injection	Screw adjust type	34.3 MPa {350 kgf/cm <sup>2</sup> } [4978 psi]	34.3 to 34.8 MPa {350 to 355 kgf/cm <sup>2</sup> } [4978 to 5049 psi] (the value when it is new)		
		Shim adjust type	33.8 MPa {345 kgf/cm <sup>2</sup> } [4902 psi]	33.8 to 35.8 MPa {345 to 365 kgf/cm <sup>2</sup> } [4902 to 5192 psi] (the value when it is new)		37860- □600□
	Orifice cone angle	P/N: 37860-□600□ ("AA" mark) 37860-□600□ ("XX" mark) 37860-□500□ ("YY" mark) 37860-□800□ ("V" mark)	158°			
		P/N: 37560-□500□ ("M" mark) 37560-□700□ ("F" mark) 37560-□900□ ("H" mark) 37560-□201□ ("N" mark) 37560-□100□ ("P" mark)	160°			
	Orifice diameter	P/N: 37860-□600□ ("XX" mark)	ø0.27 [0.0106]			
		P/N: 37560-□500□ ("M" mark) 37860-□500□ ("YY" mark)	ø0.29 [0.0114]			
		P/N: 37560-□201□ ("N" mark) 37860-□800□ ("V" mark)	ø0.31 [0.0122]			
P/N: 37560-□900□ ("H" mark) 37560-□100□ ("P" mark)		ø0.325 [0.0128]				
P/N: 37860-□600□ ("AA" mark)		ø0.33 [0.0130]				
P/N: 37560-□700□ ("F" mark)		ø0.35 [0.0138]				
Number of orifices		10				

Item				Nominal value	Standard value	Limit value	Remarks	
Fuel injection pump accessory drive	Without feed pump (Trochoid type)	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]			
		Bearing for injection pump drive shaft	Outside diameter	Small	ø90 [3.54]	89.985 to 90.000 [3.8970 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 bearing fit on drive shaft		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]				
	With feed pump (Trochoid type)	Inside diameter of case bearing housing		ø90 [3.54]	89.987 to 90.022 [3.5428 to 3.5442]			
				ø120 [4.72]	119.987 to 120.022 [4.7239 to 4.7253]			
		Bearing for injection pump drive shaft	Outside diameter	Small	ø90 [3.54]	89.985 to 90.000 [3.8970 to 3.5433]		
				Large	ø120 [4.72]	119.985 to 120.000 [4.7238 to 4.7244]		
			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 bearing fit on drive shaft		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]					
Drive gear side	Inside diameter of bearing fit		ø85 [3.35]	84.955 to 84.990 [3.3447 to 3.3461]				
	Bearing	Outside diameter	ø85 [3.35]	84.985 to 85.000 [3.3459 to 3.3465]				
		Inside diameter	ø45 [1.77]	44.988 to 45.000 [1.7712 to 1.7717]				
	Outside diameter of bearing fit on drive shaft		ø45 [1.77]	45.002 to 45.013 [1.7717 to 1.7722]				
Driven gear side	Inside diameter of bearing fit		ø55 [2.17]	54.988 to 55.018 [2.1649 to 2.1661]				
	Bearing	Outside diameter	ø55 [2.17]	54.987 to 55.000 [2.1648 to 2.1654]				
		Inside diameter	ø30 [1.18]	29.990 to 30.000 [1.1807 to 1.1811]				
	Outside diameter of bearing fit on driven shaft		ø30 [1.18]	30.002 to 30.011 [1.1812 to 1.1815]				
Backlash					0.10 to 0.51 [0.0039 to 0.0201]			

Unit: mm [in.]

Item		Nominal value	Standard value	Limit value	Remarks		
Governor drive	Common	Inside diameter of bearing fit on drive shaft side case	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]	24.990 to 25.000 [0.9839 to 0.9843]		
		Inside diameter of bearing fit on idler shaft side case	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 bearing fit on idler shaft	ø20 [0.79]	20.002 to 20.011 [0.7875 to 0.7878]			
		Outside diameter of gear fit on idler shaft	ø24 [0.94]	24.035 to 24.048 [0.9463 to 0.9468]			
		Inside diameter of counterbore on idler gear	ø24 [0.94]	24.000 to 24.013 [0.9449 to 0.9454]			
	Backlash		0.12 to 0.18 [0.0047 to 0.0071]	0.40 [0.0157]			
	PSG and EG-3P	Outside diameter of bearing fit on drive shaft	ø25 [0.98]	25.002 to 25.011 [0.9843 to 0.9847]			
		Outside diameter of gear fit on drive shaft	ø26 [1.02]	26.035 to 26.048 [1.0250 to 1.0255]			
		Inside diameter of counterbore on drive gear	ø26 [1.02]	26.000 to 26.013 [1.0236 to 1.0241]			
	EG-B2P	Outside diameter of gear fit on drive shaft A	ø29 [1.142]	28.959 to 28.980 [1.1401 to 1.1409]			
		Outside diameter of bearing fit on drive shaft B	ø25 [0.98]	24.987 to 25.000 [0.9837 to 0.9843]			
		Inside diameter of drive gear fit	ø29 [1.142]	29.000 to 29.040 [1.1417 to 1.1433]			
		Outside diameter of shrinkage fit on drive shaft A	ø29 [1.142]	28.959 to 28.980 [1.1401 to 1.1409]			
		Inside diameter of shrinkage fit on drive shaft B	ø17 [0.669]	17.000 to 17.018 [0.6693 to 0.6700]			

## 1.4 Maintenance Service Data of Lubrication System

Unit: mm [in.]

Item		Nominal value	Standard value	Limit value	Remarks
Oil pump	Backlash between drive gear and driven gear		0.100 to 0.200 [0.0039 to 0.0079]	0.400 [0.0157]	
	Top clearance between gear teeth and case		0.100 to 0.148 [0.0039 to 0.0058]	0.350 [0.0138]	
	Side clearance between gear width and case depth		0.040 to 0.116 [0.0016 to 0.0046]	0.210 [0.0083]	
	Outside diameter of drive shaft	ø30 [1.18]	29.887 to 29.900 [1.1767 to 1.1772]	29.840 [1.1748]	
	Outside diameter of driven shaft		29.947 to 29.960 [1.1790 to 1.1795]	29.920 [1.1780]	
	Inside diameter of bushing		30.000 to 30.021 [1.1811 to 1.1819]	30.055 [1.1833]	
	Opening pressure of safety valve		1.3±0.13 MPa {13±1.3 kgf/cm <sup>2</sup> } [189±19 psi]		
	Set length/load of safety valve spring		65.8/359 N {36.6 kgf} [80.7 lbf]	65.8/314 N {32.0 kgf} [70.6 lbf]	
	Free length of safety valve spring		78 [3.07]		
Relief valve	Free length of spring		188 [7.40]		
	Outside diameter of valve		33.925 to 33.950 [1.3356 to 1.3366]		
	Inside diameter of body (Measuring position 1, 2)		34.000 to 34.025 [1.3386 to 1.3396]		
Oil Thermostat	P/N: 37739-□050□	Valve opening temperature	95°C [203°F]	80 to 84°C [176 to 183.2°F]	Valve opening temperature : 82°C [179.6°F]
		Temperature at which valve lift becomes 11 [0.43] or more		95°C [203°F]	
	P/N: 37839-□050□	Valve opening temperature	85°C [185°F]	69 to 73°C [156.2 to 163.4°F]	Valve opening temperature : 71°C [159.8°F]
		Temperature at which valve lift becomes 11 [0.43] or more		85°C [185°F]	
Oil filter alarm	Turn on starting pressure (Differential pressure)		0.15 <sup>+0.03</sup> <sub>0</sub> MPa {1.5 <sup>+0.3</sup> <sub>0</sub> kgf/cm <sup>2</sup> } [21 <sup>+4.4</sup> <sub>0</sub> psi]		

## 1.5 Maintenance Service Data of Cooling System

Unit: mm [in.]

Item		Nominal	Standard	Limit	Remarks
Tension pulley	Inside diameter of pulley bearing fit		ø62 [2.44]	61.970 to 62.000 [2.4398 to 2.4409]	
	Bearing	Outside diameter	ø62 [2.44]	61.987 to 62.000 [2.4404 to 2.4409]	
		Inside diameter	ø25 [0.98]	24.990 to 25.000 [0.9839 to 0.9843]	
	Outside diameter of bracket bearing fit		ø25 [0.98]	24.987 to 25.000 [0.9837 to 0.9843]	
Thermostat	P/N: 37546-□170□ (For jacket water)	Valve opening temperature		69 to 73°C [156.2 to 163.4°F]	Valve open temperature stamp : 71°C [159.8°F]
		Temperature at which valve lift becomes 9 [0.35] or more		85°C [185°F]	
	P/N: 37751-□170□ (For air cooler)	Valve opening temperature		40 to 44°C [104 to 111.2°F]	Valve open temperature stamp : 42°C [107.6°F]
		Temperature at which valve lift becomes 9 [0.35] or more		55°C [131°F]	
Water pump	Inside diameter of bearing fit	Pump case		ø120 [4.72]	119.987 to 120.022 [4.7239 to 4.7253]
		Bearing cover		ø110 [4.33]	110.005 to 110.040 [4.3309 to 4.3323]
	Bearing	Large	Outside diameter	ø120 [4.72]	119.985 to 120.000 [4.7238 to 4.7244]
			Inside diameter	ø55 [2.17]	54.985 to 55.000 [2.1648 to 2.1654]
		Small	Outside diameter	ø110 [4.33]	109.985 to 110.000 [4.3301 to 4.3307]
			Inside diameter	ø50 [1.97]	49.988 to 50.000 [1.9680 to 1.9685]
	Outside diameter of shaft bearing fit		ø55 [2.17]	55.011 to 55.024 [2.1658 to 2.1663]	
			ø50 [1.97]	50.009 to 50.020 [1.9689 to 1.9693]	
	Clearance of impeller front		1.04 [0.041]	0.58 to 1.50 [0.0228 to 0.0591]	
	Water pump for air cooler	Inside diameter of case bearing fit	Large	ø72 [2.83]	71.961 to 71.991 [2.8331 to 2.8343]
Small			ø62 [2.44]	61.961 to 61.991 [2.4394 to 2.4406]	
Bearing		Large	Outside diameter	ø72 [2.83]	71.987 to 72.000 [2.8341 to 2.8346]
			Inside diameter	ø30 [1.18]	29.990 to 30.000 [1.1807 to 1.1811]
		Small	Outside diameter	ø62 [2.44]	61.987 to 62.000 [2.4404 to 2.4409]
			Inside diameter	ø30 [1.18]	29.990 to 30.000 [1.1807 to 1.1811]
Outside diameter of shaft bearing fit		ø30 [1.18]	30.002 to 30.015 [1.1812 to 1.1817]		
Clearance of impeller front		0.87 [0.034]	0.48 to 1.26 [0.0189 to 0.0492]		

Item			Nominal	Standard	Limit	Remarks			
Seawater pump for air cooler	P/N: 45353-□460□	Inside diameter of case bearing fit		ø110 [4.33]	109.995 to 110.030 [4.3305 to 4.3319]				
		Bearing	Outside diameter		ø110 [4.33]	109.985 to 110.000 [4.3301 to 4.3307]			
			Inside diameter		ø50 [1.97]	49.988 to 50.000 [1.9680 to 1.9685]			
		Outside diameter of shaft bearing fit		ø50 [1.97]	50.002 to 50.013 [1.9686 to 1.9690]				
Fan drive		Inside diameter of case bearing fit		ø120 [4.72]	119.987 to 120.022 [4.7239 to 4.7253]				
				ø140 [5.51]	139.986 to 140.026 [5.5112 to 5.5128]				
		Bearing	Large	Outside diameter		ø140 [5.51]	139.982 to 140.000 [5.5111 to 5.5118]		
				Inside diameter		ø55 [2.17]	54.985 to 55.000 [2.1648 to 2.1654]		
			Small	Outside diameter		ø120 [4.72]	119.985 to 120.000 [4.7238 to 4.7244]		
				Inside diameter		ø55 [2.17]	54.985 to 55.000 [2.1648 to 2.1654]		
		Outside diameter of shaft bearing fit		ø55 [2.17]	55.002 to 55.015 [2.1654 to 2.1659]				

## 1.6 Maintenance Service Data of Electrical System

Unit: mm [in.]

Item		Nominal	Standard	Limit	Remarks		
Starter	Pinion shaft	Outside diameter of shaft at front side	ø19 [0.75]	18.90 to 18.94 [0.7441 to 0.7457]			
		Inside diameter of bearing at front side	ø19 [0.75]	19.000 to 19.033 [0.7480 to 0.7493]			
		Inside diameter of pinion bearing	ø19 [0.75]	19.000 to 19.033 [0.7480 to 0.7493]			
		Outside diameter of shaft at rear side	ø30 [1.18]	30.002 to 30.011 [1.1812 to 1.1815]			
		Inside diameter of bearing fit on center bracket	ø55 [2.17]		55.1 [2.169]		
		Rear shaft bearing	Outside diameter	ø55 [2.17]	54.987 to 55.000 [2.1648 to 2.1654]		
			Inside diameter	ø30 [1.18]	29.990 to 30.000 [1.1807 to 1.1811]		
		End play		0.2 to 0.8 [0.008 to 0.031]		Adjust with the adjust washer	
		Clearance between pinion shaft and bearing				0.25 [0.0098]	
		Brush length			22 to 23 [0.78 to 0.91]	13 [0.51]	
	Spring pressure of brush spring			44.1 N {4.5 kgf} [9.9 lbf]	40.2 N {4.1 kgf} [9.0 lbf]	With brush installed	
	Armature	Outside diameter of shaft at front side	ø20 [0.79]	20.002 to 20.011 [0.7875 to 0.7878]			
		Inside diameter of bearing at front side	ø47 [1.85]		47.1 [1.854]		
		Front shaft 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 shaft at rear side	ø10 [0.39]	10.001 to 10.007 [0.3937 to 0.3940]			
		Inside diameter of bearing fit at rear side	ø30 [1.18]		30.1 [1.185]		
		Rear side shaft bearing	Outside diameter	ø30 [1.18]	29.991 to 30.000 [1.1807 to 1.1811]		
			Inside diameter	ø10 [0.39]	9.992 to 10.000 [0.3934 to 0.3937]		
		Shaft runout			0.05 [0.0020]		TIR
		End play	Single wire type (Body grounding)		0.15 to 0.75 [0.0059 to 0.0295]		Adjust with the adjust washer
2-wire type			0.2 to 0.7 [0.008 to 0.028]				
Commutator	Outside diameter	ø43 [1.69]		42 [1.65]			
	Runout		0.06 [0.0024]	0.1 [0.004]	TIR		
	Undercut depth		0.7 to 0.9 [0.028 to 0.035]	0.2 [0.008]			

Item				Nominal	Standard	Limit	Remarks		
Starter	P/N: 37766-□020□ Single wire type P/N: 37766-□030□ 2-wire type	Magnetic switch	Coil resistance (Ω)	At pull starting		0.066 [0.0026]	(reference at 20°C [68°F])		
				Hold condition		1.07 [0.0421]	(reference at 20°C [68°F])		
			Contactor deflection			1.35 to 2.05 [0.0531 to 0.0807]	0.6 [0.24]		
		Insulating resistance	Armature		Commutator to earth		100 MΩ or higher (Room temperature and humidity at 500 V megger)	0.02 MΩ or higher	
			Yoke assy		M terminal lead to ear		100 MΩ or higher (Room temperature and humidity at 500 V megger)	0.02 MΩ or higher	
			Brush holder		Positive brush box to holder ring		100 MΩ or higher (Room temperature and humidity at 500 V megger)	0.02 MΩ or higher	
Alternator	P/N: 04343-□550□ P/N: 04343-□560□	Initial exciting type (brush-less)	Output current (at 27 V)	Rotating speed (min <sup>-1</sup> )	2500		30 A or more (when the engine is cold)		
				5000		35 A or more (when engine is hot)			
			Regulator adjusting voltage (Alternator 5000 min <sup>-1</sup> , 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-□800□	Self exciting type (with brush)	Output current (at 27 V)	Rotating speed (min <sup>-1</sup> )	2500		26 A or more (when engine is hot)		
				5000		30 A or more (when engine is hot)			
			Regulator adjusting voltage (Alternator 5000 min <sup>-1</sup> , load at 5 A or lower)				28.5±0.5 V		
			Outside diameter of rotor slip ring			33 [1.30]	32.8 to 33.2 [1.291 to 1.307]	32.4 [1.276]	
			Height of brushes			21.5 [0.846]		8.0 [0.315]	The part shows a limit line.
			Pressure of brush springs			3.7 N {0.38 kgf} [0.83 lbf]	3.1 to 4.3 N {0.32 to 0.44 kgf} [0.70 to 0.97 lbf]	1.8 N {0.18 kgf} [0.40 lbf]	
	Belt tension (cogged type)					10 to 15 [0.39 to 0.59]		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]	

Unit: mm [in.]

Item					Nominal	Standard	Limit	Remarks		
Alternator	P/N: 04343-□830□	External exciting type (with brush)	Output current (at 27 V)	Rotating speed (min <sup>-1</sup> )	2500		29 A or more (when engine is hot)			
					5000		35 A or more (when engine is hot)			
			Regulator adjusting voltage (Alternator 5000 min <sup>-1</sup> , load at 5 A or lower)					28.5±0.5 V		
			Outside diameter of rotor slip ring				33 [1.30]	32.8 to 33.2 [1.291 to 1.307]	32.4 [1.276]	
			Height of brushes				21.5 [0.846]		8.0 [0.315]	The part shows a limit line.
			Pressure of brush spring				3.7 N {0.38 kgf} [0.83 lbf]	3.1 to 4.3 N {0.32 to 0.44 kgf} [0.70 to 0.97 lbf]	1.8 N {0.18 kgf} [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 [19.69 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 Maintenance Service Data

Unit: mm [in.]

Item		Nominal value	Standard value	Limit value	Remarks
Starter valve	Clearance between valve and valve guide	ø15 [0.59]	0.016 to 0.052 [0.0006 to 0.0020]	0.100 [0.0039]	
	Free length of valve spring		36 [1.42]	34 [1.34]	
Distributor valve	Height of distributor valve		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 Specifications for Engine Body

Description	Thread size Dia. × Pitch	Tightening torque			Remarks	
		N·m	kgf·m	lbf·ft		
Cylinder head bolt	M22 × 2.5	539±27	55±2.75	397.55±19.91	[Wet] 2-time tightening method, Note (a)	
Cylinder head nozzle gland (Studs)	M14 × 2.0	118±20	12±2	87.03±14.75	Apply Loctite 272 to the internal screw thread of the cylinder head	
Rocker case	M12 × 1.25	108±5.4	11±0.55	79.66±3.98		
Rocker shaft	M14 × 2.0	147±7.4	15±0.75	108.42±5.45		
Rocker arm (Lock nut)	M12 × 1.25	64±3.2	6.5±0.33	47.20±2.36		
Bridge (Lock nut)	M10 × 1.25	55±2.8	5.6±0.28	40.57±2.02		
Camshaft gear (Rear)	M12 × 1.25	108±5.4	11±0.55	79.66±3.98	Use 10T bolt w/spring washer	
		127±6.4	13±0.65	93.67±4.72	Use 12T bolt w/hard washer	
Camshaft thrust plate	M12 × 1.25	59±5.9	6±0.6	43.52±4.35		
Main bearing cap	M24 × 3.0	Note (b)			[Wet], 2-time tightening method	
Main bearing cap (Side bolt)	M20 × 2.5				[Wet], 1-time tightening method	
Hanger	M20 × 1.5	392±19.6	40±2	289.12±14.45		
	M16 × 1.5	216±10.8	22±1.1	159.31±7.96		
Piston cooling nozzle	M12 × 1.75	34±1.7	3.5±0.18	25.08±1.25	Note (c)	
Timing gear case	M16 × 1.5	255±12.8	26±1.3	188.08±9.44	Use hard washer	
		216±10.8	22±1.1	159.31±7.96	Use spring washer	
Rear plate	M12 × 1.25	108±5.4	11±0.55	79.66±3.98	Use flange bolt	
		M16 × 1.5	255±12.8	26±1.3	188.08±9.44	Use hard washer
			216±10.8	22±1.1	159.31±7.96	Use spring washer
Front mounting bracket	M20 × 1.5	392±19.6	40±2	289.12±14.45		
		245±12.3	25±1.25	180.70±9.07	Right side front mounting bracket (Only front row lower)	
Rear mounting bracket	M20 × 1.5	392±19.6	40±2	289.12±14.45		
Connecting rod cap	M22 × 1.5	Note (e)			[Wet]	
Balance weight	M22 × 1.5	490±24.5	50±2.5	361.41±18.07	[Wet]	
Flywheel	M22 × 1.5	588±29.4	60±3	433.69±21.68	[Wet]	
Ring gear	M10 × 1.25	33±1.7	3.4±0.17	24.34±1.25		
Damper	M22 × 1.5	490±24.5	50±2.5	361.41±18.07		
Rear idler shaft	M20 × 1.5	392±19.6	40±2	289.12±14.45	Apply MOLYKOT	
		M16 × 1.5	255±12.8	26±1.3	188.08±9.44	Apply MOLYKOT
			216±10.8	22±1.1	159.31±7.96	
Rear idler shaft thrust collar (Nut)	M18 × 1.5	196±9.8	20±1	144.56±7.22		
		M14 × 1.5	147±7.4	15±0.75	108.42±5.45	
Front gear case	M12 × 1.25	108±10.8	11±1.1	79.66±7.96		
		M16 × 1.5	262±26.2	26.7±2.67	193.24±19.32	Use hard washer
			216±10.8	22±1.1	159.31±7.96	Use spring washer
Front plate	M12 × 1.25	59±5.9	6±0.6	43.52±4.35		
Front idler shaft	M12 × 1.25	108±10.8	11±1.1	79.66±7.96		
Front idler shaft thrust plate	M10 × 1.25	60±3	6.1±0.31	44.25±2.21		
Mount plate of oil pump and water pump	M12 × 1.25	59±5.9	6±0.6	43.52±4.35		
Bearing cover for oil pump and water pump drive	M12 × 1.25	59±5.9	6±0.6	43.52±4.35		
Fuel injection accessory drive case	M12 × 1.25	108±5.4	11±0.55	79.66±3.98		
Governor drive case	M12 × 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 it with a snug torque 294±14.7 N·m {30±1.5 kgf·m} [216.84±10.84 lbf·ft].
  - 2) Tighten to the angle 65±3°.
  - 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) Main bearing cap bolts and main bearing cap side bolts should be tightened as shown in the table below.

Bolt	Angle controlled method (2-time tightening method)	Torque method (1-time tightening method)
Main bolt	Snug torque 245±12.3 N·m {25±1.3 kgf·m} [180.7±9.07 lbf·ft] → 60±3°	588±29.4 N·m {60±3 kgf·m} [433.69±21.68 lbf·ft]
Side bolt	-	392±19.6 N·m {40±2 kgf·m} [289.12±14.45 lbf·ft]

(c) Piston cooling nozzle check valves should be tightened 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	Angle controlled method (2-time tightening method)	Torque method (2-time tightening method)
2	Snug torque 245±12.3 N·m {25±1.3 kgf·m} [180.7±9.07 lbf·ft] → 60±3°	539±27 N·m {55±2.75kgf·m} [397.55±19.91 lbf·ft]
CS		637±31.9 N·m {65±3.25kgf·m} [469.83±23.52 lbf·ft]
CL	Snug torque 294±14.7 N·m {30±1.5 kgf·m} [216.84±10.84 lbf·ft] → 60±3°	

## 2.2 Tightening Torque Specifications for Fuel System

Description	Thread size Dia. × Pitch	Tightening torque			Remarks		
		N·m	kgf·m	lbf·ft			
Fuel injection pump	Accessory drive case	M12 × 1.25	108±5.4	11±0.55	79.66±3.98		
	Accessory drive gear (Nut)	Nut	M30 × 1.5	490±24.5	50±2.5	361.41±18.07	
		Speed pick-up	M30 × 1.5	392±19.6	40±2	289.12±14.45	
	Coupling shaft	M14 × 1.5	176±5	18±0.5	129.81±3.68	Tighten the slit portion.	
	Laminated plate	M14 × 1.5	137±5	14±0.5	101.05±3.68	2-time tightening method	
		M12 × 1.25	113±4.9	11.5±0.5	83.34±3.61	10T bolt + Nut with washer, 2-time tightening method	
			88±5	9±0.5	64.91±3.68	Identification bolt + Nut with washer, 2-time tightening method	
	Pump mounting bolt	M12 × 1.25	108±5.4	11±0.55	79.66±3.98		
	Bracket	M12 × 1.25	108±5.4	11±0.55	79.66±3.98		
Flywheel (Nut)	M24 × 1.5	392±19.6	40±2	289.12±14.45			
Air vent eye bolt	M8 × 1.25	15±2	1.5±0.2	11.06±1.47			
Plunger assembly	M12 × 1.25	81±2.5	8.3±0.25	59.74±1.84			
Delivery valve holder	M30 × 1.5	245±10	25±1	180.7±7.37			
Fuel injection pipe (Nozzle and pump side)	M18 × 1.5	59±10	6±1	43.52±7.37			
Fuel rack control lever	M8 × 1.25	25±1.25	2.5±0.13	18.44±0.92	2-time tightening method		
Fuel filter air vent plug	M8 × 1.25	9±1	0.9±0.1	6.64±0.73			
Nozzle tip retaining nut	M28 × 1.5	186.5±9.5	19±1	137.56±7.0			
Nozzle inlet connector	M16 × 1.5	69±5	7±0.5	50.89±3.68			
Nozzle holder cap nut	M14 × 1.5	74±4.9	7.5±0.5	54.58±3.61			
Nozzle holder set screw	M10 × 1.5	39±4.9	4±0.5	28.76±3.61			
Nozzle gland (Nut)	M14 × 1.5	98±4.9	10±0.5	72.28±3.61			

## 2.3 Tightening Torque Specifications for Lubrication System

Description	Dia × Pitch (M-thread)	Tightening torque			Remarks
		N·m	kgf·m	lbf·ft	
Oil pump	M12 × 1.25	60±6	6.1±0.6	44.25±4.42	
Oil pump cover	M10 × 1.25	33±3.3	3.4±0.34	24.34±2.43	
Safety valve plug	M24 × 1.5	88±10	9±1	64.91±7.37	
Safety valve assembly	M32 × 2.0	74±10	7.5±1	54.58±7.37	
Governor oil filter air vent plug	M8 × 1.25	9.8±2	1±0.2	7.23±1.47	
Governor oil filter drain plug	M8 × 1.25	9.8±2	1±0.2	7.23±1.47	
Governor oil filter center bolt	M14 × 1.5	34.3±6.9	3.5±0.7	25.30±5.08	
Oil pan	M12 × 1.25	59±5.9	6±0.6	43.52±4.35	

## 2.4 Tightening Torque Specifications for Cooling System

Description	Thread size Dia. × Pitch	Tightening torque			Remarks	
		N·m	kgf·m	lbf·ft		
Water pump	Pump	M12 × 1.25	60±6	6.1±0.6	44.25±4.42	
	Pump shaft pulley (Nut)	M30 × 1.5	392±19.6	40±2	289.12±14.45	For alternator driving
Sea water pump for air cooler	Pump cam	M10 × 1.25	24±2.4	2.45±0.24	17.7±1.77	
	Pump holder	M10 × 1.5	24±2.4	2.45±0.24	17.7±1.77	
	Pump cover	M8 × 1.25	12±1.2	1.22±0.12	8.85±0.88	
	Pump shaft pulley (Nut)	M24 × 3.0	510±51	52.01±5.2	376.16±37.61	
Fan drive	Drive shaft gear (Nut)	M30 × 1.5	392±19.6	40±2	289.12±14.45	
	Drive case	M12 × 1.25	108±10.8	11±1.1	79.66±7.96	
	Drive coupling (Nut)	M30 × 1.5	392±19.6	40±2	289.12±14.45	
	Drive hub	M12 × 1.25	108±5.4	11±0.55	79.66±3.98	
	Drive idler shaft	M12 × 1.25	59±5.9	6±0.6	43.52±4.35	
		M10 × 1.25	59±5.9	6±0.6	43.52±4.35	
	Thrust plate	M10 × 1.25	60±3	6.1±0.3	44.25±2.21	
Plate fan	M12 × 1.25	60±6	6.1±0.6	44.25±4.42		

## 2.5 Tightening Torque Specifications for Inlet and Exhaust System

Description	Thread size Dia. × Pitch	Tightening torque			Remarks	
		N·m	kgf·m	lbf·ft		
Exhaust manifold coupling (Nut)	S16R	M6 × 1.0	8.3±0.5	0.8±0.05	6.12±0.36	ø60 exhaust pipe
	S16R-2	M8 × 1.25	20±1	2±0.1	14.75±0.73	ø80, ø120, ø150 exhaust pipe
Exhaust manifold mounting bolt	M10 × 1.5	58±2.9	5.9±0.3	42.78±2.13		
Turbocharger mounting (Nut)	M12 × 1.25	60±6	6.1±0.6	44.25±4.42		
Exhaust pipe V clamp	M6 × 1.0	6±1	0.6±0.1	4.43±0.73		
	1/4-28 UNF	9±0.45	0.9±0.045	6.64±0.33	Unify screw	
Air duct clamp	M6 × 1.0	4.9±0.49	0.5±0.05	3.61±0.36	T bolt type : used only in S16R-2 and S16R-TAA(2)	
Air cooler	M10 × 1.25	60±6	6.1±0.6	44.25±4.42		
Air cooler cover	M10 × 1.25	60±6	6.1±0.6	44.25±4.42	Sea water and fresh water two stage air cooler spec	

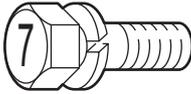
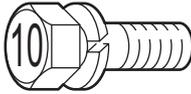
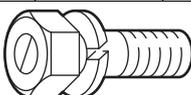
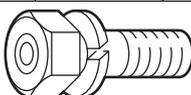
## 2.6 Tightening Torque Specifications for Electrical System

Description		Dia × Pitch (M-thread)	Tightening torque			Remarks	
			N·m	kgf·m	lbf·ft		
Starter	P/N: 37766-□020□ (Single wire type) 37766-□030□ (2-wire type)	Starter - Install	M12 × 1.25	59±5.9	6±0.6	43.52±4.35	
		Magnetic switch assembly	M6 × 1.0	4.5±0.6	0.46±0.06	3.32±0.44	
		Lever assembly	M8 × 1.25	10.9±1.3	1.1±0.14	8.04±0.95	
		Front bracket	M6 × 1.0	5.85±0.75	0.6±0.07	4.31±0.55	
		Safety switch	M6 × 1.0	4.2±0.3	0.43±0.03	3.1±0.22	
		Center bracket	M8 × 1.25	14±1.7	1.4±0.17	10.33±1.25	Hexagon socket bolt
		Brush holder	M5 × 0.8	3.2±0.4	0.33±0.04	2.36±0.29	
		Through bolt	M6 × 1.0	8.7±1.1	0.9±0.11	6.42±0.81	
		B terminal nut	M10 × 1.25	17.7±1.9	1.8±0.19	13.05±1.4	
		E terminal nut	M10 × 1.25	22.6±2.9	2.3±0.3	16.67±2.13	2- wire type only
Alternator	P/N: 04343-□550□ 04343-□560□	Pulley nut	M20 × 1.5	147±15	14.99±1.53	108.42±11.06	
		Retainer tightening screw	M5 × 0.8	3.9±1	0.4±0.1	2.88±0.73	
		Through bolt	M6 × 1.0	5.4±1.5	0.55±0.15	3.98±1.1	
		Regulator assembly tightening screw	M5 × 0.8	3.9±1	0.4±0.1	2.88±0.73	
		Rectifier assembly tightening screw	M5 × 0.8	3.9±1	0.4±0.1	2.88±0.73	
		B terminal nut	M5 × 0.8	6.9±0.9	0.7±0.09	5.09±0.66	
		E terminal nut	M5 × 0.8	6.9±0.9	0.7±0.09	5.09±0.66	
		Coil assembly tightening screw	M5 × 0.8	3.9±1	0.4±0.1	2.88±0.73	
		Screw connecting field coil and regulator	M5 × 0.8	3.9±1	0.4±0.1	2.88±0.73	
		Connector assembly tightening bolt	M6 × 1.0	5.4±1.5	0.55±0.15	3.98±1.1	
	P/N: 04343-□800□ 04343-□830□	Pulley nut	M20 × 1.5	147±29	14.99±2.95	108.42±21.38	
		Retainer tightening screw	M5 × 0.8	3.9±1	0.4±0.1	2.88±0.73	
		Through bolt	M5 × 0.8	4.4±1	0.45±0.1	3.25±0.73	
		Regulator assembly tightening screw	M5 × 0.8	3.9±1	0.4±0.1	2.88±0.73	
		Rectifier assembly tightening screw	M5 × 0.8	3.9±1	0.4±0.1	2.88±0.73	
		B terminal nut	M5 × 0.8	6.9±1.9	0.7±0.19	5.09±1.4	

## 2.7 Tightening Torque Spec for Air Start System

Description	Thread size Dia. × Pitch	Tightening torque			Remarks
		N·m	kgf·m	lbf·ft	
Starter valve nut	M8 × 1.25	19±0.95	1.94±0.09	14.01±0.7	
Starter valve cap nut	M36 × 1.5	117.6±5.88	12±0.6	86.74±4.27	

## 2.8 Tightening Torque for Standard Bolts

Threads	Thread size Dia. × Pitch (M-thread)	Width across flats (mm) [in.]	Strength classification							
			7T			10.9T				
Metric automobile screw thread										
			N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft		
			8 × 1.25	12 [0.47]	17	1.7	12.5	30	3.1	22.1
			10 × 1.25	14 [0.55]	33	3.4	24.3	60	6.1	44.3
			12 × 1.25	17 [0.67]	60	6.1	44.3	108	11.0	79.7
			14 × 1.5	22 [0.87]	97	9.9	71.5	176	18.0	129.8
			16 × 1.5	24 [0.94]	145	14.8	106.9	262	26.7	193.2
			18 × 1.5	27 [1.06]	210	21.4	154.9	378	38.5	278.8
			20 × 1.5	30 [1.18]	291	29.7	214.6	524	53.4	386.5
			22 × 1.5	32 [1.26]	385	39.3	284.0	694	70.8	511.9
24 × 1.5	36 [1.42]	487	49.7	359.2	878	89.5	647.6			
27 × 1.5	41 [1.61]	738	75.3	544.3	1328	135.4	979.5			
Metric course screw thread										
			N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft		
			10 × 1.5	14 [0.55]	32	3.3	23.6	58	5.9	42.8
			12 × 1.75	17 [0.67]	57	5.8	42.0	102	10.4	75.2
			14 × 2	22 [0.87]	93	9.5	68.6	167	17.0	123.2
			16 × 2	24 [0.94]	139	14.2	102.5	251	25.6	185.1
			18 × 2.5	27 [1.06]	194	19.8	143.1	350	35.7	258.1
			20 × 2.5	30 [1.18]	272	27.7	200.6	489	49.9	360.7
			22 × 2.5	32 [1.26]	363	37.0	267.7	653	66.6	481.6
24 × 3	36 [1.42]	468	47.7	345.2	843	86.0	621.8			
27 × 3	41 [1.61]	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 Eye Bolts

Note: Tightening condition: Dry condition (No oil is applied)

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±0.74
10 × 1.25	14 [0.55]	15±2	1.5±0.2	11.06±1.48
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±3.69
18 × 1.5	24 [0.94]	74±5	7.5±0.5	54.58±3.69
20 × 1.5	27 [1.06]	98±10	10.0±1.0	72.28±7.38
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

## 2.10 Tightening Torque for Standard Union Nuts

Note:(a) Tightening condition: Dry condition (No oil is applied)

(b) Maximum tolerance value: ±10%

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

## 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

(Dry)

## 2.12 Tightening Torque for Standard Plug

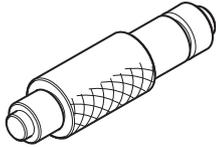
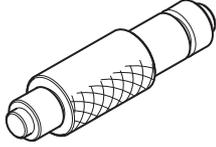
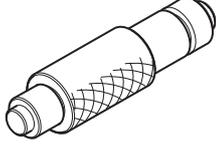
Nominal R,G,NPTF	Tighten to aluminum material			Tighten to iron material		
	N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft
1/16	6.4±1.5	0.65±0.15	4.7±1	9.8±2	1±0.2	7.2±1.5
1/8	9.8±2	1±0.2	7.2±1.5	18.1±3.4	1.85±0.35	13.3±2.5
1/4	24.5±4.9	2.5±0.5	18±3.6	39.2±4.9	4±0.5	28.9±3.6
3/8	46.6±7.4	4.75±0.75	34.4±5.5	63.7±9.8	6.5±1	46.9±7.2

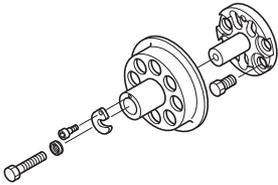
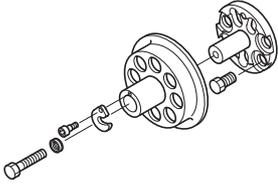
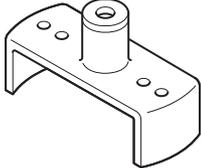
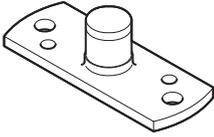
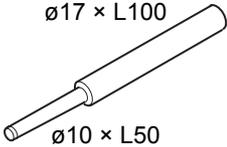
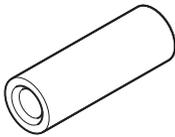
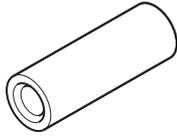
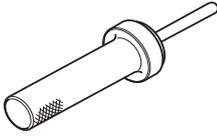
# Chapter 3 SERVICE TOOLS

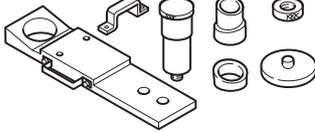
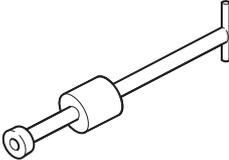
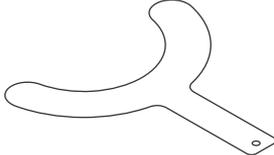
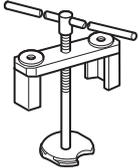
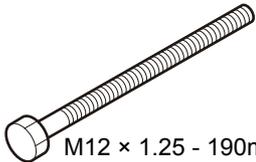
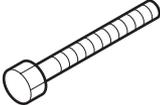
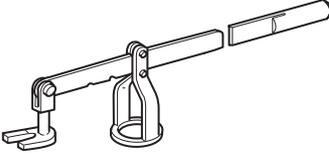
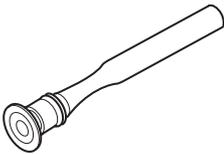
1. Special Tools.....	3-3
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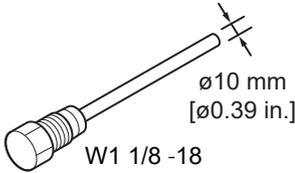
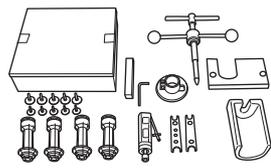
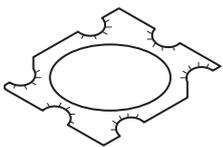
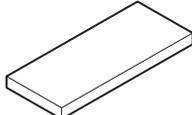
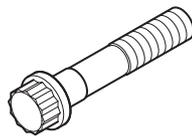
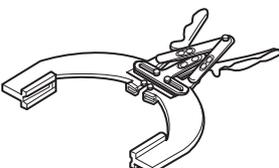
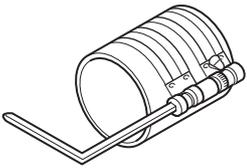


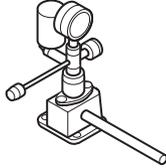
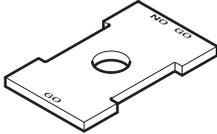
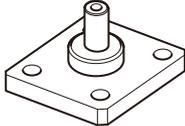
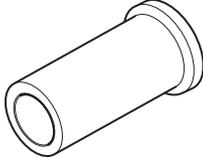
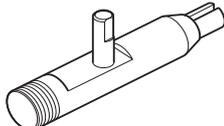
## 1. Special Tools

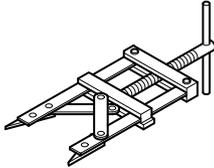
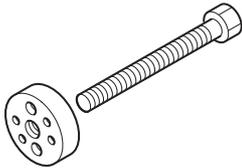
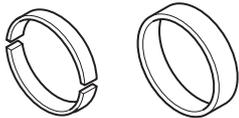
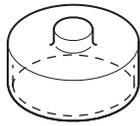
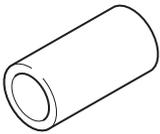
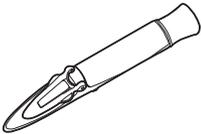
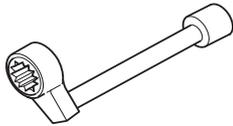
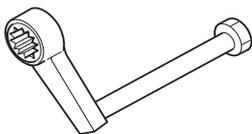
Maintenance item	Tool name	Part No.	Illustration	Usage
Engine body	Rocker bushing tool	37591-02600		Rocker bushing - replace Bushing inside/outside diam : ø36 × 40 mm [1.38 × 1.57 in.]
	Front Idler bushing puller	32591-02500		Front idler bushing - replace Bushing inside/outside diam : ø50 × 55 mm [ø1.97 × 2.17 in.]
	Rear Idler bushing installer	37791-02500		Rear idler bushing - replace Bushing inside/outside diam : ø65 × 70 mm [2.56 × 2.76 in.]
	Eye bolt	37591-02500	 M10 × 1.25	Piston and others - lift
	Eye bolt	MM321-420	 M10 × 1.5	Piston and others - lift
	Eye bolt	05930-00200	 M12 × 1.25	Gear case - lift
	Eye bolt	37791-02100	 M27 × 1.5	Main bearing cap - remove (conventional)
	Jack bolt	37791-02300		Main bearing cap - remove (New)

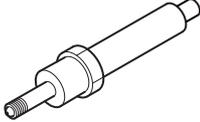
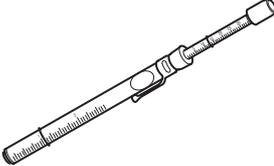
Maintenance item	Tool name	Part No.	Illustration	Usage
Engine body	Eye nut	37591-02400	 M14 × 1.5	Cylinder head assembly - install/ remove
	Front seal installer assembly	37591-05010		Front oil seal - install
	Rear seal installer assembly	37791-06010		Rear oil seal - install
	Slinger installer	37491-02100		Rear slinger - press-in With installer guide
	installer guide	37491-02200		
	Valve guide remover	33591-04300	 ø17 × L100 ø10 × L50	Valve guide - remove Applicable valve guide inside × outside diam ø10 × 18 mm [ø0.39 × 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 ring installer	37591-04011		Valve seat - press-in Big outside diam: ø59 mm [2.32 in.] Small outside diam: ø48.5 mm [1.9095 in.]

Maintenance item	Tool name	Part No.	Illustration	Usage
Engine body	Crankcase grinder	37591-07010		Crankcase counterbore depth - reface
	Connecting rod bushing installer	37591-01010		Connecting rod bushing - install/remove
	Nozzle remover	33591-10101		Fuel injection nozzle - remove
	Connecting rod gauge	Sheet thickness : 0.5 mm [0.02 in.] 37791-01500 Sheet thickness : 0.6 mm [0.024 in.] 37791-01600		Connecting rod end play - set
	Cylinder liner remover	37591-04100		Cylinder liner - removal Applicable cylinder liner inner diam: ø170 mm [6.69 in.]
	Jack bolt	37791-02200	 M12 × 1.25 - 190mm	Extra flywheel and damper - remove
	Jack bolt	64362-68500	 M12 × 1.25-95	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 [ø1.57 in.] 30091-08800		Valve - lap

Maintenance item	Tool name	Part No.	Illustration	Usage
Engine body	Valve seat cutter	Shaft 37591-06400	 ø10 mm [ø0.39 in.] W1 1/8 -18	Valve seat ring - reface Width across flats : 32 mm [1.26 in.] Applicable seat inside/outside diameter : ø45 to 66mm [ø1.77 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
	Projection plate	37598-09201		Depth of counterbore in crank case - 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 [ø4.00 to 7.00 in.]
	Piston installer	37191-07100		Piston - install Applicable piston diam : ø89 to 178 mm [ø3.50 to 7.01 in.]

Maintenance item	Tool name	Part No.	Illustration	Usage
Fuel system	Nozzle tester	05209-02100		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.]
	Gear stand	37891-06100		Feed pump bearing - press-in
	Bearing installer	37891-06200		Feed pump bearing - press-in
	Oil seal installer	37891-06300		Feed pump oil seal - press-in
	Bearing installer	37891-06400		Feed pump bearing - press-in
	Feed pump backlash tool	37891-06500		Backlash between feed pump drive gear and driven gear - measure
	Spanner M12	48293-11200		Fuel injection pump coupling -tighten M12 (Width across flats:19 mm [0.75 in.])

Maintenance item	Tool name	Part No.	Illustration	Usage
Fuel system	Spanner M14	48293-01100		Fuel injection pump coupling -tighten M14 (Width across flats:22 mm [0.87 in.])
Cooling system	Water pump pliers	37591-03100		Water pump cover Hole snap ring - install/remove Applicable diam: ø180 to 300 mm [7.09 to 11.81 in.]
	Impeller remover	37591-03200		Water pump impeller -pull-out M18 × 1.5 mm [0.059 in.]
	Ring remover	37791-03400		Water pump unit seal - remove
	Unit seal installer	37191-06300		Water pump unit seal -press-in
	Ring installer	37791-03300		Water pump unit seal ring - press-in
	Coolant tester	37591-00100		Coolant concentration - check
	Inlet exhaust system	Exhaust manifold A wrench	37791-08101	
Exhaust manifold B wrench		37791-08201		Exhaust connector - Install/remove Width across flats : 19mm [0.75 in.] Bolt across flats : 19 mm [0.75 in.]

Maintenance item	Tool name	Part No.	Illustration	Usage
Inspection and measurement	Compression gauge	33A91-01700		Compression pressure - measure Measurement range : 0 to 7 MPa {0 to 71 kgf/cm <sup>2</sup> } [0 to 1015 psi]
	Gauge adapter	37591-12200		Compression pressure - measure U5/8-18
	Belt gauge	32591-09100		Belt tension - measure



# Chapter 4 OVERHAUL INSTRUCTIONS

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## 1. Determining Overhaul Timing

### 1.1 Definition of Overhaul

Overhaul is to disassemble the engine and replace parts within a specified period to keep the engine in good conditions until the next overhaul.

When the soundness of a part may not be maintained until next overhaul even if the part is in the standard condition at the moment, the part must be replaced.

### 1.2 Determining Overhaul Timing

In most cases, the engine should be overhauled when the compression pressure of the engine decreases. 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.

Typical symptoms are:

- (1) Decrease in output power
- (2) Increase in fuel consumption
- (3) Increase in engine oil consumption
- (4) Increased blow-by gas through the breather due to worn cylinder and piston (Visually check the blow-by amount.)
- (5) Increase in gas leaks due to poor seating of inlet and exhaust valves
- (6) Degraded startability
- (7) Increase in noise of engine parts
- (8) Abnormal exhaust color after engine warm-up

The engine shows above symptoms in various combinations.

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

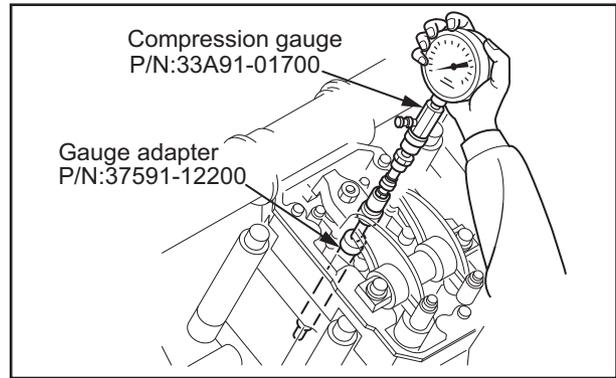
Symptoms of items (2) and (6) are affected by improper fuel injection volume and timing of the fuel injection pump, worn plunger, faulty nozzles, and also faulty conditions of electrical devices such as battery and starter.

The most valid reason to overhaul an engine is a decrease in compression pressure due to worn cylinder and piston, as described in item (4), and once this is determined, it is reasonable to take other problems into consideration for making a final evaluation.

## 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.



Compression Pressure - Measure

- (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) Crank the engine with the starter at the no-injection position.  
Read the engine speed and compression pressure while engine is running at a stable speed.

Note: Ensure the battery being fully charged while 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 inspection should be performed.

Item	Standard value	Limit value	Revolution speed at the standard pressure
Compression pressure	1.8 MPa {18.5 kgf/cm <sup>2</sup> } [263 psi]	1.27 MPa {13 kgf/cm <sup>2</sup> } [189 psi]	120 min <sup>-1</sup>

# Chapter 5 DISASSEMBLY OF BASIC ENGINE

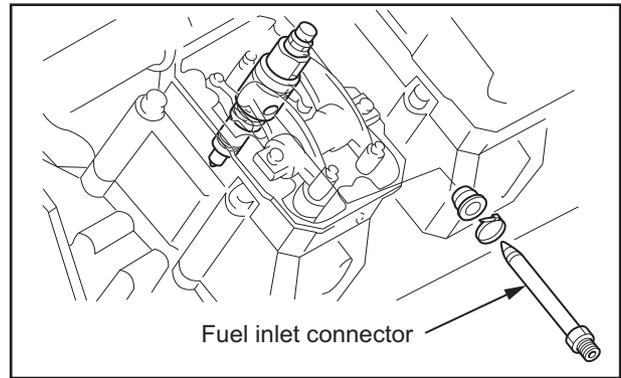
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### 1.1 Fuel Inlet Connector - Remove

Remove the fuel inlet connector.



Fuel Inlet Connector - Remove

### 1.2 Nozzle Assembly - Remove

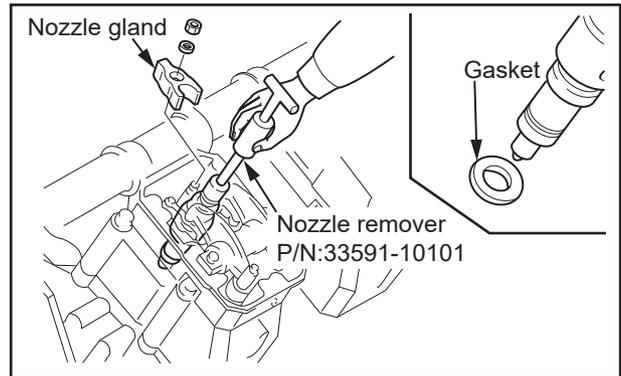
**CAUTION**

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.

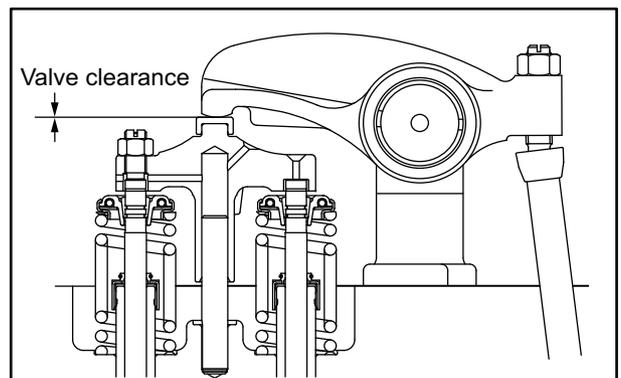
- (1) Remove the nozzle gland.
- (2) Remove the nozzle holder with nozzle remover.
- (3) Remove the gasket remained inside the cylinder head.



Nozzle Assembly - Remove

### 1.3 Valve Clearance - Inspect

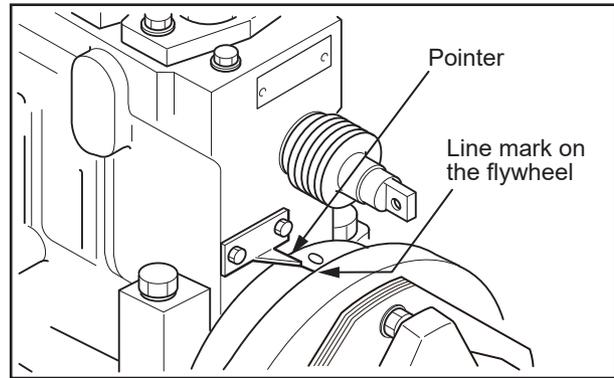
Inspect the valve clearance to check the current condition. For the inspection procedure, see "Valve Clearance - Inspect and Adjust" of "ASSEMBLY OF BASIC ENGINE".



Valve Clearance - Inspect

### 1.4 Fuel Injection Timing - Inspect

Inspect the fuel injection timing to check the current condition. For the inspection procedures, refer to "Fuel Injection Timing - Check and Adjust" of "ENGINE BODY - ASSEMBLY".



Fuel Injection Timing - Inspect

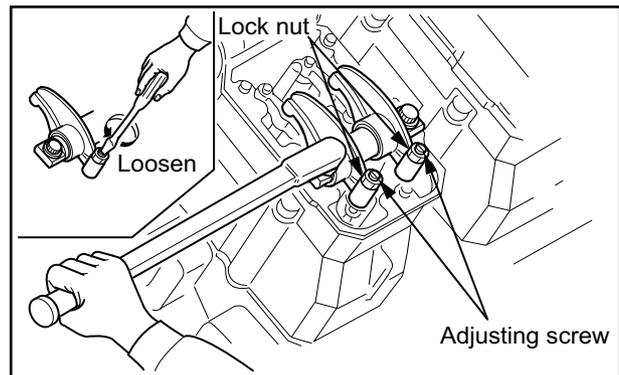
### 1.5 Rocker Shaft Assembly - Remove

(1) Loosen the adjusting screw of rocker arm.

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

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

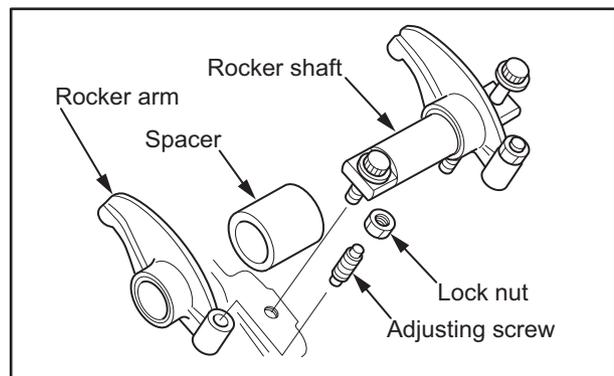
(3) Remove the push rod.



Rocker Shaft Assembly - Remove

(4) Disassemble the rocker shaft assembly.

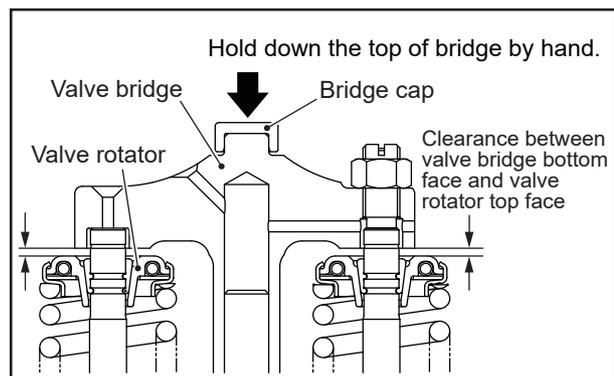
Note: DO NOT remove the rocker bushing unless it is defective or its inside diameter exceeds the limit.



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 to check the current condition. For the inspection procedure, see "Clearance Between Bottom Face of Valve Bridge and Top Face of Valve Rotator - Inspect" of "ENGINE BODY - ASSEMBLY".

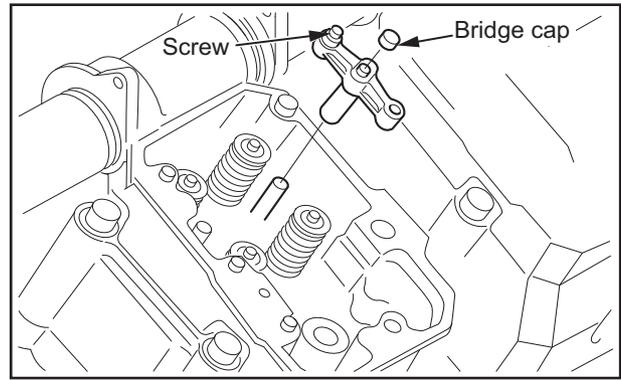


Clearance Between Bottom Face of Valve Bridge and Top Face of Valve Rotator - Inspect

### 1.7 Valve Bridge - Remove

Remove the valve bridge and bridge cap.

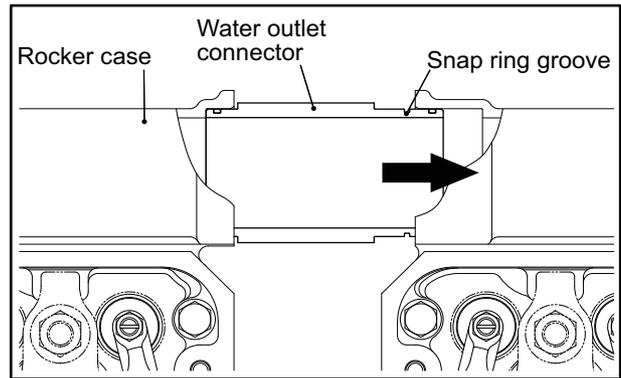
Note: Be careful not to drop the bridge cap into the cylinder head.



Valve Bridge - Remove

### 1.8 Rocker Case - Remove

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



Rocker Case - Remove

### 1.9 Cylinder Head Assembly - Remove

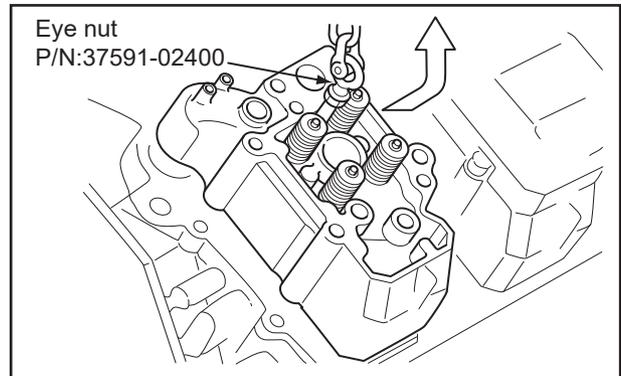
**CAUTION**

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

- (1) Remove the cylinder head bolt.
- (2) Remove the cylinder head by lifting with a hoist.

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

- (3) Remove the cylinder head gasket.



Cylinder Head Assembly - Remove

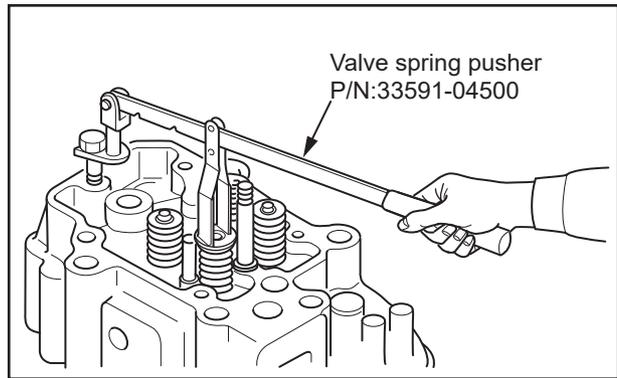
### 1.10 Valve Sinkage - Measure

Measure the valve sinkage to check the current condition. For the measurement procedure, refer to "Valve Face - Inspect" of "INSPECTION AND REPAIR OF BASIC ENGINE".

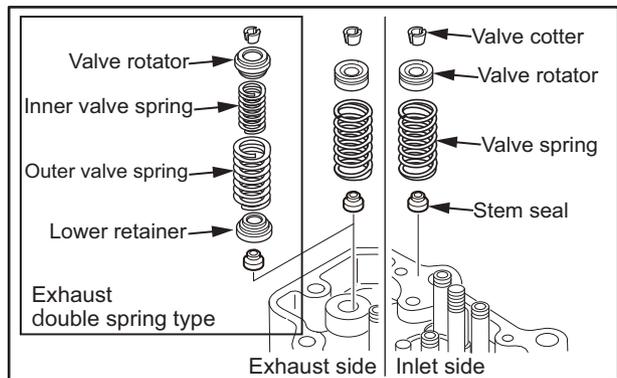
### 1.11 Valve and Valve Spring - Remove

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

Note: If valves are reusable, mark the 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

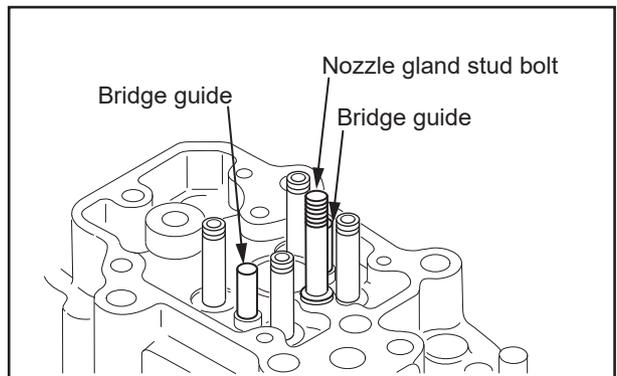


Valve and Valve Spring - Remove

### 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 "ENGINE BODY - INSPECT AND REPAIR."



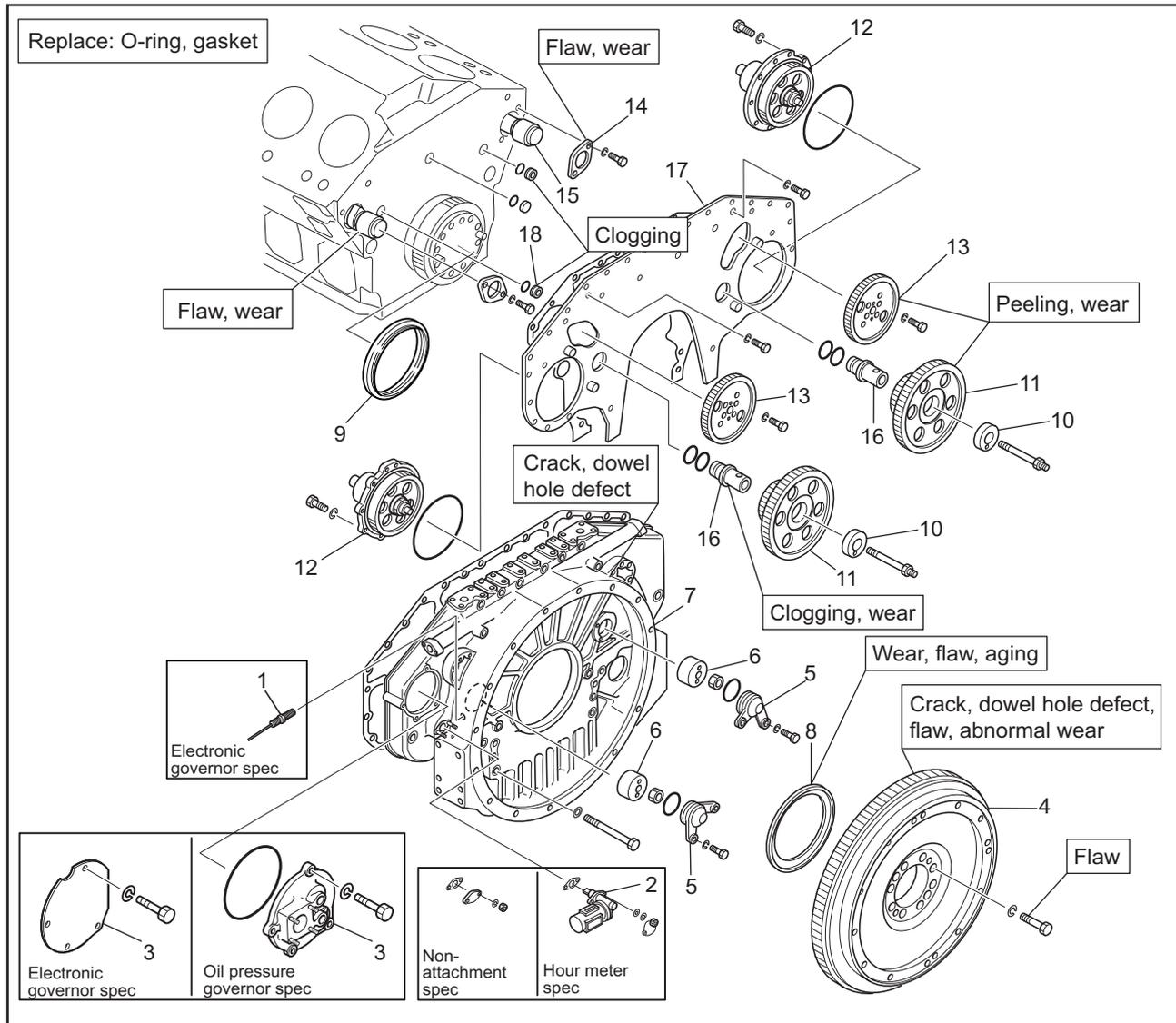
Nozzle Gland Stud Bolt and Bridge Guide - Remove

## 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
- ♦Rear Idler Gear and Camshaft End Play - Measure

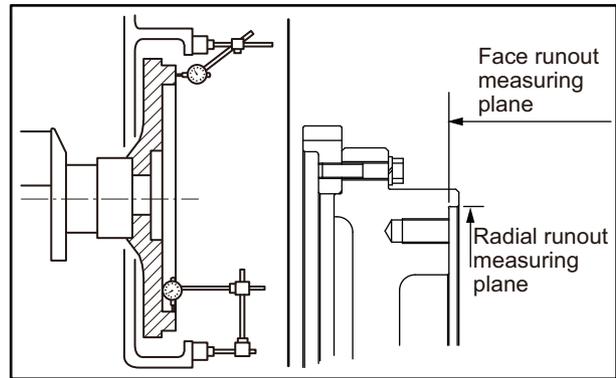


Rear Mechanism - Disassemble and Inspect

### Disassembling sequence

- |  |  |
|--|--|
| 1 Pick up (electronic governor spec)   | 9 Oil seal slinger   |
| 2 Hour meter (with hour meter spec)  | 10 Thrust plate  |
| 3 Governor drive (hydraulic governor spec)<br>(refer to the chapter "FUEL SYSTEM" for disassembly, inspection and assembly.)<br>Cover (electronic governor spec) | 11 Idler gear  |
| 4 Flywheel (approx. 140 kg [309 lb])<br>(light weight spec: approx. 104 kg [229 lb])   | 12 Accessory drive (approx. 21 kg [46 lb])<br>(refer to the chapter "FUEL SYSTEM" for disassembly, inspection and assembly.) |
| 5 Cover  | 13 Camshaft gear   |
| 6 Thrust collar  | 14 Thrust plate  |
| 7 Timing gear case (approx. 150 kg [331 lb])   | 15 Camshaft (approx. 94 kg [207 lb])   |
| 8 Oil seal   | 16 Idler shaft   |
|  | 17 Rear plate (approx. 28.5 kg [62.8 lb.])   |
|  | 18 Nozzle plate  |

**2.1 Flywheel Face and Radial Runouts - Measure**  
Measure the face and radial runouts of the flywheel to check the current condition. For the measurement procedure, see "Flywheel Face and Radial Runout - Measure" of "ASSEMBLY OF BASIC ENGINE".



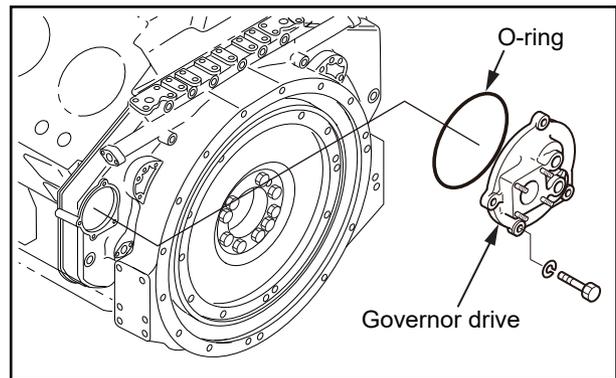
Flywheel Face and Radial Runouts - Measure

## 2.2 Governor Drive - Remove

(Hydraulic governor spec)

Remove the governor drive from the rear plate.

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



Governor Drive - Remove

## 2.3 Flywheel - Remove

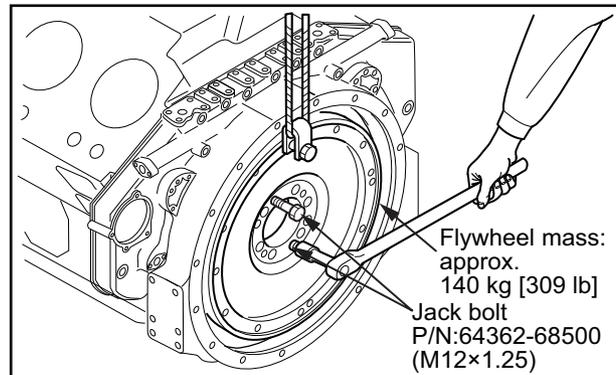
### **CAUTION**

- (a) Be careful not to drop or hit the flywheel. It can, not only cause damage, but also may cause 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) Attach a sling to the flywheel to prevent it from falling off.
- (2) Screw two jack bolts evenly into the bolt holes, and remove the flywheel.

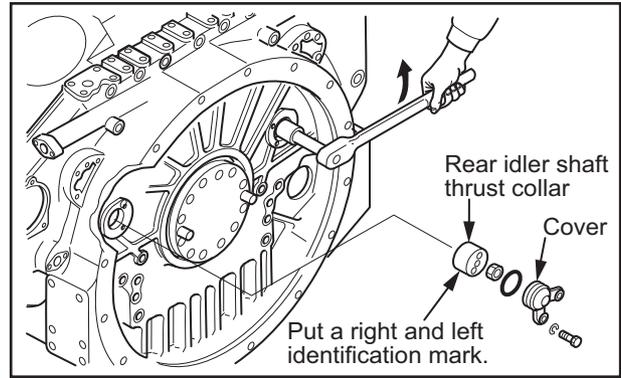


Flywheel - Remove

### 2.4 Thrust Collar of Rear Idler Shaft - Remove

- (1) Remove the cover from the timing gear case.
- (2) Install the bolts (M6 × 1.0) into the dedicated bolt holes for removal of rear idler shaft thrust collar, and remove the rear idler shaft thrust collar.

Note: Make the marking of right and left installing positions to ensure the correct backlash and end play.



Thrust Collar of Rear Idler Shaft - Remove

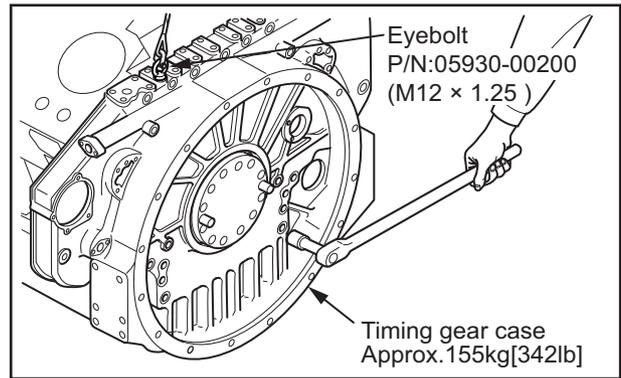
### 2.5 Timing Gear Case - Remove

**CAUTION**

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

- (1) Attach a sling to the timing gear case to prevent it from falling off.
- (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 cannot be re-used.

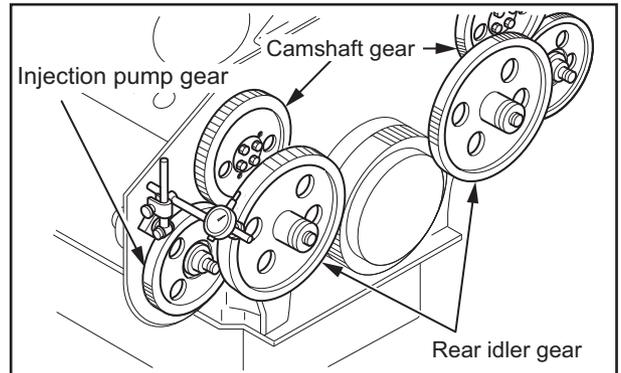


Timing Gear Case - Remove

### 2.6 Timing Gear Backlash - Measure

Measure the timing gear backlash to check the current condition. For measurement procedure, see "Timing Gear Backlash - Measure" of "ASSEMBLY OF BASIC ENGINE".

Note: When mounting the high pressure pump on the front plate during measurement, use M8 × 1.25 (length 16 mm [0.63 in.]) bolts.

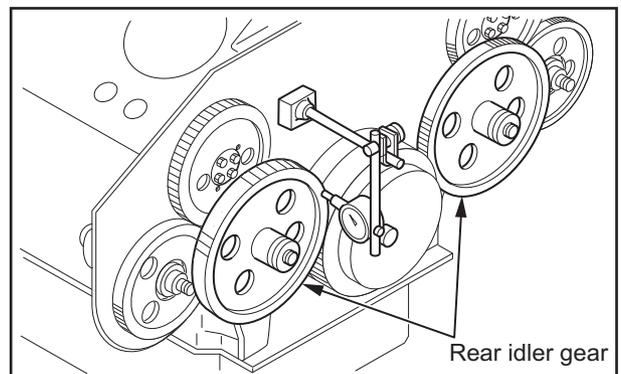


Timing Gear Backlash - Measure

### 2.7 Rear Idler Gear End Play - Measure

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

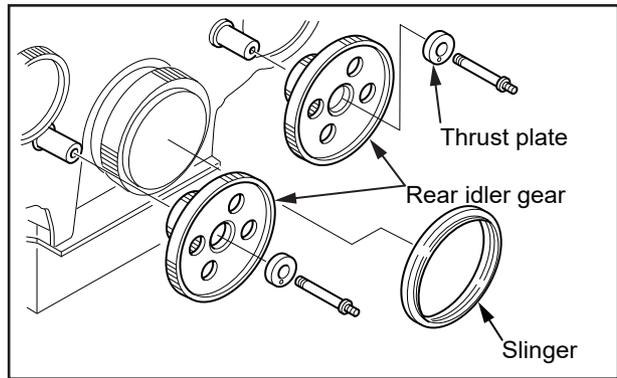
For the measurement procedure, refer to "Rear Idler Gear End Play - Measure" of "ENGINE BODY - ASSEMBLE".



Rear Idler Gear End Play - Measure

### 2.8 Rear Idler Gear - Remove

- (1) Remove the oil seal slinger from the crankshaft.
- (2) Remove thrust plate.
- (3) Remove the rear idler gears (right and left.)



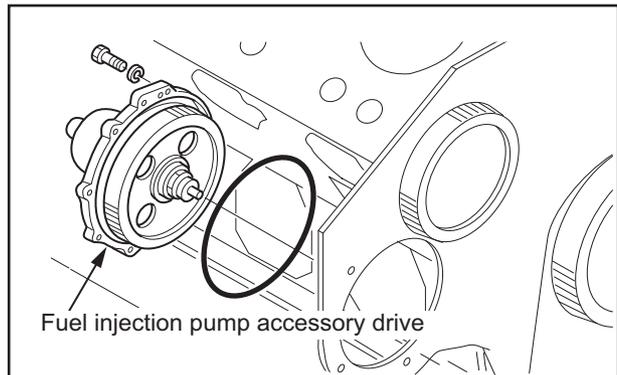
Rear Idler Gear - Remove

### 2.9 Accessory Drive - Remove

Remove the accessory drive from the rear plate.

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

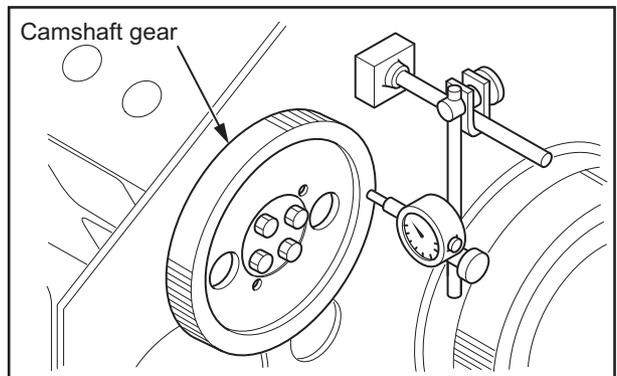
Note: Remove the rearmost cylinder cam cover on the left side before removing the left side fuel injection pump accessory drive case so that bolts do not interfere with the cover.



Accessory Drive - Remove

### 2.10 Camshaft End Play - Measure

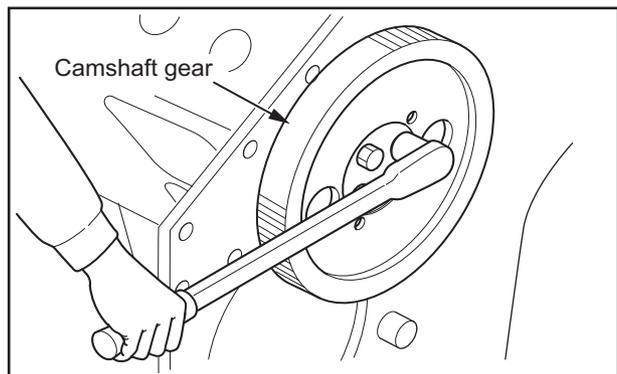
Measure the camshaft end play to check the current condition. For measurement procedure, see "Camshaft End Play - Measure" of "ENGINE BODY - ASSEMBLE".



Camshaft End Play - Measure

### 2.11 Camshaft Gear - Remove

Remove the camshaft gear from the camshaft.



Camshaft Gear - Remove

2.12 Camshaft - Remove

**CAUTION**

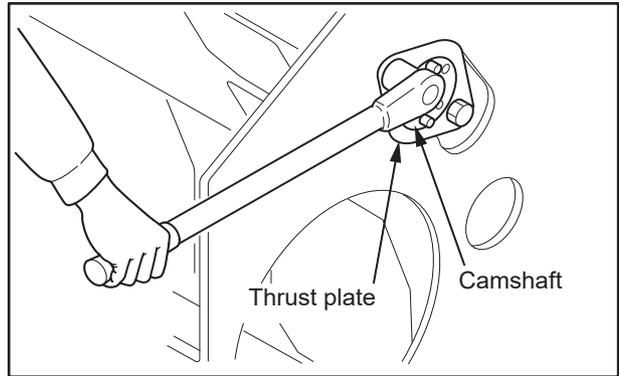
Support the camshaft with a wood stick or the like through the side cover opening. Carefully remove the camshaft so as not to cause damage to the crankcase and camshaft bushing.

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

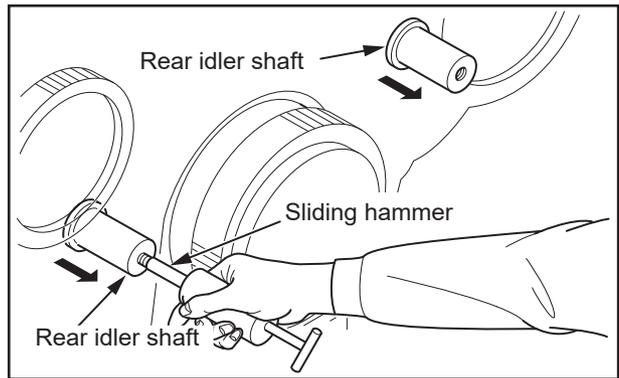
Note: Before removing camshaft, remove the oil seal case, oil seal, and coupling from the cam shaft front end.

2.13 Rear Idler Shaft - Remove

Install the sliding hammer to the top face thread (M22×1.5) for removal, and remove the rear idler shaft.



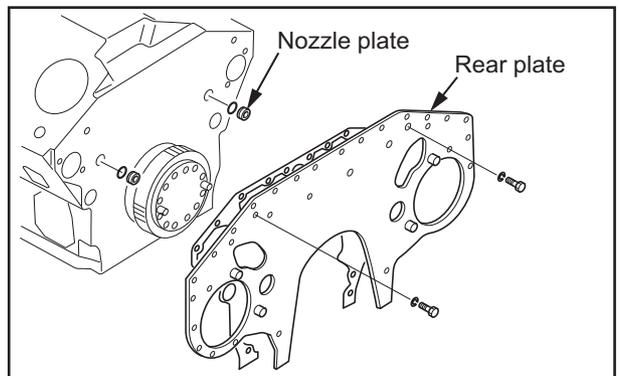
Camshaft - Remove



Rear Idler Shaft - Remove

2.14 Rear Plate - Remove

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



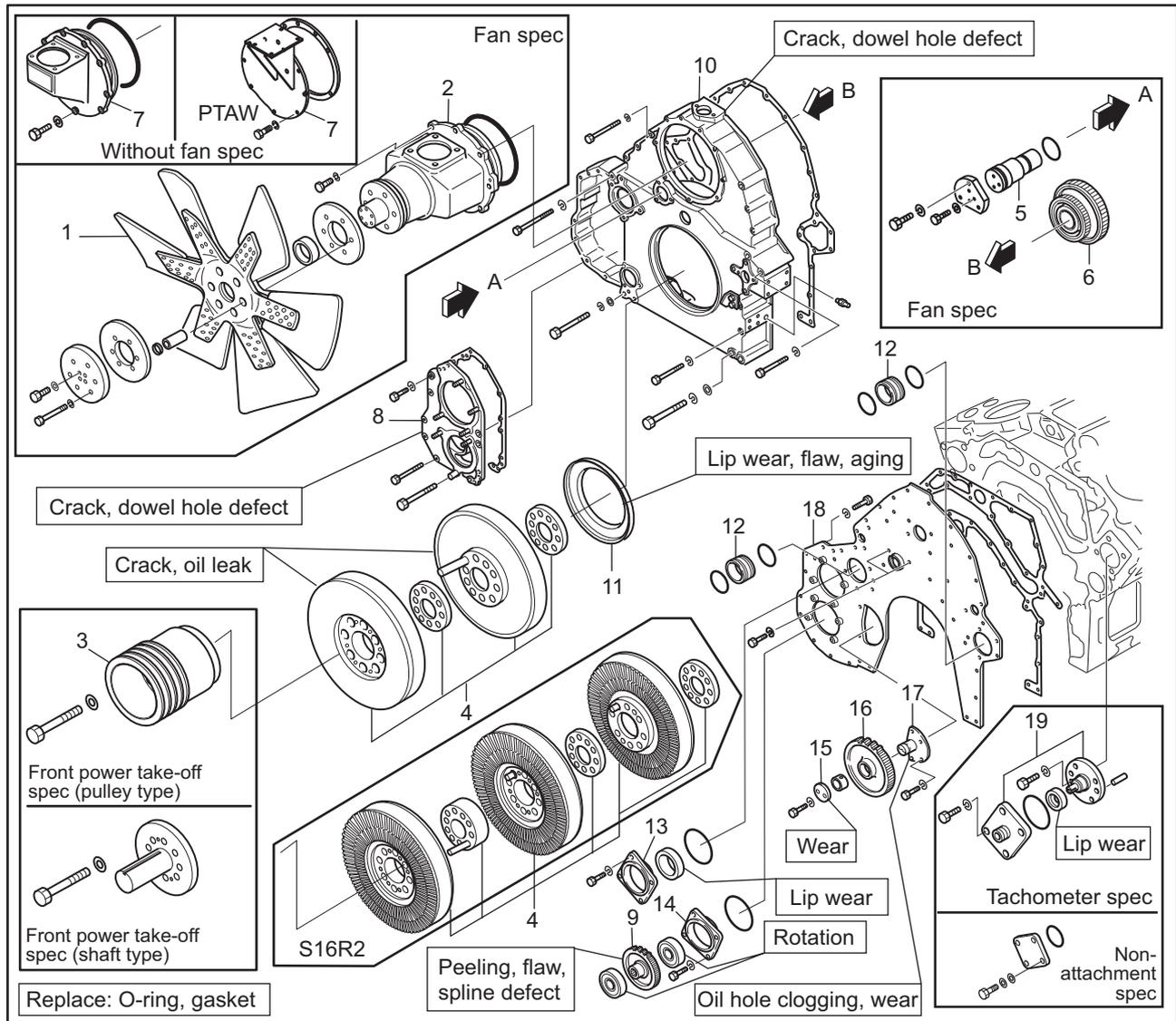
Rear Plate - Remove

### 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.

- ♦ Fan Drive Idler Gear Backlash and End Play - Measure
- ♦ Front Idler Gear Backlash and End Play - Measure



Front Mechanism - Disassemble and Inspect

#### Disassembling sequence

- |  |   |
|--|---|
| 1 Fan (with fan spec: approx. 60 kg [132 lb])<br>(big fan spec: approx. 80 kg [176 lb])  | 9 Oil pump gear                                   |
| 2 Fan drive assembly (approx. 55 kg [121 lb]) (with fan spec)<br>(Refer to the chapter "COOLING SYSTEM" for disassembly, inspection and assembly.) | 10 Front gear case (approx. 70 kg [154 lb.])      |
| 3 Crankshaft pulley  | 11 Oil seal                                       |
| 4 Damper (approx. 50 kg [110 lb]), spacer  | 12 Water coupling                                 |
| 5 Fan drive idler shaft (with fan spec)  | 13 Water pump bearing cover                       |
| 6 Fan drive idler shaft (with fan spec)  | 14 Oil pump bearing cover                         |
| 7 Breather case, Thermostat bracket (without fan spec)   | 15 Thrust plate                                   |
| 8 Pump plate   | 16 Idler gear                                     |
|  | 17 Idler shaft                                    |
|  | 18 Front plate (approx. 25 kg [55 lb.])           |
|  | 19 Oil seal case, Coupling (with tachometer spec) |

Note:(a) Fan, breather case and crankshaft pulley differ in accordance with the customization and specifications.

(b) The consisting parts of the damper differ in accordance with the customization and specification.

### 3.1 Fan Drive Assembly - Remove

(With fan spec)

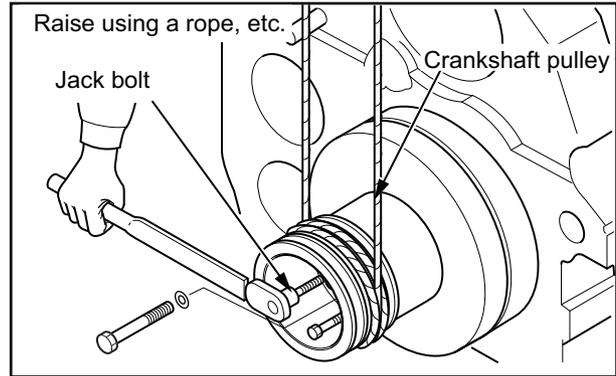
Remove the fan and fan drive from the front gear case.

### 3.2 Damper and Crankshaft Pulley - Remove

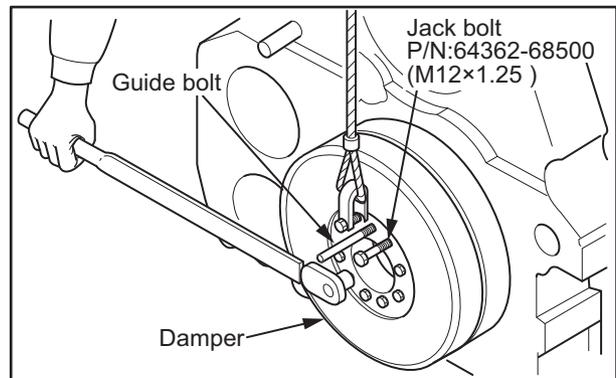
**CAUTION**

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

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



Crankshaft Pulley - Remove



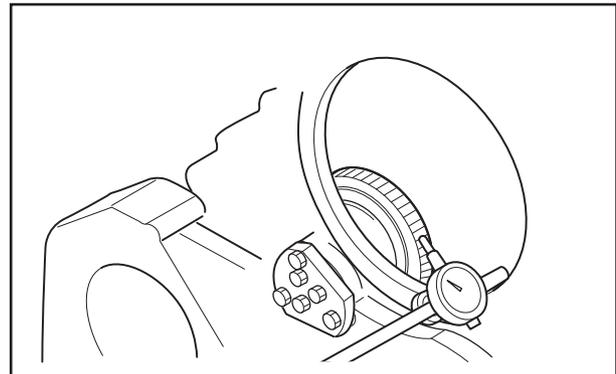
Damper - Remove

### 3.3 Fan Drive Idler Gear Backlash - Measure

(With fan spec)

Measure the fan drive idler gear backlash, and know the current condition.

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



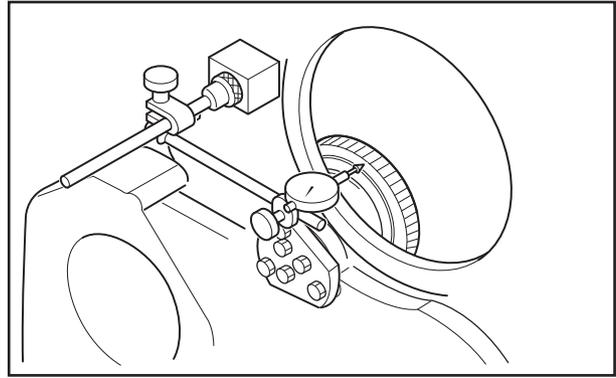
Fan Drive Idler Gear Backlash - Measure

### 3.4 Fan Drive Idler Gear End Play - Measure

(With fan spec)

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

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

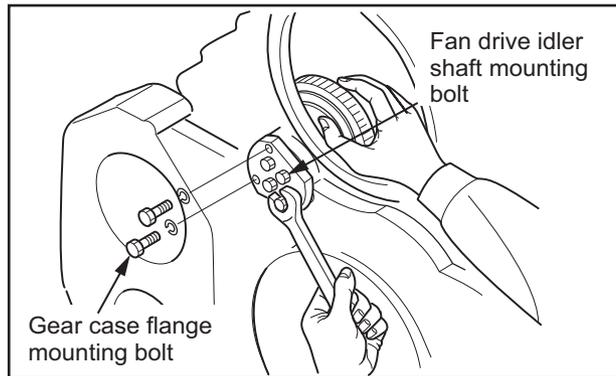


Fan Drive Idler Gear End Play - Measure

### 3.5 Fan Drive Idler Gear and Fan Drive Idler Shaft - Remove

(With fan spec)

(1) Remove the mounting bolts of gear case flange.

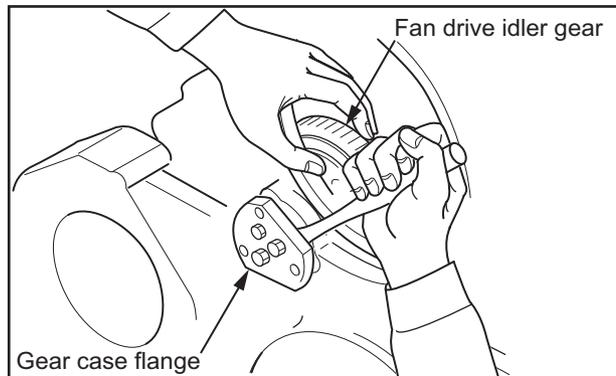


Gear Case Flange - Remove

(2) Insert your hand through the fan drive assembly mounting hole, and support the fan drive idler gear.

(3) Remove the gear case flange and the fan drive idler shaft as a set.

(4) Remove the fan drive idler gear through the fan drive assembly mounting hole.



Fan Drive Idler Gear and Fan Drive Idler Shaft - Remove

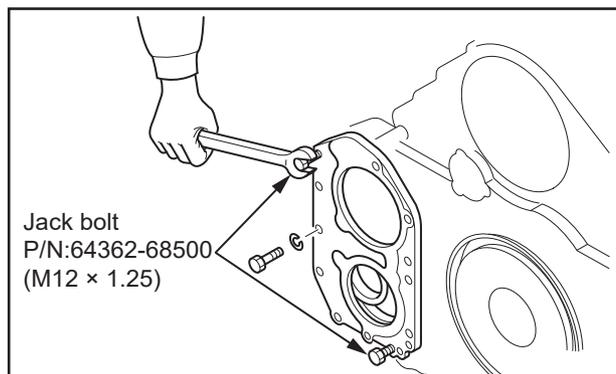
### 3.6 Pump Plate (for Water Pump and Oil Pump) - Remove

Install two jack bolts evenly into the jack bolt holes, and remove the pump plate.

Note: Remove the oil pump and water pump, then remove the pump plate.

Refer to the chapter "OIL SYSTEM" for the removal of oil pump.

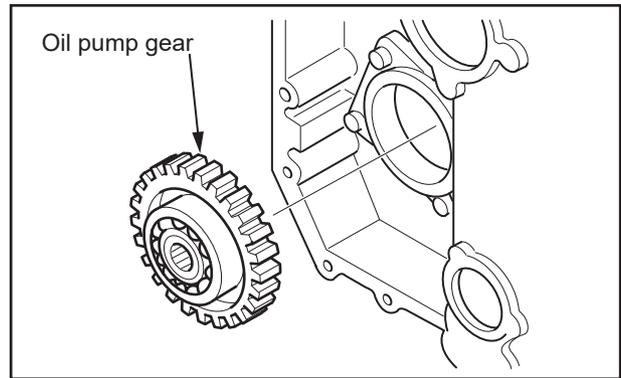
Refer to the chapter "COOLING SYSTEM" for the removal of water pump.



Pump Plate (for Water Pump and Oil Pump) - Remove

### 3.7 Oil Pump Gear - Remove

Remove the oil pump gear together with the bearing.

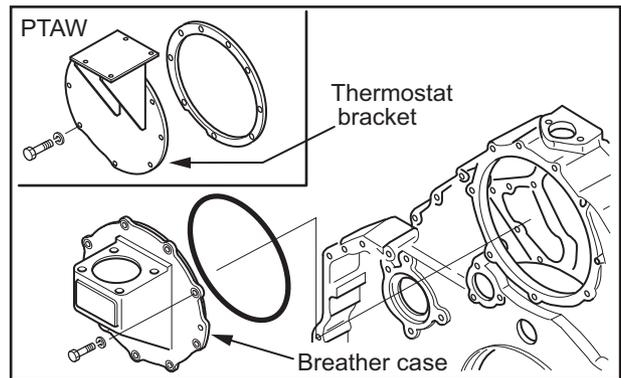


Oil Pump Gear - Remove

### 3.8 Breather Case, Thermostat Bracket - Remove

(Without fan spec)

Remove the breather case or the thermostat bracket from the front gear case.



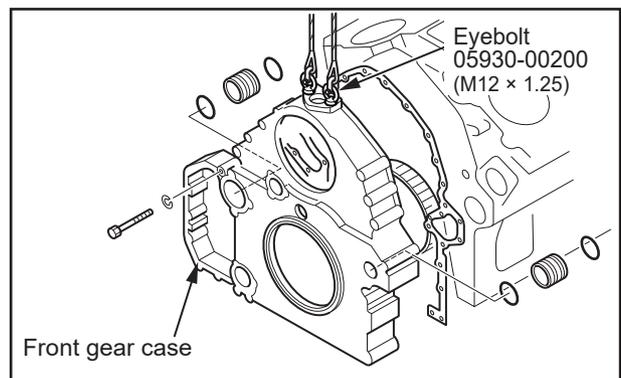
Breather Case, Thermostat Bracket - Remove

### 3.9 Front Gear Case - Remove

**CAUTION**

When removing the front gear case, be careful not to damage the oil seal or not to distort the pointer by hitting.

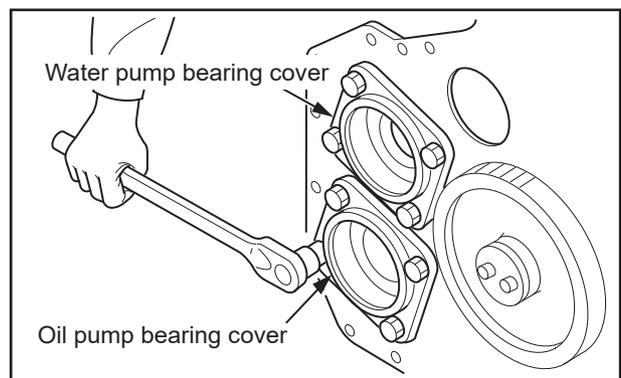
- (1) Attach slings to the front gear case.
- (2) Lift the front gear case to disengage the dowel pins, and remove the front gear case.
- (3) Remove the oil seal from the front gear case.



Front Gear Case - Remove

### 3.10 Water Pump Bearing Cover and Oil Pump Bearing Cover - Remove

Remove the water pump bearing cover and oil pump bearing cover from the front plate.

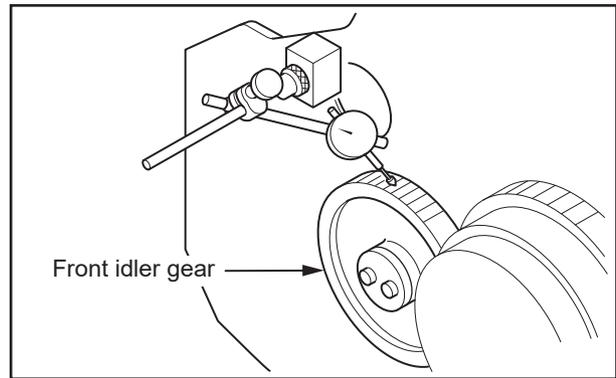


Water Pump Bearing Cover  
Oil Pump Bearing Cover - Remove

### 3.11 Front Idler Gear Backlash - Measure

Measure the front idler gear backlash to understand the current condition.

For the measurement procedure, refer to "Front Idler Gear Backlash - Measure" of "ENGINE BODY - ASSEMBLE."

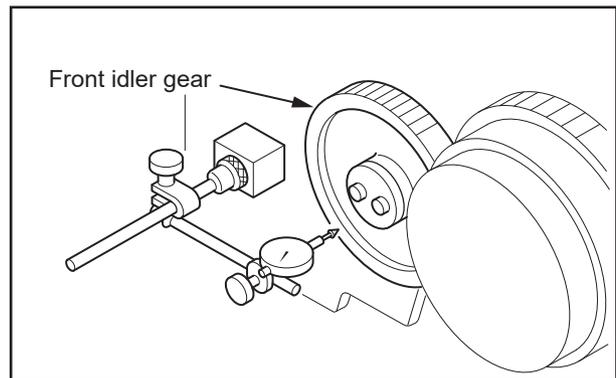


Front Idler Gear Backlash - Measure

### 3.12 Front Idler Gear End Play - Measure

Measure the end play of front idler gear to understand the current condition.

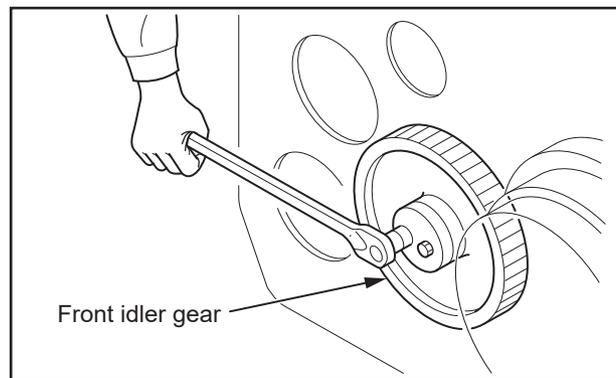
For the measurement procedure, refer to "End Play of Front Idler Gear - Measure" of "ENGINE BODY - ASSEMBLE"



Front Idler Gear End Play - Measure

### 3.13 Front Idler Gear - Remove

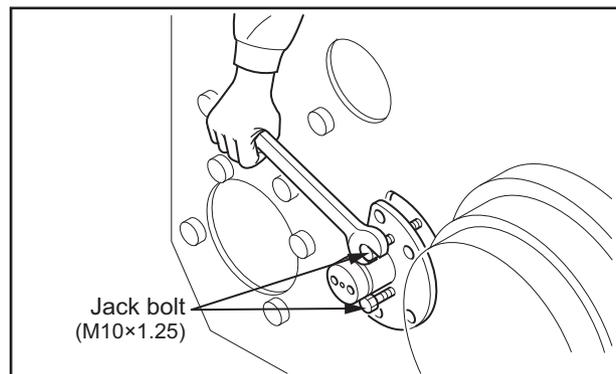
Remove the thrust plate and front idler gear from the front idler shaft.



Front Idler Gear - Remove

### 3.14 Front Idler Shaft - Remove

Do not remove the front idler shaft unless it is necessary. To remove, screw two jack bolts evenly into the front idler shaft.



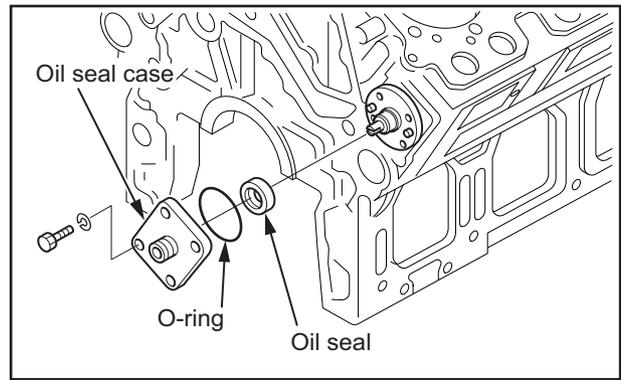
Front Idler Shaft - Remove

### 3.15 Coupling - Remove

(With tachometer spec)

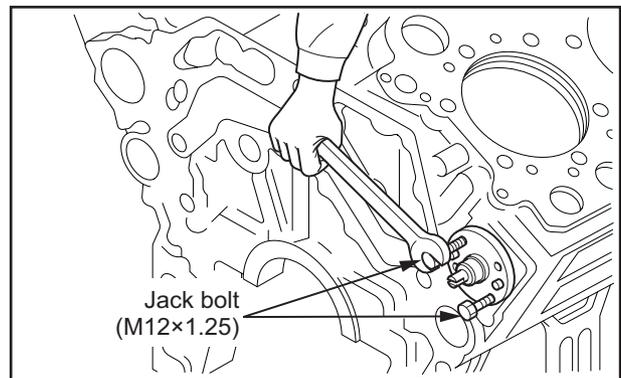
- (1) Remove the oil seal case and oil seal from the crankcase.

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.

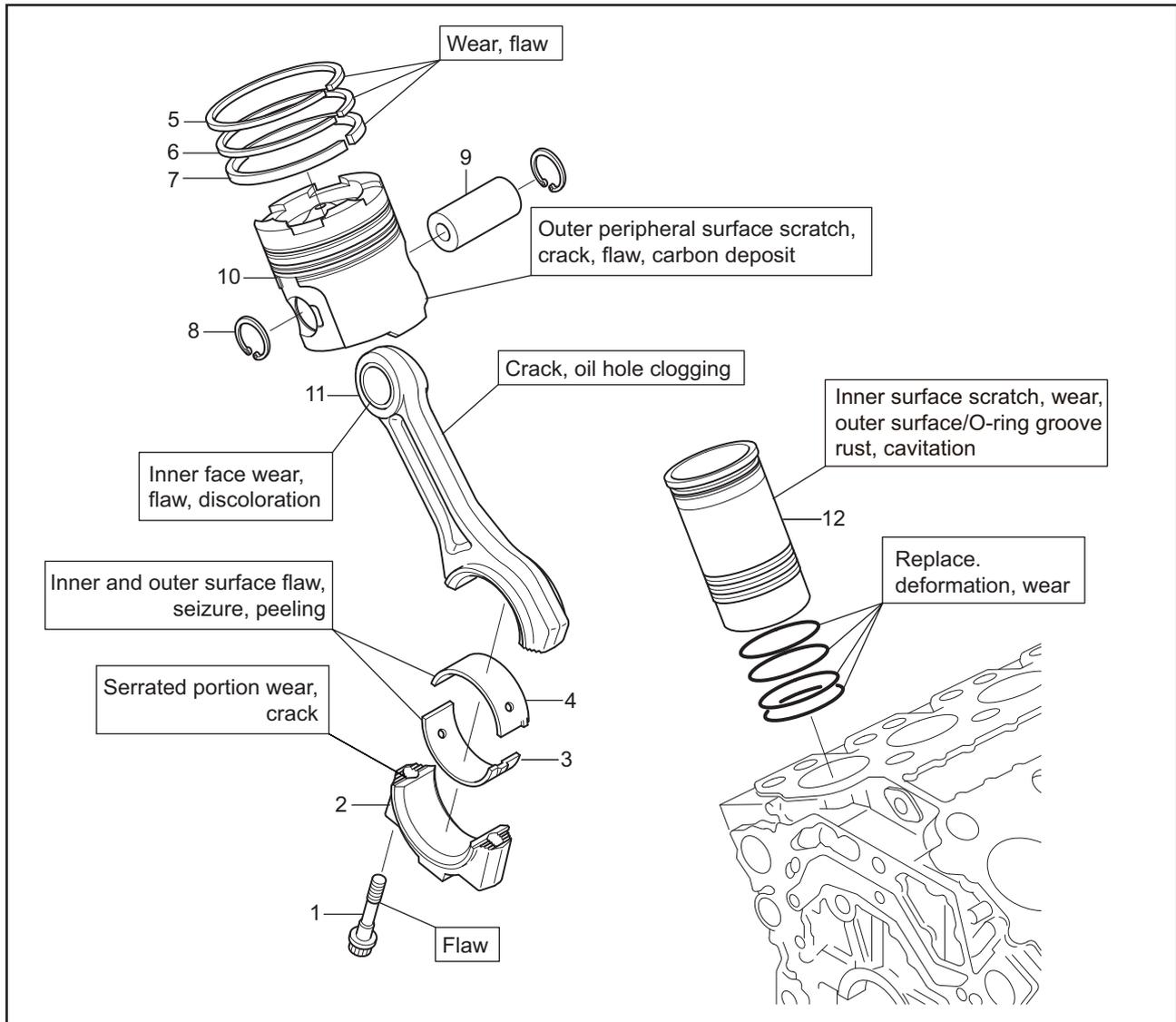


Coupling - Remove

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

Understanding of the current engine condition before disassembling is very important to find the cause of trouble and to perform efficient maintenance 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



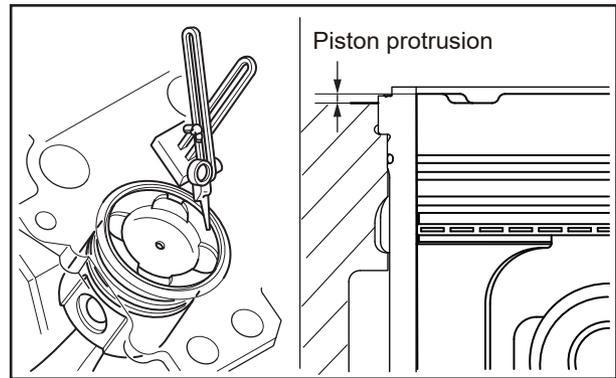
Cylinder Liner, Piston and Connecting Rod - Disassemble and Inspect

##### Disassembling sequence

- |                                |   |
|--------------------------------|---|
| 1 Connecting rod cap bolt      | 7 Oil ring  |
| 2 Connecting rod cap           | 8 Snap ring   |
| 3 Lower connecting rod bearing | 9 Piston pin  |
| 4 Upper connecting rod bearing | 10 Piston   |
| 5 No. 1 compression ring       | 11 Connecting rod   |
| 6 No. 2 compression ring       | 12 Cylinder liner (S16R: approx. 16 kg [35 lb])<br>(S16R2: approx. 19 kg [42 lb]) |

#### 4.1 Piston Protrusion - Measure

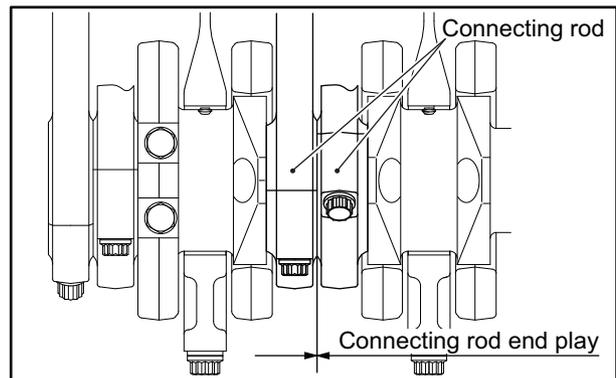
Measure the piston protrusion to check the current condition. For measurement procedure, see "Piston Protrusion - Measure" of "ASSEMBLY OF BASIC ENGINE".



Piston Protrusion - Measure

#### 4.2 Connecting Rod End Play - Measure

Measure the connecting rod end play to check the current condition. For measurement procedure, see "Connecting Rod End Play - Measure" of "ASSEMBLY OF BASIC ENGINE".



Connecting Rod End Play - Measure

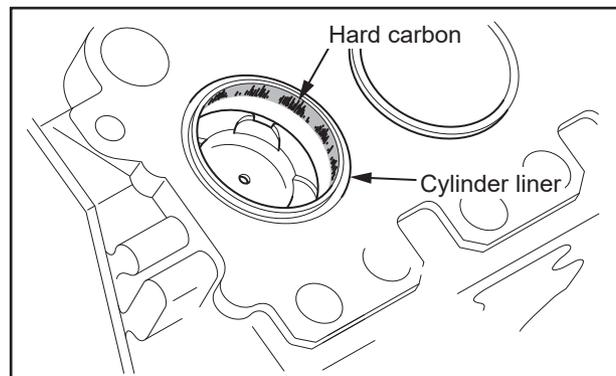
#### 4.3 Hard Carbon Deposits on the Upper Part of Cylinder Liner - Remove

**CAUTION**

Be sure to remove hard carbon deposits from the upper part of the cylinder liner before removing 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.



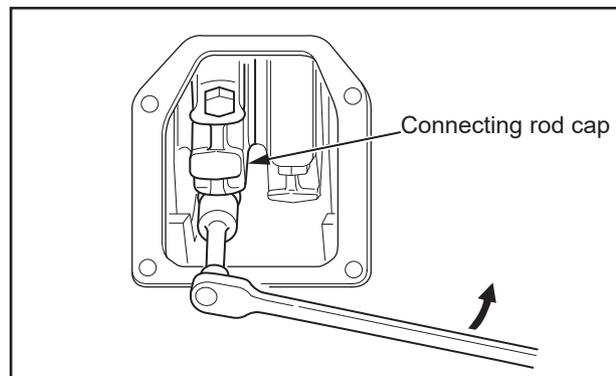
Hard Carbon Deposits on the Upper Part of Cylinder Liner - Remove

#### 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 distinction between upper and lower, on the removed connecting rod bearings to ensure the correct reassembly.



Connecting Rod Cap - Remove

## 4.5 Piston - Remove

**CAUTION**

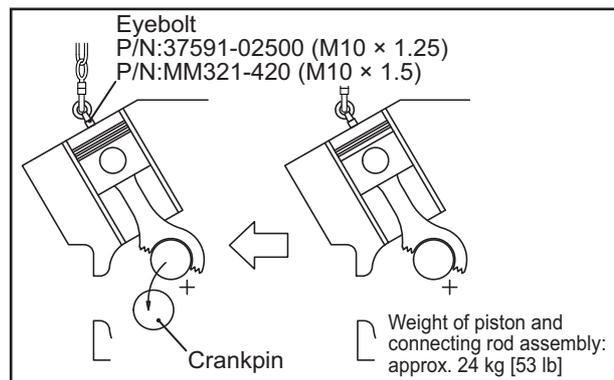
When holding the connecting rod with your hand to prevent it from swinging, be very careful. You may suffer hand injuries from accidental movement of the connecting rod.

**CAUTION**

- When pulling out the piston, be careful not to drop the upper connecting rod bearing.
- When removing the piston, be careful not to damage the cylinder liner with connecting rod movement.
- When only a few pistons remain in the cylinders, the crankshaft tends to turn due to weight imbalance. Be sure to hold the crankshaft to prevent it from rotating while removing pistons.
- Make sure that the connecting rod does not damage the piston cooling nozzle when removing the piston.
- When pulling the piston out of the cylinder liner, hold the piston by hand so that the piston does not tilt. If the piston tilts, the piston inner surface collides against the connecting rod, and results in the damage of piston.

## 4.5.1 Removing Piston by Lifting with a Chain Block

- Remove the connecting rod cap, and turn the crankshaft to bring the piston to the top dead center position.
- Install the eye bolt to the bolt hole on the piston top, and support the piston to prevent it from falling down.
- Rotate the crankshaft to place the crank pin slightly near to the inspection window so that the connecting rod big end will not contact the cylinder liner.
- Carefully pull out the piston by making sure that the connecting rod big end moves into the cylinder liner.



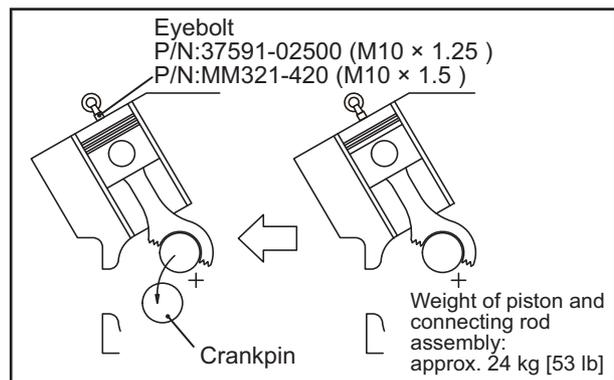
Removing Piston by Lifting with a Chain Block

## 4.5.2 Removing Piston by Pushing-up Connecting Rod Big End

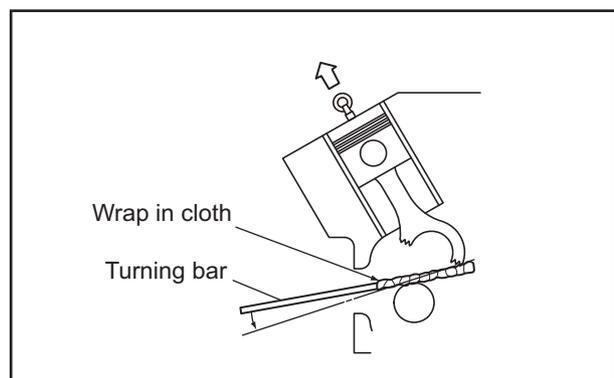
- Turn the crankshaft to bring the piston, which connecting rod cap being removed, to the top dead center position.
- Install the eye bolt to the bolt hole on the piston top, and support the piston to prevent it from falling down.
- Rotate the crankshaft carefully until the crankpin is displaced from the connecting rod, and the lower bolt hole can be seen through the inspection window.
- Insert a bar wrapped with cloth, and push up the bottom of connecting rod carefully using the crankpin as a fulcrum.

Note: Wrap the bar with cloth or rubber to protect the crankpin and connecting rod big end from damage.

- Push up the connecting rod and piston while adjusting the fulcrum position.  
When the oil ring is slid out of the cylinder liner, place the ring carefully on the top face of cylinder liner.
- Lift the piston using eye bolt on the piston top, and pull-out the piston from cylinder liner.



Crankshaft - Rotate



Connecting Rod Big End - Push Up

#### 4.6 Piston Ring - Remove

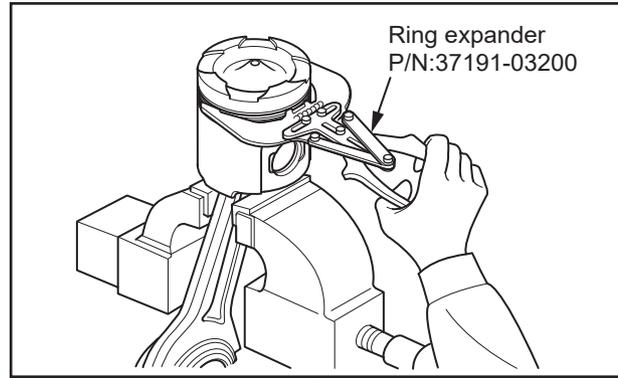
**CAUTION**

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

**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.



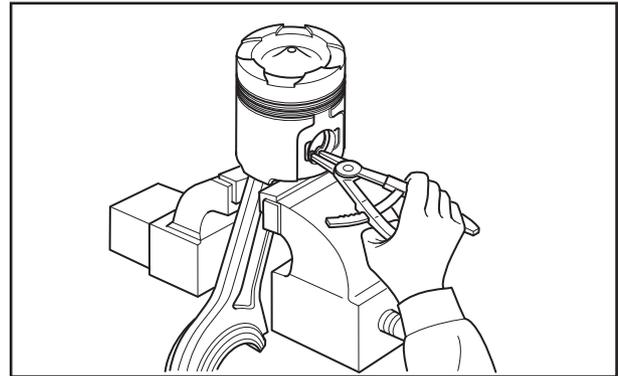
Piston Ring - Remove

#### 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 a hammer to remove the piston pin, and separate the piston from connecting rod.

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

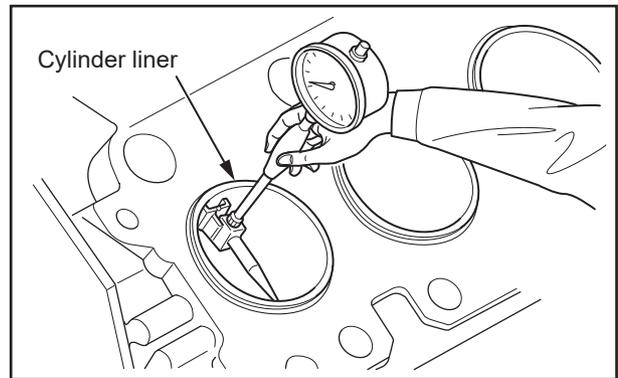
- (b) If the piston pin is stubborn, heat the piston with a heater or in hot water.



Piston Pin and Piston - Remove

#### 4.8 Cylinder Liner Inside Diameter - Measure

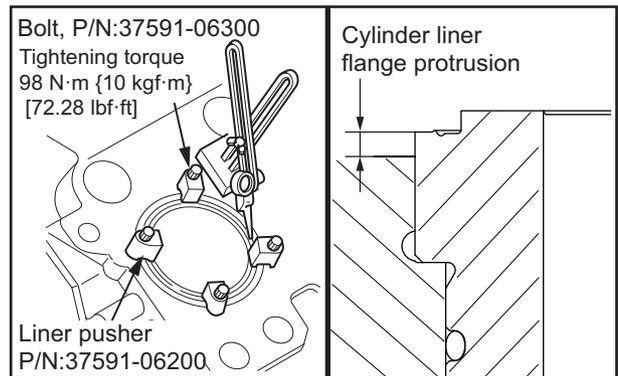
Measure the cylinder liner inside diameter to check the current condition. For measurement procedure, see "Cylinder Liner Inside Diameter - Measure" of "ENGINE BODY - ASSEMBLE".



Cylinder Liner Inside Diameter - Measure

#### 4.9 Cylinder Liner Flange Protrusion - Measure

Measure the cylinder liner flange protrusion to check the current condition. For measurement procedure, see "Cylinder Liner Flange Protrusion - Measure" of "ENGINE BODY - ASSEMBLE".



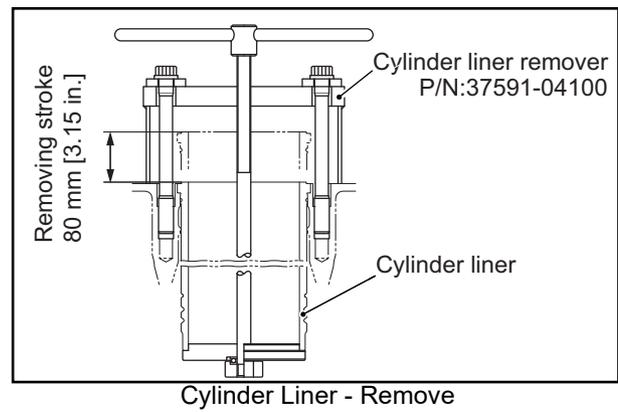
Cylinder Liner Flange Protrusion - Measure

#### 4.10 Cylinder Liner - Remove

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

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

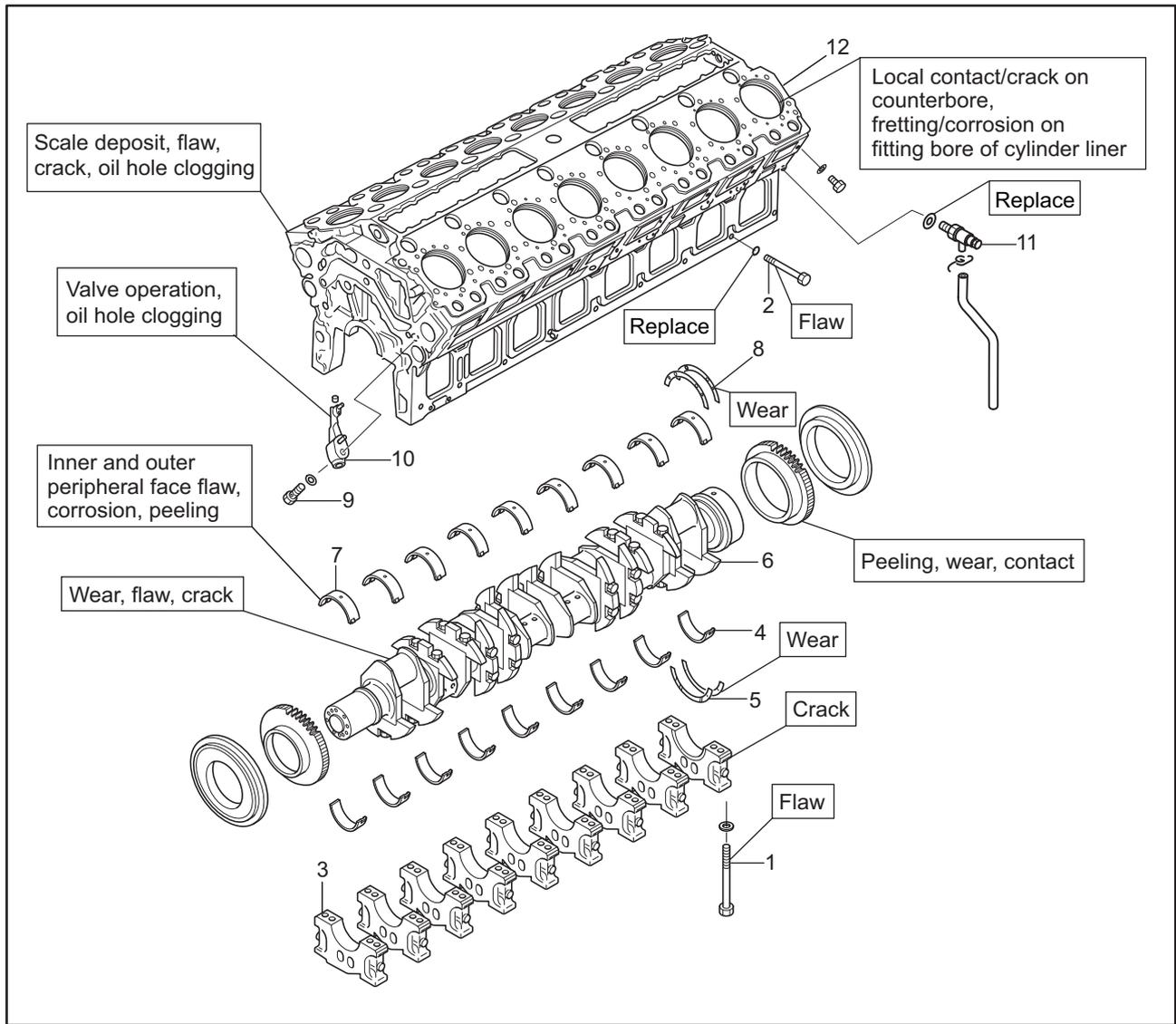
(2) Rotate the handle, and remove the cylinder liner.



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

Understanding of the current engine condition before disassembling is very important to find the cause of trouble and to perform efficient maintenance 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



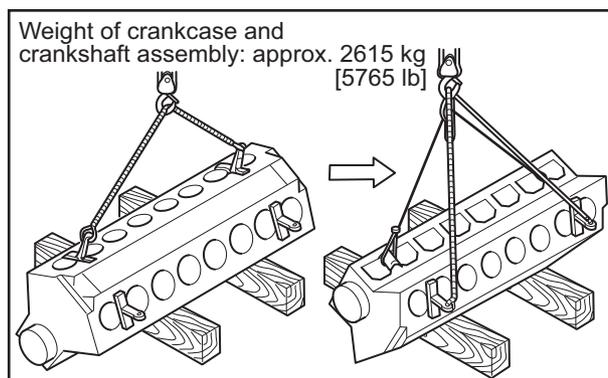
Crankcase, Crankshaft and Main Bearing - Disassemble and Inspect

Disassembling sequence

- |  |   |   |
|--|---|---|
| 1 Main bearing cap bolt                    | 5 Lower thrust plate                    | 9 Eye bolt                                |
| 2 Side bolt                                | 6 Crankshaft (approx. 620 kg [1367 lb]) | 10 Piston cooling nozzle                  |
| 3 Main bearing cap (approx. 16 kg [35 lb]) | 7 Upper main bearing                    | 11 Water drain cock                       |
| 4 Lower main bearing                       | 8 Upper thrust plate                    | 12 Crankcase (approx. 1850 kg [4079 lb.]) |

### 5.1 Crankcase - Turn Over (Upend)

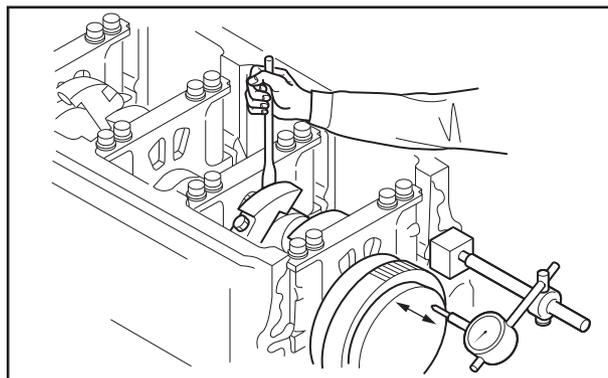
Using a turnover machine, turn over the crankcase. When the turnover machine is not available, attach slings to the crankcase using wood pieces and cloth pads, and raise the crankcase with a hoist or crane. Then lay it on its side on the wooden blocks. Then, change the positions of the slings, and turn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



Crankcase - Turn Over (Upend)

### 5.2 Crankshaft End Play - Measure

Measure the crankshaft end play to check the current condition. For measurement procedure, see "Crankshaft End Play - Measure" of "ASSEMBLY OF BASIC ENGINE".



Crankshaft End Play - Measure

### 5.3 Piston Cooling Nozzle - Remove

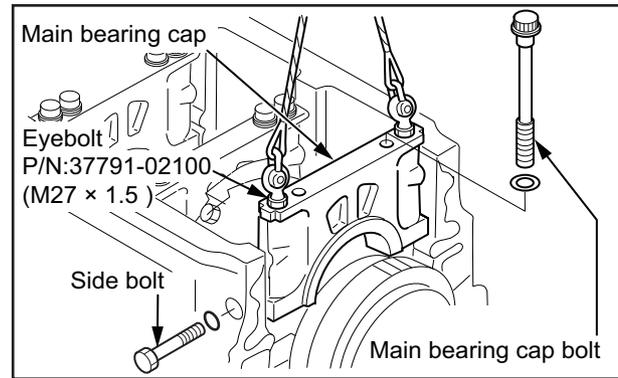
Remove the piston cooling nozzle from the crankcase.

## 5.4 Main Bearing Cap - Remove

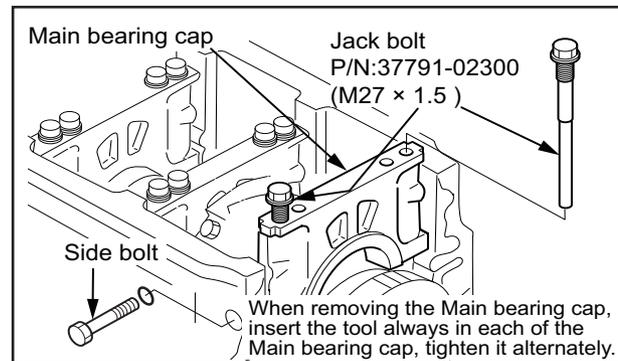
**CAUTION**

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

- (1) Remove the main bearing cap bolts and side bolts.
  - (2) Install the eye bolts to the outer bolt holes on the main bearing cap.
  - (3) Give a light shake, and remove the main bearing cap by raising gradually.
  - (4) Remove the lower thrust plate from the rearmost main bearing cap.
- Or remove the bearing cap with jack bolt.



Main Bearing Cap - Remove (Conventional)



Main Bearing Cap - Remove (New)

## 5.5 Crankshaft - Remove

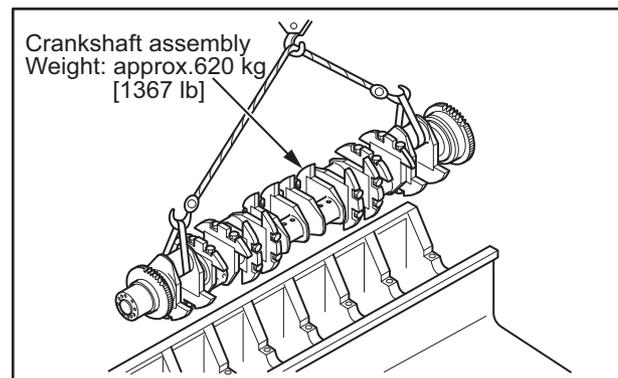
**CAUTION**

- (a) When removing the crankshaft, remove the front upper thrust plates first, and be careful not to drop into the 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 rolling.

- (1) Push a mating face of upper and lower of the front upper thrust plate, and remove while rotating.
- (2) Lift the crankshaft in a horizontal position, and slowly remove the crankshaft upward.

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

# Chapter 6 INSPECTION AND REPAIR OF BASIC ENGINE

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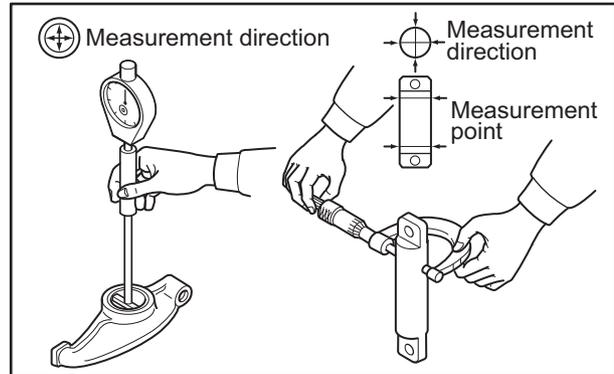
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## 1. Cylinder Head and Valve Mechanism - Inspect and Repair

### 1.1 Rocker Bushing Inside Diameter and Rocker Shaft Outside Diameter - 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 [1.42 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 [1.42 in.]	35.966 to 35.991 mm [1.4160 to 1.4170 in.]	35.940 mm [1.4150 in.]



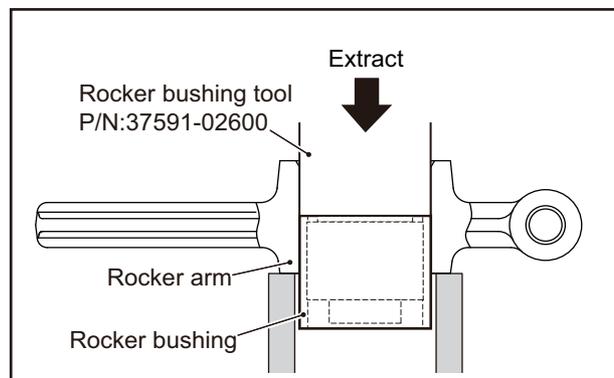
Rocker Bushing Inside Diameter and Rocker Shaft Outside Diameter - Measure

### 1.2 Rocker Bushing - Replace

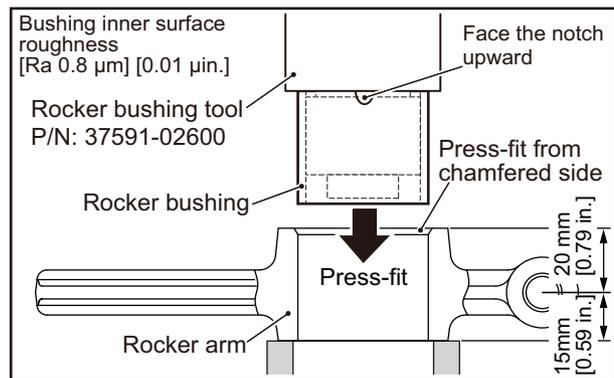
#### CAUTION

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

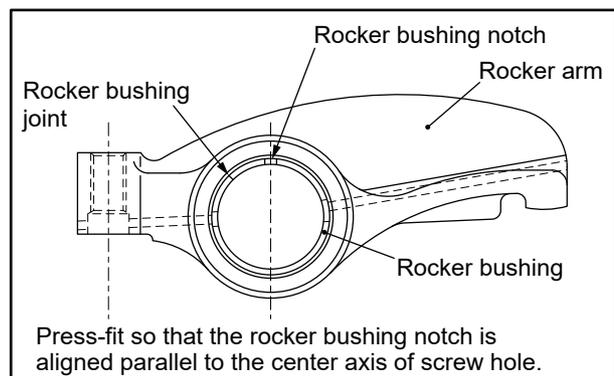
- (1) Pull-out the rocker bushing with rocker bushing tool.
- (2) Install new rocker bushing with rocker bushing tool.  
With the positioning notch (4 mm [0.16 in.] wide) of rocker bushing facing upward, align the position as shown in illustration. Press-in the rocker bushing into chamfered side of rocker arm hole.
- (3) Check the alignment of the rocker arm and rocker bushing oil holes.
- (4) Measure the inside diameter of installed rocker bushing. If the value is smaller than the standard, ream the inside diameter to the standard.



Rocker Bushing - Remove



Rocker Bushing - Press Fit



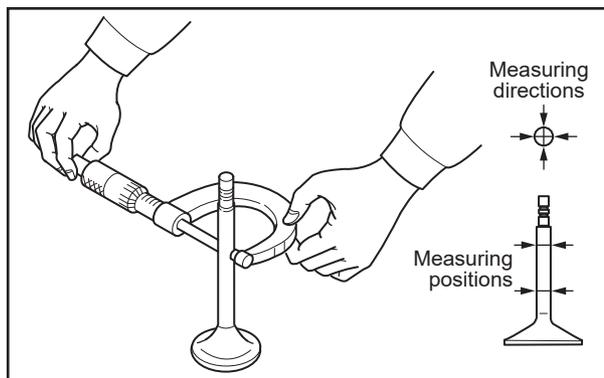
Rocker Bushing - Positioning

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

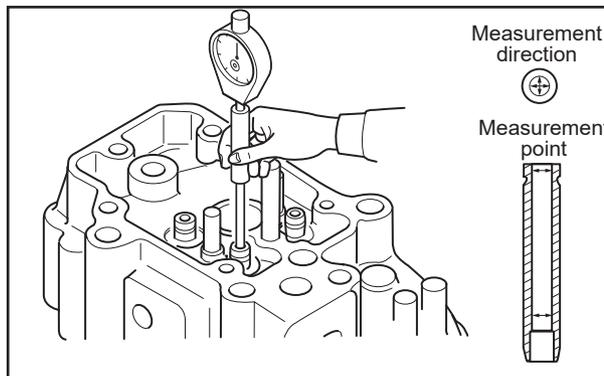
Measure the outside diameter of valve stem and the inside diameter of valve guide at the top and bottom sliding ends in mutually right-angle directions, as the sliding surfaces tend to wear at the top and bottom ends. If the measurement exceeds the limit, replace the valve guide or the valve with a new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

Note: Lap the valve and valve seat ring whenever a 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 [0.3913 to 0.3921 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



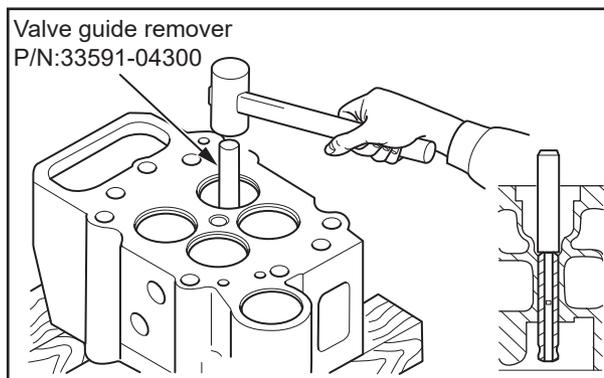
Valve Guide Inside Diameter - Measure

### 1.4 Valve Guide - Replace

**CAUTION**

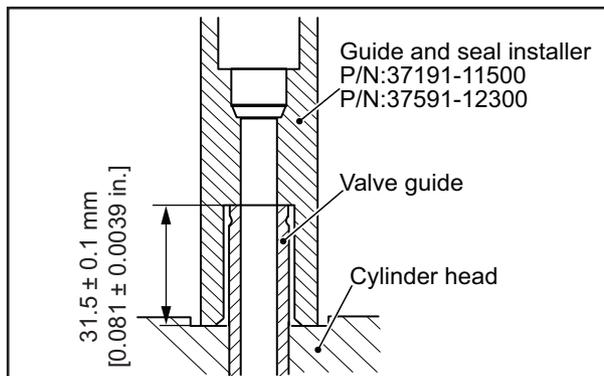
Be sure to use the guide and seal installer to install the valve guide to the specified height.

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



Valve Guide - Remove

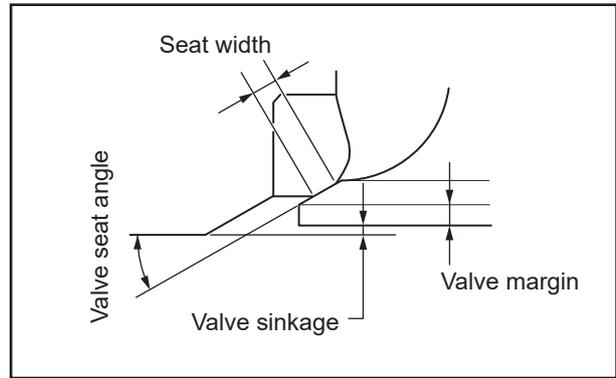
(2) Install a new valve guide slowly with the guide and seal installer.



Valve Guide - Press Fit

### 1.5 Valve Face - Inspect

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



Valve Face - Inspect

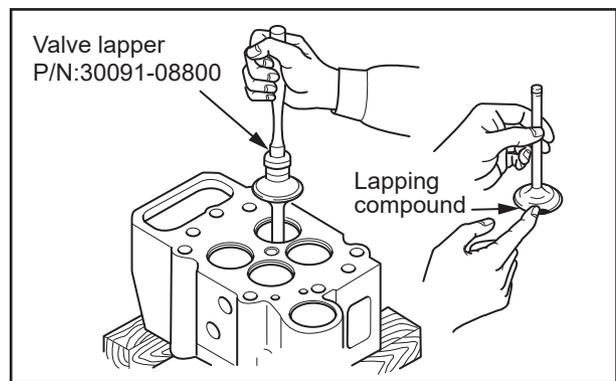
#### 1.5.1 Valve Margin - Inspect

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

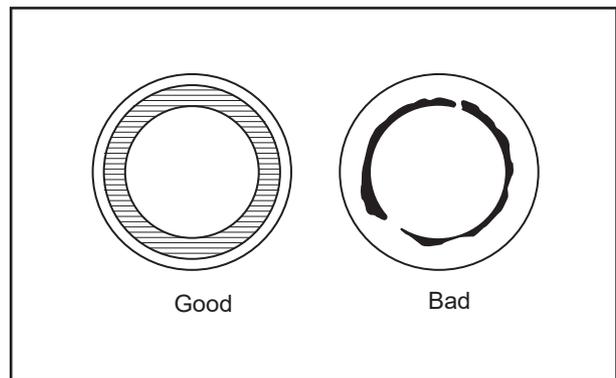
Apply a thin lead-free coloring paste on the valve face, and tap the valve face against valve seat with the valve lapper to check the contact condition. If the contact is not even, or any defects are found, or if the value exceeds the specified limit, reface or replace the valve or valve seat.

Note: Do not rotate the valve when pressing valve face coated with lead-free surface checker against valve seat ring.



Seat Width - Inspect

Item	Nominal value	Standard value	Limit value	
Valve seat angle	30°	-	-	
Valve seat ring	Seat width	2.3 mm [0.091 in.]	2.19 to 2.42 mm [0.0862 to 0.0953 in.]	2.8 mm [0.110 in.]
Valve margin		3.0 mm [0.118 in.]	2.80 to 3.26 mm [0.1102 to 0.1283 in.]	2.5 mm [0.098 in.]



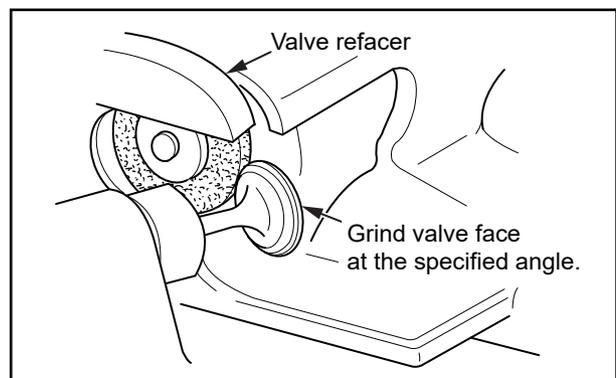
Contact Condition Between Valve and Valve Seat Ring

### 1.6 Valve Face - Reface

When refacing valve face to reuse, use the valve refacer.

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

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



Valve Face - Reface

### 1.7 Valve Seat Ring - 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 approximately 400 grit between cutter and valve, and grind valve seat lightly.

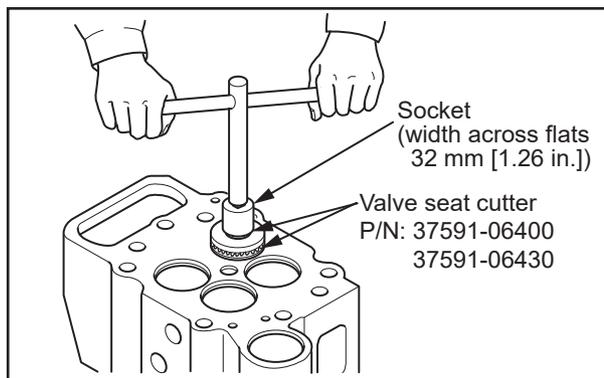
If the seat width exceeds the standard, grind the valve inner seat with a valve seat cutter having the angle of 44°50'.

- (2) Lap valve and valve seat ring.

Note:(a) Keep the valve seat refacing depth to the minimum.

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

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



Valve Seat Ring - Reface

### 1.8 Valve Seat Ring - Replace

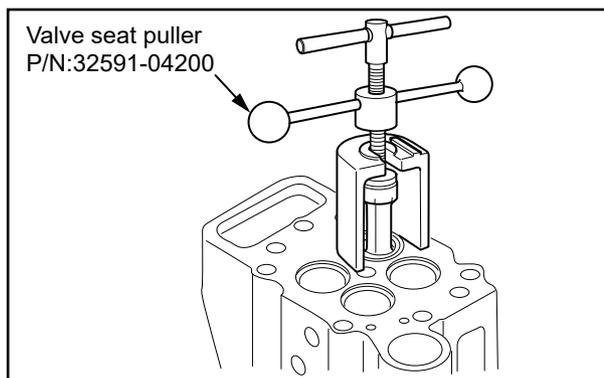
**CAUTION**

Select the valve seat ring with the 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 ring.

#### 1.8.1 Valve Seat - Remove Using Valve Seat Puller

Remove valve seat ring with the valve seat puller.

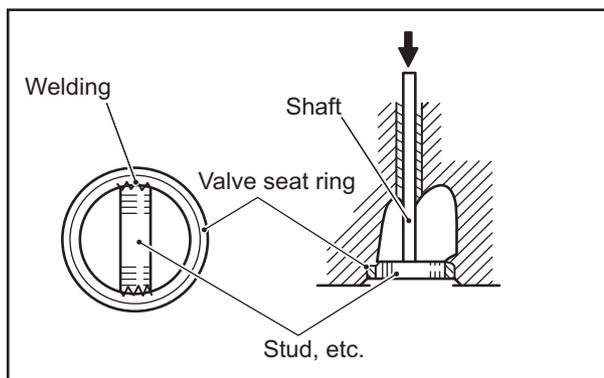


Valve Seat - Remove Using Valve Seat Puller

#### 1.8.2 Valve Seat Ring - Remove by Welding

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

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



Valve Seat Ring - Remove by Welding

1.8.3 Valve Seat Ring - Install

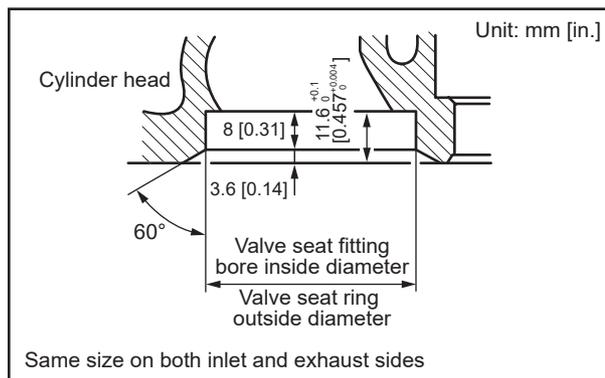
(1) Before installing valve seat ring, measure inside diameter of valve seat counterbore in cylinder head and outside diameter of valve seat ring to make sure that the interference is within the range of standard value. If the value exceeds the standard, use oversize valve seat ring. If inside diameter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

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

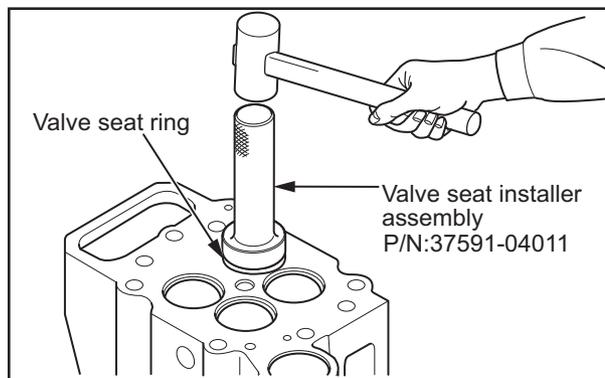
Item	Standard value	Limit value	Remarks
Inside diameter of valve seat counterbore	60.000 to 60.030 mm [2.3622 to 2.3634 in.]	60.090 mm [2.3657 in.]	-
Valve seat ring outside diameter	Standard 60.100 to 60.130 mm [2.3661 to 2.3673 in.]	-	3pcs, brown
	0.03 mm [0.0012 in.] 60.130 to 60.160 mm [2.3673 to 2.3685]	-	4pcs, brown
	0.06 mm [0.0024 in.] 60.160 to 60.190 mm [2.3685 to 2.3697 in.]	-	5pcs, brown
Valve seat interference	0.070 to 0.130 mm [0.0027 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 ring at least for 4 minutes in liquid nitrogen and keep the cylinder head in a room temperature.
- (3) Install the valve seat ring in the cylinder head with the insert caulking tool.



Valve Seat Counterbore



Valve Seat - Install

### 1.9 Valve and Valve Seat Ring - Lap

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

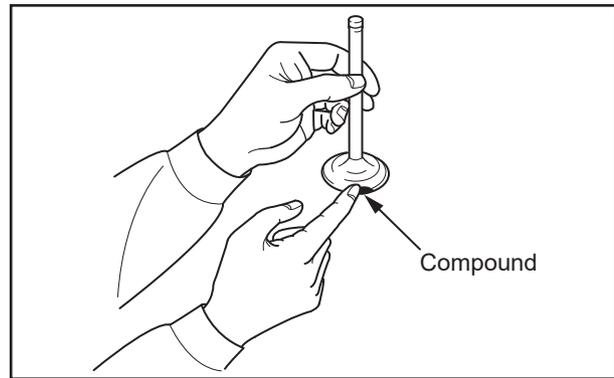
- (1) Apply a thin coat of lapping compound evenly on valve seat face.

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

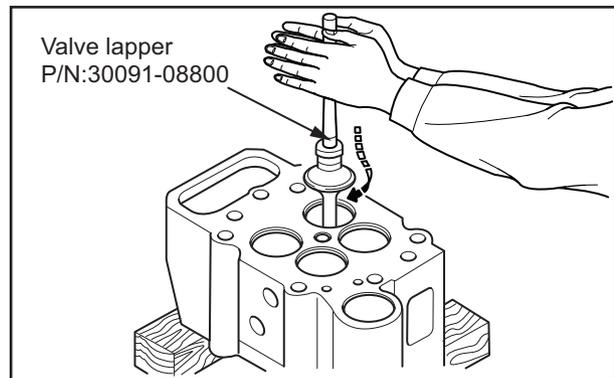
(b) The compound spreads more evenly when it is mixed with a small amount of engine oil.

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

- (2) Use a valve lapper for lapping. Tap the valve against the valve seat while rotating the valve little by little.
- (3) Wash off the compound using diesel fuel.
- (4) Apply engine oil on mating surfaces, and lap for finishing.
- (5) Apply a thin coat of lead-free coloring paste on the valve face, and tap the valve face against the valve seat using a valve lapper to check the contact condition.



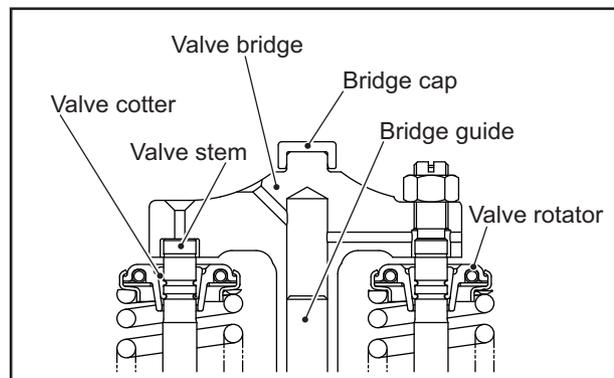
Compound - Apply



Valve and Valve Seat Ring - Lap

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

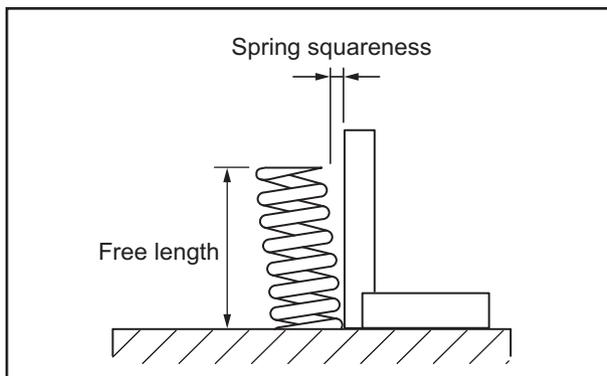
- (1) Inspect the contact surfaces between the valve bridge and the valve stem, and the sliding surfaces between the valve bridge and the bridge guide. If significant wear or uneven contact is found, replace them with new ones.
- (2) Check the bridge cap for wear. If significant wear is found, replace 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 uneven wear or significant dent is found, replace with new ones.



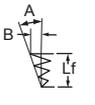
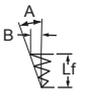
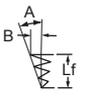
Valve Bridge, Bridge Cap, Valve Cotter, and Valve Rotator - Inspect

1.11 Squareness and Free Length of Valve Spring - Measure

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

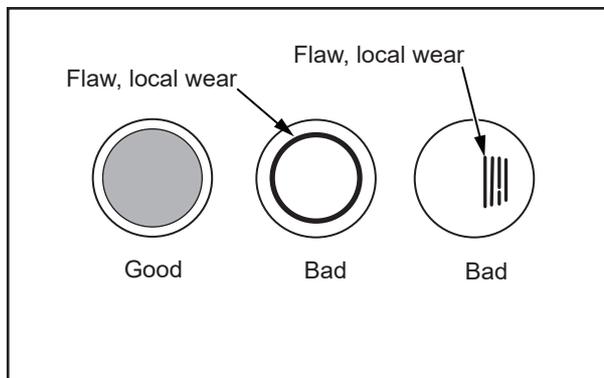


Squareness and Free Length of Spring - Measure

Item		Standard value		Limit value		
Single valve spring	P/N: 37504-□040□	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 the whole 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-□060□	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 the whole length B=3.7 mm [0.146 in.]
	Outer spring	P/N: 37504-□050□	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 the whole length B=4.9 mm [0.193 in.]
			Set length / load	62.0 mm [2.441 in.] / 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 local wear. If defective, replace the tappet with a new one.

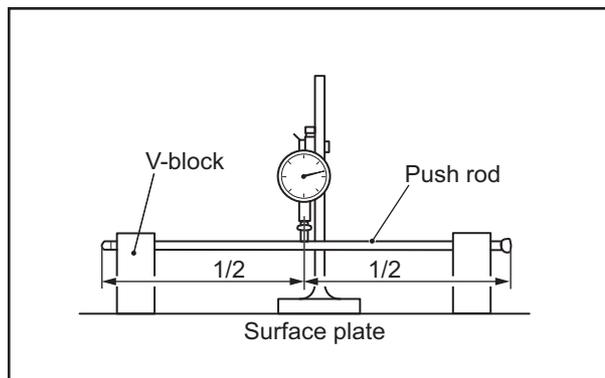


Tappet Sliding Face to Cam - Inspect

1.13 Pushrod Runout - Measure

Measure the runout of pushrod in the total indicator reading (TIR). If the runout exceeds the standard, replace the pushrod with a new one.

Item	Standard value	Remarks
Pushrod runout	0.50 mm [0.0197 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 the threaded portion.

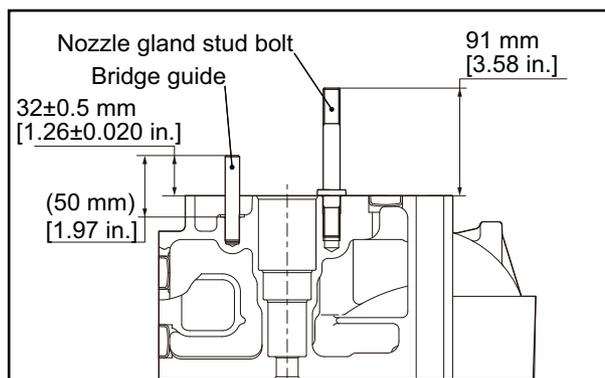
Inspect the bridge guide for uneven wear and damage on the sliding surfaces.

1.14.1 Nozzle Gland Stud - Install

Install the nozzle gland stud bolt.

1.14.2 Bridge Guide - Install

Press in the bridge guide to the specified dimension.



Nozzle Gland Stud Bolt and Bridge Guide - installing

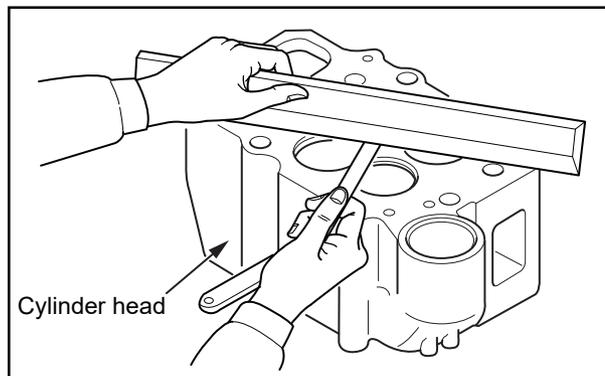
1.15 Distortion of Cylinder Head Bottom Surface - Measure

**CAUTION**  
Keep the grinding amount of cylinder head to the minimum. Excessive grinding of the cylinder head may result in defects such as contact between piston and valve.

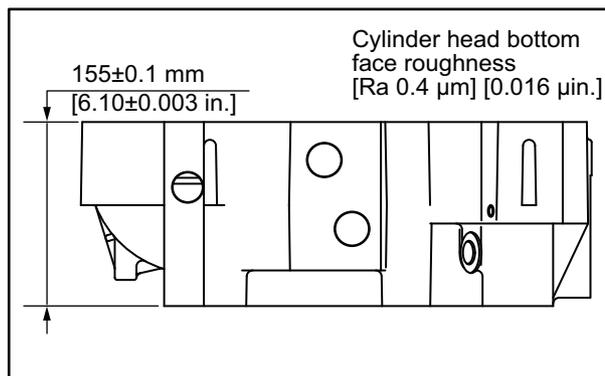
With a straight edge placed on the bottom face of cylinder head, measure the bottom face distortion with feeler gauges. If the value exceeds the limit, replace with a new one, or grind to correct.

When ground, record the maximum depth of grinding. Note that total grinding amount, which includes the 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.]
Height of cylinder head (Reference value)	155±0.1 mm [6.1024±0.0039 in.]	-



Distortion of Cylinder Head Bottom Surface - Measure



Height of Cylinder Head - Measure

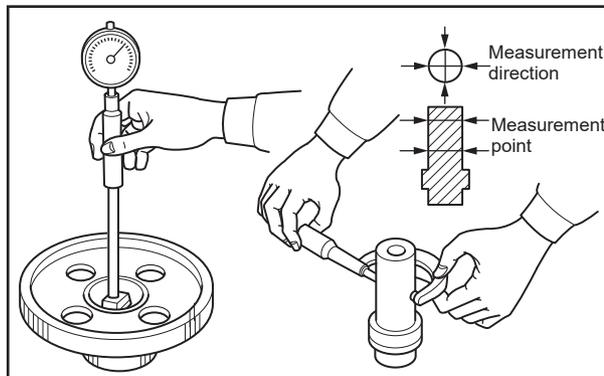
## 2. Rear Mechanism - Inspect and Repair

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

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

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

Item	Nominal value	Standard value	Limit value
Rear idler bushing inside diameter	ø65 mm [0.56 in.]	65.000 to 65.030 mm [2.5591 to 2.5602 in.]	65.060 mm [2.5614 in.]
Rear idler shaft outside diameter	ø65 mm [0.56 in.]	64.951 to 64.970 mm [2.5571 to 2.5579 in.]	64.900 mm [2.5551 in.]

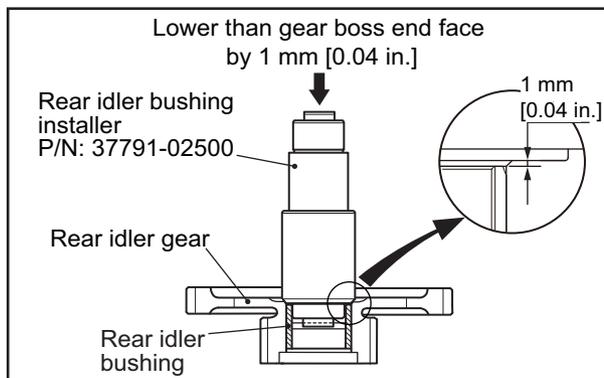


Bushing Inside Diameter and Shaft Outside Diameter of Rear Idler - Measure

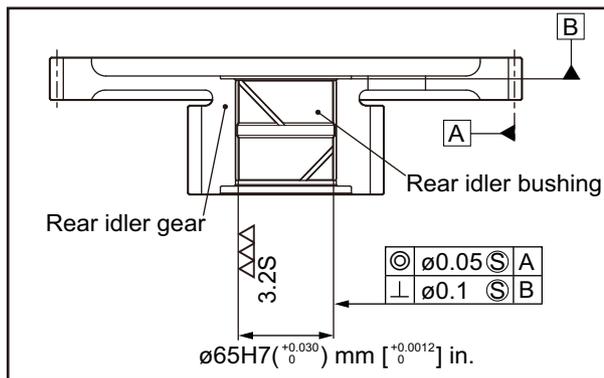
### 2.2 Rear Idler Bushing - Replace

- (1) Using the removal side of the idler bushing installer, remove the rear idler bushing.
- (2) Set the oil grooves of rear idler bushing as shown in the illustration, and with the bushing installer installing side, press-in the rear idler bushing from the large gear side.
- (3) Ream the bore of installed rear idler bushing and finish the bore to the dimension as shown.

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



Rear Idler Bushing - Replace

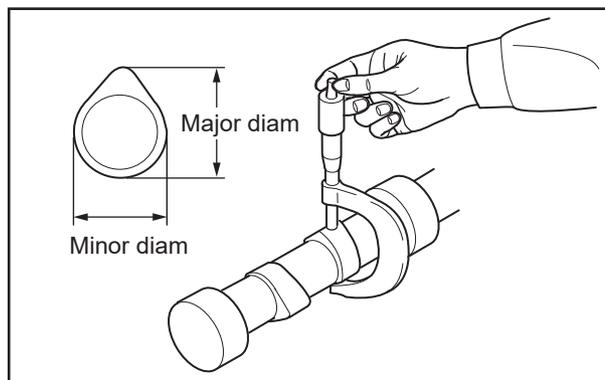


Finishing Dimension of Rear Idler Bushing

### 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)	Right: 37805-□110□ Left: 37805-□120□ (Overlap 61°)	9.207 to 9.287 mm [0.3625 to 0.3656 in.]	8.931 mm [0.3516 in.]
	Right: 37805-□130□ Left: 37805-□140□ (Overlap 93°)		
	Right: 37805-□070□ Left: 37805-□080□ (Overlap 108°)	9.260 to 9.340 mm [0.3646 to 0.3677 in.]	9.021 mm [0.3552 in.]
	Right: 37805-□410□ Left: 37805-□420□ (Overlap 108°)		
	IN	8.554 to 8.634 mm [0.3364 to 0.3399 in.]	8.687 mm [0.3420 in.]
	EX	9.260 to 9.340 mm [0.3646 to 0.3677 in.]	9.021 mm [0.3552 in.]



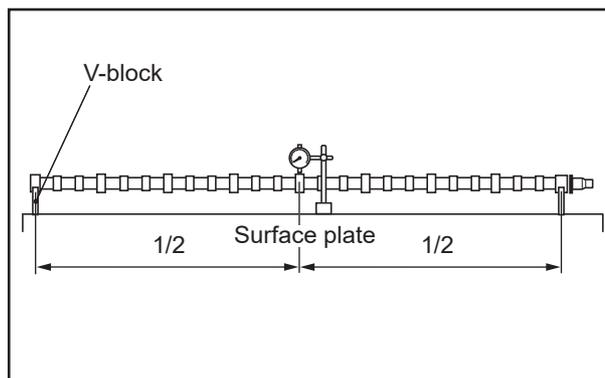
Cam Lift of Cam Shaft Lobe - Measure

### 2.4 Camshaft Runout - Measure

Measure the runout of camshaft in 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	Remark
Camshaft runout	0.1 mm [0.0039 in.] or less	0.16 mm [0.0063 in.]	TIR

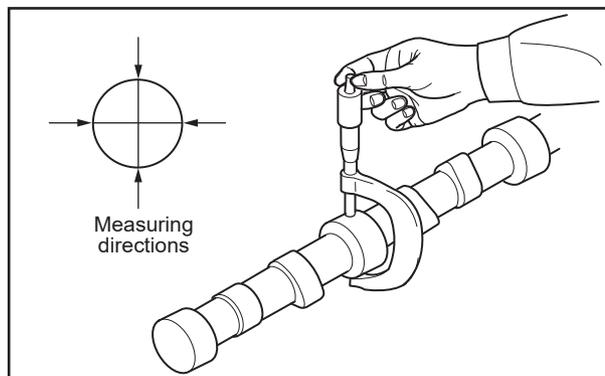


Camshaft Runout - Measure

### 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.]	83.920 to 83.940 mm [3.3039 to 3.3047 in.]	83.870 mm [3.3020 in.]



Camshaft Journal Outside Diameter - Measure

## 2.6 Camshaft Bushing - Inspect

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

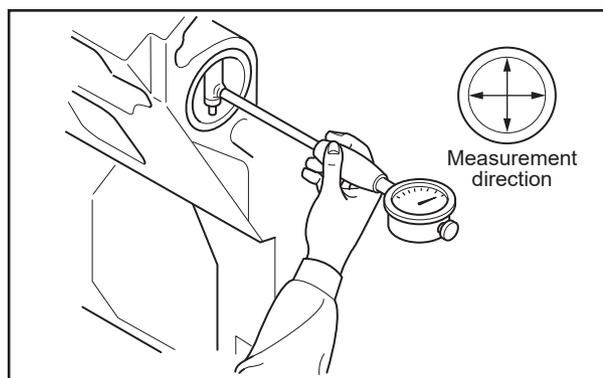
## 2.7 Camshaft Bushing - Replace

### CAUTION

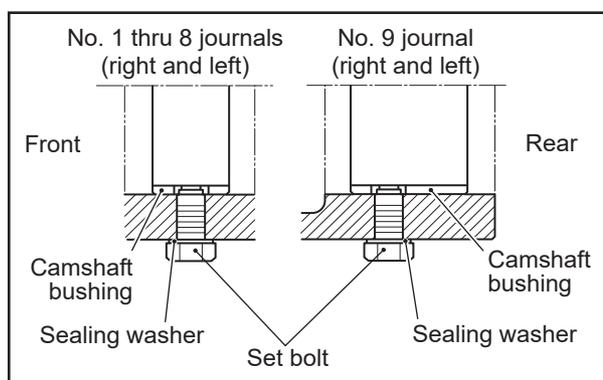
Before tightening the set bolt, be sure to check that the set bolt is in alignment with the set bolt hole in the camshaft bushing.

Make sure that the oil hole in the camshaft bushing is in alignment with crankcase.

- (1) Remove the camshaft bushing set bolt and remove the camshaft bushing.
- (2) Before inserting the camshaft bushing in the bushing hole on the crankcase, be sure to check the position of oil hole and set bolt hole.
- (3) Before securing the set bolt, be sure to check that the set bolt is in alignment with the oil hole.



Camshaft Bushing Inside Diameter - Measure

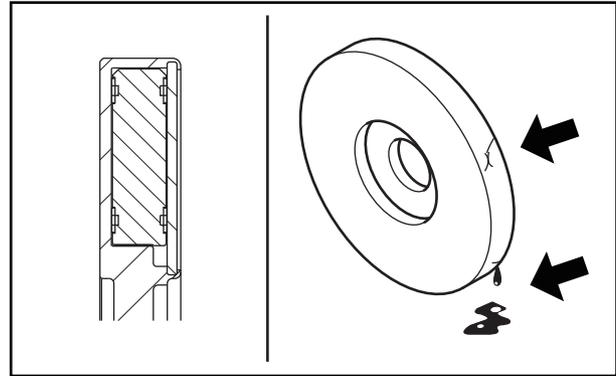


Camshaft Bushing - Install

### 3. Front Mechanism - Inspect and Repair

#### 3.1 Damper - Inspect Visually

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



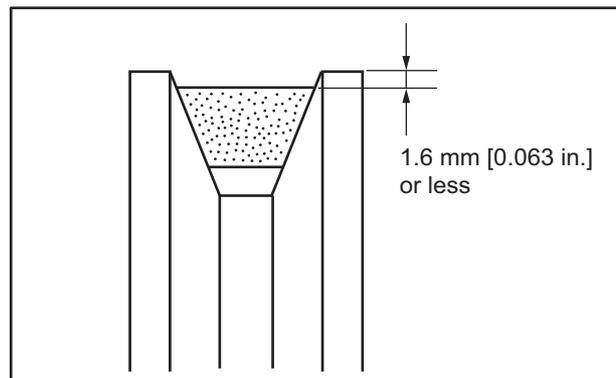
Damper - Inspect Visually

#### 3.2 Pulley - Inspect

(With pulley spec)

Check the belt groove of pulley for wear.

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



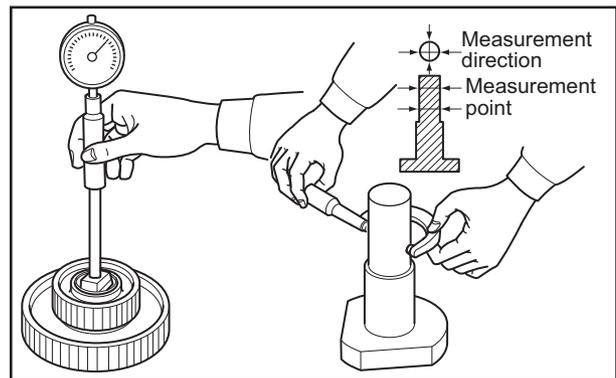
Pulley Wear - Inspect

#### 3.3 Bushing Inside Diameter and Shaft Outside Diameter of Fan Drive Idler - Measure

(With fan spec)

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

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



Fan Drive Idler Bushing Inside Diameter, Fan Drive Idler Shaft Outside Diameter - Measure

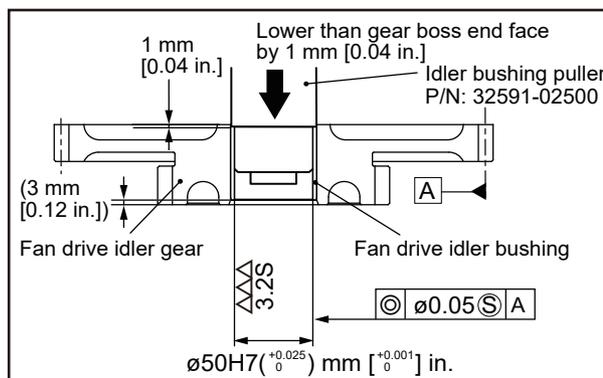
Item	Nominal value	Standard value	Limit value
Fan drive Idler bushing inside diameter	ø50 mm [1.97 in.]	50.000 to 50.025 mm [1.9685 to 1.9695 in.]	50.060 mm [1.9708 in.]
Fan drive Idler shaft outside diameter	ø50 mm [1.97 in.]	49.950 to 49.975 mm [1.9665 to 1.9675 in.]	49.900 mm [1.9646 in.]

### 3.4 Fan Drive Idler Bushing - Replace

(With fan spec)

- (1) Using the removing side of the idler bushing puller, remove the fan drive idler bushing.
- (2) Using the installing side of the idler push puller, press-in the fan drive idler bushing to 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) Ream the inside diameter of the installed fan drive idler bushing to finish it to the dimension shown.

Note: Reaming after press-fit is necessary, as the fan drive idler bushing is supplied in a semi-finished condition.



Fan Drive Idler Bushing - Replace

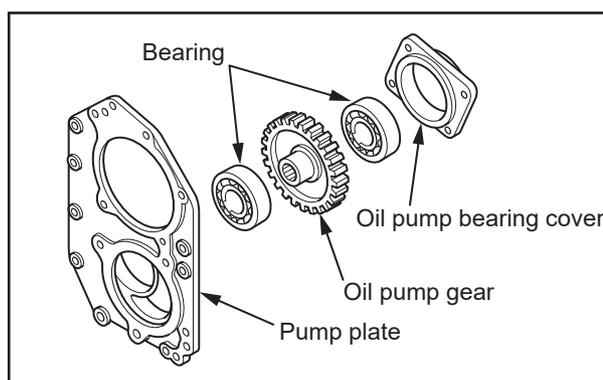
### 3.5 Outside Diameter and Inside Diameter of Oil Pump Drive Bearing Fit - Inspect

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

Inspect the fit between the oil pump bearing cover and the bearing. If significant wear is found, replace them with new ones.

Inspect the fit between the pump plate and the bearing. If significant wear is found, replace them with new ones.

Inspect the fit between oil pump gear and bearing. If significant wear is found, replace them with new ones.



Oil Pump Drive Face to Fit Bearing - Inspect

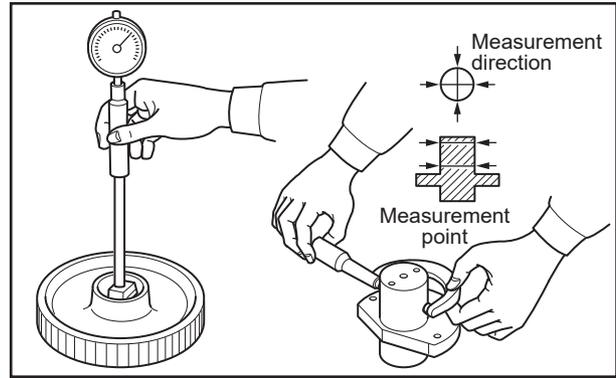
Item	Nominal value	Standard value
Inside diameter of oil pump bearing cover to fit bearing	ø110 mm [4.33 in.]	110.000 to 110.035 mm [4.3307 to 4.3321 in.]
Pump plate bearing inside diameter of housing	ø110 mm [4.33 in.]	109.987 to 110.022 mm [4.3302 to 4.3316 in.]
Bearing	Outside diameter	ø110 mm [4.33 in.]
	Inside diameter	ø50 mm [1.97 in.]
Oil pump bearing outside diameter to fit	ø50 mm [1.97 in.]	49.993 to 50.013 mm [1.9682 to 1.9690 in.]

### 3.6 Bushing Inside Diameter and Shaft Outside Diameter of Front Idler - Measure

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

Item	Nominal value	Standard value	Limit value
Front idler bushing inside diameter	ø50 mm [1.97 in.]	50.000 to 50.025 mm [1.9685 to 1.9695 in.]	50.060 mm [1.9709 in.]
Front idler shaft diameter	ø50 mm [1.97 in.]	49.950 to 49.975 mm [1.9665 to 1.9675 in.]	49.900 mm [1.9646 in.]

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

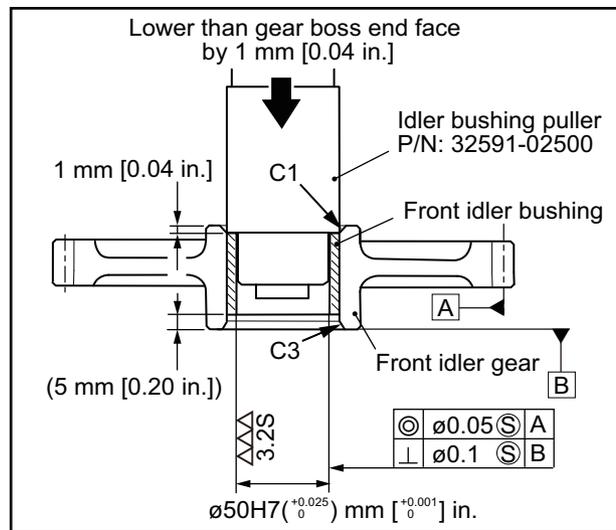


Front Idler Bushing Inside Diameter, Front idler Shaft Outside Diameter - Measure

### 3.7 Front Idler Bushing - Replace

- (1) Using the removal side of the idler bushing puller, remove the front idler bushing.
- (2) Using the installation side of the idler bushing puller, push-in the front idler bushing to the 1 mm [0.04 in.] chamfered side until the bushing end face becomes flush with the gear boss end face. 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) Ream the installed front idler bushing inside diameter to finish it to the dimension shown.

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

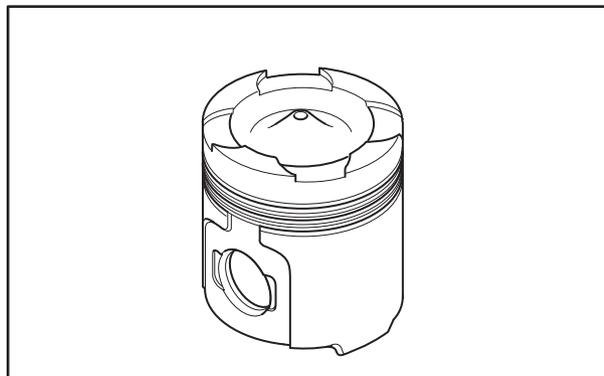


Front Idler Bushing - Replace

## 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 inside surface of the piston. If any defect is found, replace the piston with a new one.



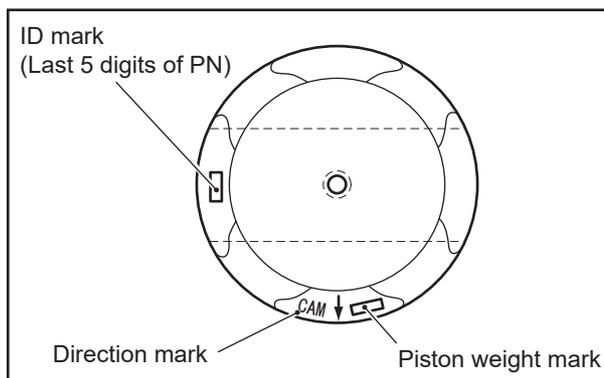
Piston - Inspect Visually

### 4.2 Piston Weight

Check the piston weight punch mark on the top face of piston.

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

Item	Part No.	ID stamp	Compression ratio	Standard value
Piston weight difference	37517-□010□	□010□	14	within ±25 g [0.88 oz]
	37517-□060□	□060□	14	
	37517-□040□	□040□	15	
	37517-□080□	□080□	14	
	37517-□090□	□090□	14.5	
	37517-□450□	□450□	14.5	
	37517-□460□	□460□	14.4	
	37517-□550□	□550□	14	
	37517-□55A□	□55A□	14	
	37517-□770□	□770□	13.5	
	37817-□710□	□710□	14	

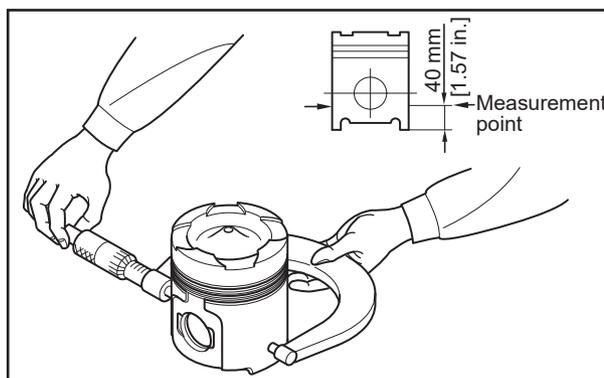


Piston Weight Stamp

### 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-□010□	ø170 mm [6.69 in.]	169.760 to 169.800 mm [6.6835 to 6.6850 in.]	169.660 mm [6.6795 in.]
	37517-□060□			
	37517-□040□			
	37517-□080□			
	37517-□090□			
	37517-□450□			
	37517-□460□			
	37517-□550□			
	37517-□55A□			
	37517-□770□	ø170 mm [6.69 in.]	169.739 to 169.779 mm [6.6826 to 6.6842 in.]	169.639 mm [6.6787 in.]
	37817-□710□	ø170 mm [6.69 in.]	169.749 to 169.789 mm [6.6830 to 6.6846 in.]	169.660 mm [6.6795 in.]



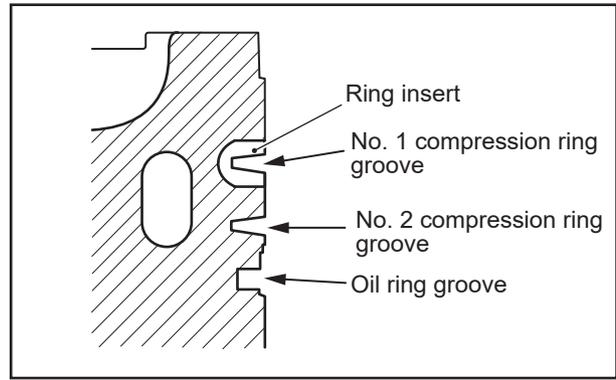
Piston Outside Diameter - Measure

#### 4.4 Piston Ring Groove - Inspect

**CAUTION**

Remove carbon deposits from the piston and inspect the whole 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 defective, replace the piston with a new one. Inspect the ring trager of No. 1 compression ring groove by dye penetration test for cracks and separation.

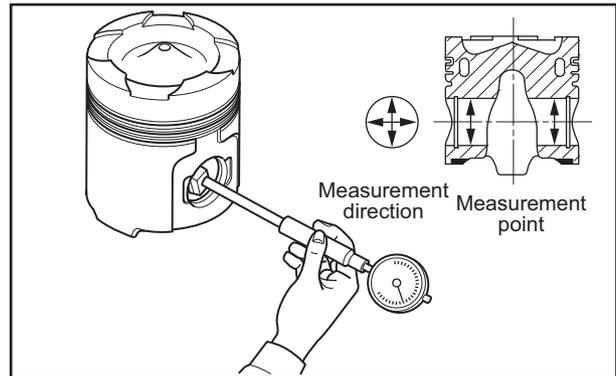


Piston Ring Groove - Inspect

#### 4.5 Piston Pin Hole Inside Diameter - Measure

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

Item	Nominal value	Standard value	Limit value
Piston pin hole 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 Hole Inside Diameter - Measure

#### 4.6 Piston Ring - Inspect Visually

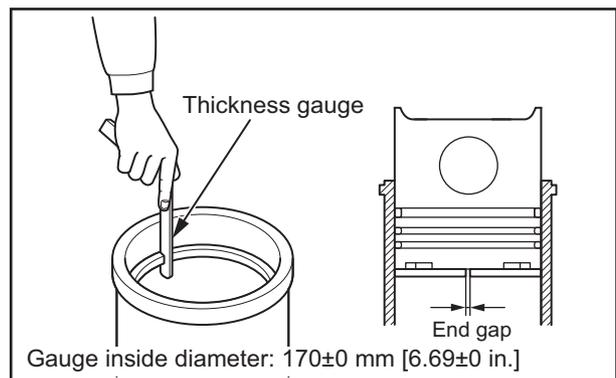
Check the sliding surface, the top and bottom surfaces for seizing, wear, foreign material inclusion, and plating flaking. If any defect is found, replace the piston ring with a new one.

#### 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 0.031 in.]	2.0 mm [0.079 in.]	
	No.2 compression	0.6 to 0.8 mm [0.024 to 0.031 in.]		
	Oil	S16R		0.3 to 0.45 mm [0.012 to 0.018 in.]
		S16R2		0.3 to 0.5 mm [0.012 to 0.020 in.]



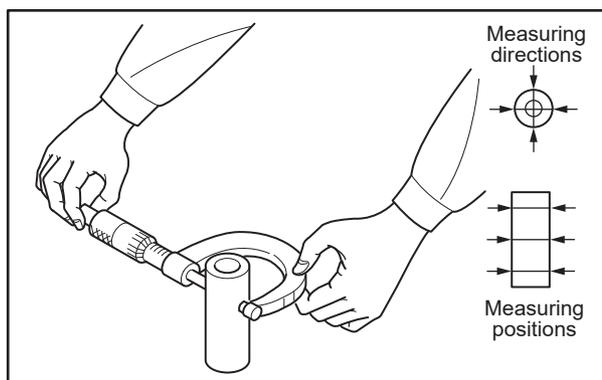
Piston Ring End Gap - Measure

#### 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.]



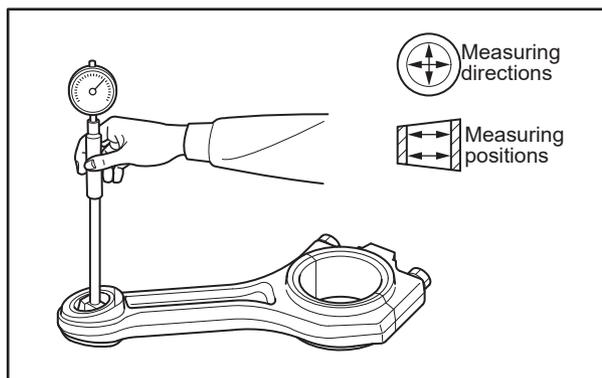
Piston Pin Outside Diameter - Measure

#### 4.9 Connecting Rod Bushing Inside Diameter - Measure

Measure the inside diameter of the connecting rod bushing.

If the value exceeds 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

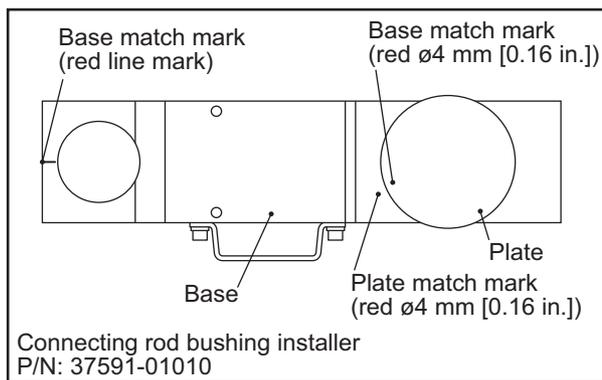
#### 4.10 Connecting Rod Bushing - Replace

Replace the connecting rod bushing using the connecting rod bushing installer.

##### 4.10.1 Connecting Rod on the Installer Base -

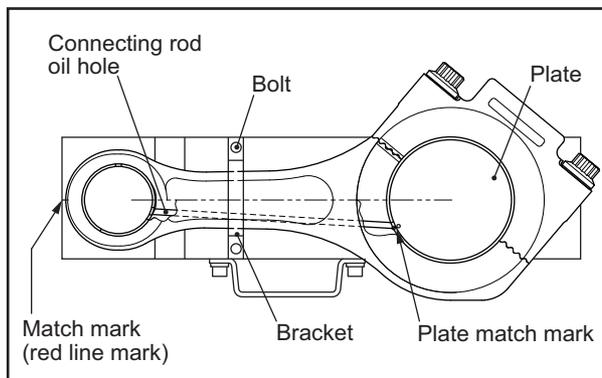
Fix

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



Connecting Rod Bushing Installer - Use (1)

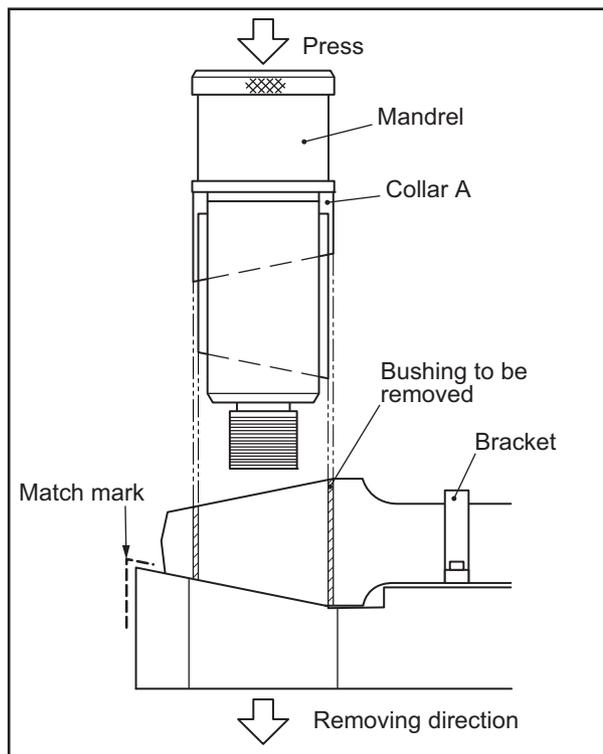
- (2) With the connecting rod bearing removed from the connecting rod, install the connecting rod cap to the plate.
- (3) Align the match mark, and install the connecting rod on the plate.
- (4) Tighten the connecting rod bolts to the specified torque.
- (5) Secure the connecting rod with the bracket.



Connecting Rod Bushing Installer - Use (2)

4.10.2 Connecting Rod Bushing - Remove

- (1) Apply engine oil on 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) Using a pressing machine, apply pressure slowly on the mandrel head to push-out the connecting rod bushing.



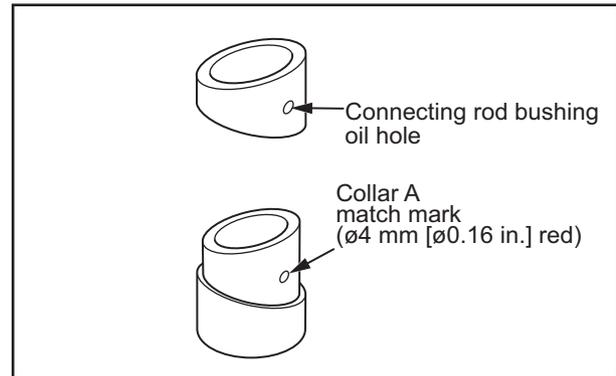
Connecting Rod Bushing Installer - Use (3)

## 4.10.3 Connecting Rod Bushing - Press In

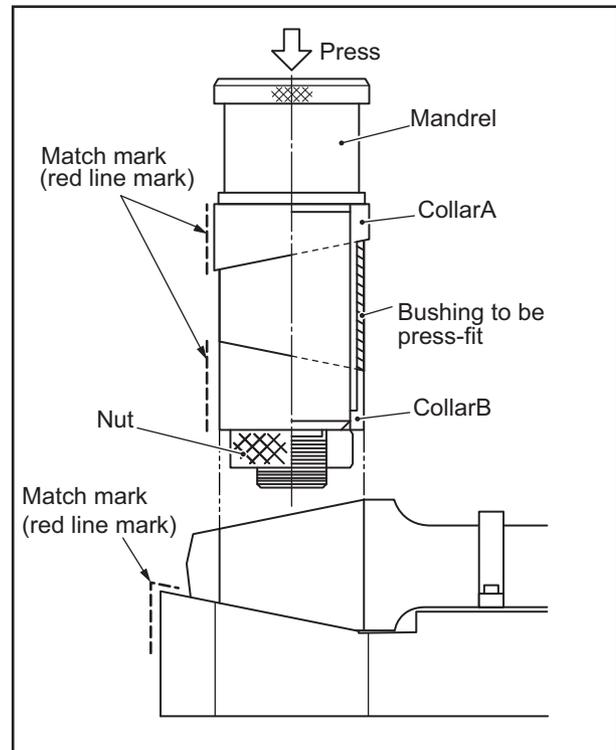
**CAUTION**

- (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  $\varnothing 4$  mm [ $\varnothing 0.16$  in.]) on collar A.

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

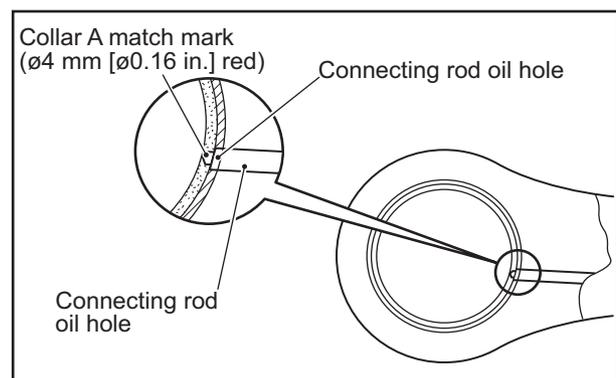


Connecting Rod Bushing Installer - Use (4)



Connecting Rod Bushing Installer - Use (5)

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

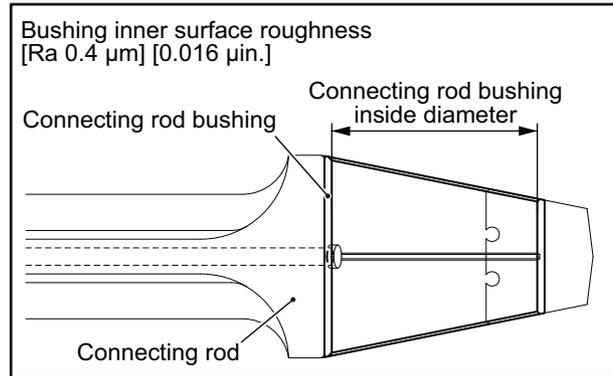


Connecting Rod Bushing Installer - Use (6)

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

If the value exceeds the limit, replace the connecting rod with a new one and measure the diameter again.

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



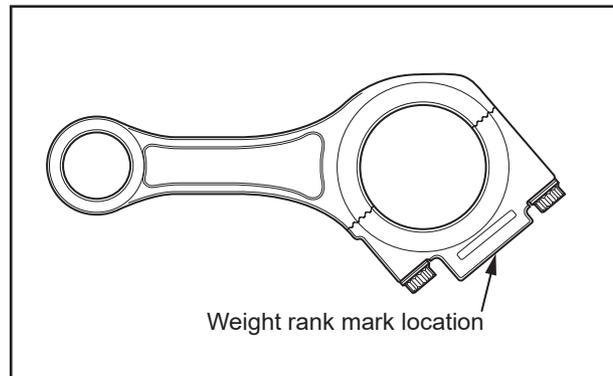
Connecting Rod Bushing Inside Diameter - Measure

#### 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.

The weight allowance in an engine is  $\pm 30$  g [1.06 oz].

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



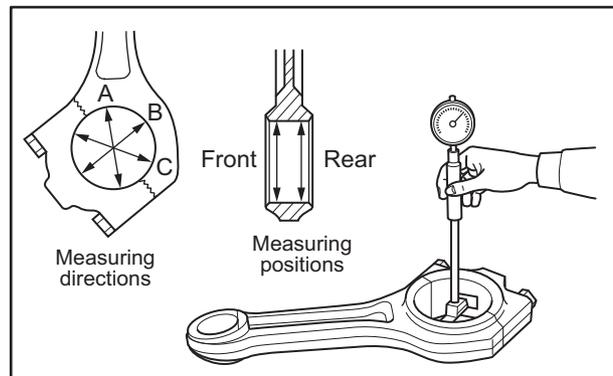
Connecting Rod Weight Rank Mark Location

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

Measure the connecting rod bore diameter at the front and rear ends respectively in the directions A, B, and C as shown in the 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	Limit value of roundness
Connecting rod big-end bore diameter	$\phi 131$ 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

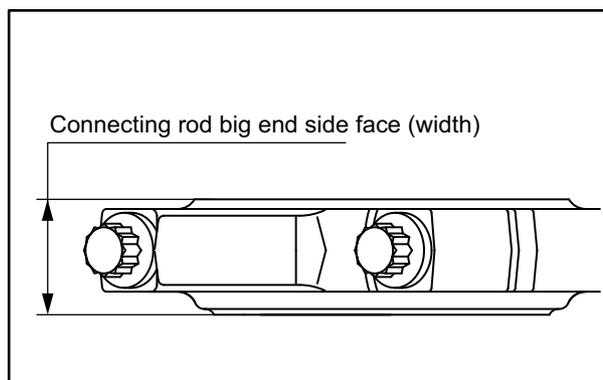
(1) Visually inspect the side face of connecting rod big end.

If any defect such as wear or flaw is observed, 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 with a new one.

Item	Standard value
Side face width of connecting rod big end	59.7 to 59.8 mm [2.3504 to 2.3543 in.]



Side Face Width of Connecting Rod Big End - Measure

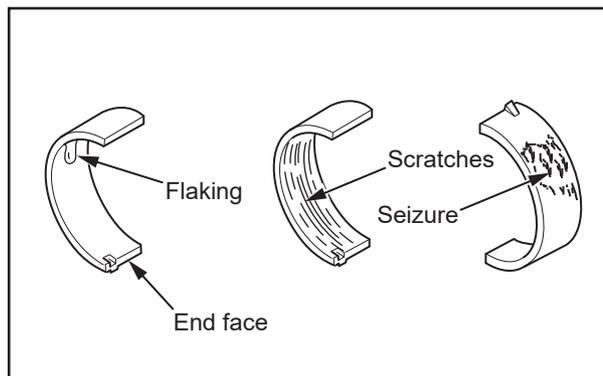
#### 4.14 Connecting Rod Big End Serration and Bolt Holes - Inspect

Inspect the connecting rod big-end serration and the bolt holes with the 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 surfaces of the 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.

Note: Whenever the connecting rod bearing is disturbed, replace it with a new one irrespective of its condition.



Connecting Rod Bearing - Inspect

4.16 Connecting Rod Bearing Thickness - Measure

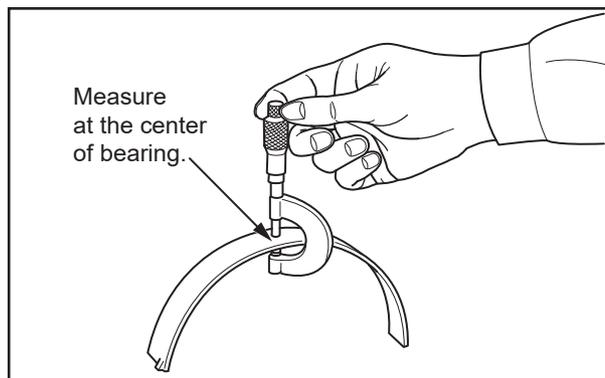
Measure the thickness of the connecting rod at its center position.

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 the crank pin, use the undersize bearing.

For crankshaft grinding procedure, see "Crankpin and Crank Journal - Grind" of "ENGINE BODY - INSPECT AND REPAIR".

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.]	
	Undersize	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 the illustration to check bend and twist of the connecting rod. Correct the connecting rod with a press machine so that the measured value meets the standard. If the value exceeds the limit, replace with a new one.

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

(2) To inspect the connecting rod in the piston installed condition, 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 a dial gauge.

Unit: mm [in.]

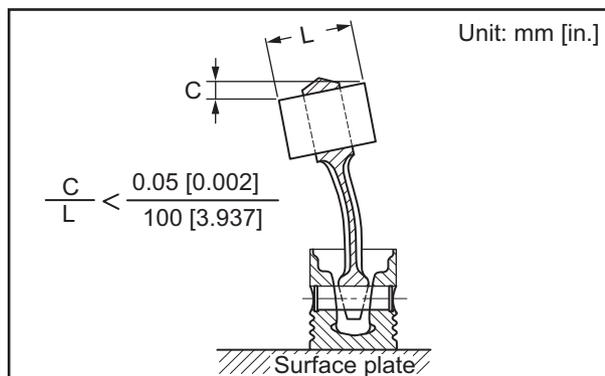
Connecting rod bend:  $\frac{C}{L} < \frac{0.05 [0.0020]}{100 [3.94]}$

Connecting rod twist:  $\frac{C}{L} < \frac{0.05 [0.0020]}{100 [3.94]}$

Bolt ID mark	2	CS, CL
Tightening torque	539±27 N·m	637±31.9 N·m
2-time tightening method [wet]	{55±2.75 kgf·m}	{65±3.25 kgf·m}
	[398±19.9 lbf·ft]	[470±23.5 lbf·ft]

Connecting Rod Bend and Twist - Inspect

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



Bend of Connecting Rod - Measure

## 5. Crankcase and Crankshaft - Inspect and Repair

### 5.1 Crankcase Top Surface Distortion - Measure

**CAUTION**

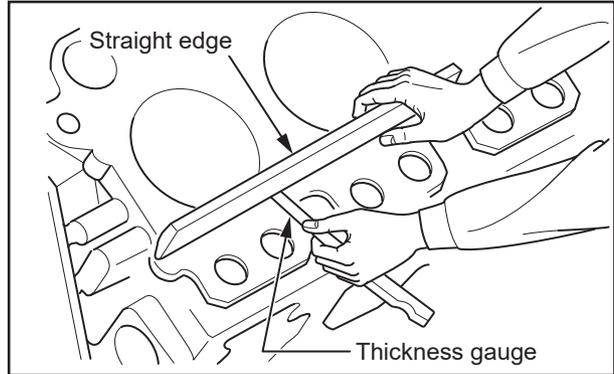
Keep the grinding amount of the crankcase to the minimum.

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

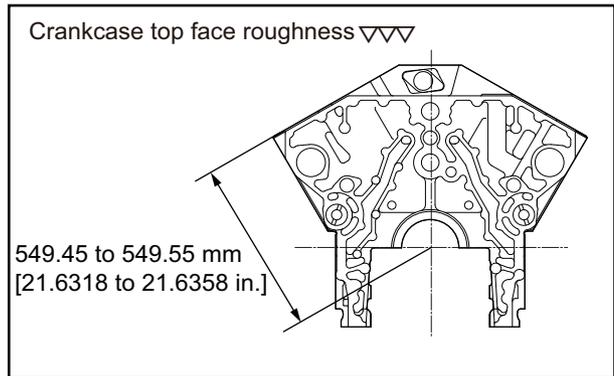
Apply a straight edge to the top surface of the crankcase and measure its distortion with feeler gauges. If the value exceeds the limit, replace with a new one, or grind to correct.

When ground, record the maximum depth of grinding. Note that the total grinding amount, which includes the grinding depth of the bottom surface of the cylinder head, must be 0.50 mm [0.0197 in.] or less.

Item	Standard value	Limit value
Crankcase top surface distortion	0.1 mm [0.0039] or less	0.2 mm [0.0079 in.]
Height from the center of crank journal to the top face of crankcase (Reference value)	549.45 to 549.55 mm [21.6318 to 21.6358 in.]	-



Crankcase Top Surface Distortion - Measure



Height from the Center of Crank Journal to the Top Face of Crankcase

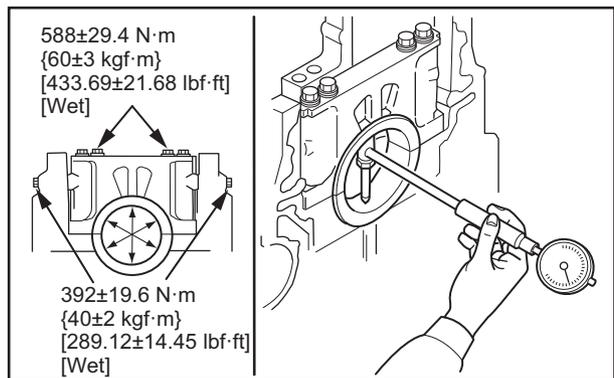
### 5.2 Inside Diameter of Main Bearing Housing Bore - Measure

(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 "ENGINE BODY - ASSEMBLE".

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

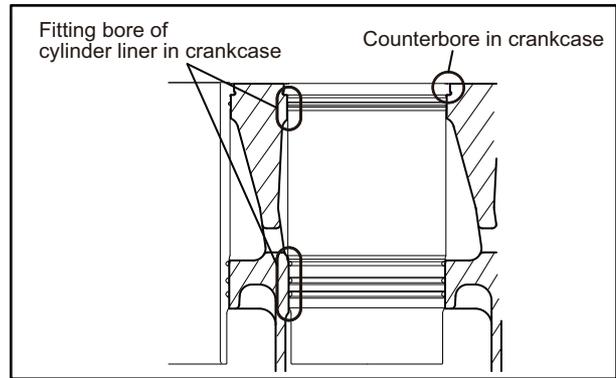
Item	Nominal value	Standard value	Limit value
Inside diameter of main bearing housing bore	ø179 mm [7.05 in.]	179.000 to 179.025 mm [7.0472 to 7.0482 in.]	179.045 mm [7.0490 in.]



Inside Diameter of Main Bearing Housing Bore - Measure

5.3 Cylinder Liner Fitting Bore in Crankcase - Inspect

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

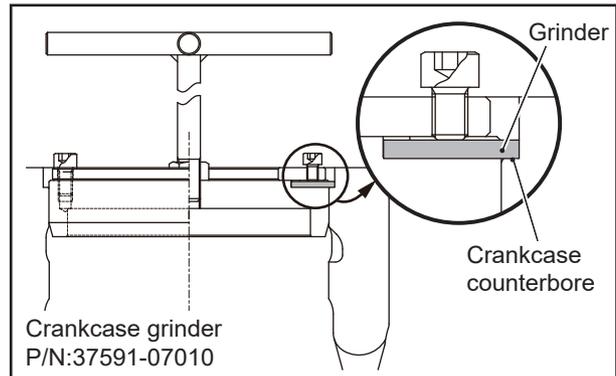


Cylinder Liner Fitting Bore in Crankcase - Inspect

5.4 Counterbore in Crankcase - Repair

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

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



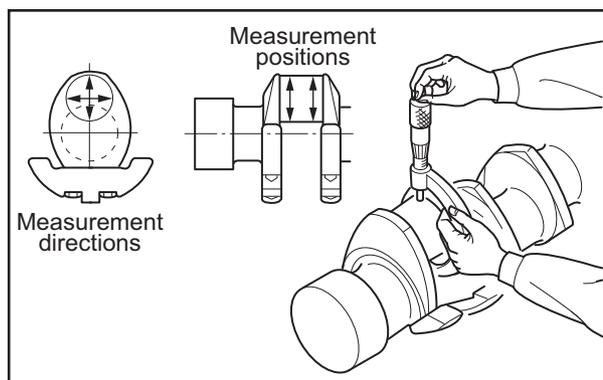
Counterbore in Crankcase - Repair

## 5.5 Crank Pin and Journal Outside Diameters - Measure

(1) Measure the outside diameter of the crankshaft pin and journal.

If the value exceeds the limit, use the undersize bearing, and grind the crankshaft to fit the undersize bearing.

If the value exceeds the limit even when 1.00 mm [0.0394 in.] undersized bearing is used, replace the crankshaft with a new one.



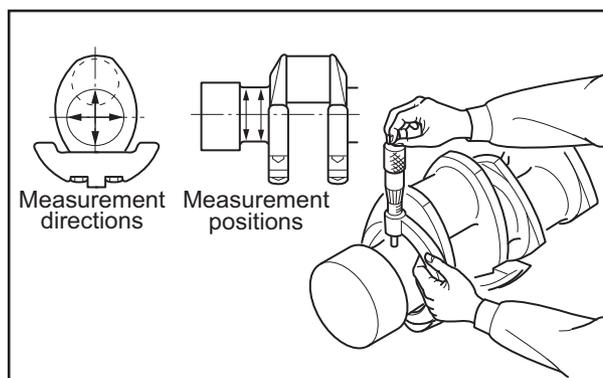
Crankpin Outside Diameter - Measure

### 5.5.1 Crankshaft Pin and Journal - Grind

When using the undersize bearing, grind to the specified value that meets the undersize bearing.

Do not change the fillet radius and the bearing journal width when grinding. If a remarkable decrease in hardness is found, quench the crankshaft again and inspect it with the magnetic particle inspection.

After the grinding, measure the width of crankpins and rear-most crank main journal.

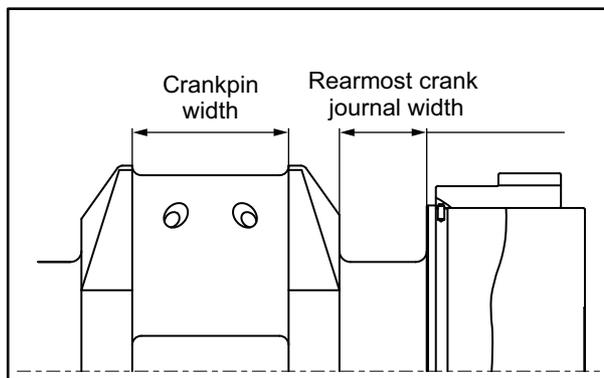


Crank Journal Outside Diameter - Measure

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 journal outside diameter	ø170 mm [6.69 in.]	Standard	169.920 to 169.940 mm [6.6898 to 6.6905 in.]	169.880 mm [6.6882 in.]		
		Under size	0.25 mm [0.0098 in.]	169.670 to 169.690 mm [6.6799 to 6.6807 in.]	169.630 mm [6.6783 in.]	
			0.50 mm [0.0197 in.]	169.420 to 169.440 mm [6.6701 to 6.6709 in.]	169.380 mm [6.6685 in.]	
			0.75 mm [0.0295 in.]	169.170 to 169.190 mm [6.6602 to 6.6610 in.]	169.130 mm [6.6586 in.]	
			1.00 mm [0.0394 in.]	168.920 to 168.940 mm [6.6504 to 6.6512 in.]	168.880 mm [6.6488 in.]	
Pin and journal	Parallelism	-	-	Runout through the pin whole length: 0.01 mm [0.0004 in.] or less in TIR	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	-	6.8 to 7.0 mm [0.268 to 0.276 in.]	-
		Journal	R8.5	-	8.3 to 8.5 mm [0.327 to 0.335 in.]	-
	Hardness	-	-	-	Hv > 590	-
Finishing surface roughness	-	-	-	Ra 0.2 μm [8 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 journal width.  
When using oversize thrust plates due to wear of rearmost crank journal width, grind the crankshaft for use with oversize thrust plates.

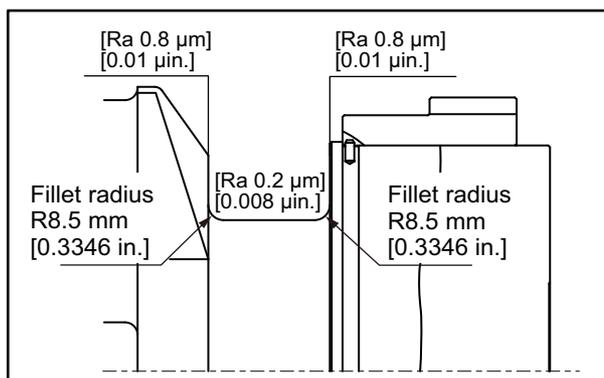


Width of Crankpin and Rearmost Crank Main Journal - Measure

5.6.1 Rearmost Crank Journal Width - Grind

When using the oversize thrust plates, grind the rearmost crank journal width to the standard value for use with oversize thrust plates.  
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 between the front and the rear thrust plate in thickness must be 0.25 mm [0.0098 in.] or less.



Rearmost Crank Journal Width - Grind

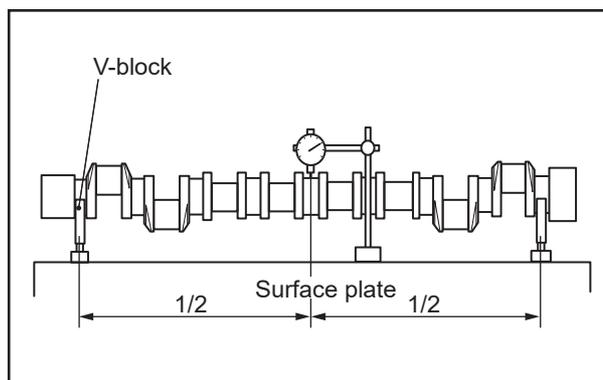
Item	Part No.	Size	Nominal value	Standard value	
Crankpin width	-	-	120 mm [4.72 in.]	120.20 to 120.30 mm [4.7323 to 4.7362 in.]	
Rearmost Crank main journal width	37820-□010□	Standard	67 mm [2.64 in.]	67.00 to 67.03 mm [2.6378 to 2.6390 in.]	
		Over size		0.25 mm [0.0098 in.]	67.25 to 67.28 mm [2.6476 to 2.6488 in.]
				0.50 mm [0.0197 in.]	67.50 to 67.53 mm [2.6575 to 2.6587 in.]
				0.75 mm [0.0295 in.]	67.75 to 67.78 mm [2.6673 to 2.6685 in.]
				1.00 mm [0.0394 in.]	68.00 to 68.03 mm [2.6772 to 2.6783 in.]
				1.25 mm [0.0492 in.]	68.25 to 68.28 mm [2.6870 to 2.6882 in.]
				1.50 mm [0.0591 in.]	68.50 to 68.53 mm [2.6968 to 2.6980 in.]
	37820-□310□ 37820-□550□ (ALFING make)	Standard	67 mm [2.64 in.]	67.00 to 67.05 mm [2.6378 to 2.6398 in.]	
		Over size		0.25 mm [0.0098 in.]	67.25 to 67.30 mm [2.6476 to 2.6496 in.]
				0.50 mm [0.0197 in.]	67.50 to 67.55 mm [2.6575 to 2.6594 in.]
				0.75 mm [0.0295 in.]	67.75 to 67.80 mm [2.6673 to 2.6693 in.]
				1.00 mm [0.0394 in.]	68.00 to 68.05 mm [2.6772 to 2.6791 in.]
				1.25 mm [0.0492 in.]	68.25 to 68.30 mm [2.6870 to 2.6890 in.]
				1.50 mm [0.0591 in.]	68.50 to 68.55mm [2.6968 to 2.6988 in.]

### 5.7 Crankshaft Runout - Measure

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

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

If the crankshaft is corrected by grinding or pressing, inspect the crankshaft for cracks and other harmful damages with the 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 tooth, such as flaking, wear, or local contact, replace the crankshaft gear with a new one.

### 5.9 Crankshaft Gear - Replace

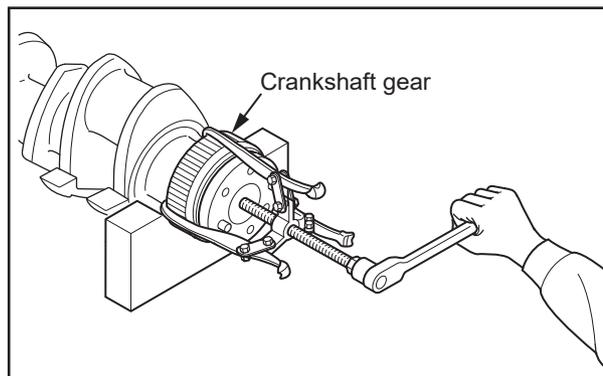
#### CAUTION

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

#### 5.9.1 Crankshaft Gear - Remove

Remove the gear from the crankshaft with a gear puller.

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



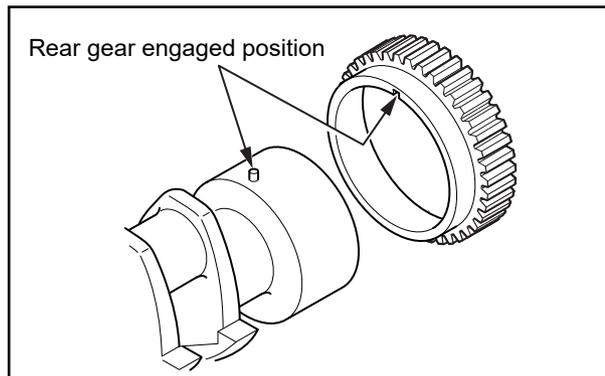
Crankshaft Gear - Remove

5.9.2 Crankshaft Gear - Install

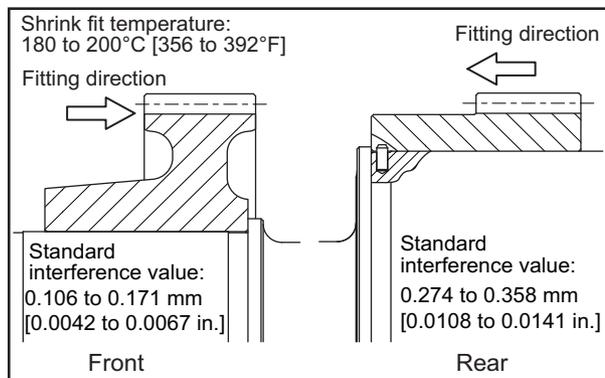
**CAUTION**

- (a) Make sure the correct orientation and position of crankshaft gear when installing.
- (b) To shrinkage-fit the crankshaft gear to the crankshaft, heat the crankshaft gear evenly at the specified temperature or below.

- (1) Measure the outside diameter of crankshaft and the inside diameter of crankshaft gear, and check the interference.
- (2) Heat the crankshaft gear evenly at the specified temperature or below. After checking gear orientation and position, install the crankshaft gear.



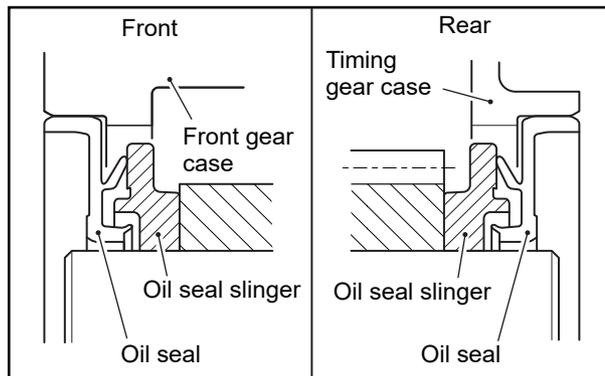
Crankshaft Gear - Install



Crankshaft Gear Installation Orientation

5.10 Oil Seal Slinger - Inspect

If any defect such as dent, damage, wear, or 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

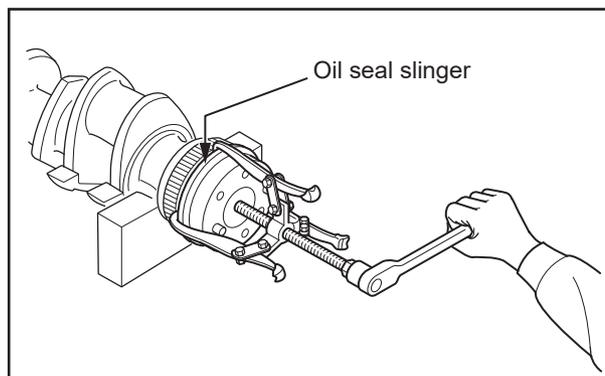
**CAUTION**

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.

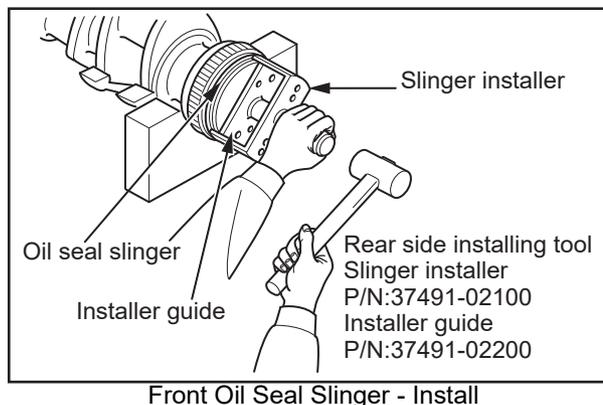
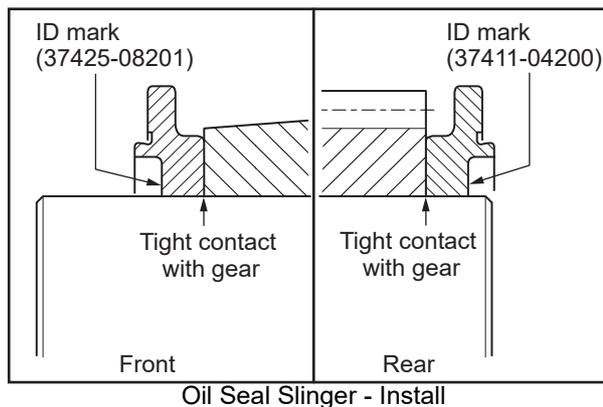
Note: When removing the oil seal slinger by heating, the heating temperature should be 100°C [212°F] or less.



Oil Seal Slinger - Remove

## 5.11.2 Oil Seal Slinger - Install

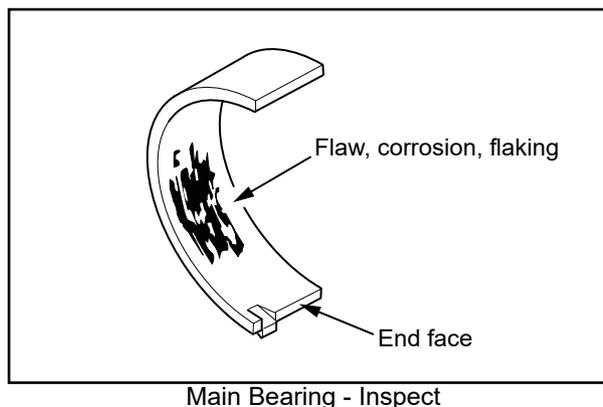
- (1) Measure the outside diameter of crankshaft and inside diameter of oil seal slinger, and check the interference.
- (2) Heat the oil seal slinger evenly at temperature of 110°C [230°F] or below. After checking the correct direction and position of slinger, install the slinger.



## 5.12 Main Bearing - Inspect

Inspect the sliding surface, back surface and end surfaces of the main bearing. If any defect such as local contact, sliding scratches, corrosion and foreign material inclusion is found, check the abnormality.

Note: Whenever the main bearing is disturbed, replace it with a new one irrespective of its condition.



5.13 Thickness of Main Bearing - Measure

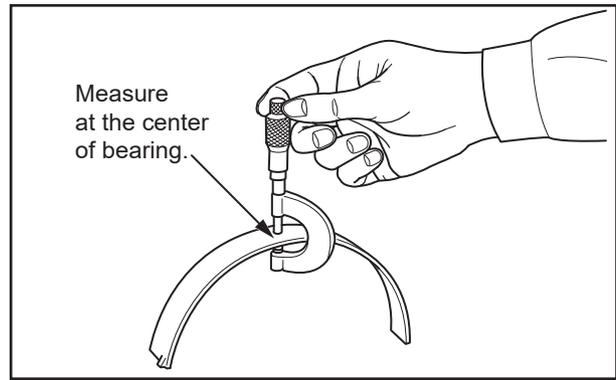
Measure the thickness of main bearing shell at the center position.

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 under size bearings.

For crankshaft grinding procedure, see "Crankpin and Crank Journal - Grind" of "ENGINE BODY - INSPECT AND REPAIR".

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.].

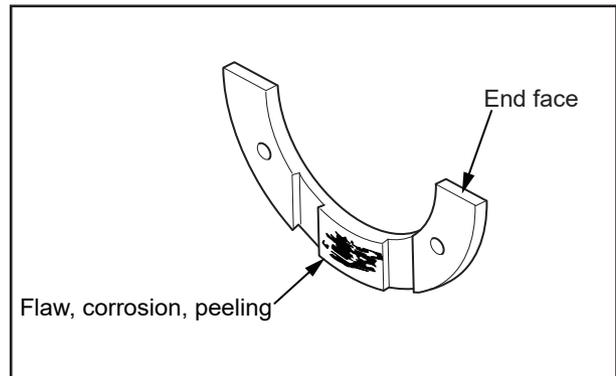


Thickness of Main Bearing - Measure

Item	Size	Nominal value	Standard value	Limit value	
Main bearing thickness at center	Standard	4.500 mm [0.1772 in.]	4.467 to 4.480 mm [0.1759 to 0.1764 in.]	4.425 mm [0.1742 in.]	
	Under size	0.25 mm [0.0098 in.]	4.625 mm [0.1821 in.]	4.592 to 4.605 mm [0.1808 to 0.1813 in.]	4.550 mm [0.1791 in.]
		0.50 mm [0.0197 in.]	4.750 mm [0.1870 in.]	4.717 to 4.730 mm [0.1857 to 0.1862 in.]	4.675 mm [0.1841 in.]
		0.75 mm [0.0295 in.]	4.875 mm [0.1919 in.]	4.842 to 4.855 mm [0.1906 to 0.1911 in.]	4.800 mm [0.1890 in.]
		1.00 mm [0.0394 in.]	5.000 mm [0.1969 in.]	4.967 to 4.980 mm [0.1956 to 0.1961 in.]	4.925 mm [0.1939 in.]

5.14 Thrust Plate - Inspect

Inspect the sliding surface, back surface, and end surfaces of the 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

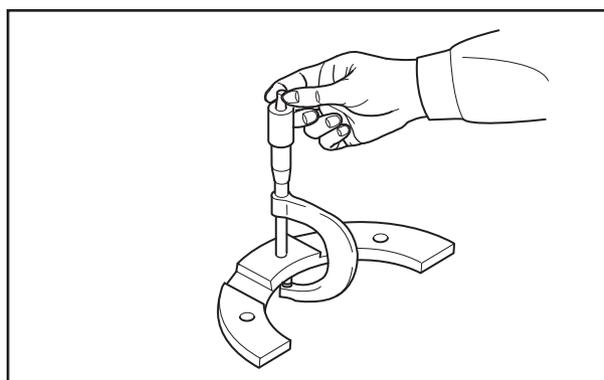
Measure the thickness of thrust plate.

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 plates.

For crankshaft grinding procedure, see "Rearmost Crank Journal Width - Grind" of "ENGINE BODY - INSPECT AND REPAIR".

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

(b) Because the oversize thrust plate can be used in only one side (a set of upper and lower plates), the end play can be adjusted with a minimum depth of the 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.]	4.76 mm [0.1874 in.]	
	Oversize	0.25 mm [0.0098 in.]	5.25 mm [0.2067 in.]	5.03 to 5.10 mm [0.1980 to 0.2008 in.]	5.01 mm [0.1972 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.]	5.26 mm [0.2071 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.]	5.51 mm [0.2169 in.]

### 5.16 Piston Cooling Nozzle - Inspect

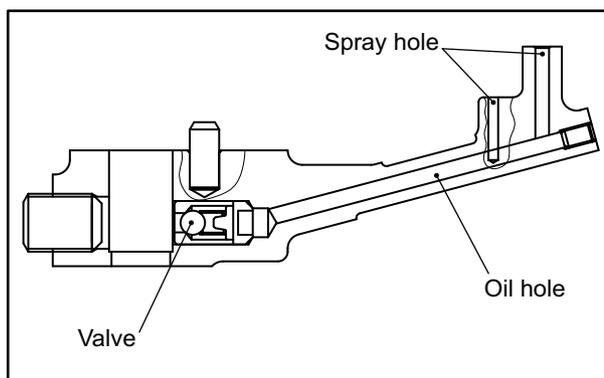
#### CAUTION

If the oil jet pipe of piston cooling nozzle is bent or deformed, a piston seizure may occur due to insufficient cooling performance.

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
Valve opening pressure of piston cooling nozzle	0.10 to 0.15 MPa {1.0 to 1.5 kgf/cm <sup>2</sup> } [14 to 21 psi]



Piston Cooling Nozzle - Inspect



# Chapter 7 ASSEMBLY OF BASIC ENGINE

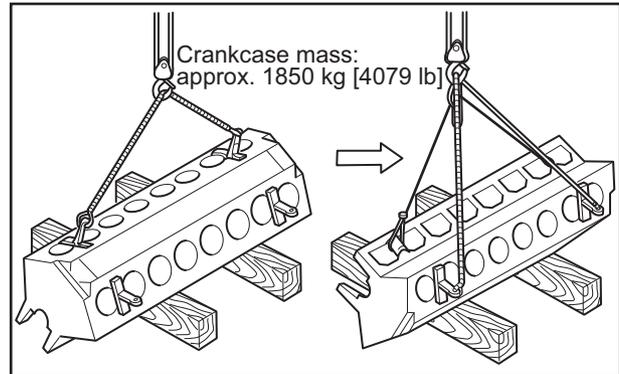
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## 1. Crankshaft and Main Bearing - Install

### 1.1 Crankcase - Turn Over (Upend)

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



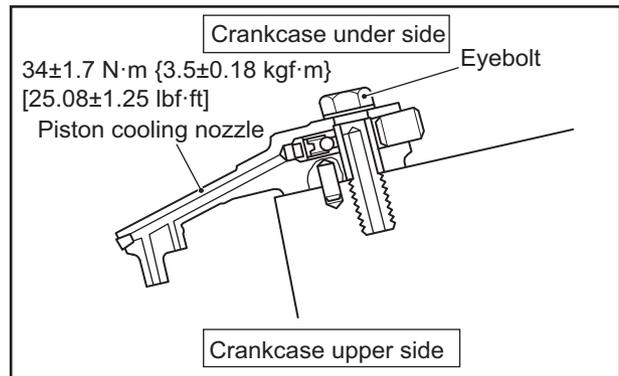
Crankcase - Turn Over (Upend)

### 1.2 Piston Cooling Nozzle - Install

#### CAUTION

Be sure to tighten the piston cooling nozzle to the specified torque using a torque wrench. If excessively tightened, piston seizure may occur due to check valve malfunction.

Install the piston cooling nozzle into the crankcase, and tighten the union bolt to the specified torque.



Piston Cooling Nozzle - Install

### 1.3 Upper Main Bearing - Install

**CAUTION**

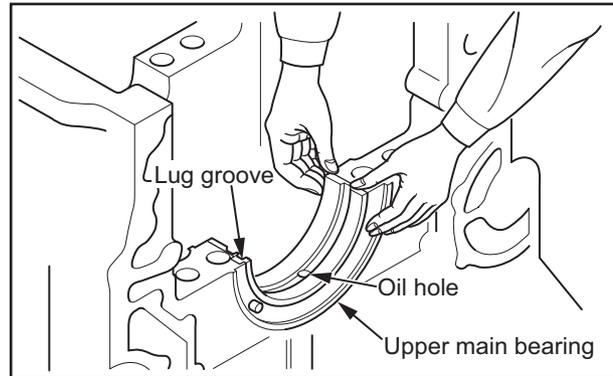
- (a) Do not apply engine oil on the back face of the main bearing shell and the main bearing housing in the crankcase when installing the main bearing. Wash those surfaces to remove foreign material, oil, and grease using a washing solvent before installing the main bearing.
- (b) When installing main bearings, be careful not to confuse the upper shell with the 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 miss the upper and lower main bearings.
- (c) Be careful not to damage the bearing when installing.

- (1) Clean the main bearing housing and the 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 or contamination.
- (3) Fit the upper main bearing shell in the crankcase bore by 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 the upper shell with the lug slot in the crankcase.

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



Upper Main Bearing - Install

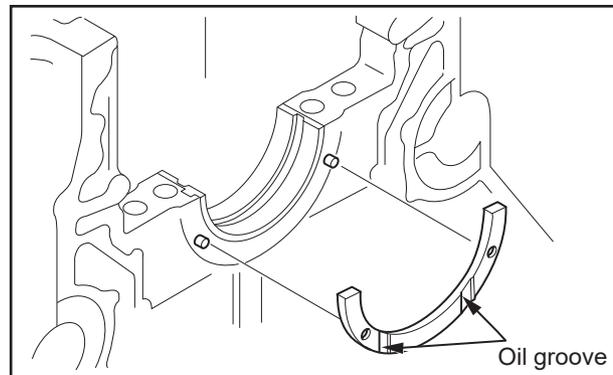
### 1.4 Rear Upper Thrust Plate - Install

**CAUTION**

Be careful not to damage the rear 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 on the sliding surface.

Note: Front upper thrust plate shall be installed after crankshaft is installed.



Rear Upper Thrust Plate - Install

### 1.5 Crankshaft - Install

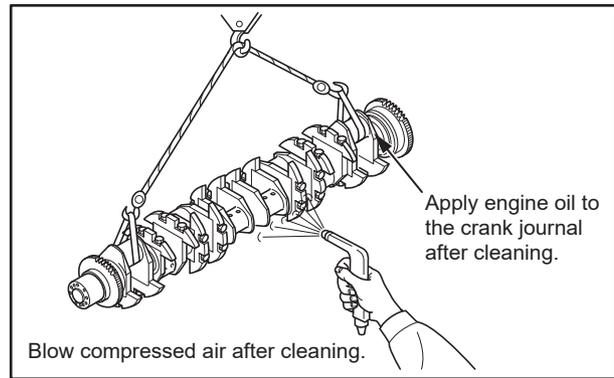
- (1) After installation, make sure that the sliding surfaces of the upper main bearing shells in the crankcase are evenly coated with clean engine oil.
- (2) Thoroughly clean the crankshaft with cleaning oil, and blow off the oil with compressed air. Then, apply an even coat of clean engine oil on the crankshaft journals.

Note: When cleaning the 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 by keeping it in a horizontal attitude, and slowly install into the crankcase.

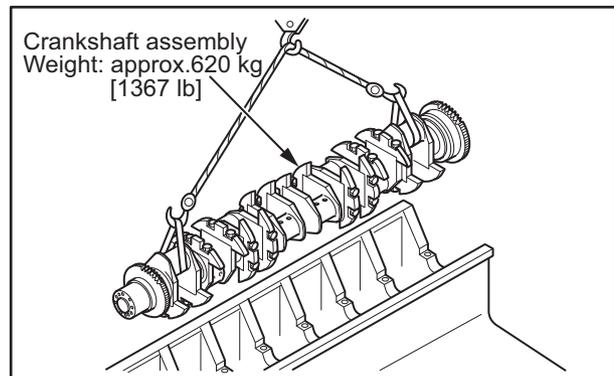
Note: When lifting the crankshaft, use fiber slings or pads to avoid any damages to the crankshaft.

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



Blow compressed air after cleaning.

Crankshaft - Clean



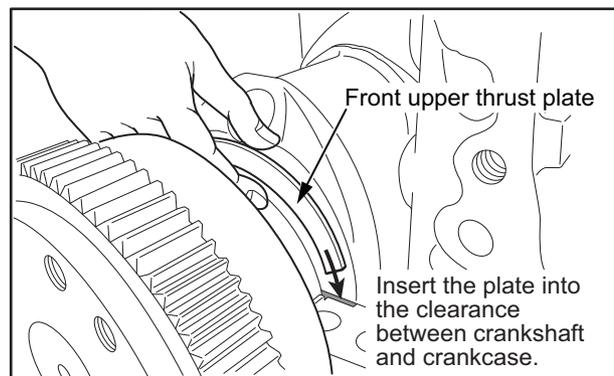
Crankshaft - Install

### 1.6 Front Upper Thrust Plate - Install

#### CAUTION

Install the front-upper thrust plate paying attention not to damage the plate.

- (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

**CAUTION**

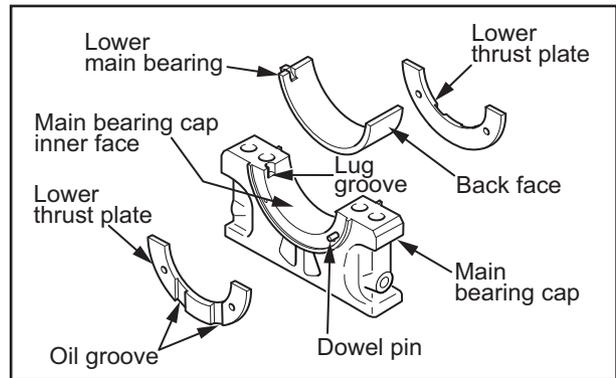
- (a) Do not apply engine oil on the back face of the main bearing shell and the main bearing housing in the crankcase when installing the main bearing. Wash those surfaces to remove foreign material, oil, and grease using a washing solvent before installing the main bearing.
- (b) When installing main bearings, be careful not to confuse the upper shell with the 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 miss the upper and lower main bearings.
- (c) Be careful not to damage the bearing when installing.

- (1) Install the lower main bearing shell by 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 on sliding surface of lower main bearing shell.
- (3) Install the lower thrust plates by aligning with the dowel pins on the rearmost main bearing cap.

Note: Install the lower thrust plates so that the oil grooves faces outward.



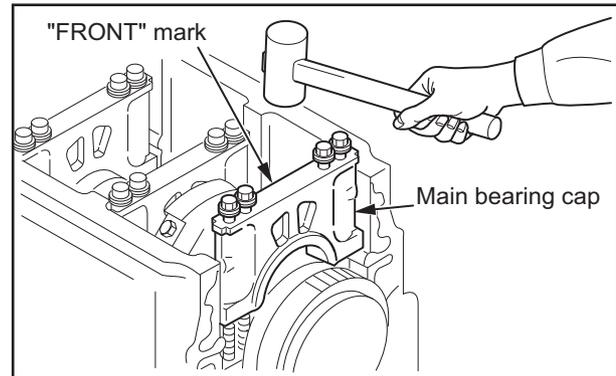
Lower Main Bearing Shell and Lower Thrust Plate - Install

## 1.8 Main Bearing Cap - Install

**CAUTION**

Be sure to tighten the main bearing cap bolts and side bolts in the specified tightening sequence.

- (1) Make sure that the main bearings and the thrust plates installed on the 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 lug slots are aligned on the same side, which shows the embossed mark of "FRONT" faces toward the engine front.
- (3) Apply engine oil on the main bearing cap bolts and washers, and hand tighten them.
- (4) Install the main bearing cap evenly with a soft-head hammer.
- (5) Apply oil on the side bolts and O-rings, and hand tighten them.
- (6) Temporarily tighten the main bearing cap bolts and side bolts except the rearmost ones, to the half of specified torque in the specified tightening sequence as shown in the illustration.
- (7) Then 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.
- (8) Hand tighten the rearmost cap bolts and side bolts to make the rearmost main bearing seated lightly. 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]

● Angle method to tighten

Main bolt (2-time tightening): 1,2,3,4

① Tighten the bolts with a snug torque of  $245 \pm 12.3 \text{ N}\cdot\text{m}$   $\{25 \pm 1.3 \text{ kgf}\cdot\text{m}\}$   $[180.7 \pm 9.07 \text{ lbf}\cdot\text{ft}]$

② Tighten the bolt a further  $60 \pm 3$  degrees

③ Loosen all bolts, and then angle controlled tighten them again

Side bolt (1-time tightening): Side bolt

① Tighten the bolts of  $392 \pm 19.6 \text{ N}\cdot\text{m}$   $\{40 \pm 2 \text{ kgf}\cdot\text{m}\}$   $[289.12 \pm 14.45 \text{ lbf}\cdot\text{ft}]$

● Torque method to tighten

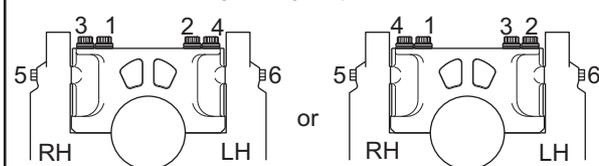
Main bolt (1-time tightening): 1,2,3,4

① Tighten the bolts of  $588 \pm 29.4 \text{ N}\cdot\text{m}$   $\{60 \pm 3 \text{ kgf}\cdot\text{m}\}$   $[433.69 \pm 21.68 \text{ lbf}\cdot\text{ft}]$

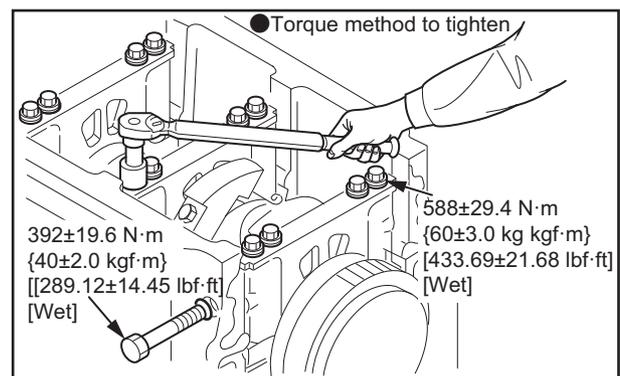
Side bolt (1-time tightening): 5,6

① Tighten the bolts of  $392 \pm 19.6 \text{ N}\cdot\text{m}$   $\{40 \pm 2 \text{ kgf}\cdot\text{m}\}$   $[289.12 \pm 14.45 \text{ lbf}\cdot\text{ft}]$

## Tightening Sequence



Tightening sequence of Main Bearing Cap Bolts



Main Bearing Cap Bolts - Install

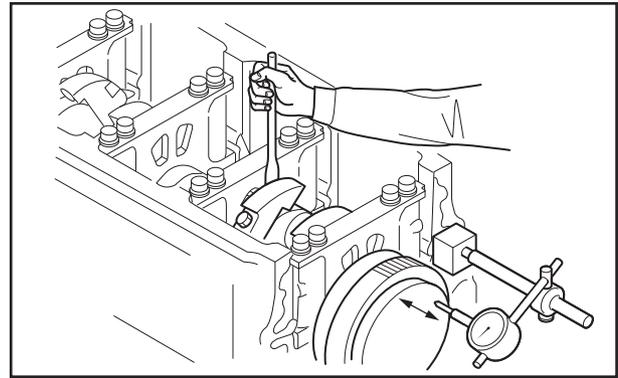
1.9 Crankshaft End Play - Measure

- (1) Verify smooth rotation of crankshaft.
- (2) Apply a dial gauge plunger to the rear end face of crankshaft.
- (3) With a bar, move crankshaft fully to front and rear, and read each measurement. The end play is the difference between front and rear measurements.

If the value exceeds the standard, inspect thrust plates and crankshaft.

If the end play is less than the standard value, loosen rear most bearing cap bolts and move crankshaft back and forth, and measure the end play again.

- (4) After tightening rearmost main bearing cap to the specified torque, measure the end play again to verify.
- (5) Again, verify the crankshaft smooth rotation.
- (6) Verify again all the main bearing cap bolts and side bolts to make sure that they are tightened properly.

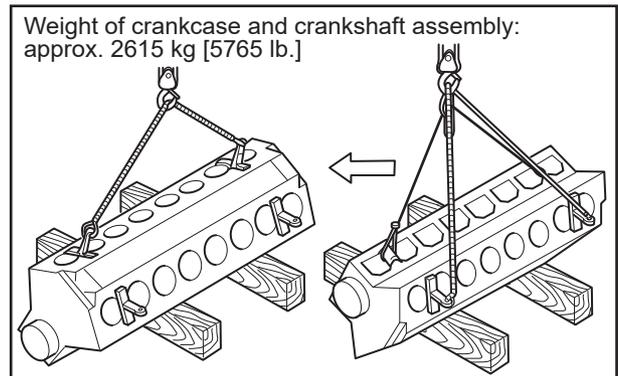


Crankshaft End Play - Measure

Item	Standard value	Limit value
Crankshaft end play	0.200 to 0.500 mm [0.0079 to 0.0197 in.]	0.600 mm [0.0236 in.]

1.10 Crankcase - Turn Over

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



Weight of crankcase and crankshaft assembly:  
approx. 2615 kg [5765 lb.]

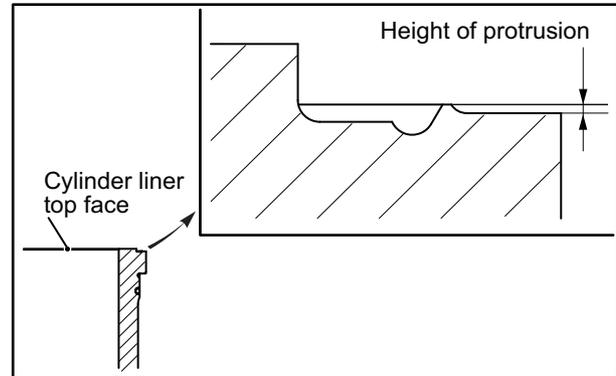
Crankcase - Turn Over

## 2. Cylinder Liner, Piston, and Connecting Rod - Assemble

### 2.1 Cylinder Liner Protrusion - Measure

- (1) Place a dial gauge probe on the top surface of cylinder liner flange, and adjust the dial to zero.
- (2) Place 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 becomes low, and it can cause gas and water leaks.

- (1) Inspect cylinder liner contact surface of the crankcase.
 

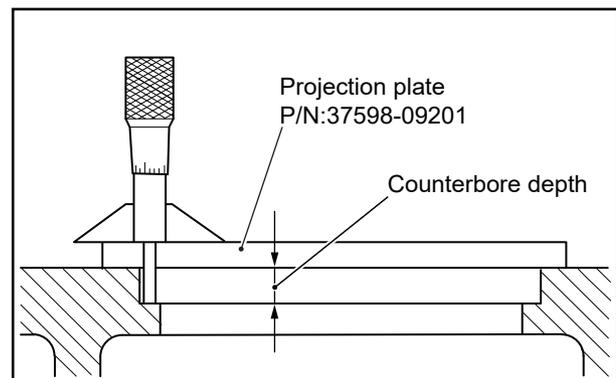
If uneven contact is presented, reface counterbore with the crankcase grinder to correct the difference of depth at four places in circumference to be less than 0.05 mm [0.0020 in.].

For repair procedure, see "Counterbore in Crankcase - Repair" of "ENGINE BODY - INSPECT AND REPAIR."
- (2) Make sure that the top and bottom faces of cylinder liner flange, top surface of crankcase, and fitting surfaces of cylinder liner and crankcase are clean before measurement.
- (3) Measure the depth of counterbore in crankcase.

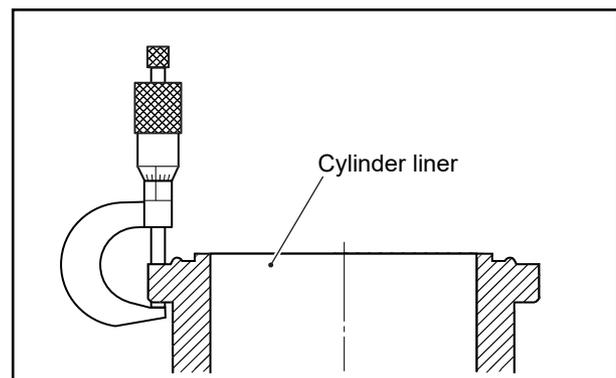
Item	Standard value
Depth of counterbore in crankcase	14.00 to 14.05 mm [0.5512 to 0.5531 in.]

- (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.]



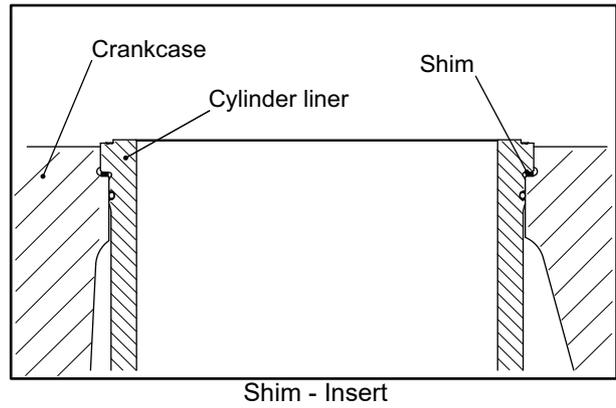
Depth of Counterbore in Crankcase - Measure



Thickness of Cylinder Liner Flange

- (5) Determine the cylinder liner flange protrusion by subtracting the depth of counterbore in crankcase from the thickness of cylinder liner flange.  
 If the value exceeds the limit, insert a shim under the cylinder liner flange. Select the shim which makes the cylinder liner flange protrusion largest within the tolerance.

Note:(a) Shims are available in thickness: 0.05, 0.10 and 0.15 mm [0.0020, 0.0039 and 0.0059 in.].  
 (b) Do not use multiple shims.



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

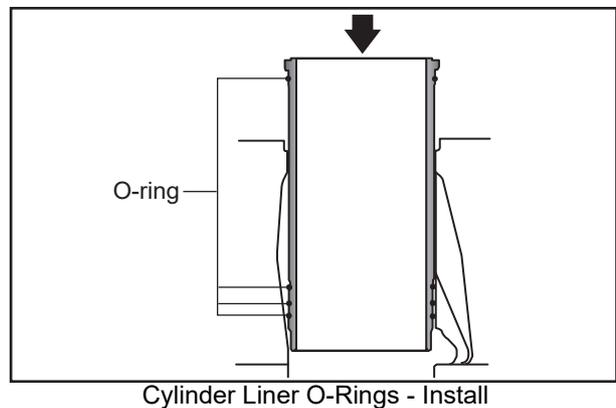
Shim thickness	Part number
0.05±0.02 mm [0.0020±0.0008 in.]	37507-□251□
0.10±0.02 mm [0.0039±0.0008 in.]	37507-□250□
0.15±0.02 mm [0.0059±0.0008 in.]	37507-□252□

### 2.3 Cylinder Liner - Install

**CAUTION**

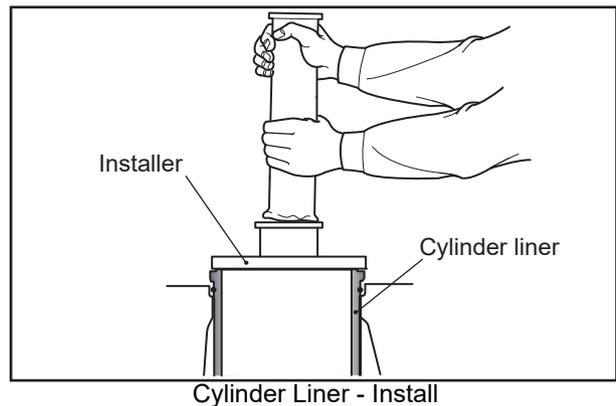
Apply engine oil on O-ring sliding surface in the Crankcase to prevent O-rings from twisting.  
 DO NOT apply engine oil on O-ring grooves on cylinder liner.

- (1) Install the O-rings on the cylinder liner.
- (2) Insert the shim into the cylinder which needs the adjustment of the cylinder liner flange protrusion.
- (3) Apply engine oil on O-ring sliding surface in the crankcase and on the cylinder liner O-rings.



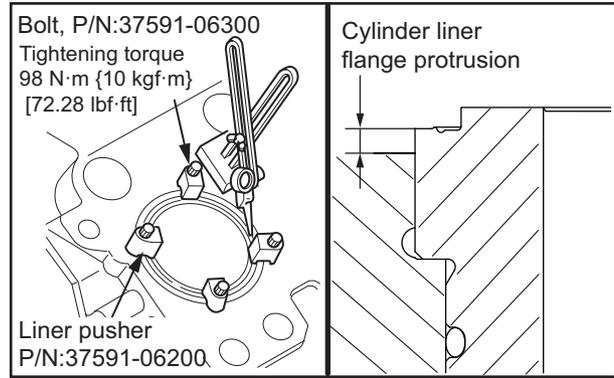
- (4) Slowly insert the cylinder liner into the bore in the crankcase. With a proper cylinder liner installer, lightly tap the cylinder liner until its flange contacts snugly on the seating surface of the crankcase. And then, lightly tap the liner several times to verify the stable seating.

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



2.4 Cylinder Liner Flange Protrusion - Measure (in Cylinder Liner Installed Condition)

- (1) Remove dust and dirt from the crankcase top face and the cylinder liner top face.
- (2) Place the liner pushers on 4 equally-spaced locations 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 adjust the gauge to zero.
- (4) Slide the probe to measure the flange protrusion at four places on the top of the cylinder liner, and obtain 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 the shim and the standard value, see "Cylinder Liner Flange Protrusion - Calculate (When Cylinder Liner Not Installed)" of "ENGINE BODY - ASSEMBLE."

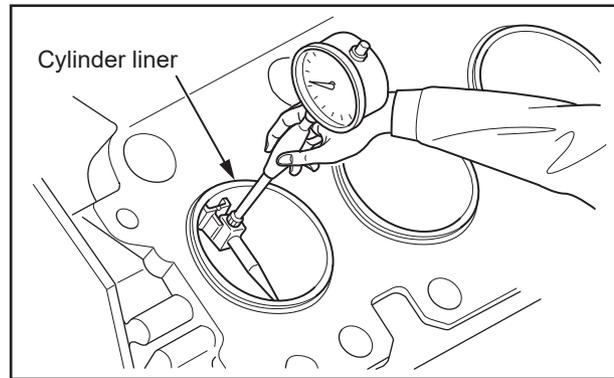


Cylinder Liner Flange Protrusion - Measure

2.5 Cylinder Liner Inside Diameter - Measure

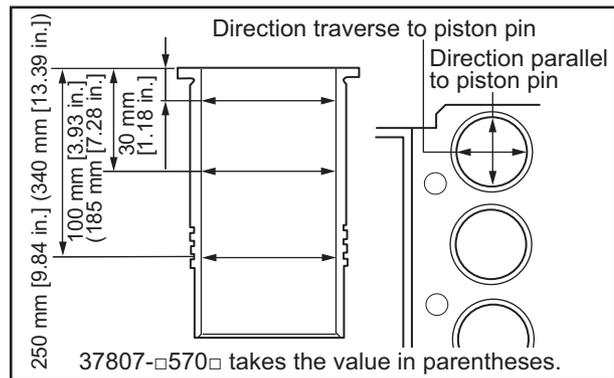
Measure the inside diameter of the cylinder liner at three levels, i.e., upper (position of No.1 compression ring when piston is at the top dead center), liner middle position, and O-ring installed position, in both parallel and perpendicular directions to the piston pin direction.

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.



Cylinder Liner Inside Diameter - Measure

Item	Part No.	Nominal value	Standard value	Limit value
Inside diameter	37507-□260□ (Standard)	ø170 mm [6.69 in.]	170.000 to 170.040 mm [6.6927 to 6.6945 in.]	170.100 mm [6.697 in.]
	37507-□270□ (High-power spec)	ø170 mm [6.69 in.]	170.020 to 170.040 mm [6.6937 to 6.6945 in.]	
	37807-□570□ (High-power spec)			
Roundness	-	-	0.02 mm [0.0008 in.] or less	-
Cylindricity	-	-	0.02 mm [0.0008 in.] or less	-



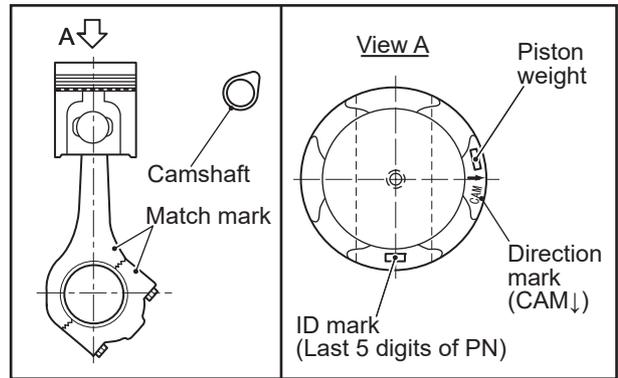
Cylinder Liner Dimension Measuring Position

### 2.6 Piston and Connecting Rod - Assemble

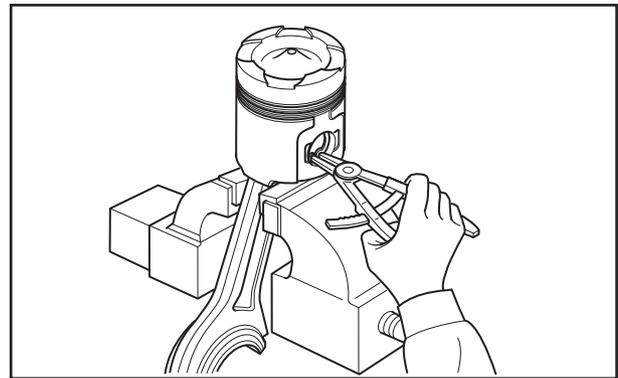
(1) Apply engine oil on the piston pin, and assemble the piston and the connecting rod. The orientation of the piston and the connecting rod is as shown in the illustration.

Note: The piston and the 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



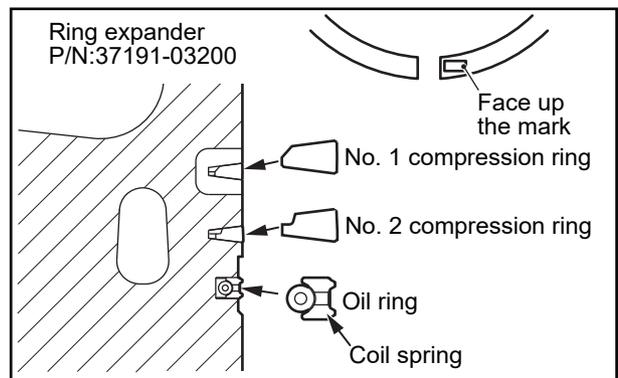
Piston and Connecting Rod - Assemble

### 2.7 Piston Ring - Install

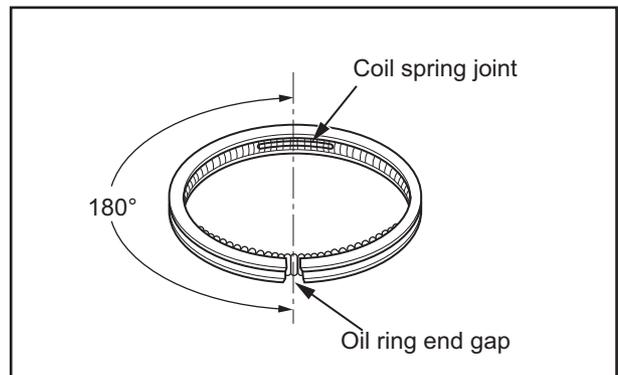
**CAUTION**

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

- (1) Install the piston rings on the piston with a 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.



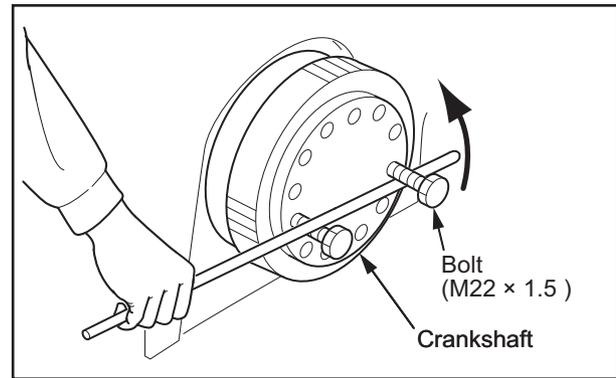
Combination of Piston and Piston Ring



Combination of Oil Ring and Coil Spring

## 2.8 Engine - Turning

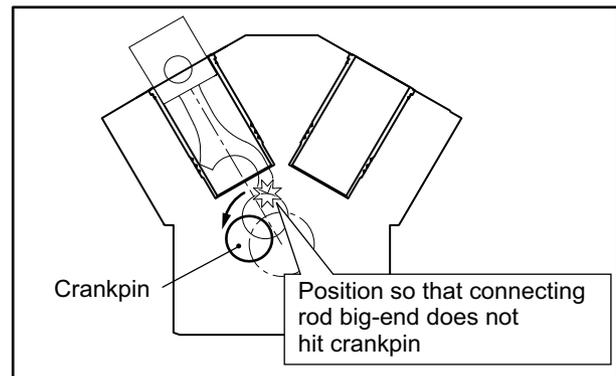
- (1) Install two bolts in flywheel mounting holes of crankshaft.
- (2) Using the bolts, turn crankshaft with a bar.



Engine - Turning

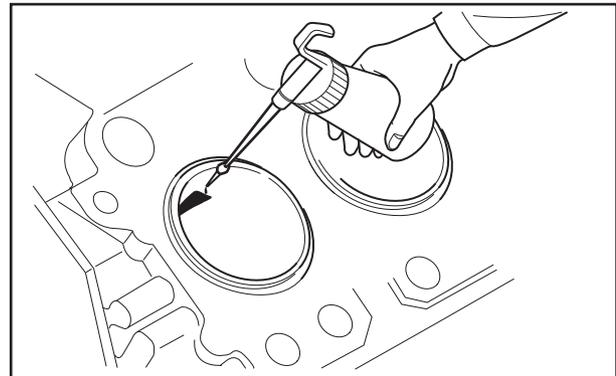
## 2.9 Piston Installation - Preparation

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



Position of Crankpin - Adjust

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



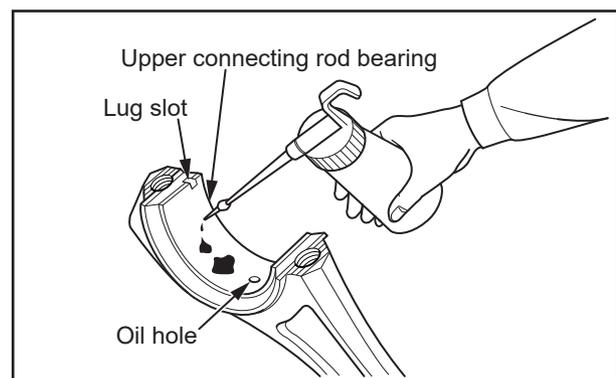
Piston Installation - Preparation

## 2.10 Upper Connecting Rod Bearing - Install

### CAUTION

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

Install the upper connecting rod bearing on the connecting rod big end by aligning the lug and the lug slot. Apply engine oil on sliding surface. Make sure the oil hole of connecting rod is aligned with 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 bolt hole on the piston top, and lift the piston with chain block. When the installation work is inevitably done by hand, be sure to take preventive measures so that the piston does not fall down, and be very careful not to hurt your hands and fingers or not to damage the parts.

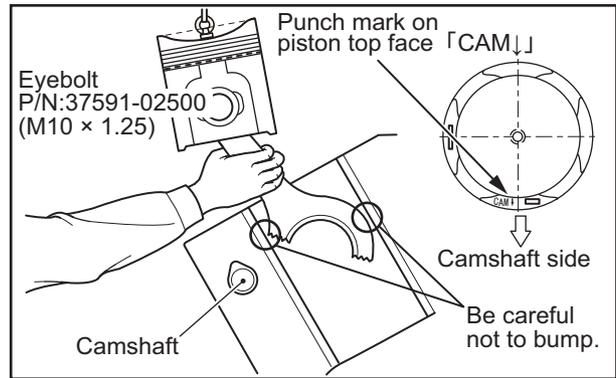
**CAUTION**

- (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 the piston.
- (c) To prevent the oil ring from impact damaging, slowly insert the piston.

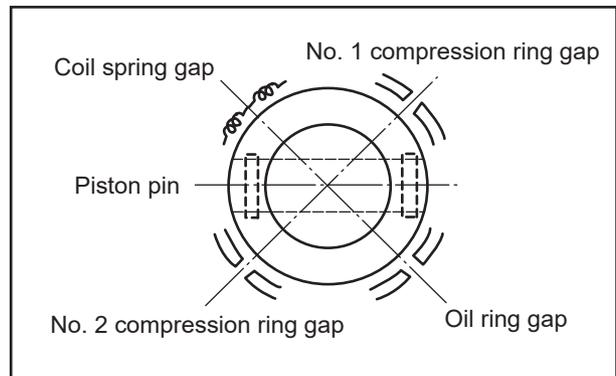
- (1) Insert the connecting rod into the cylinder liner carefully not to damage the liner, and slowly lower the piston to the upper surface of crankcase.
- (2) Apply engine oil on the piston rings. Place the end gaps equally spaced each other, avoiding piston pin and thrust/anti-thrust directions.
-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

- (4) Verify again the piston ring arrangement. Apply engine oil on the piston rings. Apply engine oil on the inner surface of the piston installer. Verify that the oil ring is firmly engaged in the groove. Then, compress the piston rings with the piston installer.

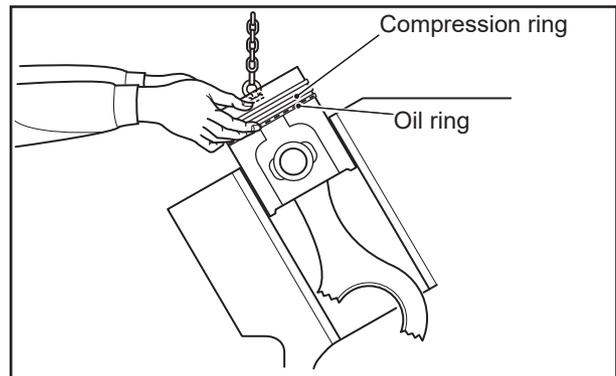
Note: For the piston ring arrangement, see above (2).



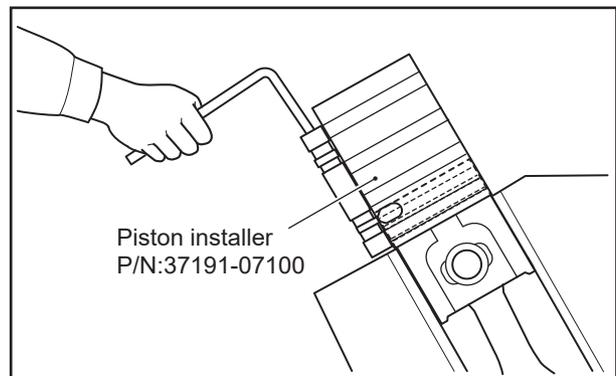
Piston and Connecting Rod - Install



Piston Ring End Gaps - Arrangement



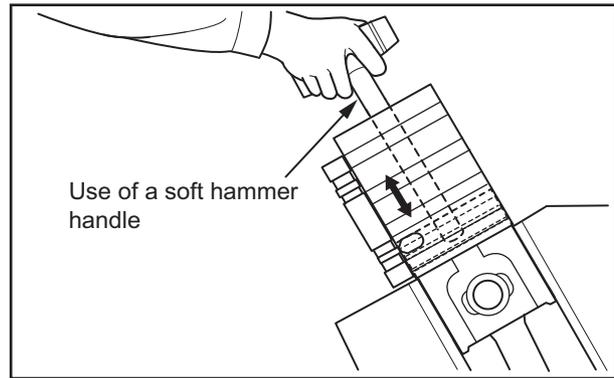
Piston Skirt - Insert



Piston Ring - Compress

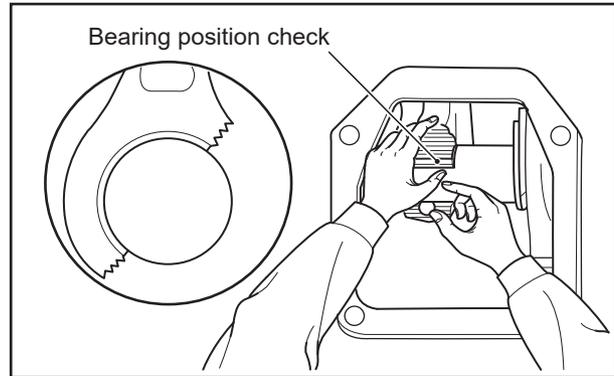
- (5) Install the piston into the cylinder liner by tapping the piston top with a soft-head hammer.

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



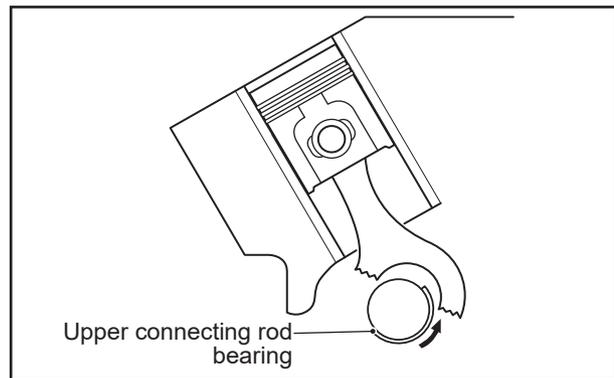
Piston - Install

- (6) Check the proper installation of the upper connecting rod bearing shell through the inspection window on the crankcase side face. If the bearing shell is not positioned properly, push the bearing upward by hand to correct the position.



Connecting Rod Bearing - Installation Check

- (7) If the upper connecting rod bearing is displaced from the connecting rod big end, rotate the crankshaft to make a space between the connecting rod big end and the 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 connecting rod.



Lug Slot - Align

2.12 Connecting Rod Cap - Install

**CAUTION**

- (a) Verify that the matching numbers on the connecting rod and the connecting rod cap are same and on the same side.
- (b) Check the identification marks of the connecting rod bolts to ensure the correct positions.
- (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 surfaces, and the sliding surface of the lower connecting rod bearing shell.
- (3) Install the connecting rod cap to the connecting rod so that 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

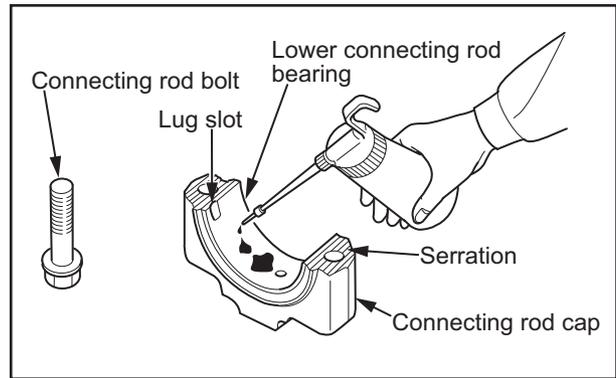
"CS": Upper (short) (Part number: 37519-□130□)

"CL": Lower (long) (Part number: 37519-□140□)

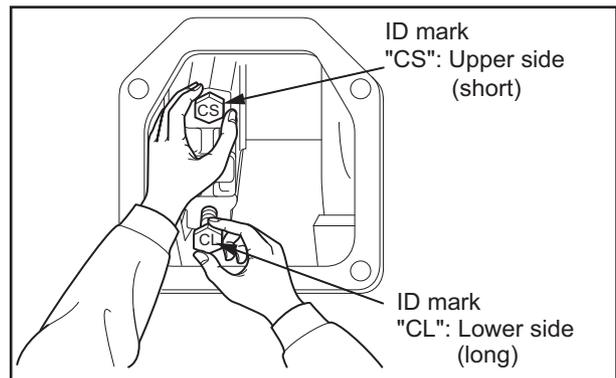
"2": No differentiation between upper and lower (Part number: 37519-□030□)

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

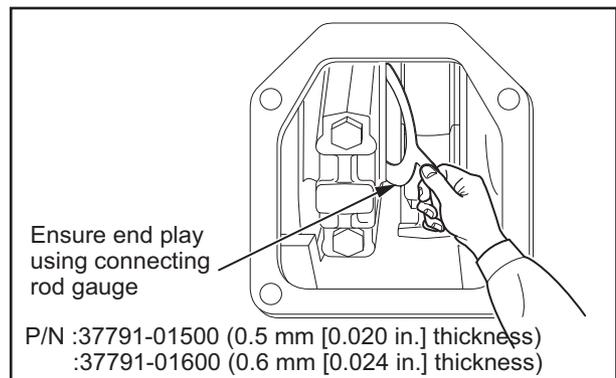
Note: To ensure the minimum end play, the connecting rod gauge may be inserted between the two connecting rods for adjustment.



Connecting Rod Cap - Install (1)



Connecting Rod Cap - Install (2)



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 location	Bolt identification mark	Snug torque	Part No.
Upper	CS	245±12.3 N·m {25±1.25 kgf·m} [180.7±9.07 lbf·ft]	37519-□130□
Lower	CL	294±14.7 N·m {30±1.5 kgf·m} [216.84±10.84 lbf·ft]	37519-□140□
-	2	245±12.3 N·m {25±1.25 kgf·m} [180.7±9.07 lbf·ft]	37519-□030□

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

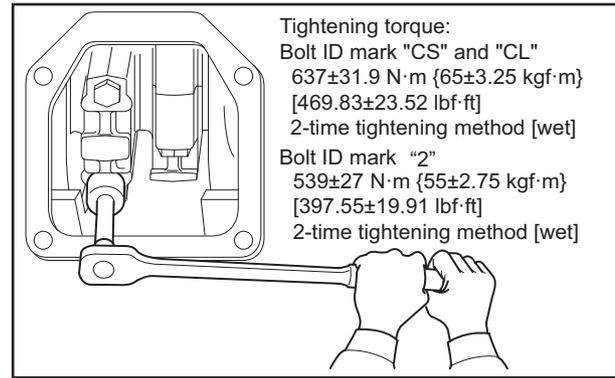
(c) Loosen all bolts, and then angle controlled tighten them again. (2-time tightening)

### 2.13 Connecting Rod End Play - Measure

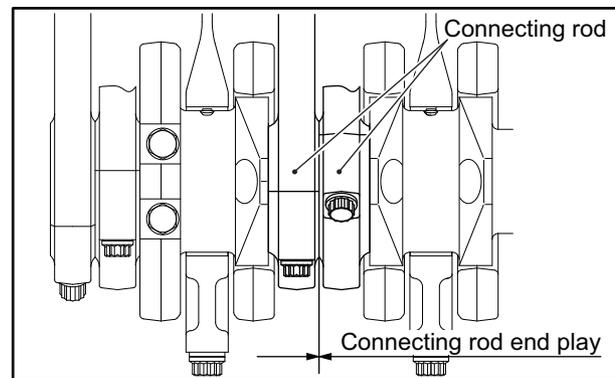
Measure the end play of the connecting rod.

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	0.6 to 0.9 mm [0.024 to 0.035 in.]	1.4 mm [0.055 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 also prevents the valves from stamping.

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

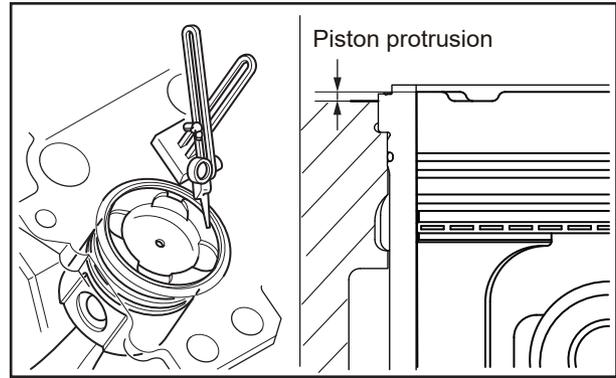
- (1) Move piston to the top dead center.
- (2) Apply a dial gauge plunger to the top face of crankcase, and adjust the dial gauge to zero.
- (3) Move the dial gauge to the top face of piston, measure the maximum protrusion by turning crankshaft near the top dead center.

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

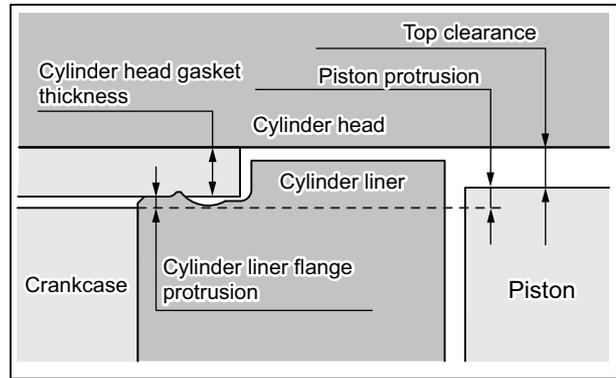
- (4) Measure protrusions at four places on piston top face, and calculate the mean value.

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

$$\text{Top clearance} = \text{Cylinder head gasket thickness} + \text{Cylinder liner flange protrusion} - \text{Piston protrusion}$$



Piston Protrusion - Measure



Top Clearance

Item	Standard value
Piston protrusion	0.03 to 0.63 mm [0.0012 to 0.0248 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	1.25 to 2.00 mm [0.0492 to 0.0787 in.]

### 3. Front Mechanism - Assemble

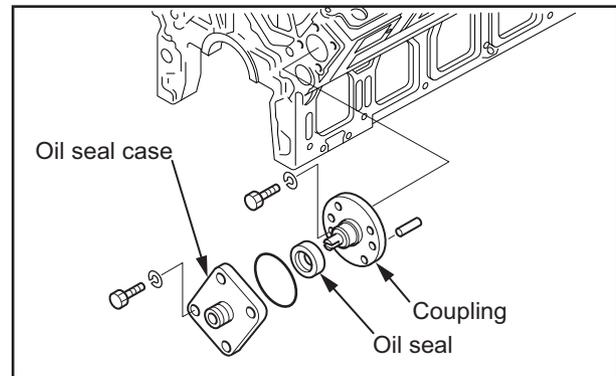
#### 3.1 Coupling - Install

(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.

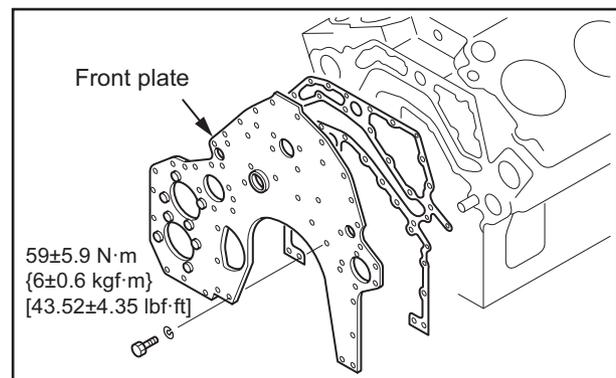
- (b) Install the camshaft, then install coupling, oil seal and oil seal case.



Coupling - Install

#### 3.2 Front Plate - Install

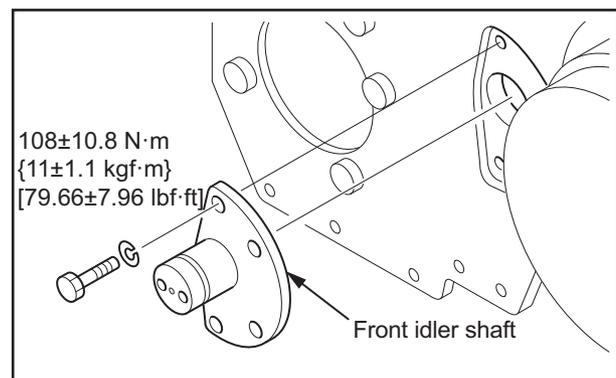
- (1) Aligning with the dowel pins, install the gasket to the crankcase.
- (2) Install the front plate over the packing aligning with dowel pin.
- (3) Tighten the bolts to the specified torque.
- (4) Make sure that the bottom face of the front plate is flush with the bottom face of the crankcase. Trim excess packing.



Front Plate - Install

#### 3.3 Front Idler Shaft - Install

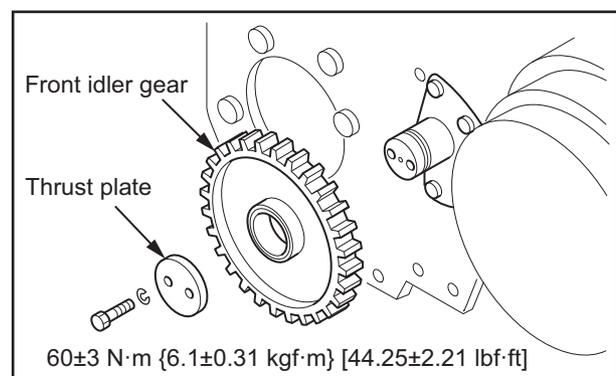
- (1) Install the front idler shaft in the crankcase.
- (2) Tighten the bolts to the specified torque.



Front Idler Shaft - Install

#### 3.4 Front Idler Gear - Install

- (1) Apply engine oil on the front idler gear shaft.
- (2) Install the front idler gear.
- (3) Install the thrust plate, and tighten the bolt to the specified torque.

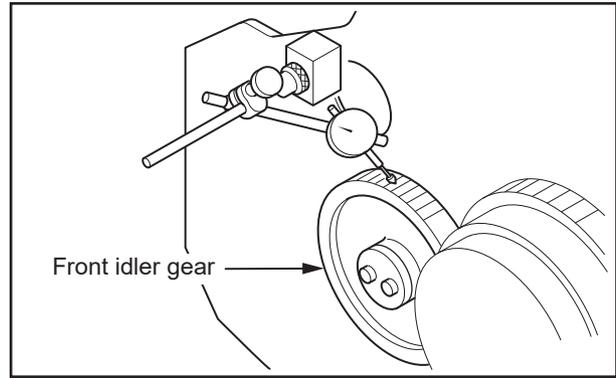


Front Idler Gear - Install

### 3.5 Front Idler Gear Backlash - Measure

Measure the backlash of the front idler gears by either of the following methods : measure the gear backlash with a dial gauge applied to a tooth flank on the pitch circle at a right angle to the tooth axis, or measure the clearance between gears by inserting a feeler gauge between the engaging gear teeth. If the value exceeds the limit, replace the gears with new ones.

Item	Standard value	Limit value
Front idler gear backlash	0.11 to 0.28 mm [0.0043 to 0.0110 in.]	0.50 mm [0.0197 in.]

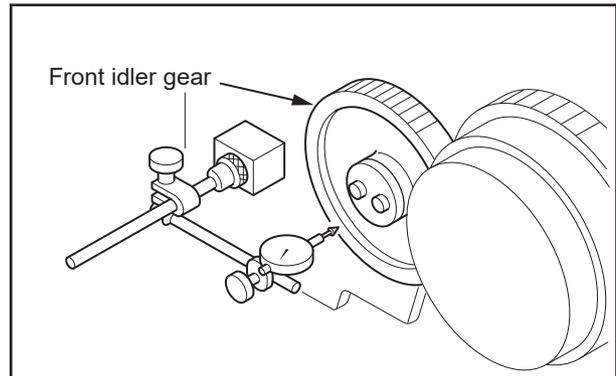


Front Idler Gear Backlash - Measure

### 3.6 Front Idler Gear End Play - Measure

Measure the end play of the front idler gear. If the value exceeds the limit, replace the thrust plate or idler gear with a new one.

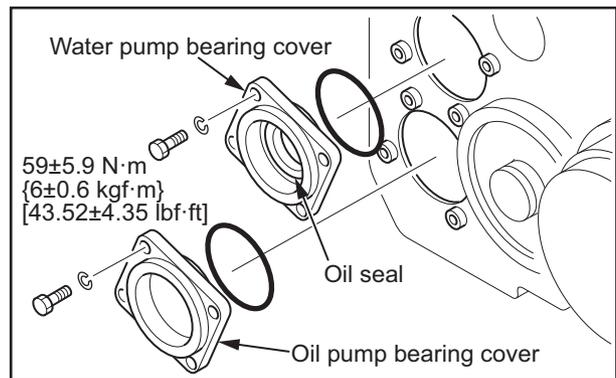
Item	Standard value	Limit value
Front idler gear end play	0.20 to 0.40 mm [0.0079 to 0.0157 in.]	0.60 mm [0.0236 in.]



Front Idler Gear End Play - Measure

### 3.7 Water Pump Bearing Cover and Oil Pump Bearing Cover - Install

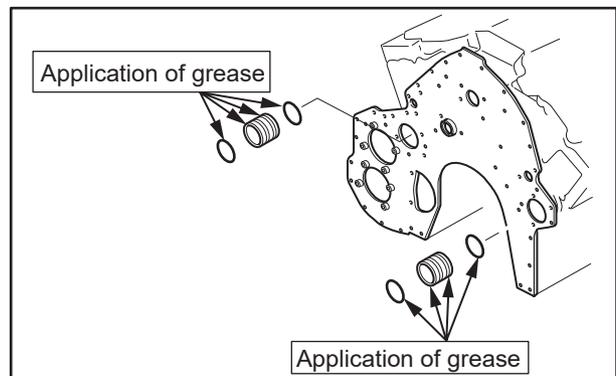
- (1) Install the oil seal to the water pump bearing cover.
- (2) Install the water pump bearing cover and oil pump bearing cover to the front plate.
- (3) Tighten the bolts to the specified torque.



Water Pump Bearing Cover  
Oil Pump Bearing Cover - Install

### 3.8 Water Coupling - Install

- (1) Apply grease to the O-ring and O-ring groove.
- (2) Install the water couplings of crankcase and gear case to the crankcase, taking care not to damage the O-ring.

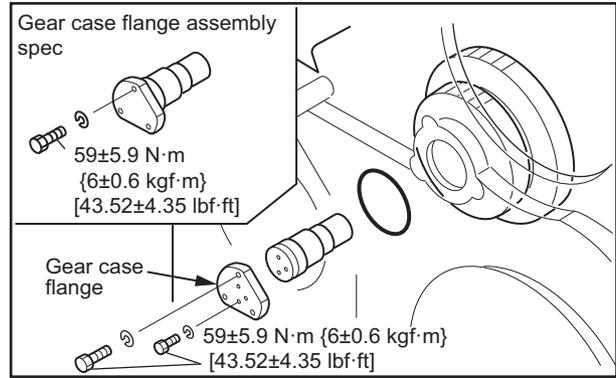


Water Coupling - Install

### 3.9 Fan Drive Idler Gear and Fan Drive Idler Shaft - Install

(With fan spec)

- (1) With the small gear of the fan drive idler gear facing out side, install the fan drive idler gear through the mounting hole, and hold the fan drive idler gear by hand so that it is aligned with the center of the fan drive idler shaft hole.
- (2) Insert the fan drive idler shaft to the fan drive idler gear.
- (3) Tighten the gear case flange mounting bolts to the specified torque.



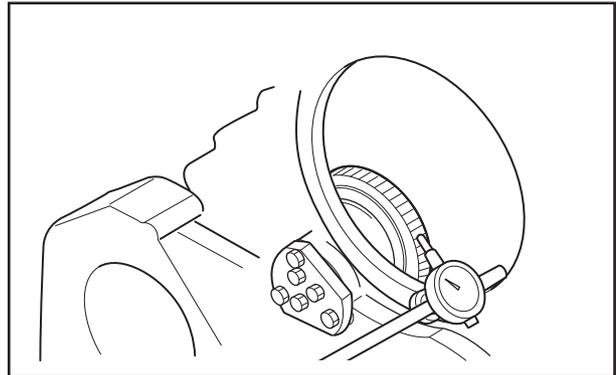
Fan Drive Idler Gear and Fan Drive Idler Shaft - Install

### 3.10 Fan Drive Idler Gear Backlash - Measure

(With fan spec)

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

Item	Standard value	Limit value
Backlash between fan drive idler gear and crank gear	0.11 to 0.30 mm [0.0043 to 0.0118 in.]	0.50 mm [0.0197 in.]
Fan drive idler gear and fan drive gear backlash	0.12 to 0.18 mm [0.0047 to 0.0071 in.]	0.50 mm [0.0197 in.]



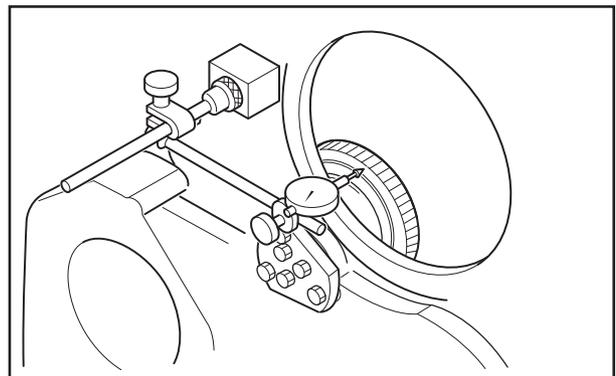
Fan Drive Idler Gear Backlash - Measure

### 3.11 Fan Drive Idler Gear End Play - Measure

(With fan spec)

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

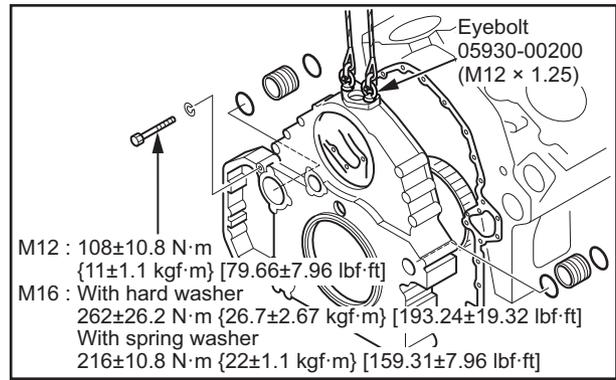
Item	Standard value	Limit value
Fan drive idler gear end play	0.40 to 1.10 mm [0.0157 to 0.0433 in.]	1.20 mm [0.047 in.]



Fan Drive Idler Gear End Play - Measure

### 3.12 Front Gear Case - Install

- (1) Apply sealant (ThreeBond 1211) on the front gear case packing mounting surface of the crankcase, and install the packing. Apply the same sealant (ThreeBond 1211) on the packing, and then install the front gear case.
- (2) Tighten the bolts evenly to the specified torque.
- (3) Make sure that the bottom face of the front gear case is flush with the bottom face of the crankcase. Cut off excessive packing carefully.

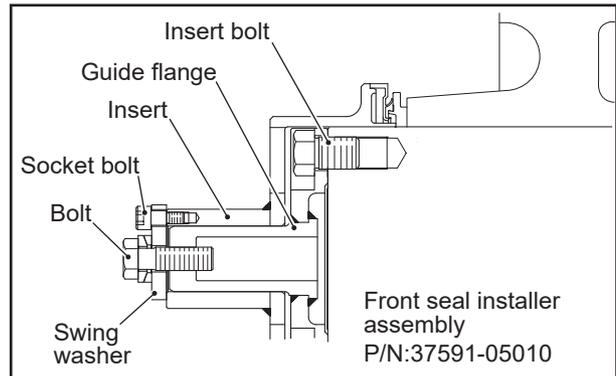


Front Gear Case - Install

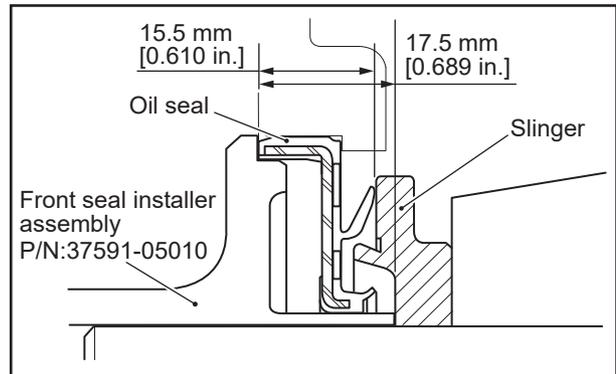
### 3.13 Front Oil Seal - Install

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

- (1) Apply clean engine oil evenly on the oil seal lip.  
Note: Pay attention to the mounting direction of the 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 in the insert, and install them to the guide flange.
- (4) Tighten the bolt on the guide flange to insert the oil seal into the front cover.
- (5) Remove the installer assembly.



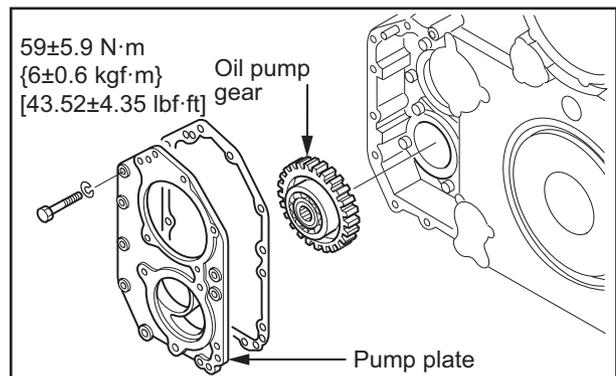
Front Oil Seal - Install (1)



Front Oil Seal - Install (2)

### 3.14 Oil Pump Gear and Pump Plate (for Water Pump and Oil Pump) - Install

- (1) Install the bearing to the oil pump gear.
- (2) Insert the oil pump gear.
- (3) Install the pump plate in the front case.
- (4) Tighten the bolts to the specified torque.

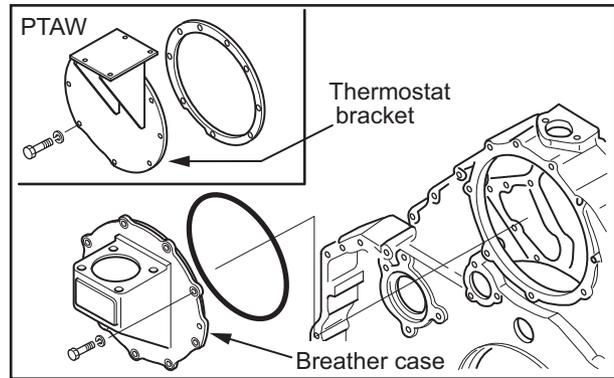


Oil Pump Gear and Pump Plate  
(for Water Pump and Oil Pump) - Install

## 3.15 Breather Case, Thermostat Bracket - Install

(Without fan spec)

Install the breather case or thermostat bracket to the front gear case.

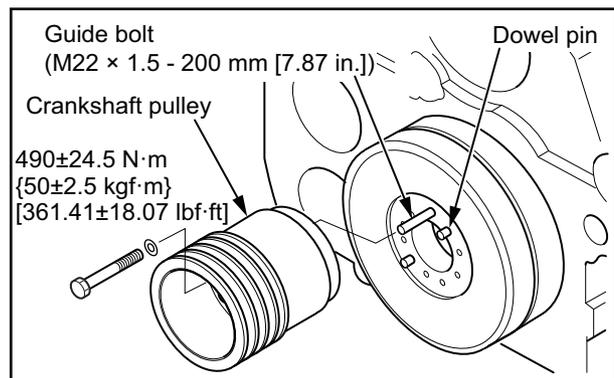


Breather Case, Thermostat Bracket - Install

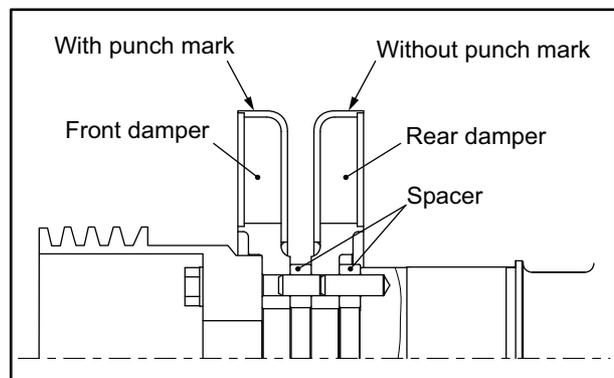
## 3.16 Damper and Crankshaft Pulley - Install

- (1) Install the guide bolt to damper mounting thread on the crankshaft.
- (2) Aligning with the dowel pins, install the spacer, rear damper, spacer, front damper, and crankshaft pulley, in correct positions, using the guide bolt.
- (3) Tighten the bolts to the specified torque.

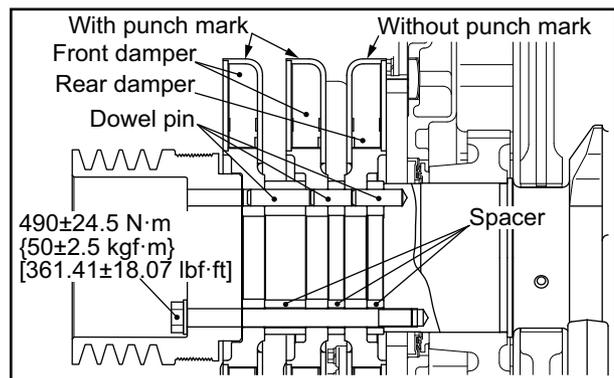
Note: Make sure the correct installation positions and orientations of dampers.



Damper and Crankshaft Pulley - Install



Damper - Installation Position and Orientation

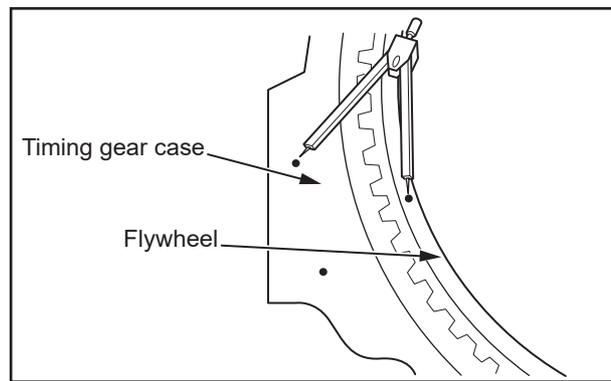


Damper - Installation Position and Orientation (S16R2)

### 3.17 Pointer - Install and Adjust

- (1) Install the pointer on the front gear case.
- (2) Turn the crankshaft to the top dead center of No. 1 cylinder. Align the top dead center line of No. 1 cylinder on the circumference of damper with the pointer.
- (3) At the No.1 cylinder top dead center, the flywheel punch mark is positioned at the same distance from the two punch marks stamped on the timing gear case.

Note: To check the top dead center by the piston movement, see "Piston Protrusion - Measure" of "ENGINE BODY - ASSEMBLE."

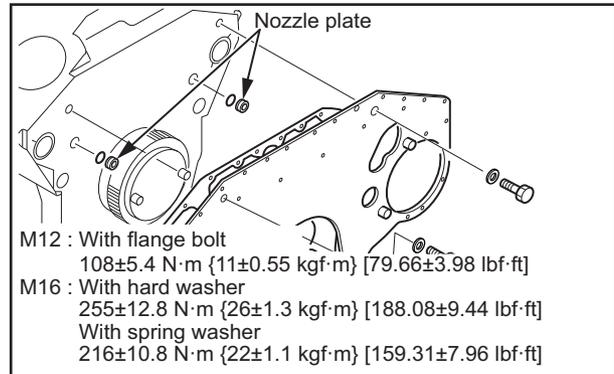


Top Dead Center - Check with Punch Marks

## 4. Rear Mechanism - Assemble

### 4.1 Rear Plate - Install

- (1) Install the nozzle plates.
- (2) Apply sealant (ThreeBond 1211) on the rear plate packing mounting surface of the crankcase, and install the packing.
- (3) Apply the same sealant (ThreeBond 1211) on 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.

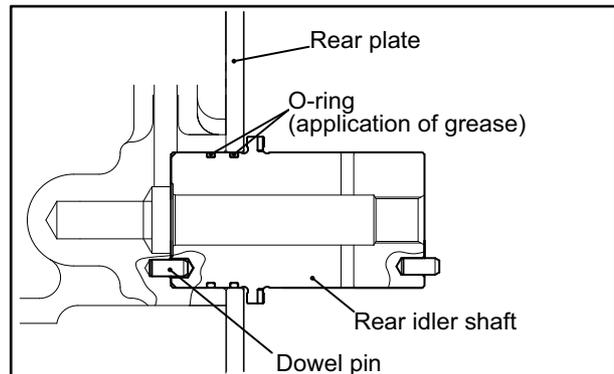


Rear Plate - Install

### 4.2 Rear Idler Shaft - Install

Install the O-rings on the rear idler shaft and apply grease on the O-rings.

Align the rear idler shaft with the dowel pin, and install the rear idler shaft on the crankcase.



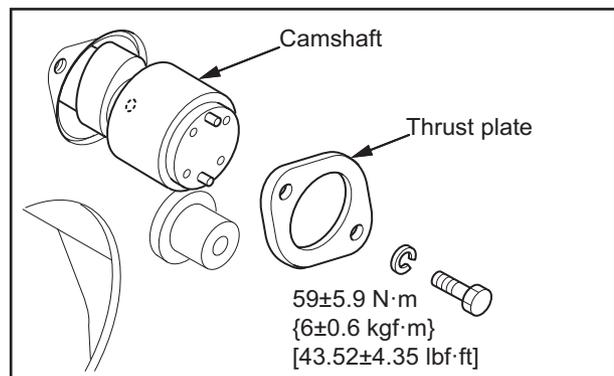
Rear Idler Shaft - Install

### 4.3 Camshaft - Install

#### CAUTION

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

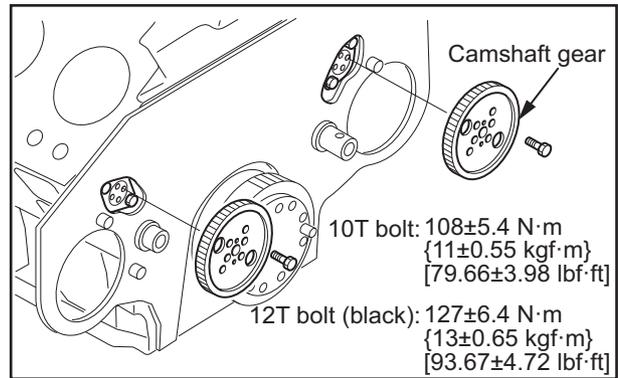
- (1) Apply engine oil on inner surface of camshaft bushing.
- (2) Apply engine oil on camshaft oil galleries, journals, and lobes.
- (3) Support camshaft with a bar, and slowly insert camshaft into crankcase.
- (4) Install thrust plate, and tighten bolts to the specified torque.
- (5) Make sure that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

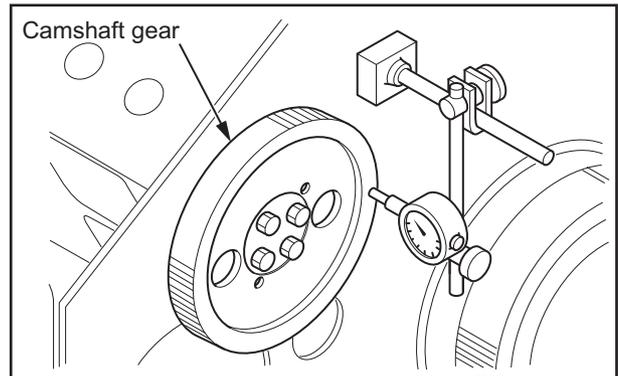


Camshaft Gear - Install

#### 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.

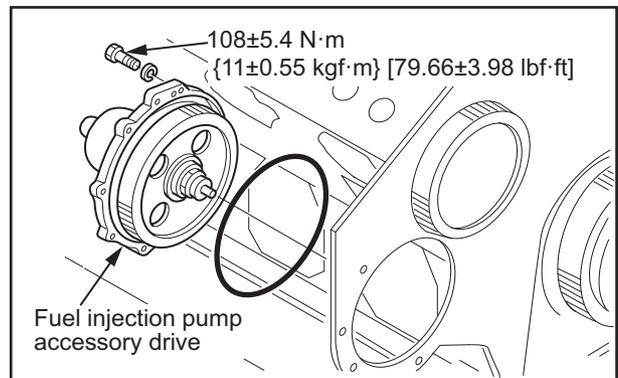
Item	Standard value	Limit value
Camshaft end play	0.10 to 0.25 mm [0.0039 to 0.0098 in.]	0.40 mm [0.0157 in.]



Camshaft End Play - Measure

#### 4.6 Fuel Injection Pump Accessory Drive - Install

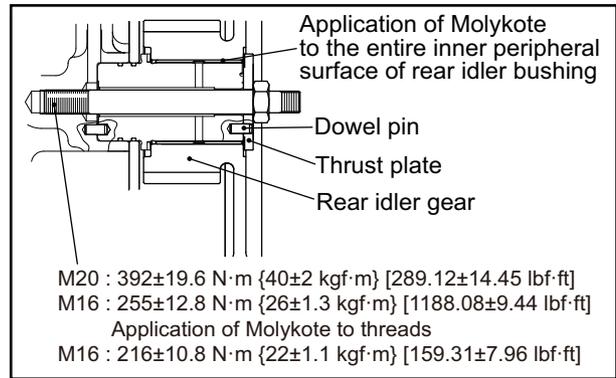
- (1) Install the O-ring to the mounting surface of the fuel injection pump accessory drive case. Apply a thin coat of ThreeBond 1212 on the flange.
- (2) Install the fuel injection pump accessory drive to the rear plate.
- (3) Tighten the bolts to the specified torque.



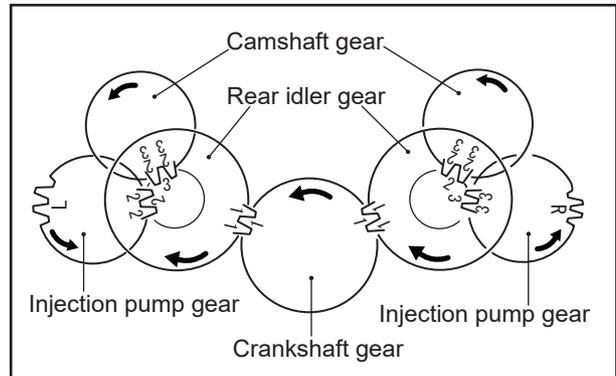
Fuel Injection Pump Accessory Drive - Install

### 4.7 Rear Idler Gear - Install

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



Rear Idler Gear - Install

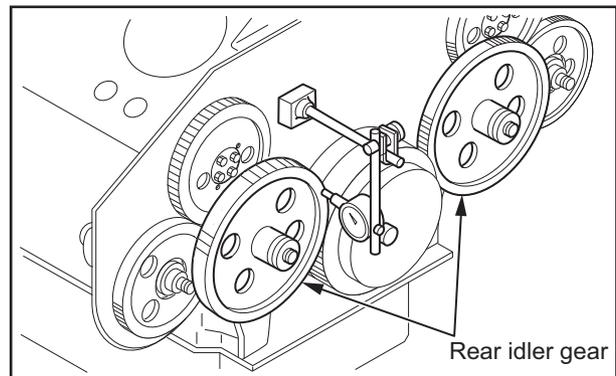


Timing Gear Train

### 4.8 Rear Idler Gear End Play - Measure

Measure the end play of the rear idler gear. If the value exceeds the limit, replace the thrust plate or idler gear with a new one.

Item	Standard value	Limit value
Rear idler gear end play	0.30 to 0.50 mm [0.0118 to 0.0197 in.]	1.00 mm [0.040 in.]

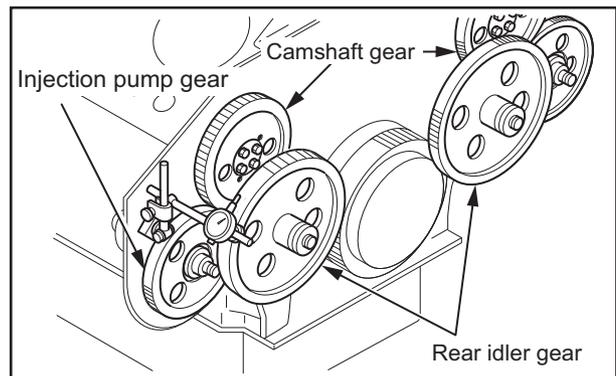


Rear Idler Gear End Play - Measure

### 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 feeler 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 rear idler gear	0.11 to 0.30 mm [0.0043 to 0.0118 in.]	0.50 mm [0.0197 in.]
Backlash between idler gear and camshaft gear		
Backlash between idler gear and fuel injection pump gear		



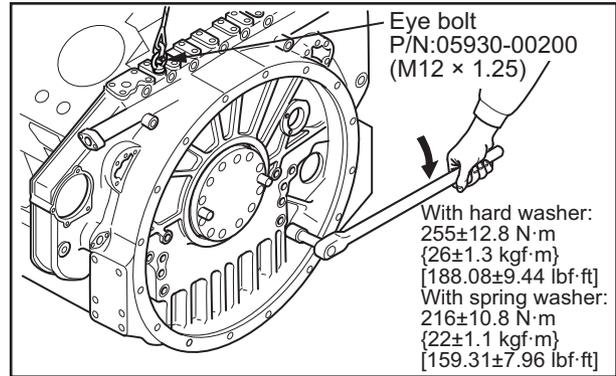
Rear Idler Gear End Play and Timing Gear Backlash - Measure

#### 4.10 Timing Gear Case - Install

**CAUTION**

Be careful not to drop or hit the timing gear case. It may result in personnel injury as well as damage to the timing gear case.

- (1) Apply sealant (ThreeBond 1211) on the rear plate packing mating surface, and install the packing.
- (2) Apply sealant (ThreeBond 1211) on the packing mating surface to timing gear case.
- (3) Attach the lifting equipment to the timing gear case, align the case with the dowel pins, and install the case.
- (4) Tighten the bolts to the specified torque.
- (5) Carefully cut off excessive packing protruding from the bottom of crankcase.



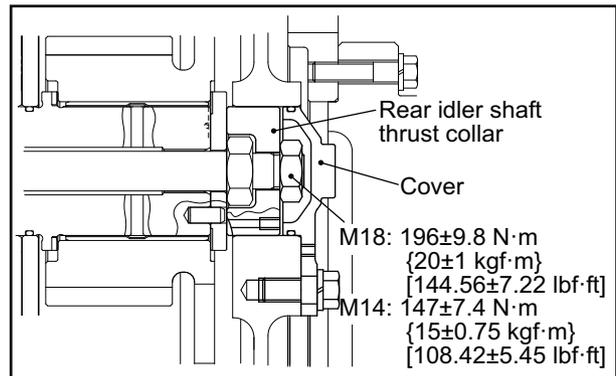
Timing Gear Case - Install

#### 4.11 Rear Idler Shaft Thrust Collar - Install

- (1) Apply grease on the rear idler shaft thrust collars, and insert the collars in the timing gear case.

Be sure that the alignment mark "TOP" is positioned at the top. Also install the parts in accordance with the identification marks made during removal.

- (2) Tighten the nuts to the specified torque.
- (3) Install the cover on the timing gear case.

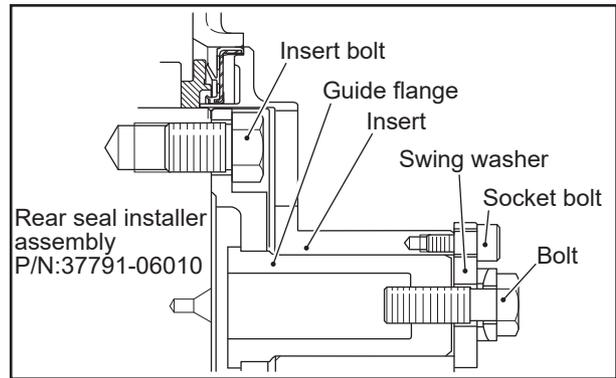


Rear Idler Shaft Thrust Collar - Install

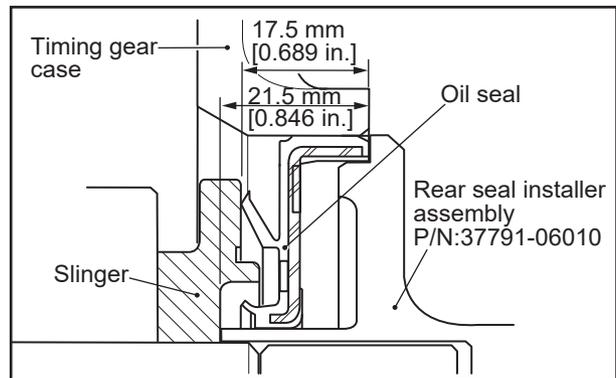
#### 4.12 Rear Oil Seal - Install

Using the rear seal installer assembly, install the rear oil seal.

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



Rear Oil Seal - Install (1)



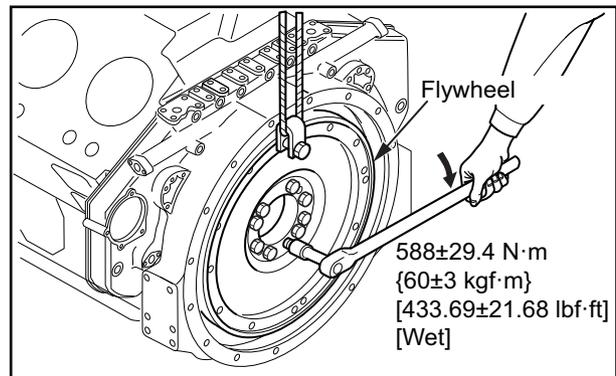
Rear Oil Seal - Install (2)

#### 4.13 Flywheel - Install

##### **CAUTION**

Be careful not to drop or bump the flywheel. It may cause damage to the flywheel or may result in personnel injury.

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

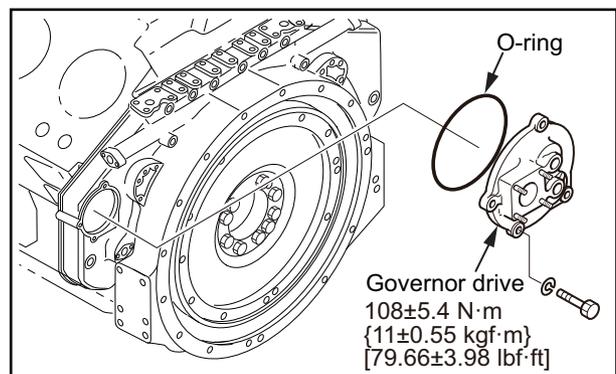


Flywheel - Install

#### 4.14 Governor Drive - Install

(Hydraulic 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.



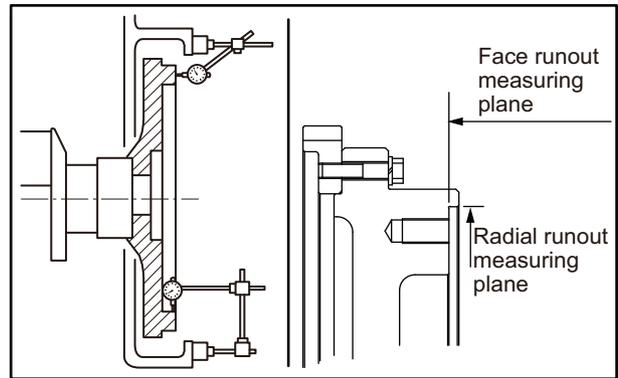
Governor Drive - Install

4.15 Flywheel Face and Radial Runouts - Measure

Measure the face and radial runouts of the flywheel.

If the value exceeds the limit significantly, check the assembled condition such as a loose bolt or foreign material adhesion on the mounting faces.

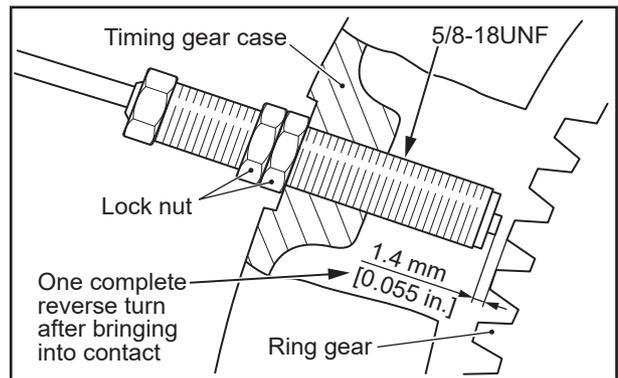
Item	Standard value
Face runout (reference)	0.336 mm [0.0132 in.] or less
Radial runout (reference)	0.130 mm [0.0051 in.] or less



Flywheel Face and Radial Runouts - Measure

4.16 Pickup - Install

- (1) Turn the crankshaft to align a top face of ring gear tooth with the center line of pickup mounting 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) Secure the pickup with the lock nut.



Pickup - Install

## 5. Cylinder Head and Valve Mechanism - Assemble

### 5.1 Cylinder Head - Assemble

#### CAUTION

- Be careful when inserting the valve through the stem seal, as the edge of stem groove can cause damage to the stem seal lip.
- Do not apply oil or liquid sealant to the fitting faces between the stem seal and the 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.

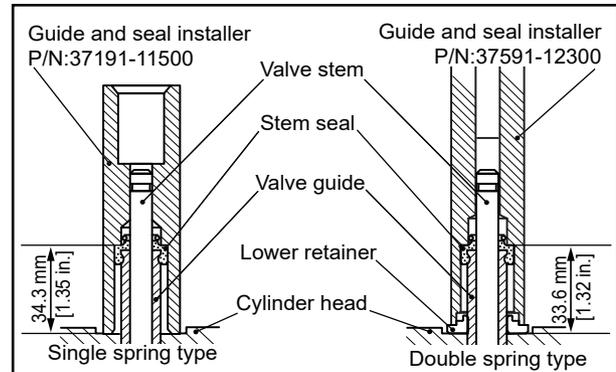
- Apply engine oil to the valve stem, and insert the valve into the valve guide.
- Install the lower retainer to valve guide on exhaust side. (Exhaust double spring spec only)
- Install stem seal to valve guide with the guide and seal installer.

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

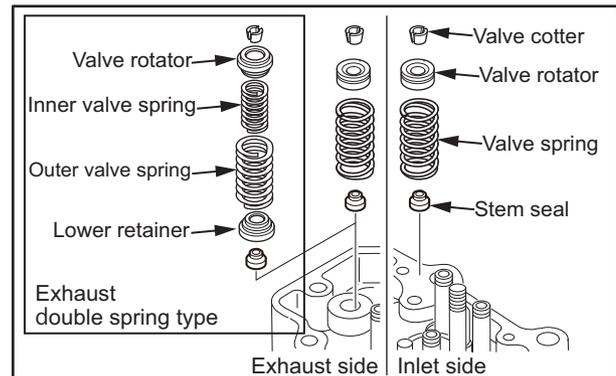
- Apply engine oil to the lip of stem seal.
- Install the retainer, valve spring and rotator to valve guide, and install the valve cotters with valve spring pusher.

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

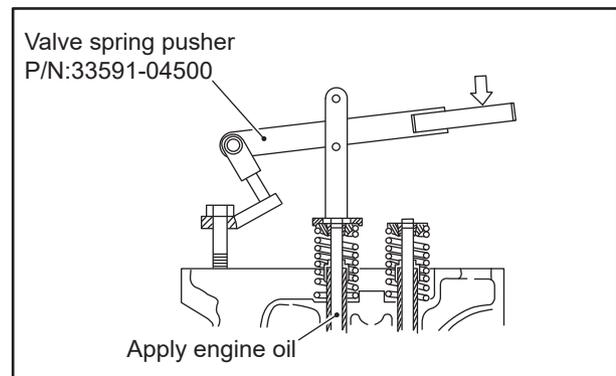
- Tap the top of valve stem lightly several times with a soft-head hammer to slightly open the valve, and make sure that the valve spring and the valve cotters are properly installed and seated firmly.



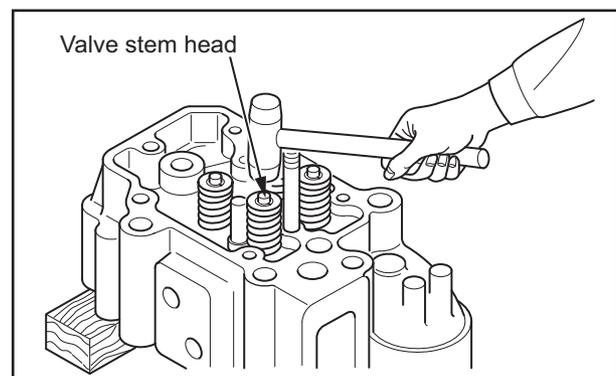
Stem Seal - Install



Valve and Valve Spring - Install



Valve Cotter - Install



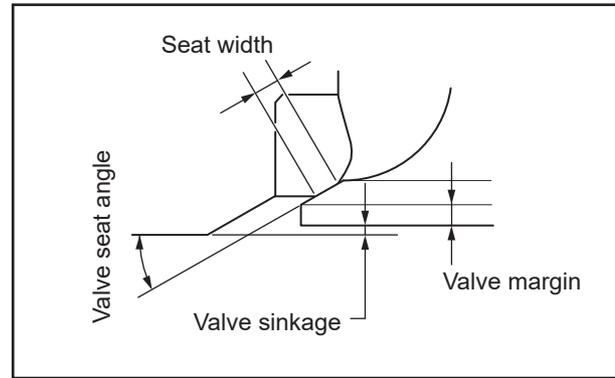
Installing valve

### 5.2 Valve Sinkage - Measure

Measure the valve sinkage.

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

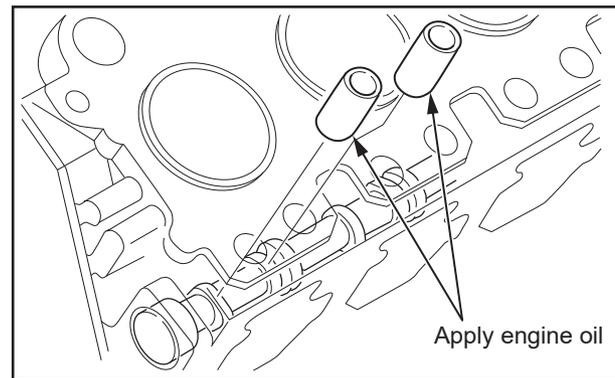
Item	Standard value	Limit value
Valve sinkage	-0.1 to 0.1 mm [-0.004 to 0.004 in.]	1.0 mm [0.040 in.]



Valve Sinkage - Measure

### 5.3 Tappet - Install

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



Tappet - Install

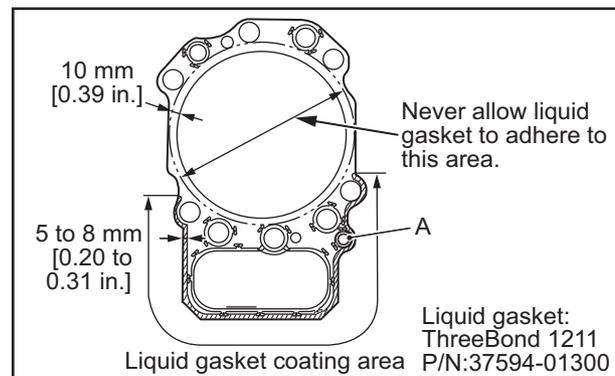
### 5.4 Liquid Gasket - Apply

**CAUTION**

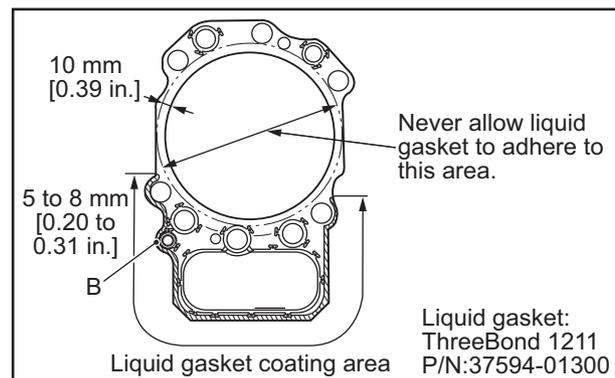
- (a) Do not apply the liquid gasket excessively. It results in O-ring deformation. Be careful to apply gasket on the portions A and B. The space to the O-ring is very narrow.
- (b) Do not apply liquid gasket around the periphery of cylinder bore. It results in gas leaks.

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

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



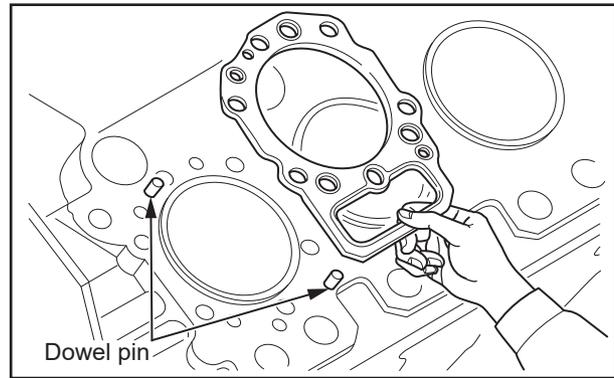
Liquid Gasket - Area of Application (Head Side)



Liquid Gasket - Area of Application (Crankcase Side)

### 5.5 Cylinder Head Gasket - Install

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



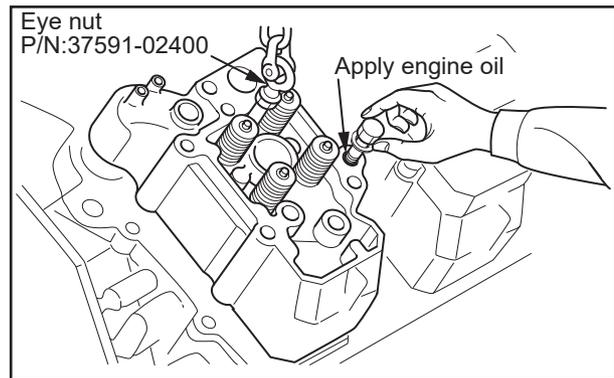
Cylinder Head Gasket - Install

### 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. Then hand tighten the cylinder head bolts.



Cylinder Head Assembly - Install

### 5.7 Cylinder Head Bolt - Tighten

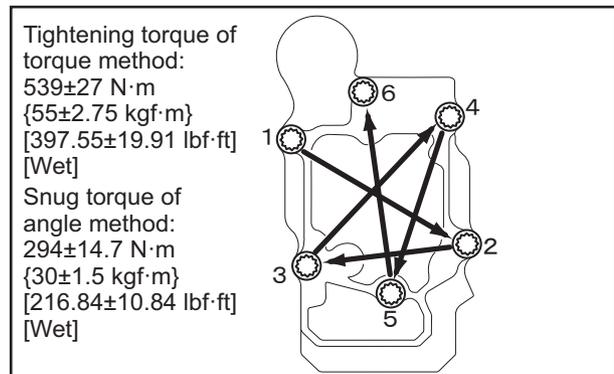
Two methods of cylinder head bolt tightening, the torque tightening and controlled angle tightening, are available.

#### 5.7.1 Torque Tightening Method

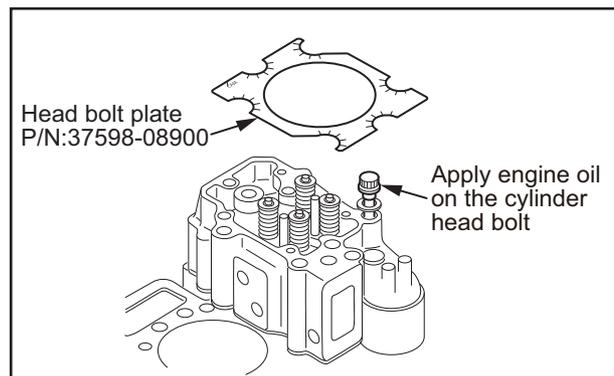
- (1) Tighten cylinder head bolts progressively to the specified torque in the sequence shown in illustration.
- (2) Tighten all the bolts, and then loosen them, and tighten them again according to this torque method. (2-time tightening)

#### 5.7.2 Controlled-Angle Tightening Method

- (1) Tighten cylinder head bolts to the specified snug torque in the sequence shown in the illustration.
- (2) Place the head bolt plate on the top of cylinder head.
- (3) Put a mark on 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)



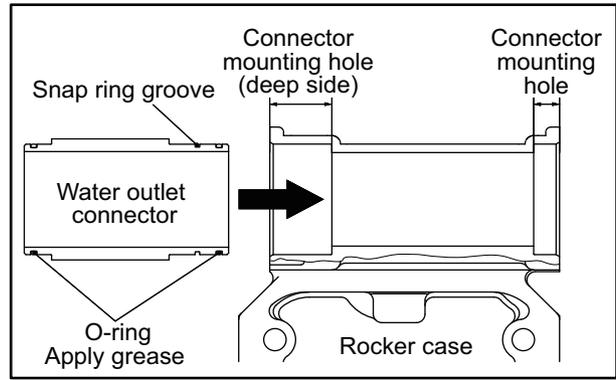
Cylinder Head Bolts - Tightening sequence



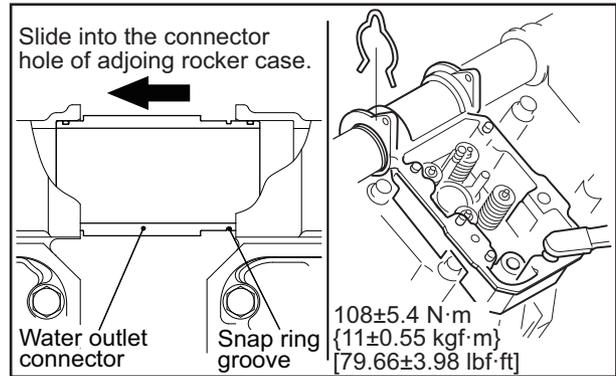
Cylinder Head Bolt - Angle Controlled Tightening Method

### 5.8 Rocker Case - Install

- (1) Install O-rings on water outlet connector. Apply grease on the O-ring sliding surface.
- (2) Apply grease on 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 by 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 to install.
- (7) Install the snap ring in snap ring groove of water outlet connector.



Water Outlet Connector - Install

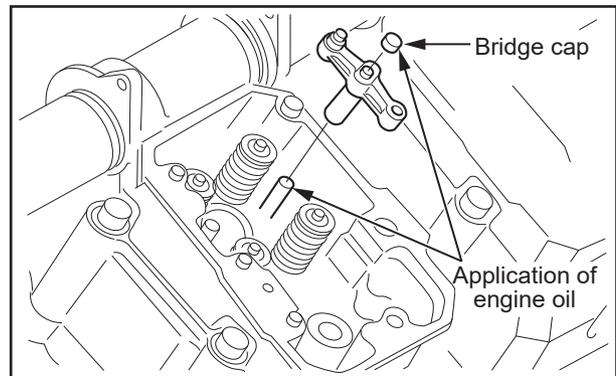


Rocker Case - Install

### 5.9 Bridge and Bridge Cap - Install

Note: Cover the pushrod hole to prevent the bridge cap from falling into the crankcase through the pushrod hole.

- (1) Apply engine oil on the bridge guide.
- (2) Orient the screw-fitted end of the bridge on the exhaust manifold side, and install the bridge on the bridge guide.
- (3) Apply engine oil on the contact face of bridge cap, and install the cap on the bridge.

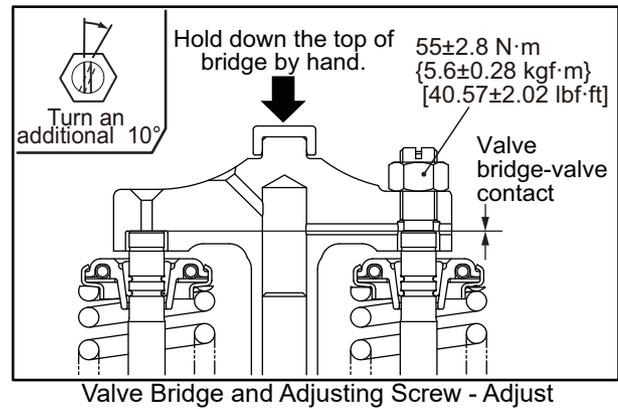


Bridge and Bridge Cap - Install

### 5.10 Valve Bridge and Adjusting Screw - Adjust

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

- (1) Loosen the adjusting screw so that the screw top face protrudes from the 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 bridge solid side (without the screw) contacts firmly to the valve stem top face.
- (3) Turn the adjusting screw slowly until the screw comes into contact with the top face of valve stem. Then, turn the screw further by 10 degrees, and tighten the lock nut to the specified torque.

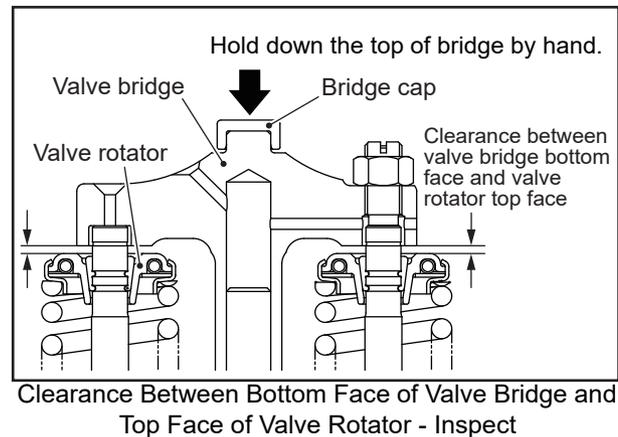


### 5.11 Clearance Between Bottom Face of Valve Bridge and Top Face of Valve Rotator - Inspect

#### 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.

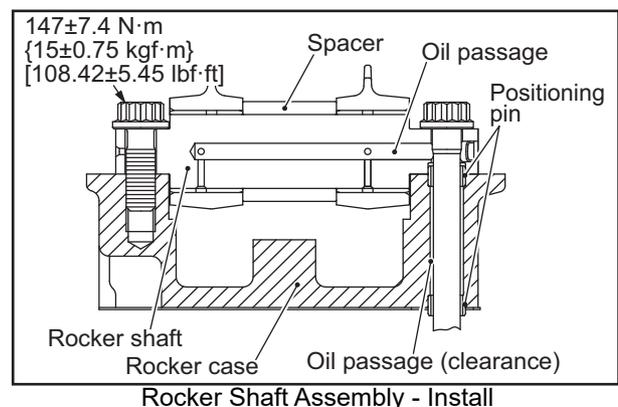
Push the valve bridge by hand to make close contact of the top end face of valve stem. Then, check the clearance between bottom face of valve bridge and top face of valve rotator. If the value deviates from the standard, find the causal parts, and replace them with new ones.



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 on 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 in rocker case.
- (3) Tighten the bolts to the specified torque.



5.13 Valve Clearance - Check and Adjust

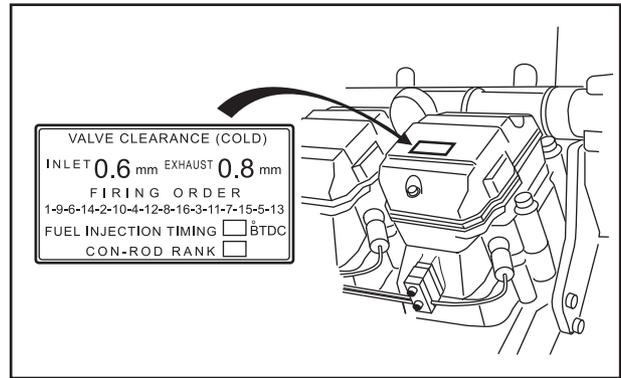
Adjust the valve clearance when the engine is cold.

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

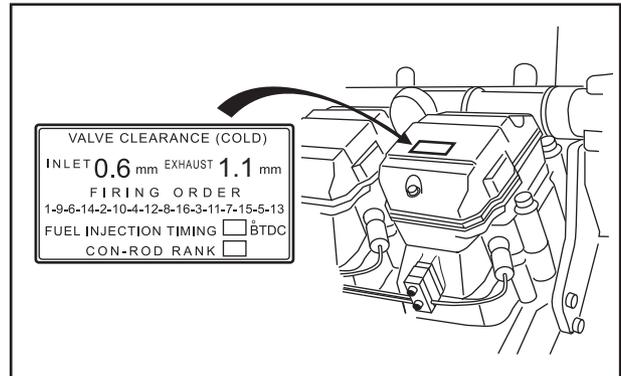
(b) The valve clearance standard values are indicated on the caution plate on the No. 1 cylinder rocker cover.

Item	Standard value
Valve clearance	Inlet 0.6 mm [0.024 in.]
	0.8 mm [0.031 in.]
	1.1 mm [0.043 in.] (S16R2-T2MPTAW-11 and sand pump ship for pump drive of S16R2-MPTK2 for China)

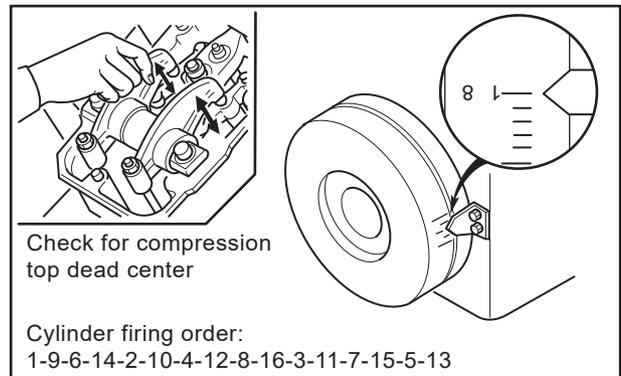
- (1) According to the firing order, adjust the valve clearance at the top dead center (TDC) of compression stroke by turning the crankshaft in the normal direction.
- (2) On each cylinder, the piston is at the top dead center on compression stroke, when the corresponding cylinder number stamped on the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



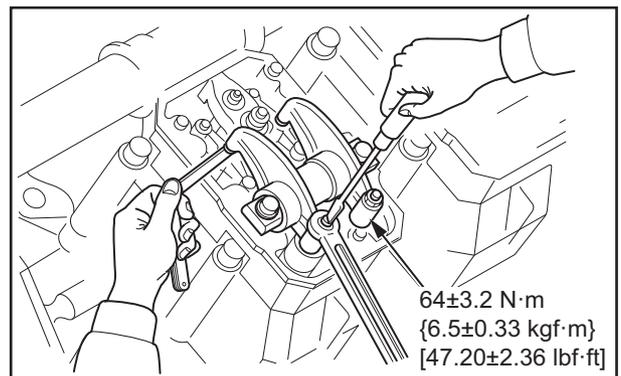
Valve Clearance Plate - Location (1)



Valve Clearance Plate - Location (2)  
(S16R2-T2MPTAW-11 and sand pump ship for pump drive of S16R2-MPTK2 for China)



No. 1 Cylinder Compression Top Dead Center - Check

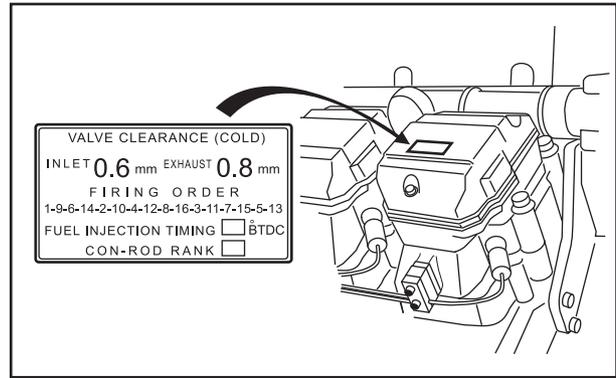


Valve Clearance - Adjust

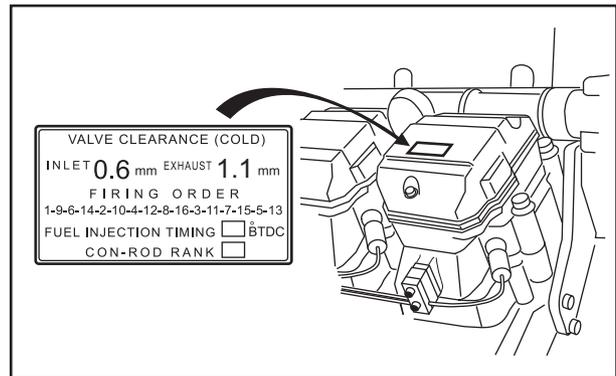
## 5.14 Fuel Injection Timing - Check and Adjust

## 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 (1)

Specified Value of Fuel Injection Timing - Check (2)  
(S16R2-T2MPTAW-11 and sand pump ship for pump drive of S16R2-MPTK2 for China)

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 approximately 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, if the clearances of inlet and exhaust valves are as specified, the valves are not pushed down.

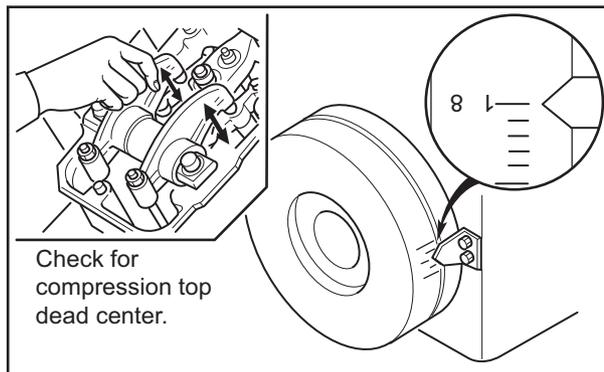
In case of the exhaust stroke top dead center, the valves are pushed down.

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

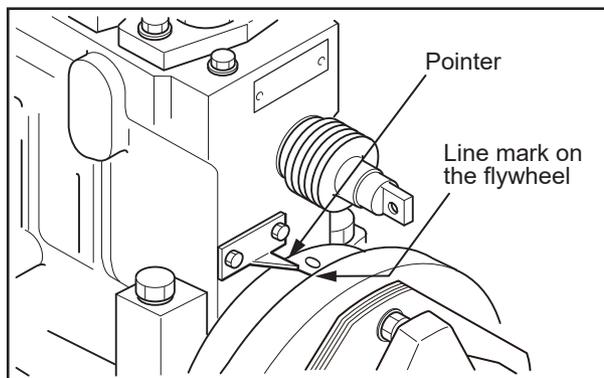
If the "0" line mark of fuel injection pump flywheel aligns with pointer, the fuel injection timing is adjusted to the specified timing.

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

Note: For the left bank fuel injection pump, rotate the crankshaft so that No. 9 piston is before the top dead center (TDC) in compression, then follow the procedure described above.



No. 1 Cylinder Compression Top Dead Center - Check



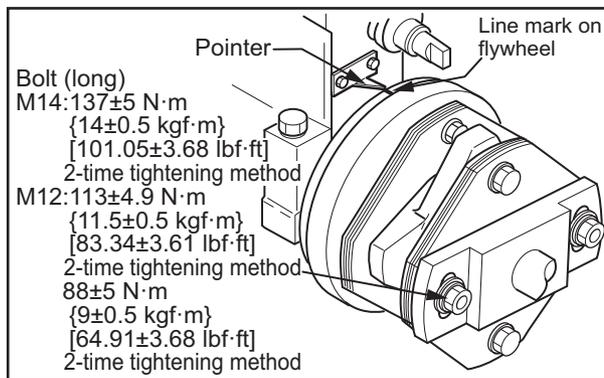
Fuel Injection Timing - Check

5.14.3 Fuel Injection Timing - Adjust

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



Fuel Injection Timing - Adjust

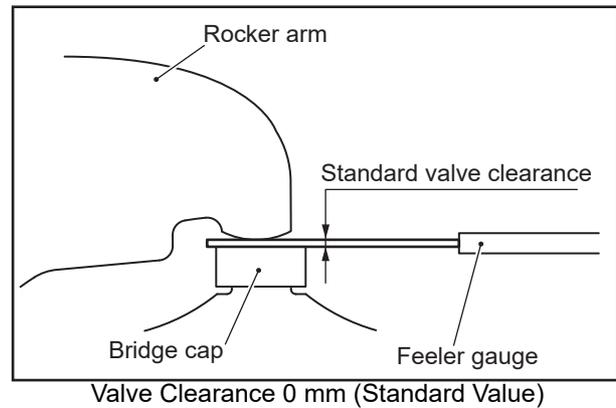
Bolt (long)  
M14:137±5 N·m  
{14±0.5 kgf·m}  
[101.05±3.68 lbf·ft]  
2-time tightening method  
M12:113±4.9 N·m  
{11.5±0.5 kgf·m}  
[83.34±3.61 lbf·ft]  
2-time tightening method  
88±5 N·m  
{9±0.5 kgf·m}  
[64.91±3.68 lbf·ft]  
2-time tightening method

### 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)

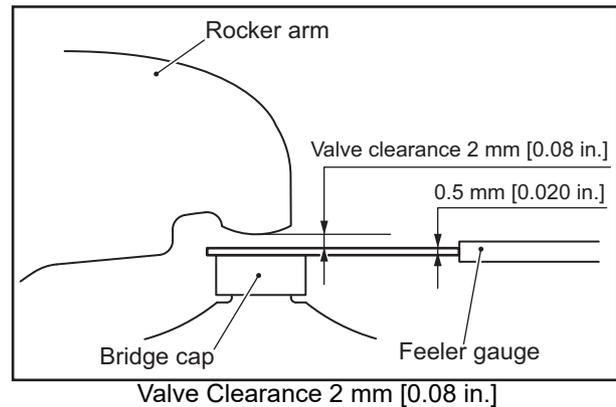
- (1) Check that the valve clearance is adjusted to the specification.
- (2) Insert the thickness gauge, which has the same thickness as the specified valve clearance, between bridge cap and rocker arm. (valve clearance 0 mm)
- (3) Turn the crankshaft in the normal direction little by little, and find 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.



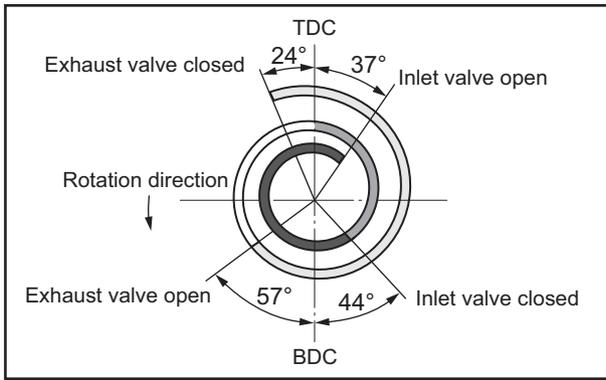
#### 5.15.2 Valve Timing When Valve Clearance is 2 mm [0.08 in.] Valve Timing

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.

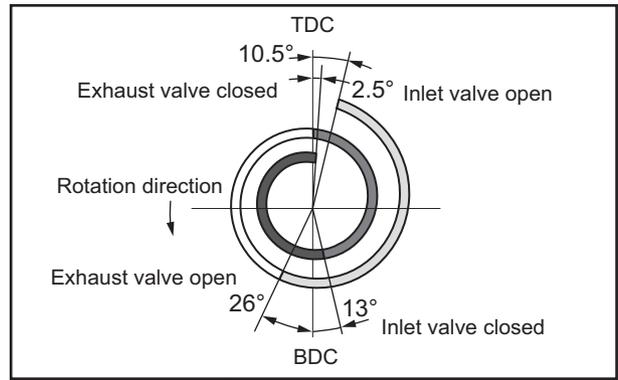


Overlap 61° Spec



Overlap 61° Spec

Valve Timing When Valve Clearance is 0 mm (Standard Value)

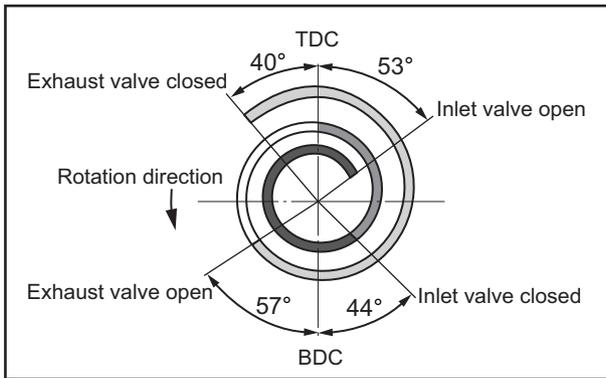


Overlap 61° Spec

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

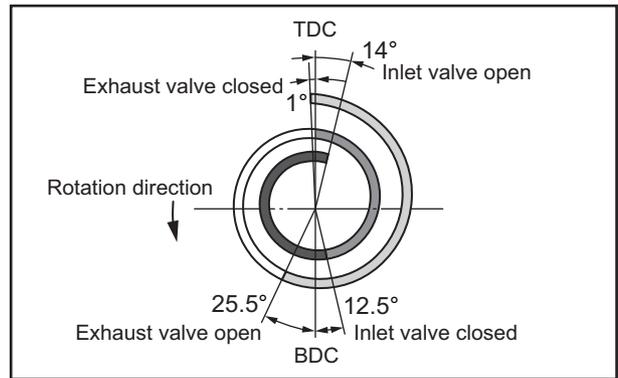
Item	Specification	Valve clearance	Item	Nominal value	Standard value	
Valve timing	Overlap 61° Camshaft P/N : Right : 37805-□110□ (Part No. stamp, green paint color) Left : 37805-□120□ (Part No. stamp, green paint color)	0 mm (Standard value)	Inlet	Open	BTDC 37°	-
				Close	ABDC 44°	
			Exhaust	Open	BBDC 57°	
				Close	ATDC 24°	
		2 mm [0.08 in.]	Inlet	Open	BTDC 2.5°	±2°
				Close	BBDC 13°	
			Exhaust	Open	BBDC 26°	
				Close	BTDC 10.5°	

Overlap 93° Spec



Overlap 93° Spec

Valve Timing When Valve Clearance is 0 mm (Standard Value)

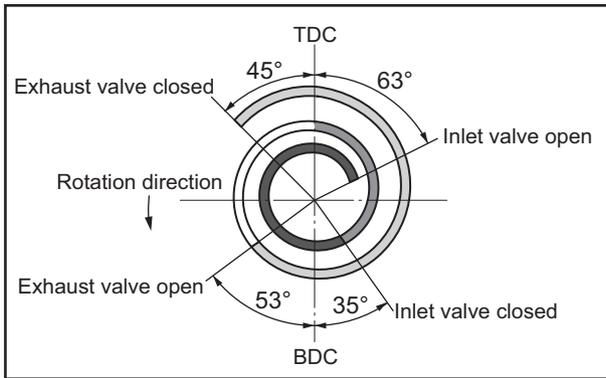


Overlap 93° Spec

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

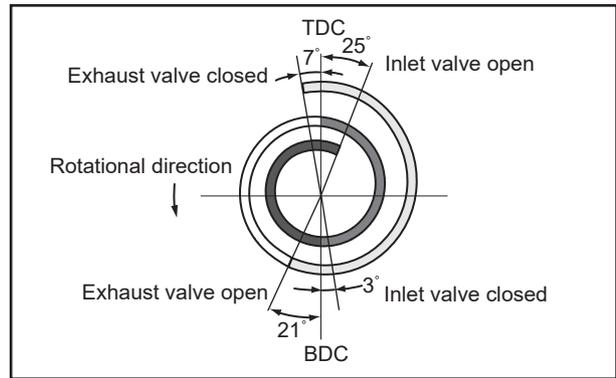
Item	Specification	Valve clearance	Item	Nominal value	Standard value	
Valve timing	Overlap 93° Camshaft P/N : Right : 37N05-□130□ (Part No. stamp) Right : 37805-□130□ (Part No. stamp, white paint color) Left : 37N05-□140□ (part No. stamp) Left : 37805-□140□ (Part No. stamp, white paint color)	0 mm (Standard value)	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 108° Spec



Overlap 108° Spec

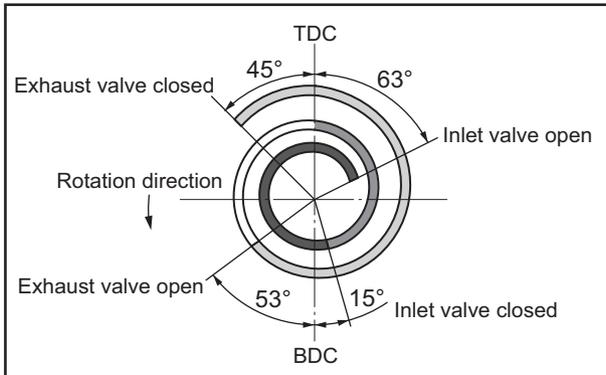
Valve Timing When Valve Clearance is 0 mm (Standard Value)



Overlap 108° Spec

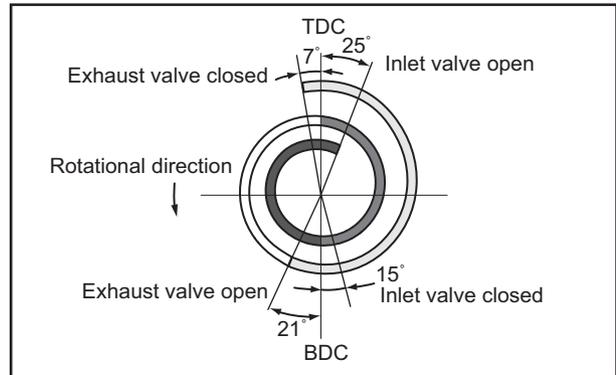
Valve Timing When Valve Clearance is 2 mm [0.08 in.]

Item	Specification	Valve clearance	Item	Nominal value	Standard value	
Valve timing	Overlap 108° Camshaft P/N : Right : 37805-□070□ (108H stamp) Left : 37805-□080□ (108H stamp)	0 mm (Standard value)	Inlet	Open	BTDC 63°	-
				Close	ABDC 35°	
			Exhaust	Open	BBDC 53°	
				Close	ATDC 45°	
		2 mm [0.08 in.]	Inlet	Open	BTDC 25°	±2°
				Close	ABDC 3°	
			Exhaust	Open	BBDC 21°	
				Close	ATDC 7°	



Overlap 108° Spec

Valve Timing When Valve Clearance is 0 mm (Standard Value)



Overlap 108° Spec

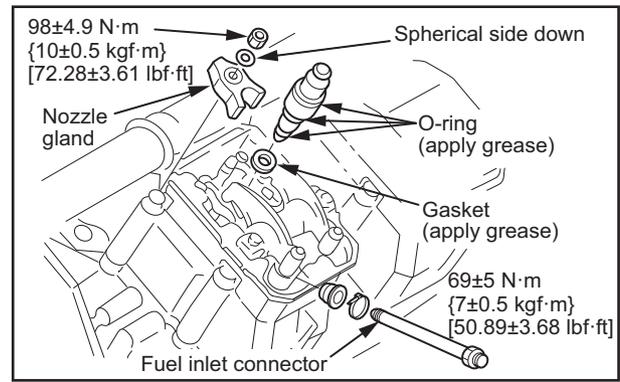
Valve Timing When Valve Clearance is 2 mm [0.08 in.]

Item	Specification	Valve clearance	Item	Nominal value	Standard value	
Valve timing	Overlap 108° Camshaft P/N : Right : 37805-□410□ (Part No. stamp) Left : 37805-□420□ (Part No. stamp)	0 mm (Standard value)	Inlet	Open	BTDC 63°	-
				Close	ABDC 15°	
			Exhaust	Open	BBDC 53°	
				Close	ATDC 45°	
		2 mm [0.08 in.]	Inlet	Open	BTDC 25°	±2°
				Close	BBDC 15°	
			Exhaust	Open	BBDC 21°	
				Close	ATDC 7°	

5.16 Fuel Injection Nozzle Assembly - Install

- (1) Remove the fuel inlet connector from fuel injection nozzle assembly.
- (2) Install O-rings (three places) on fuel injection nozzle, and apply grease on the surface.
- (3) Apply a thin coat of grease on the gasket and install it to the 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) Press the sleeve into the 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

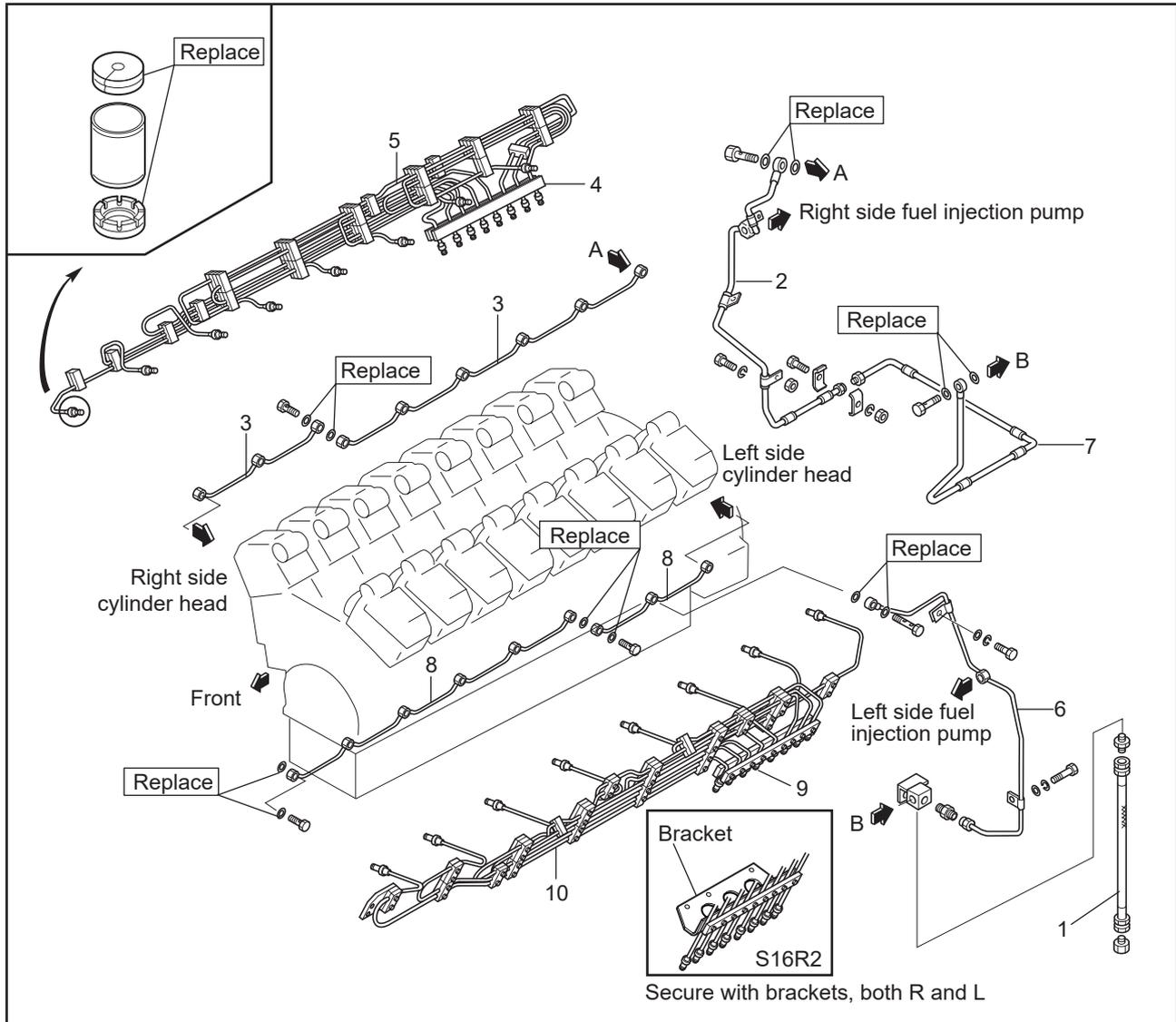
# Chapter 8 FUEL SYSTEM

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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

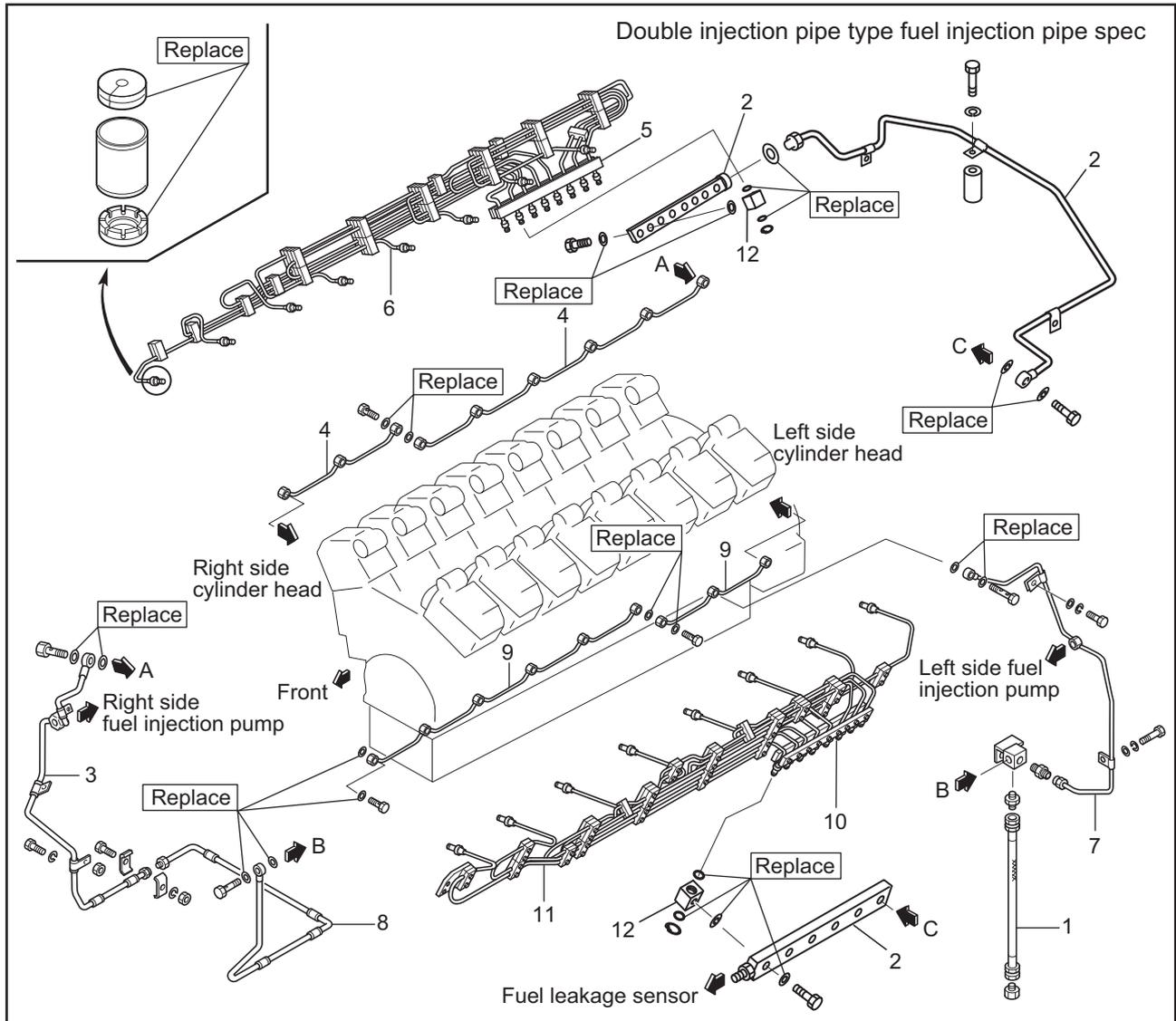
#### Removing sequence

- |                                  |                                    |
|----------------------------------|------------------------------------|
| 1 Flexible pipe                  | 6 Left leak-off pipe               |
| 2 Right leak-off pipe            | 7 Left leak-off pipe               |
| 3 Right leak-off pipe            | 8 Left leak-off pipe               |
| 4 Clamp                          | 9 Clamp                            |
| 5 No.1 to 8 fuel injection pipes | 10 No.9 to 16 fuel injection pipes |

#### CAUTION

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

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



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

Removing sequence

- |   |   |
|---|---|
| 1 Flexible pipe   | 7 Left leak-off pipe  |
| 2 Leak-off pipe   | 8 Left leak-off pipe  |
| 3 Right leak-off pipe                                     | 9 Left leak-off pipe  |
| 4 Right leak-off pipe                                     | 10 Clamp  |
| 5 Clamp   | 11 No.9 to 16 fuel injection pipes<br>(Dual injection pipe) |
| 6 No.1 to 8 fuel injection pipes<br>(Dual injection pipe) | 12 Leak-off connector                                       |

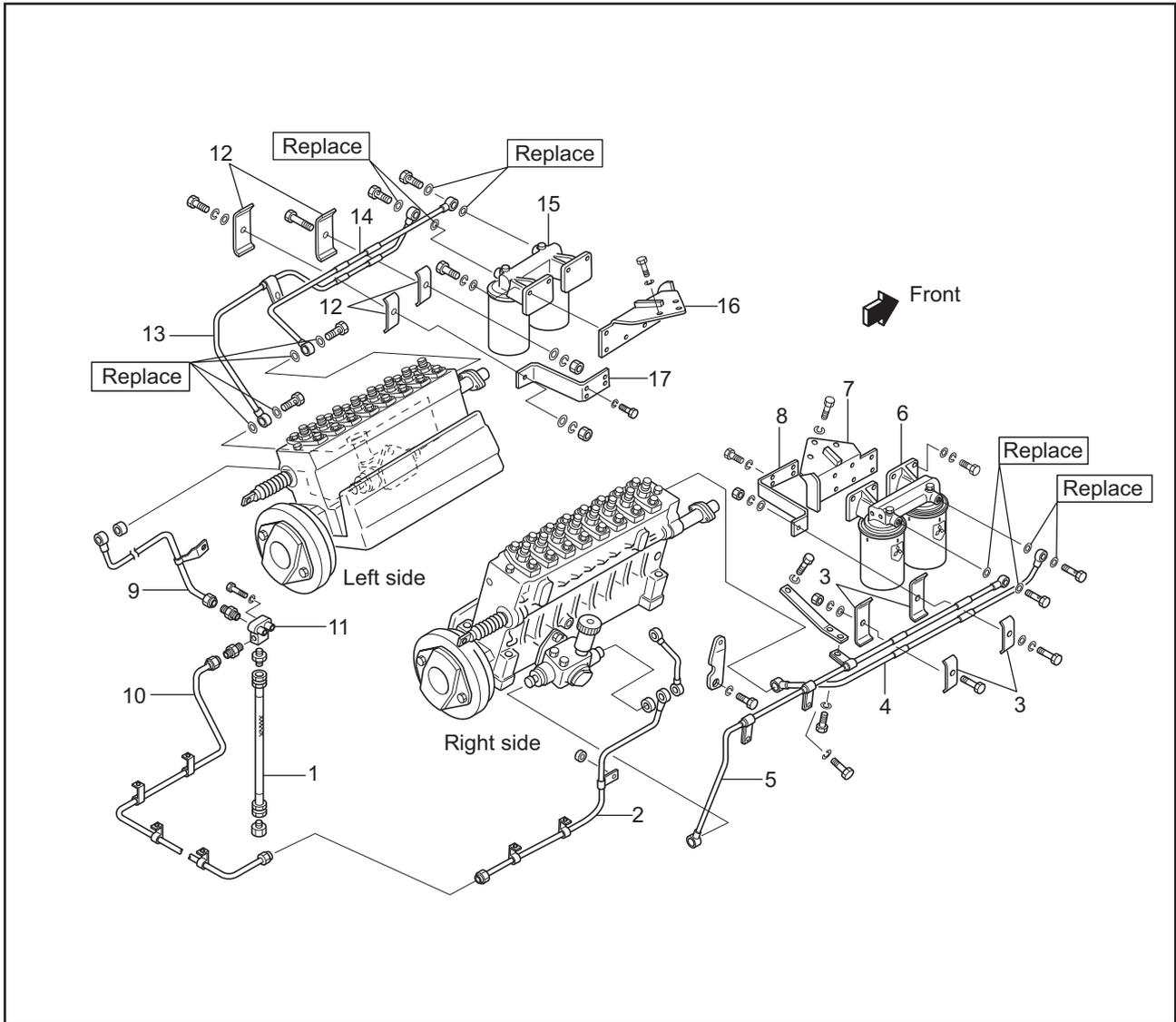
**CAUTION**

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

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



1.2 Fuel Filter and Fuel Pipe - Remove and Inspect



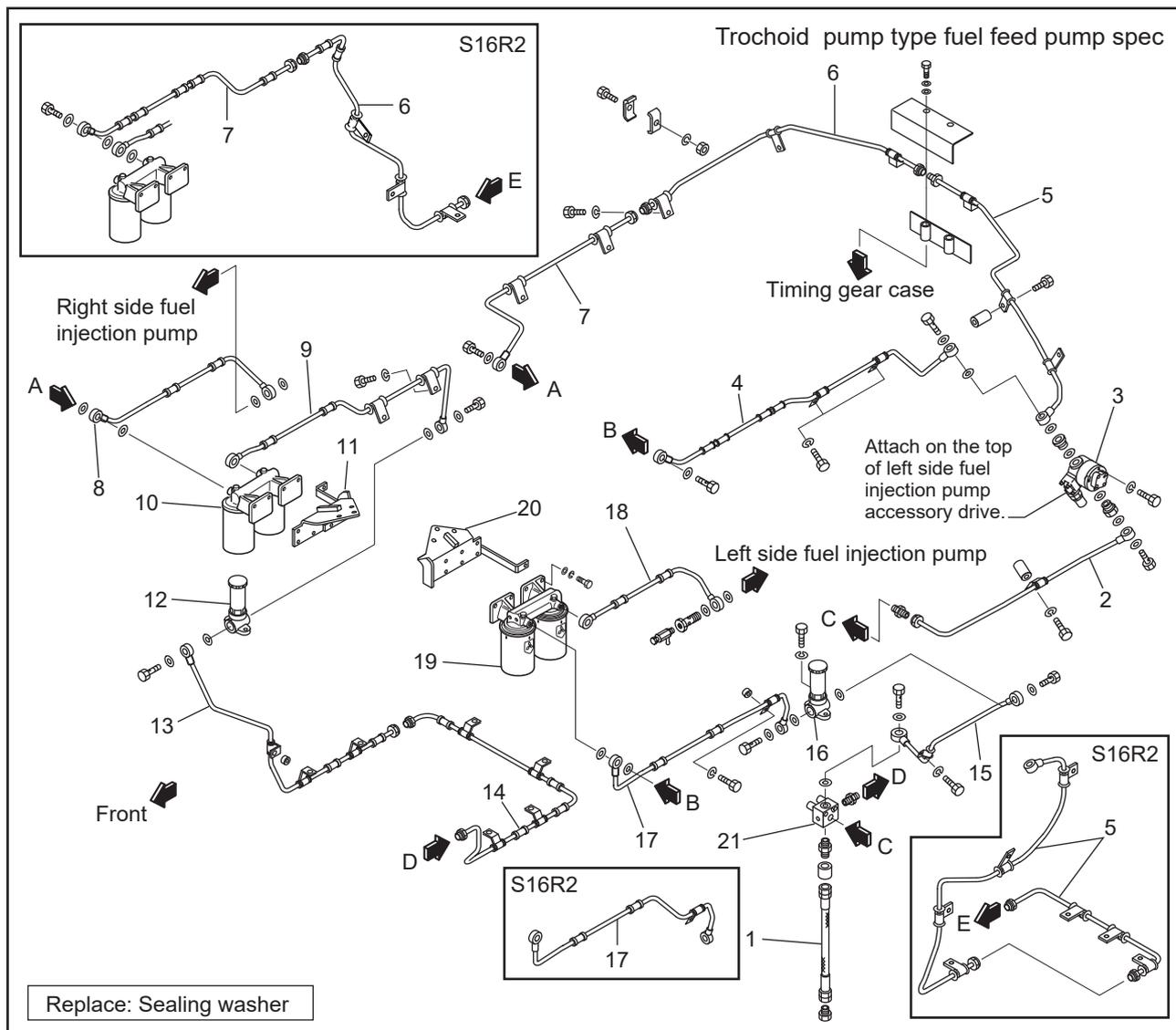
Fuel Filter and Fuel Pipe - Remove and Inspect

Removing sequence

- |                        |                       |                         |
|------------------------|-----------------------|-------------------------|
| 1 Flexible pipe        | 7 Fuel filter bracket | 13 Left fuel pipe       |
| 2 Fuel pipe            | 8 Pipe stay           | 14 Left fuel pipe       |
| 3 Clamp                | 9 Left fuel pipe      | 15 Fuel filter assembly |
| 4 Right fuel pipe      | 10 Left fuel pipe     | 16 Fuel filter bracket  |
| 5 Right fuel pipe      | 11 Connector          | 17 Pipe stay            |
| 6 Fuel filter assembly | 12 Clamp              |                         |

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



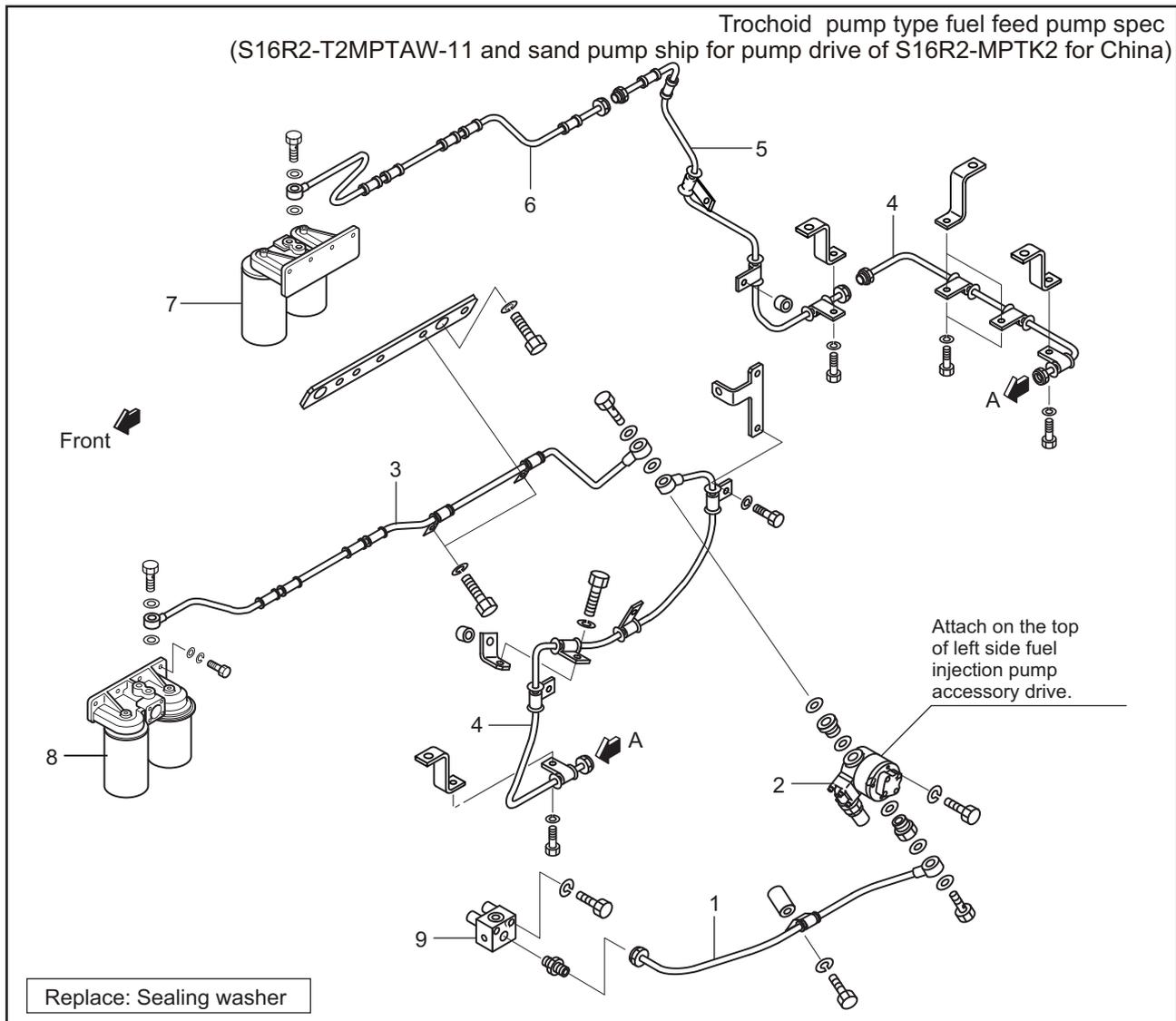


Fuel Filter and Fuel Pipe - Remove and Inspect

Removing sequence

- |  |  |
|--|--|
| 1 Flexible pipe  | 10 Fuel filter   |
| 2 Fuel pipe<br>(Fuel feed pump inlet)                              | 11 Fuel filter bracket   |
| 3 Fuel feed pump   | 12 Priming pump (Right)  |
| 4 Fuel pipe<br>(Left fuel feed pump outlet)                        | 13 Fuel pipe<br>(Right priming pump inlet)                         |
| 5 Fuel pipe<br>(Right fuel feed pump outlet)                       | 14 Fuel pipe<br>(Left priming pump inlet)                          |
| 6 Fuel pipe<br>(Right fuel feed pump outlet)                       | 15 Fuel pipe<br>(Left priming pump inlet)                          |
| 7 Fuel pipe<br>(Right fuel filter inlet)                           | 16 Priming pump (Left)   |
| 8 Fuel pipe<br>(Between right fuel filter and fuel injection pump) | 17 Fuel pipe<br>(Between left priming pump and fuel filter)        |
| 9 Fuel pipe<br>(Between right priming pump and fuel filter)        | 18 Fuel pipe<br>(Between left fuel filter and fuel injection pump) |
|  | 19 Fuel filter   |
|  | 20 Fuel filter bracket   |
|  | 21 Connector   |

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

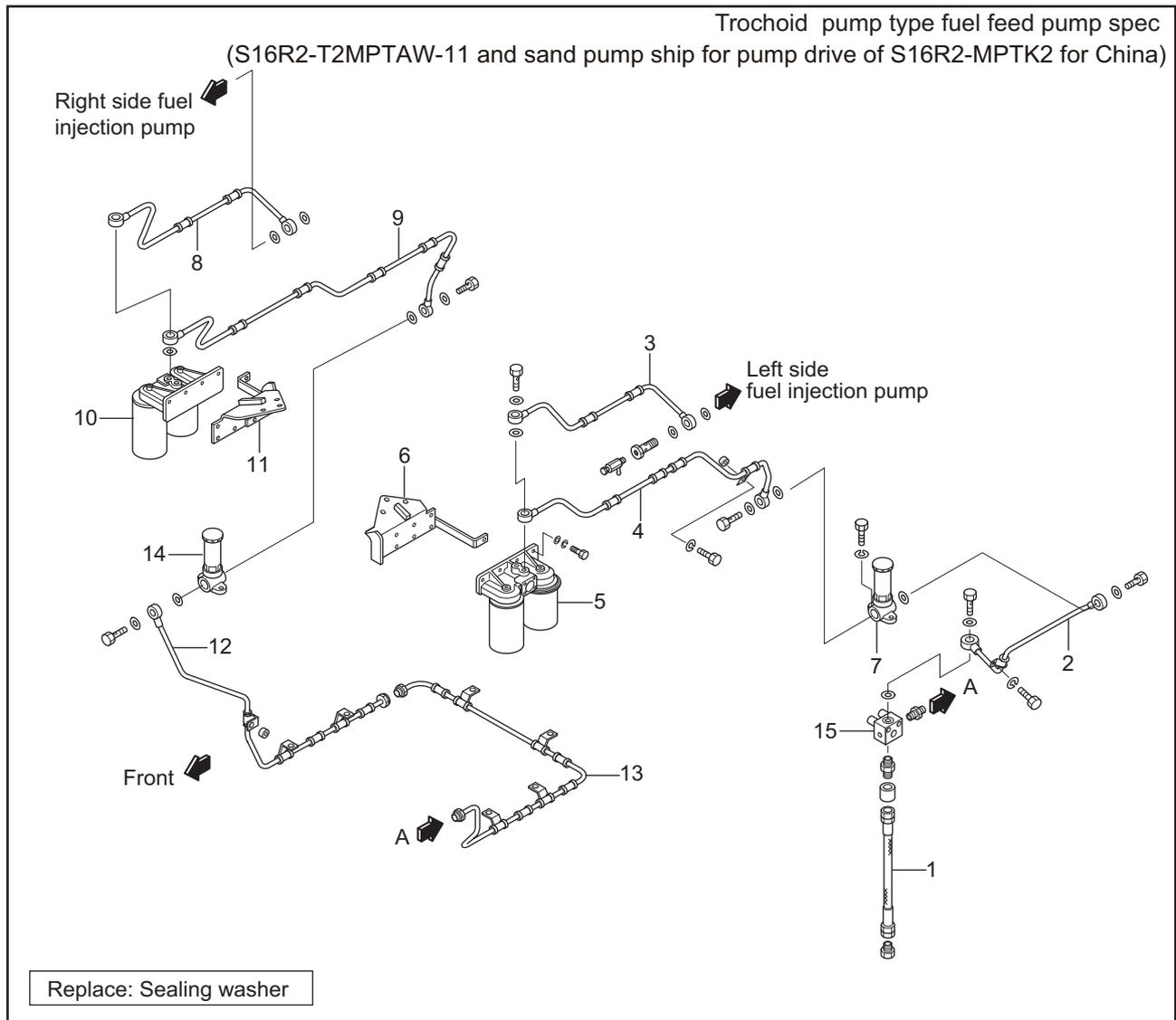


Fuel Filter and Fuel Pipe - Remove and Inspect (Feed Pump System)

## Removing sequence

- |   |                                       |
|---|---------------------------------------|
| 1 Fuel pipe (Fuel feed pump inlet)        | 6 Fuel pipe (Right fuel filter inlet) |
| 2 Fuel feed pump                          | 7 Fuel filter                         |
| 3 Fuel pipe (Left fuel feed pump outlet)  | 8 Fuel filter                         |
| 4 Fuel pipe (Right fuel feed pump outlet) | 9 Connector                           |
| 5 Fuel pipe (Right fuel feed pump outlet) |                                       |

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

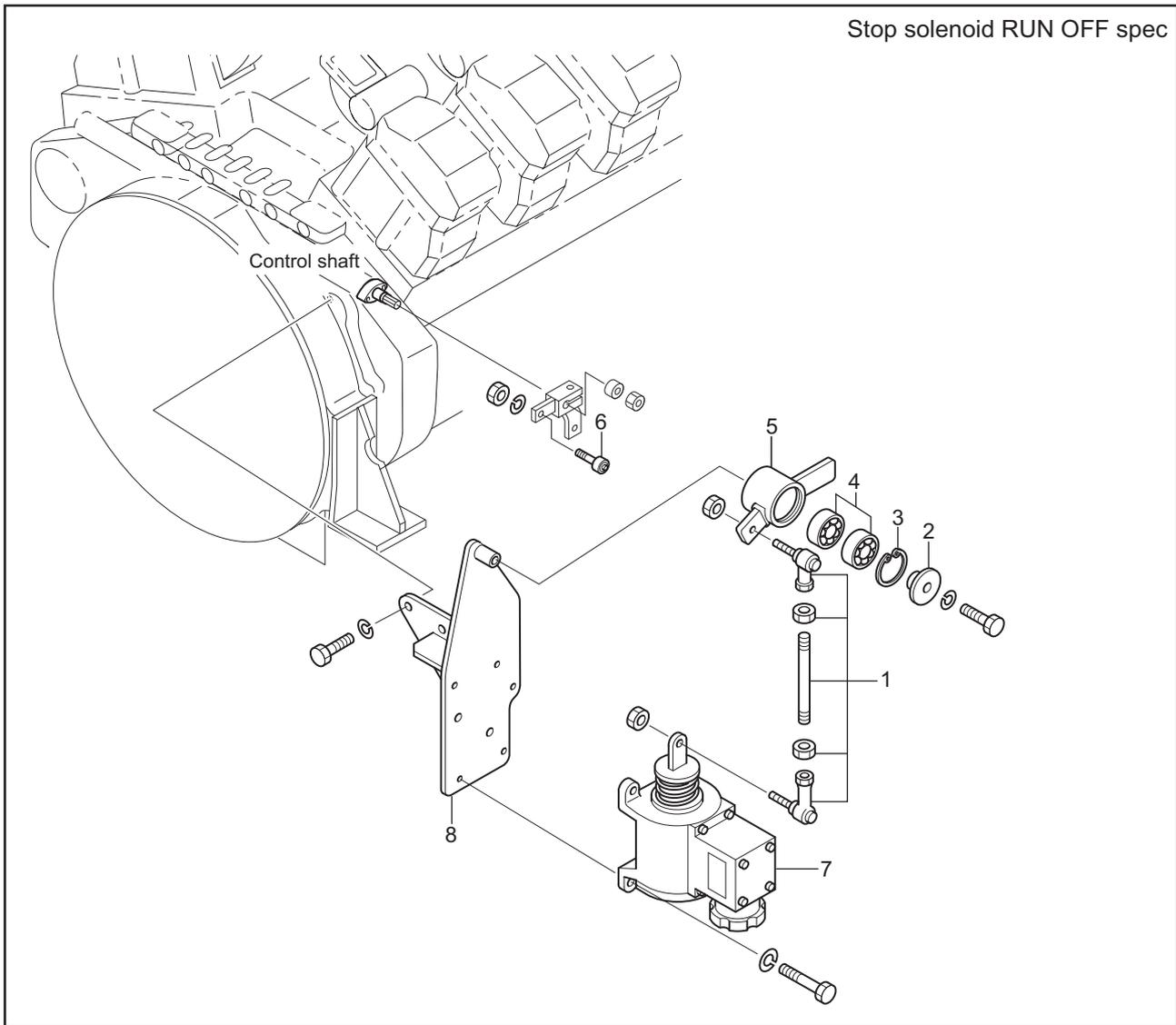


Removing sequence

- |  |   |
|--|---|
| <ul style="list-style-type: none"> <li>1 Flexible pipe</li> <li>2 Fuel pipe<br/>(Left priming pump inlet)</li> <li>3 Fuel pipe<br/>(Between left fuel filter and fuel injection pump)</li> <li>4 Fuel pipe<br/>(Between left priming pump and fuel filter)</li> <li>5 Fuel filter</li> <li>6 Fuel filter bracket</li> <li>7 Priming pump (Left)</li> </ul> | <ul style="list-style-type: none"> <li>8 Fuel pipe<br/>(Between right fuel filter and fuel injection pump)</li> <li>9 Fuel pipe<br/>(Between right priming pump and fuel filter)</li> <li>10 Fuel filter</li> <li>11 Fuel filter bracket</li> <li>12 Fuel pipe<br/>(Right priming pump inlet)</li> <li>13 Fuel pipe</li> <li>14 Priming pump (Right)</li> <li>15 Connector</li> </ul> |
|--|---|

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

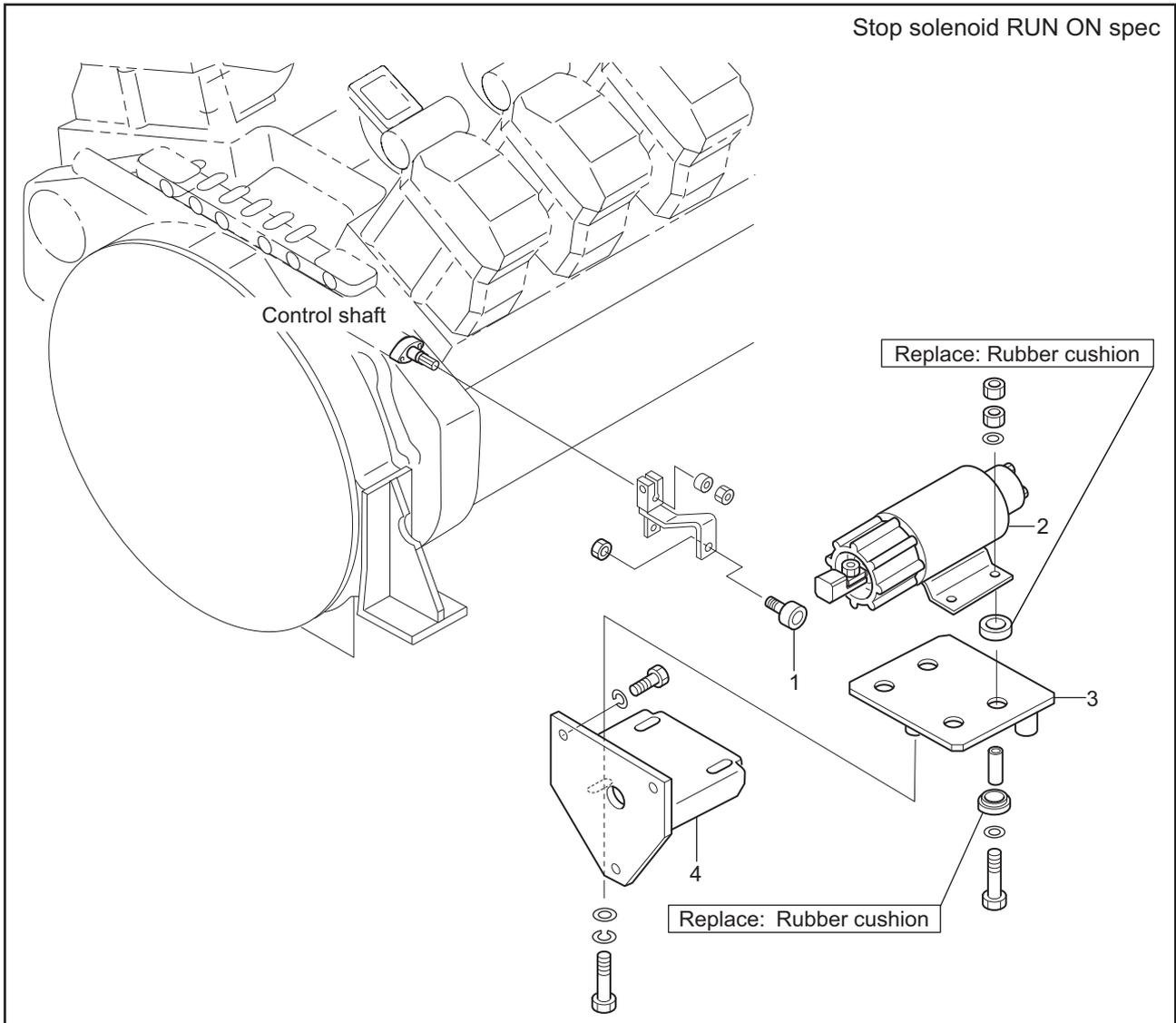
## 1.3 Stop Solenoid - Remove and Inspect



Stop Solenoid - Remove and Inspect

## Removal sequence

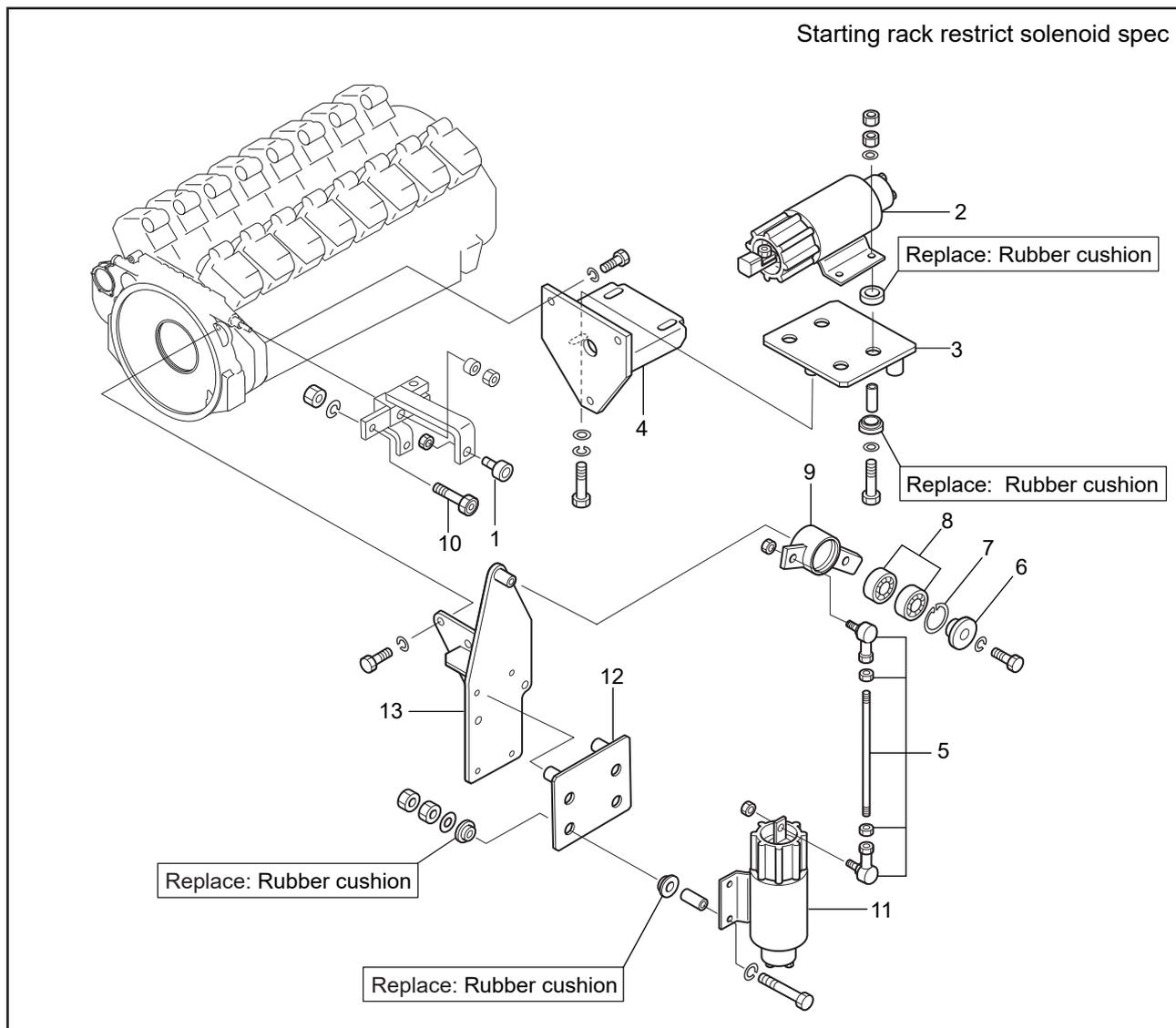
- |             |                |                 |
|-------------|----------------|-----------------|
| 1 Link      | 4 Ball bearing | 7 Stop solenoid |
| 2 End plate | 5 Stop lever   | 8 Bracket       |
| 3 Snap ring | 6 Follower     |                 |



Stop Solenoid - Remove and Inspect

Removing sequence

- |                 |           |
|-----------------|-----------|
| 1 Follower      | 3 Plate   |
| 2 Stop solenoid | 4 Bracket |

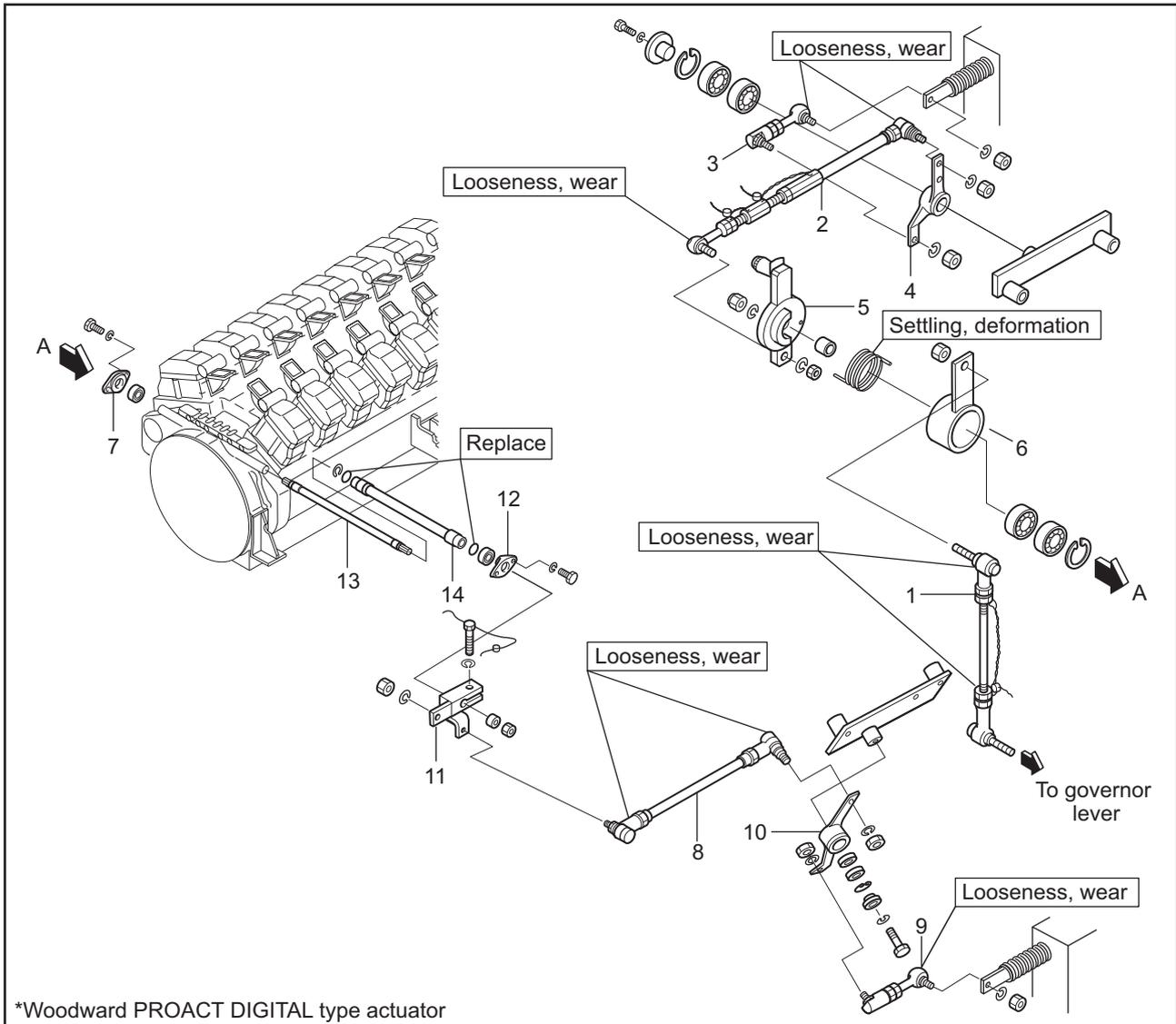


## Stop Solenoid - Remove and Inspect

## Removing sequence

- |                 |                |                                 |
|-----------------|----------------|---------------------------------|
| 1 Follower      | 6 End plate    | 11 Start rack restrict solenoid |
| 2 Stop solenoid | 7 Snap ring    | 12 Plate                        |
| 3 Plate         | 8 Ball bearing | 13 Bracket                      |
| 4 Bracket       | 9 Stop lever   |                                 |
| 5 Link          | 10 Follower    |                                 |



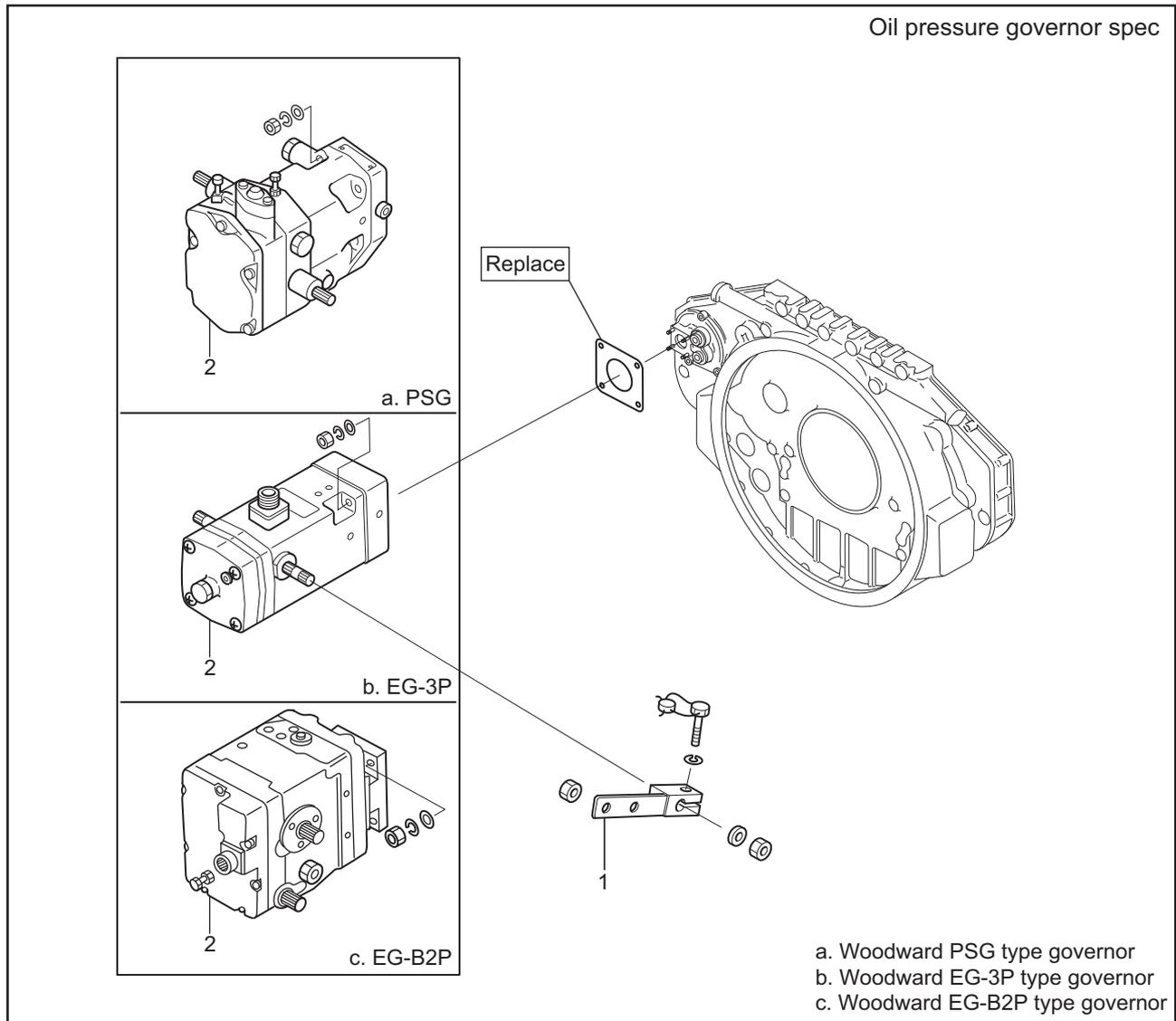


Fuel Control Link - Remove and Inspect

## Removing sequence

- |              |                 |                       |
|--------------|-----------------|-----------------------|
| 1 Left link  | 6 Left lever    | 11 Control link lever |
| 2 Left link  | 7 Bearing cover | 12 Bearing cover      |
| 3 Left link  | 8 Right link    | 13 Control shaft      |
| 4 Left lever | 9 Right link    | 14 Pipe               |
| 5 Stop lever | 10 Right lever  |                       |

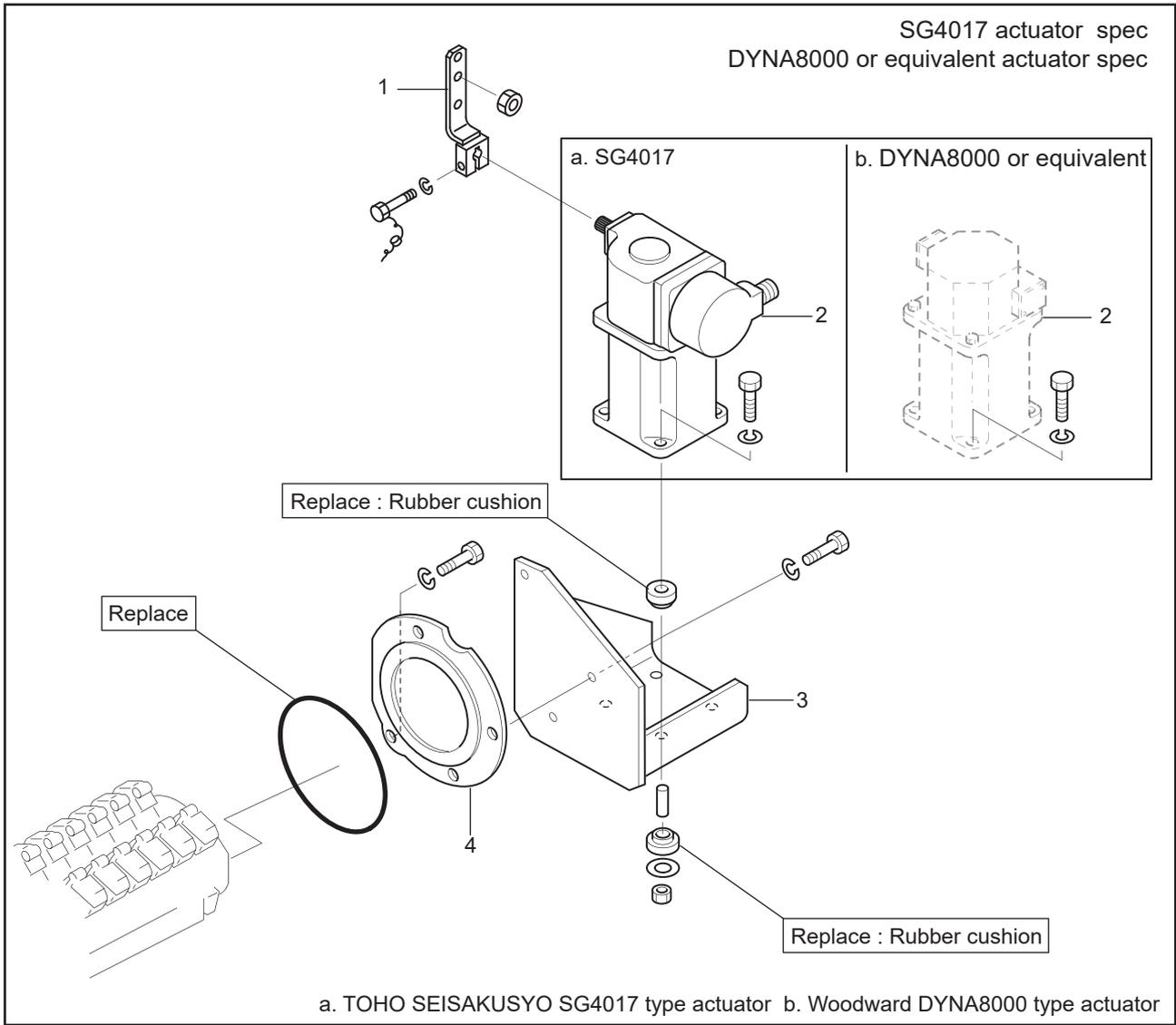
1.5 Governor and Actuator - Remove



Removing sequence

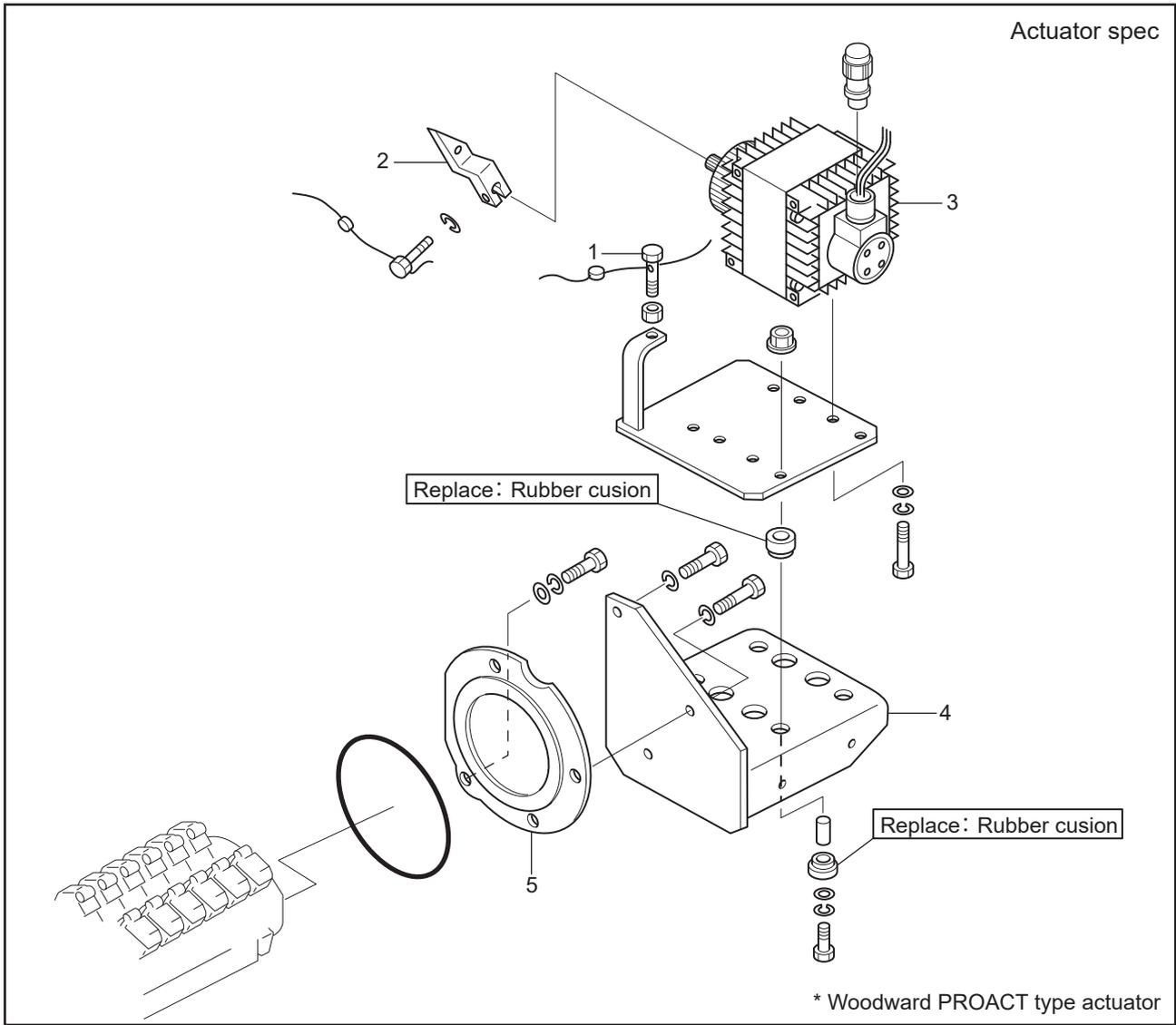
1 Governor lever

2 Governor



Removing sequence

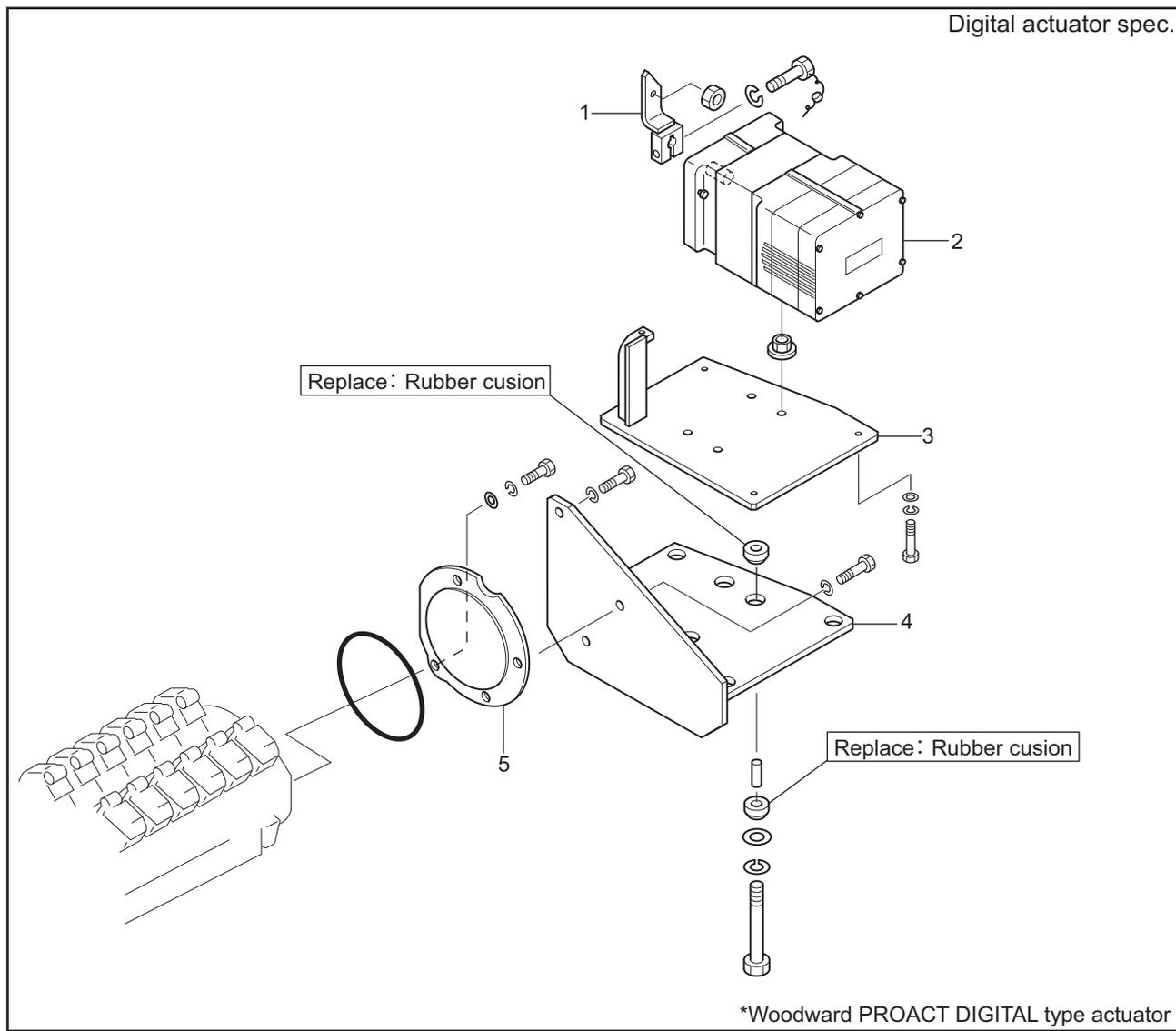
- |  |  |
|--|--|
| <ul style="list-style-type: none"> <li>1 Governor lever</li> <li>2 Actuator</li> </ul> | <ul style="list-style-type: none"> <li>3 Bracket</li> <li>4 Cover</li> </ul> |
|--|--|



Actuator - Remove and Inspect

Removing sequence

- |                  |           |
|------------------|-----------|
| 1 Stopper bolt   | 4 Bracket |
| 2 Governor lever | 5 Cover   |
| 3 Actuator       |           |

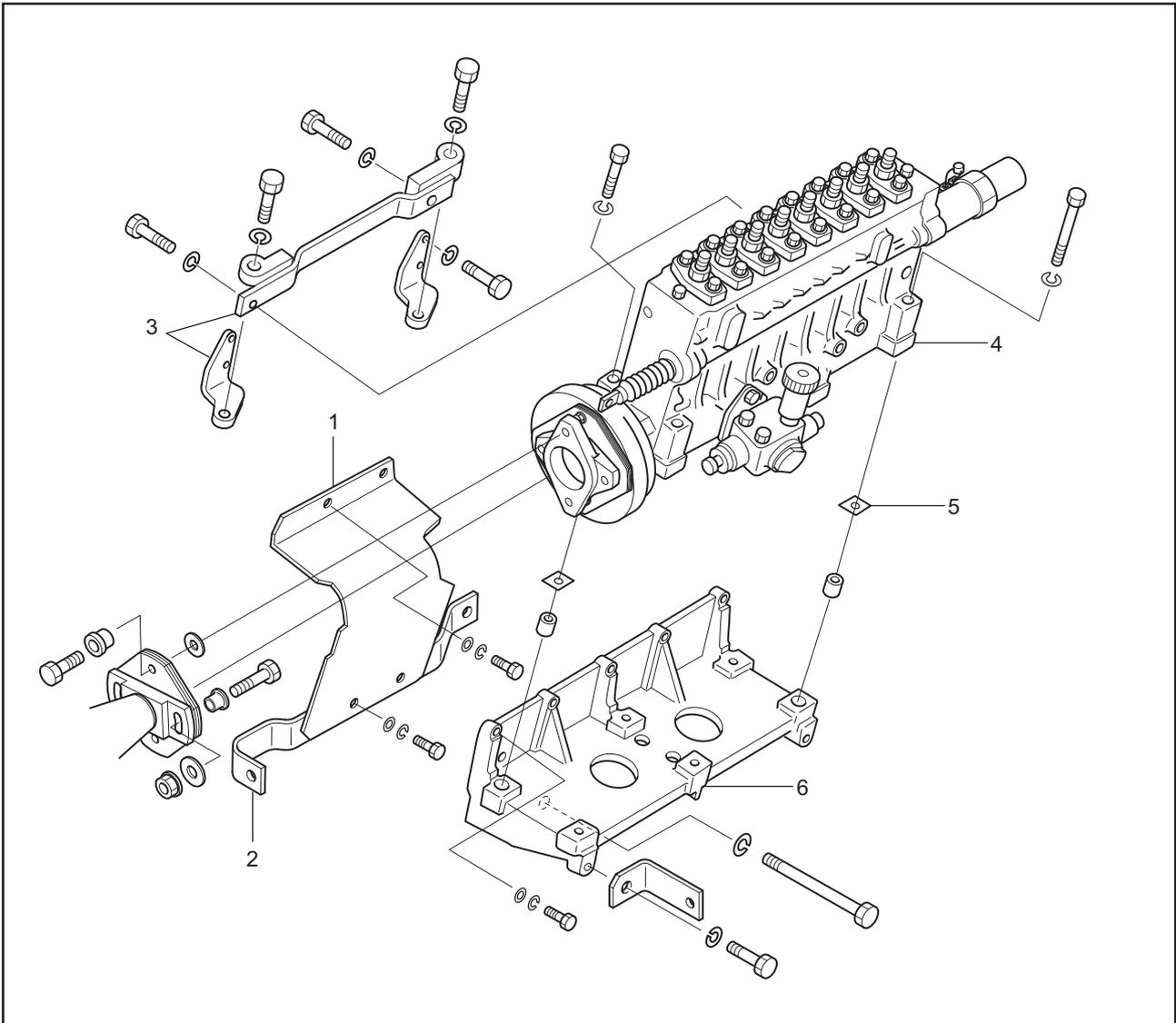


Actuator - Remove and Inspect

## Removing sequence

- |            |           |
|------------|-----------|
| 1 Lever    | 4 Bracket |
| 2 Actuator | 5 Cover   |
| 3 Plate    |           |

1.6 Fuel Injection Pump - Remove and Inspect



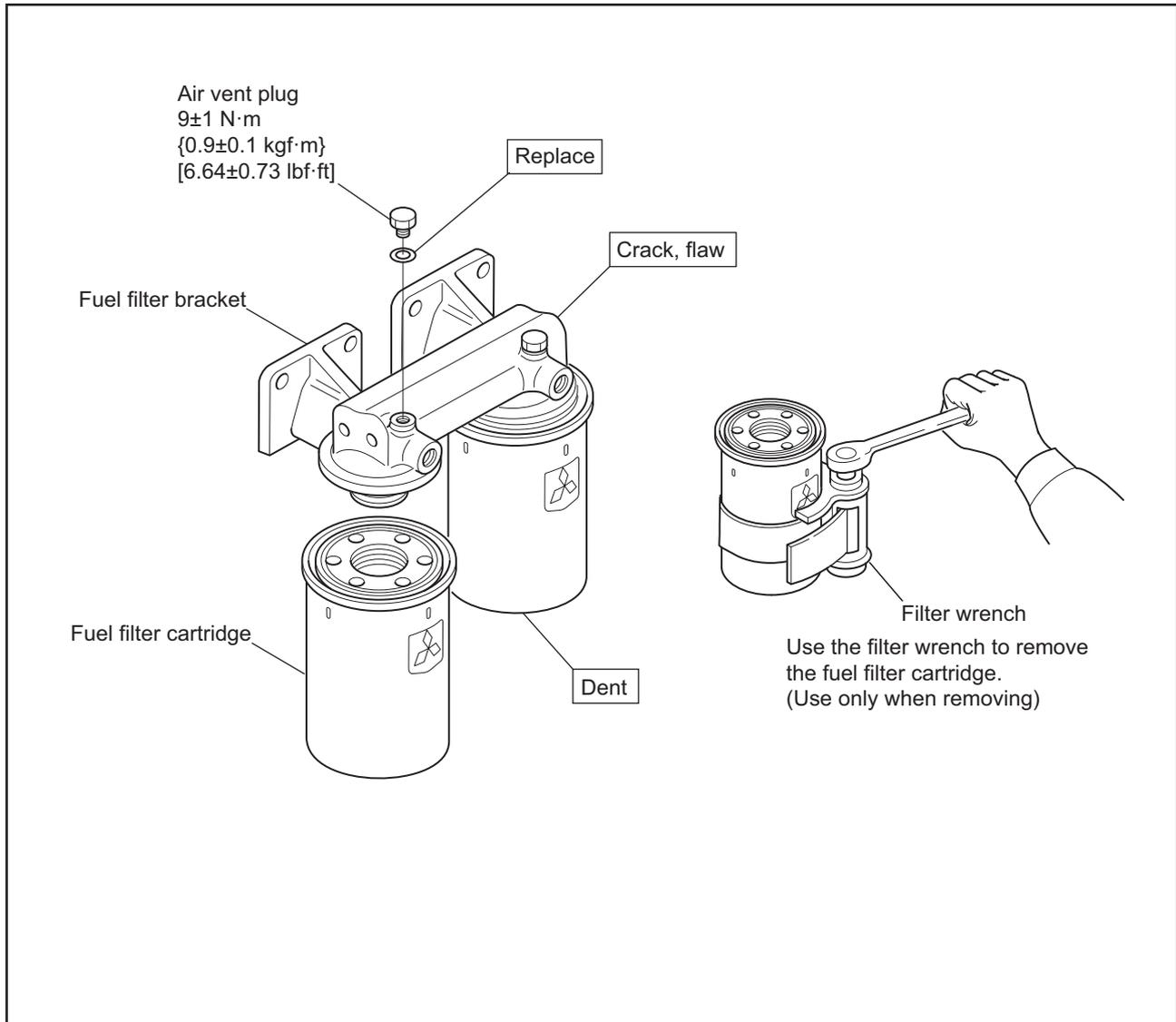
Fuel Injection Pump - Remove and Inspect

Removing sequence

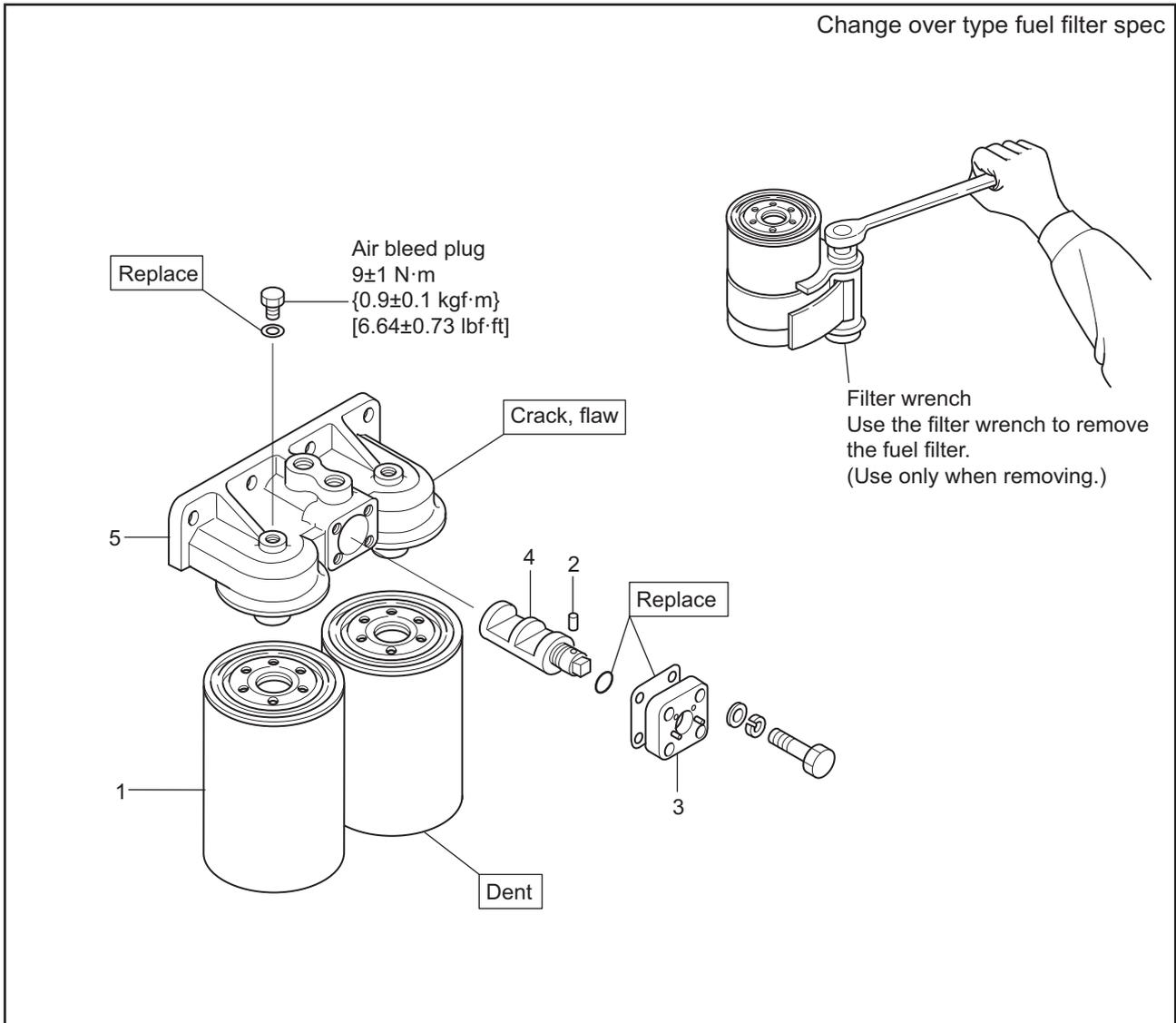
- |                  |  |
|------------------|--|
| 1 Coupling cover | 4 Fuel injection pump (approx. 68 kg [150 lb])         |
| 2 Cover stay     | 5 Shim (record the installing position and thickness.) |
| 3 Stay           | 6 Bracket  |

## 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                 |                       |

---

### 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 risk of fire.
- (c) DO NOT use the fuel filter cartridge that has a dent on the case. If the case has a dent, it can cause the damage to the fuel filter cartridge and the fuel leak during operation, and may cause a fire.

---

**CAUTION**

---

- (a) When installing the fuel filter cartridge, DO NOT use a filter wrench. Hand-tighten the cartridge.
- (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 the hand.

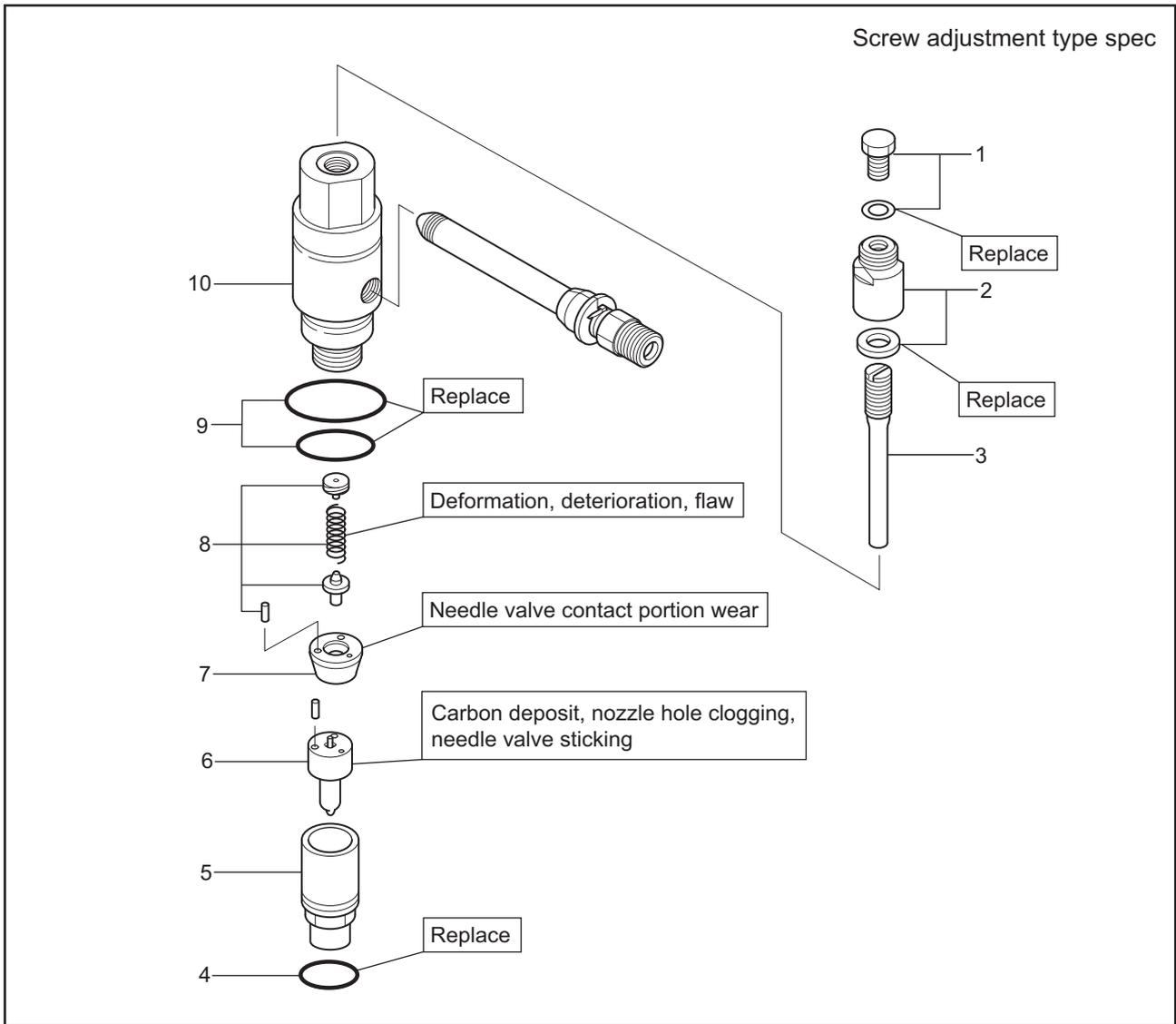
Note: After the installation, bleed air from the fuel system.

- (4) Start the engine, and make sure that there is no fuel leak.

2.2 Fuel Injection Nozzle - Disassemble and Inspect

Understanding of the current engine condition before disassembling is very important to find the cause of trouble and to perform efficient maintenance 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 Pattern - Inspect

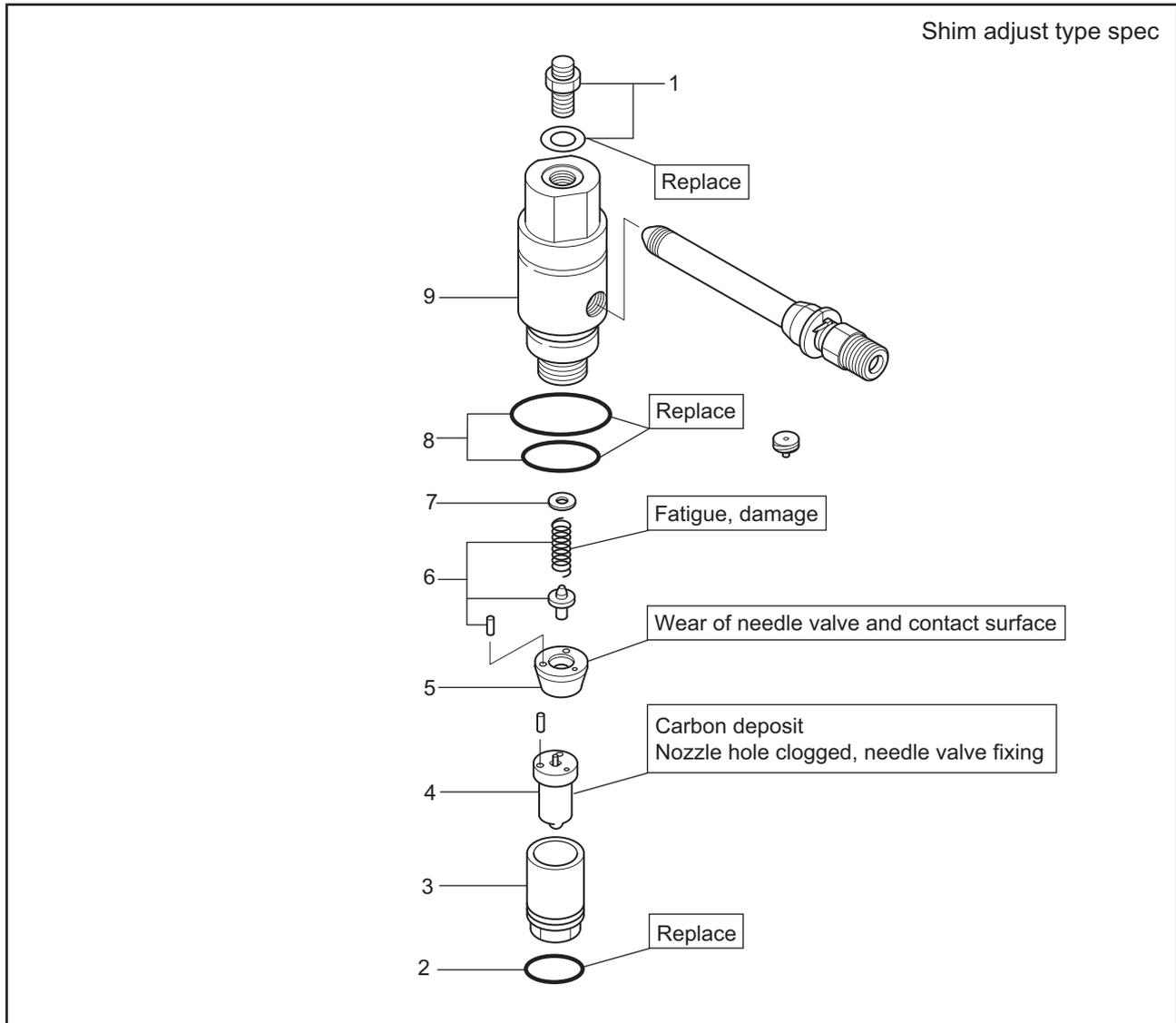


Fuel Injection Nozzle - Disassemble and Inspect

Disassembly 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

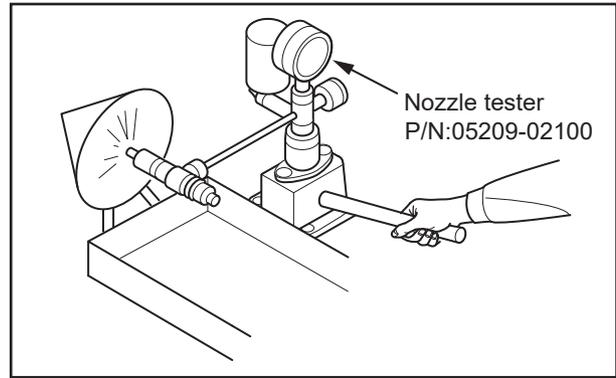
2.3.1 Fuel Injection Start Pressure - Inspect and Adjust

**CAUTION**

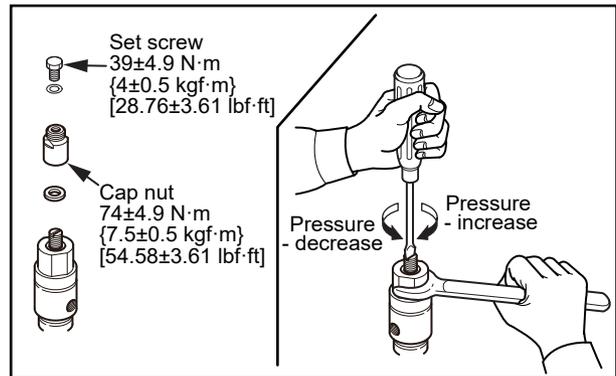
Never touch the fuel injection nozzle orifice during nozzle injection test.

(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 the 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 the adjustment, tighten the cap nut to the specified torque.
- (5) After tightening the cap nut, inspect the injection start pressure again to make sure it is within the standard value.



Fuel Injection Start Pressure - Inspect

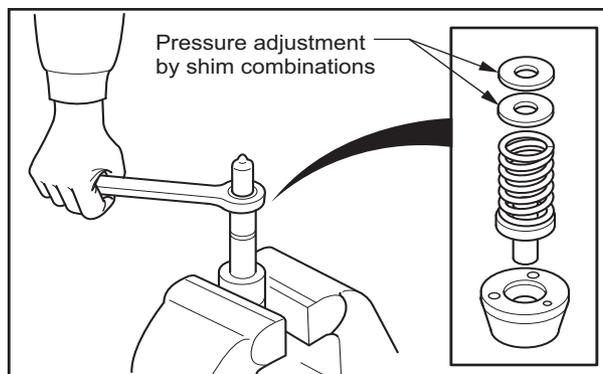


Fuel Injection Start Pressure - Adjust

Item	Nominal value	Standard value
Fuel injection starting pressure	34.3 MPa {350 kgf/cm <sup>2</sup> } [4978 psi]	34.3 to 34.8 MPa {350 to 355 kgf/cm <sup>2</sup> } [4978 to 5049 psi] (the value when it is new)

## (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 1.20 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  $186.5 \pm 9.5 \text{ N}\cdot\text{m}$  [ $19 \pm 1 \text{ kgf}\cdot\text{m}$ ] [ $137.56 \pm 7.0 \text{ lbf}\cdot\text{ft}$ ].
- (5) After tightening the retaining nut to the specified torque, inspect again the injection start pressure to see that it is as specified.



Valve Opening Pressure of Fuel Injection Nozzle -  
Adjust

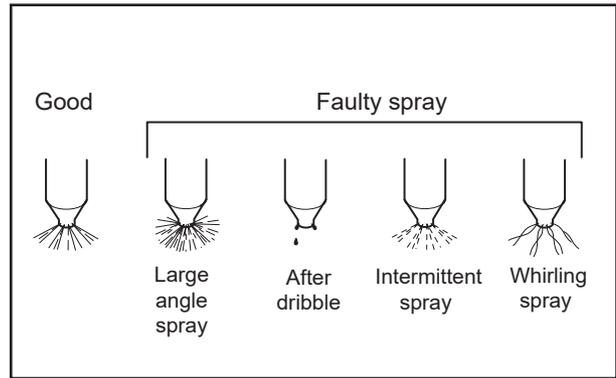
Item	Nominal value	Standard value
Fuel injection starting pressure	37860-□600□ 33.8 MPa {345 kgf/cm <sup>2</sup> } [4902 psi]	33.8 to 35.8 MPa {345 to 365 kgf/cm <sup>2</sup> } [4902 to 5192 psi] (the value when it is new)

Shim part number	Shim thickness	Valve opening pressure	
48742-□051□	0.40 mm [0.0157 in.]	-6.66 MPa	-68.0 kgf/cm <sup>2</sup> [-967 psi]
48742-□053□	0.50 mm [0.0197 in.]	-5.33 MPa	-54.4 kgf/cm <sup>2</sup> [-774 psi]
48742-□055□	0.60 mm [0.0236 in.]	-4.00 MPa	-40.8 kgf/cm <sup>2</sup> [-580 psi]
48742-□057□	0.70 mm [0.276 in.]	-2.67 MPa	-27.2 kgf/cm <sup>2</sup> [-387 psi]
48742-□059□	0.80 mm [0.0315 in.]	-1.33 MPa	-13.6 kgf/cm <sup>2</sup> [-193 psi]
48742-□061□	0.90 mm [0.0354 in.]	0.0 (Standard)	0.0 (Standard)
48742-□063□	1.00 mm [0.0394 in.]	1.33 MPa	13.6 kgf/cm <sup>2</sup> [193 psi]
48742-□065□	1.10 mm [0.0433 in.]	2.67 MPa	27.2 kgf/cm <sup>2</sup> [387 psi]
48742-□067□	1.20 mm [0.0472 in.]	4.00 MPa	40.8 kgf/cm <sup>2</sup> [580 psi]

2.3.2 Fuel Injection Nozzle Spray Pattern - Inspect

When adjusting the nozzle opening pressure with the nozzle tester, inspect the nozzle orifice clogging, fuel spray pattern or check if fuel is dripping. If the spray pattern is faulty, clean or replace the nozzle tip. Checking points of the fuel spray pattern are as follows:

- Injection spray shall be straight.
- The spray condition shall be of fine fuel droplets without big drops.
- No dripping is after injection.



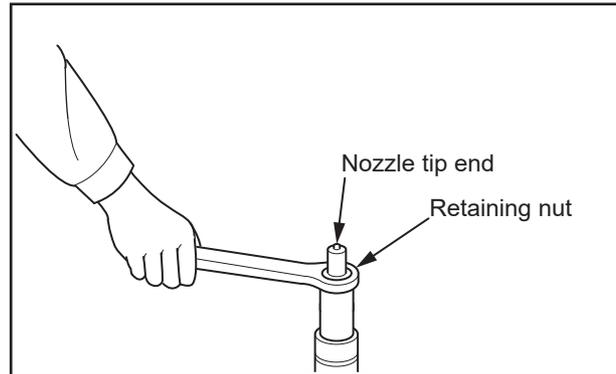
Fuel Injection Nozzle Spray Pattern - Inspect

2.3.3 Nozzle Tip - Clean and Replace

**CAUTION**

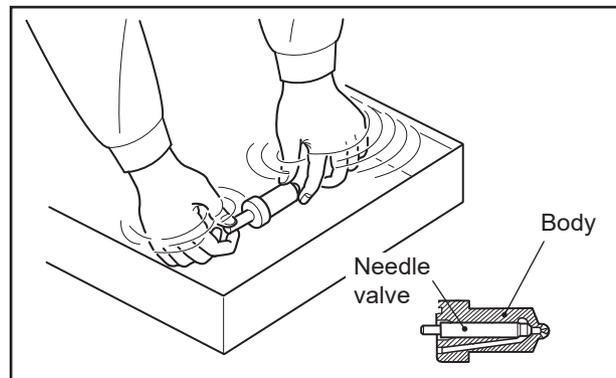
- (a) Be careful not to hit the nozzle tip point.
- (b) The needle valve and body are precision parts. Handle them carefully, and do not change the original valve and body combination.

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



Nozzle Tip - Remove

- (3) Clean the needle valve and the body of nozzle tip. When cleaning the needle valve and the nozzle tip body, use clean wash oil. Assemble the needle valve and the 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 in clean diesel fuel before installation.

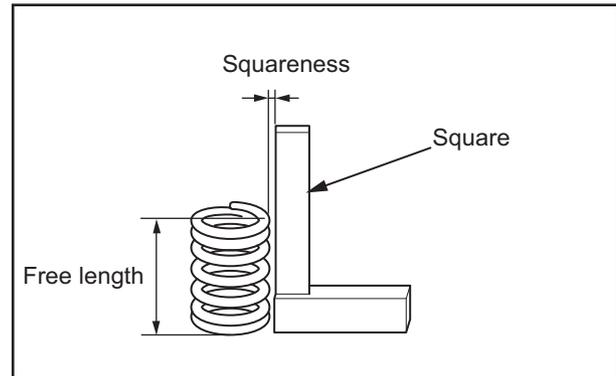


Nozzle Tip - Clean

**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	Standard value
Free length	30 mm [1.18 in.]
Squareness	0.6 mm [0.024 in.] or less
Parallelism of top and bottom surfaces	0.1 mm [0.004] or less

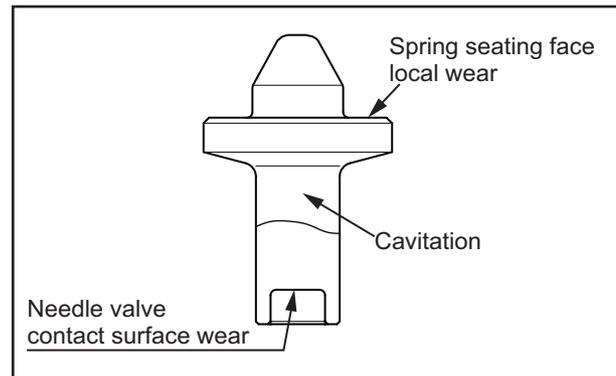
Note: When the nozzle tip is replaced, replace the spacer and the nozzle spring with new ones.



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 the needle valve contact surface wears remarkably, or the cavitation occurs under the tapered area, replace the push rod with a new one.

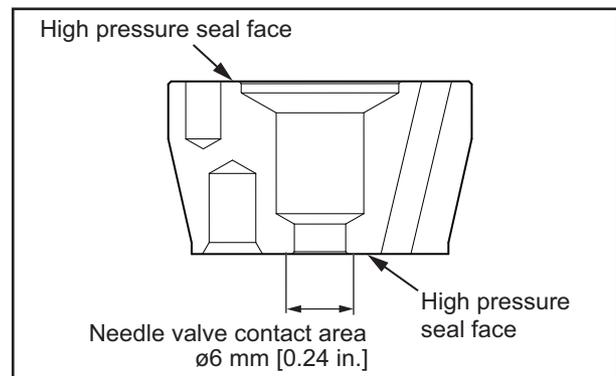


Push Rod - Inspect

### 2.3.6 Spacer - Inspect

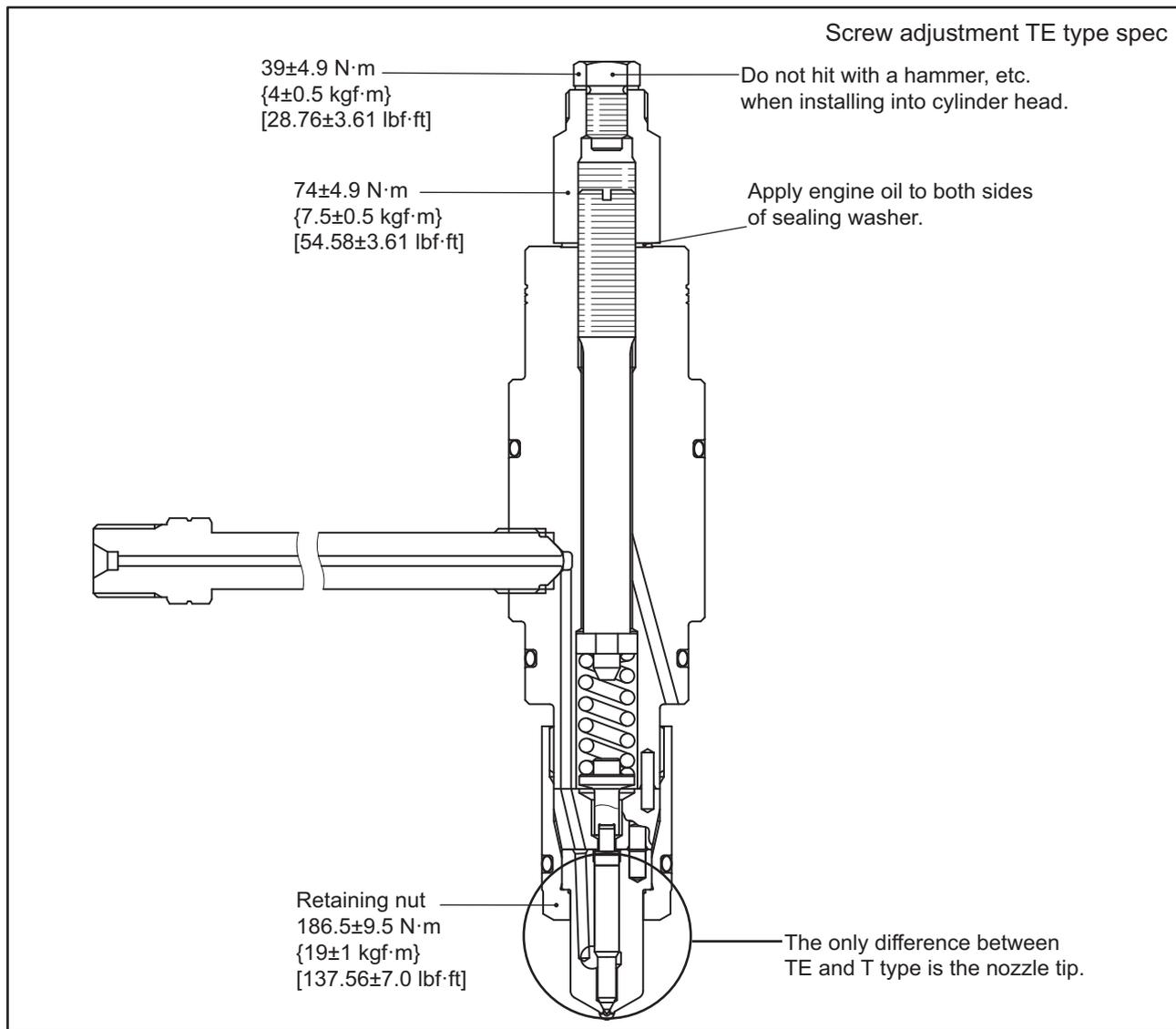
Inspect the spacer visually. If its needle valve contact surface or the high pressure seal surface wears remarkably, replace the spacer with a new one.

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



Spacer - Inspect

2.4 Fuel Injection Nozzle - Assemble

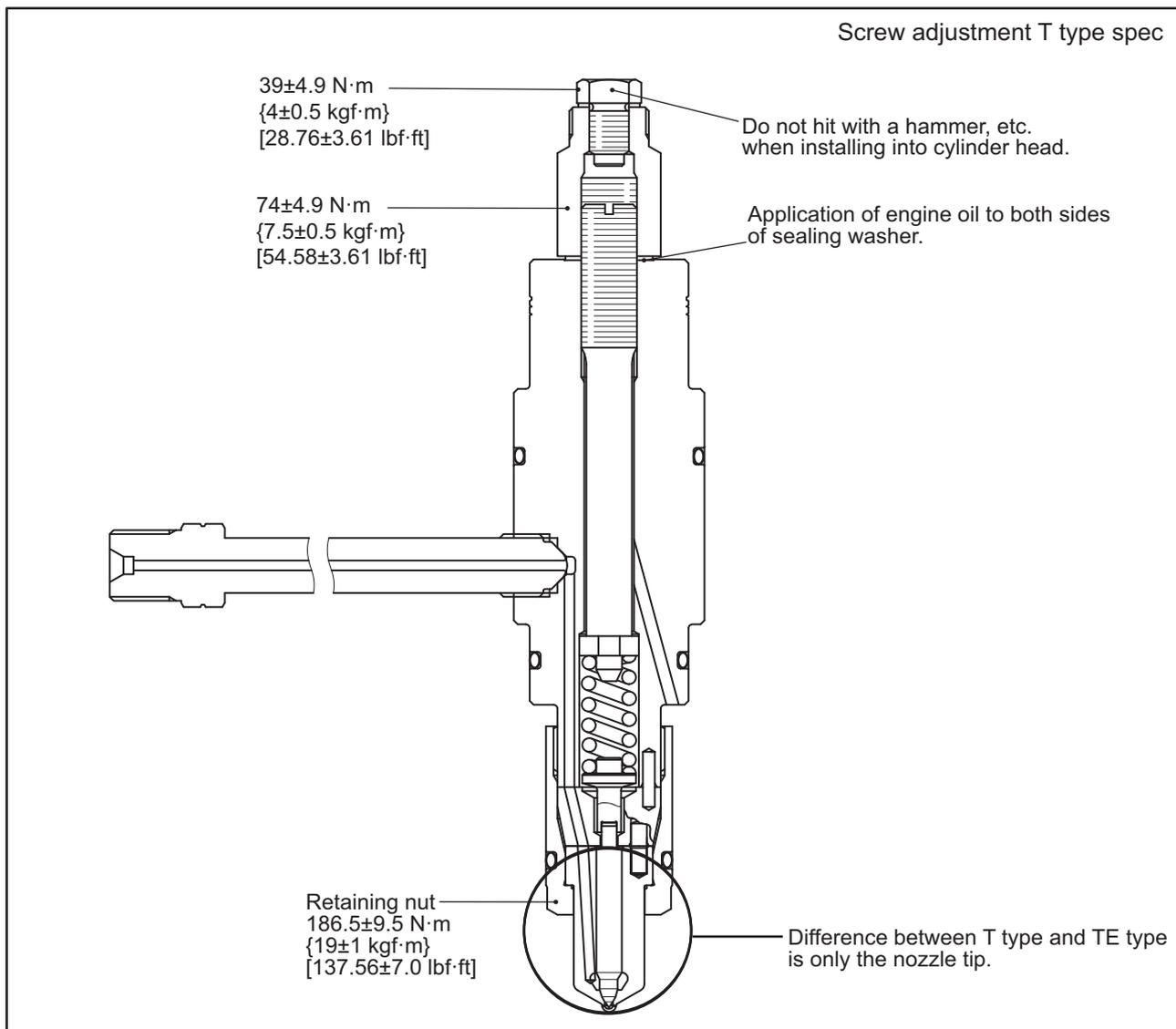


Fuel Injection Nozzle - Assemble

**CAUTION**

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

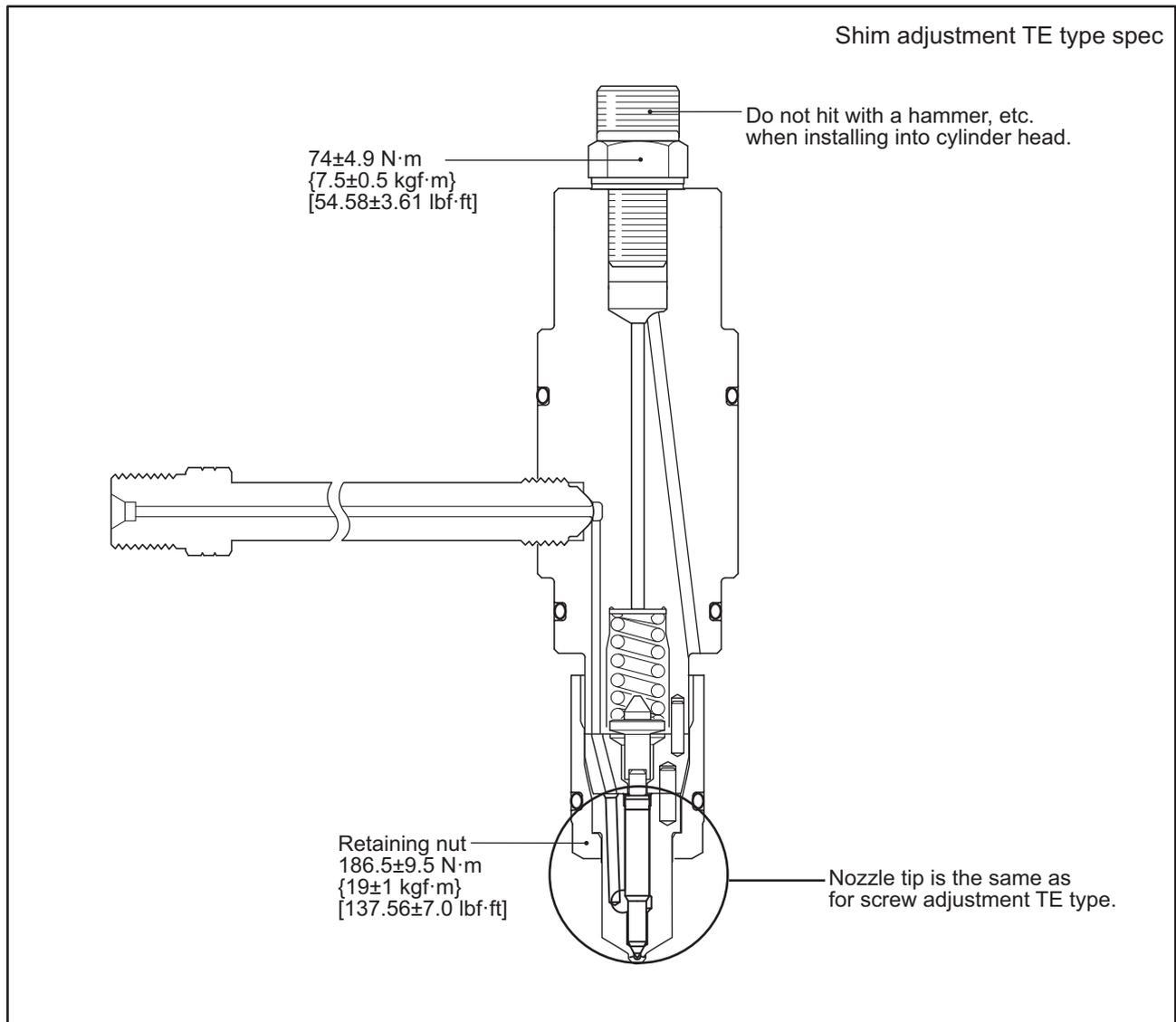
Note: When assembling the nozzle tip on the nozzle holder, make sure to align the nozzle tip knock pin with the nozzle holder hole.



### CAUTION

Be sure to tighten the retaining nut to the specified torque. The 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.



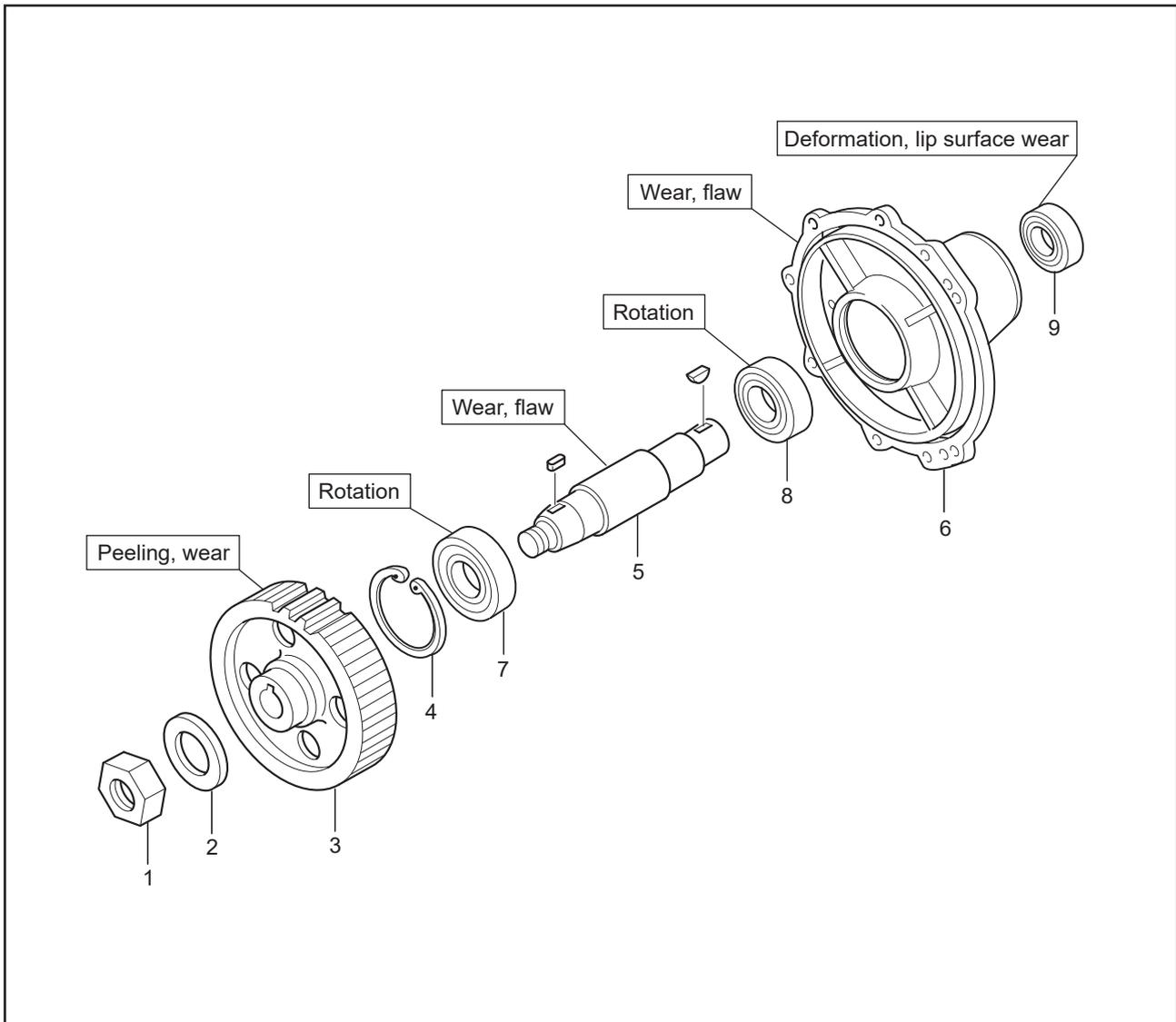
Fuel Injection Nozzle - Assemble

**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.

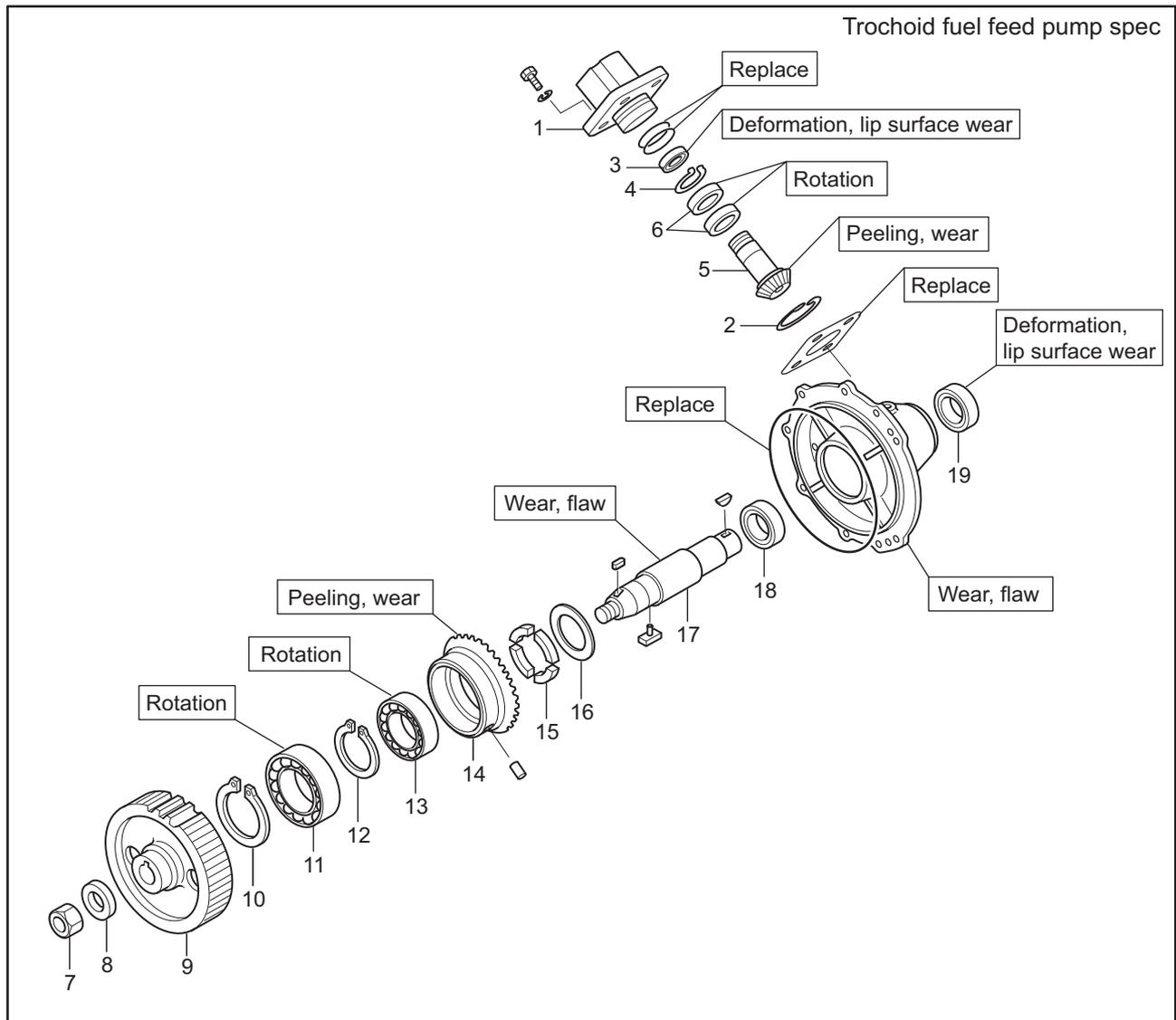
## 2.5 Fuel Injection Pump Accessory Drive - Disassemble and Inspect



Fuel Injection Pump Accessory Drive - Disassemble and Inspect

## Disassembly 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 |



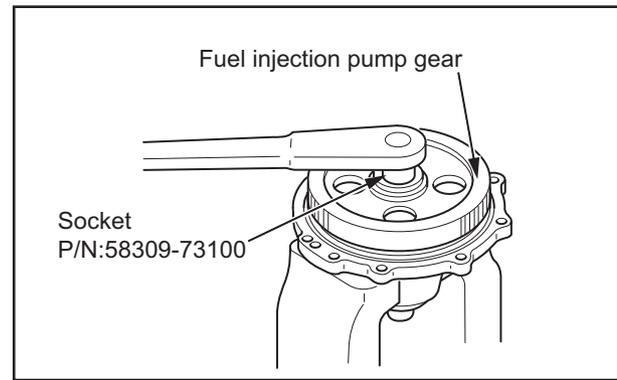
Fuel Injection Pump Accessory Drive - Disassemble and Inspect

Disassembling sequence

- |                |                            |               |
|----------------|----------------------------|---------------|
| 1 Coupling     | 8 Washer                   | 14 Drive gear |
| 2 Snap ring    | 9 Fuel injection pump gear | 15 Rubber     |
| 3 Oil seal     | 10 Snap ring               | 16 Washer     |
| 4 Snap ring    | 11 Bearing                 | 17 Shaft      |
| 5 Driven shaft | 12 Snap ring               | 18 Bearing    |
| 6 Bearing      | 13 Bearing                 | 19 Oil seal   |
| 7 Nut          |                            |               |

## 2.6 Outside Diameter and Inside Diameter of Accessory Drive Bearing Fitting Faces - 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.



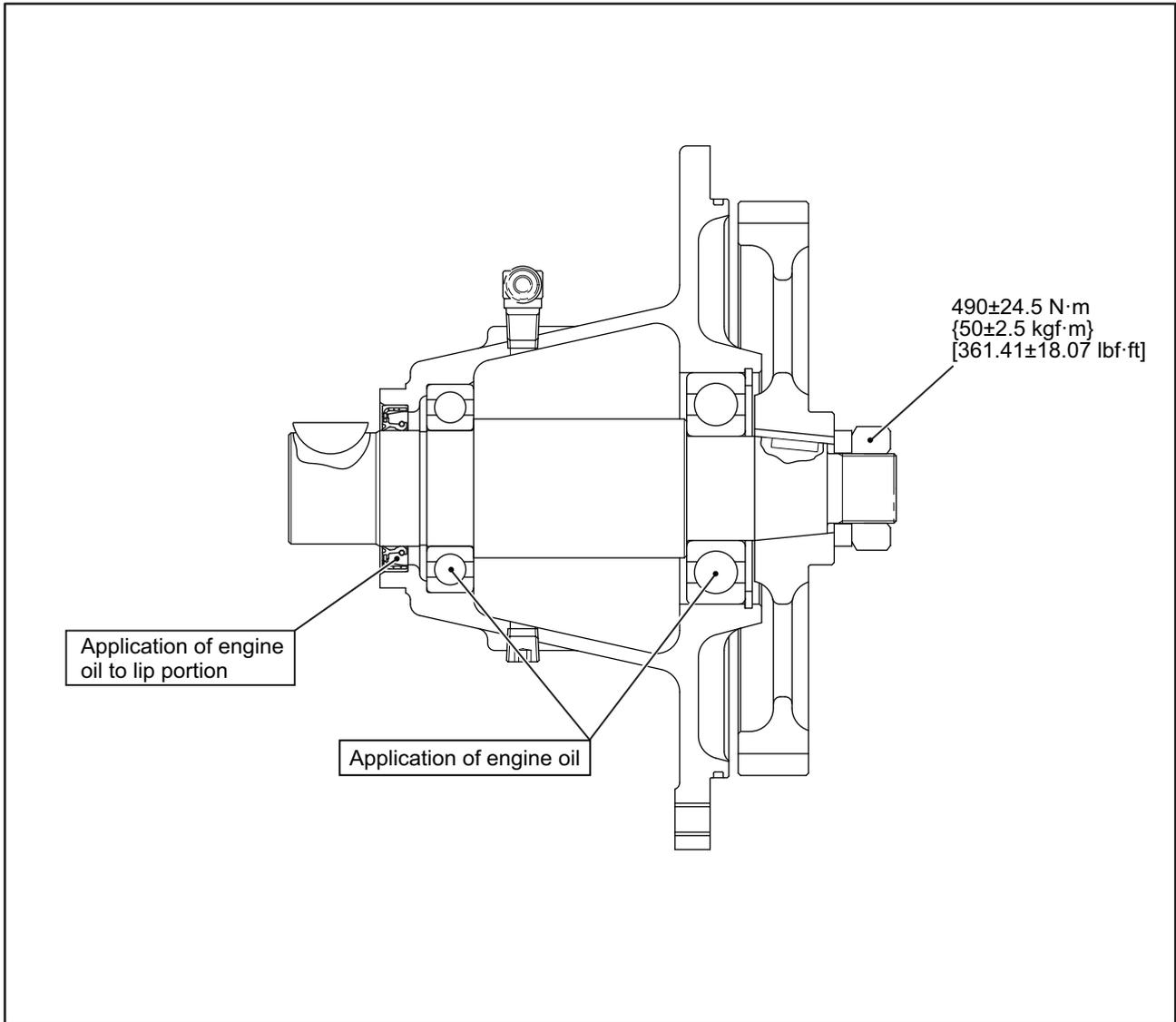
Fuel Injection Pump Gear - Remove

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.]
Bearing for fuel injection pump drive shaft	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.]

(Trochoid fuel feed pump)

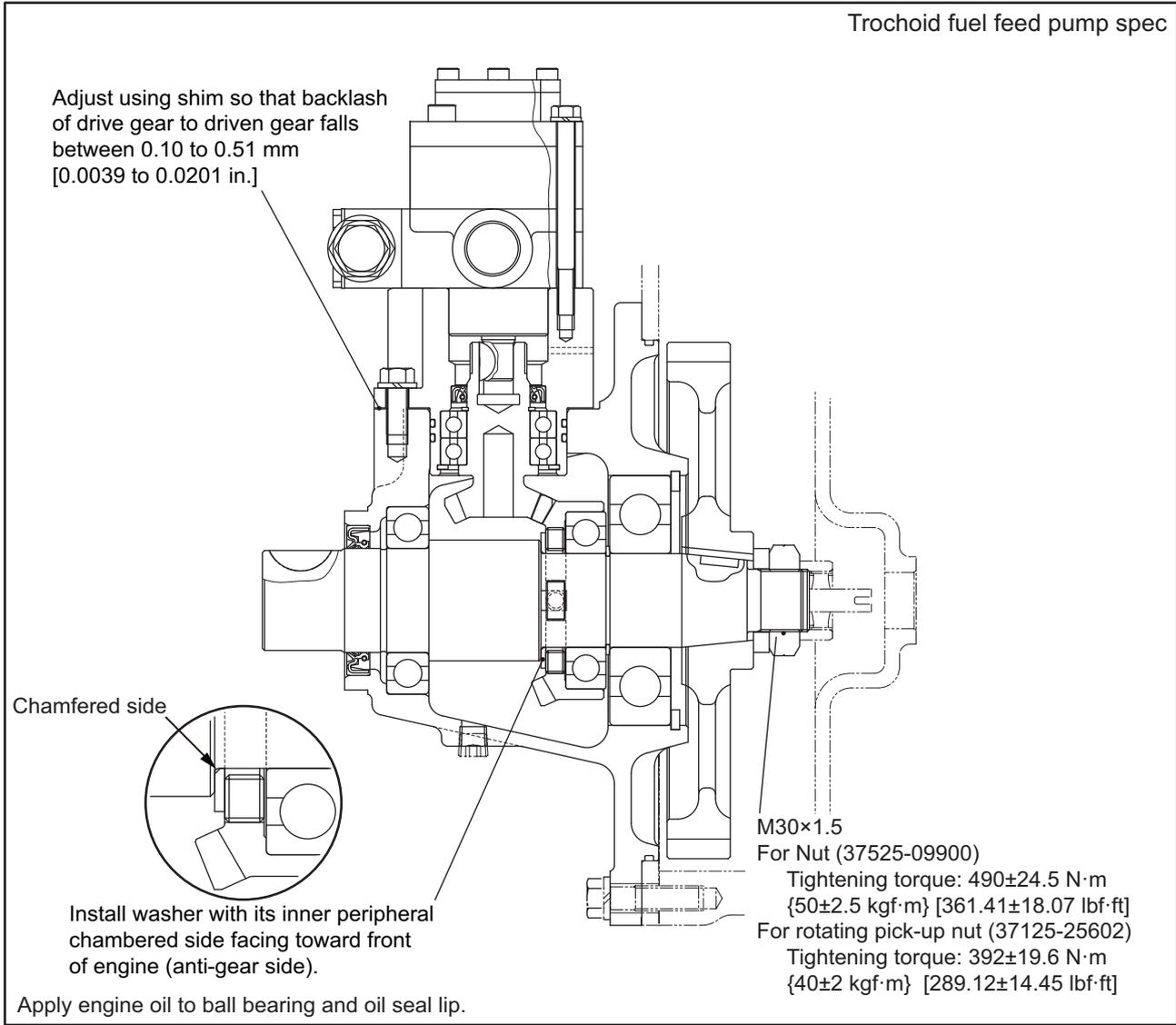
Item			Nominal value	Standard value
Inside diameter of case bearing housing			ø90 mm [3.54 in.]	89.987 to 90.022 mm [3.5428 to 3.5442 in.]
			ø120 mm [4.72 in.]	119.987 to 120.022 mm [4.7239 to 4.7253 in.]
Bearing for fuel injection pump drive shaft	Outside diameter	Small	ø90 mm [3.54 in.]	89.985 to 90.000 mm [3.5427 to 3.5433 in.]
		Large	ø120 mm [4.72 in.]	119.985 to 120.000 mm [4.7238 to 4.7244 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.]
Drive gear	Inside diameter of bearing fit		ø85 mm [3.35 in.]	84.955 to 84.990 mm [3.3447 to 3.3461 in.]
	Bearing	Outside diameter	ø85 mm [3.35 in.]	84.985 to 85.000 mm [3.3459 to 3.3465 in.]
		inside diameter	ø45 mm [1.77 in.]	44.988 to 45.000 mm [1.7712 to 1.7717 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.]
Driven gear	Inside diameter of bearing fit		ø55 mm [2.17 in.]	54.988 to 55.018 mm [2.1649 to 2.1661 in.]
	Bearing	Outside diameter	ø55 mm [2.17 in.]	54.987 to 55.000 mm [2.1648 to 2.1654 in.]
		inside diameter	ø30 mm [1.18 in.]	29.990 to 30.000 mm [1.1807 to 1.1811 in.]
	Outside diameter of drive shaft bearing fit		ø30 mm [1.18 in.]	30.002 to 30.011 mm [1.1812 to 1.1815 in.]

2.7 Fuel Injection Pump Accessory Drive - Assemble



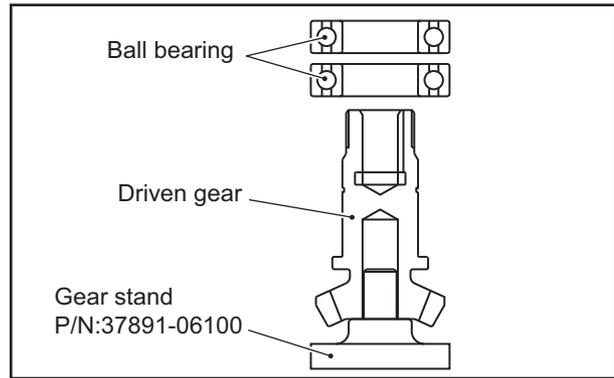
Fuel Injection Pump Accessory Drive - Assemble

## Trochoid fuel feed pump spec



2.7.1 Ball bearing press-fit to driven gear  
(Trochoid fuel feed pump)

Attach the gear stand to the driven gear when press-fit the ball bearing to the gear.



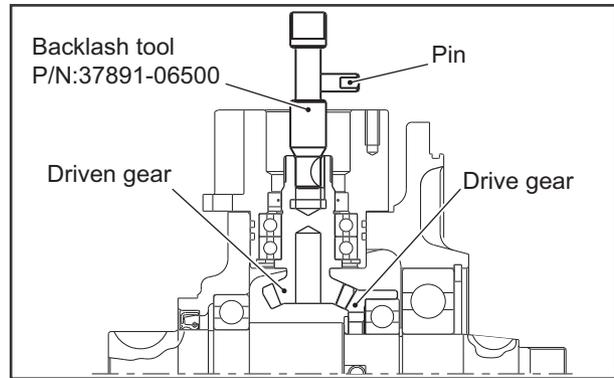
Ball bearing press-fit to driven gear

2.7.2 Backlash Between Drive Gear and Driven Gear  
- Measure (Trochoid Fuel Feed Pump)

Note: When the driven gear is pressed hard against the drive gear, the cushion rubber is deformed, and the backlash is measured larger than it actually is.

When reading the dial gauge, hold the cushion rubber intact by releasing the backlash tool.

- (1) Attach the backlash tool to the driven gear.
- (2) Apply a dial gauge to the backlash tool pin, and measure the backlash between drive gear and driven gear.
- (3) If the measured backlash is out of standard values, adjust the backlash by inserting a shim between the coupling and accessory drive.

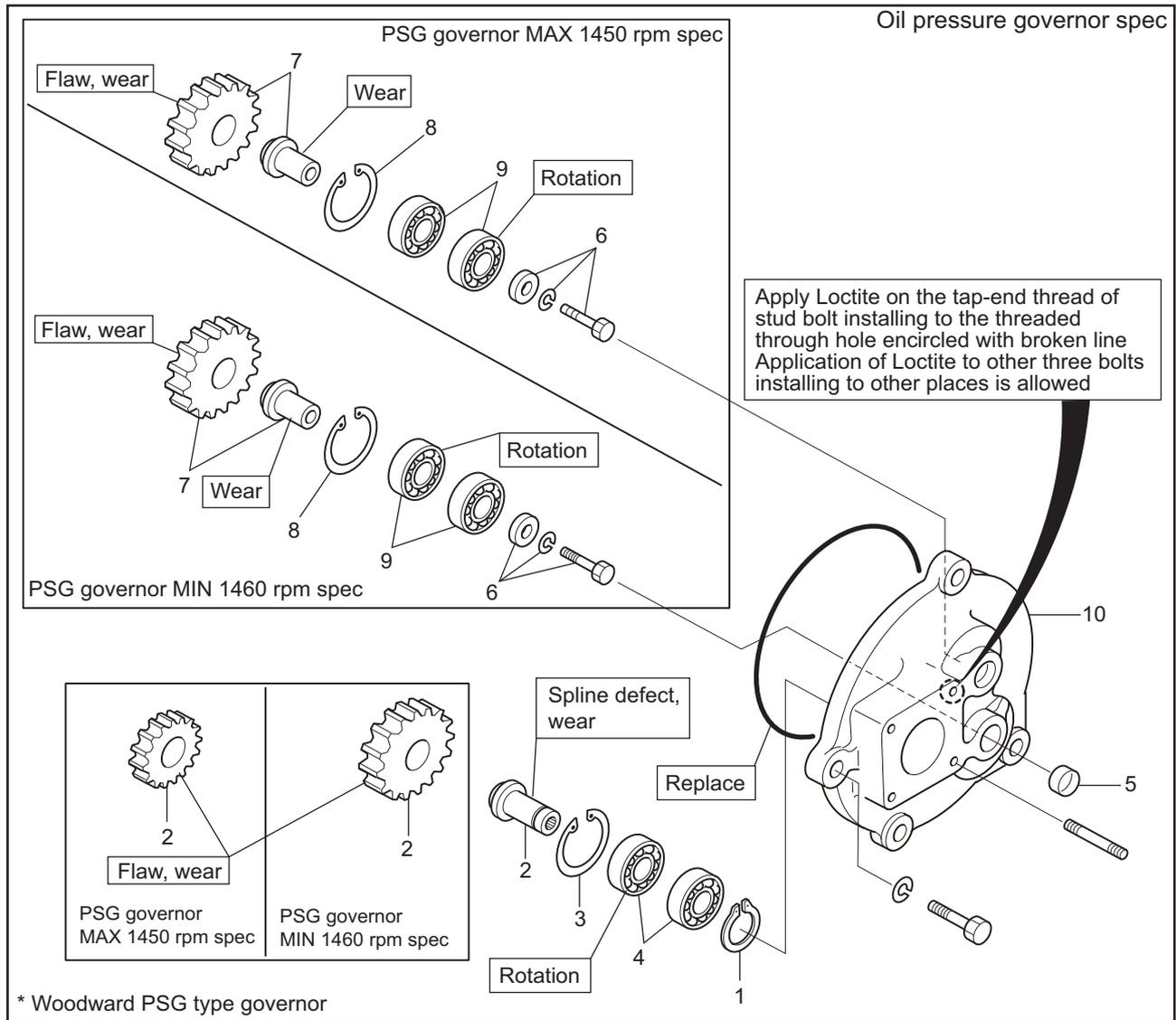


Drive Gear and Driven Gear Backlash - Measure

Item	Standard value
Backlash between drive gear and driven gear	0.10 to 0.51 mm [0.0039 to 0.0201 in.]

Shim thickness	Part No.
0.1 mm [0.004 in.]	37725-□891□
0.3 mm [0.0118 in.]	37725-□892□
0.5 mm [0.020 in.]	37725-□893□
1.0 mm [0.040 in.]	37725-□894□

## 2.8 Governor Drive - Disassemble and Inspect

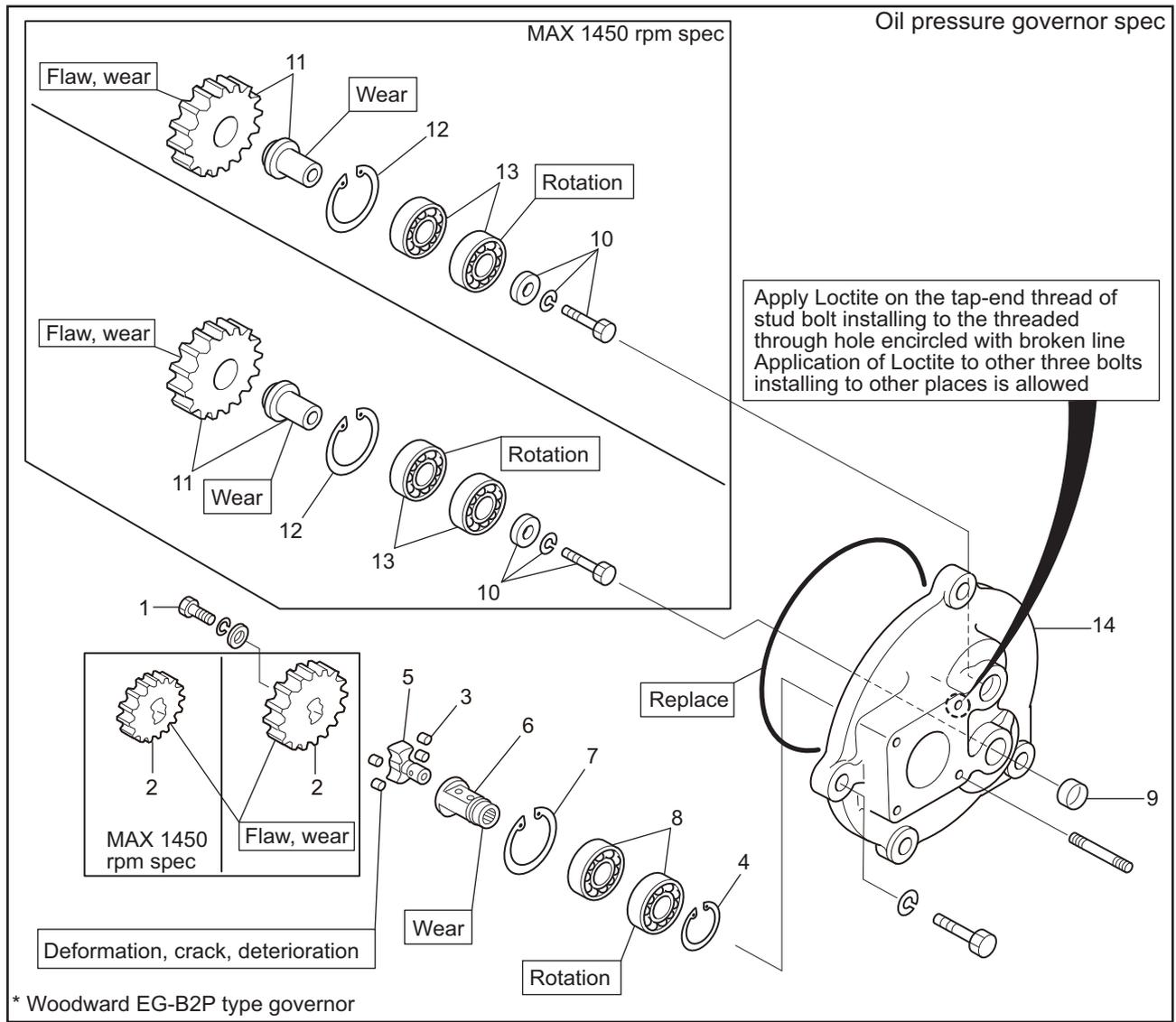


## Governor Drive - Disassemble and Inspect

## Disassembly sequence

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

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



\* Woodward EG-B2P type governor

Governor Drive - Disassemble and Inspect

Disassembling Sequence

- |              |                 |                            |
|--------------|-----------------|----------------------------|
| 1 Bolt       | 5 Drive shaft A | 10 Bolt, washer            |
| 2 Drive gear | 6 Drive shaft B | 11 Idler gear, idler shaft |
| 3 Rubber     | 7 Snap ring     | 12 Snap ring               |
| 4 Snap ring  | 8 Bearing       | 13 Bearing                 |
|              | 9 Sealing cap   | 14 Drive case              |

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

## 2.9 Outside Diameter and Inside Diameter of Bearing Fitting Faces

(Oil pressure governor spec)

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

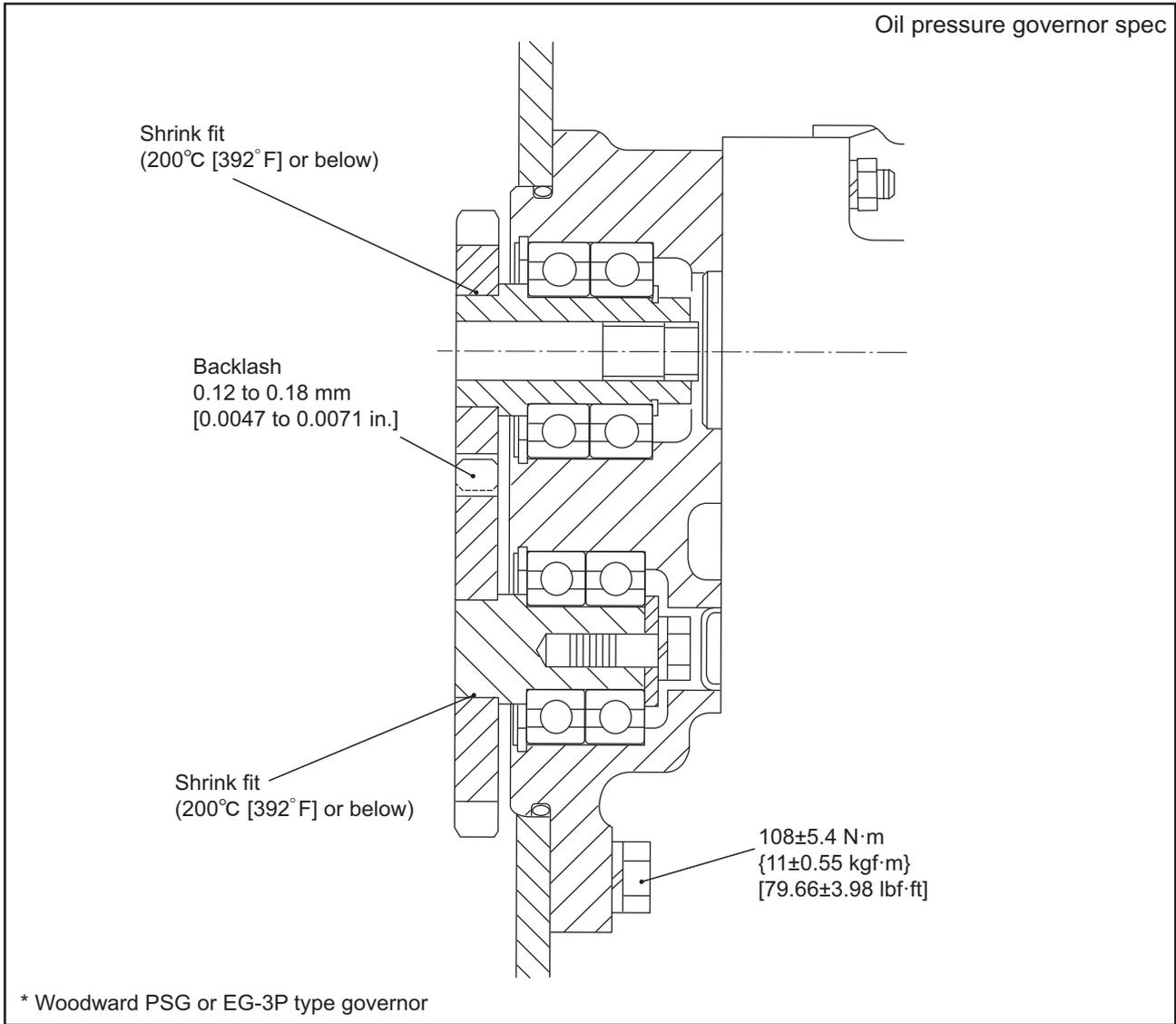
Inspect the fit of drive shaft, idler shaft and bearing. If significant wear is found, replace them with new ones.

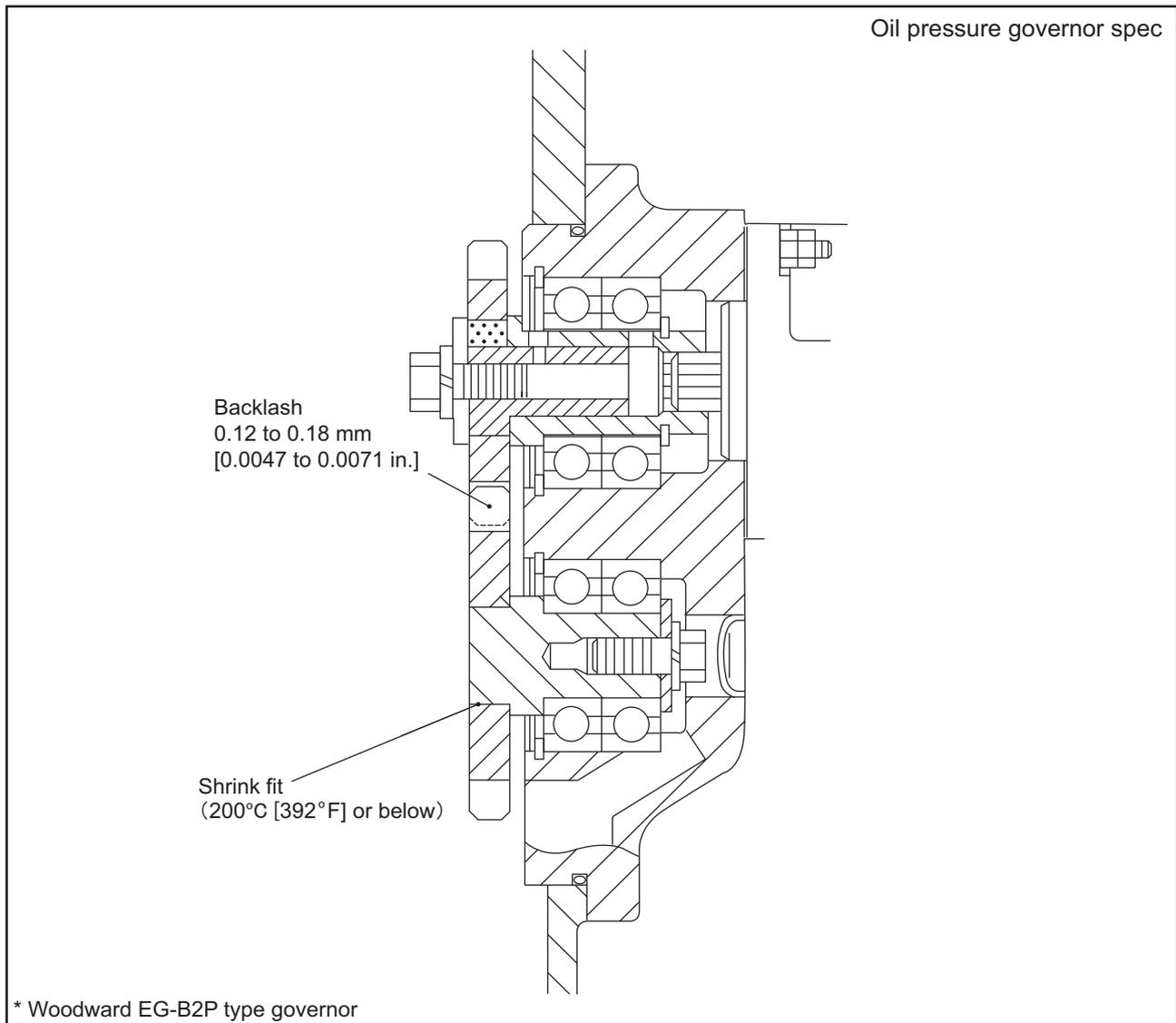
Inspect the fit of drive case and bearing. If significant wear is found, replace them with new ones.

Item		Nominal value	Standard value		
Outside Diameter and Inside Diameter of Bearing Fit	Common	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	ø52 mm [2.05 in.]	51.987 to 52.000 mm [2.0467 to 2.0472 in.]
			Inside diameter	ø25 mm [0.98 in.]	24.990 to 25.000 mm [0.9843 to 0.9847 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	ø47 mm [1.85 in.]	46.989 to 47.000 mm [1.8500 to 1.8504 in.]
			Inside diameter	ø20 mm [0.79 in.]	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 to 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.]	
	PSG EG-3P	Outside diameter of drive shaft bearing fit		ø25 mm [0.98 in.]	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.]
	EG-B2P	Outside diameter of drive shaft A gear fit		ø29 mm [1.14 in.]	28.959 to 28.980 mm [1.1401 to 1.1409 in.]
		Outside diameter of drive shaft B bearing fit		ø25 mm [0.98 in.]	24.987 to 25.000 mm [0.9837 to 0.9843 in.]
		Inside diameter of drive gear fit		ø29 mm [1.14 in.]	29.000 to 29.040 mm [1.1417 to 1.1433 in.]
Outside diameter of drive shaft A shrinkage fit		ø29 mm [1.14 in.]	28.959 to 28.980 mm [1.1401 to 1.1409 in.]		
Inside diameter of drive shaft B shrinkage fit		ø17 mm [0.67 in.]	17.000 to 17.018 mm [0.6693 to 0.6700 in.]		

\* Woodward PSG, EG-3P and EG-B2P type governors

2.10 Governor Drive - Assemble





Governor Drive - Assemble

### 2.10.1 Drive Gear and Idler Gear Backlash - Measure

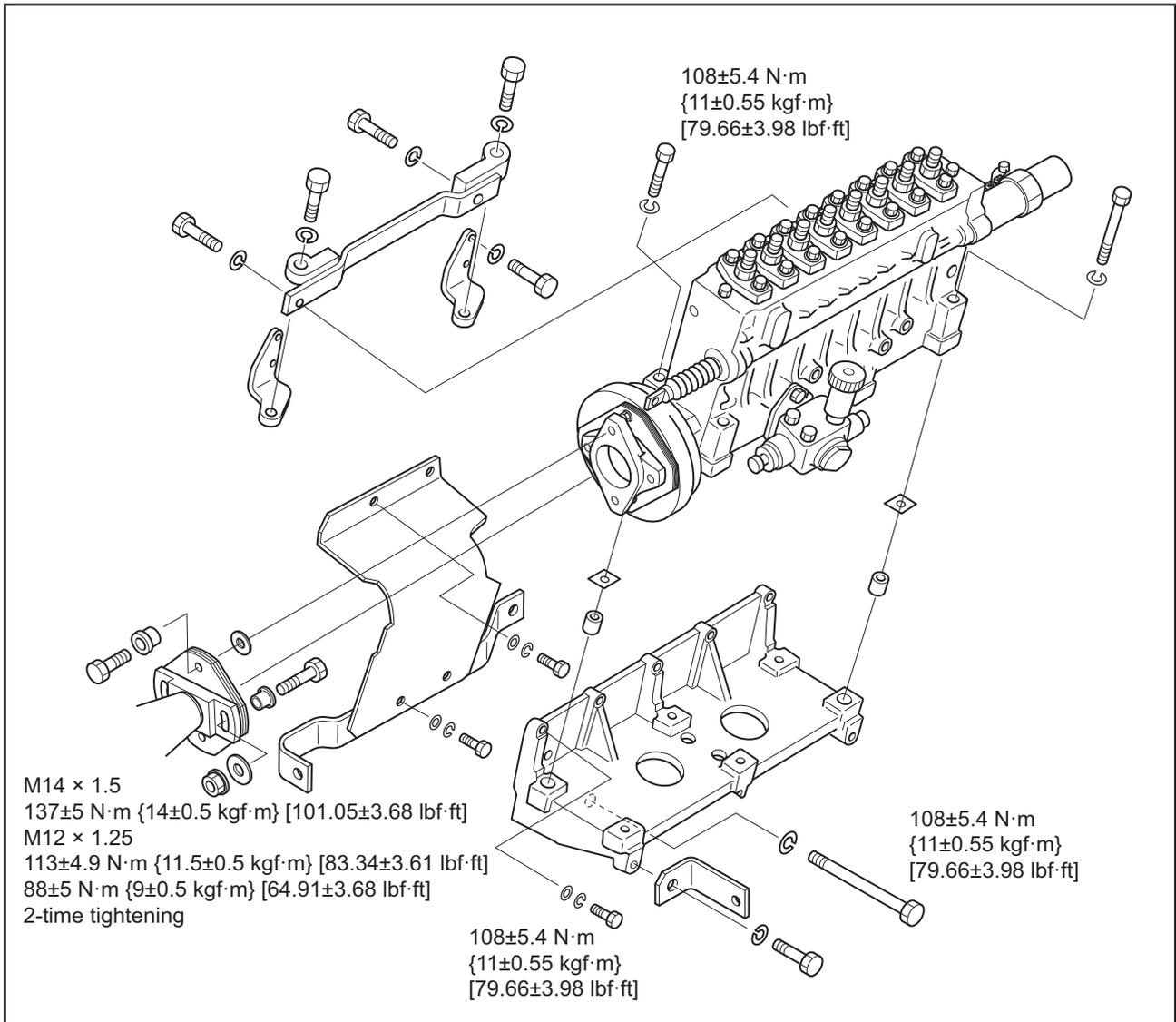
Measure the drive gear and idler gear backlash. If the value exceeds the limit, replace the drive gear or idler gear with a new one.

Item	Standard value	Limit value
Backlash between drive gear and idler gear	0.12 to 0.18 mm [0.0047 to 0.0071 in.]	0.40 mm [0.016 in.]

### 3. Fuel System - Install

- To install, follow the removal sequence in reverse. (See the illustration for disassembly.)
- Thoroughly clean fuel passages and dry them well.

#### 3.1 Fuel Injection Pump - Install



Fuel Injection Pump - Install

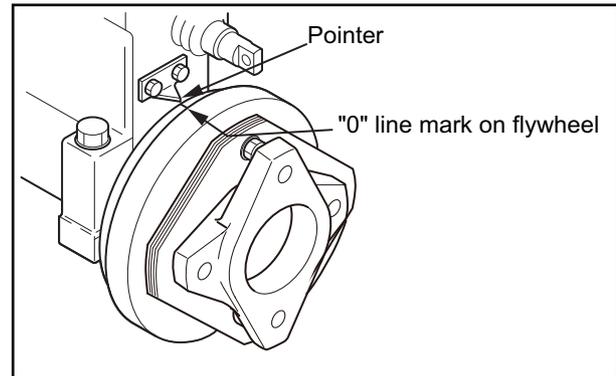
## 3.1.1 Checking before installing fuel injection pump

**CAUTION**

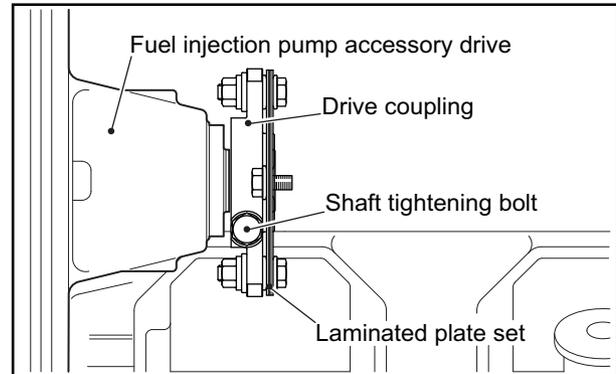
Ensure the correct mounting position of the drive coupling. If it is installed 180 degrees out of the position, the fuel injection timing cannot be adjusted.

- (1) Turn the crankshaft. Align with the No.1 compression top dead center when installing right bank fuel injection pump, and align with the No. 9 compression top dead center when installing left bank fuel injection pump.
- (2) Remove the tentatively installed drive coupling and laminated plates set on the drive coupling from the fuel injection pump. Install the coupling and the set to the accessory drive shaft with a woodruff key. Push the drive coupling to the accessory drive as close as possible, and leave the tightening bolts loose.
- (3) Align the "0" line mark on the fuel injection pump flywheel with the pointer. (the injection start timing of cylinder No. 1 and No. 9)

Note: Ensure the correct assembling orientation of drive coupling.



Pointer and Line Mark - Align



Drive Coupling - Install

3.1.2 Fuel Injection Pump - Install

**CAUTION**

- (a) Install new shims of the same thickness (t=0.25 mm [0.0098 in.]) to the removed ones on the bracket installing surfaces of right bank fuel injection pump. And install the pump to the right bank bracket.(No shims on the left bank bracket)
- (b) Tighten the nuts with specified torque while holding the bolts (long) that connect the drive coupling and laminated plates. Next tighten the bolts (long) with specified torque while holding the nuts. (2-time tightening)
- (c) Wash the bolt, bushing and washer before using. Foreign material on the contact surfaces of the drive coupling and the laminated plates can cause the slipping or the damage of couplings.
- (d) After the tightening of couplings check the laminated plates for distortion. If the plates are distorted loosen and retighten the bolts.

- (1) Install new shims of the same thickness (t=0.25 mm [0.0098 in.]) to the removed ones on the installing surfaces of right bank fuel injection pump bracket.

Note: Do not use the shims on the left bank bracket.

- (2) Lift the fuel injection pump.Slowly lower the fuel injection pump, and install the pump aligning with the dowel pin on bracket.

Note: Before setting bolts, ensure installation of the shim.

- (3) Connect the laminated plates and drive coupling, and hand tighten the bolt.

Check that the "0" stamped line of fuel injection pump flywheel with the No. 1 and 9 compression top dead center indicates near the pointer.

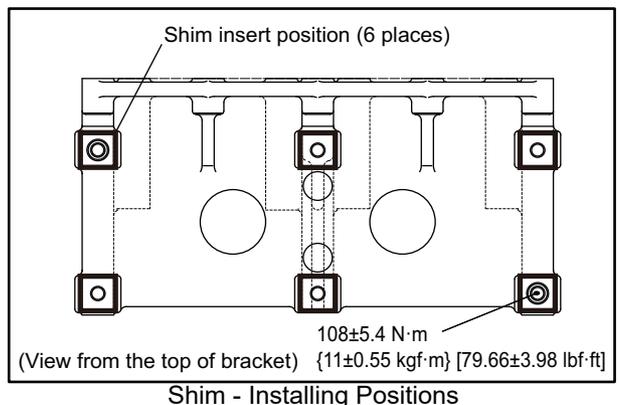
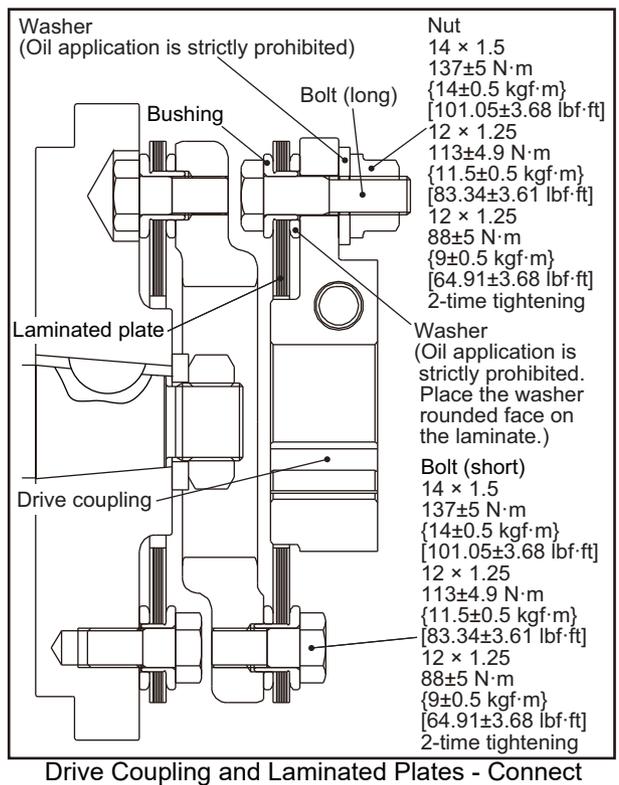
Note: When installing coupling connecting bolts, be careful not to forget bushings and washers, and also pay attention to the mounting direction.

- (4) Adjust the clearance between the drive coupling and flywheel to the standard.

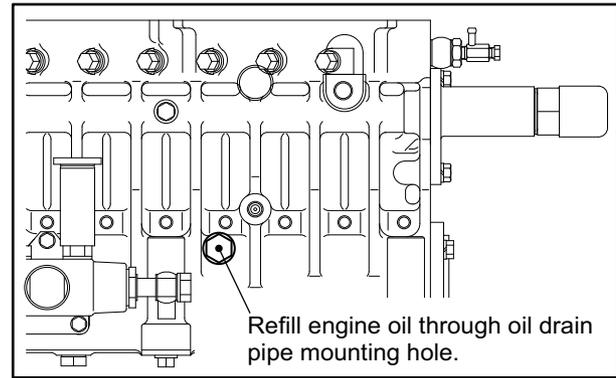
For the adjusting procedures, refer to "Clearance Between Fuel Injection Pump Flywheel and Driving Coupling - Adjust" of "FUEL SYSTEM."

- (5) Tighten all bolts and nuts that have been hand tightened to the couplings to the specified torque.

- (6) Recheck the clearance between couplings and the tightening condition of bolts and nuts.



- (7) Install the stay between the fuel injection pump case and the crankcase.
- (8) Refill engine oil through the oil drain pipe mounting hole of cam chamber.
- (9) Install the oil pipe and the fuel pipe.

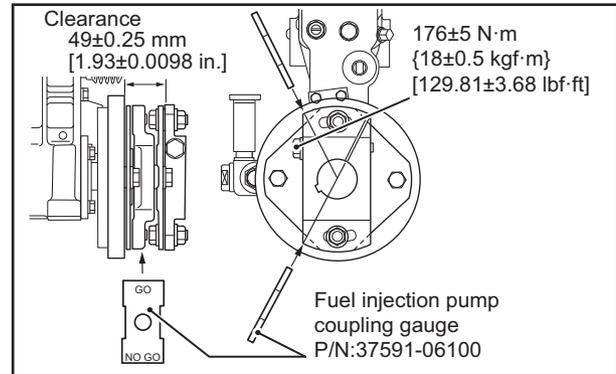


Engine Oil - Refill

### 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.

- (1) Insert the GO side of gauge into the clearance between the fuel injection pump flywheel and the drive coupling. And adjust the clearance.
- (2) Tighten the bolts to the specified torque.
- (3) Verify 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 the drive coupling should be the specified value.
- (4) When the clearance is not the specified value when the gauge is inserted, loosen the bolts and adjust the clearance again.



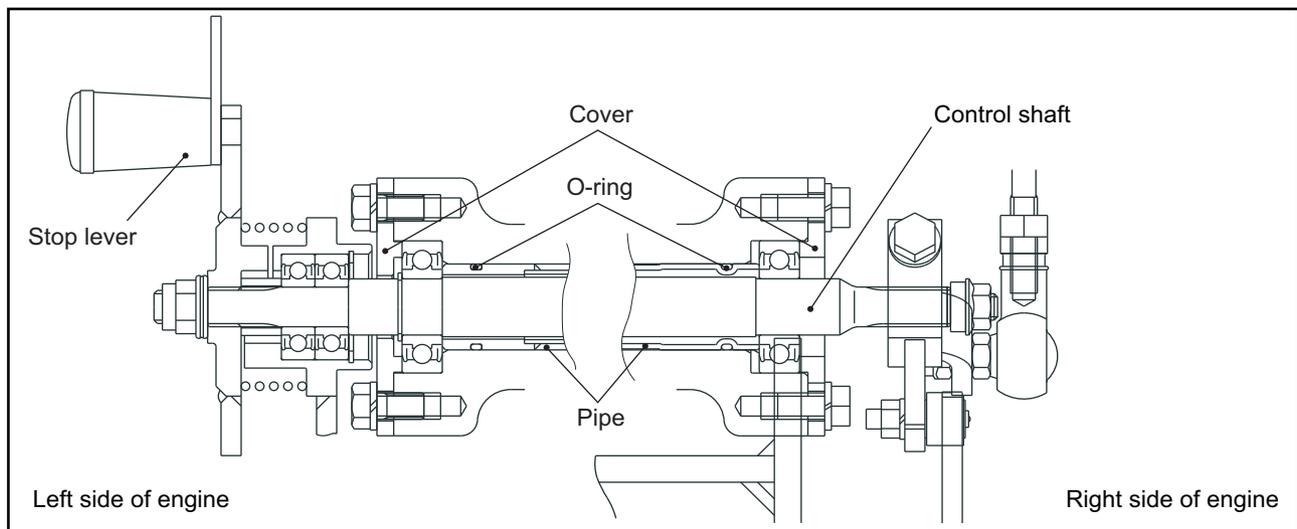
Clearance Between Fuel Injection Pump Flywheel and Drive Coupling - Adjust

### 3.2 Fuel Control Link - Install

#### 3.2.1 Control Shaft - Install

#### CAUTION

If the bearings at both ends of control shaft are not properly installed, or if the bearings do not rotate smoothly, it could result in a hunting or other malfunctions.



Control Shaft - Install

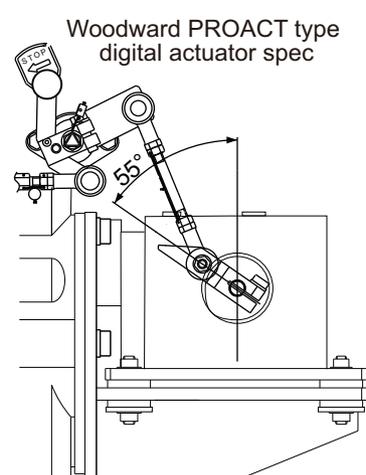
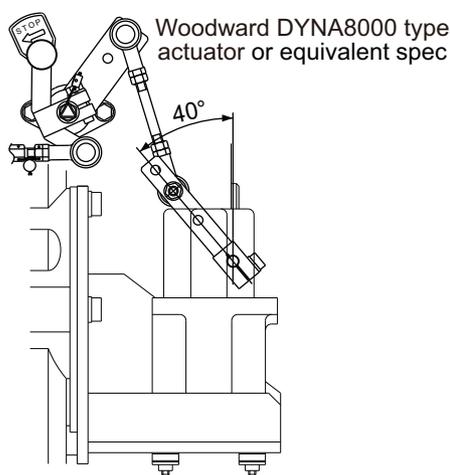
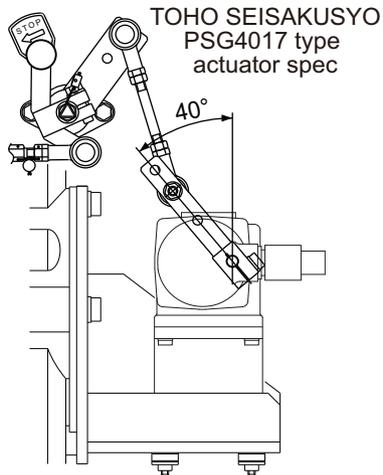
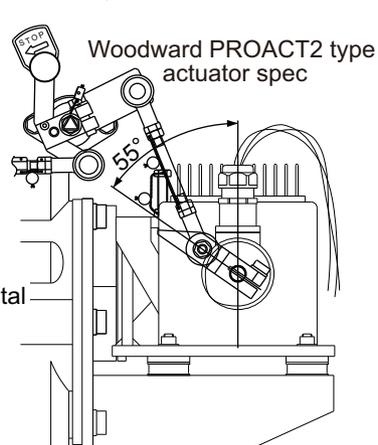
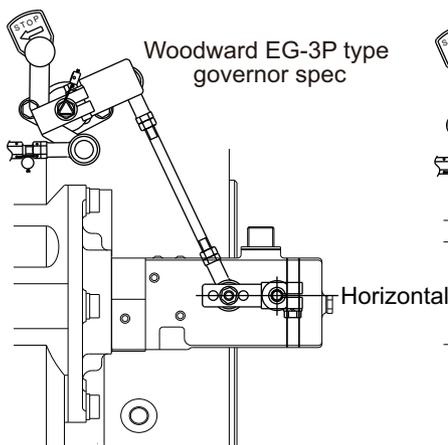
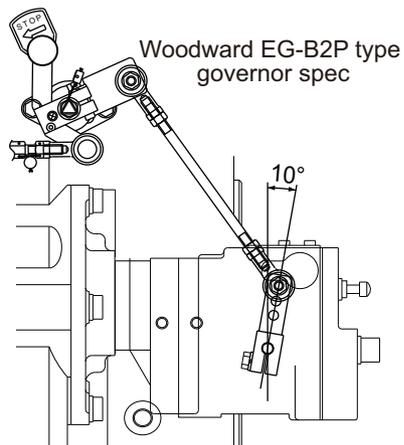
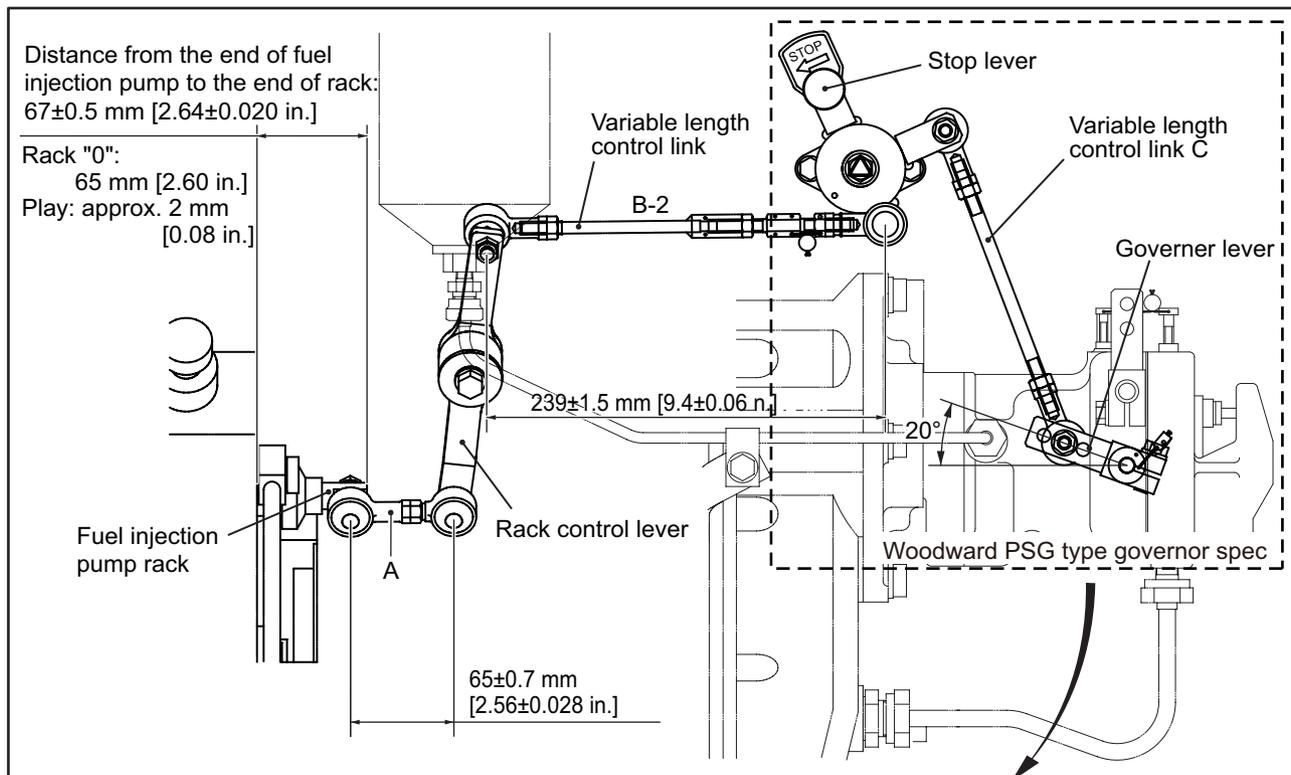
- (1) Insert the pipe with O-ring to the timing gear case.
- (2) Insert the control shaft to the pipe.
- (3) Press-fit the bearings to the both ends of control shaft, and install the bearing covers.
- (4) With a plastic head mallet, tap the both ends of control shaft alternately for snug fitting.
- (5) Rotate the control shaft by hand, and verify the smooth rotation.

#### 3.2.2 Control Link Lever - Install

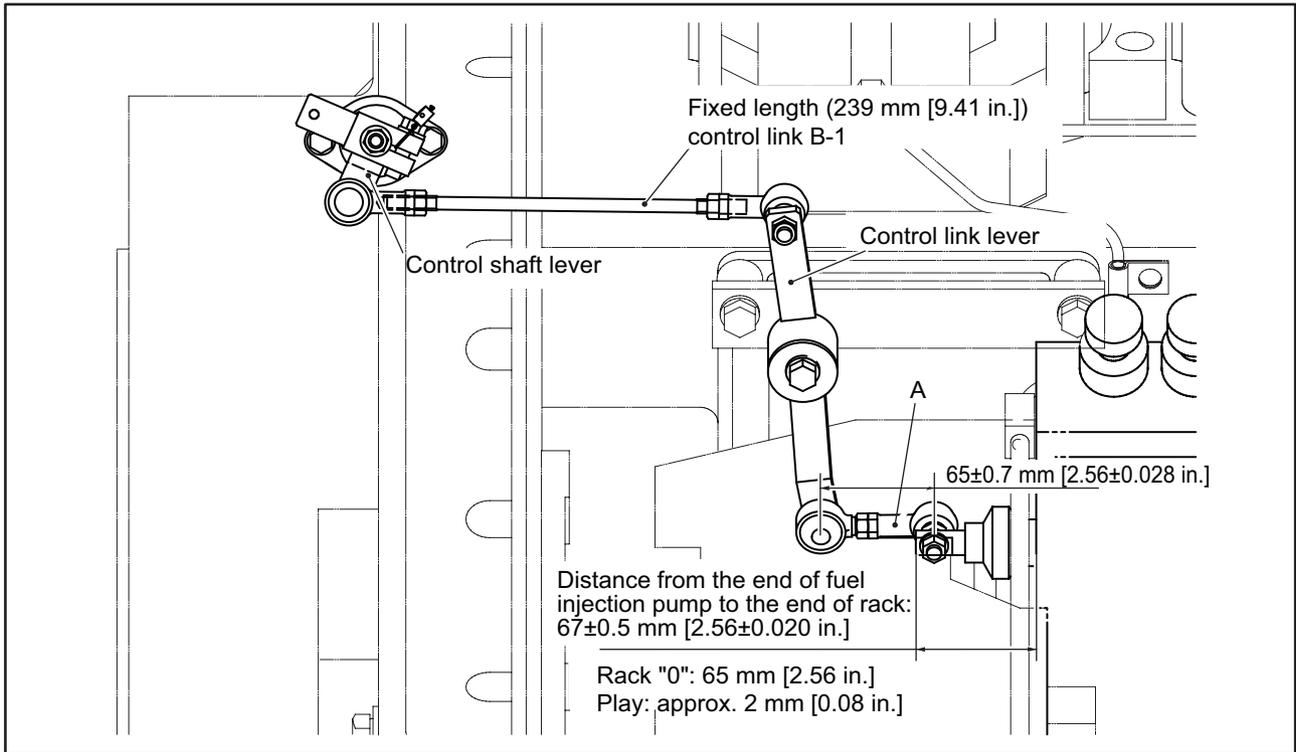
- (1) Install the link levers of each bank (stamped mark : L and R) together with ball bearings, snap ring and end plate to the bracket.
- (2) Set the link lever with a serration hole to the right end of control shaft, and hand tighten the bolt.
- (3) Set the link lever to be connected to the governor actuator together with ball bearings, snap ring and end plate to the left end of control shaft, and hand tighten the bolt.
- (4) Set the governor actuator output shaft at "0" position (no injection position), and adjust the serration while the governor lever is at the specified position.

Note: Refer to the specified governor lever position, refer to "Fuel Control Link- Install and Adjust" in "FUEL SYSTEM."

3.2.3 Fuel Control Link - Install and Adjust



Left-bank Linkage - Overall View



Right-bank Linkage - Overall View

**CAUTION**

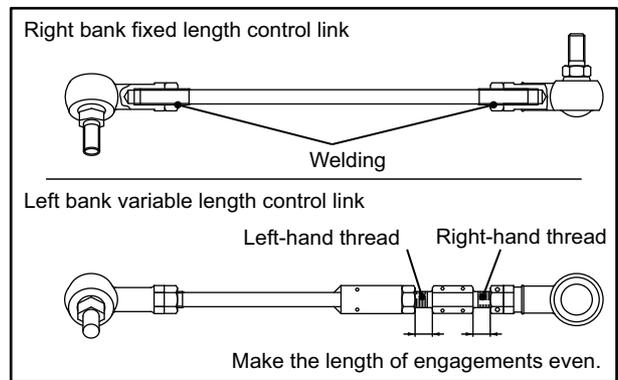
If the play of fuel injection pump rack is in excess, fuel can not be stopped even when the governor brings the link to engine stop position, and engine over-running may results.

- (1) Set the length of the link A between the fuel injection pump rack and the rack control lever (for both right and left banks) to  $65 \pm 0.7$  mm [ $2.56 \pm 0.0276$  in.], and install the link A to the right and left banks respectively.
- (2) Install the right-bank fixed length control link B-1 (239 mm [9.41 in.]) between the control link lever and control shaft lever.
- (3) Set the left-bank variable-length control link B-2 to 239 mm [9.41 in.], and fit the link to the stop lever having a serration hole.

Check that the fuel injection pump racks of both banks are at the no-injection position, then install the stop lever together with the spacer and cancel spring to the serration on the control shaft.

Note: Adjust the engagement lengths even on right and left-handed threads.

- (4) Fine adjust the left-bank variable-length control link C so that both right and left-bank fuel injection pump racks move the same distance.



Right and Left-bank Control Links

- (5) Install the variable-length control link between the control shaft lever and the governor lever.

Fine adjust the distance from the end of fuel injection pump to the end of rack to be 67 mm [2.64 in.] when the angle scale of the governor output shaft reads "0" (no injection position.)

Note: 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.

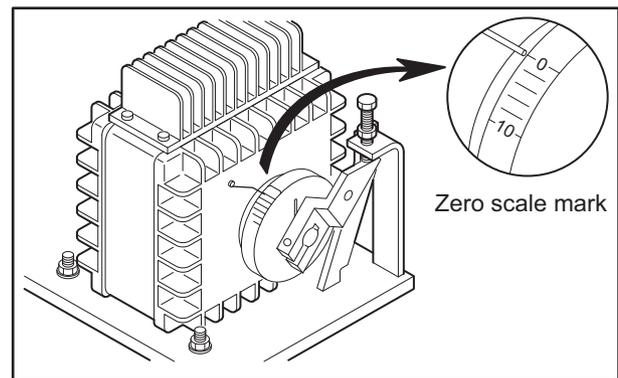
- (6) Verify the distance between the end of fuel injection pump and fuel injection pump rack is 65 mm [2.56 in.] and the play is 2 mm [0.08 in.] when the stop lever is fully pulled to the stop position.

Woodward PROACT type actuator spec only

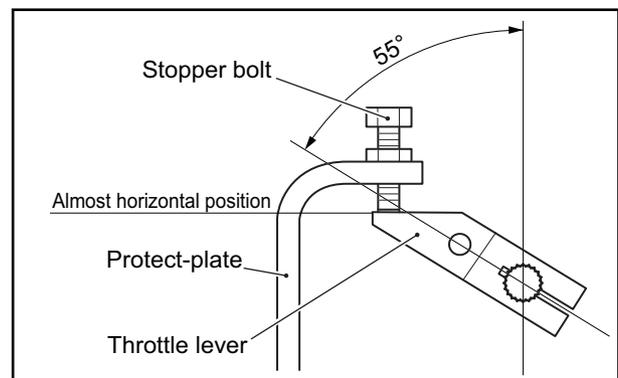
#### Stopper - Install

Install the stopper bolt to the plate.

When the governor actuator output shaft angle scale reads "0" (no injection), screw the stopper bolt until it comes into contact with the top face of the governor lever.



Governor Actuator Output Shaft - Angle Scale



Governor Lever Stopper - Adjust

### 3.3 Stop Solenoid - Install

#### 3.3.1 Stop solenoid

RUN-ON type:

Turned ON during operation, when turned OFF, the solenoid is deactivated to stop the engine.

RUN-OFF type:

Turned OFF during operation, when turned ON, the solenoid is activated to stop the engine.

#### 3.3.2 Start rack restrict solenoid

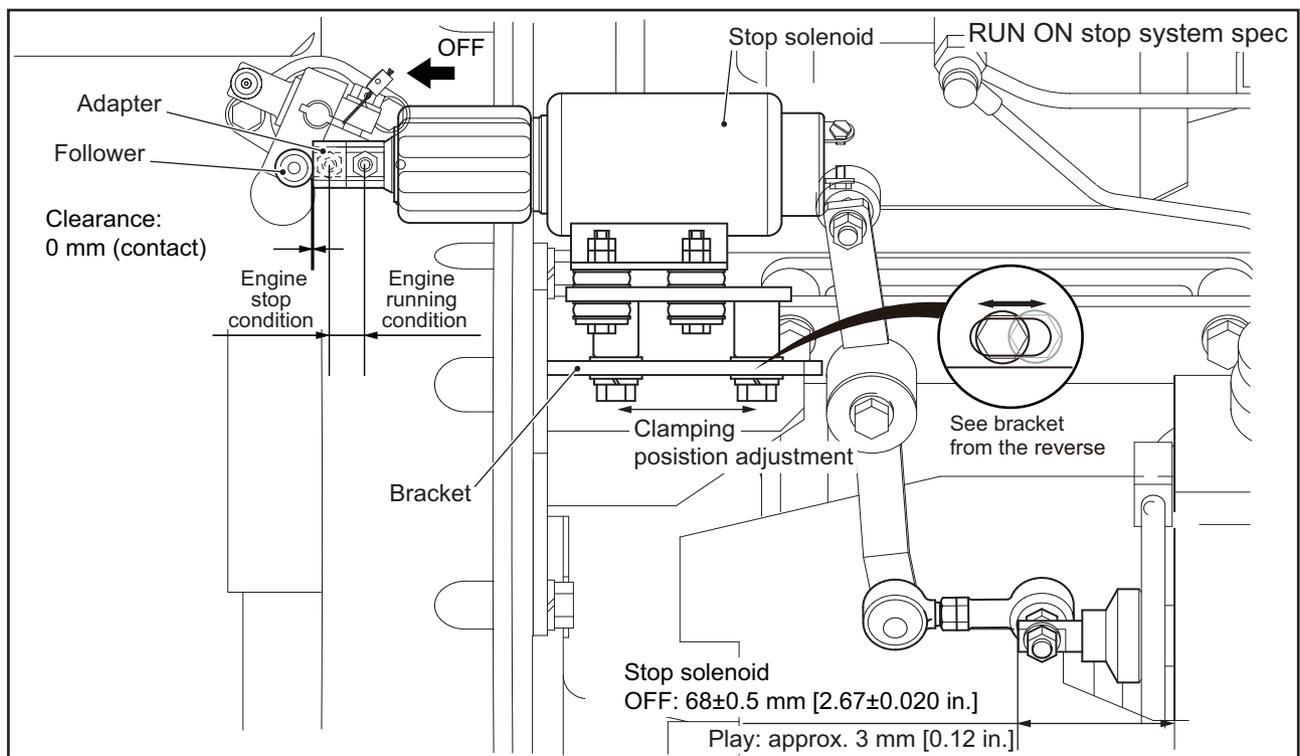
RUN-OFF type:

Turned OFF during the engine starting, when turned ON during engine running, the solenoid releases the restriction.

RUN-ON type:

Turned ON during the engine starting, when turned ONF during engine running, the solenoid releases the restriction.

#### 3.3.3 Stop Solenoid (RUN ON) - Adjust

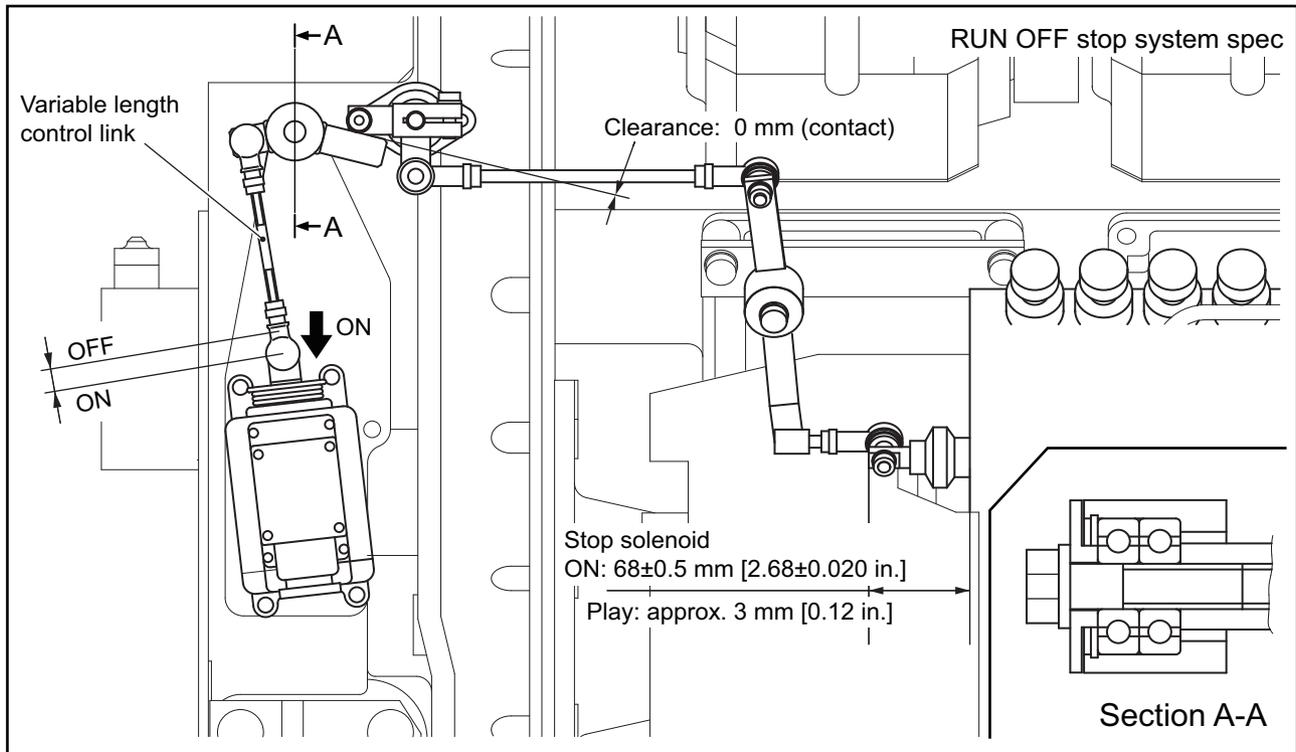


Stop Solenoid (RUN ON) - Adjust

- (1) Turn off the stop solenoid (engine stop).
- (2) Adjust the mounting position of stop solenoid using the elongate holes of bracket so that the clearance between the follower and the adapter becomes 0 mm [0 in.] (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  $68 \pm 0.5$  mm [ $2.68 \pm 0.019$  in.]

## 3.3.4 Stop Solenoid (RUN OFF) - Adjust



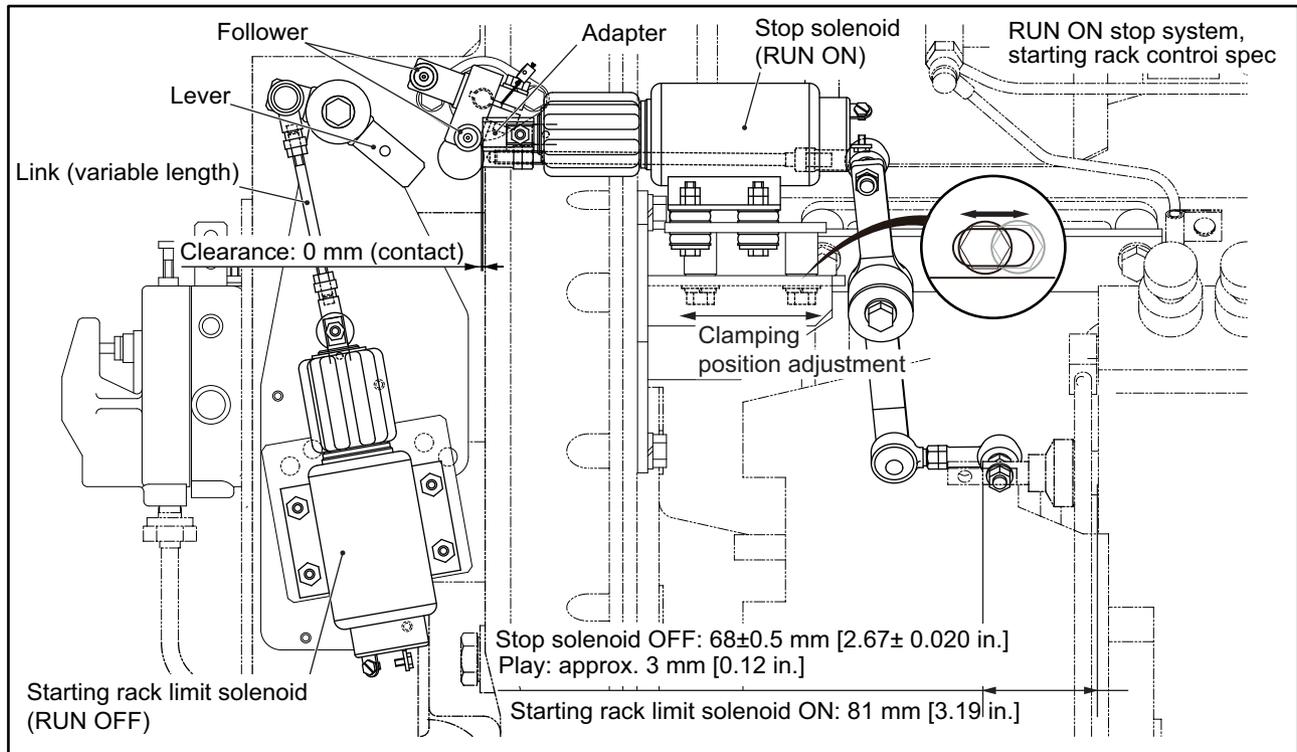
Stop Solenoid (RUN OFF) - Adjust

- (1) Pull the stop solenoid manually to the stop solenoid ON position (engine stop.)
- (2) Fine 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  $68 \pm 0.5$  mm [ $2.68 \pm 0.019$  in.]

Note:(a) Secure the approximately 3 mm [0.12 in.] play when the stop solenoid is in the 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.

## 3.3.5 Stop Solenoid (Run On), Start Rack Restrict Solenoid (RUN OFF) - Adjust



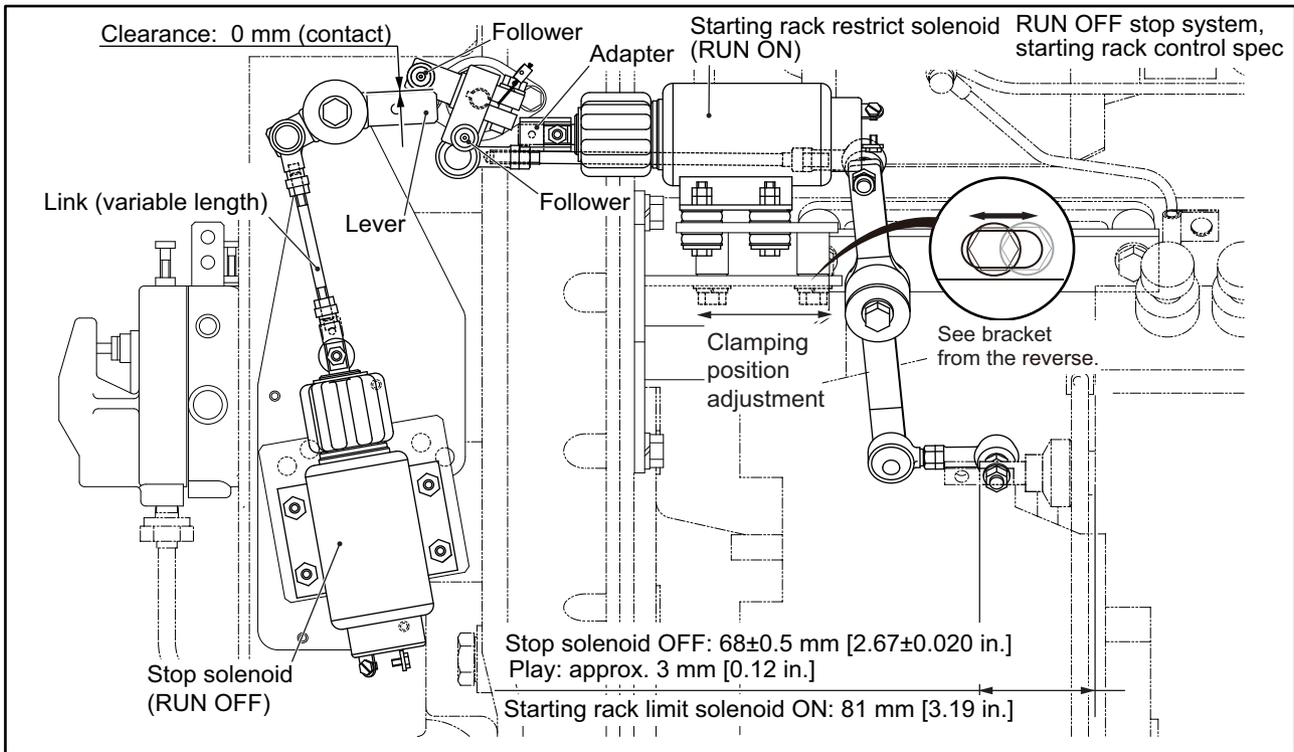
Stop Solenoid (Run On), Start Rack Restrict Solenoid (RUN OFF) - Adjust

- (1) Turn off the stop solenoid (engine stop).
- (2) Adjust the mounting position of stop solenoid using the elongate holes of bracket so that the clearance between the follower and the adapter becomes 0 mm [0 in.] (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  $68 \pm 0.5$  mm [ $2.68 \pm 0.019$  in.]

- (3) Pull the start rack restrict solenoid manually to the stop solenoid ON position (engine start.)
- (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 81 mm [3.19 in.], and the lever and follower contact.

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



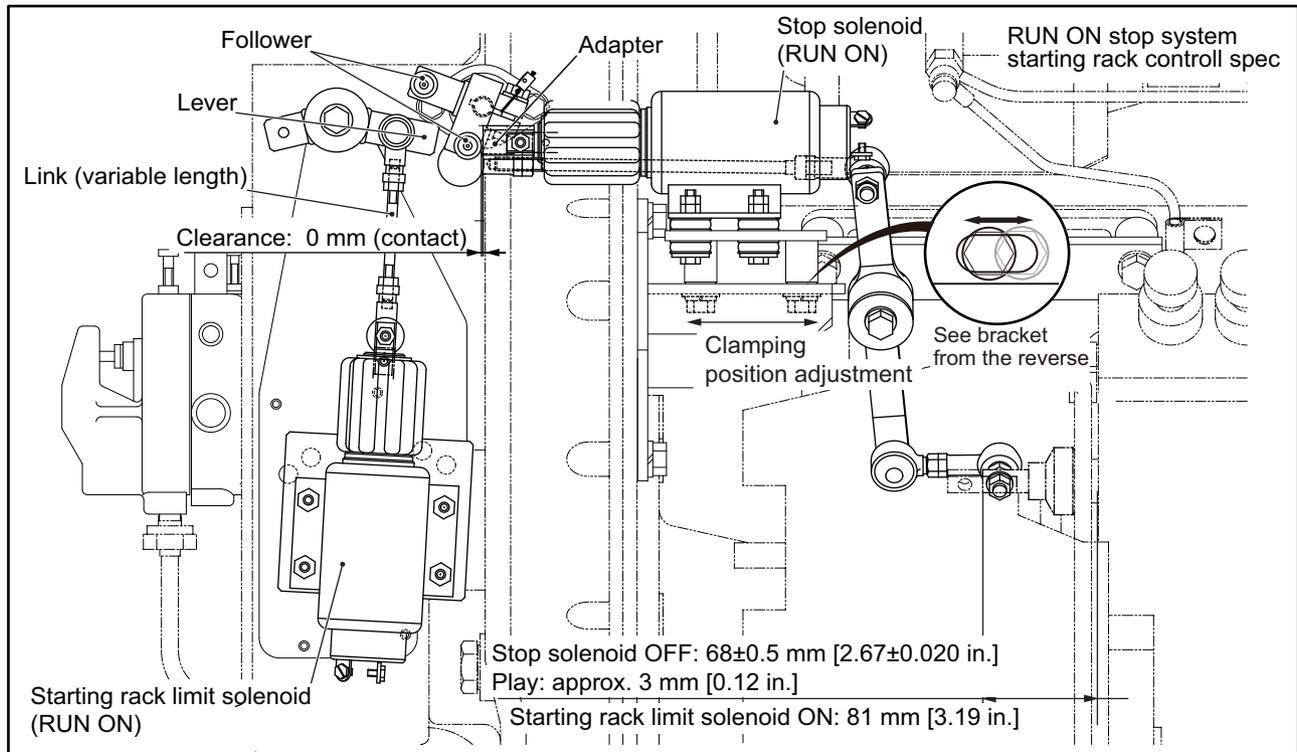
## Stop Solenoid (RUN OFF), Start Rack Restrict Solenoid (RUN ON) - Adjust

- (1) Pull 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 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  $68 \pm 0.5$  mm [ $2.68 \pm 0.019$  in.]

- (3) Turn off the start rack restrict solenoid (engine start.)
- (4) Adjust the distance between the end face of fuel injection pump and the end of control rack to be 81 mm [3.19 in.], and adjust the mounting position of the start rack restrict solenoid using the elongate holes of bracket so that the adapter and follower contact.

## 3.3.7 Stop Solenoid (RUN ON), Start Rack Restrict Solenoid (RUN ON) - Adjust



## Stop Solenoid (RUN ON), Start Rack Restrict Solenoid (RUN ON) - Adjust

- (1) Turn off the stop solenoid (engine stop).
- (2) Adjust the mounting position of stop solenoid using the elongate holes of bracket so that the clearance between the follower and the adapter becomes 0 mm [0 in.] (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  $68 \pm 0.5$  mm [ $2.68 \pm 0.019$  in.]

- (3) Turn off the start rack restrict solenoid (engine start.)
- (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 81 mm [3.19 in.], and the lever and follower contact.

### 3.3.8 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.] (the looseness is 3.5 mm [0.138 in.] or more, the engine may not be stopped.

(b) If the distance of fuel injection pump rack end is 65 mm [2.56 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 ON

Specification	Item	Engine starting	Engine running	Engine emergency stop	
Start rack restrict solenoid RUN ON	Plunger position (spring condition)	Stretched	Compressed	Compressed	Stretched
	Activation	OFF	ON	ON	OFF
	Distance from the fuel injection pump end face to control rack end	81 mm [3.19 in.]	FULL	68±0.5 mm [2.68±0.019 in.]	
Start rack restrict Solenoid RUN OFF	Plunger position (spring condition)	Compressed	Stretched	Compressed	Stretched
	Activation	ON	OFF	ON	OFF
	Distance from the fuel injection pump end face to control rack end	81 mm [3.19 in.]	FULL	68±0.5 mm [2.68±0.019 in.]	



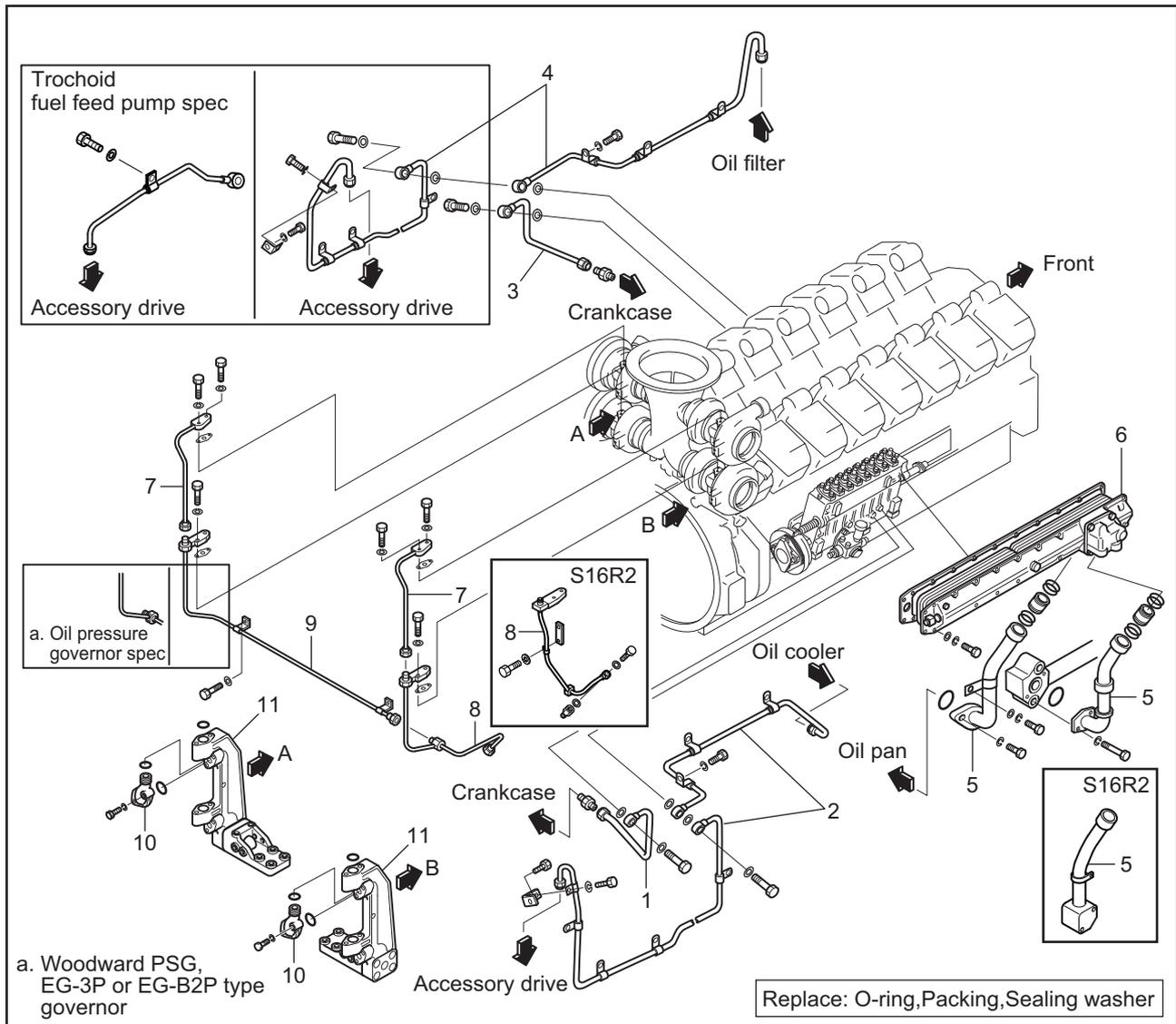
# Chapter 9 LUBRICATION SYSTEM

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## 1. Lubrication System - Remove and Inspect

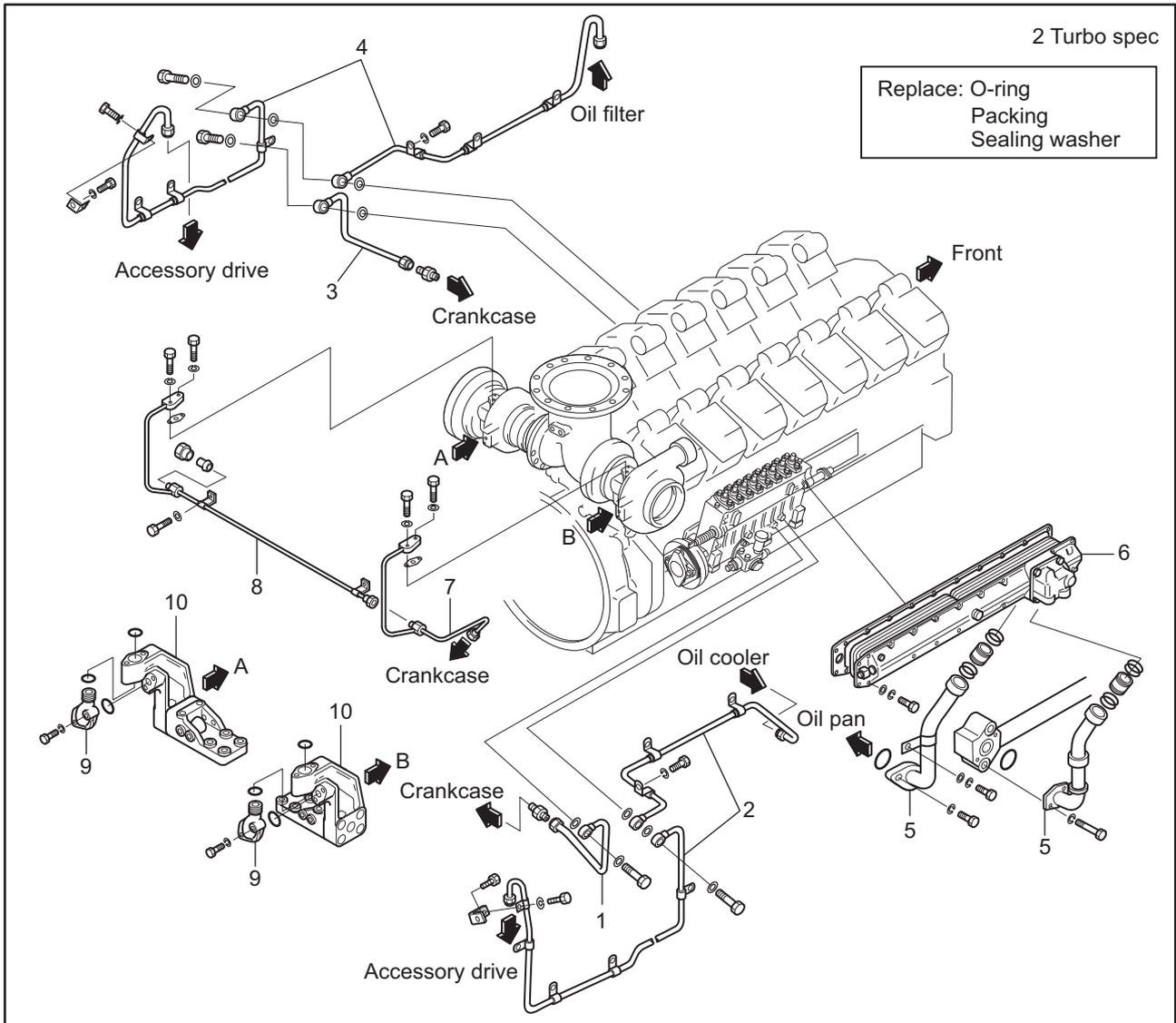
## 1.1 Oil Pipe and Right Oil Cooler - Remove and Inspect



Oil Pipe and Right Oil Cooler - Remove and Inspect

## Removing sequence

- |  |                         |
|--|-------------------------|
| 1 Right drain pipe                         | 7 Oil pipe              |
| 2 Right oil pipe                           | 8 Right oil pipe        |
| 3 Left drain pipe                          | 9 Left oil pipe         |
| 4 Left oil pipe                            | 10 Oil drain connector  |
| 5 Oil pipe                                 | 11 Turbocharger bracket |
| 6 Right oil cooler (approx. 21 kg [46 lb]) |                         |

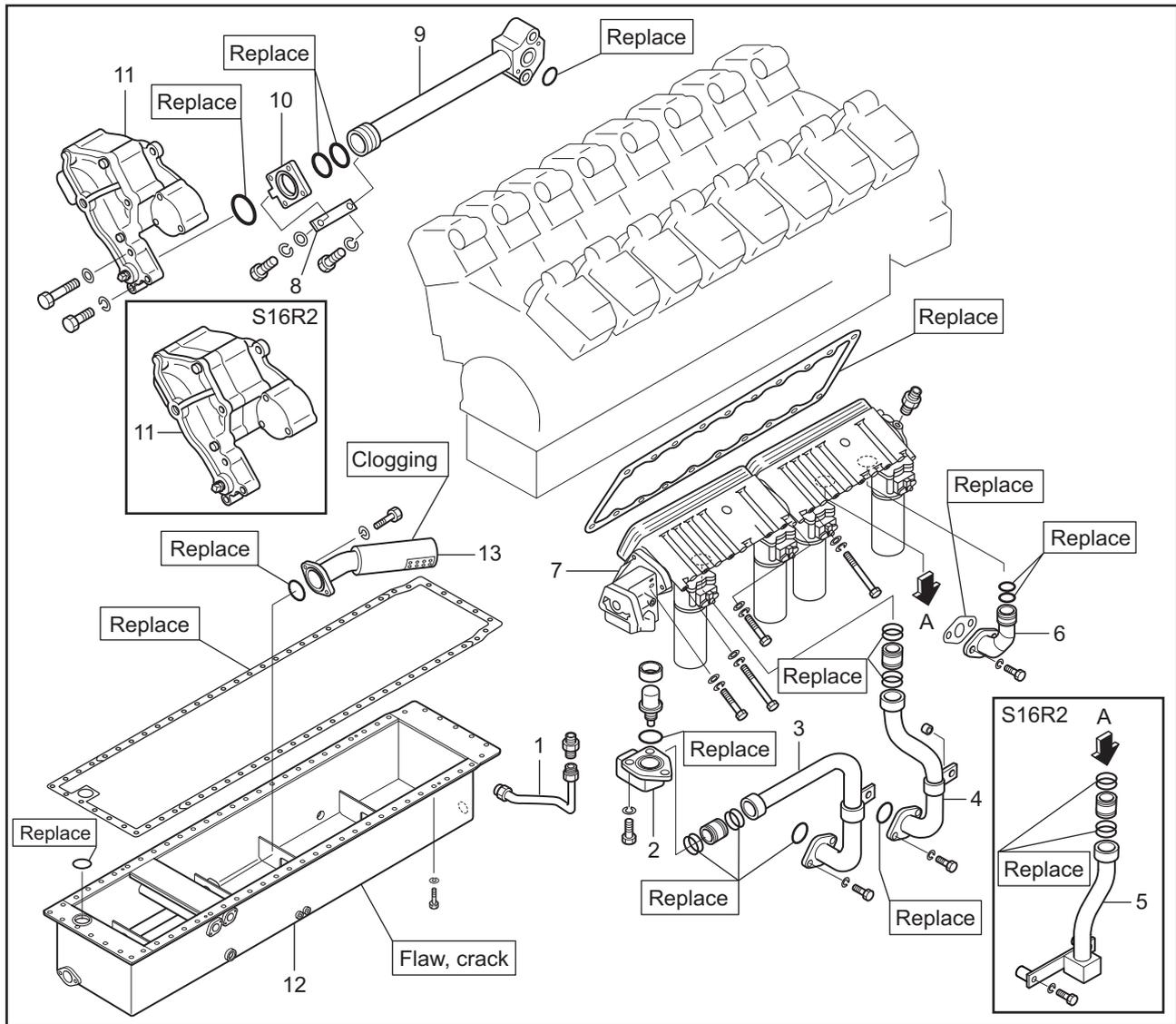


Oil Pipe and Right Oil Cooler - Remove and Inspect

Removing sequence

- |                    |  |
|--------------------|--|
| 1 Right drain pipe | 6 Right oil cooler (approx. 21 kg [46 lb]) |
| 2 Right oil pipe   | 7 Right oil pipe                           |
| 3 Left drain pipe  | 8 Left oil pipe                            |
| 4 Left oil pipe    | 9 Oil drain connector                      |
| 5 Oil pipe         | 10 Turbocharger bracket                    |

## 1.2 Oil Pump, Oil Filter, Oil Pan and Left Oil Cooler - Remove and Inspect



Oil Pump, Oil Filter, Oil Pan and Left Oil Cooler - Remove and Inspect

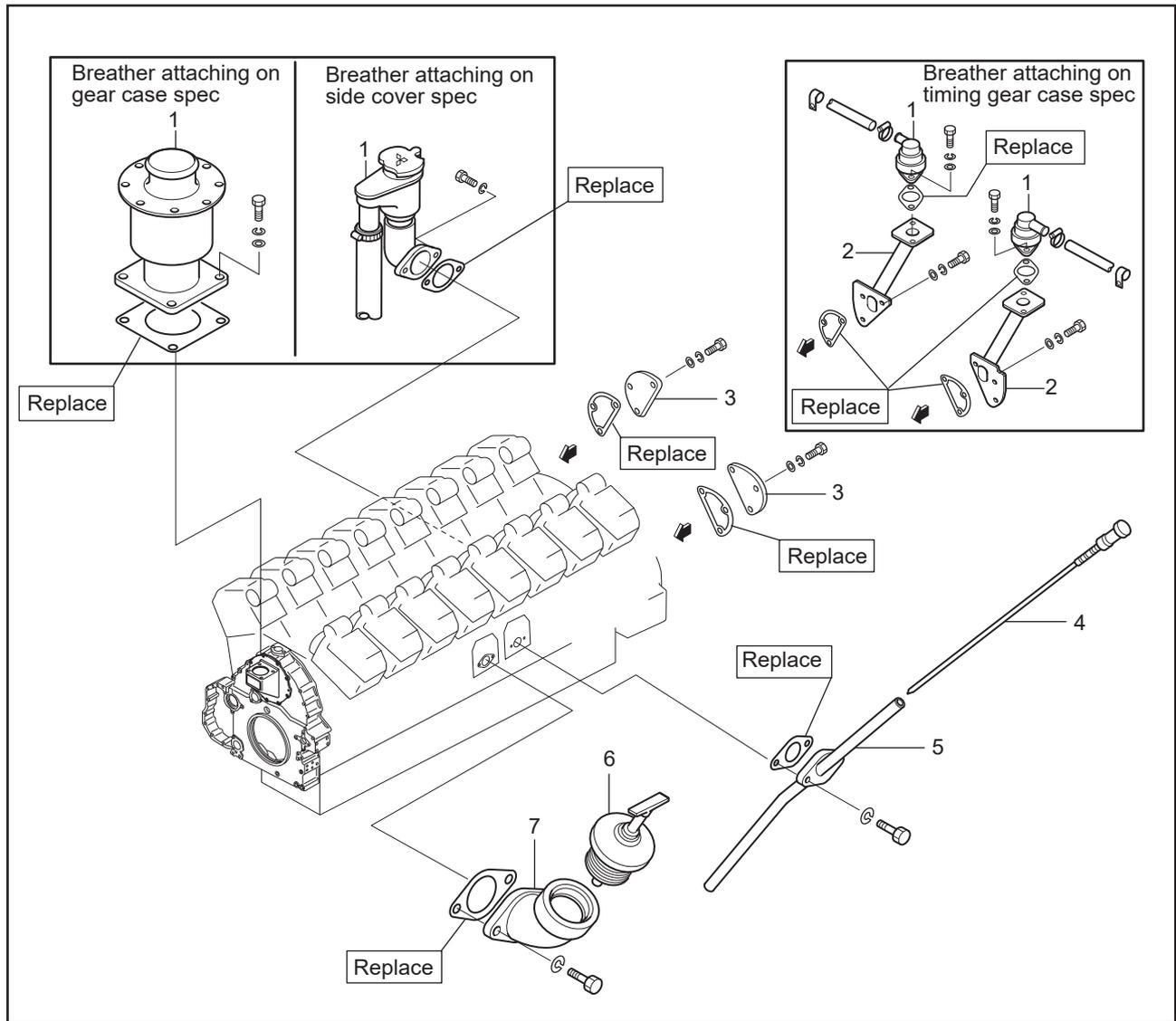
## Removing sequence

- |                     |   |   |
|---------------------|---|---|
| 1 Bypass drain pipe | 6 Oil pipe  | 10 Connector  |
| 2 Connector         | 7 Oil filter assembly,<br>Left oil cooler (approx. 40 kg [88 lb]) | 11 Oil pump (approx. 26 kg [57 lb])   |
| 3 Oil pipe          | 8 Stay  | 12 Oil pan<br>(Shallow type approx. 105 kg [231 lb])<br>(Deep type approx. 225 kg [496 lb]) |
| 4 Oil pipe          | 9 Oil pipe  | 13 Oil strainer assembly  |
| 5 Oil pipe          |   |   |

Note:(a) The oil filter assembly and oil cooler are different depending on the customization and specifications.

(b) The oil pan is different depending on the customization and specifications.

1.3 Breather and Oil Filler - Remove and Inspect



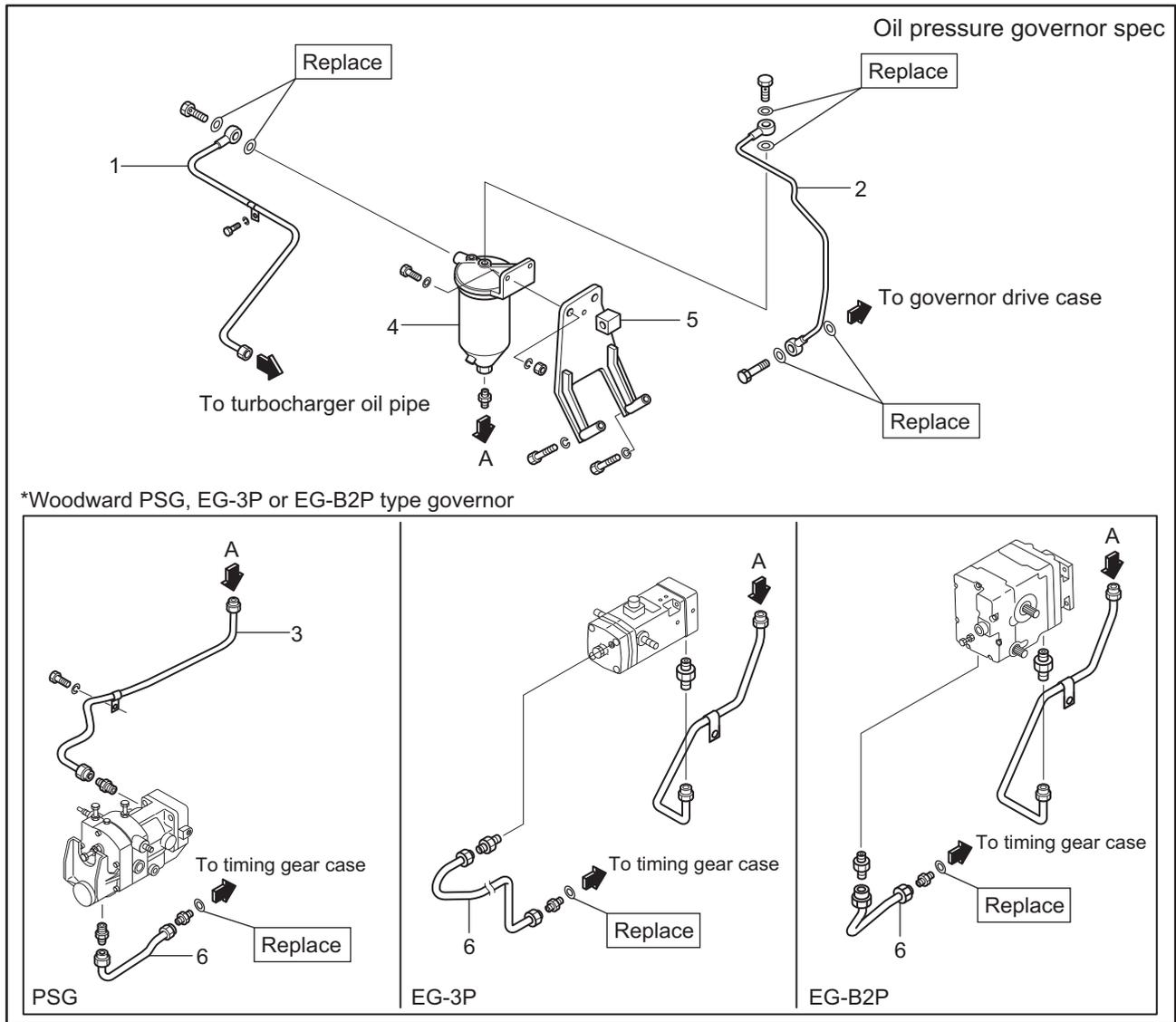
Breather and Oil Filler - Remove and Inspect

Removing sequence

- |                   |                         |
|-------------------|-------------------------|
| 1 Breather        | 5 Oil level gauge guide |
| 2 Breather pipe   | 6 Oil filler cap        |
| 3 Cover           | 7 Oil filler            |
| 4 Oil level gauge |                         |

Note: Breather shape and location differ depending on the customization and specifications.

1.4 Governor Oil Filter - Remove and Inspect



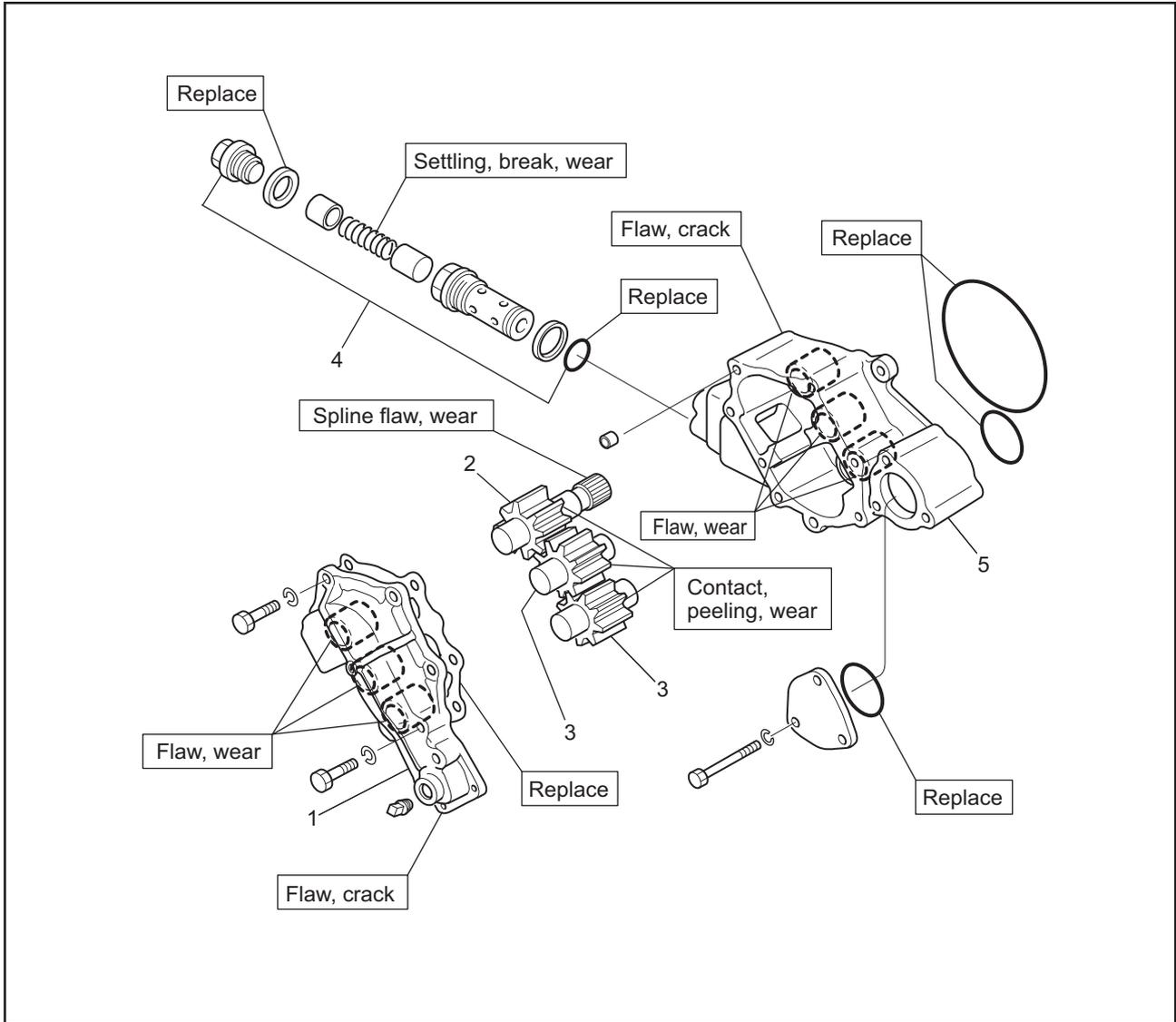
Governor Oil Filter - Remove and Inspect

Removing sequence

- |                  |                       |
|------------------|-----------------------|
| 1 Oil pipe       | 4 Governor oil filter |
| 2 Air purge pipe | 5 Bracket             |
| 3 Oil pipe       | 6 Drain pipe          |

## 2. Lubrication System - Disassemble, Inspect, and Assemble

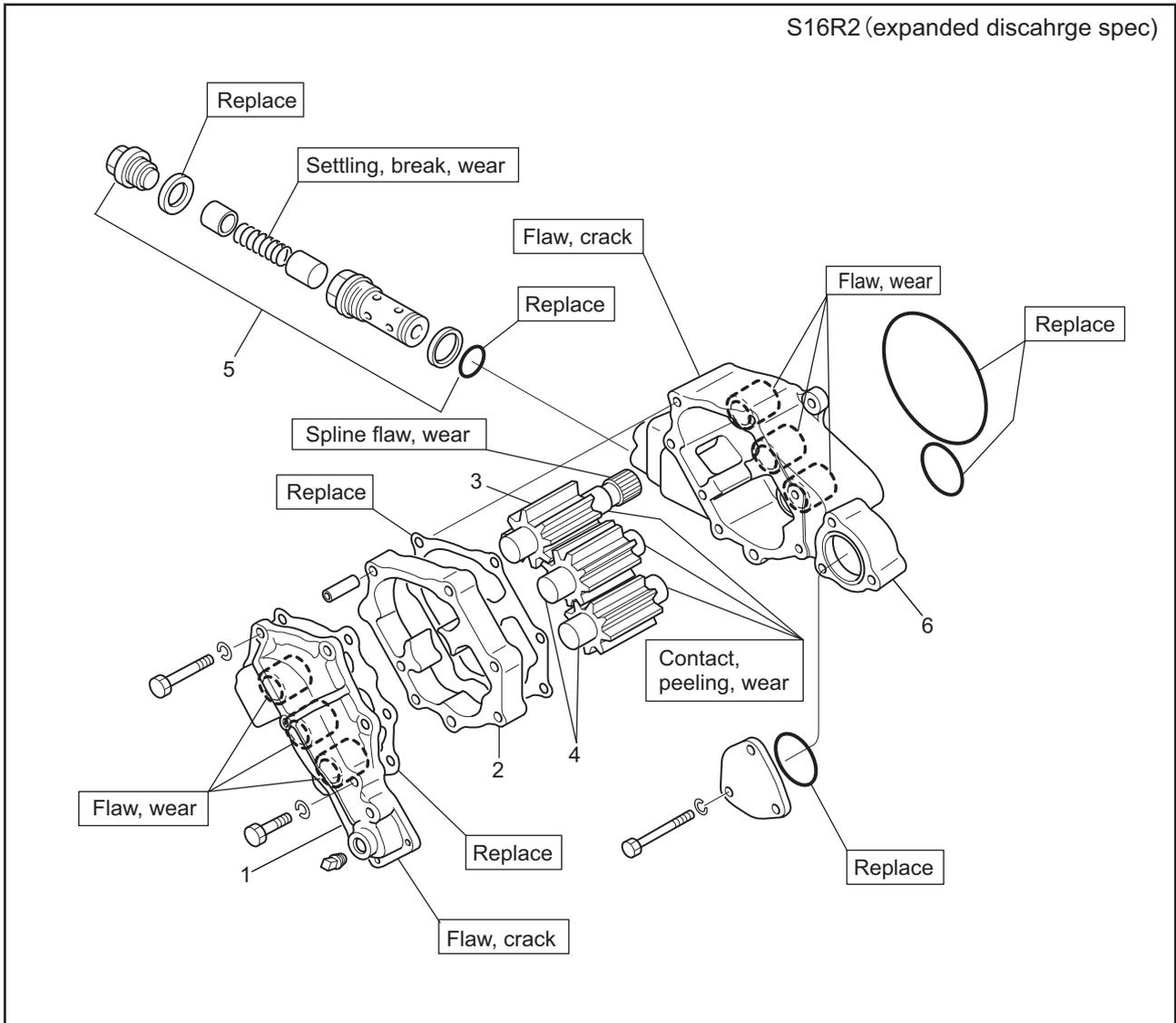
### 2.1 Oil Pump and Safety Valve - Disassemble and Inspect



Oil Pump and Safety Valve - Disassemble and Inspect

#### Disassembly sequence

- |                  |                         |
|------------------|-------------------------|
| 1 Oil pump cover | 4 Safety valve assembly |
| 2 Drive gear     | 5 Oil pump case         |
| 3 Driven gear    |                         |



Oil Pump and Safety Valve - Disassemble and Inspect

Disassembly sequence

- |                  |               |                                   |
|------------------|---------------|-----------------------------------|
| 1 Oil pump cover | 3 Drive gear  | 5 Safety valve assembly (3 units) |
| 2 Spacer         | 4 Driven gear | 6 Oil pump case                   |

2.2 Oil Pump and Safety Valve - Inspect

2.2.1 Drive Gear and Driven Gear

Backlash Measurement

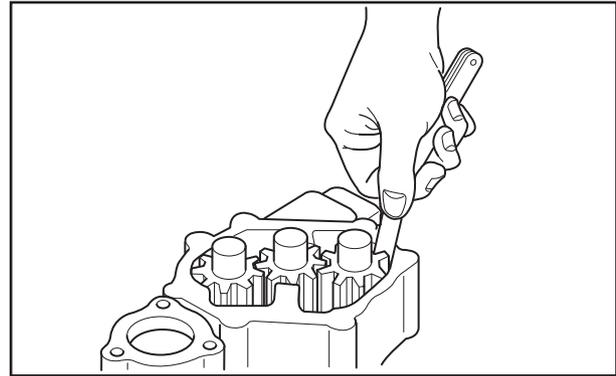
Measure the backlash between drive gear and driven gear. If the value exceeds the limit, replace the gears with new ones.

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.]

2.2.2 Top Clearance Between Gear Teeth and Case - Measure

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

Item	Standard value	Limit value
Top clearance between gear teeth and case	0.100 to 0.148 mm [0.0039 to 0.0058 in.]	0.350 mm [0.0138 in.]

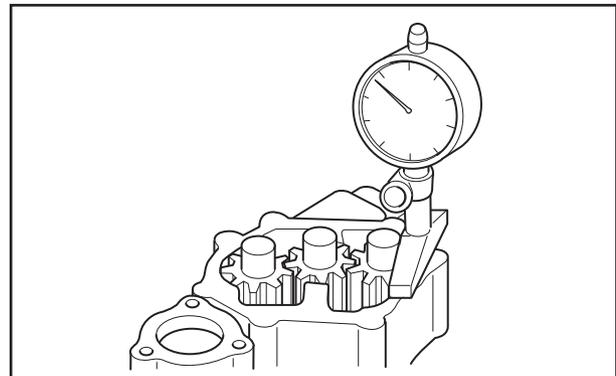


Top Clearance Between Gear Teeth and Case - Measure

2.2.3 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 the case with a new one.

Item	Standard value	Limit value
Side clearance between gear width and case depth	0.040 to 0.116 mm [0.0016 to 0.0046 in.]	0.210 mm [0.0083 in.]



Side Clearance Between Gear Width and Case - Measure

2.2.4 Drive and 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 and driven gear shaft outside diameters and bushing inside diameters. If the value exceeds the limit, replace the assembly with new one.

Item	Nominal value	Standard value	Limit value
Drive shaft outside diameter	ø30 mm [1.18 in.]	29.887 to 29.900 mm [1.1767 to 1.1772 in.]	29.840 mm [1.1748 in.]
Driven shaft outside diameter		29.947 to 29.960 mm [1.1790 to 1.1795 in.]	29.920 mm [1.1780 in.]
Bushing inside diameter		30.000 to 30.021 mm [1.1811 to 1.1819 in.]	30.055 mm [1.1833 in.]
Bushing inside diameter (Input shaft spline)	ø30.1 mm [1.185 in.]	30.100 to 30.125 mm [1.1850 to 1.1860 in.]	30.159 mm [1.1874 in.]

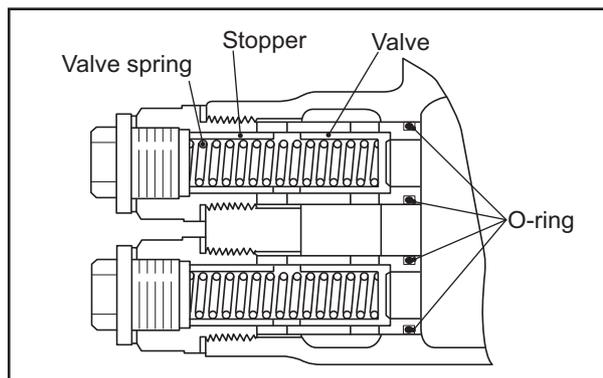
## 2.2.5 Oil Pump Safety Valve - Inspect

Item	Standard value
Safety valve opening pressure	1.3±0.13 MPa {13±1.3 kgf/cm <sup>2</sup> } [189 ± 19 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.

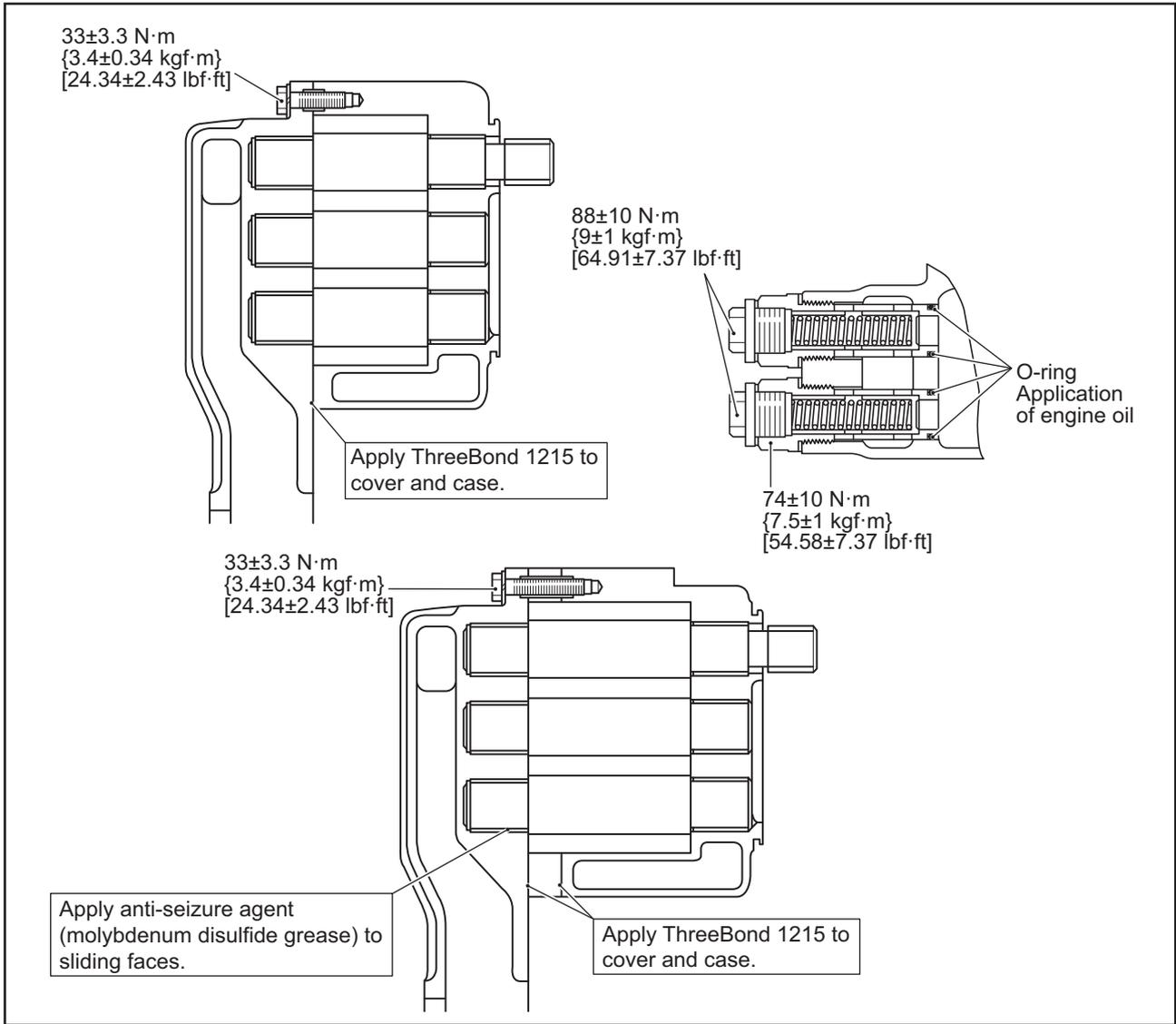
Item	Standard value	Limit value
Safety valve spring Set length / load	65.8 mm/359 N {36.6 kgf} [80.7 lbf]	65.8 mm/314 N {32.0 kgf} [70.6 lbf]
Safety valve Spring free length	78 mm [3.07 in.]	-

- (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

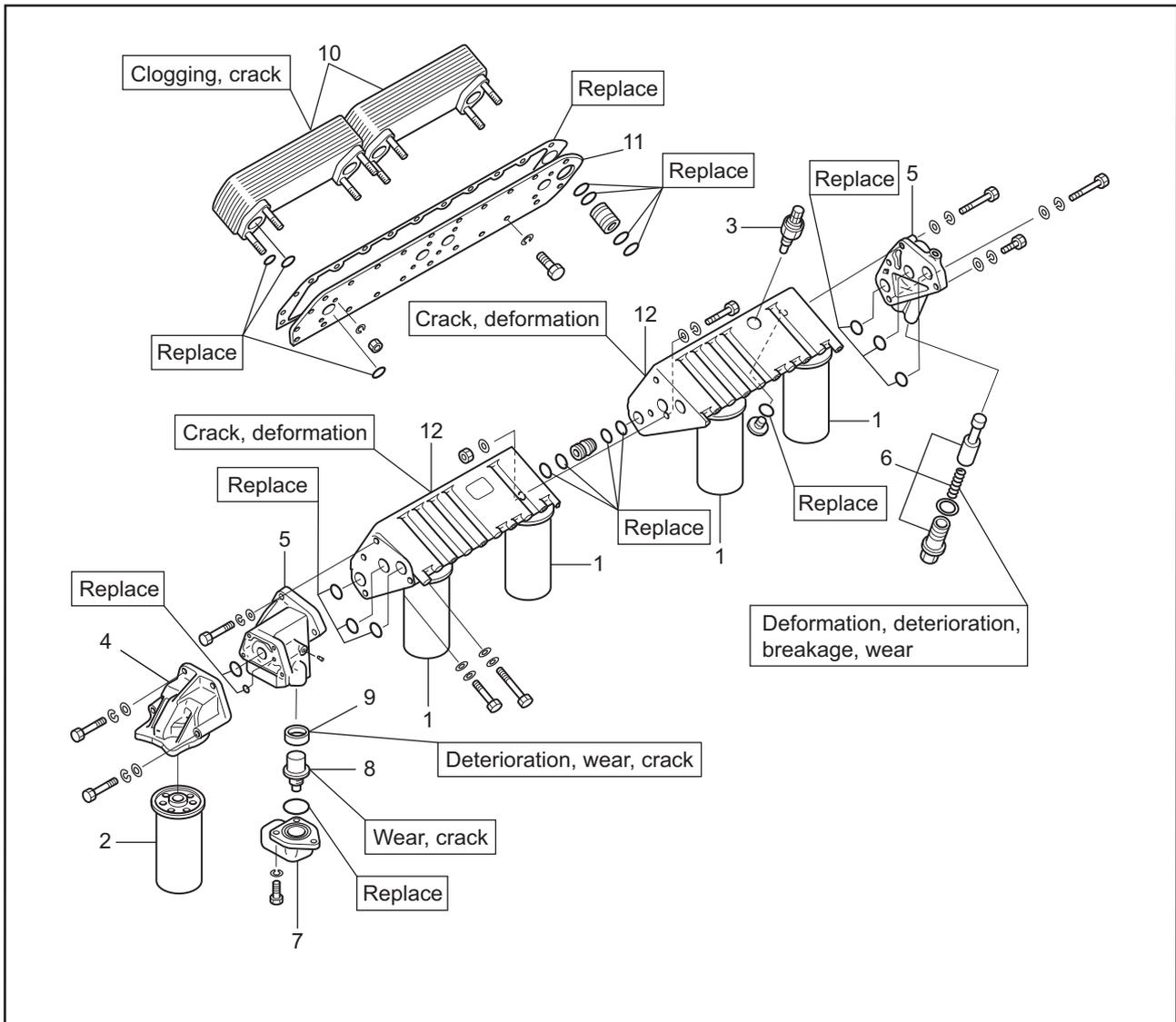


Oil Pump and Safety Valve - Assemble

**CAUTION**

Apply engine oil on each part when assembling. Apply a thick coat of engine oil on threads and seating surfaces of the nuts and bolts before tightening them.

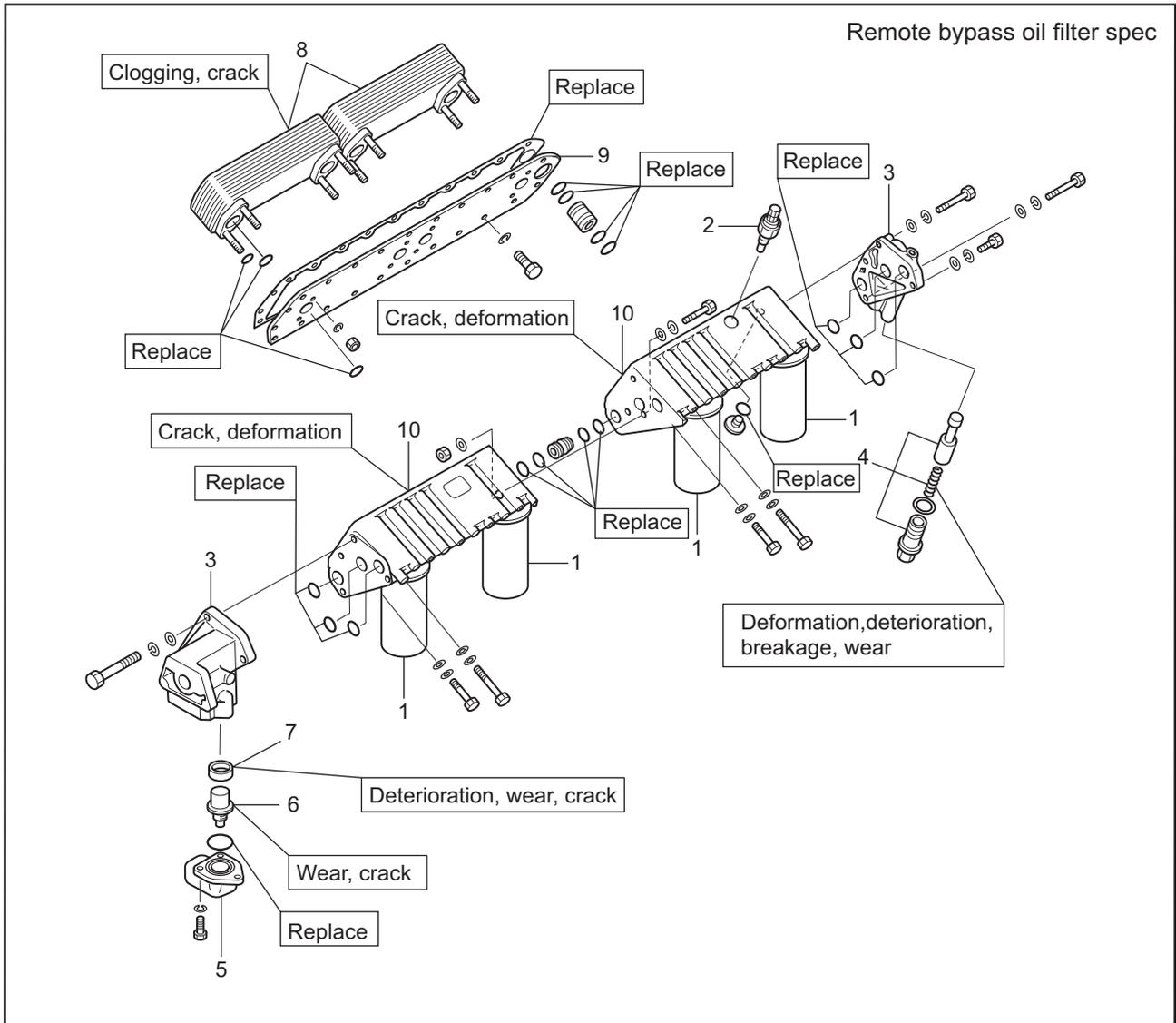
## 2.4 Oil Filter, Oil Filter Alarm, Relief Valve and Left Side Oil Cooler - Disassemble and Inspect



Oil Filter, Oil Filter Alarm, Relief Valve and Left Oil Cooler - Disassemble and Inspect

## Disassembling sequence

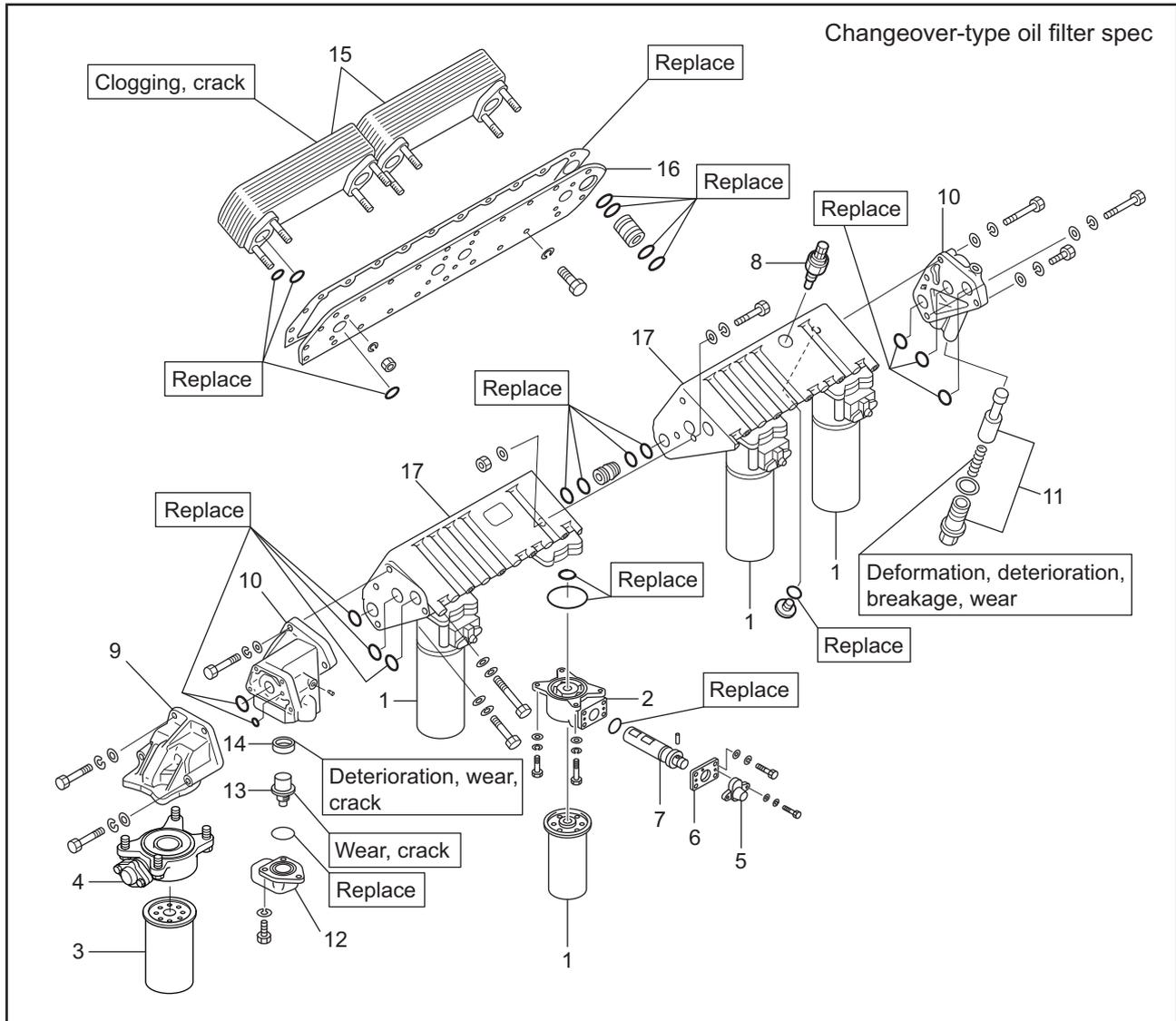
- |                        |                         |   |
|------------------------|-------------------------|---|
| 1 Full-flow oil filter | 5 Adapter assembly      | 9 Thermostat seal                             |
| 2 Bypass oil filter    | 6 Relief valve assembly | 10 Oil cooler element                         |
| 3 Oil filter alarm     | 7 Connector             | 11 Plate                                      |
| 4 Bracket              | 8 Oil thermostat        | 12 Oil filter bracket (approx. 15 kg [33 lb]) |



Oil Filter, Oil Filter Alarm, Relief Valve and Left Oil Cooler - Disassemble and Inspect

Disassembling sequence

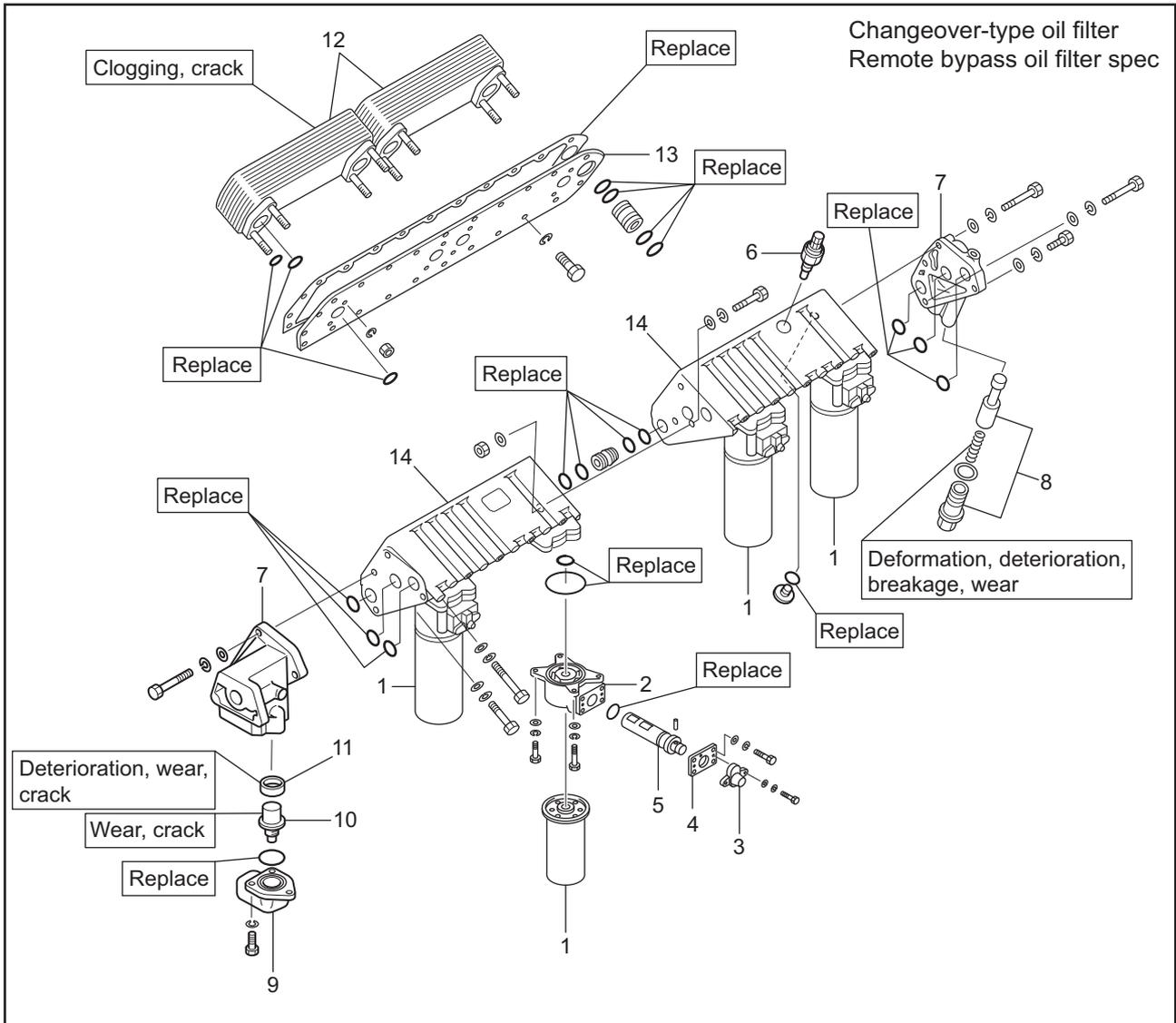
- |                         |                   |   |
|-------------------------|-------------------|---|
| 1 Full-flow oil filter  | 5 Connector       | 8 Oil cooler element                          |
| 2 Oil filter alarm      | 6 Oil thermostat  | 9 Plate                                       |
| 3 Adapter assembly      | 7 Thermostat seal | 10 Oil filter bracket (approx. 15 kg [33 lb]) |
| 4 Relief valve assembly |                   |   |



Oil Filter, Oil Filter Alarm, Relief Valve and Left Oil Cooler - Disassemble and Inspect

## Disassembling sequence

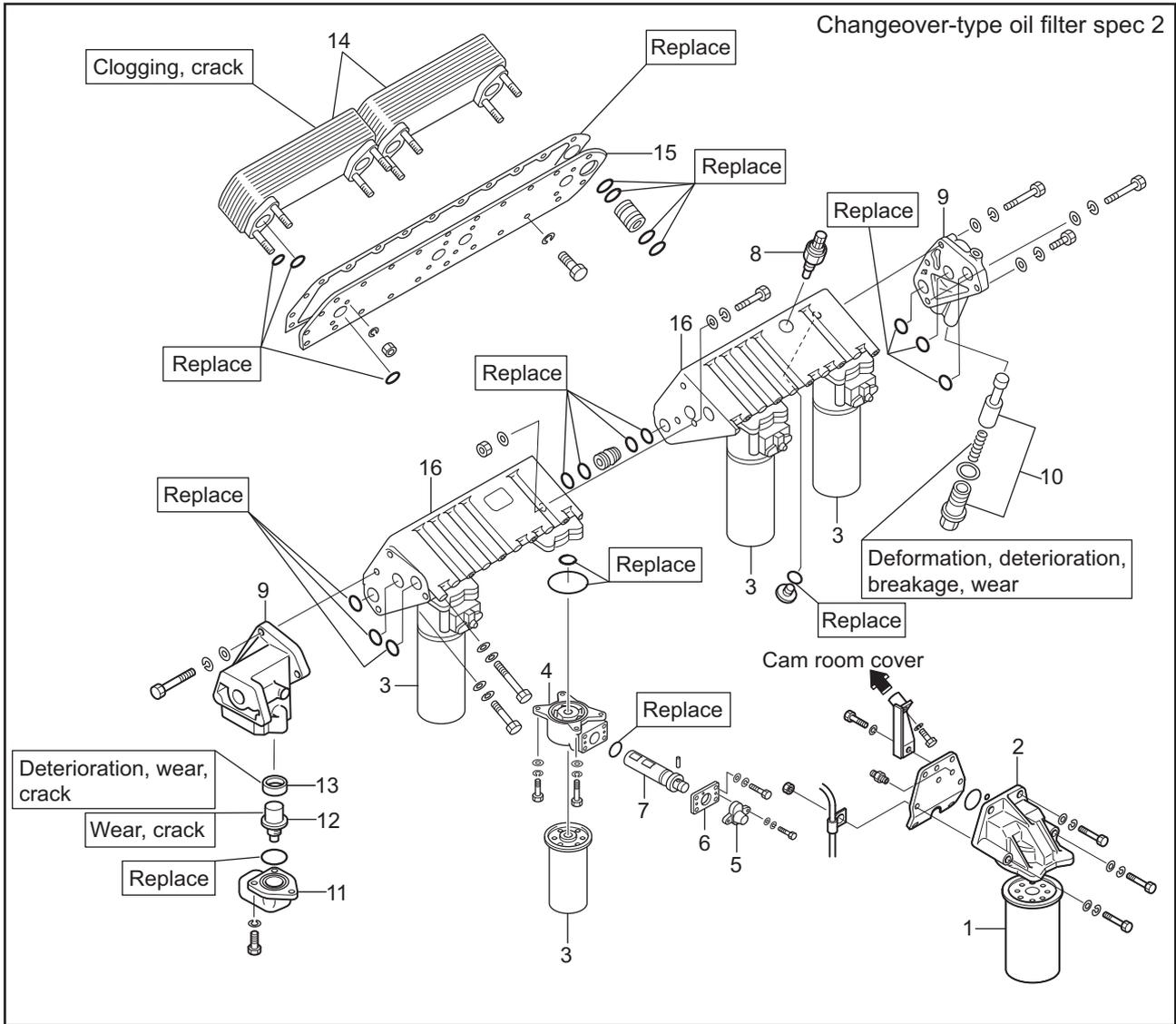
- |                        |                          |   |
|------------------------|--------------------------|---|
| 1 Full-flow oil filter | 7 Cock                   | 13 Oil thermostat                             |
| 2 Body                 | 8 Oil filter alarm       | 14 Thermostat seal                            |
| 3 Bypass oil filter    | 9 Bracket                | 15 Oil cooler element                         |
| 4 Body                 | 10 Adapter assembly      | 16 Plate                                      |
| 5 Cover                | 11 Relief valve assembly | 17 Oil filter bracket (approx. 15 kg [33 lb]) |
| 6 Cover                | 12 Connector             |   |



Oil Filter, Oil Filter Alarm, Relief Valve and Left Oil Cooler - Disassemble and Inspect

Disassembling sequence

- |                        |                         |   |
|------------------------|-------------------------|---|
| 1 Full-flow oil filter | 6 Oil filter alarm      | 11 Thermostat seal                            |
| 2 Body                 | 7 Adapter assembly      | 12 Oil cooler element                         |
| 3 Cover                | 8 Relief valve assembly | 13 Plate                                      |
| 4 Cover                | 9 Connector             | 14 Oil filter bracket (approx. 15 kg [33 lb]) |
| 5 Cock                 | 10 Oil thermostat       |   |



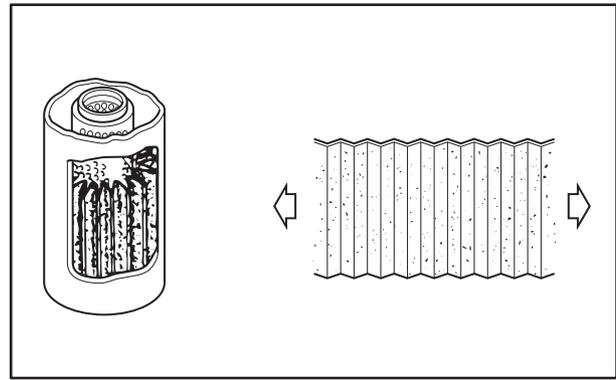
Oil Filter, Oil Filter Alarm, Relief Valve and Left Oil Cooler - Disassemble and Inspect

Disassembling sequence

- |                        |                          |   |
|------------------------|--------------------------|---|
| 1 Bypass oil filter    | 7 Cock                   | 13 Thermostat seal                            |
| 2 Bracket              | 8 Oil filter alarm       | 14 Oil cooler element                         |
| 3 Full-flow oil filter | 9 Adapter assembly       | 15 Plate                                      |
| 4 Body                 | 10 Relief valve assembly | 16 Oil filter bracket (approx. 15 kg [33 lb]) |
| 5 Cover                | 11 Connector             |   |
| 6 Cover                | 12 Oil thermostat        |   |

2.5 Oil Filter - Inspect

When replacing the oil filter, sample the oil (500 ml [0.13 US 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.

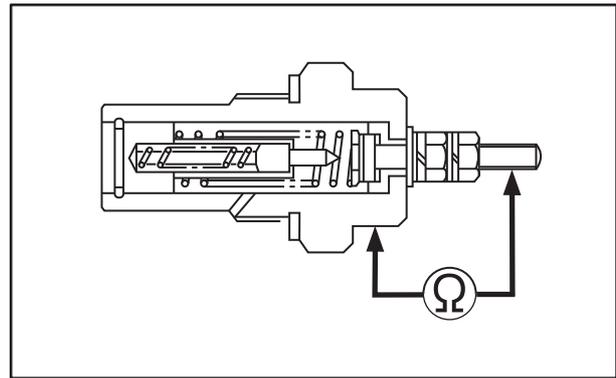


Oil Filter - Inspect

2.6 Oil Filter Alarm - Inspect

- (1) Use a tester to check the alarm for insulation and continuity. If the alarm is defective, replace it with a new one.
- (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	0.15 <sup>+0.03</sup> MPa
Turn on start pressure (differential pressure)	{1.5 <sup>+0.3</sup> kgf/cm <sup>2</sup> } [21 <sup>+4.4</sup> psi]



Oil Filter Alarm - Inspect

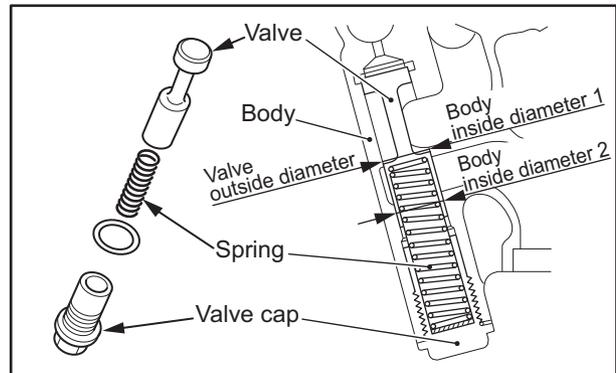
2.7 Relief Valve - Inspect

- (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	188 mm [7.40 in.]

- (2) Measure the outside diameter of relief valve and inside diameter of body, and if wear is found, replace with a new one..

Item	Standard value
Outside diameter of relief valve	33.925 to 33.950 mm [1.3356 to 1.3366 in.]
Inside diameter of body (Measuring position 1,2)	34.000 to 34.025 mm [1.3386 to 1.3396 in.]



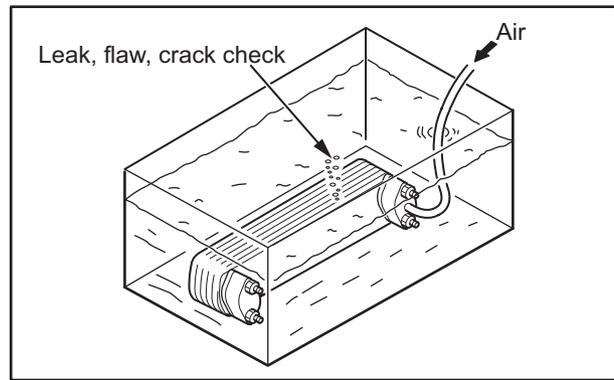
Relief Valve - Inspect

- (3) Inspect the valve, and if any wear, flaw, or sliding malfunction is found, replace the valve with a new one.

Note: Replace the adapter assembly when the oil pressure is low even after replacing the spring or valve.

### 2.8 Oil Cooler - Inspect

Check the oil passages of element for flaws or cracks by applying compressed air of 1.5 MPa {15 kgf/cm<sup>2</sup>} [218 psi]. If any leak or damage is found, replace the element with a new one.

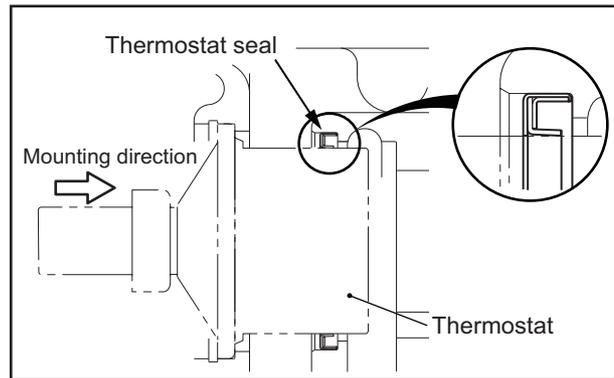


Oil Cooler - Inspect

### 2.9 Oil Thermostat - Inspect

#### 2.9.1 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.



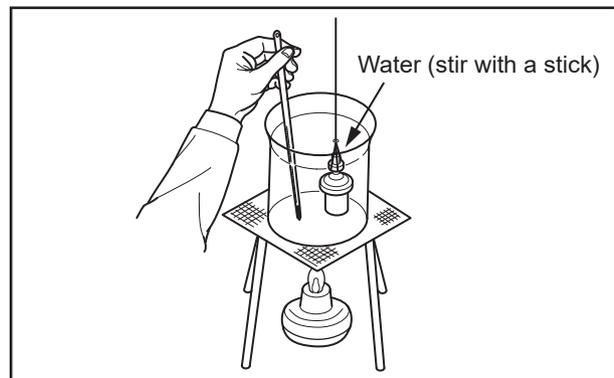
Oil Thermostat Seal - Install

#### 2.9.2 Oil Thermostat Operation - Inspect

**CAUTION**

Pay attention to 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 the valve start to open, and at which the valve lift becomes to the standard value. Replace the thermostat if a deviation from the standard temperature is significant.



Oil Thermostat Operation - Inspect

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.

Parts	Item	Standard value	Remarks
Oil thermostat	Valve opening temperature	80 to 84°C [176 to 183.2°F]	Valve opening temperature: 82°C [179.6°F]
	Temperature at which valve lift becomes 11 mm [0.43 in.] or more	95°C [203°F]	
	Valve opening temperature	69 to 73°C [156.2 to 163.4°F]	Valve opening temperature: 71°C [159.8°F]
	Temperature at which valve lift becomes 11 mm [0.43 in.] or more	85°C [185°F]	

### 2.10 Oil Filter, Oil Filter Alarm, Relief Valve, and Left Oil Cooler - Assemble

To assemble, follow the disassembly sequence in reverse.

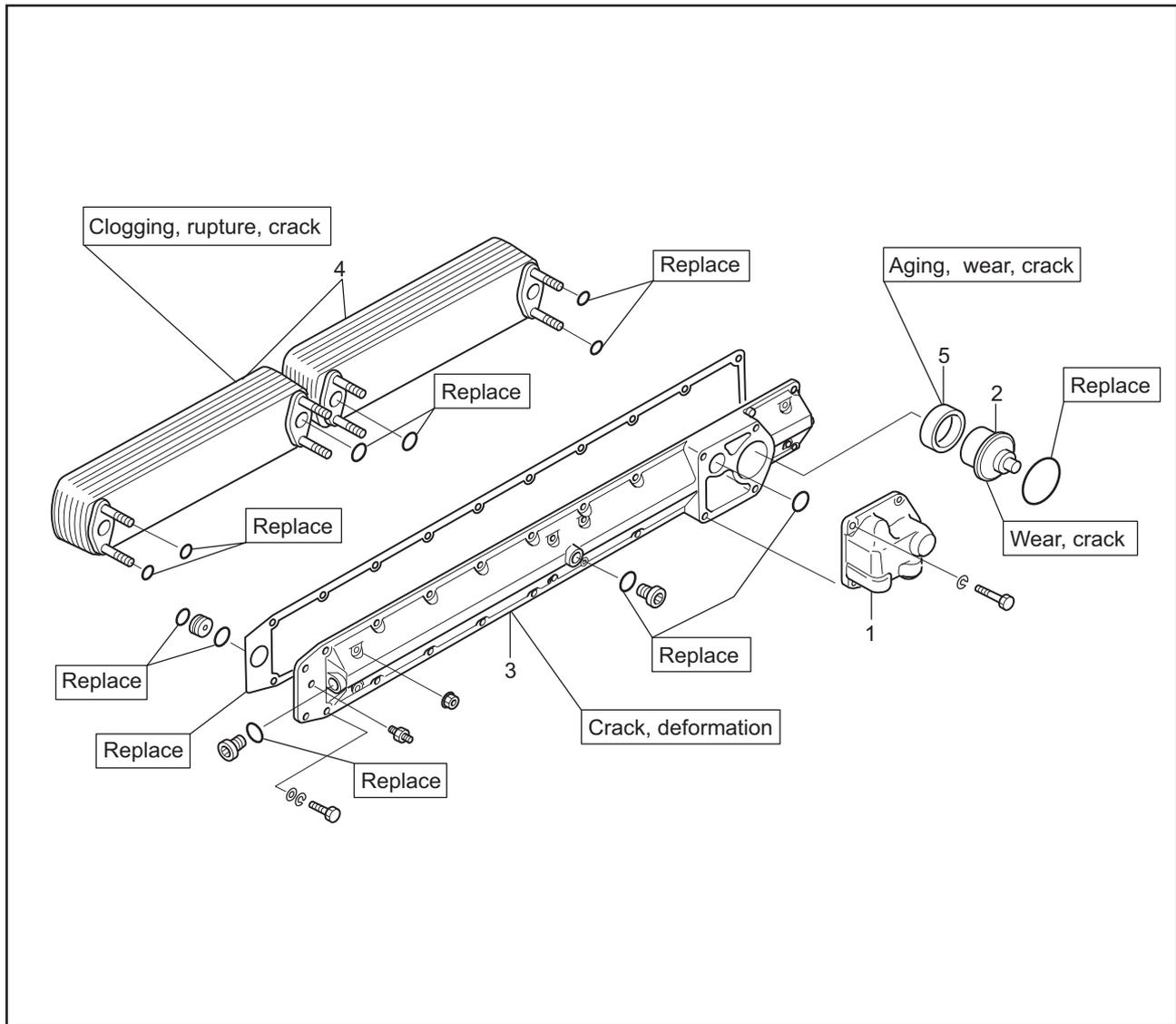
Thoroughly clean oil passages with wash oil, and dry the cleaned parts with compressed air.

### 2.11 Oil Filter Cartridge - Install

#### **CAUTION**

- (a) When installing the oil filter cartridge, tighten it by hand. (Do not use a filter wrench.)
  - (b) Be careful not to dent or damage the surface of cartridge.
- 
- (1) Remove dust and contamination on mating face of oil filter cartridge.
  - (2) Apply clean engine oil on oil filter gasket.
  - (3) After the oil filter gasket contacts with the 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 leak.

## 2.12 Right Side Oil Cooler - Disassemble and Inspect



Right Oil Cooler - Disassemble and Inspect

## Disassembling sequence

- |                  |                      |                   |
|------------------|----------------------|-------------------|
| 1 Connector      | 3 Oil cooler cover   | 5 Thermostat seal |
| 2 Oil thermostat | 4 Oil cooler element |                   |

## 2.13 Right Side Oil Cooler - Inspect

Inspect in the same manner as described for left side.

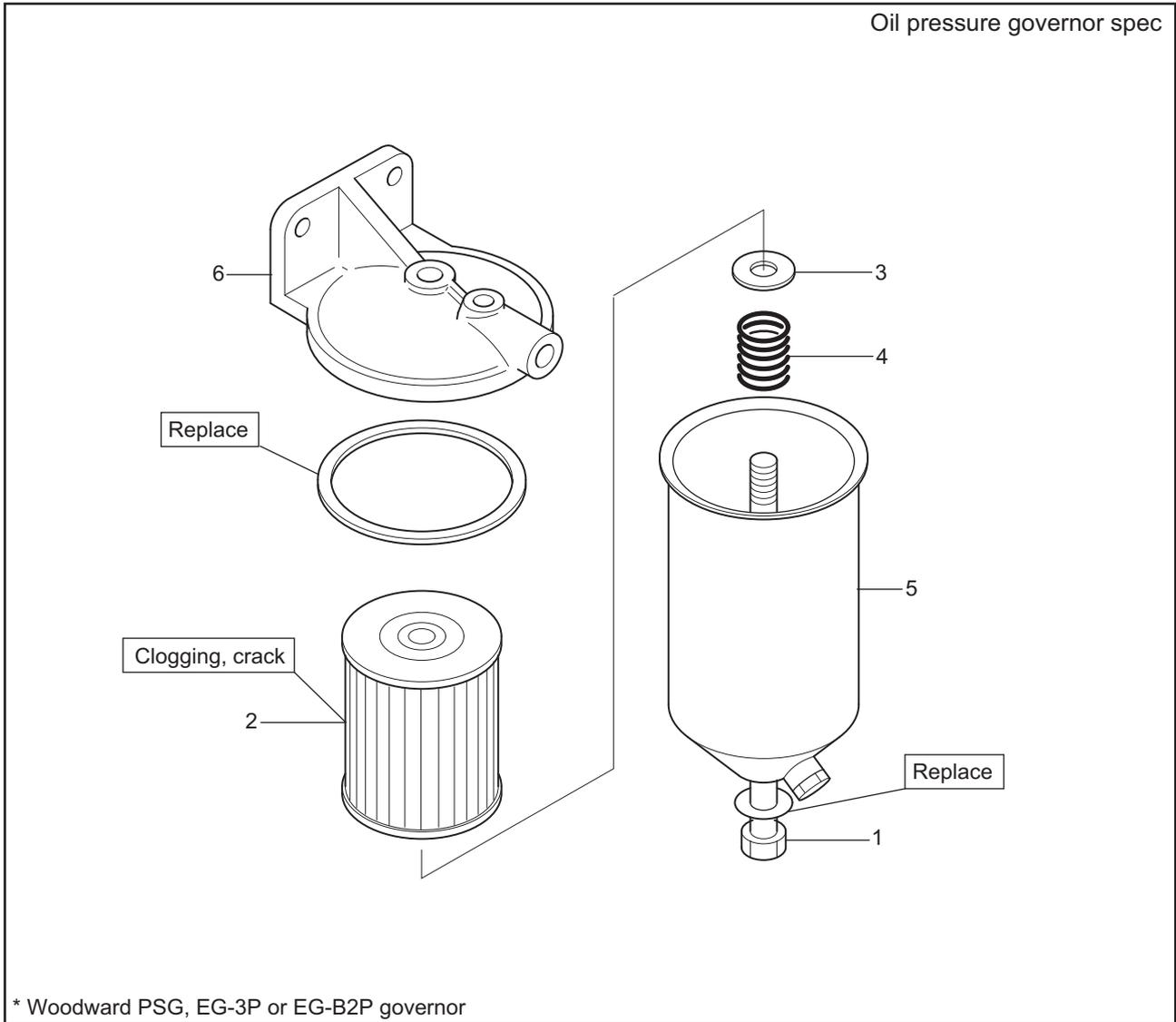
Replace the part if any defect is found.

## 2.14 Right Oil Cooler - Assemble

To assemble, follow the disassembling sequence in reverse.

Thoroughly clean oil passages with wash oil, and dry the cleaned parts with compressed air.

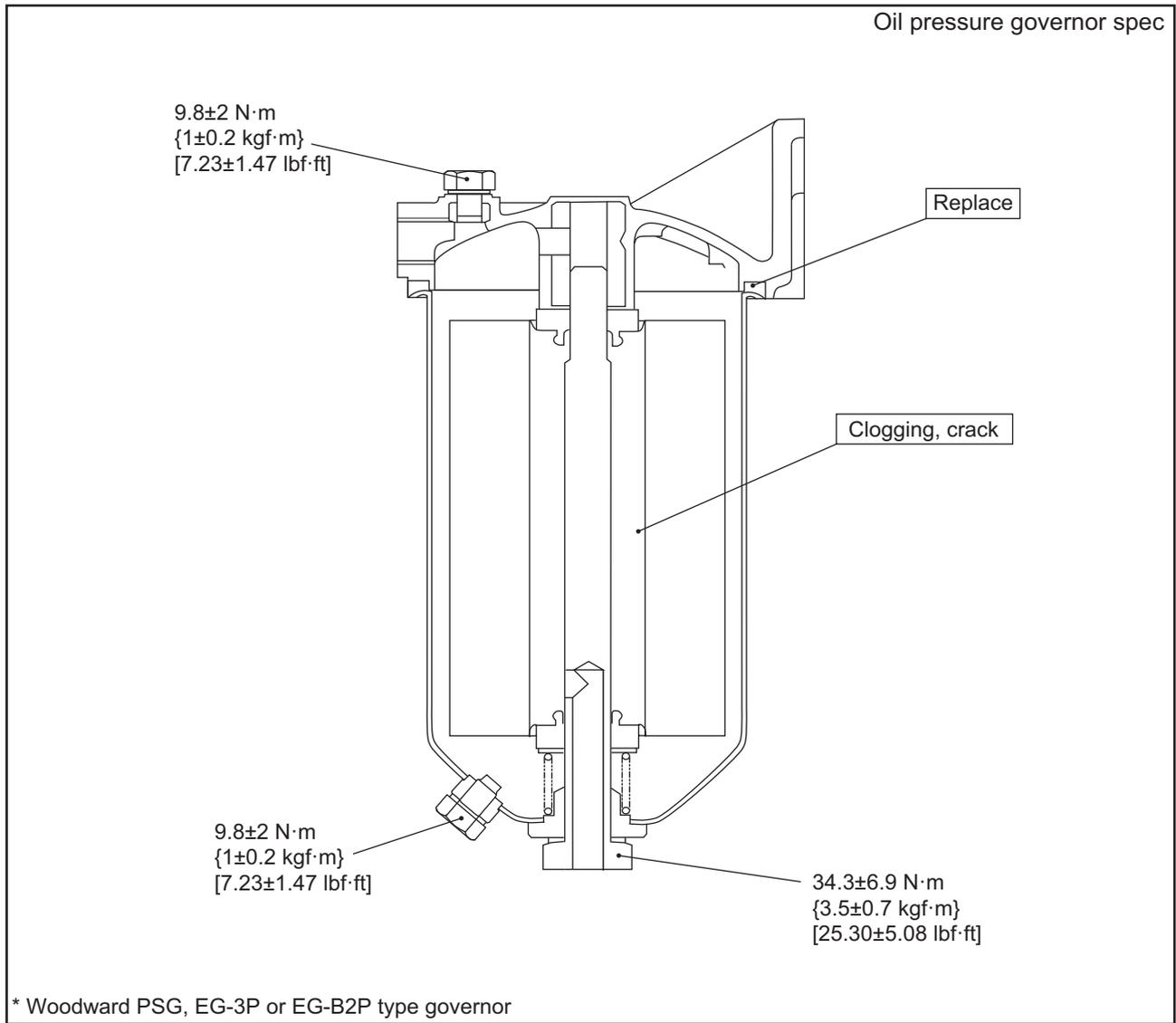
2.15 Governor Oil Filter - Disassemble and Inspect



Disassembly sequence

- |               |               |         |
|---------------|---------------|---------|
| 1 Center bolt | 3 Spring seat | 5 Case  |
| 2 Element     | 4 Spring      | 6 Cover |

## 2.16 Governor Oil Filter - Assemble



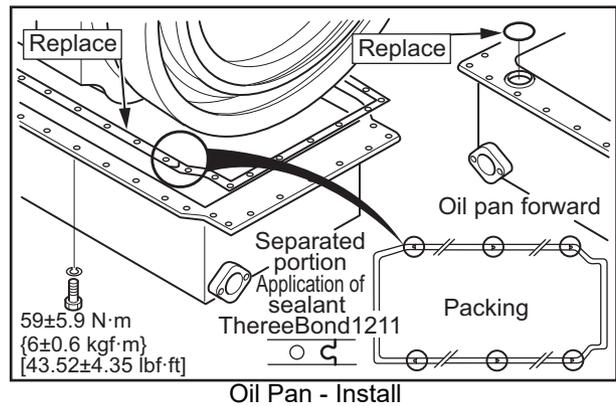
Governor Oil Filter - Assemble

### 3. Lubrication System - Install

- ♦To install, follow the removal sequence in reverse. (See the illustration for disassembly.)
- ♦Thoroughly clean oil passages and dry them well.

#### 3.1 Oil Pan - Install

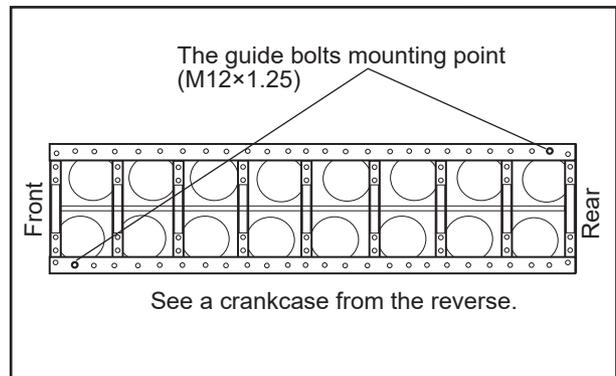
- (1) Install the O-ring to the oil passage of the oil pan mounting surface.
- (2) Apply sealant (ThreeBond 1211) to six places on both surfaces of oil pan packing joints, and attach the packing to the oil pan.
- (3) Install two guide bolts into the crankcase, and install the oil pan.
- (4) Tighten the mounting bolts to the specified torque.



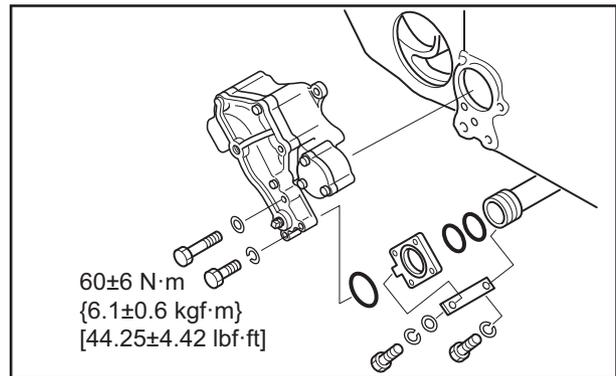
Oil Pan - Install

#### 3.2 Oil Pump - Install

Install the oil pump to the front gear case and oil pipe, and tighten the bolts to the specified torque.



Guide Bolt Setting Position



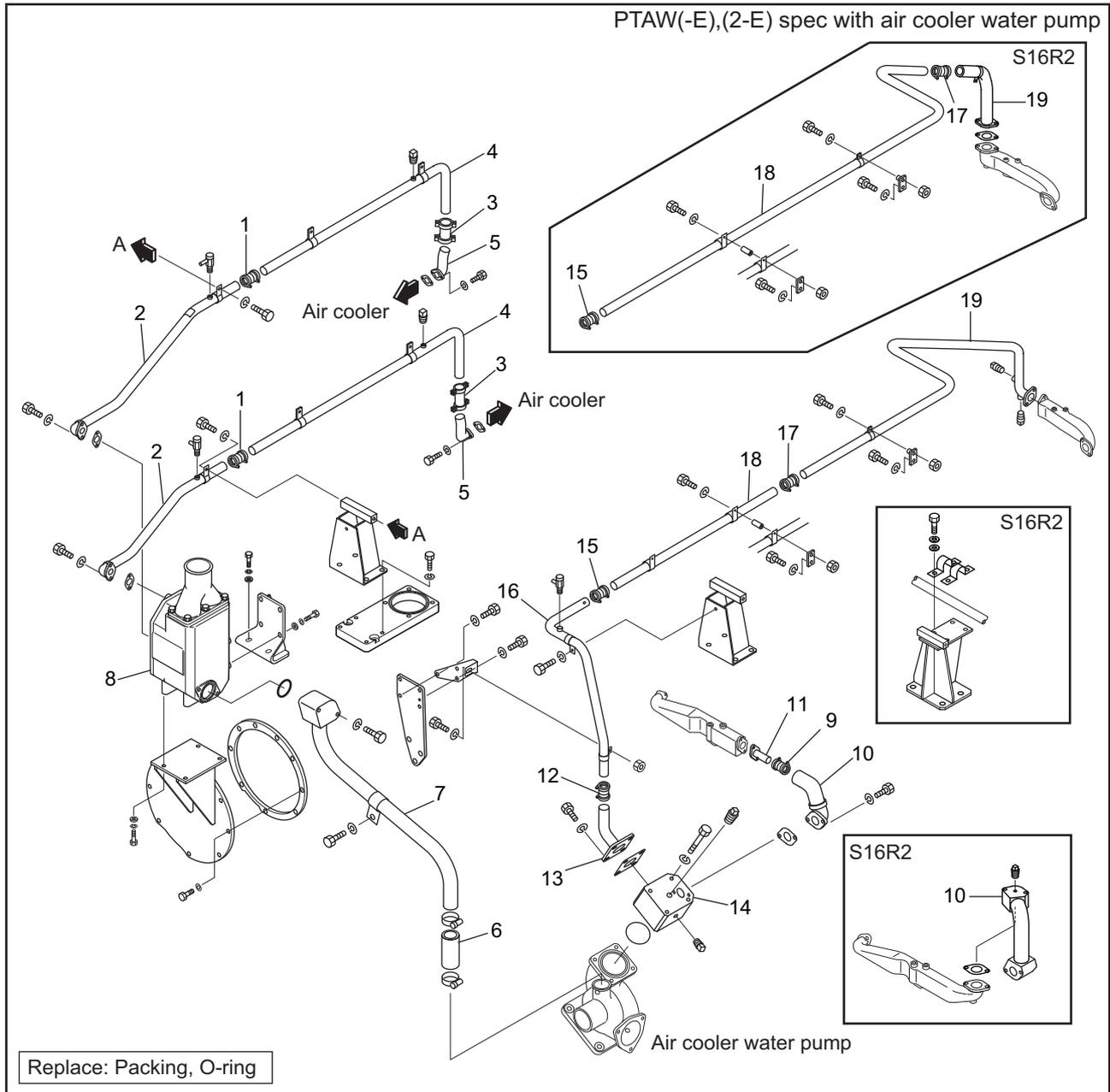
Oil Pump - Install

# Chapter 10 COOLING SYSTEM

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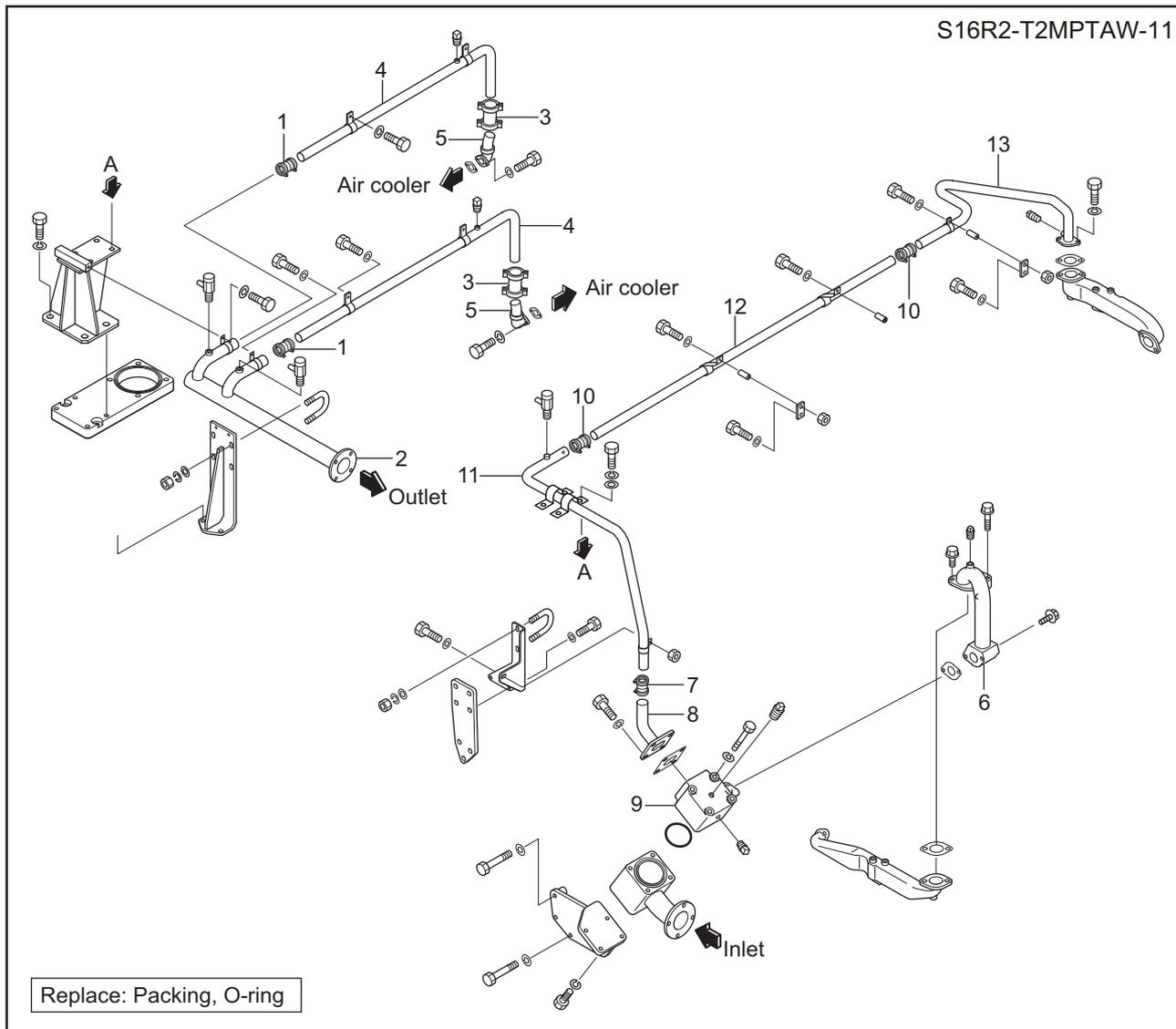






Removing sequence

- |   |   |
|---|---|
| <ul style="list-style-type: none"> <li>1 Coupling</li> <li>2 Water pipe (thermostat inlet)</li> <li>3 Coupling</li> <li>4 Water pipe (air cooler outlet)</li> <li>5 Water pipe (air cooler outlet)</li> <li>6 Rubber hose</li> <li>7 Water pipe (thermostat outlet)</li> <li>8 Thermostat case (approx. 22 kg [49 lb])</li> <li>9 Coupling</li> <li>10 Water pipe (front air cooler inlet)</li> </ul> | <ul style="list-style-type: none"> <li>11 Water pipe (front air cooler inlet)</li> <li>12 Coupling</li> <li>13 Water pipe (rear air cooler inlet)</li> <li>14 Connector</li> <li>15 Coupling</li> <li>16 Water pipe (rear air cooler inlet)</li> <li>17 Coupling</li> <li>18 Water pipe (rear air cooler inlet)</li> <li>19 Water pipe (rear air cooler inlet)</li> </ul> |
|---|---|

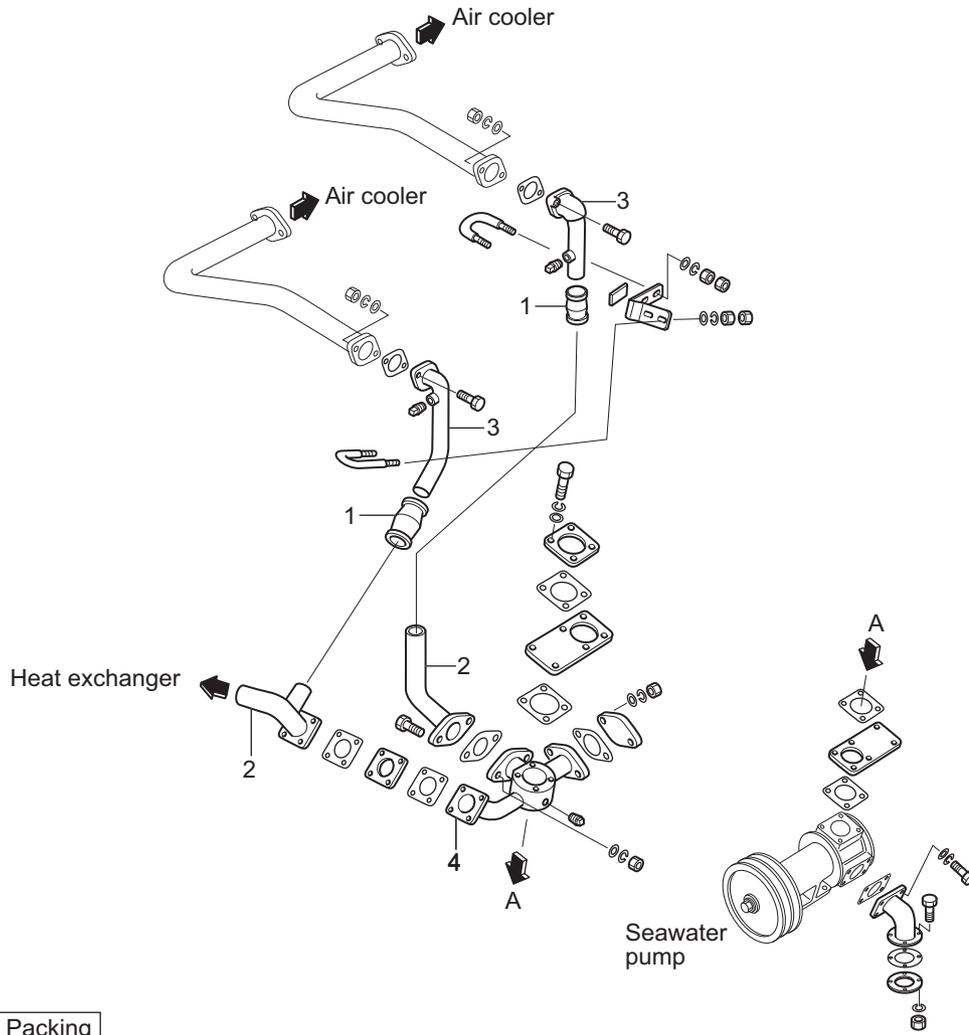


External Cooling System - Remove and Inspect

Removing sequence

- |   |   |
|---|---|
| <ul style="list-style-type: none"> <li>1 Coupling</li> <li>2 Water pipe (air cooler outlet)</li> <li>3 Coupling</li> <li>4 Water pipe (air cooler outlet)</li> <li>5 Water pipe (air cooler outlet)</li> <li>6 Water pipe (front air cooler inlet)</li> <li>7 Coupling</li> </ul> | <ul style="list-style-type: none"> <li>8 Water pipe (rear air cooler inlet)</li> <li>9 Connector</li> <li>10 Coupling</li> <li>11 Water pipe (rear air cooler inlet)</li> <li>12 Water pipe (rear air cooler inlet)</li> <li>13 Water pipe (rear air cooler inlet)</li> </ul> |
|---|---|

MPTK spec with seawater pump

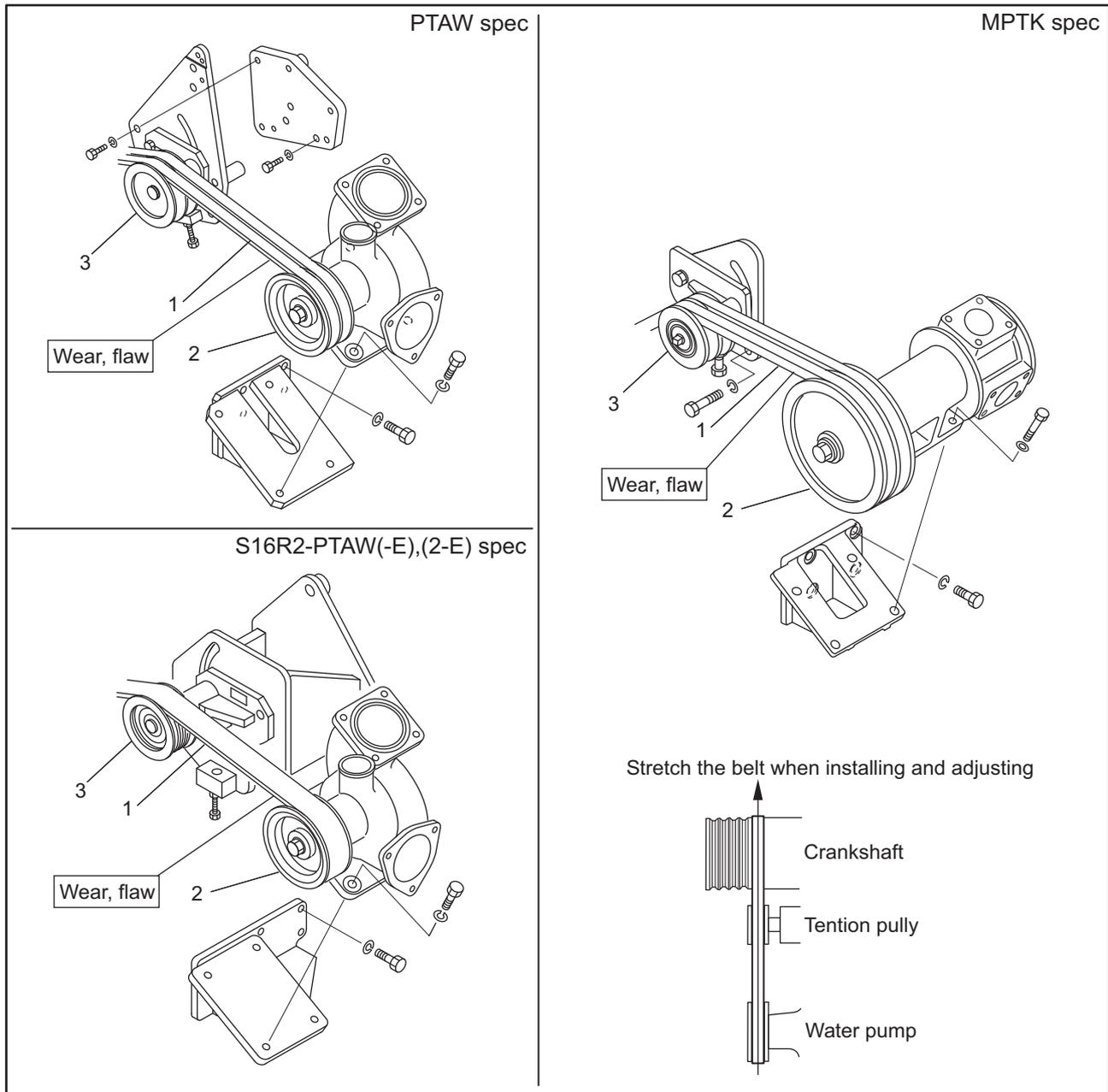


External Cooling System - Remove and Inspect

Removing sequence

- |              |              |
|--------------|--------------|
| 1 Coupling   | 3 Water pipe |
| 2 Water pipe | 4 Water pipe |

## 1.2 Air Cooler Water Pump - Remove and Inspect

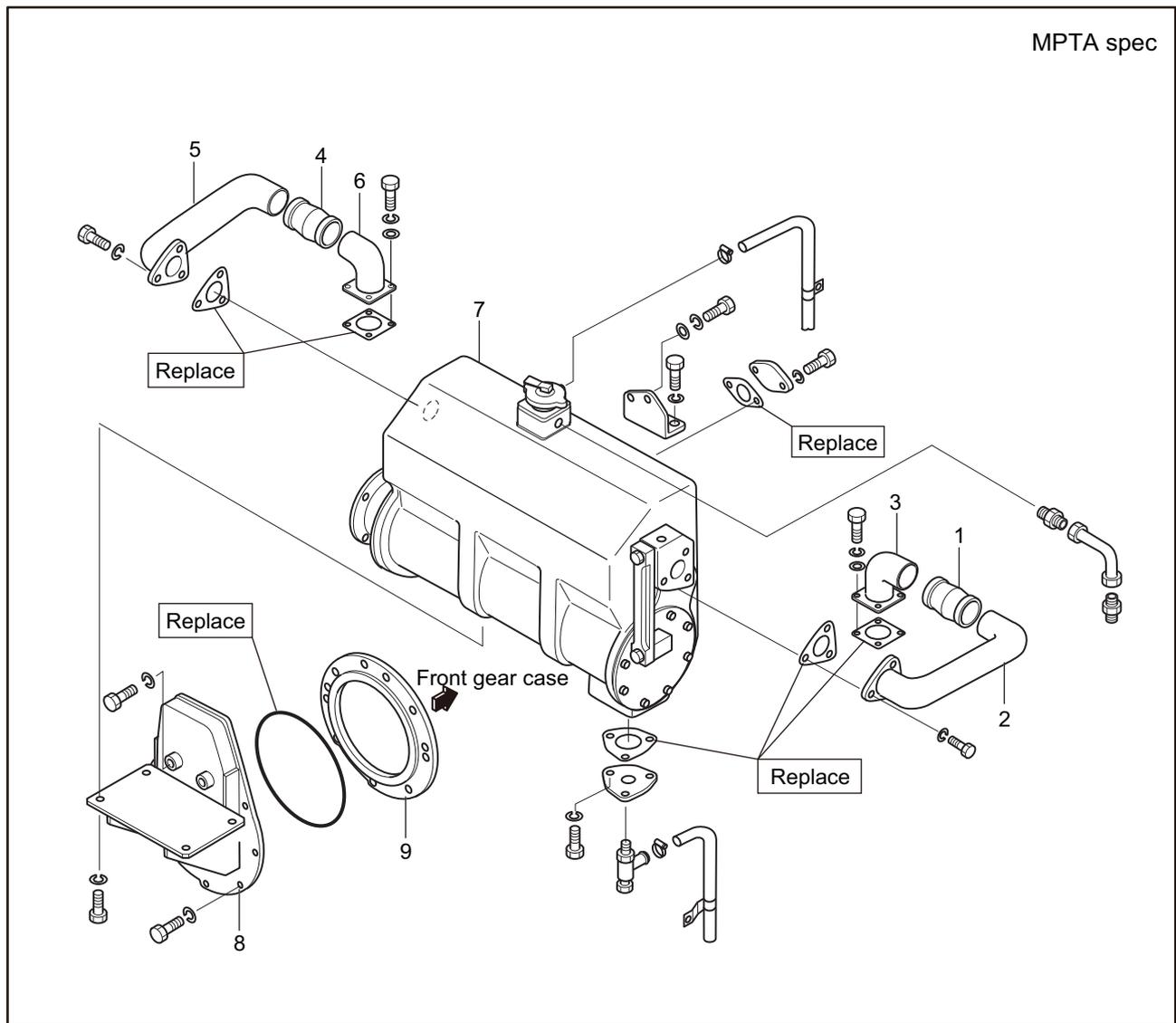


Air Cooler Water Pump - Remove and Inspect

## Removing sequence

- 1 Belt
- 2 Air cooler water pump (PTAW spec approx. 24 kg [53 lb])  
(S16R2 PTAW spec approx. 24 kg [53 lb])  
(MPTK spec approx. 34 kg [75 lb])
- 3 Tension pulley assembly

1.3 Heat Exchanger - Remove and Inspect

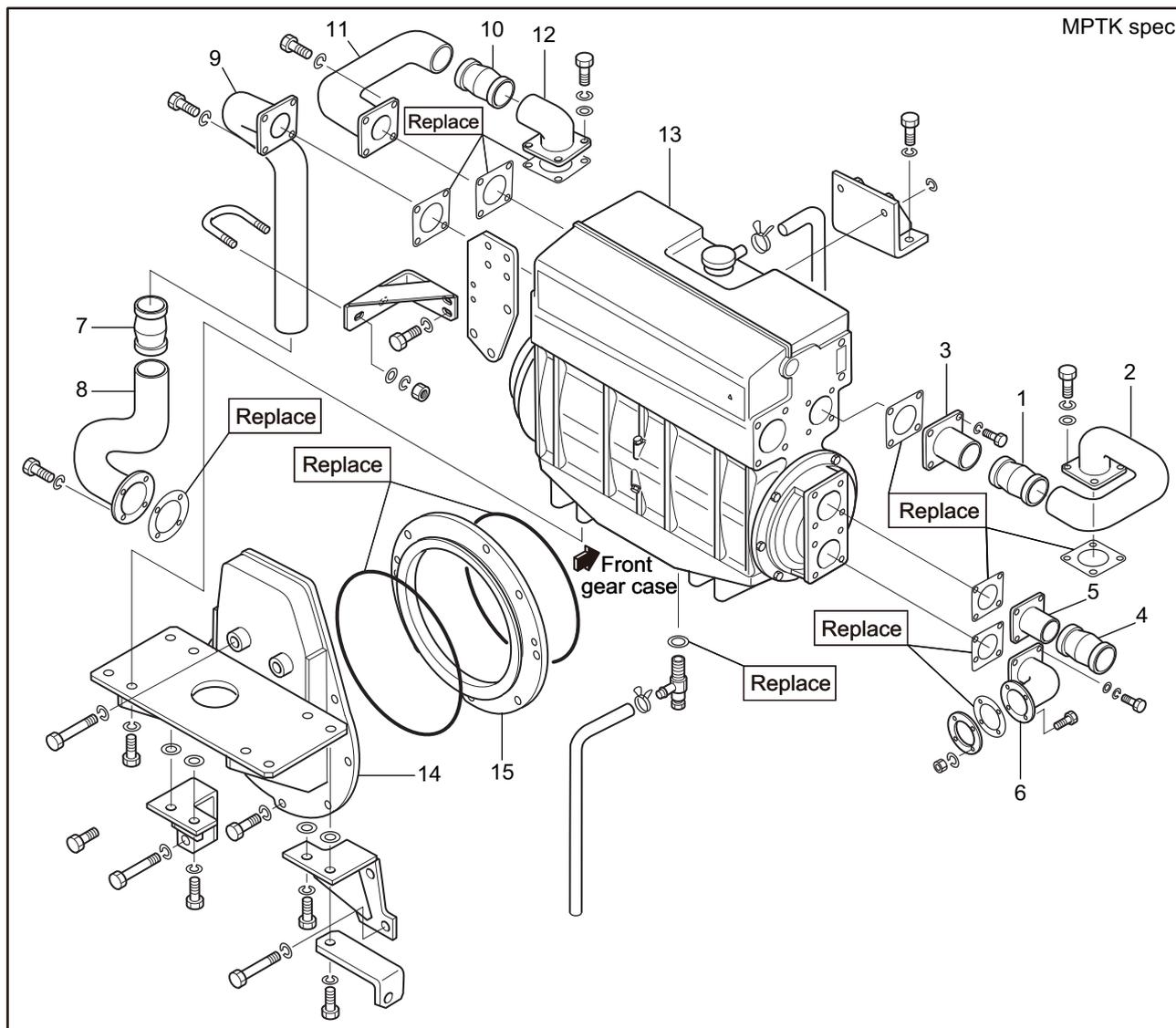


Heat Exchanger - Remove and Inspect

Removing sequence

- |              |  |
|--------------|--|
| 1 Coupling   | 6 Water pipe                             |
| 2 Water pipe | 7 Heat exchanger (approx. 30 kg [66 lb]) |
| 3 Water pipe | 8 Bracket (approx. 26 kg [57 lb])        |
| 4 Coupling   | 9 Spacer                                 |
| 5 Water pipe |  |

MPTK spec

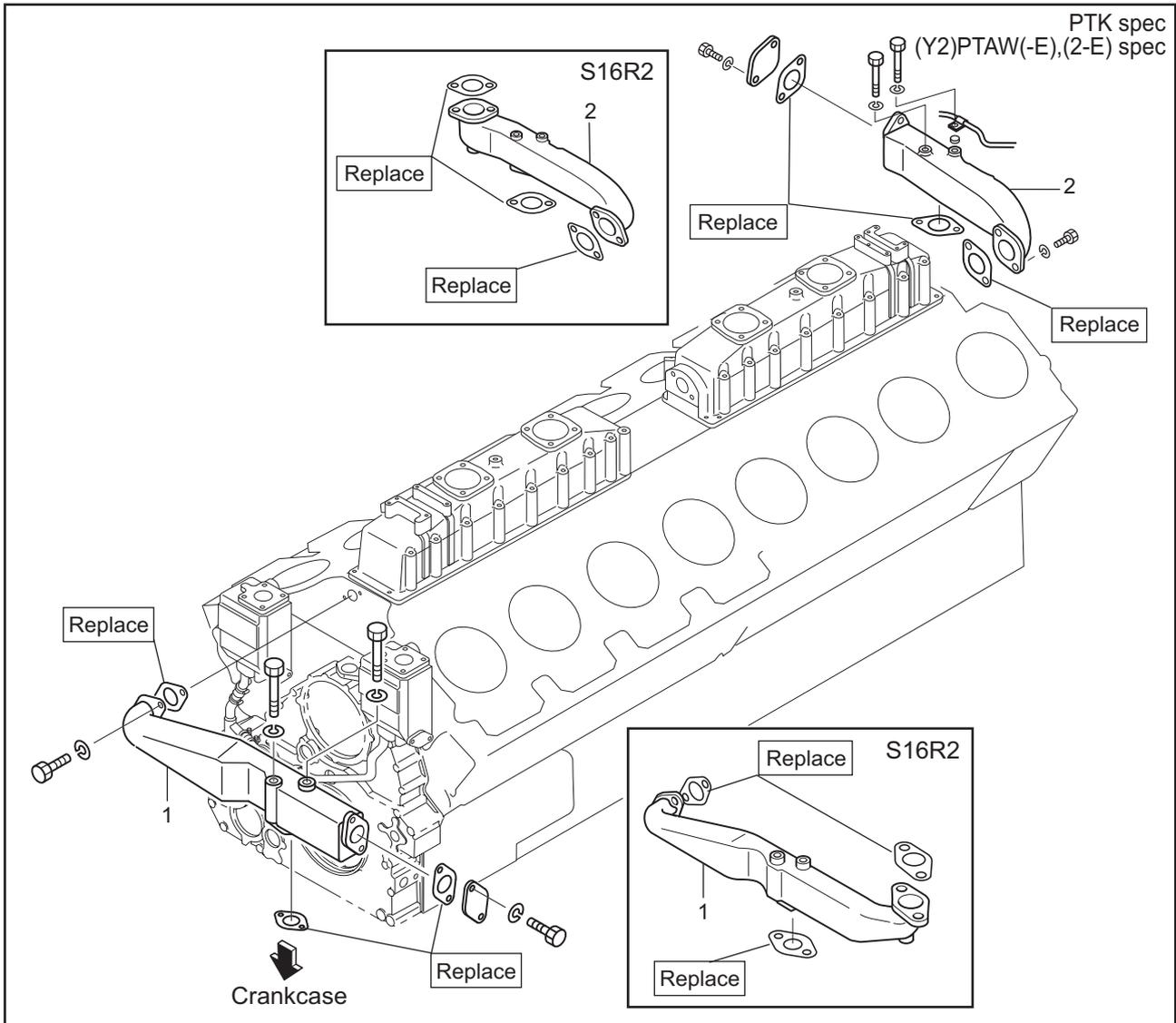


Heat Exchanger - Remove and Inspect

## Removing sequence

- |              |              |  |
|--------------|--------------|--|
| 1 Coupling   | 6 Water pipe | 11 Water pipe                              |
| 2 Water pipe | 7 Coupling   | 12 Water pipe                              |
| 3 Water pipe | 8 Water pipe | 13 Heat exchanger (approx. 73 kg [161 lb]) |
| 4 Coupling   | 9 Water pipe | 14 Bracket (approx. 79 kg [174 lb])        |
| 5 Water pipe | 10 Coupling  | 15 Spacer                                  |



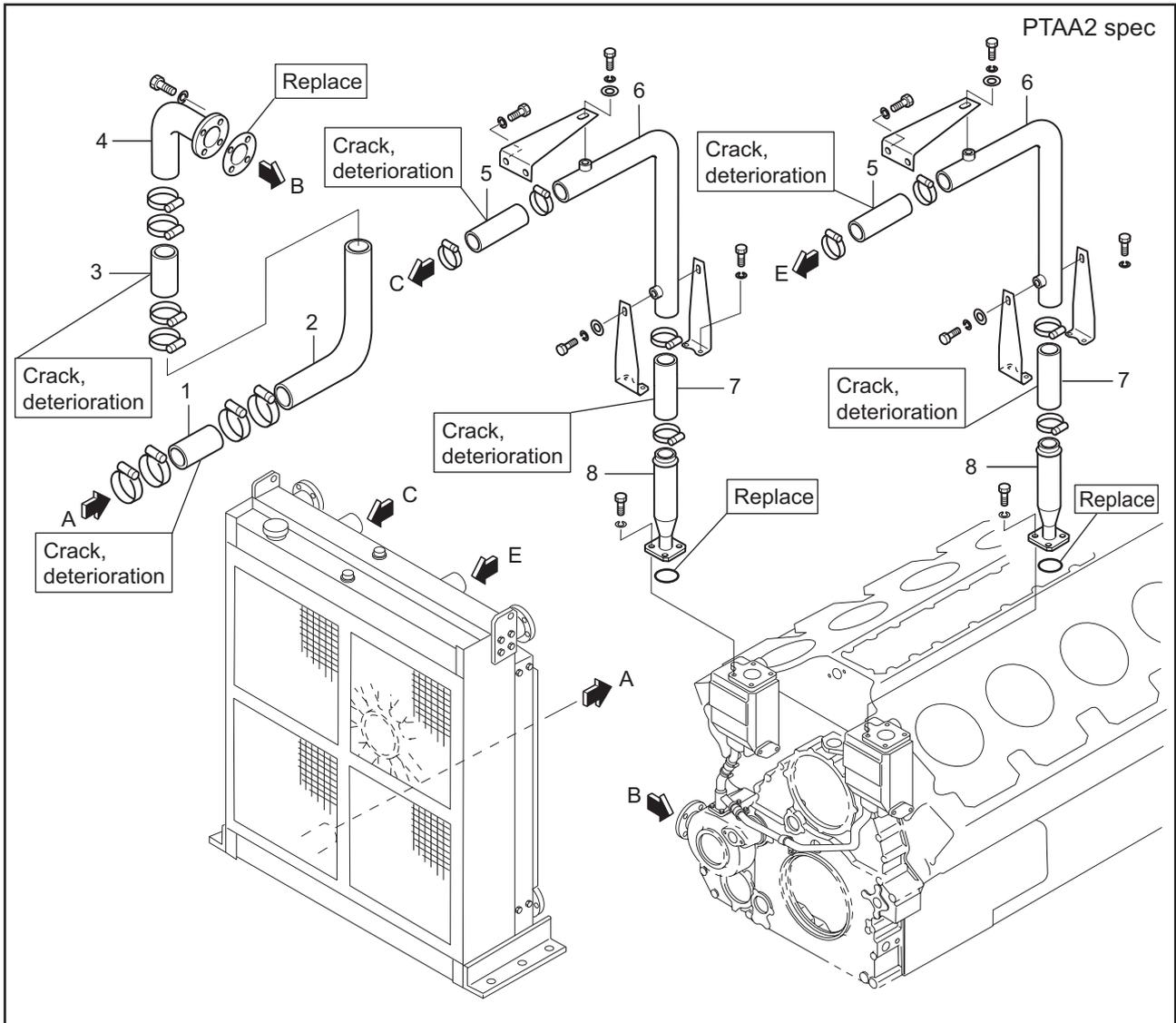


Water Pipe - Remove and Inspect

Removing sequence

1 Water connector

2 Water connector



Water Pipe - Remove and Inspect

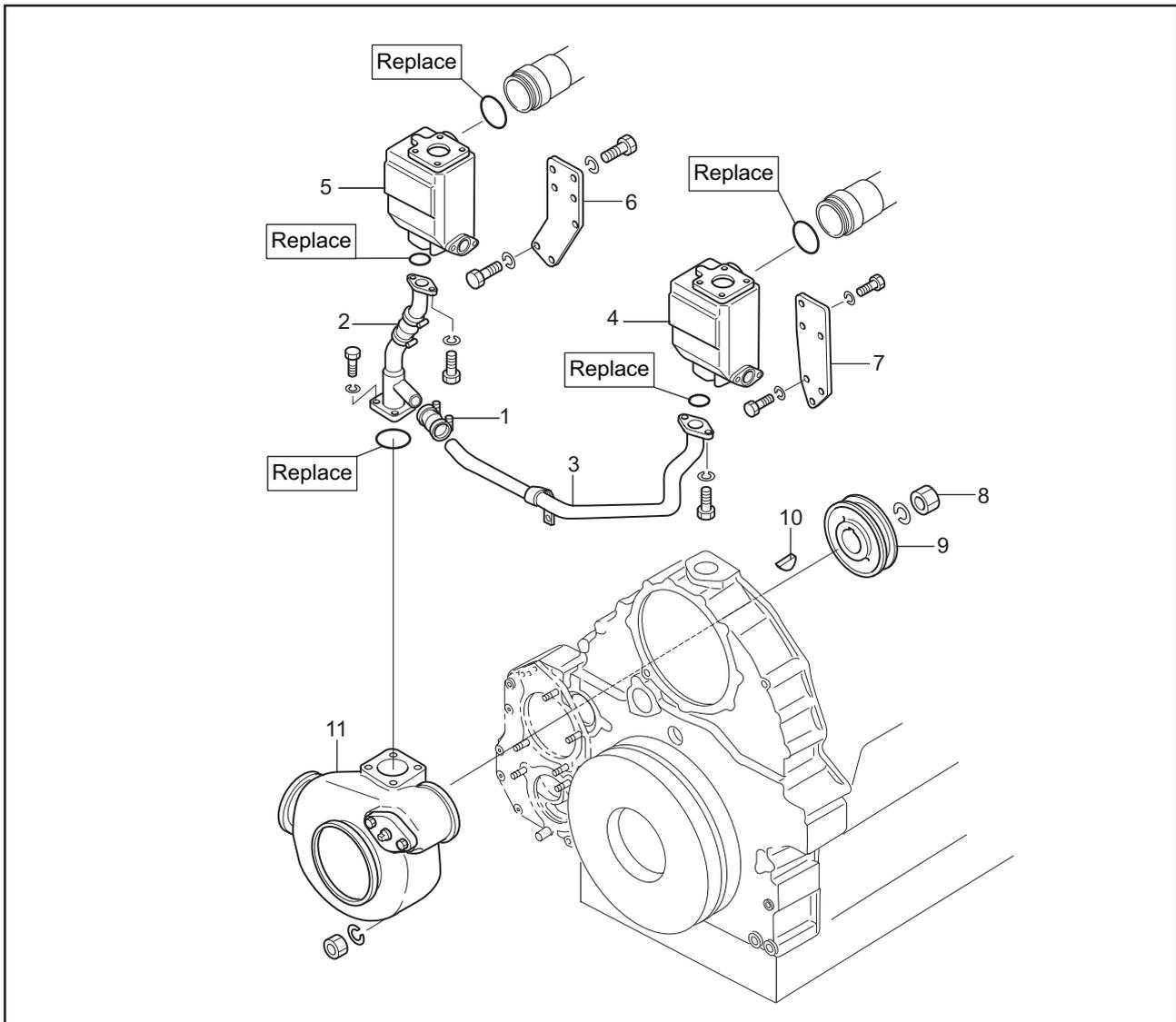
Removing sequence

- 1 Rubber hose
- 2 Water pipe
- 3 Rubber hose

- 4 Water pipe
- 5 Rubber hose
- 6 Water pipe

- 7 Rubber hose
- 8 Water pipe

## 1.5 Thermostat Case and Water Pipe - Remove and Inspect



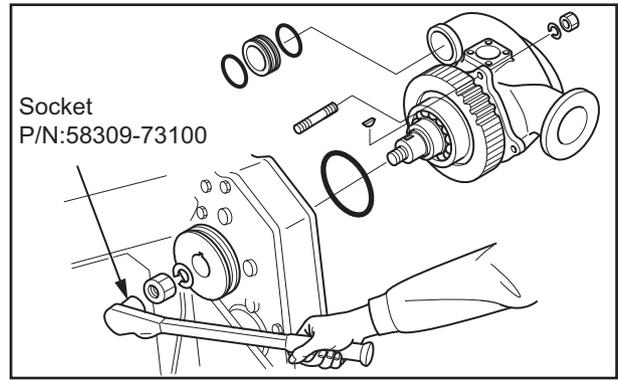
Thermostat Case and Water Pipe - Remove and Inspect

## Removing sequence

- |                         |                                       |
|-------------------------|---------------------------------------|
| 1 Coupling              | 6 Bracket                             |
| 2 Bypass water pipe     | 7 Bracket                             |
| 3 Bypass water pipe     | 8 Nut                                 |
| 4 Left thermostat case  | 9 Pulley (alternator driving)         |
| 5 Right thermostat case | 10 Key                                |
|                         | 11 Water pump (approx. 40 kg [88 lb]) |

1.6 Water Pump - Remove

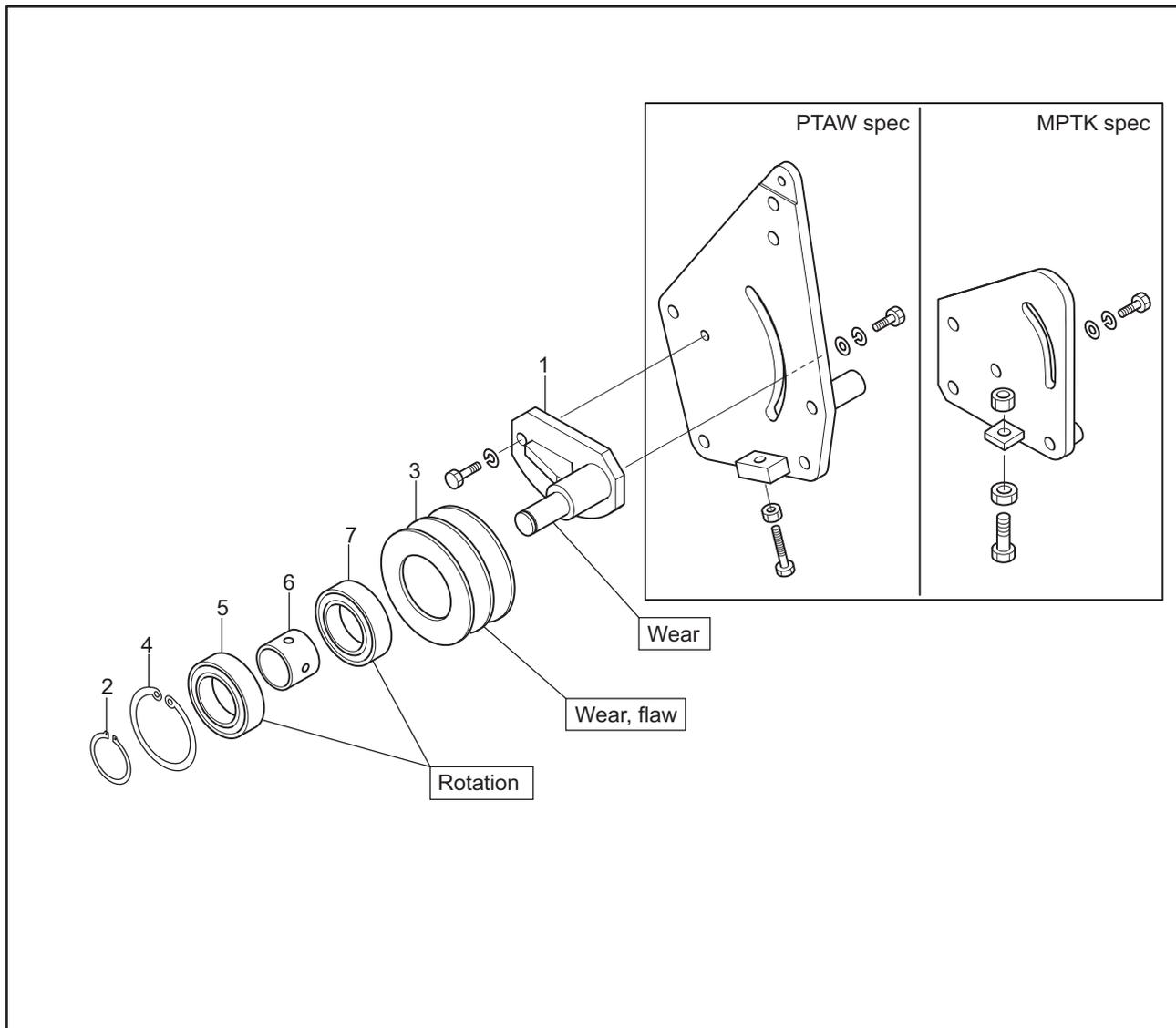
Remove the nut with the socket wrench.



Water Pump - Remove

## 2. Cooling System - Disassemble, Inspect, and Assemble

### 2.1 Tension Pulley - Disassemble and Inspect

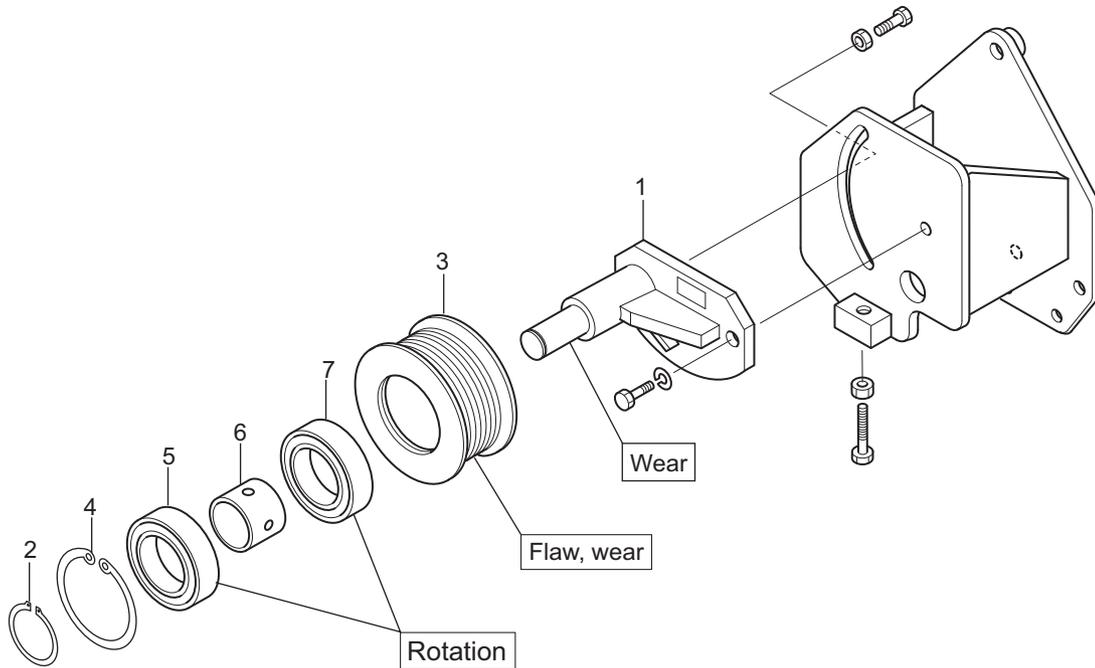


Tension Pulley - Disassemble and Inspect

#### Disassembling sequence

- |                   |             |           |
|-------------------|-------------|-----------|
| 1 Tension bracket | 4 Snap ring | 6 Spacer  |
| 2 Snap ring       | 5 Bearing   | 7 Bearing |
| 3 Tension pulley  |             |           |

S16R2 PTAW(-E),(2-E) spec



Tension Pulley - Disassemble and Inspect

Disassembling sequence

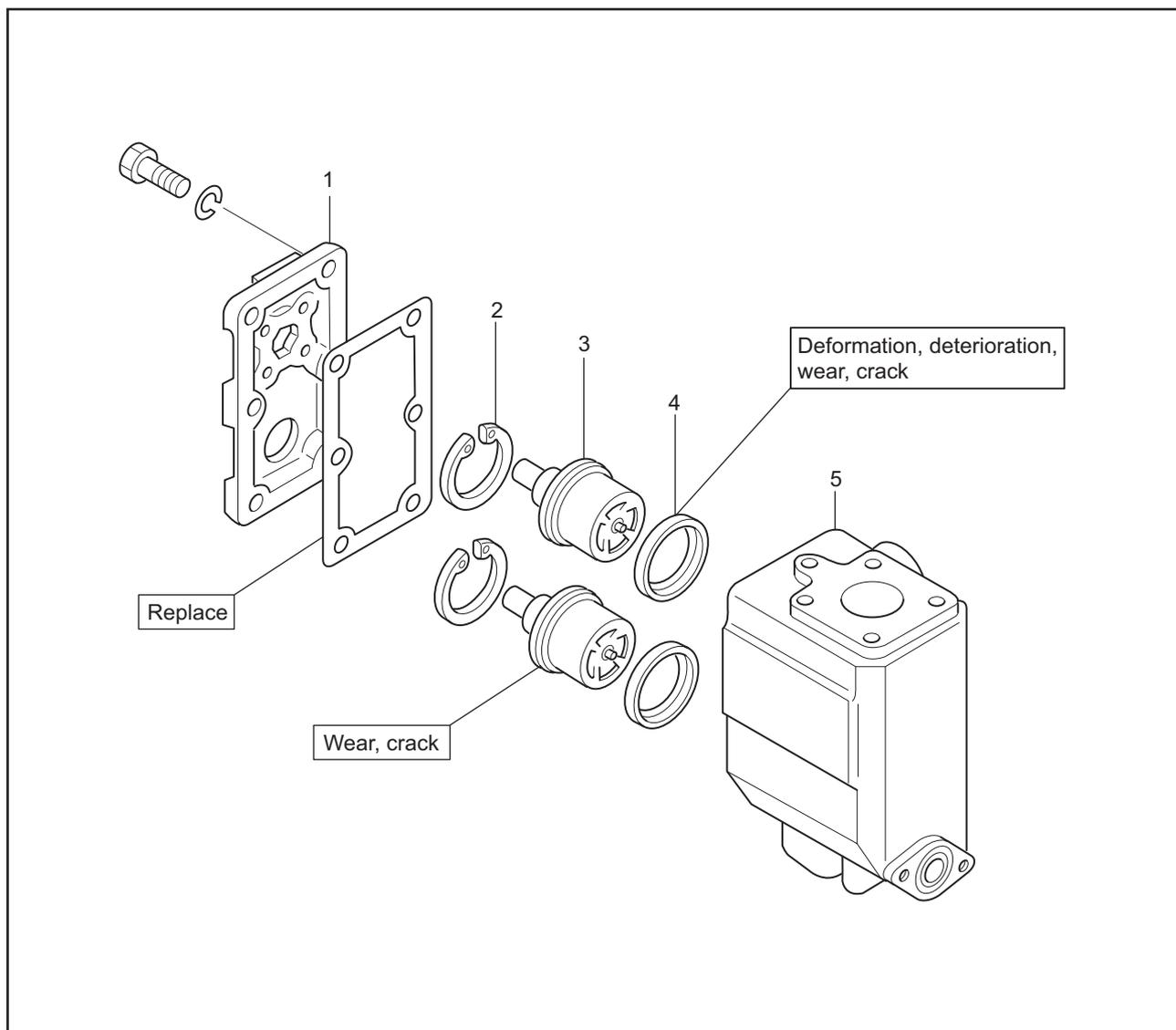
- |                   |             |           |
|-------------------|-------------|-----------|
| 1 Tension bracket | 4 Snap ring | 6 Spacer  |
| 2 Snap ring       | 5 Bearing   | 7 Bearing |
| 3 Tension pulley  |             |           |

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	ø62 mm [2.44 in.]	61.970 to 62.000 mm [2.4398 to 2.4409 in.]
Bearing	Inside diameter	ø25 mm [0.98 in.]
	Outside diameter	ø62 mm [2.44 in.]
Outside diameter of bracket bearing fit	ø25 mm [0.98 in.]	24.987 to 25.000 mm [0.9837 to 0.9843 in.]

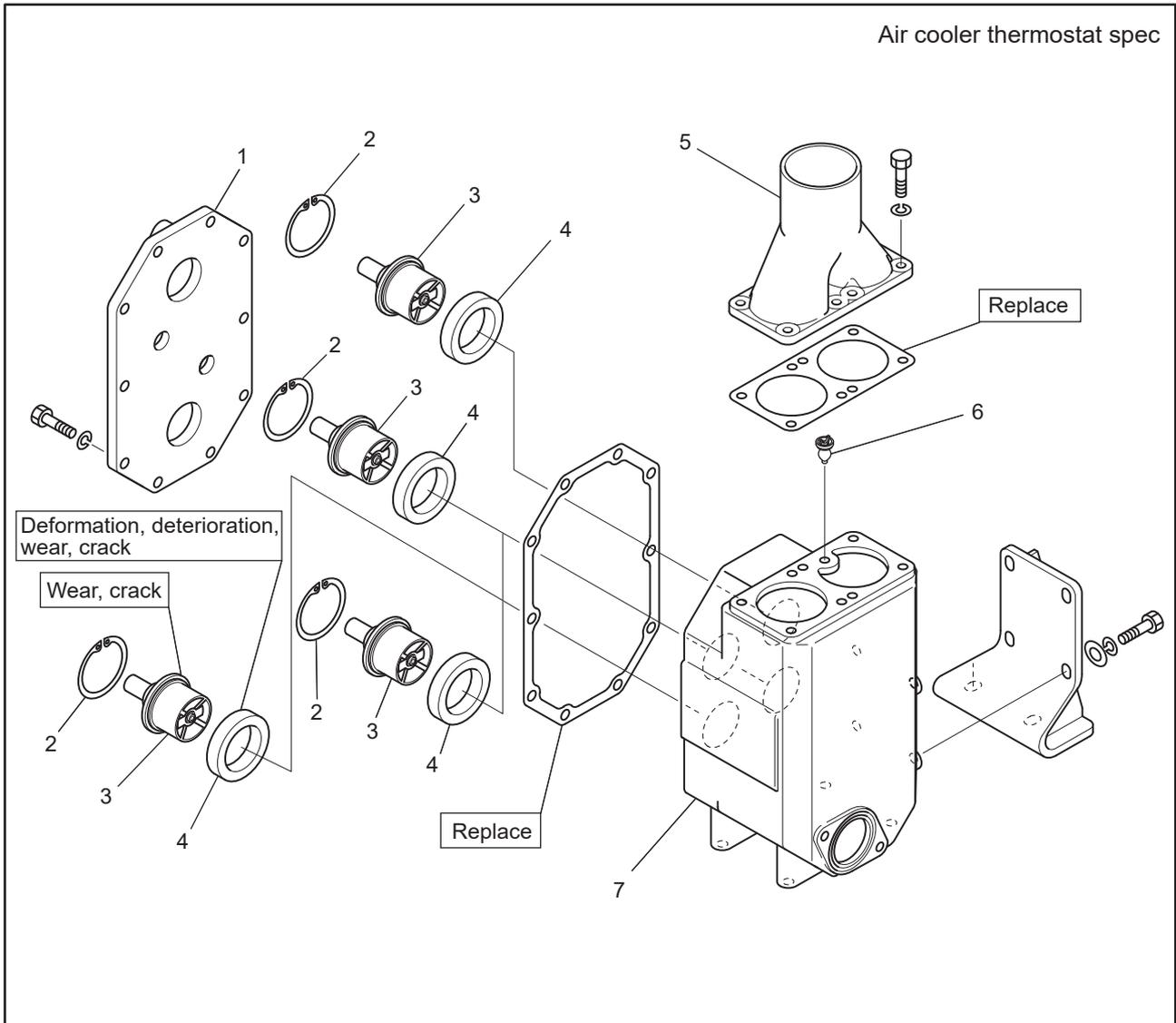
## 2.2 Thermostat - Disassemble and Inspect



Thermostat - Disassemble and Inspect

## Disassembly sequence

- |   |                  |   |                 |
|---|------------------|---|-----------------|
| 1 | Thermostat cover | 4 | Thermostat seal |
| 2 | Snap ring        | 5 | Thermostat case |
| 3 | Thermostat       |   |                 |



Thermostat - Disassemble and Inspect

Disassembling sequence

- 1 Thermostat cover
- 2 Snap ring
- 3 Thermostat

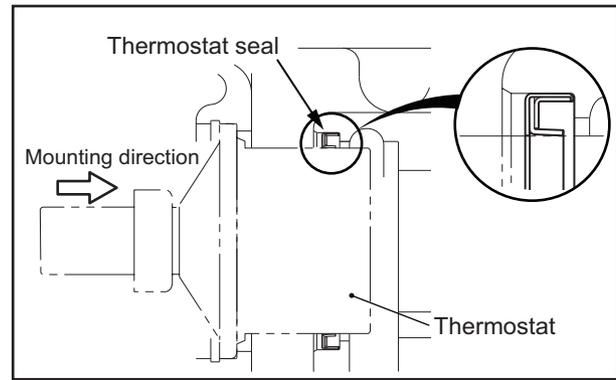
- 4 Thermostat seal
- 5 Thermostat cover

- 6 Jiggle valve
- 7 Thermostat case

## 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

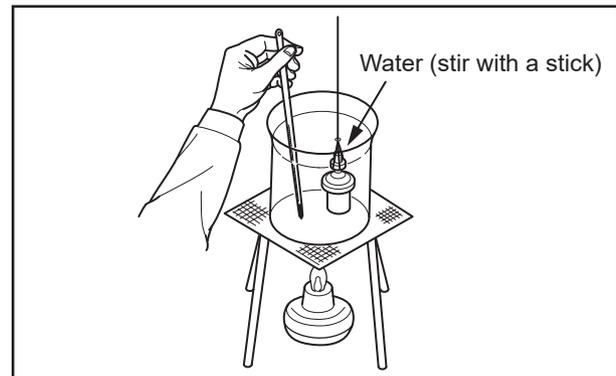
**CAUTION**

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 starts 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.

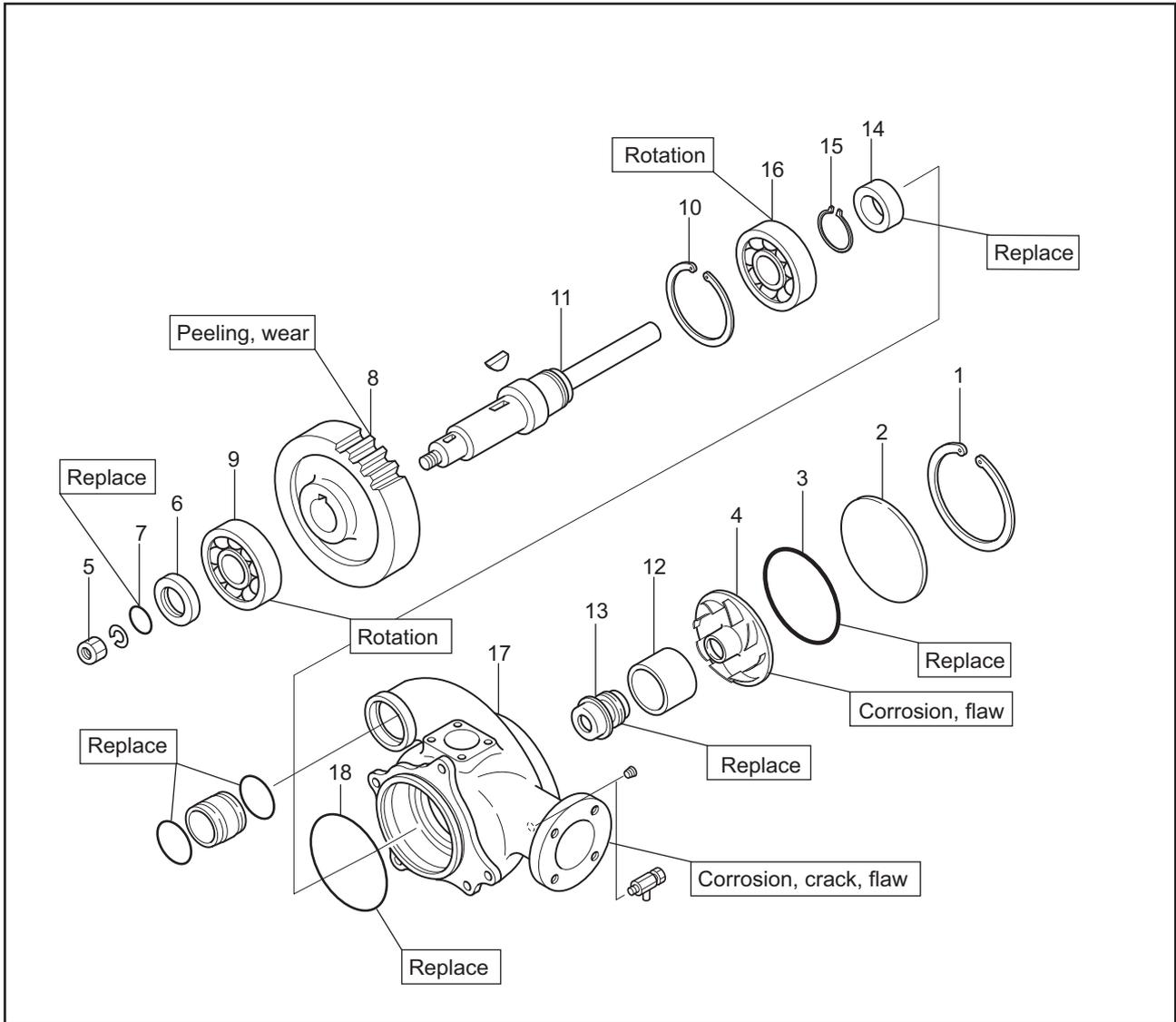
- (b) At assembling, be sure to check the valve opening temperature marked on the side of thermostat valve.



Thermostat Operation - Inspect

Part No.	Item	Standard value	Remarks
For jacket water	37546-□170□	Valve opening temperature	69 to 73°C [156.2 to 163.4°F]
		Temperature at which valve lift becomes 9 mm [0.35 in.] or more	85°C [185°F]
For air cooler	37751-□170□	Valve opening temperature	40 to 44°C [104 to 111.2°F]
			Temperature at which valve lift becomes 9 mm [0.35 in.] or more

2.4 Water Pump - Disassemble and Inspect



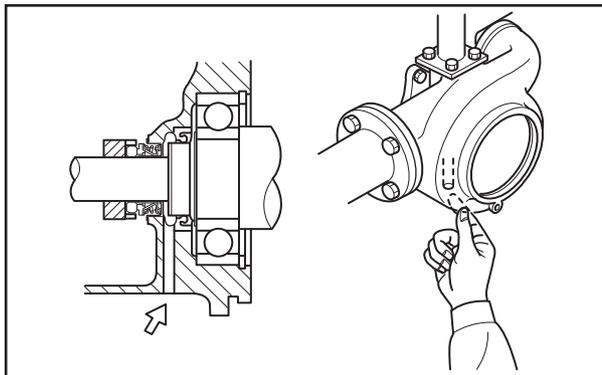
Water Pump - Disassemble and Inspect

Disassembling sequence

- |                   |                     |                                      |
|-------------------|---------------------|--------------------------------------|
| 1 Snap ring       | 7 O-ring            | 13 Unit seal                         |
| 2 Cover           | 8 Water pump gear   | 14 Oil seal                          |
| 3 O-ring          | 9 Bearing           | 15 Snap ring                         |
| 4 Impeller        | 10 Snap ring        | 16 Bearing                           |
| 5 Nut             | 11 Water pump shaft | 17 Pump case (approx. 21 kg [46 lb]) |
| 6 Oil seal sleeve | 12 ring             | 18 O-ring                            |

### 2.4.1 Water Pump Mounted on Engine - Inspect

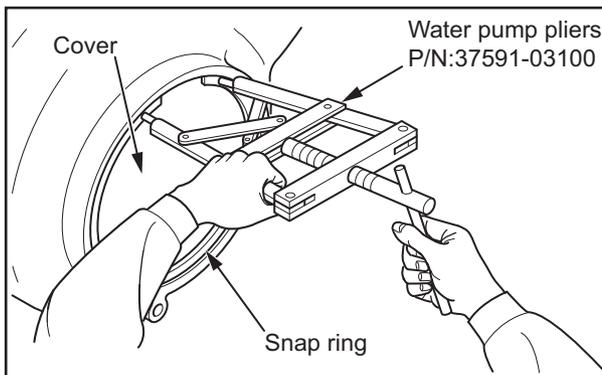
Visually check the drain port at the bottom center of water pump case with a finger. If water is oozing out, the unit seal is thought to be defective. Disassemble, check and correct the unit seal.



Water Pump Mounted on Engine - Inspect

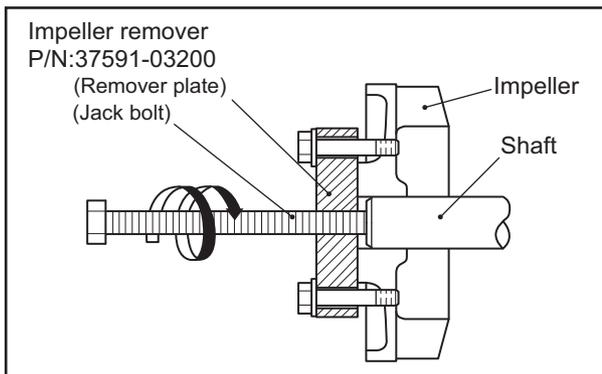
### 2.4.2 Impeller - Remove

- (1) Remove the snap ring that holds the cover with the water pump pliers, and remove the cover.



Water Pump Cover - Remove

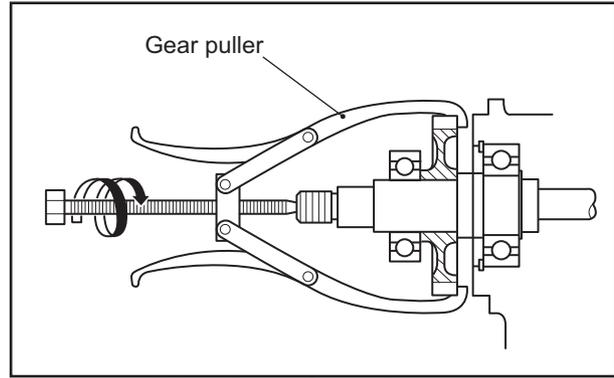
- (2) Remove the impeller with impeller remover.



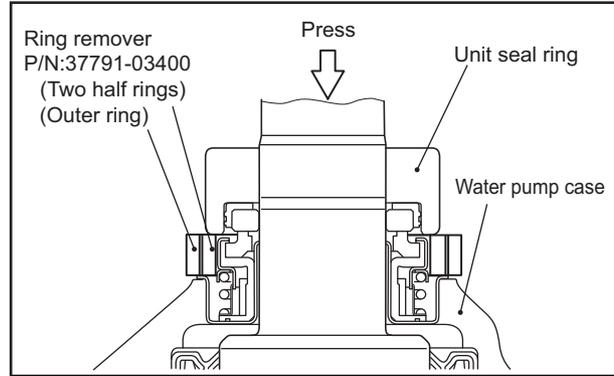
Impeller - Remove

2.4.3 Water Pump Shaft - Remove

- (1) Remove the oil seal sleeve.
- (2) Remove the gear and ball bearing together with a gear puller.
- (3) Remove the ball bearing snap ring on the water pump impeller side.
- (4) Insert the two half rings of ring remover between the unit seal ring and the water pump case as shown in the illustration.
- (5) Install the outer ring to hold the half rings in the position.
- (6) Push the impeller end face of water pump shaft with a hand press, remove the unit seal ring from the shaft.



Water Pump Gear - Remove



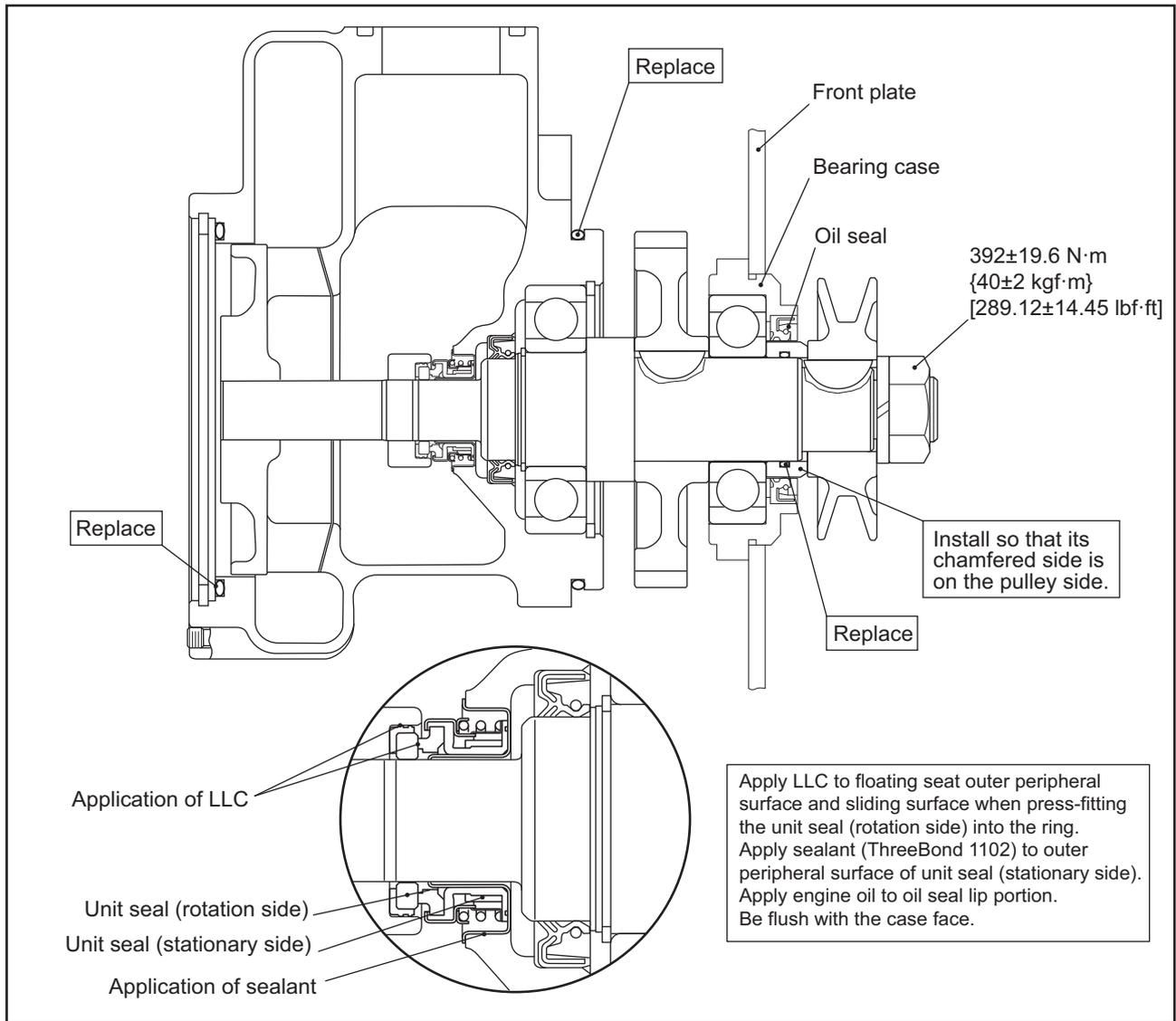
Water Pump Shaft - Remove

2.5 Water Pump - Inspect

Measure the bearing fitting diameters of water pump bearing housing and shaft, and the inside and outside diameters of the bearing. If the measurement is out of the standard, replace the part with a new one.

Item		Nominal value	Standard value
Inside diameter of bearing to fit	Pump case	ø120 mm [4.72 in.]	119.987 to 120.022 mm [4.7239 to 4.7253 in.]
	Bearing cover	ø110 mm [4.33 in.]	110.005 to 110.040 mm [4.3309 to 4.3323 in.]
Bearing	Large	Outside diameter	ø120 mm [4.72 in.] 119.985 to 120.000 mm [4.7238 to 4.7244 in.]
		Inside diameter	ø55 mm [2.17 in.] 54.985 to 55.000 mm [2.1648 to 2.1654 in.]
	Small	Outside diameter	ø110 mm [4.33 in.] 109.985 to 110.000 mm [4.3301 to 4.3307 in.]
		Inside diameter	ø50 mm [1.97 in.] 49.988 to 50.000 mm [1.9680 to 1.9685 in.]
Outside diameter of shaft to fit bearing		ø55 mm [2.17 in.]	55.011 to 55.024 mm [2.1658 to 2.1663 in.]
		ø50 mm [1.97 in.]	50.009 to 50.020 mm [1.9689 to 1.9693 in.]
Impeller front clearance		1.04 mm [0.0409 in.]	0.58 to 1.50 mm [0.0228 to 0.0591 in.]

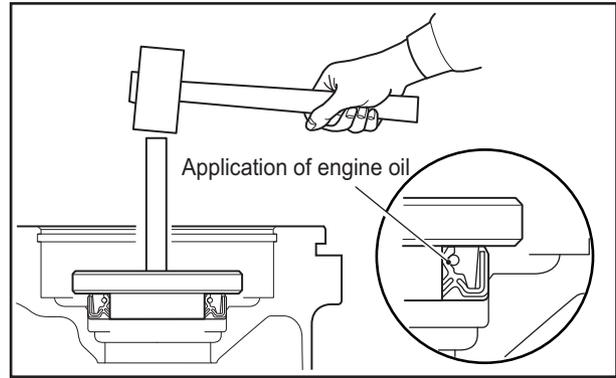
## 2.6 Water Pump - Assemble



Water Pump - Assemble

2.6.1 Oil Seal - Install

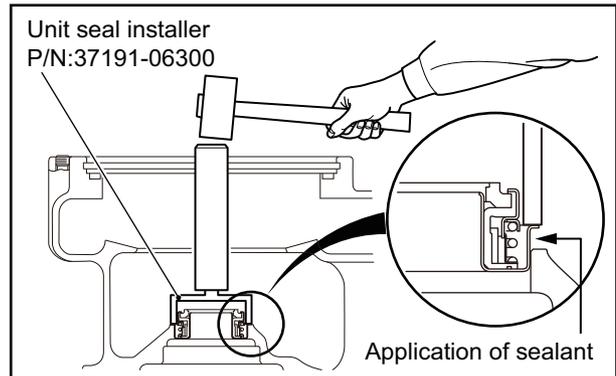
- (1) Install the oil seal with installer, making sure that oil seal surface is flush with water pump housing face.
- (2) Apply engine oil on the oil seal lip.



Oil Seal - Install

2.6.2 Unit Seal (Stationary Side) - Install

- (1) Apply sealant (ThreeBond 1102) on the outer circumference of unit seal (stationary side.)
- (2) Tap-in the unit seal into the water pump case with the unit seal installer.



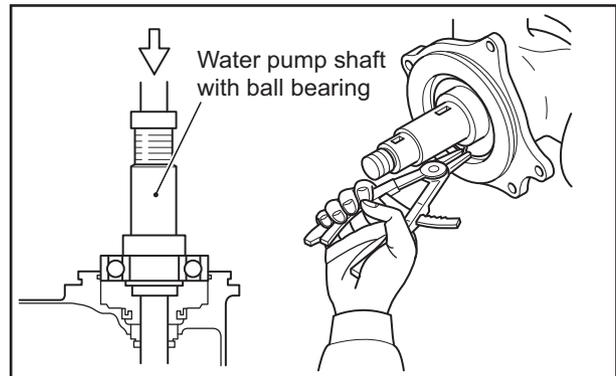
Unit Seal (Stationary Side) - Install

2.6.3 Water Pump Shaft - Install

**CAUTION**

When installing the water pump shaft, be careful not to damage the oil seal and unit seal (stationary side) inside the pump case with the shaft.

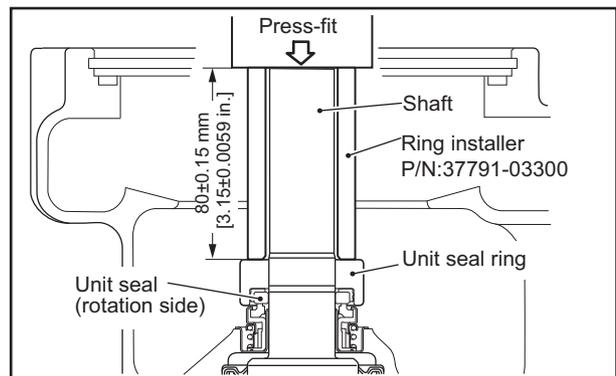
- (1) Press-in the impeller ball bearing to the water pump shaft.
- (2) Press-in the water pump shaft slowly into pump case until the end of ball bearing comes into contact with pump case.
- (3) Securely install the snap ring to groove.



Water Pump Shaft - Install

2.6.4 Unit Seal Ring and Unit Seal (Rotating Side) - Install

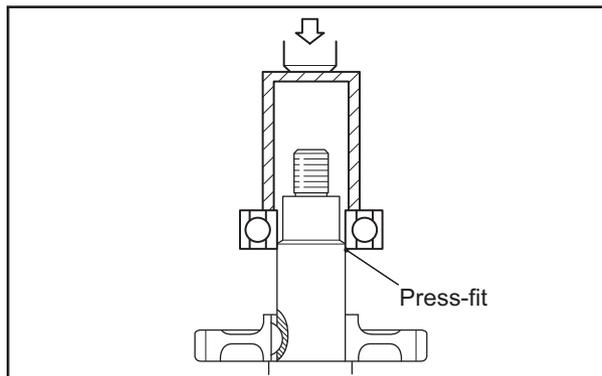
- (1) Set the unit seal (rotating side) to the unit seal ring.
- (2) Apply LLC to the unit seal (rotating side.)
- (3) Press-in the unit seal with the installer and press, slowly install the unit seal ring to the specified position.



Unit Seal Ring and Unit Seal (Rotating Side) - Install

## 2.6.5 Pulley Side Ball Bearing - Install

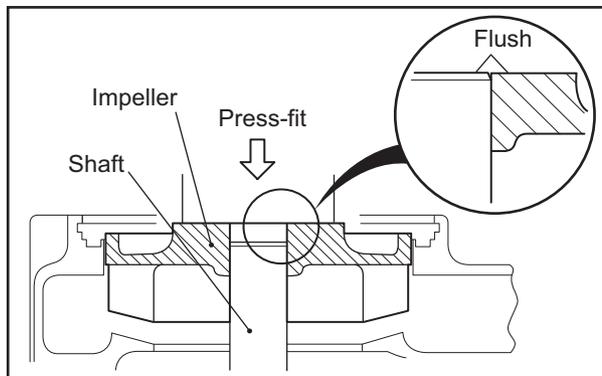
- (1) Set the gear to the shaft with the key.
- (2) Press-in the ball bearing on the pulley nut side with a press.



Pulley Side Ball Bearing - Install

## 2.6.6 Water Pump Impeller - Press In

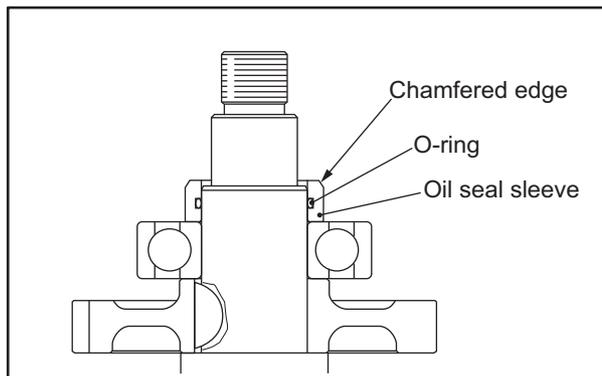
Press in the water pump impeller with a press tool. Place the water pump impeller boss face to be flush with the end face of pump shaft.



Water Pump Impeller - Press In

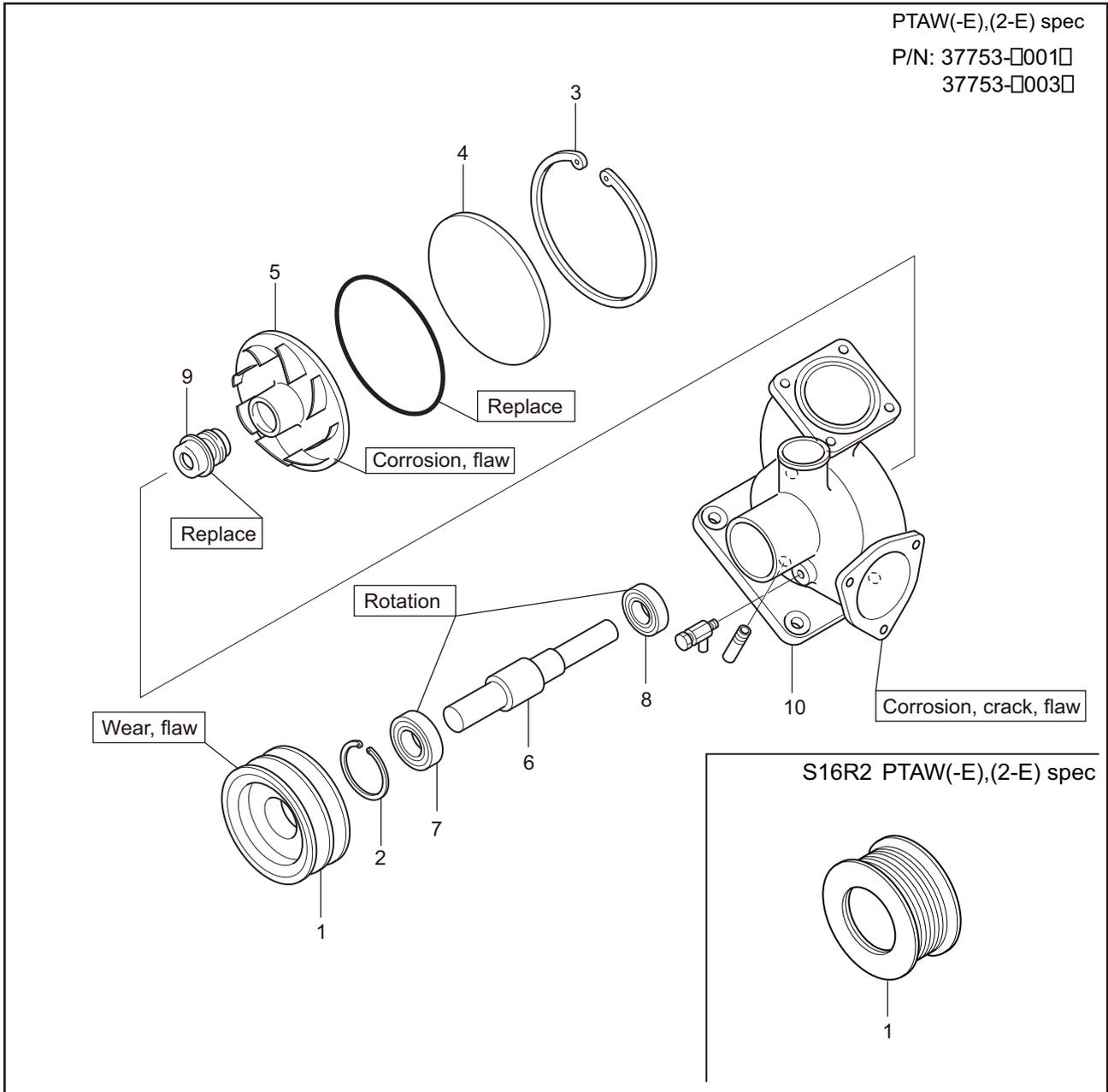
## 2.6.7 Oil Seal Sleeve - Install

- (1) Insert the O-ring to the oil seal sleeve.
- (2) With the chamfered edge on the outer periphery of sleeve facing outward (pulley side), install the oil seal sleeve into the pump shaft.



Oil Seal Sleeve - Install

2.7 Air Cooler Water Pump - Disassemble and Inspect



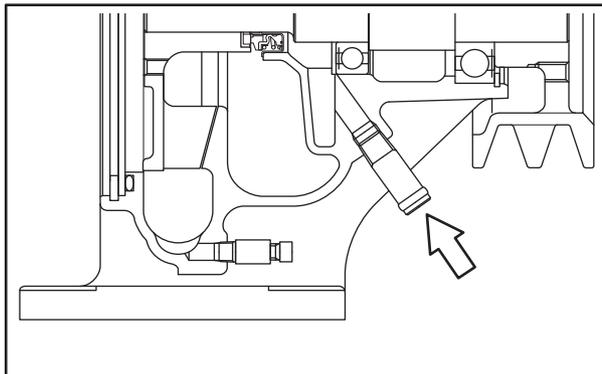
Air Cooler Water Pump - Disassemble and Inspect

Disassembling sequence

- |                     |                    |                    |
|---------------------|--------------------|--------------------|
| 1 Water pump pulley | 4 Cover            | 7 Ball bearing     |
| 2 Snap ring         | 5 Impeller         | 8 Ball bearing     |
| 3 Snap ring         | 6 Water pump shaft | 9 Unit seal        |
|                     |                    | 10 Water pump case |

### 2.7.1 Water Pump Mounted on Engine - Inspect

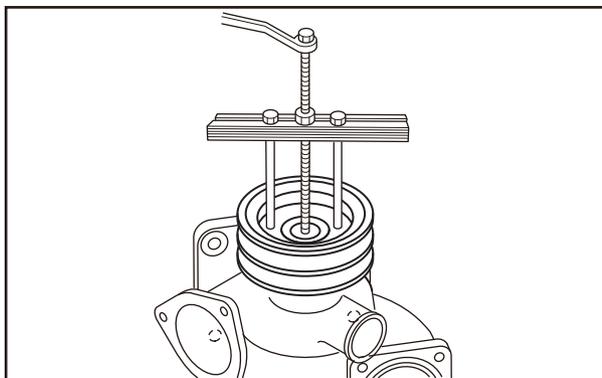
Touch the drain port at the bottom center of water pump case with a finger. If water or oil is oozing out, the unit seal is defective.



Water Pump Mounted on Engine - Inspect

### 2.7.2 Water Pump Pulley - Remove

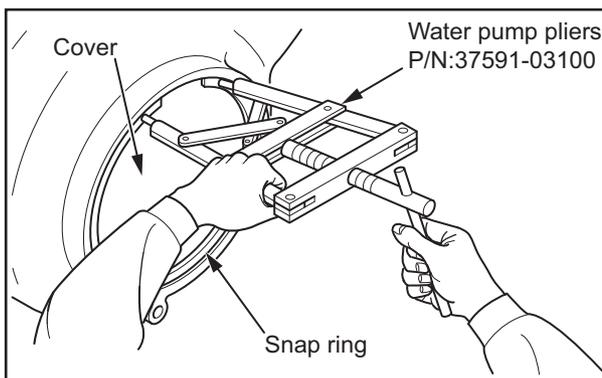
Install the pulley puller to the holes on the water pump pulley, and remove the water pump pulley.



Water Pump Pulley - Remove

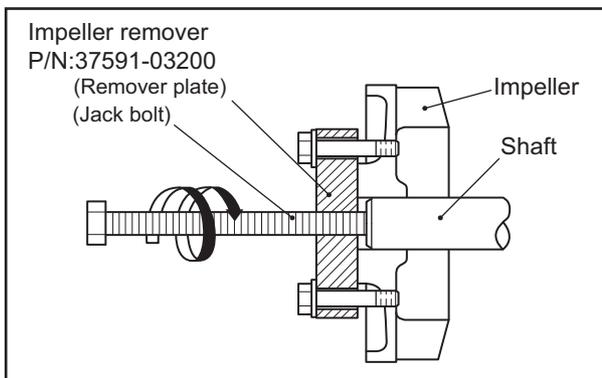
### 2.7.3 Impeller - Remove

(1) Remove the snap ring that holds the cover with the water pump pliers, and remove the cover.



Water Pump Cover - Remove

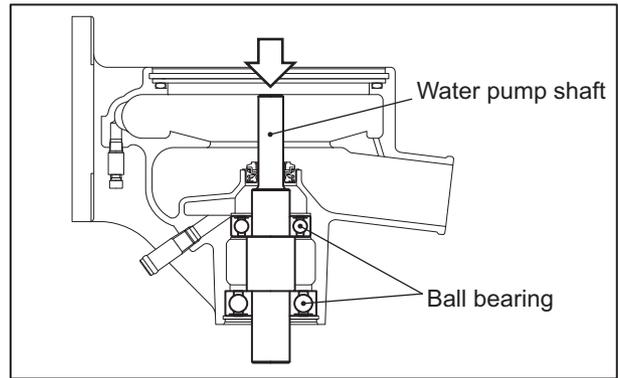
(2) Remove the impeller with impeller remover.



Impeller - Remove

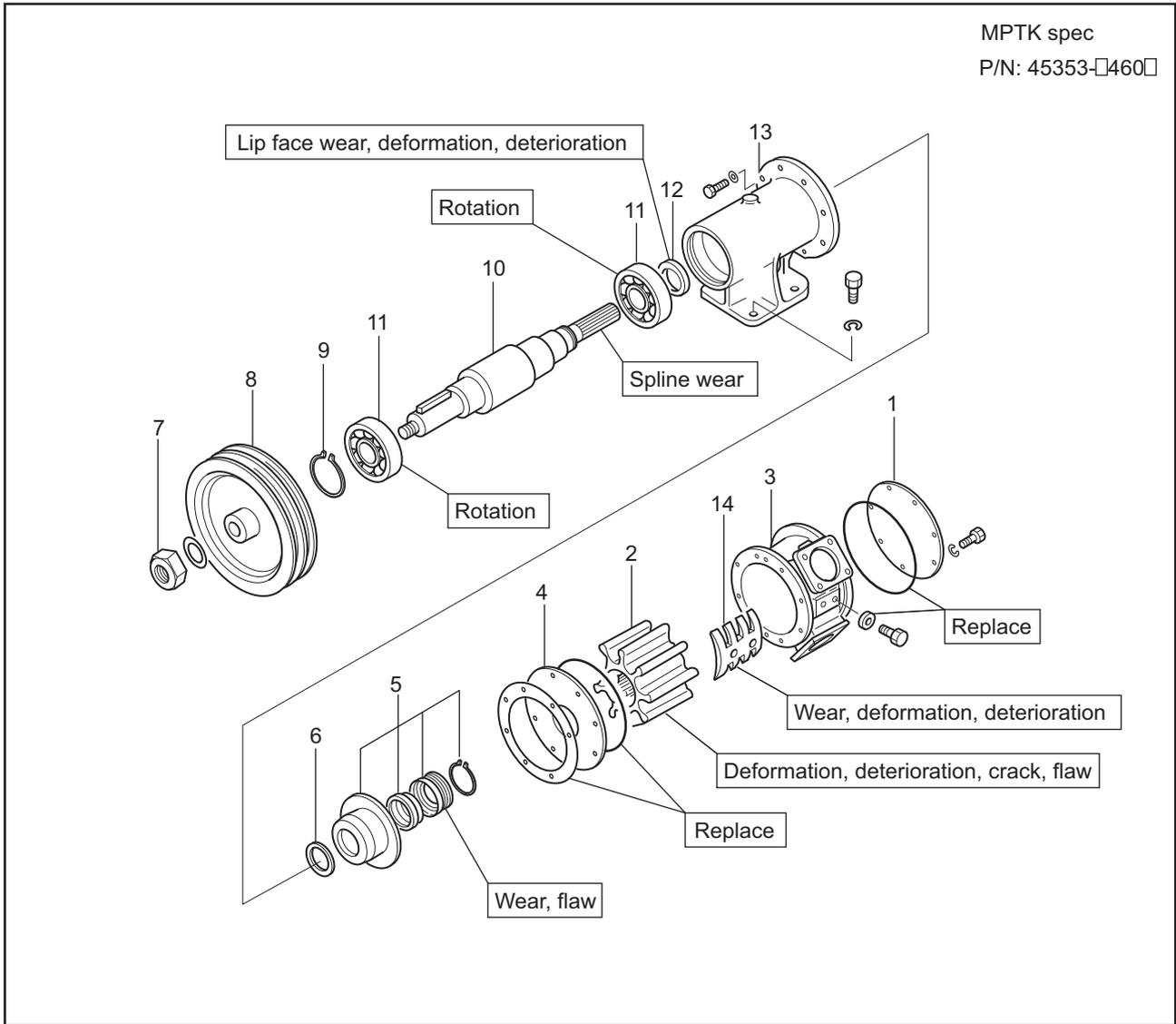
2.7.4 Water Pump Shaft - Remove

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

MPTK spec  
P/N: 45353-□460□



Sea Water Pump For Air Cooler - Disassemble and Inspect

Disassembling sequence

- |                                 |                     |             |
|---------------------------------|---------------------|-------------|
| 1 Cover                         | 6 Slinger           | 11 Bearing  |
| 2 Water pump impeller           | 7 Nut               | 12 Oil seal |
| 3 Case                          | 8 Water pump pulley | 13 Holder   |
| 4 Plate                         | 9 Snap ring         | 14 Cam      |
| 5 Snap ring, Unit seal, Bushing | 10 Water pump shaft |             |

## 2.8 Air Cooler Water Pump and Sea Water Pump - Inspect

(PTAW spec)

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.

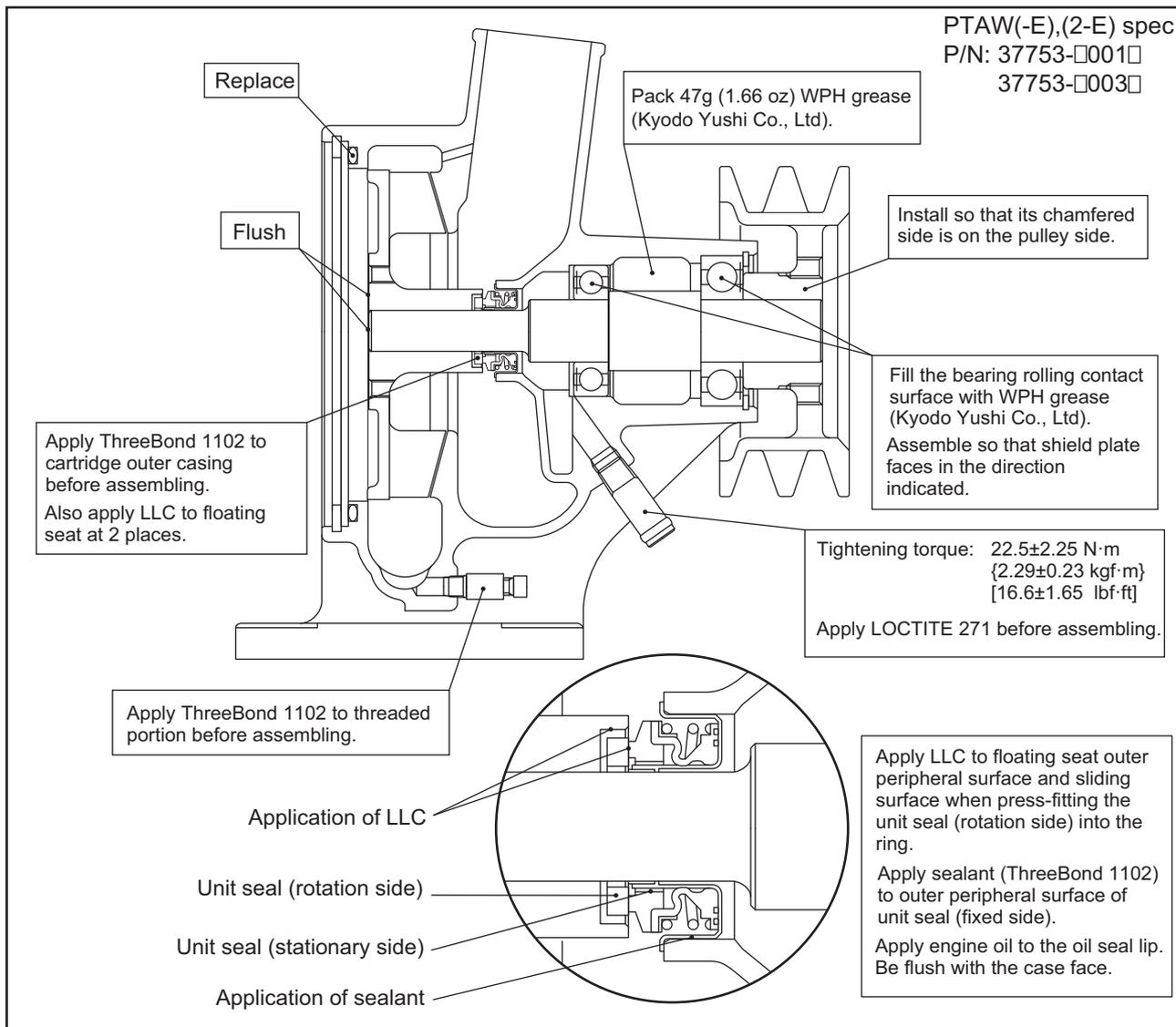
Item			Nominal value	Standard value	
PTAW spec Water pump	Inside diameter of case bearing housing	Large	ø72 mm [2.83 in.]	71.961 to 71.991 mm [2.8331 to 2.8343 in.]	
		Small	ø62 mm [2.44 in.]	61.961 to 61.991 mm [2.4394 to 2.4406 in.]	
	Bearing	Large	Outside diameter	ø72 mm [2.83 in.]	71.987 to 72.000 mm [2.8341 to 2.8346 in.]
			inside diameter	ø30 mm [1.18 in.]	29.990 to 30.000 mm [1.1807 to 1.1811 in.]
		Small	Outside diameter	ø62 mm [2.44 in.]	61.987 to 62.000 mm [2.4404 to 2.4409 in.]
			inside diameter	ø30 mm [1.18 in.]	29.990 to 30.000 mm [1.1807 to 1.1811 in.]
	Outside diameter of shaft fit to bearing			ø30 mm [1.18 in.]	30.002 to 30.015 mm [1.1812 to 1.1817 in.]
	Impeller front clearance			0.87 mm [0.0343 in.]	0.48 to 1.26 mm [0.0189 to 0.0492 in.]

(MPTK spec)

Measure the bearing fit diameters of the water pump holder bearing housing and the 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
MPTK spec Water pump	Inside diameter of bearing fit		ø110 mm [4.33 in.]	109.995 to 110.030 mm [4.3305 to 4.3319 in.]
	Bearing	Outside diameter	ø110 mm [4.33 in.]	109.985 to 110.000 mm [4.3301 to 4.3307 in.]
		inside diameter	ø50 mm [1.97 in.]	49.988 to 50.000 mm [1.9680 to 1.9685 in.]
	Outside diameter of shaft fit to bearing			ø50 mm [1.97 in.]

2.9 Air Cooler Water Pump - Assemble



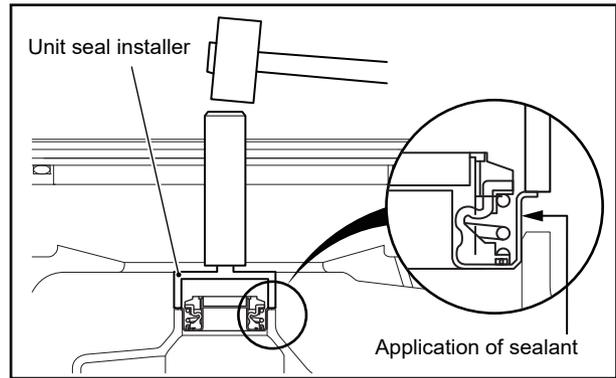
Air Cooler Water Pump - Assemble

Note: S16R2-PTAW has a different pulley shape.

2.9.1 Unit Seal (Stationary Side) - Install

- (1) Apply sealant (ThreeBond 1102) to the outer circumference of unit seal (stationary side.)
- (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.



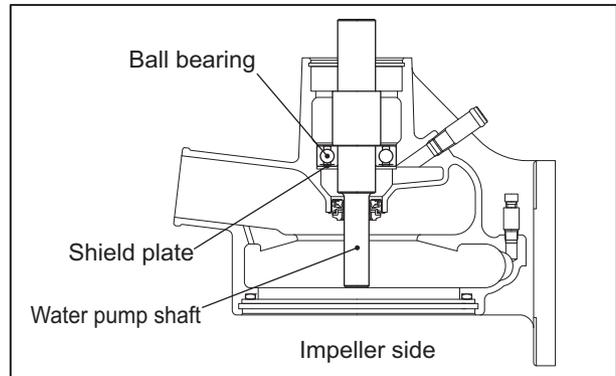
Unit Seal (Stationary Side) - Install

2.9.2 Water Pump Shaft - Install

**CAUTION**

When installing the water pump shaft, be careful not to damage the unit seal (stationary side) inside the pump case with the water pump shaft.

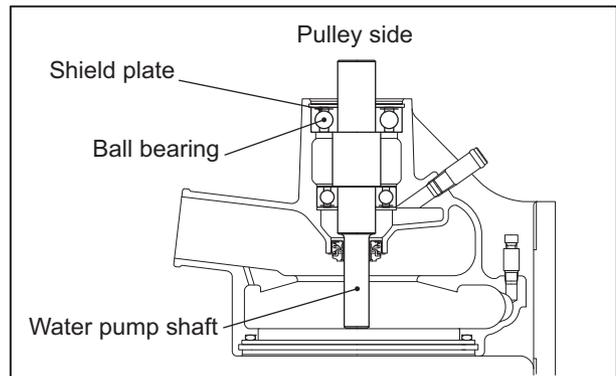
- (1) Place the impeller side bearing placing its sealed side to impeller and press-in the bearing to water pump shaft.
- (2) Press-in the water pump shaft slowly into pump case until the end face of ball bearing comes into contact with pump case.
- (3) Fill-in WPH grease (KYODO YUSHI CO., LTD.) to the bearing rotating parts.



Water Pump Shaft - Install

2.9.3 Ball Bearing - Install

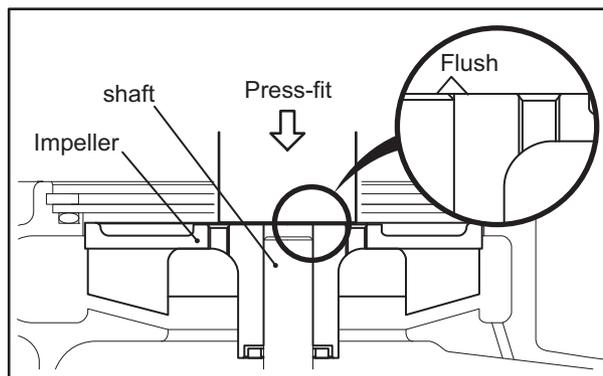
- (1) Fill-in WPH grease (KYODO YUSHI CO., LTD.) to the pulley bearing rotating parts and water pump case.
- (2) Press-in the bearing placing the impeller bearing sealed side to impeller and press-in the bearing to water pump shaft.
- (3) Securely install the snap ring to groove.



Ball Bearing - Install

## 2.9.4 Water Pump Impeller - Press-in

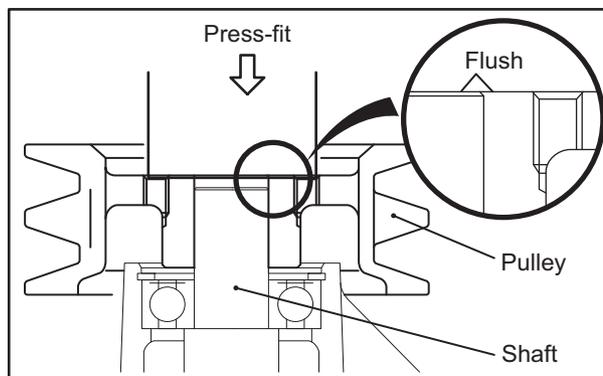
- (1) Press-in the unit seal (rotating side) to the water pump impeller.
- (2) Press-in the water pump impeller with a press. Place the water pump impeller boss face to be flush with the end face of pump shaft.



Water Pump Impeller - Press-in

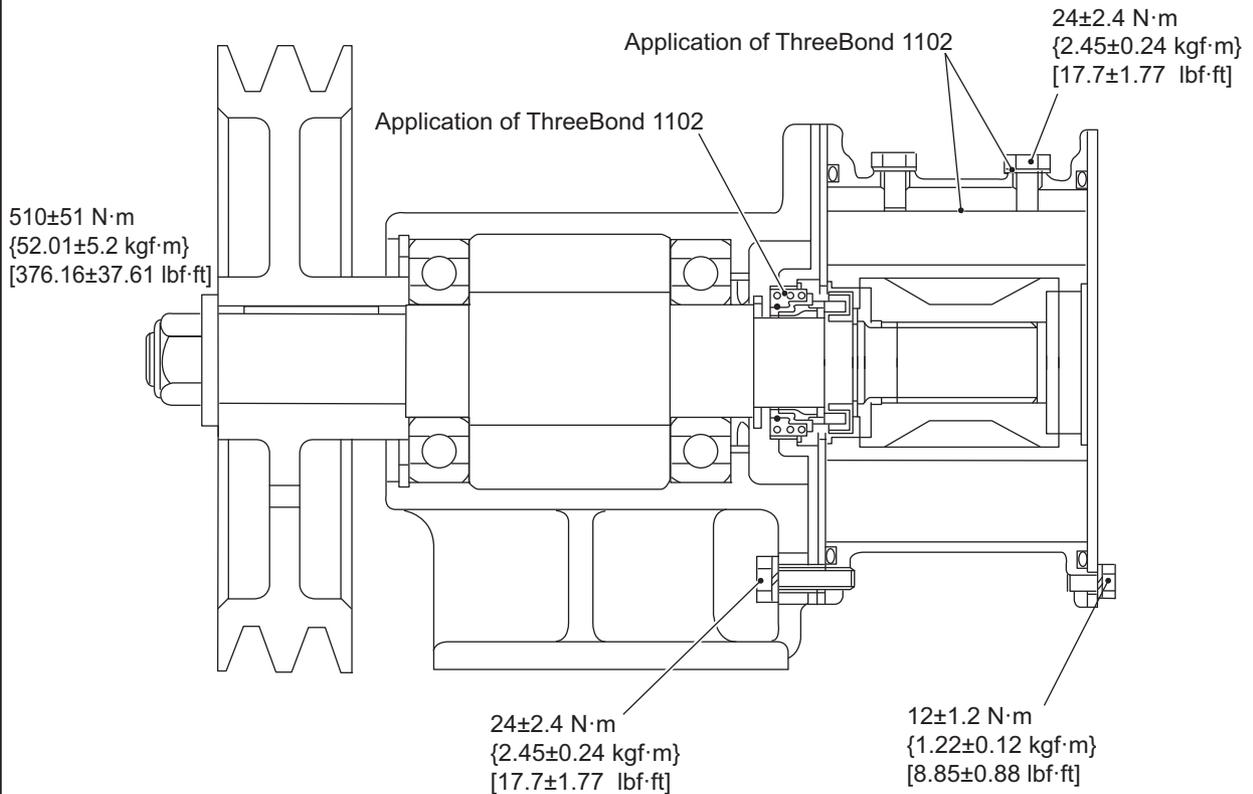
## 2.9.5 Water Pump Pulley - Install

Press-in the water pump pulley to the water pump shaft.



Water Pump Pulley - Install

MPTK spec  
P/N:45353-□460□

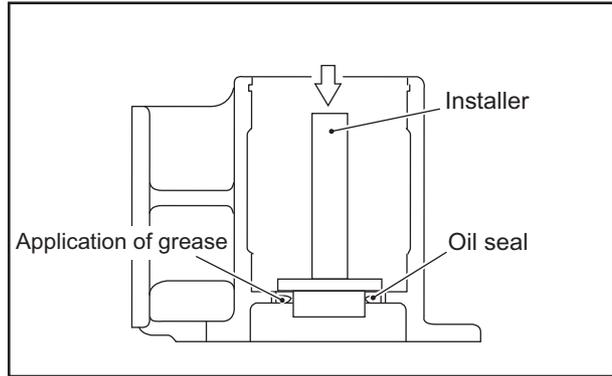


- Apply grease to:
- O-ring
  - Bearing rolling contact surface
  - Oil seal lip portion

Sea Water Pump For Air Cooler - Assemble

### 2.9.6 Oil Seal - Install

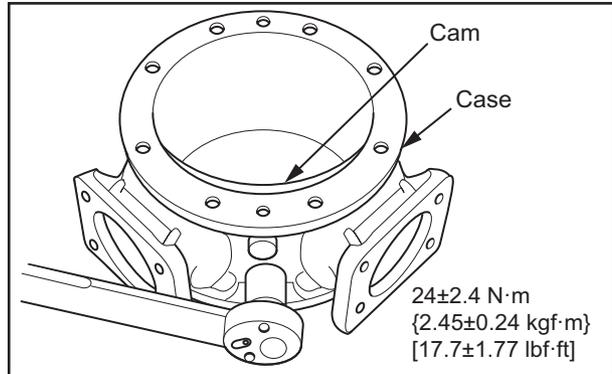
- (1) Tap-in the oil seal with the installer making sure that oil seal surface is flush with the water pump housing face.
- (2) Apply grease to the oil seal groove and lips.



Oil Seal - Install

### 2.9.7 Cam - Install

- (1) Apply sealant (ThreeBond 1102) to the mating surfaces of cam and case.
- (2) Install the cam to case, and tighten the bolt to the specified torque.



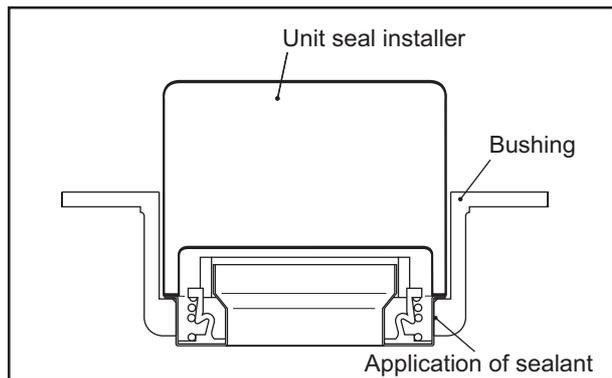
Cam - Install

### 2.9.8 Unit Seal (Stationary Side) - Install

- (1) Apply sealant (ThreeBond 1102) to the outer circumference of unit seal (stationary side.)
- (2) Hand-press the unit seal slowly into the bushing with the unit seal installer.

Note:(a) Do not use a hammer or mallet to install.

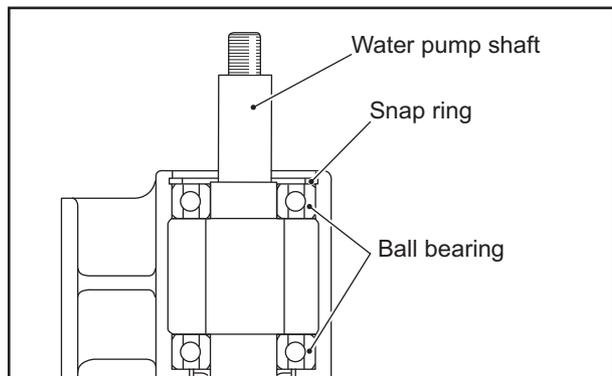
(b) Do not damage the sliding surface of the unit seal.



Unit Seal (Stationary Side) - Install

### 2.9.9 Water Pump Shaft - Install

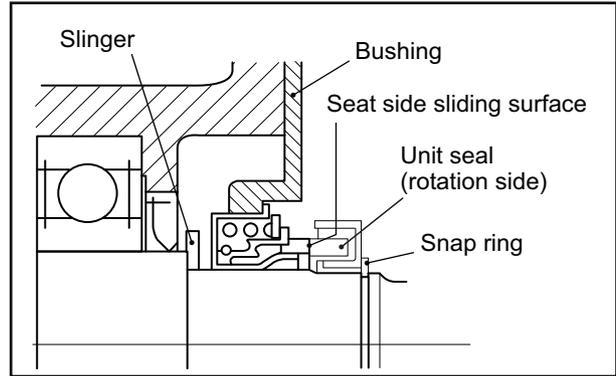
- (1) Press-in the ball bearing to the water pump shaft with the installer.
- (2) Press-in the ball bearing and water pump shaft to the holder with the installer.
- (3) Fit the snap ring to the holder.



Water Pump Shaft - Install

2.9.10 Slinger and Bushing - Install

- (1) Install the slinger to the shaft.
- (2) Install the bushing to the holder.
- (3) Clean the seal side sliding face of the unit seal (stationary side) with ethyl alcohol, and apply turbine oil. Ensure the sliding face to be free from scars or dust.



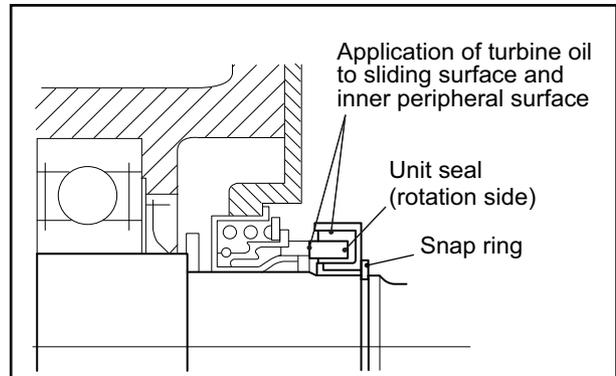
Slinger and Bushing - Install

2.9.11 Unit Seal (Rotating Side) - Install

- (1) Clean the sliding and inside faces of the unit seal (rotating side) with ethyl alcohol, and apply turbine oil.
- (2) Press-fit the unit seal (rotating side) to the water pump shaft.

Note: Verify the squareness of the unit seal (rotating side) to the shaft. If the seal is slanted, the snap ring can not be installed or water leakage will result.

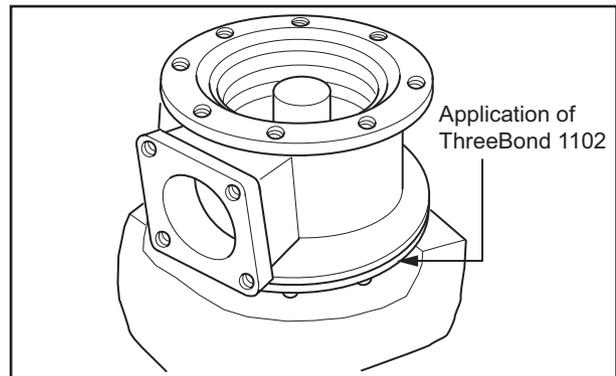
- (3) Install the snap ring to the water pump shaft.



Unit Seal (Rotating Side) - Install

2.9.12 Case - Install

- (1) Apply sealant (ThreeBond 1102) to the mating surfaces of holder and case.
- (2) Install the holder to the case, and tighten the bolts to the specified torque.

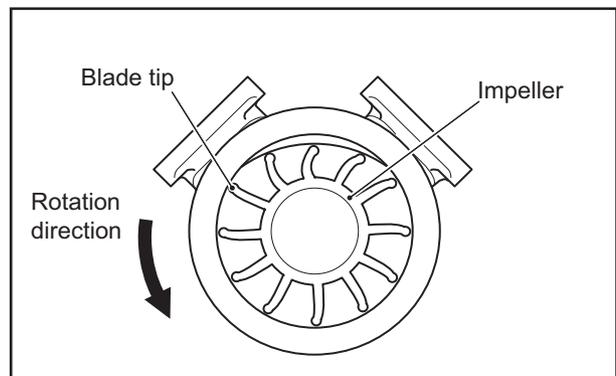


Case - Install

2.9.13 Impeller - Install

Tap-in the impeller to the shaft.

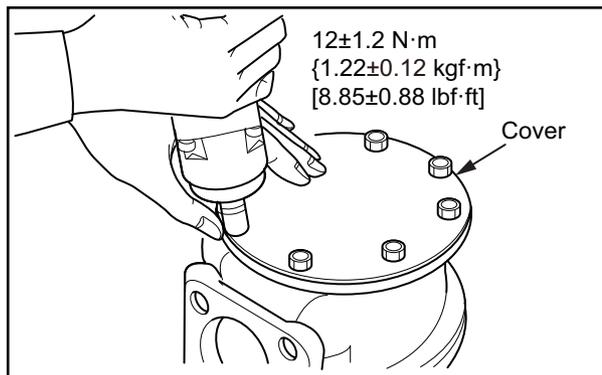
Note: Place the impeller to bend its impellers in following direction to the Water pump rotation.



Impeller - Install

### 2.9.14 Cover - Install

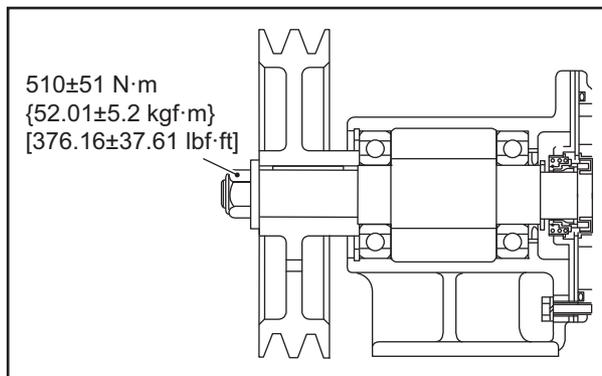
Install the cover to the case, and tighten the bolts to the specified torque.



Cover - Install

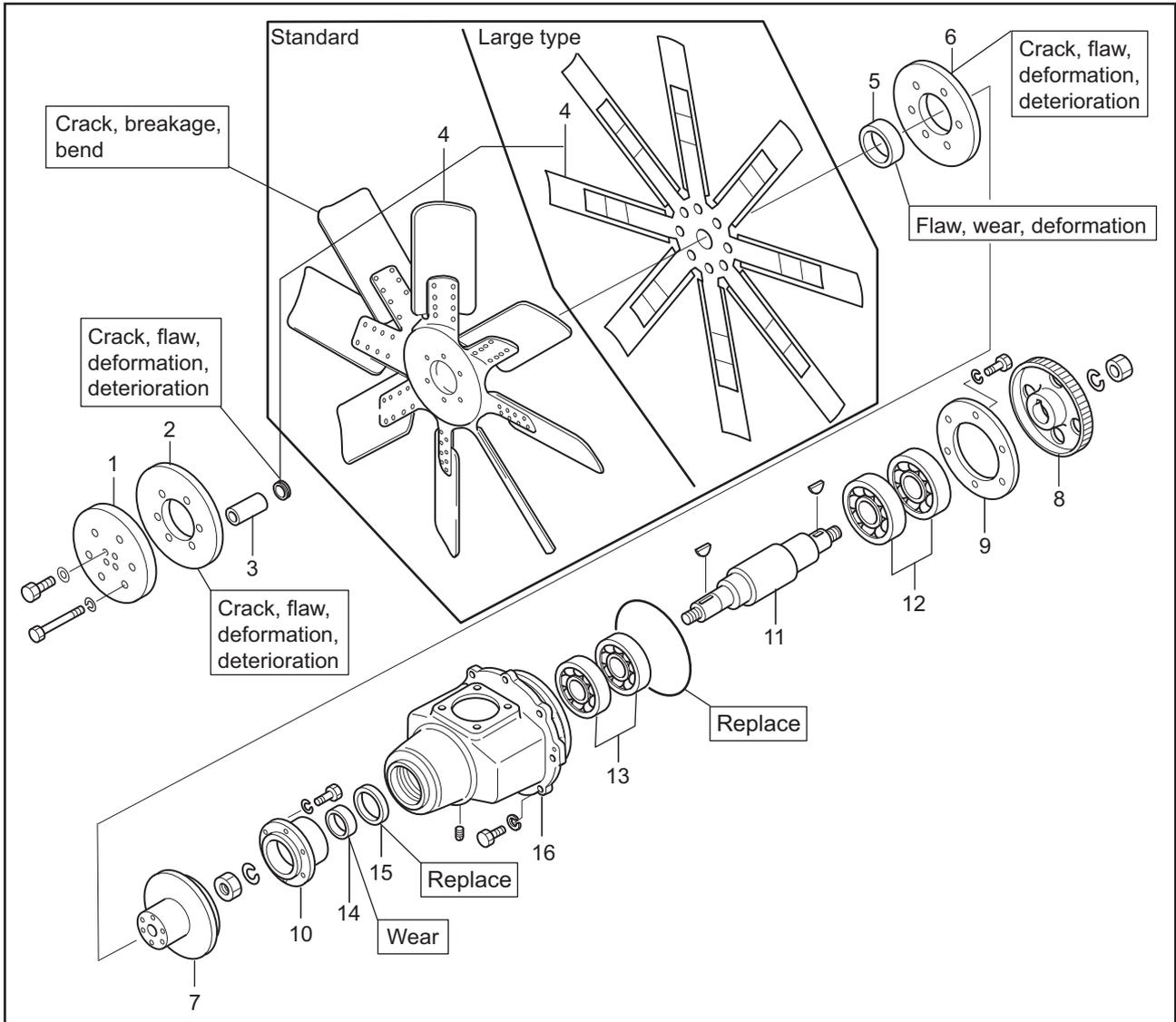
### 2.9.15 Water Pump Pulley - Install

Install the water pump pulley to the water pump shaft, and tighten the nut to the specified torque.



Water Pump Pulley - Install

2.10 Fan Drive Assembly - Disassemble and Inspect



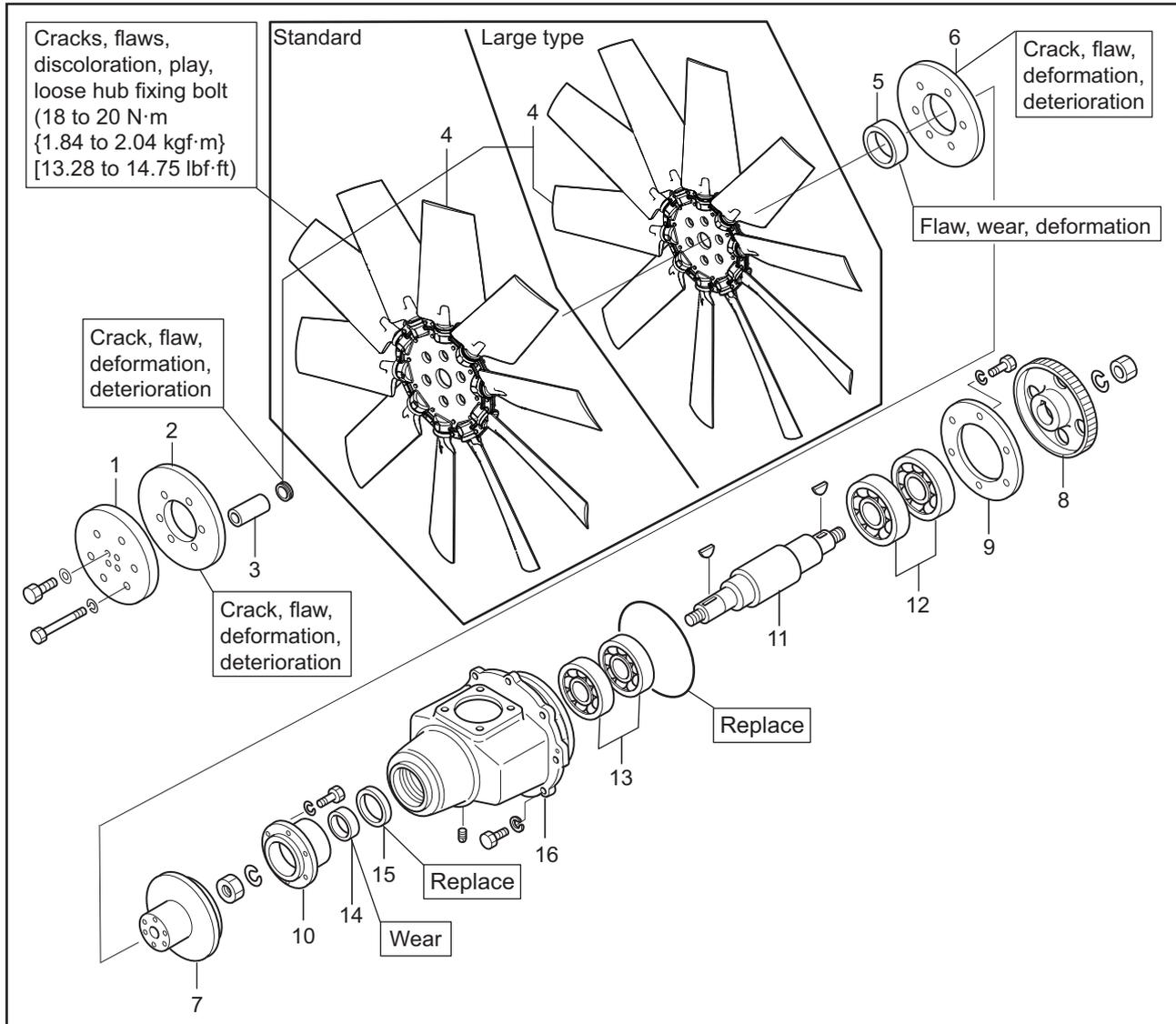
Fan Drive Assembly - Disassemble and Inspect (Metal Fan)

Disassembling sequence

- |  |                   |   |
|--|-------------------|---|
| 1 Fan plate  | 5 Bushing ring    | 11 Drive shaft                              |
| 2 Friction rubber  | 6 Friction rubber | 12 Bearing                                  |
| 3 Spacer   | 7 Fan hub         | 13 Bearing                                  |
| 4 Fan, Grommet<br>(approx. 60 kg [132 lb])<br>(big fan spec: approx. 80 kg [176 lb]) | 8 Fan drive       | 14 Oil seal sleeve                          |
|  | 9 Thrust plate    | 15 Oil seal                                 |
|  | 10 Coupling       | 16 Fan drive case (approx. 26 kg [57.3 lb]) |

**CAUTION**

If one blade of the fan is damaged, be sure to replace the fan with a new one, as such defects as the other blade damage or abnormal wear of bearing due to the vibration will result.



Fan Drive Assembly - Disassemble and Inspect (Resin Fan)

## Disassembling sequence

- |  |                   |   |
|--|-------------------|---|
| 1 Fan plate  | 5 Bushing ring    | 11 Drive shaft                              |
| 2 Friction rubber  | 6 Friction rubber | 12 Bearing                                  |
| 3 Spacer   | 7 Fan hub         | 13 Bearing                                  |
| 4 Fan, Grommet<br>(approx. 60 kg [132 lb])<br>(big fan spec: approx. 80 kg [176 lb]) | 8 Fan drive       | 14 Oil seal sleeve                          |
|  | 9 Thrust plate    | 15 Oil seal                                 |
|  | 10 Coupling       | 16 Fan drive case (approx. 26 kg [57.3 lb]) |

**CAUTION**

If one blade of the fan is damaged, be sure to replace the fan with a new one, as such defects as the other blade damage or abnormal wear of bearing due to the vibration will result.

### 2.11 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			ø120 mm [4.72 in.]	119.987 to 120.022 mm [4.7239 to 4.7253 in.]
			ø140 mm [5.51 in.]	139.986 to 140.026 mm [5.5112 to 5.5128 in.]
Bearing	Large	Outside diameter	ø140 mm [5.51 in.]	139.982 to 140.000 mm [5.5111 to 5.5118 in.]
		Inside diameter	ø55 mm [2.17 in.]	54.985 to 55.000 mm [2.1648 to 2.1654 in.]
	Small	Outside diameter	ø120 mm [4.72 in.]	119.985 to 120.000 mm [4.7238 to 4.7244 in.]
		Inside diameter	ø55 mm [2.17 in.]	54.985 to 55.000 mm [2.1648 to 2.1654 in.]
Outside diameter of shaft fit to bearing			ø55 mm [2.17 in.]	55.002 to 55.015 mm [2.1654 to 2.1659 in.]

### 2.12 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.

### 2.13 Oil Seal Sleeve - Inspect

If any defects such as dents, scars, wear, or looseness that can lead to oil leakage are found, replace the oil seal sleeve with a new one.

### 2.14 Oil Seal Sleeve - Replace



#### CAUTION

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

#### 2.14.1 Oil Seal Sleeve - Remove

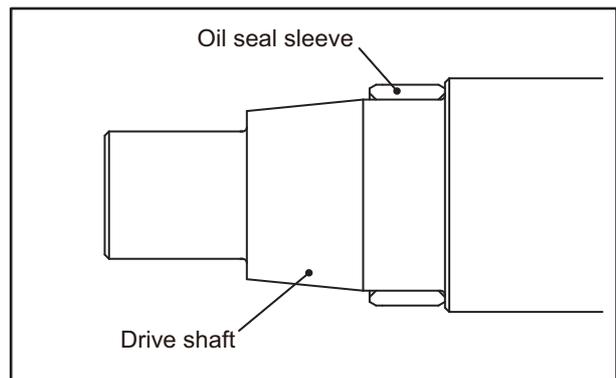
Place a chisel vertically to the periphery of sleeve end and tap three places with hammer. When the sleeve is loosened, remove the sleeve.

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.

#### 2.14.2 Oil Seal Sleeve - Install

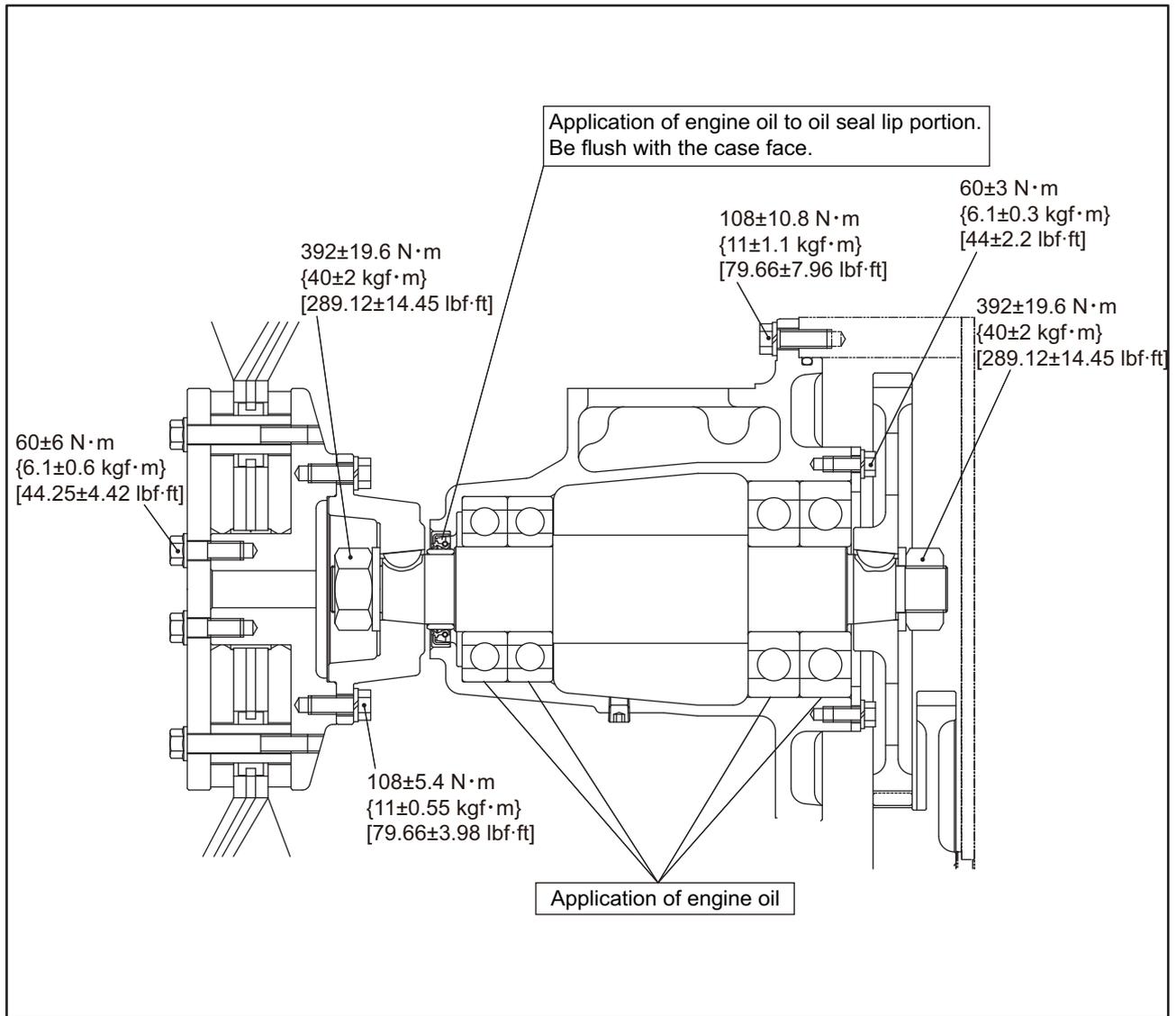
Heat the oil seal sleeve at a temperature of 180 to 200 °C [356 to 392°F] with a heater.

Insert the oil seal sleeve into the drive shaft.



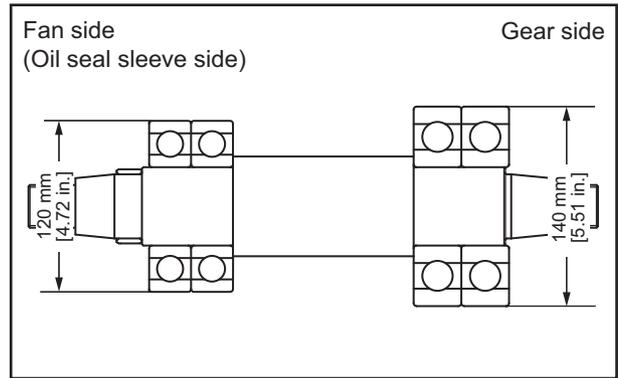
Oil Seal Sleeve - Install

## 2.15 Fan Drive - Assemble



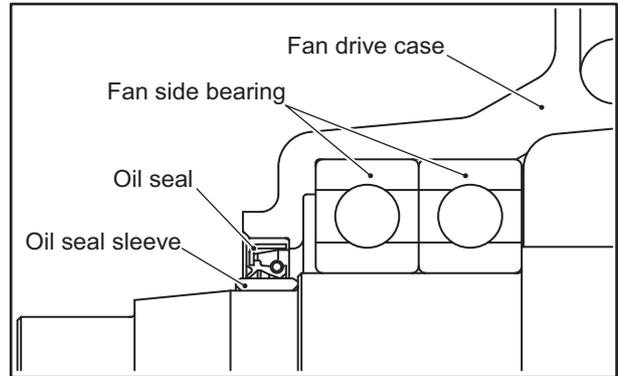
2.15.1 Fan Drive Gear Case - Assemble

(1) Press-in the bearing to drive shaft with bearing installer.



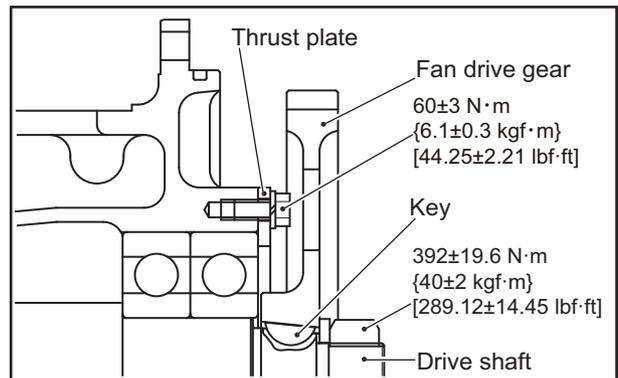
Ball Bearing - Install

- (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.



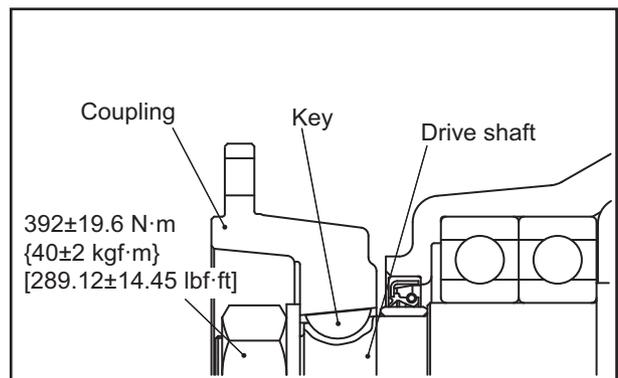
Oil Seal - Install

- (5) Install the thrust plate, and tighten the bolt to the specified torque.
- (6) Install the key to gear end of drive shaft.
- (7) Install the fan drive gear while aligning it to the key on drive shaft, and tighten the nut to the specified torque.



Fan Drive Gear - Install

- (8) Install the key to the fan end of drive shaft.
- (9) Install the coupling while aligning it to the key on drive shaft, and tighten the nut to the specified torque.



Coupling - Install

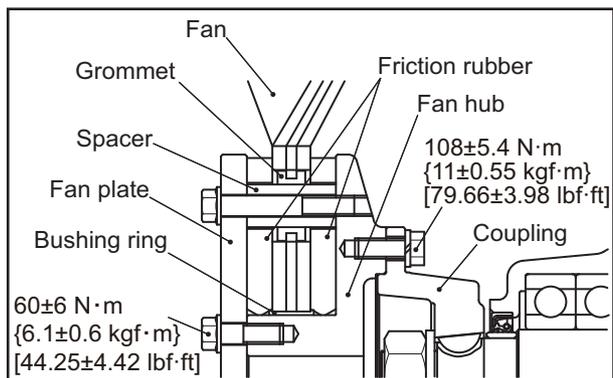
## 2.15.2 Fan - Assemble

Installation the fan at the final step of assembling work.

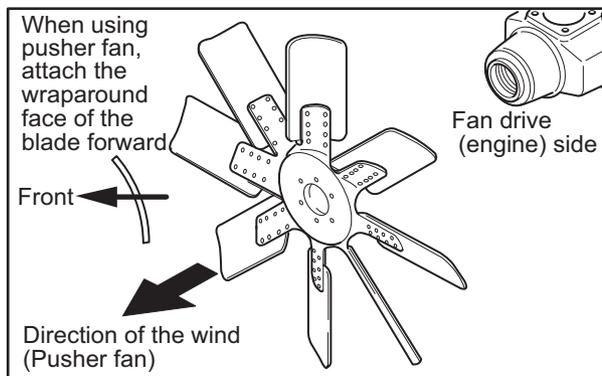
- (1) Install the fan hub to the coupling, and tighten the bolts to the specified torque.
- (2) Install the friction rubber to fan hub.
- (3) Install the bushing ring to the fan hub.
- (4) Install the fan to bushing ring.

Note: Ensure the proper fan orientation (wind direction: pusher) when installing.

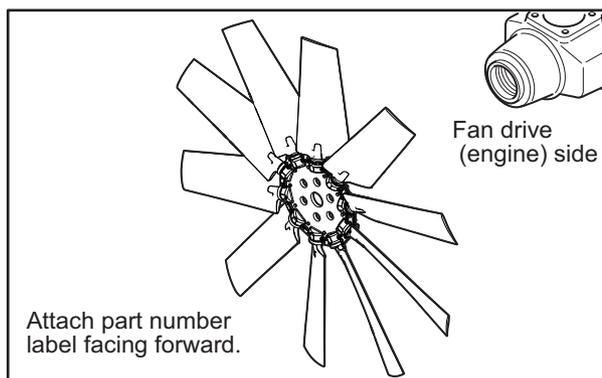
- (5) Install the grommet to fan.
- (6) Insert the spacer to grommet and friction rubber.
- (7) Install the friction rubber to fan hub.
- (8) Install the fan plate to fan hub, and tighten the bolts to the specified torque.



Fan - Assemble



Fan Installation Direction (Metal Fan)



Fan Installation Direction (Resin Fan)

### 3. Cooling System - Install

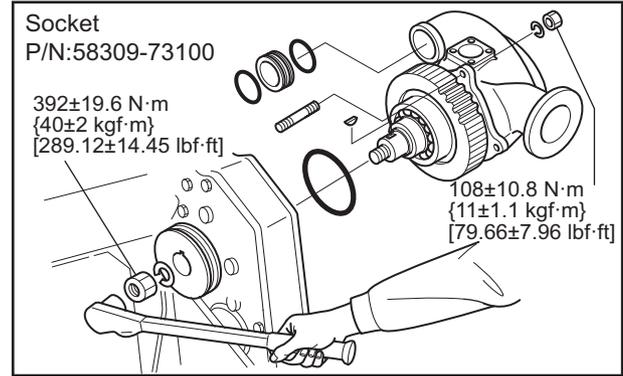
- Installation is the reverse order of the disassembly. (See the illustration for disassembly.)
- Thoroughly clean cooling passages and dry them well.

#### 3.1 Water Pipe (Air Cooler) - Install

Apply silicone sealant on both sides of packings between the air cooler inlet/outlet connectors and the water pipes.

#### 3.2 Water Pump - Install

Tighten the mounting nuts and the pulley the specified torque.



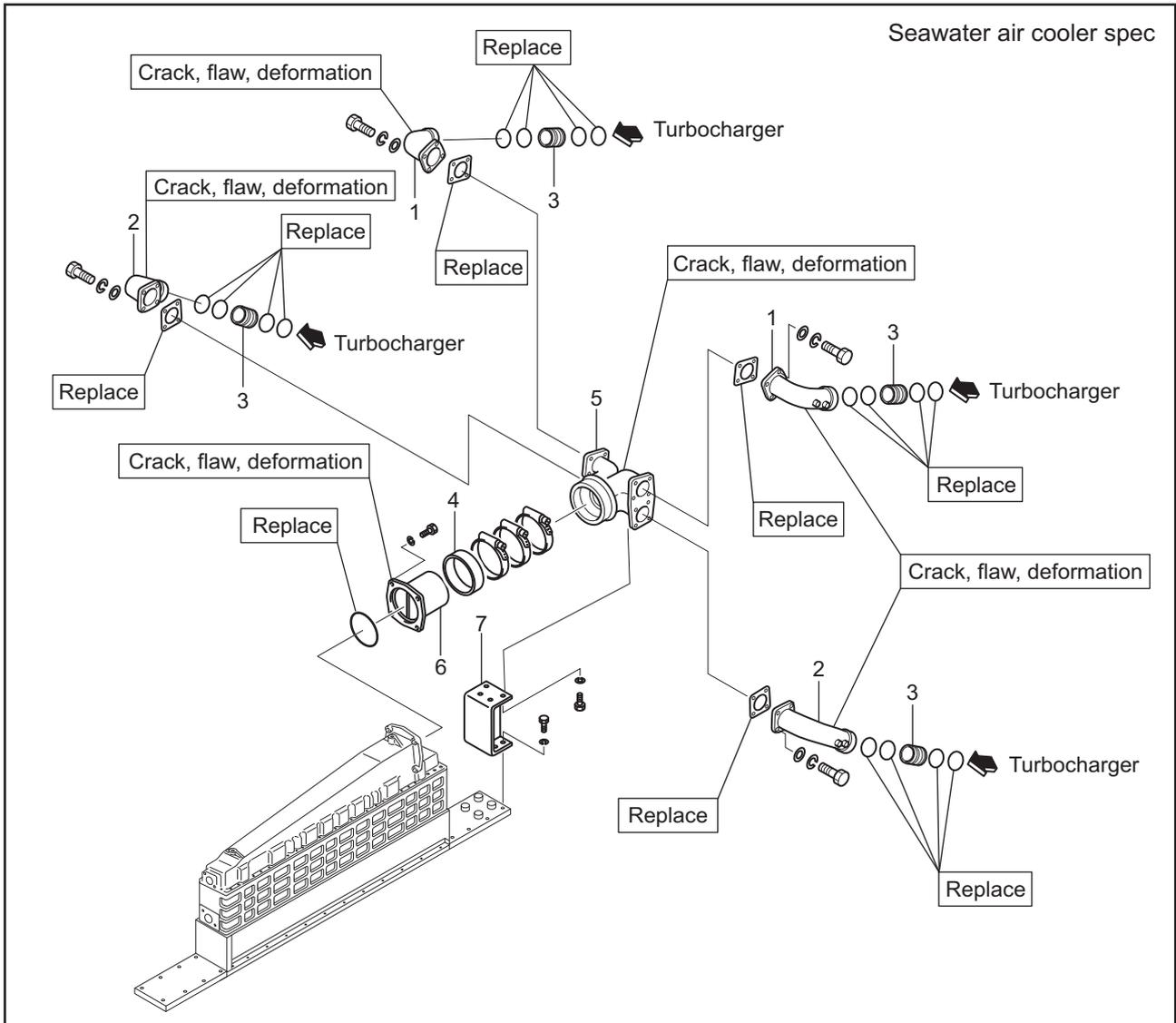
Water Pump - Install

# Chapter 11 INLET AND EXHAUST SYSTEMS

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1.1 Air Duct - Remove and inspect.....	11-3
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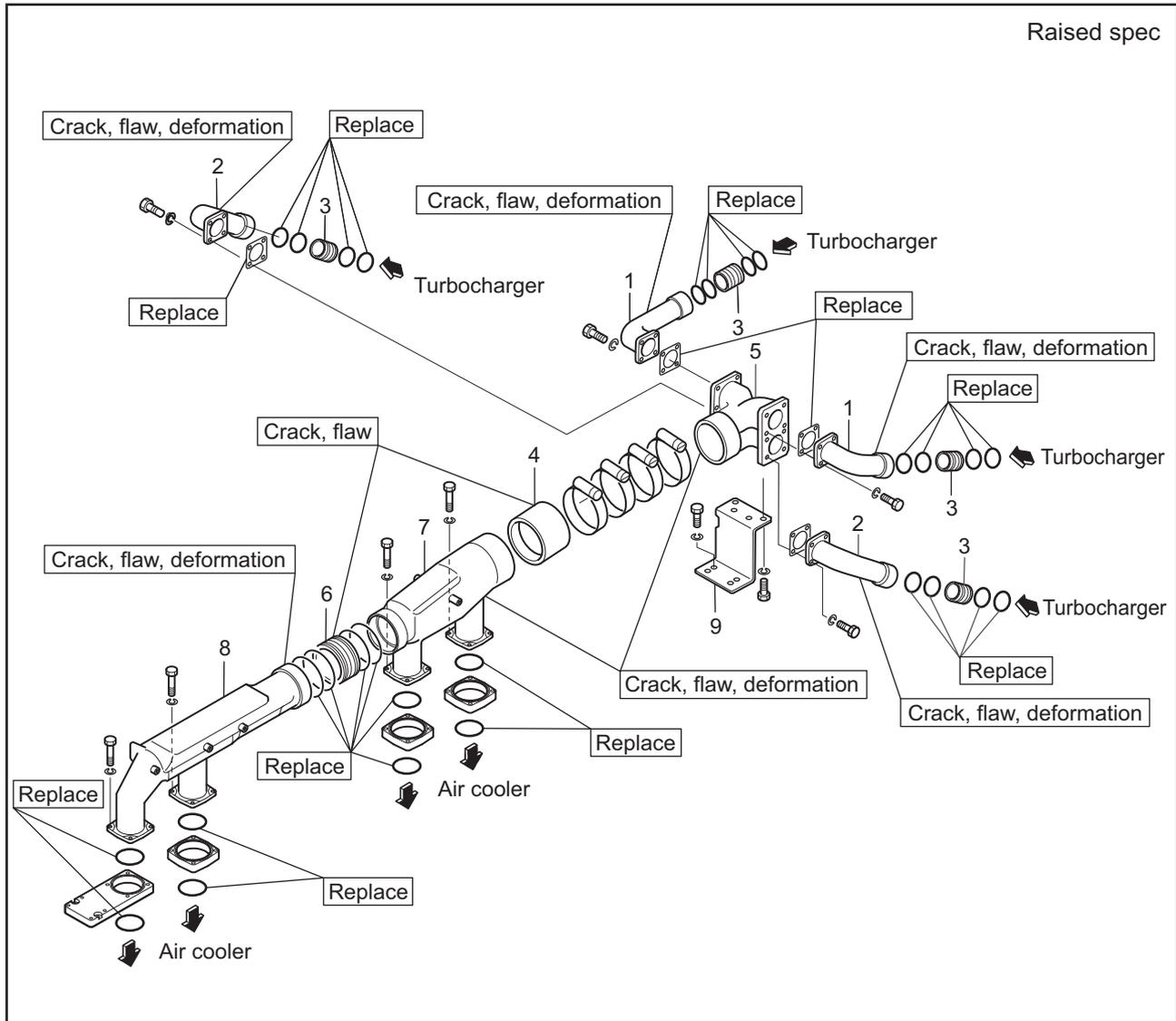


Air Duct - Remove and inspect

Removing sequence

- |                  |               |                 |
|------------------|---------------|-----------------|
| 1 Upper air duct | 4 Rubber hose | 7 Air duct stay |
| 2 Lower air duct | 5 Air duct    |                 |
| 3 Connector      | 6 Air duct    |                 |

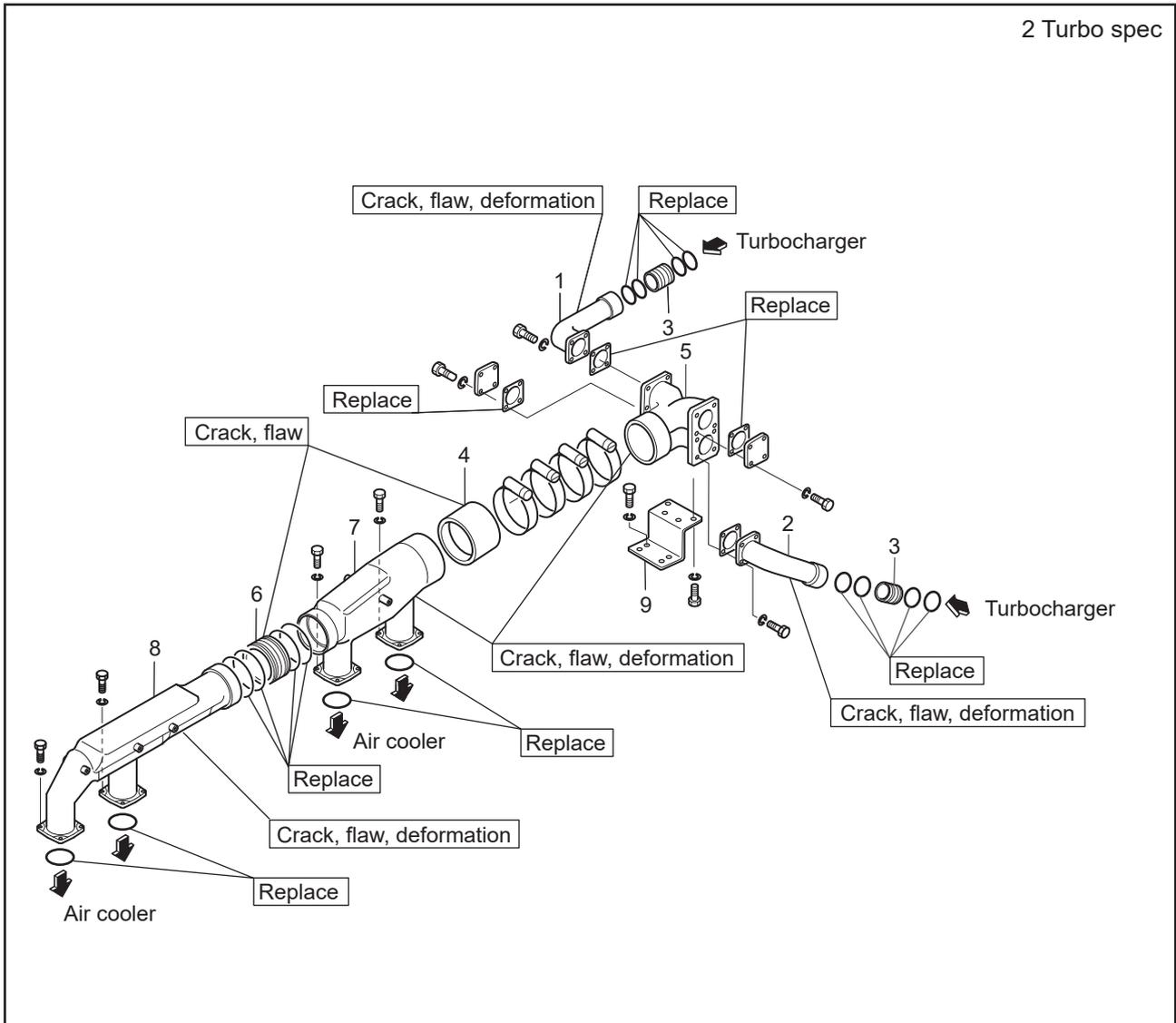
Raised spec



Air Duct - Remove and Inspect

## Removing sequence

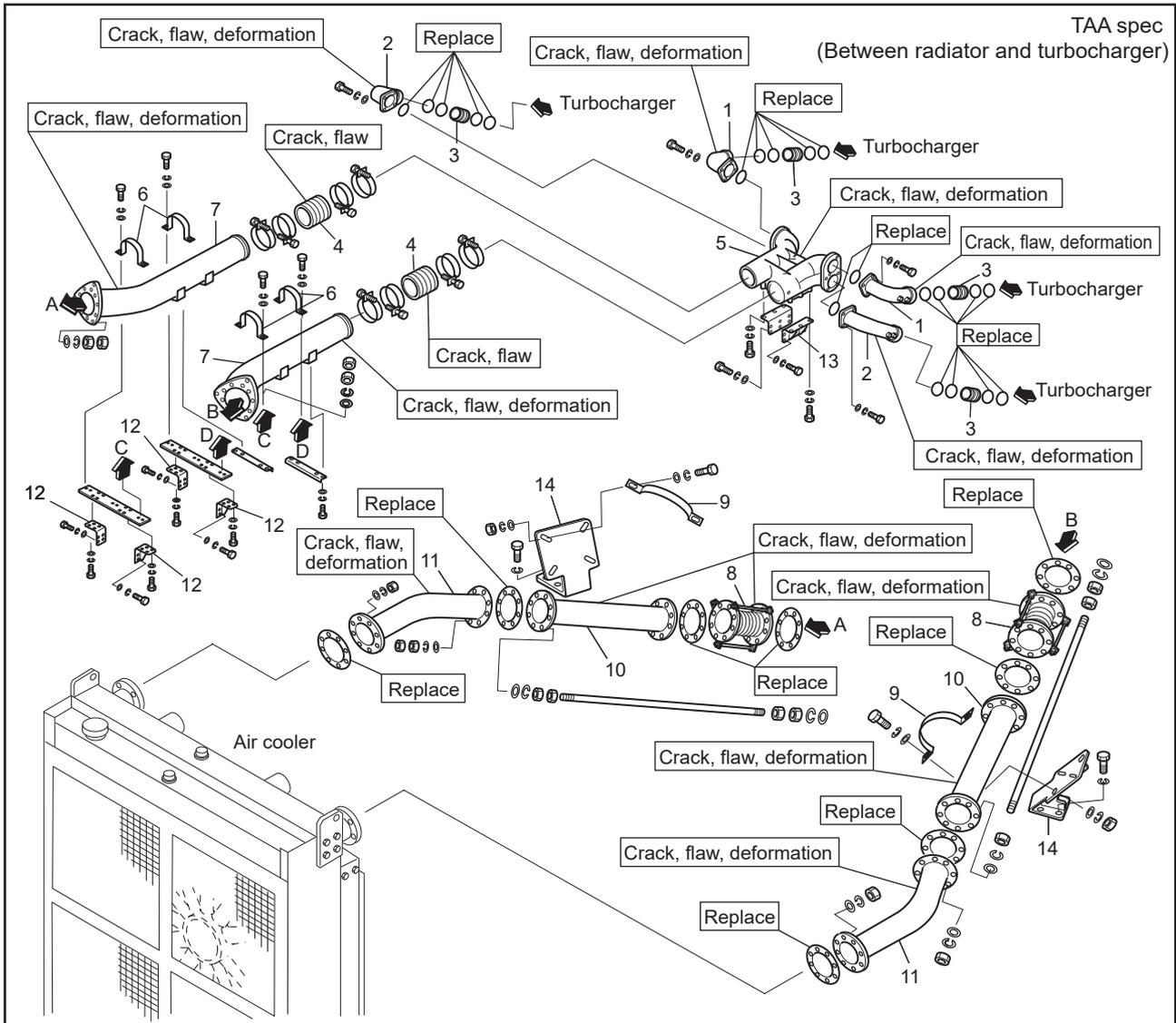
- |             |               |                  |
|-------------|---------------|------------------|
| 1 Air duct  | 4 Rubber hose | 7 Rear air duct  |
| 2 Air duct  | 5 Air duct    | 8 Front air duct |
| 3 Connector | 6 Rubber hose | 9 Air duct stay  |



Air Duct - Remove and Inspect

Removing sequence

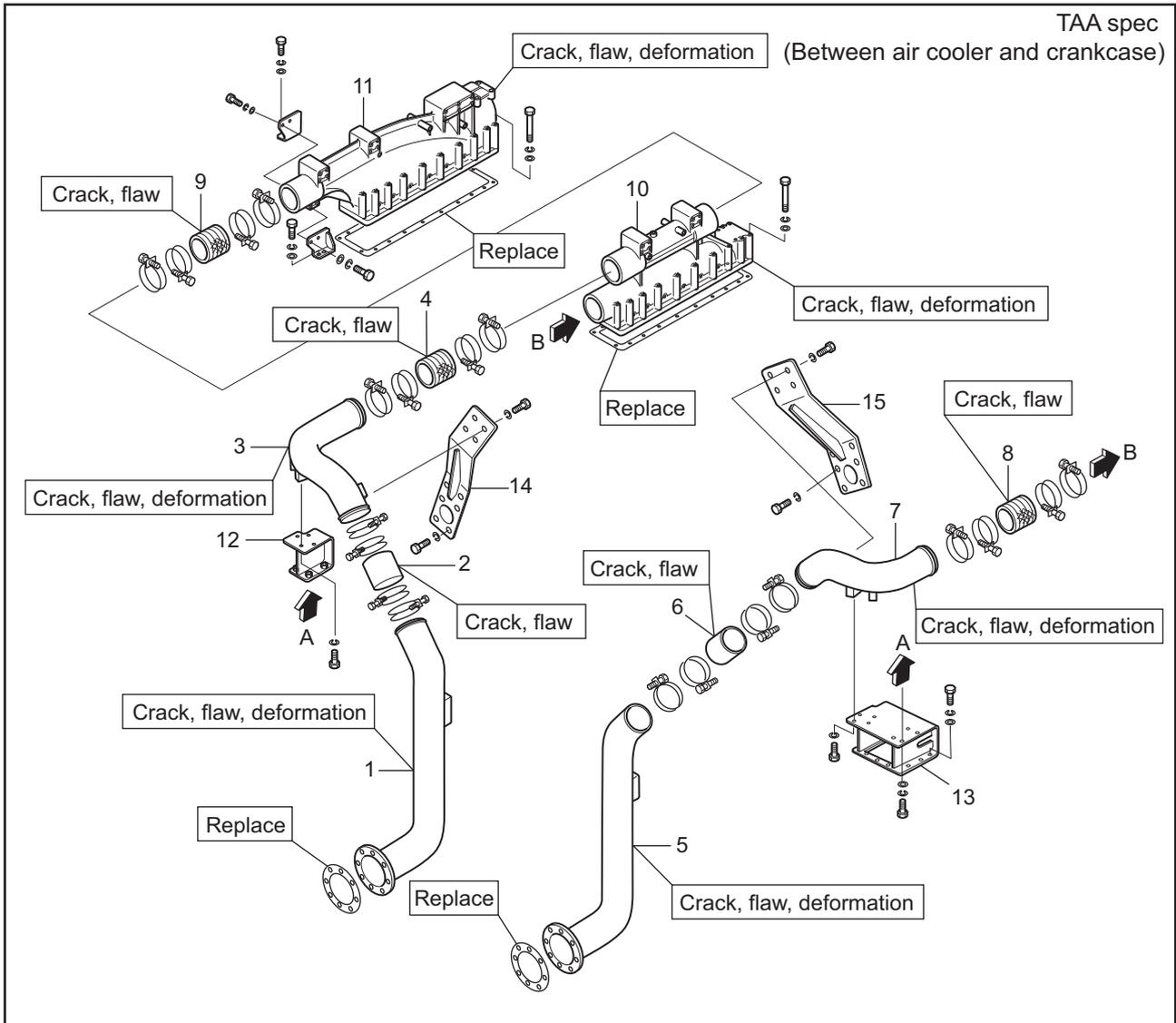
- |             |               |                  |
|-------------|---------------|------------------|
| 1 Air duct  | 4 Rubber hose | 7 Rear air duct  |
| 2 Air duct  | 5 Air duct    | 8 Front air duct |
| 3 Connector | 6 Rubber hose | 9 Air duct stay  |



Air Duct - Remove and Inspect

Removing sequence

- |                                    |                  |                  |
|------------------------------------|------------------|------------------|
| 1 Air duct                         | 6 Clamp          | 11 Air duct      |
| 2 Air duct                         | 7 Air duct       | 12 Air duct stay |
| 3 Connector                        | 8 Flexible joint | 13 Air duct stay |
| 4 Rubber hose                      | 9 Clamp          | 14 Air duct stay |
| 5 Air duct (approx. 19 kg [42 lb]) | 10 Air duct      |                  |

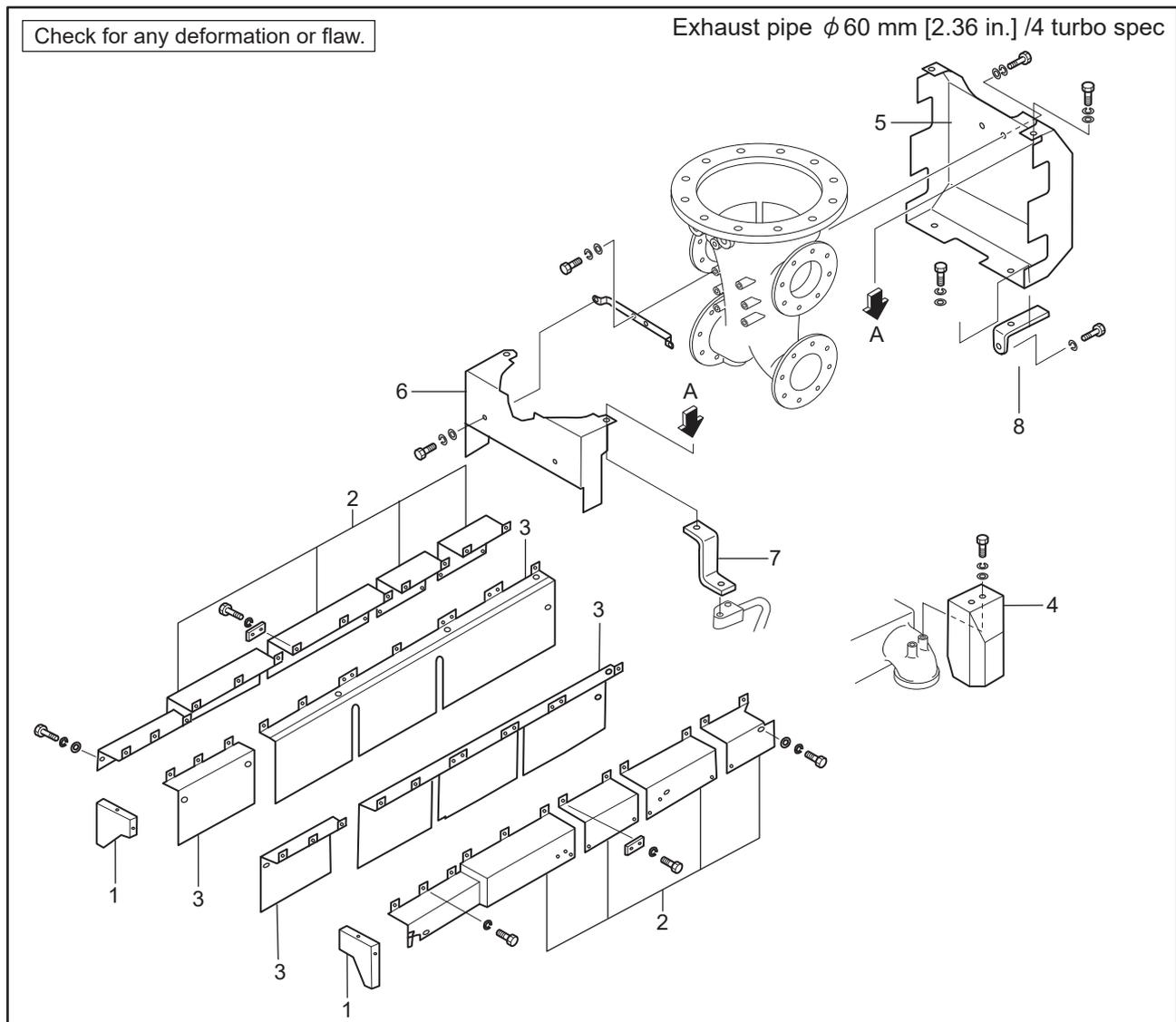


Air Duct - Remove and Inspect

Removing sequence

- |               |               |                  |
|---------------|---------------|------------------|
| 1 Air duct    | 6 Rubber hose | 11 Air box       |
| 2 Rubber hose | 7 Air duct    | 12 Air duct stay |
| 3 Air duct    | 8 Rubber hose | 13 Air duct stay |
| 4 Rubber hose | 9 Rubber hose | 14 Air duct stay |
| 5 Air duct    | 10 Air box    | 15 Air duct stay |

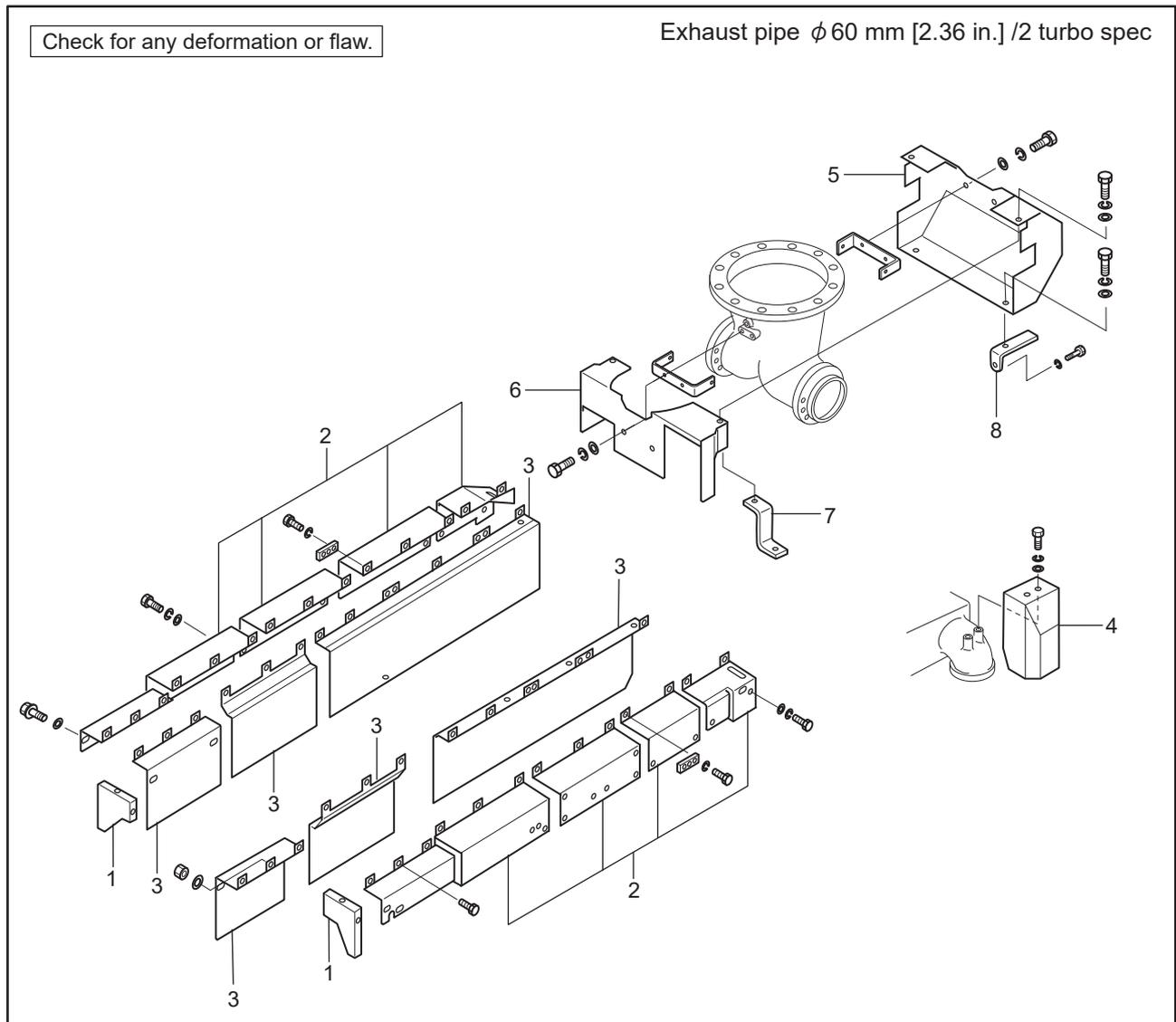
## 1.2 Insulator - Remove and Inspect



Insulator - Remove and Inspect

## Removing sequence

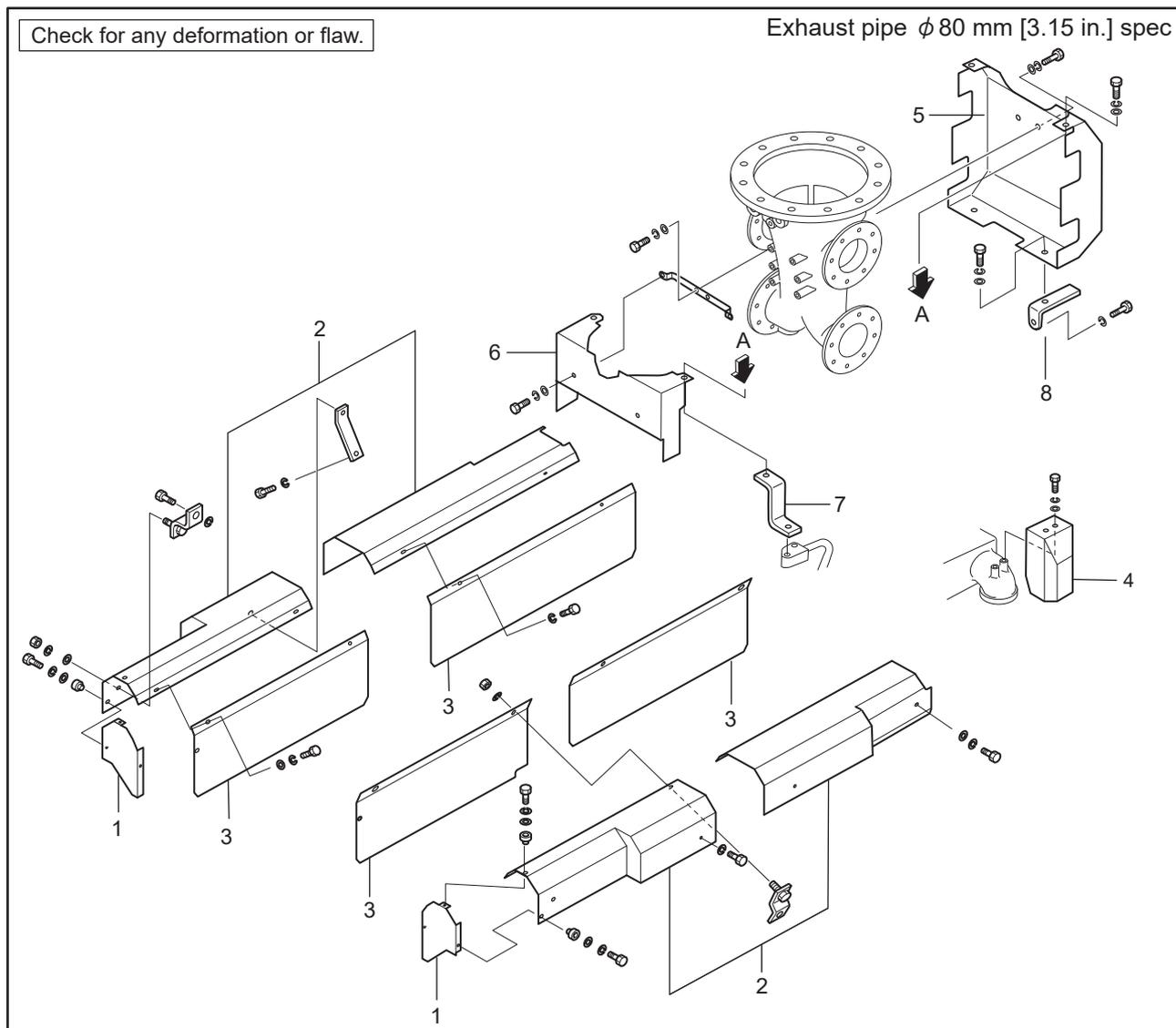
- |                   |                         |
|-------------------|-------------------------|
| 1 Insulator cover | 5 Rear turbo insulator  |
| 2 Outer insulator | 6 Front turbo insulator |
| 3 Inner insulator | 7 Stay                  |
| 4 Insulator       | 8 Stay                  |



Insulator - Remove and Inspect

Removing sequence

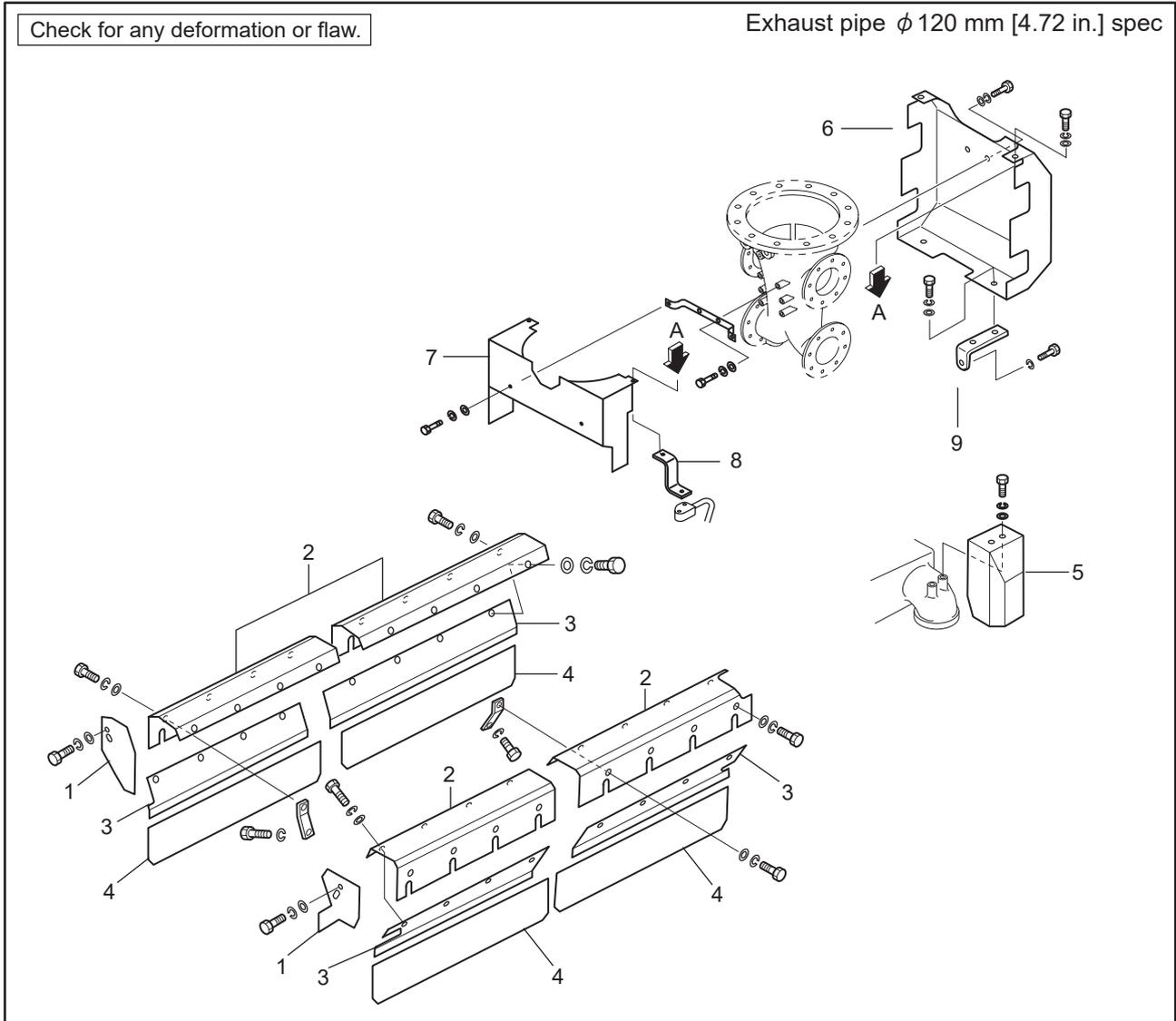
- |  |   |
|--|---|
| <ul style="list-style-type: none"> <li>1 Insulator cover</li> <li>2 Outer insulator</li> <li>3 Inner insulator</li> <li>4 Insulator</li> </ul> | <ul style="list-style-type: none"> <li>5 Rear turbo insulator</li> <li>6 Front turbo insulator</li> <li>7 Stay</li> <li>8 Stay</li> </ul> |
|--|---|



Insulator - Remove and Inspect

## Removing sequence

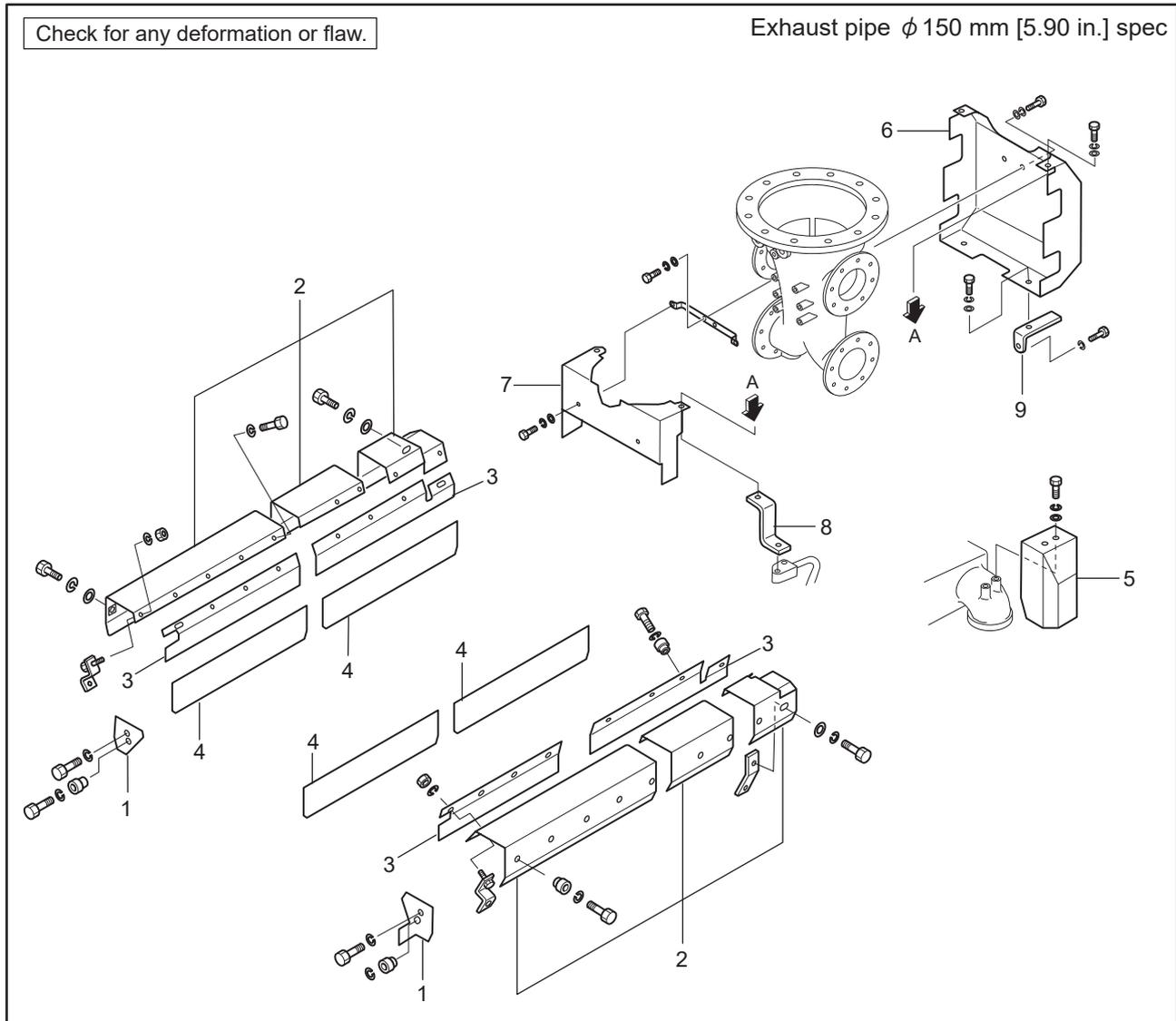
- |                   |                         |
|-------------------|-------------------------|
| 1 Insulator cover | 5 Rear turbo insulator  |
| 2 Outer insulator | 6 Front turbo insulator |
| 3 Inner insulator | 7 Stay                  |
| 4 Insulator       | 8 Stay                  |



Insulator - Remove and Inspect

Removing sequence

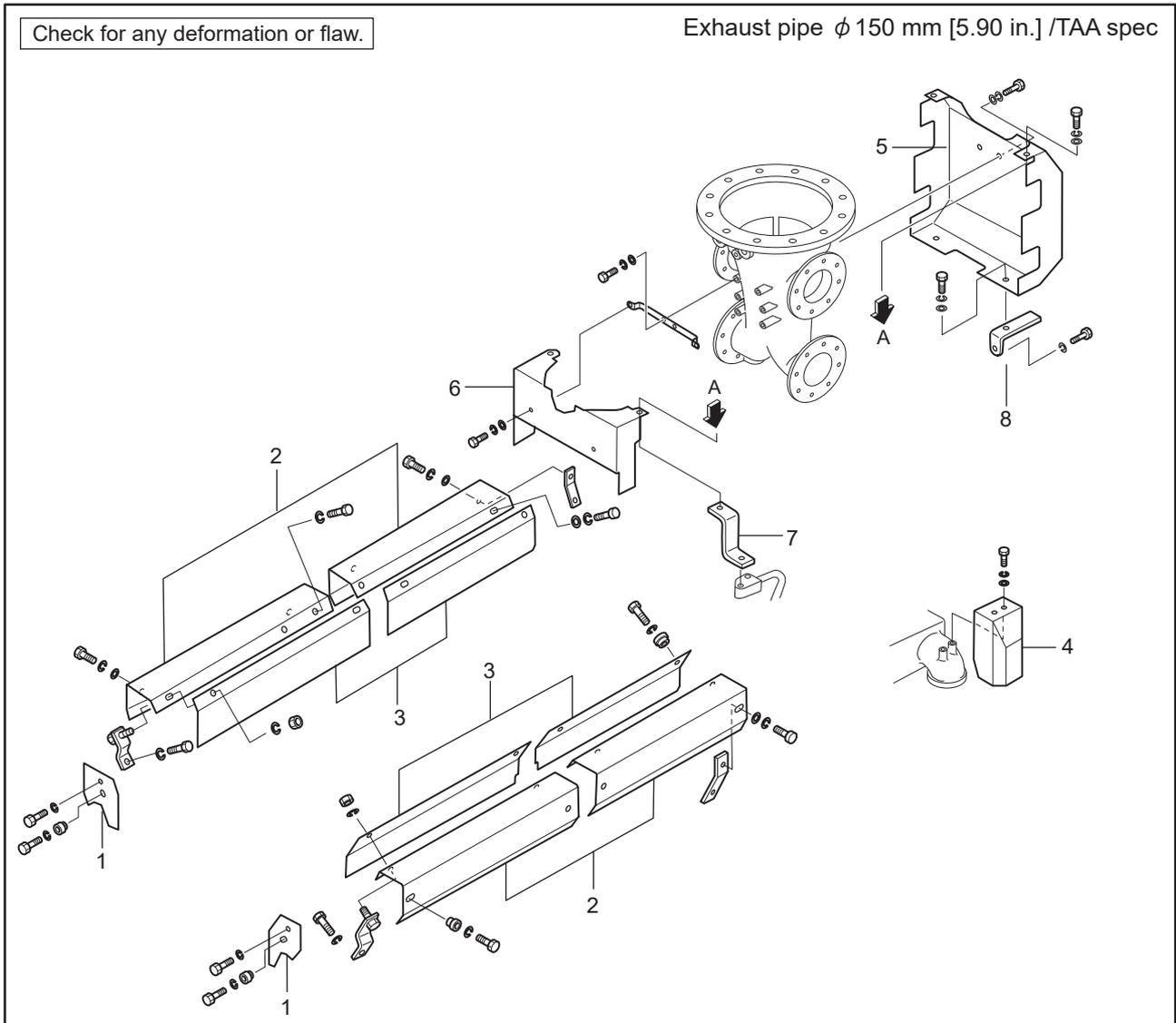
- |                    |                         |
|--------------------|-------------------------|
| 1 Insulator cover  | 6 Rear turbo insulator  |
| 2 Upper insulator  | 7 Front turbo insulator |
| 3 Middle insulator | 8 Stay                  |
| 4 Lower insulator  | 9 Stay                  |
| 5 Insulator        |                         |



Insulator - Remove and Inspect

## Removing sequence

- |                    |                         |
|--------------------|-------------------------|
| 1 Insulator cover  | 6 Rear turbo insulator  |
| 2 Upper insulator  | 7 Front turbo insulator |
| 3 Middle insulator | 8 Stay                  |
| 4 Lower insulator  | 9 Stay                  |
| 5 Insulator        |                         |

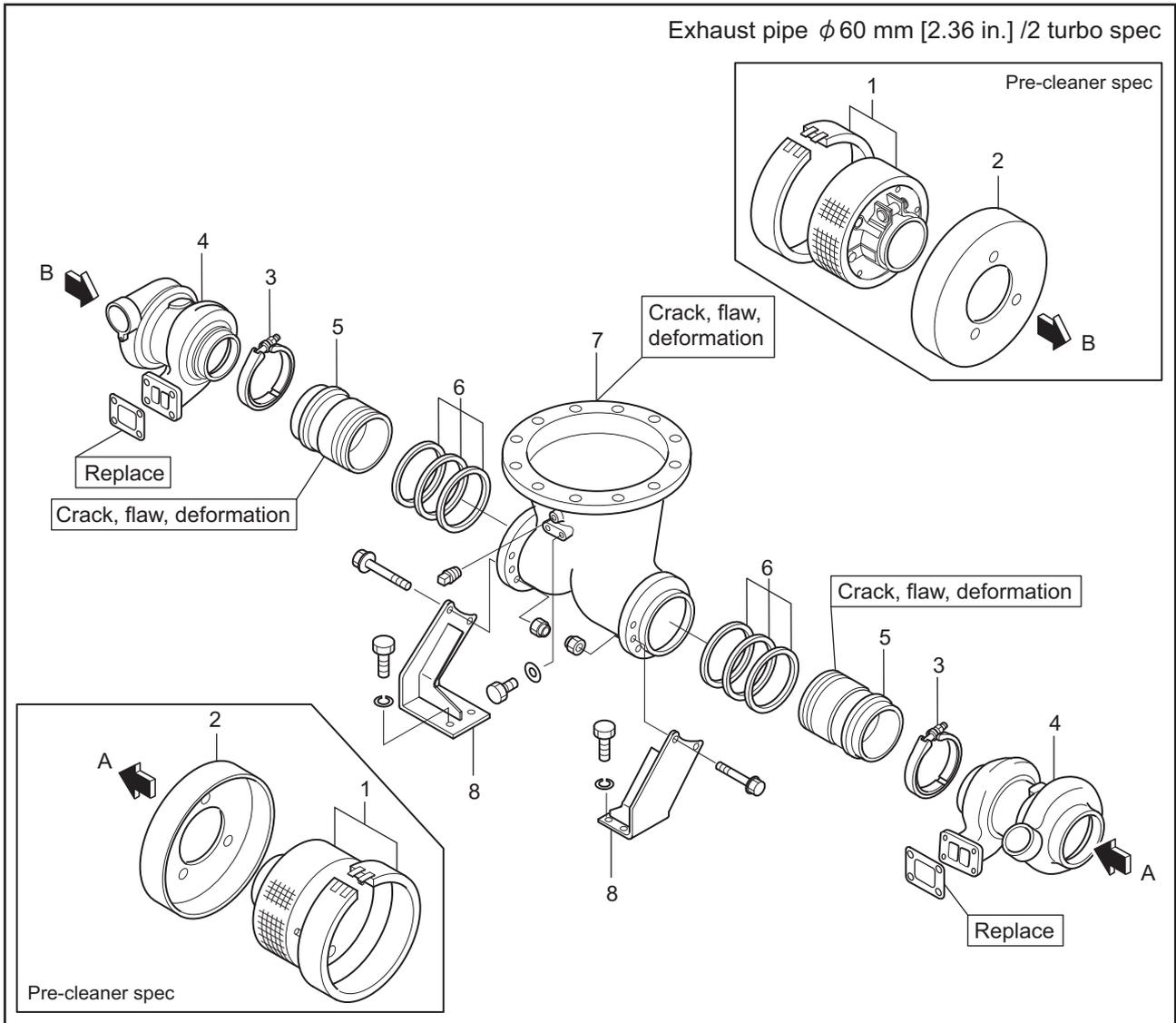


Insulator - Remove and Inspect

Removing sequence

- |                   |                         |
|-------------------|-------------------------|
| 1 Insulator cover | 5 Rear turbo insulator  |
| 2 Outer insulator | 6 Front turbo insulator |
| 3 Inner insulator | 7 Stay                  |
| 4 Insulator       | 8 Stay                  |





Exhaust Pipe - Remove and Inspect

Removing sequence

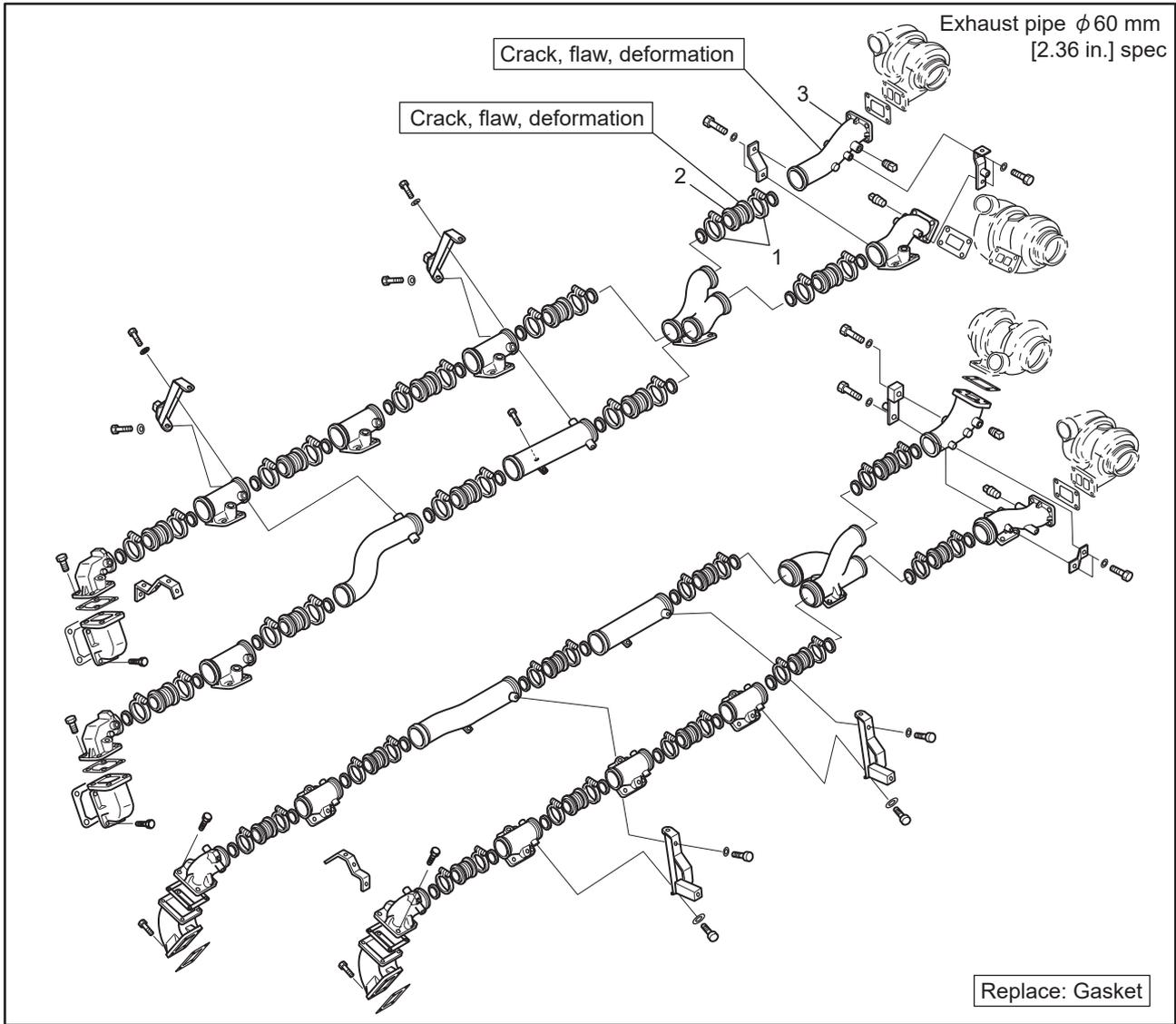
- 1 Silencer assembly
- 2 Silencer cover
- 3 V-clamp

- 4 Turbocharger
- 5 Exhaust joint
- 6 Seal ring

- 7 Exhaust pipe (approx. 29 kg [64 lb])
- 8 Bracket



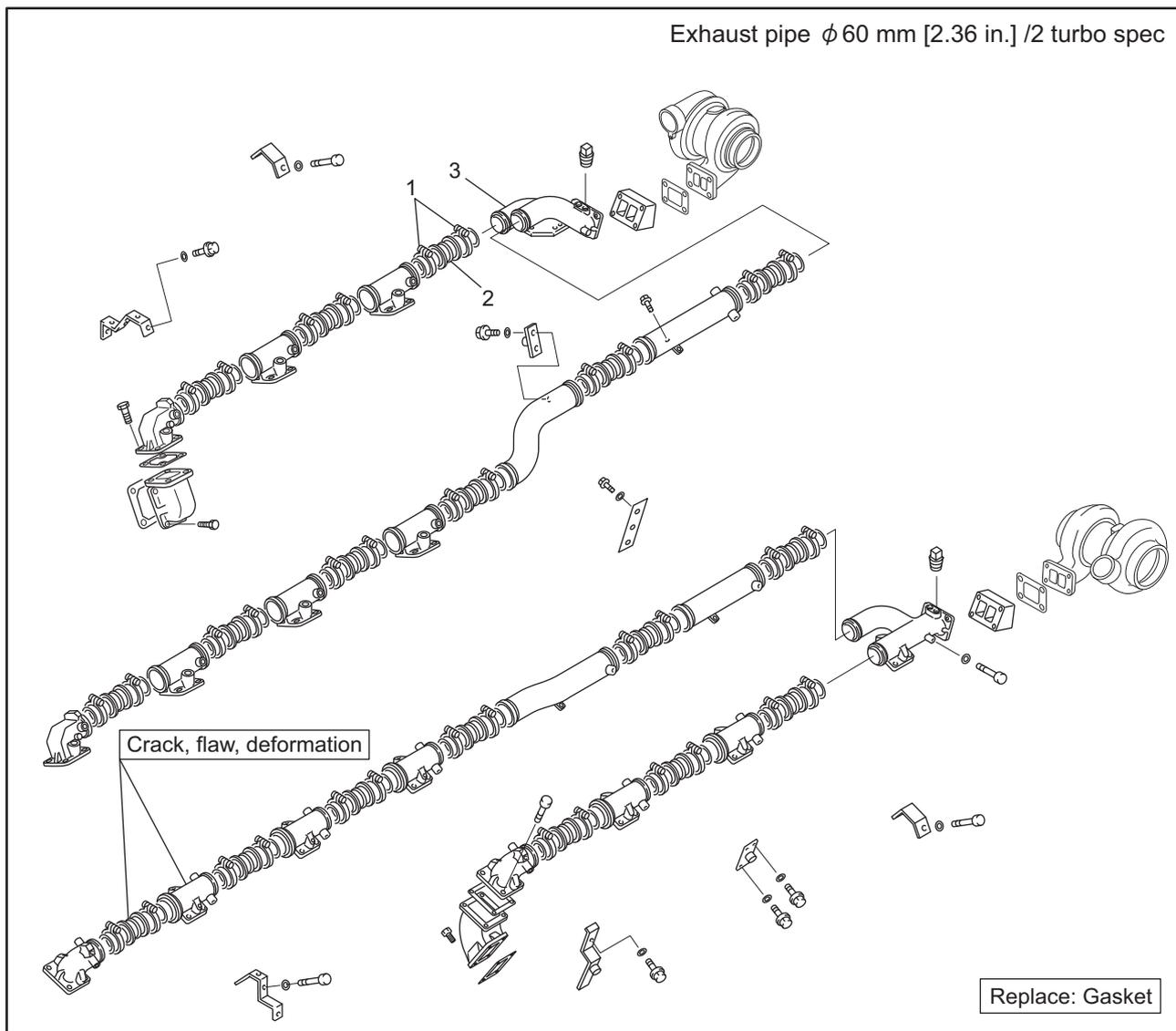
1.4 Exhaust Manifold - Remove and Inspect



Exhaust Manifold - Remove and Inspect

Removing sequence

- 1 Coupling
- 2 Flexible joint
- 3 Exhaust manifold



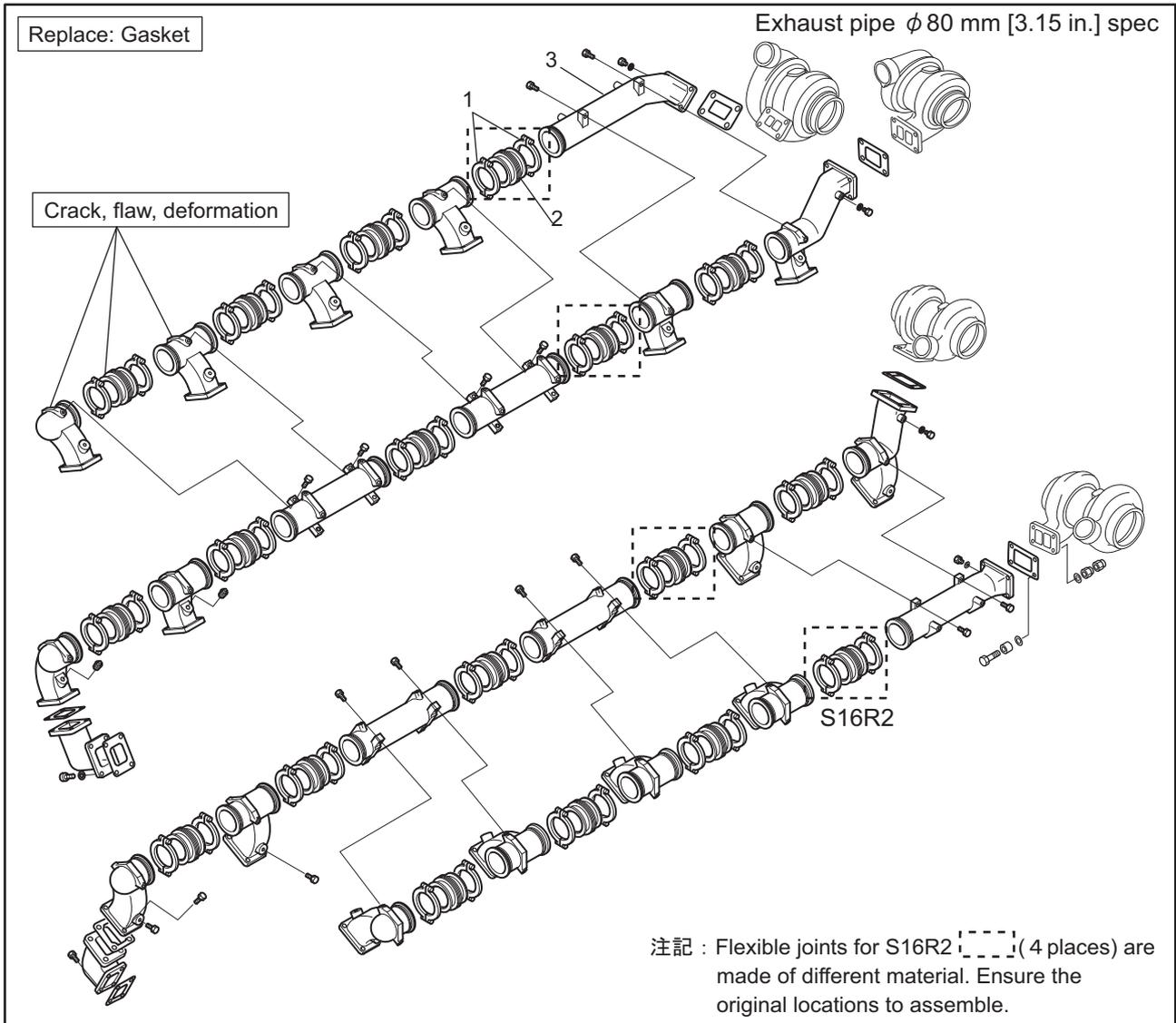
Exhaust Manifold - Remove and Inspect

Removing sequence

1 Coupling

2 Flexible joint

3 Exhaust manifold



Exhaust Manifold - Remove and Inspect

Removing sequence

1 V-clamp

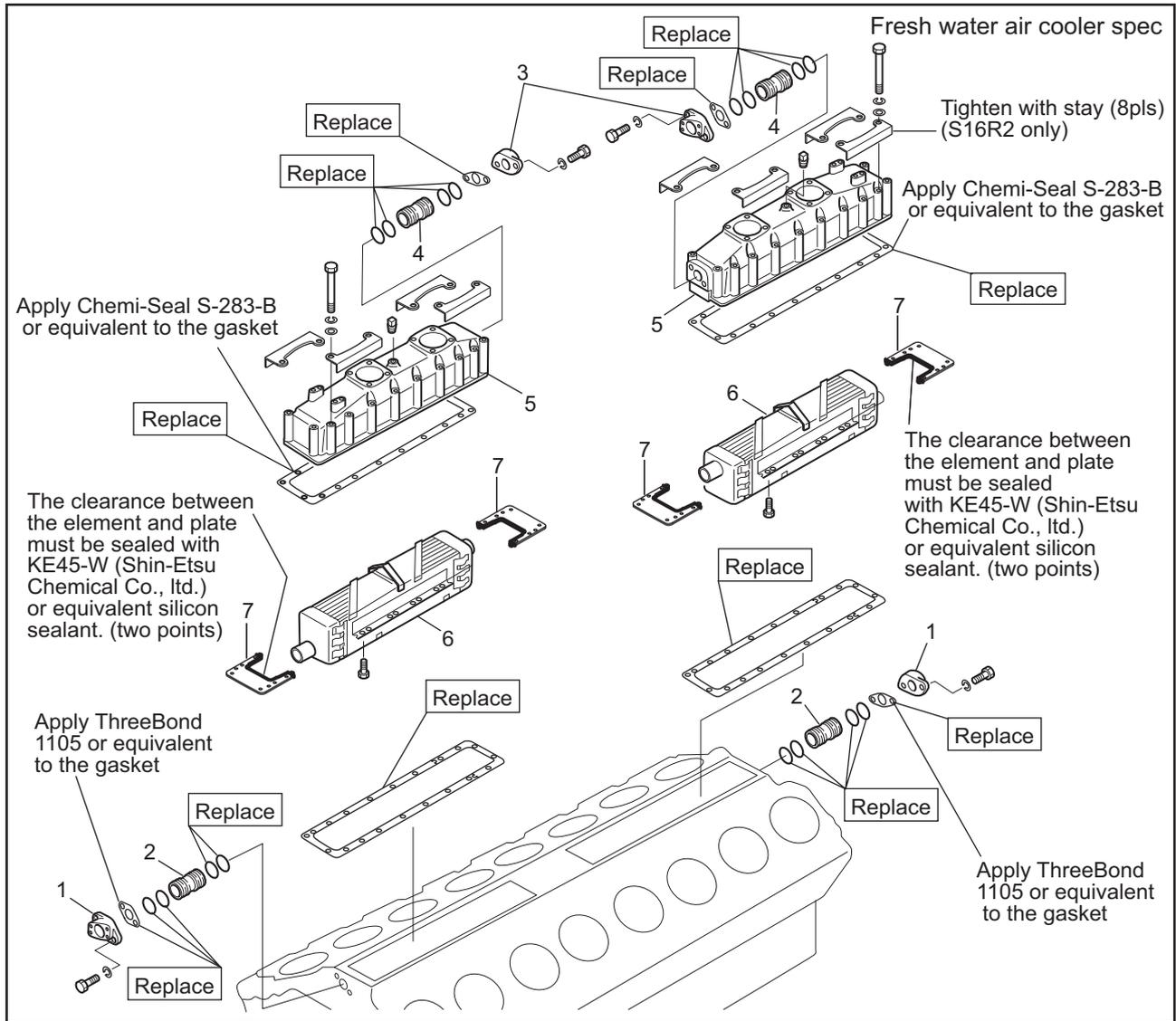
2 Flexible joint

3 Exhaust manifold



## 2. Inlet and Exhaust Systems - Disassemble, Inspect, and Assemble

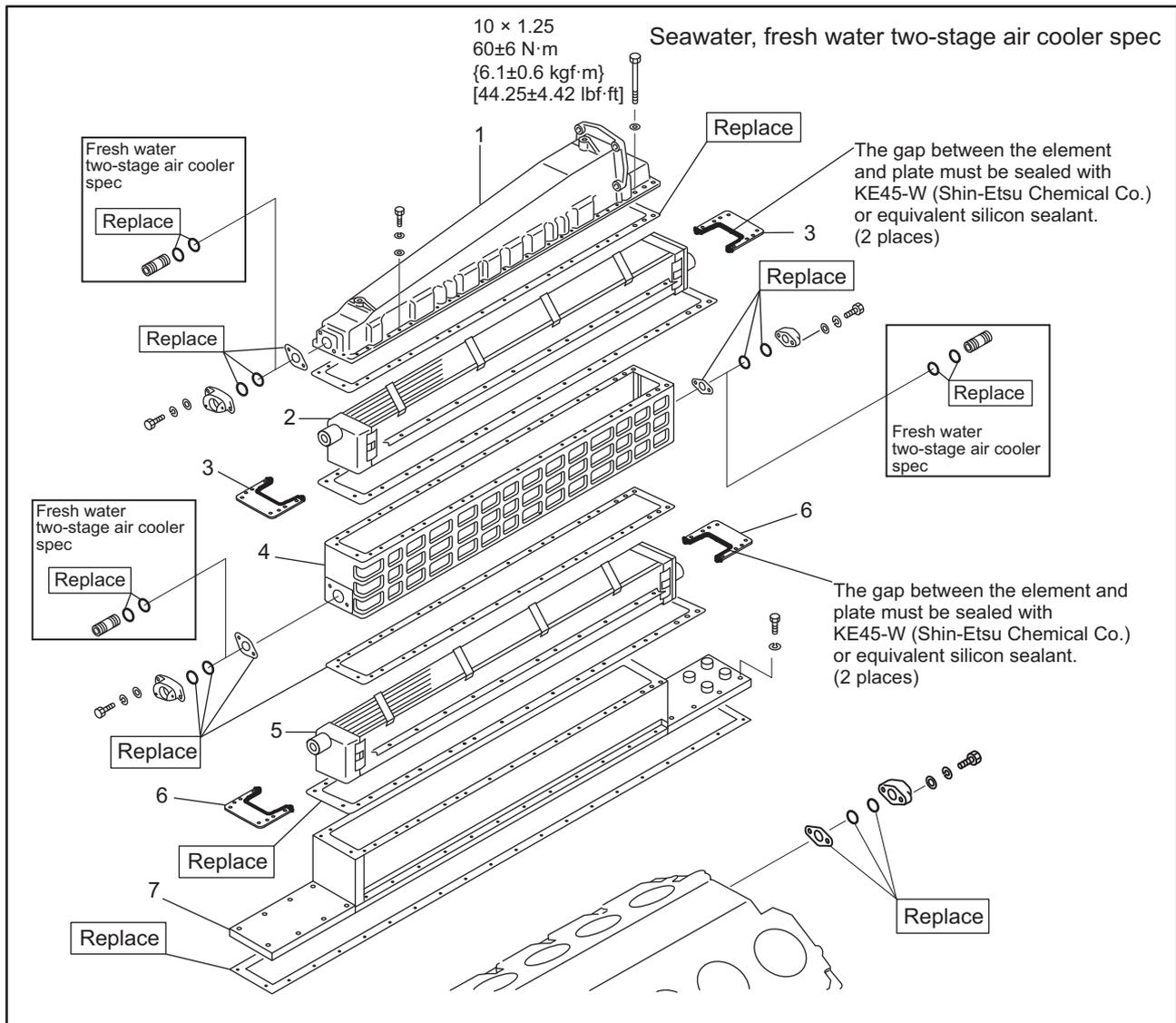
### 2.1 Air Cooler - Disassemble, Inspect, and Assemble



Air cooler - Disassemble, Inspect and Assemble

#### Disassembling sequence

- |                   |                    |  |
|-------------------|--------------------|--|
| 1 Connector       | 4 Pipe             | 6 Air cooler element<br>(weight: approx. 45 kg [99 lb])<br>(big air cooler spec: 53 kg [117 lb]) |
| 2 Air cooler pipe | 5 Air cooler cover | 7 Spacer   |
| 3 Connector       |                    |  |



Air Cooler - Disassemble, Inspect and Assemble

## Disassembling sequence

- |  |  |
|--|--|
| 1 Air cooler cover (approx. 28 kg [62 lb])               | 5 Air cooler element                                     |
| 2 Air cooler element                                     | (Seawater cooler spec: approx. 60 kg [132 lb])           |
| (Seawater cooler spec: approx. 60 kg [132 lb])           | (Fresh watertwostageaircoolerspec: approx. 51kg [112lb]) |
| (Fresh watertwostageaircoolerspec: approx. 51kg [112lb]) | 6 Plate  |
| 3 Plate  | 7 Spacer (approx. 40kg [88 lb])                          |
| 4 Air cooler case (approx. 23 kg [51 lb])                |  |

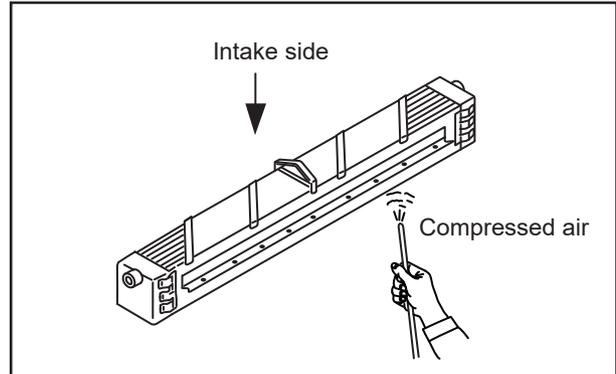
2.1.1 Air Cooler - Inspect

**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 Cleaning Method of Air Cooler

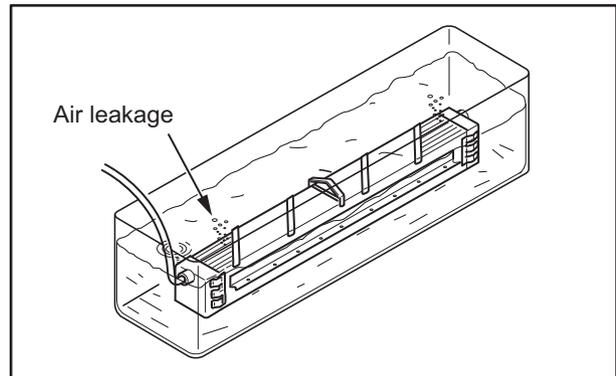
Apply compressed air (at a pressure of 0.29 to 0.49 MPa {3 to 5 kgf/cm<sup>2</sup>} [42 to 71 psi] or less) through the air cooler in the opposite direction to the normal air flow to remove the accumulation of dust and dirt. Then, inspect for corrosion and cracks.



Cleaning Method of Air Cooler

2.1.3 Air Cooler - Check for Leak

Immerse the air cooler in water. In this condition, feed compressed air (at a pressure of 0.39 MPa {4 kgf/cm<sup>2</sup>} [57 psi]) through the coolant passage to check for air leakage.



Air Cooler - Check for Leak

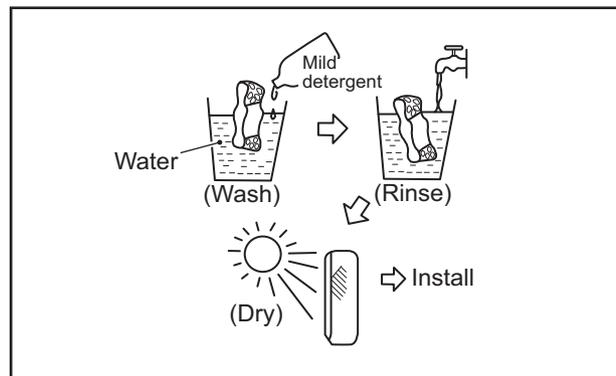
2.1.4 Air Cooler - Assemble

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 - Wash

- (1) Remove the pre-cleaner from the silencer, and hand-wash the pre-cleaner using a neutral detergent.
- (2) Rinse with freshwater.
- (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 - Wash

### 3. Inlet and Exhaust Systems - Install

♦To install, follow the removal sequence in reverse. (See the illustration for disassembly.)

♦Thoroughly clean and dry the inlet and exhaust passages.

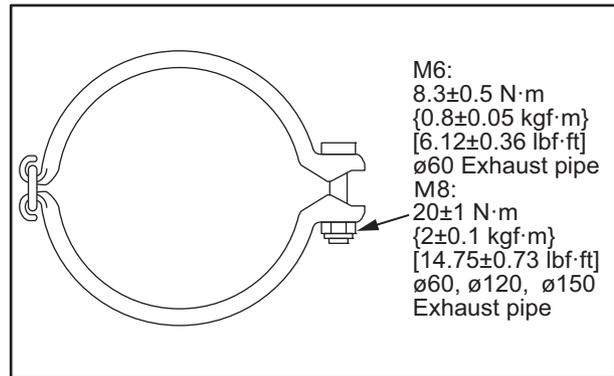
#### 3.1 Exhaust Pipe and Exhaust Manifold - Install

##### 3.1.1 Exhaust Manifold Coupling - Tighten

### CAUTION

Do not distort the exhaust manifold coupling.

- (1) Apply MOLYKOTE (molybdenum disulfide anti-seize) or equivalent on 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 the exhaust manifold mating face and the exhaust manifold coupling taper face.
- (4) Tighten the nuts to the specified torque.
- (5) Lightly shake again to check for loose bolt.



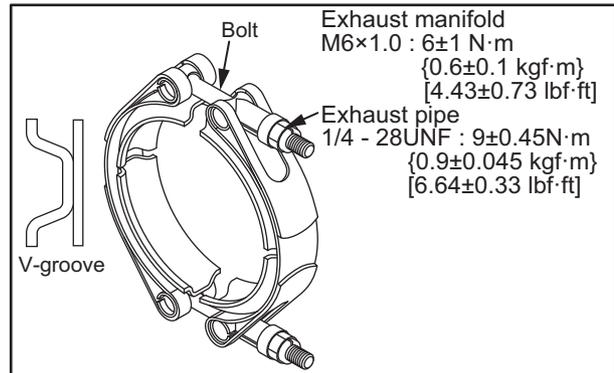
Exhaust Manifold Coupling - Tighten

##### 3.1.2 V-clamp - Tighten

### CAUTION

Do not deform the V-clamp. It results in the decrease of tightening force.

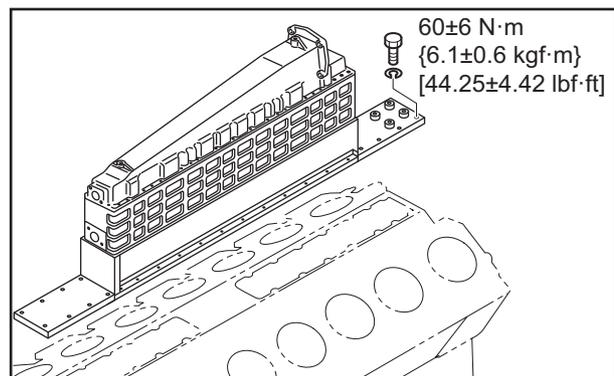
- (1) Apply MOLYKOTE (molybdenum disulfide anti-seize) or equivalent on the bolt.
- (2) Tighten the nuts to the specified torque.
- (3) Lightly shake the outer circumference of V-clamp to make a snug contact between the exhaust manifold mating face and the V-clamp tapered face.
- (4) Tighten the nuts to the specified torque.
- (5) Lightly shake again to check for loose bolt.



V-clamp - Tighten

#### 3.2 Air Cooler - Install

Install the air cooler to the crank case, and tighten bolts to the specified torque.



Air Cooler - Install



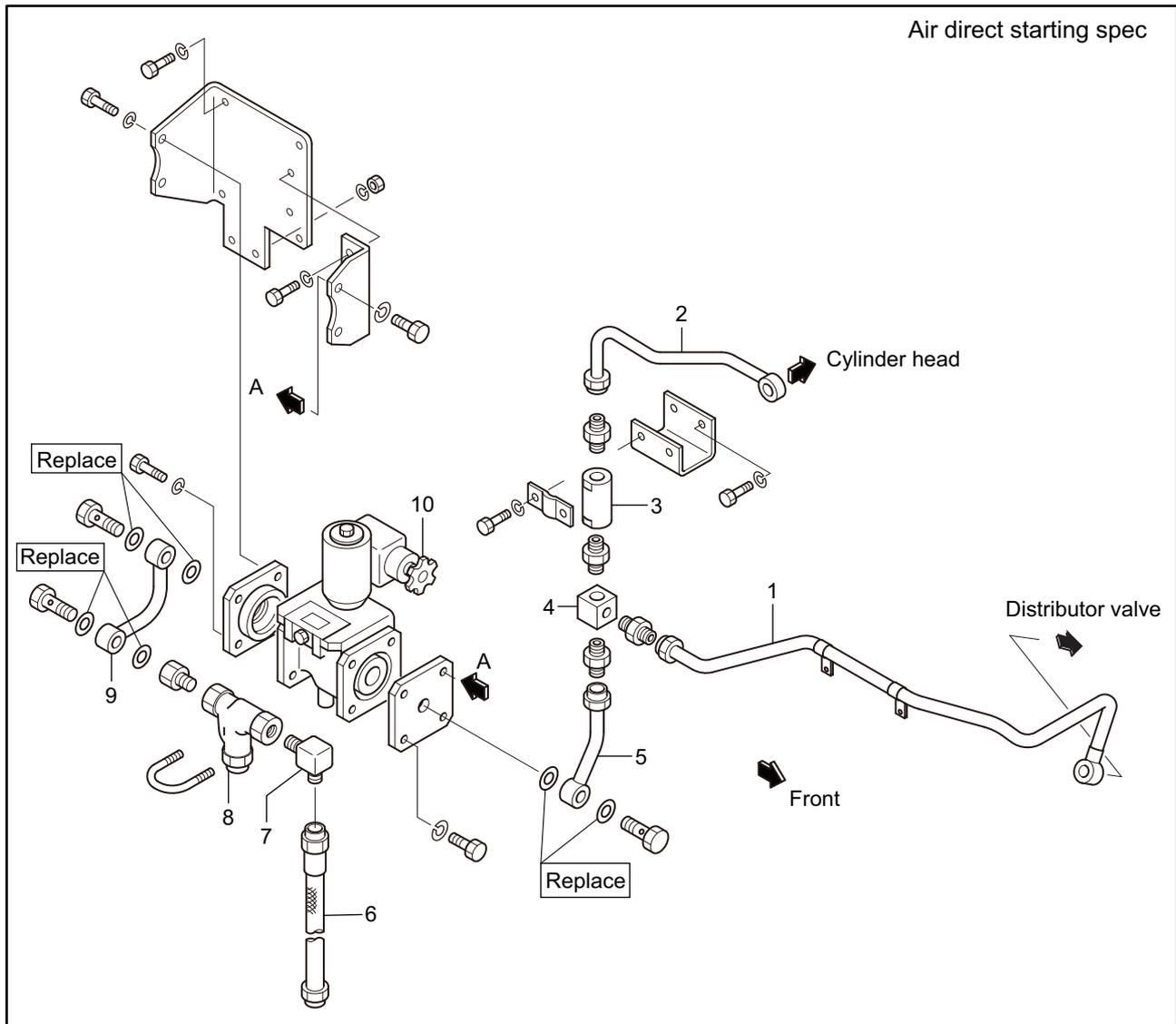
# Chapter 12 AIR START SYSTEM

<b>1. Air Start System - Remove and Inspect.....</b>	<b>12-3</b>
1.1 Magnetic Valve - Remove and Inspect.....	12-3
1.2 Air Pipe, Starter Valve and Distributor Valve - Remove and Inspect.....	12-4
1.3 Air Starter - Remove and Inspect .....	12-5
<b>2. Air Start System - Disassemble, Inspect and Assemble.....</b>	<b>12-6</b>
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2.2 Magnetic Valve - Assemble .....	12-7
2.3 Starter Valve - Disassemble and Inspect.....	12-8
2.4 Starter Valve - Inspect .....	12-9
2.5 Starter Valve - Assemble .....	12-10
2.6 Distributor Valve - Disassemble and Inspect.....	12-11
2.7 Distributor Valve - Inspect.....	12-12
2.8 Distributor Valve - Assemble .....	12-13
<b>3. Air Start System - Install .....</b>	<b>12-13</b>



# 1. Air Start System - Remove and Inspect

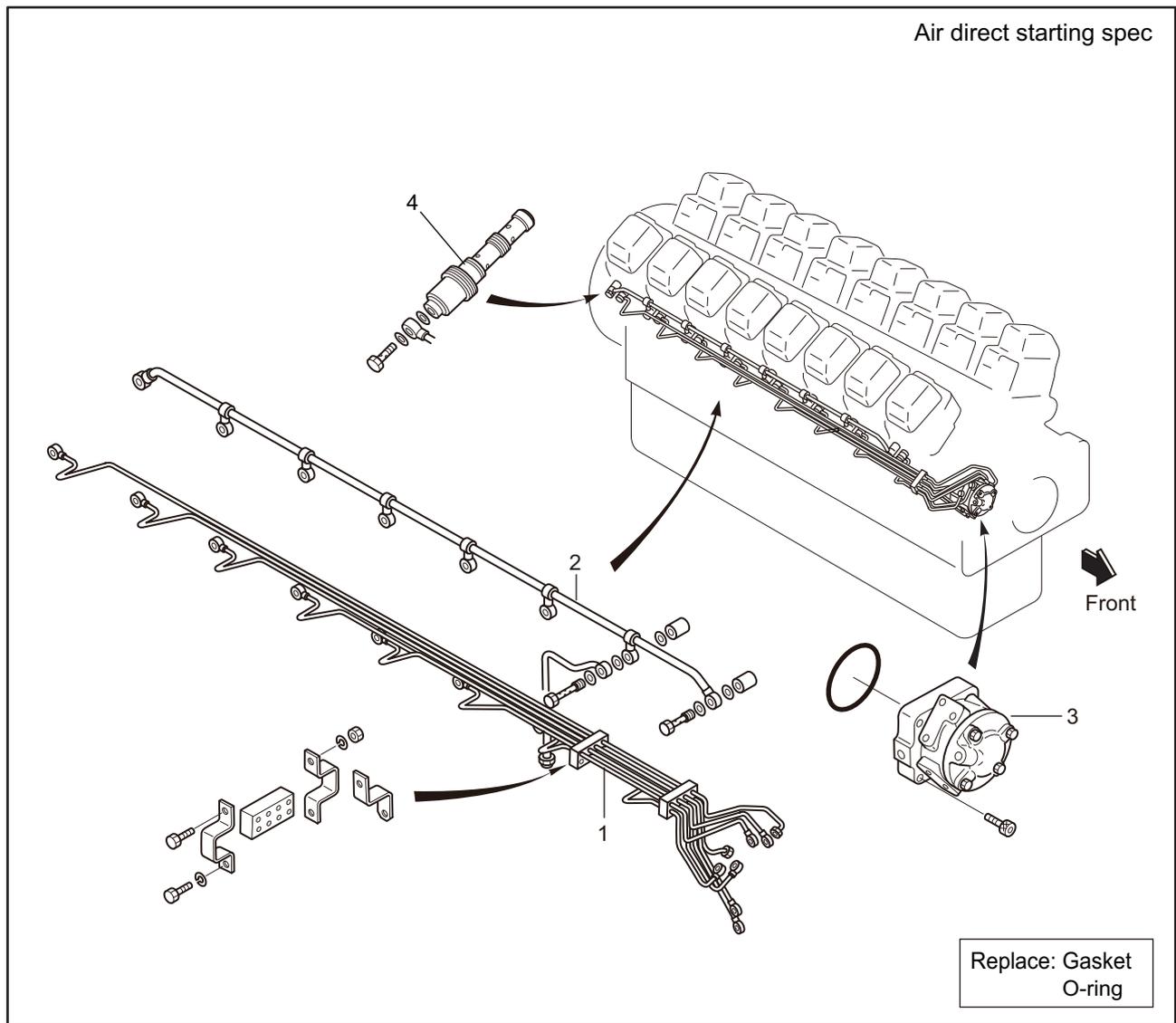
## 1.1 Magnetic Valve - Remove and Inspect



### Removing sequence

- |               |                   |
|---------------|-------------------|
| 1 Air pipe    | 6 Flexible pipe   |
| 2 Air pipe    | 7 Elbow           |
| 3 Check valve | 8 Air strainer    |
| 4 Connector   | 9 Air pipe        |
| 5 Air pipe    | 10 Magnetic valve |

1.2 Air Pipe, Starter Valve and Distributor Valve - Remove and Inspect

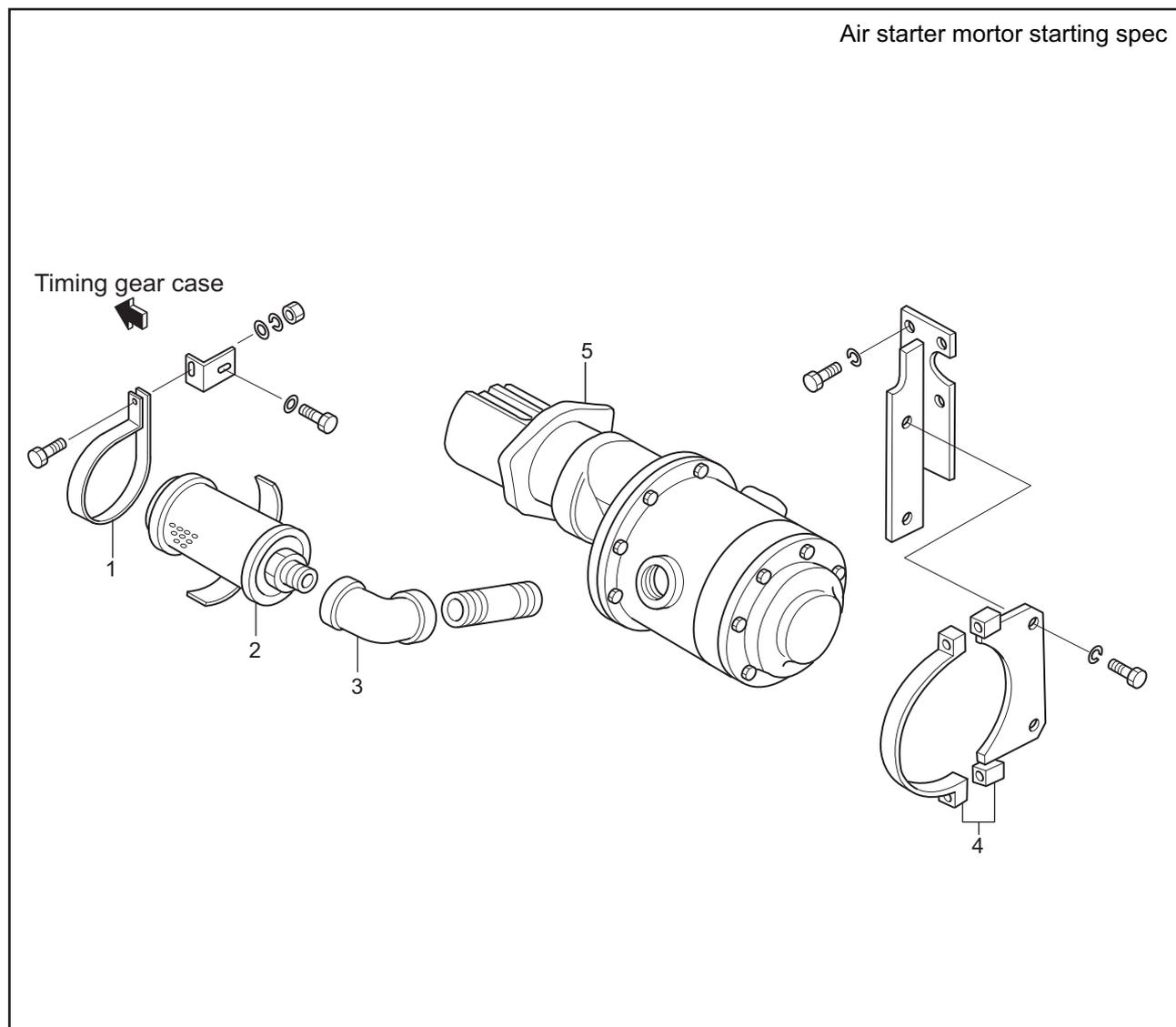


Air Pipe, Starter Valve and Distributor Valve - Inspect

Removing sequence

- |                             |                     |
|-----------------------------|---------------------|
| 1 No.1 to 8 pilot air pipes | 3 Distributer valve |
| 2 Main air pipe             | 4 Starter valve     |

## 1.3 Air Starter - Remove and Inspect

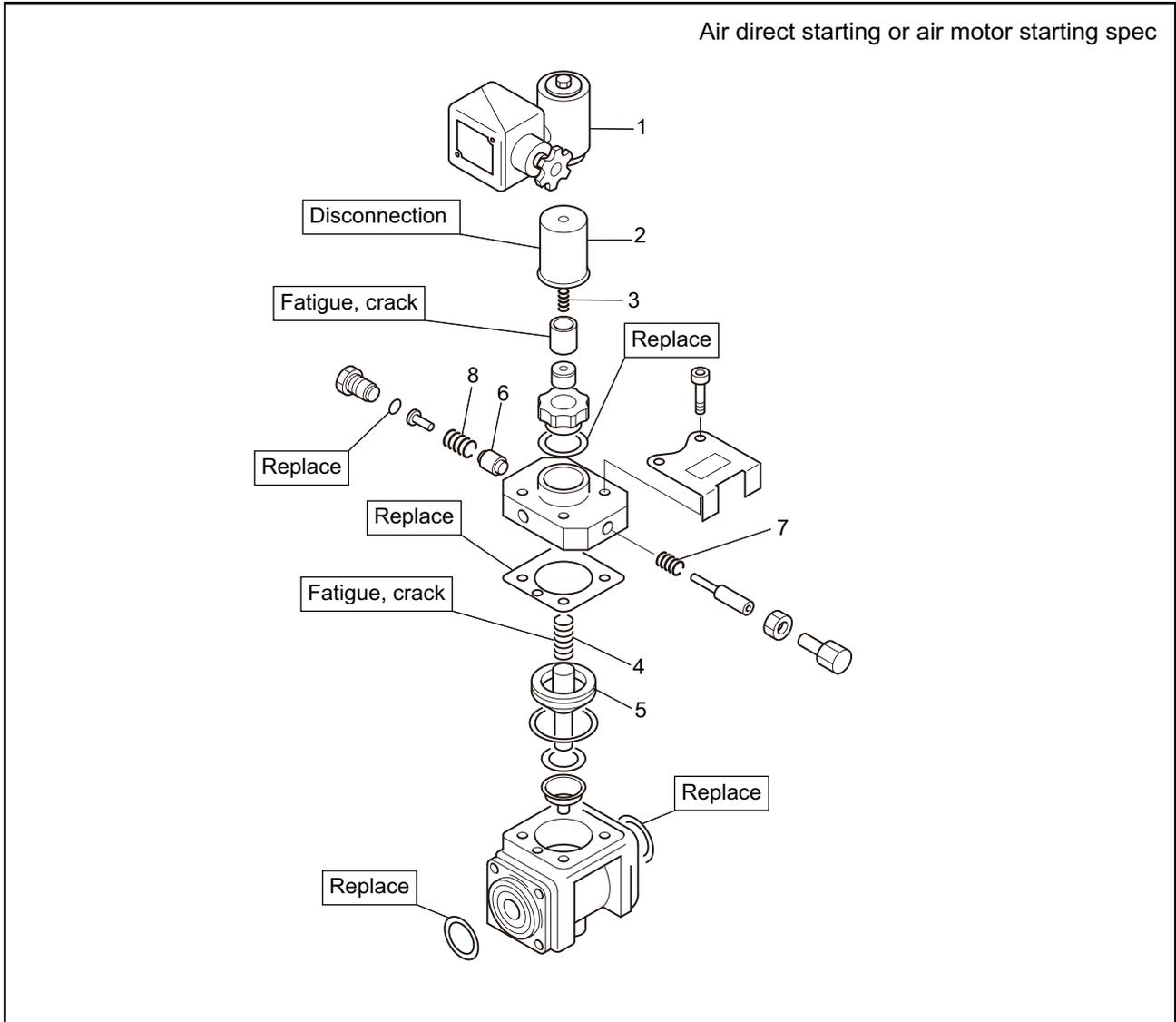


## Removing sequence

- |                |                                    |
|----------------|------------------------------------|
| 1 Clamp        | 4 Clamp                            |
| 2 Auto-muffler | 5 Air box (approx. 60 kg [132 lb]) |
| 3 Elbow        |                                    |

2. Air Start System - Disassemble, Inspect and Assemble

2.1 Magnetic Valve - Disassemble and Inspect



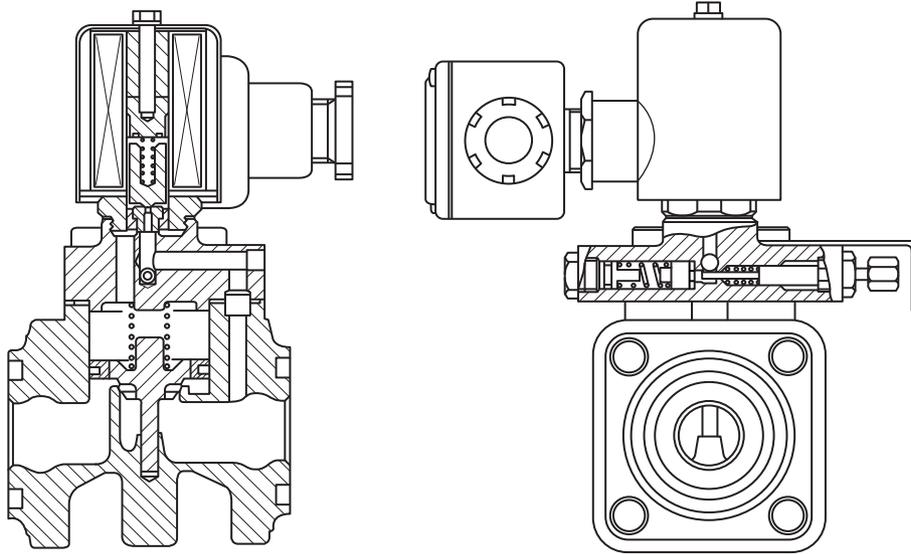
Magnetic Valve - Disassemble and Inspect

Removing sequence

- |                  |                   |
|------------------|-------------------|
| 1 Magnetic valve | 5 Piston assembly |
| 2 Coil           | 6 Valve           |
| 3 Plunger spring | 7 Return spring   |
| 4 Piston spring  | 8 Valve spring    |

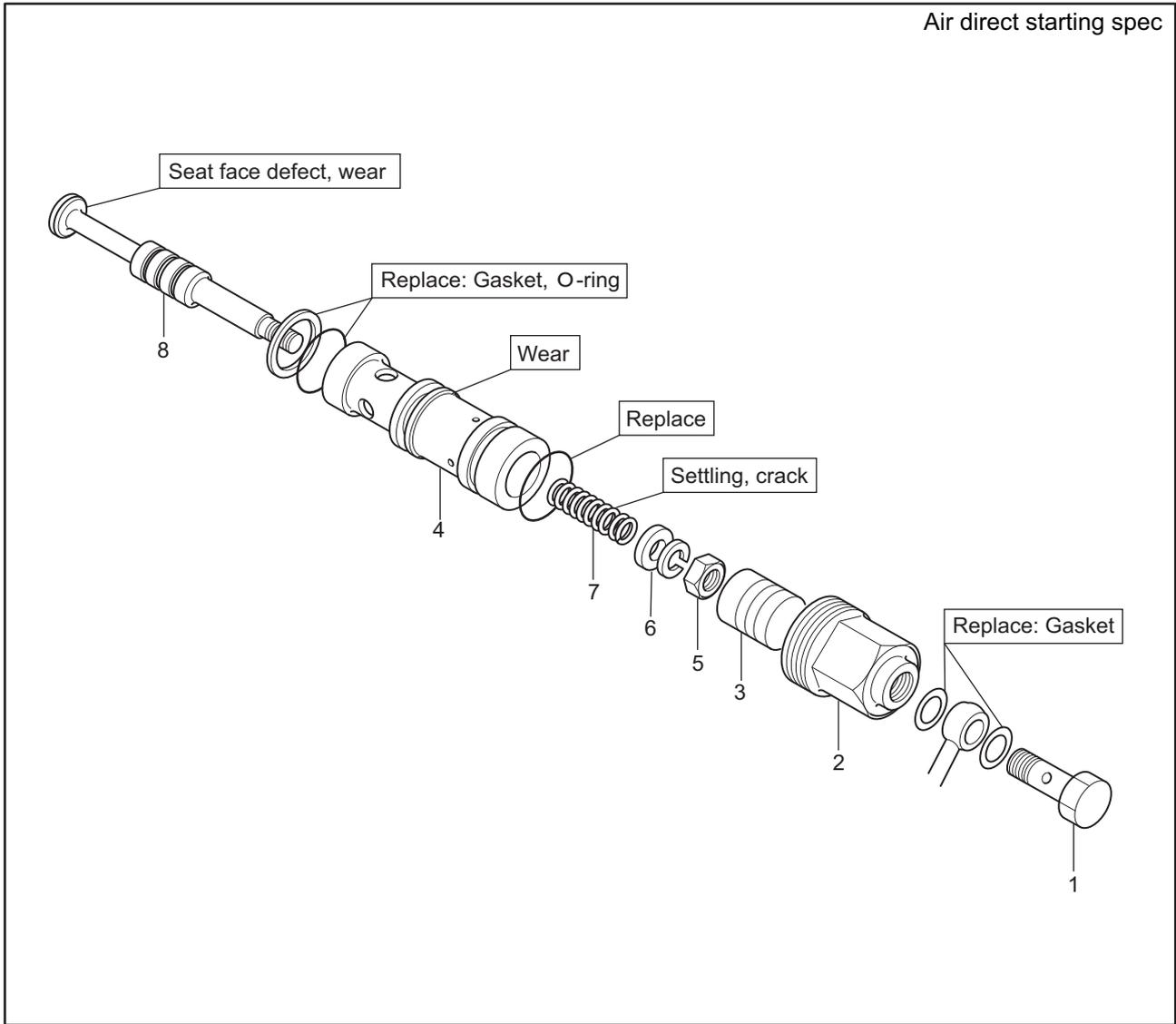
2.2 Magnetic Valve - Assemble

Air direct starting or air motor starting spec



Magnetic Valve - Assemble

2.3 Starter Valve - Disassemble and Inspect



Starter Valve - Disassemble and Inspect

Removing sequence

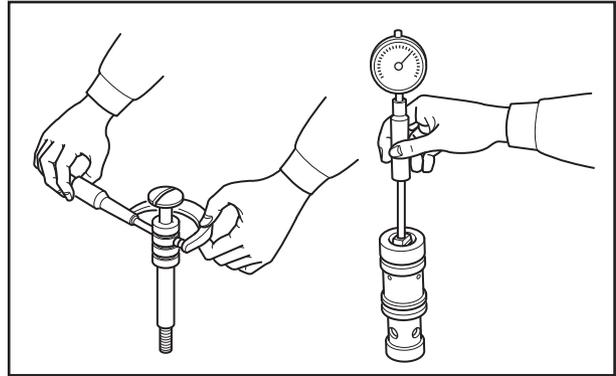
- |                        |                 |
|------------------------|-----------------|
| 1 Eye bolt             | 5 Nut           |
| 2 Cap nut              | 6 Retainer      |
| 3 Starter valve piston | 7 Spring        |
| 4 Starter valve guide  | 8 Starter valve |

## 2.4 Starter Valve - Inspect

### 2.4.1 Clearance Between Starter Valve and Starter Valve Guide - Measure

Measure the clearance between the stater 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 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

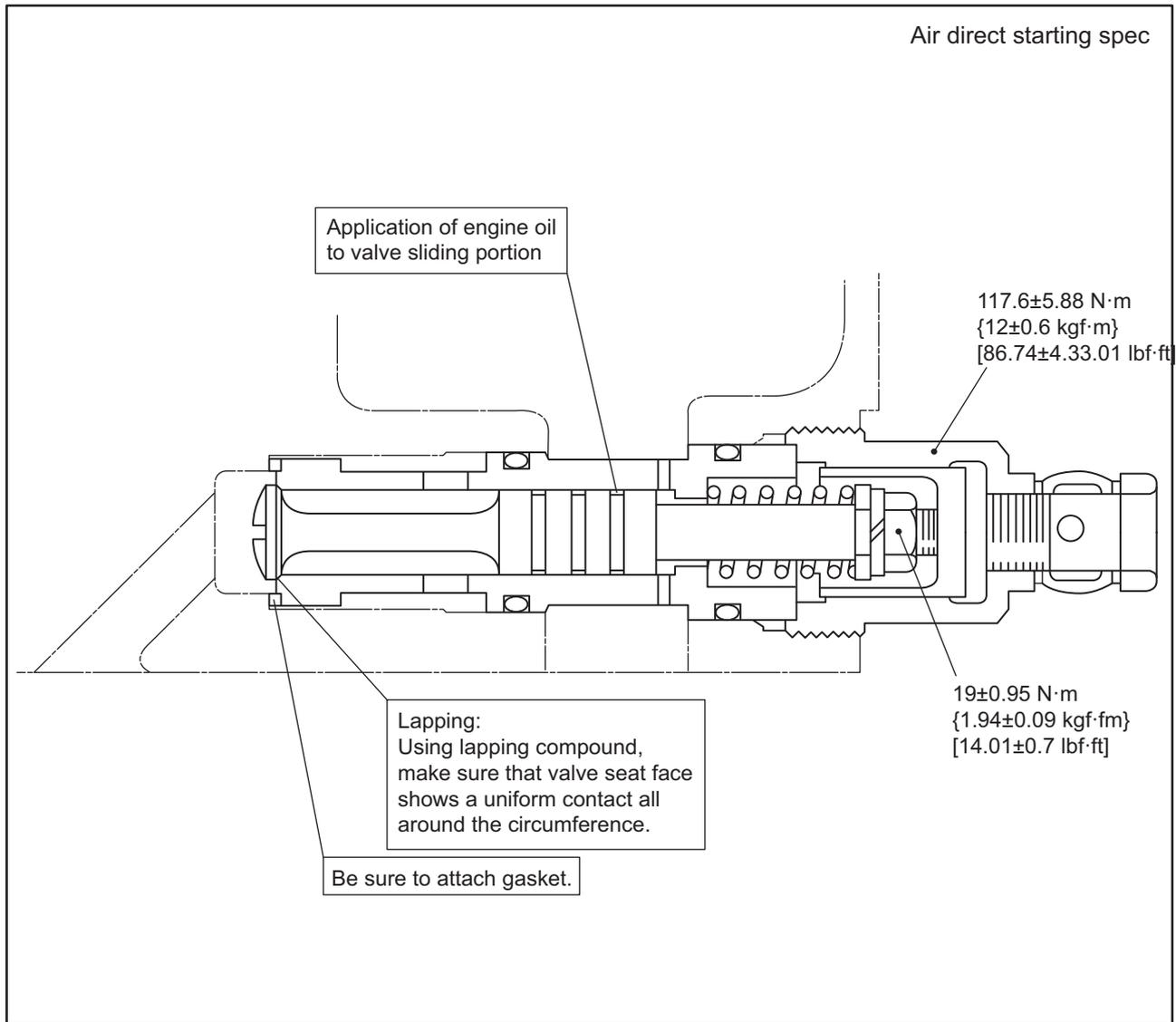
### 2.4.2 Free Length of Valve Spring - Measure

Measure the free length of valve spring.

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

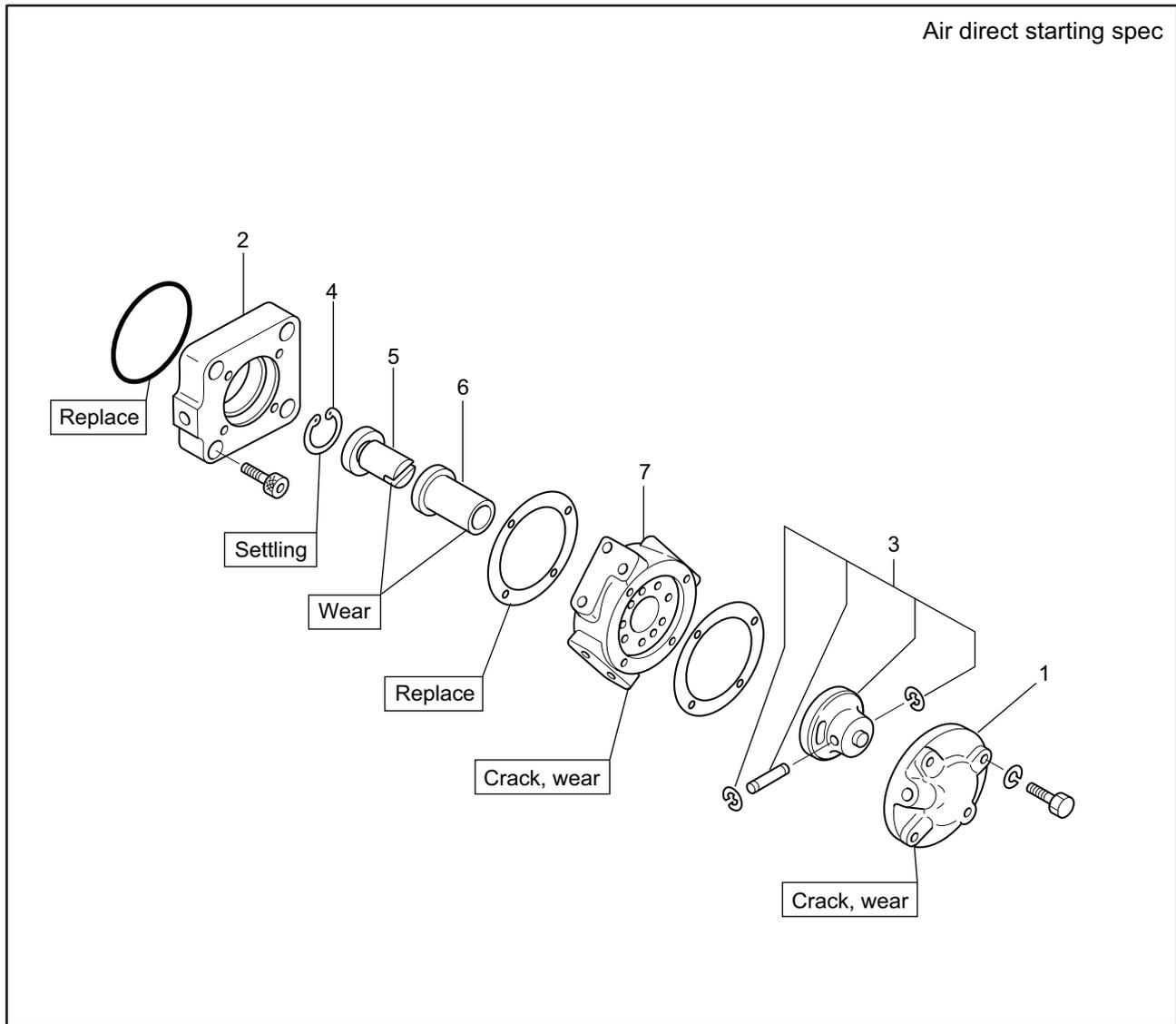
Item	Standard value	Limit value
Valve spring free length	36 mm [1.42 in.]	34 mm [1.34 in.]

2.5 Starter Valve - Assemble



Starter Valve - Assemble

## 2.6 Distributor Valve - Disassemble and Inspect



Distributer Valve - Disassemble and Inspect

## Removing sequence

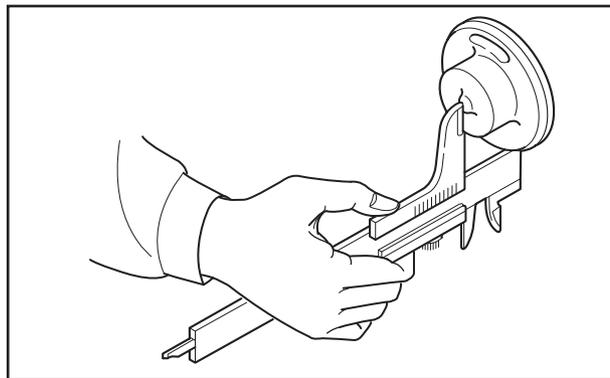
- |                                       |                     |
|---------------------------------------|---------------------|
| 1 Case cover                          | 5 Distributer valve |
| 2 Distributer spacer                  | 6 Bushing           |
| 3 Distributer valve, Lock pin, E-ring | 7 Distributer case  |
| 4 Snap ring                           |                     |

2.7 Distributor 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
Distributer valve height	21.85 to 21.95 mm [0.8602 to 0.8642 in.]	21.75 mm [0.8563 in.]

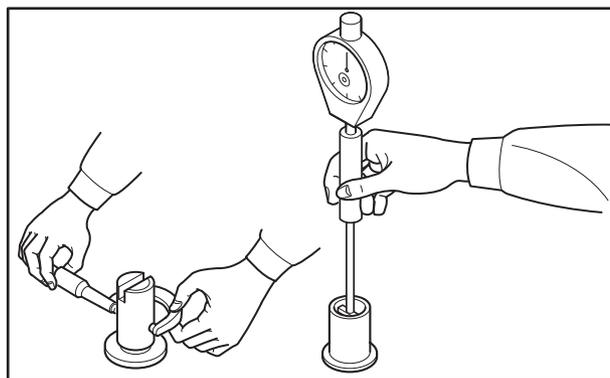


Distributer Valve Height - Measure

2.7.2 Clearance Between Distributer Shaft and Bushing - Measure

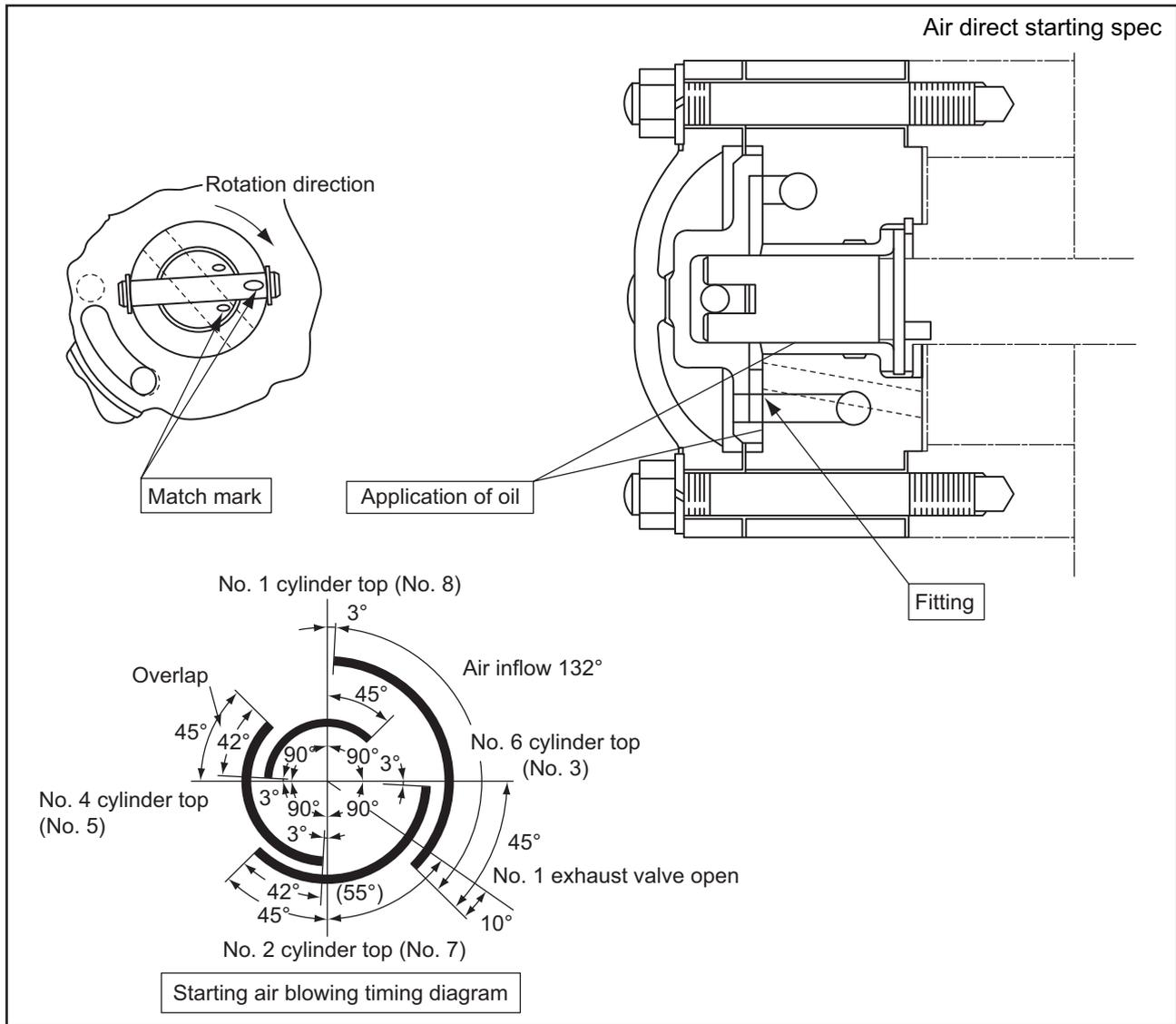
Measure the clearance between the distributor shaft and bushing. If the value exceeds the limit, replace the distributor shaft or bushing with a new one.

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 Distributor Valve - Assemble



Distributor Valve - Assemble

Note: Align the match marks to assemble the distributor. The wrong assembling results in the 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

<b>1. Engine - Adjust .....</b>	<b>13-3</b>
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3.6 Seal .....	13-12



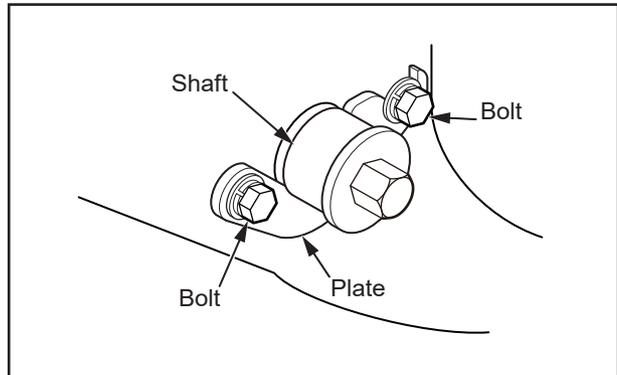
## 1. Engine - Adjust

### 1.1 Turning Gear - Use

#### WARNING

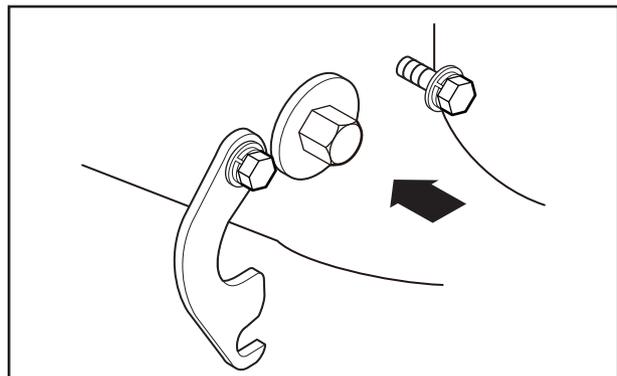
Before starting the engine, make sure that the turning gear is in the engine running position. If the engine is started with the turning gear engaged (pushed-in position), it will result in personal injury as well as damage to ring gear.

- (1) Loosen two bolts, and remove the plate from slot of shaft.



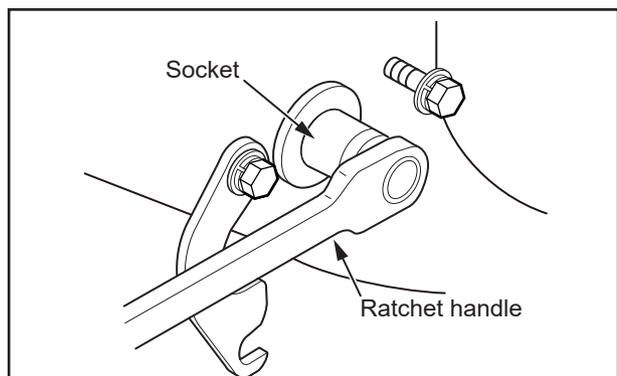
Turning Gear - Use (for Engine Running)

- (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.



Turning Gear - Use (for Turning)

#### CAUTION

Make sure that the plate is firmly fitted in slot of shaft.

### 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 adjustment, see "Valve Bridge and Adjusting Screw - Adjust" of "ENGINE BODY - ASSEMBLE".

### 1.3 Valve Clearance - Check

Check the valve clearance. Adjust to the standard value if not adjusted. After adjustment, tighten the lock nut firmly to the specified torque. Then, check the clearance again. For adjustment, see "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 adjustment, see "Fuel Injection Timing - Check and Adjust" of "ASSEMBLY OF BASIC ENGINE".

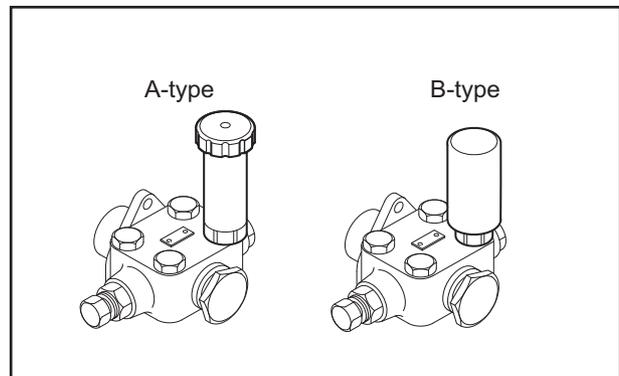
### 1.5 Fuel System - Bleed Air

**WARNING**

- (a) Thoroughly wipe off fuel spilled out of the air vent plug to prevent a risk of fire.
- (b) After the air bleeding, be sure to lock the A type priming pump handle securely. If loosely locked, it can cause damage to the priming pump and result in fuel leaks and a fire.

Note: The priming pump has A and B two types. The operation differs according to the type. Check the handling procedure before the operation.

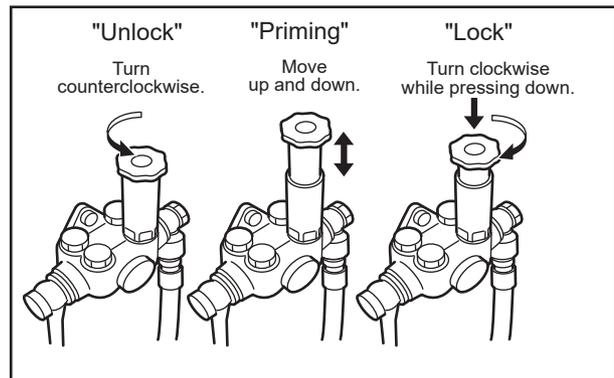
To bleed air from the fuel system, start the air bleeding at the place nearest to the fuel tank, from the fuel filter to the injection pump, while feeding fuel with the priming pump.



Comparison of Priming Pump A and B Types

**A Type Priming Pump - Operate**

- (1) Turn the priming pump handle counterclockwise to release the lock.
- (2) Feed fuel by moving the priming pump up and down.
- (3) When the fuel flowing from the bleed holes no longer contains air bubbles, lock the priming pump by turning the handle clockwise while pushing it down. Then tighten the air bleed plug.

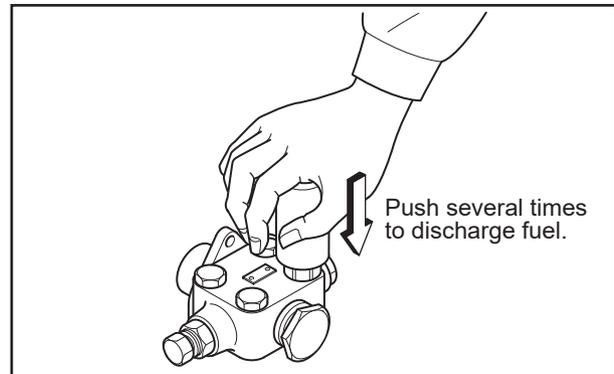


A Type Priming Pump - Operate

**B Type Priming Pump - Operate**

- (1) Move the priming pump up and down several times to discharge fuel.

Note: The release and lock of the pump are not required as the pump has a lock - less structure.

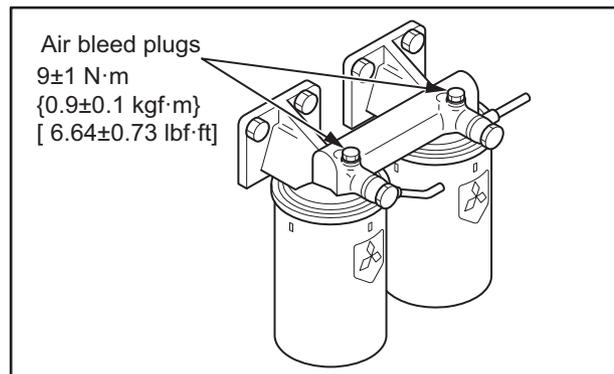


B Type Priming Pump - Operate

**1.5.1 Fuel Filter (Paper Element) - Bleed Air****CAUTION**

If the air vent plug, threads of bracket or sealing washer is damaged, replace them with a new one.

- (1) Loosen the air vent plug of fuel filter by about 1.5 turns.
- (2) Feed fuel by moving the priming pump up and down.
- (3) When fuel flowing from the bleed holes no longer contains air bubbles, tighten the air vent plugs to the specified torque.

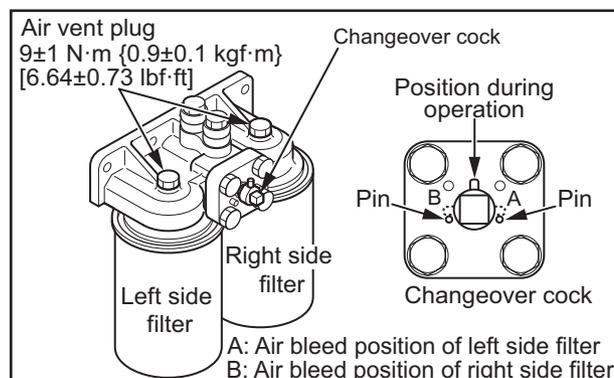


Fuel Filter (Paper Element) - Bleed Air

**1.5.2 Fuel Filter (Change Over Spec) - Bleed Air****CAUTION**

If the air bleed plugs, threads of bracket or sealing washers are damaged, replace them with new ones.

- (1) Switch the cock to the air bleeding filter, and loosen the air bleed plug of the fuel filter by approximately 1.5 turns.
- (2) Feed fuel by moving the priming pump up and down.
- (3) When fuel flowing from the bleed hole no longer contains air bubbles, tighten the air bleed plug to the specified torque.
- (4) Turn the changeover cock to the operation position.



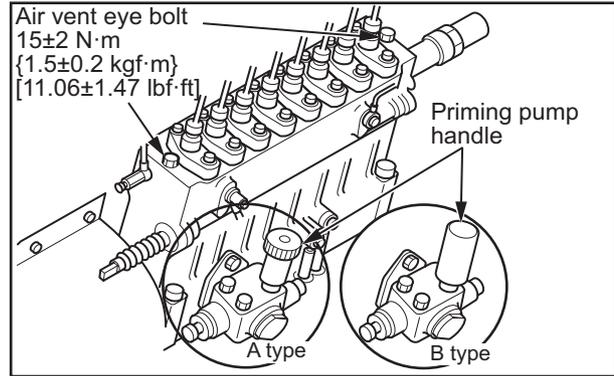
Fuel Filter (Change Over Spec) - Bleed Air

1.5.3 Fuel Injection Pump - Bleed Air

- (1) Loosen the air bleed eye bolt of fuel injection pump by about 1.5 turns.
- (2) Feed fuel by moving the priming pump handle up and down.
- (3) When the fuel flowing from the bleed holes no longer contains air bubbles, lock the A type priming pump by turning the handle clockwise while pushing it down. Then tighten the air bleed eye bolt.

Note:(a) To check the function of check valve, tighten the all air bleed eye bolts, then lock the priming pump handle. The priming pump handle 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 the air bleed eye bolt.



Fuel Injection Pump - Bleed Air

1.5.4 A type Priming Pump Handle - Locking Method

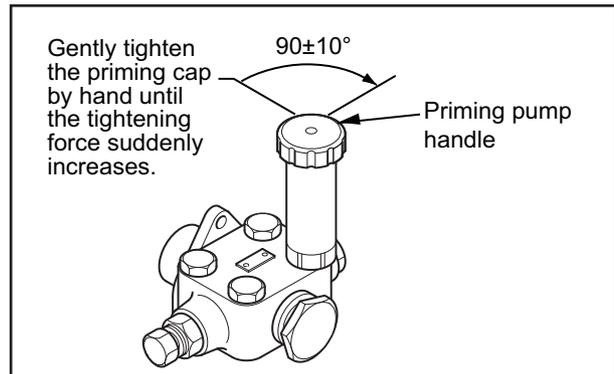
**CAUTION**

If A type priming pump handle is locked loosely, the screw inside wears due to the engine vibration, which can result in the priming pump handle to pop out and the fuel to leak. If it is over-tightened, the handle of priming pump can be damaged. Make sure to tighten the handle to the correct angle.

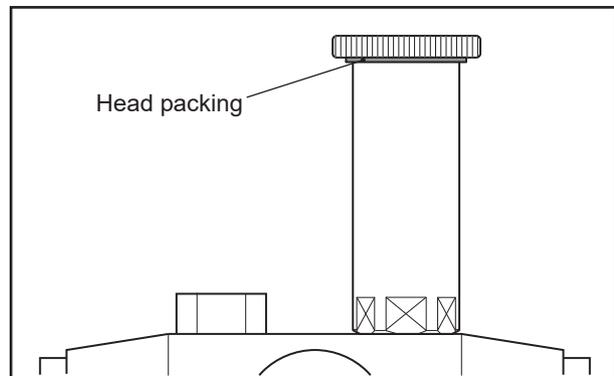
**CAUTION**

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 handle by hand until the tightening force suddenly increases. Then, mark the priming pump handle in this position.
- (2) Using a tool such as a wrench, further tighten the priming pump cap by  $90 \pm 10^\circ$  from the marked 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.



A-type Priming Pump Cap - Locking Method



A-type Priming Pump Handle Packing

## 1.6 Belt and Belt Tension - Inspect and Adjust

**CAUTION**

If any defect such as separation or damage is 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 shorten the life of the alternator bearing and belt. Adjust the belt tension properly by following the instructions 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 the belt.

## V-Belt

Inspect the belt deflection by pressing it with approximately 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.

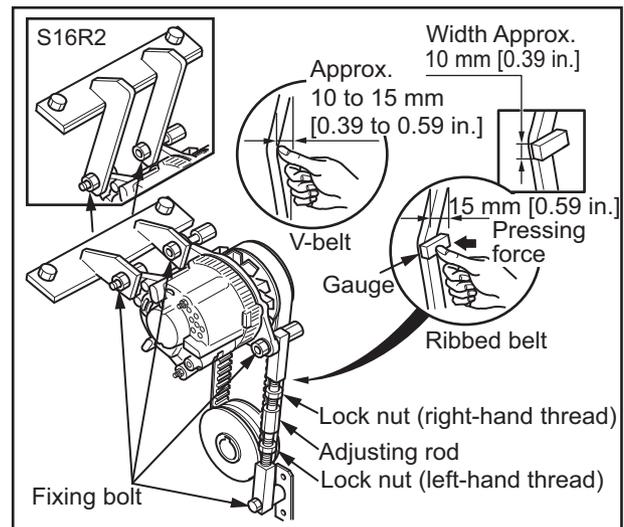
If the deflection is out of the standard, adjust the belt tension.

## Ribbed Belt

Push the belt at the middle point between pulleys with the gauge. If the pressing force does not meet the standard when the belt deflection is 15 mm [0.59 in.], adjust the belt tension.

## 1.6.2 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

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 [19.69 to 23.62]	more than 600 [23.62]
When a new belt is installed	3	74 N	49 N	37 N	29 N	25 N
	4	88 N	59 N	44 N	35 N	29 N
	5	103 N	69 N	51 N	41 N	34 N
	6	118 N	79 N	59 N	47 N	39 N
	7	132 N	88 N	66 N	53 N	44 N
	8	147 N	98 N	74 N	59 N	49 N
	9	162 N	108 N	81 N	65 N	54 N
	10	176 N	118 N	88 N	71 N	59 N
	11	191 N	127 N	96 N	76 N	64 N
	12	206 N	137 N	103 N	82 N	69 N

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 [19.69 to 23.62]	more than 600 [23.62]
When re-adjusted	3	51 N	34 N	26 N	21 N	17 N
	4	62 N	41 N	31 N	25 N	21 N
	5	72 N	48 N	36 N	29 N	24 N
	6	82 N	55 N	41 N	33 N	27 N
	7	93 N	62 N	46 N	37 N	31 N
	8	103 N	69 N	51 N	41 N	34 N
	9	113 N	75 N	57 N	45 N	38 N
	10	123 N	82 N	62 N	49 N	41 N
	11	134 N	89 N	67 N	54 N	45 N
12	144 N	96 N	72 N	58 N	48 N	

The force when the middle point of belt straight line is pushed and deflected by 15 mm [0.59 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 control rack. Check that the fuel control rack is at the no-injection position when the engine is stopped. Make sure that the control rack is at the "0" position when the stop lever is operated.
- ♦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 so that the engine runs at a low idle speed after the start-up.
- ♦Operate the stop solenoid, and make sure that the fuel injection control 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 the engine for approximately 10 seconds with starter to circulate engine oil in the engine. Repeat the cranking 2 or 3 times with one minute or more intervals between them. Check that there is no abnormality such as abnormal noise or rotation speed fluctuation.
- (2) Start the engine in the normal procedure. Make sure that the engine can run at a low idle speed after start-up.
- (3) Make sure that the oil pressure increases immediately, and the coolant circulates.
- (4) Make sure the engine is free from fluid leaks such as oil, coolant, and fuel, and gas (air) leaks, and abnormal noise and abnormal vibration.
- (5) After making sure the engine is running at the low idle speed without any problem, stop the engine.

### 2.3 Break-in Operation

#### CAUTION

Be prepared to activate the emergency stop for an unforeseeable 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										
Classification	Generator				Marine main engine					
	Item	Rotating speed (min <sup>-1</sup> )		Load (PS)	Time (min)	Rotating speed (min <sup>-1</sup> )		Load (PS)	Time (min)	
1	Low rotating speed	600 to 900		No-load	20	Low rotating speed	600 to 900		No-load	20
2	Medium rotating speed	1000 to 1200		No-load	10	Medium rotating speed	1000 to 1200		No-load	10
3	High rotating speed	1400 to rated speed		No-load	10	High rotating speed	1400 to rated speed		No-load	10
4	Rated speed			25 %	20	Marine Partial load Rotational speed	Equivalent to 25 % output		25 %	20
5				50 %	20		Equivalent to 50 % output		50 %	20
6				75 %	30		Equivalent to 75 % output		75 %	30
7				100 %	20		Rated speed		100 %	20

### 2.3.2 Engine - Inspect during Operation

During the break-in operation, pay attention to the followings and make sure that there is no abnormality.

- ♦Oil pressure and oil temperature
- ♦Coolant temperature and level
- ♦Fluid leaks such as oil, coolant, and fuel, especially oil leaks from turbocharger lubricating oil pipe mounting section
- ♦Noise and vibration
- ♦Intake air pressure and intake air temperature
- ♦Exhaust color and odor
- ♦Exhaust temperature
- ♦Difference of exhaust temperatures between right and left banks
- ♦Blow-by gas (amount and color)
- ♦Rotational fluctuation
- ♦Face and radial runouts of rotating parts
- ♦Indication and operation of meters and warnings

### 2.3.3 After Break-in Operation - Inspect and Adjust

- ♦Valve clearance (when cold)
- ♦Fuel injection timing
- ♦External Bolts and Nuts - Tighten
- ♦Belt tension
- ♦Inspection and repair of defects such as oil leak

### 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.

When the engine runs normally after the break-in operation, check and adjust the performance and functions of the engine. Record the test results by referring to the engine data at factory.

#### 3.1 Engine - General Performance Test

Specific fuel consumption, various temperatures and pressures, and exhaust color

#### 3.2 Exhaust Gas - Test

Exhaust gas analyses

#### 3.3 Governor - Performance Test

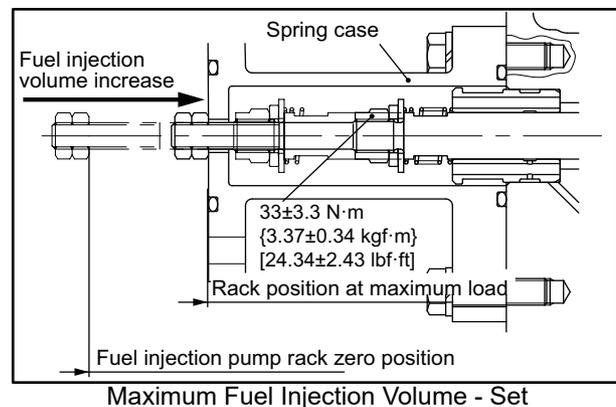
- ♦Minimum speed at no-load (low idle) - set
- ♦Maximum speed at no-load (high idle) - set
- ♦Load sudden application and rejection tests
- ♦Governor droop, hunting, and rotational fluctuation - check
- ♦Setting conditions of governor controller and others - check

#### 3.4 Warning Activation and Emergency Stop - Test

Oil pressure decrease, water temperature increase, and over speed

#### 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.



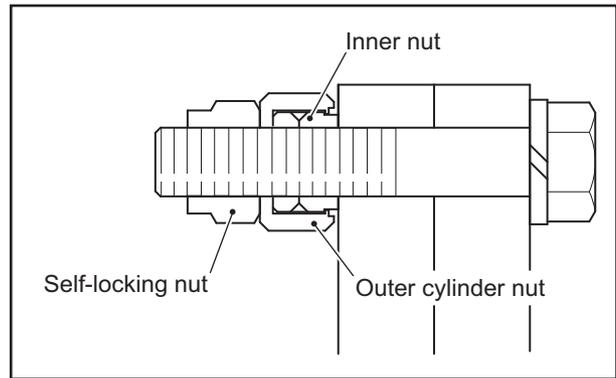
### 3.6 Seal

After all performance tests and adjustments are completed, stop the engine, and seal the specified parts 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.

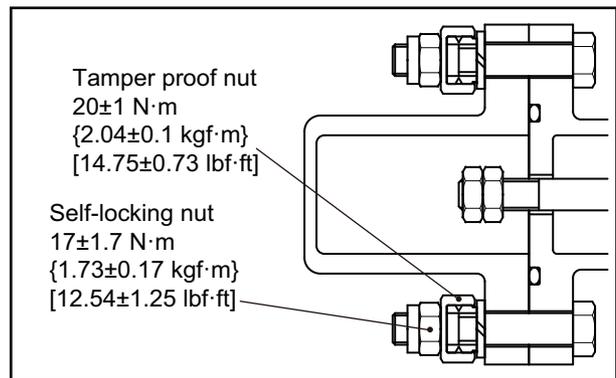
To remove, cut the outer cylinder nut and remove the inner nut.



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

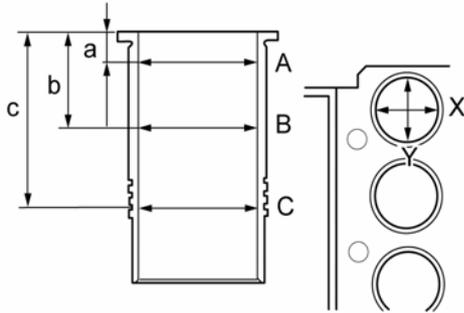


# INSPECTION RECORD SHEET

No.1

			SR
<b>Customer</b>		<b>Engine Model</b>	
		<b>Serial No.</b>	<b>Date</b>
<b>Item</b>	Cylinder liner bore inside diameter - measure	<b>Unit</b>	mm[in.]

Measuring location



X : Direction at right angles to pin  
Y : Direction parallel to pin

Standard

Item to be measured	Part No.	Nominal	Standard	Limit
Cylinder liner inside diameter	37507-82600	$\phi$ 170	170.000 to 170.040	170.100 [6.6968]
	37507-55600	[6.69]	[6.6929 to 6.6945]	
	37507-22700	$\phi$ 170	170.020 to 170.040	
	37807-05700	[6.69]	[6.6937 to 6.6945]	

Location	S6R	S6R2	S12R	S16R	S16R2
a	30[1.18]	30[1.18]	30[1.18]	30[1.18]	30[1.18]
b	100[3.94]	180[7.09]	100[3.94]	100[3.94]	185[7.28]
c	250[9.84]	250[9.84]	250[9.84]	250[9.84]	340[13.39]

Measured value

Item		Cylinder liner bore inside diameter			Item		Cylinder liner bore inside diameter		
No.	Direction	A	B	C	No.	Direction	A	B	C
1	X				9	X			
	Y					Y			
2	X				10	X			
	Y					Y			
3	X				11	X			
	Y					Y			
4	X				12	X			
	Y					Y			
5	X				13	X			
	Y					Y			
6	X				14	X			
	Y					Y			
7	X				15	X			
	Y					Y			
8	X				16	X			
	Y					Y			

Remark

Approved by

Checked by

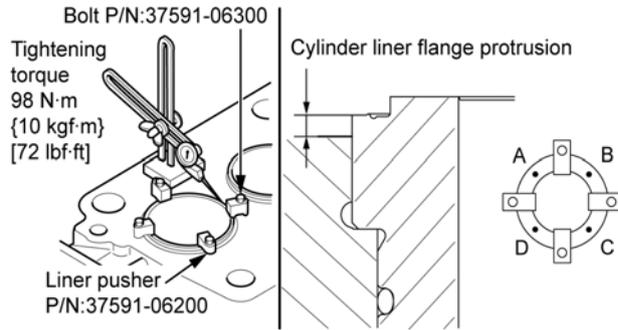
Measured by

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# INSPECTION RECORD SHEET

				<b>SR</b>
<b>Customer</b>		<b>Engine Model</b>		<b>Date</b>
		<b>Serial No.</b>		
<b>Item</b>	Cylinder liner bore flange protrusion - measure			<b>Unit</b> mm[in.]

**Measuring location**



**Standard**

Item to be measured		Standard
Cylinder liner flange protrusion	S6R,S6R2	0.16 to 0.24 [0.0063 to 0.0094]
	S12R,S16R, S16R2	0.11 to 0.20 [0.0043 to 0.0079]

**Measured value**

Item	Cylinder liner bore flange protrusion				
	No.	A	B	C	D
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

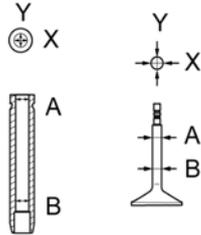
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# INSPECTION RECORD SHEET

No.3(1/3)

			<b>SR</b>
<b>Customer</b>	<b>Engine Model</b>	<b>Date</b>	
	<b>Serial No.</b>		
<b>Item</b>	Valve guide inside diameter and Valve stem diameter - measure (1/3)	<b>Unit</b>	mm[in.]

Measuring location



Standard

Item to be measured	Nominal	Standard	Limit
Valve guide inside diameter (same for inlet and exhaust)	φ 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)	φ 10 [0.39]	9.940 to 9.960 [0.3913 to 0.3921]	9.910 [0.3902]

Measured value

No.	Location	Valve guide inside diameter				Valve stem outside diameter				Clearance				
		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

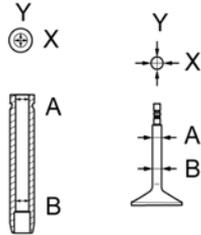
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# INSPECTION RECORD SHEET

			SR
<b>Customer</b>		<b>Engine Model</b>	
		<b>Serial No.</b>	
<b>Date</b>			
<b>Item</b>	Valve guide inside diameter and Valve stem diameter - measure (2/3)	<b>Unit</b>	mm[in.]

Measuring location



Standard

Item to be measured	Nominal	Standard	Limit
Valve guide inside diameter (same for inlet and exhaust)	φ 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)	φ 10 [0.39]	9.940 to 9.960 [0.3913 to 0.3921]	9.910 [0.3902]

Measured value

No.	Location	Valve guide inside diameter				Valve stem outside diameter				Clearance				
		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												
9	Inlet	a												
		b												
	Exhaust	a												
		b												
10	Inlet	a												
		b												
	Exhaust	a												
		b												
11	Inlet	a												
		b												
	Exhaust	a												
		b												
12	Inlet	a												
		b												
	Exhaust	a												
		b												

Remark

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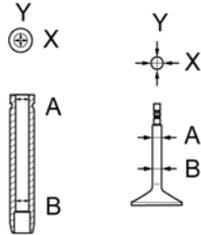
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# INSPECTION RECORD SHEET

No.3(3/3)

		<b>SR</b>	
<b>Customer</b>	<b>Engine Model</b>	<b>Date</b>	
	<b>Serial No.</b>		
<b>Item</b>	Valve guide inside diameter and Valve stem diameter - measure (3/3)	<b>Unit</b>	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

No.	Location	Valve guide inside diameter				Valve stem outside diameter				Clearance				
		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												

Remark

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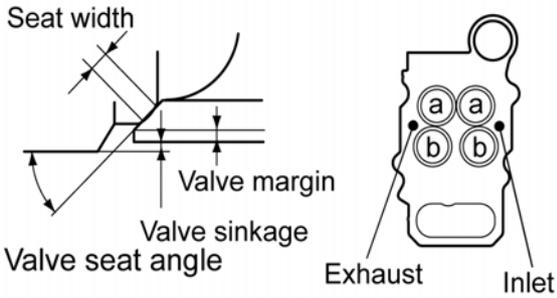
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# INSPECTION RECORD SHEET

SR

<b>Customer</b>		<b>Engine Model</b>		<b>Date</b>	
		<b>Serial No.</b>			
<b>Item</b>	Cylinder head valve sinkage, seat sidth, and valve margin - measure (1/2)	<b>Unit</b>	mm[in.]		

**Measuring location**



**Standard**

Item to be measured		Standard	Limit
Valve seat	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 2.44 [0.0862 to 0.0961]	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						Exhaust	a		
	Exhaust	a					Exhaust		b		
		b									
2	Inlet	a				6	Inlet	a			
		b						Exhaust	a		
	Exhaust	a					Exhaust		b		
		b									
3	Inlet	a				7	Inlet	a			
		b						Exhaust	a		
	Exhaust	a					Exhaust		b		
		b									
4	Inlet	a				8	Inlet	a			
		b						Exhaust	a		
	Exhaust	a					Exhaust		b		
		b									

**Remark**

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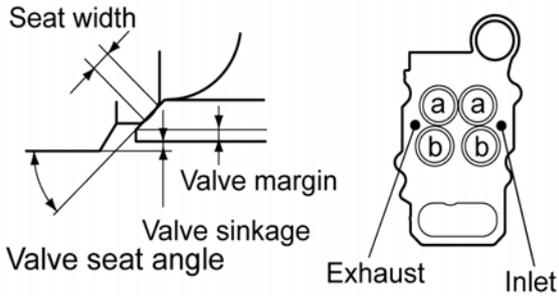
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# INSPECTION RECORD SHEET

No.4(2/2)

		<b>SR</b>
<b>Customer</b>	<b>Engine Model</b>	<b>Date</b>
	<b>Serial No.</b>	
<b>Item</b>	Cylinder head valve sinkage, seat sidth, and valve margin - measure (2/2)	<b>Unit</b>
		mm[in.]

Measuring location



Standard

Item to be measured		Standard	Limit
Valve seat	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 2.44 [0.0862 to 0.0961]	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					a				
		b					b				
2	Inlet	a				6	Inlet	a			
		b						b			
	Exhaust	a					a				
		b					b				
3	Inlet	a				7	Inlet	a			
		b						b			
	Exhaust	a					a				
		b					b				
4	Inlet	a				8	Inlet	a			
		b						b			
	Exhaust	a					a				
		b					b				

Remark

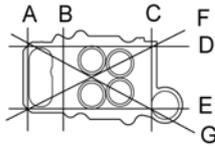
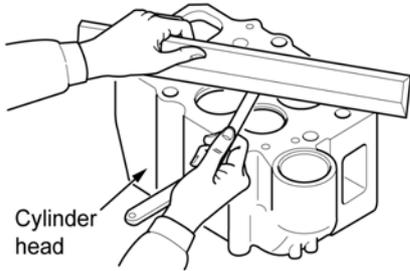
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# INSPECTION RECORD SHEET

				SR
<b>Customer</b>			<b>Engine Model</b>	<b>Date</b>
			<b>Serial No.</b>	
<b>Item</b>	Cylinder head bottom face distortion - measure			<b>Unit</b> mm[in.]

Measuring location



Standard

Item to be measured	Standard	Limit
Distortion of cylinder head bottom surface	0.03[0.0012] or less	0.07 [0.0028]

Measured value

Item	Cylinder head bottom face distortion						
No.	A	B	C	D	E	F	G
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							

Remark

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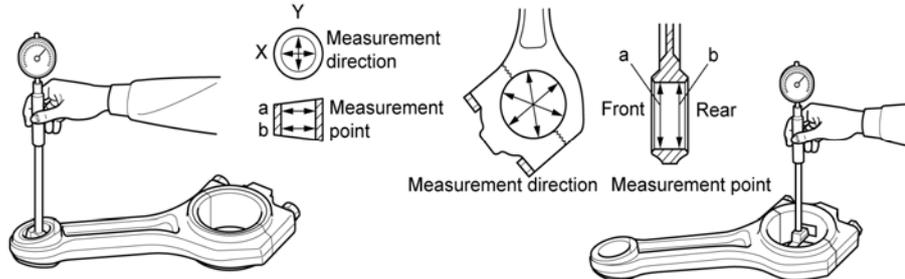
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# INSPECTION RECORD SHEET

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	$\phi$ 70 [2.76]	70.020 to 70.040 [2.7567 to 2.7575]	70.070[2.7587]	-
Connecting rod big end bore diameter	$\phi$ 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

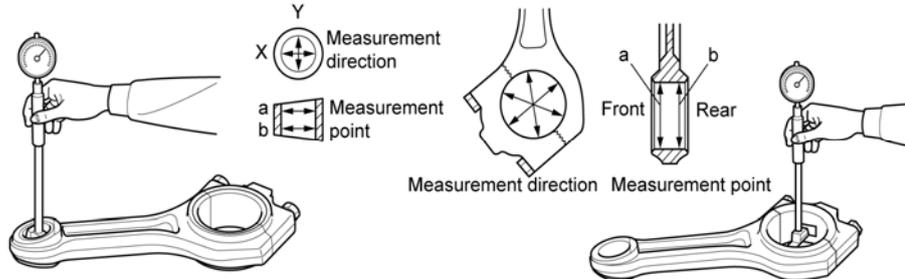
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# INSPECTION RECORD SHEET

				<b>SR</b>
<b>Customer</b>	<b>Engine Model</b>		<b>Date</b>	
	<b>Serial No.</b>			
<b>Item</b>	Connecting rod bushing inside diameter and connecting rod big-end bore diameter - measure (2/2)		<b>Unit</b>	mm[in.]

Measuring location



Standard

Item to be measured	Nominal	Standard	Limit	Roundness
Connecting rod bushing inside diameter	$\phi$ 70 [2.76]	70.020 to 70.040 [2.7567 to 2.7575]	70.070[2.7587]	-
Connecting rod big end bore diameter	$\phi$ 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

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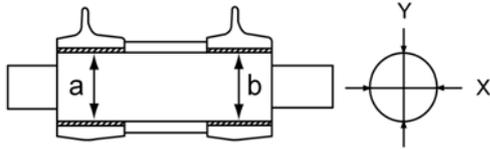
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# INSPECTION RECORD SHEET

No. 7(1/2)

			SR
<b>Customer</b>			<b>Date</b>
	<b>Engine Model</b>		
	<b>Serial No.</b>		
<b>Item</b>	Rocker bushing inside diameter and rocker shaft outside diameter - measure (1/2)	<b>Unit</b>	mm[in.]

Measuring location



Standard

Item to be measured	Nominal	Standard	Limit
Rocker bushing inside diameter	$\phi 36$ [1.42]	36.000 to 36.040 [1.4173 to 1.4189]	36.090 [1.4209]
Rocker shaft outside diameter	$\phi 36$ [1.42]	35.966 to 35.991 [1.4160 to 1.4170]	35.940 [1.4150]

Measured value

Item No.	Direction	Rocker bushing inside diameter		Rocker shaft outside diameter		Clearance	
		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

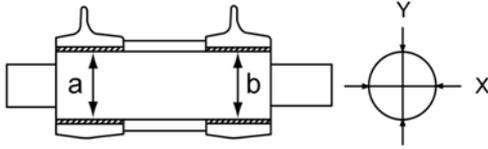
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# INSPECTION RECORD SHEET

			<b>SR</b>
<b>Customer</b>		<b>Engine Model</b>	
		<b>Serial No.</b>	
<b>Date</b>			
<b>Item</b>	Rocker bushing inside diameter and rocker shaft outside diameter - measure (2/2)	<b>Unit</b>	mm[in.]

Measuring location



Standard

Item to be measured	Nominal	Standard	Limit
Rocker bushing inside diameter	$\phi 36$ [1.42]	36.000 to 36.040 [1.4173 to 1.4189]	36.090 [1.4209]
Rocker shaft outside diameter	$\phi 36$ [1.42]	35.966 to 35.991 [1.4160 to 1.4170]	35.940 [1.4150]

Measured value

Item No.	Direction	Rocker bushing inside diameter		Rocker shaft outside diameter		Clearance	
		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

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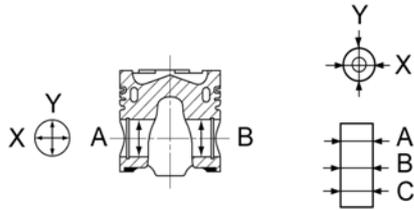
# INSPECTION RECORD SHEET

No. 8(1/2)

			<b>SR</b>
<b>Customer</b>	<b>Engine Model</b>	<b>Date</b>	
	<b>Serial No.</b>		
<b>Item</b>	Piston pin bore inside diameter and piston pin outside diameter - measure (1/2)	<b>Unit</b>	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 No.	Location	Piston pin bore diameter		Piston pin outside diameter		Clearance	
		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

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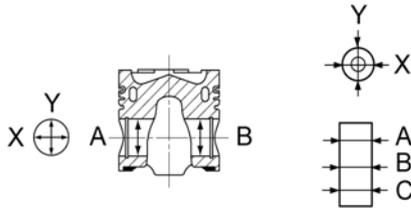
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# INSPECTION RECORD SHEET

			SR
<b>Customer</b>		<b>Engine Model</b>	
		<b>Serial No.</b>	
<b>Date</b>			
<b>Item</b>	Piston pin bore inside diameter and piston pin outside diameter - measure (2/2)	<b>Unit</b>	mm[in.]

Measuring location

Standard



Item to be measured	Nominal	Standard	Limit
Piston pin bore inside diameter	φ 70 [2.76]	70.002 to 70.015 [2.7560 to 2.7565]	70.040 [2.7575]
Piston pin outside diameter	φ 70 [2.76]	69.987 to 70.000 [2.7554 to 2.7559]	69.970 [2.7547]

Measured value

Item No.	Location	Piston pin bore diameter		Piston pin outside diameter		Clearance	
		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

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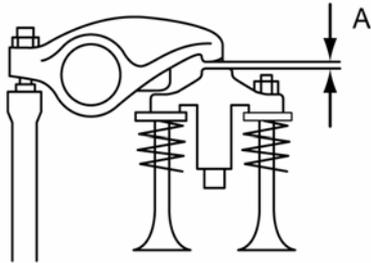
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# INSPECTION RECORD SHEET

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	
2	Before adjustment		10	Before adjustment	
	After adjustment			After adjustment	
3	Before adjustment		11	Before adjustment	
	After adjustment			After adjustment	
4	Before adjustment		12	Before adjustment	
	After adjustment			After adjustment	
5	Before adjustment		13	Before adjustment	
	After adjustment			After adjustment	
6	Before adjustment		14	Before adjustment	
	After adjustment			After adjustment	
7	Before adjustment		15	Before adjustment	
	After adjustment			After adjustment	
8	Before adjustment		16	Before adjustment	
	After adjustment			After adjustment	

Remark

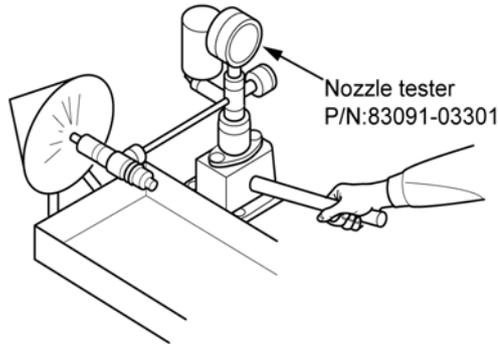
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# INSPECTION RECORD SHEET

			SR
<b>Customer</b>		<b>Engine Model</b>	
		<b>Serial No.</b>	
<b>Item</b>	Fuel injection nozzle injection pressure - measure	<b>Unit</b>	MPa{kgf/cm <sup>2</sup> }[psi]

Measuring location



Standard

Item to be measured		Part No.	Nominal	Standard	
Valve opening pressure	S6R,S6R2	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			
		37760-14001			
	37760-22001	30.40 {310}[4409]	30.40 to 30.89 {310 to 315}[4409 to 4480]		
		Shim adjust type	37560-32000	34.32 {350}[4978]	33.83 to 35.79 {345 to 365}[4907 to 5191]
	S12R S16R,S16R2	Screw adjust type	-	34.32 {350}[4978]	34.32 to 34.81 {350 to 355}[4978 to 5049]
		Shim adjust type	37860-□600□	33.8 {345}	33.8 to 35.8 {345 to 365}[4902 to 5192]

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			

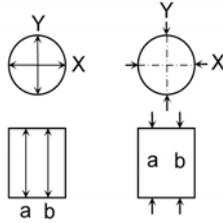
<b>Remark</b>	<b>Approved by</b>	<b>Checked by</b>	<b>Measured by</b>

# INSPECTION RECORD SHEET

No. 11

		Engine Model		Date	<b>SR</b>
Customer		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,S16R2	$\phi 84[3.31]$	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

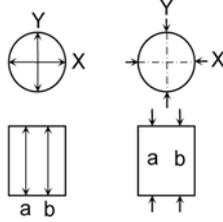
Approved by    Checked by    Measured by

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# INSPECTION RECORD SHEET

			<b>SR</b>
<b>Customer</b>		<b>Engine Model</b>	
		<b>Serial No.</b>	
<b>Item</b>	Camshaft bushing inside diameter and camshaft journal outside diameter (left side) - measure	<b>Unit</b>	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,S16R2	$\phi 84[3.31]$	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 No.	Location	Camshaft bushing inside diameter		Camshaft journal outside diameter		Clearance	
		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						

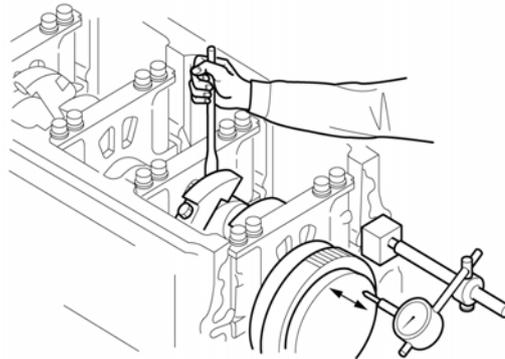
<b>Remark</b>	<b>Approved by</b>	<b>Checked by</b>	<b>Measured by</b>

# 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,S16R2	-	0.200 to 0.500 [0.0079 to 0.0197]	-

Measured value

Before disassembly	After reassembly

Remark	Approved by	Checked by	Measured by

# REVISION HISTORY

Title	Mitsubishi Diesel Engine S16R & S16R2 SERVICE MANUAL
Pub. No.	29002-00120

Revision	Issued	Description
-	July 2016	First edition issued.
-	March 2018	The document number, cover, and copyright page of Pub. No. 99249-36160 (issued in July 2016) have been changed.
1	July 2018	Description of resin fan added.
2	May 2019	Part number change of coolant tester and compression gauge in Chapter 3 SERVICE TOOLS.
3	December 2019	Changed weight tolerance of each piston (per engine) to within $\pm 25\text{g}$ .
4	March 2020	Changed standard value of backlash measurement of drive gear and driven gear of fuel system (Trochoid fuel feed pump spec.), and added the note in Chapter 8.
5	September 2020	Realigned the order of model types in the specification table, deleted the duplicate types, and corrected clerical error.
6	January 2021	Two specifications (S16R2-T2MPTAW-11 and sand pump ship for pump drive of S16R2-MPTK2 for China) are added.
7	April 2021	Changed the backlash value of the fuel injection pump accessory drive in Chapters 2 and 8.
8	June 2022	Replaced the position of "Pressure-increase" and "Pressure-decrease" in the illustration of "Fuel Injection Start Pressure - Adjust" in 8-26. Correctly, the pressure increases when turned clockwise and the pressure decreases when turned counterclockwise.

## **Mitsubishi Diesel Engine S16R & S16R2 SERVICE MANUAL**

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June 2022

**SERVICE MANUAL** **S16R·S16R2**

Pub. No. 29002-00120