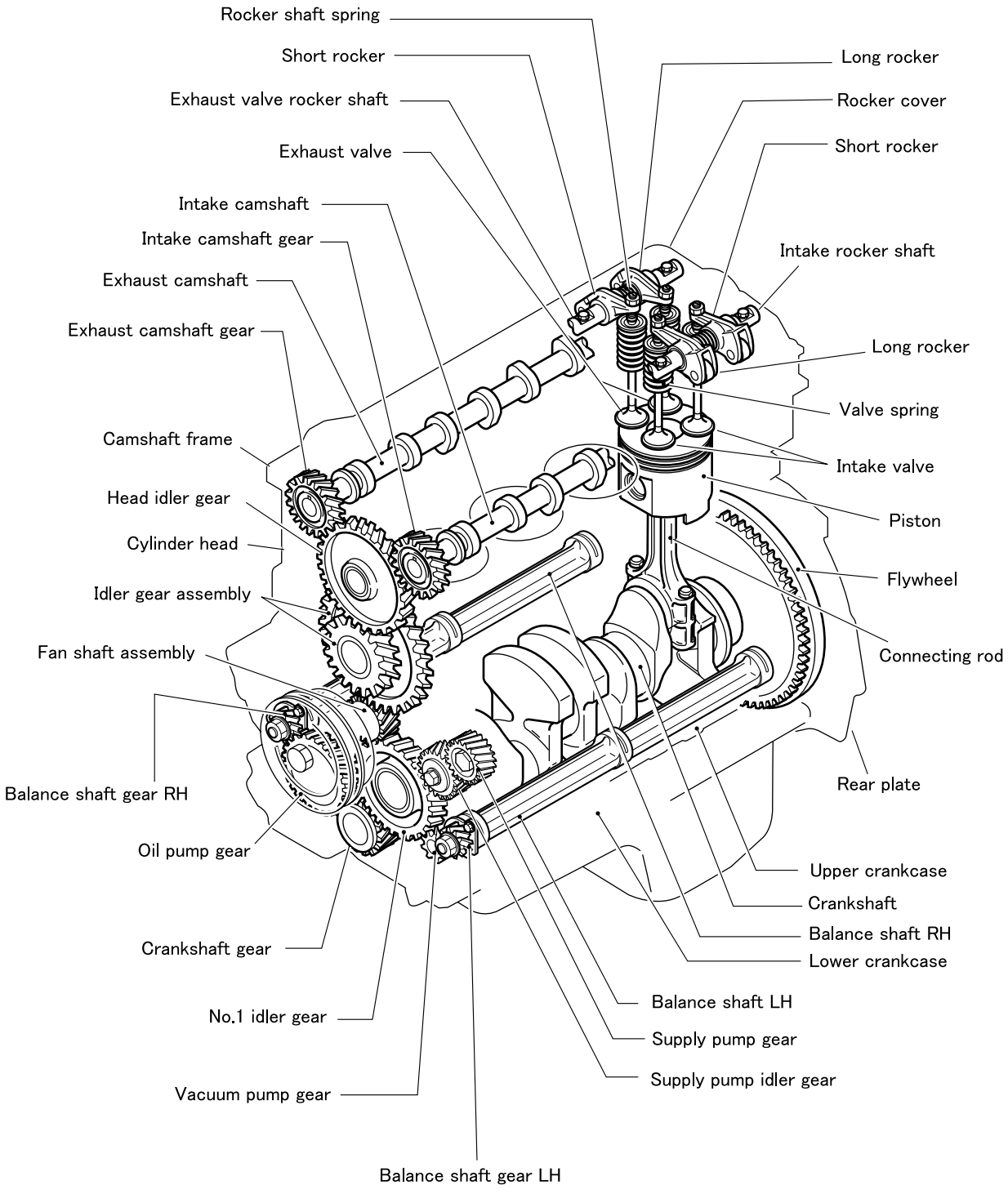
GROUP 11 INDEX

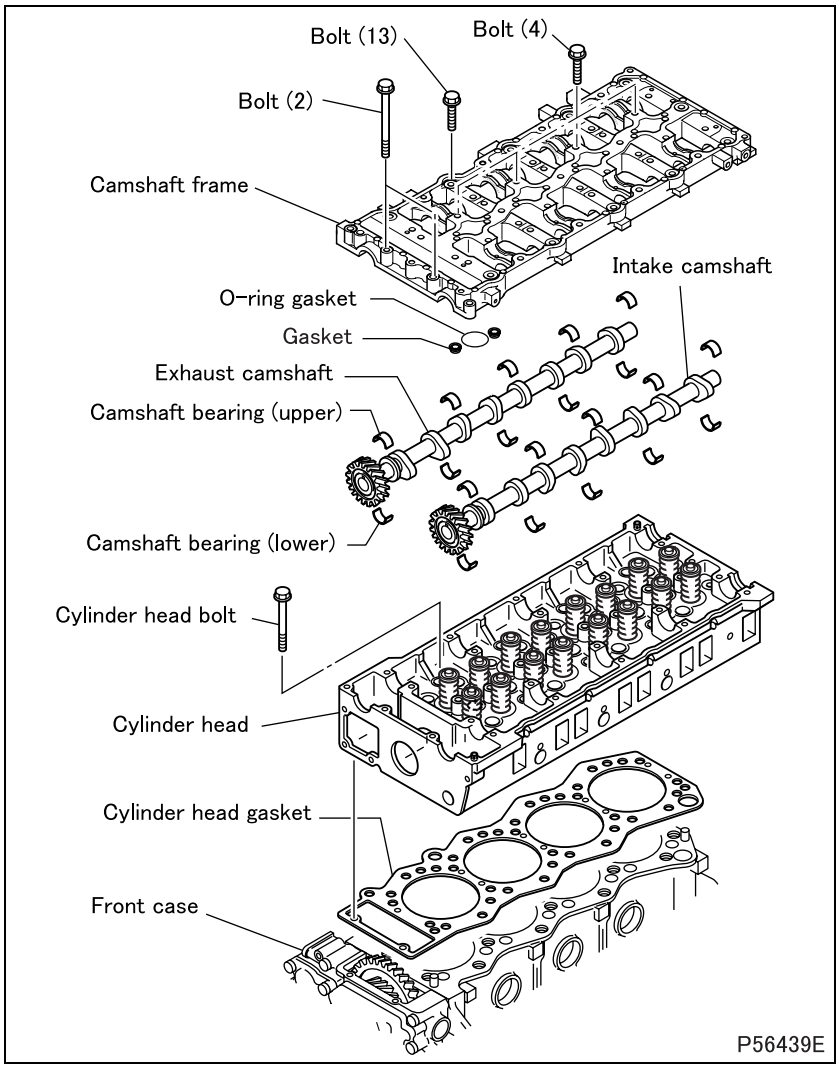
SPECIFICATIONS

Item		Specifications	
Engine model		4M50T7	4M50T8
Type		4-cylinder, in-line, water-cooled, 4-cycle diesel engine	
Combustion chamber		Direct injection type	
Valve mechanism		Double overhead camshaft (DOHC)	
Maximum output	HP / rpm	147 / 2700	175 / 2700
Maximum torque	ft.lbf / rpm	347 / 1600	391 / 1600
Bore × stroke	mm {in.}	ϕ114 × 120 {ϕ4.49 × 4.72}	
Total displacement	L {qts}	4.899 {4899}	
Compression ratio		17.5	

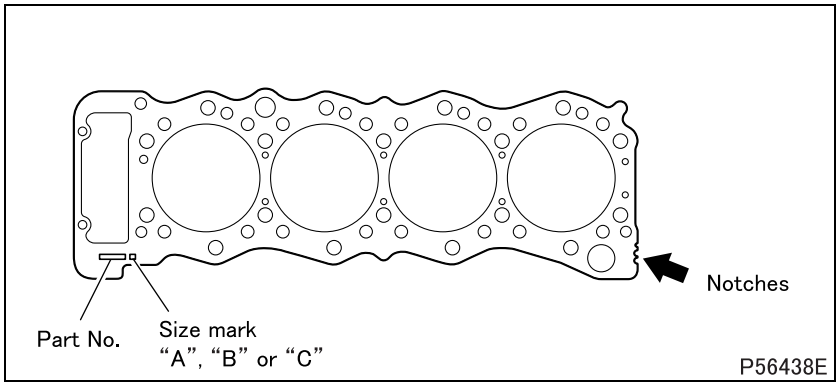
1. Exploded View



2. Cylinder Head, Cylinder Head Gasket, Camshaft, and Camshaft Frame



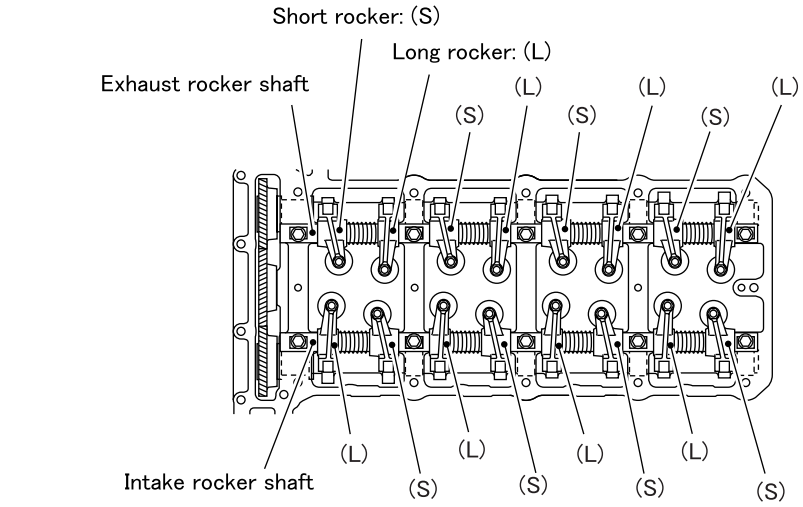
- The camshaft is supported at its journals from below by the cylinder head and retained from above by the camshaft frame.
- The upper and lower camshaft bearings are identical, but cannot be interchanged when they are reinstalled.
- The exhaust camshaft and the intake camshaft have identical gears but different cams.
- The thirteen shortest bolts and four shorter bolts fasten the camshaft frame onto the cylinder head.
- The two long bolts fasten the camshaft frame to the front case.

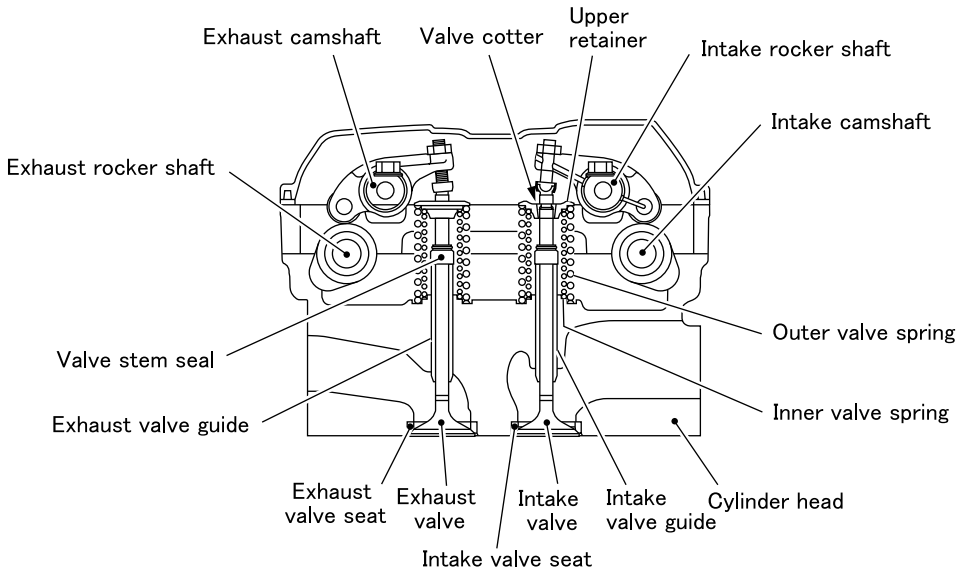


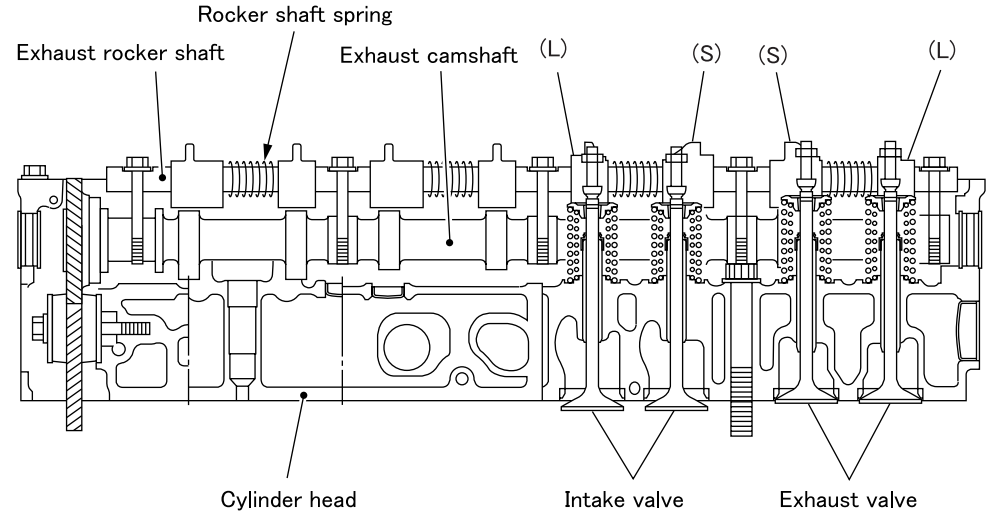
2.1 Cylinder head gasket

- Select and use a cylinder head gasket of a thickness that can accommodate the piston projection.
- The size (thickness) class of the gasket can be identified by the shape of the notches and size mark cut on the edge of each gasket.

3. Valve Mechanism



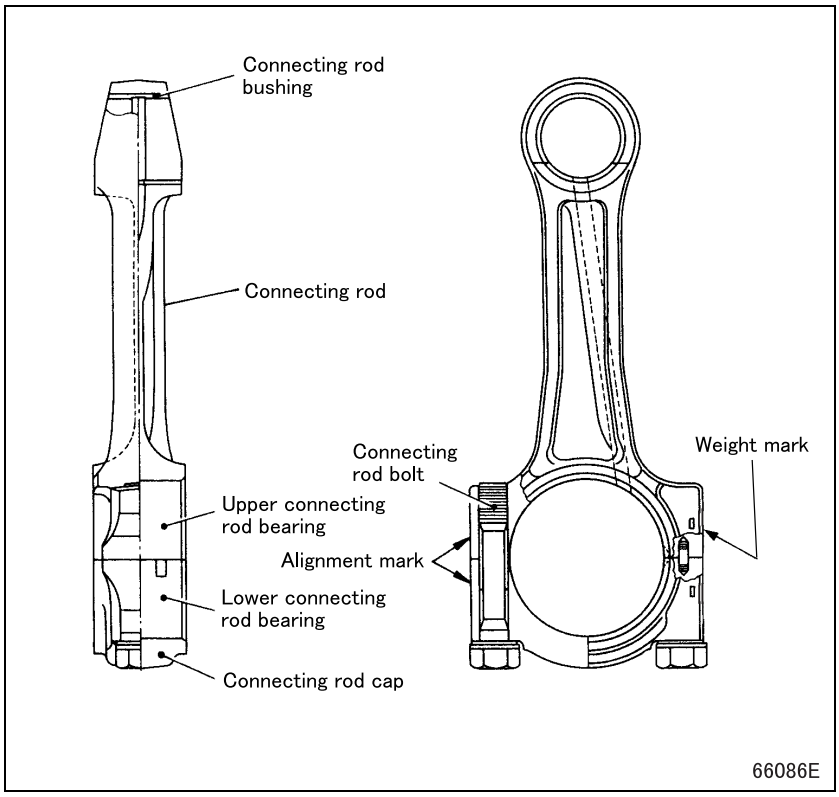




P49222E

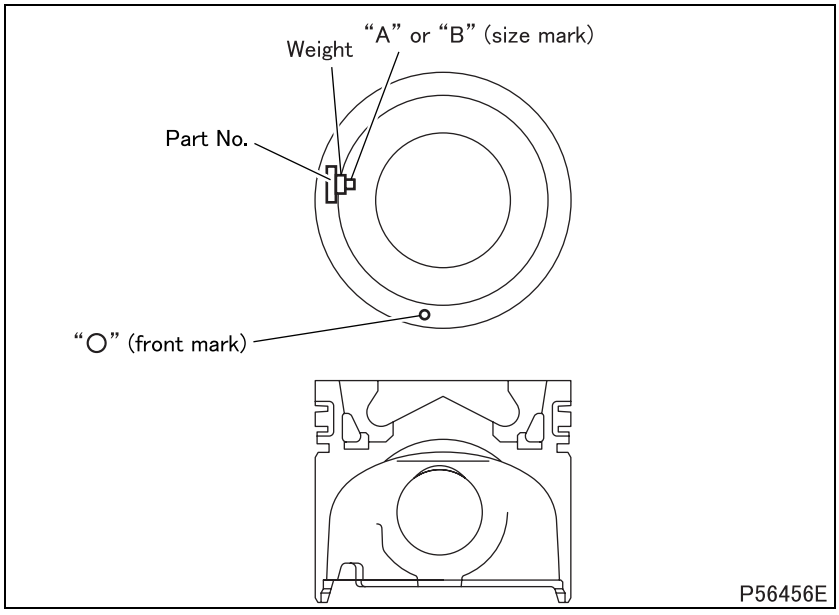
- The short rockers and the long rockers are installed differently, as shown in the illustration.
- Each valve has an inner valve spring and an outer valve spring.

4. Connecting Rod



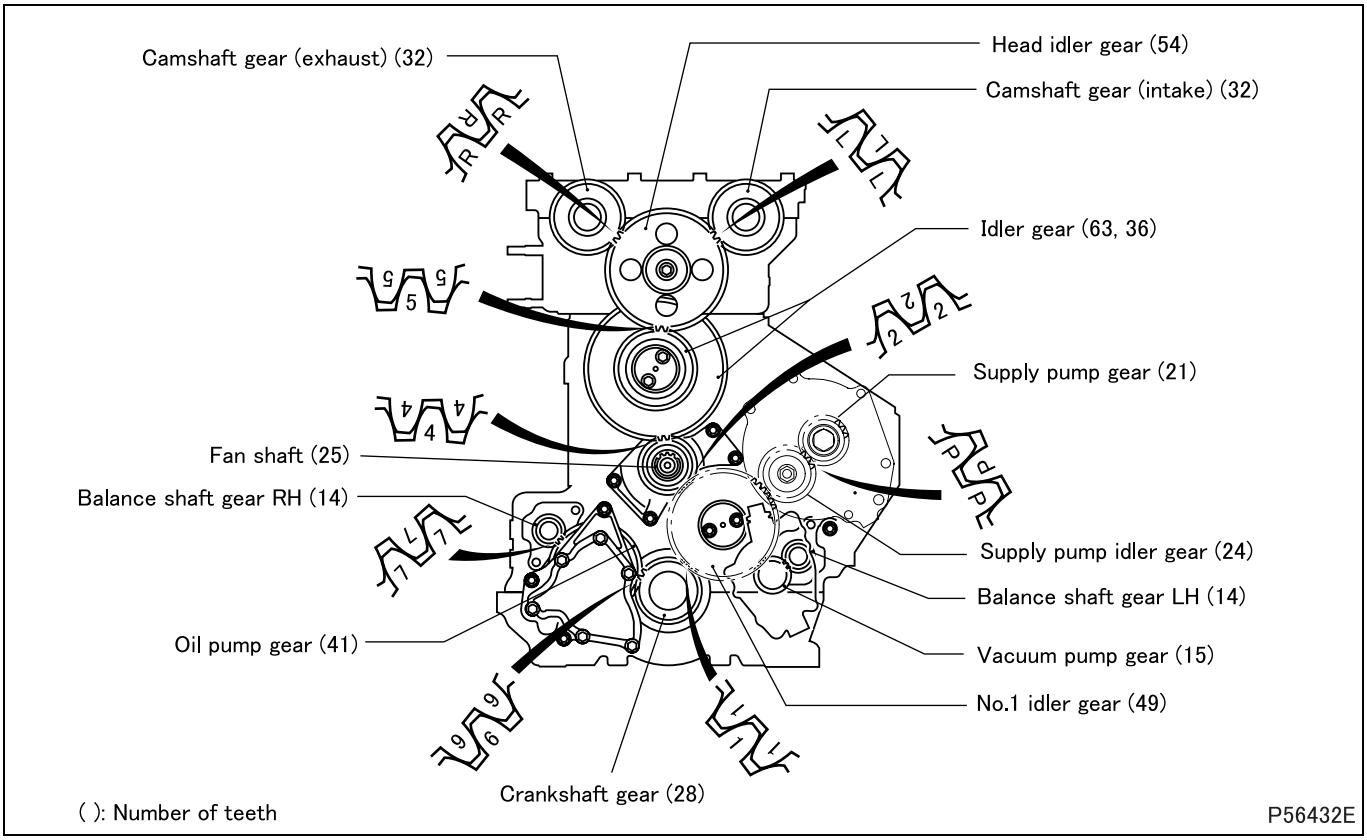
Weight mark:
"C" to **"G"**
(with **"G"** as the maximum)

5. Piston



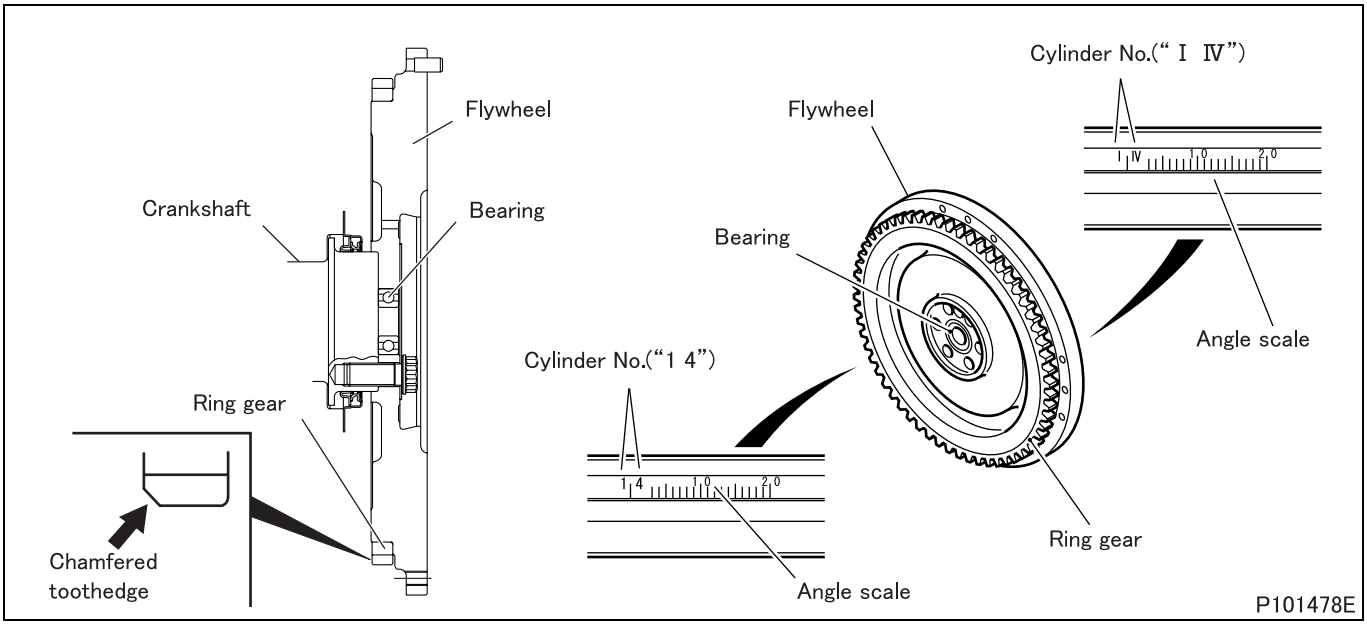
- Each piston must be mated with a cylinder in the upper crankcase that has the same size mark as the piston. The pistons are marked with either **"A"** or **"B"**, where **"B"** stands for the larger and **"A"** for the smaller of the two available diameters.
- The pistons have been made lightweight by use of a special aluminum alloy, as well as by the reduction of their height.

6. Timing Gears



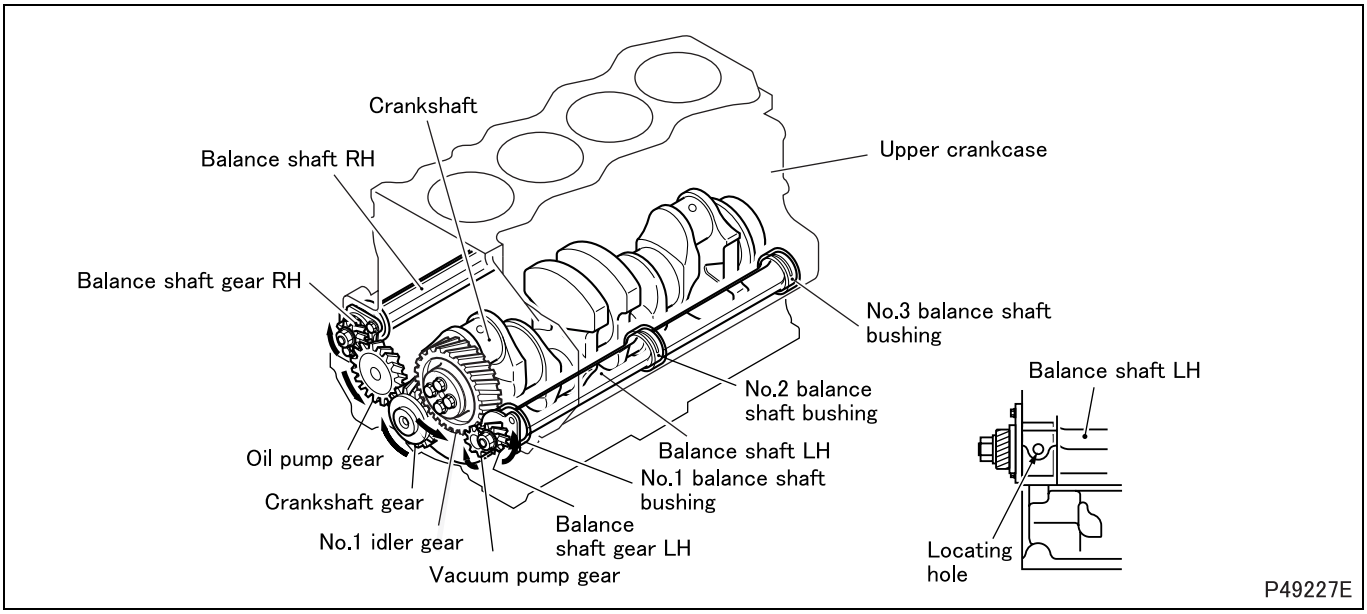
- All gears, except the vacuum pump gear, each has timing mark(s) to ensure correct engagement during assembly.

7. Flywheel

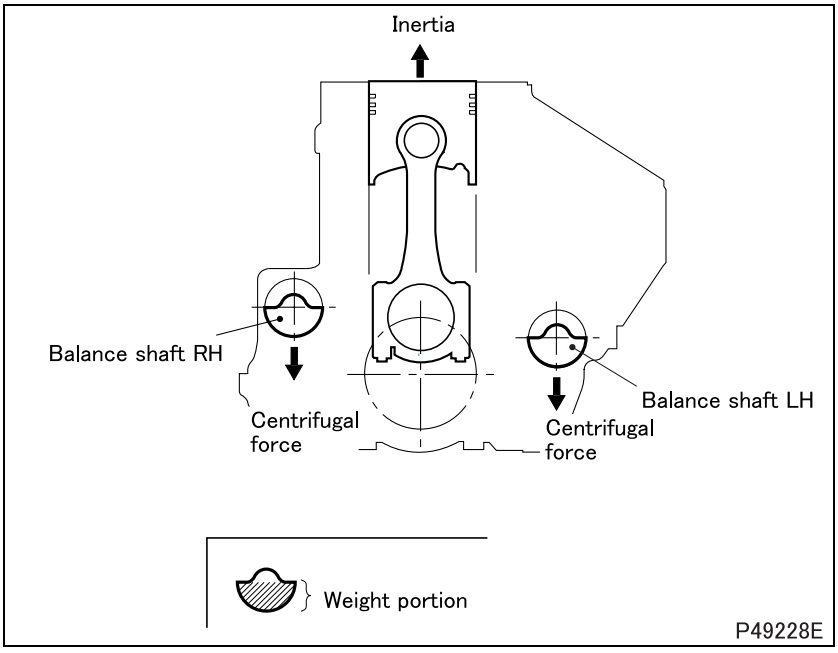


- One side of each flywheel ring gear tooth is chamfered to facilitate the engagement of the starter pinion.

8. Balance Shafts



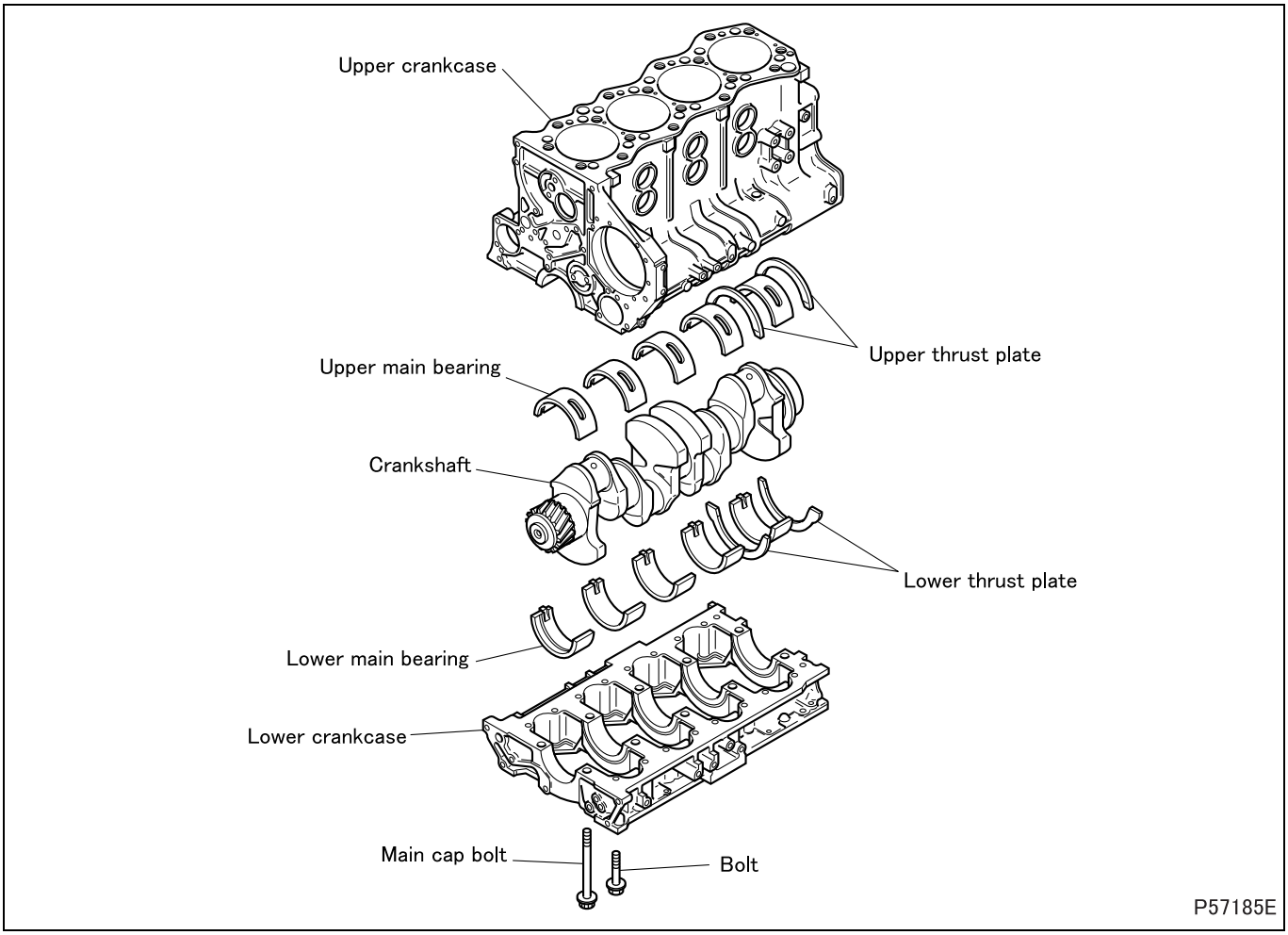
- The balance shaft RH and balance shaft LH are mounted in the upper crankcase on the right and left sides of the crankshaft. The balance shafts reduce the vibration of the engine caused by the rotation of the crankshaft.
- The balance shaft RH and balance shaft LH are both driven by timing gears. Each balance shaft is held in the upper crankcase by way of three balance shaft bushings.
- The balance shaft LH has a locating hole to enable correct installation.

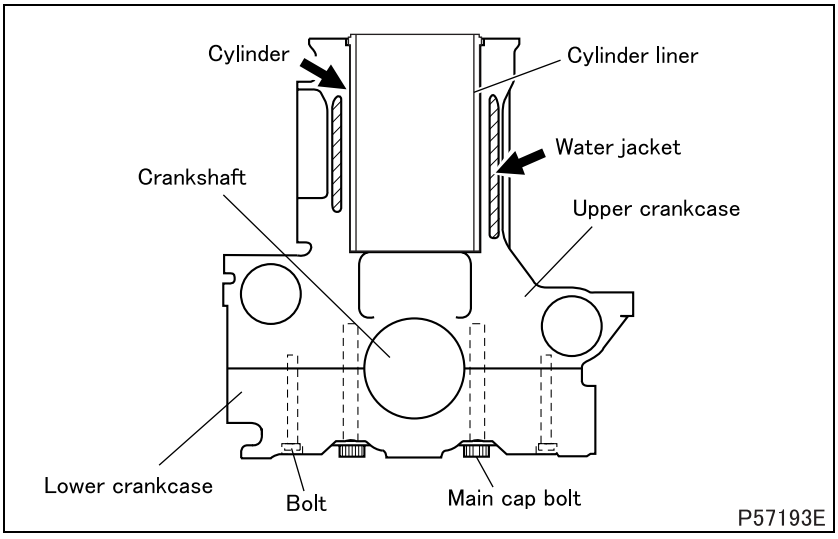


8.1 Reduction of vertical vibration (secondary vibration element)

- When the piston moves up and down, vertical vibrations are generated at the top dead center (TDC) and bottom dead center (BDC) due to inertia.
- The balance shaft LH and the balance shaft RH rotate so that their weight portions are at the bottom positions when a piston is at TDC and at the top positions when the piston is at BDC, i.e., the weight portions are always on the opposite side to the piston head.
- This creates centrifugal forces in the balance shaft RH and balance shaft LH, the total of which is equal in amount to the inertia force that the piston creates when it is at TDC or BDC. These centrifugal forces in the balance shafts cancel out the inertia forces resulting from piston's movements and reduce the amount of vertical vibration.
- The balance shafts also reduce the moment created around the crankshaft (which constitutes secondary vibration elements) when the engine is running in the middle-to-high speed range.

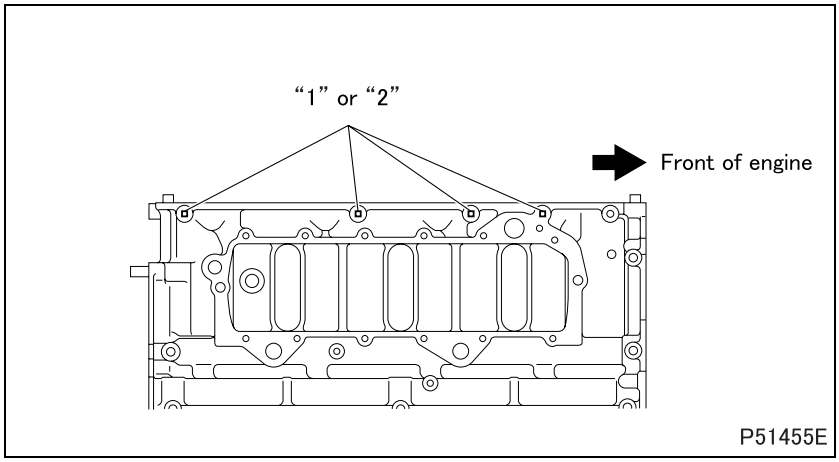
9. Crankcase and Main Bearings



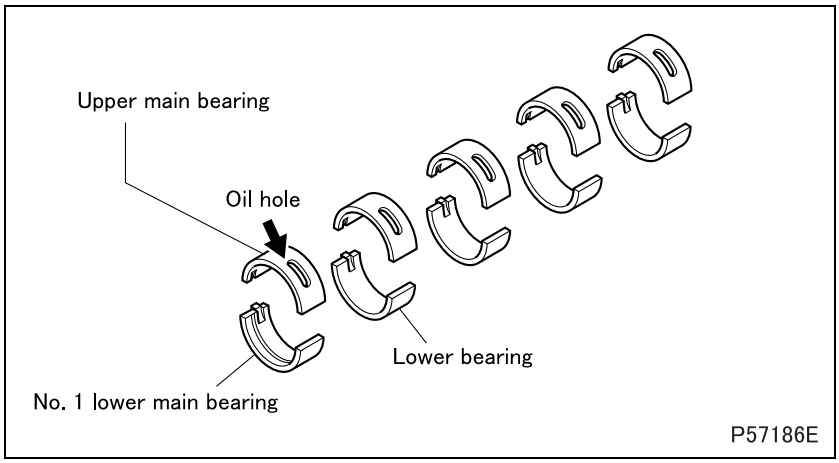


9.1 Crankcase

- The crankcase is a two-piece type consisting of an upper crankcase and a lower crankcase, which hold the crankshaft in between.
- Cylinder liners are inserted into the cylinder bores in the upper crankcase.
- An water jacket is formed in the walls of these cylinders to cool them down.
- The main cap bolts and the bolts that fasten the upper and lower crankcases together are tightened using a special method.

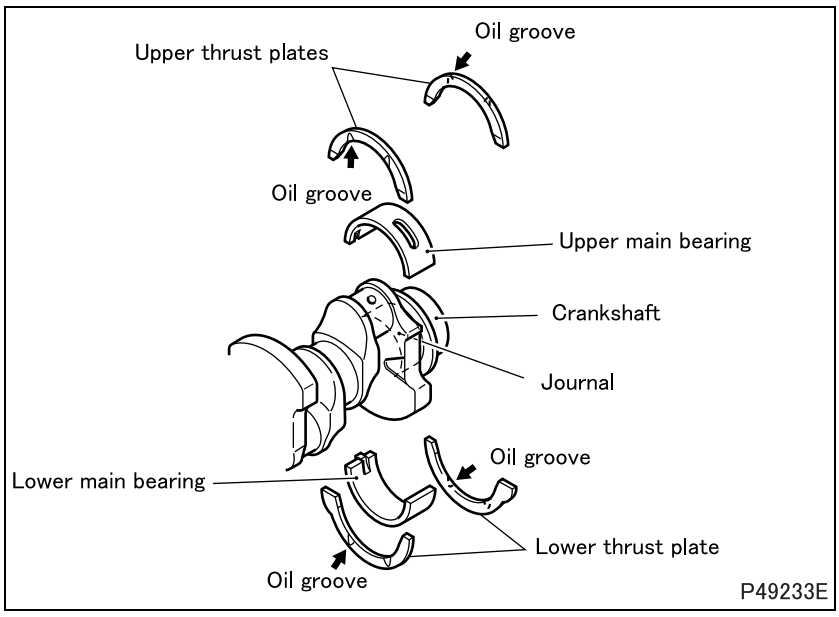


- The upper crankcase is marked with a size mark (**"1"** or **"2"**) to be used as a reference in selecting cylinder liners.
- The first to forth size marks from the front of the engine correspond to the No. 1 to No. 4 cylinders.



9.2 Main bearing

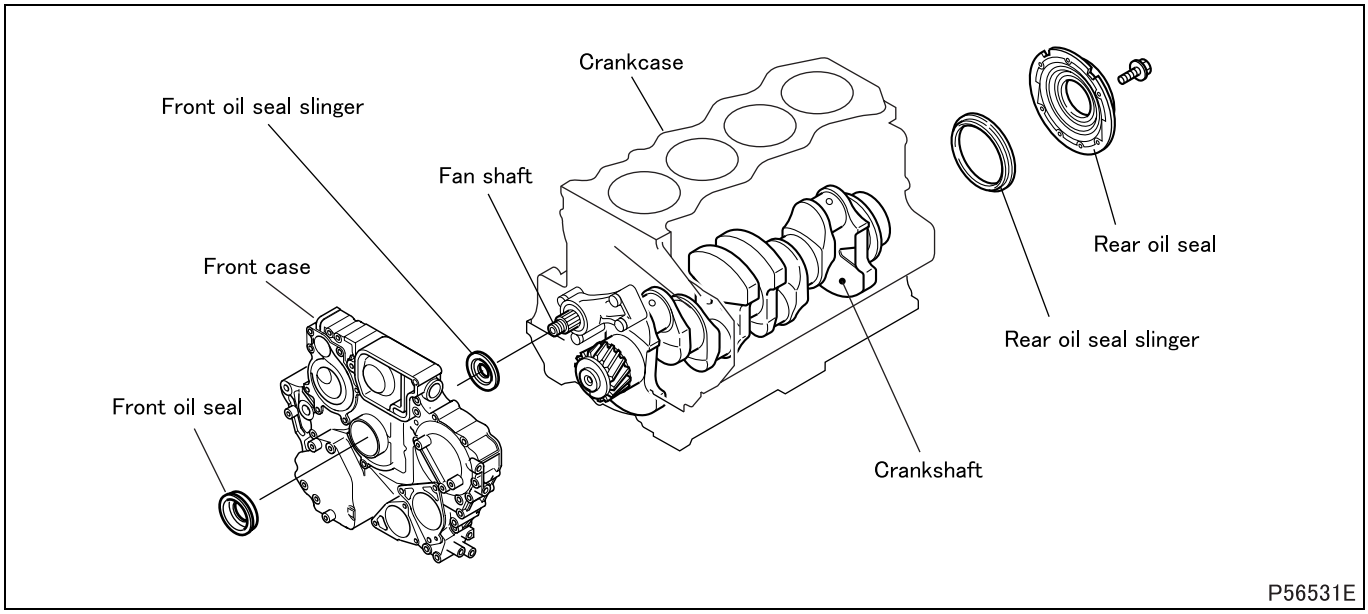
- The upper main bearings have oil holes through which engine oil is supplied to the crankshaft journals.
- An oil groove is provided in the No. 1 lower bearing.

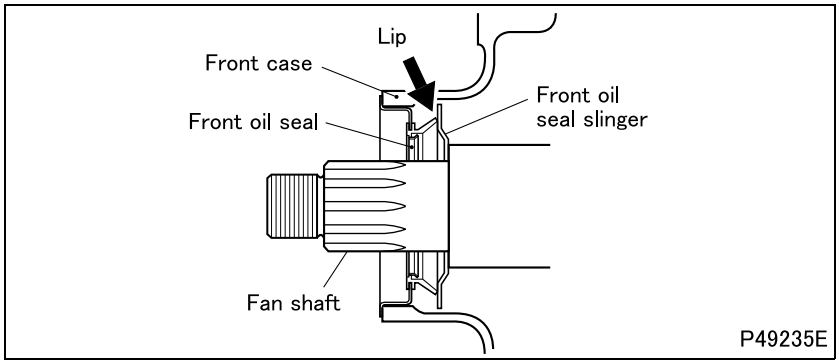


9.3 Thrust plates

- Two upper and lower thrust plate pairs are installed on both sides of the upper and lower main bearings at the rearmost journal of the crankshaft.
- Select the thrust plates of a thickness that can accommodate the crankshaft end play. The thrust plates each have two oil grooves, which assures their minimum friction against the crankshaft journal.

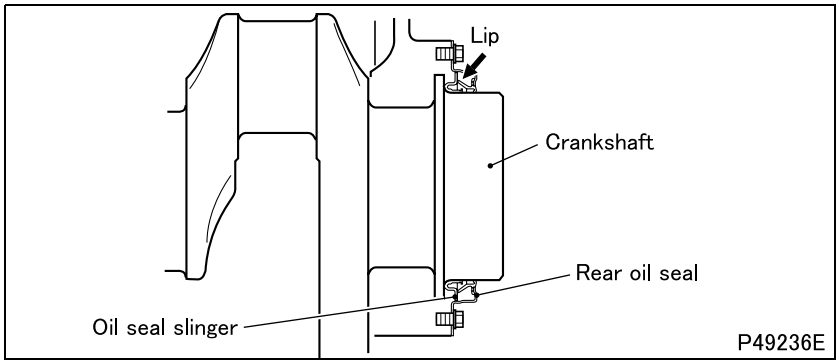
10. Oil Seals





10.1Front oil seal

- The front oil seal is fitted in the front case and prevents oil from leaking by contact of its lip with the front oil seal slinger.
- The front oil seal slinger is press-fitted onto the fan shaft.



10.2Rear oil seal

- The rear oil seal is fitted in the crankcase assembly and prevents oil from leaking by contact of its lip with the rear oil seal slinger.
- The rear oil seal slinger is press-fitted onto the rear end of the crankshaft.

Possible causes / Symptoms		Low power output	Abnormal engine noise	Reference Gr
Cylinder head and valve mechanism	Incorrect valve clearance	O	O	
	Defective cylinder head gasket	O	O	
	Worn valve and valve seat; carbon deposits	O	O	
	Weakened valve spring	O	O	
	Defective rocker shaft and camshaft frame		O	
	Poor lubrication of rocker shaft and camshaft frame		O	
Timing gears	Incorrect backlash in timing gears		O	
	Poor lubrication of timing gears and idler shaft		O	
Camshaft	Excessive end play in camshaft		O	
	Worn camshaft		O	
Pistons and connecting rods	Worn/damaged piston ring groove(s)	O	O	
	Worn/damaged piston ring(s)	O	O	
	Worn piston pin and connecting rod small end		O	
Crankshaft	Excessive end play in crankshaft		O	
	Incorrectly fitted crankshaft		O	
	Worn/damaged crankshaft pins and connecting rod bearings		O	
	Worn/damaged crankshaft journals and main bearings		O	
Fuel system	Defective supply pump	O	O	Gr13E
	Faulty fuel spray from injector	O	O	Gr13A
	Air trapped in fuel system	O		
Cooling system	Malfunctioning cooling system components	O		Gr14
	Loose/damaged V-belts		O	
Intake and exhaust system	Clogged air cleaner	O	O	Gr15
	Clogged muffler	O	O	
Incorrect oil viscosity		O		Gr12
Improper fuel		O		
Incorrectly fitted piping and hoses			O	
Defective/incorrectly fitted alternator and other auxiliaries			O	

M E M O

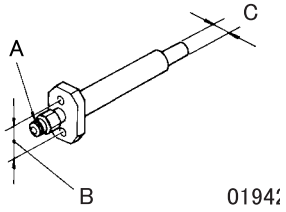
ON-VEHICLE INSPECTION AND ADJUSTMENT

1. Measuring Compression Pressure

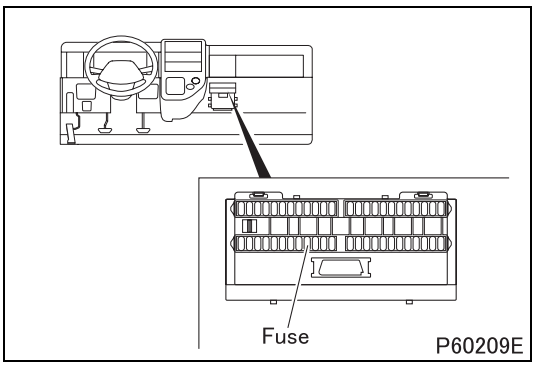
Service standards

Location	Maintenance item		Standard value	Limit	Remedy
–	Compression pressure	Each cylinder (at 200 rpm)	2550 kPa {370 psi, 26 kgf/cm^2}	1960 kPa {285 psi, 20 kgf/cm^2}	Inspect
		Cylinder-to-cylinder pressure difference	–	390 kPa {57 psi, 4 kgf/cm^2} or less	Inspect

Special tools (Unit: mm {in.})

Mark	Tool name and shape	Part No.	Application
a	Compression gauge adapter A: M14 × 1.5 B: 58 {2.28} C: ϕ7.2 {ϕ0.28} 	MH063853	Measuring compression pressure

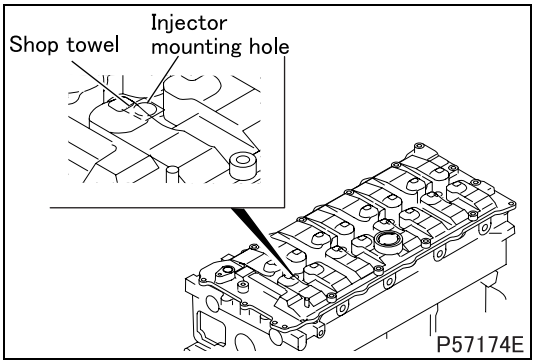
- A drop in compression pressure can be used as a guide to determine when the engine should be overhauled.
- Measure the compression pressure at regular intervals. Keeping track of its transitions can provide a useful tool for troubleshooting. On new vehicles and vehicles with newly replaced parts, the compression pressure will be somewhat higher depending on the break-in condition of piston rings, valve seats, etc., but this will return to normal as the parts wear down.
- Before the compression measurement, confirm that the engine oil, starter, and battery are in normal condition.
- Place the vehicle in the following conditions.
  - Warm up the engine until the coolant temperature reaches approximately 75 to 85°C {167 to 185°F}.
  - Turn off the lights and auxiliaries.
  - Place the transmission in neutral (in the parking range P for automatic transmissions).
  - Place the steering wheel in the straight-ahead position.



- Remove the fuse (M9) to prevent fuel from being injected when the engine is cranked by the starter.

CAUTION ⚠

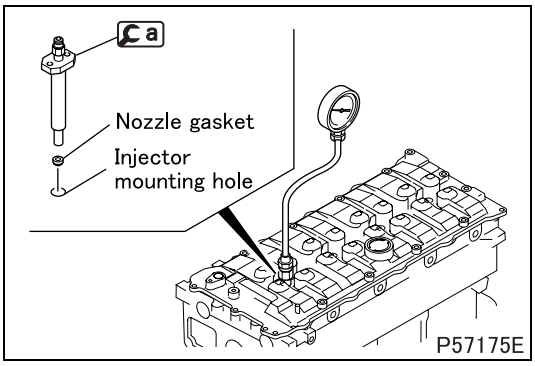
- **When cranking the engine, never shut off the power supplied to the engine electronic control unit by disconnecting the engine electronic control unit connector or other similar methods. If the engine is cranked with the power to the engine electronic control unit shut off, the supply pump will not be controlled by the electronic control unit, causing the supply pump to be malfunctioned.**



- Disconnect the injector connector and remove all injectors. (See Gr13A.)

[Inspection]

- Cover the injector mounting holes with shop towels. After cranking the engine by the starter, check that no foreign substances are deposited on the shop towels.
- If there are deposits (such as engine oil or coolant) on the shop towels, the following may be the cause:
  - Deposits of engine oil alone can mean a defective piston ring seal; the piston rings must be inspected.
  - Deposits of both engine oil and coolant can mean cracks in the cylinders; the crankcase must be replaced.



WARNING ⚠

- **When coolant and engine oil deposits are evident, cranking the engine could be dangerous as these substances, heated to high temperatures, will blow out from the injector mounting holes. Make sure to stay away from the injector mounting holes when the engine is being cranked.**

- Attach the gasket and Ca to one of the injector mounting holes. Then, connect a compression gauge to Ca.
- Crank the engine and measure the compression pressure for all the cylinders one after another. Determine the compression pressure difference between the cylinders.
- If the compression pressure is below the limit or the cylinder-to-cylinder pressure differences is not within the limit, pour a small amount of engine oil into the corresponding injector mounting hole and remeasure the compression pressure.
  - If the compression pressure increases, the piston rings and cylinder surfaces may be badly worn or otherwise damaged.
  - If the compression pressure remains unchanged, there may be seizure in the valves, the valves may be incorrectly seated or the cylinder head gasket may be defective.

[Installation]

- Install the injector. (See Gr13A.)
- Install the rocker cover and the gasket. (See later sections.)

2. Inspection and Adjustment of Valve Clearances

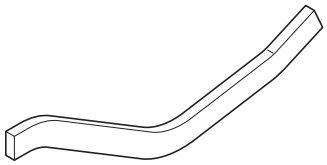
Service standards (Unit: mm {in.})

Location	Maintenance item		Standard value	Limit	Remedy
–	Valve clearance (when cold)	Intake valve	0.4 {0.016}	–	Adjust
		Exhaust valve	0.5 {0.020}	–	

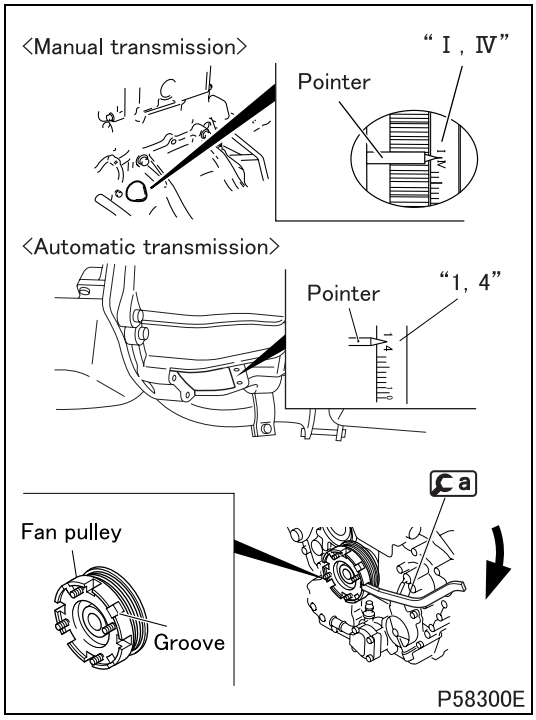
Tightening torque (Unit: N·m {lbf·ft, kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
–	Lock nut (adjusting screw stopping)	21 {15.5, 2.1}	–

Special tools

Mark	Tool name and shape	Part No.	Application
ca	Cranking handle (design may vary)  P58299	MH063704	Turning the fan pulley

- Valve clearances should be checked and adjusted as follows while the engine is still cold.

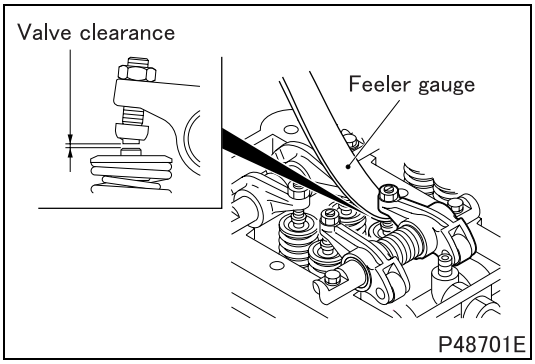


[Inspection]

CAUTION ⚠

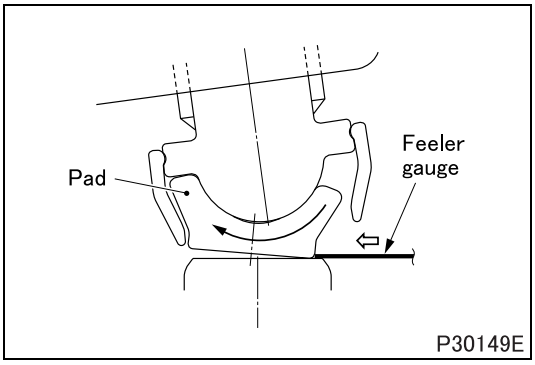
- **Never cut off the engine electronic control unit power supply when cranking the engine.**

- Remove the rocker cover.
- Disconnect the injector connector.
- Bring the No. 1 or No. 4 cylinder piston to the top dead center (TDC) on the compression stroke by the following procedure:
  - Hook ca onto the grooves in the fan pulley.
  - Turn the fan pulley in the illustrated direction to align the pointer with the **"Ⅰ, Ⅳ"** or **"1"** to **"4"** mark on the flywheel.
  - This will place either the No. 1 or No. 4 cylinder piston at TDC on the compression stroke. The cylinder in which the rocker arms for both the intake and exhaust valves can be pushed down by hand by the valve clearance amounts has its piston at TDC. Rotate the engine by one full turn to switch the TDCs of the No. 1 and No. 4 cylinder pistons.

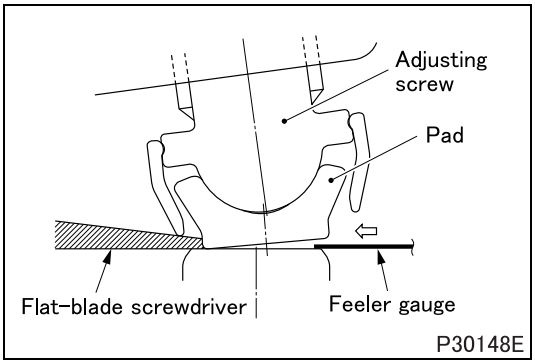


- With the No. 1 or No. 4 cylinder piston at TDC, measure the clearance of the valves marked with a circle in the table below.

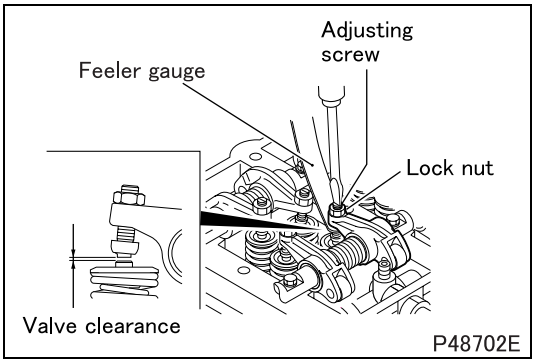
Cylinder No.	1		2		3		4	
Valve	IN	EX	IN	EX	IN	EX	IN	EX
No. 1 cylinder piston at TDC on compression stroke	O	O	O	–	–	O	–	–
No. 4 cylinder piston at TDC on compression stroke	–	–	–	O	O	–	O	O



- The feeler gauge cannot be inserted under the adjusting screw pad without carrying out the above step, as the pad will block the feeler gauge as shown in the illustration.

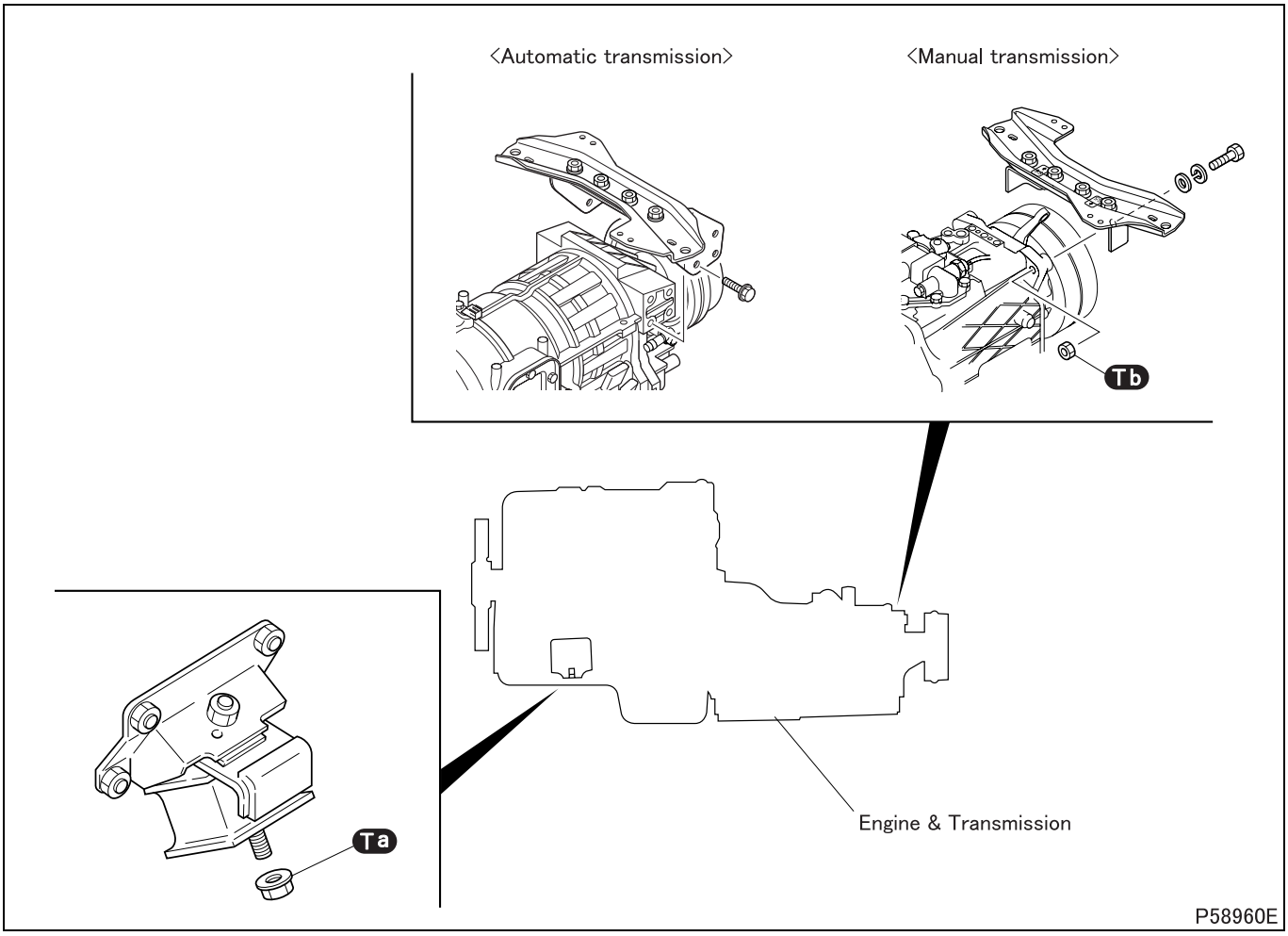


- To insert the feeler gauge under the adjusting screw pad, push the pad at the bottom on one side with a flat-blade screwdriver or a similar tool. Insert the feeler gauge into the small space created under the other side of the pad, as shown in the illustration.
- The feeler gauge must have a slight drag when taking measurements.
- If the feeler gauge can be moved without any resistance, the measurement will be incorrect.
- If the measurements are not within the standard value range, adjust the value clearance by the following procedures.



[Adjustment]

- Adjust the valve clearance by loosening the lock nut and rotating the adjusting screw so that the feeler gauge can only be moved with a slight drag.
- After the adjustment, hold the adjusting screw in position with a screwdriver and tighten the lock nut to the specified torque.
- Recheck the valve clearance with the feeler gauge, and readjust if the measurements are not within the specified value range.



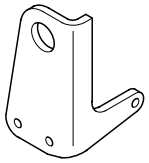
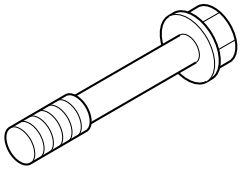
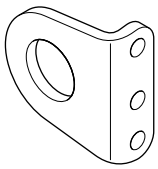
CAUTION ⚠

- **Only use hoisting equipment appropriate for the engine and transmission weight (approximately 600 kg {1320 lb}).**

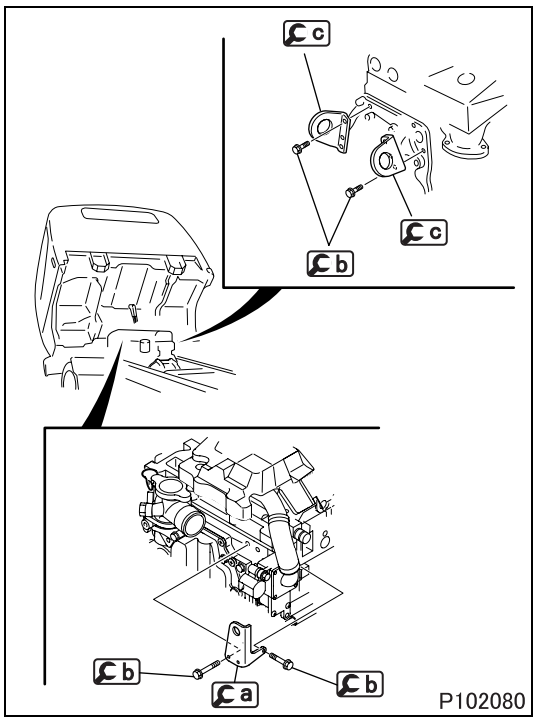
Tightening torque (Unit: N·m {lbf·ft, kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Nut (front mounting installation)	69 to 88 {51 to 65, 7 to 9}	–
Tb	Nut (rear mounting installation)	130 to 170 {96 to 125, 13 to 17}	–

Special tools

Mark	Tool name and shape	Part No.	Application
a	Engine front hanger  P57188	MH063636	Removal and installation of engine
b	Flange bolt  P29984	MF140429 MF140433 MF140421	Installation of engine front hanger
c	Engine rear hanger  P58957	MH063711	Removal and installation of engine

◆Work before removal◆

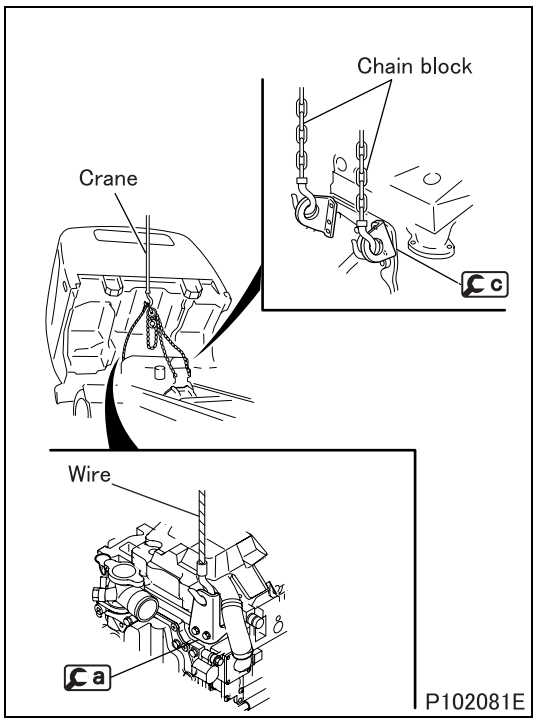


P102080

■ **Preparing for engine removal: Installation of engine front hanger and flange bolt**

- Install a, b and c on the engine.

◆Removal procedure◆

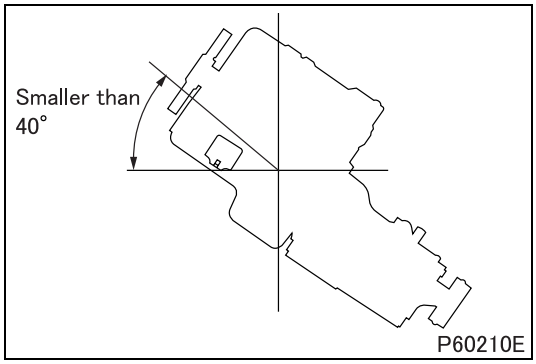


■ **Removal: Engine and transmission**

- Hook the wire rope on a and hitch the chain block to c. Then, pull all the slack out of the slings by a crane.

CAUTION ⚠

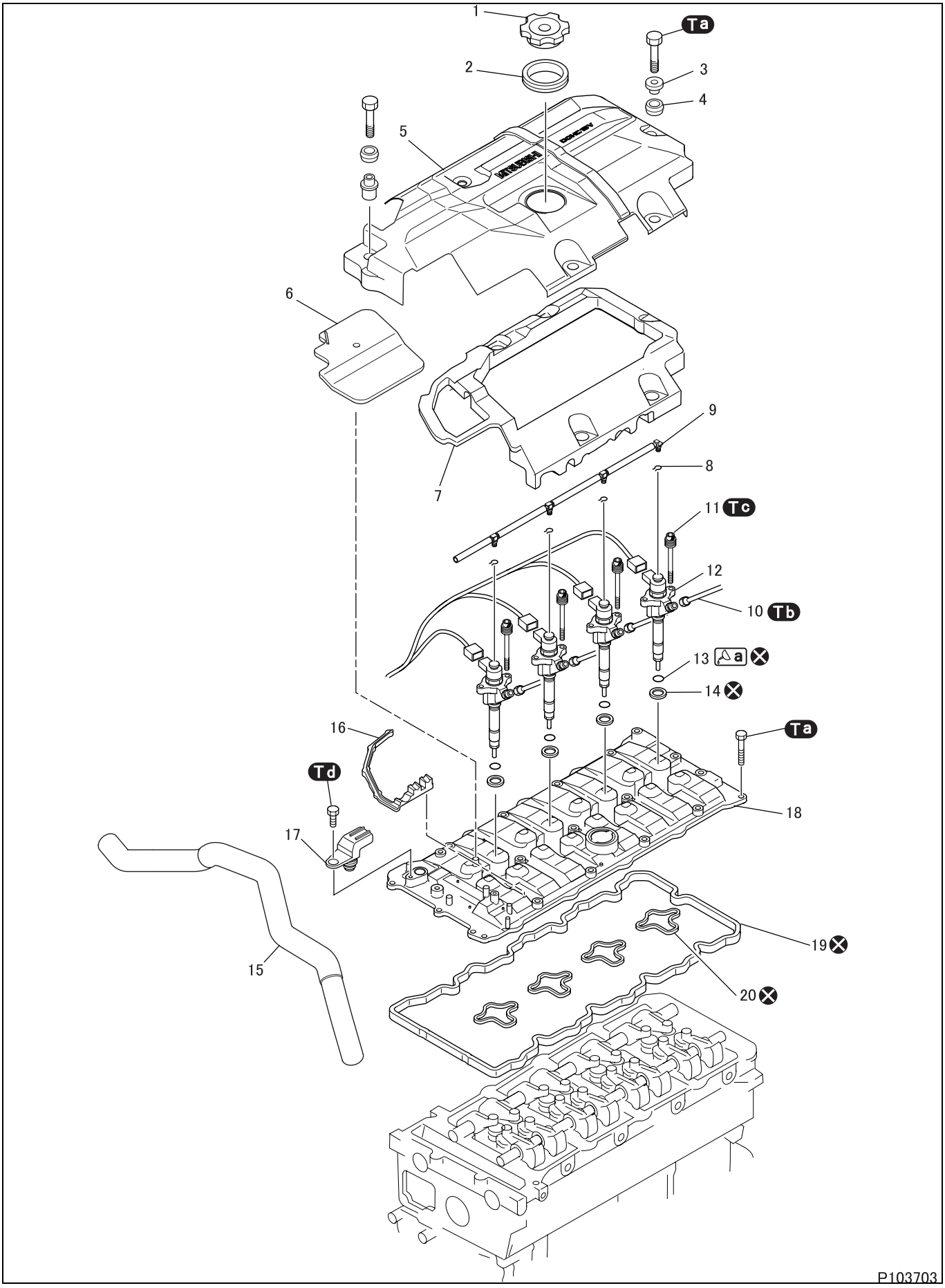
- **The slings must be strong enough to hang the engine and transmission assembly (weighing approximately 600 kg {1320 lb}).**
- **Be sure to keep the slings away from the exhaust gas recirculation pipes.**



- Make sure that all harnesses and pipes are disconnected.
- Lift the engine and transmission assembly slowing. Take care not to bump the assembly against the frame and cab.

CAUTION ⚠

- **When lifting the engine and transmission assembly, do not incline it more than 40°.**


1
Ta
2
3
4
5
6
7
9
8
11 Tc
12
10 Tb
13 a
14
16
Ta
Td
18
17
19
15
20
P103703

ROCKER COVER

● Disassembly sequence

1 Oil filler cap
2 Grommet
3 Spacer
4 Insulator
5 Cover
6 PCV hose spacer
7 Rocker cover rubber
8 Snap ring
9 Fuel return hose
10 Injection pipe
11 Bolt (with hexagonal hole)
12 Injector
13 O-ring
14 Tip gasket
15 PCV hose
16 Rubber seal
17 Cylinder sensor
18 Rocker cover
19 Rocker cover gasket A
20 Rocker cover gasket B

⊗: Non-reusable parts
PCV: Positive Crankcase Ventilation

● Assembly sequence

Follow the disassembly sequence in reverse.

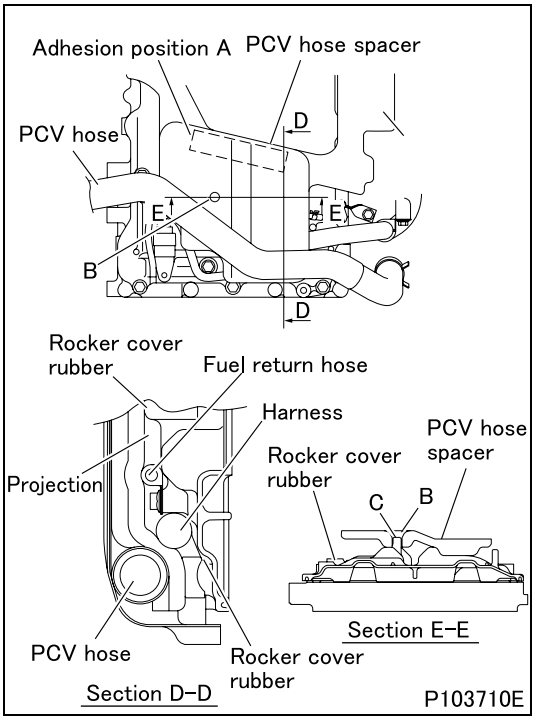
Tightening torque (Unit: N·m {lbf·ft, kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (cover installation)	23.2 {17, 2.4}	–
	Bolt (rocker cover installation)		
	Bolt (PCV pipe installation)		
Tb	Injection pipe (union nut installation)	30.4 to 35 {22 to 26, 3.1 to 3.6}	–
Tc	Bolt (injector installation)	5.2 to 7.2 {3.8 to 5.3, 0.53 to 0.73}	–
Td	Bolt (cylinder sensor installation)	8 {5.9, 0.82}	–

Lubricant and/or sealant

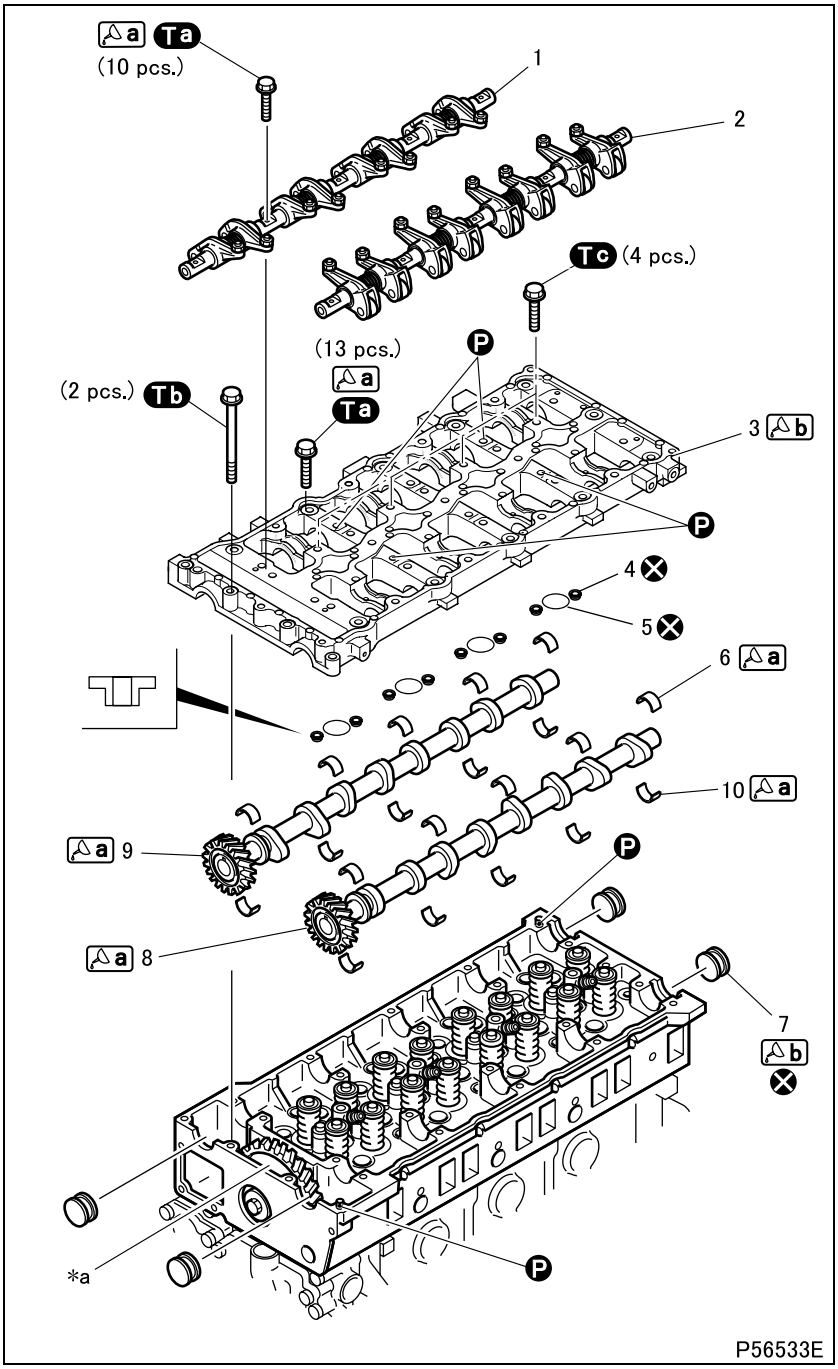
Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	O-ring	Engine oil	As required

◆Installation procedure◆



■ Installation: PCV hose spacer

- Apply a sheet of double-sided adhesive tape at the adhesion position A on the PCV hose spacer.
- Install the PCV hose spacer while aligning the hole B in the spacer with the projection C on the rocker cover rubber. Be careful not to crush the fuel return hose with the projection on the PCV hose spacer.



● Disassembly sequence

1 Exhaust rocker shaft
(See later sections.)
2 Intake rocker shaft
(See later sections.)
3 Camshaft frame
4 Gasket
5 O-ring
6 Upper camshaft bearing
7 Packing
8 Intake camshaft
(See later sections.)
9 Exhaust camshaft
(See later sections.)
10 Lower camshaft bearing

***a**: Head idler gear
Ⓟ: Locating pin
⊗: Non-reusable parts

CAUTION ⚠

- **The camshaft frame and cylinder head are manufactured as a matched set. Never replace the camshaft frame or the cylinder head individually.**
- **Do not change the upper and lower camshaft bearing combinations. Do not interchange the position of an upper and lower camshaft bearing set with that of another.**

● Assembly sequence

Follow the disassembly sequence in reverse.

Service standards (Unit: mm {in.})

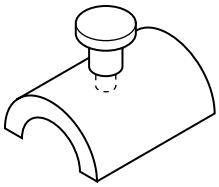
Location	Maintenance item		Standard value	Limit	Remedy
–	Backlash	Head idler gear-to-camshaft gear	0.080 to 0.126 {0.0031 to 0.0050}	0.3 {0.012}	Replace
–	End play	Camshaft	0.10 to 0.20 {0.0039 to 0.0079}	0.3 {0.012}	Replace
6, 8, 10	Camshaft bearing-to-intake camshaft clearance		0.07 to 0.12 {0.0028 to 0.0047}	0.16 {0.024}	Replace
6, 9, 10	Camshaft bearing-to-exhaust camshaft clearance		0.07 to 0.12 {0.0028 to 0.0047}	0.16 {0.024}	Replace
6, 10	Camshaft bearing span (when free)		–	35.5 {1.40}	Replace

Tightening torque (Unit: N·m {lbf·ft, kgf·m})

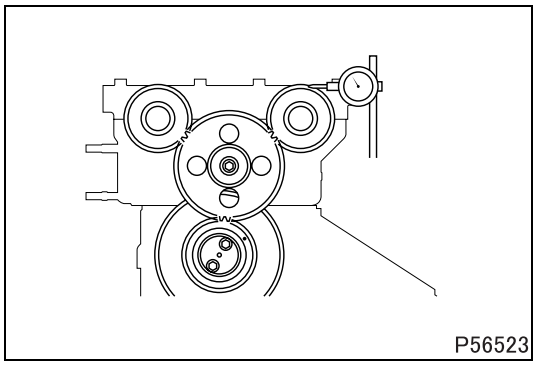
Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (rocker shaft installation: 10 places)	27.5 {20, 2.8}	Wet
	Bolt (camshaft frame installation: 13 places)		
Tb	Bolt (camshaft installation: 2 places)	23.5 {17, 2.4}	–
Tc	Bolt (camshaft frame installation: 4 places)	23.2 {17, 2.4}	–

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Bolt threads and seat	Engine oil	As required
	Camshaft bearing inner surface		
	Camshaft journals and cams		
b	Cylinder head mounting surface of camshaft frame	ThreeBond 1217H	As required
	Entire periphery of packing		

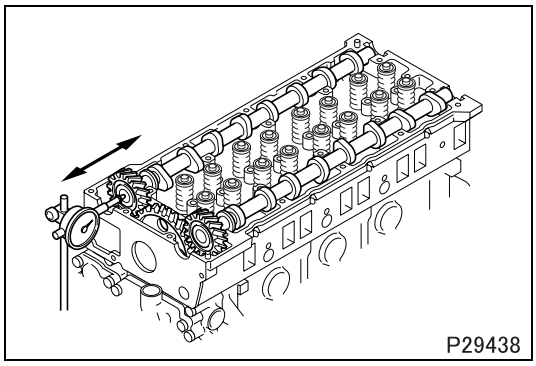
Mark	Tool name and shape	Part No.	Application
a	Rocker shaft set tool  P103819	MH063861	Installtion of rocker shaft

◆Work before removal◆


P56523

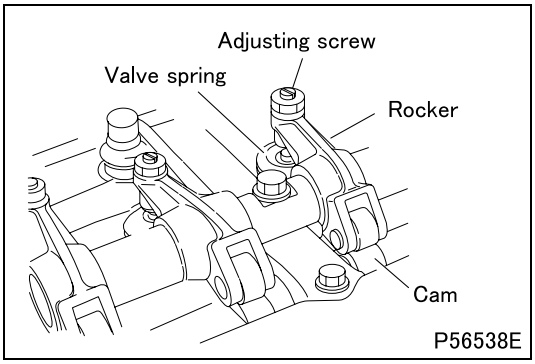
■ **Inspection: Backlash between gears**

- Measure the backlash at three or more locations for each pair of gears.
- If any of the measurements exceeds the specified limit, replace the defective part(s).


P29438

■ **Inspection: Camshaft end play**

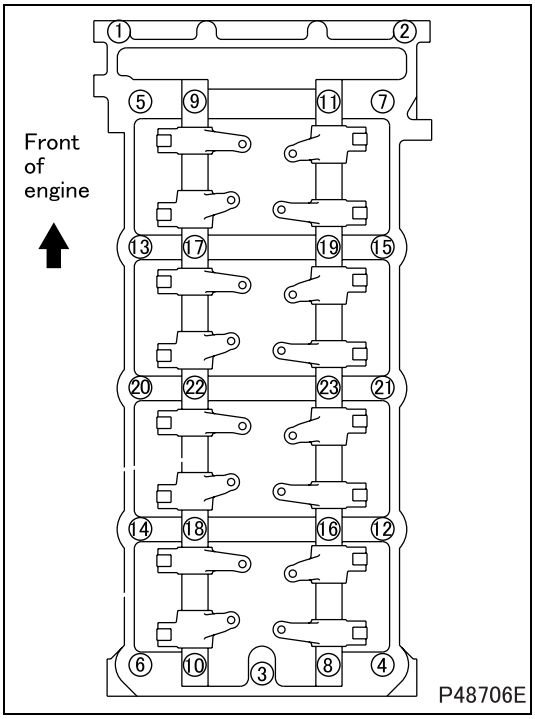
- If the end play exceeds the specified limit, replace the defective part(s).



■ Releasing valve spring tension

- Before removing the bolts in the next process, loosen the adjusting screws on the rockers whose valve springs are compressed (due to the cams lifting these rockers). This operation is necessary to release the tension in the valve springs, thus preventing other parts from undue forces when the bolts are removed.

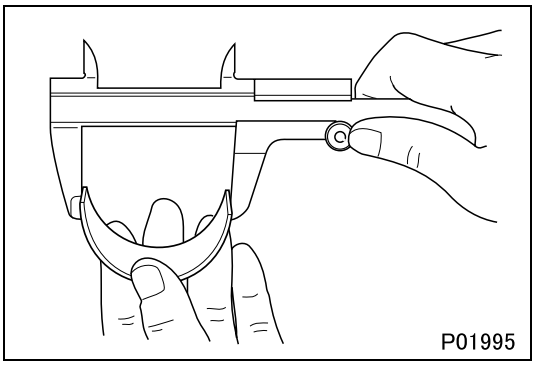
◆Removal procedure◆



■ Removal: Rocker shafts and camshaft frame

- Loosen the rocker shaft installation bolts (10 places) and the camshaft frame installation bolts (13 places) in several passes in the order indicated in the illustration (1 to 23). Then, remove the rocker shafts and the camshaft frame.

◆Inspection procedure◆

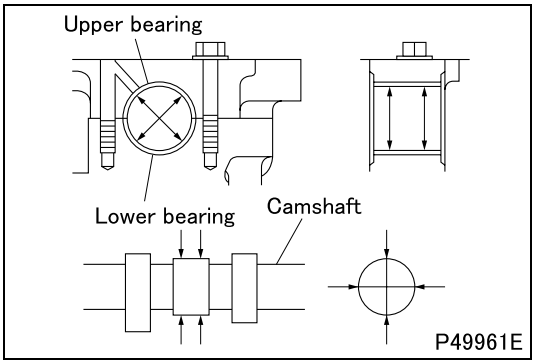


■ Inspection: Camshaft bearing free span

CAUTION ⚠

- **Do not force the bearings open.**

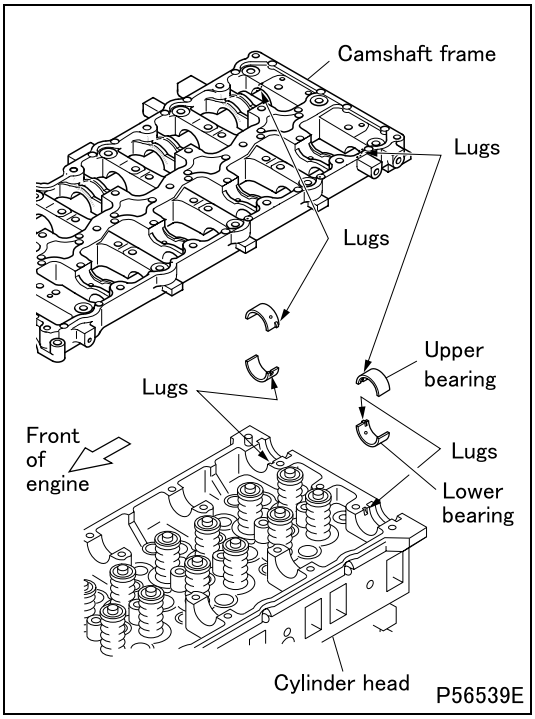
- If the measurement is less than the limit, replace upper and lower bearings as a set.



■**Inspection: Camshaft bearing-to-camshaft clearance**

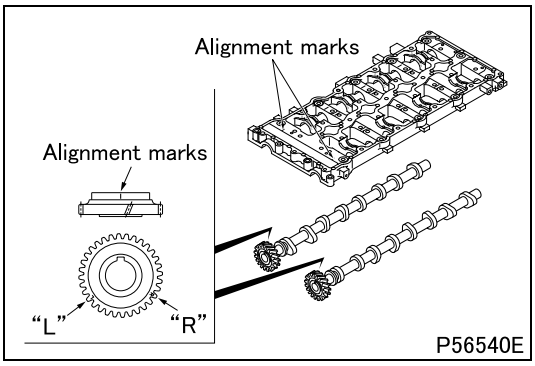
- If the measurement is not within the standard value range, replace the defective part(s).

◆Installation procedure◆



■ **Installation: Camshaft**

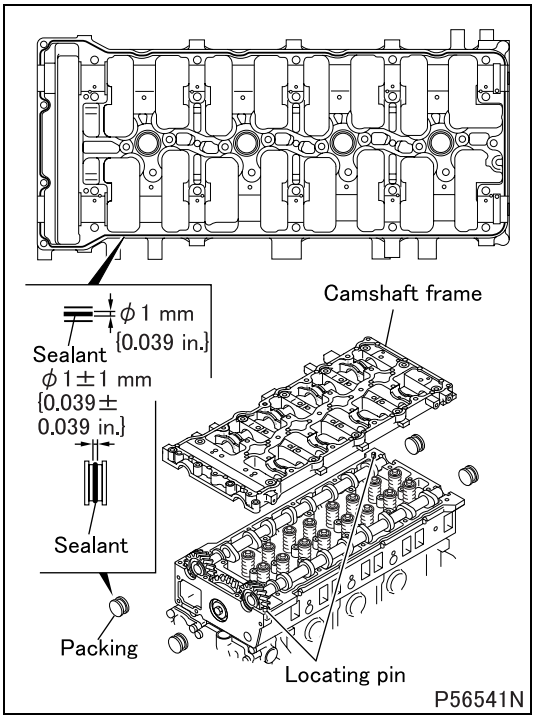
- Install the upper camshaft bearing on the camshaft frame and the lower camshaft bearing on the cylinder head by fitting their lugs into the notches in the camshaft frame and cylinder head.



- Place the No. 1 cylinder piston at the top dead center on the compression stroke.
- Align the mating marks on the camshaft gears with those on the camshaft frame when installing the camshafts.

NOTE

- **Each camshaft gear also has mating mark "L" or "R" for alignment with the head idler gear. This mark may not be exactly aligned with that on the head idler gear, as the position that the head idler gear takes when it is installed may make it impossible to align them. Such a misalignment does not lead to any undesirable consequences.**

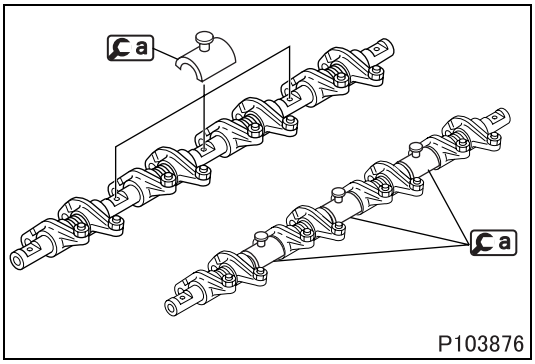


■ **Installation: Rocker shafts and camshaft frame**

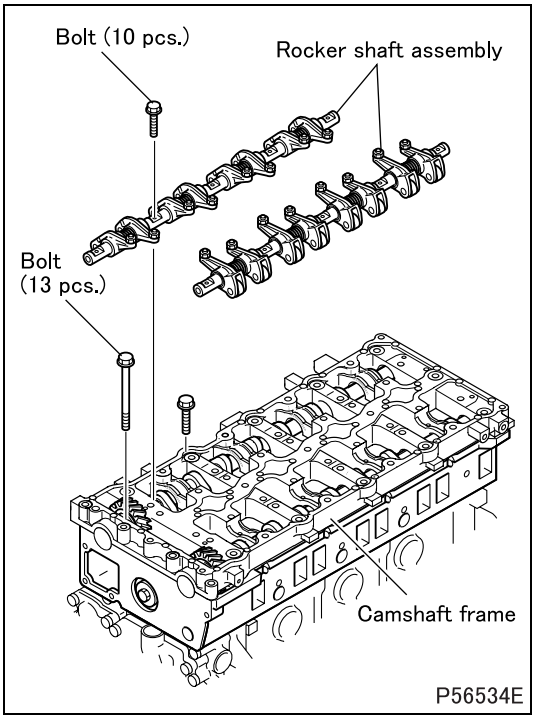
- Clean the sealant application surfaces on each part.
- Apply sealant to the entire periphery of the four packings evenly and without any breaks.
- Apply sealant to the camshaft frame evenly and without any breaks.
- Mount the camshaft frame and packing on the cylinder head within three minutes of applying the sealant, being careful not to dislodge the sealant in the process.

CAUTION ⚠

- **Do not run the engine within one hour of installing the rocker shafts and camshaft frame.**



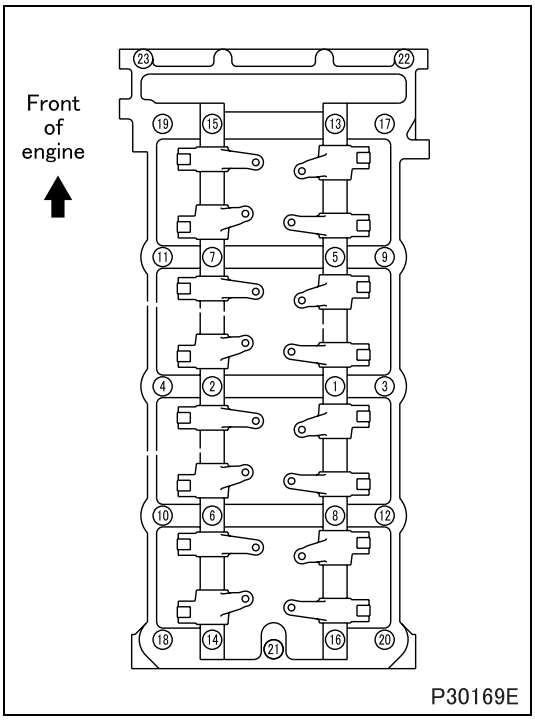
- Install a on the rocker shaft to prevent the rocker arms from moving away from each other.



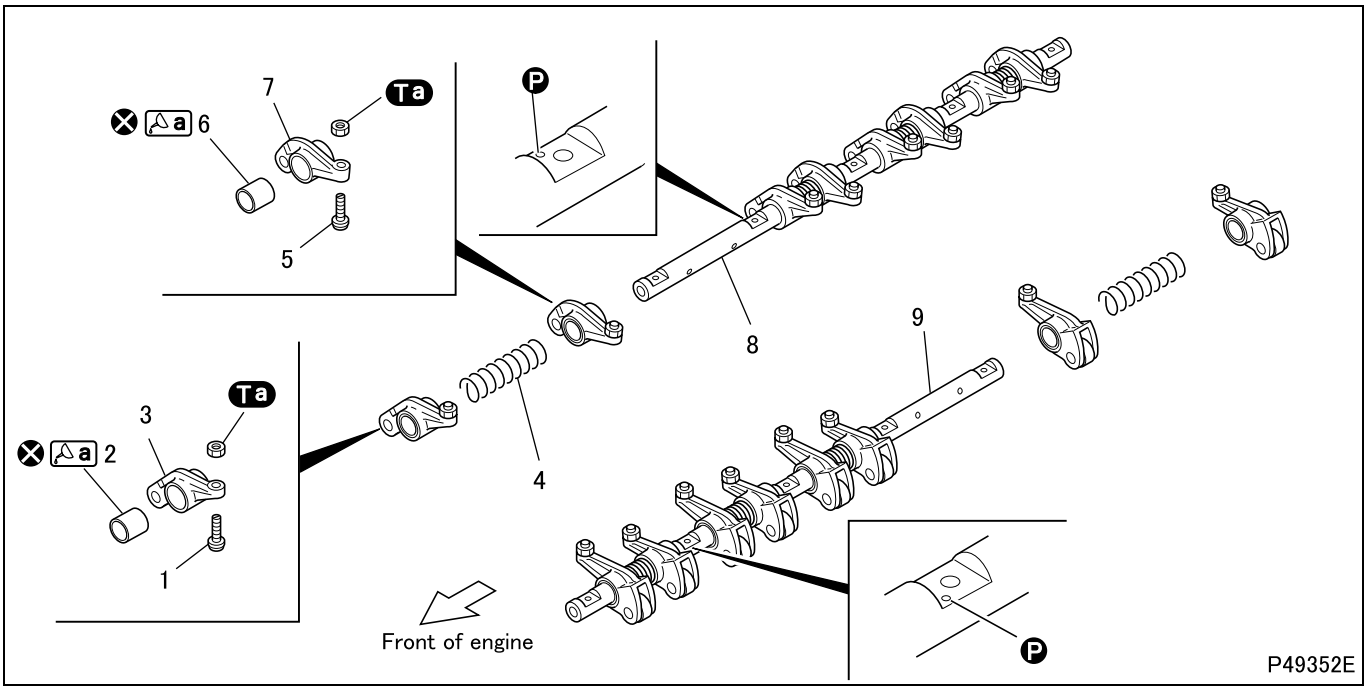
- When installing the camshaft frame on the cylinder head, also install the rocker shafts. Then, tighten the rocker shaft bolts (10 places) and the camshaft frame bolts (13 places) in the order indicated below.

CAUTION ⚠

- **Reapply sealant to the areas specified above if any of the bolts is loosened or removed after the rocker shafts and camshaft frame are installed.**



- Tighten the bolts (1 to 23) to the specified torque in the order indicated in the illustration.



● Disassembly sequence

1 Adjusting screw
2 Rocker bushing
3 Short rocker
4 Rocker shaft spring
5 Adjusting screw
6 Rocker bushing
7 Long rocker
8 Exhaust rocker shaft
9 Intake rocker shaft

Ⓟ: Hole for camshaft frame locating pin
⊗: Non-reusable parts

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION ⚠

- **The short rockers and long rockers must be installed alternately. Be aware that the order of installation for the intake rockers is different from the order of installation for the exhaust rockers.**

Service standards (Unit: mm {in.})

Location	Maintenance item	Standard value	Limit	Remedy
3, 7	Rocker (roller) radial play	0.038 to 0.100 {0.0015 to 0.0039}	–	Replace
2, 6, 8, 9	Rocker bushing-to-rocker shaft clearance	0.01 to 0.08 {0.00039 to 0.0031}	0.12 {0.0047}	Replace

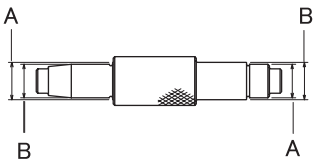
Tightening torque (Unit: N·m {lbf·ft, kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Lock nut (adjusting screw stopping)	21 {15.5, 2.1}	–

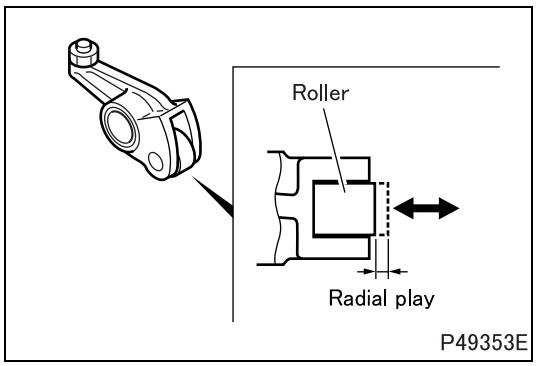
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Rocker bushing inner surface	Engine oil	As required

Special tools (Unit: mm {in.})

Mark	Tool name and shape	Part No.	Application
Ca	Rocker bushing puller A: ϕ22 {ϕ0.87}, B: ϕ24.5 {ϕ0.96}  P29932	MH062536	Removal and installation of rocker bushing

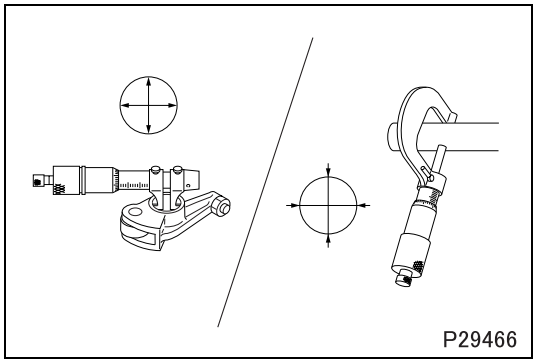
◆Inspection procedure◆



P49353E

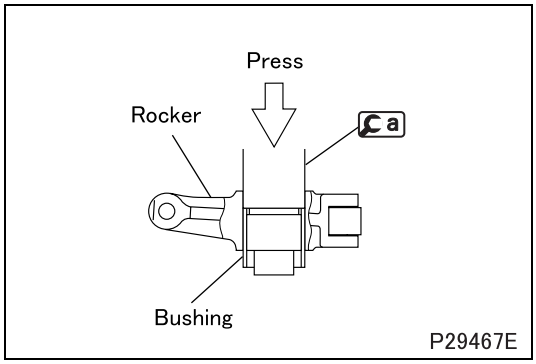
■ Inspection: Rocker (roller) radial clearance

- Replace the rocker if the radial play measurement is not within the standard value range.

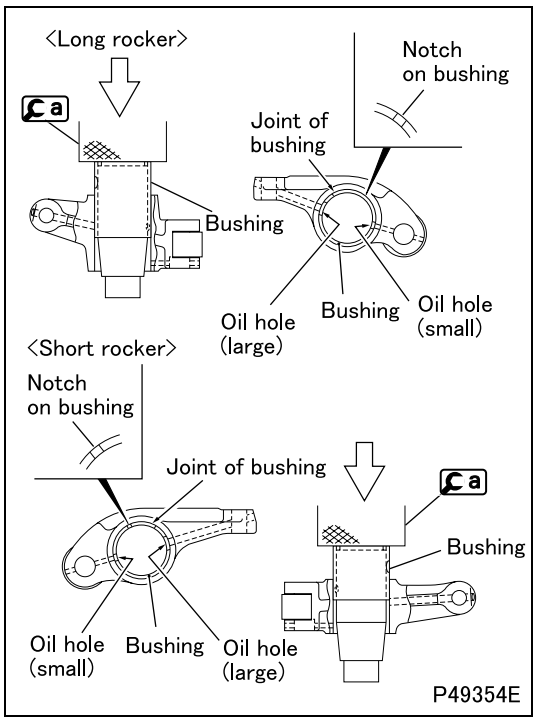

P29466

■ Inspection: Rocker bushing-to-rocker shaft clearance

- Replace the bushing if the measurement exceeds the specified limit.



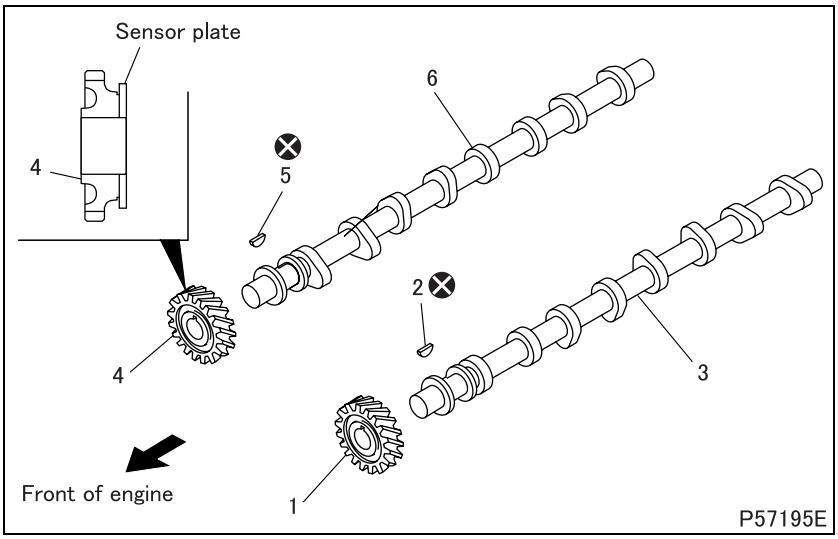
Replacement of rocker bushing
[Removal]



[Installation]

- Press-fit each rocker bushing in the rocker with its ends facing in the illustrated directions.

Camshafts



● Disassembly sequence

1 Intake camshaft gear
2 Key
3 Intake camshaft
4 Exhaust camshaft gear
5 Key
6 Exhaust camshaft

⊗: Non-reusable parts

NOTE

- **Do not remove the camshaft gears unless defects are evident.**

● Assembly sequence

Follow the disassembly sequence in reverse.

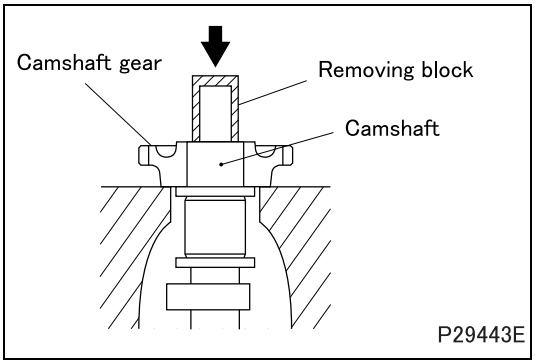
NOTE

- **The exhaust camshaft gear has the sensor plate. Do not mistake it for the intake camshaft gear. If the gears are incorrectly installed, engine malfunction will occur.**

Service standards (Unit: mm {in.})

Location	Maintenance item			Standard value	Limit	Remedy
1, 3, 4, 6	Camshaft gear-to-camshaft interference			0.007 to 0.041 {0.00028 to 0.0016}	–	Replace
3	Intake camshaft	Cam lift	Cams for long rockers	7.219 {0.284}	–	Replace
			Lobe height: 42.219 {1.66} Base circle diameter: 35 {1.38}			
			Cams for short rockers	9.281 {0.365}	–	
			Lobe height: 44.281 {1.74} Base circle diameter: 35 {1.38}			
		Bend		0.01 {0.00039}	0.03 {0.0012}	Replace
6	Exhaust camshaft	Cam lift	Cams for long rockers	7.111 {0.279}	–	Replace
			Lobe height: 42.279 {1.66} Base circle diameter: 35.168 {1.39}			
			Cams for short rockers	9.148 {0.36}	–	
			Lobe height: 44.359 {1.75} Base circle diameter: 35.211 {1.39}			
		Bend		0.01 {0.00039}	0.03 {0.0012}	Replace

◆Removal procedure◆



■ **Removal: Camshaft gears**

- Remove the camshaft gear by pushing on the camshaft using a press.

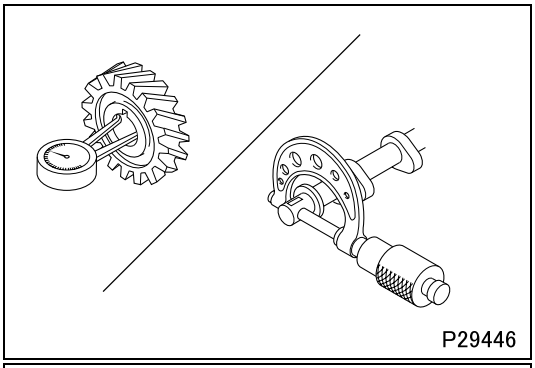
CAUTION ⚠

- **Do not use a hammer to remove the camshaft gear. Be sure to use a press for this purpose.**

◆Inspection procedure◆

■ **Inspection: Camshaft gear-to-camshaft interference**

- If the measurement is not within the standard value range, replace the defective part(s).



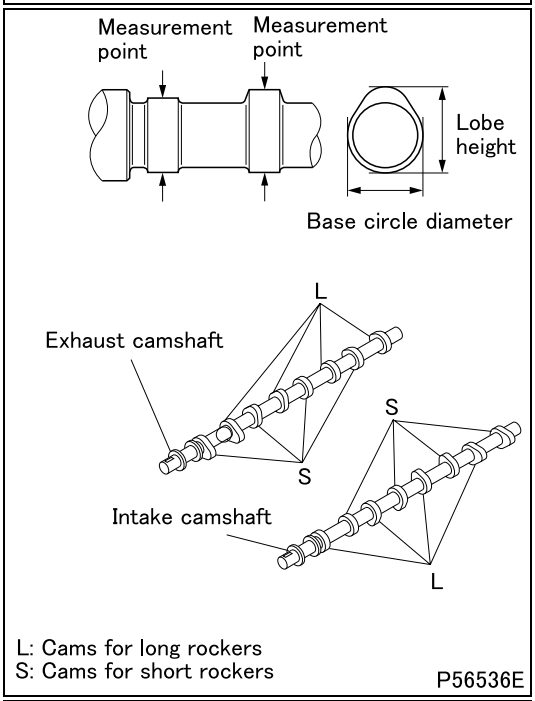
■ **Inspection: Camshaft**

(1) Cam lift

- Replace the camshaft if the difference between the cam lobe height and base circle diameter measurements is less than the specified limit.

NOTE

- **The cams for the long rockers (L) are different from the cams for the short rockers (S).**

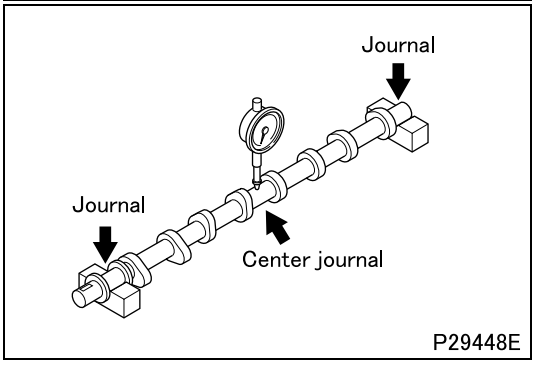


(2) Bend

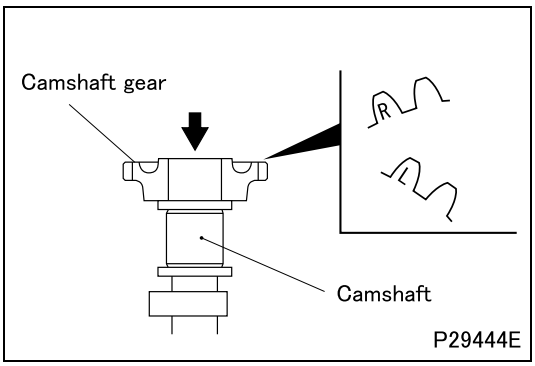
- Place supports under the journals at the ends of the camshaft and measure the bend of the camshaft at the central journal.
- If the measurement exceeds the specified limit, replace the camshaft.

NOTE

- **Turn the camshaft by one turn and read the dial gauge. Divide the reading by two to obtain the amount of camshaft bend.**



◆Installation procedure◆



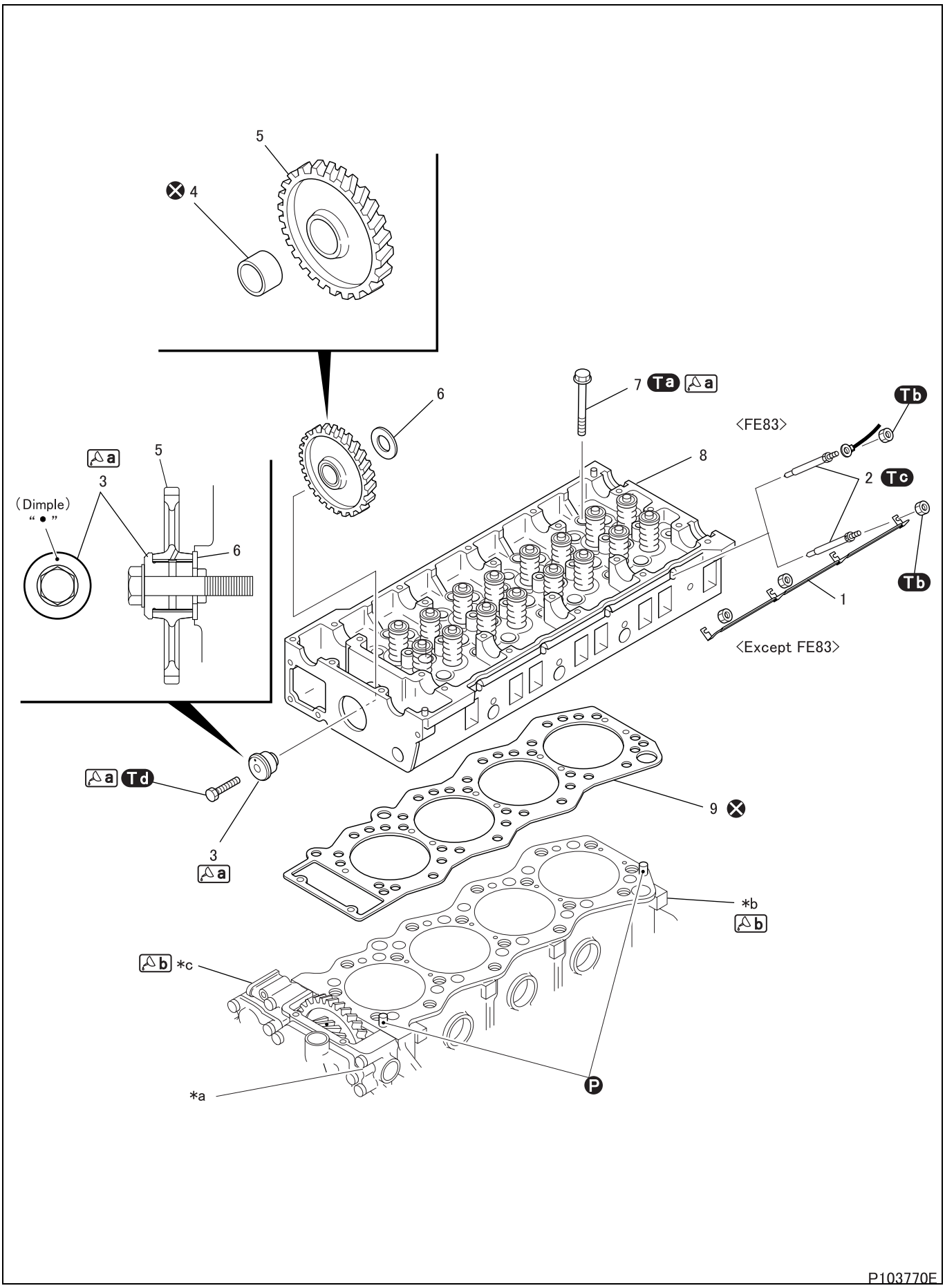
■ **Installation: Camshaft gears**

- Heat the camshaft gears to approximately 150°C {302°F} with a gas burner.

WARNING ⚠

- **You may burn yourself if you touch the heated gear.**

- Install the camshaft gear on the camshaft with a mating mark (“R” or “L”) facing in the illustrated direction.
- Press the gear until its end comes in close contact with the flange on the camshaft.


5
4
6
7 Ta a
Tb
<FE83>
8
2 Tc
a
3
5
(Dimple)
6
Tb
1
<Except FE83>
a Td
9
3 a
*b b
b *c
*a
P
P103770E

● Disassembly sequence

1 Connection plates
2 Glow plug
3 Head idler shaft
4 Head idler gear bushing
5 Head idler gear
6 Thrust plate
7 Cylinder head bolt
8 Cylinder head
(See later sections.)
9 Cylinder head gasket
∗a: Idler gear
∗b: Upper crankcase
∗c: Front case
Ⓟ: Locating pin
⊗: Non-reusable parts

CAUTION ⚠

- **Be careful not to damage the glow plugs and injectors when placing the cylinder head on the worktable, as they are protruding out of the bottom of the cylinder head.**
- **The cylinder head bolts are tightened using the torque-turn method. Any cylinder head bolt that has three marks indicating that the bolt has been tightened three times already must be replaced with a new one.**

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION ⚠

- **Do not forget to install the thrust plate.**

Service standards (Unit: mm {in.})

Location	Maintenance item	Standard value	Limit	Remedy
–	Backlash between head idler gear and idler gear	0.103 to 0.158 {0.0041 to 0.0062}	0.3 {0.012}	Replace
–	Head idler gear end play	0.1 to 0.2 {0.0039 to 0.0079}	0.3 {0.012}	Replace
3, 4	Head idler shaft-to-head idler gear bushing clearance	0.01 to 0.05 {0.00039 to 0.0020}	0.1 {0.0039}	Replace

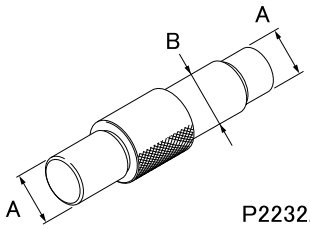
Tightening torque (Unit: N·m {lbf·ft, kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Cylinder head bolt	147 {110, 15} + 90°	Wet
Tb	Nut (connection plate installation)	1.0 to 1.5 {0.7 to 1.1, 0.1 to 0.15}	–
Tc	Glow plug	19.6 to 24.5 {14 to 18, 2 to 2.5}	–
Td	Bolt (head idler shaft installation)	40.2 {30, 4.1}	Wet

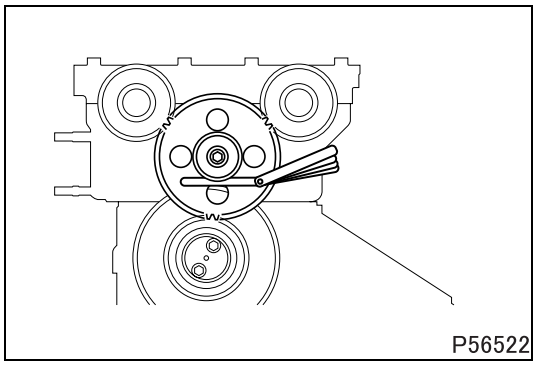
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	O-ring	Engine oil	As required
	Bolt (head idler gear installation) threads and seating surface under head		
	Head idler shaft outer peripheral surface		
	Cylinder head bolt threads		
b	Top surfaces of joints between upper crankcase and front case	ThreeBond 1207C	As required

Special tools (Unit: mm {in.})

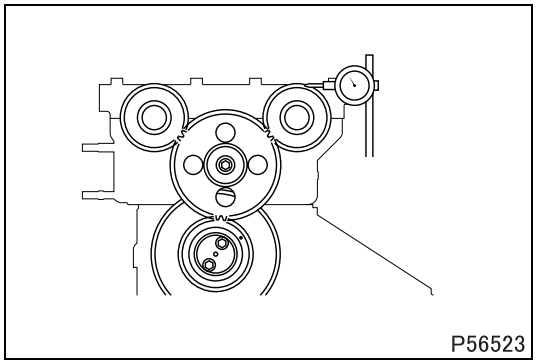
Mark	Tool name and shape	Part No.	Application
ⓒa	Idler gear bushing puller A: ϕ32 {ϕ1.26}, B: ϕ35 {ϕ1.38}  P22322	MH061779	Removal and installation of idler gear bushing

◆Inspection before removal◆


P56522

■ **Inspection: Head idler gear end play**

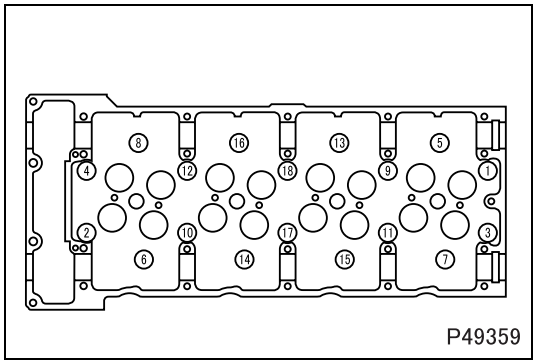
- If the measurement exceeds the specified limit, replace the defective part(s).


P56523

■ **Inspection: Backlash between gears**

- Measure the backlash at three or more locations for each pair of gears.
- If any of the measurements exceeds the specified limit, replace the defective part(s).

◆Removal procedure◆



P49359

■ **Removal: Cylinder head**

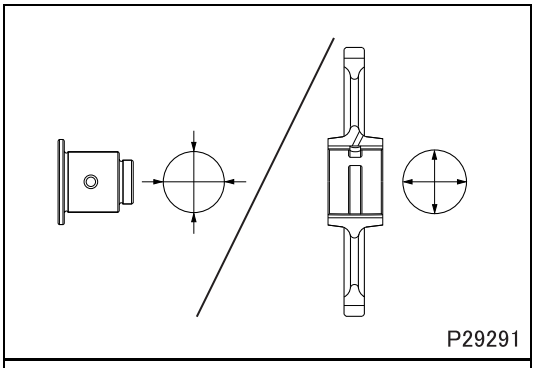
- Loosen the cylinder head bolts (1 to 18) in several passes in the order indicated in the illustration and remove the cylinder head.

■ **Removal: Cylinder head gasket**

CAUTION ⚠

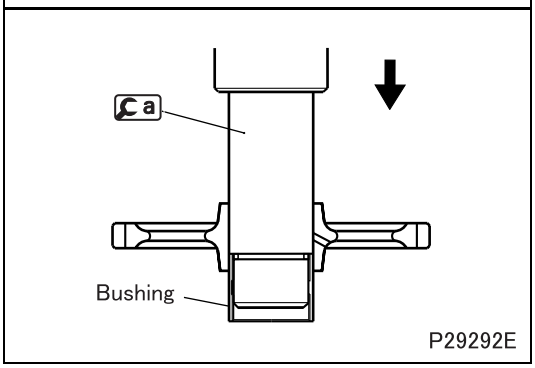
- **When removing the cylinder head gasket, be careful not to scratch the cylinder head, the upper crankcase and the front case.**

◆Inspection procedure◆


P29291

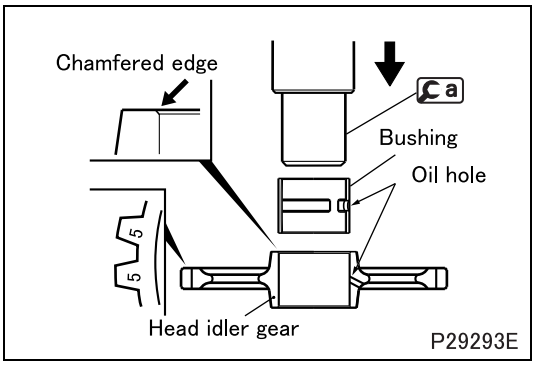
■**Inspection: Head idler shaft-to-head idler gear bushing clearance**

- Replace the bushing if the measurement exceeds the specified limit.



P29292E

Replacement of head idler gear bushing
[Removal]

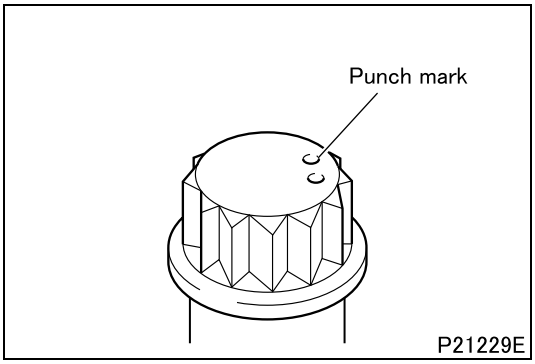


P29293E

[Installation]

- Position the bushing on the head idler gear with their ends facing the illustrated directions and their oil holes on the same line.
- Using a, press the bushing into the head idler gear until it is flush with the lower edge of the chamfer on the head idler gear.
- Remeasure the clearance between the bushing and head idler shaft.
- Ream the bushing if the measurement is less than the standard value.

◆Installation procedure◆

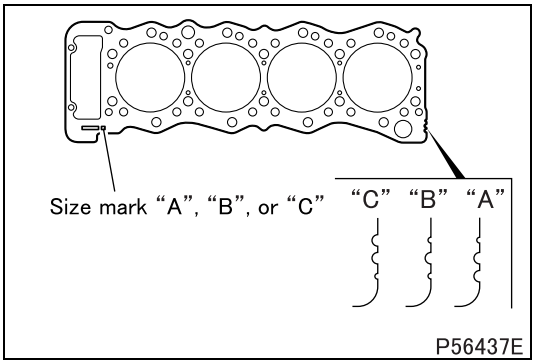


P21229E

■**Installation: Cylinder head**

CAUTION ⚠

- **Before fitting the cylinder head bolts, check the punch marks on each bolt's head. Do not use the bolt if there are three punch marks.**
- **The punch marks indicate the number of times each bolt has been tightened using the torque-turn tightening method. Any bolt that already has three punch marks must be replaced.**



- The cylinder head gasket comes in three sizes. Choose the gasket appropriate for the cylinder head by the following procedure.
  - Measure the amount of piston projection for every cylinder. (See the "**PISTONS, CONNECTING RODS AND CYLINDER LINERS**" section.)
  - Select a cylinder head gasket with the appropriate thickness for the average of the piston projection measurements from the table below.
  - If any of the piston projection measurements is more than 0.05 mm {0.0020 in.} larger than the average value, then use the gasket one class higher than that class (A→B, B→C).

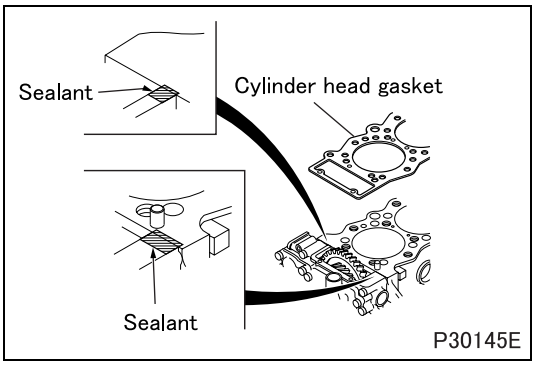
Unit: mm {in.}

Piston projection	Cylinder head gasket	
	Size	Thickness when tightened
–0.088 to –0.027 {–0.0035 to –0.0011}	"A"	0.75 ± 0.03 {0.030 ± 0.0012}
–0.027 to 0.033 {–0.0011 to 0.0013}	"B"	0.80 ± 0.03 {0.031 ± 0.0012}
0.033 to 0.094 {0.0013 to 0.0037}	"C"	0.85 ± 0.03 {0.033 ± 0.0012}

- The size class of the cylinder head gasket can be determined from the size mark or the shape of the notches cut on the gasket edge.

CAUTION ⚠

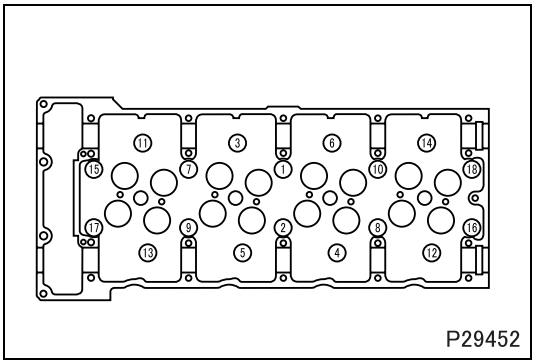
- **Replacement of the piston or connecting rod alters the piston projection. Always measure the amount of piston projection after either or both of them are replaced.**



- Clean the sealant application surfaces of each part.
- Apply sealant to the top surfaces of the joints between the upper crankcase and front case (at two places).
- Install the cylinder head and its gasket on the upper crankcase within three minutes of applying the sealant, being careful not to dislodge the sealant.

CAUTION ⚠

- **Do not run the engine within one hour of mounting the cylinderhead. If any cylinder head bolts are loosened or removed, be sure to reapply sealant to the surfaces specified above.**

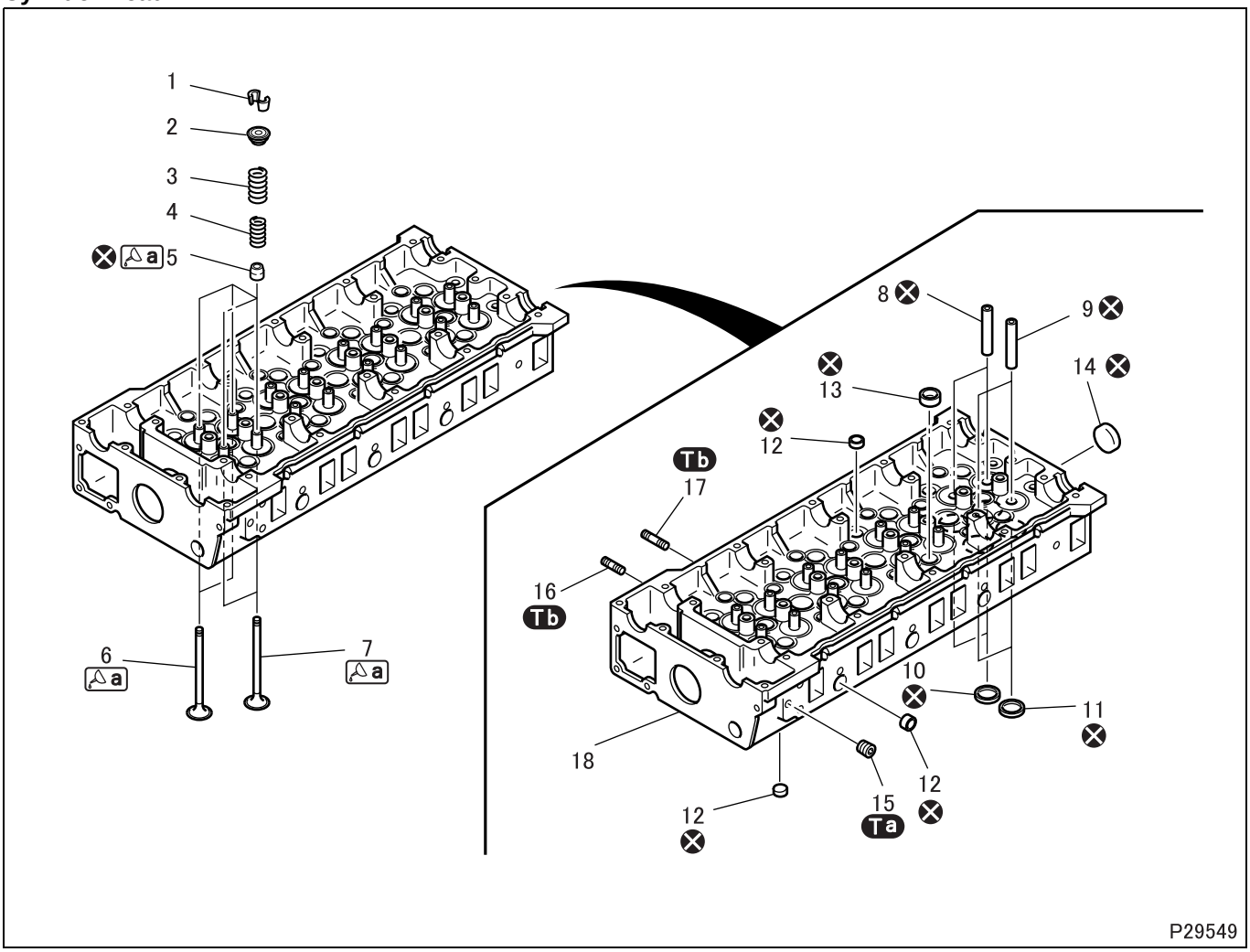


- Tighten the cylinder head bolts (1 to 18) to a torque of 147 N·m {110 lbf·ft, 15 kgf·m} (wet) in the order indicated in the illustration. Then, tighten them further by 90° in the same order.
- After tightening each bolt, make a punch mark on the head of the bolt to indicate the number of times that it has been used.

CAUTION ⚠

- **Cylinder head bolts that have been tightened using the torque-turn method must never be additionally tightened after the final angular tightening.**

Cylinder Head



● Disassembly sequence

1 Valve cotter
2 Upper retainer
3 Outer valve spring
4 Inner valve spring
5 Valve stem seal
6 Exhaust valve
7 Intake valve
8 Exhaust valve guide
9 Intake valve guide
10 Exhaust valve seat
11 Intake valve seat
12 Sealing cap (diameter: 22 mm {0.87 in.})
13 Sealing cap (diameter: 30 mm {1.18 in.})
14 Sealing cap (diameter: 40 mm {1.57 in.})
15 Taper plug
16 Stud (short)
17 Stud (long)
18 Cylinder head

⊗: Non-reusable parts

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION ⚠

- **When an intake valve or exhaust valve have been removed, make sure to replace the valve stem seal.**

Service standards (Unit: mm {in.})

Location	Maintenance item		Standard value	Limit	Remedy
3	Outer valve spring	Free length	87.8 {3.46}	83.4 {3.28}	Replace
		Installed load (57 {2.24} in installed length)	360 ± 18 N {81 ± 4.0 lbs, 36.7 ± 1.8 kgf}	–	
		Squareness	–	2.0 {0.079}	
4	Inner valve spring	Free length	78.8 {3.10}	74.9 {2.95}	Replace
		Installed load (52.3 {2.06} in installed length)	168 ± 8.4 N {38 ± 1.9 lbs, 17.1 ± 0.9 kgf}	–	
		Squareness	–	2.0 {0.079}	
6	Exhaust valve	Stem outside diameter	$\phi 8\ ^{-0.060}_{-0.075}$ {$\phi 0.31\ ^{-0.0024}_{-0.0030}$}	ϕ7.85 {ϕ0.31}	Replace
		Sinkage from cylinder head bottom surface	1.5 ± 0.25 {0.059 ± 0.0098}	2.0 {0.079}	Replace
		Valve margin	1.5 {0.059}	1.2 {0.047}	Replace
		Seat angle	45° ± 15'	–	Reface
6, 8	Exhaust valve stem-to-valve guide clearance		0.07 to 0.10 {0.0028 to 0.0039}	0.2 {0.0079}	Replace
7	Intake valve	Stem outside diameter	$\phi 8\ ^{-0.025}_{-0.040}$ {$\phi 0.31\ ^{-0.00098}_{-0.0016}$}	ϕ7.85 {ϕ0.31}	Replace
		Sinkage from cylinder head bottom surface	1.5 ± 0.25 {0.059 ± 0.0098}	2.0 {0.079}	Replace
		Valve margin	1.5 {0.059}	1.2 {0.047}	Replace
		Seat angle	45° ± 15'	–	Reface
7, 9	Intake valve stem-to-valve guide clearance		0.03 to 0.06 {0.0012 to 0.0024}	0.2 {0.0079}	Replace
10	Exhaust valve seat width		2.5 ± 0.2 {0.098 ± 0.0079}	3.5 {0.14}	Replace
11	Intake valve seat width		2 ± 0.2 {0.079 ± 0.0079}	2.8 {0.11}	Replace
16	Cylinder head	Bottom surface distortion	0.05 {0.0020}	0.2 {0.0079}	Correct or replace
		Height from top surface to bottom surface	107 ± 0.05 {4.21 ± 0.0020}	106.5 {4.19}	Replace
		Valve seat hole diameter	$\phi 38\ ^{+0.025}_{0}$ {$\phi 1.50\ ^{+0.0098}_{0}$}	–	Replace

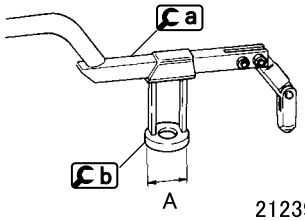
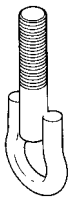
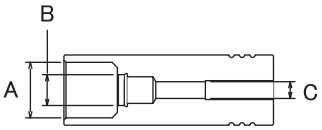
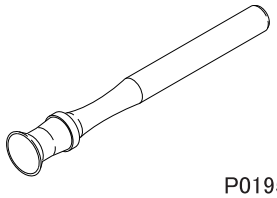
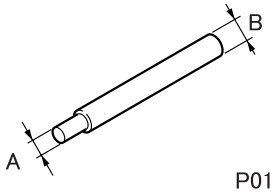
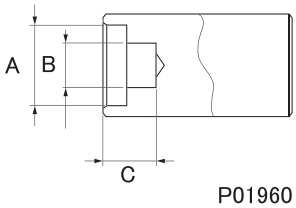
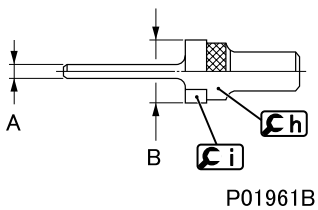
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Tapered plug	14 {10, 1.4}	–
Tb	Stud	20 {15, 2.0}	–

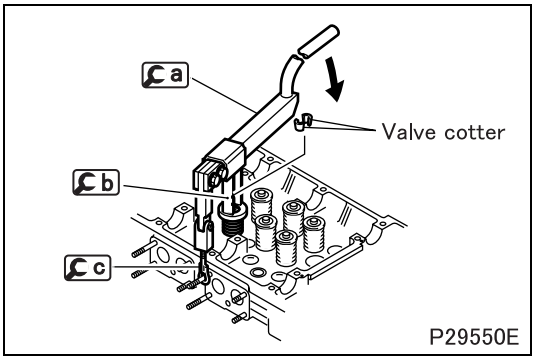
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Lip of valve stem seal	Engine oil	As required
	Valve stem and valve end		

Special tools (Unit: mm {in.})

Mark	Tool name and shape	Part No.	Application
a	Valve lifter  21239	MH061668	Removal and installation of valve cotters
b	Valve lifter seat A: φ38 {φ1.50}	MH061772	
c	Valve lifter hook  21240	MH061679	
d	Valve stem seal installer A: φ26.5 {φ1.04} B: φ14.7 {φ0.58} C: φ8 {φ0.31}  P29931	MH063607	Installation of valve stem seals
e	Valve lapper  P01958	30091-07500	Lapping valves and valve seats
f	Valve guide remover A: φ8 {φ0.31} B: φ12 {φ0.47}  P01959	31391-10500	Removal of valve guides
g	Valve guide installer A: φ25.5 {φ1.00} B: φ13 {φ0.51} C: 29 {1.14}  P01960	MH063604	Installation of valve guides
h	Caulking tool body A: φ8 {φ0.31}	31391-13100	Installation of valve seat
i	Installer ring B: φ38 {φ1.50}  P01961B	MH063605	

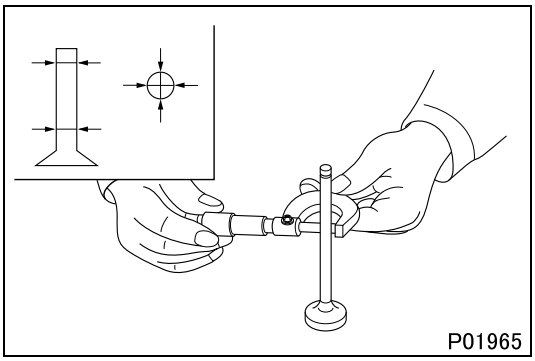
◆Removal procedure◆



■Removal: Valve cotters

- Remove the valve cotters by evenly compressing the valve springs.

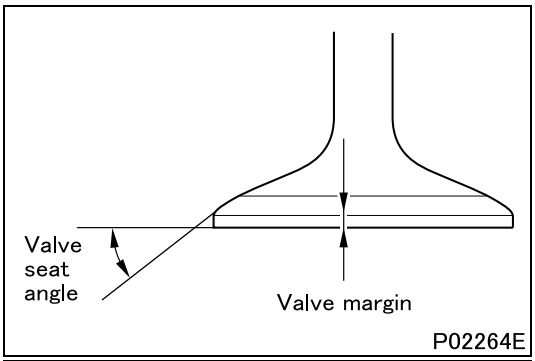
◆Inspection procedure◆



■Inspection: Intake valves and exhaust valves

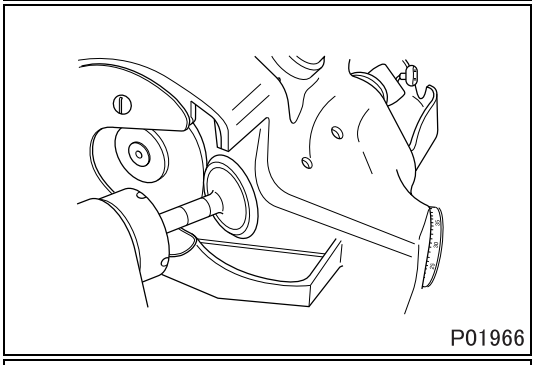
(1) Inspection of valve stem

- Replace the valve if the stem's outside diameter is below the limit or is severely worn.
- When the valve has been replaced with a new one, make sure to lap the valve and valve seat.



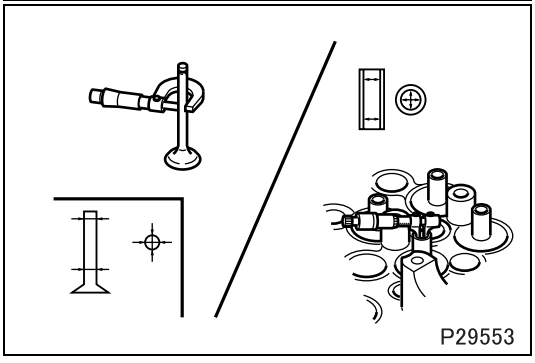
(2) Valve seat angle and valve margin

- Reface or replace the valve if the valve seat angle or valve margin exceeds the specified limits.



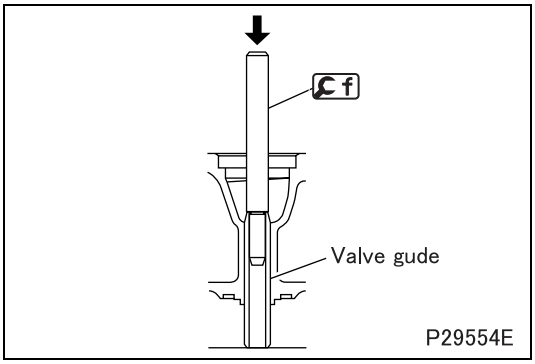
Refacing

- Limit grinding to a necessary minimum.
- If the valve margin is below the limit after grinding, replace the valve.
- After grinding, make sure to lap the valve and valve seat.

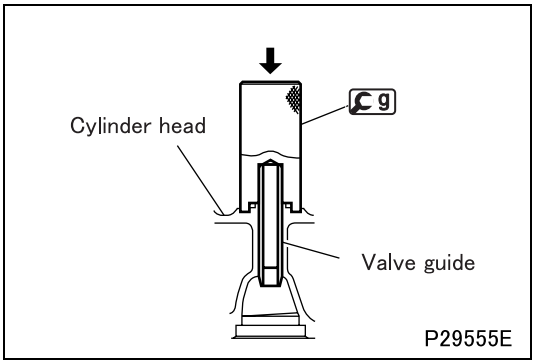


■Inspection: Valve-to-valve guide clearance

- If the clearance exceeds the specified limit, replace the defective part(s).



Replacement of valve guides
[Removal]

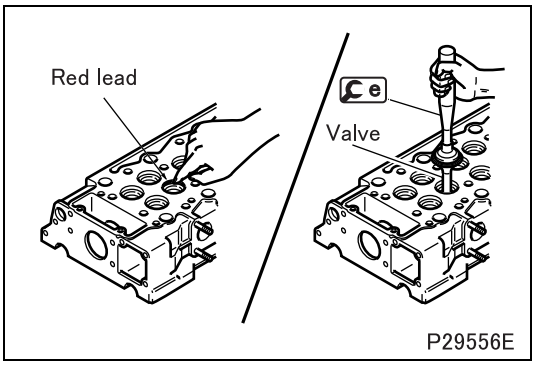


[Installation]

- Install the valve guide until g sits snugly on the cylinder head.

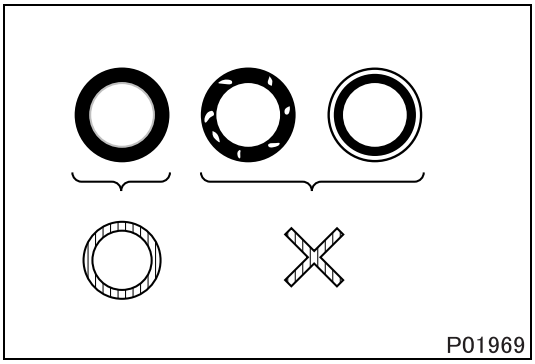
CAUTION ⚠

- **The valve guides must be pressed to the specified depth. Be sure to use g for this operation.**
- **Exhaust valve guides are longer than intake valve guides. Make sure to install the correct type of guide in each location.**



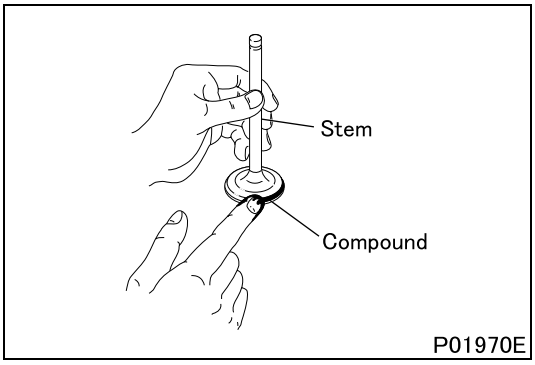
■ Inspection: Contact between valve and valve seat

- Before starting inspection, check that the valve and valve guide are intact.
- Apply an even coat of red lead to the valve contact surface of the valve seat.
- Strike the valve once against the valve seat. Do not rotate the valve during this operation.



- If the red lead deposited on the valve indicates a poor contact pattern, take either of the following corrective actions.

	Corrective action
Minor defect	Lapping
Serious defect	Reface or replace valve and valve seat

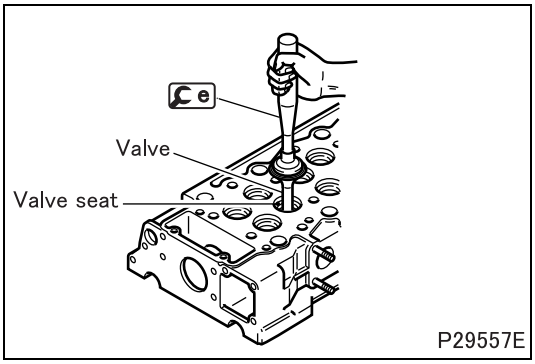


Lapping

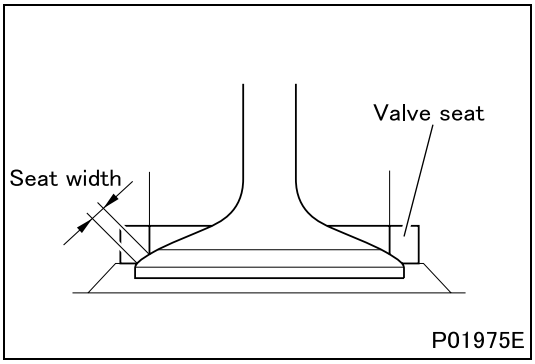
- Perform the valve lapping in the following procedure.
- Apply a thin coat of lapping compound to the seat contact surface of the valve.
- Start with an intermediate-grit compound (120 to 150 grit) and finish with a fine-grit compound (200 grit or more). Do not put any compound on the stem.
- Adding a small amount of engine oil to the lapping compound can facilitate even application.

CAUTION ⚠

- **Do not put any compound on the stem.**



- Strike the valve several times against the valve seat while rotating the valve a little at a time.
- Wash away the compound with diesel fuel.
- Apply engine oil to the valve contact surface of the valve seat and rub in the valve and seat well.
- Inspect the contact pattern of the valve and valve seat again.
- If the contact pattern is still defective, replace the valve seat.



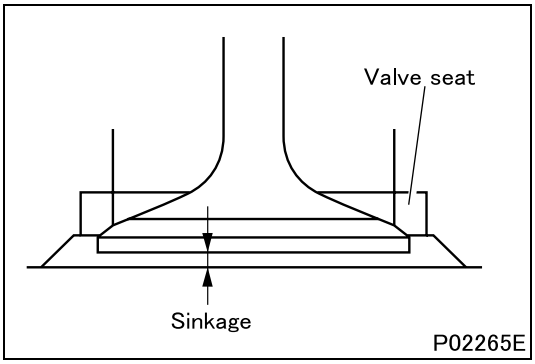
■ Inspection: Valve seats

(1) Valve seat width

- If the measurement exceeds the limit, reface or replace the valve seat.

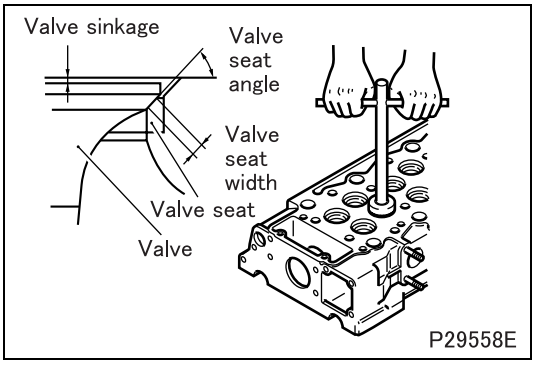
CAUTION ⚠

- **After refacing or replacing the valve seat, make sure to lap the valve seat and valve.**



(2) Valve sinkage from cylinder head bottom surface

- Make sure that the valve and valve seat are pressed together tightly when measuring the sinkage.
- If the measurement exceeds the limit, reface or replace the defective part(s).



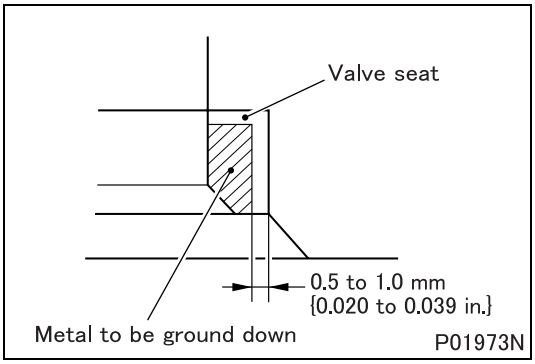
Refacing the valve seat

- Grind the valve seat using a valve seat cutter or valve seat grinder.
- Place a sandpaper of around #400 between the cutter and valve seat and grind the valve seat lightly.
- Use a 15° or 75° cutter to cut the valve seat to a width within the standard range. If the valve seat cannot be refaced to a width within the standard range, replace it.

CAUTION ⚠

- **Make sure that the valve seat refacing does not cause the valve sinkage to exceed the specified limit.**

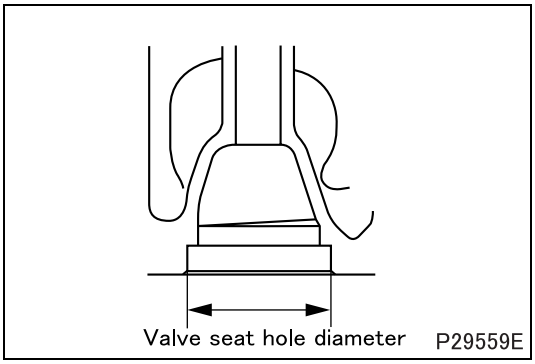
- Lap the valve and valve seat.



Replacement of valve seat

[Removal]

- The valve seats are installed by expansion fitting. To remove a valve seat, grind inside the metal stock to reduce the wall thickness, then remove the valve seat at room temperature.

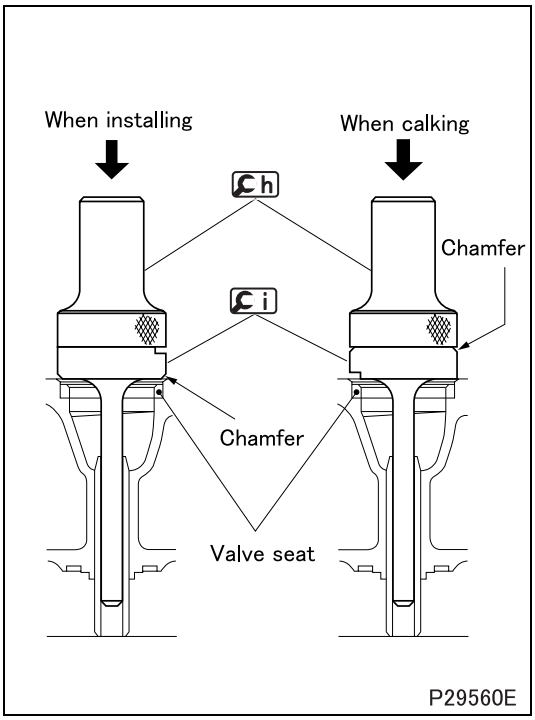


[Installation]

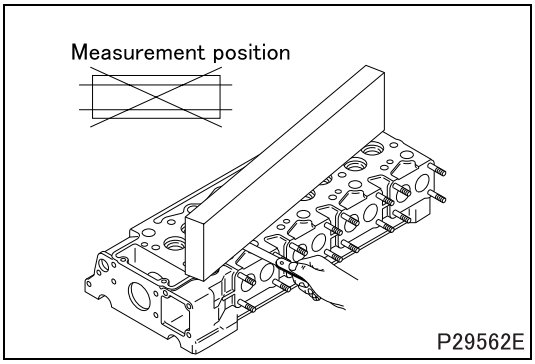
- Check that the diameter of the valve seat hole in the cylinder head conform with the value shown below.

Valve seat hole diameter	$\phi 38\ ^{+0.025}_{0}$ mm {$\phi 1.50\ ^{+0.00098}_{0}$ in.}

- Replace the cylinder head if the measurement deviates from specification.



- Chill the valve seat thoroughly by immersing in it in liquid nitrogen.
- Install the valve seat in the cylinder head using h and i, with the chamfered edge of i toward the valve seat.
- Turn i over so that its chamfered edge is toward h, and calk the valve seat.
- Lap the valve seat and valve.



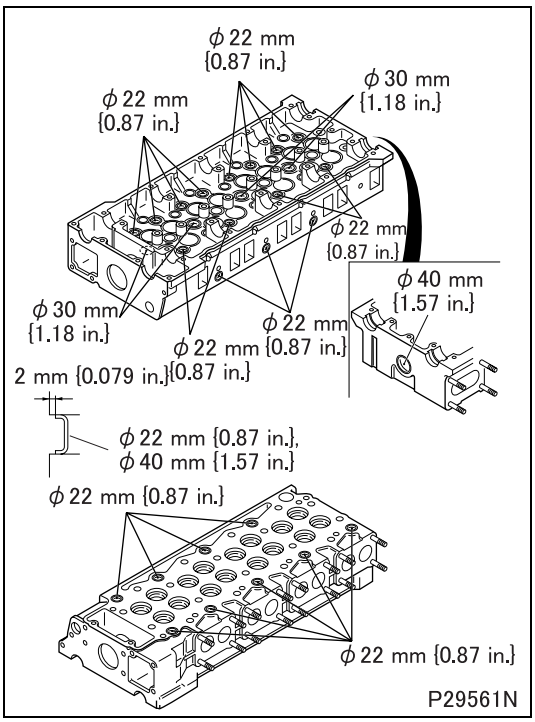
■ Inspection: Cylinder head bottom surface distortion

- If the distortion exceeds the specified limit, rectify it using a surface grinder.

CAUTION ⚠

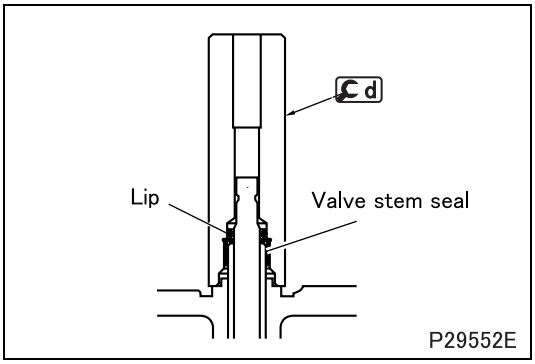
- **When grinding the cylinder head bottom surface, make sure that the height of the cylinder head (from the top surface to the bottom surface) is not reduced to a value below the specified limit.**

◆Installation procedure◆



■Installation: Sealing caps

- Drive the sealing caps into the cylinder head to the specified depth.



■Installation: Valve stem seal

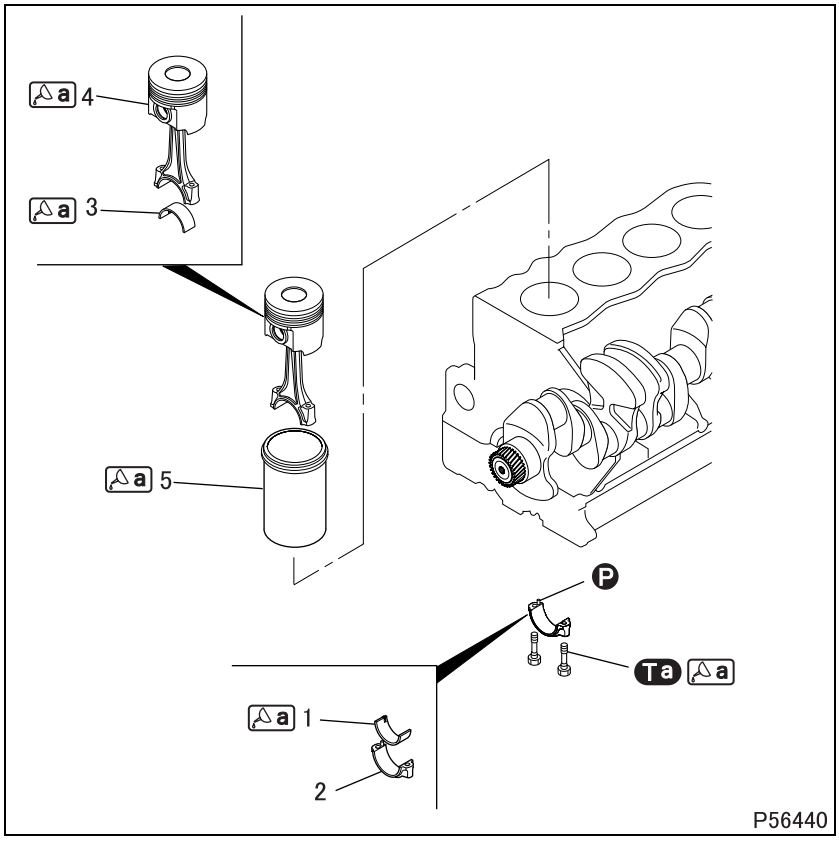
- Apply engine oil to the lip of the valve stem seal.
- Install the valve stem seal until d sits snugly on the cylinder head.

CAUTION ⚠

- **After installing the valve stem seal, check that its spring is not deformed or damaged.**

■Installation: Valve cotter

- To install the valve cotter, follow the removal procedure. (See **"■ Removal: Valve cotter"**.)



● **Disassembly sequence**

1 Lower connecting rod bearing
2 Connecting rod cap
3 Upper connecting rod bearing
4 Piston and connecting rod assembly (See later sections.)
5 Cylinder liner

Ⓟ: Locating pin

● **Assembly sequence**

Follow the disassembly sequence in reverse.

Service standards (Unit: mm {in.})

Location	Maintenance item		Standard value	Limit	Remedy
–	Piston projection from crankcase top surface (average value)		–0.088 to 0.094 {–0.0035 to 0.037}	–	Inspect
–	Connecting rod end play		0.15 to 0.45 {0.0059 to 0.018}	0.6 {0.024}	Inspect
1, 3	Connecting rod bearing	Span when free	–	Less than 69.5 {2.74}	Replace
		Oil clearance	0.034 to 0.093 {0.0013 to 0.0037}	0.2 {0.0079}	
4, 5	Piston-to-cylinder liner clearance		0.181 to 0.201 {0.0071 to 0.0079}	–	Replace

PISTONS, CONNECTING ROD, AND CYLINDER LINERS

Location	Maintenance item		Standard value	Limit	Remedy
5	Cylinder liner	Flange projection above crankcase top surface	0.01 to 0.07 {0.00039 to 0.0028}	–	Replace
		Bore diameter	ϕ114 to 114.02 {ϕ4.4881 to 4.4889}	ϕ114.25 {ϕ4.50}	
		Out-of-roundness	0.08 {0.0031} or less	–	
		Taper	0.03 {0.0012} or less	–	
		Difference in flange projection from neighboring cylinder liner	0.04 {0.0016} or less	–	

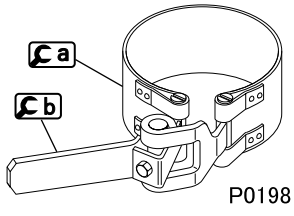
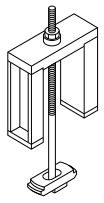
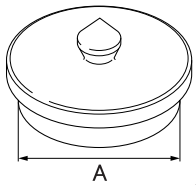
Tightening torque (Unit: N·m {lbf·ft, kgf·m})

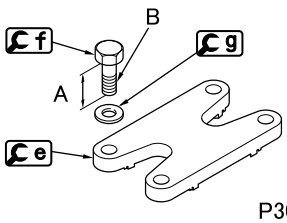
Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (connecting rod cap installation)	29 {21, 3.0} + 90° ± 5°	Wet

Lubricant and/or sealant

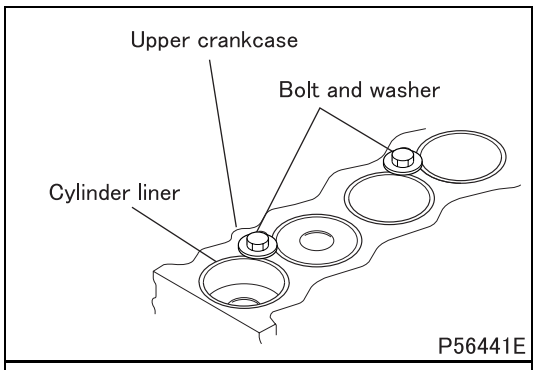
Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Bolt threads	Engine oil	As required
	Connecting rod bearing inside surface		
	Upper crankcase contact surface of cylinder liner		
	Piston outside surface		
	Cylinder liner wall surface		

Special tools (Unit: mm {in.})

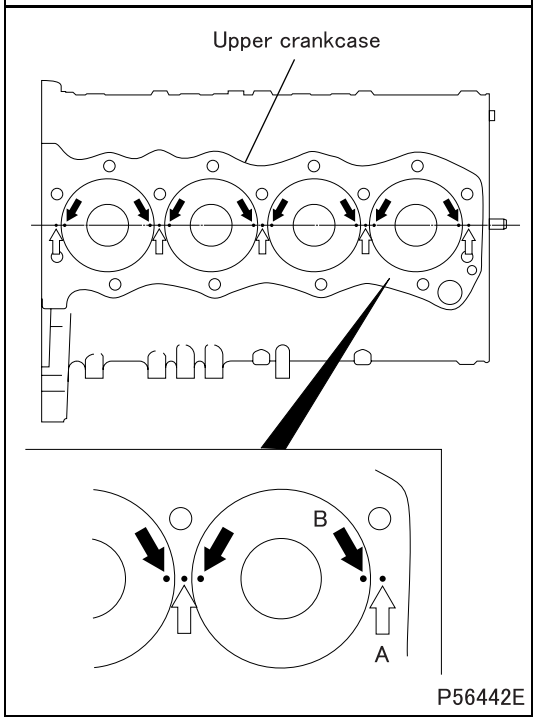
Mark	Tool name and shape		Part No.	Application
a	Piston guide clamp	 P01981	MH064332	Installation of piston and connecting rod assembly
b	Piston guide lever		MH061658	
c	Cylinder liner extractor	 P30008	MH062537	Removal of cylinder liner
d	Cylinder liner installer A: ϕ113.5 {ϕ4.47}	 P30010	MH063606	Installation of cylinder liner

e	Adapter	 P30009	MH063433	Measurement of cylinder liner flange projection above upper crankcase top surface and difference in flange projection between neighboring cylinder liners
f	Bolt A: 40 {1.57}, B: M14 × 2		MF130625	
g	Washer		MH005012	

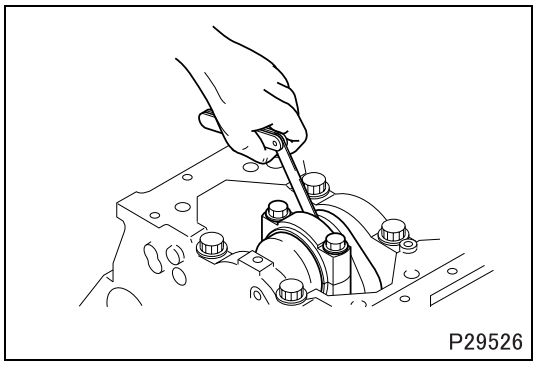
◆Inspection before removal◆



P56441E



P56442E


P29526

■Retaining cylinder liners

- The cylinder liners slips out of the upper crankcase easily when the upper crankcase is turned over or the crankshaft is rotated with pistons inside liners. To prevent this from happening, retain the flange of each cylinder liner in position with a bolt and washer.

■Inspection: Piston projection from upper crankcase top surface

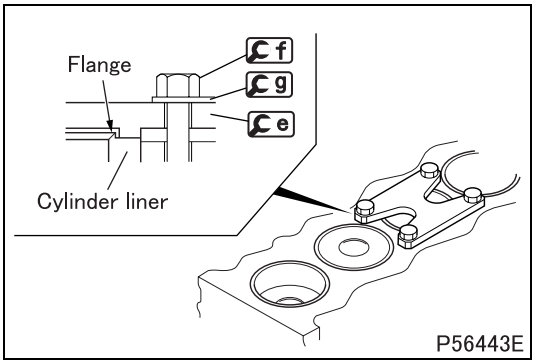
CAUTION ⚠

- **The amount of piston projection affects engine performance and must therefore be inspected without fail.**

- Set the piston at the top dead center.
- Mark reference points **A** (five points in total) on the top surface of the upper crankcase as shown in the illustration. Using each of the marks as a zero point, measure the amount of piston projection relative to the zero point (height of measurement point **B** – height of reference point **A**).
- Make the measurements at the two measurement points **B** for each cylinder (eight points in total) using the reference point **A** nearest to each measurement point, and calculate the average value of all the measurements.
- If the average value is out of the standard value range, check the clearances between all relevant parts.
- Select and use a cylinder head gasket that can accommodate the average piston projection (average value of the eight measurements).

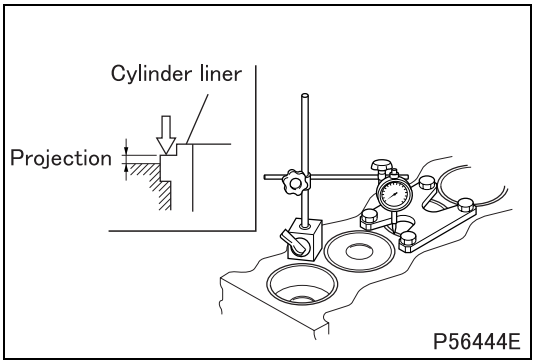
■Inspection: Connecting rod end play

- Measure the end play for every connecting rod.
- If any measurement exceeds the specified limit, replace the defective part(s).



■ **Inspection: Difference in flange projection between neighboring cylinder liners**

- Install e on the upper crankcase so that it is not lying on top of any part of the flanges. Tighten f to a torque of 49 N·m {36 lbf·ft, 5 kgf·m}.

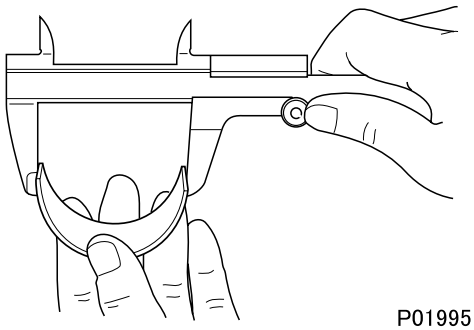


- Measure the amount of projection of the cylinder liner flange above the upper crankcase top surface.
- If the measurement is not within the standard value range, inspect the state of installation of the cylinder liner and then replace the defective part(s).

CAUTION ⚠

- **Insufficient projection of the flange can lead to a reduced pressure around the bore of the cylinder head gasket, causing gas leakage.**

◆Inspection procedure◆

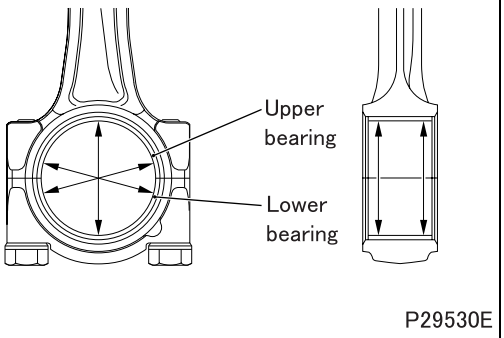

P01995

■ Inspection: Connecting rod bearing span when free

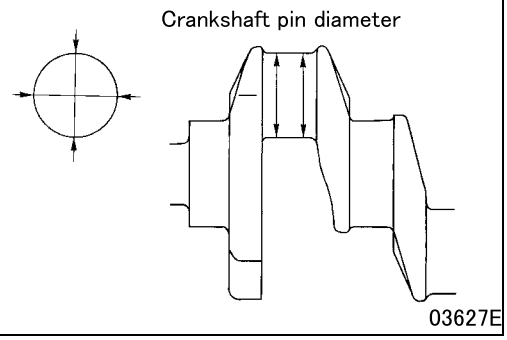
CAUTION ⚠

- **Do not attempt to manually expand the bearings.**
- **The upper and lower connecting rod bearings must be replaced as a set.**

- If the span is less than the specified limit, replace both the upper and lower bearings.



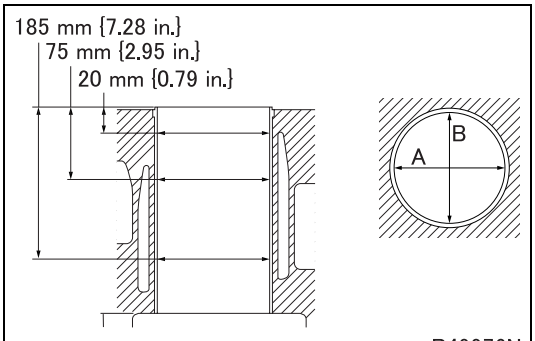
P29530E



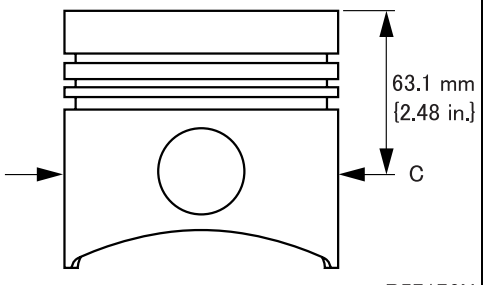
03627E

■ Inspection: Connecting rod bearing-to-crankshaft clearance (oil clearance)

- Fit the lower bearing to the connecting rod cap and the upper bearing to the connecting rod, then tighten the bolts to a torque of 30 N·m {22 lbf·ft, 3.1 kgf·m}.
- Measure the inside diameter of the bearing and the diameter of the crankshaft pin.
- If the clearance exceeds the limit, replace the defective part(s).
- If a bearing has to be replaced with an undersized one, machine the crankshaft pin to the specified undersize diameter.



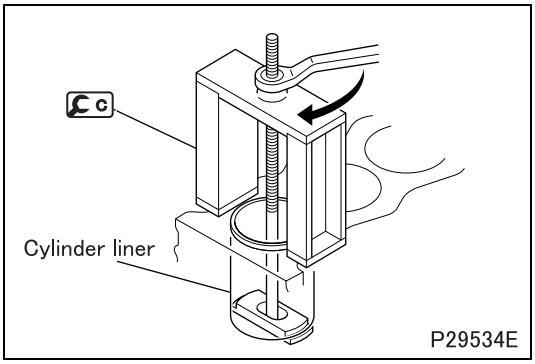
P49976N



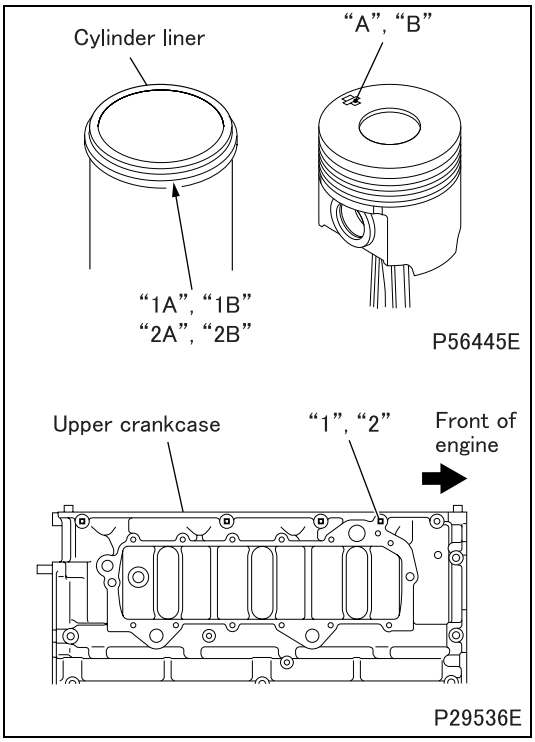
P57176N

■ Inspection: Piston-to-cylinder liner clearance

- If the measurement is not within the standard value range, replace the defective part(s).
  - **A:** Cylinder bore measurement (in direction of crankshaft axis)
  - **B:** Cylinder bore measurement (in direction perpendicular to crankshaft axis)
  - **C:** Piston diameter measurement (in direction perpendicular to piston pin hole)

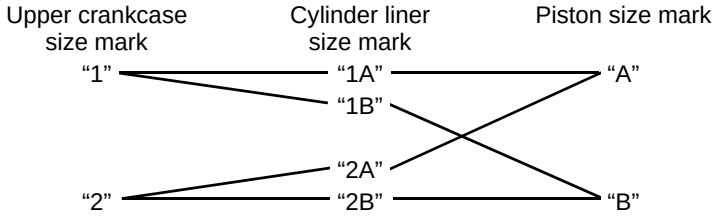


Replacement of cylinder liner
[Removal]



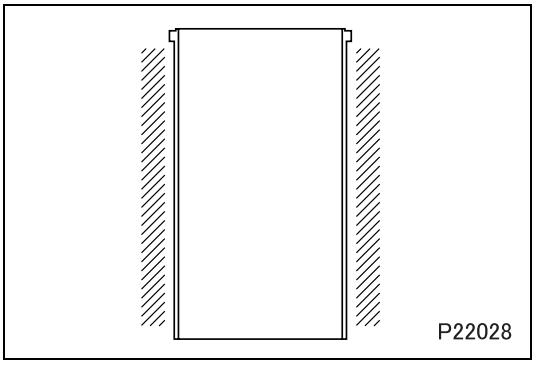
[Installation]

- Select cylinder liners with the same size marks as those on the upper crankcase and the pistons.
- The size marks on the upper crankcase are marked in the order of No. 1 cylinder, No. 2 cylinder, No. 3 cylinder and No. 4 cylinder starting with the front of the engine.

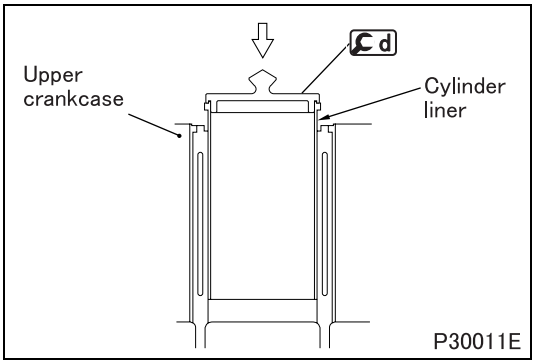


CAUTION ⚠

- **Make sure to use pistons and cylinder liners of the same size. Failure to do so may result in seizures it the engine.**



- Apply a thin coat of engine oil to the surfaces surrounding the cylinder liner of the upper crankcase (the shaded areas in the illustration).

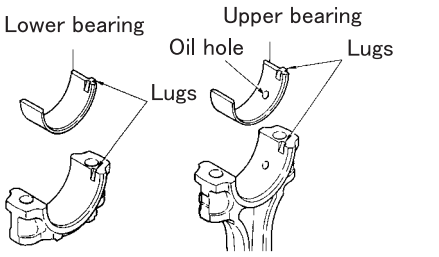


- Insert the cylinder liner into the upper crankcase by pushing down on d by hand slowly and evenly.

CAUTION ⚠

- **Handle the cylinder liner extremely carefully, as its wall is relatively thin and can be easily damaged.**

◆Installation procedure◆

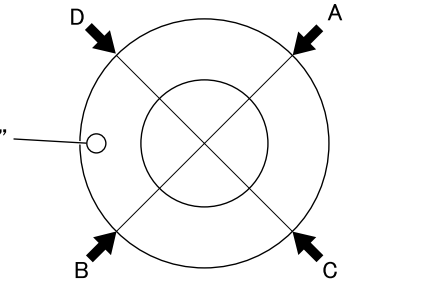


49975E

■ Installation: Connecting rod bearings

CAUTION ⚠

- **Do not reverse the positions of the lower bearing and the upper bearing (with oil hole) when installing, as this may cause seizure in the engine.**

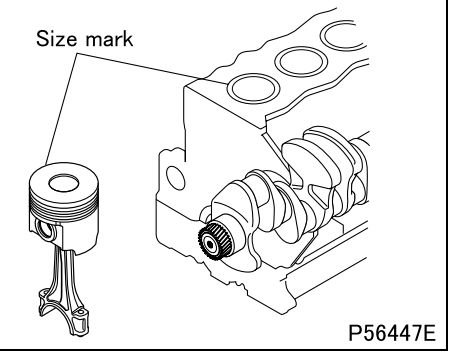


P56446

■ Installation: Piston and connecting rod assembly

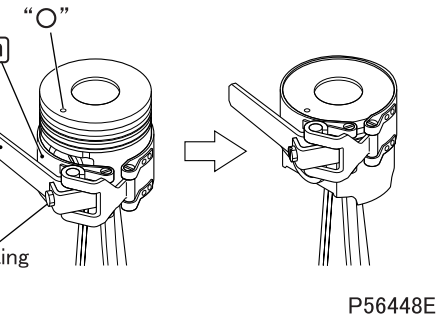
- Check that the piston ring end gaps are in their correct positions.
  - **A:** 1st compression ring gap
  - **B:** 2nd compression ring gap
  - **C:** Oil ring gap
  - **D:** Oil ring expander spring gap

"○": Front mark on piston

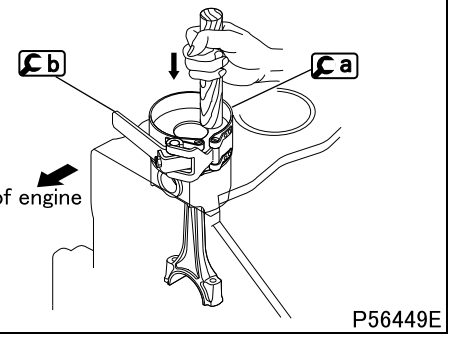


P56447E

- Check that the pistons and the cylinder liners have identical size marks (**"A"** or **"B"**).
- Install the pistons in the cylinder liners. Be careful not to scratch the inner surface of the liner and the crankshaft pins.

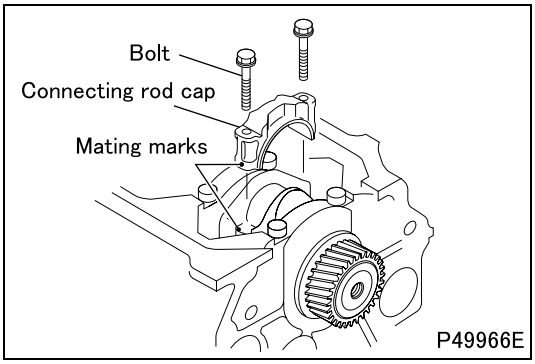


P56448E



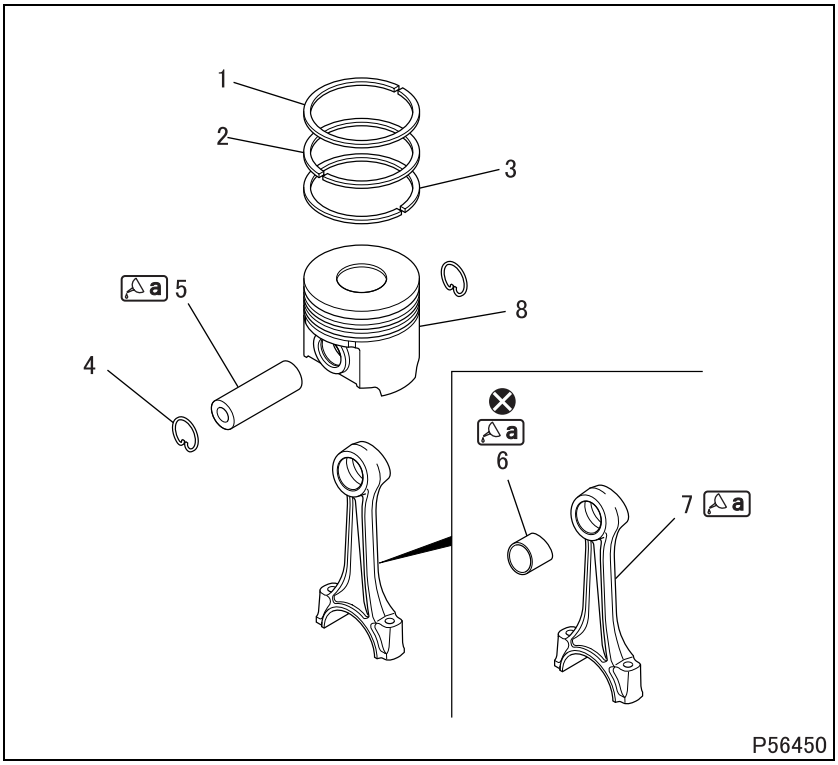
P56449E

- Face the front mark "○" of the piston toward the front of the engine.
- Using the adjusting bolt of [b], adjust the inside diameter of [a] such that it matches the piston's skirt diameter.
- Remove the tools from the piston and apply engine oil to the following parts before reinstalling the tools around the piston rings:
  - Outside surface of piston
  - Inside surface of [a]
  - Inside surface of cylinder liner



- After installing the piston and connecting rod assembly, align the mating marks on the connecting rod and connecting rod cap and tighten the bolts alternately in the following manner.
  - First tighten the bolt to a torque of 29 N·m {21 lbf·ft, 3.0 kgf·m}.
  - Tighten the bolt further by turning it clockwise by 90° ± 5°.

Piston and Connecting Rod



● Disassembly sequence

1 1st compression ring
2 2nd compression ring
3 Oil ring
4 Snap ring
5 Piston pin
6 Connecting rod bushing
7 Connecting rod
8 Piston

⊗: Non-reusable parts

● Assembly sequence

Follow the disassembly sequence in reverse.

Service standards (Unit: mm {in.})

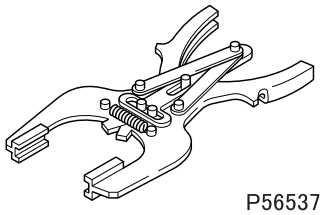
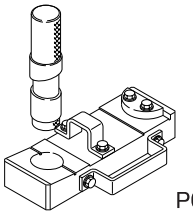
Location	Maintenance item		Standard value	Limit	Remedy
1 to 3	Piston ring end gap	1st compression ring	0.3 to 0.45 {0.012 to 0.018}	1.5 {0.059}	Replace
		2nd compression ring	0.4 to 0.55 {0.016 to 0.022}		
		Oil ring	0.3 to 0.5 {0.012 to 0.020}		
1 to 3, 8	Piston ring side clearance in piston groove	1st compression ring	0.129 to 0.178 {0.0051 to 0.0070}	0.2 {0.0079}	Replace
		2nd compression ring	0.065 to 0.105 {0.0026 to 0.0041}	0.15 {0.0059}	
		Oil ring	0.025 to 0.065 {0.00098 to 0.0026}		
4, 6	Piston pin-to-connecting rod bushing clearance		0.020 to 0.055 {0.00079 to 0.0022}	0.1 {0.0039}	Replace
4, 8	Piston pin-to-piston clearance		0.004 to 0.022 {0.00016 to 0.00087}	0.05 {0.0020}	Replace
7	Connecting rod	Bend	–	0.05 {0.0020}	Replace
		Twist	–	0.1 {0.0039}	

Lubricant and/or sealant

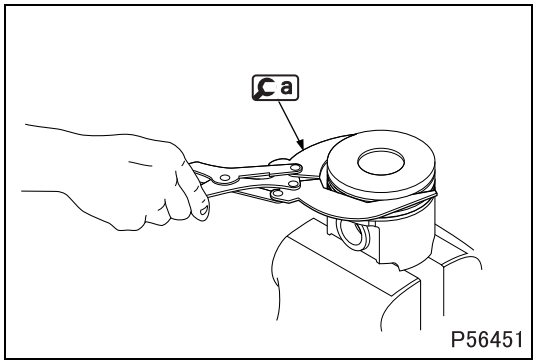
Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Piston pin outside surface	Engine oil	As required
	Connecting rod bushing outside surface		
	Connecting rod bushing fitting surface of connecting rod		

PISTONS, CONNECTING ROD AND CYLINDER LINERS

Special tools

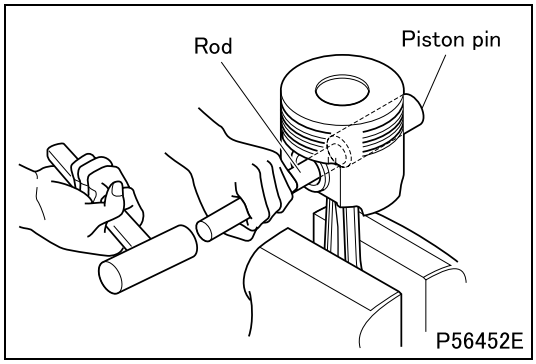
Mark	Tool name and shape	Part No.	Application
a	Piston ring tool  P56537	MH060014	Removal and installation of piston rings
b	Connecting rod bushing puller kit  P02015	MH062225	Removal and installation of connecting rod bushings

◆Removal procedure◆



P56451

■ **Removal: Piston ring**

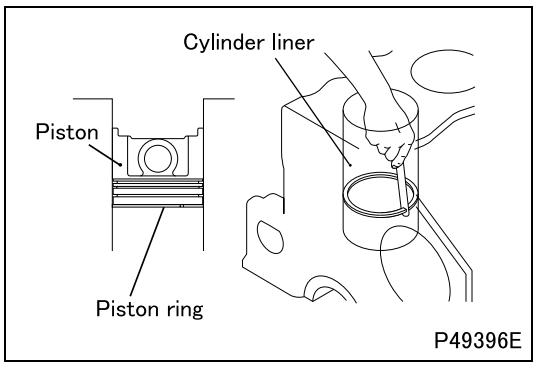


P56452E

■ **Removal: Piston pin**

- Remove the piston pin by striking it with a rod and hammer.
- If the piston pin is difficult to remove, first heat the piston in hot water or with a piston heater.

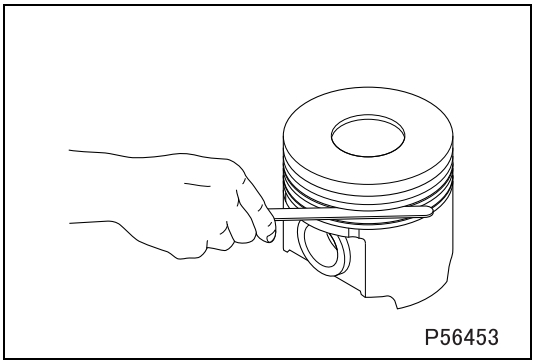
◆Inspection procedure◆



P49396E

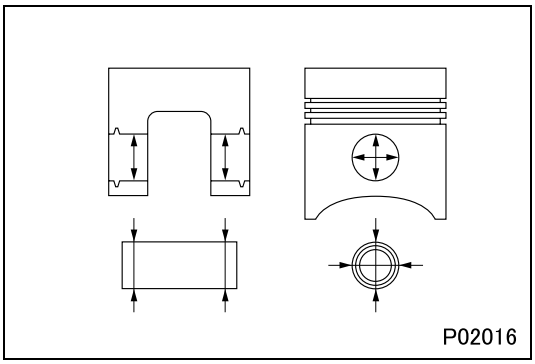
■ **Inspection: Piston ring end gap**

- Using the crown of a piston, push the piston ring horizontally into a cylinder in the cylinder liner until it reaches the lower part of the cylinder liner, where there is relatively small wear.
- Taking care not to move the piston ring, measure the end gap.
- If any of the rings has a gap exceeding the specified limit, replace all the piston rings as a set.



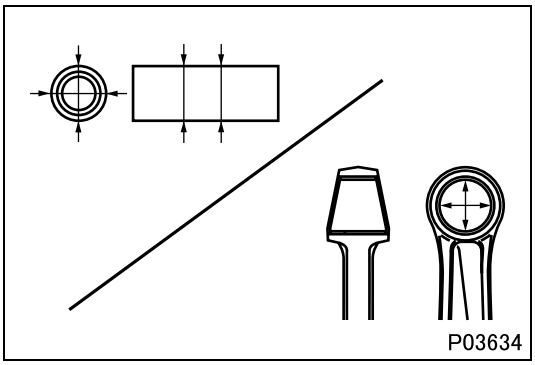
■ **Inspection: Piston ring side clearance in piston groove**

- Remove any carbon deposits from the ring groove in the piston.
- Measure the side clearance of each ring around the piston's entire periphery.
- If any of the measurements exceeds the specified limit, replace the defective part(s). If any of the piston rings is defective, replace all the rings on the piston as a set.



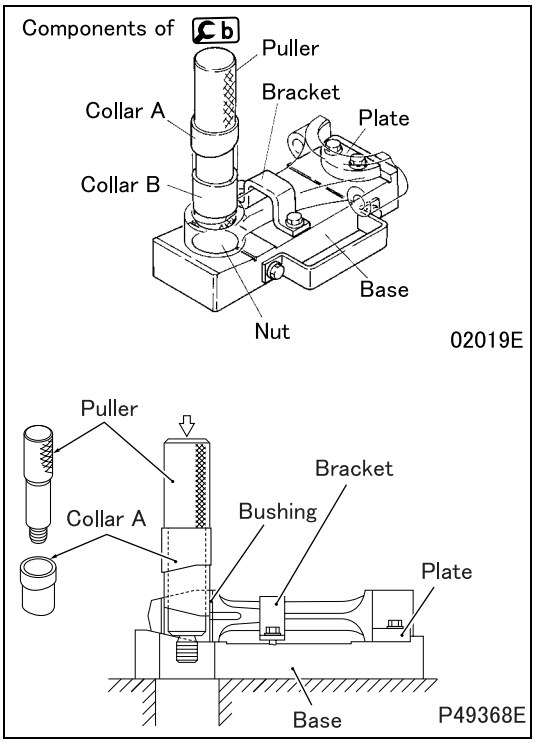
■ **Inspection: Piston pin-to-piston clearance**

- If the measurement exceeds the specified limit, replace the defective part(s).



■ **Inspection: Piston pin-to-connecting rod bushing clearance**

- If any of the measurements exceeds the specified limit, replace the bushing.

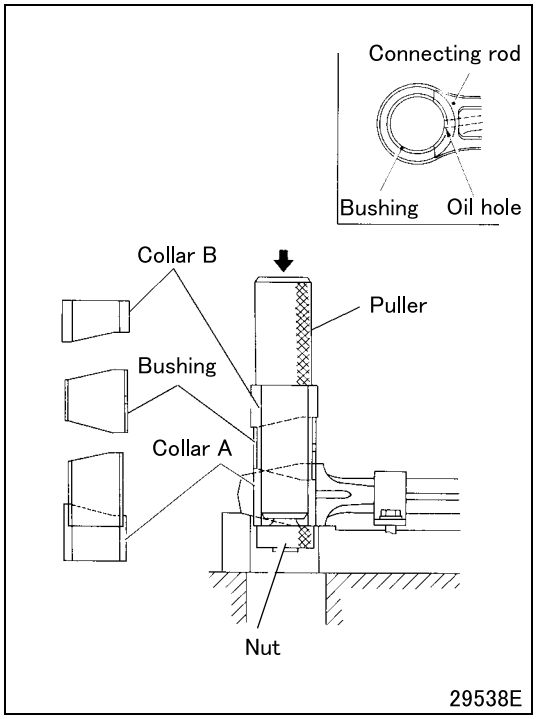


Replacement of connecting rod bushing

- Replace the connecting rod bushing using b.

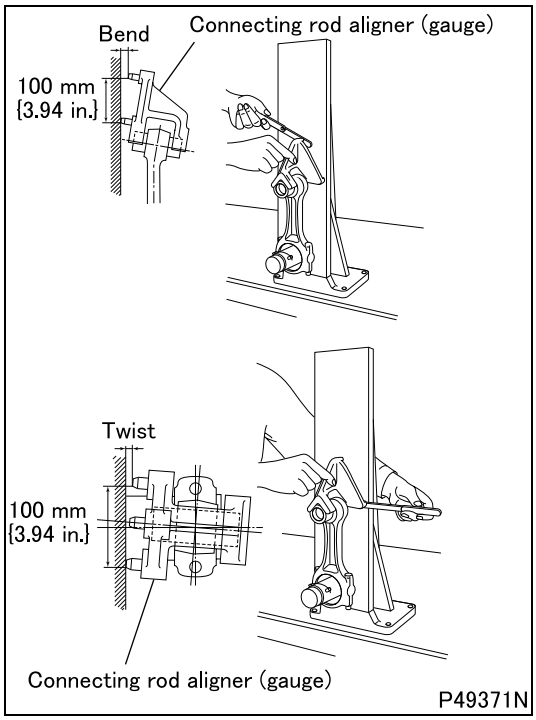
[Removal]

- Remove the upper bearing (if fitted) from the big end of the connecting rod.
- Mount the connecting rod on the base and lock it in position with the bracket and plate.
- Fit collar A over the puller with its ends facing in the illustrated directions. Then, slowly apply a pressure of approximately 49 kN {11020 lbs, 5000 kgf} to the puller with a press to force out the connecting rod bushing.



[Installation]

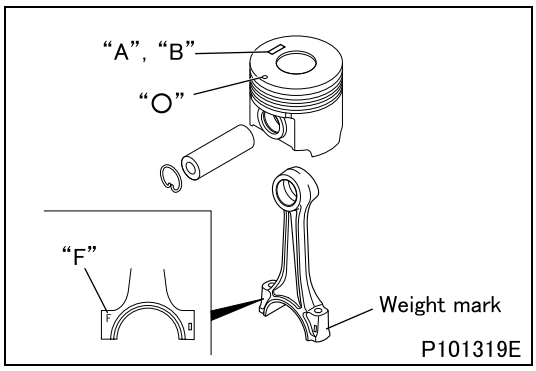
- Apply engine oil to the outside surface of the connecting rod bushing and the bushing fitting surface of the connecting rod.
- Fit collar B, the bushing, and collar A over the puller in the illustrated directions and lock this arrangement together with the nut.
- Align the oil holes in the connecting rod bushing and the connecting rod. Then, use a press to slowly apply a pressure of approximately 49 kN {11020 lbs, 5000 kgf} to the puller until the bushing is forced into place.
- After press-fitting the connecting rod bushing, measure the clearance between the piston pin and connecting rod bushing.
- If the measurement is less than the standard clearance range, ream the bushing.



■Inspection: Connecting rod bend and twist

- Mount the connecting rod on the connecting rod aligner. Also mount the connecting rod bearings, piston pin, and connecting rod cap to create the same conditions as are expected when the connecting rod is mounted on a crankshaft. Tighten the bolts of the connecting rod bearing cap to a torque of 30 N·m {22 lbf·ft, 3.1 kgf·m}.
- Measure the extent of bend and twist in the connecting rod.
- If either measurement exceeds the specified limit, replace the connecting rod.

◆Installation procedure◆

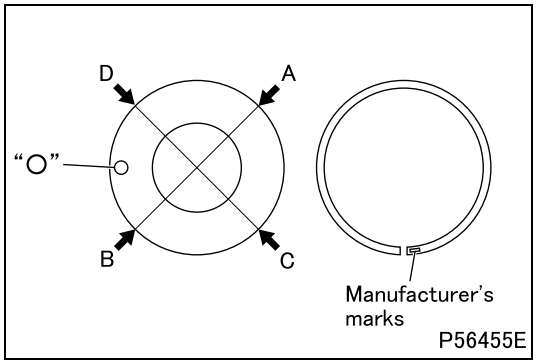


■ Installation: Piston and connecting rod

- Install pistons and connecting rods as follows when replacing them.
- All connnecting rods used in the same engine must be of the same weight size mark.
  Weight mark: "C" to "G"
- Apply engine oil to the piston pin, and assemble the piston and connecting rod with their marks facing in the illustrated directions.

"○": Front mark on piston
"F": Front mark on connecting rod

- If the piston pin is difficult to insert, heat the piston in hot water or with a piston heater.



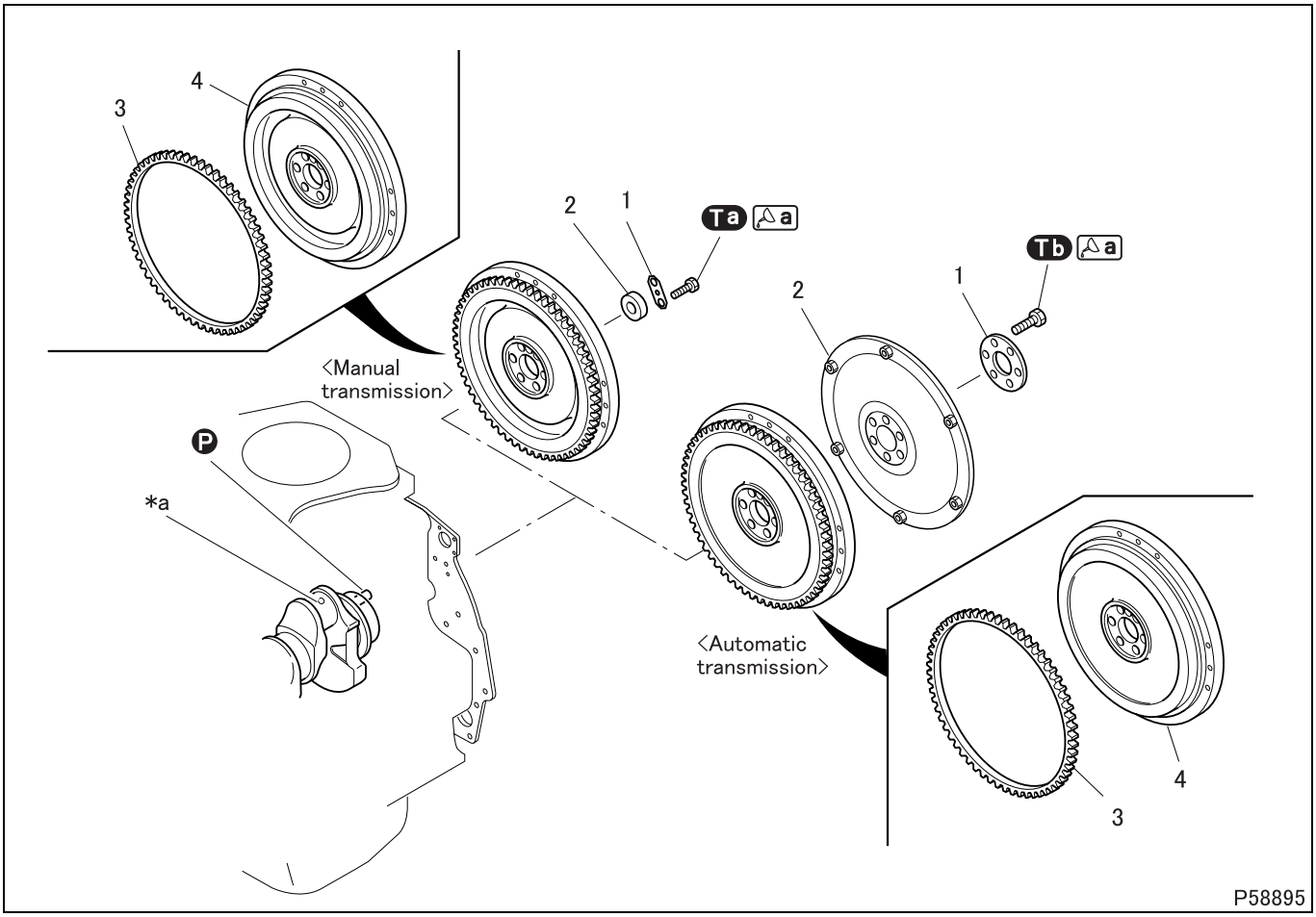
■ Installation: Piston rings

- With the manufacturer's marks (found near the piston ring end gaps) facing up, install the piston rings so that the end gap of each ring is positioned as illustrated.
  A: 1st compression ring end gap
  B: 2nd compression ring end gap
  C: Oil ring end gap
  D: Oil ring's expander spring end gap

"○": Front mark on piston

The manufacturer's marks are present only on the 1st and 2nd compression rings.

FLYWHEEL



● Disassembly sequence

1 Plate <Manual transmission>
Wear plate <Automatic transmission>
2 Bearing <Manual transmission>
Drive plate <Automatic transmission>
3 Ring gear
4 Flywheel assembly

***a**: Crankshaft
P: Locating pin

● Assembly sequence

Follow the disassembly sequence in reverse.

Service standards (Unit: mm {in.})

Location	Maintenance item		Standard value	Limit	Remedy
4	Flywheel <Manual transmission>	Friction surface runout (when fitted)	–	0.2 {0.0079}	Rectify or replace
		Friction surface height	19.5 {0.77}	18.5 {0.73}	
		Friction surface distortion	0.05 {0.0020} or less	0.2 {0.0079}	
		Friction surface parallelism	0.1 {0.0039} or less	–	

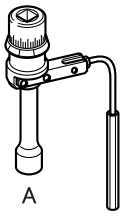
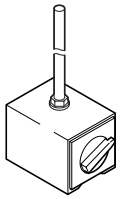
Tightening torque (Unit: N·m {lbf·ft, kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (flywheel assembly installation)	39 {44, 6.0} + 40°	Wet
Tb	Bolt (flywheel assembly installation)	118 {87, 12} + 90°	Wet

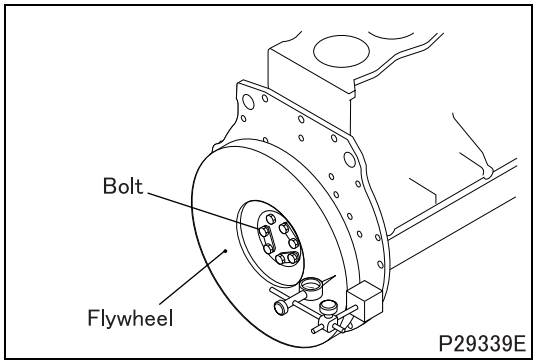
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Bolt threads	Engine oil	As required

Special tools (Unit: mm {in.})

Mark	Tool name and shape	Part No.	Application
a	Socket wrench A: Bolt head width across flats: 22 {0.87}  P01984	MH062183	Installation of flywheel assembly
b	Magnet base  P00471	MH062356	

◆Inspection before removal◆



■ **Inspection: Flywheel runout <Manual transmission>**

- If the runout exceeds the specified limit, check that the bolts are tightened correctly and that there are no abnormalities on the crankshaft mounting surface. If the runout is still excessive even after necessary steps have been taken according to the check results, rectify or replace the flywheel assembly.

◆Removal procedure◆

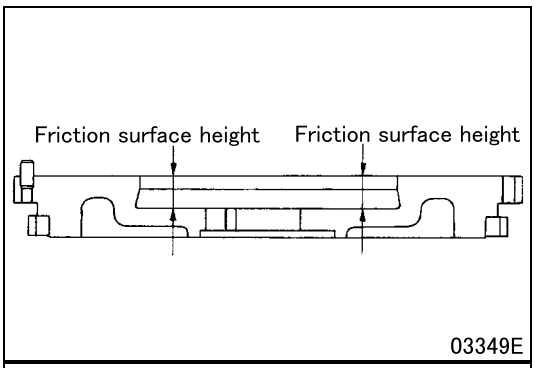
■ **Removal: Ring gear**

- Heat the ring gear evenly with a gas burner or the like until it reaches approximately 200°C {390°F}, then remove it from the flywheel assembly.

WARNING ⚠

- **You could get burnt if you touch the heated ring gear.**

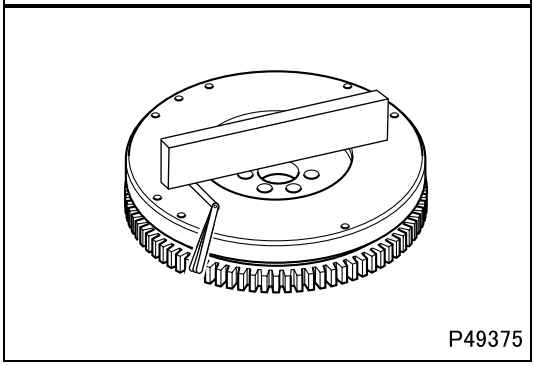
◆Inspection procedure◆



■ **Inspection: Flywheel assembly <Manual transmission>**

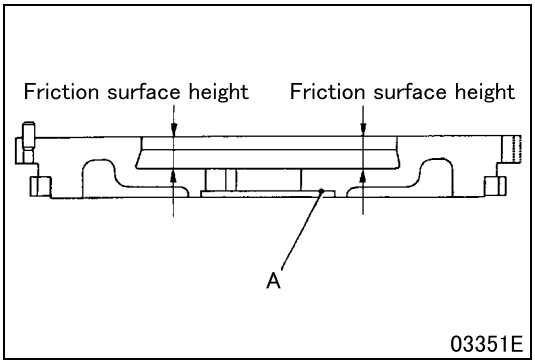
(1) Friction surface height

- If the height is below the specified limit, rectify or replace the flywheel assembly.



(2) Friction surface distortion

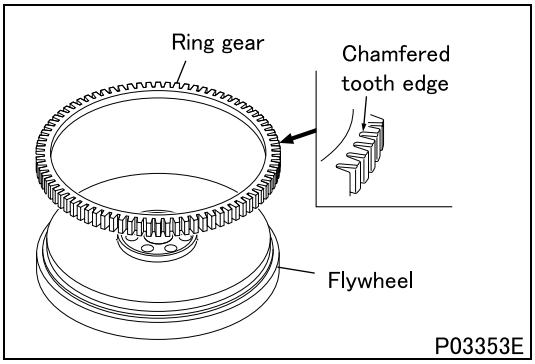
- If the measured amount of distortion is above the specified limit, rectify or replace the flywheel assembly.



Rectification of friction surface

- Rectify the friction surface so that its height is not below the specified limit, and it is parallel with surface **A** with an error not exceeding 0.1 mm {0.0039 in.}.

◆Installation procedure◆



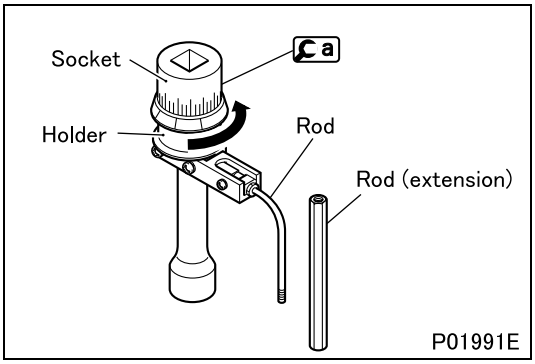
■ **Installation: Ring gear**

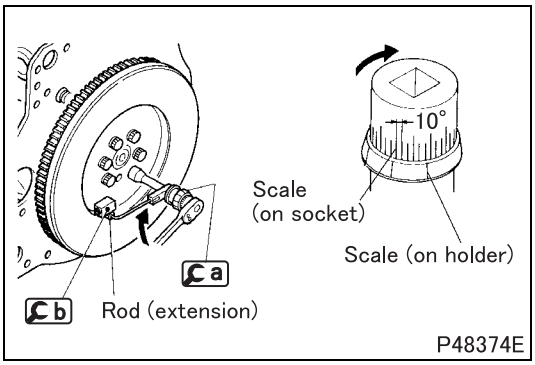
- Heat the ring gear evenly with a gas burner or the like until it reaches approximately 200°C {390°F}.

WARNING ⚠

- **You could get burnt if you touch the heated ring gear.**

- Fit the ring gear with the side having non-chamfered tooth edges toward the flywheel.

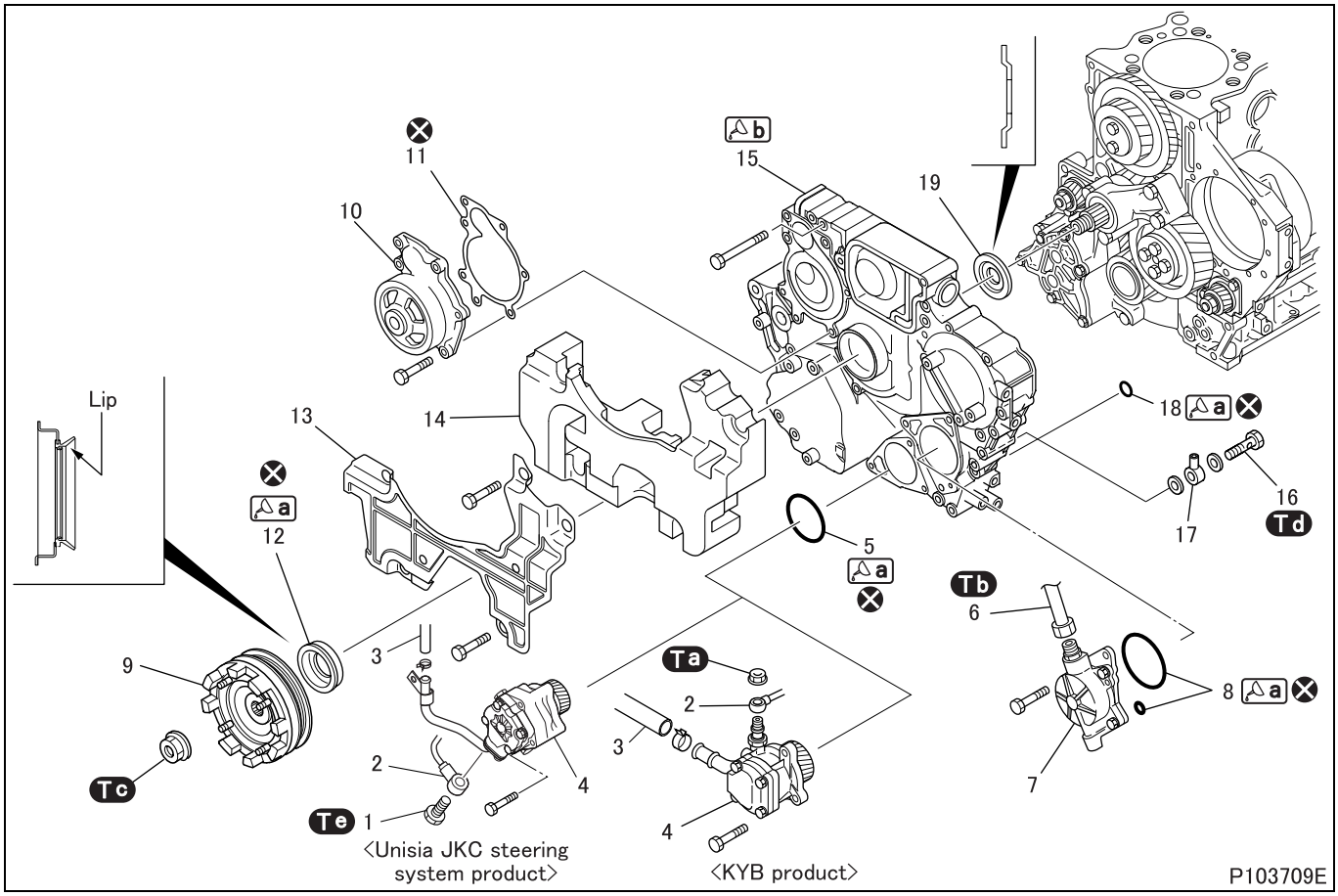




■ **Installation: Flywheel <Manual transmission>**

- Tighten all the bolts to 59 N·m {44 lbf·ft, 6.0 kgf·m} and then additionally tighten them by the following procedure.
- Rotate the holder of a counterclockwise to pretension the internal spring.
- Fit a on the bolt and set b so that the rod (extension) is held pressed against it by the spring force.
- Align a scale mark on the socket with a scale mark on the holder. (This point will be the point of reference, or the 0° point.)
- Starting with this point of reference, turn the socket clockwise with a wrench by 40° ± 5° (one graduation on the socket scale represents 10°).

FRONT CASE



● **Disassembly sequence**

1 Eyebolt <Unisia JKC steering system type>
2 Power steering pipe
3 Power steering hose
4 Power steering oil pump (See Gr37.)
5 O-ring
6 Vacuum pipe
7 Vacuum pump (See Gr35A.)
8 O-ring
9 Fan pulley
10 Water pump (See Gr14.)
11 Gasket
12 Front oil seal
13 Front case cover
14 Front case rubber
15 Front case
16 Eyebolt
17 Oil jet
18 O-ring
19 Front oil seal slinger

⊗: Non-reusable parts

● **Assembly sequence**

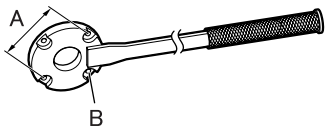
Follow the disassembly sequence in reverse.

Tightening torque (Unit: N·m {lbf·ft, kgf·m})

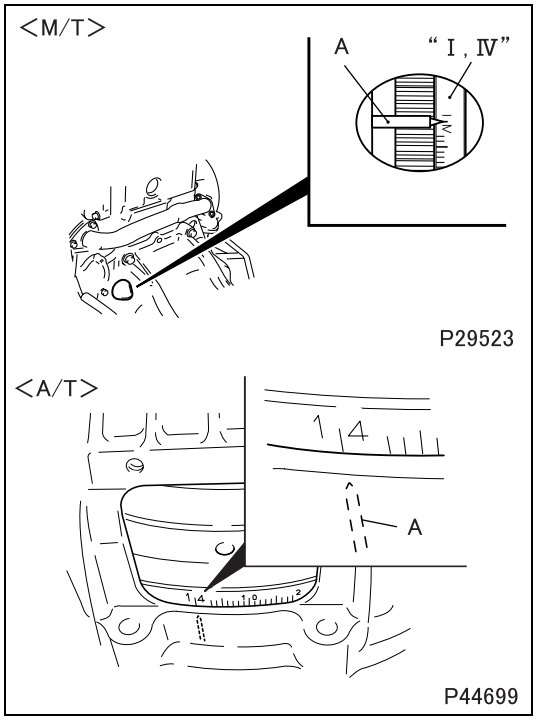
Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Nut (power steering pipe installation)	29.4 to 39.2 {22 to 29, 3 to 4}	–
Tb	Vacuum pipe	29.4 {22, 3.0}	–
Tc	Nut (fan pulley installation)	370 {270, 38}	–
Td	Eyebolt (oil jet installation)	10 {7.4, 1.0}	–
Te	Eyebolt (power steering pipe installation)	49.0 to 63.7 {36 to 47, 5.0 to 6.5}	–

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	O-ring	Engine oil	As required
	Front oil seal lip		
b	Front case installation surfaces	ThreeBond 1207C or D	As required

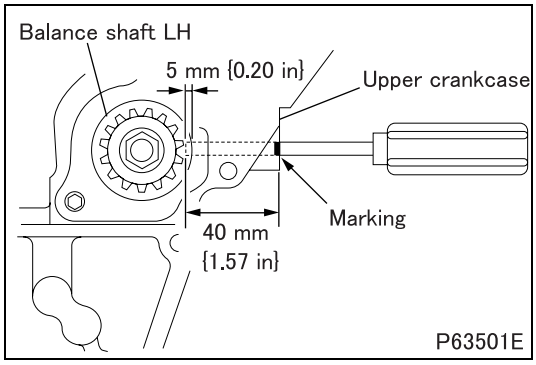
Mark	Tool name and shape	Part No.	Application
ⓒa	Holding bar A: 114 {4.49} B: ϕ9 {ϕ0.35}  P69433	MH062970	Holding of fan pulley

◆Removal procedure◆



■ Removal: Vacuum pump

- The vacuum pump also serves for positioning the balance shaft LH. Therefore, before removing the vacuum pump, hold the balance shaft in position by the following procedure.
- Align the pointer A to between the inscribed lines (**Ⅰ** and **Ⅳ** or **1** and **4**) on the flywheel. (Place No.1 cylinder piston at the top dead center on compression stroke.)

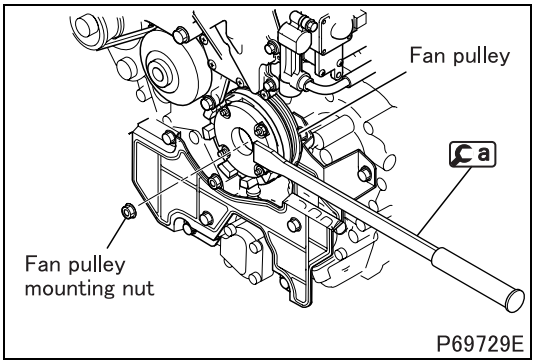


- Remove the upper crankcase plug.
- Mark a screwdriver or the like (ϕ4.5 mm {0.18 in} or less) at a point 40 mm {1.57 in} apart from its tip.
- Insert the screwdriver or the like (ϕ4.5 mm {0.18 in} or less) into the plug hole until it lightly touches the balance shaft LH.

CAUTION ⚠

- **Do not press the screwdriver hard against the balance shaft LH, as this may damage No.1 journal of the balance shaft.**

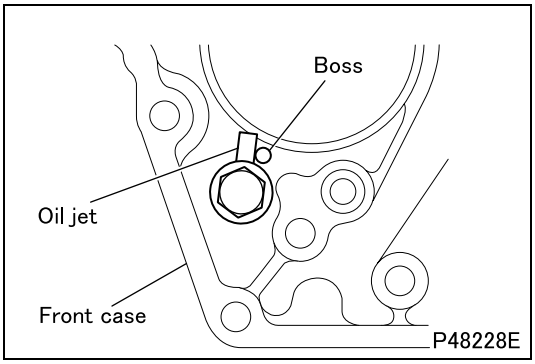
- Put the tip of the screwdriver or the like into the shaft supporting hole at No.1 journal of the balance shaft.
- This insertion depth of the screwdriver or the like into the shaft supporting hole should be 5 mm {0.20 in}.
- Remove the vacuum pump with the screwdriver or the like inserted in the hole.



■ **Removal: Fan pulley**

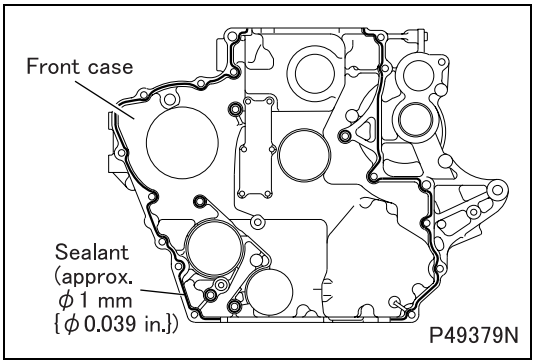
- Put Ca in position on the studs of the fan pulley and fix the tool by using nuts.
- While holding Ca, loosen the fan pulley mounting nut.

◆Installation procedure◆



■ **Installation: Oil jet**

- When installed, the oil jet must be in contact with the front case and its nozzle must face in the illustrated direction.

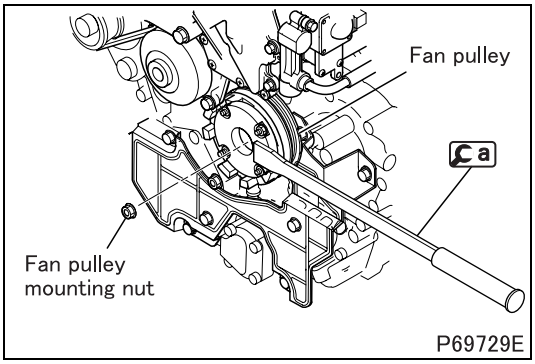


■ **Installation: Front case**

- Clean the sealant application surfaces of each part.
- Apply evenly thick beads of sealant to the upper crankcase mounting surface of the front case without any breaks.
- Mount the front case within three minutes of applying the sealant, being careful not to dislodge the sealant.

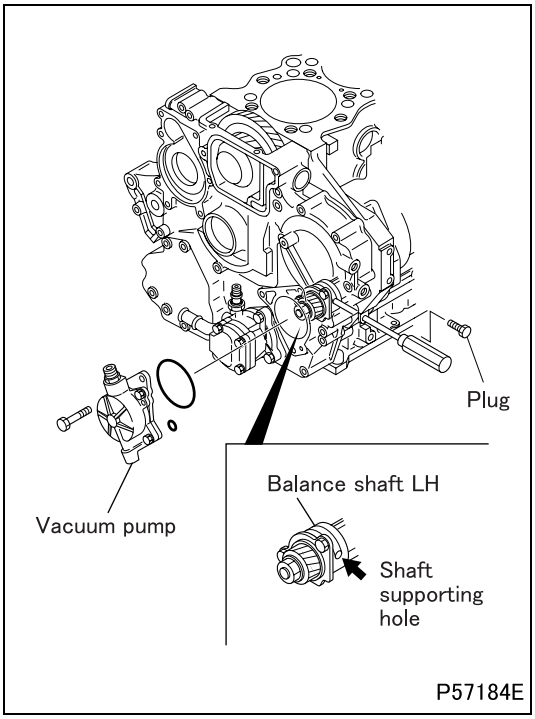
CAUTION ⚠

- **Do not run the engine within one hour of installing the front case.**
- **If the front case mounting bolts are loosened or removed, be sure to reapply sealant to the front case.**



■ **Installation: Fan pulley**

- Put Ca in position on the studs of the fan pulley and fix the tool by using nuts.
- Tighten the fan pulley mounting nut to the specified torque while holding Ca.



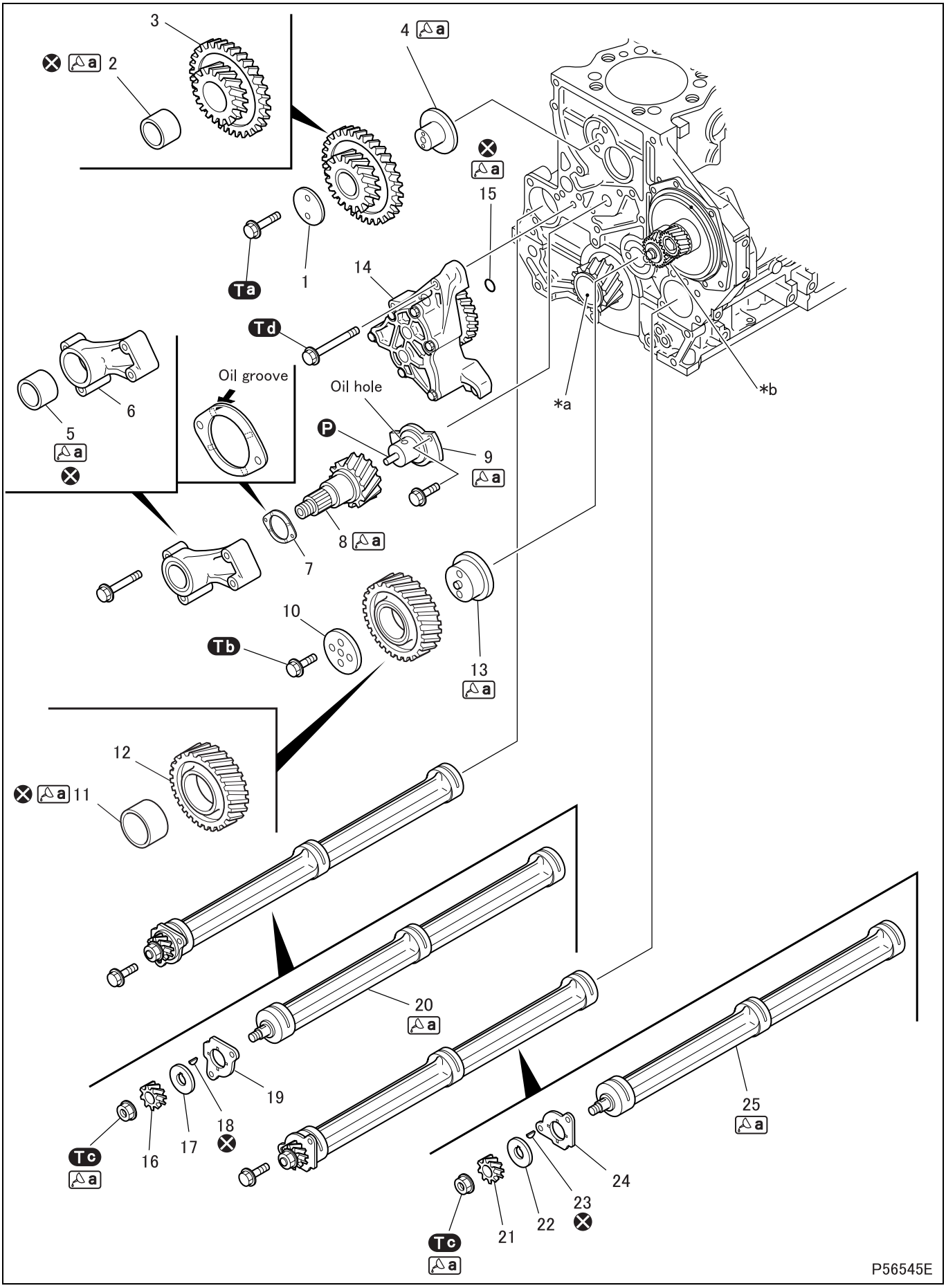
■ **Installation: Vacuum pump**

- The vacuum pump also serves as an element holding the balance shaft LH in place. Therefore, before installing the vacuum pump, hold the balance shaft LH in the correct position by the following procedure.
  - Place the No. 1 cylinder piston at the top dead center on compression stroke.
  - Remove the upper crankcase plug.
  - Insert a screwdriver or a similar tool into the plug hole until it lightly touches the balance shaft LH.

CAUTION ⚠

- **Do not press the screwdriver strongly against the balance shaft LH, as this may damage the No. 1 journal of the balance shaft.**

  - Turn the balance shaft LH slowly until the screwdriver aligns with the shaft support hole at the No. 1 journal and insert the screwdriver into the hole.
- Install the vacuum pump.
- After installing the vacuum pump, remove the screwdriver and reinstall the plug.


3
2
4
15
1
Ta
14
Td
Oil groove
Oil hole
6
5
9
8
7
*a
*b
10
Tb
13
12
11
20
19
18
17
16
Tc
25
24
23
22
21
Tc
P56545E

● Disassembly sequence

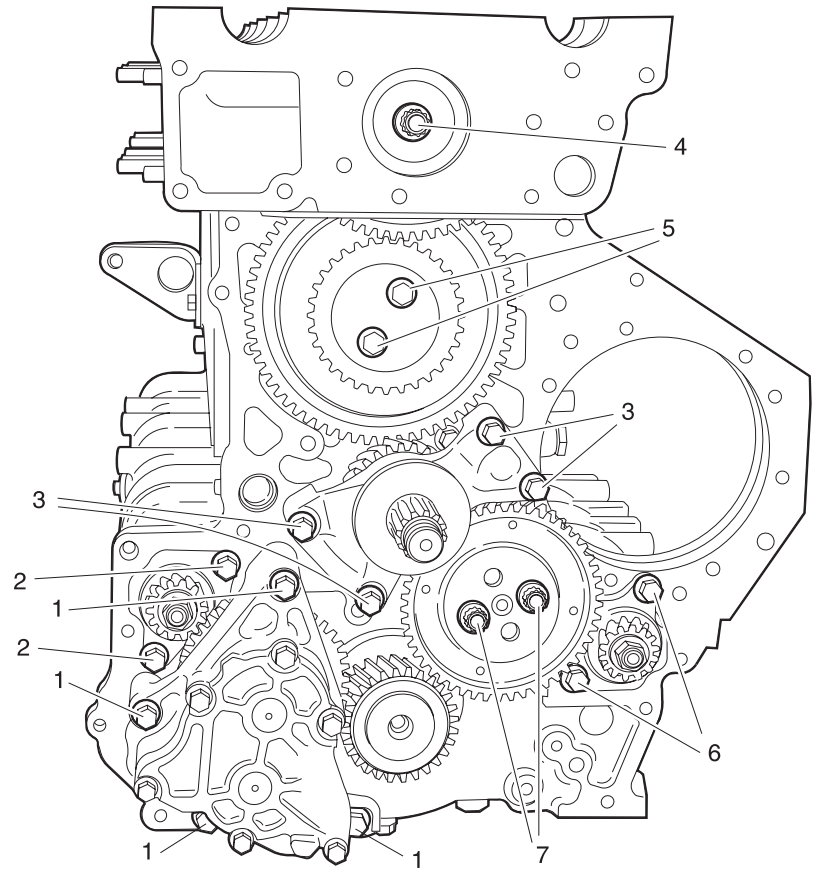
1 Thrust plate
2 Idler gear bushing
3 Idler gear
4 Idler shaft
5 Fan shaft case bushing
6 Fan shaft case
7 Thrust plate
8 Fan shaft
9 Fan gear shaft
10 Thrust plate
11 No. 1 idler gear bushing
12 No. 1 idler gear
13 No. 1 idler shaft
14 Oil pump (See Gr12)
15 O-ring
16 Balance shaft gear RH
17 Thrust spacer
18 Key
19 Thrust plate
20 Balance shaft RH
21 Balance shaft gear LH
22 Thrust spacer
23 Key
24 Thrust plate
25 Balance shaft LH

***a**: Crankshaft gear
***b**: Supply pump idler gear

Ⓟ: Locating pin
⊗: Non-reusable parts

● Assembly sequence

Follow the disassembly sequence in reverse.



02/23/2006 f012119

1 Oil pump bolts Td
2 Right balance shaft thrust plate bolts Tf
3 Fan shaft case bolts Te
4 Head idler bolt Tg
5 Idler shaft bolts Ta
6 Left balance shaft thrust plate bolts Tf
7 No. 1 idler shaft bolts Tb

Service standards (Unit: mm {in.})

Location	Maintenance item		Standard value	Limit	Remedy
–	Backlash between gears	Idler gear and fan shaft	0.09 to 0.14 {0.0035 to 0.0055}	0.3 {0.012}	Replace
		Fan shaft and No. 1 idler gear	0.06 to 0.10 {0.0024 to 0.0039}	0.3 {0.012}	
		No. 1 idler gear and crankshaft gear	0.11 to 0.13 {0.0043 to 0.0051}	0.3 {0.012}	
		No. 1 idler gear and supply pump idler gear	0.12 to 0.15 {0.0047 to 0.0059}	0.3 {0.012}	
		Oil pump gear and crankshaft gear	0.12 to 0.15 {0.0047 to 0.0059}	0.3 {0.012}	
		Oil pump gear and balance shaft gear RH	0.19 to 0.22 {0.0075 to 0.0087}	0.3 {0.012}	
–	End play of gears and shafts	Idler gear	0.10 to 0.20 {0.0039 to 0.0079}	0.3 {0.012}	Replace
		Fan shaft	0.07 to 0.19 {0.0028 to 0.0075}	0.3 {0.012}	
		No. 1 idler gear	0.15 to 0.25 {0.0059 to 0.0098}	0.3 {0.012}	
		Balance shaft RH	0.1 to 0.2 {0.0039 to 0.0079}	0.3 {0.012}	
		Balance shaft LH	0.1 to 0.2 {0.0039 to 0.0079}	0.3 {0.012}	
2, 4	Idler gear bushing-to-idler shaft clearance		0.02 to 0.06 {0.00079 to 0.0024}	0.1 {0.0039}	Replace
5, 8	Fan shaft case bushing-to-fan shaft clearance		0.03 to 0.07 {0.0012 to 0.0028}	0.1 {0.0039}	Replace
8, 9	Fan shaft-to-fan gear shaft clearance		0.01 to 0.05 {0.00039 to 0.0020}	0.1 {0.0039}	Replace
11, 13	No. 1 idler gear bushing-to-No. 1 idler shaft clearance		0.03 to 0.07 {0.0012 to 0.0028}	0.1 {0.0039}	Replace
20	Balance shaft RH bend		0.025 {0.00098}	0.05 {0.0020}	Replace
25	Balance shaft LH bend		0.025 {0.00098}	0.05 {0.0020}	Replace

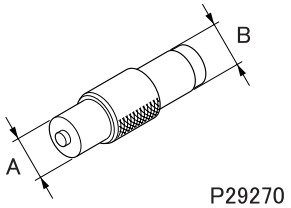
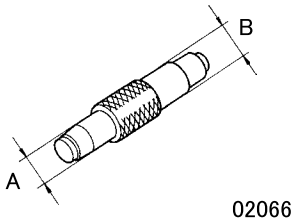
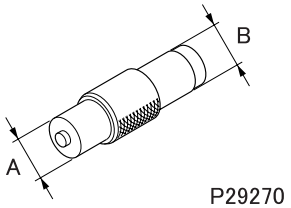
Tightening torque (Unit: N·m {lbf·ft, kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (idler shaft installation)	32.3 {24, 3.3}	–
Tb	Bolt (No. 1 idler shaft installation)	53.9 {40, 5.5}	–
Tc	Nut (balance shaft gear installation)	96.1 {71, 9.8}	Wet
Td	Bolt (oil pump installation)	28 {21, 2.9}	–
Te	Bolt (fan shaft case)	29 {21, 3.0}	–
Tf	Bolt (balance shaft thrust plate)	29 {21, 3.0}	–
Tg	Bolt (head idler shaft installation)	40.2 {30, 4.1}	Wet

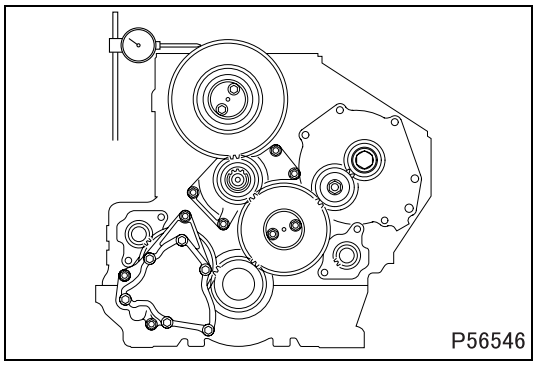
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Inner surface of every bushing	Engine oil	As required
	Outside surface of every shaft		
	O-rings		
	Nut threads		
	Balance shaft journals		

Special tools (Unit: mm {in.})

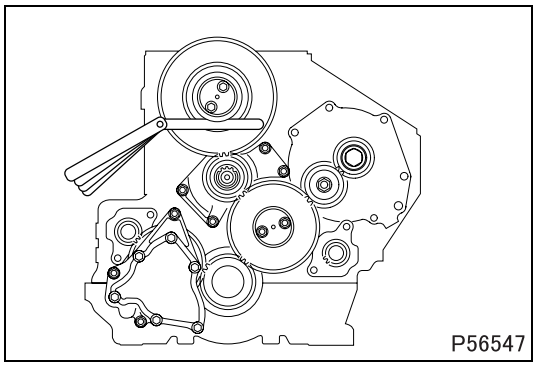
Mark	Tool name and shape	Part No.	Application
a	Idler gear bushing puller A: ϕ46.5 {ϕ1.83}, B: ϕ50 {ϕ1.97} 	MH062540	Removal and installation of idler gear bushing
b	Idler gear bushing puller A: ϕ37 {ϕ1.46}, B: ϕ40 {ϕ1.57} 	MH062601	Removal and installation of fan shaft case bushing
c	Idler gear bushing puller A: ϕ54.5 {ϕ2.15}, B: ϕ58 {ϕ2.28} 	MH062541	Removal and installation of No. 1 idler gear bushing

◆Inspection before removal◆



■Inspection: Backlash between gears

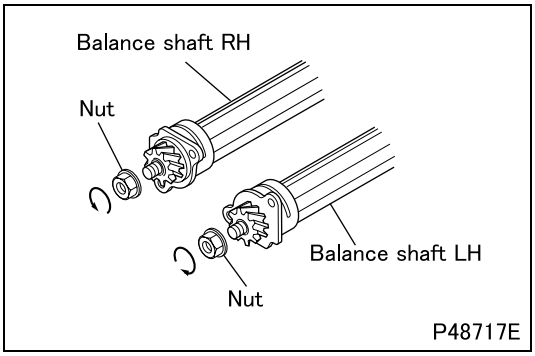
- For each pair of gears, measure the backlash at more than three teeth.
- If any of the measurements exceeds the specified limit, replace the defective part(s).



■Inspection: End play of each gear and shaft

- If the measurement exceeds the specified limit, replace the defective part(s).

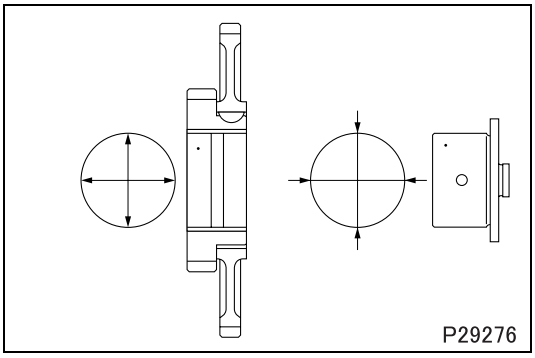
◆Removal procedure◆



■Removal: Balance shaft

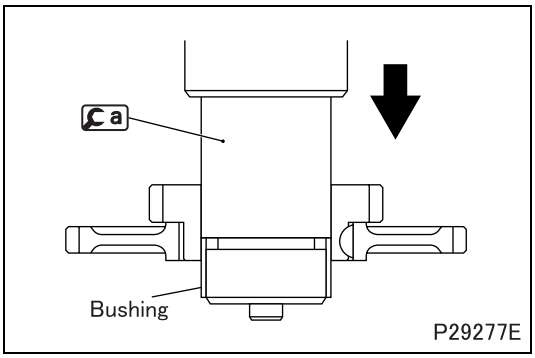
- Remove the balance shaft RH by turning its nut counterclockwise, and the balance shaft LH by turning its nut clockwise.

◆Inspection procedure◆

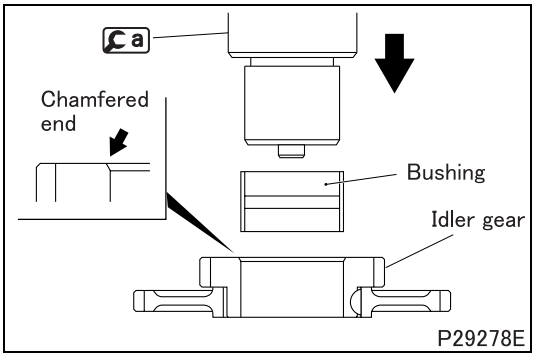


■Inspection: Idler gear bushing-to-idler shaft clearance

- If the measurement exceeds the specified limit, replace the bushing.

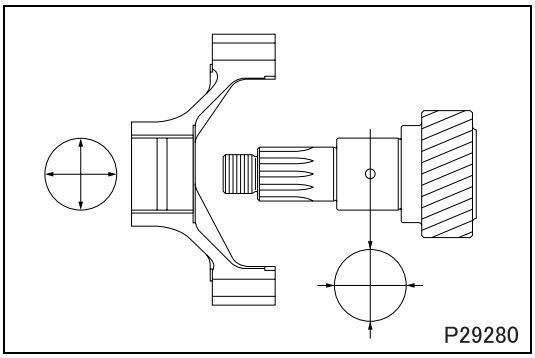


Replacement of idler gear bushing
[Removal]



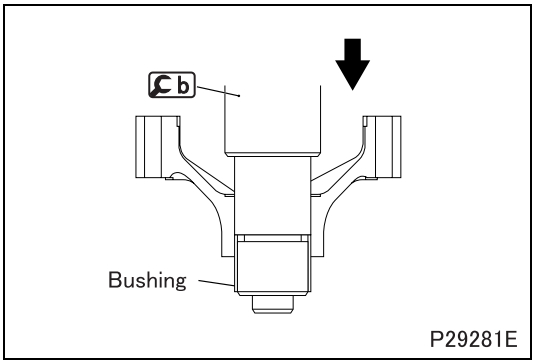
[Installation]

- Place the idler gear with its ends facing as illustrated.
- Press-fit the idler gear bushing until a sits snugly on the chamfered end of the idler gear.
- After press-fitting the bushing, measure the clearance.
- If the measurement is less than the minimum of the standard value range, ream the idler gear bushing until the clearance falls within the standard value range.

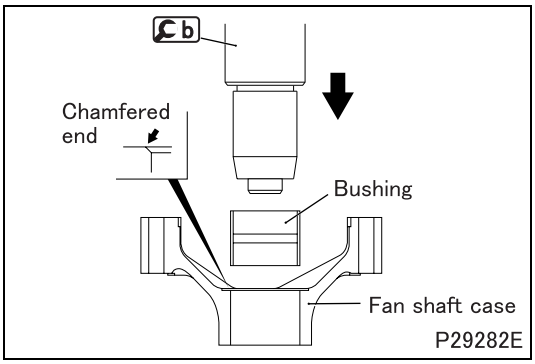


■Inspection: Fan shaft case bushing-to-fan shaft clearance

- Replace the fan shaft case bushing if the measurement exceeds the specified limit.

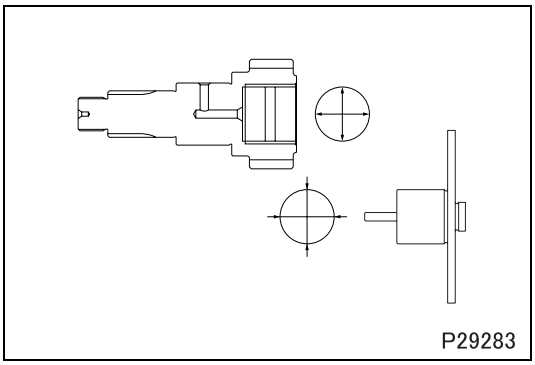


Replacement of fan shaft case bushing
[Removal]



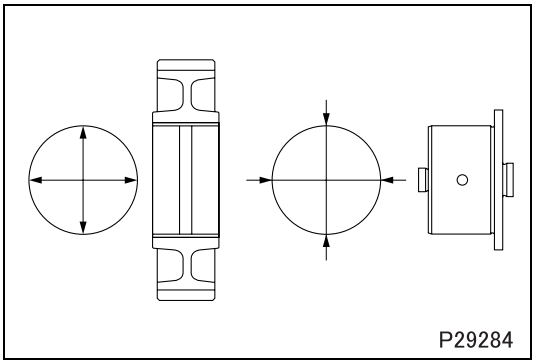
[Installation]

- Position the fan shaft case with its ends facing in the illustrated directions.
- Press in the bushing until b rests snugly on the chamfered end of the fan shaft case.
- After press-fitting the bushing, remeasure the clearance between it and the fan shaft.
- Ream the bushing if the measurement is below the standard value range.



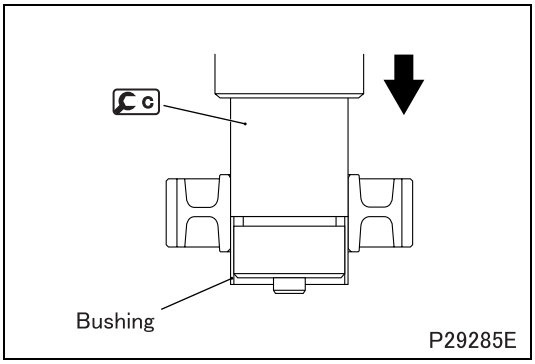
■ Inspection: Fan shaft-to-fan gear shaft clearance

- Replace the fan shaft if the measurement exceeds the specified limit.

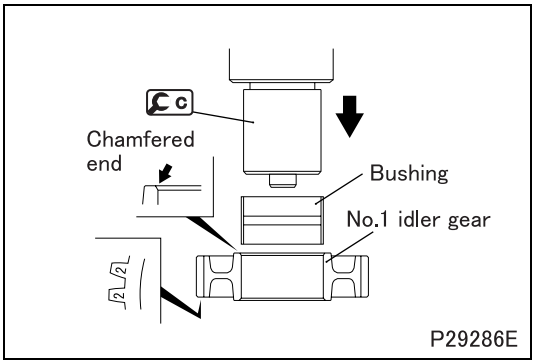


■ Inspection: No. 1 idler gear bushing-to-No. 1 idler shaft clearance

- Replace the bushing if the measurement exceeds the specified limit.

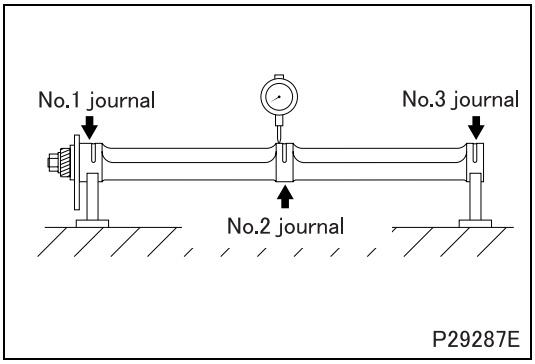


Replacement of No. 1 idler gear bushing
[Removal]



[Installation]

- Position the No. 1 idler gear with its ends facing in the illustrated directions.
- Press in the gear bushing until C sits snugly on the chamfered end of the No. 1 idler gear.
- After press-fitting the bushing, remeasure the clearance between it and the No. 1 idler shaft.
- Ream the busing if the measurement is below the standard value range.



■ Inspection: Balance shaft bend

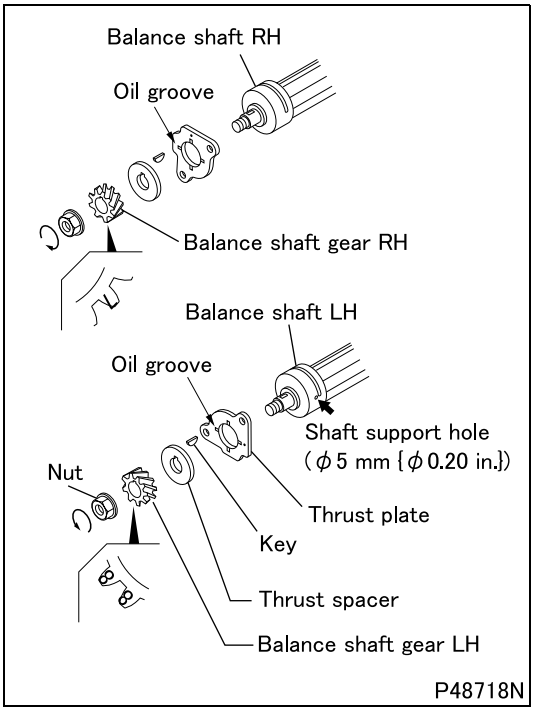
- Place supports under the No. 1 and No. 3 journals of the balance shaft and measure the bend of the balance shaft at the No. 2 journal.

NOTE

- **Turn the balance shaft by one turn and read the dial gauge. Divide the reading by two to obtain the balance shaft bend.**

- If the measurement exceeds the specified limit, replace the balance shaft.

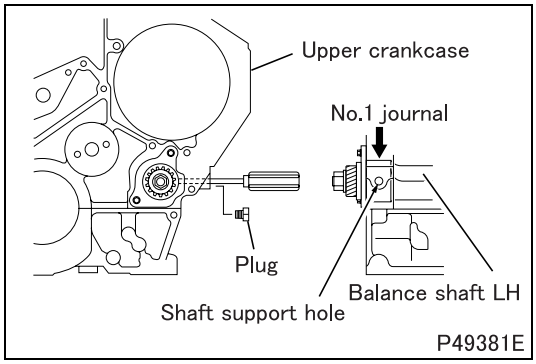
◆Installation procedure◆



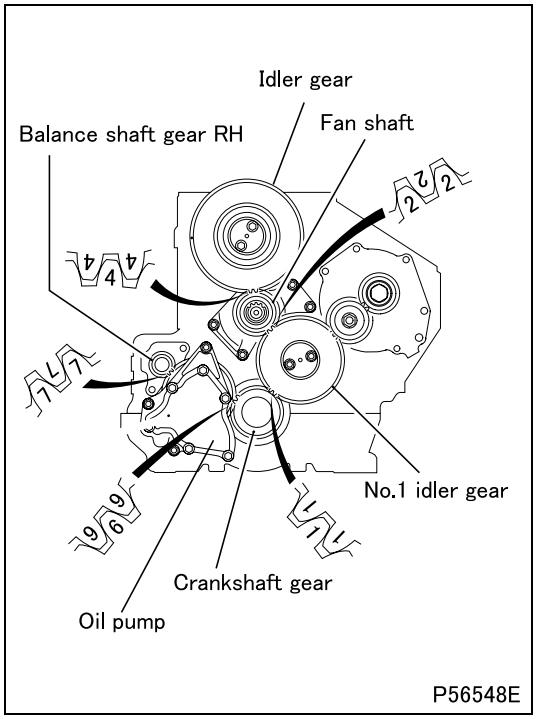
■ Installation: Balance shafts

- Install all the indicated parts on each balance shaft with their ends facing in the illustrated directions.
- Install the balance shaft RH by turning its nut clockwise, and the balance shaft LH by turning its nut counterclockwise.

- Install the balance shaft RH assembly and the balance shaft LH assembly into the crankcase according to the following procedures, which include different instructions between the two balance shafts.
  - The balance shaft RH can be installed in the crankcase without following any special procedure. (The positioning of the gear of the balance shaft RH will be finally determined by installing the oil pump.)

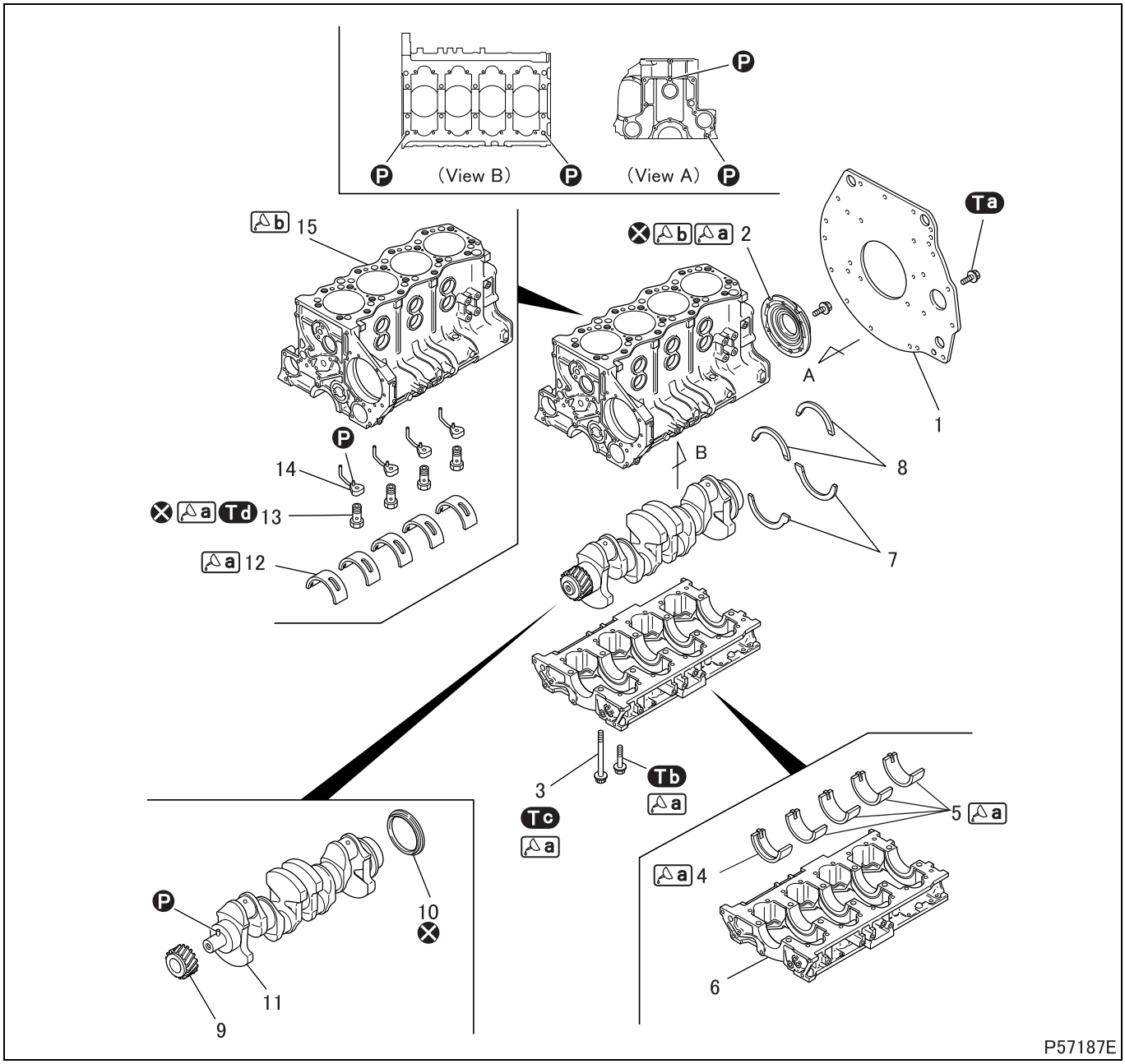


- The gear of the balance shaft LH can be engaged with other gears only after the front case is installed and then the vacuum pump is installed on the crankcase. This necessitates performing the following steps before installing the front case and vacuum pump. (The balance shaft LH cannot be rotated to adjust the gear position after the front case is installed on the crankcase.)
- Remove the plug on the upper crankcase.
- Insert a screwdriver through the plug hole and into the shaft support hole (diameter: 5 mm {0.20 in.}) on the No. 1 journal of the balance shaft LH to hold the shaft against rotation.
- Align the mating marks on each timing gear.
- This positions the balance shaft LH correctly. Leave the balance shaft in this state until installation of the front case and vacuum pump is completed.



■ Installation: Timing gears

- Place the No. 1 cylinder piston at top dead center to position the crankshaft gear.
- Install the oil pump gear by aligning mating mark **"6"** with that on the crankshaft gear, and mating mark **"7"** with that on the balance shaft gear RH.
- Install the No. 1 idler gear by aligning mating mark **"1"** with that on the crankshaft gear.
- Install the fan shaft by aligning mating mark **"2"** with that on the No. 1 idler gear.
- Install the idler gear by aligning mating mark **"4"** with that on the fan shaft.



● **Disassembly sequence**

1 Rear plate
2 Rear oil seal
3 Main bearing cap bolt
4 No.1 Lower bearing
5 Lower main bearing
6 Lower crankcase
7 Lower thrust plate
8 Upper thrust plate
9 Crankshaft gear
10 Rear oil seal slinger
11 Crankshaft
12 Upper main bearing
13 Check valve
14 Oil jet
15 Upper crankcase

Ⓟ: Locating pin
⊗: Non-reusable parts

NOTE

- **The lower crankcase and the upper crankcase are machined as a matched set, and cannot be replaced individually.**

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION ⚠

- **The main bearing cap bolts are tightened using the torque-turn tightening method. Any bolt that has three punch marks must be replaced.**
- **Do not overtighten the check valve. If it is tightened to a torque exceeding the specification, the check valve may malfunction, resulting in seizures in the engine.**
- **The No. 1 lower bearing has a oil groove. Be sure to install it in the correct position, otherwise a crankshaft seizure may result.**

Service standards (Unit: mm {in.})

Location	Maintenance item			Standard value	Limit	Remedy
–	Crankshaft end play			0.10 to 0.28 {0.0039 to 0.011}	0.4 {0.016}	Replace thrust plate
4, 5, 12	Main bearing	Oil clearance	All except No. 3	0.038 to 0.1 {0.0015 to 0.0039}	0.15 {0.0059}	Replace
			No. 3	0.058 to 0.12 {0.0023 to 0.0047}		
		Span when free		–	Less than 91.5 {3.60}	
11	Crankshaft	Bend		0.02 {0.00079} or less	0.05 {0.0020}	Replace
		Pins and journals	Out-of-roundness	0.01 {0.00039} or less	0.03 {0.0012}	Rectify or replace
			Taper	0.006 {0.00024} or less	–	
		Center-to-center distance between the journal and pin		60 ± 0.05 {2.36 ± 0.002}	–	
		Journal width	No. 1	33.5 {1.32}		
			No. 2 to 4	35 {1.38}		
			No. 5	$35\ ^{+0.039}_{0}$ {$1.38\ ^{+0.0015}_{0}$}	–	
		Pin width		$41\ ^{+0.12}_{0}$ {$1.61\ ^{+0.0047}_{0}$}	–	
		Fillet		R4	–	
15	Upper crankcase	Distortion of upper crankcase top surface		0.07 {0.0028} or less	0.2 {0.0079}	Rectify or replace
		Cylinder block	Out-of-roundness	0.005 or less {0.0002 or less}	–	Replace
			Taper	0.015 or less {0.00059 or less}	–	

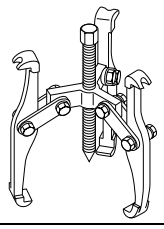
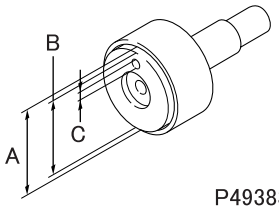
Tightening torque (Unit: N·m {lbf·ft, kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (rear plate installation)	63.7 {47, 6.5}	–
Tb	Bolt (lower crankcase installation)	23.5 {17, 2.4}	Wet
Tc	Main cap bolt (lower crankcase installation)	49 {36, 5.0} +90°	Wet Reusable up to 3 times
Td	Check valve	29.4 {22, 3.0}	Wet

Lubricant and/or sealant

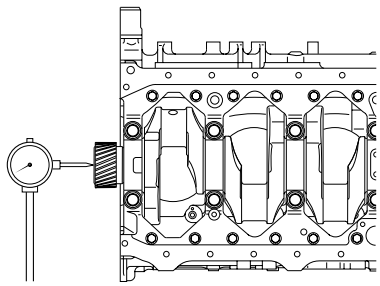
Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Rear oil seal lip	Engine oil	As required
	Bolt and main bearing cap bolt threads and seating surface of head		
	Main bearing inside surface		
	Check valve threads		
b	Upper and lower crankcase mating surface of rear oil seal	ThreeBond 1207C or D	As required
	Lower crankcase mounting surface of upper crankcase		

Special tools (Unit: mm {in.})

Mark	Tool name and shape	Part No.	Application
a	Gear puller  P02065	MH061326	Removal of crankshaft gear
b	Rear oil seal slinger installer  P49383	MH062677	Installation of rear oil seal slinger

A	B	C
ϕ103 {ϕ4.06}	ϕ100 {ϕ3.94}	ϕ15 {ϕ0.59}

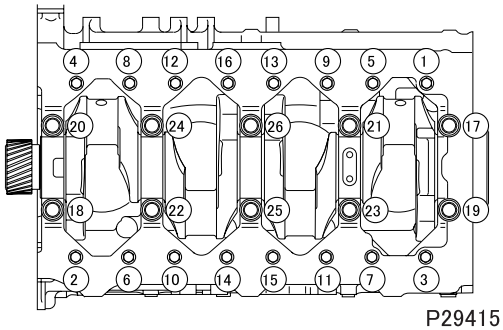
◆Inspection before removal◆


P29413

■ **Inspection: Crankshaft end play**

- If the measurement exceeds the specified limit, replace the thrust plates with oversize ones.
- Available oversizes:
  +0.15 mm, +0.30 mm, +0.45 mm {0.0059, 0.012, 0.018 in.}
- Replace the crankshaft if the end play is too large to adjust using oversize thrust plates.

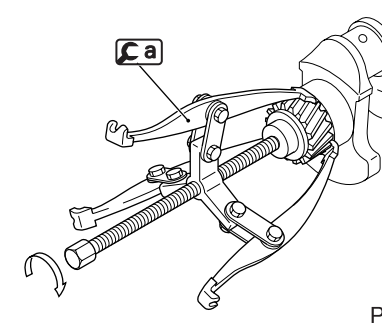
◆Removal procedure◆



P29415

■ **Removal: Lower crankcase**

- Loosen the bolts little by little in the order indicated in the illustration (1 to 16).
- After loosening the bolts, loosen the main cap bolts little by little in the order indicated in the illustration (17 to 26), then remove the main cap bolts.



P29422

■ **Removal: Crankshaft gear**

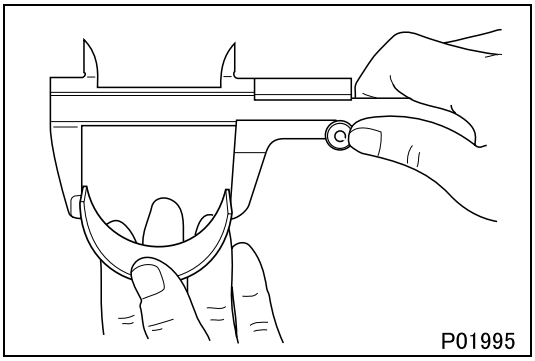
CAUTION ⚠

- **Do not tap off the crankshaft gear as this can damage it.**

■ **Removal: Rear oil seal slinger**

- Taking care not to damage the crankshaft, split the rear oil seal slinger using a chisel or a similar tool.

◆Inspection procedure◆

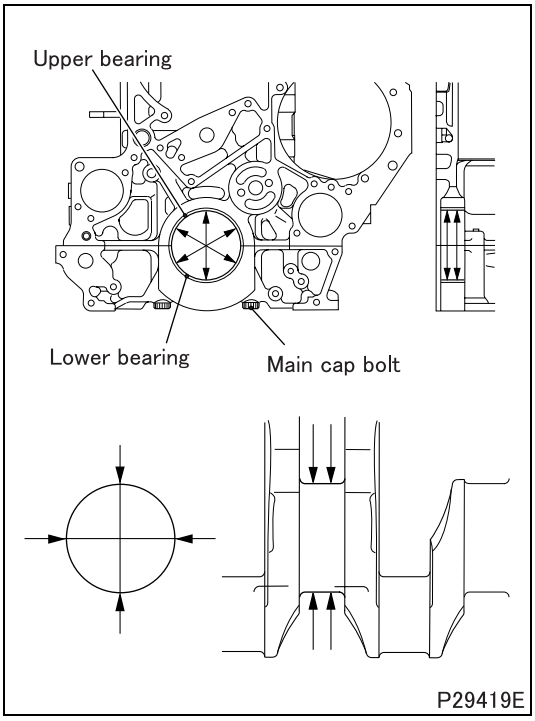


■ **Inspection: Main bearing span when free**

CAUTION ⚠

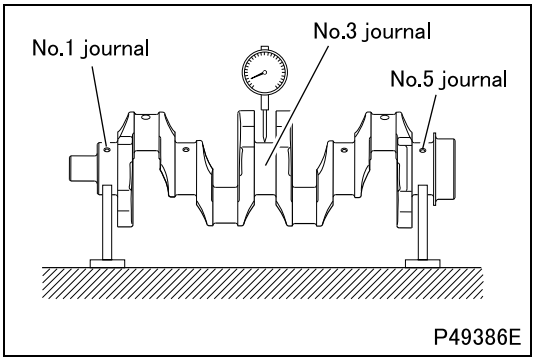
- **Do not attempt to manually expand the bearings.**
- **Always replace the upper and lower bearings as a set.**

- If the measurement exceeds the specified limit, replace the bearing.



■ **Inspection: Main bearing-to-crankshaft clearance**

- Fit the upper bearing into the upper crankcase and the lower bearing into the lower crankcase.
- Tighten the main bearing cap bolts to a torque of 49 N·m {36 lbf·ft, 5.0 kgf·m}.
- Measure the inside diameter of the main bearing and the diameter of the corresponding crankshaft journal.
- If the difference between the measurements exceeds the specified limit, machine the crankshaft journal to one of the specified undersize dimensions indicated on the next page.



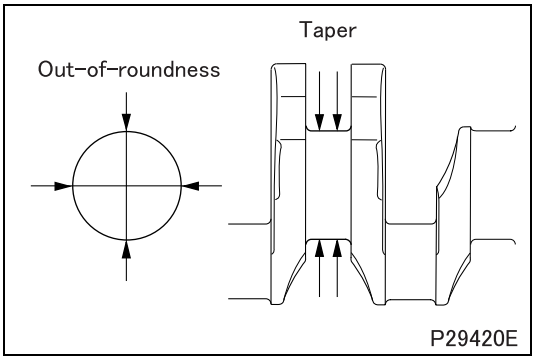
■ **Inspection: Crankshaft**

(1) Bend

- Support the crankshaft at its No. 1 journal and No. 5 journal. Measure the extent of bending in the crankshaft at the center of the No. 3 journal.
- If the measurement exceeds the specified limit, replace the crankshaft.

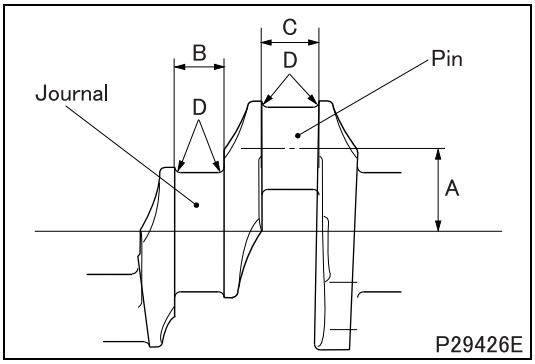
NOTE

- **Turn the crankshaft through one revolution. One-half of the dial indicator reading represents the extent of bending.**



(2) Out-of-roundness and taper of crankshaft journals and pins

- If any of the measurements exceeds the specified limits, grind the crankshaft journal(s) and/or pin(s) to undersize(s) or replace the crankshaft.



Grinding of crankshaft

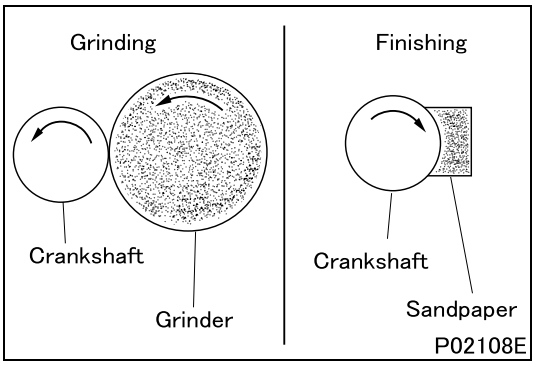
CAUTION ⚠

- **If the crankshaft is ground to an undersize, the main bearings must be replaced with the undersize ones of the corresponding undersize.**

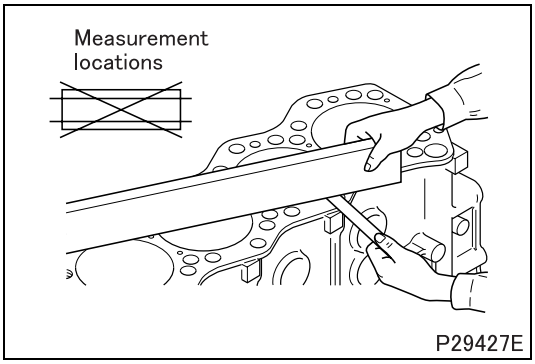
- Do not change the center-to-center distance **A** between the journal and pin.
  A: 60 ± 0.05 mm {2.36 ± 0.0020 in.}
- Do not change the journal width **B** and the pin width **C**.
  B: 33.5 mm {1.32 in.} (No. 1 journal)
  35 mm {1.38 in.} (No. 2 to No. 4 journals)
  $35\ ^{+0.039}_{0}$ mm {$1.38\ ^{+0.0015}_{0}$ in.} (No. 5 journal)
  C: $41\ ^{+0.2}_{0}$ mm {$1.61\ ^{+0.0079}_{0}$ in.} (No. 5 journal)
- Finish the fillets **D** smoothly.
  D: R4 mm {R0.16 in.}
- Carry out a magnetic inspection to check for cracks possibly caused by grinding. Also, check that the harness of the surface has not dropped below Shore hardness number (Hs) 75.
- Replace the crankshaft if defects are evident.

Crankshaft undersize dimensions (Unit: mm {in.})

		Undersizes			
		0.25 {0.0098}	0.50 {0.020}	0.75 {0.030}	1.00 {0.039}
Finished journal diameter	No. 1, 2, 4, 5	85.68 to 85.70 {3.37 to 3.37}	85.43 to 85.45 {3.36 to 3.36}	85.18 to 85.20 {3.35 to 3.35}	84.93 to 84.95 {3.34 to 3.34}
	No. 3	85.66 to 85.68 {3.37 to 3.37}	85.41 to 85.43 {3.36 to 3.36}	85.16 to 85.18 {3.35 to 3.35}	84.91 to 84.93 {3.34 to 3.34}
Finished pin diameter		64.69 to 64.71 {2.55 to 2.55}	64.44 to 64.46 {2.54 to 2.54}	64.19 to 64.21 {2.53 to 2.53}	63.94 to 63.96 {2.52 to 2.52}
Out-of-roundness		0.01 {0.00039} or less			
Taper		0.006 {0.00024} or less			



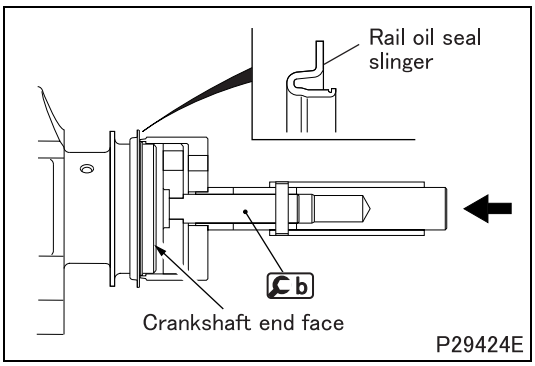
- When grinding, turn both the crankshaft and the grinder counterclockwise as viewed from the crankshaft front end.
- When finishing the crankshaft with whetstone or sandpaper, rotate the crankshaft clockwise.



■ Inspection: Distortion of upper crankcase top surface

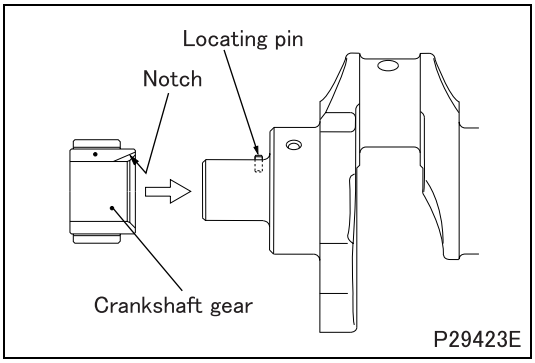
- If the measurement exceeds the specified limit, grind the crankcase top surface with a surface grinder.
- Limit the amount of removed metal to make sure that the amount of piston projection above the crankcase top surface stays within the standard value range. (See the PISTONS, CONNECTING ROD AND CYLINDER LINERS section.)

◆Installation procedure◆



■ **Installation: Rear oil seal slinger**

- Press in the rear oil seal slinger until Cb sits snugly on the crankshaft end surface.



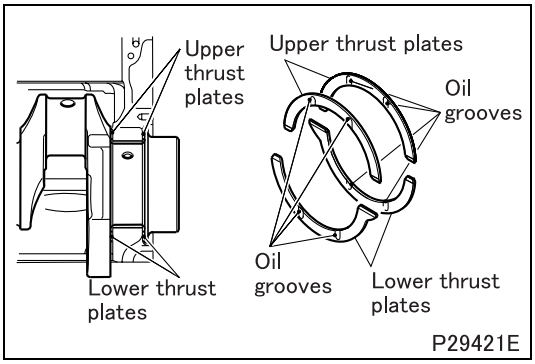
■ **Installation: Crankshaft gear**

- Heat the crankshaft gear to approximately 150°C {300°F} with a gas burner or the like.

CAUTION ⚠

- **Be careful not to get burned.**

- Align the locating pin in the crankshaft with the slot in the crankshaft gear. Drive the gear into position by lightly striking its end face with a plastic hammer.



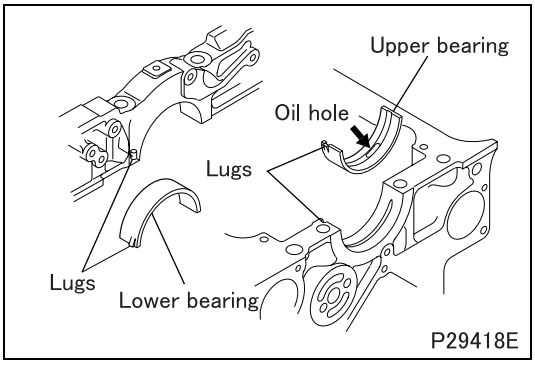
■ **Installation: Thrust plate**

- Install the thrust plates on both sides of the rearmost main bearing with the oil grooves on the inner plates facing inward and those on the outer plates outward as shown in the illustration.

CAUTION ⚠

- **Be sure to orient the oil grooves as indicated above, otherwise seizures may occur in the engine.**

- Use oversize thrust plates when adjusting the crankshaft end play. The upper and lower thrust plates on the same side must be of the same size. The thrust plates on one side may differ in size from those on the other side.

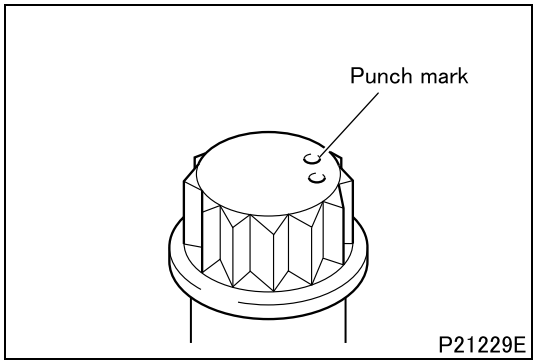


■ **Installation: Main bearings**

- Install the main bearings with their lugs aligned as shown in the illustration. When the crankshaft journals have been ground to an undersize, use undersize main bearings.
  Available main bearing undersizes:
  0.25 mm {0.0098 in.}, 0.50 mm {0.020 in.}, 0.75 mm {0.030 in.}, 1.00 mm {0.039 in.}

CAUTION ⚠

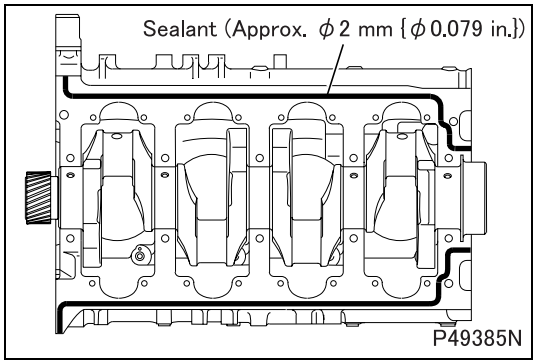
- **The upper main bearing has an oil hole. The lower main bearing has no oil hole. Do not confuse the upper and lower bearings, as this can cause seizure in the engine.**



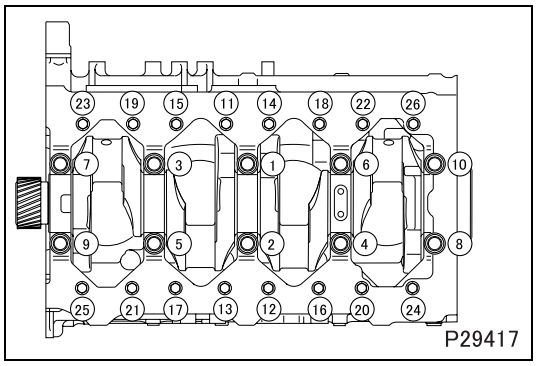
■ **Installation: Lower crankcase**

CAUTION ⚠

- **Before installing the main bearing cap bolts, check the number of punch marks on the head of each bolt. (A bolt with two or less marks is reusable.)**
- **The number of punch marks corresponds with the number of times the main cap bolt has been tightened using the torque-turn tightening method. Any bolt that has three marks (i.e. that has been used three times) must be replaced.**



- Clean all sealant application surfaces.
- Apply evenly thick beads of sealant to the upper crankcase without any breaks as shown in the illustration.
- Install the lower crankcase within three minutes of applying the sealant, being careful not to dislodge the sealant.



- Apply engine oil to the main cap bolt threads and seating surfaces of the bolt heads, then tighten them to a torque of 49 N·m {36 lbf·ft, 5.0 kgf·m} in the order indicated in the illustration (1 to 10).
- Tighten each main cap bolt further by 90° in the same order.
- Finally, tighten each bolt to the specified torque in the order indicated in the illustration (11 to 26).

CAUTION ⚠

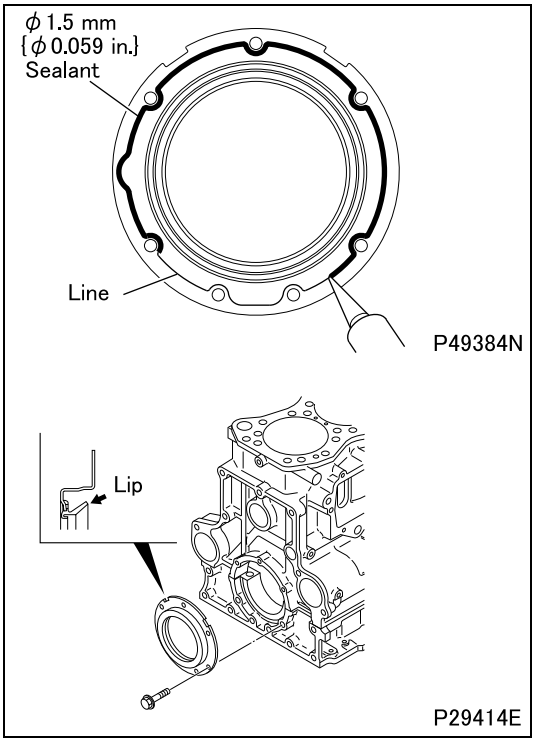
- **After installing the bolts, wait at least an hour before starting the engine.**
- **Apply new beads of sealant whenever the main cap bolts have been loosened or removed.**

- After tightening the bolts using the above torque-turn tightening method, make a punch mark on the head of each bolt to indicate the number of times that it has been used.

CAUTION ⚠

- **The bolts that have been tightened using the torque-turn method must never be additionally tightened after the final angular tightening.**

- After installing the main bearing caps, rotate the crankshaft by hand. If it cannot be rotated smoothly, inspect the main bearing caps for correct installation.

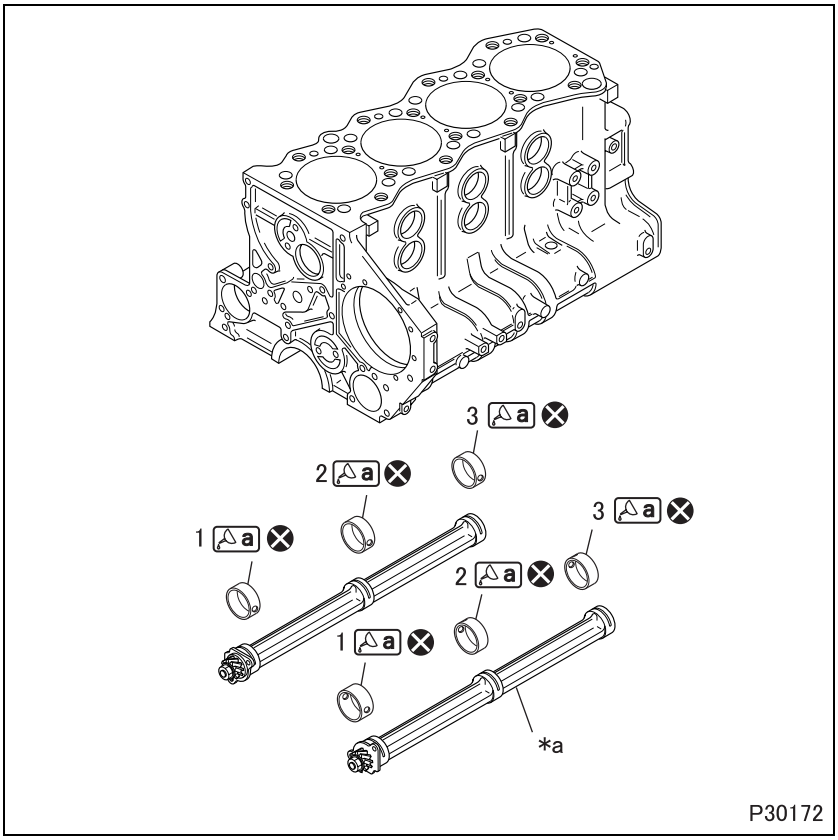


■ **Installation: Rear oil seal**

- Apply engine oil to the lip of the rear oil seal.
- Clean the seal surface of the crankshaft.
- Apply a bead of sealant along the line on the rear oil seal evenly without any breaks.
- Install the rear oil seal within three minutes after applying the sealant. Be careful not to let the applied sealant slip out of place during installation.

CAUTION ⚠

- **After fitting the rear oil seal, wait at least an hour before starting the engine.**
- **Apply a new bead of sealant whenever the mounting bolts of the rear oil seal have been loosened.**



● **Disassembly sequence**

1 No. 1 balance shaft bushing
2 No. 2 balance shaft bushing
3 No. 3 balance shaft bushing

***a**: Balance shaft
⊗: Non-reusable parts

● **Assembly sequence**

Follow the disassembly sequence in reverse.

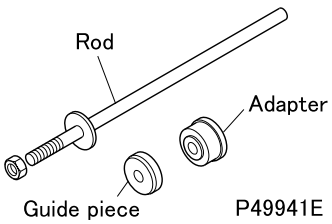
Service standards (Unit: mm {in.})

Location	Maintenance item		Standard value	Limit	Remedy
1 to 3, *a	Balance shaft journal-to-balance shaft bushing clearance	No. 1	0.055 to 0.099 {0.0022 to 0.0039}	0.15 {0.0059}	Replace
		No. 2	0.075 to 0.119 {0.030 to 0.0047}		
		No. 3	0.055 to 0.099 {0.0022 to 0.0039}		

Lubricant and/or sealant

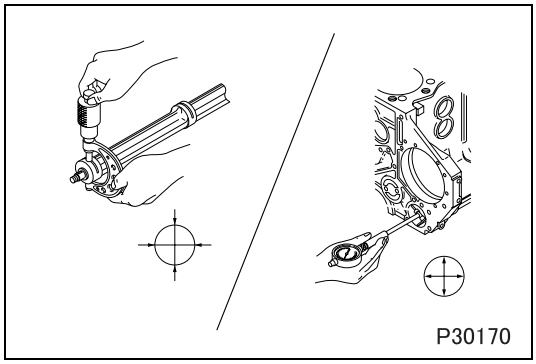
Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Balance shaft bushing inner surface	Engine oil	As required

Special tools

Mark	Tool name and shape	Part No.	Application
a	Balance shaft bushing installer and extractor 	MH062782	Removal and installation of balance shaft bushing

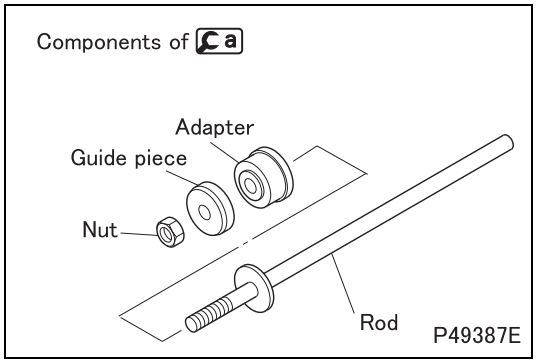
BALANCE SHAFT BUSHINGS

◆Inspection procedure◆



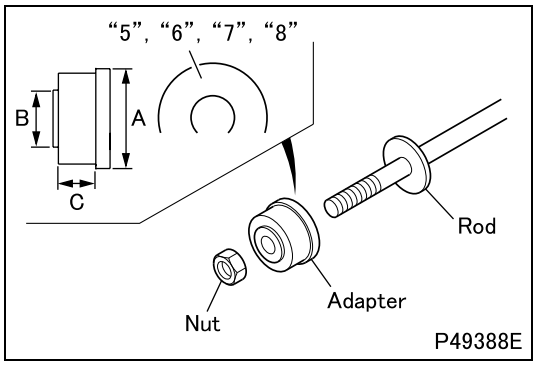
■ **Inspection: Balance shaft-to-balance shaft bushing clearance**

- Replace the bushing if the measurement exceeds the specified limit.



Replacement of balance shaft bushing

- Replace the bushing using ca.

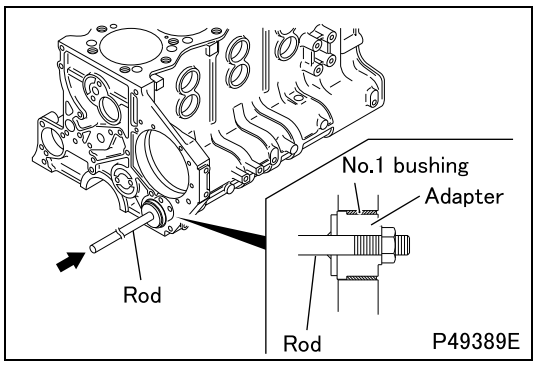


[Removal]

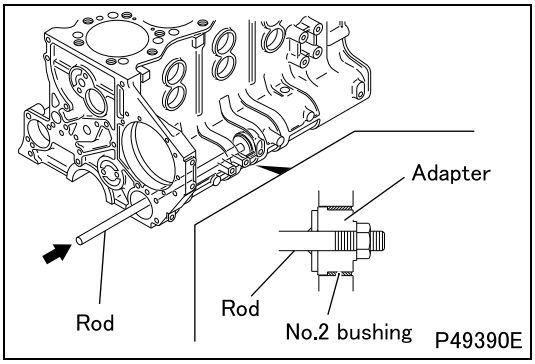
- To remove the bushings, use the rod fitted with an adapter corresponding to the size of each bushing.

Unit: mm {in.}

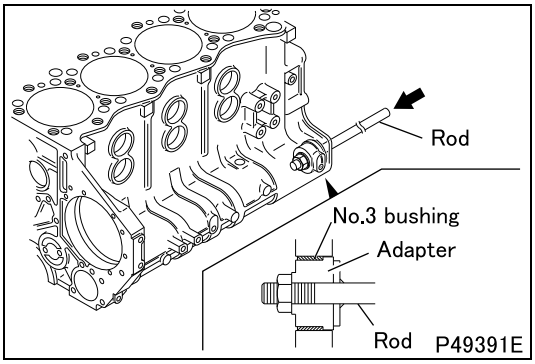
Bushing		Adapter			
		Identification mark	**A**	**B**	**C**
No. 1	Left	**"5"**	ϕ55.25 {ϕ2.18}	ϕ 51.5 {ϕ2.03}	26.5 {1.04}
	Right	**"6"**			21.5 {0.85}
No. 2		**"7"**	ϕ 55 {ϕ2.17}	ϕ 51 {ϕ2.01}	
No. 3		**"8"**	ϕ 54.75 {ϕ2.16}	ϕ 50.5 {ϕ1.99}	



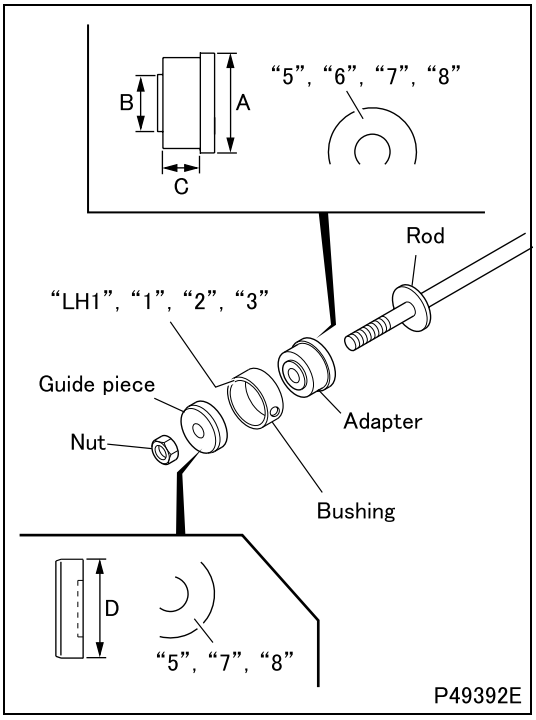
- Remove the No. 1 bushing by tapping on the rod from the front of the engine.



- Remove the No. 2 bushing by tapping on the rod from the front of the engine.



- Remove the No. 3 bushing by tapping on the rod from the back of the engine.



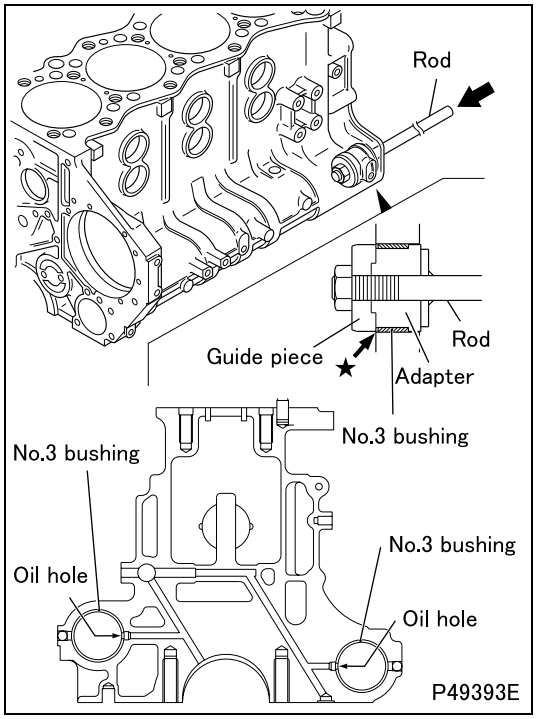
[Installation]

- To install the bushings, use the rod fitted with an adapter corresponding to the size of each bushing. Each bushing has an identification mark. These identification marks are used to distinguish between the No. 1, No. 2 and No. 3 bushings. If the identification mark is not clear, measure the outside diameter of the bushing and use the measurement as a means of identification.

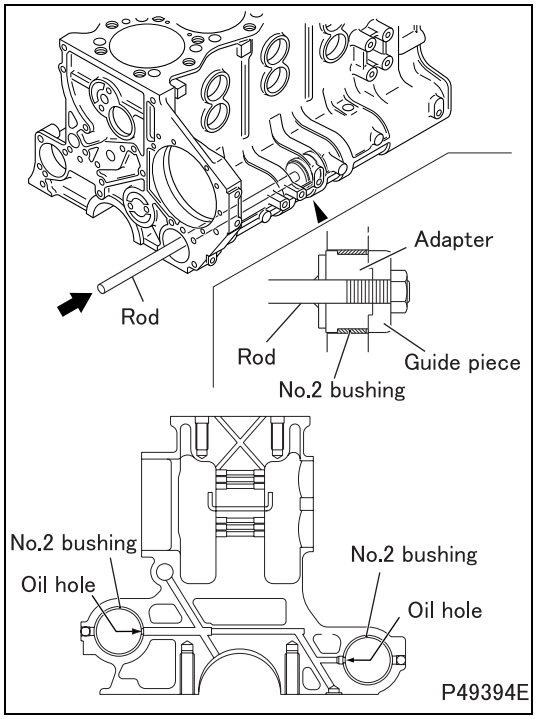
Unit: mm {in.}

Bushing				Adapter				Guide piece	
		Identification mark	Outside diameter	Identification mark	**A**	**B**	**C**	Identification mark	**D**
No. 1	Left	**"LH1"**	ϕ 55.25 {ϕ2.18}	**"5"**	ϕ 55.25 {ϕ2.18}	ϕ 51.5 {ϕ2.03}	26.5 {1.04}	**"5"**	ϕ 55.25 {ϕ2.18}
	Right	**"1"**	ϕ 55.25 {ϕ2.18}	**"6"**			21.5 {0.85}	**"6"**	
No. 2		**"2"**	ϕ55 {ϕ2.17}	**"7"**	ϕ55 {ϕ2.17}	ϕ51 {ϕ2.01}		**"7"**	ϕ55 {ϕ2.17}
No. 3		**"3"**	ϕ 54.75 {ϕ2.16}	**"8"**	ϕ 54.75 {ϕ2.16}	ϕ 50.5 {ϕ1.99}		**"8"**	ϕ 54.75 {ϕ2.16}

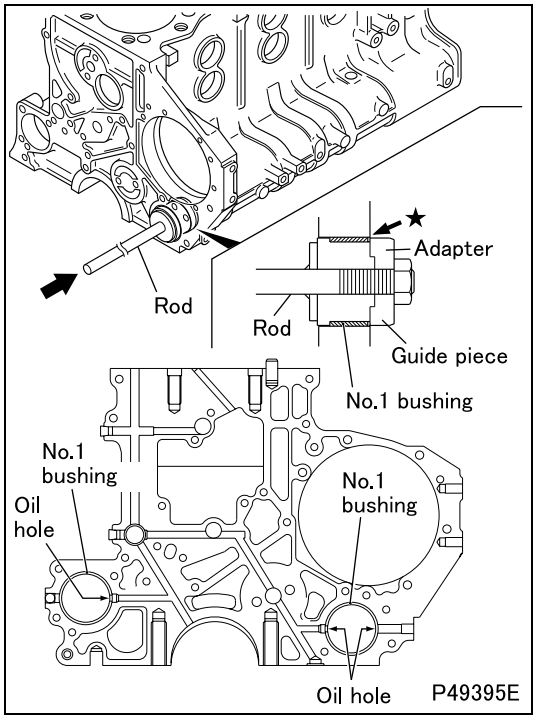
BALANCE SHAFT BUSHINGS



- Align the oil hole in the No. 3 bushing with the oil hole in the upper crankcase.
- Force the No. 3 bushing into the upper crankcase as deep as the ★ mark in the illustration by tapping on the rod from the rear of the engine.



- Align the oil hole in the No. 2 bushing with the oil hole in the upper crankcase.
- Force the No. 2 bushing into the upper crankcase to the illustrated position by tapping on the rod from the front of the engine.



- Align the oil hole(s) in the No. 1 bushing with the oil hole(s) in the upper crankcase.
- Force the No. 1 bushing into the upper crankcase as deep as the ★ mark in the illustration by tapping on the rod from the front of the engine.

CAUTION ⚠

- **The left and right No. 1 bushings are different from each other, and should not be installed in reverse positions.**
- **The left No. 1 bushing has two oil holes, whereas the right No. 1 bushing has only one oil hole.**