Group 11

Engine

MITSUBISHI FUSO TRUCK OF AMERICA, Inc.

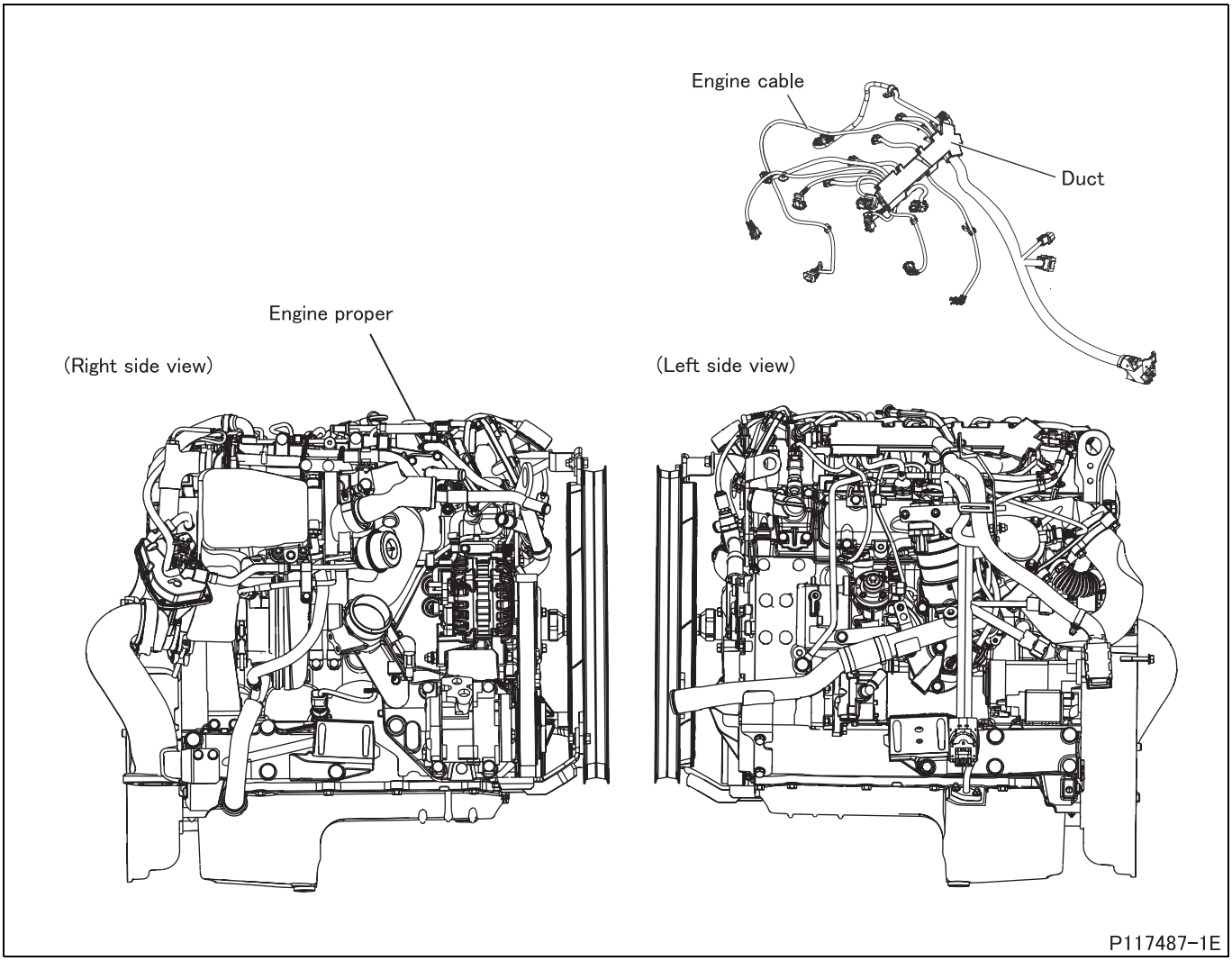
Pub.No.00ELT0001-11

INDEX

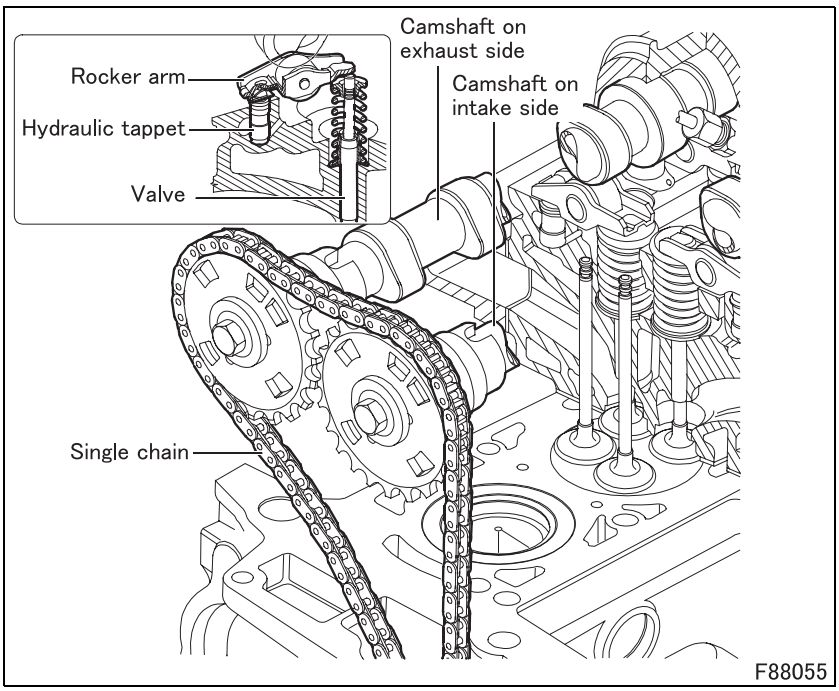
SPECIFICATIONS

Item		Specifications
Engine model		4P10T5
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	120 / 2865 to 3400
Maximum torque	ft.lbf / rpm	400 / 1300 to 2865
Bore × stroke	mm {in.}	ϕ95.8 × 104 {ϕ3.77 × 4.09}
Total displacement	L {qts}	2.998 {3.2}
Compression ratio		17.5

1. Engine Proper

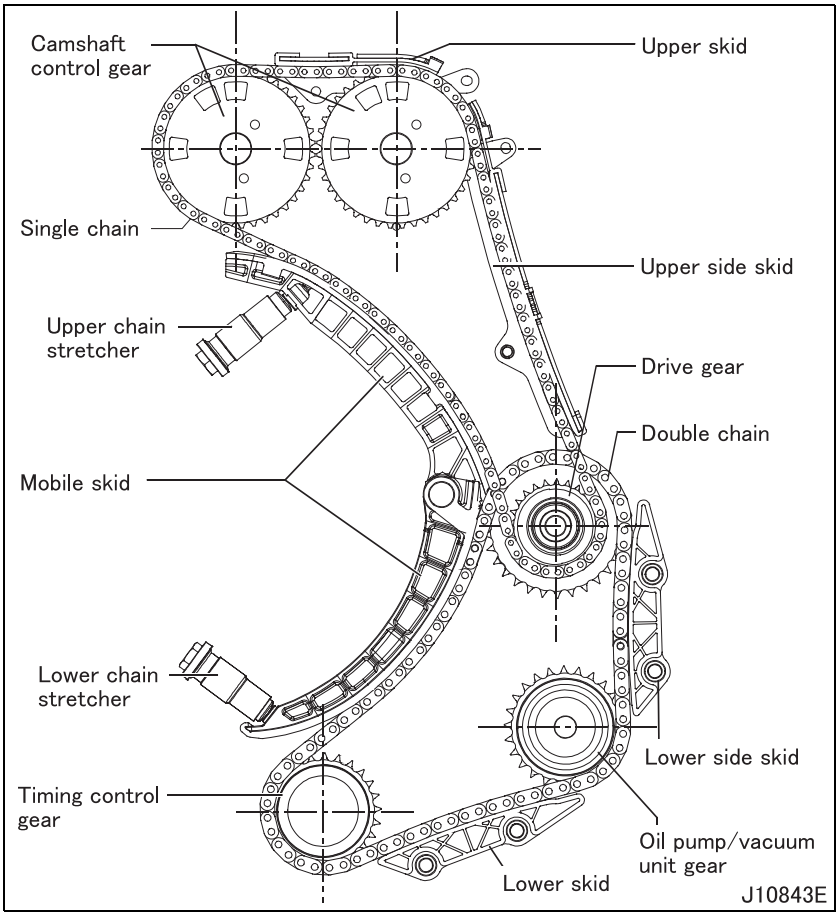


2. Timing System



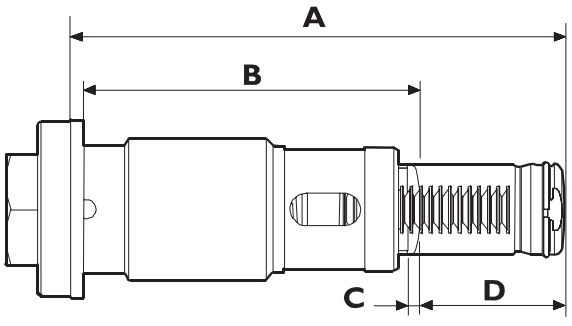
- The timing system is the type with a twin camshaft in the head and four valves per cylinder with hydraulic tappets.
- The control is transmitted by two chains.
  - A double chain by 3/8" is set in motion by the driving shaft and sets the control shafts in motion: oil pump/ vacuum pump - high pressure pump.
  - A single chain is set in motion by the high pressure control shaft gear and sets the camshafts in motion.
- The rocker arms, one for the valve, are kept in contact with the corresponding cam by an hydraulic tappet, thus eliminating the need for regular adjustments.

2.1 Timing system and auxiliary system diagram



- Replace both chains even if an abnormality occurs in only one chain. When replacing the chains, it is also necessary to replace the oil pump/vacuum unit gear, the drive gear, each skid (upper, upper side, lower side, and lower), the camshaft control gear and the chain stretcher.
- Replace the chain stretcher with anti-return device each time you disassemble the timing system. Once the lock of the main body opens and the piston is thrust outward, the chain stretcher can no longer be reinstalled in its original position.

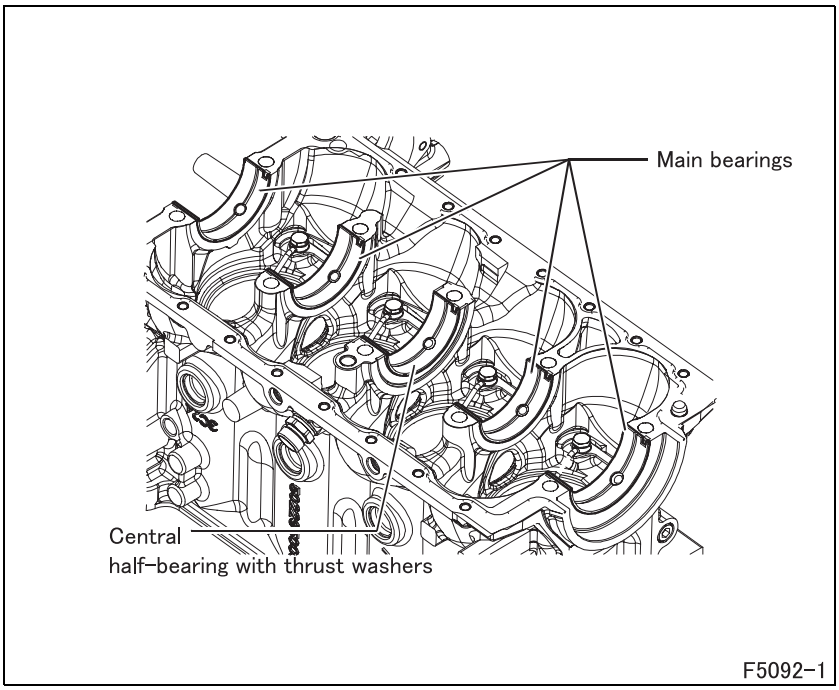
2.2 Hydraulic chain stretcher upper



A : Max. range 76.9±0.4 mm{3.03±0.016 in.}
B : Piston engaged 53.6 mm{2.11 in.}
C : Min. travel for piston disengagement 2.3 mm{0.091 in.}
D : Working travel 24.5 mm{0.96 in.}

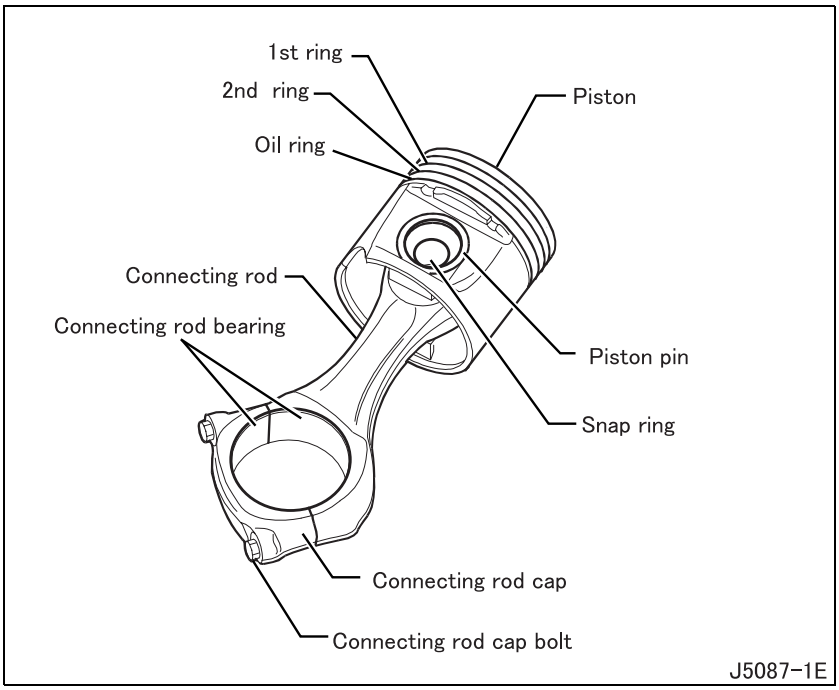
N130208

3. Main Bearing



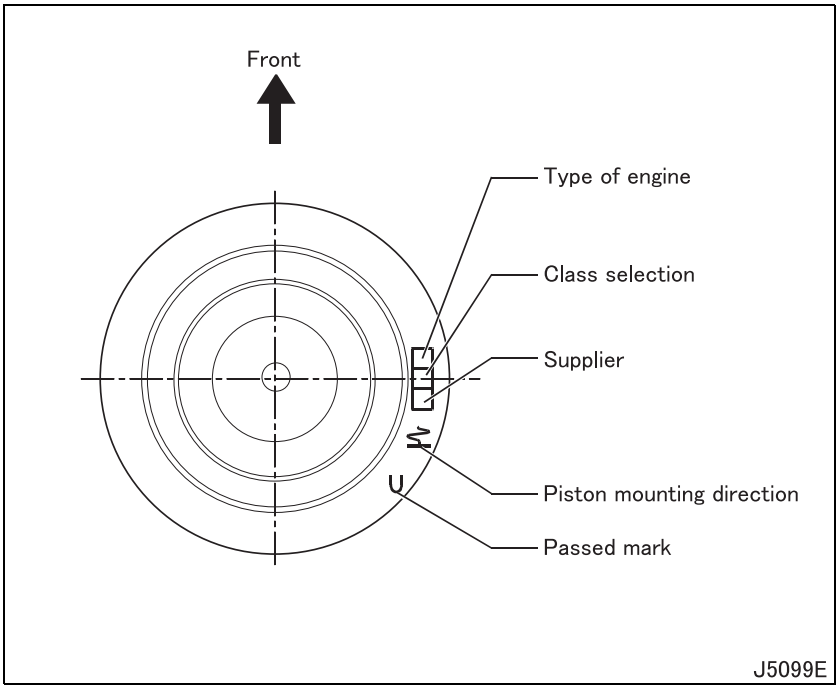
- Undersize main bearings are provided as spare parts.
- A thrust plate is installed on the central half-bearing.
- The pilot hole in bulkhead of #5 position is larger than the pilot holes in bulkheads of #1 to #4 positions. (#1 to #4 positions are the same size.)

4. Connecting Rod, Piston



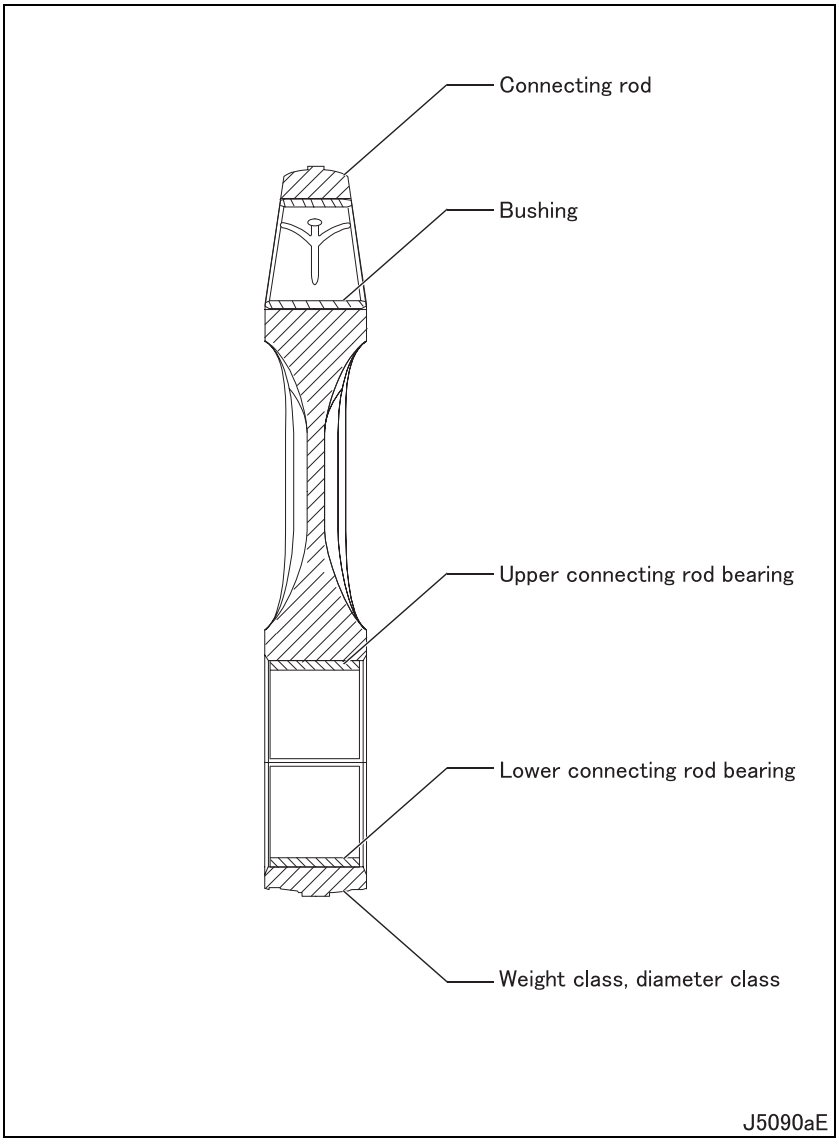
- A replacement piston is supplied with piston rings, the piston pin and the snap ring.

4.1 Piston



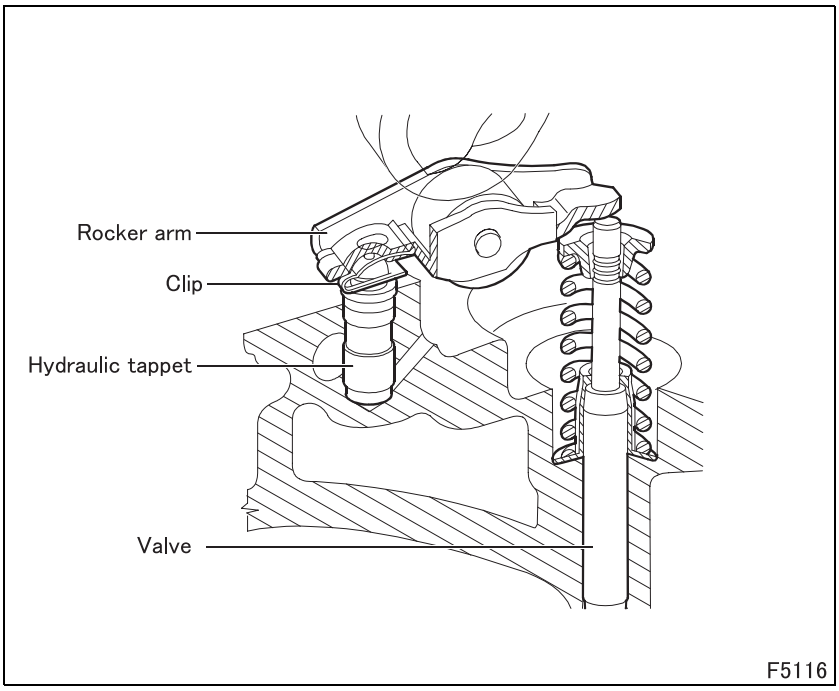
- Etched on the top of the piston are the following.
  - The type of engine.
  - Class selection and supplier.
  - Piston mounting direction.
  - Passed mark: “Test passed” symbol.

4.2 Connecting rod



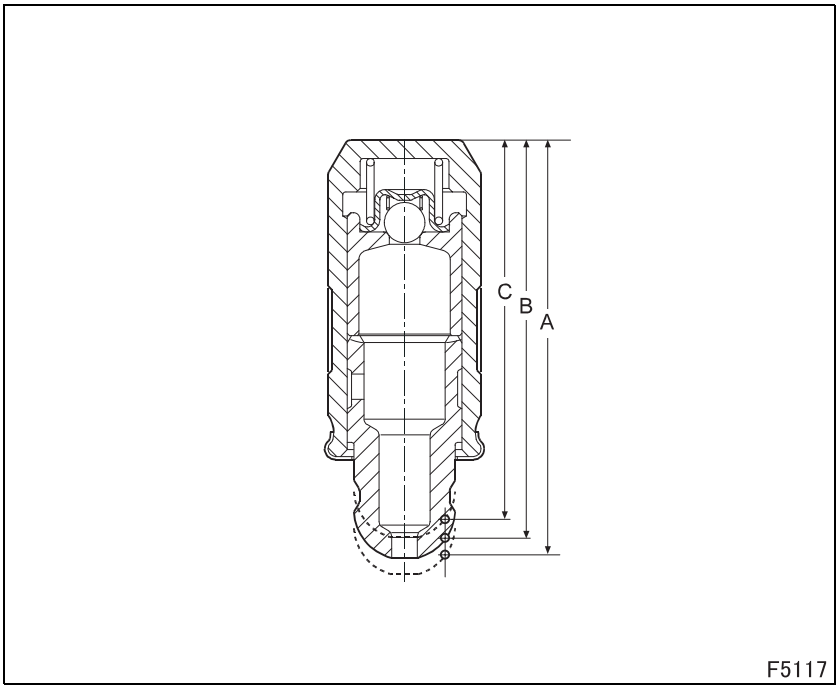
- Each connecting rod has its cap marked with the following.
  - A number indicating the weight class of the connecting rod mounted in production.
  - A letter: O or X indicating the diameter class of the big end mounted in production.

5. Rocker Arms, Tappets



- The rocker arm assembly is composed of the rocker arm, hydraulic tappet, made integral with each other by the clip.

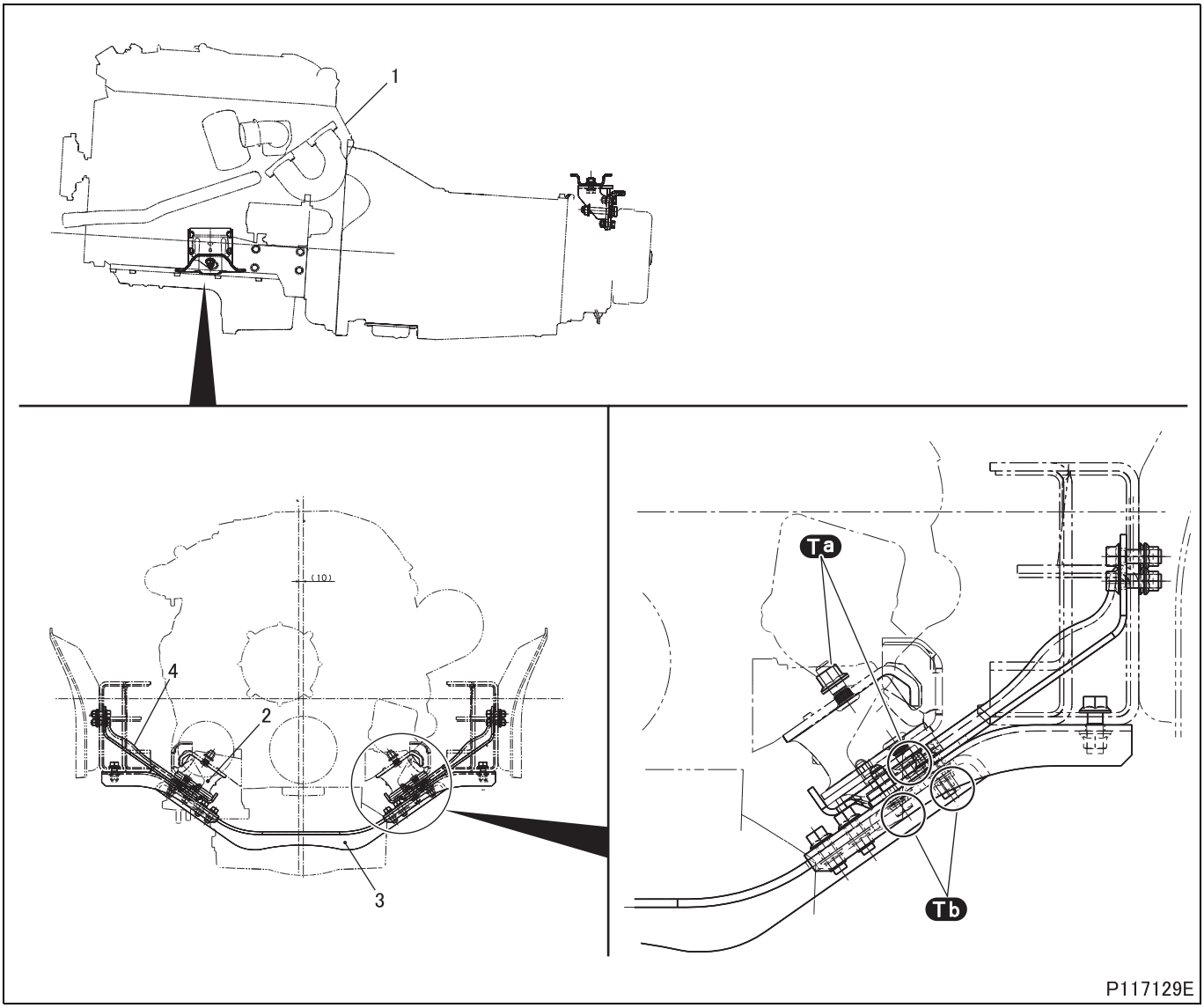
5.1 Cross section of the hydraulic tappet



- A = 32.44 mm ± 0.3 mm {1.28 in. ± 0.012 in.}, end of stroke
- B = 31.30 mm {1.23 in.}, working position
- C = 29.75 mm ± 0.25 mm {1.17 in. ± 0.0098 in.}, start of stroke

Possible causes / Symptoms		Low power output	Abnormal engine noise	Electronic control unit diagnosis lamp	Reference Gr
Cylinder head and valve mechanism	Rocker arm broken/out of place	O	O		
	Rocker arm roll worn	O	O		
	Hydraulic tappet leakage	O	O		
	Hydraulic tappet blocked	O	O		
	Worn valve and valve seat; carbon deposits	O	O		
	Defective cylinder head gasket	O	O		
	Weakened valve spring	O	O		
Defective timing chain-related parts			O	O	
Timing sprockets/skids	Incorrect tension on chain branches		O	O	
	Poor lubrication of timing gears and idler shaft		O		
Camshaft	Worn camshaft	O	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	O	Gr13
	Defective high pressure pump	O	O	O	
	Faulty fuel spray from injector	O	O		
	Inappropriate fuel injection timing	O	O	O	
	Air trapped in fuel system components	O		O	
Cooling system	Malfunctioning cooling system	O		O	Gr14
	Loose/damaged V-belts		O	O	
Intake and exhaust system	Clogged air cleaner	O			Gr15
	Clogged muffler	O			
Defective/incorrectly fitted alternator and other auxiliaries			O		Gr14
Incorrect oil viscosity		O			Gr12
Improper fuel		O			Gr13
Incorrectly fitted piping and hoses			O		
Malfunctioning turbocharger		O	O		Gr15

ENGINE REMOVAL AND INSTALLATION <TILT CAB>



● **Removal sequence**

1 Engine
2 Cushion rubber
3 Engine mounting support cross member
4 Engine mounting support bracket

● **Installation sequence**

Follow the removal sequence in reverse.

CAUTION ⚠

- **When lifting the engine, make sure that the engine does not strike the cab and the rear body.**
- **Only use hoisting equipment appropriate for the engine weight (approximately 350 kg {770 lb}).**

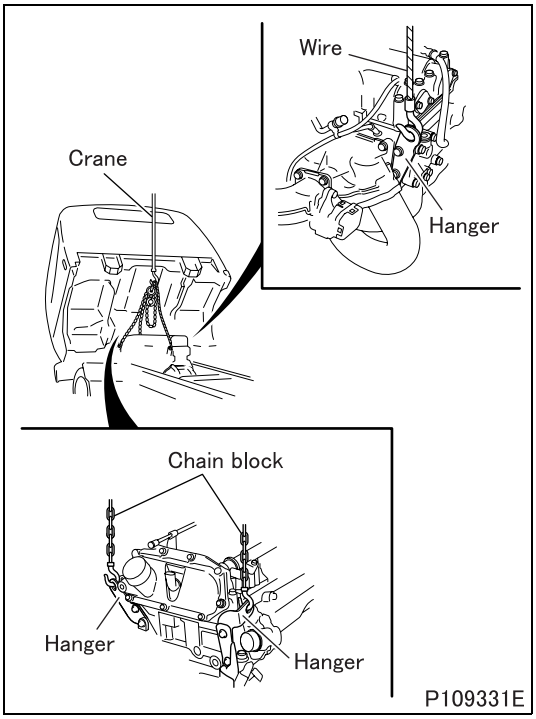
Tightening torque (Unit: N·m {ft.lbs, kgf·m})

Mark	Parts to be tightened		Tightening torque	Remarks
Ta	Nut (cushion rubber installation)	Two wheel drive	76.5 {56, 7.8}	–
		Four wheel drive	115 {85, 12}	
Tb	Bolt (engine mounting support bracket installation)		58.7 {43, 6.0}	–

◆Removal procedure◆

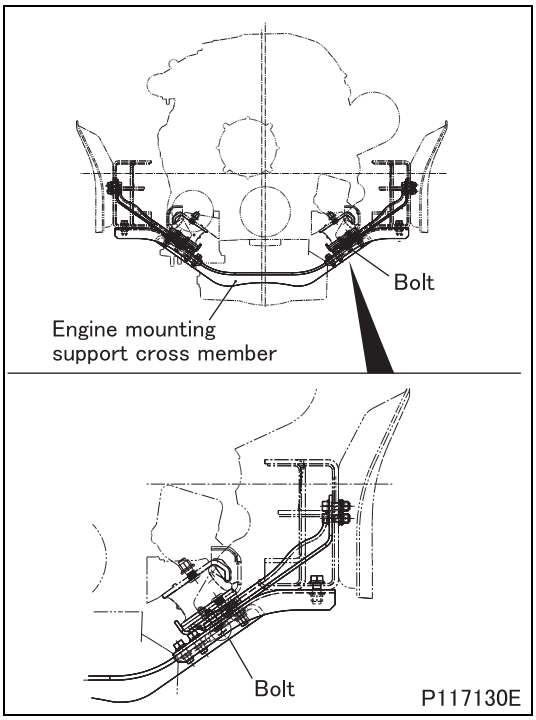
■ Work before removal

- Remove the transmission. (See Gr22.)
- Drain off the cooling water. (See Gr14.)
- Remove the wiring, pipes and related parts in the vicinity of the engine.
- Remove the rear mounting bridge. (See Gr42.)

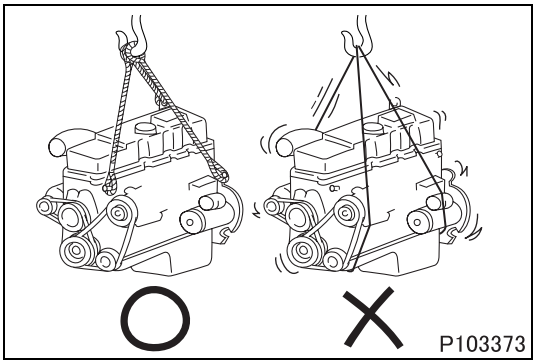


■ Removal: Engine

- Connect the wires to the chain block and onto the three hangers on the engine and lift the engine with a crane until they are tight.
- Support the transmission with a transmission jack.
- Check that all wiring and piping have been disconnected from the engine.

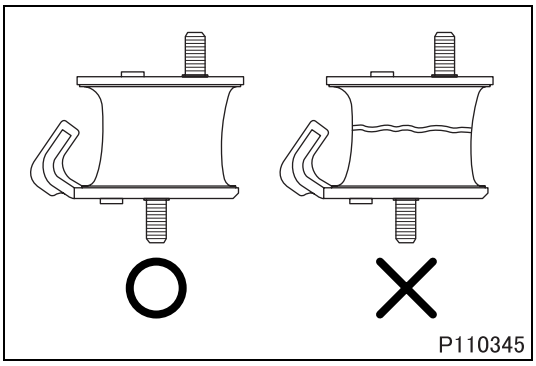


- Remove the bolts shown in the drawing from the bottom of the vehicle and separate the engine from the engine mounting support cross member.



- Adjust the lifting angle of the engine as necessary in this step. Once the engine has cleared the rear of the cab, turn the engine 90 degrees clockwise so as to prevent it from hitting the frame and cab, then lower it to the right side of the vehicle.

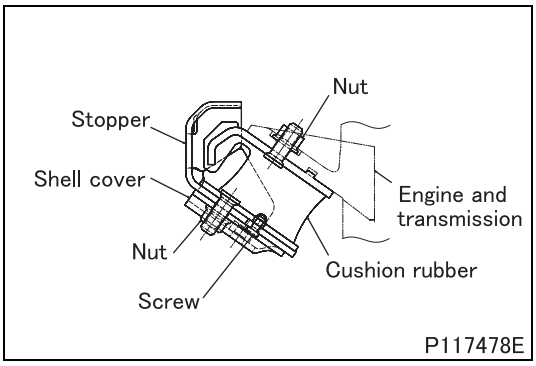
◆Inspection procedure◆



■ Inspection: Cushion rubber

- Check the entire periphery of the cushion rubber for cracks, breakage, oil stains or any other defect.
- Replace the cushion rubber if it is defective.

◆Installation procedure◆

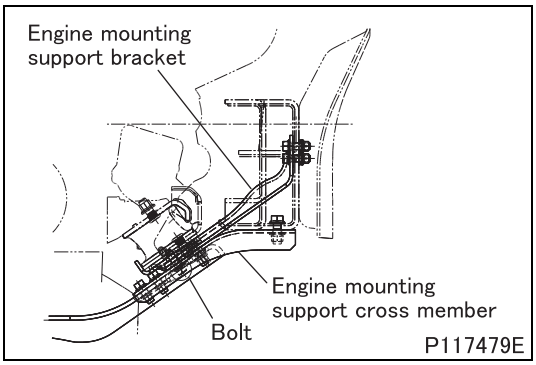


■ Installation: Cushion rubber

- Install the stopper and the shell cover on the cushion rubber, and then install them on the engine.

■ Installation: Engine

- While finely adjusting the hoisting angle of the engine, install the engine taking care that it does not strike the frame or the cab.
- Install the engine on the engine mounting support cross member.

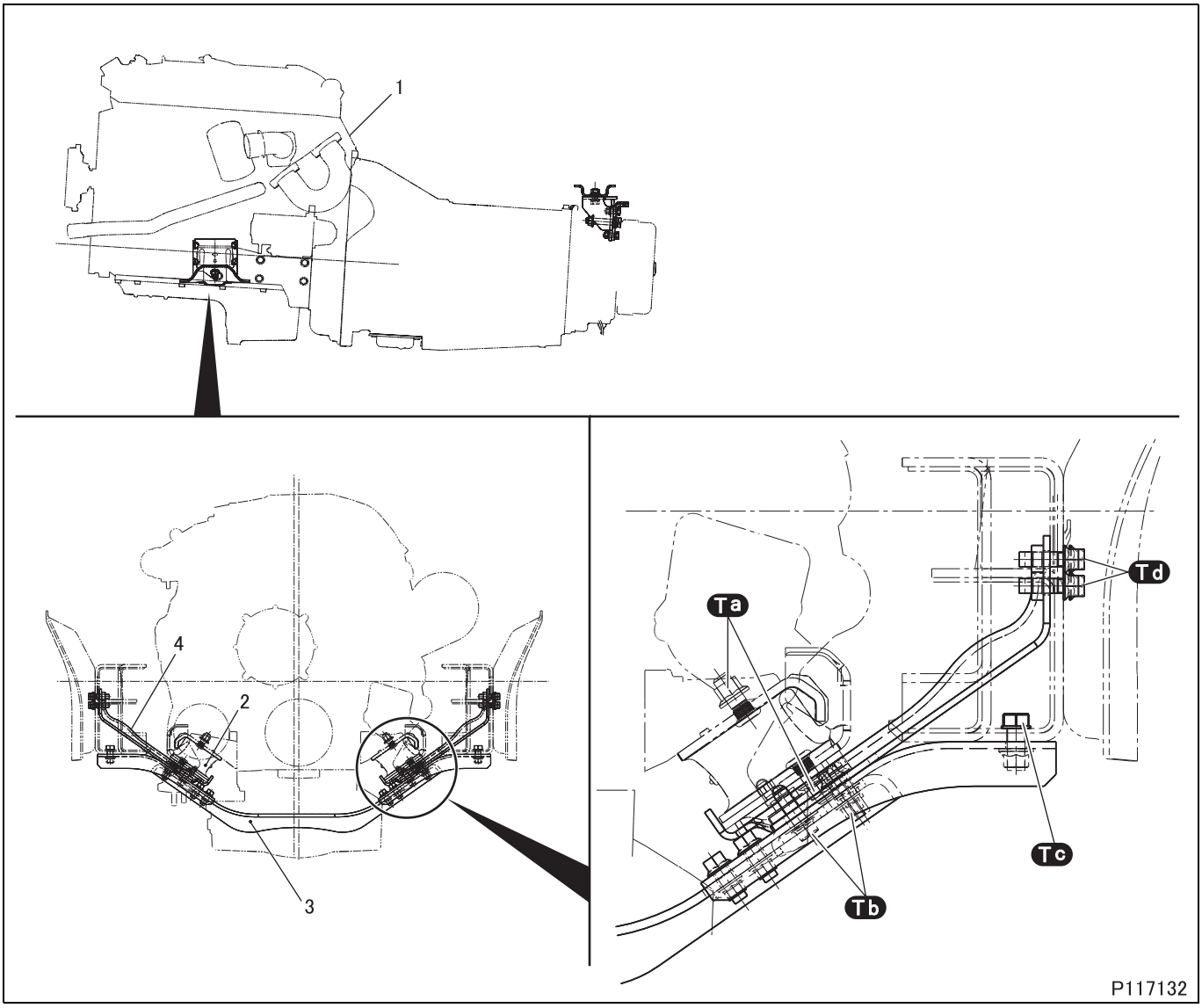


- Remove the wire and chain block from the engine hanger (3 points).

■ **Work after installation**

- Install the transmission. (See Gr22.)
- Reinstall the wiring, pipes and related parts in the vicinity of the engine.
- Reinstall the rear mounting bridge. (See Gr42.)
- Replenish cooling water. (See Gr14.)

ENGINE REMOVAL AND INSTALLATION <FIXED CAB>



● **Removal sequence**

1 Engine
2 Cushion rubber
3 Engine mounting support cross member
4 Engine mounting support bracket

● **Installation sequence**

Follow the removal sequence in reverse.

CAUTION ⚠

- **When removing and installing the engine, make sure that the engine does not strike the cab and the rear body.**
- **Secure the engine with the engine jack before removing each part.**

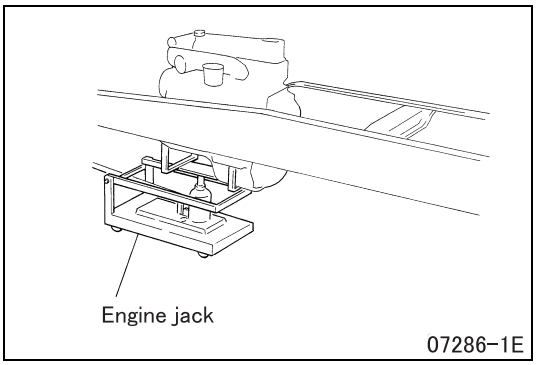
Tightening torque (Unit: N·m {ft.lbs, kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Nut (cushion rubber installation)	76.5 {56, 7.8}	–
Tb	Bolt (engine mounting support bracket installation)	58.7 {43, 6.0}	–
Tc	Bolt (engine mounting support cross member installation)	106 {78, 11}	–
Td	Bolt (engine mounting support bracket installation)	81.4 {60, 8.3}	–

◆Removal procedure◆

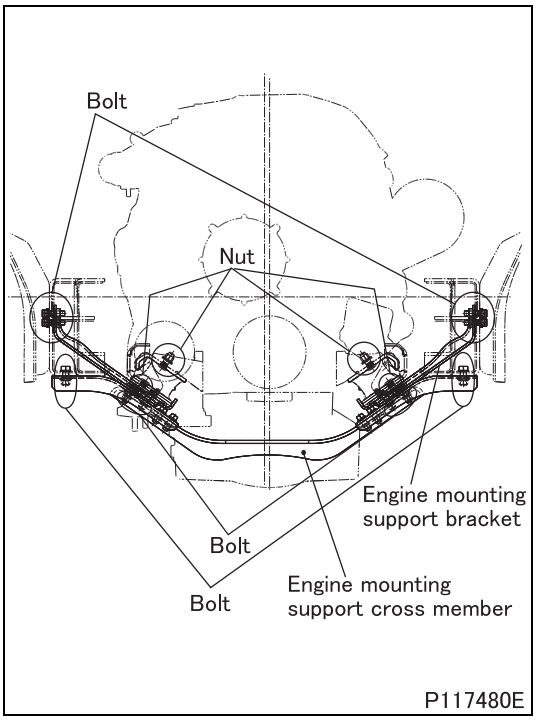
■ Work before removal

- Jack up the vehicle. (See Gr00.)
- Remove the transmission. (See Gr22.)
- Remove the front axle. (See Gr26.)
- Drain off the cooling water. (See Gr14.)
- Remove the wiring, pipes and related parts in the vicinity of the engine.

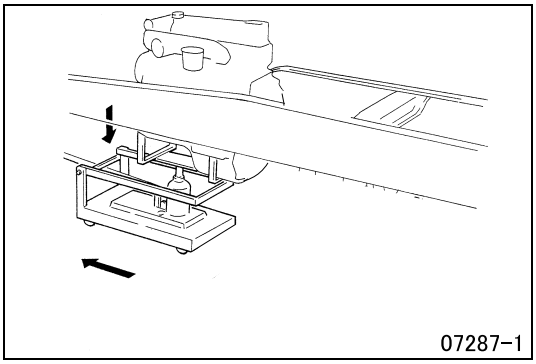


■ Removal: Engine

- Support the engine with an engine jack.
- Check that all wiring and piping are completely disconnected from the engine.

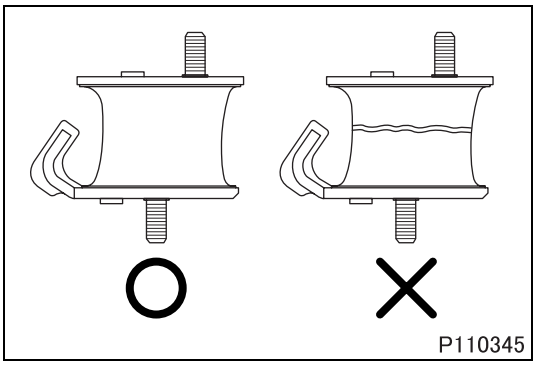


- For the rigid leaf type, separate the engine from different parts, while adjusting its lift amount (jack-up height), and remove the engine mounting support bracket from the engine compartment.



- While keeping the engine level, fully lower the engine.
- Lift the vehicle with a jack and move the engine forward.

◆Inspection procedure◆



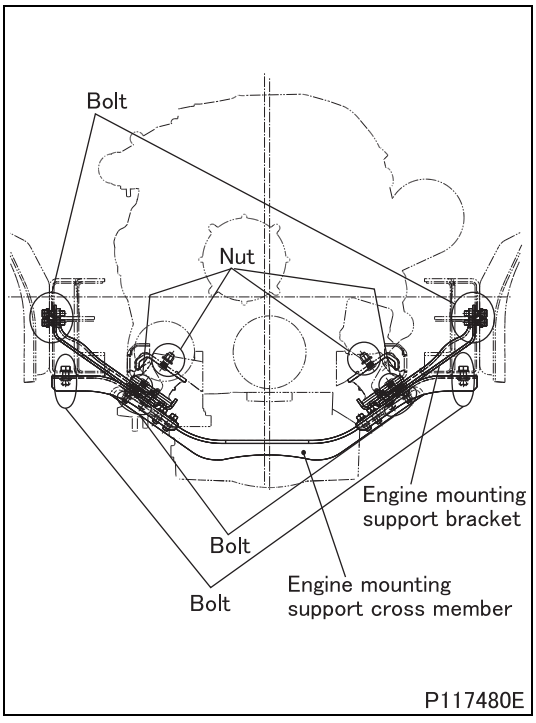
■ Inspection: Cushion rubber

- Check the entire periphery of the cushion rubber for cracks, breakage, oil stains or any other defect.
- Replace the cushion rubber if it is defective.

◆Installation procedure◆

■ Installation: Cushion rubber

- Support the engine with the engine lifter.
- While maintaining the engine horizontal, move the cushion rubber to the bottom of the frame, and then slowly raise the engine.
- While adjusting the lift of the engine (jacked-up height), install the nuts and bolts.



- Remove the engine lifter.

■ **Work after installation**

- Install the transmission. (See Gr22.)
- Install the front axle. (See Gr26.)
- Install the wiring, pipes and related parts in the vicinity of the engine.
- Jack down the vehicle. (See Gr00.)
- Replenish the cooling water. (See Gr14.)

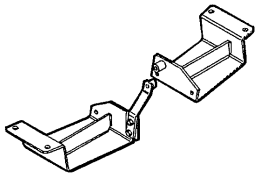
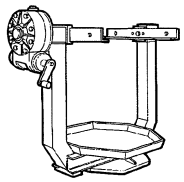
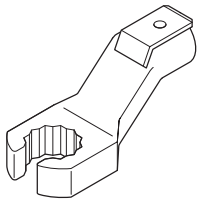
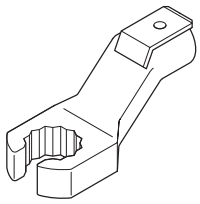
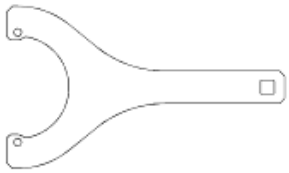
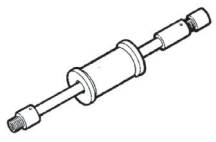
Tightening torque (Unit: N·m {ft.lbs, kgf·m})

Mark	Parts to be tightened		Tightening torque	Remarks
–	Bolt (oil return pipe mounting)		10 {7.4, 1}	–
–	Bolt (oil cooler mounting)		25 {18, 2.5}	–
	Bolt (connection pipe mounting)			
	Bolt (high pressure pipe bracket mounting)			
	Bolt (mixing pipe mounting)			
	Bolt (pulley mounting)			
	Bolt (water pump mounting)	M8		
	Bolt (alternator bracket mounting)	M8		
	Bolt (water pipe mounting)			
	Nut (air inlet pipe mounting)			
	Bolt (oil level gauge mounting)			
	Bolt (exhaust gas recirculation unit mounting)			
	Bolt (intake manifold mounting)			
	Bolt (thermostat mounting)			
	Bolt (automatic tensioner mounting)			
	Bolt (air duct mounting)			
	Bolt (oil return hose mounting)			
	Bolt (air conditioner compressor mounting)			
	Bolt (exhaust manifold and turbocharger mounting)			
	Bolt (bracket mounting)			
–	Bolt (alternator mounting)		40 {29, 4}	–
	Bolt (idle pulley mounting)			
	Water temperature sensor			
–	Bolt (water pump mounting)	M10	50 {37, 5}	–
	Bolt (alternator bracket mounting)	M10		
	Bolt (engine support mounting)			
–	Nut (pipe mounting)		30 {22, 3.1}	–
	Nut (exhaust gas recirculation valve mounting)			
	Connector (support bracket mounting)			
	Connector (oil pipe mounting)			
–	Automatic cooling fan coupling		90 to 112 {66 to 83, 9.2 to 11}	–
–	Bolt (common rail mounting)		28 {21, 2.8}	–
–	Bolt (injector bracket mounting)		32 {24, 3.2}	–
–	Union (fuel pipe mounting)	Injector side	25 ± 2 {18 ± 1.9, 2.5 ± 0.2}	–
		Common rail side	19 ± 2 {14 ± 1.9, 1.9 ± 0.2}	
–	Union (high pressure fuel pipe mounting)		19 ± 2 {14 ± 1.9, 1.9 ± 0.2}	–
–	Oil filter		25 to 30 {18 to 22, 2.5 to 3.1}	–
–	Air pulling out plug		1.5 ± 0.6 {1.1 ± 0.4, 0.15 ± 0.06}	–
–	Vacuum pipe		35 {25, 3.6}	–

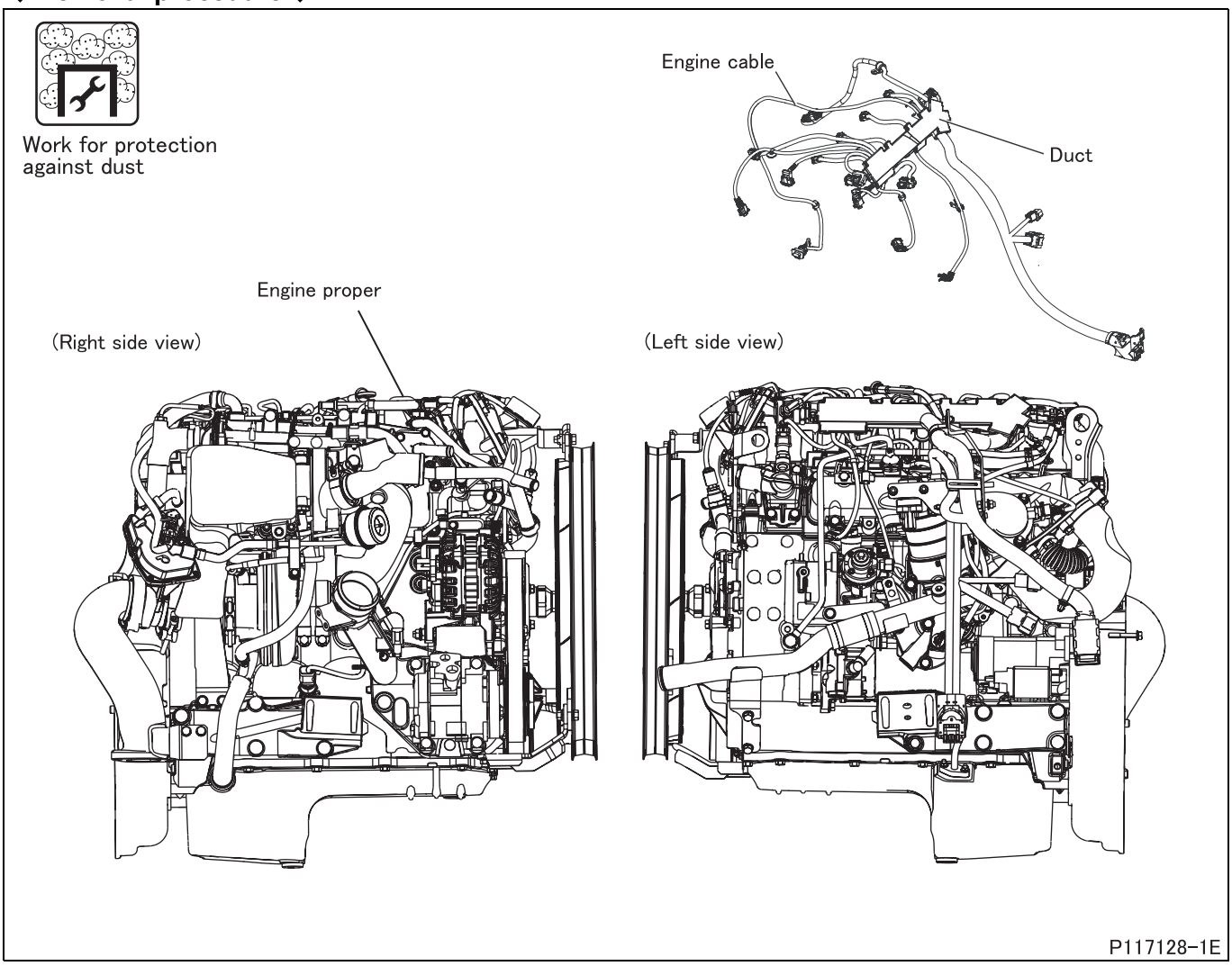
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
–	O-ring	Engine oil	As required
	Bracket bolt (turbocharger mounting)	Loctite 242	

Special tools

Mark	Tool name and shape	Part No.	Application
a	Engine rotary stand bracket  99361041	MH063991	Securing engine (to be used in combination) PRECAUTIONS ON USE 1. Drill holes in right and left rails of b for securing a. 2. Since these tools are not stable, secure them using anchor bolts. 3. Never rotate engine when oil is remaining inside. (Otherwise oil enters the combustion chamber, which will necessitate an overhaul.)
b	Rotary stand  99322205	MH063960	
d	Head, flare nut wrench (width across flats: 18 mm {0.71 in.})  P110453	MH063983	Removal and installation of injection pipe and fuel pipe
e	Head, flare nut wrench (width across flats: 19 mm {0.75 in.})  P110453	MH063982	
f	Socket wrench  P116185	MH064203	Removal and installation of injection pipe and fuel pipe <Four wheel drive>
g	Coupling fan attachment  P116337	MH064219	Removal and installation of pulley
h	Injector extractor  99340205	MH063990	Removal and installation of injector

◆Removal procedure◆



: This work requires protection against dust.

- If fine dust enters the high pressure fuel pump, engine performance will significantly be affected. Be sure to cover the openings after removing parts such as pipes.

■ Removal: Engine cable, duct, starter

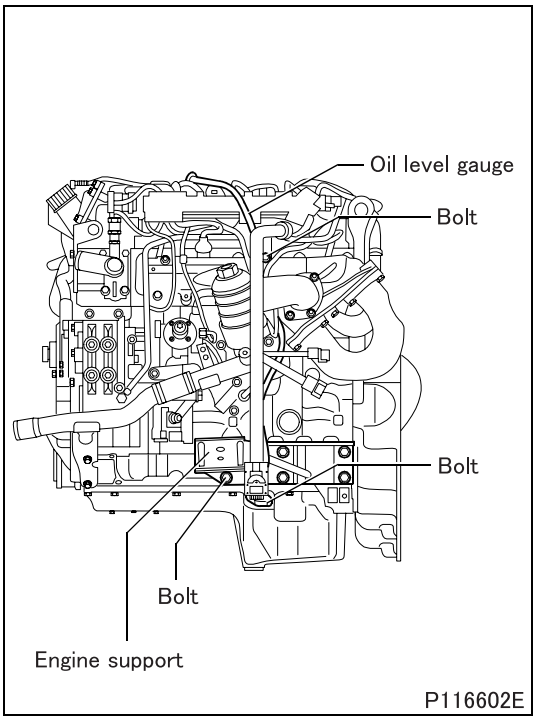
- To be able to fit the [a] for the [b] to the crankcase, it is necessary to carry out some preliminary operations as described below.
- Remove the engine cable together with the duct, disconnecting the electrical connections from the following parts.
  - Blow-by pressure sensors.
  - EBS (Exhaust Brake System) valve.
  - Glow plugs.
  - Injectors.
  - EGR (Exhaust Gas Recirculation) cooler outlet temperature sensor.
  - EGR (Exhaust Gas Recirculation) actuator.
  - Pressure sensor.
  - VGT (Variable Geometry Turbocharger) actuator.

- Pressure regulation valve.
- Boost pressure and temperature sensor.
- Water temperature sensor.
- Camshaft timing sensor.
- Engine speed sensor.
- Oil pressure sensor.

• Remove the starter motor.

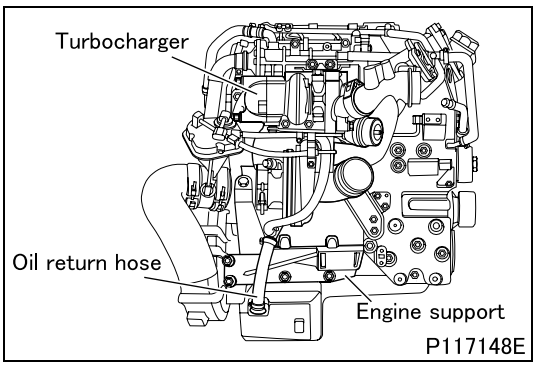
NOTE

• **Block the turbocharger air/exhaust gas inlets and outlets to prevent the entry of foreign material.**



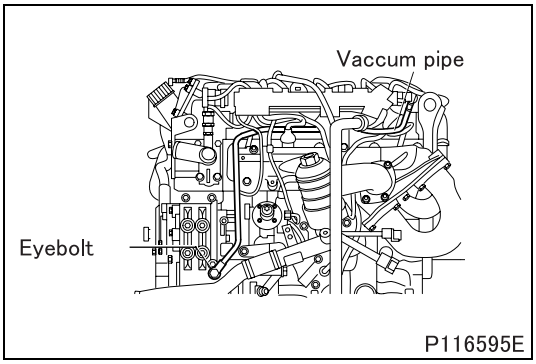
■ Working from the left-hand side

• Remove the pipe for checking the oil level. Unscrew and remove the screw fastening the pipe to the intake manifold; unscrew and remove the screws fastening the pipe to the oil pan.
• Remove the engine support.



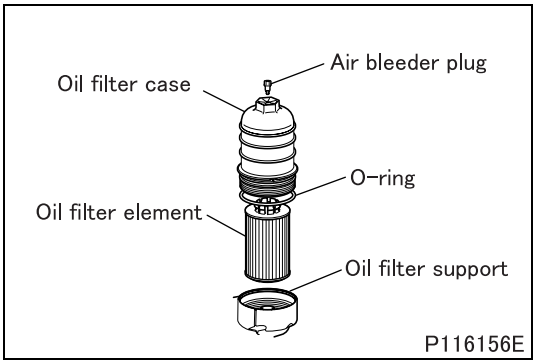
■ Working from the right-hand side

• Remove the turbocharger protector.
• Remove the oil return pipe from the turbocharger.
• Remove the fixing screws and remove the engine support.
• Fit the [a] to the crankcase and use these to secure the engine to the [b].
• Drain the oil from the engine by removing the plug from the oil pan.



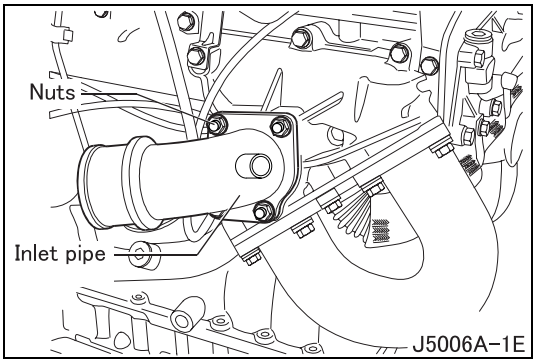
■ Removal: Vacuum pipe

• Remove the eyebolt, and remove the vacuum pipe.



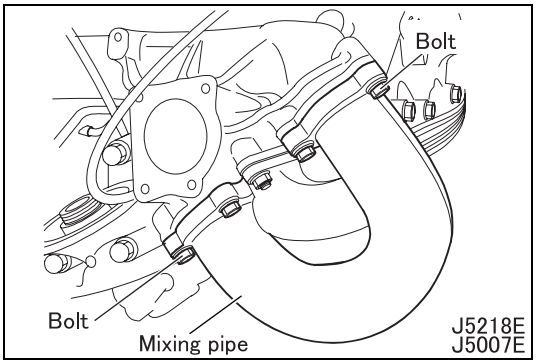
■ **Removal: Oil filter case, oil filter element**

- Loosen the oil filter case (by approx. 2.5 turns).
- Remove the air bleeder plug.
- Remove the oil filter case.
- Remove the oil filter element and O-ring.



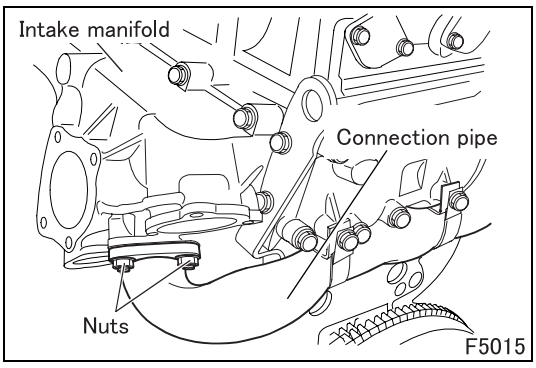
■ **Removal: Air inlet pipe**

- Remove the nuts and detach the air inlet pipe.



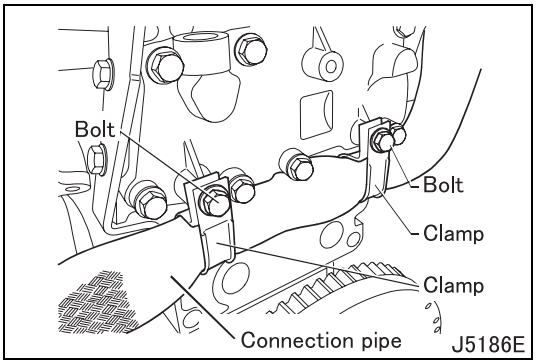
■ **Removal: Mixing pipe**

- Remove the mixing pipe.

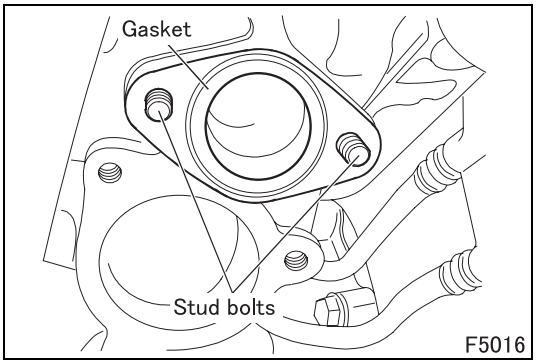


■ **Removal: Connection pipe**

- Remove the two nuts; disconnect the pipe from the intake manifold.

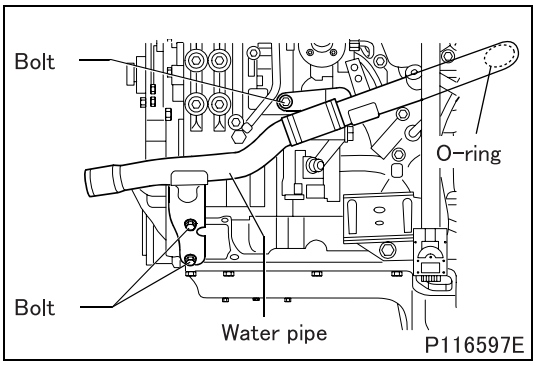


- Remove the clamps from the connection pipe.



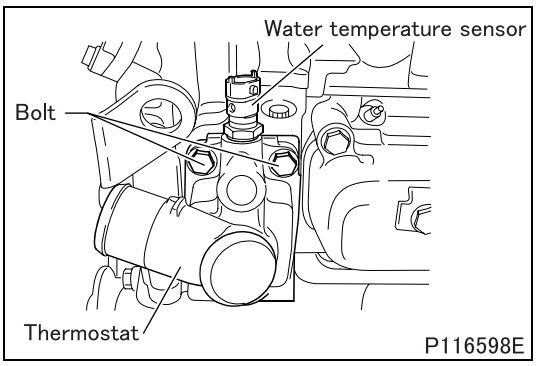
■ **Removal: Gasket, stud bolt**

- Remove the gasket.
- Remove the stud bolts.



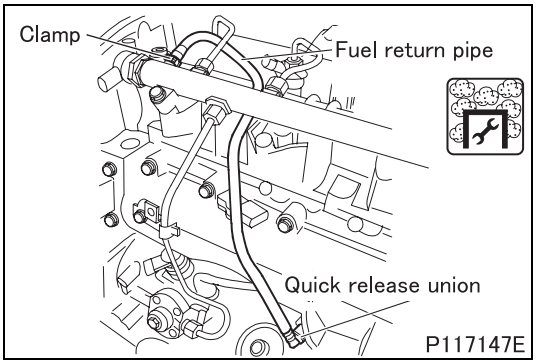
■ **Removal: Water pipe**

- Remove the water pipe from the oil cooler.



■ **Removal: Thermostat, water temperature sensors**

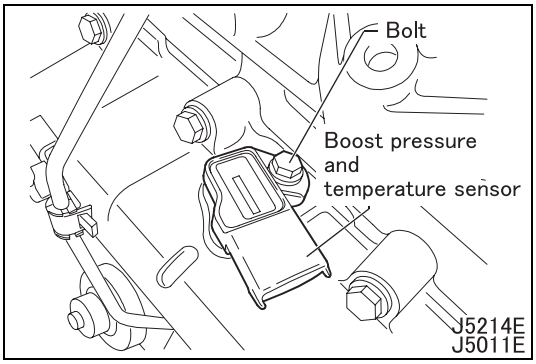
- Remove the thermostat and the water temperature sensor.



■ **Removal: Fuel return pipe**

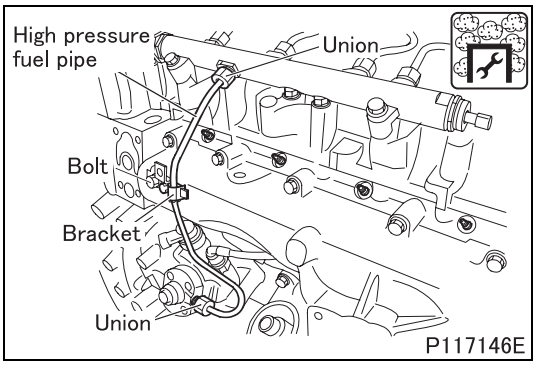
: This work requires protection against dust.

- Remove the clamp fastening the fuel return pipe to the common rail.
- Open the quick release union and remove the fuel return pipe for fuel return from the common rail.



■ **Removal: Boost pressure and temperature sensor**

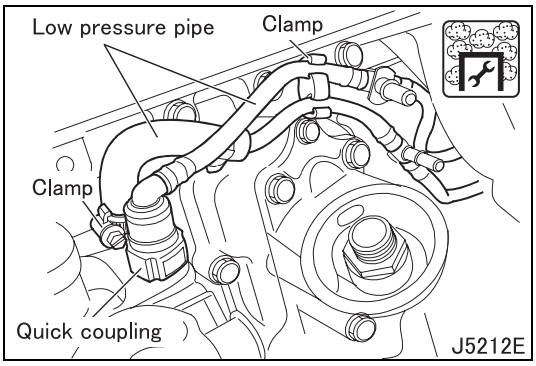
- Remove the boost pressure and temperature sensor from the intake manifold.



■ **Removal: High pressure fuel pipe**

: This work requires protection against dust.

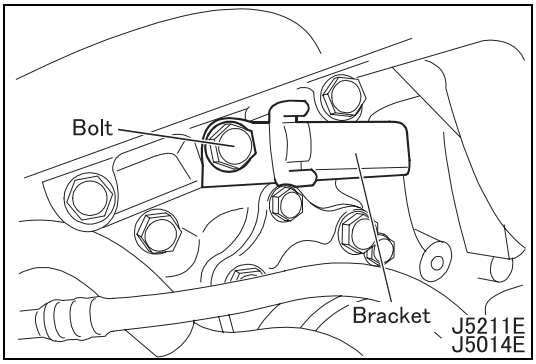
- Loosen the bolts of the pipe retaining bracket and remove the high pressure fuel pipe.



■ **Removal: Low pressure pipe**

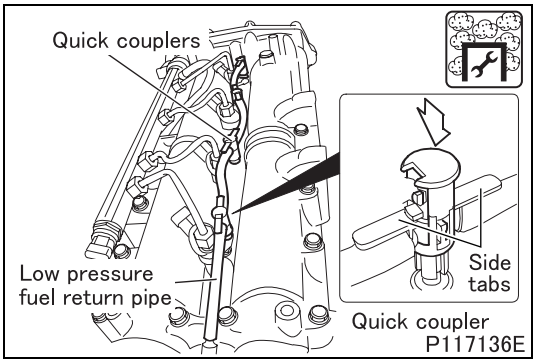
: This work requires protection against dust.

- Remove the connectors on the injector side and the common rail side of the fuel pipe.
- Remove the common rail from the engine overhead.



■ **Removal: Bracket**

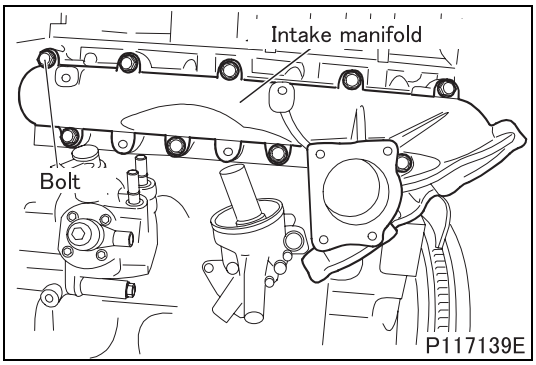
- Remove the bracket.



■ **Removal: Low pressure fuel return pipe**

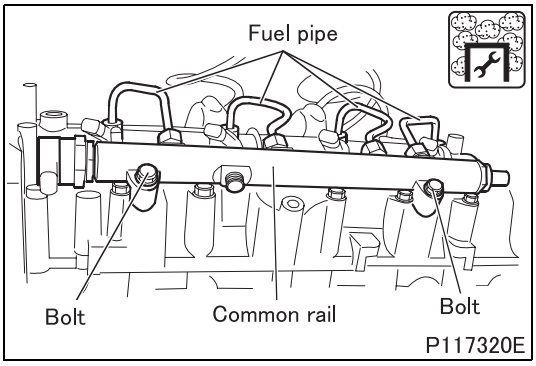
: This work requires protection against dust.

- To remove the low pressure fuel return pipe from the injectors it is necessary to open the quick couplers.
- To open the quick couplers press on the side tabs and raise the central body as shown in the figure.



■ **Removal: Intake manifold**

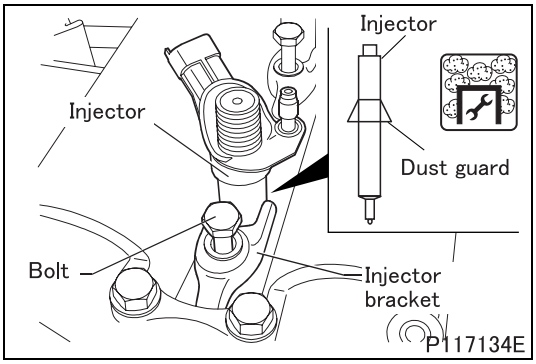
- Remove the intake manifold together with the gasket.



■ **Removal: Fuel pipe, common rail**

: This work requires protection against dust.

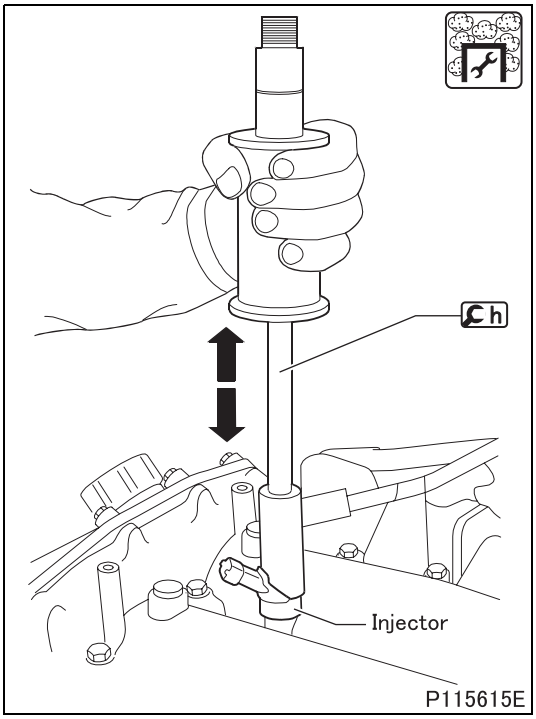
- Remove the injector side connectors using cf <Four wheel drive>.
- Remove the common rail side connectors using cd.
- Unscrew and remove the bolts. Detach the common rail from the engine overhead.



■**Removal: Injector bracket**

: This work requires protection against dust.

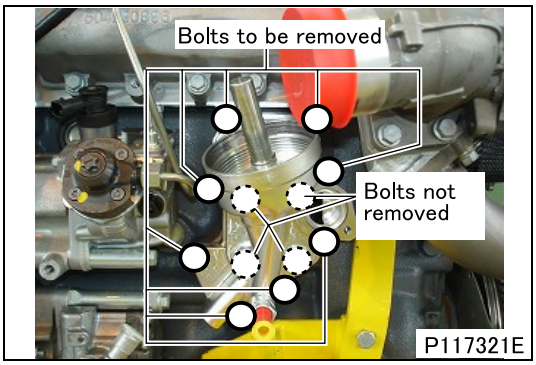
- Remove the injector bracket.



■**Removal: Injector**

: This work requires protection against dust.

- Remove the injector from the engine overhead using . (There is no gasket as the injector employs a direct sealing structure.)



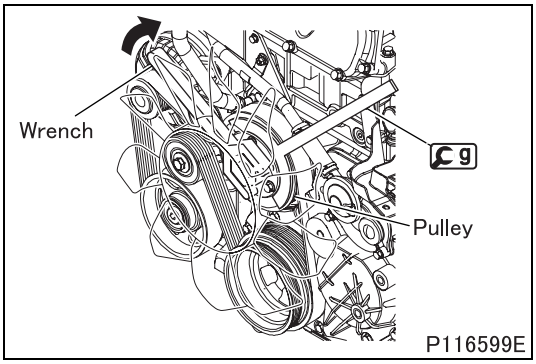
■ **Removal: Oil cooler**

- Remove the screws and detach the oil cooler with its gasket.

CAUTION ⚠

- **Do not remove the four bolts inside the oil filter support. If you remove these bolts, the heat exchanger in the oil cooler will become loose, which will mix oil and water, posing a danger.**

- The crankcase does not have a drain plug for draining off the cooling water, so when you remove the crankcase the cooling water will flow out. In this case, rotate the engine until all of the cooling water remaining in the engine flows out.

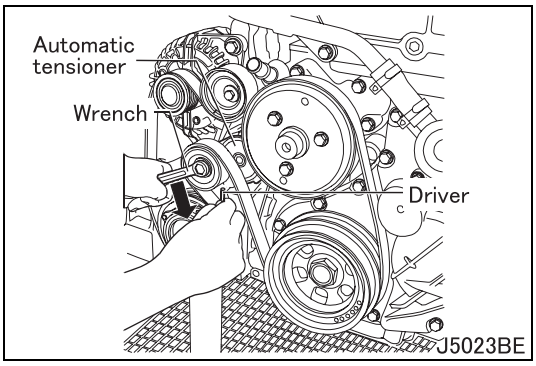


■ **Removal: Automatic cooling fan coupling, belt**

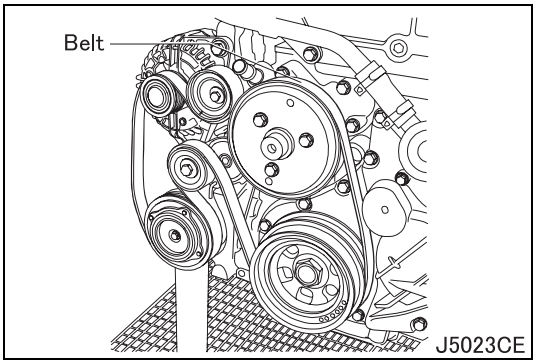
- Install [g] on the pulley, loosen the nut, and then remove the automatic cooling fan coupling.

CAUTION ⚠

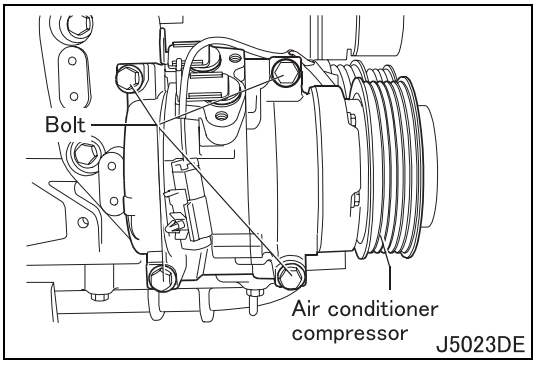
- **The automatic cooling fan coupling has left hand thread.**



- Using a wrench, by turning the automatic tensioner in the direction of the arrow so as to slacken the belt.
- Insert a screwdriver, or the like, into the hole in the automatic tensioner, and lock the automatic tensioner in the “Stop” position.

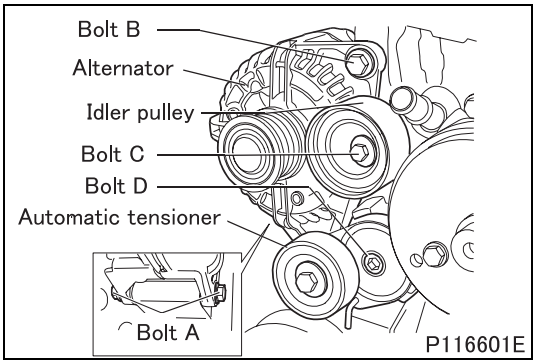


- Remove the belt.
- Remove the screwdriver that you inserted, from the automatic tensioner.



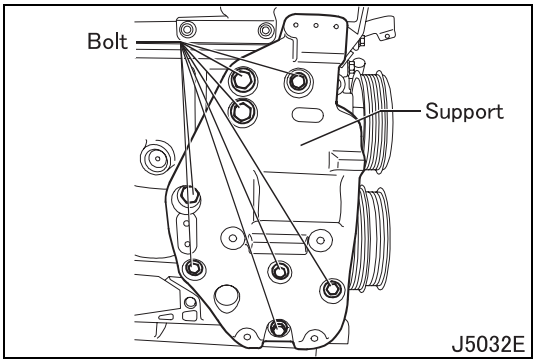
■ **Removal: Air conditioner compressor**

- Remove the air conditioner compressor.



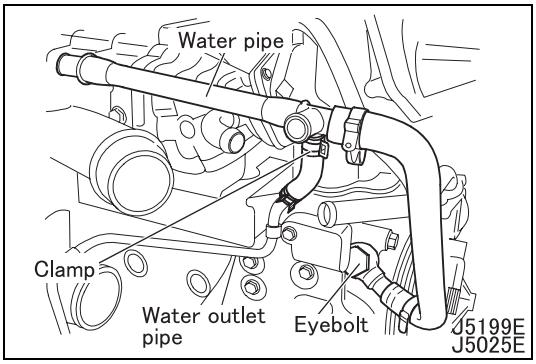
■ **Removal: Alternator, idler pulley, automatic tensioner**

- Loosen bolt C, and remove the idler pulley.
- Loosen bolt D, and remove the automatic tensioner.
- Remove through bolt A fixing the alternator.
- Remove bolt B, and then remove the alternator.



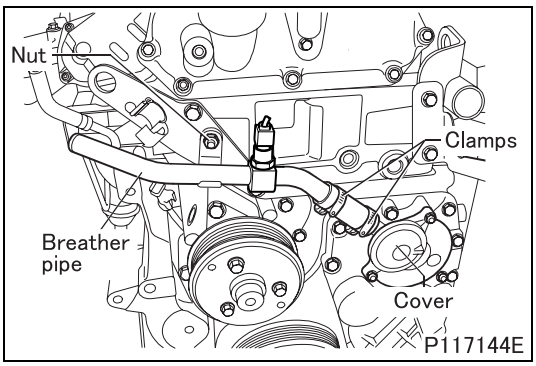
■ **Removal: Support**

- Remove the alternator support from the crankcase.



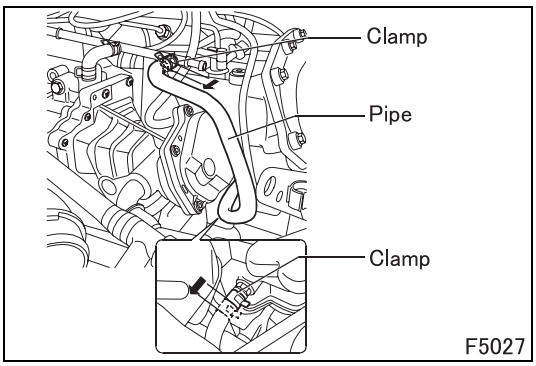
■ **Removal: Water pipe**

- Free the clamp on the water outlet pipe, and remove the water pipe.
- Remove the eyebolt together with the copper gasket.



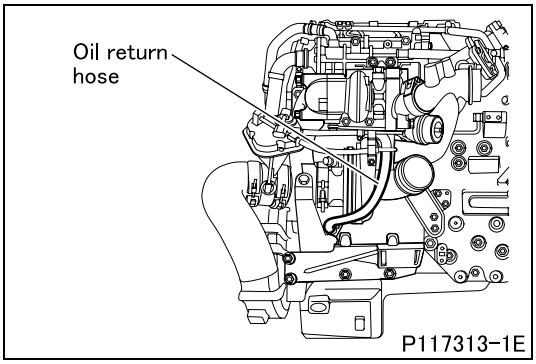
■ **Removal: Breather pipe**

- Remove the breather pipe from the cover.



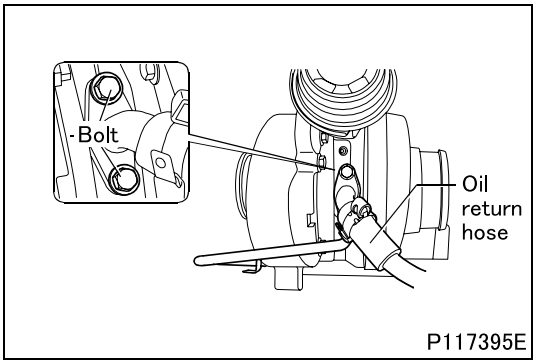
■ **Removal: Hose**

- Free the clamp, separate it from the position where it was fixing the hose, then move it in the direction of the arrow and remove the hose.



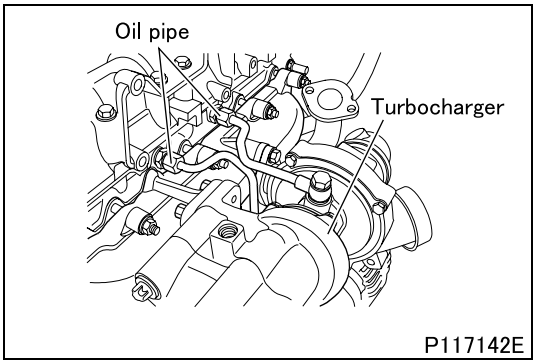
■ **Removal: Oil return hose**

- Disconnect the oil return hose from the turbocharger.



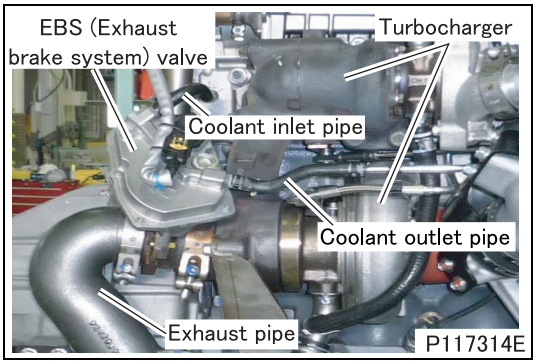
■ **Removal: Oil return hose**

- Disconnect the oil return hose.



■ **Removal: Oil pipe**

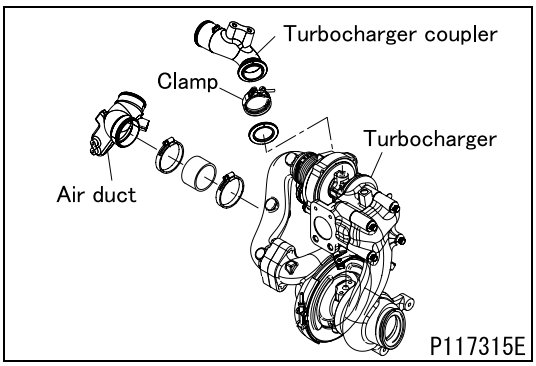
- Remove the oil pipe.



■ **Removal: Exhaust pipe, coolant inlet pipe, coolant outlet pipe, EBS (Exhaust Brake System) valve, bracket**

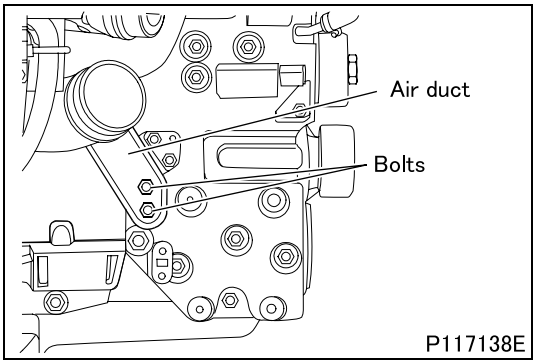
- Open the clamp and move it away form the position locking the coolant inlet pipe to the union on the EBS (Exhaust Brake System) valve.
- Remove the coolant inlet pipe from the EBS valve.
- Open the clamp and move it away from the position locking the coolant outlet pipe to the union on the EBS valve. Remove the coolant outlet pipe from the EBS valve.

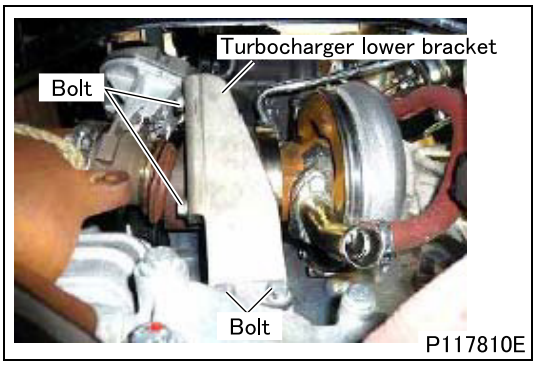
- Undo the screw, loosen the clamp and detach the exhaust pipe from the EBS valve.
- Undo the screw, loosen the clamp and remove the EBS valve from the turbocharger.



■ **Removal: Turbocharger coupler, air duct**

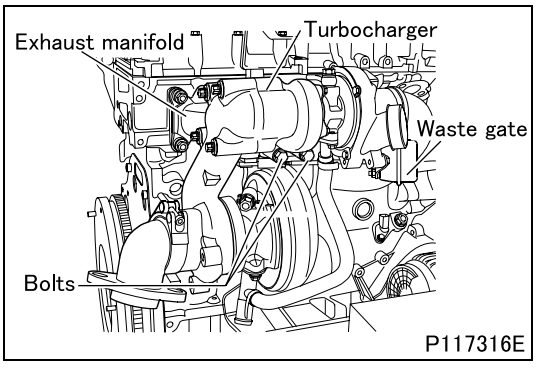
- Unfasten the clamp and remove the turbocharger coupler.
- Remove the air duct after unfastening the clamp.





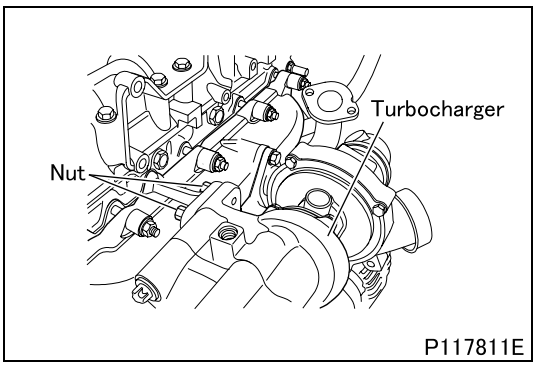
■ **Removal: Bracket**

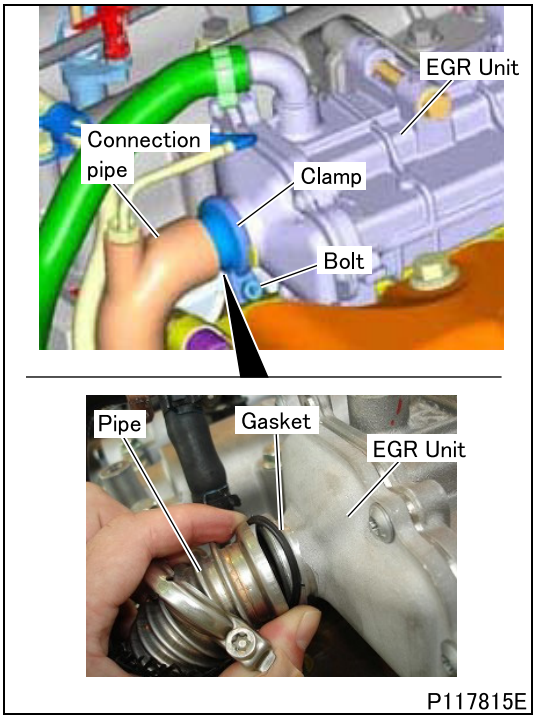
- Remove the bracket that secures the turbocharger in place.



■ **Removal: Turbocharger**

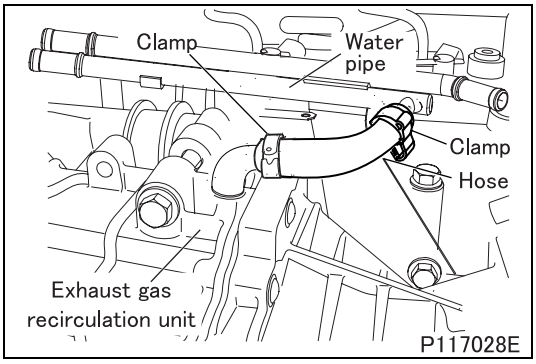
- Remove the turbocharger from the exhaust manifold.





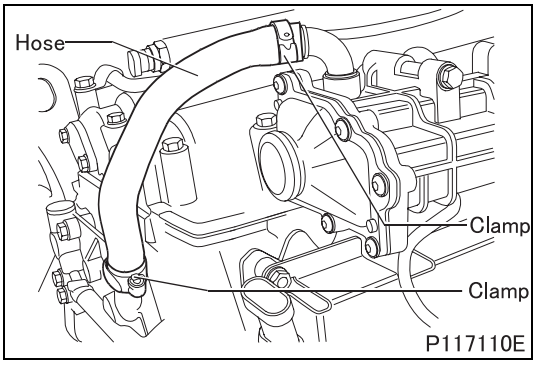
■ **Removal: Connection Pipe**

- Remove the clamp.
- Remove the connection pipe and gasket from the exhaust gas recirculation unit.



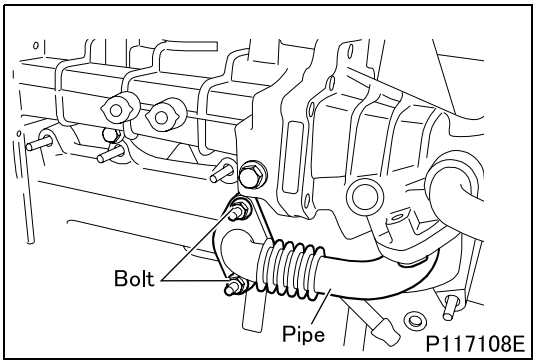
■ **Removal: Hose**

- Open the clamps and move them away from the position locking the pipe to the water outlet pipe and EGR (Exhaust Gas Recirculation) unit.
- Remove the pipe.



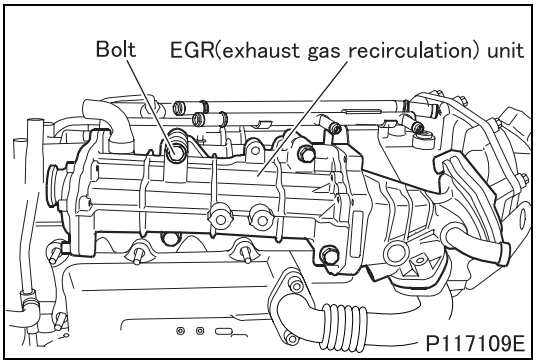
■ **Removal: Hose**

- Remove the retaining clamps.
- Remove the hose from EGR (Exhaust Gas Recirculation) and from the cover.



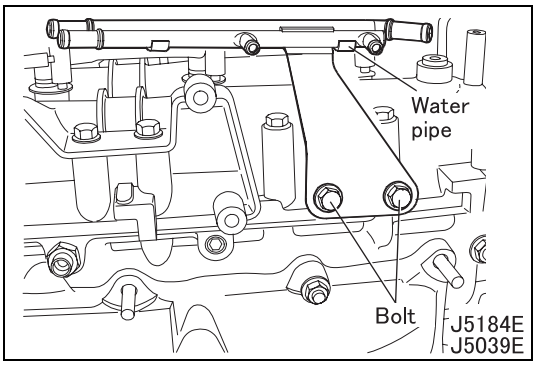
■ **Removal: EGR (Exhaust Gas Recirculation) valve pipe**

- Remove the two fixing bolts.
- Detach the pipe from the exhaust manifold, taking care to remove the gaskets.



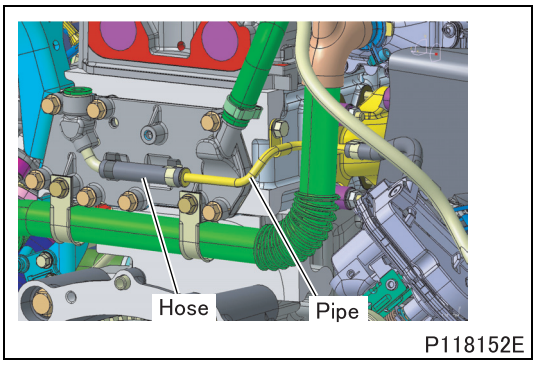
■ **Removal: EGR (Exhaust Gas Recirculation) unit**

- Remove the EGR (Exhaust Gas Recirculation) unit.



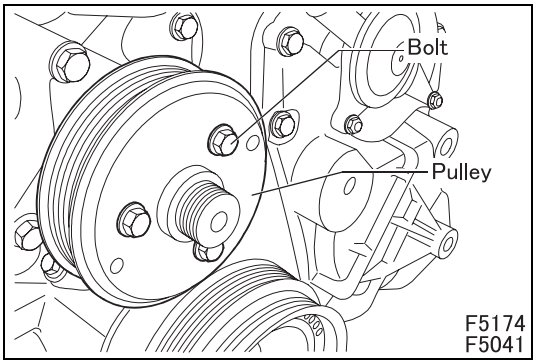
■ **Removal: Water pipe, supporting bracket**

- Remove the water pipe together with the supporting bracket.



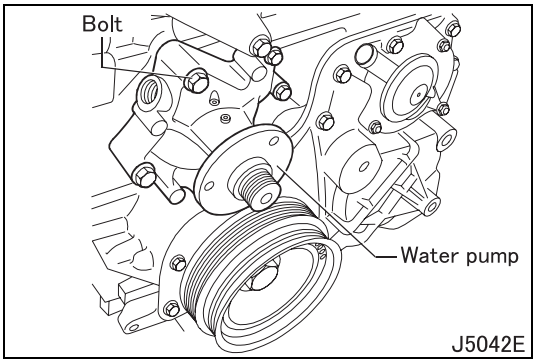
■ **Removal: Hose**

- Remove the hose.



■ **Removal: Pulley**

- Hold the pulley using [C9], then remove the pulley from the water pump.



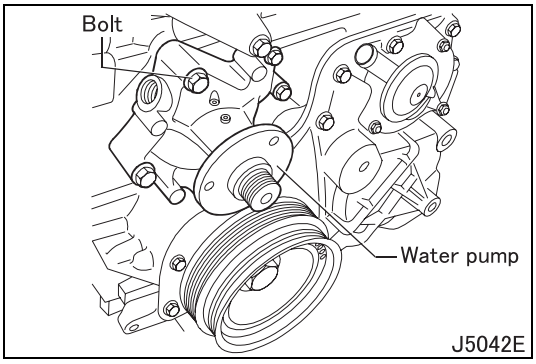
■ **Removal: Water pump**

- Remove the water pump, and remove the gasket.
- The crankcase does not have a drain plug for draining off the cooling water, so when you remove the crankcase the cooling water will flow out. In this case, rotate the engine until all of the cooling water remaining in the engine flows out.

- For further removal procedures, see later sections.
- Timing gear case
- Over head, cylinder head
- Pistons, connecting rod
- Flywheel
- Timing gears, chain

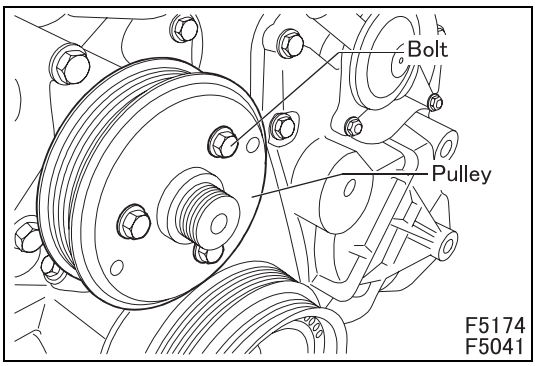
◆Installation procedure◆

- For further installation procedures, see later sections.
- Timing gear case
- Over head, cylinder head
- Pistons, connecting rod
- Flywheel
- Timing gears, chain



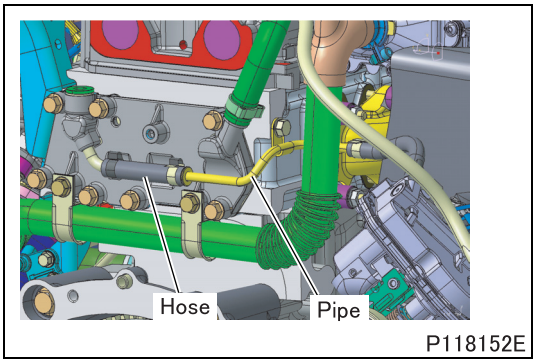
■ **Installation: Water pump**

- Install the water pump with a new gasket.
- Install the screws and tighten them to the prescribed torque.
  - Bolts M10 × 1.5 × 55 mm torque 50 N·m {37 ft.lbs, 51 kgf·m}.
  - Bolts M8 × 1.25 × 45 mm torque 25 N·m {18 ft.lbs, 2.5 kgf·m}.



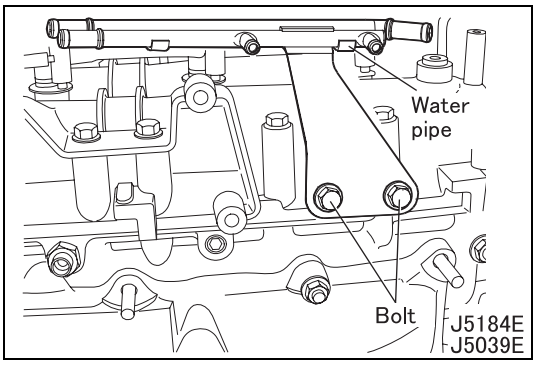
■ **Installation: Pulley**

- Install the pulley on the water pump, hold the pulley using [g], and then install the bolts to a torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.



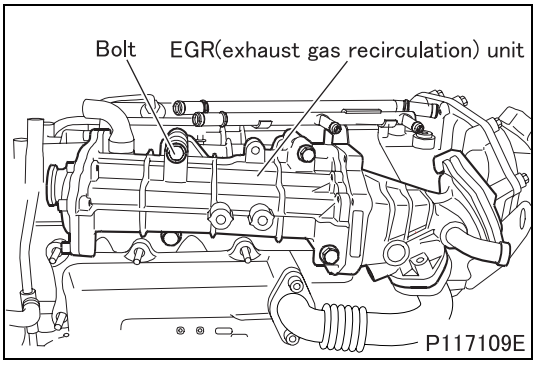
■ **Installation: Hose**

- Install the hose.



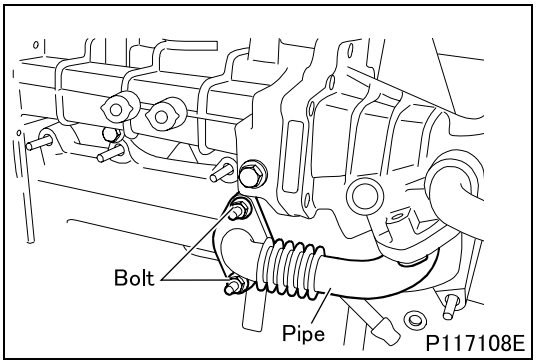
■ **Installation: Water pipe**

- Install the water pipe.
- Install the fixing screws and tighten it to a torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.



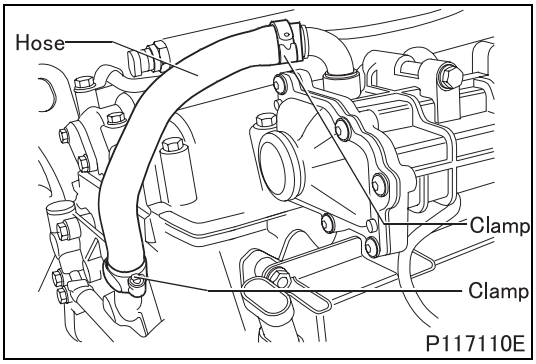
■ **Installation: EGR (Exhaust Gas Recirculation) unit**

- Install the EGR unit on the overhead and tighten the fixing screws to a tightening torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.



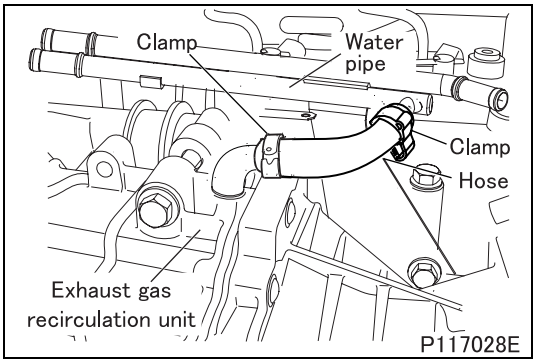
■ Installation: EGR (Exhaust Gas Recirculation) valve pipe

- Install the pipe with a new gasket to exhaust manifold.
- Tighten the two bolts.
- Tighten the two nuts to a torque of 30 N·m {22 ft.lbs, 3.1 kgf·m}.



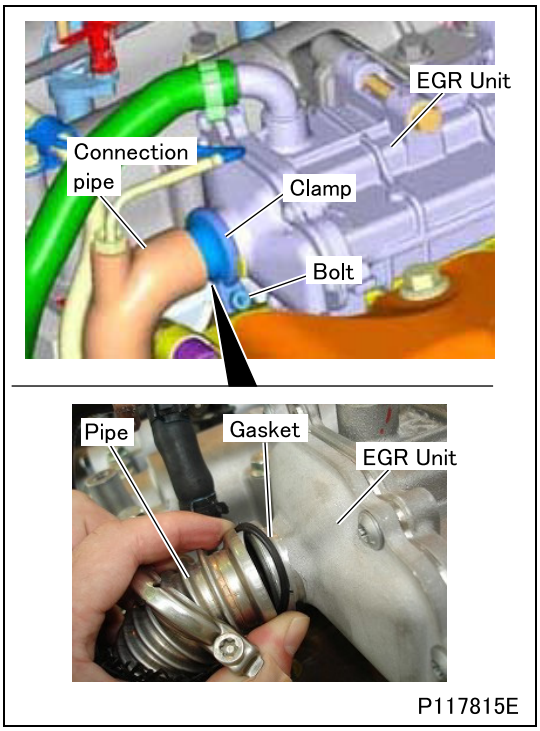
■ Installation: Cross adapter, hose

- Connect the hose with the heat exchanger and the cover.
- Retain it with the new clamps.



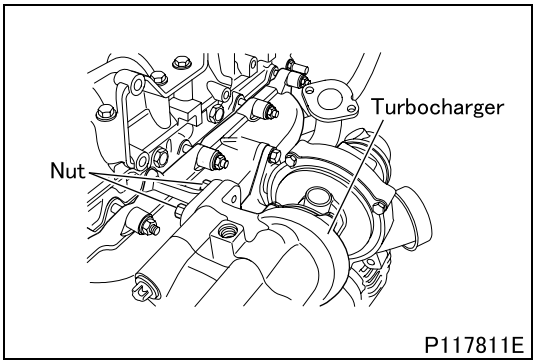
■ Installation: Hose

- Connect the hose between the water pipe and the EGR (Exhaust Gas Recirculation) unit.
- Fasten the hose to the adapters using the clamps.



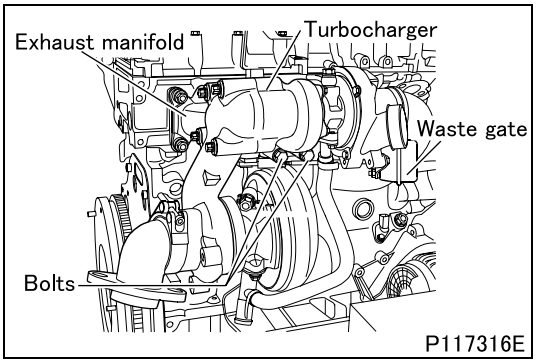
■ Installation: Connection pipe

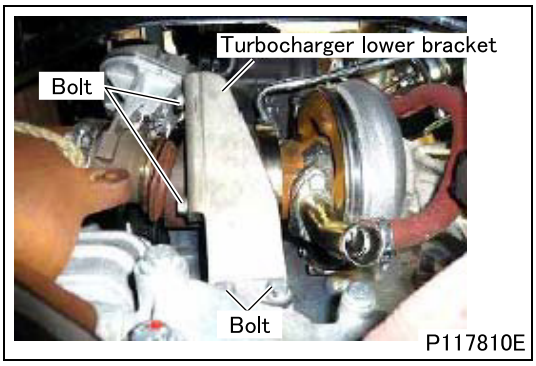
- Install the exhaust gas recirculation connection pipe and gasket on the exhaust gas recirculation unit.
- Install the clamp as shown.
- Tighten the clamp bolt.



■ **Installation: Turbocharger, exhaust manifold**

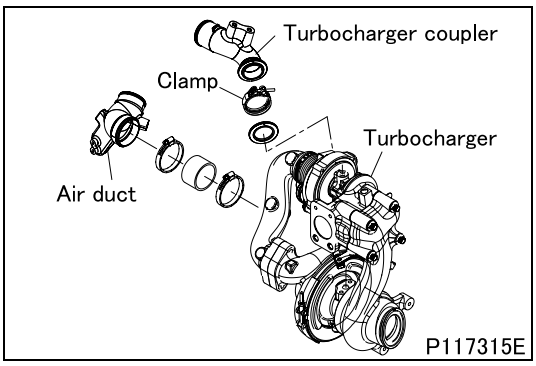
- Install the turbocharger unit with a new gasket onto the exhaust manifold complete with pipes and waste gate.
- Screw down the two lower bolts securing the turbocharger assembly to the exhaust manifold and tighten them to the prescribed torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.
- Fit the cooling pipe on the turbocharger.





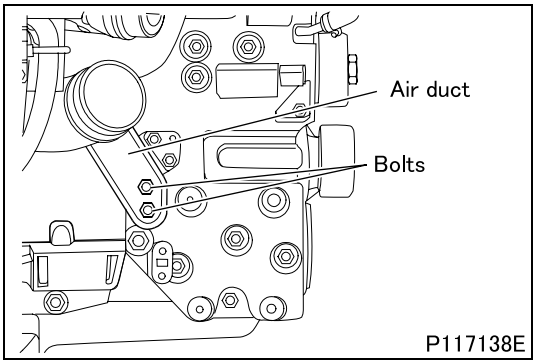
■ **Installation: Bracket**

- Install the bracket.
- Install the screws and tighten it to a torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.

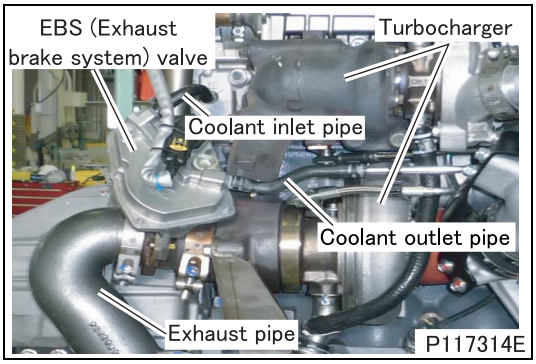


■ **Installation: Turbocharger coupler, air duct**

- Install the turbocharger coupler and air duct to the turbocharger.

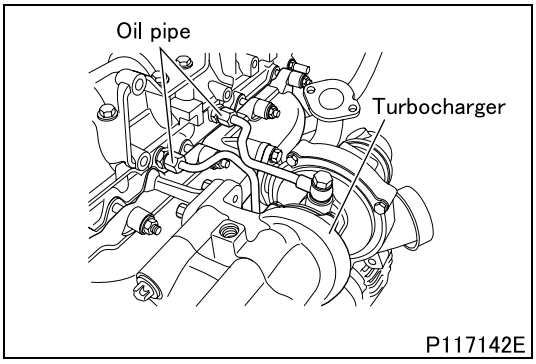


- Install the air duct.
- Install the screws and tighten it to a torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.



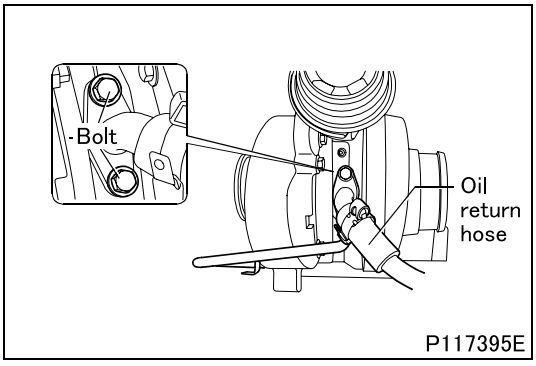
■ Installation: Exhaust pipe, coolant inlet pipe, coolant outlet pipe, EBS (Exhaust Brake System) valve, bracket

- Reinstall the EBS valve on the turbine outlet; place the clamp and tighten the screw.
- Install the exhaust pipe on the EBS valve.
- Install the clamp and position it so that the screw doesn't interfere with the operation of the valve.
- Insert the coolant inlet pipe for EBS valve in the union. Tighten the clamp to the stop position.
- Insert the coolant outlet pipe for EBS valve in the union. Tighten the clamp to the stop position.



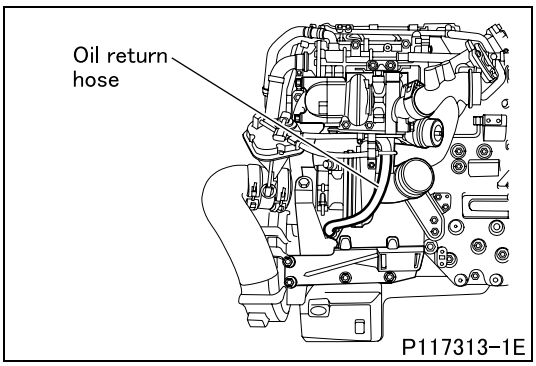
■ Installation: Oil pipe

- Connect the oil pipe to the turbocharger and the cylinder head, and tighten the pipe unions to the prescribed torque: 30 N·m {22 ft.lbs, 3.1 kgf·m}.



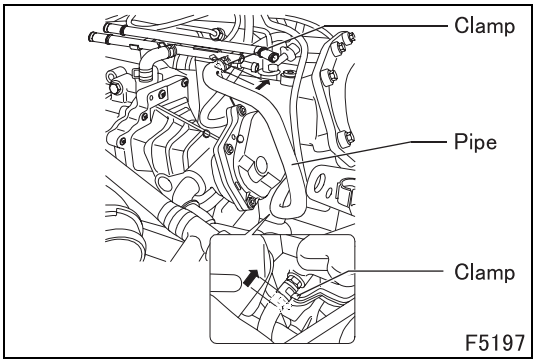
■ Installation: Oil return hose

- Install the oil return pipe on the turbocharger.
- Install the fixing bolts and tighten it to a torque of 10 N·m {7.4 ft.lbs, 1.0 kgf·m}.
- Install the coolant inlet pipe on the turbocharger.
- Install without fully tightening the union.



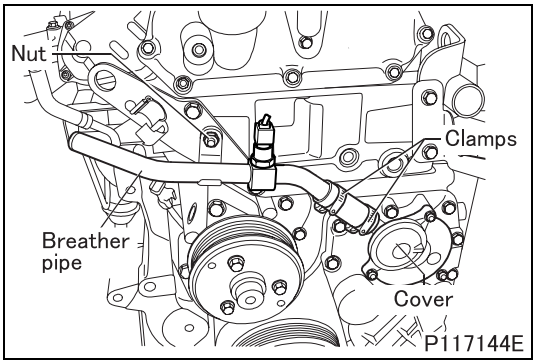
■ **Installation: Oil return hose**

- Connect the oil return hose to the turbocharger.



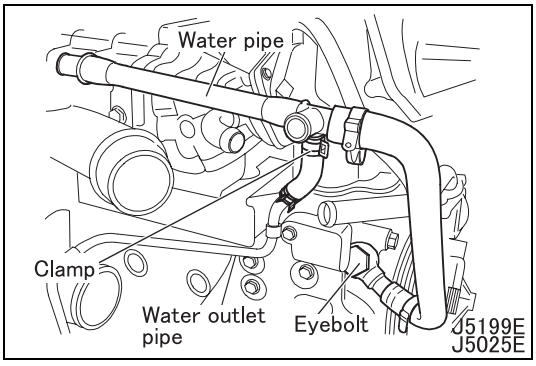
■ **Installation: Pipe**

- Install the hose with the clamp.



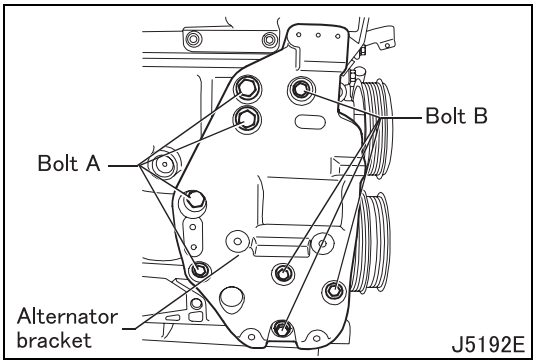
■ **Installation: Breather pipe**

- Install the breather pipe on the cover using a new clamp.



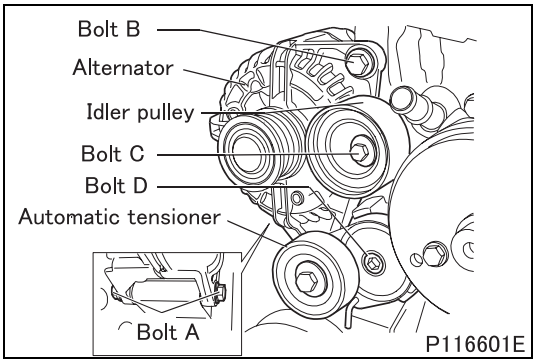
■ **Installation: Water pipe**

- Install the water outlet pipe on the crankcase using a new clamp.
- Install the eyebolt together with a new gasket.



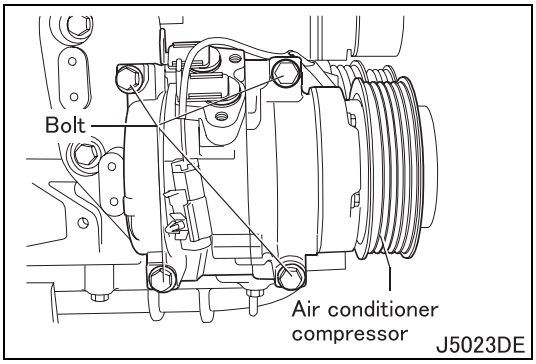
■ **Installation: Alternator bracket**

- Install the alternator bracket on the crankcase.
- Install the bolts and tighten them to the prescribed torque.
  - Bolts A M10 × 1.25 torque 50 N·m {37 ft.lbs, 5.1 kgf·m}.
  - Bolts B M8 × 1.25 torque 25 N·m {18 ft.lbs, 2.5 kgf·m}.



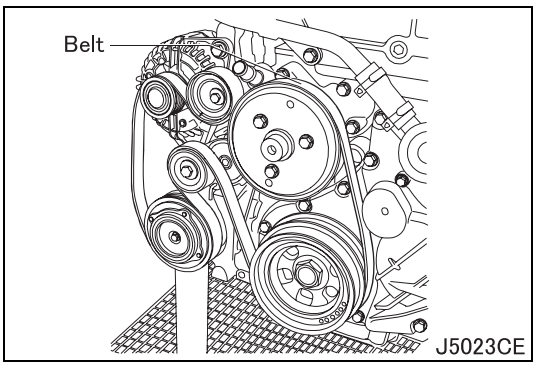
■ **Installation: Alternator, idler pulley, automatic tensioner**

- Install the alternator on the bracket, and tighten bolts A and B to a torque of 40 N·m {29 ft.lbs, 4.0 kgf·m}.
- Install the automatic tensioner, and tighten bolt D to a torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.
- Install the idler pulley, and tighten bolt C to a torque of 40 N·m {29 ft.lbs, 4.0 kgf·m}.



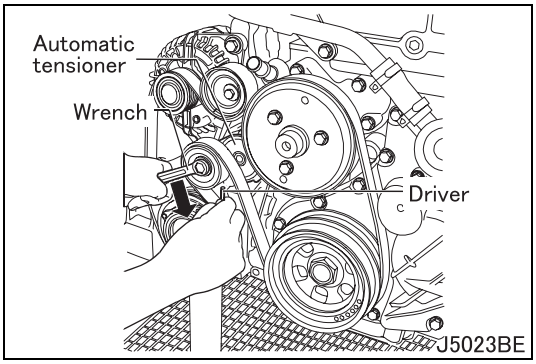
■ **Installation: Air conditioner compressor**

- Install the air conditioner compressor on the support.
- Install and tighten the bolts to a torque of 25 N·m {1.8 ft.lbs, 2.5 kgf·m}.

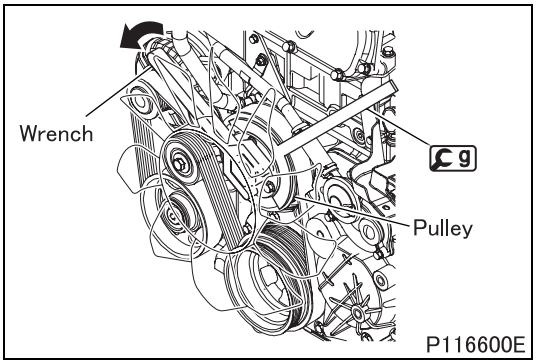


■ **Installation: Belt, automatic cooling fan coupling**

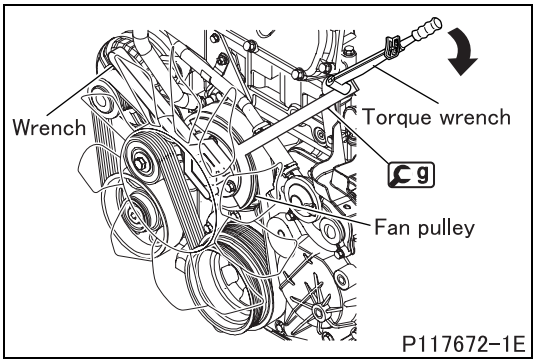
- Insert a screwdriver, or the like, into the hole in the automatic tensioner, and lock the automatic tensioner in the “Stop” position.
- Install the belt.



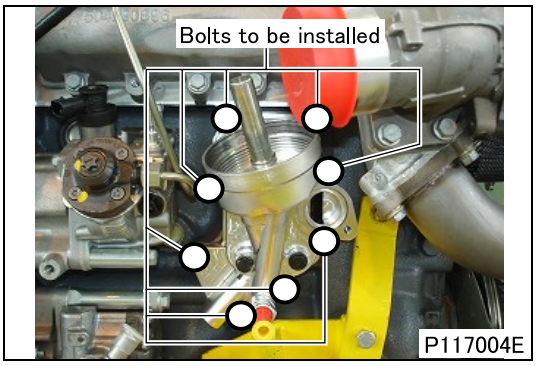
- After operating the automatic tensioner in the direction of the arrow using a wrench, remove the driver.



- Install g on the fan pulley.
- Holding g, tighten the automatic cooling fan coupling to a torque of 90 to 112 N·m {66 to 83 ft.lbs, 9.2 to 11 kgf·m}.

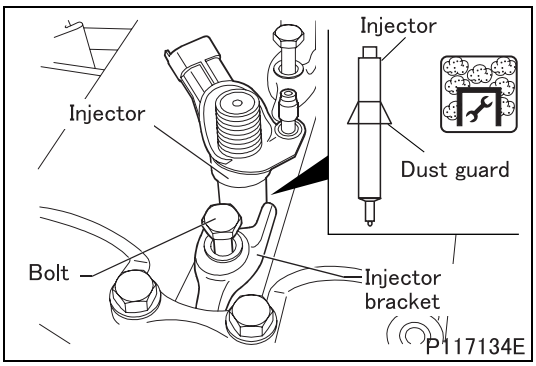


- If it is difficult to check the tightening torque of the automatic cooling fan coupling, set a torque wrench at the g while retaining the automatic cooling fan coupling with a wrench, turn the wrench so as to fix the fan pulley, and check the tightening torque.
- In this case, the value of the tightening torque must take into account of the 230 mm {9.06 in.} length of the g.



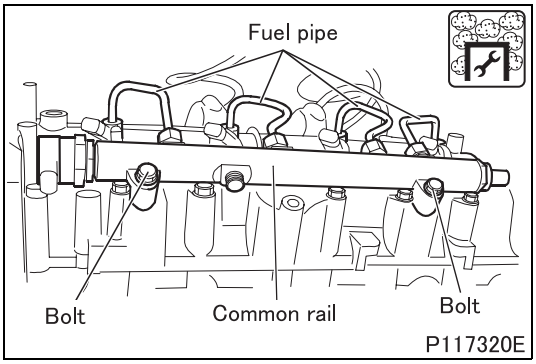
■ **Installation: Oil cooler**

- Install the oil cooler together with a new gasket on the crankcase, and install it using a torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.



: This work requires protection against dust.

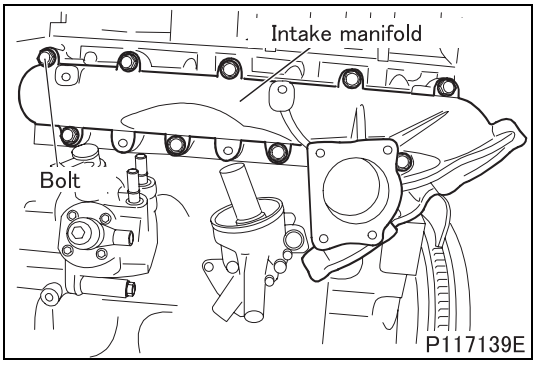
- Install a new dust guard on the injector.
- Install the injector on the engine overhead, and temporarily install the injector bracket. (The injector is of a direct sealing type, so it does not use a gasket.)
- After installing the fuel pipe and the common line, tighten the injector bracket to a torque of 32 N·m {24 ft.lbs, 3.2 kgf·m}.



■ Installation: Common rail, fuel pipe

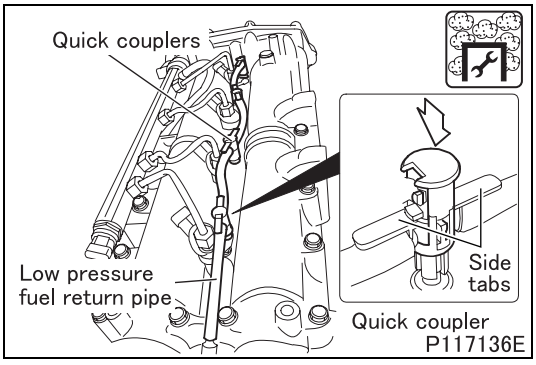
: This work requires protection against dust.

- Install the common rail on the engine overhead.
- Tighten the bolt to a torque of 28 N·m {21 ft.lbs, 2.8 kgf·m}.
- Connect the new fuel pipes to the injectors and the common rail.
- Install the injector side connectors using Cf. <Four wheel drive>
  - Connector on the injector torque 25 ± 2 N·m {18.0 ± 1.5 ft.lbs, 2.5 ± 0.2 kgf·m}
  - Install the common rail side connectors using Cd.
  - Connector on the common rail torque 19 ± 2 N·m {14.0 ± 1.5 ft.lbs, 1.9 ± 0.2 kgf·m}



■ Installation: Intake manifold

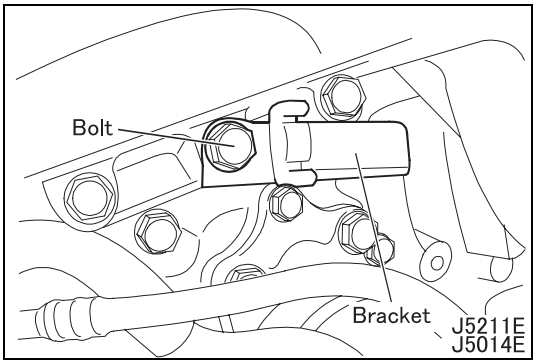
- Install the intake manifold with a new gasket.
- Tighten the screws to the prescribed torque: 25 N·m {18 ft.lbs, 2.5 kgf·m}.



■ Installation: Low pressure fuel return pipe

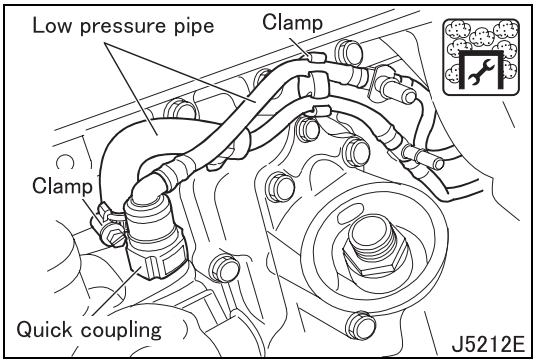
: This work requires protection against dust.

- Install the injectors low pressure fuel return pipe.
- Push down the center body of the quick coupler in the direction of the arrow.



■ **Installation: Bracket**

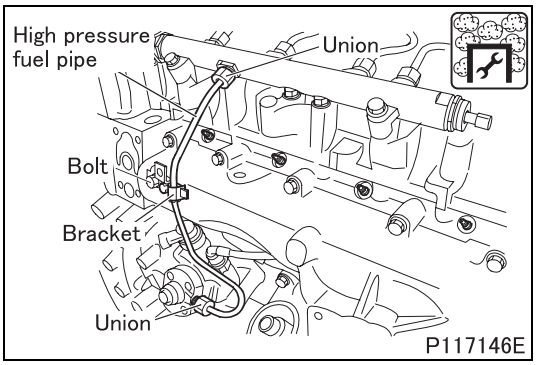
- Fit the bracket.
- Tighten the screw to a torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.



■ **Installation: Low pressure pipe**

: This work requires protection against dust.

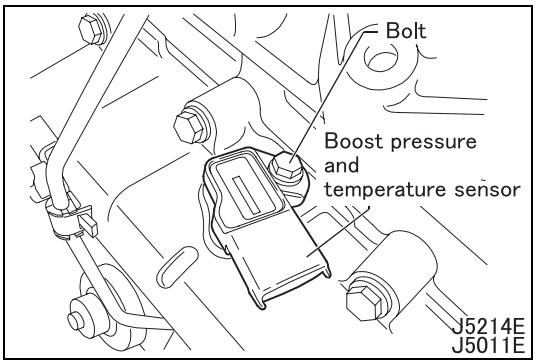
- Clamp the quick coupling and the clamp of the low pressure fuel pipe to the high pressure fuel pump, and install the low pressure fuel pipe.
- Fix the low pressure fuel pipe to the clip.



■ **Installation: High pressure fuel pipe**

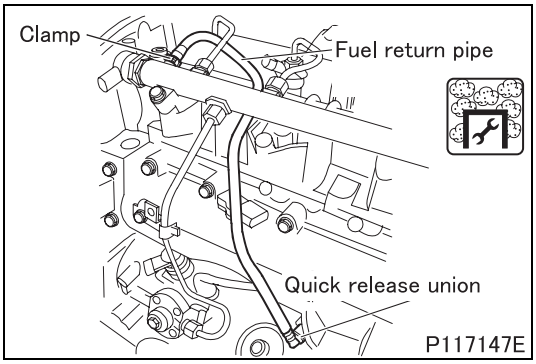
: This work requires protection against dust.

- Install a new high pressure fuel pipe.
- Screw the bracket to the intake manifold using the bolt. Tighten the bolt to a torque of 25 N·m {18.0 ft.lbs, 2.5 kgf·m}.
- Screw the connector in the high pressure fuel pump and tighten it to a torque of 19 ± 2 N·m {14.0 ± 1.5 ft.lbs, 1.9 ± 0.2 kgf·m} using e.
- Screw the connector in the common rail and tighten it to a torque of 19 ± 2 N·m {14.0 ± 1.5 ft.lbs, 1.9 ± 0.2 kgf·m} using b.



■ **Installation: Boost pressure and temperature sensor**

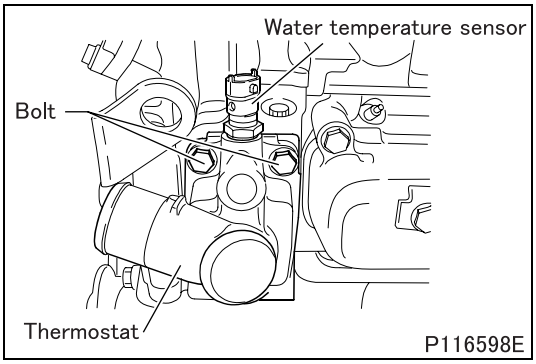
- Install the boost pressure and temperature sensor on the intake manifold.



■ **Installation: Fuel return pipe**

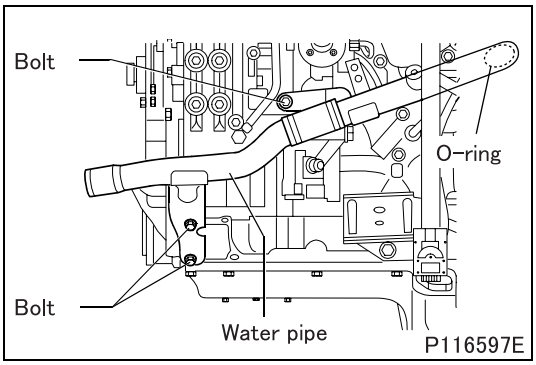
: This work requires protection against dust.

- Install the fuel return pipe.
- Fasten the fuel return pipe to the common rail by means of a clamp.
- Connect the fuel return pipe with the quick coupling to the high pressure pump return pipe.



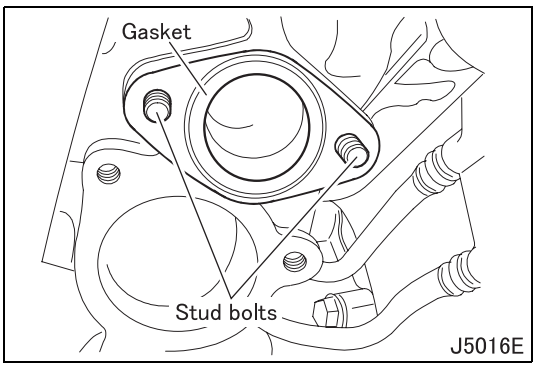
■ **Installation: Thermostat, water temperature sensors**

- Install a new gasket between the thermostat and the cylinder head, and install the thermostat on the cylinder head using a torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.
- Install the water temperature sensor on the thermostat using a torque of 40 N·m {30 ft.lbs, 4.0 kgf·m}.



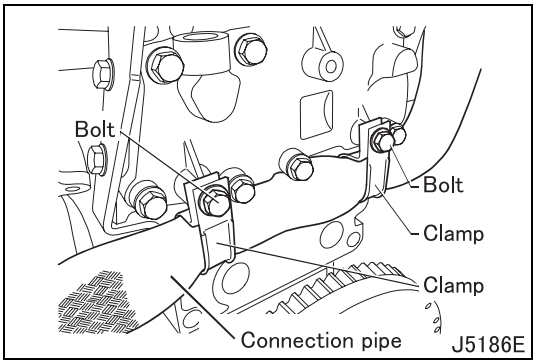
■ **Installation: Water pipe**

- Apply engine oil to a new O-ring.
- Install the water pipe on the oil cooler using a torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.

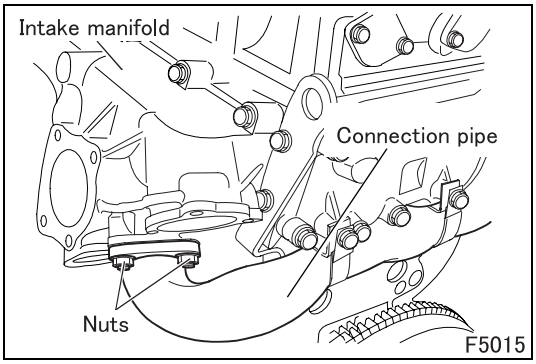


■ **Installation: Connection pipe**

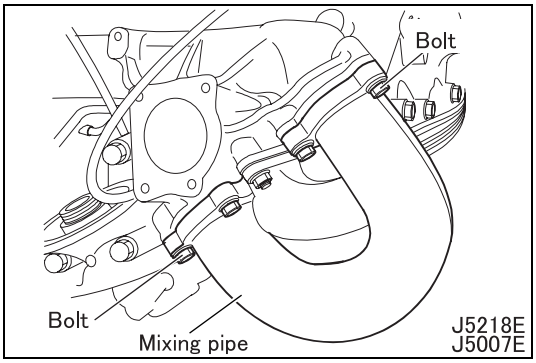
- Install a new gasket.



- Install the connection pipe using a clamp.

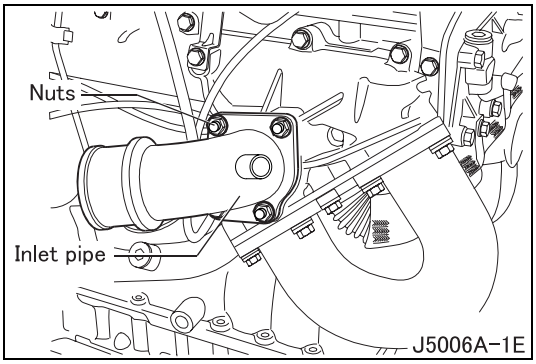


- Install the connection pipe on the intake manifold using a torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.



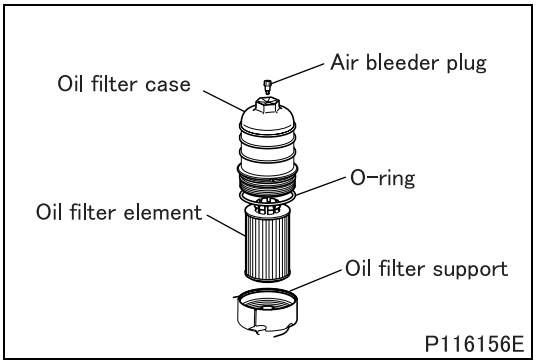
■ Installation: Mixing pipe

- Install a new gasket on the mixing pipe, and install the mixing pipe on the intake manifold using a torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.



■ Installation: Air inlet pipe

- Install the air inlet pipe together with a new gasket on the intake manifold, using a torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.



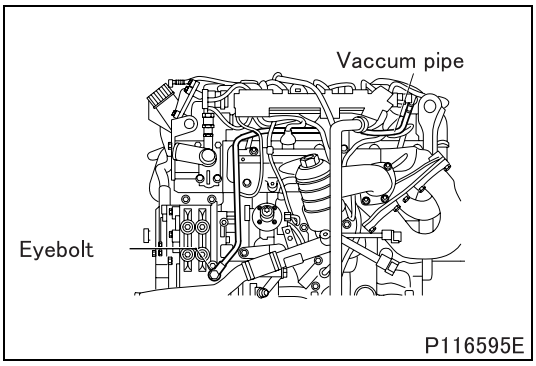
■ **Installation: Oil filter case, oil filter element**

- Apply engine oil to a new O-ring, and install the O-ring on the oil filter case.
- Use the O-ring and air bleeder plug that are provided with the new oil filter element.
- Install the oil filter element with the hole facing downward.
- Install a new air bleeder plug on the oil filter case using a torque of 1.5 ± 0.6 N·m {1.1 ± 0.4 ft.lbs, 0.15 ± 0.06 kgf·m}.

CAUTION ⚠

- **Do not overtighten the air bleeder plug. Otherwise, the air bleeder plug will be damaged.**

- Install the oil filter case on the oil filter support using a torque of 25 to 30 N·m {18 to 22 ft.lbs, 2.5 to 30 kgf·m}.



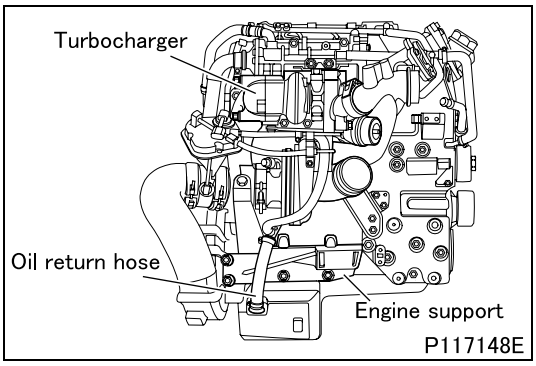
■ **Installation: Vacuum pipe**

- Install the vacuum pipe using a torque of 35 N·m {25 ft.lbs, 3.6 kgf·m}.

◆Work after installation◆

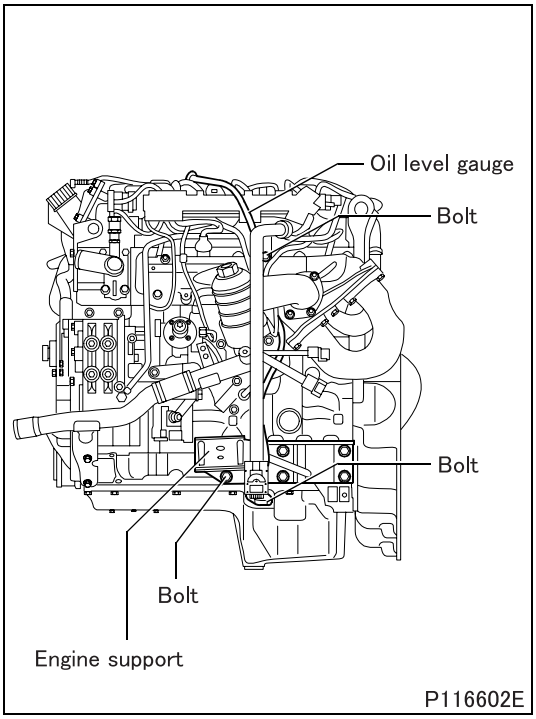
■ **Removal: Rotary stand**

- Install the suspension hook on the engine hanger, then fix the engine hanger to the hoist, and lower the engine from the [b]. Remove the [a].



■ **Working by the engine right side**

- Connect the oil return hose to the turbocharger.
- Install the engine support using a torque of 50 N·m {37 ft.lbs, 5.1 kgf·m}.



■ **Working on the left side of the engine**

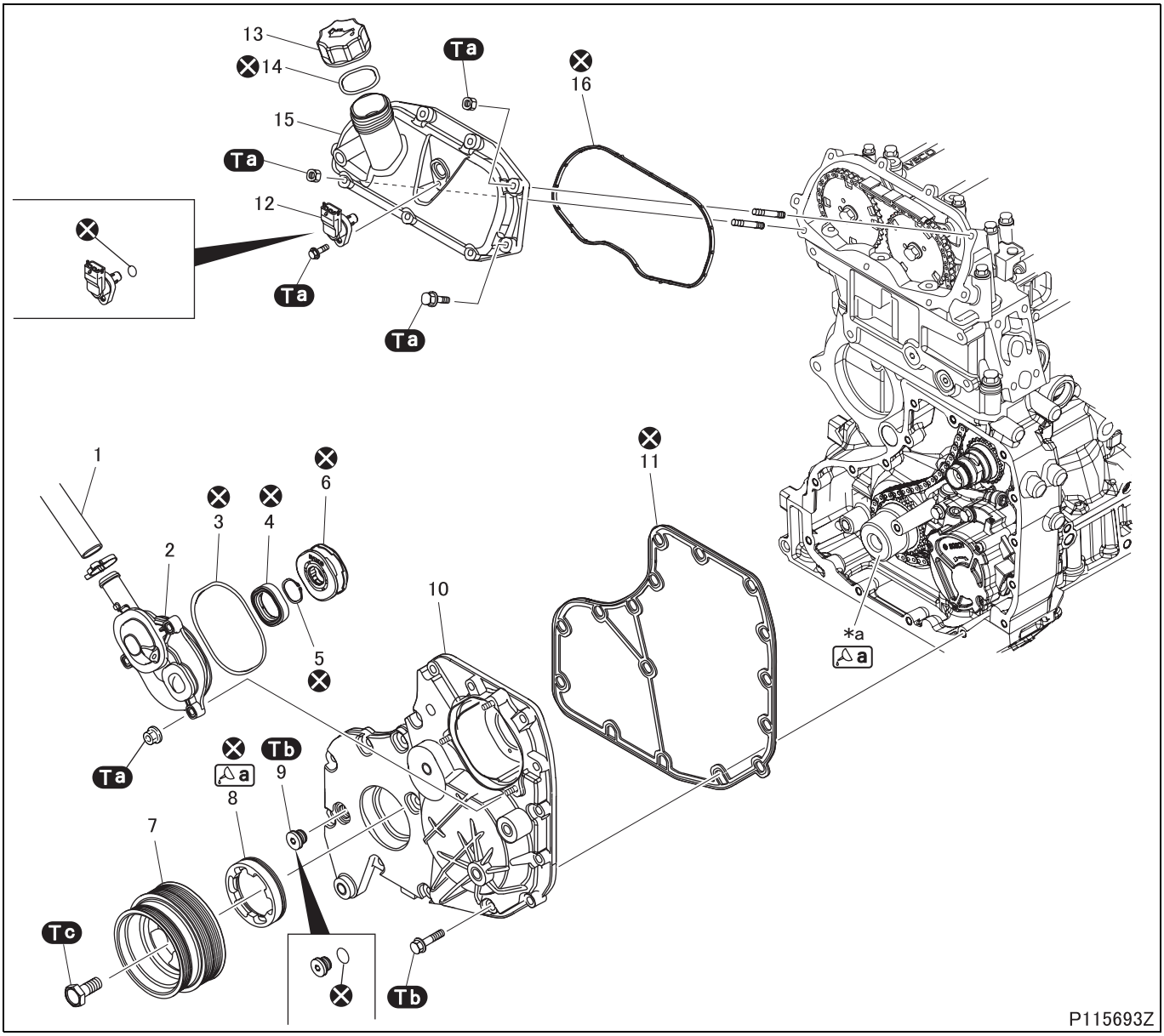
- Install the engine support using a torque of 50 N·m {37 ft.lbs, 5.1 kgf·m}.
- Install the oil level gauge guide on the intake manifold and the oil pan using a torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.

■ **Installation: Engine cable**

- Install the engine assembly with the engine cable connecting the electrical connectors.
  - Blow-by pressure sensors.
  - EBS (Exhaust Brake System) valve.
  - Glow plugs.
  - Injectors.
  - EGR (Exhaust Gas Recirculation) cooler outlet temperature sensor.
  - EGR (Exhaust Gas Recirculation) actuator.
  - Pressure sensor.
  - Pressure regulation.
  - Boost pressure and temperature sensor.
  - VGT (Variable Geometry Turbocharger) actuator.
  - Water temperature sensor.
  - Camshaft timing sensor.
  - Engine speed sensor.
  - Oil pressure sensor.

M E M O

TIMING GEAR CASE



● **Removal sequence**

1 Breather hose
2 Cover
3 O-ring
4 Seal ring
5 Snap ring
6 Air cleaner (centrifugal filter)
7 Damper pulley
8 Front oil seal
9 Plug
10 Distribution cover
11 Gasket
12 Camshaft timing sensor (See Gr54.)
13 Oil filter cap
14 O-ring
15 Cover
16 Gasket

***a**: Crankshaft
⊗: Non-reusable parts

● **Installation sequence**

Follow the disassembly sequence in reverse.

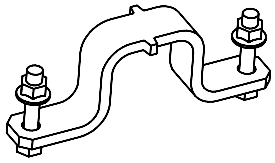
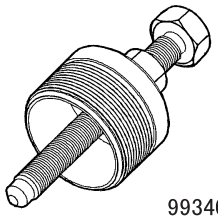
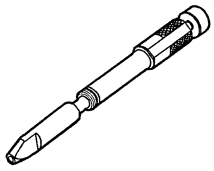
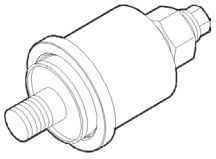
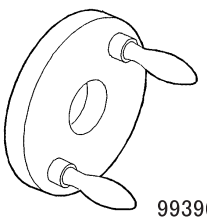
Tightening torque (Unit: N·m {ft.lbs, kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (cover mounting)	10 {7.4, 1.0}	–
	Nut (cover mounting)		
	Bolt (camshaft timing sensor mounting)		
Tb	Bolt (distribution cover mounting)	25 {18, 2.5}	–
	Plug		
Tc	Bolt (damper pulley mounting)	350 {260, 35}	–

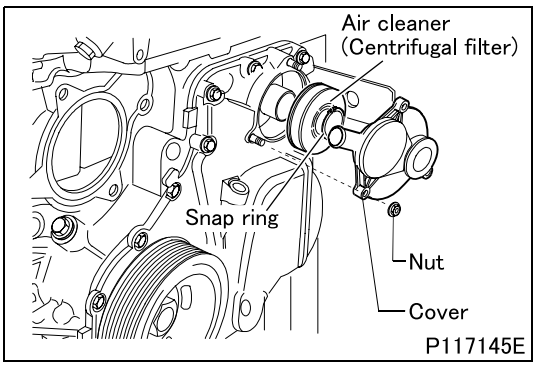
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Crankshaft tip and front oil seal installer	Engine oil	As required

Special tools

Mark	Tool name and shape	Part No.	Application
a	Retainer, flywheel  P116334	MH064205	Stop the rotation of the flywheel
b	Seal ring remover  99340059	MH063989	Removal of front oil seal
c	Shaft, cranking  99360615	MH063969	Stop the rotation of the engine <Timing locating tool>
d	Installer, front seal  99346258	MH063962	Installation of front oil seal
e	Handle  99396039	MH063979	Centering of cover

◆Removal procedure◆

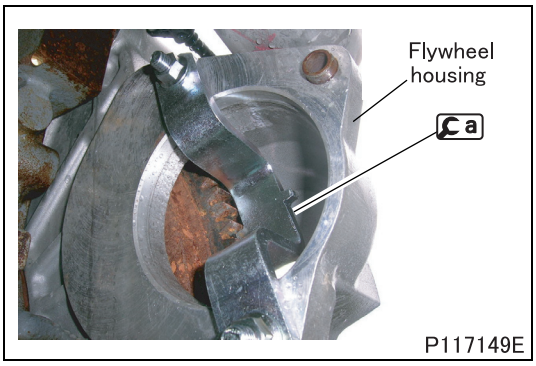


■ **Removal: Air cleaner (centrifugal filter)**

- Remove the nuts and the cover. Take off the snap ring. Pull out the air cleaner.

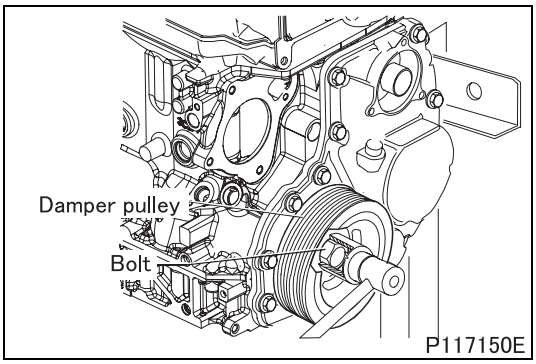
NOTE

- **The centrifugal filter and the seal ring of the cover must be changed at every removal.**

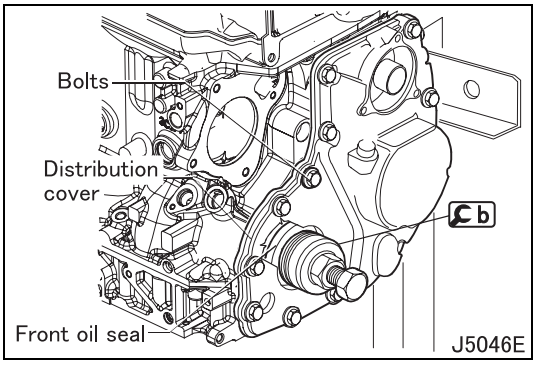


■ **Removal: Damper pulley**

- Using a, block rotation of the engine flywheel, through the starter opening.

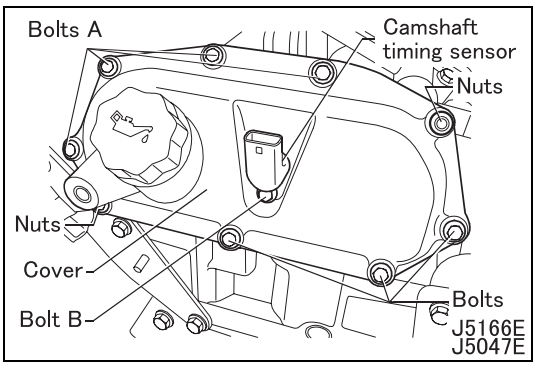


- Take out the bolt and remove the damper pulley.



■ **Removal: Distribution cover, front oil seal**

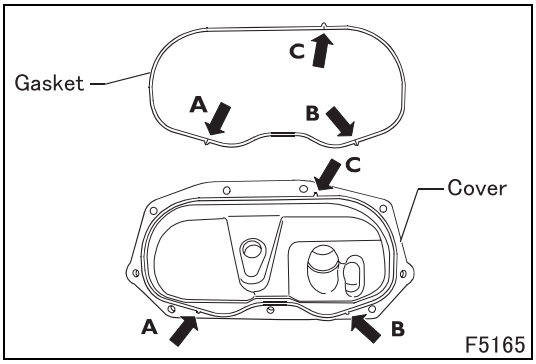
- Screw in the b to the rear of the crankshaft, and set the b.
- Remove the front oil seal from the distribution cover.
- Check the installation direction of the front oil seal.
- Remove the gasket remaining on the crankshaft.
- Remove the distributor cover.



■ **Removal: Camshaft timing sensor, cover**

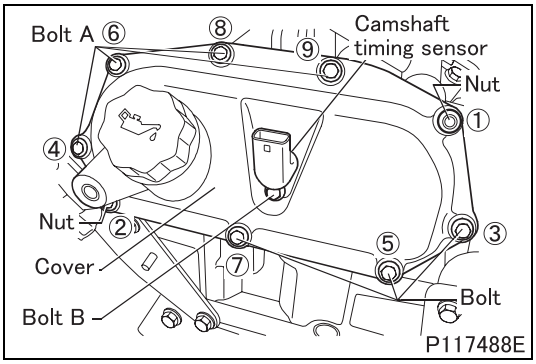
- Take out the bolt and remove the camshaft timing sensor.
- Remove the bolts and nuts; remove the cover.

◆Installation procedure◆



■ **Installation: Cover, camshaft timing sensor**

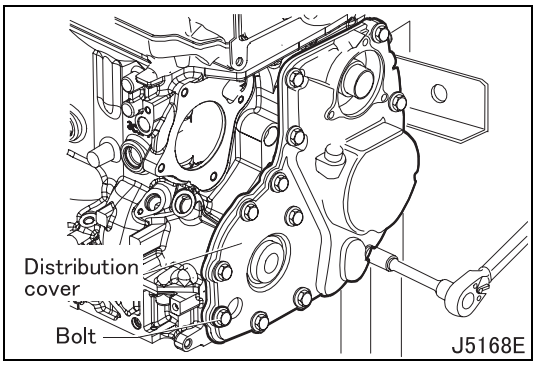
- Install a new gasket on the cover. Fit the gasket in the housing for the cover with the “knife edge” facing the engine.
- Align the three references (A, B and C) on the gasket with the seats in the cover.



- Tighten the nuts and bolts in the sequence (1) to (9) indicated in the drawing, and install the cover on the overhead cover using a torque of 10 N·m {7.4 ft.lbs, 10 kgf·m}.
- Install the camshaft timing sensor on the cover using a torque of 10 N·m {7.4 ft.lbs, 1.0 kgf·m}.

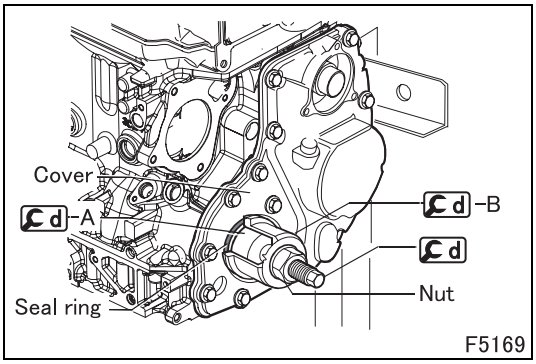
CAUTION ⚠

- **When installing the camshaft timing sensor, take care that the O-ring does not break.**

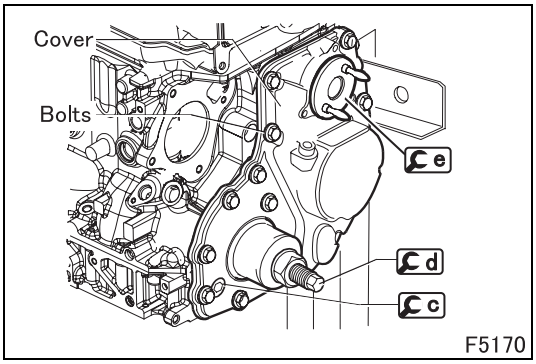


■ **Installation: Distribution cover, front oil seal**

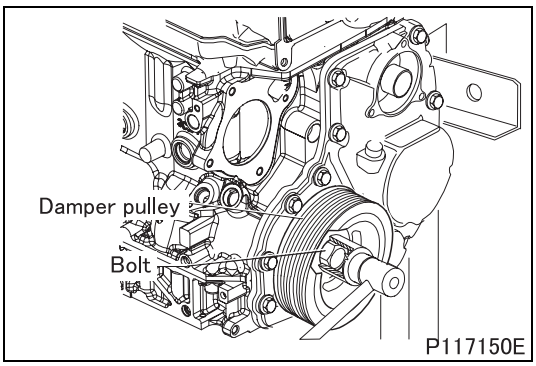
- Install a new gasket on the distribution cover.
- Temporarily fix the distribution cover.



- Clean the mounting face of the front oil seal of the distribution cover.
- Apply engine oil to the inner side of the new front oil seal and also to the crankshaft.
- Carefully install the front oil seal on the d-B.
- Place the d-B over the d-A, and tighten the nut until the front oil seal is completely installed on the cover.

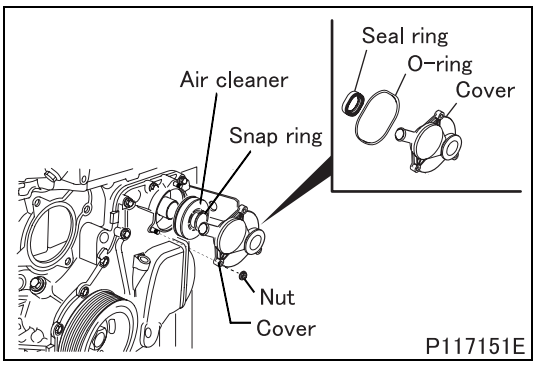


- Install the e in the housing of the air cleaner in order to center the cover.
- Turn the handle of the e, and confirm that the e rotates freely.
- Remove the plug.
- Using the c, confirm that the engine timing remains unchanged.
- While checking the rotation of the e, tighten the cover gradually, and finally tighten it to the specified torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.
- Remove the e, d and c.
- Install the plug using a torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.

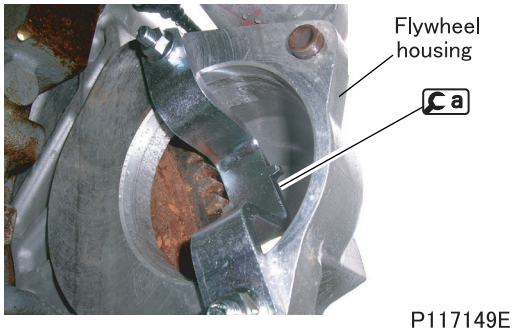


■Installation: Damper pulley and air cleaner

- Install the damper pulley and temporarily tighten it.

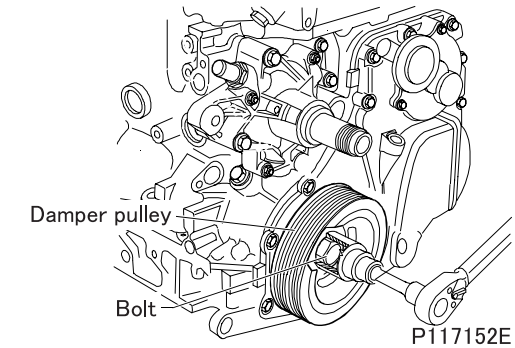


- Install on the new air cleaner with a snap ring.
- Install a new seal ring and O-ring on the cover.
- Install the cover on the distribution cover.
- Tighten the nut to a torque of 10 N·m {7.4 ft.lbs, 1.0 kgf·m}.



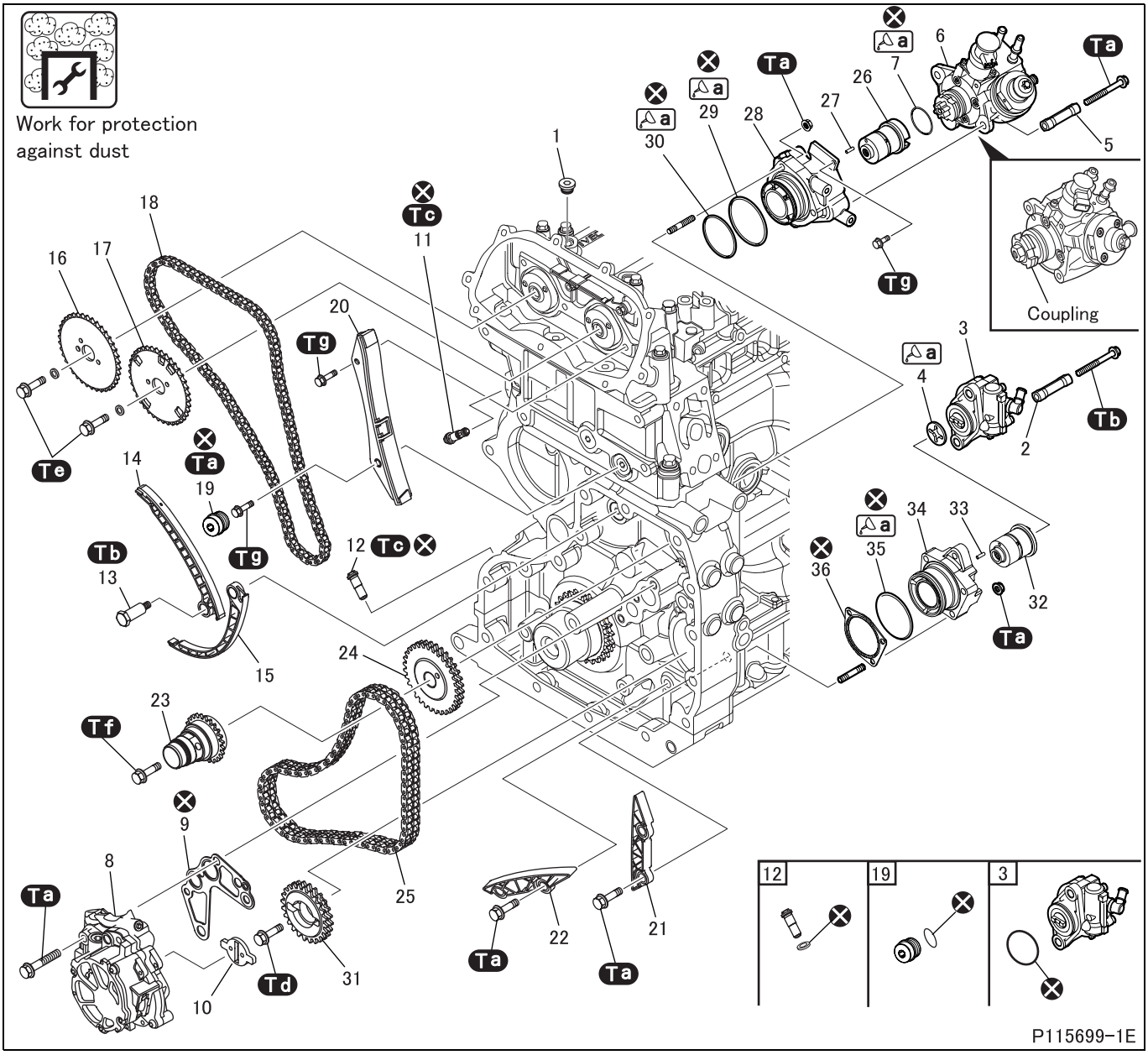
■ **Installation: Damper pulley**

- Prevent the flywheel from rotating using a through the starter opening.



- Install the damper pulley.
- Tighten the bolt to a torque of 350 N·m {260 ft.lbs, 35 kgf·m}.

TIMING GEAR, CHAIN



● **Removal sequence**

1 Lock plug
2 Spacer
3 Power steering oil pump (See Gr37.)
4 Coupling
5 Spacer
6 High pressure fuel pump (See Gr13.)
7 O-ring
8 Oil pump/vacuum unit (See Gr12 and Gr35.)
9 Gasket
10 Oil pump coupling
11 Upper chain stretcher
12 Lower chain stretcher
13 Mobile skid shaft
14 Upper mobile skid
15 Lower mobile skid
16 Camshaft control gear (exhaust)
17 Camshaft control gear (intake)
18 Single chain
19 Lock plug
20 Upper side skid
21 Lower side skid
22 Lower skid
23 Drive gear
24 High pressure fuel pump gear
25 Double chain
26 High pressure fuel pump control shaft
27 Locating pin
28 High pressure fuel pump support
29 O-ring
30 O-ring
31 Oil pump/vacuum unit gear
32 Power steering oil pump control shaft
33 Locating pin
34 Power steering oil pump support
35 O-ring
36 Gasket

⊗: Non-reusable parts

 : This work requires protection against dust.

- If fine dust enters the high pressure fuel pump, engine performance will significantly be affected. Be sure to cover the openings after removing parts such as pipes.

NOTE

- **Both chains and related parts must be replaced as a kit.**
- **A chain stretcher with self-locking mechanism needs to be replaced whenever it has been removed. The chain stretcher also needs to be replaced if the piston is inadvertently removed from the chain stretcher.**
- **Once the pump housing is unlocked and the piston protrudes, the chain stretcher cannot be assembled as before.**

● Installation sequence

36→35→34→33→32→30→29→28→27→26→31→25→24→23→22→21→20→
19→18→17→16→15→14→13→12→11→7→6→5→10→9→8→4→3→2→1

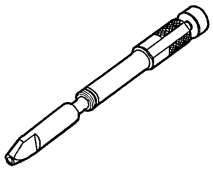
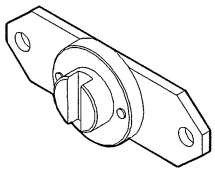
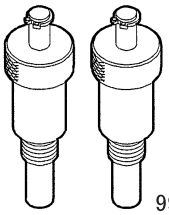
Tightening torque (Unit: N·m {ft.lbs, kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Nut (high pressure fuel pump support mounting)	25 {18, 2.5}	–
	Nut (power steering oil pump support mounting)		
	Bolt (lower side skid mounting)		
	Bolt (lower skid mounting)		
	Lock plug		
	Bolt (high pressure fuel pump mounting)		
	Bolt (oil pump/vacuum unit)		
Tb	Mobile skid shaft	40 {30, 4.0}	–
	Bolt (power steering oil pump mounting)		
Tc	Lower chain stretcher	50 {37, 5.0}	–
	Upper chain stretcher		
Td	Bolt (oil pump/vacuum unit gear mounting)	130 {96, 13}	–
Te	Bolt (camshaft control gear mounting)	110 {81, 11}	–
Tf	Bolt (drive gear mounting)	135 {100, 13.5}	–
Tg	Bolt (upper side skid mounting)	10 {7.4, 1.0}	–
	Bolt (high pressure fuel pump mounting)		

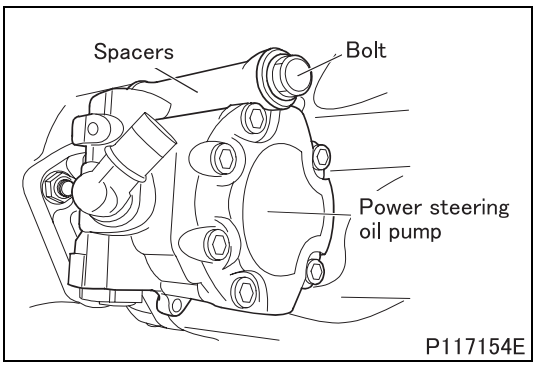
Lubricant and/or sealant

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

Special tools

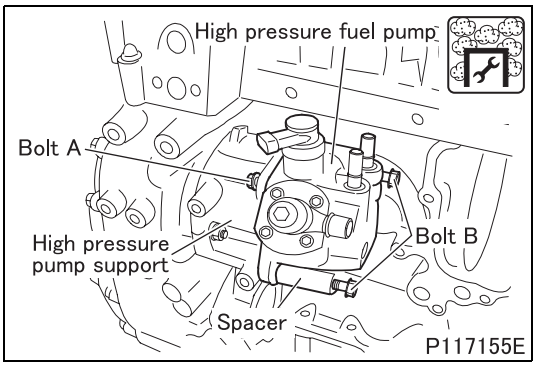
Mark	Tool name and shape	Part No.	Application
a	Cranking shaft  99360615	MH063969	Stop the rotation of the engine <Timing locating tool>
b	Power steering installer  99360187	MH063965	Stop the rotation of the hydraulic power steering pump control shaft
c	Camshaft guide  99360614	MH063968	Installation of overhead

◆Removal procedure◆



■ **Removal: Power steering oil pump**

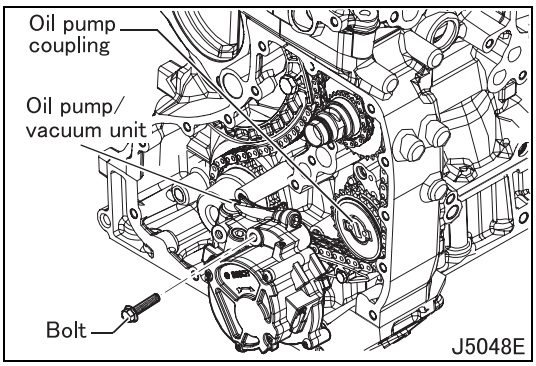
- Remove the bolts with the spacers and detach the power steering oil pump.



■ **Removal: High pressure fuel pump**

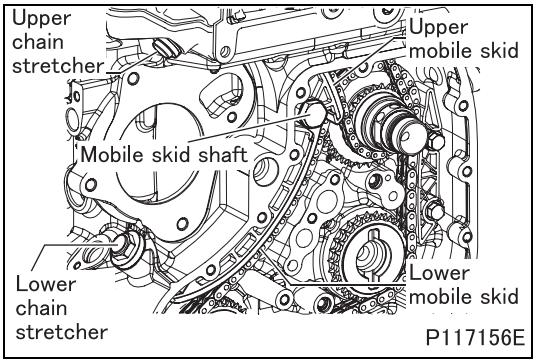
: This work requires protection against dust.

- Set the engine to top dead center at the #1 cylinder.
- Loosen bolt A, and then remove it.
- Loosen bolt B, and remove it together with the spacer.
- Remove the high pressure fuel pump from the high pressure fuel pump support.
- Check the direction of the coupling installed on the high pressure fuel pump.



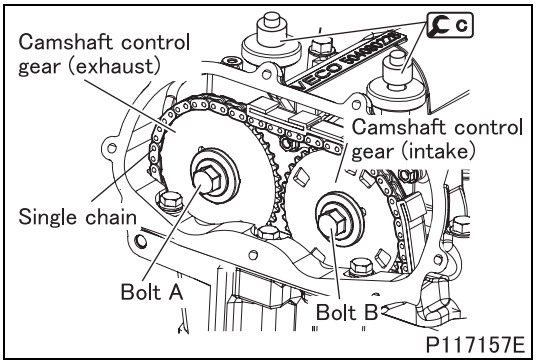
■ **Removal: Oil pump/vacuum unit**

- Remove the oil pump/vacuum unit.
- Remove the oil pump coupling.



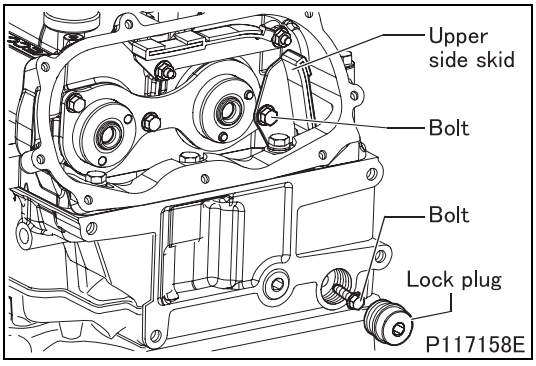
■ **Removal: Mobile skid shaft, mobile skid**

- Remove the chain stretcher: upper and lower.
- Remove the mobile skid shaft and disassemble the mobile skid: lower and upper.



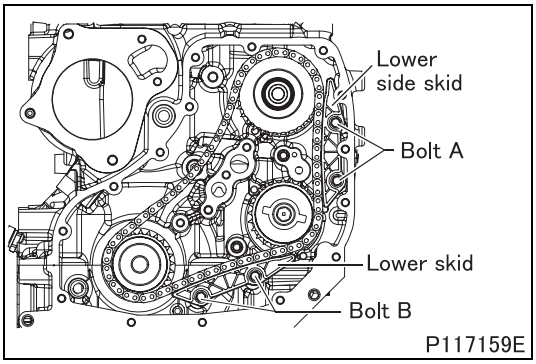
■ **Removal: Camshaft control gear and single chain**

- Install [C] on the camshaft slot through the overhead screw hole into the cam slot.
- Remove bolts A and B, and then remove the camshaft control gear (exhaust), camshaft control gear (intake) and single chain. (The single chain has no preferred mounting orientation (front/ back).)



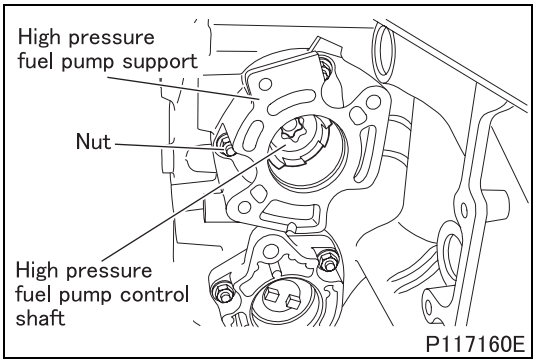
■ **Removal: Lock plug, upper side skid**

- Remove the rubber cap, the screws and the upper side skid.



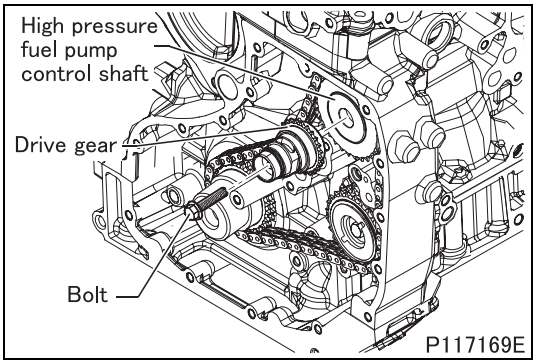
■ **Removal: Lower side skid, lower skid**

- Remove the bolts and the lower side skid.
- Remove the bolts and the lower skid.

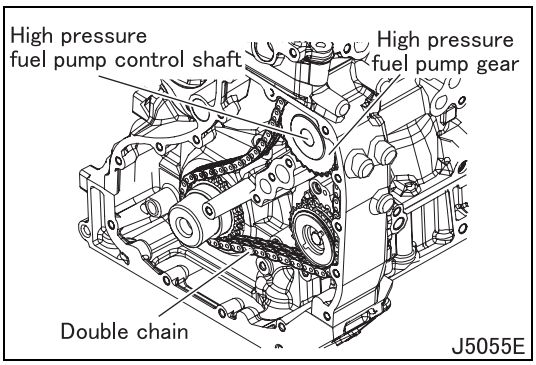


■ **Removal: Drive gear, high pressure fuel pump gear, double chain**

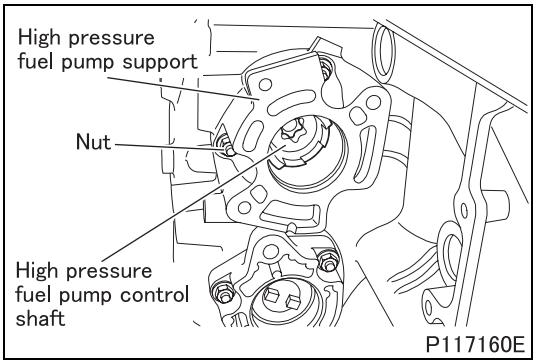
- Insert an appropriate wrench (T90 Torx bit socket) into the high pressure fuel pump control shaft to prevent the shaft from rotating.



- Remove the screw and the single chain drive gear from the high pressure fuel pump control shaft.

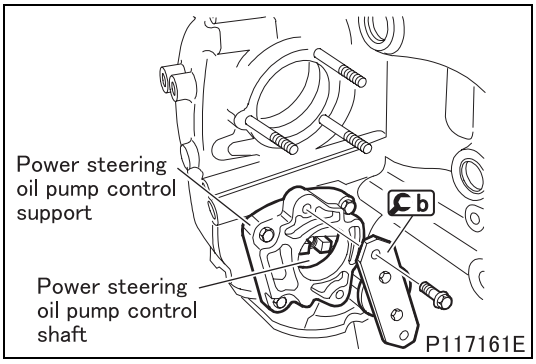


- Remove the high pressure fuel pump gear double chain and the double chain from the high pressure fuel pump control shaft. (The double chain has no preferred mounting orientation (front/back).)



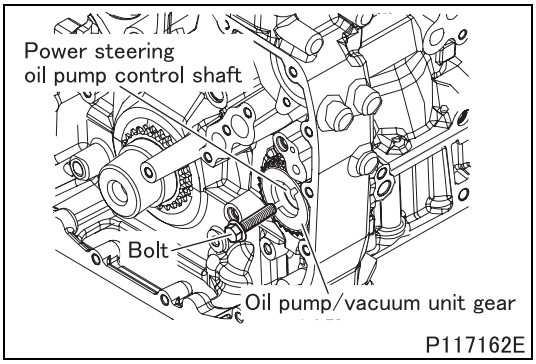
■ **Removal: High pressure fuel pump control shaft, support**

- Remove the high pressure fuel pump control shaft.
- Remove the nuts and the support.

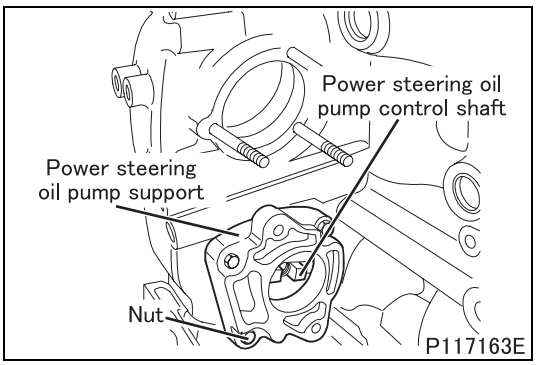


■ **Removal: Oil pump/vacuum unit gear**

- Stop the rotation of the power steering oil pump control shaft by inserting b in the shaft and fastening the b on the support by means of the bolts.



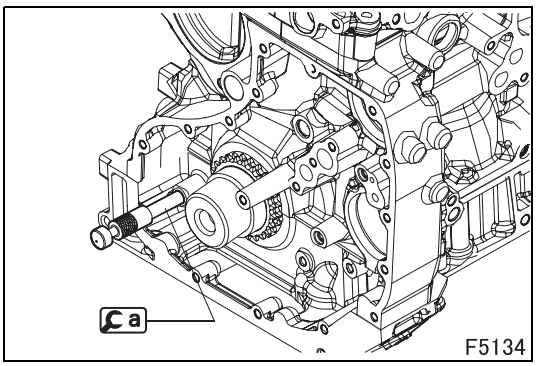
- Remove the bolt and the gear from the hydraulic power steering pump control shaft.



■ **Removal: Power steering oil pump control shaft, support**

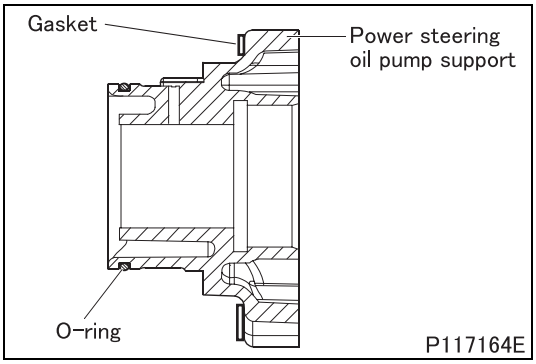
- Remove the hydraulic power steering pump control shaft.
- Remove the nuts and the support.

◆Installation procedure◆



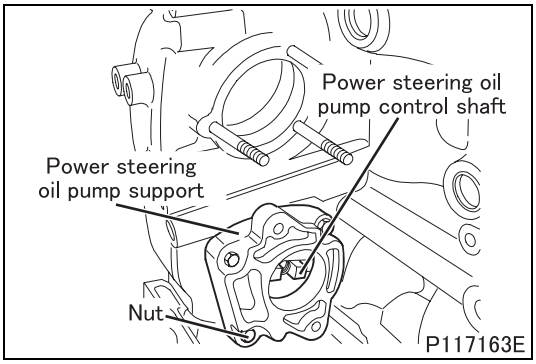
■ **Installation: Cranking shaft**

- Using the a, rotate the crankshaft and install it by inserting it into the crankshaft hole from the cylinder lock hole.
- When rotating the crankshaft, be careful that it does not interfere with the valve.
- Stop rotating the engine when it is in a condition that enables the subsequent parts to be installed on it.

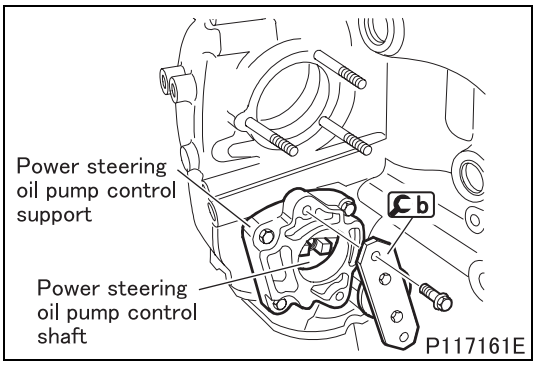


■ **Installation: Support, power steering oil pump control shaft**

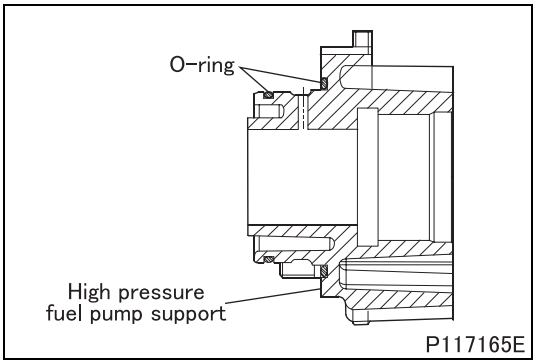
- Lubricate the O-ring with engine oil and install it on the support.
- Take care not to damage the O-ring.



- Install a new gasket and the power steering oil pump support, screw in the nuts, and then tighten them to a torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.
- Install the positioning pin on the power steering oil pump control shaft.
- Install the power steering oil pump control shaft on the inside of the power steering oil pump support.

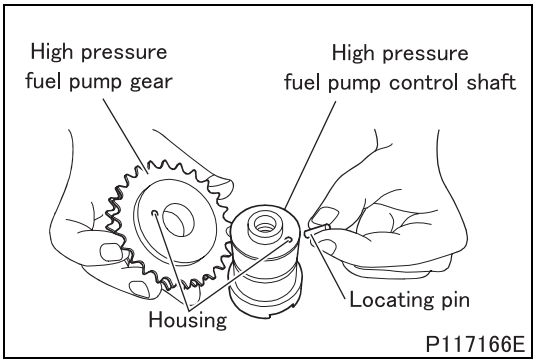


- Stop the hydraulic power steering pump control shaft rotation of the hydraulic power steering pump by inserting in the latter the b and fastening the b on the support by means of the bolts.

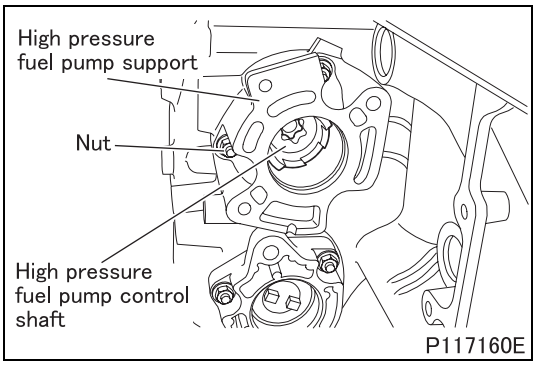


■ **Installation: High pressure fuel pump support, high pressure fuel pump control shaft**

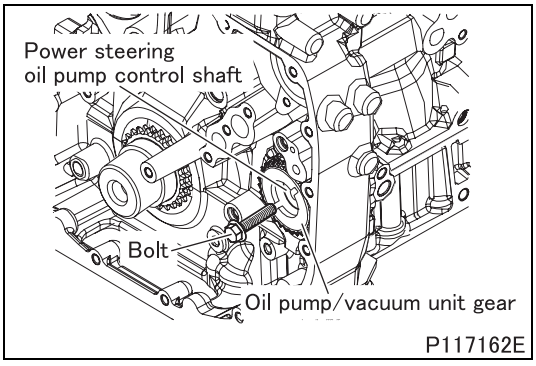
- Lubricate the new O-rings with engine oil and install them on the support.



- There is a housing for the locating pin in the through hole in the high pressure fuel pump gear.
- The through hole in the high pressure fuel pump gear has a reference point which needs to be kept in a vertical position when timing the pump.
- There is a housing for the locating pin in the high pressure fuel pump control shaft.
- The position of the housing for the locating pin in the shaft has been determined so as to ensure the timing between the pump and crankshaft.

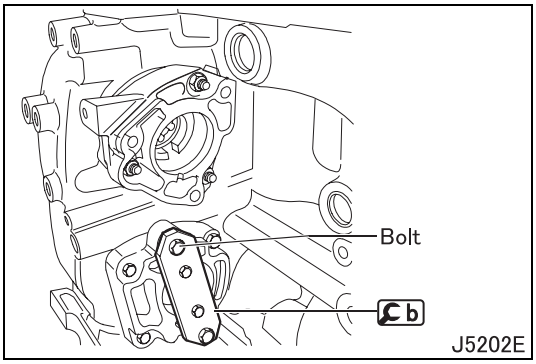


- Install the support and the nuts and tighten them to the prescribed torque (25 N·m {18 ft.lbs, 2.5 kgf·m}).
- Install the high pressure fuel pump control shaft of the high pressure fuel pump.

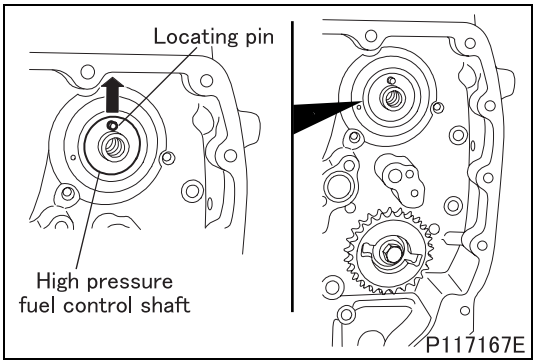


■ **Installation: Oil pump/vacuum unit gear**

- Install the oil pump/vacuum unit gear on the power steering oil pump control shaft.

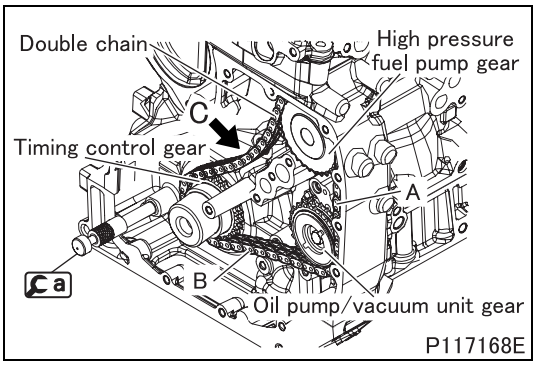


- Remove the bolt, and then remove the b.

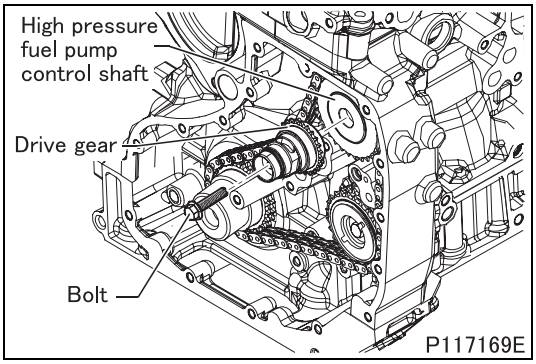


■ **Installation: Drive gears, double chain**

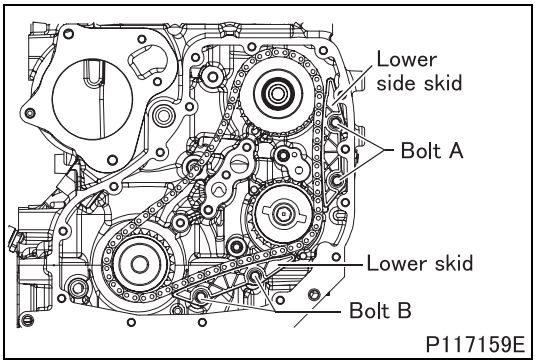
- As far as possible, install the high pressure fuel pump control shaft with the locating pin facing directly upward.



- Position the high pressure fuel pump gear so that the chamfered side is facing the drive gear, and install the double chain on the high pressure fuel pump gear.
- Align the high pressure fuel pump gear with the locating pin of the high pressure fuel pump control shaft, and then install it on the control shaft.
- After installing the fuel pump gear, press C of the double chain, and confirm that the chain is taut at sections A and B, and also that the locating pin of the high pressure fuel pump gear is facing directly upward.

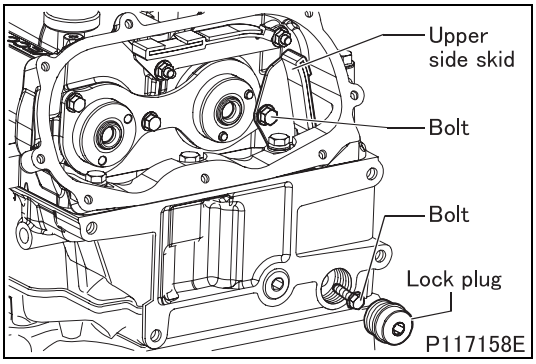


- Clean the contacting faces of the drive gear and the high pressure fuel pump gear.
- Install the drive gear on the high pressure fuel pump control shaft, and temporarily tighten the bolt (to the extent that the drive gear can be easily rotated by hand).



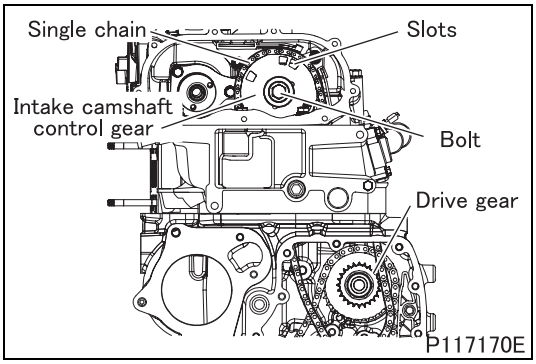
■ **Installation: Lower side skid, lower skid**

- Inspect the condition of each skid, and replace any worn skids.
- Install the lower skid, then screw in the bolt and tighten it to a torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.
- Install the lower side skid, and tighten the bolt to a torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.



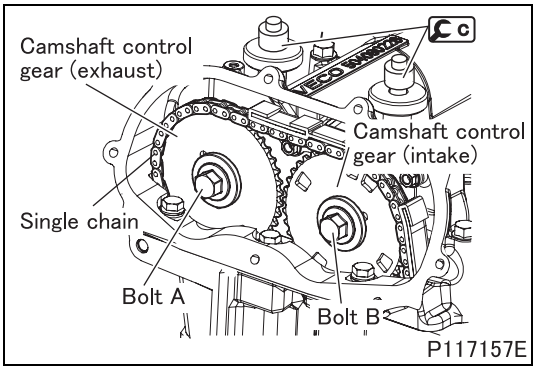
■ **Installation: Upper side skid**

- Install the upper side skid, and tighten the bolt to a torque of 10 N·m {7.4 ft.lbs, 1.0 kgf·m}.
- Tighten the bolt at the rear of the lock plug to a torque of 10 N·m {7.4 ft.lbs, 1.0 kgf·m}, then tighten the new lock plug to a torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.

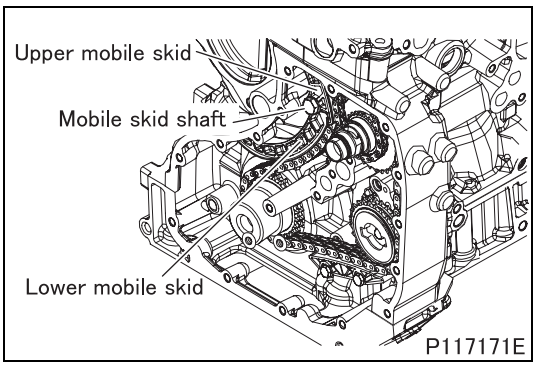


■ **Installation: Single chain, gear**

- Install the camshaft control gears (intake and exhaust) with the stamped side of the gear facing the camshaft side.
- Install the camshaft control gear (intake) with the slot on the gear at the position shown in the illustration, and then temporarily tighten the bolt.
- Install the single chain on the drive gear and the camshaft controller gear (intake).

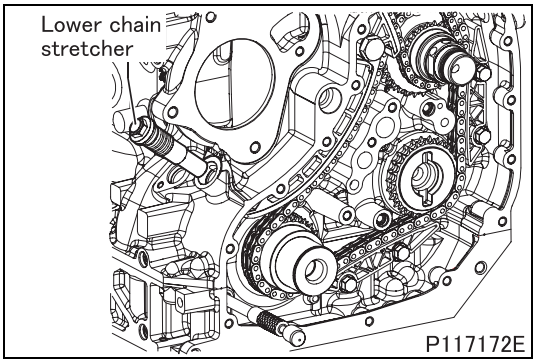


- Use the largest of the three dowel pin insertion holes in the camshaft control gear (exhaust).
- Place the single chain on the camshaft control gear (exhaust), and temporarily tighten the gear mounting bolt (to the extent that the drive gear can be easily rotated by hand).
- Then, check to see if the single chain between the exhaust and intake camshaft control gears can be tensioned by removing the play of the dowel pins in the insertion holes.



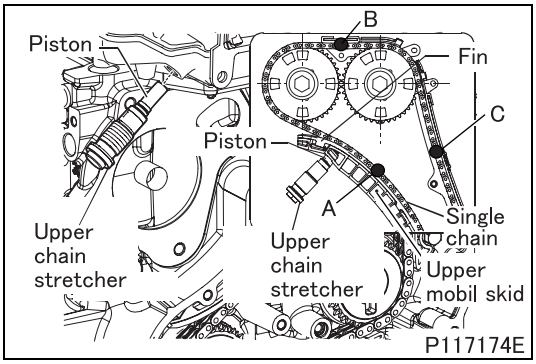
■ **Installation: Lower mobile skid, upper mobile skid**

- Check the condition of the lower and upper mobile skids. If the skids are worn, replace them.
- Install the lower and upper mobile skids, and install the mobile skid shaft on the crankshaft.
- Tighten the mobile skid shaft to a torque of 40 N·m {30 ft.lbs, 4.0 kgf·m}.



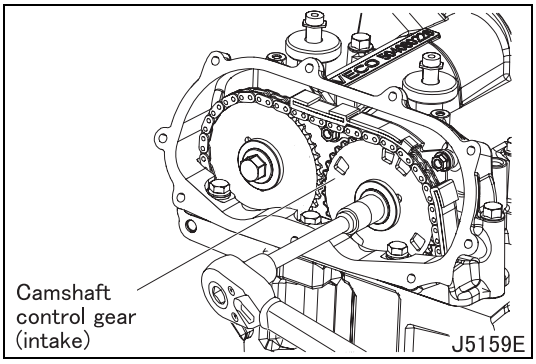
■ **Installation: Lower chain stretcher**

- Install the lower chain stretcher, and tighten it to a torque of 50 N·m {37 ft.lbs, 5.0 kgf·m}.



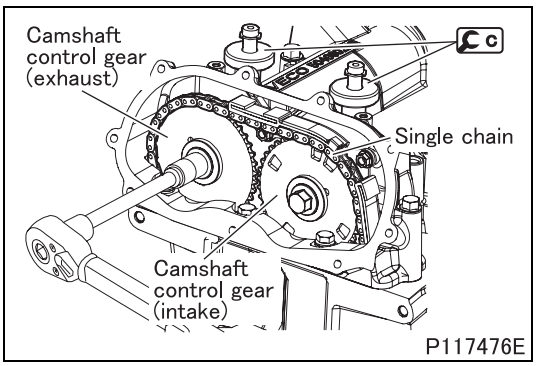
■ **Installation: Upper chain stretcher**

- A chain stretcher with self-locking mechanism needs to be replaced whenever it has been removed. The chain stretcher also needs to be replaced if the piston is inadvertently removed from the chain stretcher.
- Install the upper chain stretcher, and tighten it to a torque of 50 N·m {37 ft.lbs, 5.0 kgf·m}.
- Insert an appropriate screwdriver through the opening in the overhead and push the fin of the upper mobile skid until the piston of the upper stretcher reaches its stroke end.
- Check that tension is given to the chain when the piston is displaced from the seat.
- Then, confirm that chains A, B and C are taut. (Tighten each gear when the chains are taut.)



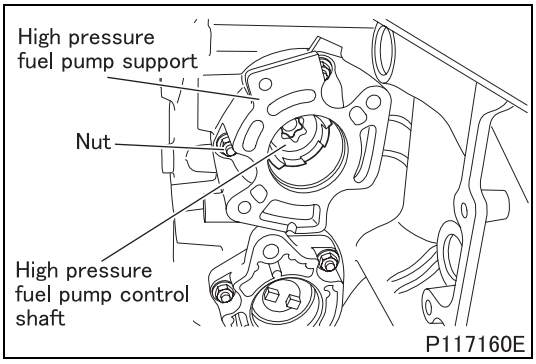
■ **Installation: Camshaft control gear (intake)**

- Tighten the temporarily installed camshaft control gear (intake) to a torque of 110 N·m {81 ft.lbs, 11 kgf·m}.

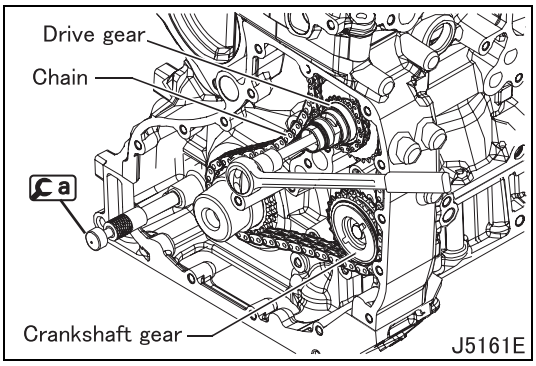


■ **Installation: Camshaft control gear (exhaust)**

- Tighten the temporarily installed camshaft control gear (exhaust) to a torque of 110 N·m {81 ft.lbs, 11 kgf·m}.
- After installation, confirm that the part of the chain between the exhaust and intake sides is taut.

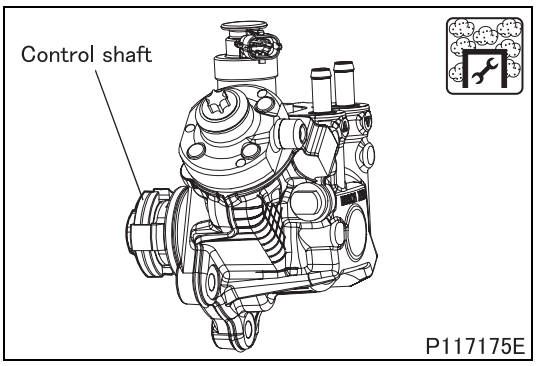


- Insert an appropriate wrench (T90 Torx bit socket) into the high pressure fuel pump control shaft to prevent the shaft from rotating.



■ **Installation: Drive gear**

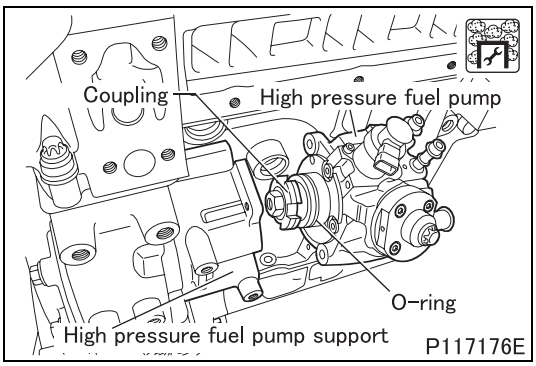
- Confirm that the part of the single chain between the drive gear and the camshaft control gear is taut, then tighten the drive gear to a torque of 135 N·m {100 ft.lbs, 14 kgf·m}, and remove the a.



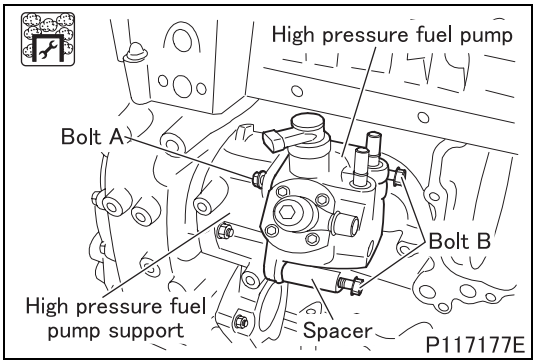
■ **Installation: High pressure fuel pump**

: This work requires protection against dust.

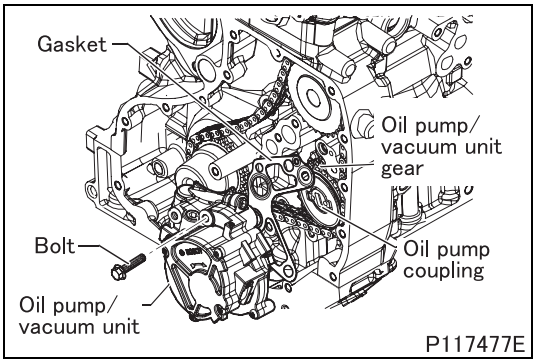
- The relative positions of the control shaft and pump axis are determined by the flange installed on the pump.
- The high pressure pump needs to be installed in a balanced position (bottom dead center), which is obtained by rotating the control shaft.
- Bosch provides a new high pressure pump in a stable and balanced position (bottom dead center) with the flange installed on the pump. Check that the pump shaft is unloaded (no tension).



- Apply engine oil to the O-ring, and then install the O-ring on the high pressure fuel pump.
- Be careful not to damage the O-ring when installing it.
- Install the pump so that the control shaft teeth are engaged with the coupling.
- Rotate the high pressure fuel pump (with the shaft and gear locked) to align the bolt holes in the high pressure fuel pump support and high pressure fuel pump.

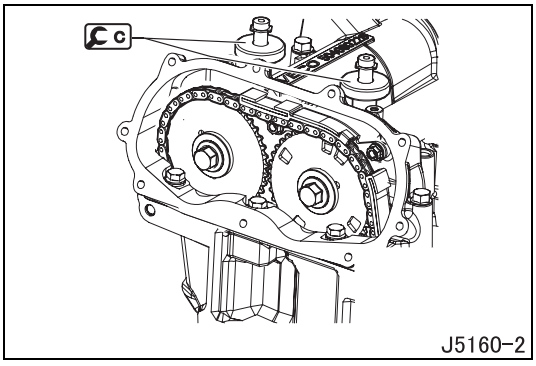


- Fully tighten mounting bolt A on the high pressure fuel pump support.
- Tighten two sets of bolt B and spacer.

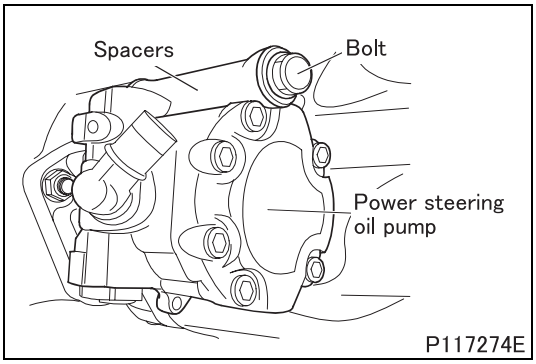


■ **Installation: Oil pump/vacuum unit**

- Install the oil pump coupling on the inner side of the oil pump/ vacuum unit gear.
- Insert a new gasket, and install the oil pump/vacuum unit.
- Screw in the bolts of the oil pump/vacuum unit, and confirm that the unit is installed correctly. Tighten the bolts to a torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.



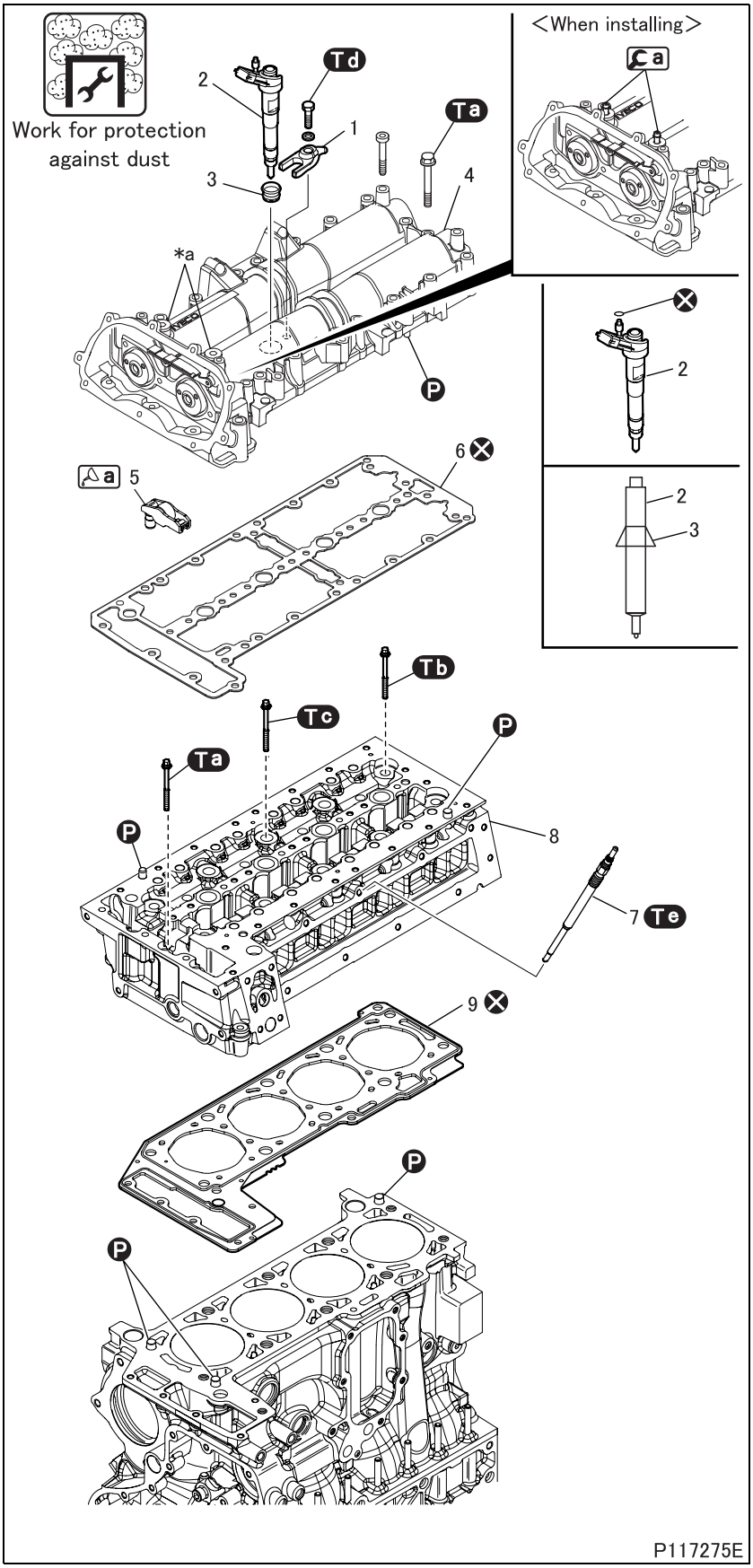
- Remove the C.



■ **Installation: Power steering oil pump**

- Apply engine oil to the O-ring, install the O-ring on the power steering oil pump, and then tighten the bolts of the power steering oil pump to a torque of 40 N·m {30 ft.lbs, 4.0 kgf·m}.

OVERHEAD, CYLINDER HEAD



P117275E

● Removal sequence

1 Injector bracket
2 Injector
3 Dust guard
4 Overhead (See later section.)
5 Rocker arm and hydraulic tappet
6 Gasket
7 Glow plug
8 Cylinder head (See later section.)
9 Cylinder head gasket

***a**: Lock plug
Ⓟ: Locating pin
⊗: Non-reusable parts

: This work requires protection against dust.

- If fine dust enters the high pressure fuel pump, engine performance will significantly be affected. Be sure to cover the openings after removing parts such as pipes.

● Installation sequence

Follow the removal sequence in reverse.

Service standards (Unit: mm {in.})

Location	Maintenance item			Standard value	Limit	Remedy
5	Rocker arm and hydraulic tappet	Hydraulic tappet length	End of stroke	32.44 ± 0.3 {1.28 ± 0.012}	–	Replace
			Start of stroke	29.75 ± 0.25 {0.471 to 0.472}	–	Replace
		Outer diameter of hydraulic tappet		11.988 to 12.000 {0.471 to 0.472}	–	Replace
5, 8	Clearance between rocker arm and hydraulic tappet and seats on cylinder head			0.016 to 0.046 {0.00063 to 0.0018}	–	Replace
8	Inner diameter of seats on cylinder head for hydraulic tappet			12.016 to 12.034 {0.473 to 0.474}	–	Replace

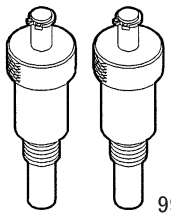
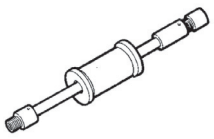
Tightening torques (Unit: N·m {ft.lbs, kgf·m})

Mark	Parts to be tightened		Tightening torque	Remarks
Ta	Bolt (overhead mounting)		25 {18, 2.5}	–
	Bolt (cylinder head mounting)	M8		
Tb	Bolt (cylinder head mounting)	M12	65 {48, 6.5} + 90° + 60°	–
Tc	Bolt (cylinder head mounting)	M15	130 {96, 13} + 90° + 90°	–
Td	Bolt (injector bracket mounting)		32 {24, 3.3}	–
Te	Glow plug		8 to 10 {5.9 to 7.4, 0.8 to 1.0}	–

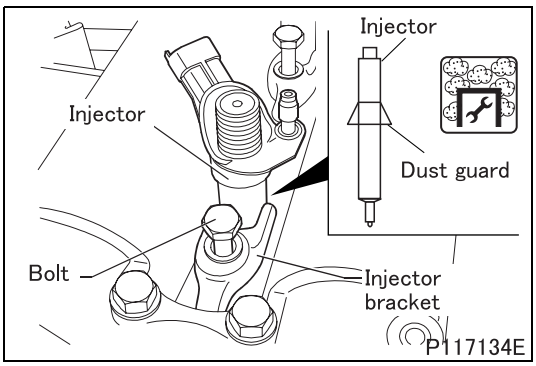
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Rocker arm and hydraulic tappet	Engine oil	As required

Special tools

Mark	Tool name and shape	Part No.	Application
a	Guide, camshaft  99360614	MH063968	Installation of overhead
b	Glow plug wrench  P116190	MH064216	Removal and installation of glow plug
c	Percussion puller  99340205	MH063990	Removal of injector

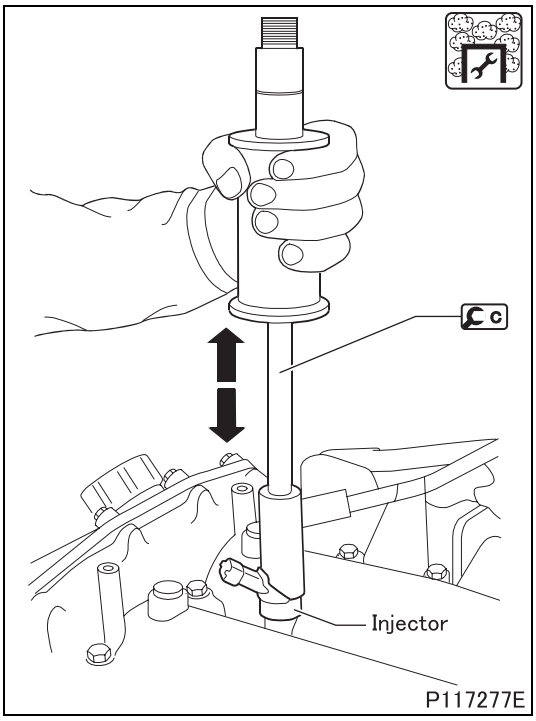
◆Removal procedure◆



■ Removal: Injector

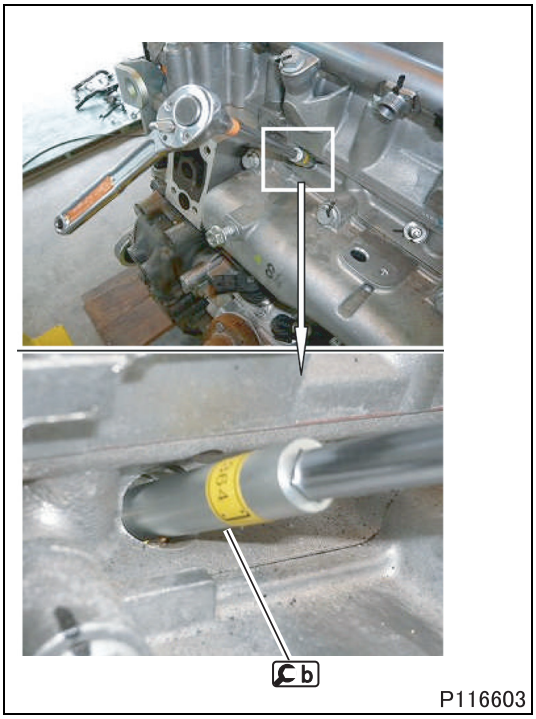
: This work requires protection against dust.

- Remove the injector bracket.

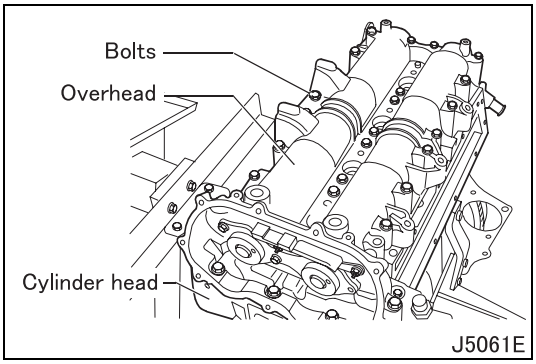


- Using the c, remove the injector from the engine overhead. (The injector is of a direct sealing type, so it does not use a gasket.)

■ Removal: Glow plug

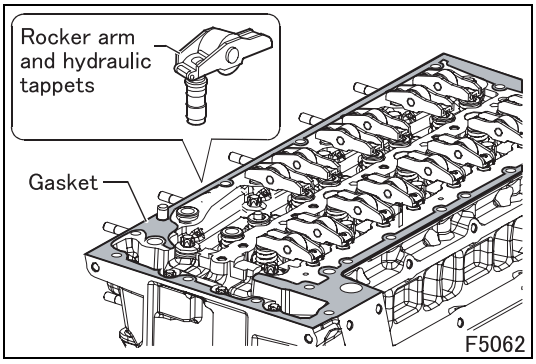


- Using the b, remove the glow plug from the cylinder head.



■ **Removal: Overhead**

- Remove the bolts and detach the overhead from the cylinder head.

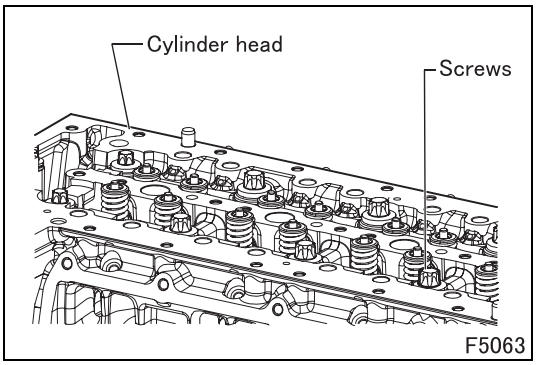


■ **Removal: Rocker arm and hydraulic tappet**

- Remove the rocker arm and the hydraulic tappets.
- Remove the gasket.

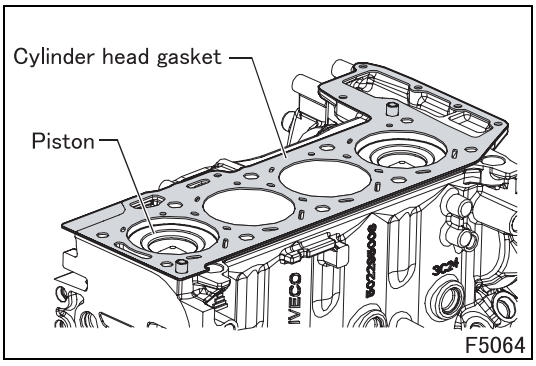
NOTE

- **Tappets must be marked for position if they are going to be reused.**



■ **Removal: Cylinder head**

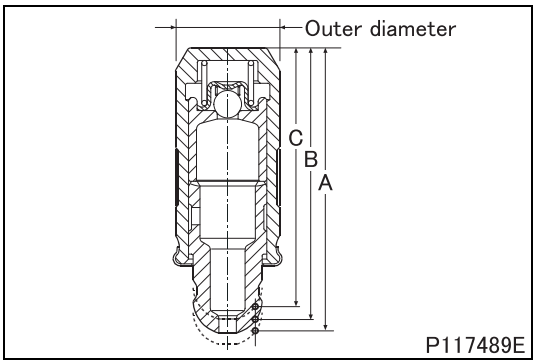
- Remove the screws and remove the cylinder head.



■ **Removal: Cylinder head gasket**

- Remove the cylinder head gasket.
- Check the protrusion of the pistons as described under the relevant heading to check the possibility of facing the crankcase if it has deformed.

◆Inspection procedure◆



■ **Inspection: Rocker arm and hydraulic tappet**

(1) Visual inspection

- The sliding surface of the tappets must have no scoring/dents; replace them if they do.

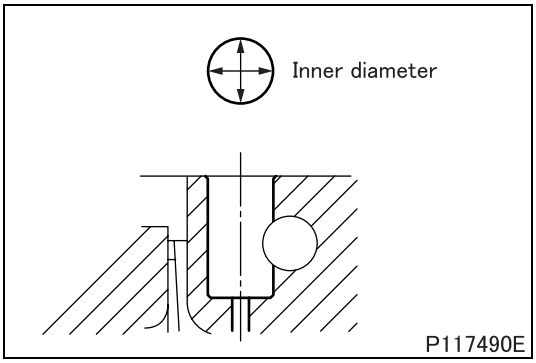
(2) Hydraulic tappet length

- Measure the each length of hydraulic tappet for the end and start of stroke.
  A = 32.44 ± 0.3 mm {1.28 ± 0.012 in.}, end of stroke
  B = 31.30 mm {1.23 in.}, working position: reference
  C = 29.75 ± 0.25 mm {1.17 ± 0.0098 in.}, start of stroke

- If the measurement is not within the standard valve range, replace the hydraulic tappet.

(3) Outer diameter of hydraulic tappet

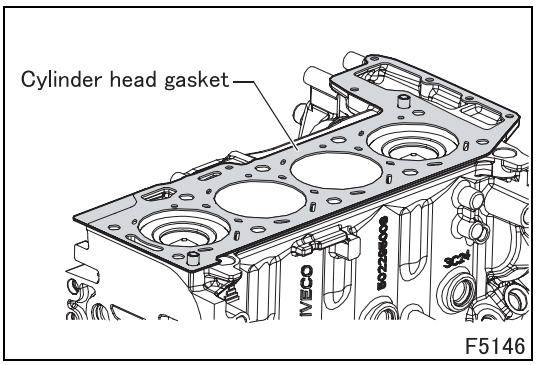
- If the measurement is not within the standard valve range, replace the hydraulic tappet.



■ **Inspection: Inner diameter of seats on cylinder head for hydraulic tappet**

- If the measurement is not within the standard value range, replace the cylinder head.

◆Installation procedure◆



■ **Installation: Cylinder head gasket**

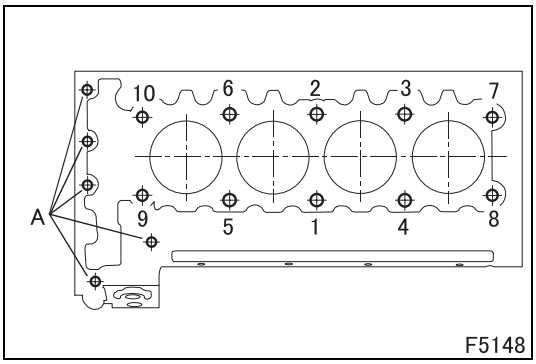
- Check that the mating surfaces of the cylinder head and crankcase are clean.
- Keep the cylinder head gasket clean.
- Place the cylinder head gasket of the cylinder head with the thickness given in section “Check piston protrusion”, with the “TOP” sign facing the head.

NOTE

- **It is essential to keep the cylinder head gasket sealed in its package until just before assembly.**

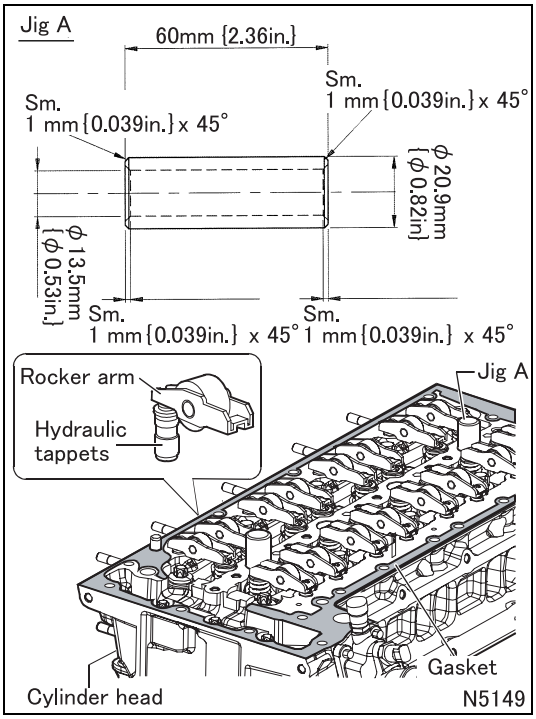
■ **Inspection: Cylinder head**

- Mount the cylinder head.
- Apply engine oil to the threads of the cylinder head bolts and install the bolts, and then tighten them in three phases as follows in the order shown in the drawing.
- Diagram of the tightening sequence for the cylinder head fixing bolts.
  - **1st phase**: pre-tightening with torque wrench
    - Bolts 1-2-3-4-5-6 to a torque of 130 N·m {96 ft.lbs, 13 kgf·m}.
    - Bolts 7-8-9-10 to a torque of 65 N·m {48 ft.lbs, 6.6 kgf·m}.
  - **2nd phase**: angle closing
    - Bolts 1-2-3-4-5-6 90°.
    - Bolts 7-8-9-10 90°.
  - **3rd phase**: angle closing
    - Bolts 1-2-3-4-5-6 90°.
    - Bolts 7-8-9-10 60°.
  - Bolts A, to a torque of 25 N·m {18 ft.lbs, 2.5 kgf·m}.

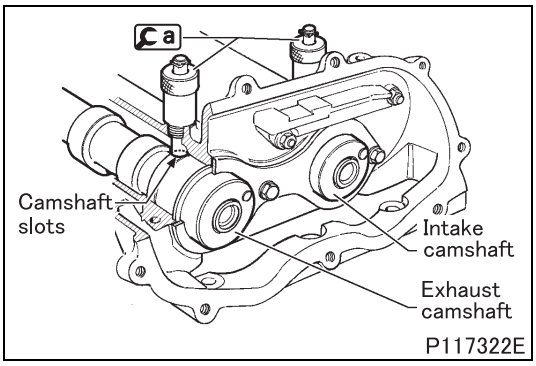


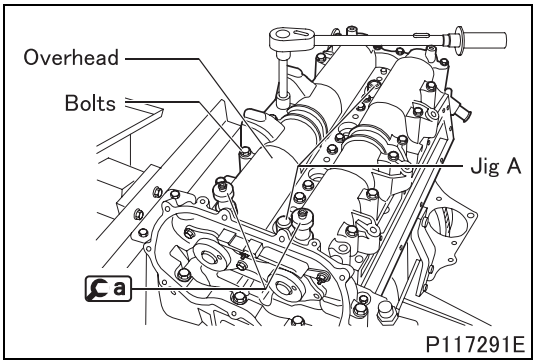
■ **Installation: Rocker arm and hydraulic tappet, overhead**

- Make a fixture jig A as shown in the illustration.
- Thoroughly clean the hydraulic tappets, lubricate them and fit them in the cylinder head, positioning the rocker arms on the valves correctly.
- Install the gasket.
- Insert the two jigs into the injector seats for subsequent centering of the overhead on the cylinder head.

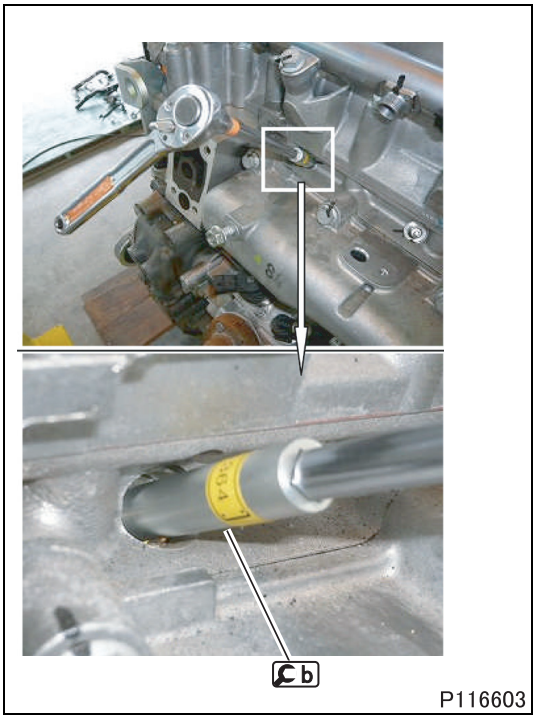


- Position the camshafts so that the Ca can be inserted in the camshaft slots through the overhead threaded holes.



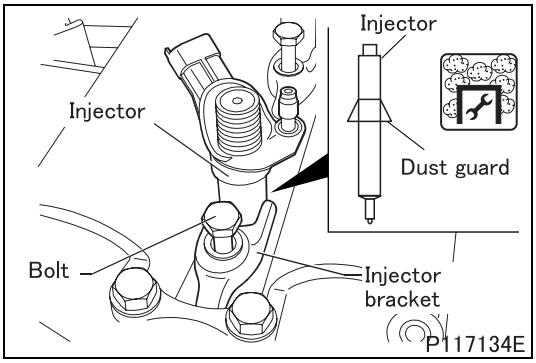


- Mount the overhead together with the a for the timing and tighten the fixing bolts to the prescribed torque: 25 N·m {18 ft.lbs, 2.5 kgf·m}.
- Take out the jig A.



■ **Installation: Glow plug**

- Using the b, install the glow plug on the cylinder head using a torque of 8 to 10 N·m {5.9 to 7.4 ft.lbs, 0.8 to 1.0 kgf·m}.

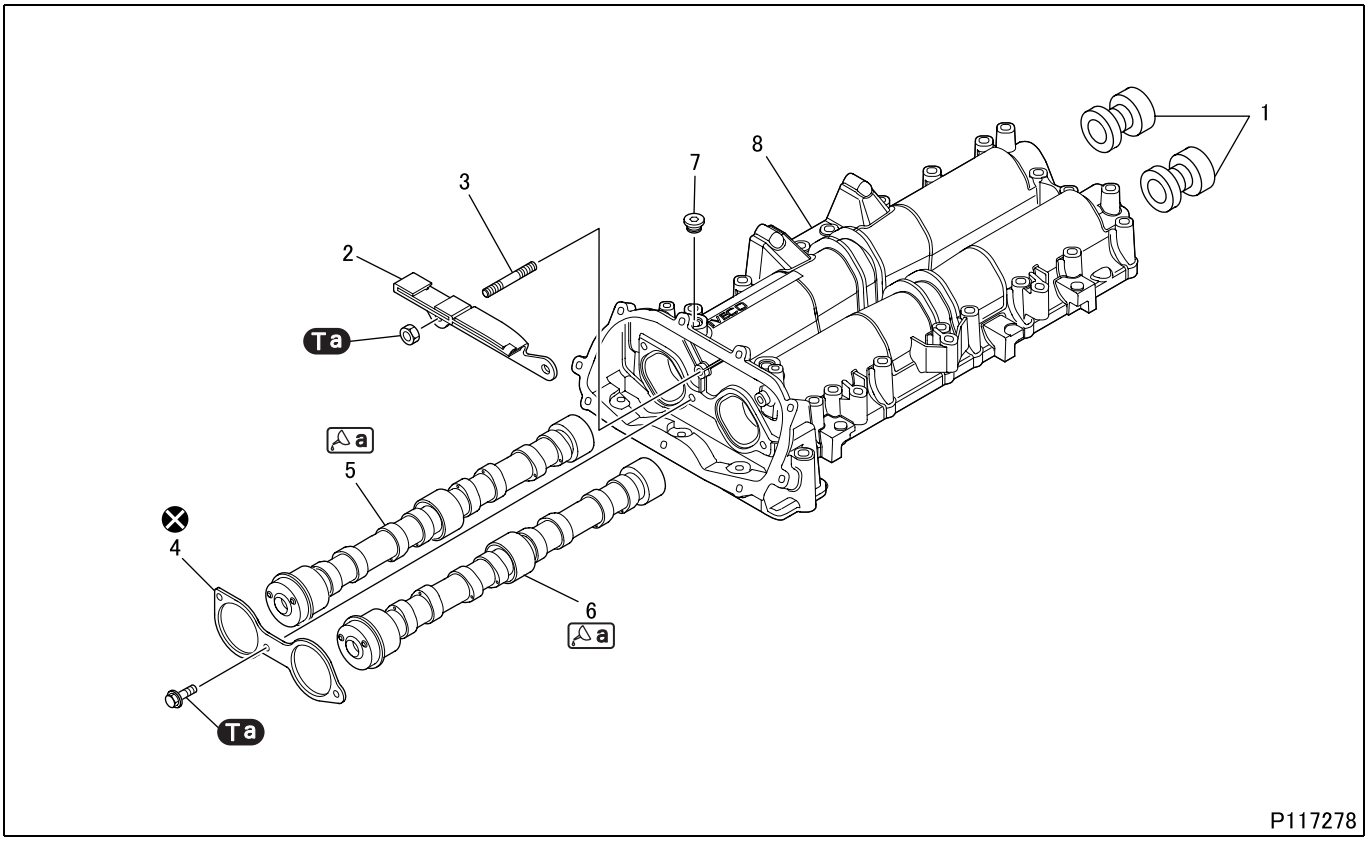


■ **Installation: Injector**

: This work requires protection against dust.

- Install a new dust guard on the injector.
- Install the injector on the overhead.
- Install the injector bracket.
- Install the bolt without tightening it.
- After installing the fuel pipes to the injector and to the common rail, tighten the injector bracket mounting bolt to the prescribed torque: 32 N·m {24 ft.lbs, 3.3 kgf·m}.

Overhead



● Disassembly sequence

1 Cover
2 Upper skid
3 Stud
4 Shoulder plate
5 Camshaft (exhaust)
6 Camshaft (intake)
7 Lock plug
8 Overhead

⊗: Non-reusable parts

● Assembly sequence

8→3→7→1→6→5→2→4

Service standards (Unit: mm {in.})

Location	Maintenance item			Standard value	Limit	Remedy
5, 6	Camshaft	Journal alignment		–	0.04 {0.0016}	Replace
		Outer diameter of supporting pin	No.1	48.925 to 48.950 {1.926 to 1.927}	–	Replace
			No.2	46.925 to 46.950 {1.848 to 1.849}	–	
			No.3	35.925 to 35.950 {1.414 to 1.415}	–	
		Useful cam lobe height	Exhaust	3.622 {0.14}	–	Replace
			Intake	4.328 {0.17}	–	
5, 6, 8	Camshaft pin-to-overhead supporting seat clearance			0.032 to 0.087 {0.0013 to 0.0034}	–	Replace

Location	Maintenance item		Standard value	Limit	Remedy
8	Inner diameter of camshaft pin seats in overhead	No.1	48.988 to 49.012 {1.929 to 1.930}	–	Replace
		No.2	46.988 to 47.012 {1.850 to 1.851}	–	
		No.3	35.988 to 36.012 {1.417 to 1.418}	–	

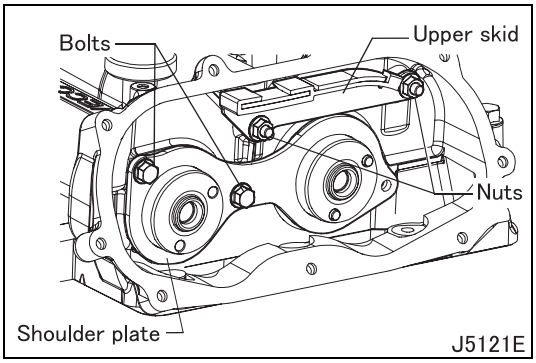
Tightening torque (Unit: N·m {ft.lbs, kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (cover mounting)	10 {7.4, 1.0}	–
	Nut (upper skid mounting)		
	Bolt (shoulder plate mounting)		

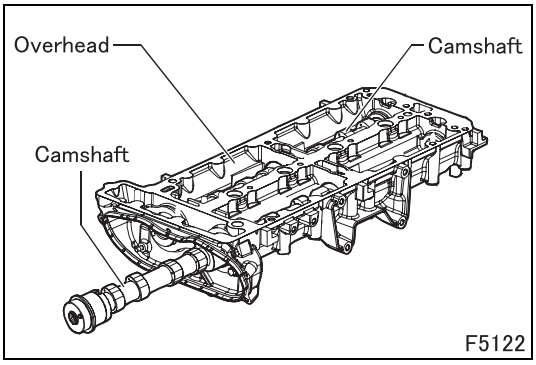
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Support pin of the camshaft	Engine oil	As required

◆Removal procedure◆

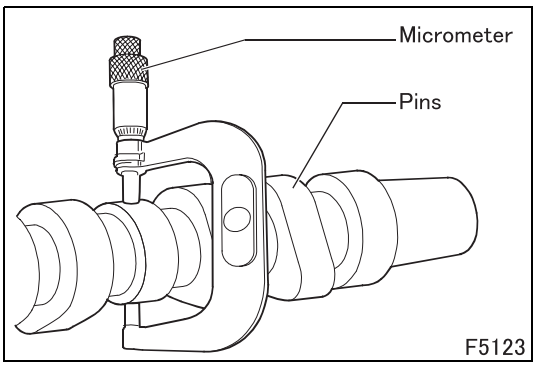


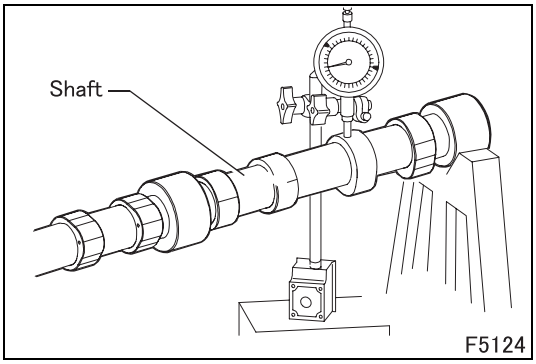
- Remove the nuts and the upper skid. Remove the bolts and the shoulder plate.



- Tilt the overhead and take care not to damage the seats, then remove the camshafts from the overhead.

◆Inspection procedure◆





■ Inspection: Camshaft and overhead

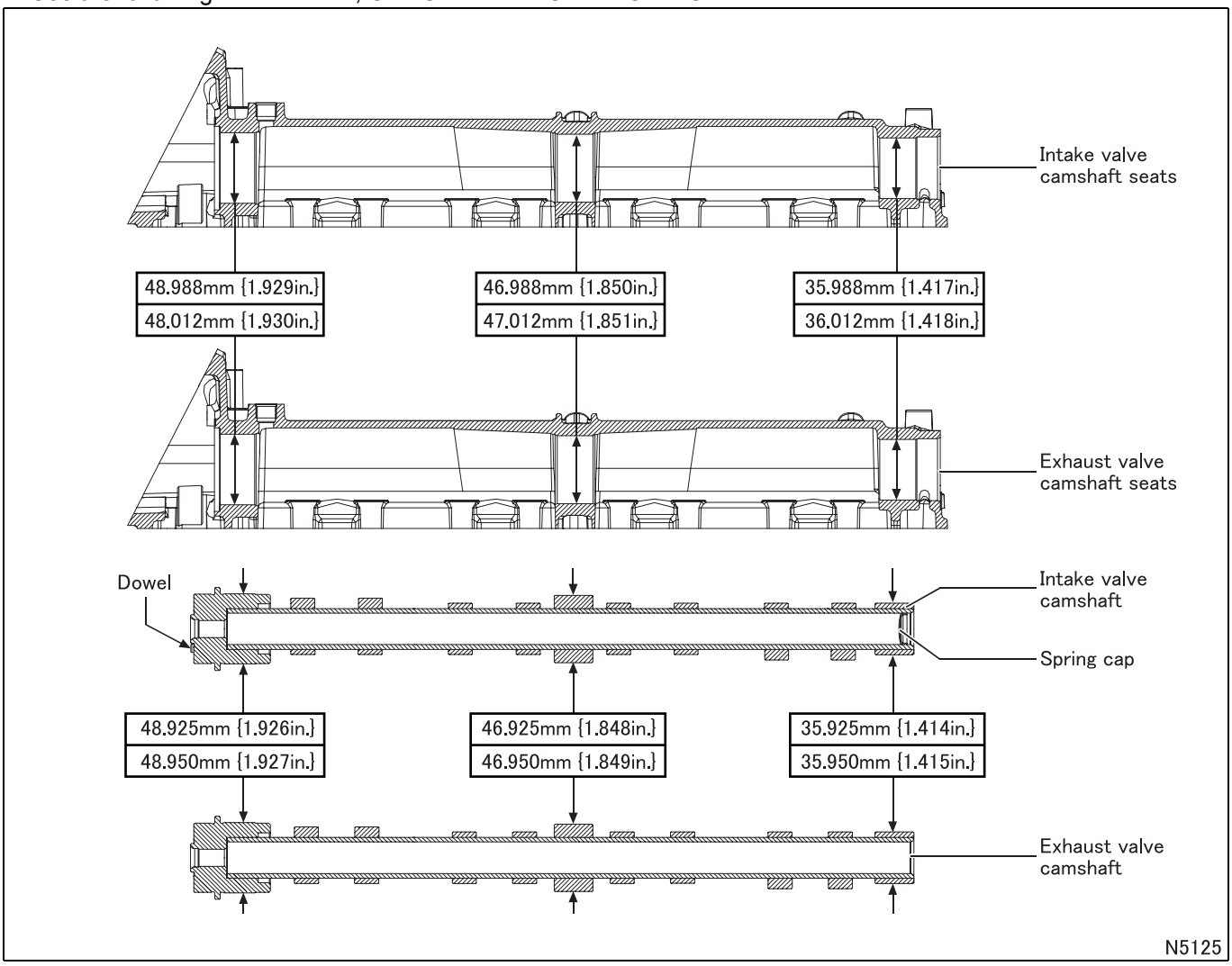
(1) Camshaft pin-to-overhead supporting seat clearance

- The surfaces of the shaft supporting pins and of the cams must be finely honed; if there is any sign of wear or scoring, replace the shaft.
- Using a micrometer, measure the diameter of the pins of the camshaft and, using a bore meter, measure the diameter of the supporting seats in the overhead.
- The difference between these two measurements gives the existing clearance.
  The nominal assembly clearance is 0.032 to 0.087 mm {0.0013 to 0.0034 in.}.

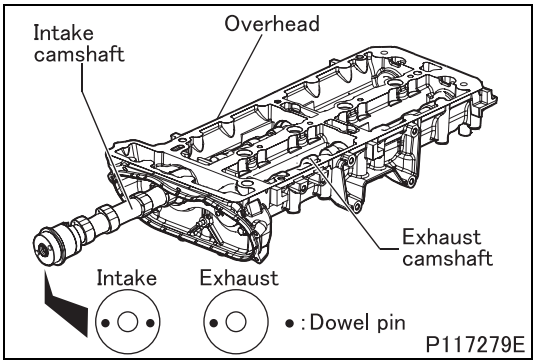
(2) Camshaft useful cam lobe height and bend

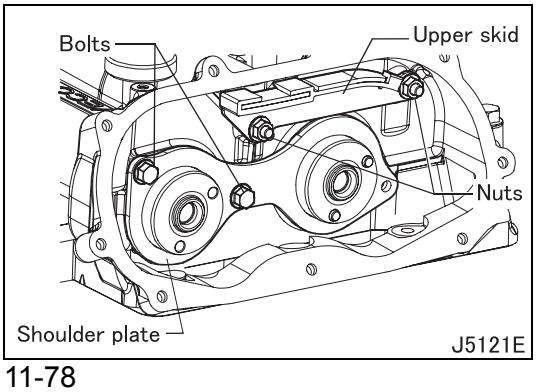
- Place the shaft on the V-blocks and use a dial gauge fitted on the central support to check that the bend does not exceed 0.04 mm {0.0016 in.}; otherwise, change the shaft.
- Check also the useful camshaft lobe height: it must correspond to the standard value; if different values are detected, change the shaft.

- See the following “MAIN DATA, CAMSHAFT PINS AND SEATS”.



◆Installation procedure◆



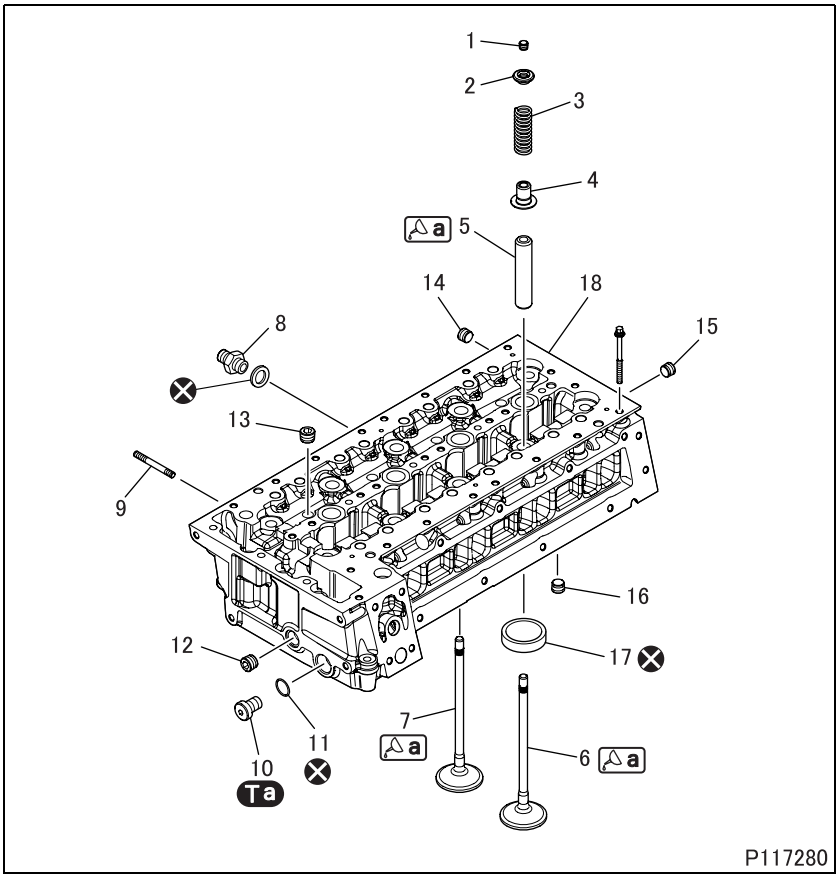


■ Installation: Camshaft

- Apply engine oil to the support pins of the intake camshaft and exhaust camshafts, and install the camshaft on the overhead.
- During this work, do not change over the mounting positions of the shafts.
  The intake camshaft can be identified by the number of dowel pins on the front face. (intake: 2 dowel pins, exhaust: 1 dowel pin) Be careful not to damage the support seat of the overhead shaft.

- Install the upper skid using a tightening torque of 10 N·m {7.4 ft.lbs, 1.0 kgf·m}.
- Install a new shoulder plate using a torque of 10 N·m {7.4 ft.lbs, 10 kgf·m}.

Cylinder head



● Disassembly sequence

1 Cotters
2 Retainer
3 Spring
4 Stem seal
5 Valve guide
6 Intake valve
7 Exhaust valve
8 Connector
9 Stud
10 Lock plug
11 Gasket
12 Taper plug (diam: 1/2”)
13 Taper plug (diam: 3/8”)
14 Taper plug (diam: 1/8”)
15 Taper plug (diam: 1/4”)
16 Taper plug (diam: 1/2”)
17 Valve seat
18 Cylinder head

⊗: Non-reusable parts

● Assembly sequence

Follow the disassembly sequence in reverse.

Service standards (Unit: mm {in.})

Location	Maintenance item		Standard value	Limit	Remedy
–	Protrusion	Injector	–0.10 to +0.20 {–0.0039 to +0.0079}	–	Reface
		Glow plug	3.77 ± 0.30 {0.15 ± 0.012}	–	Reface
3	Valve spring height	Free spring	55.05 {2.17}	–	Replace
		Load of N320 ± 16	45 {1.77}	–	Replace
		Load of N657 ± 30	35 {1.38}	–	Replace
5	Valve guide	Inside diameter	6.023 to 6.038 {0.237 to 0.238}	–	Reface or replace
		Outside diameter	10.028 to 10.039 {0.394 to 0.395}	–	Reface or replace
5, 6, 7	Clearance between valve stem and valve guide	Intake	0.023 to 0.053 {0.00091 to 0.0023}	–	Inspect
		Exhaust	0.033 to 0.063 {0.0013 to 0.0025}	–	Replace
5, 18	Interference between valve guide and seats on cylinder head		0.028 to 0.059 {0.0011 to 0.0023}	–	Replace
6	Intake valve	Stem outside diameter	5.985 to 6.000 {0.235 to 0.236}	–	Replace
		Seat angle	60° ± 7’	–	Reface
6, 7	Valve recessing (intake and exhaust)		0.475 to 0.5250 {0.019 to 0.021}	–	Inspect
	Valve centering error		–	0.03 {0.0012}	Replace

Location	Maintenance item		Standard value	Limit	Remedy
7	Exhaust valve	Stem outside diameter	5.975 to 5.990 {0.235 to 0.236}	–	Replace
		Seat angle	60° ± 7'	–	Reface
17	Valve seats (intake and exhaust)	Outside diameter	34.595 to 34.610 {1.362 to 1.363}	–	Replace
		Angle	59.5 ± 0.5°	–	Replace
17, 18	Interference between valve seat and cylinder head		0.08 to 0.12 {0.0031 to 0.0047}	–	Replace
18	Cylinder head	Deformation of mating surface	–	0.20 {0.0079}	Reface or replace
		Thickness from top to bottom	112 ± 0.1 {4.41 ± 0.0039}	111.8 {4.40}	
	Inside diameter of seat on cylinder head for valve seat (intake and exhaust)		34.490 to 34.515 {1.358 to 1.359}	–	Replace
	Inside diameter of valve guide seat		9.980 to 10.000 {0.392 to 0.394}	–	Replace

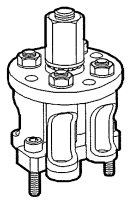
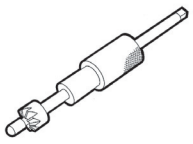
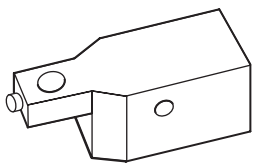
Tightening torque (Unit: N·m {ft.lbs, kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Rubber cap	25 {18, 2.5}	–

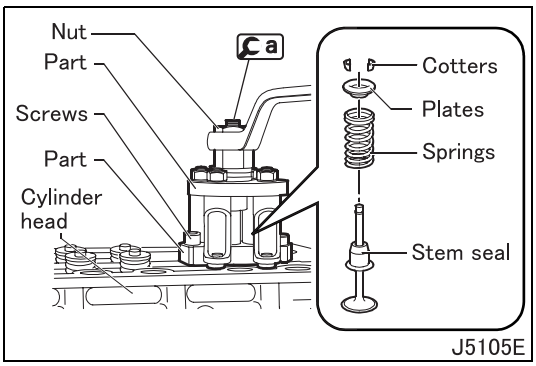
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Valve guide	Engine oil	As required
	Stem of intake valve and exhaust valve		

Special tools

Mark	Tool name and shape	Part No.	Application
a	Lifter, valve  99360260	MH063966	Tool for removing and refitting valves
b	Injector support seat cutter  99304038	MH064257	Cleaning of injector seat surface
c	Base, dial gauge  99370415	MH063971	Measurement for piston protrusion, etc.

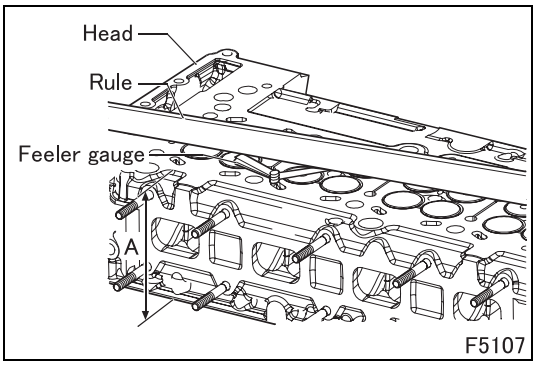
◆Removal procedure◆



■ Removal: Valve

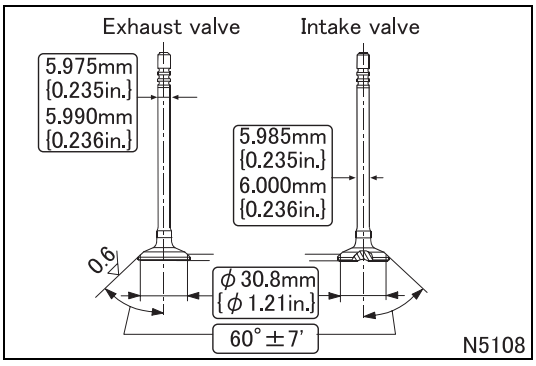
- Install part of Ca onto the cylinder head and secure it with the screws.
- Install part of Ca onto part, screw down the nut so that on compressing the springs it is possible to remove the cotters.
  Then take out the plates and the springs.
- Using suitable pliers, remove the stem seal.
- Repeat these operations on the remaining valves.
- Turn the cylinder head over.

◆Inspection procedure◆



■ Inspection: Cylinder head deformation of mating surface

- The mating surface of the head with the cylinder block is checked using a rule and a feeler gauge.
- The deformation found on the entire length of the cylinder head must be no greater than 0.2 mm {0.0079 in.}.
- The nominal thickness A of the cylinder head is 112 ± 0.1 mm {4.41 ± 0.0039 in.}; the maximum permissible removal of metal must not exceed a thickness of 0.2 mm {0.0079 in.}.
- After regrinding, check the valve recessing and if necessary regrind the valve seats to make the prescribed valve recessing.



■ Inspection: Intake valve, exhaust valve

(1) Visual inspection

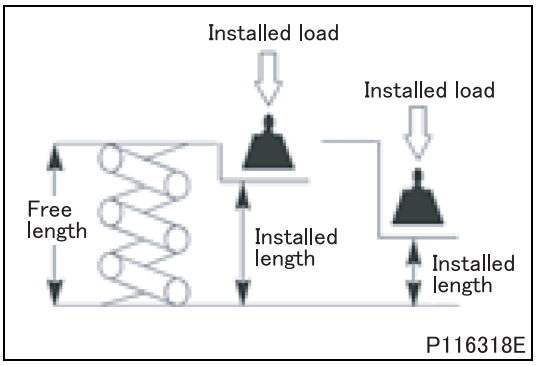
- Remove the carbon deposits on the valves with a wire brush. Check that the valves show no signs of seizure, cracking or burning.

(2) Stem outside diameter

- Replace the valve stem if the measured value is not within the standard value range.

(3) Valve seat angle

- Replace the valve seat if the measured value is not within the standard value range.



■Inspection: Valve spring

(1) Free length

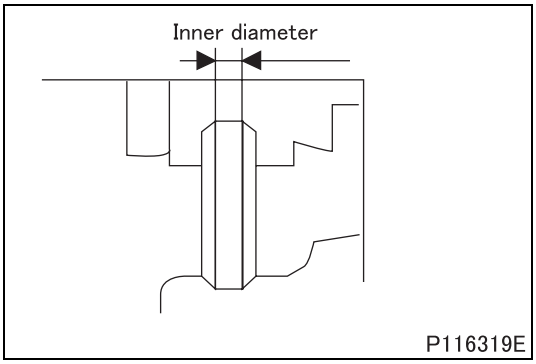
Standard value: 55.05 mm {2.17 in.}

- If the measurement is out of the standard value, replace the valve spring.

(2) Installed load (installed length)

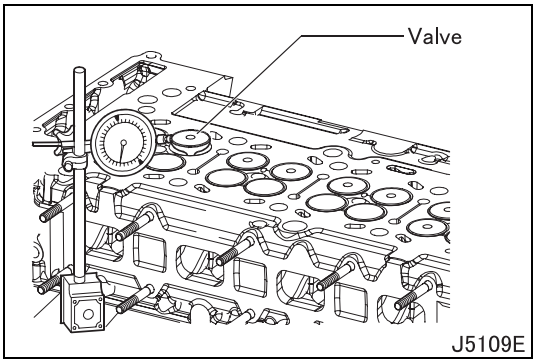
Standard value: 45 mm {1.77 in.} 320 ± 16 N {72 ± 3.6 lbs, 32.6 ± 1.6 kgf}
: 35 mm {1.38 in.} 657 ± 30 N {145 ± 6.7 lbs, 67.0 ± 3.1 kgf}

- If the measurement is out of the standard value, correct the valve.



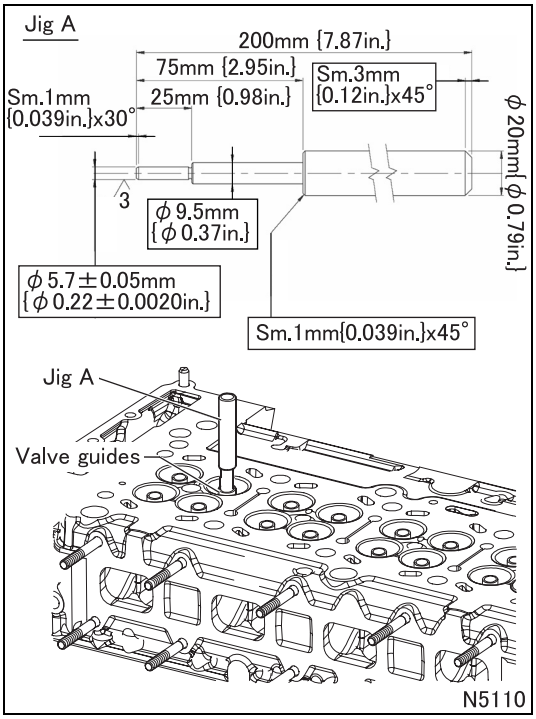
■**Inspection: Valve guide inner diameter**

- Measure the valve guide inner diameter using a small hole diameter gauge.
  Standard value: 6.023 to 6.038 mm {0.237 to 0.238 in.}
- If the measurement is out of the standard value, replace the valve guide.



■ **Inspection: Clearance between valve stem and valve guide and centering valves**

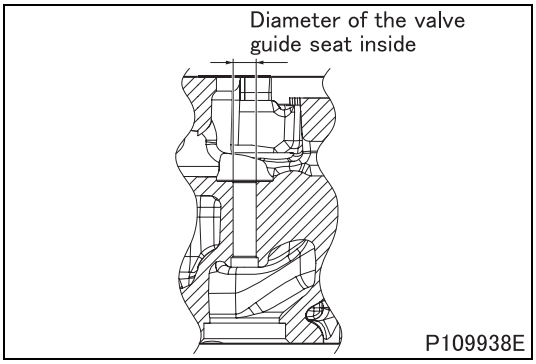
- The checks are made using CC with a magnetic base, positioned as illustrated.
- The assembly clearance is 0.033 to 0.063 mm {0.0013 to 0.0025 in.}.
  Rotate the valve, check that the centering error is no greater than 0.03 mm {0.0012 in.}.
- If measurement is not within the standard value range or exceeds the limit, replace the defective parts.



■ **Replacement of valve guide**

[Removal]

- Make the fixture jig A as shown in the illustration.
- Remove the valve guides with the drift jig A.



[Installation]

- Measure the diameter of the valve guide seat inside in the cylinder head.

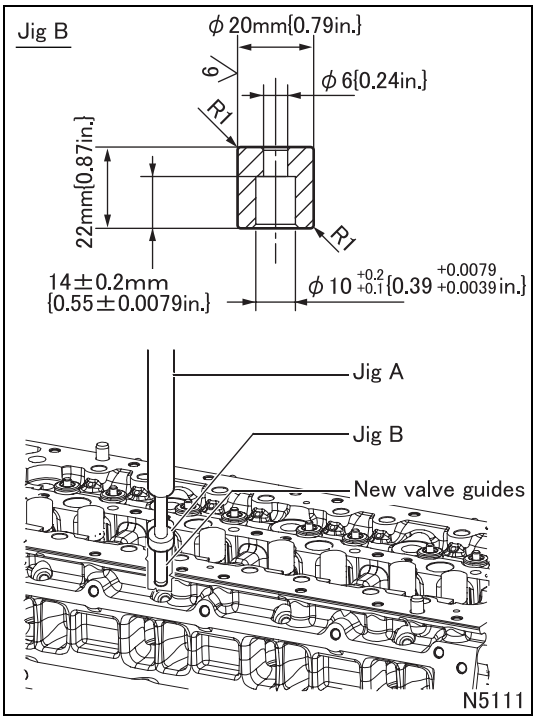
Standard value of valve guides–Seats

Valve guide seat inside φ	9.980 to 10.000 mm {0.393 to 0.394 in.}
Valve guide outside φ	10.028 mm to 10.039 mm {0.394 to 0.395 in.}

- If the measurement is not within the standard value, select an oversized valve guide from the table below.
- Recondition the valve guide mounting hole to the diameter corresponding to the diameter of the selected oversized valve guide.

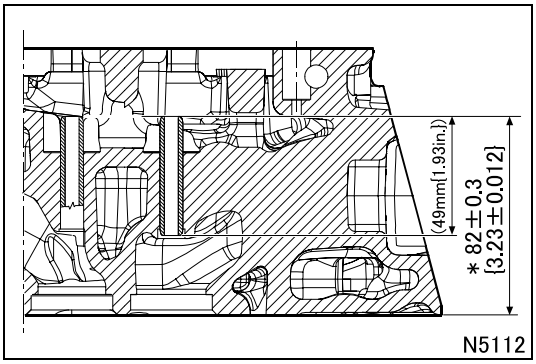
Unit: mm {in.}

Available oversize	0.05 {0.002}	0.1 {0.0039}	0.25 {0.0098}
Valve guide outside diameter	10.078 to 10.089 {0.396 to 0.397}	10.128 to 10.139 {0.398 to 0.399}	10.278 to 10.289 {0.404 to 0.405}

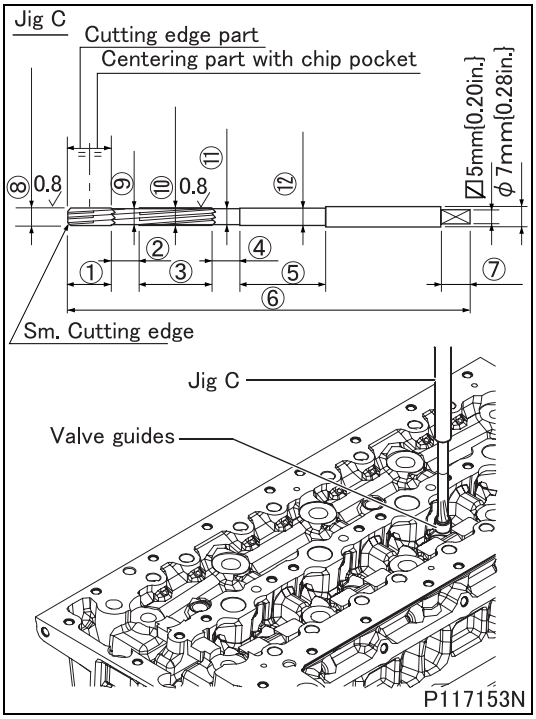


- Make the fixture jig B as shown in the illustration.
- Warm up the cylinder head to 80 to 100°C {176 to 212°F} and, by means of beater jig A fitted with element jig B, fit the new valve guides previously lubricated with engine oil. Driving force 4.2 to 12 kN {945 to 2700 lbs, 430 to 1250 kgf}.

- Measurement to be made after driving in the valve guides.



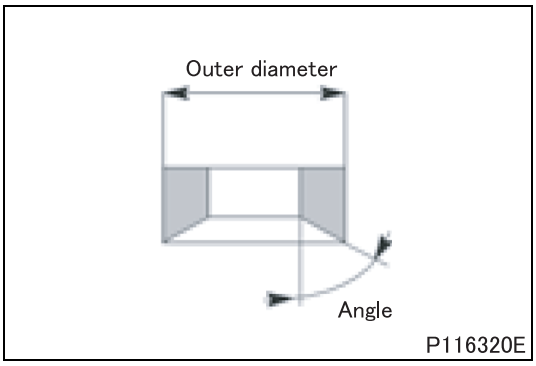
- If the above mentioned tools are not available, fit the valve guides by positioning them in the cylinder head according to the value shown in figure.



Refacing the valve guide

- Make the fixture jig C as shown in the illustration.
- After driving in the valve guides, regrind them with the smoother jig C.

(1) 15 mm {0.59 in.}
(2) 10 mm {0.39 in.}
(3) 25 mm {0.98 in.}
(4) 10 mm {0.39 in.}
(5) 30 mm {1.18 in.}
(6) 140 mm {5.51 in.}
(7) 10 mm {0.39 in.}
(8) ϕ5.9 ± 0.05 mm {0.23 ± 0.0020 in.}
(9) ϕ5.5 mm {0.22 in.}
(10) $6.03^{+0}_{+0.005}$ mm {$0.24^{+0}_{+0.00020}$ in.}
(11) ϕ5.5 mm {0.22 in.}
(12) ϕ5.95 mm {0.24 in.}



■Inspection: Valve seat (when replaced with a new part)

(1) Outer diameter

Standard value: 34.595 to 34.610 mm {1.362 to 1.363 in.}

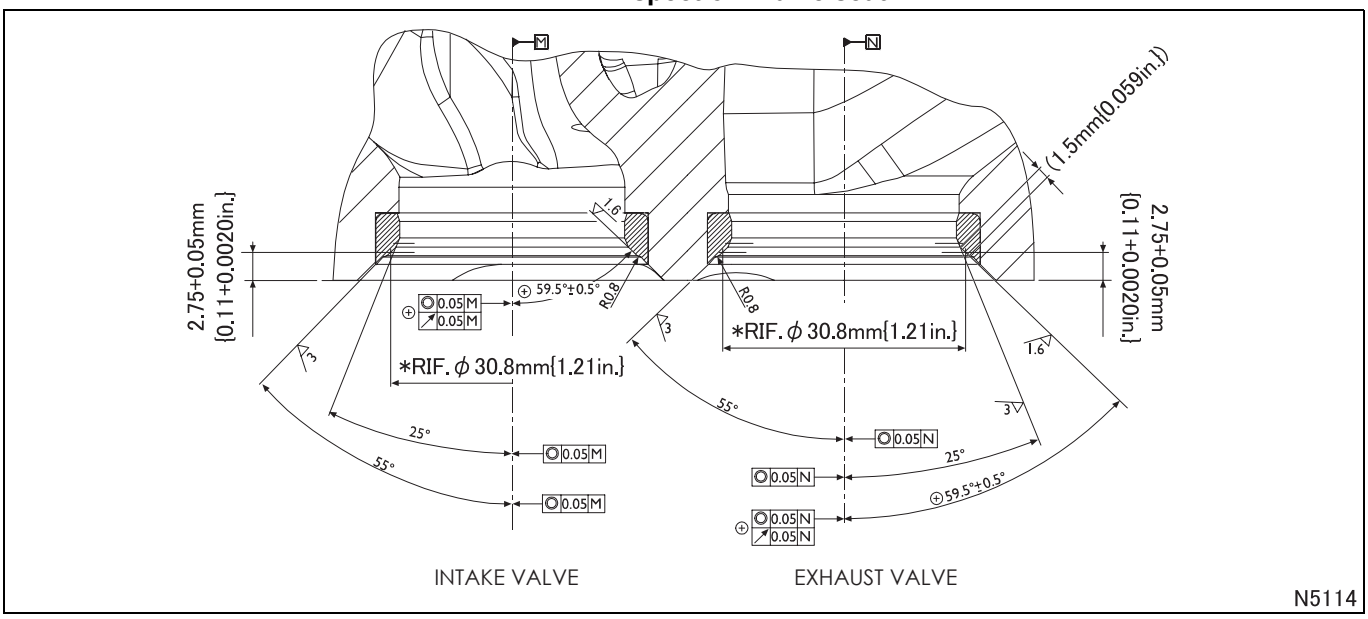
- If the measurement is out of the standard value, replace the valve seat.

(2) Angle

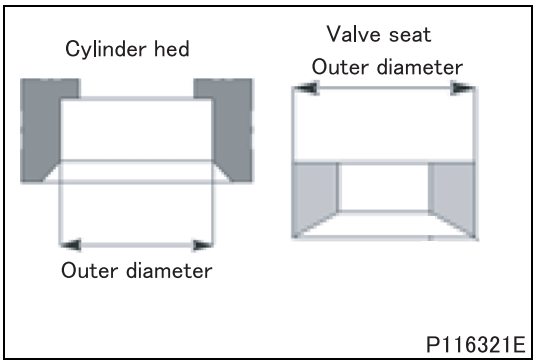
Standard value: 59.5 ± 0.5°

- If the measurement is out of the standard value, replace the valve seat.

■ Inspection: Valve seat



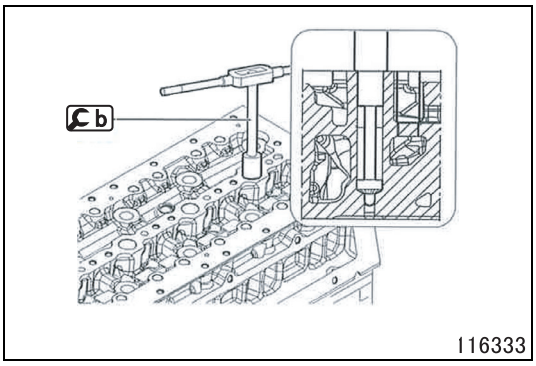
- Check the valve seats. On finding any slight scoring or burns, regrind them with an appropriate tool according to the angles given in figure.
- Having to replace them, with the same tool and taking care not to affect the cylinder head, remove as much material from the valve seats as possible until, with a punch, it is possible to extract them from the cylinder head.
- Heat the cylinder head to 80 to 100°C {176 to 212°F} and, using a suitable drift, fit in it the new valve seats, previously chilled in liquid nitrogen.
- Using a specific tool, regrind the valve seats according to the angles given in figure.
- Mount the valves, block the seat of the electro-injectors and glow plugs; using a suitable tool, check the seal of the valves/seats.



■Clearance between valve seat and cylinder head

Standard value: 0.08 to 0.12 mm {0.0031 to 0.0047 in.}

- If the measurement is out of the standard value, replace defective parts.

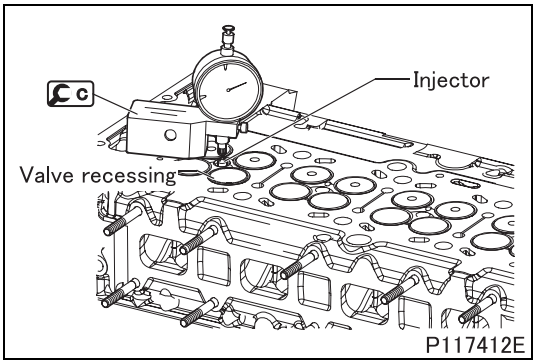


■Inspection: Injector support seat

- Check the injector support seat for carbon deposits.
- If carbon deposits are present, clean the injector support seat using b.

CAUTION ⚠

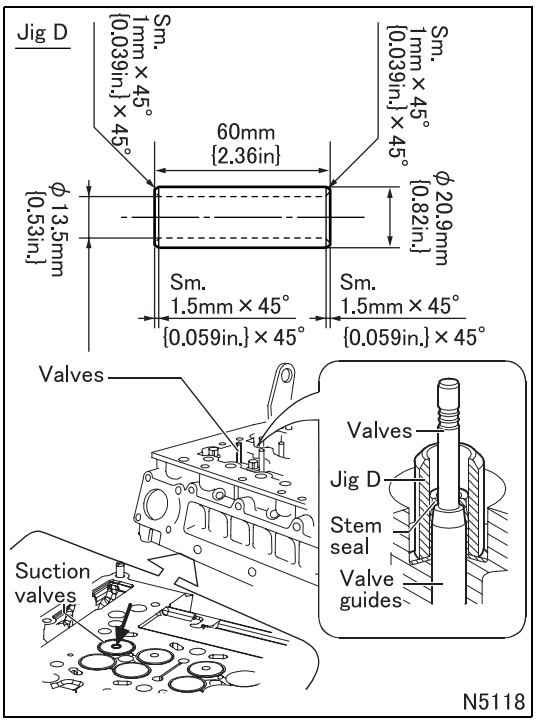
- **Never grind the aluminum surface of the injector support seat.**



■ Inspection: Valve recessing, protrusion of injector and glow plug

- Using dial gauge and relevant base c, check that, from the plane of the cylinder head, the valve recessing and the protrusion of the injector and of the glow plug have the prescribed value.
  - Valve recessing: 0.475 to 0.5250 mm {0.019 to 0.021 in.}
  - Injector protrusion: –0.10 to +0.20 mm {–0.0039 to 0.0079 in.}
  - Glow plug protrusion: 3.77 ± 0.30 mm {0.15 ± 0.012 in.}
- If the measurement is not within the standard value range, replace the defective parts.

◆Installation procedure◆

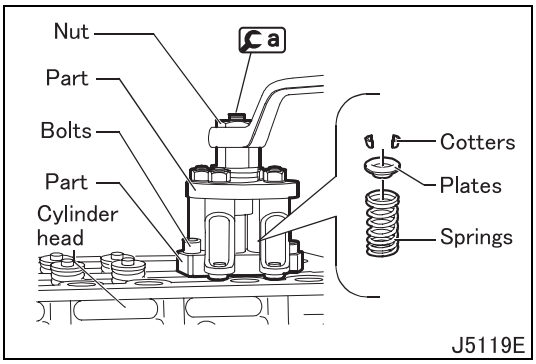


■ **Installation: Valve**

- Make a fixture jig D as shown in the illustration.
- Lubricate the stem of the valves and insert them into the associated valve guides according to the position marked during removal. Using jig D, mount the stem seals on the valve guides.

NOTE

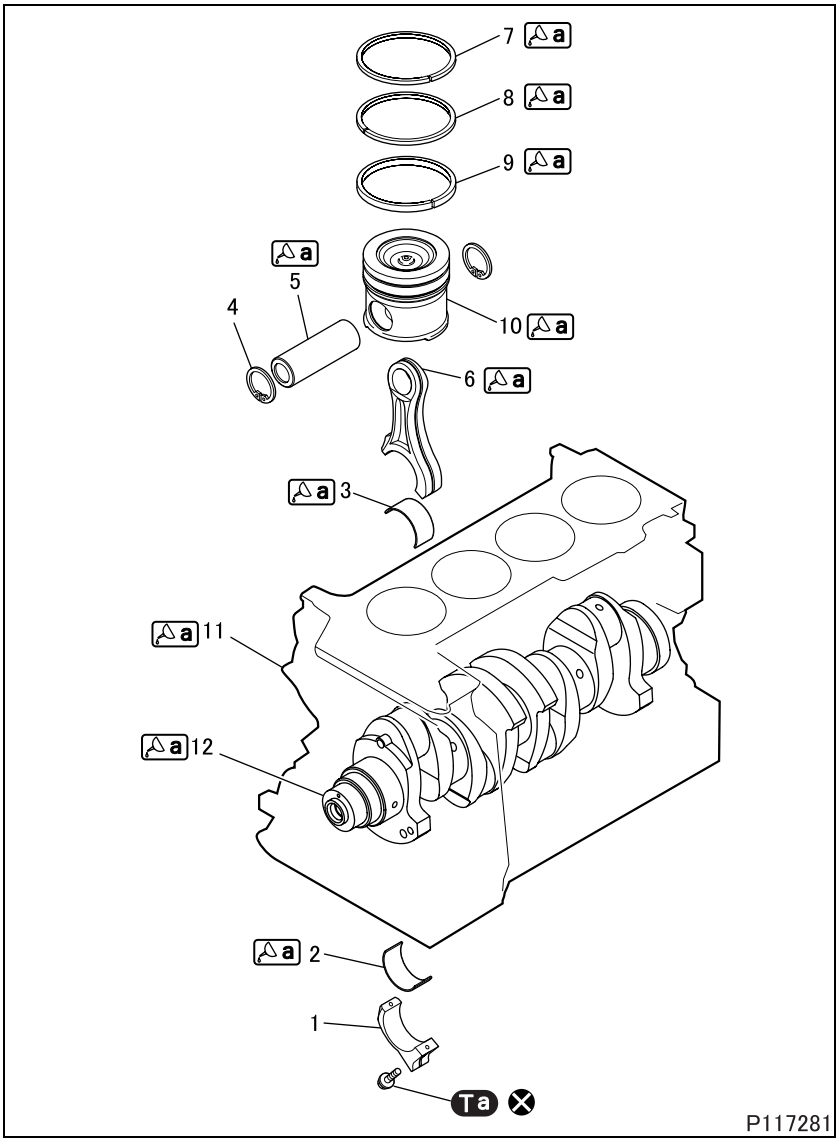
- **The intake valves are different from the exhaust ones for a dimple (→) in the center of the valve head.**



- Position the springs and plates on the cylinder head.
- Install the part of a onto the cylinder head and secure it with the screws.
- Install the part of a onto part, screw down the nut so that by compressing the springs it is possible to insert the retaining cotters; then unscrew the nut checking that the cotters have settled in correctly.
- Repeat these operations on the remaining valves.

M E M O

PISTON AND CONNECTING ROD



● **Removal sequences**

1 Connecting rod cap
2 Lower connecting rod bearing
3 Upper connecting rod bearing
4 Snap pin
5 Piston pin
6 Connecting rod
7 1st ring
8 2nd ring
9 Oil ring
10 Piston

***a**: Crankcase
***b**: Crankshaft
⊗: Non-reusable parts

● **Installation sequence**

Follow the disassembly sequence in reverse.

Service standards (Unit: mm {in.})

Location	Maintenance item	Standard value	Limit	Remedy
1	Upper rod half bearing thickness	1.882 to 1.892 {0.0741 to 0.0745}	–	Replace
1, 2, 3, 6, *b	Bearing shells to crankpins clearance	0.035 to 0.083 {0.0014 to 0.0033}	–	Replace
1, 6	Connecting rod bearing seat	67.833 to 67.848 {2.670 to 2.671}	–	Replace
3	Lower rod half bearing thickness	1.878 to 1.888 {0.073 to 0.074}	–	Replace
5	Piston pin outside diameter	35.990 to 35.996 {1.416 to 1.417}	–	Replace
5, 6	Piston pin to connecting rod bushing clearance	0.014 to 0.030 {0.00055 to 0.0012}	–	Replace
5, 10	Piston pin to pin clearance	0.07 to 0.019 {0.0028 to 0.00075}	–	Replace

Location	Maintenance item		Standard value	Limit	Remedy
7 to 9	Piston ring thickness	1st ring (measured at 1.5 {0.059} from external diameter)	2.068 to 2.097 {0.081 to 0.083}	–	Replace
		2nd ring	1.970 to 1.990 {0.077 to 0.078}	–	Replace
		Oil ring	2.470 to 2.495 {0.097 to 0.098}	–	Replace
	Piston ring end opening in cylinder liner	1st ring	0.20 to 0.35 {0.0079 to 0.014}	–	Replace
		2nd ring	0.60 to 0.80 {0.024 to 0.031}	–	Replace
		Oil ring	0.30 to 0.60 {0.012 to 0.024}	–	Replace
7 to 10	Piston ring to slots clearance	1st ring	0.103 to 0.162 {0.0041 to 0.064}	–	Replace
		2nd ring	0.060 to 0.100 {0.0024 to 0.0039}	–	Replace
		Oil ring	0.045 to 0.090 {0.0018 to 0.0035}	–	Replace
10	Piston ring slots width	1st ring (measured on ϕ92.8 {ϕ3.65})	2.200 to 2.230 {0.087 to 0.088}	–	Replace
		2nd ring	2.050 to 2.070 {0.0807 to 0.0815}	–	Replace
		Oil ring	2.540 to 2.560 {0.100 to 0.101}	–	Replace
	Piston outside diameter (measured at 10 {0.39} from bottom of piston)	Class A	95.705 to 95.715 {3.7679 to 3.7683}	–	Replace
		Class B	95.715 to 95.725 {3.7683 to 3.7687}	–	Replace
	Pistons seat diameter for pin		36.003 to 36.009 {1.4174 to 1.4177}	–	Replace
10, *a	Piston protrusion from crankcase		0.3 to 0.6 {0.012 to 0.024}	–	Replace

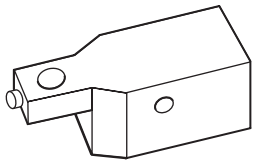
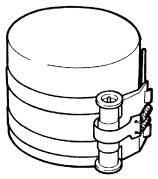
Tightening torque (Unit: N·m {ft.lbs, kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Screw (connecting rod cap mounting)	50 {37, 5.1} + 70°	–

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Piston pin outside surface	Engine oil	As required
	Piston outside surface		
	Piston ring		
	Cylinder liner of the crankcase		
	Connecting rod bearing inside surface		

Special tools

Mark	Tool name and shape	Part No.	Application
a	Base, dial gauge  99370415	MH063971	Dial gauge base for various measurements
b	Piston clamp (60 to 125 mm {2.36 to 4.92 in.})  99360605	MH063992	Installation of piston to cylinder liner

◆Removal procedure◆

■ **Removal: Piston and connecting rod**

- Before removing the piston, remove carbon deposits from the inside of the cylinder so as to prevent the piston walls from becoming damaged.
- Set the piston and connecting rod assembly to the bottom dead center.
- Loosen the connecting rod cap, and rotate the engine in the vertical position.
- Remove the connecting rod cap and the lower connecting rod bearing.

CAUTION ⚠

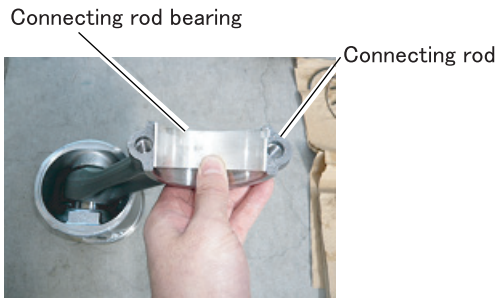
- **After removing the connecting rod cap, be sure to place the connecting rod cap and the connecting rod bearing with their sides facing downward. If you place them with the end face downward, the connecting rod bearing assembly will be damaged. If damage occurs, it will be necessary to replace the connecting rod assembly.**

- Withdraw the piston and the connecting rod assembly from the top of the crankcase.
- Next, install the connecting rod cap and the lower connecting rod bearing on the connecting rod. During this work, confirm that there is no foreign matter on the mating faces.

CAUTION ⚠

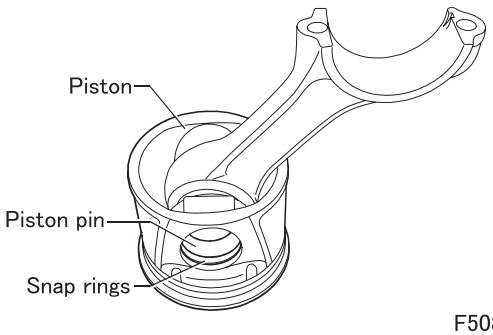
- **After removing a piston and its connecting rod assembly, install the connecting rod cap and the bearing on the same connecting rod before removing a different connecting rod cap. During this work, ensure that no clearance occurs between the mating face to prevent these faces from being damaged.**

- Because it is necessary to re-install all of the component parts in their original locations, make a note of the cylinder number and the front and rear directions of the engine on each connecting rod and the connecting rod cap before removing these parts. Also, after removing a connecting rod cap, make a mark using a scriber on the notch of the bearing shell to identify top and bottom, and also indicate the cylinder number.



P117251E

- Push the connecting rod bearing from the side, and remove the bearing from the connecting rod.



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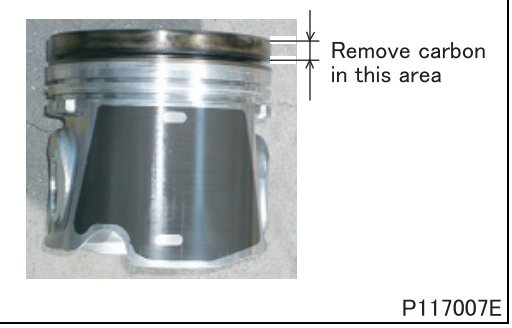
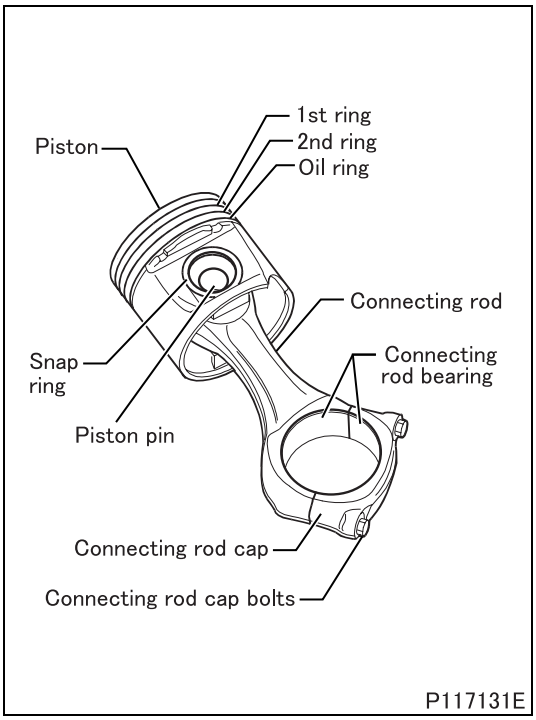
- Hold the piston with the top facing downward, and place the piston on a table.
- Using snap ring pliers, remove the snap ring from the piston.
- Slide the piston pin and remove it, then remove the connecting rod from the piston.
- Using piston ring pliers, remove the 1st ring and 2nd ring from the piston.
- Remove the oil ring by hand, and then pull out the joint core wire and remove the oil expander spring remaining on the piston side.



P117007E

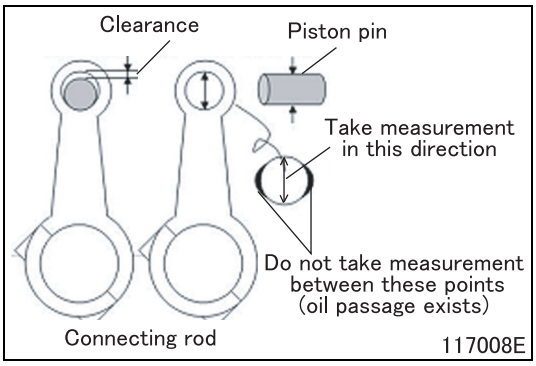
- Remove the carbon in the area shown in the drawing from the removed pistons using a carbon scraper and steel scrubbing brush.

◆Inspection procedure◆



■ **Inspection: Piston and connecting rod**

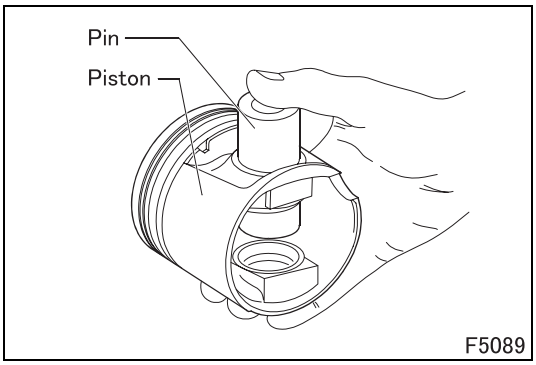
- Check the pistons. They must show no signs of seizure, scoring, cracking or excessive wear; replace them if they do.



■ **Inspection: Clearance between piston pin and connecting rod bushing**

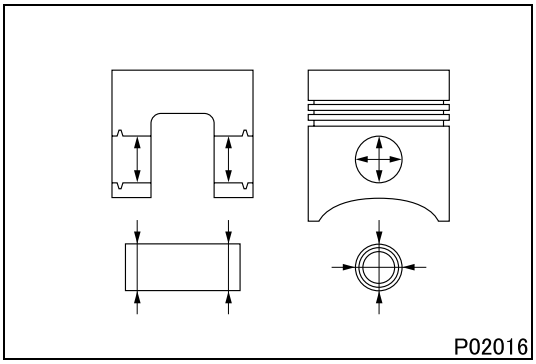
Standard value: 0.014 to 0.030 mm {0.00055 to 0.0012 in.}

- If the measurement is out of the standard value, replace the bushing.



■ **Inspection: Piston pin**

- Lubricate the pin and its seat on the hubs of the piston with engine oil. The pin must go into the piston by lightly pressing with the fingers and must not drop out by gravity.
- If the pin drops out by gravity, replace the defective part.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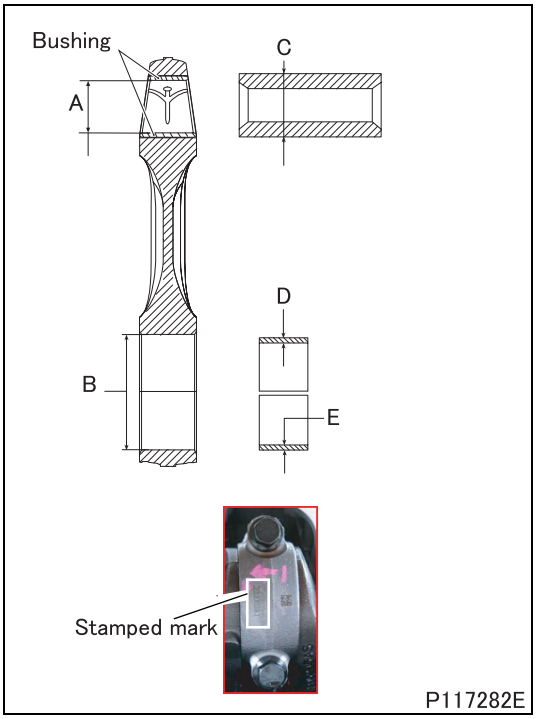
- Clearance between piston pin and piston
  Standard value: 0.07 to 0.019 mm {0.0028 to 0.00075 in.}
  - If the measurement is out of the standard value, replace defective parts.



P117282E

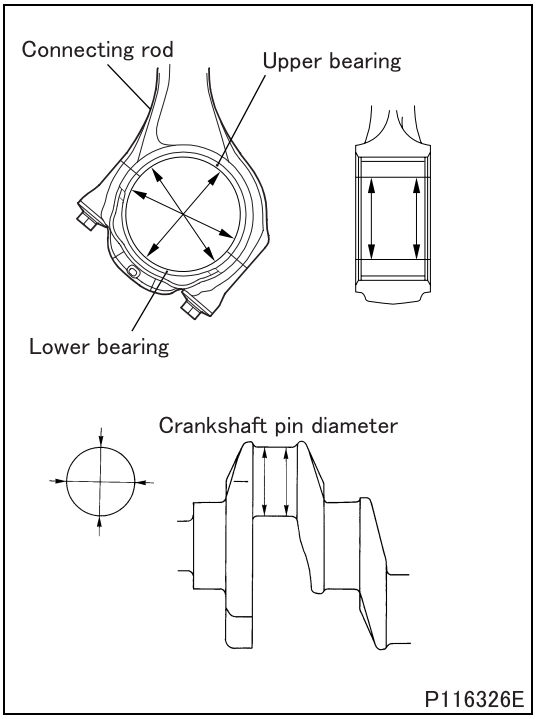
■ **Inspection: Connecting rod and bearing**

Standard value: A = 36.010 to 36.020 mm {1.417 to 1.418 in.}
B = 67.833 to 67.848 mm {2.670 to 2.671 in.}
C = 35.990 to 35.996 mm {1.416 to 1.417 in.}
D = 1.882 to 1.892 mm {0.074 to 0.0745 in.}
E = 1.878 to 1.888 mm {0.073 to 0.074 in.}

- If the measurement is out of the standard value, replace defective parts.
- Tighten the connecting rod cap bolt to a torque of 50 N·m {37 ft.lbs, 5.0 kgf·m} when measuring dimension B.

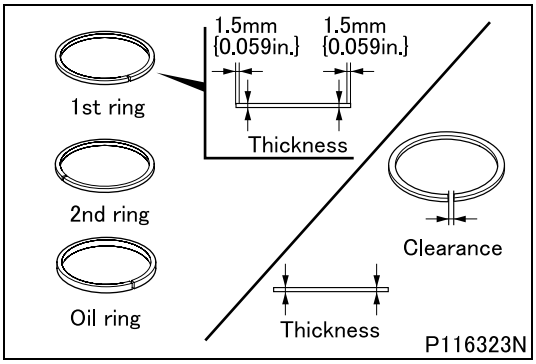
- Each connecting rod has its cap marked with the followings.
  - A number indicating the weight class of the connecting rod mounted in production.
  - A letter: O or X indicating the diameter class of the big end mounted in production.
- In addition, it could be stamped with the number of the cylinder in which it is fitted.
  In the event of replacement it is therefore necessary to number the new connecting rod with the same number as the one replaced.
- The numbering must be done on the opposite side to the bearing shell retaining slots.
  The connecting rods are supplied as spare parts with the diameter of the big end 67.833 to 67.848 mm {2.670 to 2.671 in.} marked with the letter O and the weight class marked with the number 33.
- It is not permissible to remove material.
- Connecting rods assembled on one engine must be of the same class and the same supplier.

- Check that the bushing in the small end has not come loose and shows no sign of seizure or scoring. If it does, replace the complete connecting rod.



■**Inspection: Clearance (oil clearance) between connecting rod bearing (big end) and crankshaft**

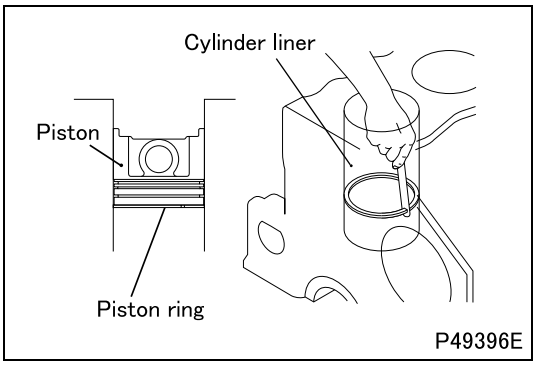
- Tighten the connecting rod cap bolt to a torque of 50 N·m {37 ft.lbs, 5.0 kgf·m} when measuring the clearance.
- For the measuring method and standard value of the crankshaft, see CRANKSHAFT AND CRANKCASE.
- Measure the inner diameter of the bearing and the outer diameter of the crankshaft pin to determine the oil clearance.
  Standard value: 0.035 to 0.083 mm {0.0014 to 0.0033 in.}
- If the measurement is out of the standard value, replace defective parts.



■**Inspection: Piston ring**

Standard value	1st ring	*Thickness	2.068 to 2.097 mm {0.081 to 0.083 in.}
		Clearance	0.20 to 0.35 mm {0.0079 to 0.014 in.}
	2nd ring	Thickness	1.970 to 1.990 mm {0.077 to 0.078 in.}
		Clearance	0.060 to 0.80 mm {0.024 to 0.031 in.}
	Oil ring	Thickness	2.470 to 2.495 mm {0.097 to 0.098 in.}
		Clearance	0.30 to 0.60 mm {0.012 to 0.024 in.}

- * Measure the 1st ring in the position shown in the drawing.
- If the measurement is out of the standard value, replace the piston ring.

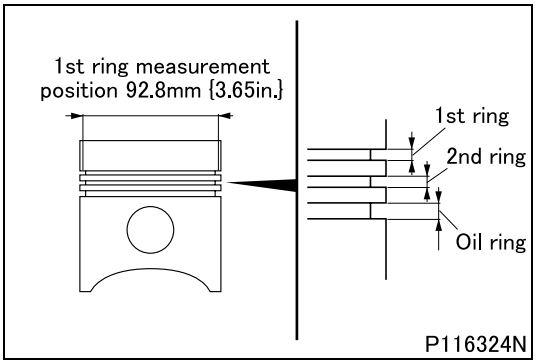


■**Inspection: Piston ring end gap**

- Using the piston head, insert the piston ring into the crankcase cylinder while keeping the ring level. The piston ring should be inserted to the lower part where cylinder wear is small.
- Measure the piston ring end gap while taking care not to allow the ring to move.

Standard value	*1st ring	0.103 to 0.162 mm {0.0041 to 0.0064 in.}
	2nd ring	0.060 to 0.100 mm {0.0024 to 0.0039 in.}
	Oil ring	0.045 to 0.090 mm {0.0018 to 0.0035 in.}

- If any of the measurements is out of the standard value, replace the piston rings as a set.

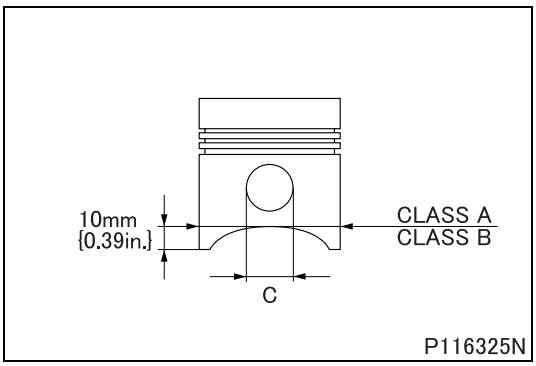


■**Inspection: Piston ring groove width**

- Remove carbon in the piston ring grooves before taking measurements.
- Take measurements at all around the piston ring groove circumferences.

Standard value	*1st ring	2.200 to 2.230 mm {0.087 to 0.088 in.}
	2nd ring	2.050 to 2.070 mm {0.0807 to 0.0815 in.}
	Oil ring	2.540 to 2.560 mm {0.100 to 0.101 in.}

- * Measure the 1st ring in the position shown in the drawing.
- If the measurement is out of the standard value, replace the piston.

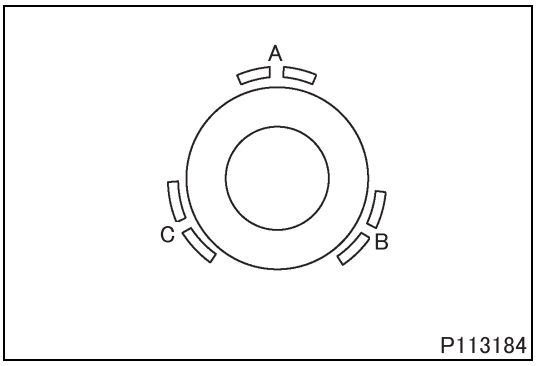


■**Inspection: Piston**

Standard value	CLASS A	95.705 to 95.715 mm {3.7679 to 3.7683 in.}
	CLASS B	95.715 to 95.725 mm {3.7683 to 3.7687 in.}
	C	36.003 to 36.009 mm {1.4174 to 1.4177 in.}

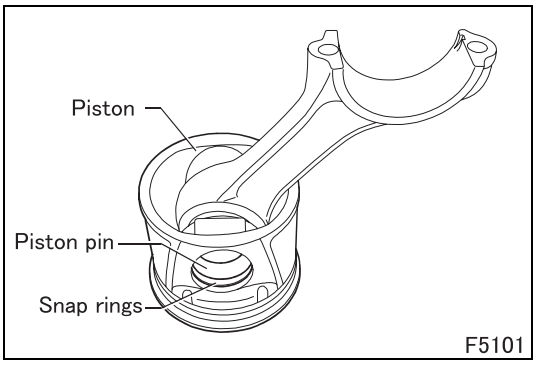
- If the measurement is out of the standard value, replace the piston.

◆Installation procedure◆

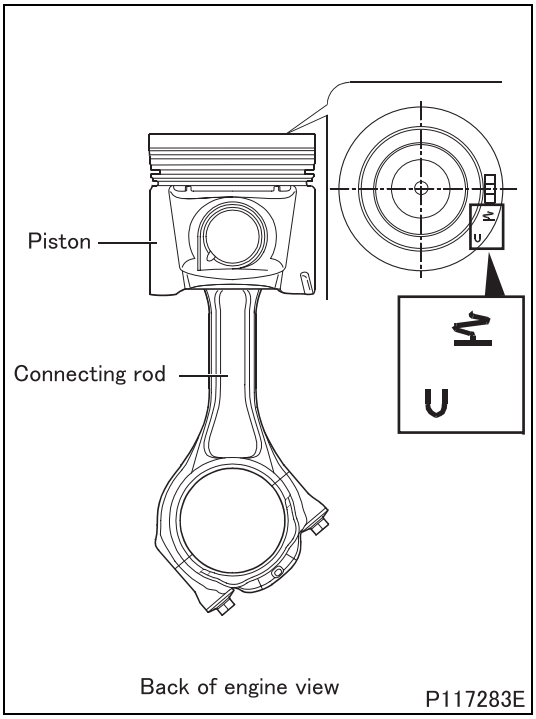


■**Installation: Piston and connecting rod**

- Apply engine oil to the piston rings and oil ring.
- Install the piston rings and oil ring so that the ring gaps are separated 120 degrees with each other.
- The oil ring gap and expander spring gap should be separated 180 degrees.

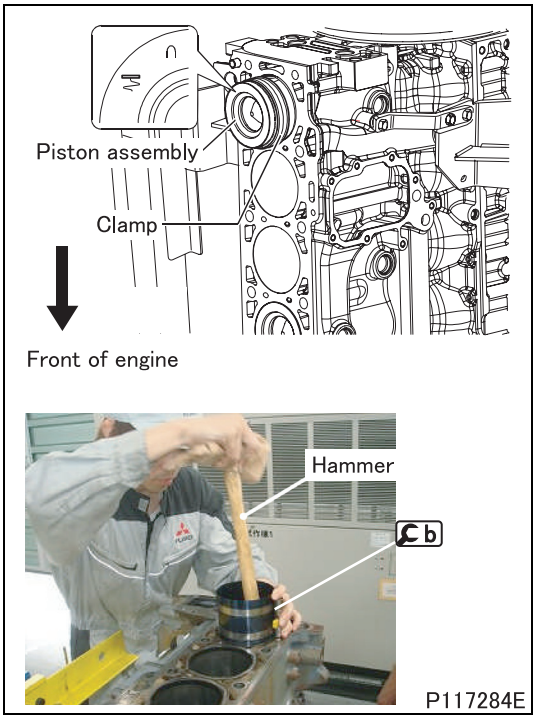


- Apply engine oil to the connecting rod and piston pin.
- Position the connecting rod on the piston, insert the piston pin and secure it with the snap rings.

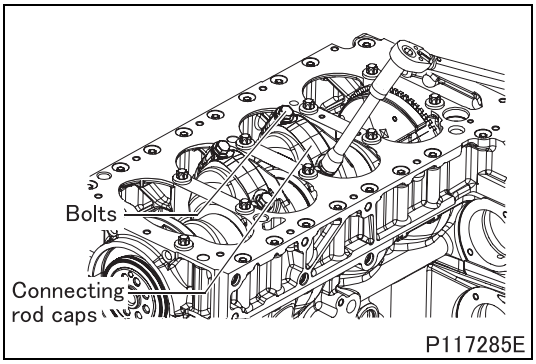


■ **Installation: Piston and connecting rod**

- Connect the piston to the connecting rod together with its cap so that the piston assembly reference, position of the connecting rod and of the cap are observed as shown in the figure.



- Lubricate the pistons well, including the piston rings and the inside of the cylinder block.
  With the aid of b, fit the connecting rod – piston assembly in the cylinder block, checking that:
  - The number of each connecting rod corresponds to the cap mating number.
  - The openings of the piston rings are staggered 120° apart.
  - The pistons are all of the same weight.
  - The symbol punched on the top of the pistons faces the engine flywheel, or the recess in the skirt of the pistons tallies with the oil spray nozzles.
- If connecting rod bearings are reused, you need to fit them back in exactly the same sequence and position found on disassembly.

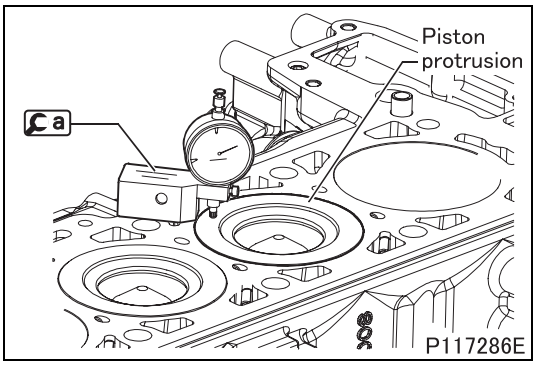


- Install the connecting rod caps with the associated bearing shells.
- The connecting rod cap fixing bolts must always be replaced for permanent assembly.

- Tighten the bolts in two steps.
  Step 1: With a torque wrench, to a torque of 50 N·m {37 ft.lbs, 5.1 kgf·m}.
  Step 2: Closing to an angle of 70°

- Manually check the connecting rod end play to ensure that the connecting rods slide axially on the pins of the crankshaft.

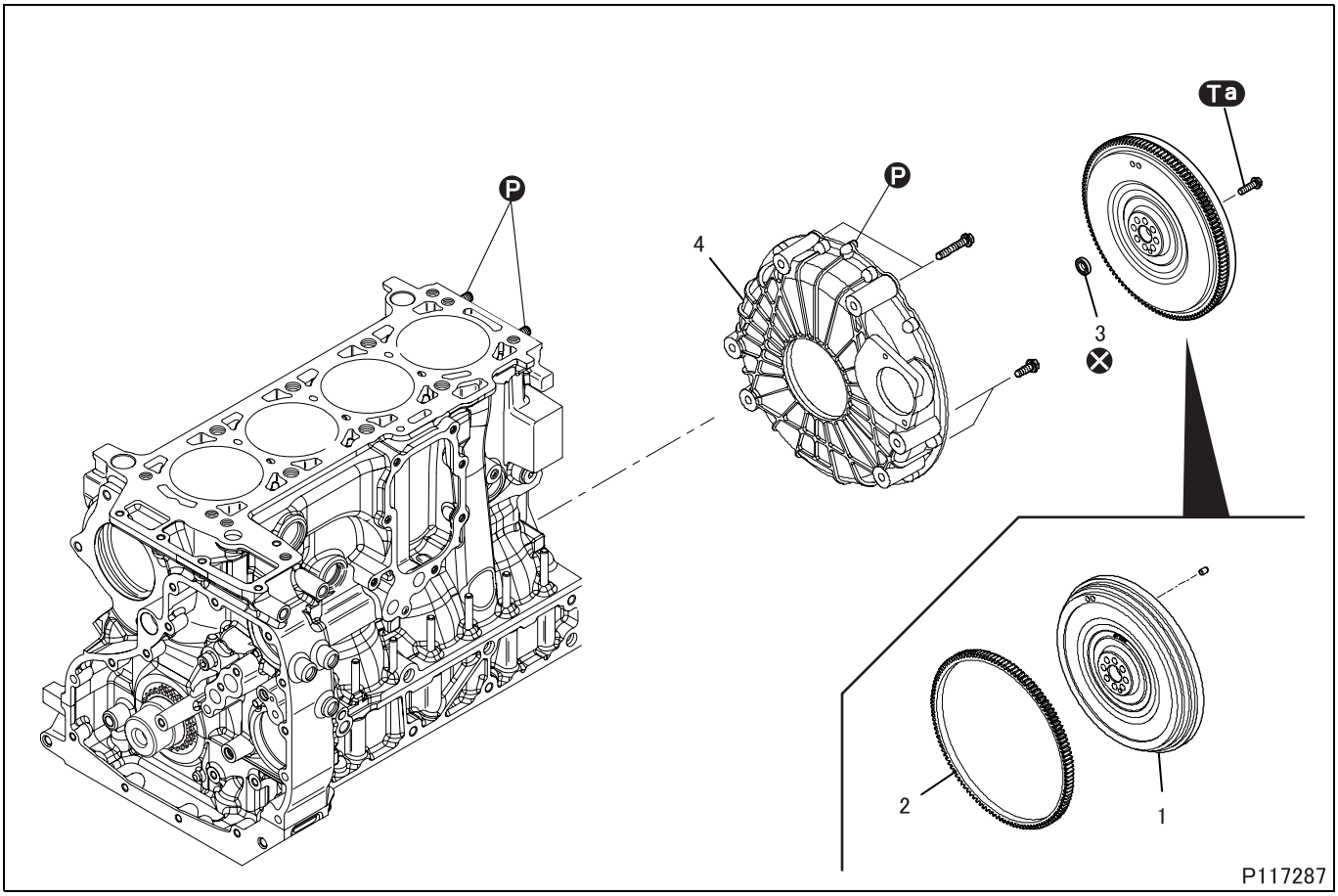
◆Work after installation◆



■ Inspection: Piston and connecting rod

- Compare the protrusion of piston at its top dead center with the cylinder block top surface using a.
- Measure the piston protrusion at the top dead center for all pistons.
- The difference between the minimum and maximum protrusions of the four pistons must be ≤ 0.15 mm {0.0059 in.}.

FLYWHEEL



● **Disassembly sequence**

1 Flywheel
2 Ring gear
3 Bearing
4 Flywheel housing

Ⓟ: Locating pin

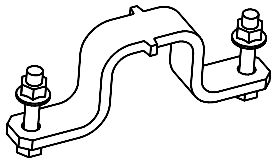
● **Assembly sequence**

Follow the disassembly sequence in reverse.

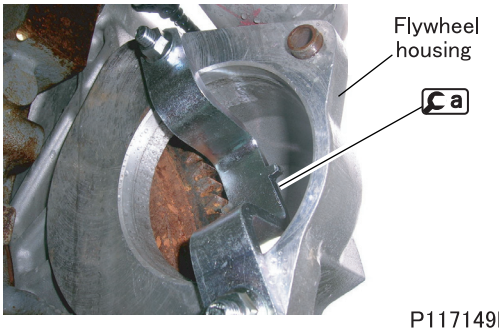
Tightening torques (Unit: N·m {ft.lbs, kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (flywheel housing mounting)	30 {22, 3.0} + 90°	–

Special tools

Mark	Tool name and shape	Part No.	Application
a	Flywheel, retainer  P116334	MH064205	Block rotation of the flywheel

◆Removal procedure◆

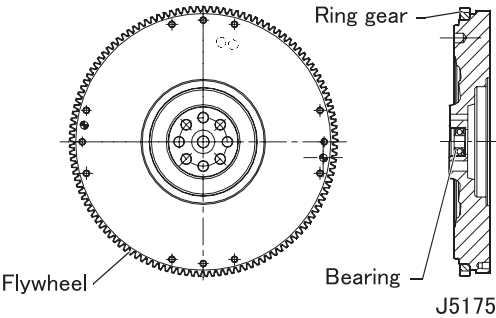


P117149E

■ **Removal: Engine flywheel**

- Set a on the starter mount of the flywheel housing to prevent the flywheel from rotating.
- Loosen the bolts to remove the flywheel housing and flywheel.
- After removing the flywheel, check the inside of the flywheel housing for contamination. Clean the inside if it is dirty.

◆Inspection procedure◆



J5175E

■ **Inspection: Engine flywheel**

(1) Visual check

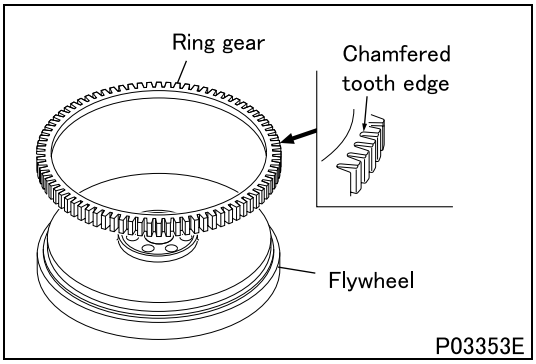
- Check the clutch disc mating surface, if there are too many scratches, change the engine flywheel.

Replacing the ring gear
[Removal]

- Heat the ring gear evenly to a temperature of 200°C {392°F} using a gas burner or the like and remove it from the flywheel.

WARNING ⚠

- **Never touch heated areas to avoid burns.**



[Installation]

- Heat the ring gear evenly to a temperature of 200°C {392°F} using a gas burner or the like.

WARNING ⚠

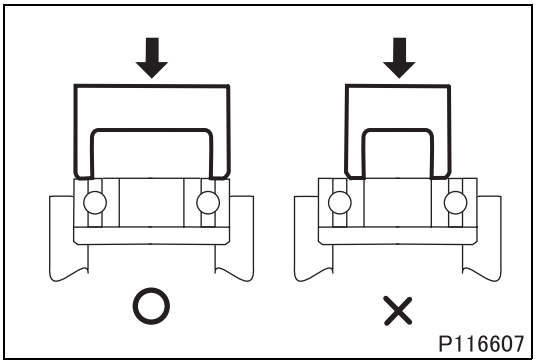
- **Never touch heated areas to avoid burns.**

- Fit the ring gear with the side having non-chamfered teeth edges side facing the flywheel.

(2) Bearing

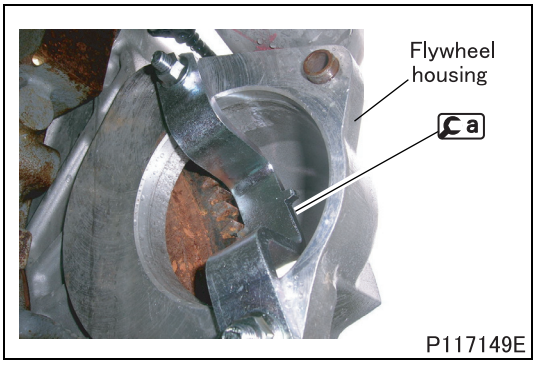
- Replace the bearing if damage, wear or poor rotation is observed.

◆Installation procedure◆



■ Installation: Bearing

- Install the bearing by setting the jig in the position shown in the drawing.

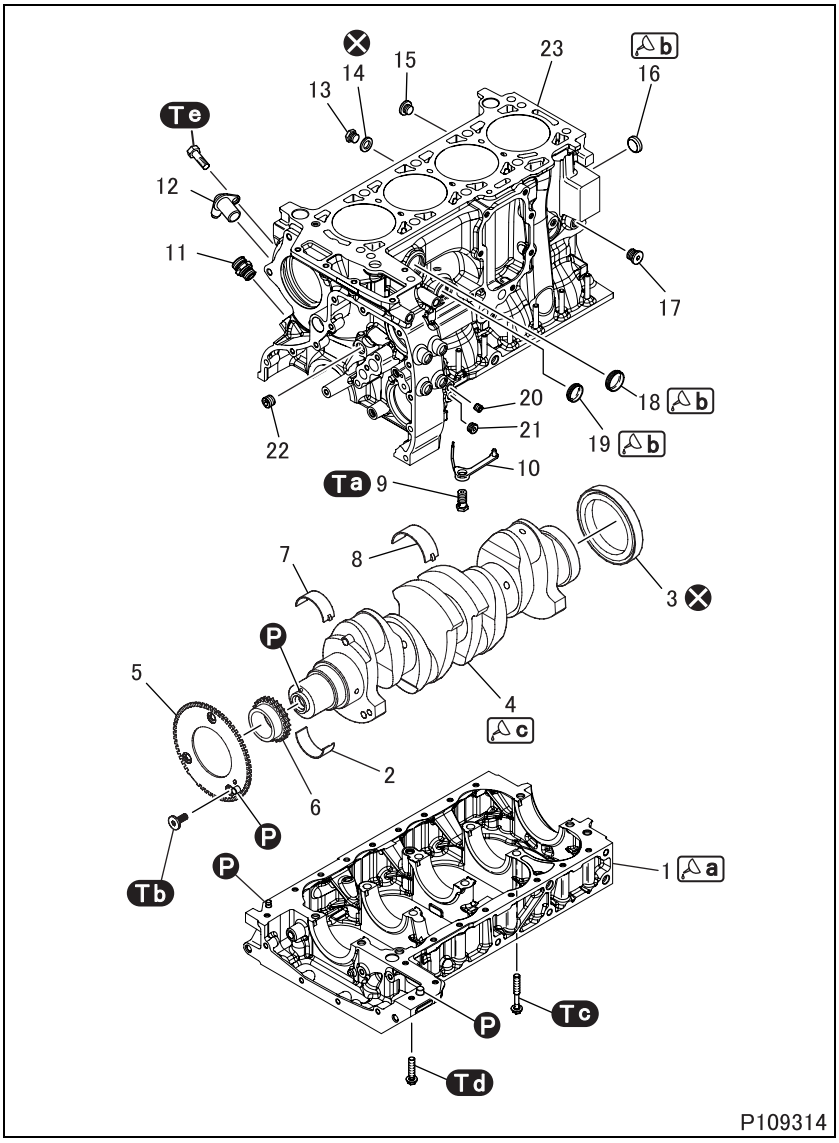


■ Installation: Engine flywheel

- Set b on the starter mount of the flywheel housing to prevent the flywheel from rotating.
- Install the flywheel housing.

- Tighten the bolts fixing the flywheel in two steps.
  Step 1: With a torque wrench, to a torque of 30 N·m {22 ft.lbs, 3.1 kgf·m}.
  Step 2: Closing to an angle of 90°.

M E M O



● **Removal sequence**

1 Lower crankcase
2 Lower main bearing
3 Rear oil seal
4 Crankshaft
5 Phonic wheel
6 Timing control gear
7 Upper main bearing
8 Central half-bearing
9 Eyebolt
10 Oil jet
11 Taper plug (diam = 1/8”)
12 Engine speed sensor
13 Taper plug (M14 × 1.5)
14 Seal gasket
15 Taper plug (M10 × 1.5)
16 Lock plug (ϕ25 mm {0.98 in.})
17 Taper plug (M14 × 1.5)
18 Lock plug (ϕ32 mm {1.26 in.})
19 Lock plug (ϕ28 mm {1.10 in.})
20 Taper plug (diam = 1/8”)
21 Taper plug (M14 × 1.5)
22 Taper plug (diam = 3/8”)
23 Upper crankcase

Ⓟ: Locating pin
⊗: Non-reusable parts

● **Installation sequence**

Follow the removal sequence in reverse, except the following sequence.
4→2→1→3

Service standards (Unit: mm {in.})

Location	Maintenance item		Standard value	Limit	Remedy
–	Crankshaft end play		0.010 to 0.210 {0.00039 to 0.083}	–	Rectify or replace
1, 23	Inside diameter of main bearing housing	No. 1, 2, 3, 4	80.588 to 80.614 {3.1727 to 3.1738}	–	Replace
		No. 5	87.588 to 87.614 {3.4483 to 3.4494}	–	
	Main bearing housing width for shoulder		27.290 to 27.340 {1.074 to 1.076}	–	Replace
2, 7	Main bearing shell thickness		2.165 to 2.174 {0.0852 to 0.0855}	–	Replace
	Bearing shells to main journals clearance		0.032 to 0.102 {0.0013 to 0.0040}		
4	Main journal width for shoulder		32.500 to 32.550 {1.280 to 1.281}	–	Replace

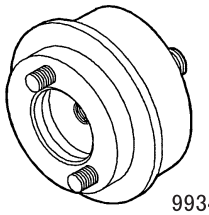
Tightening torque (Unit: N·m {ft.lbs, kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Eyebolt (oil jet mounting)	25 {18, 2.5}	–
Tb	Bolt (phonic wheel mounting)	10 ± 1 {7.4 ± 0.1, 1.0 ± 0.1}	–
Tc	Bolt (crankcase base mounting)	50 {37, 5.0} + 60° + 60°	–
Td	Bolt (crankcase base mounting)	26 {19, 2.6}	–
Te	Bolt (engine speed sensor mounting)	10 {7.4, 0.1}	–

Lubricant and/or sealant

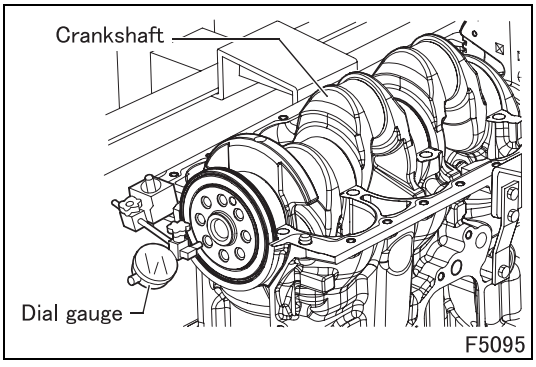
Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Crankcase mounting surface of crankcase base	Loctite 510	As required
b	Lock plug	Loctite 263	As required
c	Rear shank of the crankshaft	Engine oil	As required

Special tools

Mark	Tool name and shape	Part No.	Application
Ca	Rear oil seal installer  99346259	MH063963	Installation of rear oil seal

Bearing shells to main journals clearance is 0.032 to 0.102 mm {0.0013 to 0.0040 in.}.

◆Work before disassembly◆



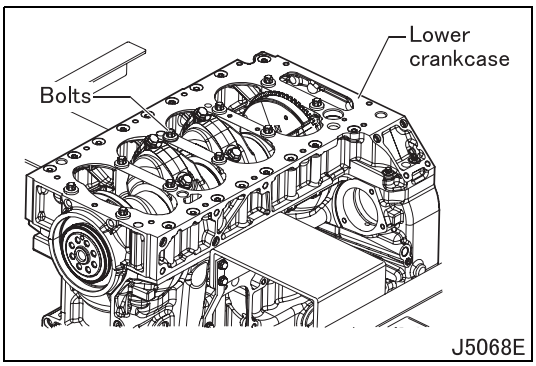
■ Crankshaft end play

- With the crankshaft installed, check the following item.
- The end play is checked by setting a dial gauge with a magnetic base on the crankshaft as shown in the figure. The normal assembly clearance is 0.010 to 0.210 mm {0.00039 to 0.0083 in.}.
- If you find the clearance to be greater than as required, replace the central half-bearing shells carrying the thrust bearings and repeat the clearance check between the crankshaft pins and the main bearing shells. Bearing shells to main journals clearance is 0.032 to 0.102 mm {0.0013 to 0.0040 in.}.
- If the end play of the crankshaft does not come within the prescribed values, it is necessary to grind the crankshaft and accordingly change the main bearing shells.

NOTE

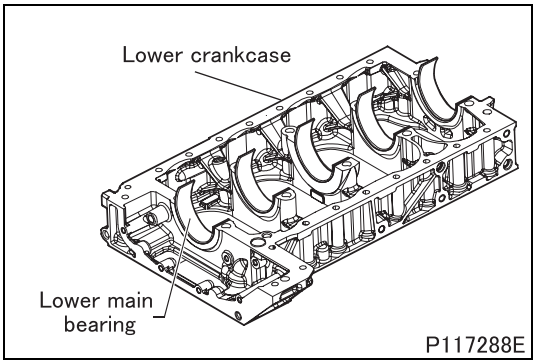
- **The central half-bearing has half thrust washers integrated in it, so it performs the function of a thrust bearing. It is supplied as a spare part only with the normal shoulder thickness.**

◆Removal procedure◆



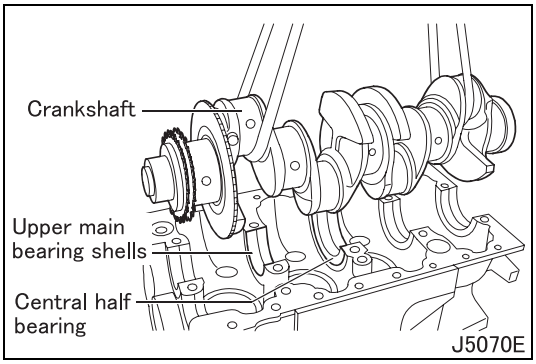
■ **Removal: Lower crankcase**

- Remove the bolts and take off the crankcase.



■ **Removal: Lower main bearing**

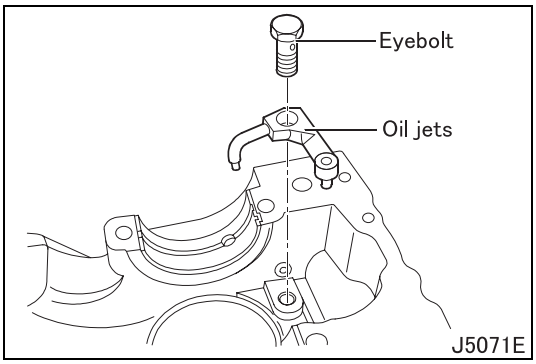
- If the lower main bearing is reused, make a note of its assembly position since it needs to be installed in the original position before removal.



■ **Removal: Crankshaft, upper main bearing, central half-bearing**

- With the aid of a hoist and a rope, remove the crankshaft.
- Note the assembly position of the top main bearing shells since, if they are reused, they will need to be fitted in the position found during removal.

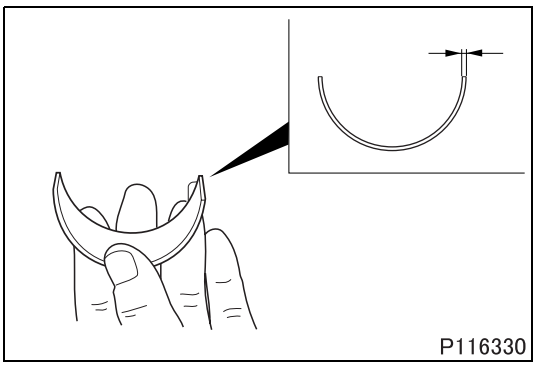
- The central half-bearing is fitted with shoulder half-rings.



■ **Removal: Oil jet**

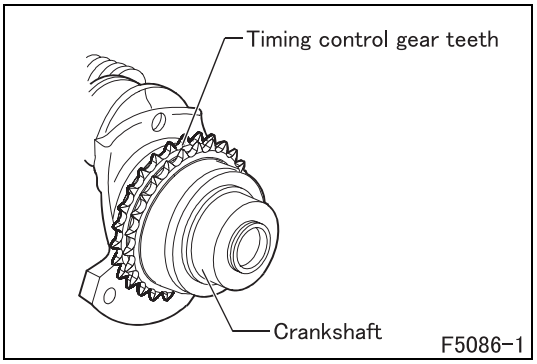
- Take out the eyebolts and remove the oil jets.

◆Inspection procedure◆



■Main bearing thickness

- If the measurement is out of the standard value, replace the main bearing.
  Standard value: 2.165 to 2.174 mm {0.0852 to 0.0855 in.}



■ Inspection: Timing control gear

- On finding the timing control gear teeth damaged or worn, remove them from the crankshaft using a suitable extractor.

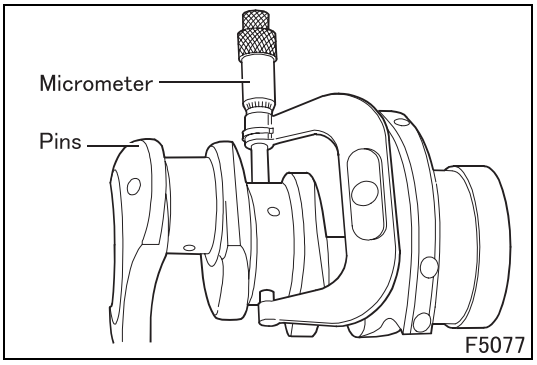
Replacement of timing control gear
[Installation]

- The new gear is fitted onto the crankshaft by heating it to a temperature of 180°C {356°F}.

WARNING ⚠

- **Never touch heated areas to avoid burns.**

- On completing assembly and after the gear has cooled, it must withstand a torque of 150 N·m {110 ft.lbs, 15 kgf·m} without slipping.



■ Inspection: Crankshaft

- When inspecting the main journals and crankpins, if any signs of seizure or scoring are found, or if they are found to be excessively out of round, it is necessary to regrind the pins. Before grinding the pins, measure the shaft pins with a micrometer to establish to what diameter it is necessary to decrease the pins.

NOTE

- **It is advisable to enter the measurements in a table.**

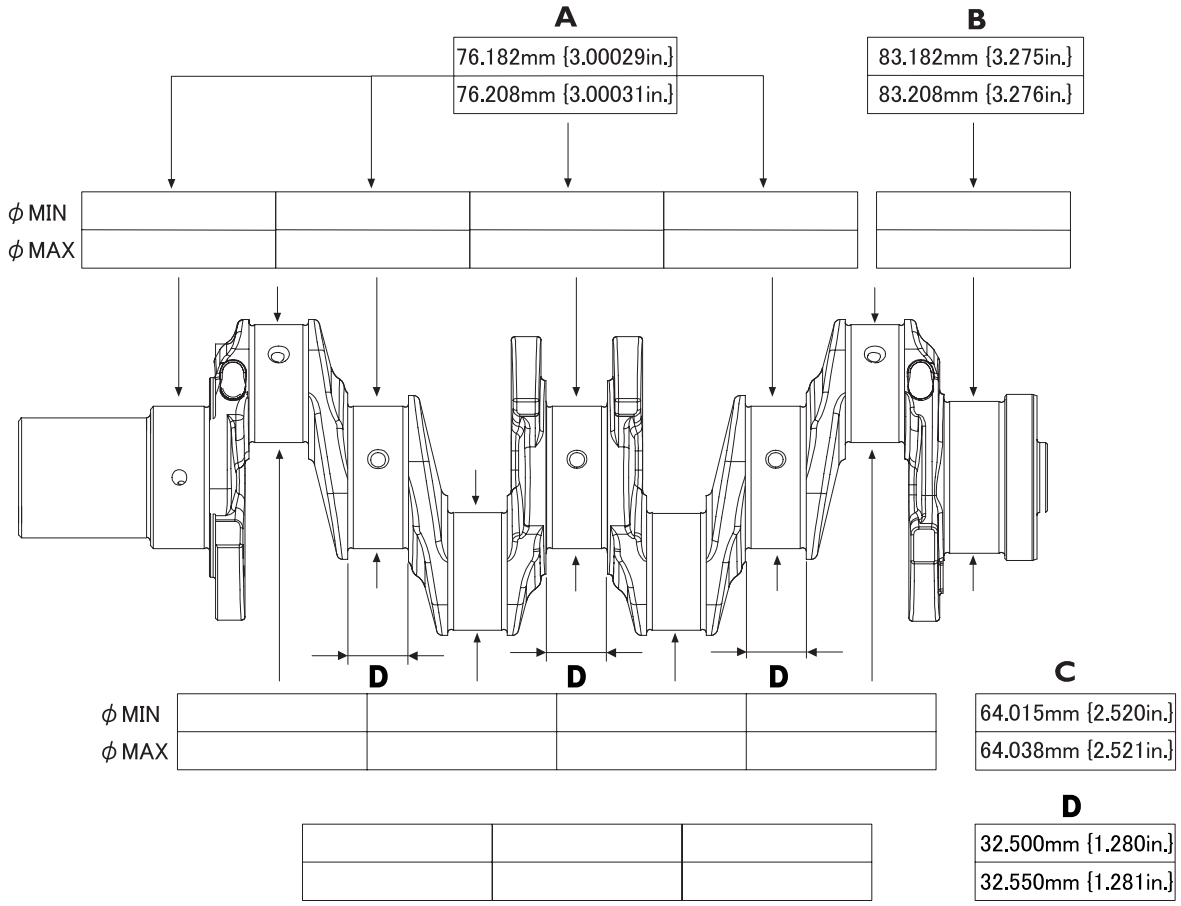


TABLE IN WHICH TO ENTER THE MEASUREMENTS OF THE CRANKSHAFT MAIN JORNALS AND CRANKPINS

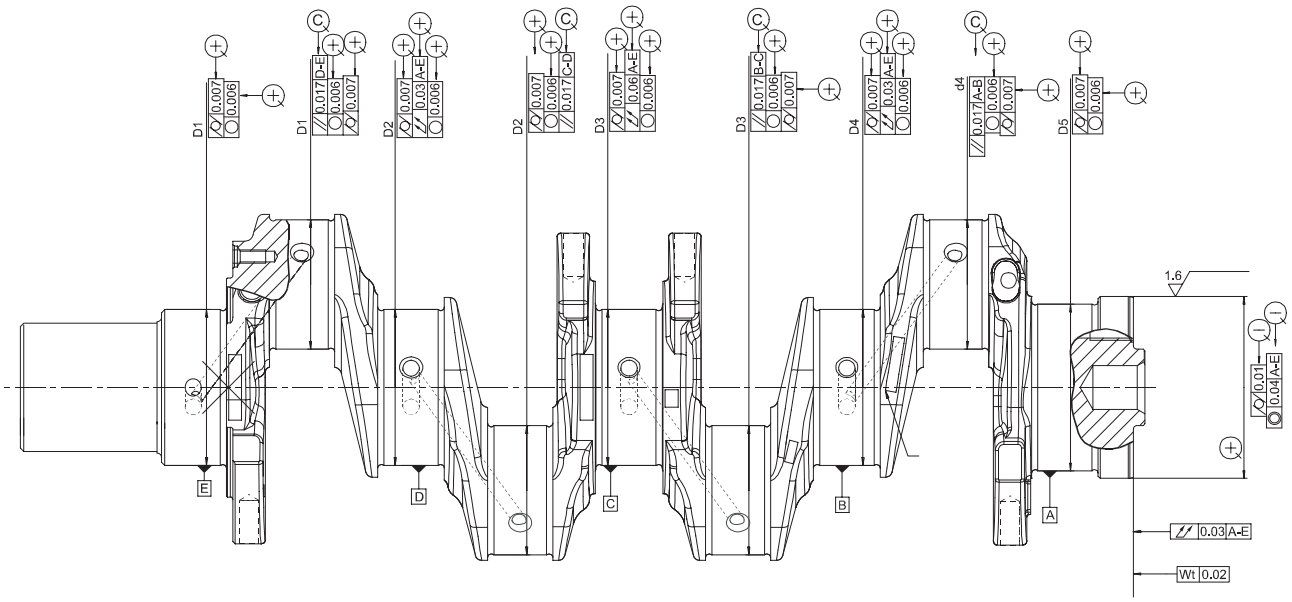
A, B, C=NOMINAL VALUE

N5078

- The main journals and crankpins must always be ground to the same undersize class.
- The undersizing performed, on the main journals or crankpins, must be marked by punching on the side of crank arm number. 1.
  - For undersized crankpins, letter M.
  - For undersized main journals, letter B.
  - For undersized crankpins and main journals, letter MB.
- The undersize classes are: 0.254 to 0.508 mm {0.0100 to 0.020 in.}.

[Correction]

- When correcting, keep the following dimension.

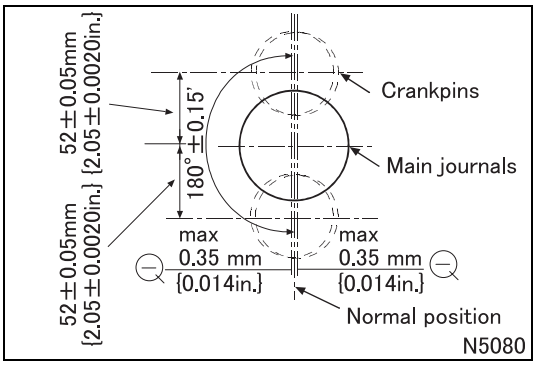


MAIN CRANKSHAFT TOLERANCES

TOLERANCES	TOLERANCE CHARACTERISTIC	GRAPHIC SYMBOL
SHAPE	Circularity	○
	Cylindricality	⌭
ORIENTATION	Parallelism	//
	Perpendicularity	⊥
POSITION	Concentricity or coaxiality	◎
OSCILLATION	Circular oscillation	↗
	Total oscillation	↗↗

CLASS OF IMPORTANCE ATTRIBUTED TO PRODUCT CHARACTERISTICS	GRAPHIC SYMBOL
CRITICAL	Ⓒ
IMPORTANT	⊕
SECONDARY	⊖

F5079



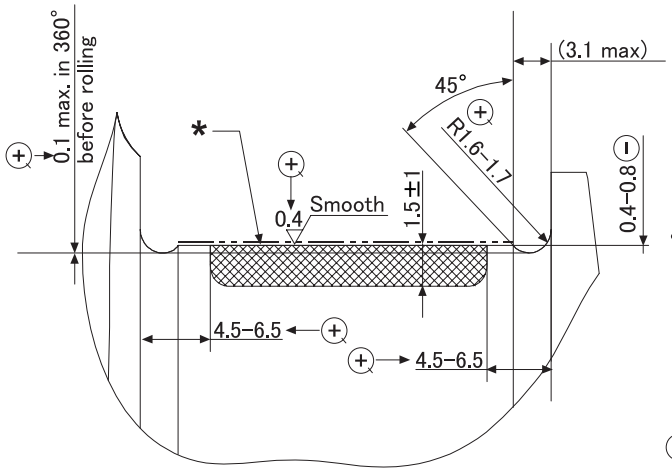
N5080

NOTE

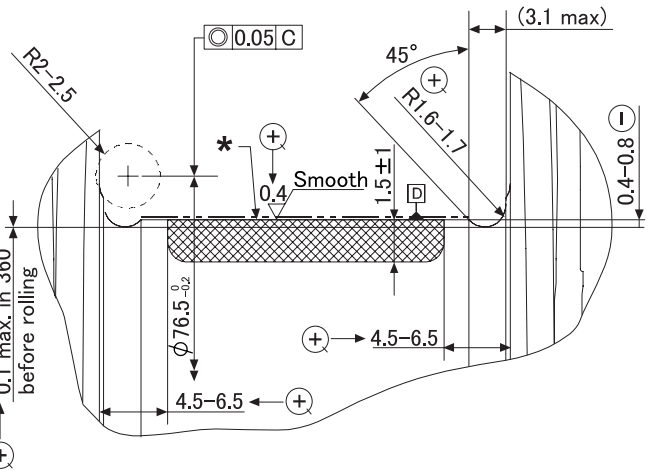
- **The checks on the tolerances indicated in the figures must be made after grinding the crankshaft pins.**

- Symmetry between main journals and crankpins
- After grinding, keep to the following.
  - Round off the edges of deburring the holes for lubrication of the main journals and crankpins.

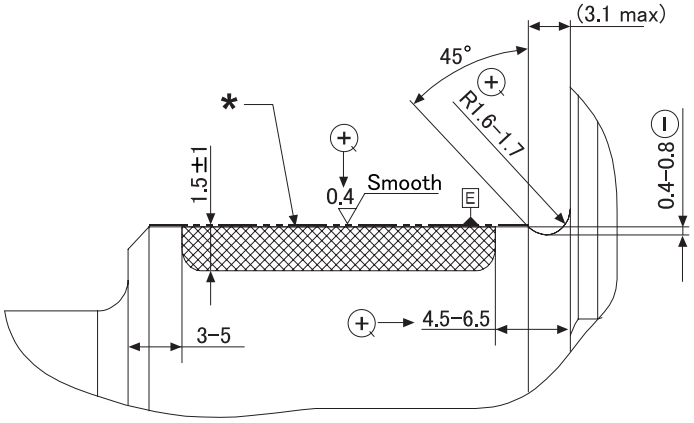
INTERMEDIATE JOURNALS No.2-4



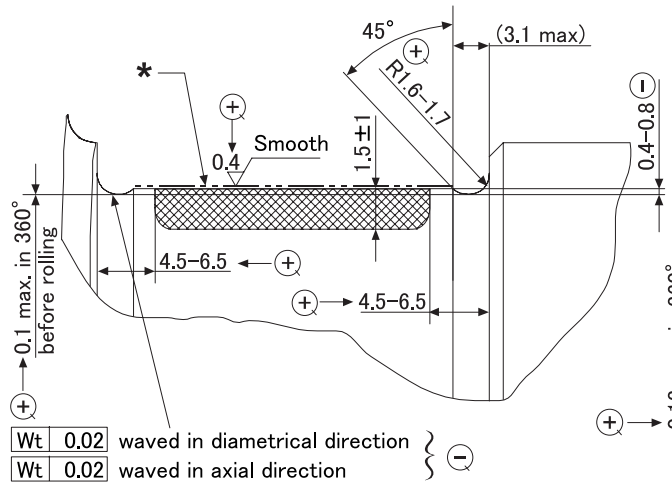
INTERMEDIATE JOURNALS No.3



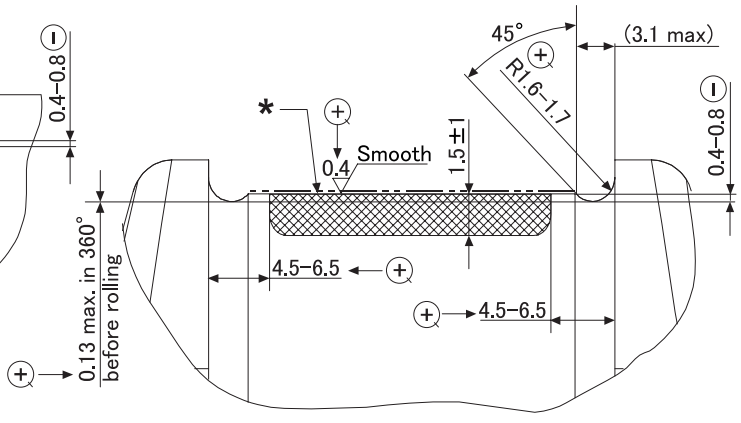
JOURNAL ON TIMING SYSTEM SIDE



JOURNAL ON FLYWHEEL SIDE



CRANKPINS



Wt 0.02 waved in diametrical direction
Wt 0.02 waved in axial direction
OGEE ZONE MADE BY ALL PIVOTS OF BED
(Process using lathe.)

F5082

NOTE

- **Since, during the 0.254 and 0.508 mm {0.0100 to 0.020 in.} under sizing on the diameter of the crankpins and main journals, the rolled portion of the side races of the pins may get involved, it is necessary to turn the races keeping to the data given in the figure and to do the rolling keeping to the following instructions.**

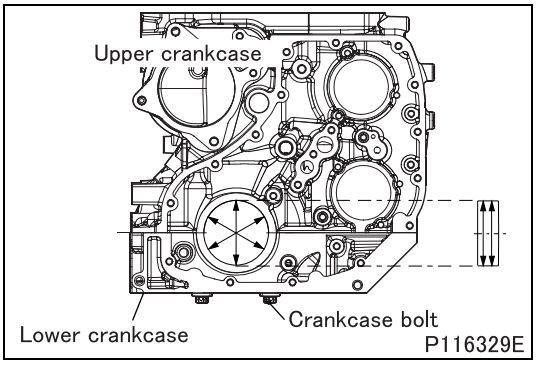
- Rolling force:
  - 1st main journal: 925 ± 25 daN.
  - 2nd - 3rd - 4th - 5th main journal: 1850 ± 50 daN.
  - Crankpin: 1850 ± 50 daN.
- Rolling turns: 3 approach, 12 effective, 3 out.
- Rolling speed: 56 rpm.
- Reduction of the connecting rod pin slot diameter after rolling: 0.15 to 0.30 mm {0.0059 to 0.012 in.}*.
- Reduction of the journal slots after rolling: 0.15 to 0.30 mm {0.0059 to 0.012 in.}*.

* Measured with calibrated rollers ϕ2.5 mm {0.098 in.}.

■ Inspection: Crankcase

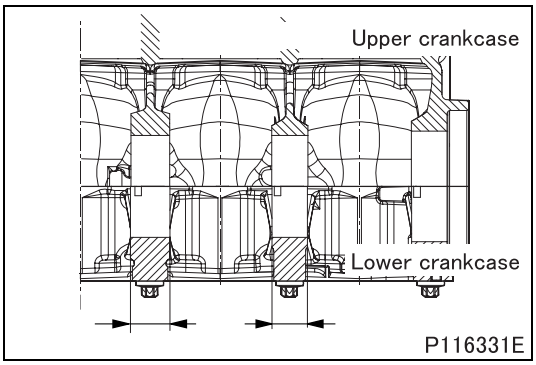
(1) Visual inspection of crankcase

- Once the engine removal is complete, carefully clean the crankcase.
- For the crankcase transportation use the suitable rings.
- Carefully check that the crankcase has no cracks in it.
- Check the state of the plugs. If they are rusty or there is any doubt about their seal, replace them. When fitting the caps into place, apply Loctite 270 sealant to the same.



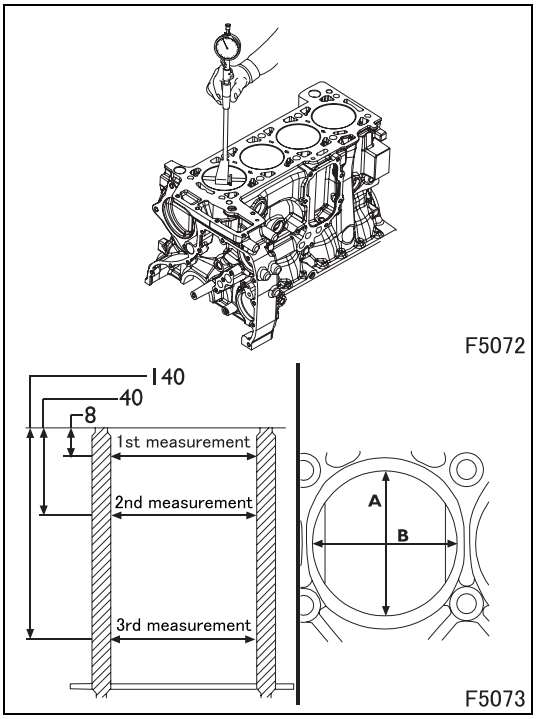
(2) Inner diameter of crankcase

- Install the lower crankcase on the upper crankcase, and then tighten the crankcase bolts to a torque of 50 N·m {37 ft.lbs, 5.1 kgf·m}.
- Measure the inner diameter of the crankcase.
  Standard value
  No.1, 2, 3, 4: 80.588 to 80.614 mm {3.1727 to 3.1738 in.}
  No.5: 87.588 to 87.614 mm {3.4483 to 3.4494 in.}
- If the measurement is out of the standard value, replace defective parts.



(3) Main bearing width of crankcase

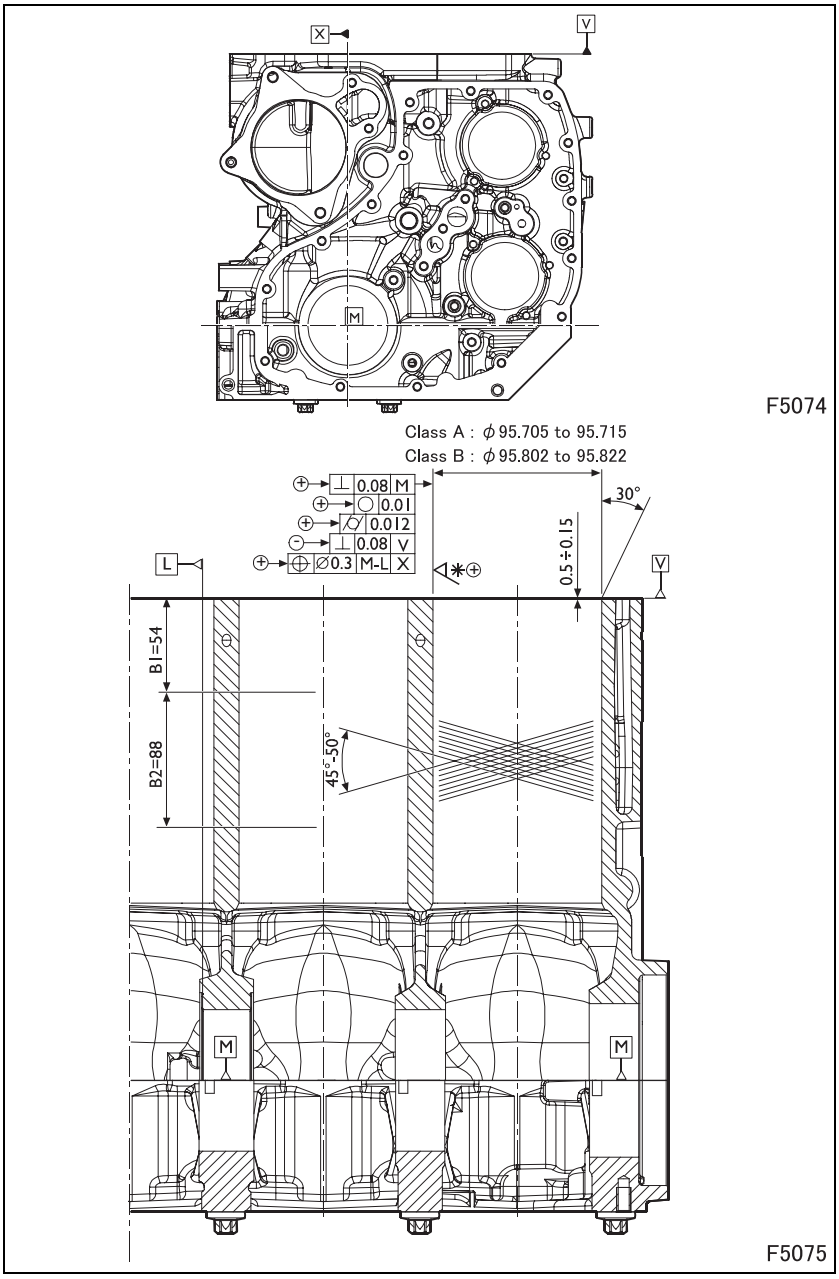
- If the measurement out of the standard value, replace the crankcase.
  Standard value: 27.290 to 27.340 mm {1.074 to 1.076 in.}



(4) Cylinder bore

[Inspection]

- Examine the surfaces of the cylinder bores; they must show no sign of meshing, scoring, out of roundness of the bores, taper or excessive wear.
- The inside diameter of the cylinder bores is checked, to ascertain the extent of out of roundness of the bores, taper and wear, using the bore meter fitted with a dial gauge previously reset on the ring gauge of the diameter of the cylinder bore or on a micrometer.
- The measurements must be made for each single cylinder at three different heights up the liner and on two planes at right angles to each other: one parallel to the longitudinal axis of the engine (B) and the perpendicular (A); the greatest wear is generally found on this last plane with the first measurement.
- On finding out of roundness of the bores, taper or wear, go ahead and bore/grind and finish the face of the cylinder bores. The refacing of the cylinder liners should be done in relation to the diameter of the pistons supplied as spare parts oversized by 0.4 mm {0.016 in.} of the nominal value and to the prescribed assembly clearance.



[Correction]

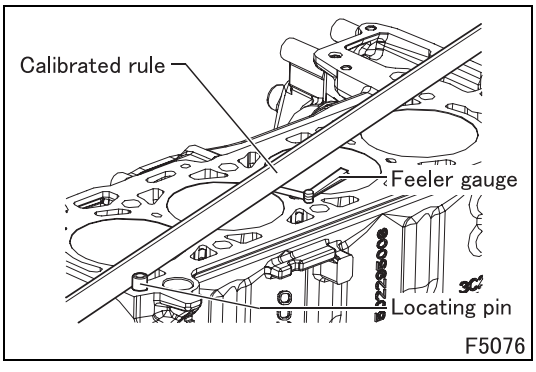
- When correcting, keep the following dimension.
  * Surface roughness parameters:
- Permissible surface porosity for machined cylinder
  - R1 = 4 to 10 µm
  - Rz = 3 to 8 µm
  - Ra = 0.25 to 0.6 µm
  - W1 ≤ 1.5 µm

ZONE B1

- Area of greatest mechanical stress, segment/liner contact: No.2 non-continuous porosities are permissible max. 0.5 × 0.5.

ZONE B2

- Surface involved in segment rubbing: No.2 non-continuous porosities are permissible max. 1 × 0.8.



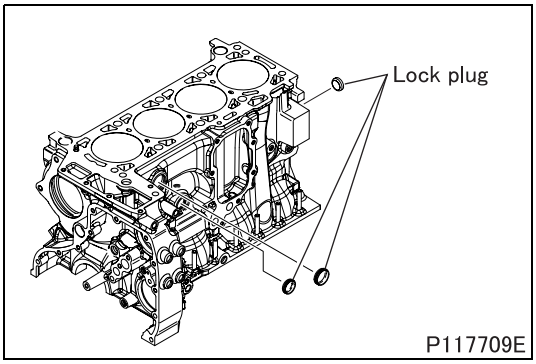
(5) Cylinder head mating surface

- See that the head mating surface, on the crankcase, has no deformation.
- This check can be made, after taking out the locating pin, with a surface plate spread with carbon black or with a calibrated rule and a feeler gauge. After ascertaining the areas of deformation, level the bearing surface with a grinding machine.

NOTE

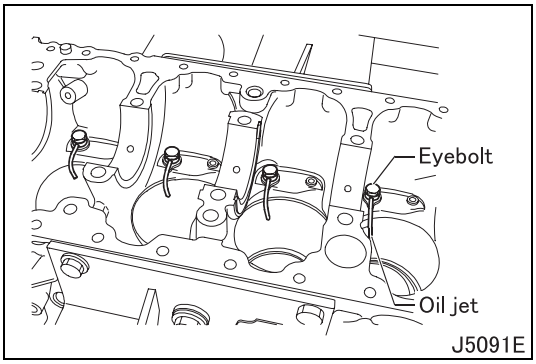
- **The crankcase can only be surfaced after making sure that, on completing the work, the piston protrudes from the cylinder liner by no more than the prescribed value.**

◆Installation procedure◆



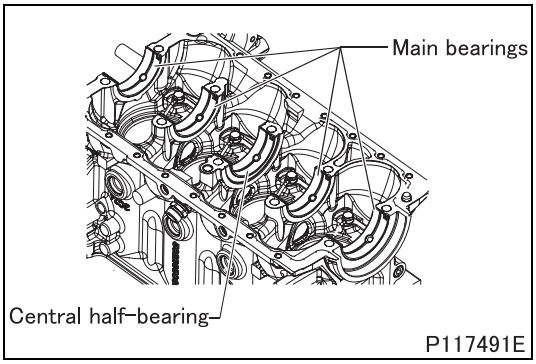
■ **Installation: Lock plug**

- Clean the lock plug mounting surface on the upper crankcase.
- Apply sealant to the lock plug. (Loctite 263)
- Install the lock plug on the upper crankcase.



■ **Installation: Oil jet**

- Replace the eyebolt with a new one.
- Fit on the oil jet and tighten the eyebolt to the prescribed torque 25 N·m {18 ft.lbs, 2.5 kgf·m}.



■ **Installation: Main bearing, central half-bearing**

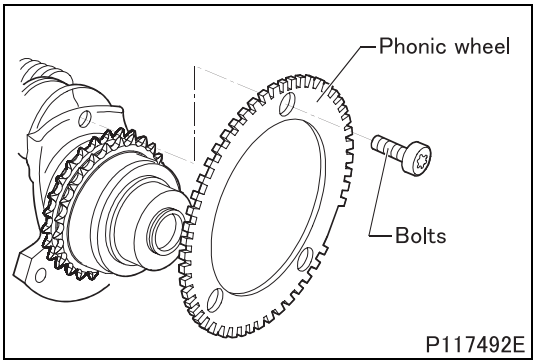
- The main bearings are supplied as spare parts undersized on the inside diameter by 0.254 to 0.508 mm {0.0100 to 0.020 in.}.
- If the main bearings are reused, they need to be fitted back on in the same sequence and position found upon disassembly.
- Thoroughly clean the top main bearing shells and position them in the crankcase.

NOTE

- **The central half-bearing is fitted with thrust washers.**

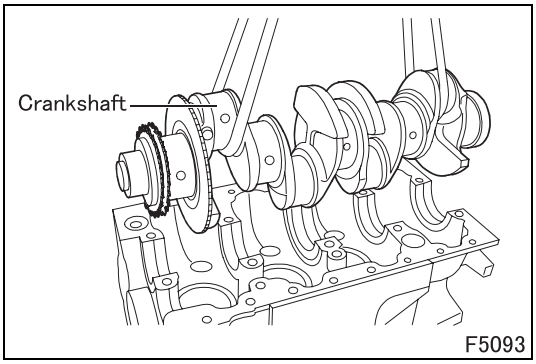
NOTE

- **Do not do any altering of the bearings.**



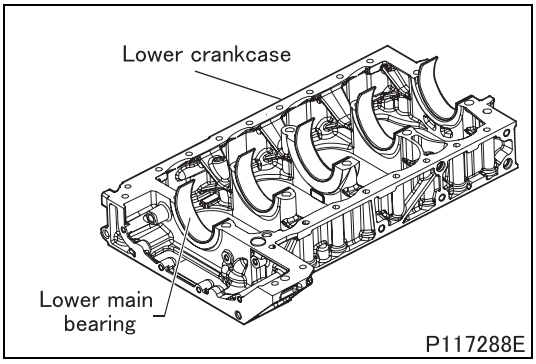
■ **Installation: Phonic wheel**

- Install the phonic wheel.
- Install the bolts and tighten them to the prescribed torque: 10 ± 1 N·m {7.4 ± 0.1 ft.lbs, 1.0 ± 0.1 kgf·m}.



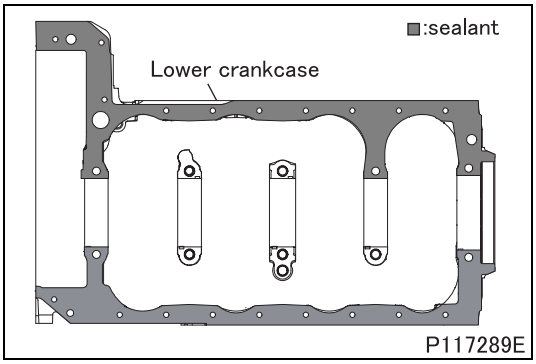
■ **Installation: Crankshaft**

- Install the crankshaft.



■ **Installation: Main bearing shell**

- Thoroughly clean the bottom main bearing shells and mount them in the lower crankcase.

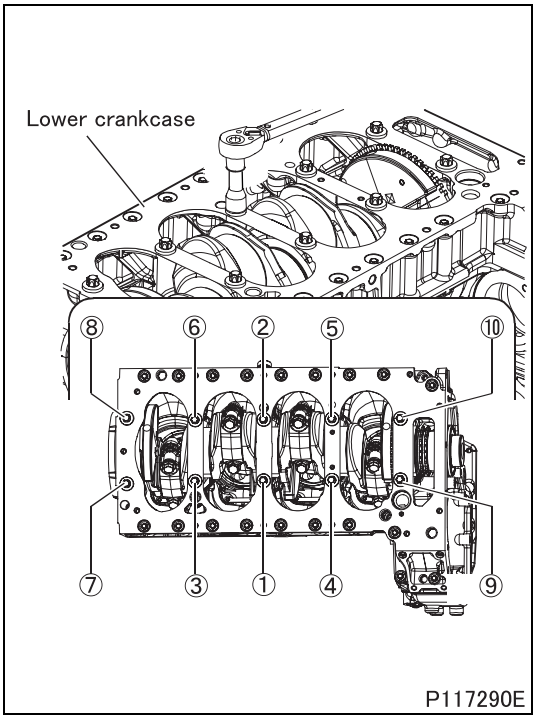


■ **Installation: Crankcase base**

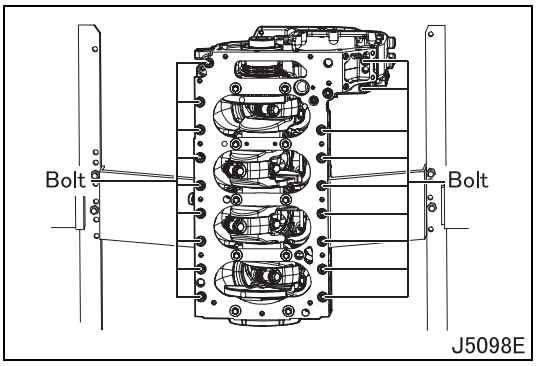
- Thoroughly clean the crankcase/crankcase base mating surface.
- Apply, on base, sealant Loctite 510 as indicated in the scheme. The sealant must be applied evenly.

NOTE

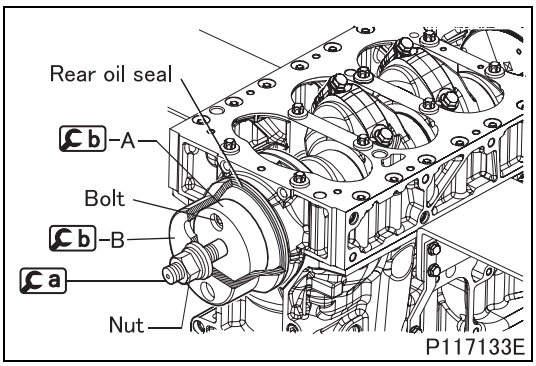
- **Mount the crankcase base within 10 minutes of applying the sealant.**



- Mount the lower crankcase and tighten the fixing screws in three stages, following the sequence shown in the figure.
  Step 1: With a torque wrench, to a torque of 50 N·m {37 ft.lbs, 5.1 kgf·m}.
  Step 2: Tighten to an angle of 60°.
  Step 3: Tighten to an angle of 60°.



- Then tighten the outer bolts to a torque of 26 N·m {19 ft.lbs, 2.7 kgf·m}.



■ **Installation: Rear oil seal**

- Clean the mating surface of the rear oil seal.
- Apply engine oil to the rear of the crankshaft.
- Install part of b -A on the rear of the crankshaft, secure it with the bolt and install a new rear oil seal over it.
  Place b -A over b -B, screw in the nut and install the rear oil seal on the seat of the upper crankcase.