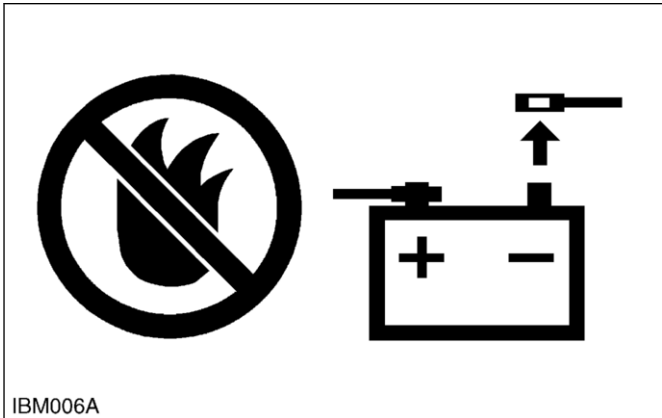


- Lock the covers before starting the machine.
- Keep away from rotating and moving objects.
- Keep tools and waste cloth away from rotating and moving objects.

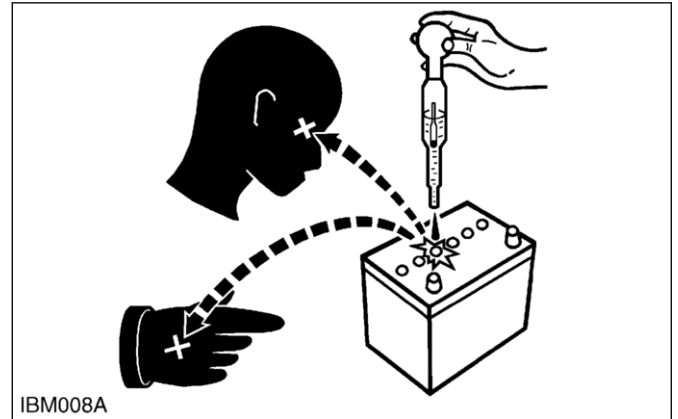
5. Preventing fires



- Keep fire (welding sparks, grinding sparks, cigarettes) away from the fuel.
- Wipe the fuel off when spilled.
- Keep fire (welding sparks, grinding sparks, cigarettes) away from the battery. The battery produces oxygen and hydrogen gas that are flammable.
- Disconnect the negative (-) terminal first when disconnecting the battery cable.

- Connect the positive (+) terminal first when connecting the battery cable.
- Do not short circuit the machine.
- Do not splash the hydraulic oil on the exhaust components.

6. Preventing acid burns



- Keep the electrolyte away from your eyes, hands, and clothes. Sulfuric acid in the battery electrolyte is poisonous: it can cause blindness and is strong enough to burn your skin and clothing. If you spill electrolyte on yourself, clean yourself with water and get a medical aid immediately.

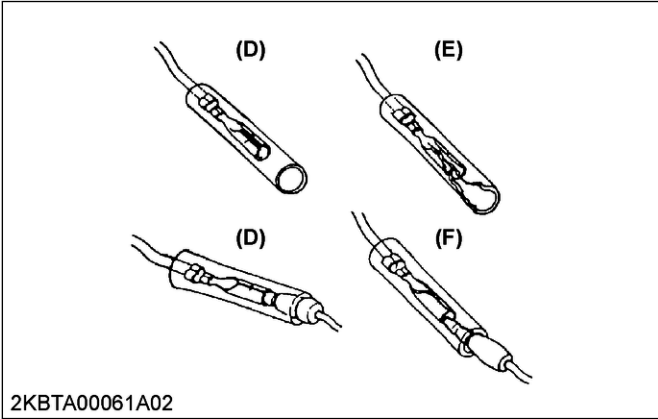
7. Avoiding high pressure fluid



- Keep away from high pressure fluids bursting from a hose or pipe. The fluid can penetrate your skin and cause serious injuries.
- Get a medical aid immediately if an accident occurs.

2. GENERAL

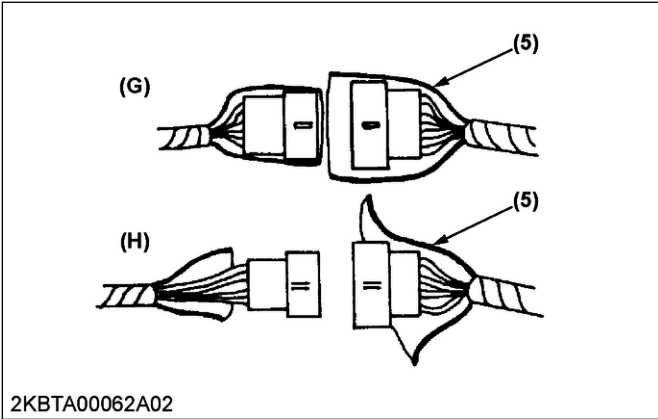
- Make sure that the bullet terminals are secure and connected securely to the tip.



2KBTA00061A02

- (D) Good
- (E) Bad: damaged cover
- (F) Bad: poor connection

- Cover the female connectors and male connectors securely with the plastic covers.

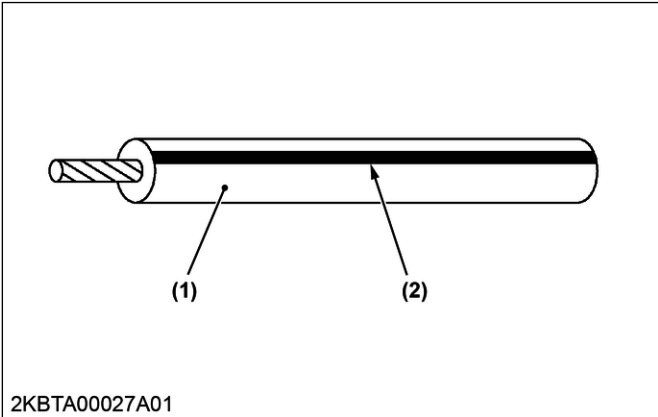


2KBTA00062A02

- (5) Cover
- (G) Good
- (H) Bad: damaged cover

11. Wiring color

- Wire colors are specified in the color codes.



2KBTA00027A01

- (1) Wire color
- (2) Stripe

Wiring Colors	Color code
Black	B
Brown	BR, Br
Green	G
Gray	GY, GR, Gr
Blue	L
Light green	LG, Lg
Orange	OR, Or
Pink	P
Purple	PU, Pu, V
Red	R
Sky blue	SB, Sb
White	W
Yellow	Y

- This symbol of "/" shows color with stripe(s).
(An example)

W/R:
White with red stripe

12. Dispose fluids correctly

- Do not dispose fluids on the ground, down the drain, into a stream, pond, or lake. Obey related environmental protection regulations when you dispose of oil, fuel, coolant, electrolyte, and other dangerous materials.



IBM009A

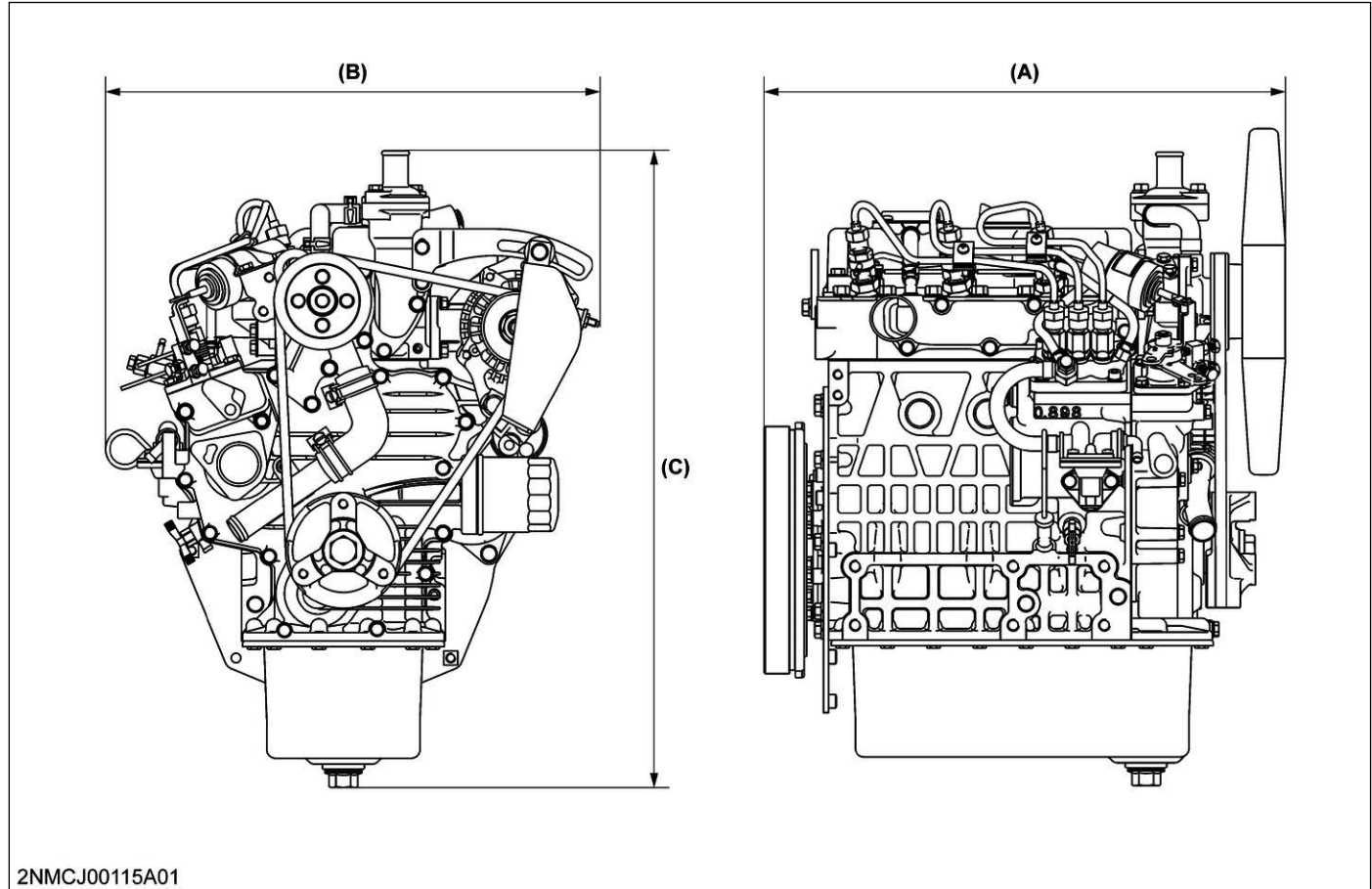
2.4 Specification for D782-E4

Model		D782-E4
Number of cylinder		3
Type		Vertical, Water-cooled, 4 cycle IDI diesel engine
Bore × stroke		67.0 × 73.6 mm (2.64 × 2.90 in.)
Total displacement		778.0 cm ³ (47.48 cu.in.)
SAE net continuous		11.9 kW/3200 min ⁻¹ (rpm) (16.0 HP/3200 min ⁻¹ (rpm))
SAE net intermittent		13.5 kW/3200 min ⁻¹ (rpm) (18.1 HP/3200 min ⁻¹ (rpm))
SAE gross intermittent		14.4 kW/3200 min ⁻¹ (rpm) (19.3 HP/3200 min ⁻¹ (rpm))
Maximum bare speed		3450 min ⁻¹ (rpm)
Minimum bare idling speed		1000 to 1100 min ⁻¹ (rpm)
Combustion chamber		Spherical type (E-TVCS)
Fuel injection pump		Bosch MD type mini pump
Governor		All speed mechanical governor
Direction of rotation		Counter-clockwise (viewed from flywheel side)
Injection nozzle		Bosch "Throttle" type
Injection timing		0.30 rad (17°) before T.D.C.
Firing order		1-2-3
Fuel injection pressure		13.73 MPa (140.0 kgf/cm ² , 1991 psi)
Compression ratio		24 : 1
Lubricating system		Forced lubrication by trochoid pump
Oil pressure indicating		Electrical type switch
Lubricating filter		Full flow paper filter (Cartridge type)
Cooling system		Pressurized radiator, forced circulation with water pump (not included in the basic engine)
Starting system		Electric starting with starter
Starting motor		12 V, 1.0 kW
Starting support device		By glow plug in combustion chamber
Battery		12 V, 36 AH equivalent
Charging alternator		12 V, 150 W
Fuel		Diesel fuel No. 2-D, see page 3-1.
Lubricating oil		Class CF lubricating oil as per API classification is recommended. For details on recommended lubricating oils, see page 3-1.
Lubricating oil capacity	Oil pan depth 101 mm (3.98 in.)	—
	Oil pan depth 121 mm (4.76 in.)	3.6 L (0.95 U.S.gals)
Weight (Dry)		63.5 kg (140 lbs)

NOTE

- *The specification described above is of the standard engine of each model.
- *Conversion Formula: HP = 0.746 kW, PS = 0.7355 kW

4.5 Dimension for D902-E4



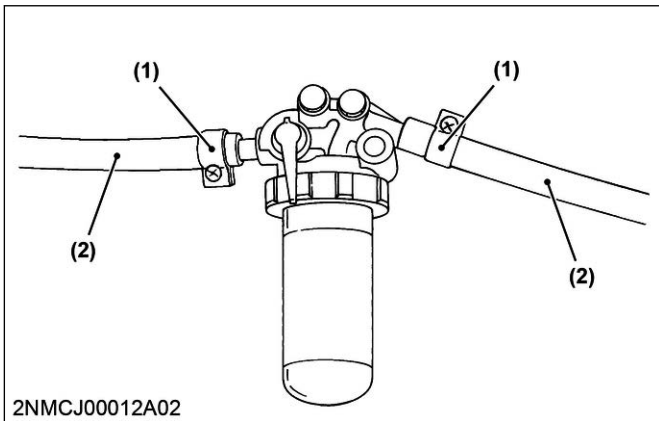
	D902-E4
(A)	467.1 mm (18.39 in.)
(B)	420.5 mm (16.56 in.)
(C)	544.1 mm (21.42 in.)

3. MAINTENANCE

1. If the clamp band (1) is loose, apply the engine oil to the screw of the band, and tighten the band securely.
2. If the fuel hoses, made of rubber, become worn out, replace them and clamp bands (1) every 2 years.
3. If the fuel hoses and clamp bands (1) are found worn out or damaged before 2 years passing, replace or repair them at once.
4. After the replacement of the hoses and bands, air-bleed the fuel system.

■ IMPORTANT

- When the fuel pipes (2) are not installed, plug them with clean cloth or paper at both ends to prevent dirt from entering the fuel pipes (2).
- Dirt in the fuel pipes (2) can cause malfunction of fuel injection pump.



(1) Clamp band (2) Fuel pipe

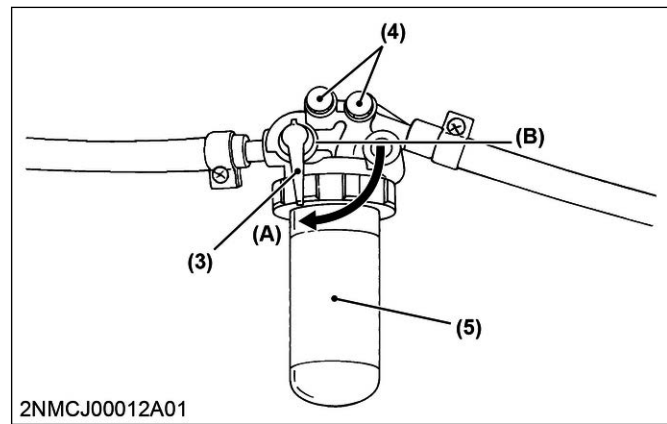
(When bleeding the fuel system)

- a. Fill the fuel tank to the fullest extent. Open the fuel filter lever (3).
- b. Loosen the air vent plug (4) of the fuel filter a few turns.
- c. Screw back the air vent plug (4), when bubbles do not come up any more.
- d. Open the air vent plug (4) on top of the fuel injection pump.
- e. Retighten the air vent plug (4), when bubbles do not come up any more.

■ NOTE

Air bleeding of the fuel system is required in the following situations:

- After the fuel filter and pipes have been detached and refitted
- After the fuel tank has become empty
- Before the engine is to be used after a long storage



(3) Fuel filter lever (A) ON
(4) Air vent plug (B) OFF
(5) Fuel filter pot

⚠ CAUTION

- Do not bleed a hot engine, as this could cause fuel to spill onto a hot exhaust manifold, raising a danger of fire.

4. Check points of every 75 hours

4.1 Changing engine oil

⚠ CAUTION

- Make sure that you have stopped the engine before you change the engine oil.

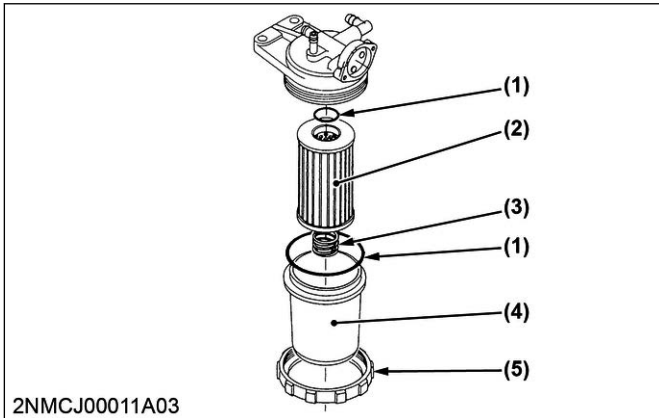
■ IMPORTANT

- When you use the engine oil of a brand or viscosity different from the previous, drain the remaining oil.
- Do not mix 2 different types of the engine oil.
- The engine oil should have properties of API classification CF.
- Use the proper SAE engine oil according to ambient temperature.
- Upon the engine oil change, be sure to replace the gasket with a new one.

5. Bleed the air from the injection pump.

■ IMPORTANT

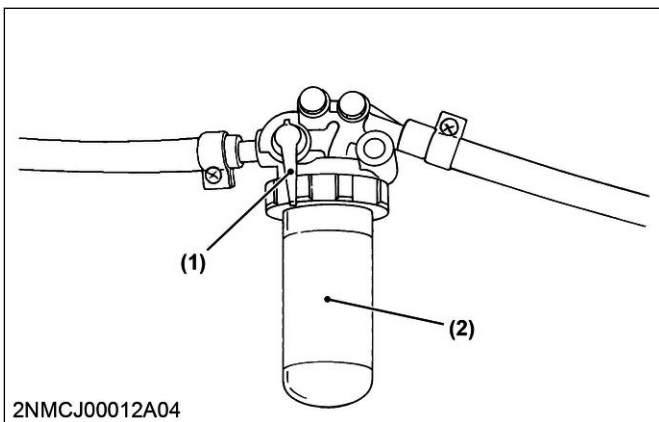
- Infiltration of dust and dirt can cause malfunction of the fuel injection pump and the injection nozzle.



- | | |
|-------------------------|---------------------|
| (1) O ring | (4) Fuel filter cup |
| (2) Fuel filter element | (5) Screw ring |
| (3) Spring | |

8.2 Cleaning water separator

1. Turn the water separator handle (1) to the close position.
2. Loosen and remove the cup (2) properly, and clean its inside with diesel fuel.
3. Tighten up the cup (2) properly.
4. Finally, be sure to air-bleed the fuel system.



- | | |
|----------------------------|---------|
| (1) Water separator handle | (2) Cup |
|----------------------------|---------|

9. Check points of every 500 hours

9.1 Cleaning water jacket and radiator interior

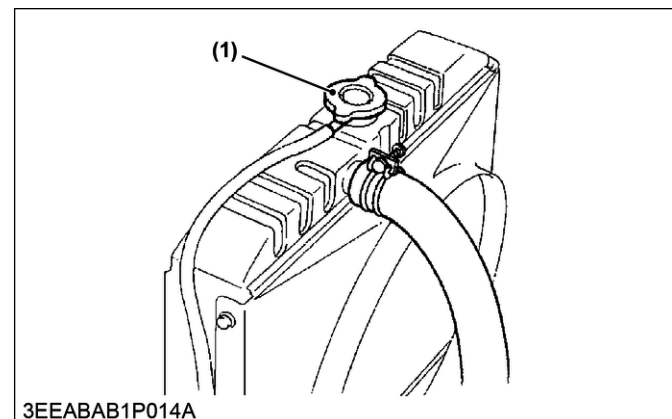
⚠ CAUTION

- Do not stop the engine suddenly, stop it after about 5 minutes of unloaded idling. Work only after letting the engine and radiator cool off completely (more than 30 minutes after the engine stopped).
- Do not remove the radiator cap (1), while the engine is hot. When the engine is cool to touch, rotate the radiator cap (1) to the first stop to allow excess pressure to escape. Then remove the radiator cap (1) completely. If the engine is overheated, steam might gush out from the radiator or recovery tank, causing severe burns.

■ IMPORTANT

- Do not start the engine without coolant.
- Use clean, fresh water and 50% anti-freeze to fill the radiator and the reserve tank.
- Make sure that when you mix the anti-freeze and water, the mixing ratio of anti-freeze must be less than 50%.
- Be sure to close the radiator cap (1) securely. If the cap is loose or improperly closed, coolant might leak out and decrease quickly.
- Do not refill reserve tank with coolant over the [FULL] level mark.
- If coolant leaks, replace the radiator.

1. Stop the engine and let the coolant temperature decreases.
2. Remove the radiator cap (1) to drain the coolant



- | |
|------------------|
| (1) Radiator cap |
|------------------|

4. ENGINE

2.6.3 Function of cylinder head cover and oil separator

The primary function of the cylinder head cover (1) is to prevent lubricating oil scattering from the valve train. Further, another function of the cylinder head cover (1) is to suppress noise emissions.

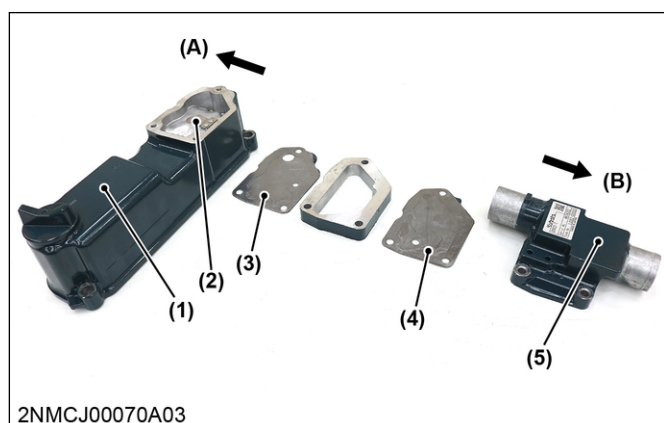
Furthermore, the cylinder head cover (1) has a built-in blow-by gas path with the oil separator (2) and the intake air path.

This system is called the piping built-in type breather system, and it has a structure that prevents piping from freezing due to engine heat.

The breather is a component that releases blow-by gases generated during the combustion stroke.

The oil separator (2) separates vaporized oil from the blow-by gases.

Separated oil is returned to the cylinder head and the gas is fed to the intake side hose and re-combusted.



- | | |
|-------------------------|--------------------|
| (1) Cylinder head cover | (5) Breather cover |
| (2) Oil separator | (A) Bottom side |
| (3) Lower gasket | (B) Top side |
| (4) Upper gasket | |

2.7 Piston

2.7.1 Outline of piston

The piston converts the explosive energy from combustion to reciprocating motion.

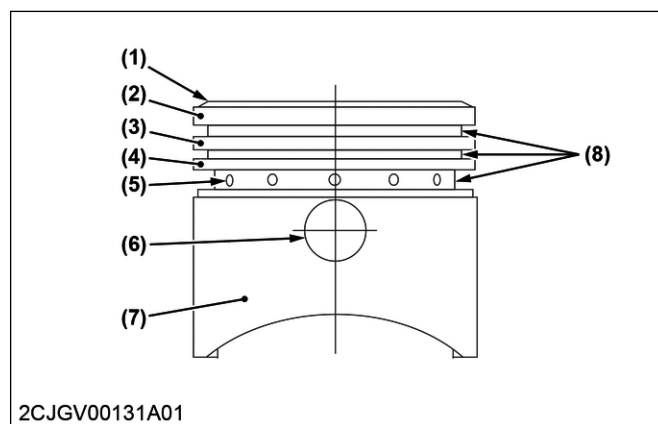
2.7.2 Structure of piston

The piston is the type of slightly concave head.

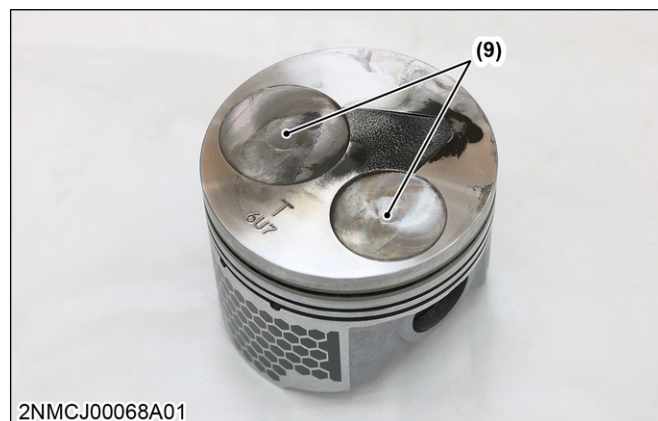
The piston head shape depends on the engine's combustion chamber.

Slightly concave head is used for IDI (Indirect injection) engines.

Since this engine has a high compression ratio and a small gap between the piston and the cylinder head, a valve recess (9) is provided on the piston surface so that the valve does not hit the piston when lifted.



2CJGV00131A01



2NMCJ00068A01

- | | |
|---------------------|---------------------|
| (1) Piston head | (6) Piston pin hole |
| (2) Top land | (7) Piston skirt |
| (3) Second land | (8) Ring groove |
| (4) Third land | (9) Valve recess |
| (5) Oil return hole | |

2.7.3 Function of piston

The piston forms the combustion chamber along with the cylinder and cylinder head.

The piston reciprocates in the cylinder during each of the intake, compression, combustion, and exhaust strokes.

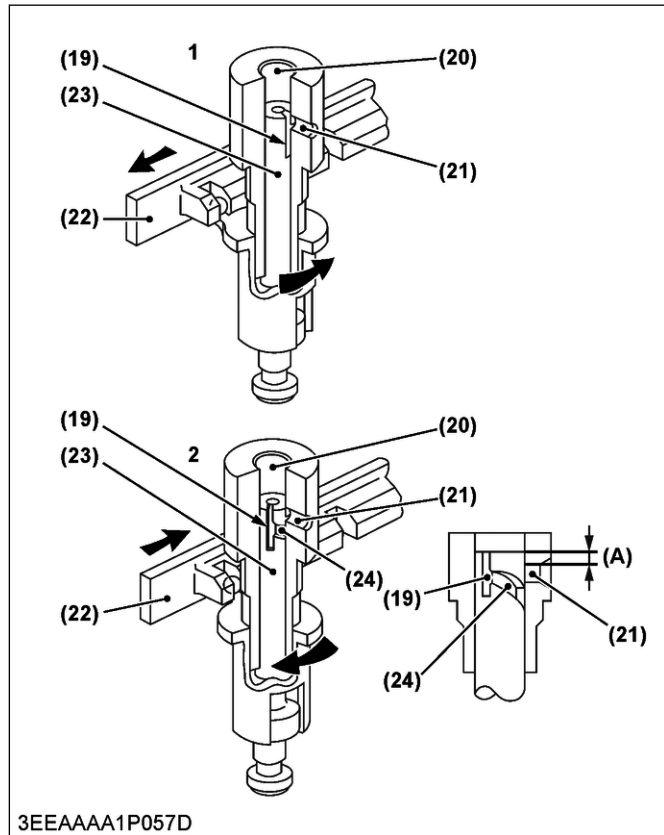
The first and primary role of the piston is to receive explosive energy during combustion and transfer this energy to the crankshaft via the connecting rod.

The head surface of piston has two different shapes. One is valve recess that prevent the hit between piston head and valve head.

Another is flat concave recess that make it easier for compressed air to flow into the sub chamber and smooth combustion gas exhaust.

Piston's skirt is coated with resin to reduce friction by engine oil accumulated in the gap of the pattern coat.

Control Valve

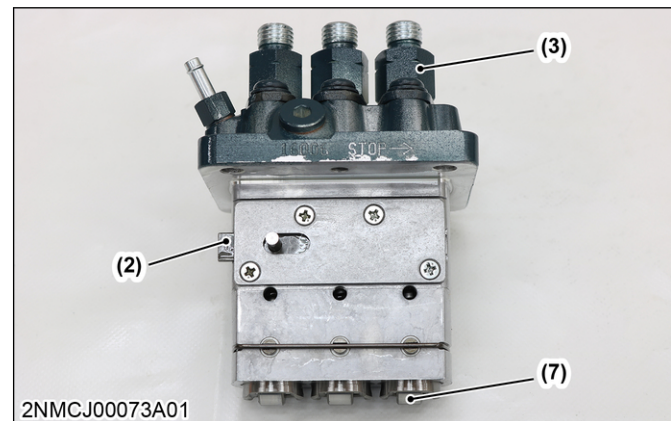
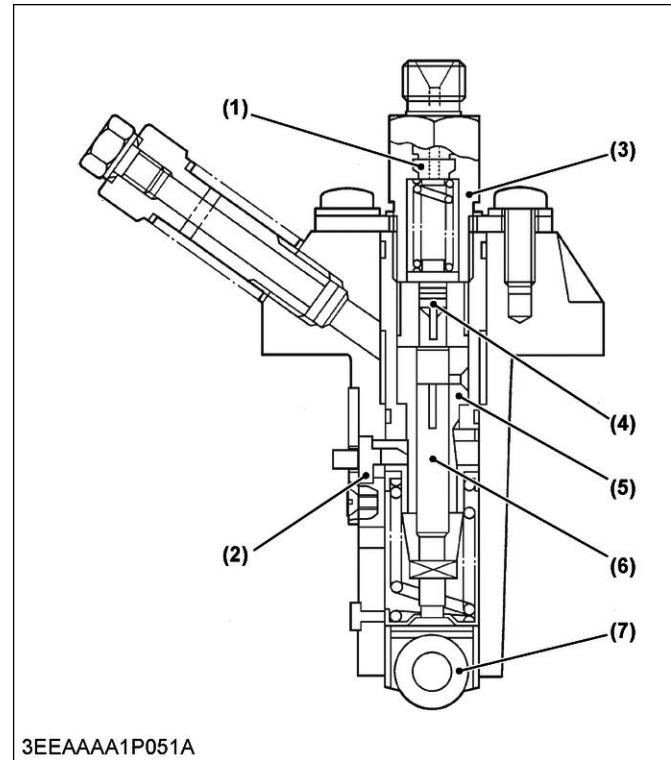


- | | |
|-----------------------|---------------------|
| (19) Slot | (23) Plunger |
| (20) Delivery chamber | (24) Control groove |
| (21) Feed hole | (A) Moving distance |
| (22) Control rack | |

3.9.3 Function of injection pump

The injection pump is a device that pumps the fuel to the injection nozzle of each cylinder.

[Injection pump]



- | | |
|---------------------------|-------------------|
| (1) Dumping valve | (5) Cylinder |
| (2) Control valve | (6) Plunger |
| (3) Delivery valve holder | (7) Tappet roller |
| (4) Delivery valve | |

A Bosch MD type mini pump is used for the injection pump. It is small, lightweight and easy to handle.

It is driven by a cam of fuel camshaft and reciprocates via the tappet roller (7). The plunger (6) with a left-hand lead delivers the fuel into the injection nozzle.

4. ENGINE

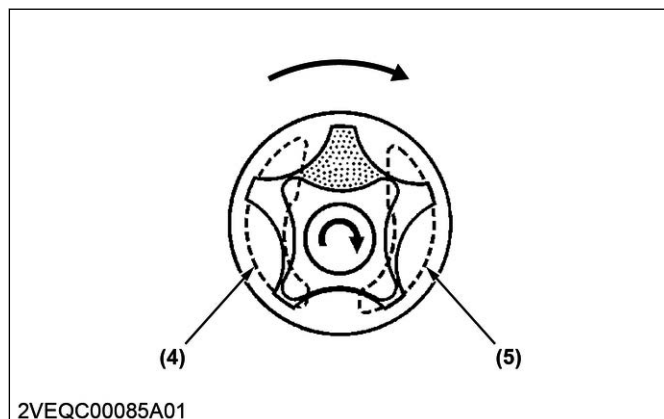
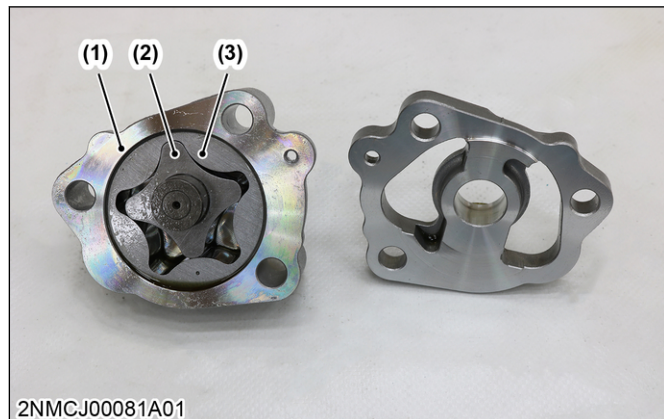
5.6 Oil pump

5.6.1 Outline of oil pump

The oil pump feeds suctioned oil to various parts.

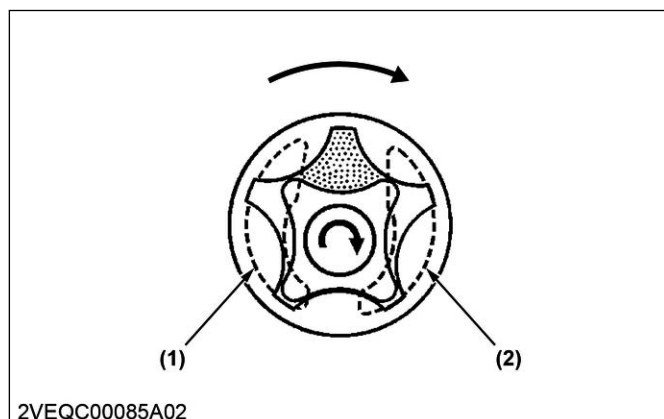
5.6.2 Structure of oil pump

The oil pump is made up of a body, an inner rotor, and an outer rotor and so on .



- (1) Body
- (2) Inner rotor
- (3) Outer rotor
- (4) Inlet port
- (5) Outlet port

5.6.3 Function of oil pump



- (1) Inlet port
- (2) Outlet port

1. This figure is an illustration as viewed from the flywheel side.
2. The oil pump is driven by the crankshaft via an oil pump drive gear.
3. Engine oil is suctioned into the pump through the pump inlet port (1).
4. Engine oil inside the pump is compressed by volumetric change based on rotation of the inner rotor.
5. Compressed engine oil is sent from the pump outlet port (2) to the sliding parts of various components.

5.6.4 Specification of oil pump

Item		Specification
Pump type		Trochoid
Number of teeth	Inner rotor	4
	Outer rotor	5
Theoretical discharge volume (Conditions are that oil temperature is 80 °C (176 °F), and used oil is SAE 10W-30)		2.5 L/min or more (at 1000 min ⁻¹ (rpm)) 8.0 L/min or more (at 2000 min ⁻¹ (rpm))

5.7 Relief valve

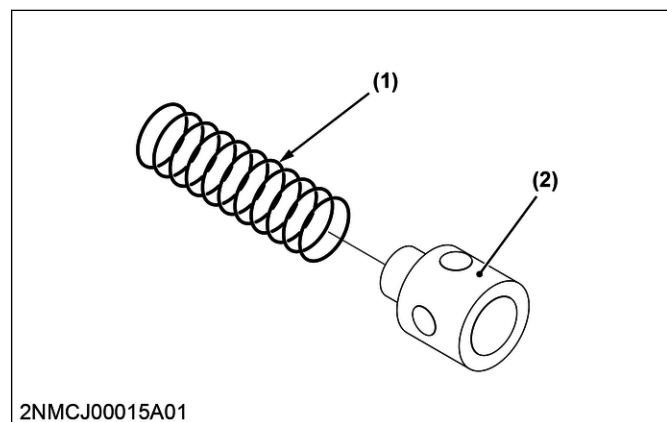
5.7.1 Outline of relief valve

The relief valve automatically opens at its set pressure and lowers oil pressure.

5.7.2 Structure of relief valve

The relief valve prevents the damage of the lubricating system due to high oil pressure.

The relief valve is made up of a valve seat (1) and a spring (2).



- (1) Valve seat
- (2) Spring

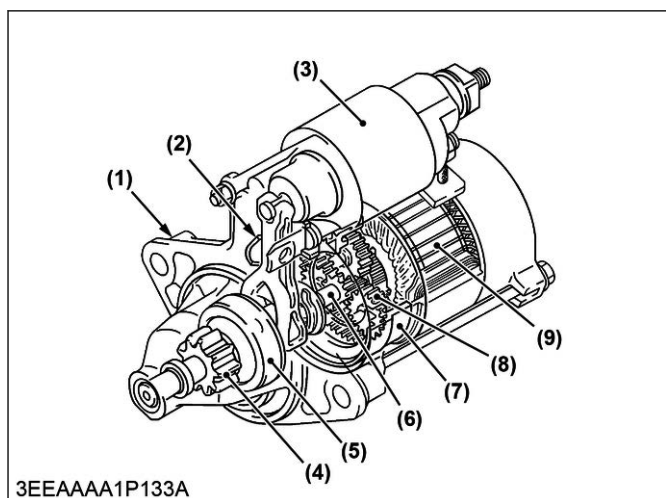
7.8 Starter (Planetary gear reduction type)

7.8.1 Outline of starter (planetary gear reduction type)

The starter uses electric power from the battery to start the engine.

7.8.2 Structure of starter (planetary gear reduction type)

The starter is made up of a magnet switch (3), various gears (4), (7), (8), shaft (6) and the like.



- | | |
|------------------------|--------------------|
| (1) Front bracket | (6) Armature shaft |
| (2) Drive lever | (7) Outer gear |
| (3) Magnetic switch | (8) Planetary gear |
| (4) Pinion gear | (9) Armature |
| (5) Overrunning clutch | |

7.8.3 Function of starter (planetary gear reduction type)

The starter uses electric power from the battery to start the engine.

Start flow

1. When the key switch is rotated to the start position, current flows from the battery to the starter.
2. Upon receiving current, the starter motor rotates and a pinion gear engages and starts to rotate.
3. The pinion gear meshes with the ring gear (flywheel) and causes the flywheel to rotate.
4. The crankshaft that is connected to the flywheel rotates, and the engine starts.

7.8.4 Specification of starter (planetary gear reduction type)

Nominal output (Z482-E4/Z482-E4BG)	12 V, 0.8 kW
Nominal output (Z602/D722/D782-E4)	12 V, 1.0 kW
Nominal output (D902-E4/TE4)	12 V, 1.2 kW
Pinion gear teeth (Z482-E4/Z482-E4BG/Z602/D722/D782/D902-E4/D902-TE4)	8 or 9

7.9 Alternator

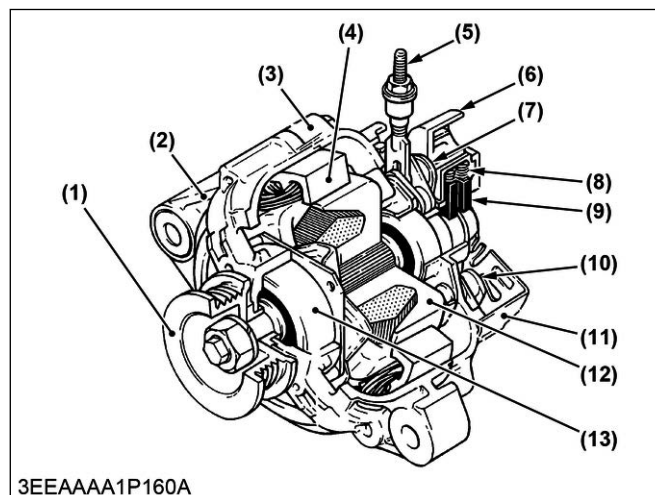
7.9.1 Outline of alternator

The alternator self energizes while the engine is running and charges the battery.

Charging the battery using the alternator prevents reduction in battery capacity making it possible to use it for long term.

7.9.2 Structure of alternator

The alternator is made up of a pulley (1), stator (4), IC regulator (7) and the like.



- | | |
|---------------------|---------------------|
| (1) Pulley | (8) Spring |
| (2) Drive end frame | (9) Brush |
| (3) Rear end frame | (10) Rectifier |
| (4) Stator | (11) Rear end cover |
| (5) Terminal | (12) Rotor |
| (6) Connector | (13) Bearing |
| (7) IC regulator | |

7.9.3 Function of alternator

The alternator generates 3 phase current by means of a fixed coil and rotation of a rotor.

The current generated is rectified using a rectifier made up of diodes.

The rectified current charges the battery.

Item	Dimension × Pitch	N·m	kgf·m	lbf·ft
Coolant temperature sensor (tighten to cylinder head)	PT 1/8	4.0 to 6.0	0.41 to 0.61	3.0 to 4.4
Coolant temperature sensor (tighten to water flange)	PT 1/8	6.0 to 9.0	0.62 to 0.91	4.5 to 6.6

4. Checking and adjusting

4.1 Checking compression pressure of cylinder

■ **NOTE**

- Check the compression pressure with the specified valve clearance.
- Always use a fully charged battery for you do this test.
- Variances in cylinder compression values must be less than 10 %.

Tools required

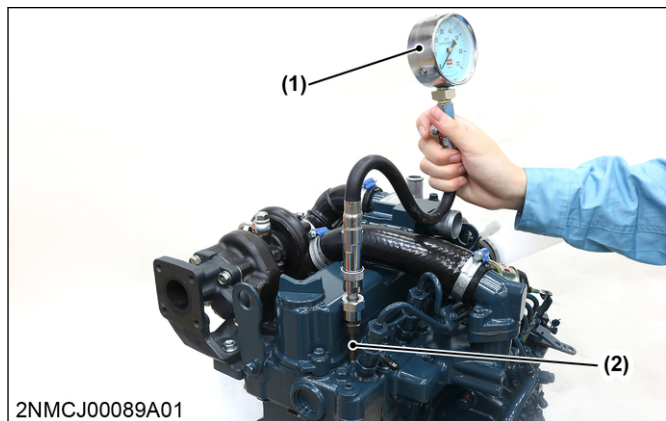
- Compression tester
- Compression tester adapter

1. Warm-up the engine.
2. Remove the air cleaner and muffler.
3. Remove the glow lead and glow plugs.

■ **NOTE**

- In case you use compression tester adapter for injection nozzle holes, remove the injection pipe, overflow pipe and injection nozzles.

4. Set a compression tester (1) with the compression tester adapter (2) to glow plug hole.



(1) Compression tester (2) Compression tester adapter

5. Set the stop lever at stop position (non-injection) and crank the engine with the starter to operate the engine approx. 200 min⁻¹ (rpm).
6. Measure a maximum value of the compression pressure.

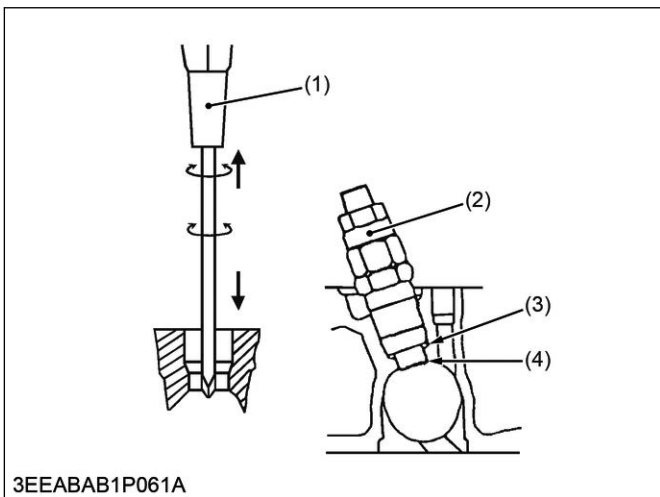
	Engine	Reference value	Service limit
Compression pressure	Z482-E4 Z482-E4BG D722-E4 D782-E4	2.85 to 3.23 MPa/ 200 min ⁻¹ (rpm) 29.1 to 32.9 kgf/cm ² / 200 min ⁻¹ (rpm) 414 to 468 psi/ 200 min ⁻¹ (rpm)	2.26 MPa/ 200 min ⁻¹ (rpm) 23.0 kgf/cm ² / 200 min ⁻¹ (rpm) 328 psi/ 200 min ⁻¹ (rpm)
	Z602-E4 D902-E4	3.53 to 4.02 MPa/ 200 min ⁻¹ (rpm) 36.0 to 40.9 kgf/cm ² / 200 min ⁻¹ (rpm) 512 to 583 psi/ 200 min ⁻¹ (rpm)	2.55 MPa/ 200 min ⁻¹ (rpm) 26.0 kgf/cm ² / 200 min ⁻¹ (rpm) 370 psi/ 200 min ⁻¹ (rpm)
	D902-TE4	2.85 to 3.23 MPa/ 200 min ⁻¹ (rpm) 29.1 to 32.9 kgf/cm ² / 200 min ⁻¹ (rpm) 414 to 468 psi/ 200 min ⁻¹ (rpm)	2.26 MPa/ 200 min ⁻¹ (rpm) 23.0 kgf/cm ² / 200 min ⁻¹ (rpm) 328 psi/ 200 min ⁻¹ (rpm)

7. Do the same steps twice for each cylinder.

- Remove the heat seal (4) and gasket (3) with a screwdriver (1).

NOTE

- In case that it can not remove the heat seal (4), repeat upper procedure.



3EEABAB1P061A

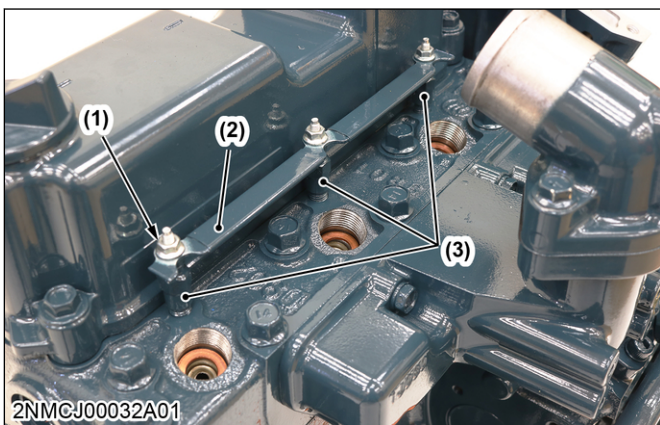
- | | |
|-------------------------------|---------------|
| (1) Screwdriver | (4) Heat seal |
| (2) Injection nozzle assembly | |
| (3) Gasket | |

5.9 Removing glow plug

- Remove the glow lead mounting nut (1).
- Remove the glow lead (2).
- Remove the glow plug (3).

NOTE

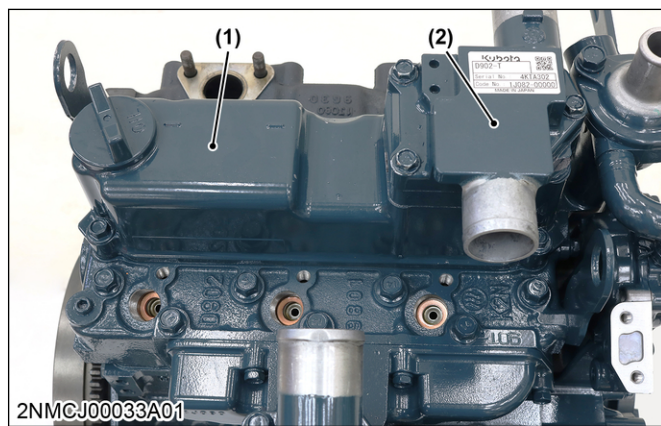
- Keep the glow plug with numbering cylinder order.



- | | |
|----------------------------|---------------|
| (1) Glow lead mounting nut | (3) Glow plug |
| (2) Glow lead | |

5.10 Removing cylinder head cover

- Remove the cylinder head cover mounting screw.
- Remove the cylinder head cover (1).



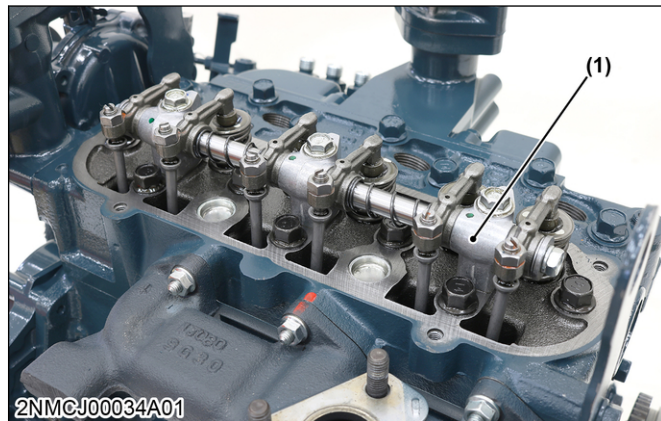
2NMCJ00033A01

- | | |
|-------------------------|--------------------|
| (1) Cylinder head cover | (2) Breather cover |
|-------------------------|--------------------|

- Remove the breather cover (2). (If necessary)

5.11 Removing rocker arm assembly

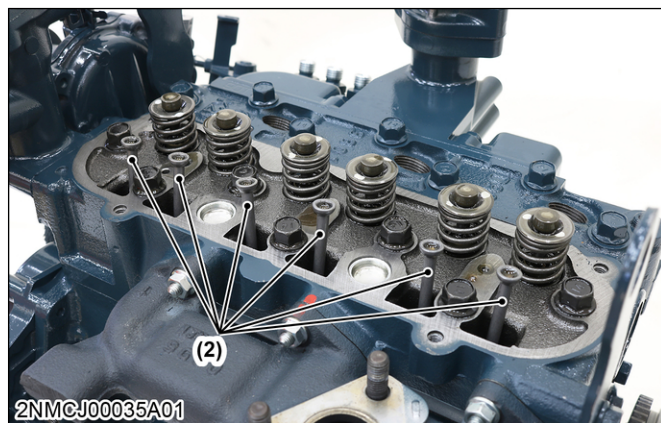
- Remove the rocker arm assembly (1).



2NMCJ00034A01

- | |
|-------------------------|
| (1) Rocker arm assembly |
|-------------------------|

- Remove the push rod (2).

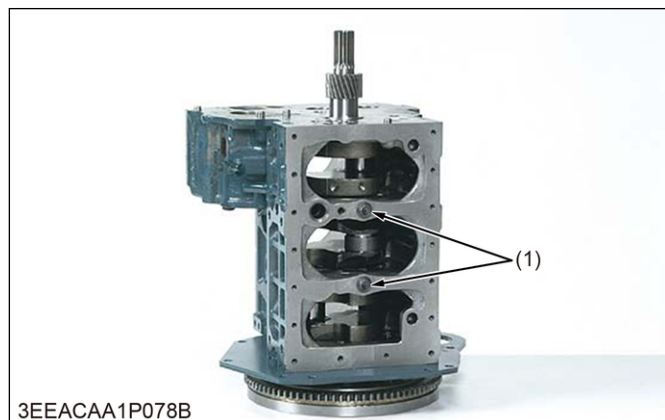


2NMCJ00035A01

- | |
|--------------|
| (2) Push rod |
|--------------|

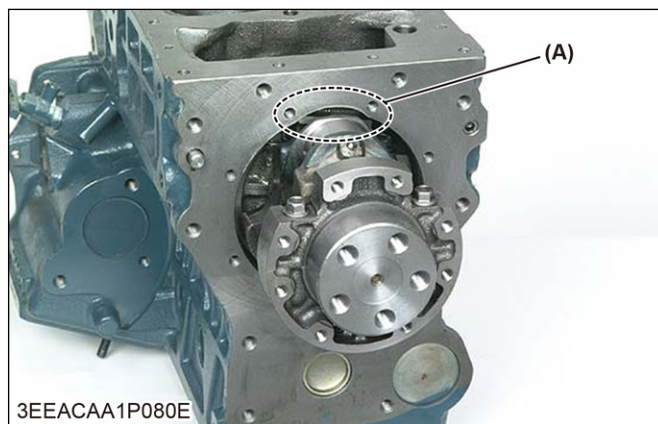
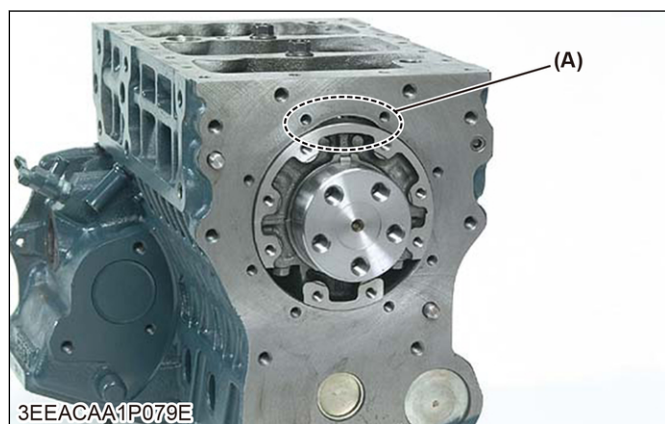
5.36 Removing crankshaft assembly for D782-E4 D902-E4 D902-TE4

1. Remove the main bearing case mounting screw 2 (1).



- (1) Main bearing case mounting screw 2

2. Turn the crankshaft to set the No. 3 cylinder crankpin at bottom dead center position.
3. Pull out the crankshaft until the No. 2 cylinder crankpin comes to center of No. 3 cylinder.
4. Turn crankshaft by 2.09 rad (120°) counterclockwise to set No. 2 cylinder crankpin to bottom dead center position.
5. Pull out the crankshaft until the No. 1 cylinder crankpin comes to the center of the No.3 cylinder.
6. Repeat the above steps again to pull out the crankshaft completely.



- (A) Cut place for removing or installing crankshaft assembly

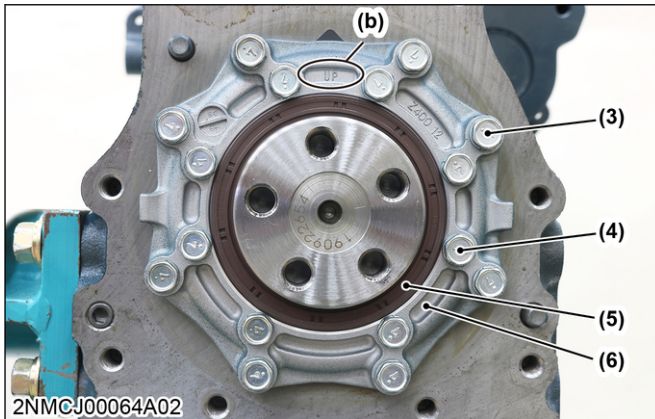
5.37 Removing main bearing case assembly

1. Remove the main bearing case mounting screw 1 (4).
2. Remove the main bearing case assembly 1 (1).

- Put the casting mark **[UP]**(b) of the bearing case cover (6) upward, then install the bearing case cover (6).

■ **NOTE**

- Apply a thin layer of the engine oil to the oil seal (5).
- Then install the oil seal not to come off the lip.

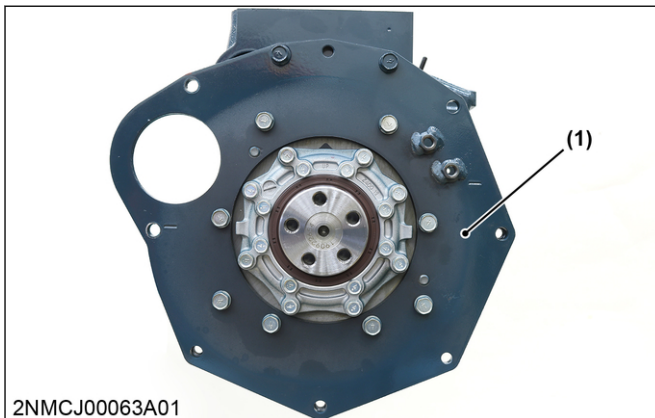


- | | |
|---|------------------------------|
| (3) External mounting screw of bearing case cover | (5) Oil seal |
| (4) Inner mounting screw of bearing case cover | (6) Bearing case cover |
| | (b) Casting mark [UP] |

- Tighten the external mounting screws of bearing case cover (3) and the inner mounting screws of bearing case cover (4) to the specified tightening torque with even force on the diagonal line.

6.8 Installing rear end plate

- Install the rear end plate.



- (1) Rear end plate

6.9 Installing flywheel

■ **IMPORTANT**

- The flywheel is heavy, so securely hold the flywheel when installing.

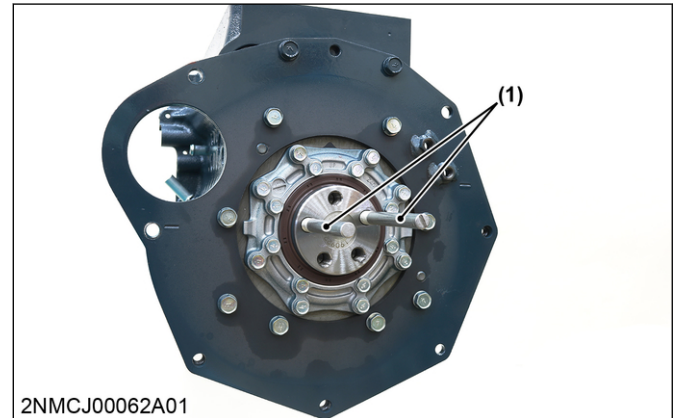
■ **NOTE**

- Do not use an impact wrench. Serious damage will occur.

Tools required

- Flywheel stopper
- Flywheel guide screw

- Set the flywheel guide screw (1).



- (1) Flywheel guide screw

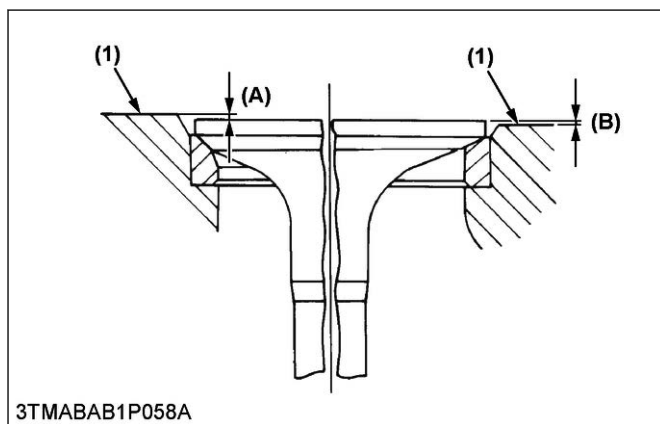
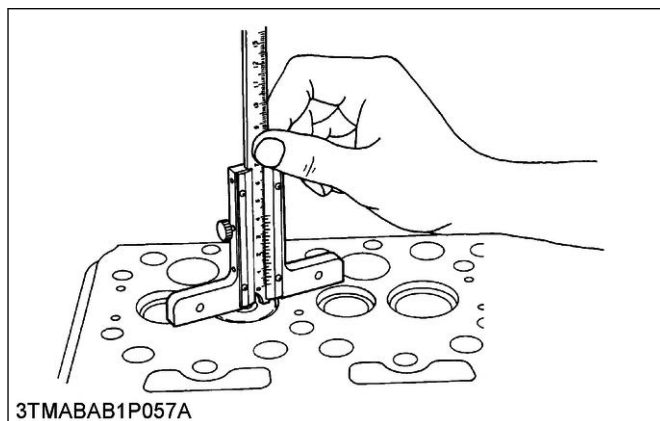
- Set the No.1 crankpin at the top dead center.

3. Measure the valve recessing with a depth gauge.

■ **NOTE**

- If the measurement is more than the service limit, replace the valve.
- If it stays more than the service limit after you replace the valve, replace the cylinder head.

Valve recessing	Service specification	-0.10 (protrusion) to 0.10 (recessing) mm -0.0039 to 0.0039 in.
	Service limit	0.30 mm 0.012 in.

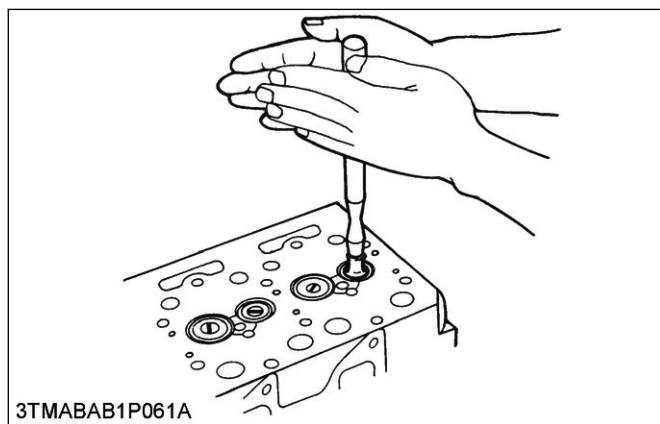


(1) Cylinder head surface (B) Protrusion
(A) Recessing

7.5 Adjusting valve lapping

Tools required

- Compound
 - Valve lapping tool
 - Prussian Blue
1. Apply the compound equally to the valve lapping surface.
 2. Put the valve into the valve guide. Lap the valve on its seat with a valve lapping tool.
 3. After you lap the valve, clean away the compound and apply oil, then lap the valve again with oil.



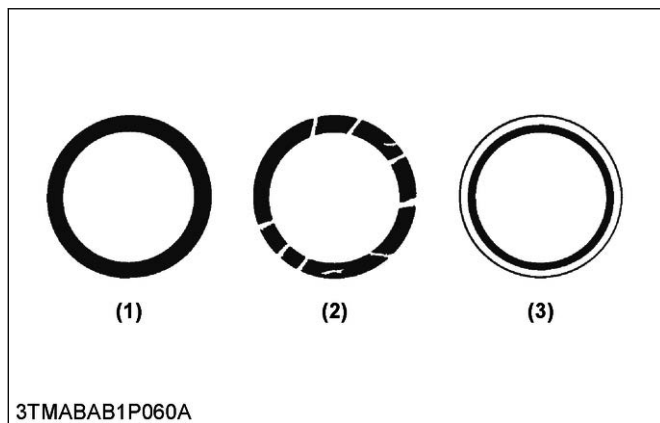
4. Apply Prussian Blue to the contact surface to measure the seated rate.

■ **NOTE**

- If the seated rate is less than 70%, lap the valve again.

■ **IMPORTANT**

- After you complete the valve lapping and assemble the valve, check the valve recessing and adjust the valve clearance.



(1) Good (3) Bad
(2) Bad

— RELATED PAGE —

[4.2 Checking valve clearance on page 4-72](#)

[7.4 Checking valve recessing on page 4-136](#)

7.6 Checking clearance between valve stem and valve guide

Tools required

- Outside micrometer
 - Inside micrometer
1. Remove carbon from the valve guide section.