# WSM

## WORKSHOP MANUAL

# DIESEL ENGINE

# SM-E4,SM-E4BG

Kubota

KiSC issued 10, 2022 A

# TO THE READER

This workshop manual provides safety information for service activity, general information such as specifications and dimensions of the machine, mechanisms and structure descriptions of the machine, and service procedures.

**Safety**
This section contains safety service descriptions and safety label information.

**General**
This section contains general instructions, tightening torques, general machine information and special tools.

**Maintenance**
This section contains information for the recommended oil and general maintenance procedures.

Each section basically consists of mechanism and servicing.

**Mechanism**
Mechanism part contains information and explanations for the structure, functions, and specifications of the machine or component parts. This part should be comprehended before proceeding with troubleshooting, disassembling, assembling, and servicing works.

**Servicing**
Servicing part contains information and procedures for maintenance, troubleshooting and repair works. The reader should follow these instructions in order to satisfy any servicing work safely, correctly and quickly.

In this WSM, service specifications and service limits are defined as followings.

**Service specifications:**
Specification which corresponds to new machine's ex-factory. It is based on quality standard, drawings, or actual measurements conducted by Kubota. This value is used to determine whether there is a problem with the machine in the event of a troubleshooting. However, it is necessary to consider degradation due to wear, based on the operating time of the machine, application or maintenance condition.

**Service limits:**
Service limit is a value corresponding to the recommended performance limit by taking long term-use wear into account. When the service limit is reached, the machine is required to have proper repair, overhaul or replacement in order to keep safe and adequate performance.

All of the illustrations, photographs, specifications, and other information in this manual were created based on the latest model at the time of publication.
The parts names used in this manual are unified into names representing the functions of the parts. Therefore, it does not necessarily correspond to the names used in other materials (parts list, operators manual etc.) and the name on the label / identification plates on the product.
Kubota reserves the right to change all information at any time without notice.

**March 2020**

# RECORD OF REVISIONS

Main revised contents and corrective measures are described in a table.
Find the main revised point and corrective measure through the reference page.

| Last digit of the code No. | Month of revision | Part name | Main revised point and corrective measure | Reference page |
|---|---|---|---|---|
| 1 | March 2021 | — | Due to add the information about SM-E4 series to D902-TE4 | — |
| 2 | July 2021 | Cylinder head mounting screw (1J080-03450) | Due to add the information about SM-E4BG series and the information of tightening torque of the cylinder head mounting screw (D722-E4 (Serial Number:below 4MM3857) | 4-69<br>4-127 |
| 3 | October 2022 | Alternator | Corrected the service specification of regulating voltage at no load | 4-79 |
| | | — | Changed tightening torque due to design modification. | 4-69<br>4-109 |

# CONTENTS

## 3. MAINTENANCE

## 4. ENGINE

# 1. SAFETY

# SAFETY FIRST

This symbol, the industry's "Safety Alert Symbol", is used throughout this manual and on labels on the machine itself to warn of the possibility of personal injury. Read these instructions carefully. It is essential that you read the instructions and safety regulations before you attempt to assemble or use this unit.

**DANGER**
- **Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.**

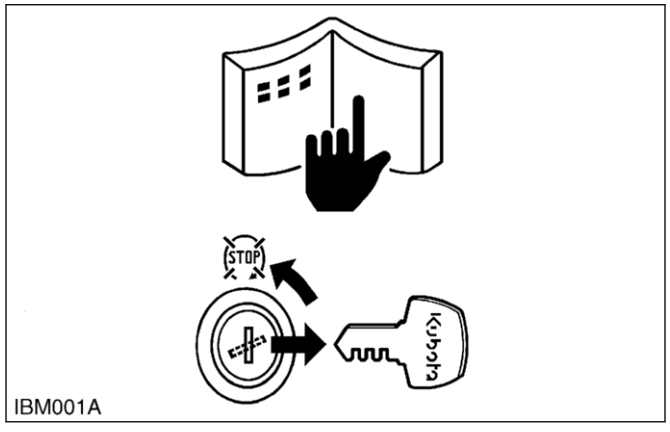
**WARNING**
- **Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.**

**CAUTION**
- **Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury.**

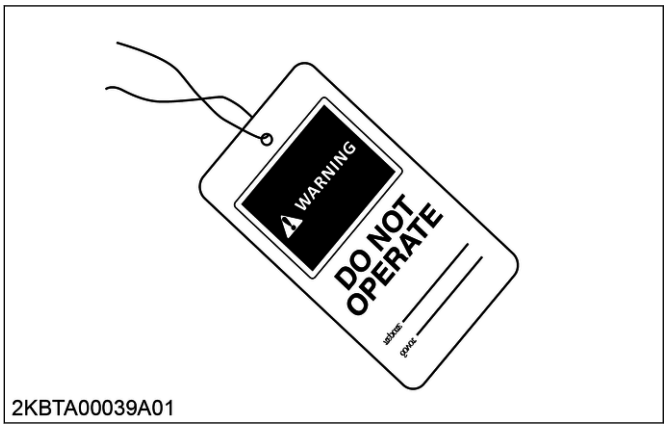
**IMPORTANT**
- **Indicates that equipment or property damage could result if instructions are not followed.**

**NOTE**
- **Gives helpful information.**

## 1. Working precautions

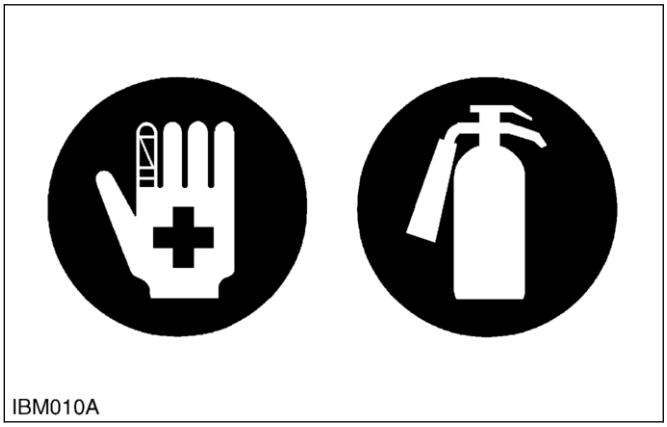



- Understand all safety instructions and safety labels in this manual.
- Park the machine on a stable and level ground then lower the attachment to check the machine safely.
- Stop the engine and remove the key when leaving the operator's seat for cleaning, maintenance, and servicing.



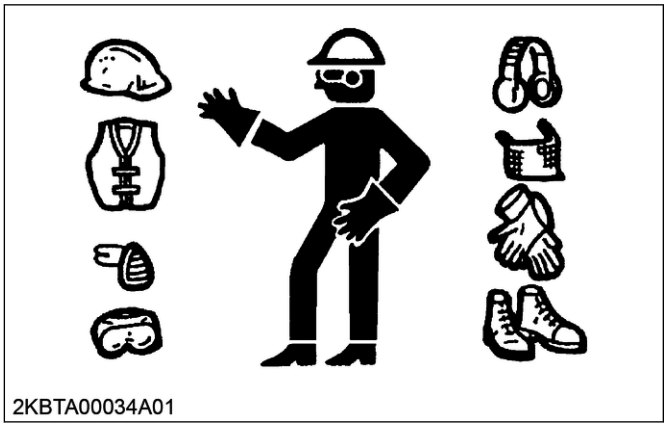

- Hang a DO NOT OPERATE tag near the operator's seat.
- Do not use worn or cracked tools. Use tools in a proper way with enough strength.
- In regards to the facility which is used in the workshop, follow each safety instruction.

## 2. Preparing for emergencies




- Keep a first aid kit and fire extinguisher ready at all times.
- Keep emergency numbers near your telephone at all times.

# 3. Working cautions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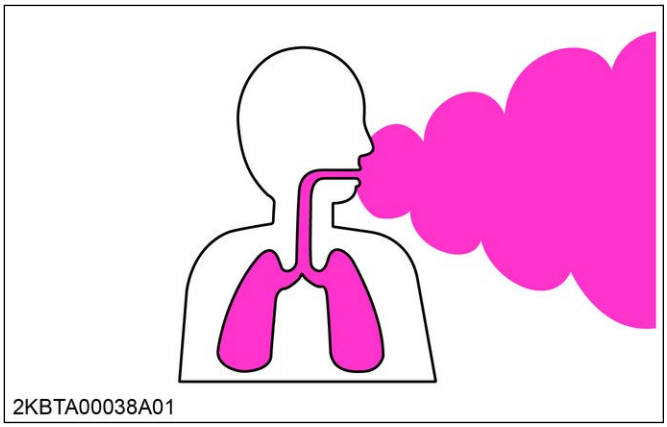
- Wear proper service attire when performing work. Do not wear loose clothing as they could get caught on machine components.
- Wear the proper protective equipment when working around the machine. For example helmet, eye protector and protective shoes.
- Do not work around the machine if you are tired or have consumed alcohol or drugs.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- Keep the machine away from obstacles and hazardous materials.
- Ensure the working environment is properly ventilated.
- Do not allow third parties to come near the machine.


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- Make sure you have the support of the 3 points with both hands holding the handle and one foot at the step when getting on and off the machine.
- When working under the machine, make sure the machine does not move back and forth or side-to-side.
- When working under the machine, provide secure support for the machine.
- When using a hydraulic jack, always use with a rigid rack to prevent the machine from falling.

# 4. Starting machine safely


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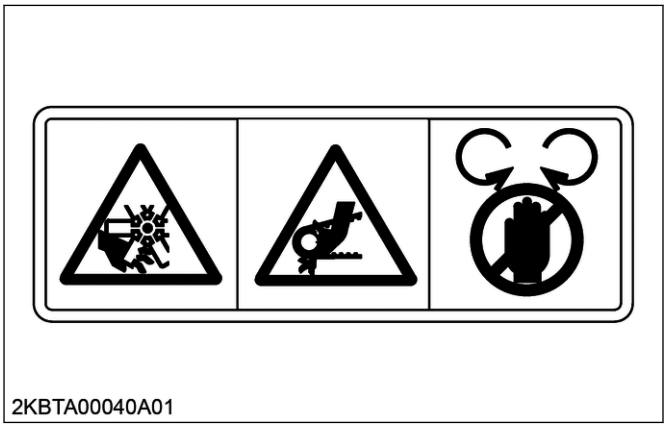
- Do not do the following work when starting the engine.
  - Short across starter terminals.
  - Bypass the safety start switch.
- Make sure there are no bystanders or obstacles present around the machine before starting the engine.
- Do not start the engine unless the operator is seated in the operator's seat.
- Make sure that the pilot levers are in neutral before starting the engine.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- 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


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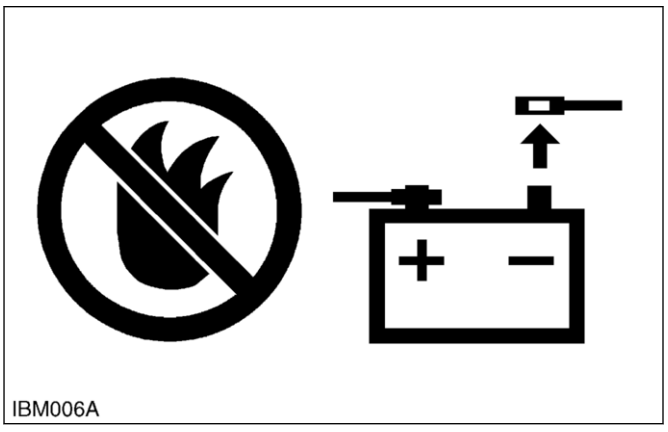
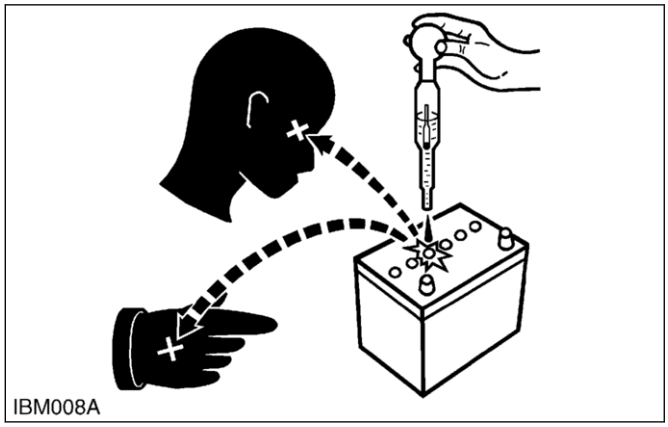

IBM006A

- 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


IBM008A

- 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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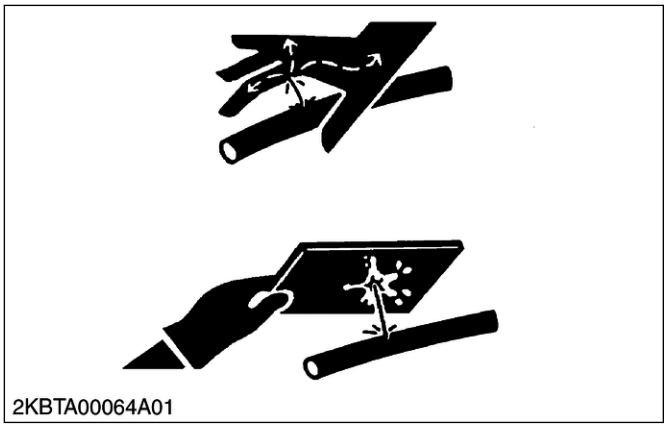
- Keep away from high pressure fluids bursting from a hose or pipe. The fluid can penetrate your skin and cause serious injuries.
- Get a medical aid immediately if an accident occurs.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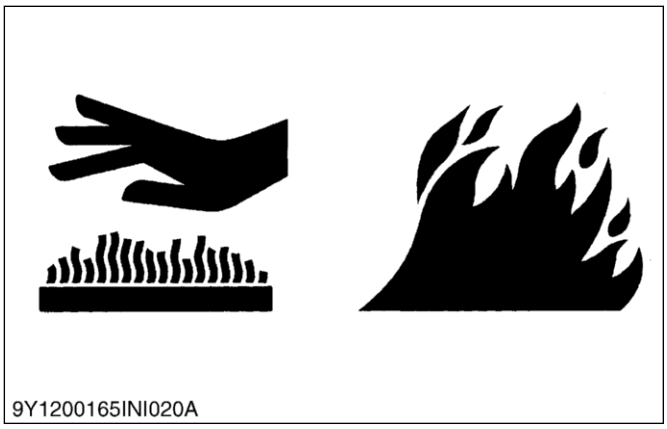
- Release residual pressure in the hydraulic circuit before removing the hydraulic components.
- Pay attention when releasing pressure in hydraulic circuit, because the machine or attachment might move unexpectedly.
- Check the coolant temperature and release the pressure before opening the radiator cap.

## 8. Avoiding hot exhaust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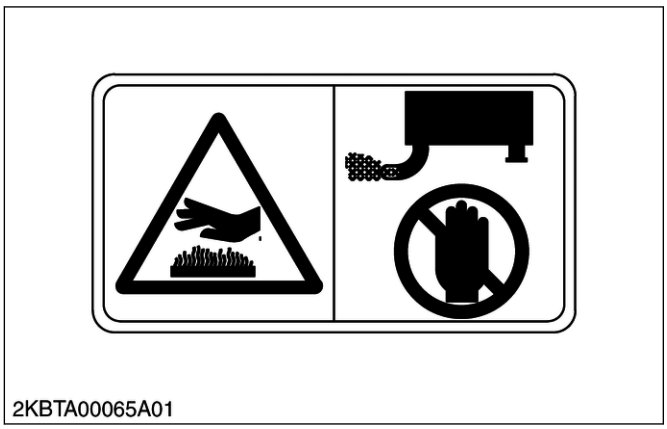
- Avoid skin exposure and contact with hot exhaust gas or components.
- Exhaust gas and components are extremely hot during operation.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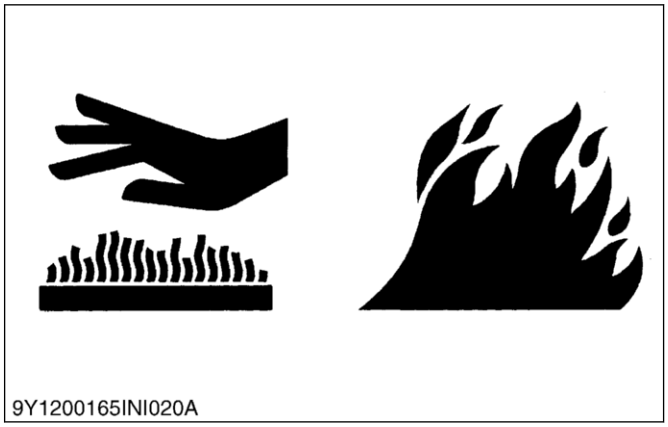
- Do not work immediately after stopping the engine. The engine, muffler, radiator, and hydraulic components are extremely hot.
- Do not remove caps and plugs soon after stopping the engine. The temperature and pressure of the coolant, hydraulic oil, and fuel are still high.

## 9. Cleaning exhaust filter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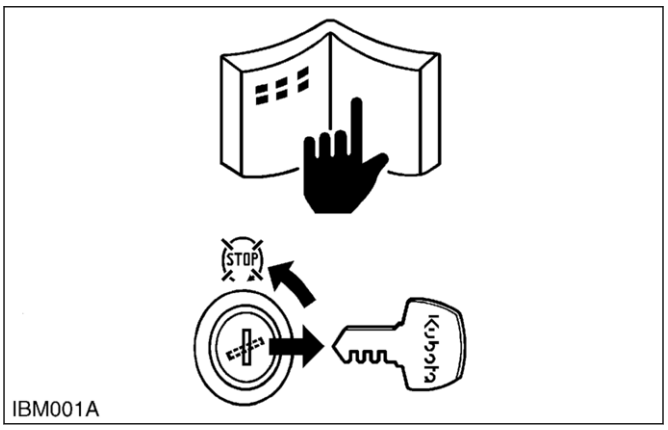
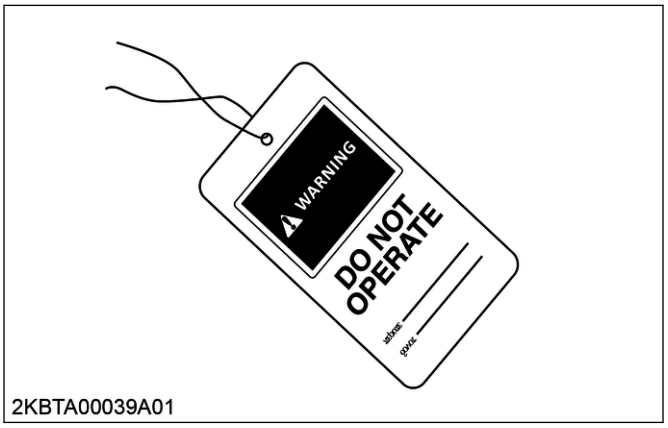
- Avoid skin exposure and contact with hot exhaust gas or components. Exhaust gas and components are extremely hot during regeneration of the diesel particulate filter (DPF).

# 2. GENERAL

# GENERAL WORKING PRECAUTIONS




- When servicing, observe the safety instructions in the operator's manual and workshop manual.
- Clean the machine before maintenance.
- Service the machine at a clean location.
- Park the machine on a stable and level ground then lower the attachment to check the machine safely.
- Stop the engine and remove the key when leaving the operator's seat for cleaning, maintenance, and servicing.
- Before working, remove the negative (-) terminal from the battery or turn off the battery isolator switch.
- Whenever a special tool is required, use the special tool that Kubota recommends.
- Use genuine Kubota parts to ensure safety and machine performance.

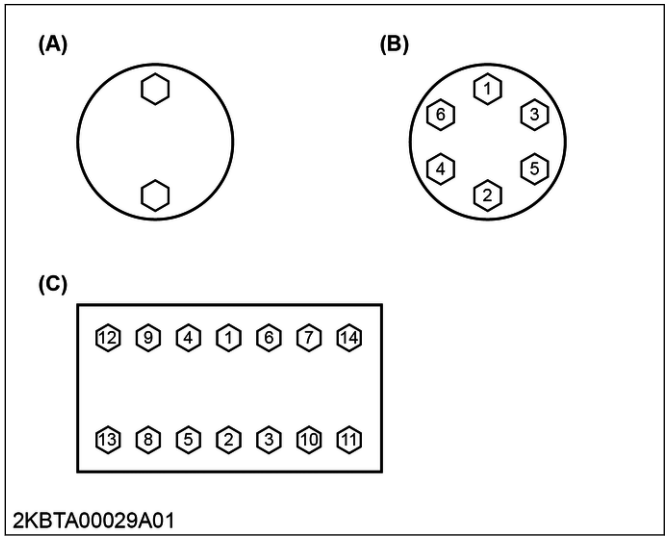



- Hang a DO NOT OPERATE tag near the operator's seat.
- Observe workplace safety rules when performing service and work.

## 1. Tightening bolts and nuts

- Tighten the bolts and nuts to their specified torque.

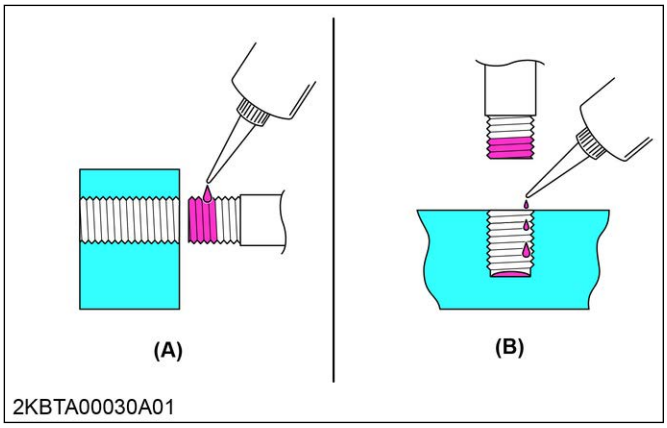
**NOTE**
- **Tighten the bolts and nuts alternately from top to bottom and left to right so the torque is distributed evenly.**
- **Gradually tighten the bolts and nuts two or three times.**




(A) Alternately
(B) Diagonally
(C) Diagonally from center to outside

## 2. Applying thread-locking fluid

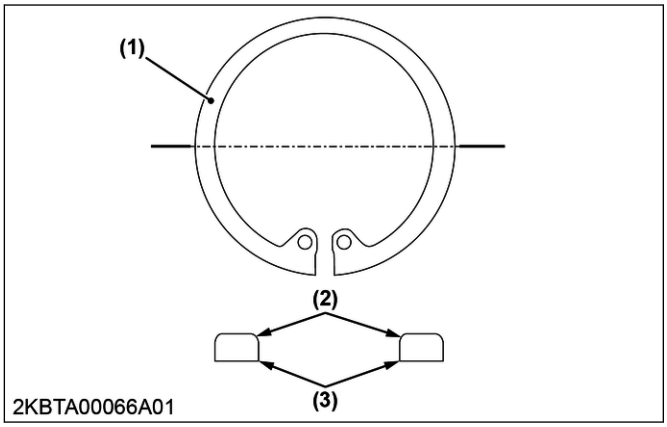
1. Clean and dry the location where a thread-locking fluid will be applied with a solvent to remove moisture, oil, and dirt.
2. Apply the thread-locking fluid to the tip of the bolt.
3. If the threads are large, apply the thread-locking fluid all around the bolt hole.



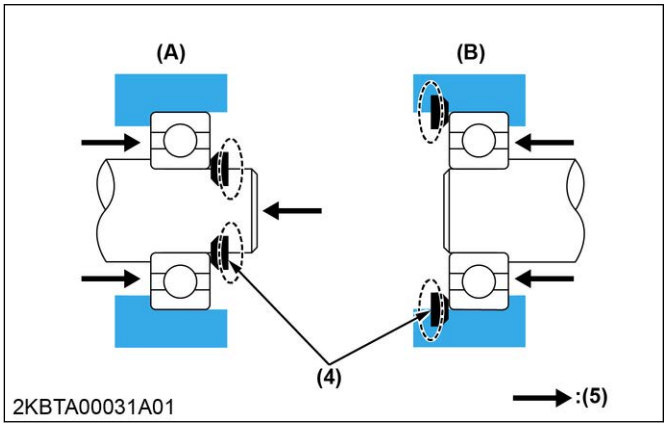

(A) Bolt hole (bolts, nuts) (B) Screw hole

# 3. Installing circlips

- When installing the circlip, assemble the circlip's angular side (3) toward the side that receives force (4) as shown in the figure.



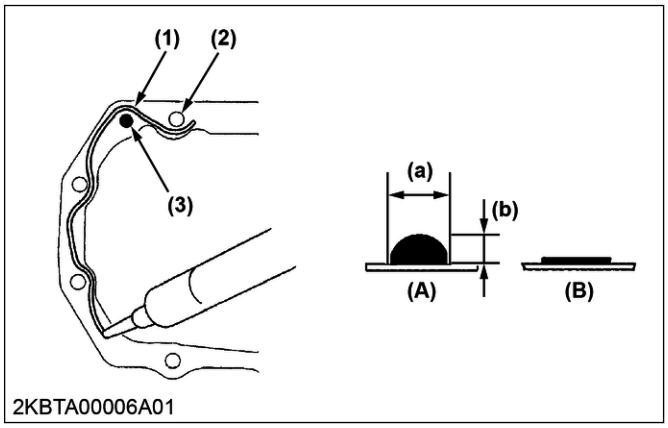

(1) Circlip (3) Angular side
(2) Rounded side




(4) Side that receives force (A) External circlip
(5) Force (B) Internal circlip

# 4. Handling liquid gasket

- Use the specified liquid gasket.
- When using liquid gasket, fully remove the old gasket and grease or oil.
- When applying liquid gasket, apply it on the joint surface with a thickness of 3.0 to 5.0 mm (0.12 to 0.13 in.) without making any gaps.
- When applying liquid gasket near the bolt hole (2), apply it in the inner side.
- If there is a risk of oil leakage or if the hole goes all the way through when applying liquid gasket near the dowel pin (3) hole, apply it in the inner side.
  If there is no concern of oil leakage, apply it on the outer side.
- Reassemble within 15 minutes after applying; wait for 30 minutes or more then fill with oil.



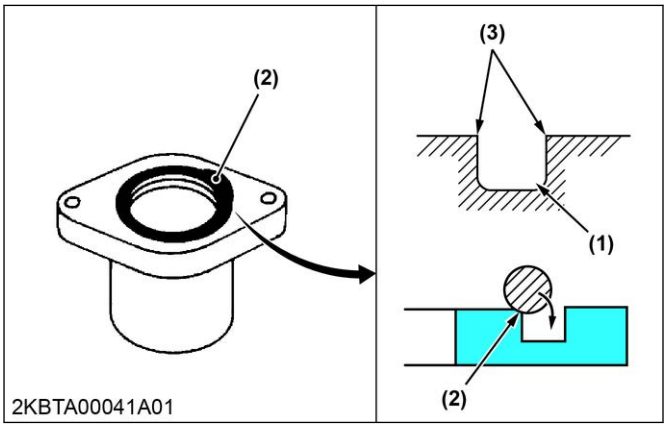

(1) Application route (a) 3.0 to 3.5 mm (0.12 to 0.13 in.)
(2) Bolt hole
(3) Dowel pin (b) 3.0 to 5.0 mm (0.12 to 0.19 in.)
(A) Correct
(B) Incorrect

# 5. Replacing O-rings

1. Remove the burr and clean the O-ring groove.
2. Lubricate the O-ring. Do not apply any grease to the floating seal.
3. Put the O-ring in the groove.

**■ NOTE**

- **Do not twist the O-ring.**
- **Remove the burr to avoid damage on the O-ring caused by the burr.**




(1) O-ring groove
(2) O-ring
(3) Burr

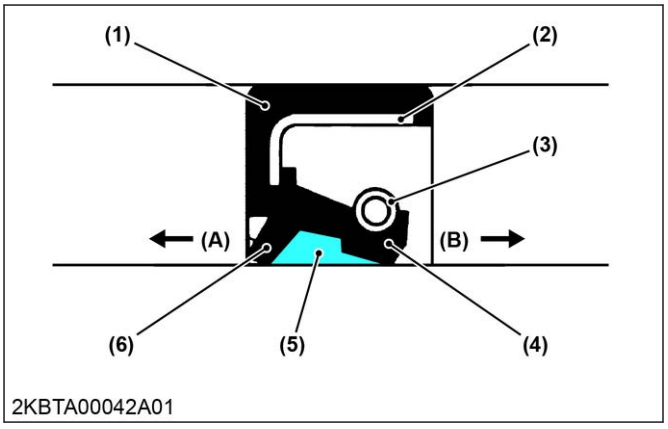
# 6. Replacing oil seals

1. Do not face the lip of the oil seal in the wrong direction. Face the seal lip toward the material to be sealed.
2. Use a press to install the oil seal until firmly fixed to the boss.

**NOTE**
- **In cases when installing an oil seal without a press, place a wooden board on the seal and gently tap the board with a hammer; install the oil seal straightly and evenly.**

3. Grease the seal lip and dust lip.

**NOTE**
- **If the seal has a dust lip, grease the gap between the lips.**
- **After oil seals are replaced, grease the moving parts around the lip to prevent the dry surfaces from wearing against each other during engine start up.**

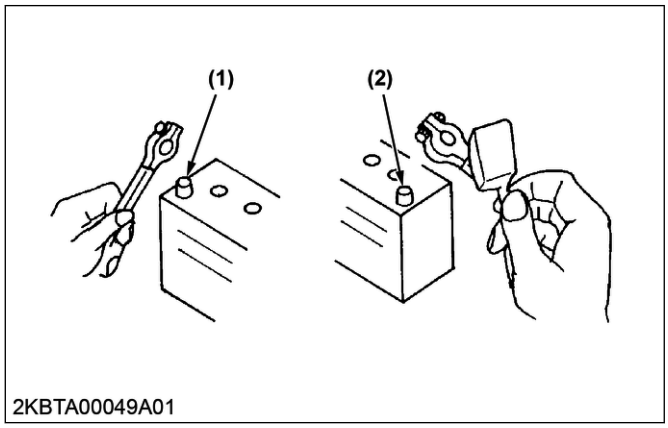



(1) Packing
(2) Metal ring
(3) Spring
(4) Seal lip
(5) Grease
(6) Dust lip
(A) Air side
(B) Oil side

# 7. Handling the battery

**CAUTION**
- **When removing battery cables, disconnect negative (-) terminal first.**
- **When installing battery cables, connect positive (+) terminal first.**

- Do not install any battery with a capacity (Ah) other than is specified.
- Securely attach the terminal covers on the cables when connecting the cables to the battery terminal posts. There is a danger of short-circuiting if the tip of the cables attached to the battery terminal post is exposed.
- Do not allow dirt and dust to collect on the battery.
- Connect the battery terminals after removing dust, old grease, blue rust and others.
- Apply conductive grease thinly to the battery terminal posts to prevent corrosion.

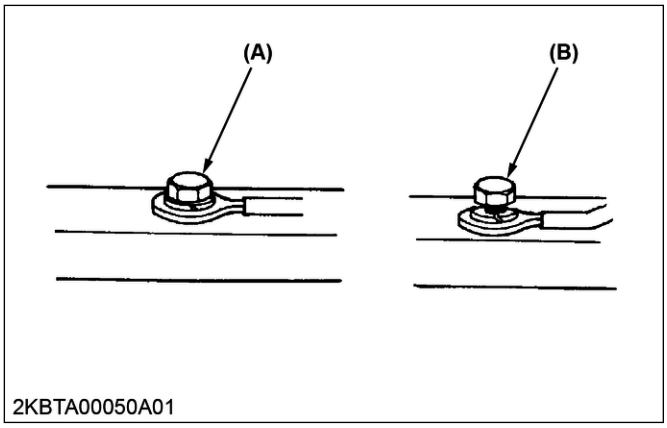



(1) Battery negative (-) terminal
(2) Battery positive (+) terminal

# 8. Handling wire harness

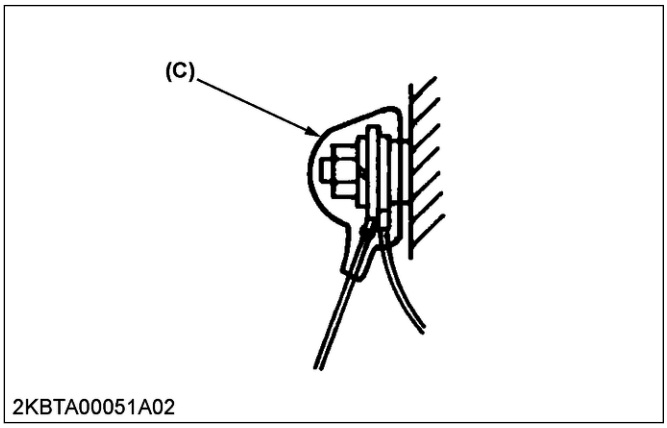
**CAUTION**
- **Do not let an unprotected wire harness to come in contact with other components.**
- **Do not clamp the wire harness to fuel hoses.**
- **If the wire harness is damaged, replace it immediately with a new one.**
- **Do not alter the electrical device and wire harness.**

- Tighten the electrical terminals securely.



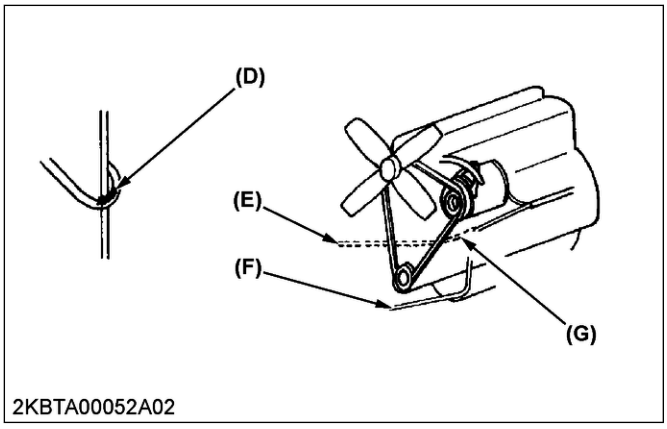

(A) Good (B) Bad: Loose bolt

- Check the electrical terminal protection and clamping conditions before connecting the battery cable.



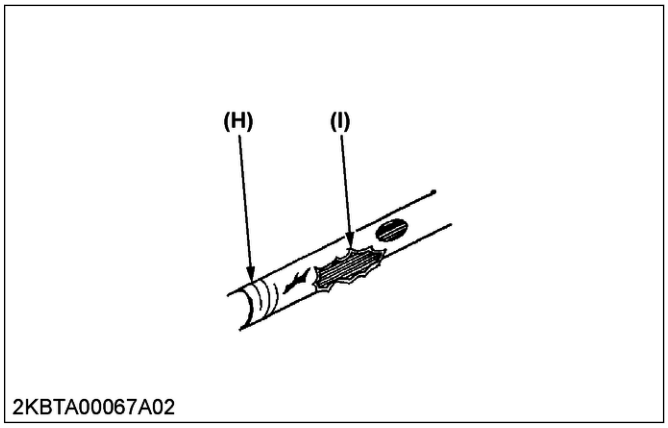

(C) Covered completely with a protection cover

- Keep the wire harness away from hazardous positions such as rotating parts or high-temperature sections.



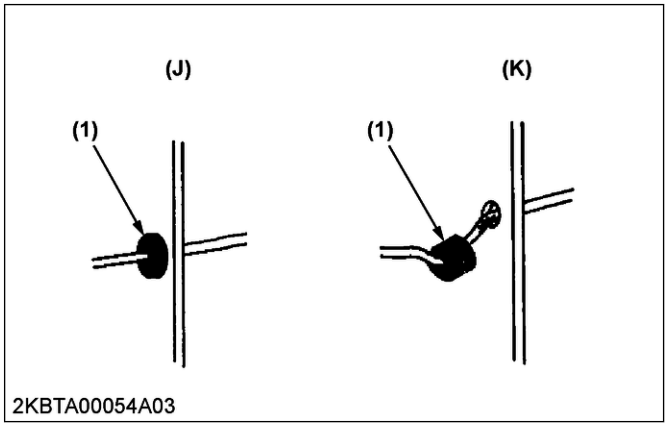

(D) Hazardous position (G) Hazardous position
(E) Wiring position: bad
(F) Wiring position: good

- If wire harness is damaged or degraded, replace immediately.



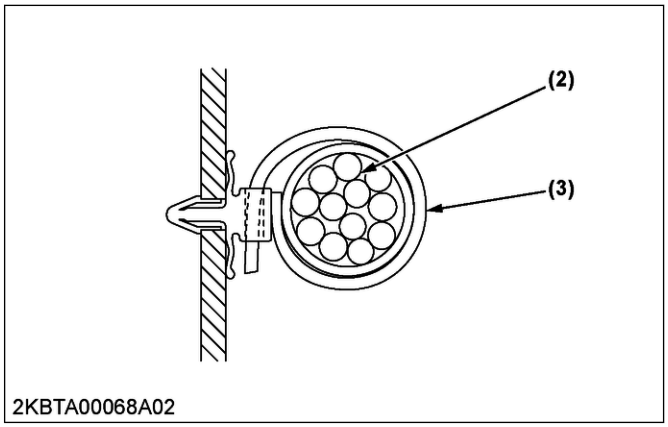

(H) Damaged (I) Torn

- Install the grommet securely.



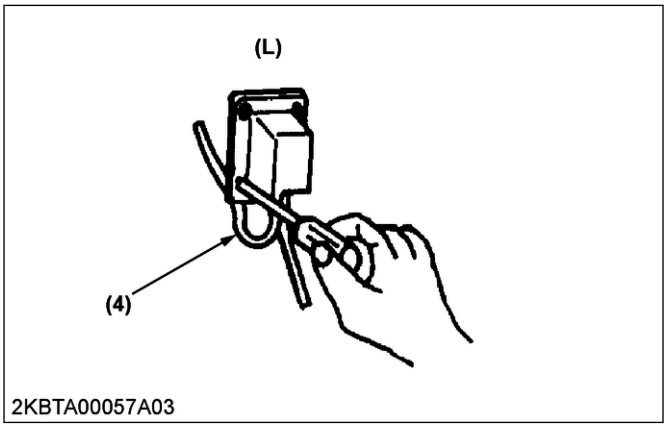

(1) Grommet (K) Bad: poor installation
(J) Good

- Clamp the wire harness securely. Do not damage the wire harness by the clamp.
- Clamp the wire harness correctly. Do not slack, twist, and pull.




(2) Wire harness (3) Clamp

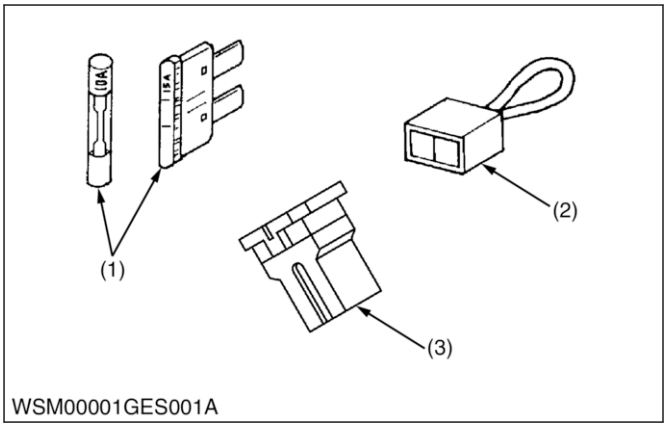
- Do not pinch the wire harness when installing parts.




(4) Wire harness (L) Bad

# 9. Handling fuses

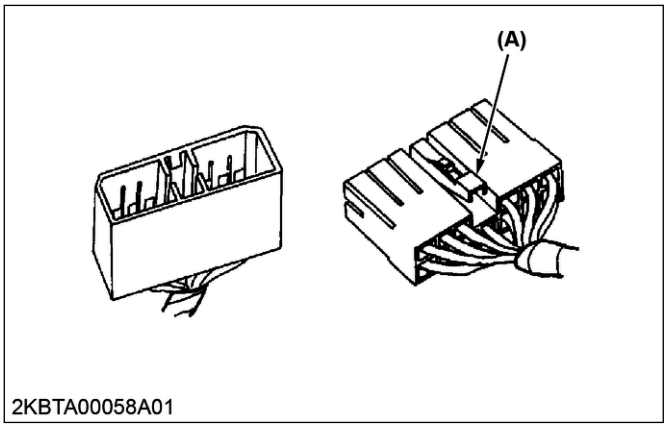
- Always use fuses of the specified capacity.
- Do not use steel or copper wiring instead of fuse.
- Do not install work light or radio without auxiliary power line.
- Do not install auxiliaries to the fuses. The fuses may blow.




(1) Fuse (3) Slow blow fuse
(2) Fusible link

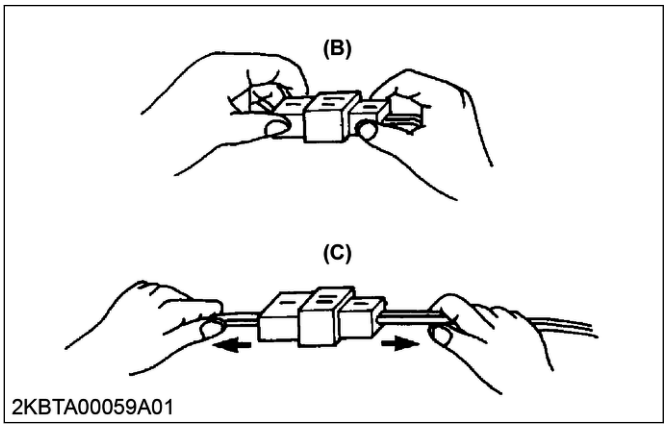
# 10. Handling connectors

- When disconnecting the locking connectors, be sure to disengage the lock before disconnecting. There are two kinds of locks: one requires pressing and the other requires pulling.



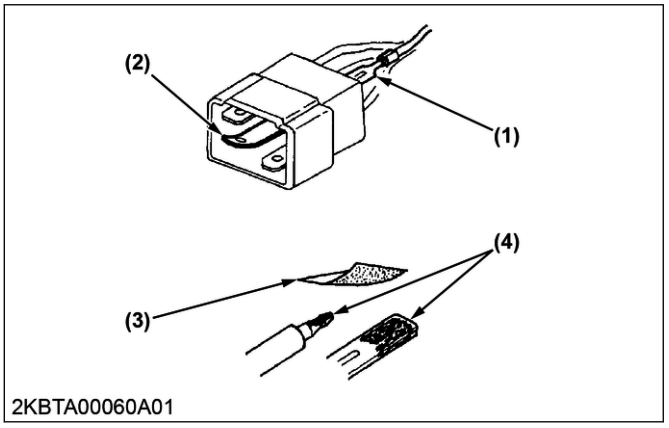

(A) Press

- Hold on tightly to the connectors when disconnecting them.
- Do not pull wire harness itself.




(B) Correct method (C) Incorrect method

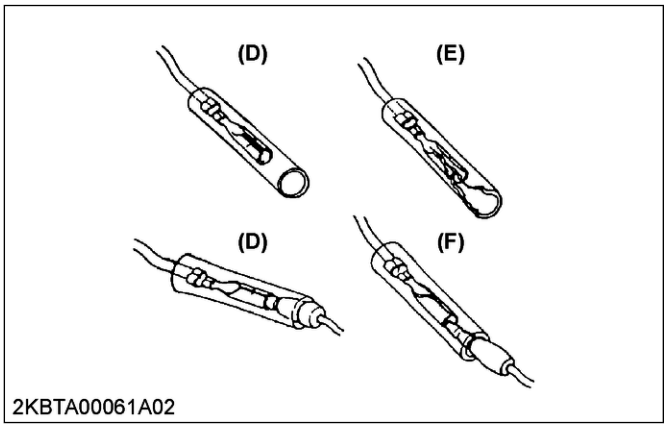
- Make sure the terminal condition of the connectors is not bent, rusty, and so on.
- If the terminal is rusted, remove rust with sandpaper.
  However, do not polish the terminal of the waterproof connector or the plated terminal.




(1) Missing terminal (4) Rust
(2) Bent terminal
(3) Sandpaper

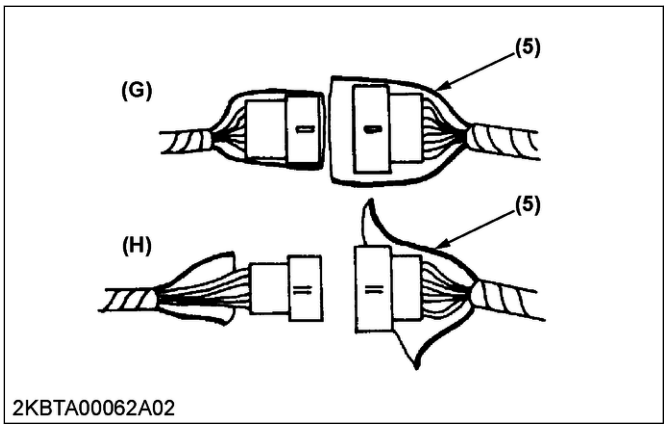
- Cover the female bullet terminals and male bullet terminals securely with the plastic covers.

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




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

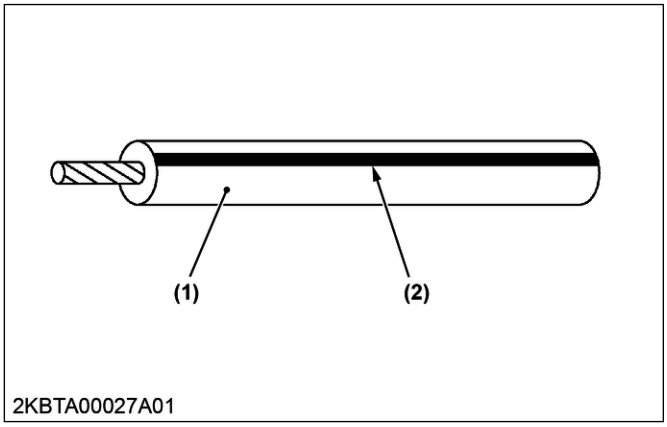
- Cover the female connectors and male connectors securely with the plastic covers.




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

# 11. Wiring color

- Wire colors are specified in the color codes.




(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).

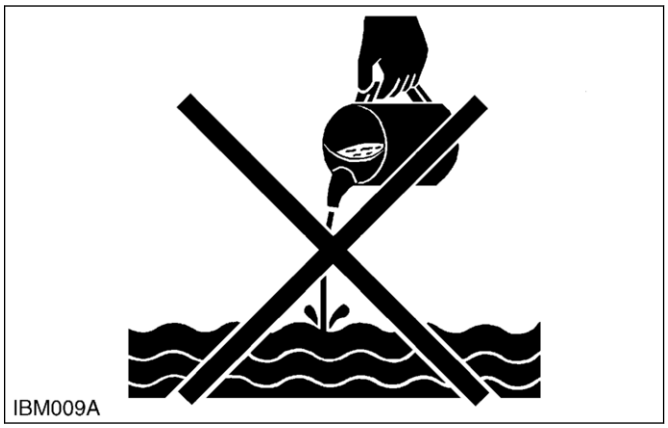
(An example)

**W/R:**

White with red stripe

# 12. Dispose fluids correctly

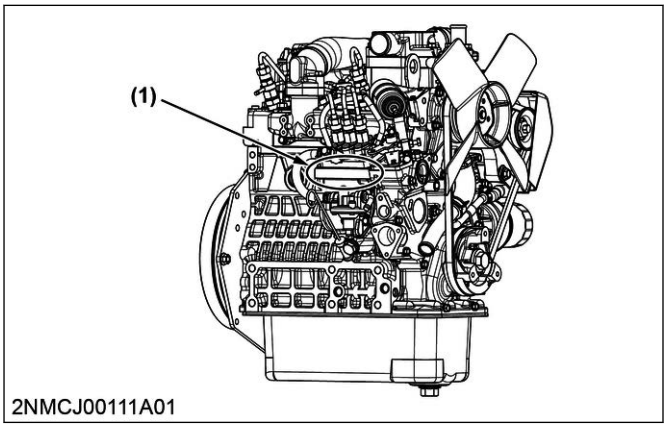
- Do not dispose fluids on the ground, down the drain, into a stream, pond, or lake. Obey related environmental protection regulations when you dispose of oil, fuel, coolant, electrolyte, and other dangerous materials.



# GENERAL MACHINE INFORMATION

## 1. Engine identification

### 1.1 Engine model name and engine serial number




(1) Engine model name and serial number

You must identify the engine model name and serial number before you start a job.
When you get in touch with the manufacturer, always tell your engine model name and serial number.

**Engine serial number**

The engine serial number is an identified number for the engine.
It appears after the engine model name.
It shows the month and year of manufacture as below.

**Engine series**

| Number or alphabet | Series |
|---|---|
| 1 | 05 (include: WG) |
| 2 | V3 (include: WG) |
| 3 | 08 |
| 4 | SM (include: WG) |
| 5 | Air cooled gasoline |
| 6 | GZ, OC, AC, EA, E |
| 7 | 03 (include: WG) |
| 8 | 07 |
| A | Diesel engine (PTKI production) |
| B | 03 (KET production) |
| C | V3, 07 (KEW production) |
| D | 08 (KEW production) |
| E | Gasoline engine (PTKI production) |
| F | 05 (CRS) |
| G | 09 |

### Production year

| Alphabet or number | Year |
|---|---|
| 1 | 2001 |
| 2 | 2002 |
| 3 | 2003 |
| 4 | 2004 |
| 5 | 2005 |
| 6 | 2006 |
| 7 | 2007 |
| 8 | 2008 |
| 9 | 2009 |
| A | 2010 |
| B | 2011 |
| C | 2012 |
| D | 2013 |
| E | 2014 |
| F | 2015 |
| G | 2016 |
| H | 2017 |
| J | 2018 |
| K | 2019 |
| L | 2020 |
| M | 2021 |
| N | 2022 |
| P | 2023 |
| R | 2024 |
| S | 2025 |
| T | 2026 |
| V | 2027 |

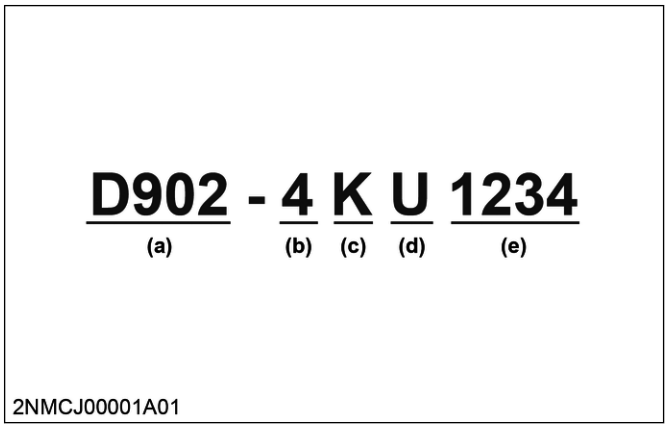
* Alphabetical letters "I" and "O" are not used.

### Production month and lot number

| Month | Engine lot number | |
|---|---|---|
| January | A0001～A9999 | B0001～ |
| February | C0001～C9999 | D0001～ |
| March | E0001～E9999 | F0001～ |
| April | G0001～G9999 | H0001～ |
| May | J0001～J9999 | K0001～ |
| June | L0001～L9999 | M0001～ |
| July | N0001～N9999 | P0001～ |
| August | Q0001～Q9999 | R0001～ |
| September | S0001～S9999 | T0001～ |
| October | U0001～U9999 | V0001～ |
| November | W0001～W9999 | X0001～ |
| December | Y0001～Y9999 | Z0001～ |

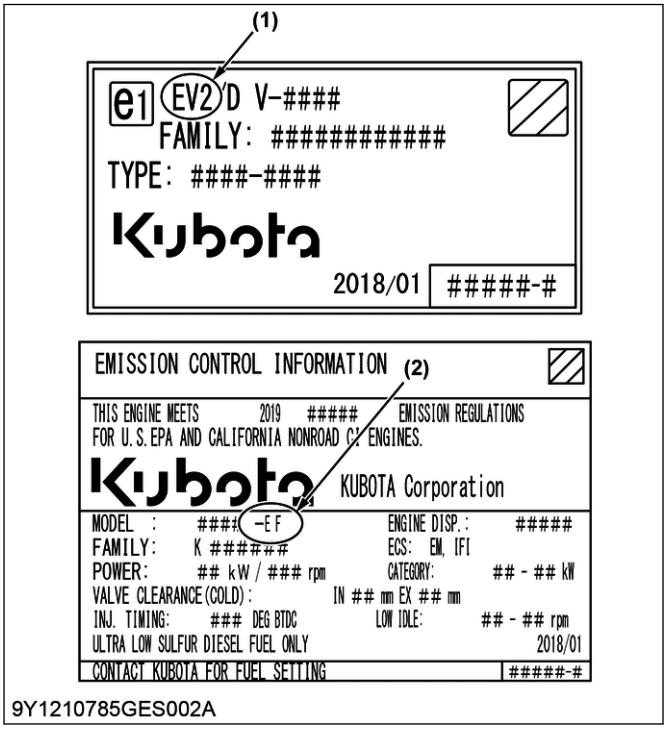
* Alphabetical letters "I" and "O" are not used.

### Example of model name and engine serial number




(a) D902: Engine model name
(b) 4: Engine series (SM series)
(c) K: Production year (2019)
(d) U: Production month (October)
(e) 0001: Lot number (0001～9999 or A001～Z999)

## 1.2 E4B engine



9Y1210785GES002A

(1) Engine category identification code.

(2) "E4B" engines are identified with "EF" at the end of model designation on the US EPA label.
"E4B" designates some Interim Tier 4 / Tier 4 models according to engine output classification.

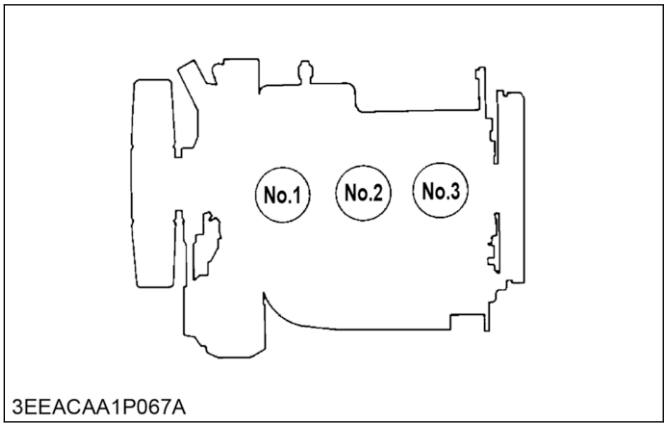
| Category (1) | Engine output classification | EU regulation |
|---|---|---|
| EV1 | Less than 8 kW | STAGE V |
| EV2 | From 8 to less than 19 kW | STAGE V |

| Category (2) | Engine output classification | EPA regulation |
|---|---|---|
| EF | Less than 19 kW | Tier 4 |

The emission controls previously implemented in various countries to prevent air pollution will be stepped up as nonroad Emission Standards and continue to change. The timing or applicable date of the specific nonroad Emission regulations depends on the engine output classification.
Over the past several years, Kubota has been supplying diesel engines that comply with regulations in the respective countries affected by nonroad Emission regulations. For Kubota Engines, E4B will be the designation that identifies engine models affected by the next emission phase (See the table above).
When servicing or repairing ###-E4B series of engines, use replacement parts only for that specific E4B engine designated by the appropriate E4B Kubota Parts List, and perform all the maintenance services listed in the appropriate Kubota Operator's Manual or the appropriate E4B Kubota Workshop Manual. Use of incorrect replacement parts or those replacement parts for other emission level engines (for example: E3B engines), might result in emission levels out of compliance with the original E4B design and EPA or other applicable regulations. Please refer to the emission label located on the engine head cover to identify the engine's output classification and emission control information. E4B engines are identified with "EF" at the end of the Model designation on the US EPA label. Please note: E4B is not marked on the engine.

Example: Engine model name D902-TE4B-XXXX

## 1.3 Cylinder number



3EEACAA1P067A

The cylinder numbers of Kubota diesel engines are designated as shown in the figure. The sequence of cylinder numbers is given as No.1, No.2, and No.3, and it starts from the gear case cover side.

# 2. Specifications

## 2.1 Specification for Z482-E4 Z482-E4BG

| Model | | Z482-E4 | Z482-E4BG | |
|---|---|---|---|---|
| | | | BG | BG2 |
| Number of cylinder | | 2 | | |
| Type | | Vertical, Water-cooled, 4 cycle IDI diesel engine | | |
| Bore × stroke | | 67.0 × 68.0 mm (2.64 × 2.68 in.) | | |
| Total displacement | | 479.0 $cm^3$ (29.23 cu.in.) | | |
| SAE net continuous | | 8.10 kW/3600 $min^{-1}$ (rpm)<br>(10.9 HP/3600 $min^{-1}$ (rpm)) | 3.80 kW/1800 $min^{-1}$ (rpm)<br>(5.10 HP/1800 $min^{-1}$ (rpm)) | 3.00 kW/1500 $min^{-1}$ (rpm)<br>(4.03 HP/1500 $min^{-1}$ (rpm)) |
| SAE net intermittent | | 9.30 kW/3600 $min^{-1}$ (rpm)<br>(12.5 HP/3600 $min^{-1}$ (rpm)) | - | - |
| SAE gross intermittent | | 9.90 kW/3600 $min^{-1}$ (rpm)<br>(13.3 HP/3600 $min^{-1}$ (rpm)) | - | - |
| STAND BY SAE J-1349 | | - | 4.20 kW/1800 $min^{-1}$ (rpm)<br>(5.63 HP/1800 $min^{-1}$ (rpm)) | 3.20 kW/1500 $min^{-1}$ (rpm)<br>(4.29 HP/1500 $min^{-1}$ (rpm)) |
| Maximum bare speed | | 3800 $min^{-1}$ (rpm) | 2190 $min^{-1}$ (rpm) | 2000 $min^{-1}$ (rpm) |
| Minimum bare idling speed | | 1250 to 1350 $min^{-1}$ (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 | | 0.3316 rad (19.00°) before T.D.C. | 0.2836 rad (16.25°) before T.D.C. | 0.2583 rad (14.80°) before T.D.C. |
| Firing order | | 1-2 | | |
| Injection pressure | | 13.73 MPa (140.0 $kgf/cm^2$, 1991 psi) | | |
| Compression ratio | | 23.5 : 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, 0.8 kW | | |
| Starting support device | | By glow plug in combustion chamber | | |
| Battery | | 12 V, 28 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.<br>For details on recommended lubricating oils, see page 3-1. | | |
| Lubricating oil capacity | Oil pan depth 101 mm (3.98 in.) | 2.1 L (0.55 U.S.gals) | | |

(Continued)

| Model | | Z482-E4 | Z482-E4BG | |
|---|---|---|---|---|
| | | | BG | BG2 |
| Lubricating oil capacity | Oil pan depth 121 mm (4.76 in.) | 2.5 L (0.66 U.S.gals) | | |
| Weight (Dry) | | 53.1 kg (117 lbs) | 81.0 kg (179 lbs) | |

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

# 2.2 Specification for Z602-E4

| Model | | Z602-E4 |
|---|---|---|
| Number of cylinder | | 2 |
| Type | | Vertical, Water-cooled, 4 cycle IDI diesel engine |
| Bore × stroke | | 72.0 × 73.6 mm (2.83 × 2.90 in.) |
| Total displacement | | 599.0 $cm^3$ (36.55 cu.in.) |
| SAE net continuous | | 10.1 kW/3600 $min^{-1}$ (rpm)<br>(13.5 HP/3600 $min^{-1}$ (rpm)) |
| SAE net intermittent | | 11.6 kW/3600 $min^{-1}$ (rpm)<br>(15.5 HP/3600 $min^{-1}$ (rpm)) |
| SAE gross intermittent | | 12.5 kW/3600 $min^{-1}$ (rpm)<br>(16.8 HP/3600 $min^{-1}$ (rpm)) |
| Maximum bare speed | | 3850 $min^{-1}$ (rpm) |
| Minimum bare idling speed | | 1050 to 1150 $min^{-1}$ (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 | | 0.33 rad (19 °) before T.D.C. |
| Firing order | | 1-2 |
| 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, 480 W |
| Fuel | | Diesel fuel No. 2-D, see page 3-1. |
| Lubricating oil | | Class CF lubricating oil as per API classification is recommended.<br>For details on recommended lubricating oils, see page 3-1. |
| Lubricating oil capacity | Oil pan depth 101 mm (3.98 in.) | 2.5 L (0.66 U.S.gals) |
| | Oil pan depth 121 mm (4.76 in.) | — |
| Weight (Dry) | | 57.0 kg (125.7 lbs) |

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

# 2.3 Specification for D722-E4

| Model | | D722-E4 |
|---|---|---|
| Number of cylinder | | 3 |
| Type | | Vertical, Water-cooled, 4 cycle IDI diesel engine |
| Bore × stroke | | 67.0 × 68.0 mm (2.64 × 2.68 in.) |
| Total displacement | | 719.0 $cm^3$ (43.88 cu.in.) |
| ISO net continuous | | 12.2 kW/3600 $min^{-1}$ (rpm)<br>(16.3 HP/3600 $min^{-1}$ (rpm)) |
| ISO/SAE net intermittent | | 14.0 kW/3600 $min^{-1}$ (rpm)<br>(18.8 HP/3600 $min^{-1}$ (rpm)) |
| SAE gross intermittent | | 14.9 kW/3600 $min^{-1}$ (rpm)<br>(20.0 HP/3600 $min^{-1}$ (rpm)) |
| Maximum bare speed | | 3800 $min^{-1}$ (rpm) |
| Minimum bare idling speed | | 1250 to 1350 $min^{-1}$ (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 | | 0.35 rad (20°) before T.D.C. |
| Firing order | | 1-2-3 |
| Injection pressure | | 13.73 MPa (140.0 $kgf/cm^2$, 1991 psi) |
| Compression ratio | | 23.5 : 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.<br>For details on recommended lubricating oils, see page 3-1 |
| Lubricating oil capacity | Oil pan depth<br>101 mm (3.98 in.) | 3.2 L (0.85 U.S.gals) |
| | Oil pan depth<br>121 mm (4.76 in.) | 3.8 L (1.0 U.S.gals) |
| Weight (Dry) | | 63.1 kg (139.1 lbs) |

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

# 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)<br>(16.0 HP/3200 $min^{-1}$ (rpm)) |
| SAE net intermittent | | 13.5 kW/3200 $min^{-1}$ (rpm)<br>(18.1 HP/3200 $min^{-1}$ (rpm)) |
| SAE gross intermittent | | 14.4 kW/3200 $min^{-1}$ (rpm)<br>(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.<br>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**

# 2.5 Specification for D902-E4

| Model | | D902-E4 |
|---|---|---|
| Number of cylinder | | 3 |
| Engine type | | Vertical, Water-cooled, 4 cycle IDI diesel engine |
| Bore × stroke | | 72.0 × 73.6 mm (2.83 × 2.90 in.) |
| Total displacement | | 898.0 $cm^3$ (54.80 cu.in.) |
| SAE net continuous | | 15.2 kW/3600 $min^{-1}$ (rpm)<br>(20.4 HP/3600 $min^{-1}$ (rpm)) |
| SAE net intermittent | | 17.5 kW/3600 $min^{-1}$ (rpm)<br>(23.5 HP/3600 $min^{-1}$ (rpm)) |
| SAE gross intermittent | | 18.5 kW/3600 $min^{-1}$ (rpm)<br>(24.8 HP/3600 $min^{-1}$ (rpm)) |
| Maximum bare speed | | 3850 $min^{-1}$ (rpm) |
| Minimum bare idling speed | | 900 to 1000 $min^{-1}$ (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 | | 0.331 rad (19°) before T.D.C. |
| Firing order | | 1-2-3 |
| 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, 1.2 kW |
| Starting support device | | By glow plug in combustion chamber |
| Battery | | 12 V, 52 AH equivalent |
| Charging alternator | | 12 V, 480 W |
| Fuel | | Diesel fuel No. 2-D, see page 3-1. |
| Lubricating oil | | Class CF lubricating oil as per API classification is recommended.<br>For details on recommended lubricating oils, see page 3-1 |
| Lubricating oil capacity | Oil pan depth<br>101 mm (3.98 in.) | 3.7 L (0.98 U.S.gals) |
| | Oil pan depth<br>121 mm (4.76 in.) | — |
| Weight (Dry) | | 72.0 kg (159 lbs) |

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

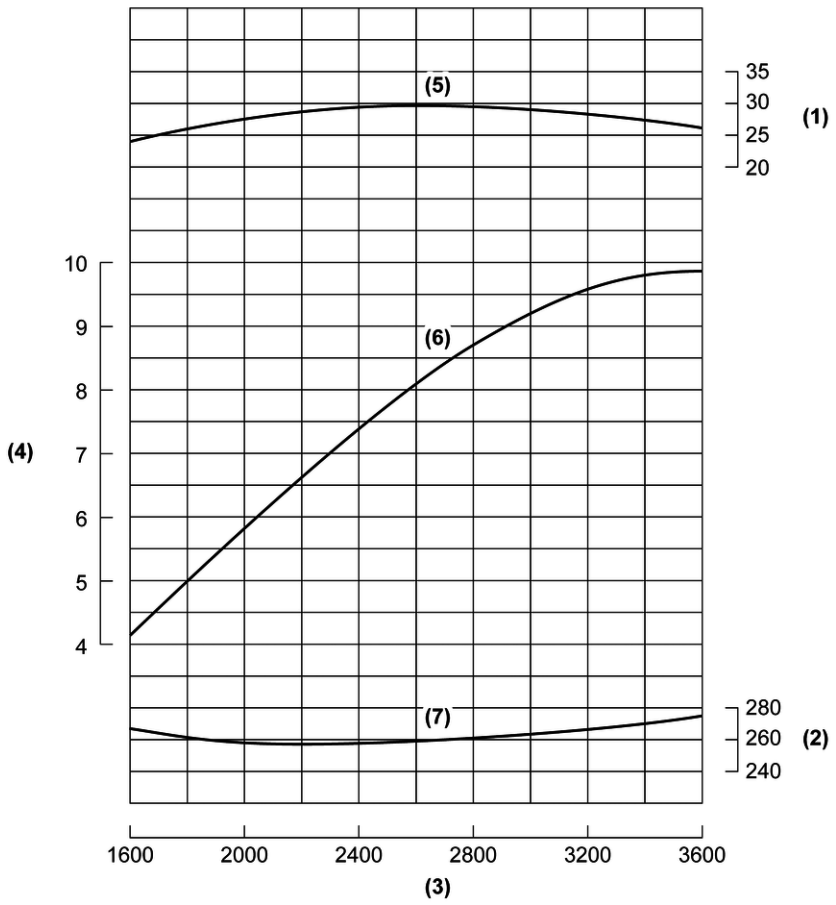
# 2.6 Specification for D902-TE4

| Model | D902-TE4 |
|---|---|
| Number of cylinders | 3 |
| Engine type | Vertical, water-cooled, 4-cycle diesel |
| Bore × Stroke | 72.0 × 73.6 mm (2.83 × 2.90 in.) |
| Total displacement | 898.0 $cm^3$ (54.80 cu.in.) |
| SAE net continuous | 16.1 kW/3200 $min^{-1}$ (rpm)<br>(21.6 HP/3200 $min^{-1}$ (rpm)) |
| SAE net intermittent | 17.7 kW/3200 $min^{-1}$ (rpm)<br>(23.7 HP/3200 $min^{-1}$ (rpm)) |
| SAE gross intermittent | 18.5 kW/3200 $min^{-1}$ (rpm)<br>(24.8 HP/3200 $min^{-1}$ (rpm)) |
| Maximum bare speed | 3530 $min^{-1}$ (rpm) |
| Minimum bare idling speed | 1300 to 1400 $min^{-1}$ (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 | DN4PD mini nozzle |
| Injection timing | 0.35 rad (20.0°) before T.D.C. |
| Firing order | 1-2-3 |
| Fuel injection pressure | 13.7 MPa (140 $kgf/cm^2$, 1990 psi) |
| Compression ratio | 23.0 |
| 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 |
| Starting system | Cell starter (with glow plug) |
| Starter motor | 12 V, 1.2 kW |
| Starting support device | By glow plug in combustion chamber |
| Battery | 12 V, 55 AH, equivalent |
| Charging alternator | 12 V, 480 W |
| Fuel | Diesel fuel No. 2-D, see page 3-1. |
| Lubricating oil (API classification) | Above CF<br>For details on recommended lubricating oils, see page 3-1. |
| Lubricating oil capacity | 3.7 L (0.98 U.S.gals, 0.81 Imp.gals) |
| Weight (Dry) | 75 kg (170 lbs) |

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

# 3. Performance curves

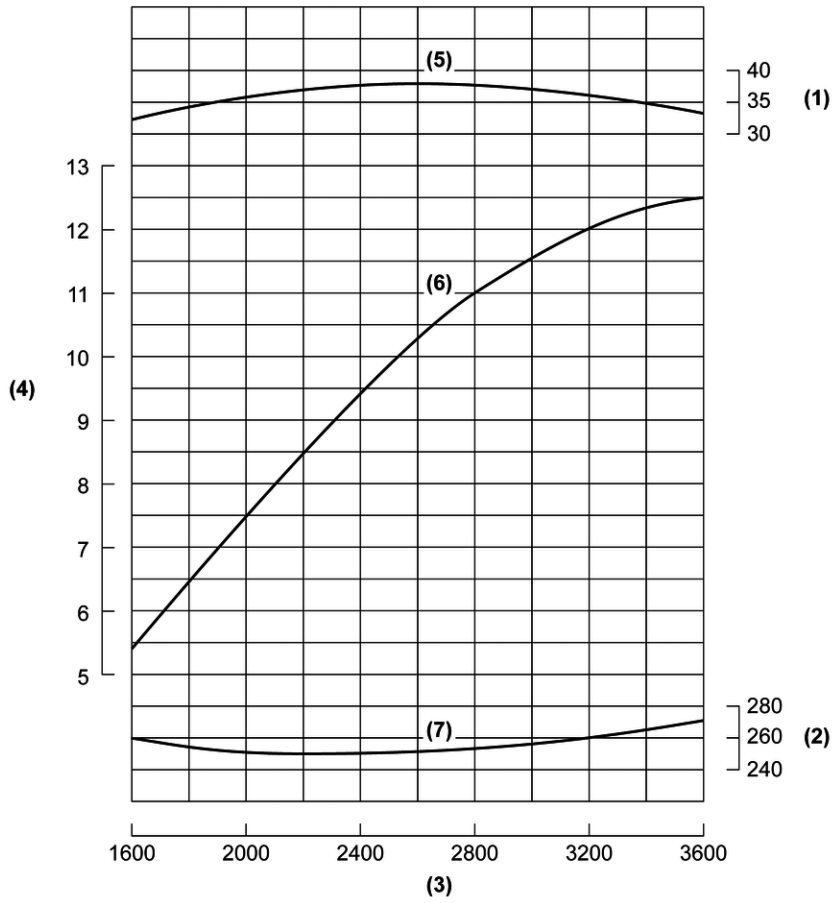
## 3.1 Performance curves for Z482-E4




2NMCJ00122A01

(1) Torque (N·m)
(2) Brake specific fuel consumption (B.S.F.C.) (G/kWh)
(3) Engine speed (rpm)
(4) Brake horsepower (kW)
(5) Gross intermittent torque
(6) Gross intermittent brake horsepower
(7) Gross intermittent B.S.F.C.

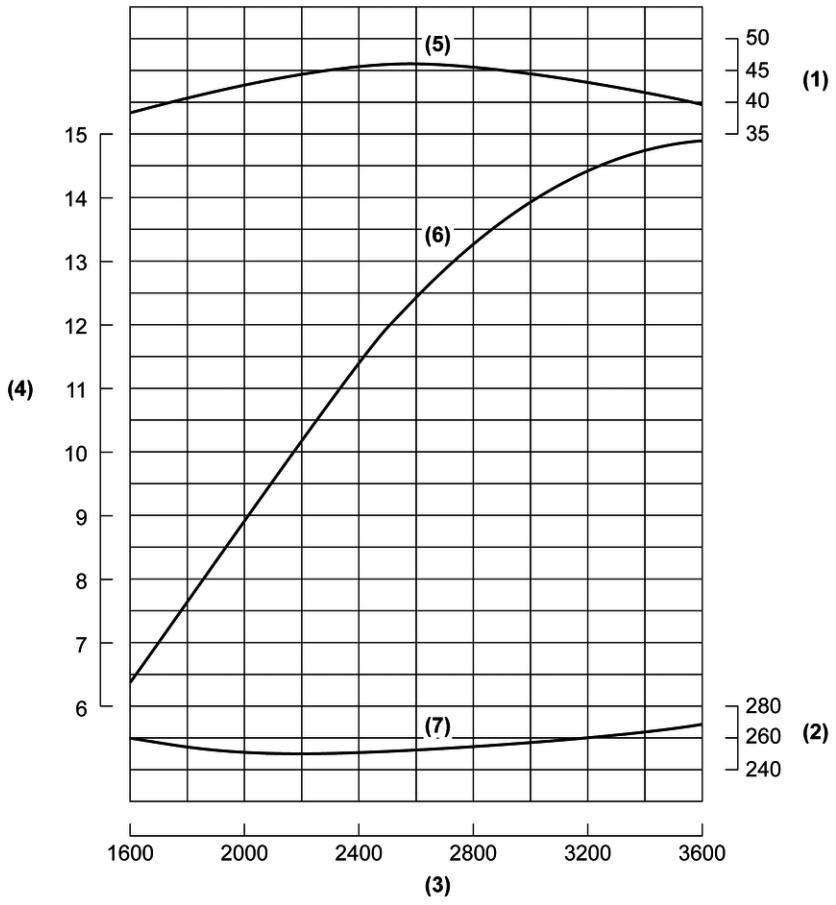
## 3.2 Performance curves for Z602-E4




2NMCJ00120A01

(1) Torque (N·m)
(2) Brake specific fuel consumption (B.S.F.C.) (G/kWh)
(3) Engine speed (rpm)
(4) Brake horsepower (kW)
(5) Gross intermittent torque
(6) Gross intermittent brake horsepower
(7) Gross intermittent B.S.F.C.

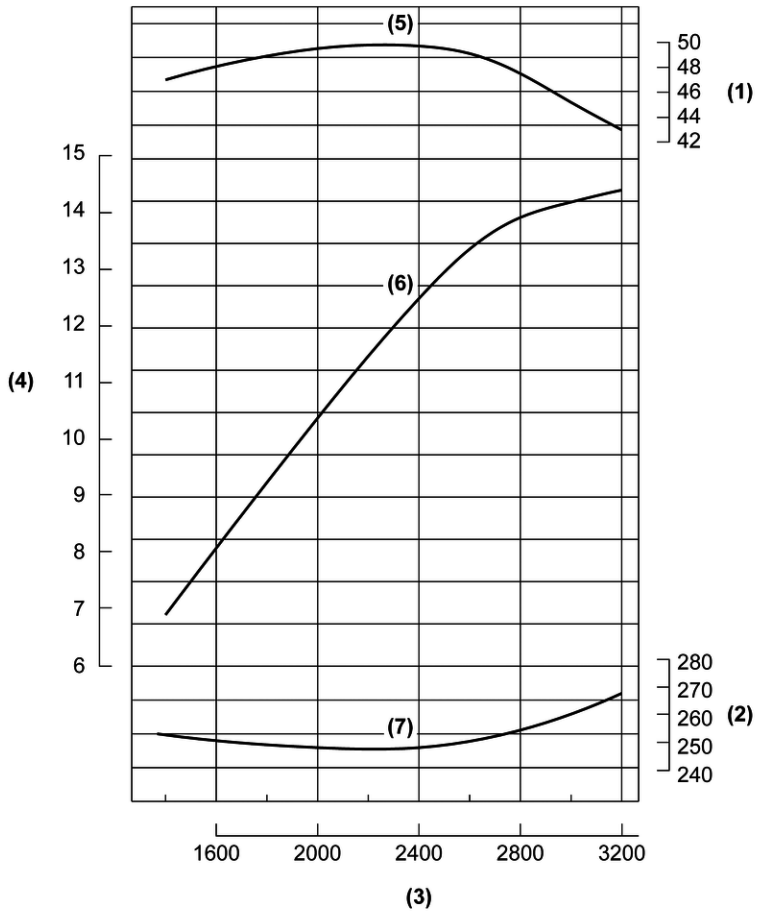
# 3.3 Performance curves for D722-E4




2NMCJ00118A01

(1) Torque (N·m)
(2) Brake specific fuel consumption (B.S.F.C.) (G/kWh)
(3) Engine speed (rpm)
(4) Brake horsepower (kW)
(5) Gross intermittent torque
(6) Gross intermittent brake horsepower
(7) Gross intermittent B.S.F.C.

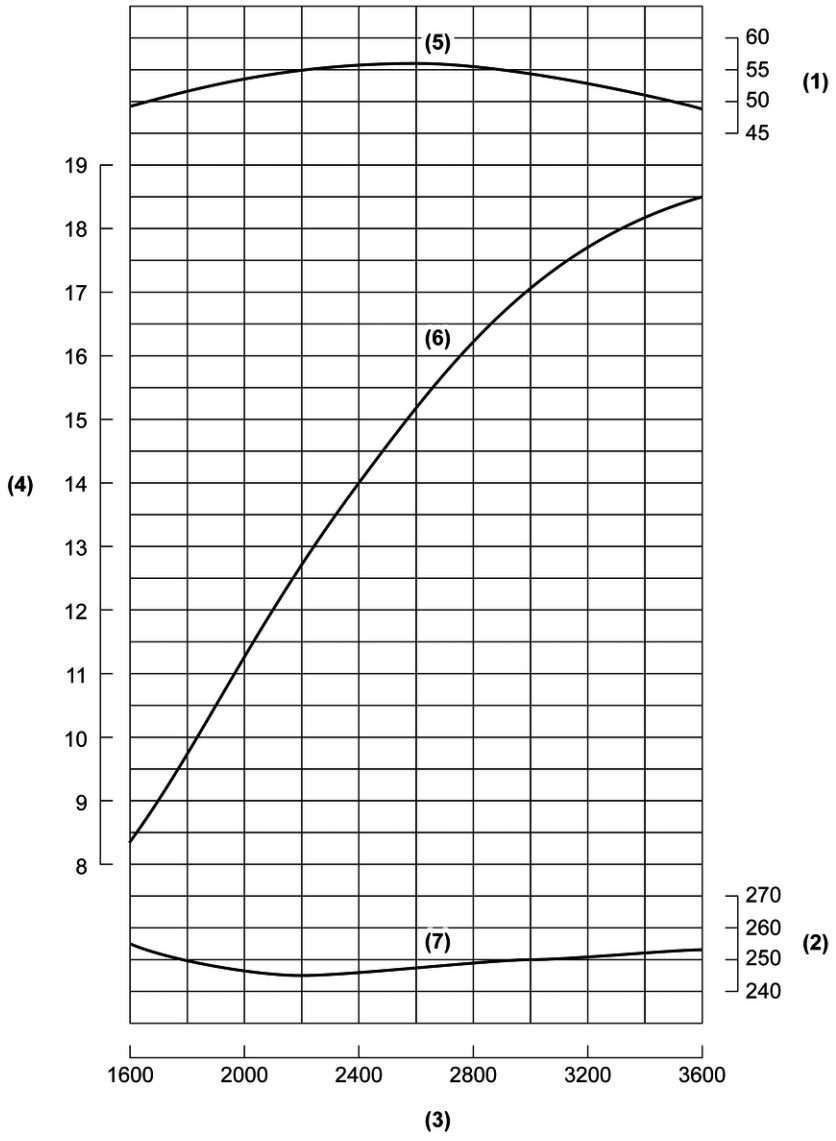
# 3.4 Performance curves for D782-E4




2NMCJ00124A01

(1) Torque (N·m)
(2) Brake specific fuel consumption (B.S.F.C.) (G/kWh)
(3) Engine speed (rpm)
(4) Brake horsepower (kW)
(5) Gross intermittent torque
(6) Gross intermittent brake horsepower
(7) Gross intermittent B.S.F.C.

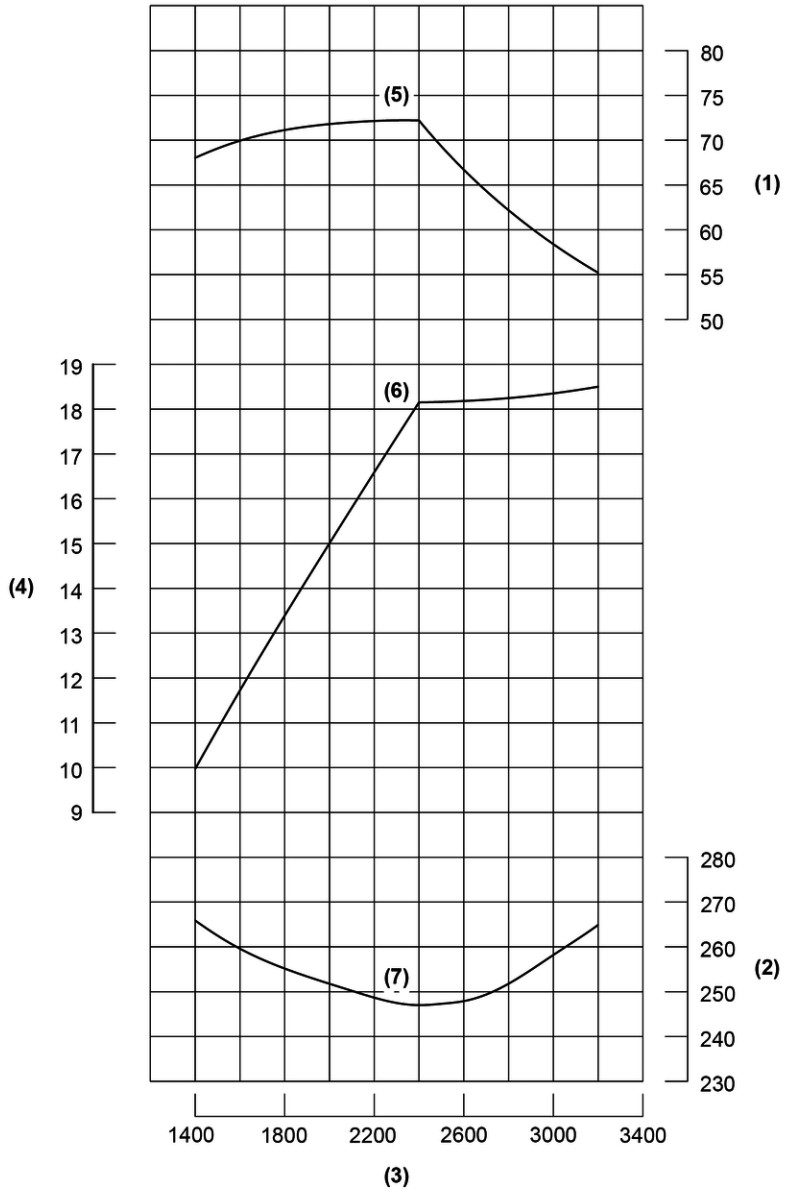
# 3.5 Performance curves for D902-E4




2NMCJ00114A01

(1) Torque (N·m)
(2) Brake specific fuel consumption (B.S.F.C.) (G/kWh)
(3) Engine speed (rpm)
(4) Brake horsepower (kW)
(5) Gross intermittent torque
(6) Gross intermittent brake horsepower
(7) Gross intermittent B.S.F.C.

# 3.6 Performance curves for D902-TE4



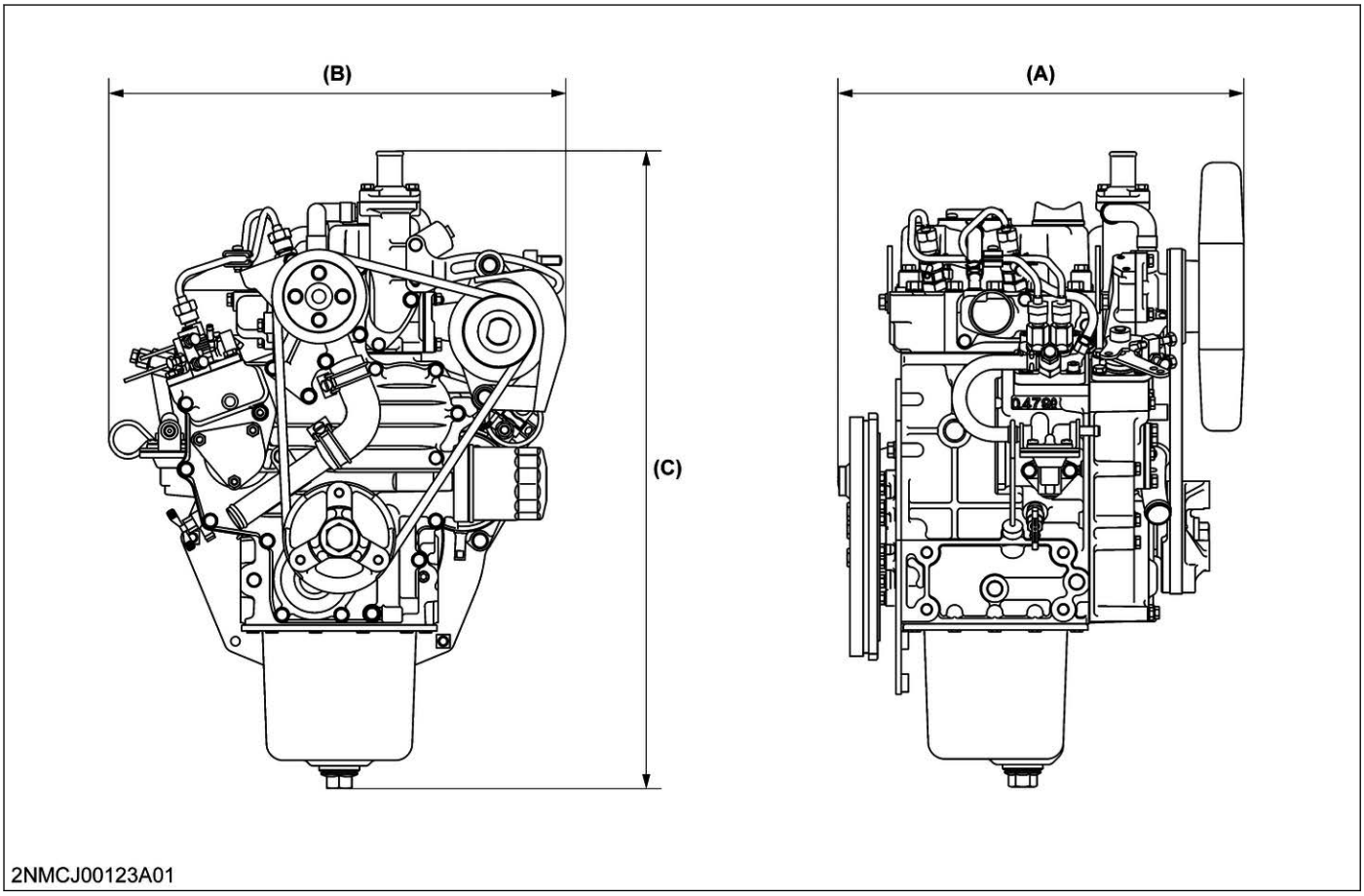

2NMCJ00002A02

(1) Torque (N·m)
(2) Brake specific fuel consumption (B.S.F.C.) (G/kWh)
(3) Engine speed (rpm)
(4) Brake horsepower (kW)
(5) Gross intermittent torque
(6) Gross intermittent brake horsepower
(7) Gross intermittent B.S.F.C.

# 4. Dimensions

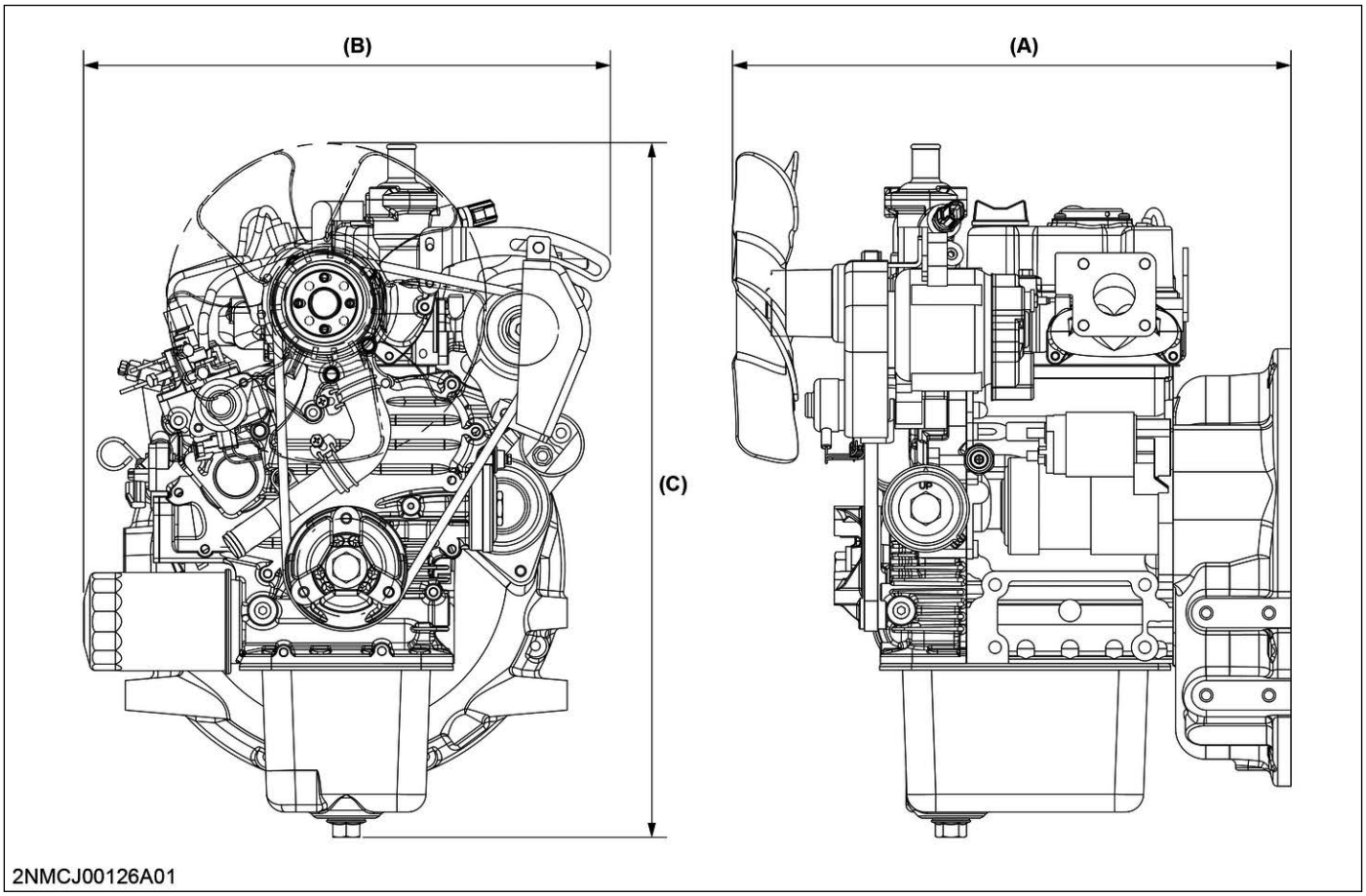
## 4.1 Dimension for Z482-E4 Z482-E4BG

**Z482-E4**



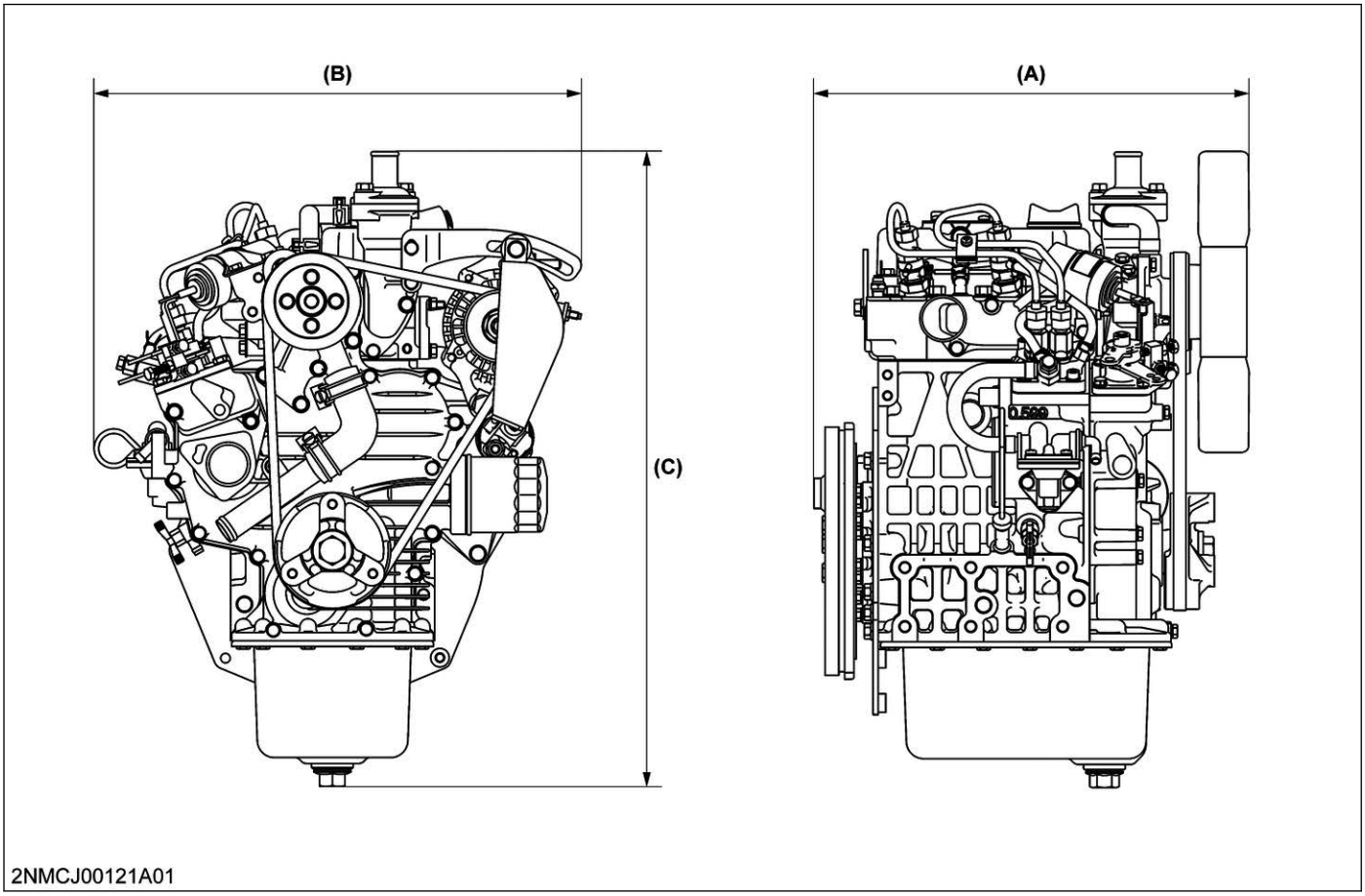

| | Z482-E4 |
|---|---|
| (A) | 360.6 mm (14.20 in.) |
| (B) | 404.0 mm (15.91 in.) |
| (C) | 564.1 mm (22.21 in.) |

## Z482-E4BG



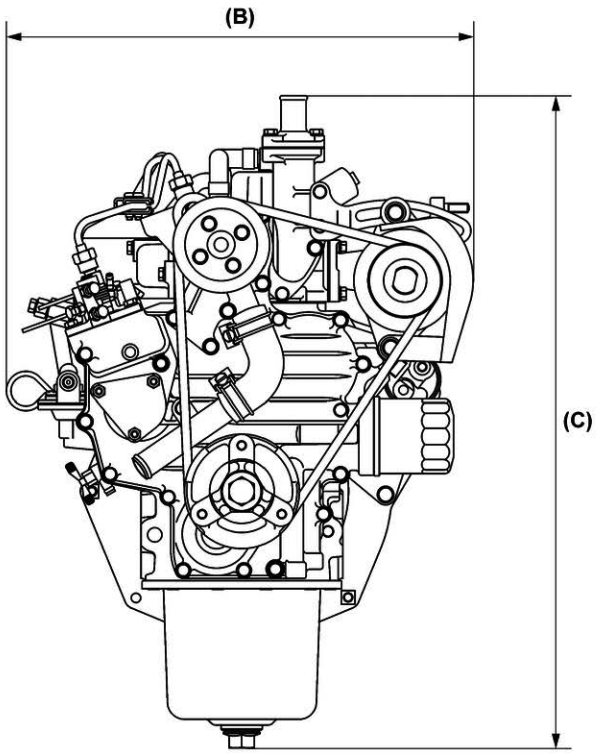

| | Z482-E4BG |
|---|---|
| (A) | 454.9 mm (17.91 in.) |
| (B) | 428.9 mm (16.89 in.) |
| (C) | 564.0 mm (22.20 in.) |

# 4.2 Dimension for Z602-E4




| | Z602-E4 |
|---|---|
| (A) | 382.6 mm (15.06 in.) |
| (B) | 420.5 mm (16.56 in.) |
| (C) | 544.1 mm (21.42 in.) |

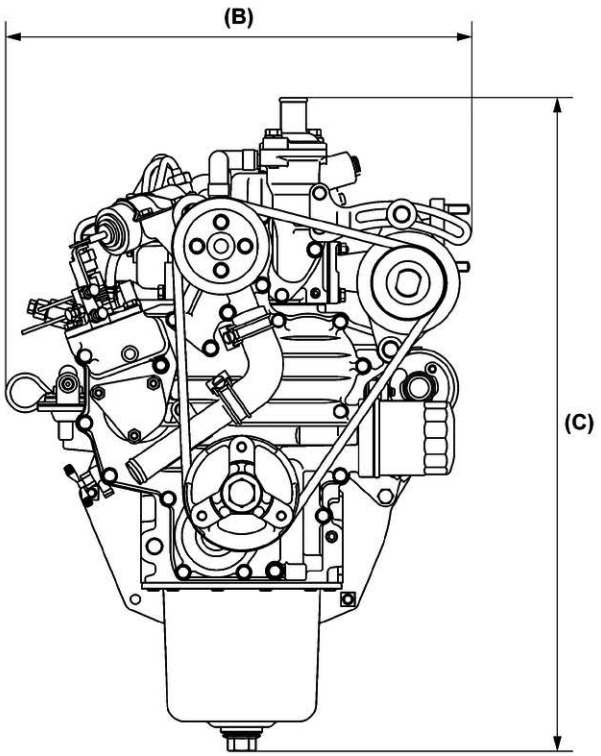
# 4.3 Dimensions for D722-E4

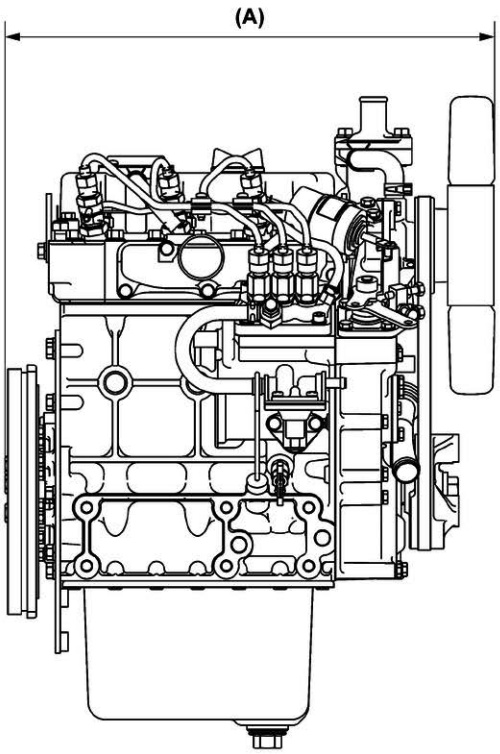



2NMCJ00119A01

| | D722-E4 |
|---|---|
| (A) | 435.1 mm (17.13 in.) |
| (B) | 404.0 mm (15.91 in.) |
| (C) | 564.1 mm (22.21 in.) |

# 4.4 Dimension for D782-E4

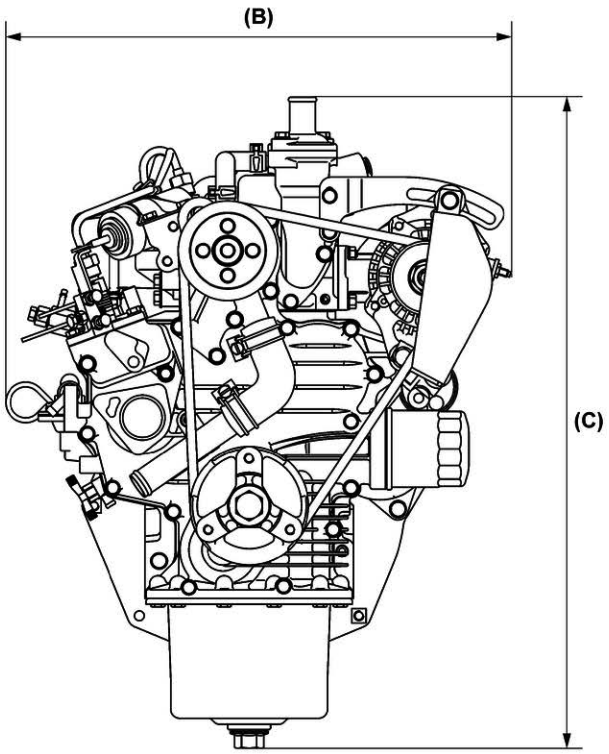



2NMCJ00117A01

| | D782-E4 |
|---|---|
| (A) | 427.7 mm (16.84 in.) |
| (B) | 404.0 mm (15.91 in.) |
| (C) | 564.1 mm (22.21 in.) |

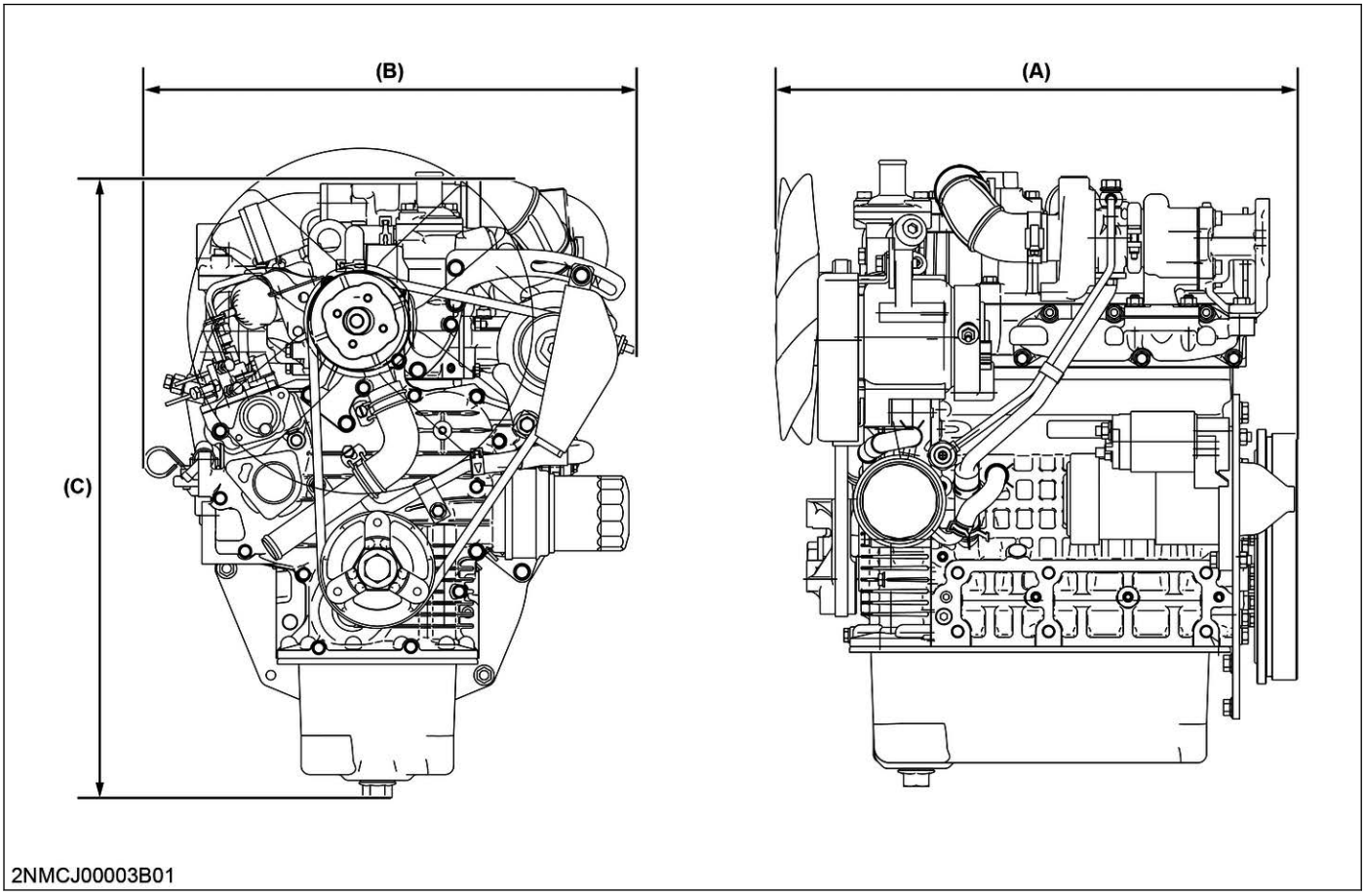
# 4.5 Dimension for D902-E4




2NMCJ00115A01

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

# 4.6 Dimension for D902-TE4




| | D902-TE4 |
|---|---|
| (A) | 453 mm (17.8 in.) |
| (B) | 425 mm (16.7 in.) |
| (C) | 544 mm (21.4 in.) |

# SPECIAL TOOLS

## 1. Diesel engine compression tester

Use for measuring the diesel engine compression.
**Code No.**
07909-30208 (Assembly)

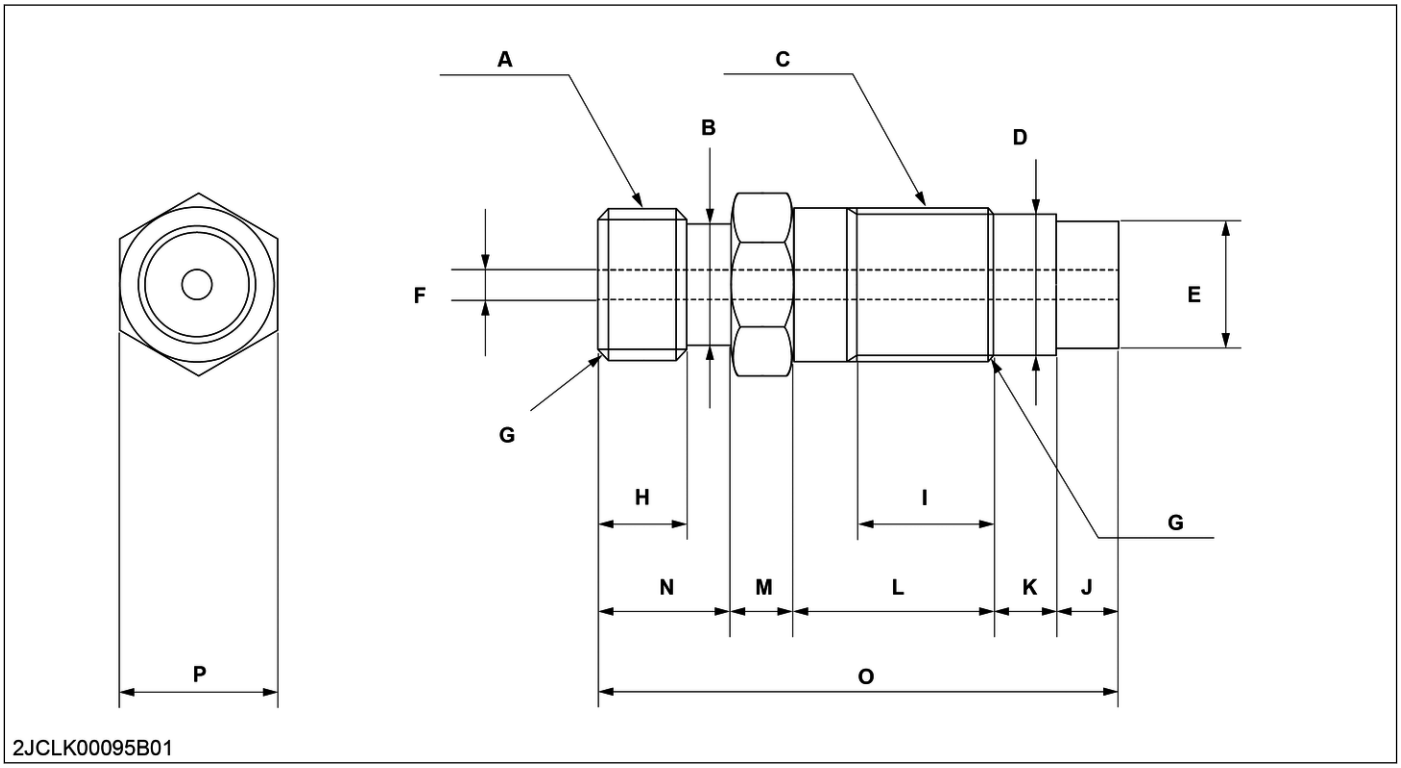

(1) Gauge

# 2. Compression tester adapter H

Use for measuring diesel engine compression pressure from the nozzle hole.

**NOTE**

- **This special tool is not provided, so make it referring to the figure.**

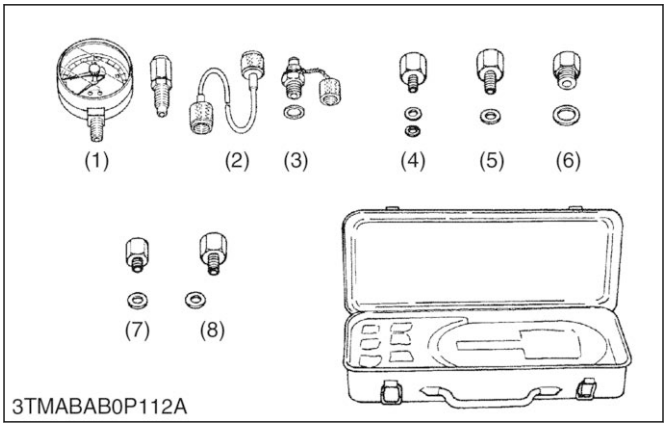



2JCLK00095B01

| | |
|---|---|
| A | 5/8-18UNF |
| B | 13 mm dia. (0.51 in.) |
| C | M20 × 1.5 |
| D | 17.2 to 17.5 mm (0.678 to 0.688 in.) |
| E | 10.8 to 10.9 mm (0.426 to 0.429 in.) |
| F | 3 mm dia. (0.1 in. dia.) |
| G | Chamfer 1 mm (0.04 in.) |
| H | 10 mm (0.39 in.) |
| I | 13 mm (0.51 in.) |
| J | 7 mm (0.3 in.) |
| K | 7 mm (0.3 in.) |
| L | 20 mm (0.79 in.) |
| M | 7 mm (0.3 in.) |
| N | 15 mm (0.59 in.) |
| O | 56 mm (2.2 in.) |
| P | 21 mm (0.83 in.) |
| Material | SS400 |

# 3. Oil pressure tester

Use for measuring the engine oil pressure.



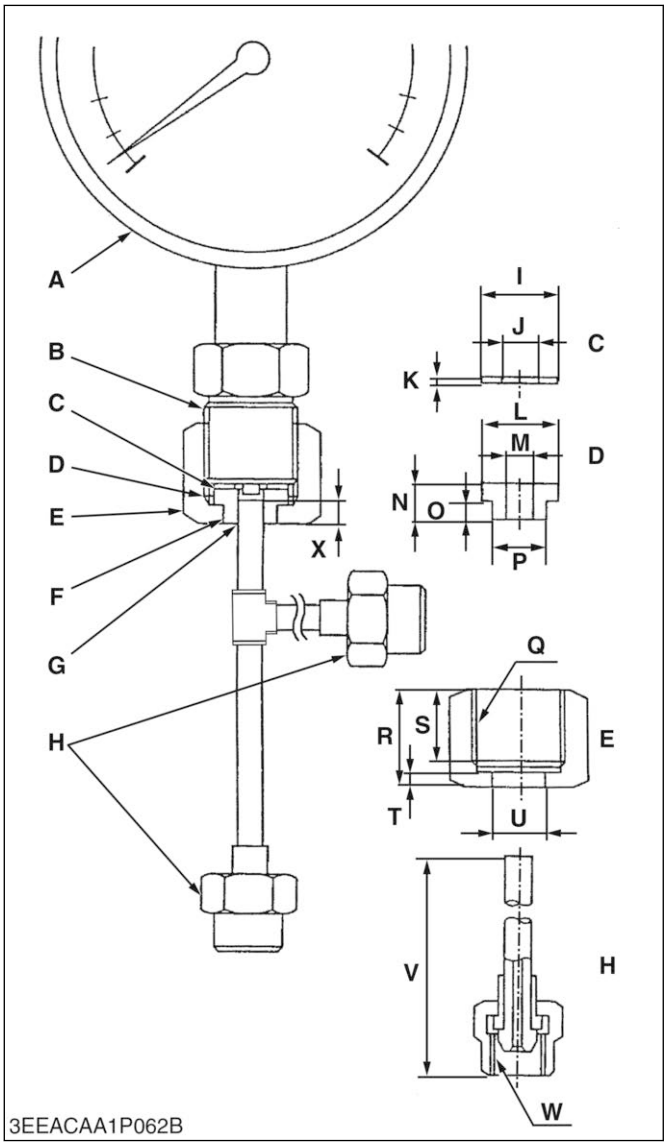

(1) Gauge
(2) Cable
(3) Threaded joint
(4) Adapter 1
(5) Adapter 2
(6) Adapter 3
(7) Adapter 4
(8) Adapter 5

# 4. Injection pump pressure tester

Use to check fuel tightness of injection pumps.

**■ NOTE**

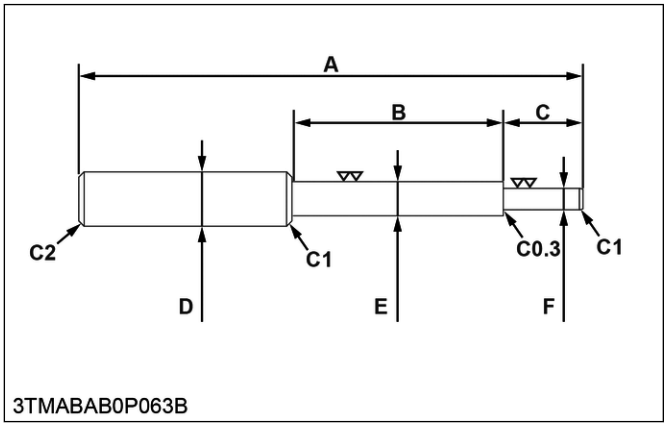
- **The following special tools are not provided, so make them referring to the figure.**



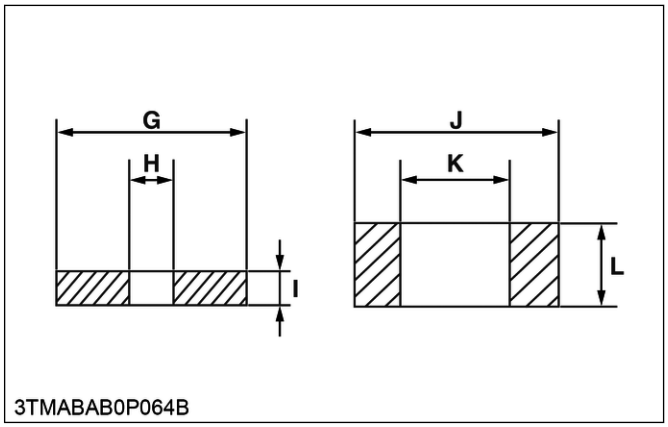
| | |
|---|---|
| A | Pressure gauge full scale: more than 29.4 MPa (300 kgf/cm$^2$ , 4260 psi) |
| B | PF 1/2 |
| C | Copper gasket |
| D | Flange (material steel) |
| E | Hex. nut 27 mm (1.1 in.) across the plat |
| F | Adhesive application |
| G | Fillet welding on the enter circumference |
| H | Retaining nut |
| I | 17 mm dia. (0.67 in. dia.) |
| J | 8.0 mm dia. (0.31 in. dia.) |
| K | 1.0 mm (0.039 in.) |
| L | 17 mm dia. (0.67 in. dia.) |
| M | 6.10 to 6.20 mm dia. (0.241 to 0.244 in. dia.) |
| N | 8.0 mm (0.31 in.) |
| O | 4.0 mm (0.16 in.) |
| P | 11.97 to 11.99 mm dia. (0.4713 to 0.4720 in. dia.) |
| Q | PF 1/2 |
| R | 23 mm (0.91 in.) |
| S | 17 mm (0.67 in.) |
| T | 4.0 mm (0.16 in.) |
| U | 12.00 to 12.02 mm dia. (0.4725 to 0.4732 in. dia.) |
| V | 100 mm (3.94 in.) |
| W | M12 × P1.5 |
| X | 5.0 mm (0.20 in.) |

# 5. Valve guide replacing tool

Use to press out or press fit the valve guide.



3TMABAB0P063B

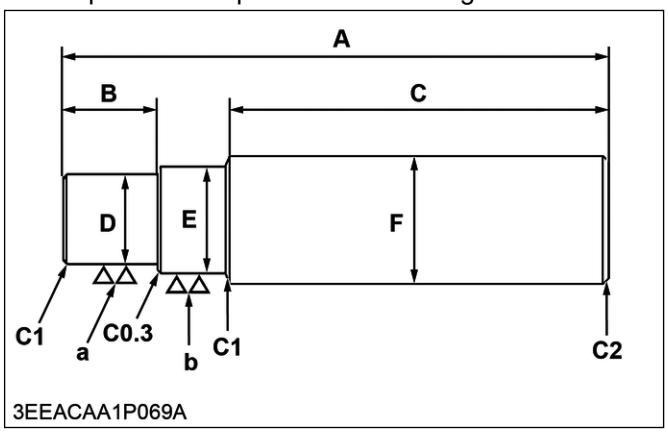


3TMABAB0P064B

| | |
|---|---|
| A | 220 mm (8.66 in.) |
| B | 80 mm (3.1 in.) |
| C | 40 mm (1.6 in.) |
| D | 20 mm dia. (0.79 in. dia.) |
| E | 9.960 to 9.980 mm dia. (0.3922 to 0.3929 in. dia.) |
| F | 5.50 to 5.70 mm dia. (0.217 to 0.224 in. dia.) |
| G | 25mm dia. (0.98 in. dia.) |
| H | 6.00 to 6.10 mm dia. (0.237 to 0.240 in. dia.) |
| I | 5.0 mm (0.20 in.) |
| J | 18 mm dia. (0.71 in. dia.) |
| K | 10.6 to 10.7 mm dia. (0.418 to 0.421 in. dia.) |
| L | 6.90 to 7.10 mm (0.272 to 0.279 in.) |
| C1 | Chamfer 1.0 mm (0.039 in.) |
| C2 | Chamfer 2.0 mm (0.079 in.) |
| C0.3 | Chamfer 0.3 mm (0.01 in.) |
| Material | SS400 |

# 6. Bushing replacing tools

Use to press out or press fit the bushing.



3EEACAA1P069A

**For small end bushing**

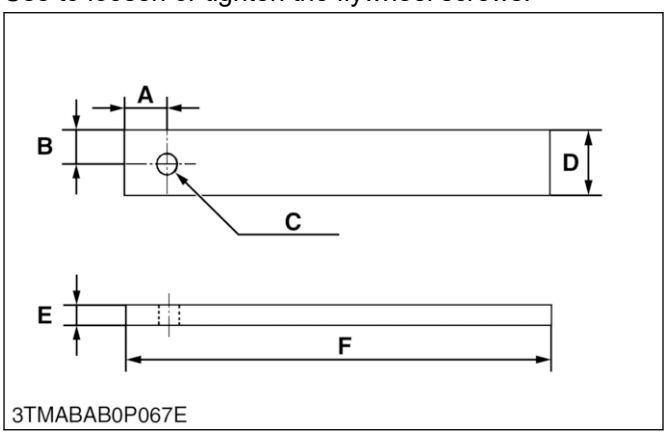
| | |
|---|---|
| A | 145 mm (5.71 in.) |
| B | 20 mm (0.79 in.) |
| C | 100 mm (3.94 in.) |
| D | 19.90 to 19.95 mm dia. (0.7835 to 0.7854 in. dia.) |
| E | 21.90 to 21.95 mm dia. (0.8622 to 0.8641 in. dia.) |
| F | 25 mm dia. (0.98 in. dia.) |
| C1 | Chamfer 1.0 mm (0.039 in.) |
| C2 | Chamfer 2.0 mm (0.079 in.) |
| C0.3 | Chamfer 0.3 mm (0.01 in.) |
| a | 6.3 µm (250 µin.) |
| b | 6.3 µm (250 µin.) |
| Material | SS400 |

**For idle gear bushing**

| | |
|---|---|
| A | 150 mm (5.91 in.) |
| B | 23 mm (0.91 in.) |
| C | 100 mm (3.94 in.) |
| D | 19.90 to 19.95 mm dia. (0.7835 to 0.7854 in. dia.) |
| E | 21.90 to 21.95 mm dia. (0.8622 to 0.8641 in. dia.) |
| F | 25 mm dia. (0.98 in. dia.) |
| C1 | Chamfer 1.0 mm (0.039 in.) |
| C2 | Chamfer 2.0 mm (0.079 in.) |
| C0.3 | Chamfer 0.3 mm (0.01 in.) |
| a | 6.3 µm (250 µin.) |
| b | 6.3 µm (250 µin.) |
| Material | SS400 |

# 7. Flywheel stopper

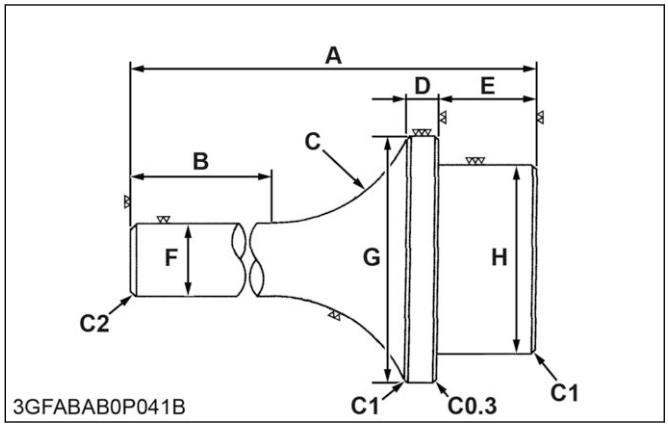
Use to loosen or tighten the flywheel screws.




| | |
|---|---|
| A | 20 mm (0.79 in.) |
| B | 15 mm (0.59 in.) |
| C | 10 mm dia. (0.39 in. dia.) |
| D | 30 mm (1.2 in.) |
| E | 8.0 mm (0.31 in.) |
| F | 200 mm (7.87 in.) |
| Material | SS400 |

# 8. Crankshaft bearing 1 replacing tool

Use to press out or press fit the crankshaft bearing 1.




**Press out tool**

| | |
|---|---|
| A | 135 mm (5.31 in.) |
| B | 72 mm (2.8 in.) |
| C | 40 mm radius (1.6 in. radius) |
| D | 10.0 mm (0.394 in.) |
| E | 22 mm (0.87 in.) |
| F | 20 mm dia. (0.79 in. dia.) |
| G | 47.90 to 47.95 mm dia. (1.886 to 1.887 in. dia.) |
| H | 43.90 to 43.95 mm dia. (1.729 to 1.730 in. dia.) |
| C1 | Chamfer 1.0 mm (0.039 in.) |
| C2 | Chamfer 2.0 mm (0.079 in.) |
| C0.3 | Chamfer 0.3 mm (0.01 in.) |
| Material | SS400 |

### Press fit tool

| | |
|---|---|
| A | 130 mm (5.12 in.) |
| B | 72 mm (2.8 in.) |
| C | 40 mm radius (1.6 in. radius) |
| D | 9.0 mm (0.35 in.) |
| E | 24 mm (0.94 in.) |
| F | 20 mm dia. (0.79 in. dia.) |
| G | 68 mm dia. (2.7 in. dia.) |
| H | 43.90 to 43.95 mm dia. (1.729 to 1.730 in. dia.) |
| C1 | Chamfer 1.0 mm (0.039 in.) |
| C2 | Chamfer 2.0 mm (0.079 in.) |
| C0.3 | Chamfer 0.3 mm (0.01 in.) |
| Material | SS400 |

# 3. MAINTENANCE

# MAINTENANCE CHECK LIST

To make sure that the engine operates safely for a long time, refer to the table below to do regular inspections.

| Inspection item | | Service interval | | | | | | | | | | | | | | Reference page |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Daily | Initial 50 hrs | Every 50 hrs | Every 75 hrs | Every 100 hrs | Every 150 hrs | Every 200 hrs | Every 400 hrs | Every 500 hrs | Every 800 hrs | Every 1500 hrs | Every 3000 hrs | Every 1 year | Every 2 years | |
| | Checking engine oil level | ○ | | | | | | | | | | | | | | 3-8 |
| | Checking fuel level | ○ | | | | | | | | | | | | | | 3-6 |
| | Checking coolant level | ○ | | | | | | | | | | | | | | 3-6 |
| | Checking fan belt | ○ | | | | | | | | | | | | | | 3-7 |
| (1) | Changing engine oil<br>Oil pan depth<br>(101 mm, 3.98 in.) | | ○ | | ○ | | | | | | | | | | | 3-8 |
| (2) | Changing engine oil<br>Oil pan depth<br>(121 mm, 4.76 in.) | | ○ | | | ○ | | | | | | | | | | |
| (3) | Changing engine oil<br>Extended oil pan depth<br>(101 mm, 3.98 in.) | | ○ | | | ○ | | | | | | | | | | |
| (1) | Replacing oil filter cartridge<br>Oil pan depth<br>(101 mm, 3.98 in.) | | ○ | | | | ○ | | | | | | | | | 3-9 |
| (2) | Replacing oil filter cartridge<br>Oil pan depth<br>(121 mm, 4.76 in.) | | ○ | | | | | ○ | | | | | | | | |
| (3) | Replacing oil filter cartridge<br>Extended oil pan depth<br>(101 mm, 3.98 in.) | | ○ | | | | | ○ | | | | | | | | |
| @ | Checking fuel hoses and clamp bands | | | ○ | | | | | | | | | | | | 3-9 |
| @ *1 | Cleaning air cleaner element | | | | | ○ | | | | | | | | | | 3-13 |
| | Cleaning fuel filter | | | | | ○ | | | | | | | | | | 3-13 |
| | Adjusting fan belt tension | | | | | ○ | | | | | | | | | | 3-14 |
| | Checking water separator | | | | | ○ | | | | | | | | | | 3-14 |
| @ | Checking intake air line | | | | | | | ○ | | | | | | | | 3-16<br>3-16 |
| | Checking radiator hose and clamp bands | | | | | | | ○ | | | | | | | | 3-17 |
| @ | Replacing fuel filter element | | | | | | | | ○ | | | | | | | 3-17 |
| | Cleaning water separator | | | | | | | | ○ | | | | | | | 3-18 |
| | Cleaning water jacket and radiator interior | | | | | | | | | ○ | | | | | | 3-18 |
| | Replacing fan belt | | | | | | | | | ○ | | | | | | 3-20 |
| | Checking valve clearance | | | | | | | | | | ○ | | | | | 3-21 |
| @ | Checking Nozzle Spraying Condition | | | | | | | | | | | ○ | | | | 3-22 |
| | Checking fuel injection pressure | | | | | | | | | | | ○ | | | | 3-22 |
| | Checking injection timing | | | | | | | | | | | | ○ | | | 3-23 |

(Continued)

| | Inspection item | Service interval | | | | | | | | | | | | | Reference page |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Daily | Initial 50 hrs | Every 50 hrs | Every 75 hrs | Every 100 hrs | Every 150 hrs | Every 200 hrs | Every 400 hrs | Every 500 hrs | Every 800 hrs | Every 1500 hrs | Every 3000 hrs | Every 1 year | Every 2 years | |
| @ | Checking fuel tightness of pump element | | | | | | | | | | | | ○ | | | 3-24 |
| | Checking fuel tightness of delivery valve | | | | | | | | | | | | ○ | | | 3-25 |
| | Checking turbo-charger | | | | | | | | | | | | ○ | | | 3-25 |
| @ *2 | Replacing air cleaner element | | | | | | | | | | | | | ○ | | 3-26 |
| | Changing radiator coolant (L.L.C.) | | | | | | | | | | | | | | ○ | 3-27 |
| | Replacing radiator hose and clamp bands | | | | | | | | | | | | | | ○ | 3-28 |
| @ | Replacing fuel hose and clamps | | | | | | | | | | | | | | ○ | 3-29 |
| @ *3 | Replacing intake air line | | | | | | | | | | | | | | ○ | 3-29 |

## CAUTION

- **When changing or inspecting, be sure to level and stop the engine.**

## IMPORTANT

- **The items listed above (@ marked) are registered as emission related critical parts by Kubota in the nonroad emission regulation of the U.S. EPA.**
  **As the engine's owner, you are responsible for the performance of the required maintenance on the engine according to the instruction above.**
  **Please see the warranty statement for details.**
- **(1) This oil pan depth is optional for Z482-E4, Z482-E4BG and D722-E4.**
  **(2) This oil pan depth is standard for Z482-E4, Z482-E4BG, D722-E4 and D782-E4.**
  **(3) This oil pan depth is standard for Z602-E4 and D902-E4.**
- ***1 Air cleaner should be cleaned more often in dusty conditions than in normal conditions.**
  ***2 After 6 times of cleaning.**
  ***3 Replace only if necessary.**

### Engine oil

## NOTE

- **Refer to the following table for the suitable American Petroleum Institute (API) classification of the engine oil according to the engine type (with internal EGR, external EGR or non-EGR) and the fuel type used (ultra low sulfur or high sulfur fuels).**

| Fuel type | Engine oil classification (API classification) |
|---|---|
| | D902-TE4 |
| Ultra low sulfur fuel<br>Sulfur content <0.0015% (15 ppm) | CF, CF-4, CG-4, CH-4 or CI-4 |
| High sulfur fuel<br>0.05% (500 ppm) sulfur content < 0.50% (5000 ppm) | CF (If a CF-4, CG-4, CH-4 or CI-4 engine uses high-sulfur fuel as its engine oil, change the engine oil at shorter intervals (approximately half of recommended intervals)) |

- **The engine oil should be MIL-L-2104C or have the properties of API classification CF or higher.**
- **Change the type of the engine oil according to ambient temperatures.**
- **The engine oil used in the engine should have API classification and proper quality of SAE engine oil according to the ambient temperatures as shown below:**

| | | |
|---|---|---|
| Z482-E4 Z482-E4BG<br>Z602-E4<br>D722-E4<br>D782-E4<br>D902-E4 | Above 25 ℃ (77 ℉) | SAE 10W-30 or SAE 10W-40, SAE 30 |
| | -10 ℃ to 25 ℃ (14 ℉ to 77 ℉) | SAE 10W-30 or SAE 10W-40, SAE 20 |
| | Below -10 ℃ (14 ℉) | SAE 10W-30 or SAE 10W-40 or SAE 10W |
| D902-TE4 | Above 25 ℃ (77 ℉) | SAE 10W-30 or SAE 10W-40, SAE 15W-40 |
| | -10 ℃ to 25 ℃ (14 ℉ to 77 ℉) | SAE 10W-30 or SAE 10W-40, SAE 15W-40 |
| | Below -10 ℃ (14 ℉) | SAE 10W-30 or SAE 10W-40 |

- **When using the engine oil different from the previous, be sure to drain all the previous engine oil before adding new engine oil.**

**Fuel**

The fuel is flammable and can be dangerous. You should handle the fuel with care.

**⚠ CAUTION**

**To avoid personal injury:**

- **Do not mix gasoline or alcohol with diesel fuel. This mixture can cause an explosion.**
- **Be careful not to spill the fuel during refueling. If the fuel is spilled, wipe it off at once, or it may cause a fire.**
- **Make sure to stop the engine before refueling. Keep the engine away from fire.**
- **Be sure to stop the engine while refueling, bleeding, cleaning, and changing fuel filter or fuel pipes. Do not smoke, when refueling or working around the engine battery.**
- **Check the fuel systems at a wide and well-ventilated place.**
- **When the fuel or lubricant are spilled, refuel after letting the engine cool off.**
- **Always keep spilled the fuel or lubricant away from engine.**

**■ IMPORTANT**

- **Be sure to use a strainer when filling the fuel tank, otherwise dirt or sand contained in the fuel might cause trouble inside the fuel injection pump.**
- **For the fuel, always use diesel fuel. You are required not to use alternative fuel, because the quality of alternative fuel is unknown or might be inferior.**
  **Kerosene, which is very low in cetane rating, adversely affects the engine. Diesel fuel differs in grades, depending on the temperature.**
- **Be careful not to let the fuel tank become empty. Otherwise air enters the fuel system, fuel system bleeding may be necessary.**

**■ NOTE**

**Fuel level checking and refueling**

1. **Check whether the fuel level is above the lower limit of the fuel level gauge.**
2. **If the fuel level is too low, add fuel to the upper limit. Do not overfill.**

| Flash point,℃ (℉) | Water and sediment, volume % | Carbon residue on 10 percent residuum, % | Ash, weight % |
|---|---|---|---|
| Min | Max | Max | Max |
| 52 (126) | 0.05 | 0.35 | 0.01 |

| Distillation temperatures,℃ (℉) 90% point | | Viscosity kinematic cSt or $mm^2$ /s at 40 ℃ (104 ℉) | | Viscosity saybolt, SUS at 37.8 ℃ (100.0 ℉) | |
|---|---|---|---|---|---|
| Min | Max | Min | Max | Min | Max |
| 282 (540) | 338 (640) | 1.9 | 4.1 | 32.6 | 40.1 |

- **The recommended minimum cetane rating of the fuel is 45.**
  **A cetane rating higher than 50 is preferred, especially for ambient temperatures below -20 ℃ (-4 ℉) or elevations above 1500 m (5000 ft).**
- **Diesel fuel specification type and sulfur content % (ppm) must be compliant with all applicable emission regulations for the area in which the engine is operated.**

- **The use of diesel fuel with sulfur content less than 0.10 % (1000 ppm) is strongly recommended.**
- **If high-sulfur fuel (with sulfur content 0.50 % (5000 ppm) to 1.0 % (10000 ppm)) is used as diesel fuel, change the engine oil and oil filter at shorter intervals (approximately half of recommended intervals).**
- **Do not use fuels that have sulfur content higher than 1.0 % (10000 ppm).**
- **Diesel fuels specified in EN 590 or ASTM D975 are recommended.**
- **No.2-D is distillate fuel of lower volatility for industrial engines and heavy mobile services. (SAE J313 JUN87)**
- **Since Kubota diesel engines below 56 kW (75 hp) use EPA Tier 4 and Interim Tier 4 standards, the use of ultra low sulfur fuel is mandatory for these engines, when operated in US EPA regulated areas. Therefore, use No.2-D S15 diesel fuel as an alternative to No.2-D, and use No.1-D S15 diesel fuel as an alternative to No.1-D for ambient temperatures below -10 ℃ (14 ℉).**
  - **SAE: Society of Automotive Engineers**
  - **EN: European Norm**
  - **ASTM: American Society of Testing and Materials**
  - **US EPA: United States Environmental Protection Agency**
  - **No.1-D or No.2-D, S15 : Ultra Low Sulfur Diesel (ULSD) 15 ppm or 0.0015 wt.%**

# CHECK AND MAINTENANCE

## 1. Daily check points

### 1.1 Checking engine oil level

**■ IMPORTANT**

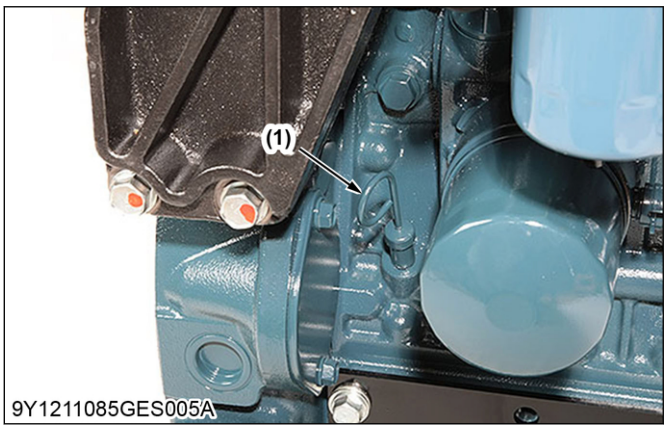
- **When you use the engine oil of a brand or viscosity different from the previous, drain the remaining oil.**
  **Do not mix 2 different types of the engine oil.**

**■ NOTE**

- **When you check the engine oil level, make sure that you put the engine in a horizontal position.**
  **If not, you cannot measure the engine oil quantity accurately.**
- **Make sure that you keep the engine oil level between the upper and lower lines of the dipstick (1).**
  **Too much engine oil can decrease the output or cause too much blow-by gas.**
  **On the closed breather type engine, the port absorbs the engine oil mist, too much engine oil can cause oil hammer.**
  **But if the engine oil level is not sufficient, the moving parts of engine might get a seizure.**

| | | |
|---|---|---|
| Z482-E4<br>Z482-E4BG<br>Z602-E4<br>D722-E4<br>D782-E4<br>D902-E4 | Above 25 ℃ (77 ℉) | SAE 10W-30 or SAE 10W-40, SAE 30 |
| | -10 ℃ to 25 ℃ (14 ℉ to 77 ℉) | SAE 10W-30 or SAE 10W-40, SAE 20 |
| | Below -10 ℃ (14 ℉) | SAE 10W-30 or SAE 10W-40 or SAE 10W |
| D902-TE4 | Above 25 ℃ (77 ℉) | SAE 10W-30 or SAE 10W-40, SAE 15W-40 |
| | -10 ℃ to 25 ℃ (14 ℉ to 77 ℉) | SAE 10W-30 or SAE 10W-40, SAE 15W-40 |
| | Below -10 ℃ (14 ℉) | SAE 10W-30 or SAE 10W-40 |

1. Make the engine horizontal.
2. To check the engine oil level, draw out the dipstick (1), wipe it clean, then reinsert it, and draw it out again.

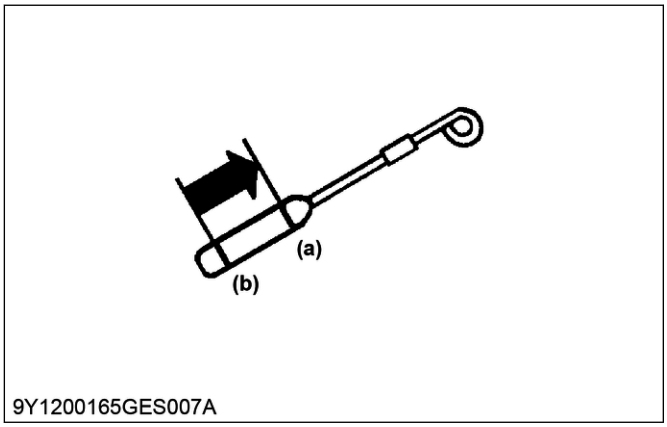



(1) Dipstick

3. Make sure that the engine oil level is between the upper line (a) and lower line (b).

4. If the engine oil level is too low, add new engine oil to the specified level.

| Model | Engine oil capacity | |
|---|---|---|
| | Oil pan depth | |
| | 101 mm (3.98 in.) | 121 mm (4.76 in.) |
| Z482-E4<br>Z482-E4BG | 2.1 L<br>0.55 U.S.gals<br>0.46 Imp.gals | 2.5 L<br>0.66 U.S.gals<br>0.55 Imp.gals |
| D722-E4 | 3.2 L<br>0.85 U.S.gals<br>0.70 Imp.gals | 3.8 L<br>1.0 U.S.gals<br>0.84 Imp.gals |
| D782-E4 | — | 3.6 L<br>0.95 U.S.gals<br>0.79 Imp.gals |
| Z602-E4 | 2.5 L<br>0.66 U.S.gals<br>0.55 Imp.gals | — |
| D902-E4<br>D902-TE4 | 3.7 L<br>0.98 U.S.gals<br>0.81 Imp.gals | — |




(a) Upper line (b) Lower line

## 1.2 Checking fuel level

**■ IMPORTANT**

- **When Biodiesel fuel is used, it is advisable to replace the fuel filter with a new one after half the specified replacement intervals. (Compared with the use of mineral oil diesel fuels, the filtration performance of fuel filters gets degraded earlier than expected.)**
- **Be sure to use a strainer when filling the fuel tank, or dirt or sand in the fuel may cause trouble.**
- **Do not operate the fuel tank level too low or completely out of the fuel.**
  **Additionally, fuel system bleeding may be necessary if air enters the fuel system.**

1. Make the engine level.
2. Make sure that the fuel level is above the lower limit of the fuel level gauge.

**■ NOTE**

- **If the fuel level is too low, add the fuel to the upper limit.**

## 1.3 Checking coolant level

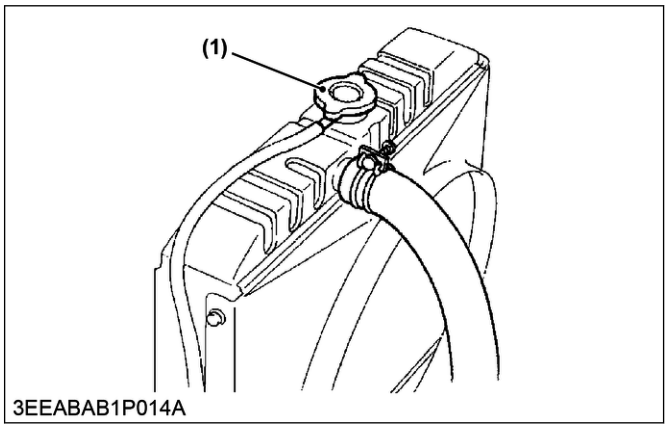
**⚠ CAUTION**

- **Do not remove the radiator cap when the engine is hot.**
  **Then loosen the cap slightly to release unwanted pressure before you remove the cap fully.**

**■ IMPORTANT**

- **When you add the coolant, release the air from the engine coolant channels.**
  **The engine releases the air when it shakes the radiator upper and lower hoses.**
- **Make sure that you close the radiator cap correctly.**
  **If the cap is loose or incorrectly closed, coolant can flow out and the engine can overheat.**
- **Do not use an anti-freeze and scale inhibitor at the same time.**
- **Do not mix the different type or brand of L.L.C.**

1. Remove the radiator cap (1).




(1) Radiator cap

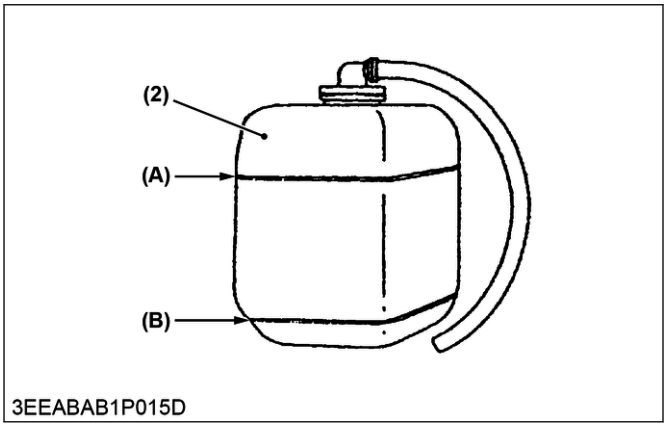
2. Make sure that the coolant level is immediately below the port.

**■ NOTE**

- **This case is without reserve tank.**

3. Make sure that the coolant level is between **[FULL]** (A) and **[LOW]** (B).

**■ NOTE**
- **This case is with reserve tank (2).**

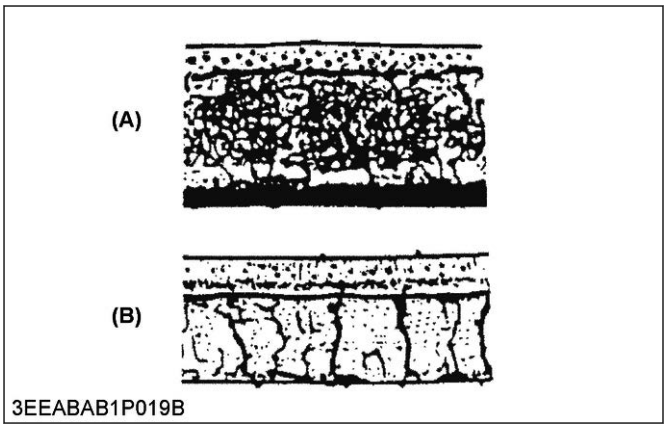


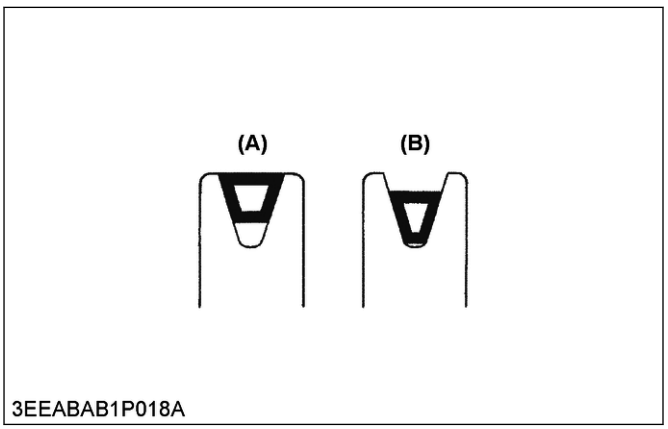

(2) Reserve tank
(A) FULL
(B) LOW

## 1.4 Checking fan belt

**Tools required**
- Sonic belt tension meter

1. Check that the fan belt is worn out and sunk in the pulley groove or not.
   - If it is, replace it.



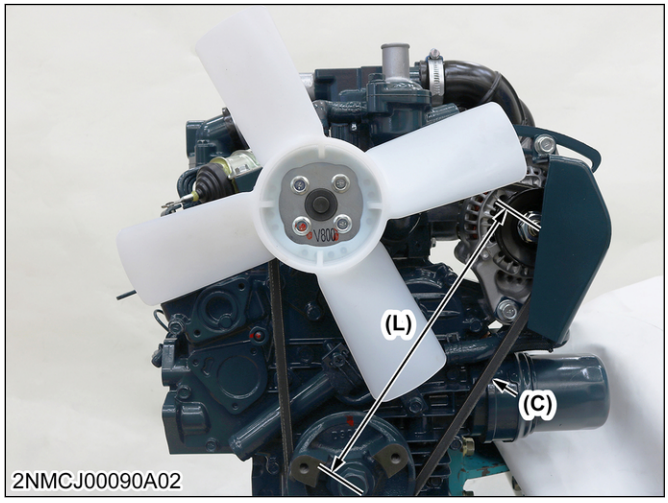

(A) OK
(B) Wear

2. Check the tension of fan belt at the position (C) between the fan drive pulley and alternator pulley with sonic belt tension meter.

**■ NOTE**
- **If the measurement is out of the service specifications, loosen the alternator mounting screws and adjust its position.**

| Sonic belt tension meter setting value | |
|---|---|
| Mass<br>(Mass per 1 rib 1 m of belt) | 80 g/rib/m |
| Width<br>(Number of ribs) | 1 |
| Span L | Measure at location (C) in the figure with (L) as the distance between the fan drive pulley and alternator pulley. |

| | | |
|---|---|---|
| Belt tension | Service specification | 200 to 300 N<br>20.4 to 30.5 kgf<br>45.0 to 67.4 lbf |



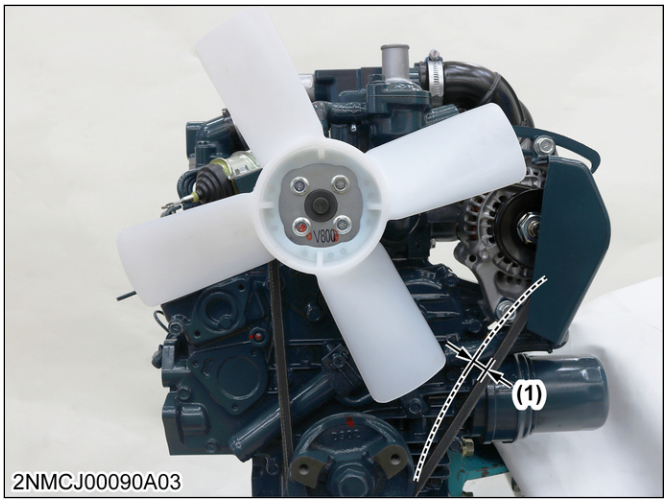

(C) Fan belt halfway

**(Reference)**

a. Push the belt halfway between the fan drive pulley and alternator pulley at a specified force to measure the deflection (1).

**■ NOTE**
- **If the measurement is out of the service specifications, loosen the alternator mounting screws and adjust its position.**

| | | |
|---|---|---|
| Deflection (1) | Service specification | 7.0 to 9.0 mm<br>0.28 to 0.35 in.<br>(Under load of 98 N<br>(10 kgf, 22 lbf)) |




(1) Deflection

# 2. Check point of initial 50 hours

## 2.1 Changing engine oil

**CAUTION**

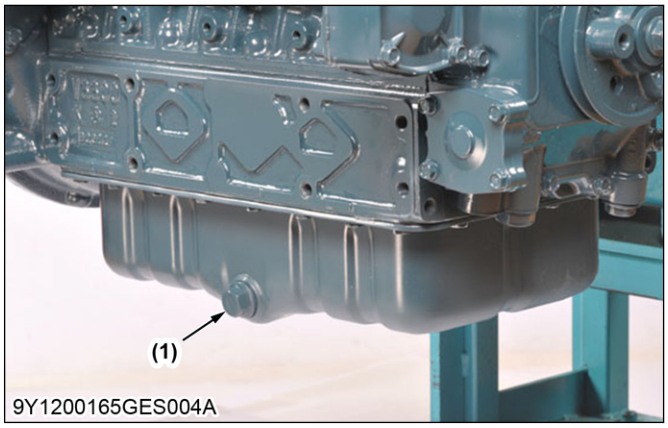
- **Make sure that you have stopped the engine before you change the engine oil.**

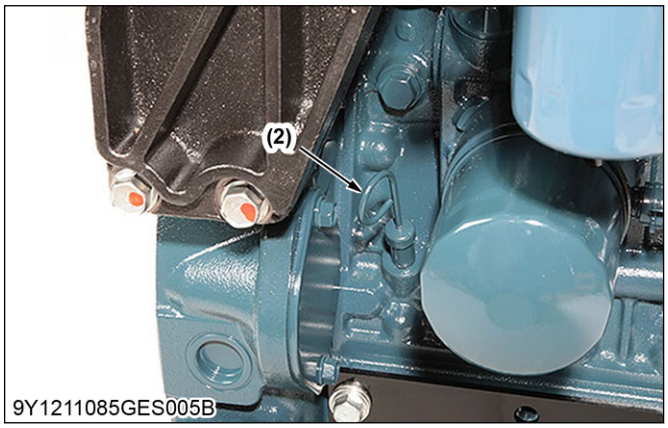
**IMPORTANT**

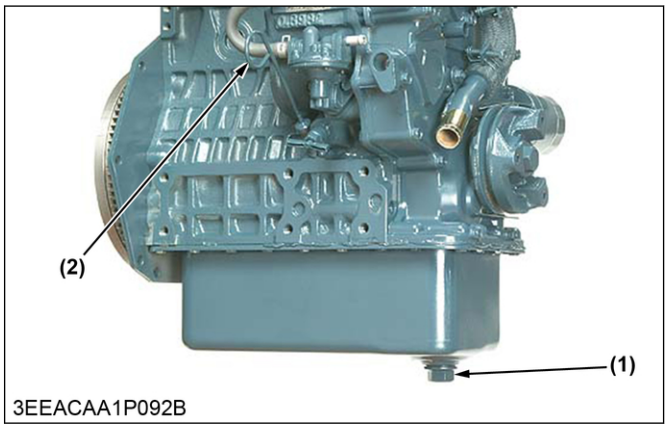
- **When you use the engine oil of a brand or viscosity different from the previous, drain the remaining oil.**
- **Do not mix 2 different types of the engine oil.**
- **The engine oil should have properties of API classification CF.**
- **Use the proper SAE engine oil according to ambient temperature.**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

| | | |
|---|---|---|
| Z482-E4<br>Z482-E4BG<br>Z602-E4<br>D722-E4<br>D782-E4<br>D902-E4 | Above 25 ℃ (77 ℉) | SAE 10W-30 or SAE 10W-40, SAE 30 |
| | -10 ℃ to 25 ℃ (14 ℉ to 77 ℉) | SAE 10W-30 or SAE 10W-40, SAE 20 |
| | Below -10 ℃ (14 ℉) | SAE 10W-30 or SAE 10W-40 or SAE 10W |
| D902-TE4 | Above 25 ℃ (77 ℉) | SAE 10W-30 or SAE 10W-40, SAE 15W-40 |
| | -10 ℃ to 25 ℃ (14 ℉ to 77 ℉) | SAE 10W-30 or SAE 10W-40, SAE 15W-40 |
| | Below -10 ℃ (14 ℉) | SAE 10W-30 or SAE 10W-40 |

1. Start and warm-up the engine for approximately 5 minutes.
2. Put an oil pan below the engine.
3. Remove the drain plug (1) at the bottom of the engine, and drain the engine oil completely.




(1) Drain plug (2) Dipstick

4. Tighten the drain plug (1) to the specified torque.

**NOTE**
- **Make sure the drain plug (1) is tightened.**

| | | | |
|---|---|---|---|
| Tightening torque | Drain plug with copper gasket | M12 × 1.25 | 33.0 to 37.0 N·m<br>3.37 to 3.77 kgf·m<br>24.4 to 27.2 lbf·ft |
| | | M22 × 1.5 | 64.0 to 73.0 N·m<br>6.53 to 7.44 kgf·m<br>47.2 to 53.8 lbf·ft |
| | Drain plug with rubber coated gasket | M22 × 1.5 | 45.0 to 53.0 N·m<br>4.59 to 5.40 kgf·m<br>33.2 to 39.0 lbf·ft |
| | Drain plug (D902-TE4) | M22 × 1.5 | 44.1 to 53.9 N·m<br>4.50 to 5.49 kgf·m<br>32.6 to 39.7 lbf·ft |

5. Fill new engine oil until the upper line on the dipstick (2).

| Model | Engine oil capacity | |
|---|---|---|
| | Oil pan depth | |
| | 101 mm (3.98 in.) | 121 mm (4.76 in.) |
| Z482-E4<br>Z482-E4BG | 2.1 L<br>0.55 U.S.gals<br>0.46 Imp.gals | 2.5 L<br>0.66 U.S.gals<br>0.55 Imp.gals |
| D722-E4 | 3.2 L<br>0.85 U.S.gals<br>0.70 Imp.gals | 3.8 L<br>1.0 U.S.gals<br>0.84 Imp.gals |
| D782-E4 | — | 3.6 L<br>0.95 U.S.gals<br>0.79 Imp.gals |
| Z602-E4 | 2.5 L<br>0.66 U.S.gals<br>0.55 Imp.gals | — |
| D902-E4<br>D902-TE4 | 3.7 L<br>0.98 U.S.gals<br>0.81 Imp.gals | — |

101 mm (3.98 in.) oil pan depth of Z482-E4, Z482-E4BG and D722-E4 is optional.

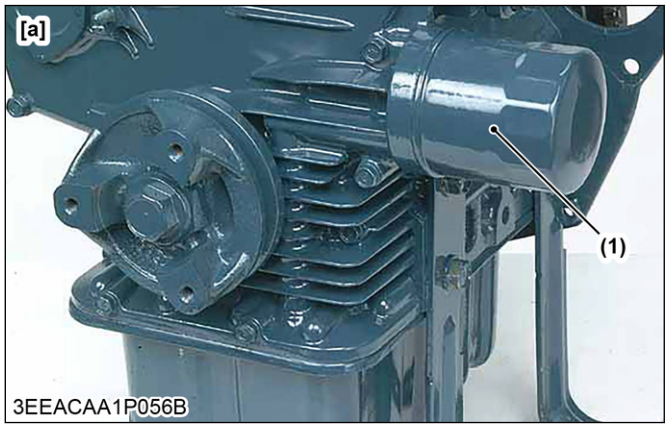
## 2.2 Replacing oil filter cartridge

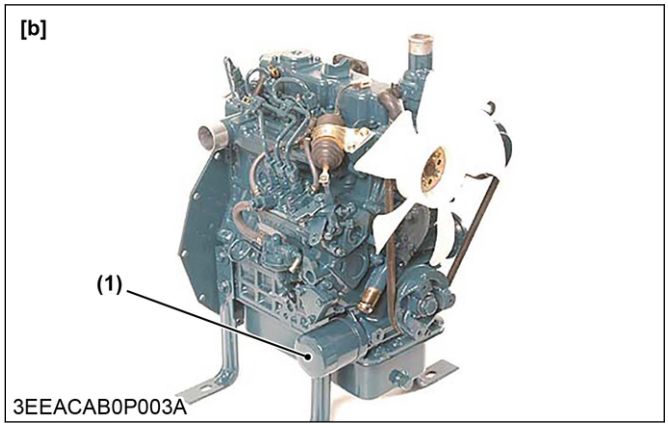
**CAUTION**
- **Make sure that you stop the engine before you replace the oil filter cartridge.**

**IMPORTANT**
- **To prevent serious damage to the engine, replacement element must be highly efficient. Use only a Kubota genuine filter or its equivalent.**

**Tools required**
- Filter wrench

1. Remove the oil filter cartridge (1) with the filter wrench.




(1) Oil filter cartridge [b] One-side maintenance type
[a] Standard type

2. Apply a thin layer of oil on the new cartridge gasket.
3. Install the new cartridge by hand.

**NOTE**
- **Do not tighten too much because it can cause deformation of the rubber gasket.**

4. Make sure that the engine oil does not flow through the seal and read the oil level on the dipstick.
5. Fill the engine oil until the specified level.

**NOTE**
- **After you replace the cartridge, the engine oil usually decrease by a small level.**

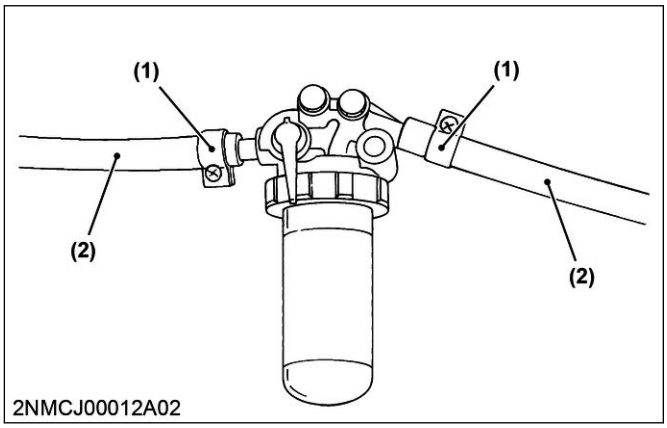
# 3. Check point of every 50 hours

## 3.1 Checking fuel hoses and clamp bands

**CAUTION**
- **Check or replace the fuel pipes (2) after stopping the engine. Broken fuel hoses can cause fires.**

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.

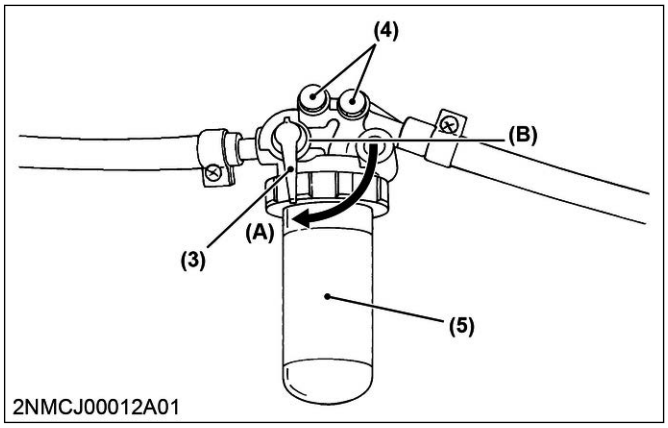
**■ IMPORTANT**
- **When the fuel pipes (2) are not installed, plug them with clean cloth or paper at both ends to prevent dirt from entering the fuel pipes (2).**
- **Dirt in the fuel pipes (2) can cause malfunction of fuel injection pump.**




(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

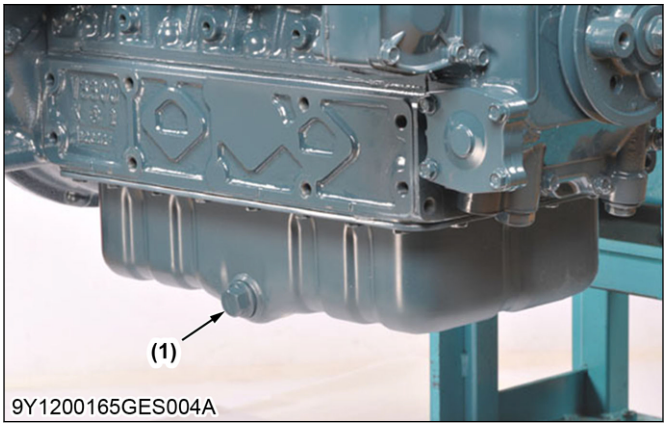
## 4.1 Changing engine oil

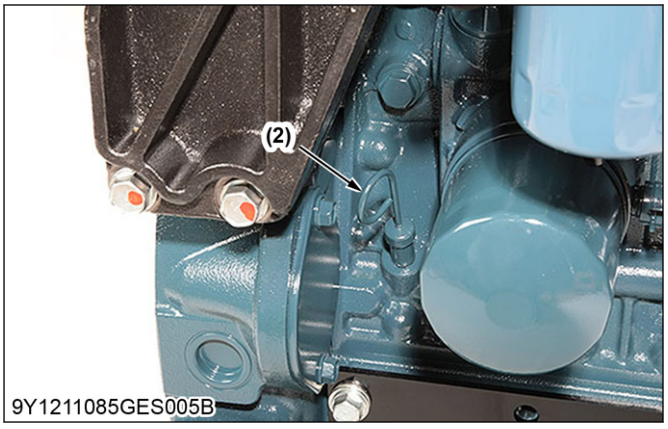
**⚠ CAUTION**
- **Make sure that you have stopped the engine before you change the engine oil.**

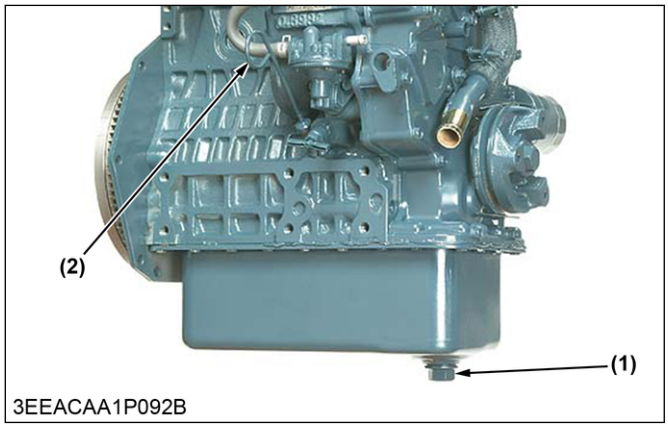
**■ IMPORTANT**
- **When you use the engine oil of a brand or viscosity different from the previous, drain the remaining oil.**
- **Do not mix 2 different types of the engine oil.**
- **The engine oil should have properties of API classification CF.**
- **Use the proper SAE engine oil according to ambient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

| | | |
|---|---|---|
| Z482-E4<br>Z482-E4BG<br>Z602-E4<br>D722-E4<br>D782-E4<br>D902-E4 | Above 25 ℃ (77 ℉) | SAE 10W-30 or SAE 10W-40, SAE 30 |
| | -10 ℃ to 25 ℃ (14 ℉ to 77 ℉) | SAE 10W-30 or SAE 10W-40, SAE 20 |
| | Below -10 ℃ (14 ℉) | SAE 10W-30 or SAE 10W-40 or SAE 10W |
| D902-TE4 | Above 25 ℃ (77 ℉) | SAE 10W-30 or SAE 10W-40, SAE 15W-40 |
| | -10 ℃ to 25 ℃ (14 ℉ to 77 ℉) | SAE 10W-30 or SAE 10W-40, SAE 15W-40 |
| | Below -10 ℃ (14 ℉) | SAE 10W-30 or SAE 10W-40 |

1. Start and warm-up the engine for approximately 5 minutes.
2. Put an oil pan below the engine.
3. Remove the drain plug (1) at the bottom of the engine, and drain the engine oil completely.




(1) Drain plug (2) Dipstick

4. Tighten the drain plug (1) to the specified torque.

**NOTE**
- **Make sure the drain plug (1) is tightened.**

| | | | |
|---|---|---|---|
| Tightening torque | Drain plug with copper gasket | M12 × 1.25 | 33.0 to 37.0 N·m<br>3.37 to 3.77 kgf·m<br>24.4 to 27.2 lbf·ft |
| | | M22 × 1.5 | 64.0 to 73.0 N·m<br>6.53 to 7.44 kgf·m<br>47.2 to 53.8 lbf·ft |
| | Drain plug with rubber coated gasket | M22 × 1.5 | 45.0 to 53.0 N·m<br>4.59 to 5.40 kgf·m<br>33.2 to 39.0 lbf·ft |
| | Drain plug (D902-TE4) | M22 × 1.5 | 44.1 to 53.9 N·m<br>4.50 to 5.49 kgf·m<br>32.6 to 39.7 lbf·ft |

5. Fill new engine oil until the upper line on the dipstick (2).

| Model | Engine oil capacity | |
|---|---|---|
| | Oil pan depth | |
| | 101 mm (3.98 in.) | 121 mm (4.76 in.) |
| Z482-E4<br>Z482-E4BG | 2.1 L<br>0.55 U.S.gals<br>0.46 Imp.gals | 2.5 L<br>0.66 U.S.gals<br>0.55 Imp.gals |
| D722-E4 | 3.2 L<br>0.85 U.S.gals<br>0.70 Imp.gals | 3.8 L<br>1.0 U.S.gals<br>0.84 Imp.gals |
| D782-E4 | — | 3.6 L<br>0.95 U.S.gals<br>0.79 Imp.gals |
| Z602-E4 | 2.5 L<br>0.66 U.S.gals<br>0.55 Imp.gals | — |
| D902-E4<br>D902-TE4 | 3.7 L<br>0.98 U.S.gals<br>0.81 Imp.gals | — |

101 mm (3.98 in.) oil pan depth of Z482-E4, Z482-E4BG and D722-E4 is optional.

# 5. Check points of every 100 hours

## 5.1 Changing engine oil

**CAUTION**

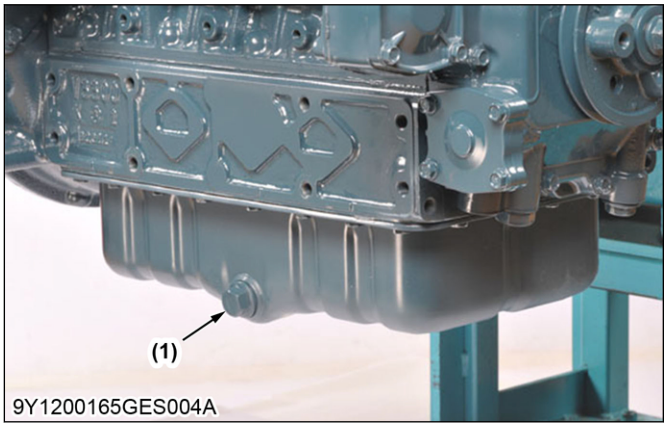
- **Make sure that you have stopped the engine before you change the engine oil.**

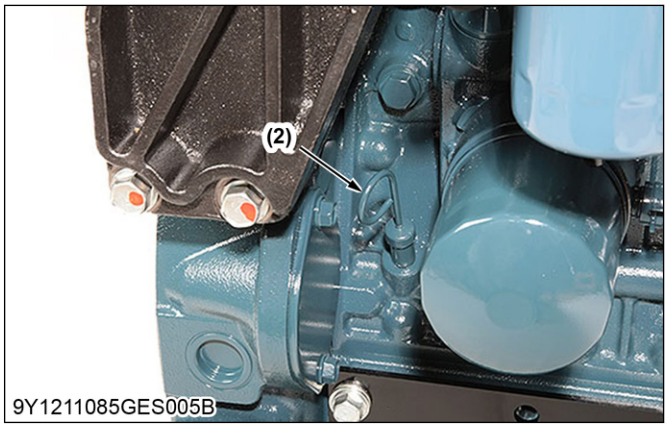
**IMPORTANT**

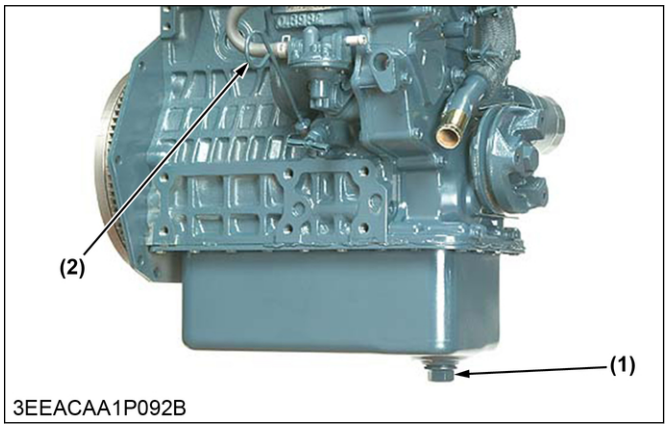
- **When you use the engine oil of a brand or viscosity different from the previous, drain the remaining oil.**
- **Do not mix 2 different types of the engine oil.**
- **The engine oil should have properties of API classification CF.**
- **Use the proper SAE engine oil according to ambient temperature.**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

| | | |
|---|---|---|
| Z482-E4<br>Z482-E4BG<br>Z602-E4<br>D722-E4<br>D782-E4<br>D902-E4 | Above 25 ℃ (77 ℉) | SAE 10W-30 or SAE 10W-40, SAE 30 |
| | -10 ℃ to 25 ℃ (14 ℉ to 77 ℉) | SAE 10W-30 or SAE 10W-40, SAE 20 |
| | Below -10 ℃ (14 ℉) | SAE 10W-30 or SAE 10W-40 or SAE 10W |
| D902-TE4 | Above 25 ℃ (77 ℉) | SAE 10W-30 or SAE 10W-40, SAE 15W-40 |
| | -10 ℃ to 25 ℃ (14 ℉ to 77 ℉) | SAE 10W-30 or SAE 10W-40, SAE 15W-40 |
| | Below -10 ℃ (14 ℉) | SAE 10W-30 or SAE 10W-40 |

1. Start and warm-up the engine for approximately 5 minutes.
2. Put an oil pan below the engine.
3. Remove the drain plug (1) at the bottom of the engine, and drain the engine oil completely.




(1) Drain plug (2) Dipstick

4. Tighten the drain plug (1) to the specified torque.

**NOTE**

- **Make sure the drain plug (1) is tightened.**

| | | | |
|---|---|---|---|
| Tightening torque | Drain plug with copper gasket | M12 × 1.25 | 33.0 to 37.0 N·m<br>3.37 to 3.77 kgf·m<br>24.4 to 27.2 lbf·ft |
| | | M22 × 1.5 | 64.0 to 73.0 N·m<br>6.53 to 7.44 kgf·m<br>47.2 to 53.8 lbf·ft |
| | Drain plug with rubber coated gasket | M22 × 1.5 | 45.0 to 53.0 N·m<br>4.59 to 5.40 kgf·m<br>33.2 to 39.0 lbf·ft |
| | Drain plug (D902-TE4) | M22 × 1.5 | 44.1 to 53.9 N·m<br>4.50 to 5.49 kgf·m<br>32.6 to 39.7 lbf·ft |

5. Fill new engine oil until the upper line on the dipstick (2).

| Model | Engine oil capacity | |
|---|---|---|
| | Oil pan depth | |
| | 101 mm (3.98 in.) | 121 mm (4.76 in.) |
| Z482-E4<br>Z482-E4BG | 2.1 L<br>0.55 U.S.gals<br>0.46 Imp.gals | 2.5 L<br>0.66 U.S.gals<br>0.55 Imp.gals |
| D722-E4 | 3.2 L<br>0.85 U.S.gals<br>0.70 Imp.gals | 3.8 L<br>1.0 U.S.gals<br>0.84 Imp.gals |
| D782-E4 | — | 3.6 L<br>0.95 U.S.gals<br>0.79 Imp.gals |
| Z602-E4 | 2.5 L<br>0.66 U.S.gals<br>0.55 Imp.gals | — |
| D902-E4<br>D902-TE4 | 3.7 L<br>0.98 U.S.gals<br>0.81 Imp.gals | — |

101 mm (3.98 in.) oil pan depth of Z482-E4, Z482-E4BG and D722-E4 is optional.

## 5.2 Cleaning air cleaner element

**■ NOTE**

- **The air cleaner uses a dry element. Never apply oil to the element.**
- **Change the air cleaner element once a year or every 6th cleaning.**
- **Do not operate the engine with the air cleaner element removed.**

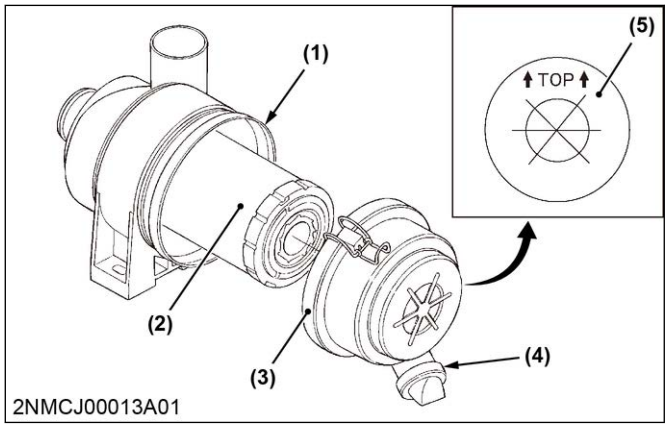
**■ IMPORTANT**

- **Make sure the hooking clip of the air cleaner element cover is tight enough.**
  **If the hooking clip is loose, dust and dirt might be sucked into the engine, wearing down the cylinder liner and piston ring faster, thereby resulting in poor power output.**

1. Open the evacuator valve once a week or daily under ordinary conditions to get rid of large particles of dust and dirt, when used in a dusty place.
2. Wipe the inside of the air cleaner clean with cloth or the like, if the inside is dirty or wet.
3. Avoid touching the air cleaner element except when cleaning.
4. When dry dust adhered to the air cleaner element, blow compressed air from the inside of the element with rotating the element. The pressure of compressed air must be under 205 kPa (2.09 kgf/cm$^2$ , 29.7 psi).

| | |
|---|---|
| Pressure of compressed air | Less than<br>205 kPa<br>2.09 kgf/cm$^2$<br>29.7 psi |

5. Replace the air cleaner element every year or every 6th cleaning.



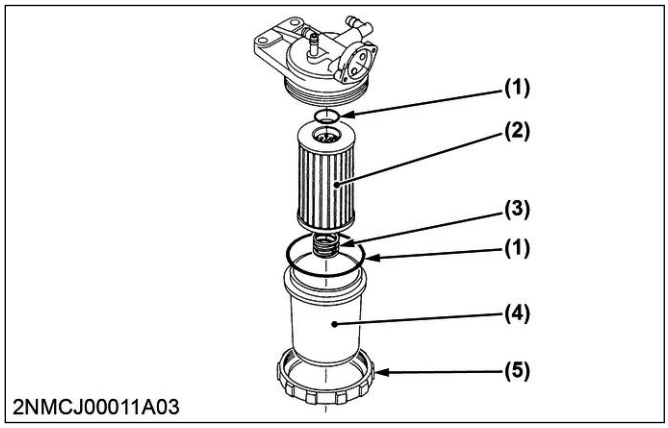

(1) Air cleaner body
(2) Air cleaner element
(3) Air cleaner element cover
(4) Evacuator valve
(5) TOP mark

## 5.3 Cleaning fuel filter element

1. Close the filter lever.
2. Remove the screw ring (5) and rinse the inside with diesel fuel.
3. Take out the fuel filter element (2), and rinse it with diesel fuel.
4. After cleaning, reinstall the fuel filter element (2) with keeping out of dust and dirt.
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.**
  **Wash the fuel filter periodically.**



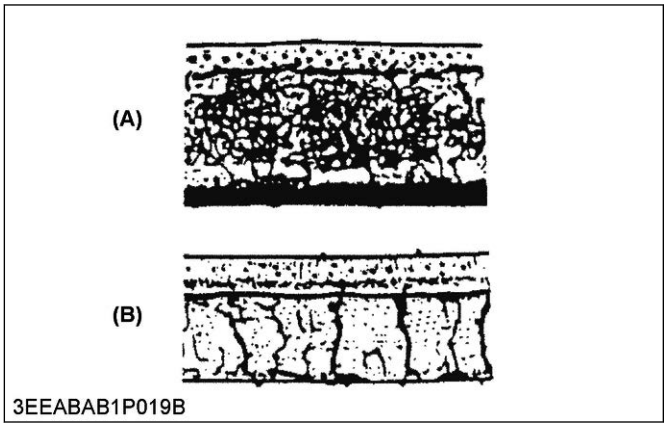

(1) O ring
(2) Fuel filter element
(3) Spring
(4) Fuel filter cup
(5) Screw ring

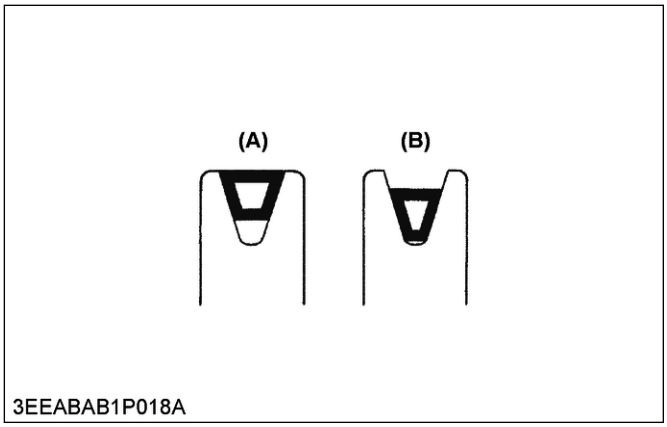
## 5.4 Adjusting fan belt tension

**Tools required**

- Sonic belt tension meter

1. Check that the fan belt is worn out and sunk in the pulley groove or not.
   - If it is, replace it.




(A) OK (B) Wear

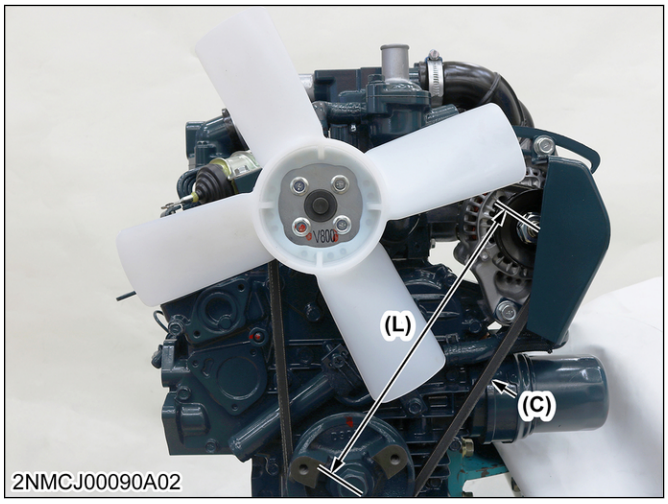
2. Check the tension of fan belt at the position (C) between the fan drive pulley and alternator pulley with sonic belt tension meter.

**■ NOTE**

- **If the measurement is out of the service specifications, loosen the alternator mounting screws and adjust its position.**

| Sonic belt tension meter setting value | |
|---|---|
| Mass<br>(Mass per 1 rib 1 m of belt) | 80 g/rib/m |
| Width<br>(Number of ribs) | 1 |
| Span L | Measure at location (C) in the figure with (L) as the distance between the fan drive pulley and alternator pulley. |

| | | |
|---|---|---|
| Belt tension | Service specification | 200 to 300 N<br>20.4 to 30.5 kgf<br>45.0 to 67.4 lbf |




(C) Fan belt halfway

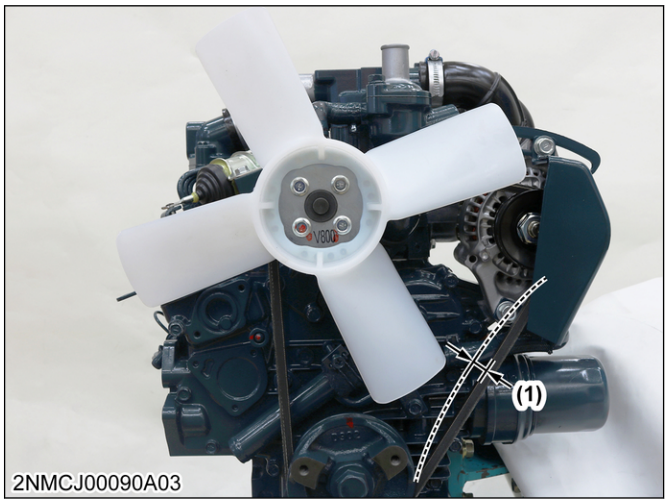
**(Reference)**

a. Push the belt halfway between the fan drive pulley and alternator pulley at a specified force to measure the deflection (1).

**■ NOTE**

- **If the measurement is out of the service specifications, loosen the alternator mounting screws and adjust its position.**

| | | |
|---|---|---|
| Deflection (1) | Service specification | 7.0 to 9.0 mm<br>0.28 to 0.35 in.<br>(Under load of 98 N<br>(10 kgf, 22 lbf)) |

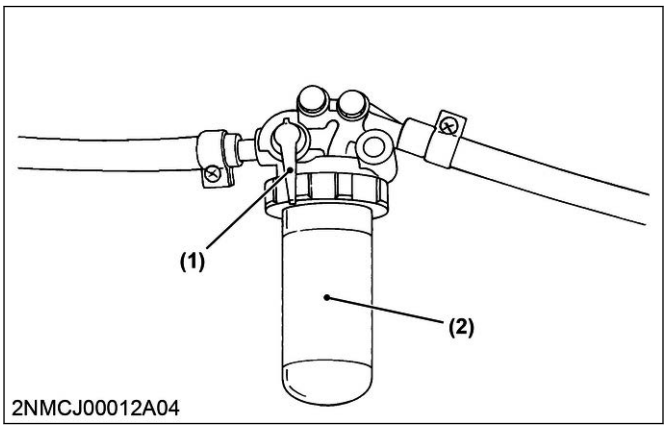



(1) Deflection

## 5.5 Checking water separator

1. Check if water and dirt contained in fuel precipitate inside the water separator.

2. When such foreign substances are precipitated, set the water separator handle (1).
3. Loosen and remove the cup (2) properly, and clean its inside with diesel fuel.
4. Tighten up the cup (2) properly.
5. Finally be sure to air-bleed the fuel system.




(1) Water separator handle (2) Cup

# 6. Check points of every 150 hours

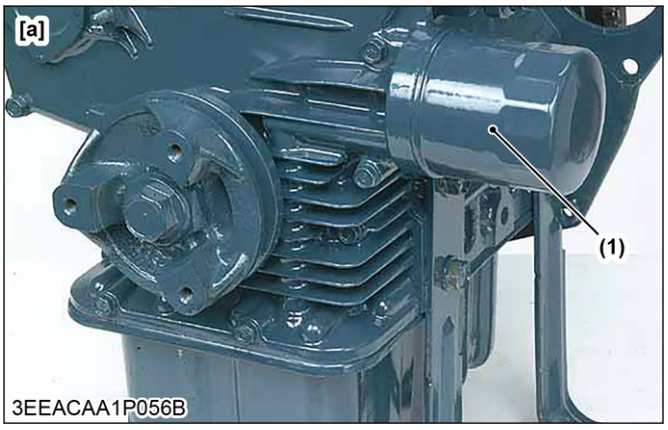
## 6.1 Replacing oil filter cartridge

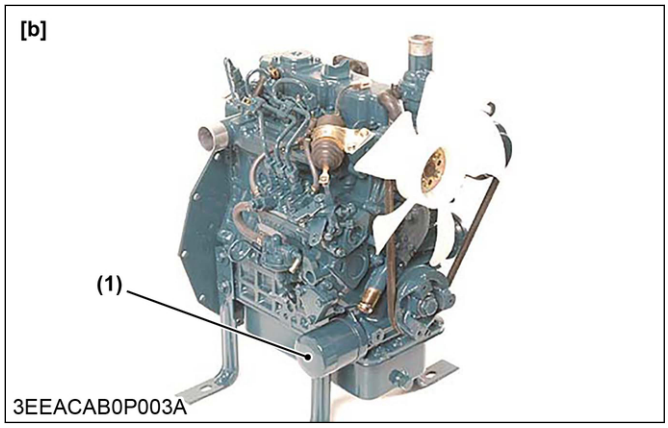
**⚠ CAUTION**
- **Make sure that you stop the engine before you replace the oil filter cartridge.**

**■ IMPORTANT**
- **To prevent serious damage to the engine, replacement element must be highly efficient. Use only a Kubota genuine filter or its equivalent.**

**Tools required**
- Filter wrench

1. Remove the oil filter cartridge (1) with the filter wrench.




(1) Oil filter cartridge [b] One-side maintenance type
[a] Standard type

2. Apply a thin layer of oil on the new cartridge gasket.
3. Install the new cartridge by hand.

**■ NOTE**
- **Do not tighten too much because it can cause deformation of the rubber gasket.**

4. Make sure that the engine oil does not flow through the seal and read the oil level on the dipstick.
5. Fill the engine oil until the specified level.

**■ NOTE**
- **After you replace the cartridge, the engine oil usually decrease by a small level.**

# 7. Check points of every 200 hours

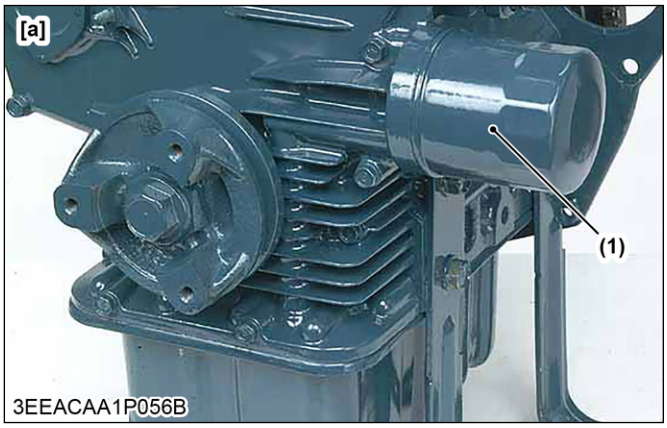
## 7.1 Replacing oil filter cartridge

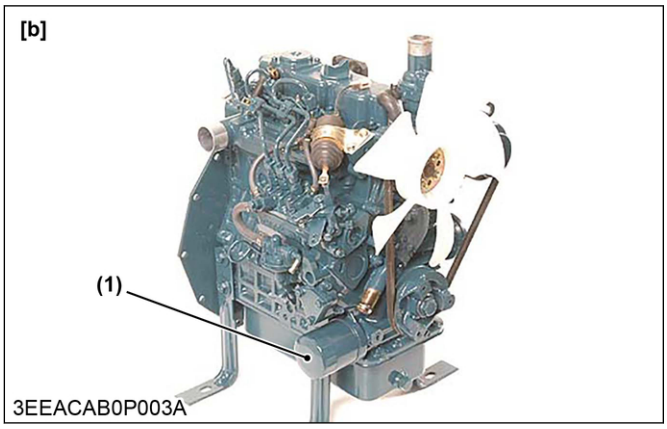
**⚠ CAUTION**
- **Make sure that you stop the engine before you replace the oil filter cartridge.**

**■ IMPORTANT**
- **To prevent serious damage to the engine, replacement element must be highly efficient. Use only a Kubota genuine filter or its equivalent.**

**Tools required**
- Filter wrench

1. Remove the oil filter cartridge (1) with the filter wrench.




(1) Oil filter cartridge [b] One-side maintenance type
[a] Standard type

2. Apply a thin layer of oil on the new cartridge gasket.
3. Install the new cartridge by hand.

**■ NOTE**
- **Do not tighten too much because it can cause deformation of the rubber gasket.**

4. Make sure that the engine oil does not flow through the seal and read the oil level on the dipstick.
5. Fill the engine oil until the specified level.

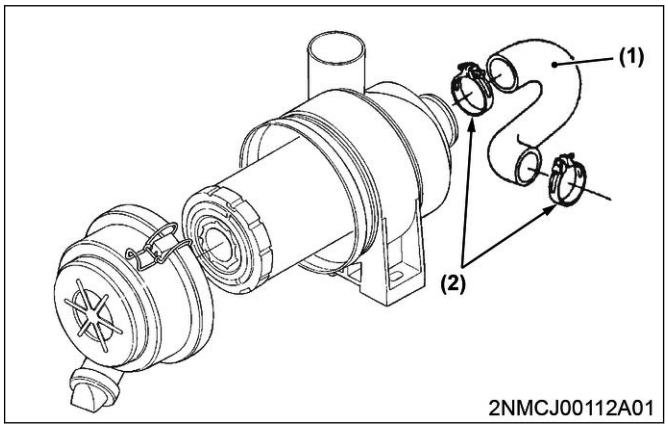
**■ NOTE**
- **After you replace the cartridge, the engine oil usually decrease by a small level.**

## 7.2 Checking intake air line

**■ IMPORTANT**
- **To prevent serious damage to the engine, keep dust out of the intake air line.**

1. Make sure that the intake air hose (1) is connected correctly.
2. Visually check for cracks, gas leak and anything else unusual.
3. If the clamp (2) is loose, apply oil to the threads and tighten them again correctly.

**■ NOTE**
- **The intake air hose (1) must be replaced every 2 years.**
  **Also replace the clamp (2) every 2 years and tighten it correctly.**




(1) Intake air hose (2) Clamp

## 7.3 Checking intake air line for D902-TE4

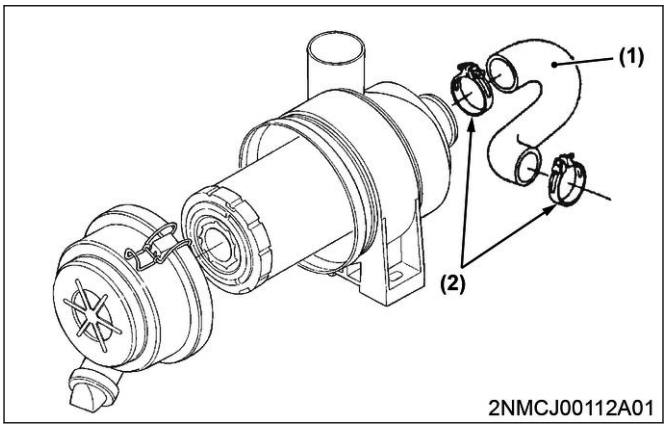
**■ IMPORTANT**
- **To prevent serious damage to the engine, keep dust out of the intake air line.**

1. Make sure that the intake air hose (1), the inlet hose 1 (3), and the inlet hose 2 (4) are connected correctly.
2. Visually check for cracks, gas leak and anything else unusual.

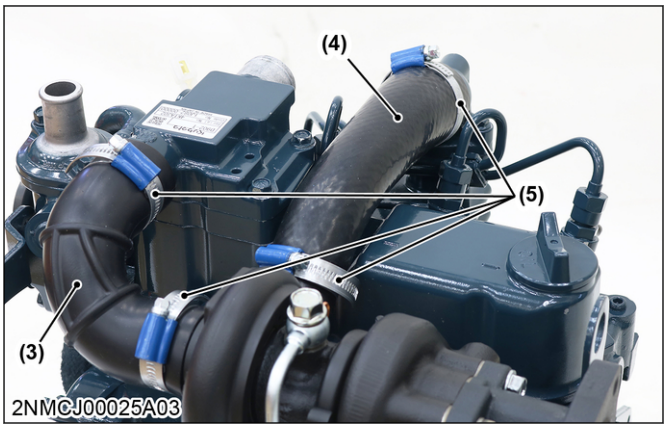
3. If the clamp (2) and (5) are loose, apply oil to the threads and tighten them again correctly.

**■ NOTE**

- **The intake air hose (1), the inlet hose 1 (3), and the inlet hose 2 (4) must be replaced every 2 years.**
  **Also replace the clamp (2) every 2 years and tighten it correctly.**




(1) Intake air hose (2) Clamp




(3) Inlet hose 1 (5) Clamp
(4) Inlet hose 2

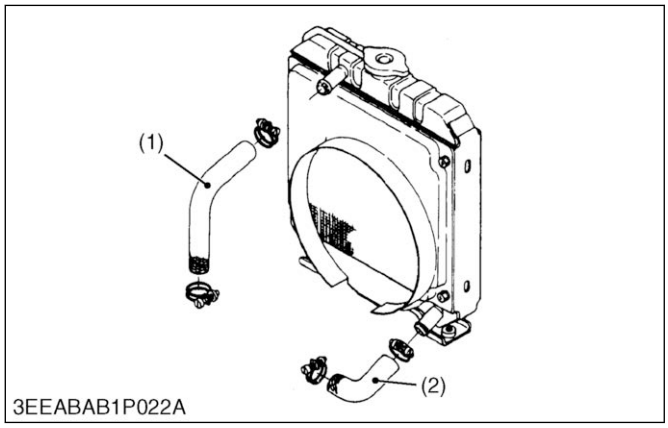
## 7.4 Checking radiator hose and clamp bands

1. Check whether the radiator hoses (1), (2) are connected correctly or not.

**■ NOTE**

- **Check to see if radiator hoses are properly fixed every 200 hours of operation or 6 months, whichever comes first.**

2. Check whether the radiator hoses (1), (2) and clamp are damaged or not.
   - If the radiator hose (1), (2) or clamp is damaged, replace it.




(1) Upper radiator hose (2) Lower radiator hose

3. If the clamp is loose, apply oil to the threads and tighten it again correctly.

**■ NOTE**

- **Replace hoses and hose clamps every 2 years or earlier whenever check and find that hoses are swollen, hardened or cracked.**
  **Also replace the hose clamps every 2 years and tighten them correctly.**

# 8. Check points of every 400 hours

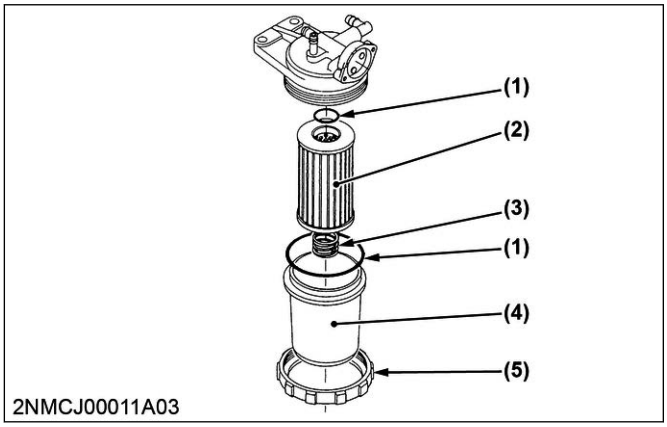
## 8.1 Replacing fuel filter element

1. Close the filter lever.
2. Remove the screw ring (5).
3. Take out the fuel filter element (2).
4. After taking out the fuel filter element (2), reinstall a new one, with keeping out of dust and dirt.

5. Bleed the air from the injection pump.

**IMPORTANT**

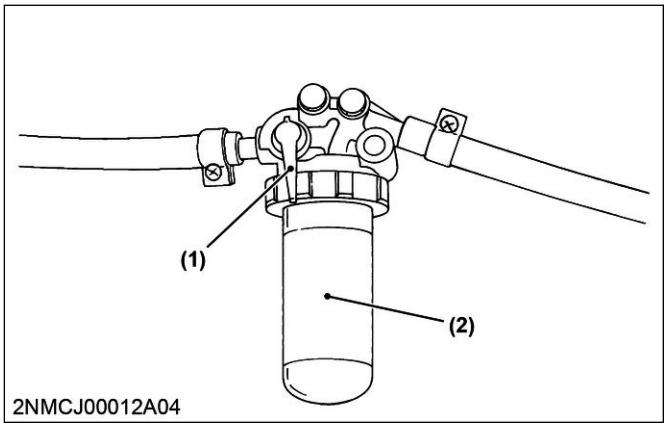
- **Infiltration of dust and dirt can cause malfunction of the fuel injection pump and the injection nozzle.**




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

## 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

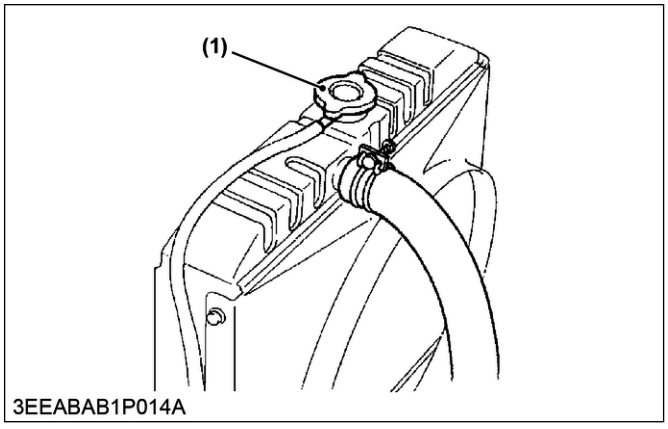
**CAUTION**

- **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**

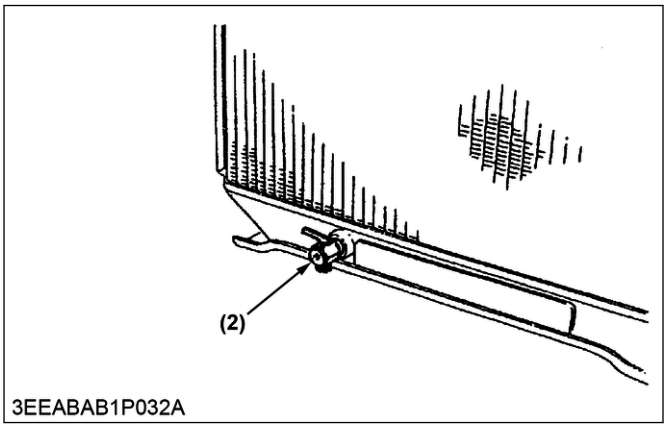
- **Do not start the engine without coolant.**
- **Use clean, fresh water and 50% anti-freeze to fill the radiator and the reserve tank.**
- **Make sure that when you mix the anti-freeze and water, the mixing ratio of anti-freeze must be less than 50%.**
- **Be sure to close the radiator cap (1) securely.**
  **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.**

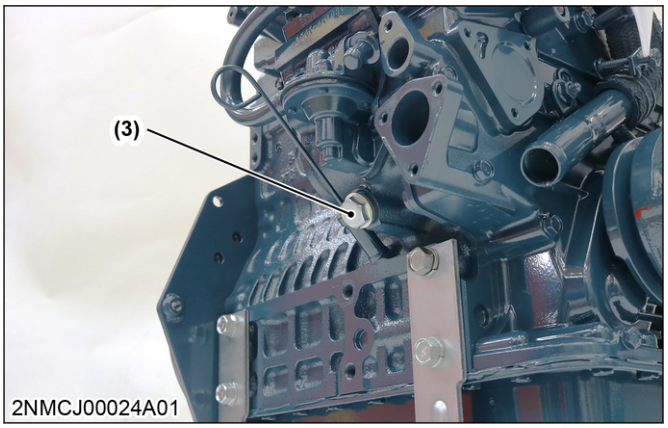
1. Stop the engine and let the coolant temperature decreases.
2. Remove the radiator cap (1) to drain the coolant




(1) Radiator cap

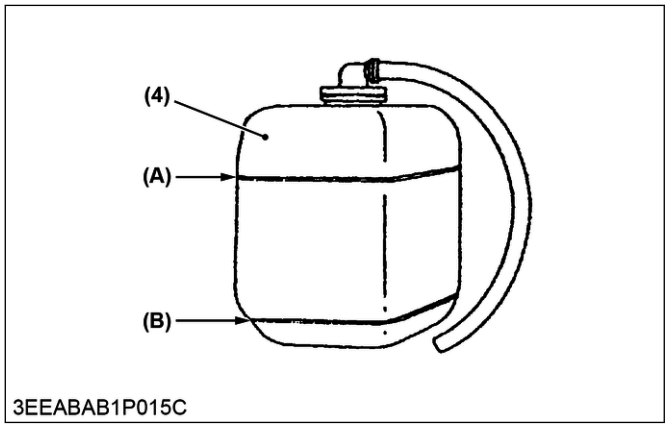
3. Open the drain valve (2) and drain plug (3).




(2) Drain valve (3) Drain plug

4. After you drained all of the coolant, close the drain valve (2) and the drain plug(3).
5. Fill the radiator with clean water and cooling system cleaner.
6. Obey the directions of the cooling system cleaner instruction.
7. After you flush, fill the radiator with clean water and anti-freeze until the coolant level is immediately below the port.
8. Install the radiator cap (1) correctly.
9. Fill the reserve tank (4) with the coolant until the **[FULL]** (A) mark on the reserve tank (4).




(4) Reserve tank (B) LOW
(A) FULL

10. Start and operate the engine for a few minutes.
11. Stop the engine and let the coolant temperature decreases.

12. Check the coolant level of radiator and reserve tank (4), and add coolant if necessary.

**Anti-freeze**

**■ NOTE**

- **There are 2 types of anti-freeze available: use the permanent type (PT) for this engine.**
- **When you add anti-freeze for the first time, flush the water jacket and radiator interior with clean, soft water several times.**
- **The brand of the anti-freeze and the ambient temperature have an effect on the procedure to mix water and anti-freeze.**
  **Refer to the SAE J1034 standard, especially to the SAE J814c.**
- **Mix the anti-freeze with clean, soft water, and then fill into the radiator.**

**■ IMPORTANT**

- **Make sure that when you mix the anti-freeze and water, the ratio of anti-freeze is less than 50%.**

**⚠ CAUTION**

**To avoid personal injury**

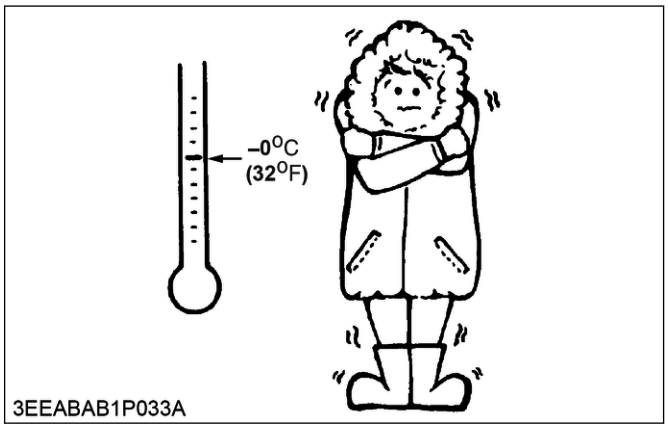
- **When using anti-freeze, put on some protection such as rubber gloves (anti-freeze contains poison).**
- **If accidentally drank anti-freeze, throw up at once and take medical attention.**
- **When anti-freeze came in contact with skin or clothing, wash it off immediately.**
- **Do not mix different types of anti-freeze. The mixture can cause chemical reaction, producing harmful substances.**
- **Anti-freeze is extremely flammable and explosive under certain conditions. Keep fire and children away from anti-freeze.**
- **When draining fluids from the engine, place a container underneath the engine body.**
- **Do not pour waste on the ground, down a drain, or into any water source.**
- **Also, refer to relevant environmental protection regulations, when disposing anti-freeze.**

| Anti-freeze volume | Freezing point | | Boiling point* | |
|---|---|---|---|---|
| | ℃ | ℉ | ℃ | ℉ |
| 50% | -37 | -35 | 108 | 226 |

* 1.01×100000 Pa (760 mmHg) standard atmospheric pressure. Use a radiator pressure cap that increases the pressure inside the cooling system to get a higher boiling point.

**■ NOTE**

- **The above data is the industrial standards that shows the minimum glycol content necessary in the concentrated anti-freeze.**
- **When the coolant level decreases because of evaporation, add clean, soft water only to keep the anti-freeze mixing ratio less than 50%.**
  **If there is a leakage, add anti-freeze and clean, soft water in the specified mixing ratio.**
- **The anti-freeze absorbs moisture. Keep new anti-freeze in a tightly sealed container.**
- **Do not use the radiator cleaning agents after you add anti-freeze to the coolant.**
  **Anti-freeze contains an anti-corrosive agent, which reacts with the radiator cleaning agent to make sludge and cause damages to the engine parts.**

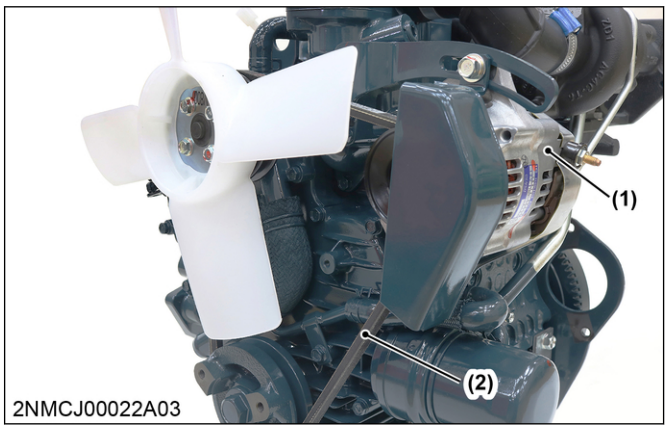



## 9.2 Replacing fan belt

**Tools required**

- Sonic belt tension meter

1. Remove the alternator (1).
2. Remove the fan belt (2).




(1) Alternator (2) Fan belt

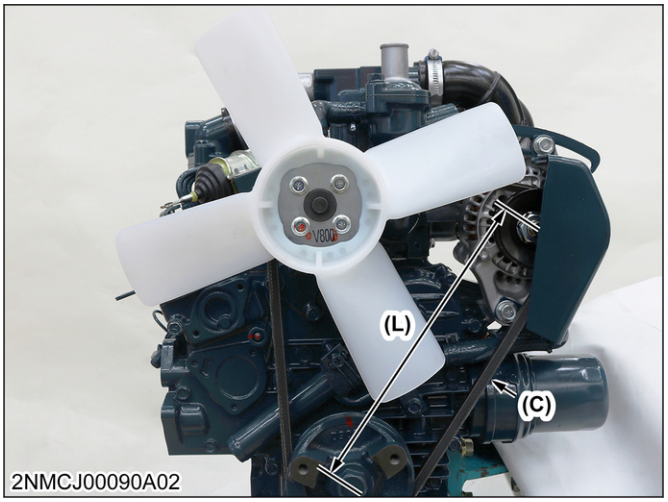
3. Replace the fan belt (2) with a new one.

4. Install the alternator (1).
5. Adjust the tension of fan belt at the position (C) between the fan drive pulley and alternator pulley with sonic belt tension meter.

**■ NOTE**
- **If the measurement is out of the service specifications, loosen the alternator mounting screws and adjust its position.**

| Sonic belt tension meter setting value | |
|---|---|
| Mass<br>(Mass per 1 rib 1 m of belt) | 80 g/rib/m |
| Width<br>(Number of ribs) | 1 |
| Span L | Measure at location (C) in the figure with (L) as the distance between the fan drive pulley and alternator pulley. |

| | | |
|---|---|---|
| Belt tension | Service specification | 344 to 441 N<br>35.1 to 44.9 kgf<br>77.4 to 99.1 lbf |



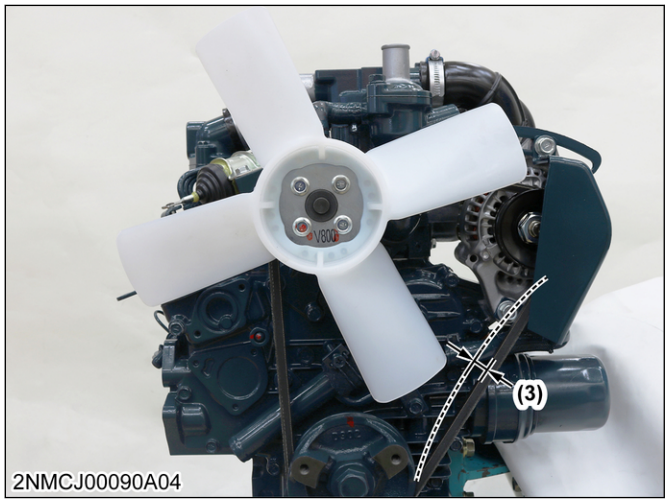

(C) Fan belt halfway

**(Reference)**

a. Push the belt halfway between the fan drive pulley and alternator pulley at a specified force to measure the deflection (3).

**■ NOTE**
- **If the measurement is out of the service specifications, loosen the alternator mounting screws and adjust its position.**

| | | |
|---|---|---|
| Deflection (3) | Service specification | 7.0 to 9.0 mm<br>0.28 to 0.35 in.<br>(Under load of 98 N<br>(10 kgf, 22 lbf)) |




(3) Deflection

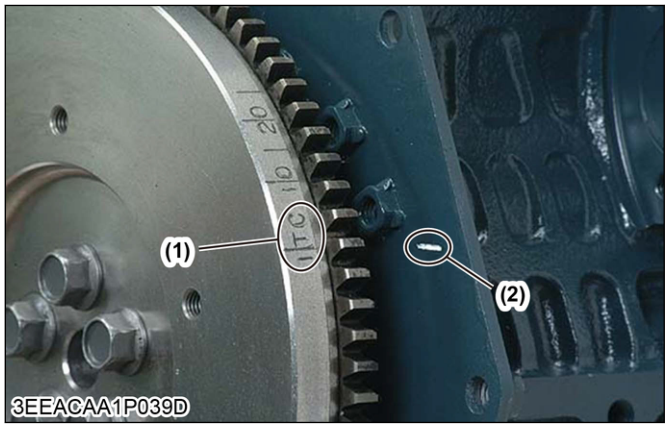
# 10. Check point of every 800 hours

## 10.1 Checking valve clearance

**■ IMPORTANT**
- **You must check and adjust the valve clearance (5), when the engine is cold.**

**Tools required**
- Feeler gauge

1. Remove the inlet hose 1 and 2.
2. Remove the cylinder head cover.
3. Remove the glow lead and glow plugs.
4. Align the **[1TC]** mark (1) on the flywheel and the alignment mark (2) on the rear end plate.




(1) 1TC mark (2) Alignment mark

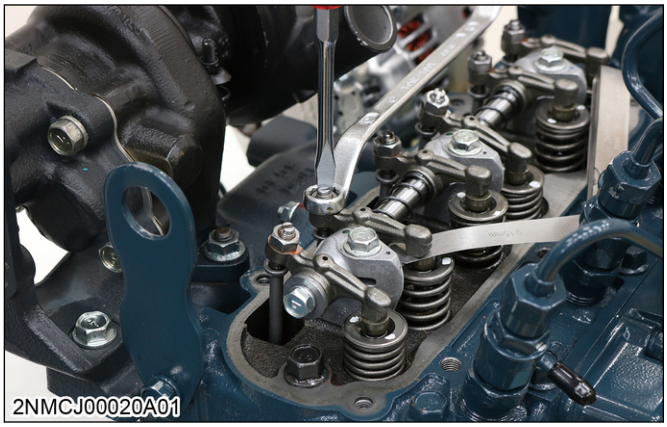
5. Make sure that the No. 1 piston comes to the compression or overlap top dead center.

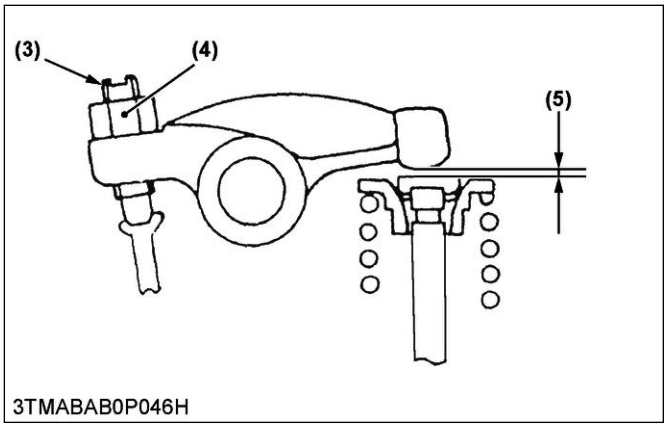
6. Check the subsequent valve clearance (5) at the **[1TC]** mark (1) position with a feeler gauge.

**NOTE**
- **If the valve clearance (5) is out of the service specification, adjust the clearance with the adjusting screw (3).**
- **Tighten the lock nut (4) of the adjusting screw (3).**

| | | |
|---|---|---|
| Valve clearance (Cold) | Service specification | 0.145 to 0.185 mm<br>0.00571 to 0.00728 in. |

| Adjustable cylinder location of piston | | Valve arrangement | |
|---|---|---|---|
| | | Intake | Exhaust |
| When No. 1 piston is at compression top dead center | 1 | ☆ | ☆ |
| | 2 | | ☆ |
| | 3 | ☆ | |
| When No. 1 piston is at overlap top dead center | 1 | | |
| | 2 | ☆ | |
| | 3 | | ☆ |




(3) Adjusting screw
(4) Lock nut
(5) Valve clearance

7. Install the removed parts.

| | | |
|---|---|---|
| Tightening torque | Cylinder head cover screw | 6.86 to 11.3 N·m<br>0.700 to 1.15 kgf·m<br>5.06 to 8.33 lbf·ft |

# 11. Check points of every 1500 hours

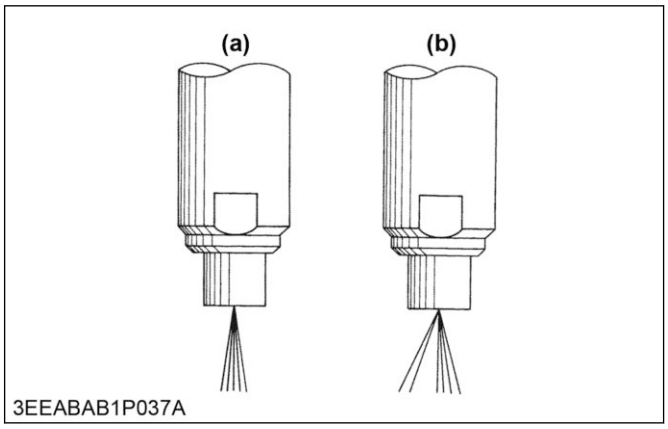
## 11.1 Checking nozzle spraying condition

**CAUTION**
- **Check the injection pressure and condition, after you make sure that there is nobody standing in the direction the fume goes.**
  **If the fume from the nozzle directly contacts a human body, the fume might destroy cells of the human body and cause blood poisoning.**

**Tools required**
- Nozzle tester

1. Set the injection nozzle to the nozzle tester.
2. Check the nozzle spraying condition.

**NOTE**
- **If the spraying condition is bad, replace the nozzle piece.**




(a) Good (b) Bad

## 11.2 Checking fuel injection pressure

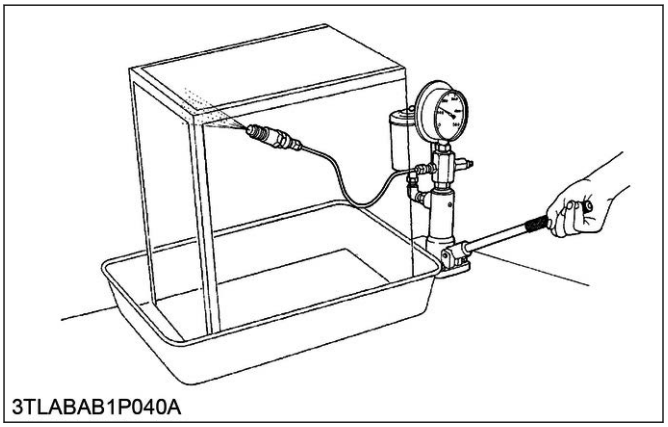
**CAUTION**
- **Check the injection pressure and condition, after you make sure that there is nobody standing in the direction the fume goes.**
  **If the fume from the nozzle directly contacts a human body, the fume might destroy cells of the human body and cause blood poisoning.**

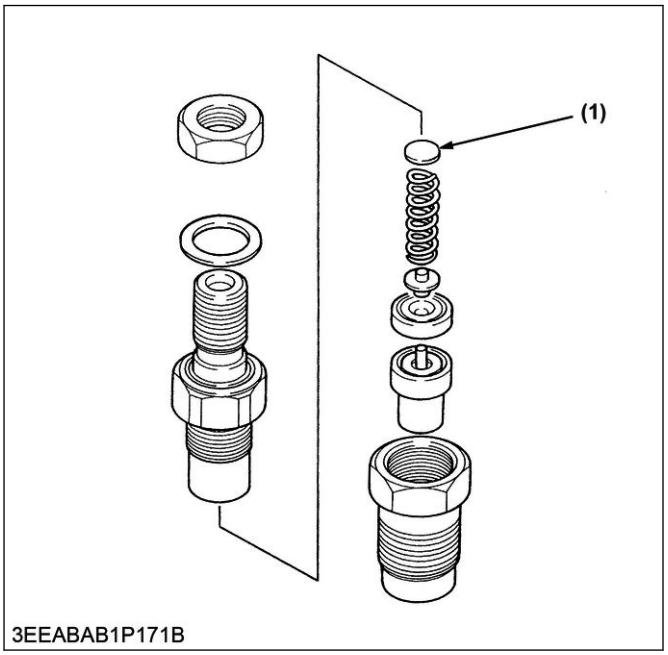
**Tools required**
- Nozzle tester

1. Set the injection nozzle to the nozzle tester.
2. Slowly move the handle of nozzle tester to measure the pressure at which the fuel begins to jet out from the injection nozzle.

**NOTE**
- **If the measurement is not within the service specification, replace the adjusting washer (1) in the nozzle holder to adjust it.**
- **Pressure changes approx. 590 kPa (6.02 kgf/cm$^2$ , 85.6 psi) for every 0.025mm (0.00098 in.) change in thickness of washers.**

| | | |
|---|---|---|
| Fuel injection pressure | Service specification | 13.7 to 14.7 MPa<br>140 to 149 kgf/cm$^2$<br>1990 to 2130 psi |


3TLABAB1P040A



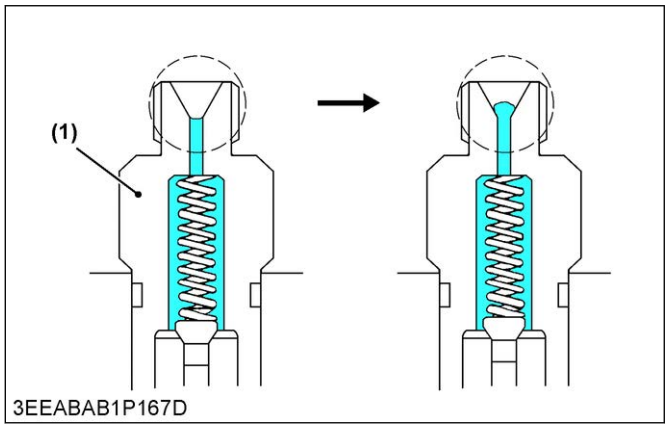
3EEABAB1P171B

(1) Adjusting washer

# 12. Check points of every 3000 hours

## 12.1 Checking injection timing

1. Remove the injection pipes.
2. Turn the flywheel counterclockwise (viewed from flywheel side), until the fuel fills up to the hole of the delivery valve holder (1) of No. 1 cylinder.

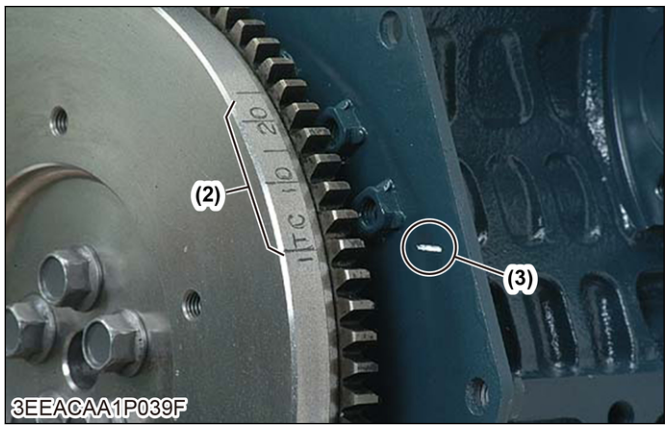


3EEABAB1P167D

(1) Delivery valve holder

3. After the fuel fills up to the hole of the delivery valve holder (1) of No. 1 cylinder, turn back (clockwise) the flywheel around 1.6 rad (90°).
4. Turn the flywheel counterclockwise to set at around 0.44 rad (25°) before T.D.C..
5. Slowly turn the flywheel counterclockwise and stop turning, when the fuel begins to come up to get present injection timing.
6. Check and read the timing line (2) of flywheel that matches the alignment mark (3).

**NOTE**
- **The flywheel has mark "[1TC]", "[10]" and "[20]" for the crank angle before the top dead center of No. 1 cylinder.**



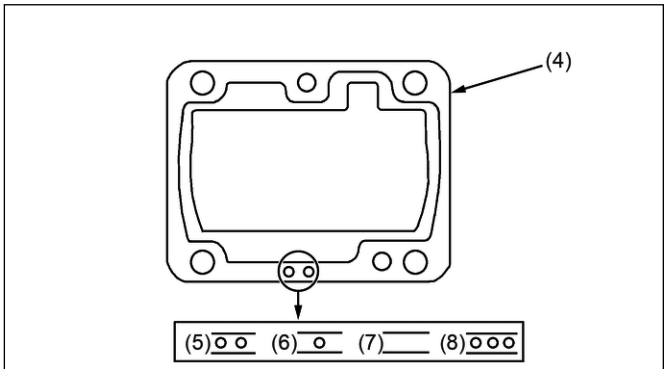
3EEACAA1P039F

(2) Timing line (3) Alignment mark

7. If injection timing is out of adjustment, readjust the timing with shims.

**■ NOTE**

- **The liquid gasket is not required for assembling.**
- **Shims are available in thickness of 0.20 mm (0.0079 in.), 0.25 mm (0.0098 in.), 0.30 mm (0.012 in.), 0.35 mm (0.014 in.) and 0.175 mm (0.00689 in.).**
  **Combine these shims for adjustments.**
- **Addition or reduction of a shim (0.050 mm, 0.0020 in.) delays or advances the injection timing by approx. 0.0087 rad (0.5°).**
- **During disassembling and replacing the injection pump, be sure to use the same number of new shims with the same thickness.**
- **The 0.175 mm (0.00689 in.) thick shim is coated only on the lower face.**
  **Therefore, do not use the 0.175 mm (0.00689 in.) thick shim as the top shim of the combination (injection pump side), because this can cause oil leakage.**
- **Refer to the figure of the shim to check the thicknesses of the shims.**
- **The injection timing might be changed by the application.**



3EEAEAE0P001A

(4) Shim (soft metal gasket shim)
(5) Two-holes: 0.20 mm (0.0079 in.)
Two-holes: 0.175 mm (0.00689 in.)
(6) One-hole: 0.25 mm (0.0098 in.)
(7) Without hole: 0.30 mm (0.012 in.)
(8) Three-holes: 0.35 mm (0.014 in.)

| Injection timing | | |
|---|---|---|
| Engine model | (min$^{-1}$ (rpm)) | Service specification |
| Z482/D602-E4 | 3600 | 0.3186 to 0.3447 rad 18.25 to 19.75° before T.D.C |
| Z482-E4BG | 1800 | 0.2706 to 0.2967 rad 15.50 to 17.00° before T.D.C |
| Z482-E4BG2 | 1500 | 0.2453 to 0.2713pi rad 14.05 to 15.55° before T.D.C |
| D722-E4 | 3200 | 0.3360 to 0.3621 rad 19.25 to 20.75° before T.D.C |
| D782-E4 | 3200 | 0.2837 to 0.3097 rad 16.25 to 17.75° before T.D.C |
| D902-E4 | 3600 | 0.3186 to 0.3447 rad 18.25 to 19.75° before T.D.C |
| D902-TE4 | 3200 | 0.3360 to 0.3621 rad 19.25 to 20.75° before T.D.C |

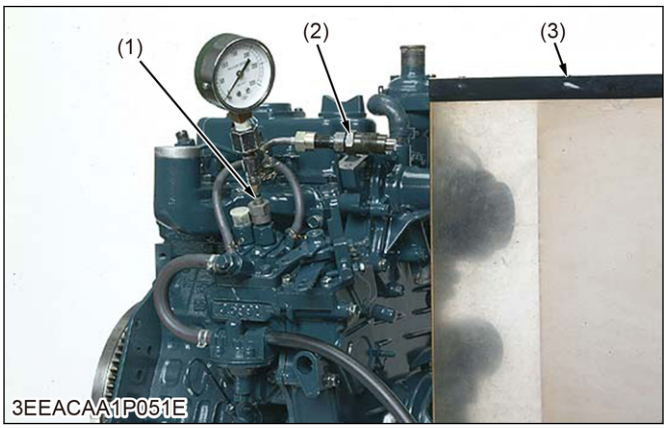
## 12.2 Checking fuel tightness of pump element

**Tools required**

- Injection pump pressure tester

1. Remove the injection pipes and glow plugs.
2. Install the injection pump pressure tester (1) to the injection pump.

3. Install the injection nozzle (2) jetted with the proper injection pressure to the injection pump pressure tester (1). (Refer to the photo.)




(1) Injection pump pressure tester
(2) Injection nozzle
(3) Protection cover for jetted fuel

4. Set the speed control lever to the maximum speed position.
5. Operate the starter to increase the pressure.

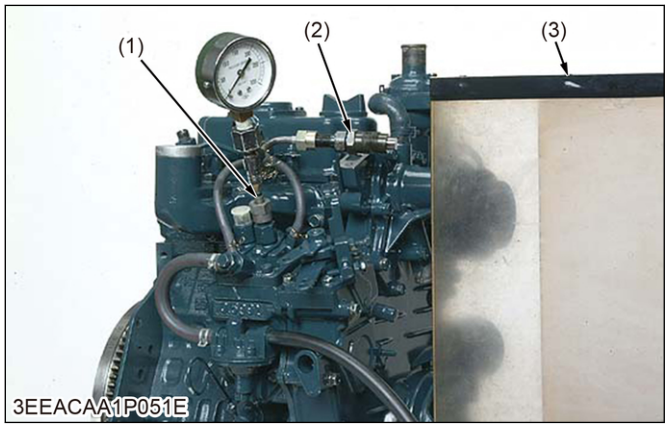
**NOTE**
- **If the pressure can not reach the service limit, replace the pump with a new one or repair it at a Kubota-authorized pump service shop.**
- **Never try to disassemble the injection pump assembly.**
  **For repairs, you are strongly requested to contact a Kubota-authorized pump service shop.**

| | | |
|---|---|---|
| Fuel tightness of pump element | Service limit | 13.7 MPa<br>140 kgf/cm$^2$<br>1990 psi |

## 12.3 Checking fuel tightness of delivery valve

**Tools required**
- Injection pump pressure tester

1. Remove the injection pipes and glow plugs.
2. Set an injection pump pressure tester (1) to the fuel injection pump.
3. Install the injection nozzle (2) jetted with the proper injection pressure to the injection pump pressure tester (1).




(1) Injection pump pressure tester
(2) Injection nozzle
(3) Protection cover for jetted fuel

4. Operate the starter to increase the pressure.
5. Stop the starter when the fuel jets from the injection nozzle (2). After that, turn the flywheel by hands and raise the pressure to approx. 13.73 MPa (140.0 kgf/cm$^2$ , 1991 psi).
6. Now turn the flywheel back about half a turn (to keep the plunger free) and keep the flywheel at this position.
7. Measure the time until the pressure drops.

**NOTE**
- **If the measurement is less than service limit, replace the pump with a new one or repair it at a Kubota-authorized pump service shop.**
- **Never try to disassemble the injection pump assembly.**
  **For repairs, you are strongly requested to contact a Kubota-authorized pump service shop.**

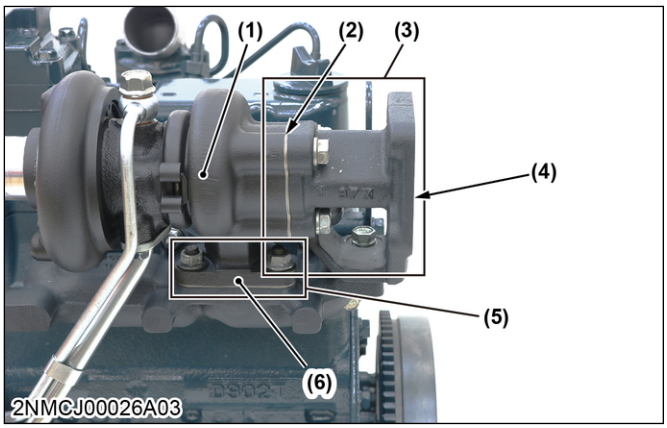
| | | |
|---|---|---|
| Fuel tightness of delivery valve | Service specification | 10 seconds<br>From 13.73 to 12.75 MPa<br>From 140.0 to 130.0 kgf/cm$^2$<br>From 1991 to 1849 psi |
| | Service limit | 5 seconds<br>From 13.73 to 12.75 MPa<br>From 140.0 to 130.0 kgf/cm$^2$<br>From 1991 to 1849 psi |

## 12.4 Checking turbocharger for D902-TE4

**Turbine side**

1. Check the exhaust port (3) and the inlet port (5) side of the turbine housing (1) for exhaust gas leakage.

**NOTE**
- **If you find gas leakage, tighten the bolts and nuts again or replace the gasket (2), (4), (6) with new ones.**

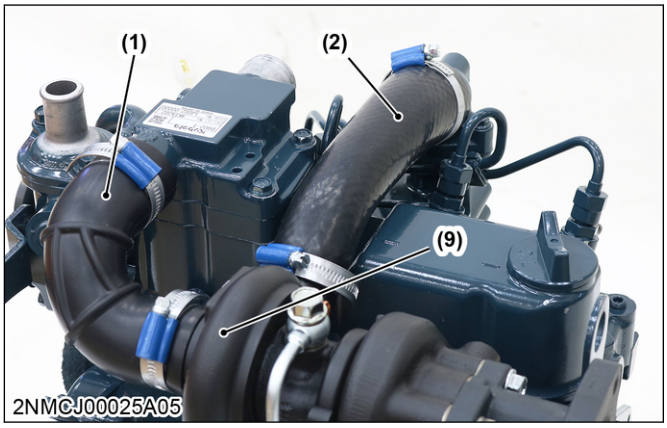



(1) Turbine housing
(2) Gasket
(3) Exhaust port
(4) Gasket
(5) Inlet port
(6) Gasket

**Compressor side**

1. Check the inlet hose 1 (7) and 2 (8) of the compressor cover (9) for air leakage.

**NOTE**
- **If you find air leakage, change the clamps or the inlet hose 1 (7) and 2 (8)**




(7) Inlet hose 1
(8) Inlet hose 2
(9) Compressor cover

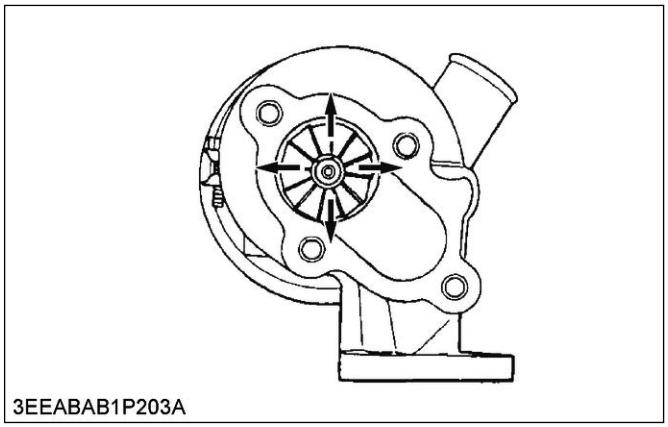
2. Replace the inlet hose 1 (7), 2 (8) and check the suction side of the inlet hoses for loose connections or cracks.

**NOTE**
- **If you find loose connections or cracks, tighten the clamps or replace the hoses.**

**Radial clearance**

1. Check the radial clearance between the wheel and the housing.

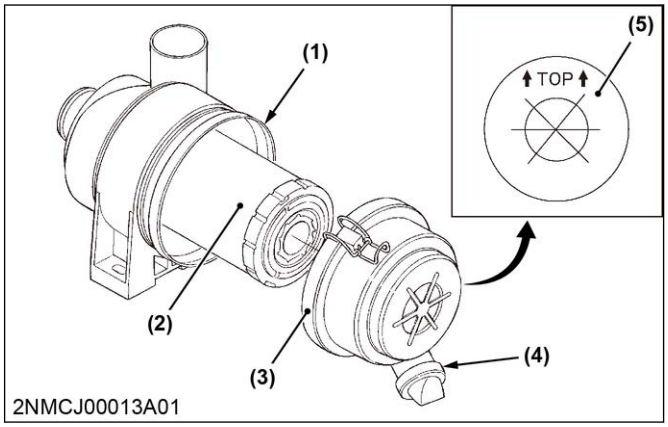
**NOTE**
- **If the wheel touches the housing, replace the turbocharger assembly with a new one.**




# 13. Check points of every 1 year

## 13.1 Replacing air cleaner element

1. Remove the air cleaner cap and used air cleaner element (2).
2. Replace a new air cleaner element (2).




(1) Air cleaner body
(2) Air cleaner element
(3) Air cleaner cover
(4) Evacuator valve
(5) TOP mark

**NOTE**
- **As the air cleaner element (2) employed on this engine is a dry type, never apply oil to the element.**
- **Do not operate the engine with its air cleaner element removed.**

**IMPORTANT**
- **Make sure the hooking clip of the air cleaner cover (3) is tight enough.**
  **If the hooking clip is loose, dust and dirt might be sucked into the engine, and wear down the cylinder liner and piston ring faster, thereby resulting in poor power output.**

# 14. Check points of every 2 years

## 14.1 Changing radiator coolant (L.L.C.)

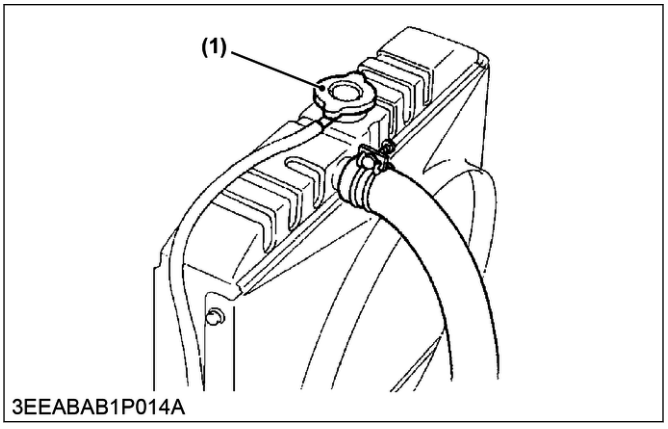
**⚠ CAUTION**

- **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**

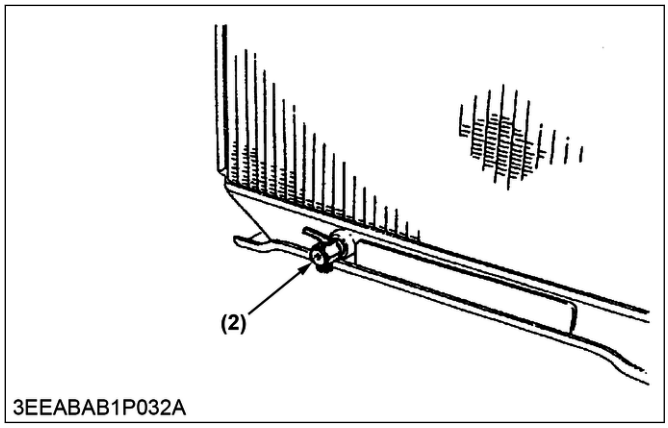
- **Do not start the engine without coolant.**
- **Use clean, fresh water and 50% anti-freeze to fill the radiator and the reserve tank.**
- **Make sure that when you mix the anti-freeze and water, the mixing ratio of anti-freeze must be less than 50%.**
- **Be sure to close the radiator cap (1) securely.**
  **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.**

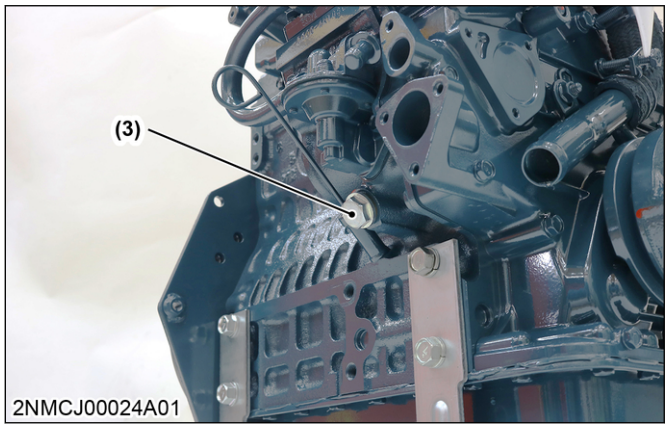
1. Stop the engine and let the coolant temperature decreases.
2. Remove the radiator cap (1) to drain the coolant




(1) Radiator cap

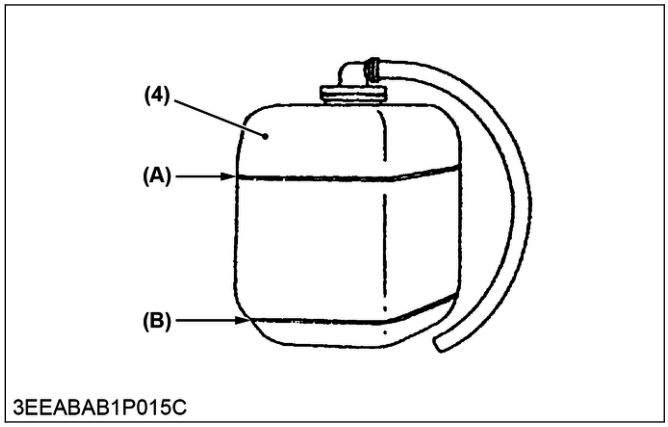
3. Open the drain valve (2) and drain plug (3).




(2) Drain valve (3) Drain plug

4. After you drained all of the coolant, close the drain valve (2) and the drain plug(3).
5. Fill the radiator with clean water and cooling system cleaner.
6. Obey the directions of the cooling system cleaner instruction.
7. After you flush, fill the radiator with clean water and anti-freeze until the coolant level is immediately below the port.
8. Install the radiator cap (1) correctly.
9. Fill the reserve tank (4) with the coolant until the **[FULL]** (A) mark on the reserve tank (4).




(4) Reserve tank (B) LOW
(A) FULL

10. Start and operate the engine for a few minutes.

11. Stop the engine and let the coolant temperature decreases.
12. Check the coolant level of radiator and reserve tank (4), and add coolant if necessary.

**Anti-freeze**

**■ NOTE**

- **There are 2 types of anti-freeze available: use the permanent type (PT) for this engine.**
- **When you add anti-freeze for the first time, flush the water jacket and radiator interior with clean, soft water several times.**
- **The brand of the anti-freeze and the ambient temperature have an effect on the procedure to mix water and anti-freeze.**
  **Refer to the SAE J1034 standard, especially to the SAE J814c.**
- **Mix the anti-freeze with clean, soft water, and then fill into the radiator.**

**■ IMPORTANT**

- **Make sure that when you mix the anti-freeze and water, the ratio of anti-freeze is less than 50%.**

**⚠ CAUTION**

**To avoid personal injury**

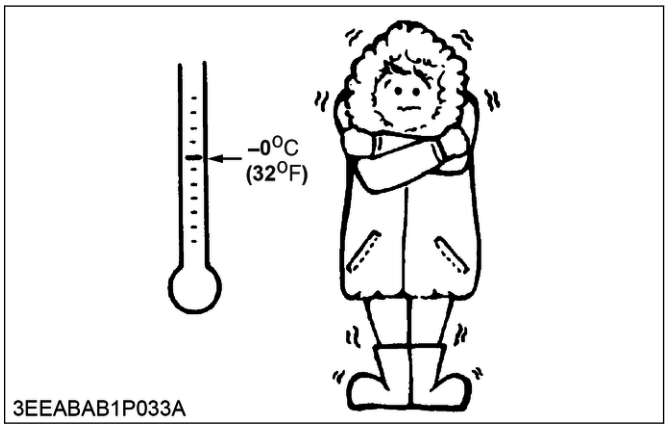
- **When using anti-freeze, put on some protection such as rubber gloves (anti-freeze contains poison).**
- **If accidentally drank anti-freeze, throw up at once and take medical attention.**
- **When anti-freeze came in contact with skin or clothing, wash it off immediately.**
- **Do not mix different types of anti-freeze. The mixture can cause chemical reaction, producing harmful substances.**
- **Anti-freeze is extremely flammable and explosive under certain conditions. Keep fire and children away from anti-freeze.**
- **When draining fluids from the engine, place a container underneath the engine body.**
- **Do not pour waste on the ground, down a drain, or into any water source.**
- **Also, refer to relevant environmental protection regulations, when disposing anti-freeze.**

| Anti-freeze volume | Freezing point | | Boiling point* | |
|---|---|---|---|---|
| | ℃ | ℉ | ℃ | ℉ |
| 50% | -37 | -35 | 108 | 226 |

* At 1.01 × 100000 Pa (760 mmHg) pressure (atmospheric), use a radiator pressure cap that increases the pressure inside the cooling system to get a higher boiling point.

**■ NOTE**

- **The above data is the industrial standards that shows the minimum glycol content necessary in the concentrated anti-freeze.**
- **When the coolant level decreases because of evaporation, add clean, soft water only to keep the anti-freeze mixing ratio less than 50%.**
  **If there is a leakage, add anti-freeze and clean, soft water in the specified mixing ratio.**
- **The anti-freeze absorbs moisture. Keep new anti-freeze in a tightly sealed container.**
- **Do not use the radiator cleaning agents after you add anti-freeze to the coolant.**
  **Anti-freeze contains an anti-corrosive agent, which reacts with the radiator cleaning agent to make sludge and cause damages to the engine parts.**



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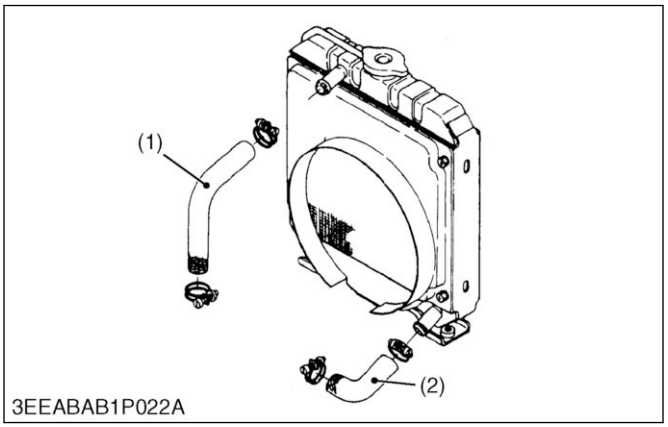
## 14.2 Replacing radiator hose and clamp bands

**⚠ CAUTION**

- **Do not remove the radiator cap when the engine is hot.**
  **Then loosen the cap slightly to release unwanted pressure before you remove the cap fully.**

1. Drain the coolant.
2. Loosen the clamp bands.

3. Remove the upper hose (1) and lower hose (2).

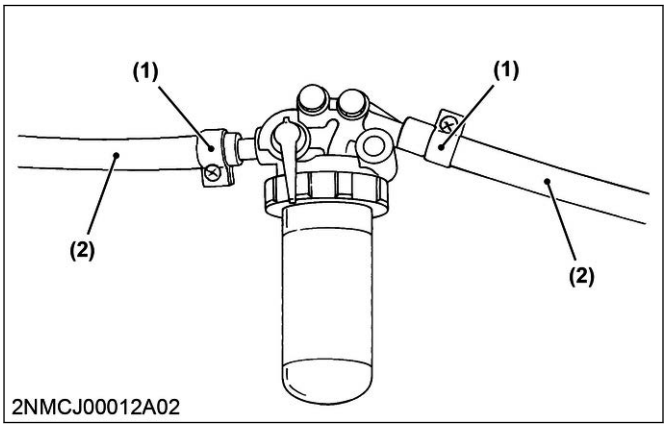



(1) Upper hose (2) Lower hose

4. Replace the upper / lower hose (1), (2) and clamp bands with new ones.
5. Tighten the clamp bands correctly.

## 14.3 Replacing fuel hose and clamps

1. Loosen the clamp (2) and remove the fuel hose (1).




(1) Clamp band (2) Fuel pipe

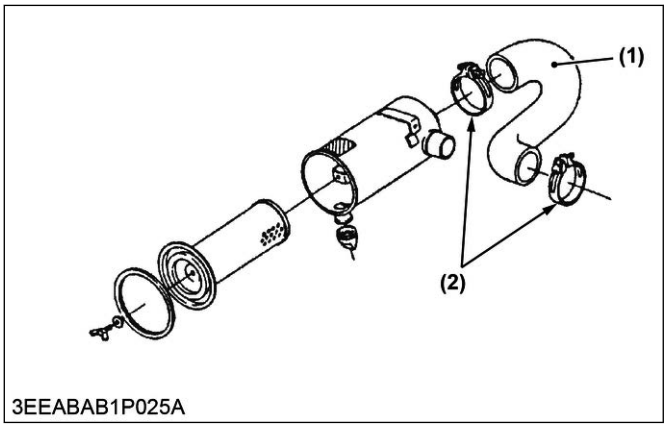
2. Replace the fuel hose (1) and clamp (2) with new ones.
3. Tighten the clamp (2) correctly.
4. After you replace the fuel hose and the clamp, bleed the fuel system.

## 14.4 Replacing intake air line

**IMPORTANT**

- **To prevent serious damage to the engine, keep out dust in the intake air line.**

1. Loosen the clamp (2).
2. Remove the intake air hose (1) and clamp (2).




(1) Intake air hose (2) Clamp

3. Replace the intake air hose (1) and clamp (2) with new ones.
4. Tighten the clamp (2) correctly.

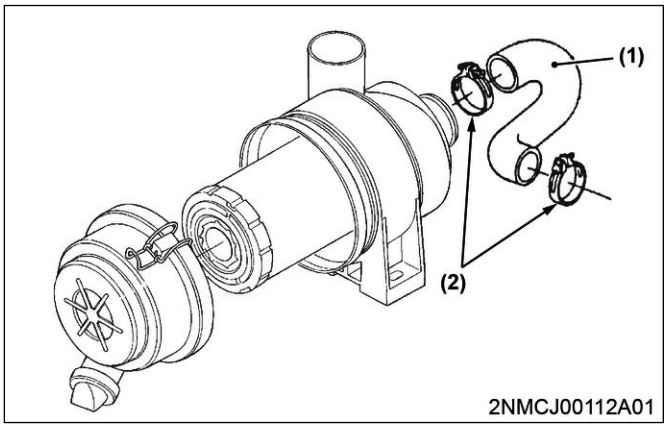
## 14.5 Replacing intake air line for D902-TE4

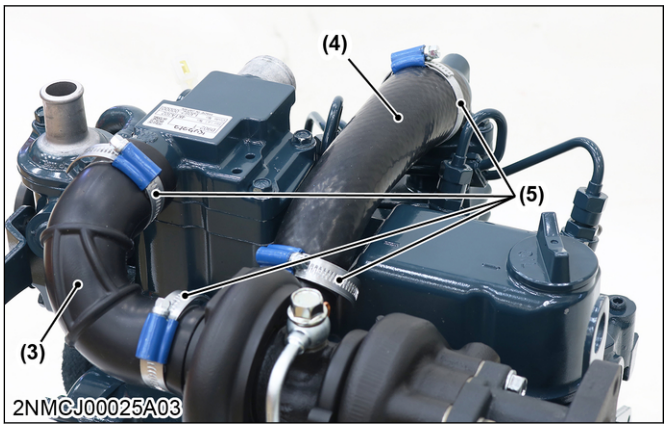
**IMPORTANT**

- **To prevent serious damage to the engine, keep dust out of the intake air line.**

1. Loosen the clamps (2), (5).

2. Remove the intake air hose (1), clamps (2), (5), Inlet hose 1 (3) and Inlet hose 2 (4).




(1) Intake air hose
(2) Clamp
(3) Inlet hose 1
(4) Inlet hose 2
(5) Clamp

3. Replace the intake air hose (1), Inlet hose 1 (3) and Inlet hose 2 (4) with new ones.
4. Tighten the clamps (2), (5) correctly.

# 4. ENGINE

# MECHANISM

## 1. General (Introduction)

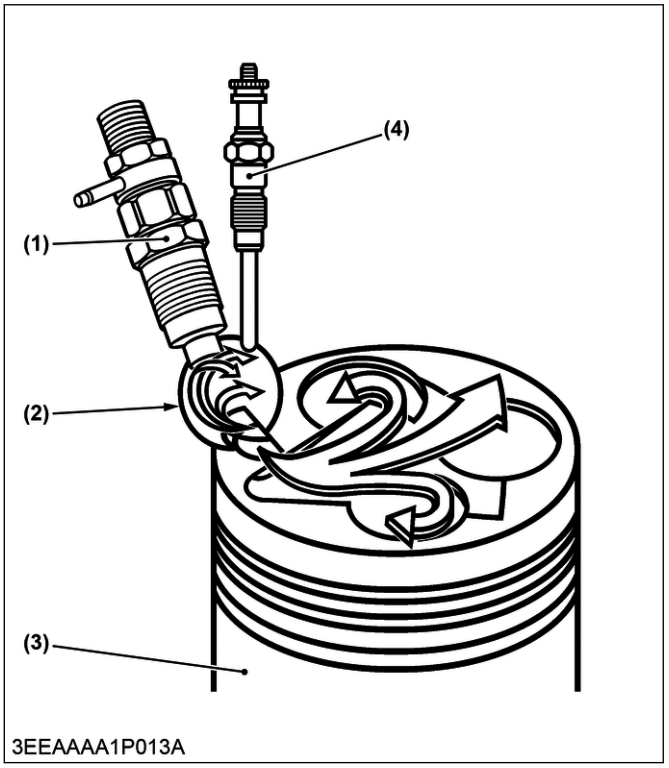
### 1.1 Feature of combustion (E-TVCS)

This engine adopts the IDI (in-direct injection) combustion system called a swirl chamber system.
The swirl chamber system consists a main combustion chamber on the piston side and a sub chamber (overflow chamber) on the cylinder head side.
Both chambers are connected by a narrow passage.
Kubota employs a originally developed E-TVCS (Three vortex combustion system) for the swirl chamber system.
In this system, the fuel that injected into the swirl chamber self-ignites, burns,and expands to form three vortex.
And then, the structure is such that the combustion gas flows uniformly into the main combustion chamber.
This system has improved combustion and achieved emission regulations.

### 1.2 Structure of E-TVCS

The combustion system is made up of the injection nozzle (1), glow plug (4) and combustion chamber (2) and the like.

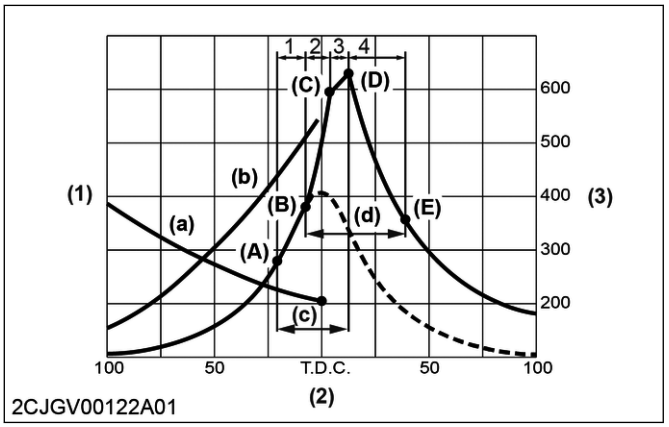
- The combustion chamber (2) is of Kubota's exclusive E-TVCS combustion chamber type. Suction air is whirled to be mixed effectively with the fuel, prompting combustion and reducing fuel consumption.




(1) Injection nozzle
(2) Combustion chamber
(3) Piston
(4) Glow plug

### 1.3 Flow of combustion (E-TVCS)

Combustion flow is separated into 4 processes.




(1) Pressure
(2) Crank angle (degree)
(3) Temperature (℃)
(a) Spontaneous combustion temperature of the fuel
(b) Air temperature
(c) Injection
(d) Combustion
(A) Point A
(B) Point B
(C) Point C
(D) Point D
(E) Point E
1: Ignition delay period
2: Flame propagation period
3: Direct combustion period
4: Late combustion period

1. Ignition delay period

The ignition delay period is the period from when the fuel is injected into the cylinder as a mist until start of combustion is attempted.
The fuel that injected into the cylinder at the high temperature high pressure compressed air through several degrees before compression top dead center is vaporized by heat of air.
Thereafter, the fuel mixes with air nearing ignition point (B point) and ignites.

2. Flame propagation period
The gas mixture accumulated in the ignition delay period ignites at B point and rapidly combusts instantly raising the pressure and temperature in the cylinder.
3. Direct combustion period
The fuel continues to be injected even after passing point C but the fuel combusts immediately due to the ignition that took place between B and C.
This continues through the point (point D) where injection stops and here pressure rise is relatively slow.
4. Late combustion period
After fuel injection stops, combustion continues for a short period burning the remaining the fuel.
This period is called late combustion period and this period should be as short as possible.
If this is extended, exhaust temperature rises causing thermal losses to increase accordingly.

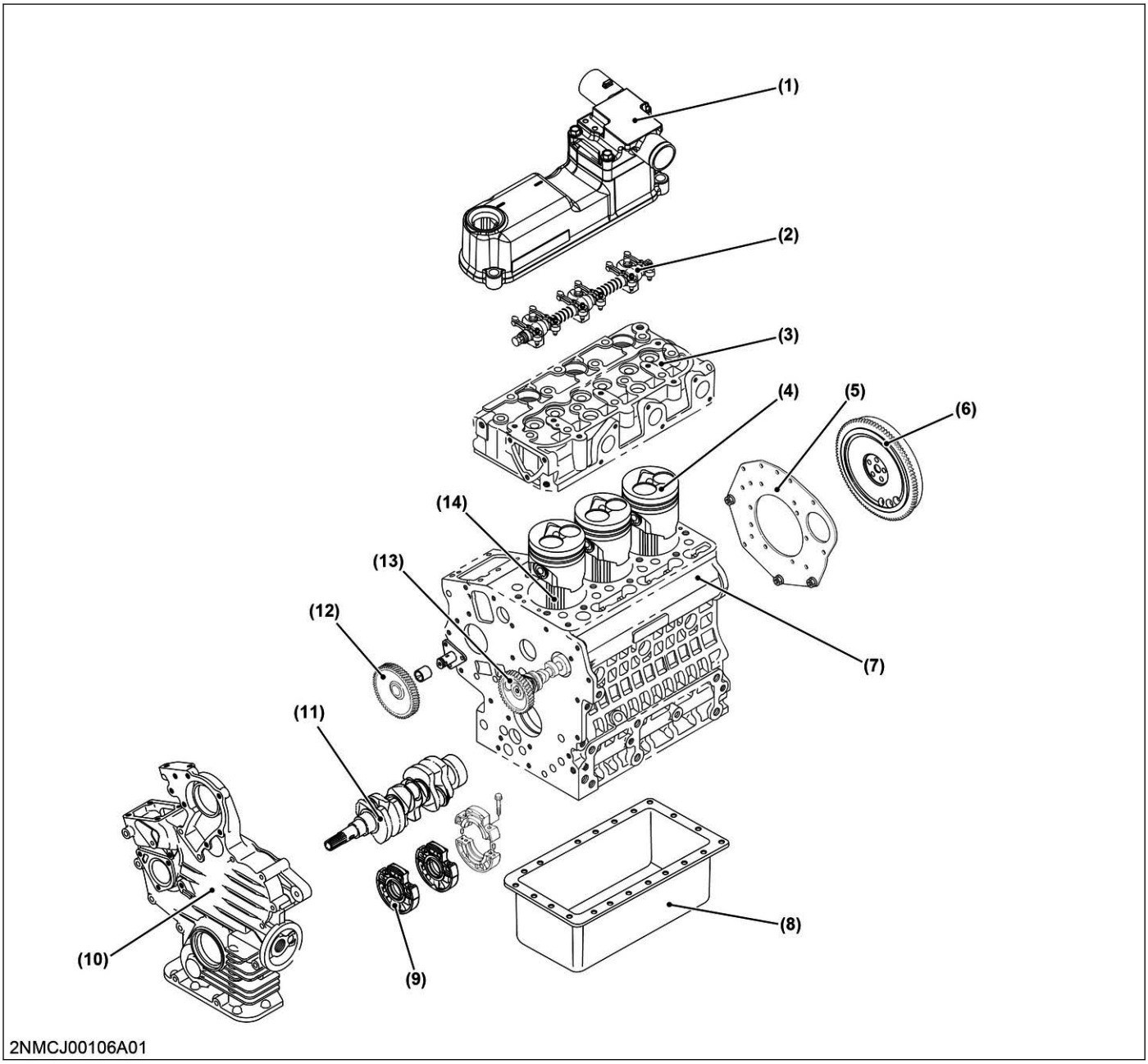
## 1.4 Control of combustion (E-TVCS)

Combustion control consists of fuel injection volume control, fuel injection timing control, fuel injection rate control, and fuel pressure control.
The fuel injection volume is controlled by a pump element of a fuel injection pump.
The timing of injection is controlled by shim plates between the fuel injection pump and a crankcase.
The injection rate and the fuel pressure are controlled by the injection nozzle.

# 2. Engine body

## 2.1 Structure of engine body

The engine body is the main part of the engine.
It is made up of related cylinders, primary motion, and valve train mechanisms.




(1) Cylinder head cover
(2) Rocker arm
(3) Cylinder head
(4) Piston
(5) Rear end plate
(6) Flywheel
(7) Crankcase
(8) Oil pan
(9) Main bearing case
(10) Gear case
(11) Crankshaft
(12) Idle gear
(13) Camshaft with cam gear
(14) Connecting rod

## 2.2 Feature of engine body

The engine body is the main part of the engine.
It is made up of cylinder related, primary motion, and valve train mechanisms.
Each of the parts are designed and assembled with passages for lubricating oil and coolant for circulating within the engine.

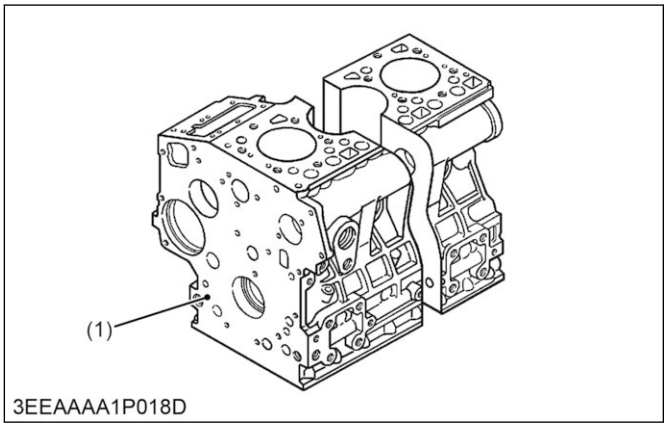
## 2.3 Crankcase

### 2.3.1 Outline of crankcase

The main function of the crankcase is to support the main parts.

### 2.3.2 Structure of crankcase

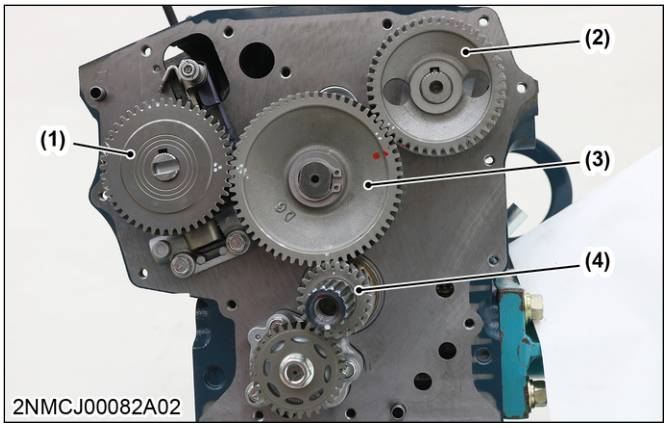
The tunnel type crankcase is used.




(1) Crankcase

### 2.3.3 Function of crankcase

The crankcase has cylinders inside and supports the crankshaft and camshaft.
Furthermore, the crankcase has an internal water jacket and oil passageways to cool the cylinders.




(1) Fuel cam gear
(2) Cam gear
(3) Idle gear
(4) Crank gear

### 2.3.4 Specification of crankcase

| | |
|---|---|
| Cylinder liner diameter (Z482-E4BG/Z482/D722/D782-E4) | 67.000 to 67.019 mm<br>2.6378 to 2.6385 in. |
| Cylinder liner diameter (Z602/D902-E4/D902-TE4) | 72.000 to 72.019 mm<br>2.8347 to 2.8353 in. |
| Finish machining | Honing (2.2 to 3.0 µmRz)<br>Honing (87 to 110 µin.Rz) |
| Oversize | +0.25 mm<br>+0.0098 in. |

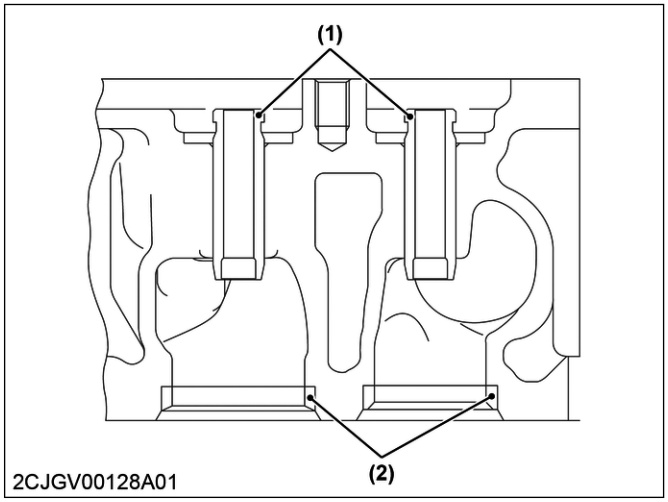
## 2.4 Cylinder head

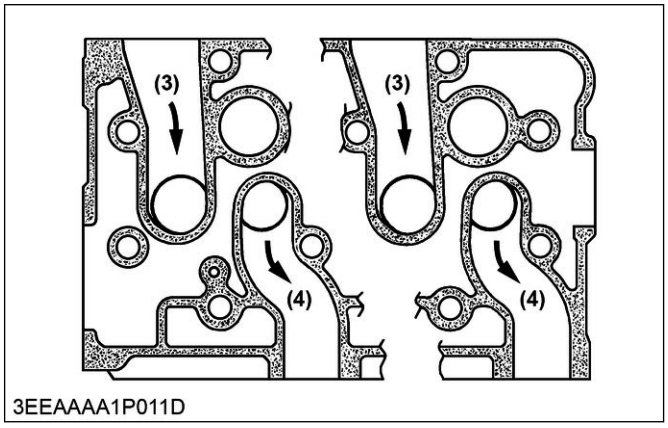
### 2.4.1 Outline of cylinder head

Along with the crankcase, the cylinder head is the most fundamental part that makes up the engine.

### 2.4.2 Structure of cylinder head

The cylinder head is provided with valve guides and valve seats.




(1) Valve guide
(2) Valve seat
(3) Intake port
(4) Exhaust port

### 2.4.3 Function of cylinder head

- The cylinder head is one of the most fundamental parts that form the combustion chamber of the engine along with the crankcase and piston.
- It also makes up the intake air path (intake port) and exhaust gases path (exhaust port).
  Using a helical structure on the intake air path integrates more air and mixes the fuel with the air.
  Using valves on the exhaust side quickly expels exhaust gases.
- A passageway for cooling water (water jacket) is provided to suppress engine temperature rising.
- A passageway for oil to flow into the valve train is provided at the top of the cylinder head.

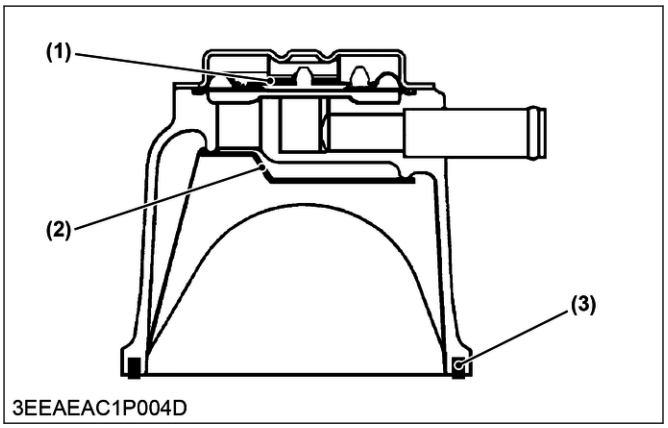
## 2.5 Half-floating head cover

### 2.5.1 Outline of cylinder head cover and oil separator

The cylinder head cover is a part that covers the valve train.
The cylinder head cover prevents scattering of lubricating oil from the valve train and suppresses noise emissions.

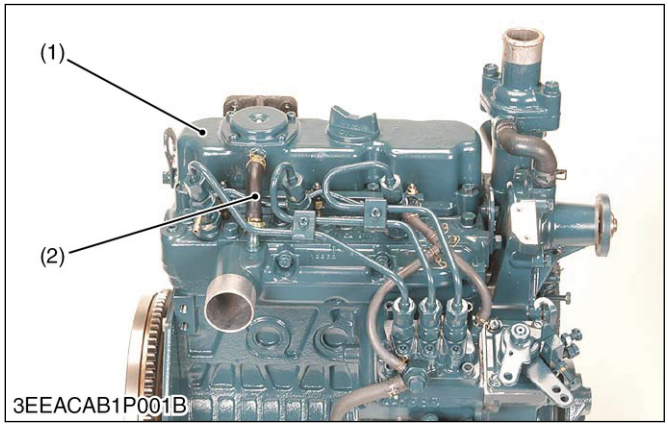
### 2.5.2 Structure of cylinder head cover and closed breather

After its oil content is filtered by oil shield (2), the blow-by gas is fed back to the intake manifold through breather valve (1) to be used for re-combustion.




(1) Breather valve
(2) Oil shield
(3) Rubber packing

### 2.5.3 Function of cylinder head cover and closed breather




(1) Cylinder head cover
(2) Breather hose

Closed breather system has been adopted to prevent the release of blow-by gas into the atmosphere.

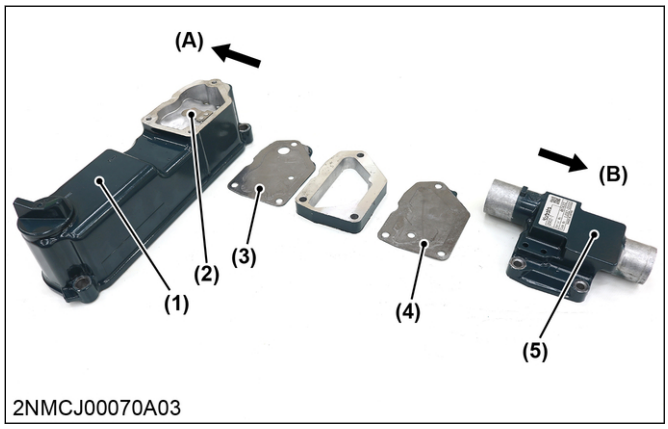
## 2.6 Cylinder head cover

### 2.6.1 Outline of cylinder head cover and oil separator

The cylinder head cover is a part that covers the valve train.
The cylinder head cover prevents scattering of lubricating oil from the valve train and suppresses noise emissions.
The cylinder head cover has a built-in blow-by gas path with the oil separator.
The oil separator separates vaporized oil from the blow-by gases.

### 2.6.2 Structure of cylinder head cover and oil separator for D902-TE4

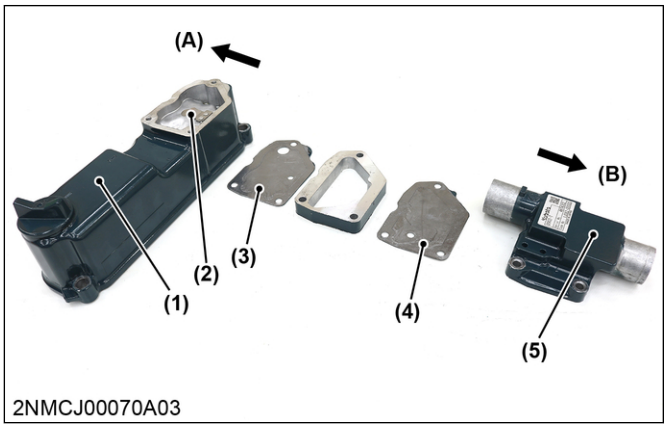
The cylinder head cover and the oil separator are mounted to the cylinder head.




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

### 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.



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

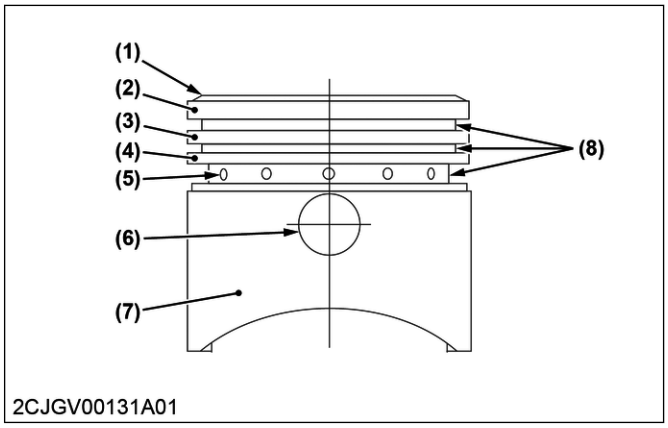
## 2.7 Piston

### 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.



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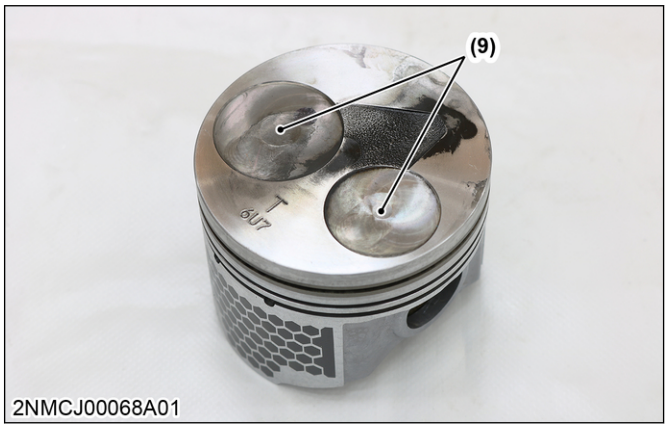

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(1) Piston head
(2) Top land
(3) Second land
(4) Third land
(5) Oil return hole
(6) Piston pin hole
(7) Piston skirt
(8) Ring groove
(9) Valve recess

### 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.

### 2.7.4 Specification of piston

| | |
|---|---|
| Piston diameter (Z482-E4BG/ Z482/D722/D782-E4) | 67.0 mm 2.64 in. |
| Piston diameter (Z602/D902-E4/D902-TE4) | 72.0 mm 2.83 in. |
| Oversize | +0.25 mm +0.0098 in. |

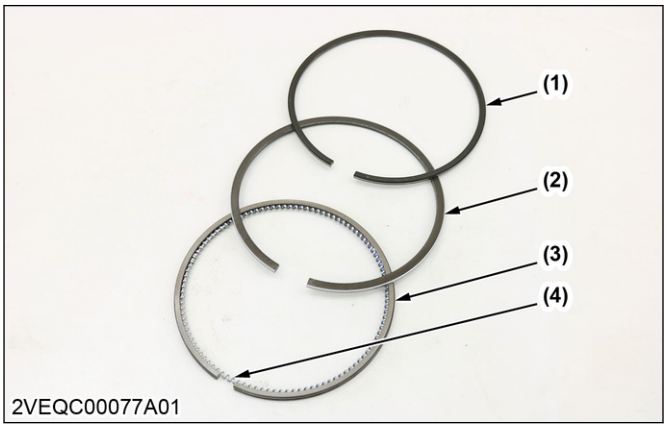
## 2.8 Piston ring

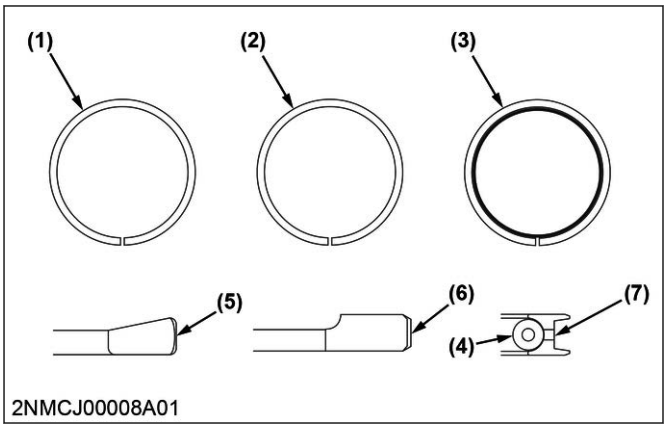
### 2.8.1 Outline of piston ring

Piston rings primarily maintain air tightness of the combustion chamber.

### 2.8.2 Structure of piston ring

The piston rings are top ring (Key-stone (barrel face)), second ring (Under cut), and oil ring (Bevel cutter).




(1) Top ring
(2) Second ring
(3) Oil ring
(4) Expander
(5) Key-stone (barrel face) type
(6) Plane (under cut) type
(7) Bevel cutter type

### 2.8.3 Function of piston ring

1. Maintain airtightness of the combustion chamber during the compression stroke and combustion stroke.
2. Wipe down oil on the cylinder wall. Also prevent oil getting into combustion chamber.
3. Transfer piston heat to the cylinder wall.
4. Support piston posture.

### 2.8.4 Specification of piston ring

| | | |
|---|---|---|
| Service specification of piston ring gap (Z482/D722/D782-E4) | Top ring | 0.12 to 0.27 mm 0.0048 to 0.010 in. |
| | Second ring | 0.30 to 0.45 mm 0.012 to 0.017 in. |
| | Oil ring | 0.15 to 0.35 mm 0.0059 to 0.013 in. |
| Service specification of piston ring gap (Z602/D902-E4/D902-TE4) | Top ring | 0.15 to 0.30 mm 0.0059 to 0.011 in. |
| | Second ring | 0.35 to 0.50 mm 0.014 to 0.019 in. |
| | Oil ring | 0.15 to 0.35 mm 0.0059 to 0.013 in. |

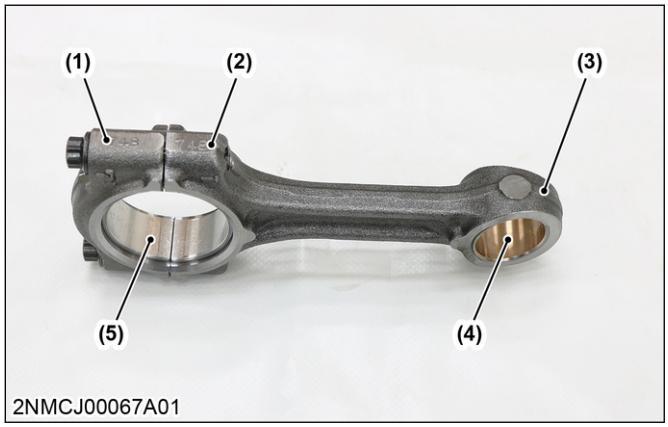
## 2.9 Connecting rod

### 2.9.1 Outline of connecting rod

The connecting rod connects the piston and the crankshaft.
The connecting rod transfers the combustion pressure received by the piston to the crankshaft.

### 2.9.2 Structure of connecting rod

The connecting rod is made up of a connecting rod cap (1), connecting rod and so on.




(1) Connecting rod cap
(2) Big end
(3) Small end
(4) Small end bushing
(5) Bearing metal

### 2.9.3 Function of connecting rod

The connecting rod connects the piston and crankshaft and transfers the combustion pressure received by the piston to the crankshaft.
The part that connects to the crankshaft is called the big end and the part that connects to the piston pin is called the small end.
The big end is provided with bearing metal.
The small end is provided with a bushing.
Oil is supplied between it and the shafts at both ends to reduce friction resistance and enable smooth rotation.

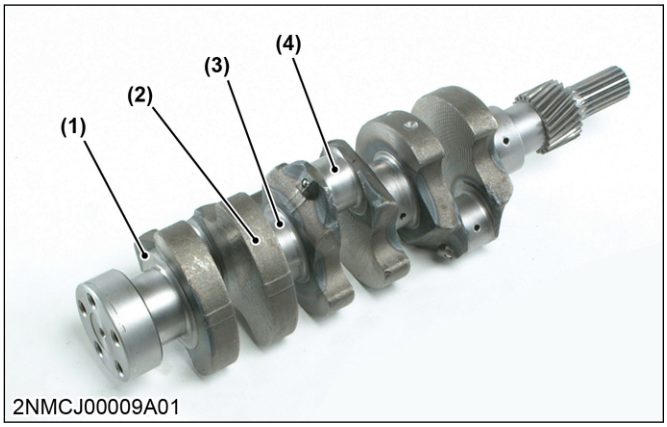
## 2.10 Crankshaft

### 2.10.1 Outline of crankshaft

The crankshaft converts the reciprocating motion obtained from combustion to rotational motion via the connecting rod.

### 2.10.2 Structure of crankshaft

The crankshaft is formed with the crank arms (1) and crankpin (4) integrated.




(1) Crank arm
(2) Balance weight
(3) Crank journal
(4) Crankpin

### 2.10.3 Function of crankshaft

The crankshaft converts the reciprocating motion obtained from combustion to rotational motion via the connecting rod.
The part of the shaft supported in the main bearing case and that rotates is called the crank journal, the part connected to the connecting rod is called a crankpin, and the part that connects both of these is called the crank arm.
While conducting continuous power to outside the engine, this also causes each of the intake, compression, combustion, and exhaust strokes to be performed.

### 2.10.4 Specification of crankshaft

| | |
|---|---|
| Crankpin (Undersize) | 0.2 mm<br>0.0079 in. |
| | 0.4 mm<br>0.016 in. |
| Crankshaft journal (Undersize) | 0.2 mm<br>0.0079 in. |
| | 0.4 mm<br>0.016 in. |

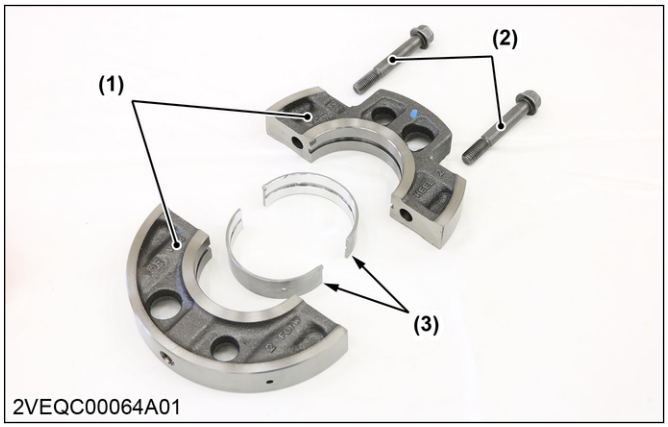
## 2.11 Main bearing case

### 2.11.1 Outline of main bearing case

The main bearing case is a bearing that supports the crankshaft.

### 2.11.2 Structure of main bearing case

The main bearing case is holds the crankshaft.




(1) Main bearing case
(2) Screw
(3) Bearing metal

### 2.11.3 Function of main bearing case

The main bearing case supports the crankshaft and also fulfills the role as a passage for supplying oil to the crankshaft.
The main bearing case is provided with bearing metal.
Oil is supplied between this metal and the crankshaft to reduce friction resistance and enable smooth rotation.

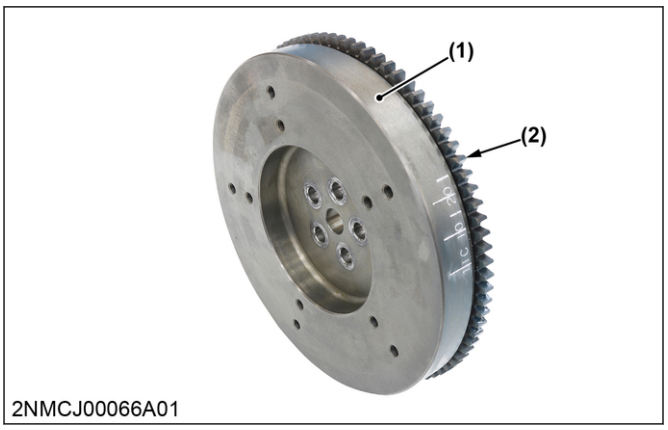
# 2.12 Flywheel

## 2.12.1 Outline of flywheel

The flywheel transfers power generated in the engine externally.

## 2.12.2 Structure of flywheel

The flywheel (1) is made up of a body of the flywheel and ring gear (2).




(1) Flywheel (2) Ring gear

## 2.12.3 Function of flywheel

The flywheel stores inertial energy during the combustion stroke and transfers this power generated in the engine externally.
In addition, a ring gear is provided that receives power from the starter while starting the engine and causes the crankshaft to rotate.
Based on its inertia, the flywheel causes the engine to rotate smoothly during strokes other than the combustion stroke.

## 2.12.4 Specification of flywheel

**(Reference value)**

| | |
|---|---|
| Flywheel diameter | 214 mm<br>8.43 in. |

*This value is for STD engine, so it might be different depending on the product used.

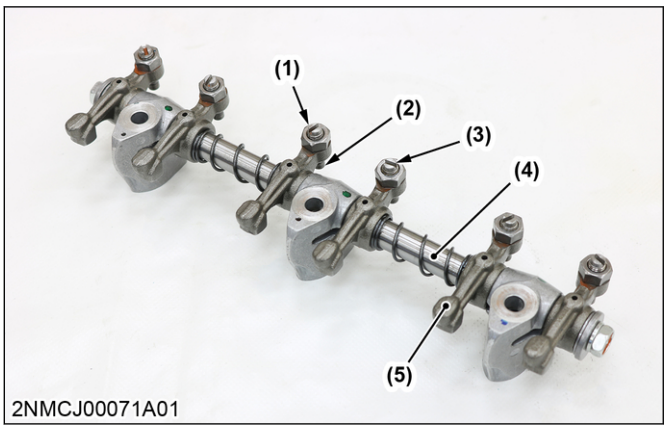
# 2.13 Rocker arm assembly

## 2.13.1 Outline of rocker arm assembly

Rocker arm assembly transfer camshaft movement to valves via push rods.

## 2.13.2 Structure of rocker arm assembly

Rocker arms assembly is made up of arms, rocker arm shafts (4), and adjusting screws (3) and so on.




(1) Lock nut
(2) Contact to push rod
(3) Adjusting screw
(4) Rocker arm shaft
(5) Contact to valve

## 2.13.3 Function of rocker arm assembly

When one end of a rocker arm assembly is pushed up by a push rod, the rocker arm rotates centered on the

rocker arm shaft and the other end pushes open a valve.

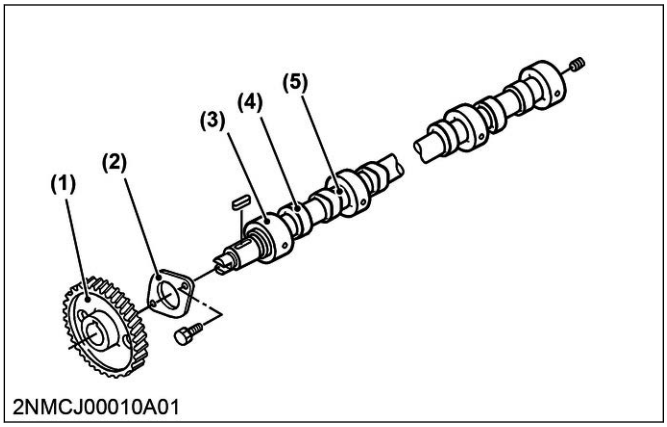
# 2.14 Camshaft

## 2.14.1 Outline of camshaft

The camshaft determines the intake and exhaust valve timing.

## 2.14.2 Structure of camshaft

The camshaft is made up of a camshaft and cam gear.




(1) Cam gear
(2) Camshaft stopper
(3) Cam journal
(4) Intake valve cam
(5) Exhaust valve cam

## 2.14.3 Function of camshaft

The camshaft determines the intake and exhaust valve timing.
Intake cams and exhaust cams are integrated onto the camshaft for each cylinder.
The rotation of the gear at the end of the crankshaft is transferred to the cam gear and the camshaft rotates synchronized with the crankshaft.
The camshaft rotates once for every two rotations of the crankshaft.

## 2.14.4 Specification of camshaft

| | | |
|---|---|---|
| Intake valve timing (Z482-E4BG/Z482/D722/D782-E4/D902-TE4) | Open | 0.445 rad (25.5°) before T.D.C. |
| | Close | 0.881 rad (50.5°) after B.D.C. |
| Intake valve timing (Z602/D902-E4) | Open | 0.35 rad (20°) before T.D.C. |
| | Close | 0.79 rad (45°) after B.D.C. |
| Exhaust valve timing (Z482-E4BG/Z482/D722/D782-E4/D902-TE4) | Open | 0.969 rad (55.5°) before B.D.C. |
| | Close | 0.358 rad (20.5°) after T.D.C. |
| Exhaust valve timing (Z602/D902-E4) | Open | 0.87 rad (50°) before B.D.C. |
| | Close | 0.26 rad (15°) after T.D.C. |

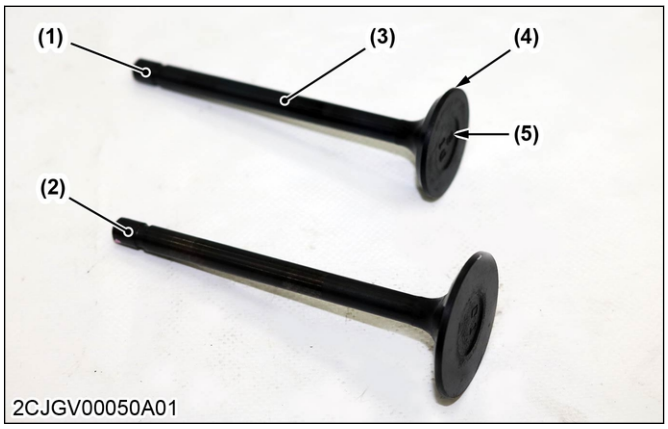
# 2.15 Valve

## 2.15.1 Outline of valve

Valves open and close passages (ports) that conducted to the combustion chamber.

## 2.15.2 Structure of valve

Intake and exhaust valves (2), (1) are mounted to the cylinder head via valve springs, valve retainers, and collets.




(1) Exhaust valve
(2) Intake valve
(3) Valve stem
(4) Valve face
(5) Valve head

## 2.15.3 Function of valve

In general, intake valve diameters are designed larger than exhaust valve diameters.
Have a function of making the combustion chamber airtight while the intake and exhaust valves are closed.
**Intake valve**

- Intake valves are valves through which intake air flows into the combustion chamber.
- Open and close timing is determined by the intake cams.

**Exhaust valve**

- Exhaust valves are valves that eject exhaust gases after combustion.
- Open and close timing is determined by the exhaust cams.

### 2.15.4 Specification of valve

| | |
|---|---|
| Intake valve head diameter (Z482-E4BG/Z482/D722/D782-E4) | 29.5 mm<br>1.16 in. |
| Exhaust valve head diameter (Z482-E4BG/Z482/D722/D782-E4) | 25.0 mm<br>0.984 in. |
| Intake valve head diameter (Z602/D902-E4/D902-TE4) | 26.0 mm<br>1.02 in. |
| Exhaust valve head diameter (Z602/D902-E4/D902-TE4) | 22.5 mm<br>0.886 in. |
| Valve clearance | 0.145 to 0.185 mm<br>0.00571 to 0.00728 in. |

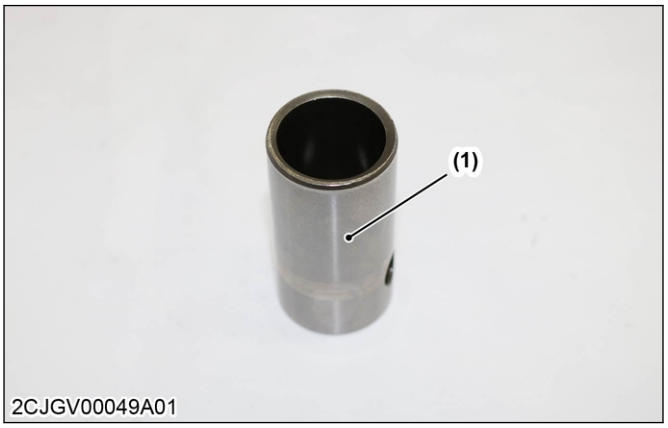
## 2.16 Tappet

### 2.16.1 Outline of tappet

The tappet converts cam rotation into linear reciprocating motion.

### 2.16.2 Structure of tappet

The tappet (1) receives the push rod with an push rod seat.




(1) Tappet

### 2.16.3 Function of tappet

The tappet converts cam rotation into linear reciprocating motion.
Receives cam force on the surface.
Further, the cam and tappet are set with centers slightly offset and the tappet rotates while the engine is running so uneven wear does not readily occur.

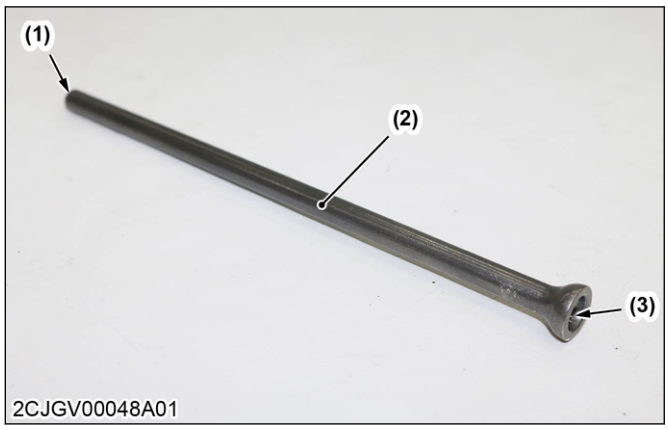
## 2.17 Push rod

### 2.17.1 Outline of push rod

The push rod transfers tappet movement to the rocker arm.

### 2.17.2 Structure of push rod

The push rod (2) is mounted so as to contact the tappet and rocker arm.




(1) Tappet side
(2) Push rod
(3) Rocker arm side

### 2.17.3 Function of push rod

The push rod transfers movement of the tappet in contact with the cam to the rocker arm.

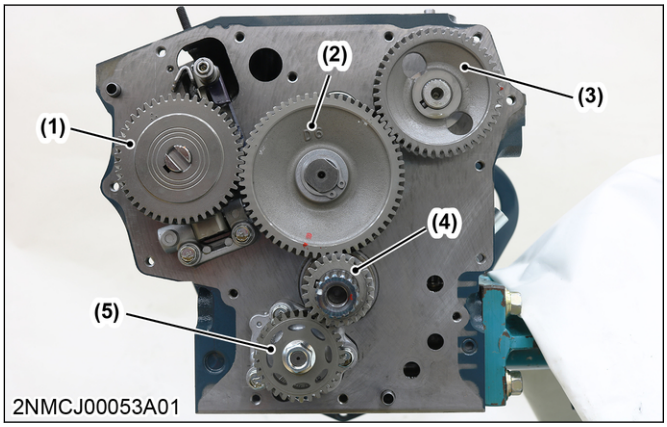
## 2.18 Timing gears

### 2.18.1 Outline of timing gears

The timing gear transfers power from the crankshaft to each gears.

### 2.18.2 Structure of timing gears

Timing gears are made up of the crank gear (4), idle gear (2), and fuel cam gear (1) and so on.




(1) Fuel cam gear
(2) Idle gear
(3) Cam gear
(4) Crank gear
(5) Oil pump drive gear

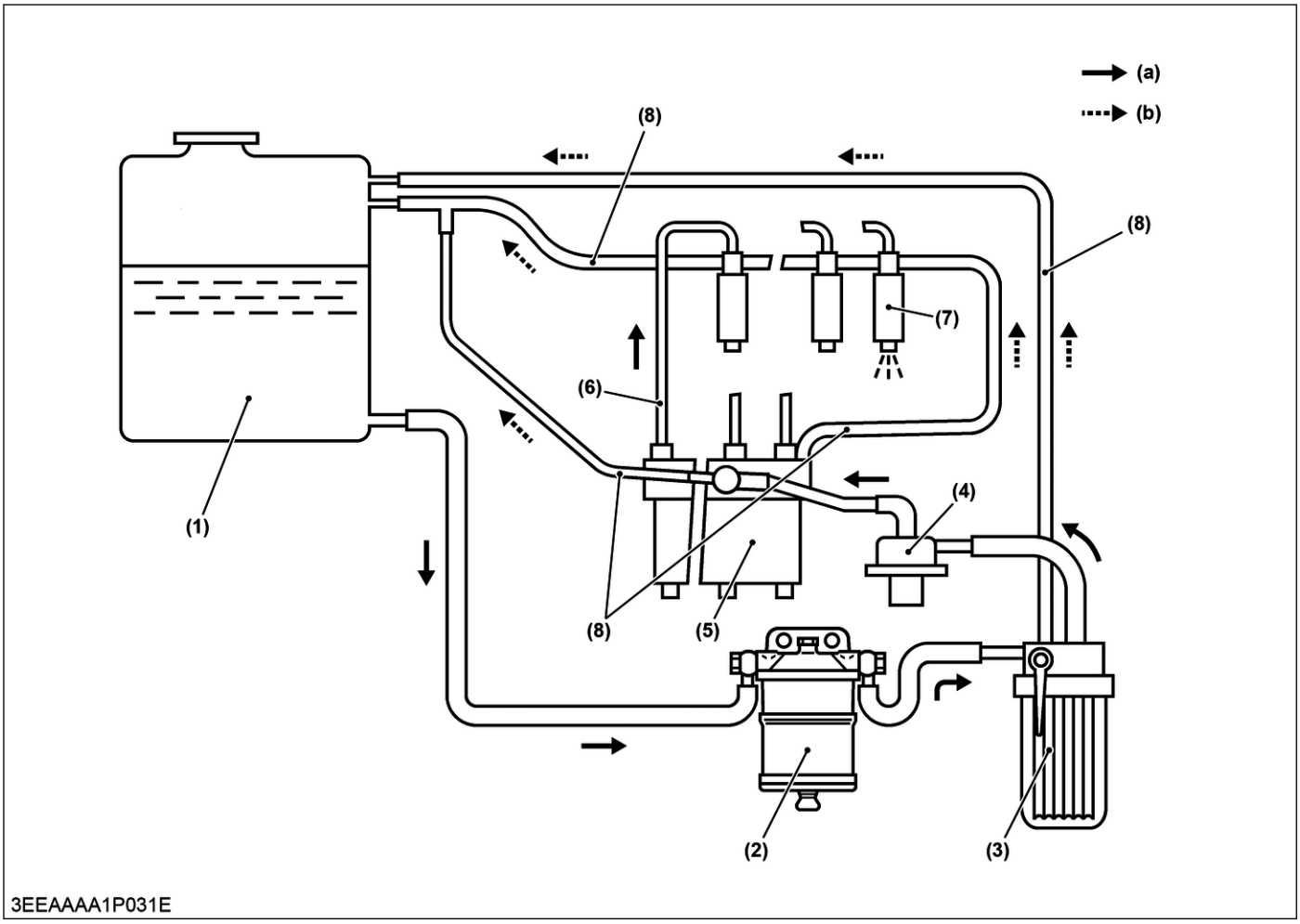
### 2.18.3 Function of timing gears

The timing gears transfer power from the crankshaft to each gears.
The timing gears determine movement timing of each of the parts in conjunction with movement of the piston.
Timing gears synchronize timing for rotation of the crankshaft and opening and closing of valves.
Therefore, when assembling each of the marks has to be aligned.

# 3. Fuel system

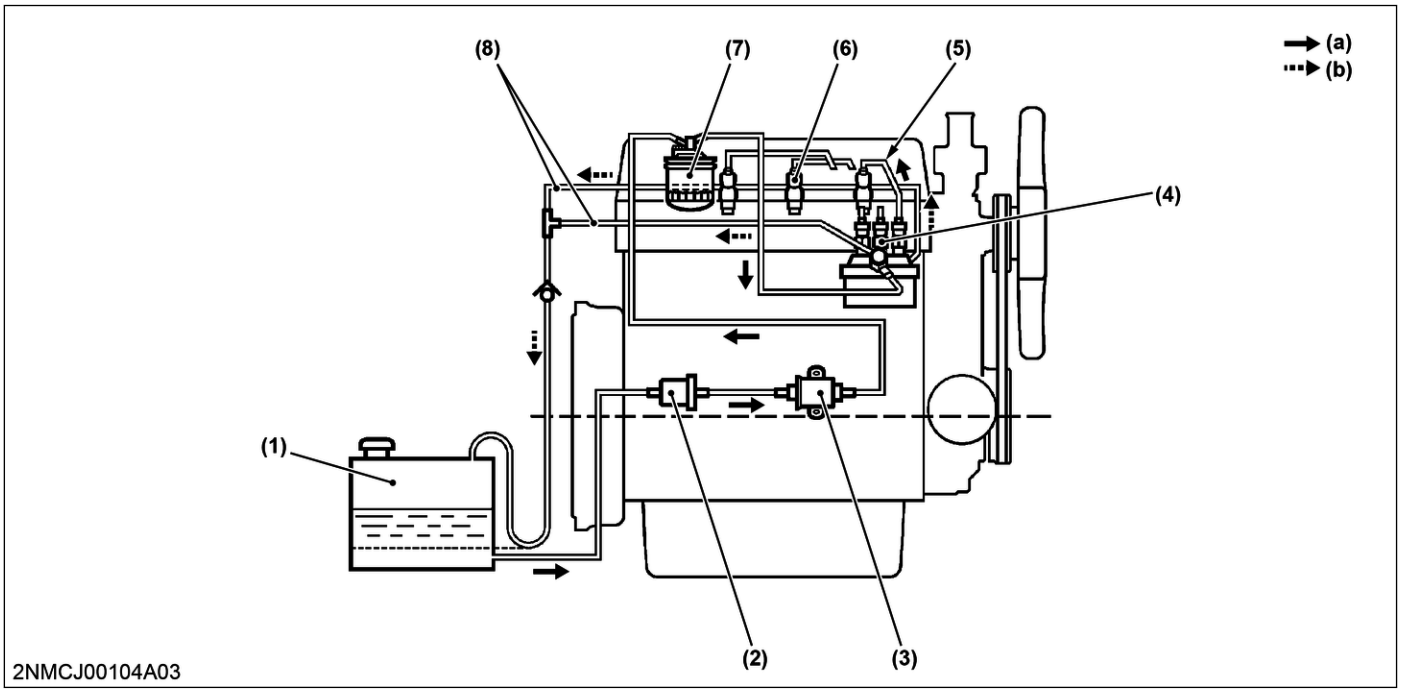
## 3.1 Structure of fuel system

The fuel system is made up of an injection pump, an injection nozzle, a fuel feed pump, and the like.
**(When the position of a fuel tank is high)**




(1) Fuel tank
(2) Water separator
(3) Fuel filter
(4) Fuel feed pump
(5) Injection pump
(6) Injection pipe
(7) Injection nozzle
(8) Fuel overflow pipe
(a) Injected fuel flow
(b) Returned fuel flow

**(When the position of a fuel tank is low)**




(1) Fuel tank
(2) Pre-filter
(3) Electromagnetic fuel feed pump
(4) Injection pump
(5) Injection pipe
(6) Injection nozzle
(7) Fuel filter
(8) Fuel overflow pipe
(a) Injected fuel flow
(b) Returned fuel flow

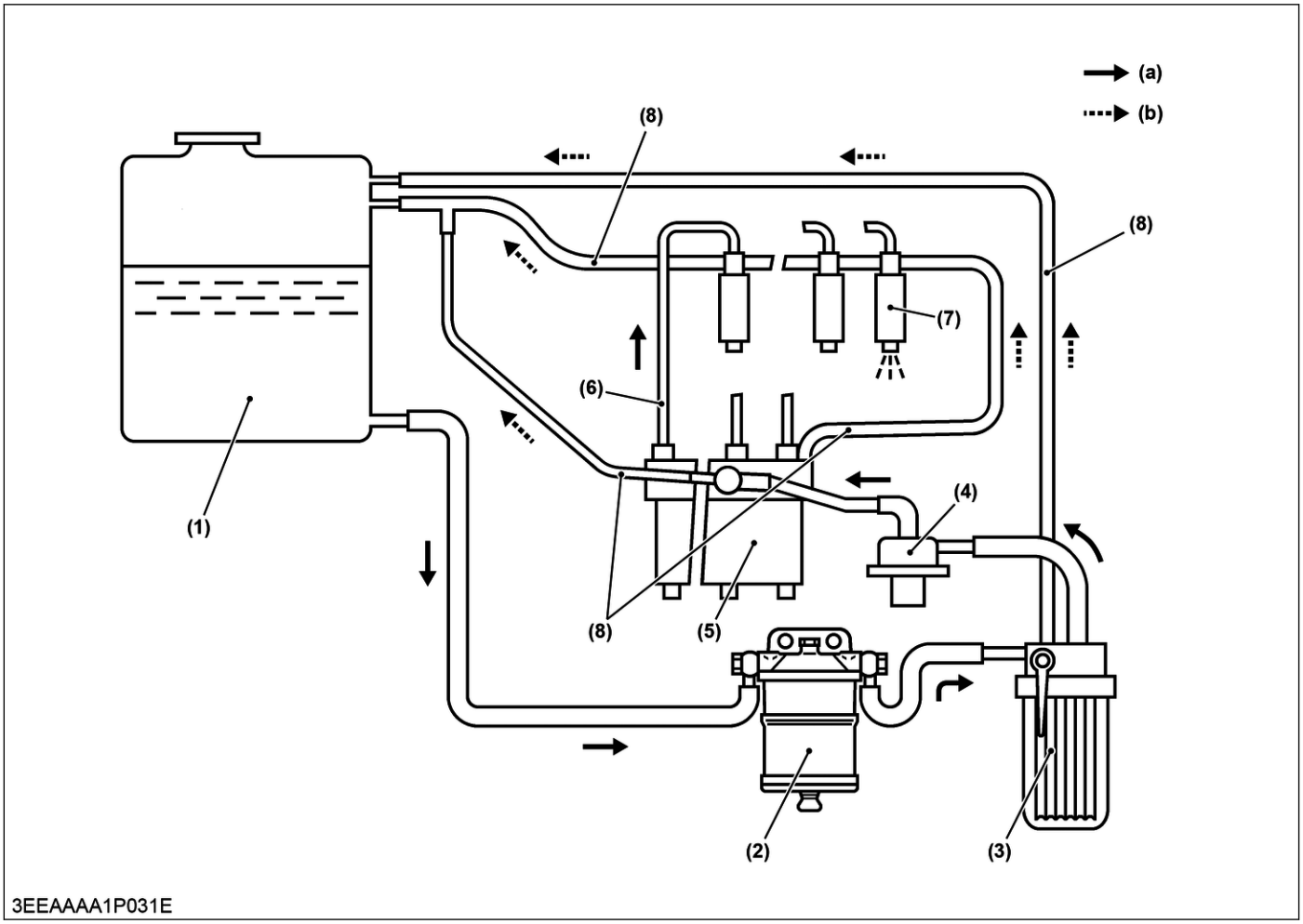
## 3.2 Feature of fuel system

In this fuel system, all elements such as fuel injection amount, fuel injection pressure, and injection timing are mechanically controlled.
The fuel system includes filters and other components to protect itself from the infiltration of air, water and dust.
When the position of the fuel tank is low, the fuel must be pumped to the position of the injection pump using an electromagnetic pump.

## 3.3 Flow of fuel system

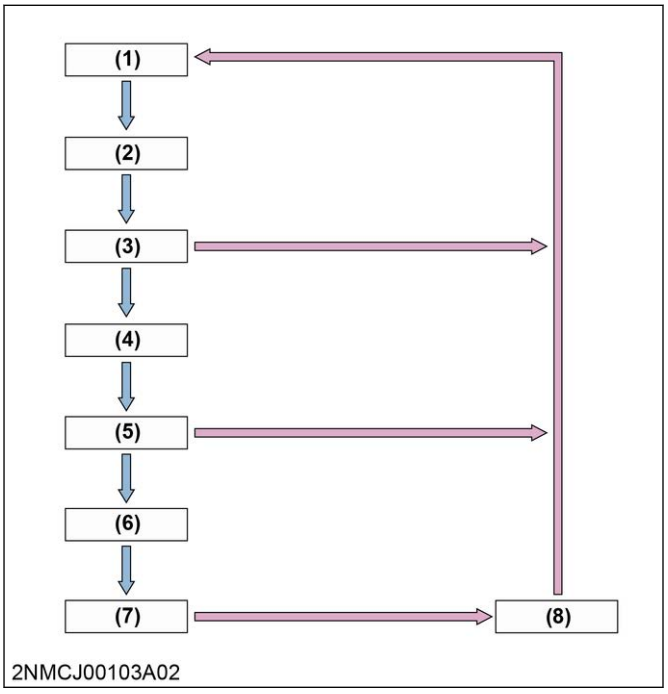
**(When the position of a fuel tank is high)**

- 1. While the engine is running, fuel is fed into the injection pump (5) by the fuel feed pump (4), after passing through the water separator (2) and fuel filter (3) where any foreign matter is removed.
  2. The injection pump (5) is moved by the fuel camshaft and pumps fuel to the injection nozzle (7) through the injection pipe.
  3. Then, fuel is sprayed through the injection nozzle (7) into the combustion chamber.
  4. The fuel discharged after lubricating and cooling the injection nozzle (7) is returned to the fuel tank (1) automatically through the overflow pipe (8).




3EEAAAA1P031E

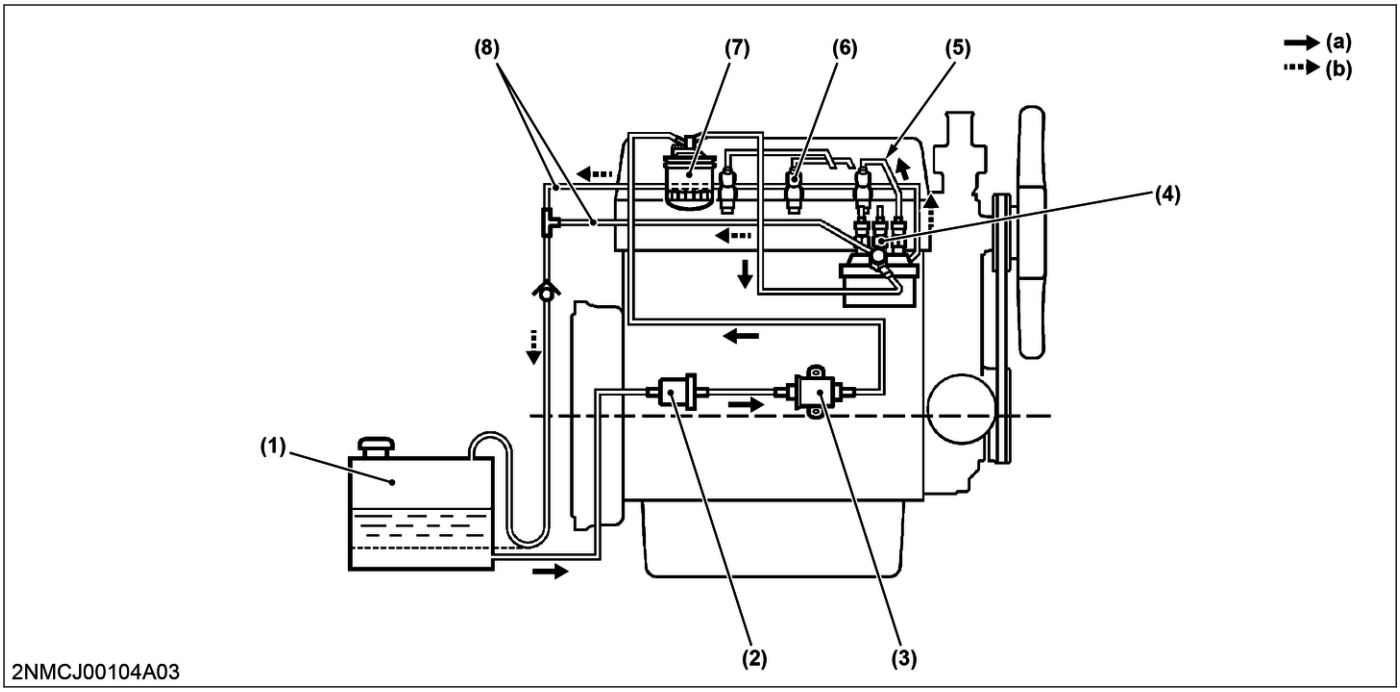
## Fuel flow



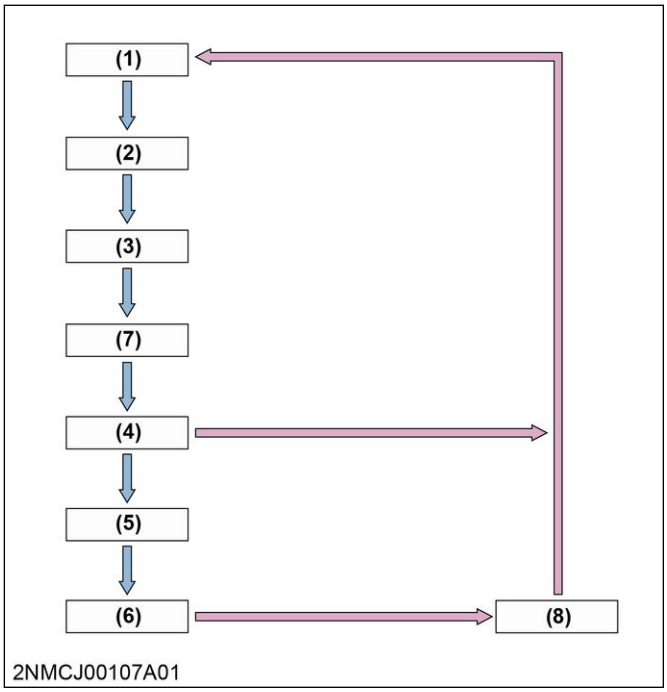

(1) Fuel tank
(2) Water separator
(3) Fuel filter
(4) Fuel feed pump
(5) Injection pump
(6) Injection pipe
(7) Injection nozzle
(8) Overflow pipe
(a) Supply flow
(b) Return flow

**(When the position of a fuel tank is low)**

- 1. While the engine is running, the fuel is fed into the injection pump (4) by the electromagnetic fuel feed pump (3) after passing through the pre-filter (2) where any foreign matter is removed.
  2. The injection pump (4) is moved by the fuel camshaft and pumps the fuel to the injection nozzle (6) through the injection pipe (5).
  3. Then, the fuel is sprayed through the injection nozzle (6) into the combustion chamber.
  4. The fuel discharged after lubricating and cooling the injection nozzle (6) is returned to the fuel tank (1) automatically through the overflow pipe (8).



## Fuel flow




(1) Fuel tank
(2) Pre-filter
(3) Electromagnetic fuel feed pump
(4) Injection pump
(5) Injection pipe
(6) Injection nozzle
(7) Fuel filter
(8) Overflow pipe
(a) Supply flow
(b) Return flow

# 3.4 Fuel tank

## 3.4.1 Outline of fuel tank

The fuel tank stores fuel.

## 3.4.2 Structure of fuel tank

The fuel tank is made up of a tank body and fuel inlet opening.

## 3.4.3 Function of fuel tank

The fuel tank stores fuel.
A float is generally provided in the tank to show the amount of fuel remaining.
This float detects float liquid surface position and sends a signal to a meter on the operator panel.

## 3.4.4 Specification of fuel tank

Tank volume is different depending on the model equipped on.
Check the specifications of the model equipped on for details.

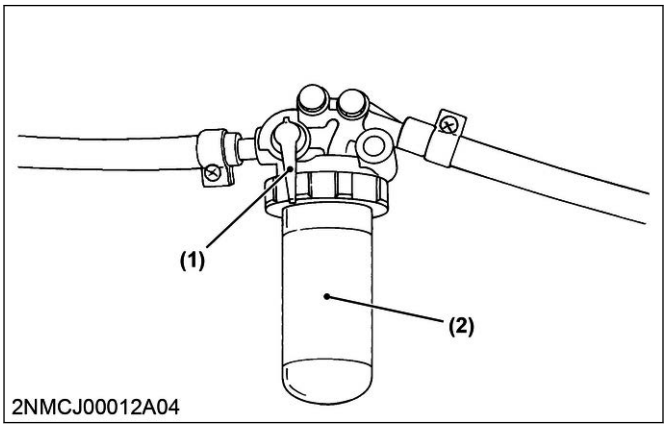
# 3.5 Water separator

## 3.5.1 Outline of water separator

The water separator removes the water included in the fuel.

## 3.5.2 Structure of water separator

The water separator is made up of a water separator handle (1) and a cup (2).




(1) Water separator handle (2) Cup

## 3.5.3 Function of water separator

The water separator removes water and solid particles included in the fuel.
The amount of water in the water separator can not be determined by looking at the outside so an alarm is sent to the operator using a level sensor.

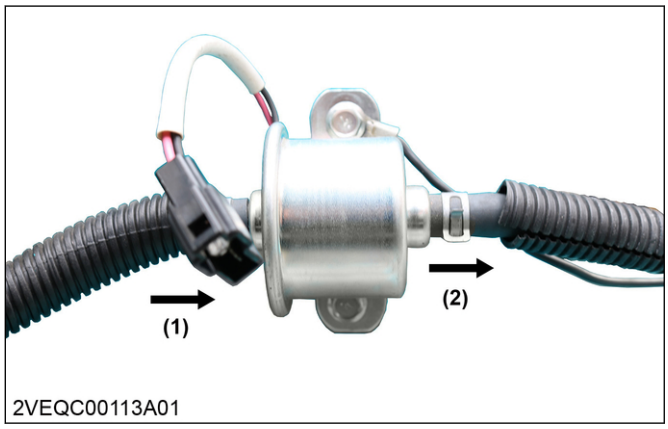
# 3.6 Electromagnetic fuel feed pump

## 3.6.1 Outline of electromagnetic fuel feed pump

The electromagnetic fuel feed pump supplies fuel to the engine.

## 3.6.2 Structure of electromagnetic fuel feed pump

The electromagnetic fuel feed pump is made up of a pump filter and connector and the like.




(1) Fuel inlet (2) Fuel outlet

## 3.6.3 Function of electromagnetic fuel feed pump

In many engines, the fuel tanks are installed at a lower level than the injection pump or at the same level.
An electromagnetic fuel feed pump is used, when the fuel tank is positioned below the injection pump of the engine.
An electromagnetic fuel feed pump uses a transistor that makes the pump start to pump the fuel, when the main switch is turned to the **ON** position.

## 3.6.4 Specification of electromagnetic fuel feed pump

| | |
|---|---|
| Rated voltage | 12 V |

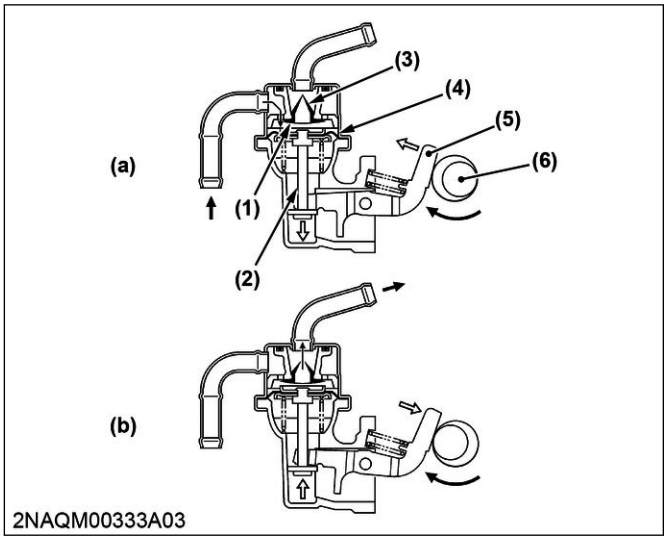
# 3.7 Fuel feed pump

## 3.7.1 Outline of fuel feed pump

The fuel feed pump sends the fuel to the injection pump.

## 3.7.2 Structure of fuel feed pump

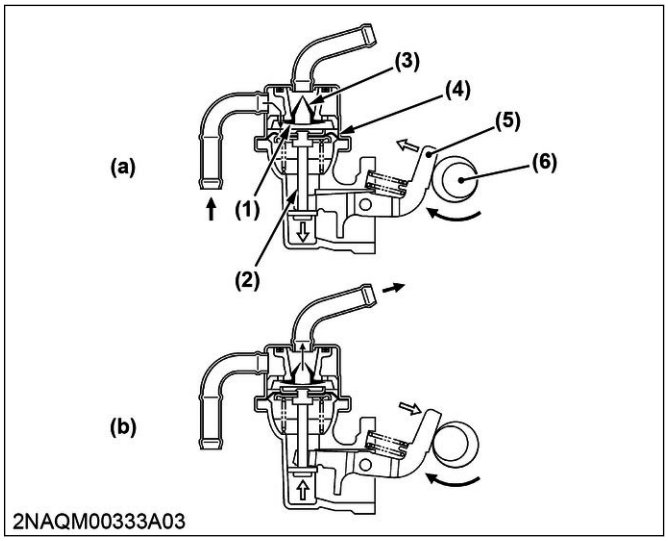
The fuel feed pump is made up of an inlet (1) and an outlet valve (3), a pull rod (2), and a diaphragm (4).
This type of fuel feed pump uses a diaphragm (4) in which the flexing of the diaphragm attached to the pump body changes the capacity of the pump chamber to create the vacuum necessary for pumping.
The fuel is pumped by pulling and releasing an arm (5) with a fuel camshaft (6).




(1) Inlet valve
(2) Pull rod
(3) Outlet valve
(4) Diaphragm
(5) Arm
(6) Fuel camshaft
(a) Intake stroke
(b) Discharge stroke

## 3.7.3 Function of fuel feed pump

The fuel feed pump sends the fuel to the injection pump.
This type of fuel feed pump uses a diaphragm (4) in which the flexing of the diaphragm attached to the pump body changes the capacity of the pump chamber to create the vacuum necessary for pumping.
The fuel feed pump is mounted on the side of the injection pump, and driven by an eccentric cam on the fuel camshaft.




(1) Inlet valve
(2) Pull rod
(3) Outlet valve
(4) Diaphragm
(5) Arm
(6) Fuel camshaft
(a) Intake stroke
(b) Discharge stroke

## 3.7.4 Specification of fuel feed pump

| | |
|---|---|
| Quantity of delivery | 0.3 L/min or more (at 1000 $min^{-1}$(rpm)) |

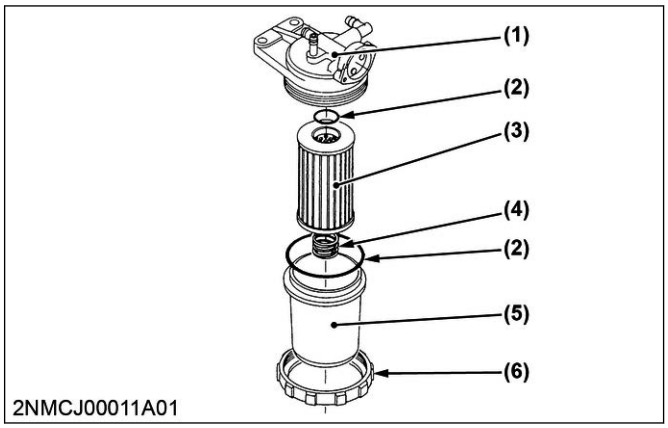
# 3.8 Fuel filter

## 3.8.1 Outline of fuel filter

The fuel filter removes small particles and impurities from the fuel.

## 3.8.2 Structure of fuel filter

The fuel filter is made up of a bracket (1), a filter element (3), a filter bowl (5) and the like.




(1) Bracket
(2) O-ring
(3) Filter element
(4) Spring
(5) Filter bowl
(6) Screw ring

### 3.8.3 Function of fuel filter

The fuel filter removes small particles and impurities from the fuel.

### 3.8.4 Specification of fuel filter

| | |
|---|---|
| Filtration accuracy | 99% or higher @5 μm or larger |

## 3.9 Injection pump

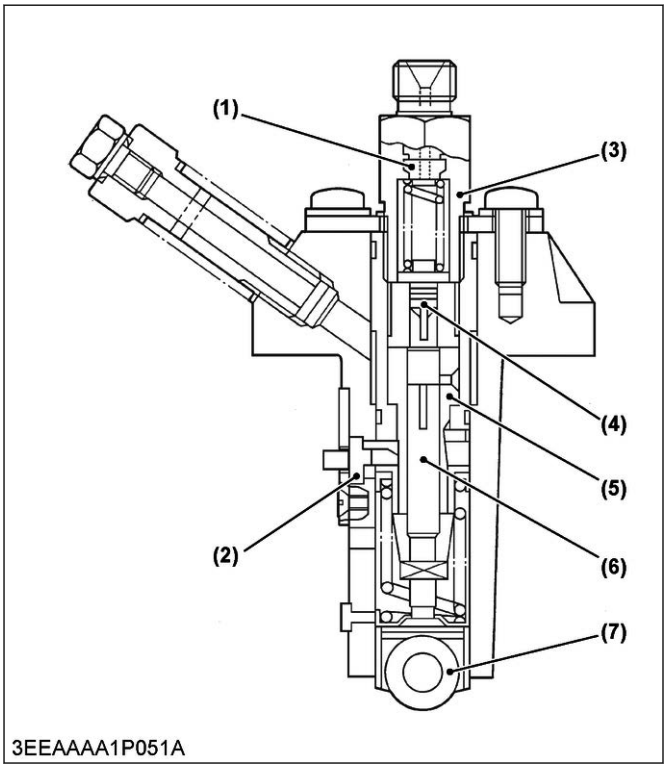
### 3.9.1 Outline of injection pump

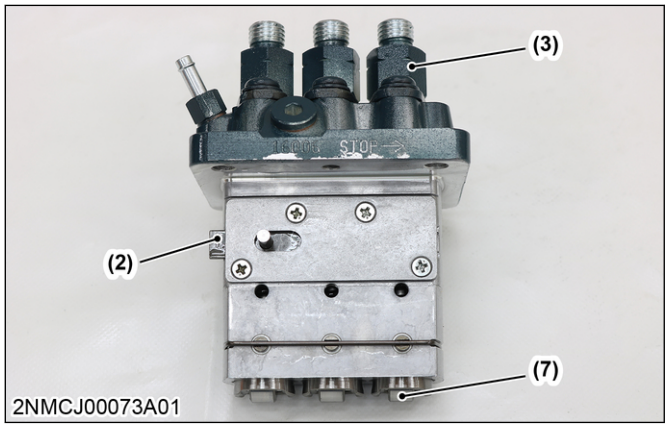
The injection pump is a device that pumps the fuel to the injection nozzle of each cylinder.

### 3.9.2 Structure of injection pump

The injection pump is made up of a control valve (2), a delivery valve (4), a plunger (6) and the like.

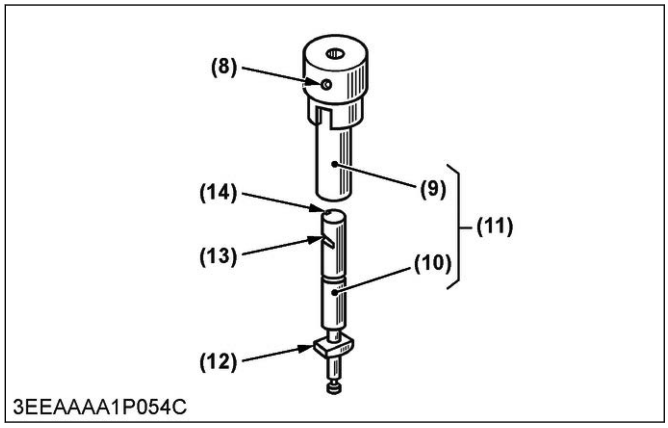
**Injection pump**



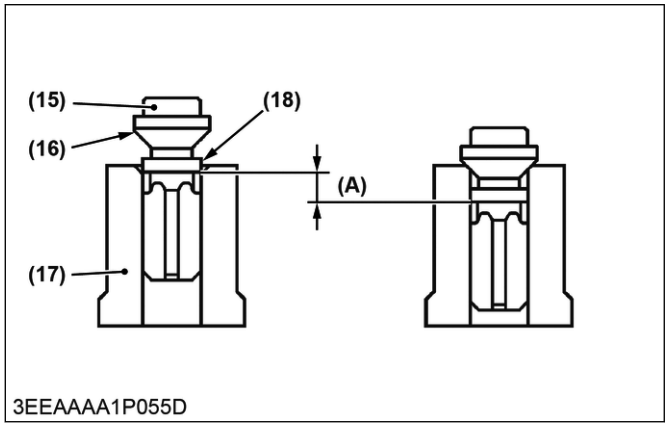

(1) Dumping valve
(2) Control valve
(3) Delivery valve holder
(4) Delivery valve
(5) Cylinder
(6) Plunger
(7) Tappet roller

**Pump Element (Plunger and cylinder)**



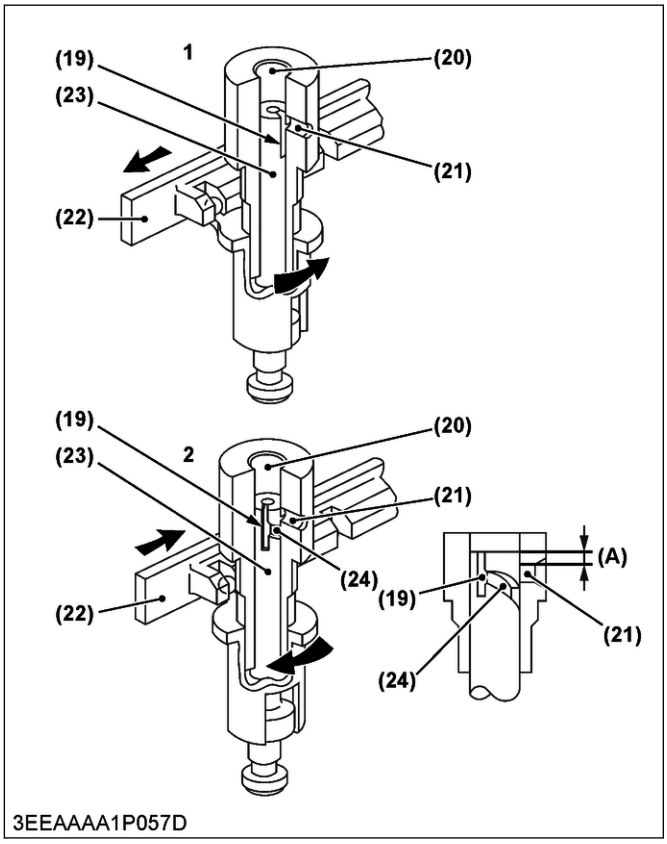

(8) Feed Hole
(9) Cylinder
(10) Plunger
(11) Pump element
(12) Driving face
(13) Control groove
(14) Slot

**Delivery Valve**




(15) Valve
(16) Seat surface
(17) Valve seat
(18) Relief plunger
(A) Moving distance

**Control Valve**

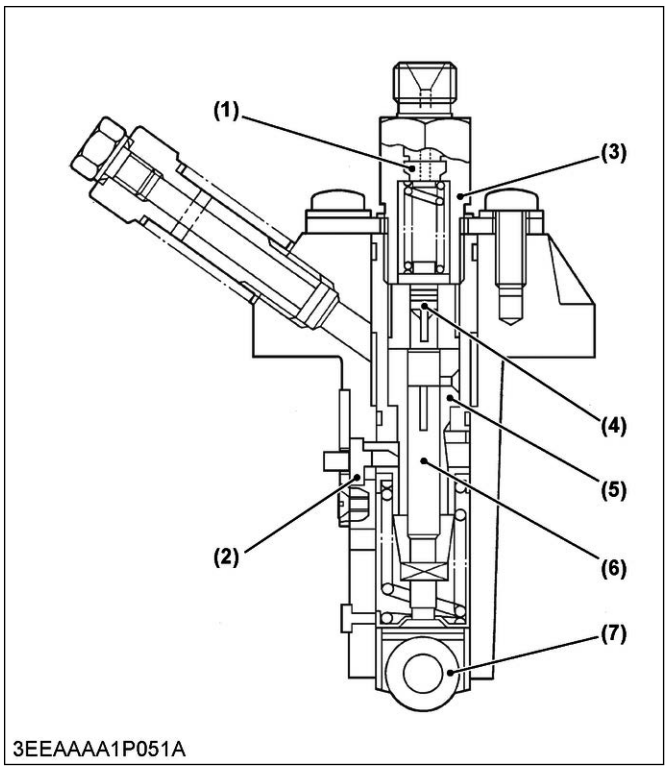


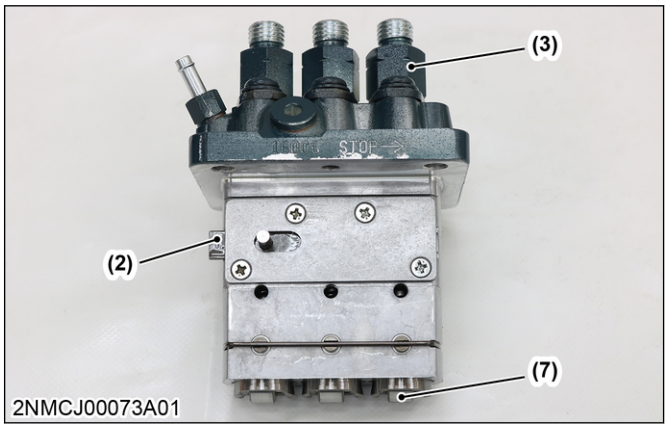

(19) Slot
(20) Delivery chamber
(21) Feed hole
(22) Control rack
(23) Plunger
(24) Control groove
(A) Moving distance

## 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]**

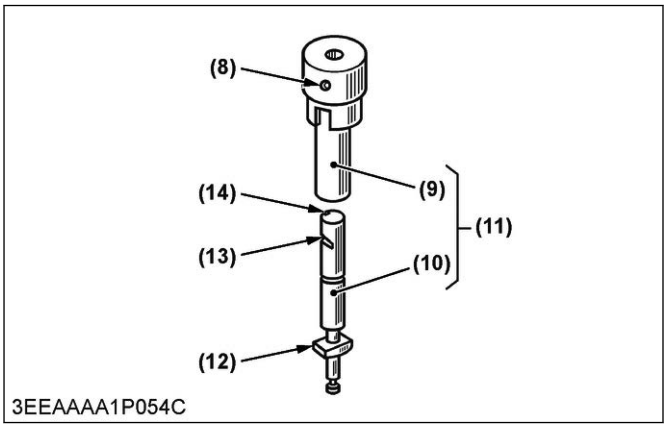



(1) Dumping valve
(2) Control valve
(3) Delivery valve holder
(4) Delivery valve
(5) Cylinder
(6) Plunger
(7) Tappet roller

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.

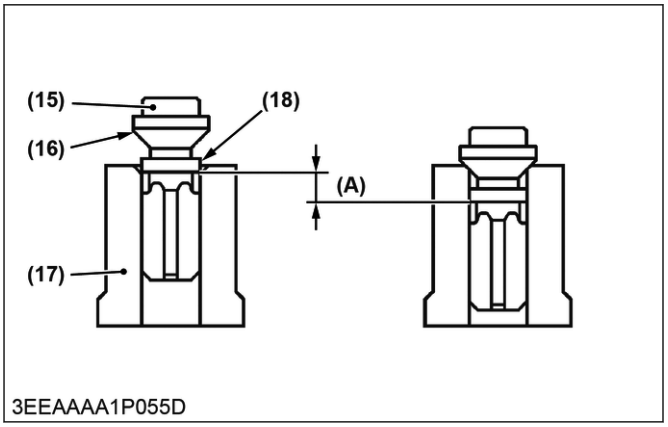
**[Pump element (plunger and cylinder) ]**




(8) Feed Hole
(9) Cylinder
(10) Plunger
(11) Pump element
(12) Driving face
(13) Control groove
(14) Slot

The pump element (11) is consist of the cylinder (9) and the plunger (10).
The sliding surfaces are super-precision machined to maintain injection pressure even at low engine speeds.
Since the driving face (12) fits in the control sleeve, the plunger (10) is rotated by the movement of the control rack to increase or decrease of fuel delivery.
As described above, the plunger (10) is machined to have the slot (14) and the control groove (13).

**[Delivery valve]**

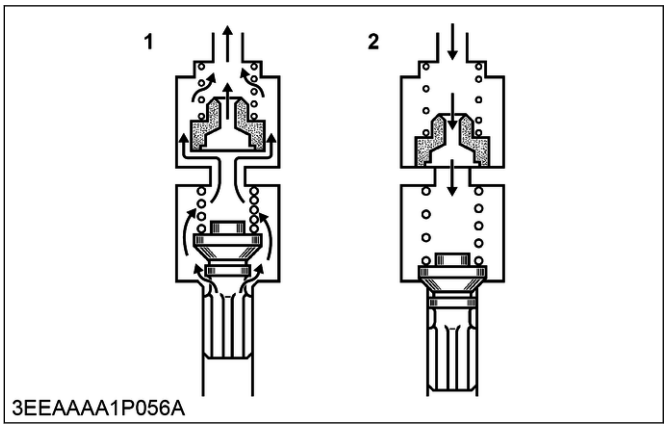



(15) Valve
(16) Seat surface
(17) Valve seat
(18) Relief plunger
(A) Moving distance

The delivery valve consists of the valve (15) and valve seat (17).
The delivery valve performs the following functions.

1. Reverse flow-preventing function
   If the fuel flow reverses from the injection nozzle side when the relief plunger (18) lowers, the time lag between the start of the next delivery and the nozzle injection increases.
   To avoid the increase of this time lag, valve (15) mounts between the delivery chamber and injection pipe. As a result, valve (15) prevents this reverse flow, and keeping the fuel always filled in the injection nozzle and injection pipe.
2. Suck-back function
   After completing the fuel delivery, the valve (15) lowers, and the end of the relief plunger (18) contacts the valve seat (17). The valve (15) lowers further, until its seat surface (16) seats firmly on the valve seat (17).
   During this time, the amount of fuel corresponding to (A) is sucked back from the injection pipe, the pressure inside the injection pipe is reduced,thus leading to an improved injection shut off and preventing after leakage dribbling.

**[Dumping valve]**

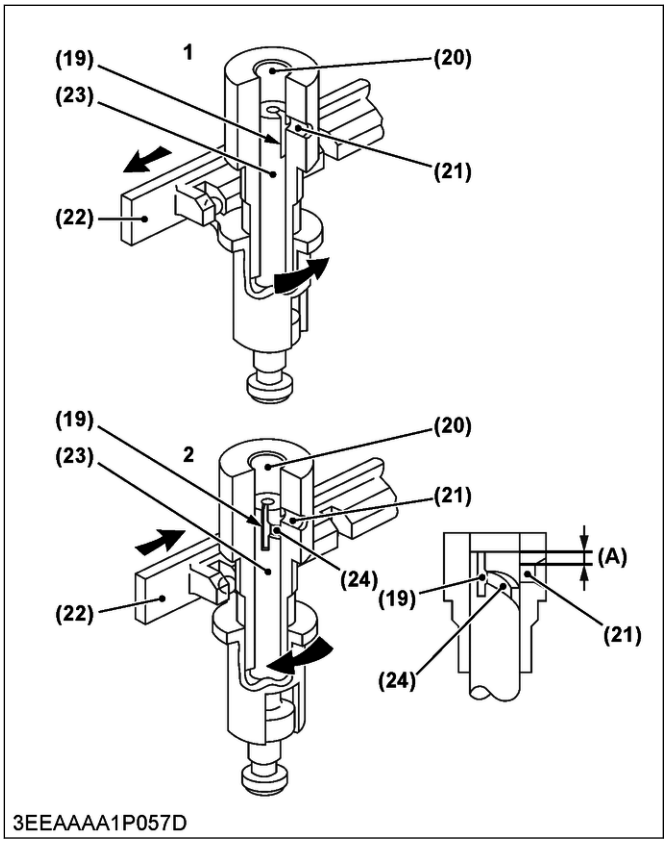



1: Fuel injection
2: Suck-back

1. At fuel injection
   Since dumping valve is pushed up to press the spring, the fuel passage is opened to be pressure-fed to injection nozzle.
2. At suck-back
   At suck-back by delivery valve after fuel injection, fuel returns through dumping valve orifice.
   Generally, a second injection is apt to occur by reflex pressure due to the reaction of sudden pressure drop, when changing into suck-back by delivery valve from high injection pressure.
   The durability of injection nozzle is improved, because this second injection is perfectly prevented by dumping valve and also resolving nozzle clogging.

**[Control valve]**

**Control Valve**




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

1. No fuel delivery (Engine stop position)
   At the engine stop position of the control rack (22), the lengthwise slot (19) on the plunger (23) aligns with the feed hole (21). And the delivery chamber (20) is led to the feed hole (21) during the entire stroke of the plunger (23).
   The pressure in the delivery chamber (20) does not build up and no fuel can be forced to the injection nozzle.
2. Fuel delivery
   The plunger (23) is rotated (see figure) by the control rack (22). When the plunger (23) is pushed up, the feed hole (21) is closed.
   The pressure in the delivery chamber (20) builds up and force-feeds the fuel to the injection nozzle, until the control groove (24) meets the feed hole (21).
   The amount of the corresponds to the moving distance (A).

### 3.9.4 Specification of injection pump

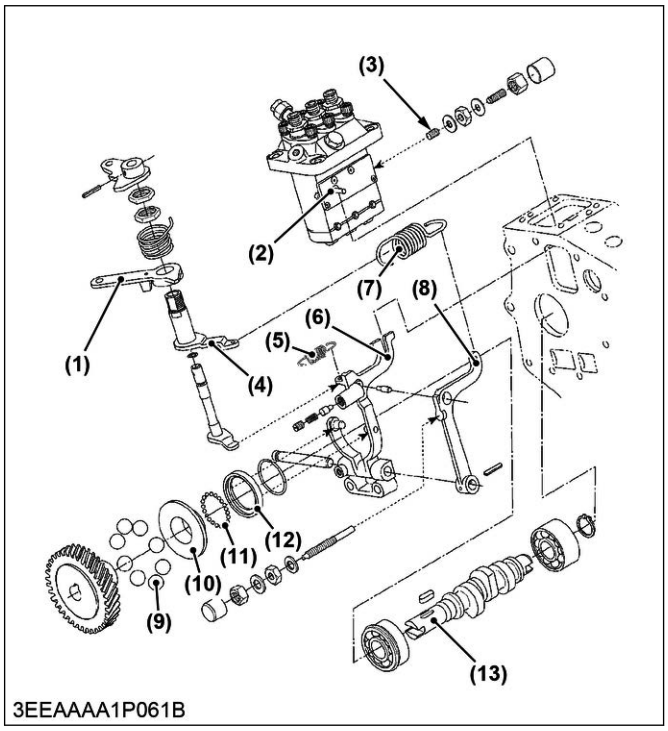
| | |
|---|---|
| Pump type | Bosch MD type mini pump |

# 3.10 Governor

## 3.10.1 Outline of governor (Steel ball type)

A governor maintains engine speed at constant level even under fluctuating loads, provides stable idling and regulates maximum engine speed by controlling the fuel injection rate.

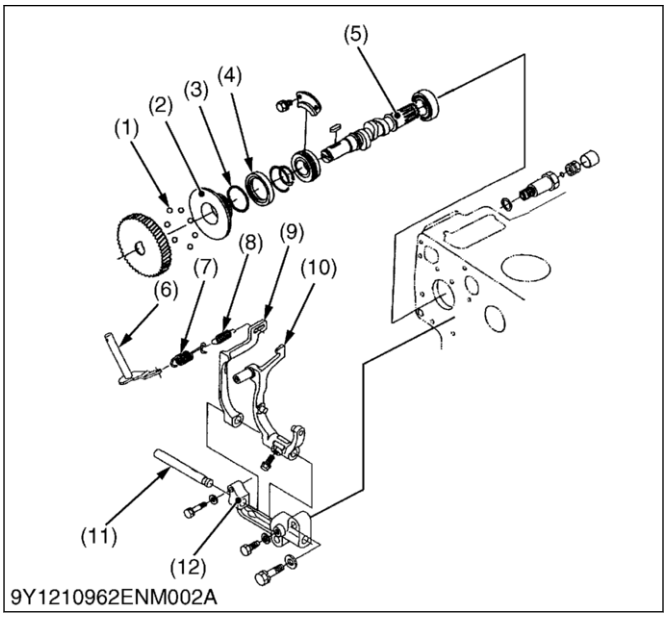
## 3.10.2 Structure of governor (Steel ball type)




(1) Speed control lever
(2) Control rod
(3) Idling adjust spring
(4) Governor lever
(5) Start spring
(6) Fork lever 1
(7) Governor spring
(8) Fork lever 2
(9) Steel ball
(10) Governor sleeve
(11) Steel ball
(12) Governor ball case
(13) Fuel camshaft

## 3.10.3 Function of governor (Steel ball type)

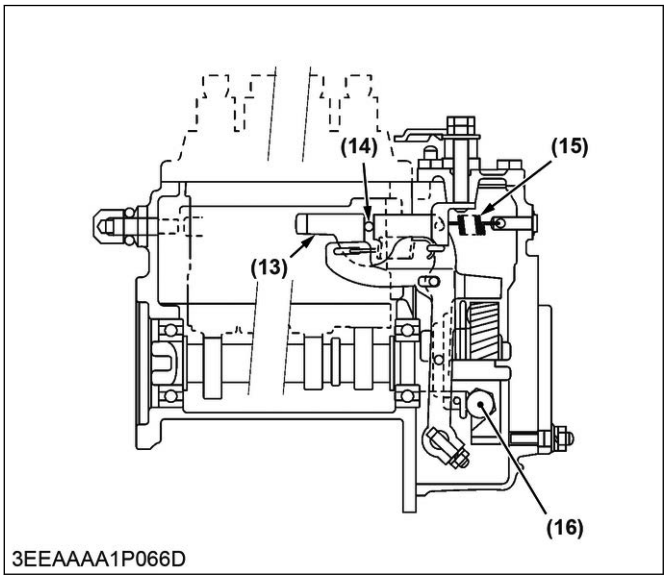
The governor serves to keep engine speed constant by automatically adjusting the amount of fuel supplied to the engine according to changes in the load.




(1) Steel ball
(2) Governor sleeve
(3) Steel ball
(4) Governor ball case
(5) Fuel camshaft
(6) Governor lever
(7) Start spring
(8) Governor spring
(9) Fork lever 2
(10) Fork lever 1
(11) Fork lever shaft
(12) Fork lever holder

This engine employs an all-speed governor called steel ball type.
This governor maintains engine speed at a constant level even under fluctuating loads, provides stable idling and regulates maximum engine speed by controlling the fuel injection rate.

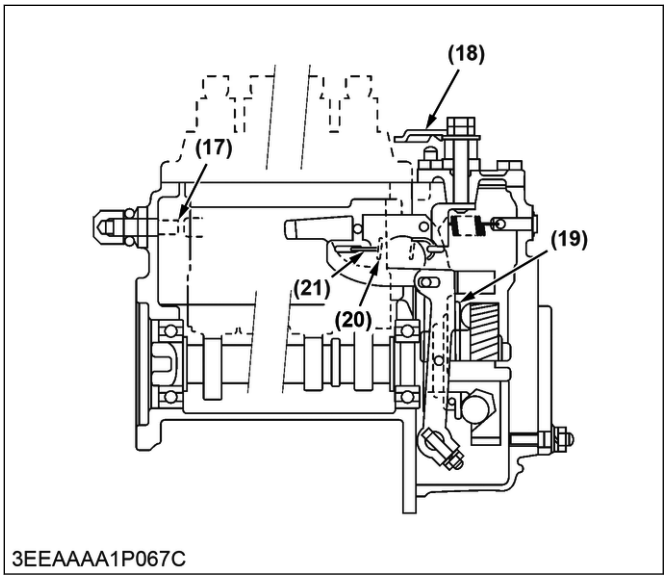
**[At start]**




(13) Fork lever 1
(14) Control Rack
(15) Start Spring
(16) Steel Ball

Since the steel ball (16) have no centrifugal force, a fork lever 1 (13) is pulled to the right by the start spring (15).
Accordingly, the control rack (14) moves to the maximum injection position to assure easy starting.

**[At Idling]**




(17) Idle Limit Spring
(18) Speed Control Lever
(19) Governor Sleeve
(20) Governor Spring 1
(21) Governor Spring 2

When the speed control lever (18) is set at the idling position after the engine starts, the governor spring 1 (20) does not work at all.
On the other hand, the governor spring 2 (21) only act slightly.
The governor sleeve (19) is pushed leftward by a centrifugal force of steel ball (16).

Therefore, the fork lever 1 (13) and control rack (14) are moved to the left by the governor sleeve.
And then, the idle limit spring (17) is compressed by the control rack (14).
As a result, the control rack (14) is kept at a position where a centrifugal force of governor spring 2 (21) and idle limit spring (17) are balanced, providing stable idling.

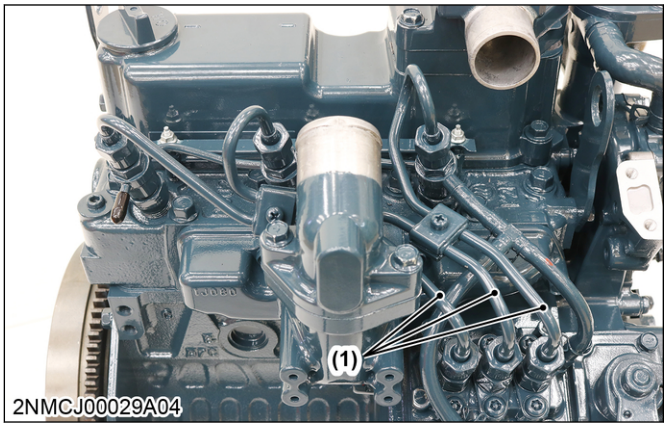
# 3.11 Injection pipe

## 3.11.1 Outline of injection pipe

Injection pipes connect the injection pump and injection nozzles.

## 3.11.2 Structure of injection pipe

The injection pipes between the injection pump and injection nozzles are designed with equal length.




(1) Injection pipes

## 3.11.3 Function of injection pipe

Injection pipes connect the injection pump and injection nozzles.

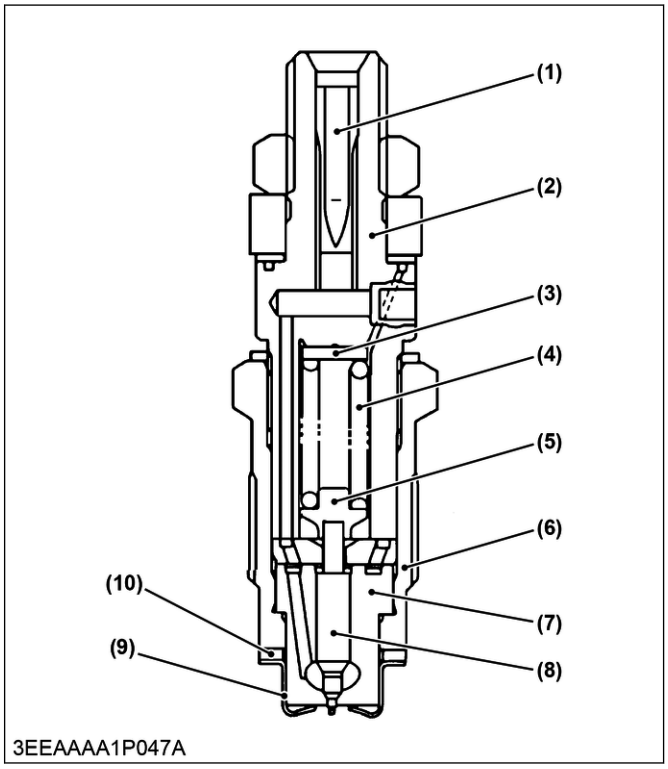
# 3.12 Injection nozzle

## 3.12.1 Outline of injection nozzle

The injection nozzle injects high pressure fuel from the injection pump into the combustion chamber.

## 3.12.2 Structure of injection nozzle

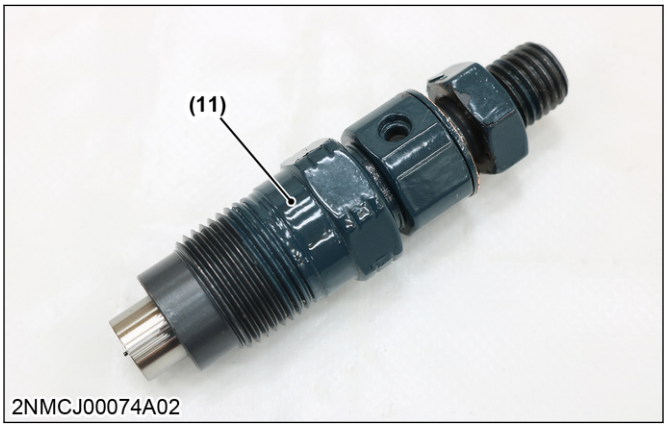
The injection nozzle is made up of a nozzle holder body (2), a nozzle spring (4), a needle valve (8) and the like.



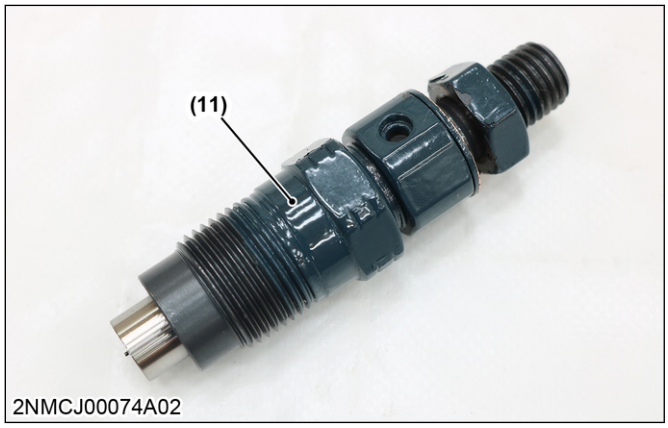

(1) Bar filter
(2) Nozzle holder body
(3) Adjusting washer
(4) Nozzle spring
(5) Push rod
(6) Retaining nut
(7) Nozzle piece
(8) Needle valve
(9) Heat seal
(10) Gasket

**NOTE**

- **Heat seal (9) and Gasket (10) are separate parts.**



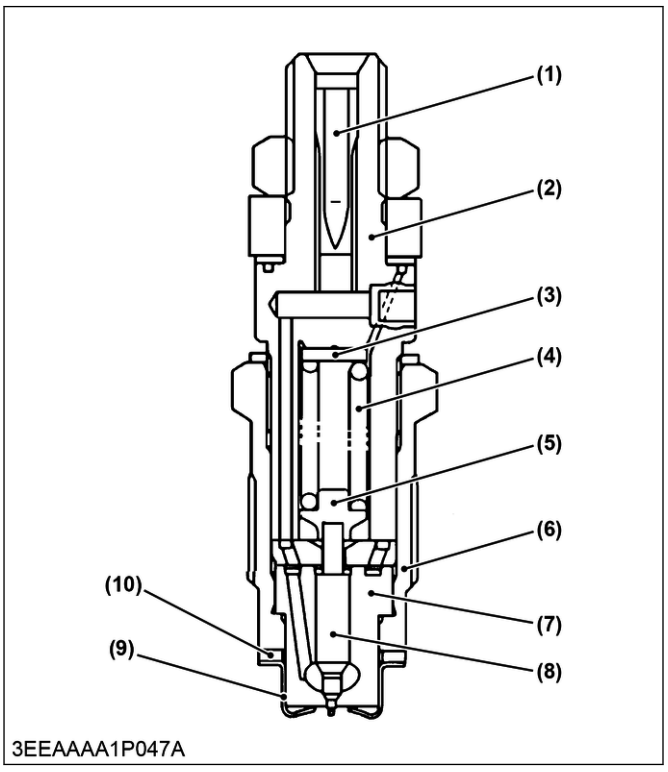

(11) Injection nozzle




(11) Injection nozzle

## 3.12.3 Function of injection nozzle

The injection nozzle injects high pressure fuel into the combustion chamber from the injection pump.




(1) Bar filter
(2) Nozzle holder body
(3) Adjusting washer
(4) Nozzle spring
(5) Push rod
(6) Retaining nut
(7) Nozzle piece
(8) Needle valve
(9) Heat seal
(10) Gasket

An injection nozzle can be classified as a throttle nozzle for IDI (IDI: in-direct injection)
The small OPD mini nozzle used for the E-TVCS system is an equipment of double throttle type with flat cut.
This type of nozzle is designed to control the injection quantity, when the lift rate is low at the start of the injection. And this type can cut down the knocking sound caused by excessive fuel injection, through giving the needle valve section more taper than before. And this type can also prevent the rapid increase in the injection quantity, when the initial injection turns into the full-force injection.
In addition, the flat cut design at the needle valve section is employed to prevent the injection quantity loss caused by carbon in the throttle section, and helps the throttle withstand long use, and also reduces as much knocking sound as when the injection nozzle was new.
The heat seal is employed to improve durability and reliability of the nozzle.

## 3.12.4 Specification of injection nozzle

| | |
|---|---|
| Operating pressure range | 13.7 to 14.7 MPa<br>140.0 to 149.0 kgf/cm$^2$<br>1990 to 2130 psi |

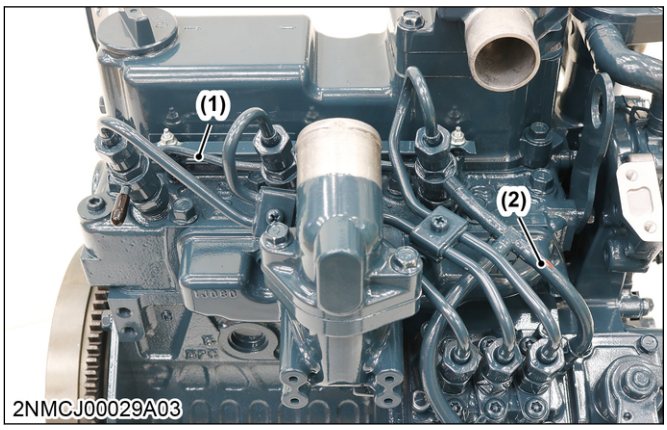
# 3.13 Overflow pipe

## 3.13.1 Outline of overflow pipe

The overflow pipe is a path for returning surplus fuel to the fuel tank after fuel injection.

## 3.13.2 Structure of overflow pipe

The overflow pipe is the return pipe from the injection nozzles to the tank.




(1) Overflow pipe (2) Overflow hose

## 3.13.3 Function of overflow pipe

The overflow pipe is a path for returning surplus fuel to the fuel tank after fuel injection.

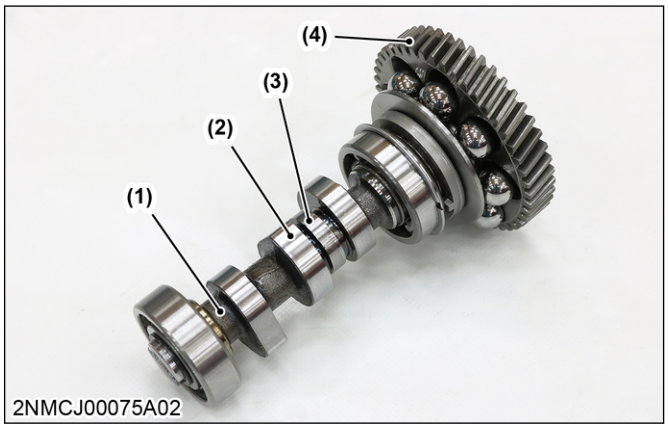
# 3.14 Fuel camshaft

## 3.14.1 Outline of fuel camshaft

The fuel camshaft push the tappet roller of the injection pump to compress fuel.

## 3.14.2 Structure of fuel camshaft

The fuel camshaft is made up of a fuel camshaft (1), a cam for an injection pump (2),a cam for a fuel feed pump (3) and an injection pump gear (4).




(1) Fuel camshaft (3) Cam for a fuel feed pump
(2) Cam for an injection pump (4) Injection pump gear

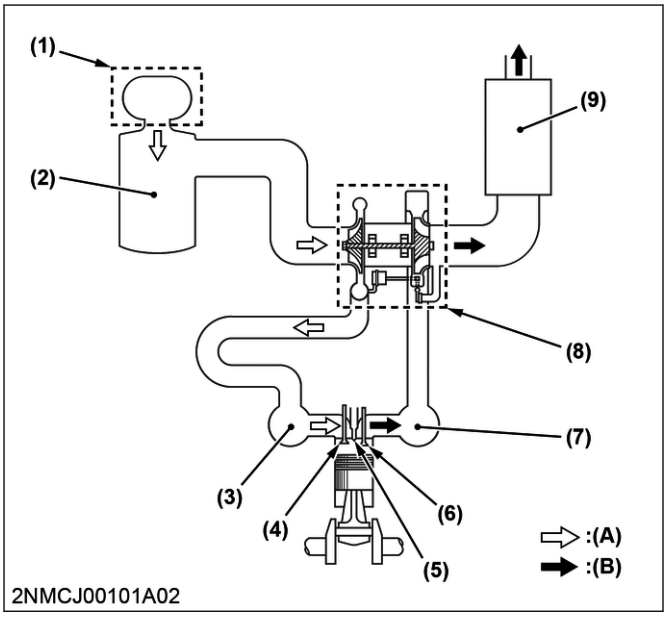
## 3.14.3 Function of fuel camshaft

The fuel camshaft pushes the tappet roller of the injection pump to compress the fuel.
The fuel camshaft is driven by the crankshaft gear via idle gear, and controls the reciprocating movement of the injection pump and the mechanical fuel feed pump.
The fuel camshaft is made of carbon steel, and the cam sections are quenched and tempered to provide greater wear resistance.

# 4. Intake and exhaust system

## 4.1 Structure of intake and exhaust system

The intake and exhaust system is made up of intake manifold (3), combustion chamber (5), exhaust manifold (7) and the like.



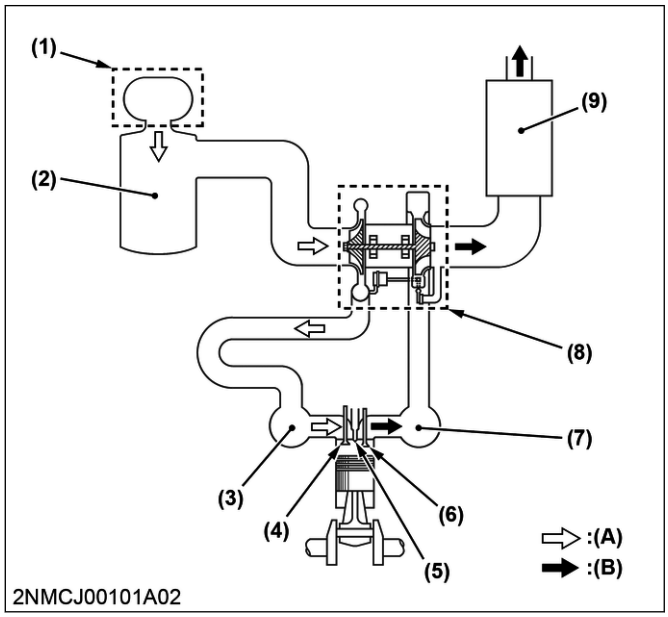

(1) Pre-cleaner
(2) Air cleaner
(3) Intake manifold
(4) Intake valve
(5) Combustion chamber
(6) Exhaust valve
(7) Exhaust manifold
(8) Turbocharger
(9) Muffler
(A) Intake air flow
(B) Exhaust gas flow

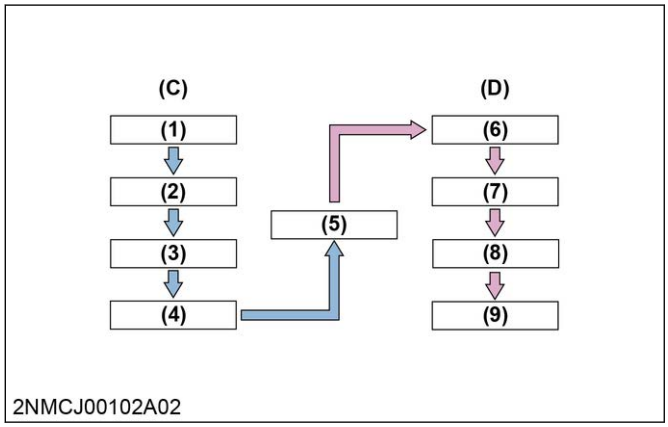
## 4.2 Feature of the air intake and exhaust system

The air intake system supplies clean air to the engine, while the exhaust system collects exhaust gases from the engine and carries them away.
The air intake system supplies the engine with the proper quantity of clean air, while the exhaust system collects exhaust gases from the engine and carries them away.

## 4.3 Flow of intake and exhaust system

This shows the flow of the intake system (C) and exhaust system (D).




(1) Pre-cleaner
(2) Air cleaner
(3) Intake manifold
(4) Intake valve
(5) Combustion chamber
(6) Exhaust valve
(7) Exhaust manifold
(8) Turbocharger
(9) Muffler
(A) Intake air flow
(B) Exhaust gas flow
(C) Intake system
(D) Exhaust system

**(A) Intake air flow**

The intake system (C) consists of a pre-cleaner (1) (if equipped), an air cleaner (2), a turbocharger (8), an intake manifold (3), a glow plug and intake valves (4).

1. Fresh air from the atmosphere passes through the pre-cleaner (1) and air cleaner (2), with debris removed from the air.
2. And then purified air is compressed by the turbocharger (8).
3. Compressed intake air passes through the intake manifold (3) and is distributed to each of the cylinders.

**(B) Exhaust gas flow**

The exhaust system (D) consists of exhaust valves (6), an exhaust manifold (7), a turbocharger (8) and a muffler (9).

1. Post combustion gases discharged from the combustion chamber (5) in each cylinder are collected by the exhaust manifold (7).
2. Combustion gases passed through the turbocharger (8) rotate the turbine and pressurize the intake air.
3. The exhaust gases are discharged to the atmosphere from the muffler (9).

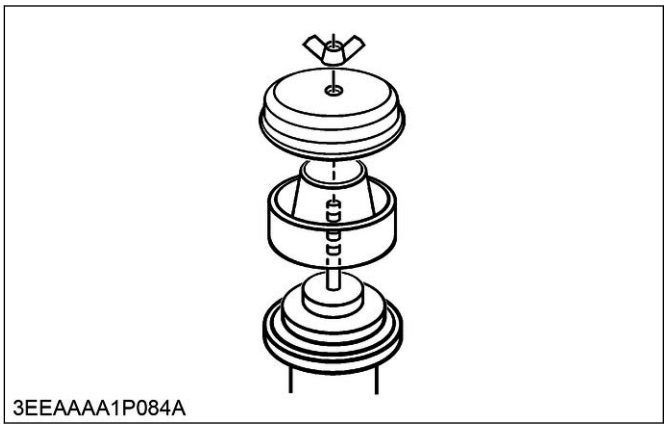
# 4.4 Pre-cleaner

## 4.4.1 Outline of pre-cleaner

The pre-cleaner removes large debris from the intake air.

## 4.4.2 Structure of pre-cleaner

The pre-cleaner is made up of a body and cover.




## 4.4.3 Function of pre-cleaner

Removal of large debris prior to entering the air cleaner enables raising the maintenance interval of the air cleaner.

## 4.4.4 Specification of pre-cleaner

| | |
|---|---|
| Airflow range | Max. 2.5 $m^3$/min. |

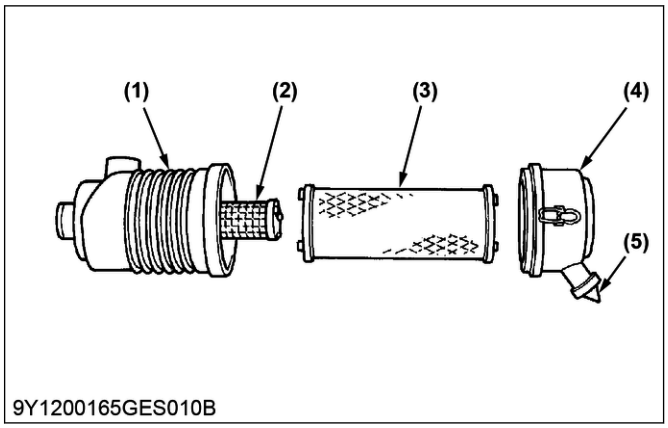
# 4.5 Air cleaner

## 4.5.1 Outline of air cleaner

The air cleaner removes debris etc. from the engine intake air.

## 4.5.2 Structure of air cleaner

The air cleaner is made up of an air cleaner, housing, element, and dust cup. Clean air is essential to satisfactory performance and long engine life.
The air cleaner must be able to remove fine materials such as dust and blown sand as well as chaff, or lawn from the air.




(1) Air cleaner housing
(2) Secondary element
(3) Primary element
(4) Dust cup
(5) Evacuator valve

## 4.5.3 Function of air cleaner

The air cleaner removes debris etc. from the engine intake air.
It also reduces noise generated by air intake.

## 4.5.4 Specification of air cleaner

| | |
|---|---|
| Cleaning efficiency | 99.9% or higher |
| Operating temperature range | -30 to 80 ℃<br>-22 to 176 ℉ |

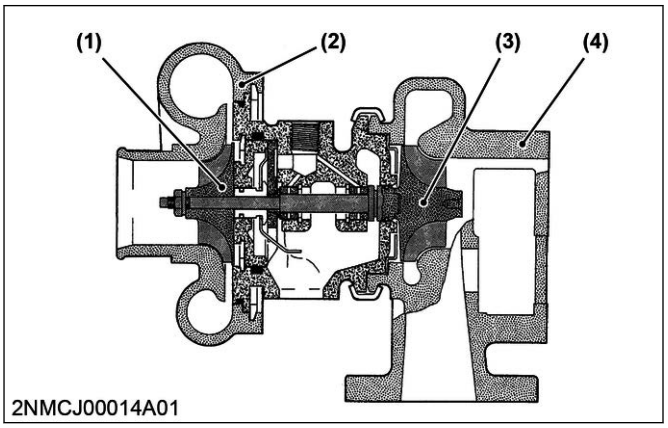
# 4.6 Turbocharger

## 4.6.1 Outline of turbocharger

The turbocharger uses the engine exhaust gas to compress intake air.
The turbocharger increases engine output power.

### 4.6.2 Structure of turbocharger

The turbocharger is made up of a compressor wheel (1) ,a turbine wheel (3) and the like.




(1) Compressor wheel
(2) Compressor housing
(3) Turbine wheel
(4) Turbine housing

### 4.6.3 Function of turbocharger

The turbocharger uses exhaust gas to compress intake air.
When combustion gases pass through the turbocharger, they make the turbine wheel rotate at high speed.
This rotation also make the compressor wheel mounted on the same shaft to rotate at high speed, compressing and supplying intake air to each cylinder.

### 4.6.4 Specification of turbocharger

| Turbine pressure ratio | Corrected flow rate | Efficiency of turbine |
|---|---|---|
| 1.5 | 0.524 | 0.747 |
| 2.0 | 0.613 | 0.737 |
| 2.5 | 0.643 | 0.721 |

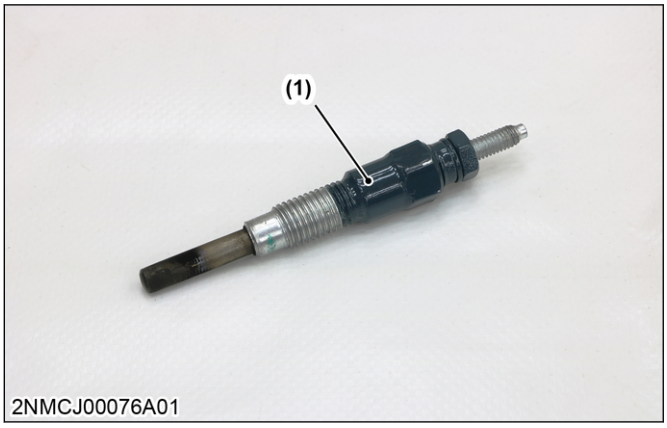
## 4.7 Glow plug

### 4.7.1 Outline of glow plug

The glow plugs warm intake air at combustion chamber to help with starting.

### 4.7.2 Structure of glow plug

The glow plug is made up of a heating point and an applied point.




(1) Glow plug

### 4.7.3 Function of glow plug

The glow plugs warm intake air at combustion chamber to help with starting.
When the key position turn to glow position, the voltage applied to the glow plug.
After 6 seconds past, the tip of heating point reach to over 800 ℃ (1472 ℉).

### 4.7.4 Specification of glow plug

| | |
|---|---|
| Voltage at rated operation | DC 11 V |
| Resistance | Approx. 1.1 Ω<br>(at normal temperature) |

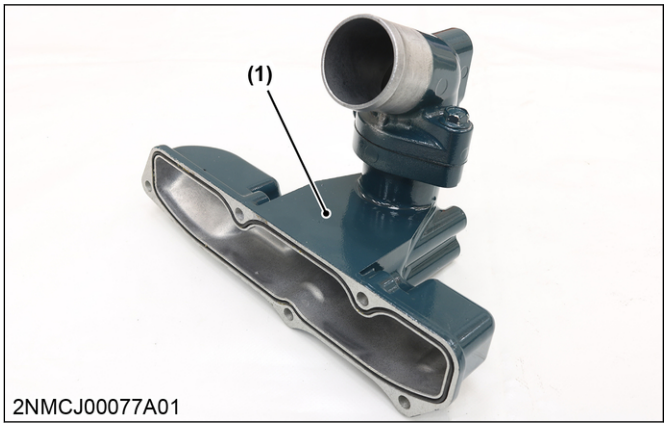
# 4.8 Intake manifold

## 4.8.1 Outline of intake manifold

The intake manifold efficiently distributes intake air to each cylinder.

## 4.8.2 Structure of intake manifold

The intake manifold is mounted on the intake air side of the cylinder head.




(1) Intake manifold

## 4.8.3 Function of intake manifold

The intake manifold efficiently distributes intake air to each cylinder.

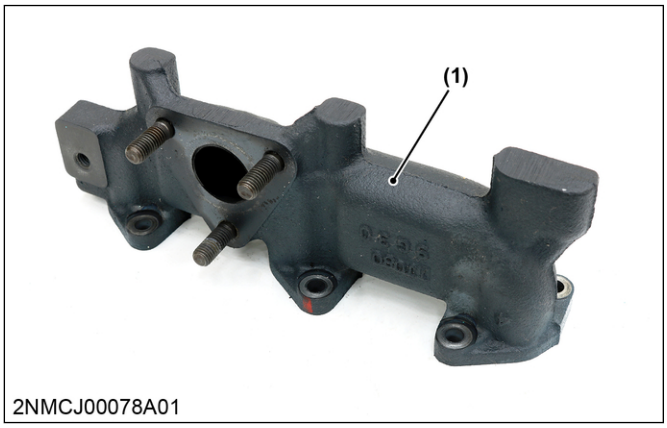
# 4.9 Exhaust manifold

## 4.9.1 Outline of exhaust manifold

The exhaust manifold is ducting that collects exhaust gases combusted in each of the cylinders.

## 4.9.2 Structure of exhaust manifold

The exhaust manifold is mounted on the exhaust side of the cylinder head.




(1) Exhaust manifold

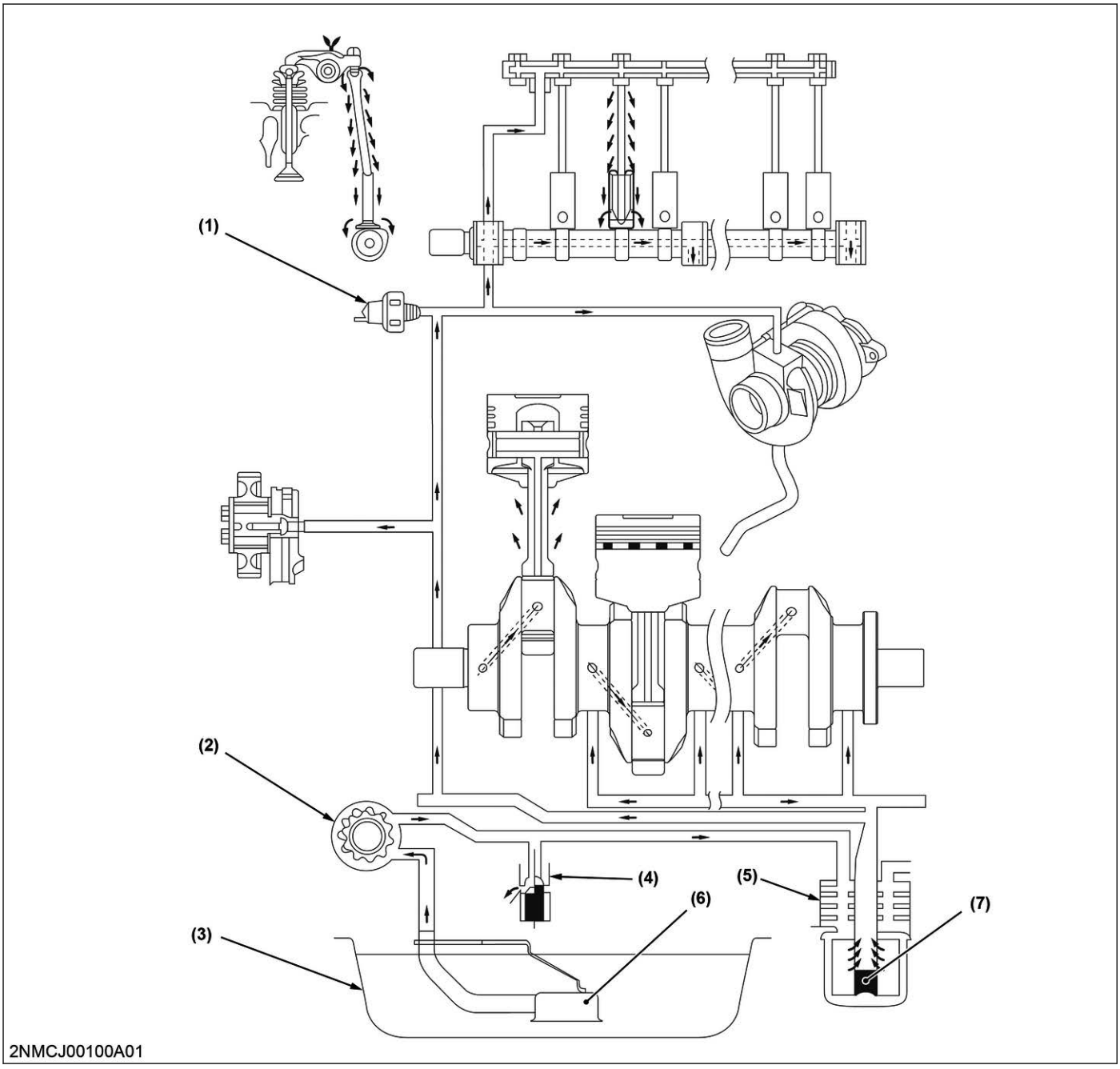
## 4.9.3 Function of exhaust manifold

The exhaust manifold collects exhaust gases combusted in each of the cylinders and feeds this to the aftertreatment units.

# 5. Lubricating system

## 5.1 Structure of lubricating system

The lubricating system is made up of an oil pump (2) and an oil filter (7) and the like.

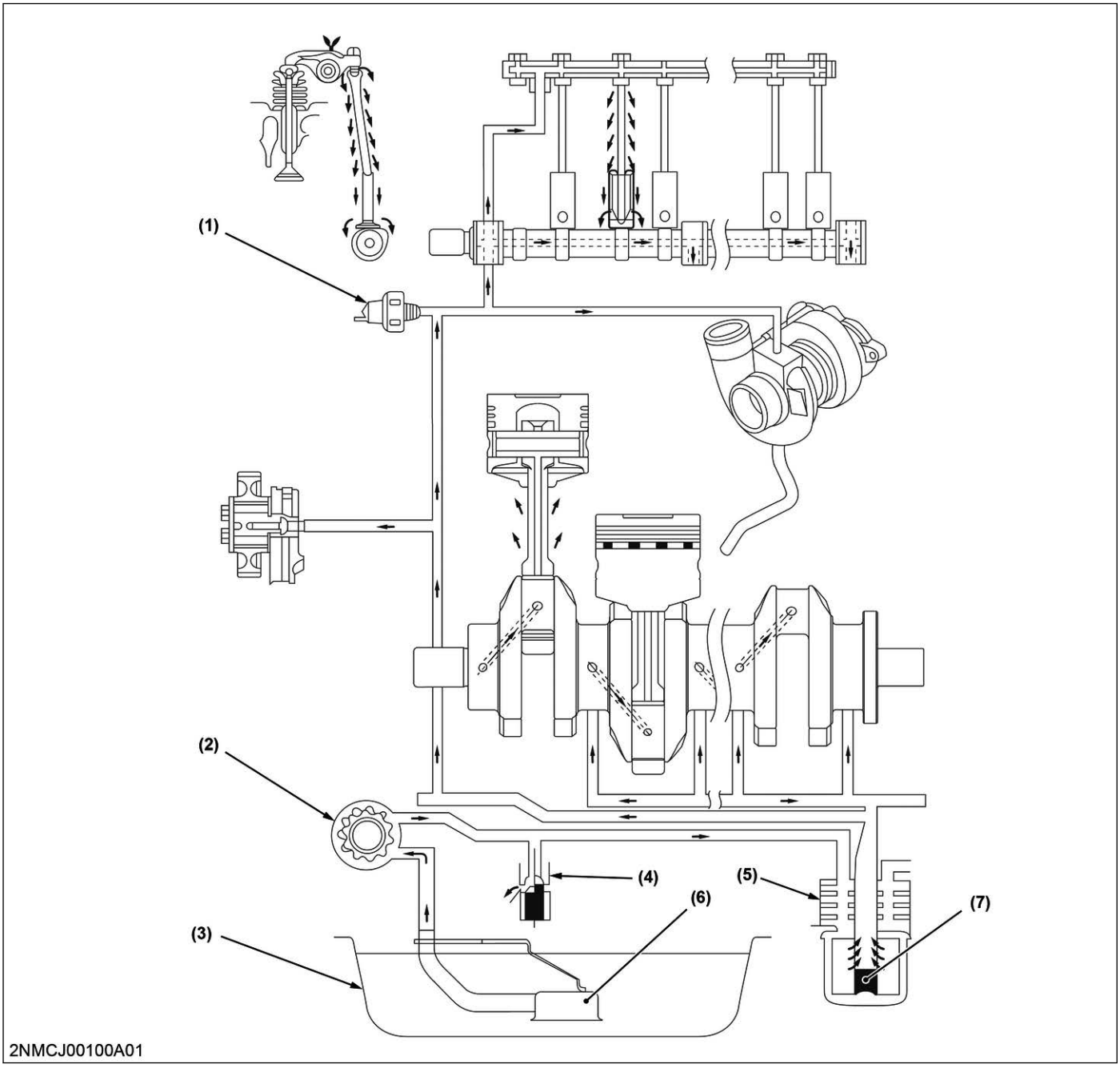


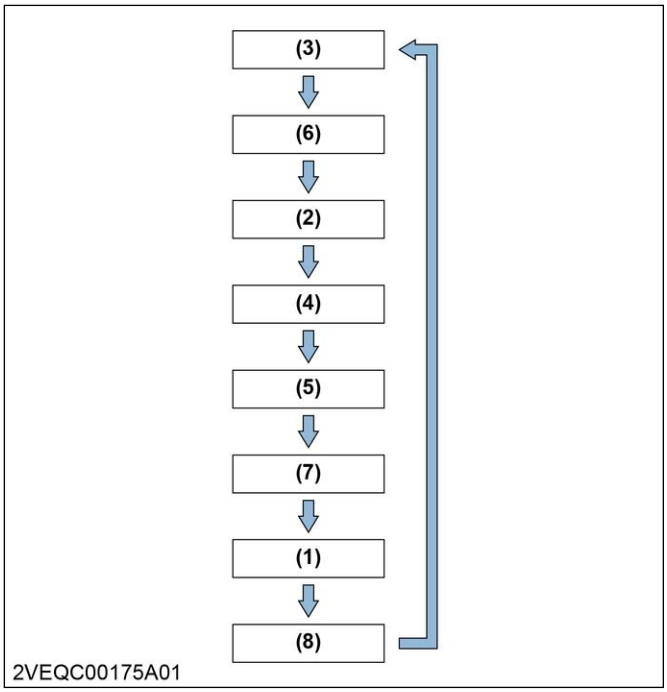

(1) Oil pressure switch
(2) Oil pump
(3) Oil pan
(4) Relief valve
(5) Oil cooler
(6) Oil strainer
(7) Oil filter

## 5.2 Feature of lubricating system

The lubricating system supplies engine oil to the rotating parts and sliding parts in the engine enabling these parts to run smoothly.
In addition, the lubricating system has the important role of enabling full exhibiting of engine function through the effects of oil on lubricated parts.
The method for supplying oil to various parts of the engine uses "pressurized supply" of supplying oil to each of the parts using a pump.

## 5.3 Flow of lubricating system






(1) Oil pressure switch
(2) Oil pump
(3) Oil pan
(4) Relief valve
(5) Oil cooler
(6) Oil strainer
(7) Oil filter
(8) Sliding parts of various components

1. Oil is suctioned from the oil pan (3) by the oil pump (2).
2. Suctioned oil is pumped to sliding parts of various components (8) by the oil pump (2) through oil passages.
3. After lubricating sliding parts of various components (8), the oil returns to the oil pan (3).

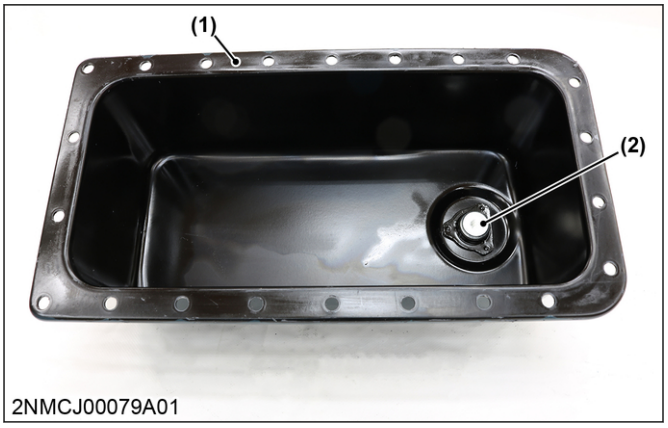
# 5.4 Oil pan

## 5.4.1 Outline of oil pan

The oil pan stores oil in the engine.

## 5.4.2 Structure of oil pan

The oil pan is made up of the oil pan body and a drain plug.




(1) Oil pan (2) Drain plug

## 5.4.3 Function of oil pan

The oil pan stores oil in the engine and has the role as receptacle of circulated oil.

## 5.4.4 Specification of oil pan

| Model | Engine oil capacity | |
|---|---|---|
| | Oil pan depth | |
| | 101 mm (3.98 in.) | 121 mm (4.76 in.) |
| Z482-E4<br>Z482-E4BG | 2.1 L<br>0.55 U.S.gals<br>0.46 Imp.gals | 2.5 L<br>0.66 U.S.gals<br>0.55 Imp.gals |
| D722-E4 | 3.2 L<br>0.85 U.S.gals<br>0.70 Imp.gals | 3.8 L<br>1.0 U.S.gals<br>0.84 Imp.gals |
| D782-E4 | — | 3.6 L<br>0.95 U.S.gals<br>0.79 Imp.gals |
| Z602-E4 | 2.5 L<br>0.66 U.S.gals<br>0.55 Imp.gals | — |
| D902-E4<br>D902-TE4 | 3.7 L<br>0.98 U.S.gals<br>0.81 Imp.gals | — |

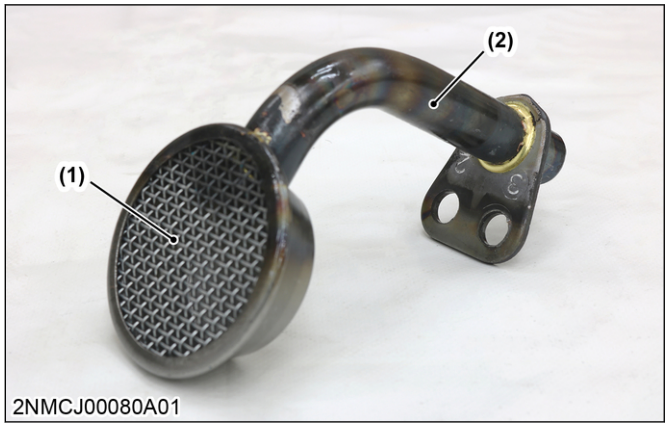
# 5.5 Oil strainer

## 5.5.1 Outline of oil strainer

The oil strainer removes foreign material from the oil.

## 5.5.2 Structure of oil strainer

The oil strainer has a structure of mesh entrance at its tip.




(1) Mesh entrance (2) Oil strainer

## 5.5.3 Function of oil strainer

The oil strainer removes foreign material contained in the oil circulating in the engine.

## 5.5.4 Specification of oil strainer

| | |
|---|---|
| Mesh pore size | 1.74 × 1.74 mm<br>0.0685 × 0.0685 in. |
| Open area | 46.9 % |

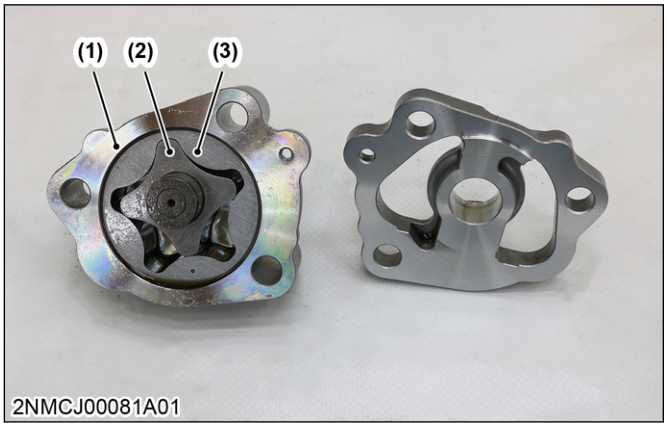
# 5.6 Oil pump

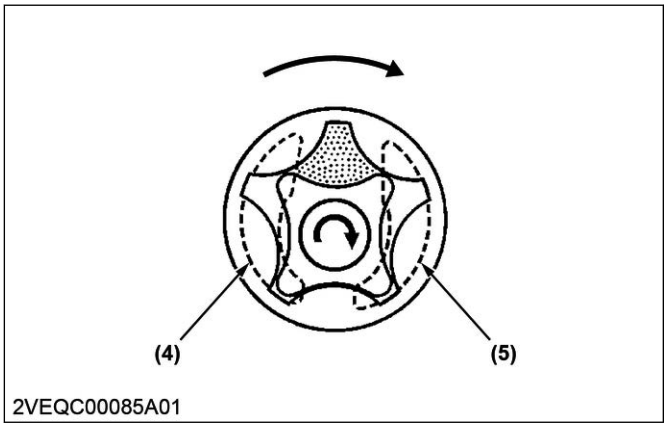
## 5.6.1 Outline of oil pump

The oil pump feeds suctioned oil to various parts.

## 5.6.2 Structure of oil pump

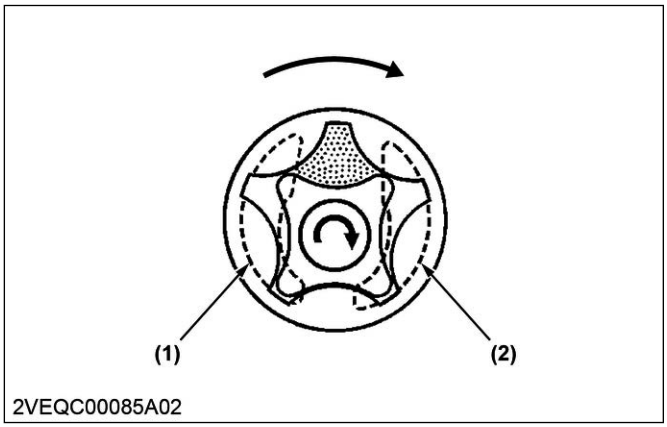
The oil pump is made up of a body, an inner rotor, and an outer rotor and so on .




(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 ℃ (176 ℉), 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)) |

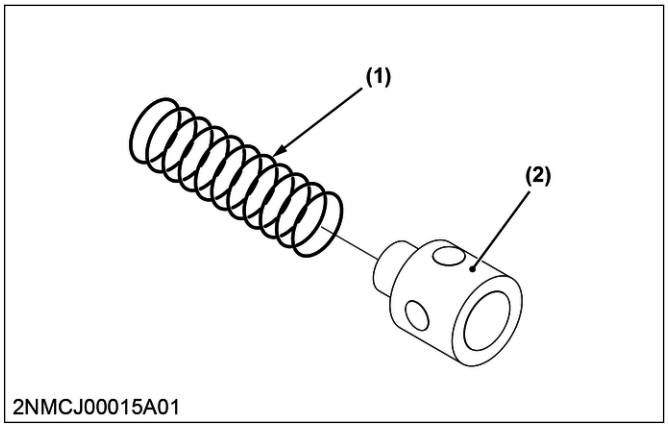
# 5.7 Relief valve

## 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

### 5.7.3 Function of relief valve

When the pressure in the oil passage reaches a set pressure, the spring force is released and the relief valve opens, allowing oil to flow.
This enables controlling the max pressure inside the oil passage.

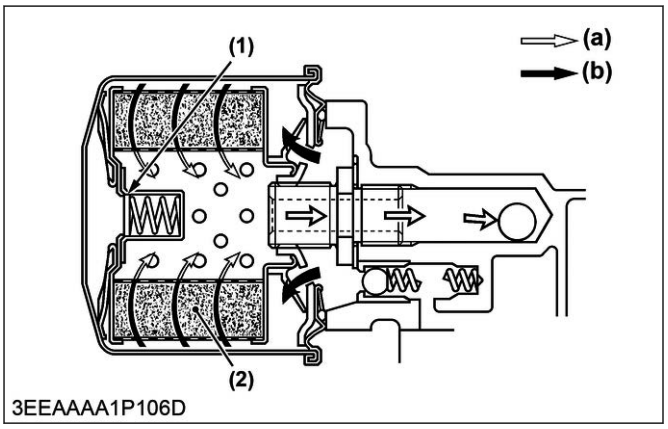
## 5.8 Oil filter

### 5.8.1 Outline of oil filter

The oil filter removes foreign material in the engine oil.

### 5.8.2 Structure of oil filter

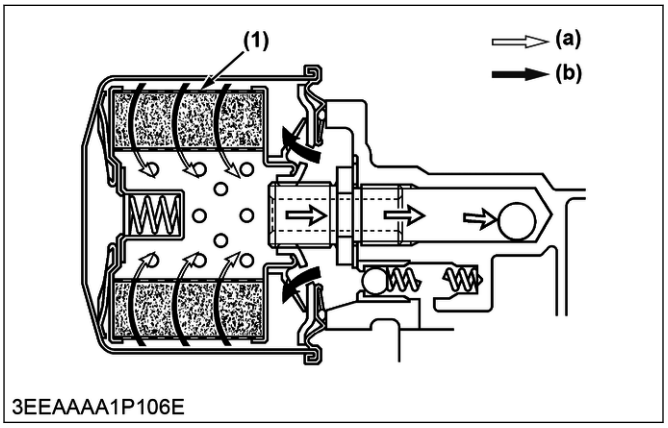
The oil filter is made up of a bypass valve (1) and element (2).




(1) Bypass valve
(2) Element
(a) Filtered oil
(b) Unfiltered oil

### 5.8.3 Function of oil filter

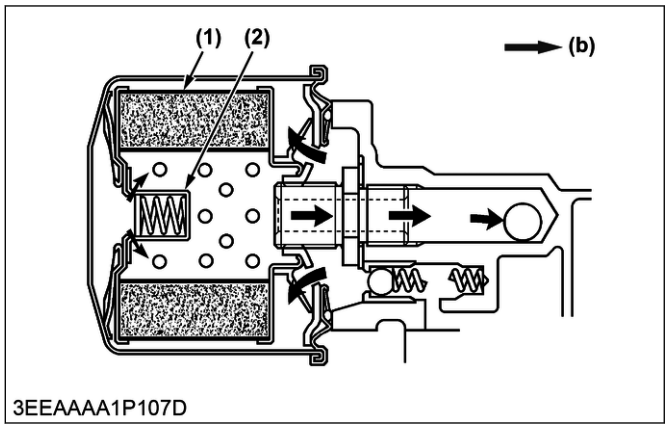
**[Normal State]**




(1) Element
(a) Filtered oil
(b) Unfiltered oil

The engine oil enters through the outer surface of the element and is filtered through to the inside.

**[When element is clogged]**




(1) Element
(2) Bypass valve
(b) Unfiltered oil

If the oil pressure flowing to the filter reaches the bypass valve open pressure, the bypass valve opens.
Engine oil passes through the bypass valve and is pumped without being filtered.

### 5.8.4 Specification of oil filter

| | |
|---|---|
| Bypass valve open pressure | Approximately<br>98 kPa<br>1.0 kgf/cm$^2$<br>14 psi |

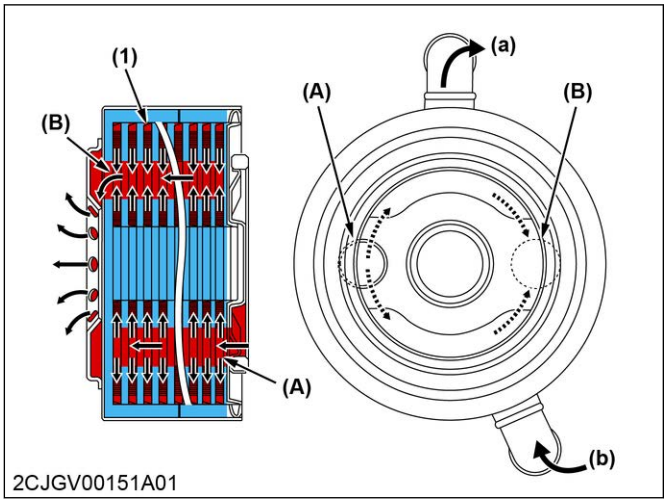
# 5.9 Oil cooler

## 5.9.1 Outline of oil cooler

The oil cooler prevents the oil temperature from rising excessively during engine operation and keeps the oil temperature at an appropriate level.

## 5.9.2 Structure of oil cooler

The oil cooler has a structure partitioned internally using cooling plates (1).




(1) Cooling plates
(A) Oil inlet
(B) Oil outlet
(a) Coolant outlet
(b) Coolant inlet

## 5.9.3 Function of oil cooler

The oil cooler prevents the oil temperature from rising excessively during engine operation and keeps the oil temperature at an appropriate level.
Also, this has the role of warming a cool engine just after starting.
In water cooled oil coolers, engine oil flows on the inside of the cooler plate and the engine oil is cooled or warmed by the coolant flowing on the outside of the cooler plate.

## 5.9.4 Specification of oil cooler

| | |
|---|---|
| Cooling method | Water cooled |

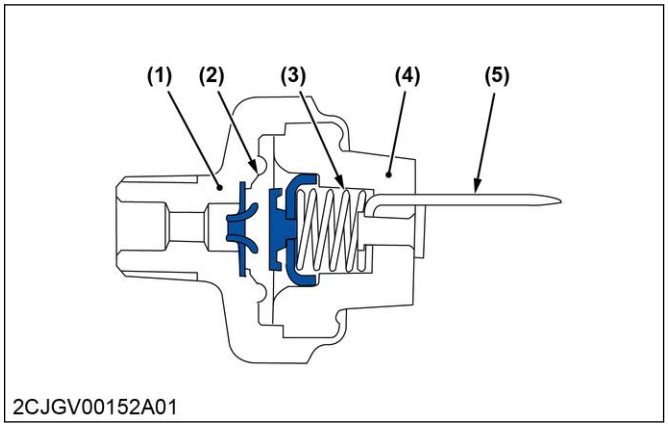
# 5.10 Oil pressure switch

## 5.10.1 Outline of oil pressure switch

The oil pressure switch determines if the oil pressure is within specified range while the engine is running.

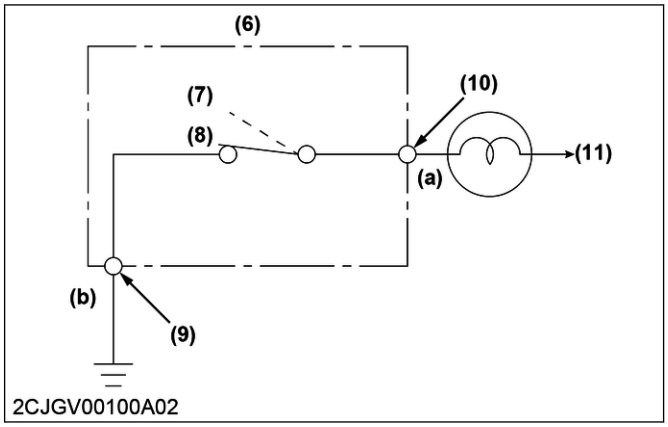
## 5.10.2 Structure of oil pressure switch

The oil pressure switch is made up of a body (1), diaphragm (2) and spring (3) and the like.




(1) Body
(2) Diaphragm
(3) Spring
(4) Insulator
(5) Terminal

**Circuit diagram and connection table**




| Pressure | Terminal | |
|---|---|---|
| | (a) | (b) |
| Pressurization | | |
| Barometric pressure | ● | ● |

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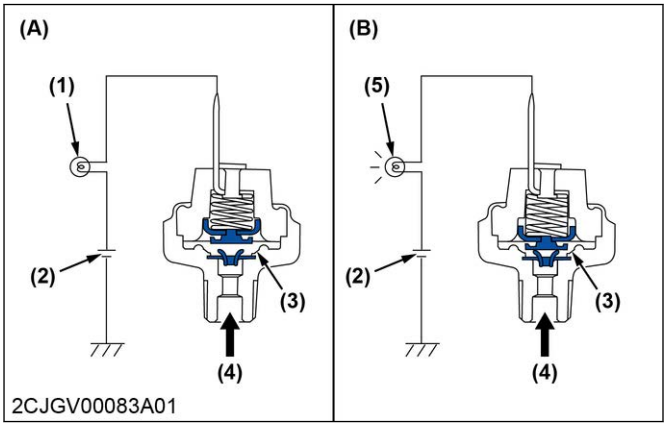
(6) Oil pressure switch
(7) Pressurization
(8) Atmospheric pressure
(9) Mounting screw part
(10) Terminal
(11) IG

## 5.10.3 Function of oil pressure switch




(1) Oil lamp (Off)
(2) Battery
(3) Diaphragm
(4) Oil pressure
(5) Oil lamp (On)
(A) Specified oil pressure
(B) Less than specified oil pressure

The oil pressure switch determines if the oil pressure is within specified range while the engine is running.

**While normal (Oil pressure is within specified range)**

- The spring and diaphragm operate based on the oil pressure opening the circuit and the oil lamp does not turn *"ON"*.

**When abnormal (Oil pressure is less than specified range)**

- The oil pressure is weaker than the spring force so circuit remains closed.
  Therefore the oil lamp turns *"ON"* to provide notification that oil pressure is abnormal.

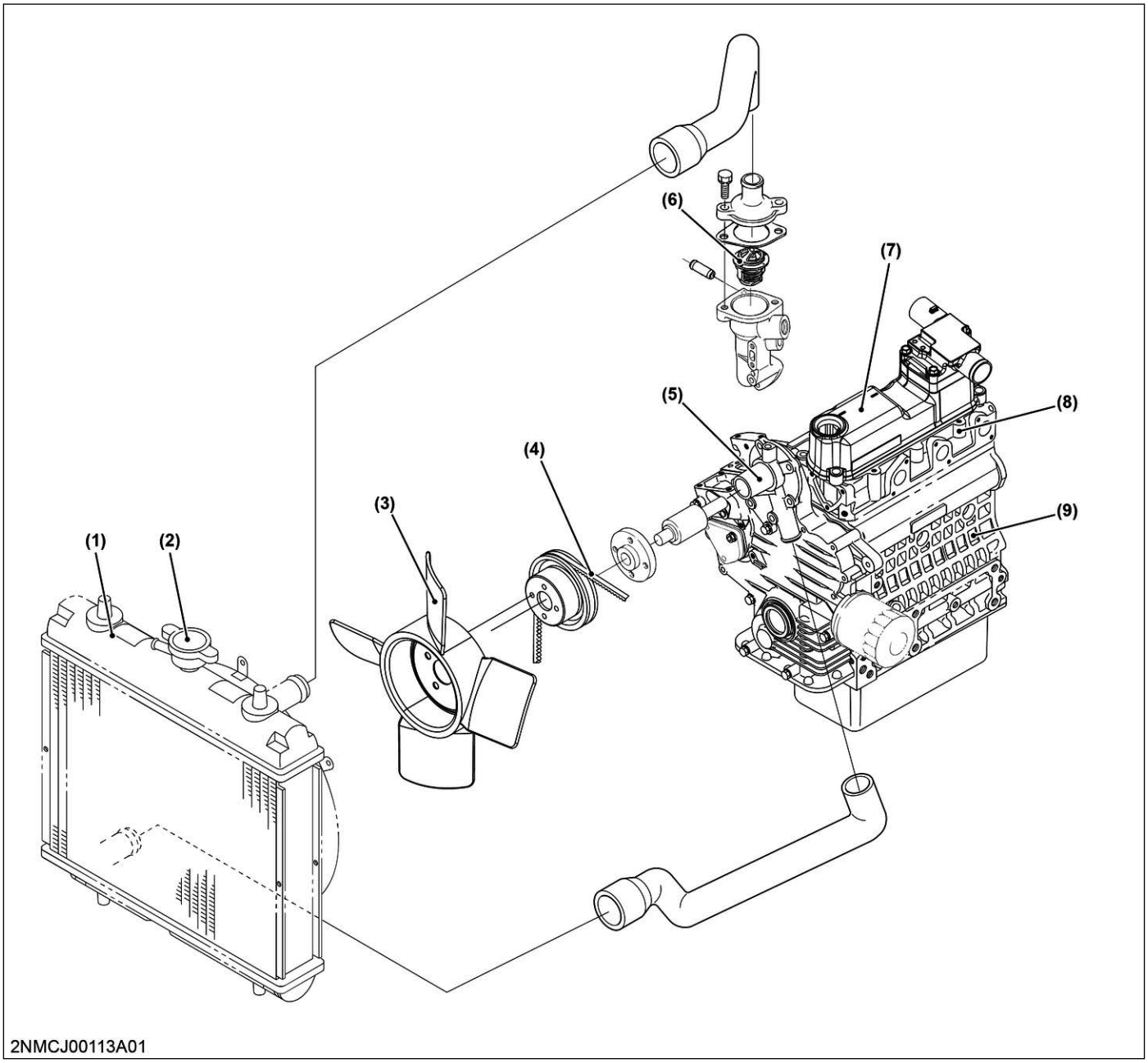
## 5.10.4 Specification of oil pressure switch

| | |
|---|---|
| Rated voltage | 12 V |
| Operating pressure | 39.2 to 58.8 kPa<br>0.400 to 0.599 kgf/cm$^2$<br>5.69 to 8.52 psi |

# 6. Cooling system

## 6.1 Structure of cooling system

The cooling system is made up of a radiator (1), a cooling fan (3), a water pump(5), and the like.



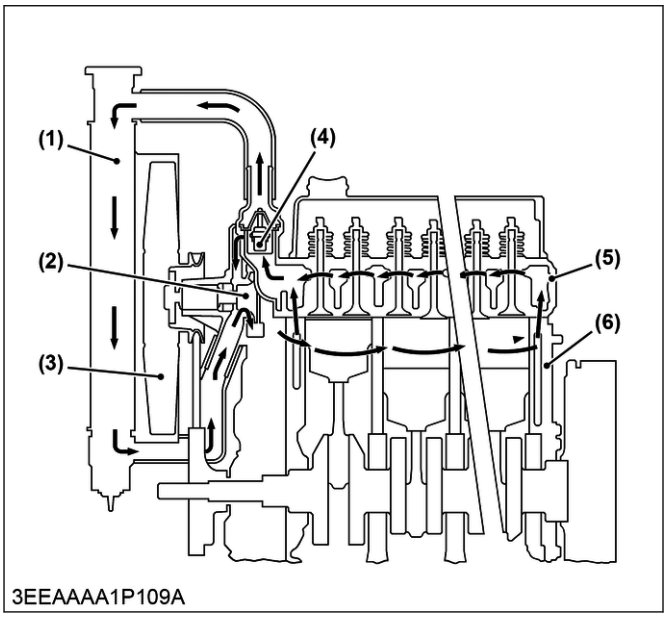

(1) Radiator
(2) Radiator cap
(3) Cooling fan
(4) Fan belt
(5) Water pump
(6) Thermostat
(7) Cylinder head cover
(8) Cylinder head
(9) Crankcase

## 6.2 Feature of cooling system

The cooling system prevents overheating while the engine is running, and maintains coolant temperature at a suitable range during operation.
Kubota engines use a forced circulation cooling system driven by a water pump.
The coolant is cooled through a radiator core, and the fan set behind the radiator pulls cooling air through the radiator core to improve cooling.

## 6.3 Flow of cooling system

When the coolant in the engine is at a low temperature, the thermostat valve is closed so that the coolant only circulates through the bypass pipe in the engine.
When the temperature of the coolant reaches the valve opening temperature of thermostat (4), the thermostat (4) opens the valve to return the heated coolant to the radiator (1).
The water pump (2) sucks the cooled coolant into the crankcase (6) and draws out the hot coolant.




(1) Radiator
(2) Water pump
(3) Cooling fan
(4) Thermostat
(5) Cylinder head
(6) Crankcase

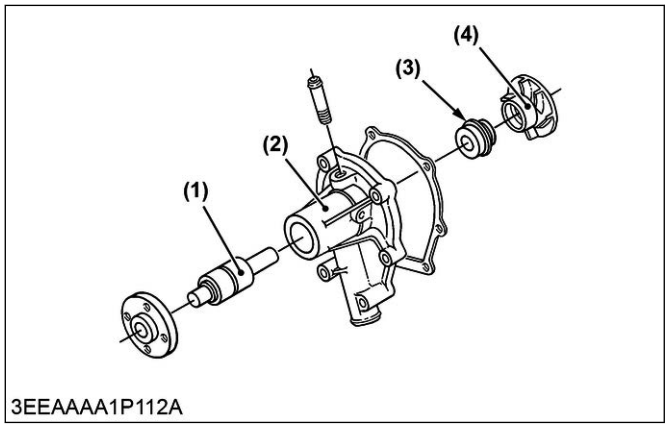
## 6.4 Water pump

### 6.4.1 Outline of water pump

The water pump force circulates coolant inside the system.

### 6.4.2 Structure of water pump

The water pump is made up of a mechanical seal and an impeller and the like.
The water pump is mounted on the same shaft as the cooling fan and fan pulley.




(1) Bearing unit
(2) Pump body
(3) Mechanical seal
(4) Impeller

### 6.4.3 Function of water pump

The water pump is driven by the fan drive pulley that is attached the crankshaft via the fan belt and fan pulley.
Coolant is suctioned into the impeller rotating at high speed, pressurized by the centrifugal force, and fed to the crankcase water jacket.
The mechanical seal provided between the bearing and pump chamber prevents leaking of the coolant.

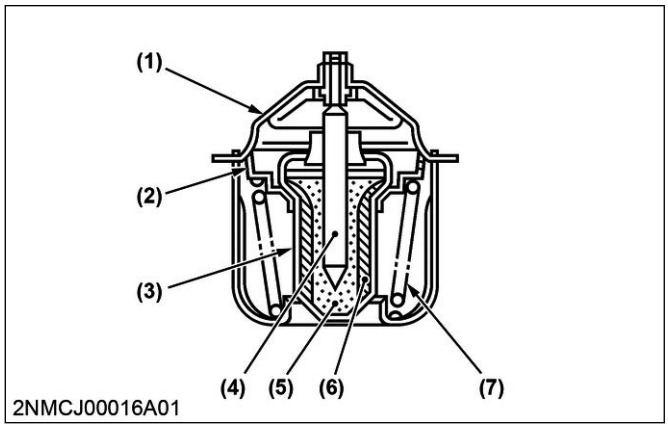
## 6.5 Thermostat

### 6.5.1 Outline of thermostat

The thermostat opens and closes the coolant path based on the engine coolant temperature.
The thermostat maintains coolant at a suitable temperature.

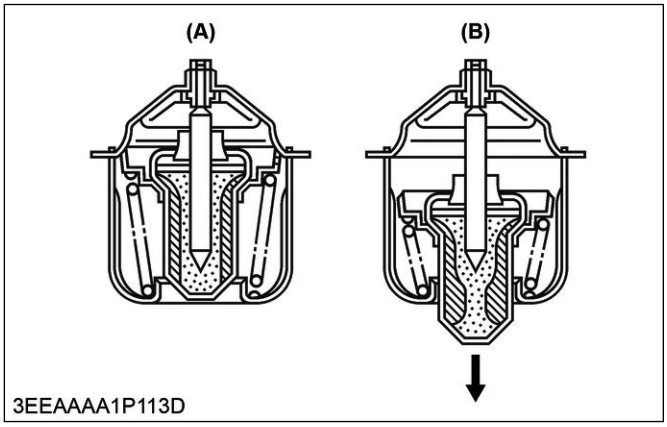
### 6.5.2 Structure of thermostat

The thermostat is made up of a wax (6), a valve (2), a spring (7) and the like.




(1) Flange
(2) Valve
(3) Wax Case
(4) Spindle
(5) Synthetic Rubber
(6) Wax
(7) Spring

### 6.5.3 Function of thermostat




(A) When coolant temperature is low (valve is closed)
(B) When coolant temperature is high (valve is open)

The thermostat opens or closes the coolant path to maintain suitable coolant temperature.

**(A) When coolant temperature is low (valve is closed)**

The wax inside the pellet is solidified, resulting in the valve of the thermostat is closed by the spring.

**(B) When coolant temperature is high (valve is open)**

The wax inside the pellet liquefies and expands, pushing down the valve and opening the thermostat.

### 6.5.4 Specification of thermostat

| | |
|---|---|
| Coolant suitable temperature | 85 to 95 ℃<br>185 to 203 ℉ |

| Code number | Valve opening temperature | Valve full-open temperature |
|---|---|---|
| 19434-730 10 | 69.5 to 72.5 ℃<br>157.1 to 162.5 ℉ | 85 ℃<br>185 ℉ |

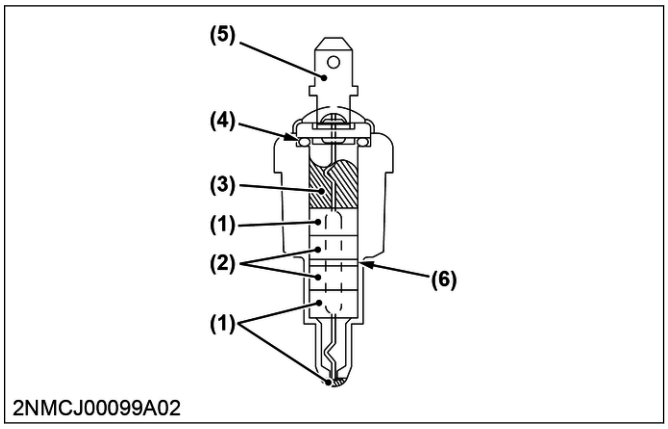
## 6.6 Coolant temperature switch

### 6.6.1 Outline of coolant temperature switch

The coolant temperature switch detects the coolant temperature inside the engine.

### 6.6.2 Structure of coolant temperature switch

The coolant temperature switch is made up of a thermo sensitive ferrite (2), a terminal (5) and the like.




(1) Permanent magnet
(2) Thermo sensitive ferrite
(3) Resin
(4) O-ring
(5) Terminal
(6) Magnetic gap spacer

### 6.6.3 Function of coolant temperature switch

The coolant temperature switch detects the temperature of the coolant inside the engine.
When the coolant temperature goes up higher than the specified value, the read switch of the coolant temperature switch connects and the warning lamp turns on.
When the coolant temperature falls below the specified value, the read switch of the coolant temperature switch disconnects and the warning lamp turns off.

### 6.6.4 Specification of coolant temperature switch

**Characteristics of Coolant Temperature Switch**

**■ NOTE**

- **The type of the temperature switch and operation temperature depend on the OEM.**
- **Below table shows a standard model.**

| Code Number | Type | Operation Temperature | |
|---|---|---|---|
| | | Lamp *"ON"* | Lamp *"OFF"* |
| 15543-83040 | Normally open | 115 ℃<br>(235 ℉) | 108 ℃<br>(226 ℉) |

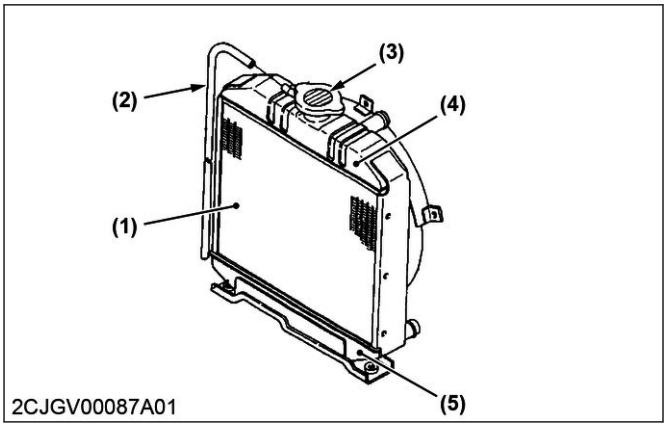
# 6.7 Radiator

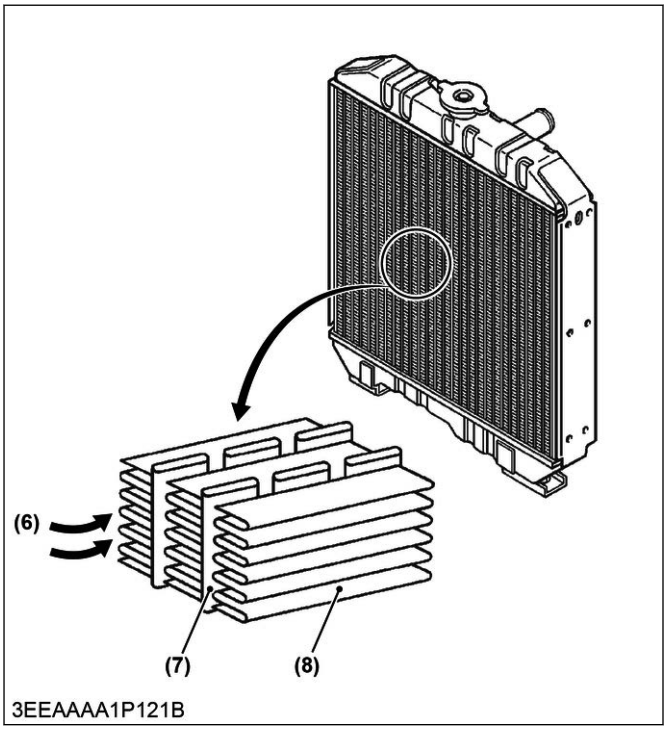
## 6.7.1 Outline of radiator

The radiator cools coolant whose temperature has been raised.
Returning of cooled coolant to the engine maintains cooling performance of the engine.

## 6.7.2 Structure of radiator

The radiator is made up of an upper tank (4), lower tank (5), core (1) and the like.




(1) Core
(2) Overflow pipe
(3) Radiator cap
(4) Upper tank
(5) Lower tank
(6) Cooling air
(7) Tube
(8) Fin

## 6.7.3 Function of radiator

The radiator has the role of cooling coolant whose temperature has been raised by heat from the engine.
When passing through the radiator core passage, coolant is cooled by heat dissipation from the core to air.

## 6.7.4 Specification of radiator

**(Reference values)**

| | |
|---|---|
| Radiator capacity | 2.0 L<br>0.53 U.S.gals<br>0.44 Imp.gals |
| Test pressure | 177 kPa<br>1.80 kgf/cm$^2$<br>25.7 psi |

*These values might be different depending on the products used.

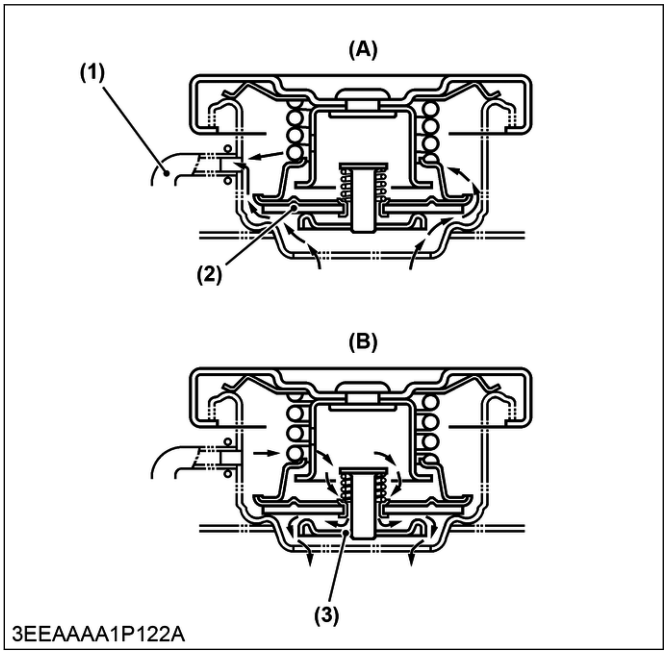
# 6.8 Radiator cap

## 6.8.1 Outline of radiator cap

The radiator cap maintains the pressure in the cooling system at the specified pressure.

## 6.8.2 Structure of radiator cap

The radiator cap is made up of a pressure valve (2), vacuum valve (3) and the like.




(1) Overflow tube
(2) Pressure valve
(3) Vacuum valve
(A) When radiator internal pressure is high
(B) When radiator internal pressure is below atmospheric pressure

### 6.8.3 Function of radiator cap

**(1) When at specified pressure inside radiator**
The pressure valve and vacuum valve are fully seated on their respective seats and maintain air-tightness.
Thus coolant is pressurized based on thermal expansion of coolant water vapor raising the boiling point temperature, preventing generation of bubbles, and exhibiting full cooling effect.

**(2) When the pressure in the radiator exceeds specified pressure the pressure valve opens and releases water vapor to the reserve tank maintaining a constant pressure inside the radiator**
The pressure valve opens and releases water vapor to the reserve tank maintaining a constant pressure inside the radiator.

**(3) When pressure inside radiator is below atmospheric pressure**
When the pressure in the radiator is below atmospheric pressure, the vacuum valve opens suctioning coolant from the reserve tank and preventing deformation of the radiator.

### 6.8.4 Specification of radiator cap

**(Reference values)**

| | |
|---|---|
| Pressure valve open pressure | 88 kPa<br>0.90 kgf/cm$^2$<br>13 psi |

*These values may be different depending on the product used

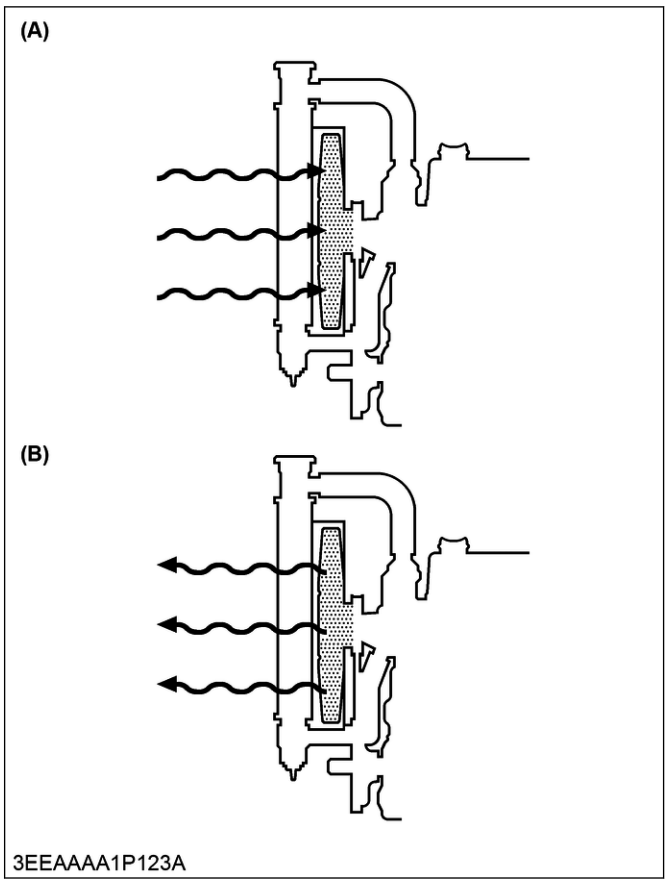
## 6.9 Cooling fan

### 6.9.1 Outline of cooling fan

The cooling fan draws in outdoor air or allows air to pass causing air to pass through the radiator.

### 6.9.2 Structure of cooling fan

Cooling fans are classified as suction type (A) or blower type (B) depending on the direction the blades face.




(A) Suction type (B) Blower type

### 6.9.3 Function of cooling fan

The cooling fan is rotated via the fan belt and fan pulley.
The cooling fan causes outdoor air to pass through the radiator core for cooling.
Cooling performance changes depending on the number of blades, angle of the blades, outer diameter, and rotation speed.

### 6.9.4 Specification of cooling fan

**(Reference values)**

| | |
|---|---|
| Number of blades | 4 |
| Outer diameter | 300 mm<br>11.8 in. |

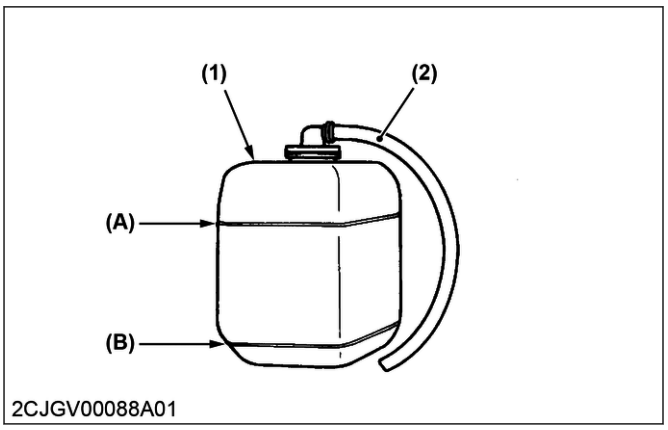
# 6.10 Reserve tank

## 6.10.1 Outline of reserve tank

The reserve tank stores coolant discharged from the radiator cap.

## 6.10.2 Structure of reserve tank

The reserve tank is made up of an overflow pipe (2) and the tank body.




(1) Reserve tank
(2) Overflow pipe
(A) Upper limit line
(B) Lower limit line

## 6.10.3 Function of reserve tank

**When radiator internal pressure is above specified pressure**
Coolant expanded by high temperature is discharged to and stored in the reserve tank.

**When radiator internal pressure is below atmospheric pressure**
When the engine cools, the coolant in the reserve tank returns to the radiator based on lower than atmospheric pressure.

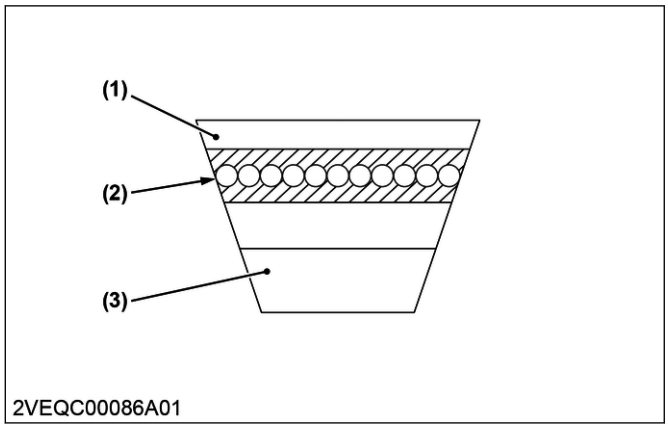
# 6.11 Fan belt

## 6.11.1 Outline of fan belt

The fan belt drives the cooling fan and alternator.

## 6.11.2 Structure of fan belt

The fan belt is made up of rubber and synthetic fibers.




(1) Top fabric
(2) Cord
(3) Rib rubber

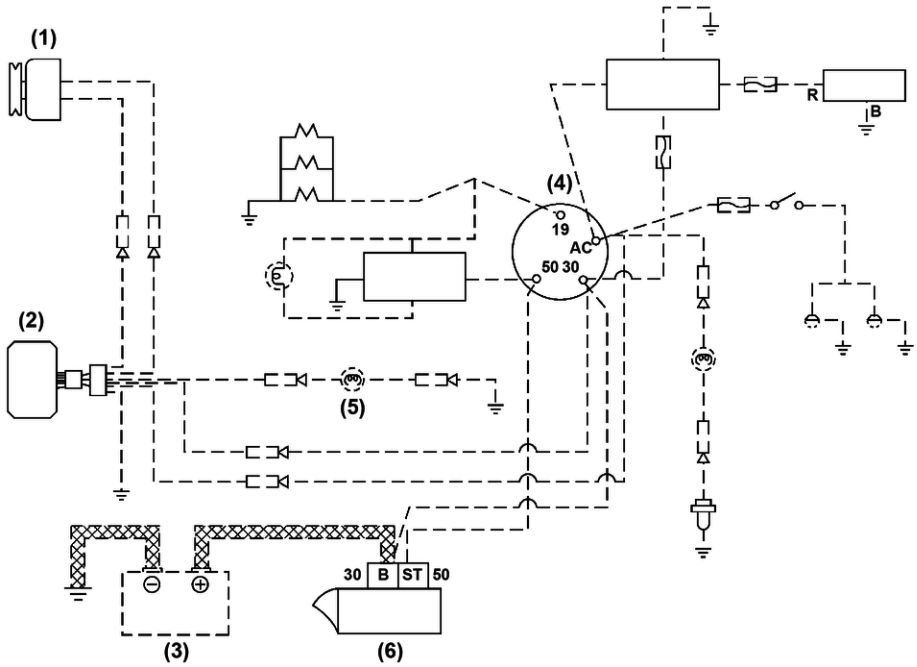
## 6.11.3 Function of fan belt

The fan belt transfers rotation of the fan drive pulley to the cooling fan.
The fan belt also drives the alternator and the water pump.

# 7. Electrical system

## 7.1 Structure of electrical system

The electrical system is separated into the starting system and charging system.

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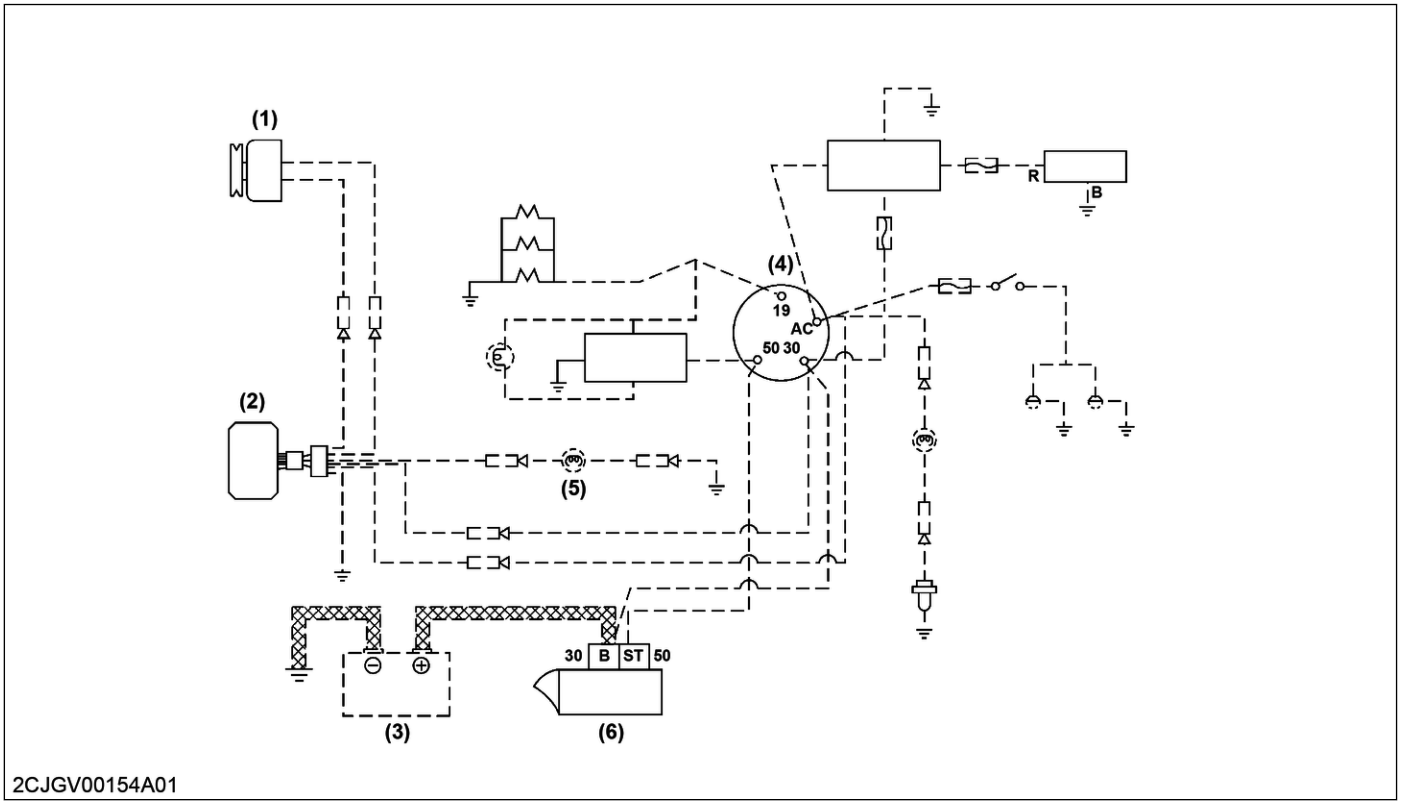
(1) Alternator
(2) Regulator
(3) Battery
(4) Key switch
(5) Charge lamp
(6) Starter

## 7.2 Feature of electrical system

The electrical system shown in this section represents the engine's starting circuit and charging circuit.
The starting circuit starts up the starter by means of the key switch, and starts the engine by turning the flywheel.
The charging circuit generates electricity in the alternator using the power when the engine is running, and this is used to charge the battery.

# 7.3 Flow of electrical system

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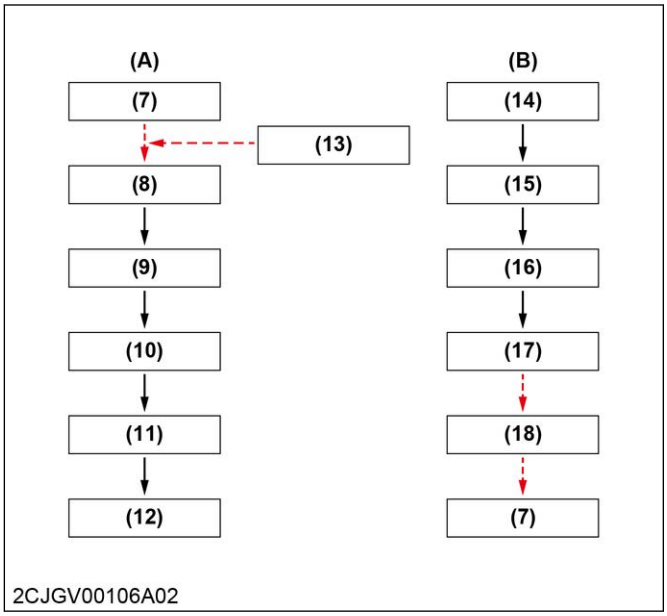



2CJGV00106A02

(1) Alternator
(2) Regulator
(3) Battery
(4) Key switch
(5) Charge lamp
(6) Starter
(7) Battery
(8) Starter
(9) Pinion gear
(10) Ring gear (flywheel)
(11) Crankshaft
(12) Start engine
(13) Key switch on the start position
(14) Crankshaft
(15) Fan drive pulley
(16) Fan belt
(17) Alternator pulley
(18) Alternator
(A) Start flow
(B) Charge flow

**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 that engages 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.

**Charge flow**

1. Power from the crankshaft turns the fan drive pulley.
2. Power is transferred to the alternator via the fan belt.
3. Rotation of the alternator pulley causes the alternator to rotate generating power.
4. The generated electricity is supplied to and charges the battery via the B terminal of the alternator.

# 7.4 Control of electrical system

**Control after start of engine**

1. After the engine starts and the key is released, the key switch returns to the ON position.
2. Here, the pinion gear returns to its original position releasing mesh with the ring gear (flywheel).

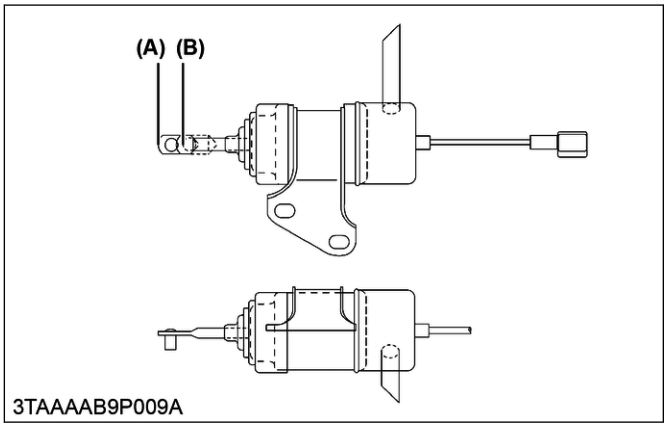
# 7.5 Stop solenoid

## 7.5.1 Outline of engine stop solenoid

Flowing of the battery current into the coil while the controller's timer works attracts the plunger to actuate the stop lever or control rack of the injection pump.
When the battery current stops, the plunger is returned to the original position by the spring.

## 7.5.2 Feature of engine stop solenoid

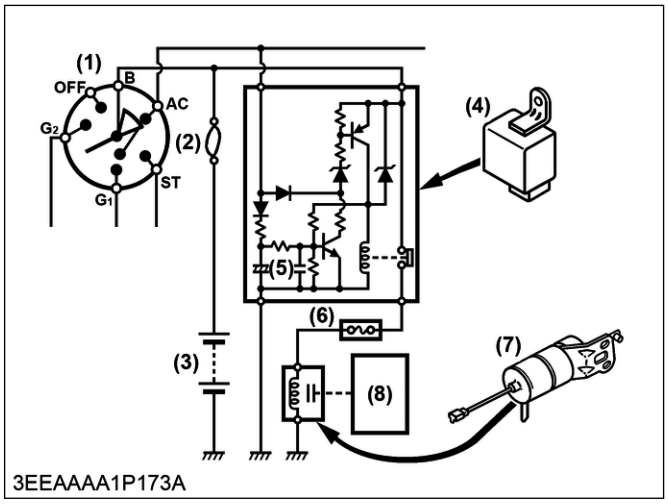
Controller is provided to actuate the engine stop solenoid approx. 10 seconds to stop after the main switch is turned from *"ON"* position to *"OFF"* position.




(A) ON (B) OFF

## 7.5.3 Structure of engine stop solenoid (Energized to stop type)

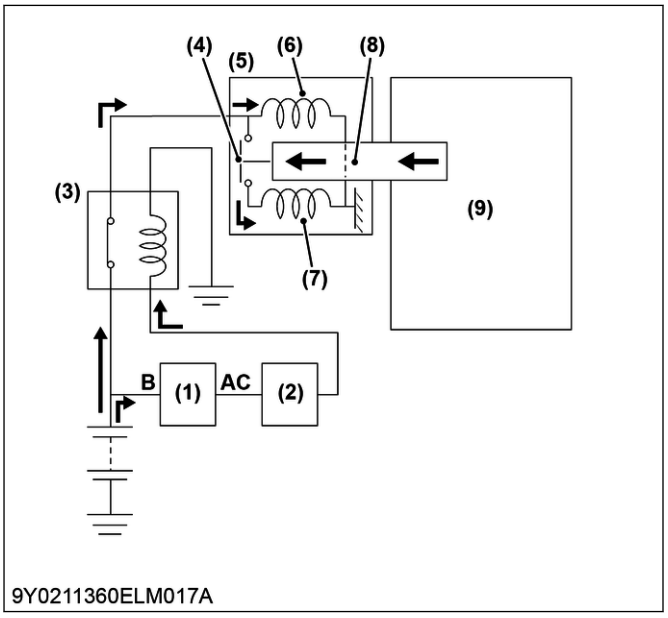
The timer relay capacitor (5) stores a certain quantity of electricity while the engine is running.
Just when the main switch (1) has turned off to stop the engine, this timer relay capacitor (5) starts discharging the current for about 10 seconds.
During this discharging period only, the current flows in this route from battery (3), main switch (1), timer relay (4), stop solenoid (7) to grounding circuit.
10 seconds later, the timer circuit is shut off to keep the battery (3) against an over discharge.




(1) Main switch
(2) Fusible link
(3) Battery
(4) Timer relay
(5) Timer relay capacitor
(6) Fuse
(7) Stop solenoid
(8) Injection pump

## 7.5.4 Structure of engine stop solenoid (Energized to operate type)

When the main switch (1) is set to the *"START"* position, the current starts flowing from the main switch (1) AC terminal to the engine stop solenoid relay (3) via the OPC timer (2). Then the current starts flowing from the engine stop solenoid relay (3) to the engine stop solenoid (5).
At this point, the current flows both the hold coil (6) and the pull-in coil (7) because the switch (4) is closed. Then the plunger (8) is drawn in because of the exciting coils, and the injection pump (9) becomes running condition.
During the engine running, the plunger is pushing the switch (4) and the current to the pull-in coil (7) is cut. Although only the hold coil (6) is exciting, it is enough to hold the plunger (8) so that the engine can keep running.
When the main switch (1) is set to the *"OFF"* position, the current flowing into the engine stop solenoid (5) is shut off. At this point, the plunger pops out by its spring force and the injection pump (9) becomes stopping condition. Then the engine stops.




(1) Main switch
(2) OPC timer
(3) Engine stop solenoid relay
(4) Switch
(5) Engine stop solenoid
(6) Hold coil
(7) Pull-in coil
(8) Plunger
(9) Injection pump

### 7.5.5 Specification of engine stop solenoid

**■ NOTE**

- **When measure the voltage, turn the main switch *"ON"*, and when you turn it *"OFF"* again, there is a voltage of approx. 12 V for 10 sec, then the voltage drops to 0 V.**

| Item | Terminal | Value |
|---|---|---|
| Battery line | Terminal (red/black) - Chassis | Approx. 12 V |

## 7.6 Battery

### 7.6.1 Outline of battery

The battery can extract direct current electrical power. Further, it can store electrical power provided externally.

### 7.6.2 Structure of battery

The battery is made up of a main body, battery fluid, positive electrode, and negative electrode and the like.


(1) Positive terminal
(2) Negative terminal
(3) Indicator

### 7.6.3 Function of battery

The battery supplies electrical power to the starter when starting the engine.
The battery is charged by the alternator during operation and stores electrical power.
During operation the battery is used as a power supply along with the alternator.

### 7.6.4 Specification of battery

**■ NOTE**

- **Battery capacities can be different depending on the OEM specifications of the batteries installed, so see the OEM specification for details.**

| | | |
|---|---|---|
| Battery capacity | Z482-E4<br>Z482-E4BG | 12 V, 28 AH |
| | Z602-E4<br>D722-E4<br>D782-E4 | 12 V, 36 AH |
| | D902-E4 | 12 V, 52 AH |
| | D902-TE4 | 12 V, 55 AH |

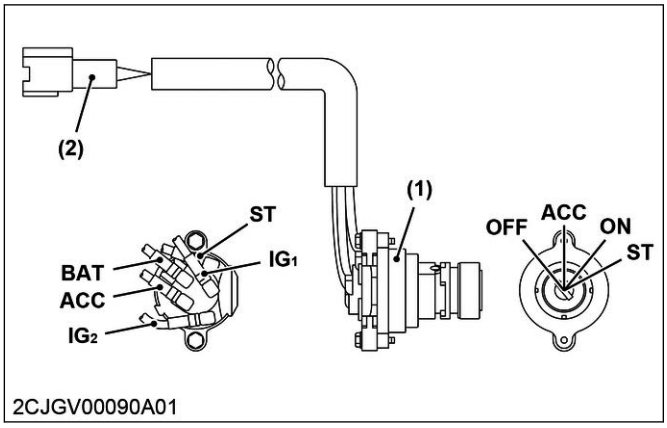
# 7.7 Key switch

## 7.7.1 Outline of key switch

The key switch turns ON/OFF the main power supply to the vehicle and starts/stops the engine.

## 7.7.2 Structure of key switch

The key switch is made up of a key cylinder (1), harness (2) and key (3).



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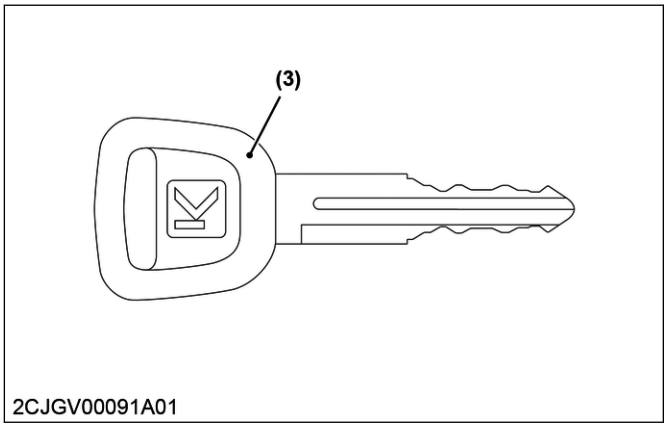

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(1) Key cylinder
(2) Harness
(3) Key

## 7.7.3 Function of key switch

| Key switch position | Operation |
|---|---|
| OFF | • Power supply is turned OFF and engine is stopped<br>• Key can be inserted and removed |
| ON | • All electrical equipment can be used<br>• Engine operating position<br>• Pre-heats combustion chamber (depending on vehicle type) |
| Start (ST) | • Starters rotates and starts the engine<br>• When the hand is removed it automatically returns to the ON position |
| ACC | • Accessories can be used while engine is stopped |
| Preheat (glow) | • Pre-heats engine combustion chamber (depending on vehicle type) |

## 7.7.4 Specification of key switch

Specification is different depending on the OEM installed so reference the installed OEM specification for details.
A standard contact connections table for Kubota is given below.

**Contact connections table**

| Position | Terminal | | | | |
|---|---|---|---|---|---|
| | ACC | BAT | IG1 | IG2 | ST |
| OFF | | | | | |
| ACC | ● | ● | | | |
| ON | ● | ● | ● | ● | |
| START | | ● | ● | | ● |

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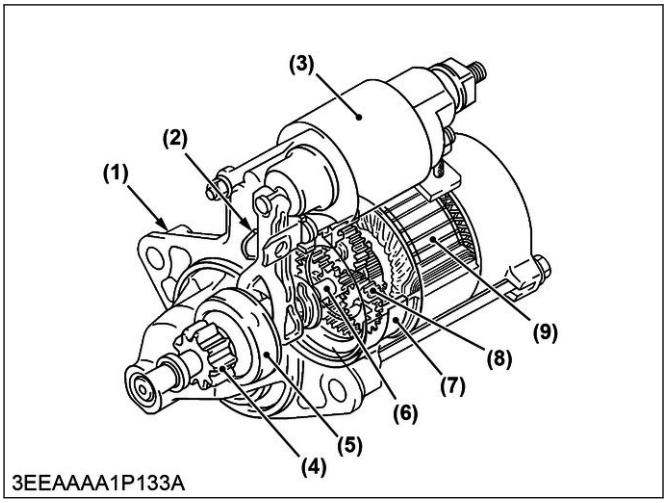
# 7.8 Starter (Planetary gear reduction type)

## 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
(2) Drive lever
(3) Magnetic switch
(4) Pinion gear
(5) Overrunning clutch
(6) Armature shaft
(7) Outer gear
(8) Planetary gear
(9) Armature

## 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 |

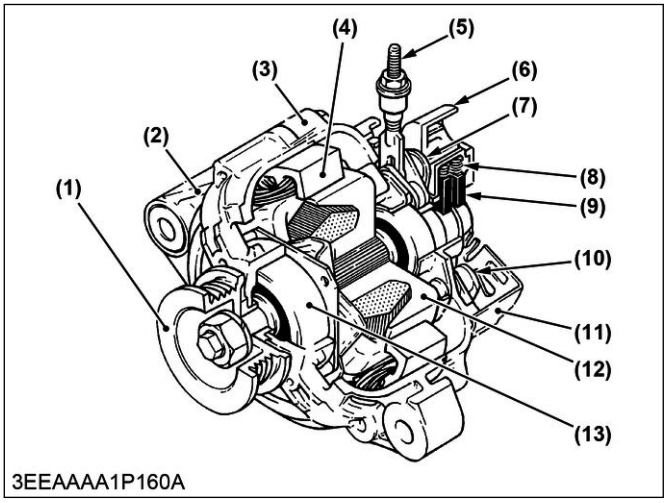
# 7.9 Alternator

## 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.

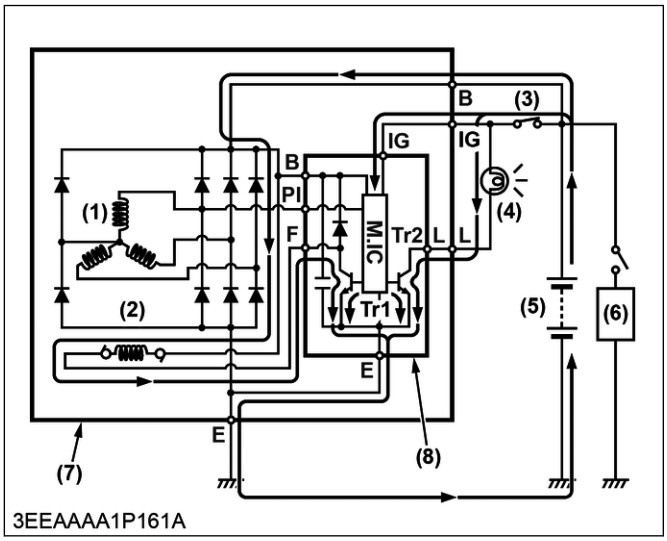



(1) Pulley
(2) Drive end frame
(3) Rear end frame
(4) Stator
(5) Terminal
(6) Connector
(7) IC regulator
(8) Spring
(9) Brush
(10) Rectifier
(11) Rear end cover
(12) Rotor
(13) Bearing

## 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.

### Operation of charging system

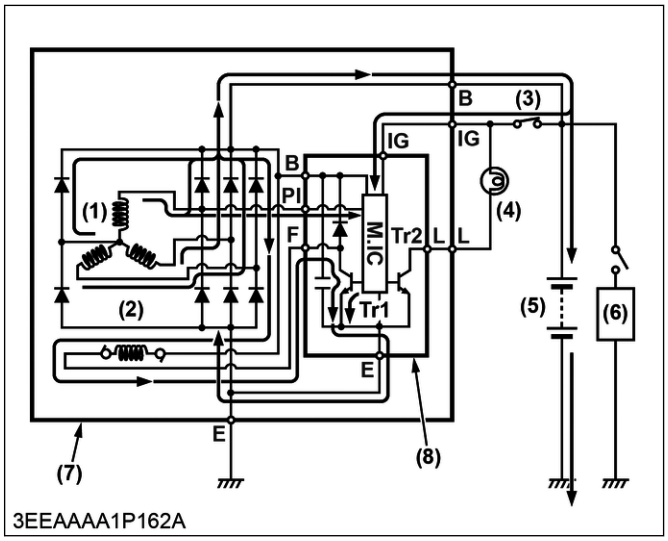


3EEAAAA1P161A

(1) Stator coil
(2) Rotor coil
(3) Main switch (IG)
(4) Charge lamp
(5) Battery
(6) Load
(7) Alternator
(8) IC regulator
M.I C Monolithic IC
Tr1 Transistor
Tr2 Transistor

**When Main Switch Is Turned to *"ON"* Position**

As the battery voltage is added to the terminal IG, M.IC circuit detects it and makes current pour to the Tr1.
It results to pour the initial exciting current to the rotor coil (2).
(In this case, M.IC circuit makes current pour on and off the Tr1 in pulse and limits the battery discharging current to small value (Approx. 0.17 A) when the main switch (IG) (3) is turned on.)
As the alternator (7) is not rotated, it doesn't generate. Therefore the voltage of terminal PI is zero volt.
M.IC circuit detects it and makes current pour to the Tr2.
It results light on the charge lamp (4).



3EEAAAA1P162A

(1) Stator coil
(2) Rotor coil
(3) Main switch (IG)
(4) Charge lamp
(5) Battery
(6) Load
(7) Alternator
(8) IC regulator
M.I C Monolithic IC
Tr1 Transistor
Tr2 Transistor

**When Engine Starts**

When the engine starts and the alternator (7) rotates, M.IC circuit makes current pour continuously to the Tr1 instead of the uncontinuous (in pulse) current.
Therefore a sufficient exciting current flows and a generated voltage rises rapidly.
As a result, the current to the Tr2 is shut and lights off the charge lamp (4).
When terminal B voltage rises over the battery voltage, a charged current flows to the battery (5).
When the terminal B voltage further rises over the regulated voltage (14.2 to 14.8 V: 25 ℃, 77 ℉), M.IC circuit shuts the current to the Tr1.
Therefore the current to the rotor coil (2) is shut, resulting to decrease the terminal B voltage.
When the terminal B voltage lowers below the regulated voltage, the Tr1 turns on again and makes current pour to the rotor coil (2).

## 7.9.4 Specification of alternator

| | |
|---|---|
| Capacity (Z482-E4/Z482-E4BG/D722-E4/D782-E4) | 150 W |
| Capacity (Z602-E4/D902-E4/D902-TE4) | 480 W |
| Battery voltage | 12 V |

# SERVICING

## 1. Troubleshooting

### 1.1 Troubleshooting for engine

This "Troubleshooting" shows mechanical failures.

| Symptom | Probable cause and checking procedure | Solution | Reference page |
|---|---|---|---|
| The engine does not start | 1. No fuel | Fill up the fuel | — |
| | 2. Air in the fuel system | Bleed the air | — |
| | 3. Water in the fuel system | Change the fuel and repair or replace the fuel system | 3-9<br>3-14 |
| | 4. The injection pump is damaged | Replace | 4-92<br>4-123 |
| | 5. The fuel hose is clogged | Clean or replace | 3-9 |
| | 6. The fuel filter is clogged | Clean or replace | 3-13<br>3-17 |
| | 7. The viscosity of fuel at low temperature is too high | Replace the specified fuel | 3-1 |
| | 8. The cetane number of fuel is low | Replace the specified fuel | 3-1 |
| | 9. Fuel leakage because of loose injection pipe retaining nut | Tighten the retaining nut | 4-131 |
| | 10. The injection timing is incorrect | Adjust | 3-23 |
| | 11. The fuel camshaft is worn out | Replace | 4-98<br>4-117 |
| | 12. The injection nozzle is clogged | Clean or replace | 4-89<br>4-130<br>4-88<br>4-131 |
| | 13. Seizure of the crankshaft, camshaft, piston or bearing | Repair or replace | 4-98<br>4-118<br>4-99<br>4-116<br>4-102<br>4-111 |
| | 14. Compression leakage from the cylinder | Replace the head gasket<br>Tighten the cylinder head screw | 4-91<br>4-127 |
| | 15. Incorrect valve timing | Check the timing gear | 4-118 |

(Continued)

| Symptom | Probable cause and checking procedure | Solution | Reference page |
|---|---|---|---|
| The engine does not start | 16. The piston ring and cylinder are worn out | Replace | 4-115<br>4-153 |
| | 17. Incorrect valve clearance | Adjust valve clearance | 4-72 |
| | 18. Stop solenoid is damaged | Replace | 4-81<br>4-88<br>4-124 |
| The starter does not operate | 1. Discharged battery | Charge or replace | 4-76 |
| | 2. Starter is damaged | Repair or replace | 4-78 |
| | 3. The key switch is damaged | Replace | — |
| | 4. The connection of the wires is incorrect | Check or correct | — |
| The engine revolution is not smooth | 1. The fuel filter is clogged | Clean or replace | 3-13<br>3-17 |
| | 2. The air cleaner is clogged | Clean or replace the air cleaner element | 3-13<br>3-26 |
| | 3. Fuel leakage because of loose injection pipe retaining nut | Tighten the retaining nut | 4-131 |
| | 4. The injection pump is damaged | Replace | 4-92<br>4-123 |
| | 5. The nozzle injection pressure is incorrect | Adjust | 4-84 |
| | 6. The injection nozzle is stuck or clogged | Replace | 4-88<br>4-131 |
| | 7. The turbocharger bearing is worn out | Replace the turbocharger assembly | 4-85<br>4-85<br>4-88<br>4-131 |
| | 8. The turbocharger shaft is bent | Replace the turbocharger assembly | 4-85<br>4-85<br>4-88<br>4-131 |
| | 9. The turbocharger fin or other part has a damage because of unwanted materials | Replace the turbocharger assembly | 4-85<br>4-85<br>4-88<br>4-131 |
| | 10. The governor is damaged | Replace | 4-98<br>4-117 |
| The exhaust gas is white or blue | 1. Too much engine oil | Reduce it to the specified level | 3-5 |
| | 2. The piston ring, piston and cylinder is worn out | Replace the piston ring or piston, or repair the cylinder | 4-147<br>4-148<br>4-153 |

(Continued)

| Symptom | Probable cause and checking procedure | Solution | Reference page |
|---|---|---|---|
| The exhaust gas is white or blue | 3. The injection timing is incorrect | Adjust | 3-23 |
| There is oil leakage into the exhaust pipe or suction pipe | 1. The oil pipe is clogged or has a damage | Replace the exhaust pipe or suction pipe | 4-88<br>4-131 |
| | 2. The piston ring seal of the turbocharger is damaged | Replace the turbocharger assembly | 4-85<br>4-85<br>4-88<br>4-131 |
| The exhaust gas is black or dark gray | 1. The air cleaner is clogged | Clean or replace the element | 3-13<br>3-26 |
| | 2. The grade of the fuel is low | Replace the specified fuel | 3-1 |
| | 3. The fuel filter is clogged | Clean or replace | 3-13<br>3-17 |
| | 4. The injection nozzle is damaged | Replace | 4-88<br>4-131 |
| | 5. Overload | Reduce the load | — |
| The output is deficient | 1. The injection timing is incorrect | Adjust | 3-23 |
| | 2. The moving parts of engine have a seizure | Replace | — |
| | 3. The injection pump is damaged | Replace | 4-92<br>4-123 |
| | 4. The injection nozzle is damaged | Replace | 4-88<br>4-131 |
| | 5. There is compression leakage | Check the compression pressure and repair | 4-71 |
| | 6. There is a gas leakage from the exhaust system | Repair or replace | 4-85<br>4-85<br>4-88<br>4-131 |
| | 7. The air cleaner is clogged | Clean or replace the element | 3-13<br>3-26 |
| | 8. There is an air leakage from the compressor discharge side | Replace the turbocharger assembly | 4-85<br>4-88<br>4-131 |
| The lubricant oil consumption is too much | 1. The gap of the piston ring points to the same direction | Move the ring gap direction | 4-116 |
| | 2. The oil ring is worn out or cannot move | Replace the oil ring or piston assembly | 4-147<br>4-148<br>4-116 |

(Continued)

| Symptom | Probable cause and checking procedure | Solution | Reference page |
|---|---|---|---|
| The lubricant oil consumption is too much | 3. The piston ring groove is worn out | Replace the piston and piston ring | 4-147<br>4-148<br>4-116 |
| | 4. The valve stem and valve guide are worn out | Replace | 4-137<br>4-138 |
| | 5. The crankshaft bearing and the crankpin bearing is worn out | Replace | 4-149 |
| The fuel is mixed into the lubricant oil | 1. The injection nozzle is damaged | Replace | 4-88<br>4-131 |
| | 2. The plunger of injection pump is worn out | Replace | 3-24<br>4-92<br>4-123 |
| | 3. The injection pump is broken | Replace | 4-92<br>4-123 |
| Water is mixed into the lubricant oil | 1. The head gasket is damaged | Replace | 4-91<br>4-127 |
| | 2. The crankcase or cylinder head is damaged | Replace | 4-91<br>4-127 |
| The oil pressure is low | 1. The engine oil is not sufficient | Fill oil to the specified amount | 3-1<br>3-8 |
| | 2. The oil strainer is clogged | Clean | 4-120— |
| | 3. The relief valve does not operate with dirt | Repair or replace | 4-121 |
| | 4. The oil clearance of the bearings are too much | Replace the metal, bushing or shaft | 4-149<br>4-150<br>4-152 |
| | 5. The oil passage is clogged | Clean | — |
| | 6. The type of oil used is incorrect | Use the specified type of oil | 3-1 |
| | 7. The oil pump is damaged | Replace | 4-154<br>4-154<br>4-155 |
| The oil pressure is high | 1. The type of oil used is incorrect | Use the specified type of oil | 3-1 |
| | 2. The relief valve is damaged | Repair or replace | 4-121 |
| The engine is overheated | 1. The engine oil is not sufficient | Fill oil to the specified amount | 3-1<br>3-8 |
| | 2. The fan belt is broken or the fan belt tension is too loose | Replace or adjust | 3-14<br>3-20 |
| | 3. The coolant is not sufficient | Fill to the specified amount | 3-27 |

(Continued)

| Symptom | Probable cause and checking procedure | Solution | Reference page |
|---|---|---|---|
| The engine is overheated | 4. The radiator net and the radiator fin are clogged with dust | Clean | — |
| | 5. There is corrosion in the inner side of the radiator | Clean or replace | 3-18 |
| | 6. There is clogged in the coolant flow route | Clean or replace | 3-18 |
| | 7. The radiator or radiator cap is damaged | Replace | 4-75 |
| | 8. The load is too much | Reduce the load | — |
| | 9. The head gasket is damaged | Replace | 4-91<br>4-127 |
| | 10. The injection timing is incorrect | Adjust | 3-23 |
| | 11. The fuel used is incorrect | Replace the specified fuel | 3-1 |

# 2. Service specifications

## 2.1 Service specifications for engine

### Engine body

| Item | | Service specification | Service limit |
|---|---|---|---|
| Cylinder head surface | Flatness | — | 0.05 mm<br>0.002 in. |
| Top clearance | Z482-E4<br>Z482-E4BG<br>D722-E4<br>D782-E4<br>Z602-E4<br>D902-E4 | 0.50 to 0.70 mm<br>0.020 to 0.027 in. | — |
| | D902-TE4 | 0.980 to 1.18 mm<br>0.0386 to 0.0465 in. | — |
| Compression pressure | Z482-E4<br>Z482-E4BG<br>D722-E4<br>D782-E4 | Reference value<br>2.85 to 3.23 MPa/200 $min^{-1}$ (rpm)<br>29.1 to 32.9 $kgf/cm^2$/200 $min^{-1}$ (rpm)<br>414 to 468 psi/200 $min^{-1}$ (rpm) | 2.26 MPa/200 $min^{-1}$ (rpm)<br>23.0 $kgf/cm^2$/200 $min^{-1}$ (rpm)<br>328 psi/200 $min^{-1}$ (rpm) |
| | Z602-E4<br>D902-E4 | Reference value<br>3.53 to 4.02 MPa/200 $min^{-1}$ (rpm)<br>36.0 to 40.9 $kgf/cm^2$/200 $min^{-1}$ (rpm)<br>512 to 583 psi/200 $min^{-1}$ (rpm) | 2.55 MPa/200 $min^{-1}$ (rpm)<br>26.0 $kgf/cm^2$/200 $min^{-1}$ (rpm)<br>370 psi/200 $min^{-1}$ (rpm) |
| | D902-TE4 | Reference value<br>2.85 to 3.23 MPa/200 $min^{-1}$ (rpm)<br>29.1 to 32.9 $kgf/cm^2$/200 $min^{-1}$ (rpm)<br>414 to 468 psi/200 $min^{-1}$ (rpm) | 2.26 MPa/200 $min^{-1}$ (rpm)<br>23.0 $kgf/cm^2$/200 $min^{-1}$ (rpm)<br>328 psi/200 $min^{-1}$ (rpm) |
| Variance among cylinders | | — | 10 % or less |
| Valve seat | Angle | 0.79 rad<br>45° | — |
| | Width | 2.12 mm<br>0.0835 in. | — |
| Valve face | Angle | 0.79 rad<br>45° | — |
| Valve recessing | | -0.10 to 0.10 mm<br>-0.0039 to 0.0039 in. | 0.30 mm<br>0.012 in. |
| Valve stem to valve guide | Clearance | 0.030 to 0.057 mm<br>0.0012 to 0.0022 in. | 0.10 mm<br>0.0039 in. |
| • Valve stem | O.D. | 5.968 to 5.980 mm<br>0.2350 to 0.2354 in. | — |
| • Valve guide | I.D. | 6.010 to 6.025 mm<br>0.2367 to 0.2372 in. | — |
| Valve clearance (Cold) | | 0.145 to 0.185 mm<br>0.00571 to 0.00728 in. | — |
| Intake valve timing (Z482-E4BG/ Z482/D722/D782-E4/D902-TE4) | Open | 0.445 rad (25.5°) before T.D.C. | — |
| | Close | 0.881 rad (50.5°) after B.D.C. | — |
| Intake valve timing (Z602/D902-E4) | Open | 0.35 rad (20°) before T.D.C. | — |
| | Close | 0.79 rad (45°) after B.D.C. | — |

(Continued)

| Item | | Service specification | Service limit |
|---|---|---|---|
| Exhaust valve timing (Z482-E4BG/Z482/D722/D782-E4/D902-TE4) | Open | 0.969 rad (55.5°) before B.D.C. | — |
| | Close | 0.358 rad (20.5°) after T.D.C. | — |
| Exhaust valve timing (Z602/D902-E4) | Open | 0.87 rad (50°) before B.D.C. | — |
| | Close | 0.26 rad (15°) after T.D.C. | — |
| Valve spring | Free length | 31.3 to 31.8 mm<br>1.24 to 1.25 in. | 28.4 mm<br>1.12 in. |
| | Tilt | — | 1.2 mm<br>0.047 in. |
| | Setting load/Setting length | 65 N/27.0 mm<br>6.6 kgf/27.0 mm<br>15 lbf/1.06 in. | 55 N/27.0 mm<br>5.6 kgf/27.0 mm<br>12 lbf/1.06 in. |
| Rocker arm to rocker arm shaft | Oil clearance | 0.016 to 0.045 mm<br>0.00063 to 0.0017 in. | 0.15 mm<br>0.0059 in. |
| • Rocker arm shaft | O.D. | 10.473 to 10.484 mm<br>0.41233 to 0.41275 in. | — |
| • Rocker arm | I.D. | 10.500 to 10.518 mm<br>0.41233 to 0.41275 in. | — |
| Push rod | Alignment | — | 0.25 mm<br>0.0098 in. |
| Tappet to tappet guide bore | Oil clearance | 0.016 to 0.052 mm<br>0.00063 to 0.0020 in. | 0.10 mm<br>0.0039 in. |
| • Tappet | O.D. | 17.966 to 17.984 mm<br>0.70867 to 0.70937 in. | — |
| • Tappet guide bore | I.D. | 18.000 to 18.018 mm<br>0.70733 to 0.70803 in. | — |
| Camshaft | Side clearance | 0.15 to 0.31 mm<br>0.0059 to 0.012 in. | 0.50 mm<br>0.020 in. |
| | Alignment | — | 0.01 mm<br>0.0004 in. |
| Cam height | Intake | 26.88 mm<br>1.058 in. | 26.83 mm<br>1.056 in. |
| | Exhaust (Z482-E4BG/Z482/D722/D782-E4) | 25.88 mm<br>1.019 in. | 25.83 mm<br>1.017 in. |
| | Exhaust (Z602/D902-E4/D902-TE4) | 26.88 mm<br>1.058 in. | 26.83 mm<br>1.056 in. |
| Camshaft journal to crankcase bore | Oil clearance | 0.050 to 0.091 mm<br>0.0020 to 0.0035 in. | 0.15 mm<br>0.0059 in. |
| • Camshaft journal | O.D. | 32.934 to 32.950 mm<br>1.2967 to 1.2972 in. | — |
| • Crankcase bore | I.D. | 33.000 to 33.025 mm<br>1.2993 to 1.3001 in. | — |
| Timing gear | | | |
| Idle gear to crank gear | Backlash | 0.0430 to 0.124 mm<br>0.00170 to 0.00488 in. | 0.15 mm<br>0.0059 in. |
| Idle gear to cam gear | Backlash | 0.0470 to 0.123 mm<br>0.00185 to 0.00484 in. | 0.15 mm<br>0.0059 in. |
| Idle gear to injection pump gear | Backlash | 0.0460 to 0.124 mm<br>0.00182 to 0.00488 in. | 0.15 mm<br>0.0059 in. |

(Continued)

| Item | | Service specification | Service limit |
|---|---|---|---|
| Crank gear to oil pump drive gear | Backlash | 0.0410 to 0.123 mm<br>0.00162 to 0.00484 in. | 0.15 mm<br>0.0059 in. |
| Idle gear | Side clearance | 0.20 to 0.51 mm<br>0.0079 to 0.020 in. | 0.80 mm<br>0.031 in. |
| Idle gear shaft to idle gear bushing | Oil clearance | 0.020 to 0.084 mm<br>0.00079 to 0.0033 in. | 0.10 mm<br>0.0039 in. |
| • Idle gear shaft | O.D. | 19.967 to 19.980 mm<br>0.78611 to 0.78661 in. | — |
| • Idle gear bushing | I.D. | 20.000 to 20.051 mm<br>0.78741 to 0.78940 in. | — |
| Piston diameter (Z482-E4BG/ Z482/D722/D782-E4) | O.D. | 67.0 mm<br>2.64 in. | — |
| Piston diameter (Z602/D902-E4/ D902-TE4) | O.D. | 72.0 mm<br>2.83 in. | — |
| Piston pin bore | I.D. | 20.000 to 20.013 mm<br>0.78741 to 0.78791 in. | 20.05 mm<br>0.7894 in. |
| Top ring to ring groove | Clearance | — | — |
| Second ring to ring groove | Clearance | 0.090 to 0.120 mm<br>0.00355 to 0.00472 in. | 0.15 mm<br>0.0059 in. |
| Oil ring to ring groove | Clearance | 0.020 to 0.060 mm<br>0.00079 to 0.0023 in. | 0.15 mm<br>0.0059 in. |
| Piston ring gap (Z482-E4BG/ Z482/D722/D782-E4) | Top ring | 0.12 to 0.27 mm<br>0.0047 to 0.010 in. | 1.15 mm<br>0.0453 in. |
| | Second ring | 0.30 to 0.45 mm<br>0.012 to 0.017 in. | 1.20 mm<br>0.0472 in. |
| | Oil ring | 0.35 to 0.50 mm<br>0.014 to 0.019 in. | 1.20 mm<br>0.0472 in. |
| Piston ring gap (Z602/D902-E4/ D902-TE4) | Top ring | 0.15 to 0.30 mm<br>0.0059 to 0.011 in. | 1.20 mm<br>0.0472 in. |
| | Second ring | 0.15 to 0.35 mm<br>0.0059 to 0.013 in. | 1.25 mm<br>0.0492 in. |
| | Oil ring | 0.15 to 0.35 mm<br>0.0059 to 0.013 in. | 1.20 mm<br>0.0472 in. |
| Connecting rod | Alignment | — | 0.05 mm<br>0.002 in. |
| Piston pin to small end bushing | Oil clearance | 0.014 to 0.038 mm<br>0.00056 to 0.0014 in. | 0.10 mm<br>0.0039 in. |
| Piston pin to small end bushing (Spare parts) | | 0.015 to 0.075 mm<br>0.00059 to 0.0029 in. | 0.15 mm<br>0.0059 in. |
| • Piston pin | O.D. | 20.002 to 20.011 mm<br>0.78748 to 0.78783 in. | — |
| • Small end bushing | I.D. | 20.025 to 20.040 mm<br>0.78839 to 0.78897 in. | — |
| • Small end bushing (Spare parts) | | 20.026 to 20.077 mm<br>0.78843 to 0.79043 in. | — |
| Crankshaft | Side clearance | 0.15 to 0.31 mm<br>0.0059 to 0.012 in. | 0.50 mm<br>0.020 in. |
| | Alignment | — | 0.02 mm<br>0.0008 in. |

(Continued)

| Item | | Service specification | Service limit |
|---|---|---|---|
| Crankshaft journal to crankshaft bearing 1 | Oil clearance | 0.0340 to 0.106 mm<br>0.00134 to 0.00417 in. | 0.20 mm<br>0.0079 in. |
| • Crankshaft journal (Z482-E4BG/Z482/D722/D782-E4) | O.D. | 39.934 to 39.950 mm<br>1.5722 to 1.5728 in. | – |
| • Crankshaft journal (Z602/D902-E4/D902-TE4) | | 43.934 to 43.950 mm<br>1.7297 to 1.7303 in. | – |
| • Crankshaft bearing 1 (Z482-E4BG/Z482/D722/D782-E4) | I.D. | 39.984 to 40.040 mm<br>1.5742 to 1.5763 in. | – |
| • Crankshaft bearing 1 (Z602/D902-E4/D902-TE4) | | 43.984 to 44.040 mm<br>1.7317 to 1.7338 in. | – |
| Crankshaft journal to crankshaft bearing 2 | Oil clearance | 0.028 to 0.059 mm<br>0.0011 to 0.0023 in. | 0.20 mm<br>0.0079 in. |
| Crankshaft journal to crankshaft bearing 2 (D902-TE4) | | 0.034 to 0.092 mm<br>0.0014 to 0.0036 in. | |
| • Crankshaft bearing 2 | I.D. | 43.978 to 43.993 mm<br>1.7315 to 1.7320 in. | – |
| • Crankshaft bearing 2 (D902-TE4) | | 43.984 to 44.026 mm<br>1.7317 to 1.7333 in. | |
| Crankshaft journal to crankshaft bearing 3 | Oil clearance | 0.028 to 0.059 mm<br>0.0011 to 0.0023 in. | 0.20 mm<br>0.0079 in. |
| Crankshaft journal to crankshaft bearing 3 (D902-TE4) | | 0.034 to 0.092 mm<br>0.0014 to 0.0036 in. | |
| • Crankshaft bearing 3 (Z482-E4BG/Z482/D722/D782-E4) | I.D. | 39.978 to 39.993 mm<br>1.5740 to 1.5745 in. | – |
| • Crankshaft bearing 3 (Z602/D902-E4) | | 43.978 to 43.993 mm<br>1.7315 to 1.7320 in. | |
| • Crankshaft bearing 3 (D902-TE4) | | 43.984 to 44.026 mm<br>1.7317 to 1.7333 in. | |
| Crankpin to crankpin bearing | Oil clearance | 0.020 to 0.051 mm<br>0.00079 to 0.0020 in. | 0.15 mm<br>0.0059 in. |
| Crankpin to crankpin bearing (D902-TE4) | | 0.019 to 0.081 mm<br>0.00075 to 0.0031 in. | |
| • Crankpin | O.D. | 33.959 to 33.975 mm<br>1.3370 to 1.3375 in. | – |
| • Crankpin bearing | I.D. | 33.995 to 34.010 mm<br>1.3384 to 1.3389 in. | – |
| • Crankpin bearing (D902-TE4) | | 33.994 to 34.040 mm<br>1.3384 to 1.3401 in. | |
| Cylinder bore (Z482-E4BG/Z482/D722/D782-E4) | I.D. | 67.000 to 67.019 mm<br>2.6378 to 2.6385 in. | 67.150 mm<br>2.6437 in. |
| Cylinder bore (Z602/D902-E4/D902-TE4) | | 72.000 to 72.019 mm<br>2.8347 to 2.8353 in. | 72.150 mm<br>2.8406 in. |
| Cylinder bore (Oversize: 0.25 mm (0.0098 in.)) (Z482-E4BG/Z482/D722/D782-E4) | I.D. | 67.250 to 67.269 mm<br>2.6477 to 2.6483 in. | 67.400 mm<br>2.6535 in. |
| Cylinder bore (Oversize: 0.25 mm (0.0098 in.)) (Z602/D902-E4/D902-TE4) | | 72.250 to 72.269 mm<br>2.8445 to 2.8452 in. | 72.400 mm<br>2.8504 in. |

## Lubricating system

| Item | | Service specification | Service limit |
|---|---|---|---|
| Engine oil pressure | At idle speed | More than<br>49 kPa<br>0.50 kgf/cm$^2$<br>7.1 psi | – |
| | At idle speed (D902-TE4) | More than<br>98 kPa<br>1.0 kgf/cm$^2$<br>14 psi | – |
| | At rated speed | 197 to 441 kPa<br>2.01 to4.49 kgf/cm$^2$<br>28.6 to 63.9 psi | 147 kPa<br>1.50 kgf/cm$^2$<br>21.3 psi |
| | At rated speed (D902-TE4) | 260 to 456 kPa<br>2.66 to 4.64 kgf/cm$^2$<br>37.7 to 66.1 psi | 260 kPa<br>2.65 kgf/cm$^2$<br>37.7 psi |
| Inner rotor to outer rotor | Clearance | 0.030 to 0.14 mm<br>0.0012 to 0.0055 in. | 0.25 mm<br>0.0098 in. |
| Outer rotor to pump body | Clearance | 0.070 to 0.15 mm<br>0.0028 to 0.0059 in. | 0.30 mm<br>0.012 in. |
| Inner rotor to cover | Clearance | 0.075 to 0.135 mm<br>0.00296 to 0.00531 in. | 0.20 mm<br>0.0079 in. |

## Cooling system

| Item | | Service specification | Service limit |
|---|---|---|---|
| Thermostat | Valve opening temperature | 69.5 to 72.5 ℃<br>157.1 to 162.5 ℉ | – |
| | Valve full opening temperature<br>(Opened completely) | 85 ℃<br>185 ℉ | – |
| Radiator | Water tightness | No leak at specified pressure | – |
| Radiator cap | Air leakage | 10 seconds or more<br>88 → 59 kPa<br>0.90 → 0.60 kgf/cm$^2$<br>13 → 8.6 psi | – |
| Fan belt | Belt tension (Adjusting) | 200 to 300 N<br>20.4 to 30.5 kgf<br>45.0 to 67.4 lbf | – |
| | Belt tension (After replacing) | 344 to 441 N<br>35.1 to 44.9 kgf<br>77.4 to 99.1 lbf | – |
| | Deflection | 7.0 to 9.0 mm<br>0.28 to 0.35 in.<br>(under load of 98 N (10 kgf,<br>22.1 lbf)) | – |

## Electrical system

| Item | | Service specification | Service limit |
|---|---|---|---|
| Starter (Electromagnetic Drive Type) | | | |
| • Commutator | O.D. | 28.0 mm<br>1.10 in. | 27.0 mm<br>1.06 in. |
| • Mica | Undercut | 0.50 to 0.80 mm<br>0.020 to 0.031 in. | 0.20 mm<br>0.0079 in. |
| • Brush | Length | 16.0 mm<br>0.630 in. | 10.5 mm<br>0.413 in. |
| Starter (Planetary Gear Reduction Type) | | | |
| • Commutator | O.D. | 30.0 mm<br>1.18 in. | 29.0 mm<br>1.14 in. |
| • Mica | Undercut | 0.50 to 0.80 mm<br>0.020 to 0.031 in. | 0.20 mm<br>0.0079 in. |
| • Brush | Length | 14.0 mm<br>0.55 in. | 9.0 mm<br>0.35 in. |
| Dynamo | | | |
| • No-load | Output voltage | AC 20 V or more at 5200 $min^{-1}$ (rpm) | — |
| • Regulating | Output voltage | 13.3 to 14.3 V at 5200 $min^{-1}$ (rpm) | — |
| Alternator | | | |
| • Stator | Resistance | Less than<br>1.0 Ω | — |
| • Rotor | Resistance | 2.9 Ω | — |
| • Slip ring | O.D. | 14.4 mm<br>0.567 in. | 14.0 mm<br>0.551 in. |
| • Brush | Length | 10.0 mm<br>0.394 in. | 8.4 mm<br>0.33 in. |
| Glow plug | Resistance | Approx. 1.1 Ω | — |

## Fuel system

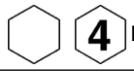
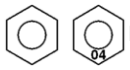
| Item | | Service specification | Service limit |
|---|---|---|---|
| Injection pump (Z482/D602-E4) | Injection timing ($3600\ min^{-1}$ (rpm)) | 0.3186 to 0.3447 rad<br>18.25 to 19.75°<br>before T.D.C | – |
| Injection pump (Z482-E4BG) | Injection timing ($1800\ min^{-1}$ (rpm)) | 0.2706 to 0.2967 rad<br>15.50 to 17.00°<br>before T.D.C | – |
| Injection pump (Z482-E4BG2) | Injection timing ($1500\ min^{-1}$ (rpm)) | 0.2453 to 0.2713pi rad<br>14.05 to 15.55°<br>before T.D.C | – |
| Injection pump (D722-E4) | Injection timing ($3200\ min^{-1}$ (rpm)) | 0.3360 to 0.3621 rad<br>19.25 to 20.75°<br>before T.D.C | – |
| Injection pump (D782-E4) | Injection timing ($3200\ min^{-1}$ (rpm)) | 0.2837 to 0.3097 rad<br>16.25 to 17.75°<br>before T.D.C | – |
| Injection pump (D902-E4) | Injection timing ($3600\ min^{-1}$ (rpm)) | 0.3186 to 0.3447 rad<br>18.25 to 19.75°<br>before T.D.C | – |
| Injection pump (D902-TE4) | Injection timing ($3200\ min^{-1}$ (rpm)) | 0.3360 to 0.3621 rad<br>19.25 to 20.75°<br>before T.D.C | – |
| Pump element | Fuel tightness | – | 13.7 MPa<br>140 $kgf/cm^2$<br>1990 psi |
| Delivery valve | Fuel tightness | 10 seconds<br>From 13.73 to 12.75 MPa<br>From 140.0 to 130.0 $kgf/cm^2$<br>From 1991 to 1849 psi | 5 seconds<br>From 13.73 to 12.75 MPa<br>From 140.0 to 130.0 $kgf/cm^2$<br>From 1991 to 1849 psi |
| Injection nozzle | Injection pressure | 13.7 to 14.7 MPa<br>140 to 149 $kgf/cm^2$<br>1990 to 2130 psi | – |
| Injection nozzle valve seat | Valve seat tightness | No fuel leak at<br>12.75 MPa<br>130.0 $kgf/cm^2$<br>1849 psi | – |

# 3. Tightening torques

Refer to the following table if the tightening torques of screws, bolts and nuts are not specified in each part.

## 3.1 Tightening torques of screws, bolts and nuts for general use

If the tightening torque is not specified, refer to the table below for the none specified torques values.

| Indication on top of bolt |  No-grade or 4T | | |  7T | | |
|---|---|---|---|---|---|---|
| Indication on top of nut |  No-grade or 4T | | | | | |
| Unit | N·m | kgf·m | lbf·ft | N·m | kgf·m | lbf·ft |
| M6 | 7.8 to 9.3 | 0.80 to 0.94 | 5.8 to 6.8 | 9.80 to 11.3 | 1.00 to 1.15 | 7.23 to 8.33 |
| M8 | 17.7 to 20.6 | 1.81 to 2.10 | 13.1 to 15.1 | 23.5 to 27.5 | 2.40 to 2.80 | 17.4 to 20.2 |
| M10 | 39.2 to 45.1 | 4.00 to 4.59 | 29.0 to 33.2 | 49.0 to 55.9 | 5.00 to 5.70 | 36.2 to 41.2 |
| M12 | 62.8 to 72.6 | 6.41 to 7.40 | 46.4 to 53.5 | 77.5 to 90.2 | 7.91 to 9.19 | 57.2 to 66.5 |

## 3.2 Tightening torques of screws, bolts and nuts for special use

**■ NOTE**

- **For the screws, bolts and nuts with the mark "*", apply the engine oil to their threads and seats before you tighten.**
- **The alphabet "M" in Dimension × Pitch shows that the screw, bolt or nut dimensions are in the metric system. The dimension is the nominal external diameter in mm of the threads. The pitch is the nominal distance in mm between 2 threads.**

**Disassembling and assembling**

| Item | Dimension × Pitch | N·m | kgf·m | lbf·ft |
|---|---|---|---|---|
| Drain plug with copper gasket | M12 × 1.25 | 33.0 to 37.0 | 3.37 to 3.77 | 24.4 to 27.2 |
| | M22 × 1.5 | 64.0 to 73.0 | 6.53 to 7.44 | 47.2 to 53.8 |
| Drain plug with rubber coated gasket | M22 × 1.25 | 45.0 to 53.0 | 4.59 to 5.40 | 33.2 to 39.0 |
| Drain plug (D902-TE4) | M22 × 1.5 | 44.1 to 53.9 | 4.50 to 5.49 | 32.6 to 39.7 |
| Dynamo pulley nut | M10 × 1.25 | 29.4 to 34.3 | 3.00 to 3.49 | 21.7 to 25.2 |
| Alternator pulley nut | — | 58.4 to 78.9 | 5.95 to 8.05 | 43.1 to 58.2 |
| Starter terminal B mounting nut (Electromagnetic drive type) | M8 | 7.9 to 9.8 | 0.81 to 0.99 | 5.9 to 7.2 |
| Starter terminal B mounting nut (Planetary gear reduction type) | M8 | 5.9 to 11 | 0.61 to 1.1 | 4.4 to 8.1 |
| *Main bearing case screw 1 (M6) | M6 × 1.0 | 12.7 to 15.7 | 1.30 to 1.60 | 9.37 to 11.5 |
| Main bearing case screw 1 (M8) | M8×1.25 | 23.5 to 27.5 | 2.40 to 2.80 | 17.4 to 20.2 |
| *Main bearing case screw 2 | M7 × 1.0 | 26.5 to 30.4 | 2.71 to 3.09 | 19.6 to 22.4 |

(Continued)

| Item | Dimension × Pitch | N·m | kgf·m | lbf·ft |
|---|---|---|---|---|
| *Flywheel screw | M10 × 1.25 | 53.9 to 58.8 | 5.50 to 5.99 | 39.8 to 43.3 |
| *Connecting rod screw | M7 × 0.75 | 26.5 to 30.4 | 2.71 to 3.09 | 19.6 to 22.4 |
| Oil pump drive gear mounting nut | M10 × 1.25 | 39.2 to 45.1 | 4.00 to 4.59 | 29.0 to 33.2 |
| Crankshaft screw | M12 × 1.5 | 117.7 to 127.5 | 12.01 to 13.00 | 86.82 to 94.03 |
| Oil cooler joint screw | M18 × 1.5 | 39.2 to 49.0 | 4.00 to 4.99 | 29.0 to 36.1 |
| Fuel injection pump mounting nut | M6 × 1.0 | 9.80 to 11.3 | 1.00 to 1.15 | 7.23 to 8.33 |
| Fuel injection pump mounting screw | M6 × 1.0 | 9.80 to 11.3 | 1.00 to 1.15 | 7.23 to 8.33 |
| *Cylinder head mounting screw | M8 × 1.25 | 38 to 42 | 3.8 to 4.3 | 28 to 31 |
| *Cylinder head mounting screw (D722-E4 (Serial Number:below 4MM3857) | M8 × 1.25 | 40.2 to 45.4 | 4.10 to 4.62 | 29.7 to 33.4 |
| *Cylinder head mounting screw (D902-TE4) | M8 × 1.25 | 40.2 to 45.4 | 4.10 to 4.62 | 29.7 to 33.4 |
| Exhaust manifold mounting nut | M6 × 1.0 | 9.80 to 11.3 | 1.00 to 1.15 | 7.23 to 8.33 |
| Exhaust manifold mounting screw | M6 × 1.0 | 9.80 to 11.3 | 1.00 to 1.15 | 7.23 to 8.33 |
| Rocker arm bracket screw | M6 × 1.0 | 9.80 to 11.3 | 1.00 to 1.15 | 7.23 to 8.33 |
| *Cylinder head cover screw | M6 × 1.0 | 6.86 to 11.3 | 0.700 to 1.15 | 5.06 to 8.33 |
| Glow plug | M8 × 1.0 | 7.84 to 14.7 | 0.800 to 1.49 | 5.79 to 10.8 |
| Glow lead mounting nut | M4 × 0.7 | 0.980 to 1.76 | 0.100 to 0.179 | 0.723 to 1.29 |
| Nozzle holder | — | 29 to 49 | 3.0 to 4.9 | 22 to 36 |
| Injection nozzle holder | M20 × 1.5 | 49.0 to 68.6 | 5.00 to 6.99 | 36.2 to 50.5 |
| Overflow pipe retaining nut | M12 × 1.5 | 34.3 to 39.2 | 3.50 to 3.99 | 25.3 to 28.9 |
| Injection pipe retaining nut | M12 × 1.5 | 24.5 to 34.3 | 2.50 to 3.49 | 18.1 to 25.2 |
| Turbocharger assembly mounting nut | M6 × 1.0 | 9.80 to 11.3 | 1.00 to 1.15 | 7.23 to 8.33 |
| Oil pipe joint screw | M10 × 1.5 PS 1/8 | 15.7 to 19.6 | 1.60 to 1.99 | 11.6 to 14.4 |
| Cooling fan mounting screw | M6 × 1.0 | 9.81 to 11.3 | 1.00 to 1.15 | 7.24 to 8.33 |
| Thermo switch (Option) | PT 1/8 | 5.0 to 7.0 | 0.51 to 0.71 | 3.7 to 5.1 |

**Servicing**

| Item | Dimension × Pitch | N·m | kgf·m | lbf·ft |
|---|---|---|---|---|
| Oil pressure switch | R 1/8 | 14.7 to 19.6 | 1.50 to 1.99 | 10.9 to 14.4 |
| Oil pressure switch terminal | M4 × 0.7 | 1.37 to 1.96 | 0.140 to 0.199 | 1.01 to 1.44 |

(Continued)

| 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**

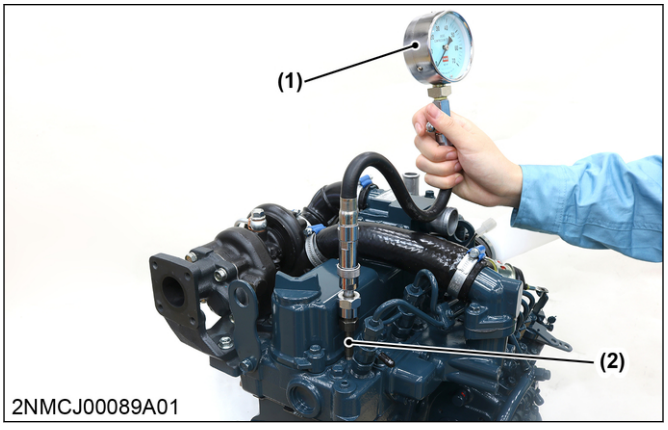
- Compression tester
- Compression tester adapter

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<br>Z482-E4BG<br>D722-E4<br>D782-E4 | 2.85 to 3.23 MPa/ 200 $min^{-1}$ (rpm)<br>29.1 to 32.9 $kgf/cm^2$/ 200 $min^{-1}$ (rpm)<br>414 to 468 psi/ 200 $min^{-1}$ (rpm) | 2.26 MPa/ 200 $min^{-1}$ (rpm)<br>23.0 $kgf/cm^2$/ 200 $min^{-1}$ (rpm)<br>328 psi/ 200 $min^{-1}$ (rpm) |
| | Z602-E4<br>D902-E4 | 3.53 to 4.02 MPa/ 200 $min^{-1}$ (rpm)<br>36.0 to 40.9 $kgf/cm^2$/ 200 $min^{-1}$ (rpm)<br>512 to 583 psi/ 200 $min^{-1}$ (rpm) | 2.55 MPa/ 200 $min^{-1}$ (rpm)<br>26.0 $kgf/cm^2$/ 200 $min^{-1}$ (rpm)<br>370 psi/ 200 $min^{-1}$ (rpm) |
| | D902-TE4 | 2.85 to 3.23 MPa/ 200 $min^{-1}$ (rpm)<br>29.1 to 32.9 $kgf/cm^2$/ 200 $min^{-1}$ (rpm)<br>414 to 468 psi/ 200 $min^{-1}$ (rpm) | 2.26 MPa/ 200 $min^{-1}$ (rpm)<br>23.0 $kgf/cm^2$/ 200 $min^{-1}$ (rpm)<br>328 psi/ 200 $min^{-1}$ (rpm) |

7. Do the same steps twice for each cylinder.

8. Install the removed parts.

| | | |
|---|---|---|
| Tightening torque | Injection nozzle assembly | 49.0 to 68.6 N·m<br>5.00 to 6.99 kgf·m<br>36.2 to 50.5 lbf·ft |
| | Overflow pipe retaining nut | 34.3 to 39.2 N·m<br>3.50 to 3.99 kgf·m<br>25.3 to 28.9 lbf·ft |
| | Injection pipe retaining nut | 24.5 to 34.3 N·m<br>2.50 to 3.49 kgf·m<br>18.1 to 25.2 lbf·ft |
| | Glow plug | 7.84 to 14.7 N·m<br>0.800 to 1.49 kgf·m<br>5.79 to 10.8 lbf·ft |
| | Glow lead mounting nut | 0.980 to 1.76 N·m<br>0.100 to 0.179 kgf·m<br>0.723 to 1.29 lbf·ft |

## 4.2 Checking valve clearance

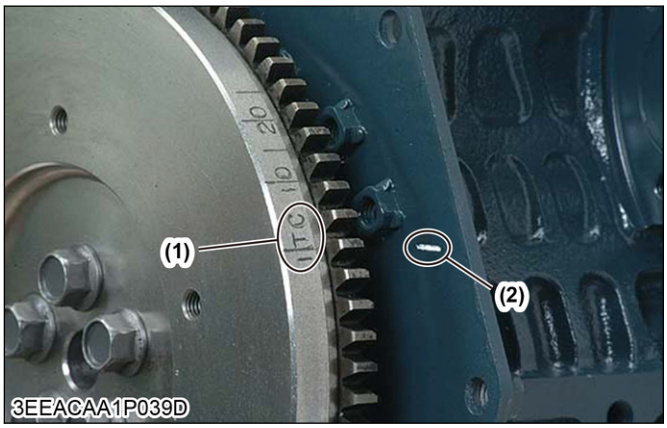
**IMPORTANT**

- **You must check and adjust the valve clearance (5) when the engine is cold.**

**Tools required**

- Feeler gauge

1. Remove the inlet hose 1 and 2.
2. Remove the cylinder head cover.
3. Remove the glow lead and glow plugs.
4. Align the **[1TC]** mark (1) on the flywheel and alignment mark (2) on the rear end plate.




(1) **[1TC]** mark (2) Align mark

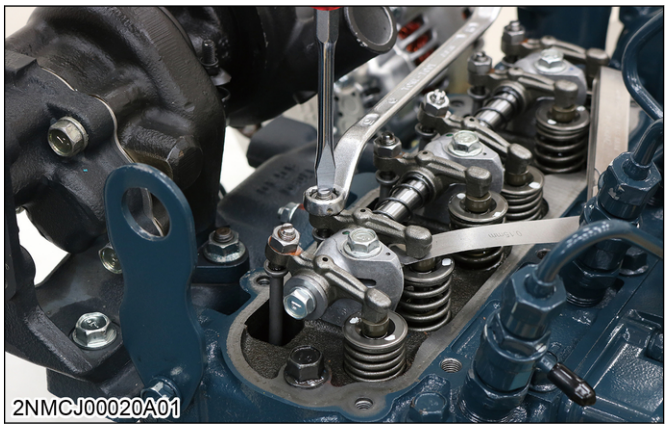
5. Make sure that the No. 1 piston comes to the compression or overlap top dead center.
6. Check the subsequent valve clearance (5) at the mark **[1TC]** position with a feeler gauge.

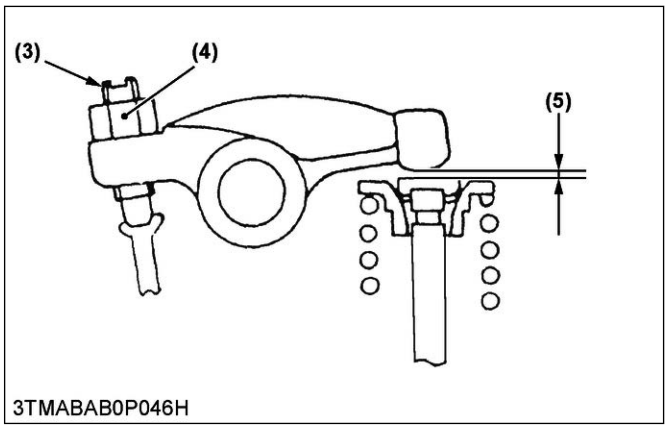
**NOTE**

- **If the clearance is out of the service specifications, adjust with the adjusting screw (3).**
- **Tighten the lock nut (4) of the adjusting screw (3).**

| | | |
|---|---|---|
| Valve clearance (Cold) | Service specification | 0.145 to 0.185 mm<br>0.00571 to 0.00728 in. |

| Adjustable cylinder location of piston | | Valve arrangement | |
|---|---|---|---|
| | | Intake | Exhaust |
| When No. 1 piston is at compression top dead center. | 1 | ☆ | ☆ |
| | 2 | | ☆ |
| | 3 | ☆ | |
| When No. 1 piston is at overlap top dead center. | 1 | | |
| | 2 | ☆ | |
| | 3 | | ☆ |




(3) Adjusting screw (5) Valve clearance
(4) Lock nut

7. Install the removed parts.

| | | |
|---|---|---|
| Tightening torque | Cylinder head cover screw | 6.86 to 11.3 N·m<br>0.700 to 1.15 kgf·m<br>5.06 to 8.33 lbf·ft |

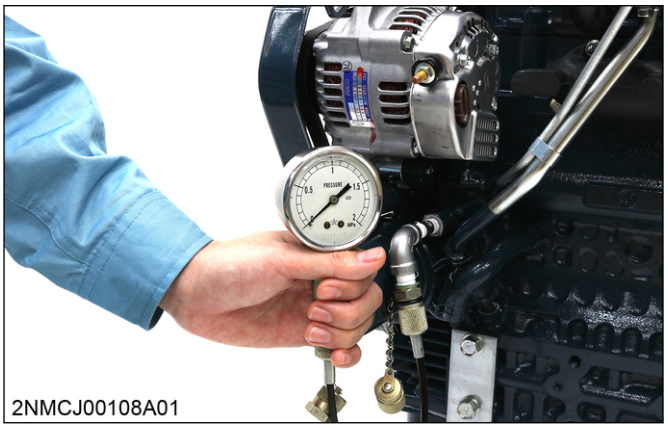
## 4.3 Checking engine oil pressure

**Tools required**

- Oil pressure tester

1. Remove the engine oil pressure switch.
2. Set the oil pressure tester.
3. Operate the engine for warming-up.
4. Measure the oil pressure at the idle speed and rated speed.

| | | | |
|---|---|---|---|
| Engine oil pressure | At idle speed | Service specification | More than<br>49 kPa<br>0.50 kgf/cm$^2$<br>7.1 psi |
| | At idle speed (D902-TE4) | | More than<br>98 kPa<br>1.0 kgf/cm$^2$<br>14 psi |
| | At rated speed | Service specification | 197 to<br>441 kPa<br>2.01 to<br>4.49 kgf/cm$^2$<br>28.6 to<br>63.9 psi |
| | At rated speed (D902-TE4) | | 260 to<br>456 kPa<br>2.66 to<br>4.64 kgf/cm$^2$<br>37.7 to<br>66.1 psi |
| | At rated speed | Service limit | 147 kPa<br>1.50 kgf/cm$^2$<br>21.3 psi |
| | At rated speed (D902-TE4) | | 260 kPa<br>2.65 kgf/cm$^2$<br>37.7 psi |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**■ NOTE**

- **If the oil pressure is less than the service limit, do a check below.**
  - **Engine oil level**
  - **Oil pump**
  - **Oil strainer**
  - **Oil filter cartridge**
  - **Oil passage**
  - **Oil clearance**
  - **Relief valve**

5. After checking the engine oil pressure, tighten its oil pressure switch to the specified torque.

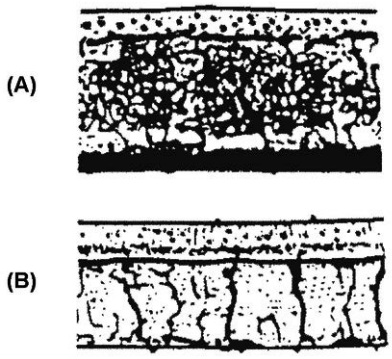
| | | |
|---|---|---|
| Tightening torque | Oil pressure switch | 14.7 to 19.6 N·m<br>1.50 to 1.99 kgf·m<br>10.9 to 14.4 lbf·ft |

## 4.4 Checking fan belt

**Tools required**

- Sonic belt tension meter

1. Check that the fan belt is worn out and sunk in the pulley groove or not.
   - If it is, replace it.



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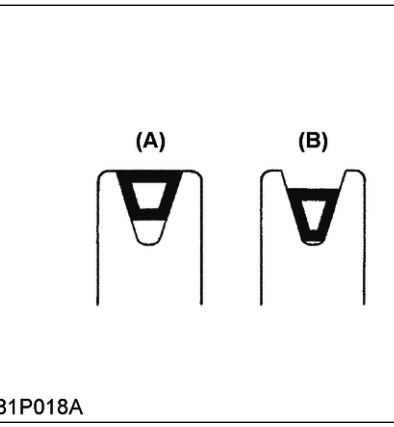

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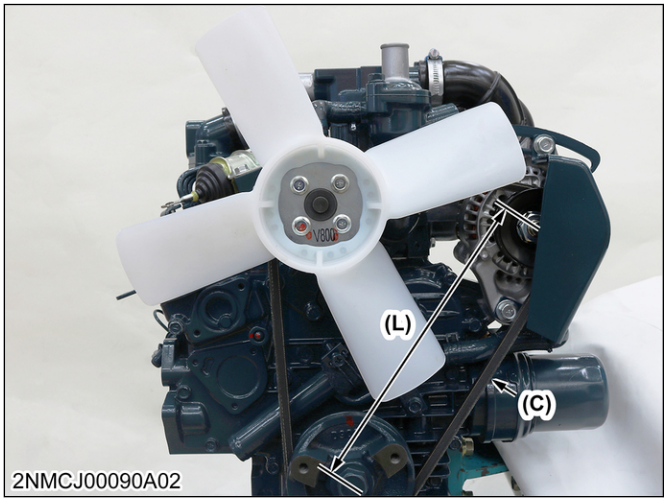
(A) OK (B) Wear

2. Check the tension of fan belt at the position (C) between the fan drive pulley and alternator pulley with sonic belt tension meter.

**■ NOTE**
- **If the measurement is out of the service specifications, loosen the alternator mounting screws and adjust its position.**

| Sonic belt tension meter setting value | |
|---|---|
| Mass<br>(Mass per 1 rib 1 m of belt) | 80 g/rib/m |
| Width<br>(Number of ribs) | 1 |
| Span L | Measure at location (C) in the figure with (L) as the distance between the fan drive pulley and alternator pulley. |

| | | |
|---|---|---|
| Belt tension | Service specification | 200 to 300 N<br>20.4 to 30.5 kgf<br>45.0 to 67.4 lbf |



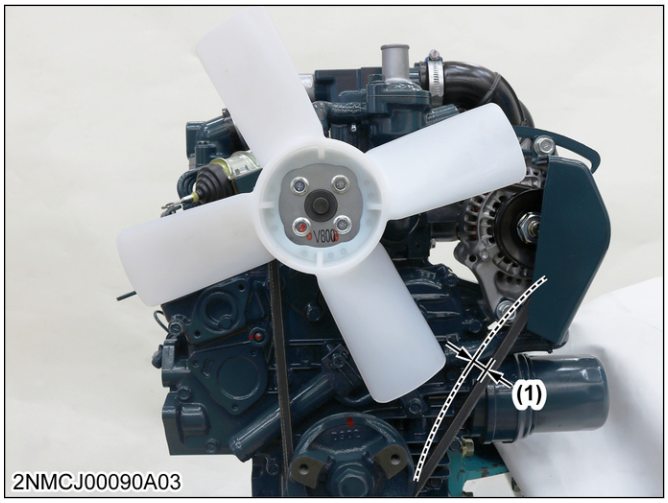

(C) Fan belt halfway

**(Reference)**

a. Push the belt halfway between the fan drive pulley and alternator pulley at a specified force to measure the deflection (1).

**■ NOTE**
- **If the measurement is out of the service specifications, loosen the alternator mounting screws and adjust its position.**

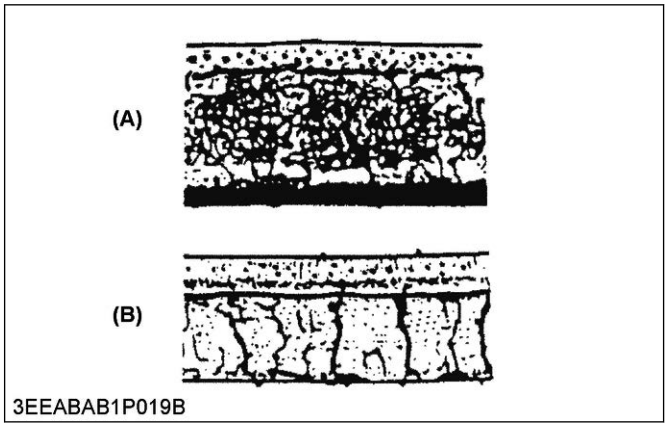
| | | |
|---|---|---|
| Deflection (1) | Service specification | 7.0 to 9.0 mm<br>0.28 to 0.35 in.<br>(Under load of 98 N<br>(10 kgf, 22 lbf)) |




(1) Deflection

## 4.5 Checking fan belt damage and wear

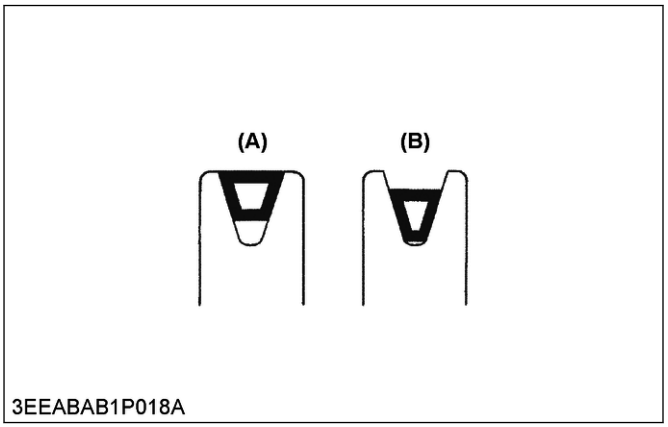
1. Check the fan belt for damage.




(A) Good (B) Bad

**■ NOTE**
- **If the fan belt has a damage, replace it.**

2. Check if the fan belt is worn out and sunk in the pulley groove.




(A) Good (B) Bad

**■ NOTE**
- **If it is "Bad" (B), replace it.**

## 4.6 Checking radiator cap air leakage

**⚠ CAUTION**
- **Remove the radiator cap only after you stop the engine for a minimum of 10 minutes to decrease its temperature.**
  **If not, hot water can gush out and cause injury.**

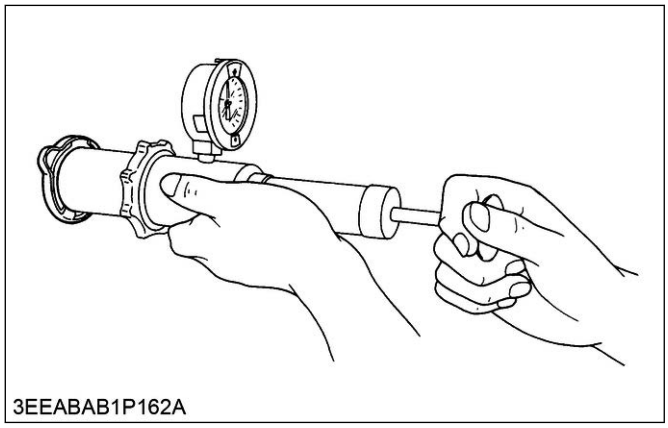
**Tools required**
- Radiator cap tester and an adapter

1. Set a radiator tester and an adapter on the radiator cap.
2. Apply the specified pressure.

| | |
|---|---|
| Specified pressure | 88 kPa<br>0.90 kgf/cm$^2$<br>13 psi |

3. Measure the time for the pressure to decrease to specified pressure.

| | | |
|---|---|---|
| Pressure decreasing time | Service specification | More than 10 seconds for pressure decrease<br>From 88 to 59 kPa<br>From 0.90 to 0.60 kgf/cm$^2$<br>From 13 to 8.6 psi |




**■ NOTE**
- **If the measurement is less than the service specification, replace the radiator cap.**

## 4.7 Checking radiator water leakage

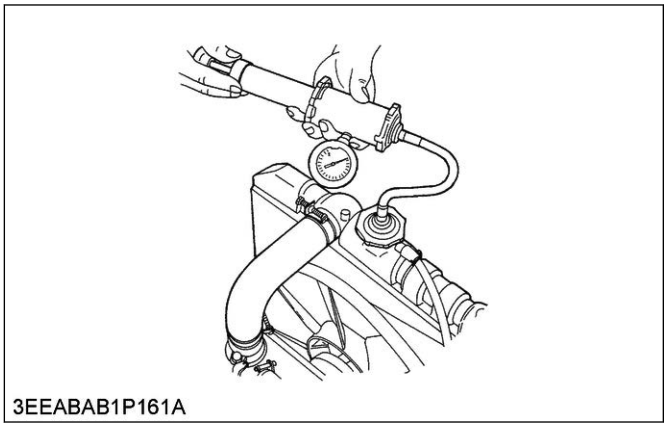
**■ NOTE**
- **The pressure of the leak test is different for each radiator specification.**
  **Thus, refer to the test pressure of each radiator specification to do the leakage test.**

**Tools required**
- Radiator tester and an adapter

1. Fill a specified quantity of water into the radiator.
2. Set a radiator tester and an adapter on the radiator.
3. Increase the water pressure to the specified pressure with the radiator tester and an adapter.

4. Check the radiator for water leakage.

| | | |
|---|---|---|
| Radiator water leakage test | Service specification | No leak at specified pressure |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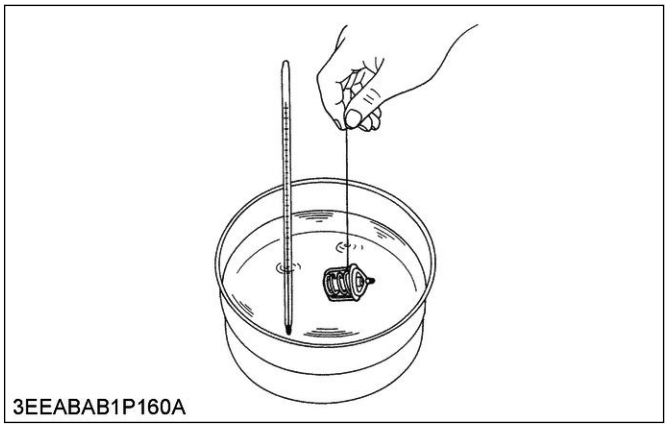
**■ NOTE**
- **For water leakages from the pinhole, replace the radiator or repair with the radiator cement.**
- **When water leak is too much, replace the radiator.**

## 4.8 Checking opening temperature of thermostat valve

**Tools required**
- Thermometer

1. Push down the thermostat valve and put the thread between the valve and the valve seat.
2. Put the thermostat and the thermometer in the container and increase the temperature of the water gradually.
3. Take the thread, and float the thermostat in the water.
4. As the coolant temperature rises, the valve will open, and the thermostat will separate from the thread.
5. Measure the temperature at this moment.

| | | |
|---|---|---|
| Thermostat valve opening temperature | Service specification | 69.5 to 72.5 ℃<br>157.1 to 162.5 ℉ |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6. Continue to increase the temperature and read the temperature when the valve full opens gap.

| | |
|---|---|
| Valve full opens gap | Approx.<br>8 mm<br>0.3 in. |

| | | |
|---|---|---|
| Full opening temperature | Service specification | 85 ℃<br>185 ℉ |

**■ NOTE**
- **If the measurement is out of the service specifications, replace the thermostat.**

## 4.9 Checking battery voltage

**⚠ CAUTION**
- **To prevent an accidental short circuit, attach the positive cable to the positive terminal before the negative cable is attached to the negative terminal.**
- **Do not remove the battery cap while the engine operates.**
- **Keep electrolyte away from eyes, hands and clothes.**
  **If you are spattered with it, clean with water immediately.**
- **Keep open sparks and flames away from the battery at all times.**
  **Hydrogen gas mixed with oxygen becomes very explosive.**

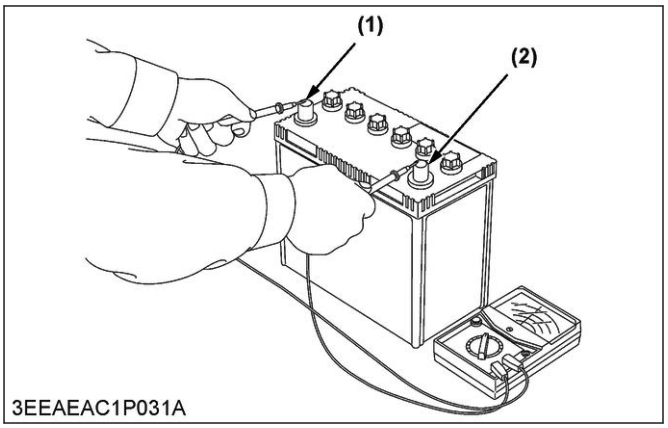
**■ IMPORTANT**
- **Do not disconnect or remove the battery when you operate engine.**

**Tools required**
- Circuit tester

1. Stop the engine.

2. Measure the voltage with a circuit tester between the battery terminals.

| | | |
|---|---|---|
| Battery voltage | Service specification | More than 12 V |




(1) Positive terminal (2) Negative terminal

**NOTE**
- **If the battery voltage is less than the service specification, check the battery specific gravity and charge the battery.**

## 4.10 Checking battery specific gravity

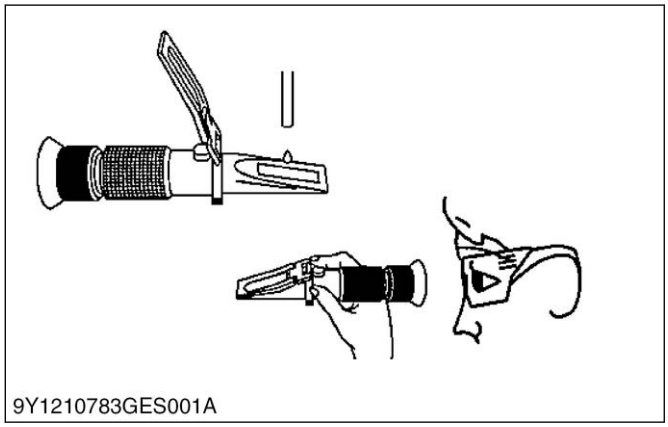
**CAUTION**
- **To prevent an accidental short circuit, attach the positive cable to the positive terminal before the negative cable is attached to the negative terminal.**
- **Do not remove the battery cap while the engine operates.**
- **Keep electrolyte away from eyes, hands and clothes.**
  **If you are spattered with it, clean with water immediately.**
- **Keep open sparks and flames away from the battery at all times.**
  **Hydrogen gas mixed with oxygen becomes very explosive.**
- **If battery acid (dilute sulfuric acid) gets on you, it could cause blindness or burns, or could cause corrosion of machinery and tools so please be careful when handling.**
- **Wear safety glasses and rubber gloves when performing battery maintenance and inspection (measuring specific gravity, filling water, or charging).**
- **If the gas that is generated is ignited by an ignition source, it may explode so be very careful with sparks and fire.**
- **Keep your body and face as far away from the battery as you can when performing maintenance and inspection.**
- **Do not allow people who do not know how to handle a battery or who do not sufficiently understand the danger perform inspection or maintenance.**

**IMPORTANT**
- **Do not disconnect or remove the battery when you operate engine.**

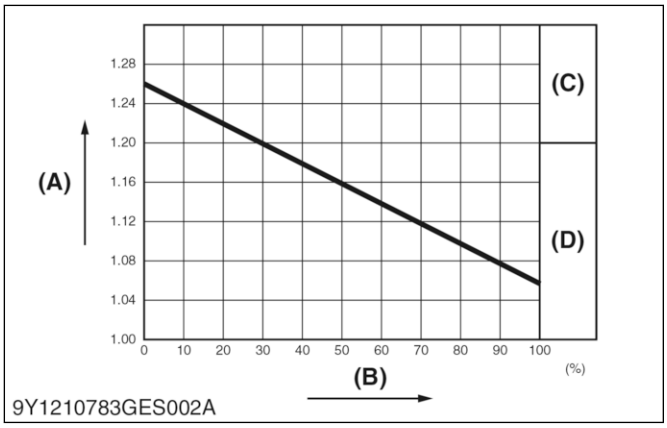
**Tools required**
- Battery / coolant tester

**Zero adjustment**
1. Open the cover and drip water on the prism surface using the included rod.
2. Close the cover.
3. Aim in a direction that is bright, look into the lens, and adjust the focus until the gradations can be seen clearly.
4. If the boundary line is not on the gradation baseline (0 position), turn the adjustment screw until it matches.
5. When zero adjustment is complete, wipe the prism and cover surface with a soft cloth or tissue paper.

**Measurement of test field**
1. Open the cover and drip test fluid on the prism surface using the included rod.
2. Close the cover.
3. Aim in a direction that is bright, look into the lens and read the gradation of the blue boundary line.
4. When the measurement is complete, wipe the prism and cover surface with a soft cloth or tissue paper.




**NOTE**
- **Electrolyte specific gravity and amount of discharge.**
  **Use the following table as a reference.**




(A) Electrolyte specific gravity
(B) Discharge
(C) Good
(D) Charging is necessary.

**■ NOTE**

- **Temperature conversion of electrolyte specific gravity.**
- **Battery electrolyte specific gravity changes based on temperature.**
- **Insert the value identified on a specific gravity meter into the following conversion equation for temperature correction to learn an accurate specific gravity value. (Standard temperature assumed to be 20 ℃ [68 ℉].)**
  **$D_{20} = D_t + 0.0007 (t - 20)$**
  **$D_{20}$ = specific gravity value converted to standard temperature of 20 ℃ (68 ℉)**
  **$D_t$ = measured specific gravity value at the electrolyte temperature t ℃**

## 4.11 Checking starter motor

**⚠ CAUTION**

- **To prevent an accidental short circuit, attach the positive cable to the positive terminal before the negative cable is attached to the negative terminal.**
- **Do not remove the battery cap while the engine operates.**
- **Keep electrolyte away from eyes, hands and clothes.**
  **If you are spattered with it, clean with water immediately.**
- **Keep open sparks and flames away from the battery at all times.**
  **Hydrogen gas mixed with oxygen becomes very explosive.**
- **Hold the starter to prevent its movement when you do a test on the motor.**

**■ IMPORTANT**

- **Do not disconnect or remove the battery when you operate engine.**

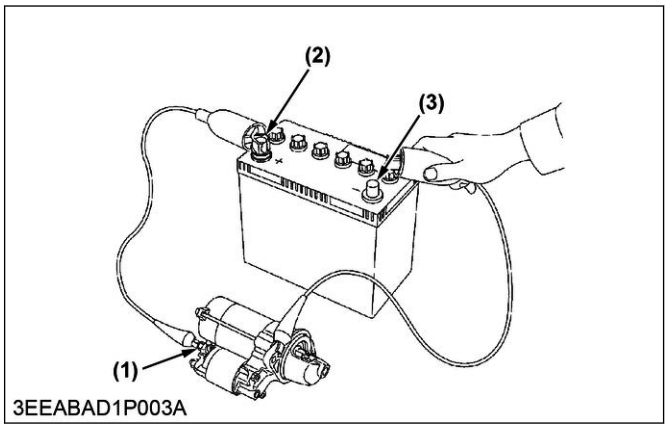
**■ NOTE**

- **B terminal: It is the terminal that connects the cable from the battery to the starter.**
- **C terminal: It is the terminal that connects the cable from the motor to the magnet switch.**

**Tools required**

- Circuit tester
- Jumper lead

1. Disconnect the negative cable from the battery.
2. Disconnect the positive cable from the battery.
3. Disconnect the leads from the starter B terminal.
4. Remove the starter from the engine.
5. Connect a jumper lead from the starter C terminal (1) to the battery positive terminal (2).
6. Connect a jumper lead momentarily between the starter body and the battery negative terminal (3).




(1) C terminal
(2) Positive terminal
(3) Negative terminal

**■ NOTE**

- **If the motor does not operate, starter is damaged, repair or replace the starter.**

## 4.12 Checking magnetic switch continuity

**⚠ CAUTION**

- **To prevent an accidental short circuit, attach the positive cable to the positive terminal before the negative cable is attached to the negative terminal.**
- **Do not remove the battery cap while the engine operates.**
- **Keep electrolyte away from eyes, hands and clothes.**

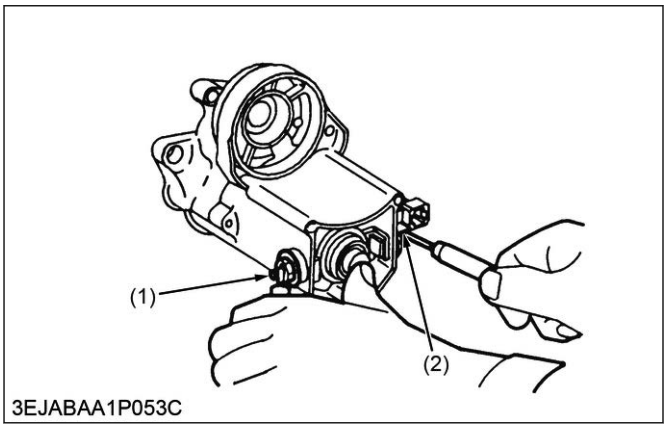
**If you are spattered with it, clean with water immediately.**
- **Keep open sparks and flames away from the battery at all times.**
  **Hydrogen gas mixed with oxygen becomes very explosive.**

**Tools required**
- Circuit tester

1. Push in the plunger.
2. Check the continuity across the C terminal (1) and the B terminal (2) with a circuit tester.

**■ NOTE**
- **If it is not continuous or it shows a value, replace the magnetic switch.**

| | | |
|---|---|---|
| Resistance between the C terminal (1) and the B terminal (2) | Service specification | Continuity |




(1) C terminal (2) B terminal

## 4.13 Checking magnetic switch of starter

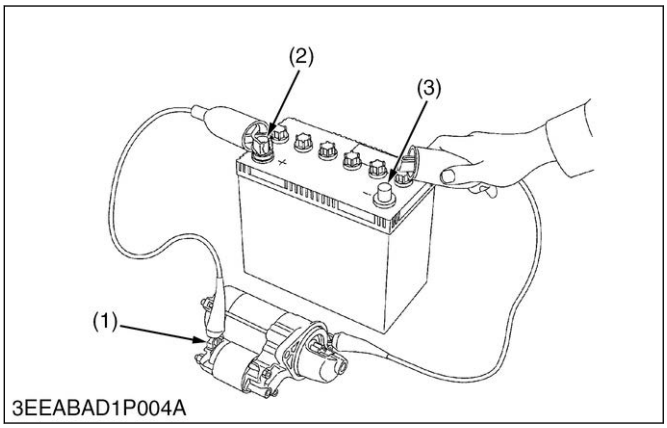
**⚠ CAUTION**
- **To prevent an accidental short circuit, attach the positive cable to the positive terminal before the negative cable is attached to the negative terminal.**
- **Do not remove the battery cap while the engine operates.**
- **Keep electrolyte away from eyes, hands and clothes.**
  **If you are spattered with it, clean with water immediately.**
- **Keep open sparks and flames away from the battery at all times.**
  **Hydrogen gas mixed with oxygen becomes very explosive.**

**■ IMPORTANT**
- **Do not disconnect or remove the battery when you operate engine.**

**■ NOTE**
- **B terminal: It is the terminal that connects the cable from the battery to the starter.**
- **C terminal: It is the terminal that connects the cable from the motor to the magnet switch.**

**Tools required**
- Circuit tester
- Jumper lead

1. Disconnect the negative cable from the battery.
2. Disconnect the positive cable from the battery.
3. Disconnect the leads from the starter B terminal.
4. Remove the starter from the engine.
5. Connect a jumper lead from the starter S terminal (1) to the battery positive terminal (2).
6. Connect a jumper lead momentarily between the starter body and the battery negative terminal (3).




(1) S terminal (3) Negative terminal
(2) Positive terminal

**■ NOTE**
- **If the pinion gear does not come out, the magnetic switch is damaged, repair or replace the starter.**

## 4.14 Checking alternator on unit

**⚠ CAUTION**
- **To prevent an accidental short circuit, attach the positive cable to the positive terminal before the negative cable is attached to the negative terminal.**
- **Do not remove the battery cap while the engine operates.**
- **Keep electrolyte away from eyes, hands and clothes.**

**If you are spattered with it, clean with water immediately.**
- **Keep open sparks and flames away from the battery at all times.**
  **Hydrogen gas mixed with oxygen becomes very explosive.**

**■ NOTE**
- **Before check alternator on unit, do a check of the below list.**
  - **Battery terminal connections**
  - **Circuit connection**
  - **Fan belt tension**
  - **Charge indicator lamp**
  - **Fuses on the circuit**
  - **Abnormal noise from the alternator**
  - **Prepare full charged battery for the test.**
- **Do not touch the engine parts that turns while the engine operates.**
- **Keep a safety distance from the engine parts that turn.**

**Tools required**
- Circuit tester

1. Start the engine.
2. Measure the voltage between battery terminals.

**■ NOTE**
- **If the results of alternator-on unit test are not in the service specifications, disassemble the alternator and check each component part to find out the problem.**
- **Refer to the alternator section about Disassembling, Assembling and Servicing.**

| | | |
|---|---|---|
| Regulating voltage at no load | Service specification | Approx. 13.0 to 15.0 V (at 25 ℃ (77 ℉)) |

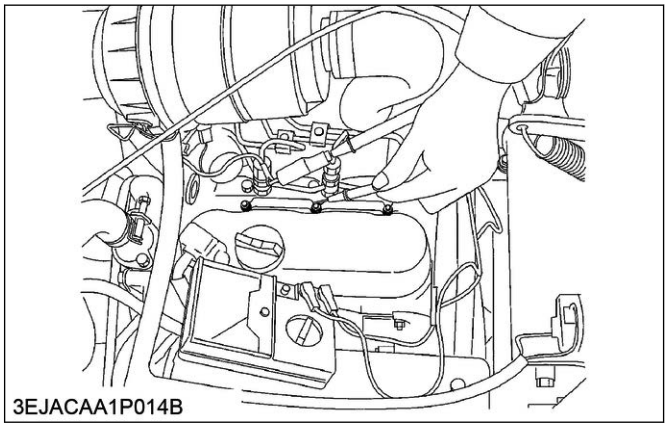

## 4.15 Checking voltage of glow lead terminal

**Tools required**
- Circuit tester

1. Turn the key switch to the *"GLOW"* (or *"PREHEAT"*) position.
2. Measure the voltage between the glow lead terminal and the engine body with a circuit tester.

**■ NOTE**
- **If the voltage differs from the battery voltage, the wiring harness or key switch is damaged.**

| | | |
|---|---|---|
| Voltage | Key switch at *"GLOW"* (or *"PREHEAT"*) | Approx. battery voltage |

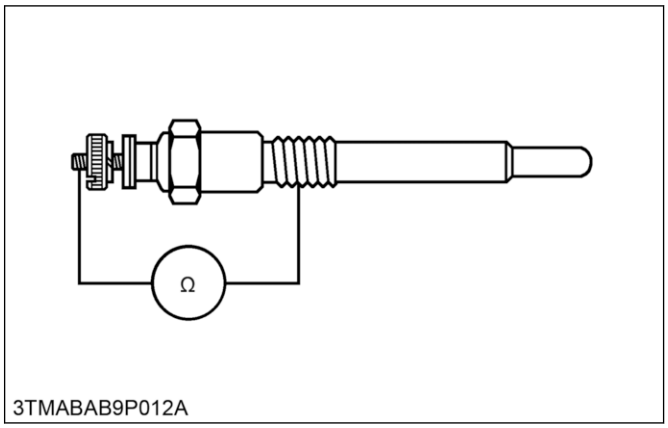



## 4.16 Checking glow plug continuity

**Tools required**
- Circuit tester

1. Remove the glow plug.
2. Measure the resistance between the glow plug terminal and the glow plug housing with a circuit tester.

| | | |
|---|---|---|
| Resistance | Service specification | Approx. 1.1 Ω |



## 4.17 Checking engine stop solenoid

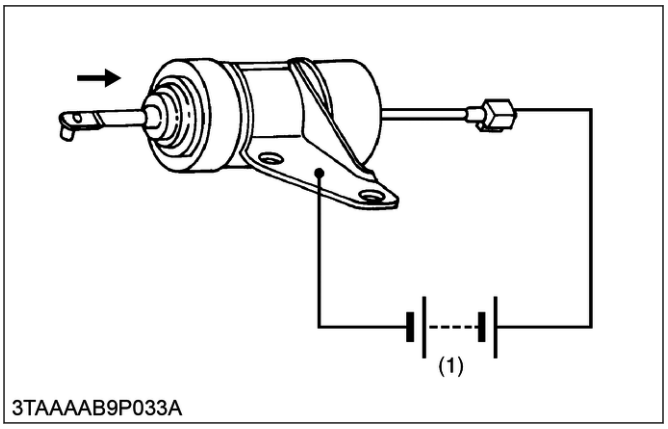
**Tools required**

- Jumper leads

1. Disconnect the 1P connector from the engine stop solenoid.
2. Remove the engine stop solenoid.
3. Connect the jumper leads from the battery's positive terminal to the 1P connector, and from the battery's negative terminal to the engine stop solenoid body.

**NOTE**

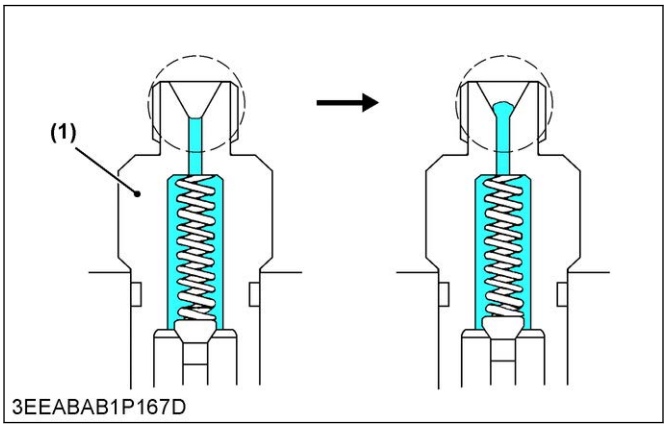
- **If the solenoid plunger is not attracted, the engine stop solenoid is damaged.**




(1) Battery (12 V)

## 4.18 Checking injection timing

1. Remove the injection pipes.
2. Turn the flywheel counterclockwise (viewed from flywheel side), until the fuel fills up to the hole of the delivery valve holder (1) of No. 1 cylinder.

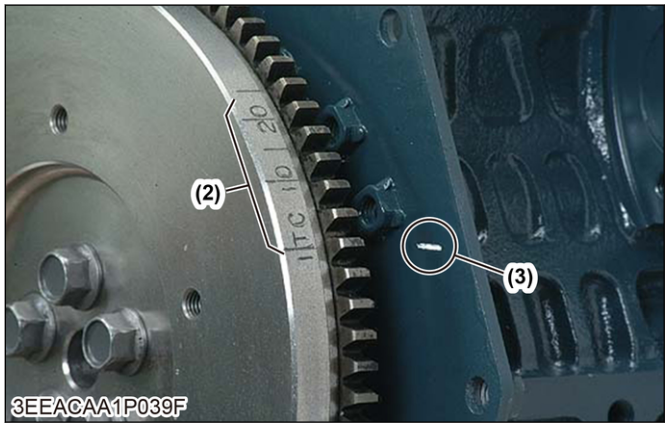



(1) Delivery valve holder

3. After the fuel fills up to the hole of the delivery valve holder (1) of No. 1 cylinder, turn back (clockwise) the flywheel around 1.6 rad (90°).
4. Turn the flywheel counterclockwise to set at around 0.44 rad (25°) before T.D.C..
5. Slowly turn the flywheel counterclockwise and stop turning, when the fuel begins to come up to get present injection timing.
6. Check and read the timing line (2) of flywheel that matches the alignment mark (3).

**NOTE**

- **The flywheel has mark "[1TC]", "[10]" and "[20]" for the crank angle before the top dead center of No. 1 cylinder.**

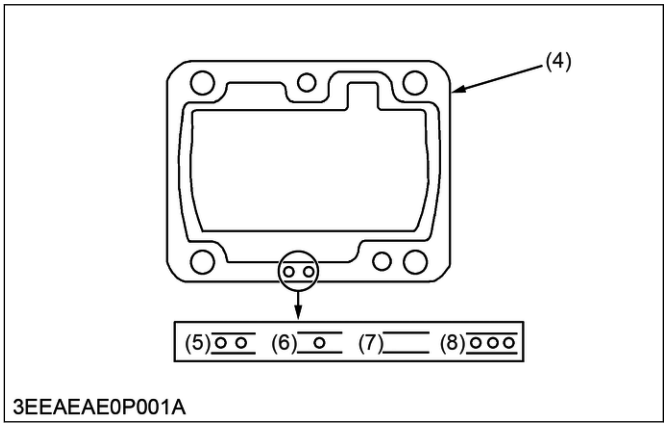



(2) Timing line (3) Alignment mark

7. If injection timing is out of adjustment, readjust the timing with shims.

**■ NOTE**

- **The liquid gasket is not required for assembling.**
- **Shims are available in thickness of 0.20 mm (0.0079 in.), 0.25 mm (0.0098 in.), 0.30 mm (0.012 in.), 0.35 mm (0.014 in.) and 0.175 mm (0.00689 in.).**
  **Combine these shims for adjustments.**
- **Addition or reduction of a shim (0.050 mm, 0.0020 in.) delays or advances the injection timing by approx. 0.0087 rad (0.5°).**
- **During disassembling and replacing the injection pump, be sure to use the same number of new shims with the same thickness.**
- **The 0.175 mm (0.00689 in.) thick shim is coated only on the lower face.**
  **Therefore, do not use the 0.175 mm (0.00689 in.) thick shim as the top shim of the combination (injection pump side), because this can cause oil leakage.**
- **Refer to the figure of the shim to check the thicknesses of the shims.**
- **The injection timing might be changed by the application.**



3EEAEAE0P001A

(4) Shim (soft metal gasket shim)
(5) Two-holes: 0.20 mm (0.0079 in.)
Two-holes: 0.175 mm (0.00689 in.)
(6) One-hole: 0.25 mm (0.0098 in.)
(7) Without hole: 0.30 mm (0.012 in.)
(8) Three-holes: 0.35 mm (0.014 in.)

| Injection timing | | |
|---|---|---|
| Engine model | ($min^{-1}$ (rpm)) | Service specification |
| Z482/D602-E4 | 3600 | 0.3186 to 0.3447 rad 18.25 to 19.75° before T.D.C |
| Z482-E4BG | 1800 | 0.2706 to 0.2967 rad 15.50 to 17.00° before T.D.C |
| Z482-E4BG2 | 1500 | 0.2453 to 0.2713pi rad 14.05 to 15.55° before T.D.C |
| D722-E4 | 3200 | 0.3360 to 0.3621 rad 19.25 to 20.75° before T.D.C |
| D782-E4 | 3200 | 0.2837 to 0.3097 rad 16.25 to 17.75° before T.D.C |
| D902-E4 | 3600 | 0.3186 to 0.3447 rad 18.25 to 19.75° before T.D.C |
| D902-TE4 | 3200 | 0.3360 to 0.3621 rad 19.25 to 20.75° before T.D.C |

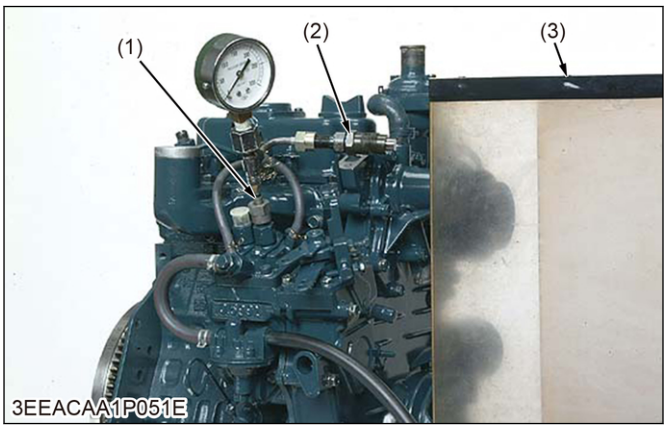
## 4.19 Checking fuel tightness of pump element

**Tools required**

- Injection pump pressure tester

1. Remove the injection pipes and glow plugs.
2. Install the injection pump pressure tester (1) to the injection pump.

3. Install the injection nozzle (2) jetted with the proper injection pressure to the injection pump pressure tester (1). (Refer to the photo.)




(1) Injection pump pressure tester
(2) Injection nozzle
(3) Protection cover for jetted fuel

4. Set the speed control lever to the maximum speed position.
5. Operate the starter to increase the pressure.

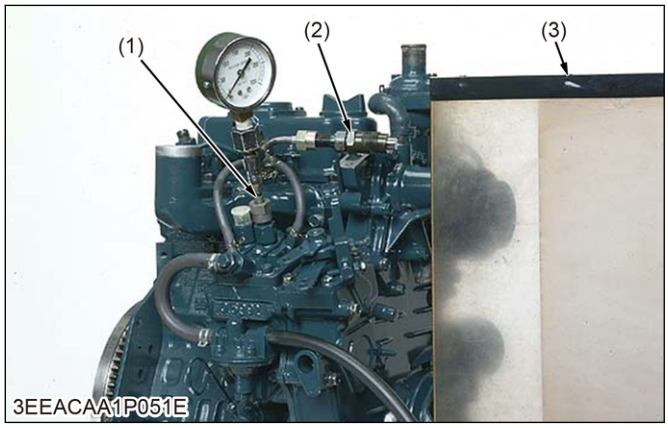
**NOTE**
- **If the pressure can not reach the service limit, replace the pump with a new one or repair it at a Kubota-authorized pump service shop.**
- **Never try to disassemble the injection pump assembly.**
  **For repairs, you are strongly requested to contact a Kubota-authorized pump service shop.**

| | | |
|---|---|---|
| Fuel tightness of pump element | Service limit | 13.7 MPa<br>140 kgf/cm$^2$<br>1990 psi |

## 4.20 Checking fuel tightness of delivery valve

**Tools required**
- Injection pump pressure tester

1. Remove the injection pipes and glow plugs.
2. Set an injection pump pressure tester (1) to the fuel injection pump.
3. Install the injection nozzle (2) jetted with the proper injection pressure to the injection pump pressure tester (1).




(1) Injection pump pressure tester
(2) Injection nozzle
(3) Protection cover for jetted fuel

4. Operate the starter to increase the pressure.
5. Stop the starter when the fuel jets from the injection nozzle (2). After that, turn the flywheel by hands and raise the pressure to approx. 13.73 MPa (140.0 kgf/cm$^2$ , 1991 psi).
6. Now turn the flywheel back about half a turn (to keep the plunger free) and keep the flywheel at this position.
7. Measure the time until the pressure drops.

**NOTE**
- **If the measurement is less than service limit, replace the pump with a new one or repair it at a Kubota-authorized pump service shop.**
- **Never try to disassemble the injection pump assembly.**
  **For repairs, you are strongly requested to contact a Kubota-authorized pump service shop.**

| | | |
|---|---|---|
| Fuel tightness of delivery valve | Service specification | 10 seconds<br>From 13.73 to 12.75 MPa<br>From 140.0 to 130.0 kgf/cm$^2$<br>From 1991 to 1849 psi |
| | Service limit | 5 seconds<br>From 13.73 to 12.75 MPa<br>From 140.0 to 130.0 kgf/cm$^2$<br>From 1991 to 1849 psi |

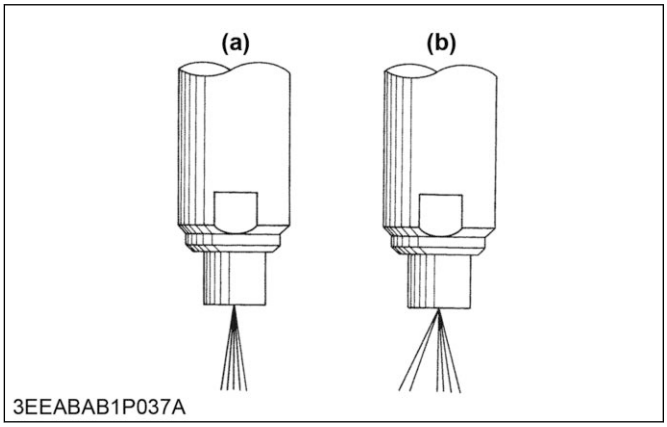
## 4.21 Checking injection nozzle spraying condition

**CAUTION**
- **Check the injection pressure and condition after you make sure that there is nobody standing in the direction the fume goes.**

- **If the fume from the nozzle directly contacts the human body, cells may be destroyed and blood poisoning may be caused.**

1. Set the injection nozzle to the nozzle tester.
2. Check the nozzle spraying condition.

**NOTE**
- **If the spraying condition is damaged, replace the nozzle piece.**



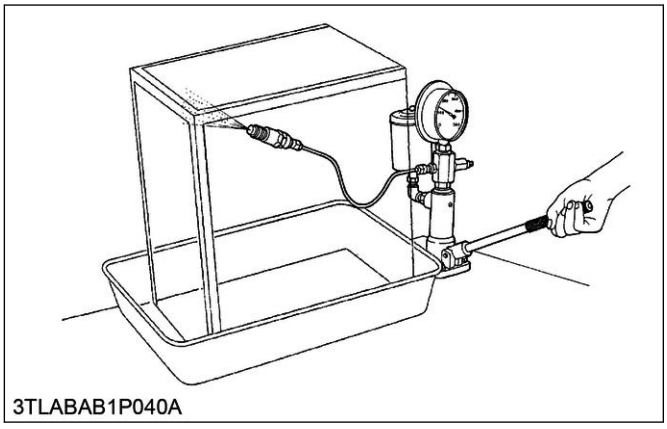

(1) Good (2) Bad

## 4.22 Checking fuel injection pressure

**CAUTION**
- **Check the injection pressure and condition, after you make sure that there is nobody standing in the direction the fume goes.**
- **If the fume from the nozzle directly contacts a human body, the fume might destroy cells of a human body and cause blood poisoning.**

**Tools required**
- Nozzle tester

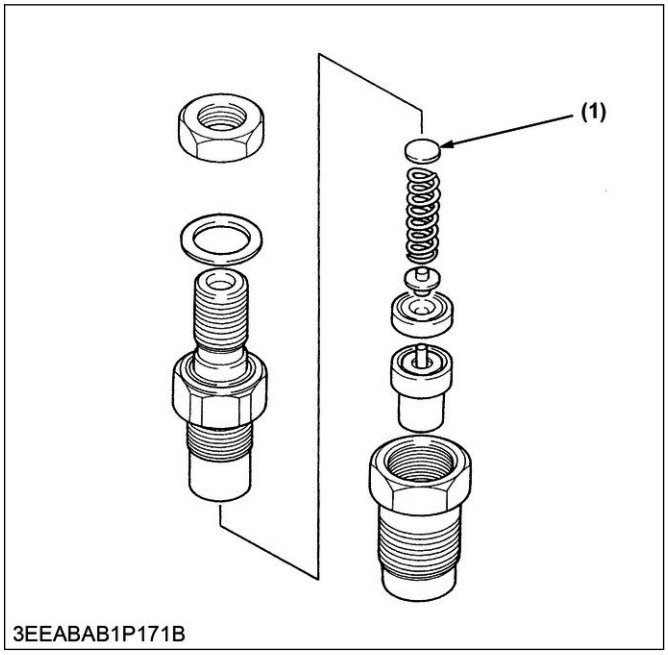
1. Set the injection nozzle to the nozzle tester.




2. Slowly move the nozzle tester's handle to measure the pressure at which the fuel begins to jet out from the injection nozzle.

**NOTE**
- **If the measurement is not within the service specification, replace the adjusting washer (1) in the nozzle holder to adjust.**
- **Pressure changes approx. 590 kPa (6.02 kgf/cm$^2$ , 85.6 psi) for every 0.025mm (0.00098 in.) change in thickness of washers.**

| | | |
|---|---|---|
| Fuel injection pressure | Service specification | 13.7 to 14.7 MPa<br>140 to 149 kgf/cm$^2$<br>1990 to 2130 psi |

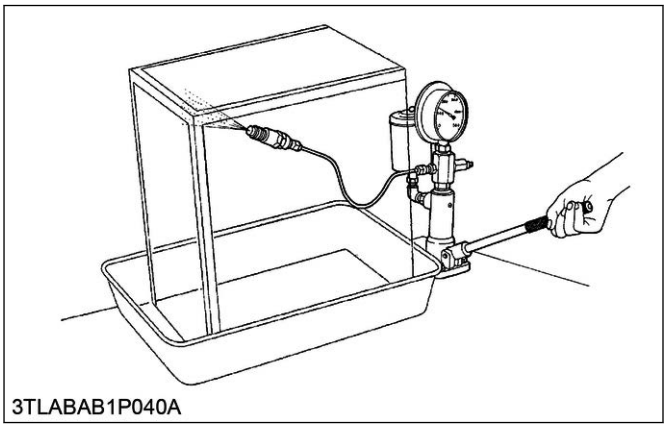



(1) Adjusting washer

## 4.23 Checking nozzle valve seat tightness

**CAUTION**
- **Check the injection pressure and condition after you make sure that there is nobody standing in the direction the fume goes.**
- **If the fume from the nozzle directly contacts the human body, cells may be destroyed and blood poisoning may be caused.**

1. Set the injection nozzle to the nozzle tester.



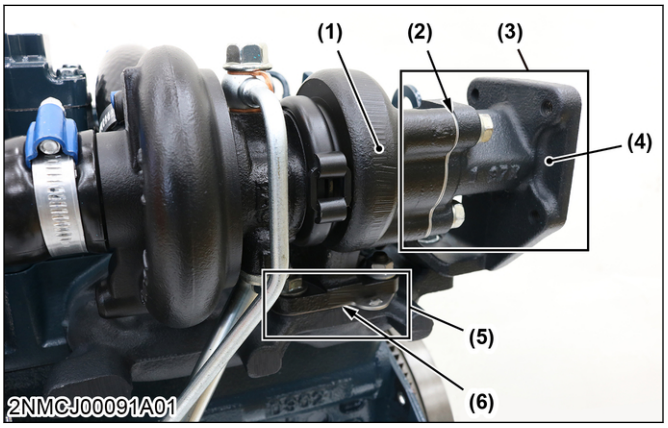

2. Raise the fuel pressure, and keep at specified pressure for 10 seconds.

**■ NOTE**
- **If any fuel leak is found, replace the nozzle piece.**

| | | |
|---|---|---|
| Valve seat tightness | Service specification | No fuel leak at<br>12.75 MPa<br>130.0 kgf/cm$^2$<br>1849 psi |

## 4.24 Checking exhaust gas leakage of turbocharger turbine side

1. Check the exhaust port (3) and the inlet port (5) side of the turbine housing (1) for exhaust gas leakage.

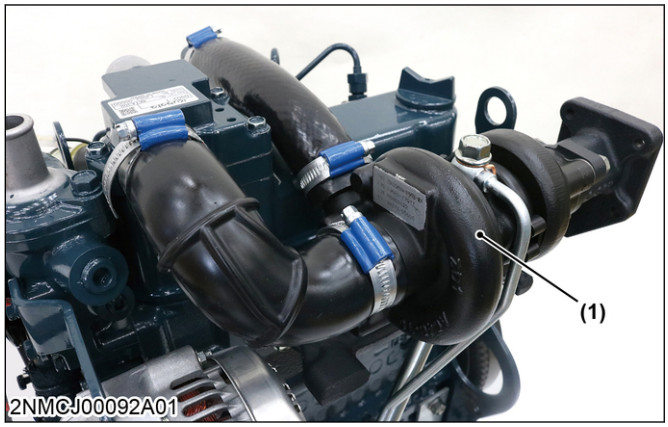



(1) Turbine housing
(2) Gasket
(3) Exhaust port
(4) Gasket
(5) Inlet port
(6) Gasket

**■ NOTE**
- **If you find a gas leakage, tighten the screws and nuts again or replace the gasket (2) / (4) / (6) with a new one.**

## 4.25 Checking air leakage of turbocharger compressor side

1. Check the inlet hose of the compressor cover (1) for air leakage.
2. Check the suction side of the inlet hose for loose connections or cracks.

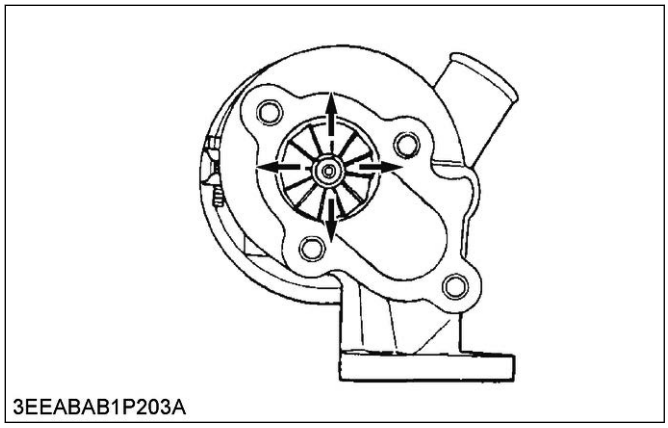



(1) Compressor cover

**■ NOTE**
- **If you find an air leakage, change the clamps and / or the inlet hose.**

## 4.26 Checking radial clearance of turbocharger

1. Check the radial clearance between the wheel and the housing.



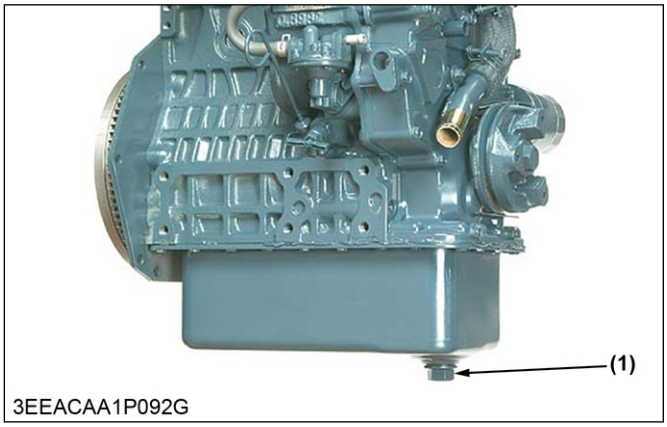

**■ NOTE**
- **If the wheel touches the housing, replace the turbocharger assembly with a new one.**

# 5. Disassembling

## 5.1 Draining engine oil

1. Start and increase the temperature of the engine for approximately 5 minutes.

2. Put an oil pan below the engine.
3. Remove drain plug (1) to drain the engine oil.




(1) Drain plug

4. After you drain the engine oil, tighten the drain plug (1) to the specified torque..

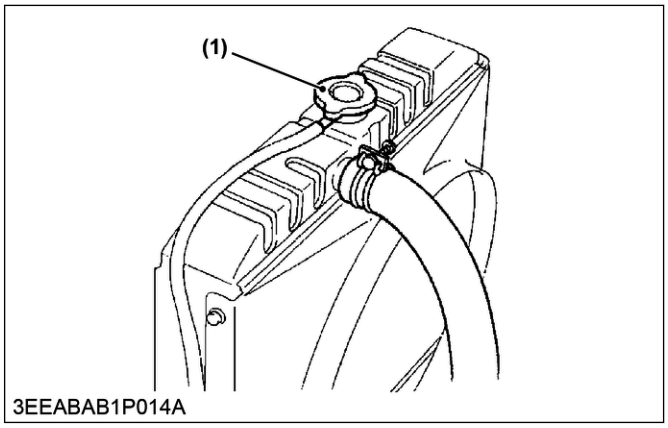
| | | | |
|---|---|---|---|
| Tightening torque | Drain plug with copper gasket | M12 × 1.25 | 33.0 to 37.0 N·m<br>3.37 to 3.77 kgf·m<br>24.4 to 27.2 lbf·ft |
| | | M22 × 1.5 | 64.0 to 73.0 N·m<br>6.53 to 7.44 kgf·m<br>47.2 to 53.8 lbf·ft |
| | Drain plug with rubber coated gasket | M22 × 1.5 | 45.0 to 53.0 N·m<br>4.59 to 5.40 kgf·m<br>33.2 to 39.0 lbf·ft |
| | Drain plug (D902-TE4) | M22 × 1.5 | 44.1 to 53.9 N·m<br>4.50 to 5.49 kgf·m<br>32.6 to 39.7 lbf·ft |

## 5.2 Draining coolant

**CAUTION**

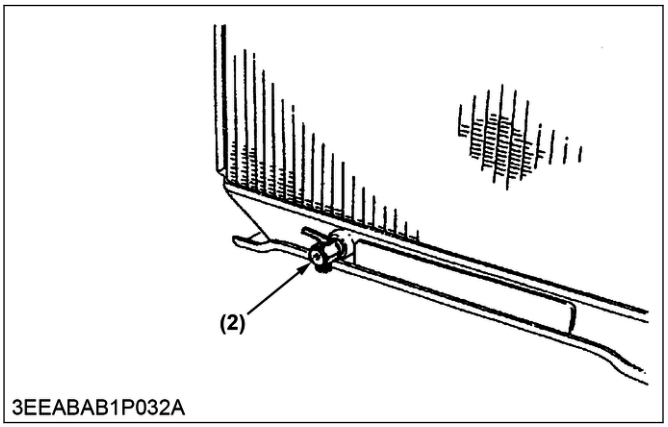
- **Do not remove the radiator cap while you operate or immediately after you stop the engine.**
- **If not, hot water can flow out from the radiator.**
- **Only open the cap after more than 10 minutes for the temperature of the radiator to decrease.**

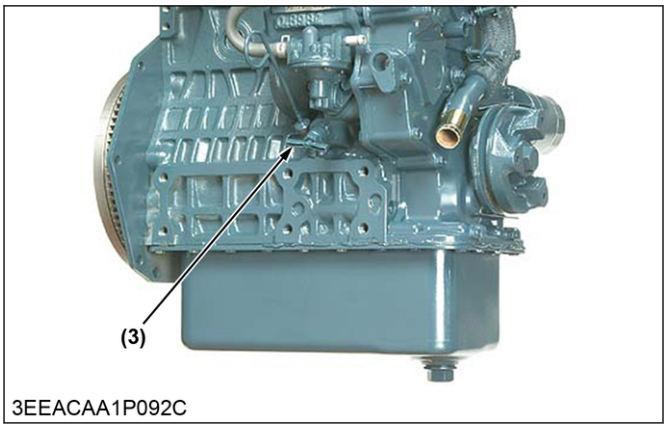
1. Prepare a bucket.
2. Remove the radiator cap (1) to drain the coolant fully.

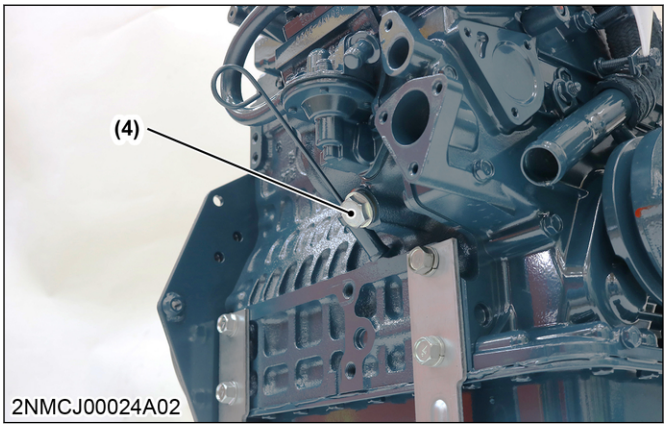



(1) Radiator cap

3. Open the drain valve (2) (3) and drain plug (4) to drain the coolant.



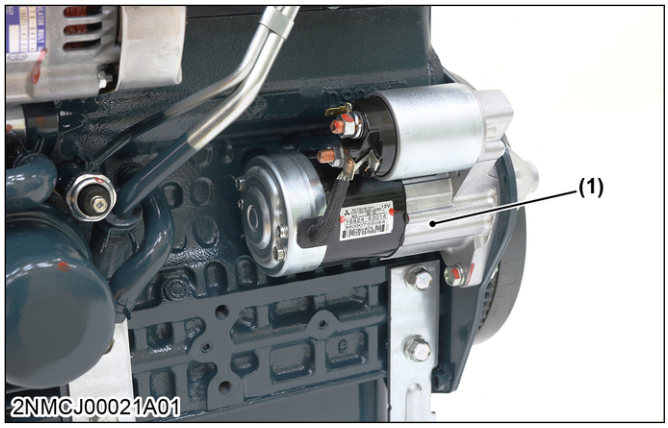

(2) Drain valve
(3) Drain valve for Z482-E4BG/ Z482 Z602 D722 D782 D902-E4
(4) Drain plug for D902-TE4

4. After you drain, close the drain valve (2) (3) and tighten the drain plug (4) to the specified torque.

| | | |
|---|---|---|
| Tightening torque | Drain plug (4) | 32.0 to 43.0 N·m<br>3.27 to 4.38 kgf·m<br>23.6 to 31.7 lbf·ft |

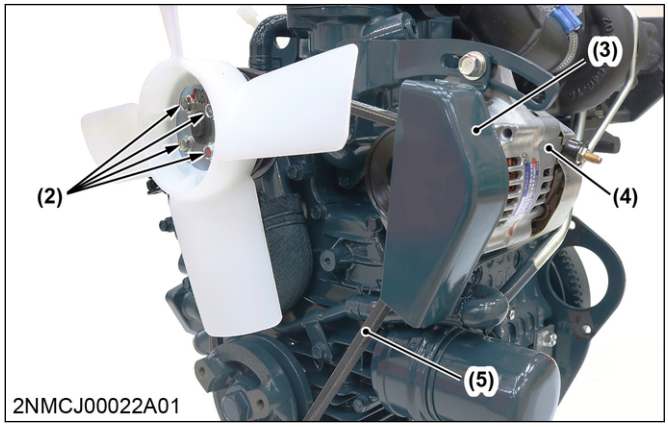
## 5.3 Removing external components

1. Remove the air cleaner.
2. Remove the starter (1).



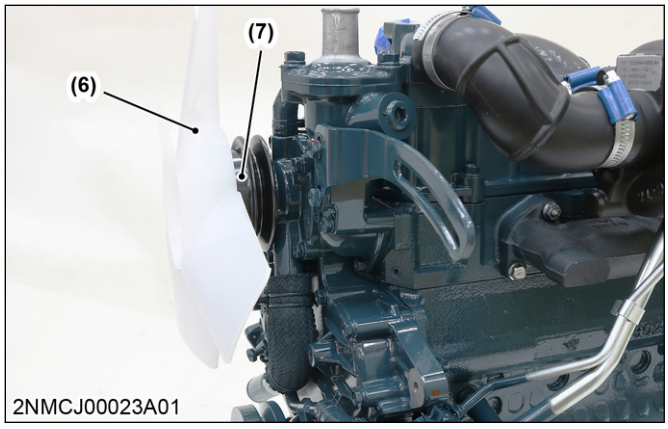

(1) Starter

3. Loosen the cooling fan mounting screws (2).
4. Remove the alternator (4) and fan belt cover (3).
5. Remove the fan belt (5).




(2) Cooling fan mounting screw
(3) Fan belt cover
(4) Alternator
(5) Fan belt

6. Remove the cooling fan (6) and fan pulley (7).



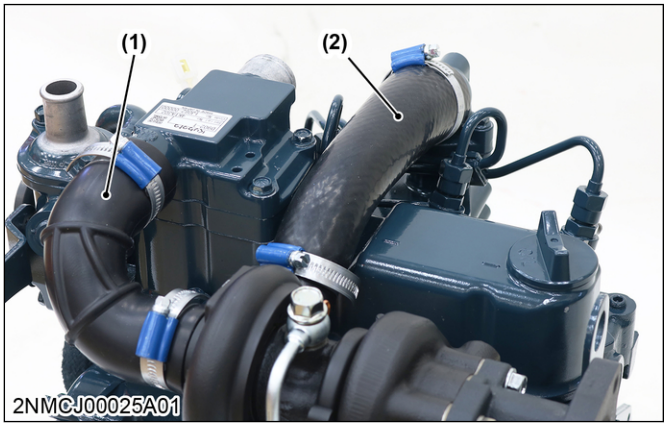

(6) Cooling fan
(7) Fan pulley

## 5.4 Removing turbocharger assembly for D902-TE4

**CAUTION**
- **While the engine operates or just after it stops, do not touch the hot turbocharger assembly.**

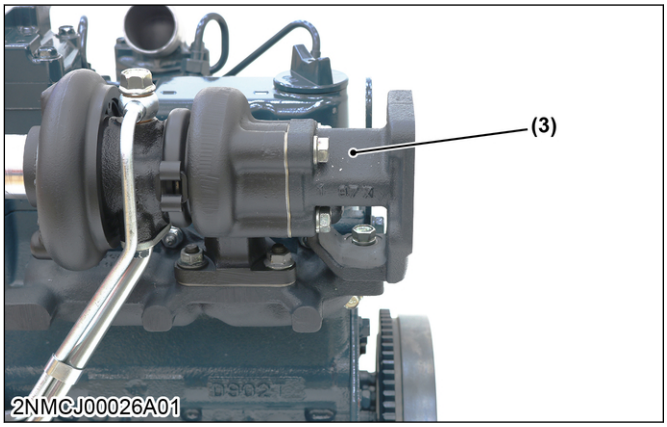
**NOTE**
- **When you remove the turbocharger assembly, do not let dust, dirt and other unwanted materials in the oil pipes.**

1. Remove the inlet hose (1), (2).




(1) Inlet hose (2) Inlet hose

2. Remove the turbocharger bracket (3).



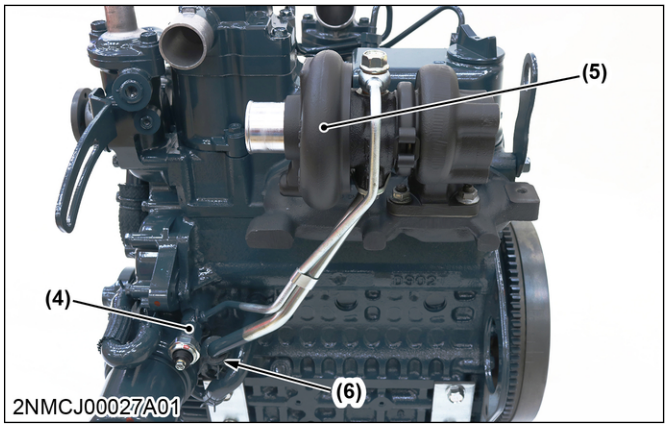

(3) Turbocharger bracket

3. Remove the oil pipe joint screw (4).

**NOTE**
- **No need to remove the oil pressure switch. Remove the oil joint screw directory.**

4. Remove the turbocharger assembly (5) with the return pipe (6).

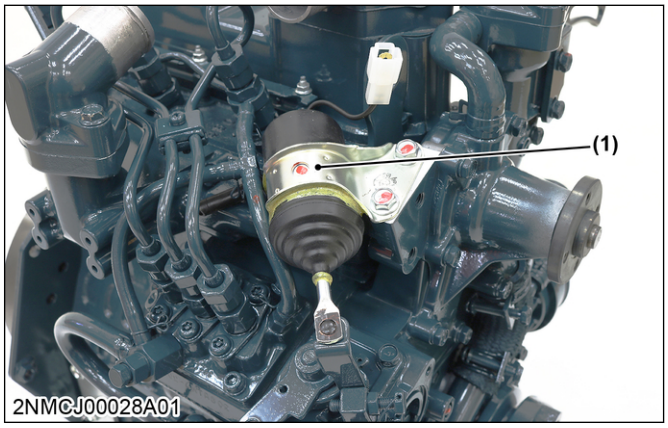
**NOTE**
- **Put tape or cover on all openings to prevent damage in the oil holes in the turbocharger by unwanted materials.**




(4) Oil pipe joint screw (6) Return pipe
(5) Turbocharger assembly

## 5.5 Removing engine stop solenoid

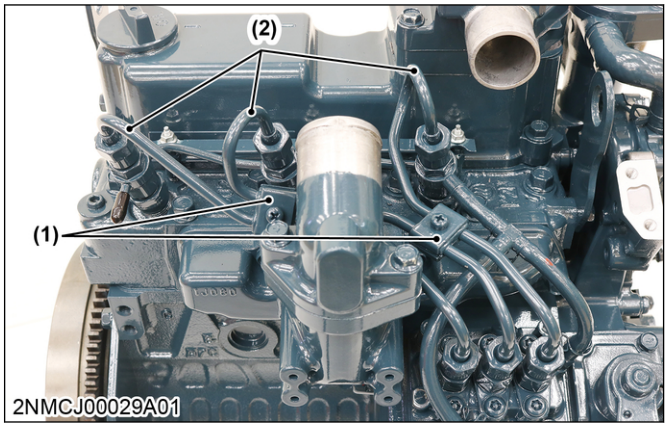
1. Remove the engine stop solenoid (1).




(1) Engine stop solenoid

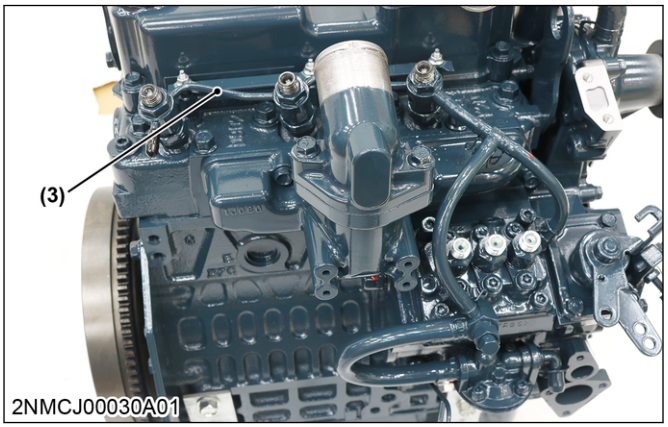
## 5.6 Removing injection nozzle holder

1. Remove the screws of the pipe clamp (1).
2. Remove the injection pipe (2).




(1) Pipe clamp (2) Injection pipe

3. Remove the overflow pipe (3).

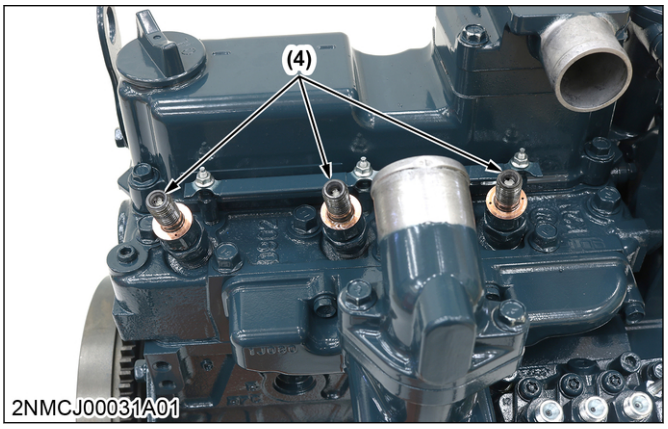



(3) Overflow pipe

4. Remove the injection nozzle holder (4).

**CAUTION**

- **Keep the injection nozzle holder with numbering cylinder order.**



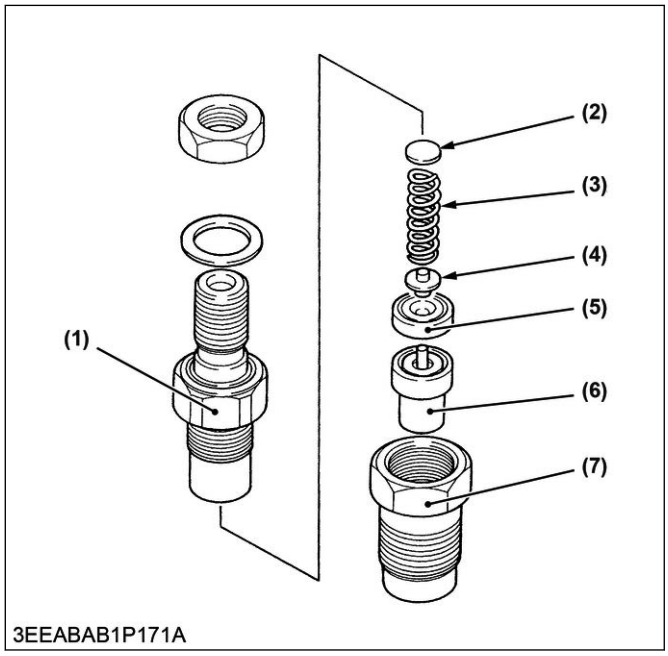

(4) Injection nozzle holder

## 5.7 Disassembling injection nozzle holder assembly

**Tools required**

- Vise

1. Secure the nozzle retaining nut (7) with a vise.
2. Remove the nozzle holder (1).
3. Remove the inside parts.




(1) Nozzle holder
(2) Adjusting washer
(3) Nozzle spring
(4) Push rod
(5) Distance piece
(6) Nozzle piece
(7) Nozzle retaining nut

## 5.8 Removing injection nozzle heat seal

**IMPORTANT**

- **Be careful not to apply the power than necessary when knock in a screwdriver (1). It may break the combustion chamber.**

1. Insert a screwdriver (1) to the hole of heat seal and hit with light power.

**NOTE**

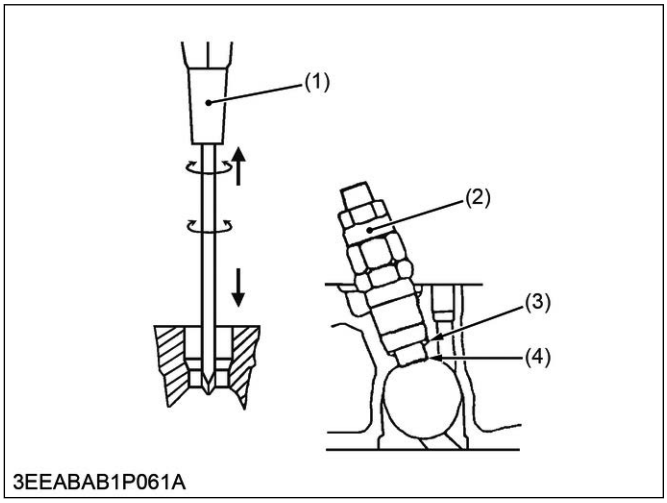
- **Use tip of a screwdriver (1) bigger than the heat seal hole.**

| | |
|---|---|
| Hole diameter of the heat seal (4) | Approx.<br>6.0 mm<br>0.24 in. |

2. Rotate a screwdriver (1) 3 or 4 times.

3. 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.**

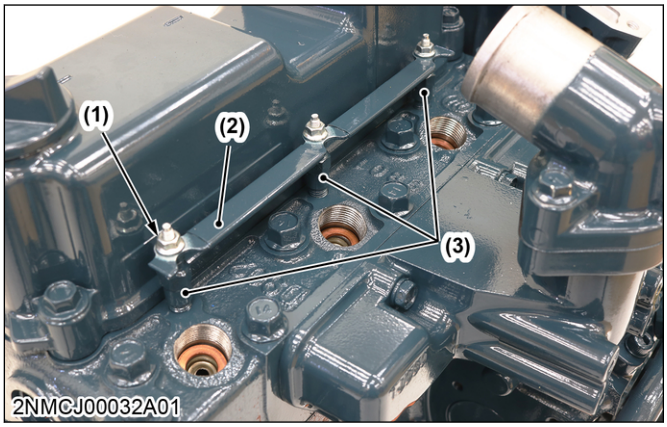



(1) Screwdriver
(2) Injection nozzle assembly
(3) Gasket
(4) Heat seal

## 5.9 Removing glow plug

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

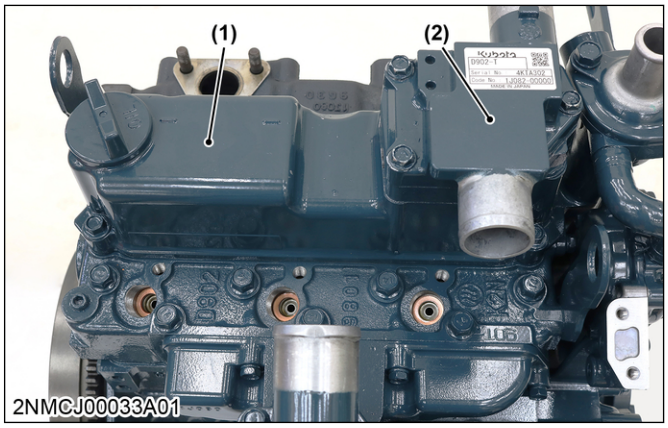
**■ NOTE**
- **Keep the glow plug with numbering cylinder order.**




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

## 5.10 Removing cylinder head cover

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

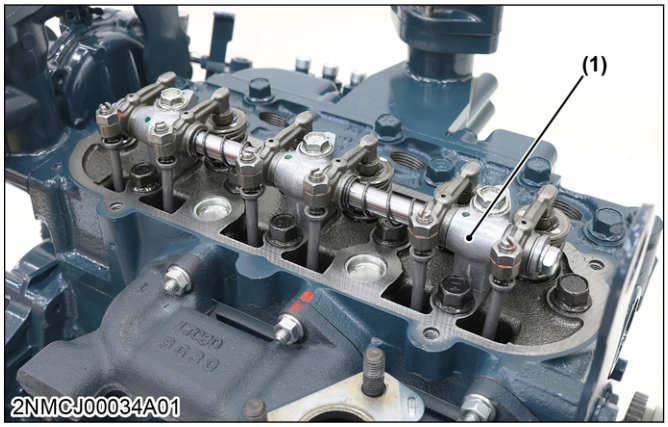



(1) Cylinder head cover
(2) Breather cover

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

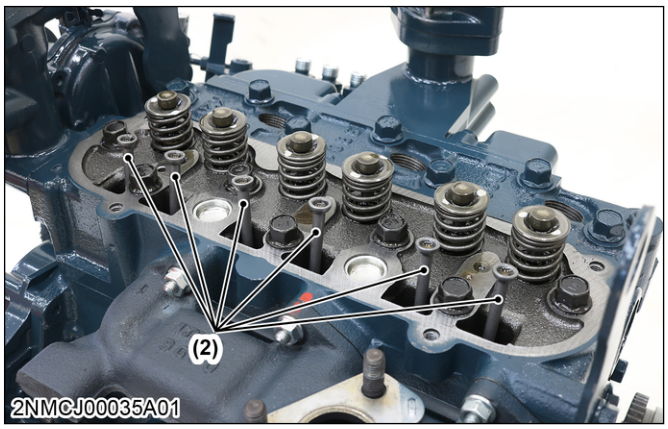
## 5.11 Removing rocker arm assembly

1. Remove the rocker arm assembly (1).




(1) Rocker arm assembly

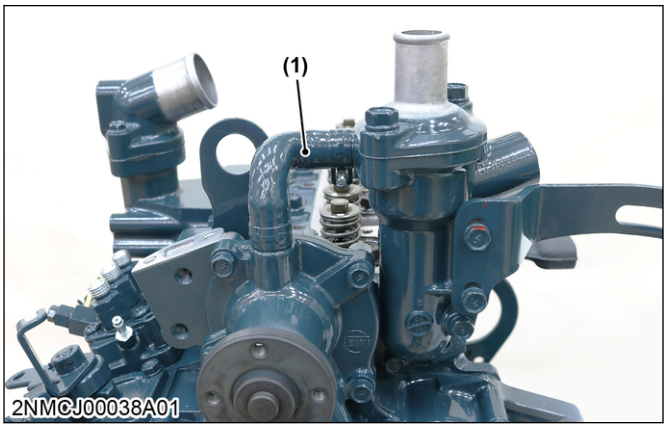
2. Remove the push rod (2).




(2) Push rod

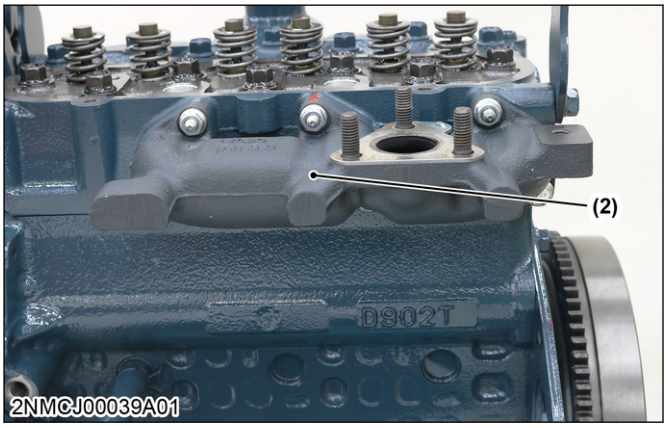
## 5.12 Removing cylinder head

1. Loosen the pipe clamps and remove the water return hose (1).



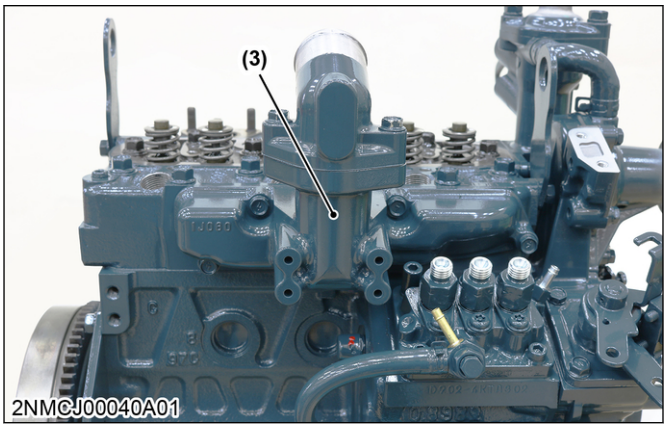

(1) Water return hose

2. Remove the exhaust manifold (2).



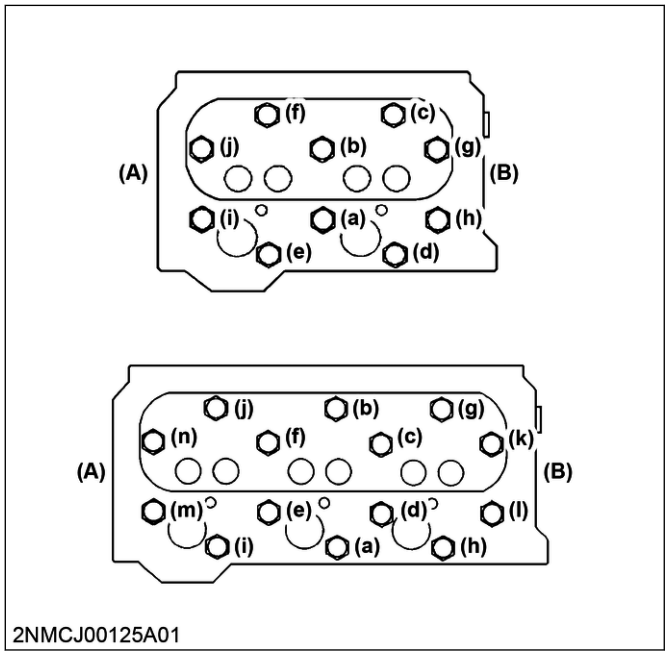

(2) Exhaust manifold

3. Remove the intake manifold (3).



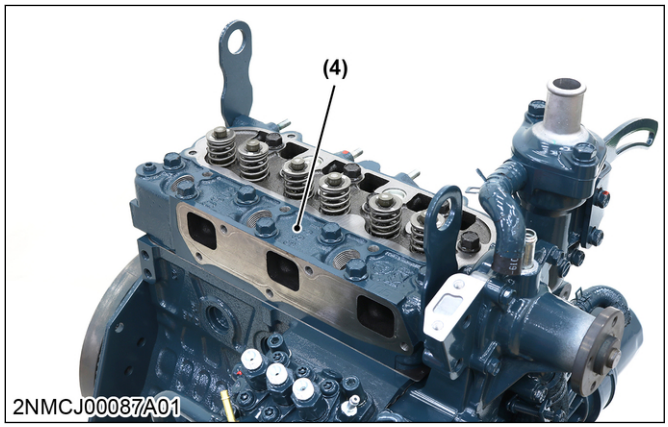

(3) Intake manifold

4. Remove the cylinder head mounting screw in the sequence of (n) or (j) to (a).




(A) Flywheel side (B) Gear case side

5. Remove the cylinder head (4) and the cylinder head gasket.



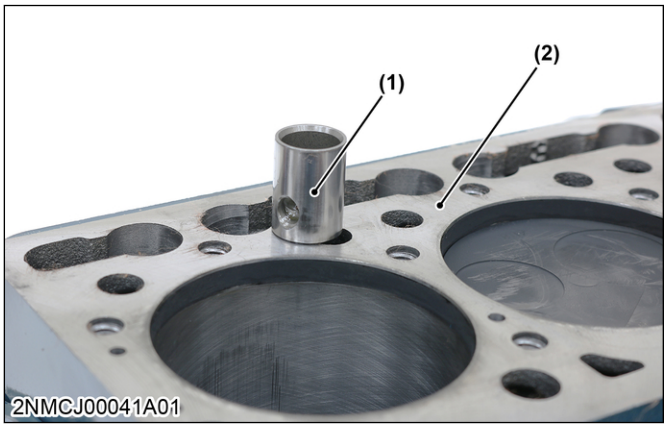

(4) Cylinder head

## 5.13 Removing tappet

**NOTE**

- **Mark the cylinder number to the tappet to prevent interchanging.**

1. Remove the tappet (1) from the crankcase (2).




(1) Tappet
(2) Crankcase

## 5.14 Removing valve

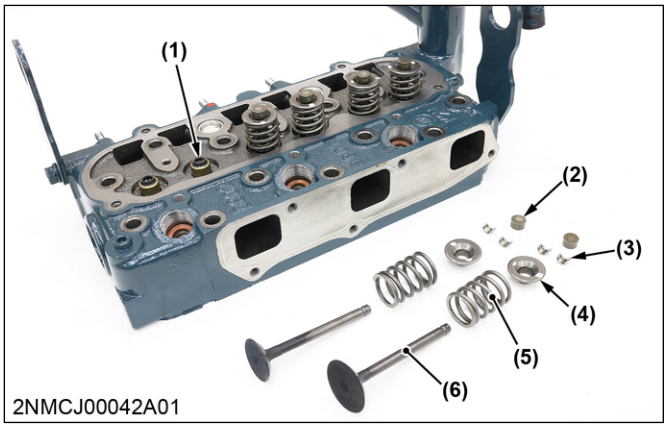
**NOTE**

- **Mark the cylinder number to the valve to prevent interchanging.**

**Tools required**

- Valve spring compressor

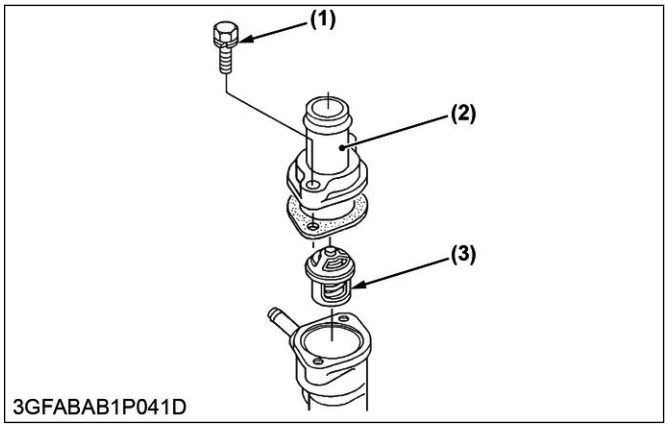
1. Remove the valve cap (2).
2. Push the valve spring (5) with the valve spring retainer (4) by valve spring compressor and remove the valve spring collet (3).
3. Remove the valve spring (5), valve spring retainer (4) and valve (6).
4. Remove the valve stem seal (1).




(1) Valve stem seal
(2) Valve cap
(3) Valve spring collet
(4) Valve spring retainer
(5) Valve spring
(6) Valve

## 5.15 Removing thermostat assembly

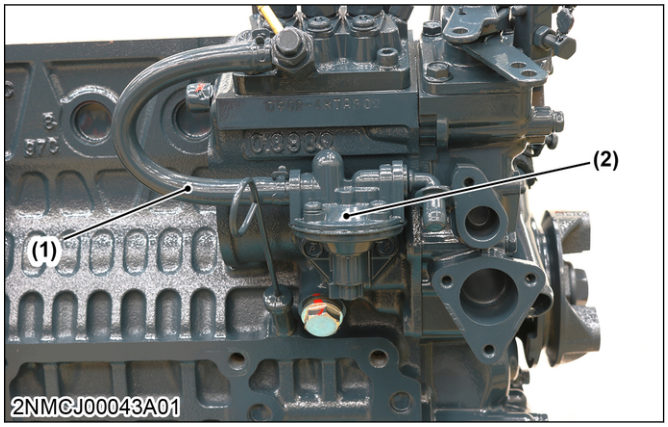
1. Remove the thermostat cover mounting screws (1), and remove the thermostat cover (2).
2. Remove the thermostat assembly (3).




(1) Thermostat cover mounting screw
(2) Thermostat cover
(3) Thermostat assembly

## 5.16 Removing fuel injection pump (Energized to stop type engine stop solenoid)

1. Remove the fuel hose (1) and the fuel feed pump (2).

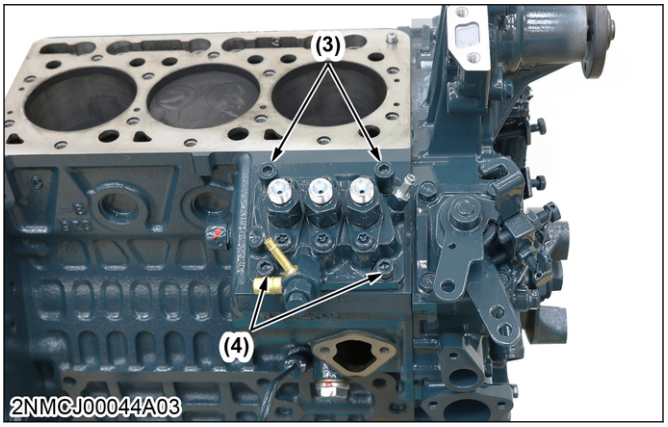



(1) Fuel hose
(2) Fuel feed pump

2. Remove the hex socket cap screw (4) and the cap nut (3).

**■ NOTE**

- **Hold the fuel injection pump (6) to prevent from pushed out.**

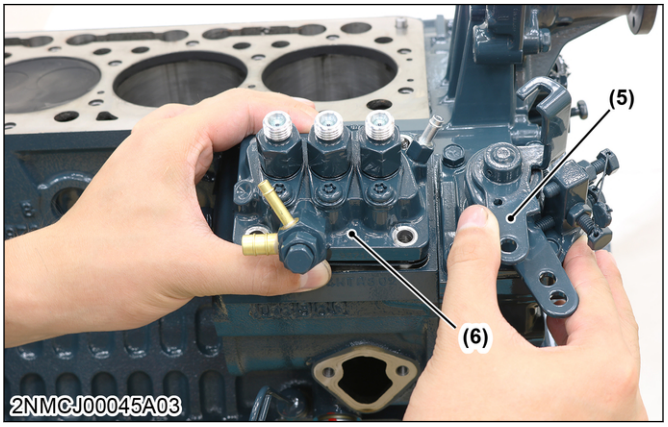


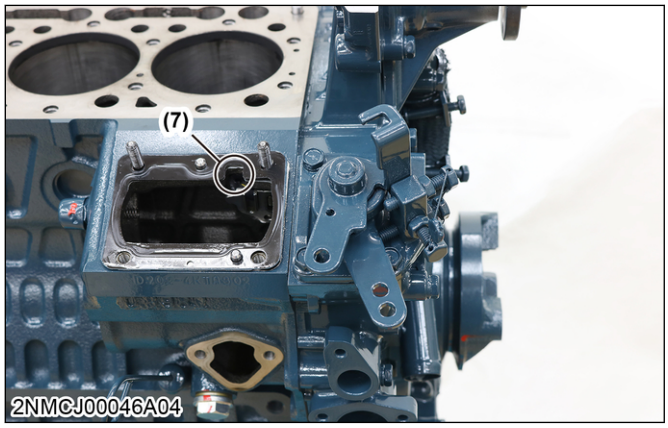

(3) Cap nut
(4) Hex socket cap screw

3. Fit the control rack pin to the slot (7) position of the crankcase with moving the speed control lever (5).

**■ IMPORTANT**

- **If control rack pin is not fitted at slot (7) position of crankcase, it is difficult to remove the fuel injection pump (6). Furthermore, this case will occur to break control rack pin.**



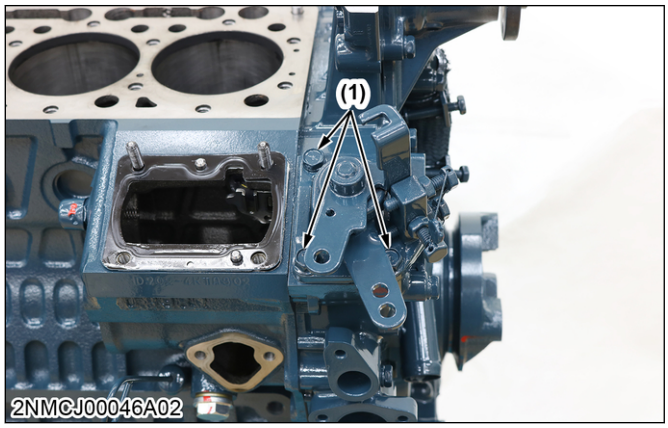




(5) Speed control lever
(6) Fuel injection pump
(7) Slot

4. Remove the fuel injection pump (6).

## 5.17 Removing speed control plate (Energized to stop type engine stop solenoid)

1. Remove the speed control plate mounting screw (1).

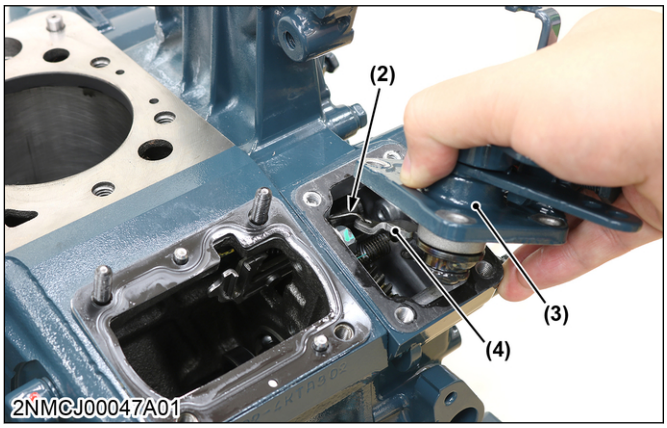


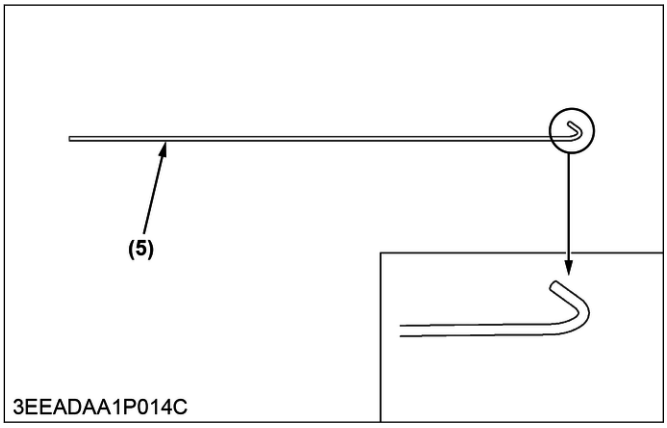

(1) Speed control plate mounting screw

2. Pick up the speed control plate (3).

3. Disconnect the governor spring (2) from the governor lever (4) and remove the speed control plate (3) with the specific tool.

**IMPORTANT**
- **Specific tool (5) is 1.2 mm (0.047 in.) diameter hard wire with its end hooked, overall length 200 mm (7.87 in.).**
  **The tip of wire is bent like the hook to hang springs.**
- **Do not use the pliers or the longnose pliers when deal with springs.**
- **The governor spring is connected to the speed control plate, so that be careful in fear of broken when remove the speed control plate.**



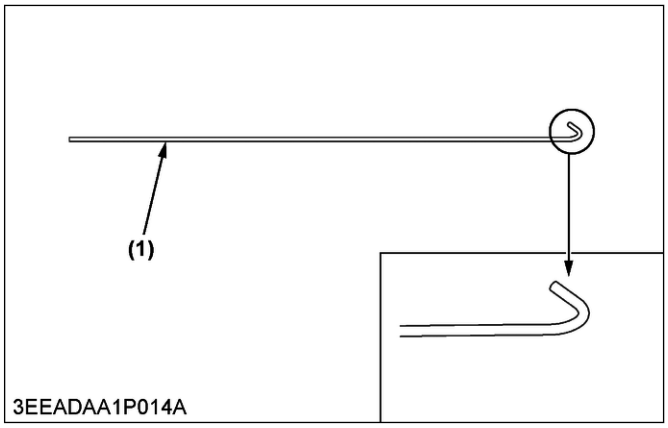




(2) Governor spring
(3) Speed control plate
(4) Governor lever
(5) Specific tool

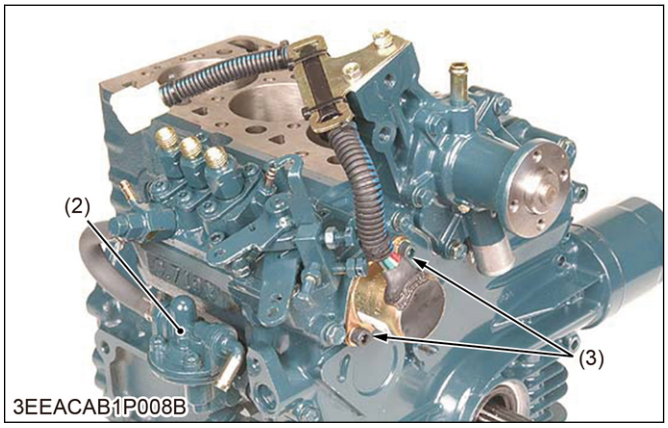
## 5.18 Removing fuel injection pump and speed control plate (Energized to operate type engine stop solenoid)

**Tools required**
- Specific tool (1)

**IMPORTANT**
- **Specific tool (1) is 1.2 mm (0.047 in.) diameter hard wire with its end hooked, overall length 200 mm (7.87 in.).**
  **The tip of wire is bent like the hook to hang springs.**

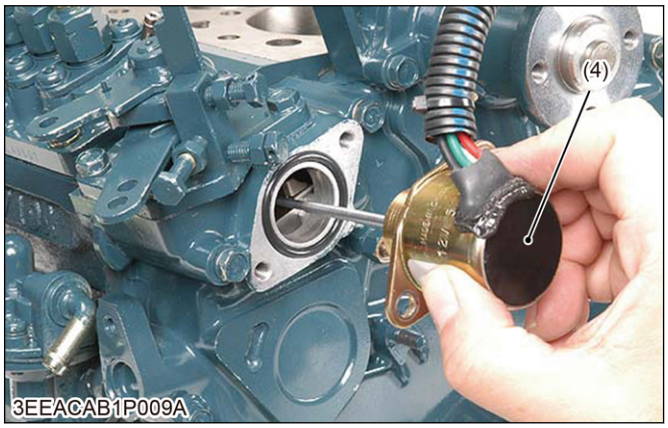



1. Remove the fuel hose, the fuel feed pump (2), and the socket head screws (3).




(2) Fuel feed pump
(3) Socket head screw

2. Remove the engine stop solenoid (4).



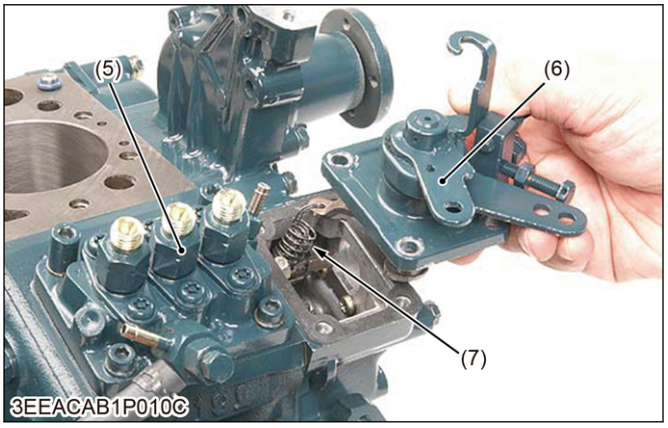

(4) Engine stop solenoid

3. Remove the screws and separate the speed control plate (6), being careful not to damage the governor spring (7).

4. Disconnect the governor spring (7) and remove the speed control plate (6) using the specific tool (1).

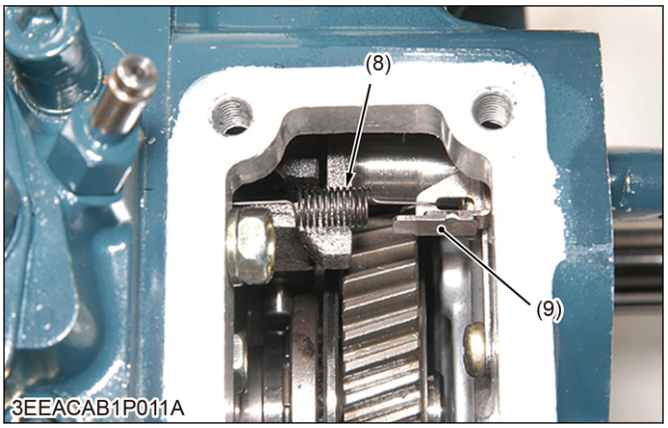
**IMPORTANT**

- **Do not use the pliers or the long nose pliers when deal with springs.**
- **The governor spring is connected to the speed control plate, so that be careful in fear of broken when remove the speed control plate.**




(5) Fuel injection pump
(6) Speed control plate
(7) Governor spring

5. Disconnect the start spring (8) from the bracket (9) using the specific tool (1).




(8) Start spring
(9) Bracket

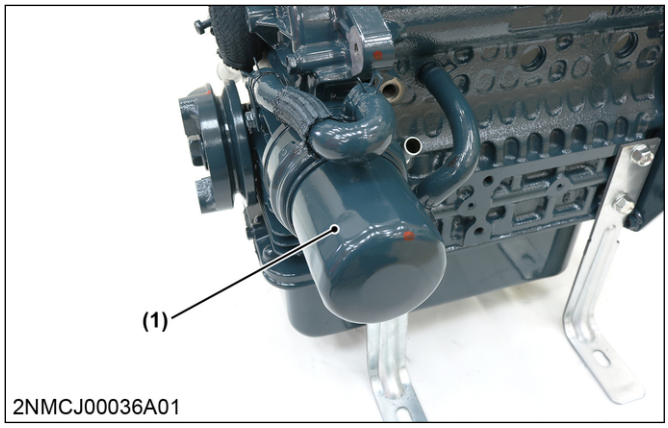
6. Remove the socket head screws and nuts, and remove the fuel injection pump (5).

## 5.19 Removing oil cooler

**Tools required**

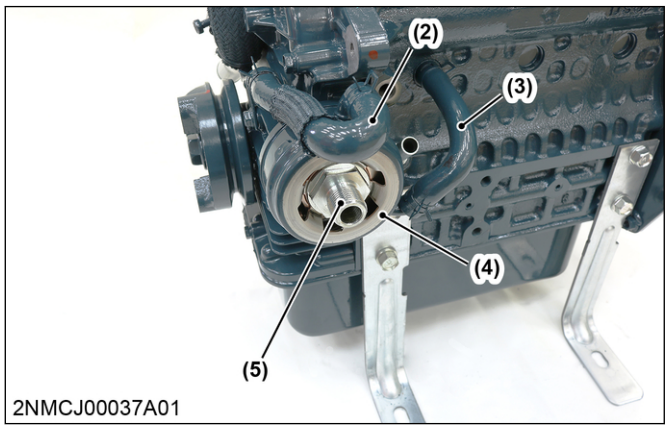
- Filter wrench

1. Remove the oil filter cartridge (1) with the filter wrench.




(1) Oil filter cartridge

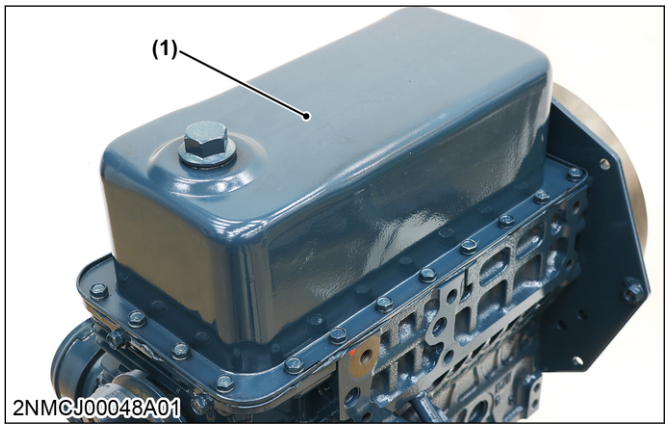
2. Remove the water hoses (2) (3).
3. Remove the oil cooler joint screw (5).
4. Remove the oil cooler (4).




(2) Water hose
(3) Water hose
(4) Oil cooler
(5) Oil cooler joint screw

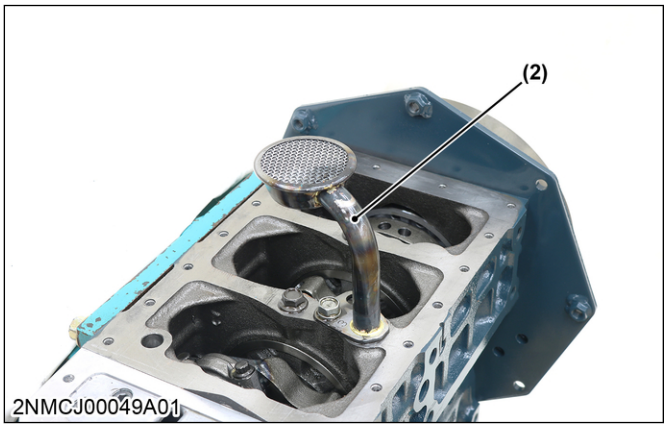
## 5.20 Removing oil pan and oil strainer

1. Remove the oil pan (1).




(1) Oil pan

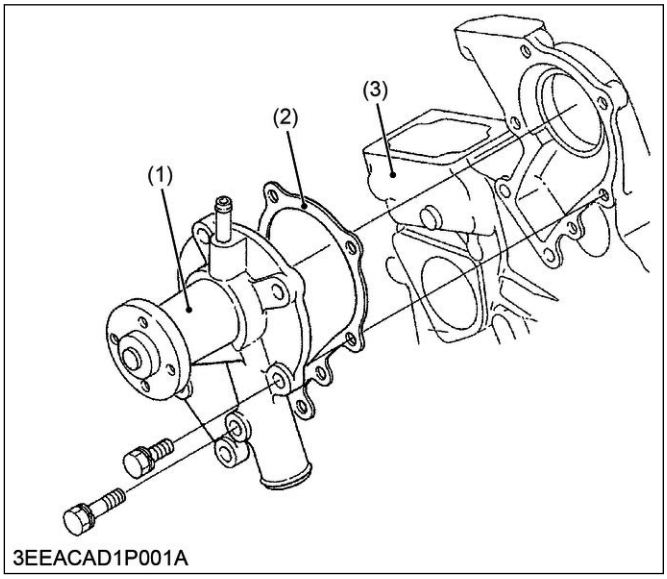
2. Remove the oil strainer (2).




(2) Oil strainer

## 5.21 Removing water pump

1. Remove the water pump assembly from the gear case cover.



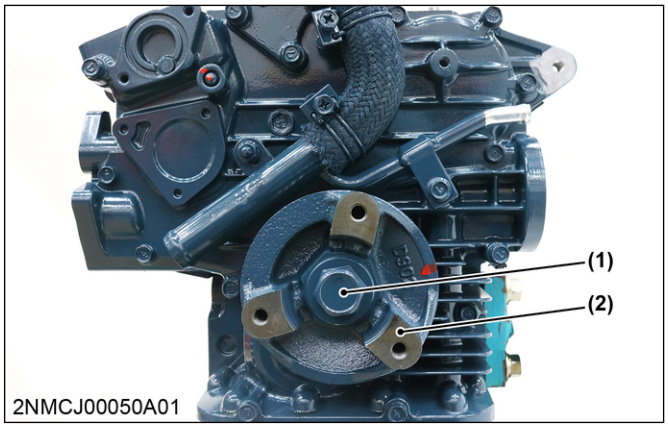

(1) Water pump assembly
(2) Gasket
(3) Gear case cover

## 5.22 Removing fan drive pulley

**Tools required**

- Flywheel stopper

1. Fix the flywheel with a flywheel stopper.
2. Remove the crankshaft screw (1).
3. Remove the fan drive pulley (2).




(1) Crankshaft screw
(2) Fan drive pulley

## 5.23 Removing gear case cover

**IMPORTANT**

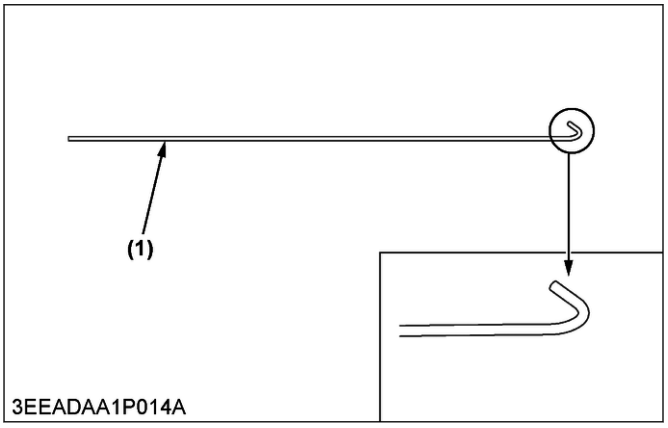
- **Do not touch the tamper proof cap.**
- **If you damage or move the fuel limit screw, please contact your Sales company.**
  **It is necessary to readjust the fuel limit screw with limit restoring tools.**
- **If you replace the gear case cover (5), please contact your Sales company.**
  **It is necessary to readjust the fuel limit screw with limit restoring tools.**

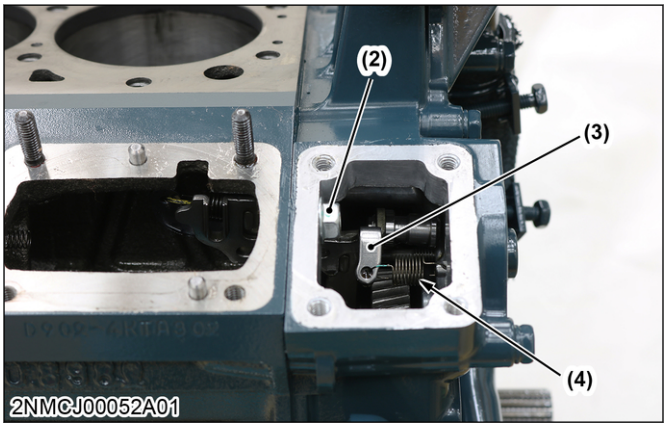
1. Remove the start spring (4) from the fork lever 1 (3) with the specific tool (1).

2. Remove the gear case cover mounting screw (2).

**IMPORTANT**

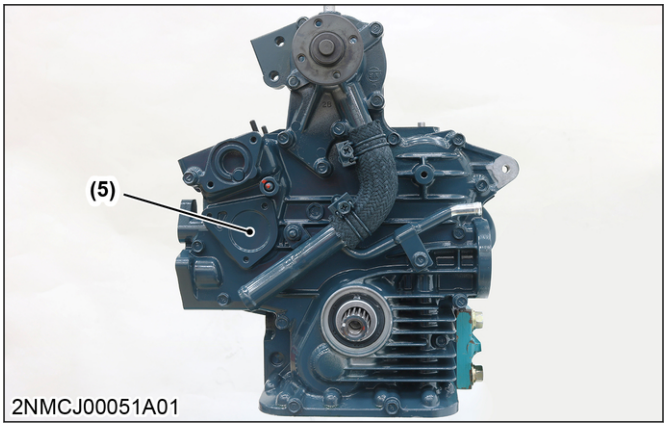
- **Specific tool is 1.2 mm (0.047 in.) diameter hard wire with its end hooked, overall length 200 mm (7.87 in.).**
  **The tip of wire is bent like the hook to hang springs.**
- **Do not use pliers or longnose pliers when deal with the spring.**




(1) Specific tool
(2) Gear case cover mounting screw
(3) Fork lever 1
(4) Start spring

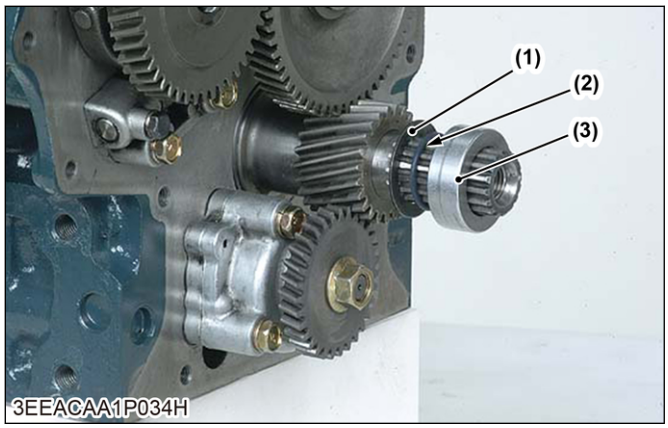
3. Remove the gear case cover (5).




(5) Gear case cover

## 5.24 Removing crankshaft oil slinger

1. Remove the crankshaft collar (3).
2. Remove the O-ring (2).
3. Remove the crankshaft oil slinger (1).




(1) Crankshaft oil slinger
(2) O-ring
(3) Crankshaft collar

## 5.25 Removing oil pump

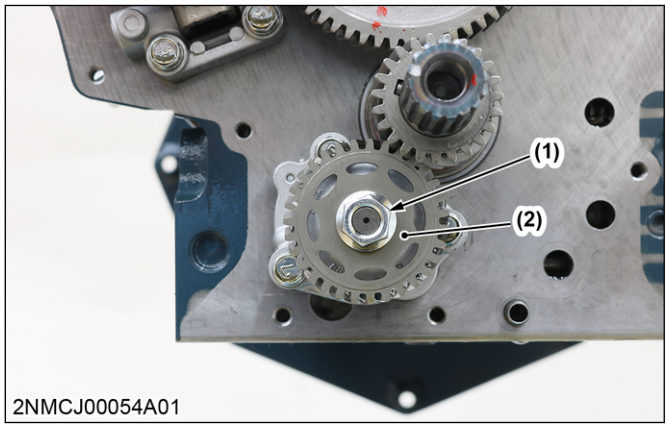
**Tools required**

- Flywheel stopper
- Gear puller

1. Fix the flywheel with flywheel stopper.
2. Remove the oil pump drive gear mounting nut (1).
3. Pull out the oil pump drive gear (2).

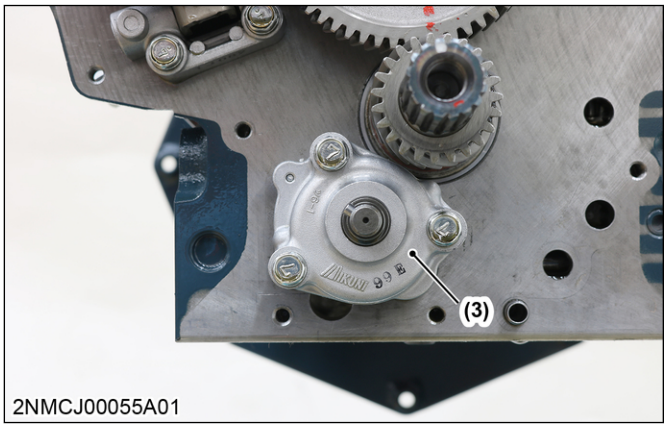
**NOTE**

- **If it is difficult to pull out the oil pump drive gear by hand, use a gear puller.**




(1) Oil pump drive gear mounting nut
(2) Oil pump drive gear

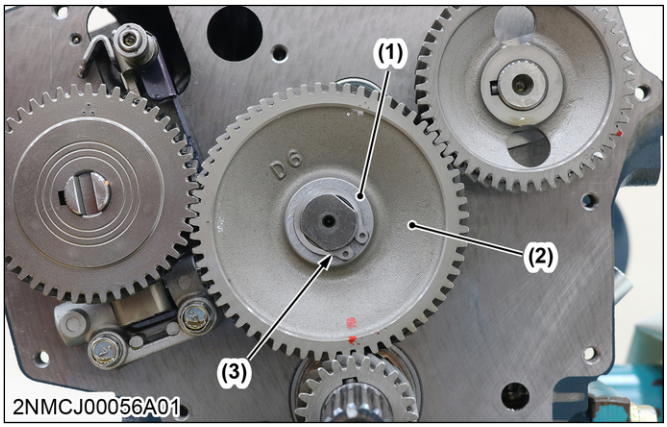
4. Remove the oil pump (3).




(3) Oil pump

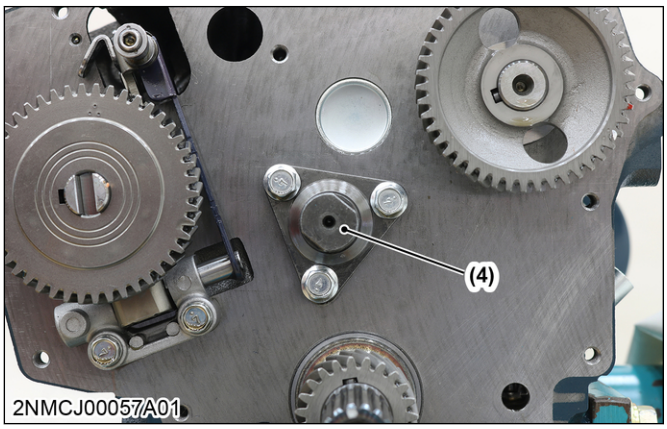
## 5.26 Removing idle gear

1. Remove the snap ring (3).
2. Remove the idle gear collar (1).
3. Remove the idle gear (2).




(1) Idle gear collar
(2) Idle gear
(3) Snap ring

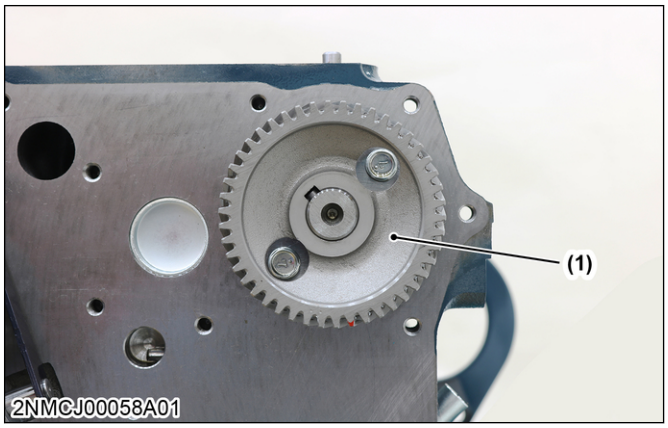
4. Remove the idle gear shaft.




(4) Idle gear shaft

## 5.27 Removing camshaft with cam gear

1. Remove the camshaft set screws and draw out the camshaft with cam gear (1).



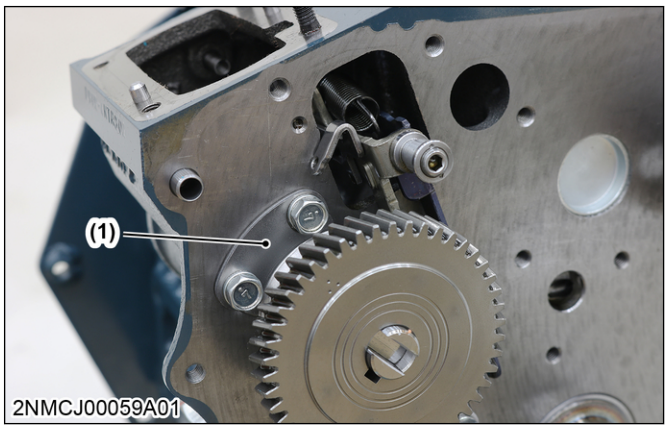

(1) Camshaft with cam gear

## 5.28 Removing fuel camshaft with gear and fork lever assembly

**CAUTION**

- **Do not remove the lock screw of the fork lever shaft.**

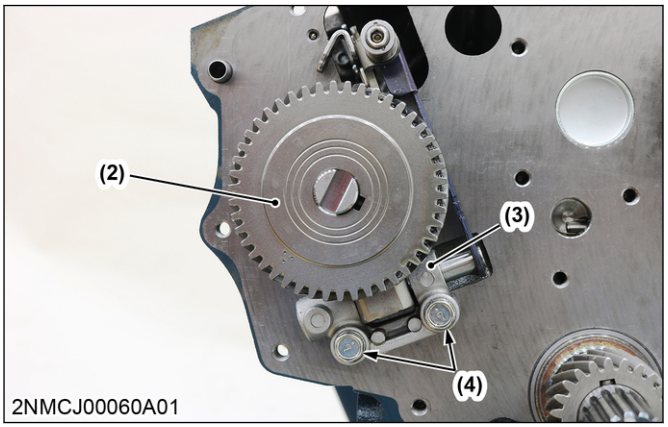
1. Remove the fuel camshaft retaining plate (1).

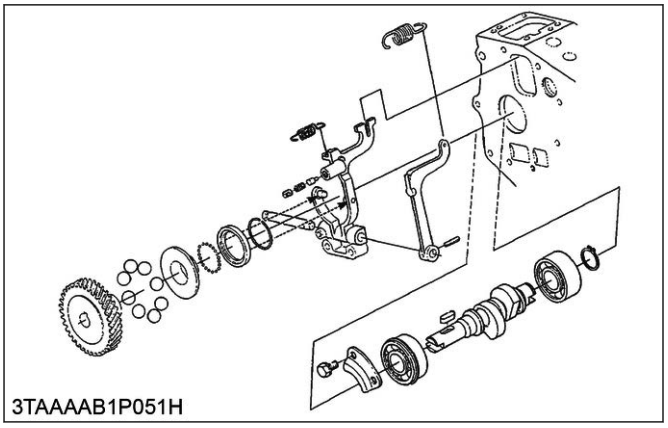



(1) Fuel camshaft retaining plate

2. Remove the fork lever holder mounting screw (4).

3. Remove the fuel camshaft (2) with the fork lever assembly (3).

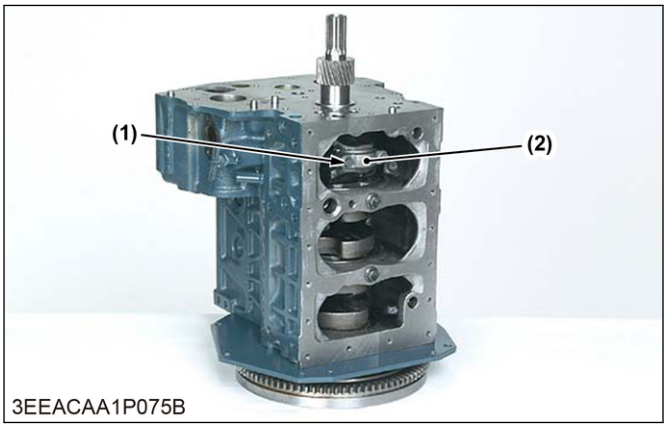



(2) Fuel camshaft
(3) Fork lever assembly
(4) Fork lever holder mounting screw

## 5.29 Removing piston

1. Turn the flywheel and move the piston to bottom dead center.
2. Remove the connecting rod screws (1).
3. Remove the connecting rod cap (2).

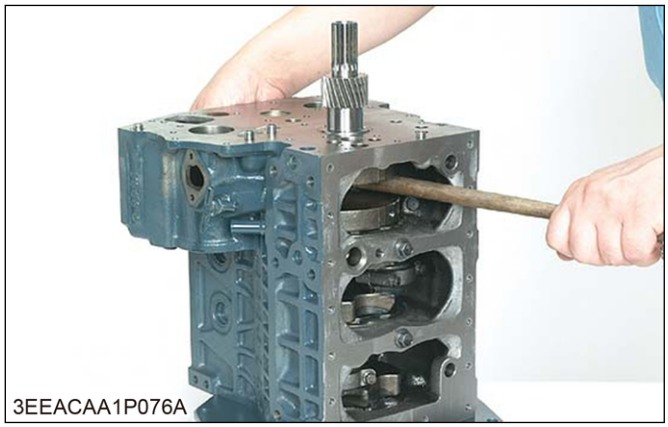



(1) Connecting rod screw
(2) Connecting rod cap

4. Fully clean the carbon in the cylinders.
5. Turn the flywheel and move the piston to top dead center.
6. Lightly tap the connecting rod big end bore from the bottom of the crankcase with the grip of a hammer to pull the piston out.

**IMPORTANT**

- **Do not change the combination of cylinder and piston.**
  **Align the position of each piston by the its mark. For example, mark *"1"* on the No. 1 piston.**

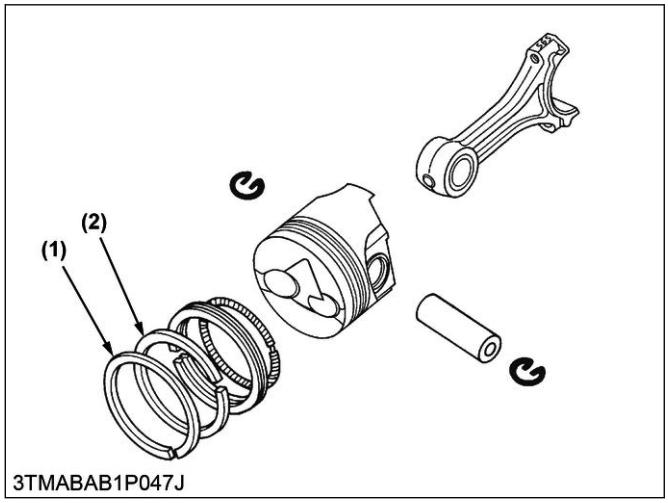



## 5.30 Removing piston ring

**Tools required**

- Piston ring pliers

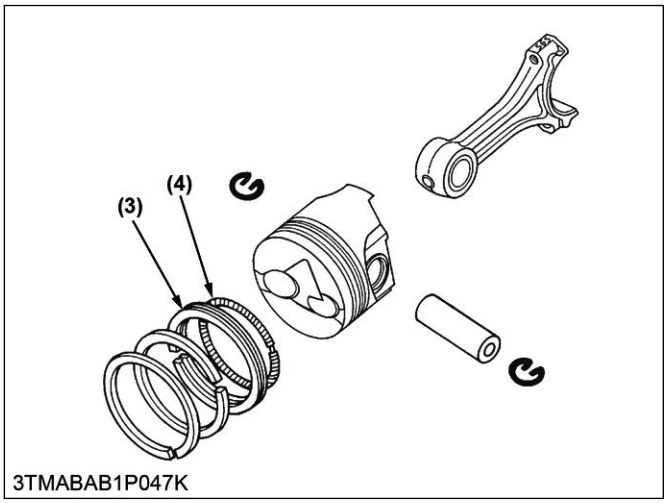
1. Remove the top ring (1) and second ring (2) with a piston ring pliers.




(1) Top ring
(2) Second ring

2. Remove the oil ring (3) with a piston ring pliers.

3. Remove the expander (4).



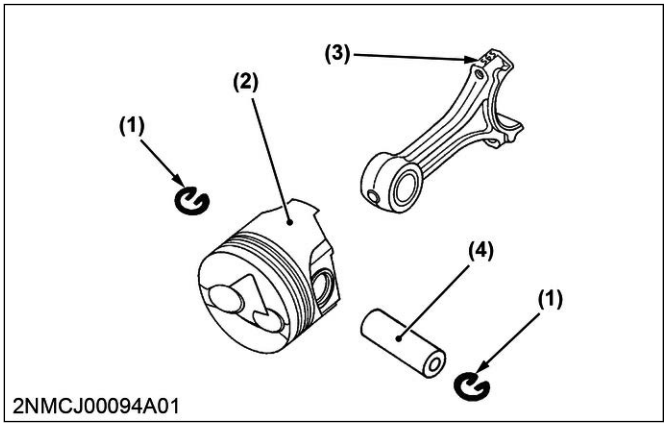

(3) Oil ring
(4) Expander

## 5.31 Disassembling piston assembly

1. Remove the piston pin snap ring (1) from the piston (2).
2. Remove the piston pin (4) to disconnect the connecting rod (3) from the piston (2).

**■ IMPORTANT**
- **Put a mark on the connecting rod (3) and the piston (2) with the same number to keep the same combination.**

**■ NOTE**
- **If do not remove the piston pin (4) easily, put the piston fully in 80 ℃ (176 ℉) oil for 10 to 15 minutes.**




(1) Piston pin snap ring
(2) Piston
(3) Connecting rod
(4) Piston pin

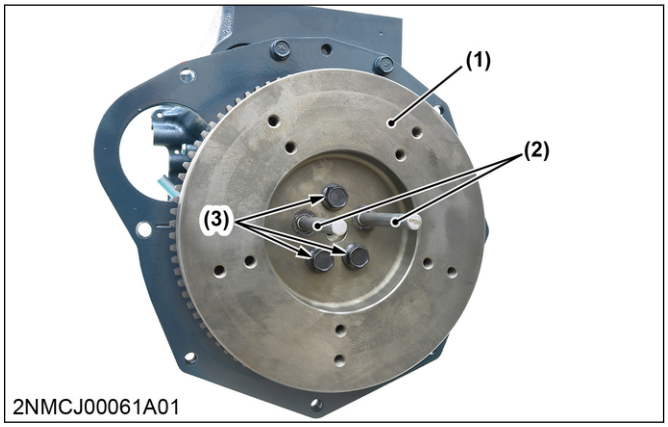
## 5.32 Removing flywheel

**■ IMPORTANT**
- **The flywheel is heavy, so securely hold the flywheel when removing.**

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

**Tools required**
- Flywheel stopper
- Flywheel guide screw

1. Fix the flywheel with the flywheel stopper.
2. Loose the flywheel screws (3).
3. Remove two flywheel screws and set the flywheel guide screw (2).

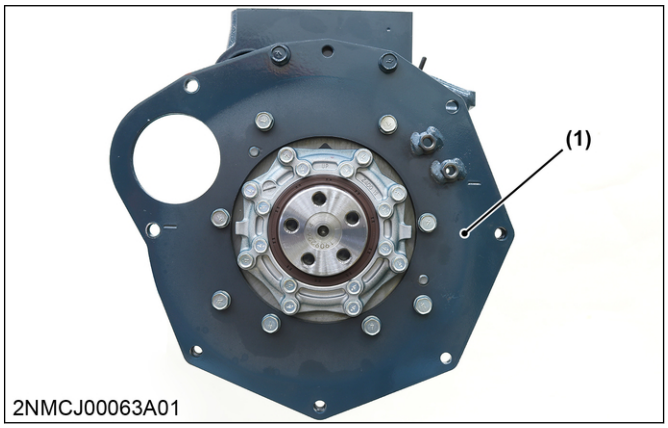



(1) Flywheel
(2) Flywheel guide screw
(3) Flywheel screw

4. Remove the remained flywheel screws.
5. Remove the flywheel (1).

## 5.33 Removing rear end plate

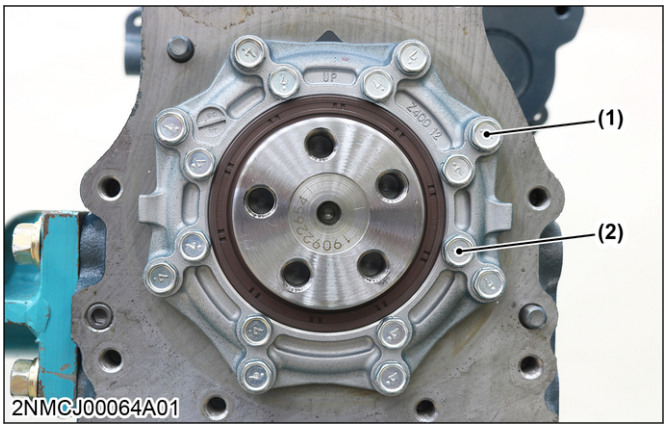
1. Remove the rear end plate (1).




(1) Rear end plate

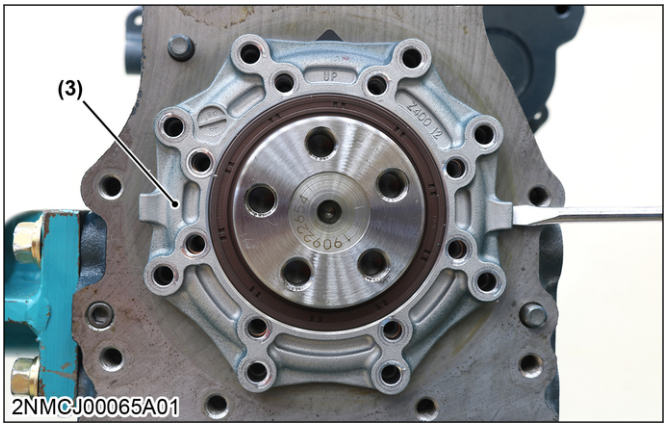
## 5.34 Removing bearing case cover

1. Remove the inner mounting screws of bearing case cover (2).
2. Remove the external mounting screws of bearing case cover (1).




(1) External mounting screw of bearing case cover
(2) Inner mounting screw of bearing case cover

3. Remove the bearing case cover (3).

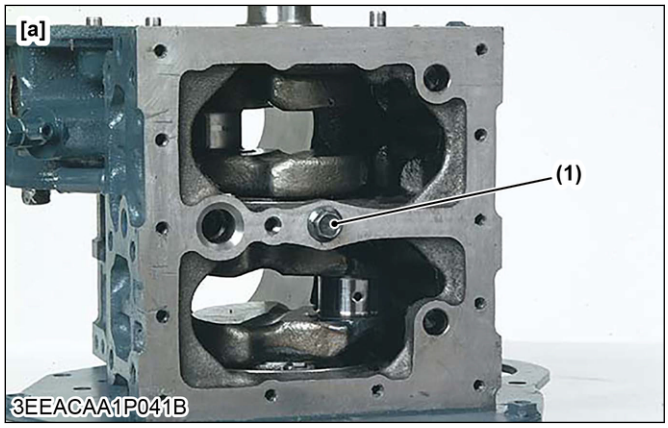


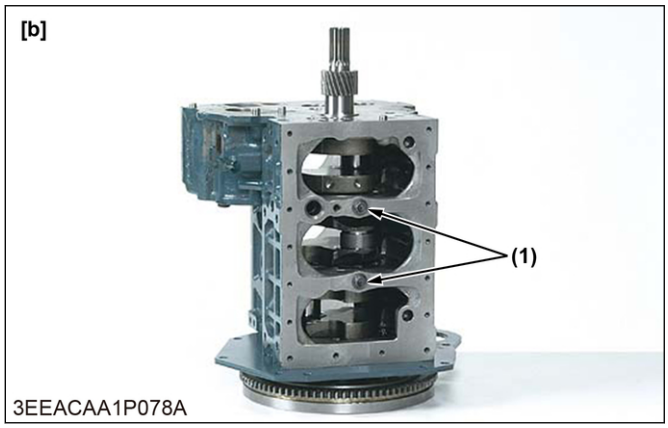

(3) Bearing case cover

## 5.35 Removing crankshaft assembly for Z482-E4 Z482-E4BG Z602-E4 D722-E4

**For Z482-E4 Z482-E4BG D722-E4**

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

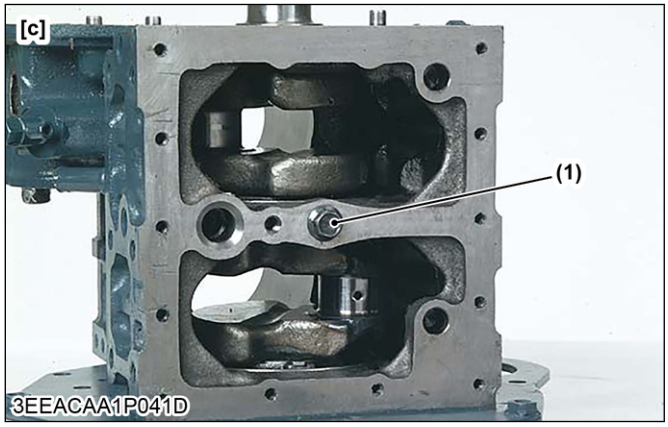



(1) Main bearing case mounting screw 2
[b] D722-E4
[a] Z482-E4 Z482-E4BG

**For Z602-E4**

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

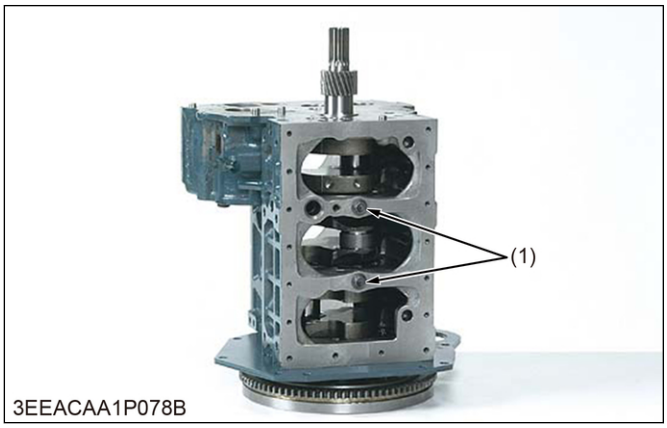



(1) Main bearing case mounting screw 2
[c] Z602-E4

2. Turn the crankshaft to set the crankpin of the cylinder to the horizontal directions (right or left).
3. Draw out all the crankshaft, holding the crankpin to the horizontal directions.

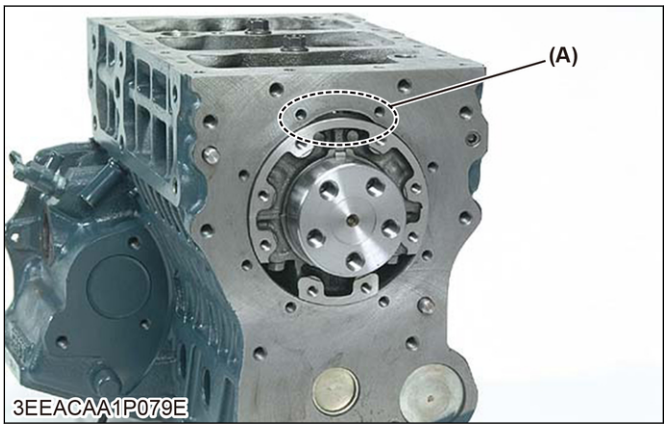
## 5.36 Removing crankshaft assembly for D782-E4 D902-E4 D902-TE4

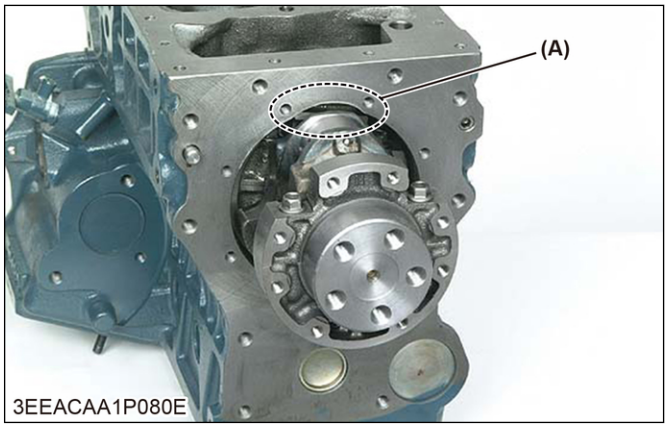
1. Remove the main bearing case mounting screw 2 (1).




(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.



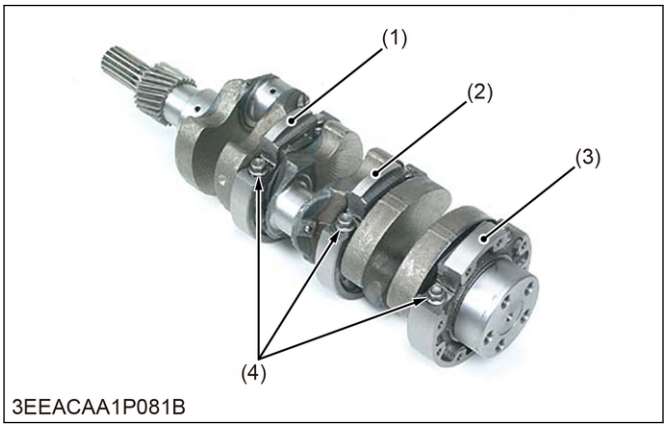




(A) Cut place for removing or installing crankshaft assembly

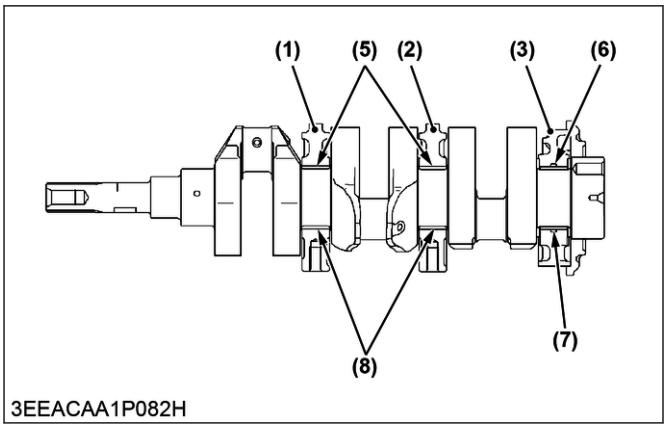
## 5.37 Removing main bearing case assembly

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

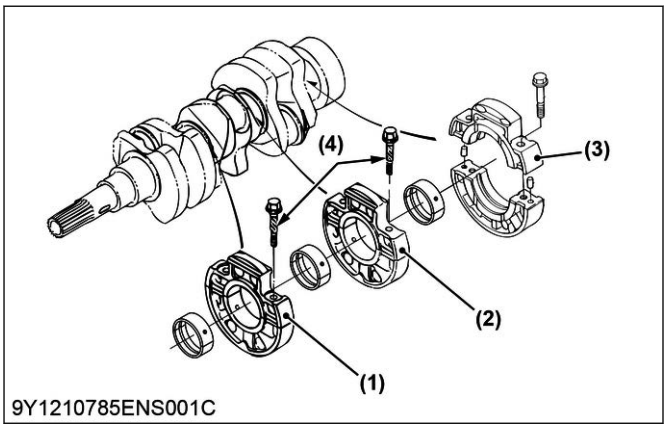
3. Remove other main bearing cases as above steps.



3EEACAA1P081B



3EEACAA1P082H



9Y1210785ENS001C

(1) Main bearing case assembly 1
(2) Main bearing case assembly 2
(3) Main bearing case assembly
(4) Main bearing case screw 1
(5) Crankshaft bearing 3 (upper, with oil groove)
(6) Crankshaft bearing 2 (lower, with oil groove)
(7) Crankshaft bearing 2 (lower, without oil groove)
(8) Crankshaft bearing 3 (lower, without oil groove)

## 5.38 Disassembling starter

1. Disconnect the solenoid switch (3).
2. Remove the 2 through screws (10) and the 2 brush holder lock screws.
3. Remove the rear end frame (14) and the brush holder (13).

**■ NOTE**
- **Do not damage the brush and commutator.**

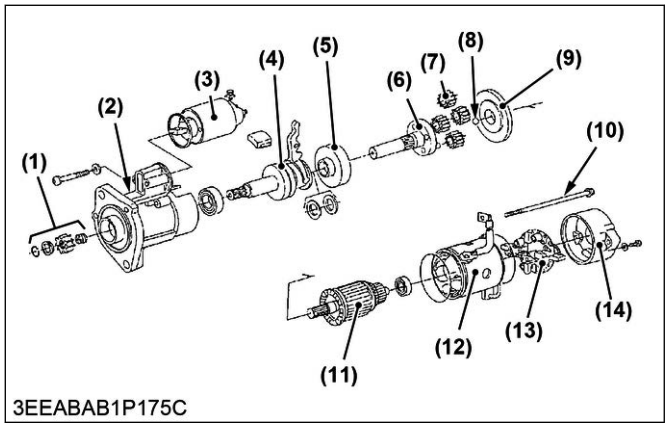
4. Disconnect the armature (11) and the yoke (12).

**■ IMPORTANT**
- **Before disconnecting the yoke, put tally marks on the yoke and the front bracket.**

5. Remove also the ball (8) from the tip of the armature.
6. Remove the set of packings (9), the 4 planetary gears and another packing.

**■ IMPORTANT**
- **Take note of the positions of the set of packings and the setup bolt.**

7. Remove the gear (1) and shaft assembly (4), (5), (6). Take note of the position of the lever.

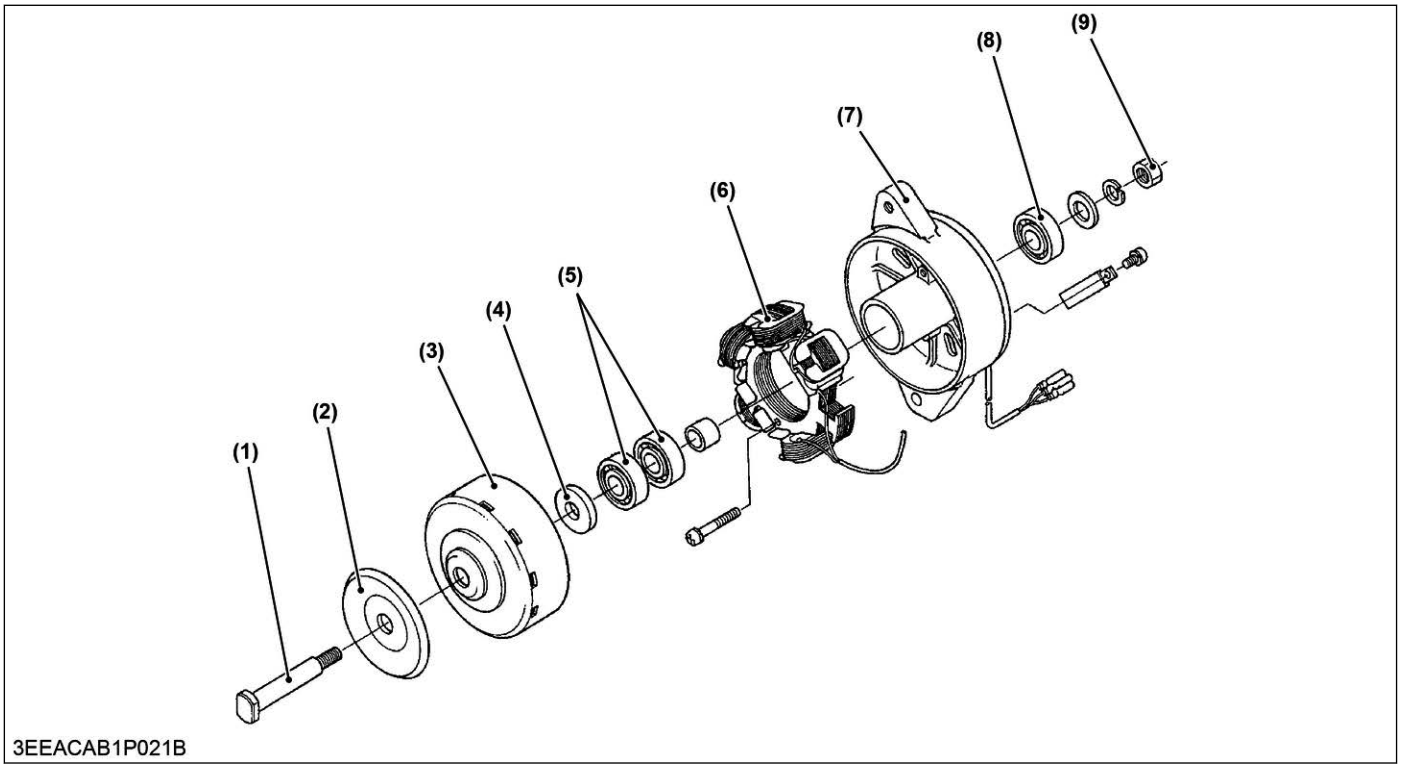


3EEABAB1P175C

(1) Gear
(2) Front bracket
(3) Solenoid switch
(4) Overrunning clutch
(5) Internal gear
(6) Shaft
(7) Planetary gear
(8) Ball
(9) Set of packings
(10) Through screws
(11) Armature
(12) Yoke
(13) Brush holder
(14) Rear end frame

## 5.39 Disassembling dynamo

1. Remove pulley nut (9).
2. Remove shaft (1).
3. Remove component parts.



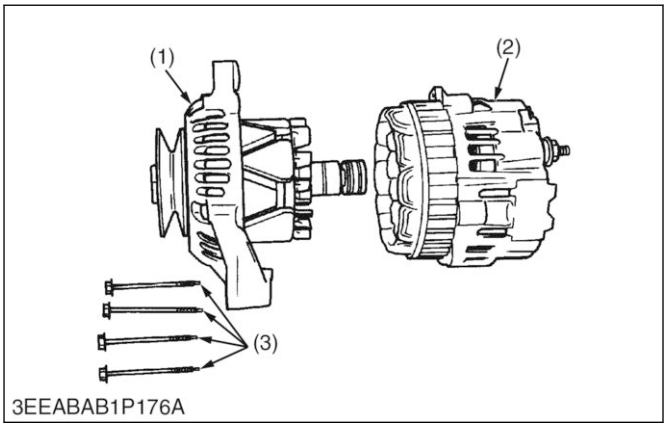

(1) Shaft
(2) Pulley
(3) Rotor
(4) Collar
(5) Bearing cover
(6) Bearing
(7) Stator
(8) Plate
(9) Pulley nut

## 5.40 Disassembling alternator

1. Remove the 4 screws (3).
2. Separate the front bracket (1) and the rear bracket (2) from each other.

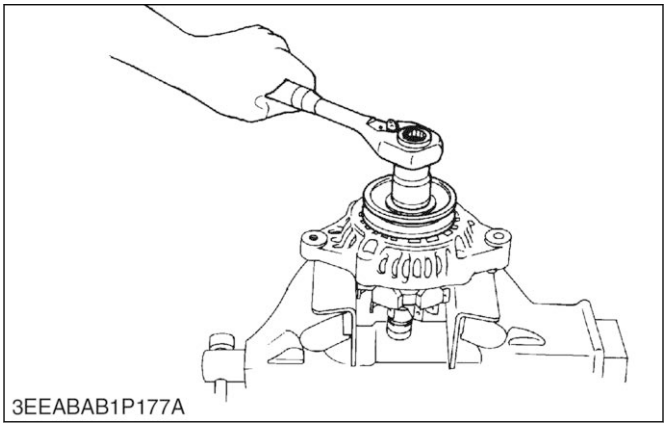
**IMPORTANT**

- **Put a tally line on the front bracket (1) and the rear bracket for reassembling them later.**

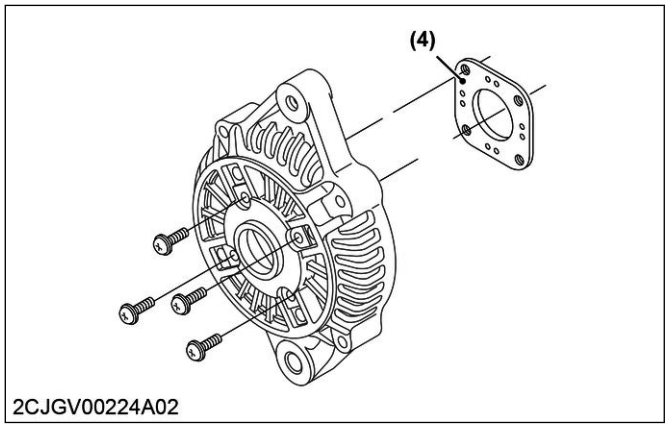



(1) Front bracket
(2) Rear bracket
(3) Screw

3. Hold the rotor (base of the claw) in a vise.
4. Loosen the lock nut.

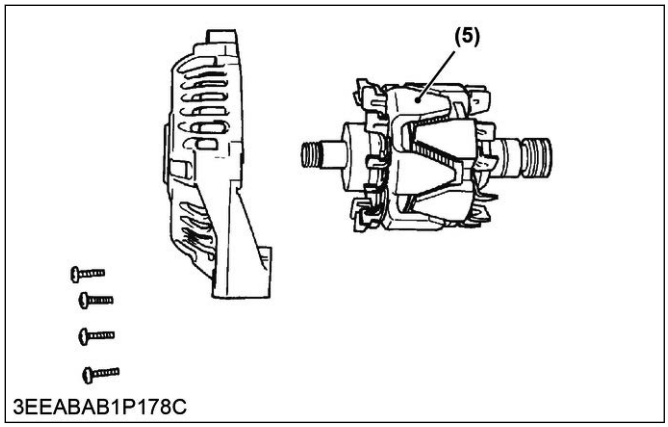



5. Remove the 4 screws to detach the bearing retainer (4).



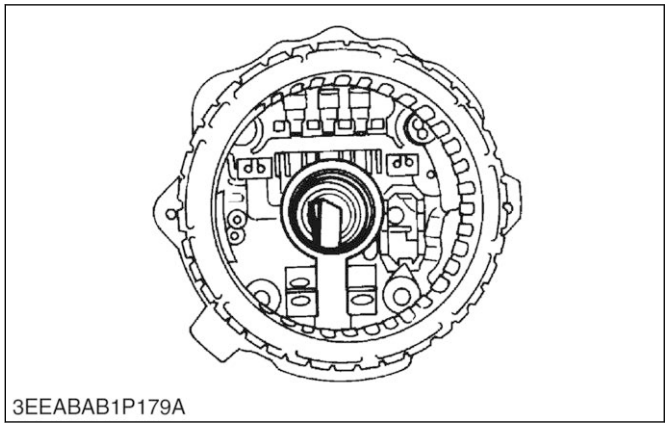

(4) Bearing retainer

6. Temporarily install the nut on the pulley screw.
7. Detach the rotor (5).



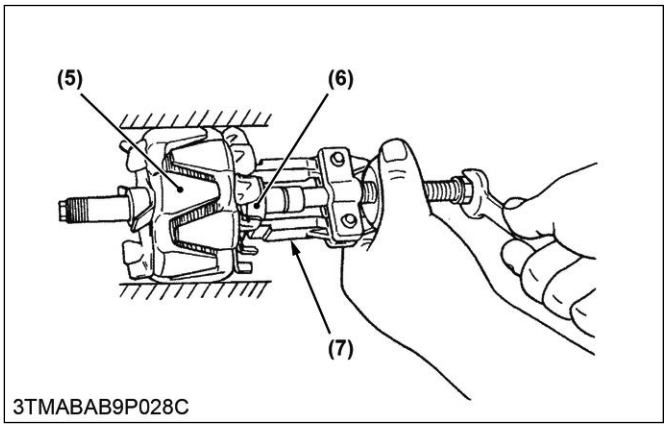

(5) Rotor

8. When the rotor is detached, the 2 brushes are found to stretch out of the shaft hole.




9. Lightly secure the rotor (5) with a vise to prevent damage.

10. Remove the bearing (6) with a puller (7).

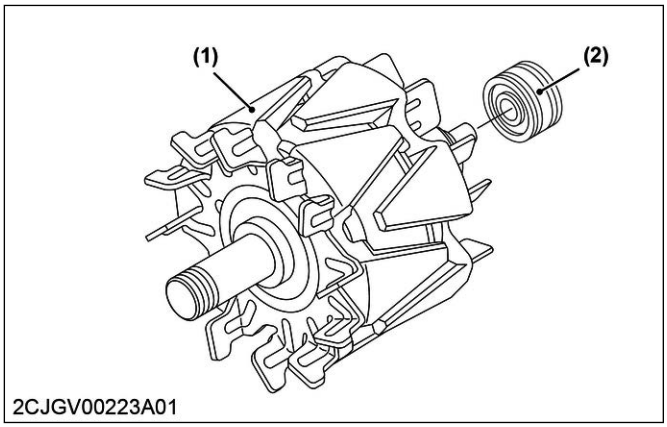



(5) Rotor
(6) Bearing
(7) Puller

# 6. Assembling

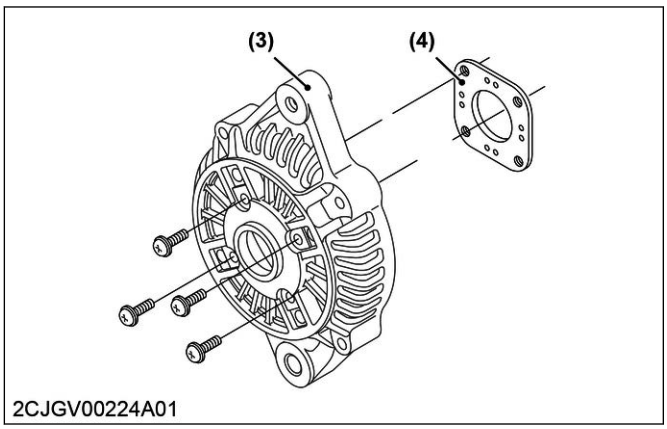
## 6.1 Assembling alternator

1. Lightly secure the rotor with a vise to prevent damage.
2. Install the bearing (2) to the slip ring side of rotor (1).



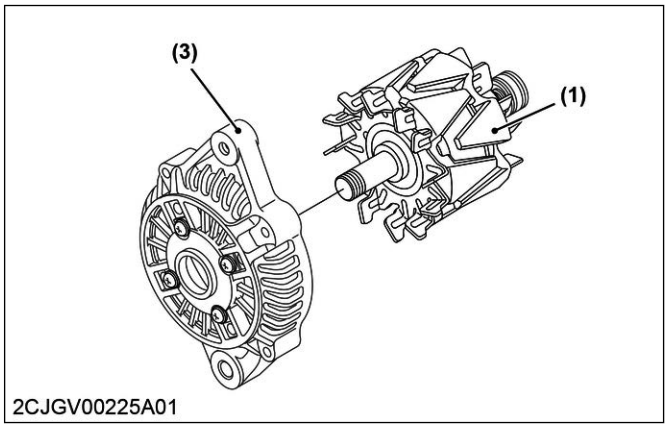

(1) Rotor
(2) Bearing

3. Install the bearing retainer (4) to the front bracket (3).




(3) Front bracket
(4) Bearing retainer

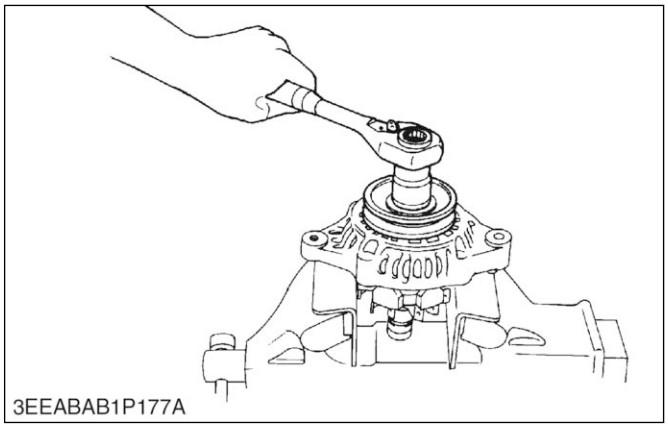
4. Install the rotor (1) to the front bracket (3).




(1) Rotor
(3) Front bracket

5. Lightly secure the rotor with a vise to prevent damage.
6. Install the pulley and tighten the pulley nut to the specified torque.

| | | |
|---|---|---|
| Tightening torque | Pulley nut | 58.4 to 78.9 N·m<br>5.95 to 8.05 kgf·m<br>43.1 to 58.2 lbf·ft |



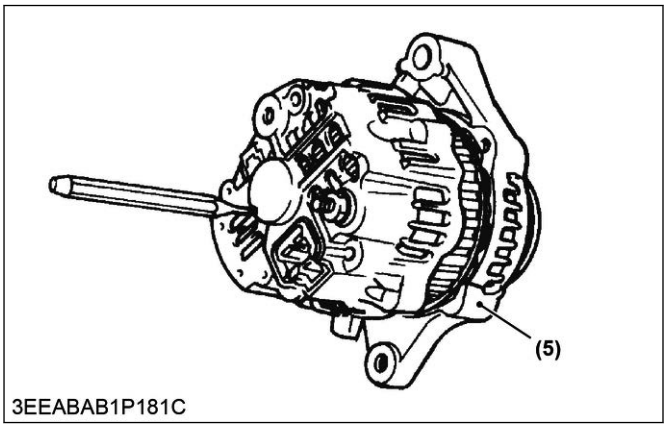

7. Fit the brush with its sliding face in the clockwise direction when viewed from front.

**IMPORTANT**

- **Be sure to keep the 2 brushes deep in the brush holder.**
  **Otherwise the rotor and the rear section can not be fitted into the position.**

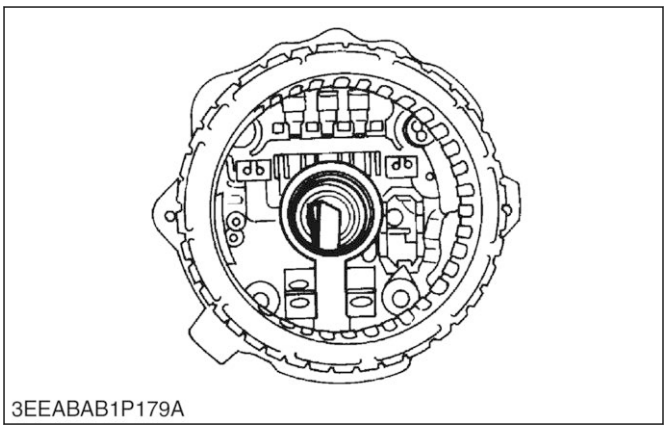
8. Push the brushes into place using a 4 mm hex. wrench.
9. Keep the brushes from popping out using a pin-pointed punch.

10. Align the mark line (5) of the front bracket with that of the rear bracket.

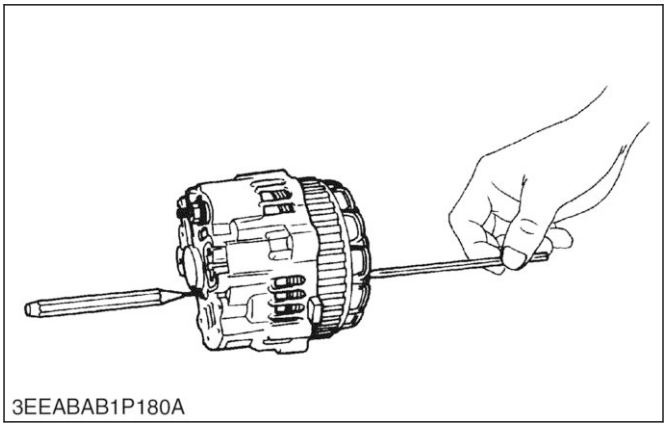



(5) Mark line

11. Tighten the 4 screws.



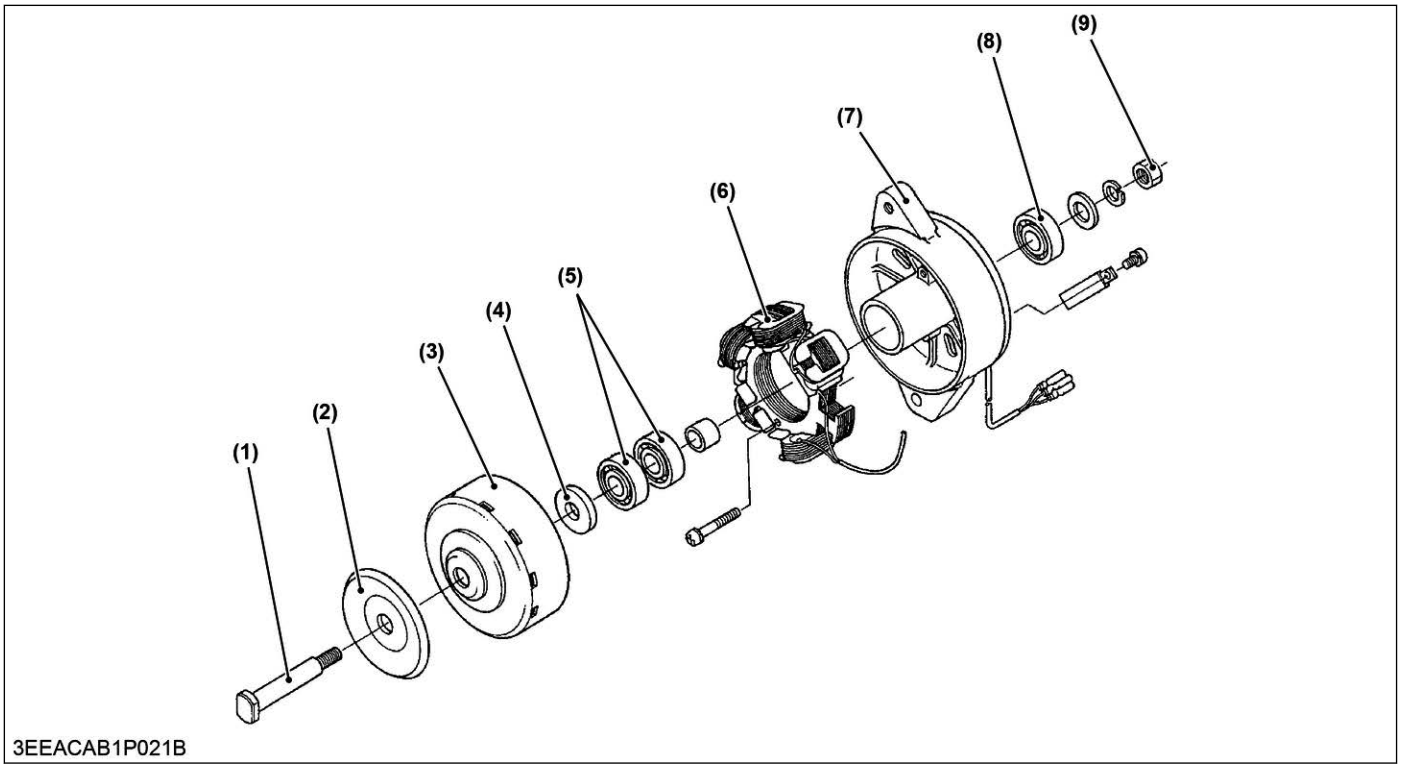

12. Draw out the pin-pointed punch out of the brush holder.



## 6.2 Assembling dynamo

1. Install component parts.
2. Install shaft (1).
3. Install pulley nut (9).

| | | |
|---|---|---|
| Tightening torque | Pulley nut (9) | 29.4 to 34.3 N·m<br>3.00 to 3.49 kgf·m<br>21.7 to 25.2 lbf·ft |




(1) Shaft
(2) Pulley
(3) Rotor
(4) Collar
(5) Bearing cover
(6) Bearing
(7) Stator
(8) Plate
(9) Pulley nut

## 6.3 Assembling starter

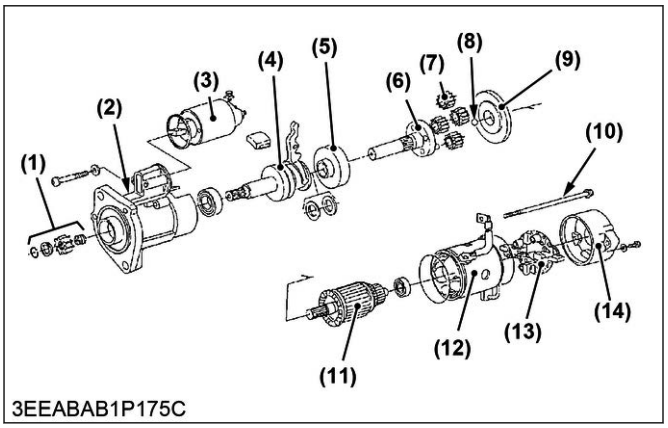
**■ IMPORTANT**

- **Apply grease to the gears, bearings, shaft's sliding part and ball.**

**■ NOTE**

- **Do not damage the brush and commutator.**

1. Install the shaft assembly (4), (5), (6) to the front bracket (2).
2. Install the pinion gear (1).
3. Install the set of packings (9), the 4 planetary gears (7) and another packing.
4. Install the armature (11) to the yoke (12).
5. Install the ball (8) to the tip of the armature (11).
6. Install the brush holder (13) and rear end frame (14).
7. Install the 2 brush holder lock screws.
8. Install the 2 through screws (10).
9. Install the solenoid switch (3).



3EEABAB1P175C

(1) Pinion gear
(2) Front bracket
(3) Solenoid switch
(4) Overrunning clutch
(5) Internal gear
(6) Shaft
(7) Planetary gear
(8) Ball
(9) Set of packings
(10) Through screws
(11) Armature
(12) Yoke
(13) Brush holder
(14) Rear end frame

## 6.4 Installing main bearing case

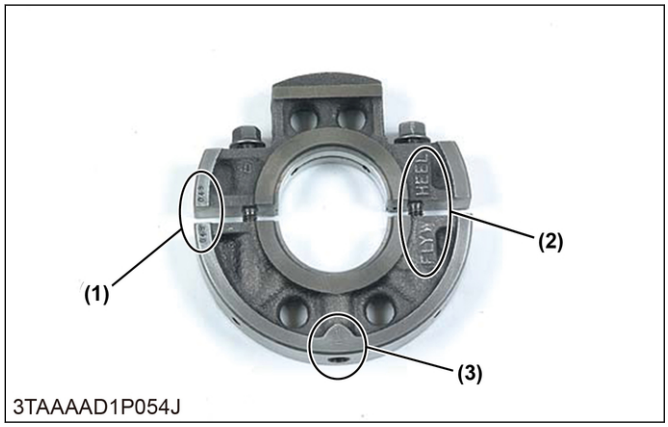
1. Install the main bearing case.

**■ IMPORTANT**

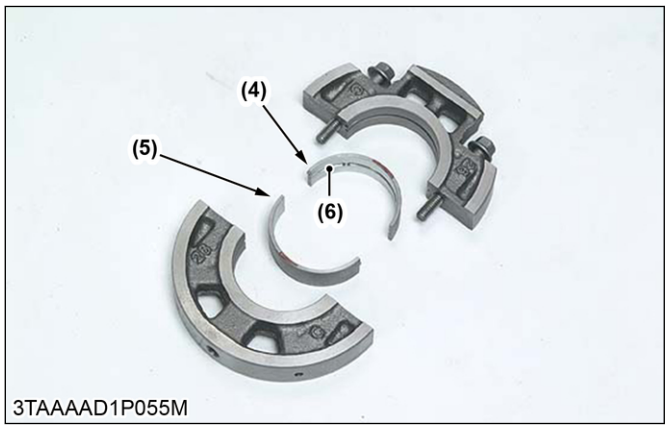
- **Clean the oil channel in the main bearing case.**
- **Align the numbers (1) on the main bearing case.**
- **When you install the crankshaft bearing, set the crankshaft bearing with oil groove (6) to upper side.**
- **When you install the main bearing case, point the [FLYWHEEL] mark (2) to the flywheel.**
- **Install the main bearing case assemblies in the initial positions. Since the diameters of the main bearing cases are different, install them in the sequence of their marks (1, 2) from the gear case cover side.**

**■ NOTE**

- **Apply oil to the crankshaft bearing.**



3TAAAAD1P054J



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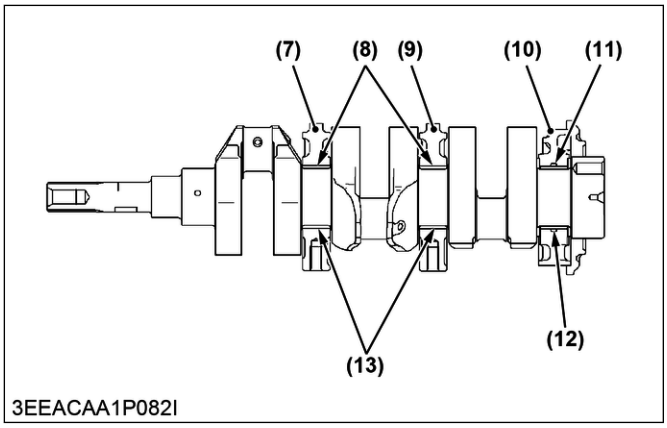


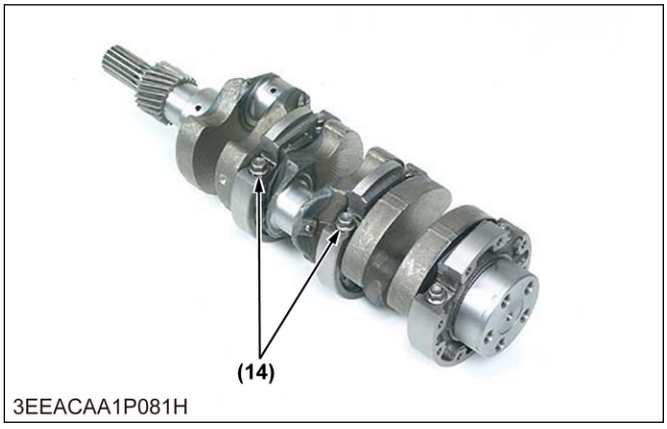
3EEACAA1P082I

(1) Number
(2) FLYWHEEL mark
(3) Marking (1 or 2)
(4) Crankshaft bearing (upper, with oil groove)
(5) Crankshaft bearing (lower, without oil groove)
(6) Oil groove
(7) Main bearing case assembly 1
(8) Crankshaft bearing 3 (upper, with oil groove)
(9) Main bearing case assembly 2
(10) Main bearing case assembly
(11) Crankshaft bearing 2 (lower, with oil groove)
(12) Crankshaft bearing 2 (lower, without oil groove)
(13) Crankshaft bearing 3 (lower, without oil groove)

2. Tighten the main bearing case screw 1 (M6) (14) to the specified torque.

**■ NOTE**
- **Apply the engine oil to the main bearing case screws 1 (M6) (14).**
- **After you tighten the main bearing case screw 1 (M6) (14) to the specified torque, make sure that the main bearing case moves smoothly.**

| | | |
|---|---|---|
| Tightening torque | Main bearing case screw 1 (M6) (14) | 12.7 to 15.7 N·m<br>1.30 to 1.60 kgf·m<br>9.37 to 11.5 lbf·ft |



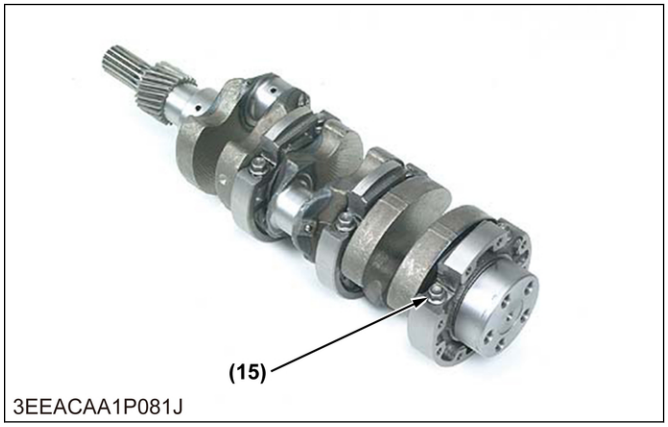
3EEACAA1P081H

(14) Main bearing case screw 1 (M6)

3. Tighten the main bearing case screw 1 (M8) (15) to the specified torque.

**■ NOTE**
- **After you tighten the main bearing case screw 1 (M8) (15) to the specified torque, make sure that the main bearing case moves smoothly.**

| | | |
|---|---|---|
| Tightening torque | Main bearing case screw 1 (M8) (15) | 23.5 to 27.5 N·m<br>2.40 to 2.80 kgf·m<br>17.4 to 20.2 lbf·ft |



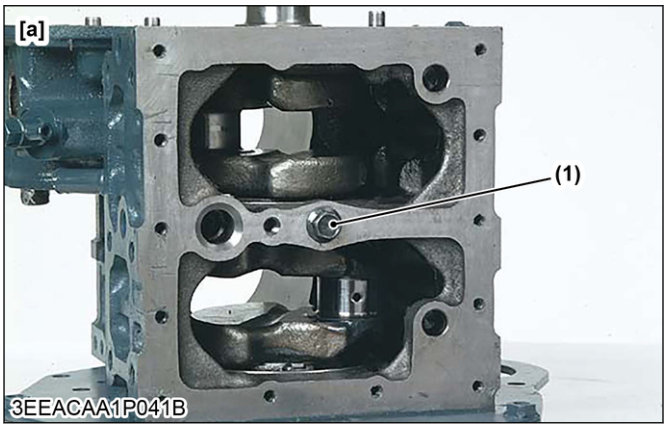
3EEACAA1P081J

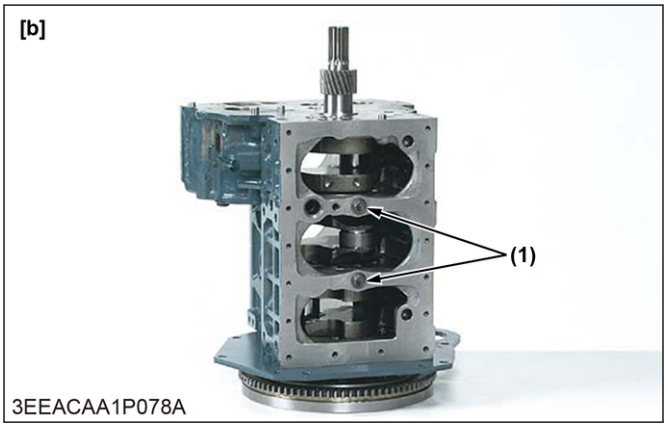
(15) Main bearing case screw 1 (M8)

## 6.5 Installing crankshaft assembly for Z482-E4 Z482-E4BG Z602-E4 D722-E4

1. Install the crankshaft assembly completely.

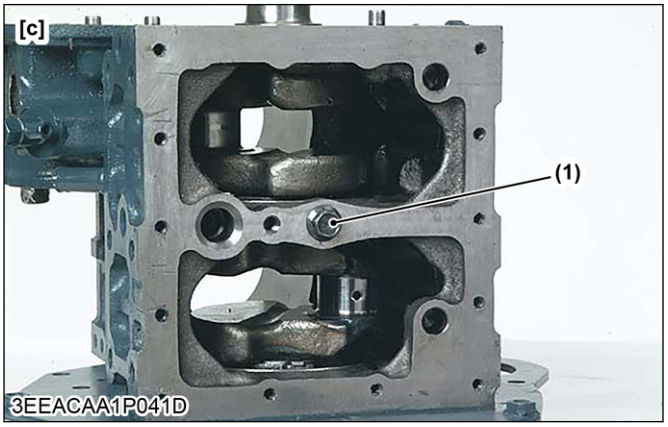
**For Z482-E4 Z482-E4BG D722-E4**




(1) Main bearing case mounting screw 2
[b] D722-E4
[a] Z482-E4 Z482-E4BG

**For Z602-E4**




(1) Main bearing case mounting screw 2
[c] Z602-E4

2. Align the screw hole of the main bearing case with the screw hole of the crankcase.
3. Install the main bearing case mounting screw 2 (1) by hand.

**NOTE**
- **Apply oil to the main bearing case mounting screw 2.**
- **If you cannot turn the screw 2 smoothly, align the screw holes between the crankcase and the main bearing case correctly.**

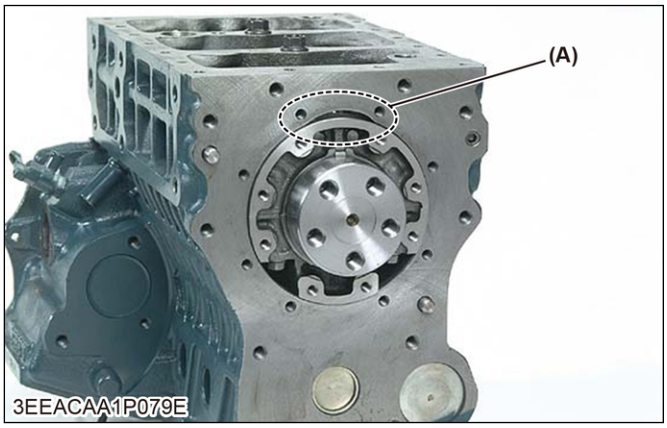
4. Tighten the main bearing case screw 2 (1) to specified torque.

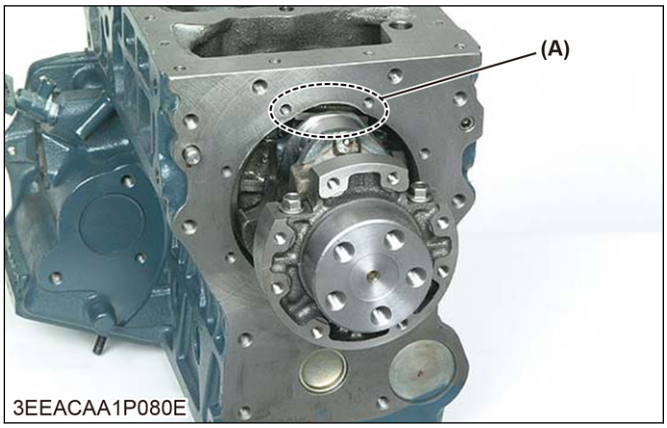
| | | |
|---|---|---|
| Tightening torque | Main bearing case mounting screw 2 (1) | 26.5 to 30.4 N·m<br>2.71 to 3.09 kgf·m<br>19.6 to 22.4 lbf·ft |

## 6.6 Installing crankshaft assembly for D782-E4 D902-E4 D902-TE4

1. Install the crankshaft until the crankpin of the first cylinder comes to the center of the third cylinder.
2. Turn the crankshaft by 2.09 rad (120°) counterclockwise to set the crankpin of the second cylinder to the bottom dead center.
3. Install the crankshaft until the crankpin of the second cylinder comes to the center of the third cylinder.
4. Turn the crankshaft to set the crankpin of the third cylinder to the bottom dead center.

5. Install the crankshaft completely.

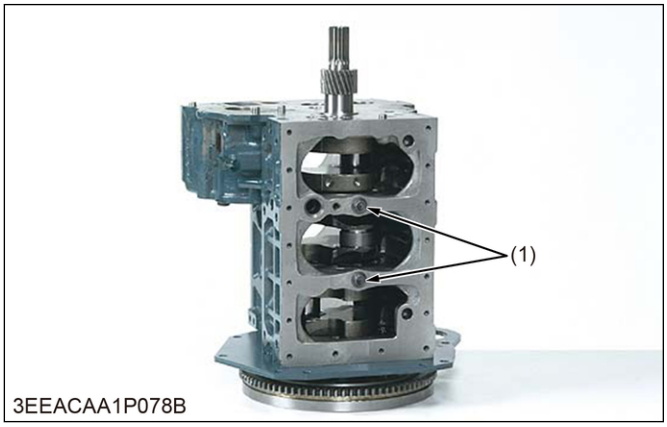



(A) Cut place for removing or installing crankshaft assembly

6. Align the screw hole of the main bearing case with the screw hole of the crankcase.
7. Install the main bearing case screw 2 (1) by hand.

**■ NOTE**
- **Apply oil to the main bearing case screw 2.**
- **If you cannot turn the screw 2 smoothly, align the screw holes between the crankcase and the main bearing case correctly.**




(1) Main bearing case screw 2

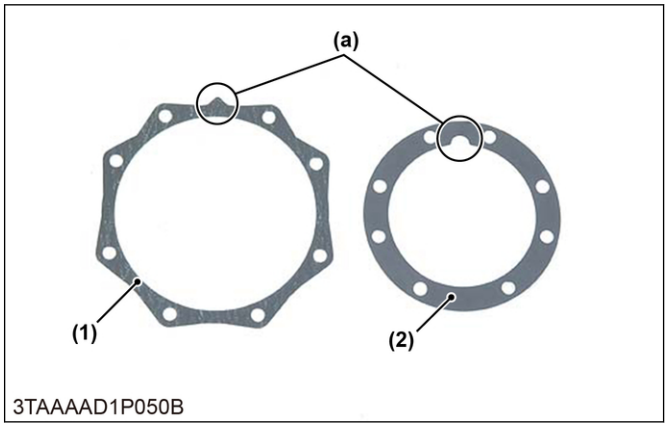
8. Tighten the main bearing case screw 2 (1) to specified torque.

| | | |
|---|---|---|
| Tightening torque | Main bearing case screw 2 (1) | 26.5 to 30.4 N·m<br>2.71 to 3.09 kgf·m<br>19.6 to 22.4 lbf·ft |

## 6.7 Installing bearing case cover

**■ IMPORTANT**
- **In case of replacing the oil seal, install the oil seal to the bearing case cover not to be tilted. The seal should be flush with the cover.**
- **Before installing the bearing case cover / oil seal assembly, lube the seal and install it not to damage the seal.**

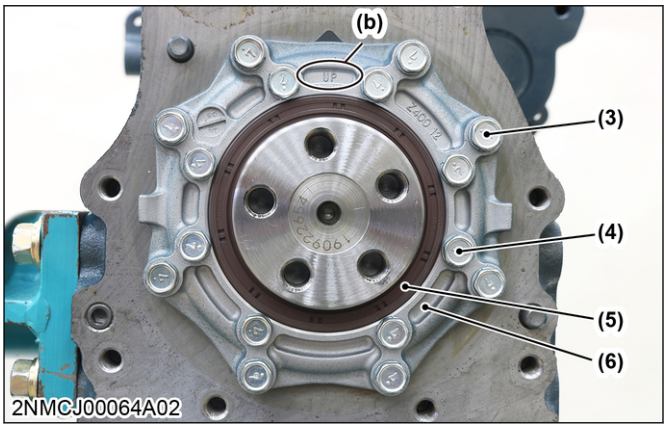
1. Attach the bearing case gasket (2) and the bearing case cover gasket (1) in the correct position of upside mark (a).




(1) Bearing case cover gasket
(2) Bearing case gasket
(a) Upside mark

2. 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.**

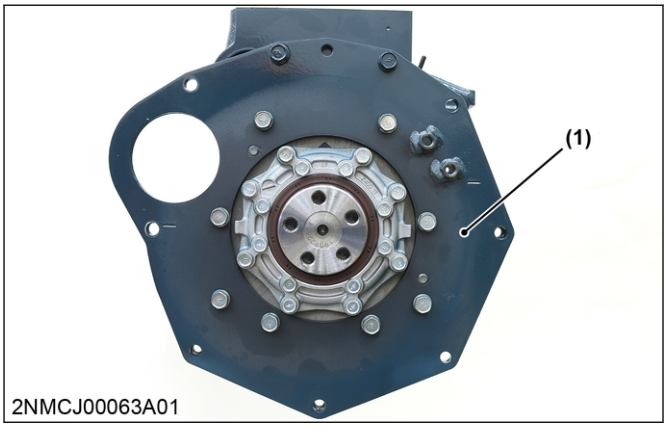



(3) External mounting screw of bearing case cover
(4) Inner mounting screw of bearing case cover
(5) Oil seal
(6) Bearing case cover
(b) Casting mark **[UP]**

3. 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

1. Install the rear end plate.




(1) Rear end plate

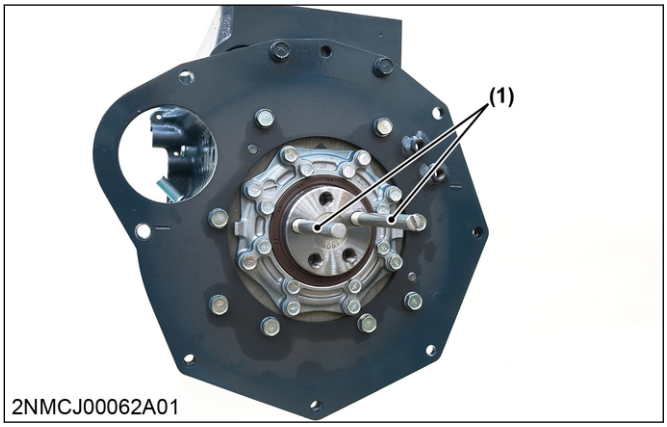
## 6.9 Installing flywheel

**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

1. Set the flywheel guide screw (1).

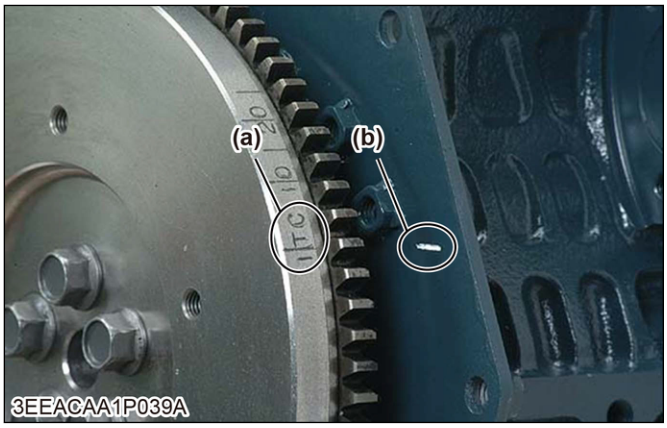


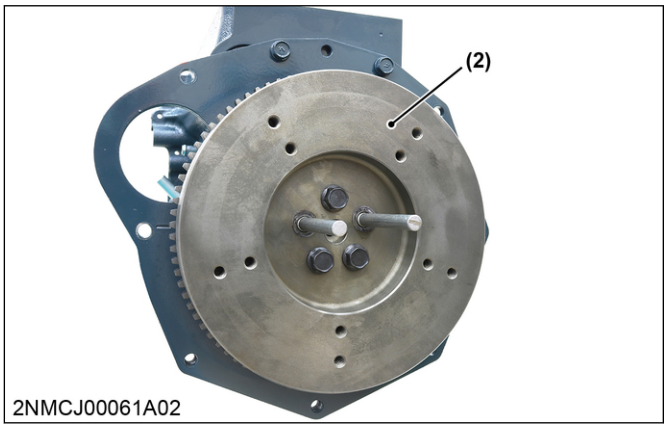

(1) Flywheel guide screw

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

3. Install the flywheel (2) and flywheel screw.

**■ NOTE**
- **Apply the engine oil to the flywheel screws (3).**
- **Align the 1TC mark (a) on the outer surface of the flywheel horizontally with the alignment mark (b) on the rear end plate.**




(2) Flywheel
(a) 1TC mark
(b) Alignment mark

4. Remove the flywheel guide screw and install remaining flywheel screw (3).
5. Attach the flywheel stopper and tighten the flywheel screw (3) to the specified torque.

**■ NOTE**
- **Check that there are no metal particles that remain on the flywheel mounting surfaces.**

| | | |
|---|---|---|
| Tightening torque | Flywheel screw (3) | 53.9 to 58.8 N·m<br>5.50 to 5.99 kgf·m<br>39.8 to 43.3 lbf·ft |


(3) Flywheel screw

## 6.10 Assembling piston assembly

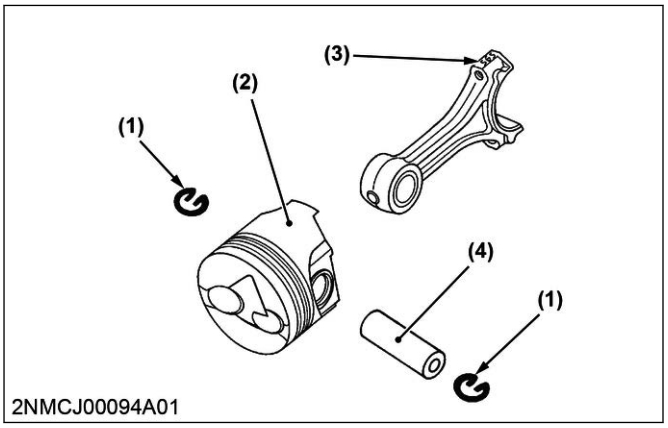
**⚠ CAUTION**
- **The end faces of the oil ring are plated with hard chrome. When you install the piston into the cylinder, do not give a damage to the cylinder by the oil ring. If the ring's planting is scratched, it may get stuck on the cylinder wall, causing serious damage.**

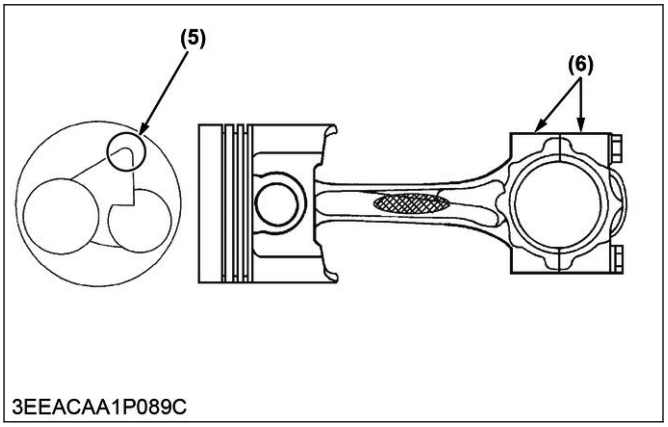
**■ IMPORTANT**
- **Put a mark on the connecting rod and the piston with the same number to keep the same combination.**

1. Put the piston fully in 80 ℃ (176 ℉) oil for 10 to 15 minutes.

2. Install the piston pin (4) and the connecting rod (3) to the piston (2).

**NOTE**
- **Apply the engine oil to the piston pin.**
- **Align the mark (6) on the connecting rod to the fan-shaped concave (5).**




(1) Piston pin snap ring
(2) Piston
(3) Connecting rod
(4) Piston pin
(5) Fan-shaped concave
(6) Mark

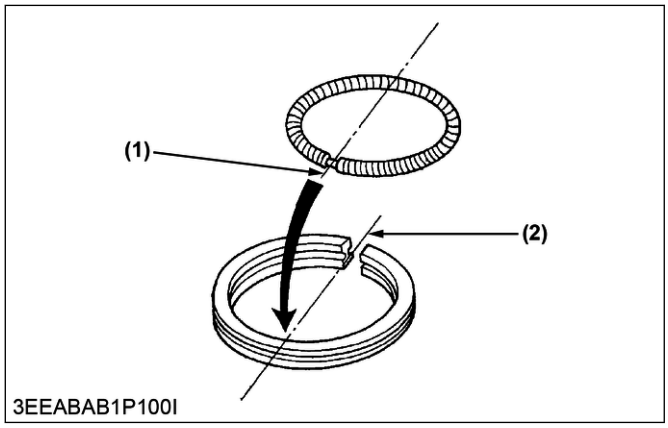
3. Install the piston pin snap ring (1).

## 6.11 Installing piston ring

**Tools required**
- Piston ring pliers

1. Install the expander.
2. Install the oil ring (3) to the piston with a piston ring pliers.

**NOTE**
- **Set the expander joint (1) on the opposite side of the oil ring gap (2).**

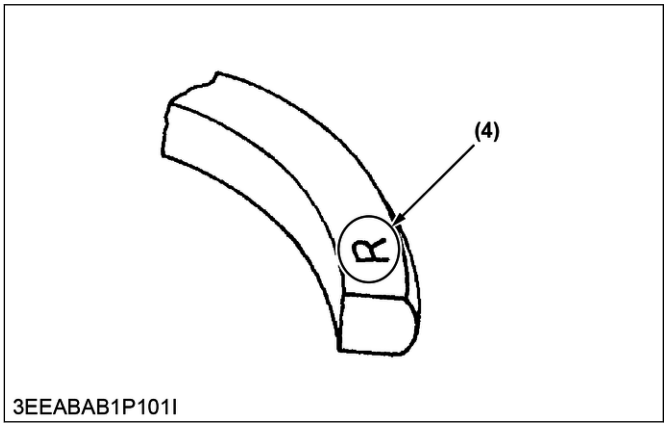


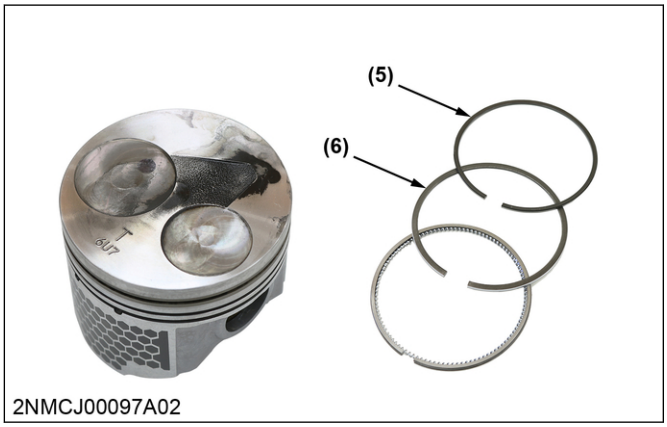


(1) Expander joint
(2) Oil ring gap
(3) Oil ring

3. Install the second ring (6) and top ring (5) to the piston with a piston ring pliers.

**■ NOTE**
- **Set the manufacturer mark (4) upward.**



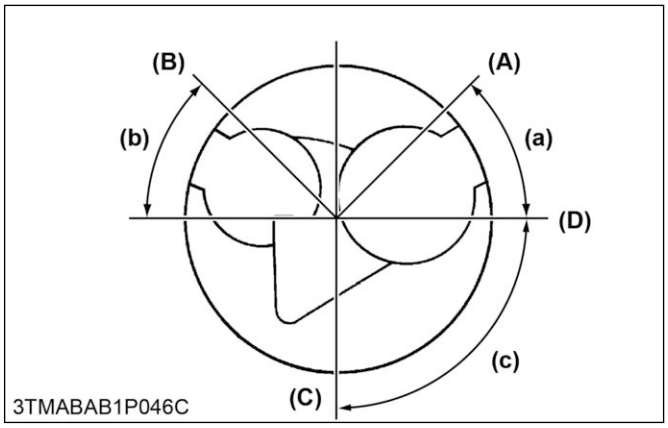

(4) Manufacturer mark
(5) Top ring
(6) Second ring

## 6.12 Installing piston

**■ IMPORTANT**
- **Do not change the combination of cylinder number and piston.**
  **Align the position of each piston by the its mark. For example, mark *"1"* on the No. 1 piston.**

**Tools required**
- Piston ring compressor

1. Clean the carbon in the cylinders.
2. Turn the flywheel and move the crankshaft to top dead center.
3. Place the gap of each piston ring like the figure.

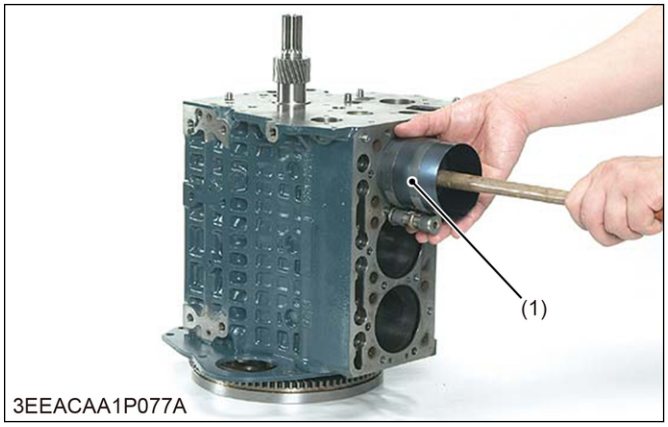



(A) Top ring gap
(B) Second ring gap
(C) Oil ring gap
(D) Piston pin hole
(a) 0.79 rad (45°)
(b) 0.79 rad (45°)
(c) 1.6 rad (90°)

4. Set the piston ring compressor (1) to the piston.
5. Install the piston to cylinder.

**■ IMPORTANT**
- **Be carefully to set the piston ring compressor. Otherwise, their chrome-plated section of piston rings may be scratched, causing trouble inside the liner.**
- **When inserting the piston into the cylinder, face the mark (d) on the connecting rod to the injection pump.**

**■ NOTE**
- **Apply sufficient the engine oil to the piston.**

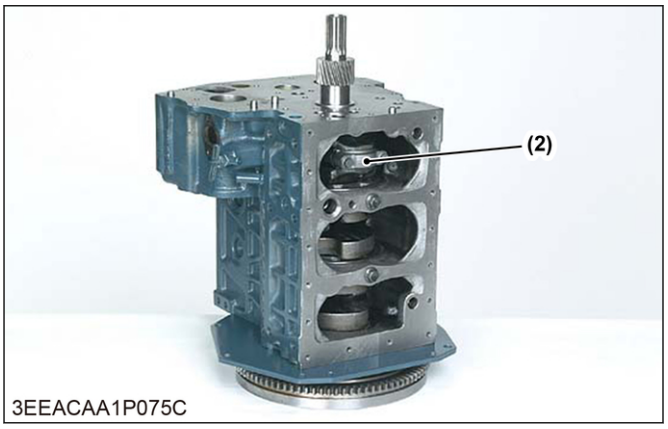


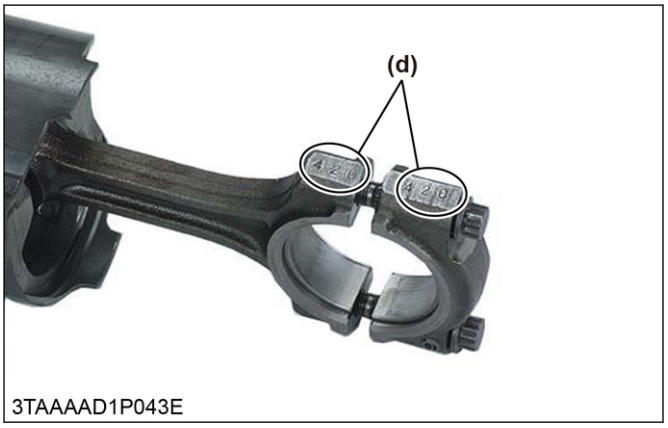

(1) Piston ring compressor

6. Turn the flywheel and move the piston to bottom dead center.

7. Install the connecting rod cap (2) and loosely tighten the connecting rod screw by hand.

**NOTE**
- **Apply the engine oil to the connecting rod screws.**
- **Align the marks (d) with each other.**
- **If the connecting rod screw won't be screwed in smoothly, clean the threads. If the connecting rod screw is still hard to screw in, replace it.**
- **When using the existing crankpin bearing again, put tally marks on the crankpin bearing and the connecting rod in order to keep their positioning.**




(2) Connecting rod cap (d) Mark

8. Tighten the connecting rod screw to the specified torque.

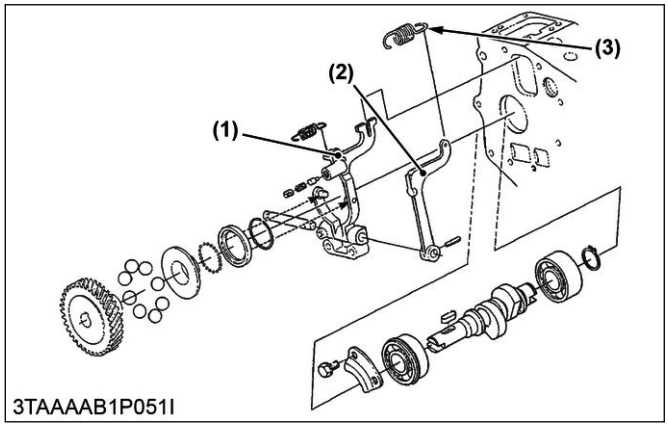
| | | |
|---|---|---|
| Tightening torque | Connecting rod screw | 26.5 to 30.4 N·m<br>2.71 to 3.09 kgf·m<br>19.6 to 22.4 lbf·ft |

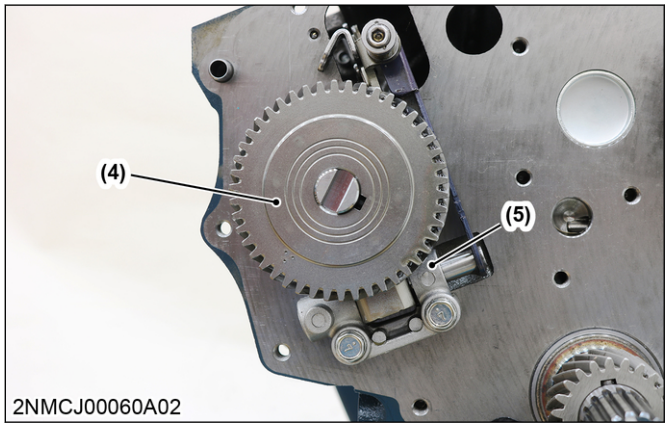
## 6.13 Installing fuel camshaft with gear and fork lever assembly

**CAUTION**
- **Do not remove lock screw of fork lever shaft.**

1. Install the fuel camshaft with gear (4) and fork lever assembly (5) together.

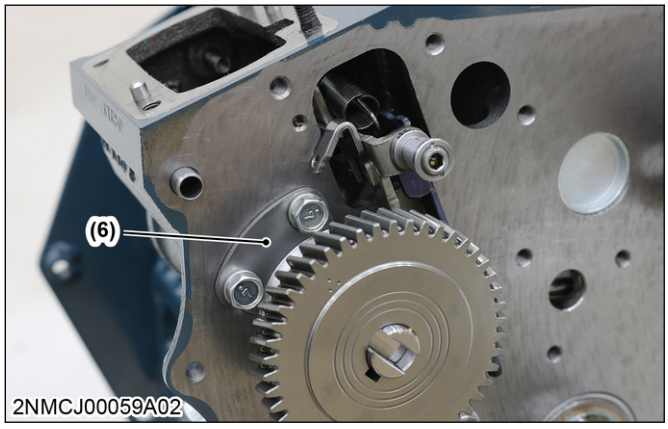
**NOTE**
- **Hook the governor spring (3) to the fork lever 2 (2) before installing the fork lever assembly (5) to the crankcase.**
- **Make sure that fuel camshaft with gear (4) and fork lever assembly (5) contact at correct point.**




(1) Fork lever 1
(2) Fork lever 2
(3) Governor spring
(4) Fuel camshaft with gear
(5) Fork lever assembly

2. Tighten the fork lever holder mounting screw.
3. Install the fuel camshaft retaining plate (6).

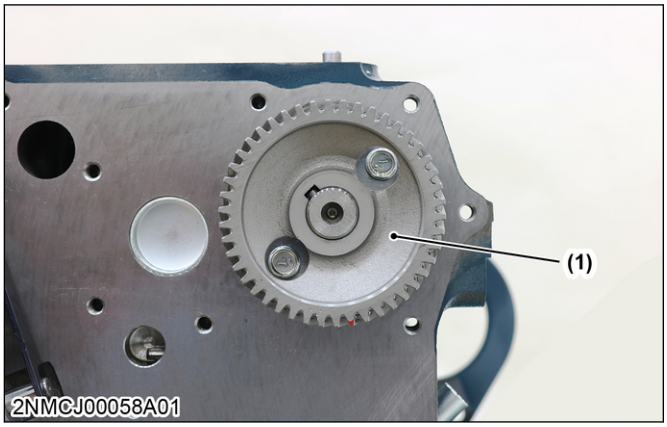



(6) Fuel camshaft retaining plate

## 6.14 Installing camshaft with cam gear

1. Install the camshaft with cam gear (1).

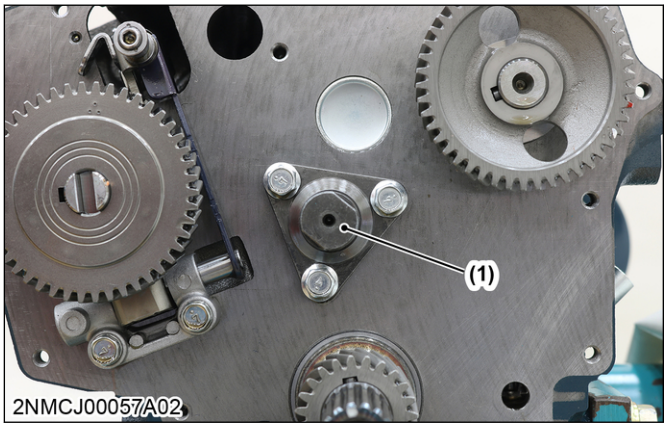
**NOTE**
- **When install the camshaft, apply the engine oil to the camshaft journals.**




(1) Camshaft with cam gear

## 6.15 Installing idle gear

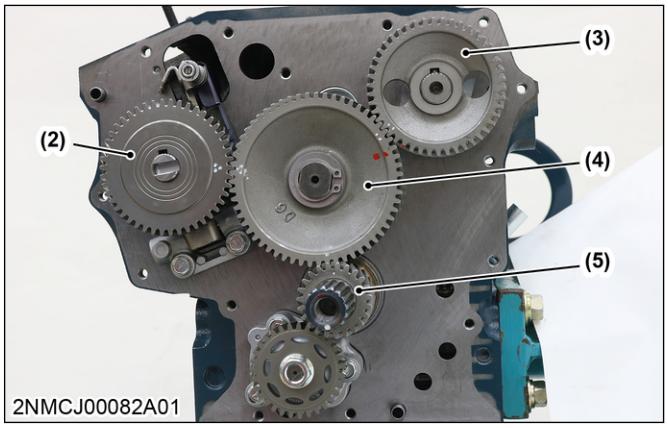
1. Install the idle gear shaft (1).




(1) Idle gear shaft

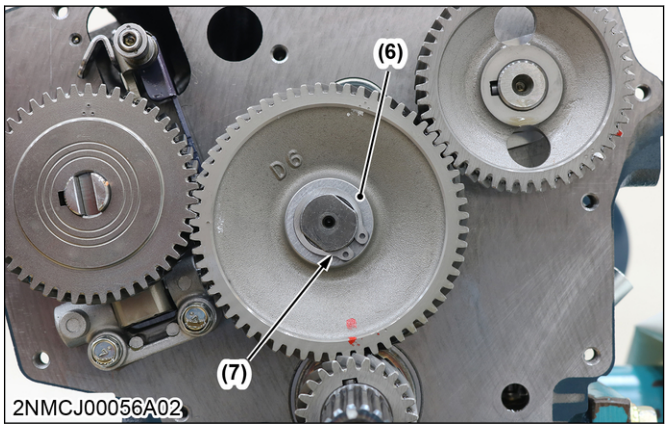
2. Install the idle gear (4).

**IMPORTANT**
- **Apply the engine oil inside of idle gear (4).**
- **When installing idle gear (4), bring the piston of cylinder 1 to T.D.C. and mount the gears with their marks aligned to the respective gears.**
  - **a. Idle gear (4) and cam gear (3)**
  - **b. Idle gear (4) and crank gear (5)**
  - **c. Idle gear (4) and fuel cam gear (2)**




(2) Fuel cam gear
(3) Cam gear
(4) Idle gear
(5) Crank gear

3. Install the idle gear collar (6) and the snap ling (7).

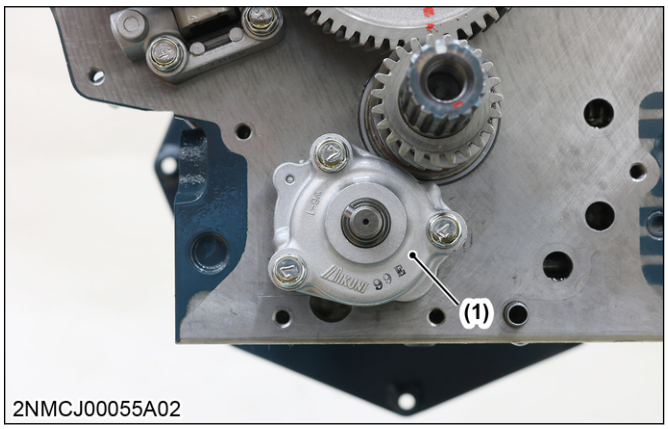



(6) Idle gear collar
(7) Snap ring

## 6.16 Installing oil pump

**Tools required**
- Flywheel stopper

1. Install the oil pump (1).



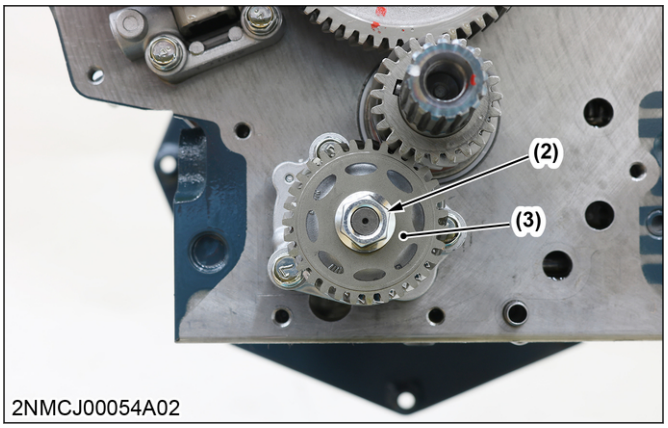

(1) Oil pump

2. Fix the flywheel with a flywheel stopper.

3. Install the oil pump drive gear (3) and tighten the oil pump drive gear mounting nut (2) to the specified torque.

**NOTE**
- **Check the direction of oil pump drive gear.**

| | | |
|---|---|---|
| Tightening torque | Oil pump drive gear mounting nut (2) | 39.2 to 45.1 N·m<br>4.00 to 4.59 kgf·m<br>29.0 to 33.2 lbf·ft |

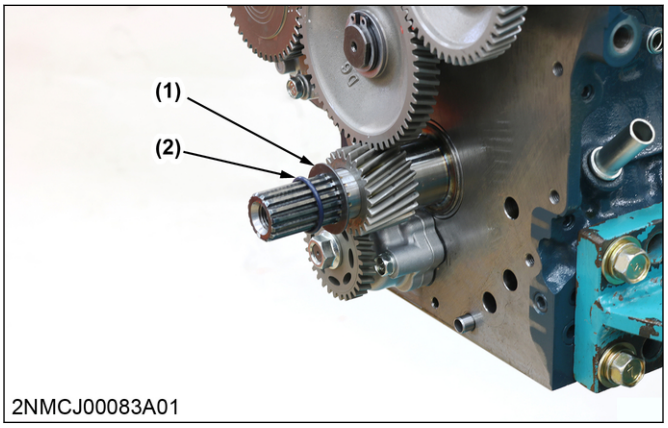



(2) Oil pump drive gear mounting nut
(3) Oil pump drive gear

## 6.17 Installing crankshaft oil slinger

1. Install the crankshaft oil slinger (1).
2. Install the O-ring (2).

**NOTE**
- **Replace the O-ring with a new one.**
- **Install the crankshaft collar after you install the gear case cover to the crankcase.**



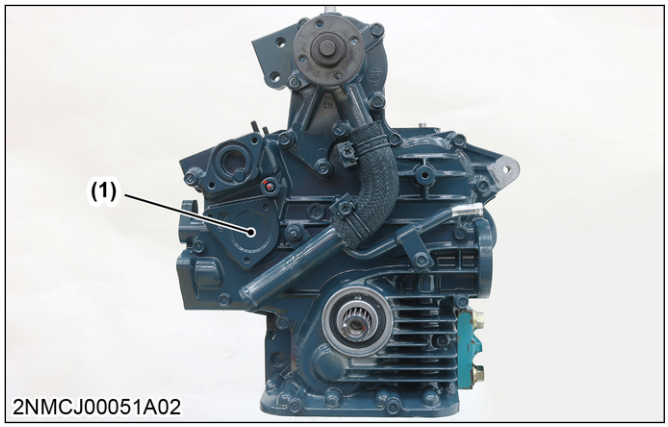

(1) Crankshaft oil slinger
(2) O-ring

## 6.18 Installing gear case cover

**IMPORTANT**
- **Do not touch the tamper proof cap.**
- **If you damage or move the fuel limit screw, please contact your Sales company.**
  **It is necessary to readjust the fuel limit screw with limit restoring tools.**
- **If you replace the gear case cover (1), please contact your Sales company.**
  **It is necessary to readjust the fuel limit screw with limit restoring tools.**

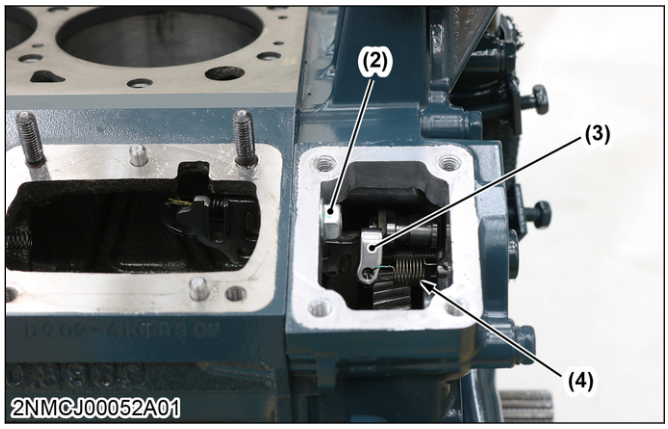
1. Install the gear case cover (1).

**NOTE**
- **Replace the gasket with a new one.**
- **Apply oil to the lip of oil seal.**
- **Do not forget the screw (2) that installing inside of gear case cover.**




(1) Gear case cover

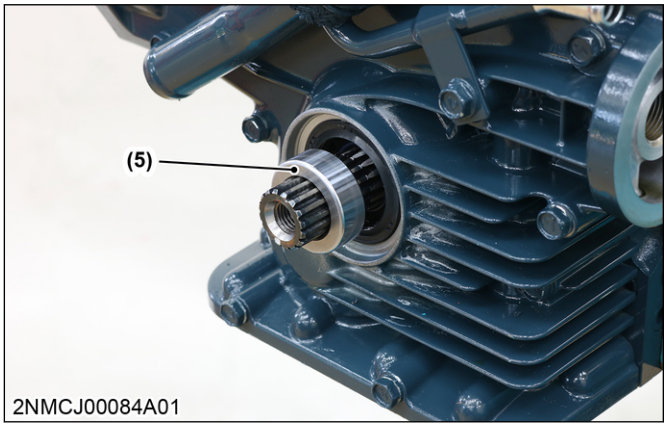
2. Hook the start spring (4) between gear case cover and fork lever 1 (3).




(2) Screw
(3) Fork lever 1
(4) Start spring

3. Install the crankshaft collar (5).

**NOTE**
- **Install so that the groove of crankshaft collar (5) is on the O-ring side.**



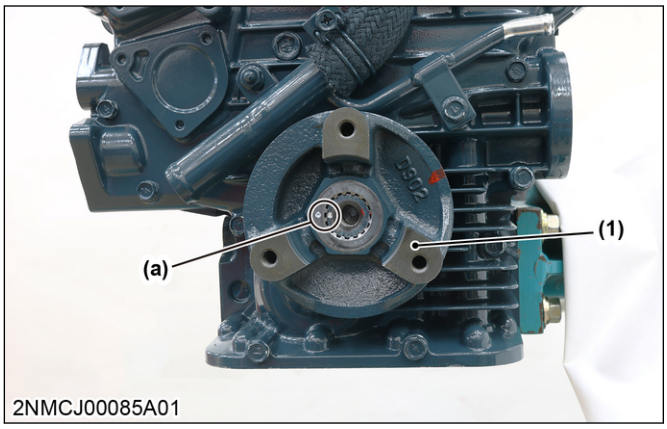

(5) Crankshaft collar

## 6.19 Installing fan drive pulley

**Tools required**
- Flywheel stopper

1. Fix the flywheel with a flywheel stopper.
2. Install the fan drive pulley (1).

**NOTE**
- **Align the alignment mark (a) between the crankshaft and fan drive pulley.**

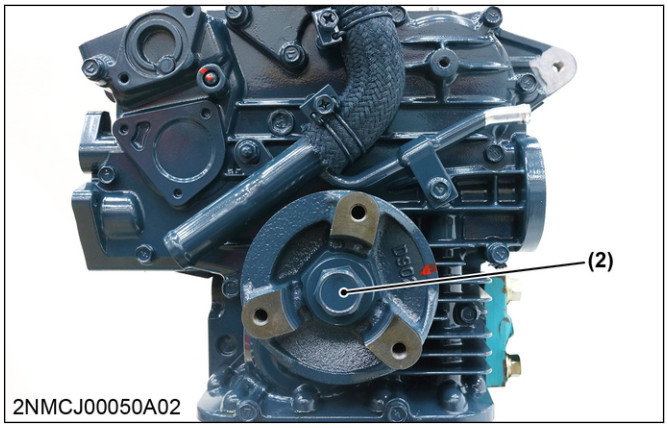



(1) Fan drive pulley (a) Alignment mark

3. Install the crankshaft screw (2) and tighten to specified torque.

**NOTE**
- **Apply the engine oil to Crankshaft screw (2).**

| | | |
|---|---|---|
| Tightening torque | Crankshaft screw (2) | 117.7 to 127.5 N·m<br>12.01 to 13.00 kgf·m<br>86.82 to 94.03 lbf·ft |

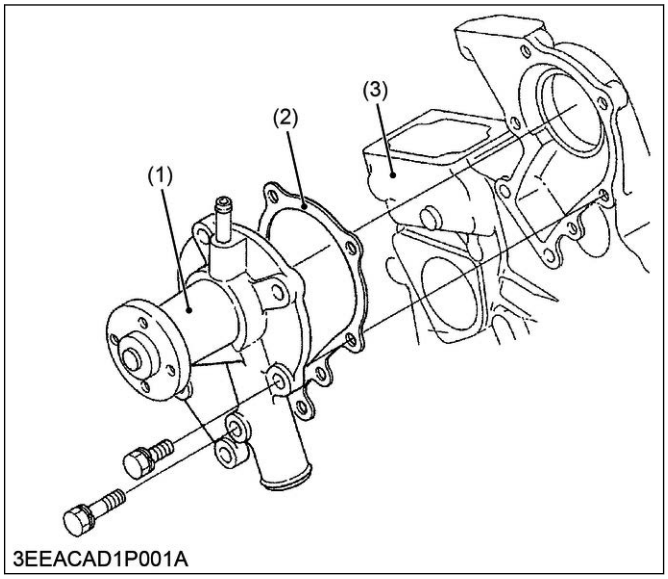



(2) Crankshaft screw

## 6.20 Installing water pump

1. Install the water pump (1).

**NOTE**
- **Replace the gasket with a new one.**




(1) Water pump (3) Gear case cover
(2) Gasket

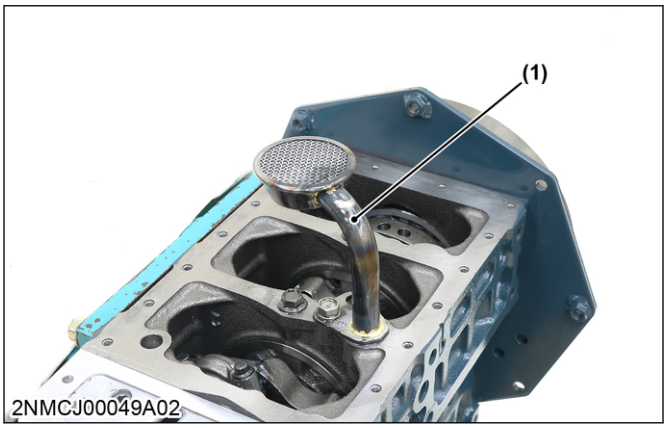
## 6.21 Installing oil strainer and oil pan

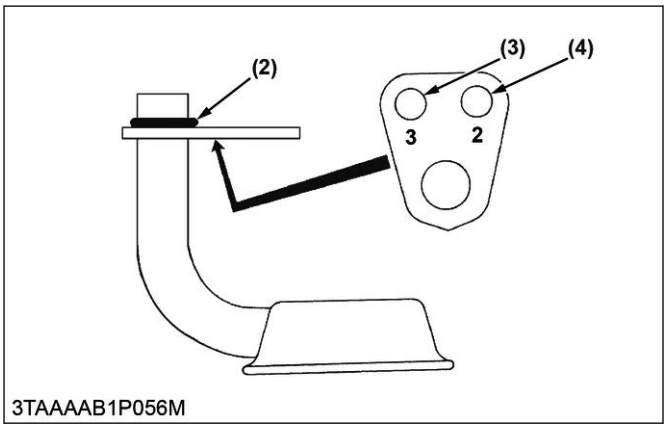
**NOTE**
- **Clean the oil pan and crankcase surface that attached each other.**

**Tools required**
- Liquid gasket (Three Bond 1217D) or equivalent

1. Install the oil strainer (1).

**NOTE**
- **Replace the O-ring (2) with a new one.**
- **Using care not to damage the O-ring (2).**
- **After cleaning the oil strainer (1), install it.**
- **Use the hole numbered 3 (3).**

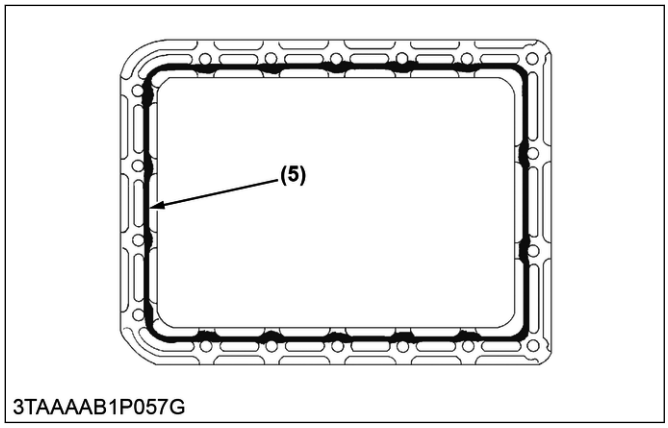


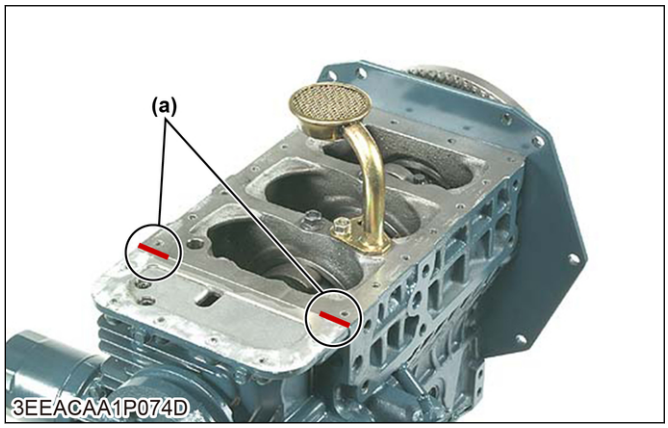




(1) Oil strainer
(2) O-ring
(3) Hole numbered 3
(4) Hole numbered 2

2. Apply liquid gasket (5) to the oil pan as shown in the figure and matching face (a) about crankcase and gear case cover as shown in the figure.

**NOTE**
- **Make sure that the liquid gasket (5) coating surface is free of water, dust and oil in order to keep sealing effect.**
- **Make sure the surfaces align when mounting parts with a liquid gasket (5) applied to them.**
- **Carefully apply the liquid gasket (5) evenly.**

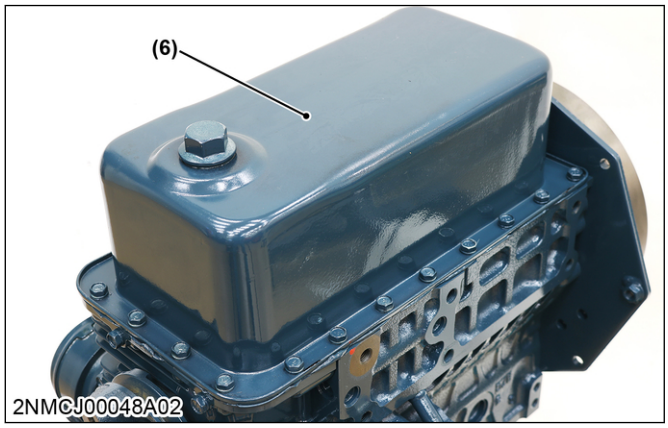



(5) Liquid gasket
(a) Matching face

3. Install the oil pan (6).

**NOTE**
- **Mount parts with a liquid gasket within 10 minutes of application.**
- **Tighten the mounting screws of the oil pan (6) in diagonal sequence from the center to tighten equally.**
- **Install the oil pan (6) with drain plug facing toward the gear case side.**



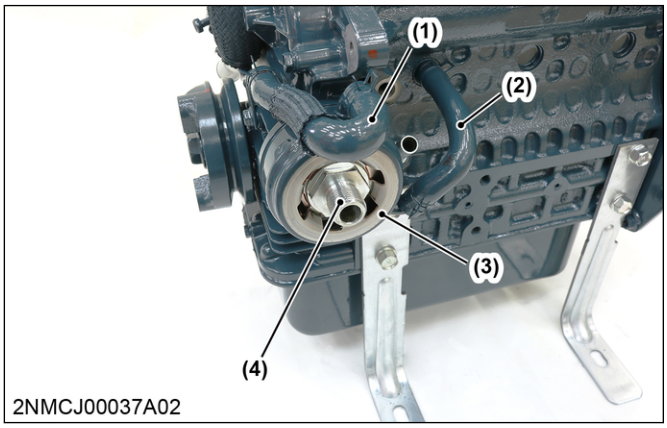

(6) Oil pan

## 6.22 Installing oil cooler

1. Install the oil cooler (3) and the water hose (1), (2).

2. Install the oil cooler joint screw (4) and tighten to the specified tightening torque.

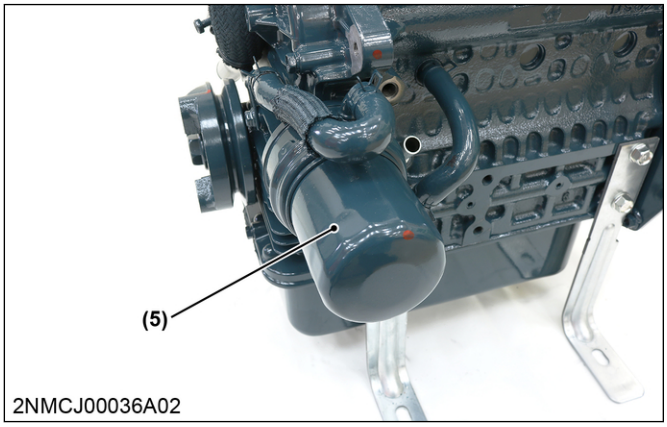
| | | |
|---|---|---|
| Tightening torque | Oil cooler joint screw (4) | 39.2 to 49.0 N·m<br>4.00 to 4.99 kgf·m<br>29.0 to 36.1 lbf·ft |




(1) Water hose
(2) Water hose
(3) Oil cooler
(4) Oil cooler joint screw

3. Tighten the oil filter cartridge (5) by hand.

**NOTE**
- **Apply the engine oil to O-ring of oil filter cartridge (5).**

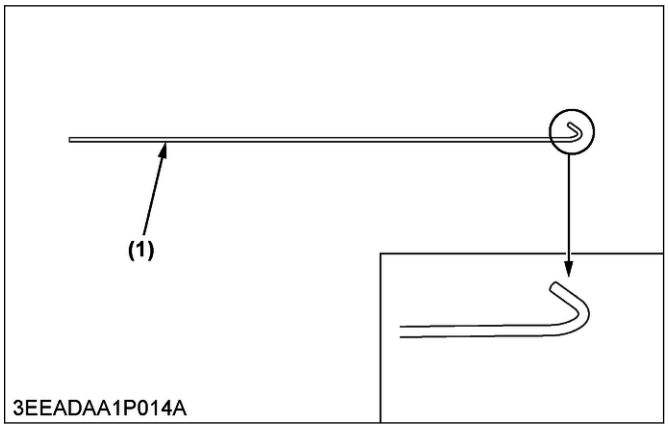


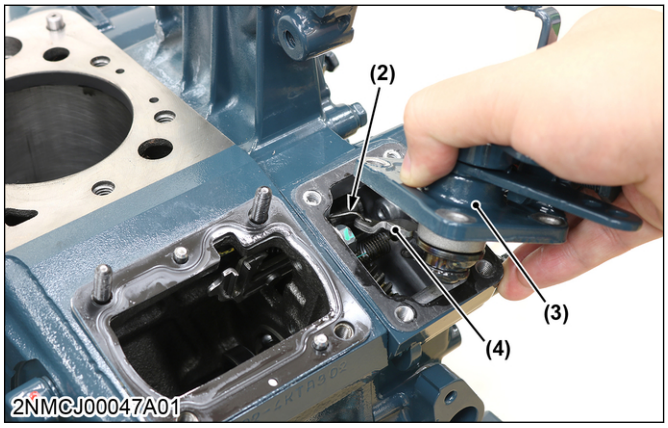

(5) Oil filter cartridge

## 6.23 Installing speed control plate (energed to stop type engine stop solenoid)

1. Hook the governor spring (2) to the governor lever (4) with the speed control plate (3) using with the specific tool (1).

**IMPORTANT**
- **Specific tool (1) is 1.2 mm (0.047 in.) diameter hard wire with its end hooked, overall length 200 mm (7.87 in.).**
  **The tip of wire is bent like the hook to hang springs.**
- **Do not use the pliers or the longnose pliers when deal with springs.**
- **The governor spring (2) is connected to the speed control plate (3), so that be careful in fear of broken when install the speed control plate (3).**

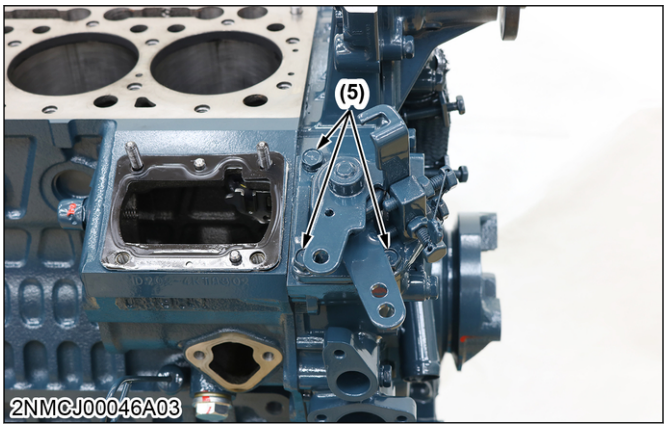



(1) Specific tool
(2) Governor spring
(3) Speed control plate
(4) Governor lever

2. Install the speed control plate (3).

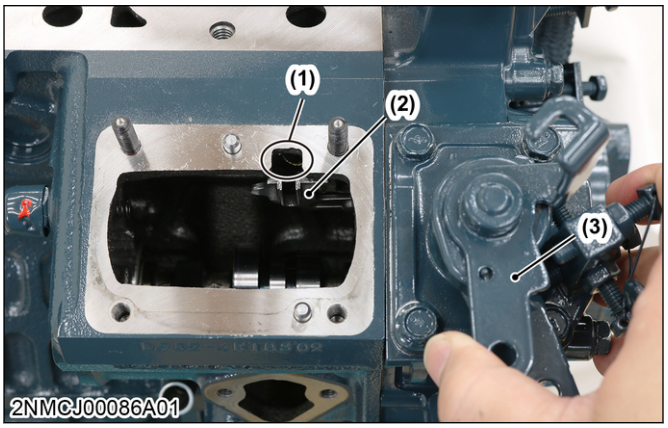
**IMPORTANT**
- **Use two copper gaskets and screws for crankcase side.**
- **Use two screws with spring washer for fuel feed pump side.**




(5) Speed control plate mounting screw

## 6.24 Installing fuel injection pump (energed to stop type engine stop solenoid)

1. Align the slot of fork lever 1 (2) and the slot of the crankcase (1) with moving the speed control lever (3).

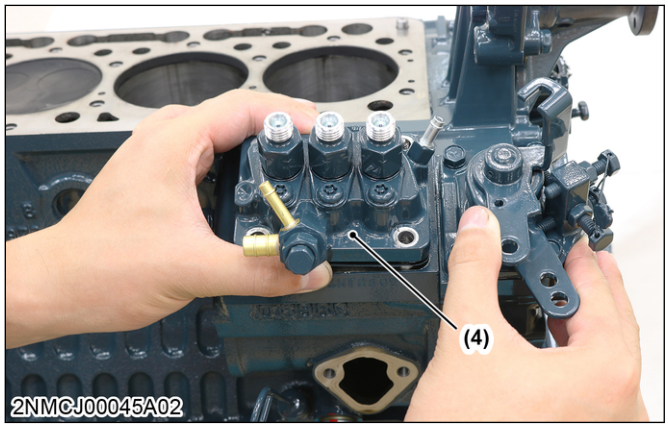


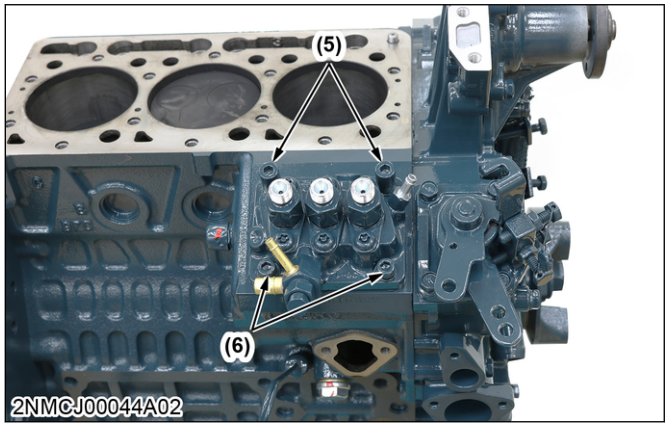

(1) Slot of crankcase
(2) Fork lever 1
(3) Speed control lever

2. Install the fuel injection pump (4) and tighten fuel injection pump mounting screw (6) and nut (5) to the specified torque.

**IMPORTANT**
- **Align the control rack pin and slot of the crankcase (1).**
- **Be sure to use the same number of new gasket shims with the same thickness.**
- **When you exchange the fuel injection pump (4) or fuel camshaft with gear, you have to adjust the injection timing by selecting shim.**
- **After install the fuel injection pump (4), check the movement of speed control lever and stop lever.**

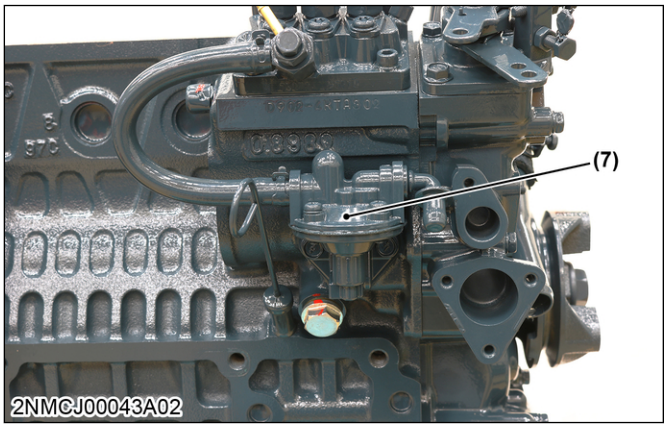
| | | |
|---|---|---|
| Tightening torque | Fuel injection pump mounting screw (6) | 9.80 to 11.3 N·m<br>1.00 to 1.15 kgf·m<br>7.23 to 8.33 lbf·ft |
| | Fuel injection pump mounting nut (5) | 9.80 to 11.3 N·m<br>1.00 to 1.15 kgf·m<br>7.23 to 8.33 lbf·ft |




(4) Fuel injection pump
(5) Fuel injection pump mounting nut
(6) Fuel injection pump mounting screw

3. Install the fuel feed pump (7).



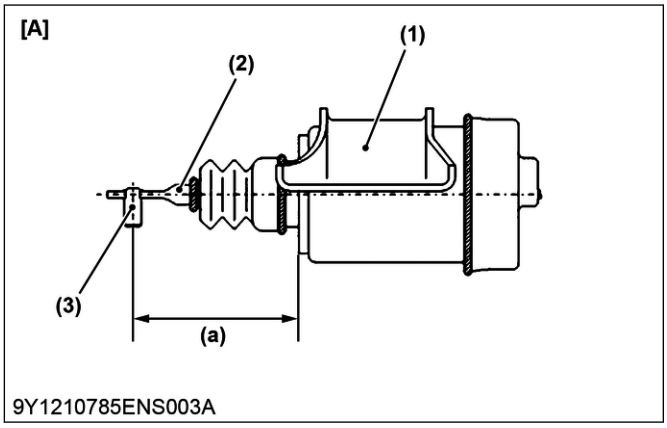

(7) Fuel feed pump

## 6.25 Installing engine stop solenoid (energed to stop type engine stop solenoid)

**IMPORTANT**

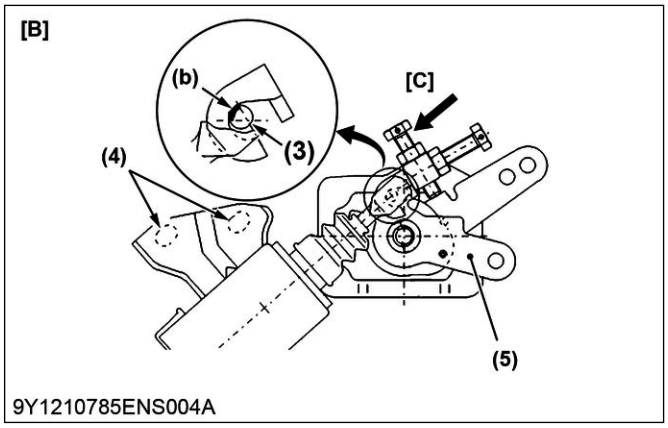
- **Check to see that there are no dust on the mounting surface of the engine stop solenoid (1).**

1. Make sure that the plunger (2) of the engine stop solenoid (1) is maximum pulled out position.




(1) Engine stop solenoid
(2) Plunger
(3) Pin
[A] Plunger installation
(a) Maximum pulled out position

2. Make sure that the pin (3) of the solenoid makes contact with the engine stop lever (5) in the direction of figure [B].

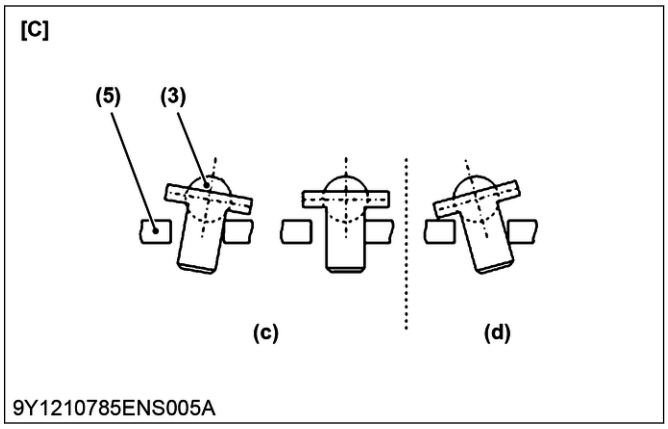



(3) Pin
(4) Engine stop solenoid mounting screw
(5) Engine stop lever
[B] Contact position
(b) Contact area

3. Make sure that the contact between the pin (3) of the engine stop solenoid (1) and the engine stop lever (5) meets to the good condition of figure [C].

**IMPORTANT**

- **Do not press the pin strongly.**



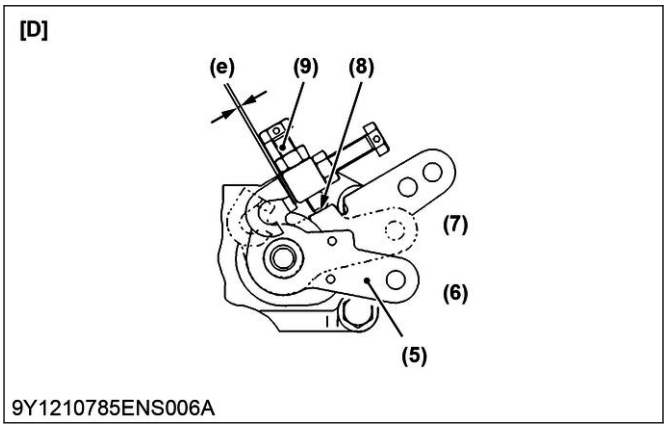

(3) Pin
(5) Engine stop lever
[C] Contact condition
(c) Good
(d) Bad

4. Tighten the engine stop solenoid mounting screw (4) with satisfied above all conditions.

5. Apply under 8 V to the stop solenoid and make sure that figure [D] is satisfied.

**IMPORTANT**

- **Make sure that the engine stops after the engine stop solenoid (1) operates the engine stop lever (5) and comes in contact with the stopper adjusting bolt (9).**



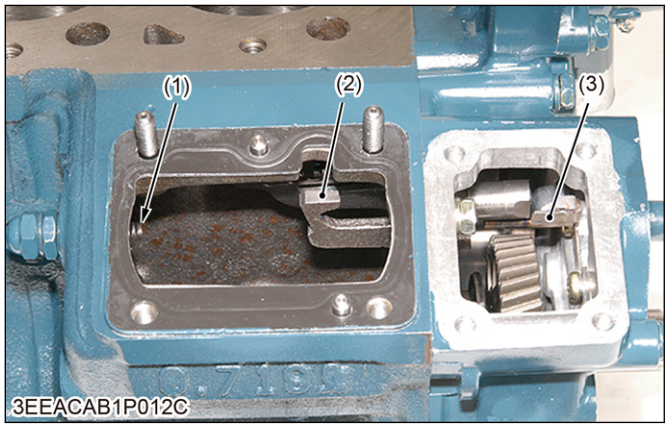

(5) Engine stop lever
(6) Engine start position
(7) Engine stop position
(8) Contact point
(9) Stopper adjusting bolt
[D] Tightening position
(e) Less than 1 mm (0.04 in.)

## 6.26 Installing speed control plate, fuel injection pump, and engine stop solenoid

**NOTE**

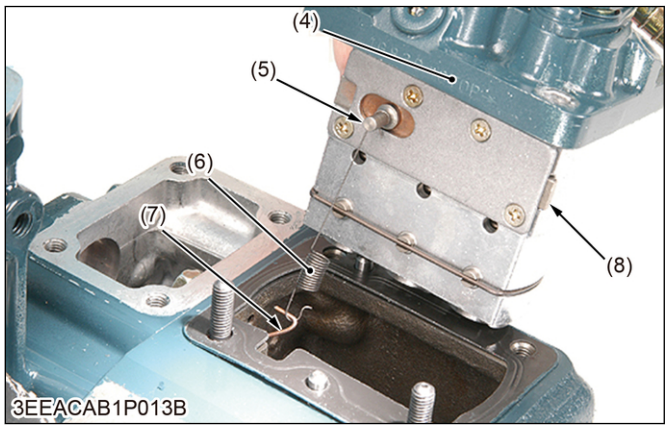
- **Be careful not to stretch the start spring (6) too long. Otherwise it may get deformed permanently.**
- **Make sure the start spring (6) is tight on the bracket (3).**
- **The sealant is applied to both sides of the soft metal gasket shim. The liquid gasket is not required for assembling.**
- **Addition or reduction of shim (0.05 mm, 0.002 in.) delays or advances the injection timing by approx. 0.009 rad (0.5°).**
- **In disassembling and replacing, be sure to use the same number of new gasket shims with the same thickness.**

1. Move the fork lever (2) to the gear case side.



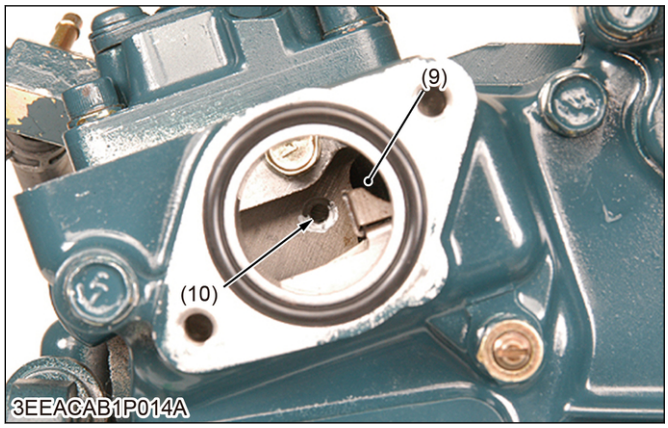

(1) Idling adjusting spring
(2) Fork lever
(3) Bracket

2. Hook the start spring (6) to the injection pump control rack pin (5).



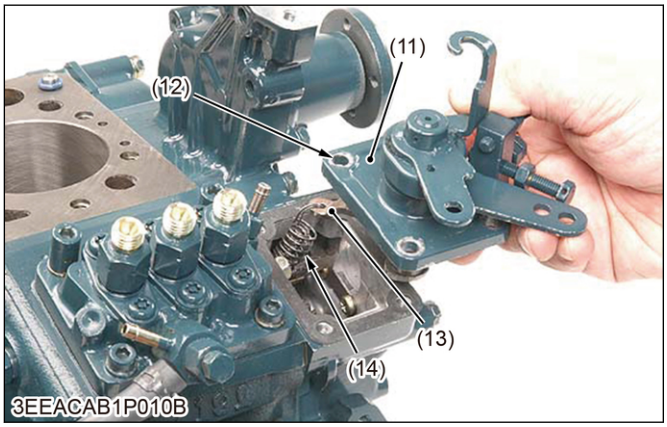

(4) Injection pump
(5) Injection pump control rack pin
(6) Start spring
(7) Specific tool
(8) Injection pump control rod

3. Put the specific tool (7) through the fork lever hole of cylinder block (9) and hook the start spring (6).



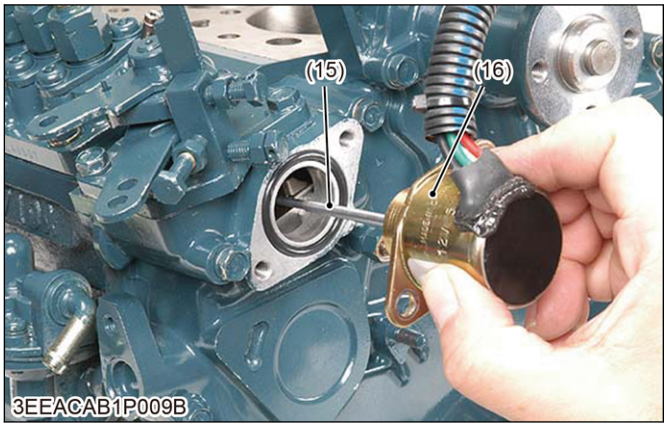

(9) Fork lever hole of cylinder block
(10) Guide hole of cylinder block

4. Keep this spring slightly extended and install the injection pump (4). Make sure the injection pump control rod (8) should be pushed by the idling adjusting spring (1) and the injection pump control rack pin (5) on the rod engages with the fork lever (2).
5. Hook the start spring (6) to the bracket (3) using the specific tool (7).
6. Hook the governor springs (small and large) (14) to the governor lever (13) using the specific tool (7) and install the speed control plate (11). Be sure to place the copper washers underneath two screws (12) in the upper of the speed control plate.




(11) Speed control plate
(12) Screw and copper washer
(13) Governor lever
(14) Governor spring

7. Install the engine stop solenoid rod (15) to the guide hole of cylinder block (10) and fix the engine stop solenoid (16) with socket head screws.

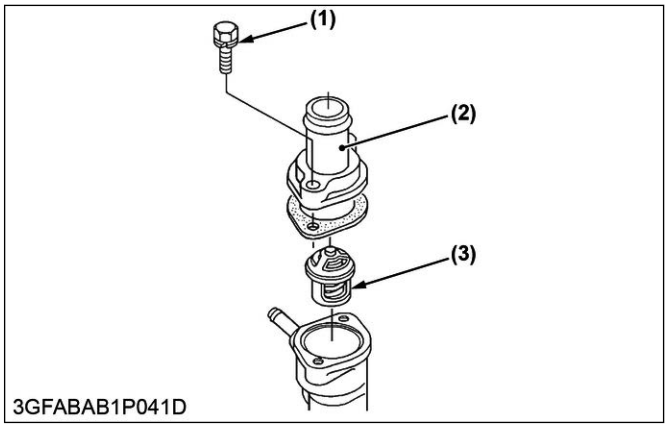



(15) Engine stop solenoid rod
(16) Engine stop solenoid

## 6.27 Installing thermostat assembly

1. Install the thermostat assembly (3).
2. Install the thermostat cover (2), and install the thermostat cover mounting screw (1).

**■ NOTE**
- **Replace the gasket with a new one.**




(1) Thermostat cover mounting screw
(2) Thermostat cover
(3) Thermostat assembly

## 6.28 Installing valve

**■ NOTE**
- **Clean the valve stem and valve guide hole.**

**Tools required**
- Valve spring compressor

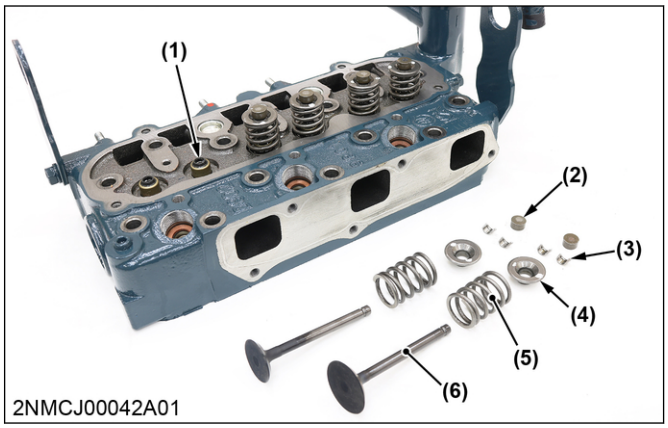
1. Install the valve stem seal (1).

**■ NOTE**
- **Apply the engine oil sufficiently.**

2. Install the valve (6).

**■ NOTE**
- **Do not change the combination of valve and valve guide.**

3. Set the valve spring (5) and valve spring retainer (4).
4. Compress the valve spring with valve spring compressor and install the valve spring collet (3).




(1) Valve stem seal
(2) Valve cap
(3) Valve spring collet
(4) Valve spring retainer
(5) Valve spring
(6) Valve

5. Remove the valve spring compressor.

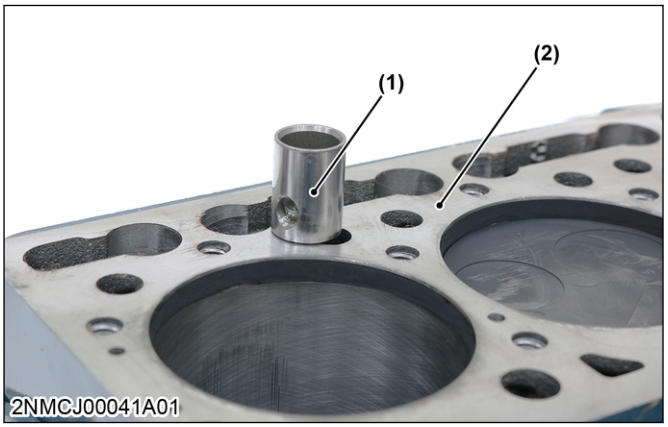
6. After installing the valve spring collets (3), lightly tap the stem tip to attach it correctly with the plastic hammer.
7. Install the valve cap (2).

## 6.29 Installing tappet

**■ IMPORTANT**
- **Do not change the combination of cylinder number and tappet.**

**■ NOTE**
- **Apply the engine oil thinly around tappet.**

1. Install the tappet (1) to the crankcase (2).




(1) Tappet (2) Crankcase

## 6.30 Installing cylinder head

**■ NOTE**
- **Replace the cylinder head gasket (2) with a new one.**
- **The cylinder head (1) should be free of scratches and dust.**

1. Install the cylinder head gasket (2).

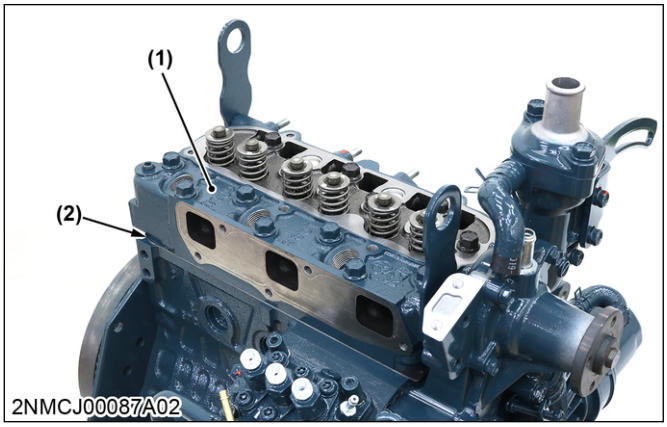
**■ NOTE**
- **When installing the gasket, set it to the knock pin hole. Be careful not to mount it reversely.**
- **Be careful for handling the gasket not to damage it.**

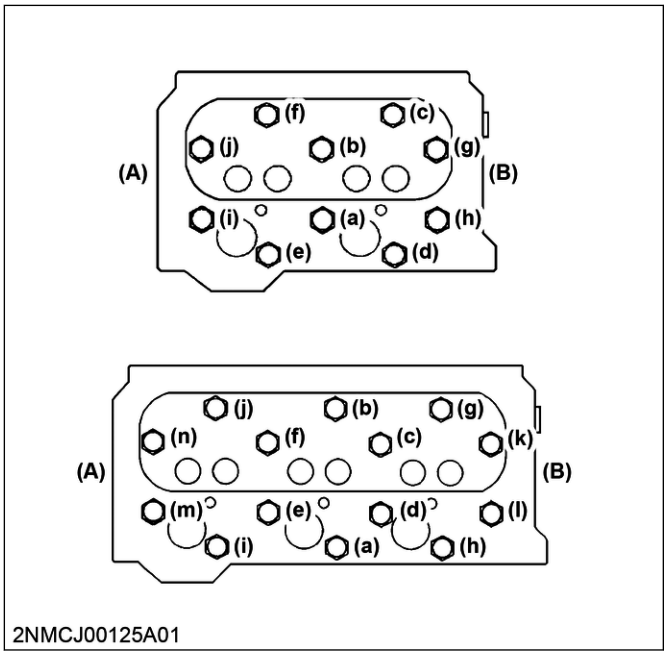
2. Install the cylinder head (1) and tighten to the specified torque.

**■ IMPORTANT**
- **Use the cylinder head screw (1J080-03450) when tightening the cylinder head mounting screw of D722-E4 (Serial Number 4MM3857 ～). Otherwise, the cylinder head screw may be plastic deformation.**

**■ NOTE**
- **If reuse the cylinder head mounting screw, apply the engine oil.**
  **If use new cylinder head mounting screw, do not need to apply the engine oil.**
- **Tighten the cylinder head mounting screw gradually in the sequence of (a) to (n) or (j).**
- **The polished cylinder head mounting screw with no marking on the screw head has possibly used.**
- **In this case, tighten this screw to the same torque as normal one.**

| | | |
|---|---|---|
| Tightening torque | Cylinder head mounting screw | 38 to 42 N·m<br>3.9 to 4.2 kgf·m<br>28 to 30 lbf·ft |
| Tightening torque (D722-E4 (Serial Number:below 4MM3857)) | | 40.2 to 45.4 N·m<br>4.10 to 4.62 kgf·m<br>29.7 to 33.4 lbf·ft |
| Tightening torque (D902-TE4) | | 40.2 to 45.4 N·m<br>4.10 to 4.62 kgf·m<br>29.7 to 33.4 lbf·ft |

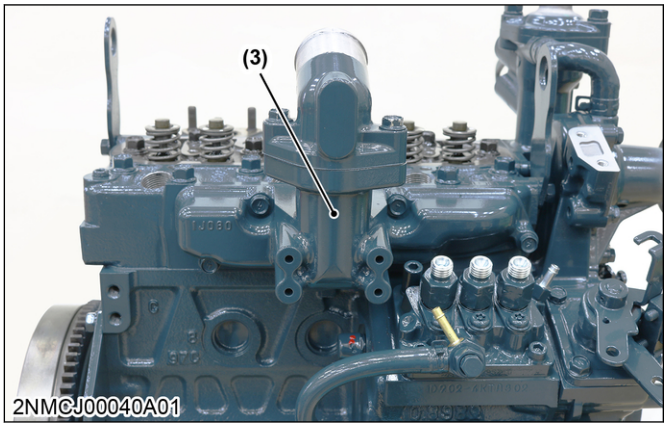





(1) Cylinder head
(2) Cylinder head gasket
(A) Flywheel side
(B) Gear case side

3. Install the intake manifold (3).

**■ NOTE**
- **Replace the intake manifold gasket with a new one.**




(3) Intake manifold

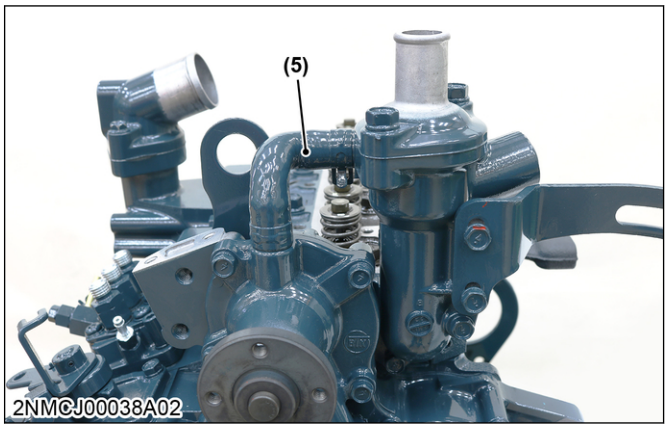
4. Install the exhaust manifold (4) and tighten to the specified torque.

**■ NOTE**
- **Replace the exhaust manifold gasket with a new one.**

| | | |
|---|---|---|
| Tightening torque | Exhaust manifold mounting nut | 9.80 to 11.3 N·m<br>1.00 to 1.15 kgf·m<br>7.23 to 8.33 lbf·ft |
| | Exhaust manifold mounting screw | 9.80 to 11.3 N·m<br>1.00 to 1.15 kgf·m<br>7.23 to 8.33 lbf·ft |


(4) Exhaust manifold

5. Connect the water return hose (5).

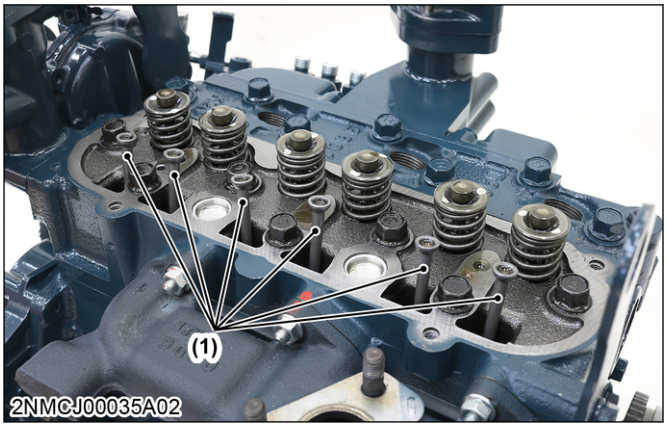


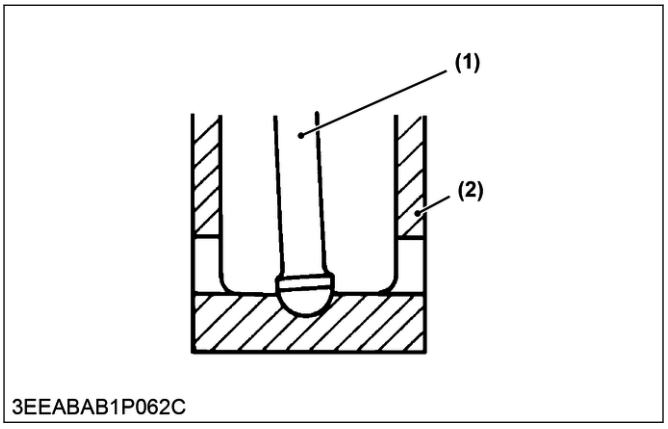

(5) Water return hose

## 6.31 Installing rocker arm assembly

1. Install the push rod (1).

**NOTE**
- **When installing the push rod (1), mount it securely in the groove of the tappet (2).**



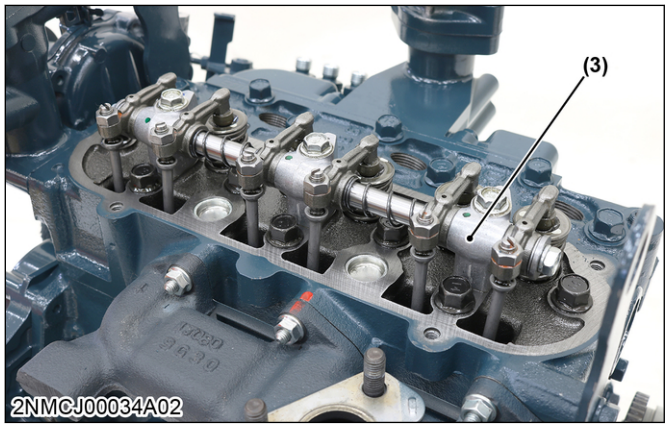

(1) Push rod (2) Tappet

2. Install the rocker arm assembly (3) and tighten the rocker arm bracket screw to the specified torque.

**IMPORTANT**
- **After installing the rocker arm assembly, adjust the valve clearance.**

| | | |
|---|---|---|
| Tightening torque | Rocker arm bracket screw | 9.80 to 11.3 N·m<br>1.00 to 1.15 kgf·m<br>7.23 to 8.33 lbf·ft |

| | | |
|---|---|---|
| Valve clearance (Cold) | Service specification | 0.145 to 0.185 mm<br>0.00571 to 0.00728 in. |




(3) Rocker arm assembly

RELATED PAGE
4.2 Checking valve clearance on page 4-72

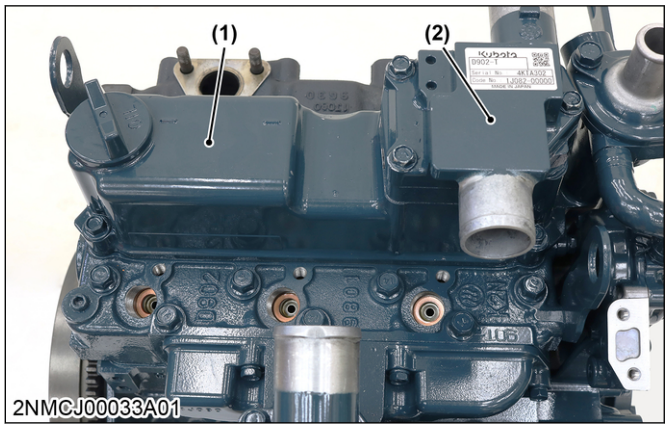
## 6.32 Installing cylinder head cover

**NOTE**
- **Replace the gasket with a new one.**

1. Install the cylinder head cover (1) and tighten to the specified torque.

**NOTE**
- **Apply the engine oil to the cylinder head cover screw.**

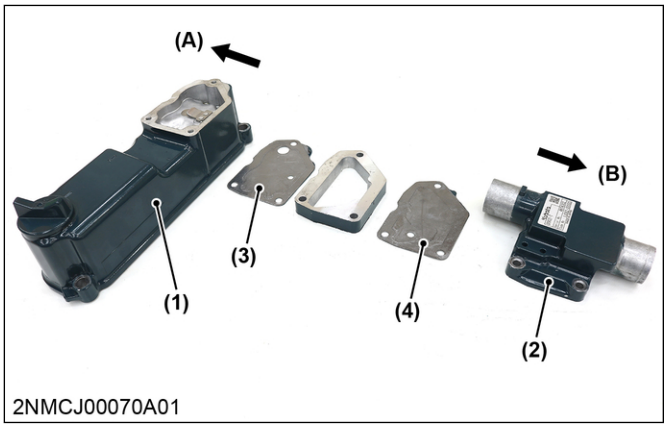
| | | |
|---|---|---|
| Tightening torque | Cylinder head cover screw | 6.86 to 11.3 N·m<br>0.700 to 1.15 kgf·m<br>5.06 to 8.33 lbf·ft |




(1) Cylinder head cover (2) Breather cover

2. Install the breather cover if removed.

**IMPORTANT**
- **Make sure the direction of upper gasket (4) and lower gasket (3).**




(1) Cylinder head cover
(2) Breather cover
(3) Lower gasket
(4) Upper gasket
(A) Bottom side
(B) Top side

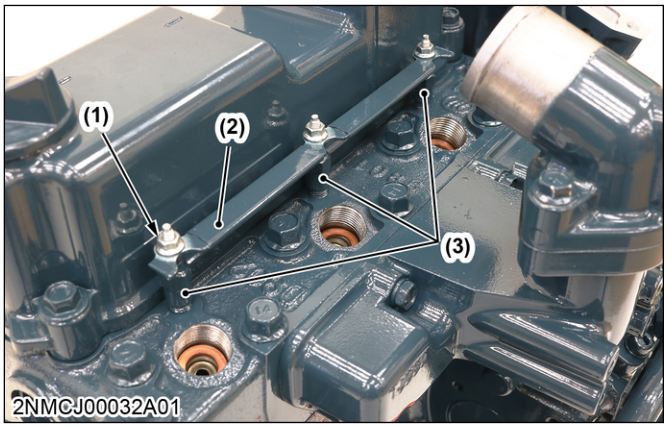
## 6.33 Installing glow plug

1. Install the glow plug (3) and tighten to the specified torque.

| | | |
|---|---|---|
| Tightening torque | Glow plug (3) | 7.84 to 14.7 N·m<br>0.800 to 1.49 kgf·m<br>5.79 to 10.8 lbf·ft |

2. Install the glow lead (2) and tighten glow lead mounting nut (1) to the specified torque.

| | | |
|---|---|---|
| Tightening torque | Glow lead mounting nut (1) | 0.980 to 1.76 N·m<br>0.100 to 0.179 kgf·m<br>0.723 to 1.29 lbf·ft |




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

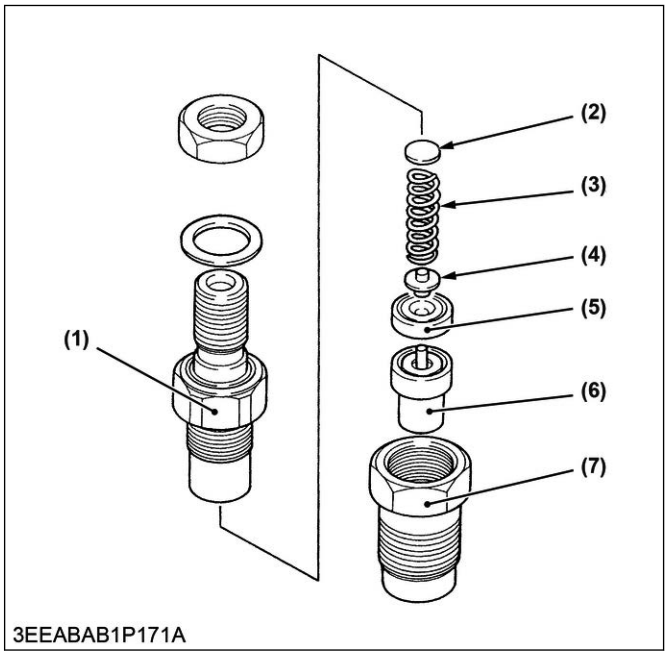
## 6.34 Assembling injection nozzle holder assembly

**IMPORTANT**
- **Assemble the nozzle holder assembly in clean the fuel.**

**Tools required**
- Vise

1. Install the inside parts in order.

**NOTE**
- **Refer to the illustration for the order.**
- **Check the direction of inside parts, but push rod (4) can be in either direction.**




(1) Nozzle holder
(2) Adjusting washer
(3) Nozzle spring
(4) Push rod
(5) Distance piece
(6) Nozzle piece
(7) Nozzle retaining nut

2. Install the nozzle holder (1) and tighten loosely.
3. Secure the nozzle retaining nut (7) with a vise.
4. Tighten the nozzle holder (1) to the specified torque.

**NOTE**
- **After assembling the nozzle, be sure to adjust the fuel injection pressure.**

| | | |
|---|---|---|
| Tightening torque | Nozzle holder | 29 to 49 N·m<br>3.0 to 4.9 kgf·m<br>22 to 36 lbf·ft |

RELATED PAGE
4.22 Checking fuel injection pressure on page 4-84

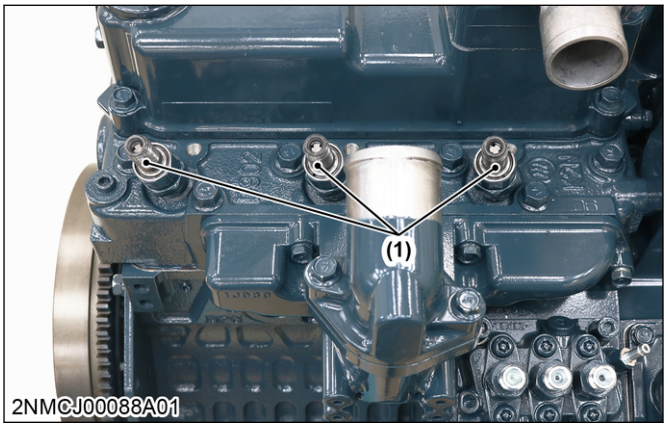
## 6.35 Installing injection nozzle holder

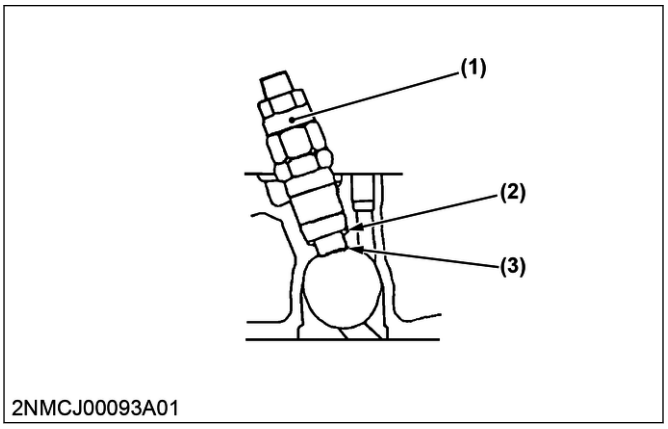
1. Install the heat seal (3) and copper gasket (2).

**NOTE**
- **Replace the copper gasket (2) and heat seal (3) with new ones.**

2. Install the injection nozzle holder (1) and tighten to the specified torque.

| | | |
|---|---|---|
| Tightening torque | Injection nozzle holder (1) | 49.0 to 68.6 N·m<br>5.00 to 6.99 kgf·m<br>36.2 to 50.5 lbf·ft |

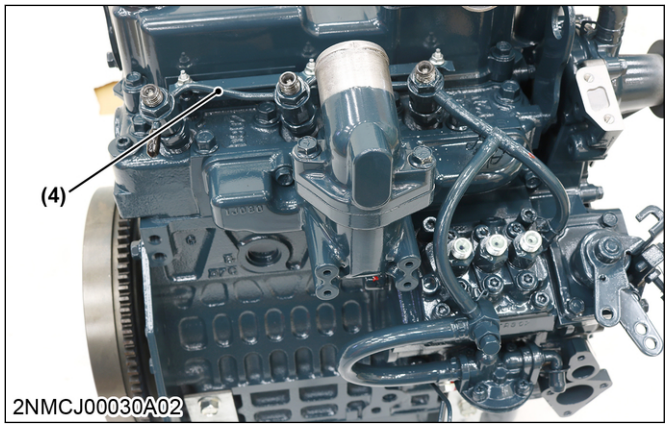



(1) Injection nozzle holder
(2) Copper gasket
(3) Heat seal

3. Install the overflow pipe (4) and tighten the overflow pipe retaining nut to the specified torque.

| | | |
|---|---|---|
| Tightening torque | Overflow pipe retaining nut | 34.3 to 39.2 N·m<br>3.50 to 3.99 kgf·m<br>25.3 to 28.9 lbf·ft |

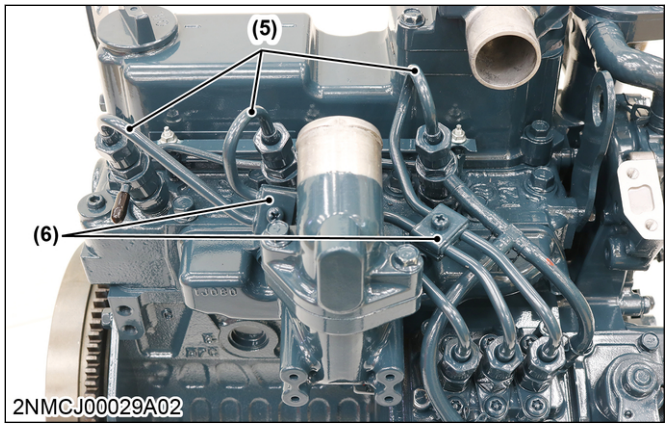



(4) Overflow pipe

4. Install the injection pipes (5) and tighten the injection pipe retaining nut to the specified torque.

| | | |
|---|---|---|
| Tightening torque | Injection pipe retaining nut | 24.5 to 34.3 N·m<br>2.50 to 3.49 kgf·m<br>18.1 to 25.2 lbf·ft |

5. Install the pipe clamp (6).




(5) Injection pipe
(6) Pipe clamp

## 6.36 Installing turbocharger assembly for D902-TE4

**NOTE**
- **Before you start the engine, make sure that the air cleaner is in the correct position.**
- **Replace the gaskets with new ones.**

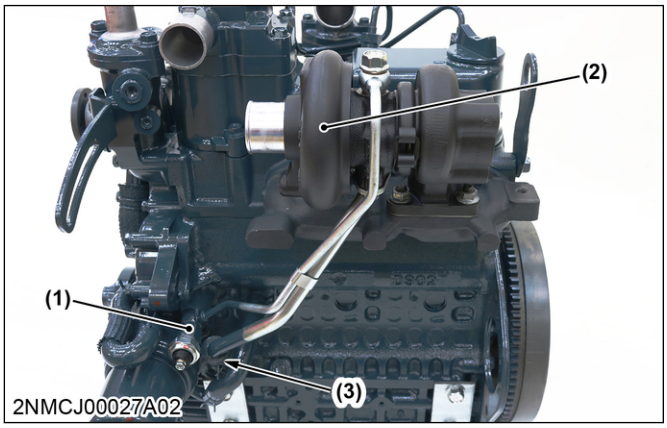
1. Install turbocharger assembly (2) to the specified torque.

**■ NOTE**
- **Do not let dust, dirt and other unwanted materials in the oil pipes.**
- **Fill clean the engine oil through the oil filler port of the turbocharger.**

| | | |
|---|---|---|
| Tightening torque | Turbocharger assembly mounting nut | 9.80 to 11.3 N·m<br>1.00 to 1.15 kgf·m<br>7.23 to 8.33 lbf·ft |

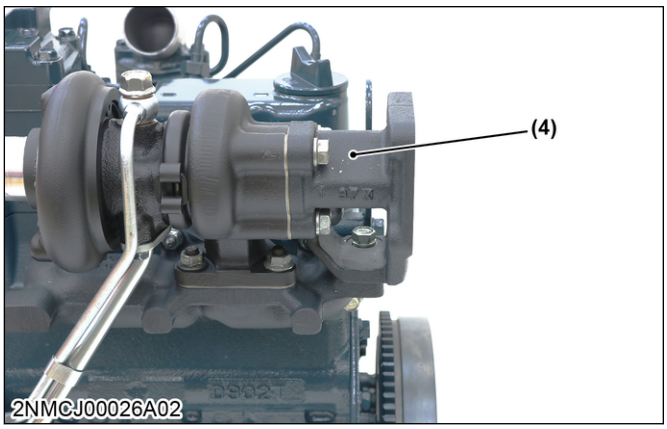
2. Connect the return pipe (3) and oil pipe.
3. Tighten the oil pipe joint screw (1) to the specified torque.

| | | |
|---|---|---|
| Tightening torque | Oil pipe joint screw (1) | 15.7 to 19.6 N·m<br>1.60 to 1.99 kgf·m<br>11.6 to 14.4 lbf·ft |



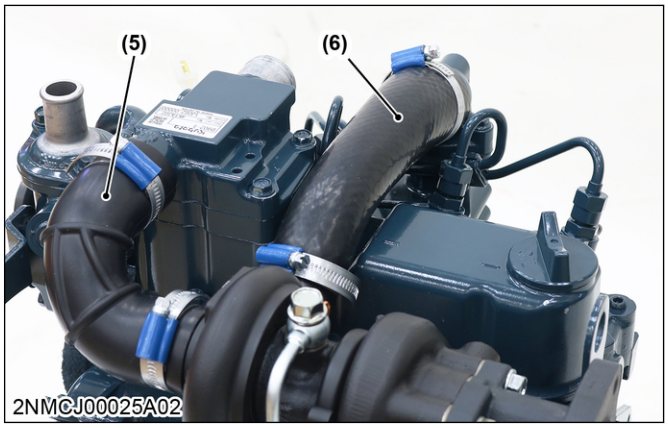

(1) Oil pipe joint screw
(2) Turbocharger assembly
(3) Return pipe

4. Install the turbocharger bracket (4).




(4) Turbocharger bracket

5. Connect the inlet hose (5), (6).




(5) Inlet hose
(6) Inlet hose

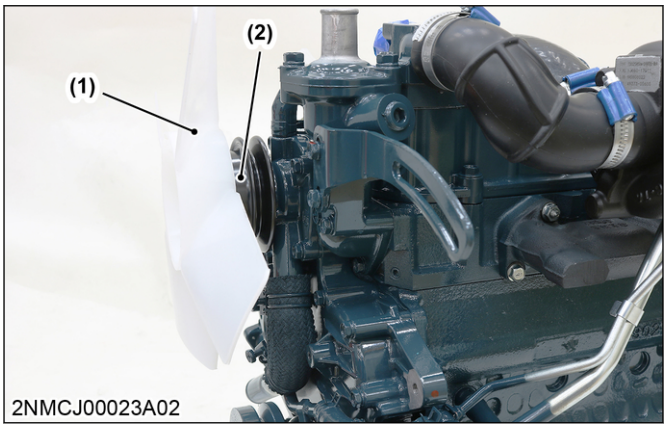
## 6.37 Installing external components

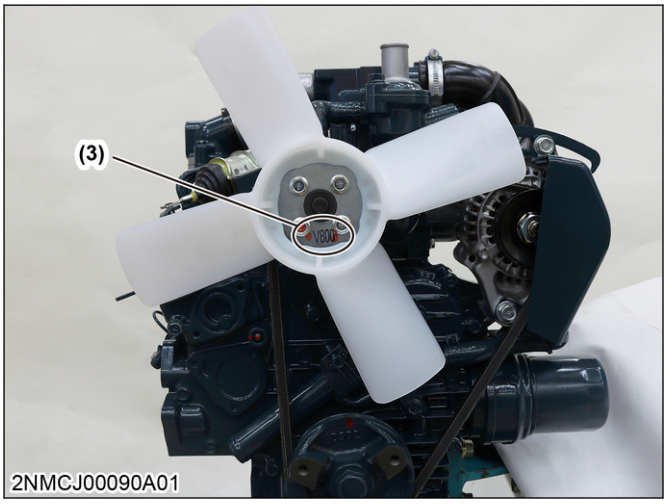
**■ NOTE**
- **Check for cracks on the fan belt surface.**

1. Install the fan pulley (2) and the cooling fan (1) and loosely tighten the cooling fan mounting screw.

**■ IMPORTANT**

- **Do not put the cooling fan (1) in the incorrect direction.**
- **Install the cooling fan so that the number (3) of the cooling fan is toward the front side (radiator side).**



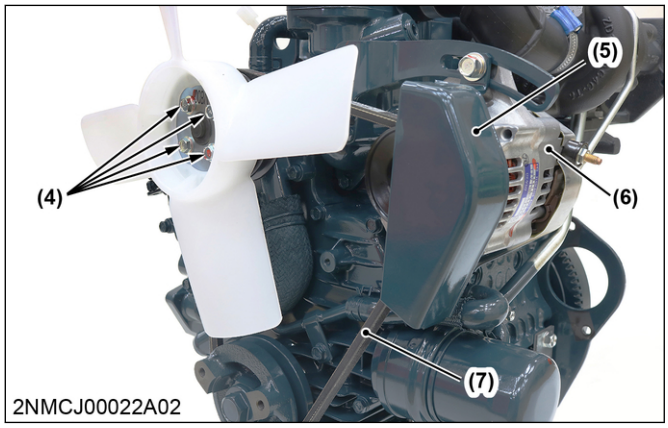

(1) Cooling fan
(2) Fan pulley
(3) Number

2. Install the alternator (6) and fan belt cover (5).
3. Install the fan belt (7).
4. Tighten the cooling fan mounting screw (4).

**■ IMPORTANT**

- **After install the fan belt, adjust the fan belt tension.**
- **If replacing the fan belt with a new one, adjust the fan belt tension to the specified value.**

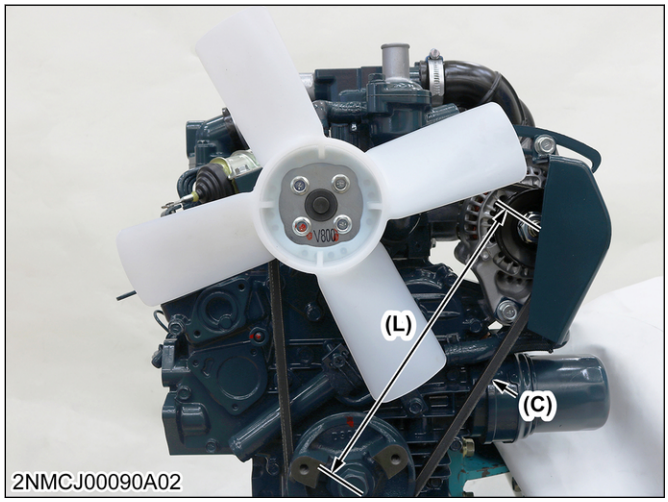
| | | |
|---|---|---|
| Tightening torque | Cooling fan mounting screw (4) | 9.81 to 11.3 N·m<br>1.00 to 1.15 kgf·m<br>7.24 to 8.33 lbf·ft |




(4) Cooling fan mounting screw
(5) Fan belt cover
(6) Alternator
(7) Fan belt

| Sonic belt tension meter setting value | |
|---|---|
| Mass<br>(Mass per 1 rib 1 m of belt) | 80 g/rib/m |
| Width<br>(Number of ribs) | 1 |
| Span L | Measure at location (C) in the figure with (L) as the distance between the fan drive pulley and alternator pulley. |

| | | |
|---|---|---|
| Belt tension | Service specification | 200 to 300 N<br>20.4 to 30.5 kgf<br>45.0 to 67.4 lbf |
| | Service specification (Replacing the fan belt with a new one) | 344 to 441 N<br>35.1 to 44.9 kgf<br>77.4 to 99.1 lbf |



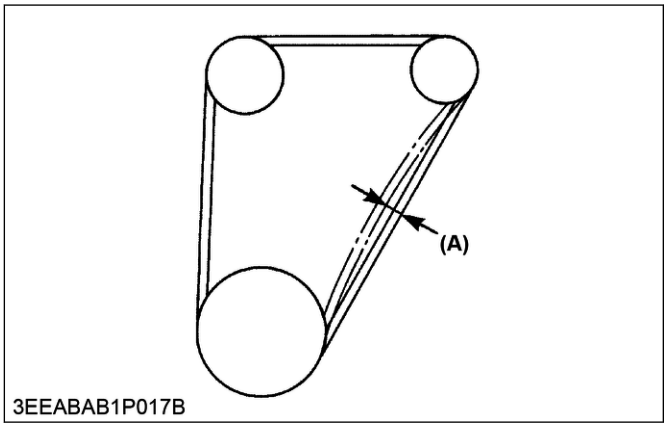

(C) Fan belt halfway

**(Reference)**

a. Push the belt halfway between the fan drive pulley and alternator pulley at a specified force to measure the deflection (A).

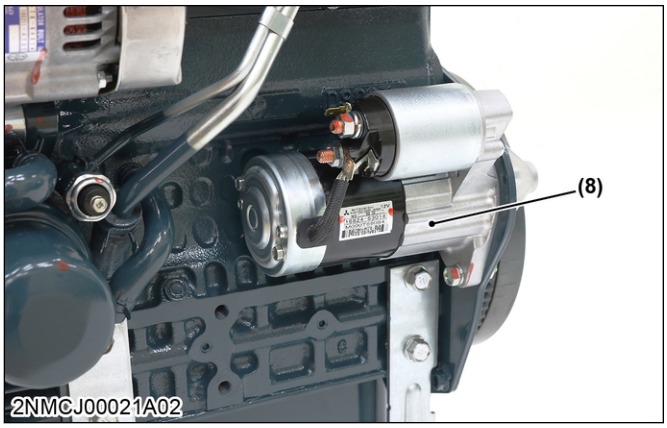
**■ NOTE**
- **If the measurement is out of the service specifications, loosen the alternator mounting screws and adjust its position.**

| | | |
|---|---|---|
| Deflection (A) | Service specification | 7.0 to 9.0 mm<br>0.28 to 0.35 in.<br>(Under load of 98 N<br>(10 kgf, 22 lbf)) |




(A) Deflection

5. Install the starter (8).




(8) Starter

6. Install the air cleaner.

## 6.38 Filling coolant

**■ IMPORTANT**
- **Do not mix the different type or brand of L.L.C.**
- **Do not use an anti-freeze and scale inhibitor at the same time.**

**■ NOTE**
- **Make sure the drain valve is closed.**

1. Fill the coolant until below the port from filling port of radiator.

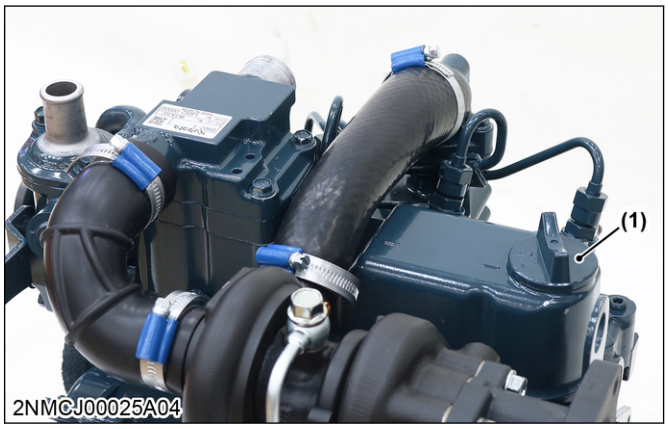
**■ IMPORTANT**
- **Make sure that you close the radiator cap correctly.**
- **When you add the coolant, release the air from the engine coolant channels.**
- **The engine releases the air when it shakes the radiator upper and lower hoses.**

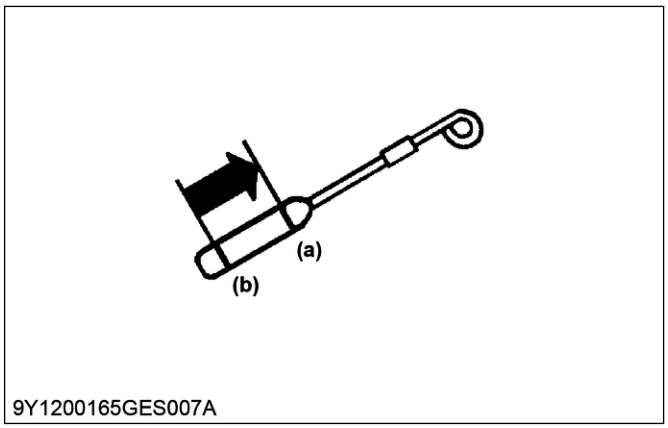
## 6.39 Filling engine oil

**■ IMPORTANT**
- **Do not mix different types of oil.**
- **Use the correct SAE engine oil by reference to the ambient temperature.**

**■ NOTE**
- **Make sure the drain plug is tightened.**

1. Fill the engine oil until the upper line (a) on the dipstick from filling port (1).




(1) Filling port
(a) Upper line
(b) Lower line

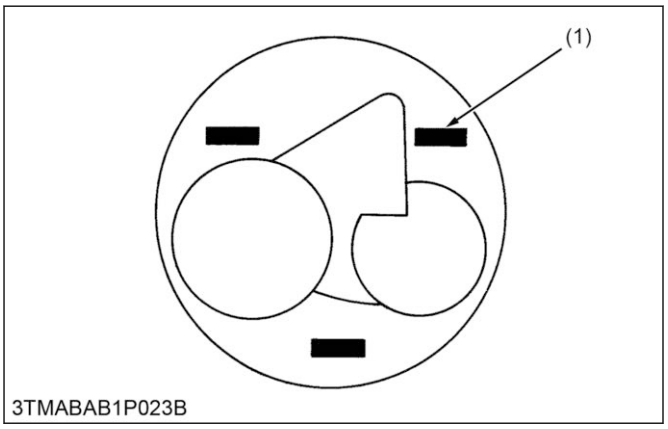
# 7. Servicing

## 7.1 Checking cylinder head top clearance

**Tools required**
- Plastigauge

1. Remove the cylinder head.
2. With the piston at T.D.C., use grease to affix three or four plastigauges (1) to the crown of the piston; keep the gauges away from the intake valve and combustion chamber fittings.

| | | |
|---|---|---|
| Plastigauge (1) cut size | Diameter | 1.5 mm<br>0.059 in. |
| | Length | 5.0 to 7.0 mm<br>0.20 to 0.27 in. |




(1) Plastigauge

3. Take the piston to an intermediate position, install the cylinder head and tighten the cylinder head mounting screw to the specified torque.

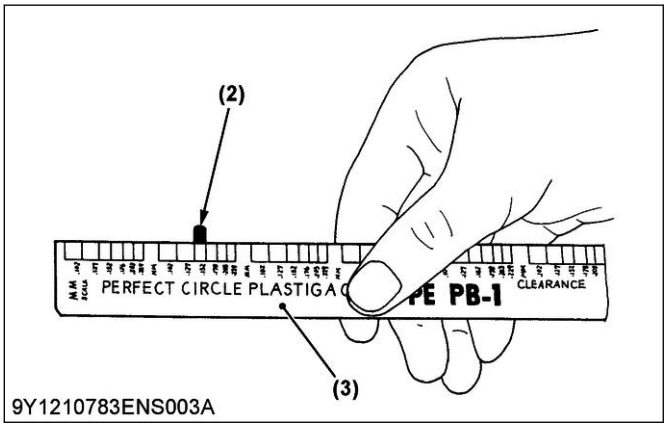
**■ NOTE**
- **The polished cylinder head mounting screw with no marking on the screw head has possibly used.**
- **In this case, tighten this screw to the same torque as normal one.**

| | | |
|---|---|---|
| Tightening torque | Cylinder head mounting screw | 38 to 42 N·m<br>3.8 to 4.3 kgf·m<br>28 to 31 lbf·ft |
| Tightening torque (D722-E4 (Serial Number: below 4MM3857)) | | 40.2 to 45.4 N·m<br>4.10 to 4.62 kgf·m<br>29.7 to 33.4 lbf·ft |
| Tightening torque (D902-TE4) | | 40.2 to 45.4 N·m<br>4.10 to 4.62 kgf·m<br>29.7 to 33.4 lbf·ft |

4. Turn the crankshaft so the piston goes through T.D.C.
5. Remove the cylinder head and compare the width of the crushed plastigauges (2) with the scale (3).

**■ NOTE**
- **Top clearance = Width of the crushed plastigauge (2)**
- **If they are out of service specification, check the oil clearance of the crankpin, journal and piston pins.**

| | | |
|---|---|---|
| Top clearance | Service specification (Z482-E4BG/Z482/Z602/D722/D782/D902-E4) | 0.50 to 0.70 mm<br>0.020 to 0.027 in. |
| | Service specification (D902-TE4) | 0.980 to 1.18 mm<br>0.0386 to 0.0465 in. |

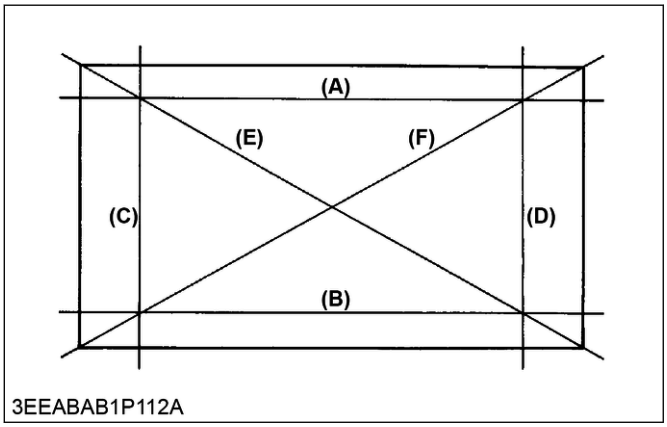



(2) Crushed plastigauge (3) Scale

## 7.2 Checking cylinder head surface flatness

**Tools required**
- Straightedge
- Feeler gauge

1. Clean the cylinder head surface.
2. Place a straightedge on the cylinder head's four sides (A), (B), (C) and (D) and two diagonal (E) and (F) as shown in the figure.

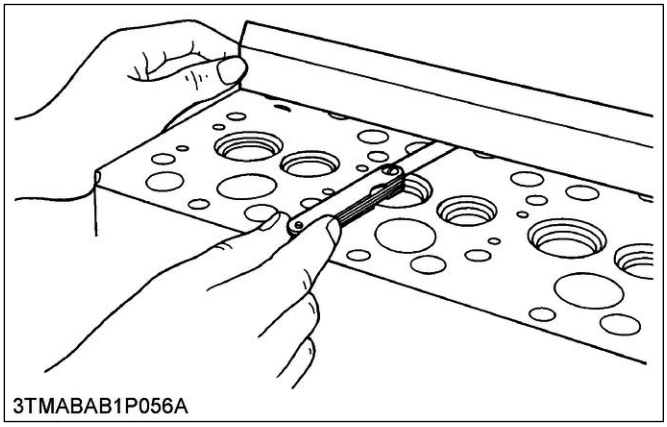


3. Measure the clearance with a feeler gauge.

**■ NOTE**
- **If the measurement is more than the service limit, replace the cylinder head.**

**■ IMPORTANT**
- **Do not place the straightedge on the combustion chamber.**
- **Check the valve recessing after you replace.**

| | | |
|---|---|---|
| Cylinder head surface flatness | Service limit | 0.05 mm<br>0.002 in. |

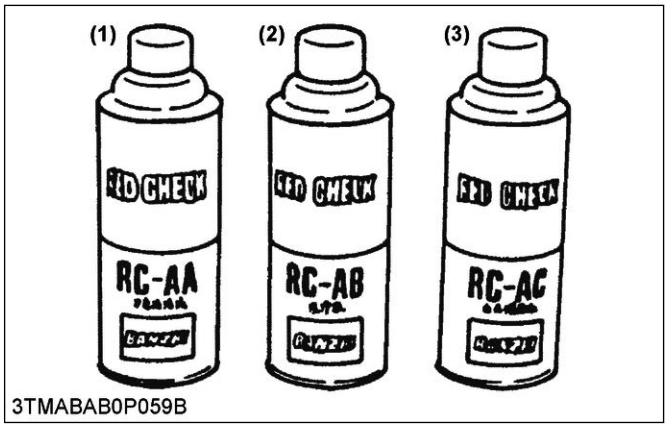

3TMABAB1P056A

## 7.3 Checking cylinder head flaw

**Tools required**
- Red permeative liquid
- Detergent
- White developer

1. Clean the surface of the cylinder head with detergent (2).
2. Apply some red permeative liquid (1) on the cylinder head surface.
3. After you apply, do not touch it for 5 to 10 minutes.
4. Clean away the red permeative liquid on the cylinder head surface with detergent (2).
5. Apply the white developer (3) on the cylinder head surface.

**■ NOTE**
- **If you found a red flaw, replace the cylinder head.**



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(1) Red permeative liquid
(2) Detergent
(3) White developer

## 7.4 Checking valve recessing

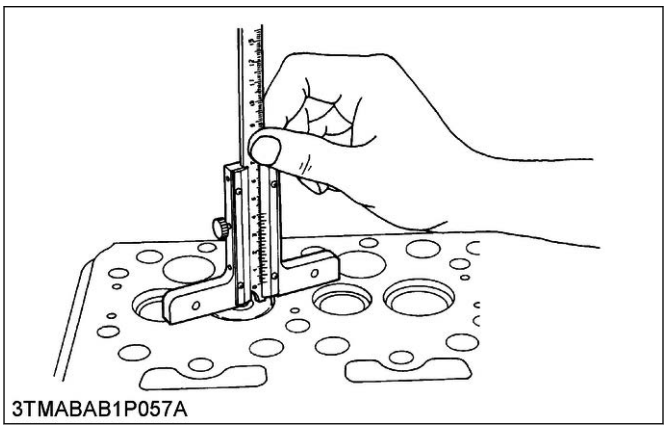
**Tools required**
- Depth gauge

1. Clean the cylinder head surface (1), valve face and valve seat.
2. Set the valve into the valve guide.

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 (resessing) mm<br>-0.0039 to 0.0039 in. |
| | Service limit | 0.30 mm<br>0.012 in. |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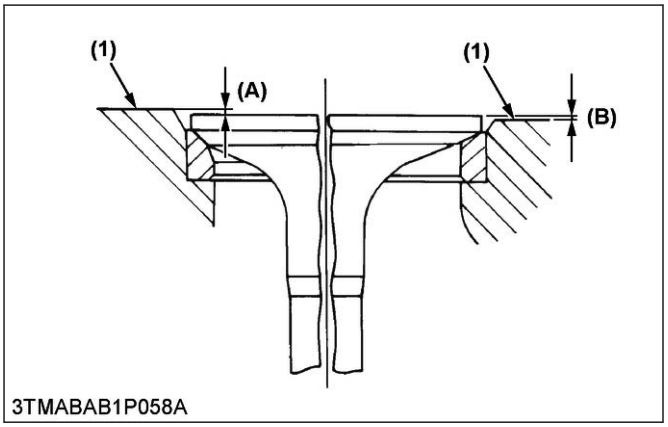


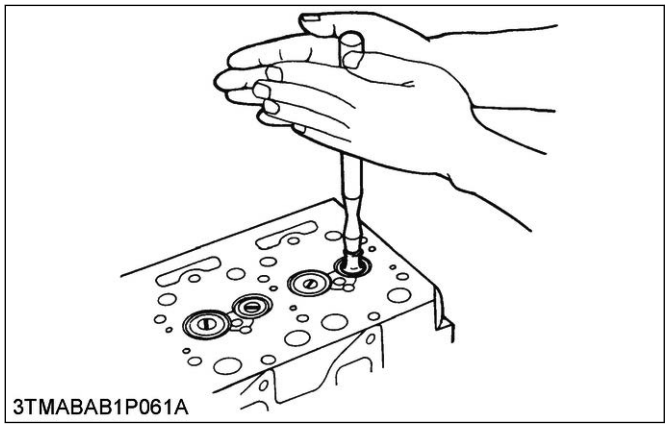
3TMABAB1P058A

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

## 7.5 Adjusting valve lapping

**Tools required**
- Compound
- Valve lapping tool
- Prussian Blue

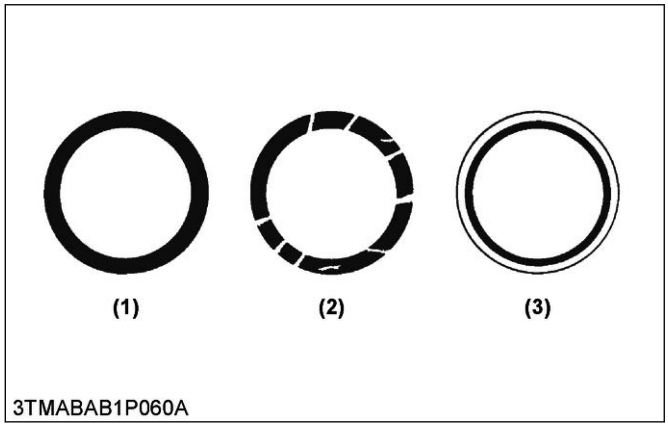
1. Apply the compound equally to the valve lapping surface.
2. Put the valve into the valve guide. Lap the valve on its seat with a valve lapping tool.
3. After you lap the valve, clean away the compound and apply oil, then lap the valve again with oil.


3TMABAB1P061A

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.**



3TMABAB1P060A

(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

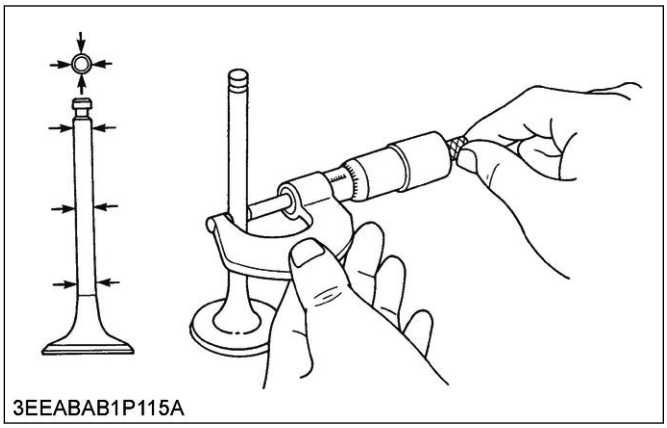
## 7.6 Checking clearance between valve stem and valve guide

**Tools required**
- Outside micrometer
- Inside micrometer

1. Remove carbon from the valve guide section.

2. Measure the valve stem O.D. with an outside micrometer.

| | | |
|---|---|---|
| Valve stem O.D. | Service specification | 5.968 to 5.980 mm<br>0.2350 to 0.2354 in. |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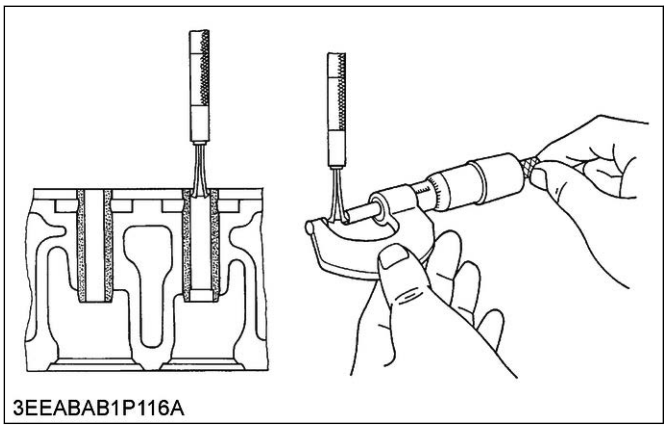
3. Measure the valve guide I.D. with an inside micrometer.

| | | |
|---|---|---|
| Valve guide I.D. | Service specification | 6.010 to 6.025 mm<br>0.2367 to 0.2372 in. |


3EEABAB1P116A

4. Calculate the clearance.

**■ NOTE**
- **If the clearance is more than the service limit, replace the valves.**
- **If the clearance stays more than the service limit, replace the valve guide also.**

| | | |
|---|---|---|
| Clearance between valve stem and valve guide | Service specification | 0.030 to 0.057 mm<br>0.0012 to 0.0022 in. |
| | Service limit | 0.10 mm<br>0.0039 in. |

RELATED PAGE
7.7 Replacing valve guide on page 4-138

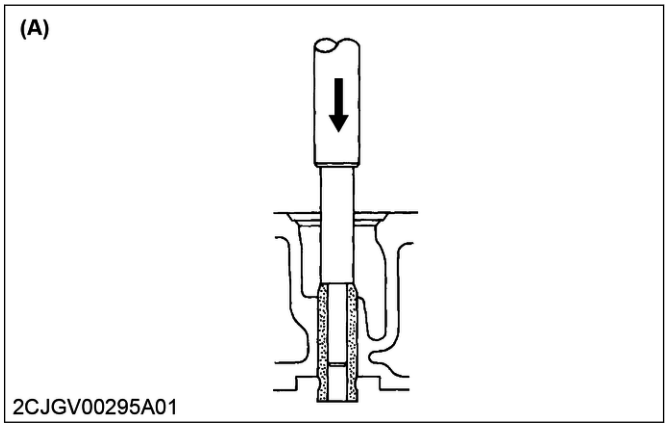
# 7.7 Replacing valve guide

**■ IMPORTANT**
- **Do not hit the valve guide with a hammer during replacement.**

**Tools required**
- Press tool
- Valve guide replacing tool

**Removing valve guide**

1. Press out the used valve guide with the valve guide replacing tool.

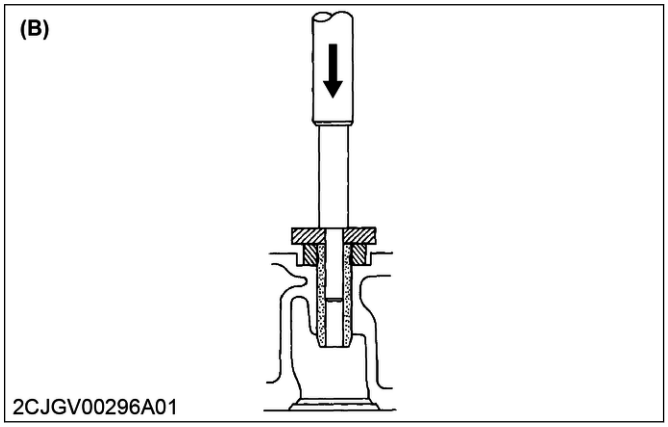


2CJGV00295A01

(A) Removing direction

**Installing valve guide**

1. Clean the new valve guide and valve guide bore, and apply engine oil to them.
2. Press fit the new valve guide with the valve guide replacing tool.



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(B) Installing direction

3. Ream accurately the I.D. of the valve guide to the specified dimension.

| | | |
|---|---|---|
| Valve guide I.D. | Service specification | 6.010 to 6.025 mm<br>0.2367 to 0.2372 in. |

## 7.8 Adjusting valve angle

**■ NOTE**

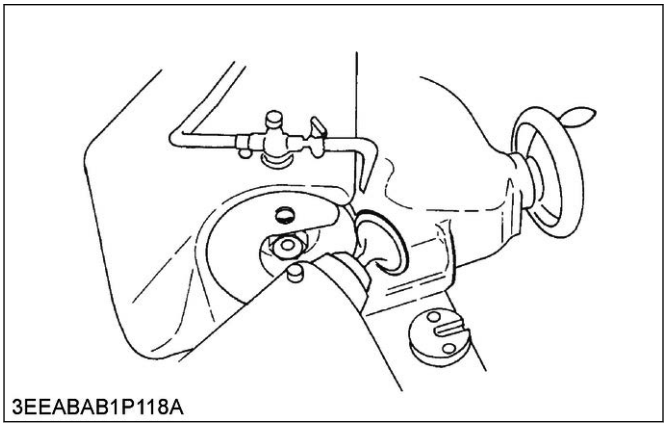
- **Before you adjust the valve, check the valve stem and measure the I.D. of the valve guide section.**
  **Repair them if necessary.**

**Tools required**

- Valve refacer

1. Adjust the valve with a valve refacer.

| | | |
|---|---|---|
| Valve face angle | Service specification | 0.79 rad<br>45° |


3EEABAB1P118A

## 7.9 Adjusting valve seat

**■ NOTE**

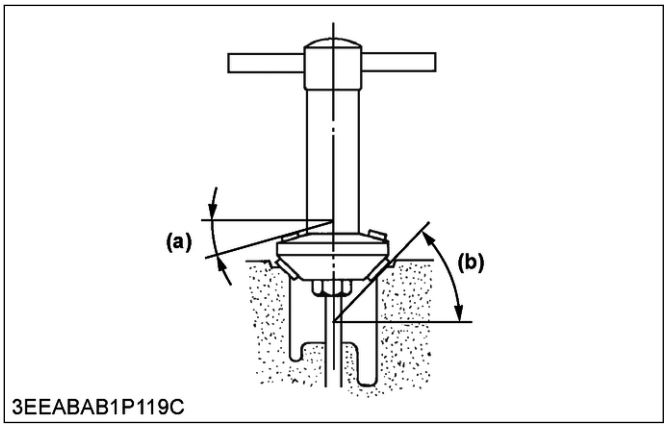
- **Before you adjust the valve seat, check the valve stem and measure the I.D. of the valve guide section.**
  **Repair them if necessary.**
- **After you adjust the valve seat, be sure to check the valve recessing.**

**Tools required**

- Valve seat cutter
- Valve lapping tool.
- Prussian Blue

1. Slightly adjust the seat surface with a 1.0 rad (60°) or 0.79 rad (45°) valve seat cutter.

| | | |
|---|---|---|
| Valve seat angle | Service specification | 0.79 rad<br>45° |



3EEABAB1P119C

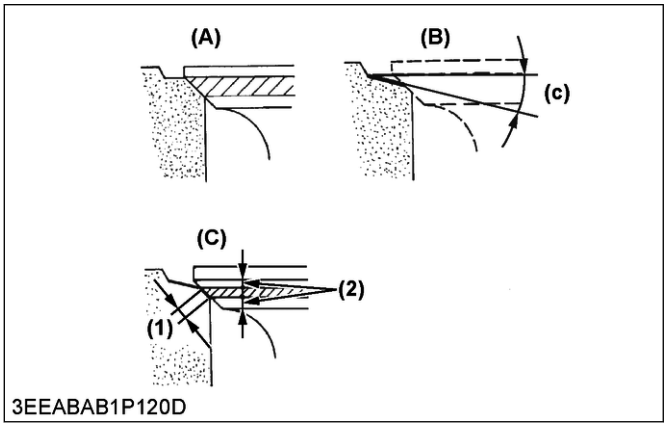
(a) 0.26 rad (15°) (b) 0.79 rad (45°)

2. Adjust the seat width with a 0.52 rad (30°) or 0.26 rad (15°) valve seat cutter.
3. After you adjust the seat, check that the valve seating is flat.
4. Apply a thin layer of compound between the valve face and valve seat, and lap them with a valve lapping tool.
5. Check the valve seating with Prussian Blue.

**■ NOTE**

- **The valve seating surface must show good contact on all sides.**

| | | |
|---|---|---|
| Valve seat width (1) | Service specification | 2.12 mm<br>0.0835 in. |



3EEABAB1P120D

(1) Valve seat width
(2) Identical dimensions
(A) Check the contact
(B) Correct seat width
(C) Check the contact
(c) 0.26 rad (15°)

RELATED PAGE
7.4 Checking valve recessing on page 4-136
7.6 Checking clearance between valve stem and valve guide on page 4-137

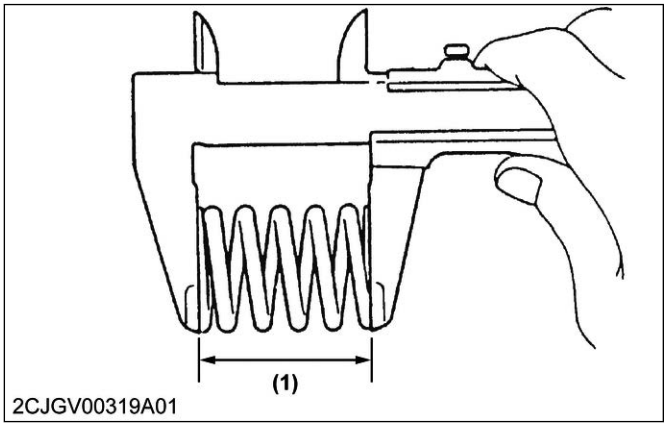
## 7.10 Checking free length of valve spring

**Tools required**
- Vernier caliper

1. Measure the free length (1) of valve spring with a vernier calipers.

**NOTE**
- **If the measurement is less than the service limit, replace it.**

| | | |
|---|---|---|
| Free length (1) | Service specification | 31.3 to 31.8 mm<br>1.24 to 1.25 in. |
| | Service limit | 28.4 mm<br>1.12 in. |




(1) Free length

2. Check the full surface of the valve spring for scratches.

**NOTE**
- **If there is a damage, replace it.**

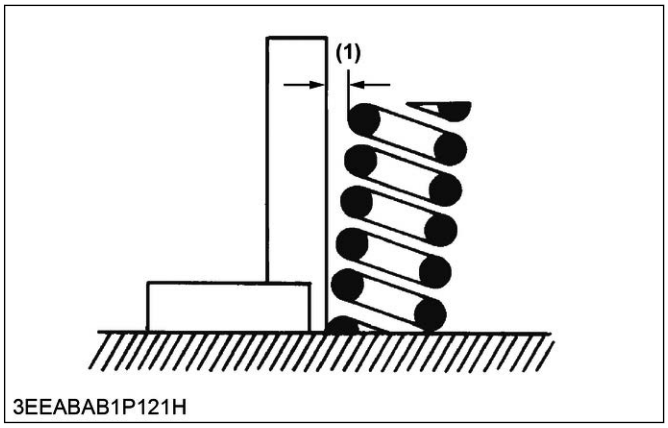
## 7.11 Checking tilt of valve spring

**Tools required**
- Surface plate
- Square

1. Put the valve spring on a surface plate, and put a square on the side of the valve spring.
2. Turn the valve spring to measure the maximum tilt (1).

**NOTE**
- **If the measurement is more than the service limit, replace it.**

| | | |
|---|---|---|
| Tilt (1) | Service limit | 1.2 mm<br>0.047 in. |




(1) Tilt

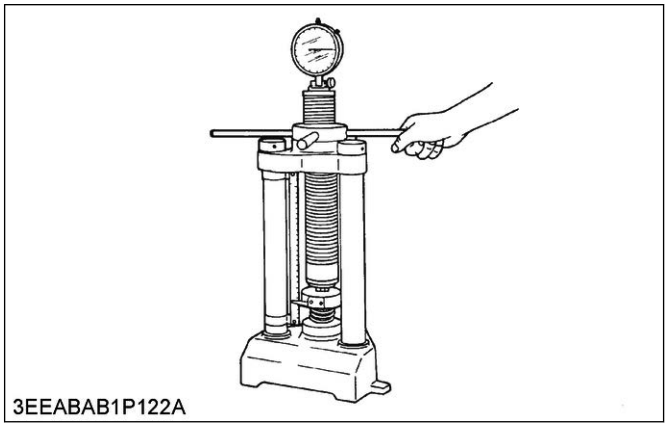
3. Check the full surface of the valve spring for scratches.

**NOTE**
- **If there is a damage, replace it.**

## 7.12 Checking set load of valve spring

**Tools required**
- Valve spring tester

1. Put the valve spring on a tester and compress the valve spring to the specified setting length.




2. Read the compression load on the gauge.

**NOTE**
- **If the measurement is less than the service specification, replace the valve spring.**

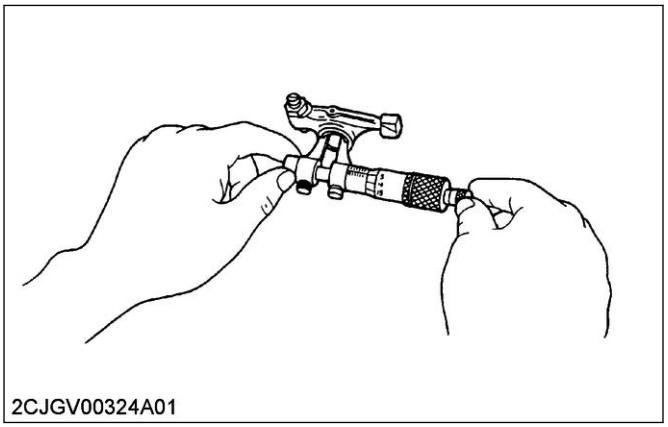
| | | |
|---|---|---|
| Setting load / Setting length | Service specification | 65 N / 27.0 mm<br>6.6 kgf / 27.0 mm<br>15 lbf / 1.06 in. |
| | Service limit | 55 N / 27.0 mm<br>5.6 kgf / 27.0 mm<br>12 lbf / 1.06 in. |

## 7.13 Checking oil clearance between rocker arm and rocker arm shaft

**Tools required**
- Inside micrometer
- Outside micrometer

1. Measure the rocker arm I.D. with an inside micrometer.

| | | |
|---|---|---|
| Rocker arm I.D. | Service specification | 10.500 to 10.518 mm<br>0.41233 to 0.41275 in. |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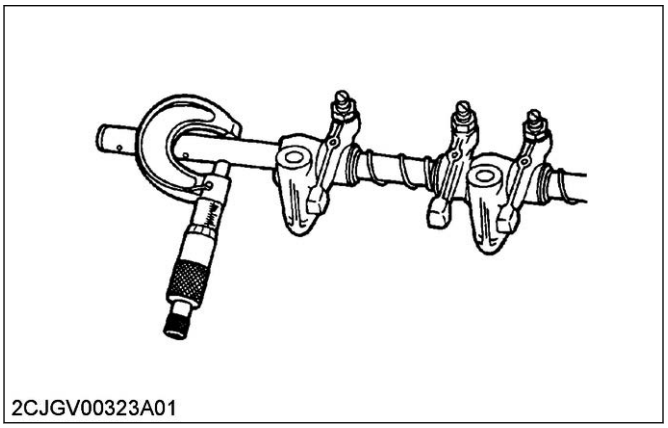
2. Measure the rocker arm shaft O.D. with an outside micrometer.

| | | |
|---|---|---|
| Rocker arm shaft O.D. | Service specification | 10.473 to 10.484 mm<br>0.41339 to 0.41409 in. |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3. Calculate the oil clearance.

**■ NOTE**
- **If the oil clearance is more than the service limit, replace the rocker arm and measure the oil clearance again.**
- **If the oil clearance stays more than the service limit, replace the rocker arm shaft also.**

| | | |
|---|---|---|
| Oil clearance between rocker arm and rocker arm shaft | Service specification | 0.016 to 0.045 mm<br>0.00063 to 0.0017 in. |
| | Service limit | 0.15 mm<br>0.0059 in. |

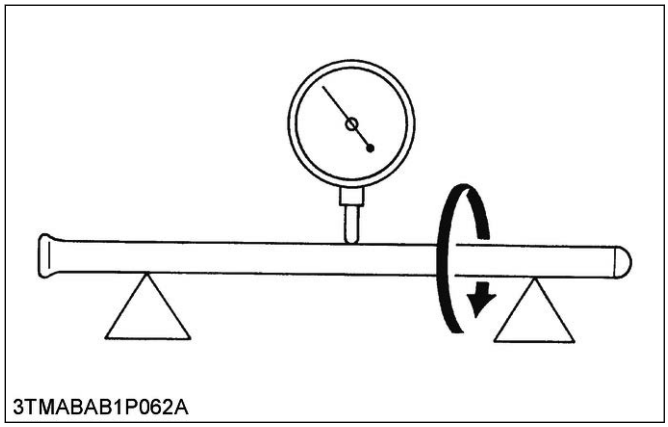
## 7.14 Checking push rod alignment

**Tools required**
- V blocks
- Surface plate
- Dial gauge

1. Put the push rod on V blocks.
2. Measure the push rod alignment.

**■ NOTE**
- **If the measurement is more than the service limit, replace the push rod.**

| | | |
|---|---|---|
| Push rod alignment | Service limit | 0.25 mm<br>0.0098 in. |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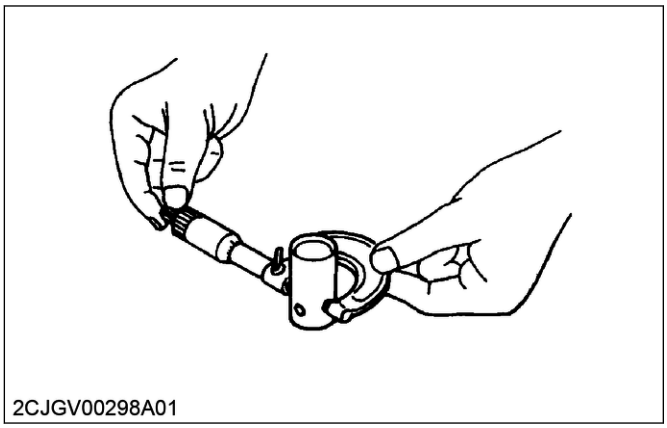
## 7.15 Checking oil clearance between tappet and tappet guide bore

**Tools required**
- Outside micrometer
- Cylinder gauge

1. Measure the tappet O.D. with an outside micrometer.

| | | |
|---|---|---|
| Tappet O.D. | Service specification | 17.966 to 17.984 mm<br>0.70867 to 0.70937 in. |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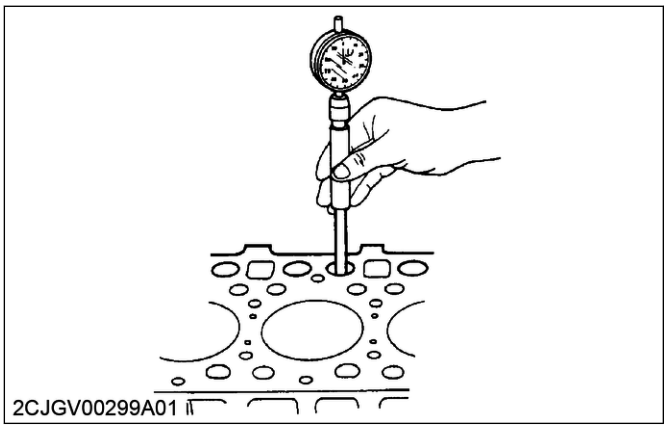
2. Measure the tappet guide bore I.D. with a cylinder gauge.

| | | |
|---|---|---|
| Tappet guide bore I.D. | Service specification | 18.000 to 18.018 mm<br>0.70733 to 0.70803 in. |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3. Calculate the oil clearance.

**■ NOTE**
- **If the oil clearance is more than the service limit or the tappet has a damage, replace the tappet.**

| | | |
|---|---|---|
| Oil clearance between tappet and tappet guide bore | Service specification | 0.016 to 0.052 mm<br>0.00063 to 0.0020 in. |
| | Service limit | 0.10 mm<br>0.0039 in. |

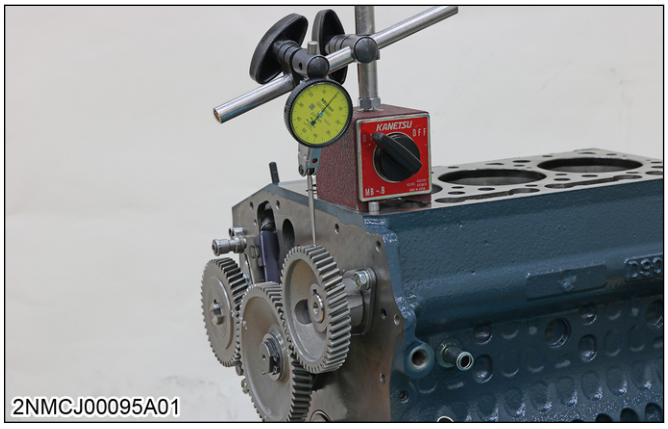
## 7.16 Checking timing gear backlash

**Tools required**
- Dial gauge (Lever type)

1. Set a dial gauge (lever type) with its point on the gear tooth.
2. Hold the mating gear and move the gear to measure the backlash.

**■ NOTE**
- **If the backlash is more than the service limit, measure the oil clearance in the journal part of each shaft.**
- **If the oil clearance is correct, replace the gear.**

| | | |
|---|---|---|
| Backlash between idle gear and crank gear | Service specification | 0.0430 to 0.124 mm<br>0.00170 to 0.00488 in. |
| | Service limit | 0.15 mm<br>0.0059 in. |
| Backlash between idle gear and cam gear | Service specification | 0.0470 to 0.123 mm<br>0.00185 to 0.00484 in. |
| | Service limit | 0.15 mm<br>0.0059 in. |
| Backlash between idle gear and injection pump gear | Service specification | 0.0460 to 0.124 mm<br>0.00182 to 0.00488 in. |
| | Service limit | 0.15 mm<br>0.0059 in. |
| Backlash between crank gear and oil pump drive gear | Service specification | 0.0410 to 0.123 mm<br>0.00162 to 0.00484 in. |
| | Service limit | 0.15 mm<br>0.0059 in. |



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RELATED PAGE
7.22 Checking oil clearance between camshaft journal and crankcase bore on page 4-144
7.23 Checking oil clearance between idle gear shaft and idle gear bushing on page 4-145
7.33 Checking oil clearance between crankshaft journal and crankshaft bearing 1 on page 4-150

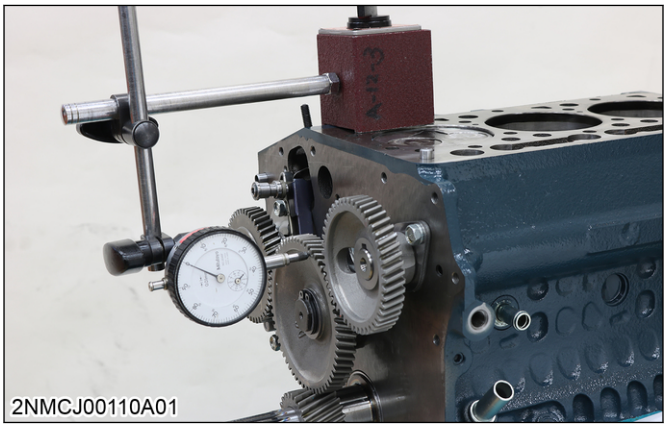
## 7.17 Checking side clearance of idle gear

**Tools required**
- Dial gauge

1. Set a dial gauge with its point on the idle gear.
2. Move the idle gear to the front and rear to measure the side clearance.

**NOTE**
- **If the measurement is more than the service limit, replace the idle gear collar.**

| | | |
|---|---|---|
| Side clearance of idle gear | Service specification | 0.20 to 0.51 mm<br>0.0079 to 0.020 in. |
| | Service limit | 0.80 mm<br>0.031 in. |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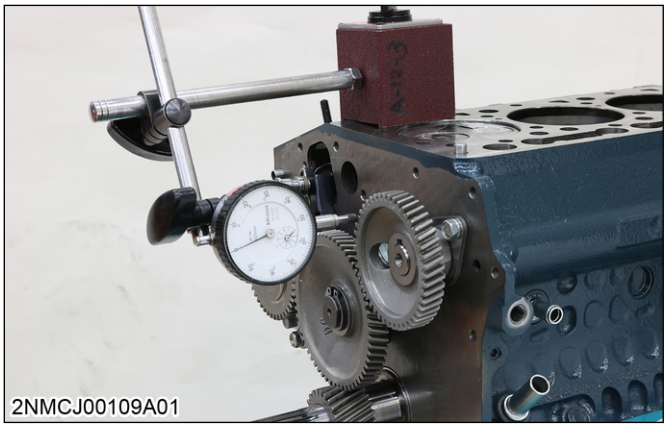
## 7.18 Checking side clearance of camshaft

**Tools required**
- Dial gauge

1. Set a dial gauge with its point on the camshaft.
2. Move the cam gear to the front and rear to measure the side clearance.

**NOTE**
- **If the measurement is more than the service limit, replace the camshaft stopper.**

| | | |
|---|---|---|
| Side clearance of camshaft | Service specification | 0.15 to 0.31 mm<br>0.0059 to 0.012 in. |
| | Service limit | 0.50 mm<br>0.020 in. |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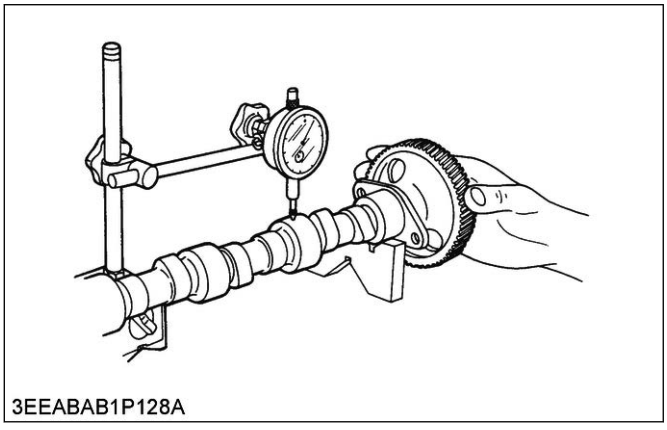
## 7.19 Checking camshaft alignment

**Tools required**
- V blocks
- Surface plate
- Dial gauge

1. Hold the two end journals of camshaft with V blocks on the surface plate.
2. Set a dial gauge with its point on the middle journal.
3. Turn the camshaft slowly and read the variation on the indicator (Half of the measurement).

**NOTE**
- **If the measurement is more than the service limit, replace the camshaft.**

| | | |
|---|---|---|
| Camshaft alignment | Service limit | 0.01 mm<br>0.0004 in. |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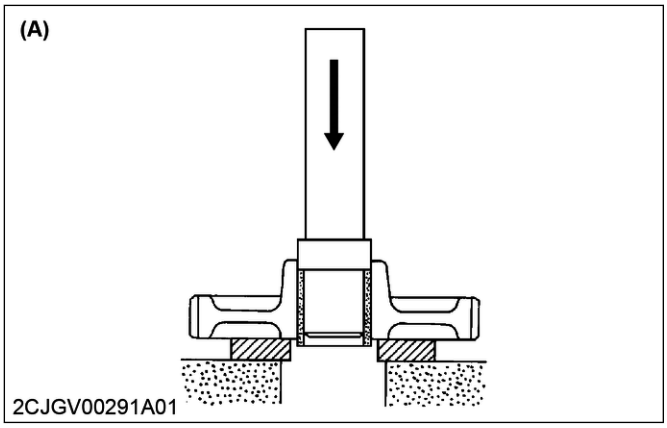
## 7.20 Replacing idle gear bushing

**Tools required**
- Press tool
- Idle gear bushing replacing tool

**Removing idle gear bushing**
1. Press out the used idle gear bushing with the replacing tool.



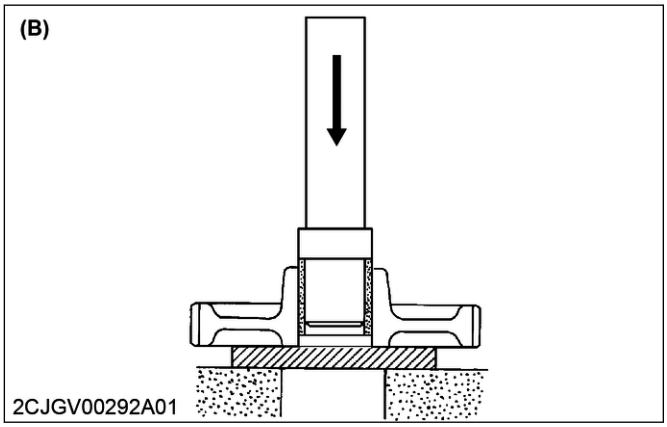

(A) Removing direction

**Installing idle gear bushing**

1. Clean a new idle gear bushing and idle gear bore, and apply engine oil to them.
2. Press fit the new bushing with the replacing tool.

**■ NOTE**

- **Make sure that the bushing end aligns the end of the idle gear.**




(B) Installing direction

## 7.21 Checking cam height

**Tools required**

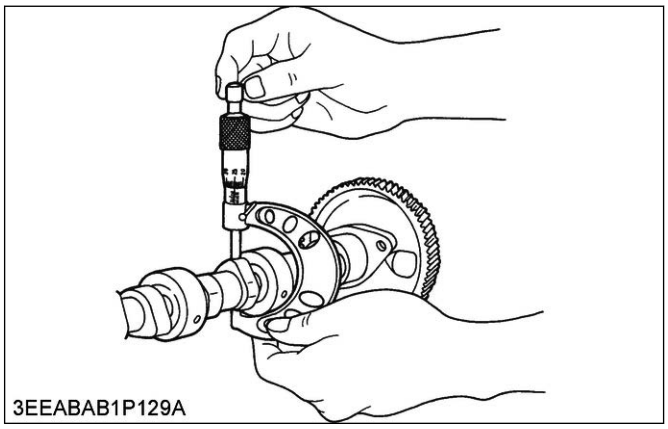
- Outside micrometer

1. Measure the height of the cam at its highest point with an outside micrometer.

**■ NOTE**

- **If the measurement is less than the service limit, replace the camshaft.**

| | Item | Service specification | Service limit |
|---|---|---|---|
| Cam height | Intake | 26.88 mm 1.058 in. | 26.83 mm 1.056 in. |
| | Exhaust (Z482-E4BG/ Z482/D722/ D782-E4) | 25.88 mm 1.019 in. | 25.83 mm 1.017 in. |
| | Exhaust (Z602/D902-E4/D902-TE4) | 26.88 mm 1.058 in. | 26.83 mm 1.056 in. |



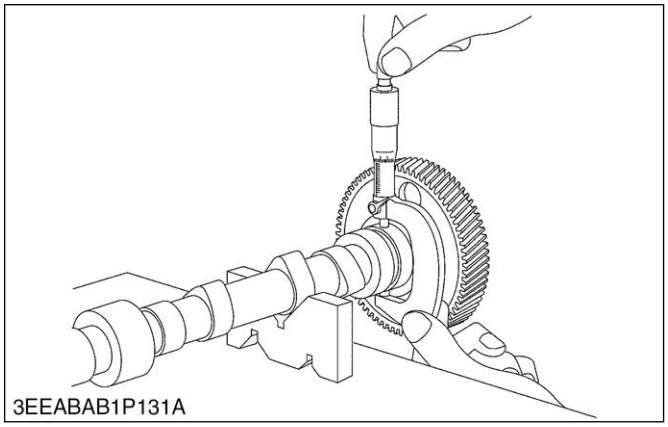

## 7.22 Checking oil clearance between camshaft journal and crankcase bore

**Tools required**

- Inside micrometer
- Outside micrometer
- Cylinder gauge

1. Measure the camshaft journal O.D. with an outside micrometer.

| | | |
|---|---|---|
| Camshaft journal O.D. | Service specification | 32.934 to 32.950 mm 1.2967 to 1.2972 in. |



2. Measure the crankcase bore I.D. for the camshaft with an inside micrometer or cylinder gauge.

| | | |
|---|---|---|
| Crankcase bore I.D. | Service specification | 33.000 to 33.025 mm<br>1.2993 to 1.3001 in. |


3. Calculate the oil clearance.

**NOTE**
- **If the oil clearance is more than the service limit, replace the camshaft.**

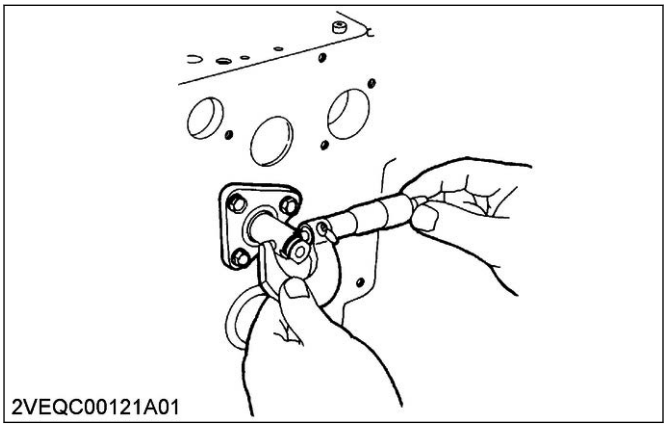
| | | |
|---|---|---|
| Oil clearance of camshaft journal | Service specification | 0.050 to 0.091 mm<br>0.0020 to 0.0035 in. |
| | Service limit | 0.15 mm<br>0.0059 in. |

## 7.23 Checking oil clearance between idle gear shaft and idle gear bushing

**Tools required**
- Inside micrometer
- Outside micrometer

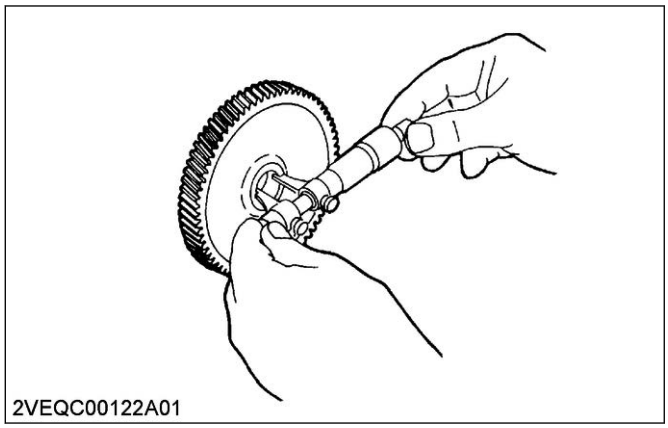
1. Measure the idle gear shaft O.D. with an outside micrometer.

| | | |
|---|---|---|
| Idle gear shaft O.D. | Service specification | 19.967 to 19.980 mm<br>0.78611 to 0.78661 in. |




2. Measure the idle gear bushing I.D. with an inside micrometer.

| | | |
|---|---|---|
| Idle gear bushing I.D. | Service specification | 20.000 to 20.051 mm<br>0.78741 to 0.78940 in. |




3. Calculate the oil clearance.

**NOTE**
- **If the oil clearance is more than the service limit, replace the bushing.**
- **If the oil clearance is still more than the service limit, replace the idle gear shaft.**

| | | |
|---|---|---|
| Oil clearance between idle gear shaft and idle gear bushing | Service specification | 0.020 to 0.084 mm<br>0.00079 to 0.0033 in. |
| | Service limit | 0.10 mm<br>0.0039 in. |

RELATED PAGE
7.20 Replacing idle gear bushing on page 4-143

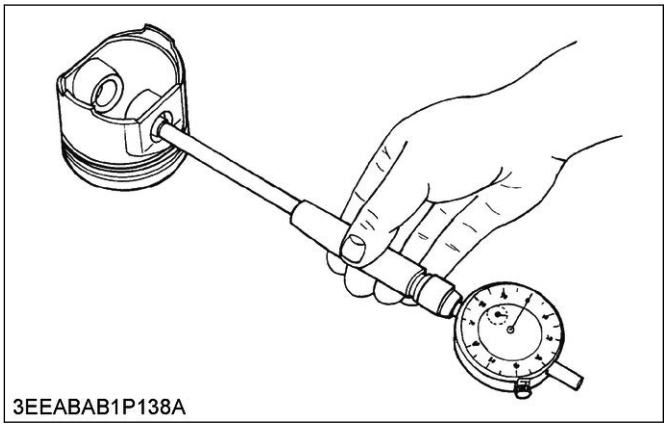
## 7.24 Checking piston pin bore I.D.

**Tools required**
- Cylinder gauge

1. Measure the piston pin bore I.D. in the horizontal and vertical directions with a cylinder gauge.

**■ NOTE**
- **If the measurement is more than the service limit, replace the piston.**

| | | |
|---|---|---|
| Piston pin bore I.D. | Service specification | 20.000 to 20.013 mm<br>0.78741 to 0.78791 in. |
| | Service limit | 20.05 mm<br>0.7894 in. |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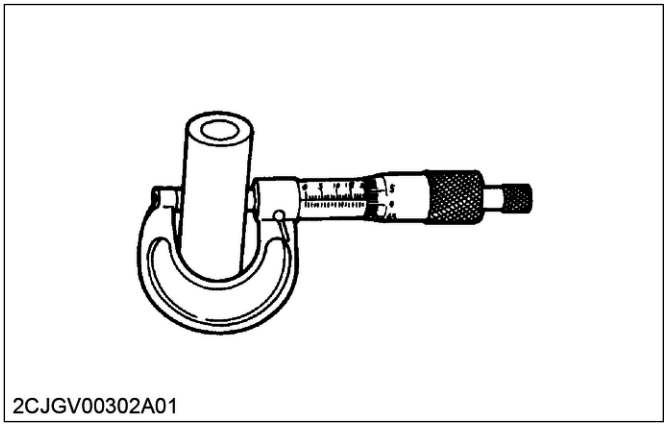
## 7.25 Checking oil clearance between piston pin and small end bushing

**Tools required**
- Outside micrometer
- Inside micrometer or cylinder gauge

1. Measure the piston pin O.D. at where it contacts the bushing with an outside micrometer.

| | | |
|---|---|---|
| Piston pin O.D. | Service specification | 20.002 to 20.011 mm<br>0.78748 to 0.78783 in. |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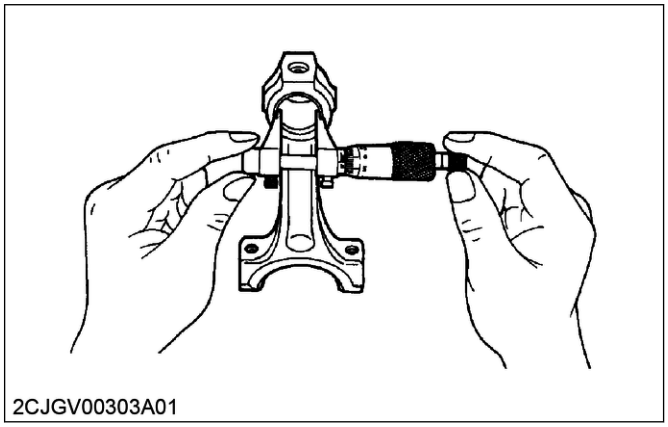
2. Measure the small end bushing I.D. at the small end of the connecting rod with an inside micrometer or cylinder gauge.

| | | |
|---|---|---|
| Small end bushing ID | Service specification | 20.025 to 20.040 mm<br>0.78839 to 0.78897 in. |
| Small end bushing ID (Spare parts) | | 20.026 to 20.077 mm<br>0.78843 to 0.79043 in. |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3. Calculate the oil clearance.

**■ NOTE**
- **If the oil clearance is more than the service limit, replace the piston pin.**
- **If the oil clearance is still more than the service limit, replace the connecting rod.**

| | | |
|---|---|---|
| Oil clearance between piston pin and small end bushing | Service specification | 0.014 to 0.038 mm<br>0.00056 to 0.0014 in. |
| | Service limit | 0.10 mm<br>0.0039 in. |

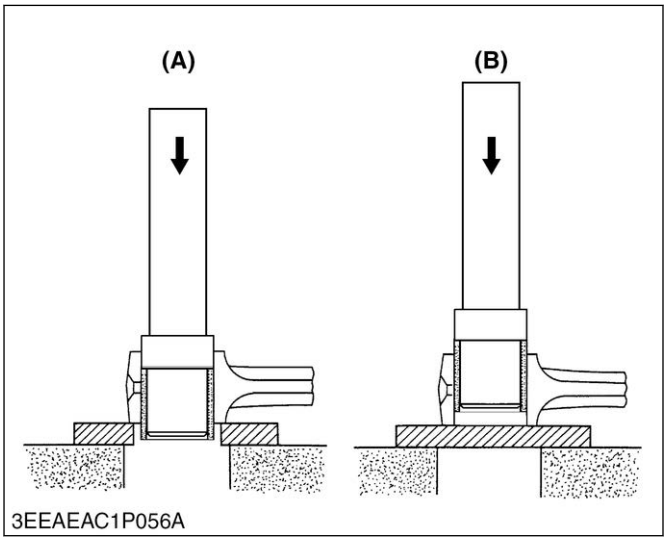
## 7.26 Replacing small end bushing (except for D902-TE4)

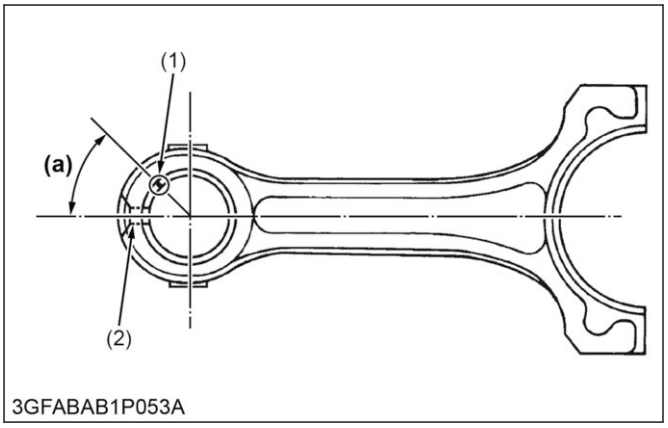
**■ NOTE**
- **D902-TE4 is excluded.**

**Tools required**
- Bushing replacing tool

**(When removing)**
1. Press out the used bushing using a bushing replacing tool.

**(When installing)**
1. Clean a new small end bushing and bore, and apply engine oil to them.
2. Using a bushing replacing tool, press in a new bushing (service parts) be careful to see that the connecting rod oil hole matches the bushing hole.




(1) Seam
(2) Oil hole
(A) When removing
(B) When installing
(a) 0.79 rad (45°)

**Servicing parts dimension**

| | | |
|---|---|---|
| Oil clearance between piston pin and small end bushing (Spare parts) | Service specification | 0.015 to 0.075 mm<br>0.00059 to 0.0029 in. |
| | Service limit | 0.15 mm<br>0.0059 in. |

| | | |
|---|---|---|
| Small end bushing I.D. (Spare parts) | Service specification | 20.026 to 20.077 mm<br>0.78843 to 0.79043 in. |

## 7.27 Checking connecting rod alignment

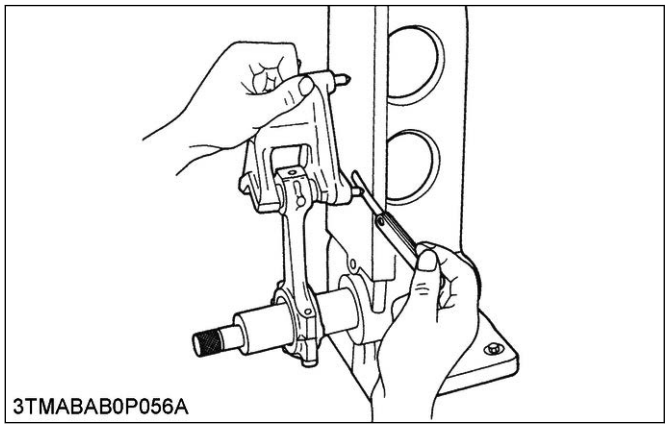
**■ NOTE**
- **Make sure that the oil clearance of the small end bushing is less than the service limit.**

**Tools required**
- Connecting rod alignment tool
- Feeler gauge

1. Remove the piston pin from the piston.
2. Install the piston pin into the connecting rod.
3. Install the connecting rod on the alignment tool for the connecting rod.
4. Put a gauge on the piston pin, and move it against the face plate.

**■ NOTE**
- **If the gauge does not touch fully against the face plate, measure the space between the gauge pin and face plate.**
- **If the measurement is more than the service limit, replace the connecting rod.**

| | | |
|---|---|---|
| Connecting rod alignment | Service limit | 0.05 mm<br>0.002 in. |




RELATED PAGE
7.25 Checking oil clearance between piston pin and small end bushing on page 4-146

## 7.28 Checking piston ring gap

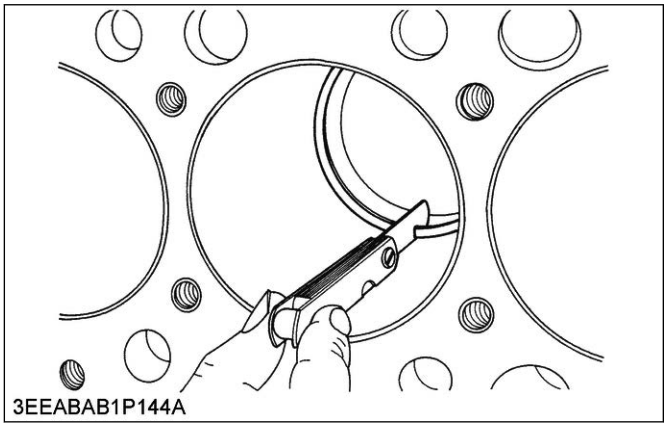
**Tools required**
- Feeler gauge

1. Put the piston ring into the lower part of the liner (the least worn out part) with the piston.

2. Measure the ring gap with a feeler gauge.

**■ NOTE**
- **If the ring gap is more than the service limit, replace the ring.**

| | | |
|---|---|---|
| Top ring (Z482-E4BG/Z482/D722/D782-E4) | Service specification | 0.12 to 0.27 mm 0.0047 to 0.010 in. |
| | Service limit | 1.15 mm 0.0453 in. |
| Top ring (Z602/D902-E4/D902-TE4) | Service specification | 0.15 to 0.30 mm 0.0059 to 0.011 in. |
| | Service limit | 1.20 mm 0.0472 in. |
| Second ring (Z482-E4BG/Z482/D722/D782-E4) | Service specification | 0.30 to 0.45 mm 0.012 to 0.017 in. |
| | Service limit | 1.20 mm 0.0472 in. |
| Second ring (Z602/D902-E4/D902-TE4) | Service specification | 0.15 to 0.35 mm 0.0059 to 0.013 in. |
| | Service limit | 1.25 mm 0.0492 in. |
| Oil ring (Z482-E4BG/Z482/D722/D782-E4) | Service specification | 0.35 to 0.50 mm 0.014 to 0.019 in. |
| | Service limit | 1.20 mm 0.0472 in. |
| Oil ring (Z602/D902-E4/D902-TE4) | Service specification | 0.15 to 0.35 mm 0.0059 to 0.013 in. |
| | Service limit | 1.20 mm 0.0472 in. |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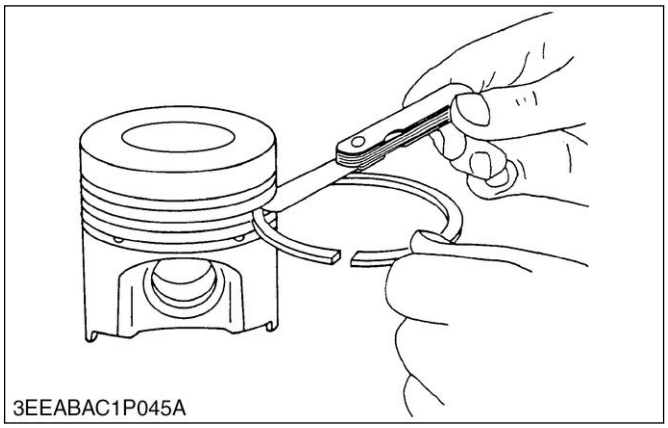
## 7.29 Checking clearance between piston ring and ring groove

**Tools required**
- Feeler gauge

1. Clean the piston rings and the ring grooves, and install each piston ring in its groove.
2. Measure the clearance between the piston ring and the groove with a feeler gauge.

**■ NOTE**
- **If the clearance is more than the service limit, replace the piston ring.**
- **If the clearance stays more than the service limit with a new piston ring, replace the piston, too.**

| | | | |
|---|---|---|---|
| Clearance between piston ring and ring groove | Second ring | Service specification | 0.090 to 0.120 mm 0.00355 to 0.00472 in. |
| | | Service limit | 0.15 mm 0.0059 in. |
| | Oil ring | Service specification | 0.020 to 0.060 mm 0.00079 to 0.0023 in. |
| | | Service limit | 0.15 mm 0.0059 in. |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## 7.30 Checking side clearance of crankshaft

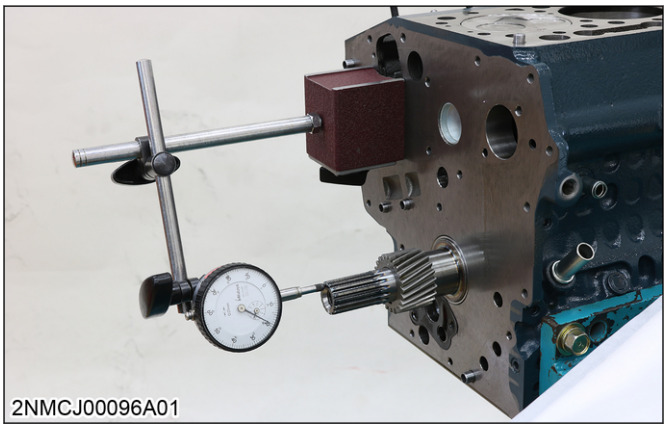
**Tools required**
- Dial gauge

1. Set a dial gauge with its point on the end of the crankshaft.

2. Move the crankshaft to the front and rear to measure the side clearance.

**NOTE**
- **If the measurement is more than the service limit, replace the main bearing case assembly.**

| | | |
|---|---|---|
| Side clearance of crankshaft | Service specification | 0.15 to 0.31 mm<br>0.0059 to 0.012 in. |
| | Service limit | 0.50 mm<br>0.020 in. |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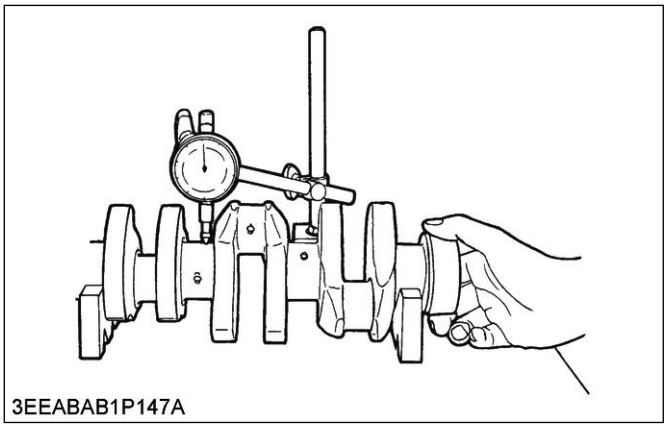
## 7.31 Checking crankshaft alignment

**Tools required**
- V blocks
- Surface plate
- Dial gauge

1. Hold the two end journals of crankshaft with V blocks on the surface plate.
2. Set a dial gauge with its point on the middle journal.
3. Turn the crankshaft slowly and read the variation on the indicator. Half of the measured value is the alignment value.

**NOTE**
- **If the measurement is more than the service limit, replace the crankshaft.**

| | | |
|---|---|---|
| Crankshaft alignment | Service limit | 0.02 mm<br>0.0008 in. |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## 7.32 Checking oil clearance between crankpin and crankpin bearing

**Tools required**
- Plastigauge

1. Clean the crankpin and crankpin bearing.
2. Put a strip of plastigauge on the center of the crankpin.

**NOTE**
- **Do not put the plastigauge into the crankpin oil hole.**

3. Install the connecting rod cap.
4. Tighten the connecting rod screws to the specified torque.

**NOTE**
- **When you tighten the connecting rod screws, do not move the crankshaft.**

| | | |
|---|---|---|
| Tightening torque | Connecting rod screw | 26.5 to 30.4 N·m<br>2.71 to 3.09 kgf·m<br>19.6 to 22.4 lbf·ft |

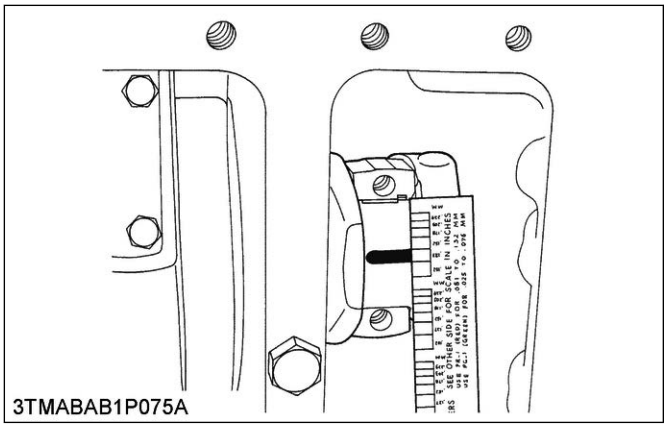
5. Remove the connecting rod cap again.

6. Measure the width that it becomes flat with the scale to get the oil clearance.

**■ NOTE**
- **If the clearance more than the service limit, replace the crankpin bearing.**
- **If the same dimension bearing is not applicable because of the crankpin wear, replace it with an undersize one.**

| | | |
|---|---|---|
| Crankpin O.D. | Service specification | 33.959 to 33.975 mm<br>1.3370 to 1.3375 in. |
| Crankpin bearing I.D. | Service specification | 33.995 to 34.010 mm<br>1.3384 to 1.3389 in. |
| | Service specification (D902-TE4) | 33.994 to 34.040 mm<br>1.3384 to 1.3401 in. |

| | | |
|---|---|---|
| Oil clearance between crankpin and crankpin bearing | Service specification | 0.020 to 0.051 mm<br>0.00079 to 0.0020 in. |
| | Service specification (D902-TE4) | 0.019 to 0.081 mm<br>0.00075 to 0.0031 in. |
| | Service limit | 0.15 mm<br>0.0059 in. |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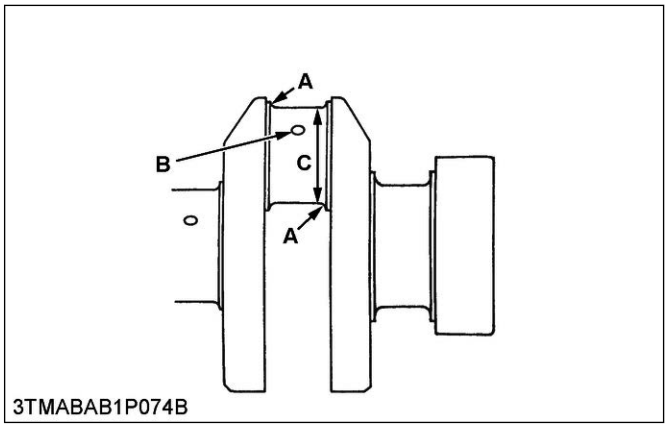
**(Reference)**
- Undersize dimensions of crankpin

| Undersize | 0.20 mm<br>0.0079 in. | 0.40 mm<br>0.016 in. |
|---|---|---|
| Dimension A | 2.3 to 2.7 mm radius<br>0.091 to 0.10 in. radius | 2.3 to 2.7 mm radius<br>0.091 to 0.10 in. radius |
| Dimension B* | 1.0 to 1.5 mm relief<br>0.040 to 0.059 in. relief | 1.0 to 1.5 mm relief<br>0.040 to 0.059 in. relief |
| Dimension C | 33.759 to 33.775 mm dia.<br>1.3291 to 1.3297 in. dia. | 33.559 to 33.575 mm dia.<br>1.3213 to 1.3218 in. dia. |
| The crankpin must be fine-finished to higher than Rmax = 0.8 S | | |

* Holes to be de-burred and edges rounded with 1.0 to 1.5 mm (0.040 to 0.059 in.) relief.



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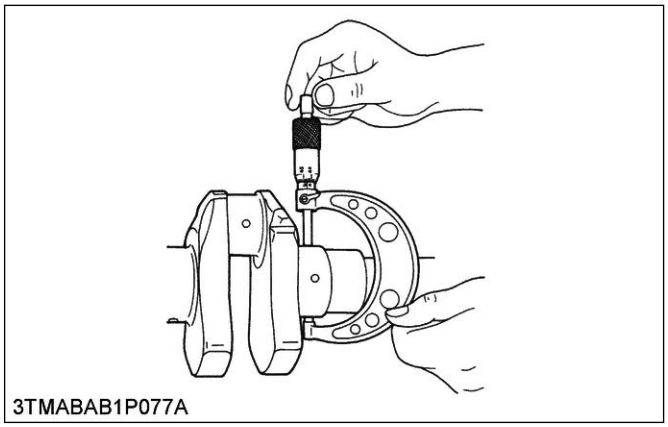
A Dimension A
B Dimension B
C Dimension C

## 7.33 Checking oil clearance between crankshaft journal and crankshaft bearing 1

**Tools required**
- Inside micrometer
- Outside micrometer

1. Measure the O.D. of the crankshaft journal with an outside micrometer.

| | | |
|---|---|---|
| Crankshaft journal O.D. | Service specification(Z482-E4BG/Z482/D722/D782-E4) | 39.934 to 39.950 mm<br>1.5722 to 1.5728 in. |
| | Service specification(Z602/D902-E4/D902-TE4) | 43.934 to 43.950 mm<br>1.7297 to 1.7303 in. |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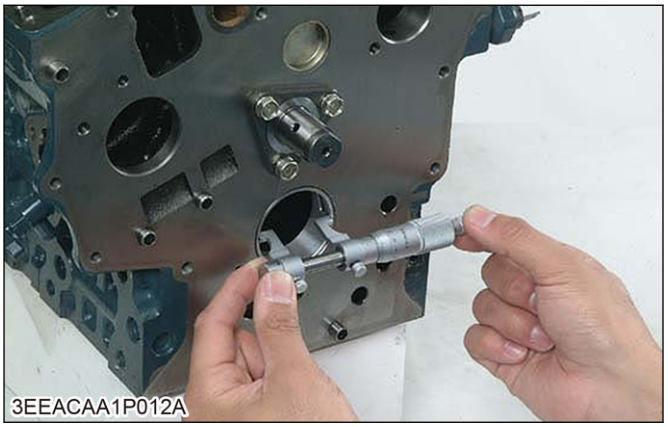
2. Measure the I.D. of the crankshaft bearing 1 with an inside micrometer.

| | | |
|---|---|---|
| Crankshaft bearing 1 I.D. | Service specification(Z482-E4BG/Z482/D722/D782-E4) | 39.984 to 40.040 mm<br>1.5742 to 1.5763 in. |
| | Service specification(Z602/D902-E4/D902-TE4) | 43.984 to 44.040 mm<br>1.7317 to 1.7338 in. |




3. Calculate the oil clearance.

**NOTE**

- **If the oil clearance is more than the service limit, replace the crankshaft bearing 1.**
- **If the same dimension bearing is not applicable because of the crankshaft journal wear, replace it with an undersize one.**

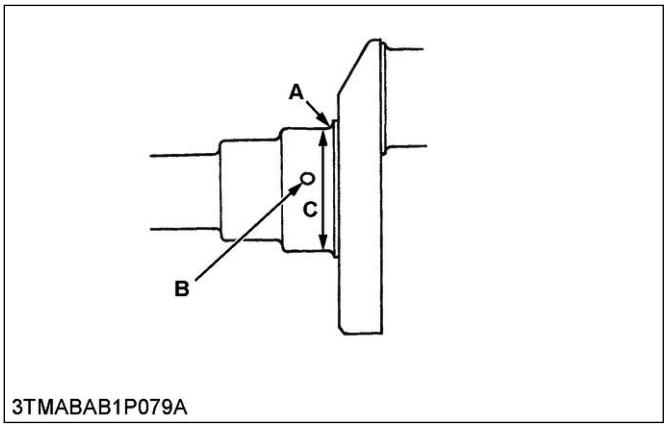
| | | |
|---|---|---|
| Oil clearance between crankshaft journal and crankshaft bearing 1 | Service specification | 0.0340 to 0.106 mm<br>0.00134 to 0.00417 in. |
| | Service limit | 0.20 mm<br>0.0079 in. |

**(Reference)**

- Undersize dimensions of crankshaft journal

| Undersize | 0.2 mm<br>0.008 in. | 0.4 mm<br>0.02 in. |
|---|---|---|
| Dimension A | 1.8 to 2.2 mm radius<br>0.071 to 0.086 in. radius | 1.8 to 2.2 mm radius<br>0.071 to 0.086 in. radius |
| Dimension B* | 1.0 to 1.5 mm relief<br>0.040 to 0.059 in. relief | 1.0 to 1.5 mm relief<br>0.040 to 0.059 in. relief |
| Dimension C | 43.734 to 43.750 mm dia.<br>1.7219 to 1.7224 in. dia. | 43.534 to 43.550 mm dia.<br>1.7140 to 1.7145 in. dia. |
| The crankshaft journal must be fine-finished to higher than Rmax = 0.8 S | | |

* Holes to be de-burred and edges rounded with 1.0 to 1.5 mm (0.040 to 0.059 in.) relief.




A: Dimension A
B: Dimension B
C: Dimension C

RELATED PAGE
7.34 Replacing crankshaft bearing 1 on page 4-151

## 7.34 Replacing crankshaft bearing 1

**Tools required**

- Crankshaft bearing 1 replacing tool

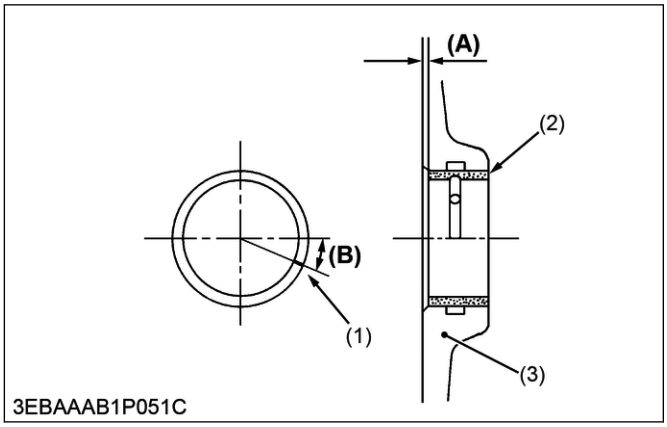
**Removing crankshaft bearing 1**

1. Press out the used crankshaft bearing 1 with the crankshaft bearing 1 replacing tool.

**Installing crankshaft sleeve**

1. Clean a new crankshaft bearing 1 and crankshaft journal bore and apply engine oil to them.
2. Make sure that the seam (1) of the new bearing 1 (2) points to the exhaust manifold side (see the figure).
3. Press fit the new crankshaft bearing 1 (2) with the crankshaft bearing replacing tool.

| | | |
|---|---|---|
| Dimension (A) | Service specification | 0.00 to 0.30 mm<br>0.00 to 0.11 in. |




(1) Seam
(2) Crankshaft bearing 1
(3) Crankcase
(A) Dimension
(B) 0.37 rad (21°)

## 7.35 Checking oil clearance between crankshaft journal and crankshaft bearing 2, 3

**Tools required**
- Plastigauge

1. Clean the crankshaft journal and crankshaft bearing.
2. Put a strip of plastigauge on the center of the journal.

**■ IMPORTANT**
- **Do not put the plastigauge into the oil hole of the journal.**

3. Install the main bearing case.
4. Tighten the main bearing case screws 1 to the specified torque.

**■ NOTE**
- **When you tighten the main bearing case screws 1, do not move the crankshaft.**

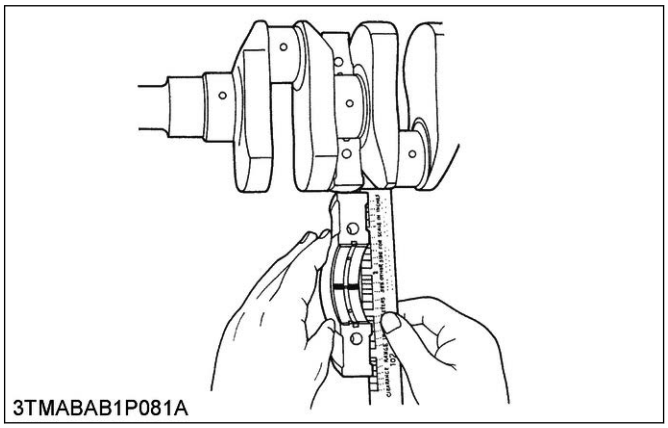
| | | |
|---|---|---|
| Tightening torque | Main bearing case screw 1 | 12.7 to 15.7 N·m<br>1.30 to 1.60 kgf·m<br>9.37 to 11.5 lbf·ft |

5. Remove the main bearing case again.
6. Measure the width that it becomes flat with the scale to get the oil clearance.

**■ NOTE**
- **If the clearance more than the service limit, replace the crankshaft bearing 2.**
- **If the same dimension bearing is not applicable because of the crankshaft journal wear, replace it with an undersize one. Refer to the table and figure.**

| | | |
|---|---|---|
| Crankshaft bearing 2 I.D. | Service specification | 43.978 to 43.993 mm<br>1.7315 to 1.7320 in. |
| | Service specification (D902-TE4) | 43.984 to 44.026 mm<br>1.7317 to 1.7333 in. |
| Crankshaft bearing 3 I.D. | Service specification (Z482-E4BG/Z482/D722/D782-E4) | 39.978 to 39.993 mm<br>1.5740 to 1.5745 in. |
| | Service specification (Z602/D902-E4) | 43.978 to 43.993 mm<br>1.7315 to 1.7320 in. |
| | Service specification (D902-TE4) | 43.984 to 44.026 mm<br>1.7317 to 1.7333 in. |

| | | |
|---|---|---|
| Oil clearance between crankshaft journal and crankshaft bearing 2 | Service specification | 0.028 to 0.059 mm<br>0.0011 to 0.0023 in. |
| | Service specification (D902-TE4) | 0.034 to 0.092 mm<br>0.0014 to 0.0036 in. |
| | Service limit | 0.20 mm<br>0.0079 in. |
| Oil clearance between crankshaft journal (flywheel side) and crankshaft bearing 3 | Service specification | 0.028 to 0.059 mm<br>0.0011 to 0.0023 in. |
| | Service specification (D902-TE4) | 0.034 to 0.092 mm<br>0.0014 to 0.0036 in. |
| | Service limit | 0.20 mm<br>0.0079 in. |



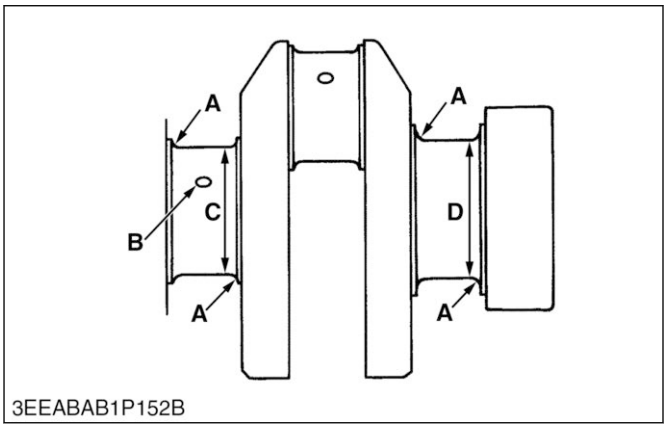

**(Reference)**
- Undersize dimensions of crankshaft journal

| Undersize | 0.2 mm<br>0.008 in. | 0.4 mm<br>0.02 in. |
|---|---|---|
| Dimension A | 1.8 to 2.2 mm radius<br>0.071 to 0.086 in. radius | 1.8 to 2.2 mm radius<br>0.071 to 0.086 in. radius |

(Continued)

| Undersize | 0.2 mm 0.008 in. | 0.4 mm 0.02 in. |
|---|---|---|
| Dimension B* | 1.0 to 1.5 mm relief 0.040 to 0.059 in. relief | 1.0 to 1.5 mm relief 0.040 to 0.059 in. relief |
| Dimension C, D | 43.734 to 43.750 mm 1.7219 to 1.7224 in. | 43.534 to 43.550 mm 1.7140 to 1.7145 in. |
| The crankshaft journal must be fine-finished to higher than Rmax = 0.8 S | | |

* Holes to be de-burred and edges rounded with 1.0 to 1.5 mm (0.040 to 0.059 in.) relief.



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A: Dimension A
B: Dimension B
C: Dimension C
D: Dimension D

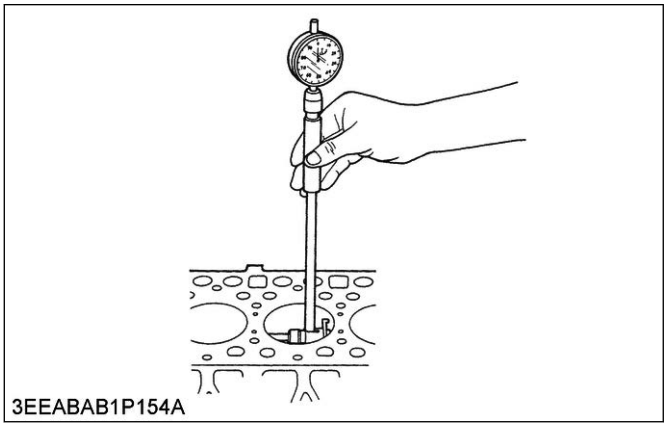
## 7.36 Checking cylinder wear

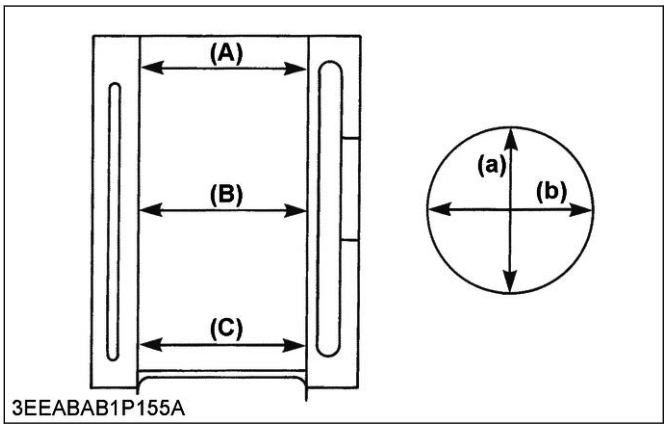
**Tools required**
- Cylinder gauge

1. Measure the cylinder bore I.D. at the 6 positions (see figure) with a cylinder gauge and find the maximum and minimum inner diameters.
2. Find the difference between the maximum and the minimum inner diameters.

**NOTE**
- **If the maximum I.D. or the difference is more than the service limit, bore and hone it to the oversize dimension.**

| | | |
|---|---|---|
| Cylinder bore I.D. | Service specification (Z482-E4BG/Z482/D722/D782-E4) | 67.000 to 67.019 mm 2.6378 to 2.6385 in. |
| | Service limit (Z482-E4BG/Z482/D722/D782-E4) | 67.150 mm 2.6437 in. |
| | Service specification (Z602/D902-E4/D902-TE4) | 72.000 to 72.019 mm 2.8347 to 2.8353 in. |
| | Service limit (Z602/D902-E4/D902-TE4) | 72.150 mm 2.8406 in. |


3EEABAB1P154A



3EEABAB1P155A

(A) Top
(B) Middle
(C) Bottom
(a) Right-angled to piston pin
(b) Piston pin direction

3. Check the cylinder wall for scratches.

**NOTE**
- **If you find deep scratches, bore the cylinder.**

RELATED PAGE
7.37 Adjusting cylinder correction (over size) on page 4-154

## 7.37 Adjusting cylinder correction (over size)

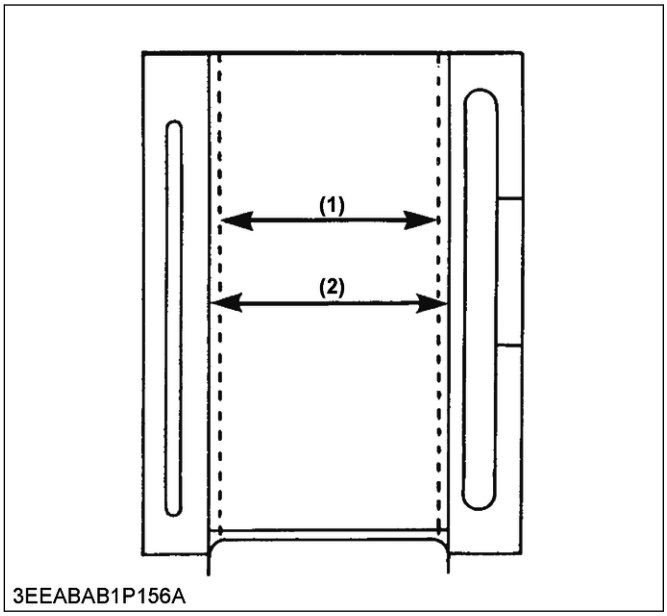
**Tools required**
- Cylinder gauge

1. Measure the cylinder bore I.D. at the 6 positions (see figure) with a cylinder gauge and find the maximum and minimum inner diameters.
2. If the cylinder wear is more than the service limit, bore and hone it to the specified dimension.

**NOTE**
- **If the maximum I.D. or the difference for the oversize cylinder is more than the service limit, replace the crankcase with a new one.**

- Oversize cylinder bore I.D.

| | | |
|---|---|---|
| Oversize cylinder I.D. | Service specification (Z482-E4BG/Z482/D722/D782-E4) | 67.250 to 67.269 mm<br>2.6477 to 2.6483 in. |
| | Service limit (Z482-E4BG/Z482/D722/D782-E4) | 67.400 mm<br>2.6535 in. |
| | Service specification (Z602/D902-E4/D902-TE4) | 72.250 to 72.269 mm<br>2.8445 to 2.8452 in. |
| | Service limit (Z602/D902-E4/D902-TE4) | 72.400 mm<br>2.8504 in. |
| Finishing | Hone to 2.2 to 3.0 μmRz (0.000087 to 0.00011 in.Rz) | |




(1) Cylinder bore I.D. (Before Correction)
(2) Cylinder bore I.D. (Oversize)

3. Replace the piston and piston rings with oversize ones.

| | | |
|---|---|---|
| Oversize piston and piston rings | Service specification | 0.25 mm<br>0.0098 in. |

RELATED PAGE
7.36 Checking cylinder wear on page 4-153

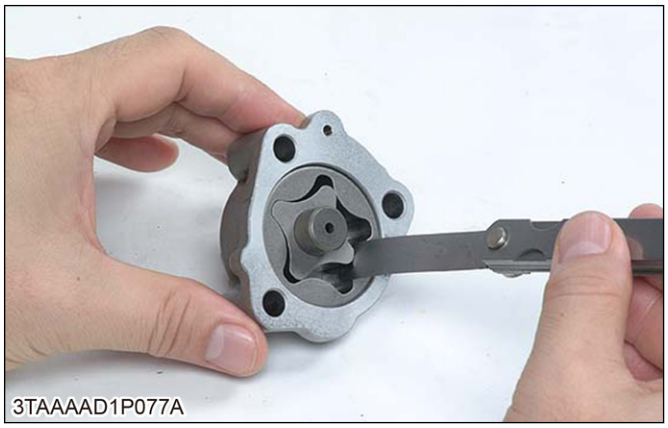
## 7.38 Checking clearance between inner rotor and outer rotor

**Tools required**
- Feeler gauge

1. Measure the clearance between the lobes of the inner rotor and the outer rotor with a feeler gauge.

**NOTE**
- **If the clearance more than the service limit, replace the oil pump rotor assembly.**

| | | |
|---|---|---|
| Clearance between inner rotor and outer rotor | Service specification | 0.030 to 0.14 mm<br>0.0012 to 0.0055 in. |
| | Service limit | 0.25 mm<br>0.0098 in. |



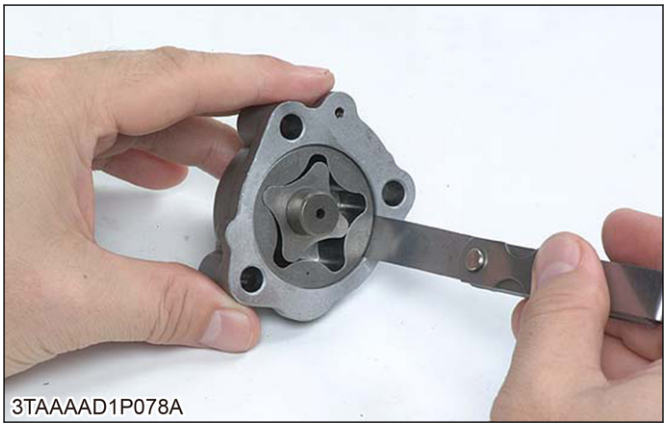

## 7.39 Checking clearance between outer rotor and pump body

**Tools required**
- Feeler gauge

1. Measure the clearance between the outer rotor and the pump body with a feeler gauge.

**NOTE**
- **If the clearance more than the service limit, replace the oil pump rotor assembly.**
- **If the clearance stays more than the service limit after replacing the oil pump rotor assembly, replace the oil pump body.**

| | | |
|---|---|---|
| Clearance between outer rotor and pump body | Service specification | 0.070 to 0.15 mm<br>0.0028 to 0.0059 in. |
| | Service limit | 0.30 mm<br>0.012 in. |


3TAAAAD1P078A

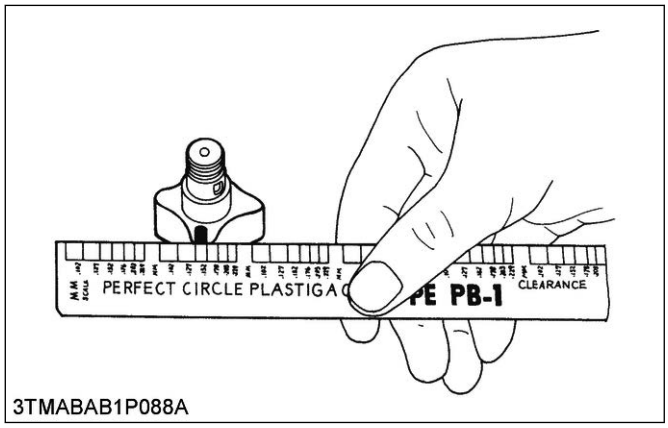
## 7.40 Checking clearance between rotor and cover

**Tools required**
- Plastigauge

1. Put a strip of plastigauge on the rotor face with grease.
2. Install the oil pump.
3. Remove the oil pump carefully.
4. Measure the width that plastigauge becomes flat with the scale to get the oil clearance.

**NOTE**
- **If the clearance is more than the service limit, replace oil pump rotor assembly and the cover.**

| | | |
|---|---|---|
| Clearance between rotor and cover | Service specification | 0.075 to 0.135 mm<br>0.00296 to 0.00531 in. |
| | Service limit | 0.20 mm<br>0.0079 in. |



3TMABAB1P088A

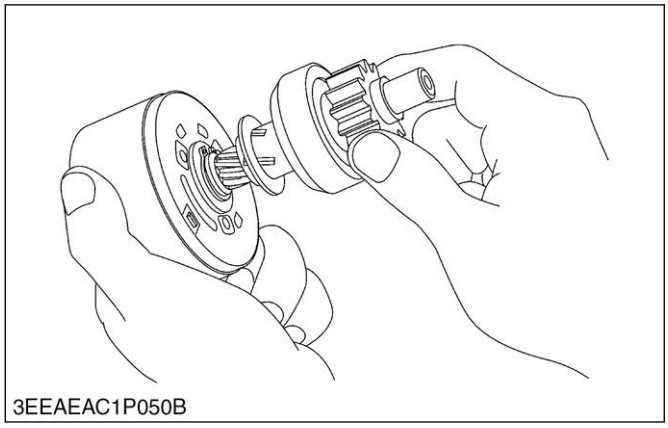
## 7.41 Checking overrunning clutch of starter

1. Check the pinion for wear or damage.

**NOTE**
- **If there is any damage, replace the overrunning clutch assembly.**

2. Check that the pinion turns freely and smoothly in the direction that it overruns.

**NOTE**
- **If there is any damage, replace the overrunning clutch assembly.**

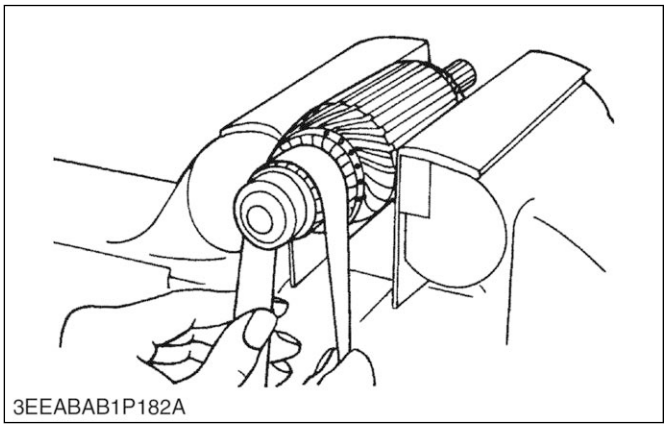

3EEAEAC1P050B

## 7.42 Checking commutator and mica of starter

**Tools required**
- Emery paper (#300)
- External micrometer

1. Check the contact of the commutator for wear.

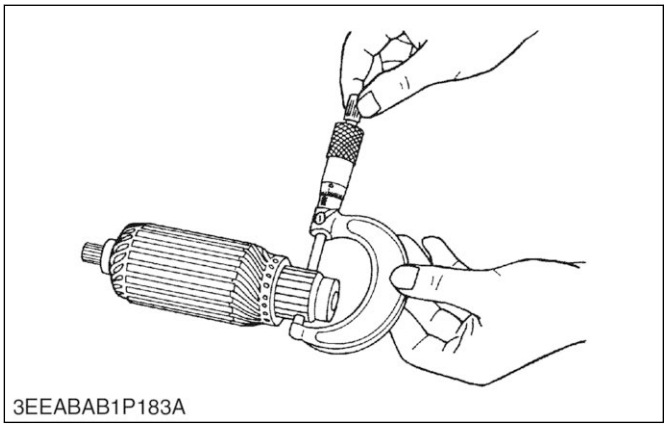
2. Grind the commutator with emery paper (#300) if it is lightly worn.


3EEABAB1P182A

3. Measure the commutator O.D. with an external micrometer at several points.

**NOTE**
- **If the minimum O.D. is less than the service limit, replace the armature assembly.**
- **If the difference of the O.D.'s more than the service limit, correct the commutator on a lathe to the service specification.**

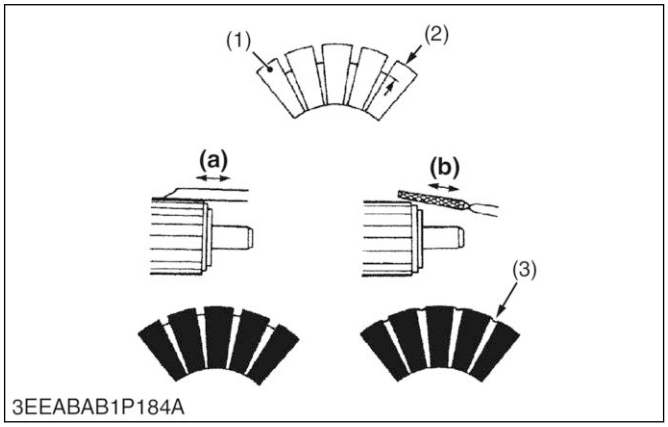
| | | |
|---|---|---|
| Commutator O.D. | Service specification | 30.0 mm<br>1.18 in. |
| | Service limit | 29.0 mm<br>1.14 in. |
| Difference of O.D.'s | Service specification | Less than<br>0.02 mm<br>0.0008 in. |
| | Service limit | 0.05 mm<br>0.002 in. |


3EEABAB1P183A

4. Measure the mica undercut.

**NOTE**
- **If the undercut is less than the service limit, correct it with a saw blade. Chamfer the segment edges.**

| | | |
|---|---|---|
| Mica undercut | Service specification | 0.50 to 0.80 mm<br>0.020 to 0.031 in. |
| | Service limit | 0.20 mm<br>0.0079 in. |



3EEABAB1P184A

(1) Segment
(2) Depth of mica
(3) Mica
(a) Good
(b) Bad

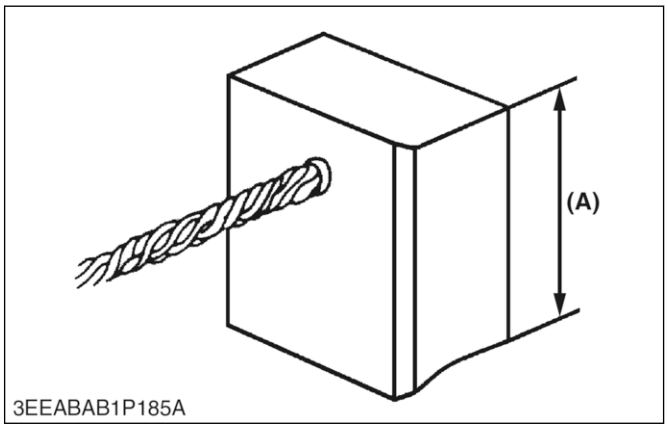
## 7.43 Checking brush wear of starter

**Tools required**
- Vernier caliper
- Emery paper (#300 or above)

1. Measure the brush length (A) with a vernier caliper.

**NOTE**
- **If the length is less than the service limit, replace the yoke assembly and brush holder assembly.**

| | | |
|---|---|---|
| Brush length (A) | Service specification | 14.0 mm<br>0.55 in. |
| | Service limit | 9.0 mm<br>0.35 in. |



3EEABAB1P185A

(A) Brush length

2. After you replace the brush, put an emery paper (#300 or above) on the commutator and correct the contact position.

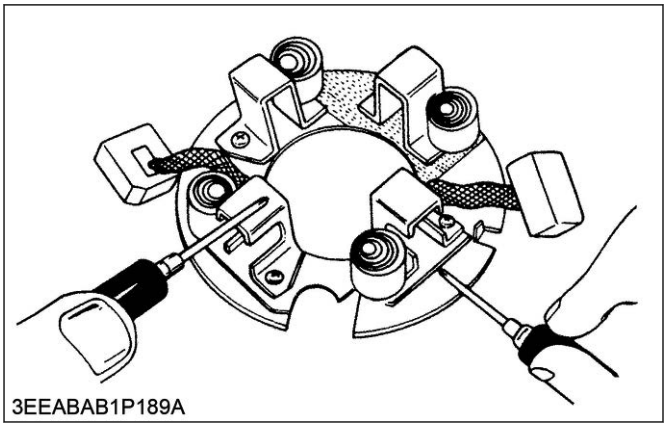
## 7.44 Checking brush holder of starter

**Tools required**
- Circuit tester

1. Check the continuity across the brush holder and the holder support with a circuit tester.

**NOTE**
- **If electricity flows, replace the brush holder assembly.**

| | | |
|---|---|---|
| Resistance between brush holder and holder support | Service specification | Infinity |


3EEABAB1P189A

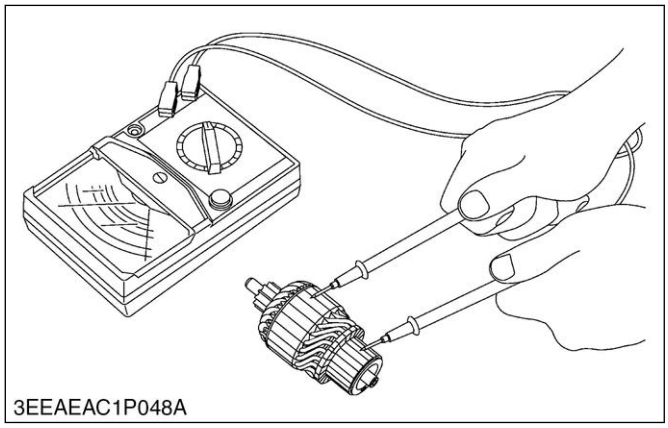
## 7.45 Checking armature coil of starter

**Tools required**
- Circuit tester

1. Check the continuity across the commutator and armature coil core with the resistance range of circuit tester.

**NOTE**
- **If electricity is out of service specification, replace the armature assembly.**

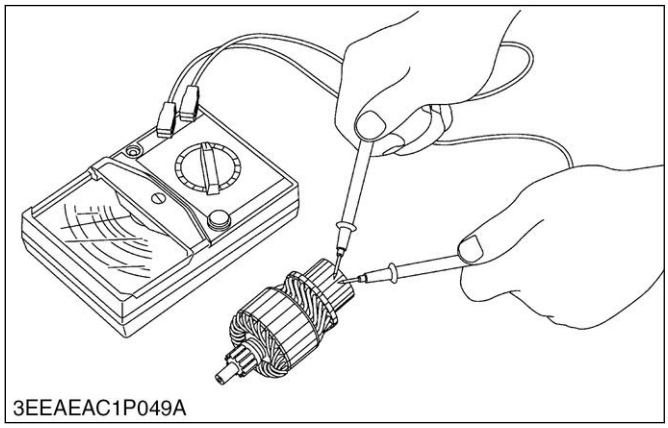
| | | |
|---|---|---|
| Resistance between commutator and armature coil core | Service specification | Infinity |


3EEAEAC1P048A

2. Check the continuity across the segments of the commutator with the resistance range of circuit tester.

**NOTE**
- **If electricity is out of service specification, replace the armature assembly.**

| | | |
|---|---|---|
| Resistance between commutator and segment | Service specification | Continuity |


3EEAEAC1P049A

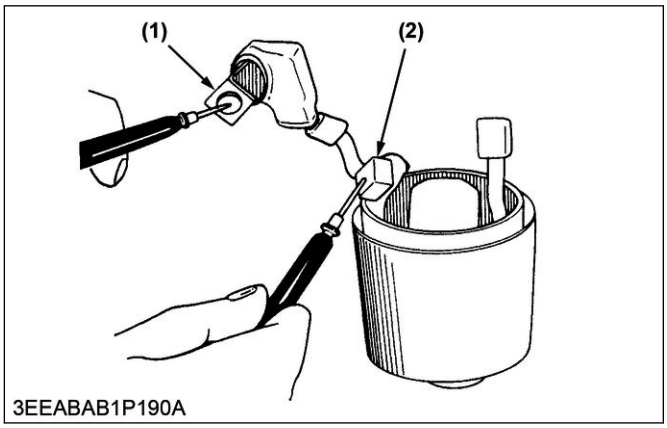
## 7.46 Checking field coil of starter

**Tools required**
- Circuit tester

1. Check the continuity across the lead (1) and brush (2) with a resistance range of circuit tester.

**NOTE**
- **If electricity is out of service specification, replace the yoke assembly.**

| | | |
|---|---|---|
| Resistance between lead and brush | Service specification | Continuity |

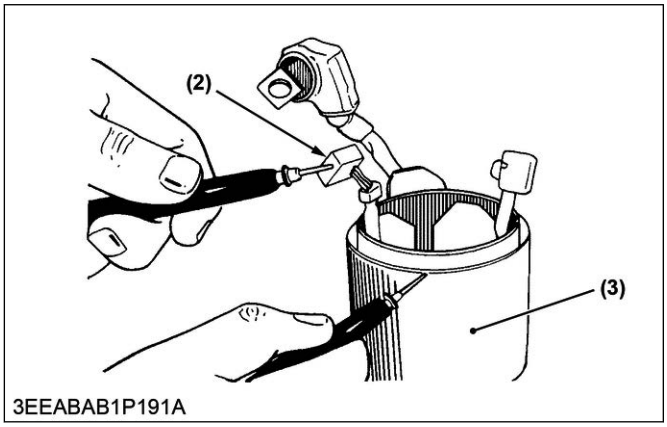



(1) Lead (2) Brush

2. Check the continuity across the brush (2) and yoke (3) with a resistance range of circuit tester.

**NOTE**
- **If electricity is out of service specification, replace the yoke assembly.**

| | | |
|---|---|---|
| Resistance between brush and yoke | Service specification | Infinity |

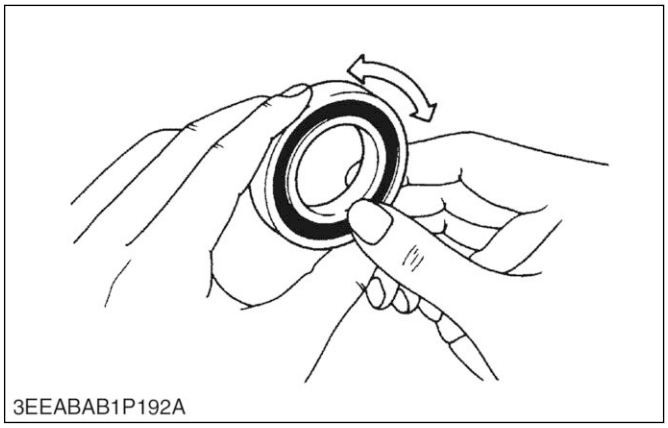



(2) Brush (3) Yoke

## 7.47 Checking bearing of alternator

1. Check that the bearing can turn smoothly.

**NOTE**
- **If not smoothly, replace it.**



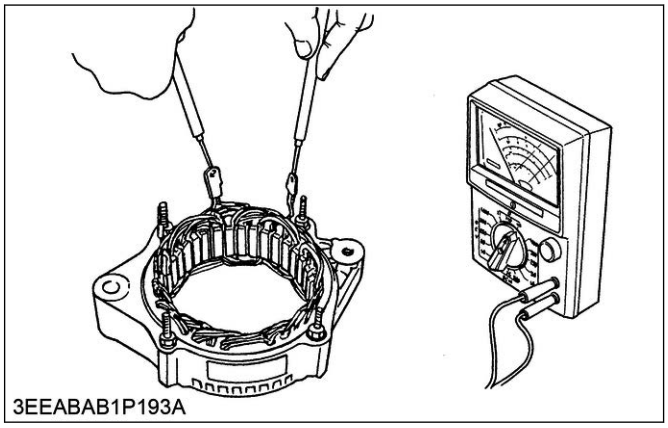

## 7.48 Checking stator of alternator

**Tools required**
- Circuit tester

1. Measure the resistance across each lead of the stator coil with the resistance range of circuit tester.

**NOTE**
- **If electricity is out of service specification, replace the stator assembly.**

| | | |
|---|---|---|
| Resistance | Service specification | Less than 1.0 Ω |




2. Check the continuity across each stator coil lead and core with the resistance range of circuit tester.

**NOTE**
- **If it does not show infinity, replace the stator assembly.**

| | | |
|---|---|---|
| Resistance | Service specification | Infinity |

## 7.49 Checking rotor of alternator

**Tools required**
- Circuit tester

1. Measure the resistance across the slip rings with the resistance range of circuit tester.

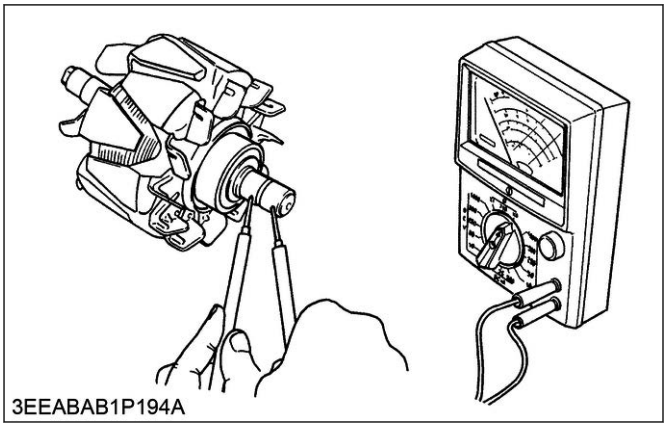
**■ NOTE**
- **If electricity is out of service specification, replace the rotor.**

| | | |
|---|---|---|
| Resistance between slip rings | Service specification | 2.9 Ω |

2. Check the continuity across the slip ring and core with the resistance range of circuit tester.

**■ NOTE**
- **If electricity is out of service specification, replace the rotor.**

| | | |
|---|---|---|
| Resistance between slip ring and rotor core | Service specification | Infinity |


3EEABAB1P194A

## 7.50 Checking slip ring of alternator

**Tools required**
- Emery paper (#500 to 600)
- Vernier caliper

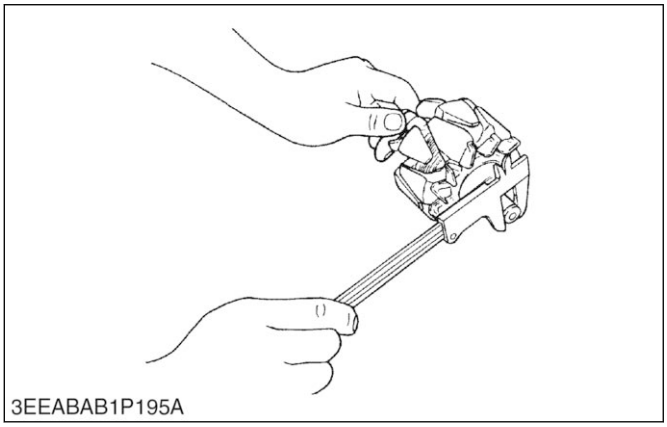
1. Check the slip ring for dirt or scratch.

**■ NOTE**
- **If dirt is detected, clean the slip ring using a cloth soaked in alcohol.**
- **If there is slight score, correct with an emery paper (#500 to 600).**

2. Measure the O.D. of the slip ring with a vernier calipers.

**■ NOTE**
- **If the measurement is less than the service limit, replace the rotor assembly.**

| | | |
|---|---|---|
| Slip ring O.D. | Service specification | 14.4 mm<br>0.567 in. |
| | Service limit | 14.0 mm<br>0.551 in. |


3EEABAB1P195A

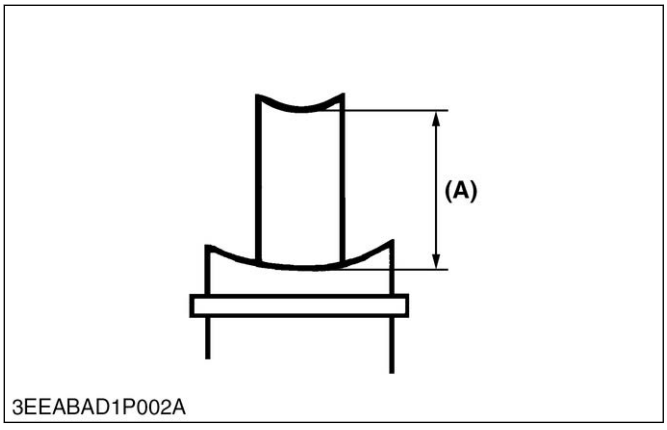
## 7.51 Checking brush wear of alternator

**Tools required**
- Vernier caliper

1. Measure the brush length (A) with a vernier calipers.

**■ NOTE**
- **If the measurement is less than the service limit, replace it.**

| | | |
|---|---|---|
| Brush length (A) | Service specification | 10.0 mm<br>0.394 in. |
| | Service limit | 8.4 mm<br>0.33 in. |



3EEABAD1P002A

(A) Brush length

2. Make sure that the brush moves smoothly.

**■ NOTE**
- **If the brush is damaged and not smoothly, replace it.**

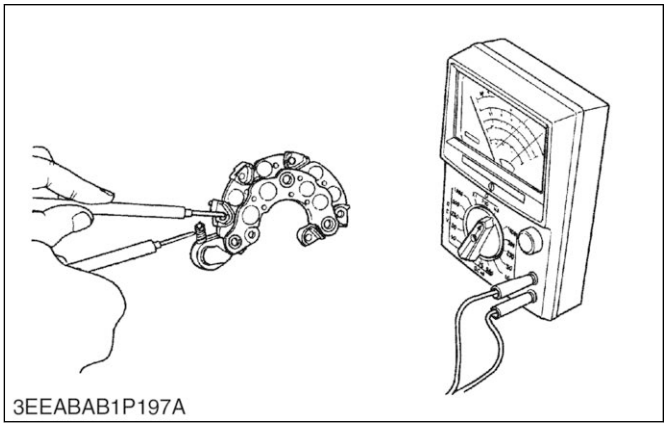
## 7.52 Checking rectifier

**Tools required**
- Circuit tester

1. Check the continuity across each diode of rectifier with the resistance range of circuit tester.

**NOTE**
- **The rectifier is correct if the diode in the rectifier conducts electricity only in one direction.**

| | | |
|---|---|---|
| Resistance | Service specification | Less than 1.0 Ω |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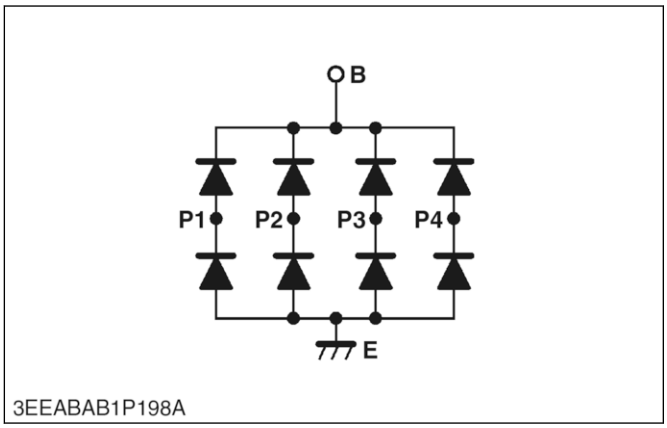

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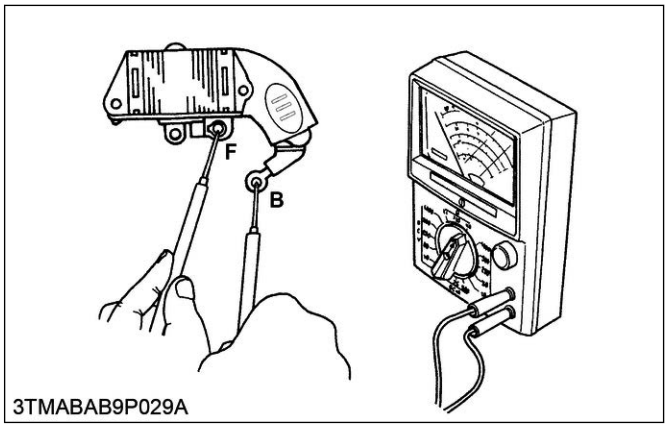

3TMABAB9P029A

(1) **F** terminal (2) **B** terminal

## 7.53 Checking IC regulator

**Tools required**
- Circuit tester

1. Check the continuity across the **B** terminal (2) and the **F** terminal (1) of IC regulator with the resistance range of circuit tester.

**NOTE**
- **The IC regulator is correct if it conducts electricity only in one direction.**

| | | |
|---|---|---|
| Resistance | Service specification | Less than 1.0 Ω |

# INDEX

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