WSM

WORKSHOP MANUAL
DIESEL ENGINE

V3800-CR-TE4B,
V3800-CR-TIE4B
(HYUNDAI)

Kubota

TO THE READER

This Workshop Manual tells the servicing personnel about the mechanism, servicing and maintenance of the V3800-CR-TE4B-HHI-1 and V3800-CR-TIE4B-HHI-1. It contains 4 parts: **"Information"**, **"General"**, **"Mechanism"** and **"Servicing"**.

■ **Information**

This section primarily contains information below.

- Safety First
- Specification
- Performance Curve
- Dimension

■ **General**

This section primarily contains information below.

- Engine Identification
- Muffler Full Assembly Identification
- General Precautions
- Maintenance Check List
- Check and Maintenance
- Special Tools

■ **Mechanism**

This section contains information on the structure and the function of the unit. Before you continue with the subsequent sections, make sure that you read this section.

Refer to Workshop Manual (Code No. 9Y021-01870) for the diesel engine mechanism that this workshop manual does not include.

■ **Servicing**

This section primarily contains information below.

- Troubleshooting
- Servicing Specifications
- Tightening Torques
- Checking, Disassembling and Servicing

All illustrations, photographs and specifications contained in this manual are of the newest information available at the time of publication.

KUBOTA reserves the right to change all information at any time without notice.

Since this manual includes many models, information or illustrations and photographs can show more than one model.

November, 2013

I INFORMATION

INFORMATION

CONTENTS

1. SAFETY FIRST

⚠ 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 try to repair 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, may result in minor or moderate injury.**

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

■ NOTE
- **Gives helpful information.**

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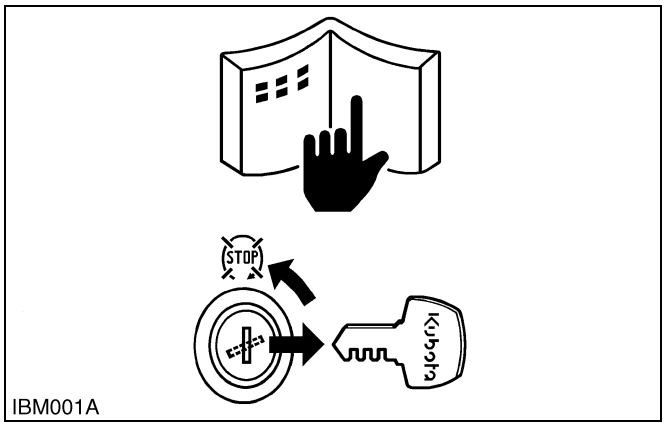

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BEFORE YOU START SERVICE

- Read all instructions and safety instructions in this manual and on your engine safety decals.
- Clean the work area and engine.
- Park the machine on a stable and level ground.
- Let the temperature of the engine decrease before you start a job.
- Stop the engine, then remove the key.
- Disconnect the battery negative cable.
- Hang a **"DO NOT OPERATE"** tag in the operator station.

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START SAFELY

- Do not do the procedures below when you start the engine.
  - short across starter terminals
  - bypass the safety start switch
- Do not make unauthorized modifications to the engine. This can cause damage and decrease the engine life.

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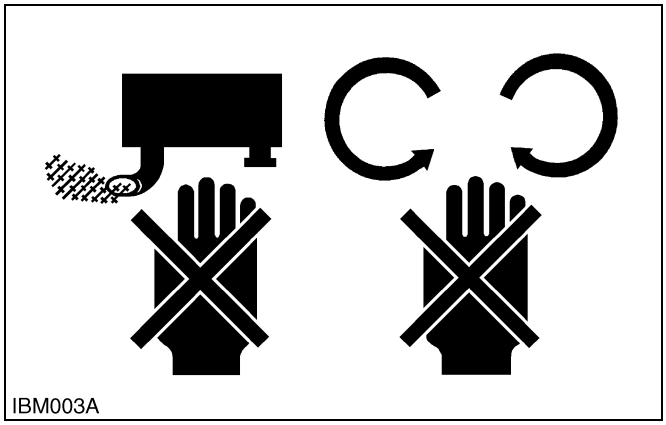
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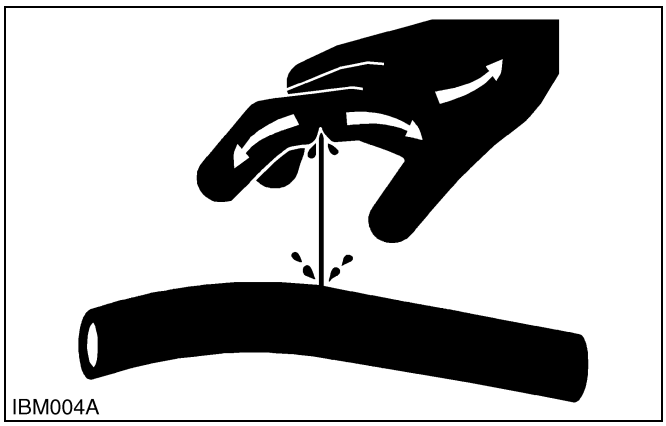
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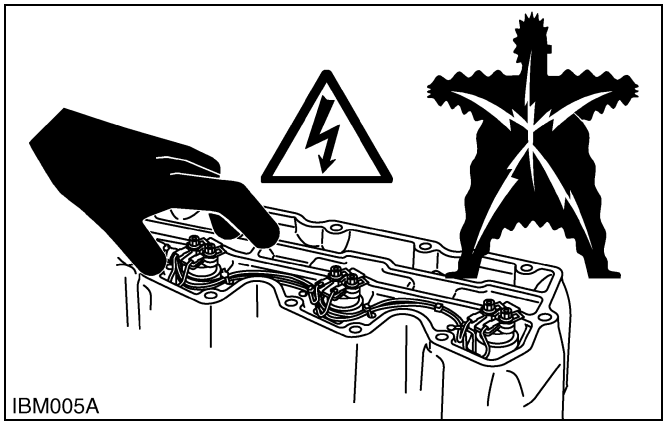
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OPERATE SAFELY

- Do not use the machine after you consume alcohol or medication or when you are tired.
- Put on applicable clothing and safety equipment.
- Use applicable tools only. Do not use alternative tools or parts.
- When 2 or more persons do servicing, make sure that you do it safely.
- Do not touch the hot parts or parts that turn when the engine operates.
- Do not remove the radiator cap when the engine operates, or immediately after it stops. If not, hot water can spout out from the radiator. Only remove the radiator cap when it is at a sufficiently low temperature to touch with bare hands. Slowly loosen the cap to release the pressure before you remove it fully.
- Released fluid (fuel or hydraulic oil) under pressure can cause damage to the skin and cause serious injury. Release the pressure before you disconnect hydraulic or fuel lines. Tighten all connections before you apply the pressure.
- Do not open a fuel system under high pressure.
  The fluid under high pressure that stays in fuel lines can cause serious injury. Do not disconnect or repair the fuel lines, sensors, or any other components between the fuel pump and injectors on engines with a common rail fuel system under high pressure.
- Put on an applicable ear protective device (earmuffs or earplugs) to prevent injury against loud noises.
- Be careful about electric shock. The engine generates a high voltage of more than DC100 V in the ECU and is applied to the injector.

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PROTECT AGAINST HIGH PRESSURE SPRAY

- Spray from high pressure nozzles can penetrate the skin and cause serious injury. Keep spray from contacting hands or body.
- If an accident occurs, see a doctor immediately. Any high pressure spray injected into the skin must be surgically removed within a few hours or gangrene may result.
  Doctors unfamiliar with this type of injury should reference a knowledgeable medical source.

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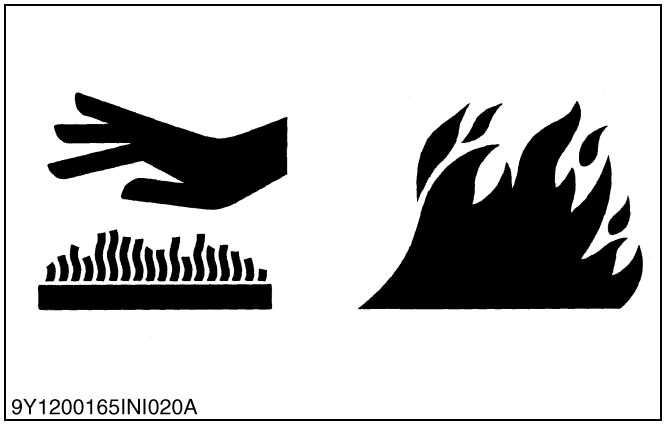
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AVOID HOT EXHAUST

- Servicing machine or attachments with engine running can result in serious personal injury. Avoid exposure and skin contact with hot exhaust gases and components.
- Exhaust parts and streams become very hot during operation. Exhaust gases and components reach temperatures hot enough to burn people, ignite, or melt common materials.

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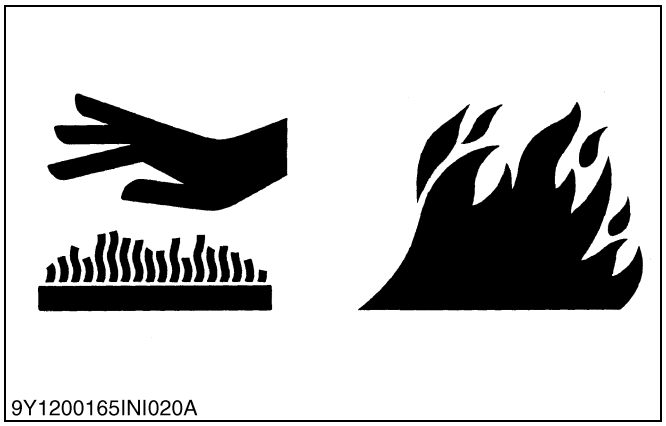
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EXHAUST FILTER CLEANING

- Servicing machine or attachments during exhaust filter cleaning can result in serious personal injury. Avoid exposure and skin contact with hot exhaust gases and components.
- During auto or manual/stationary exhaust filter cleaning operations, the engine will run at elevated idle and hot temperatures for an extended period of time. Exhaust gases and exhaust filter components reach temperatures hot enough to burn people, or ignite, or melt common materials.

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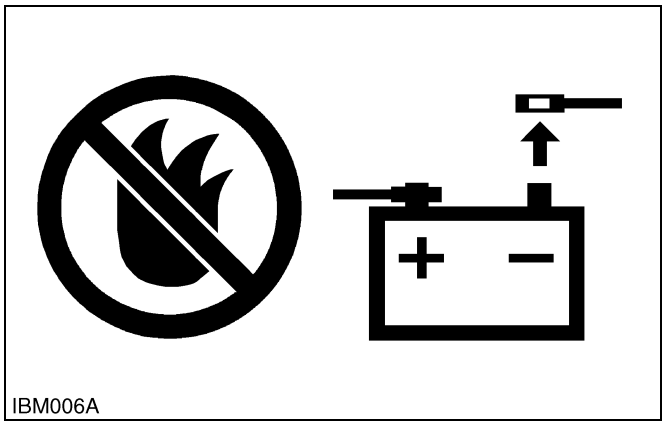
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PREVENT A FIRE

- Fuel is very flammable and explosive under some conditions. Do not smoke or let flames or sparks in your work area.
- To prevent sparks from an accidental short circuit, always disconnect the battery negative cable first and connect it last.
- The battery gas can cause an explosion. Keep the sparks and open flame away from the top of battery, especially when you charge the battery.
- Make sure that you do not spill fuel on the engine.

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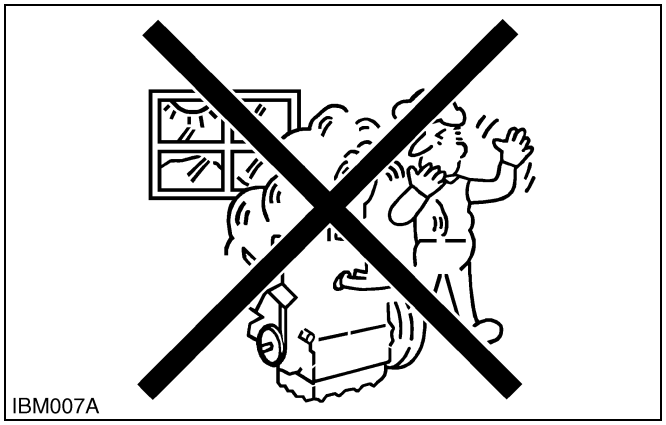
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KEEP A GOOD AIRFLOW IN THE WORK AREA

- If the engine is in operation, make sure that the area has good airflow. Do not operate the engine in a closed area. The exhaust gas contains poisonous carbon monoxide.

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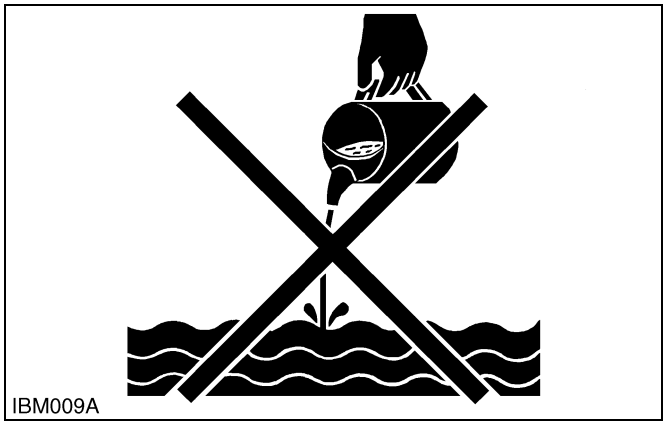
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DISCARD FLUIDS CORRECTLY

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

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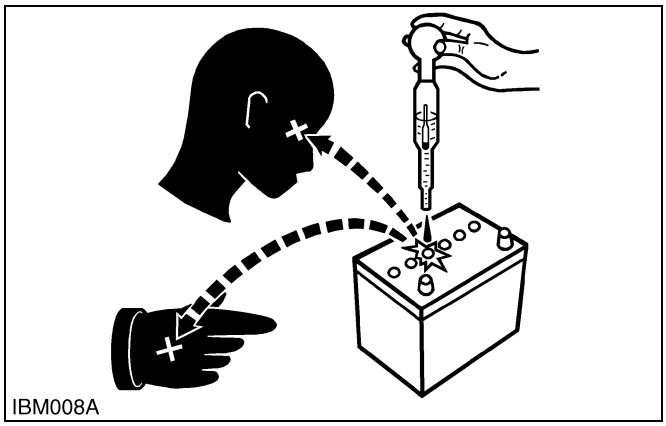
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PREVENT ACID BURNS

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

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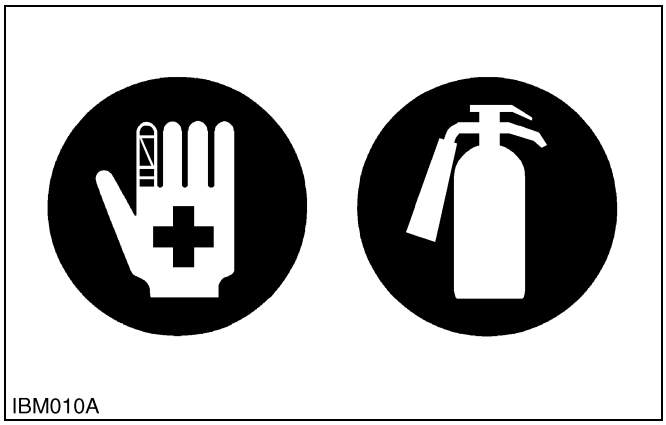
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PREPARE FOR EMERGENCIES

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

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2. SPECIFICATIONS

Model	V3800-CR-TE4B-HHI-1	V3800-CR-TIE4B-HHI-1
Number of Cylinder	4	
Engine Type	Vertical, water-cooled, 4-cycle DI diesel engine	
Bore x Stroke	100 × 120 mm (3.94 × 4.72 in.)	
Total Displacement	3769 cm^3 (230.0 cu.in.)	
SAE Gross Continuous	61.0 kW / 2200 min^{-1}(rpm) 81.8 HP / 2200 min^{-1}(rpm)	68.3 kW / 2200 min^{-1}(rpm) 91.6 HP / 2200 min^{-1}(rpm)
SAE Gross Intermittent	70.2 kW / 2200 min^{-1}(rpm) 94.1 HP / 2200 min^{-1}(rpm)	78.6 kW / 2200 min^{-1}(rpm) 105 HP / 2200 min^{-1}(rpm)
Maximum Bare Speed	2400 min^{-1} (rpm)	2525 min^{-1} (rpm)
Minimum Bare Idling Speed	900 min^{-1} (rpm)	
Combustion Chamber	Reentrant Type, Center Direct Injection Type (E-CDIS)	
Fuel Injection Pump	DENSO Common Rail System	
Governor		
Injector		
Fuel Injection Timing		
Fuel Injection Pressure		
Direction of Rotation	Counter-clockwise (Viewed from flywheel side)	
Firing Order	1-3-4-2	
Compression Ratio	17.5	
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	Electric Starting with Starter	
Starter Motor	24 V, 3.2 kW	
Starting Support Device	Intake Air Heater in Intake Manifold	
EGR	External EGR (EGR Cooler + Electric EGR Valve + Reed Valve)	
Battery	12 V, 115E41 x2 equivalent	
Charging Alternator	24 V, 1.92 kW	
Fuel	Diesel Fuel No. 2-D S15, see page G-9.	
Lubricating Oil	Class CJ-4 lubricating oil as per API classification is recommended. For details on recommended lubricating oils, see page G-9.	
Lubricating Oil Capacity	13.2 L (3.49 U.S.gals)	
Weight (Dry)	316 kg (697 lbs)	

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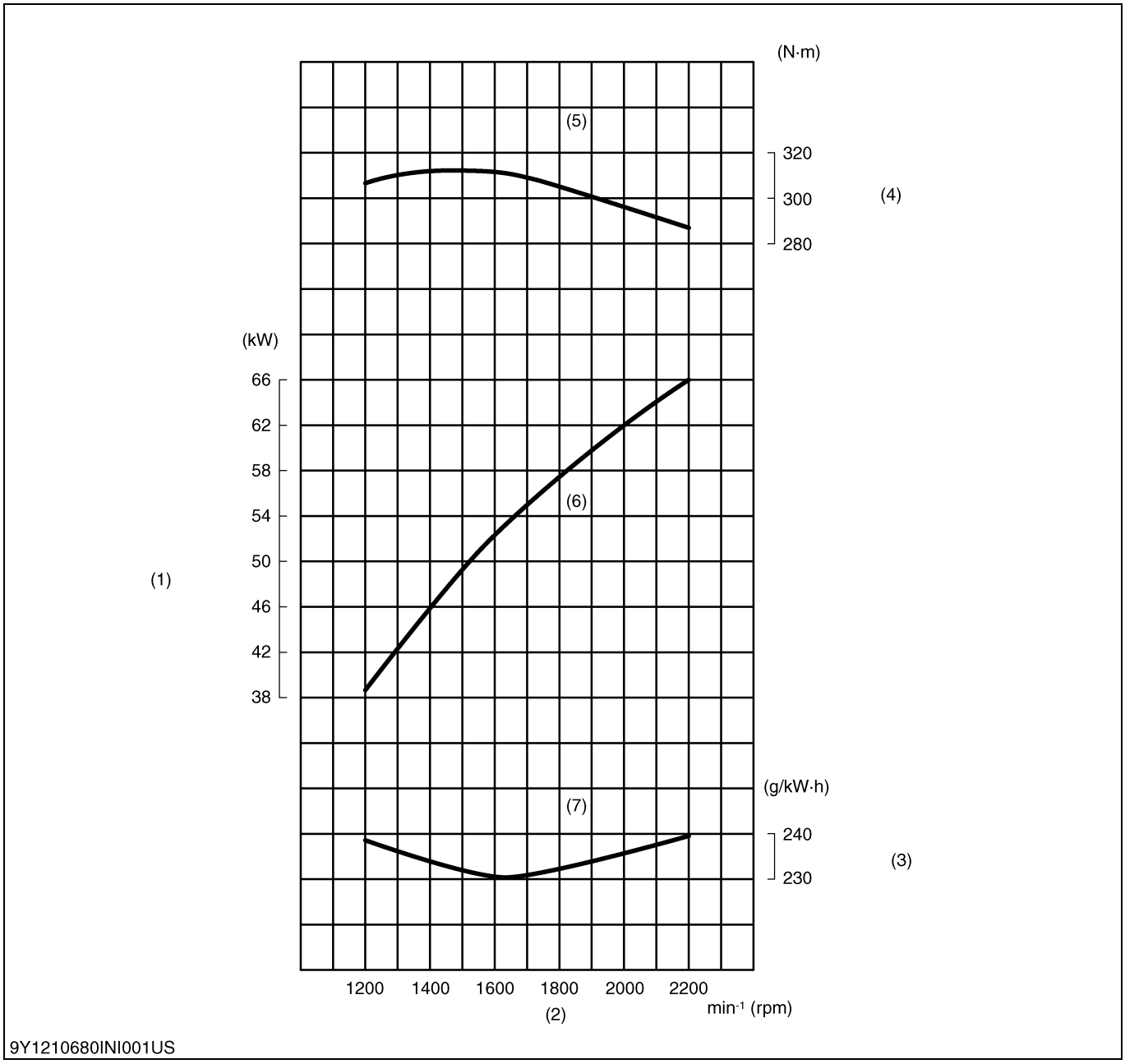
3. PERFORMANCE CURVES

V3800-CR-TE4B-HHI-1



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(1) Brake Horsepower
(2) Engine Speed
(3) Torque
(4) Gross Intermittent Torque
(5) Gross Intermittent Brake Horsepower

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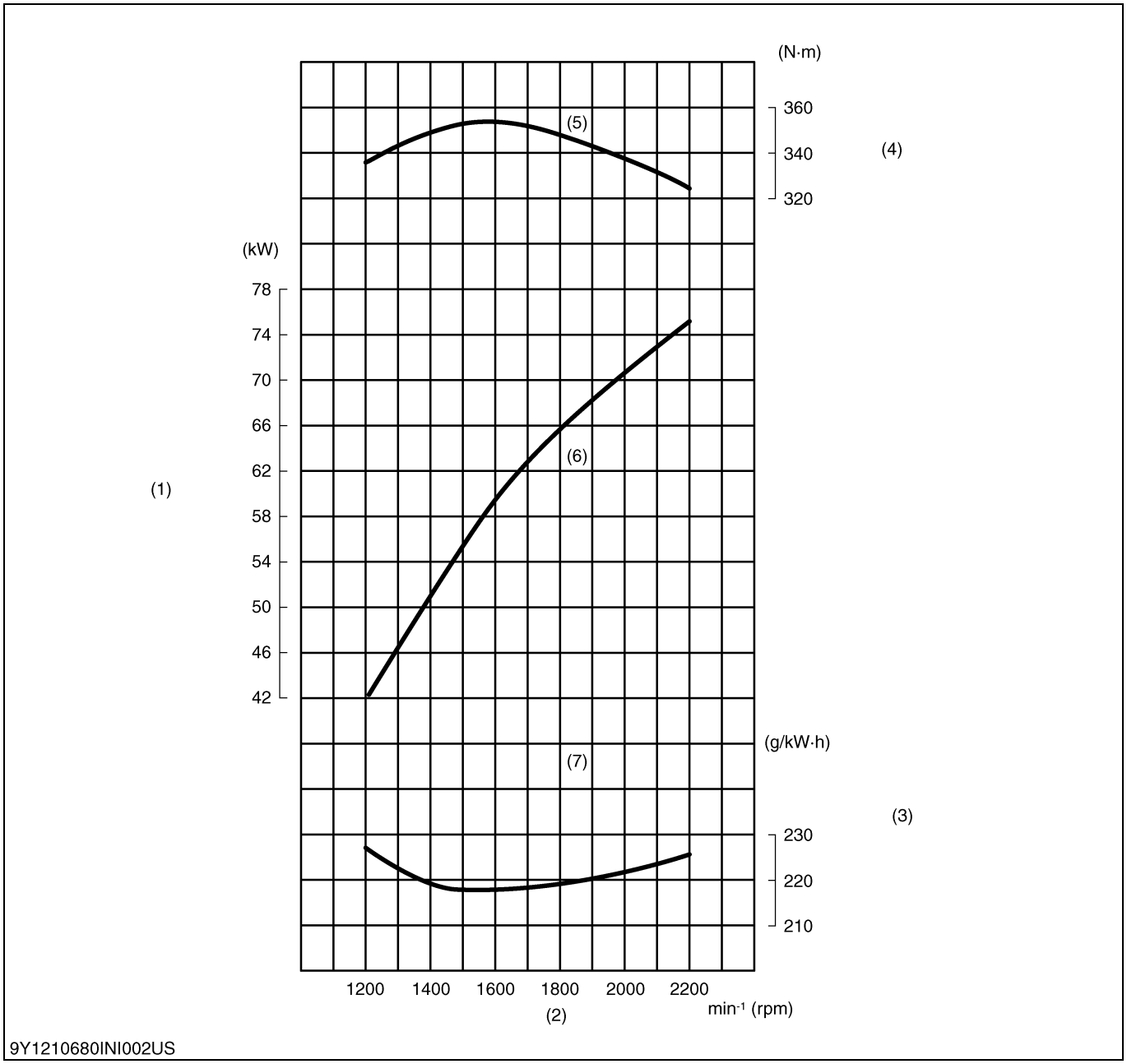
V3800-CR-TIE4B-HHI-1



(1) Brake Horsepower
(2) Engine Speed
(3) Torque
(4) Gross Intermittent Torque
(5) Gross Intermittent Brake Horsepower

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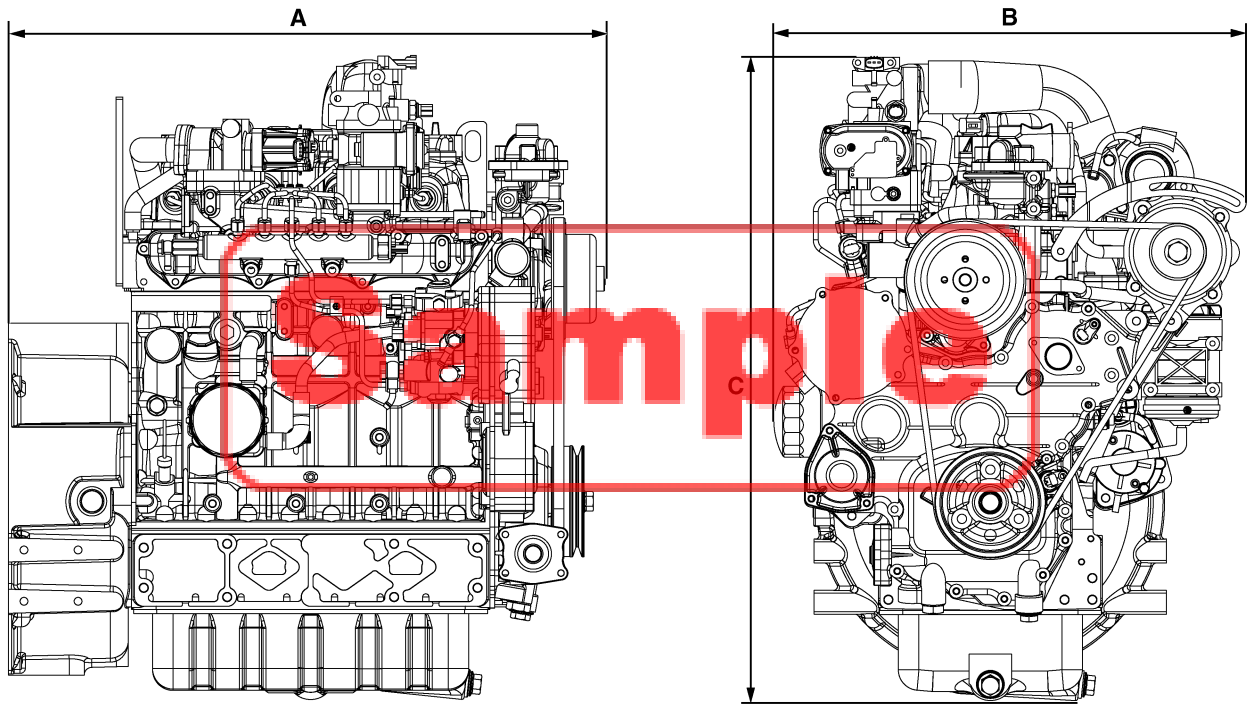
4. DIMENSIONS



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	V3800-CR-TE4B-HHI-1
A	839.3 mm (33.04 in.)
B	610 mm (24.0 in.)
C	837 mm (33.0 in.)

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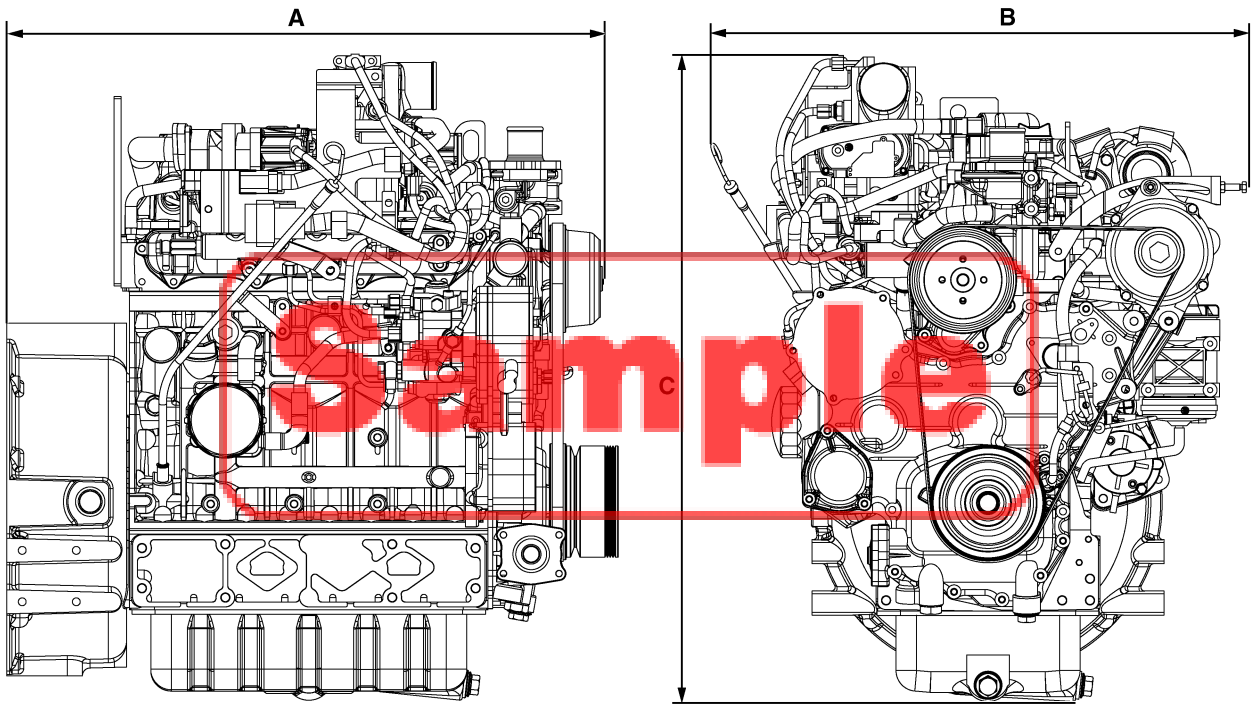

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	V3800-CR-TIE4B-HHI-1
A	839.3 mm (33.04 in.)
B	610 mm (24.0 in.)
C	837 mm (33.0 in.)

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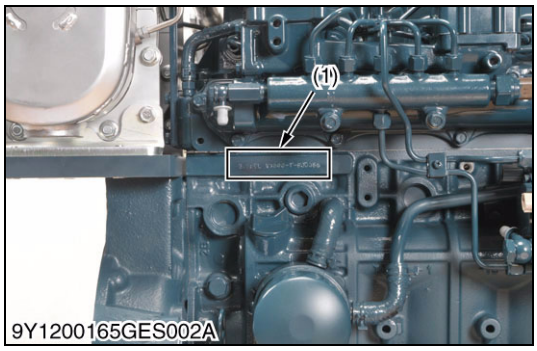
G GENERAL

GENERAL

CONTENTS

1. ENGINE IDENTIFICATION

[1] MODEL NAME AND OLD ENGINE 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.

(1) Engine Model Name and Serial Number

Year of manufacture

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

Month of manufacture

Month	Engine Lot Number	
January	A0001 ~ A9999	B0001 ~ BZ999
February	C0001 ~ C9999	D0001 ~ DZ999
March	E0001 ~ E9999	F0001 ~ FZ999
April	G0001 ~ G9999	H0001 ~ HZ999
May	J0001 ~ J9999	K0001 ~ KZ999
June	L0001 ~ L9999	M0001 ~ MZ999
July	N0001 ~ N9999	P0001 ~ PZ999
August	Q0001 ~ Q9999	R0001 ~ RZ999
September	S0001 ~ S9999	T0001 ~ TZ999
October	U0001 ~ U9999	V0001 ~ VZ999
November	W0001 ~ W9999	X0001 ~ XZ999
December	Y0001 ~ Y9999	Z0001 ~ ZZ999

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

(a) (b)(c) (d)
e.g. V3800-T - B B A001

(a) Engine Model Name **V3800-T**
(b) Year: B indicates 2011
(c) Month: A or B indicates January
(d) Lot Number: (**0001 ~ 9999** or **A001 ~ Z999**)

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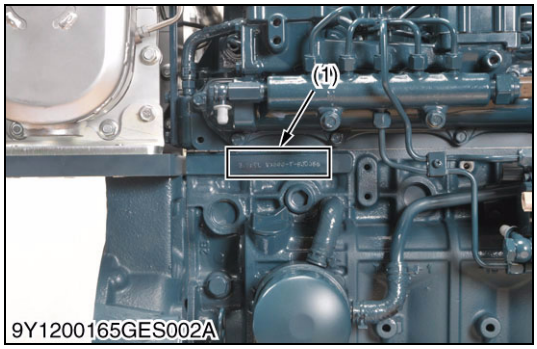
[2] MODEL NAME AND NEW ENGINE SERIAL NUMBER



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	Number or Alphabet	Series
1	05 (include: WG)	7	03
2	V3	8	07
3	08	A	EA, RK
4	SM (include: WG)	B	03 (KET Production)
5	Air Cooled Gasoline	C	V3, 07 (KEW Production)
6	GZ, OC, AC, EA, E		

Production Year

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

(1) Engine Model Name and Serial Number

(To be continued)

(Continued)

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.

(a) (b)(c)(d) (e)
e.g. V3800-T - 2 C MA001

(a) **V3800-T**: Engine Model Name
(b) **2**: Engine Series (V3 series)
(c) **C**: Production Year (2012)
(d) **M**: Production Month (June)
(e) **A001**: Lot Number: (**0001 ~ 9999** or **A001 ~ Z999**)

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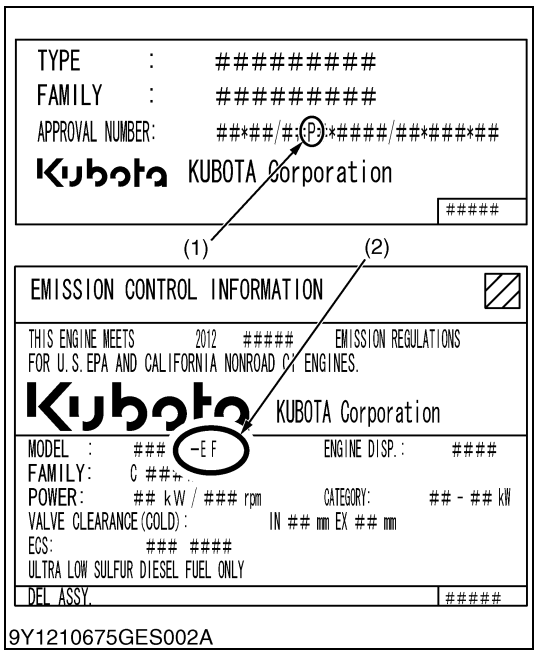
[3] E4B ENGINE

[Example: Engine Model Name V3800-CR-TE4B-HHI-1 or V3800-CR-TIE4B-HHI-1]

The emission controls previously implemented in various countries to prevent air pollution will be stepped up as Nonroad Emission Standards 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 below).

When servicing or repairing ###-E4B series engines, use only replacement parts for that specific E4B engine, designated by the appropriate E4B KUBOTA Parts List and perform all maintenance services listed in the appropriate KUBOTA Operator's Manual or in the appropriate E4B KUBOTA Workshop Manual. Use of incorrect replacement parts or replacement parts from other emission level engines (for example: E3B engines), may 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 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.



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Category (1)	Engine output classification	EU regulation
P	From 37 to less than 56 kW	STAGE IIIB
N	From 56 to less than 75 kW	STAGE IIIB
M	From 75 to less than 130 kW	STAGE IIIB

Category (2)	Engine output classification	EPA regulation
EF	Less than 19 kW	Tier 4
	From 19 to less than 56 kW	Interim Tier 4
	From 56 to less than 75 kW	Interim Tier 4
	From 75 to less than 130 kW	Interim Tier 4

(1) EU regulation engine output classification category
(2) "E4B" engines are identified with "EF" at the end of the Model designation, on the US EPA label.
"E4B" designates some Interim Tier 4 / Tier 4 models, depending on engine output classification.

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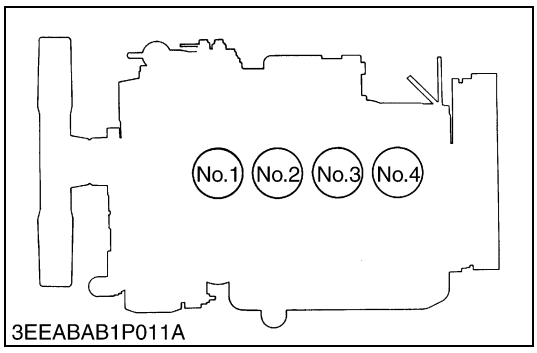
[4] CYLINDER NUMBER



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You can see the cylinder numbers of KUBOTA diesel engine in the figure.

The sequence of cylinder numbers is No.1, No.2, No.3 and No.4 and it starts from the gear case side.

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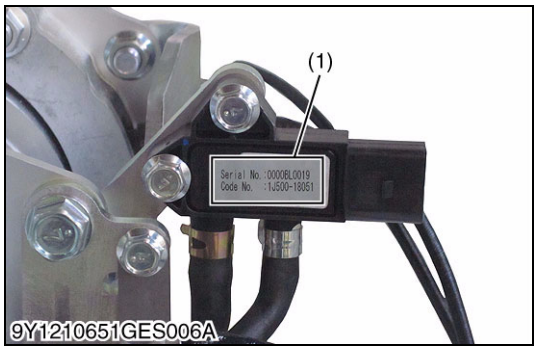
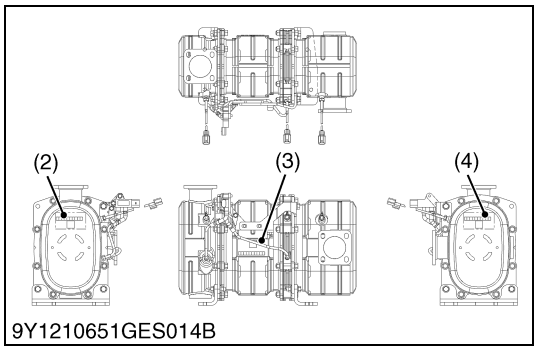
2. MUFFLER FULL ASSEMBLY IDENTIFICATION

[1] PART NUMBER AND SERIAL NUMBER





Diesel Particulate Filter (hereinafter referred to as the "DPF") Muffler Full Assembly Serial Number

You must keep the records of the filter comp (DPF) part number and serial number (3) and catalyst (DOC) part number and serial number (4) before you remove the DPF for cleaning.

(1) DPF Muffler Full Assembly Part Number and Serial Number
(2) Body (DPF Outlet) Part Number and Serial Number
(3) Filter Comp (DPF) Part Number and Serial Number
(4) Catalyst (DOC) Part Number and Serial Number

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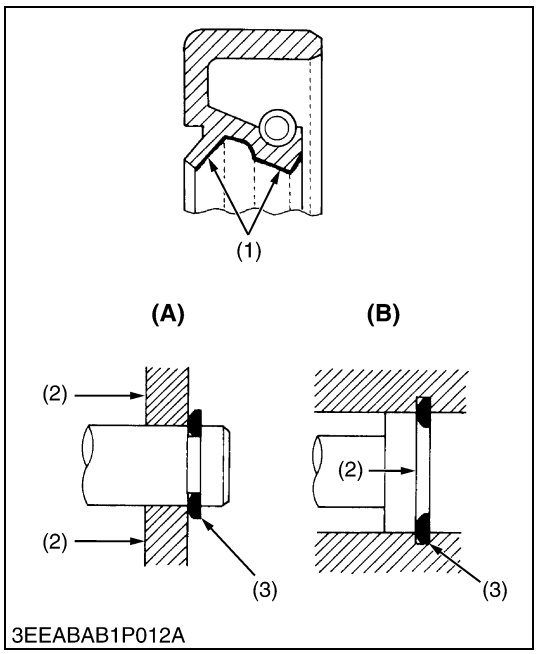
3. GENERAL PRECAUTIONS



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- When you disassemble, carefully put the parts in a clean area to make it easy to find the parts.
  You must install the screws, bolts and nuts in their initial position to prevent the reassembly errors.
- When it is necessary to use special tools, use KUBOTA special tools. Refer to the drawings when you make special tools that you do not use frequently.
- Before you disassemble or repair machine, make sure that you always disconnect the ground cable from the battery first.
- Remove oil and dirt from parts before you measure.
- Use only KUBOTA genuine parts for replacement to keep the machine performance and to make sure of safety.
- You must replace the gaskets and O-rings when you assemble again. Apply grease (1) to new O-rings or oil seals before you assemble.
- When you assemble the external or internal snap rings, make sure that the sharp edge (3) faces against the direction from which force (2) is applied.
- Make sure that you try to operate the engine after you repair or assemble it.

(1) Grease
(2) Force
(3) Sharp Edge

(A) External Snap Ring
(B) Internal Snap Ring

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4. 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									
		Daily	Initial 50 hrs	Every 50 hrs	Every 250 hrs	Every 500 hrs	Every 1000 hrs	Every 1500 hrs	Every 3000 hrs	Every 1 year	Every 2 years
	Check of engine oil level	❍									
	Check of fuel level	❍									
	Check of coolant level	❍									
	Check of fan belt	❍									
	Check of fuel hoses and clamp bands			❍							
	Check of draining of water separator			❍							
	Check of radiator hoses and clamp bands				❍						
	Cleaning of air cleaner element (Replace the element after 6-times cleaning)				❍						
	Adjustment of fan belt tension				❍						
	Check of intake air line				❍						
	Change of engine oil		❍			❍					
	Replacement of oil filter cartridge		❍			❍					
★1	Replacement of fuel filter cartridge					❍					
	Cleaning of water separator					❍					
★2	Cleaning of fuel tank interior					❍					
★2	Cleaning of water jacket and radiator interior					❍					
★2	Replacement of fan belt					❍					❍
★2	Check of valve clearance						❍				
★2,★3	Check of injector							❍			
★2,★3	Check of EGR cooler							❍			
★3	Replacement of oil separator element							❍			
★2	Check of PCV (Positive Crankcase Ventilation) valve							❍			
★2,★3	Check of turbocharger								❍		
★2,★3	Cleaning of DPF								❍		
★2,★3	Check of EGR system								❍		
★2	Replacement of air cleaner element									❍	
★2	Check of DPF differential pressure pipes and hoses									❍	
★2	Check of EGR piping									❍	
	Check of intake air line									❍	
	Check of exhaust manifold (Crack, gas leakage and mounting screw)									❍	
★2	Replacement of oil separator rubber hose										❍
★2	Replacement of rubber hose of DPF differential pressure sensor										❍
★2	Replacement of intake hose (After air flow sensor) and inter cooler hose										❍
★2	Replacement of pressure detection hose of boost sensor										❍
★2	Replacement of EGR cooler hose										❍
★2	Replacement of water hose										❍
★2	Replacement of lubricant hose										❍
	Change of radiator coolant (L.L.C.)										❍
★2	Replacement of radiator hoses and clamp bands										❍

Inspection Item		Service Interval									
		Daily	Initial 50 hrs	Every 50 hrs	Every 250 hrs	Every 500 hrs	Every 1000 hrs	Every 1500 hrs	Every 3000 hrs	Every 1 year	Every 2 years
★1,★2	Replacement of fuel hoses and clamps										❍
★2	Replacement of intake air line										❍

- When the battery is used for less than 100 hours in a year, check its electrolyte yearly. (for refillable battery's only)
- ★1: When biodiesel fuel is used, change the fuel filter cartridge, fuel hose and clamp bands with new ones at intervals half of the usual ones.
- ★2: Consult your local KUBOTA dealer for this service.
- The items above (★3 marked) are registered as emission related critical parts by KUBOTA in the U.S. EPA nonroad emission regulation. As the engine owner, you are responsible for the performance of the required maintenance on the engine according to the above instruction.
  Please see the warranty statement in detail.
- The items listed above other than ★3 marked are not necessary to keep the emission-related warranty valid.
- Failure to perform the maintenance will cause problems that will significantly degrade the engine performance.

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CAUTION

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

NOTE

- **Changing interval of engine oil:**

Models	Interval
V3800-CR-TE4B-HHI-1 V3800-CR-TIE4B-HHI-1	Every 500 Hrs or 1 year whichever comes first
	Initial 50 Hrs

API service classification: above CJ-4 grade
Ambient temperature: below 35 °C (95 °F)

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■ **NOTE**

Engine Oil:

- Refer to the following table for the suitable American Petroleum Institute (API) classification of engine oil according to the engine type and the Fuel Type.

Fuel Type	Engine oil classification (API classification)
	Engines with DPF
Ultra Low Sulfur Fuel [Sulfur Content < 0.0015 % (15 ppm)]	**CJ-4**

- Engine oil should be API classification CJ-4.
- Change the type of engine oil according to the ambient temperature.
- When using oil of different brands from the previous one, be sure to drain all the previous oil before adding the new engine oil.
- On DPF-equipped engines, part of the fuel may get mixed with engine oil during the regenerating process. This may dilute the oil and increase its quantity. If the oil rises above the oil level gauge upper limit, it means the oil has been diluted too much, resulting in a trouble. In such case, immediately change the oil for new one.
- If the interval of DPF regeneration becomes 5 hours or less, be sure to change the oil for new one.

Fuel:

- Cetane Rating: The minimum recommended Fuel Cetane Rating is 45. A cetane rating greater than 50 is preferred, especially for ambient temperatures below −20 °C (−4 °F) or elevations above 1500 m (4921 ft).
- Diesel Fuel Specification Type and Sulfur Content % (ppm) used, must be compliant with all applicable emission regulations for the area in which the engine is operated.
- DO NOT USE Fuels that have sulfur content greater than 0.0015 % (15 ppm).
- Diesel fuels specified to EN 590 or ASTM D975 are recommended.
- No.2-D is a distillate fuel of lower volatility for engines in industrial and heavy mobile service. (SAE J313 JUN87)
- These engines utilize Interim Tier 4 standards, the use of ultra low sulfur fuel is mandatory for these engines, when operated in US EPA regulated areas. Therefore, please 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 temperature below −10 °C (14 °F).
  a) SAE: Society of Automotive Engineers
  b) EN: European Norm
  c) ASTM: American Society of Testing and Materials
  d) US EPA: United States Environmental Protection Agency
  e) No.1-D or No.2-D, S15: Ultra Low Sulfur Diesel (ULSD)) 15 ppm or 0.0015 wt.%
- When biodiesel fuel is used, change the fuel filter cartridge, fuel hose and clamp bands with new ones at intervals half of the usual ones.

■ **IMPORTANT**

- **Be sure to use a strainer when filling the fuel tank, or dirt or sand in the fuel may cause trouble.**
- **Do not run the fuel tank level too low or completely out of fuel. You may experience improper engine running and/or a DTC (Diagnostic Trouble Code) error code may be recorded in the Engine Control. Additionally, fuel system bleeding may be necessary if air enters the fuel system.**

(To be continued)

(Continued)

■ **Biodiesel fuel**

[When the B7 blended fuel is used]

When the finally blended Biodiesel fuel is B7, make sure it conforms to the updated EN590 (European) standard. Be also sure that the mineral oil diesel fuel, if used, conforms to the updated EN590 (European) standard and that the B100 blend conforms to the updated EN14214 (European) standard.

[When the B5 blended fuel is used]

When the finally blended Biodiesel fuel is B5, make sure it conforms to the updated EN590 (European) standard. Be also sure that the mineral oil diesel fuel, if used, conforms to the updated EN5950 (European) standard or the ASTM D975 (U.S.) standard and that the B100 blend conforms to the updated EN 14214 (European) standard or the ASTM D6751 (U.S.) standard.

■ **Precautions in handling Biodiesel fuels**

1. Keep the fuel tank full whenever possible to prevent water vapor from accumulating inside the fuel tank. Tighten up the fuel tank filler cap to avoid the entry of moisture.
2. Routinely check the oil level before the operation. Also strictly follow the specified oil change intervals.
3. Biodiesel fuels (BDF) during the supply process or in the machine easily deteriorate due to oxygen, water, heat and other foreign substances. With this in mind, take the following precautions.
   - Do not leave those fuels in the fuel tank or a metallic drum longer than 3 months.
   - Before storing the machine for a prolonged period, change such fuel for a conventional type of diesel fuel and run the machine for 30 minutes or longer to clean up the fuel system.
4. Bear it in mind that Biodiesel fuels have the characteristics below. Referring to the servicing intervals specified in the KUBOTA products' Operator's Manuals, be sure to maintain and clean up the fuel system, replace the fuel hose with new ones and take other necessary measures. It is advisable to replace the fuel filter, fuel hose and clamp bands with new ones 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.)

- Biodiesel fuels easily induce the growth of microorganisms and foul themselves. This may get the fuel system corroded and the fuel filter clogged.
- In cold weather, some problems may occur: the clog of the fuel line or fuel system, starting failure, and other unforeseen troubles.
- Biodiesel fuels easily soak up moisture, which means that they may contain higher moisture content than conventional diesel fuels.

5. Palm oil-based Biodiesel fuels are inferior in low-temperature fluidity to soy-based and rapeseed-based Biodiesel fuels. In cold season in particular, this may clog the fuel filter.
6. If Biodiesel fuels are spilt on a coated surface, the coating may get damaged. Immediately wipe the spill off the surface.

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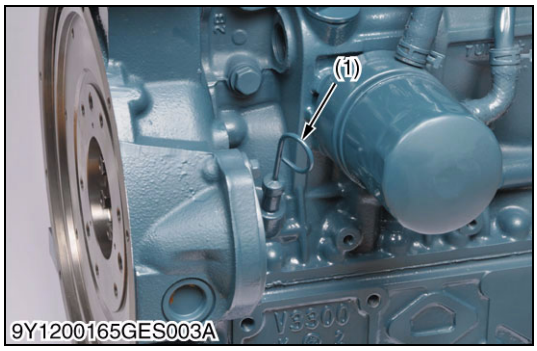
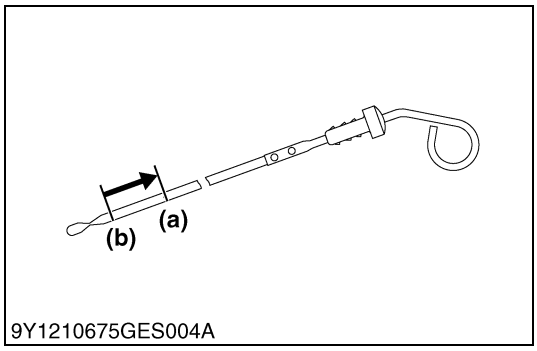
5. CHECK AND MAINTENANCE

[1] DAILY CHECK POINTS





Check of Engine Oil Level

1. Make the engine level.
2. Pull out the dipstick (1) and clean it. Put in and pull it out again. Make sure that the oil level is between the 2 notches.
3. If the level is too low, add new oil to the specified level.

■ **IMPORTANT**

- **On Diesel Particulate Filter (DPF) equipped engines, part of the fuel may get mixed with engine oil during the regenerating process. This may dilute the oil and increase its quantity. If the oil rises above the dipstick upper limit, it means the oil has been diluted too much, resulting in a trouble. In such case, immediately change the oil for new one.**
- **When you use an oil of different brand or viscosity from the previous, drain the remaining oil. Do not mix 2 different types of oil.**

■ **NOTE**

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

(1) Dipstick
(a) Upper Line
(b) Lower Line

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Check of Fuel Level

1. Make the engine level.
2. Make sure that the fuel level is above the lower limit of the fuel level gauge.
3. If the fuel level is too low, add fuel to the upper limit.

■ **IMPORTANT**

- **When Biodiesel fuel is used, change the fuel filter cartridge, fuel hose and clamp bands with new ones at intervals half of the usual ones.**
- **Be sure to use a strainer when filling the fuel tank, or dirt or sand in the fuel may cause trouble.**
- **Do not run the fuel tank level too low or completely out of fuel. You may experience improper engine running and/or a DTC (Diagnostic Trouble Code) error code may be recorded in the Engine Control. Additionally, fuel system bleeding may be necessary if air enters the fuel system.**

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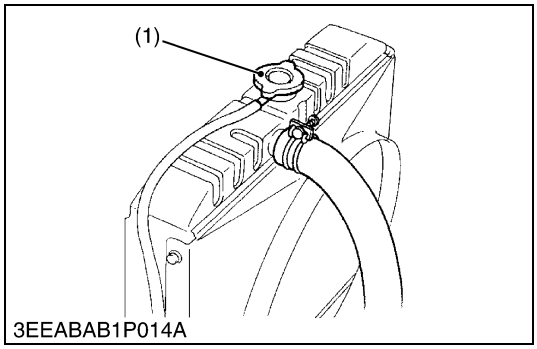

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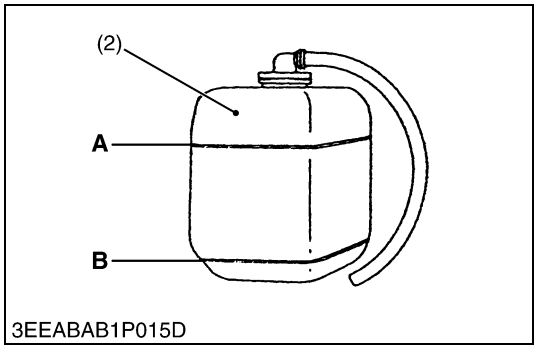

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Check of Coolant Level

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.**

1. Without recovery tank: Remove the radiator cap (1). Make sure that the coolant level is immediately below the port.
   With recovery tank (2): Make sure that the coolant level is between **FULL A** and **LOW B**.
2. If the coolant level is too low, find out the cause that there is less coolant. **Case 1** If the coolant decreases by evaporation, add only clean and soft water. **Case 2** If the coolant decreases by leak, add coolant of the same manufacturer and brand in the specified mixture ratio (clean, soft water and L.L.C.). If you cannot identify the coolant brand, drain all the remaining coolant and add a new brand of coolant mix.

■ **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) Radiator Cap **A: FULL**
(2) Recovery Tank **B: LOW**

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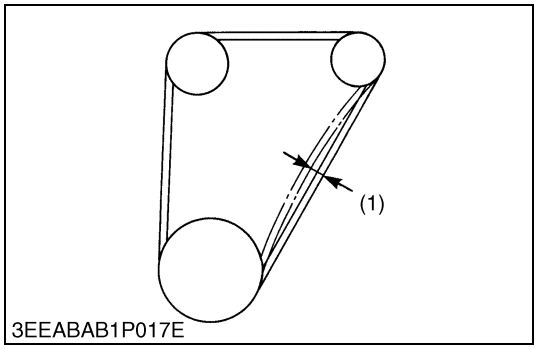

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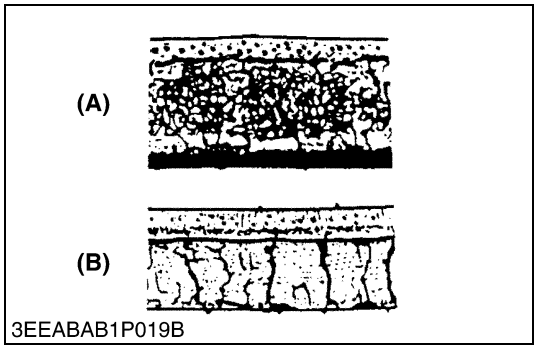

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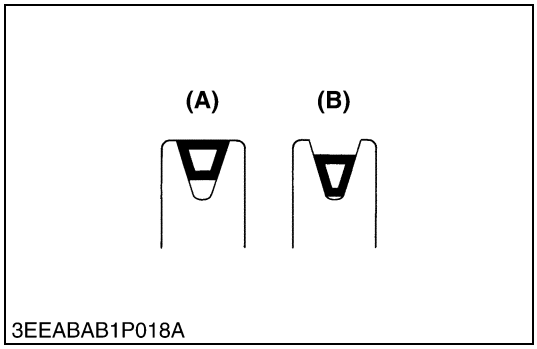

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Check of Fan Belt

1. Examine if the fan belt is worn out and sunk in the pulley groove, and if it is, replace it.
2. Push the belt halfway between the fan drive pulley and alternator pulley at a specified force 98 N (10 kgf, 22 lbf) to measure the deflection (1).
3. If the measurement is out of the factory specifications, loosen the alternator mounting screws and adjust its position.

Deflection (1)	Factory specification	10 to 12 mm 0.40 to 0.47 in.

(1) Deflection

(A) OK
(B) Wear

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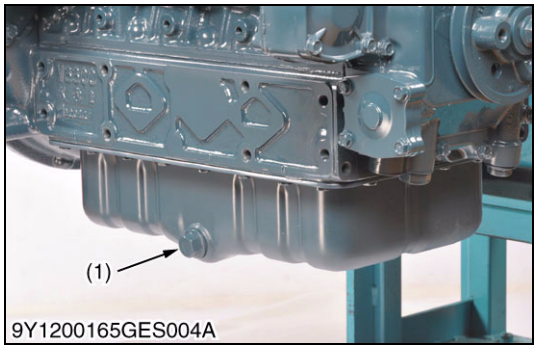
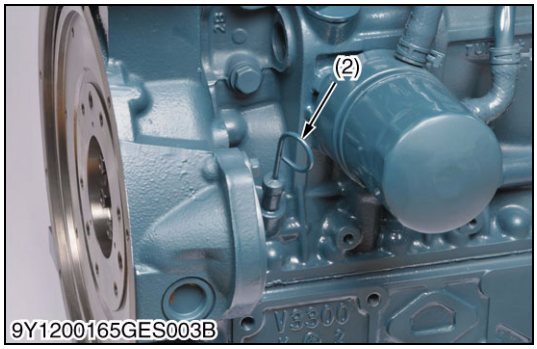
[2] INITIAL 50 HOURS





Change of Engine Oil

CAUTION

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

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 oil fully.
4. Tighten the drain plug (1).
5. Fill new oil until the upper line on the dipstick (2).

IMPORTANT

- **When you use an oil of different brand or viscosity from the previous, drain the remaining oil.**
- **Do not mix 2 different types of oil.**
- **Engine oil must have the properties of API classification CJ-4. Use the correct SAE Engine Oil by reference to the ambient temperature.**

Above 25 °C (77 °F)	SAE 30 or SAE 10W-30, SAE 15W-40
0 °C to 25 °C (32 °F to 77 °F)	SAE 20 or SAE 10W-30, SAE 15W-40
Below 0 °C (32 °F)	SAE 10W or SAE 10W-30, SAE 15W-40

Engine oil capacity	13.2 L 3.49 U.S.gals

(1) Drain Plug (2) Dipstick

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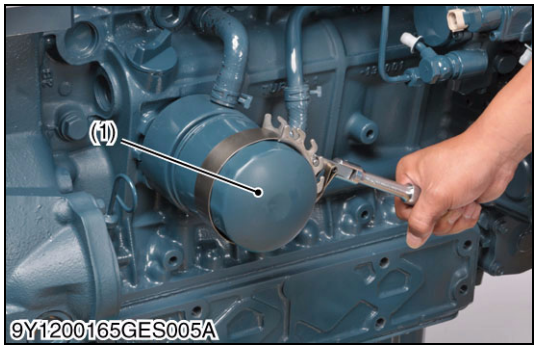

Replacement of Oil Filter Cartridge

CAUTION

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

1. Remove the oil filter cartridge (1) with the filter wrench.
2. Apply a thin layer of oil on the new cartridge gasket.
3. Install the new cartridge by hand. Do not tighten too much because it can cause deformation of the rubber gasket.
4. After you replace the cartridge, the engine oil usually decrease by a small level. Make sure that the engine oil does not flow through the seal and read the oil level on the dipstick. Fill the engine oil until the specified level.

IMPORTANT

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

(1) Oil Filter Cartridge

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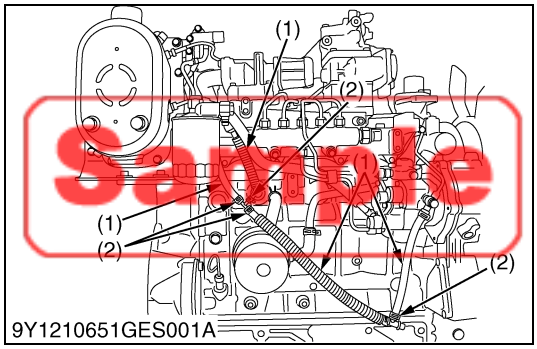
[3] EVERY 50 HOURS



Check of Fuel Hoses and Clamp Bands

1. If the clamp (2) is loose, apply oil to the threads and tighten it again correctly.
2. Replace the fuel hose (1) together with the clamp in a 2 years interval.
3. But if the fuel hose and clamp has damages before 2 years, then replace them.
4. After you replace the fuel hose and the clamp, bleed the fuel system.

(1) Fuel Hose (2) Clamp

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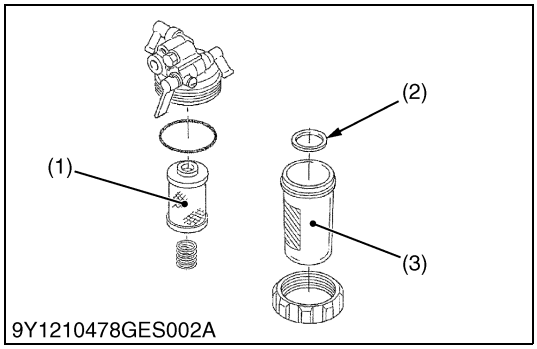

Check and Draining of Water Separator

1. Remove and flush the filter cup (3) if the float (2) goes up with water, or the filter cup (3) has the dust.
2. Flush the element (1) with kerosene to prevent dust to go into the inner element (1).
3. After you replace, bleed the fuel system.

(1) Element (3) Filter Cup
(2) Float

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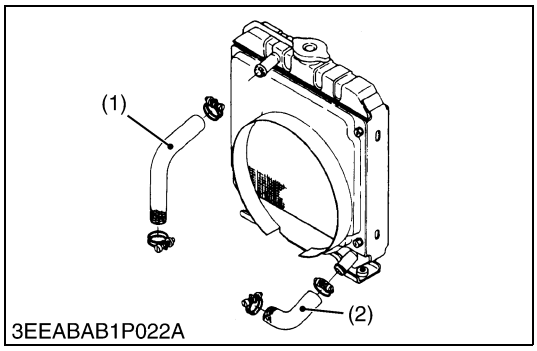
[4] EVERY 250 HOURS



Check of Radiator Hoses and Clamp Bands

1. Make sure that the radiator hoses connections (1), (2) are correct for every 250 hours of operation.
2. If the clamp is loose, apply oil to the threads and tighten it again correctly.
3. You must replace the radiator hose(s) every 2 years. Also replace the clamp every 2 years and tighten it correctly.

(1) Upper Hose (2) Lower Hose

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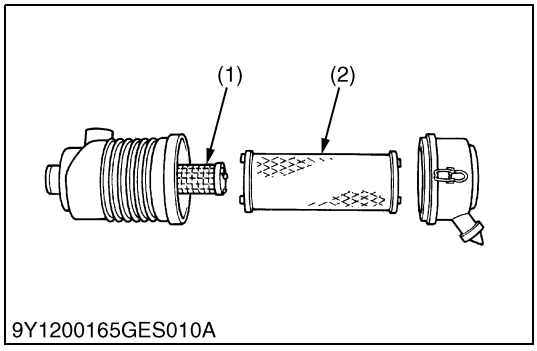

Cleaning of Air Cleaner Primary Element

1. Remove the primary element (2).
2. Use clean dry compressed air on the inner side of the primary element (2). The pressure of compressed air must be less than 205 kPa (2.1 kgf/cm^2, 30 psi).

■ **NOTE**

- **Replace the primary element once a year or every sixth cleaning.**
- **The air cleaner uses a dry element, never apply oil.**
- **Do not run the engine with filter element removed.**
- **Do not touch the secondary element (1) except in cases where replacing is required.**

(1) Secondary Element (2) Primary Element

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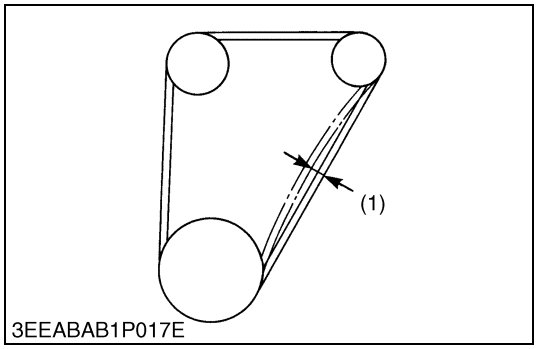

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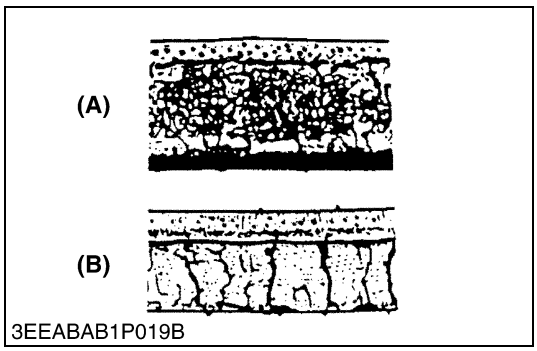
Adjustment of Fan Belt Tension

1. Examine if the fan belt is worn out and sunk in the pulley groove, and if it is, replace it.
2. Push the belt halfway between the fan drive pulley and alternator pulley at a specified force 98 N (10 kgf, 22 lbf) to measure the deflection (1).
3. If the measurement is out of the factory specifications, loosen the alternator mounting screws and adjust its position.

Deflection (1)	Factory specification	10 to 12 mm 0.40 to 0.47 in.

(1) Deflection



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(A) OK
(B) Wear

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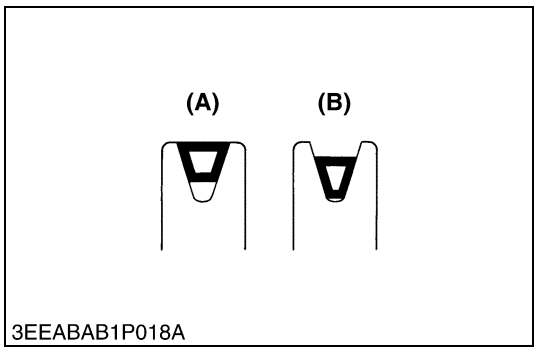

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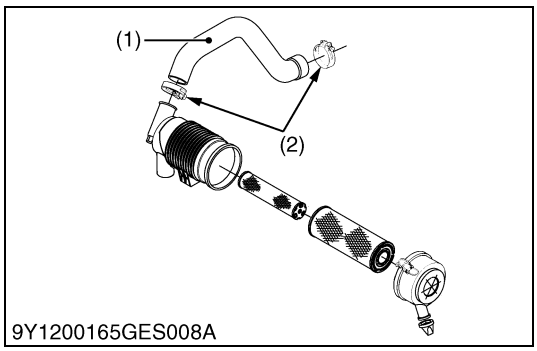

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Check of Intake Air Line

1. Make sure that the intake air hose(s) (1) connections are correct for every 250 hours of operation.
2. If the clamp (2) is loose, apply oil to the threads and tighten it again correctly.
3. You must replace the intake air hose(s) every 2 years. Also replace the clamp every 2 years and tighten it correctly.

■ **IMPORTANT**

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

(1) Intake Air Hose (2) Clamp

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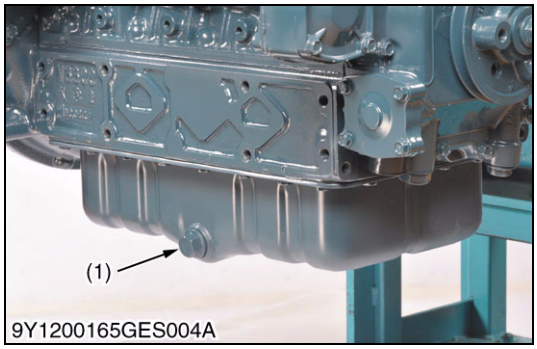
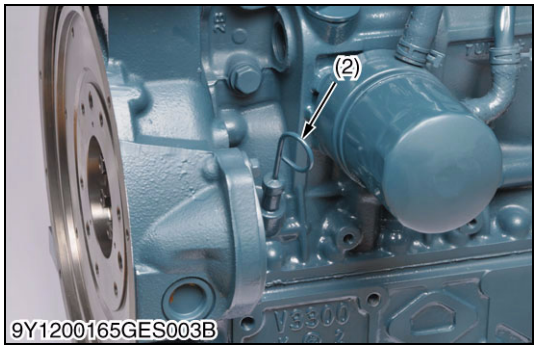
[5] EVERY 500 HOURS





Change of Engine Oil

CAUTION

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

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 oil fully.
4. Tighten the drain plug (1).
5. Fill new oil until the upper line on the dipstick (2).

IMPORTANT

- **When you use an oil of different brand or viscosity from the previous, drain the remaining oil.**
- **Do not mix 2 different types of oil.**
- **Engine oil must have the properties of API classification CJ-4. Use the correct SAE Engine Oil by reference to the ambient temperature.**

Above 25 °C (77 °F)	SAE 30 or SAE 10W-30, SAE 15W-40
0 °C to 25 °C (32 °F to 77 °F)	SAE 20 or SAE 10W-30, SAE 15W-40
Below 0 °C (32 °F)	SAE 10W or SAE 10W-30, SAE 15W-40

Engine oil capacity	13.2 L 3.49 U.S.gals

(1) Drain Plug (2) Dipstick

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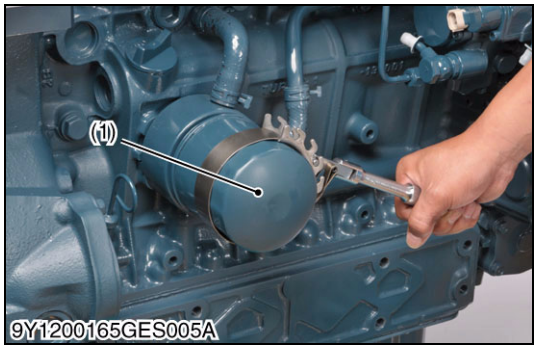

Replacement of Oil Filter Cartridge

CAUTION

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

1. Remove the oil filter cartridge (1) with the filter wrench.
2. Apply a thin layer of oil on the new cartridge gasket.
3. Tighten the new cartridge by hand.
4. After you replace the cartridge, the engine oil usually decrease by a small level. Make sure that the engine oil does not flow through the seal and read the oil level on the dipstick. Fill the engine oil until the specified level.

(1) Oil Filter Cartridge

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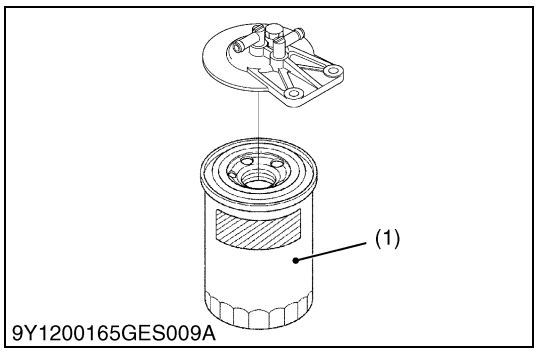

Replacement of Fuel Filter Cartridge

1. Remove the fuel filter cartridge (1) with filter wrench.
2. Apply a thin layer of fuel to the surface of the new filter cartridge gasket before you put it on.
3. Tighten the new cartridge by hand.
4. Open the fuel valve and bleed the fuel system.
5. Operate the engine for a while and check if there is not the fuel leakage from the filter.

(1) Fuel Filter Cartridge

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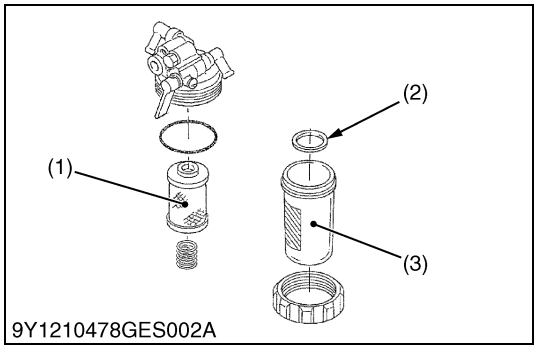

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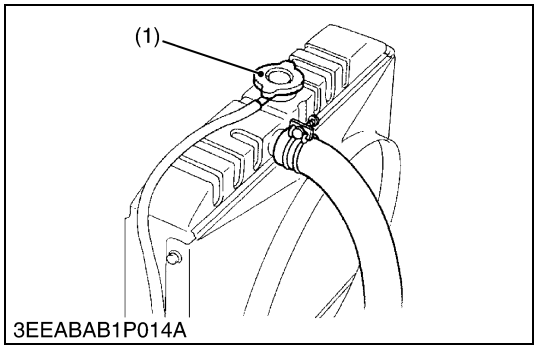

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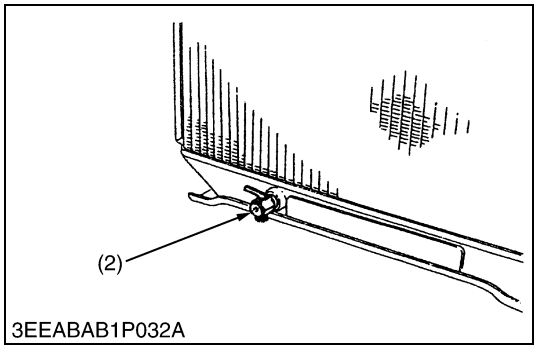

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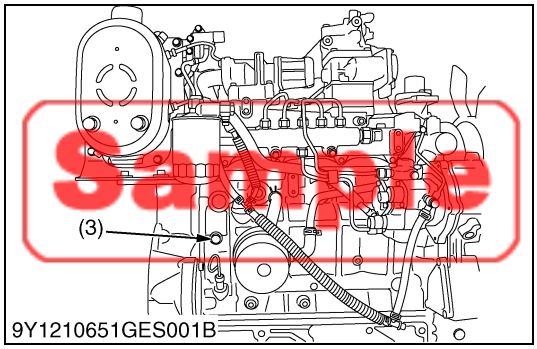

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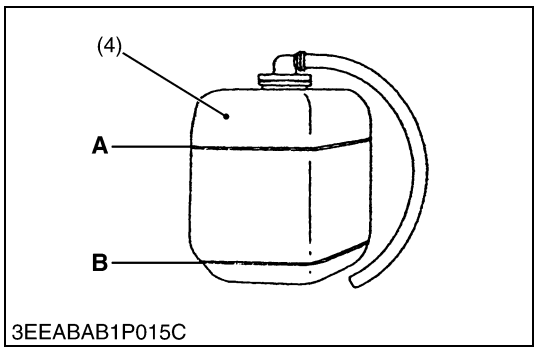

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Cleaning of Water Separator

1. Remove and flush the filter cup (3) if the float (2) goes up with water, or the filter cup (3) has the dust.
2. Flush the element (1) with kerosene to prevent dust to go into the inner element (1).
3. After you replace, bleed the fuel system.

(1) Element
(2) Float
(3) Filter Cup

9Y1210651GEG0024US0

Cleaning of Water Jacket and Radiator Interior

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. Stop the engine and let the coolant temperature decreases.
2. Remove the radiator cap (1) to drain the coolant fully.
3. Open the drain valve (2) and drain plug (3).
4. After you drained all coolant, close the drain valve and plug.
5. Fill with clean water and cooling system cleaner.
6. Obey the directions of the cleaner instruction.
7. After you flush, fill with clean water and anti-freeze until the coolant level is immediately below the port. Install the radiator cap (1) correctly.
8. Fill with the coolant until the "FULL" **A** mark on the recovery tank (4).
9. Start and operate the engine for a few minutes.
10. Stop the engine and let the coolant temperature decreases. Examine the coolant level of radiator and recovery tank (4) and add coolant if necessary.

IMPORTANT

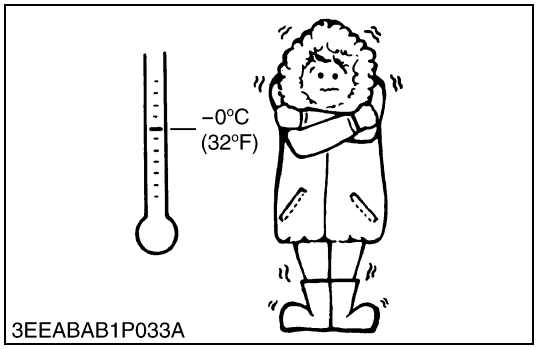
- **Do not start the engine without coolant.**
- **Use clean and soft water with anti-freeze to fill the radiator and recovery tank.**
- **Make sure that when you mix the anti-freeze and water, the ratio of anti-freeze is less than 50 %.**
- **Make sure that you close the radiator cap correctly. If the cap is loose or incorrectly closed, coolant can flow out and the engine can overheat.**

(1) Radiator Cap
(2) Drain Valve
(3) Drain Plug
(4) Recovery Tank

A: FULL
B: LOW

(To be continued)

(Continued)



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■ **Anti-freeze**

- 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 %.**

Vol % Anti-freeze	Freezing Point		Boiling Point*	
	°C	°F	°C	°F
40	−24	−11	106	223
50	−37	−35	108	226

* At 1.01 × 100000 Pa (760 mmHg) pressure (atmospheric). Use a radiator pressure cap that lets the pressure collect in 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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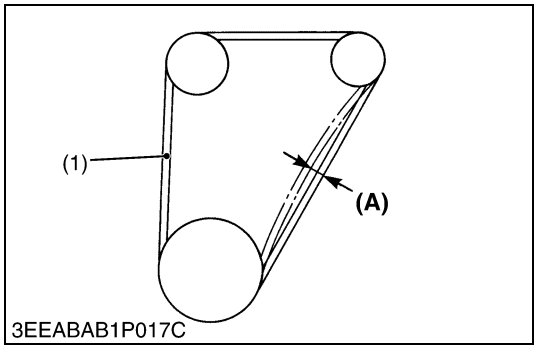

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Replacement of Fan Belt

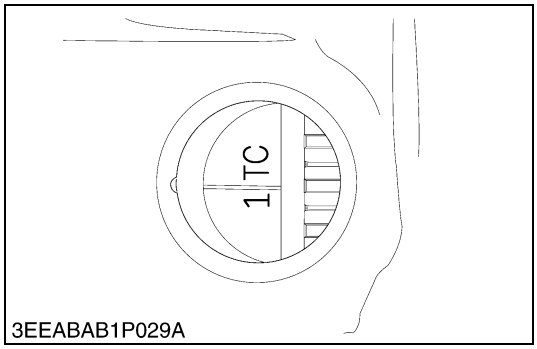
1. Remove the alternator.
2. Remove the fan belt (1).
3. Replace the fan belt with a new one.
4. Install the alternator.
5. Examine the deflection **(A)** of fan belt.

Deflection **(A)**	Factory specification	10 to 12 mm / 98 N 0.40 to 0.47 in. / 98 N (10 kgf, 22 lbf)

(1) Fan Belt **(A) Deflection**

9Y1210651GEG0027US0

[6] EVERY 1000 HOURS



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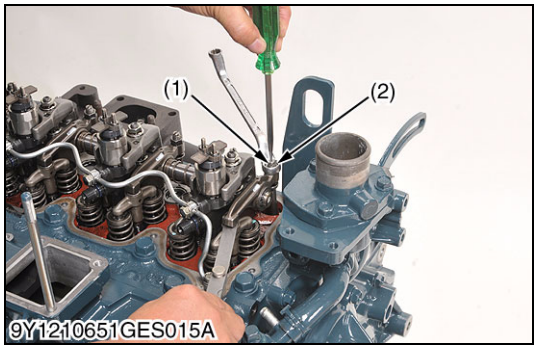

9Y1210651GES015A

Check of Valve Clearance

■ **IMPORTANT**

- **You must examine and adjust the valve clearance when the engine is cold.**

1. Remove the injection pipes and cylinder head cover.
2. Align the "1TC" mark line on the flywheel and projection on the housing. Make sure that the No.1 piston comes to the compression or overlap top dead center.
3. Examine the subsequent valve clearance at the mark "1TC" with a feeler gauge. If the clearance is out of the factory specifications, adjust with the adjusting screw (1) and tighten the lock nut (2) of the adjusting screw.

Valve Clearance	Factory specification	0.23 to 0.27 mm 0.0091 to 0.010 in.

■ **NOTE**

- **After you adjust the valve clearance, tighten the lock nut (2) of the adjusting screw.**

Adjustable Cylinder Location of Piston		IN.	EX.
When No. 1 piston is at compression top dead center	1	☆	☆
	2	☆	
	3		☆
	4		
When No. 1 piston is at overlap position	1		
	2		☆
	3	☆	
	4	☆	☆

Tightening Torque	Injector clamp nut	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft
	Overflow pine joint screw (M6 × 1.0)	9.81 to 11.2 N·m 1.00 to 1.15 kgf·m 7.24 to 8.31 lbf·ft
	Cylinder head cover 1 screw	6.87 to 11.2 N·m 0.700 to 1.15 kgf·m 5.07 to 8.31 lbf·ft
	Cylinder head cover 2 screw	9.81 to 11.2 N·m 1.00 to 1.15 kgf·m 7.24 to 8.31 lbf·ft
	Injection pipe retaining nut	23 to 36 N·m 2.3 to 3.7 kgf·m 17 to 26 lbf·ft

(1) Adjusting Screw (2) Lock Nut

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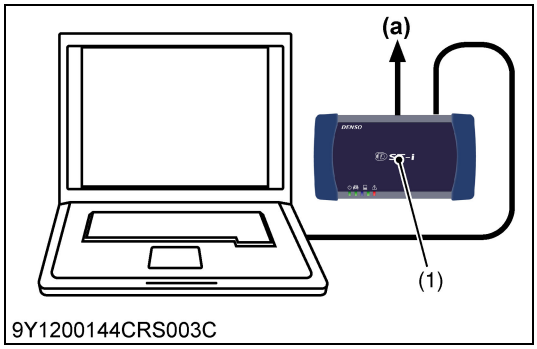
[7] EVERY 1500 HOURS



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Check of Injector

1. Connect the diagnosis tool.
2. Stop the injector for each cylinder using active testing and confirm that the injectors are injecting normally.
   If it is injecting normally, the engine vibration and noise will increase and engine speed will fluctuate when the injector is stopped.
3. If it is determined that there is a failure, check for a plug in the injection pipe.
4. If the injector pipe is normal, this may be an injector failure so replace the injector using the procedure for replacing injectors.

(1) Interface **(a) CAN1 Connector**

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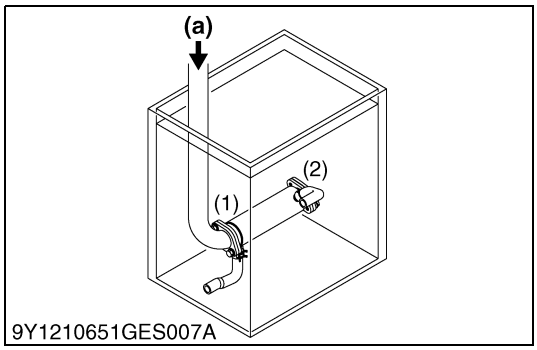
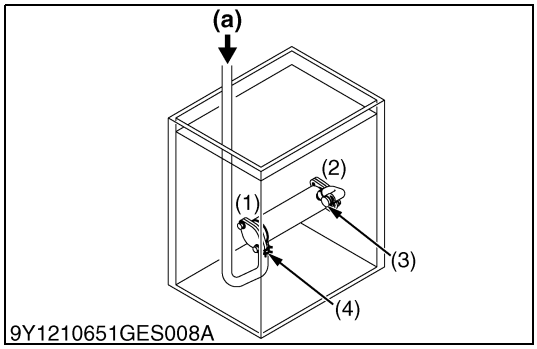




Check of EGR Cooler

(Exhaust gas passage)

1. Block the EGR cooler exhaust gas outlet (2).
2. Attach an air hose to the EGR cooler exhaust gas inlet (1) and then submerge it in a water tank.
3. Check that the coolant passage is full of water.
4. Apply the specified amount of air pressure **(a)** (290 kPa, 3.0 kgf/cm^2, 43 psi) to the air hose side, and check that there are no air leaks in any of the EGR cooler parts.
5. If there are air leaks, replace the EGR cooler.

(Coolant passage)

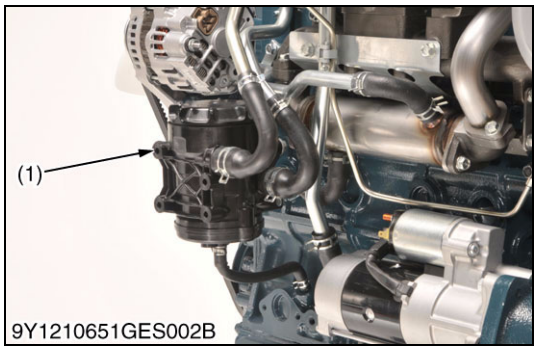
1. Block the EGR cooler exhaust gas inlet (1), EGR cooler exhaust gas outlet (2), and the coolant outlet (3).
2. Attach an air hose to the EGR cooler coolant inlet (4), and then submerge it in a water tank.
3. Apply the specified amount of air pressure **(a)** (250 kPa, 2.5 kgf/cm^2, 36 psi) to the air hose side, and check that there are no air leaks in any of the EGR cooler parts.
4. If there are air leaks, replace the EGR cooler.

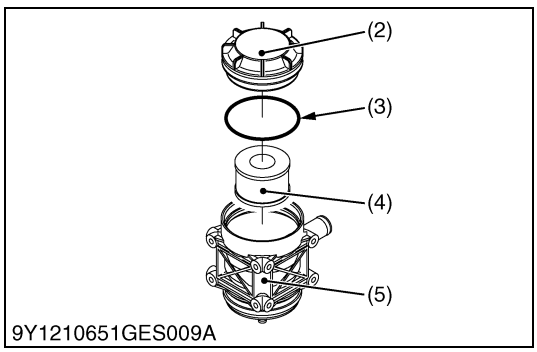
EGR cooler leakage test pressure	Factory specifica-tion	Exhaust gas passage	290 kPa 3.0 kgf/cm^2 43 psi
		Coolant passage	250 kPa 2.5 kgf/cm^2 36 psi

(1) Exhaust Gas Inlet
(2) Exhaust Gas Outlet
(3) Coolant Outlet
(4) Coolant Inlet

(a) Air Pressure

9Y1210651GEG0054US0





Replacement of Oil Separator Element

CAUTION

- **Be sure to stop the engine before replacement the oil separator element.**

1. Remove the cover (2).
2. Remove the oil separator element (4) and O-ring (3).
3. Replace the oil separator element and O-ring with a new one.

(1) Oil Separator
(2) Cover
(3) O-ring
(4) Element
(5) Body

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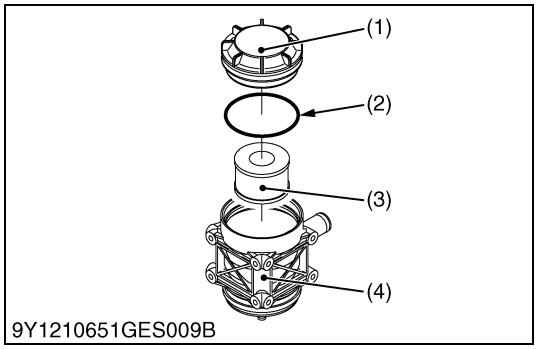

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9Y1210651GES016A

Check of PCV (Positive Crankcase Ventilation) Valve

1. Remove the cover (1) and element (3).
2. Press on the PCV valve and check that it moves smoothly.
3. If it does not move smoothly, replace the oil separator.

(1) Cover
(2) O-ring
(3) Element
(4) Body

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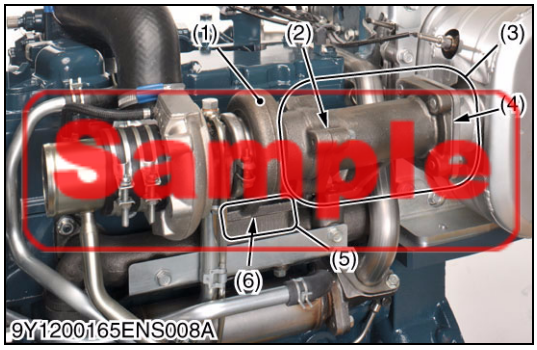
[8] EVERY 3000 HOURS



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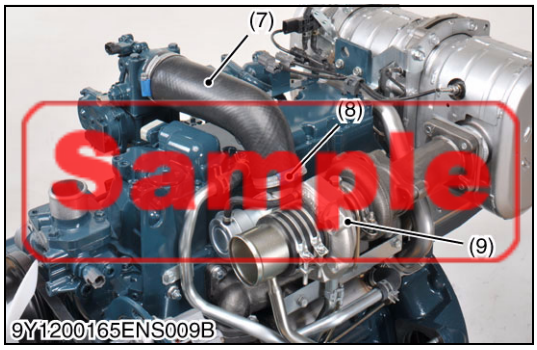

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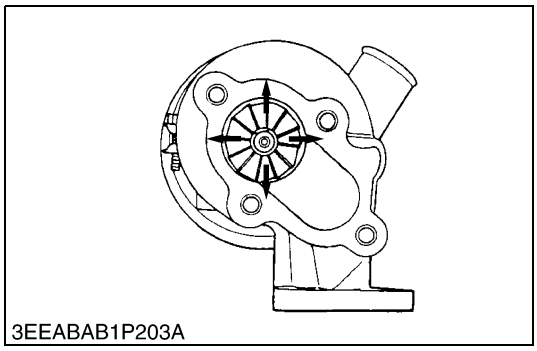
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Check of Turbocharger

(Turbine Side)

1. Examine the exhaust port (3) and the inlet port (5) side of the turbine housing (1) for exhaust gas leakage.
2. If you find a gas leakage, tighten the bolts and nuts again or replace the gasket (2), (4), (6) with a new one.

(Compressor Side)

1. Examine the inlet hose of the compressor cover (9) for air leakage.
2. If you find an air leakage, change the clamp (8) and / or the inlet hoses.
3. Replace the inlet hose (7) and examine the suction side of the intake hose for loose connections or cracks.
4. If you find loose connections or cracks, tighten the clamp or replace the hoses.

(Radial Clearance)

1. If the wheel touches the housing, replace the turbocharger assembly with a new one.

(1) Turbine Housing
(2) Gasket
(3) Exhaust Port
(4) Gasket
(5) Inlet Port
(6) Gasket
(7) Inlet Hose
(8) Clamp
(9) Compressor Cover

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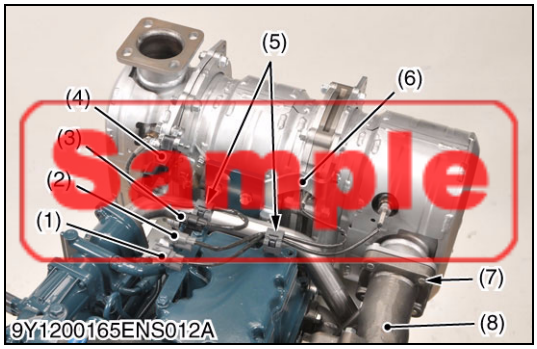
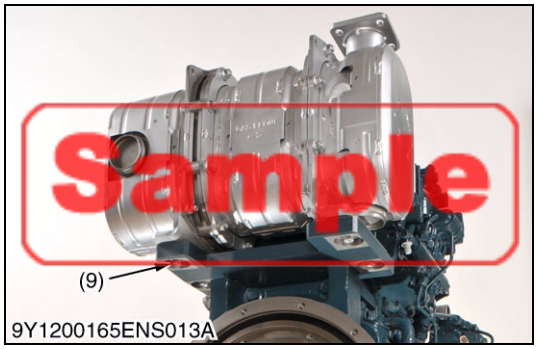
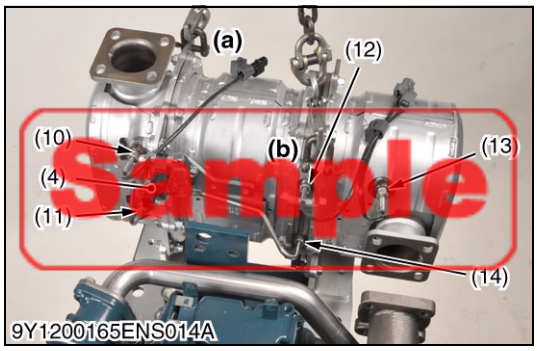
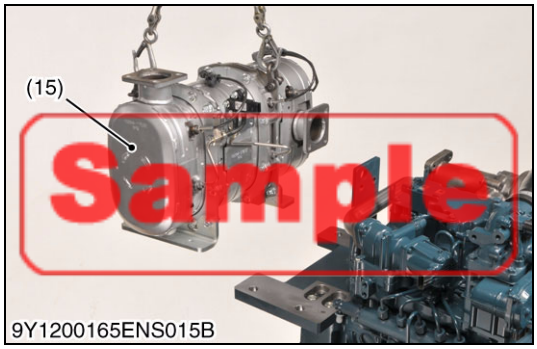
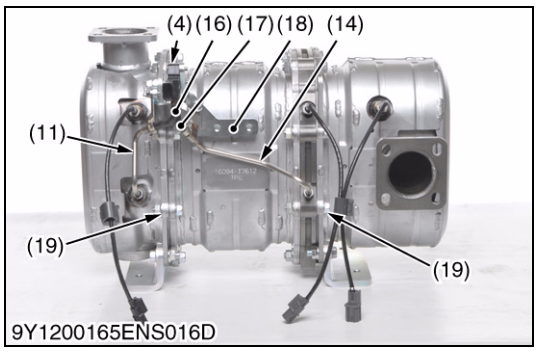










Cleaning of DPF

■ **IMPORTANT**

- **Since the DPF that was dropped or given a shock cannot be reused even if there is no damage outwardly, replace it with a new one.**
- **Be sure to loosen the temperature sensor tightening nut or the differential pressure pipe tightening nut with crowfoot wrench to prevent the damage of the sensor or pipe.**
  If it is still hard to loosen, apply the lubricant spray to threaded portion and soak it with lubricant.

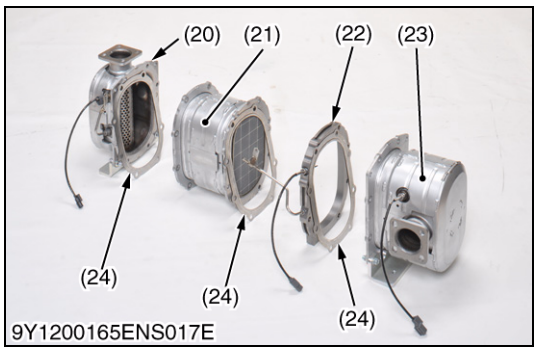
■ **NOTE**

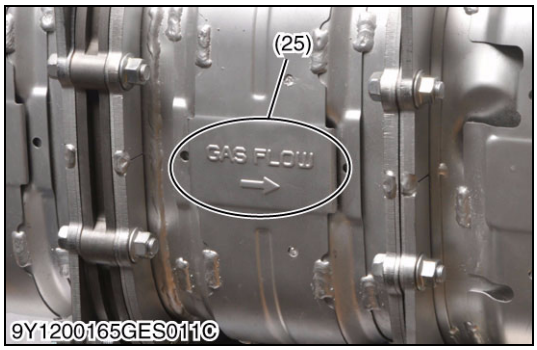
- **Always work in the workshop equipped with a electric hoist (including mobile hoist).**
- **Put a product (engine) on a stable ground, and set the parking brake.**
- **As the DPF muffler full assembly is hot just after the engine shutdown, make sure to start operation after it gets cool.**
- **Make sure not to let any foreign substances enter the opening section during the operation.**
- **Make sure not to damage the DPF muffler full assembly by falling or impact as it contains a ceramic filter.**
- **Before removing the DPF muffler full assembly from a product (engine), connect the diagnosis tool (Diagmaster), check the failure history, and save the project.**
- **Before removing the DPF for cleaning, keep the records of the engine serial number, filter comp (DPF) part number, filter comp (DPF) serial number, catalyst (DOC) part number, catalyst (DOC) serial number, and engine operating time, which are required in preparing the DPF cleaning order form.**
  Since the engine operating time is recorded in the ECU, check the operating time by connecting the service tool (Diagmaster).
- **When installing and removing the muffler full assembly (DPF), make sure that the temperature sensor, differential pressure sensor, and differential pressure pipe do not make contact with surrounding parts.**

1. Disconnect the harness from the connector (1), (2), (3) of temperature sensor and differential pressure sensor (4).
2. Remove the connector (1), (2), (3) of temperature sensor from the bracket.
3. Remove the 2 clamps (5).
4. Remove the DPF stay 1 (6).
5. Remove the 4 screws (7) of muffler flange (8).
6. Remove the muffler full assembly (DPF) mounting screws (9).
7. Set the shackle to the position **(a)**, **(b)** of the muffler full assembly (DPF) (15). (Refer to the photo.)
8. Hoist the muffler full assembly (DPF) (15) and remove the DPF muffler assembly (15).
9. Remove the tube (16), (17) from the differential pressure pipe (11), (14).
10. Remove the differential pressure sensor (4).
11. Remove the DPF stay 2 (18).
12. Loosen the filter comp (DPF) mounting screw (19) and remove the filter comp (DPF) (21).

(To be continued)

(Continued)





(When reassembling)

- Replace the gaskets (24) with new ones.
- If the differential pressure tube is damaged or cracked, replace it.
- When the differential pressure pipe (11), (14) and temperature sensor (10), (12), (13) is removed, wipe off the anti-seize & lubricating compound, apply a anti-seize & lubricating compound (Bostik, NEVER SEEZ, Pure Nickel Special Grade), and then attach them to their correct position.
- When replacing the differential pressure pipe (11), (14), apply a anti-seize & lubricating compound (Bostik, NEVER SEEZ, Pure Nickel Special Grade), and then attach it to its correct position.
- When replacing the temperature sensor, check that it is coated with anti-seize & lubricating compound, and then attach it to its correct position.
- Tighten bolts and nuts to their specified torque. Also tighten the temperature sensor tightening nut or the differential pressure pipe tightening nut to the specified torque with crowfoot wrench.
- After attaching the assembly, start the engine and make sure that there are no gas leaks.
- Reassemble the filter comp (DPF) (21) in the correct direction by referring the mark "GAS FLOW→" (25) (Catalyst (DOC) to Body (DPF Outlet)) on the side showing the flow of exhaust gas.

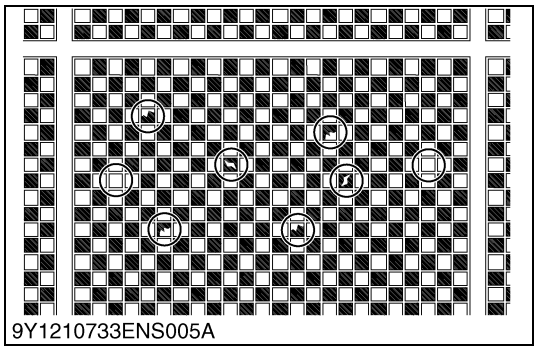
Tightening torque	DPF Stay 1	M8	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft
		M10	49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	DPF Stay 2		49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	Screw of muffler flange		49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	Muffler full assembly (DPF) mounting screw		49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	Filter comp (DPF) mounting screw		49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	Temperature sensor		25 to 34 N·m 2.5 to 3.5 kgf·m 18 to 25 lbf·ft
	Differential pressure pipe		16 to 22 N·m 1.6 to 2.3 kgf·m 12 to 16 lbf·ft

(To be continued)

(Continued)

(1) Connector of Temperature Sensor (T_0)
(2) Connector of Temperature Sensor (T_1)
(3) Connector of Temperature Sensor (T_2)
(4) Differential Pressure Sensor
(5) Clamp
(6) DPF Stay 1
(7) Screw of Muffler Flange
(8) Muffler Flange
(9) Muffler Full Assembly (DPF) Mounting Screw
(10) Temperature Sensor (T_2)
(11) Differential Pressure Pipe
(12) Temperature Sensor (T_1)
(13) Temperature Sensor (T_0)
(14) Differential Pressure Pipe
(15) Muffler Full Assembly (DPF)
(16) Tube
(17) Tube
(18) DPF Stay 2
(19) Filter Comp (DPF) Mounting Screw
(20) Body (DPF Outlet)
(21) Filter Comp (DPF)
(22) Collar (DPF)
(23) Catalyst (DOC)
(24) Gasket
(25) Gas Flow →

9Y1210651GEG0030US0


9Y1210733ENS005A

Judgment of Reuse of Filter Comp (DPF) Before Cleaning (Service Dealer)

■ **IMPORTANT**

- **Before ordering to a cleaning contractor, follow the procedures below to make a Judgment on whether the separated filter comp (DPF) is reusable.**

1. Check to see that the surface of the removed filter comp (DPF) on the exhaust gas outlet side is not darkened.
2. Check whether there is no crack or loss of the sealing part of the cell holes on both ends of the filter (inlet side and outlet side).
   If the number of missing sealing parts more than the allowable limit, the filter comp cannot be reused even after cleaning.

Number for Judgment of non-reusability of filter	Allowable limit	Number of missing sealing parts: 15 or more

3. Check whether there is no crack and loss of the ceramics element.
   If there are any cracks or losses of the ceramics element, the filter comp (DPF) cannot be reused even if it is cleaned.
4. If it is judged that the filter comp (DPF) is not reusable, report the result of the evaluation to the customer that requested the filter cleaning, and replace the filter comp (DPF) with a new one.

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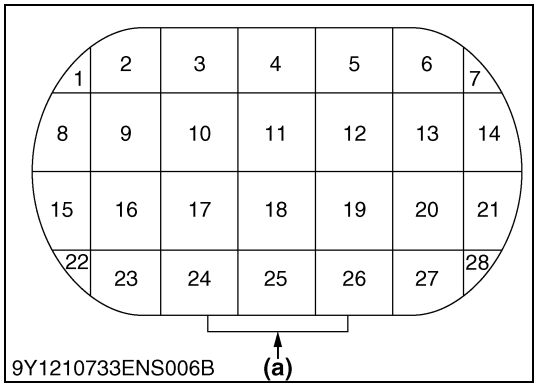

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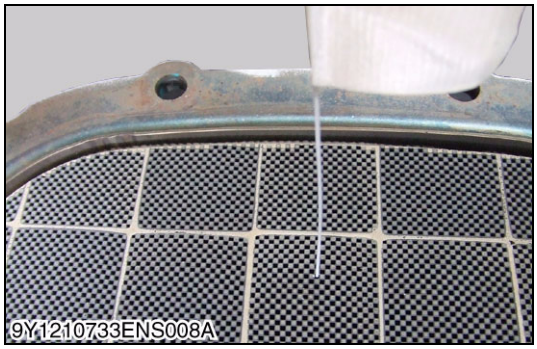
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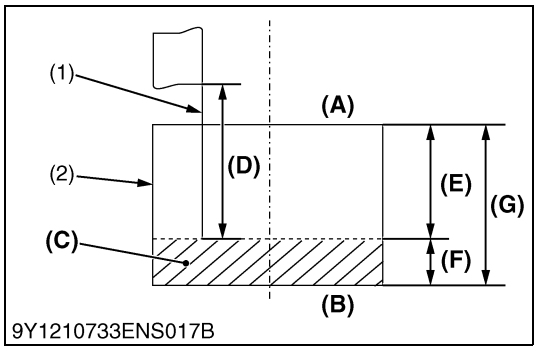


9Y1210733ENS017B

Judgment of Reuse of Filter Comp (DPF) After Cleaning (Cleaning Contractor)

■ **IMPORTANT**

- **After the cleaning contractor has cleaned the filter comp (DPF), measure the quantity of remaining ash in the following procedure, and evaluate the reusability.**

1. After having cleaned the filter comp (DPF), measure the actual cell depth **(E)** with a pin gauge in the each block shown in the figure. One cell (The measurement point is not specified) is measured in each block.

Model	Measurement total
V3800	28 blocks

2. If the actual cell depth (E) is less than the allowable limit, the DPF filter complete cannot be reused.
   If the DPF filter complete is judged as non-reusable, report the result of the judgment to the customer that requested the filter cleaning via the service dealer, and replace the DPF filter complete with a new one.

(Reference)

Actual Cell Depth **(E)** = Cell Depth **(G)** − Accumulated Ash Depth **(F)**

■ **NOTE**

- **Select a metal pin gauge having a wire size slightly thinner than the cell width (0.60 to 0.80 mm dia., 0.024 to 0.031 in. dia.).**
- **When the pin gauge is inserted into the cell hole, insert it by lightly tapping on the gage end with a finger tip.**
- **If the pin gauge is forcibly pushed in, the pin pierces through the accumulated ash and it cannot be measured accurately. So be careful not to push the pin forcibly.**

Actual Cell Depth (Average of all measurement blocks)	Allowable limit	less than 106 mm (less than 4.17 in.)

(1) Pin Gauge (0.60 to 0.80 mm dia., 0.024 to 0.031 in. dia.)
(2) Filter Comp (DPF)

(a) Serial Number

(A) Exhaust Inlet Side
(B) Exhaust Outlet Side
(C) Accumulated Ash
(D) 150 mm (5.91 in.)
(E) Actual Cell Depth
(F) Accumulated Ash Depth
(G) Cell Depth

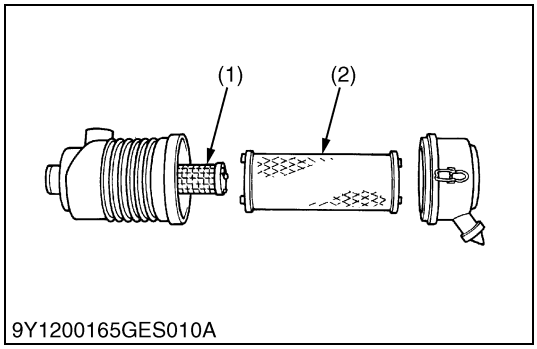
9Y1210651GEG0058US0

Check of EGR System

1. Perform an EGR actuation test.
2. Based on test results, check that the EGR valve gas passage and coolant passage are not clogged.
3. Clean any soot from the gas passage so that it does not damage the EGR valve.
4. Clean the coolant passage by running it with water.

9Y1210651GEG0059US0

[9] EVERY 1 YEAR



9Y1200165GES010A

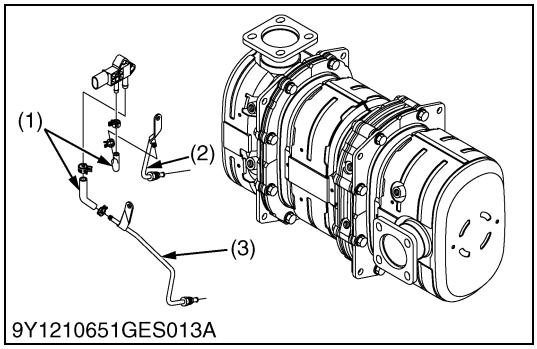
Replacement of Air Cleaner Element

1. Remove used air cleaner primary (2) and secondary (1) element.
2. Replace new air cleaner primary (2) and secondary (1) element.

■ **NOTE**
- **The air cleaner uses a dry element. Never apply oil to it.**
- **Do not run the engine with filter element removed.**

(1) Secondary Element (2) Primary Element

9Y1210651GEG0031US0



9Y1210651GES013A

Check of DPF Differential Pressure Pipes and Hoses

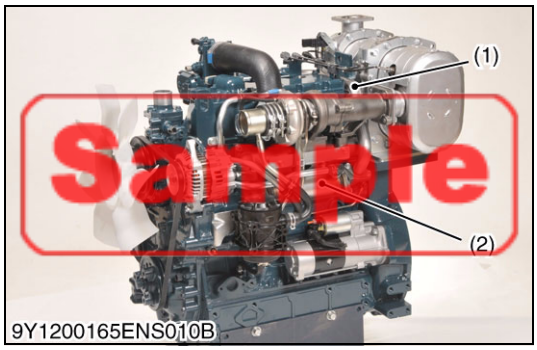
■ **IMPORTANT**
- **Be sure to loosen the differential pressure pipe tightening nut with crowfoot wrench to prevent the damage of the sensor or pipe.**
  If it is still hard to loosen, apply the lubricant spray to threaded portion and soak it with lubricant.
- **Tighten bolts and nuts to their specified torque.**
  Also tighten the differential pressure pipe tightening nut to the specified torque with crowfoot wrench.

1. Examine the DPF differential pressure pipe (2), (3) for crack, gas leakage and loose mounting nut.
2. If you find a crack, change the DPF differential pressure pipe.
3. If you find a gas leakage, remove the DPF differential pressure pipe and wipe off the anti-seize & lubricating compound.
4. Apply the anti-seize & lubricating compound again, then tighten the DPF differential pressure pipe to the specified torque.
5. Examine the DPF differential pressure hose (1) for crack, gas leakage.
6. If you find a crack or gas leakage, change the DPF differential pressure hose.

■ **NOTE**
- **When you change the DPF differential pressure pipe, apply the anti-seize & lubricating compound (Bostik, NEVER-SEEZ, Pure nickel special grade) to the DPF differential pressure pipe.**

(1) DPF Differential Pressure Hose (3) DPF Differential Pressure Pipe
(2) DPF Differential Pressure Pipe

9Y1210651GEG0060US0



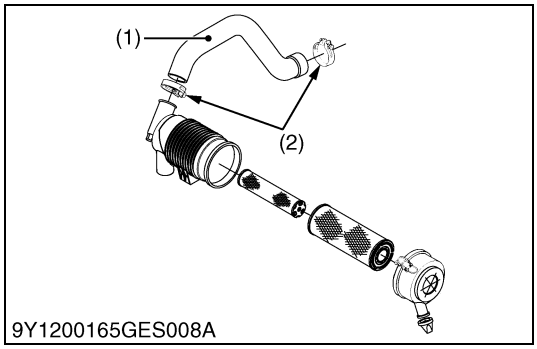
9Y1200165ENS010B

Check of EGR Piping

1. Examine the EGR cooler (2) and the EGR pipe (1) for crack, gas leakage and loose mounting screw.
2. If you find a crack, the cracked EGR cooler (2) or the cracked EGR pipe (1).
3. If you find a gas leakage, tighten the mounting screw again or replace the gasket with a new one.
4. If you find a loose mounting screw, tighten the mounting screw again.

(1) EGR Pipe (2) EGR Cooler

9Y1210682GEG0009US0



Check of Intake Air Line

1. Make sure that the intake air hose(s) (1) connections are correct for every year of operation.
2. If the clamp (2) is loose, apply oil to the threads and tighten it again correctly.
3. You must replace the intake air hose(s) every 2 years. Also replace the clamp every 2 years and tighten it correctly.

■ **IMPORTANT**

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

(1) Intake Air Hose (2) Clamp

9Y1210651GEG0032US0

Check of Exhaust Manifold

1. Examine the exhaust manifold for crack, exhaust gas leakage and loose mounting screw.
2. If you find a crack, change the exhaust manifold.
3. If you find a gas leakage, tighten the mounting screw again or replace the gasket with a new one.
4. If you find a loose mounting screw, tighten the mounting screw again.

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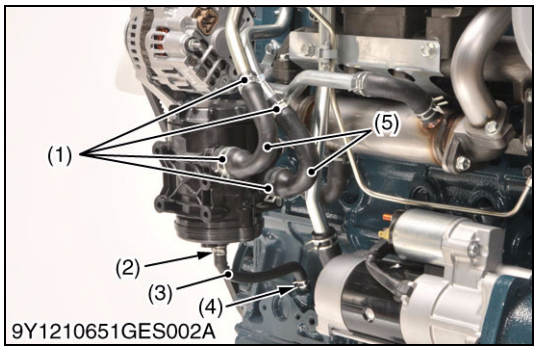
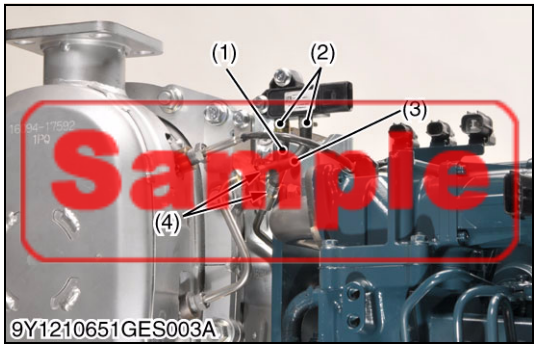
[10] EVERY 2 YEARS





Replacement of Oil Separator Rubber Hose

1. Loosen the clamp (1), (2), (4) and remove the rubber hose (3), (5).
2. Replace the rubber hose (3), (5) and clamp (1), (2), (4) with new ones.
3. Tighten the clamp correctly.

(1) Clamp
(2) Clamp
(3) Rubber Hose
(4) Clamp
(5) Rubber Hose

9Y1210651GEG0062US0

Replacement of Rubber Hose of DPF Differential Pressure Sensor

1. Loosen the clamp (2), (4) and remove the rubber hose (1), (3).
2. Replace the rubber hose (1), (3) and clamp (2), (4) with new ones.
3. Tighten the clamp correctly.

(1) Rubber Hose
(2) Clamp
(3) Rubber Hose
(4) Clamp

9Y1210651GEG0063US0

Replacement of Intake Hose (After Air Flow Sensor) and Inter Cooler Hose

1. Loosen the clamp and remove the hose.
2. Replace the hose and clamp with new ones.
3. Tighten the clamp correctly.

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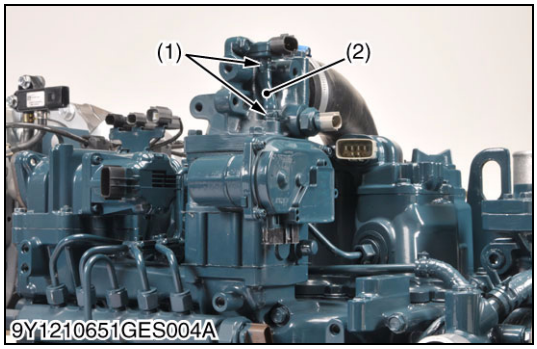

Replacement of Pressure Detection Hose of Boost Sensor

1. Loosen the clamp (1) and remove the hose (2).
2. Replace the hose (2) and clamp (1) with new ones.
3. Tighten the clamp correctly.

(1) Clamp
(2) Hose

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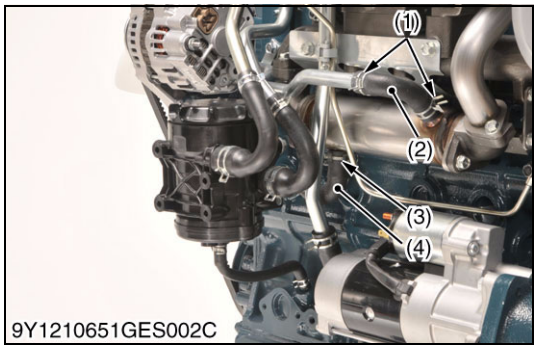

Replacement of EGR Cooler Hose

1. Loosen the clamp (1), (3) and remove the hose (2), (4).
2. Replace the hose (2), (4) with new ones.
3. Tighten the clamp correctly.

(1) Clamp
(2) Hose
(3) Clamp
(4) Hose

9Y1210651GEG0066US0

Replacement of Water Hose

1. Loosen the clamp and remove the hose.
2. Replace the hose with new ones.
3. Tighten the clamp correctly.

9Y1210651GEG0067US0

Replacement of Lubricant Hose

1. Loosen the clamp and remove the hose.
2. Replace the hose with new ones.
3. Tighten the clamp correctly.

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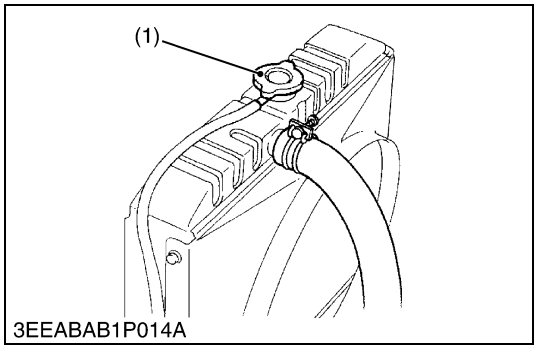

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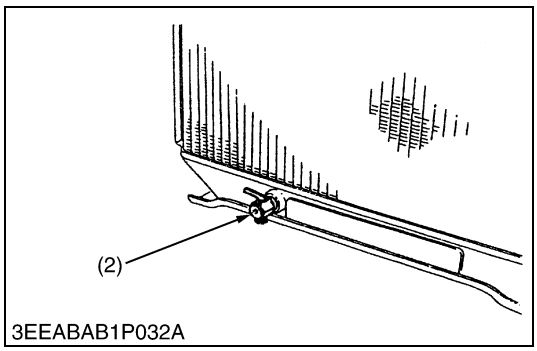

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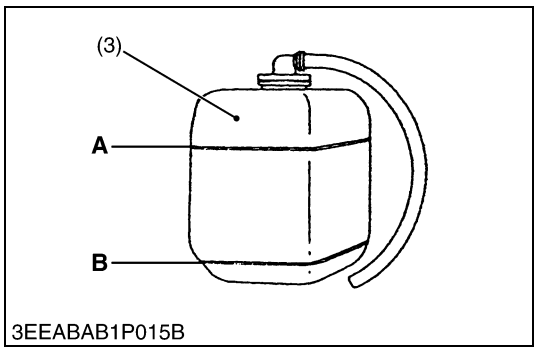

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Change of Radiator Coolant (L.L.C.)

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. Stop the engine and let the coolant temperature decreases.
2. Remove the radiator cap (1) to drain the coolant fully. Open the drain valve (2) and drain plug.
3. After you drained all coolant, close the drain valve (2) and drain plug.
4. Fill with the coolant until the "FULL" **A** mark on the recovery tank (3).
5. Start and operate the engine for a few minutes.
6. Stop the engine and let the coolant temperature decreases. Examine the coolant level of radiator and recovery tank (3) and add coolant if necessary.

■ **IMPORTANT**

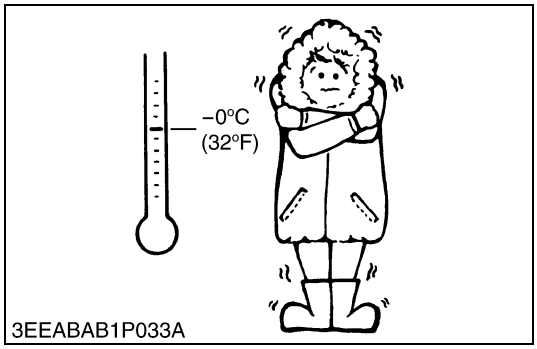
- **Do not start the engine without coolant.**
- **Use clean and soft water with anti-freeze to fill the radiator and recovery tank.**
- **Make sure that when you mix the anti-freeze and water, the ratio of anti-freeze is less than 50 %.**
- **Make sure that you close the radiator cap correctly. If the cap is loose or incorrectly closed, coolant can flow out and the engine can overheat.**

(1) Radiator Cap
(2) Drain Valve
(3) Recovery Tank

A: FULL
B: LOW

(To be continued)

(Continued)



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■ **Anti-freeze**

- 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 %.**

Vol % Anti-freeze	Freezing Point		Boiling Point*	
	°C	°F	°C	°F
40	−24	−11	106	223
50	−37	−35	108	226

* At 1.01 × 100000 Pa (760 mmHg) pressure (atmospheric). Use a radiator pressure cap that lets the pressure collect in 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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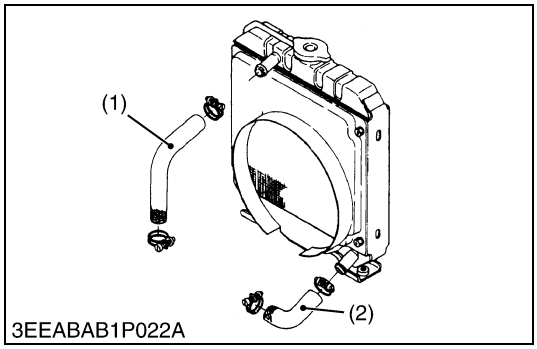

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Replacement of Radiator Hoses and Clamp Bands

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

(1) Upper Hose (2) Lower Hose

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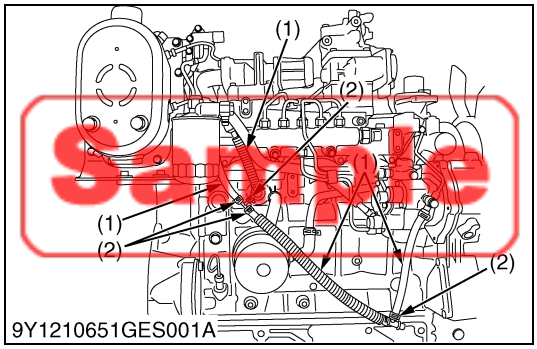
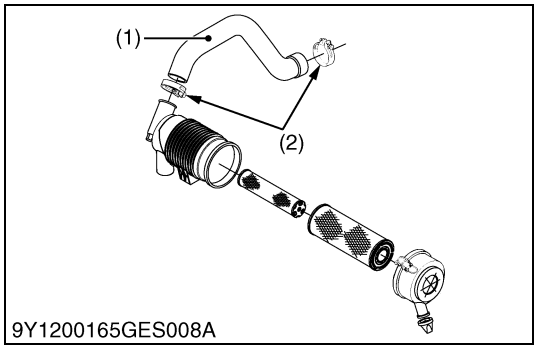




Replacement of Fuel Hoses and Clamps

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

(1) Fuel Hose (2) Clamp

9Y1210682GEG0010US0

Replacement of Intake Air Line

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

■ **IMPORTANT**

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

(1) Intake Air Hose (2) Clamp

9Y1210651GEG0037US0

6. SPECIAL TOOLS

Diesel Engine Compression Tester

Code No.

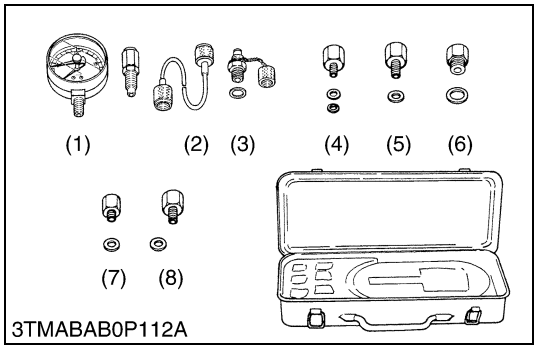
- 07909-30208 (Assembly)

Application

- To measure the diesel engine compression and to make a decision for a large overhaul if necessary.

(1) Gauge

9Y1210651GEG0038US0



Oil Pressure Tester

Code No.

- 07916-32032

Application

- To measure the engine oil pressure.

(1) Gauge
(2) Cable
(3) Threaded Joint
(4) Adaptor **1**
(5) Adaptor **2**
(6) Adaptor **3**
(7) Adaptor **4**
(8) Adaptor **5**

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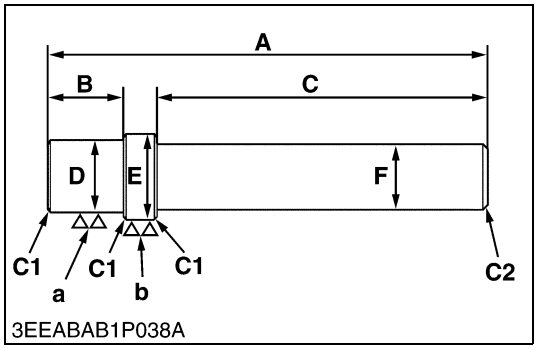

Small End Bushing Replacing Tool

Application

- To press out and press fit the bushing.

■ **NOTE**

- **These special tools are not provided, so make it referring to the figure.**

[Press out]

A	157 mm (6.18 in.)
B	14.5 mm (0.571 in.)
C	120 mm (4.72 in.)
D	30.0 mm dia. (1.18 in. dia.)
E	32.95 mm dia. (1.297 in. dia.)
F	20 mm dia. (0.79 in. dia.)
a	6.3 µm (250 µin.)
b	6.3 µm (250 µin.)
C1	Chamfer 1.0 mm (0.039 in.)
C2	Chamfer 2.0 mm (0.079 in.)

[Press fit]

A	157 mm (6.18 in.)
B	14.5 mm (0.571 in.)
C	120 mm (4.72 in.)
D	30.0 mm dia. (1.18 in. dia.)
E	42.000 mm dia. (1.6535 in. dia.)
F	20 mm dia. (0.79 in. dia.)
a	6.3 µm (250 µin.)
b	6.3 µm (250 µin.)
C1	Chamfer 1.0 mm (0.039 in.)
C2	Chamfer 2.0 mm (0.079 in.)

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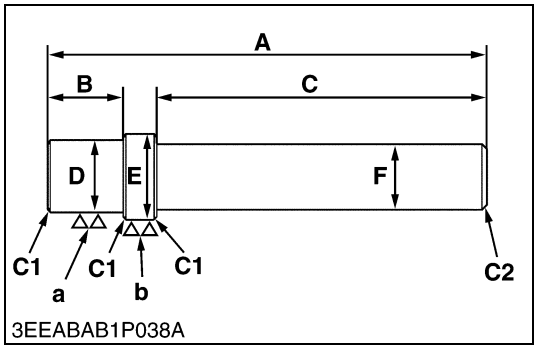

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Idle Gear Bushing Replacing Tool

Application

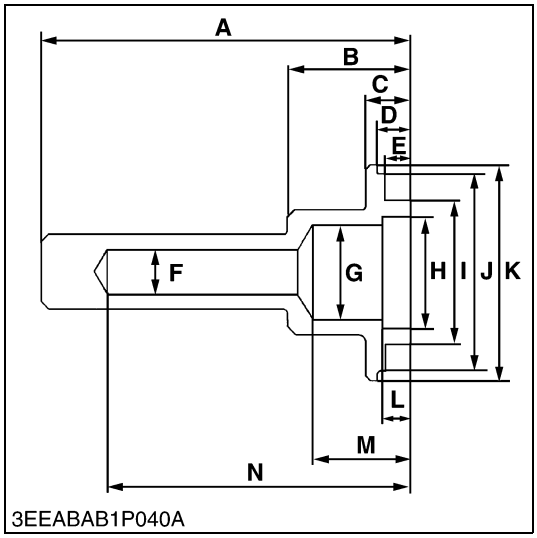
- To press out and press fit the bushing.

■ **NOTE**

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

A	196 mm (7.72 in.)
B	37.5 mm (1.48 in.)
C	150 mm (5.91 in.)
D	44.95 mm dia. (1.770 in. dia.)
E	48.075 to 48.100 mm dia. (1.8928 to 1.8937 in. dia.)
F	20 mm dia. (0.79 in. dia.)
a	6.3 µm (250 µin.)
b	6.3 µm (250 µin.)
C1	Chamfer 1.0 mm (0.039 in.)
C2	Chamfer 2.0 mm (0.079 in.)

9Y1210651GEG0041US0



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Gear Case Oil Seal Press Fit Tool

Application

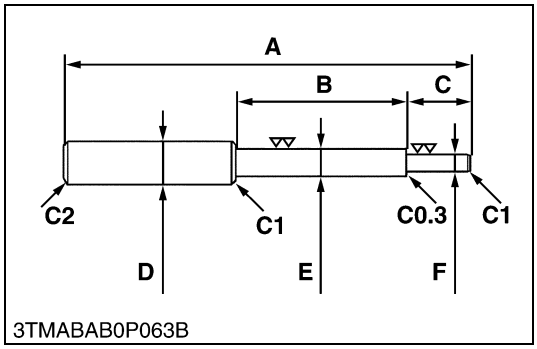
- To press fit the oil seal.

■ **NOTE**

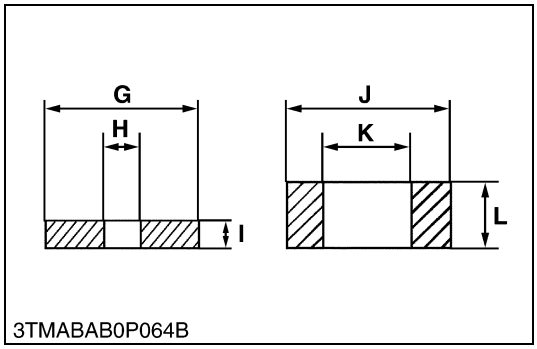
- **This special tool is not provided, so make it referring to the figure.**

A	148.8 mm (5.858 in.)
B	50 mm (2.0 in.)
C	18.8 mm (0.740 in.)
D	13.7 to 13.9 mm (0.540 to 0.547 in.)
E	11 mm (0.43 in.)
F	18 mm dia. (0.71 in. dia.)
G	38 mm dia. (1.5 in. dia.)
H	45 mm dia. (1.8 in. dia.)
I	57.90 to 58.10 mm dia. (2.280 to 2.287 in. dia.)
J	79.5 mm dia. (3.13 in. dia.)
K	87 mm dia. (3.4 in. dia.)
L	12 mm (0.47 in.)
M	40 mm (1.6 in.)
N	120 mm (4.72 in.)

9Y1210651GEG0042US0



3TMABAB0P063B



3TMABAB0P064B

Valve Guide Replacing Tool

Application

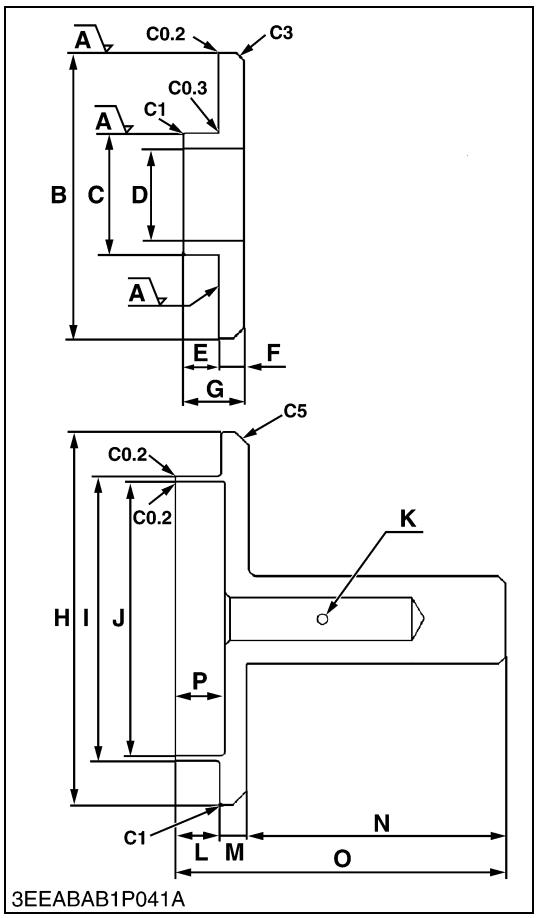
- To press out and press fit the valve guide.

■ **NOTE**

- **These special tools are not provided, so make it referring to the figure.**

A	225 mm (8.86 in.)
B	70 mm (2.8 in.)
C	45 mm (1.8 in.)
D	20 mm dia. (0.79 in dia.)
E	11.7 to 11.9 mm dia. (0.461 to 0.468 in. dia.)
F	6.50 to 6.60 mm dia. (0.256 to 0.259 in. dia.)
G	25 mm dia. (0.98 in. dia.)
H	6.70 to 7.00 mm dia. (0.264 to 0.275 in. dia.)
I	5 mm (0.2 in.)
J	20 mm dia. (0.79 in. dia.)
K	12.5 to 12.8 mm dia. (0.493 to 0.503 in. dia.)
L	7.90 to 8.10 mm (0.311 to 0.318 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.)

9Y1210651GEG0043US0



3EEABAB1P041A

Crankshaft Sleeve Press Fit Tool

Application

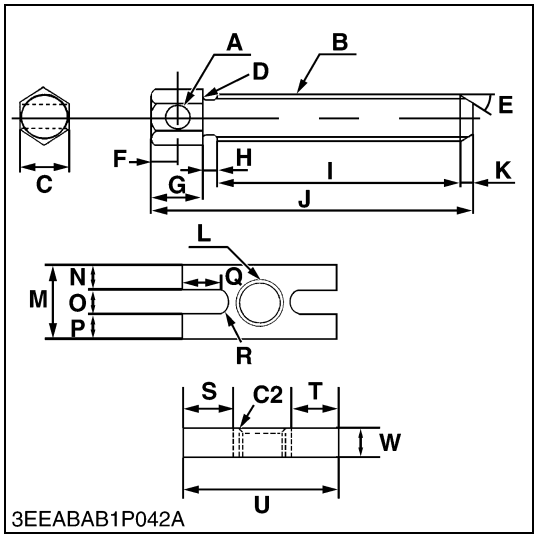
- To press fit the crankshaft sleeve.

■ **NOTE**

- **These special tools are not provided, so make it referring to the figure.**

A	Rmax = 12.5 S
B	94.5 to 95.0 mm dia. (3.72 to 3.74 in. dia.)
C	40 mm dia. (1.6 in. dia.)
D	30 mm dia. (1.2 in. dia.)
E	12 mm (0.47 in.)
F	7.90 to 8.10 mm (0.311 to 0.318 in.)
G	20 mm (0.79 in.)
H	130 mm dia. (5.12 in. dia.)
I	99.40 to 99.60 mm dia. (3.914 to 3.921 in. dia.)
J	95.05 to 95.20 mm dia. (3.743 to 3.748 in. dia.)
K	3 mm dia. (0.1 in. dia.)
L	15 mm (0.59 in.)
M	10 mm (0.39 in.)
N	90 mm (3.5 in.)
O	115 mm (4.53 in.)
P	16.9 to 17.1 mm (0.666 to 0.673 in.)
C1	Chamfer 1.0 mm (0.039 in.)
C3	Chamfer 3.0 mm (0.12 in.)
C5	Chamfer 5.0 mm (0.20 in.)
C0.2	Chamfer 0.2 mm (0.008 in.)
C0.3	Chamfer 0.3 mm (0.01 in.)

9Y1210651GEG0044US0



3EEABAB1P042A

Injection Pump Gear Puller

Application

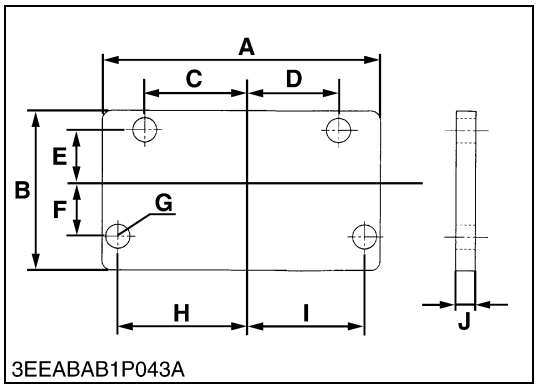
- To remove the injection pump gear.

■ **NOTE**

- **These special tools are not provided, so make it referring to the figure.**

A	10 mm dia. (0.39 in. dia.)
B	M16 × Pitch 1.5
C	19 mm (0.75 in.)
D	0.5 mm radius (0.02 in. radius)
E	0.87 rad (50 °)
F	10 mm (0.39 in.)
G	20 mm (0.79 in.)
H	5 mm (0.2 in.)
I	95 mm (3.7 in.)
J	125 mm (4.92 in.)
K	5 mm (0.2 in.)
L	M16 × Pitch 1.5
M	30 mm (1.2 in.)
N	9.5 mm (0.37 in.)
O	11 mm (0.43 in.)
P	9.5 mm (0.37 in.)
Q	14.5 mm (0.571 in.)
R	5.5 mm radius (0.22 in. radius)
S	20 mm (0.79 in.)
T	20 mm (0.79 in.)
U	80 mm (3.1 in.)
W	12 mm (0.47 in.)
C2	Chamfer 2.0 mm (0.079 in.)

9Y1210651GEG0045US0



3EEABAB1P043A

Flywheel Stopper

Application

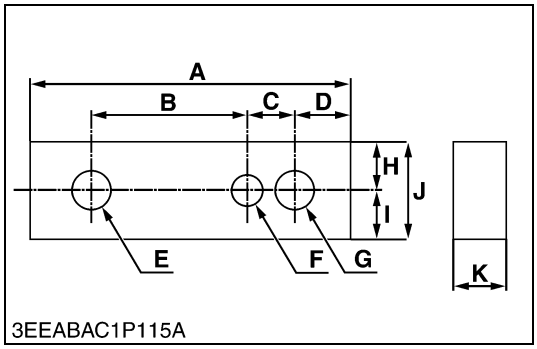
- To loosen and tighten the flywheel screw.

■ **NOTE**

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

A	140 mm (5.51 in.)
B	80 mm (3.1 in.)
C	49.3 mm (1.94 in.)
D	49.3 mm (1.94 in.)
E	23.8 mm (0.937 in.)
F	23.8 mm (0.937 in.)
G	11 mm dia. (0.43 in. dia.)
H	56.5 mm (2.22 in.)
I	56.5 mm (2.22 in.)
J	8 mm (0.3 in.)

9Y1210651GEG0046US0



3EEABAC1P115A

Crankcase 1 and 2 Aligning Tool

Application

- To aligning the crankcase 1 and 2.

■ **NOTE**

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

A	115 mm (4.53 in.)
B	56 mm (2.2 in.)
C	17 mm (0.67 in.)
D	20 mm (0.79 in.)
E	14 mm dia. (0.55 in. dia.)
F	11 mm dia. (0.43 in. dia.)
G	14 mm dia. (0.55 in. dia.)
H	17.5 mm (0.689 in.)
I	17.5 mm (0.689 in.)
J	35 mm (1.4 in.)
K	19 mm (0.75 in.)

9Y1210651GEG0047US0

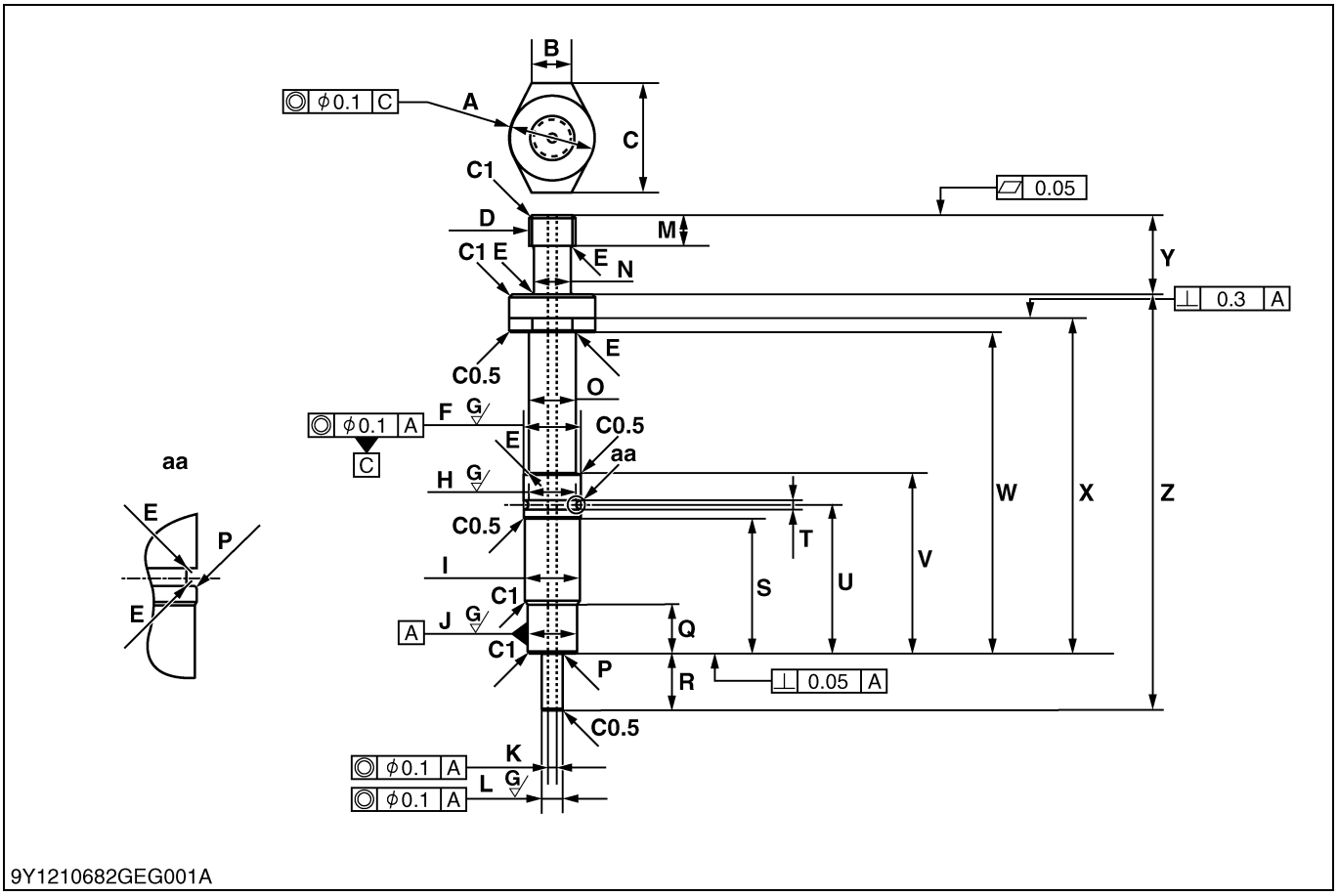
Compression Tester Adaptor

Application

- To measure the diesel engine compression and to make a decision for a large overhaul if necessary.

■ **NOTE**

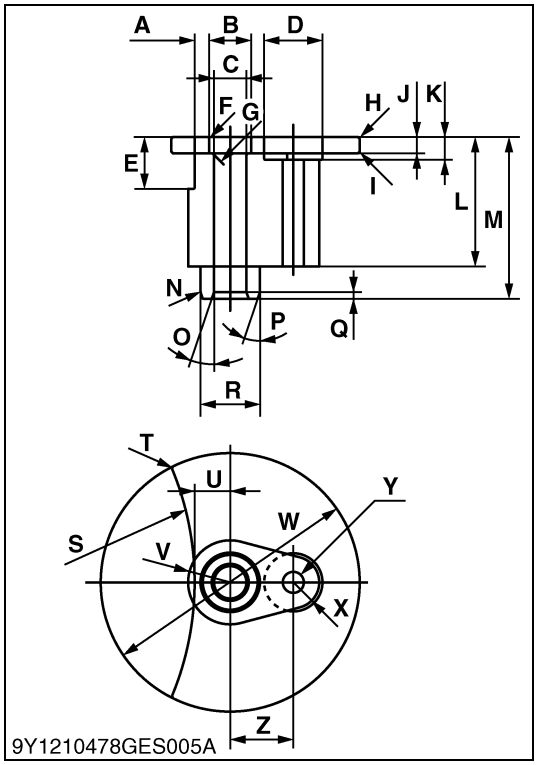
- **These special tools are not provided, so make it referring to the figure.**



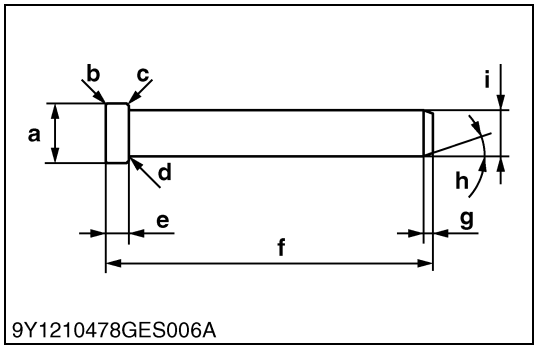
9Y1210682GEG001A

A	29.80 to 30.00 mm dia. (1.174 to 1.181 in. dia.)	**O**	16 mm dia. (0.63 in. dia.)
B	14 mm (0.55 in.)	**P**	0.4 mm radius (0.02 in. radius)
C	39.2 to 40.2 mm (1.55 to 1.58 in.)	**Q**	18 mm (0.71 in.)
D	5/8-18UNF-2B	**R**	20.4 mm (0.803 in.)
E	0.8 mm radius (0.03 in. radius)	**S**	48.6 mm (1.91 in.)
F	19.84 to 19.95 mm (0.7811 to 0.7854 in.)	**T**	3.20 to 3.45 mm (0.126 to 0.135 in.)
G	Ra = 3.2a	**U**	53.6 mm (2.11 in.)
H	16.14 to 16.20 mm (0.6355 to 0.6377 in.)	**V**	65 mm (2.6 in.)
I	19.08 to 19.20 mm (0.7512 to 0.7559 in.)	**W**	116 mm (4.57 in.)
J	16.89 to 17.00 mm (0.6650 to 0.6692 in.)	**X**	120.7 to 121.3 mm (4.752 to 4.775 in.)
K	3.0 mm dia. (0.12 in. dia.)	**Y**	28.5 mm (1.12 in.)
L	7.10 to 7.20 mm (0.280 to 0.283 in.)	**Z**	150 mm (5.91 in.)
M	11 mm (0.43 in.)	**C0.5**	Chamfer 0.5 mm (0.02 in.)
N	13 mm dia. (0.51 in. dia.)	**C1**	Chamfer 1.0 mm (0.039 in.)

9Y1210651GEG0048US0



9Y1210478GES005A



9Y1210478GES006A

Air Gap of the Crankshaft Position Sensor Measuring Jig 1

Application

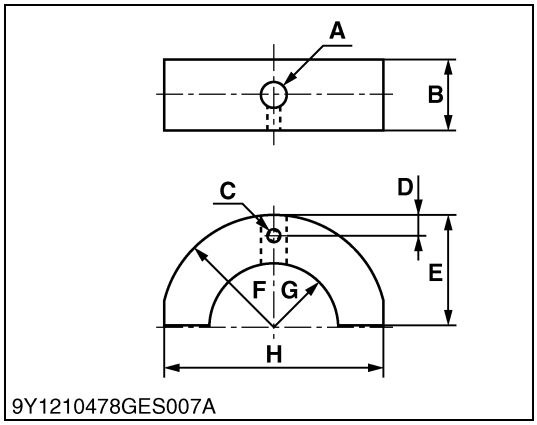
- To measure the air gap of the crankshaft position sensor.

■ **NOTE**

- **These special tools are not provided, so make it referring to the figure.**

A	92 mm radius (3.6 in. radius)
B	13.0 to 13.1 mm dia. (0.512 to 0.515 in. dia.)
C	10.000 to 10.015 mm dia. (0.39370 to 0.39429 in. dia.)
D	18 mm dia. (0.71 in. dia.)
E	16 mm (0.63 in.)
F	Chamfer 0.3 mm (0.01 in.)
G	Chamfer 0.5 mm (0.02 in.)
H	Chamfer 0.5 mm (0.02 in.)
I	Chamfer 0.5 mm (0.02 in.)
J	5.00 to 5.05 mm (0.197 to 0.198 in.)
K	7.0 mm (0.28 in.)
L	39.990 to 40.010 mm (1.5744 to 1.5751 in.)
M	50 mm (2.0 in.)
N	5.0 mm radius (0.20 in. radius)
O	0.35 rad (20 °)
P	0.35 rad (20 °)
Q	2.0 mm (0.079 in.)
R	18.380 to 18.393 mm dia. (0.72363 to 0.72413 in. dia.)
S	92 mm radius (3.6 in. radius)
T	Chamfer 0.5 mm (0.02 in.)
U	11 mm (0.43 in.)
V	13 mm radius (0.51 in. radius)
W	80 mm dia. (3.1 in. dia.)
X	8.0 mm radius (0.31 in. radius)
Y	6.5 mm dia. (0.26 in. dia.)
Z	19.5 mm (0.768 in.)
a	12.8 to 12.9 mm dia. (0.504 to 0.507 in. dia.)
b	Chamfer 0.3 mm (0.01 in.)
c	Chamfer 0.5 mm (0.02 in.)
d	0.4 mm radius (0.02 in. radius)
e	4.95 to 5.00 mm (0.195 to 0.196 in.)
f	70.940 to 70.960 mm (2.7930 to 2.7937 in.)
g	2.0 mm (0.079 in.)
h	0.35 rad (20 °)
i	9.978 to 9.987 mm (0.3929 to 0.3931 in.)

9Y1210651GEG0049US0



9Y1210478GES007A

Air Gap of the Crankshaft Position Sensor Measuring Jig 2

Application

- To measure the air gap of the crankshaft position sensor.

■ **NOTE**

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

A	8.0 mm dia. reamer (0.31 in. dia. reamer)
B	22.0 mm (0.866 in.)
C	M4 x Pitch 0.7
D	6.5 mm (0.26 in.)
E	34.0 mm (1.34 in.)
F	35 mm radius (1.4 in. radius)
G	20 mm radius (0.79 in. radius)
H	68.0 mm (2.68 in.)

9Y1210651GEG0050US0

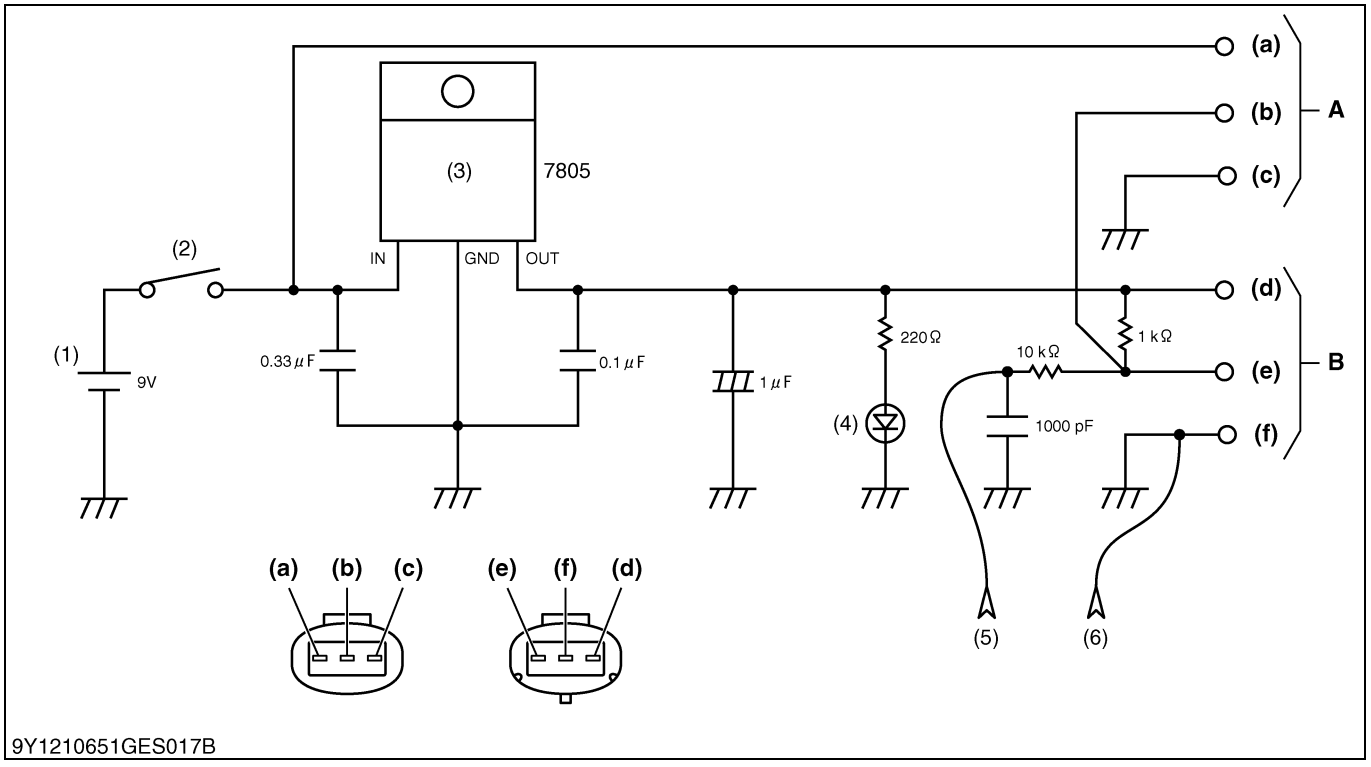
Rotation Sensor Signal Interface Unit

Application

- Use for reading rotatino sensor signal.

■ **NOTE**

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



9Y1210651GES017B

(1) 9V Battery
(2) Switch
(3) 3-Terminal Regulator
(4) LED
(5) Clip (Red)
(6) Clip (Black)

A: for Panasonic
B: for DENSO

(a) +9 V
(b) Signal
(c) GND
(d) +5 V
(e) Signal
(f) GND

9Y1210674GEG0076US0

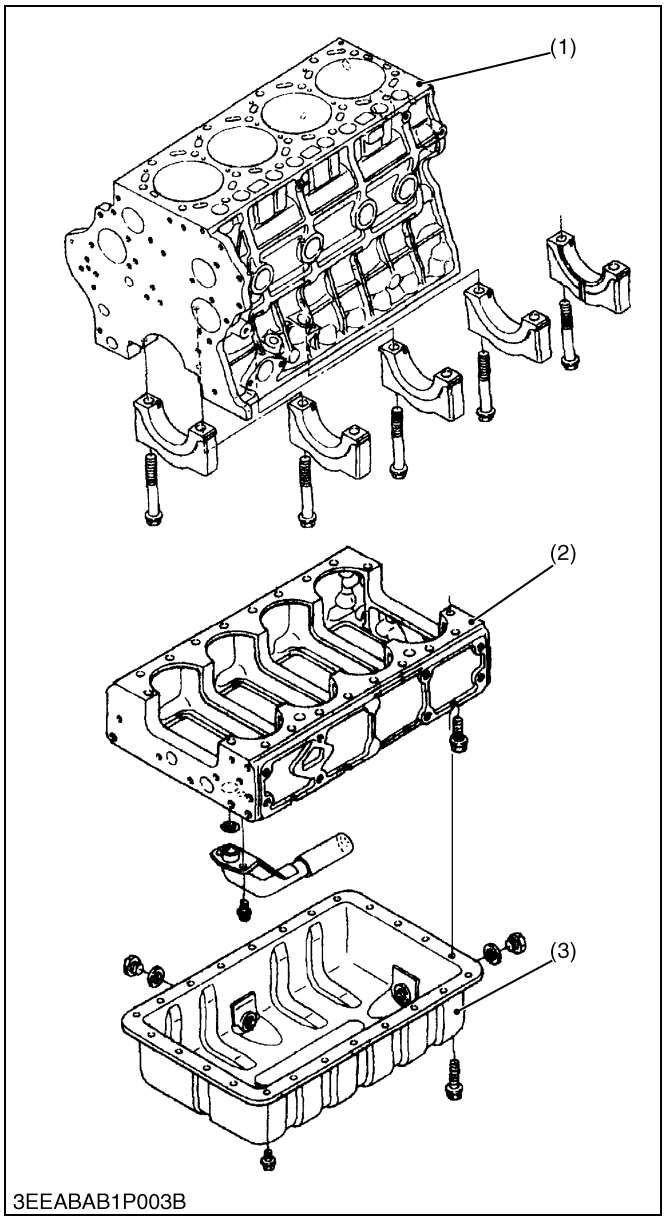
1 ENGINE

MECHANISM

CONTENTS

1. ENGINE

[1] CYLINDER BLOCK



3EEABAB1P003B

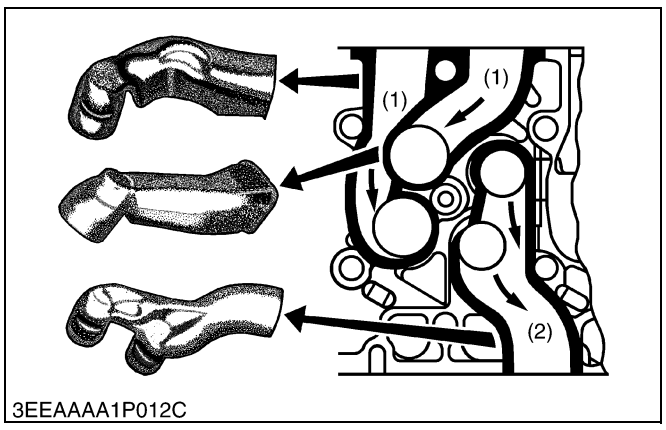
The engine utilizes a split crankcase to produce greater durability and operate more quietly; the crankcase is split into two parts, crankcase 1 (1), which houses the parts for combustion and crankcase 2 (2), which completes crankcase 1 and produces low-noise.

It uses a hanger type of crankshaft support which allows for easy dis/assembly and the lining of the cylinder is a linerless type, which offers good cooling performance and excellent resistance to wear as it is little affected by distortion.

(1) Crankcase 1
(2) Crankcase 2
(3) Oil Pan

9Y1210651ENM0001US0

[2] CYLINDER HEAD



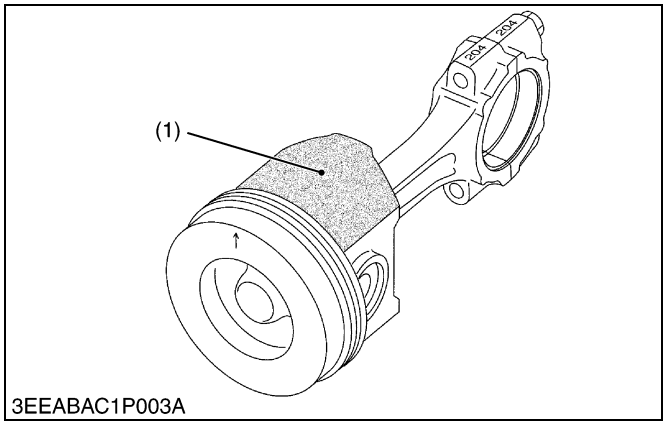
3EEAAAA1P012C

We have improved the helical shaped 2-valve, 2-stage ports in order to generate an ideal swirl and intake air inertia at the intake port and to gain a greater amount of air for the air/fuel mixture.

(1) Intake Port
(2) Exhaust Port

9Y1210651ENM0002US0

[3] PISTON



3EEABAC1P003A

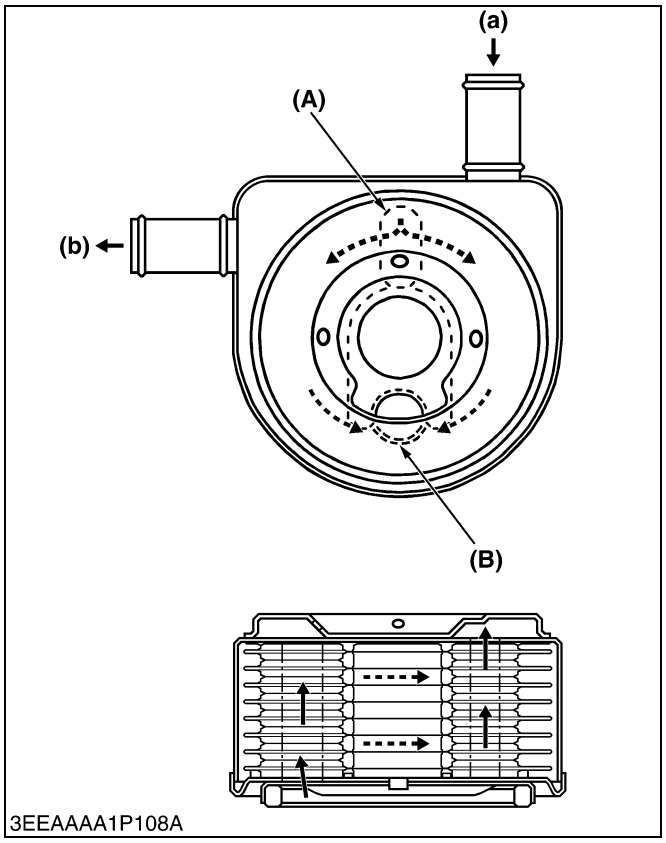
The piston skirt has a disulfide molybdenum coating (1), improving the fit of the piston with the cylinder and preventing scorching.

(1) Molybdenum

9Y1210651ENM0003US0

2. LUBRICATING SYSTEM

[1] OIL COOLER



3EEAAAA1P108A

The engine is equipped with a water-cooled oil cooler to keep the temperature of the oil from rising while the engine is running and provide it with proper lubrication.

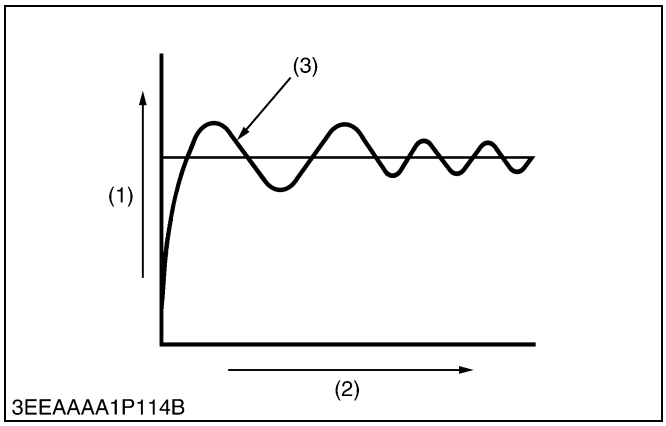
The oil flows on the inside of the cooler plate and is cooled by the coolant flowing on the outside of the plate.

(A) Oil Inlet
(B) Oil Outlet
(a) Coolant Inlet
(b) Coolant Outlet

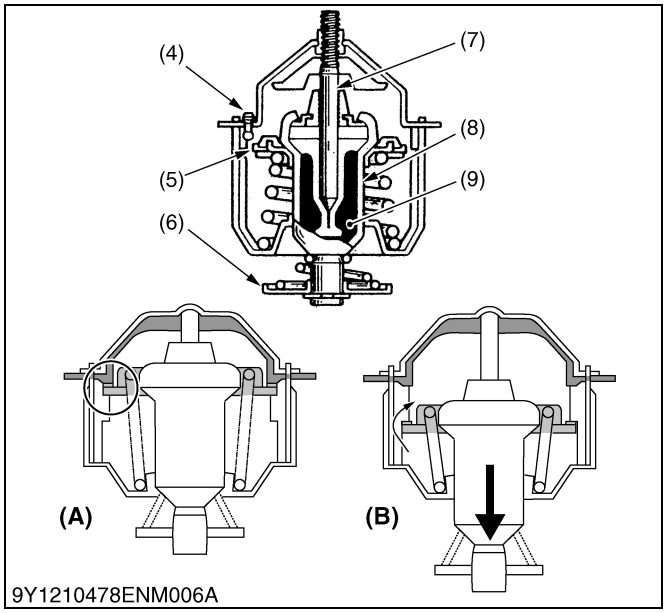
9Y1210651ENM0004US0

3. COOLING SYSTEM

[1] THERMOSTAT



3EEAAAA1P114B



9Y1210478ENM006A

This thermostat uses a wax-pellet type. When temperature goes up, wax in metal container (pellet) changes to a liquid from a solid.

The volume starts to expand in this process. As spindle is fixed, pellet goes down and valve goes down.

There is a jiggle valve on the top depending on the specification.

When you put coolant and thermostat is closed, coolant can not go in easily because air at the engine side can not go out.

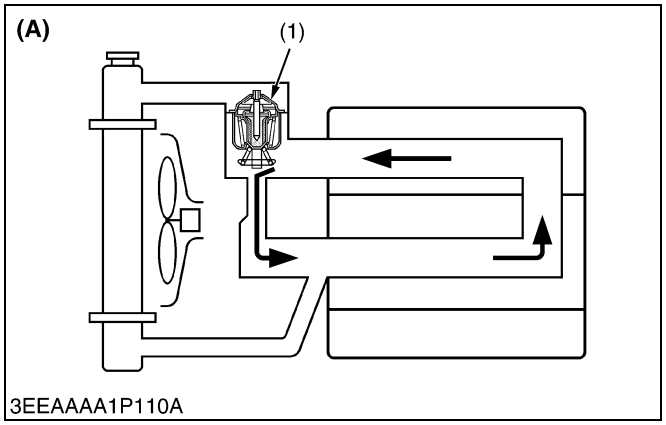
The jiggle valve helps to remove air from this hole, and then coolant can go in easily.

(1) Coolant Temperature
(2) Time
(3) Overshoot
(4) Jiggle Valve
(5) Valve
(6) Bypass Valve
(7) Piston
(8) Pellet
(9) Wax

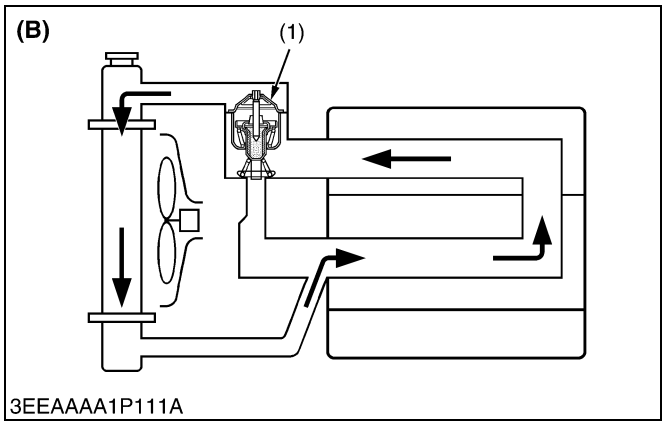
(A) When The Valve is Closed
(B) When The Valve is Opened

9Y1210651ENM0005US0

[2] BOTTOM BYPASS SYSTEM



3EEAAAA1P110A



3EEAAAA1P111A

In addition to improving the cooling performance of the radiator by utilizing a bottom bypass system, the mechanism utilizes a 3-stage thermostat valve that reduces thermal shock considerably compared to previous radiators.

When the coolant inside the engine is cool, the thermostat (1) stays closed and coolant circulates inside the engine via the bypass pipe.

When the temperature of the coolant exceeds the opening temperature of the thermostat (1), the thermostat opens in three stages, sending the now hot coolant to the radiator. Further, when the thermostat is fully open, it is structured so the hot coolant does not flow into the engine via the bypass circuit, thus increasing the cooling performance of the system.

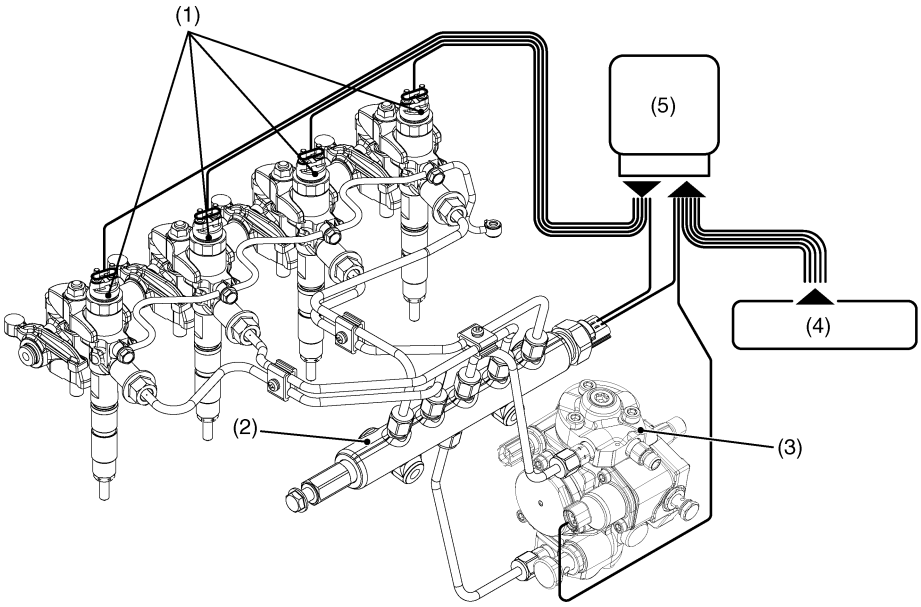
(1) Thermostat

(A) Bypass Opened
(B) Bypass Closed

9Y1210651ENM0006US0

4. COMMON RAIL SYSTEM (CRS)

[1] OVERVIEW



3EEABAI1P067A

(1) Injector
(2) Rail
(3) Supply Pump
(4) Different Sensors
(5) Engine ECU

The fuel system of this engine is completely different from previous jerk fuel injection pumps. Our common rail system not only complies with strict emission regulations, it enables multiple, precise high-pressure injections that do not vary with engine RPM.

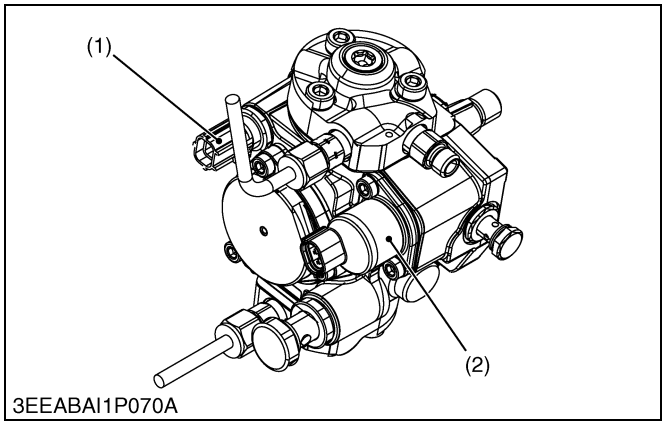
The system is an electronically controlled fuel injection device, with a supply pump (3) that pressurizes the fuel, a rail (2) that stores the high-pressure fuel, injectors (1) that inject the fuel under high-pressure via solenoids into each cylinder and an engine ECU that controls them all.

Various parameters are controlled by the engine ECU, such as the amount of fuel from the injectors and their timing, the pressure of fuel in the rail, etc., as sensed via signals from each sensor and CAN communications from the engine's ECU.

This results in fuel always being injected under ideal conditions, which suppresses the hallmark of a diesel engine, the black smoke during takeoff and acceleration, so there is less smoke, it is cleaner and with a higher output of power.

9Y1210651ENM0007US0

[2] SUPPLY PUMP



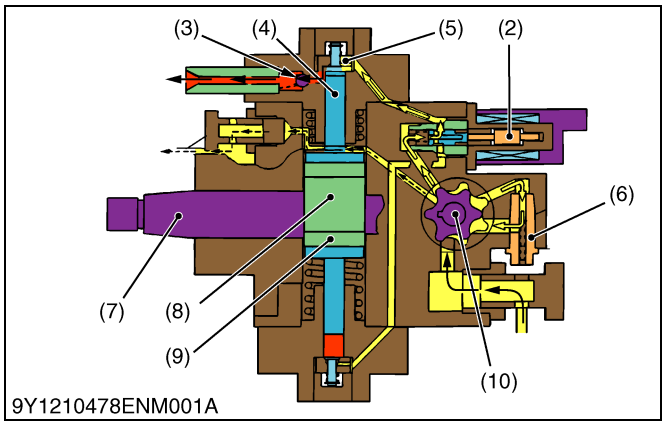
3EEABAI1P070A

The supply pump is equivalent to previously used injection pumps and it delivers fuel to the rail at a pressure more than double that of previous pumps.

It consists of a feed pump (10), regulating valve (6), SCV (suction control valve) (2), pump unit, delivery valve (3) and a fuel temperature sensor (1).

(1) Fuel Temperature Sensor
(2) SCV (Suction Control Valve)
(3) Delivery Valve
(4) Plunger
(5) Suction Valve
(6) Regulating Valve
(7) Drive Shaft
(8) Eccentric Cam
(9) Ring Cam
(10) Feed Pump

9Y1210651ENM0008US0

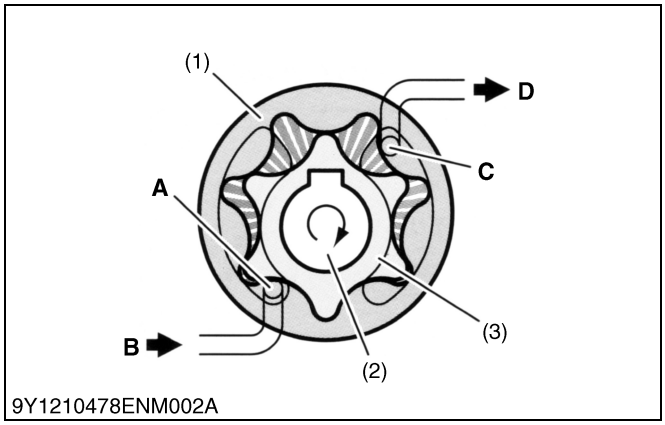


9Y1210478ENM001A

Feed Pump

The feed pump sucks up fuel filtered by the fuel filter and supplies it to the pump unit.

The feed pump is a trochoid pump with an inner rotor and outer rotor (1) geared elliptically; the inner rotor (3) is driven by the drive shaft (2) and drives the outer rotor in turn in the same direction. In the process, the volume of the part enclosed by the teeth of the rotor changes and thus pumps the fuel.



9Y1210478ENM002A

(1) Outer Rotor
(2) Drive Shaft
(3) Inner Rotor

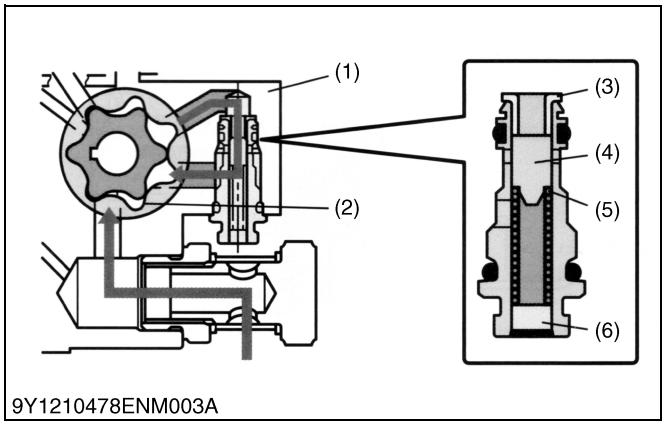
A: Suction Port
B: From The Fuel Tank
C: Discharge Port
D: To Pump Chamber

9Y1210651ENM0009US0

Regulating Valve

The regulating valve controls the fuel feed pressure (feed pump discharge pressure) so it always stays at the set pressure.

When the feed pressure exceeds the set pressure due to changes in the pump's RPM, the piston (4) overcomes the pressure of the spring, opening the valve and returning fuel to the suction side of the feed pump (2).

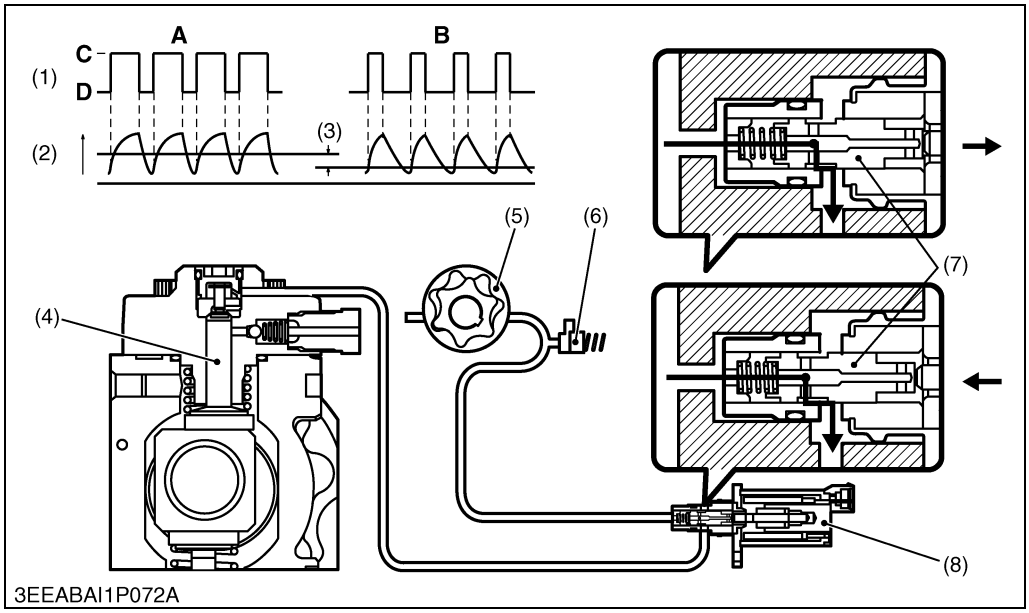


9Y1210478ENM003A

(1) Pump Housing
(2) Feed Pump
(3) Bushing
(4) Piston
(5) Spring
(6) Plug

9Y1210651ENM0010US0

SCV (suction control valve)



(1) Drive Voltage
(2) Amperage
(3) Average Current Differential
(4) Plunger
(5) Feed Pump
(6) Regulating Valve
(7) Cylinder
(8) SCV (Suction Control Valve)

A: Low Suction Volume
B: High Suction Volume
C: ON
D: OFF

By regulating the amount of fuel supplied to the plunger (4), the SCV (8) controls the pressure of fuel in the rail. The SCV uses a linear solenoid valve and the fuel flow is controlled by controlling how long the SCV is energized by the ECU.

There are two types of SCV valve, the fail-open type (max flow with no power) and the fail-closed type (min flow with no power) and the engine uses a fail-open SCV.

When power flows to the SCV (8), the actuator inside moves according to the duty ratio, pressing on the cylinder (7) and altering the flow of fuel corresponding to the size of the cylinder opening and establishing the appropriate amount.

1) Fail-open type

With no power to the solenoid, the cylinder is returned via spring force and the valve opens wide, supplying a large quantity of fuel to the plunger.

When the solenoid is energized, the armature presses on the cylinder, compressing the spring and reducing the quantity of fuel supplied. The solenoid turns ON & OFF according to the duty ratio. The quantity of fuel supplied to the plunger is in proportion to the size of the cylinder opening.

2) Duty ratio control

The engine's ECU outputs a waveform signal for a set interval. The current amperage is the average amperage of the average current differential. When this average value rises, the size of the valve opening is reduced, and conversely, when it drops, the valve opens wider.

3) When the SCV operates for a short time

The average current to the solenoid is low, so the cylinder is returned via spring force and the valve opens wide, supplying a large quantity of fuel to the plunger.

4) When the SCV operates for a long time

The average current to the solenoid is high, so the armature presses on the cylinder, compressing the spring, closing the valve opening and supplying a smaller quantity of fuel to the plunger.

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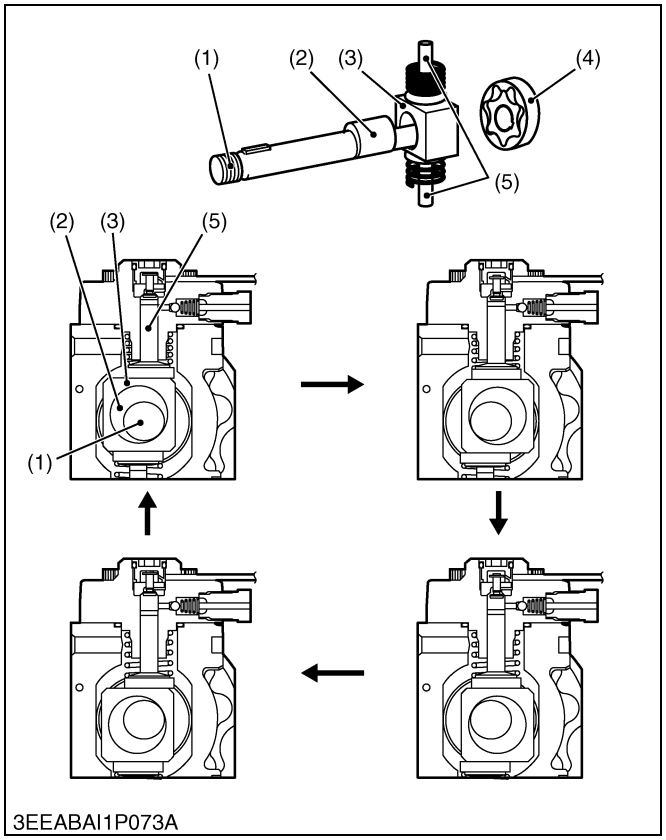

Pump Unit

The pump unit works to increase the pressure of fuel received from the SCV and is composed of a drive shaft (1), ring cam (3) and two plungers (5). A ring cam (3) is mounted on the outside of the eccentric cam (2), which is on the same axle as the drive shaft; the plungers are arranged symmetrically vertically on the ring cam.

When the drive shaft rotates, the eccentric cam rotates eccentrically and the ring cam (3) is driven up and down by it, which operates the two plungers (5) through their cycles.

(1) Drive Shaft
(2) Eccentric Cam
(3) Ring Cam
(4) Feed Pump
(5) Plunger

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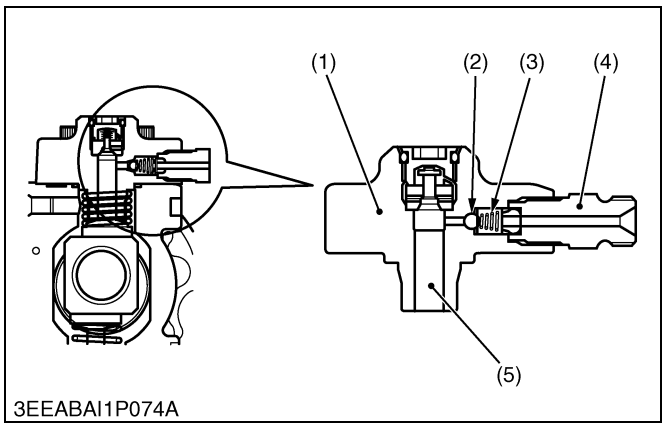

Delivery Valve

The delivery valve is integrated with the element (1) and is composed of a check ball (2), spring (3) and holder (4).

When the pressure on the plunger side (5) equals/exceeds the pressure on the rail side, the check ball opens and discharges fuel. As soon as the fuel pressure feed is complete, the check ball is pressed back by the spring and when it touches the seat of the element, it cuts off the rail side from the plunger side, thus preventing any backflow of fuel.

(1) Element
(2) Check Ball
(3) Spring
(4) Holder
(5) Plunger

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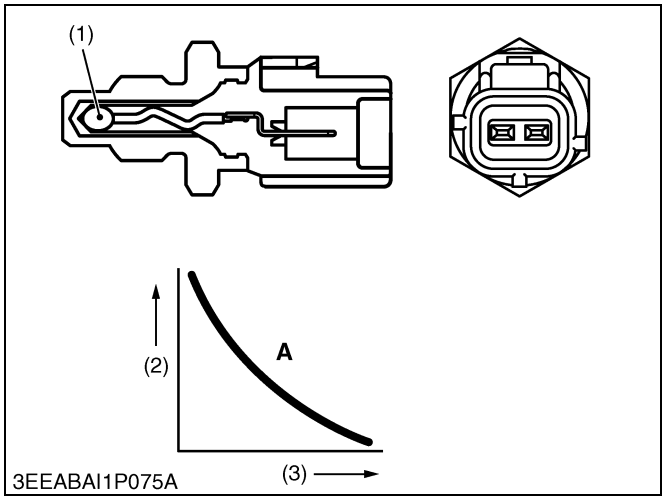

Fuel Temperature Sensor

The fuel temperature sensor is mounted on the fuel intake side and detects the temperature of the fuel using the characteristic of the thermistor (1), whose electrical conductivity varies with temperature.

Please note that the fuel temperature sensor is not treated as a part, so replacing it requires replacement of the supply pump.

(1) Thermistor
(2) Resistance
(3) Temperature

A: Thermistor Temperature Change Curve

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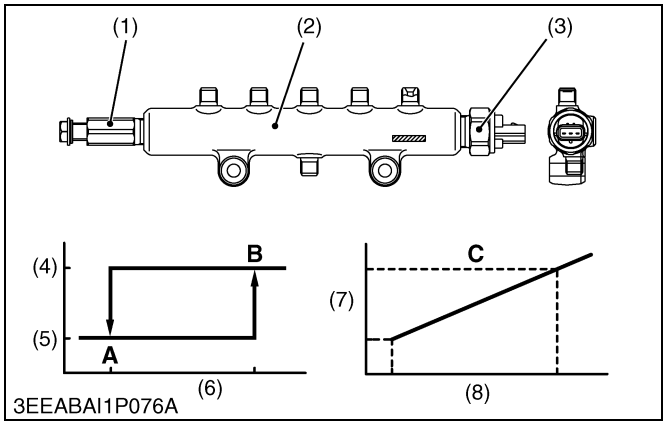
[3] RAIL



The rail (2) stores fuel at the high pressure applied by the supply pump and supplies the shared pressure to the injectors of each cylinder. The rail incorporates control parts-a rail pressure sensor (3) and a pressure limiter (1).

The pressure of the fuel in the rail is detected by the rail pressure sensor, and optimal feedback control is provided for the engine RPM and load. This greatly improves the ability to raise the pressure at low RPMs and enables high-pressure injection from low speed ranges.

Pressure Limiter

The pressure limiter operates when the pressure inside the rail becomes excessively high (valve opens), and then once the pressure drops to a certain pressure, it acts to maintain the pressure (valve closes).

Fuel discharged by the pressure limiter returns to the fuel tank.

Please note that the pressure limiter is not treated as a part, so replacement requires replacing the rail assembly.

Valve opening pressure	Reference value	Approx. 220 MPa (2240 kgf/cm^2, 31900 psi)
Valve closing pressure		Approx. 50 MPa (510 kgf/cm^2, 7300 psi)

Rail Pressure Sensor

The rail pressure sensor is mounted on the rail, detects the pressure inside the rail and sends a signal to the engine ECU.

This sensor is a semiconductor type of pressure sensor, which uses the piezo resistance effect, in which increasing the pressure on its silicon element changes its electrical resistance. Please note that the rail pressure sensor is not treated as a part, so replacement requires replacing the rail assembly.

(1) Pressure Limiter
(2) Rail
(3) Rail Pressure Sensor
(4) Valve (Open)
(5) Valve (Close)
(6) Rail Pressure
(7) Output Voltage
(8) Rail Pressure

A: Return
B: Abnormally High Pressure
C: Rail Pressure Characteristics

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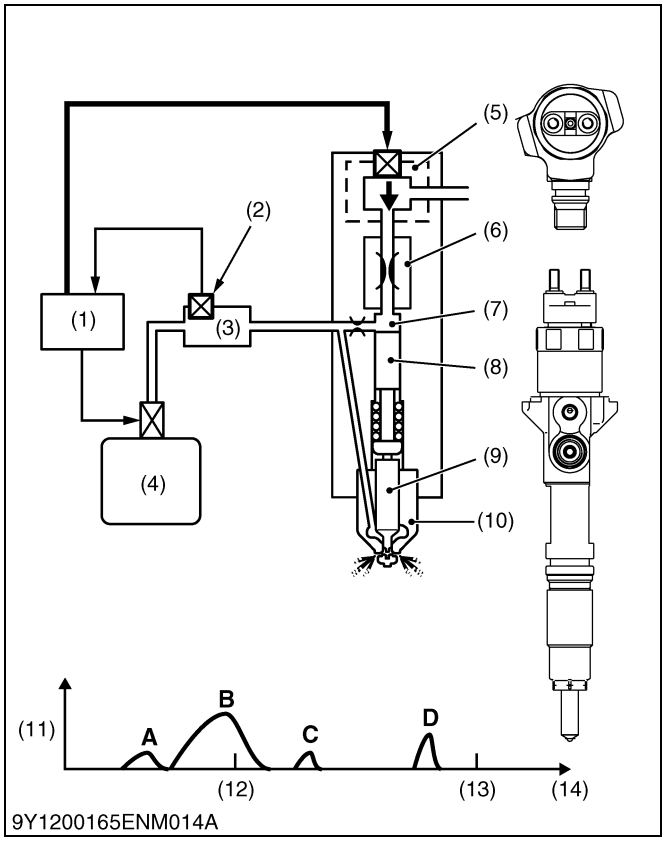
[4] INJECTOR



The injectors inject high-pressure fuel from the rail into the combustion chamber of the engine, using signals from the engine's ECU to produce the ideal timing, amount of fuel, mixture and spray.

The injector injects a finely tuned spray in three pulses during the combustion stage. First a small amount is injected, mitigating the effect of the initial burn and reducing NOx (oxides of nitrogen) and noise. The main injection follows with the real burn, and in the last stage, a diffuse combustion is induced, thus reducing particulate matter (PM) generated by the main injection.

Injector Architecture

Injectors consist of nozzle components (nozzle (10) and needle valve (9)), a TWV (two-way valve) (5), which controls the volume and mixture of fuel, a control chamber (7) with an intake orifice and discharge orifice (6), a command piston (8) and a nozzle spring.

(1) Engine ECU
(2) Rail Pressure Sensor
(3) Rail
(4) Supply Pump
(5) TWV (Two-way Valve)
(6) Discharge Orifice
(7) Control Chamber
(8) Command Piston
(9) Needle Valve
(10) Nozzle
(11) Injection Amount
(12) T.D.C (Top Dead Center)
(13) B.D.C (Bottom Dead Center)
(14) Crank Angle

A: Pre-injection
B: Main Injection
C: After Injection
D: Post Injection

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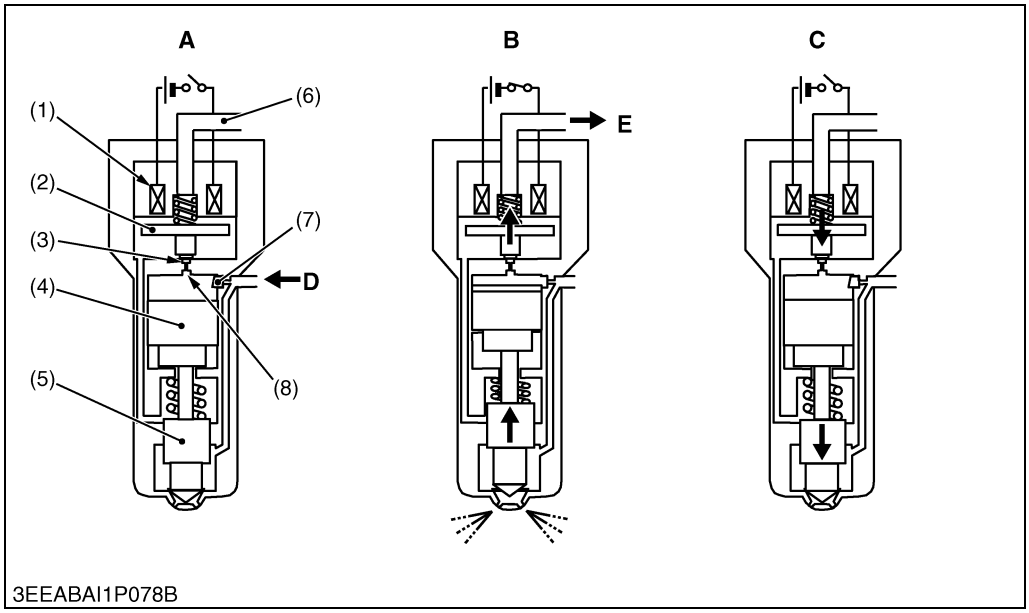
Injector Operation



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(1) Solenoid
(2) TWV (Two-way Valve)
(3) Discharge Orifice
(4) Command Piston
(5) Needle Valve
(6) Leak Passage
(7) Intake Orifice
(8) Control Chamber

A: Injection Stop
B: Injection Start
C: Injection Finish
D: From Rail
E: To Fuel Tank

The injector uses the signal output from the engine ECU to control the injection with the fuel pressure in the control chamber.

The system for controlling the pressure of the control chamber works by energizing the solenoid, which opens the passage of the chamber's discharge orifice and the fuel is injected due to the drop in pressure. When the current stops, the pressure in the control chamber returns to what it was and injection ceases.

1) Injection Stop

With no current to the solenoid (1), the TWV (2) cuts off the discharge orifice (3) passage, so rail pressure is applied to the control chamber (8) and the bottom of the needle valve (5). As the diameter of the command piston (4) on the control chamber side is larger than the diameter of the bottom of the needle valve, it works to push the needle valve down, which is compounded by the nozzle spring pushing it down, and the needle valve is closed.

2) Injection Start

When the solenoid (1) is energized, it draws the TWV (2) up, opening the passage of the discharge orifice (3), returning fuel in the control chamber (8) to the fuel tank via the leak passage (6) and dropping the pressure.

The drop in the pressure of the control chamber causes the pressure applied to the bottom of the needle valve (5) to become greater than the pressure on the control chamber side, and the needle valve compresses the nozzle spring and starts injecting fuel.

3) Injection Finish

When current to the solenoid (1) stops, the TWV (2) lowers and the discharge orifice (3) passage is closed.

When the passage of the discharge orifice closes, the fuel pressure in the control chamber (8) recovers to the rail pressure, so the needle valve (5) is pressed back via the command piston (4), stopping the injection.

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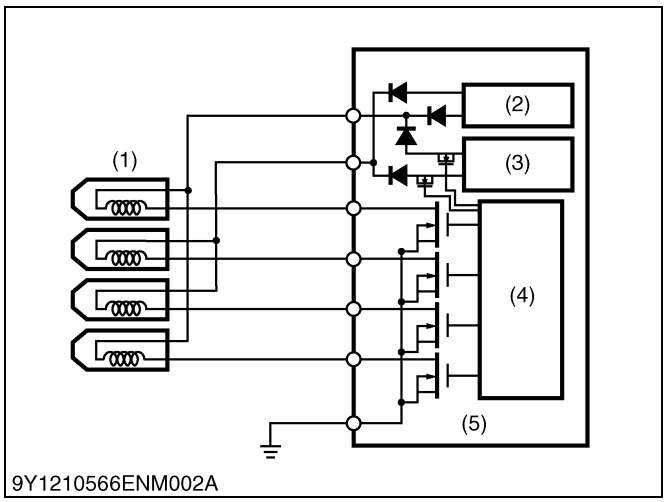

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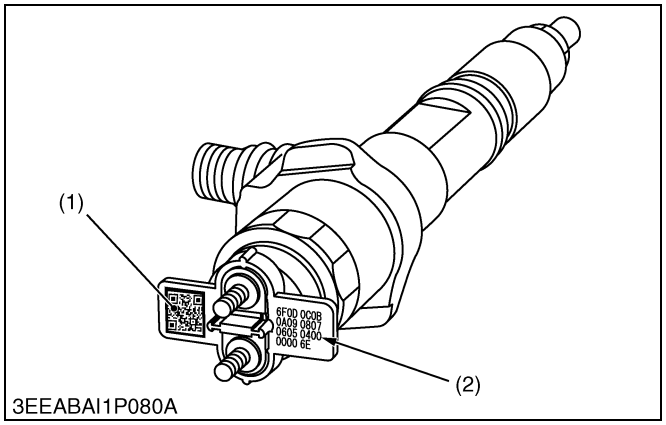
Injector Drive Circuit

To increase the responsiveness of the injector, the voltage that drives the injector is raised to a high voltage, accelerating the magnetization of the solenoid and increasing the responsiveness of the TWV.

The battery voltage is raised to about 110 V by a high-voltage generating circuit inside the ECU and that voltage is supplied to the injector to actuate it.

(1) Injector
(2) Rated Amperage Circuit
(3) High-voltage Generating Circuit
(4) Control Circuit
(5) Engine ECU

9Y1210651ENM0018US0



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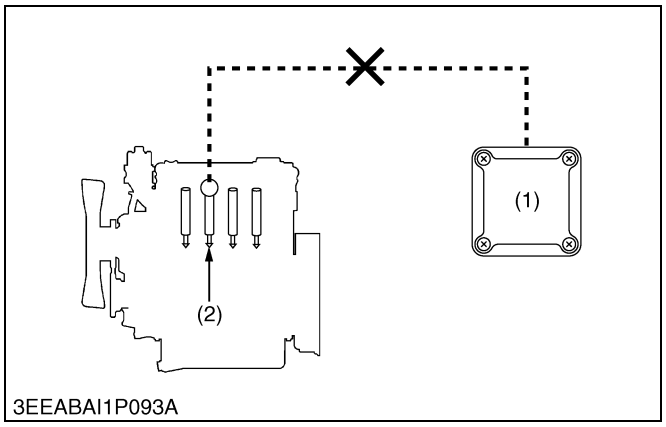
Injector QR/ID Codes

Injectors are processed to exacting tolerances, but there are minute variations in the amount they inject, so to correct for these variations, a correction volume is recorded on the QR/ID codes of the injectors.

During manufacture, the QR code is read by a scanner and the correction value is registered in the ECU.

(1) QR Code (2) ID Code

9Y1210651ENM0019US0



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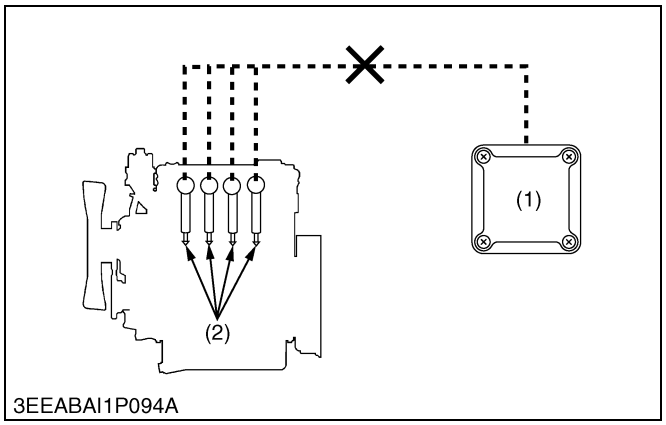
When Replacing an Injector

Register the ID code of the replacement injector into the ECU.

(1) Engine ECU (2) Replacement Injector

9Y1210651ENM0020US0



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When Replacing the Engine ECU

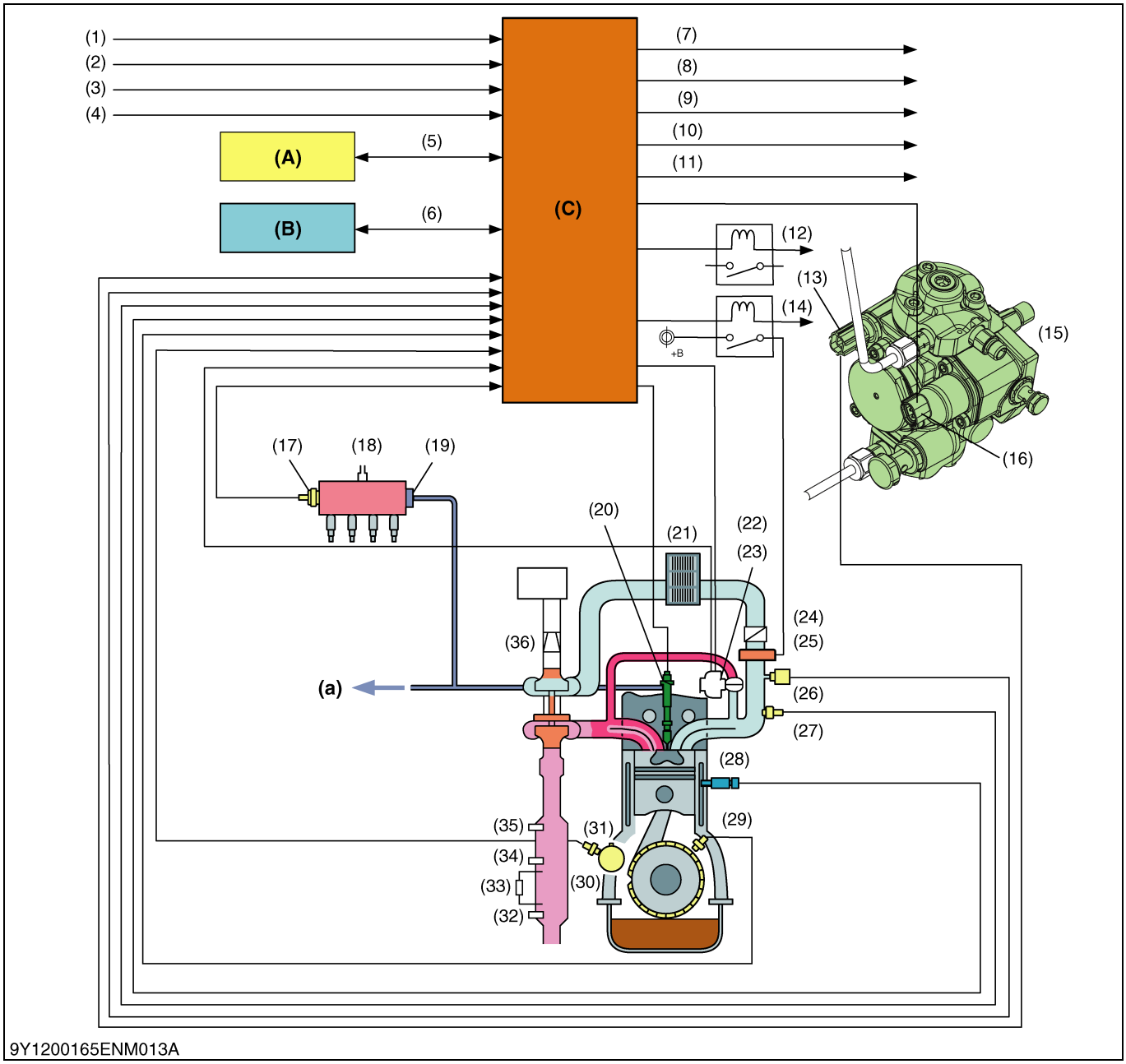
Register the ID codes of all of the injectors into the replacement engine ECU.

When replacing an ECU, as it is necessary to write all of the data, including the injector corrections, only KUBOTA can write the data to the ECU.

(1) Replacement ECU (2) Injector

9Y1210651ENM0021US0

[5] ENGINE CONTROL SYSTEM



9Y1200165ENM013A

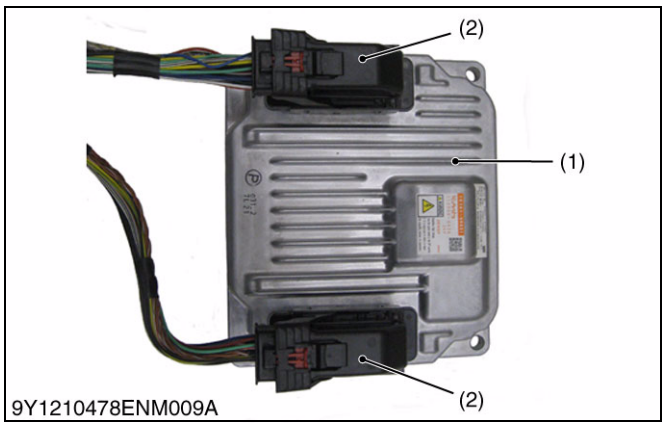
(1) Key Switch ON Signal
(2) Starter Switch Signal
(3) Emergency Stop Switch
(4) Oil Pressure Switch
(5) CAN Communication for OEM Machine (Accelerator Position Signal*, Neutral Switch*, Machine Travel Speed Signal*)
(6) CAN Communication for Service
(7) Engine Warning Light Signal
(8) Stop Lamp Signal
(9) Oil Pressure Warning Lamp Signal
(10) Overheat Lamp Signal
(11) Glow (Air Heater) Lamp Signal
(12) Starter Relay
(13) Fuel Temperature Sensor
(14) Glow (Air Heater) Relay
(15) Supply Pump
(16) SCV (Suction Control Valve)
(17) Rail Pressure Sensor
(18) Rail
(19) Pressure Limiter
(20) Injector
(21) Inter cooler
(22) EGR DC Motor
(23) EGR Lift Sensor
(24) Intake Throttle Valve
(25) Intake Air Heater
(26) Intake Air Pressure Sensor
(27) Intake Air Temperature Sensor
(28) Coolant Temperature Sensor
(29) Crankshaft Position Sensor
(30) Diesel Particulate Filter (Hereinafter Referred To As The "DPF") Muffler
(31) Camshaft Position Sensor
(32) Temperature Sensor (DPF Outlet Exhaust Temperature) (T_2)
(33) Differential Pressure Sensor (DPF Differential Pressure) (ΔP)
(34) Temperature Sensor (DPF Inlet Exhaust Temperature) (T_1)
(35) Temperature Sensor (DOC Inlet Exhaust Temperature) (T_0)
(36) Air Flow Sensor

(A) CAN2 Connector (For OEM Machine)
(B) CAN1 Connector (For Service)
(C) Engine ECU
(a) To Fuel Tank

■ **NOTE**
- **The signals marked with * are CAN communication.**

9Y1210651ENM0022US0

(1) Engine ECU



The engine ECU (1) controls the amount, timing, mixture and pressure of fuel that is injected. The engine ECU (1) operates each kind of control based on the signals from each type of sensor.

The actuator for controlling the amount, timing and mixture of fuel injection is the injector, while the actuator for controlling fuel pressure is the supply pump.

■ **Fuel Quantity Control**

The amount of fuel to be injected is determined using a basic injection amount, which is calculated based on the state of the engine and driving conditions, with corrections added for parameters such as water temperature, fuel temperature, intake air temperature, intake pressure, etc.

■ **Injection Timing Control**

The ECU controls the timing for starting to energize the injectors, first determining the timing for the main injection and then setting the timing of other injections, such as pilot injections.

■ **Fuel Mixture Control**

By conducting a pilot injection, the initial fuel mixture is kept to a minimum, mitigating the explosive initial combustion and reducing NOx and noise.

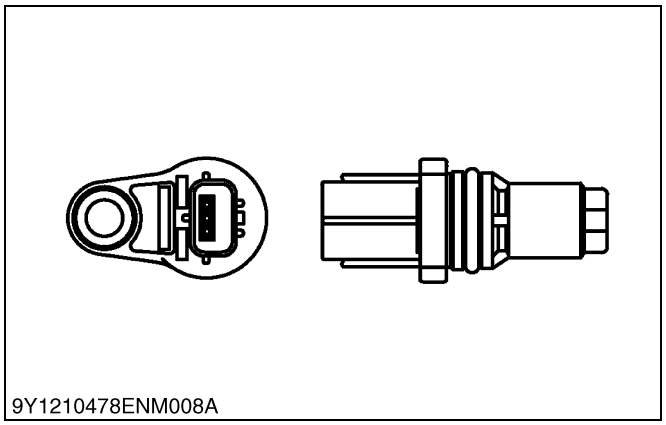
■ **Fuel Pressure Control**

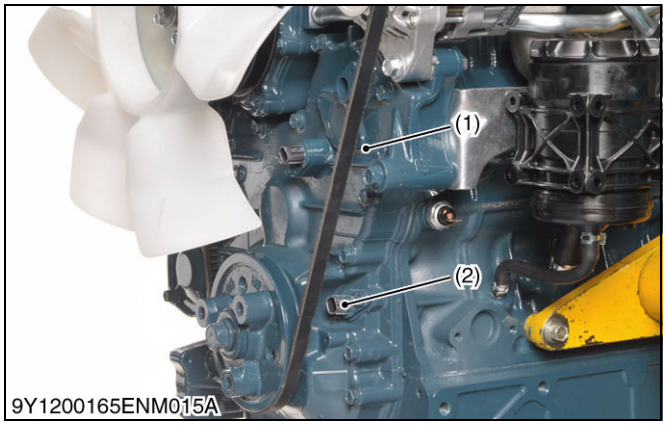
The ECU calculates the set fuel injection pressure based on the engine load (last injection amount and engine RPM) and controls the amount the supply pump supplies and the fuel pressure inside the rail.

(1) Engine ECU (2) ECU Connector

9Y1210651ENM0023US0

(2) Sensor





Crankshaft Position Sensor

The crankshaft position sensor (2) is mounted near the crankshaft gear of the gear case (1) and the sensor utilizes an MRE (magnetic resistance element) type of sensor.

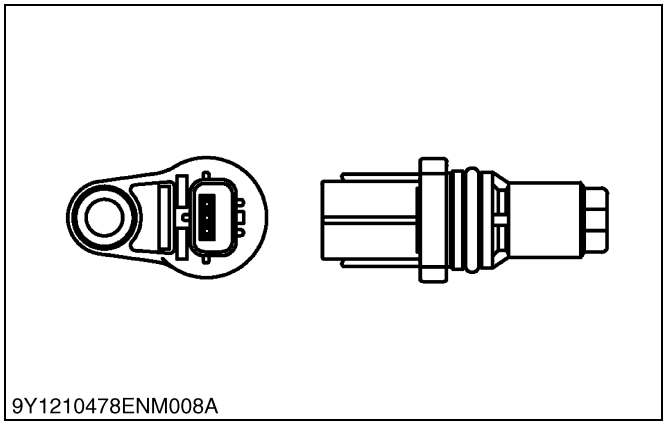
When the crankshaft pulsar gear passes by the sensor, it alters the magnetic field inside the sensor, generating an AC voltage, which is output to the engine ECU.

Further, the gear has a wide part between teeth, which alters the waveform of the AC voltage and the sensor detects the crankshaft position with every revolution; this change in the voltage is amplified by the IC circuit inside the sensor and outputs it to the engine ECU.

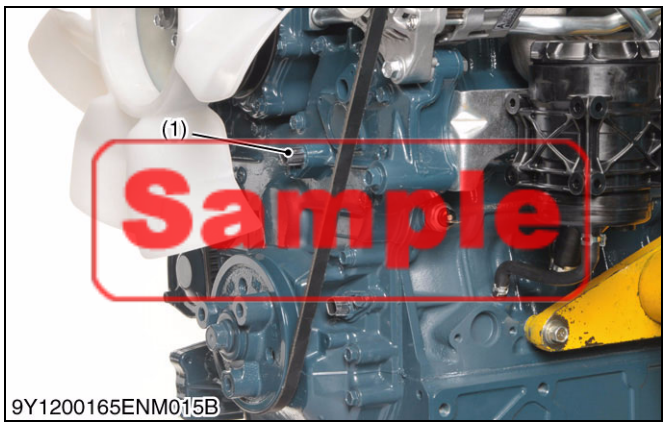
The engine ECU uses the signals to calculate the piston position and engine RPM.

(1) Gear Case (2) Crankshaft Position Sensor

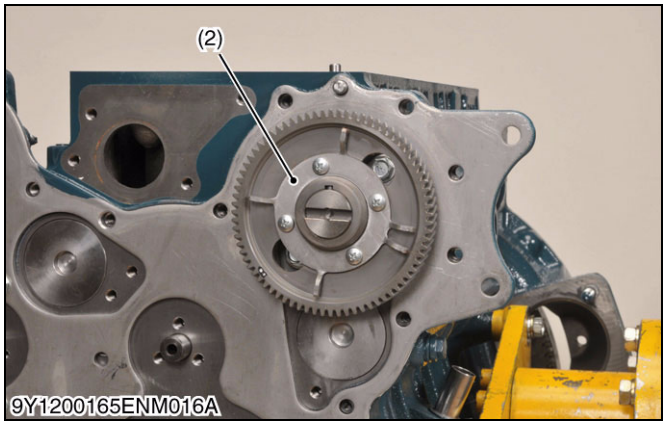
9Y1210682ENM0001US0



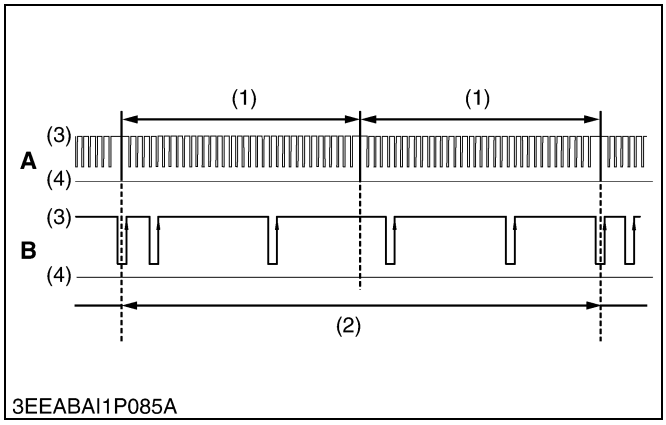
9Y1210478ENM008A



9Y1200165ENM015B



9Y1200165ENM016A



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Camshaft Position Sensor

The camshaft position sensor (1) is mounted near the camshaft gear and the sensor functions in the same way as the crankshaft position sensor.

This sensor detects the extra teeth (two teeth) of the camshaft pulsar gear (2) and the engine ECU uses the signal to calculate the piston position.

(1) Camshaft Position Sensor (2) Camshaft Pulsar Gear

9Y1210682ENM0002US0

This figure shows the pulse chart of the crankshaft position sensor output signal and camshaft position sensor output signal.

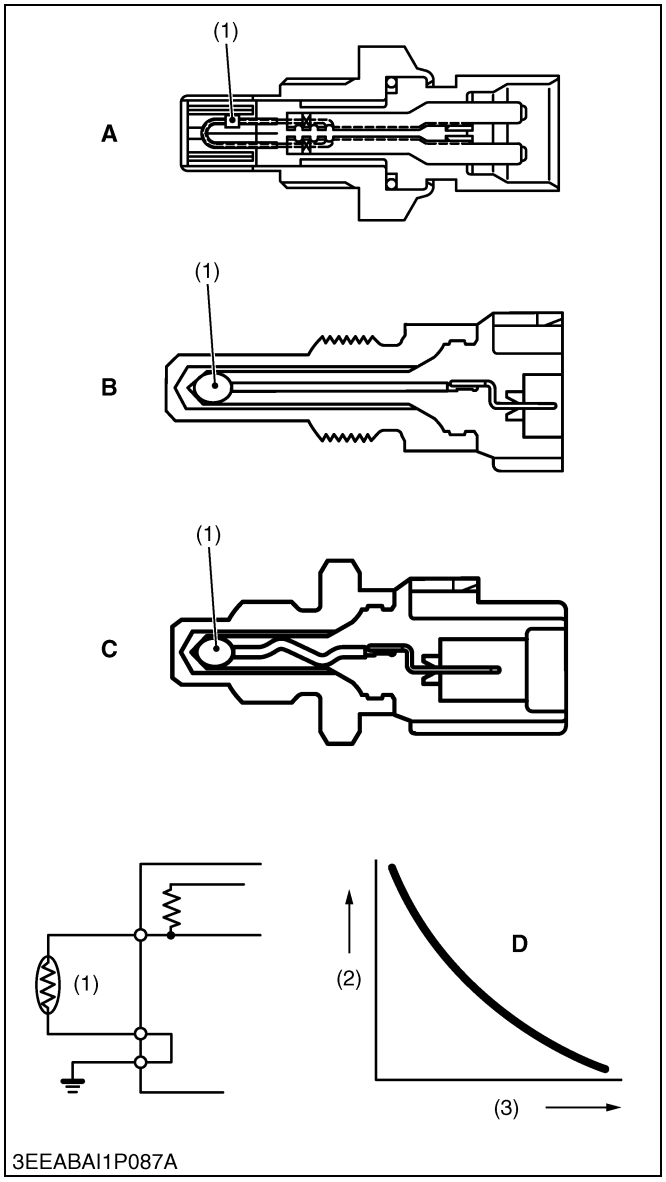
The camshaft pulsar gear rotates once when the crankshaft pulsar gear rotates twice (12.6 rad (720 °) crank angle).

there is a gearless section in the crankshaft pulsar gear. The ECU determines whether it is TDC if the camshaft position sensor signal is detected while the crankshaft position sensor is passing this gearless section.

(1) 56 pulses (6.28 rad (360 °) crank angle)
(2) 5 pulses (12.6 rad (720 °) crank angle)
(3) 5 V
(4) 0 V

A: Crankshaft Position Sensor Output Voltage
B: Camshaft Position Sensor Output Voltage

9Y1210651ENM0026US0



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These sensors utilize thermistors to detect temperature.

A characteristic of thermistors is that their electrical resistance varies with temperature, and this characteristic is used by the different sensors to detect temperature via voltage.

Intake Air Temperature Sensor

The intake air temperature sensor **"A"** measures the intake temperature after it passes through the turbocharger.

Coolant Temperature Sensor

The coolant temperature sensor **"B"** is mounted on the cylinder head and detects the temperature of the coolant.

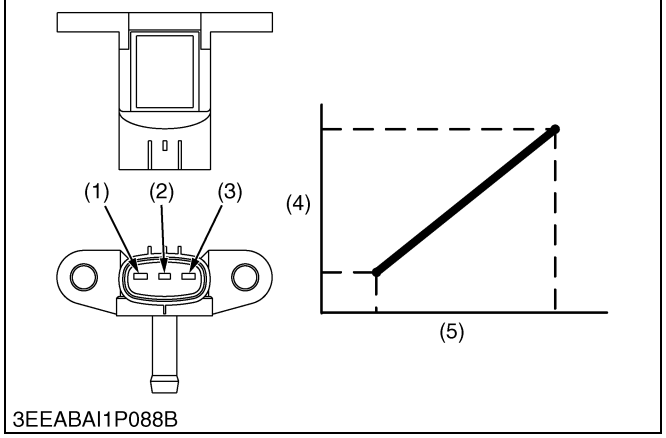
Fuel Temperature Sensor

The fuel temperature sensor **"C"** is mounted on the fuel intake side of the supply pump and detects the temperature of the fuel.

(1) Thermistor
(2) Resistance
(3) Temperature

A: Intake Air Temperature Sensor
B: Coolant Temperature Sensor
C: Fuel Temperature Sensor
D: Thermistor Temperature Curve

9Y1210651ENM0027US0



3EEABAI1P088B

Boost Sensor

The boost sensor is a semiconductor pressure sensor and when there are changes in the pressure on the silicon element inside the sensor, its electrical resistance changes and this piezo resistance effect is used to detect pressure using voltage.

The boost sensor measures the intake air pressure after it passes through the turbocharger.

(1) Supply Terminal
(2) Output Terminal
(3) Ground Terminal
(4) Output Voltage
(5) Intake Air Pressure

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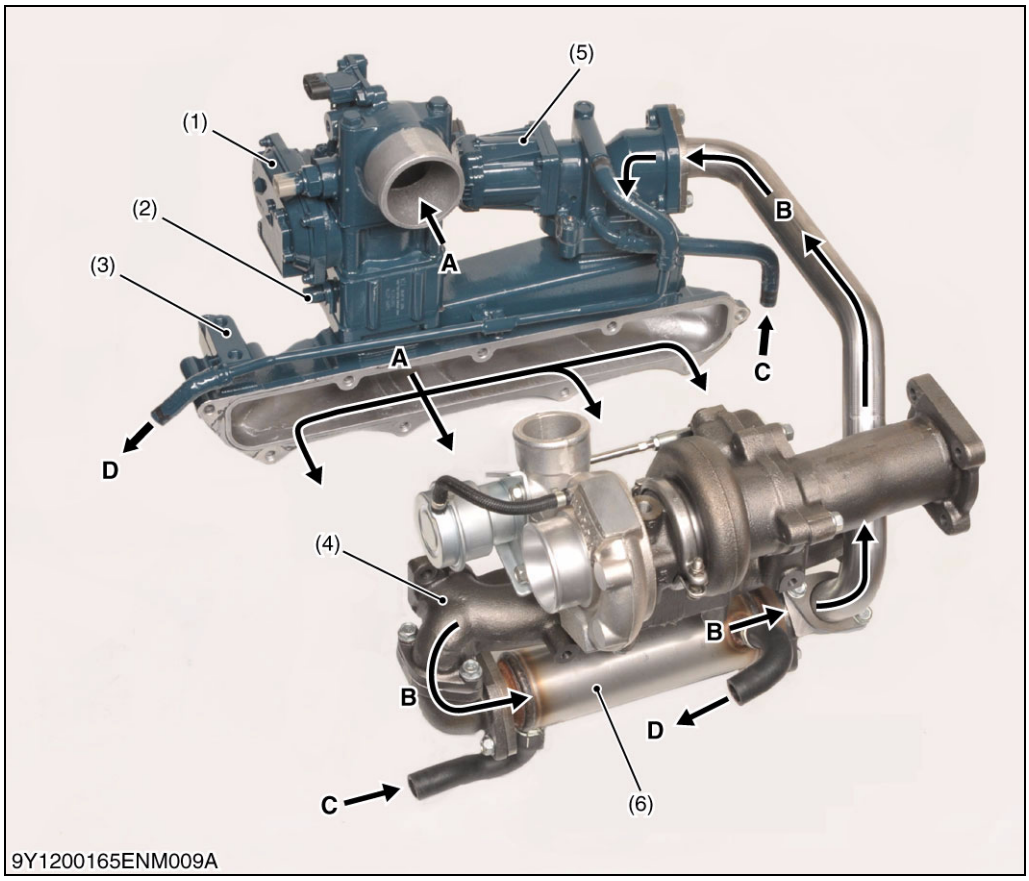
5. EGR SYSTEM

[1] OVERVIEW



9Y1200165ENM009A

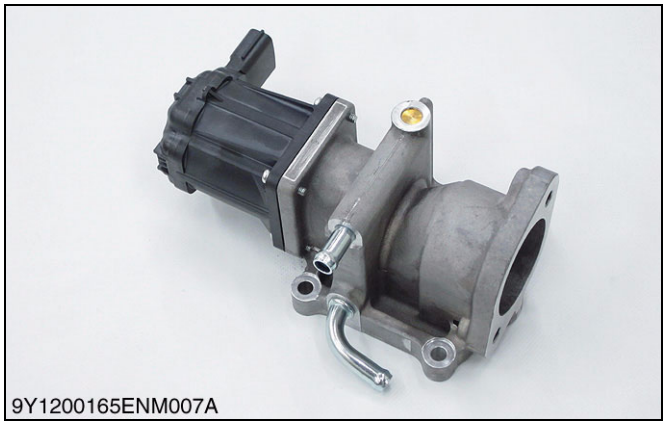
(1) Intake Throttle Valve
(2) Intake Air Heater
(3) Intake Manifold
(4) Exhaust Manifold
(5) EGR Valve
(6) EGR Cooler

A: Intake Air
B: Exhaust Gas
C: Coolant Inlet
D: Coolant Outlet

An EGR (exhaust gas recirculation) system takes out a portion of the exhaust gas and recirculates it to the intake side, thus reducing the amount of available oxygen and lowering the temperature of combustion, which suppresses the generation of nitrogen oxide (NOx).

9Y1210651ENM0029US0

[2] EGR VALVE



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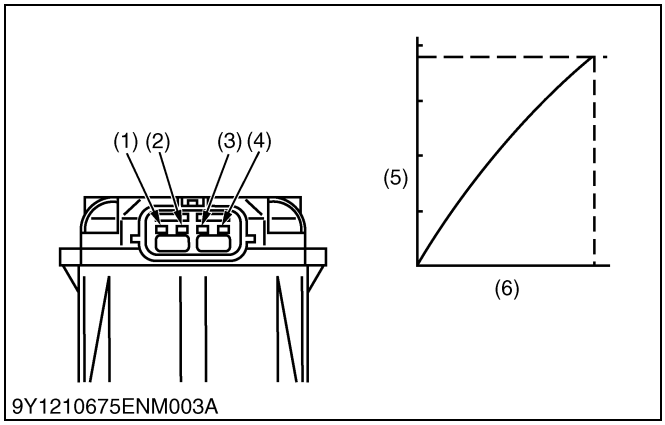
Water Cooled EGR Valve

This is a device that regulates EGR gas flow. The degree the valve is open is detected using a lift sensor and a motor is used to set this to the degree of open calculated using signals including the engine speed.

Also, passing engine coolant through the housing enables controlling temperature rise of the EGR valve.

9Y1210651ENM0030US0



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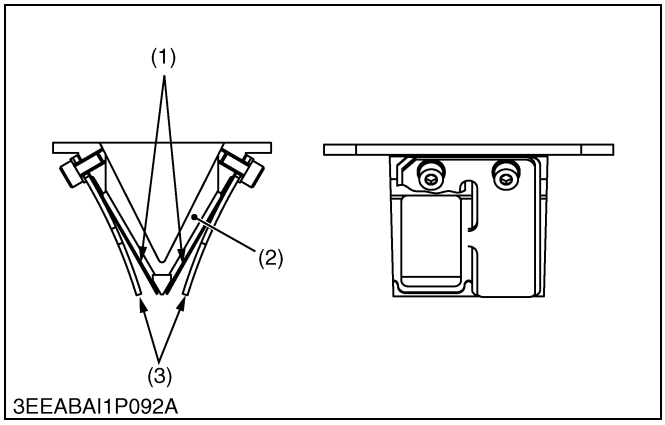
EGR Valve Lift Sensor

How far the EGR valve is open is detected by a contact type of position sensor that detects the movement of the motor's shaft. The motor's shaft opens and closes the valve by changing the rotation of the motor into linear motion via a screw deceleration mechanism.

(1) CAN H
(2) CAN L
(3) GND (−)
(4) Power (+)
(5) Exhaust Gas Flow
(6) CAN Communication Data

9Y1210675ENM0003US0

[3] REED VALVE



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The reed valves are positioned at the point where exhaust gases that have passed through the EGR valve mix with intake air and they prevent air on the air cleaner side from flowing to the EGR cooler side.

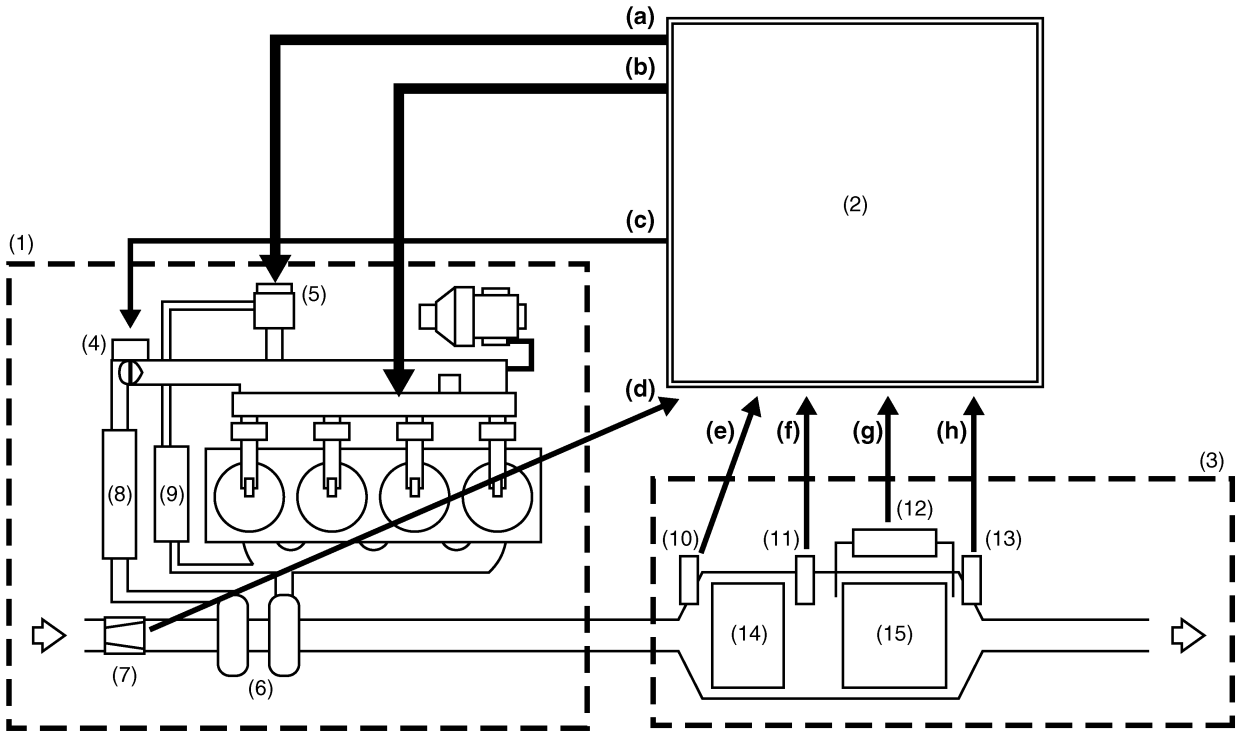
These thin plate springs (reed valves) mounted at the bottom of the EGR valve motor open and close the EGR gas passage (during intake: reed valve is closed; during exhaust: open) and prevent the intake air from backflowing to the exhaust side.

(1) Valve
(2) Case
(3) Stopper

9Y1210651ENM0032US0

6. AFTER TREATMENT SYSTEM

[1] AFTER TREATMENT DEVICES



9Y1200165ENM001A

(1) Common Rail System
(2) ECU
(3) After Treatment Devices
(4) Intake Throttle Valve
(5) EGR Valve
(6) Turbo Charger
(7) Air Flow Sensor
(8) Inter Cooler
(9) EGR Cooler
(10) Temperature Sensor (DOC Inlet Exhaust Temperature) (T_0)
(11) Temperature Sensor (DPF Inlet Exhaust Temperature) (T_1)
(12) Differential Pressure Sensor (DPF Differential Pressure) (ΔP)
(13) Temperature Sensor (DPF Outlet Exhaust Temperature) (T_2)
(14) Diesel Oxidation Catalyst (DOC)
(15) Diesel Particulate Filter (DPF)

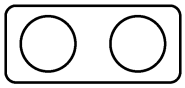
(a) EGR Valve Opening
(b) Injection Pattern
(c) Inlet Throttle Valve Angle
(d) Air Flow Sensor
(e) T_0 (DOC Inlet Exhaust Temperature)
(f) T_1 (DPF Inlet Exhaust Temperature)
(g) ΔP (DPF Differential Pressure)
(h) T_2 (DPF Outlet Exhaust Temperature)

9Y1210651ENM0033US0

■ **NOTE**
- **Lighting patterns when the lamp is lighted by ECU directly.**

9Y1210651ENM0043US0

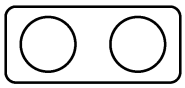
Permit

Auto Regeneration Permit	RGN and Inhibit Lamp	Manual RGN Demand Lamp	Warning Lamp	State of Regeneration
				
Level 0 (No need Regeneration)				Regeneration is not required
Level 1 (Auto Regeneration)	●			Regeneration starts automatically when the PM level reachs to this level. Parked regeneration is impossible in this level.
Level 2 (Request parked Regeneration)	●	★		ECU requests parked regeneration if the PM level does not decrease to automatic regeneration level in 1800 seconds after automatic regeneration starts. (Automatic regeneration does not stop in this level.)
Level 3 (Parked Regeneration)	●	★	●	Automatic regeneration stops. Operator had better park the machine and start manual regeneration as soon as possible. During parked regeneration, machine operation is restricted.
Level 4 (Regeneration with service tools)			●	Parked regeneration is impossible. Regeneration is possible with service tools only. (Service tools are available among all levels without level 5)
Level 5 (DPF Cleaning)			●	Regeneration is impossible even with service tools. DPF cleaning is necessary.

●: Lighting, ★: Blinking

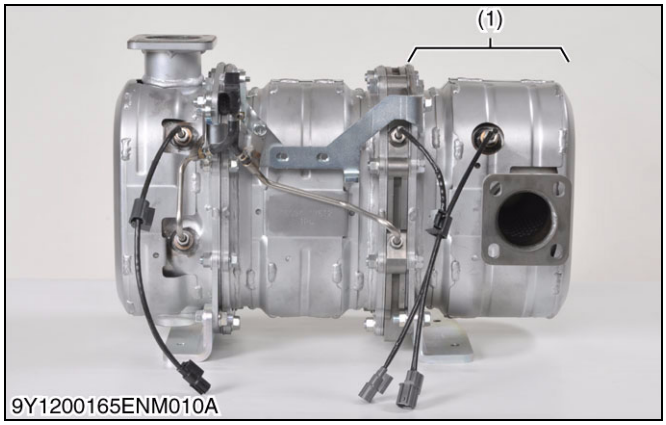
9Y1210651ENM0034US0

Inhibit

Auto Regeneration Inhibit	RGN and Inhibit Lamp	Manual RGN Demand Lamp	Warning Lamp	State of Regeneration
				
Level 0 (No need Regeneration)	★			Regeneration is not required
Level 1 (Auto Regeneration)	★			Automatic regeneration inhibit
Level 2 (Request parked Regeneration)	★	★		ECU requests parked regeneration if the PM level does not decrease to automatic regeneration level in 1800 seconds after automatic regeneration starts. (Automatic regeneration does not stop in this level.)
Level 3 (Parked Regeneration)	★	★	●	Automatic regeneration stops. Operator had better park the machine and start manual regeneration as soon as possible. During parked regeneration, machine operation is restricted.
Level 4 (Regeneration with service tools)	★		●	Parked regeneration is impossible. Regeneration is possible with service tools only. (Service tools are available among all levels without level 5)
Level 5 (DPF Cleaning)	★		●	Regeneration is impossible even with service tools. DPF cleaning is necessary.

●: Lighting, ★: Blinking

9Y1210651ENM0035US0

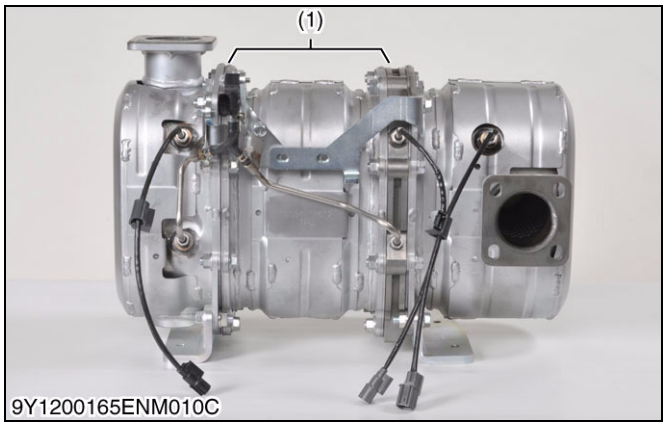


Diesel Oxidation Catalyst (DOC)

An oxidizing catalyst positioned in front of the Diesel Particulate Filter (DPF) step that uses post injection unburned fuel to actively regenerate the DPF.

(1) Diesel Oxidation Catalyst (DOC)

9Y1210651ENM0036US0



Diesel Particulate Filter (DPF)

The Diesel Particulate Filter (DPF) is a device that captures and combusts PM in the exhaust gas.

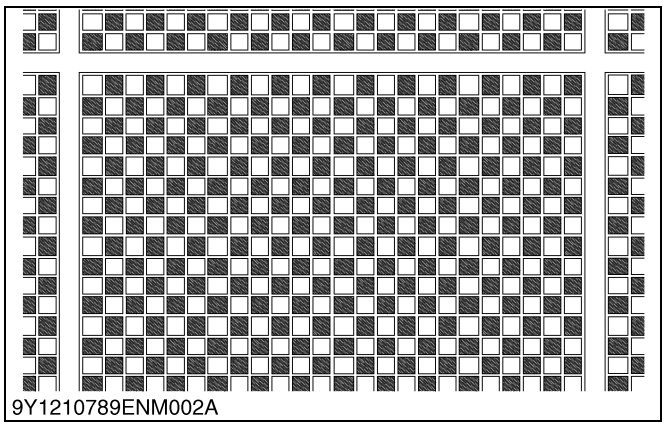
Physically captures the PM using a filter which spontaneously combusts when exhaust gas temperature is high.

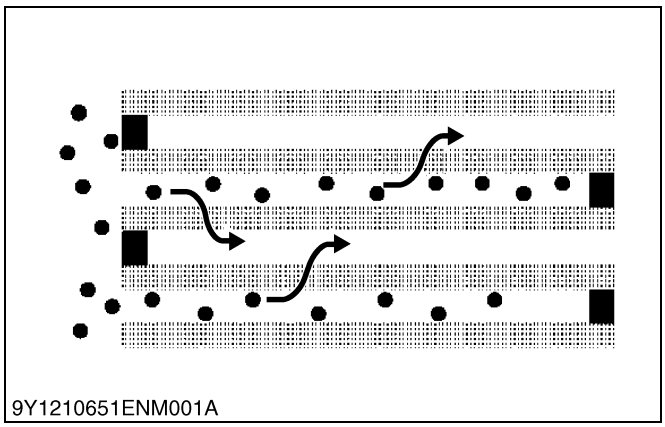
However, while exhaust gas temperature is low PM does not spontaneously combust the pressure differential between the inlet and outlet of the DPF is detected and the PM is combusted using a heat source generated using DOC to regenerate the filter.

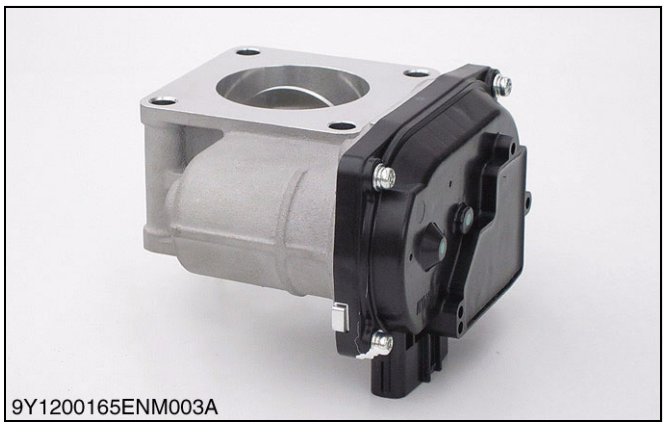
(1) Diesel Particulate Filter (DPF))

9Y1210651ENM0037US0


9Y1210789ENM001A


9Y1210789ENM002A


9Y1210651ENM001A


9Y1200165ENM003A

Function of Diesel Particulate Filter (DPF)

The Diesel Particulate Filter (DPF) is a filter to capture fine particles (soot and ash) contained in the exhaust gas of a diesel engine.

The ash content is mainly metallic additives contained in burnt lubricating oil.

The filter has a honeycomb structure with adjacent cell holes alternately closed.

In addition, by alternately closing the inlet side and the outlet side of the exhaust gas, the thin ceramics wall is used as a filter.

As shown in the figure, fine particles in the exhaust gas are captured when they pass through this thin wall, and the exhaust gas is discharged as clean gas.

9Y1210789ENM0043US0

Intake Throttle Valve

The amount of air intake is regulated by the angle of the throttle valve and the exhaust temperature is controlled when regenerating the DPF muffler.

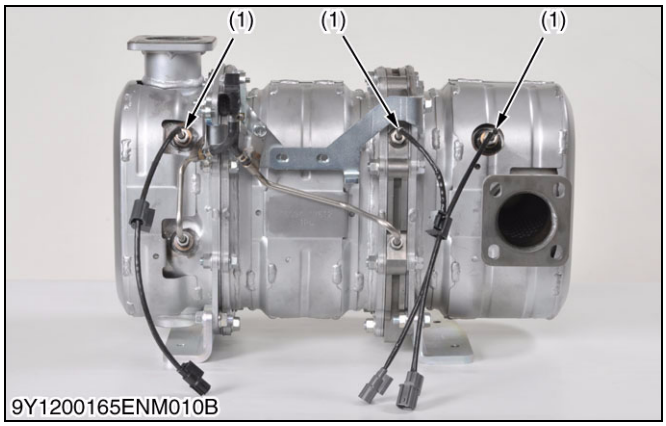
9Y1210651ENM0038US0


9Y1200165ENM004A

Air Flow Sensor

The amount of air intake required for control of the EGR valve used to reduce NOx is measured.

9Y1210651ENM0039US0



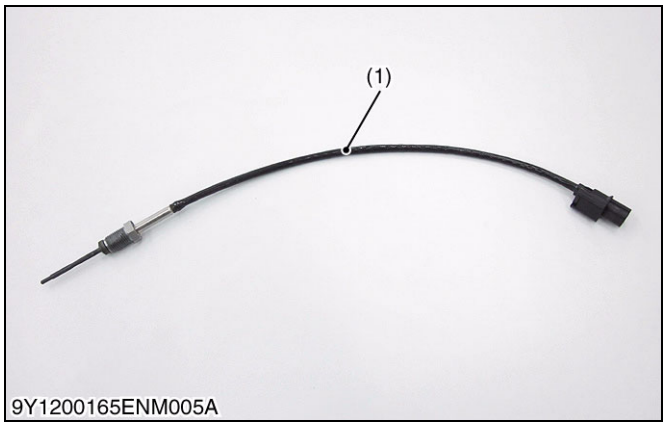
9Y1200165ENM010B

Temperature Sensor

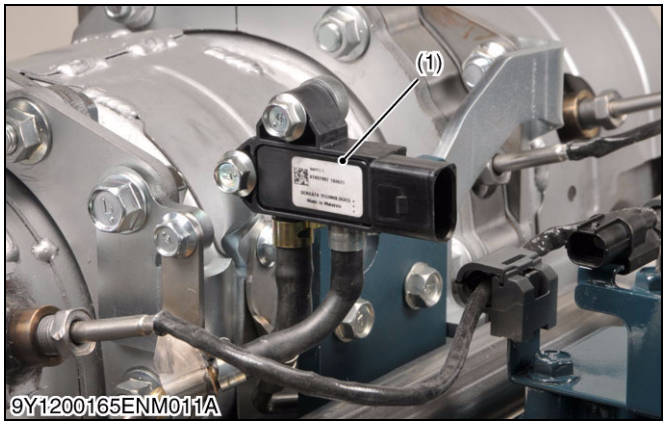
This is mounted on the DPF muffler and the DPF muffler DOC intake, DPF intake, and DPF discharge exhaust temperature, needed for the post processing system, are measured.

(1) Temperature Sensor

9Y1210651ENM0040US0



9Y1200165ENM005A



9Y1200165ENM011A

Differential Pressure Sensor

The differential pressure sensor is a sensor that detects the pressure differential between the inlet and the outlet of the DPF.

The engine ECU calculates the amount of accumulated PM in the DPF using this signal.

(1) Differential Pressure Sensor

9Y1210651ENM0041US0

Oil Separator

Removes oil in the blowby gases that pass through the element (1) and the oil is returned to the oil pan.

Blowby gases that pass through the element (1) are mixed into the intake upstream from the turbo charger.

(1) Element

9Y1210651ENM0042US0

SERVICING

CONTENTS

1. TROUBLESHOOTING

This -.2 shows only mechanical failures. The failures related to the common rail system (CRS), refer to the diagnosis manual (DM) for common rail system engine (9Y120-01740).

Symptom	Probable Cause	Solution	Reference Page
The engine does not start	No fuel	Fill up the fuel	–
	Air in the fuel system	Bleed the air	–
	Water in the fuel system	Change the fuel and repair or replace the fuel system	G-15
	The fuel pump is defective	Replace	–
	The fuel hose is clogged	Clean or replace	G-15
	The fuel filter is clogged	Replace	G-17
	The viscosity of fuel at low temperature is too high	Replace the specified fuel	I-5, G-9
	The cetane number of fuel is low	Replace the specified fuel	I-5, G-9
	Fuel leakage because of loose injection pipe retaining nut	Tighten the retaining nut	1-S30
	The injector is clogged	Replace	1-S35
	The supply pump is defective	Replace	1-S41
	Seizure of the crankshaft, camshaft, piston or bearing	Repair or replace	–
	Compression leakage from the cylinder	Replace the head gasket Tighten the cylinder head screw	1-S38, 1-S39
	Incorrect valve timing	Examine the timing gear	1-S45
	Piston ring and cylinder are worn out	Replace	1-S68, 1-S72
	Incorrect valve clearance	Adjust valve clearance	1-S14
The starter does not operate	Discharged battery	Charge or replace	–
	Starter is defective	Repair or replace	1-S19
	The key switch is defective	Replace	–
	The connection of the wires is incorrect	Examine or correct	–

Symptom	Probable Cause	Solution	Reference Page
The engine revolution is not smooth	The fuel filter is clogged	Replace	G-17
	The air cleaner is clogged	Clean or replace the air cleaner element	G-15
	Fuel leakage because of loose injection pipe retaining nut	Tighten the retaining nut	1-S30
	The supply pump is defective	Replace	1-S41
	The injector is defective	Replace	1-S35
	The turbocharger bearing is worn out	Replace the turbocharger assembly	1-S28
	The turbocharger shaft is bent	Replace the turbocharger assembly	1-S28
	The turbocharger fin or other part has a damage because of unwanted materials	Replace the turbocharger assembly	1-S28
The exhaust gas is white or blue	Too much engine oil	Reduce it to the specified level	G-11
	The piston ring, piston and cylinder is worn out	Replace the piston ring or piston, or repair the cylinder	1-S68, 1-S72
There is oil leakage into the exhaust pipe or suction pipe	The oil pipe is clogged or has a damage	Examine, replace or clean the oil pipe	–
	The piston ring seal of the turbocharger is defective	Replace the turbocharger assembly	1-S28
The exhaust gas is black or dark gray	Filter comp (DPF) is defective	Replace	1-S26
	Overload	Decrease the load	–
	The grade of the fuel is low	Replace the specified fuel	I-5, G-9
	The fuel filter is clogged	Replace	G-17
	The air cleaner is clogged	Clean or replace the element	G-15
	The injector is defective	Replace	1-S35
The output is deficient	The moving parts of engine have a seizure	Repair or replace	–
	The supply pump is defective	Replace	1-S41
	The injector is defective	Replace	1-S35
	There is compression leakage	Examine the compression pressure and repair	1-S13
	There is a gas leakage from the exhaust system	Repair or replace	1-S20, 1-S28
	The air cleaner is clogged	Clean or replace the element	G-15
	There is an air leakage from the compressor discharge side	Replace the turbocharger assembly	1-S28

Symptom	Probable Cause	Solution	Reference Page
The lubricant oil consumption is too much	The gap of the piston ring points to the same direction	Move the ring gap direction	1-S47
	The oil ring is worn out or cannot move	Replace	1-S48, 1-S68
	The piston ring groove is worn out	Replace the piston and piston ring	1-S68
	The valve stem and valve guide are worn out	Replace	1-S40
	The crankshaft bearing and the crank pin bearing is worn out	Replace	1-S70, 1-S71
The fuel is mixed into the lubricant oil	The injector is defective	Replace	1-S35
	Fuel leak from the overflow pipe of the inner cylinder head cover	Replace the gasket	–
	Oil dilution due to regeneration	Change the engine oil	G-11
Water is mixed into the lubricant oil	The head gasket is defective	Replace	1-S38, 1-S39
	The cylinder block or cylinder head is defective	Replace	1-S38
The oil pressure is low	The engine oil is not sufficient	Replenish oil to the specified amount	G-11
	The oil strainer is clogged	Clean	1-S46
	The relief valve does not operate with dirt	Repair or replace	1-S44
	The oil clearance of the bearings are too much	Replace the metal, bushing or shaft	1-S46, 1-S54, 1-S70, 1-S71
	The oil passage is clogged	Clean	–
	The type of oil used is incorrect	Use the specified type of oil	I-5, G-9
	The oil pump is defective	Replace	1-S72
The oil pressure is high	The type of oil used is incorrect	Use the specified type of oil	I-5, G-9
	The relief valve is defective	Repair or replace	1-S44

Symptom	Probable Cause	Solution	Reference Page
The engine is overheated	The engine oil is not sufficient	Replenish oil to the specified amount	I-5, G-9
	The fan belt is broken or the fan belt tension is too loose	Replace or adjust	1-S15, 1-S16
	The coolant is not sufficient	Replenish to the specified amount	G-12
	The radiator net and the radiator fin are clogged with dust	Clean	–
	There is corrosion in the inner side of the radiator	Clean or replace	G-31, G-32
	There is clogged in the coolant flow route	Clean or replace	G-31, G-32
	The radiator or radiator cap is defective	Replace	1-S16
	The load is too much	Reduce the load	–
	The head gasket is defective	Replace	1-S38, 1-S39
	The fuel used is incorrect	Replace the specified fuel	I-5, G-9

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2. SERVICING SPECIFICATIONS

ENGINE BODY

Item		Factory Specification	Allowable Limit
Cylinder Head Surface	Flatness	–	0.005 mm 0.002 in.
Top Clearance		0.70 to 0.90 mm 0.028 to 0.035 in.	–
Compression Pressure		3.09 to 3.28 MPa / 200 min^{-1} (rpm) 31.5 to 33.5 kgf/cm^2 / 200 min^{-1} (rpm) 448 to 476 psi / 200 min^{-1} (rpm)	2.41 MPa / 200 min^{-1} (rpm) 24.6 kgf/cm^2 / 200 min^{-1} (rpm) 350 psi / 200 min^{-1} (rpm)
Variance Among Cylinders		–	10 % or less
Valve Seat	Angle (Intake)	1.0 rad 60 °	–
	Angle (Exhaust)	0.79 rad 45 °	–
	Width (Intake)	1.5 to 1.9 mm 0.059 to 0.074 in.	–
	Width (Exhaust)	2.0 to 2.3 mm 0.079 to 0.091 in.	–
Valve Face	Angle (Intake)	1.0 rad 60 °	–
	Angle (Exhaust)	0.79 rad 45 °	–
Valve Recessing	Intake	0.60 to 0.80 mm 0.024 to 0.031 in.	1.2 mm 0.047 in.
	Exhaust	0.85 to 1.05 mm 0.0335 to 0.0413 in.	1.2 mm 0.047 in.
Valve Stem to Valve Guide	Clearance (Intake)	0.035 to 0.065 mm 0.0014 to 0.0025 in.	0.1 mm 0.004 in.
• Valve Stem	O.D. (Intake)	6.960 to 6.975 mm 0.2741 to 0.2746 in.	–
• Valve Guide	I.D. (Intake)	7.010 to 7.025 mm 0.2760 to 0.2765 in.	–
Valve Stem to Valve Guide	Clearance (Exhaust)	0.035 to 0.065 mm 0.0014 to 0.0025 in.	0.1 mm 0.004 in.
• Valve Stem	O.D. (Exhaust)	6.960 to 6.975 mm 0.2741 to 0.2746 in.	–
• Valve Guide	I.D. (Exhaust)	7.010 to 7.025 mm 0.2760 to 0.2765 in.	–
Valve Clearance (Cold)		0.23 to 0.27 mm 0.0091 to 0.010 in	–

Item		Factory Specification	Allowable Limit
Intake Valve Timing	Open	0.24 rad (14 °) before T.D.C.	–
	Close	0.63 rad (36 °) after B.D.C.	–
Exhaust Valve Timing	Open	0.79 rad (45 °) before B.D.C.	–
	Close	0.30 rad (17 °) after T.D.C.	–
Valve Spring	Free Length (Intake)	35.1 to 35.6 mm 1.39 to 1.40 in.	34.6 mm 1.36 in.
	Free Length (Exhaust)	35.1 to 35.6 mm 1.39 to 1.40 in.	34.6 mm 1.36 in.
	Tilt	–	1.0 mm 0.039 in.
Valve Spring	Setting Load / Setting Length (Intake)	63.5 N / 31.5 mm 6.48 kgf / 31.5 mm 14.3 lbf / 1.24 in.	45.9 N / 31.5 mm 4.68 kgf / 31.5 mm 10.3 lbf / 1.24 in.
	Setting Load / Setting Length (Exhaust)	63.5 N / 31.5 mm 6.48 kgf / 31.5 mm 14.3 lbf / 1.24 in.	45.9 N / 31.5 mm 4.68 kgf / 31.5 mm 10.3 lbf / 1.24 in.
Rocker Arm Shaft to Rocker Arm	Clearance	0.016 to 0.045 mm 0.00063 to 0.0017 in.	0.15 mm 0.0059 in.
• Rocker Arm Shaft	O.D.	15.973 to 15.984 mm 0.62886 to 0.62929 in.	–
• Rocker Arm	I.D.	16.000 to 16.018 mm 0.62993 to 0.63062 in.	–
Valve Bridge Arm and Valve Bridge Arm Shaft	Clearance	0.018 to 0.042 mm 0.00071 to 0.0016 in.	0.15 mm 0.0059 in.
• Valve Bridge Arm	I.D.	9.050 to 9.065 mm 0.3563 to 0.3568 in.	–
• Valve Bridge Arm Shaft	O.D.	9.023 to 9.032 mm 0.3552 to 0.3555 in.	–
Push Rod	Alignment	–	0.25 mm 0.0098 in.
Tappet to Tappet Guide	Clearance	0.020 to 0.062 mm 0.00079 to 0.0024 in.	0.07 mm 0.003 in.
• Tappet Guide Bore	I.D.	24.000 to 24.021 mm 0.94489 to 0.94570 in.	–
• Tappet	O.D.	23.959 to 23.980 mm 0.94327 to 0.94409 in.	–

Item		Factory Specification	Allowable Limit
Camshaft	Side Clearance	0.070 to 0.22 mm 0.0028 to 0.0086 in.	0.30 mm 0.012 in.
	Alignment	–	0.01 mm 0.0004 in.
Cam Height	Intake	37.64 mm 1.482 in.	37.14 mm 1.462 in.
	Exhaust	38.96 mm 1.534 in.	38.46 mm 1.514 in.
Camshaft	Oil Clearance	0.050 to 0.091 mm 0.0020 to 0.0035 in.	0.15 mm 0.0059 in.
• Camshaft Journal	O.D.	45.934 to 45.950 mm 1.8085 to 1.8090 in.	–
• Camshaft Bearing	I.D.	46.000 to 46.025 mm 1.8111 to 1.8120 in.	–
Timing Gear Idle Gear 1 to Crank Gear	Backlash	0.0490 to 0.193 mm 0.00193 to 0.00759 in.	0.22 mm 0.0087 in.
Idle Gear 1 to Cam Gear	Backlash	0.0490 to 0.189 mm 0.00193 to 0.00744 in.	0.22 mm 0.0087 in.
Idle Gear 1 to Idle Gear 2	Backlash	0.0440 to 0.185 mm 0.00174 to 0.00728 in.	0.22 mm 0.0087 in.
Idle Gear 2 to Supply Pump Gear	Backlash	0.0440 to 0.177 mm 0.00174 to 0.00696 in.	0.22 mm 0.0087 in.
Idle Gear Shaft 1,2 to Idle Gear 1,2 Bushing	Oil Clearance	0.050 to 0.091 mm 0.0020 to 0.0035 in.	0.10 mm 0.0039 in.
• Idle Gear 1,2 Bushing	I.D.	45.025 to 45.050 mm 1.7727 to 1.7736 in.	–
• Idle Gear Shaft 1,2	O.D.	44.959 to 44.975 mm 1.7701 to 1.7706 in.	–
Idle Gear	Side Clearance	0.15 to 0.30 mm 0.0059 to 0.011 in.	0.90 mm 0.035 in.
Piston Pin Bore	I.D.	30.006 to 30.013 mm 1.1814 to 1.1816 in.	30.05 mm 1.183 in.
Top Ring to Ring Groove	Clearance	0.05 to 0.09 mm 0.002 to 0.003 in.	0.15 mm 0.0059 in.
Second Ring to Ring Groove	Clearance	0.0930 to 0.120 mm 0.00367 to 0.00472 in.	0.20 mm 0.0079 in.
Oil Ring to Ring Groove	Clearance	0.020 to 0.060 mm 0.00079 to 0.0023 in.	0.15 mm 0.0059 in.

Item		Factory Specification	Allowable Limit
Piston Ring Gap	Top Ring	0.30 to 0.45 mm 0.012 to 0.017 in.	1.25 mm 0.0492 in.
	Second Ring	0.30 to 0.45 mm 0.012 to 0.017 in.	1.25 mm 0.0492 in.
	Oil Ring	0.025 to 0.045 mm 0.0099 to 0.017 in.	1.25 mm 0.0492 in.
Connecting Rod	Alignment	–	0.05 mm 0.002 in.
Piston Pin to Small End Bushing	Clearance	0.020 to 0.040 mm 0.00079 to 0.0015 in.	0.15 mm 0.0059 in.
• Piston Pin	O.D.	30.006 to 30.011 mm 1.1814 to 1.1815 in.	–
• Small End Bushing	I.D.	30.031 to 30.046 mm 1.1824 to 1.1829 in.	–
Crankshaft	Side Clearance	0.15 to 0.31 mm 0.0059 to 0.012 in.	0.50 mm 0.020 in.
	Alignment	–	0.02 mm 0.0008 in.
Crankshaft Journal to Crankshaft Bearing	Oil Clearance	0.018 to 0.062 mm 0.00071 to 0.0024 in.	0.20 mm 0.0079 in.
• Crankshaft Journal	O.D.	74.977 to 74.990 mm 2.9519 to 2.9523 in.	–
Crank Pin to Pin Bearing	Oil Clearance	0.018 to 0.051 mm 0.00071 to 0.0020 in.	0.20 mm 0.0079 in.
• Crank Pin	O.D	52.977 to 52.990 mm 2.0857 to 2.0862 in.	–
Cylinder Bore	I.D.	100.000 to 100.022 mm 3.93701 to 3.93787 in.	100.150 mm 3.9429 in.
Cylinder Bore (Oversize)	I.D.	100.500 to 100.522 mm 3.95670 to 3.95755 in.	100.650 mm 3.96260 in.

LUBRICATING SYSTEM

Item		Factory Specification	Allowable Limit
Engine Oil Pressure	At Idle Speed	–	50 kPa 0.5 kgf/cm^2 7 psi
	At Rated Speed	200 to 390 kPa 2.0 to 4.0 kgf/cm^2 29 to 56 psi	150 kPa 1.5 kgf/cm^2 21 psi
Engine Oil Pressure Switch	Working Pressure	40 to 50 kPa 0.4 to 0.6 kgf/cm^2 6 to 8 psi	–
Inner Rotor to Outer Rotor	Clearance	0.040 to 0.16 mm 0.0016 to 0.0062 in.	0.3 mm 0.01 in.
Outer Rotor to Pump Body	Clearance	0.100 to 0.184 mm 0.00394 to 0.00724 in.	0.3 mm 0.01 in.
Inner Rotor to Cover	Clearance	0.025 to 0.075 mm 0.00099 to 0.0029 in.	0.225 mm 0.00886 in.

COOLING SYSTEM

Item		Factory Specification	Allowable Limit
Thermostat	Valve Opening Temperature	74.5 to 78.5 °C 166.1 to 173.3 °F	–
	Valve Full Opening Temperature (Opened Completely)	90 °C 194 °F	–
Radiator	Water Tightness	No leak at specified pressure	–
Radiator Cap	Air Leakage	10 seconds or more 90 → 60 kPa 0.9 → 0.6 kgf/cm^2 10 → 9 psi	
Fan Belt	Tension	10 to 12 mm / 98 N 0.40 to 0.47 in. / 98 N (10 kgf, 22 lbf)	–

ELECTRICAL SYSTEM

Item		Factory Specification	Allowable Limit
Commutator	O.D.	32.0 mm 1.26 in.	31.4 mm 1.24 in.
Mica	Undercut	0.50 mm 0.020 in.	0.2 mm 0.0079 in.
Brush (Starter)	Length	18.0 mm 0.709 in.	11.0 mm 0.433 in.
Rotor Coil	Resistance	2.8 to 3.3 Ω	–
Slip Ring	O.D.	22.7 mm 0.894 in.	22.1 mm 0.870 in.
Brush (Alternator)	Length	10.0 mm 0.394 in.	1.5 mm 0.059 in.
Intake Air Heater	Resistance (at cold occasion)	Approx. 0.3 Ω	–

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3. TIGHTENING TORQUES

Use a torque wrench to tighten the screws, bolts and nuts to the specified torque. Tighten the screws, bolts and nuts used, such as on the cylinder head in the correct sequence and torque.

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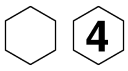
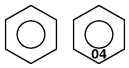
[1] TIGHTENING TORQUES OF SCREWS, BOLTS AND NUTS FOR GENERAL USE

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	7.9 to 9.3	0.80 to 0.95	5.8 to 6.8	9.81 to 11.2	1.00 to 1.15	7.24 to 8.31
M8	18 to 20	1.8 to 2.1	13 to 15	24 to 27	2.4 to 2.8	18 to 20
M10	40 to 45	4.0 to 4.6	29 to 33	49 to 55	5.0 to 5.7	37 to 41
M12	63 to 72	6.4 to 7.4	47 to 53	78 to 90	7.9 to 9.2	58 to 66

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[2] TIGHTENING TORQUES OF SCREWS, BOLTS AND NUTS FOR SPECIAL USE

■ **NOTE**

- **For the screws, bolts and nuts with the mark "*", apply 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.**

Item	Dimension × Pitch	N·m	kgf·m	lbf·ft
Injector clamp nut	M8 × 1.25	24 to 27	2.4 to 2.8	18 to 20
Overflow pipe joint screw	M6 × 1.0	9.81 to 11.2	1.00 to 1.15	7.24 to 8.31
Cylinder head cover 1 screw	M6 × 1.0	6.87 to 11.2	0.700 to 1.15	5.07 to 8.31
Cylinder head cover 2 screw	M6 × 1.0	9.81 to 11.2	1.00 to 1.15	7.24 to 8.31
Injection pipe retaining nut	M12 × 1.5	23 to 36	2.3 to 3.7	17 to 26
Oil pressure switch taper screw	R 1/8	15 to 19	1.5 to 2.0	11 to 14
Supply pump mounting nut	M8 × 1.25	24 to 27	2.4 to 2.8	18 to 20
Supply pump gear mounting nut	M14 × 1.5	59 to 68	6.0 to 7.0	44 to 50
Overflow pipe joint screw	M8	7.9 to 12	0.80 to 1.3	5.8 to 9.4
Overflow pipe joint screw	M10	16 to 19	1.6 to 2.0	12 to 14
Supply pump gear cover mounting screw	M8 × 1.25	24 to 27	2.4 to 2.8	18 to 20
Common rail mounting screw	M8 × 1.25	24 to 27	2.4 to 2.8	18 to 20
Coolant temperature sensor	–	16 to 23	1.6 to 2.4	12 to 17
Camshaft position sensor mounting screw	–	4 to 5	0.4 to 0.6	3 to 4
Crankshaft position sensor mounting screw	–	4 to 5	0.4 to 0.6	3 to 4
Intake air temperature sensor	–	30 to 39	3.0 to 4.0	22 to 28
Injector terminal nut	–	1.6 to 2.2	0.16 to 0.23	1.2 to 1.6
Rocker arm bracket nut	M10 × 1.25	49 to 55	5.0 to 5.7	37 to 41
*Cylinder head mounting screw	M12 × 1.25	98.1 to 107	10.0 to 11.0	72.4 to 79.5
Oil cooler joint screw	M20 × 1.5	40 to 44	4.0 to 4.5	29 to 32
*Crankshaft screw	M16 × 1.5	255 to 274	26.0 to 28.0	188 to 202
Gear case cover mounting screw	M8 × 1.25	24 to 27	2.4 to 2.8	18 to 20
Relief valve retaining screw	M22 × 1.5	69 to 78	7.0 to 8.0	51 to 57
Idle gear mounting screw	M8 × 1.25	24 to 27	2.4 to 2.8	18 to 20
Camshaft set screw	M8 × 1.25	24 to 27	2.4 to 2.8	18 to 20
Mounting screw of camshaft position pulsar gear	M5	4.7 to 5.6	0.48 to 0.58	3.5 to 4.1
Plate mounting screw	M8 × 1.25	24 to 27	2.4 to 2.8	18 to 20
*Connecting rod screw	M10 × 1.25	79 to 83	8.0 to 8.5	58 to 61
*Flywheel screw	M12 × 1.25	98.1 to 107	10.0 to 11.0	72.4 to 79.5
Flywheel housing mounting screw	M12 × 1.25	78 to 90	7.9 to 9.2	58 to 66
Crankcase 2 mounting screw	M10 × 1.25	49 to 55	5.0 to 5.7	37 to 41
*Main bearing case screw	M14 × 1.5	138 to 147	14.0 to 15.0	102 to 108

Item	Dimension × Pitch	N·m	kgf·m	lbf·ft
Bearing case cover mounting screw	M8 × 1.25	24 to 27	2.4 to 2.8	18 to 20
Intake air heater terminal nut	M6 × 1.0	3.5 to 5.3	0.35 to 0.55	2.6 to 3.9
B terminal nut of starter	M8 × 1.25	9.8 to 11	1.0 to 1.2	7.3 to 8.6
Pulley nut of alternator	–	58.4 to 78.9	5.95 to 8.05	43.1 to 58.2
Oil pump cover screw	M6	7.9 to 9.3	0.80 to 0.95	5.8 to 6.8
Diesel Particulate Filter (hereinafter referred to as the "DPF") stay 1	M8 × 1.25	24 to 27	2.4 to 2.8	18 to 20
	M10 × 1.25	49 to 55	5.0 to 5.7	37 to 41
DPF stay 2	M10 × 1.25	49 to 55	5.0 to 5.7	37 to 41
Screw of muffler flange	M10 × 1.25	49 to 55	5.0 to 5.7	37 to 41
Muffler full assembly (DPF) mounting screw	M10 × 1.25	49 to 55	5.0 to 5.7	37 to 41
DPF bracket mounting screw	M12 × 1.25	78 to 90	7.9 to 9.2	58 to 66
Filter comp (DPF) mounting screw	M10 × 1.25	49 to 55	5.0 to 5.7	37 to 41
Temperature sensor	M12 × 1.25	25 to 34	2.5 to 3.5	18 to 25
Differential pressure pipe	M12 × 1.0	16 to 22	1.6 to 2.3	12 to 16
Exhaust manifold mounting nut (Serial No.: below BXZ999)	M8 × 1.25	24 to 27	2.4 to 2.8	18 to 20
Exhaust manifold mounting nut (Serial No.: above BY0001 and 2CL0001)	M8 × 1.25	30 to 34	3.0 to 3.5	22 to 25
EGR cooler flange screw (Serial No.: below BZZ999)	M8 × 1.25	24 to 27	2.4 to 2.8	18 to 20
EGR cooler flange screw (Serial No.: above CA0001 and 2CL0001)	M8 × 1.25	30 to 34	3.0 to 3.5	22 to 25
Boost sensor mounting screw	–	4 to 5	0.4 to 0.6	3 to 4
Air flow sensor mounting screw	M4 × 0.7	1.17 to 1.77	0.120 to 0.180	0.863 to 1.30

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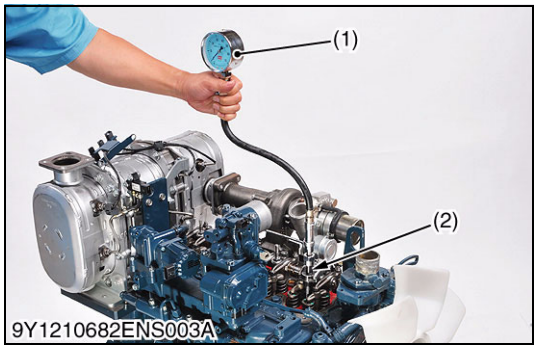
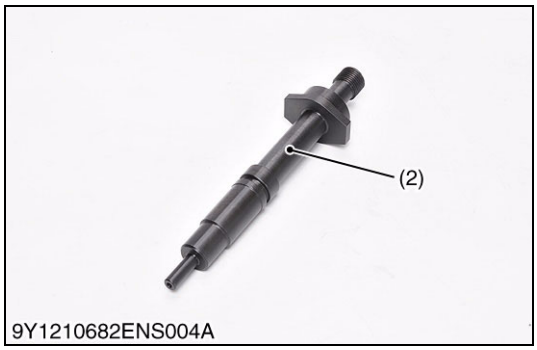
4. CHECKING, DISASSEMBLING AND SERVICING

[1] CHECKING AND ADJUSTING

(1) Engine Body





Compression Pressure

1. After warming-up the engine.
2. Remove the air cleaner, muffler and EGR cooler pipe.
3. Remove the injection pipe, cylinder head cover, overflow pipe, injectors and gaskets of injector.
4. Set a compression tester (1) (Code No.: 07909-30208) with the adaptor (2) to the injector hole.
5. Crank the engine with the starter to operate the engine approx. 200 min^{-1} (rpm).
6. Measure a maximum value of the compression pressure. Do the same steps twice for each cylinder.

■ **NOTE**

- **Examine 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 %.**

Compression pressure	Factory specification	3.09 to 3.28 MPa / 200 min^{-1} (rpm) 31.5 to 33.5 kgf/cm^2 / 200 min^{-1} (rpm) 448 to 476 psi / 200 min^{-1} (rpm)
	Allowable limit	2.41 MPa / 200 min^{-1} (rpm) 24.6 kgf/cm^2 / 200 min^{-1} (rpm) 350 psi / 200 min^{-1} (rpm)

Tightening torque	Injector clamp nut	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft
	Overflow pipe joint screw (M6 × 1.0)	9.81 to 11.2 N·m 1.00 to 1.15 kgf·m 7.24 to 8.31 lbf·ft
	Cylinder head cover 1 screw	6.87 to 11.2 N·m 0.700 to 1.15 kgf·m 5.07 to 8.31 lbf·ft
	Cylinder head cover 2 screw	9.81 to 11.2 N·m 1.00 to 1.15 kgf·m 7.24 to 8.31 lbf·ft
	Injection pipe retaining nut	23 to 36 N·m 2.3 to 3.7 kgf·m 17 to 26 lbf·ft

(1) Compression Tester (2) Injector Adaptor

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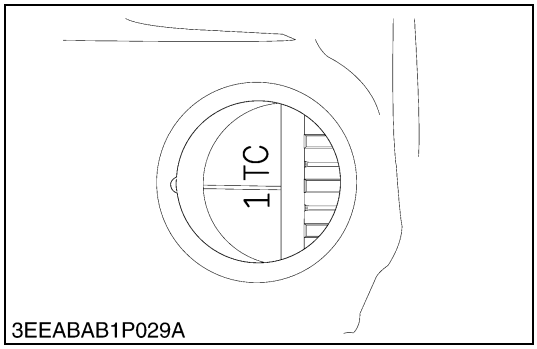

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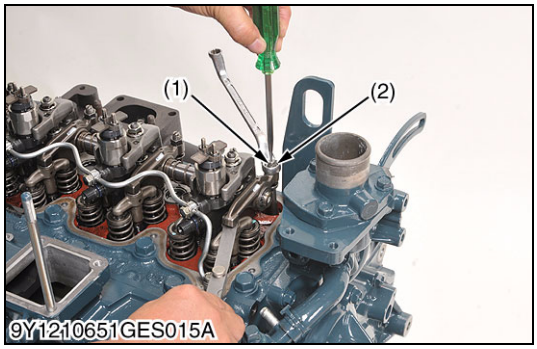

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Valve Clearance

■ **IMPORTANT**

- **You must examine and adjust the valve clearance when the engine is cold.**

1. Remove the injection pipes and cylinder head cover.
2. Align the "1TC" mark line on the flywheel and projection on the housing.
3. Make sure that the No.1 piston comes to the compression or overlap top dead center.
4. Examine the subsequent valve clearance at the mark "1TC" with a feeler gauge.
5. If the clearance is out of the factory specifications, adjust with the adjusting screw (1).
6. Tighten the lock nut (2) of the adjusting screw.

Valve clearance (cold)	Factory specification	0.23 to 0.27 mm 0.0091 to 0.010 in.

■ **NOTE**

- **After you adjust the valve clearance, tighten the lock nut (2) of the adjusting screw.**

Adjustable Cylinder Location of Piston		IN.	EX.
When No. 1 piston is at compression top dead center	1	☆	☆
	2	☆	
	3		☆
	4		
When No. 1 piston is at overlap position	1		
	2		☆
	3	☆	
	4	☆	☆

Tightening torque	Injector clamp nut	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft
	Overflow pipe joint screw (M6 × 1.0)	9.81 to 11.2 N·m 1.00 to 1.15 kgf·m 7.24 to 8.31 lbf·ft
	Cylinder head cover 1 screw	6.87 to 11.2 N·m 0.700 to 1.15 kgf·m 5.07 to 8.31 lbf·ft
	Cylinder head cover 2 screw	9.81 to 11.2 N·m 1.00 to 1.15 kgf·m 7.24 to 8.31 lbf·ft
	Injection pipe retaining nut	23 to 36 N·m 2.3 to 3.7 kgf·m 17 to 26 lbf·ft

(1) Adjusting Screw (2) Lock Nut

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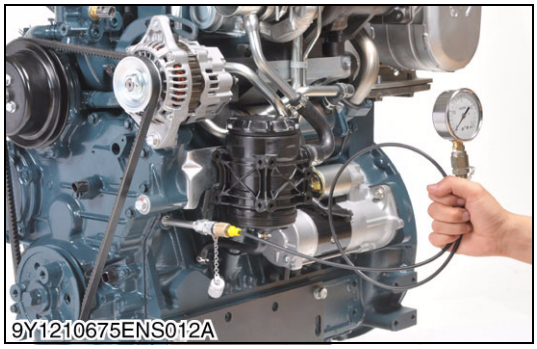
(2) Lubricating System



Engine Oil Pressure

1. Remove the engine oil pressure switch, and set the oil pressure tester (Code No.: 07916-32032).
2. Operate the engine for warming-up.
3. Measure the oil pressure at the idle speed and rated speed.
4. If the oil pressure is less than the allowable limit, do a check below.
   - Engine oil level
   - Oil pump
   - Oil strainer
   - Oil filter cartridge
   - Oil passage
   - Oil clearance
   - Relief valve

(When reassembling)

- After you examine the oil pressure of the engine, tighten its oil pressure switch to the specified torque.

Engine oil pressure	At idle speed	Allowable limit	50 kPa 0.5 kgf/cm^2 7 psi
	At rated speed	Factory specification	200 to 390 kPa 2.0 to 4.0 kgf/cm^2 29 to 56 psi
		Allowable limit	150 kPa 1.5 kgf/cm^2 21 psi

Tightening torque	Oil pressure switch taper screw	15 to 19 N·m 1.5 to 2.0 kgf·m 11 to 14 lbf·ft

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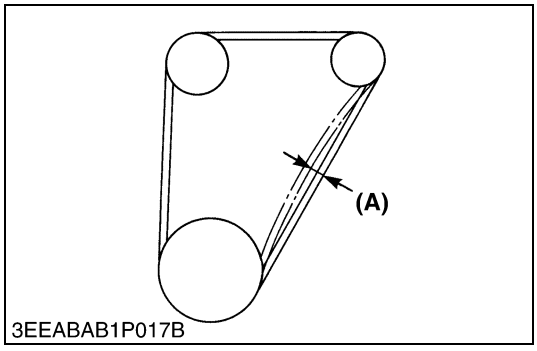
(3) Cooling System



Fan Belt Tension

1. Push the belt halfway between the fan drive pulley and alternator pulley at a specified force 98 N (10 kgf, 22 lbf) to measure the deflection **(A)**.
2. If the measurement is out of the factory specifications, loosen the alternator mounting screws and adjust its position.

Deflection **(A)**	Factory specification	10 to 12 mm 0.40 to 0.47 in.

(A) Deflection

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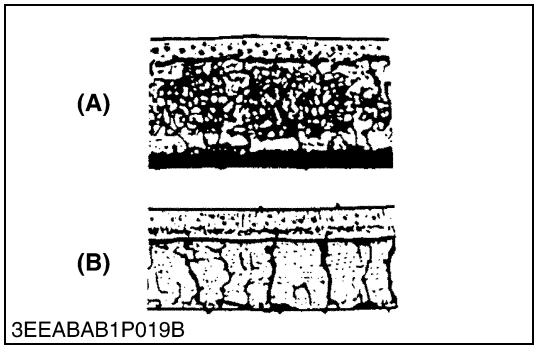

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Fan Belt Damage and Wear

1. Examine the fan belt for damage.
2. If the fan belt has a damage, replace it.
3. Examine if the fan belt is worn out and sunk in the pulley groove.
4. If it is, replace it.

(A) Good **(B) Bad**

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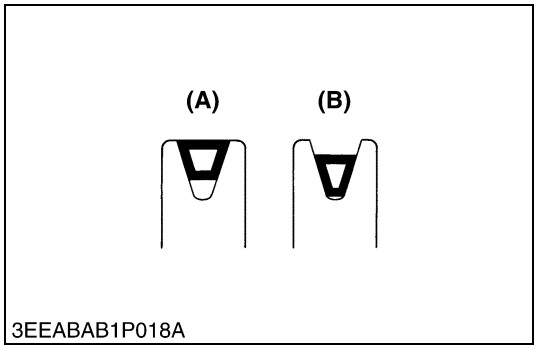

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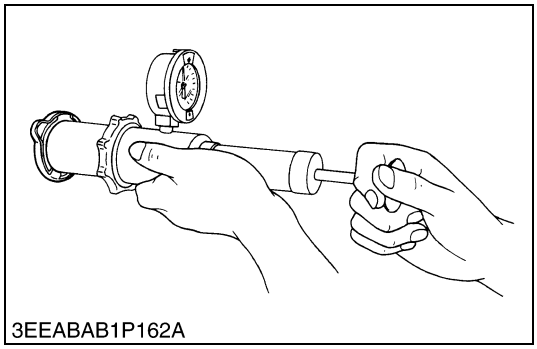
Radiator Cap Air Leakage

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.**

1. Set a radiator tester and an adaptor on the radiator cap.
2. Apply the specified pressure 90 kPa (0.9 kgf/cm^2, 10 psi).
3. Measure the time for the pressure to decrease to 60 kPa (0.6 kgf/cm^2, 9 psi).
4. If the measurement is less than the factory specification, replace the radiator cap.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Pressure decreasing time	Factory specification	More than 10 seconds for pressure decrease from 90 to 60 kPa (from 0.9 to 0.6 kgf/cm^2, from 10 to 9 psi)

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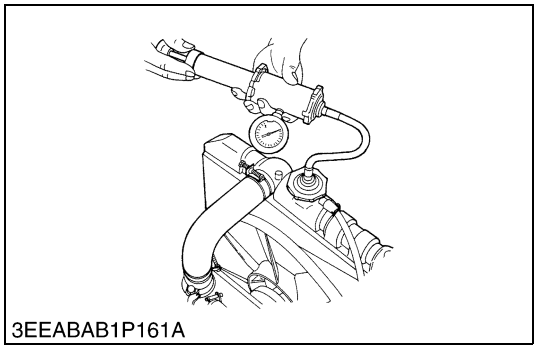
Radiator Water Leakage

1. Fill a specified quantity of water into the radiator.
2. Set a radiator tester and an adaptor on the radiator. Increase the water pressure to the specified pressure with the radiator tester and adaptor.
3. Examine the radiator for water leakage.
4. For water leakages from the pinhole, replace the radiator or repair with the radiator cement. When water leak is too much, replace the radiator.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Radiator water leakage test	Factory specification	No leak at specified pressure

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.**

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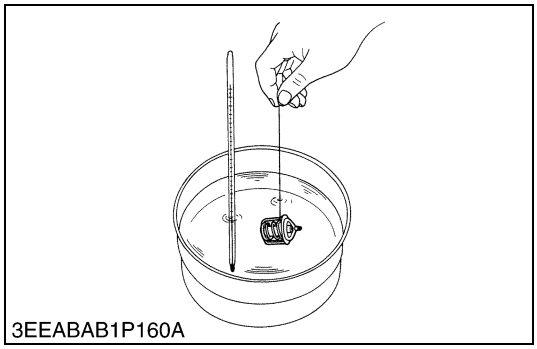
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Opening-temperature of Thermostat Valve

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. As the water temperature rises, the valve will open, and the thermostat will separate from the thread. Measure the temperature at this moment.
4. Continue to increase the temperature and read the temperature when the valve opens approximately 8 mm (0.3 in.).
5. If the measurement is out of the factory specifications, replace the thermostat.

Thermostat valve opening temperature	Factory specification	74.5 to 78.5 °C 166.1 to 173.3 °F
Full opening temperature	Factory specification	90 °C 194 °F

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(4) Electrical System

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.**

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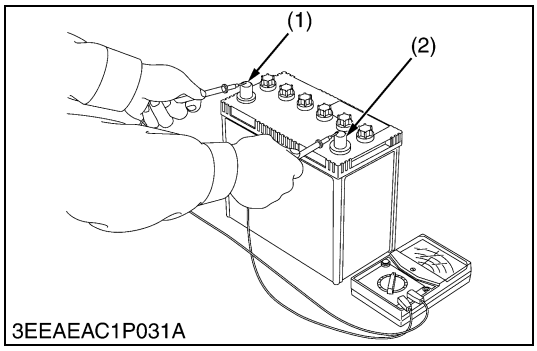

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Battery Voltage

1. Stop the engine.
2. Measure the voltage with a circuit tester between the battery terminals.
3. If the battery voltage is less than the factory specification, examine the battery specific gravity and charge the battery.

Battery voltage	Factory specification	More than 24 V

(1) Positive Terminal (2) Negative Terminal

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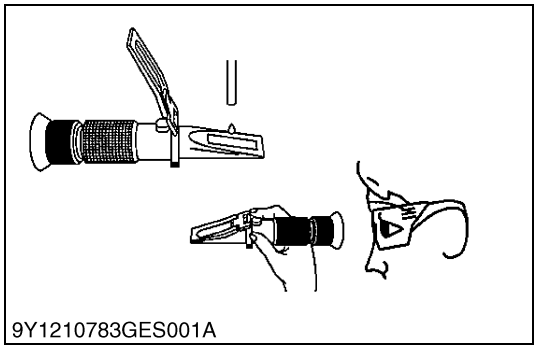
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Battery Specific Gravity

CAUTION

- **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, replenishing 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.**

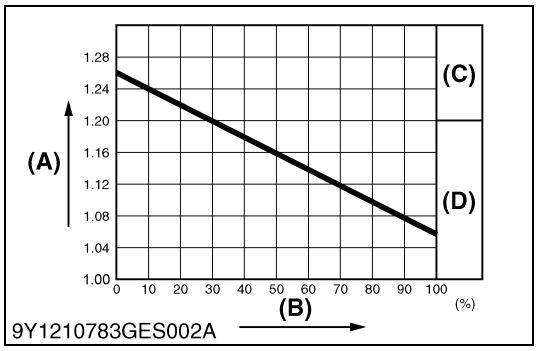
(Measurement items)

■ **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 fluid**

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.



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(Reference)

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 °C (68 °F))**
  D_{20} = Dt + 0.0007 (t - 20)
  D_{20} = specific gravity value converted to standard temperature of 20 °C (68 °F)
  D_t = measured specific gravity value at the electrolyte temperature t °C

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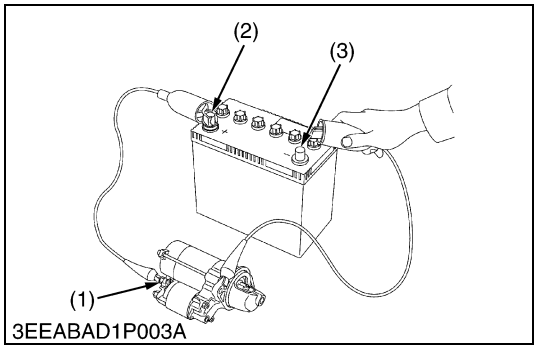

Motor Test

CAUTION

- **Hold the starter to prevent its movement when you do a test on the motor.**

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).
7. If the motor does not operate, starter is defective. Repair or replace the starter.

■ **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.**

(1) **C** Terminal
(2) Positive Terminal
(3) Negative Terminal

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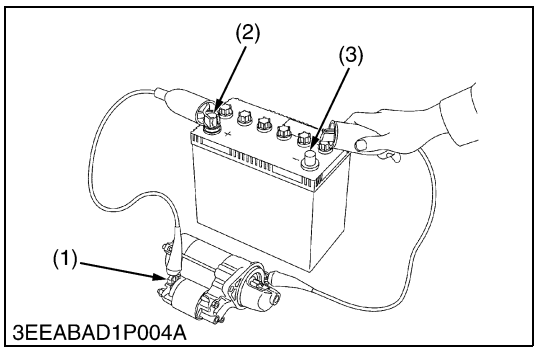

Magnetic Switch Test

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).
7. If the pinion gear does not come out, the magnetic switch is defective. Repair or replace the starter.

■ **NOTE**

- **B terminal: It is the terminal that connects the cable from the battery to the starter.**
- **S terminal: It is the terminal that connects the cable from the starter switch to the magnetic switch.**

(1) **S** Terminal
(2) Positive Terminal
(3) Negative Terminal

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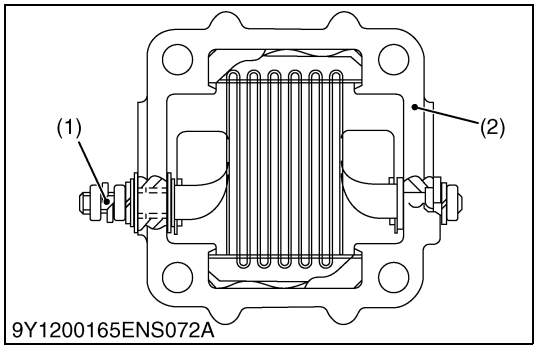

Intake Air Heater

1. Disconnect the leads from the intake air heater.
2. Measure the resistance between the positive terminal (1) and the air heater body (2).
3. If the resistance value is at 0 Ω (ground short), replace the intake air heater. If the resistance value is infinity, the heat coil is disconnected. Replace the intake air heater.

Resistance of the heater coil	24 V Specification	Approx. 0.3 Ω (Approx. 42 A: at 25 °C)

(1) Positive Terminal
(2) Intake Air Heater Body

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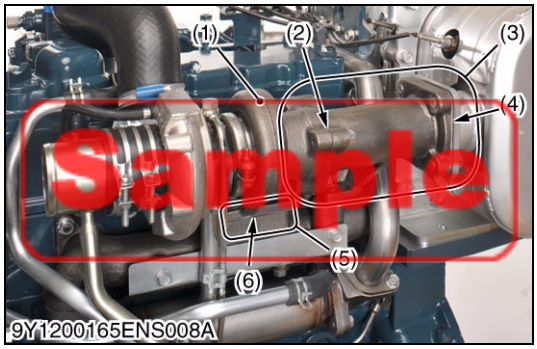
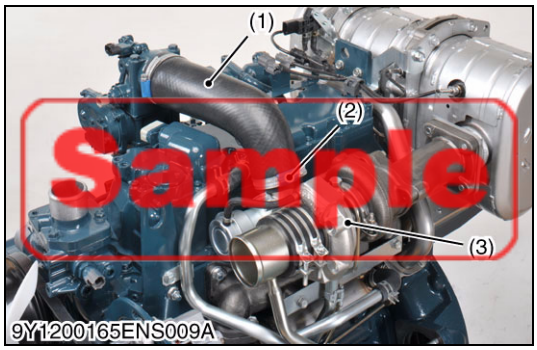
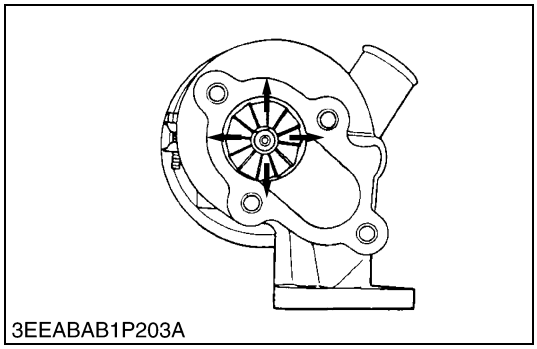
(5) Turbocharger







Exhaust Gas Leakage of Turbine Side

1. Examine the exhaust port (3) and the inlet port (5) side of the turbine housing (1) for exhaust gas leakage.
2. If you find a gas leakage, tighten the screws and nuts again or replace the gasket (2) / (4) / (6) with a new one.

(1) Turbine Housing
(2) Gasket
(3) Exhaust Port
(4) Gasket
(5) Inlet Port
(6) Gasket

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Air Leakage of Compressor Side

1. Examine the inlet hose (1) of the compressor cover (3) for air leakage.
2. Examine the suction side of the inlet hose for loose connections or cracks.
3. If you find an air leakage, change the clamps (2) and / or the inlet hose.

(1) Inlet Hose
(2) Clamp
(3) Compressor Cover

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Radial Clearance

1. If the wheel touches the housing, replace the turbocharger assembly with a new one.

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[2] DISASSEMBLING AND ASSEMBLING

(1) Draining Engine Oil and Coolant

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 the drain plug to drain the oil.
4. After you drain, tighten the drain plug.

(When reassembling)

- Fill the engine oil until the upper line on the dipstick.

■ **IMPORTANT**

- **Do not mix different types of oil.**
- **Use the correct SAE Engine Oil by reference to the ambient temperature.**

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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. Open the drain valve to drain the coolant.
3. After you drain, close the drain valve.

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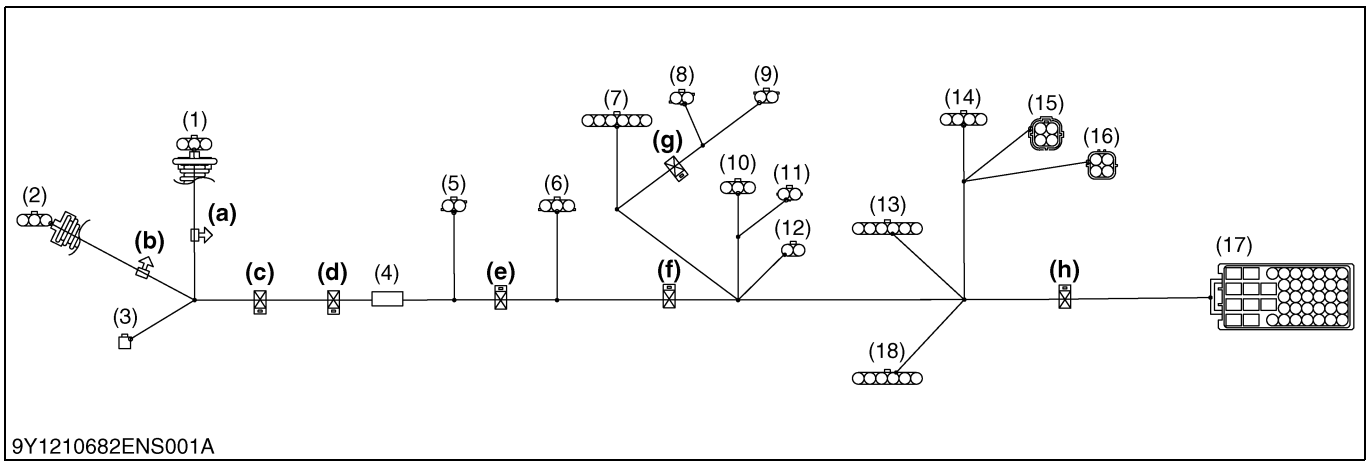
(2) External Components

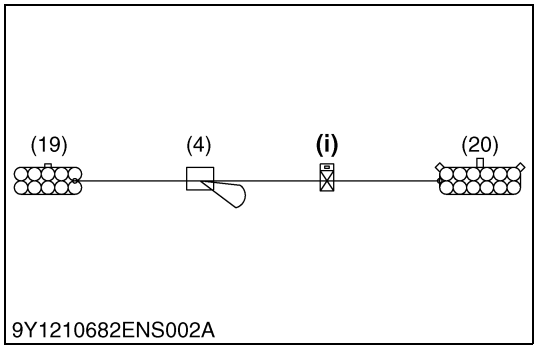
CRS Intermediate Harness

[A] Engine Intermediate Harness (Engine Side Harness)



(1) Camshaft Position (G) Sensor Connector (3P)
(2) Crankshaft Position (NE) Sensor Connector (3P)
(3) Oil Pressure Switch Connector (1P)
(4) Name Plate
(5) Coolant Temperature Sensor Connector (2P)
(6) Rail Pressure Sensor Connector (3P)
(7) Intake Throttle Valve Connector (6P)
(8) Fuel Temperature Sensor Connector (2P)
(9) SCV (Suction Control Valve) Connector (2P)
(10) Boost Pressure Sensor Connector (3P)
(11) Intake Air Temperature Sensor Connector (2P)
(12) Resistor 120 Ω (2P)
(13) Engine Joint Connector 1 (6P)
(14) EGR Valve Connector (3P)
(15) CAN Connector (4P)
(16) CAN Connector (4P)
(17) Engine Intermediate Connector
(18) Engine Joint Connector 2 (6P)
(a) to (h): Clamp

[B] Injector Intermediate Harness (Engine Side Harness)



(4) Name Plate
(19) Injector Connector (10P)
(20) Injector Intermediate Connector (12P)
(i) Clamp

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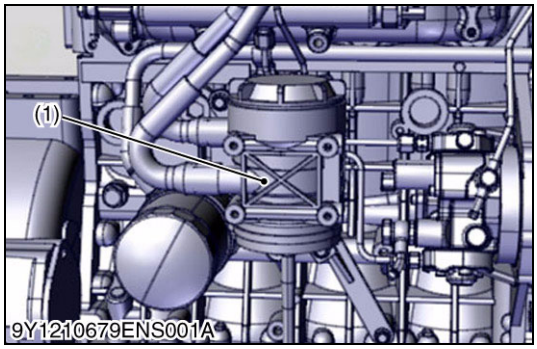

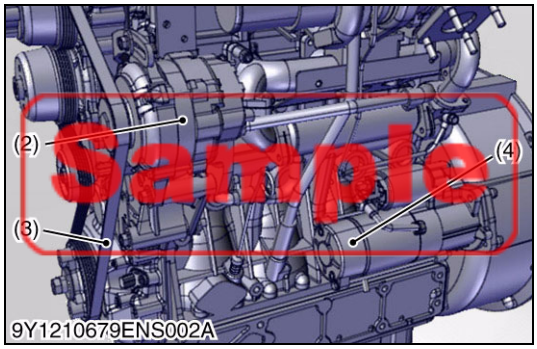

Air Cleaner and Others

1. Remove the air cleaner.
2. Remove the fan, fan belt (3), alternator (2) and starter (4).
3. Remove the oil separator (1).

(When reassembling)

- Examine for cracks on the belt surface.

■ IMPORTANT

- **After you assemble the fan belt, adjust the fan belt tension.**

(1) Oil Separator
(2) Alternator
(3) Fan Belt
(4) Starter

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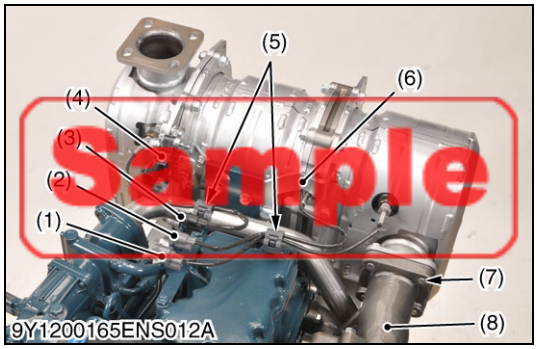

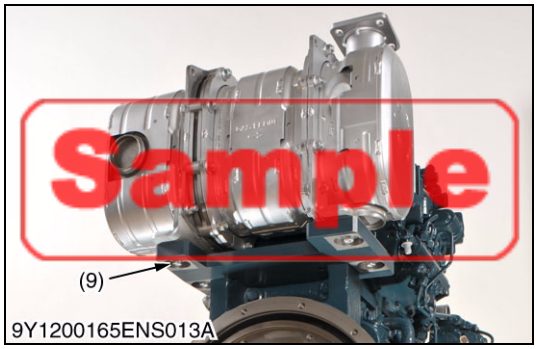

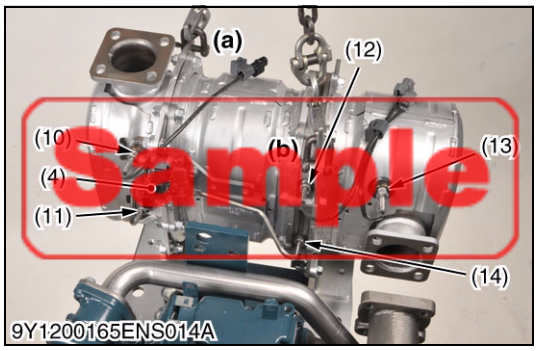

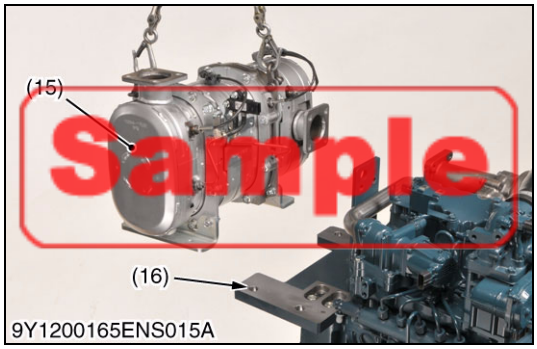

Muffler Full Assembly (DPF)

■ **IMPORTANT**

- **Since the DPF that was dropped or given a shock cannot be reused even if there is no damage outwardly, replace it with a new one.**
- **Be sure to loosen the temperature sensor tightening nut or the differential pressure pipe tightening nut with crowfoot wrench to prevent the damage of the sensor or pipe.**
  If it is still hard to loosen, apply the lubricant spray to threaded portion and soak it with lubricant.

■ **NOTE**

- **Always work in the workshop equipped with a electric hoist (including mobile hoist).**
- **Put a product (engine) on a stable ground, and set the parking brake.**
- **As the DPF muffler full assembly is hot just after the engine shutdown, make sure to start operation after it gets cool.**
- **Make sure not to let any foreign substances enter the opening section during the operation.**
- **Make sure not to damage the DPF muffler full assembly by falling or impact as it contains a ceramic filter.**
- **Before removing the DPF muffler full assembly from a product (engine), connect the diagnosis tool (Diagmaster), check the failure history, and save the project.**
- **Before removing the DPF for cleaning, keep the records of the engine serial number, filter comp (DPF) part number, filter comp (DPF) serial number, catalyst (DOC) part number, catalyst (DOC) serial number, and engine operating time, which are required in preparing the DPF cleaning order from.**
  Since the engine operating time is recorded in the ECU, check the operating time by connecting the service tool (Diagmaster).
- **When installing and removing the muffler full assembly (DPF), make sure that the temperature sensor, differential pressure sensor, and differential pressure pipe do not make contact with surrounding parts.**

1. Disconnect the harness from the connector (1), (2), (3) of temperature sensor and differential pressure sensor (4).
2. Remove the connector (1), (2), (3) of temperature sensor from the bracket.
3. Remove the 2 clamps (5).
4. Remove the DPF stay 1 (6).
5. Remove the 4 screws (7) of muffler flange (8).
6. Remove the muffler full assembly (DPF) mounting screws (9).
7. Set the shackle to the position **(a)**, **(b)** of the muffler full assembly (DPF) (15). (Refer to the photo)
8. Hoist the muffler full assembly (DPF) (15) and remove the muffler full assembly (DPF) (15).
9. Remove the DPF bracket (16).

(To be continued)

(Continued)

(When reassembling)

- Replace the gaskets with new ones.
- If the differential pressure tube is damaged or cracked, replace it.
- When the differential pressure pipe (11), (14) and temperature sensor (10), (12), (13) is removed, wipe off the anti-seize & lubricating compound, apply a anti-seize & lubricating compound (Bostik, NEVER SEEZ, Pure Nickel Special Grade), and then attach them to their correct position.
- When replacing the differential pressure pipe (11), (14), apply a anti-seize & lubricating compound (Bostik, NEVER SEEZ, Pure Nickel Special Grade), and then attach it to its correct position.
- When replacing the temperature sensor, check that it is coated with anti-seize & lubricating compound, and then attach it to its correct position.
- Tighten bolts and nuts to their specified torque. Also tighten the temperature sensor tightening nut or the differential pressure pipe tightening nut to the specified torque with crowfoot wrench.
- After attaching the assembly, start the engine and make sure that there are no gas leaks.

Tightening torque	DPF Stay 1	M8	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft
		M10	49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	Screw of muffler flange		49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	Muffler full assembly (DPF) mounting screw		49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	DPF bracket mounting screw		78 to 90 N·m 7.9 to 9.2 kgf·m 58 to 66 lbf·ft

(1) Connector of Temperature Sensor (T_0)
(2) Connector of Temperature Sensor (T_1)
(3) Connector of Temperature Sensor (T_2)
(4) Differential Pressure Sensor
(5) Clamp
(6) DPF Stay 1
(7) Screw of Muffler Flange
(8) Muffler Flange
(9) Muffler Full Assembly (DPF) Mounting Screw
(10) Temperature Sensor (T_2)
(11) Differential Pressure Pipe
(12) Temperature Sensor (T_1)
(13) Temperature Sensor (T_0)
(14) Differential Pressure Pipe
(15) Muffler Full Assembly (DPF)
(16) DPF Bracket

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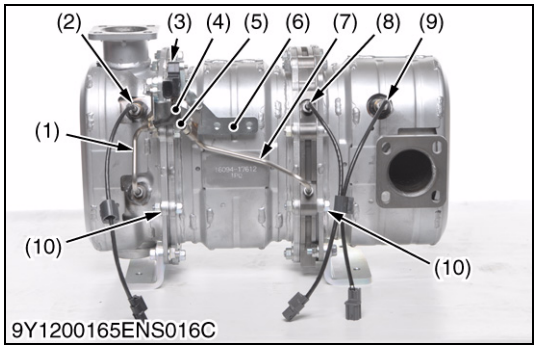

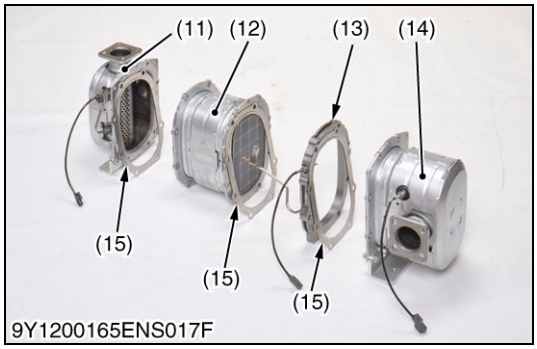

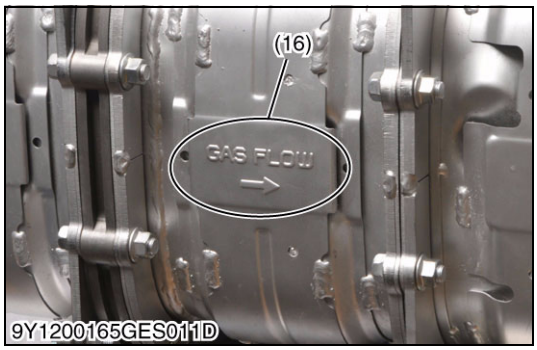

Filter Comp (DPF) (If necessary)

■ **NOTE**

- **Always work in the workshop equipped with a electric hoist (including mobile hoist).**
- **Put a product (engine) on a stable ground, and set the parking brake.**
- **As the DPF muffler full assembly is hot just after the engine shutdown, make sure to start operation after it gets cool.**
- **Make sure not to let any foreign substances enter the opening section during the operation.**
- **Make sure not to damage the DPF muffler full assembly by falling or impact as it contains a ceramic filter.**
- **Before removing the DPF for cleaning, keep the records of the engine serial number, filter comp (DPF) part number, filter comp (DPF) serial number, catalyst (DOC) part number, catalyst (DOC) serial number, and engine operating time, which are required in preparing the DPF cleaning order from.**
  Since the engine operating time is recorded in the ECU, check the operating time by connecting the service tool (Diagmaster).
- **When installing and removing the muffler full assembly (DPF), make sure that the temperature sensor, differential pressure sensor, and differential pressure pipe do not make contact with surrounding parts.**

1. Remove the tube (4), (5) from the differential pressure pipe (1), (7).
2. Remove the differential pressure sensor (3).
3. Remove the DPF stay 2 (6).
4. Loosen the filter comp (DPF) mounting screw (10) and remove the filter comp (DPF) (12).

(1) Differential Pressure Pipe
(2) Temperature Sensor (T_2)
(3) Differential Pressure Sensor
(4) Tube
(5) Tube
(6) DPF Stay 2
(7) Differential Pressure Pipe
(8) Temperature Sensor (T_1)
(9) Temperature Sensor (T_0)
(10) Filter Comp (DPF) Mounting Screw
(11) Body (DPF Outlet)
(12) Filter Comp (DPF)
(13) Collar (DPF)
(14) Catalyst (DOC)
(15) Gasket
(16) Gas Flow →

(To be continued)

(Continued)

(When reassembling)

- Replacing the gaskets (15) with new ones.
- If the differential pressure tube is damaged or cracked, replace it.
- When the differential pressure pipe (1), (7) and temperature sensor (2), (8), (9) is removed, wipe off the anti-seize & lubricating compound, apply a anti-seize & lubricating compound (Bostik, NEVER SEEZ, Pure Nickel Special Grade), and then attach them to their correct position.
- When replacing the differential pressure pipe (1), (7) apply a anti-seize & lubricating compound (Bostik, NEVER SEEZ, Pure Nickel Special Grade), and then attach it to its correct position.
- When replacing the temperature sensor, check that it is coated with anti-seize & lubricating compound, and then attach it to its correct position.
- Tighten bolts and nuts to their specified torque. Also tighten the temperature sensor tightening nut or the differential pressure pipe tightening nut to the specified torque with crowfoot wrench.
- After attaching the assembly, start the engine and make sure that there are no gas leaks.
- Reassemble the filter comp (DPF) (12) in the correct direction by referring the mark "GAS FLOW→" (16) (Catalyst (DOC) to Body (DPF Outlet)) on the side showing the flow of exhaust gas.

Tightening torque	Filter comp (DPF) mounting screw	49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	Temperature sensor	25 to 34 N·m 2.5 to 3.5 kgf·m 18 to 25 lbf·ft
	Differential pressure pipe	16 to 22 N·m 1.6 to 2.3 kgf·m 12 to 16 lbf·ft
	DPF Stay 2	49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft

(1) Differential Pressure Pipe
(2) Temperature Sensor (T_2)
(3) Differential Pressure Sensor
(4) Tube
(5) Tube
(6) DPF Stay 2
(7) Differential Pressure Pipe
(8) Temperature Sensor (T_1)
(9) Temperature Sensor (T_0)
(10) Filter Comp (DPF) Mounting Screw
(11) Body (DPF Outlet)
(12) Filter Comp (DPF)
(13) Collar (DPF)
(14) Catalyst (DOC)
(15) Gasket
(16) Gas Flow →

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(3) Turbocharger and EGR

CAUTION

- **While the engine operates or just after it stops, do not touch the hot turbocharger.**

■ **NOTE**

- **When you remove or install the turbocharger assembly, do not let dust, dirt and other unwanted materials in the oil pipes.**
- **After you replace the turbocharger assembly, fill clean engine oil through the oil filter port of the turbocharger.**
- **Before you start the engine, make sure that the air cleaner is in the correct position.**

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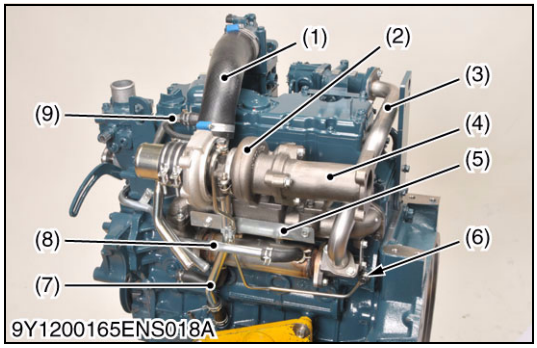

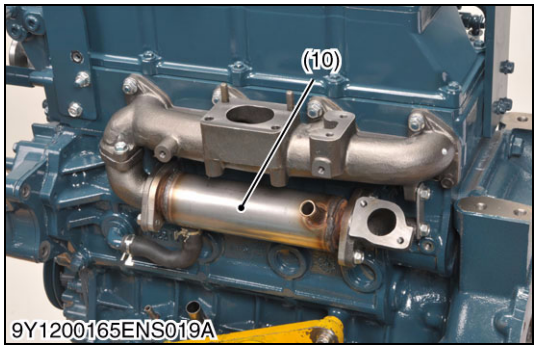

EGR Pipe, Turbocharger and EGR Cooler

1. Remove the intake hose (1).
2. Remove the EGR pipe (3).
3. Remove the muffler flange (4).
4. Remove the EGR cooler pipe (8).
5. Remove the breather pipe (9).
6. Remove the screw (6) for the oil pipe.
7. Remove the return pipe (crankcase side) (7).
8. Remove the cover (5).
9. Remove the turbocharger assembly (2).
10. Remove the EGR cooler (10).

(When reassembling)

- Fill clean engine oil through the oil filter port of the turbocharger.
- Replace the gaskets with new ones.
- Do not to let dust, dirt and other unwanted materials in the oil pipes.

■ **NOTE**

- **Put tape or cover on all openings to prevent damage in the oil holes in the turbocharger by unwanted materials.**

Tightening torque	EGR cooler flange screw (Serial No.: below BZZ999)	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft
	EGR cooler flange screw (Serial No.: above CA0001 and 2CL0001)	30 to 34 N·m 3.0 to 3.5 kgf·m 22 to 25 lbf·ft

(1) Intake Hose
(2) Turbocharger Assembly
(3) EGR Pipe
(4) Muffler Flange
(5) Cover
(6) Screw
(7) Return Pipe
(8) EGR Cooler Pipe
(9) Breather Pipe
(10) EGR Cooler

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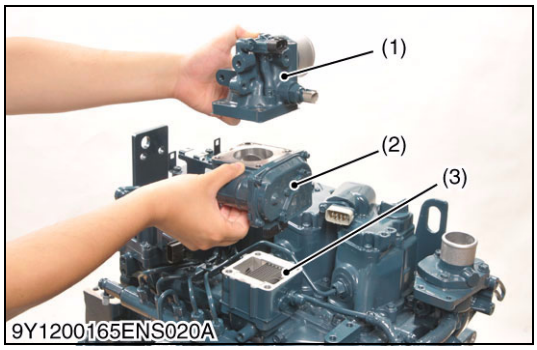

Intake Throttle Valve and Intake Air Heater

1. Remove the air cleaner flange (1).
2. Remove the intake throttle valve (2).
3. Remove the intake air heater (3).

■ **NOTE**

- **Do not disassemble the intake throttle valve.**

(When reassembling)

- Replace the gaskets with new ones.

(1) Air Cleaner Flange
(2) Intake Throttle Valve
(3) Intake Air Heater

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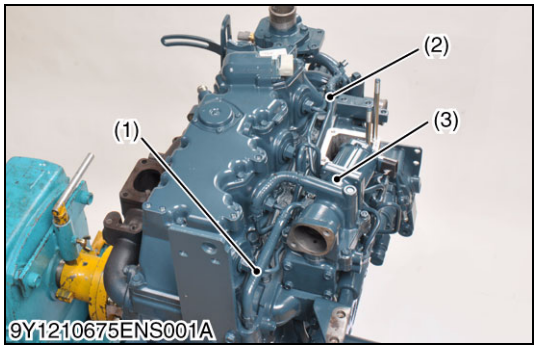

EGR Valve

1. Disconnect the cooler pipe (1), (2) of EGR valve.
2. Remove the EGR valve (3).

■ **NOTE**

- **Do not disassemble the EGR valve assembly.**

(When reassembling)

- Replace the gaskets with new ones.

(1) Cooler Pipe
(2) Cooler Pipe
(3) EGR Valve

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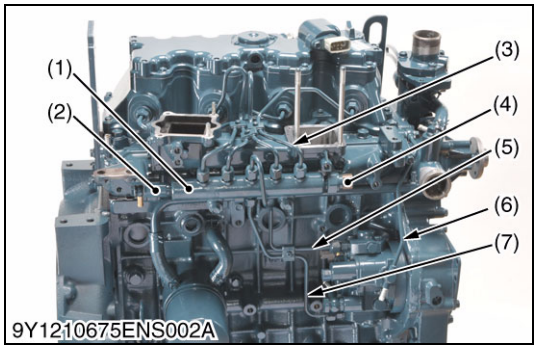
(4) Common Rail



Common Rail and Injection Pipes

CAUTION

- **Do not loosen the injection pipe when the fuel is under high pressure (within five minutes of stopping the engine).**

NOTE

- **Please replace the rail assembly, if the exchange of the pressure limiter or the rail pressure sensor is necessary.**
- **Do not remove the pressure limiter (2) and rail pressure sensor (4) from the common rail (1).**
- **When removing the common rail (1), do not hold it by the pressure limiter (2) and rail pressure sensor (4).**

1. Remove the injection pipe (5), (7).
2. Remove the overflow pipe (6).
3. Remove the injection pipes (3).
4. Remove the common rail (1).

IMPORTANT

- **Store the injection pipes (3), (5), (7) so it does not get any dust in it.**
- **Store the common rail (1) so it does not get any dust in it.**

(When reassembling)

NOTE

- **Tighten the injection pipes securely to their specified torques.**

Tightening torque	Common rail mounting screw	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft
	Injection pipe retaining nut	23 to 36 N·m 2.3 to 3.7 kgf·m 17 to 26 lbf·ft
	Overflow pipe joint screw (M8)	7.9 to 12 N·m 0.80 to 1.3 kgf·m 5.8 to 9.4 lbf·ft
	Overflow pipe joint screw (M10)	16 to 19 N·m 1.6 to 2.0 kgf·m 12 to 14 lbf·ft

(1) Common Rail
(2) Pressure Limiter
(3) Injection Pipe
(4) Rail Pressure Sensor
(5) Injection Pipe
(6) Overflow Pipe
(7) Injection Pipe

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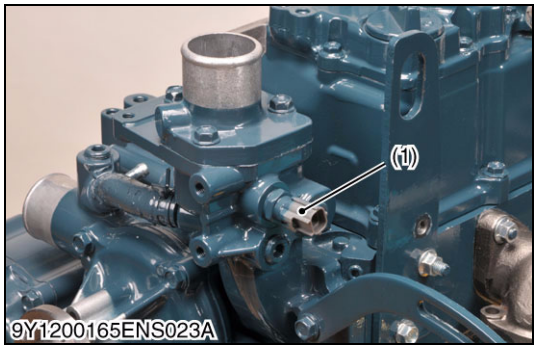

Coolant Temperature Sensor

1. Remove the coolant temperature sensor (1).

(When reassembling)

- Replace the gaskets with new ones.

Tightening torque	Coolant Temperature Sensor	16 to 23 N·m 1.6 to 2.4 kgf·m 12 to 17 lbf·ft

(1) Coolant Temperature Sensor

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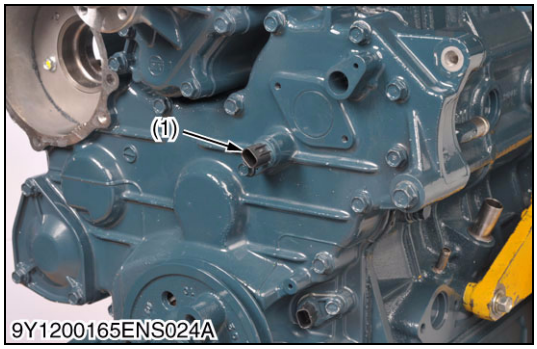

Camshaft Position Sensor

1. Remove the camshaft position sensor mounting screw.
2. Remove the camshaft position sensor (1).

(When reassembling)

- Replace the O-ring with a new one.

Tightening torque	Camshaft position sensor mounting screw	4 to 5 N·m 0.4 to 0.6 kgf·m 3 to 4 lbf·ft

(1) Camshaft Position Sensor

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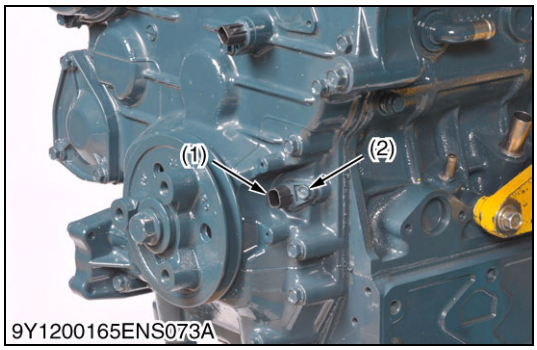

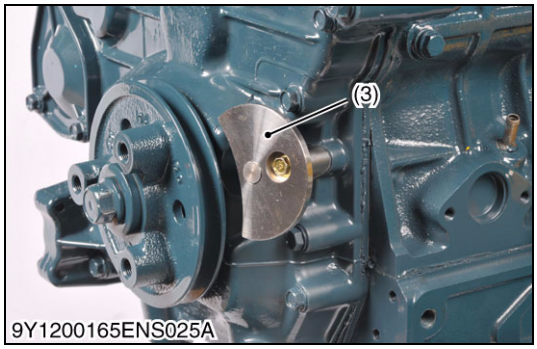

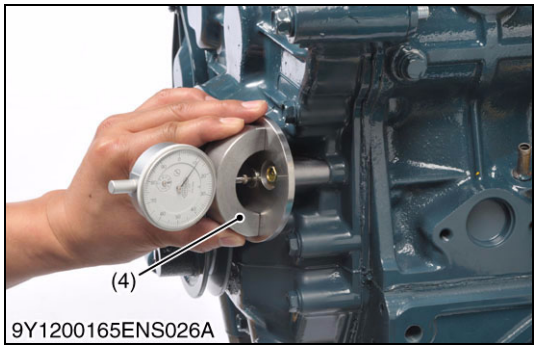

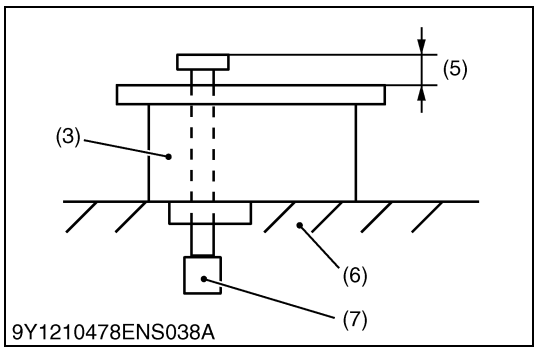

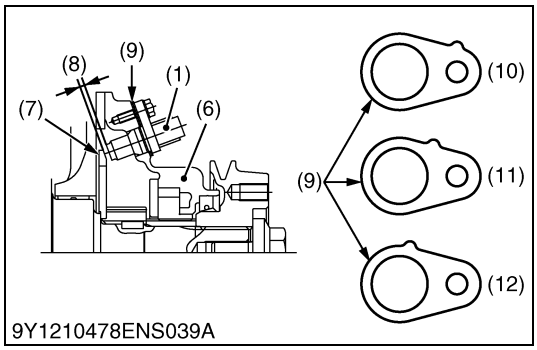

Crankshaft Position Sensor

1. Remove the crankshaft position sensor mounting screw (2).
2. Remove the crankshaft position sensor (1).

(When reassembling)

- Replace the O-ring with a new one.

■ IMPORTANT

- **If you drop the sensor, do not reuse it.**
- **If the sensor (1), gear case (6) and/or pulsar gear (7) are replaced, use a combination of shims (9) to adjust the sensor's air gap.**

Selecting adjustment shims

1. Align the TC mark of flywheel with the flywheel housing timing window.
2. Install the measurement jig 1 (3) to the sensor mounting position.
3. Set the dial gauge at the measurement jig 2 (4), then measure the protrusion (5) of the jig 1 (3).
4. Refer to the protrusion (5) you measured, and select the number of adjusting shims (9) from the following table.

Combination of Shims

Protrusion (5)	Thickness & Number of Shims		
	0.25 mm (0.0098 in.) (10)	0.50 mm (0.020 in.) (11)	1.00 mm (0.0394 in.) (12)
	1G381-04420	1G381-04430	1G381-04440
2.25 to 2.50 mm 0.0886 to 0.0984 in.	1		2
2.00 to 2.25 mm 0.0788 to 0.0885 in.			2
1.75 to 2.00 mm 0.0689 to 0.0787 in.	1	1	1
1.50 to 1.75 mm 0.0591 to 0.0688 in.		1	1
1.25 to 1.50 mm 0.0493 to 0.0590 in.	1		1
1.00 to 1.25 mm 0.0394 to 0.0492 in.			1
0.750 to 1.00 mm 0.0296 to 0.0393 in.	1	1	
0.500 to 0.750 mm 0.0197 to 0.0295 in.		1	
0.250 to 0.500 mm 0.00985 to 0.0196 in.	1		
0 to 0.250 mm 0 to 0.00984 in.			

Air Gap (8)	Factory specification	0.25 to 1.4 mm 0.0099 to 0.055 in.

Tightening torque	Crankshaft position sensor mounting screw	4 to 5 N·m 0.4 to 0.6 kgf·m 3 to 4 lbf·ft

(1) Crankshaft Position Sensor
(2) Crankshaft Position Sensor Mounting Screw
(3) Jig 1
(4) Jig 2
(5) Protrusion
(6) Gear Case
(7) Pulsar Gear
(8) Air Gap
(9) Shim
(10) Shim (0.25 mm (0.0098 in.))
(11) Shim (0.50 mm (0.020 in.))
(12) Shim (1.00 mm (0.0394 in.))

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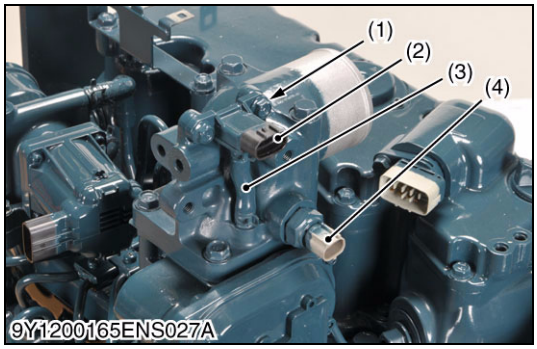

Intake Air Temperature Sensor and Boost Sensor

■ **IMPORTANT**
- **Be careful not to damage the sensor when removing the hose from the boost sensor.**

1. Remove the intake air temperature sensor (4).
2. Remove the hose (3) from the boost sensor (2).
3. Remove the boost sensor mounting screw (1).
4. Remove the boost sensor (2).

(When reassembling)
- Replace the gaskets with new ones.
- If the hose is damaged, replace it with a new hose.

Tightening torque	Intake air temperature sensor	30 to 39 N·m 3.0 to 4.0 kgf·m 22 to 28 lbf·ft
	Boost sensor mounting screw	4 to 5 N·m 0.4 to 0.6 kgf·m 3 to 4 lbf·ft

(1) Boost Sensor Mounting Screw
(2) Boost Sensor
(3) Hose
(4) Intake Air Temperature Sensor

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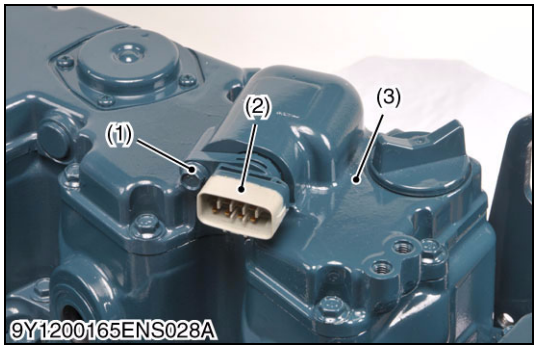

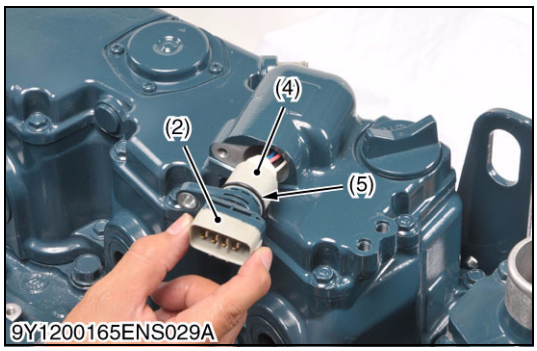

Injector Harness Connector

1. Remove the screw (1).
2. Pull the injector harness connector (2) out from cylinder head cover 2 (3).
3. Remove the connector (2) from the injector harness (4).

■ **IMPORTANT**
- **Be careful not to damage the harness when you pull the connector out.**

(When reassembling)
- If the O-ring (5) is damaged, replace the injector harness connector (2).

(1) Screw
(2) Injector Harness Connector
(3) Cylinder Head Cover 2
(4) Injector Harness
(5) O-ring

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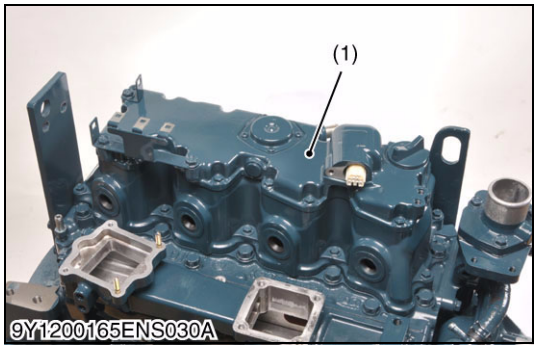
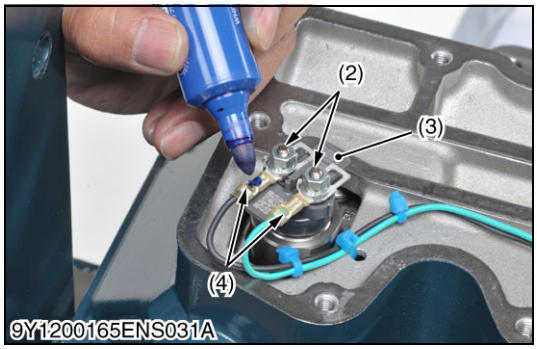
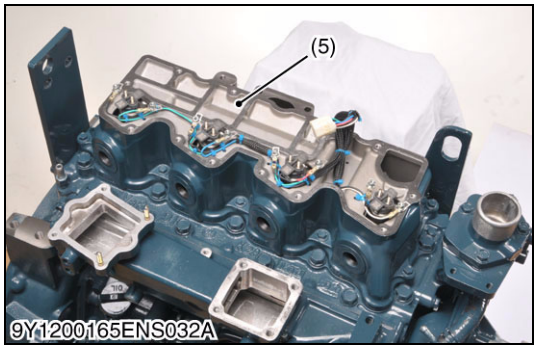
(5) Cylinder Head and Valves







Cylinder Head Cover

1. Remove cylinder head cover 2 (1).
2. To prevent miswiring during reassembly, mark the injector terminals (2) and the leads (4).
3. Remove the injector harness from the injectors.
4. Remove cylinder head cover 1 (5).

(When reassembling)

- Do not damage injector QR code tags (3) when installing cylinder head cover 1 (5).
- Replace the gasket of cylinder head cover 2 with a new one.
- Make sure to tighten the injector terminal nut with the specified torque.

Tightening torque	Cylinder head cover 1 screw	6.87 to 11.2 N·m 0.700 to 1.15 kgf·m 5.07 to 8.31 lbf·ft
	Cylinder head cover 2 screw	9.81 to 11.2 N·m 1.00 to 1.15 kgf·m 7.24 to 8.31 lbf·ft
	Injector terminal nut	1.6 to 2.2 N·m 0.16 to 0.23 kgf·m 1.2 to 1.6 lbf·ft

(1) Cylinder Head Cover 2
(2) Injector Terminal
(3) Injector QR Code Tag
(4) Lead
(5) Cylinder Head Cover 1

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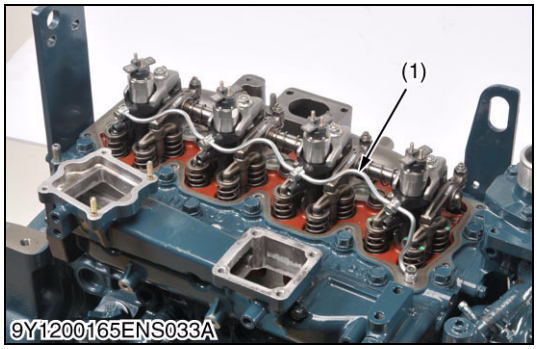

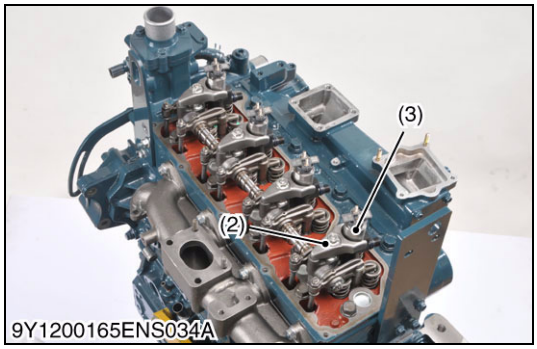

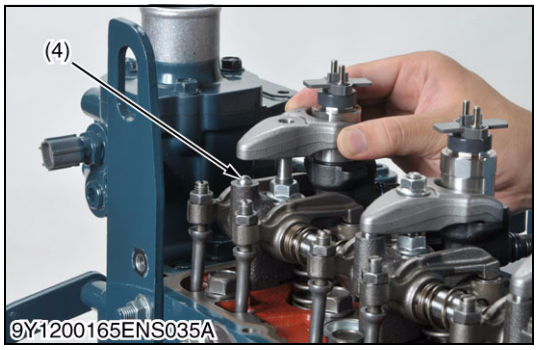

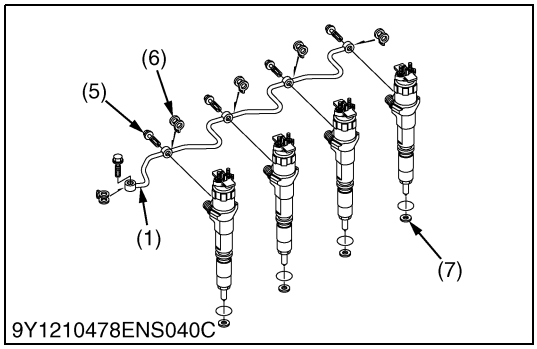

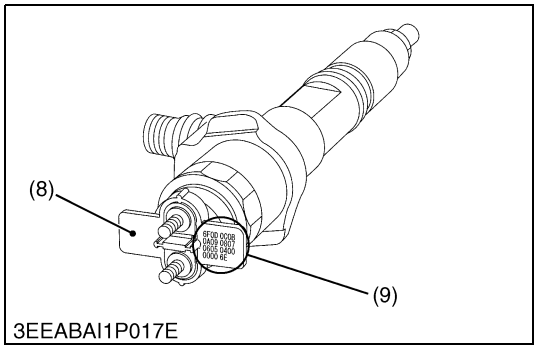

Overflow Pipe and Injectors

1. Remove the overflow pipe (1).
2. Remove the injector clamp (2).
3. Remove the injector (3) and its gasket (7).

■ **IMPORTANT**

- **Do not disassemble the injector (3).**
- **Do not remove the injector QR code tag (8).**
- **Do not damage the injector QR code tag (8).**
- **Do not lose the ball (4) of the rocker arm bracket.**
- **Do not get the injectors out of order. If the injectors get out of order, it is necessary to perform injector correction (writing the injector ID codes (9) to the ECU).**
- **Store the injectors so they do not get any dust in them.**

(When reassembling)

- Replace the injectors' gaskets (7) with new ones.
- When installing injector clamps (2), check and make sure the ball (4) is in the rocker arm bracket.
- When attaching the overflow pipe (1) to the injector, replace the gasket (6) with a new one.
- Install the overflow pipe joint screw (5).
- Tighten the injector clamp nuts securely to their specified torques.
- Tighten the overflow pipe joint screws (5) securely to their specified torques.
- After installing the overflow pipe, in order to check the fuel leakage, add pressure by air from the fuel pipe joint, and check the fuel leakage of overflow pipe and gasket (6).
- In case there is fuel leakage, replace the gasket (6), then check the fuel leakage again.

■ **NOTE**

- **If you replace the injectors, it is necessary to perform injector correction (writing the injector ID codes (9) to the ECU).**

Tightening torque	Injector clamp nut	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft
	Overflow pipe joint screw (M6 × 1.0)	9.81 to 11.2 N·m 1.00 to 1.15 kgf·m 7.24 to 8.31 lbf·ft

(1) Overflow Pipe
(2) Injector Clamp
(3) Injector
(4) Ball
(5) Overflow Pipe Joint Screw
(6) Gasket
(7) Gasket
(8) Injector QR Code Tag
(9) Injector ID Code

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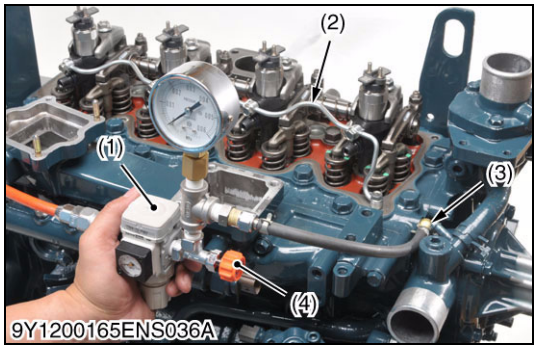

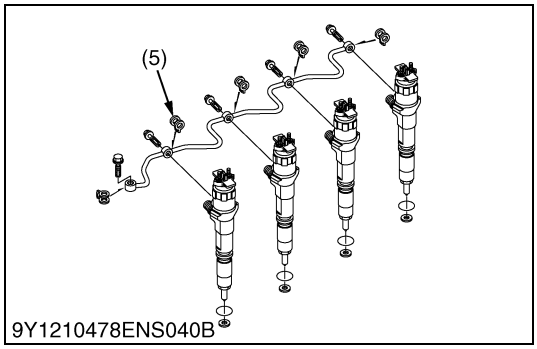

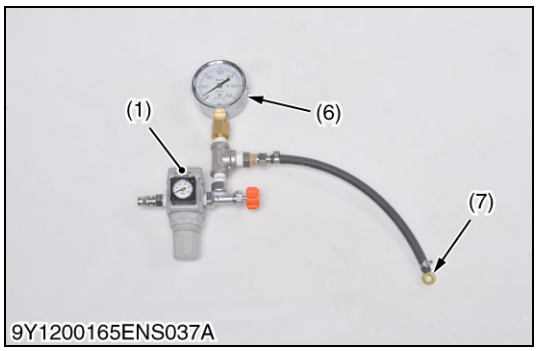

Check the Fuel Leakage of the Overflow Pipe

1. Connect the fuel pipe joint (7) of air pressure adjustment equipment to the eye joint bolt (3).
2. Tighten the valve (4).
3. Connect the air hose to the air pressure adjustment equipment.
4. Adjust air pressure of the regulator (1) between 0.03 and 0.05 MPa (0.3 and 0.5 kgf/cm^2, 5 and 7 psi).
5. Open the valve (4) gradually, then add 0.03 MPa (0.3 kgf/cm^2, 4 psi) pressure.
6. Tighten the valve (4).
7. Check the decreased pressure after 4 seconds.

■ **NOTE**

- **If the decreased pressure is higher than 0.001 MPa (0.01 kgf/cm^2, 0.1 psi), it means that there is fuel leakage. Replace the gasket (5), then check the fuel leakage again.**

Leakage Check	Decreased pressure after 4 seconds is lower than 0.001 MPa (0.01 kgf/cm^2, 0.1 psi)

Specification of components

Parts Name	Specification or Code No.
Regulator (1)	0.030 to 0.86 MPa 0.31 to 8.7 kgf/cm^2 4.4 to 120 psi
Pressure Gauge (6)	0 to 0.06 MPa 0 to 0.6 kgf/cm^2 0 to 8 psi
Fuel Pipe Joint (7)	14117-42560

(1) Regulator
(2) Overflow Pipe
(3) Eye Joint Bolt
(4) Valve
(5) Gasket
(6) Pressure Gauge
(7) Fuel Pipe Joint

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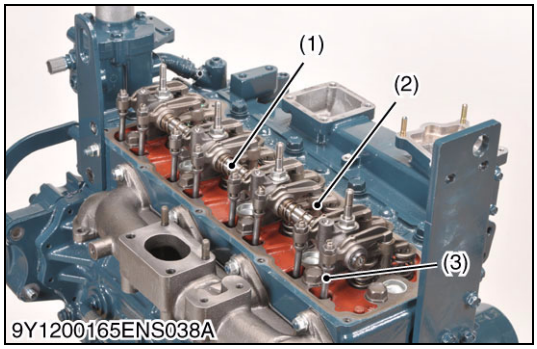

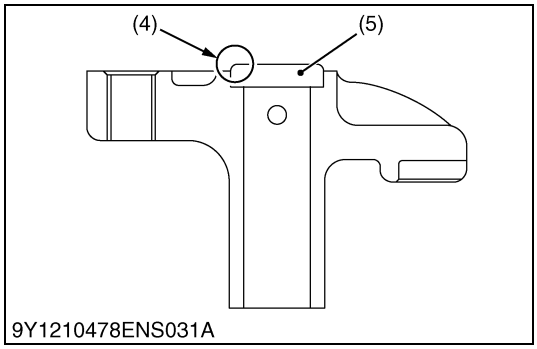

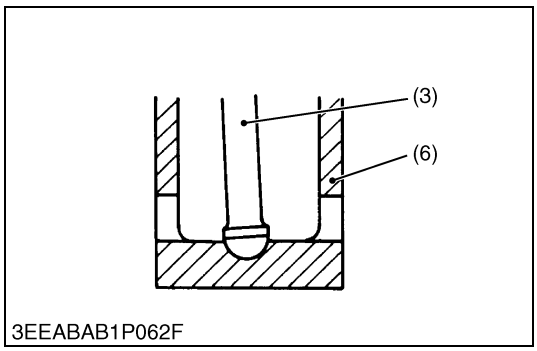

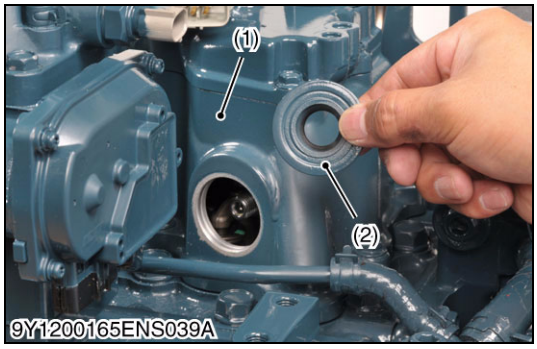

Rocker Arms and Push Rods

1. Remove the rocker arm (1).
2. Remove the push rod (3).
3. Remove the valve bridge arm (2).

(When reassembling)

- Face the pad (5) R face (4) up and install it on the bridge arm.
- When installing the push rod (3), mount it securely in the groove of the tappet (6).

■ **IMPORTANT**

- **After installing the rocker arm, adjust the valve clearance.**

Tightening torque	Rocker arm bracket nut	49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft

(1) Rocker Arm
(2) Valve Bridge Arm
(3) Push Rod
(4) R Face
(5) Pad
(6) Tappet

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Injector Oil Seal (If necessary)

1. Remove the injector oil seal (2) from cylinder head cover1 (1).

(When reassembling)

- When install the injector oil seal (2), use the new one.

(1) Cylinder Head Cover 1
(2) Injector Oil Seal

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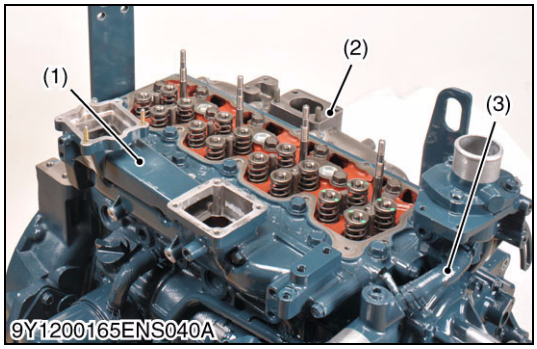

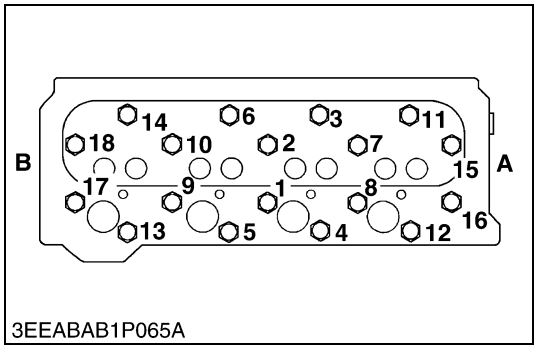

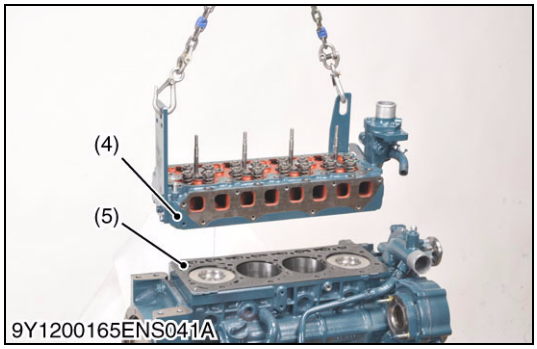

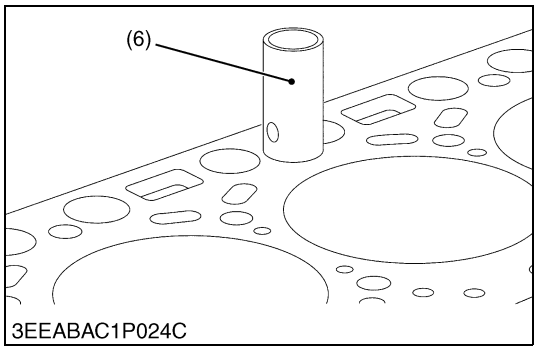

Cylinder Head and Tappet

1. Loosen the pipe clamp and remove the water return hose (3).
2. Remove the inlet manifold (1) and exhaust manifold (2).
3. Remove the cylinder head mounting screw in the sequence of **18** to **1**, and remove the cylinder head (4).
4. Remove the cylinder head gasket (5).
5. Remove the tappets (6) from the crankcase,

(When reassembling)

- Replace the cylinder head gasket (5) with a new one.
- Before installing the tappets (6), apply engine oil thinly around them.
- When mounting the gasket, set it to the knock pin hole. Take care not to mount it reversely.
- The cylinder head should be free of scratches and dust.
- Take care for handling the gasket not to damage it.
- Install the cylinder head.
- Tighten the cylinder head mounting screw gradually in the sequence of **1** to **18** after applying engine oil.
- Be sure to adjust the valve clearance. (Refer to the "Valve Clearance")
- It is not necessary to retighten the cylinder head mounting screw after running the engine for 30 minutes.

■ **IMPORTANT**

- **When replacing the piston, piston pin bushing, connecting rod or crank pin bearing, select the cylinder head gasket thickness to meet with the top clearance refer to the "To Select the Cylinder Head Gasket".**

■ **NOTE**

- **Mark the cylinder number to the tappets to prevent interchanging.**

Tightening torque	Cylinder head mounting screw	98.1 to 107 N·m 10.0 to 11.0 kgf·m 72.4 to 79.5 lbf·ft
	Exhaust manifold mounting nut (Serial No.: below BXZ999)	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft
	Exhaust manifold mounting nut (Serial No.: above BY0001 and 2CL0001)	30 to 34 N·m 3.0 to 3.5 kgf·m 22 to 25 lbf·ft

(1) Inlet Manifold
(2) Exhaust Manifold
(3) Return Hose
(4) Cylinder Head
(5) Cylinder Head Gasket
(6) Tappet
A: Gear Case Side
B: Flywheel Side

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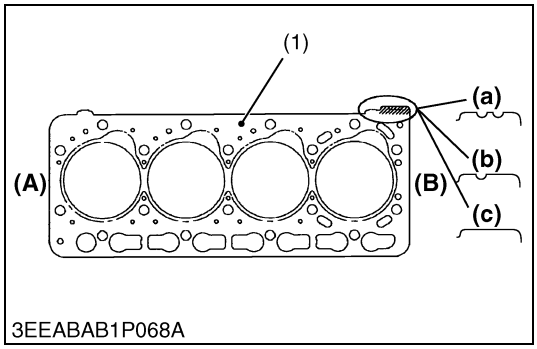

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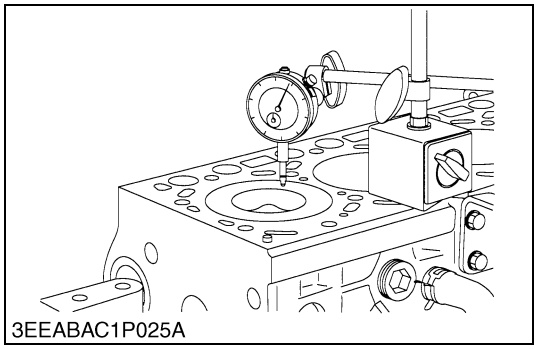
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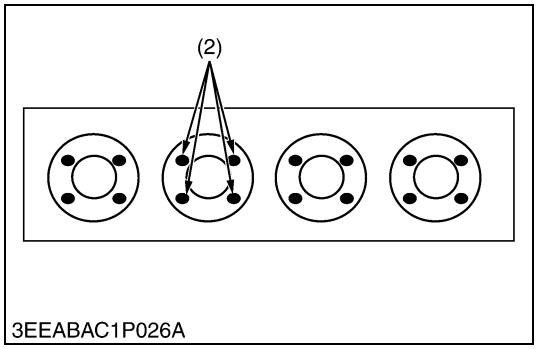

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To Select the Cylinder Head Gasket

■ Replacement of Cylinder Head Gasket

1. Make sure to note the notch **(a)**, **(b)** or **(c)** of cylinder head gasket in advance.
2. Replace the same notch **(a)**, **(b)** or **(c)** as the original cylinder head gasket (1).

■ To Select the Cylinder Head Gasket

- When replacing the piston, piston pin bushing, connecting rod or crank pin bearing, select the cylinder head gasket thickness to meet with the top clearance refer to the "To Select the Cylinder Head Gasket".

1. Measure the piston head's protrusion or recessing from the crankcase cylinder face 4 spots per each piston using the dial gauge as shown in figure, and get the average of the measurements.
2. Use the table below to select an applicable cylinder head gasket.

Notch of Cylinder Head Gasket	Thickness of cylinder head gasket		Code Number	Piston Head's protrusion or recessing from the level of crankcase cylinder face. (average of 4 pistons)
	Before tighten-ing	After tighten-ing		
2 notches **(a)**	0.90 mm 0.035 in.	0.80 mm 0.031 in.	1G514-03310	–0.0700 to +0.0490 mm –0.00275 to +0.00192 in.
1 notch **(b)**	1.00 mm 0.0394 in.	0.90 mm 0.035 in.	1G514-03600	+0.0500 to +0.149 mm +0.00197 to +0.00586 in.
Without notch **(c)**	1.05 mm 0.0413 in.	0.95 mm 0.037 in.	1G514-03610	+0.150 to +0.200 mm +0.00591 to +0.00787 in.

(1) Cylinder Head Gasket
(2) Points of Measurement
(A) Gear Case Side
(B) Flywheel Side
(a) 2 Notches
(b) 1 Notch
(c) Without Notch

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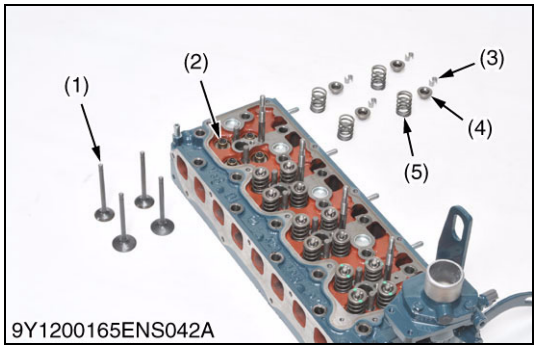

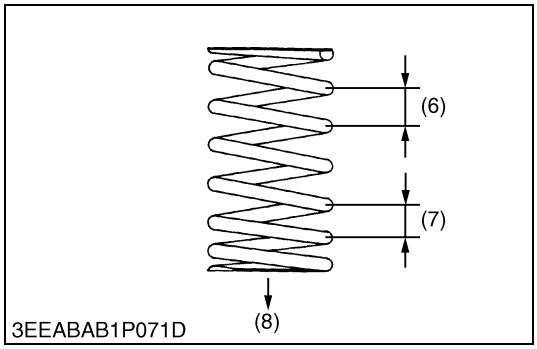

Valve

1. Push the valve spring (5) with the valve spring retainer (4) and remove the valve spring collets (3).
2. Remove the valve spring (5) and valve (1).

(When reassembling)

- Install the valve spring with its small pitch (7) end downward (at the head side).
- Clean the valve stem and valve guide hole, and apply engine oil sufficiently.
- After you install the valve spring collets (3), lightly tap the stem tip to attach it correctly with the plastic hammer.

(1) Valve
(2) Valve Stem Seal
(3) Valve Spring Collet
(4) Valve Spring Retainer
(5) Valve Spring
(6) Large Pitch
(7) Small Pitch
(8) Install the Spring with Its Smaller Pitch End Downward (at the Head Side).

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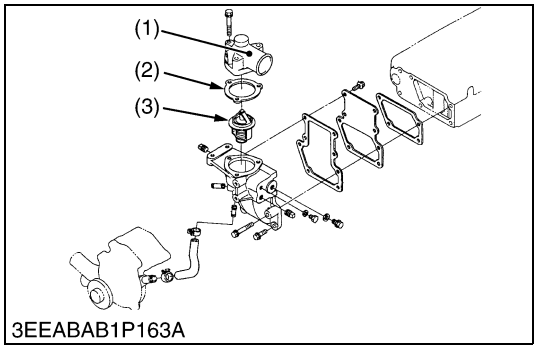
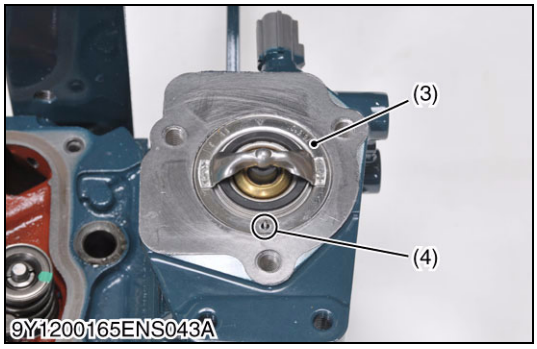
(6) Thermostat





Thermostat Assembly

1. Remove the thermostat cover mounting screws, and remove the thermostat cover (1).
2. Remove the thermostat assembly (3).

(When reassembling)

- Replace the gasket with a new one.
- Apply a liquid gasket (Three Bond 1217H) only at the thermostat cover side of the gasket (2).
- Attach the thermostat with its hole (4) facing toward the air suction side.

(1) Thermostat Cover
(2) Thermostat Cover Gasket
(3) Thermostat Assembly
(4) Hole

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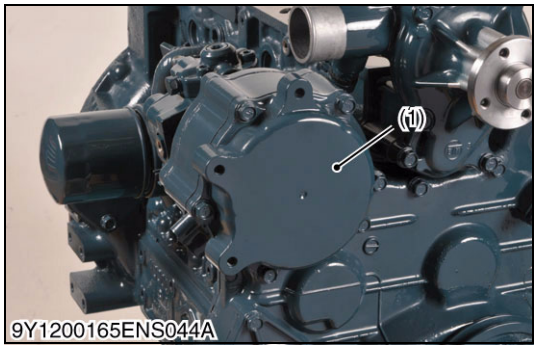
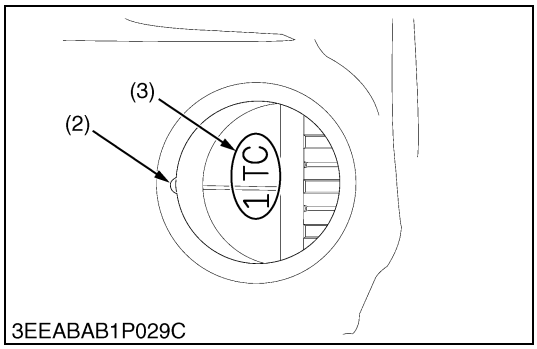
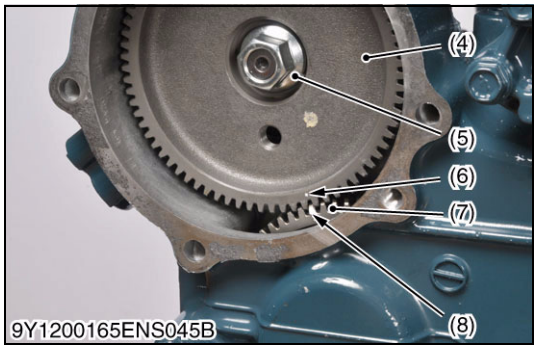
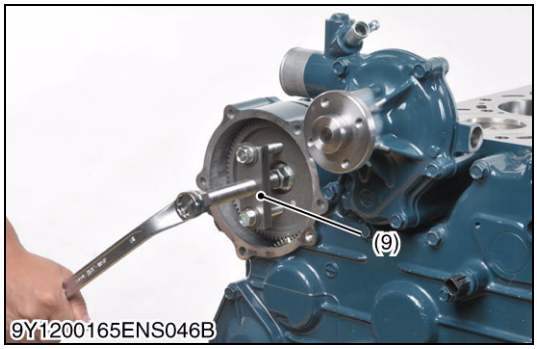
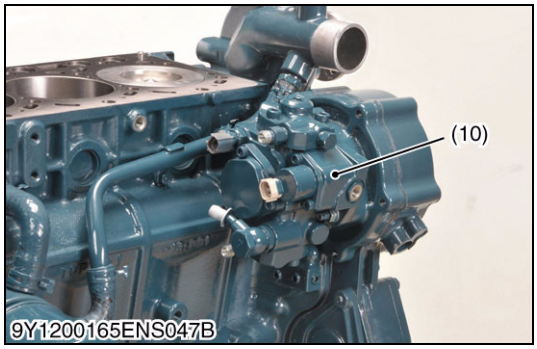
(7) Supply Pump











Supply Pump

CAUTION

- **Do not loosen the injection pipe when the fuel is under high pressure (within five minutes of stopping the engine).**

1. Remove the supply pump's gear cover (1).
2. Put the piston of the number 4 cylinder at TDC.

NOTE

- **When positioning the piston of the 4th cylinder to TDC, rotate the flywheel counterclockwise and align the TC mark (3) on the flywheel with the mark (2) on the housing of the flywheel. If the supply pump gear timing mark (6) meshes with idle gear 2 (7), then the piston of the 4th cylinder is TDC. If they do not mesh, rotate the flywheel counterclockwise one revolution.**

3. Make a temporary mark (8) with a white paint marker pen on the tooth of idle gear 2 (7).

NOTE

- **This mark is extremely useful during reassembly of the supply pump gear and idle gear 2 (7) to get the timing right.**

4. Fix the flywheel in place.
5. Remove the supply pump gear's mounting nut (5).
6. Use gear puller (9) to remove the supply pump gear (4).
7. Remove the supply pump (10).

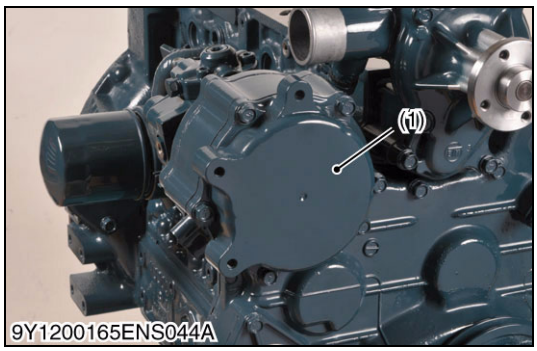
NOTE

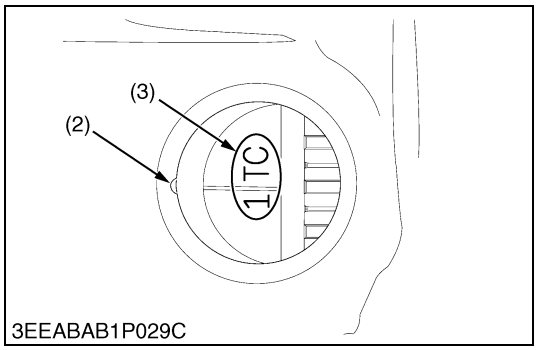
- **Do not disassemble the supply pump.**
- **Store the supply pump so it does not get any dust in it.**

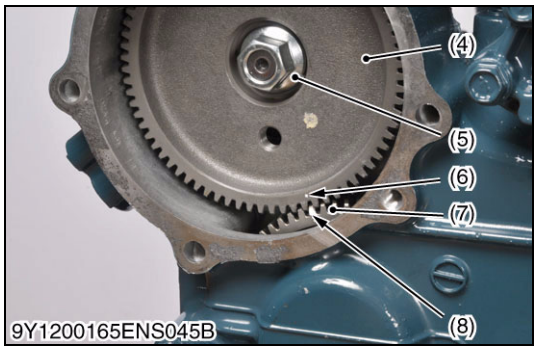
(1) Supply Pump Gear Cover
(2) Mark
(3) TC Mark
(4) Supply Pump Gear
(5) Supply Pump Gear Mounting Nut
(6) Timing Mark
(7) Idle Gear 2
(8) Mark
(9) Gear Puller
(10) Supply Pump

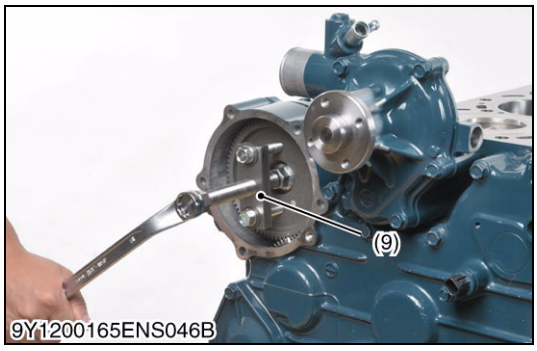
(To be continued)

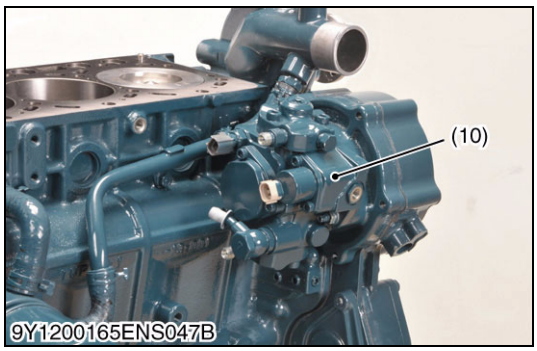
(Continued)











(When reassembling)

- Align the alignment marks of the supply pump gear (4) and idle gear 2 (7).
- Replace the O-ring of the supply pump (10) with a new one.
- Replace the gasket of supply pump gear cover with a new one.
- Line up the key of the supply pump gear (4) and install the supply pump (10).
- Tighten the supply pump mounting nut.
- Tighten the supply pump gear mounting nut (5) to its specified torque.
- Mount the supply pump gear cover (1).

■ **NOTE**

- **When replacing the supply pump with a new one, use the diagnosis tool to conduct learning of discrepancies in the new supply pump.**

Tightening torque	Supply pump mounting nut	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft
	Supply pump gear mounting nut	59 to 68 N·m 6.0 to 7.0 kgf·m 44 to 50 lbf·ft
	Supply pump gear cover mounting screw	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft

(1) Supply Pump Gear Cover
(2) Mark
(3) TC Mark
(5) Supply Pump Gear Mounting Nut
(4) Supply Pump Gear
(6) Timing Mark
(7) Idle Gear 2
(8) Mark
(9) Gear Puller
(10) Supply Pump

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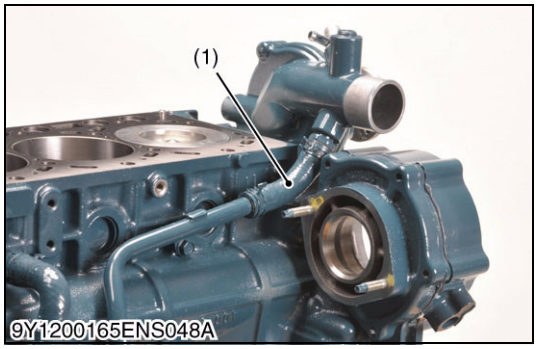
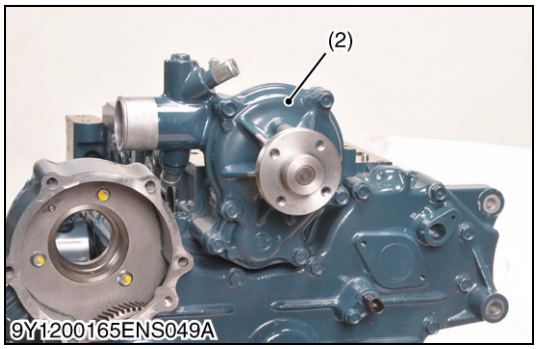
(8) Water Pump and Oil Cooler





Water Pump

1. Remove the pipe band and the water pipe (water pump side) (1).
2. Remove the water pump (2).

(When reassembling)

- When mounting the water pump, take care not to forget mounting the O-ring and not to let it out of position.

(1) Water Pipe
(2) Water Pump

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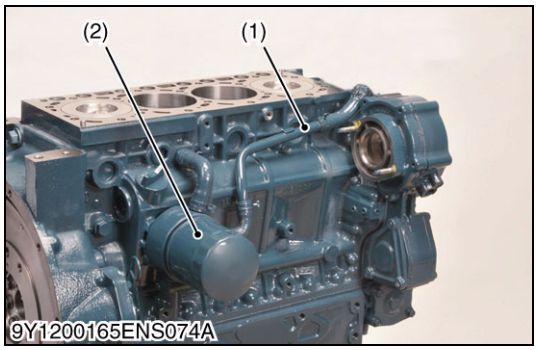

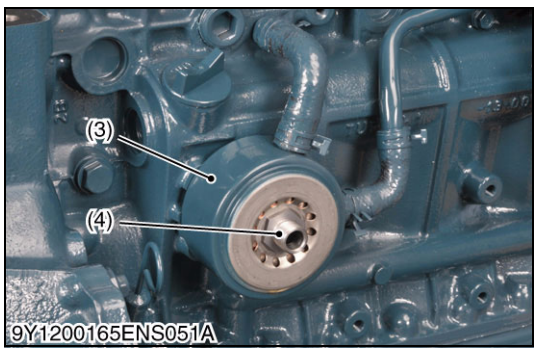

Oil Cooler

1. Remove the water pipe (1).
2. Remove the oil filter cartridge (2).
3. Remove the oil cooler joint screw (4).
4. Remove the oil cooler (3).

Tightening torque	Oil cooler joint screw	40 to 44 N·m 4.0 to 4.5 kgf·m 29 to 32 lbf·ft

(1) Water Pipe
(2) Oil Filter Cartridge
(3) Oil Cooler
(4) Oil Cooler Joint Screw

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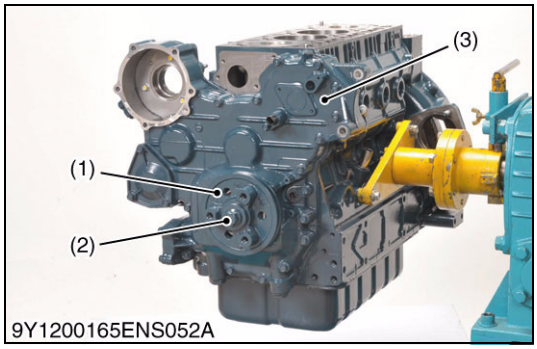
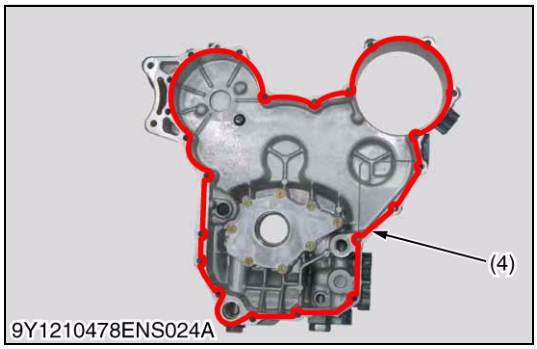
(9) Gear Case and Timing Gear





Fan Drive Pulley & Gear Case Cover

1. Mount a flywheel stopper on the flywheel.
2. Remove the crankshaft screw (2).
3. Remove the fan drive pulley (1).
4. Remove the gear case cover (3).

(When reassembling)

- In order to maintain an airtight seal, check and make sure there is no water, debris, or oil on the surface where the liquid gasket will be applied.
- Be careful to apply the liquid gasket (4) evenly. (Refer to the photo.)

■ **NOTE**

- **Make sure the surfaces align when mounting parts with a liquid gasket applied to them.**
- **Mount parts with a liquid gasket within 10 minutes of application.**
- **Apply a liquid gasket (4) to the gear case cover (Three Bond 1217H).**
- **When the gear case is replaced, check the air gap of the crankshaft position sensor. (Refer to page 1-S32.)**
- **When the gear case is replaced, it is necessary to calibrate the injection timing with the diagnosis tool. (Refer to page 1-S50.)**

Tightening torque	Crankshaft screw	255 to 274 N·m 26.0 to 28.0 kgf·m 188 to 202 lbf·ft
	Gear case cover mounting screw	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft

(1) Fan Drive Pulley
(2) Crankshaft Screw
(3) Gear Case Cover
(4) Liquid Gasket

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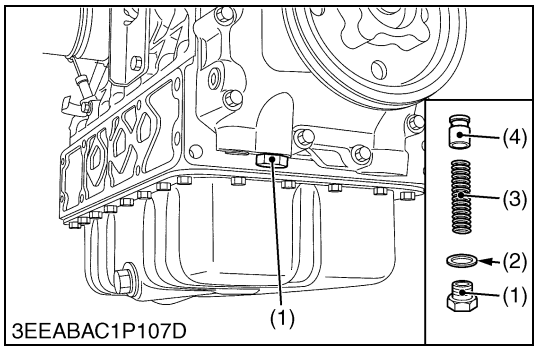

Relief Valve

1. Remove the relief valve retaining screw (1).
2. Remove the relief valve (4), the spring (3) and the packing (2).

Tightening torque	Relief valve retaining screw	69 to 78 N·m 7.0 to 8.0 kgf·m 51 to 57 lbf·ft

(1) Relief Valve Retaining Screw
(2) Packing
(3) Spring
(4) Relief Valve

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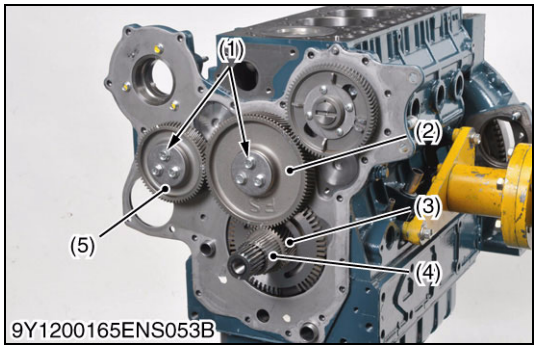

Idle Gear 1,2, Oil Pump Drive Gear and Crank Gear

1. Remove the idle gear mounting screw (1).
2. Remove the idle gear 1 (2) and idle gear 2 (5).
3. Remove the oil pump drive gear (4).
4. Remove the crank gear (3).

(When reassembling)

- When mounting idle gear 1 (2) and idle gear 2 (5), bring the piston of cylinder 4 to TDC and mount the gears with their marks aligned to the respective gears.

■ **NOTE**

- **When the crank gear is replaced, check the air gap of the crankshaft position sensor. (Refer to page 1-S32.)**
- **When the crank gear is replaced, it is necessary to calibrate the injection timing with the diagnosis tool. (Refer to page 1-S50.)**

Tightening torque	Idle gear mounting screw	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft

(1) Idle Gear Mounting Screw
(2) Idle Gear 1
(3) Crank Gear
(4) Oil Pump Drive Gear
(5) Idle Gear 2

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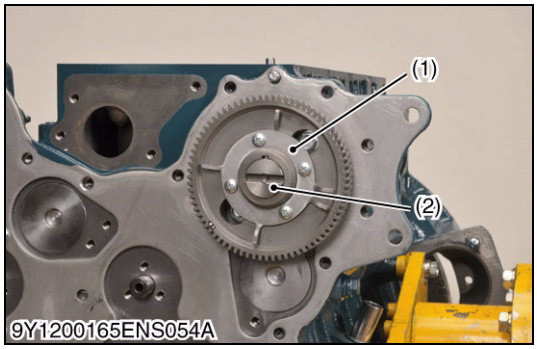

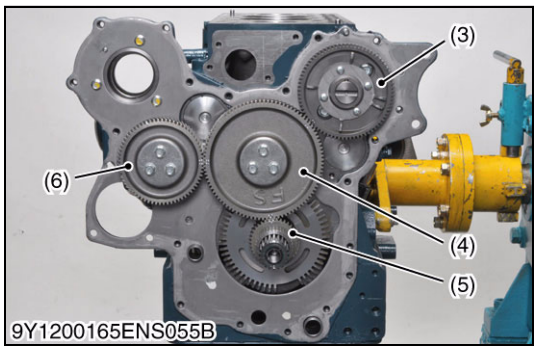

Camshaft

1. Remove the camshaft position pulsar gear (1).
2. Remove the camshaft set screws and draw out the camshaft (2).

(When reassembling)

- Align all mating marks on each gear to assemble the timing gears, set the idle gear last.
  - Idle gear 1 (4) and cam gear (3)
  - Idle gear 1 (4) and crank gear (5)
  - Idle gear 1 (4) and idle gear 2 (6)

Tightening torque	Camshaft set screw	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft
	Mounting screw of camshaft position pulsar gear	4.7 to 5.6 N·m 0.48 to 0.58 kgf·m 3.5 to 4.1 lbf·ft

(1) Camshaft Position Pulsar Gear
(2) Camshaft
(3) Cam Gear
(4) Idle Gear 1
(5) Crank Gear
(6) Idle Gear 2

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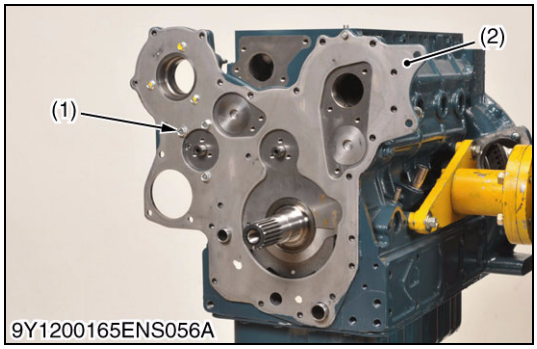

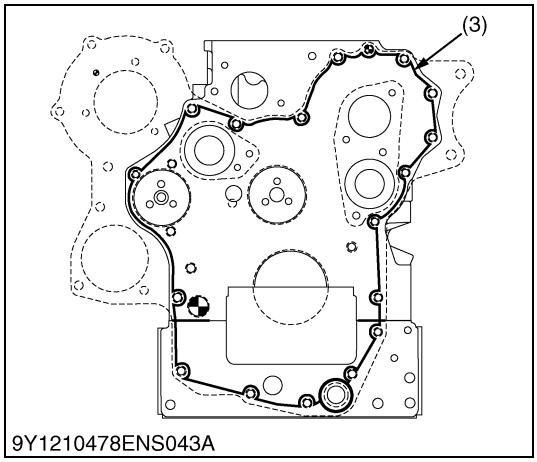

Plate (Gear Case)

1. Remove the plate mounting screws (1) and detach the plate (2).

(When reassembling)

- Apply liquid gasket (3) (Three Bond1217H) on the surface of the crankcase side where the plate will be installed to.

Tightening torque	Plate mounting screw	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft

(1) Plate Mounting Screw
(2) Plate
(3) Liquid Gasket

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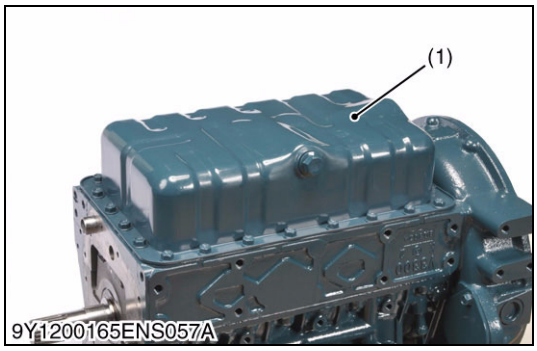
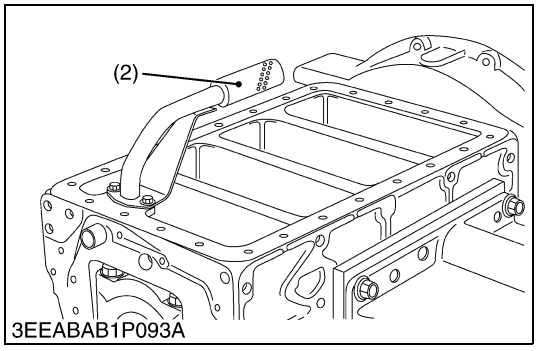
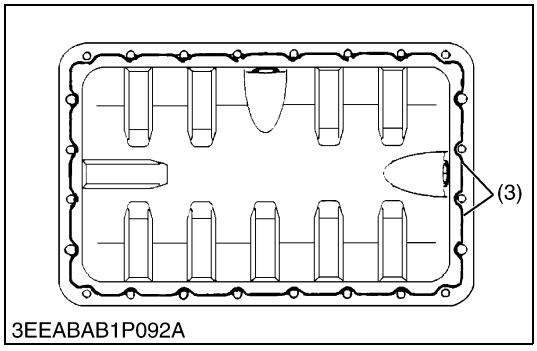
(10) Piston and Connecting Rod







Oil Pan and Oil Strainer

1. Unscrew the oil pan mounting screws and remove the oil pan (1).
2. Unscrew the oil strainer mounting screw, and remove the oil strainer (2).

(When reassembling)

- Install the oil strainer, using care not to damage the O-ring.
- Apply liquid gasket (3) (Three Bond 1217H) to the oil pan as shown in the figure.
- Confirm that the liquid gasket coating surface is free of water, dust and oil in order to maintain sealing effect.
- Carefully apply the adhesive evenly.

■ **NOTE**

- **Make sure the surfaces align when mounting parts with a liquid gasket applied to them.**
- **Mount parts with a liquid gasket within 10 minutes of application.**
- **Tighten the mounting screws of the oil pan in diagonal sequence from the center to tighten equally.**
- **After cleaning the oil strainer, install it.**
- **Attach the oil pan with its central drain plug facing toward the air suction side.**

(1) Oil Pan
(2) Oil Strainer
(3) Liquid Gasket

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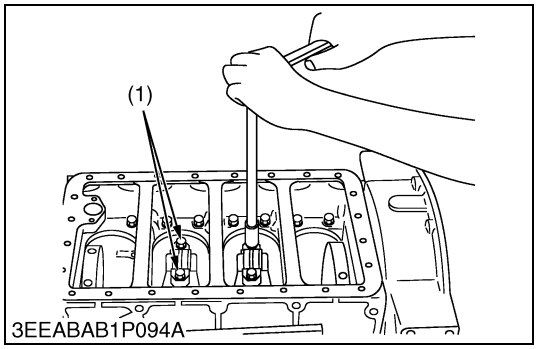

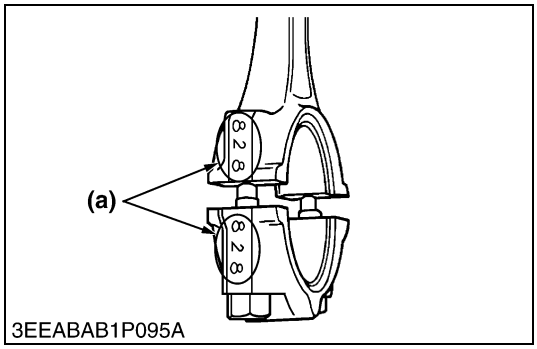

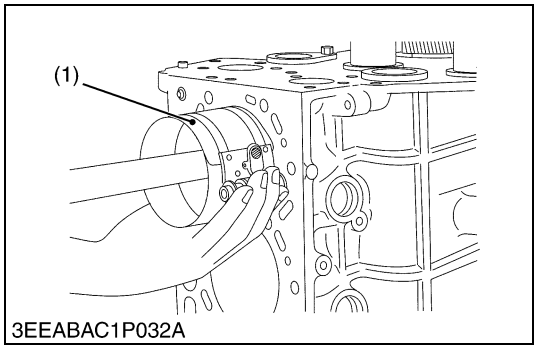

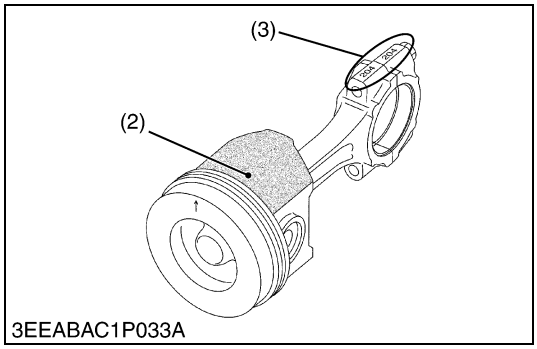

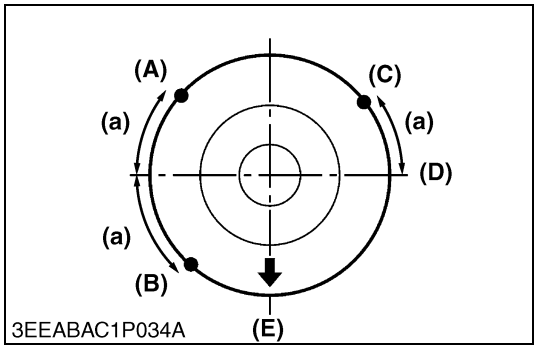

Connecting Rod Cap

1. Remove the connecting rod screws (1).
2. Remove the connecting rod cap.

(When reassembling)

- Align the marks **(a)** with each other. (Face the marks toward the supply pump.)
- Apply engine oil to the connecting rod screws and lightly screw it in by hand, then tighten it to the specified torque. 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 crank pin bearing again, put tally marks on the crank pin bearing and the connecting rod in order to keep their positioning.

Tightening torque	Connecting rod screw	79 to 83 N·m 8.0 to 8.5 kgf·m 58 to 61 lbf·ft

(1) Connecting Rod Screw **(a) Mark**

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Piston

1. Fully clean the carbon in the cylinders.
2. Turn the flywheel and move the piston to top dead center.
3. Lightly tap the piston from the bottom of the crankcase with the grip of a hammer to pull the piston out.

(When reassembling)

- Before you install the piston into the cylinder, apply sufficient engine oil to the piston.
- When you install the piston into the cylinder, point the mark (3) on the connecting rod to the supply pump.

■ **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.**
- **When inserting the piston into the cylinder, place the gap of each piston ring like the figure.**
- **Install the pistons with a piston ring compressor (1) carefully. Otherwise, their chrome-plated section of piston rings may be scratched, causing trouble inside the liner.**
- **When you install the piston in position, do not give a damage to the layer of molybdenum disulfide on the piston skirt. This layer can decrease the clearance with the cylinder liner. Immediately after you press-fit the piston pin, the piston is hot and the layer comes off easily. Only put in the piston after its temperature decreases.**

(1) Piston Ring Compressor
(2) Layer of Molybdenum Disulfide in Piston Skirt
(3) Mark
(A) Top Ring Gap
(B) Second Ring Gap
(C) Oil Ring Gap
(D) Piston Pin Hole
(E) Supply Pump Side
(a) 0.79 rad (45 °)

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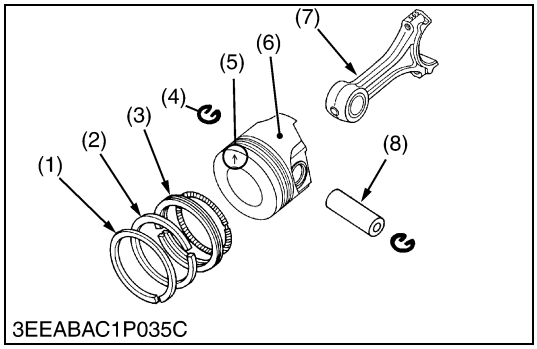

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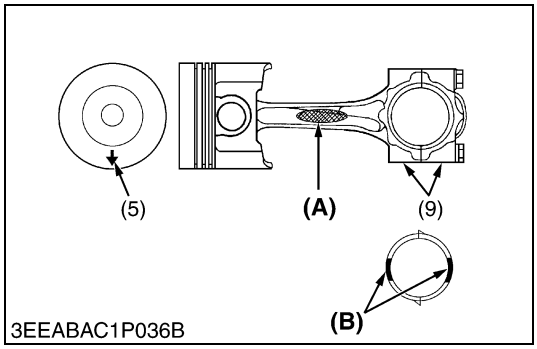

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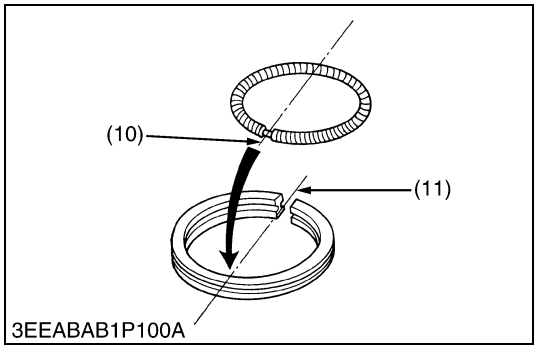

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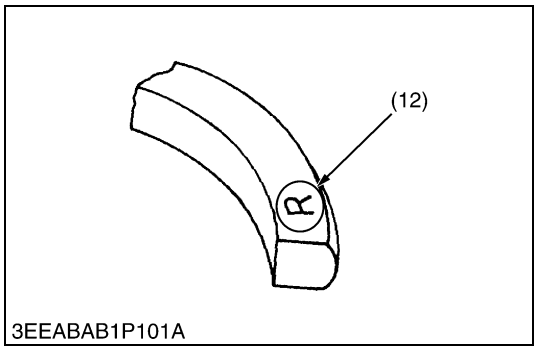

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Piston Ring and Connecting Rod

1. Remove the piston rings with a piston ring tool.
2. Remove the piston pin (8) to disconnect the connecting rod (7) from the piston (6).

(When reassembling)

- Be sure the crank pin bearing and the connecting rod are same I.D. colors.
- When you install the rings to the piston, set the manufacturer mark (12) upward.
- When you install the oil ring on the piston, set the expander joint (10) on the opposite side of the oil ring gap (11).
- Apply engine oil to the piston pin.
- When you install the piston pin, put the piston fully in 80 °C (176 °F) oil for 10 to 15 minutes.
- When you install the piston to the connecting rod, align the mark (↑) (5) on the piston to the connecting rod numbering mark (9).
- 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) Top Ring
(2) Second Ring
(3) Oil Ring
(4) Piston Pin Snap Ring
(5) Mark (↑)
(6) Piston
(7) Connecting Rod
(8) Piston Pin
(9) Numbering Mark
(10) Expander Joint
(11) Oil Ring Gap
(12) Manufacturer Mark

(A) Connecting Rod ID Color: Blue or without Color
(B) Crank Pin Bearing ID Color: Blue or without Color

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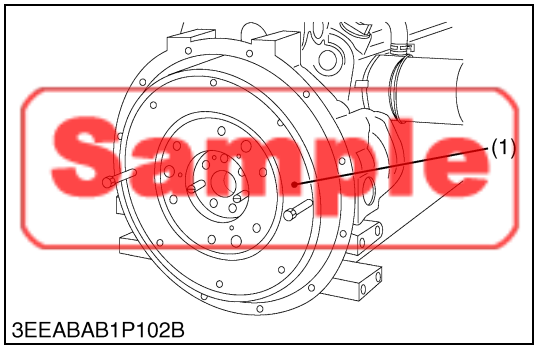
(11) Flywheel and Crankshaft



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Flywheel

1. Attach the stopper to the flywheel.
2. Remove the flywheel screws.
3. Remove the flywheel (1).

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

■ **IMPORTANT**
- **The flywheel is very heavy, so securely hold the flywheel when removing.**

(When reassembling)
- Apply engine oil to the flywheel screws.
- Examine that there are no metal particles that remain on the flywheel mounting surfaces.
- The flywheel and the crankshaft fit together in just one position. Make sure they are securely fit and tighten the screws.

Tightening torque	Flywheel screw	98.1 to 107 N·m 10.0 to 11.0 kgf·m 72.4 to 79.5 lbf·ft

(1) Flywheel

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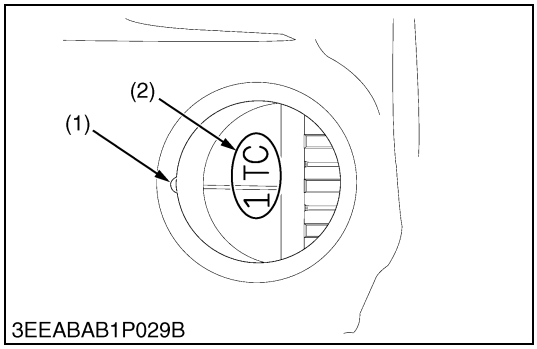

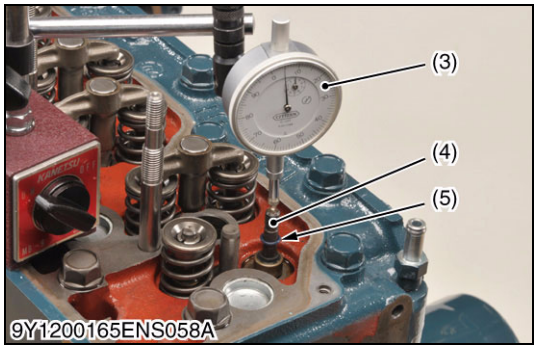

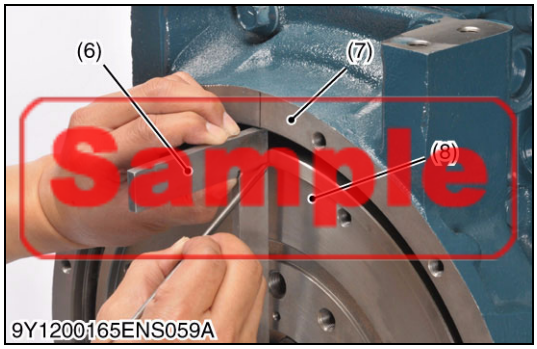

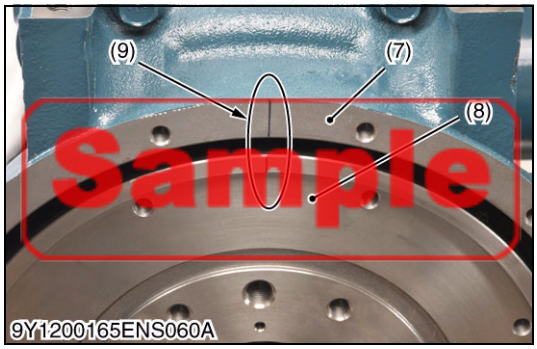

Measuring Angular Deviation between Crankshaft TDC and Crank Position Sensor Detected TDC

■ **IMPORTANT**

- **If the crankshaft, gear case and/or crank gear are replaced, it is necessary to calibrate the injection timing with the diagnosis tool.**

1. Remove the cylinder head cover, an injector and rocker arm.
2. Bring the piston of cylinder 4 to TDC.
3. Remove the #4 exhaust valve bridge arm and valve spring.
4. Insert a small O-ring (5) so the valve does not fall into the cylinder.
5. Set a dial gauge (3) on the tip of the valve (4).
6. Turn the flywheel counterclockwise and measure the position where the tip of the valve is the highest.
7. Stop the flywheel at the position where the tip of the valve is the highest.
8. Put a tri-square (6) on the flywheel housing (7) and flywheel (8) and draw a reference line (9).

■ **IMPORTANT**

- **Do not drop the valve (4) into the cylinder.**
- **When measuring the highest position of the tip of the valve, do not rotate the flywheel clockwise. If you go past the highest point of the valve, back the flywheel up slightly and measure the highest point of the valve.**
- **The reference line (9) indicates the TDC of the crankshaft.**

(1) TC Mark (Flywheel Housing)
(2) TC Mark (Flywheel)
(3) Dial Gauge
(4) Valve
(5) O-ring
(6) Tri-square
(7) Flywheel Housing
(8) Flywheel
(9) Reference Line

(To be continued)

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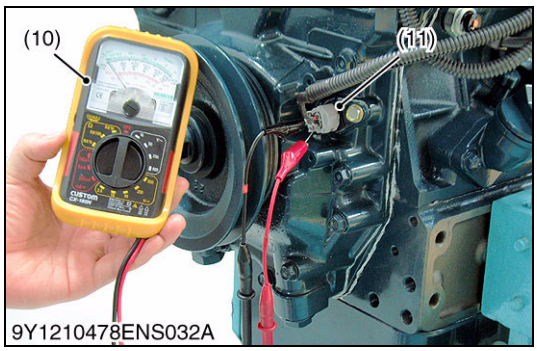

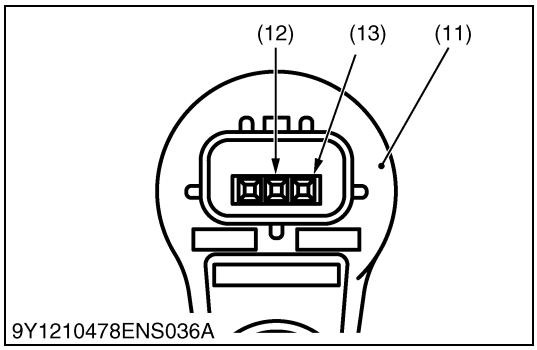

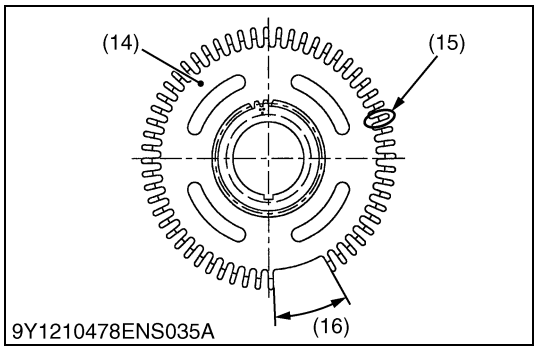

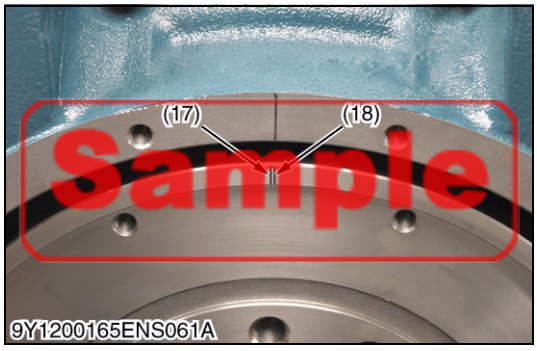

9. Connect the engine harness and the main switch.
10. Connect the battery.
11. Attach a tester (10) to the output terminal (13) and ground terminal (12) of the crankshaft position sensor (11).
12. Turn the main switch "ON".
13. Turn the flywheel and make sure that the voltage of the crankshaft position sensor goes from 0 → 5 V or 5 → 0 V.
14. Rotate the flywheel and align the crankshaft position sensor to the part of the pulsar gear (14) that is missing teeth (16).
15. The 14th tooth (15) from the missing teeth is the standard.
16. Slowly turn the flywheel counterclockwise and stop the flywheel at the point where the needle of the tester changes momentarily from 0 → 5 V, the 14th tooth.
17. That point is where the crankshaft position sensor detects TDC.
18. Set the tri-square (6) on the reference line (9) on the flywheel housing side and mark the detection point of crankshaft position sensor TDC (18) on the flywheel.
19. Measure the interval (19) between the crankshaft TDC (17) and the detection point of crankshaft position sensor TDC (18).
20. Calculation of fuel injection timing correction 1.0 mm (0.039 in.): 0.298 °.
    Corrected angle = 0.298 ° X actual interval
21. Overwrite the injection timing correction value in the ECU.

■ **IMPORTANT**

- **When the crankshaft position sensor detects the teeth of the pulsar gear, the tester indicates 0 V.**
- **The position where the needle of the tester changes momentarily from 0 → 5 V is the detection point of crankshaft position sensor TDC (18).**
- **The reference line indicates the crankshaft TDC (17) of the crankshaft. If the detected TDC is ahead of the crankshaft TDC, it is considered minus. If the detected TDC lags behind the crankshaft TDC, it is considered plus.**

(10) Tester
(11) Crankshaft Position Sensor
(12) Ground Terminal
(13) Output Terminal
(14) Pulsar Gear
(15) 14th Tooth
(16) Missing Teeth
(17) Crankshaft TDC
(18) Detection Point of Crankshaft Position Sensor TDC
(19) Interval

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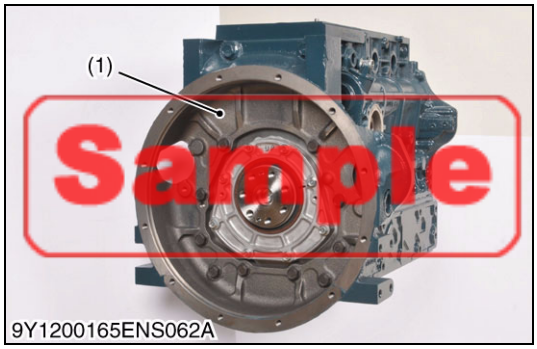

Flywheel Housing

1. Remove the flywheel housing (1).

(When reassembling)

- Apply liquid gasket (Three Bond 1217H) to flywheel housing.
- Confirm that the liquid gasket coating surface is free of water, dust and oil in order to maintain sealing effect.
- Make sure the surface of the crankcase 1, 2 are clean and alignment between crankcase 1 and 2 is correct.
- Tighten the flywheel housing mounting screws with even force on the diagonal line.

■ **NOTE**

- **Make sure the surfaces align when mounting parts with a liquid gasket applied to them.**
- **Mount parts with a liquid gasket within 10 minutes of application.**

Tightening torque	Flywheel housing mounting screw	78 to 90 N·m 7.9 to 9.2 kgf·m 58 to 66 lbf·ft

(1) Flywheel Housing

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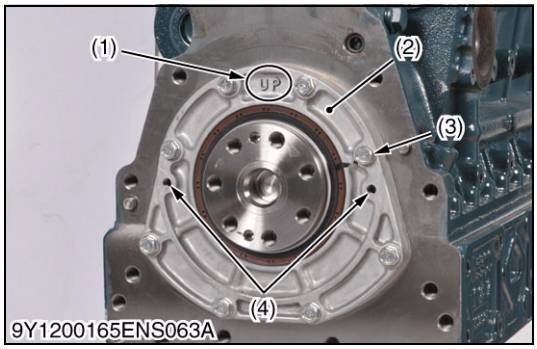

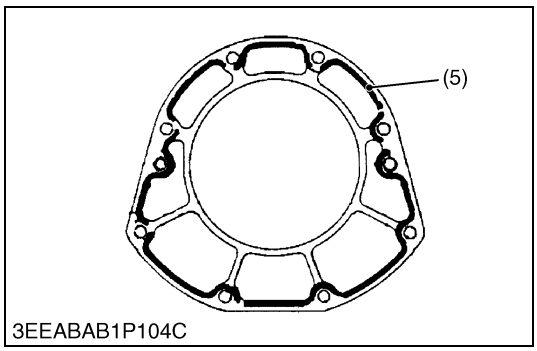

Bearing Case Cover

■ **NOTE**

- **Before disassembling check the side clearance of crankshaft. Also check it after reassembling.**

1. Remove the bearing case over mounting screws (3).
2. Set the screws in the jack-up holes (4) to remove the bearing case cover (2).

(When reassembling)

■ **IMPORTANT**

- **In case of replacing the oil seal, insert the oil seal to the bearing case cover not to be tilted. The seal should be flush with the cover.**
- **Confirm that the liquid gasket coating surface is free of water, dust and oil in order to maintain sealing effect.**
- **Apply liquid gasket (5) (Three Bond 1217H) to the bearing case cover as shown in the figure.**
- **Before installing the bearing case cover / oil seal assembly, lube the seal and install it not to damage the seal.**
- **Install the bearing case cover / oil seal assembly to position the casting mark "UP" (1) on it upward.**
- **Tighten the bearing case cover mounting screws with even force on the diagonal line.**

■ **NOTE**

- **When mounting the adhesive-applied parts, take care to fit them to the mating parts.**
- **Assemble the adhesive-applied parts within ten minutes.**

Tightening torque	Bearing case cover mounting screw	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft

(1) Casting Mark **"UP"**
(2) Bearing Case Cover
(3) Bearing Case Cover Mounting Screw
(4) Jack-up Hole
(5) Liquid Gasket

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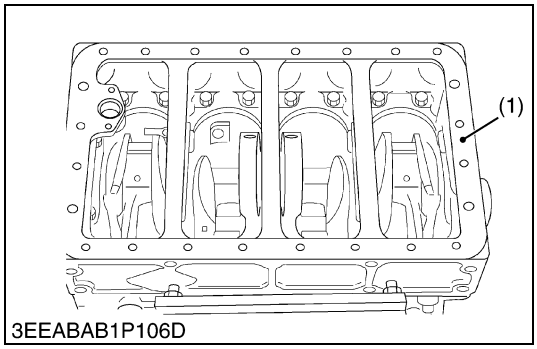

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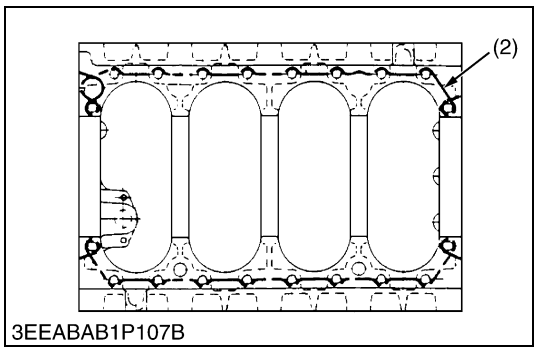

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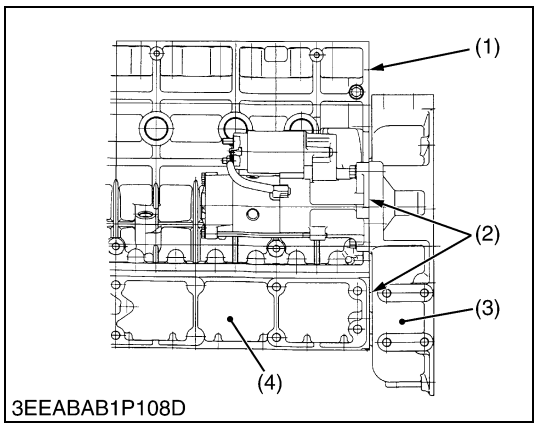

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Crankcase 2

1. Remove the crankcase 2 (1).

(When reassembling)

■ **IMPORTANT**
- **Make sure the crankcase 1 and 2 are clean.**
- **Apply liquid gasket (2) (Three Bond 1217H) to the crankcase 2 as shown in the figure.**
- **Tighten the crankcase 2 mounting screws with even force on the diagonal line.**
- **Confirm that the liquid gasket coating surface is free of water, dust and oil in order to maintain sealing effect.**
- **Carefully apply the adhesive evenly.**

■ **NOTE**
- **Make sure the surfaces align when mounting parts with a liquid gasket applied to them.**
- **Mount parts with a liquid gasket within 10 minutes of application.**

Tightening torque	Crankcase 2 mounting screw	49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft

(1) Crankcase 2 (2) Liquid Gasket

9Y1210651ENS0068US0

Crankcase 1 and Crankcase 2

(When reassembling)
- Using the surface that touches the flywheel housing as a reference, line up crankcases 1 and 2.
- Temporarily screw in the crankcase 2 mounting screws.
- Tighten the flywheel housing to the specified torque. Get the difference in the levels of crankcases 1 and 2 to as little as possible. The gap has to be 0.05 mm or less.

■ **NOTE**
- **Make sure the surfaces align when mounting parts with a liquid gasket applied to them.**
- **Mount parts with a liquid gasket within 10 minutes of application. Get the difference in the levels of crankcases 1 and 2 to as little as possible. The gap has to be 0.05 mm (0.002 in.) or less.**

Tightening torque	Crankcase 2 mounting screw	49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	Flywheel housing mounting screw	78 to 90 N·m 7.9 to 9.2 kgf·m 58 to 66 lbf·ft

(1) Crankcase 1
(2) Gap in Alignment at 0.05 mm (0.002 in.) or Less
(3) Flywheel Housing
(4) Crankcase 2

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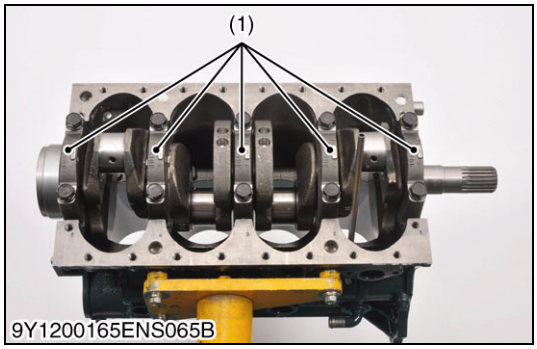

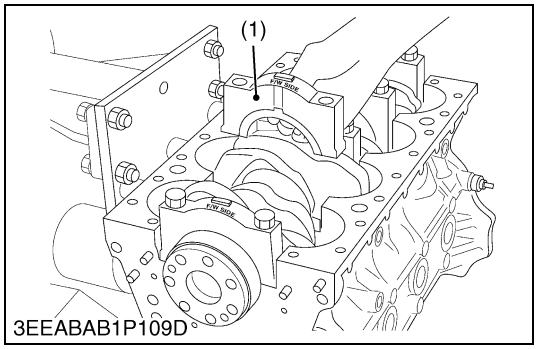

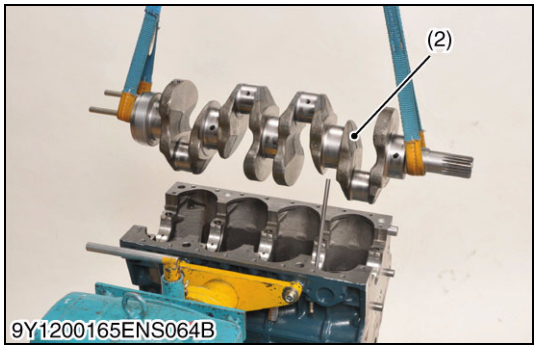

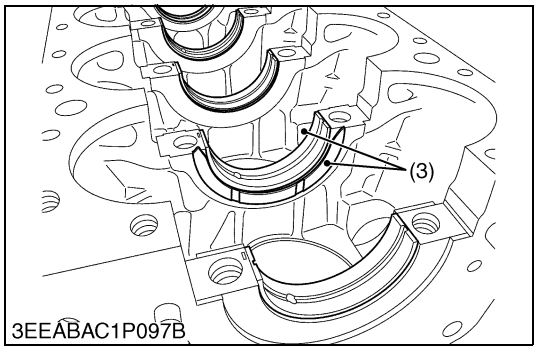

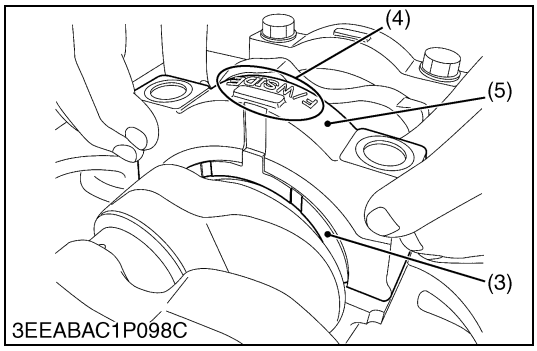

Crankshaft

1. Remove the main bearing case (1).
2. Remove the crankshaft (2).

(When reassembling)

- Reassemble the main bearing case having the same number as the one engraved on the crankcase, and set the casting mark "F / W SIDE" (4) on the main bearing case facing towards the flywheel side.
- Reassemble the thrust bearing (3), with the oil groove facing outside, into both side of the 4th main bearing case (5).
- Apply oil to the bearing case screws and tighten them to the specified torque.

Tightening torque	Main bearing case screw	138 to 147 N·m 14.0 to 15.0 kgf·m 102 to 108 lbf·ft

(1) Main Bearing Case
(2) Crankshaft
(3) Thrust Bearing
(4) F / W SIDE Mark
(5) 4th Main Bearing Case

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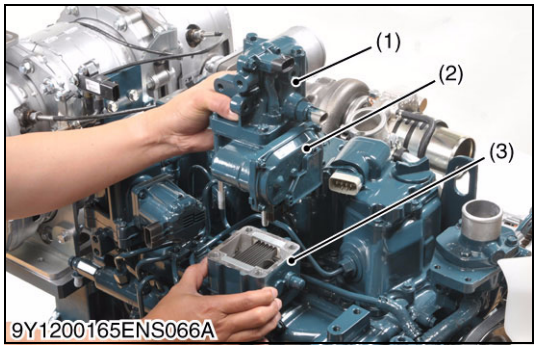
(12) Intake Air Heater



Intake Air Heater

1. Remove the inlet hose.
2. Disconnect the lead.
3. Remove the air cleaner flange (1) and intake throttle valve (2).
4. Remove the intake air heater (3).

Tightening torque	Intake air heater terminal nut	3.5 to 5.3 N·m 0.35 to 0.55 kgf·m 2.6 to 3.9 lbf·ft

(1) Air Cleaner Flange
(2) Intake Throttle Valve
(3) Intake Air Heater

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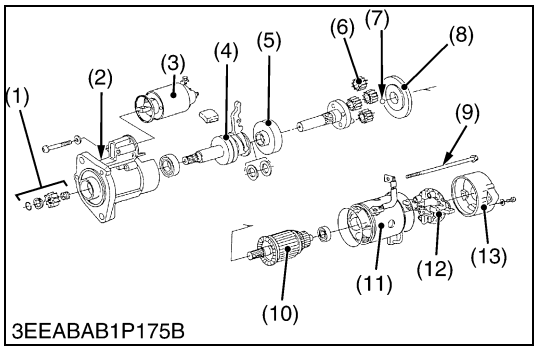
(13) Starter



Disassembling Motor

1. Disconnect the solenoid switch (3).
2. Remove the 2 through screws (9) and the 2 brush holder lock screws. Take out the rear end frame (13) and the brush holder (12). Disconnect the armature (10) and the yoke (11). Remove also the ball (7) from the tip of the armature.
3. Remove the set of packings (8), the 4 planetary gears and another packing.
4. Take out the shaft assembly. Take note of the position of the lever.

■ **IMPORTANT**

- **Before disconnecting the yoke, put tally marks on the yoke and the front bracket.**
- **Take note of the positions of the set of packings and the setup bolt.**
- **Apply grease to the gears, bearings, shaft's sliding part and ball.**

■ **NOTE**

- **Do not damage to the brush and commutator.**

(When reassembling)

- Apply grease to the parts indicated in the figure.

Tightening torque	**B** terminal nut	9.8 to 11 N·m 1.0 to 1.2 kgf·m 7.3 to 8.6 lbf·ft

(1) Gear
(2) Front Bracket
(3) Solenoid Switch
(4) Overrunning Clutch
(5) Internal Gear
(6) Planetary Gear
(7) Ball
(8) Set of Packings
(9) Through Screws
(10) Armature
(11) Yoke
(12) Brush Holder
(13) Rear End Frame

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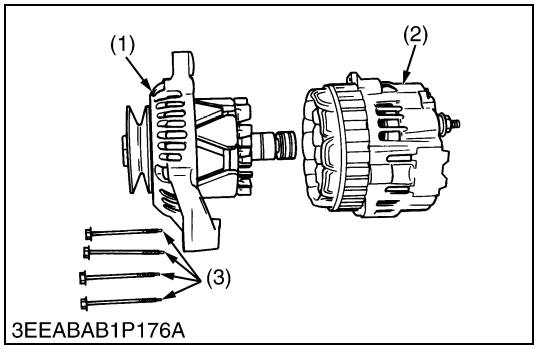
(14) Alternator



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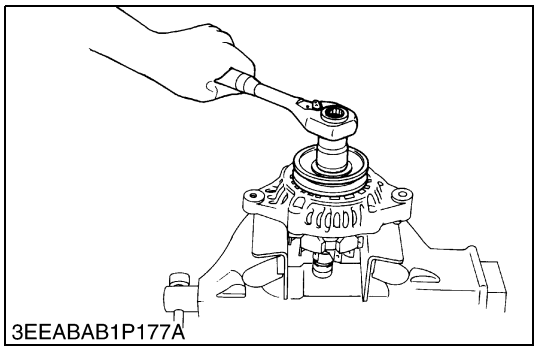
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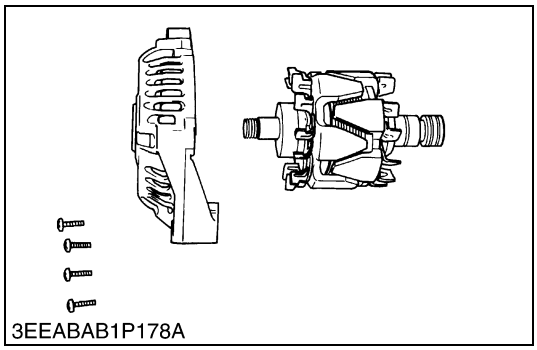
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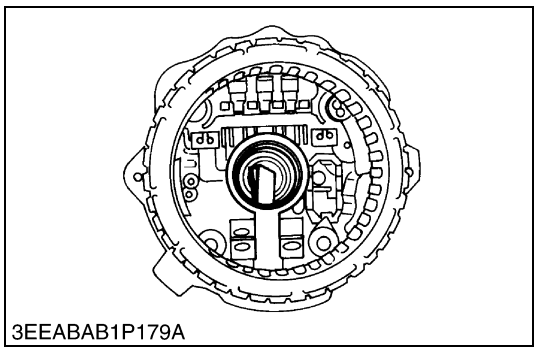
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Front Bracket

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 and the rear bracket for reassembling them later.**

(1) Front Bracket
(2) Rear Bracket
(3) Screw

9Y1210651ENS0073US0

Pulley

1. Hold the rotor (base of the claw) in a vise.
2. Loosen the lock nut using a M24 box wrench.

Tightening torque	Pulley nut	58.4 to 78.9 N·m 5.95 to 8.05 kgf·m 43.1 to 58.2 lbf·ft

9Y1210651ENS0074US0

Rotor

1. Remove the 4 screws to detach the bearing retainer.
2. Temporarily install the nut on the pulley screw.
3. Detach the rotor.

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Brush

1. When the rotor is detached, the 2 brushes are found to stretch out of the shaft hole.

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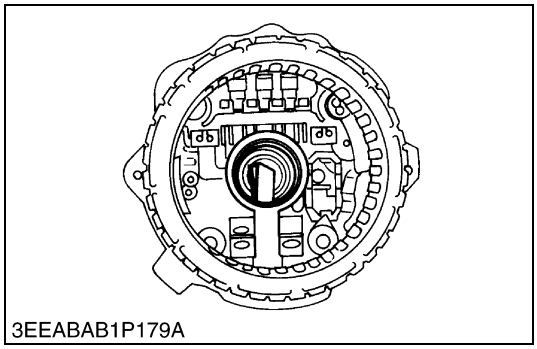
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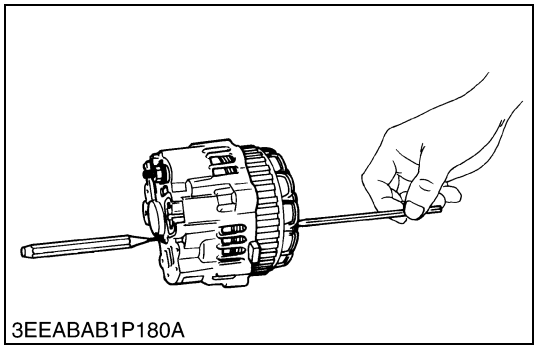
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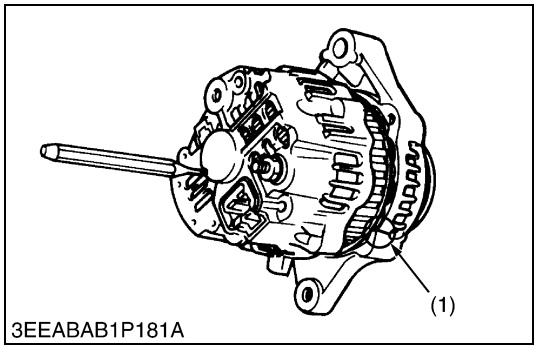

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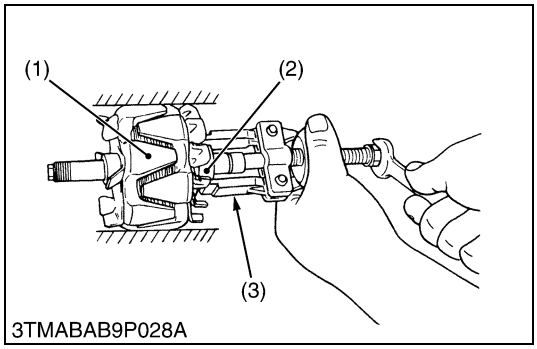

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Reassembling the Brush

1. 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.**
- **Use a 4 mm hex. wrench to push the brushes into place.**
- **Using a pin-pointed (2 mm (0.08 in.)) punch, keep the brushes from popping out.**

2. Match the tally line of the front section with that of the rear section.
3. Tighten the 4 screws.
4. Draw out the pin-pointed punch out of the brush holder.

(1) Marking

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Bearing at Slip Ring Side

1. Lightly secure the rotor (1) with a vise to prevent damage.
2. Remove the bearing (2) with a puller (3).

(1) Rotor
(2) Bearing
(3) Puller

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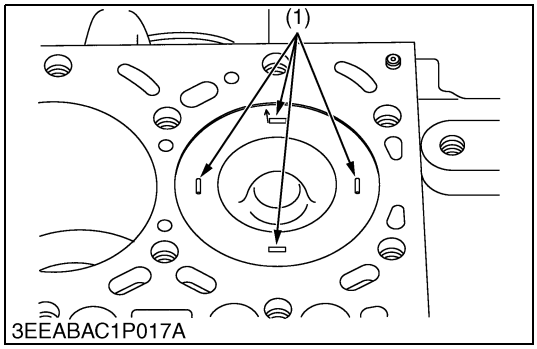
[3] ENGINE BODY AND SERVICING

(1) Cylinder Head



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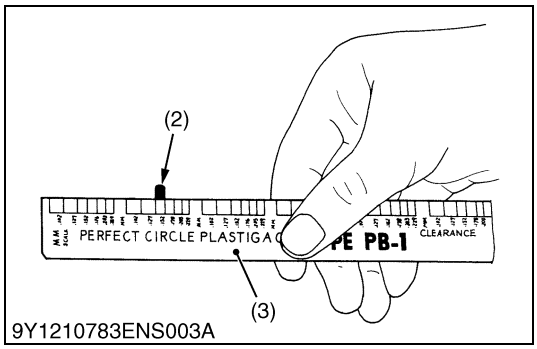

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Top clearance

1. Remove the cylinder head.
2. With the piston at TDC, use grease to affix three or four plastigauges (1) of a diameter 1.5 mm (0.059 in.) × 5.0 to 7.0 mm (0.20 to 0.27 in.) long to the crown of the piston; keep the gauges away from the intake valve and combustion chamber fittings.
3. Take the piston to an intermediate position, install the cylinder head and tighten the head bolts to the specified torque.
4. Turn the crankshaft so the piston goes through TDC.
5. Remove the cylinder head and compare the width of the crushed plastigauges (2) with the scale (3).
6. If they are out of spec, check the oil clearance of the crank pin, journal and piston pins.

■ **NOTE**

- **Top clearance = Width of the crushed plastigauge (2)**

Top clearance	Factory Specification	0.70 to 0.90 mm 0.028 to 0.035 in.

Tightening torque	Cylinder head mounting screw	98.1 to 107 N·m 10.0 to 11.0 kgf·m 72.4 to 79.5 lbf·ft

(1) Plastigauge
(2) Crushed Plastigauge
(3) Scale

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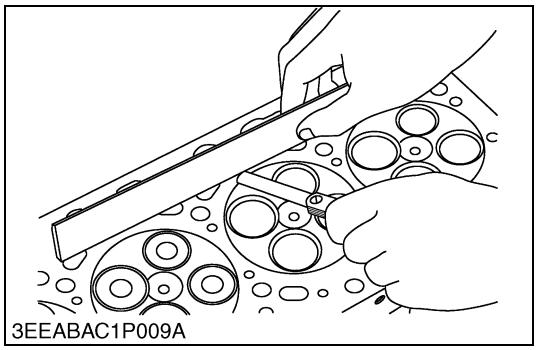
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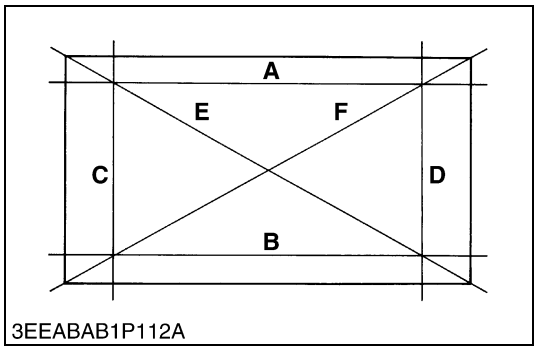
Cylinder Head Surface Flatness

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. Measure the clearance with a feeler gauge.
3. If the measurement is more than the allowable limit, make it straight with a surface grinder.

■ **IMPORTANT**

- **Examine the valve recessing after you correct.**



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Cylinder head surface flatness	Allowable limit	0.05 mm 0.002 in.

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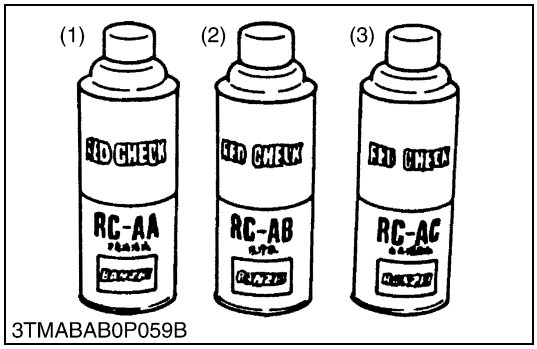

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Cylinder Head Flaw

1. Prepare an air spray red check.
2. Clean the surface of the cylinder head with detergent (2).
3. Apply some red permeative liquid (1) on the cylinder head surface. 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.
6. If you found a red flaw, replace the cylinder head.

(1) Red Permeative Liquid
(2) Detergent
(3) White Developer

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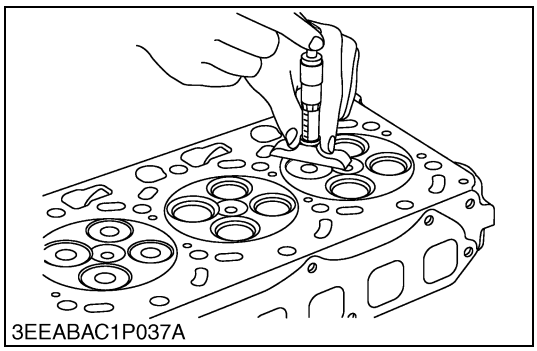
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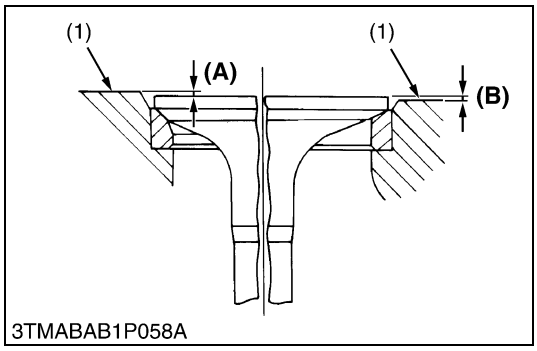
Valve Recessing

1. Clean the cylinder head surface, valve face and valve seat.
2. Set the valve into the valve guide.
3. Measure the valve recessing with a depth gauge.
4. If the measurement is more than the allowable limit, replace the valve. If it stays more than the allowable limit after you replace the valve, replace the cylinder head.

Valve recessing	Factory specification	Intake valve	(recessing) 0.60 to 0.80 mm 0.024 to 0.031 in.
		Exhaust valve	(recessing) 0.850 to 1.05 mm 0.0335 to 0.0413 in.
	Allowable limit	(recessing) 1.2 mm 0.047 in.	



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(1) Cylinder Head Surface

(A) Recessing
(B) Protrusion

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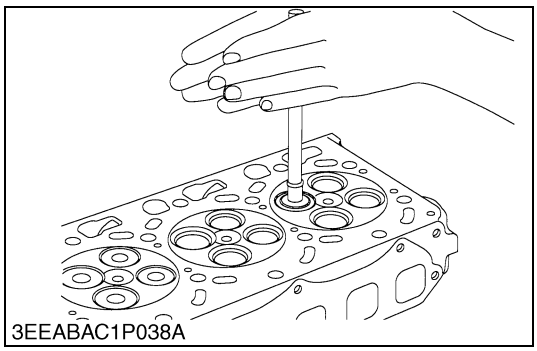
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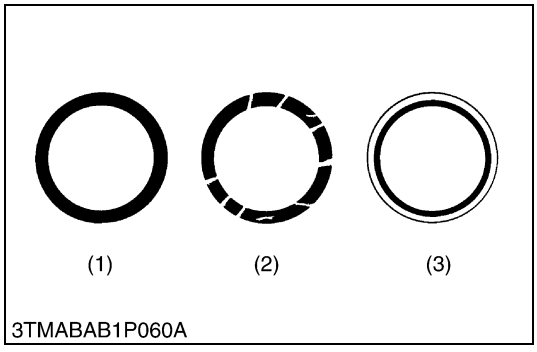
Valve Lapping

1. Apply the compound equally to the valve lapping surface.
2. Put the valve into the valve guide. Lap the valve on its seat with a valve lapping tool.
3. After you lap the valve, clean away the compound and apply oil, then lap the valve again with oil.
4. Apply Prussian Blue to the contact surface to measure the seated rate. If the seated rate is less than 70 %, lap the valve again.

■ **IMPORTANT**

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



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

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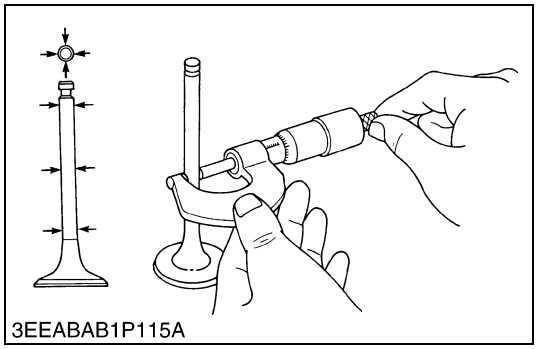
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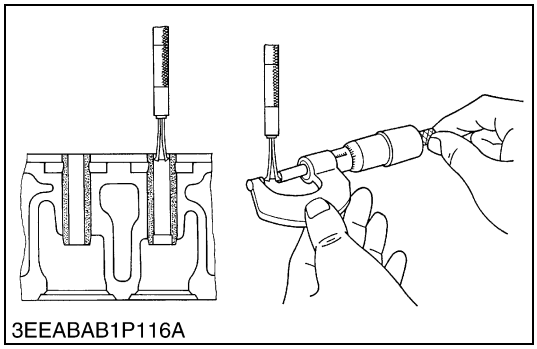
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Clearance between Valve Stem and Valve Guide

1. Remove carbon from the valve guide section.
2. Measure the valve stem O.D. with an external micrometer.
3. Measure the valve guide I.D. with a small hole gauge. Calculate the clearance.
4. If the clearance is more than the allowable limit, replace the valves. If the clearance stays more than the allowable limit, replace the valve guide also.

Clearance between valve stem and valve guide	Factory specification	Intake valve	0.035 to 0.065 mm 0.0014 to 0.0025 in.
		Exhaust valve	0.035 to 0.065 mm 0.0014 to 0.0025 in.
	Allowable limit	0.1 mm 0.004 in.	
Valve stem outside diameter	Factory specification	Intake valve	6.960 to 6.975 mm 0.2741 to 0.2746 in.
		Exhaust valve	6.960 to 6.975 mm 0.2741 to 0.2746 in.
Valve guide inside diameter	Factory specification	Intake valve	7.010 to 7.025 mm 0.2760 to 0.2765 in.
		Exhaust valve	7.010 to 7.025 mm 0.2760 to 0.2765 in.

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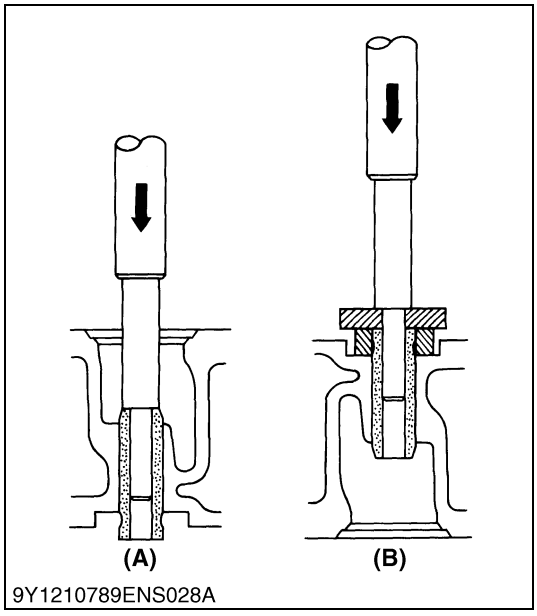

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Replacement of Valve Guide

(When removing)

1. Press out the used valve guide with the valve guide replacing tool.

(When installing)

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.
3. Ream accurately the I.D. of the valve guide to the specified dimension.

■ **IMPORTANT**

- **Do not hit the valve guide with a hammer during replacement.**

(A) When Removing **(B) When Installing**

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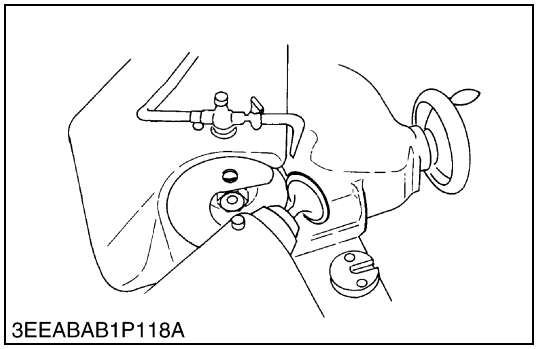
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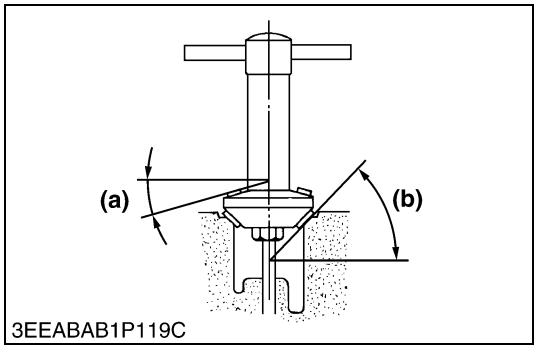

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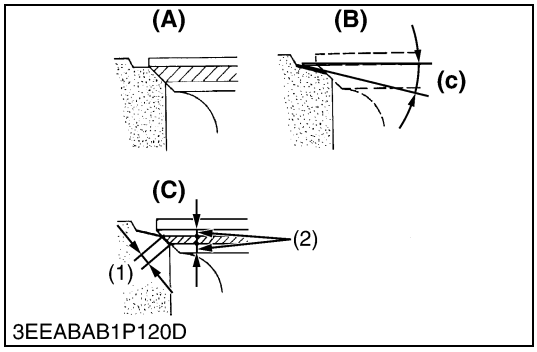

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Correction of Valve and Valve Seat

■ **NOTE**
- **Before you correct the valve and seat, examine the valve stem and measure the I.D. of the valve guide section. Repair them if necessary.**
- **After you correct the valve seat, be sure to examine the valve recessing.**

1) Correction of valve

1. Correct the valve with a valve refacer.

Valve face angle	Factory specification	Intake	1.0 rad 60 °
		Exhaust	0.79 rad 45 °

2) Correction of valve seat

1. Slightly correct the seat surface with a 1.0 rad (60 °) or 0.79 rad (45 °) valve seat cutter.
2. Correct the seat surface with a 0.52 rad (30 °) or 0.26 rad (15 °) valve seat cutter.

Valve seat width	Factory specification	Intake	1.5 to 1.9 mm 0.059 to 0.074 in.
		Exhaust	2.0 to 2.3 mm 0.079 to 0.091 in.

3. After you correct the seat, examine that the valve seating is flat. Apply a thin layer of compound between the valve face and valve seat, and lap them with a valve lapping tool.
4. Examine the valve seating with Prussian Blue. The valve seating surface must show good contact on all sides.

Valve seat angle	Factory specification	Intake	1.0 rad 60 °
		Exhaust	0.79 rad 45 °

(1) Valve Seat Width
(2) Identical Dimensions

(A) Examine the Contact
(B) Correct Seat Width
(C) Examine the Contact
(a) 0.26 rad (15 °) or 0.52 rad (30 °)
(b) 0.79 rad (45 °) or 1.0 rad (60 °)
(c) 0.52 rad (30 °) or 0.26 rad (15 °)

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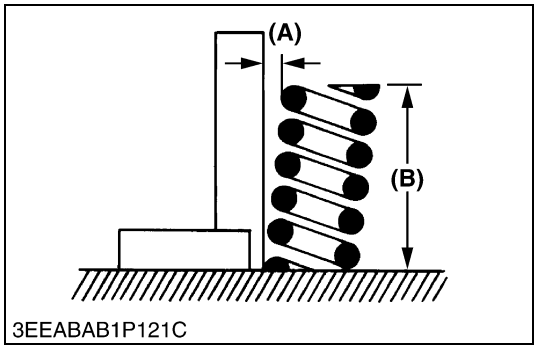

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Free Length and Tilt of Valve Spring

1. Measure the free length **(B)** of valve spring with a vernier calipers. If the measurement is less than the allowable limit, replace it.
2. Put the valve spring on a surface plate, and put a square on the side of the valve spring. Turn the valve spring to measure the maximum tilt **(A)**. If the measurement is more than the allowable limit, replace it.
3. Examine the full surface of the valve spring for scratches. If there is a defect, replace it.

Tilt **(A)**	Allowable limit		1.0 mm 0.039 in.
Free length **(B)**	Factory specification	Intake valve	35.1 to 35.6 mm 1.39 to 1.40 in.
		Exhaust valve	35.1 to 35.6 mm 1.39 to 1.40 in.
	Allowable limit	Intake valve	34.6 mm 1.36 in.
		Exhaust valve	34.6 mm 1.36 in.

(A) Tilt **(B) Free Length**

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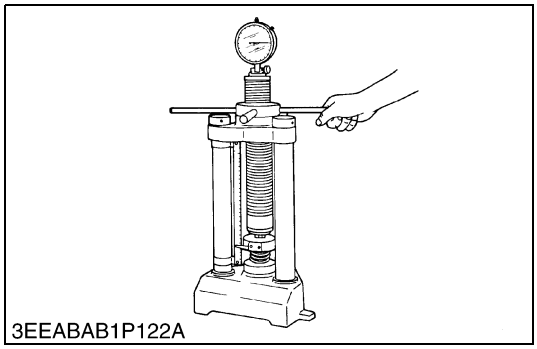
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Setting Load of Valve Spring

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.
3. If the measurement is less than the allowable limit, replace the valve spring.

Setting load / Setting length	Factory specification	Intake valve	63.5 N / 31.5 mm 6.48 kgf / 31.5 mm 14.3 lbf / 1.24 in.
		Exhaust valve	63.5 N / 31.5 mm 6.48 kgf / 31.5 mm 14.3 lbf / 1.24 in.
	Allowable limit	Intake valve	45.9 N / 31.5 mm 4.68 kgf / 31.5 mm 10.3lbf / 1.24 in.
		Exhaust Valve	45.9 N / 31.5 mm 4.68 kgf / 31.5 mm 10.3lbf / 1.24 in.

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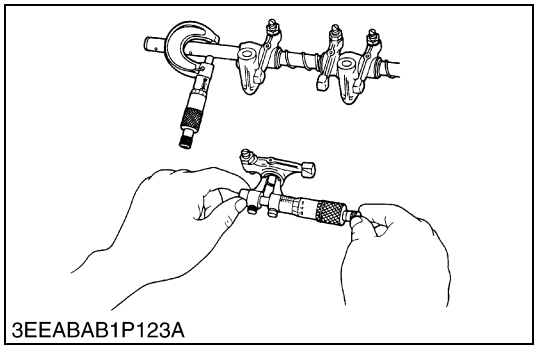
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Oil Clearance between Rocker Arm and Rocker Arm Shaft

1. Measure the rocker arm I.D. with an internal micrometer.
2. Measure the rocker arm shaft O.D. with an external micrometer.
3. Calculate the oil clearance.
4. If the oil clearance is more than the allowable limit, replace the rocker arm and measure the oil clearance again. If the oil clearance stays more than the allowable limit, replace the rocker arm shaft also.

Oil clearance between rocker arm and rocker arm shaft	Factory specification	0.016 to 0.045 mm 0.00063 to 0.0017 in.
	Allowable limit	0.15 mm 0.0059 in.

Rocker arm shaft O.D.	Factory specification	15.973 to 15.984 mm 0.62886 to 0.62929 in.
Rocker arm I.D.	Factory specification	16.000 to16.018 mm 0.62993 to 0.63062 in.

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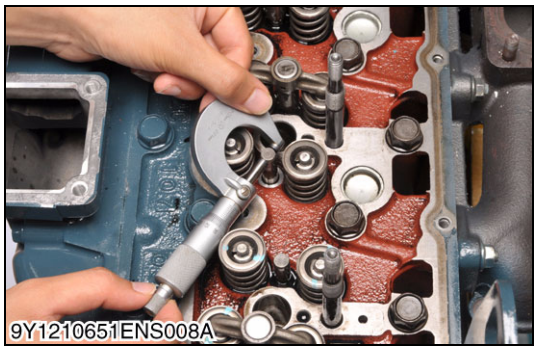
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Oil Clearance between Valve Bridge Shaft and Valve Bridge Arm

1. Measure the valve bridge arm I.D. with an internal micrometer.
2. Measure the valve bridge shaft O.D with an external micrometer.
3. Calculate the oil clearance.
4. If the oil clearance is more than allowable limit, replace the valve bridge arm and measure the oil clearance again. If the oil clearance stays more than the allowable limit, replace the valve bridge shaft also.

Oil clearance between valve bridge shaft and valve bridge arm	Factory specification	0.018 to 0.042 mm 0.00071 to 0.0016 in.
	Allowable limit	0.15 mm 0.0059 in.

Valve bridge shaft O.D.	Factory specification	9.023 to 9.032 mm 0.3552 to 0.3555 in.
Valve bridge arm I.D.	Factory specification	9.050 to 9.065 mm 0.3563 to 0.3568 in.

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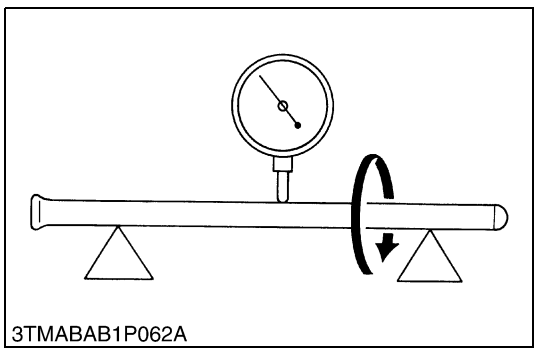
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Push Rod Alignment

1. Put the push rod on V blocks.
2. Measure the push rod alignment.
3. If the measurement is more than the allowable limit, replace the push rod.

Push rod alignment	Allowable limit	0.25 mm 0.0098 in.

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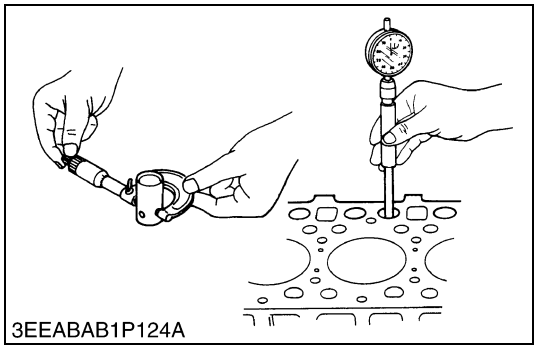
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Oil Clearance between Tappet and Tappet Guide Bore

1. Measure the tappet O.D. with an external micrometer.
2. Measure the tappet guide bore I.D. with a cylinder gauge.
3. Calculate the oil clearance.
4. If the oil clearance is more than the allowable limit or the tappet has a damage, replace the tappet.

Oil Clearance between tappet and guide bore	Factory specification	0.020 to 0.062 mm 0.00079 to 0.0024 in.
	Allowable limit	0.07 mm 0.003 in.

Tappet O.D.	Factory specification	23.959 to 23.980 mm 0.94327 to 0.94409 in.
Tappet guide bore I.D.	Factory specification	24.000 to 24.021 mm 0.94489 to 0.94570 in.

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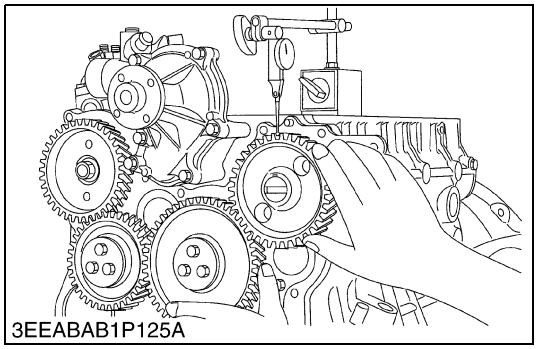
(2) Timing Gears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Timing Gear Backlash

1. Set a dial indicator (lever type) with its point on the gear tooth.
2. Hold the mating gear and move the gear to measure the backlash.
3. If the backlash is more than the allowable limit, measure the oil clearance in the journal part of each shaft.
4. If the oil clearance is correct, replace the gear.

Backlash between crank gear and idle gear 1	Factory specification	0.0490 to 0.193 mm 0.00193 to 0.00759 in.
	Allowable limit	0.22 mm 0.0087 in.

Backlash between idle gear 1 and cam gear	Factory specification	0.0490 to 0.189 mm 0.00193 to 0.00744 in.
	Allowable limit	0.22 mm 0.0087 in.

Backlash between idle gear 2 and supply pump gear	Factory specification	0.0440 to 0.177 mm 0.00174 to 0.00699 in.
	Allowable limit	0.22 mm 0.0087 in.

Backlash between idle gear 1 and idle gear 2	Factory specification	0.0440 to 0.185 mm 0.00174 to 0.00728 in.
	Allowable limit	0.22 mm 0.0087 in.

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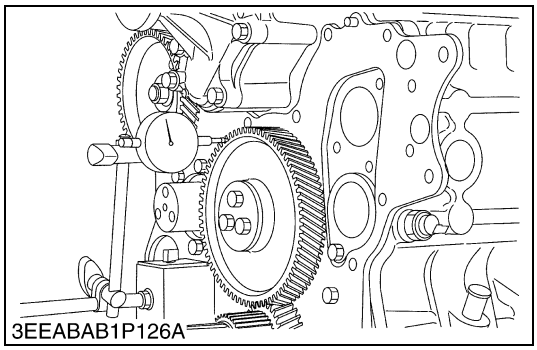
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Side Clearance of Idle Gear

1. Set a dial indicator with its point on the idle gear.
2. Move the idle gear to the front and rear to measure the side clearance.
3. If the measurement is more than the allowable limit, replace the idle gear collar.

Side clearance of idle gear	Factory specification	0.15 to 0.30 mm 0.0059 to 0.011 in.
	Allowable limit	0.90 mm 0.035 in.

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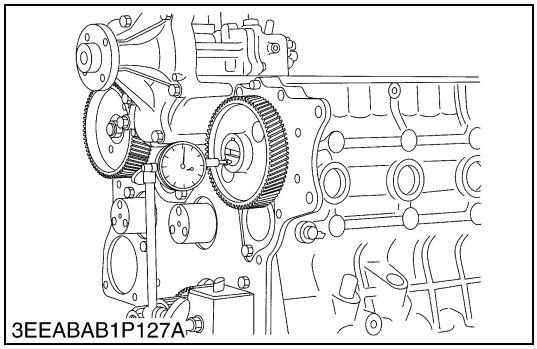
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Side Clearance of Camshaft

1. Set a dial indicator with its point on the camshaft.
2. Move the cam gear to the front and rear to measure the side clearance.
3. If the measurement is more than the allowable limit, replace the camshaft stopper.

Side clearance of camshaft	Factory specification	0.070 to 0.22 mm 0.0028 to 0.0086 in.
	Allowable limit	0.30 mm 0.012 in.

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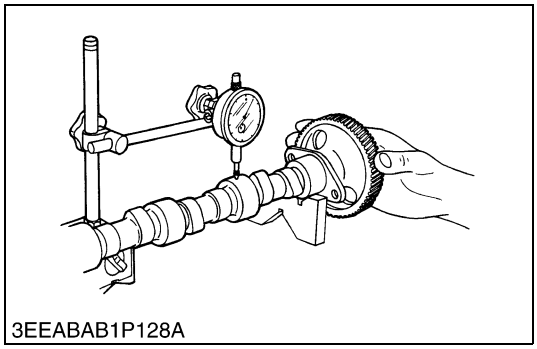
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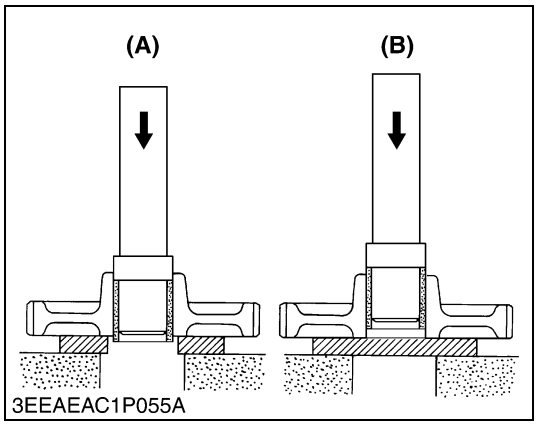
Camshaft Alignment

1. Hold the 2 end journals of camshaft with V blocks on the surface plate.
2. Set a dial indicator with its point on the middle journal.
3. Turn the camshaft slowly and read the variation on the indicator. (Half of the measurement)
4. If the measurement is more than the allowable limit, replace the camshaft.

Camshaft alignment	Allowable limit	0.01 mm 0.0004 in.

9Y1210651ENS0095US0



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Replacement of Idle Gear Bushing

(When removing)

1. Press out the used idle gear bushing with the replacing tool.

(When installing)

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. Make sure that the bushing end aligns the end of the idle gear.

(A) When Removing **(B) When Installing**

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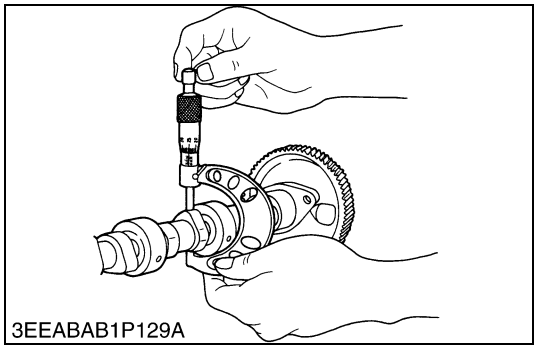
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Cam Height

1. Measure the height of the cam at its highest point with an external micrometer.
2. If the measurement is less than the allowable limit, replace the camshaft.

Cam height	Factory specification	Intake valve	37.64 mm 1.482 in.
		Exhaust Valve	38.96 mm 1.534 in.
	Allowable limit	Intake valve	37.14 mm 1.462 in.
		Exhaust valve	38.46 mm 1.514 in.

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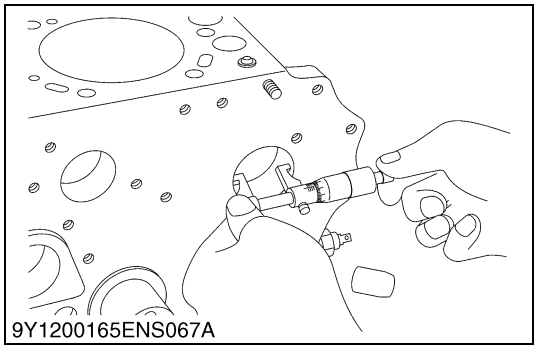
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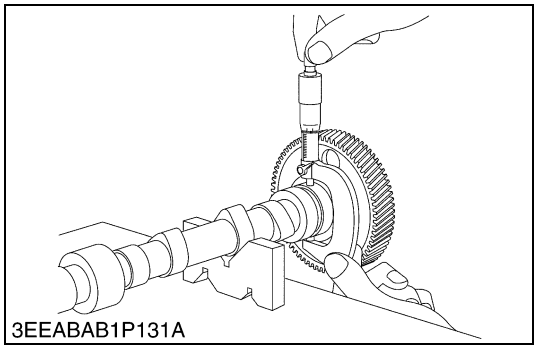
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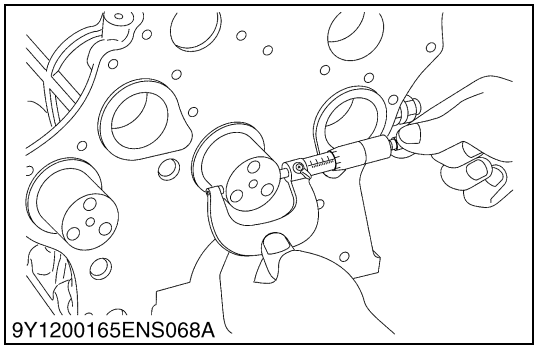
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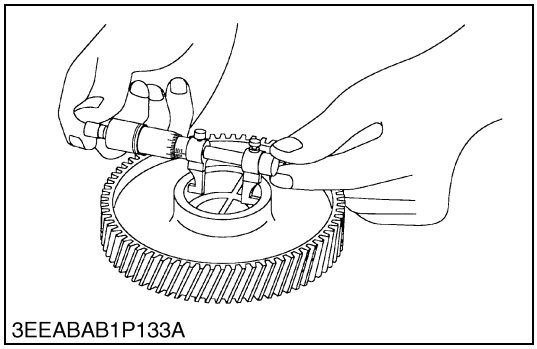
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Oil Clearance between Camshaft Journal and Cylinder Block Bore

1. Measure the camshaft journal O.D. with an external micrometer.
2. Measure the cylinder block bore I.D. for the camshaft with an internal micrometer.
3. Calculate the oil clearance.
4. If the oil clearance is more than the allowable limit, replace the camshaft.

Oil clearance of camshaft journal	Factory specification	0.050 to 0.091 mm 0.0020 to 0.0035 in.
	Allowable limit	0.15 mm 0.0059 in.

Camshaft journal O.D.	Factory specification	45.934 to 45.950 mm 1.8085 to 1.8090 in.
Camshaft bearing I.D.	Factory specification	46.000 to 46.025 mm 1.8111 to 1.8120 in.

9Y1210651ENS0098US0

Oil Clearance between Idle Gear Shaft 1, 2 and Idle Gear 1, 2 Bushing

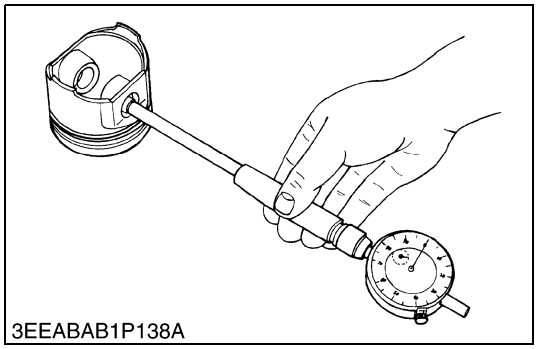
1. Measure the idle gear shaft O.D. with an external micrometer.
2. Measure the idle gear bushing I.D. with an internal micrometer.
3. Calculate the oil clearance.
4. If the oil clearance is more than the allowable limit, replace the bushing.

Oil clearance between idle gear shaft 1, 2 and idle gear 1, 2 bushing	Factory specification	0.050 to 0.091 mm 0.0020 to 0.0035 in.
	Allowable limit	0.10 mm 0.0039 in.

Idle gear 1, 2 bushing I.D.	Factory specification	45.025 to 45.050 mm 1.7727 to 1.7736 in.
Idle gear shaft 1, 2 O.D.	Factory specification	44.959 to 44.975 mm 1.7701 to 1.7706 in.

9Y1210651ENS0099US0

(3) Piston and Connecting Rod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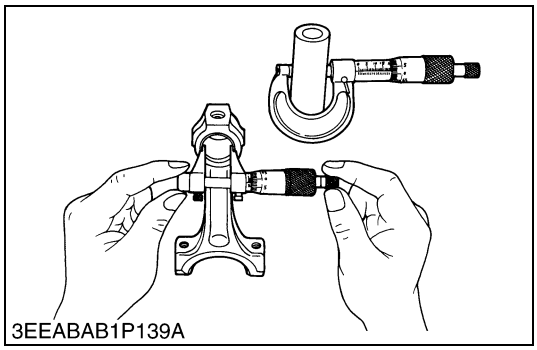
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Piston Pin Bore I.D.

1. Measure the piston pin bore I.D. in the horizontal and vertical directions with a cylinder gauge.
2. If the measurement is more than the allowable limit, replace the piston.

Piston pin bore I.D.	Factory specification	30.006 to 30.013 mm 1.1814 to 1.1816 in.
	Allowable limit	30.05 mm 1.183 in.

9Y1210651ENS0100US0

Oil Clearance between Piston Pin and Small End Bushing

1. Measure the O.D. of the piston pin where it contacts the bushing with an outside micrometer.
2. Measure the I.D. of the piston pin bushing at the connecting rod small end with a cylinder gauge.
3. Calculate the oil clearance.
4. If the clearance more than the allowable limit, replace the bushing.
5. If it still more than the allowable limit, replace the piston pin.

Oil clearance between piston pin and small end bushing	Factory specification	0.020 to 0.040 mm 0.00079 to 0.0015 in.
	Allowable limit	0.15 mm 0.0059 in.

Piston pin O.D.	Factory specification	30.006 to 30.011 mm 1.1814 to 1.1815 in.
Small end bushing I.D.	Factory specification	30.031 to 30.046 mm 1.1824 to 1.1829 in.

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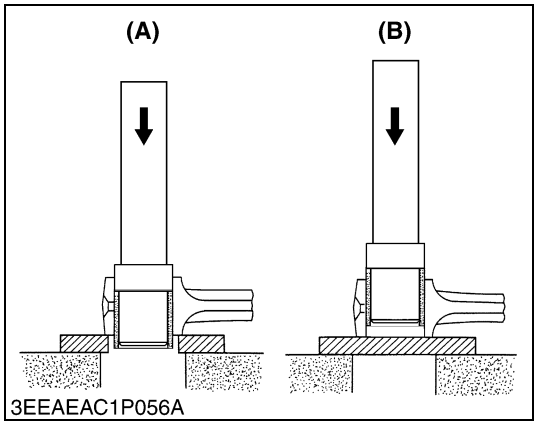

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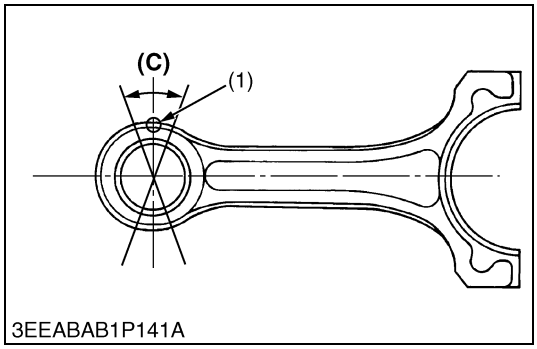

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Replacement of Small End Bushing

(When removing)

1. Press out the used bushing with small end bushing replacing tool.

(When installing)

1. Clean a new small end bushing and bore.
2. Apply engine oil to a new small end bushing and bore.
3. Insert a new bushing onto the tool.
4. Press-fit it with a press so that the seam (1) of bushing position as shown in the figure, until it is flash with the connecting rod.

(1) Seam

(A) When Removing
(B) When Installing
(C) 0.26 rad (15 °)

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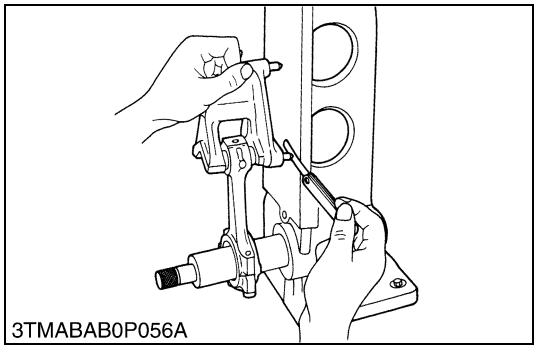
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Connecting Rod Alignment

■ **NOTE**
- **Make sure that the oil clearance of the small end bushing is less than the allowable limit.**

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 of the connecting rod.
4. Put a gauge on the piston pin, and move it against the face plate.
5. If the gauge does not touch fully against the face plate, measure the space between the gauge pin and face plate.
6. If the measurement is more than the allowable limit, replace the connecting rod.

Connecting rod alignment	Allowable limit	0.05 mm 0.002 in.

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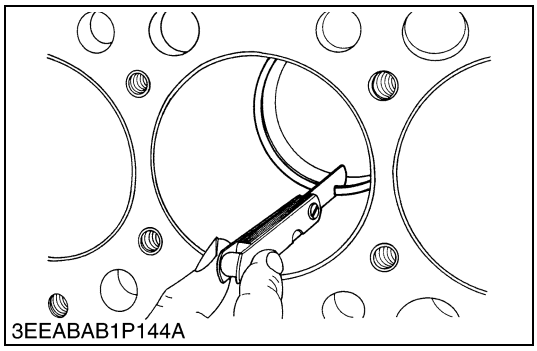
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Piston Ring Gap

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.
3. If the ring gap is more than the allowable limit, replace the ring.

Top ring and second ring	Factory specification	0.30 to 0.45 mm 0.012 to 0.017 in.
	Allowable limit	1.25 mm 0.0492 in.

Oil ring	Factory specification	0.25 to 0.45 mm 0.0099 to 0.017 in.
	Allowable limit	1.25 mm 0.0492 in.

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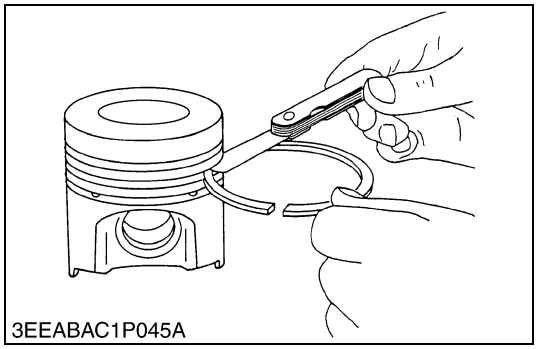
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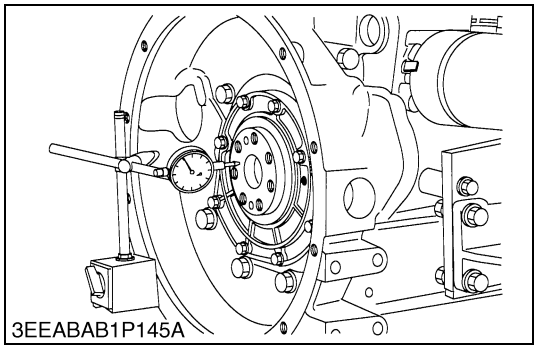
Clearance between Piston Ring and Ring Groove

1. Clean the rings and the ring grooves, and install each ring in its groove.
2. Measure the clearance between the ring and the groove with a feeler gauge or depth gauge.
3. If the clearance is more than the allowable limit, replace the piston ring.
4. If the clearance stays more than the allowable limit with new ring, replace the piston also.

Clearance between piston ring and ring groove	Factory specification	Top ring	0.05 to 0.09 mm 0.002 to 0.003 in.
		Second ring	0.0930 to 0.120 mm 0.00367 to 0.00472 in.
		Oil ring	0.020 to 0.060 mm 0.00079 to 0.0023 in.
	Allowable limit	Top ring	0.15 mm 0.0059 in.
		Second ring	0.20 mm 0.0079 in.
		Oil ring	0.15 mm 0.0059 in.

9Y1210651ENS0105US0

(4) Crankshaft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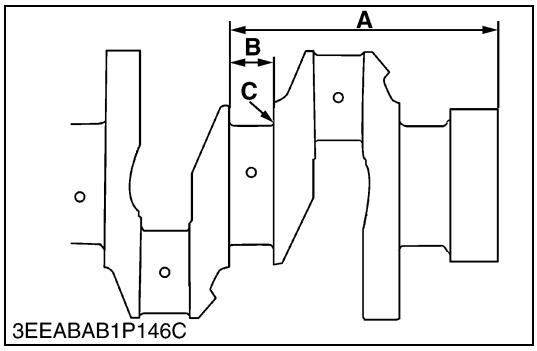

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Side Clearance of Crankshaft

1. Set a dial indicator with its point on the end of the crankshaft.
2. Move the crankshaft to the front and rear to measure the side clearance.
3. If the measurement is more than the allowable limit, replace the thrust bearings.
4. If the same dimension bearing is not applicable because of the crankshaft journal wear, replace it with an oversize one. Refer to the table and figure.

Side clearance of crankshaft	Factory specification	0.15 to 0.31 mm 0.0059 to 0.012 in.
	Allowable limit	0.50 mm 0.020 in.

(Reference)

- Oversize dimensions of crankshaft journal

Oversize	**0.2 mm 0.008 in.**	**0.4 mm 0.02 in.**
Dimension **A**	169.10 to 169.15 mm 6.6575 to 6.6594 in.	169.2 to 169.25 mm 6.6615 to 6.6633 in.
Dimension **B**	29.20 to 29.25 mm 1.150 to 1.151 in.	29.40 to 29.45 mm 1.158 to 1.159 in.
Dimension **C**	2.8 to 3.2 mm radius 0.11 to 0.12 in. radius	2.8 to 3.2 mm radius 0.11 to 0.12 in. radius
The crankshaft journal must be fine-finished to higher than Rmax = 0.8S		

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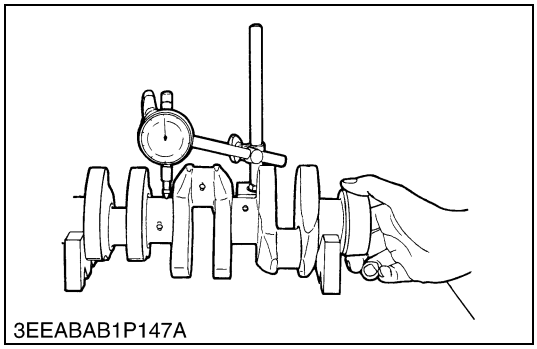
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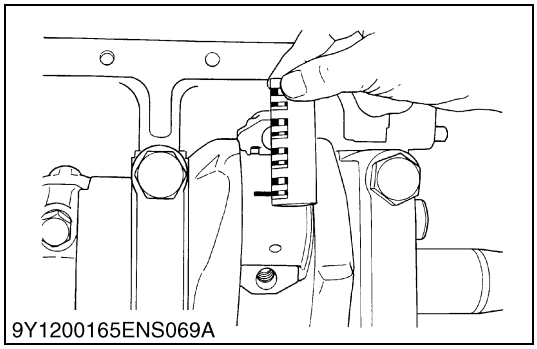
Crankshaft Alignment

1. Hold the 2 end journals of crankshaft with V blocks on the surface plate.
2. Set a dial indicator with its point on the middle journal.
3. Turn the crankshaft slowly and read the variation on the indicator. (Half of the measurement)
4. If the measurement is more than the allowable limit, replace the crankshaft.

Crankshaft alignment	Allowable limit	0.02 mm 0.0008 in.

9Y1210651ENS0107US0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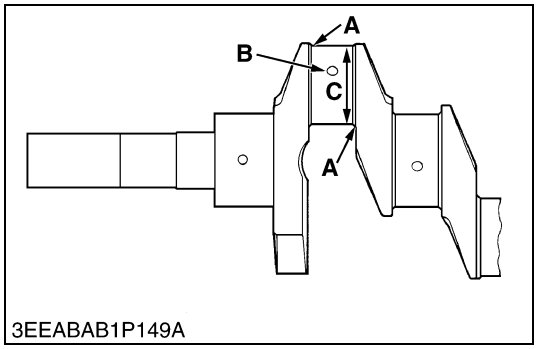

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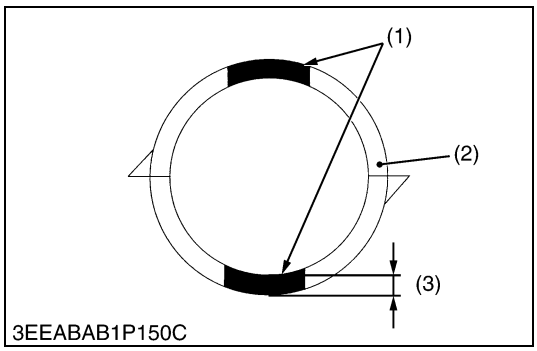

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Oil Clearance between Crank Pin and Crank Pin Bearing

1. Clean the crank pin and crank pin bearing.
2. Put a strip of Plastigauge on the center of the crank pin.
3. Install the connecting rod cap.
4. Tighten the connecting rod screws to the specified torque.
5. Remove the connecting rod cap again.
6. Measure the width that it becomes flat with the scale to get the oil clearance.
7. If the oil clearance is more than the allowable limit, replace the crank pin bearing.
8. If the same dimension bearing is not applicable because of the crank pin wear, replace it with an undersize one. Refer to the table and figure.

■ **NOTE**
- **Do not put the Plastigauge into the crank pin oil hole.**
- **When you tighten the connecting rod screws, do not move the crankshaft.**

Crank pin O.D.	Factory specification	52.977 to 52.990 mm 2.0857 to 2.0862 in.

Oil clearance between crank pin and crank pin bearing	Factory specification	0.018 to 0.051 mm 0.00071 to 0.0020 in.
	Allowable limit	0.20 mm 0.0079 in.

■ **IMPORTANT**
- **To replace it with a specific STD service part, make sure the crank pin bearing has the same ID color as the connecting rod.**

ID Color	Connecting rod	Crank pin bearing		
	Large-end in. dia.	Class	Part code	Center wall thick
Blue	56.010 to 56.020 mm 2.2052 to 2.2055 in.	L	1C020-22313	1.496 to 1.501 mm 0.05890 to 0.05909 in.
Without color	56.00 to 56.01 mm 2.2048 to 2.2051 in.	S	1C020-22334	1.491 to 1.496 mm 0.05870 to 0.05889 in.

(Reference)
- Undersize dimensions of crank pin

Undersize	0.2 mm 0.008 in.	0.4 mm 0.02 in.
Dimension **A**	3.3 to 3.7 mm radius 0.13 to 0.14 in. radius	3.3 to 3.7 mm radius 0.13 to 0.14 in. radius
*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**	52.777 to 52.790 mm dia. 2.0779 to 2.0783 in. dia.	52.577 to 52.590 mm dia. 2.0700 to 2.0704 in. dia.
The crank pin must be fine-finished to higher than Rmax = 0.8S *Holes to be de-burred and edges rounded with 1.0 to 1.5 mm (0.040 to 0.059 in.) relief.		

(1) ID Color
(2) Crank Pin Bearing
(3) Center Wall Thick

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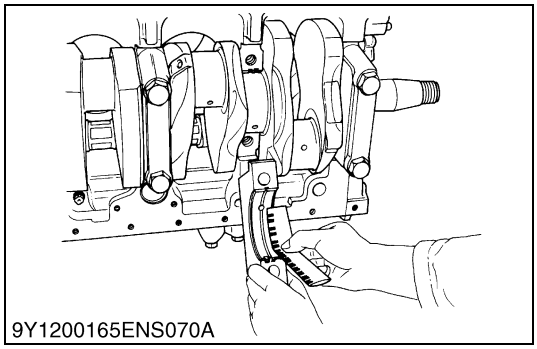
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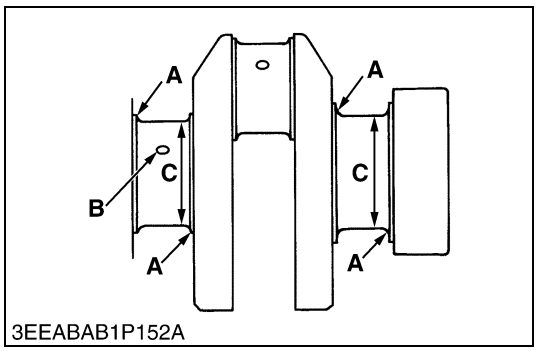

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Oil Clearance between Crankshaft Journal and Crankshaft Bearing

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 screws to the specified torque.
5. Remove the main bearing case again.
6. Measure the width that it becomes flat with the scale to get the oil clearance.
7. If the clearance more than the allowable limit, replace the crankshaft bearing.
8. 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 journal O.D.	Factory specification	74.977 to 74.990 mm 2.9519 to 2.9523 in.

Oil clearance between crankshaft journal and crankshaft bearing	Factory specification	0.018 to 0.062 mm 0.00071 to 0.0024 in.
	Allowable limit	0.20 mm 0.0079 in.

(Reference)

- Undersize dimensions of crankshaft journal

Undersize	0.2 mm 0.008 in.	0.4 mm 0.02 in.
Dimension **A**	2.8 to 3.2 mm radius 0.11 to 0.12 in. radius	2.8 to 3.2 mm radius 0.11 to 0.12 in. radius
*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**	74.777 to 74.790 mm dia. 2.9440 to 2.9444 in. dia.	74.577 to 74.590 mm dia. 2.9361 to 2.9366 in. dia.
The crankshaft journal must be fine-finished to higher than Rmax = 0.8S *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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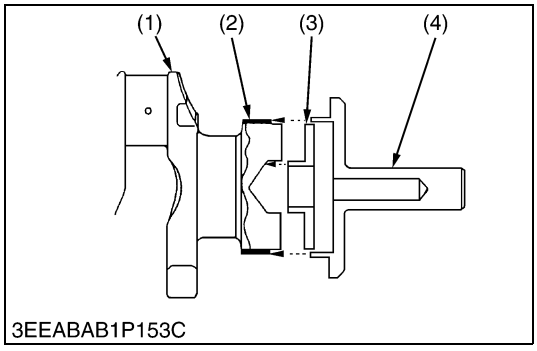

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Replacement of Crankshaft Sleeve

1. Remove the used crankshaft sleeve (2).
2. Set the sleeve guide (3) to the crankshaft (1).
3. Increase the temperature of a new sleeve to between 150 and 200 °C (302 and 392 °F).
4. Set the sleeve to the crankshaft as shown in figure.
5. Press fit the sleeve using the auxiliary socket for pushing (4).

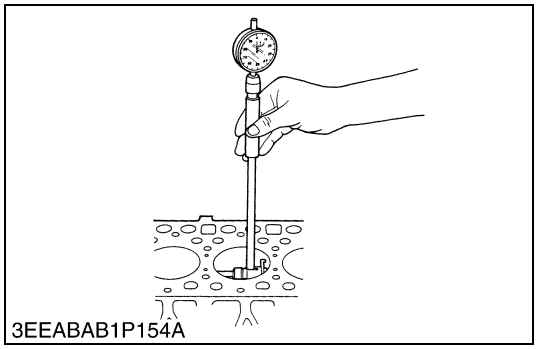
■ **NOTE**

- **Make sure that the large chamfer of the sleeve points to outward.**

(1) Crankshaft
(2) Crankshaft Sleeve
(3) Sleeve Guide
(4) Auxiliary Socket for Pushing

9Y1210651ENS0110US0

(5) Cylinder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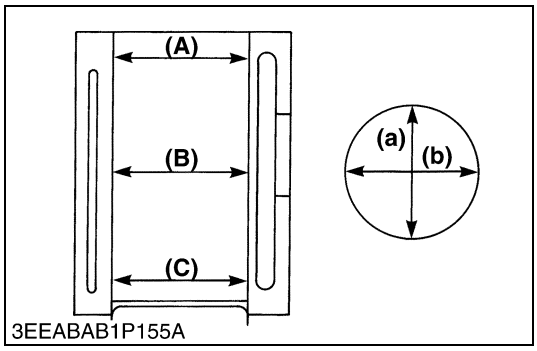

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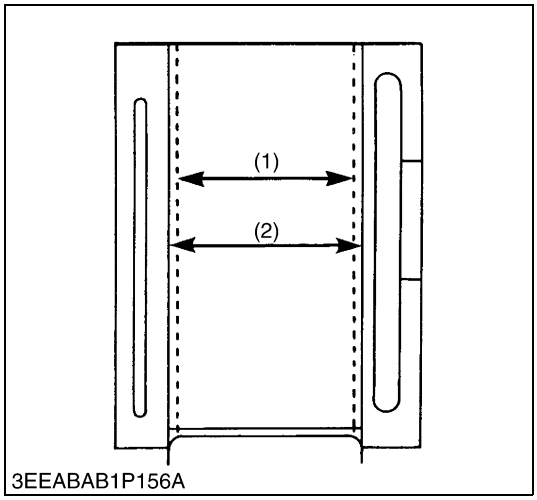

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Cylinder Wear

1. Measure the I.D. of the cylinder 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.
3. If the maximum I.D. or the difference is more than the allowable limit, bore and hone it to the oversize dimension. (Refer to "Cylinder Correction (Oversize)".)
4. Examine the cylinder wall for scratches. If you find deep scratches, bore the cylinder. (Refer to "Cylinder Correction (Oversize)".)

Cylinder Bore I.D.	Factory specification	100.000 to 100.022 mm 3.93701 to 3.93787 in.
	Allowable limit	100.150 mm 3.9429 in.

(A) Top
(B) Middle
(C) Bottom
(a) Right-angled to Piston Pin
(b) Piston Pin Direction

9Y1210651ENS0111US0

Cylinder Correction (Oversize)

1. If the cylinder wear is more than the allowable limit, bore and hone it to the specified dimension.

Oversize cylinder I.D.	Factory specification	100.500 to 100.522 mm 3.95670 to 3.95755 in.
Maximum wear	Allowable limit	100.650 mm 3.96260 in.
Finishing	Hone to 1.2 to 3.0 µmRz (0.000048 to 0.00011 in.Rz)	

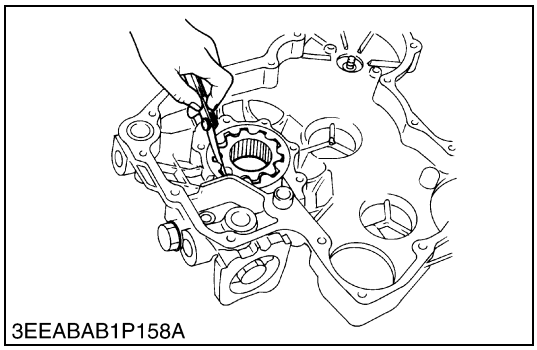
2. Replace the piston and piston rings with oversize ones (0.5 mm, 0.02 in.).

■ **NOTE**
- **If the maximum I.D. or the difference for the oversize cylinder is more than the allowable limit, replace the cylinder block with a new one.**

(1) Cylinder I.D. (Before Correction) (2) Cylinder I.D. (Oversize)

9Y1210651ENS0112US0

(6) Oil Pump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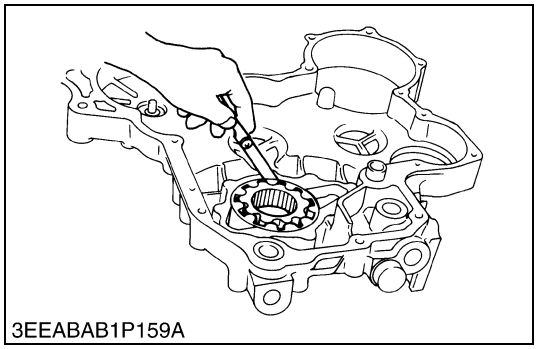
Clearance between Inner Rotor and Outer Rotor

1. Measure the clearance between the lobes of the inner rotor and the outer rotor with a feeler gauge.
2. If the clearance more than the allowable limit, replace the oil pump rotor assembly.

Clearance between Inner Rotor and Outer Rotor	Factory specification	0.040 to 0.16 mm 0.0016 to 0.0062 in.
	Allowable limit	0.3 mm 0.01 in.

9Y1210651ENS0113US0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Clearance between Outer Rotor and Pump Body

1. Measure the clearance between the outer rotor and the pump body with a feeler gauge.
2. If the clearance more than the allowable limit, replace the oil pump rotor assembly.
3. If the clearance stays more than the allowable limit after replacing the oil pump rotor assembly, replace the gear case.

Clearance between outer rotor and pump body	Factory specification	0.100 to 0.184 mm 0.00394 to 0.00724 in.
	Allowable limit	0.3 mm 0.01 in.

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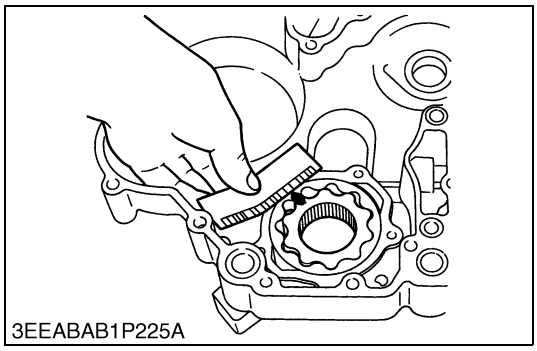
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Clearance between Rotor and Cover

1. Put a strip of Plastigauge on the rotor face with grease.
2. Install the cover and tighten the screws with the specified torque.
3. Remove the cover carefully.
4. Measure the width that Plastigauge becomes flat with the scale to get the oil clearance.
5. If the clearance is more than the allowable limit, replace oil pump rotor assembly and the cover.

Clearance between rotor and cover	Factory specification	0.025 to 0.075 mm 0.00099 to 0.0029 in.
	Allowable limit	0.225 mm 0.00886 in.

Tightening torque	Oil pump cover screw	7.9 to 9.3 N·m 0.80 to 0.95 kgf·m 5.8 to 6.8 lbf·ft

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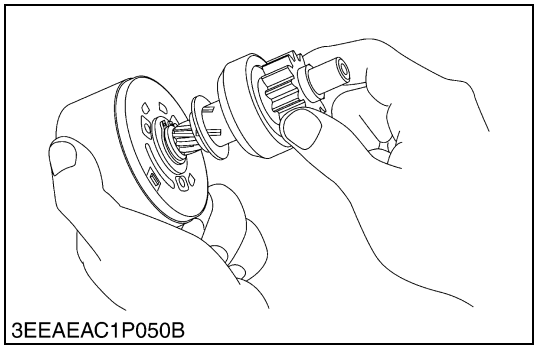
(7) Starter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Overrunning Clutch

1. Examine the pinion for wear or damage.
2. If there is any defect, replace the overrunning clutch assembly.
3. Examine that the pinion turns freely and smoothly in the direction that it overruns. (Examine the overrunning function.)
4. If there is any defect, replace the overrunning clutch assembly.

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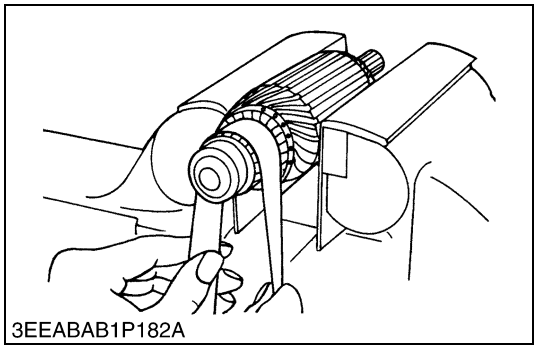
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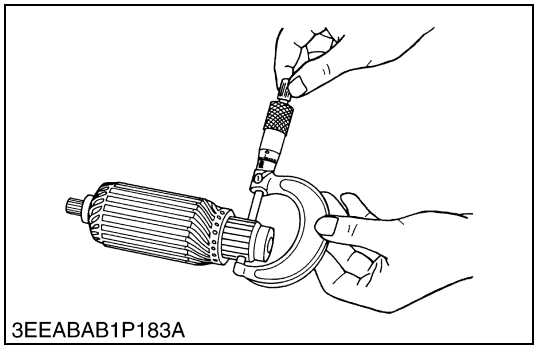
Commutator and Mica

1. Examine the contact of the commutator for wear.
2. Grind the commutator with emery paper (#300) if it is lightly worn.
3. Measure the commutator O.D. with an outside micrometer at several points.
4. If the minimum O.D. is less than the allowable limit, replace the armature assembly.
5. If the difference of the O.D.'s more than the allowable limit, correct the commutator on a lathe to the factory specification.
6. Measure the mica undercut.
7. If the undercut is less than the allowable limit, correct it with a saw blade. Chamfer the segment edges.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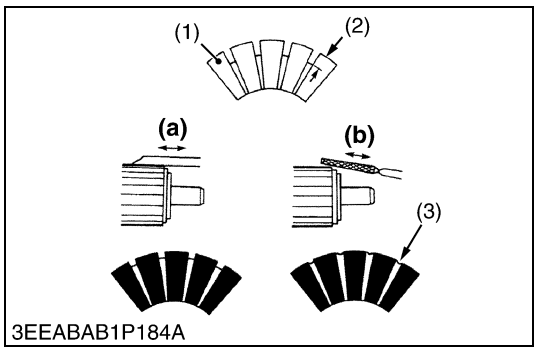
Commutator O.D.	Factory specification	32.0 mm 1.26 in.
	Allowable limit	31.4 mm 1.24 in.
Mica under cut	Factory specification	0.50 mm 0.020 in.
	Allowable limit	0.20 mm 0.0079 in.



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(1) Segment
(2) Depth of Mica
(3) Mica

(a) Good
(b) Bad

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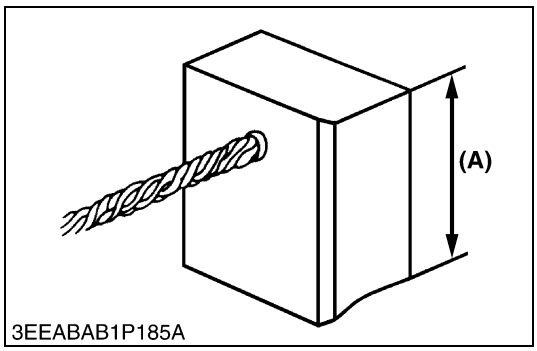

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Brush Wear

1. Measure the brush length **(A)** with a vernier caliper.
2. If the length is less than the allowable limit, replace the yoke assembly and brush holder assembly.
3. After you replace the brush, put an emery paper (#300 or above) on the commutator and correct the contact position.

Brush length **(A)**	Factory specification	18.0 mm 0.709 in.
	Allowable limit	11.0 mm 0.433 in.

(A) Brush Length

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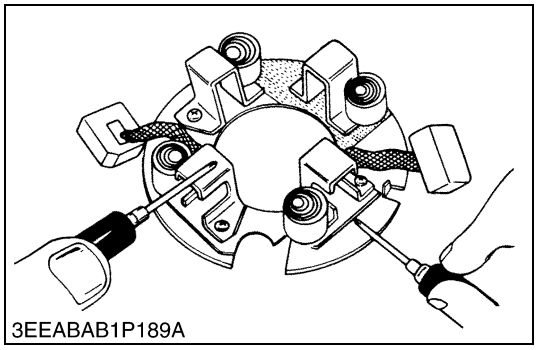
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Brush Holder

1. Examine the continuity across the brush holder and the holder support with a circuit tester.
2. If electricity flows, replace the brush holder assembly.

Resistance between brush holder and holder support	Factory specification	Infinity

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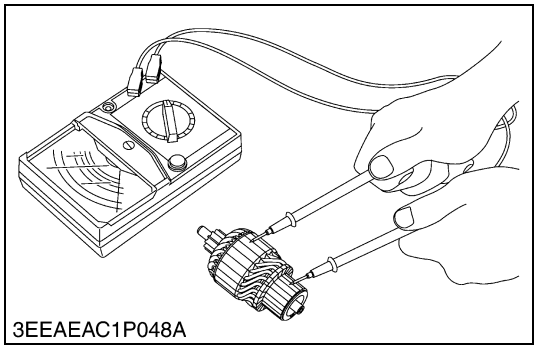
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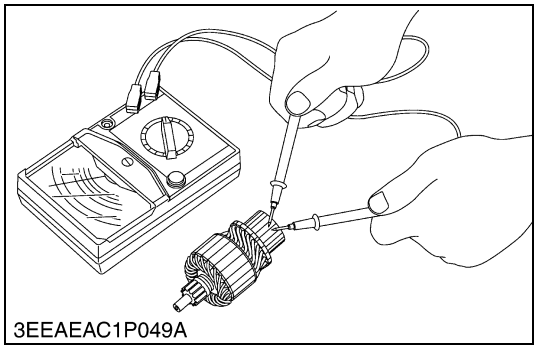
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Armature Coil

1. Examine the continuity across the commutator and armature coil core with the resistance range of circuit tester.
2. Examine the continuity across the segments of the commutator with the resistance range of circuit tester.
3. If electricity is out of factory specification, replace the armature assembly.

Resistance between commutator and armature coil core	Factory specification	Infinity
Resistance between commutator and segment	Factory specification	0 Ω

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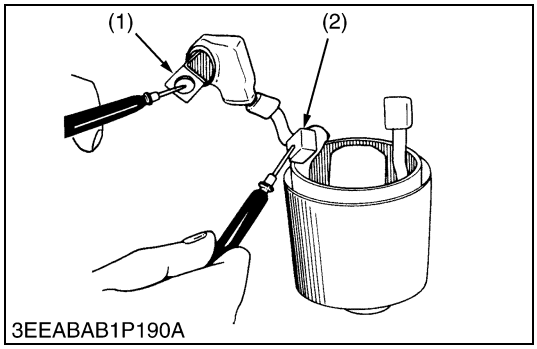

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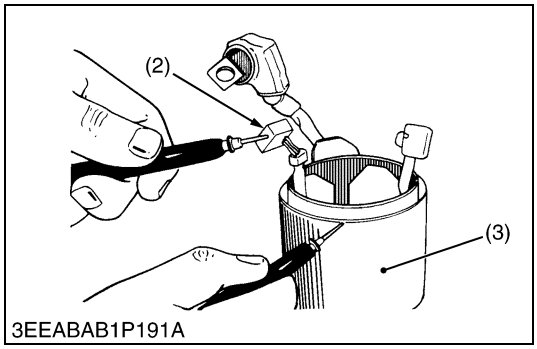
Field Coil

1. Examine the continuity across the lead (1) and brush (2) with a circuit tester.
2. Examine the continuity across the brush (2) and yoke (3) with a circuit tester.
3. If electricity is out of factory specification, replace the yoke assembly.

Resistance between lead and brush	Factory specification	0 Ω
Resistance between brush and yoke		Infinity



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(1) Lead
(2) Brush
(3) Yoke

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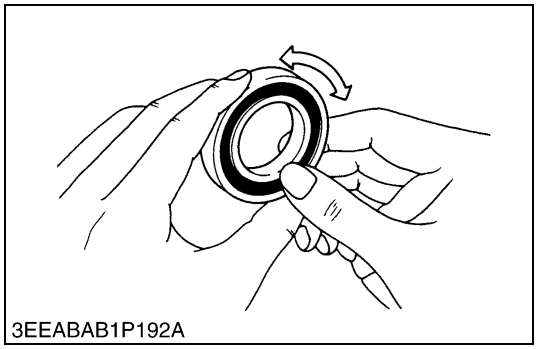
(8) Alternator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Bearing

1. Examine that the bearing can turn smoothly.
2. If not, replace it.

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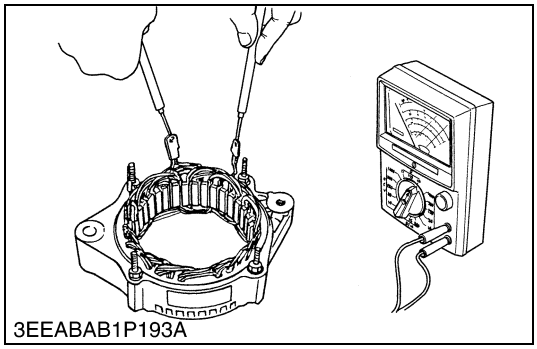
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Stator

1. Measure the resistance across each lead of the stator coil with the resistance range of circuit tester.
2. If the measurement is not in the factory specification, replace the stator assembly.
3. Examine the continuity across each stator coil lead and core with the resistance range of circuit tester.
4. If it does not show infinity, replace the stator assembly.

Resistance	Factory specification	Less than 1.0 Ω

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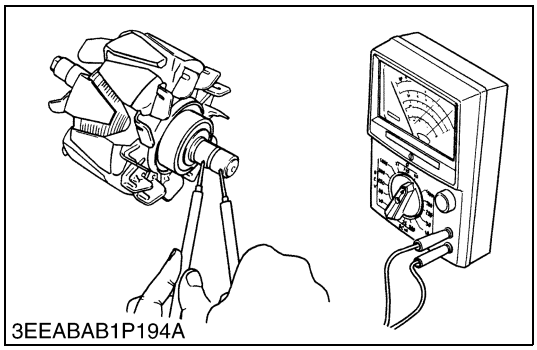
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Rotor

1. Measure the resistance across the slip rings.
2. Examine the continuity across the slip ring and core with the resistance range of circuit tester.
3. If electricity is out of factory specification, replace the rotor.

Resistance between slip rings	Factory specification	2.8 to 3.3 Ω
Resistance between slip ring and rotor core		Infinity

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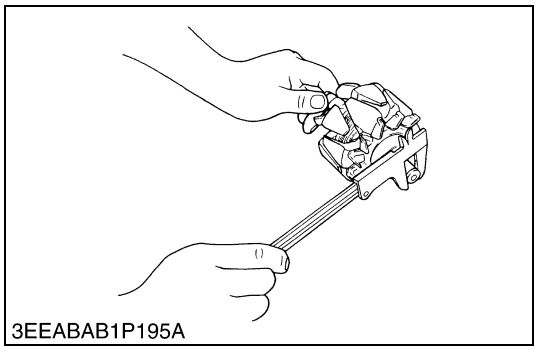
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Slip Ring

1. Examine the slip ring for dirt or scratch.
2. If dirt is detected, clean the slip ring using a cloth soaked in alcohol.
3. If there is slight score, correct with an emery paper (#500 to 600).
4. Measure the O.D. of the slip ring with a vernier calipers.
5. If the measurement is less than the allowable limit, replace the rotor assembly.

Slip ring O.D.	Factory specification	22.7 mm 0.894 in.
	Allowable limit	22.1 mm 0.870 in.

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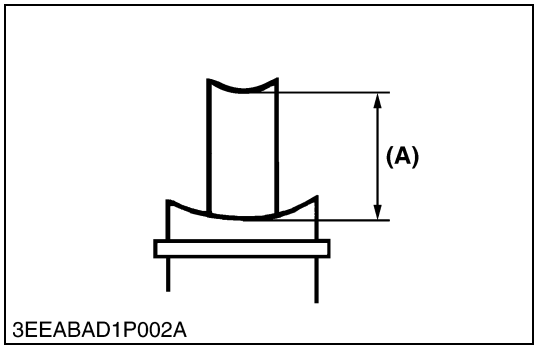

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Brush Wear

1. Measure the brush length **(A)** with a vernier calipers.
2. If the measurement is less than the allowable limit, replace it.
3. Make sure that the brush moves smoothly.
4. If the brush is defective, replace it.

Brush length **(A)**	Factory specification	10.0 mm 0.394 in.
	Allowable limit	1.5 mm 0.059 in.

(A) Brush Length

9Y1210651ENS0125US0

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