WSM

WORKSHOP MANUAL

DIESEL ENGINE

V3800-TIEF4, V3800-TIEF4C, V3800-TIEF4H

Kubota

KiSC issued 08, 2018 A

TO THE READER

This Workshop Manual tells the servicing personnel about the mechanism, servicing and maintenance of the *V3800-TIEF4, V3800-TIEF4C and V3800-TIEF4H*. It contains 4 parts: "Information", "General", "Mechanism" and "Servicing".

Information

This section primarily contains information below.

- Safety first
- Specifications
- Performance curve
- Dimensions
- Wiring diagram

General

This section primarily contains information below.

- Engine identification
- General precautions
- Maintenance check list
- Check and maintenance
- Special tools

Mechanism

This section primarily contains information below.

- General (Introduction)
- Engine body
- Fuel system
- Intake and exhaust system
- Exhaust gas recirculation (EGR) system
- Lubricating system
- Cooling system
- Electrical system
- After treatment system

Servicing

This section primarily contains information below.

- Troubleshooting
- Servicing specifications
- Tightening torques
- Checking and adjusting
- Disassembling
- Assembling
- 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.

May, 2015

RECORD OF REVISIONS

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

Last digit of the Code No.	Month of Revision	Part name	Main revised point and corrective measure	Reference page
1	2016.01	DEF/AdBlue® injector SCR (Selective Catalytic Reduction) muffler Supply pump	Replacing water separator filter (Type 2). Checking DEF/AdBlue® injector tip. Checking DEF/AdBlue® injector Tightening torques of screws, bolts and nuts for special use • SCR (Selective Catalytic Reduction) muffler • SCR mixing pipe • Supply pump ("AdBlue®" is a registered trademark of Verband der Automobilin-dustrie e.V. in Germany.)	2-22 2-29 2-37 3-99
2	2016.02	—	The following sentence was added up ("AdBlue®" is a registered trademark of Verband der Automobilindustrie e.V. in Germany.).	—
3	2017.01	DEF/AdBlue® injector	Checking DEF/AdBlue® injector.	2-37
4	2018.08	Supply pump V3800-TIEF4H	Added the information of V3800-TIEF4H • Each parts of mechanism • How to check electrical parts (Checking and adjusting) • Procedure when replacing electrical parts (Servicing) Separate assembling and disassembling. Correction for procedure of removing supply pump.	1-5 3-138

CONTENTS

3. ENGINE

1. INFORMATION

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.**

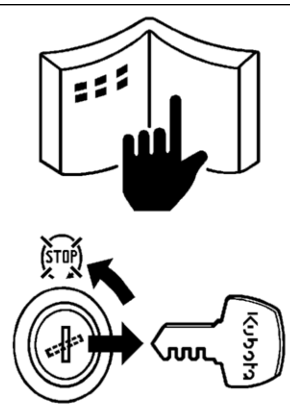
WARNING
- **Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.**

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.**

1. Before you start service



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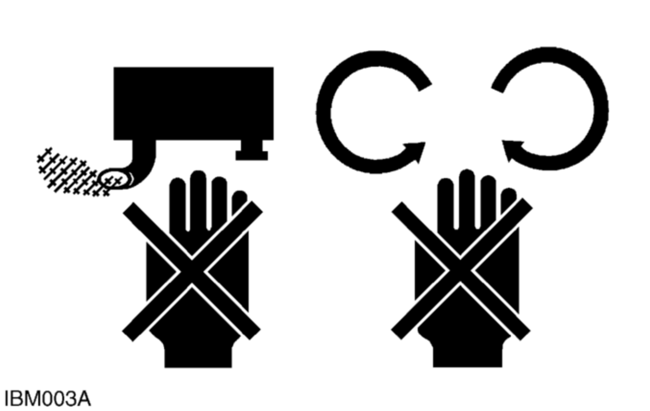
- Read all instructions and safety instructions in this manual and on your machine safety decals.
- Clean the work area and machine.
- Park the machine on a stable and level ground, and set the parking brake.
- Lower the implement to the ground.
- Stop the engine, then remove the key.
- Disconnect the battery negative cable.
- Hang a **[DO NOT OPERATE]** tag in the operator station.

2. Start safely

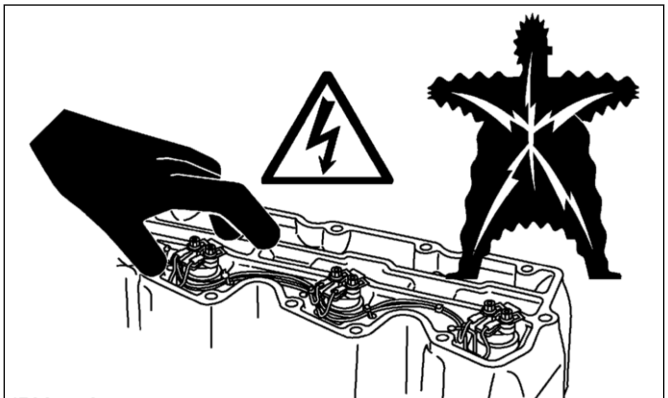

IBM011A

- 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.

3. Operate safely

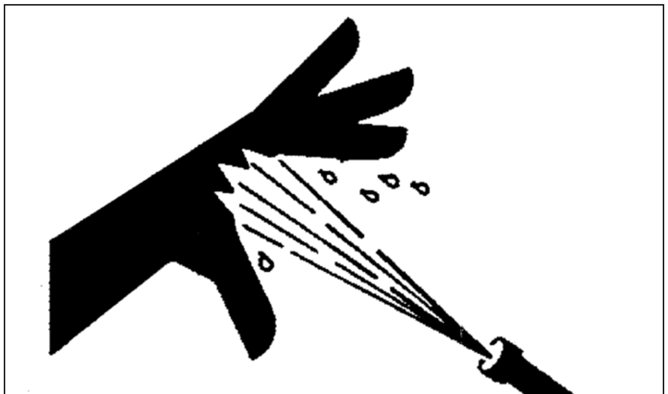

IBM003A


IBM004A


IBM005A

- 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 operate below the machine that only a jack holds. Always use a safety stand to hold the machine.
- 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.

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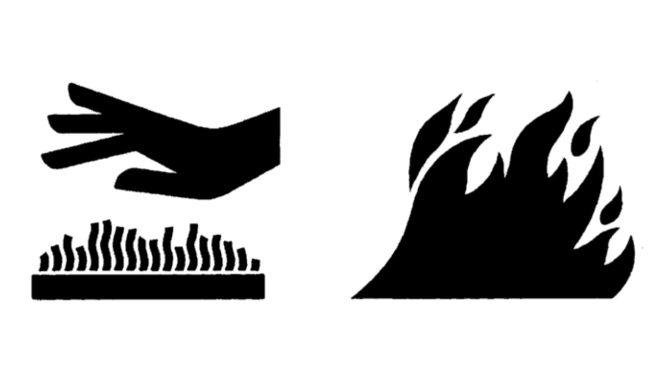
- Keep away from high pressure fluids bursting from a hose or pipe. The fluid can penetrate your skin and cause serious injuries.
- Get a medical aid immediately if the accident occurs.

5. Avoiding hot exhaust



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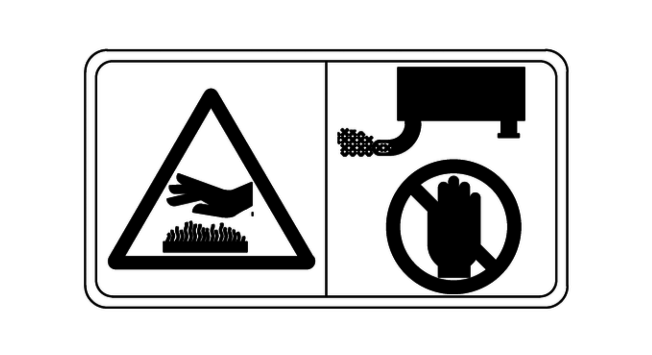
- Avoid skin exposure and contact with hot exhaust gas or components.
- Exhaust gas and components are extremely hot during operation.



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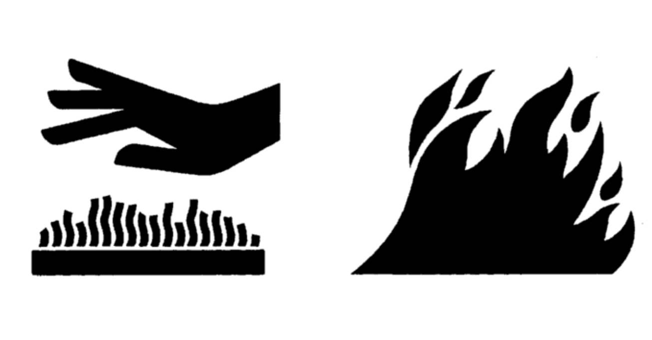
- Do not work immediately after stopping the engine. The engine, muffler, radiator, and hydraulic components are extremely hot.
- Do not remove caps and plugs soon after stopping the engine. The temperature and pressure of the coolant, hydraulic oil, and fuel are still high.

6. Cleaning exhaust filter



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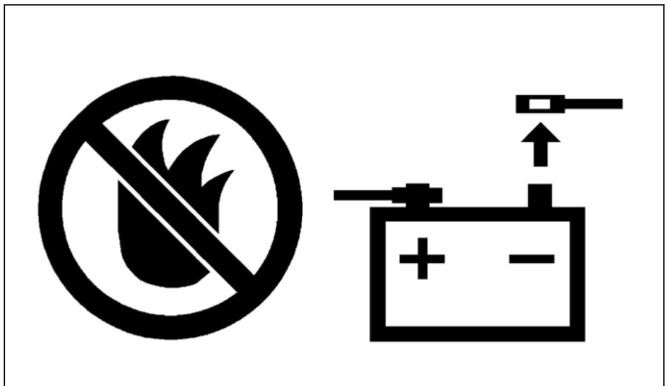
- Avoid skin exposure and contact with hot exhaust gas or components. Exhaust gas and components are extremely hot during regeneration of diesel particulate filter (DPF).

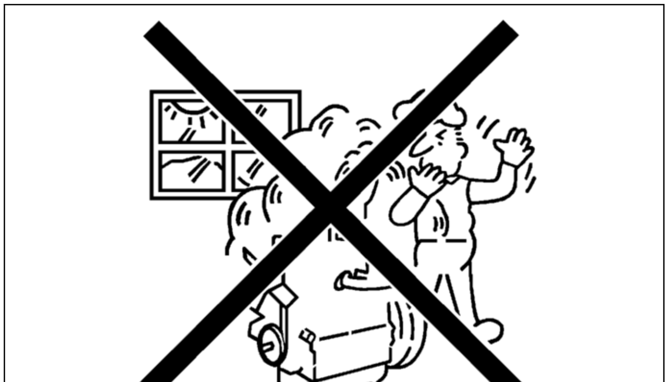
7. Prevent a fire



IBM006A

- 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.

8. Keep a good airflow in the work area



IBM007A

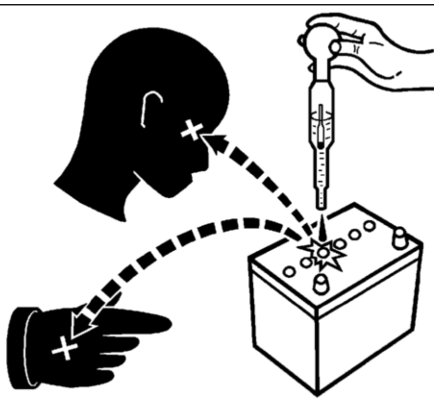
- If the engine is in operation, make sure that the area has good airflow. Do not operate the engine in a closed area. The exhaust gas contains poisonous carbon monoxide.

9. Discard fluids correctly


IBM009A

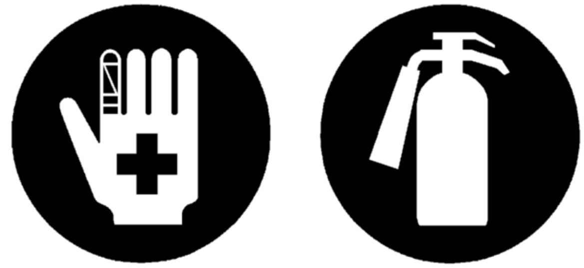
- Do not discard fluids on the ground, down the drain, into a stream, pond, or lake. Obey related environmental protection regulations when you discard oil, fuel, coolant, electrolyte and other dangerous waste.

10. Prevent acid burns


IBM008A

- 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.

11. Preparing for emergencies


IBM010A

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

SPECIFICATIONS

1. Specification for V3800-TIEF4, TIEF4C, TIEF4H

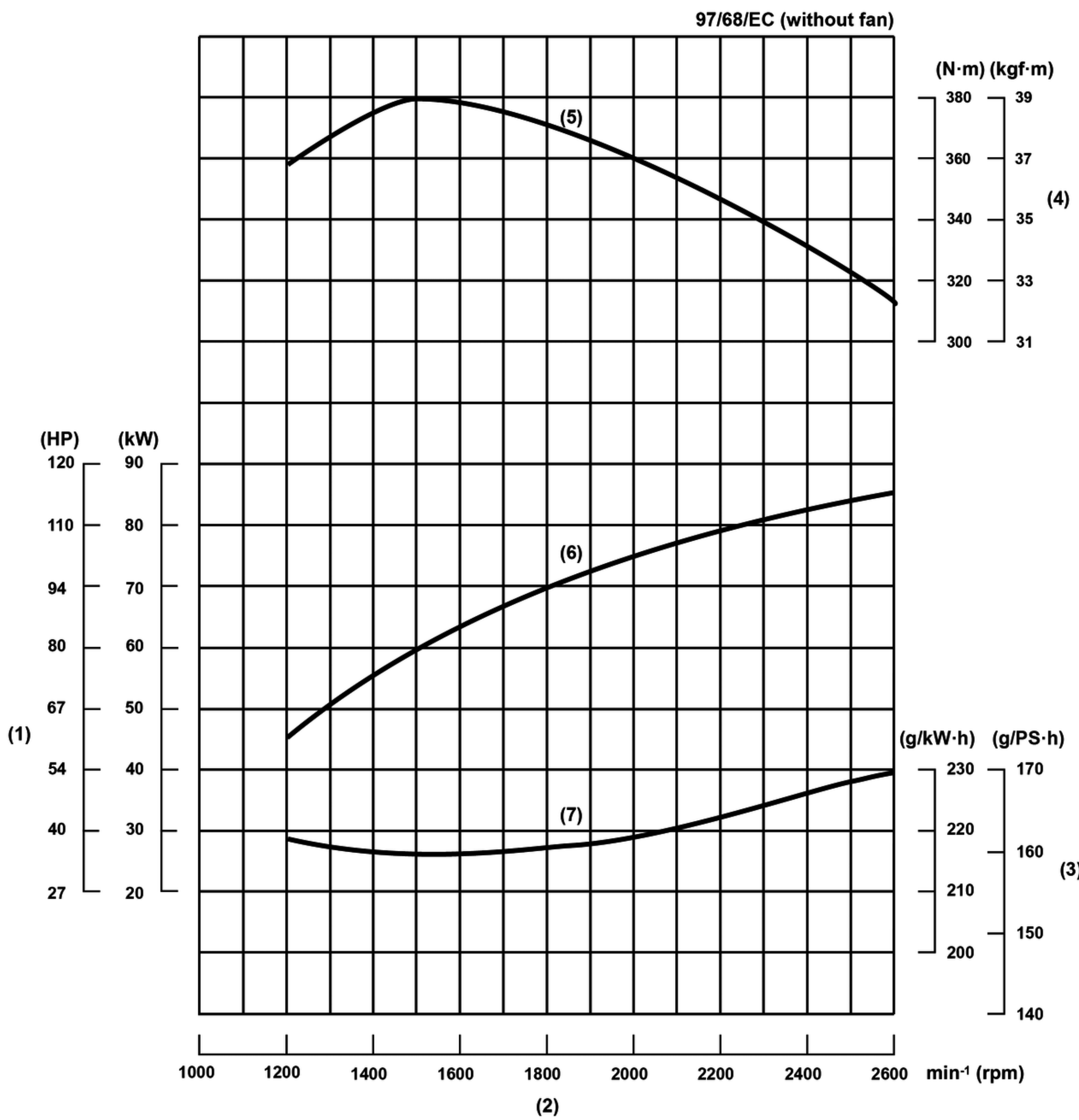
Model	V3800-TIEF4	V3800-TIEF4C	V3800-TIEF4H
Number of cylinder	4		
Engine type	Vertical, water-cooled, 4-cycle DI diesel engine		
Bore × stroke	100 × 120 mm (3.94 × 4.72 in.)		
Total displacement	3769 cm^3 (230.0 cu.in.)		
SAE gross continuous	75.1 kW / 2600 min^{-1}(rpm) (101 HP / 2600 min^{-1}(rpm))		83.8 kW / 2400 min^{-1}(rpm) (121 HP / 2400 min^{-1}(rpm))
SAE gross intermittent	86.4 kW / 2600 min^{-1}(rpm) (116 HP / 2600 min^{-1}(rpm))		96.4 kW / 2400 min^{-1}(rpm) (129 HP / 2400 min^{-1}(rpm))
Maximum bare speed	2800 min^{-1}(rpm)		2600 min^{-1}(rpm)
Minimum bare idling speed	800 min^{-1}		
Combustion chamber	Reentrant type, Center Direct Injection System (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	17.0		
Lubricating system	Forced lubrication by trochoid pump		
Oil pressure indicating	Electrical type switch		
Lubricating filter	Full flow paper filter (Cartridge type)		
Cooling system	Pressurized radiator, forced circulation with water pump		
Starting system	Electric starting with starter		
Starter motor	12 V, 3.0 kW		
Starting support device	Intake air heater in intake manifold		
EGR	External EGR (EGR cooler + electric EGR valve + reed valve)		
Battery	12 V, 136 AH equivalent		12 V, 120 AH equivalent
Charging alternator	12 V, 720 W		12 V, 1200 W
Fuel	Diesel Fuel No. 2-D S15		
Lubricating oil	Class CJ-4 lubricating oil as per API classification is recommended. For details on recommended lubricating oils.		
Lubricating oil capacity	13.2 L (3.49 U.S.gals, 2.90 Imp.gals)		16.5 L (4.36 U.S.gals, 3.63 Imp.gals)
Weight (dry)	368 kg (811 lbs)		405 kg (893 lbs)

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

PERFORMANCE CURVES

1. Performance curve for V3800-TIEF4, TIEF4C

V3800-TIEF4, V3800-TIEF4C

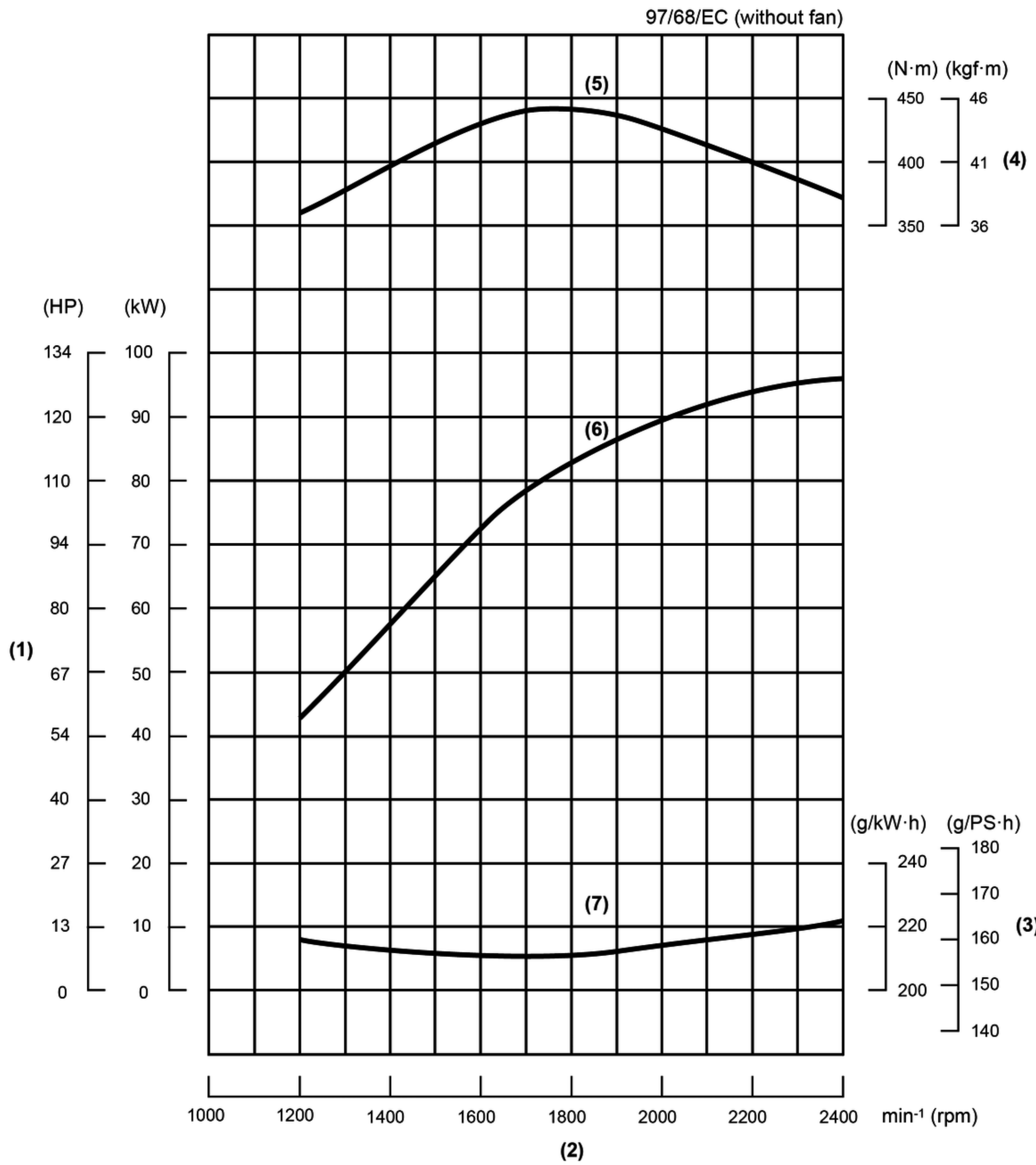


9Y1211085INI001US

(1) Brake horsepower
(2) Engine speed
(3) B.S.F.C. (Brake Specific Fuel Consumption)
(4) Torque
(5) Gross intermittent torque
(6) Gross intermittent brake horsepower
(7) Gross intermittent B.S.F.C.

2. Performance curve for V3800-TIEF4H

V3800-TIEF4H



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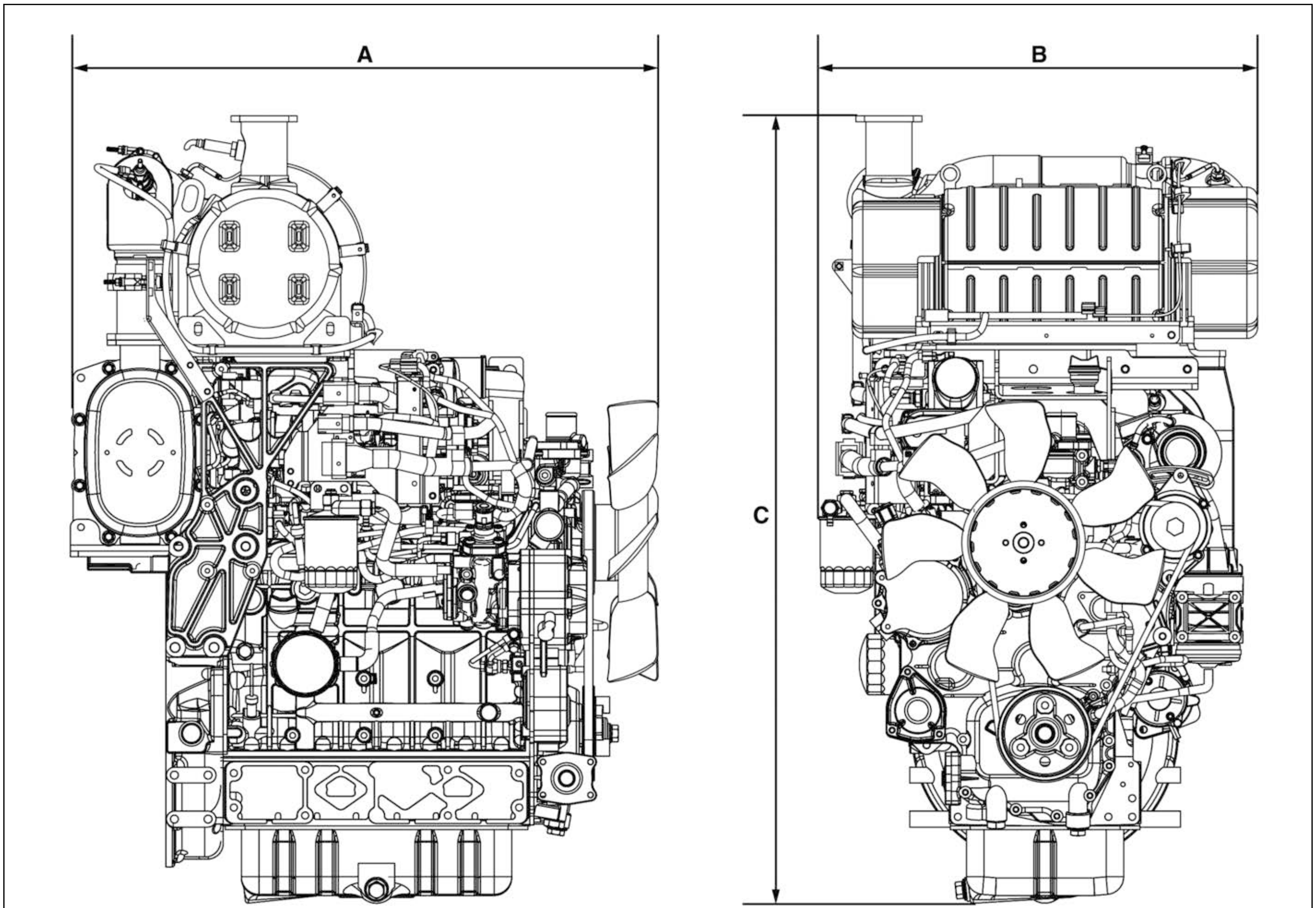
(1) Brake horsepower
(2) Engine speed
(3) B.S.F.C. (Brake Specific Fuel Consumption)
(4) Torque
(5) Gross intermittent torque
(6) Gross intermittent brake horsepower
(7) Gross intermittent B.S.F.C.

DIMENSIONS

1. Dimension for V3800-TIEF4, TIEF4C, TIEF4H



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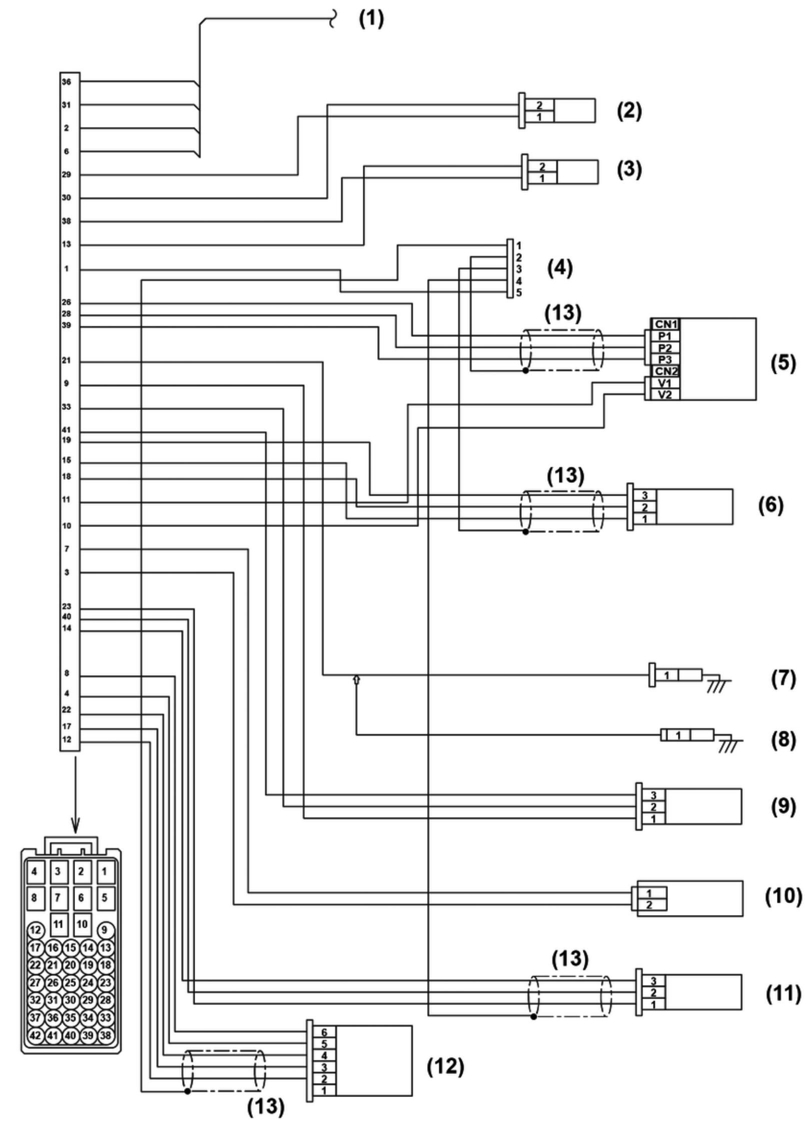
	V3800-TIEF4	V3800-TIEF4C	V3800-TIEF4H
A	889.8 mm 35.03 in.	890.1 mm 35.04 in.	933.7 mm 36.76 in.
B	664.1 mm 26.15 in.	688.1 mm 27.09 in.	664.0 mm 26.14 in.
C	1190.5 mm 46.870 in.		1225.5 mm 48.248 in.

WIRING DIAGRAM

1. Engine intermediate harness (Engine side harness)



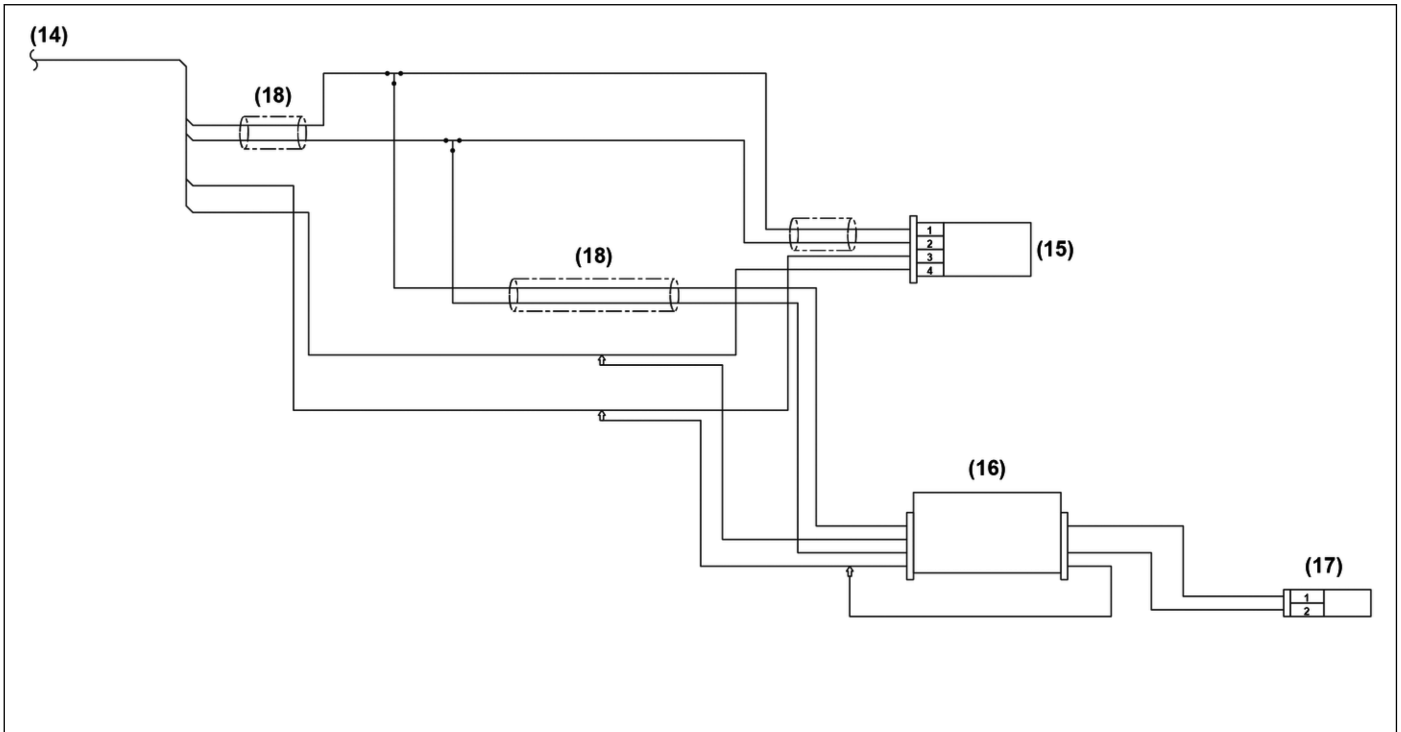
9Y1211085INI002A

(1)	—	CAN and EGR
(2)	CN201	Intake air temperature sensor
(3)	CN202	Coolant temperature sensor
(4)	—	Border 12 (ENG)
(5)	CN204	Rail assembly
(6)	CN206	Crankshaft position sensor
(7)	CN207	Oil pressure switch 1

(Continued)

(8)	CN208	Oil pressure switch 2
(9)	CN209	Boost pressure sensor
(10)	CN210	Supply pump assembly
(11)	CN211	Camshaft position sensor
(12)	CN212	Intake throttle valve
(13)	–	Shield cable

■ **NOTE**
- **The picture shows the pin arrangement of the connector housing viewed from wire side, not mating side.**

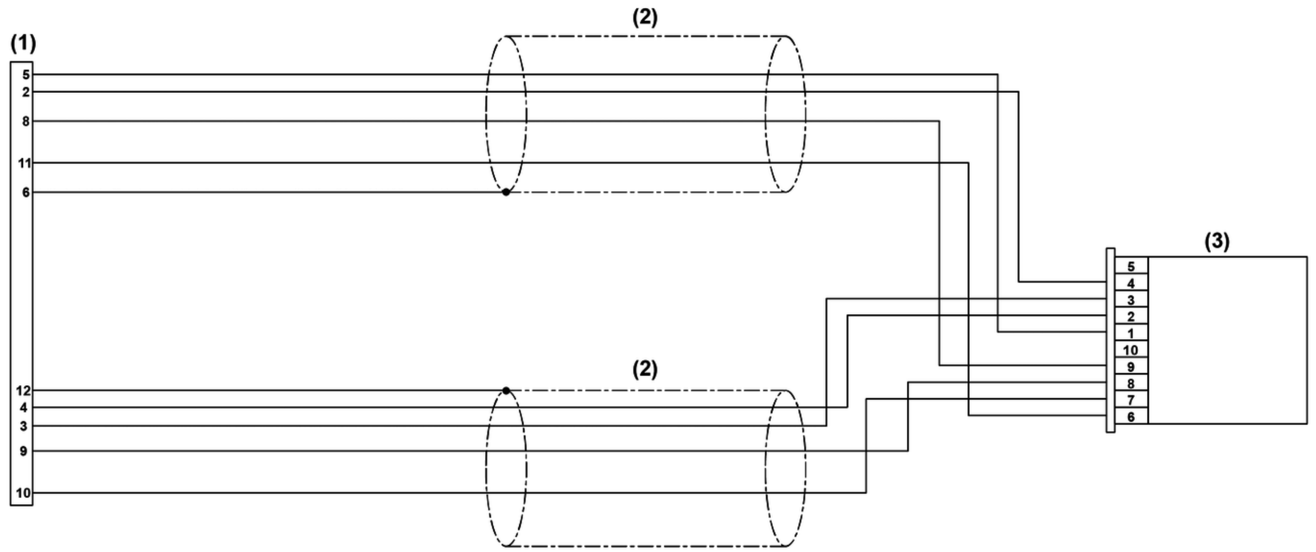


9Y1211085INI003B

(14)	–	CAN and EGR
(15)	CN222	EGR valve
(16)	CN223 / 224	CAN tool
(17)	–	Resistance connector (120 Ω)
(18)	–	Shield cable

■ **NOTE**
- **The picture shows the pin arrangement of the connector housing viewed from wire side, not mating side.**

2. Injector intermediate harness (Engine side harness)



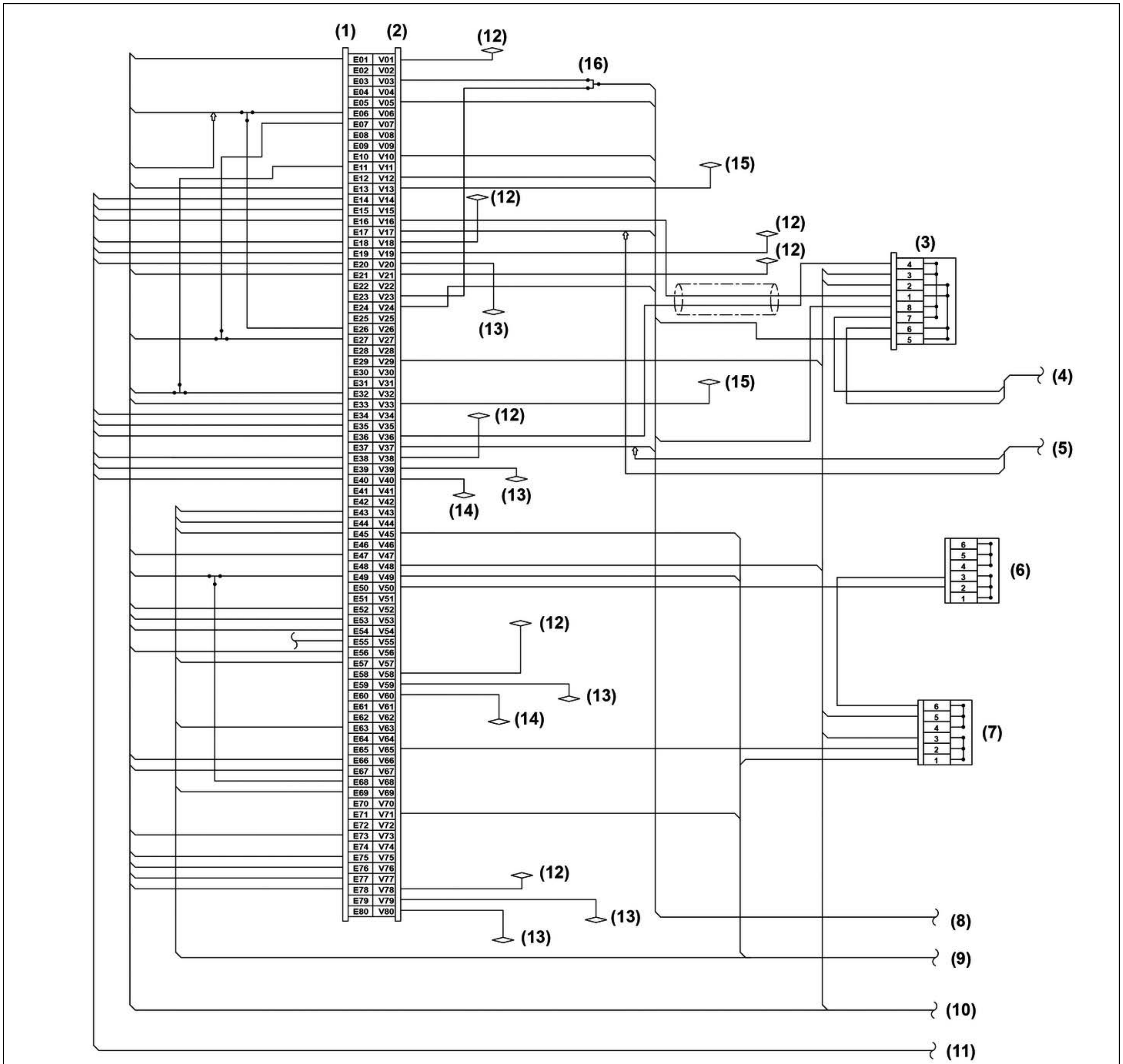
9Y1211085INI004A

(1)	CN302	Injector intermediate connector
(2)	—	Shield cable
(3)	CN301	Injector

■ **NOTE**

- **The picture shows the pin arrangement of the connector housing viewed from wire side, not mating side.**

3. ECU intermediate harness (OEM side harness)



9Y1211085INI005A

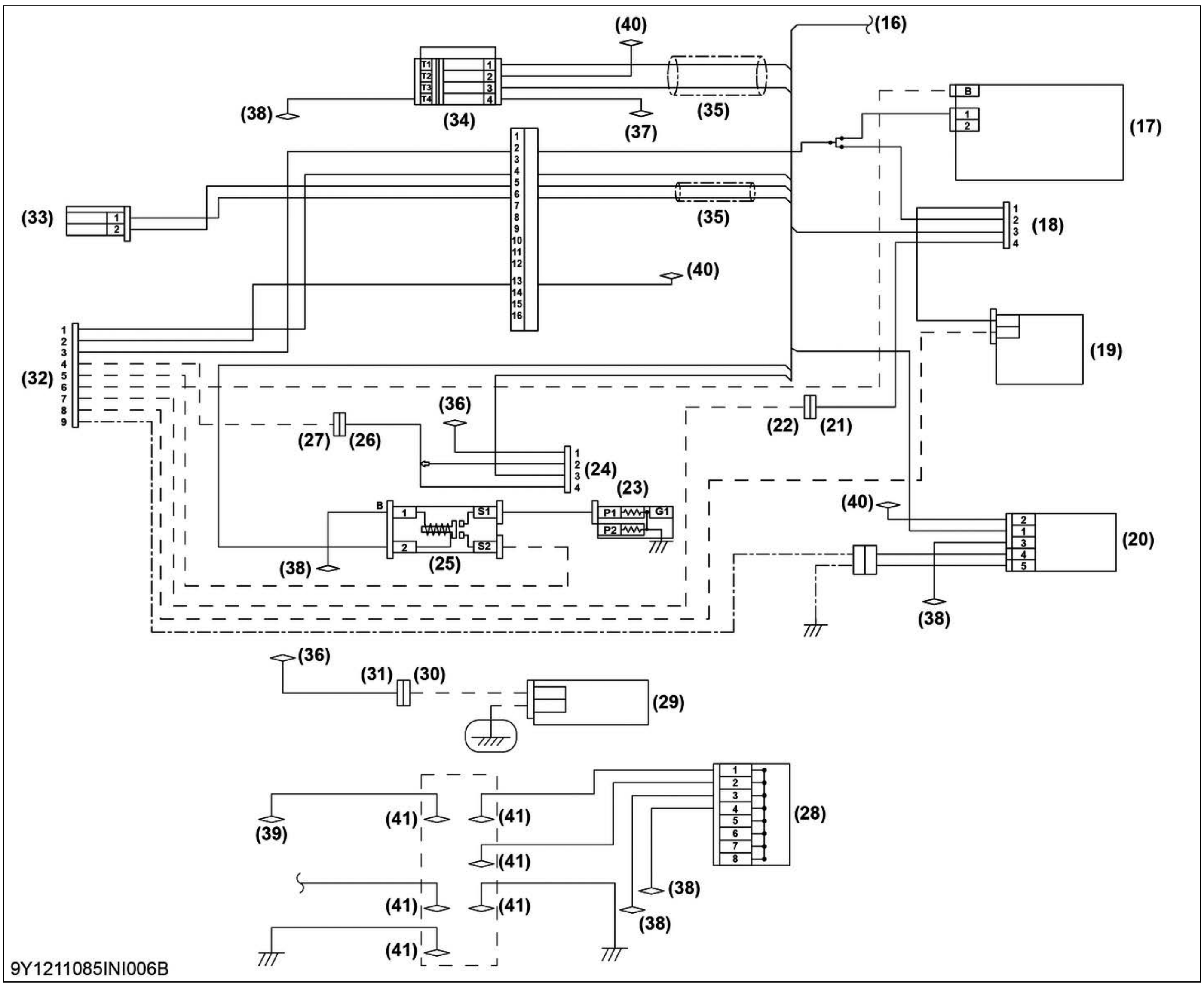
(1)	CN701	Engine ECU (1)
(2)	CN702	Engine ECU (2)
(3)	CN703	Engine ECU joint connector 3
(4)	—	CAN 1
(5)	—	CAN 2
(6)	CN704	Engine ECU joint connector 12

(Continued)

(7)	CN705	Engine ECU joint connector 9
(8)	–	Power unit
(9)	–	Diesel particulate filter (hereinafter referred to as the "DPF")
(10)	–	Engine
(11)	–	Injector
(12)	–	Border 1 (BAT)
(13)	–	Border 2A (EARTH)
(14)	–	Border 3 (EARTH-SIG)
(15)	–	Border 4 (BAT-IG)

■ **NOTE**

- **The picture shows the pin arrangement of the connector housing viewed from wire side, not mating side.**



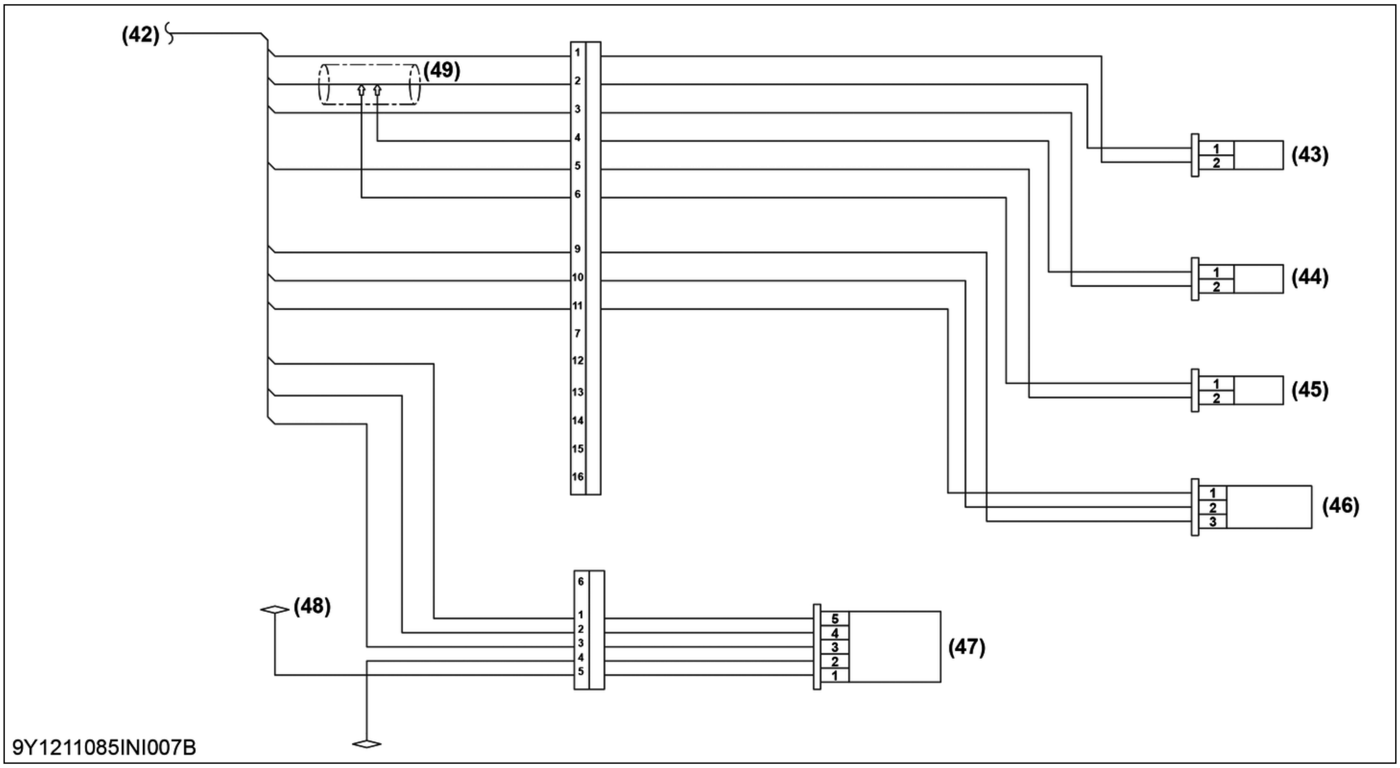
(16)	–	Power unit
(17)	CN602	Alternator

(Continued)

(18)	CN603	Starter relay
(19)	CN604	Starter
(20)	CN619	Water separator
(21)	CN605	Connector
(22)	CN606	Connector
(23)	–	Intake air heater
(24)	CN613	Main relay
(25)	CN616	Intake air heater relay
(26)	CN614	Connector
(27)	CN615	Connector
(28)	CN620	Engine ECU joint connector 13
(29)	–	Fuel feed pump
(30)	CN617	Connector
(31)	CN618	Connector
(32)	–	Battery unit
(33)	–	CAN for vehicle
(34)	CN607 / 608	CAN 1 for service tool
(35)	–	Shield cable
(36)	–	Border 1 (BAT)
(37)	–	Border 2A (EARTH)
(38)	–	Border 2B (EARTH)
(39)	–	Border 3 (EARTH-SIG)
(40)	–	Border 4 (BAT-IG)
(41)	–	Border 7 (EARTH)

■ **NOTE**

- **The picture shows the pin arrangement of the connector housing viewed from wire side, not mating side.**

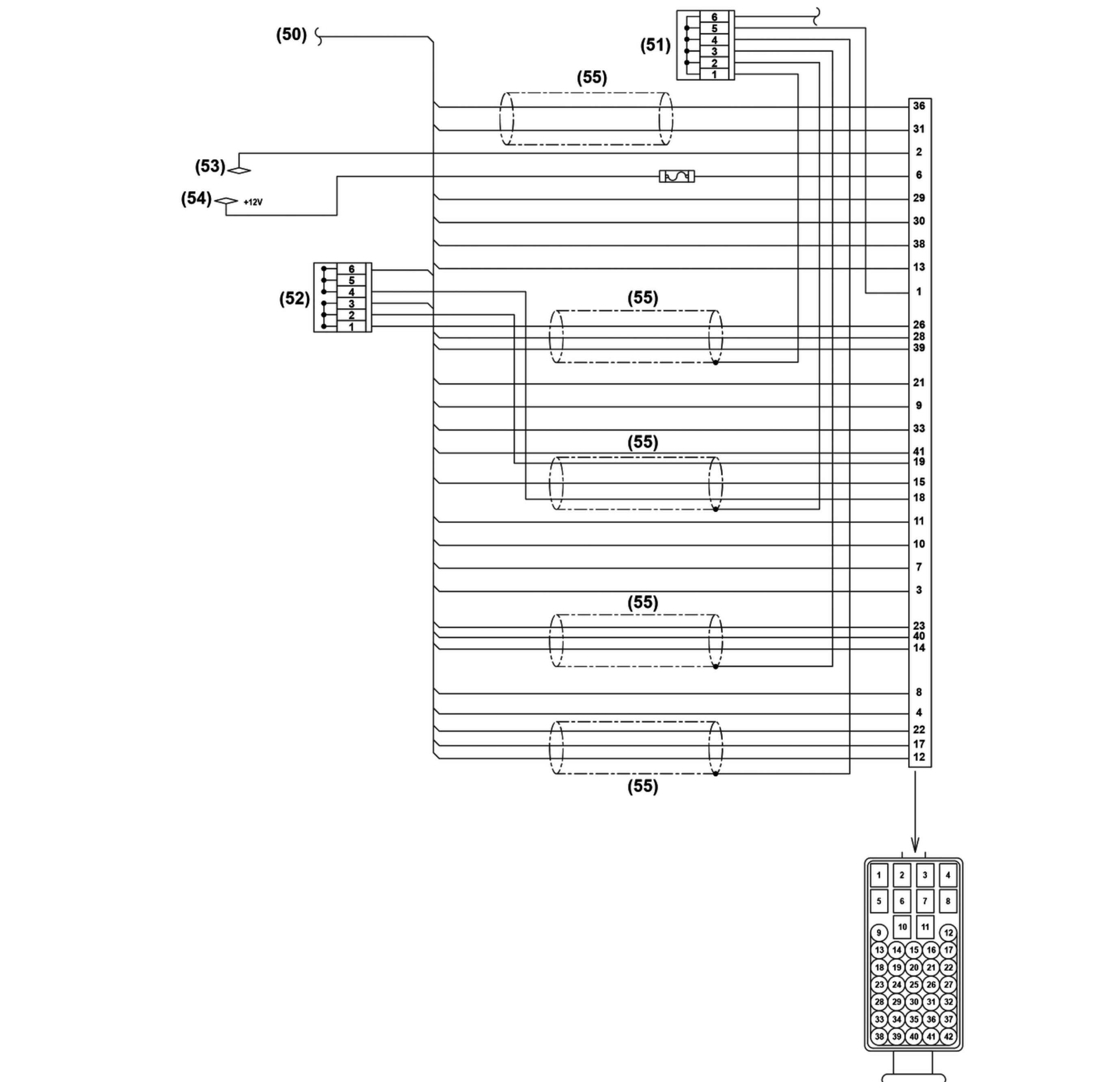


(42)	—	DPF
(43)	CN101	DPF temperature sensor (T_2)
(44)	CN102	DPF temperature sensor (T_1)
(45)	CN103	DPF temperature sensor (T_0)
(46)	CN104	DPF differential pressure sensor (ΔP)
(47)	CN105	Air flow sensor
(48)	—	Border 1 (BAT)
(49)	—	Shield cable

■ **NOTE**

- **The picture shows the pin arrangement of the connector housing viewed from wire side, not mating side.**

1. INFORMATION

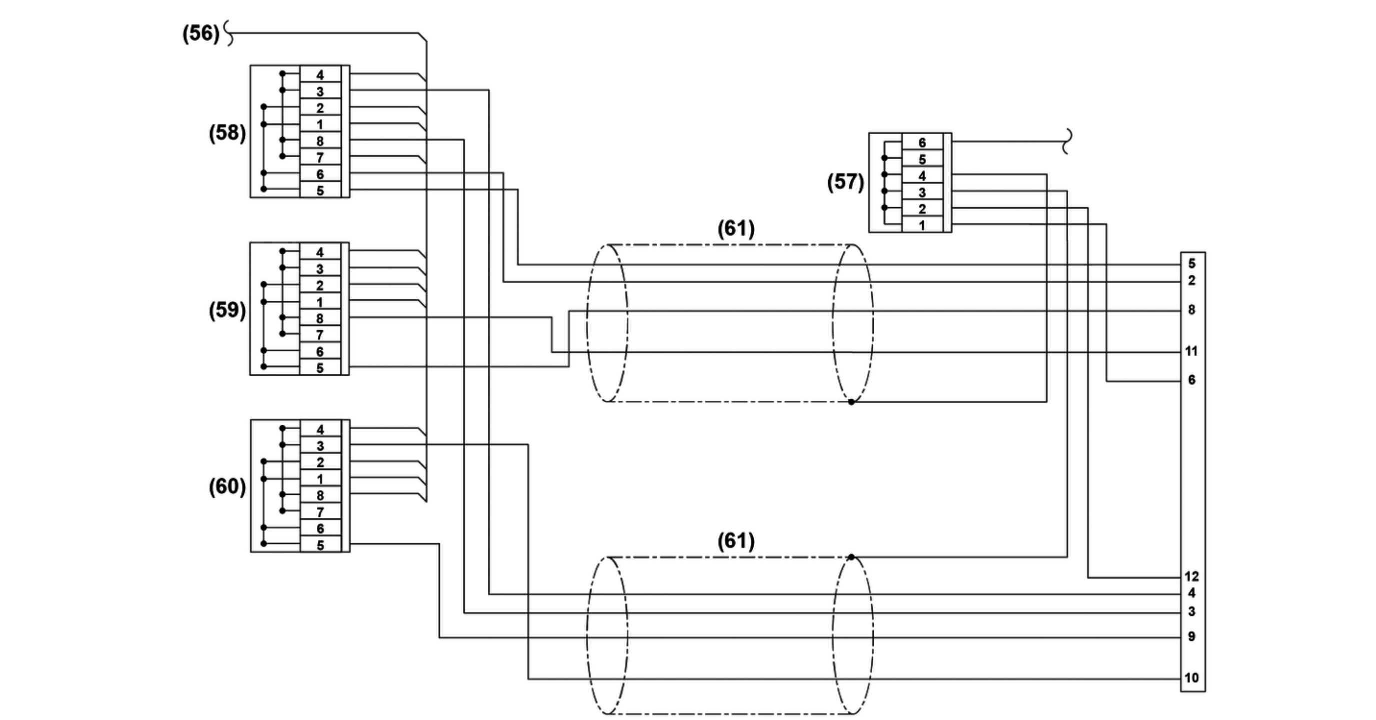


9Y1211085INI008B

(50)	—	Engine
(51)	CN215	Engine ECU joint connector 5
(52)	CN216	Engine ECU joint connector 8
(53)	—	Border 2A (EARTH)
(54)	—	Border 1 (BAT)
(55)	—	Shield cable

■ **NOTE**

- **The picture shows the pin arrangement of the connector housing viewed from wire side, not mating side.**



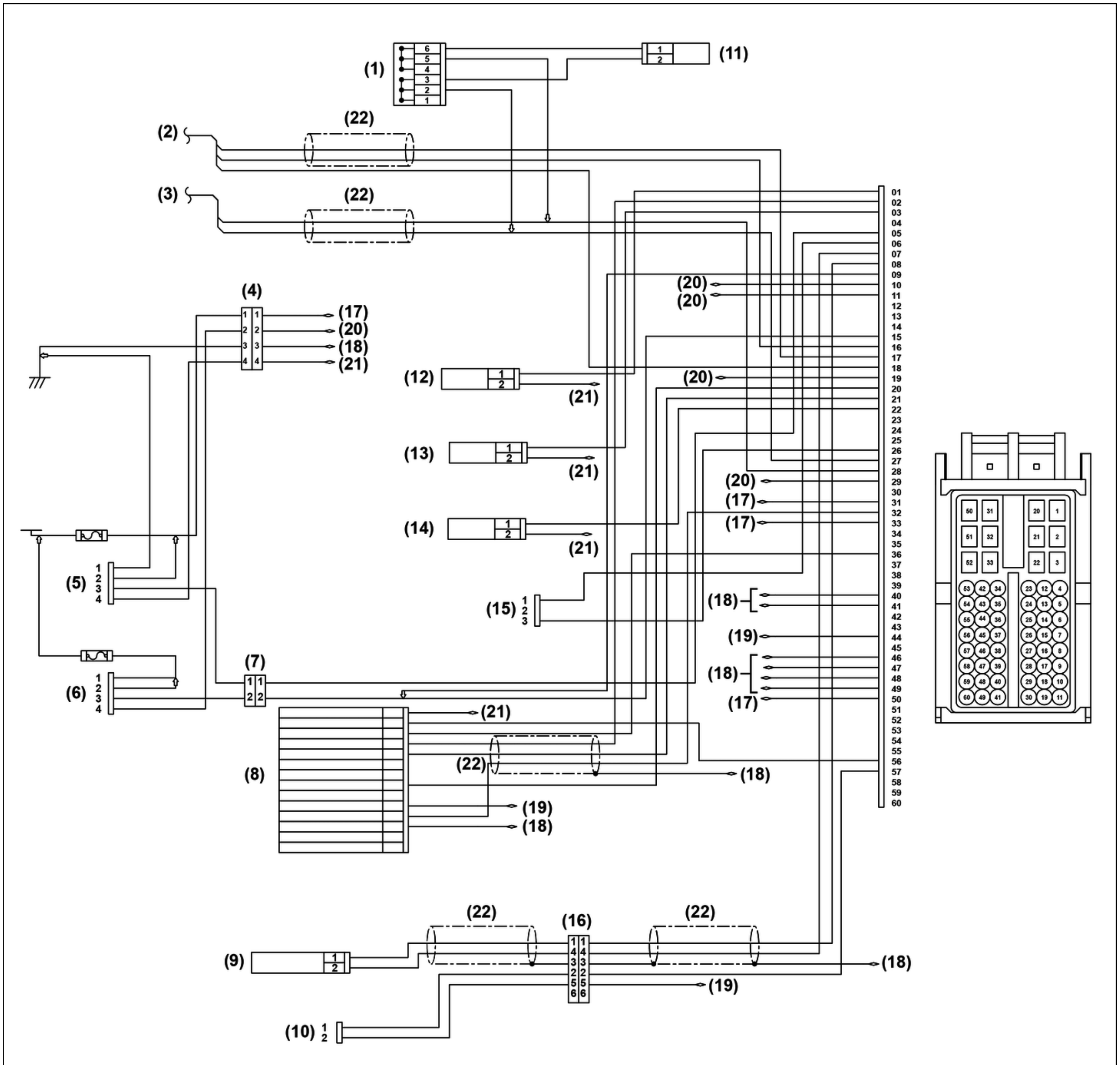
9Y1211085INI009B

(56)	–	Injector
(57)	CN304	Engine ECU joint connector 7
(58)	CN305	Engine ECU joint connector 2
(59)	CN306	Engine ECU joint connector 11
(60)	CN307	Engine ECU joint connector 6
(61)	–	Shield cable

■ **NOTE**

- **The picture shows the pin arrangement of the connector housing viewed from wire side, not mating side.**

4. ACU intermediate harness (OEM side harness)



9Y1211085INI010A

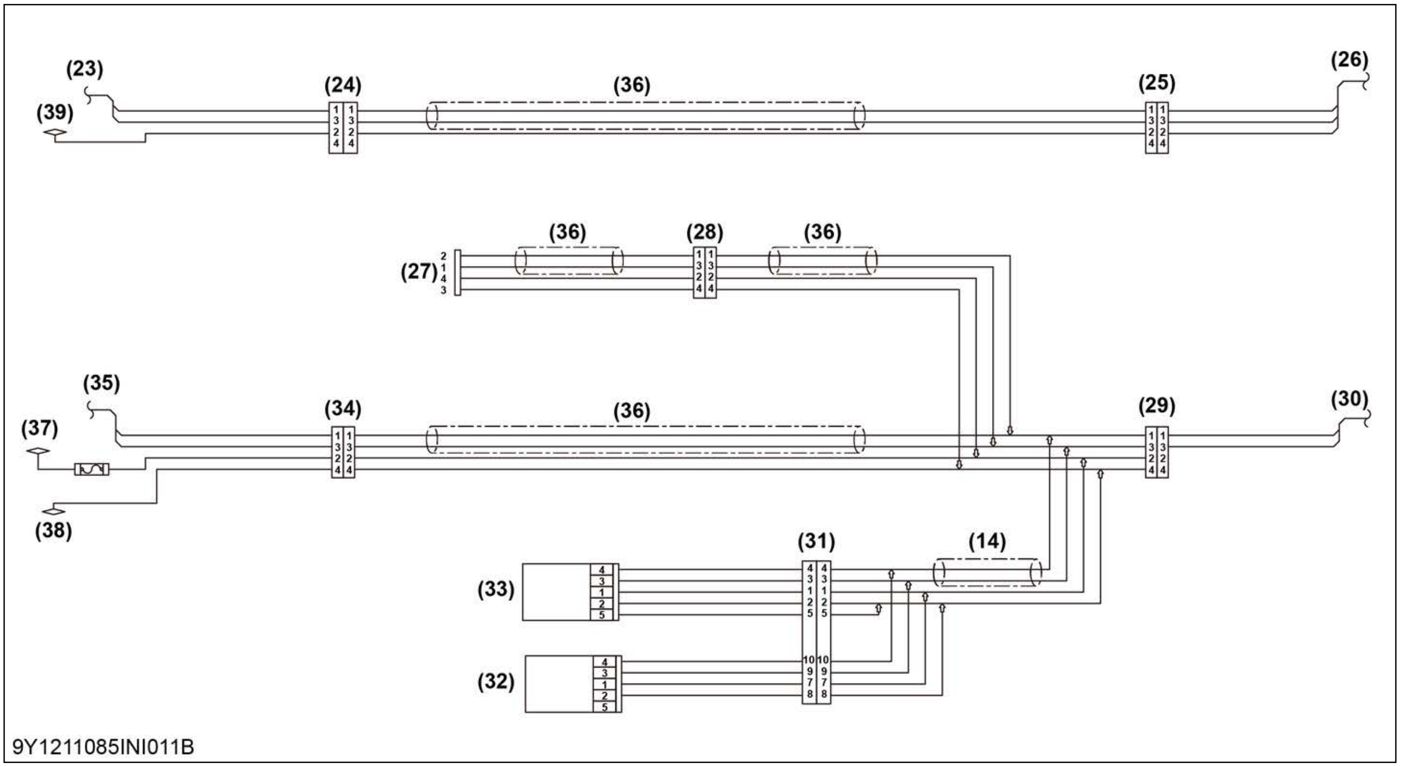
(1)	–	CAN 2 joint connector
(2)	–	ACU CAN 1
(3)	–	ACU CAN 2
(4)	CN413 / 414	Connector
(5)	CN411	Connector
(6)	CN412	Connector

(Continued)

(7)	CN415 / 416	Connector
(8)	CN406	DEF pump unit
(9)	CN409	DEF injector
(10)	CN410	Pre SCR temperature sensor
(11)	–	Resistance connector (120 Ω)
(12)	CN402	Delivery tube heater
(13)	CN403	Return tube heater
(14)	CN404	Suction tube heater
(15)	CN405	Coolant valve
(16)	CN407 / 408	Connector
(17)	–	Border 8 (ACU-HEATER)
(18)	–	Border 9 (ACU-EARTH)
(19)	–	Border 10 (ACU-SGND)
(20)	–	Border 11 (ACU-COMP)
(21)	–	Border 12 (HEATER-EARTH)
(22)	–	Shield cable

■ **NOTE**

- **The picture shows the pin arrangement of the connector housing viewed from wire side, not mating side.**



9Y1211085INI011B

(23)	–	CAN 1
(24)	CN503 / 504	Connector
(25)	CN501 / 502	Connector

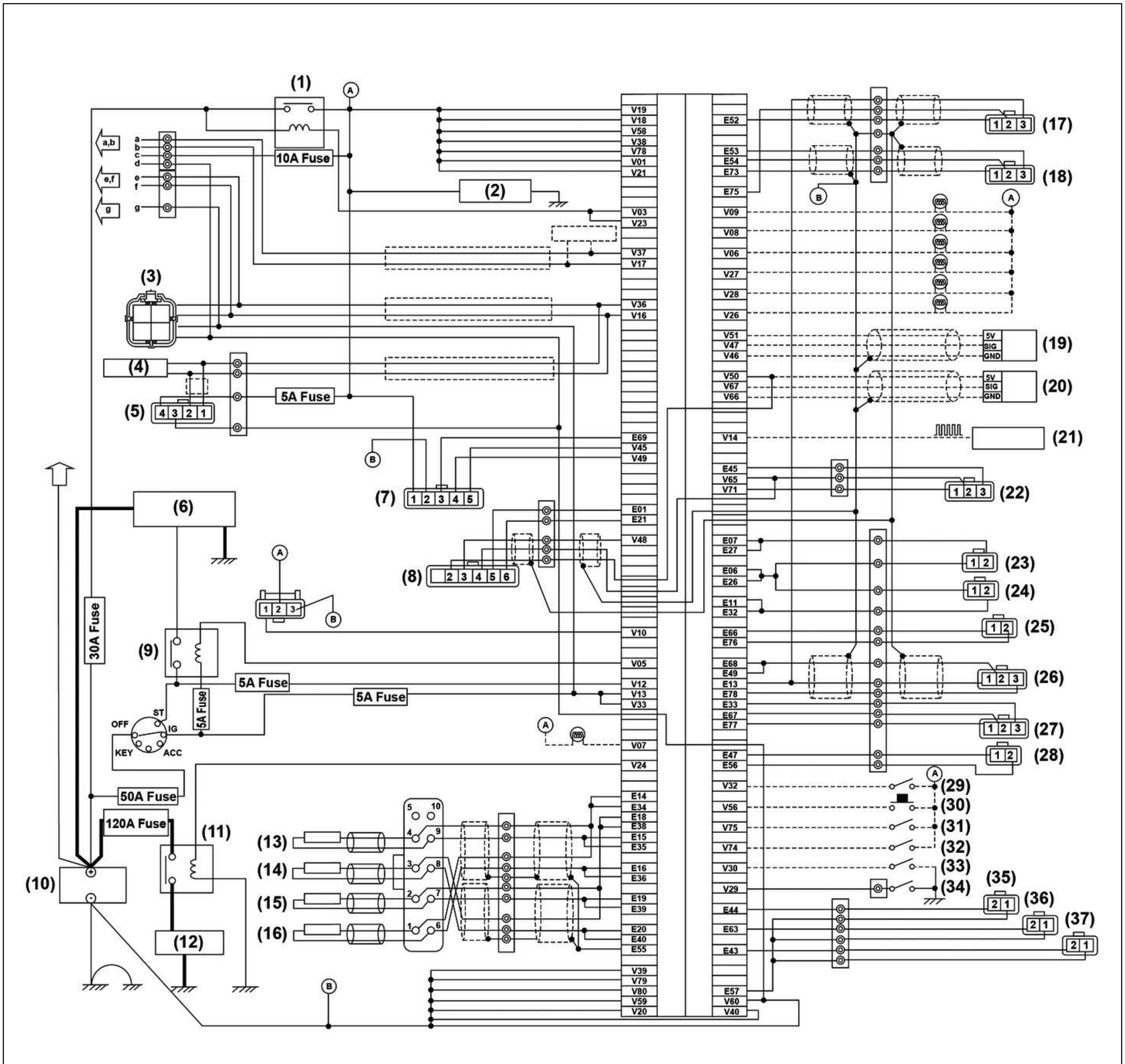
(Continued)

(26)	–	ACU CAN 1
(27)	CN507	Tank sensor
(28)	CN505 / 506	Connector
(29)	CN508 / 509	Connector
(30)	–	ACU CAN 2
(31)	CN512 / 513	Connector
(32)	CN515	Post NOx sensor
(33)	CN514	Pre NOx sensor
(34)	CN510 / 511	Connector
(35)	–	CAN 2
(36)	–	Shield cable
(37)	–	Border 1 (BAT)
(38)	–	Border 8 (EARTH)
(39)	–	Border 8 (BAT-IG)

■ **NOTE**

- **The picture shows the pin arrangement of the connector housing viewed from wire side, not mating side.**

5. System wiring diagram



9Y1211085INI012A

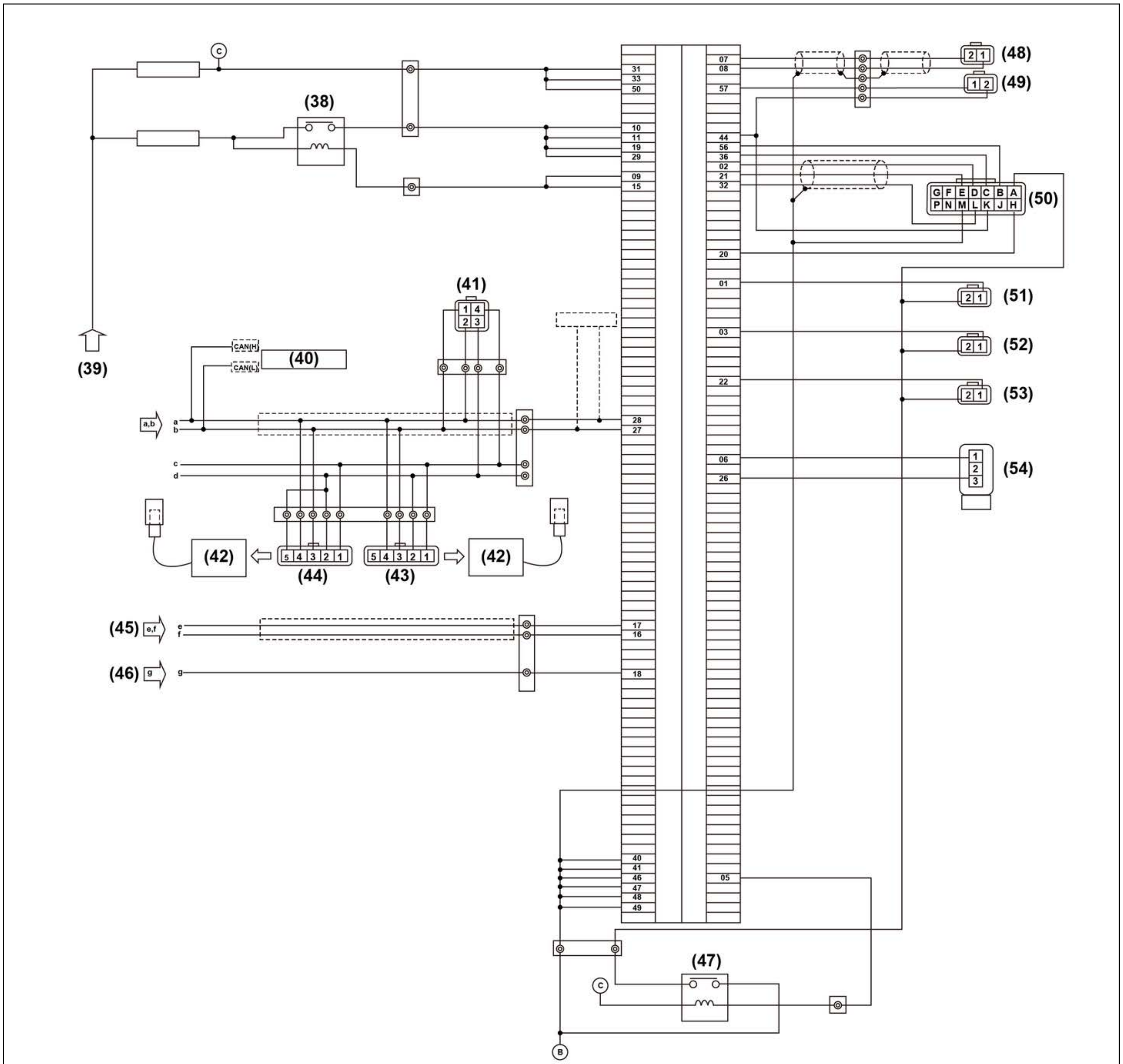
(1)	Main relay	(14)	Injector 2	(27)	Boost sensor
(2)	Fuel feed pump	(15)	Injector 3	(28)	Intake air temperature sensor
(3)	CAN 1 connector (for service)	(16)	Injector 4	(29)	Stop switch
(4)	Resistance connector (120 Ω)	(17)	Crankshaft position sensor	(30)	Parked regeneration switch
(5)	EGR valve	(18)	Camshaft position sensor	(31)	Parking switch
(6)	Starter	(19)	Accel sensor 1	(32)	Regeneration inhibit switch

(Continued)

1. INFORMATION

(7)	Air flow sensor	(20)	Accel sensor 2	(33)	Neutral switch
(8)	Intake throttle valve	(21)	Vehicle speed sensor	(34)	Oil pressure switch
(9)	Starter relay	(22)	DPF differential pressure sensor (ΔP)	(35)	DPF temperature sensor (T_0)
(10)	Battery	(23)	PCV (Pre-stroke control valve)	(36)	DPF temperature sensor (T_1)
(11)	Intake air heater relay	(24)	PRV (Pressure relief valve)	(37)	DPF temperature sensor (T_2)
(12)	Intake air heater	(25)	Coolant temperature sensor		
(13)	Injector 1	(26)	Rail pressure sensor		

DPF : Diesel particulate filter



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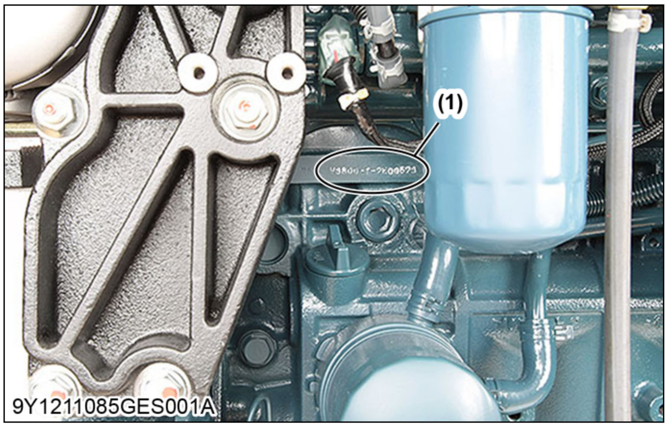
(38)	Comp relay	(44)	Pre NOx sensor	(50)	DEF pump unit
(39)	Power line (from battery)	(45)	CAN 1 (from engine ECU)	(51)	Delivery tube heater
(40)	CAN for vehicle	(46)	KEY-IG (from engine ECU)	(52)	Return tube heater
(41)	Tank sensor	(47)	Heater relay	(53)	Suction tube heater
(42)	NOx electronic unit	(48)	DEF injector	(54)	Coolant valve
(43)	Post NOx sensor	(49)	SCR inlet temperature sensor		

2. GENERAL

ENGINE IDENTIFICATION

1. Model name and engine serial number



(1) Engine model name and serial number

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

Engine serial number

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

Engine series

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

Production year

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

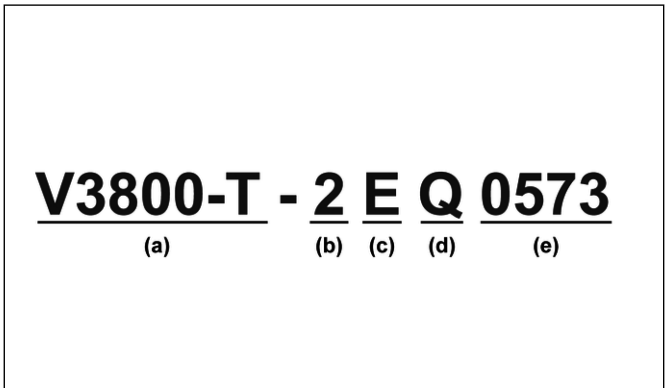
* Alphabetical letters "I" and "O" are not used.

Production month and lot number

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

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

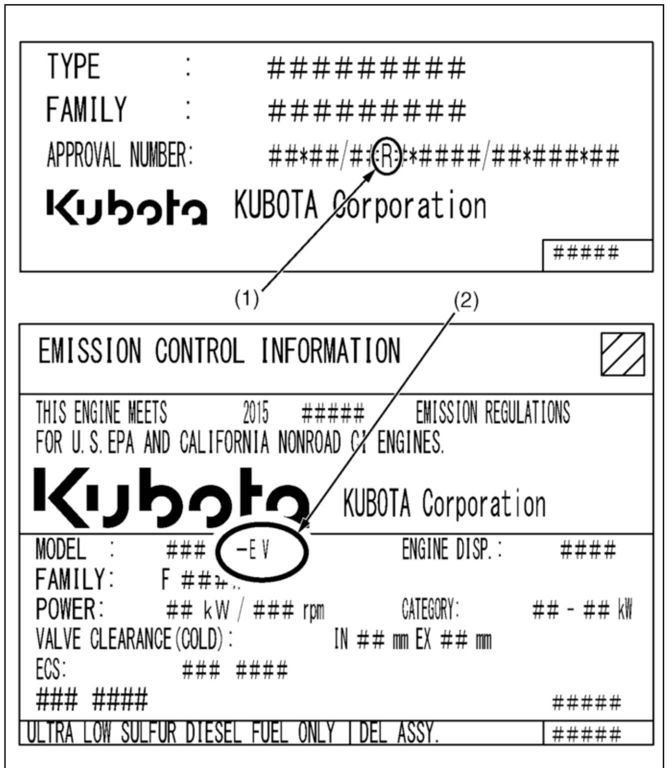
Example of model name and engine serial number



2CJGV00290A01

(a) V3800-T: Engine model name
(b) 2: Engine series (V3 series)
(c) E: Production year (2014)
(d) Q: Production month (August)
(e) 0573: Lot number (0001 ~ 9999 or A001 ~ Z999)

2. EF4B engine



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(1) EU regulation engine output classification category
(2) "EF4B" engines are identified with "EV" at the end of the Model designation, on the US EPA label. "EF4B" designates some Tier 4 models, depending on engine output classification.

Category (1)	Engine output classification	EU regulation
K	From 19 to less than 37 kW	STAGE IIIA
P	From 37 to less than 56 kW	STAGE IIIB
R	From 56 to less than 130 kW	STAGE IV

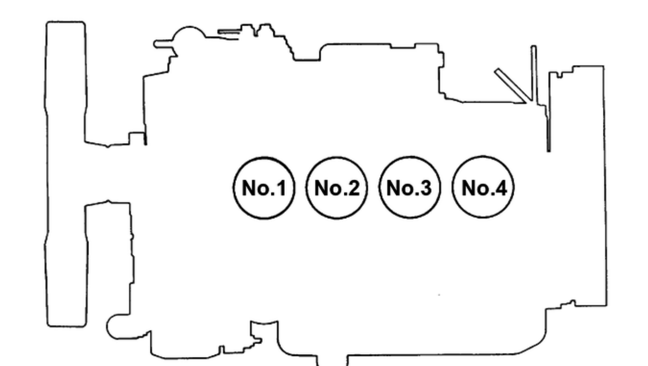
Category (2)	Engine output classification	EPA regulation
EV	Less than 19 kW	Tier 4
	From 19 to less than 56 kW	Tier 4
	From 56 to less than 75 kW	Tier 4
	From 75 to less than 130 kW	Tier 4

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, EF4B will be the designation that identifies engine models affected by the next emission phase.
When servicing or repairing ###-EF4B series engines, use only replacement parts for that specific EF4B engine, designated by the appropriate EF4B Kubota Parts List and perform all maintenance services listed in the appropriate Kubota Operator's Manual or in the appropriate EF4B Kubota Workshop Manual. Use of incorrect replacement parts or replacement parts from other emission level engines (for example: E4B engines), may result in emission levels out of compliance with the original EF4B 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. EF4B engines are identified with "EV" at the end of the Model designation, on the US EPA label. Please note: EF4B is not marked on the engine.

Example: Engine Model Name V3800-TIEF4-XXXX or V3800-TIEF4C-XXXX

3. Cylinder number



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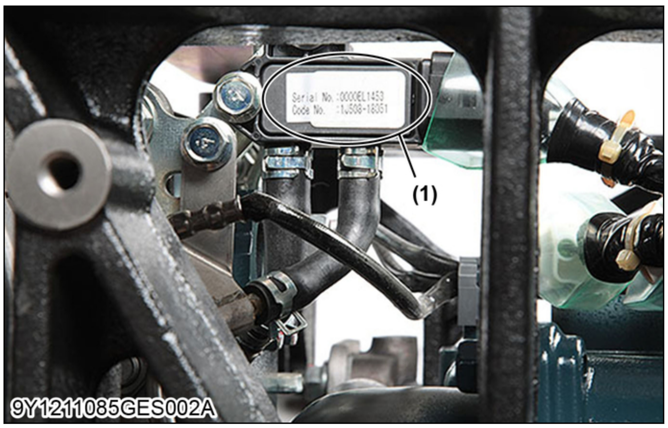
You can see the cylinder numbers of Kubota diesel engine in the figure. The sequence of cylinder numbers is No.1, No.2, No.3 and No.4 and it starts from the gear case side.

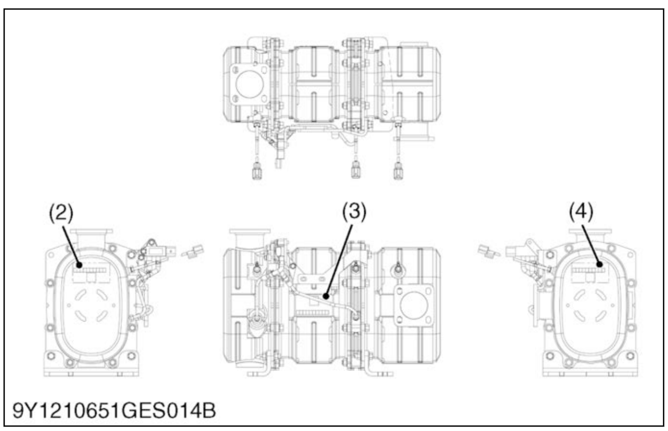
MUFFLER FULL ASSEMBLY IDENTIFICATION

1. Part number and serial number (DPF)

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.



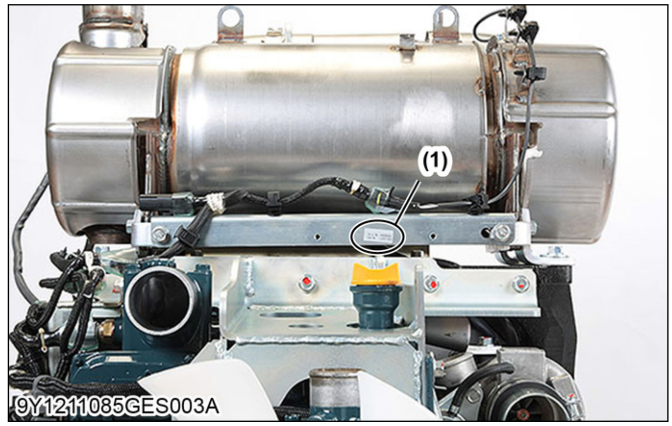


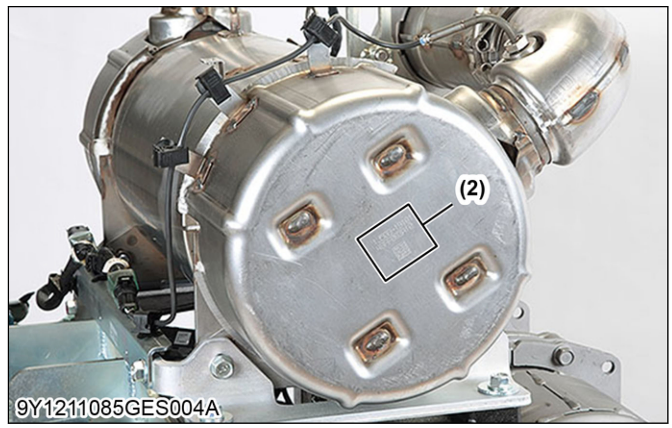
(1) DPF muffler full assembly part number and serial number
(2) Body (DPF outlet) part number and serial number
(3) Filter comp (DPF) part number and serial number
(4) Catalyst (DOC) part number and serial number

2. Parts number and serial number (SCR)

Selective catalytic reduction (hereinafter referred to as the "SCR") muffler full assembly serial number

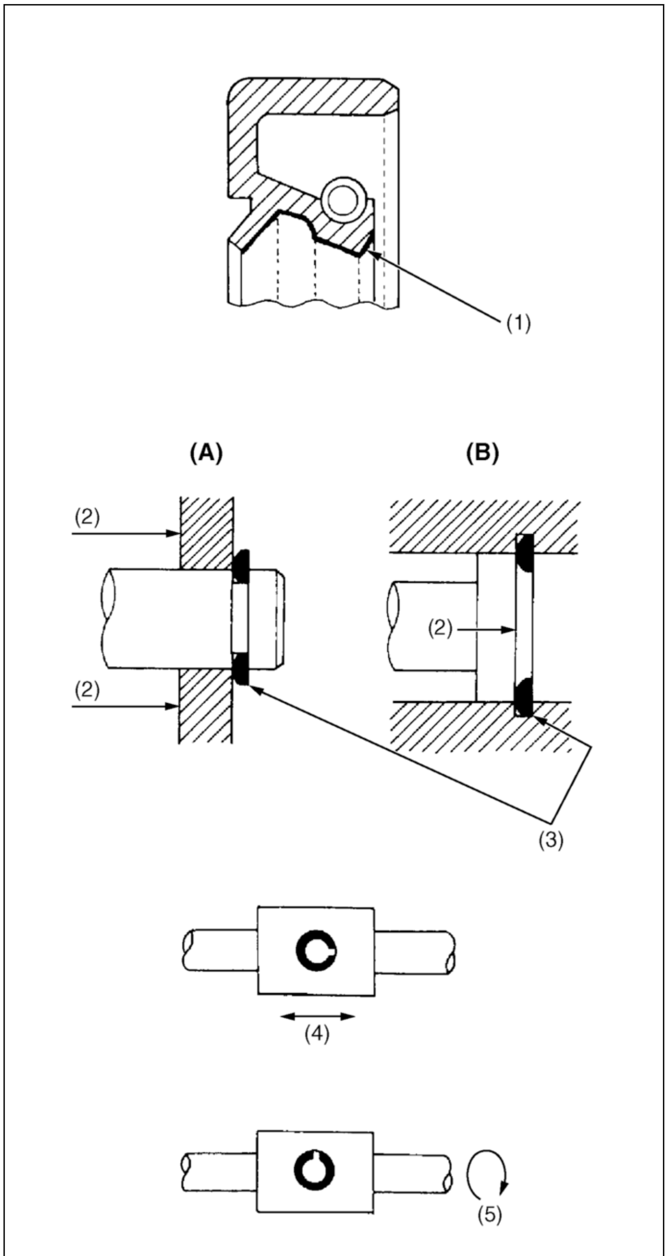
You must keep the records of the SCR muffler assembly part number and serial number.





(1) SCR muffler full assembly serial number
(2) SCR muffler assembly part number and serial number

GENERAL PRECAUTIONS



(1) Grease
(2) Force
(3) Sharp edge
(4) Axial force
(5) Rotating movement
(A) External circlip
(B) Internal circlip

- 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 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 circlips, make sure that the sharp edge (3) faces against the direction from which force (2) is applied.
- When inserting spring pins, their splits must face the direction from which a force is applied.
- To prevent damage to the hydraulic system, use specified fluid or equivalent.
- Clean the parts before you measure them.
- Tighten the fittings to the specified torque. Too much torque can cause damage to the hydraulic units or the fittings. Insufficient torque can cause oil leakage.
- When you use a new hose or pipe, tighten the nuts to the specified torque. Then loosen (approx. by 45°) and let them be stable before you tighten to the specified torque (This is not applied to the parts with seal tape.).
- When you remove the two ends of a pipe, remove the lower end first.
- Use two pliers in removal and installation. One to hold the stable side, and the other to turn the side you remove to prevent twists.
- Make sure that the sleeves of flared connectors and tapers of hoses are free of dust and scratches.
- After you tighten the fittings, clean the joint and apply the maximum operation pressure 2 to 3 times to check oil leakage.

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												Refer-ence page
		Daily	Every fuel refill-ing	Initial 50 hrs	Every 50 hrs	Every 250 hrs	Every 500 hrs	Every 1000 hrs	Every 1500 hrs	Every 3000 hrs	Every 8000 hrs	Every 1 year	Every 2 years	
	Checking engine oil level	○												2-13
	Checking fuel level	○												2-13
	Checking coolant level	○												2-14
	Checking fan belt	○												2-14
	Checking DEF/ AdBlue®* level	○												2-16
*4	Refilling diesel exhaust fluid (DEF/AdBlue®*)		○											2-16
	Changing engine oil			○			○							2-17
	Replacing oil filter cartridge			○			○							2-17
	Checking fuel hoses and clamp bands				○									2-18
	Checking radiator hose and clamp bands					○								2-18
*2	Cleaning of air cleaner primary element					○								2-19
	Adjusting fan belt tension					○								2-19
	Checking intake air line					○								2-20
*1	Replacing fuel filter cartridge						○							2-22
	Replacing water separator filter (Type 2)						○					○		2-22
*3	Cleaning water jacket and radia-tor interior						○							2-22
*3	Replacing fan belt						○						○	2-24
*3	Checking valve clearance							○						2-25
*3 *4	Checking injector (with Diagmas-ter)								○					2-26
*3 *4	Checking EGR cooler								○					2-27
*4	Replacing oil separator element								○					2-28
*3	Checking PCV (Positive crank-case ventilation) valve								○					2-28
*3 *4	Checking DEF/ AdBlue®* injector tip								○					2-29
	Checking DEF/AdBlue®* hoses								○					2-29
*3 *4	Checking turbocharger									○				2-29
*3 *4	Cleaning DPF									○				2-30
*3 *4	Judging to reuse DPF filter comp before cleaning (only service dealer)									○				2-34

(Continued)

Inspection item		Service interval												Reference page
		Daily	Every fuel refilling	Initial 50 hrs	Every 50 hrs	Every 250 hrs	Every 500 hrs	Every 1000 hrs	Every 1500 hrs	Every 3000 hrs	Every 8000 hrs	Every 1 year	Every 2 years	
*3 *4	Judging to reuse DPF filter comp after cleaning (only cleaning contractor)									○				2-34
*3 *4	Checking EGR system (with Diagmaster)									○				2-35
	Replacing DEF/AdBlue®* pump filter									○				2-36
*3 *4	Checking DEF/AdBlue®* injector									○				2-37
*3	Replacing DEF/AdBlue®* tank filter										○			2-38
*2 *3	Replacing air cleaner element											○		2-39
*3	Checking DPF differential pressure pipes and hoses											○		2-39
*3	Checking EGR piping											○		2-40
	Checking intake air line											○		2-20
	Checking exhaust manifold											○		2-40
*3	Replacing oil separator rubber hose												○	2-42
*3	Replacing rubber hose of differential pressure sensor												○	2-42
*3	Replacing intake hose (after air flow sensor) and intercooler hose												○	2-42
*3	Replacing pressure detection hose of boost sensor												○	2-42
*3	Replacing EGR cooler hose												○	2-43
*3	Replacing water hose												○	2-43
*3	Replacing lubricant hose												○	2-43
	Changing radiator coolant												○	2-43
*3	Replacing radiator hose and clamp bands												○	2-45
*1 *3	Replacing fuel hose and clamps												○	2-46
*3	Replacing intake air line												○	2-46

* AdBlue® is a registered trademark of Verband der Automobilindustrie e.V. in Germany.

■ NOTE

- **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: After 6 times of cleaning.**
- ***3: Consult your local Kubota dealer for this service.**
- **The items above (*4 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 *4 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.**

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

NOTE
- **Changing interval of engine oil.**

Models	Interval
V3800-TIEF4 V3800-TIEF4C	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)	

Engine oil

NOTE
- **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		CJ-4
Europe Japan	Sulfur content <0.001% (10 ppm)	
US	<0.0015% (15 ppm)	

- **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

NOTE
- **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 0.001% (10 ppm) in Europe and Japan, 0.0015% (15 ppm) in the US.**
- **Diesel fuels specified to EN590 (0.001% (10 ppm) sulfur maximum) or ASTM D975 (0.0015% (15 ppm) sulfur maximum) 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 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).

- **SAE: Society of Automotive Engineers**
- **EN: European Norm**
- **ASTM: American Society of Testing and Materials**
- **US EPA: United States Environmental Protection Agency**
- **No. 1-D or No. 2-D, S15: Ultra Low Sulfur Diesel (ULSD)) 15 ppm or 0.0015 wt.%**

- **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 operate the fuel tank level too low or completely out of fuel.**
  You may experience improper engine operating 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.

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 month.
   - Before storing the machine for a prolonged period, change such fuel for a conventional type of diesel fuel and operate 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.

CHECK AND MAINTENANCE

1. Daily check points

1.1 Checking engine oil level

■ IMPORTANT

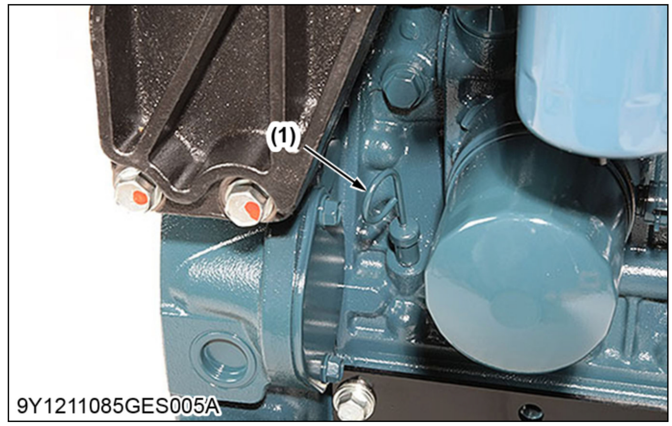
- **On diesel particulate filter (DPF) equipped engines, part of the fuel may get mixed with engine oil during the regenerating process.**
  This may dilute the oil and increase its quantity.
  If the oil rises above the dipstick upper limit, it means the oil has been diluted too much, resulting in a 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 check 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.

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)	SAE10W or SAE 10W-30, SAE 15W-40

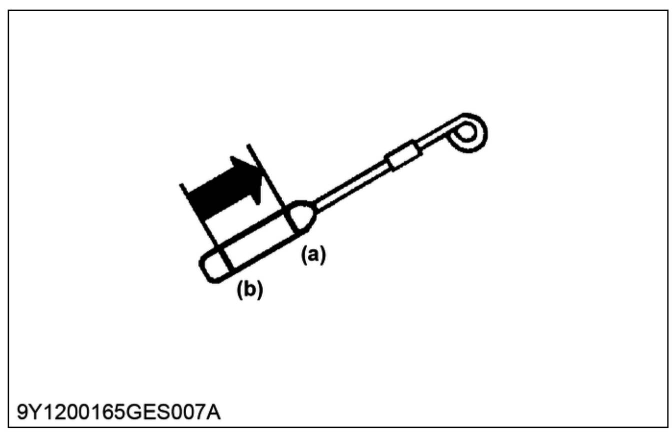
1. Make the engine level.
2. Pull out the dipstick (1) and clean it. Put in and pull it out again.



(1) Dipstick

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

Engine oil capacity	V3800-TIEF4 V3800-TIEF4C	13.2 L 3.49 U.S.gals 2.90 Imp.gals
	V3800-TIEF4H	16.5 L 4.36 U.S.gals 3.63 Imp.gals



(a) Upper line (b) Lower line

■ NOTE

- **If the level is too low, add new oil to the upper line (a).**

1.2 Checking fuel level

■ IMPORTANT

- **When Biodiesel fuel is used, it is advisable to replace the fuel filter with a new one after half the specified replacement intervals. (Compared with the use of mineral oil diesel fuels, the**

filtration performance of fuel filters gets degraded earlier than expected.)
- **Be sure to use a strainer when filling the fuel tank, or dirt or sand in the fuel may cause trouble.**
- **Do not operate the fuel tank level too low or completely out of fuel.**
  You may experience improper engine operating 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.

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

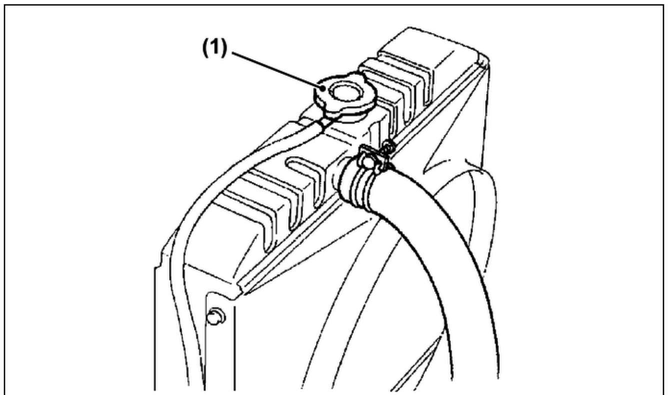
■ **NOTE**
- **If the fuel level is too low, add fuel to the upper limit.**

1.3 Checking coolant level

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

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

1. Remove the radiator cap (1).



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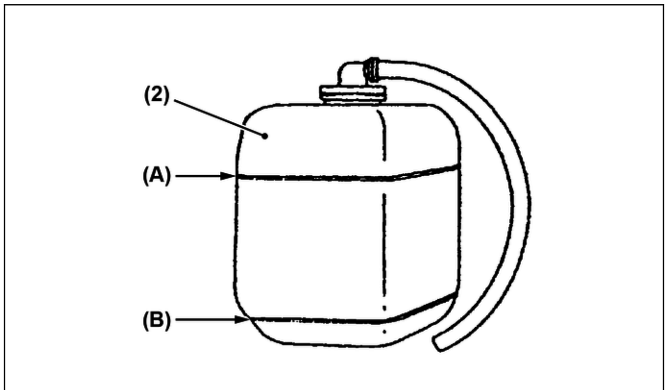
(1) Radiator cap

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

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

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

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



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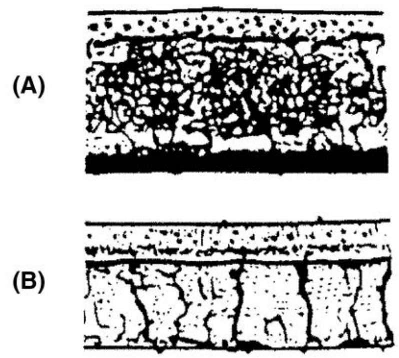
(2) Reserve tank
(A) FULL
(B) LOW

1.4 Checking fan belt

Tools required
- Sonic belt tension meter

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



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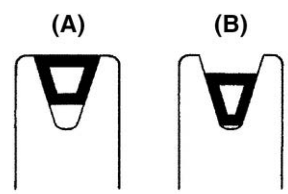

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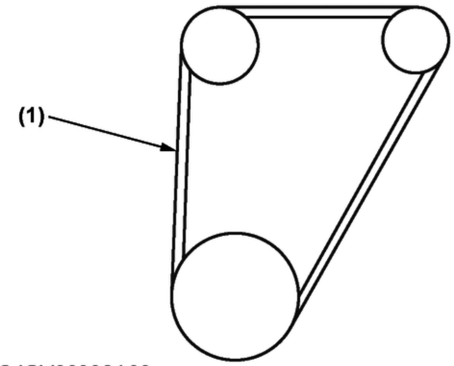
(A) OK (B) Wear

2. Check the tension of fan belt halfway (1) between the fan drive pulley and fan pulley with sonic belt tension meter.

Sonic belt tension meter setting value	V3800-TIEF4, V3800-TIEF4C	V3800-TIEF4H
Mass (Mass per 1 rib 1 m of belt)	110 g/rib/m	18 g/rib/m
Width (Number of ribs)	1	6
Span (Distance of between the fan drive pulley and alternator pulley)	290 mm 11.4 in.	317 mm 12.5 in.

Belt tension (After engine operation)	Factory specification	V3800-TIEF4 V3800-TIEF4C	391 to 480 N 39.9 to 48.9 kgf 87.9 to 107 lbf
		V3800-TIEF4H	420 to 550 N 42.9 to 56.0 kgf 94.5 to 123 lbf



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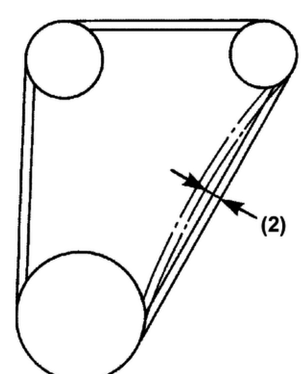
(1) Fan belt halfway

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

Belt tension (After installing)	Factory specification	V3800-TIEF4 V3800-TIEF4C	441 to 480 N 45.0 to 48.9 kgf 99.2 to 107 lbf
		V3800-TIEF4H	650 to 850 N 66.3 to 86.6 kgf 147 to 191 lbf
Belt tension (After engine operation)	Factory specification	V3800-TIEF4 V3800-TIEF4C	391 to 480 N 39.9 to 48.9 kgf 87.9 to 107 lbf
		V3800-TIEF4H	420 to 550 N 42.9 to 56.0 kgf 94.5 to 123 lbf

(Reference)

a. Push the belt halfway between the fan drive pulley and alternator pulley at a specified force to measure the deflection (2).



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(2) Deflection

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

Deflection (2)	Factory specification	V3800-TIEF4 V3800-TIEF4C	10 to 12 mm 0.40 to 0.47 in. (under load of 59 to 68 N (6.0 to 7.0 kg, 14 to 15 lbf))
		V3800-TIEF4H	9.0 to 11 mm 0.36 to 0.43 in. (under load of 59 to 68 N (6.0 to 7.0 kg, 14 to 15 lbf))

1.5 Checking DEF/AdBlue® level

1. Before starting the operation, check the DEF/AdBlue®* level in the DEF/AdBlue®* tank.

■ **NOTE**
- **The remaining amount of DEF/AdBlue®* is shown on the DEF/AdBlue®* level indicator on the meter panel.**
- **For details, refer to the operator's manual of the connected machine.**

2. Every fuel refilling

2.1 Refilling diesel exhaust fluid (DEF/AdBlue®)

WARNING
- **Do not breathe the vapors from the DEF/AdBlue®* tank when the cap is removed.**
- **Before starting the operation, check the DEF/AdBlue®* level in the DEF/AdBlue®* tank.**
- **The remaining amount of DEF/AdBlue®* is shown on the DEF/AdBlue®* level indicator on the meter panel.**
- **For details, refer to the operator's manual of the connected machine.**

■ **IMPORTANT**
- **Add the manufacturer-specified DEF/AdBlue®* in the DEF/AdBlue®* tank.**
- **Do not put any type of fluid other than DEF/AdBlue®* in the DEF/AdBlue®* tank.**
- **If any fluid other than the specified DEF/AdBlue®* the SCR system may get damaged.**
- **If contamination such as above has occurred, inspection of the SCR system by your local dealer is necessary.**
  Repair or overhaul as needed.
- **When refilling the DEF/AdBlue®* tank, never do the following or SCR system malfunction will result.**
  - **Do not dilute DEF/AdBlue®* with water.**
  - **Do not mix or add gasoline, diesel, oils or other products into the DEF/AdBlue®*.**
- **In removeing the DEF/AdBlue®* tank cap, be careful not to allow mud and anything dirty into the DEF/AdBlue®* tank.**
  Otherwise, the DEF/AdBlue®* filter may become clogged or the DEF/AdBlue®* quality turns degraded, possibly resulting in a SCR system failure.
- **If DEF/AdBlue®* runs short, the engine speed and loading capacity are limited.**
  Do not keep up running the engine without replenishing it with this fluid.
  Otherwise the engine will stay idling.
- **Do not overfill DEF/AdBlue®* tank or fill while the machine is in use.**
  DEF/AdBlue®* leakage out of the breather and freeze up may occur.
  If freeze-up occurs,sensor damage may result.
- **Do not stand on or place anything on the DEF/AdBlue®* tank as the tank, piping and sensor damage may result.**
- **It is normal for the SCR system to continue to run to complete a DEF/AdBlue®* piping purge cycle process even after the starter switch has been set to the [OFF] position.**
  When the battery or main electrical connections are disconnected for inspection repair or long term storage, should wait several minutes until the system has completed this process.
- **When the engine is stopped, it is normal to hear some continued related noise from the SCR system such as DEF/AdBlue®* tank, or DEF/AdBlue®* pump.**
  This is a normal function of the DEF/AdBlue®* piping purge process.
- **If DEF/AdBlue®* splashes on the machine body or frame, it may result in rust.**
  Wipe off the spilled fluid and rinse the affected spot(s).
- **Do not tamper with the exhaust pipe and muffler.**
  Do not relocate the DEF/AdBlue®* tank, either.
  Such action may adversely affect the exhaust gas purifying performance.

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* AdBlue is a registered trademark of Verband der Automobilindustrie e.V. in Germany.

* **AdBlue® is a registered trademark of Verband der Automobilindustrie e.V. in Germany.**

- **DEF/AdBlue®* is a transparent and colorless aqueous solution.**
  Depending on situations, it may smell, but it is not unusual.
- **When DEF/AdBlue®* stuck on the filler port has dried up, white powder may be found.**
  This is nothing unusual.
  Wipe it off with care not to allow it into the DEF/AdBlue®* tank.
- **If DEF/AdBlue®* is added with the engine running or the starter switch at the "ON" position, it takes much time until the DEF/AdBlue®* level comes back to its true level.**

1. Set the starter switch to the **[OFF]** position to stop the engine.
2. Slightly remove the DEF/AdBlue®* tank cap and wipe clean the cap and filler port to remove dust and mud. (The cap is colored in blue.)
3. Slowly remove the tank cap to fully open it.
4. Replenish the tank with DEF/AdBlue®* to its specified level.
5. Screw the tank cap to tighten it up to the DEF/AdBlue®* tank.
6. Make sure the tank cap is tight enough.

3. Check points of initial 50 hours

3.1 Changing engine oil

CAUTION

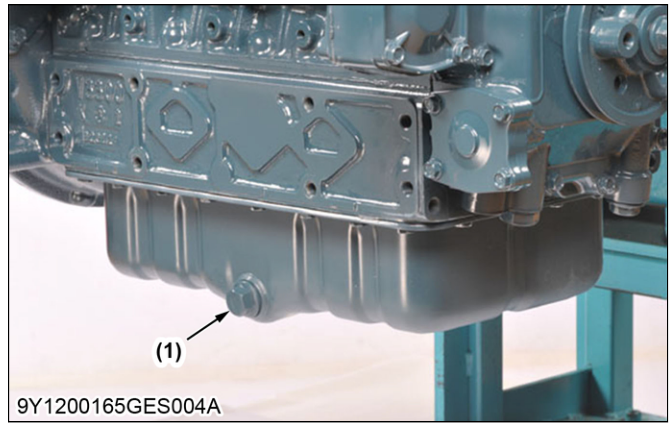
- **Make sure that you stop the engine before you change the engine oil.**

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)	SAE10W or SAE 10W-30, SAE 15W-40

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



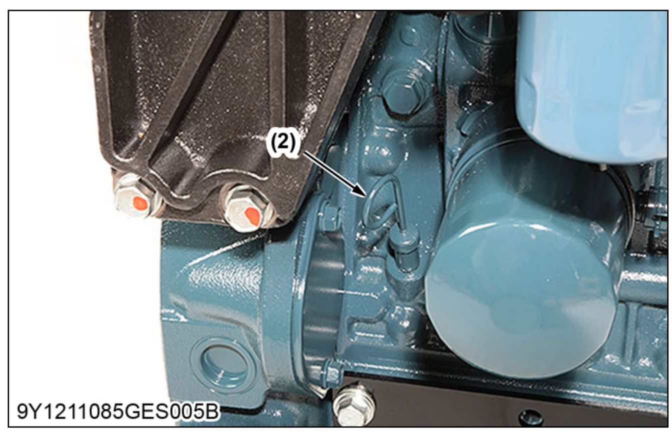
(1) Drain plug

4. Tighten the drain plug (1).

Tightening torque	Drain plug (1)	45 to 53 N·m 4.5 to 5.5 kgf·m 33 to 39 lbf·ft

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

Engine oil capacity	V3800-TIEF4 V3800-TIEF4C	13.2 L 3.49 U.S.gals 2.90 Imp.gals
	V3800-TIEF4H	16.5 L 4.36 U.S.gals 3.63 Imp.gals



(2) Dipstick

3.2 Replacing oil filter cartridge

CAUTION

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

IMPORTANT

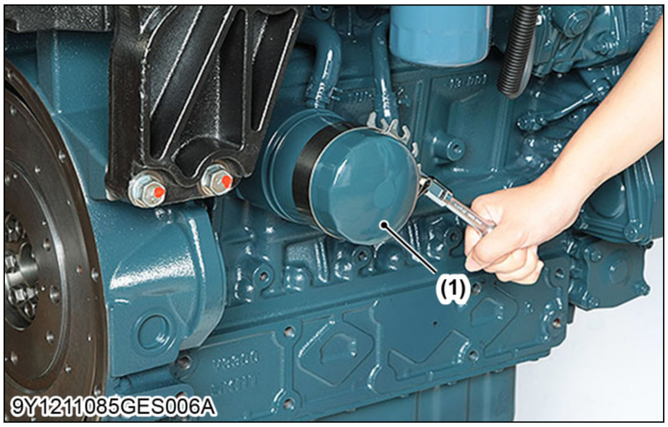
- **To prevent serious damage to the engine, replacement element must be highly efficient.**

Use only a Kubota genuine filter or its equivalent.

Tools required

- Filter wrench

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



(1) Oil filter cartridge

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

■ **NOTE**

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

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

■ **NOTE**

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

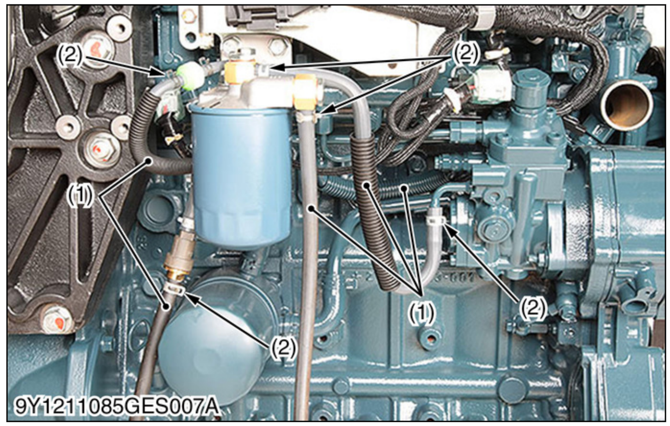
4. Check point of every 50 hours

4.1 Checking fuel hoses and clamp bands

1. Check the fuel hose (1) and clamp (2) are damaged or not.
2. If the fuel hose (1) or clamp (2) is damaged, replace it.
3. If the clamp (2) is loose, apply oil to the threads and tighten it again correctly.

■ **NOTE**

- **Replace the fuel hose (1) together with the clamp (2) in a 2 years interval.**
- **After replace the fuel hose (1) and the clamp (2), bleed the fuel system.**

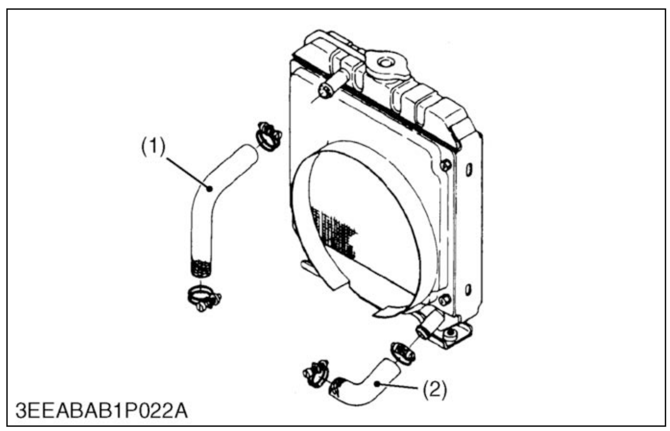


(1) Fuel hose (2) Clamp

5. Check points of every 250 hours

5.1 Checking radiator hose and clamp bands

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



(1) Upper hose (2) Lower hose

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

■ **NOTE**

- **You must replace the radiator hose(s) every 2 years.**
  Also replace the clamp every 2 years and tighten it correctly.

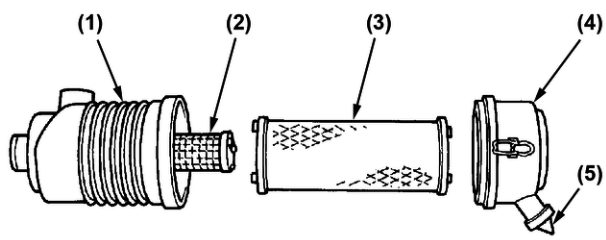
5.2 Cleaning air cleaner primary element

■ NOTE

- **Replace the primary element (3) once a year or every 6th cleaning.**
- **The air cleaner uses a dry element, never apply oil.**
- **Do not operate the engine with filter element removed.**
- **Do not touch the secondary element (2) except in cases where replacing is required.**

1. Remove the dust cup (4).
2. Remove the primary element (3).
3. Clean the inner side of the primary element (3) by clean dry compressed air.

Pressure of compressed air	Less than 205 kPa 2.1 kgf/cm^2 30 psi



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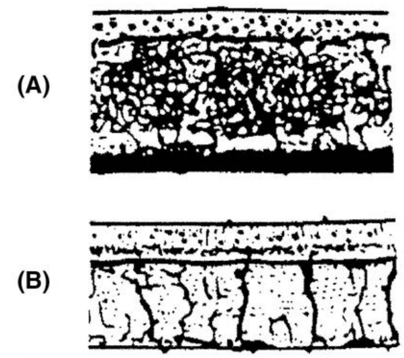
(1) Air cleaner housing
(2) Secondary element
(3) Primary element
(4) Dust cup
(5) Evacuator valve

4. Install the removed parts.



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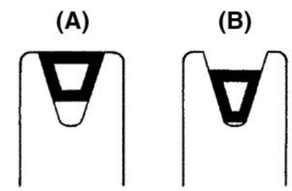

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(A) OK
(B) Wear

5.3 Adjusting fan belt tension

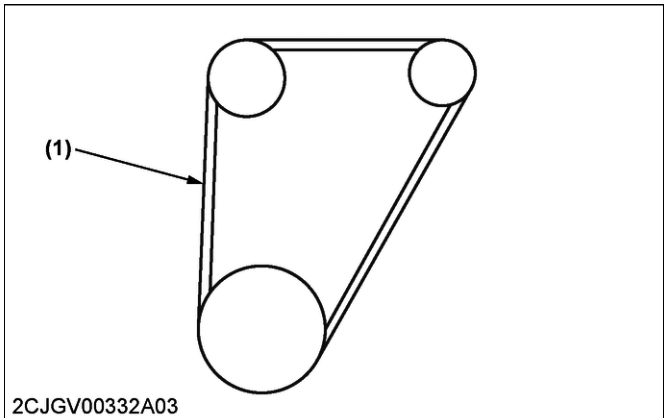
Tools required

- Sonic belt tension meter

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

2. Check the tension of fan belt halfway (1) between the fan drive pulley and fan pulley with sonic belt tension meter.

Sonic belt tension meter setting value	V3800-TIEF4, V3800-TIEF4C	V3800-TIEF4H
Mass (Mass per 1 rib 1 m of belt)	110 g/rib/m	18 g/rib/m
Width (Number of ribs)	1	6
Span (Distance of between the fan drive pulley and alternator pulley)	290 mm 11.4 in.	317 mm 12.5 in.



(1) Fan belt halfway

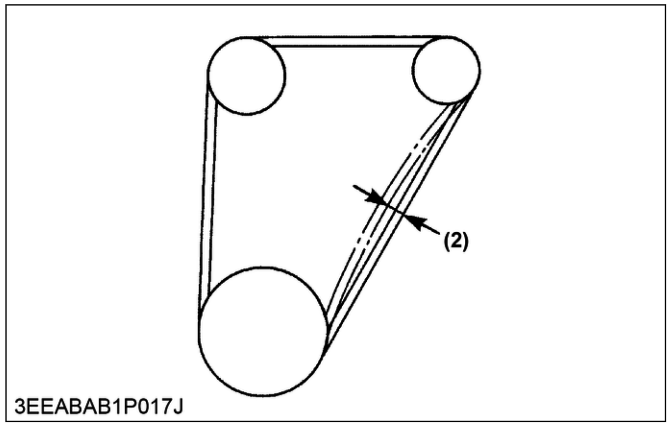
NOTE

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

Belt tension (After installing)	Factory specification	V3800-TIEF4 V3800-TIEF4C	441 to 480 N 45.0 to 48.9 kgf 99.2 to 107 lbf
		V3800-TIEF4H	650 to 850 N 66.3 to 86.6 kgf 147 to 191 lbf
Belt tension (After engine operation)	Factory specification	V3800-TIEF4 V3800-TIEF4C	391 to 480 N 39.9 to 48.9 kgf 87.9 to 107 lbf
		V3800-TIEF4H	420 to 550 N 42.9 to 56.0 kgf 94.5 to 123 lbf

(Reference)

a. Push the belt halfway between the fan drive pulley and alternator pulley at a specified force to measure the deflection (2).



(2) Deflection

NOTE

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

Deflection (2)	Factory specification	V3800-TIEF4 V3800-TIEF4C	10 to 12 mm 0.40 to 0.47 in. (under load of 59 to 68 N (6.0 to 7.0 kg, 14 to 15 lbf))
		V3800-TIEF4H	9.0 to 11 mm 0.36 to 0.43 in. (under load of 59 to 68 N (6.0 to 7.0 kg, 14 to 15 lbf))

5.4 Checking intake air line

IMPORTANT

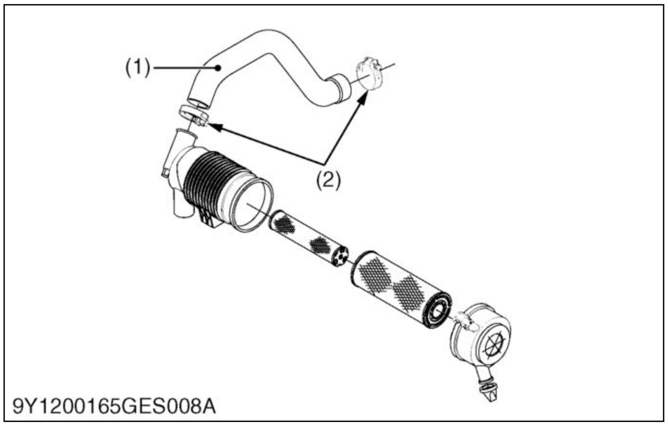
- **To prevent serious damage to the engine, keep out dust in the intake air line.**

1. Make sure that the intake air hose(s) (1) are connected correctly or not.
2. Visually check for cracks gas leak and anything else unusual.

3. If the clamp (2) is loose, apply oil to the threads and tighten it again correctly.

■ **NOTE**

- **You must replace the intake air hose(s) every 2 years.**
  Also replace the clamp (2) every 2 years and tighten it correctly.



(1) Intake air hose (2) Clamp

6. Check points of every 500 hours

6.1 Changing engine oil

CAUTION

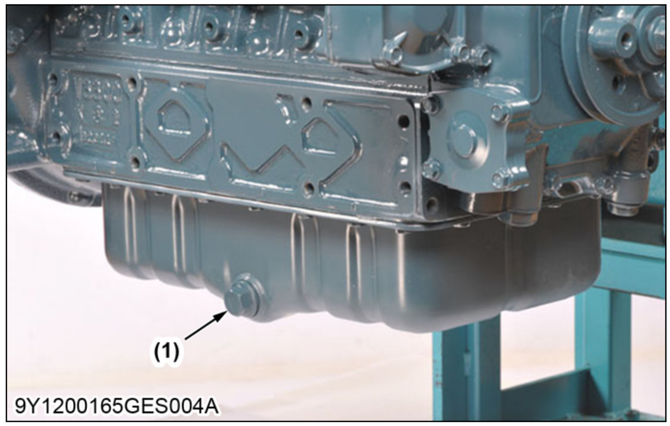
- **Make sure that you stop the engine before you change the engine oil.**

■ **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)	SAE10W or SAE 10W-30, SAE 15W-40

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



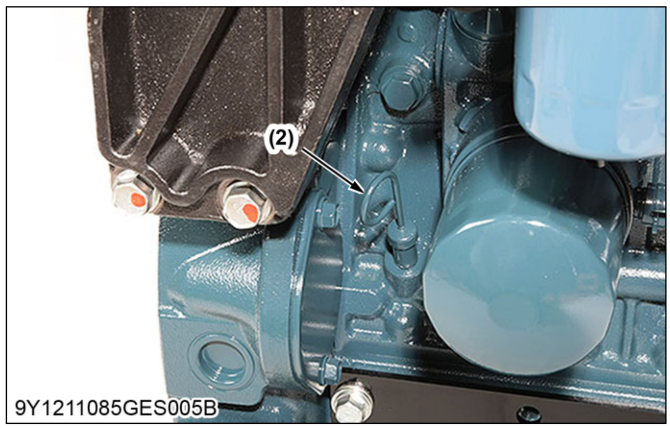
(1) Drain plug

4. Tighten the drain plug (1).

Tightening torque	Drain plug (1)	45 to 53 N·m 4.5 to 5.5 kgf·m 33 to 39 lbf·ft

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

Engine oil capacity	V3800-TIEF4 V3800-TIEF4C	13.2 L 3.49 U.S.gals 2.90 Imp.gals
	V3800-TIEF4H	16.5 L 4.36 U.S.gals 3.63 Imp.gals



(2) Dipstick

6.2 Replacing oil filter cartridge

CAUTION

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

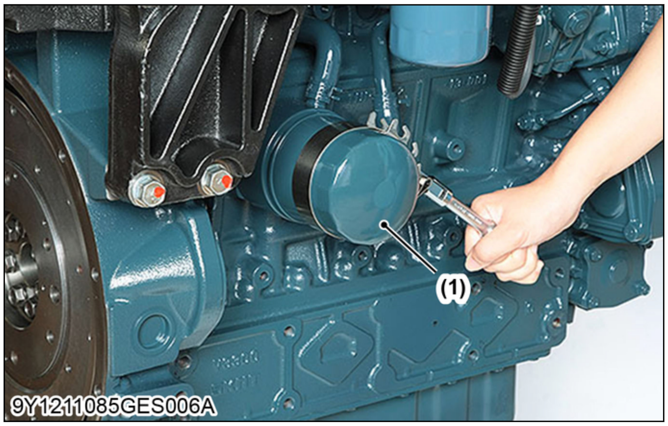
■ **IMPORTANT**

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

Tools required

- Filter wrench

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



(1) Oil filter cartridge

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

NOTE

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

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

NOTE

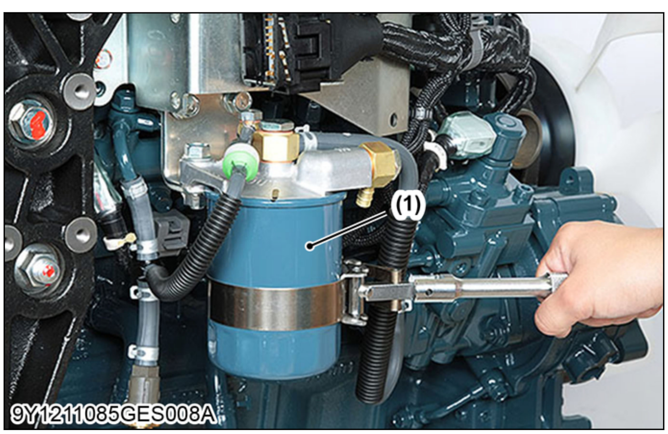
- **After you replace the cartridge, the engine oil usually decrease by a small level.**

6.3 Replacing fuel filter cartridge

Tools required

- Filter wrench

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



(1) Fuel filter cartridge

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.

6.4 Replacing water separator filter (Type 2)

IMPORTANT

- **Replace the water separator filter periodically to prevent wear of the supply pump or the injector, due to dirt in the fuel.**

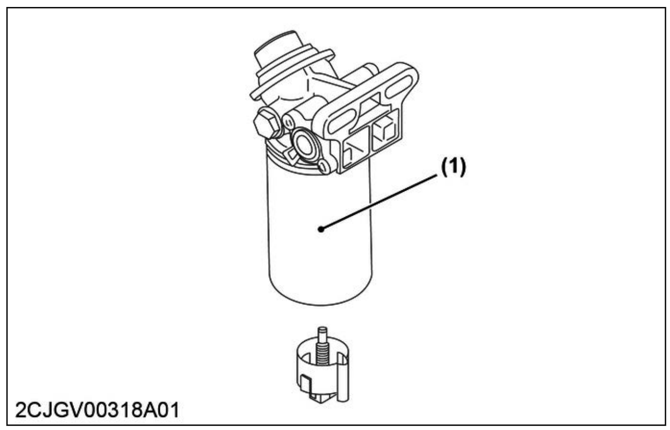
NOTE

- **Replace the water separator filter with a new one every 500 hours or 1 year.**

Tools required

- Filter wrench

1. Remove the old water separator filter (1) with a filter wrench.



(1) Water separator filter

2. Apply a thin layer of oil on the new water separator filter.
3. Tighten the new water separator filter by hand.
4. Operate the engine for a while and check if there is not the fuel leakage from the filter.

6.5 Cleaning water jacket and radiator interior

CAUTION

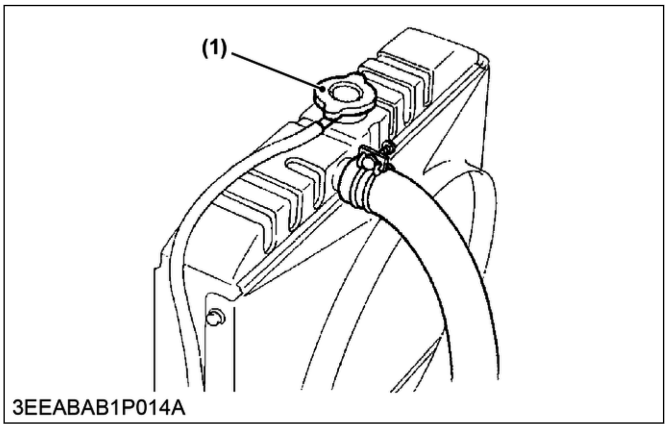
- **Do not remove the radiator cap when the engine is hot.**
  Then loosen the cap slightly to release unwanted pressure before you remove the cap fully.

IMPORTANT

- **Do not start the engine without coolant.**

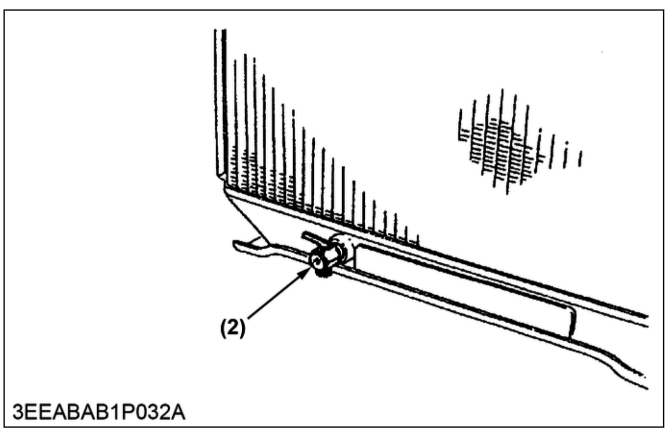
- **Use clean and soft water with anti-freeze to fill the radiator and reserve tank.**
- **Make sure that when you mix the anti-freeze and water, the ratio of anti-freeze is less than 50%.**
- **Make sure that you close the radiator cap correctly.**
  If the cap is loose or incorrectly closed, coolant can flow out and the engine can overheat.

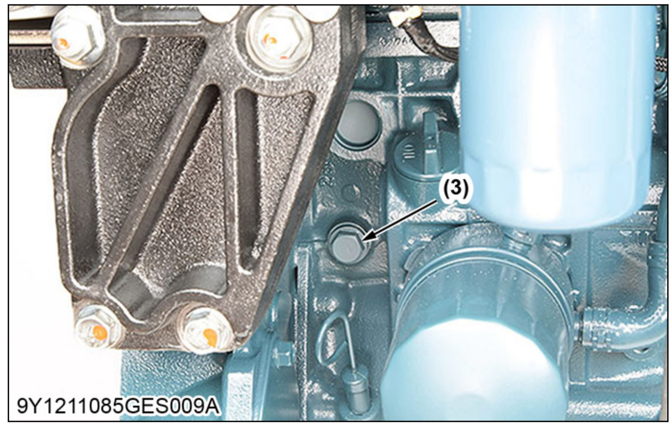
1. Stop the engine and let the coolant temperature decreases.
2. Remove the radiator cap (1) to drain the coolant fully.



(1) Radiator cap

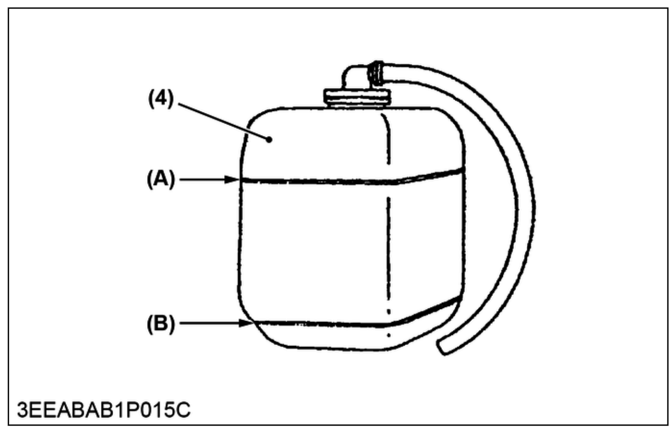
3. Open the drain valve (2) and drain plug (3).





(2) Drain valve (3) Drain plug

4. After you drained all coolant, close the drain valve (2) and drain plug (3).
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.
8. Install the radiator cap (1) correctly.
9. Fill with the coolant until the **[FULL]** (A) mark on the reserve tank (4).



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

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

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

Anti-freeze

■ **NOTE**

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

■ **IMPORTANT**

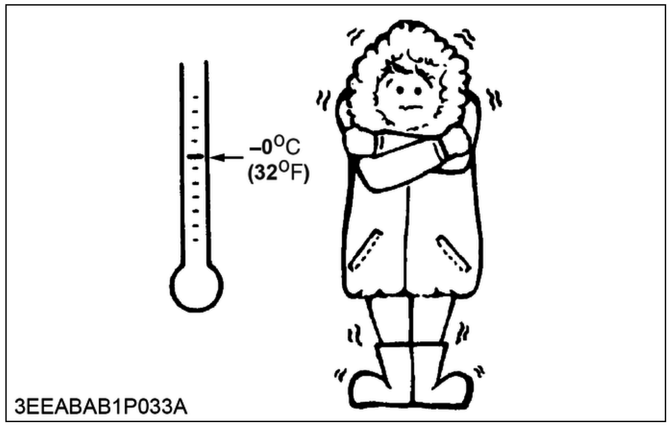
- **Make sure that when you mix the anti-freeze and water, the ratio of anti-freeze is less than 50%.**

Anti-freeze volume	Freezing point		Boiling point*	
	℃	℉	℃	℉
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.

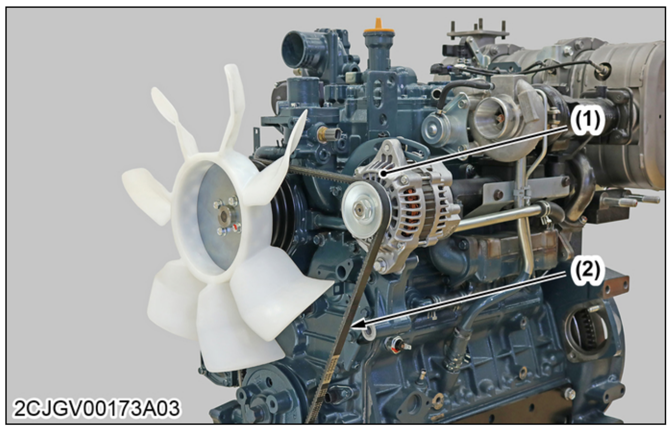


6.6 Replacing fan belt

Tools required

- Sonic belt tension meter

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

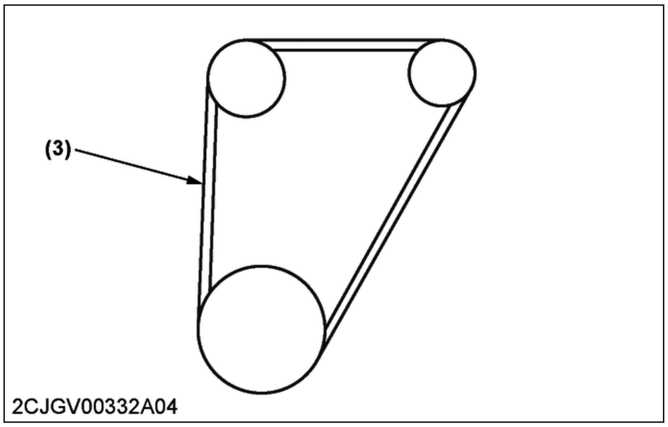


(1) Alternator (2) Fan belt

3. Replace the fan belt (2) with a new one.
4. Install the alternator (1).

5. Adjust the tension of fan belt halfway (3) between the fan drive pulley and fan pulley with sonic belt tension meter.

Sonic belt tension meter setting value	V3800-TIEF4, V3800-TIEF4C	V3800-TIEF4H
Mass (Mass per 1 rib 1 m of belt)	110 g/rib/m	18 g/rib/m
Width (Number of ribs)	1	6
Span (Distance of between the fan drive pulley and alternator pulley)	290 mm 11.4 in.	317 mm 12.5 in.

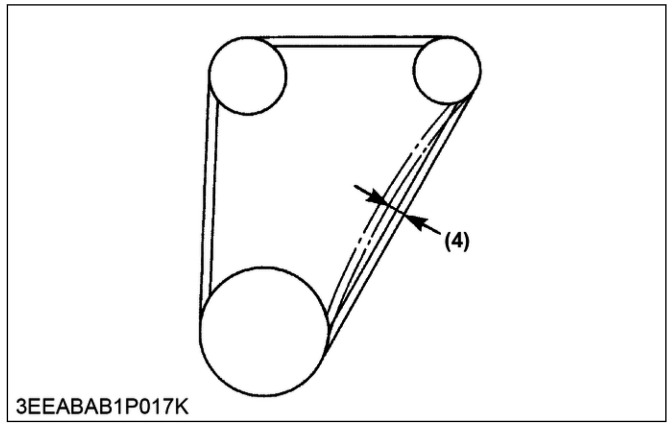


(3) Fan belt halfway

Belt tension (After installing)	Factory specification	V3800-TIEF4 V3800-TIEF4C	441 to 480 N 45.0 to 48.9 kgf 99.2 to 107 lbf
		V3800-TIEF4H	650 to 850 N 66.3 to 86.6 kgf 147 to 191 lbf
Belt tension (After engine operation)	Factory specification	V3800-TIEF4 V3800-TIEF4C	391 to 480 N 39.9 to 48.9 kgf 87.9 to 107 lbf
		V3800-TIEF4H	420 to 550 N 42.9 to 56.0 kgf 94.5 to 123 lbf

(Reference)

a. Push the belt halfway between the fan drive pulley and alternator pulley at a specified force to measure the deflection (4).



(4) Deflection

■ **NOTE**

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

Deflection (4)	Factory specification	V3800-TIEF4 V3800-TIEF4C	10 to 12 mm 0.40 to 0.47 in. (under load of 59 to 68 N (6.0 to 7.0 kg, 14 to 15 lbf))
		V3800-TIEF4H	9.0 to 11 mm 0.36 to 0.43 in. (under load of 59 to 68 N (6.0 to 7.0 kg, 14 to 15 lbf))

7. Check point of every 1000 hours

7.1 Checking valve clearance

■ **IMPORTANT**

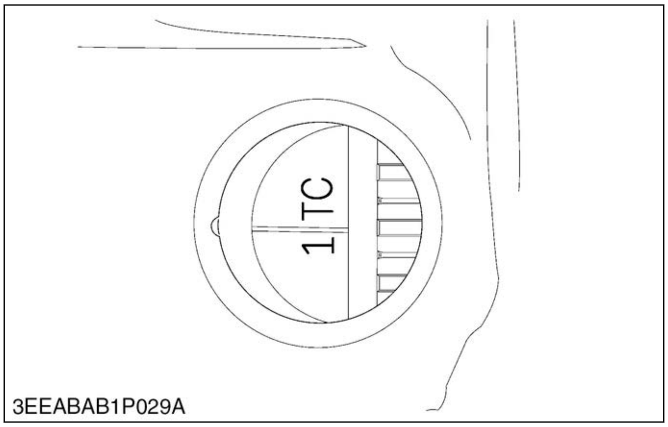
- **You must check and adjust the valve clearance when the engine is cold.**

Tools required

- Feeler gauge

1. Remove the air cleaner and muffler.
2. Remove the SCR muffler assembly.
3. Remove the SCR stay and base of SCR.
4. Remove the DPF intermediate harness, injector intermediate harness and engine intermediate harness from the bracket.
5. Remove the EGR cooler pipe.
6. Remove the injection pipes and cylinder head cover.

7. Align the **[1TC]** mark line on the flywheel and projection on the housing.



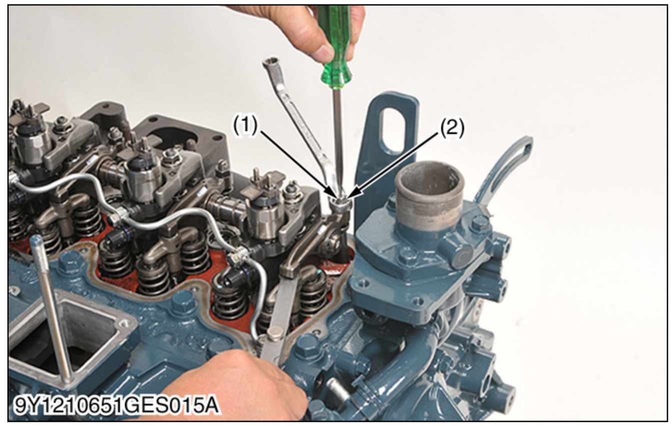
8. Make sure that the No.1 piston comes to the compression or overlap top dead center.
9. Check the subsequent valve clearance at the mark **[1TC]** with a feeler gauge.

■ NOTE

- **If the clearance is out of the factory specifications, adjust with the adjusting screw (1).**
- **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.

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	☆	☆



(1) Adjusting screw (2) Lock nut

10. Install the removed parts.

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	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
	Injection pipe retaining nut	23 to 36 N·m 2.3 to 3.7 kgf·m 17 to 26 lbf·ft
	Base of SCR	124 to 147 N·m 12.6 to 15.0 kgf·m 91.2 to 108 lbf·ft
	SCR mounting screw	49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	Slip band nut of SCR mixing pipe	15 to 17 N·m 1.6 to 1.7 kgf·m 11 to 12 lbf·ft

RELATED PAGE

5.3 Removing selective catalytic reduction (SCR) muffler on page 3-126
5.4 Removing CRS intermediate harness on page 3-127
6.42 Installing CRS intermediate harness on page 3-177
6.44 Installing SCR muffler assembly on page 3-181

8. Check points of every 1500 hours

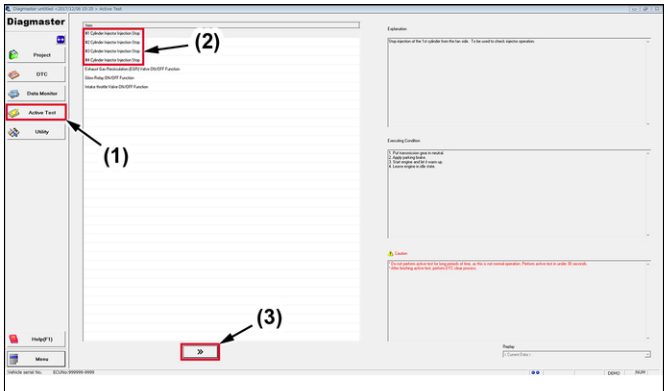
8.1 Checking injector (with Diagmaster)

Tools required

- Laptop computer (Diagmaster (software) installed)

- Interface (DST-i)

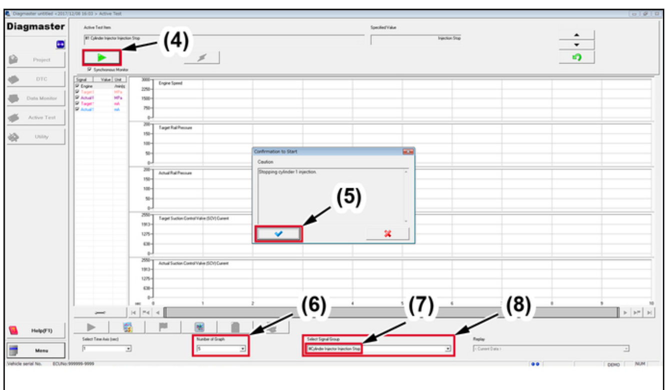
1. Connect the diagnosis tool.
2. Start "Diagmaster", then click the **[Active Test]** button (1) from the project window.
3. Select the "#1, 2, 3 and 4 Cylinder Injector Injection Stop" item (2), then click the **[proceed]** button (3).



2CJGV00304A01

(1) Active Test button
(2) #1, 2, 3 and 4 Cylinder Injector Injection Stop item
(3) Proceed button

4. Select the "#Cylinder Injector Injection Stop" (7) from the "select signal group" (8).
5. Select the "number of graph" (6).
6. Click the **[Start Active Test]** button (4), then click the **[OK]** button (5).



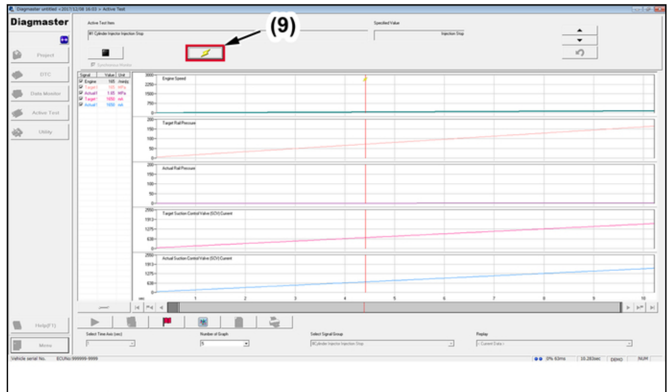
2CJGV00305A01

(4) Start Active Test button
(5) OK button
(6) Number of graph
(7) #Cylinder Injector Injection Stop
(8) Select signal group

7. Click the **[Send Specified Active Test Value]** button (9).

■ NOTE

- **Confirm that the each 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.**



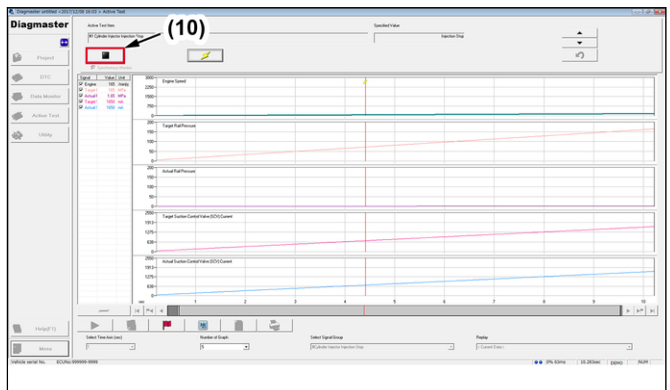
2CJGV00306A01

(9) Send Specified Active Test Value button

8. Click the **[Finish Active Test]** button (10).

■ NOTE

- **If it is determined that there is a failure, check for a plug in the injection pipe.**
- **If the injector pipe is normal, this may be an injector failure so replace the injector using the procedure for replacing injectors.**



2CJGV00306A02

(10) Finish Active Test button

RELATED PAGE

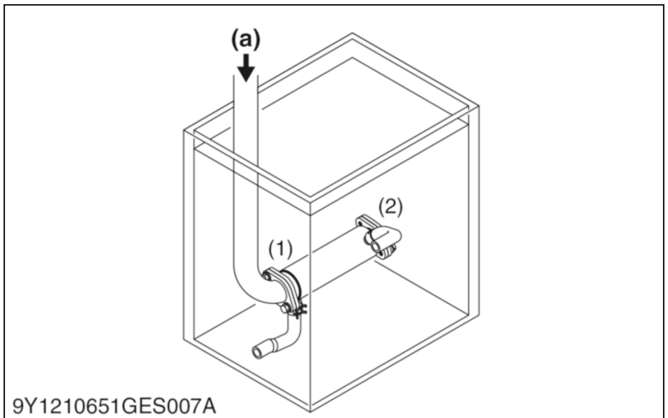
7.55 Replacing injector on page 3-212

8.2 Checking 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) to the air hose side.

EGR cooler leakage test pressure	Factory specification	Exhaust gas passage	290 kPa 3.0 kgf/cm^2 43 psi



9Y1210651GES007A

(1) Exhaust gas inlet
(2) Exhaust gas outlet
(a) Air pressure

5. Check that there are no air leaks in any of the EGR cooler parts.

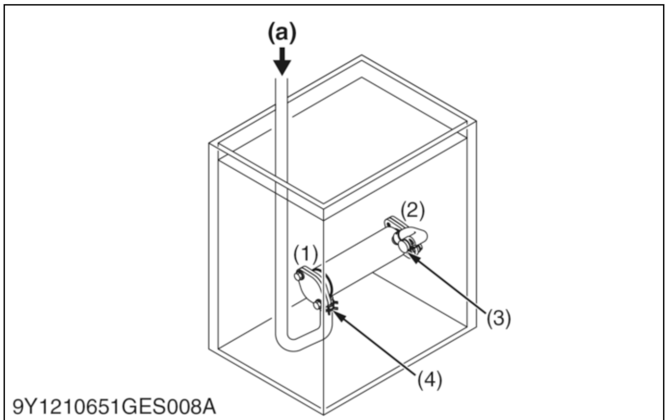
■ **NOTE**
- **If there are air leaks, replace the EGR cooler.**

6. Install the removed parts.

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) to the air hose side.

EGR cooler leakage test pressure	Factory specification	Coolant passage	250 kPa 2.5 kgf/cm^2 36 psi



9Y1210651GES008A

(1) Exhaust gas inlet
(2) Exhaust gas outlet
(3) Coolant outlet
(4) Coolant inlet
(a) Air pressure

4. Check that there are no air leaks in any of the EGR cooler parts.

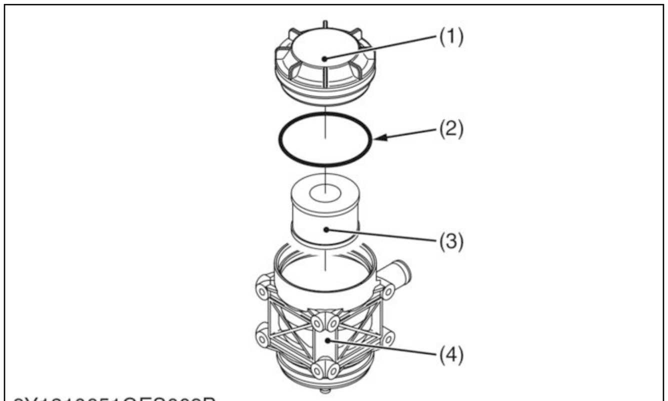
■ **NOTE**
- **If there are air leaks, replace the EGR cooler.**

5. Install the removed parts.

8.3 Replacing oil separator element

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

1. Remove the cover (1).
2. Remove the oil separator element (3) and O-ring (2).



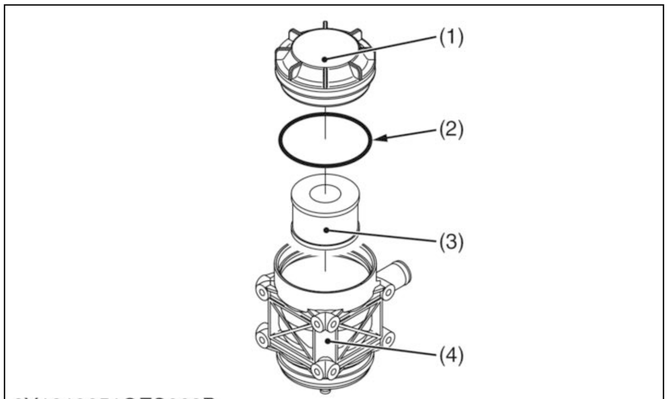
9Y1210651GES009B

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

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

8.4 Checking PCV (positive crankcase ventilation) valve

1. Remove the cover (1) and element (3).



9Y1210651GES009B

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

2. Press on the PCV valve and check that it moves smoothly.

■ **NOTE**
- **If it does not move smoothly, replace the oil separator.**


9Y1210651GES016A

8.5 Checking DEF/AdBlue® injector tip

CAUTION
- **When removing the DEF tube from the clamp, remove after cooling down and DEF purge are complete.**
  Maximum 12 minutes after engine stops.
- **When removing the DEF tube from the DEF injector, be careful not to scatter the DEF that remains in the DEF tube.**
- **Wait until the mixing pipe has cooled substantially before removing the DEF injector band.**
- **Do not apply excessive force when removing the DEF injector from the mixing pipe.**

■ **NOTE**
- **AdBlue® is a registered trademark of Verband der Automobilindustrie e.V. in Germany.**

1. Remove the DEF tube from the clamp.
2. Remove the DEF tube from the DEF injector.
3. Remove the DEF injector band.
4. Remove the DEF injector from the mixing pipe.
5. Make sure there are no deposits in the mixing pipe.
6. Check for rust on the DEF injector terminal.

■ **NOTE**
- **If there is rust, replace the DEF injector.**

7. Make sure there are no issues with the external appearance (corrosion or deformation) of the DEF injector.
8. Check the tip of the DEF injector for deposits.

■ **NOTE**
- **If there are any solids deposited, wash the tip with water.**
- **Be careful not to get any water on the connector of the DEF injector.**

9. Wipe the tip of the DEF injector several times with a soft sponge wet with clean water.
10. Visually check the injection holes after washing with water.
11. Install the removed parts.

■ **NOTE**
- **Replace the DEF injector band and gasket with new one.**
- **Make sure keep clean the contact surface of gasket.**
- **Tighten the DEF injector band to their specified torque.**

Tightening torque	DEF injector band	3.7 to 4.0 N·m 0.38 to 0.40 kgf·m 2.8 to 2.9 lbf·ft

8.6 Checking DEF/AdBlue® hoses

1. Visually check for cracks, DEF/AdBlue®* leak and anything else unusual.
2. Check to see if the lock bolts and nuts are tight enough.

9. Check points of every 3000 hours

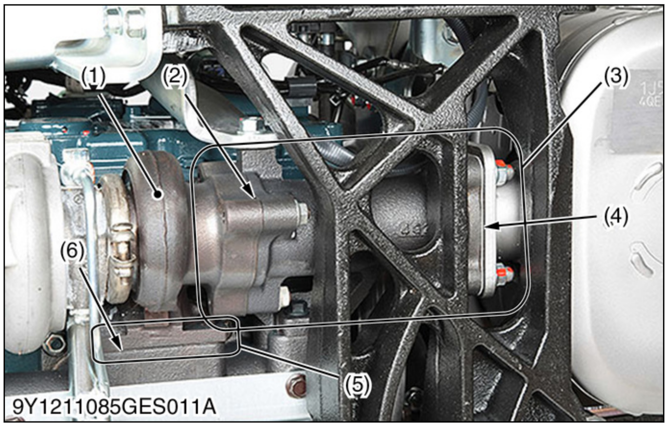
9.1 Checking turbocharger

Turbine side

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

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

* AdBlue® is a registered trademark of Verband der Automobilindustrie e.V. in Germany.



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

Compressor side

1. Check the inlet hose of the compressor cover (7) for air leakage.

■ **NOTE**

- **If you find an air leakage, change the clamp and / or the inlet hoses.**

(7) Compressor cover

2. Replace the inlet hose and check the suction side of the intake hose for loose connections or crack.

■ **NOTE**

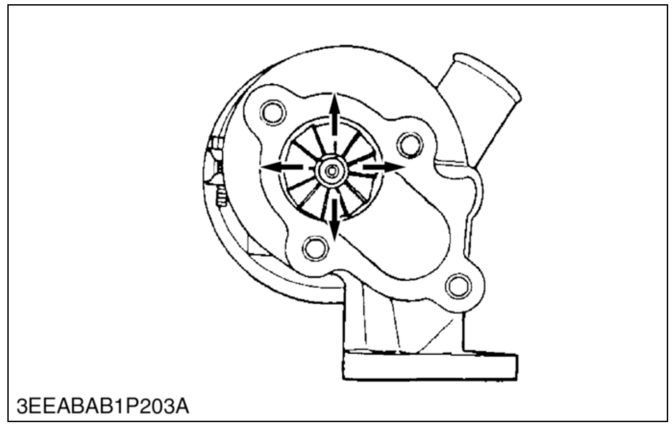
- **If you find loose connections or cracks, tighten the clamp or replace the hoses.**

Radial clearance

1. Check the radial clearance between wheel and housing.

■ **NOTE**

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



9.2 Cleaning 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**

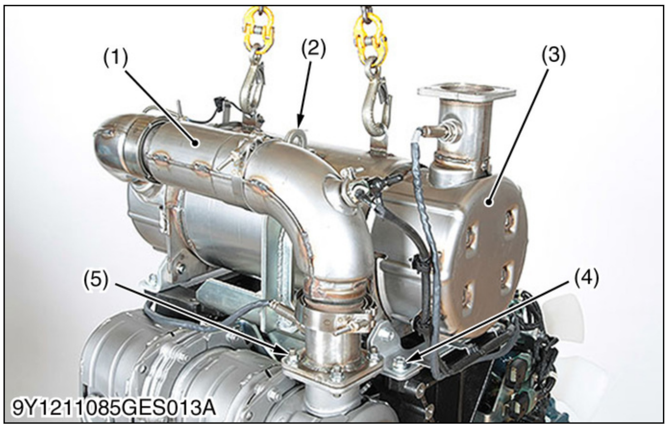
- **Always work in the workshop equipped with a electric lift (including mobile lift).**
- **Put a product (engine) on a stable ground, and set the parking brake.**
- **As the DPF muffler full assembly is hot just after the engine shutdown, make sure to start operation after it gets cool.**
- **Make 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.

Tools required

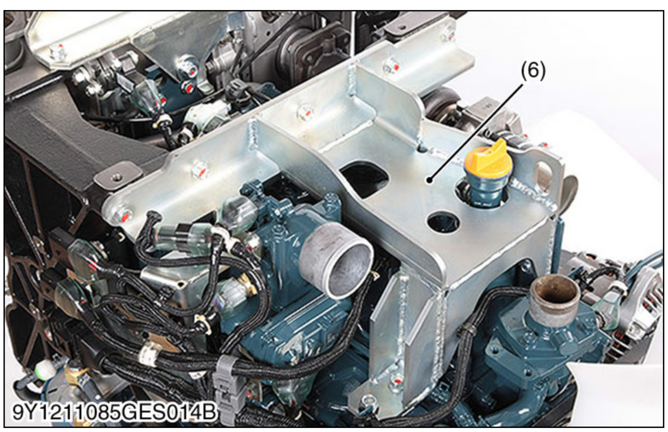
- Crowfoot wrench

1. Lift the SCR muffler assembly (3).
2. Loosen the SCR mounting screw (4) and remove the 4 nuts (5) of SCR mixing pipe (1).
3. Remove the SCR mixing pipe stay (2).
4. Remove the SCR muffler assembly (3).



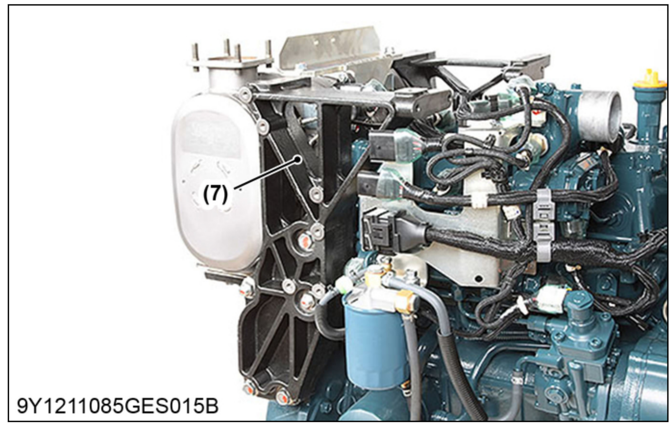
(1) SCR mixing pipe
(2) SCR mixing pipe stay
(3) SCR muffler assembly
(4) SCR mounting screw
(5) Nut

5. Remove the SCR stay (6).



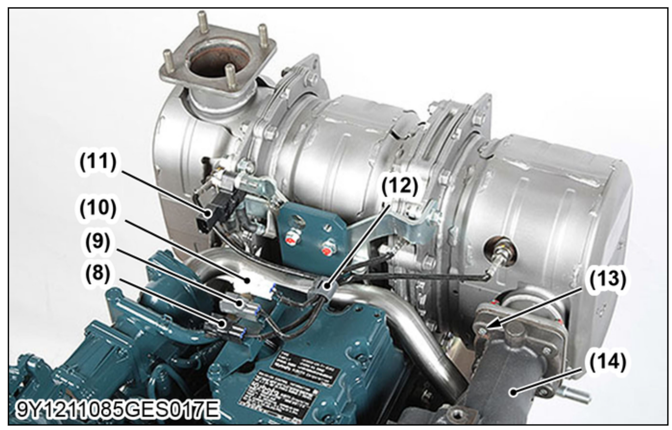
(6) SCR stay

6. Remove the base of SCR (7).



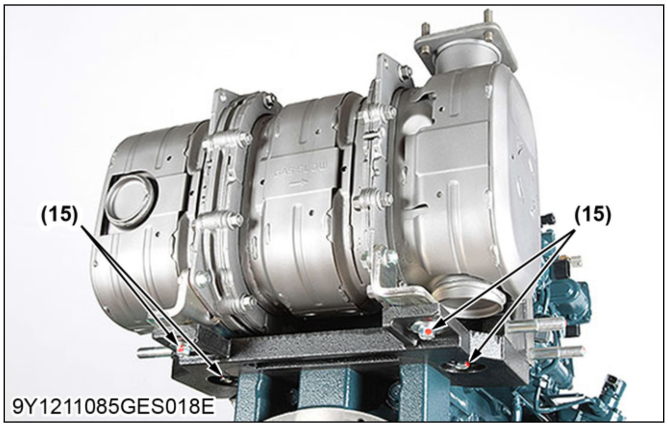
(7) Base of SCR

7. Disconnect the harness (engine side) of connector (8), (9), (10), (11) from the each sensor.
8. Remove the connector (8), (9), (10) of temperature sensor from the bracket.
9. Remove the clamp (12).
10. Remove the muffler flange screws (13).



(8) Connector of temperature sensor (T_0)
(9) Connector of temperature sensor (T_1)
(10) Connector of temperature sensor (T_2)
(11) Differential pressure sensor
(12) Clamp
(13) Muffler flange screw
(14) Muffler flange

11. Remove the muffler full assembly (DPF) mounting screws (15).



(15) Muffler full assembly (DPF) mounting screw

12. Set the shackle to the position (a), (b) of the muffler full assembly (DPF) (21). (Refer to the photo.)
13. Lift the muffler full assembly (DPF) (21) and remove the DPF muffler assembly (21).
14. Remove the tube (22), (23) from the differential pressure pipe (17), (20).

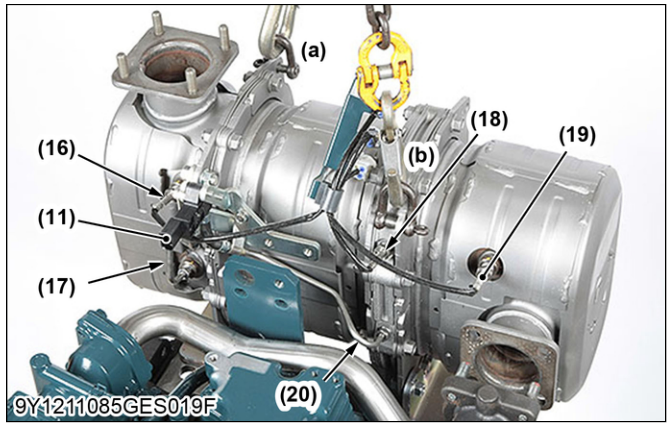
NOTE

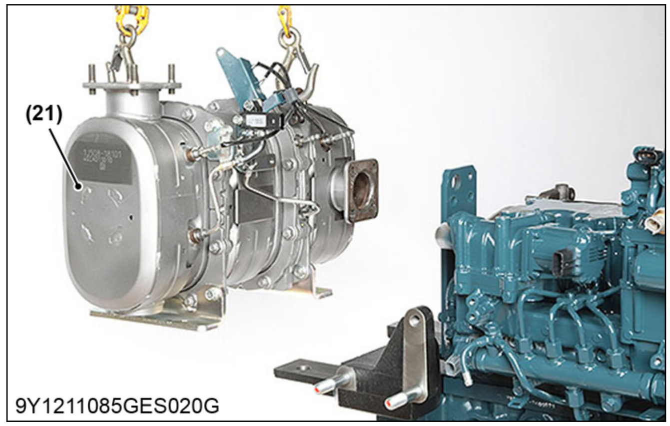
- **If the differential pressure tube is damaged or cracked, replace it.**

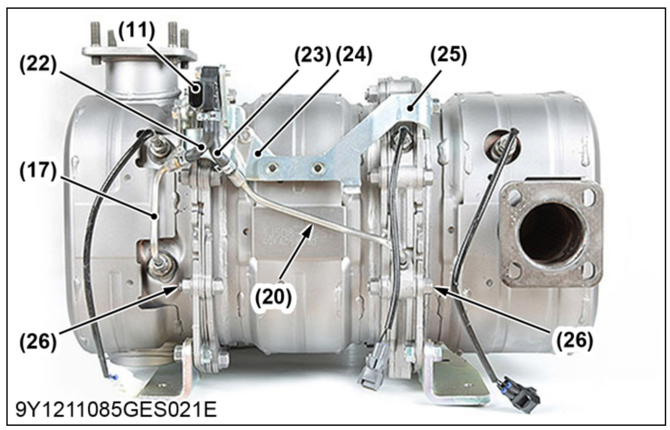
15. Remove the differential pressure sensor (11).
16. Remove the DPF stay (24), (25).
17. Loosen the filter comp (DPF) mounting screw (26) and remove the filter comp (DPF) (28).

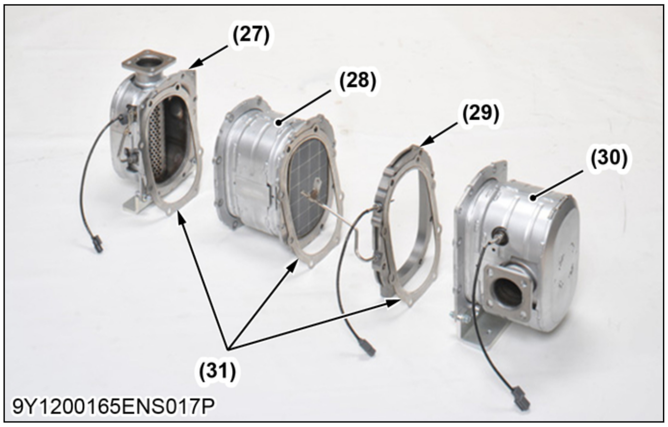
NOTE

- **When the differential pressure pipe (17), (20) and temperature sensor (16), (18), (19) 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 (17), (20), 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.**



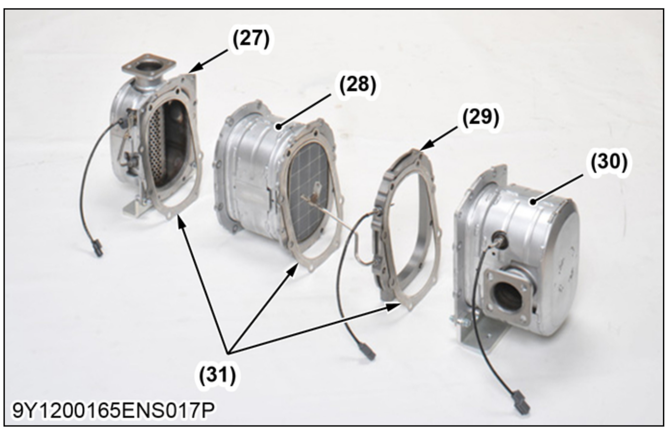






(11) Differential pressure sensor
(16) Temperature sensor (T2)
(17) Differential pressure pipe
(18) Temperature sensor (T1)
(19) Temperature sensor (T0)
(20) Differential pressure pipe
(21) Muffler full assembly (DPF)
(22) Tube
(23) Tube
(24) DPF stay
(25) DPF stay
(26) Filter comp (DPF) mounting screw
(27) Body (DPF outlet)
(28) Filter comp (DPF)
(29) Collar
(30) Catalyst (DOC)
(31) Gasket
(a) Position
(b) position

18. Pack the filter comp (DPF) (28) and send it to a cleaning contractor.



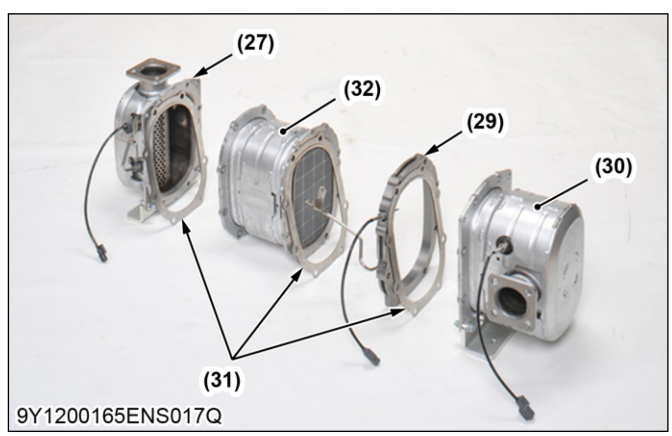
(27) Body (DPF outlet)
(28) Filter comp (DPF)
(29) Collar
(30) Catalyst (DOC)
(31) Gasket

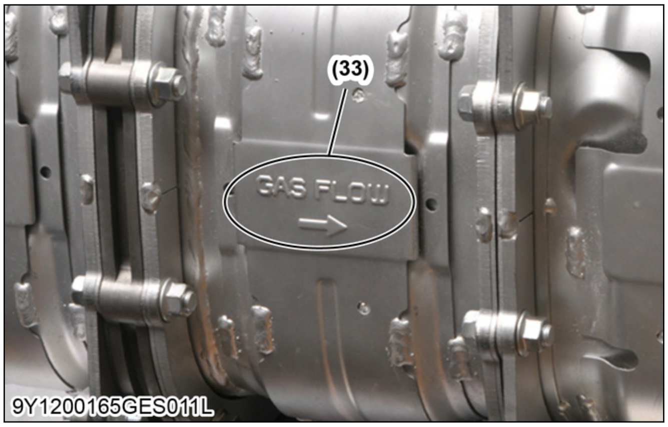
19. Install the removed parts and cleaned filter comp (DPF) (32).

■ **NOTE**

- **Replace the gaskets (31) with new ones.**
- **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 cleaned filter comp (DPF) (32) in the correct direction by referring the mark "GAS FLOW→" (33) (Catalyst (DOC) (30) to Body (DPF Outlet) (27)) on the side showing the flow of exhaust gas.**

Tightening torque	DPF stay (24), (25)	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
	Muffler flange screw (13)		49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	Muffler full assembly (DPF) mounting screw (15)		49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	Filter comp (DPF) mounting screw (26)		49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	Temperature sensor (T0) (19) Temperature sensor (T1) (18) Temperature sensor (T2) (16)		25 to 34 N·m 2.5 to 3.5 kgf·m 18 to 25 lbf·ft
	Base of SCR (7)		124 to 147 N·m 12.6 to 15.0 kgf·m 91.2 to 108 lbf·ft
	SCR stay (6)		49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	SCR mounting screw (4)		49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	Slip band nut of SCR mixing pipe		15 to 17 N·m 1.6 to 1.7 kgf·m 11 to 12 lbf·ft





(27) Body (DPF outlet)
(29) Collar
(30) Catalyst (DOC)
(31) Gasket
(32) Cleaned Filter comp (DPF)
(33) Gas flow →

— RELATED PAGE —
7.57 Replacing DPF on page 3-218

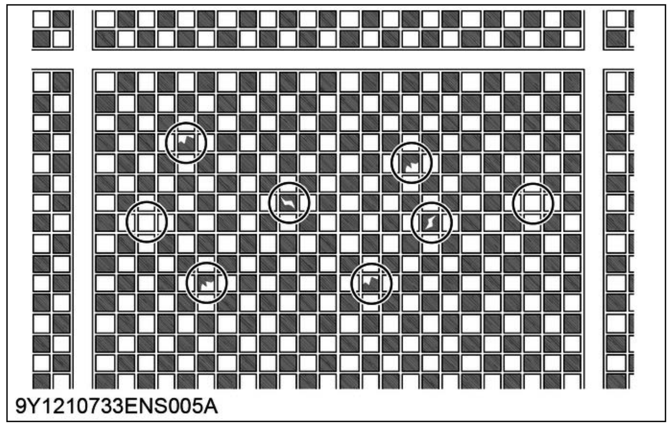
9.3 Judging reuse of DPF filter comp before cleaning (Service dealer)

■ **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).

■ **NOTE**
- **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.

■ **NOTE**
- **If there are any cracks or losses of the ceramics element, the filter comp (DPF) cannot be reused even if it is cleaned.**
- **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.**

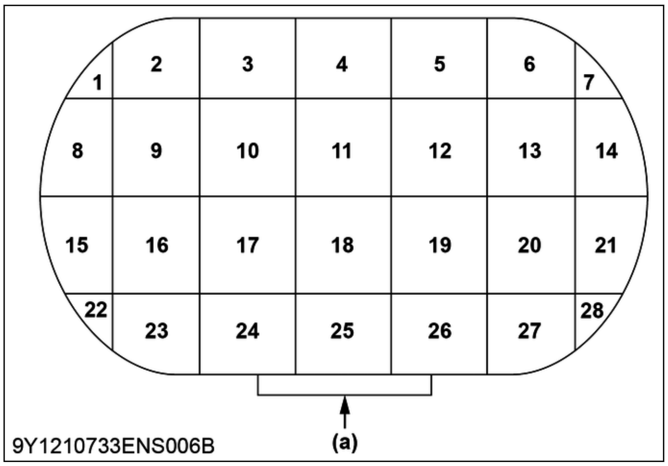
9.4 Judging reuse of DPF filter comp after cleaning (Cleaning contractor)

■ **IMPORTANT**
- **After the cleaning contractor has cleaned the filter comp (DPF) (2), measure the quantity of remaining ash in the following procedure, and evaluate the reusability.**

1. After having cleaned the filter comp (DPF) (2), measure the actual cell depth (D) with a pin gauge (1) in the each block shown in the figure.

■ **NOTE**
- **One cell (The measurement point is not specified) is measured in each block.**

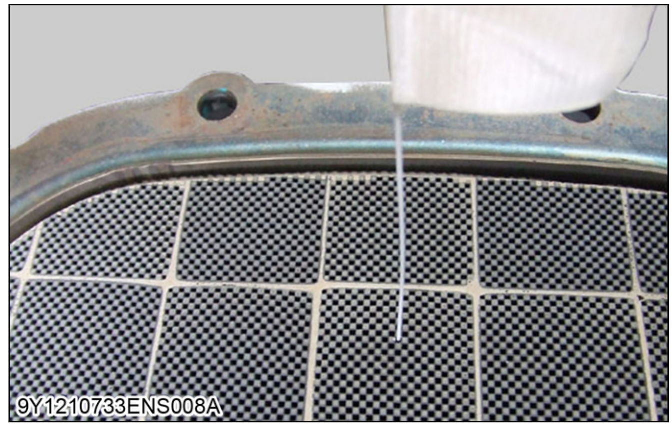
Model	Measurement total
V3800	28 blocks

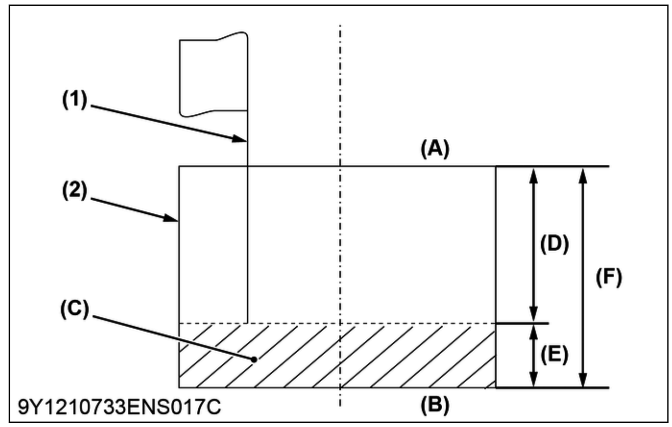


(a) Serial number

■ **NOTE**
- **If the actual cell depth (D) 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.**
- **Actual cell depth (D) = Cell depth (F) − Accumulated ash depth (E)**

Actual cell depth (D) (Average of all measurement blocks)	Allowable limit	Less than 106 mm 4.17 in.





(1) Pin gauge
(2) Filter comp (DPF)
(A) Exhaust gas inlet side
(B) Exhaust gas outlet side
(C) Accumulated ash
(D) Actual cell depth
(E) Accumulated ash depth
(F) Cell depth

- **Select a metal pin gauge (1) having a wire size slightly thinner than the cell width.**

Pin gauge (1)	Diameter	0.60 to 0.80 mm 0.024 to 0.031 in.
	Length	150 mm 5.91 in.

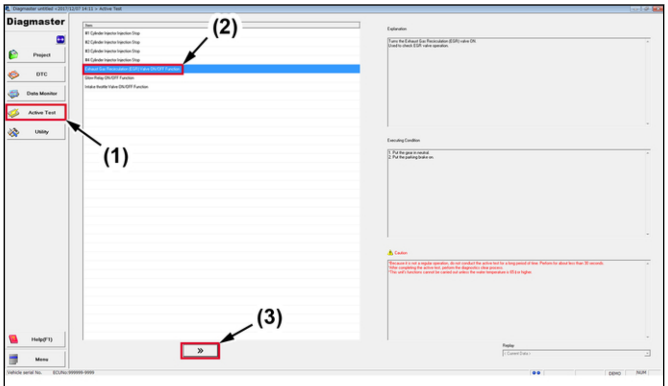
- **When the pin gauge (1) is inserted into the cell hole, insert it by lightly tapping on the gauge end with a finger tip.**
- **If the pin gauge (1) is forcibly pushed in, the pin pierces through the accumulated ash (C) and it cannot be measured accurately.**
  So be careful not to push the pin forcibly.

9.5 Checking EGR system (with Diagmaster)

Tools required
- Laptop computer (Diagmaster (software) installed)
- Interface (DST-i)

1. Connect the diagnosis tool.
2. Start "Diagmaster", then click the **[Active Test]** button (1) from the project window.

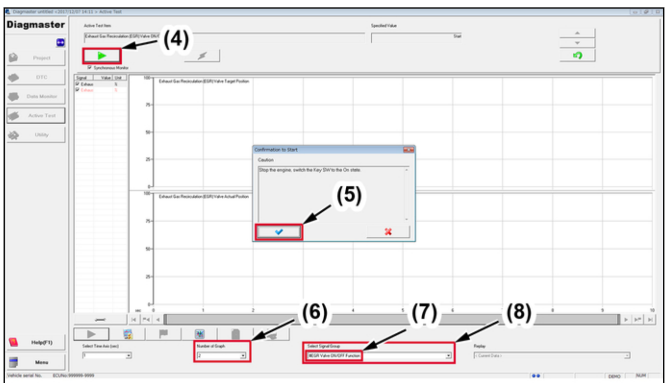
3. Select the "Exhaust Gas Recirculation (EGR) Valve ON/OFF Function" item (2), then click the **[proceed]** button (3).



2CJGV00307A01

(1) Active Test button
(2) Exhaust Gas Recirculation (EGR) Valve ON/OFF Function item
(3) Proceed button

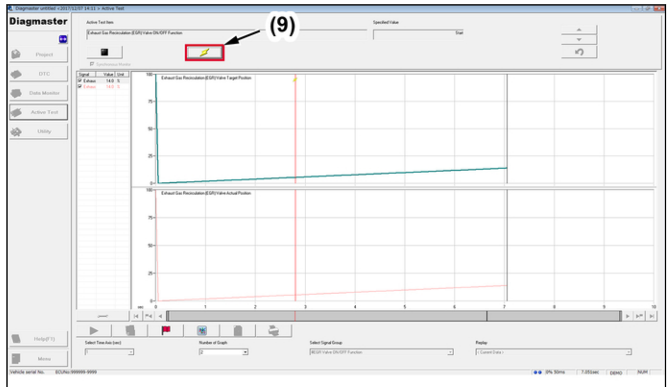
4. Select the "EGR Valve ON/OFF Function" (7) from the "select signal group" (8).
5. Select the "number of graph" (6).
6. Click the **[Start Active Test]** button (4), then click the **[OK]** button (5).



2CJGV00308A01

(4) Start Active Test button
(5) OK button
(6) Number of graph
(7) EGR Valve ON/OFF Function
(8) Select signal group

7. Click the **[Send Specified Active Test Value]** button (9).



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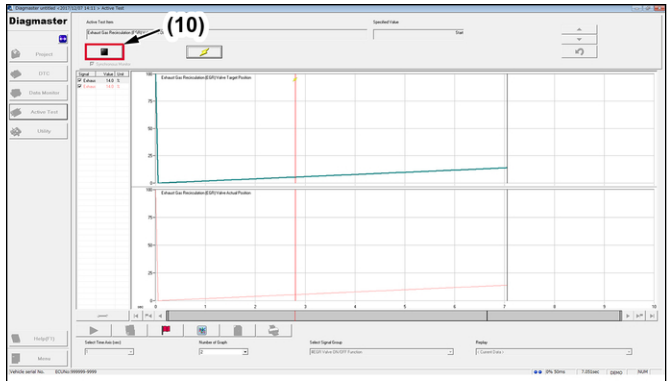
(9) Send Specified Active Test Value button

8. Click the **[Finish Active Test]** button (10).



2CJGV00309A02

(10) Finish Active Test button

9. Based on test results, check that the EGR valve gas passage and coolant passage are not clogged.
10. Clean any soot from the gas passage so that it does not damage the EGR valve.
11. Clean the coolant passage by operating it with water.

9.6 Replacing DEF/AdBlue® pump filter

WARNING

- **Dispose of discharged/used DEF/AdBlue®* properly in accordance with local regulations.**

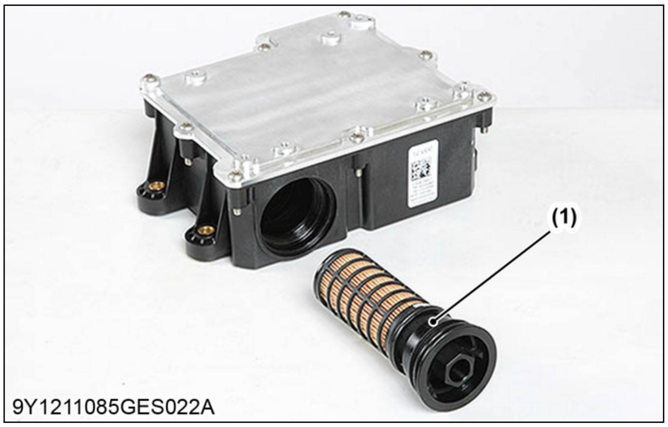
IMPORTANT

- **The DEF/AdBlue®* filter serves to keep DEF/AdBlue®* clean.**
  When replacing it with new one, use Kubota genuine filter or its equivalent for best performance.

* **AdBlue® is a registered trademark of Verband der Automobilindustrie e.V. in Germany.**

- **The SCR system keeps on running for several minutes even after the starter switch has set to the [OFF] position.
If an inspection or repair is needed, wait for a couple or minutes.**
- **Discharged/used DEF/AdBlue®* from lines during service cannot be reused or SCR system malfunction may result.**

1. Set the starter switch to the **[OFF]** position.
2. Wait for maximum 12 minutes for the supply module to get deactivated.
3. Place a receiving pan below the supply module.
4. Loosen the cover and draw out the filter (1) and equalizing element at the same time.



(1) Filter

5. Install a new filter and equalizing element in place.
6. Reattach the cover back into position.

Tightening torque	DEF filter cover	9.00 to 11.0 N·m 0.918 to 1.12 kgf·m 6.64 to 8.11 lbf·ft

9.7 Checking DEF/AdBlue® injector

CAUTION

- **Get the temperature of the DEF closer to 20 ℃(68 ℉) to the extent possible.**
- **When removing the DEF tube from the clamp, remove after cooling down and DEF purge are complete.
Maximum 12 minutes after engine stops.**
- **When removing the DEF tube from the DEF injector, be careful not to scatter the DEF that remains in the DEF tube.**
- **Wait until the mixing pipe has cooled substantially before removing the DEF injector band.**
- **Do not apply excessive force when removing the DEF injector from the mixing pipe.**
- **Be careful not to scatter DEF during an active test.**

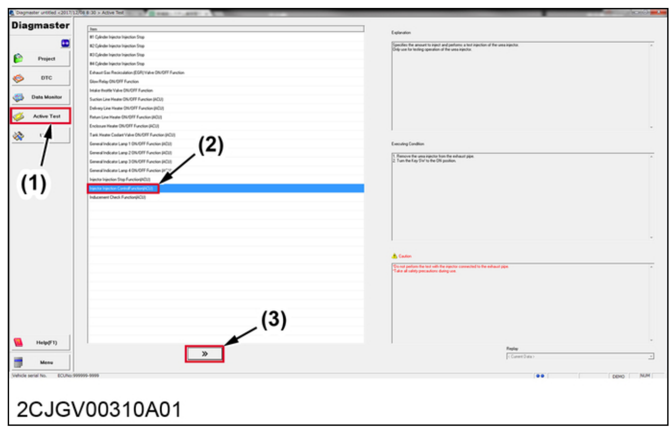
Tools required

- Diagmaster
- Interface (DST-i)
- Electronic scale (minimum scale value 0.01 g)
- Container (approximately 250 ml)

NOTE

- **AdBlue® is a registered trademark of Verband der Automobilindustrie e.V. in Germany.**

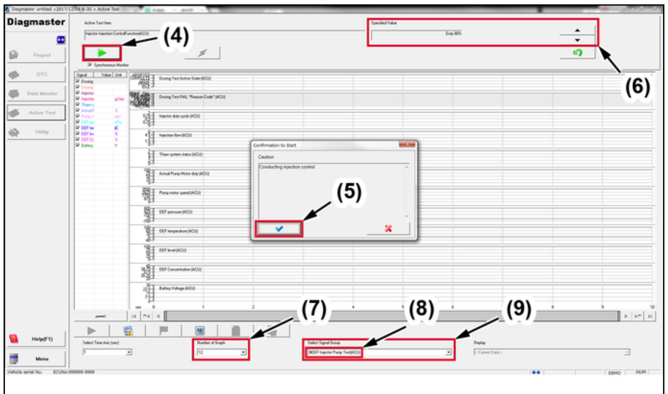
1. Remove the DEF tube from the clamp.
2. Remove the DEF tube from the DEF injector.
3. Remove the DEF injector band.
4. Remove the DEF injector from the mixing pipe.
5. Connect the DEF tube and connector to the DEF injector.
6. Start up the Diagmaster and initiate communication with the ACU.
7. Start "Diagmaster", then click the **[Active Test]** button (1) from the project window.
8. Select the "Injector Injection Control Function (ACU)" item (2), then click the **[proceed]** button (3).



(1) Active Test button
(2) Injector Injection Control Function (ACU) item
(3) Proceed button

9. Select "#DEF Injector Pump Test (ACU)" (8) signal group from "Select Signal Group" (9). Automatically the signals are selected.
10. Select the "number of graph" (7).
11. Select the "duty 80%" (6) as the duty for the DEF injector from "Specified Value".

12. Click the **[Start Active Test]** button (4), then click the **[OK]** button (5).



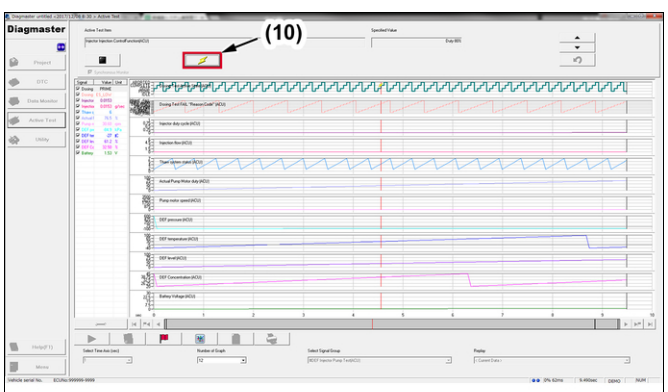
2CJGV00311A01

(4) Start Active Test button
(5) OK button
(6) Duty 80%
(7) Number of graph
(8) #DEF Injector Pump Test (ACU)
(9) Select signal group

13. Measure the weight of the container prior to collection.
14. Set conditions so that all of the DEF injected can be collected and then start monitoring and active tests.
15. Click the **[Send Specified Active Test Value]** button (10).

■ NOTE
- **Enable visibility of the spray, start the active test, and check the spray conditions during injection.**

Atomizing state	Factory specification	Make sure it is a cone shape and there are no deviations



2CJGV00312A01

(10) Send Specified Active Test Value button

16. Store log data as needed.
17. After completing the active test, measure the increase in weight of the container for measuring DEF weight.

Weight of DEF collected	Factory specification	80.0 to 120 g 0.177 to 0.264 lbs

■ NOTE
- **If the weight of the DEF collected does not meet evaluation criteria, perform the following corrective actions.**
  - **If the DEF pressure is unstable: leaking in of air is a possibility so check the connection status of the DEF tube.**
  - **If DEF pressure is low: replace the filter in the DEF tank and the filter in the DEF pump.**
    Check the connection status of the DEF tube.
  - **If DEF pressure is high: this may be caused by a plugged DEF injector so replace the DEF injector.**
    Check the connection status of the DEF tube.
  - **If DEF injection amount is low : wash the DEF injector holes.**

18. Make sure there is no DEF leak or abnormal noise during the active test.
19. Install the removed parts.

■ NOTE
- **Replace the DEF injector band and gasket with new one.**
- **Make sure keep clean the contact surface of gasket.**
- **Tighten the DEF injector band to their specified torque.**

Tightening torque	DEF injector band	3.7 to 4.0 N·m 0.38 to 0.40 kgf·m 2.8 to 2.9 lbf·ft

10. Check point of every 8000 hours

10.1 Replacing DEF/AdBlue® tank filter

■ NOTE
- **AdBlue® is a registered trademark of Verband der Automobilindustrie e.V. in Germany.**

1. Remove the header assembly (2) from the DEF tank (1).

2. Remove the filter (3) from the header assembly (2).

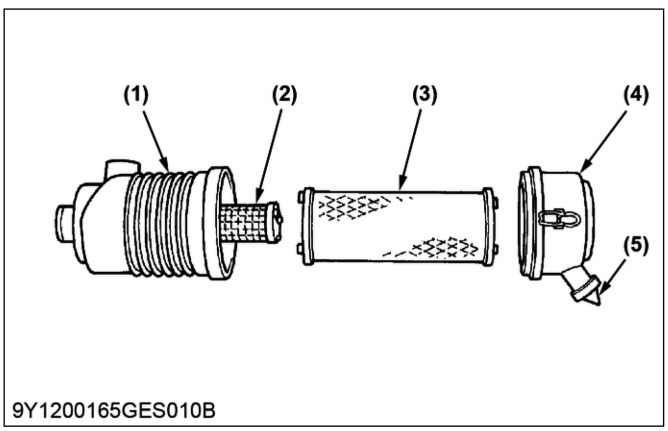
(1) DEF tank
(2) Header assembly
(3) Filter

3. Replace the filter (3) with a new one.
4. Install the header assembly (2) to the DEF tank (1).

11. Check points of every 1 year

11.1 Replacing air cleaner element

1. Remove the dust cup (4).
2. Remove used air cleaner primary element (3) and secondary element (2).



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

3. Replace new air cleaner primary element (3) and secondary element (2).

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

4. Install the removed parts.

11.2 Checking 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.

Tools required
- Crowfoot wrench

1. Check the DPF differential pressure pipe (2), (3) for crack, gas leakage and loose mounting nut.

   ■ NOTE
   - **If you find a crack, change the DPF differential pressure pipe.**
   - **If you find a gas leakage, remove the DPF differential pressure pipe and wipe off the anti-seize & lubricating compound.**

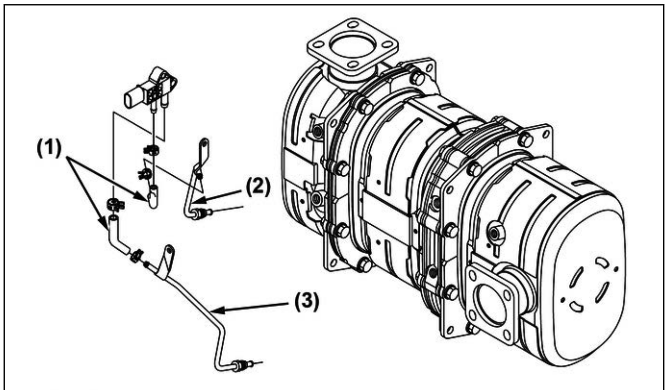
2. Apply the anti-seize and lubricating compound again, then tighten the DPF differential pressure pipe to the specified torque.

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

3. Check the DPF differential pressure hose (1) for crack, gas leakage.

■ **NOTE**

- **If you find a crack or gas leakage, change the DPF differential pressure hose.**



9Y1210651GES013A

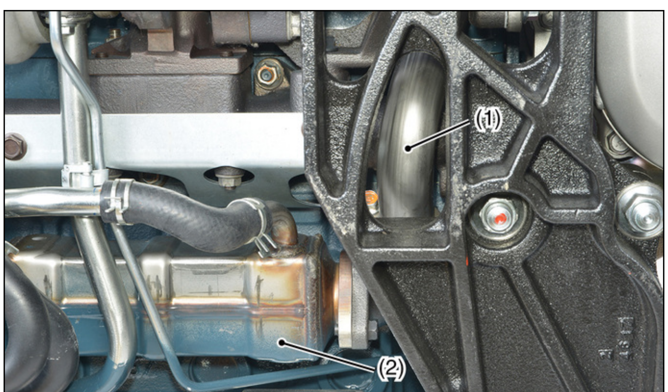
(1) DPF differential pressure hose
(2) DPF differential pressure pipe
(3) DPF differential pressure pipe

11.3 Checking EGR piping

1. Check the EGR cooler (2) and the EGR pipe (1) for crack, gas leakage and loose mounting screw.

■ **NOTE**

- **If you find a crack, replace the EGR cooler (2) or EGR pipe (1) which has cracked.**
- **If you find a gas leakage, tighten the mounting screw again or replace the gasket with a new one.**
- **If you find a loose mounting screw, tighten the mounting screw again.**



9Y1211085GES031A

(1) EGR pipe
(2) EGR cooler

11.4 Checking intake air line

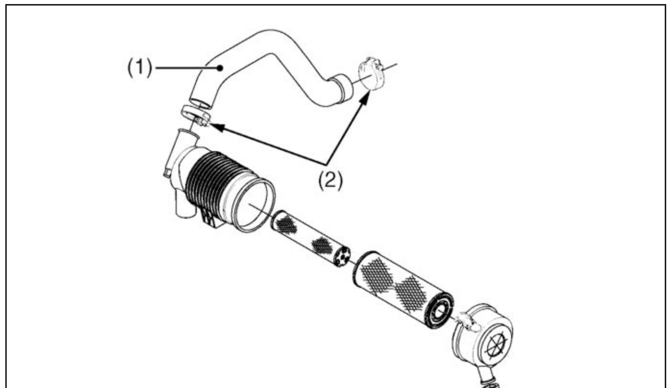
■ **IMPORTANT**

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

1. Make sure that the intake air hose(s) (1) are connected correctly or not.
2. Visually check for cracks gas leak and anything else unusual.
3. If the clamp (2) is loose, apply oil to the threads and tighten it again correctly.

■ **NOTE**

- **You must replace the intake air hose(s) every 2 years.**
  Also replace the clamp (2) every 2 years and tighten it correctly.



9Y1200165GES008A

(1) Intake air hose
(2) Clamp

11.5 Checking exhaust manifold

1. Check the exhaust manifold for crack, exhaust gas leakage and loose mounting screw.

■ **NOTE**

- **If you find a crack, change the exhaust manifold.**
- **If you find a gas leakage, tighten the mounting screw again or replace the gasket with a new one.**
- **If you find a loose mounting screw, tighten the mounting screw again.**

11.6 Replacing water separator filter (Type 2)

■ **IMPORTANT**

- **Replace the water separator filter periodically to prevent wear of the supply pump or the injector, due to dirt in the fuel.**

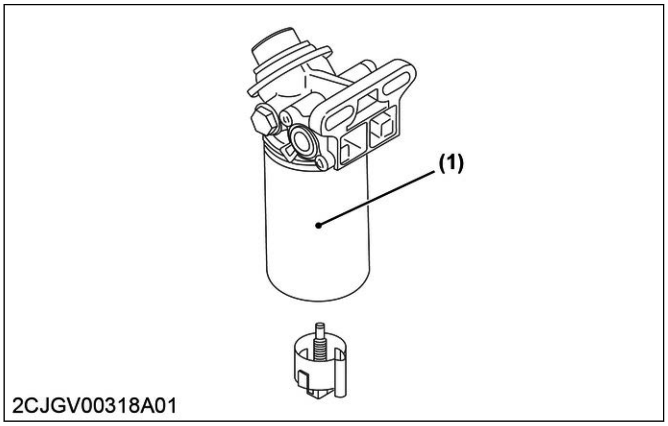
■ **NOTE**

- **Replace the water separator filter with a new one every 500 hours or 1 year.**

Tools required

- Filter wrench

1. Remove the old water separator filter (1) with a filter wrench.



(1) Water separator filter

2. Apply a thin layer of oil on the new water separator filter.
3. Tighten the new water separator filter by hand.
4. Operate the engine for a while and check if there is not the fuel leakage from the filter.

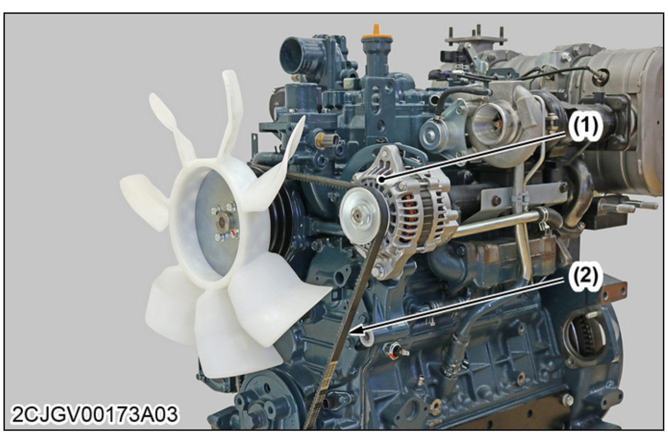
12. Check points of every 2 years

12.1 Replacing fan belt

Tools required

- Sonic belt tension meter

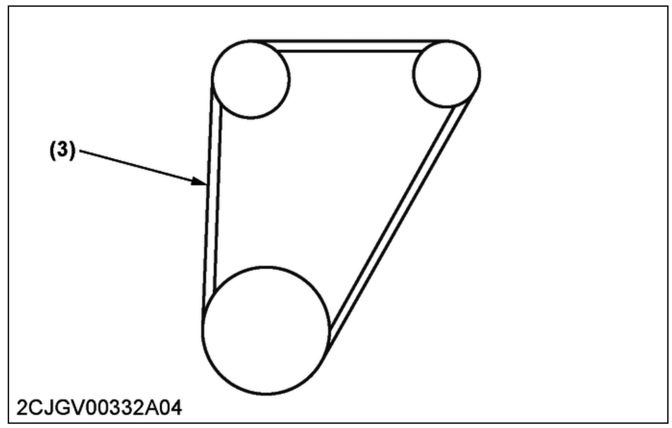
1. Remove the alternator (1).
2. Remove the fan belt (2).



(1) Alternator (2) Fan belt

3. Replace the fan belt (2) with a new one.
4. Install the alternator (1).
5. Adjust the tension of fan belt halfway (3) between the fan drive pulley and fan pulley with sonic belt tension meter.

Sonic belt tension meter setting value	V3800-TIEF4, V3800-TIEF4C	V3800-TIEF4H
Mass (Mass per 1 rib 1 m of belt)	110 g/rib/m	18 g/rib/m
Width (Number of ribs)	1	6
Span (Distance of between the fan drive pulley and alternator pulley)	290 mm 11.4 in.	317 mm 12.5 in.

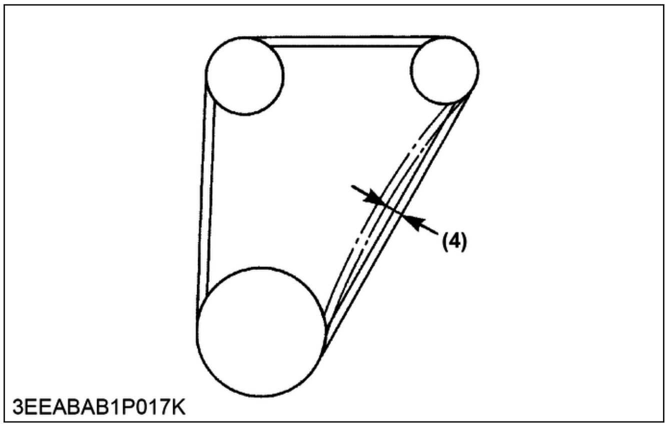


(3) Fan belt halfway

Belt tension (After installing)	Factory specification	V3800-TIEF4 V3800-TIEF4C	441 to 480 N 45.0 to 48.9 kgf 99.2 to 107 lbf
		V3800-TIEF4H	650 to 850 N 66.3 to 86.6 kgf 147 to 191 lbf
Belt tension (After engine operation)	Factory specification	V3800-TIEF4 V3800-TIEF4C	391 to 480 N 39.9 to 48.9 kgf 87.9 to 107 lbf
		V3800-TIEF4H	420 to 550 N 42.9 to 56.0 kgf 94.5 to 123 lbf

(Reference)

a. Push the belt halfway between the fan drive pulley and alternator pulley at a specified force to measure the deflection (4).



(4) Deflection

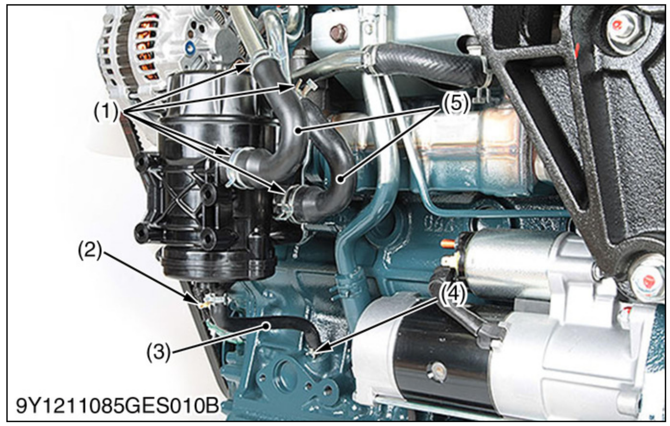
■ **NOTE**

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

Deflection (4)	Factory specification	V3800-TIEF4 V3800-TIEF4C	10 to 12 mm 0.40 to 0.47 in. (under load of 59 to 68 N (6.0 to 7.0 kg, 14 to 15 lbf))
		V3800-TIEF4H	9.0 to 11 mm 0.36 to 0.43 in. (under load of 59 to 68 N (6.0 to 7.0 kg, 14 to 15 lbf))

12.2 Replacing 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.

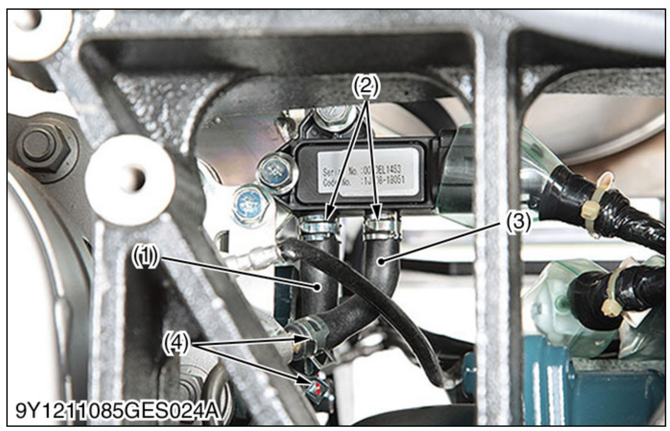


(1) Clamp
(2) Clamp
(3) Rubber hose
(4) Clamp
(5) Rubber hose

3. Tighten the clamp (1), (2), (4) correctly.

12.3 Replacing rubber hose of 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.



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

3. Tighten the clamp (2), (4) correctly.

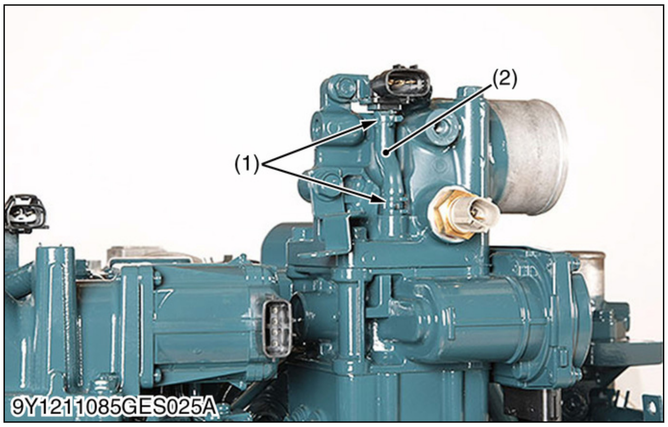
12.4 Replacing intake hose (after air flow sensor) and intercooler hose

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

12.5 Replacing 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.

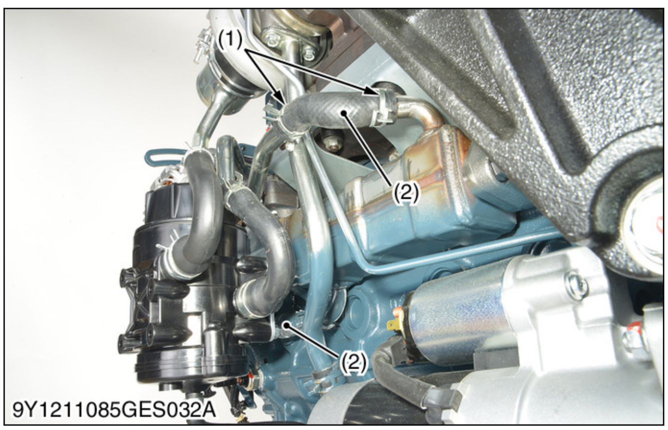


(1) Clamp (2) Hose

3. Tighten the clamp correctly.

12.6 Replacing EGR cooler hose

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



(1) Clamp (2) Hose

3. Tighten the clamp (1) correctly.

12.7 Replacing water hose

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

12.8 Replacing lubricant hose

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

12.9 Changing radiator coolant

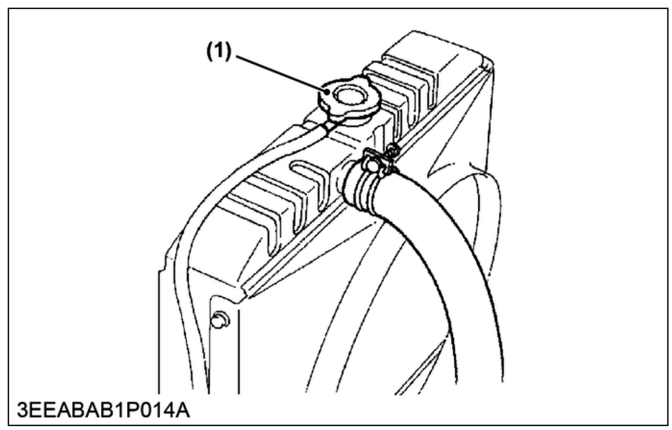
CAUTION

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

■ **IMPORTANT**

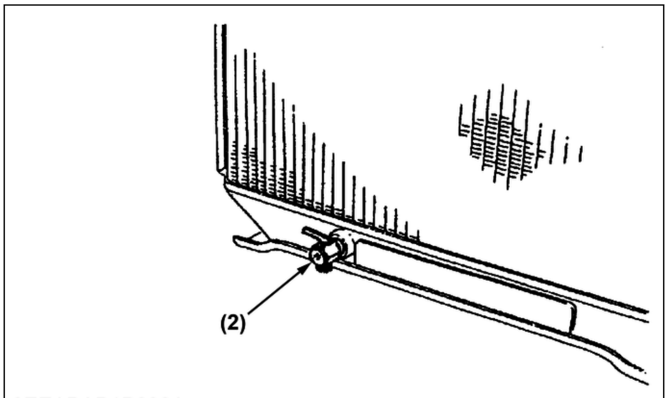
- **Do not start the engine without coolant.**
- **Use clean and soft water with anti-freeze to fill the radiator and reserve tank.**
- **Make sure that when you mix the anti-freeze and water, the ratio of anti-freeze is less than 50%.**
- **Make sure that you close the radiator cap correctly.**
  If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

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

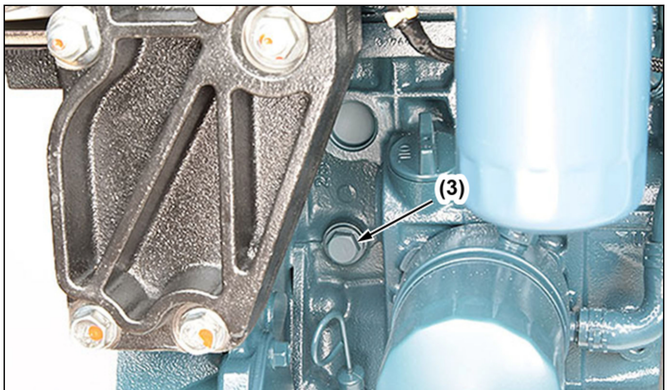


(1) Radiator cap

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



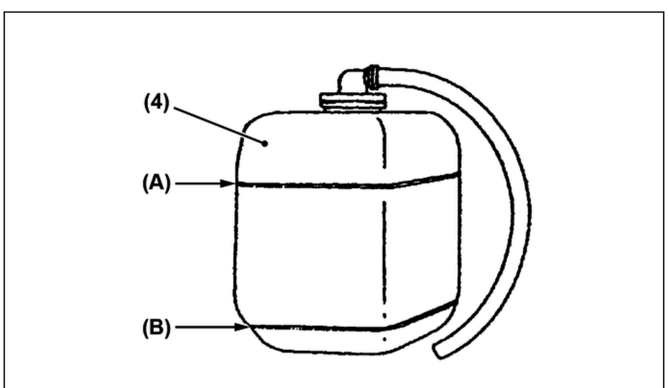
3EEABAB1P032A



9Y1211085GES009A

(2) Drain valve
(3) Drain plug

4. After you drained all coolant, close the drain valve (2) and drain plug (3).
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.
8. Install the radiator cap (1) correctly.
9. Fill with the coolant until the **[FULL]** (A) mark on the reserve tank (4).



3EEABAB1P015C

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

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

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

Anti-freeze

■ **NOTE**

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

■ **IMPORTANT**

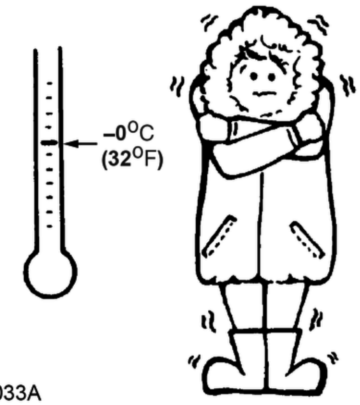
- **Make sure that when you mix the anti-freeze and water, the ratio of anti-freeze is less than 50%.**

Anti-freeze volume	Freezing point		Boiling point*	
	℃	℉	℃	℉
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.



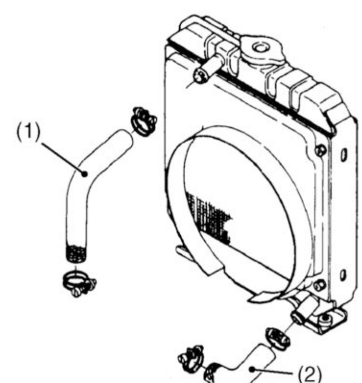
3EEABAB1P033A

12.10 Replacing radiator hose and clamp bands

⚠ CAUTION

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

1. Drain the coolant.
2. Loosen the clamp bands.
3. Remove the upper hose (1) and lower hose (2).



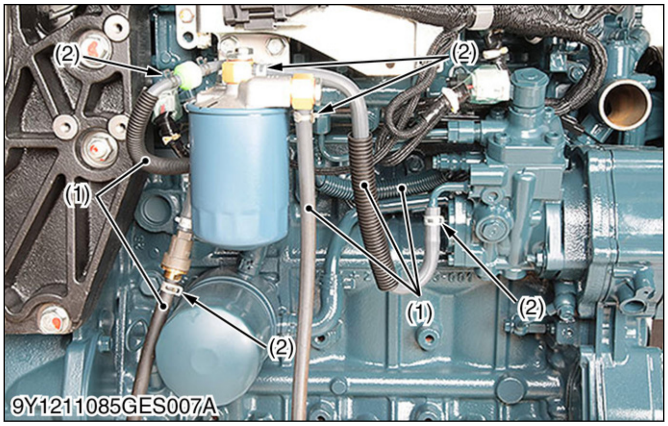
3EEABAB1P022A

(1) Upper hose (2) Lower hose

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

12.11 Replacing fuel hose and clamps

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



(1) Fuel hose (2) Clamp

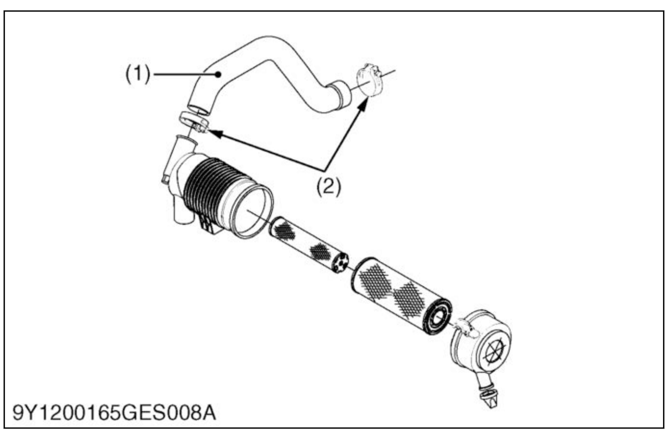
2. Replace the fuel hose (1) and clamp (2) with new ones.
3. Tighten the clamp (2) correctly.
4. After you replace the fuel hose and the clamp, bleed the fuel system.

12.12 Replacing intake air line

IMPORTANT

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

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



(1) Intake air hose (2) Clamp

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

SPECIAL TOOLS

1. Diesel engine compression tester

Use for measuring the diesel engine compression.

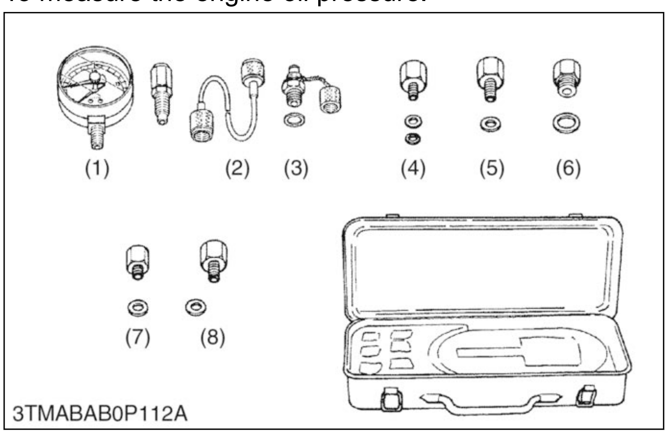
Code No.

07909-30208 (Assembly)

(1) Gauge

2. Oil pressure tester

To measure the engine oil pressure.



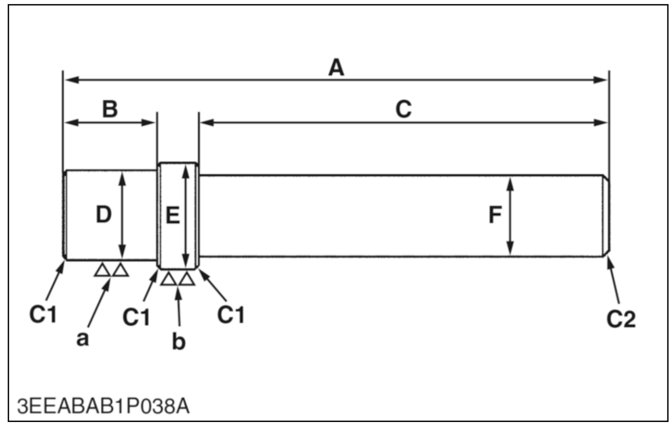
(1) Gauge
(2) Cable
(3) Threaded joint
(4) Adaptor 1
(5) Adaptor 2
(6) Adaptor 3
(7) Adaptor 4
(8) Adaptor 5

3. Small end bushing replacing tool

Use to press out and to press fit the small end.

■ **NOTE**

- **The special tool is not provided, therefore make it by referring to the figure below.**



[Press out]

A	157 mm (6.1811 in.)
B	14.5 mm (0.571 in.)
C	120 mm (4.7244 in.)
D	30.0 mm dia. (1.1811 in. dia.)
E	32.95 mm dia. (1.2972 in. dia.)
F	20 mm dia. (0.7874 in. dia.)
a	6.3 μm (0.00025 in.)
b	6.3 μm (0.00025 in.)
C1	Chamfer 1.0 mm (0.039 in.)
C2	Chamfer 2.0 mm (0.079 in.)

[Press fit]

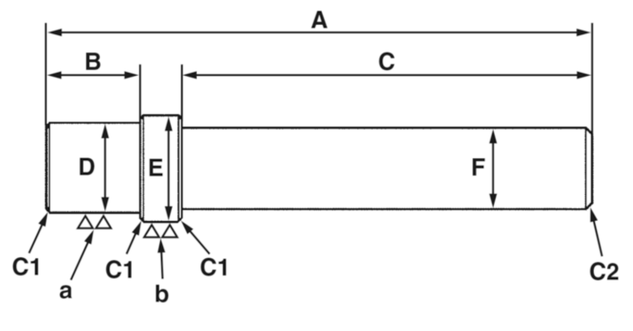
A	157 mm (6.1811 in.)
B	14.5 mm (0.571 in.)
C	120 mm (4.7244 n.)
D	30.0 mm dia. (1.1811 in. dia.)
E	42.000 mm dia. (1.6535 in. dia.)
F	20 mm dia. (0.7874 in. dia.)
a	6.3 μm (0.00025 in.)
b	6.3 μm (0.00025 in.)
C1	Chamfer 1.0 mm (0.039 in.)
C2	Chamfer 2.0 mm (0.079 in.)

4. Idle gear bushing replacing tool

Use to press out and to press fit the bushing.

■ **NOTE**

- **The special tool is not provided, therefore make it by referring to the figure below.**



3EEABAB1P038A

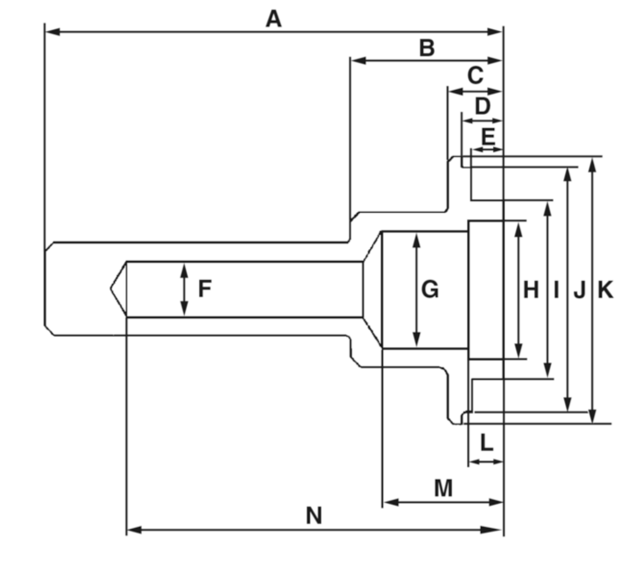
A	196 mm (7.7165 in.)
B	37.5 mm (1.476 in.)
C	150 mm (5.9055 in.)
D	44.95 mm dia. (1.7697 in. dia.)
E	48.075 to 48.100 mm dia. (1.8927 to 1.8937 in. dia.)
F	20 mm dia. (0.7874 in. dia.)
a	6.3 μm (0.00025 in.)
b	6.3 μm (0.00025 in.)
C1	Chamfer 1.0 mm (0.039 in.)
C2	Chamfer 2.0 mm (0.079 in.)

5. Gear case oil seal press fit tool

To press fit the oil seal.

■ **NOTE**

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



3EEABAB1P040A

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.)

6. Valve guide replacing tool

To press out and press fit the valve guide.

■ **NOTE**

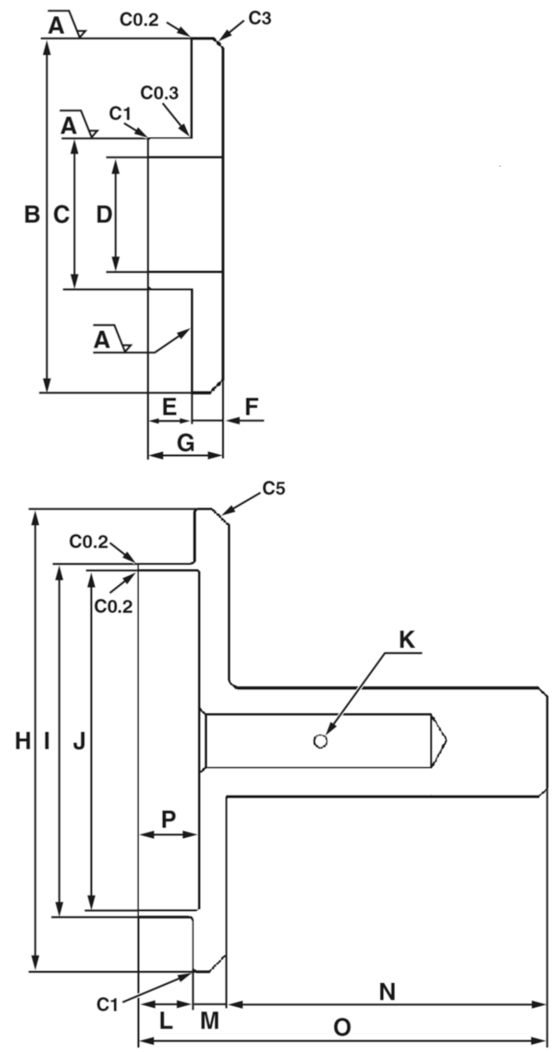
- **The special tool is not provided, therefore make it by referring to the figure below.**

7. Crankshaft sleeve press fit tool

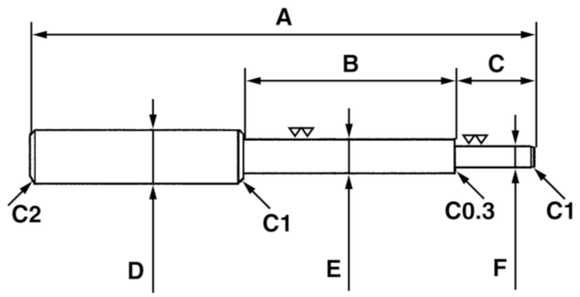
To press fit the crankshaft sleeve.

■ **NOTE**

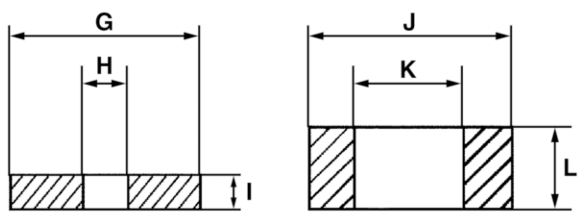
- **The special tool is not provided, therefore make it by referring to the figure below.**



3EEABAB1P041A



3TMABAB0P063B



3TMABAB0P064B

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.)

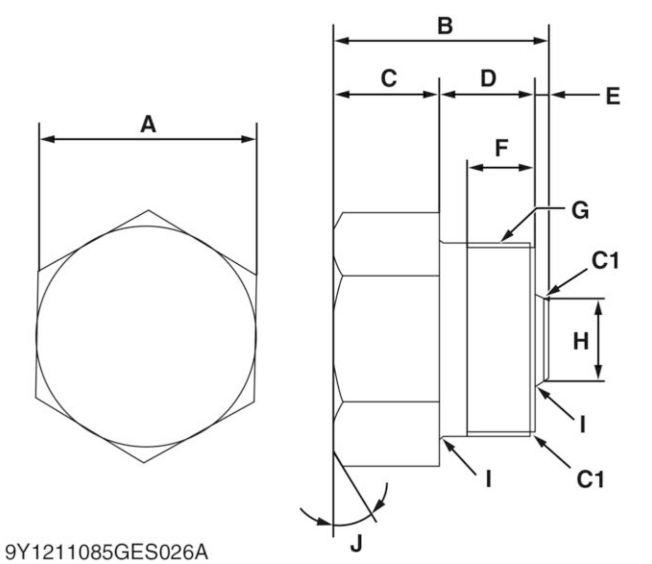
A	Rmax = 12.5 S
B	94.5 to 95.0 mm dia. (3.72 to 3.74 in. dia.)
C	40 mm dia. (1.6 in. dia.)
D	30 mm dia. (1.2 in. dia.)
E	12 mm (0.47 in.)
F	7.90 to 8.10 mm (0.311 to 0.318 in.)
G	20 mm (0.79 in.)
H	130 mm dia. (5.12 in. dia.)
I	99.40 to 99.60 mm dia. (3.914 to 3.921 in. dia.)
J	95.05 to 95.20 mm dia. (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.)

8. Supply pump gear puller

To remove the injection pump gear.

■ **NOTE**

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



9Y1211085GES026A

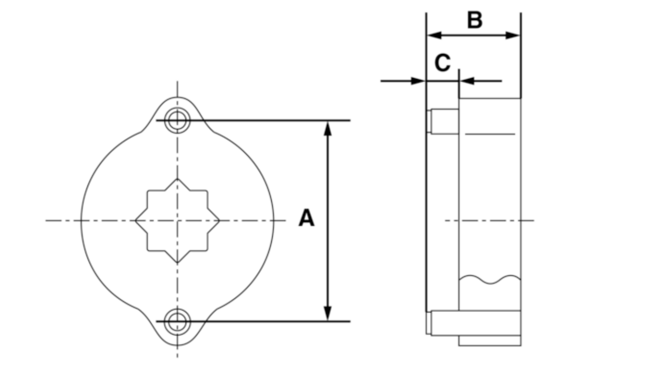
A	41 mm (1.6 in.)
B	40.5 mm (1.59 in.)
C	20 mm (0.79 in.)
D	18 mm (0.71 in.)
E	2.5 mm (0.098 in.)
F	13 mm (0.51 in.)
G	M36 × Pitch 1.5
H	16 mm dia. (0.63 in. dia.)
I	1 mm radius (0.04 in. radius)
J	0.52 rad (30°)
C1	Chamfer 1.0 mm (0.039 in.)

9. Supply pump gear reinstall jig

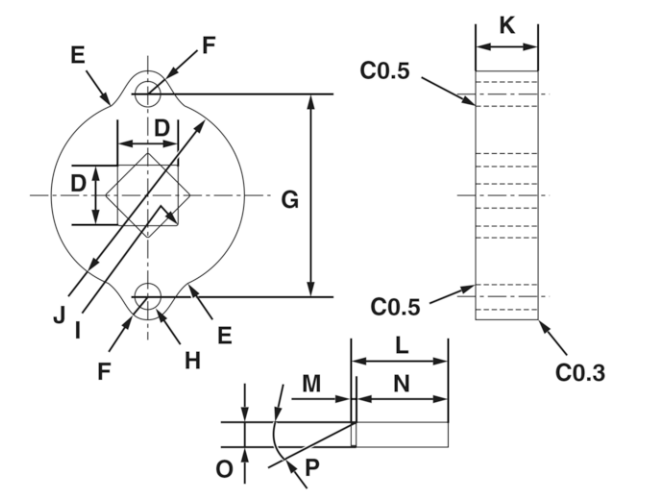
To remove the injection pump gear.

■ **NOTE**

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



9Y1211085GES028A



9Y1211085GES029A

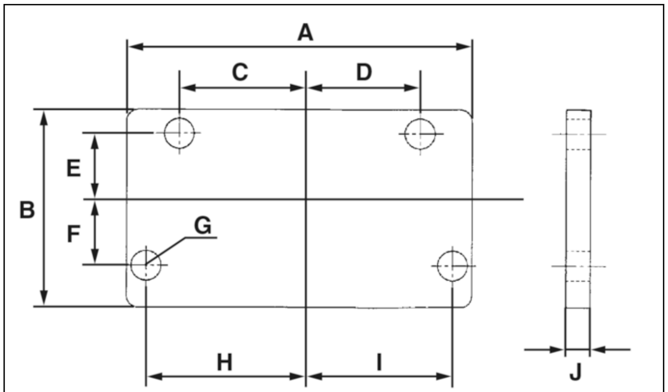
A	43.95 to 44.05 mm (1.731 to 1.734 in.)
B	21 mm (0.83 in.)
C	8 mm (0.3 in.)
D	12.9 to 13.1 mm square (0.508 to 0.515 in. square)
E	10 mm radius (0.39 in. radius)
F	5 mm radius (0.2 in. radius)
G	43.95 to 44.05 mm (1.731 to 1.734 in.)
H	5.240 to 5.255 mm dia. (0.2063 to 0.2068 in. dia.)
I	0.4 mm radius (0.02 in. radius)
J	42 mm (1.7 in.)
K	13 mm (0.51 in.)
L	21 mm (0.83 in.)
M	1 mm (0.04 in.)
N	20 mm (0.79 in.)
O	5.265 to 5.275 mm dia. (0.2073 to 0.2076 in. dia.)
P	0.52 rad (30°)
C0.3	Chamfer 0.3 mm (0.01 in.)
C0.5	Chamfer 0.5 mm (0.02 in.)

10. Flywheel stopper

To loosen and tighten the flywheel screw.

■ **NOTE**

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



3EEABAB1P043A

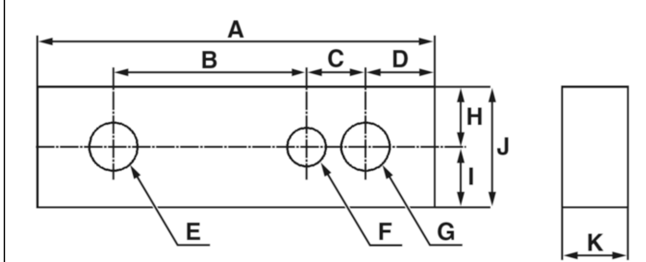
A	140 mm (5.51 in.)
B	80 mm (3.1 in.)
C	49.3 mm (1.94 in.)
D	49.3 mm (1.94 in.)
E	23.8 mm (0.937 in.)
F	23.8 mm (0.937 in.)
G	11 mm dia. (0.43 in. dia.)
H	56.5 mm (2.22 in.)
I	56.5 mm (2.22 in.)
J	8 mm (0.3 in.)

11. Crankcase 1 and 2 aligning tool

To aligning the crankcase 1 and 2.

■ **NOTE**

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



3EEABAC1P115A

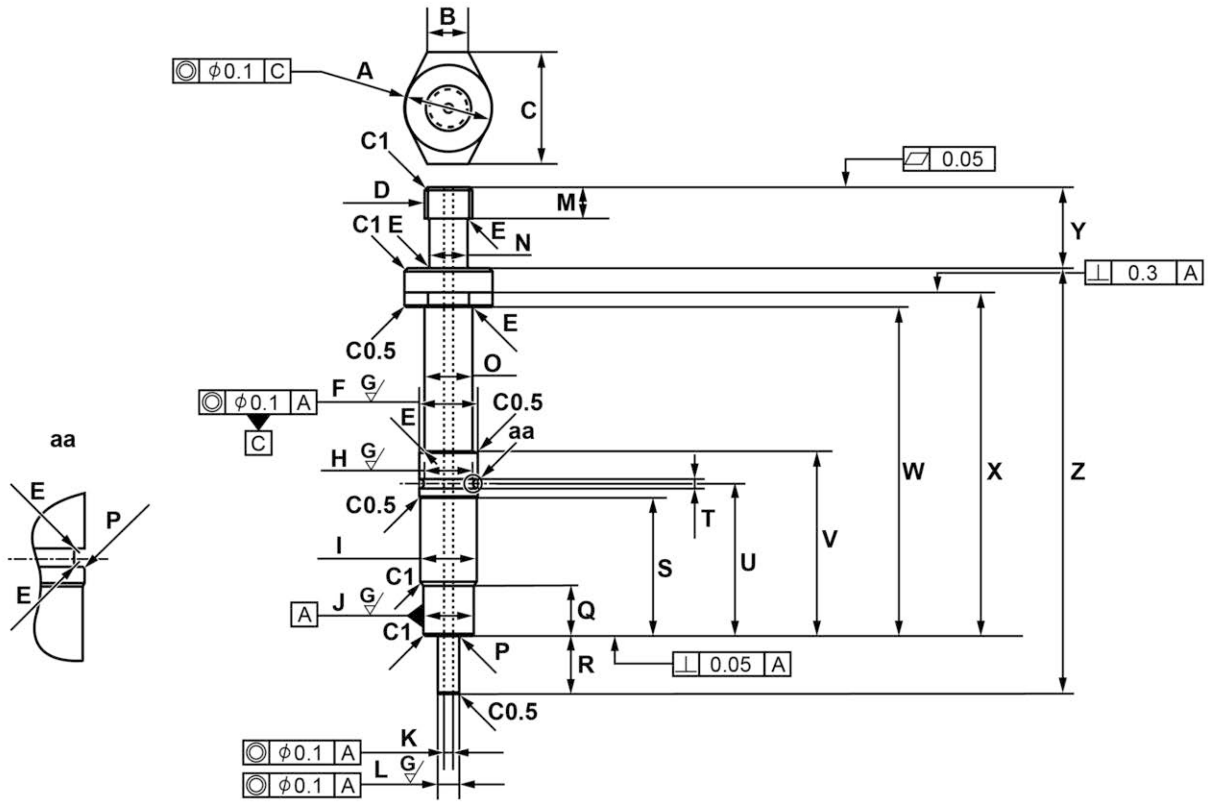
A	115 mm (4.53 in.)
B	56 mm (2.2 in.)
C	17 mm (0.67 in.)
D	20 mm (0.79 in.)
E	14 mm dia. (0.55 in. dia.)
F	11 mm dia. (0.43 in. dia.)
G	14 mm dia. (0.55 in. dia.)
H	17.5 mm (0.689 in.)
I	17.5 mm (0.689 in.)
J	35 mm (1.4 in.)
K	19 mm (0.75 in.)

12. Compression tester adaptor

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

NOTE

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



9Y1210682GES001A

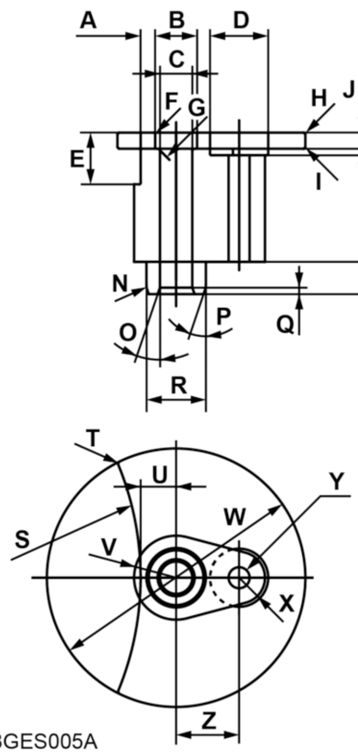
A	29.80 to 30.00 mm dia. (1.174 to 1.181 in. dia.)
B	14 mm (0.55 in.)
C	39.2 to 40.2 mm (1.55 to 1.58 in.)
D	5/8-18UNF-2B
E	0.8 mm radius (0.03 in. radius)
F	19.84 to 19.95 mm (0.7811 to 0.7854 in.)
G	Ra = 3.2a
H	16.14 to 16.20 mm (0.6355 to 0.6377 in.)
I	19.08 to 19.20 mm (0.7512 to 0.7559 in.)
J	16.89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

13. Air gap of the crankshaft position sensor measuring jig 1

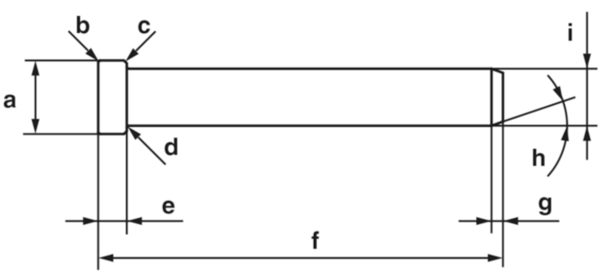
To measure the air gap of the crankshaft position sensor.

■ **NOTE**

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



9Y1210478GES005A



9Y1210478GES006A

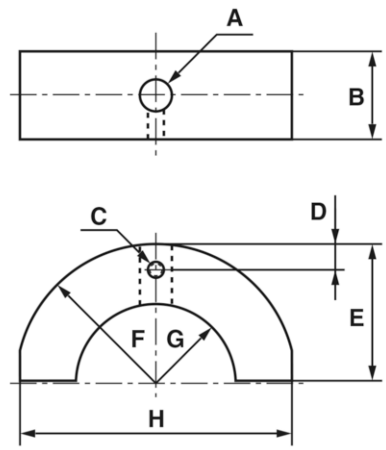
A	92 mm radius (3.6 in. radius)
B	13.0 to 13.1 mm dia. (0.512 to 0.515 in. dia.)
C	10.000 to 10.015 mm dia. (0.39370 to 0.39429 in. dia.)
D	18 mm dia. (0.71 in. dia.)
E	16 mm (0.63 in.)
F	Chamfer 0.3 mm (0.01 in.)
G	Chamfer 0.5 mm (0.02 in.)
H	Chamfer 0.5 mm (0.02 in.)
I	Chamfer 0.5 mm (0.02 in.)
J	5.00 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.)

14. Air gap of the crankshaft position sensor measuring jig 2

To measure the air gap of the crankshaft position sensor.

■ **NOTE**

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



9Y1210478GES007A

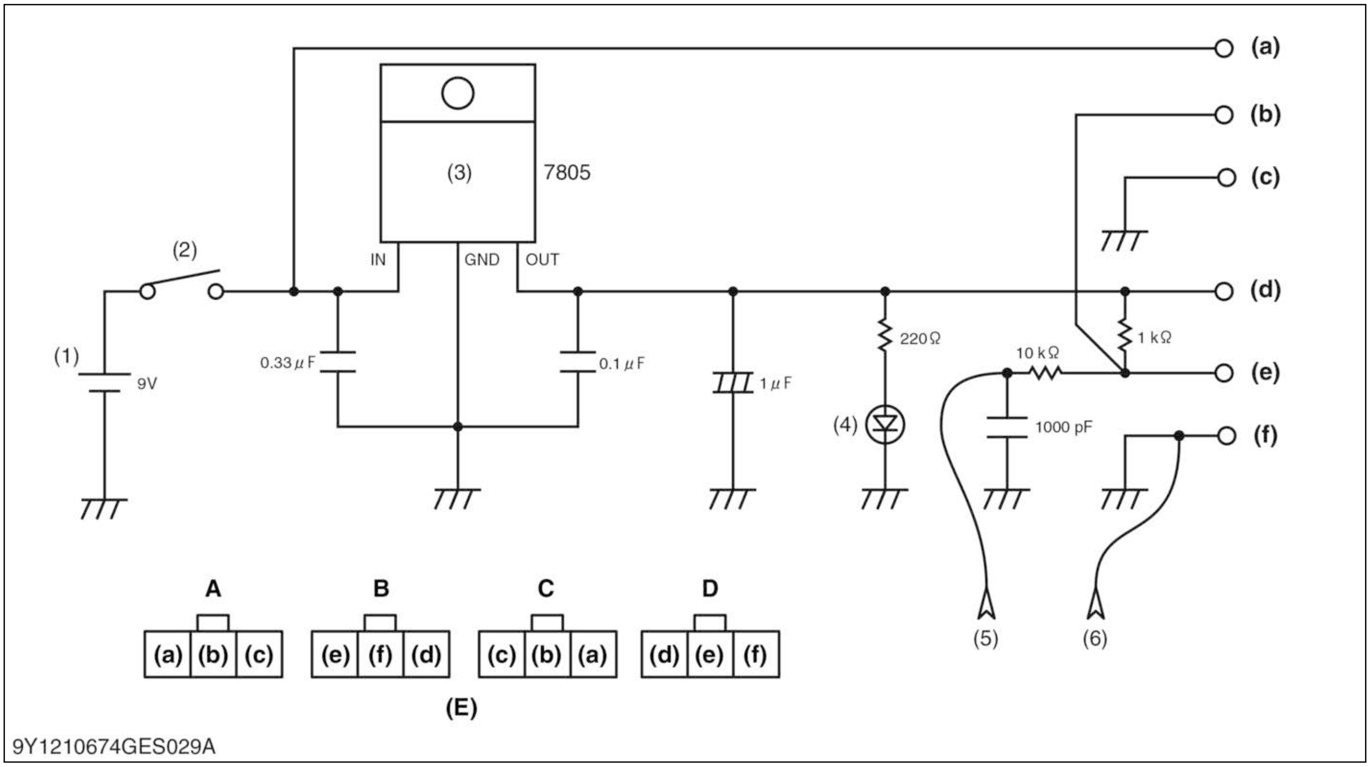
A	8.0 mm dia. reamer (0.31 in. dia. reamer)
B	22.0 mm (0.866 in.)
C	M4 × Pitch 0.7
D	6.5 mm (0.26 in.)
E	34.0 mm (1.34 in.)
F	35 mm radius (1.4 in. radius)
G	20 mm radius (0.79 in. radius)
H	68.0 mm (2.68 in.)

15. Rotation sensor signal interface unit

Use for reading rotation sensor signal.

■ **NOTE**

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



(1) 9 V battery	(6) Clip (Black)	(E) Connector side	(e) Signal
(2) Switch	A: for Panasonic	(a) +9 V	(f) GND
(3) 3-terminal regulator	B: for DENSO	(b) Signal	
(4) LED	C: for BOSCH cam angle	(c) GND	
(5) Clip (Red)	D: for BOSCH crank angle	(d) +5 V	

3. ENGINE

MECHANISM

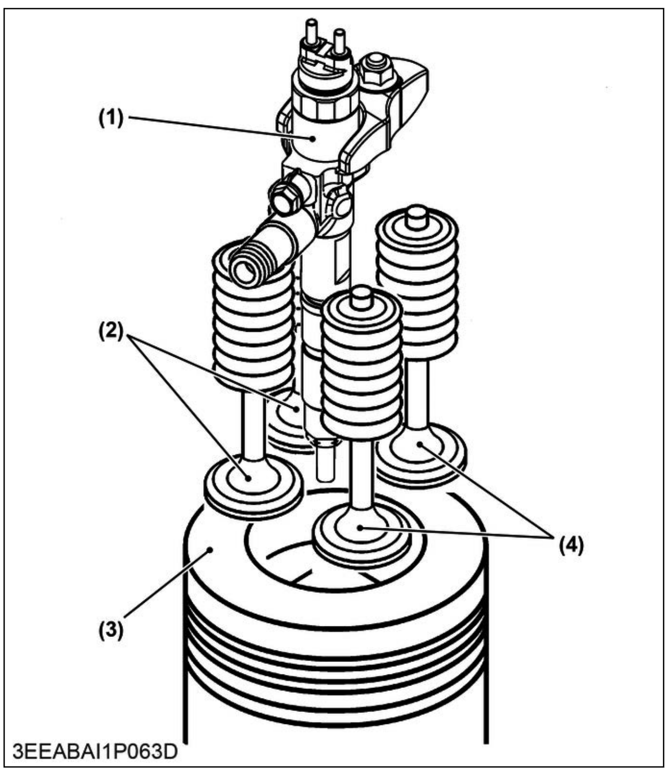
1. General (Introduction)

1.1 Feature of combustion (E-CDIS)

This model utilizes a structure called E-CDIS where injectors are arranged on the centerline of pistons. (E-CDIS: Center Direct Injection System)
With this system fuel is injected directly to the center of the top of the piston.
The combustion chamber at the top of the piston is a reentrant type so fuel and intake air form a swirl and mix uniformly.
This effect enables a stable and high efficiency combustion.

1.2 Structure of combustion (Center direct injection system (E-CDIS))

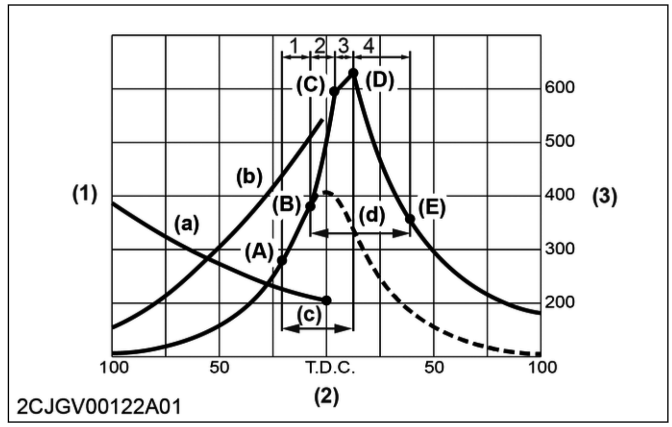
The combustion system is made up of the injectors and pistons and the like.



(1) Injector
(2) Exhaust valve
(3) Piston
(4) Intake valve

1.3 Flow of combustion (E-CDIS)

Combustion flow is separated into 4 processes.



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

1. Ignition delay period
   The ignition delay period is the period from when fuel is injected into the cylinder as a mist until start of combustion is attempted.
   Fuel that injected into the cylinder at the high temperature high pressure compressed air through several degrees before compression top dead center is vaporized by heat of air.
   Thereafter, the fuel mixes with air nearing ignition point (B point) and ignites.
2. Flame propagation period
   The gas mixture accumulated in the ignition delay period ignites at B point and rapidly combusts instantly raising the pressure and temperature in the cylinder.
3. Direct combustion period
   Fuel continues to be injected even after passing point C but the fuel combusts immediately due to the ignition that took place between B and C.
   This continues through the point (point D) where injection stops and here pressure rise is relatively slow.
4. Late combustion period
   After fuel injection stops, combustion continues for a short period burning the remaining fuel.
   This period is called late combustion period and this period should be as short as possible.

If this is extended, exhaust temperature rises causing thermal losses to increase accordingly.

1.4 Control of combustion (E-CDIS)

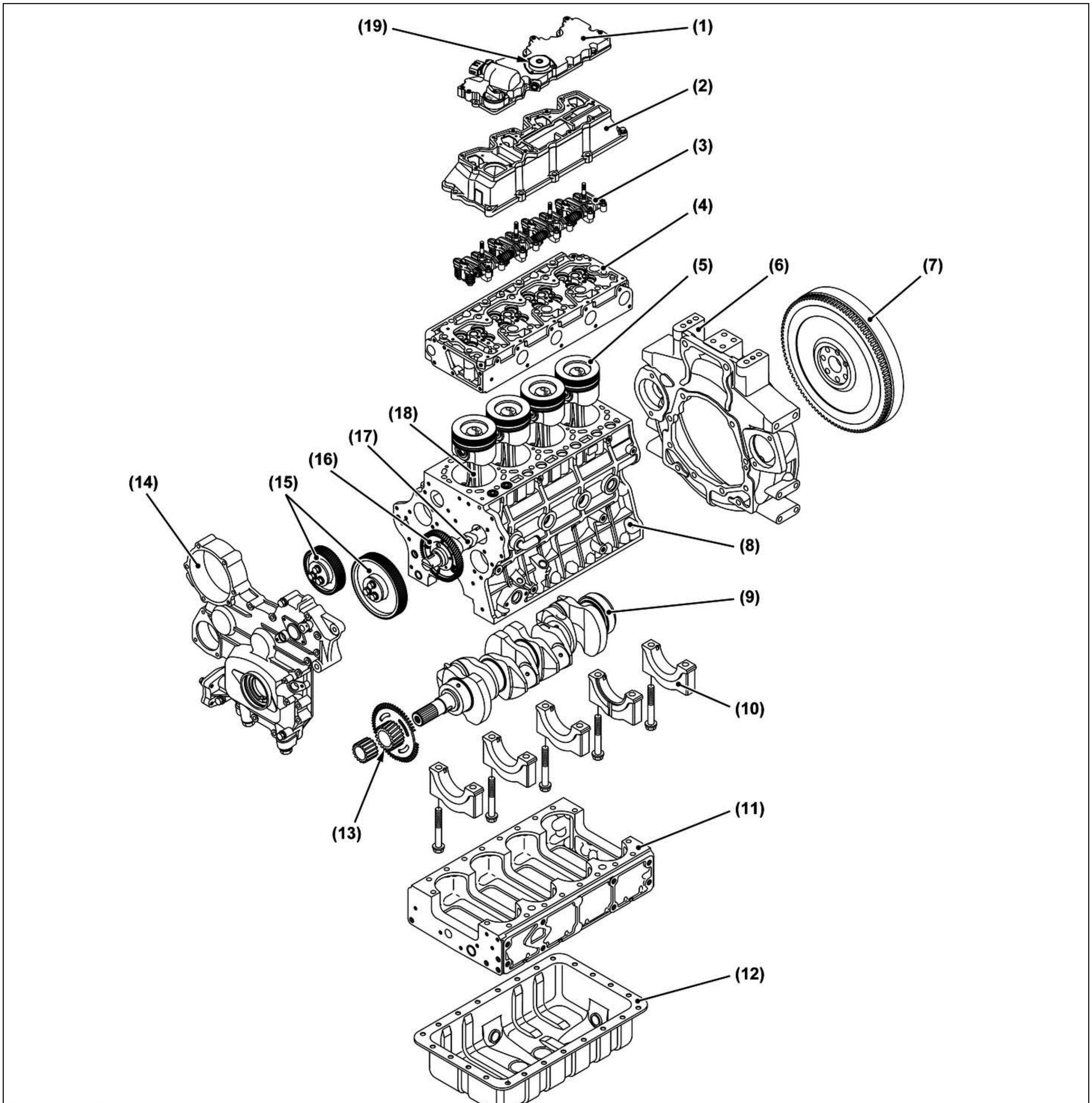
Combustion control consists of fuel injection volume control, fuel injection timing control, fuel injection rate control, and fuel pressure control.
See the CRS section for details.

RELATED PAGE
3.4 Control of common rail system (CRS) engine on page 3-17

2. Engine body

2.1 Structure of engine body

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



(1) Cylinder head cover 1
(2) Cylinder head cover 2
(3) Rocker arm
(4) Cylinder head
(5) Piston
(6) Flywheel housing
(7) Flywheel
(8) Crank case 1
(9) Crankshaft
(10) Main bearing case
(11) Crank case 2
(12) Oil pan
(13) Crank gear
(14) Gear case
(15) Idle gears
(16) Cam gear
(17) Camshaft
(18) Connecting rod
(19) Breather

2.2 Feature of engine body

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

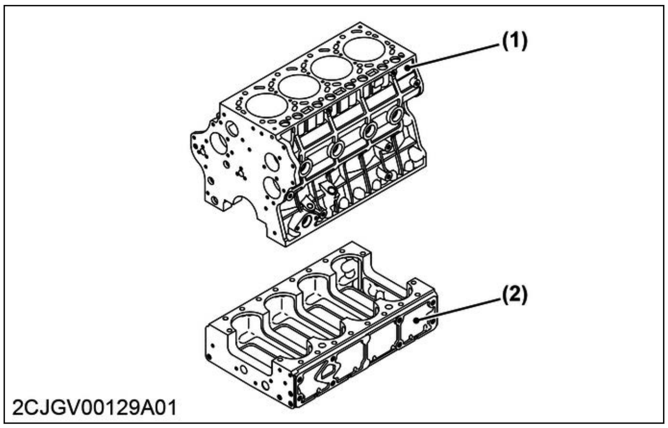
2.3 Crankcase

2.3.1 Outline of crankcase

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

2.3.2 Structure of crankcase

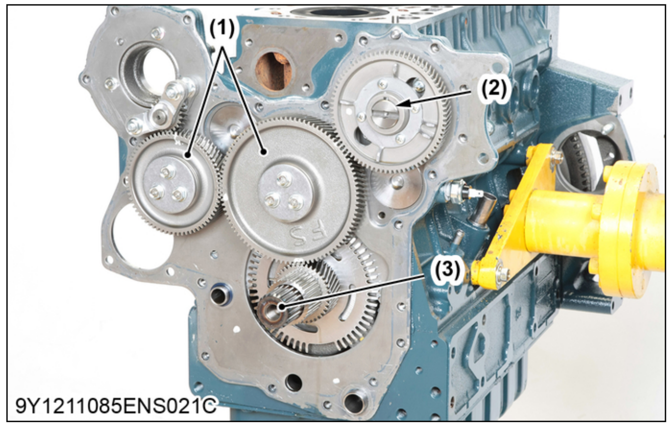
The crankcase is made up of crankcase 1 and 2.



(1) Crankcase 1 (2) Crankcase 2

2.3.3 Function of crankcase

The crankcase has cylinders inside and supports the crankshaft and camshaft.
Further, it has an internal water jacket and oil passageways to cool the cylinders.
A hanger type crankcase improves cooling performance.
Further, it also improves resistance to wear due to slight deformation.
Mounting of crankcase 2 to crankcase 1 raises the rigidity as well as reduces the noise level.



(1) Idle gear
(2) Camshaft
(3) Crankshaft

2.3.4 Specification of crankcase

Cylinder liner diameter (D)	100.000 to 100.022 mm 3.93701 to 3.93787 in.
Finish machining	Honing (1.5 to 3.0 μmRz)
Oversize	+0.5 mm +0.02 in.

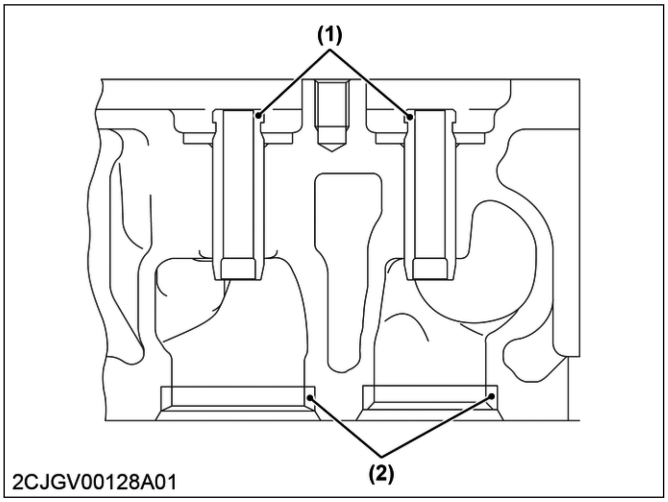
2.4 Cylinder head

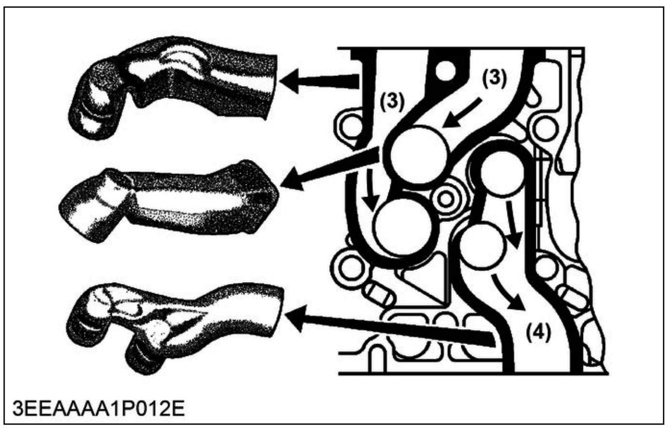
2.4.1 Outline of cylinder head

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

2.4.1.1 Structure of cylinder head

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





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

2.4.2 Function of cylinder head

1. Along with the crankcase, the cylinder head is the most fundamental part that makes up the engine forming the combustion chamber along with the crankcase and piston.
2. It also makes up the intake air path (intake port) and exhaust gases path (exhaust port).
   Using a helical structure on the intake integrates more air and mixes fuel with the air.
   Use of two valves on the exhaust side quickly expels the exhaust gases.
3. A passageway for cooling water (water jacket) is provided to suppress rise in temperature of the engine.
4. A passageway to allow oil to flow used for the valve train is provided in the upper part of the cylinder head.

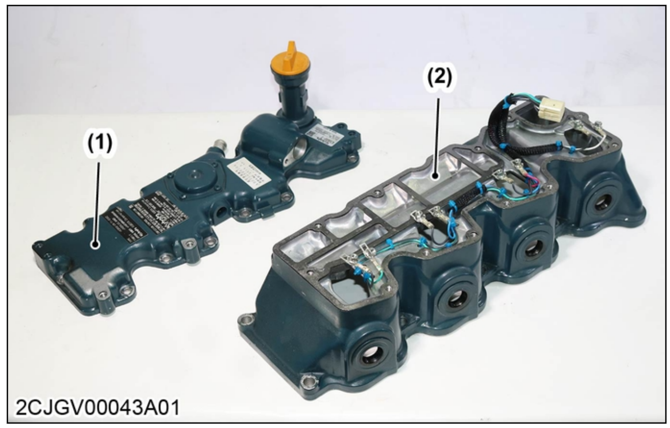
2.5 Cylinder head cover

2.5.1 Outline of cylinder head cover

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

2.5.2 Structure of cylinder head cover

The cylinder head cover is made up of the cylinder head covers 1 and 2.



(1) Cylinder head cover 2
(2) Cylinder head cover 1

2.5.3 Function of cylinder head cover

The primary function of the cylinder head cover is to prevent scattering of lubricating oil from the valve train.
Further, another function is to suppress noise emissions.
Furthermore, the interior side of the cylinder head cover is provided with a structure in the passage blow-by gas flows in for liquifying oil enabling the oil to stay within the head cover.
The cylinder head cover is separable to protect the injector harness from oil.
The half float type cylinder head cover reduces noise from the cylinder head.

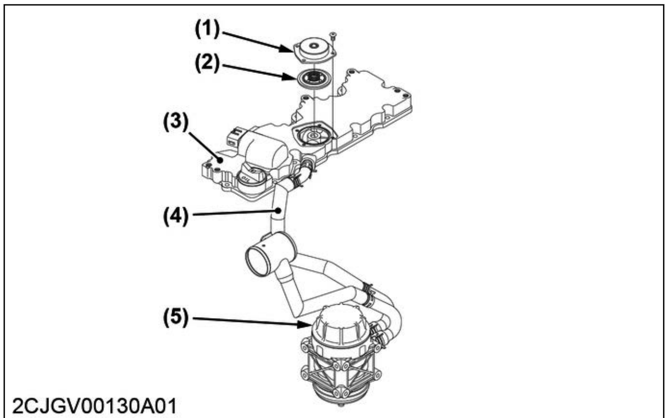
2.6 Breather

2.6.1 Outline of breather

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

2.6.2 Structure of breather

The breather is made up of a breather valve, diaphragm, and breather pipe.



(1) Breather valve
(2) Diaphragm
(3) Cylinder head cover 2
(4) Breather pipe
(5) Oil separator

2.6.3 Function of breather

The breather releases blow-by gases generated during the combustion stroke.
The breather is provided with a diaphragm type valve and mitigates pressure changes in the crankcase.

2.6.4 Specification of breather

Valve opening pressure	5.0 to 25 mmAq 0.049 to 0.24 kPa 0.00050 to 0.0025 kgf/cm^2

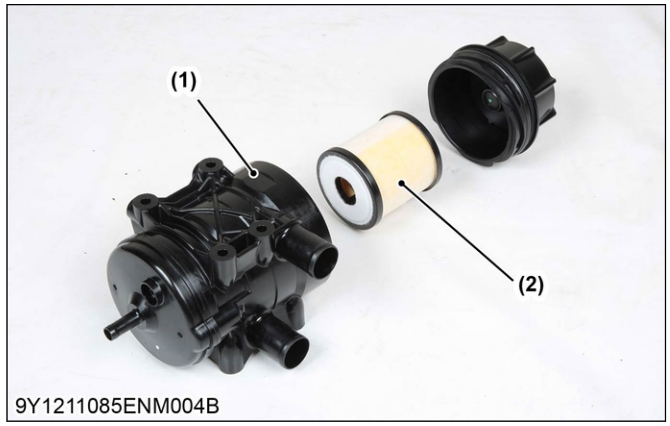
2.7 Oil separator

2.7.1 Outline of oil separator

The oil separator separates oil and gases in the blow-by gases.
Separated oil is returned to the oil pan.
The gas is fed to the intake side hose and re-combusted.

2.7.2 Structure of oil separator

The oil separator is made up of a separator body and element.



(1) Separator body
(2) Element

2.7.3 Function of oil separator

The oil separator separates oil and gases in the blow-by gases.
Part that returns oil to the oil pan.
The blow-by gas that escapes from the crankcase is separated into oil and gases when it passes through the element in the oil separator.
Separated oil is returned to the oil pan and the blow-by gas is fed to the intake side hose.
The gas fed to the intake hose is re-combusted.

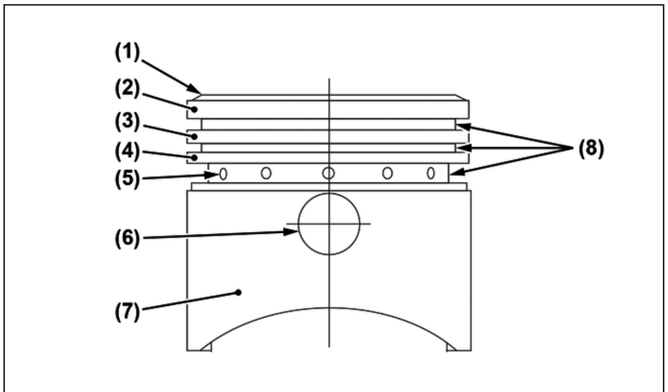
2.8 Piston

2.8.1 Outline of piston

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

2.8.2 Structure of piston

The piston is a re-entrant shape.
The piston skirt has a molybdenum coating.



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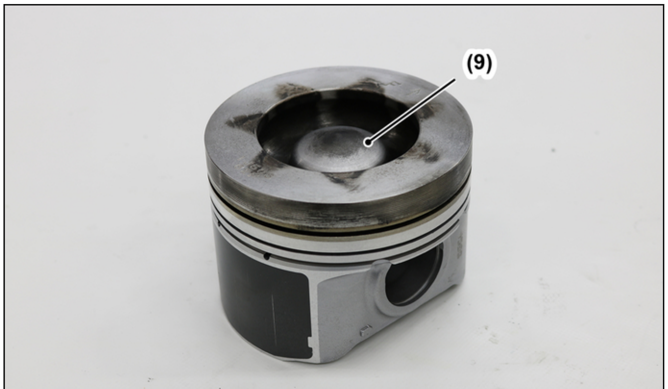

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(1) Piston head
(2) Top land
(3) Second land
(4) Third land
(5) Oil return hole
(6) Piston pin hole
(7) Piston skirt
(8) Ring groove
(9) Piston profile (re-entrant shape)

2.8.3 Function of piston

Along with the cylinder and cylinder head, the piston forms the combustion chamber.
In addition, it reciprocates in the cylinder during each of the intake, compression, combustion, and exhaust strokes.
The first and primary role is to receive explosive energy during combustion and transfer this to the crankshaft via the connecting rod.
The piston surface is formed to provide swirl that simplifies combustion of fuel injected from the injector.
Piston's skirt is coated with molybdenum disulfide, which reduces the piston slap noise and thus the entire operating noise.
Molybdenum disulfide (MoS_2)
The molybdenum disulfide serves as a solid lubricant, like a Graphite or Teflon.
This material helps resist metal wears even with little lube oil.

2.8.4 Specification of piston

Piston diameter (D)	100 mm 3.94 in.
Oversize	+0.5 mm +0.02 in.

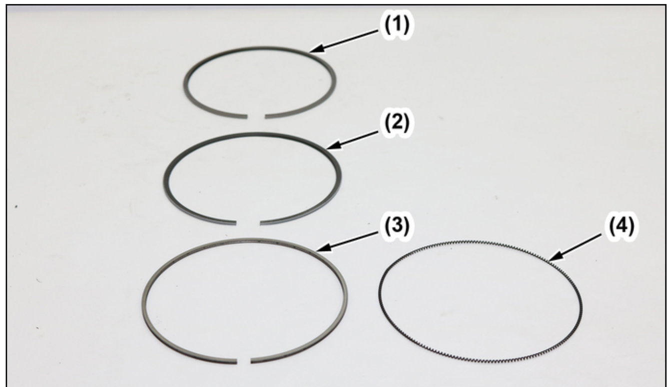
2.9 Piston ring

2.9.1 Outline of piston ring

Piston rings primarily maintain air tightness of the combustion chamber.

2.9.2 Structure of piston ring

The piston rings are top ring (barrel face), second ring (taper face), and oil ring.



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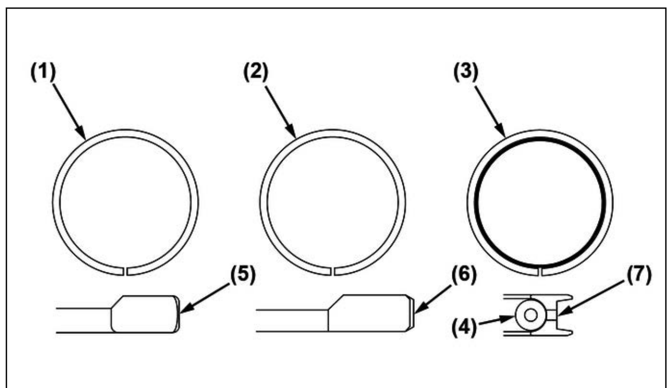

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(1) Top ring
(2) Second ring
(3) Oil ring
(4) Expander
(5) Inner bevel (barrel face) type
(6) Inner bevel (taper face) type
(7) Bevel cutter type

2.9.3 Function of piston ring

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

2.9.4 Specification of piston ring

Factory specification of piston ring gap	Top ring		0.30 to 0.40 mm 0.012 to 0.015 in.
	Second ring	V3800-TIEF4 V3800-TIEF4C	0.45 to 0.60 mm 0.018 to 0.023 in.
		V3800-TIEF4H	0.30 to 0.40 mm 0.012 to 0.015 in.
	Oil ring		0.25 to 0.45 mm 0.0099 to 0.017 in.

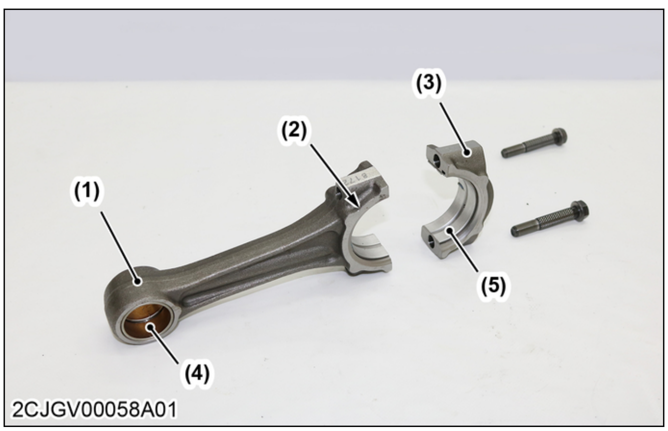
2.10 Connecting rod

2.10.1 Outline of connecting rod

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

2.10.2 Structure of connecting rod

The connecting rod is made up of a connecting rod cap and connecting rod etc.



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

2.10.3 Function of connecting rod

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

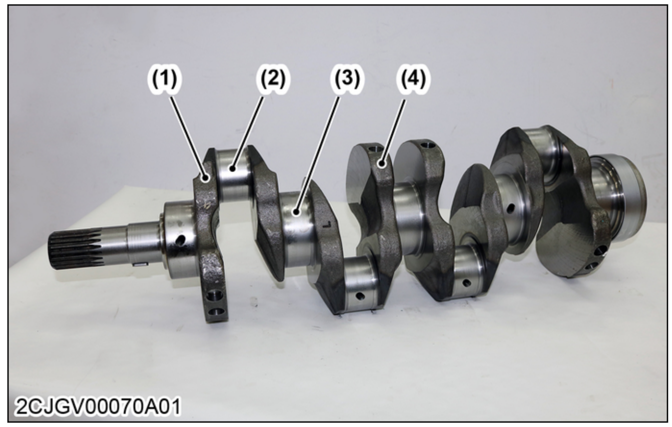
2.11 Crankshaft

2.11.1 Outline of crankshaft

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

2.11.2 Structure of crankshaft

The crankshaft is formed with the crank arms and crank pins integrated.



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

2.11.3 Function of crankshaft

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

2.11.4 Specification of crankshaft

Crank pin (undersize)	0.20 mm 0.0079 in.
	0.40 mm 0.016 in.
Crankshaft journal (undersize)	0.20 mm 0.0079 in.
	0.40 mm 0.016 in.

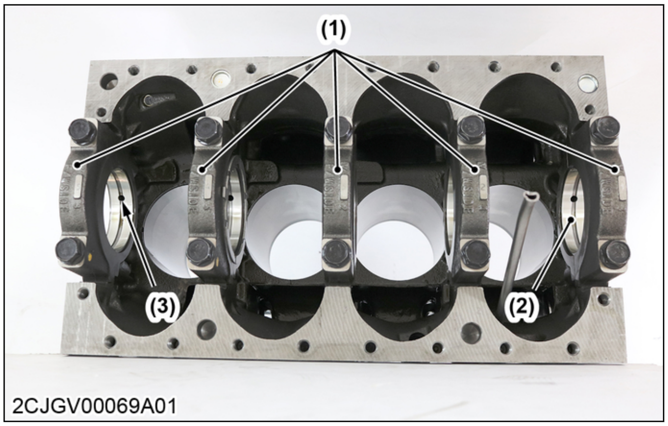
2.12 Main bearing case

2.12.1 Outline of main bearing case

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

2.12.2 Structure of main bearing case

The main bearing case is mounted in the bottom of the crankcase and holds the crankshaft.



(1) Main bearing case
(2) Bearing metal
(3) Oil hole

2.12.3 Function of main bearing case

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

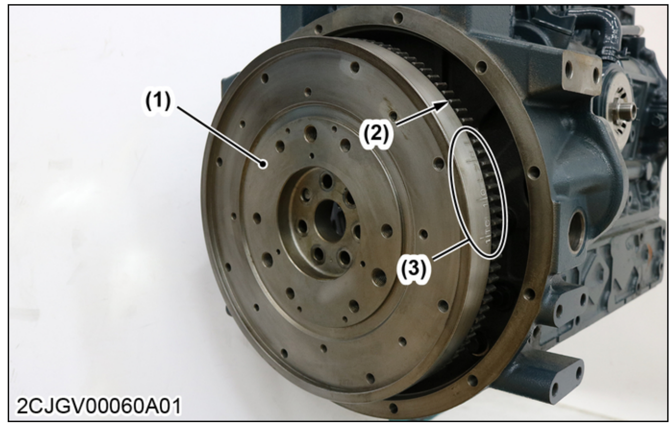
2.13 Flywheel

2.13.1 Outline of flywheel

The flywheel transfers power generated in the engine externally.

2.13.2 Structure of flywheel

The flywheel is made up of the flywheel and ring gear.



(1) Flywheel
(2) Ring gear
(3) TC mark

2.13.3 Function of flywheel

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

2.13.4 Specification of flywheel

(Reference value)

Flywheel diameter	335 mm 13.2 in.

*This value is for STD engine so that it may be different depending on the product used

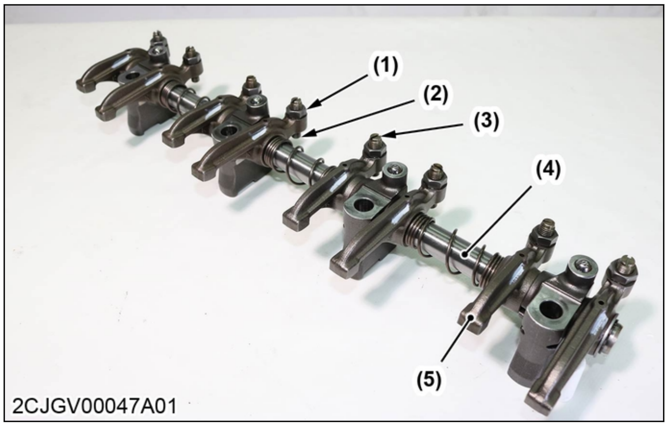
2.14 Rocker arm

2.14.1 Outline of rocker arm

Rocker arms transfer camshaft movement to valves via push rods.

2.14.2 Structure of rocker arm

Rocker arms are made up of arms, rocker arm shafts, and adjustment screws etc.



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

2.14.3 Function of rocker arm

When one end of a rocker arm is pushed up by a push rod, the rocker arm rotates centered on the rocker arm shaft and the other end pushes open a valve.

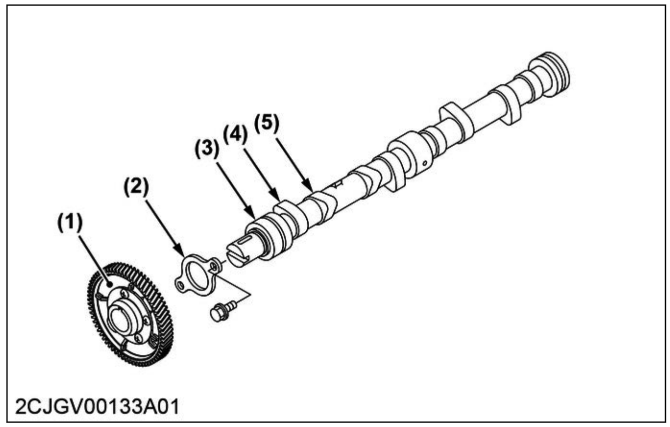
2.15 Camshaft

2.15.1 Outline of camshaft

The camshaft determines the intake and exhaust valve timing.

2.15.2 Structure of camshaft

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



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

2.15.3 Function of camshaft

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

2.15.4 Specification of camshaft

Intake valve timing	Open angle	0.24 rad (14°) before T.D.C.
	Close angle	0.63 rad (36°) after B.D.C.
Exhaust valve timing	Open angle	0.79 rad (45°) before B.D.C.
	Close angle	0.30 rad (17°) after T.D.C.

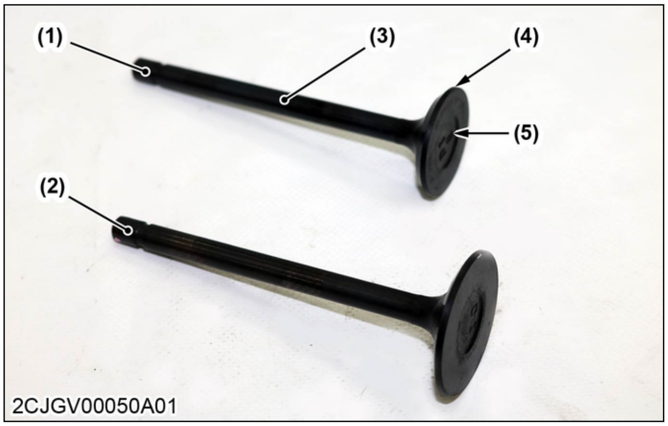
2.16 Valve

2.16.1 Outline of valve

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

2.16.2 Structure of valve

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



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

2.16.3 Function of valve

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

Intake valve

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

Exhaust valve

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

2.16.4 Specification of valve

Intake valve head diameter	35 mm 1.4 in.
Exhaust valve head diameter	30 mm 1.2 in.
Valve clearance	0.23 to 0.27 mm 0.0091 to 0.010 in.

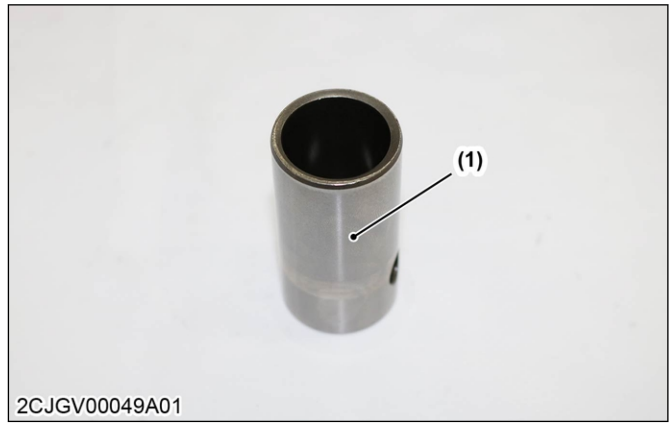
2.17 Tappet

2.17.1 Outline of tappet

The tappet converts cam rotation into linear reciprocating motion.

2.17.2 Structure of tappet

The tappet receives the push rod with an push rod seat.



(1) Tappet

2.17.3 Function of tappet

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

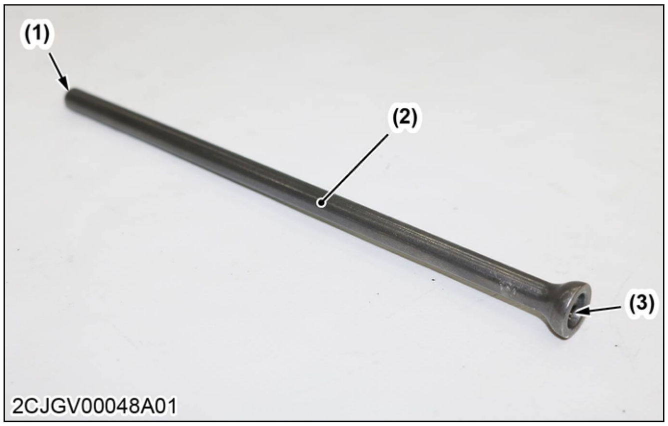
2.18 Push rod

2.18.1 Outline of push rod

The push rod transfers tappet movement to the rocker arm.

2.18.2 Structure of push rod

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



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

2.18.3 Function of push rod

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

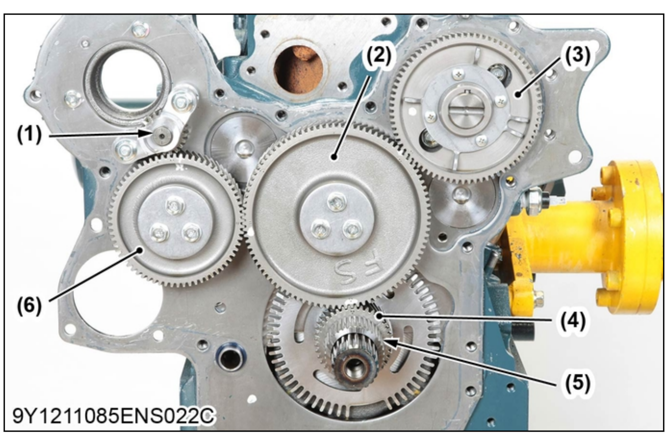
2.19 Timing gears

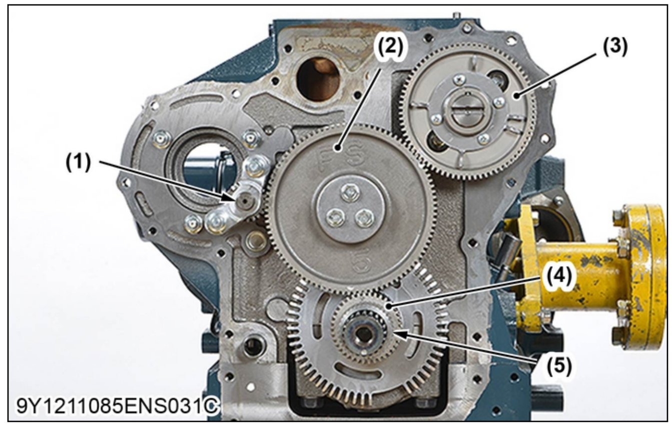
2.19.1 Outline of timing gears

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

2.19.2 Structure of timing gears

Timing gears are made up of the crank gear, idler gear, and cam gear.





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

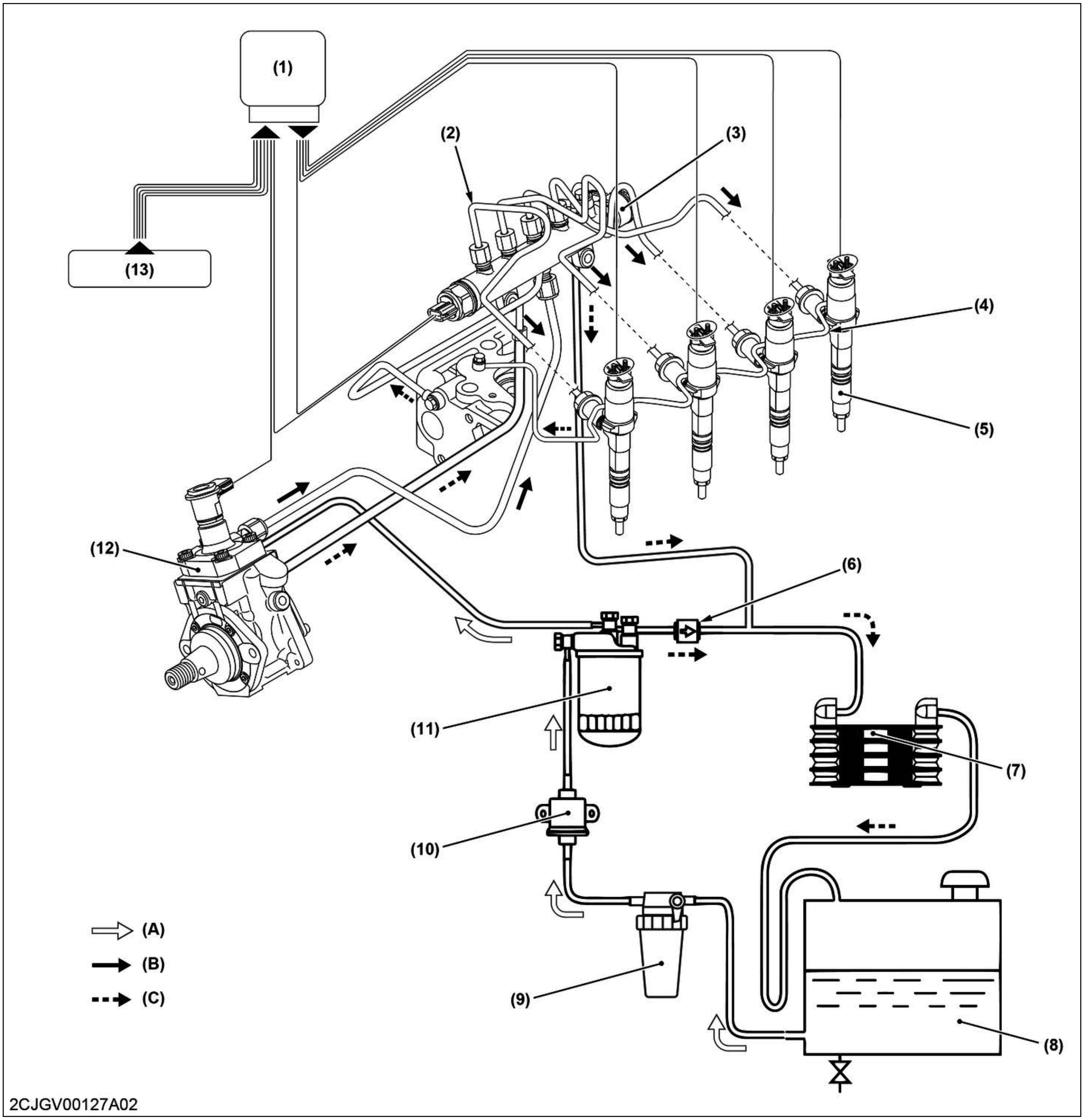
2.19.3 Function of timing gears

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

3. Fuel system

3.1 Structure of common rail system (CRS) engine

The common rail system is made up of a supply pump, injector, and rails.

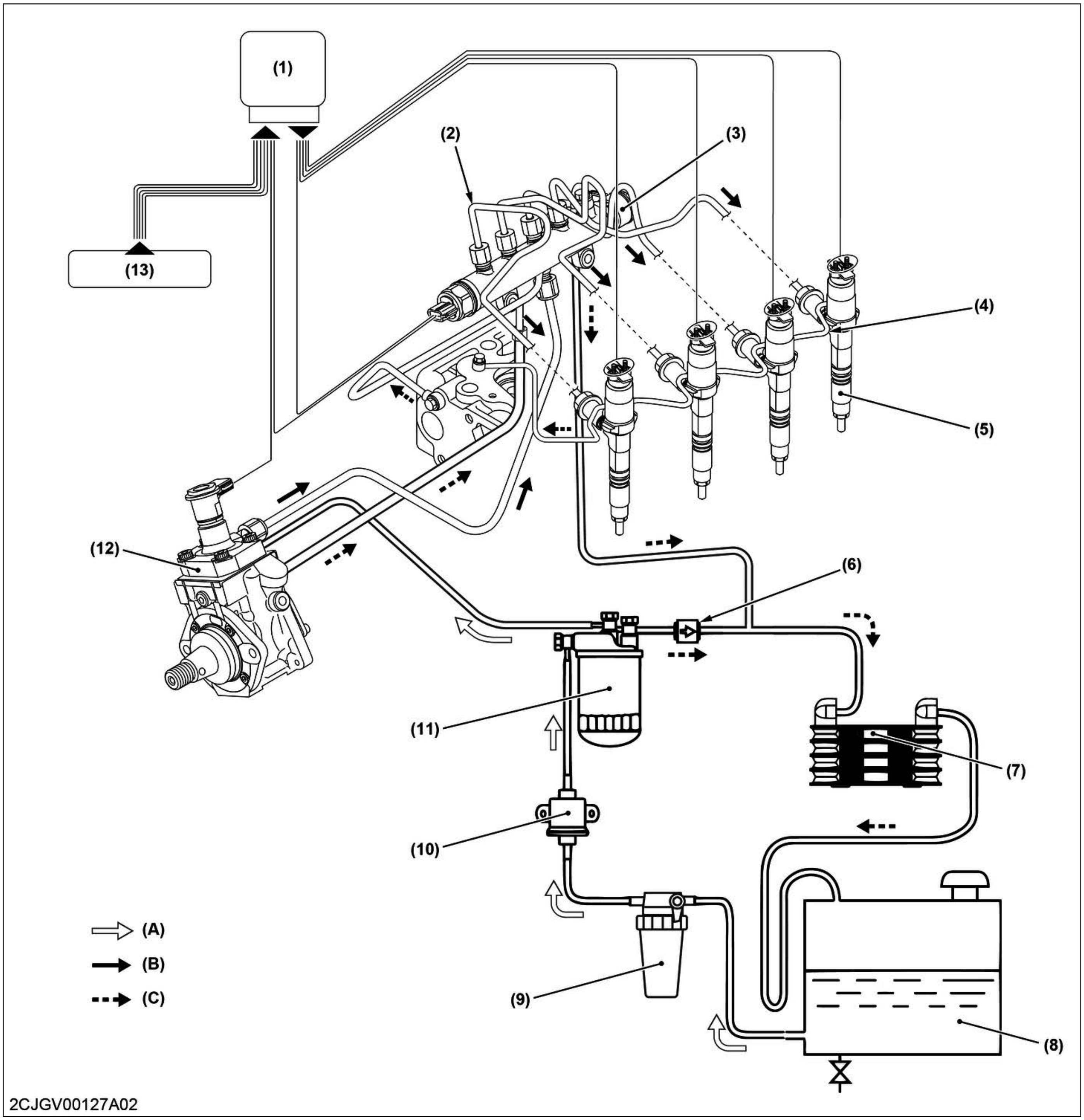


(1) Engine ECU
(2) Injection pipe
(3) Rail
(4) Overflow pipe
(5) Injector
(6) Check valve
(7) Fuel cooler
(8) Fuel tank
(9) Water separator
(10) Electromagnetic fuel feed pump
(11) Fuel filter
(12) Supply pump
(13) Various sensors
(A) Low pressure fuel flow
(B) High pressure fuel flow
(C) Return fuel flow

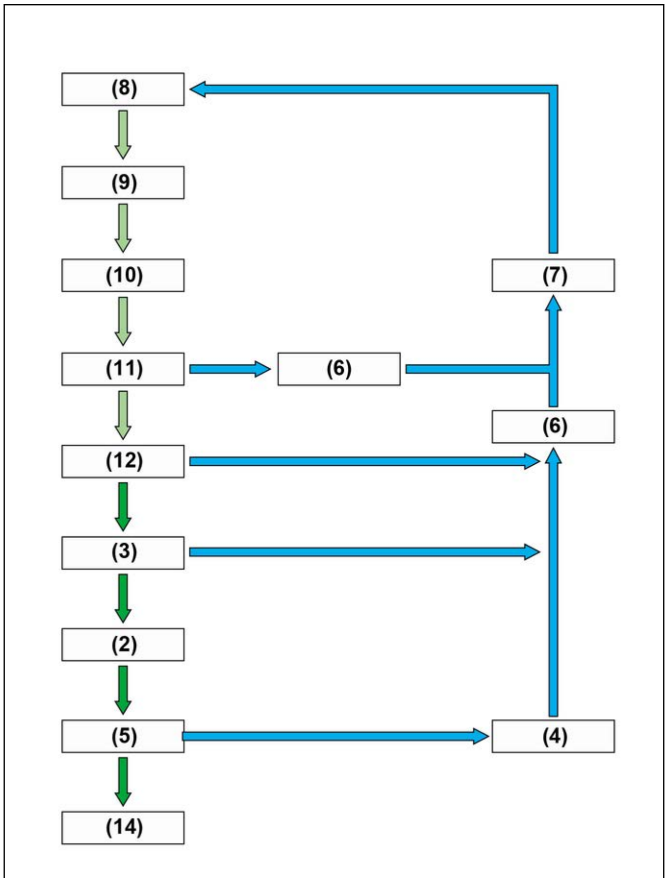
3.2 Feature of common rail system (CRS) engine

The fuel system of a common rail engine is completely different from that of a mechanical fuel injection pump.
Not only does a common rail system conform to stringent emission regulation restrictions, it is feasible to multiple highly accurate high pressure fuel injections that are not affected by engine speed.
Various parameters such as fuel pressure in the rail, intake air temperature, intake air pressure are transmitted from various sensors to the ECU as a signal.
This information and command signals from the engine ECU and between various control units are communicated via CAN communication.
The fuel system of a common rail engine is controlled by the engine ECU.
As a result fuel is injected at ideal conditions at all times suppressing the weak point of diesel engines of black smoke when starting and when accelerating and achieves reduction of exhaust gas cleanup as well as high power output.

3.3 Flow of common rail system (CRS) engine



Fuel flow



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(1) Engine ECU
(2) Injection pipe
(3) Rail
(4) Overflow pipe
(5) Injector
(6) Check valve
(7) Fuel cooler
(8) Fuel tank
(9) Water separator
(10) Electromagnetic fuel feed pump
(11) Fuel filter
(12) Supply pump
(13) Various sensors
(14) Fuel injection
(A) Low pressure fuel flow
(B) High pressure fuel flow
(C) Return fuel flow

1. Fuel from the fuel tank is passed through a water separator and fuel filter by an electromagnetic fuel feed pump and is supplied to the supply pump.
2. Fuel is pressurized by the supply pump and fed to the rail and injectors.
3. The injectors inject fuel based on instructions from the engine ECU.
4. After injection, surplus fuel passes through overflow pipe and fuel cooler and is returned to the fuel tank.

3.4 Control of common rail system (CRS) engine

The following items are controlled by the engine ECU as control for a common rail system engine.

1. Fuel injection quantity control
   The amount of fuel injected is determined using standard injection volume calculated based on engine state and operating conditions.
   A calibration value is added to this information through parameters such as coolant temperature, intake air temperature, and intake air pressure.
2. Fuel injection timing control
   The ECU controls injection timing through start of energization of the injectors.
   First the main injection timing is determined and next other injection timing such as pilot injections are set.
3. Fuel injection rate control
   A pilot injection enables maintaining minimum initial fuel injection rate.
   This mitigates explosive initial combustion and reduces NOx and noise.
4. Fuel injection pressure control
   Based on engine load (final injection volume and engine speed), the engine ECU calculates the set fuel injection pressure.
   Calculated data is used to control the volume supplied by the supply pump as well as the fuel pressure in the rail.

3.5 Fuel tank

3.5.1 Outline of fuel tank

The fuel tank stores fuel.

3.5.2 Structure of fuel tank

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

3.5.3 Function of fuel tank

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

3.5.4 Specification of fuel tank

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

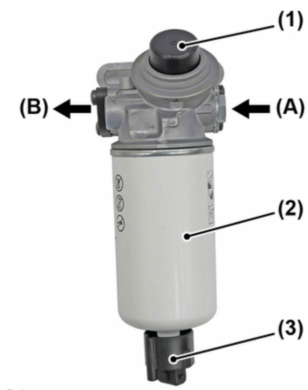
3.6 Water separator

3.6.1 Outline of water separator

The water separator removes the water included in the fuel.

3.6.2 Structure of water separator

The water separator is made up of the separator body, hand pump, and level sensor and the like.
The fuel flow direction of the water separator is set.



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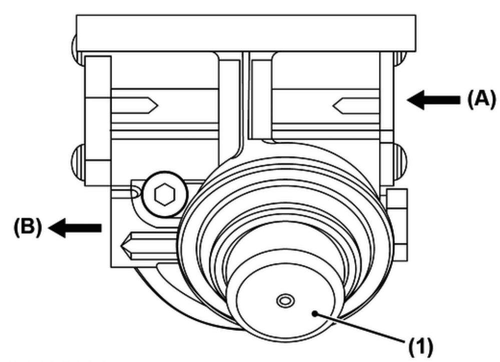

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(1) Hand pump
(2) Separator body
(3) Level sensor
(A) Fuel inlet
(B) Fuel outlet

3.6.3 Function of water separator

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

3.6.4 Specification of water separator

Hand pump discharge volume	15 cm^3 / stroke 0.92 cu.in. / stroke

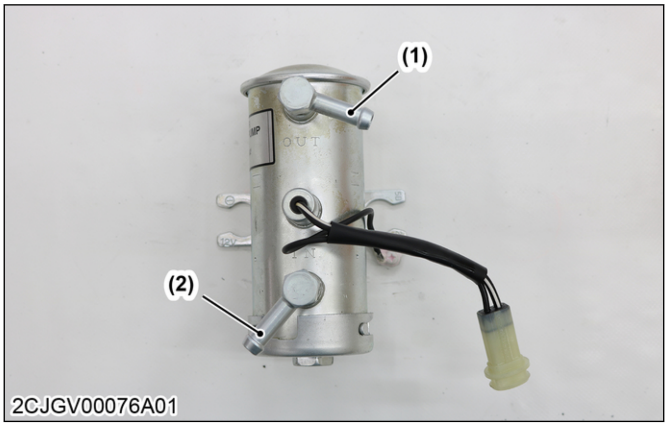
3.7 Electromagnetic fuel feed pump

3.7.1 Outline of electromagnetic fuel feed pump

The electromagnetic fuel feed pump supplies fuel to the engine.

3.7.2 Structure of electromagnetic fuel feed pump

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



(1) Fuel outlet (2) Fuel inlet

3.7.3 Function of electromagnetic fuel feed pump

The electromagnetic fuel feed pump feeds fuel to supply the fuel to the supply pump.
Voltage is supplied to the electromagnetic fuel feed pump when the key is turned ON.

3.7.4 Specification of electromagnetic fuel feed pump

Rated voltage	12 V*

* The operating voltage is dependent on the ECU specification and is 24V for a 24V specification ECU.

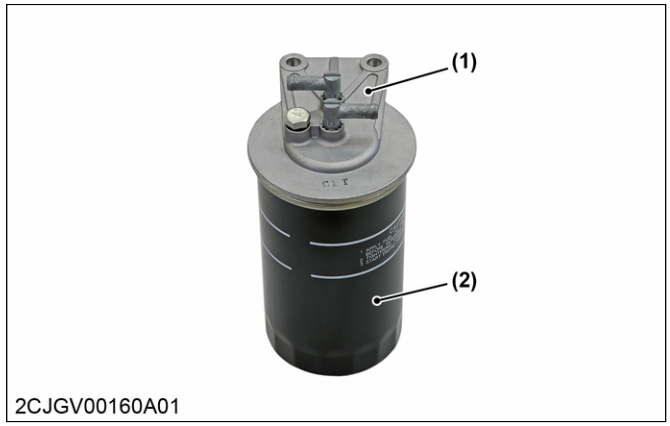
3.8 Fuel filter

3.8.1 Outline of fuel filter

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

3.8.2 Structure of fuel filter

The fuel filter is made up of a bracket and a filter body and the like.



(1) Bracket (2) Filter body

3.8.3 Function of fuel filter

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

3.8.4 Specification of fuel filter

Filtration accuracy	99% or higher @5 μor larger

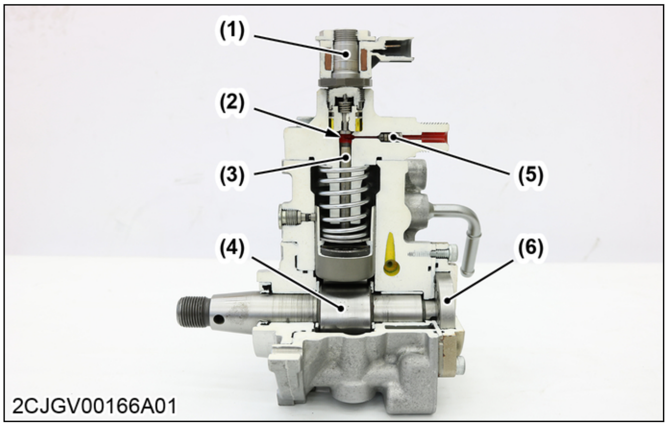
3.9 Supply pump

3.9.1 Outline of supply pump

The supply pump pressurizes and supplies fuel to the rail.

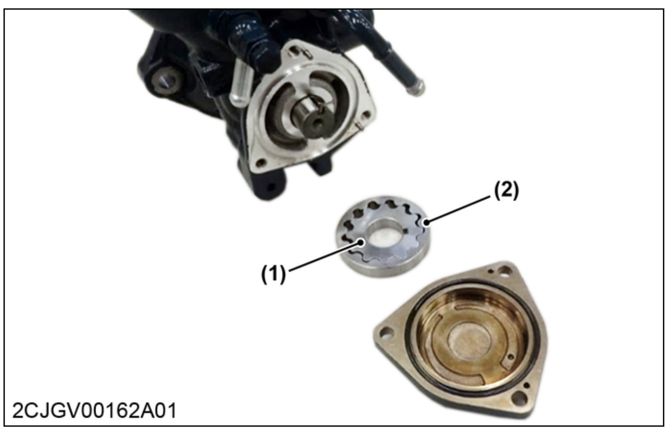
3.9.2 Structure of supply pump

The supply pump is made up of a PCV, feed pump, cam, and plunger and the like.



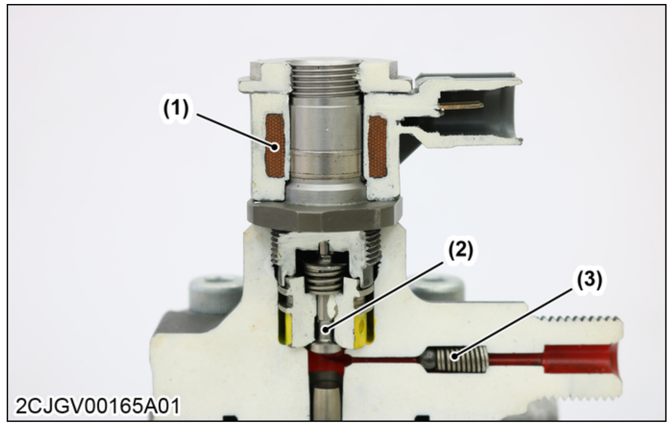
(1) PCV (Pre-stroke Control Valve)
(2) Plunger chamber
(3) Plunger
(4) Cam
(5) Delivery valve
(6) Feed pump

[Feed pump]



(1) Inner rotor
(2) Outer rotor

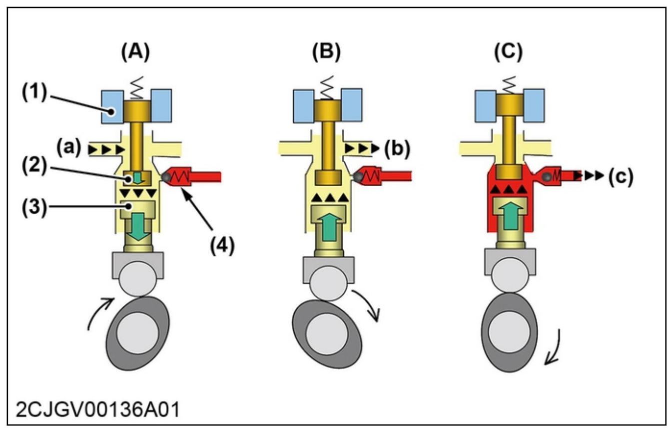
[PCV, Delivery valve]



(1) Coil
(2) Valve
(3) Delivery valve

3.9.3 Function of supply pump

The supply pump further increases the pressure of fuel fed by the electromagnetic fuel feed pump and delivers it to the rail.



(1) PCV (Pre-stroke Control Valve)
(2) Plunger
(3) Plunger chamber
(4) Delivery valve
(A) Suction stroke
(B) Pre-stroke
(C) Pressure feed stroke
(a) From feed pump
(b) To fuel tank
(c) To rail

Suction stroke
During the suction stroke of the plunger the PCV opens and fuel fed from the feed pump into the supply pump is pulled from (a) into the plunger chamber (3).

Pre-stroke
During the pre-stroke of the plunger, fuel is not pressurized while the PCV is open but is discharged from (b) to the fuel tank.

Pressure feed stroke
When a close PCV signal is sent from the ECU to the coil, the PCV closes.
Here, the plunger chamber (3) is sealed causing the fuel pressure to increase.
As the fuel pressure increases, the delivery valve (4) opens and fuel is fed from (c) to the rail.

3.9.4 Specification of supply pump

Pump type	Denso HP5S
Resistance of PCV coil	0.47 Ω (20 °C (68 °F))

3.10 Injection pipe

3.10.1 Outline of injection pipe

Injection pipes connect the supply pump and rail as well as the rail and injectors.

3.10.2 Structure of injection pipe

The injection pipes between the rail and injectors are designed with equal length.

3.10.3 Function of injection pipe

Injection pipes connect the supply pump and rail as well as the rail and injectors.

3.10.4 Specification of injection pipe

Pipe withstand pressure	250 MPa or higher 2550 kgf/cm^2 36300 psi

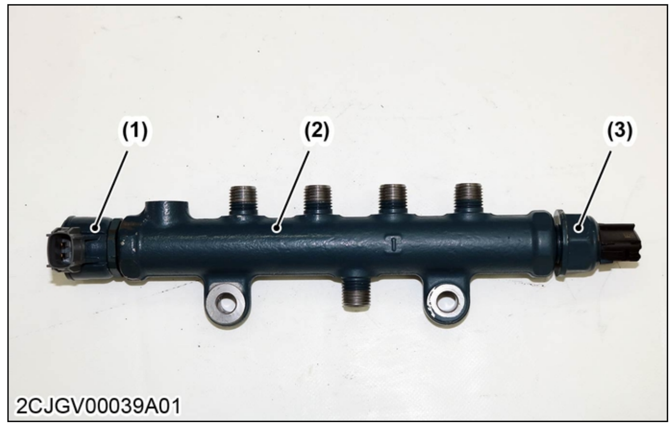
3.11 Rail assembly

3.11.1 Outline of rail assembly

The rail stores high pressure fuel and delivers it to each of the injectors.

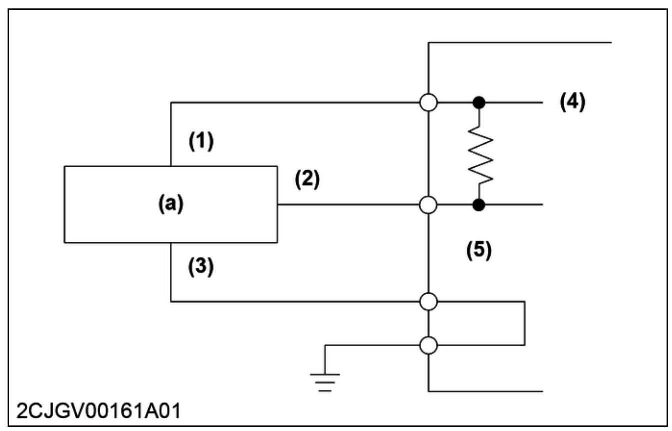
3.11.2 Structure of rail assembly

The rail assembly is made up of a rail body, rail pressure sensor, and pressure relief valve (PRV).



(1) Pressure relief valve (PRV)
(2) Rail body
(3) Rail pressure sensor

Wiring diagram



(1) Terminal A-VCC1
(2) Terminal PFUEL
(3) Terminal A-GND6
(4) +5 V
(5) Engine ECU
(a) Engine ECU connector 1

3.11.3 Function of rail assembly

The rail assembly stores high pressure fuel fed from the supply pump and while retaining the pressure, delivers fuel to the injectors for each cylinder.
The rail pressure sensor is a semiconductor type pressure sensor with a structure that utilizes the piezo resistance effect where electrical resistance changes based on change in pressure on a silicon element.
This function enables detecting fuel pressure inside the rail and transmitting an electrical signal to the engine ECU.

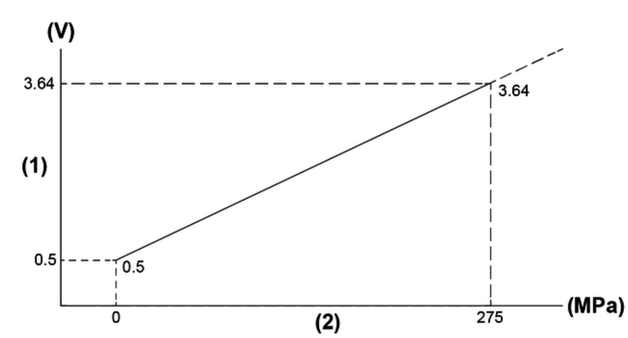
When the fuel pressure inside the rail increases above the upper limit the pressure relief valve energizes a solenoid coil and opens a path to a pressure relief valve.
As a result fuel is returned to the fuel tank lowering pressure in the rail, and preventing failure.
Furthermore, opening of the valve for pressure reduction of rail pressure improves response and through opening this when the key is turned off, residual pressure in the rail can be reduced.

3.11.4 Specification of rail assembly

Rail pressure sensor

Operating voltage	5 V

Output characteristics



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(1) Output voltage (2) Pressure

Pressure relief valve

Operating voltage	5 V
Resistance between terminals	0.47 Ω (20 °C)

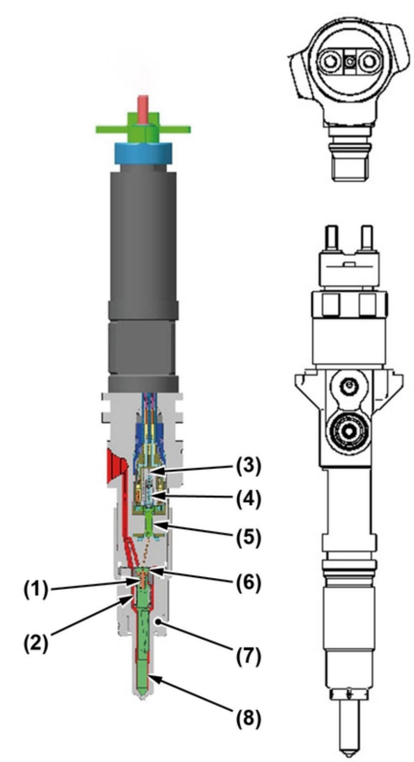
3.12 Injector

3.12.1 Outline of injector

The injector injects high pressure fuel from the rail into the combustion chamber.

3.12.2 Structure of injector

The injector is made up of a solenoid, control valve, and nozzle body and the like.



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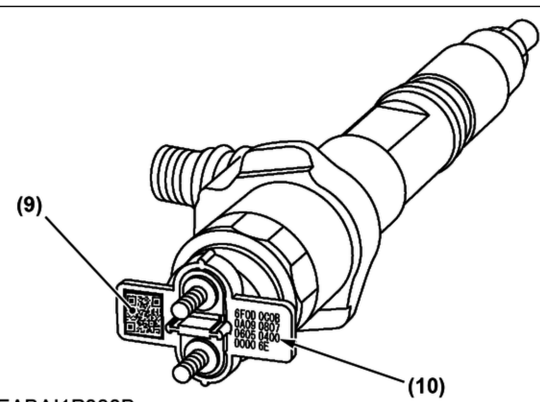
(1) Controller plate spring
(2) Nozzle pressure spring
(3) Solenoid
(4) Control valve spring
(5) Control valve
(6) Control plate
(7) Nozzle body
(8) Needle valve



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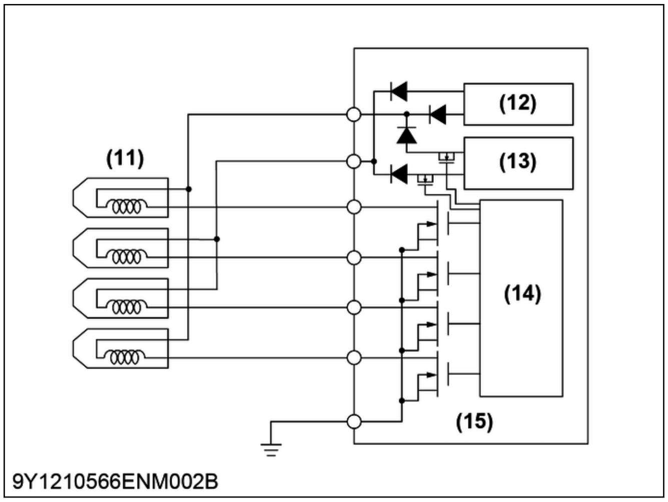
(9) QR code (10) ID code

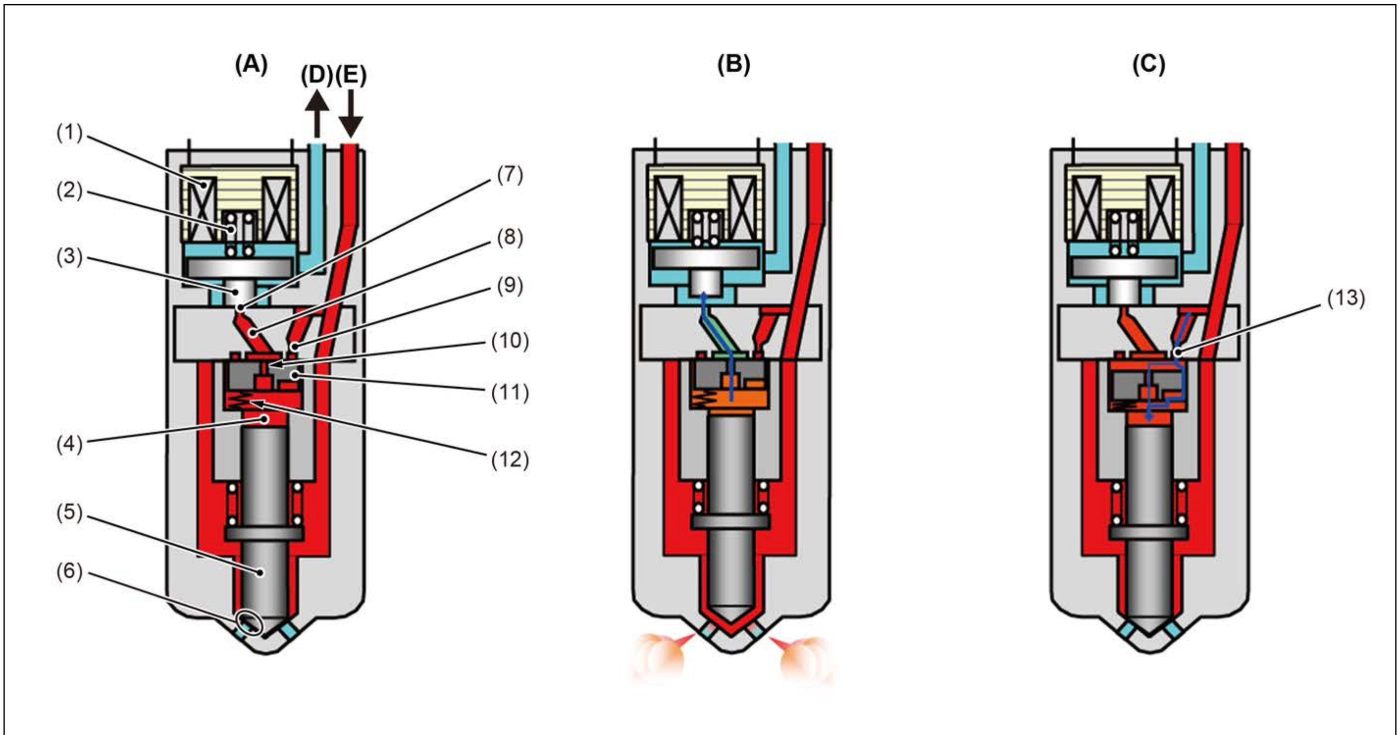
Wiring diagram



(11) Injector
(12) Rated amperage circuit
(13) High-voltage generating circuit
(14) Control circuit
(15) Engine ECU

3.12.3 Function of injector

The injector injects high pressure fuel from the rail into the combustion chamber.
Injection is performed based on a signal received from the engine ECU indicating fuel injection timing and fuel amount.
The injector injects fuel 3 times for one combustion. The initial injection is called the pre-injection.
The initial injection is called the pre-injection.
A small amount is injection during this injection reducing the effects of initial combustion and lowering NOx and noise.
The second injection is called the main injection, is used primarily for combustion and affects output. Therefore this injection has the highest volume.
The 3rd injection is called the after injection and combusts unburned fuel from combustion.
In addition to these injections, an injection called post injection is performed during DPF regeneration.
This injection is not used to burn fuel in the combustion chamber but is used for raising the temperature of the DOC.
There are differences in amount injected between injectors and the QR/ID codes are used to correct for these differences information for correcting is input to the ECU.



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(1) Solenoid
(2) Control valve spring
(3) Control valve
(4) Control chamber
(5) Needle valve
(6) Nozzle seat
(7) Sub discharge orifice
(8) Intermediate chamber
(9) Intake orifice
(10) Discharge orifice
(11) Control plate
(12) Control plate spring
(13) High pressure circular groove
(A) Injection stop
(B) Injection start
(C) Injection finish
(D) To fuel tank
(E) From rail

Injector operation theory

The injector uses a signal output from the engine ECU and fuel pressure in the control chamber to control injection.
The system for controlling pressure in the control chamber is opening the discharge orifice path of the control chamber by operating a solenoid through excitation and injecting fuel through lowering of the pressure. When the current is stopped pressure in the control chamber returns to the previous state and injection stops.

1. Injection stop
   When there is no excitation of the solenoid (1), the control valve (3) closes the sub discharge orifice (7) based on the force of the control valve spring (2) and based on the difference in pressure between the controller chamber (4) and nozzle seat (6), the needle valve (5) remains closed and injection is not performed.
2. Injection start
   When excitation of the solenoid (1) is performed, the control valve (3) is pulled up and fuel flows from the sub discharge orifice (7) and the discharge orifice (10) to the control chamber (4).

When pressure inside the control chamber (4) pressure at the nozzle seat (6) rises until pressure applied to the nozzle seat (6) grows larger than the pressure in the control chamber pushing up the needle valve (5) and injecting fuel.
The control plate (11) is pushed up by the pressure difference between the control chamber (4) and intermediate chamber (8) and the control plate spring (12) force, closing the intake orifice (9).
Therefore fuel leak is only the residual fuel in the control chamber (4) and is suppressed to a minimum.

3. Injection finish
When energization of the solenoid is turned OFF, the control valve (3) closes the secondary discharge orifice (7) and fuel in the control chamber flows into the intermediate chamber (8) increasing the pressure in the intermediate chamber.
Thereafter, the pressure in intermediate chamber (8) and high pressure circular groove (13) increases above that of the control chamber (4) and the control plate spring (12) lowering the control plate (11) and causing the fuel to flow from the intake orifice (9) into the control chamber (4).
Pressure in the control chamber(4) increases raising the pressure pushing down on the needle valve (5), lowering the needle valve (5) and completing injection.
Thereafter, the pressure in the control chamber (4), intermediate chamber (8), and high pressure circular groove (13) becomes equivalent and the control plate (11) is pushed up by the control plate spring (12).

3.12.4 Specification of injector

Operating voltage	110 V
Operating pressure range	32.0 to 210 MPa 327 to 2140 kgf/cm^2 4650 to 30400 psi
Number of injection holes	7
QR correction points	6

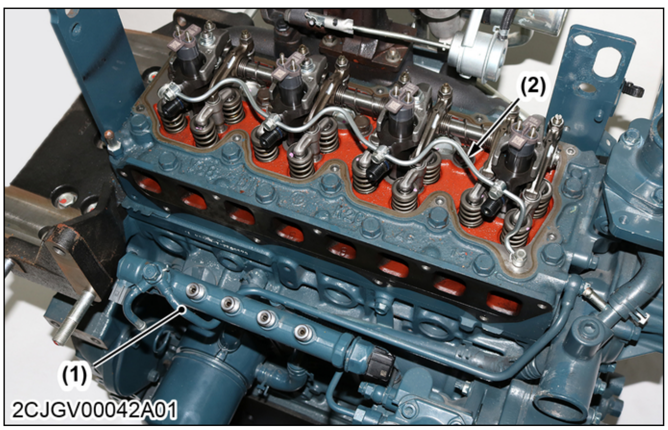
3.13 Overflow pipe

3.13.1 Outline of overflow pipe

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

3.13.2 Structure of overflow pipe

The overflow pipe is made up of two pipes, the return from the injectors and the return from the supply pump and rail.



(1) Overflow pipe (2) Overflow pipe

3.13.3 Function of overflow pipe

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

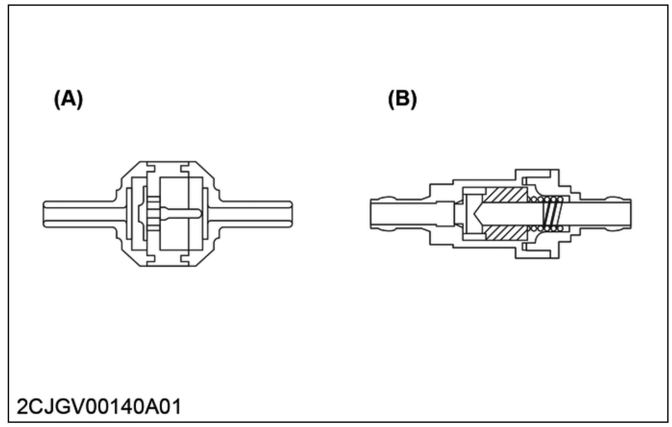
3.14 Check valve

3.14.1 Outline of check valve

The check valve prevents reverse flow of fuel inside the fuel piping.

3.14.2 Structure of check valve

There are two types of check valves, with or without a regulator.



(A) No regulator (B) Regulator included

3.14.3 Function of check valve

The check valve prevents reverse flow of fuel inside the fuel piping.
The check valve is being used as a no-return valve.
A check valve without a regulator is used in the return path from the fuel filter.
This path is used as a return path for excess fuel and for air bleeding.
A check valve with a regulator is used in the return path from the overflow pipe.
This is to retain back pressure inside the return path from the overflow pipe.

3.14.4 Specification of check valve

Valve opening pressure	Regulator included	11 kPa 0.11 kgf/cm^2 1.6 psi

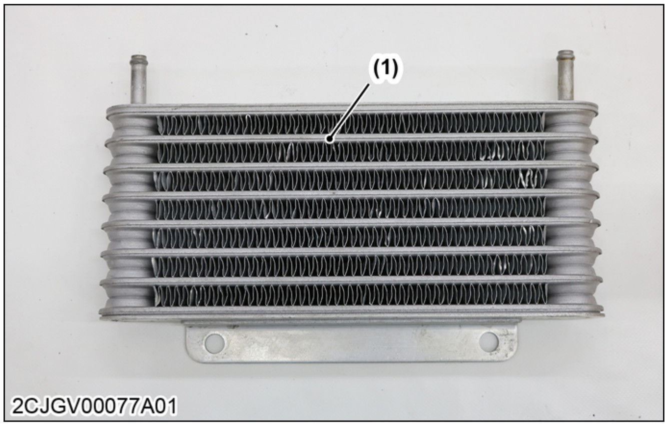
3.15 Fuel cooler

3.15.1 Outline of fuel cooler

The fuel cooler cools fuel returning from the engine.
Cooling fuel returning to the fuel tank prevents temperature increase of the fuel in the fuel tank.

3.15.2 Structure of fuel cooler

The fuel cooler is made up of a core (inner fins) and heat dissipating fins.



(1) Fuel cooler

3.15.3 Function of fuel cooler

Fuel supplied to the engine is pressurized by the fuel feed pump and the supply pump.
Here, the temperature of the fuel also increases.
Therefore, before returning the excess fuel to the tank, cooling in the fuel cooler suppresses temperature increase of the fuel in the fuel tank.

3.16 Engine ECU

3.16.1 Outline of engine ECU

The engine ECU controls fuel injection and after treatment devices.

3.16.2 Structure of engine ECU

The engine ECU is made up of a case and electronics part mounting board.
Furthermore, it has a program called software installed.

(1) Engine ECU

3.16.3 Function of engine ECU

The engine ECU controls the injection amount, injection timing, injection rate, and injection pressure during fuel injection.
Control based on the engine ECU is performed by sending instructions to each actuator based on input signals from each sensor.
See CRS control topics for details regarding control content.

3.16.4 Specification of engine ECU

Operating voltage	12 V*

* Depending on the machinery equipped in, there are 24 V specification units.

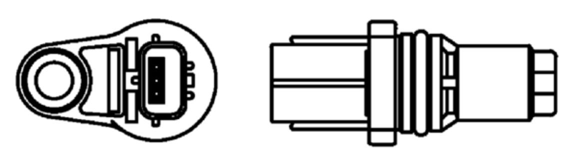
3.17 Crankshaft position sensor

3.17.1 Outline of crankshaft position sensor

The crank position sensor senses the teeth on a pulsar gear and detects the angular position of the crankshaft.

3.17.2 Structure of crankshaft position sensor

The crank position sensor is made up of a magnet and connector and the like.



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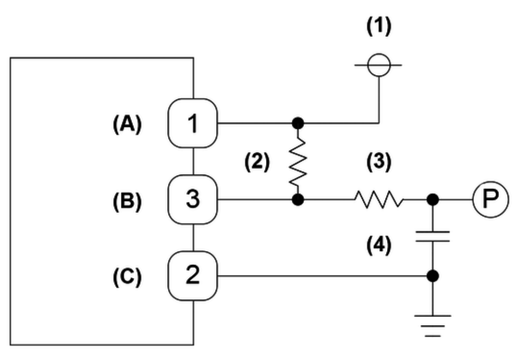

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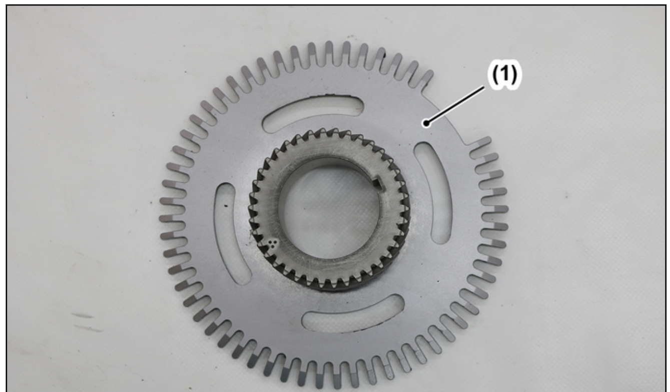
(1) Vcc
(2) 1 kΩ
(3) 10 kΩ
(4) 1000 pF
(A) Vcc
(B) Output signal (Vout)
(C) Ground

3.17.3 Function of crankshaft position sensor

The crank position sensor senses the teeth on a pulsar gear and detects the angular position of the crankshaft.
The pulsar gear has some teeth missing.
The engine ECU calculates the piston position and engine speed based on the signal detected.
The crank position sensor is a magnetic resistance element type sensor.
When the pulsar gear passes by the sensor part, the internal magnetic field changes.
AC voltage is generated by the change in magnetic field and this is rectified and output to the ECU.



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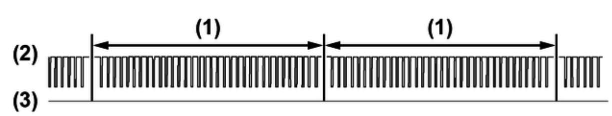
(1) Pulsar gear (crank)

3.17.4 Specification of crankshaft position sensor

Operating voltage	5 V
Pulsar gear number of teeth	56

Output waveform



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

■ NOTE

- **Noted as Ne sensor on Diagmaster.**

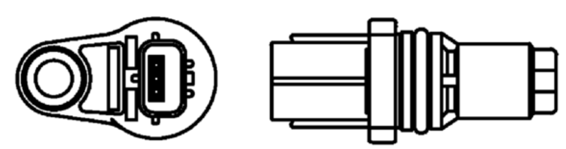
3.18 Camshaft position sensor

3.18.1 Outline of camshaft position sensor

The cam position sensor senses the teeth on a pulsar gear and detects the angular position of the camshaft.

3.18.2 Structure of camshaft position sensor

The cam position sensor is made up of a magnet and connector and the like.



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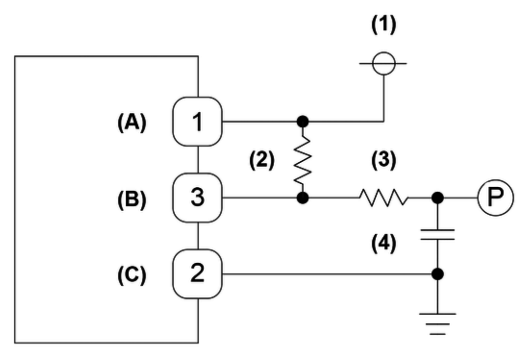


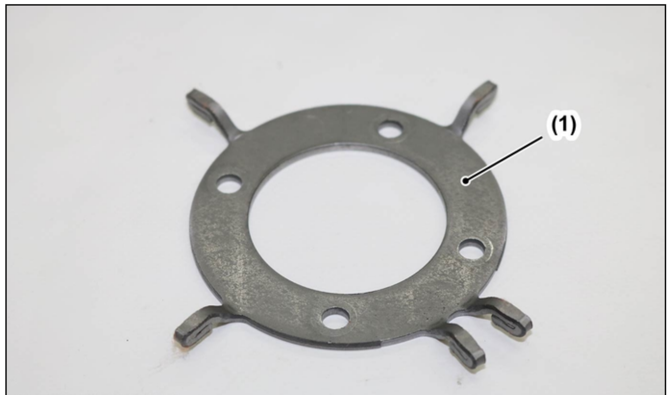
2CJGV00141A01

(1) Vcc
(2) 1 kΩ
(3) 10 kΩ
(4) 1000 pF

(A) Vcc
(B) Output signal (Vout)
(C) Ground

3.18.3 Function of camshaft position sensor

The cam position sensor senses the teeth on a pulsar gear and detects the angular position of the camshaft.
The pulsar gear has teeth at non-equal intervals.
The engine ECU calculates the piston position based on the signal detected.
The crank position sensor is a magnetic resistance element type sensor.
When the pulsar gear passes by the sensor part, the internal magnetic field changes.
AC voltage is generated by the change in magnetic field and this is rectified and output to the ECU.



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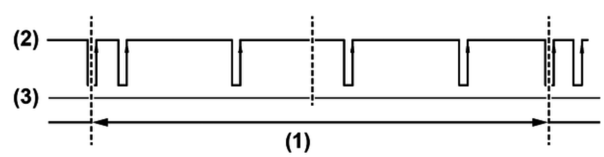
(1) Pulsar gear (cam)

3.18.4 Specification of camshaft position sensor

Operating voltage	5 V
Pulsar gear number of teeth	5

Output waveform



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(1) 5 pulses (12.6 rad 720°) crank angle
(2) 5 V
(3) 0 V

■ **NOTE**

- **Noted as G sensor on Diagmaster**

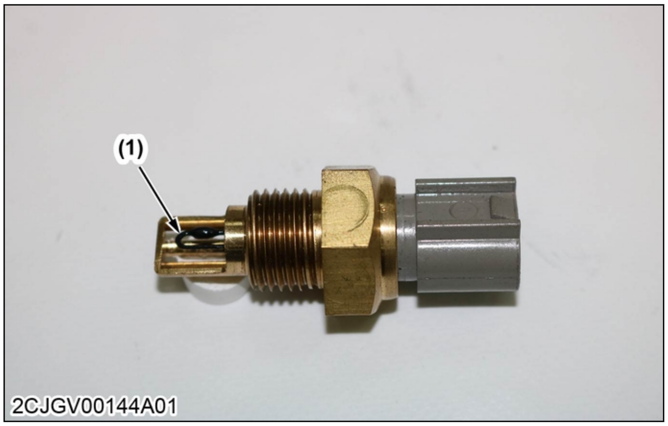
3.19 Intake air temperature sensor

3.19.1 Outline of intake air temperature sensor

The intake air temperature sensor detects that temperature of intake air at the inlet of the intake manifold.

3.19.2 Structure of intake air temperature sensor

The intake air temperature sensor is made up of a thermistor and connector and the like.



(1) Thermistor

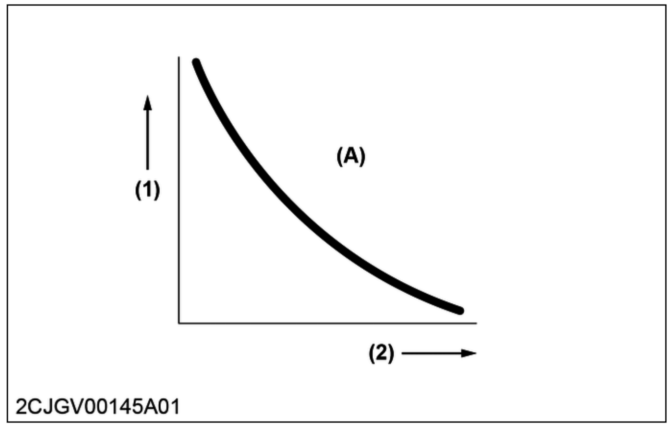
3.19.3 Function of intake air temperature sensor

The intake air temperature sensor detects that temperature of intake air at the inlet of the intake manifold.
When the intake air temperature changes the resistance of the thermistor at the tip of the sensor changes.
Then the resistance of the thermistor changes, the sensor output voltage changes.
The output voltage signal of the sensor is sent to the engine ECU.

3.19.4 Specification of intake air temperature sensor

Operating voltage	5 V

Output characteristics



(1) Resistance
(2) Temperature
(A) Thermistor temperature curve

Temperature	Resistance
20 ℃ 68 ℉	Approx. 2.4 kΩ
60 ℃ 140 ℉	Approx. 0.58 kΩ
100 ℃ 212 ℉	Approx. 0.18 kΩ

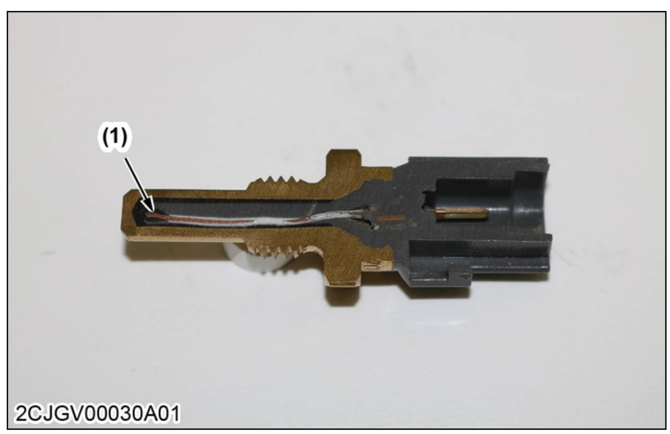
3.20 Coolant temperature sensor

3.20.1 Outline of coolant temperature sensor

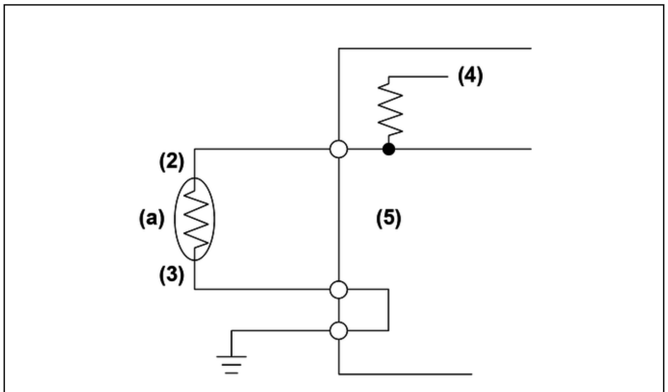
The coolant temperature sensor detects the temperature of the coolant inside the engine.

3.20.2 Structure of coolant temperature sensor

The coolant temperature sensor is made up of a thermistor and connector and the like.



(1) Thermistor



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(2) Terminal THW
(3) Terminal A-GND2
(4) +5V
(5) Engine ECU
(a) Coolant temperature sensor

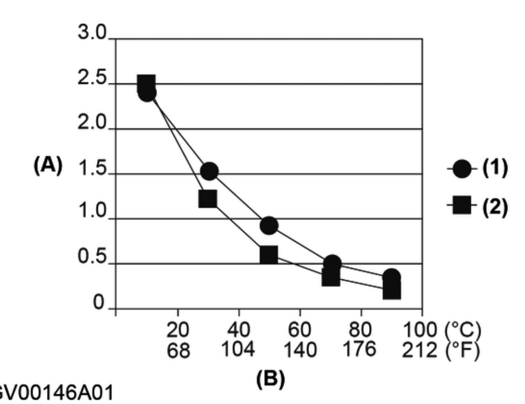
3.20.3 Function of coolant temperature sensor

The coolant temperature sensor detects the temperature of the coolant inside the engine.
When the engine coolant temperature changes the resistance of the thermistor at the tip of the sensor changes.
Then the resistance of the thermistor changes, the sensor output voltage changes.
The output voltage signal of the sensor is sent to the engine ECU.

3.20.4 Specification of coolant temperature sensor

Operating voltage	5 V

Output characteristics



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(1) Voltage
(2) Resistance
(A) Voltage (V) / Resistance (kΩ)
(B) Temperature (℃ / ℉)

Temperature	Resistance (kΩ)
20 ℃ 68 ℉	Approx. 2.5
40 ℃ 104 ℉	Approx. 1.2
60 ℃ 140 ℉	Approx. 0.58
80 ℃ 176 ℉	Approx. 0.32
100 ℃ 212 ℉	Approx. 0.18

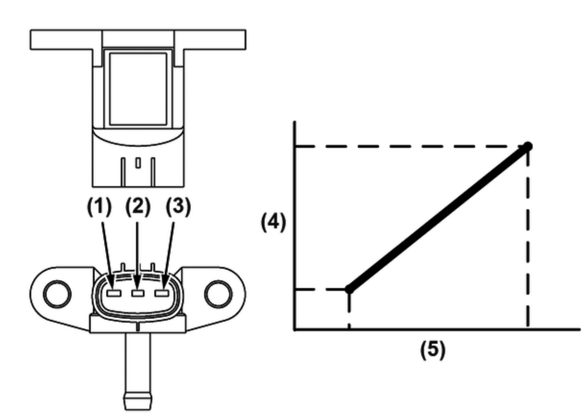
3.21 Boost sensor

3.21.1 Outline of boost sensor

The boost pressure sensor detects that pressure of intake air at the inlet of the intake manifold.

3.21.2 Structure of boost sensor

The boost pressure sensor is made up of a diaphragm and connector and the like.



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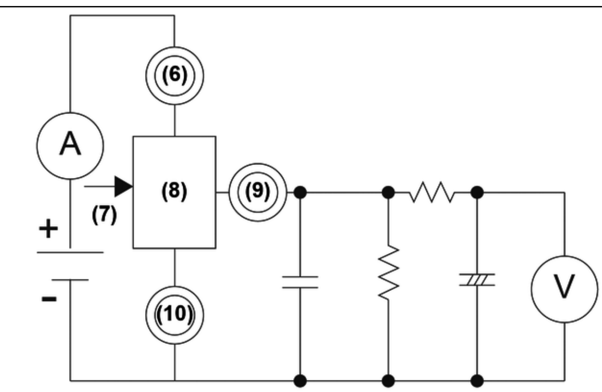
(1) Supply terminal
(2) Output terminal
(3) Ground terminal
(4) Output voltage
(5) Intake air pressure



2CJGV00147B01

(6) Vcc
(7) Port
(8) Pressure sensor
(9) Vout
(10) GND

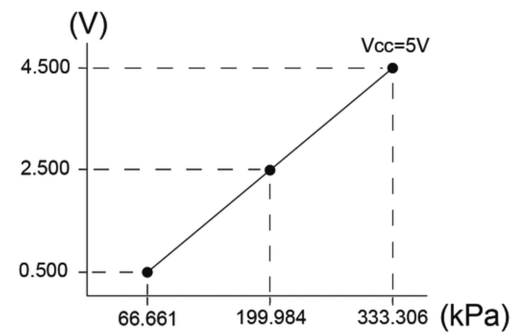
3.21.3 Function of boost sensor

The boost pressure sensor detects that pressure of intake air at the inlet of the intake manifold.
This sensor is a semiconductor type pressure sensor.
A silicon element in the sensor changes with pressure fluctuations and converts pressure detected using the piezo resistance effect to voltage.
The output voltage signal of the sensor is sent to the engine ECU.

3.21.4 Specification of boost sensor

Operating voltage	5 V

Pressure characteristics



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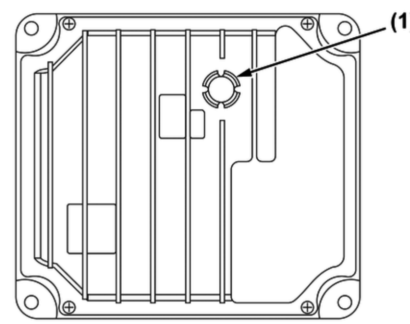
3.22 Atmosphere pressure sensor

3.22.1 Outline of atmosphere pressure sensor

The atmosphere pressure sensor detects atmosphere pressure.

3.22.2 Structure of atmosphere pressure sensor

The atmosphere pressure sensor is installed in the engine ECU.



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(1) Atmosphere pressure sensor

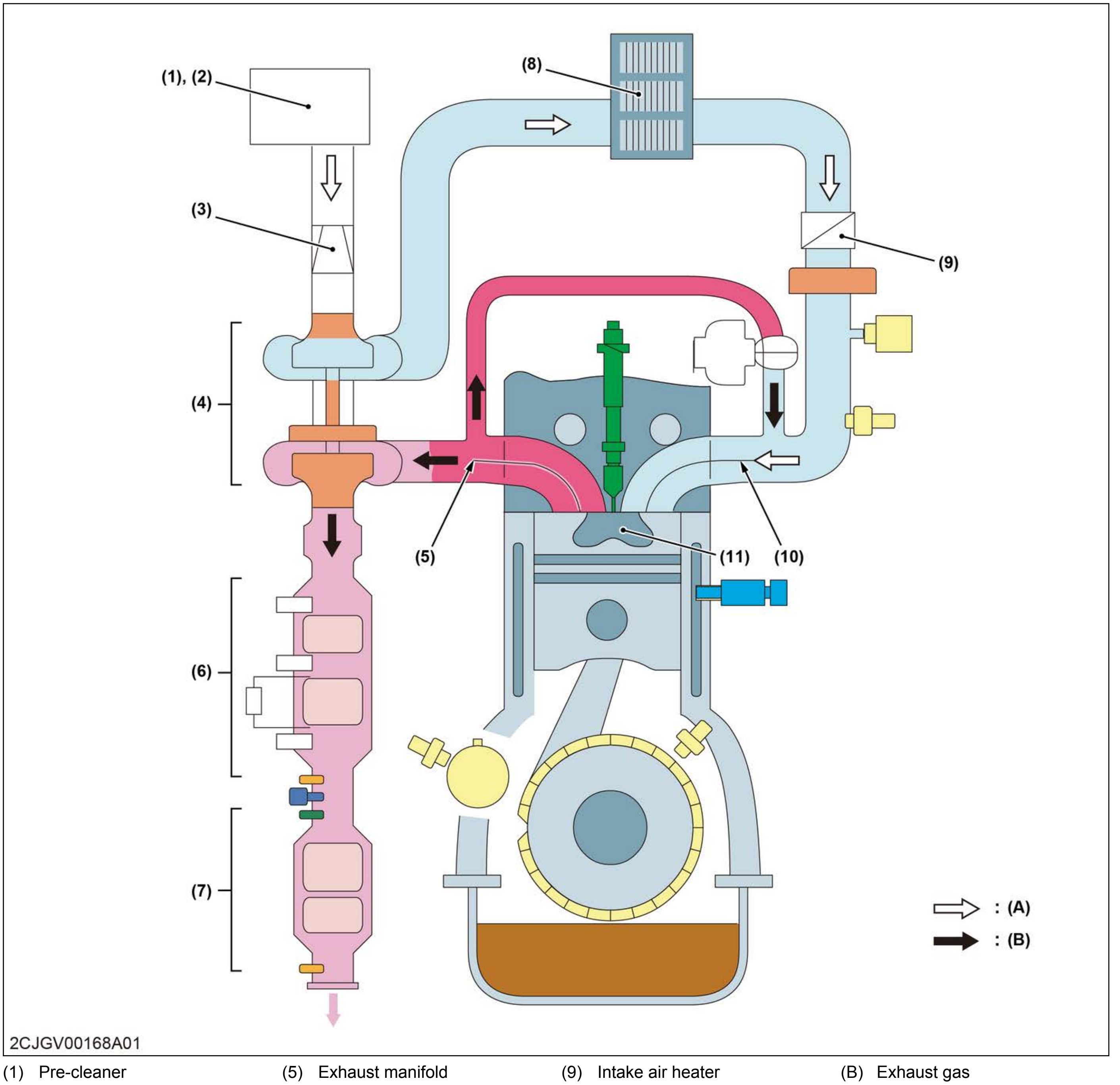
3.22.3 Function of atmosphere pressure sensor

The atmosphere pressure sensor detects atmosphere pressure.
The output signal of the sensor is sent to the engine ECU.

4. Intake and exhaust system

4.1 Structure of intake and exhaust system

The intake and exhaust system is made up of intake system and exhaust system components.



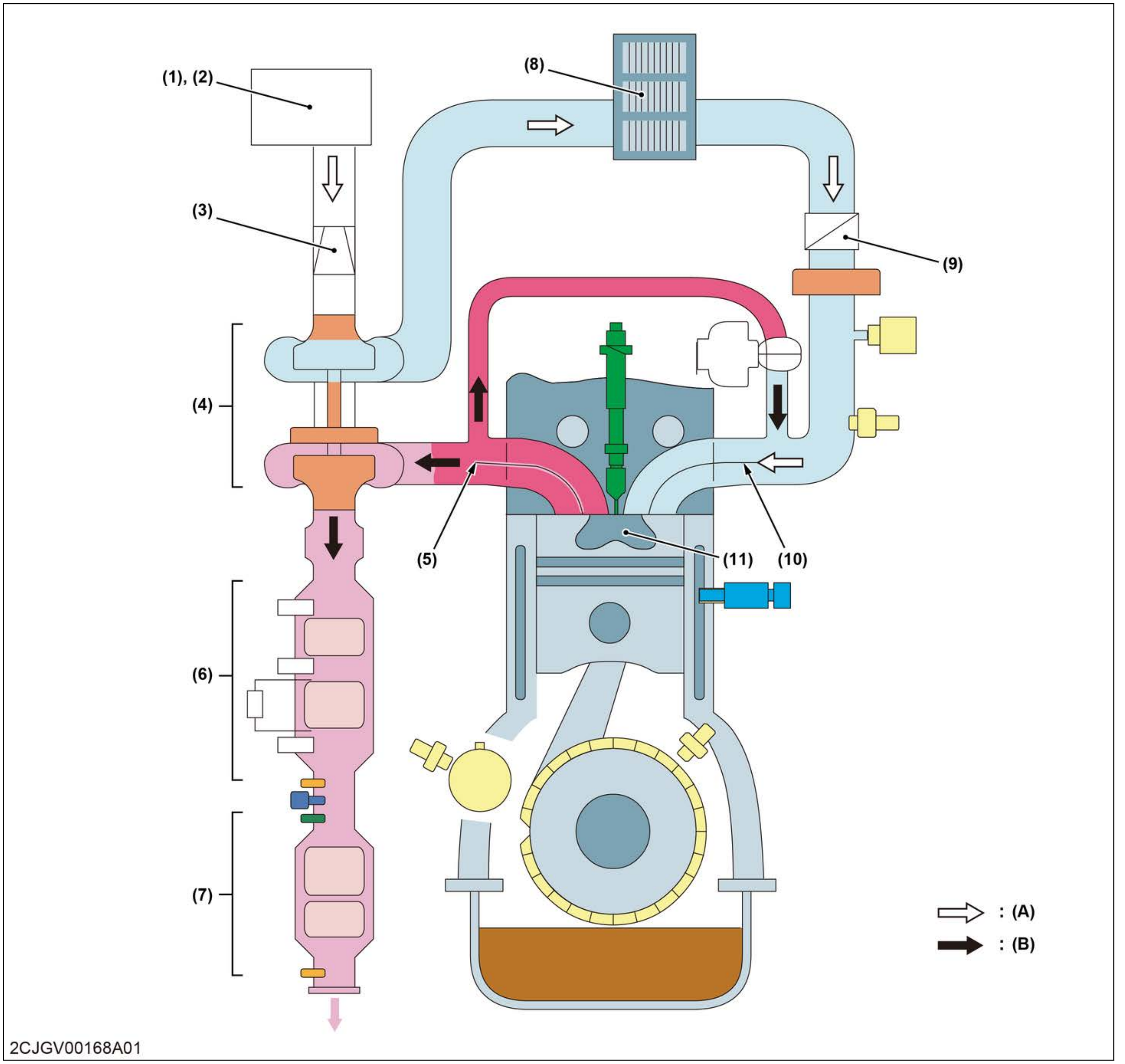
(1) Pre-cleaner	(5) Exhaust manifold	(9) Intake air heater	(B) Exhaust gas
(2) Air cleaner	(6) After treatment unit (DPF)	(10) Intake manifold	
(3) Airflow sensor	(7) After treatment unit (SCR)	(11) Combustion chamber	
(4) Turbocharger	(8) Intercooler	(A) Intake air	

4.2 Feature of intake and exhaust system

The air intake system supplies clean air to the engine.
Also, installing of a turbocharger and intercooler enables increasing the amount of intake air.
The exhaust system aggregates exhaust gases after combustion and discharges them to the atmosphere after after treatment.

4.3 Flow of intake and exhaust system

This shows the flow of the intake system and exhaust system.



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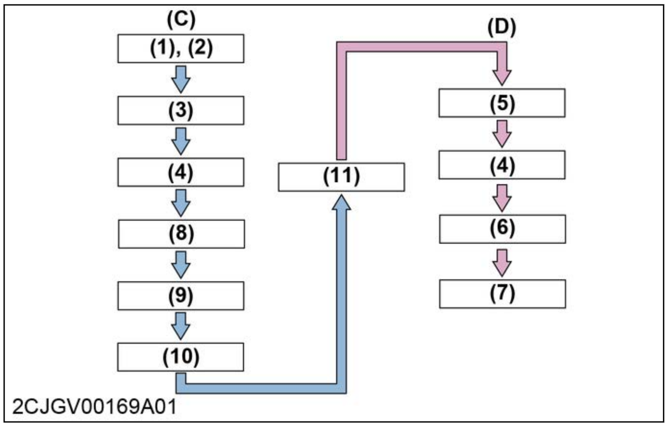


(1) Pre-cleaner
(2) Air cleaner
(3) Airflow sensor
(4) Turbocharger
(5) Exhaust manifold
(6) After treatment unit (DPF)
(7) After treatment unit (SCR)
(8) Intercooler
(9) Intake air heater
(10) Intake manifold
(11) Combustion chamber
(A) Intake air
(B) Exhaust gas
(C) Intake system
(D) Exhaust system

(A) Intake stroke

1. Fresh air from the atmosphere passes through the pre-cleaner and air cleaner removing debris from the air
2. And is then compressed by the turbocharger.
3. Compressed intake air passes through the intercooler where it is cooled increasing the intake air density
4. This is distributed from the intake manifold to each of the cylinders.

(B) Exhaust stroke

1. Post combustion gases discharged from the combustion chamber in each cylinder are collected by the exhaust manifold
2. Pass through the turbocharger rotating the turbine and pressurizing the intake air.
3. Hazardous components in the exhaust gas are cleaned in after treatment units and the exhaust is discharged to the atmosphere

4.4 Control of intake and exhaust system

- See DPF control
- See common rail system

RELATED PAGE
3.4 Control of common rail system (CRS) engine on page 3-17
9.4 Control of diesel particulate filter (DPF) system on page 3-72

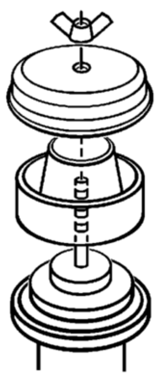
4.5 Pre-cleaner

4.5.1 Outline of pre-cleaner

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

4.5.2 Structure of pre-cleaner

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



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4.5.3 Function of pre-cleaner

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

4.5.4 Specification of pre-cleaner

Airflow range	Max. 2.5 m^3/min.

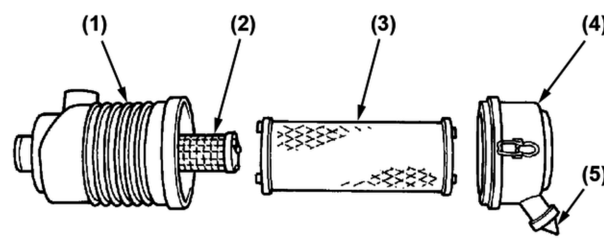
4.6 Air cleaner

4.6.1 Outline of air cleaner

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

4.6.2 Structure of air cleaner

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



9Y1200165GES010B

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

4.6.3 Function of air cleaner

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

4.6.4 Specification of air cleaner

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

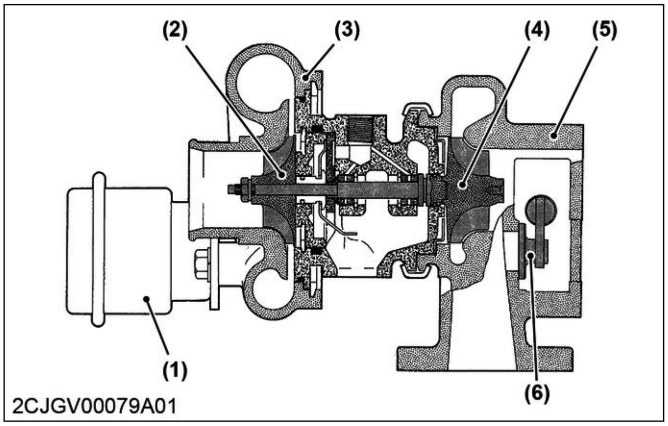
4.7 Turbocharger

4.7.1 Outline of turbocharger

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

4.7.2 Structure of turbocharger

The turbocharger is made up of a compressor wheel and turbine wheel.



(1)	Wastegate actuator	(4)	Turbine wheel
(2)	Compressor wheel	(5)	Turbine housing
(3)	Compressor housing	(6)	Wastegate valve

4.7.3 Function of turbocharger

The turbocharger uses the exhaust gas to compress intake air.
When combustion gases pass through the turbocharger they cause the turbine wheel to rotate at high speeds.
This rotation causes the compressor wheel mounted on the same shaft to rotate at high speeds compressing intake air and supplying this to each cylinder.
Furthermore, when intake air pressure rises too high, the wastegate actuator opens the wastegate valve via a rod allowing a part of the exhaust gases to flow directly to the muffler without passing over the turbine wheel.
Therefore, intake air pressure is kept constant.

4.7.4 Specification of turbocharger

Actuator set pressure	1 mm point	120 to 130 kPa 1.23 to 1.32 kgf/cm^2 17.4 to 18.8 psi

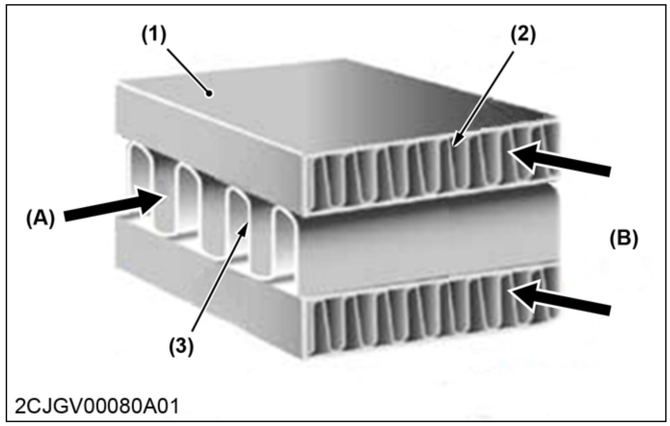
4.8 Intercooler

4.8.1 Outline of intercooler

The intercooler uses outdoor air temperature to cool air compressed in the turbocharger whose temperature has risen.

4.8.2 Structure of intercooler

The intercooler is made up of a core (inner fins) and heat dissipating fins.



(1)	Core	(A)	Running wind
(2)	Inner fin	(B)	Intake air
(3)	Radiating fine		

4.8.3 Function of intercooler

Intake air is compressed and its temperature rises as it passes through the turbocharger.
The intercooler is designed to contact outside air passed through or from the fan and cools the high temperature intake air utilizing this outside air increasing the intake air density.

4.8.4 Specification of intercooler

Cooling method	Air cooled

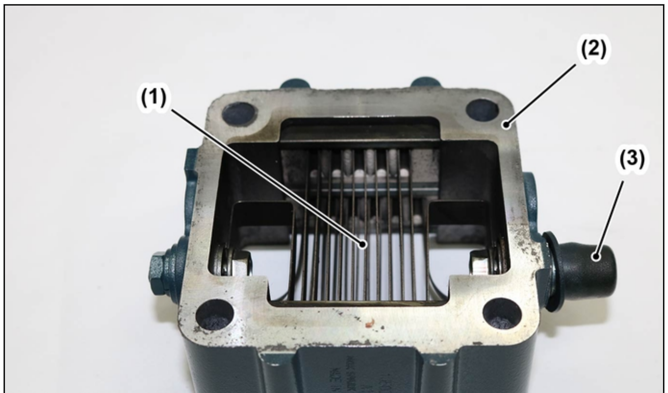
4.9 Intake air heater

4.9.1 Outline of intake air heater

The intake air heater warms intake air to help with starting.

4.9.2 Structure of intake air heater

The intake air heater is made up of a heater body and heater element.



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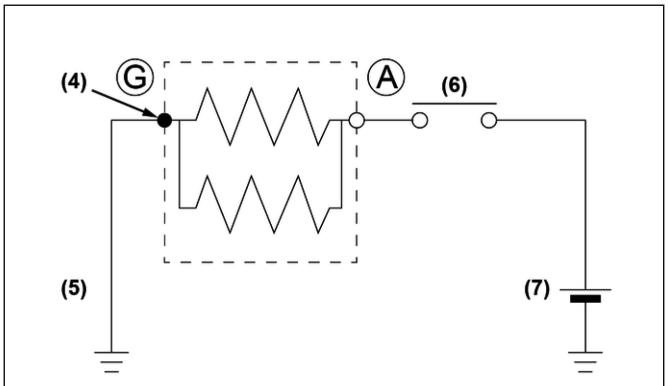

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(1) Heater element
(2) Intake air heater body
(3) +terminal
(4) Body earth
(5) Harness
(6) Relay
(7) 12 V

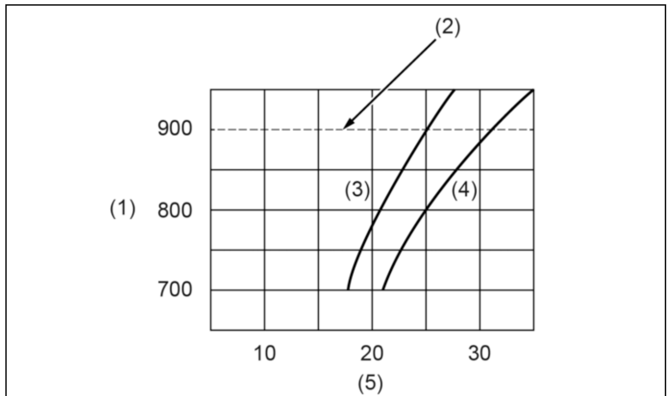
4.9.3 Function of intake air heater

The intake air heater warms intake air improving startability when it is cold.
This also prevents discharge of white smoke generated due to reduction in cetane number (fuel ignitability).

4.9.4 Specification of intake air heater

Voltage at rated operation	DC 11 V, 90 to 110 A (5 seconds after being energized)
Energization time (pre-heat, no wind)	30 seconds or less

Temperature rise characteristics



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(1) Heater temperature (℃)
(2) Energization limit temperature
(3) Case of 12 V
(4) Case of 11 V
(5) Time (sec.)

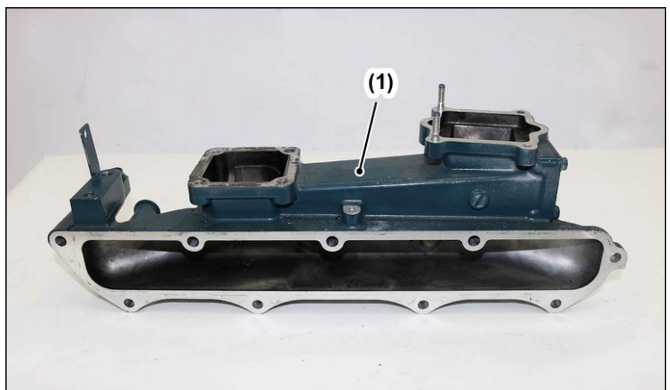
4.10 Intake manifold

4.10.1 Outline of intake manifold

The intake manifold efficiently distributes intake air to each cylinder.

4.10.2 Structure of intake manifold

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



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(1) Intake manifold

4.10.3 Function of intake manifold

The intake manifold efficiently distributes intake air to each cylinder.

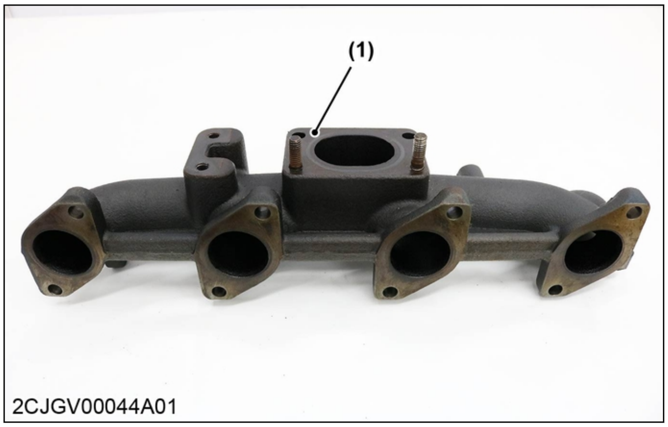
4.11 Exhaust manifold

4.11.1 Outline of exhaust manifold

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

4.11.2 Structure of exhaust manifold

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



(1) Exhaust manifold

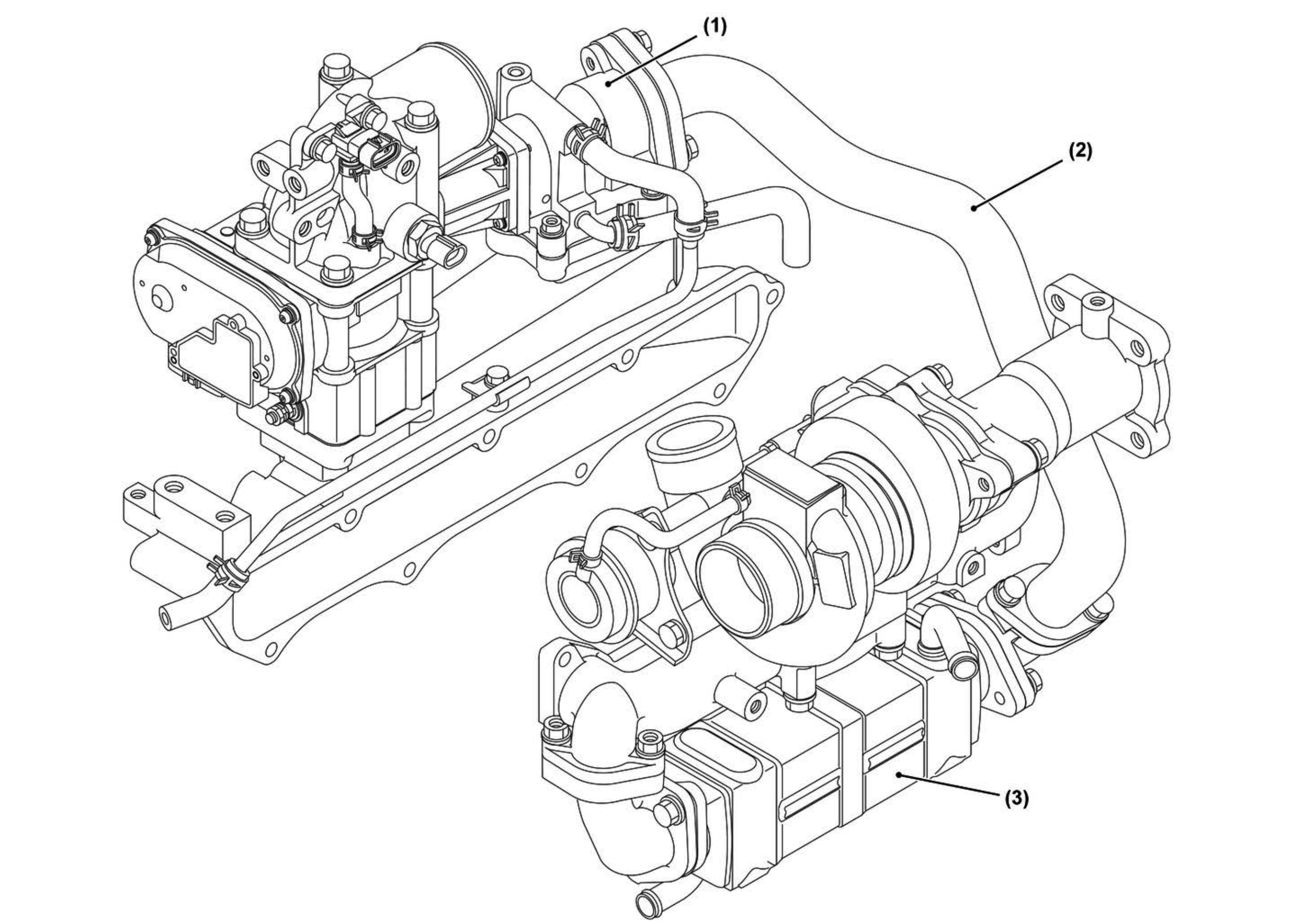
4.11.3 Function of exhaust manifold

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

5. Exhaust gas recirculation (EGR) system

5.1 Structure of EGR system

The EGR system is made up of the EGR valve, cooler, and pipe.



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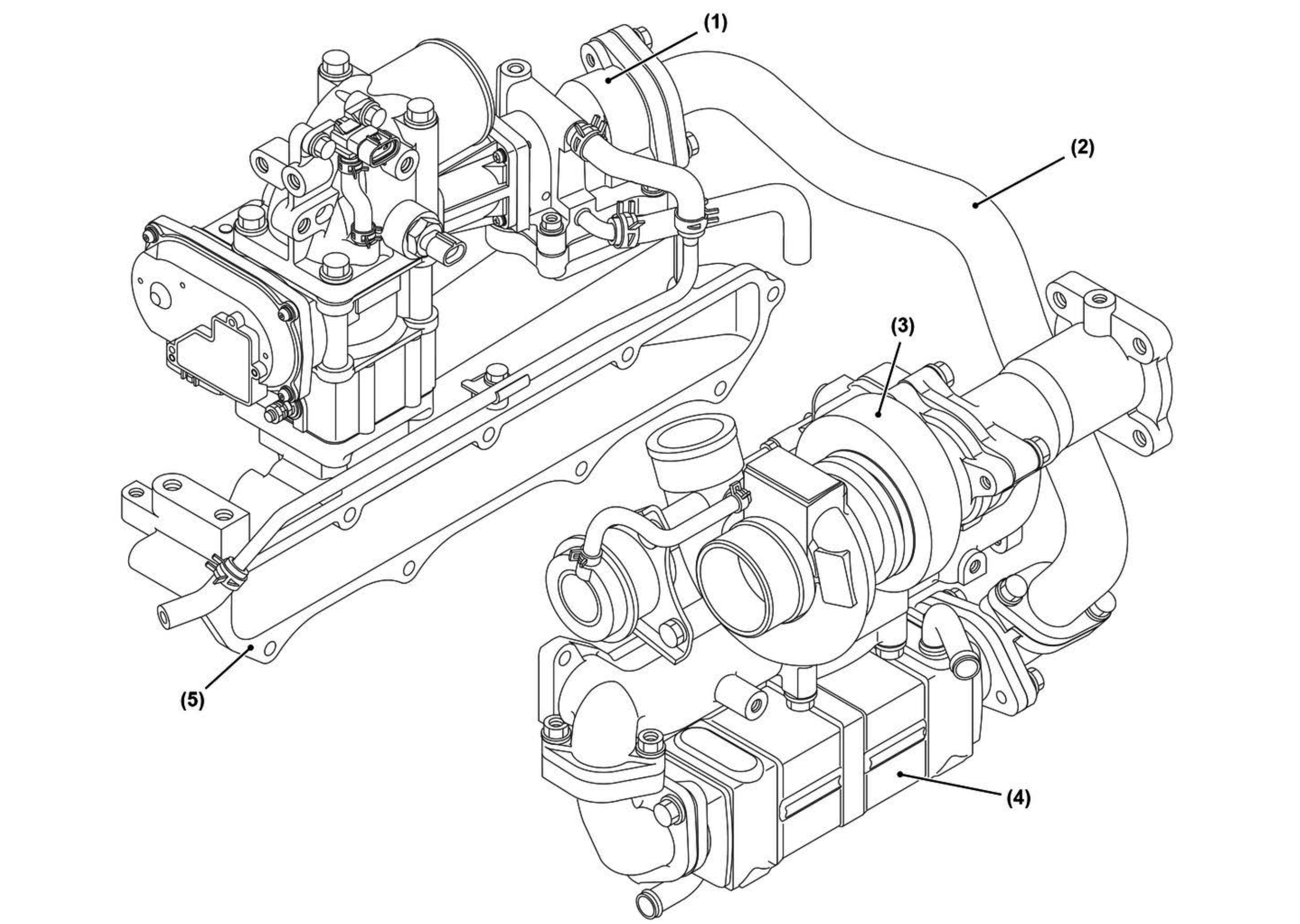
(1) EGR valve (2) EGR pipe (3) EGR cooler

5.2 Feature of EGR system

The primary purpose of the EGR system is to reduce NOx in the exhaust gases.
NOx is generated through combustion at high temperature.
Combustion chamber temperature is lowered by the EGR system to reduce NOx.
Exhaust gases include components with high thermal capacity.
Returning a part of the exhaust gases to the combustion chamber enables reducing the combustion chamber temperature.
The amount of exhaust gas returned to the combustion chamber is controlled using the amount the EGR valve is opened.

5.3 Flow of EGR system



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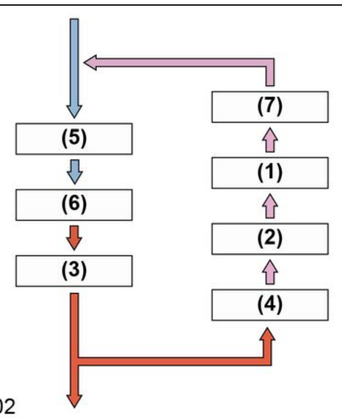

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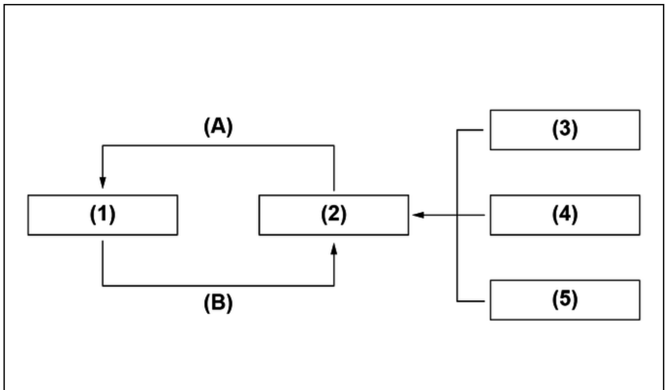
(1) EGR valve
(2) EGR pipe
(3) Turbocharger
(4) EGR cooler
(5) Intake manifold
(6) Combustion chamber
(7) Reed valve

1. A part of the exhaust gases that pass through the turbocharger (3) are cooled in the EGR cooler (4).
2. Thereafter the gases pass through the EGR pipe (2), EGR valve (1), reed valve (7), and are returned to the intake manifold (5).
3. Intake air and recirculation gases are mixed in the intake manifold (5) and are fed to the combustion chamber (6).

5.4 Control of EGR system

<System control diagram> / System schematics



2CJGV00095A01

(1) EGR valve
(2) Engine ECU
(3) Coolant temperature sensor
(4) Air flow sensor
(5) Others
(A) Opening instruction
(B) Valve position sensor value

The ECU controls the amount the EGR valve is open based on the coolant temperature sensor and air flow sensor etc. values.
The EGR valve is wide open at coolant temperatures lower than 65 ℃ (149 ℉) and starts to close at coolant temperatures of 65 ℃ (149 ℉)and higher.
When a DTC is occurred, one system action is to force closure of the EGR valve.

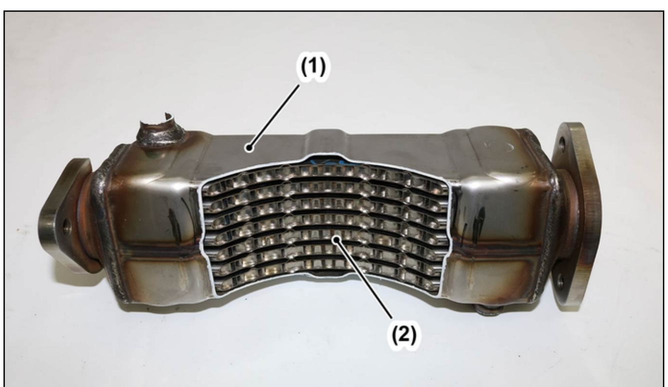
5.5 EGR cooler

5.5.1 Outline of EGR cooler

The EGR cooler cools the exhaust gas.
This suppresses generation of nitrogen oxides (NOx) by reducing combustion temperature.

5.5.2 Structure of EGR cooler

The EGR cooler is made up of the cooler and tubes.



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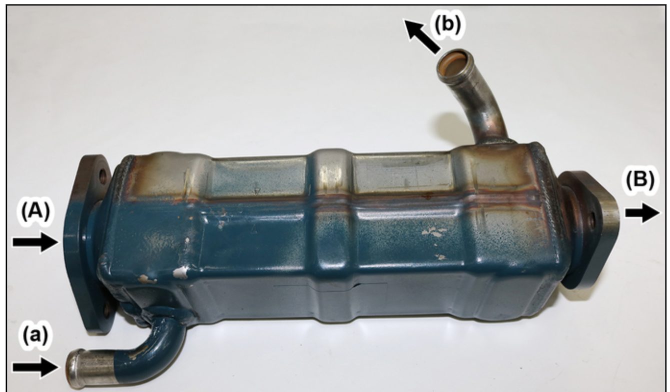

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(1) EGR cooler
(2) Tubes
(A) Exhaust gas inlet
(B) Exhaust gas outlet
(a) Coolant inlet
(b) Coolant outlet

5.5.3 Function of EGR cooler

The EGR cooler cools the exhaust gas.
Exhaust gas passes through narrow tubes provided in the cooler and cools the area around these with engine coolant to lower the temperature of the exhaust gas.
This enables preventing rise in intake air temperature.
As a result, this suppresses generation of nitrogen oxides by reducing combustion temperature.

5.5.4 Specification of EGR cooler

Cooling method	Water cooled	
Cooling performance	Exhaust gas inlet temperature	600 ℃ 1112 ℉
	Exhaust gas outlet temperature	137 to 169 ℃ 279 to 336 ℉

*Initial cooling performance with new parts.

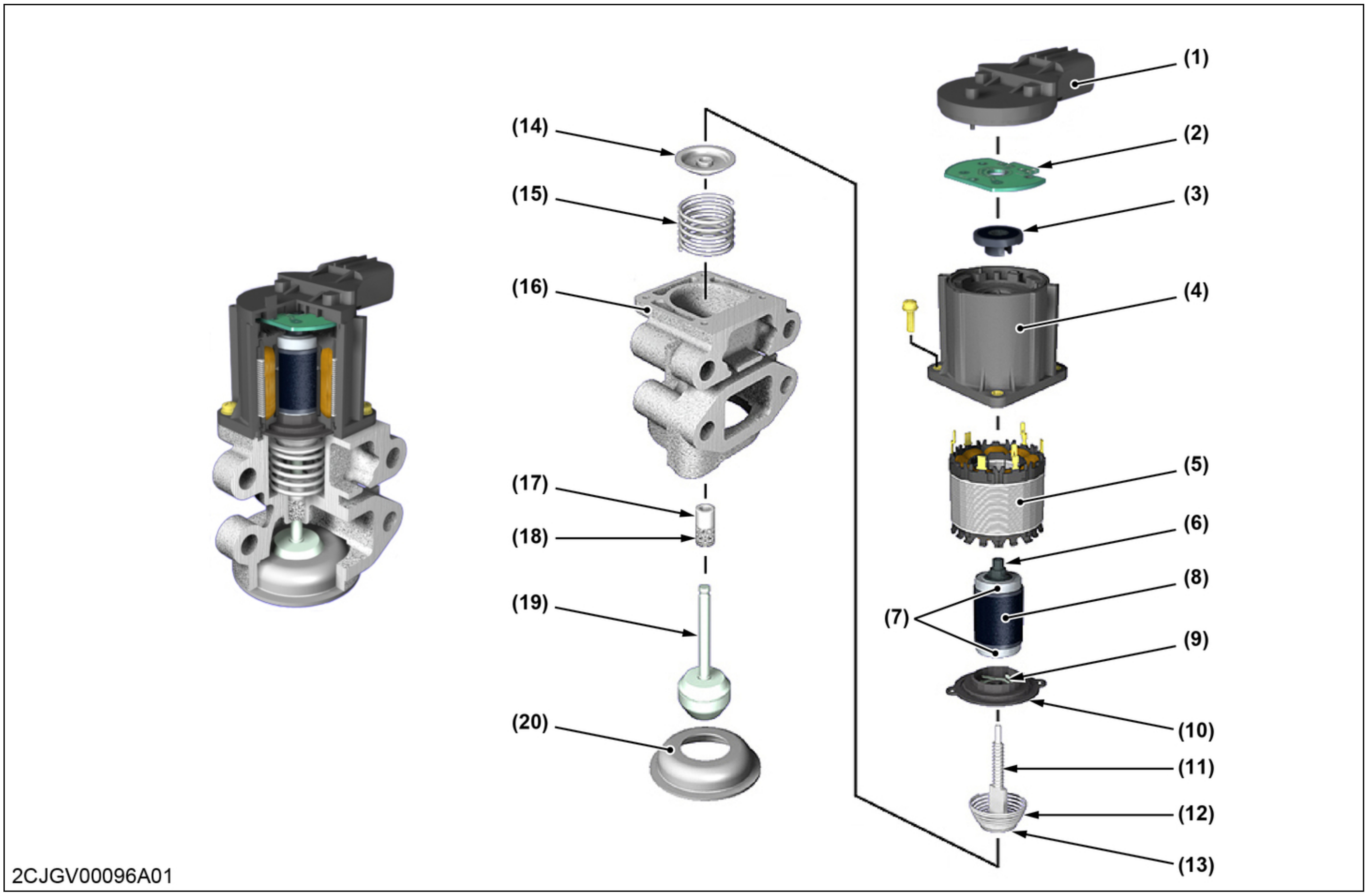
5.6 EGR valve

5.6.1 Outline of EGR valve

The EGR valve regulates recirculation gas volume.

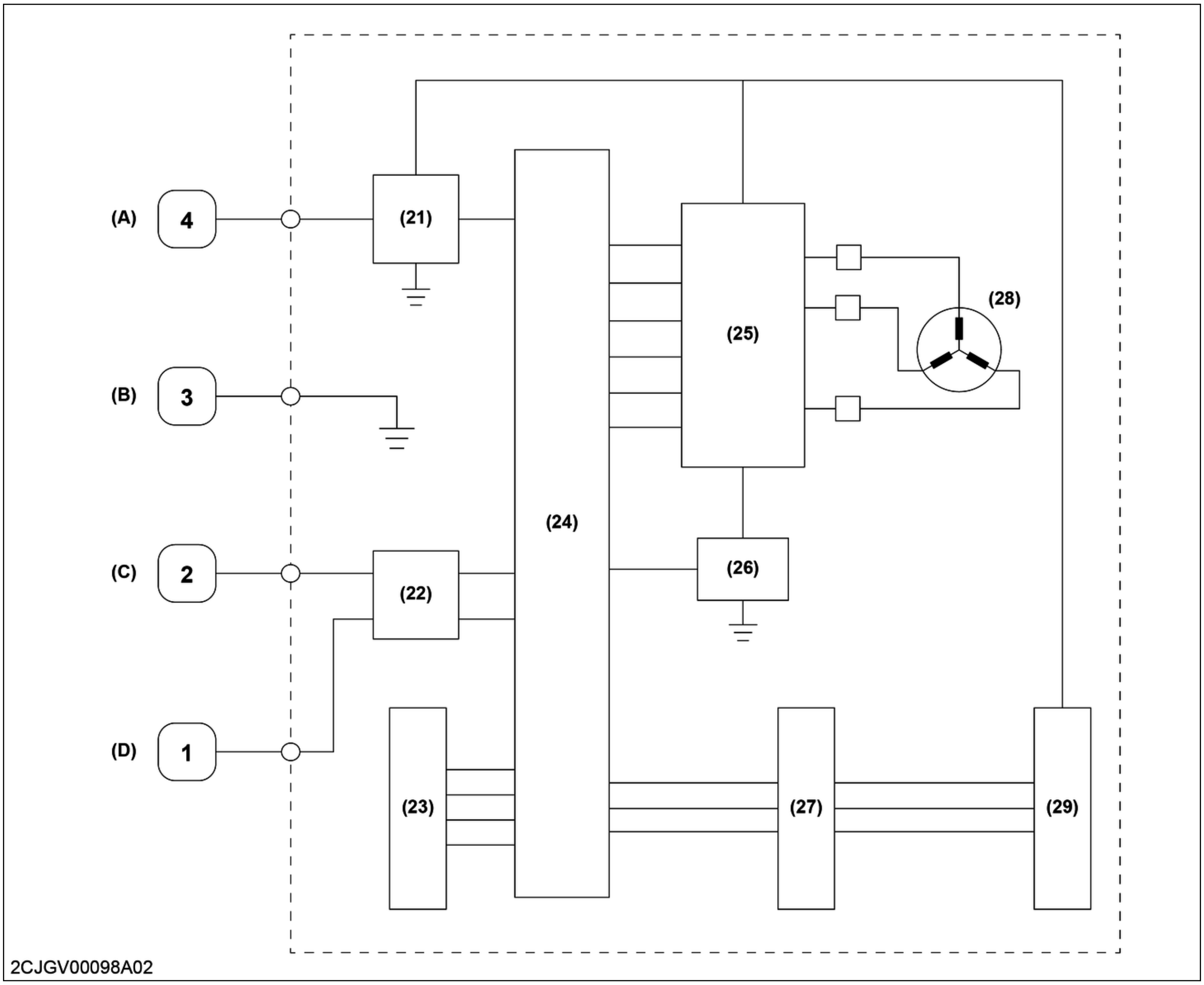
5.6.2 Structure of EGR valve

The EGR valve is made up of a lift sensor, motor, and valve.



(1) Connector	(6) Rotor	(11) Shaft	(16) Housing
(2) Circuit board	(7) Bearing	(12) Assist Spring	(17) Bush
(3) Magnet	(8) Magnet	(13) Spring holder	(18) Filter
(4) Motor exterior	(9) Washer	(14) Spring holder	(19) Valve assembly
(5) Bent core	(10) Boss	(15) Spring	(20) Valve seat

Wiring diagram



(21) Power supply circuit unit
(22) CAN I/F circuit unit
(23) EEPROM
(24) Micro computer
(25) Motor drive circuit unit
(26) Overcurrent detection circuit unit
(27) Hall-IC I/F circuit unit
(28) Brush less motor
(29) Hall-IC
(A) Power
(B) GND
(C) CAN L
(D) CAN H

5.6.3 Function of EGR valve

The EGR valve regulates recirculation gas volume.
The EGR valve position is detected using the lift sensor.
The lift sensor is a non contact type sensor made up of 3 ICs (hall switches) with hall elements embedded and a magnet for position detection.
As the rotor rotates and the magnet for position detection passes, on/off signals are output from each hall switch.
Built in microcomputer in the EGR valve input output signals from each of the hall switches and detect the valve position.
The valve position detected by the microcomputer is converted to a CAN signal and transferred to the engine ECU.
The EGR valve motor is a brushless type DC motor.
Built in microcomputer in the EGR valve controls the rotor to provide the position specified by the engine ECU.
Built in microcomputer in the EGR valve input output signals from each of the hall switches and detect the valve position.
The microcomputers drive the rotor by turning energization on/off of coils arranged on the outer circumference at set timing.

5.6.4 Specification of EGR valve

Cooling method	Water cooled

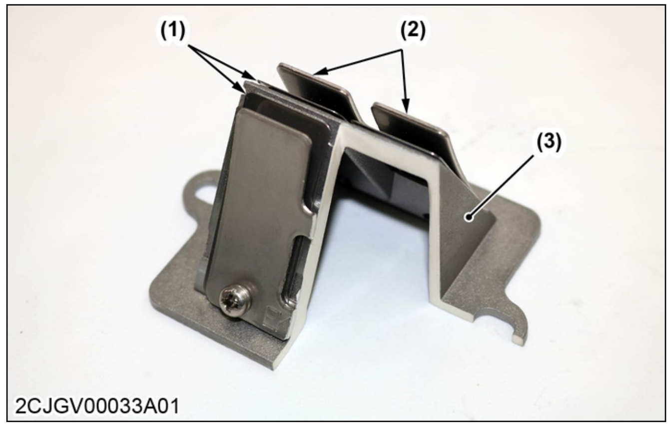
5.7 Reed valve

5.7.1 Outline of reed valve

The reed valve prevents backflow of intake air into the EGR cooler.

5.7.2 Structure of reed valve

The reed valve is made up of a valve, case, and stopper.



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

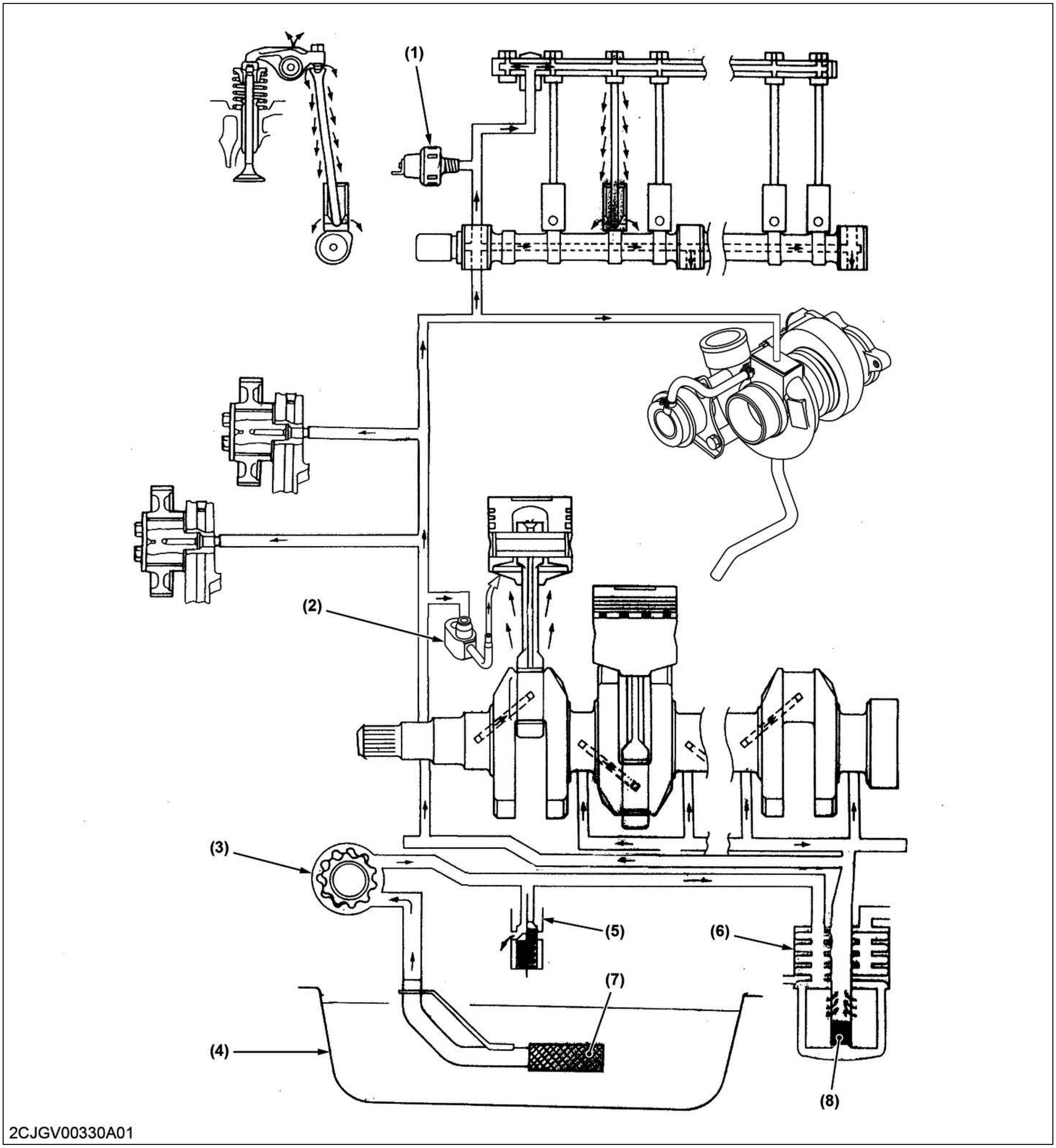
5.7.3 Function of reed valve

The reed valve prevents backflow of intake air into the EGR cooler while supercharging.
The valve is designed to close during the intake stroke and open during the exhaust stroke.

6. Lubricating system

6.1 Structure of lubricating system

The lubrication system is made up of an oil pump and oil filter and the like.



(1) Oil switch	(3) Oil pump	(5) Relief valve	(7) Oil strainer
(2) *Oil jet	(4) Oil pan	(6) Oil cooler	(8) Oil filter

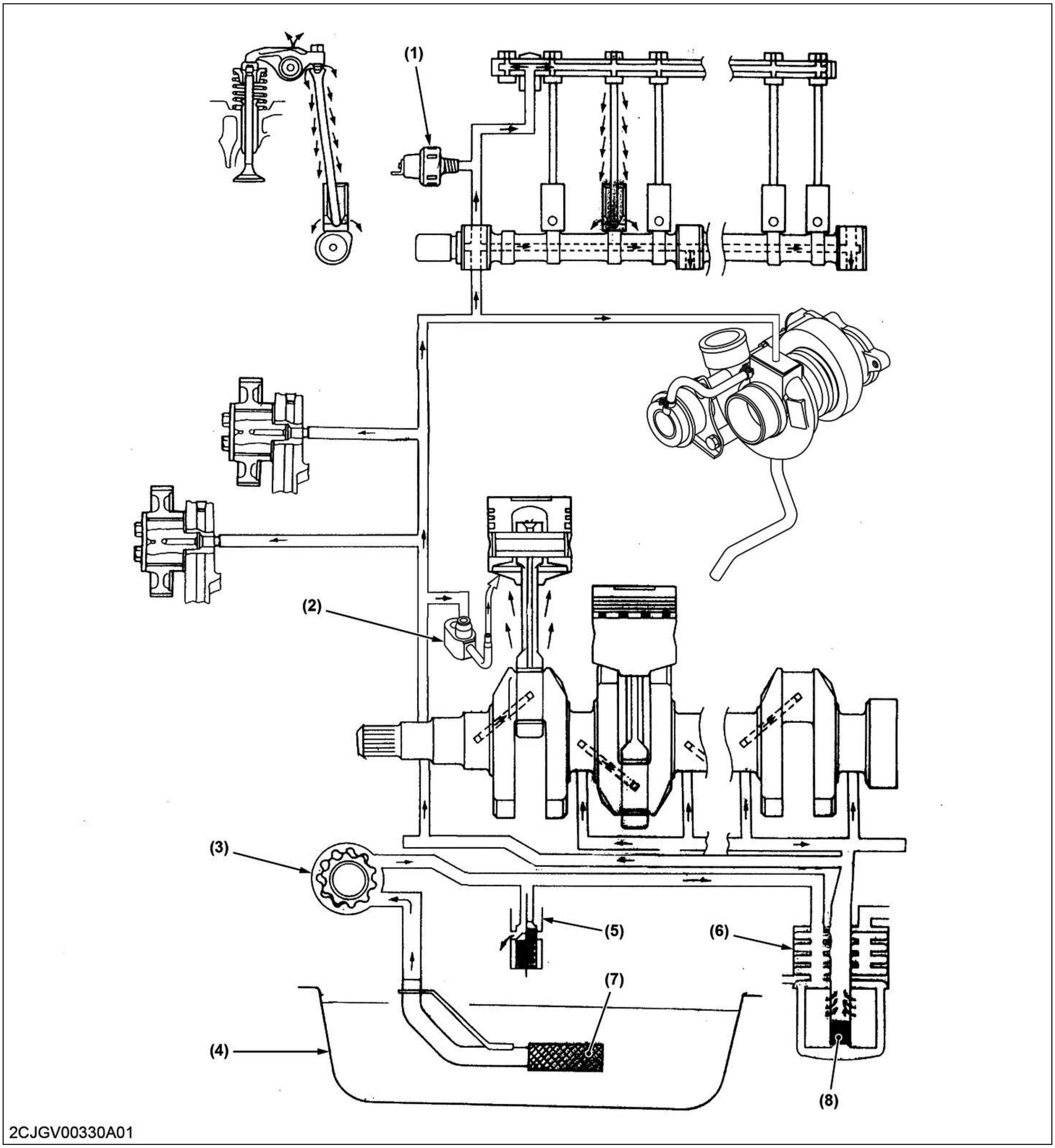
■ **NOTE**

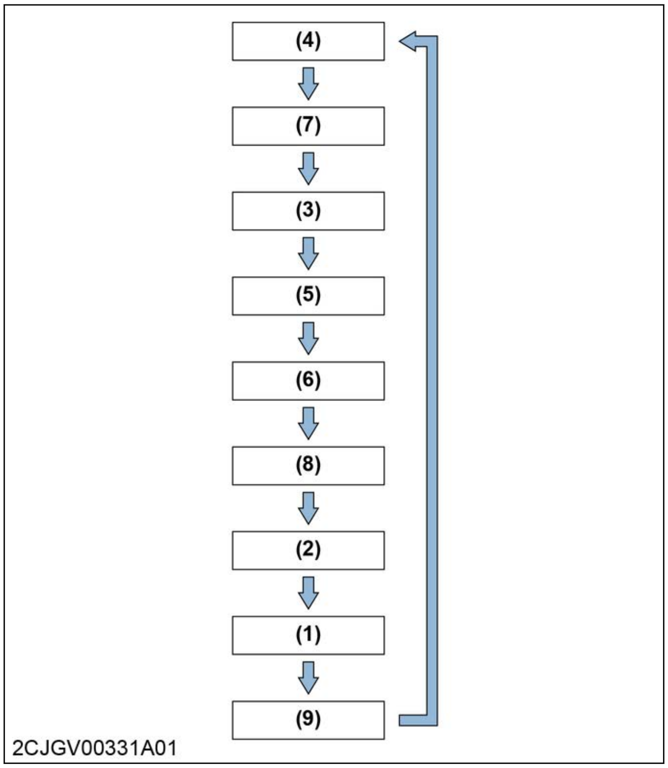
- **The parts marked with * are only for V3800-TIEF4H.**

6.2 Feature of lubricating system

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

6.3 Flow of lubricating system





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

■ **NOTE**

- **The parts marked with * are only for V3800-TIEF4H.**

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

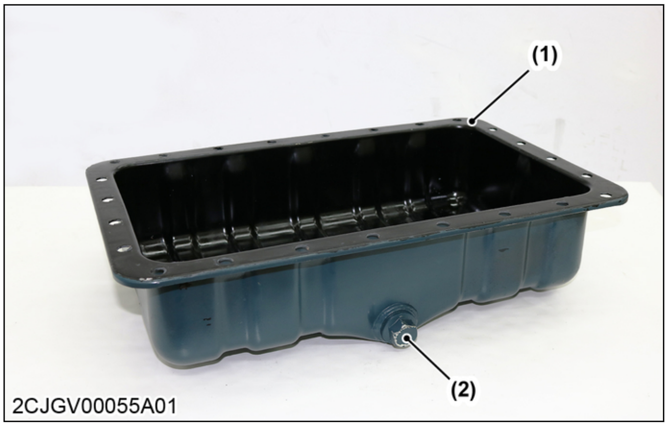
6.4 Oil pan

6.4.1 Outline of oil pan

The oil pan stores oil in the engine.

6.4.2 Structure of oil pan

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



(1) Oil pan (2) Drain plug

6.4.3 Function of oil pan

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

6.4.4 Specification of oil pan

Amount of oil	V3800-TIEF4 V3800-TIEF4C	13.2 L 3.49 U.S.gals 2.90 Imp.gals
	V3800-TIEF4H	16.5 L 4.36 U.S.gals 3.63 Imp.gals
Liquid gasket		Three Bond 1217H

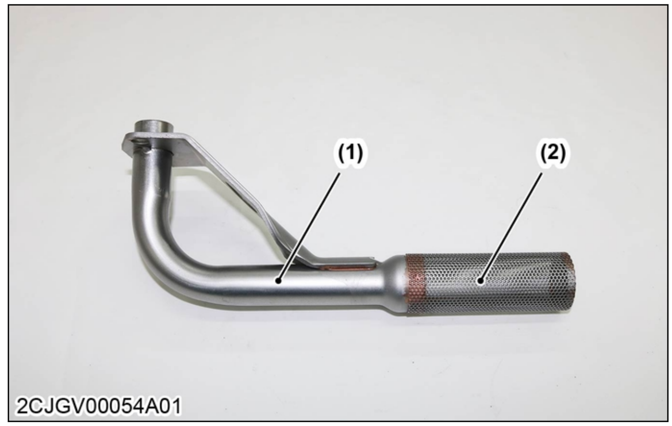
6.5 Oil strainer

6.5.1 Outline of oil strainer

The oil strainer removes foreign material from the oil.

6.5.2 Structure of oil strainer

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



(1) Oil strainer (2) Mesh

6.5.3 Function of oil strainer

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

6.5.4 Specification of oil strainer

Mesh pore size	1.5 mm 0.059 in.

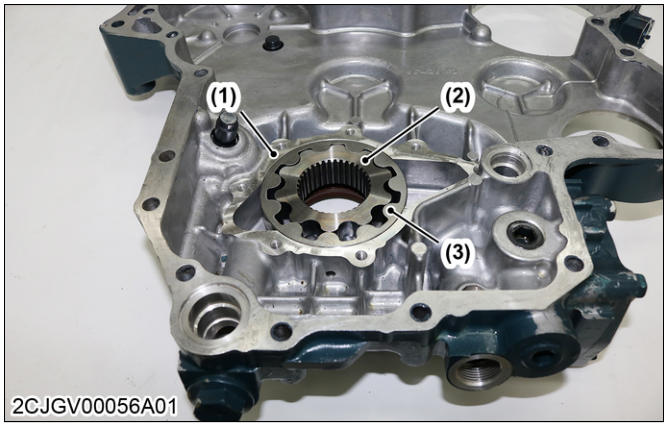
6.6 Oil pump

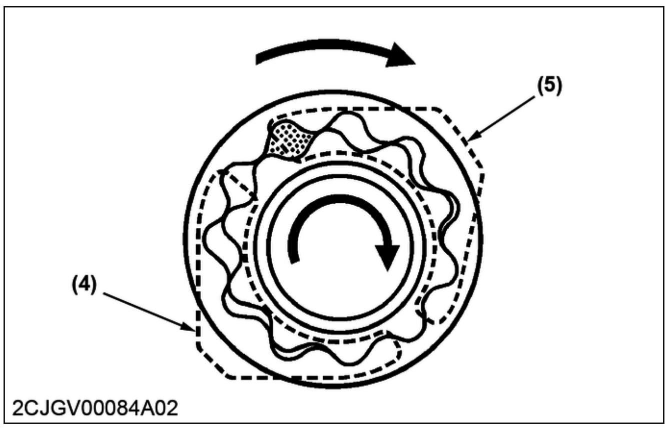
6.6.1 Outline of oil pump

The oil pump feeds suctioned oil to various parts.

6.6.2 Structure of oil pump

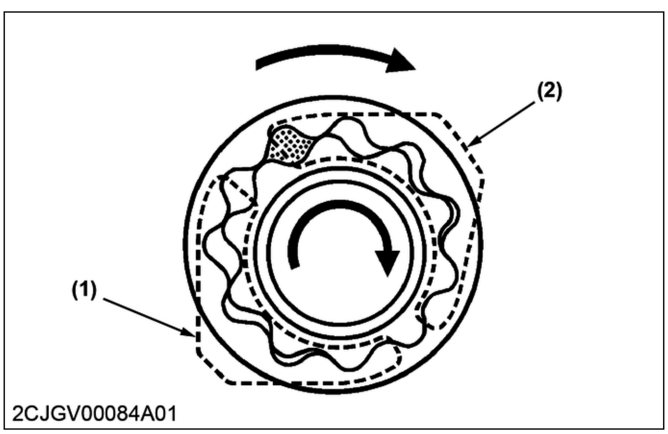
The oil pump is made up of a body, inner rotor, and outer rotor etc.





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

6.6.3 Function of oil pump



(1) Inlet port
(2) Outlet port

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

6.6.4 Specification of oil pump

Item		Specification
Pump type		Trochoid
Number of teeth	Inner rotor	10
	Outer rotor	11
Theoretical discharge volume	V3800-TIEF4 V3800-TIEF4C	22.8 cc/rev
	V3800-TIEF4H	34.0 cc/rev

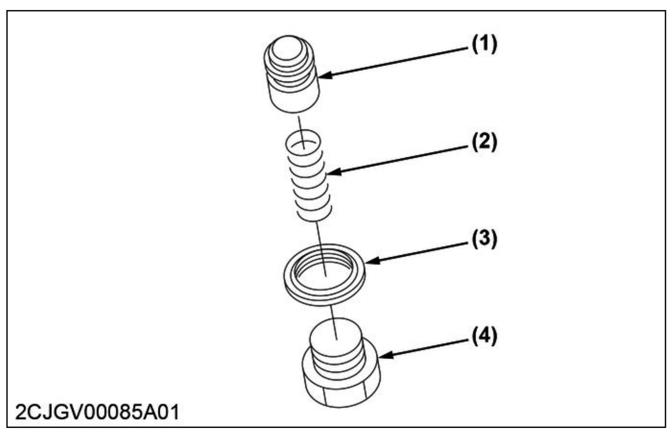
6.7 Relief valve

6.7.1 Outline of relief valve

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

6.7.2 Structure of relief valve

The relief valve prevents the damage of the lubricating system due to high oil pressure.
The relief valve is made up of a spring and plug etc.



(1) Relief valve
(2) Spring
(3) Packing
(4) Relief valve retaining plug

6.7.3 Function of relief valve

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

6.7.4 Specification of relief valve

Opening pressure	290 kPa* 3.0 kgf/cm2* 43 psi*

* This value is measured by oil switch attachment point and the measurement condition is below.

NOTE
- **Rated speed**
- **Without balancer**
- **Oil temperature is between 90 to 100 ℃ (194 to 212 ℉)**

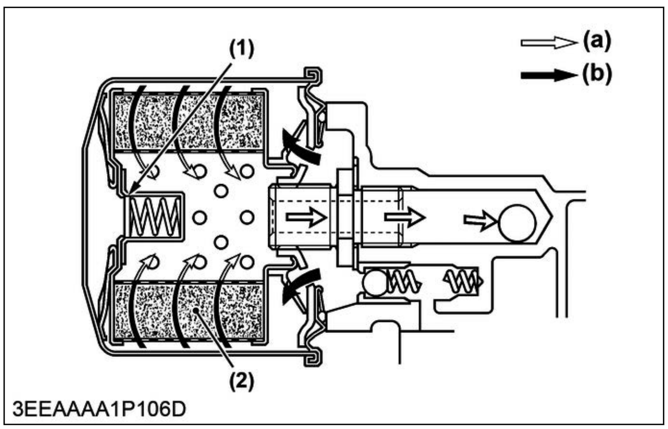
6.8 Oil filter

6.8.1 Outline of oil filter

The oil filter removes foreign material in the engine oil.

6.8.2 Structure of oil filter

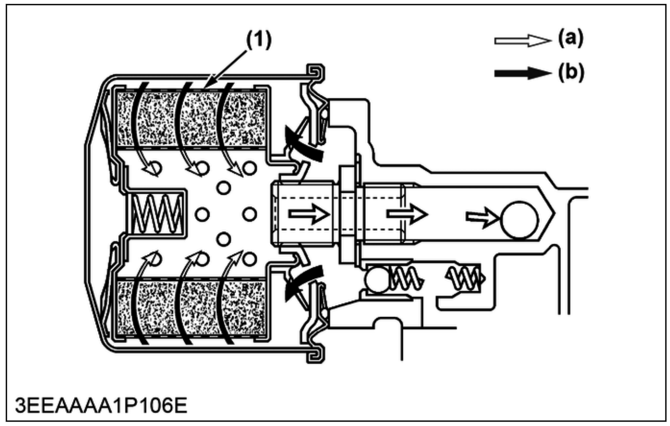
The oil filter is made up of a bypass valve and element.



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

6.8.3 Function of oil filter

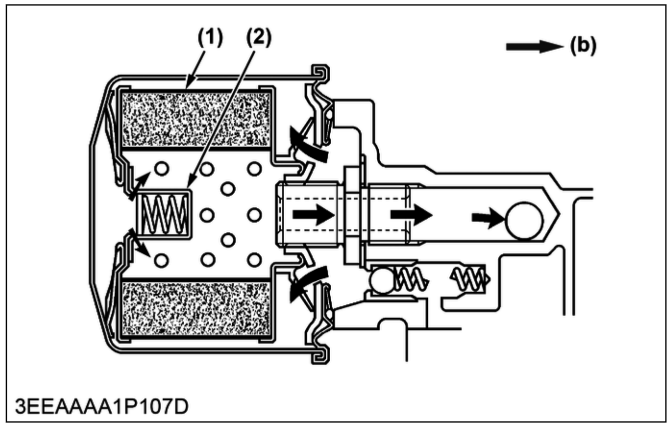
[Normal State]



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

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

[When element is clogged]



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

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

6.8.4 Specification of oil filter

Bypass valve open pressure	Approx. 157 kPa Approx. 1.60 kgf/cm2 Approx. 22.8 psi

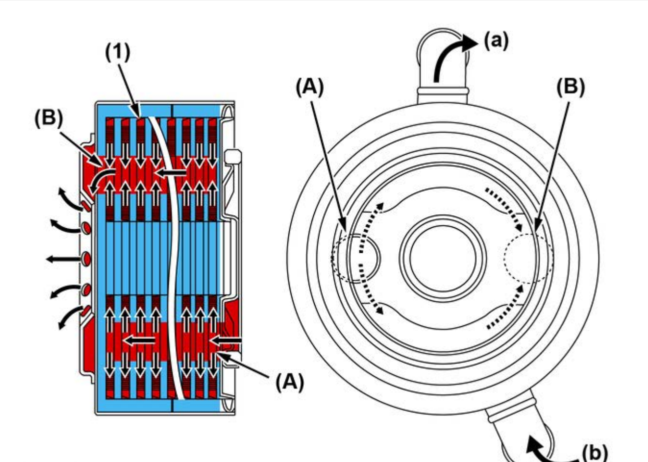
6.9 Oil cooler

6.9.1 Outline of oil cooler

The oil cooler suppresses excessive oil temperature while the engine is running through cooling.

6.9.2 Structure of oil cooler

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



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

6.9.3 Function of oil cooler

The oil cooler has the role of suppressing excessive oil temperature while the engine is running through cooling.
Also, this has the role of warming a cool engine just after starting.
In water cooled oil coolers, engine oil flows on the inside of the cooler plate and the engine oil is cooled or warmed by the coolant flowing on the outside of the cooler plate.

6.9.4 Specification of oil cooler

Cooling method	Water cooled

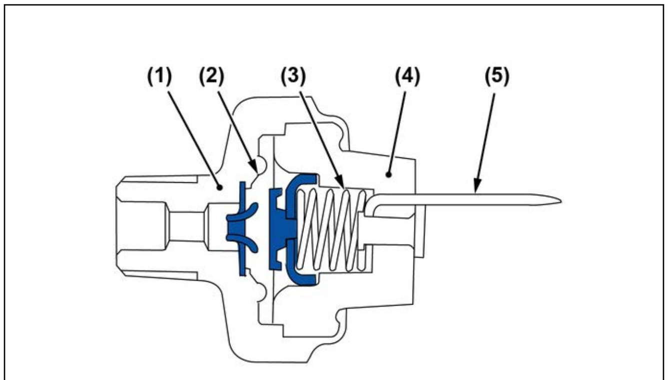
6.10 Oil switch

6.10.1 Outline of oil switch

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

6.10.2 Structure of oil switch

The oil switch is made up of a body, diaphragm, and spring and the like.



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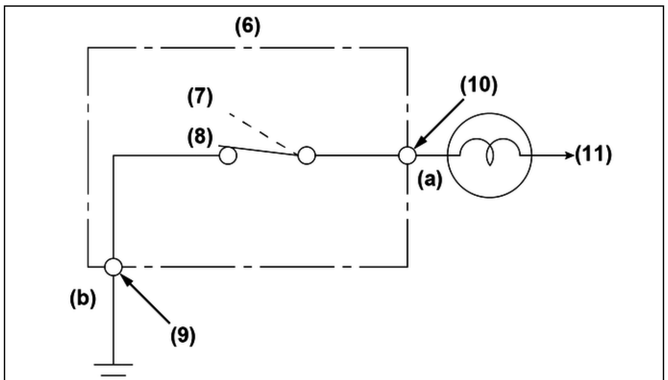
(1) Body
(2) Diaphragm
(3) Spring
(4) Insulator
(5) Terminal

Circuit diagram and connection table



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

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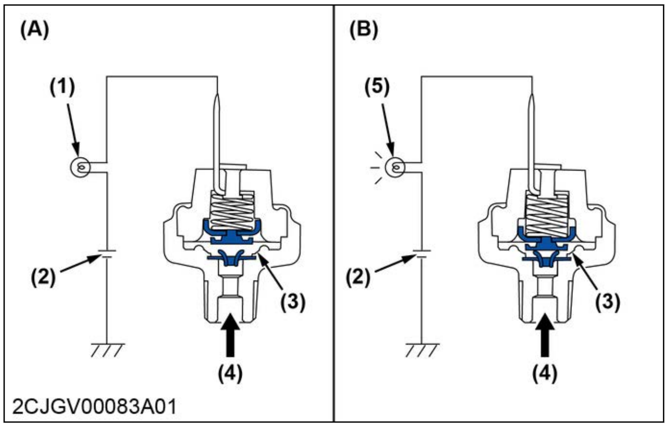
(6) Oil pressure switch
(7) Pressurization
(8) Atmospheric pressure
(9) Mounting screw part
(10) Terminal
(11) IG

6.10.3 Function of oil switch



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

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

While normal (oil pressure is within specified range)

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

When abnormal (oil pressure is less than specified range)

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

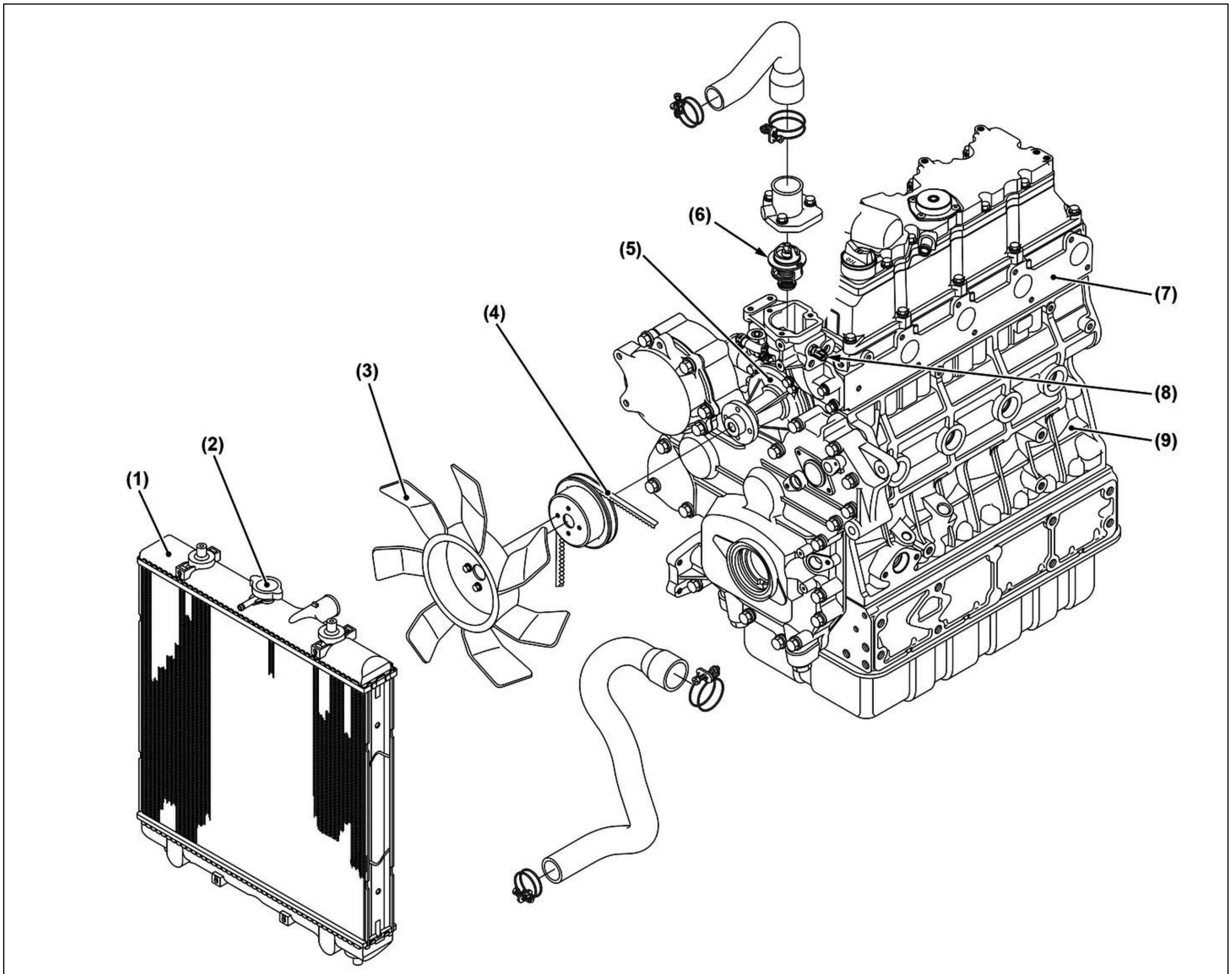
6.10.4 Specification of oil switch

Rated voltage		12 V
Operating pressure		68.60 to 127.4 kPa 0.6996 to 1.299 kgf/cm^2 9.950 to 18.47 psi
Rated oil pressure	V3800-TIEF4 V3800-TIEF4C	200 to 390 kPa 2.0 to 4.0 kgf/cm^2 29 to 56 psi
	V3800-TIEF4H	200 to 450 kPa 2.0 to 4.6 kgf/cm^2 29 to 65 psi

7. Cooling system

7.1 Structure of cooling system

The cooling system is made up of a radiator, water pump, cooling fan and the like.



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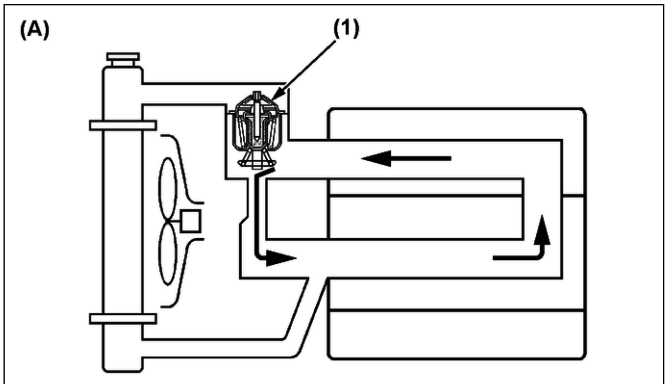
(1)	Radiator	(4)	Fan belt	(7)	Cylinder head
(2)	Radiator cap	(5)	Water pump	(8)	Coolant temperature sensor
(3)	Cooling fan	(6)	Thermostat	(9)	Crankcase

7.2 Feature of cooling system

The cooling system prevents overheating while the engine is running and maintains coolant temperature at a suitable temperature during operation.
KUBOTA engines use a cooling system with forced circulation using a water pump.
This series of engines use a bottom bypass system.
The bottom bypass system improves the cooling performance of the radiator.

7.3 Flow of cooling system (Bottom by-pass system)



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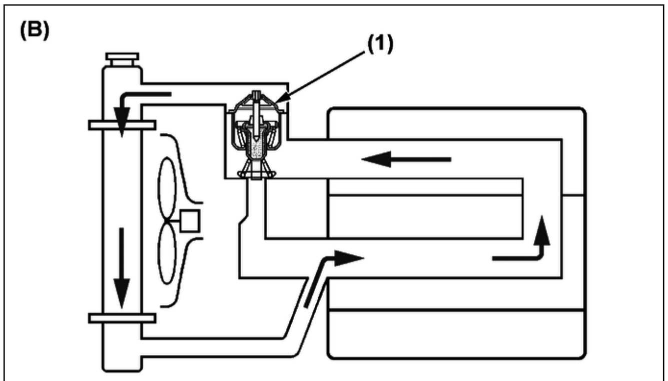

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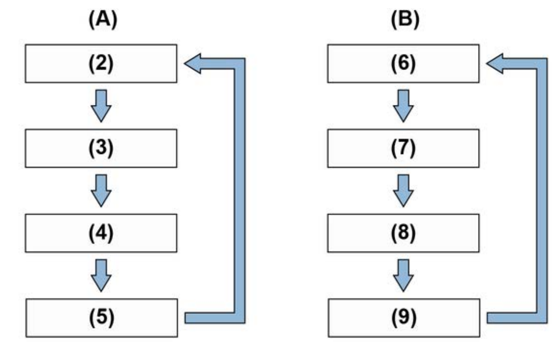
(1) Thermostat
(A) When thermostat closes
(B) When thermostat opens



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(2) Cylinder head
(3) By-pass
(4) Water pump
(5) Crank case
(6) Cylinder head
(7) Radiator
(8) Water pump
(9) Crank case
(A) When thermostat closes
(B) When thermostat opens

(A) When thermostat closes

1. The bypass is open while coolant temperature in the engine is low.
2. Here, coolant circulates in the engine through the bypass.

(B) When thermostat opens

1. When coolant temperature reaches the thermostat valve open temperature, the valve closes the bypass.
2. As the bypass is closed, warmed coolant flows to the radiator and is cooled.
3. Coolant that has been cooled in the radiator is returned to the engine by the water pump.

7.4 Control of cooling system (Bottom by-pass system)

The cooling system includes a coolant temperature sensor that fulfills the following roles.

1. Suppressing overheating of engine.
2. Conditions during difference learning of the supply pump device (coolant temperature 65 degrees or higher).
3. Conditions for regeneration of the DPF (coolant temperature 50 degrees or higher).

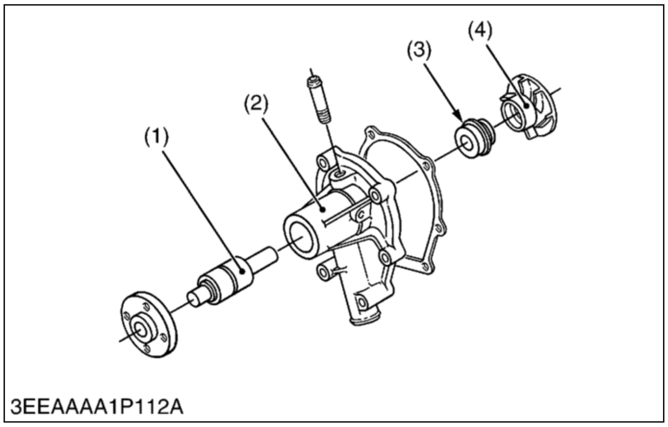
7.5 Water pump

7.5.1 Outline of water pump

The water pump force circulates coolant inside the system.

7.5.2 Structure of water pump

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



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

7.5.3 Function of water pump

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

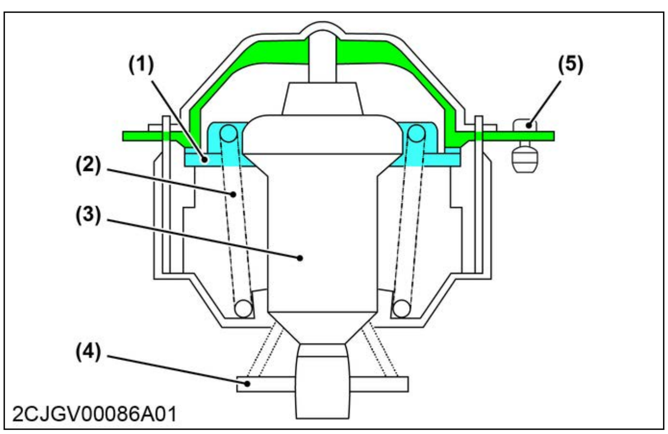
7.6 Thermostat

7.6.1 Outline of thermostat

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

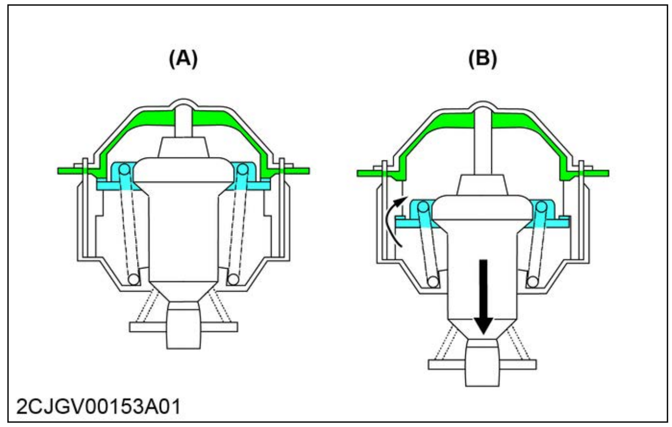
7.6.2 Structure of thermostat

The thermostat is made up of a pellet, bypass valve, and spring and the like.



(1) Valve
(2) Spring
(3) Pellet
(4) Bypass valve
(5) Jiggle valve

7.6.3 Function of thermostat



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

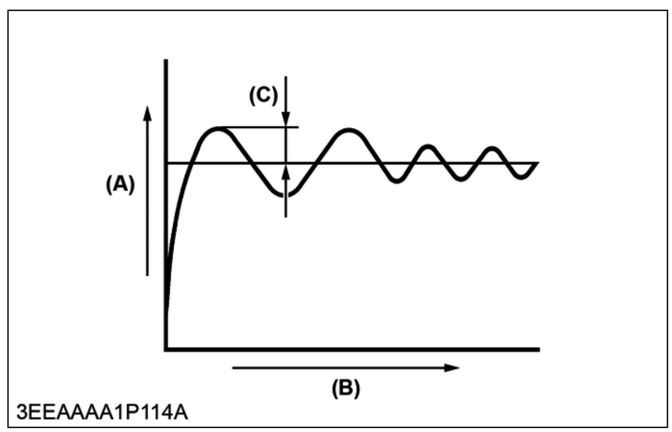
The thermostat opens and closes the coolant path based on the engine coolant temperature to maintain suitable temperature.

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

The wax inside the pellet is solidified so that the valve of the thermostat is closed by the spring.
Also, the bypass part is opened by the bypass valve.

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

The wax inside the pellet liquefies and expands pushing down the valve and opening the thermostat.
Here, the bypass valve closes the bypass part.
The jiggle valve is a valve to prevent build up of air inside the thermostat.



(A) Coolant temperature
(B) Time (min)
(C) Overshoot

7.6.4 Specification of thermostat

Coolant suitable temperature	80 to 90 ℃ 176 to 194 ℉

Code number	Model	Valve opening temperature	Valve full-open temperature
1C011-73012	V3800-TIEF4 V3800-TIEF4C	74.5 to 78.5 ℃ 166.1 to 173.3 ℉	90 ℃ 194 ℉
1J507-73011	V3800-TIEF4H		

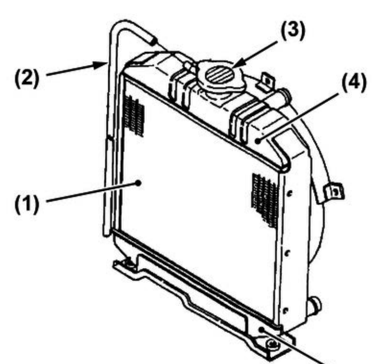
7.7 Radiator

7.7.1 Outline of radiator

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

7.7.2 Structure of radiator

The radiator is made up of an upper tank, lower tank, and core and the like.



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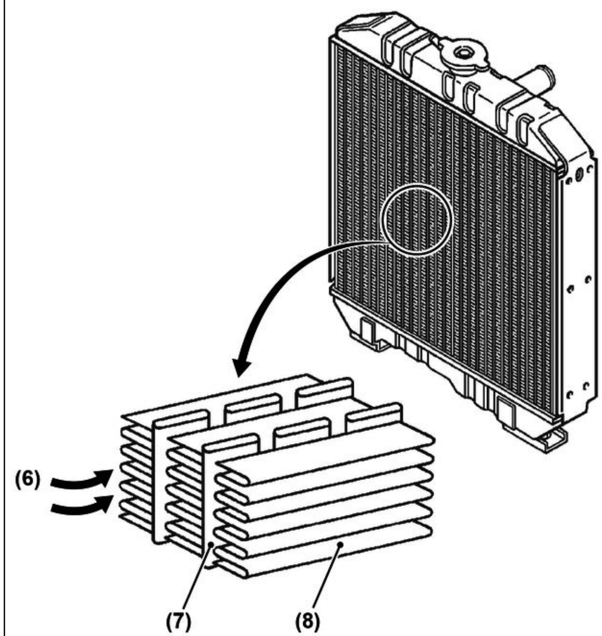

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(1) Core
(2) Overflow pipe
(3) Radiator cap
(4) Upper tank
(5) Lower tank
(6) Cooling air
(7) Tube
(8) Fin

7.7.3 Function of radiator

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

7.7.4 Specification of radiator

(Reference values)

Radiator capacity	4.0 L 1.1 U.S.gals 0.88 Imp.gals
Test pressure	137 kPa 1.40 kgf/cm^2 19.9 psi

*These values may be different depending on the product used

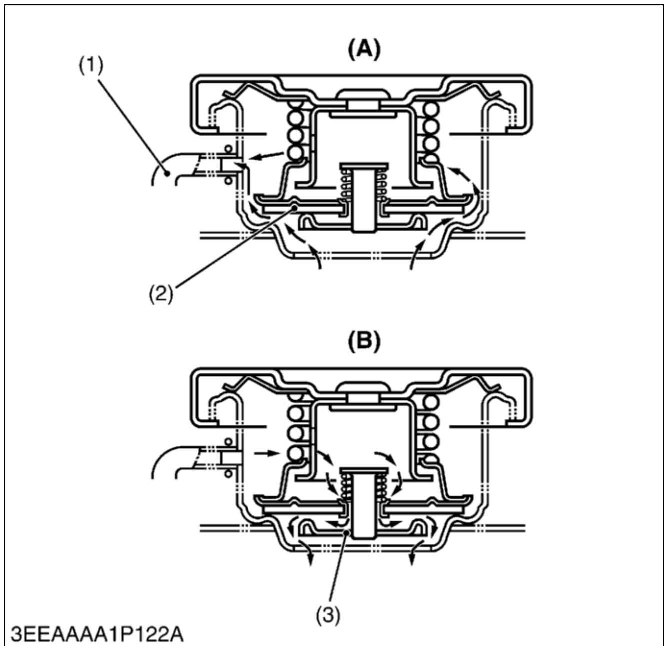
7.8 Radiator cap

7.8.1 Outline of radiator cap

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

7.8.2 Structure of radiator cap

The radiator cap is made up of a pressure valve and vacuum valve and the like.



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

7.8.3 Function of radiator cap

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

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

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

7.8.4 Specification of radiator cap

Pressure valve open pressure	88 kPa 0.90 kgf/cm^2 13 psi

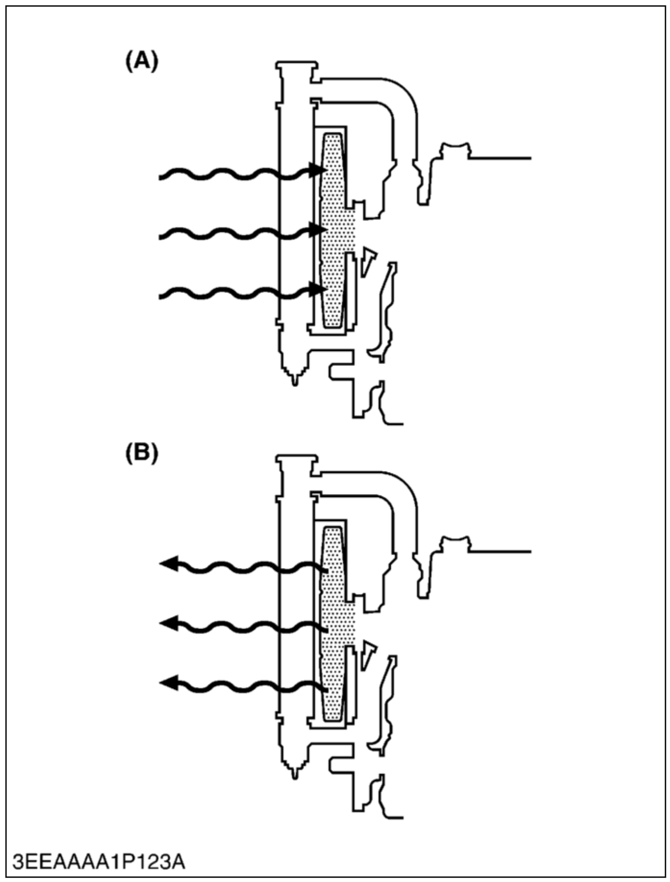
7.9 Cooling fan

7.9.1 Outline of cooling fan

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

7.9.2 Structure of cooling fan

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



(A) Suction type
(B) Blower type

7.9.3 Function of cooling fan

The cooling fan is rotated via the fan belt and fan pulley.
The cooling fan causes outdoor air to pass through the radiator core for cooling.

Cooling performance changes depending on the number of blades, angle of the blades, outer diameter, and rotation speed.

7.9.4 Specification of cooling fan

(Reference values)

Number of blades	V3800-TIEF4, V3800-TIEF4C	7
	V3800-TIEF4H	8
Outer diameter	V3800-TIEF4, V3800-TIEF4C	430 mm 16.9 in.
	V3800-TIEF4H	460 mm 18.1 in.

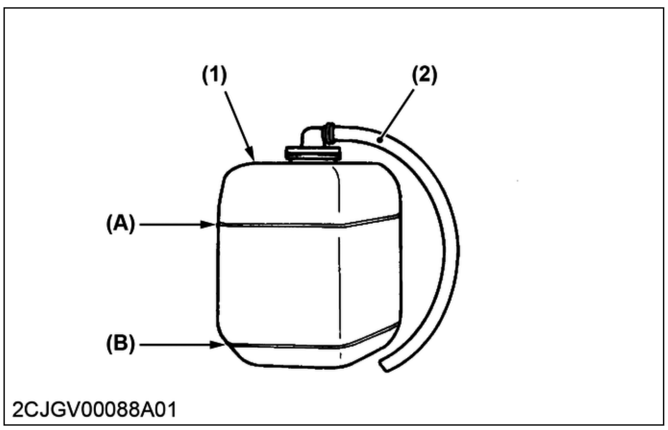
7.10 Reserve tank

7.10.1 Outline of reserve tank

The reserve tank stores coolant discharged from the radiator cap.

7.10.2 Structure of reserve tank

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



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

7.10.3 Function of reserve tank

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

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

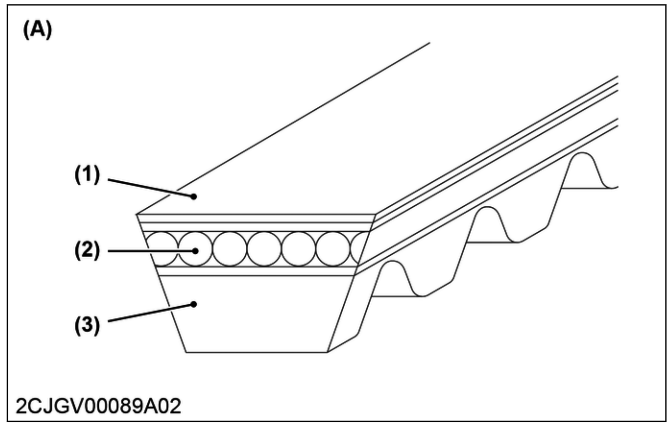
7.11 Fan belt

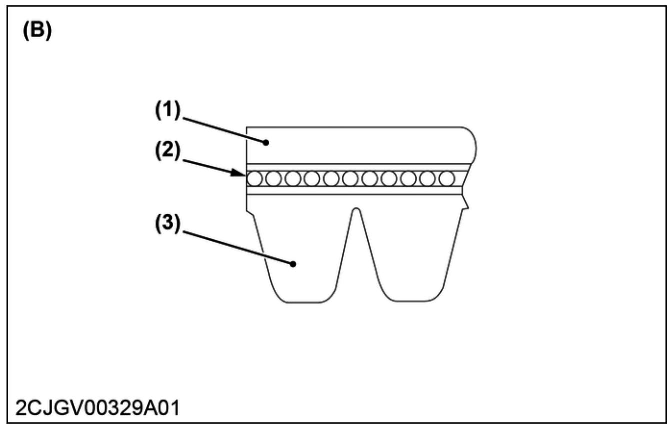
7.11.1 Outline of fan belt

The fan belt drives the cooling fan and alternator.

7.11.2 Structure of fan belt

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





(1) Top fabric
(2) Cord
(3) Rib rubber
(A) V belt
(B) V ribbed belt

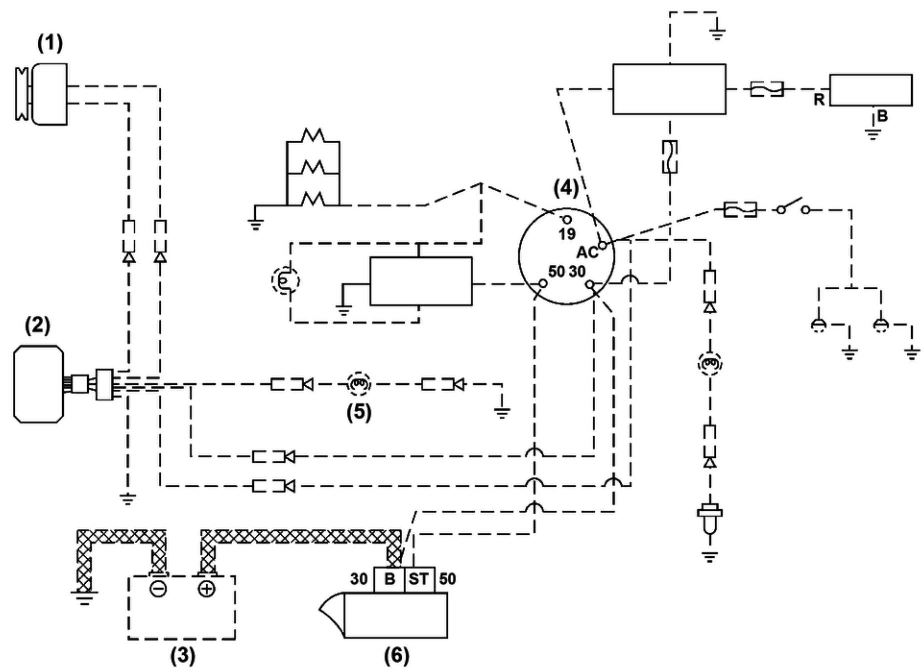
7.11.3 Function of fan belt

The fan belt transfers rotation of the fan drive pulley to the fan and in conjunction with coupling mechanisms for driving, drives the alternator and water pump as well.

8. Electrical system

8.1 Structure of electrical system

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



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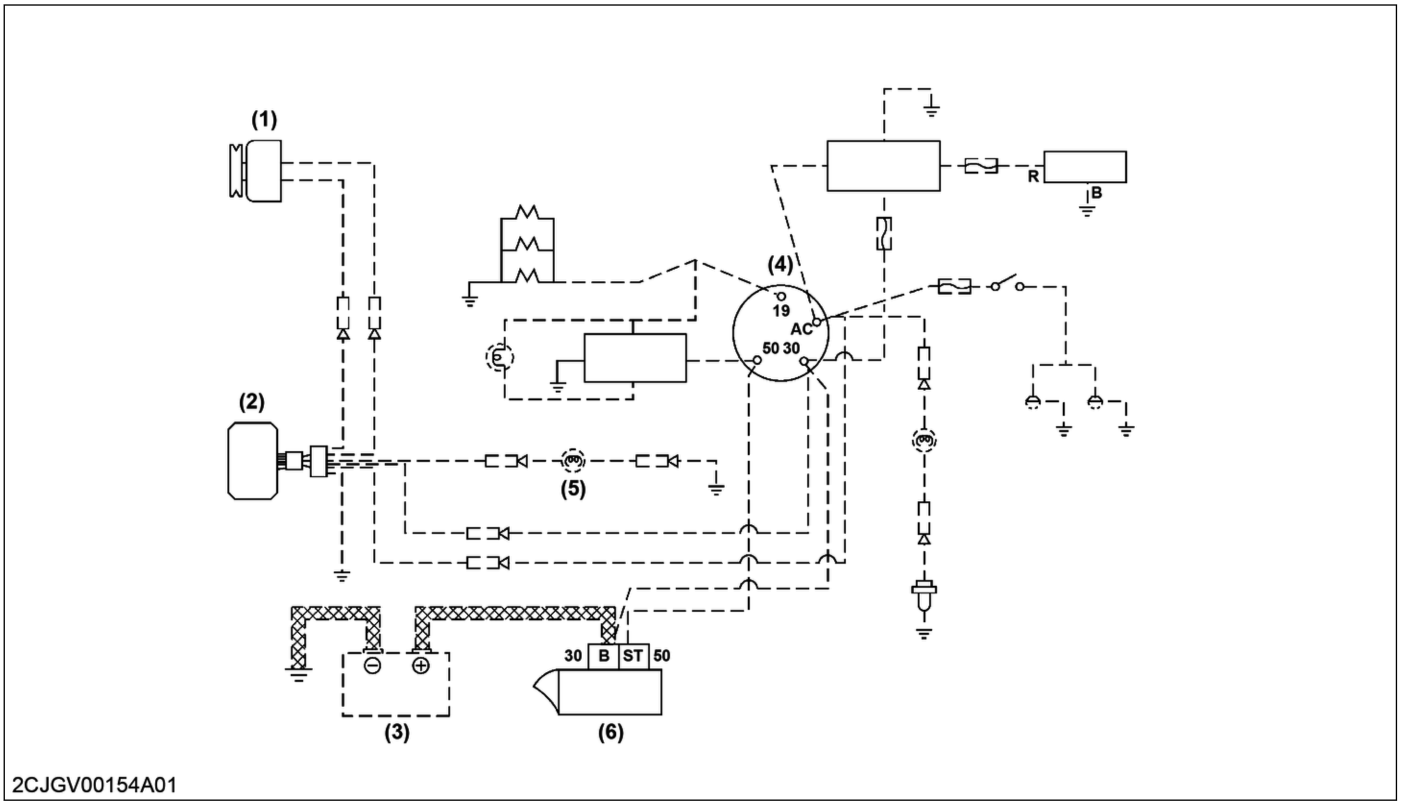
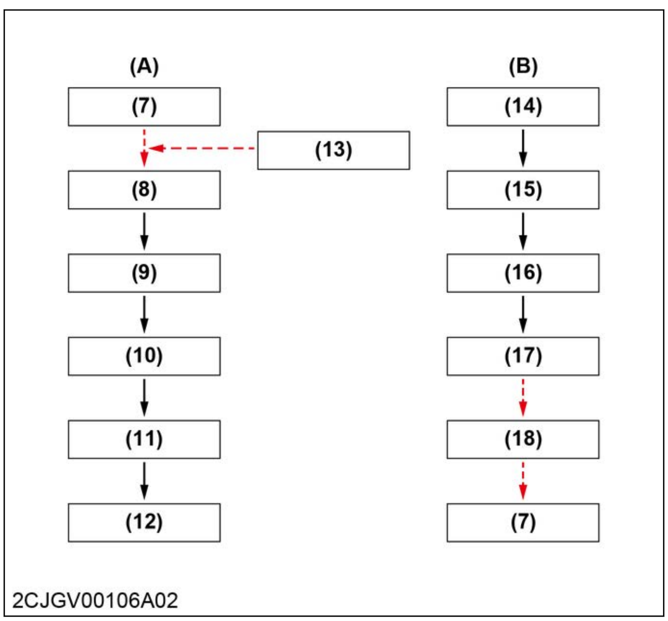
(1) Alternator
(2) Regulator
(3) Battery
(4) Key switch
(5) Charge lamp
(6) Starter

8.2 Feature of electrical system

The electrical system shown in this section represents the engine start circuit and the charge circuit.
See the CRS system section regarding the electrical system for the CRS system.
The starting circuit starts up the starter by means of the key switch and starts the engine by turning the flywheel.
The charge circuit generates electricity in the alternator utilizing power when the engine is running and this is used to charge the battery.

8.3 Flow of electrical system





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

Start flow

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

Charge flow

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

8.4 Control of electrical system

Control after start of engine

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

8.5 Battery

8.5.1 Outline of battery

The battery can produce direct current electrical energy.
Further, it can store electrical energy provided externally.

8.5.2 Structure of battery

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

2CJGV00035A01

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

8.5.3 Function of battery

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

8.5.4 Specification of battery

Battery capacity	V3800-TIEF4 V3800-TIEF4C	12 V, 136 AH
	V3800-TIEF4H	12 V, 120 AH

■ **NOTE**

- **Battery capacity can be different depending on the OEM specification of the battery installed so see the OEM specification for details.**

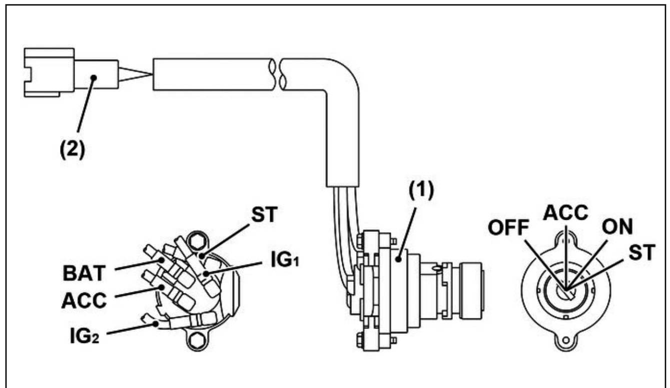
8.6 Key switch

8.6.1 Outline of key switch

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

8.6.2 Structure of key switch

The key switch is made up of a key cylinder, harness and key.



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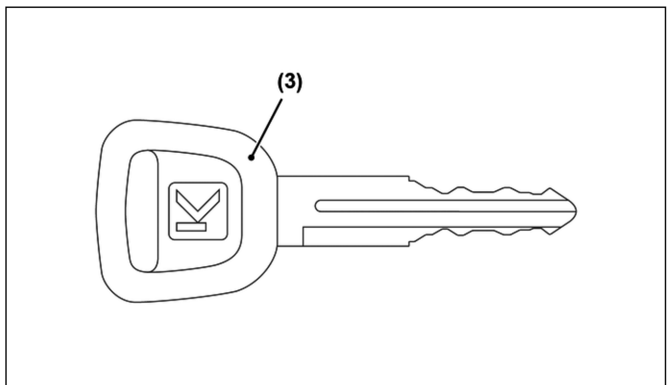

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(1) Key cylinder
(2) Harness
(3) Key

8.6.3 Function of key switch

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

8.6.4 Specification of key switch

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

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

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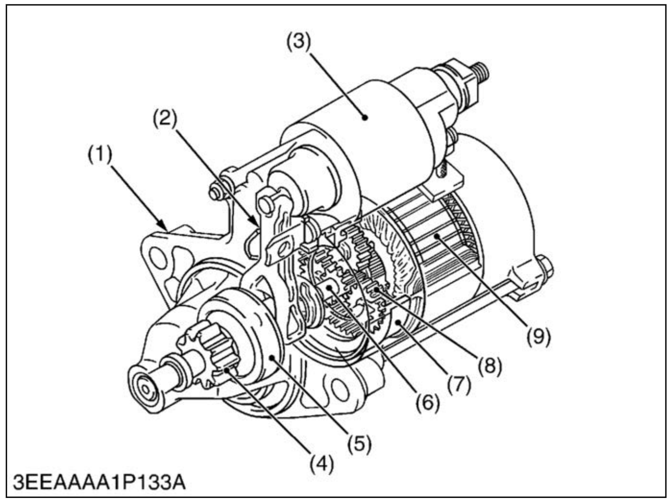
8.7 Starter (Planetary gear reduction type)

8.7.1 Outline of starter (planetary gear reduction type)

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

8.7.2 Structure of starter (planetary gear reduction type)

The starter is made up of a magnet switch, various gears, and shaft and the like.



(1) Front bracket
(2) Drive lever
(3) Magnetic switch
(4) Pinion gear
(5) Overrunning clutch
(6) Gear shaft
(7) Internal gear
(8) Pinion gear
(9) Armature shaft

8.7.3 Function of starter (planetary gear reduction type)

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

8.7.4 Specification of starter (planetary gear reduction type)

Nominal output	12 V, 3.0 kW
Pinion gear teeth	9

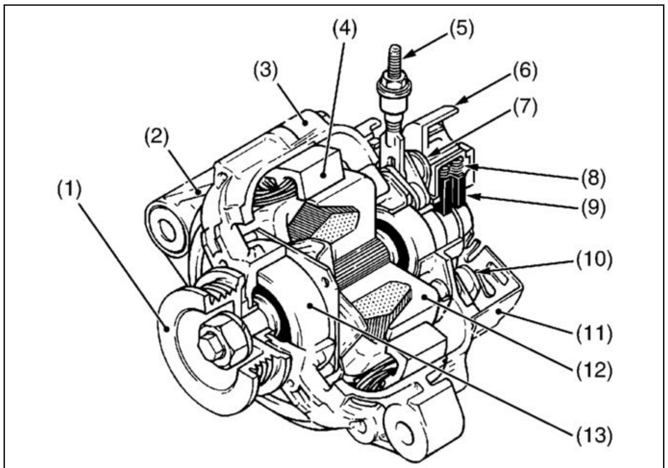
8.8 Alternator

8.8.1 Outline of alternator

The alternator self energizes while the engine is running and charges the battery.
Charging the battery using the alternator prevents reduction in battery capacity making it possible to use it for long term.

8.8.2 Structure of alternator

The alternator is made up of a pulley, starter, and IC regulator and the like.

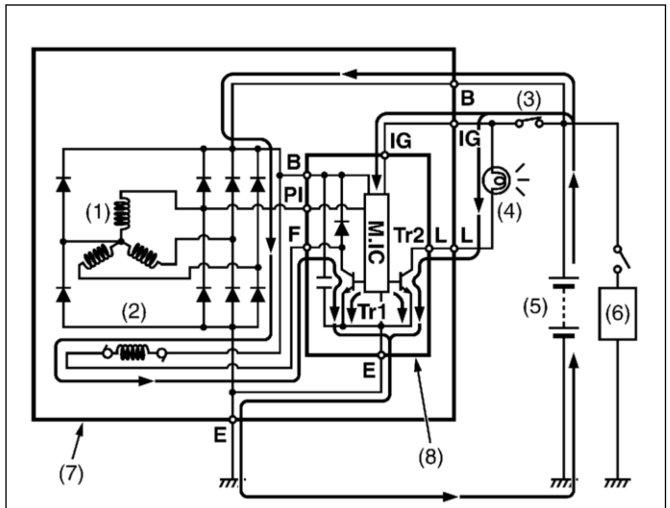


(1) Pulley
(2) Drive end frame
(3) Rear end frame
(4) Stator
(5) Terminal
(6) Connector
(7) IC regulator
(8) Spring
(9) Brush
(10) Rectifier
(11) Rear end cover
(12) Rotor
(13) Bearing

8.8.3 Function of alternator

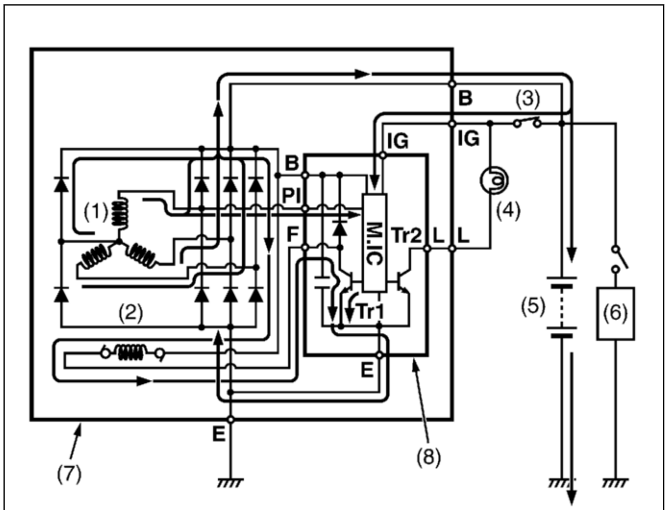
The alternator generates 3 phase current by means of a fixed coil and rotation of a rotor.
The current generated is rectified using a rectifier made up of diodes.
The rectified current charges the battery.

Operation of charging system



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

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



3EEAAAA1P162A

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

When Engine Starts

When the engine starts and the alternator (7) rotates, M.IC circuit makes current pour continuously to the Tr1 instead of the uncontinuous (in pulse) current.

Therefore a sufficient exciting current flows and a generated voltage rises rapidly.

As a result, the current to the Tr2 is shut and lights off the charge lamp (4).

When terminal B voltage rises over the battery voltage, a charged current flows to the battery (5).

When the terminal B voltage further rises over the regulated voltage (14.2 to 14.8 V : 25 ℃, 77 ℉), M.IC circuit shuts the current to the Tr1.

Therefore the current to the rotor coil (2) is shut, resulting to decrease the terminal B voltage.

When the terminal B voltage lowers below the regulated voltage, the Tr1 turns on again and makes current pour to the rotor coil(2).

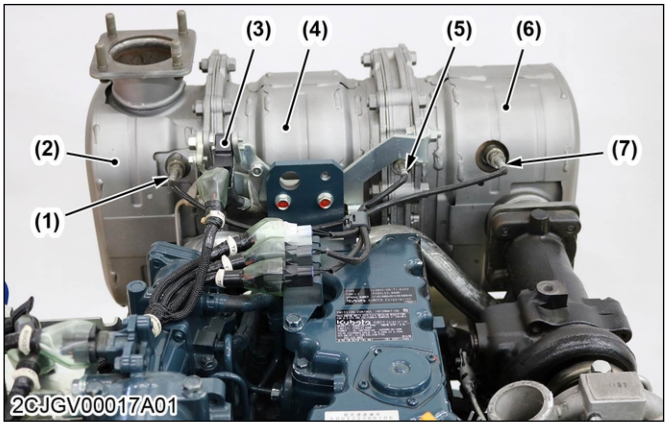
8.8.4 Specification of alternator

Capacity	V3800-TIEF4 V3800-TIEF4C	12 V, 720 W
	V3800-TIEF4H	12 V, 1200 W
Battery voltage		12 V

9. After treatment system

9.1 Structure of diesel particulate filter (DPF) system

The diesel particulate filter (hereinafter referred to as the "DPF") system is made up of a diesel oxidation catalyst (hereinafter referred to as the "DOC"), DPF, temperature sensor, and a differential pressure sensor.

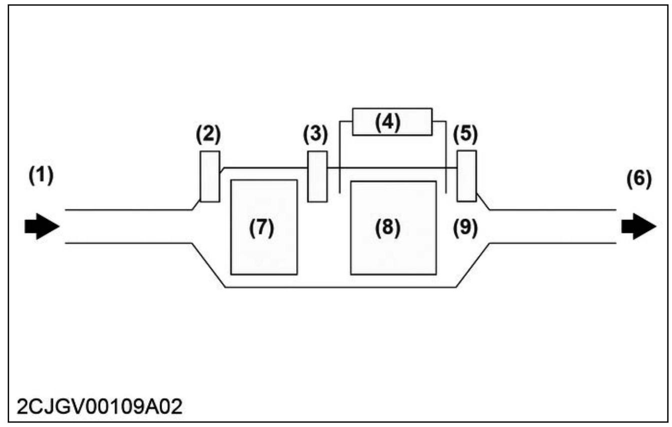


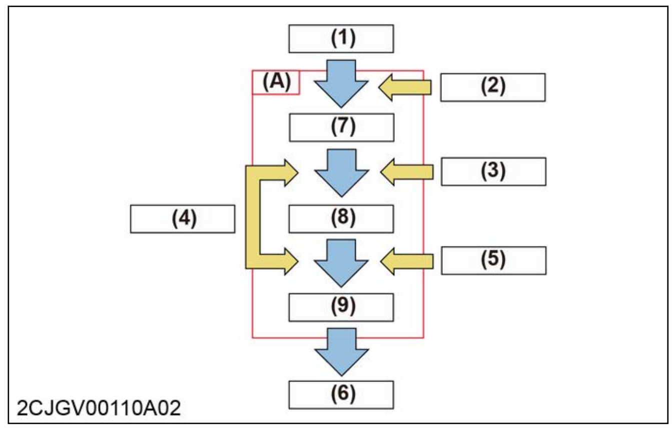
(1) Temperature sensor (DPF outlet exhaust gas temperature) (T_2)
(2) Body (DPF outlet)
(3) Differential pressure sensor
(4) DPF
(5) Temperature sensor (DPF inlet exhaust gas temperature) (T_1)
(6) DOC
(7) Temperature sensor (DOC inlet exhaust gas temperature) (T_0)

9.2 Feature of diesel particulate filter (DPF) system

The DPF system captures particulate matter (PM) such as soot and ash contained in exhaust gas and performs after treatment on it.
The PM captured is combusted in a regeneration process and separated into carbon dioxide and ash.
The carbon dioxide is released to the atmosphere and ash accumulated in the DPF.

9.3 Flow of diesel particulate filter (DPF) system





(1) Exhaust manifold
(2) Exhaust gas temperature sensor (T_0)
(3) Exhaust gas temperature sensor (T_1)
(4) Differential pressure sensor
(5) Exhaust gas temperature sensor (T_2)
(6) Selective catalyst reduction (SCR)
(7) DOC
(8) DPF
(9) DPF outlet
(A) DPF assembly

1. Exhaust gas that passes through the exhaust manifold flows into the DOC.
2. Exhaust gas that passes through the DOC flows into the DPF.
3. PM is captured by the DPF.
4. Flows from the DPF assembly to the SCR.

9.4 Control of diesel particulate filter (DPF) system

The engine ECU determines the PM accumulation status from information from each sensor and sets regeneration or cleaning level and timing.

1. Auto regeneration
   When the PM level reaches 1, the engine ECU performs regeneration control to burn the PM that has been accumulated.
   If the DOC temperature (value of exhaust sensor 0) is 250 ℃ (482 ℉) or higher, the engine ECU gives instruction to the injector to perform post injection.
   Unburned fuel is combusted in the DOC raising the exhaust gas temperature to 550 ℃ (1022 ℉) or higher and combusting the PM in the DPF.
   If the temperature of the DOC is less than 250 ℃ (482 ℉), the fuel will not burn even if a post injection is performed so post injection is not performed.
   Therefore, regeneration is also not performed.
   If the DOC temperature is 550 ℃ (1022 ℉) or higher, the PM combusts on its own so post injection is not performed (Passive regeneration state).
   In addition, if auto regeneration is not completed within specified time while in PM level 2 state, the engine ECU requests parked regeneration.
2. Parked regeneration
   When the PM level reaches 3, the engine ECU sends a warning to the machine on which it is equipped to perform parked regeneration and commands output restriction.
   During parked regeneration, pre-programmed operation processes are performed automatically.
   As a preparation step for regeneration, first the intake throttle valve is operated reducing the amount of intake air raising the exhaust temperature.
   Further, engine speed is raised and adjusted so that the DOC temperature rises to 250 ℃ (482 ℉) or higher.
   After the DOC reaches 250 ℃ (482 ℉) or higher, control is performed the same as for auto regeneration.
   When regeneration is finished, the operation state is returned what it was prior to auto regeneration (idle speed).
3. Forced regeneration
   When the PM level reaches 4, forced regeneration has to be performed using a failure diagnostics tool (Diagmaster).
   Regeneration control itself is the same as that for parked regeneration.

PM warning level		Regereration method			Regeneration status	Control	Remarks
		Auto regeneration	Parked regeneration	Regeneration with service tools			
0	Not necessary	×	×	○	Not necessary regeneration.		
1	Auto regeneration	○	×	○	When the warning level reaches 1, regeneration is started automatically.	1. If the DOC temperature (value of exhaust sensor 0) is 250 ℃ (482 ℉) or higher, the engine ECU gives instruction to the injector to perform post injection. 2. Unburned fuel is combusted in the DOC raising the exhaust gas temperature to 550 ℃ (1022 ℉) or higher and combusting the PM in the DPF. 3. If the temperature of the DOC is less than 250 ℃ (482 ℉), the fuel will not burn even if a post injection is performed so	PM Accumulation value : over 21.0g

(Continued)

<table>
<tr><th colspan="2" rowspan="2">PM warning level</th><th colspan="3">Regereration method</th><th rowspan="2">Regeneration status</th><th rowspan="2">Control</th><th rowspan="2">Remarks</th></tr>
<tr><th>Auto regeneration</th><th>Parked regeneration</th><th>Regeneration with service tools</th></tr>
<tr><td>2-1</td><td>Auto regeneration</td><td>○</td><td>×</td><td>○</td><td>When the warning level reaches 2, regeneration is started automatically.</td><td>post injection is not performed. Therefore, regeneration is also not performed.
4. If the DOC temperature is 550 ℃ (1022 ℉) or higher, the PM combusts on its own so post injection is not performed (Passive regeneration state).</td><td>30 minutes past after indicated PM warning level 1.</td></tr>
<tr><td>2-2</td><td>Require parked regeneration</td><td>×</td><td>○</td><td>○</td><td>If PM warning level does not fall to 0 within 30 minutes after started auto regeneration, parked regeneration is required.</td><td rowspan="2">1. Stop the machine at safty position.
2. The intake throttle valve is operated reducing the amount of intake air raising the exhaust temperature.
3. Engine speed is raised and adjusted so that the DOC temperature rises to 250 ℃ (482 ℉) or higher.
4. After the DOC reaches 250 ℃ (482 ℉) or higher, control is performed the same as for auto regeneration.
5. When regeneration is finished, the operation state is returned what it was prior to auto regeneration (idle speed).</td><td>PM Accumulation value：over 23.5 g</td></tr>
<tr><td>3</td><td>Parked regeneration（with output limitation）</td><td>×</td><td>○</td><td>○</td><td>Auto regeneration stops.
Require parked regeneration with machine stop.</td><td>PM Accumulation value：over 26.0 g</td></tr>
<tr><td>4</td><td>Regeneration with Diagmaster（with output limitation）</td><td>×</td><td>×</td><td>○</td><td>Parked regeneration becomes impossible.
Need to use Diagmaster for regeneration.</td><td>Regenerate using diagnostic tool (Diagmaster).</td><td>PM Accumulation value：over 31.0 g</td></tr>
<tr><td>5</td><td>Cleaning DPF（with output limitation）</td><td>×</td><td>×</td><td>×</td><td>Regeneration with Diagmaster becomes impossible.
Need to change or clean DPF.</td><td></td><td>PM Accumulation value：over 36.0 g</td></tr>
</table>

9.5 Diesel oxidation catalyst (DOC)

9.5.1 Outline of diesel oxidation catalyst (DOC)

The DOC energizes increase in exhaust temperature.

9.5.2 Structure of diesel oxidation catalyst (DOC)

The DOC is constructed with a single core and has an open end structure.

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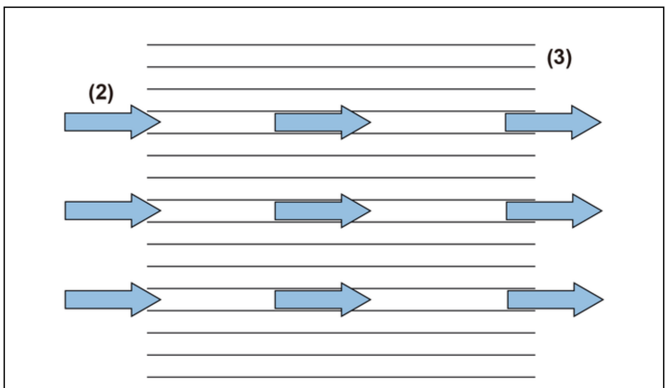


2CJGV00108A01

(1) Diesel Oxidation Catalyst (DOC)
(2) Exhaust gas flow
(3) Open end structure

9.5.3 Function of diesel oxidation catalyst (DOC)

During regeneration of the diesel particulate filter (DPF), the DOC places the post injection fuel into contact with the core thereof and raises the exhaust gas temperature to a temperature where regeneration is feasible.

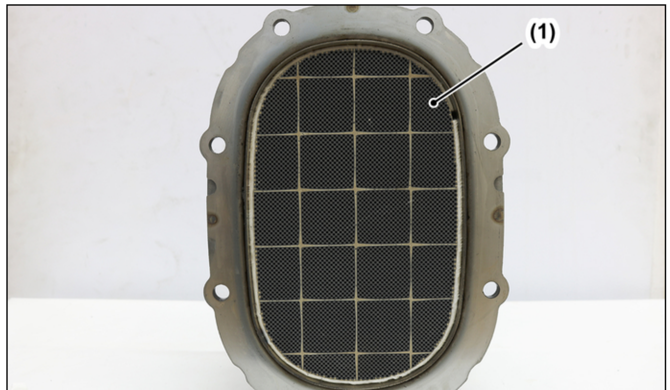
9.6 Diesel particulate filter (DPF)

9.6.1 Outline of diesel particulate filter (DPF)

The DPF captures PM (soot).

9.6.2 Structure of diesel particulate filter (DPF)

The DPF is constructed with a single core and has an closed end structure.



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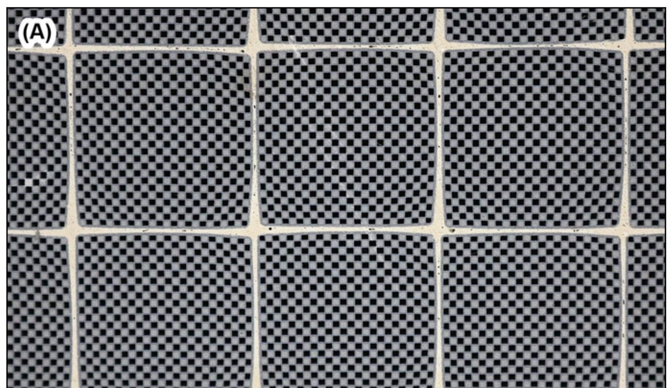

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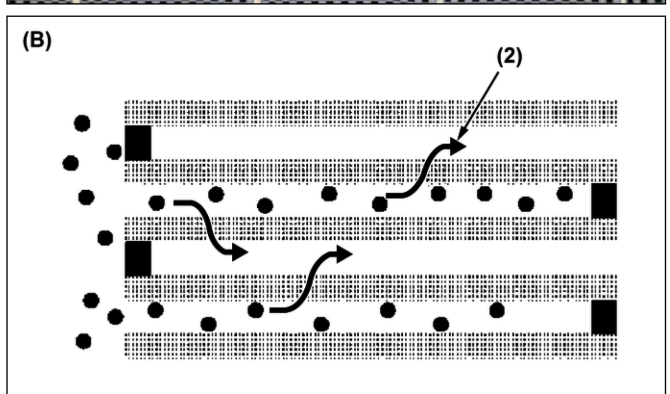
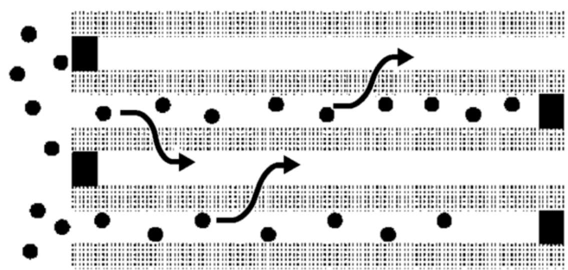


9Y1210651ENM001D

(1) Diesel particulate filter (DPF)
(2) Exhaust gas flow
(A) Honeycomb structure
(B) Closed-end structure

9.6.3 Function of diesel particulate filter (DPF)

With a closed end structure, gases in the exhaust gas flow through the wall surface while large particulate matter (PM) can not pass through the wall surface and accumulate.



9Y1210651ENM001A

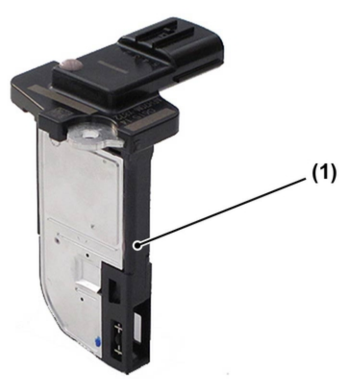
9.7 Air flow sensor

9.7.1 Outline of air flow sensor

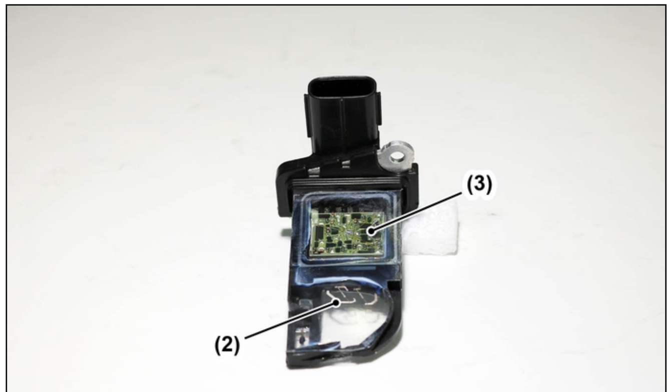
The air flow sensor detects intake air temperature and intake air flow amount.

9.7.2 Structure of air flow sensor

The air flow sensor is made up of a hot wire, cold wire, and temperature sensor.



9Y1200165ENM004B



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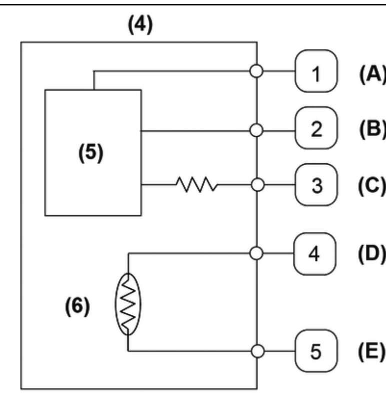
(1) Air flow sensor
(2) Hot wire, cold wire
(3) Circuit

Wiring Diagram



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(4) Air flow sensor
(5) Drive circuit
(6) Intake air temperature sensor
(A) Battery voltage (+12 V)
(B) Ground
(C) Output signal (Vo)
(D) Intake air temperature sensor (+)
(E) Intake air temperature sensor (-)

9.7.3 Function of air flow sensor

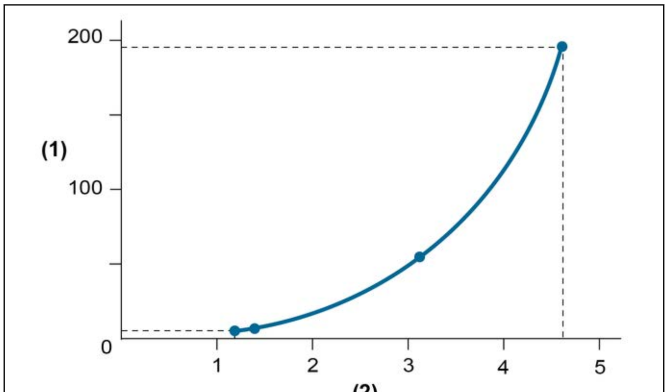
The air flow sensor uses the hot wire and cold wire to measure the intake air flow amount.
Also, the air flow sensor is an intake air temperature sensor and measures the temperature of the intake air.
The wire and intake air temperature sensor have power supplied from the ECU.
The wire is maintained at a specified temperature by the power supplied.
The wire part changes temperature based on intake air passing over the wire.
The wire has characteristics such that resistance value changes based on temperature and flow rate is measured based on these resistance changes.
The resistance value changes based on intake air temperature and the intake air temperature sensor measures the temperature based on this change in resistance.

9.7.4 Specification of air flow sensor

Power supply voltage	12 V
Temperature sensor resistance value	Approx. 2.00 kΩ (25 ℃ (77 ℉))

Flow rate

Air flow rate	Output voltage
194 g/s	4.598 V
55.6 g/s	3.121 V
5.6 g/s	1.440 V
3.6 g/s	1.239 V



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(1) Flow rate (g/s)
(2) Output voltage (V)

■ **NOTE**

- **Standard conditions: voltage 14 V, temperature 25 ℃ (77 ℉), humidity 65%, air pressure 101.3 kPa**

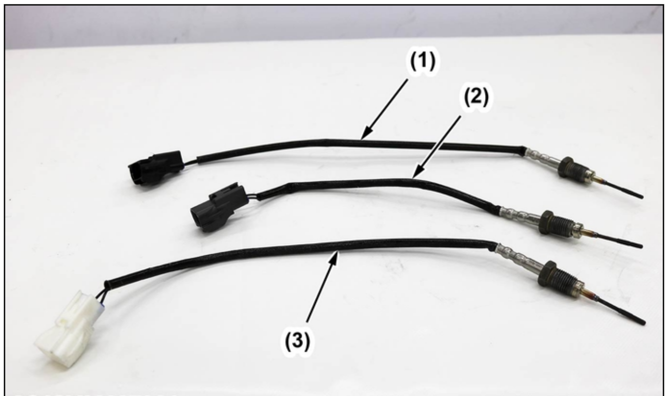
9.8 Exhaust temperature sensor

9.8.1 Outline of exhaust gas temperature sensor

The exhaust temperature sensor detects the exhaust gas temperature of the DPF system.

9.8.2 Structure of exhaust gas temperature sensor

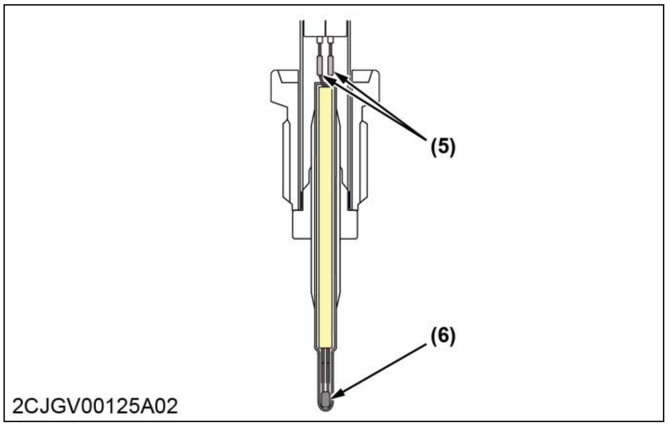
The exhaust gas temperature sensor is made up of a thermistor and connector and the like.



2CJGV00027A01

2CJGV00028A01

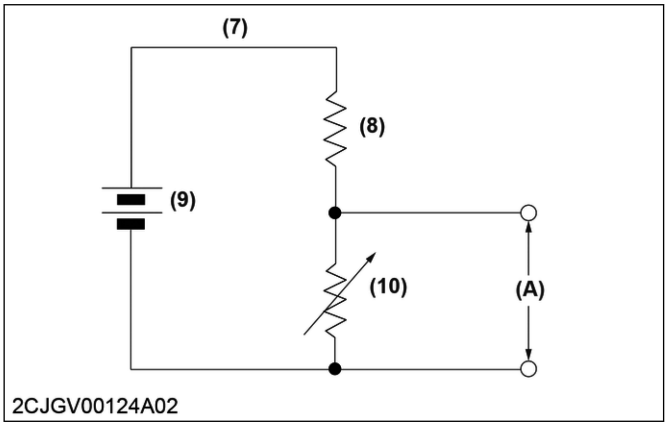
(1) Exhaust temperature sensor (T_0)
(2) Exhaust temperature sensor (T_1)
(3) Exhaust temperature sensor (T_2)
(4) Thermistor



2CJGV00125A02

(5) Connector (6) Thermistor element

Circuit Diagram



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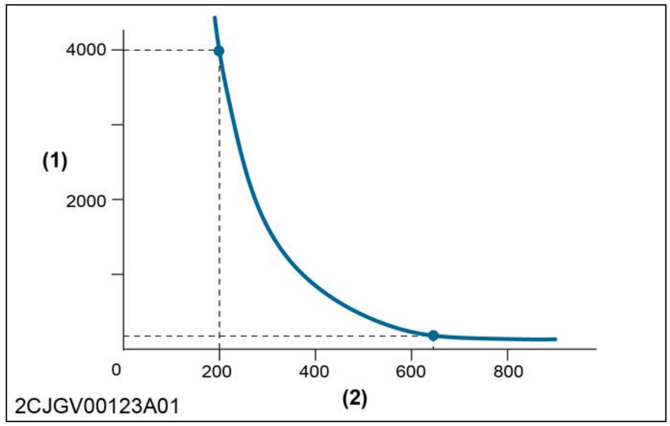
(7) Recommended measurement circuit
(8) Pull up resistance (2.7 kΩ)
(9) Power supply (+5 V)
(10) Exhaust temperature sensor
(A) Output signal (Vout)

9.8.3 Function of exhaust gas temperature sensor

The exhaust temperature sensors detect exhaust gas temperature at the DPF muffler DOC inlet, DPF inlet, and DPF outlet.
They are mounted in the DPF system and are provided with the names as indicated in the table below.

DOC inlet	Exhaust temperature sensor 0 (T_0)
DPF inlet	Exhaust temperature sensor 1 (T_1)
DPF outlet	Exhaust temperature sensor 2 (T_2)

The exhaust gas temperature sensors are sensors that utilize resistance changes based on an NTC thermistor.
When the exhaust gas temperature changes the resistance of the thermistor at the tip of the sensor changes.
Then the resistance of the thermistor changes, the sensor output voltage changes.
The output voltage signal of the sensor is sent to the engine ECU.



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(1) Resistance (Ω) (2) Temperature (℃)

9.8.4 Specification of exhaust gas temperature sensor

Resistance	200 ℃ (392 ℉)	3.68 to 4.37 kΩ
	650 ℃ (1202 ℉)	157.1 to 171.4 Ω
Heat resistance temp.	1000 ℃ (1832 ℉) Tip Part	
Connector color	T_0: Black	
	T_1: Gray	
	T_2: White	
Lubrication for mounting screws	Bostik NEVER SEEZ Pure Nickel Special Grade	

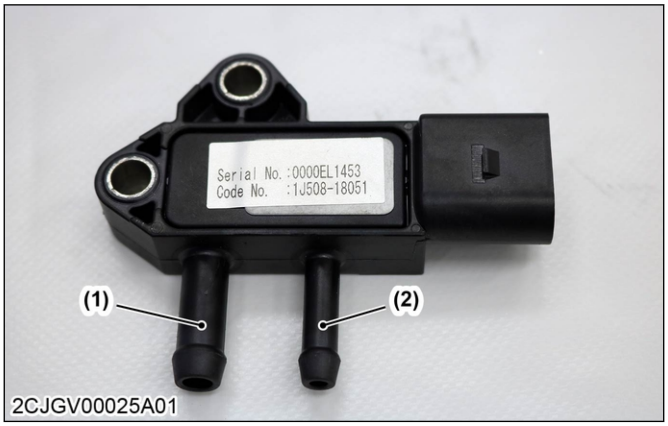
9.9 Differential pressure sensor

9.9.1 Outline of differential pressure sensor

The differential pressure sensor detects the pressure difference between the inlet and outlet of the DPF.

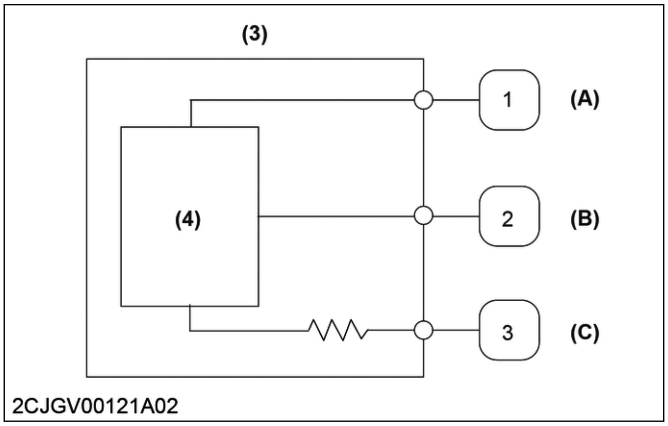
9.9.2 Structure of differential pressure sensor

The differential pressure sensor is made up of wire and silicon and the like.



(1) DPF inlet pressure (high pressure port)
(2) DPF outlet pressure (low pressure port)

Circuit diagram



(3) Differential pressure sensor
(4) ASIC
(A) Power supply (+5 V)
(B) Ground
(C) Output signal (Vout)

9.9.3 Function of differential pressure sensor

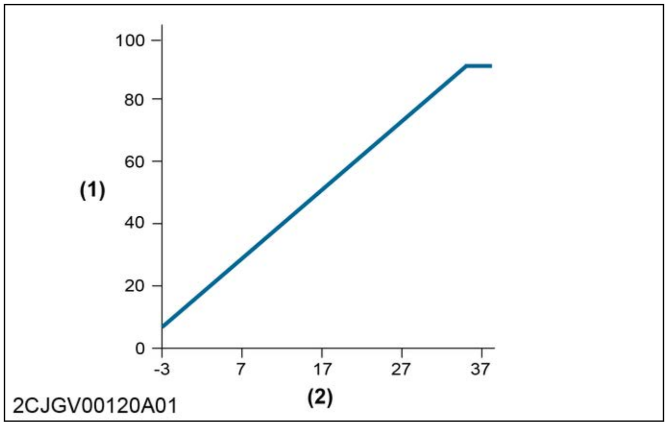
The differential pressure sensor measures the pressure difference between the inlet and outlet of the DPF and sends this information to the engine ECU.
The engine ECU calculates the amount of PM accumulated in the DPF based on the differential pressure sensor information.

The differential pressure sensor has an internal silicon diaphragm and the output changes based on diaphragm displacement due to pressure differences.

9.9.4 Specification of differential pressure sensor

Supply voltage	5.0 V
Output resistance	5 kΩ

Output characteristics



(1) Output (%Vdd)
(2) Differential pressure (kPaD)

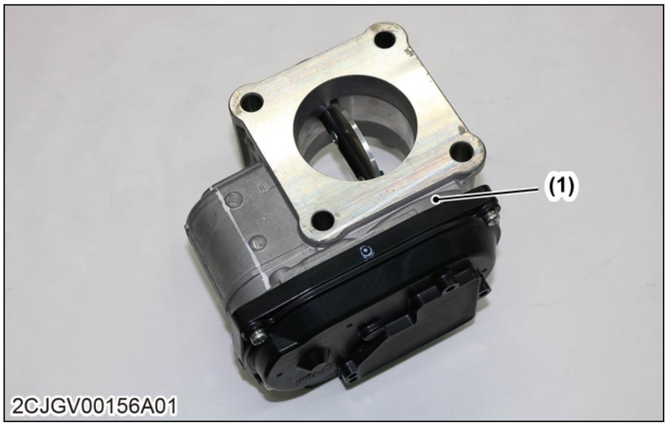
9.10 Intake throttle valve

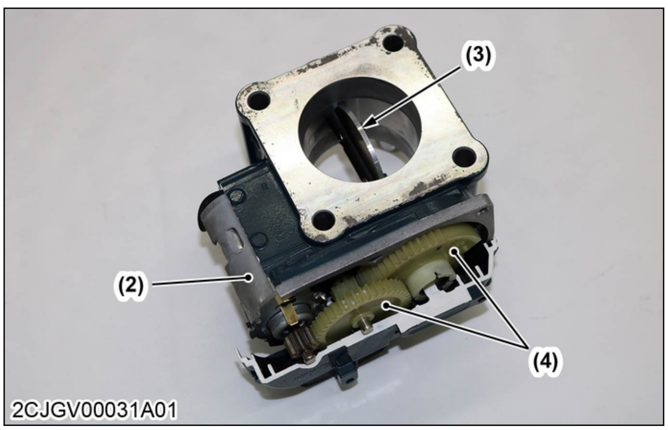
9.10.1 Outline of intake throttle valve

The intake throttle valve adjusts the intake air flow amount.

9.10.2 Structure of intake throttle valve

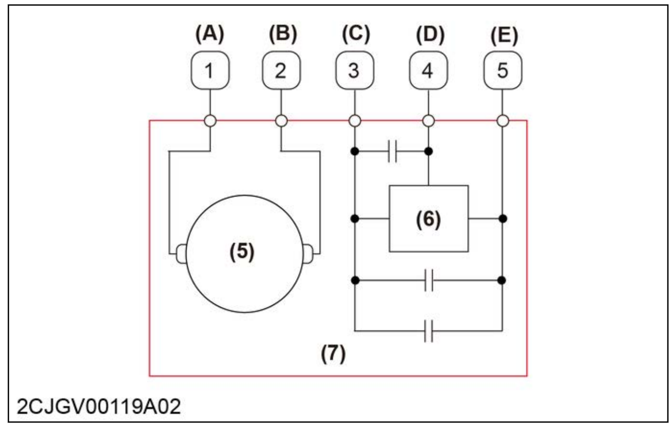
The intake throttle valve is made up of a valve, motor, and gear and the like.





(1) Intake throttle valve
(2) Motor
(3) Valve
(4) Gear

Circuit diagram



(5) Motor
(6) Hall IC
(7) Intake throttle valve
(A) Motor1
(B) Motor2
(C) Ground
(D) Output signal (TPS)
(E) Power supply (+5 V)

9.10.3 Function of intake throttle valve

The intake throttle valve adjusts the intake air flow amount.
Wide open throttle state is maintained during normal operation.
The engine ECU changes the amount the intake throttle valve is open during DPF regeneration control, raising the exhaust gas temperature.

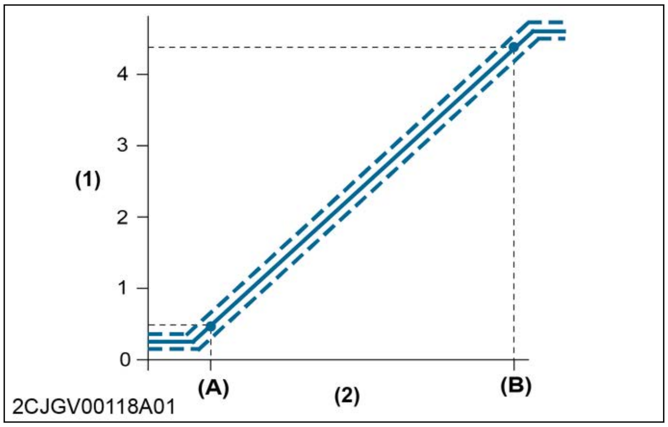
9.10.4 Specification of intake throttle valve

Motor rated voltage	12 V

Voltage applied polarity and valve rotating direction

Shaft rotating direction	Voltage applied polarity	
	M1	M2
Valve opening direction	+	–
Valve closing direction	–	+

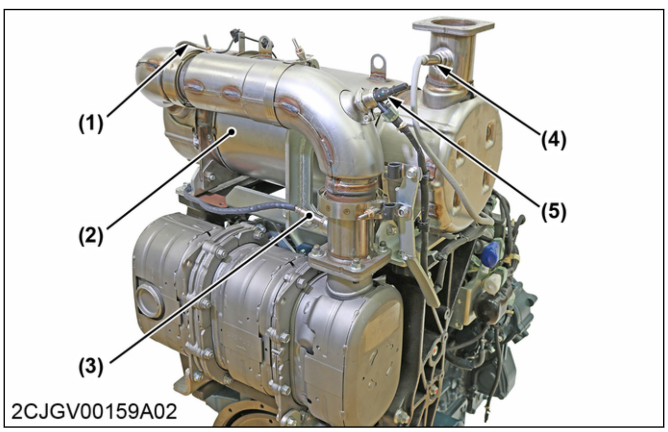
Output characteristics



(1) Sensor output (V)
(2) Sensor operating angle (degree)
(A) Fully closed (0°)
(B) Fully open (81.4°)

9.11 Structure of selective catalyst reduction (SCR) system

The selective reduction catalyst (hereinafter referred to as the "SCR") system is made up of a SCR, NOx sensor, temperature sensor, and DEF injector and the like.

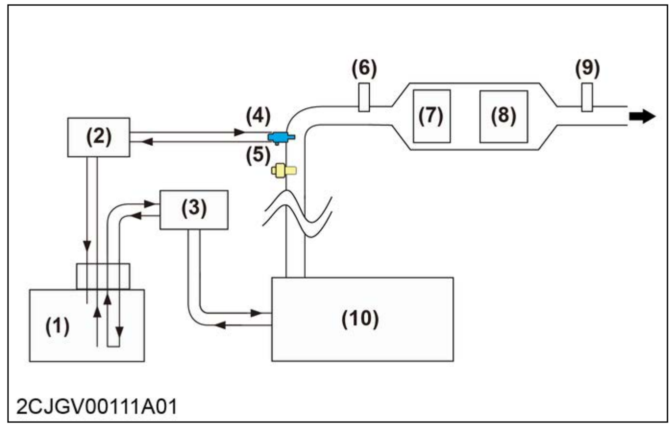


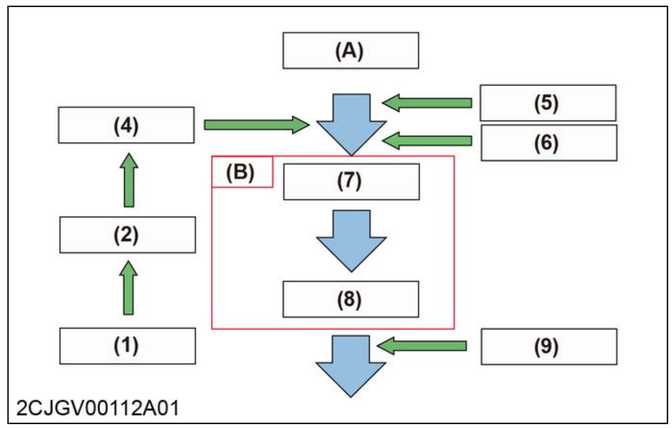
(1) SCR temperature sensor
(2) SCR
(3) Pre-NOx sensor
(4) Post NOx sensor
(5) DEF injector

9.12 Feature of selective catalyst reduction (SCR) system

The SCR system converts the nitrogen compounds (NOx) included in the exhaust gas to nitrogen and water and releases them into the atmosphere.
Ammonia is generated in the DEF and this ammonia has a reduction reaction with NOx in the SCR.
The ACU judges based on information from the various sensors and sets the DEF injection timing and injection volume and monitors whether or not NOx is being processed.

9.13 Flow of selective catalyst reduction (SCR) system





(1) DEF tank
(2) DEF pump
(3) Coolant valve
(4) DEF injector
(5) SCR inlet temperature sensor
(6) Pre NOx sensor
(7) SCR
(8) ASC
(9) Post NOx sensor
(10) Engine
(A) DPF
(B) SCR assembly

1. Exhaust gas that has passed through the DPF flows into the SCR.
2. Exhaust gas that has passed through the SCR flows into the ASC.
3. Exhaust gas that has passed through the ASC is released into the atmosphere.

9.14 Control of selective catalyst reduction (SCR) system

There are 3 controls in the SCR system, the DEF pump, injector control, thaw control, and inducement.

1. DEF pump, injector control
   The DEF injector has low heat resistance so normally, circulation is performed through the DEF to cool the DEF injector while the engine is running.
   However, during defrost control, the DEF is frozen so circulation is not feasible.
   Injection starting and stopping is performed based on SCR temperature sensor information.

Note, when the SCR reaches a prescribed temperature (510 ℃ (950 ℉)) or higher during DPF regeneration, DEF injection is stopped to protect the DEF injector.
The SCR remains hot after the engine is stopped so circulation is continued through the DEF.
The DEF pump may run for a maximum of 11.5 minutes after the engine is stopped.
The pump run time after the engine stops differs depending on SCR temperature.

CAUTION

- **Due to the reason described above, do not disconnect the battery cable right after stopping the engine.**

2. Thaw control
The DEF freezes at -11 ℃ (12 ℉) or lower.
Therefore, depending on timing and location, the DEF may be frozen when the engine is started.
Here, the ACU performs thaw control.
Thaw control method is to open the coolant valve and circulate engine coolant through the DEF tank.
In addition, the DEF tube heater is turned ON to warm inside the DEF tube.
During defrost control, the DEF pump attempts to circulate through the DEF at prescribed timing.
Repeating this operation, when the DEF pump pressure reaches its normal value (350 k Pa, 3.57 kgf/cm^2, 50.8 psi), defrost control stops and control transitions to normal control.
3. Inducement
Inducement is control reducing output to project the engine when some type of trouble occurs in the SCR system.
Inducement has two setting levels, the first level performs output control at 50% and speed control at 60% while the second level is forced idling.
Cause for inducement is broadly classified into the following 3 categories.
   a. Inducement based on DEF tank water level
   Operates when the remaining amount in the DEF tank is low.
   b. Inducement based on DEF quality
   Operates when DEF quality changes (example: when oil or fuel is inadvertently put in).
   c. Tampering (everything other than for 1, 2 are grouped and called tampering)
   Operates when some type of trouble other than that indicated above such as a sensor or DEF pump failure or the like.

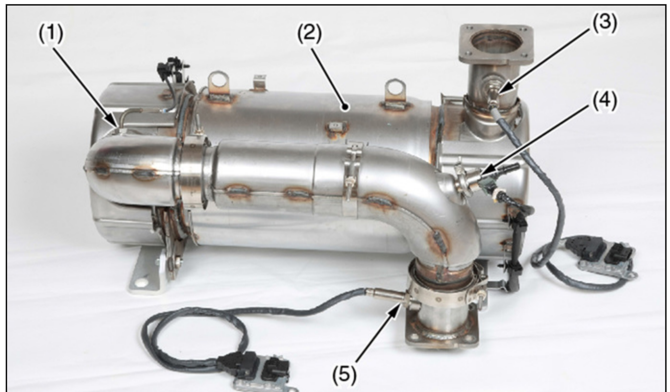
9.15 Selective catalytic reduction (SCR)

9.15.1 Outline of selective catalytic reduction (SCR)

A selective reduction catalyst (SCR) cleans NOx included in exhaust gas.

9.15.2 Structure of selective catalytic reduction (SCR)

The SCR is made up of a SCR catalyst and ammonia slip catalyst (ASC).



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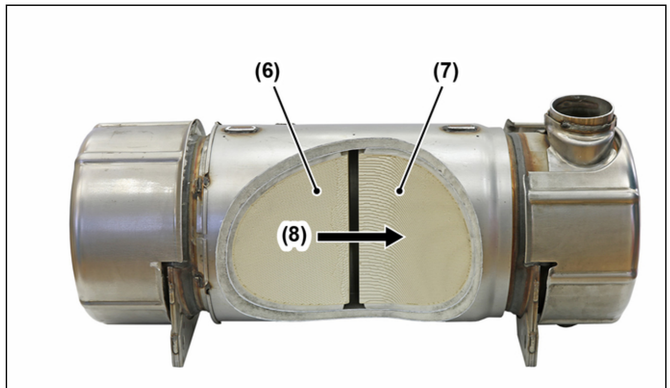


2CJGV00170A01

(1) SCR temperature sensor
(2) SCR
(3) Pre-NOx sensor
(4) Post NOx sensor
(5) DEF injector
(6) Selective Catalyst Reduction (SCR)
(7) Ammonia slip catalyst (ASC)
(8) Exhaust gas flow

9.15.3 Function of selective catalytic reduction (SCR)

The SCR has the function of cleaning NOx included in the exhaust gas.
The DEF injected by the DEF injector is converted into ammonia by exhaust heat.
This ammonia causes a reduction reaction with NOx in the SCR catalyst converting it to nitrogen and water.
In addition, the ASC converts the surplus generated ammonia to nitrogen.

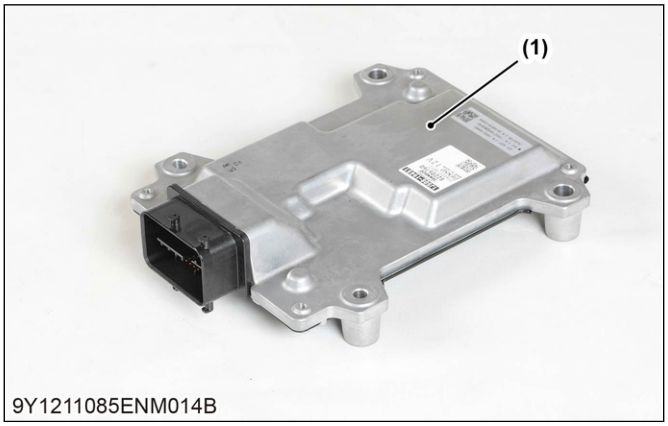
9.16 After treatment control unit (ACU)

9.16.1 Outline of after treatment control unit (ACU)

The after treatment control unit (ACU) controls the selective reduction catalyst (SCR) system.

9.16.2 Structure of after treatment control unit (ACU)

The ACU is made up of an electronic circuit board and a connector.



(1) After treatment control unit (ACU)

9.16.3 Function of after treatment control unit (ACU)

The ACU controls the SCR system.
The ACU control content is the following 3 items.

1. DEF pump, injector control
2. Thaw control
3. Inducement

See SCR system control regarding control details.

— RELATED PAGE —

9.14 Control of selective catalyst reduction (SCR) system on page 3-80

9.16.4 Specification of after treatment control unit (ACU)

Operating voltage	10 to 16 V

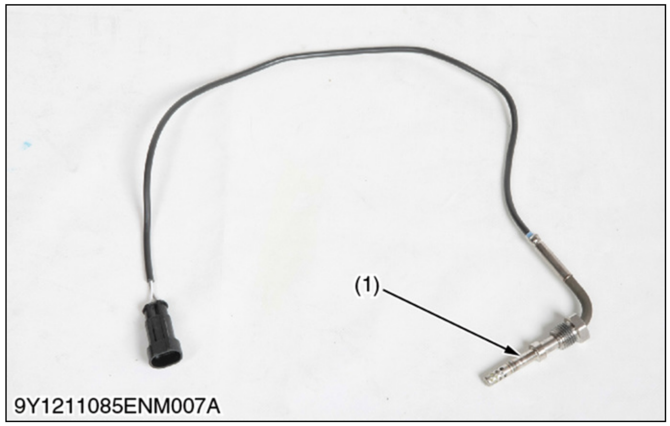
9.17 SCR inlet temperature sensor

9.17.1 Outline of SCR inlet temperature sensor

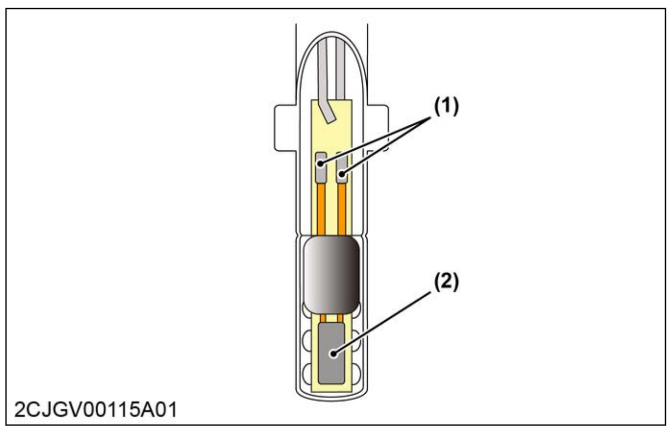
The SCR inlet temperature sensor detects temperature at the SCR inlet.

9.17.2 Structure of SCR inlet temperature sensor

The SCR temperature sensor is made up of a thermistor and connector and the like.

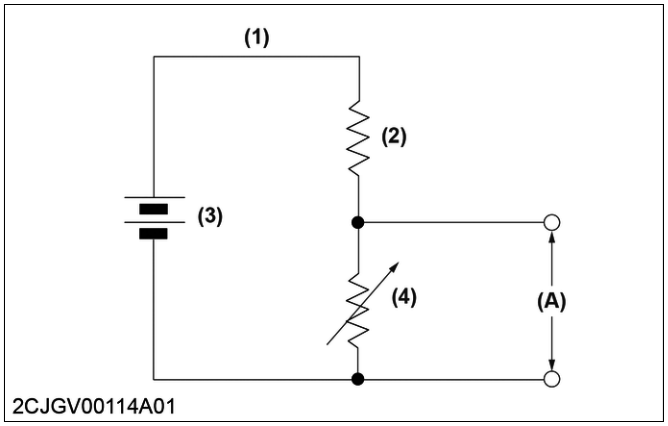


(1) SCR inlet temperature sensor



(1) Connector (2) Thermistor element

Circuit diagram



(1) Recommended measurement circuit
(2) Pull up resistance (1.0 kΩ)
(3) Power supply (+5 V)
(4) SCR temperature sensor
(A) Output signal (Vout)

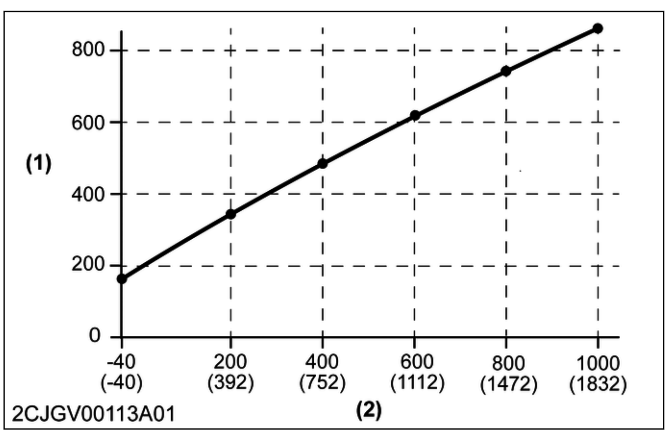
9.17.3 Function of SCR inlet temperature sensor

The SCR temperature sensor detects exhaust gas temperature at the SCR inlet and sends this information to the ACU.
The ACU performs control regarding whether or not to perform DEF injection based on this information.
In addition, the ACU calculates the DEF injector cooling time after the engine stops from the SCR temperature.

9.17.4 Specification of SCR inlet temperature sensor

Operating voltage	5 V
Resistance	220 Ω @25 ℃ (77 ℉)

Output characteristics and resistance



(1) Sensor resistance (Ω)
(2) SCR temperature (℃(℉))

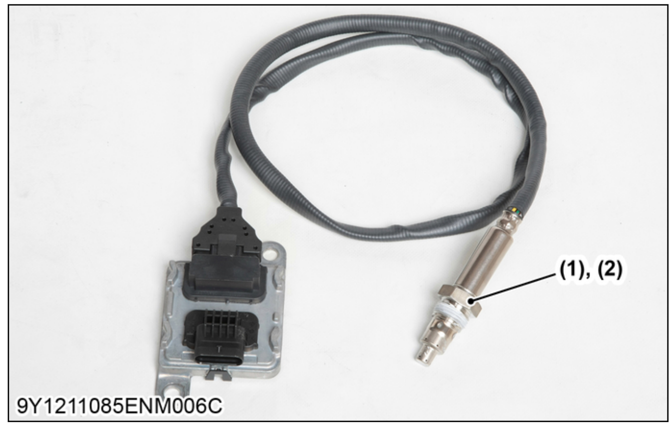
9.18 NOx sensor

9.18.1 Outline of NOx sensor

The NOx sensor measures the NOx concentration in the exhaust gas.

9.18.2 Structure of NOx Sensor

The NOx sensor is made up of a sensor, heater, and connector and the like.



(1) Post NOx sensor
(2) Pre NOx sensor

9.18.3 Function of NOx sensor

The NOx sensor measures the NOx concentration in the exhaust gas.
The pre-NOx sensor measures NOx concentration before the SCR and sends a signal to the ACU.
The ACU determines DEF injection timing and injection volume based on the pre-NOx sensor signal.
The post NOx sensor measures NOx concentration after the SCR and sends this signal to the ACU.
The ACU determines whether NOx has been cleaned up in the SCR based on the post-NOx sensor signal.

9.18.4 Specification of NOx sensor

Cable color	Pre-Nox sensor: black
	Post-NOx sensor: gray
Lubrication for mounting screws	Anti-Seize High-Tech Paste

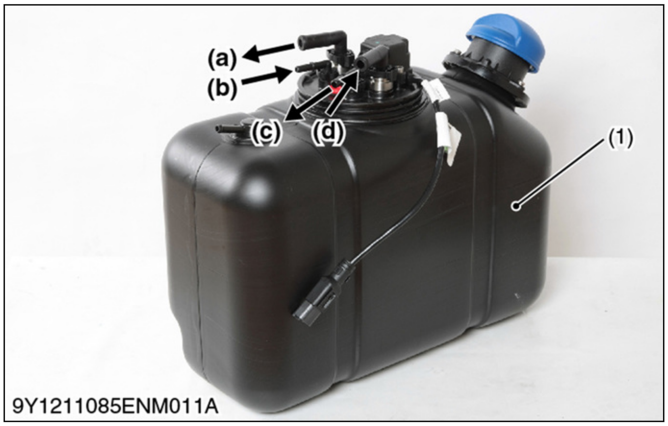
9.19 Diesel exhaust fluid (DEF) tank

9.19.1 Outline of diesel exhaust fluid (DEF) tank

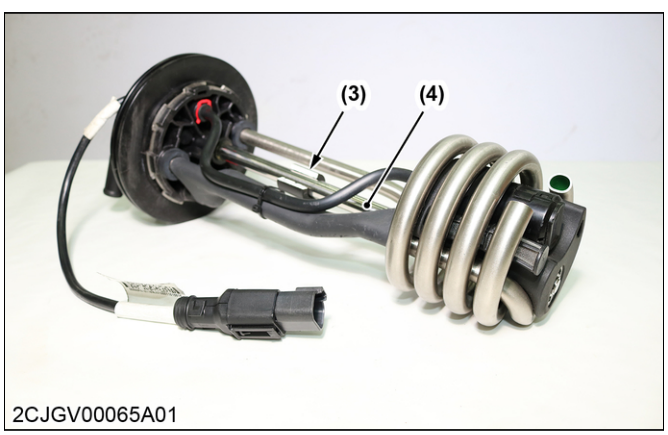
The DEF tank stores DEF.

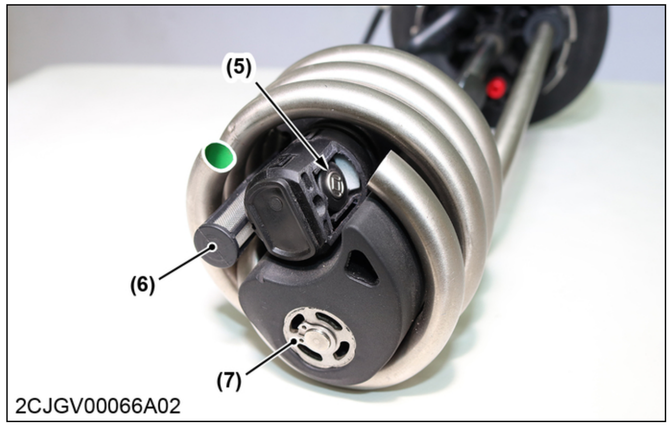
9.19.2 Structure of diesel exhaust fluid (DEF) tank

The DEF tank is made up of the tank body and header unit.



(1) DEF tank
(2) Header unit
(a) Coolant (return to engine)
(b) DEF (return from DEF injector)
(c) DEF (outlet to DEF pump)
(d) Coolant (into DEF tank)





(3) Float
(4) DEF level sensor
(5) DEF quality sensor
(6) Filter
(7) DEF temperature sensor

9.19.3 Function of diesel exhaust fluid (DEF) tank

The DEF tank stores DEF.
The header unit is equipped with a DEF level sensor, DEF quality sensor, and DEF temperature sensor.

DEF level sensor

The DEF level sensor is positioned at the center of the header unit and is a sensor that uses a float.
The float moves with the level in the DEF and indicates the amount remaining.

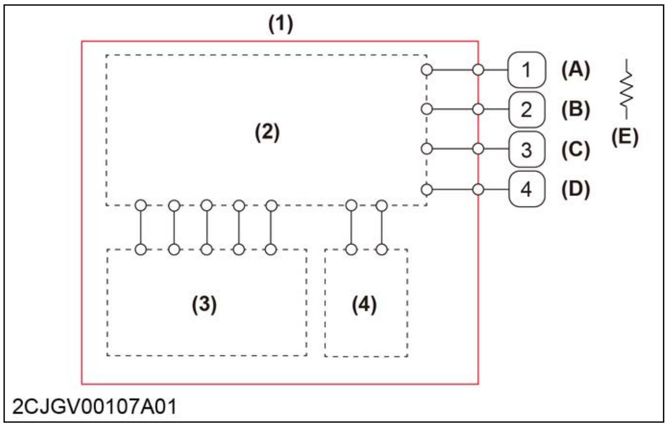
DEF quality sensor

The DEF quality sensor detects concentration using difference in conductivity based on temperature.
The ACU detects mixture of fuel or water in DEF using this conductivity.

DEF temperature sensor

The DEF temperature sensor is a sensor that utilizes resistance changes based on an NTC thermistor.
When the DEF temperature changes the resistance of the thermistor at the tip of the sensor changes.
Then the resistance of the thermistor changes, the sensor output voltage changes.
The output voltage signal of the sensor is sent to the ACU.

DEF tank header unit circuit diagram



(1) DEF tank header assembly
(2) Power supply board
(3) Urea quality sensor and temperature sensor
(4) Level sensor
(A) CAN-L
(B) CAN-H
(C) Ground
(D) Battery voltage (+12 V)
(E) The sensor does not include the terminator.

9.19.4 Specification of diesel exhaust fluid (DEF) tank

Rated voltage	12 V

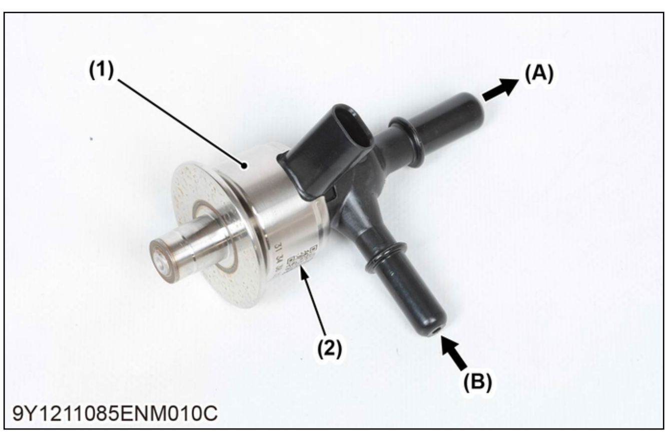
9.20 DEF injector

9.20.1 Outline of DEF injector

The DEF injector is injects the DEF in to the upstream of the SCR (mixing pipe).

9.20.2 Structure of DEF injector

The DEF injector is made up of an injector body and connector.



(1) DEF injector
(2) QR code
(A) DEF outlet
(B) DEF inlet

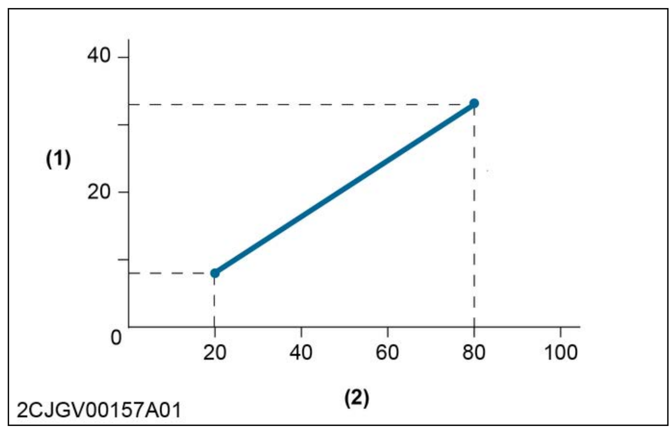
9.20.3 Function of DEF injector

The DEF injector is injects the DEF in to the upstream of the SCR (mixing pipe).
The injection volume of DEF injectors differs for individual injectors based on variability when they are manufactured.
Therefore, a QR code is used to correct these individual differences.
Ammonia is generated from the DEF injected by the exhaust gas heat.
The ammonia causes a reduction reaction and NOx is released to the atmosphere as nitrogen.

9.20.4 Specification of DEF injector

Flow rate characteristics

Duty cycle (%)	Flow rate (g/min)
20	8.25
50	20.62
80	32.99



(1) Flow rate (g/min)
(2) Duty cycle (%)

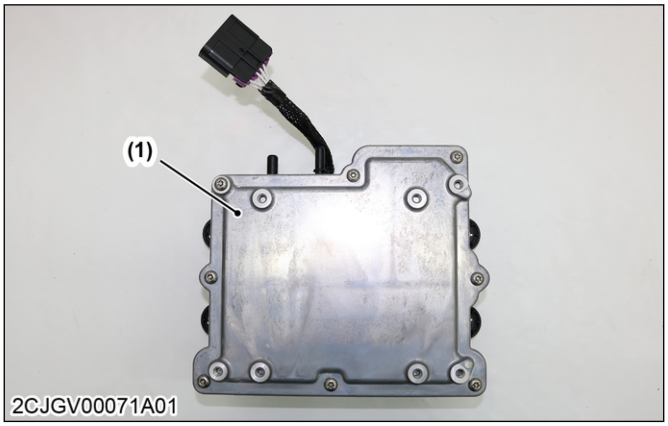
9.21 DEF pump

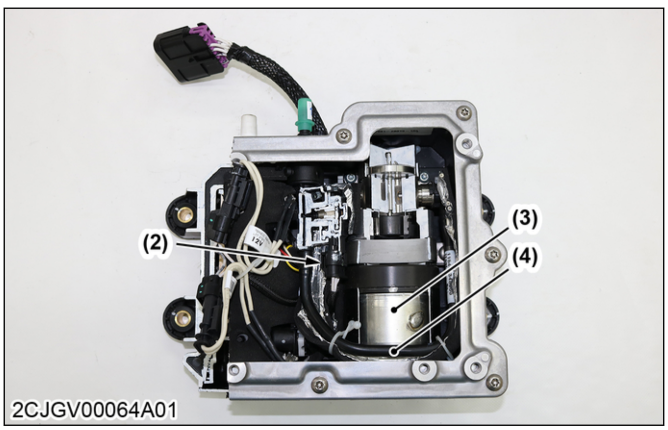
9.21.1 Outline of DEF pump

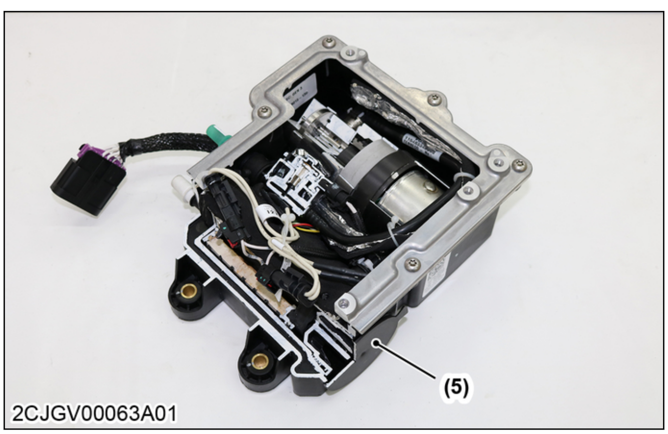
The DEF pump supplies DEF/AdBlue® to the DEF injector.

9.21.2 Structure of DEF pump

The DEF pump is made up of a motor, heater, and pressure sensor and the like.







(1) DEF pump
(2) DEF pressure sensor
(3) Motor
(4) Heater
(5) Filter

9.21.3 Function of DEF pump

The DEF pump supplies DEF/AdBlue® to the DEF injector.
The DEF pump runs the motor based on instruction from the ACU and supplies DEF.
In addition, dust in the DEF is removed by passing it through a filter.
The DEF pump circulates DEF while the engine is operating.
Regarding the DEF pump, the pressure is different during DEF injection and when there is no injection.
The embedded sensor detects DEF pressure and sends this information to the ACU.
The DEF pump heater warms the DEF when the DEF is frozen.

9.21.4 Specification of DEF pump

Pump pressure	During DEF injection	550 kPa 5.61 kgf/cm^2 79.8 psi
	When DEF is not injected	350 kPa 3.57 kgf/cm^2 50.8 psi
Pump power	12 V	
Pressure sensor power supply	5 V	
Resistance between terminals	D-E	Approximately 1.5 kΩ or higher
	D-L	Approximately 1.5 kΩ or higher
	E-L	Approximately 1.5 kΩ or higher
	A-H	Approximately 3.4 Ω

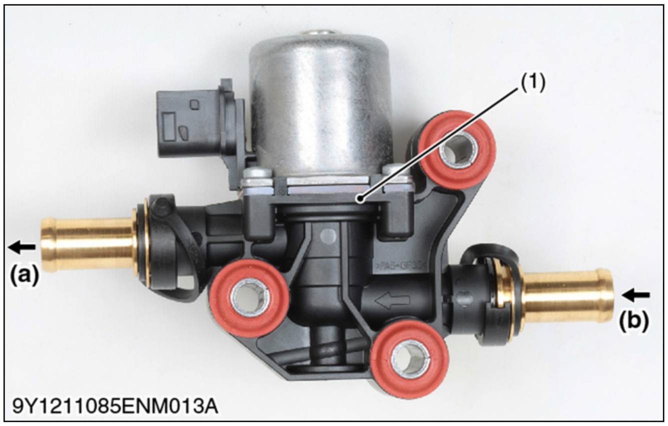
9.22 Coolant valve

9.22.1 Outline of coolant valve

The coolant valve supplies coolant to the header unit of the DEF tank.

9.22.2 Structure of coolant valve

The coolant valve is made up of an electromagnetic valve and connector and the like.



(1) Coolant valve
(a) Coolant outlet
(b) Coolant inlet

9.22.3 Function of coolant valve

The coolant valve supplies coolant to the header unit of the DEF tank.
Coolant is used to defrost frozen DEF.
The coolant valve is normally closed and receives direction to open the valve when the ACU performs thaw control.

9.22.4 Specification of coolant valve

Rated voltage	12 V
Coil resistance (between terminals)	9.0 to 13.0 Ω (@20 °C (68 °F))
Inlet pressure	0 to 250 kPa 0 to 2.5 kgf/cm^2 0 to 36 psi

SERVICING

1. Troubleshooting

1.1 Troubleshooting for V3800-TIEF4, TIEF4C

This "Troubleshooting" shows only mechanical failures. The failures related to the common rail system (CRS), refer to the diagnosis manual (DM) for common rail system engine.

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	2-22
	The fuel pump is damaged	Replace	—
	The fuel hose is clogged	Replace	2-18
	The fuel filter is clogged	Replace	2-22
	The viscosity of fuel at low temperature is too high	Replace the specified fuel	1-5 2-9
	The cetane number of fuel is low	Replace the specified fuel	1-5 2-9
	Fuel leakage because of loose injection pipe retaining nut	Tighten the retaining nut	3-172
	The injector is clogged	Replace	3-212
	The supply pump is damaged	Replace	3-210
	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	3-136 3-165 3-120
	Incorrect valve timing	Check the timing gear	3-141 3-159
	Piston ring and cylinder are worn out	Replace	3-198 3-198 3-203 3-204
	Incorrect valve clearance	Adjust valve clearance	3-102
The starter does not operate	Discharged battery	Charge or replace	—
	Starter is damaged	Repair or replace	3-108
	The key switch is damaged	Replace	—

(Continued)

Symptom	Probable cause	Solution	Reference page
The starter does not operate	The connection of the wires is incorrect	Check or correct	—
The engine revolution is not smooth	The fuel filter is clogged	Replace	2-22
	The air cleaner is clogged	Clean or replace the air cleaner element	2-19
	Fuel leakage because of loose injection pipe retaining nut	Tighten the retaining nut	3-172
	The supply pump is damaged	Replace	3-210
	The injector is damaged	Replace	3-212
	The turbocharger bearing is worn out	Replace the turbocharger assembly	3-130 3-174
	The turbocharger shaft is bent	Replace the turbocharger assembly	3-130 3-174
	The turbocharger fin or other part has a damage because of unwanted materials	Replace the turbocharger assembly	3-130 3-174
The exhaust gas is white or blue	Too much engine oil	Reduce it to the specified level	2-13
	The piston ring, piston and cylinder is worn out	Replace the piston ring or piston, or repair the cylinder	3-198 3-198 3-203 3-204
There is oil leakage into the exhaust pipe or suction pipe	The oil pipe is clogged or has a damage	Check, replace or clean the oil pipe	—
	The piston ring seal of the turbocharger is damaged	Replace the turbocharger assembly	3-130 3-174
The exhaust gas is black or dark gray	Filter comp (DPF) is damaged	Replace	3-218
	Overload	Decrease the load	—
	The grade of the fuel is low	Replace the specified fuel	1-5 2-9
	The fuel filter is clogged	Replace	2-22
	The air cleaner is clogged	Clean or replace the element	2-19
	The injector is damaged	Replace	3-212
The output is deficient	The moving parts of engine have a seizure	Repair or replace	—
	The supply pump is damaged	Replace	3-210
	The injector is damaged	Replace	3-212
	There is compression leakage	Check the compression pressure and repair	3-101

(Continued)

Symptom	Probable cause	Solution	Reference page
The output is deficient	There is a gas leakage from the exhaust system	Repair or replace	3-110 3-174
	The air cleaner is clogged	Clean or replace the element	2-19
	There is an air leakage from the compressor discharge side	Replace the turbocharger assembly	3-130 3-174
The lubricant oil consumption is too much	The gap of the piston ring points to the same direction	Move the ring gap direction	3-143 3-155
	The oil ring is worn out or cannot move	Replace the oil ring or piston assembly	3-144 3-154 3-143 3-155 3-198 3-198
	The piston ring groove is worn out	Replace the piston and piston ring	3-198 3-198
	The valve stem and valve guide are worn out	Replace	3-137 3-164
	The crankshaft bearing and the crank pin bearing is worn out	Replace	3-201 3-202
The fuel is mixed into the lubricant oil	The injector is damaged	Replace	3-212
	Fuel leak from the overflow pipe of the inner cylinder head cover	Replace the gasket	—
	Oil dilution due to regeneration	Change the engine oil	2-17
Water is mixed into the lubricant oil	The head gasket is damaged	Replace	3-136 3-165 3-120
	The crankcase or cylinder head is damaged	Replace	3-136 3-165
The oil pressure is low	The engine oil is not sufficient	Replenish oil to the specified amount	2-13
	The oil strainer is clogged	Clean	3-143 3-156
	The relief valve does not operate with dirt	Repair or replace	3-141 3-159
	The oil clearance of the bearings are too much	Replace the metal, bushing or shaft	3-143 3-155 3-146 3-150 3-201 3-202
	The oil passage is clogged	Clean	—

(Continued)

Symptom	Probable cause	Solution	Reference page
The oil pressure is low	The type of oil used is incorrect	Use the specified type of oil	1-5 2-9
	The oil pump is damaged	Replace	3-204 3-204 3-205
The oil pressure is high	The type of oil used is incorrect	Use the specified type of oil	1-5 2-9
	The relief valve is damaged	Repair or replace	3-141 3-159
The engine is overheated	The engine oil is not sufficient	Replenish oil to the specified amount	2-17
	The fan belt is broken or the fan belt tension is too loose	Replace or adjust	3-127 3-179 3-104 3-105
	The coolant is not sufficient	Replenish to the specified amount	2-14
	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	2-43 2-45
	There is clogged in the coolant flow route	Clean or replace	2-43 2-45
	The radiator or radiator cap is damaged	Replace	3-105 3-106
	The load is too much	Reduce the load	—
	The head gasket is damaged	Replace	3-136 3-165 3-120
	The fuel used is incorrect	Replace the specified fuel	1-5 2-9

2. Servicing specifications

2.1 Servicing specification for engine

Engine body

Item		Factory specification	Allowable limit
Cylinder head surface	Flatness	–	0.05 mm 0.002 in.
Top clearance		0.701 to 0.930 mm 0.0276 to 0.0366 in.	–
Compression pressure		2.95 to 3.13 MPa / 200 min^{-1} (rpm) 30.0 to 32.0 kgf/cm^2 / 200 min^{-1} (rpm) 427 to 455 psi / 200 min^{-1} (rpm)	2.30 MPa / 200 min^{-1} (rpm) 23.5 kgf/cm^2 / 200 min (rpm) 334 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	0.850 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.	–
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.

(Continued)

Item		Factory specification	Allowable limit
Valve spring	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	Oil clearance	0.016 to 0.054 mm 0.00063 to 0.0021 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 16.027 mm 0.62993 to 0.63098 in.	—
Valve bridge arm and valve bridge shaft	Oil clearance	0.018 to 0.042 mm 0.00071 to 0.0016 in.	0.15 mm 0.0059 in.
• Valve bridge shaft	O.D.	9.023 to 9.032 mm 0.3553 to 0.3555 in.	—
• Valve bridge arm	I.D.	9.050 to 9.065 mm 0.3563 to 0.3568 in.	—
Push rod	Alignment	—	0.25 mm 0.0098 in.
Tappet to tappet guide bore	Oil clearance	0.020 to 0.062 mm 0.00079 to 0.0024 in.	0.07 mm 0.003 in.
• Tappet	O.D.	23.959 to 23.980 mm 0.94327 to 0.94409 in.	—
• Tappet guide bore	I.D.	24.000 to 24.021 mm 0.94489 to 0.94570 in.	—
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 [V3800-TIEF4]			
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.

(Continued)

Item		Factory specification	Allowable limit
Idle gear 2 to idle gear 3	Backlash	0.0490 to 0.159 mm 0.00193 to 0.00625 in.	0.22 mm 0.0087 in.
Idle gear 3 to supply pump gear	Backlash	0.0540 to 0.167 mm 0.00213 to 0.00657 in.	0.22 mm 0.0087 in.
Timing gear [V3800-TIEF4C]			
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 3	Backlash	0.0490 to 0.162 mm 0.00193 to 0.00637 in.	0.22 mm 0.0087 in.
Idle gear 3 to supply pump gear	Backlash	0.0540 to 0.167 mm 0.00213 to 0.00657 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 shaft 1, 2	O.D.	44.959 to 44.975 mm 1.7701 to 1.7706 in.	—
• Idle gear 1, 2 bushing	I.D.	45.025 to 45.050 mm 1.7727 to 1.7736 in.	—
Idle gear 3 shaft to idle gear 3 holder	Oil clearance	0.016 to 0.061 mm 0.00063 to 0.0024 in.	0.10 mm 0.0039 in.
• Idle gear 3 shaft	O.D.	15.957 to 15.984 mm 0.62823 to 0.62929 in.	—
• Idle gear 3 holder	I.D.	16.000 to 16.018 mm 0.62993 to 0.63062 in.	—
Idle gear 1, 2	Side clearance	0.15 to 0.30 mm 0.0059 to 0.011 in.	0.90 mm 0.035 in.
Idle gear 3	Side clearance	0.10 to 0.40 mm 0.0040 to 0.015 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.
Piston ring [V3800-TIEF4, V3800-TIEF4C]			
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	0.065 to 0.10 mm 0.0026 to 0.0039 in.	0.15 mm 0.0059 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.
Piston ring gap	Top ring	0.30 to 0.40 mm 0.012 to 0.015 in.	1.25 mm 0.0492 in.
	Second ring	0.45 to 0.60 mm 0.018 to 0.023 in.	1.25 mm 0.0492 in.
	Oil ring	0.25 to 0.45 mm 0.0099 to 0.017 in.	1.25 mm 0.0492 in.
Piston ring [V3800-TIEF4H]			
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	—	—

(Continued)

Item		Factory specification	Allowable limit
Oil ring to ring groove	Clearance	0.020 to 0.060 mm 0.00079 to 0.0023 in.	0.15 mm 0.0059 in.
Piston ring gap	Top ring	0.30 to 0.40 mm 0.012 to 0.015 in.	1.25 mm 0.0492 in.
	Second ring	0.30 to 0.40 mm 0.012 to 0.015 in.	1.25 mm 0.0492 in.
	Oil ring	0.25 to 0.45 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	Oil 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 crank 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 3.94291 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 **[V3800-TIEF4, V3800-TIEF4C]**	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 **[V3800-TIEF4H]**	At idle speed	—	50 kPa 0.5 kgf/cm^2 7 psi
	At rated speed	200 to 450 kPa 2.0 to 4.6 kgf/cm^2 29 to 65 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 ℃ 166.1 to 173.3 ℉	—
	Valve full opening temperature (Opened completely)	90 ℃ 194 ℉	—
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 **[V3800-TIEF4, V3800-TIEF4C]**	Tension (After installing)	441 to 480 N 45.0 to 48.9 kgf 99.2 to 107 lbf	—
	Tension (After engine operation)	391 to 480 N 39.9 to 48.9 kgf 87.9 to 107 lbf	—
[V3800-TIEF4H]	Tension (After installing)	650 to 850 N 66.3 to 86.6 kgf 147 to 191 lbf	—
	Tension (After engine operation)	420 to 550 N 42.9 to 56.0 kgf 94.5 to 123 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.	0.20 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	—

3. Tightening torques

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

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

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

Indication on top of bolt	4 No-grade or 4T			7 7T		
Indication on top of nut	04 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

3.2 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.**

Disassembling and assembling

Item	Dimension × Pitch	N·m	kgf·m	lbf·ft
Drain plug	M22 × 1.5	45 to 53	4.5 to 5.5	33 to 39
Alternator pulley nut	–	58.4 to 78.9	5.95 to 8.05	43.1 to 58.2
*Main bearing case screw	M14 × 1.5	138 to 147	14.0 to 15.0	102 to 108
Flywheel housing mounting screw	M12 × 1.25	103 to 117	10.5 to 12.0	76.0 to 86.7
*Flywheel screw	M12 × 1.25	98.1 to 107	10.0 to 11.0	72.4 to 79.5
*Connecting rod screw	M10 × 1.25	79 to 83	8.0 to 8.5	58 to 61
Camshaft set screw	M8 × 1.25	24 to 27	2.4 to 2.8	18 to 20
Cam pulsar gear retaining screw	M5	4.7 to 5.6	0.48 to 0.58	3.5 to 4.1
Idle gear mounting screw	M8 × 1.25	24 to 27	2.4 to 2.8	18 to 20
Relief valve retaining plug	M22 × 1.5	95.2 to 108	9.70 to 11.1	70.2 to 80.2
Oil pump cover screw	M6	7.9 to 9.3	0.80 to 0.95	5.8to 6.8
Gear case cover mounting screw	M8 × 1.25	33 to 36	3.3 to 3.7	24 to 26
*Crankshaft screw	M16 × 1.5	255 to 274	26.0 to 28.0	188 to 202

(Continued)

Item	Dimension × Pitch	N·m	kgf·m	lbf·ft
Oil cooler joint screw	M20 × 1.5	40 to 44	4.0 to 4.5	29 to 32
Supply pump gear mounting nut	M18 × 1.5	128 to 147	13.0 to 15.0	94.1 to 108
*Cylinder head mounting screw **[V3800-TIEF4, V3800-TIEF4C]**	M12 × 1.25	98.1 to 107	10.0 to 11.0	72.4 to 79.5
*Cylinder head mounting screw **[V3800-TIEF4H]**	M12 × 1.25	120 to 130	12.3 to 13.2	88.5 to 95.8
Exhaust manifold mounting nut	M8 × 1.25	30 to 34	3.0 to 3.5	22 to 25
Exhaust manifold mounting screw	M8 × 1.25	30 to 34	3.0 to 3.5	22 to 25
Intake manifold mounting screw	M8 × 1.25	24 to 27	2.4 to 2.8	18 to 20
*Rocker arm bracket nut	M10 × 1.25	49 to 55	5.0 to 5.7	37 to 41
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
Injector terminal nut	M4	1.6 to 2.2	0.16 to 0.23	1.2 to 1.6
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
Coolant temperature sensor	—	16 to 23	1.6 to 2.4	12 to 17
Camshaft position sensor mounting screw	M6 × 1.0	4 to 5	0.4 to 0.6	3 to 4
Crankshaft position sensor mounting screw	M6 × 1.0	4 to 5	0.4 to 0.6	3 to 4
Intake air temperature sensor	M16 × 1.5	30 to 39	3.0 to 4.0	22 to 28
Boost sensor mounting screw	M6 × 1.0	4 to 5	0.4 to 0.6	3 to 4
Overflow pipe joint screw (M8)	M8 × 1.25	16 to 19	1.6 to 2.0	12 to 14
Overflow pipe joint screw (M10)	M10 × 1.0	7.9 to 12	0.80 to 1.3	5.8 to 9.4
Injection pipe retaining nut	M14 × 1.5 M16 × 1.5	23 to 36	2.3 to 3.7	17 to 26
EGR valve mounting screw	M8 × 1.25	24 to 27	2.4 to 2.8	18 to 20
Intake throttle valve mounting screw	M8 × 1.25	24 to 27	2.4 to 2.8	18 to 20
Turbocharger mounting nut	M8 × 1.25	30 to 34	3.0 to 3.5	22 to 25
Turbocharger mounting screw	M8 × 1.25	30 to 34	3.0 to 3.5	22 to 25
Oil pipe joint screw	M8	16 to 19	1.6 to 2.0	12 to 14
EGR cooler flange	M8 × 1.25	30 to 34	3.0 to 3.5	22 to 25
Filter comp (DPF) mounting screw	M10 × 1.25	49 to 55	5.0 to 5.7	37 to 41
Exhaust gas temperature sensor	M12 × 1.25	25 to 34	2.5 to 3.5	18 to 25
Differential pressure pipe	M8 × 1.0	16 to 22	1.6 to 2.3	12 to 16
Muffler flange screw	M10 × 1.25	49 to 55	5.0 to 5.7	37 to 41

(Continued)

Item	Dimension × Pitch	N·m	kgf·m	lbf·ft
Starter B terminal nut	M8	9.8 to 11	1.0 to 1.2	7.3 to 8.6
Intake air heater terminal nut	M6	3.5 to 5.3	0.35 to 0.55	2.6 to 3.9
Cooling fan mounting screw	M6 × 1.0	9.81 to 11.2	1.00 to 1.15	7.24 to 8.31
Base of SCR	M14 × 1.5	124 to 147	12.6 to 15.0	91.2 to 108
SCR muffler assembly mounting screw	M10 × 1.25	49 to 55	5.0 to 5.7	37 to 41
NOx sensor	–	40 to 60	4.1 to 6.1	30 to 44
SCR inlet temperature sensor	–	40.5 to 49.5	4.13 to 5.04	29.9 to 36.5

Servicing

Item	Dimension × Pitch	N·m	kgf·m	lbf·ft
Slip band nut of SCR mixing pipe	M10 × 1.25	15 to 17	1.6 to 1.7	11 to 12
Oil pressure switch	R 1/8	15 to 19	1.5 to 2.0	11 to 14
DEF injector band	–	3.7 to 4.0	0.38 to 0.40	2.8 to 2.9
DEF filter cover	–	9.00 to 11.0	0.918 to 1.12	6.64 to 8.11

4. Checking and adjusting

4.1 Checking compression pressure of cylinder

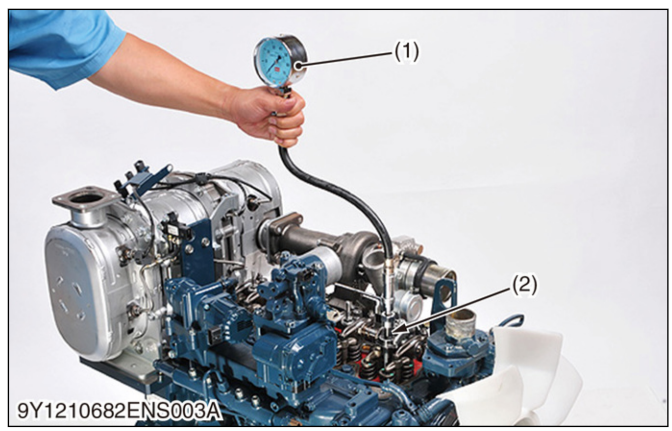
■ **NOTE**

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

Tools required

- Compression tester
- Injector adaptor

1. Warm-up the engine.
2. Remove the air cleaner and muffler.
3. Remove the SCR muffler assembly.
4. Remove the SCR stay and base of SCR.
5. Remove the DPF intermediate harness, injector intermediate harness and engine intermediate harness from the bracket.
6. Remove the EGR cooler pipe.
7. Remove the injection pipe, cylinder head cover, overflow pipe, injectors and gaskets of injector.
8. Set a compression tester (1) with the compression tester adaptor (2) to the injector hole.



(1) Compression tester (2) Compression tester adaptor

9. Crank the engine with the starter to operate the engine approx. 200 min^{-1}(rpm).
10. Measure a maximum value of the compression pressure.

Compression pressure	Factory specification	2.95 to 3.13 MPa / 200 min^{-1}(rpm) 30.0 to 32.0 kgf/cm^2 / 200 min^{-1}(rpm) 427 to 455 psi / 200 min^{-1}(rpm)
	Allowable limit	2.30 MPa / 200 min^{-1}(rpm) 23.5 kgf/cm^2 / 200 min^{-1}(rpm) 334 psi / 200 min^{-1}(rpm)

11. Do the same steps twice for each cylinder.

12. Install the removed parts.

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	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
	Base of SCR	124 to 147 N·m 12.6 to 15.0 kgf·m 91.2 to 108 lbf·ft
	SCR stay	49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	SCR mounting screw	49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	Slip band nut of SCR mixing pipe	15 to 17 N·m 1.6 to 1.7 kgf·m 11 to 12 lbf·ft

RELATED PAGE

5.3 Removing selective catalytic reduction (SCR) muffler on page 3-126

5.4 Removing CRS intermediate harness on page 3-127

6.42 Installing CRS intermediate harness on page 3-177

6.44 Installing SCR muffler assembly on page 3-181

4.2 Adjusting valve clearance

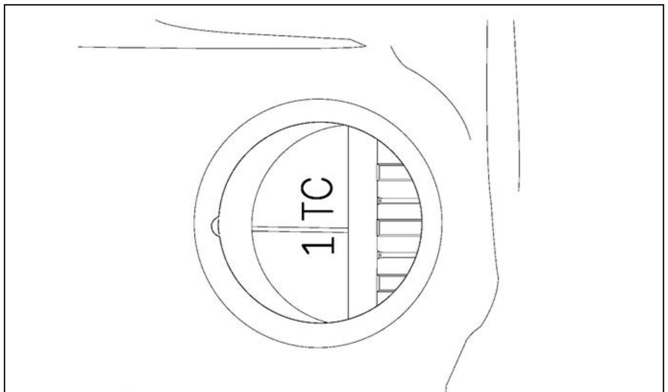
IMPORTANT

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

Tools required

- Feeler gauge

1. Remove the air cleaner and muffler.
2. Remove the SCR muffler assembly.
3. Remove the SCR stay and base of SCR.
4. Remove the DPF intermediate harness, injector intermediate harness and engine intermediate harness from the bracket.
5. Remove the EGR cooler pipe.
6. Remove the injection pipes and cylinder head cover.
7. Align the **[1TC]** mark line on the flywheel and projection on the housing.



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

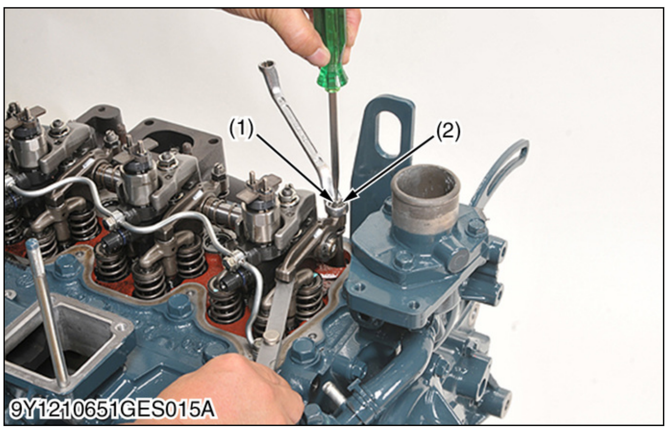
9. Check the subsequent valve clearance at the mark **[1TC]** with a feeler gauge.

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

■ **NOTE**

- **If the clearance is out of the factory specifications, adjust with the adjusting screw (1).**
- **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	☆	☆



(1) Adjusting screw (2) Lock nut

10. Install the removed parts.

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	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
	Injection pipe retaining nut	23 to 36 N·m 2.3 to 3.7 kgf·m 17 to 26 lbf·ft
	Base of SCR	124 to 147 N·m 12.6 to 15.0 kgf·m 91.2 to 108 lbf·ft
	SCR mounting screw	49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	Slip band nut of SCR mixing pipe	15 to 17 N·m 1.6 to 1.7 kgf·m 11 to 12 lbf·ft

RELATED PAGE
5.3 Removing selective catalytic reduction (SCR) muffler on page 3-126
5.4 Removing CRS intermediate harness on page 3-127
6.42 Installing CRS intermediate harness on page 3-177
6.44 Installing SCR muffler assembly on page 3-181

4.3 Checking engine oil pressure

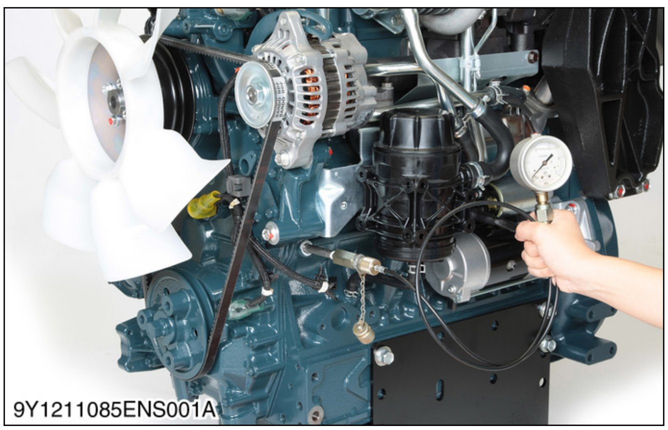
Tools required

- Oil pressure tester

1. Remove the engine oil pressure switch.
2. Set the oil pressure tester.
3. Operate the engine for warming-up.

4. Measure the oil pressure at the idle speed and rated speed.

Engine oil pressure	At idle speed	Allowable limit	50 kPa 0.5 kgf/cm^2 7 psi	
	At rated speed	Factory specification	V3800-TIEF4 V3800-TIEF4C	200 to 390 kPa 2.0 to 4.0 kgf/cm^2 29 to 56 psi
			V3800-TIEF4H	200 to 450 kPa 2.0 to 4.6 kgf/cm^2 29 to 65 psi
		Allowable limit	150 kPa 1.5 kgf/cm^2 21 psi	



■ **NOTE**
- **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**

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

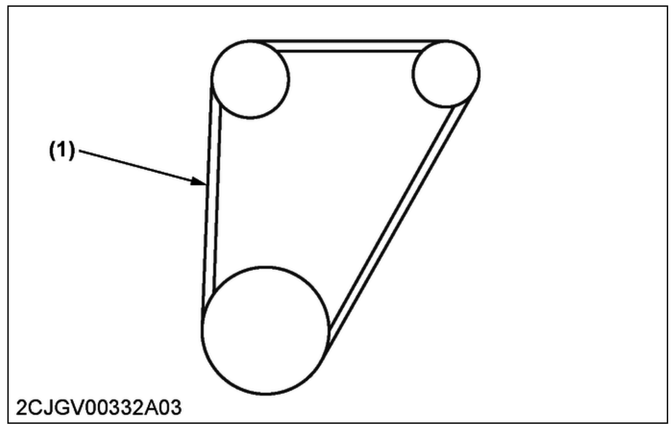
Tightening torque	Oil pressure switch taper screw	15 to 19 N·m 1.5 to 2.0 kgf·m 11 to 14 lbf·ft

4.4 Checking fan belt tension

Tools required
- Sonic belt tension meter

1. Check the tension of fan belt halfway (1) between the fan drive pulley and fan pulley with sonic belt tension meter.

Sonic belt tension meter setting value	V3800-TIEF4, V3800-TIEF4C	V3800-TIEF4H
Mass (Mass per 1 rib 1 m of belt)	110 g/rib/m	18 g/rib/m
Width (Number of ribs)	1	6
Span (Distance of between the fan drive pulley and alternator pulley)	290 mm 11.4 in.	317 mm 12.5 in.



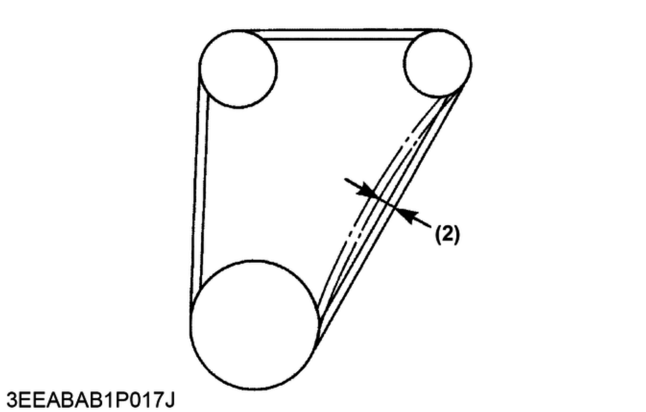
(1) Fan belt halfway

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

Belt tension (After installing)	Factory specification	V3800-TIEF4 V3800-TIEF4C	441 to 480 N 45.0 to 48.9 kgf 99.2 to 107 lbf
		V3800-TIEF4H	650 to 850 N 66.3 to 86.6 kgf 147 to 191 lbf
Belt tension (After engine operation)	Factory specification	V3800-TIEF4 V3800-TIEF4C	391 to 480 N 39.9 to 48.9 kgf 87.9 to 107 lbf
		V3800-TIEF4H	420 to 550 N 42.9 to 56.0 kgf 94.5 to 123 lbf

(Reference)

a. Push the belt halfway between the fan drive pulley and alternator pulley at a specified force to measure the deflection (2).



(2) Deflection

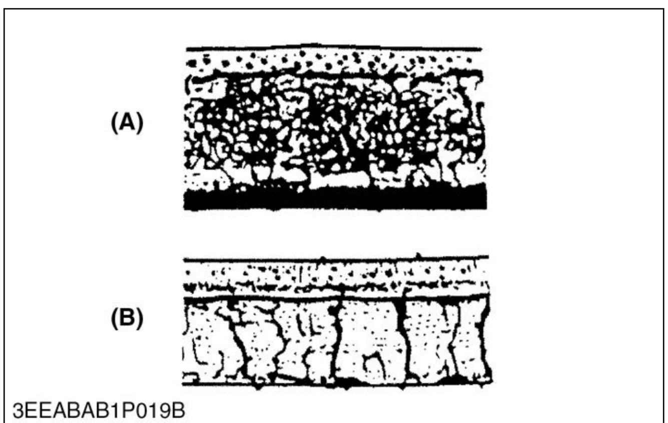
■ **NOTE**

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

Deflection (2)	Factory specification	V3800-TIEF4 V3800-TIEF4C	10 to 12 mm 0.40 to 0.47 in. (under load of 59 to 68 N (6.0 to 7.0 kg, 14 to 15 lbf))
		V3800-TIEF4H	9.0 to 11 mm 0.36 to 0.43 in. (under load of 59 to 68 N (6.0 to 7.0 kg, 14 to 15 lbf))

4.5 Checking fan belt damage and wear

1. Check the fan belt for damage.

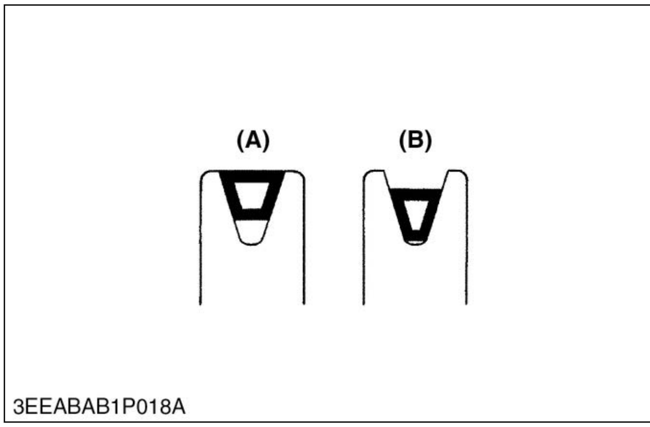


(A) Good (B) Bad

■ **NOTE**

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

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



(A) Good (B) Bad

■ **NOTE**

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

4.6 Checking radiator cap air leakage

CAUTION

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

Tools required

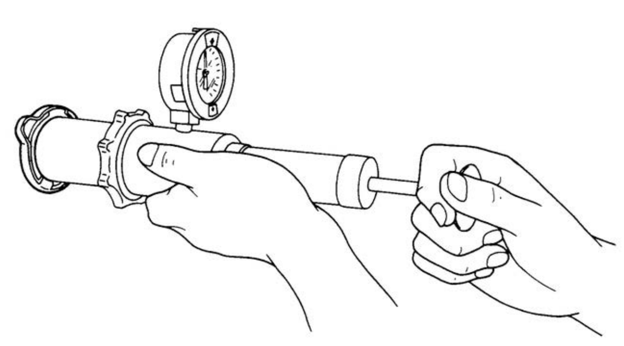
- Radiator cap tester and an adaptor

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

Specified pressure	88 kPa 0.90 kgf/cm^2 12 psi

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

Pressure decreasing time	Factory specification	More than 10 seconds for pressure decrease from 88 to 59 kPa from 0.90 to 0.60 kgf/cm^2 from 12 to 8.6 psi



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

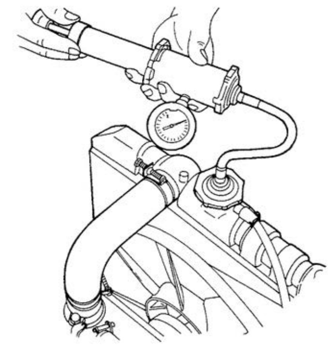
4.7 Checking radiator water leakage

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

Tools required
- Radiator tester and an adaptor

1. Fill a specified quantity of water into the radiator.
2. Set a radiator tester and an adaptor on the radiator.
3. Increase the water pressure to the specified pressure with the radiator tester and an adaptor.
4. Check the radiator for water leakage.

Radiator water leakage test	Factory specification	No leak at specified pressure



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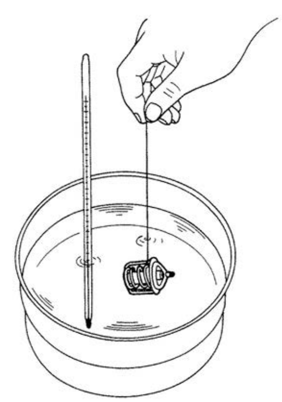
■ **NOTE**
- **For water leakages from the pinhole, replace the radiator or repair with the radiator cement.**
- **When water leak is too much, replace the radiator.**

4.8 Checking opening temperature of thermostat valve

Tools required
- Thermometer

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

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



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6. Continue to increase the temperature and read the temperature when the valve full opens gap.

Valve full opens gap	Approx. 8 mm Approx. 0.3 in.

Full opening temperature	Factory specification	90 ℃ 194 ℉

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

4.9 Checking battery voltage

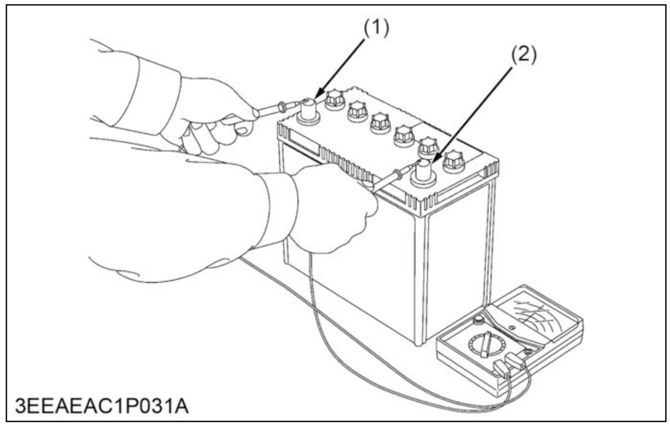
CAUTION
- **To prevent an accidental short circuit, attach the positive cable to the positive terminal before the negative cable is attached to the negative terminal.**
- **Do not remove the battery cap while the engine operates.**
- **Keep electrolyte away from eyes, hands and clothes.**
  If you are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

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

Tools required
- Circuit tester

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

Battery voltage	Factory specification	More than 12 V



(1) Positive terminal (2) Negative terminal

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

4.10 Checking battery specific gravity

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

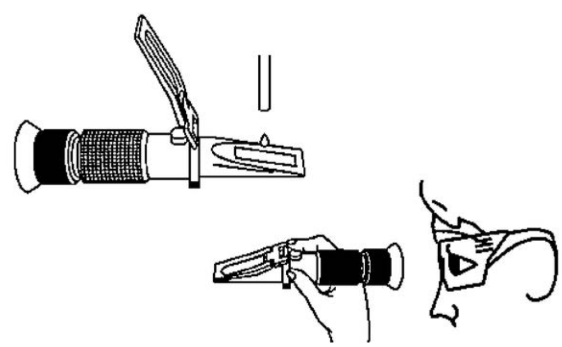
understand the danger perform inspection or maintenance.

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

Tools required
- Battery / coolant tester

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

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



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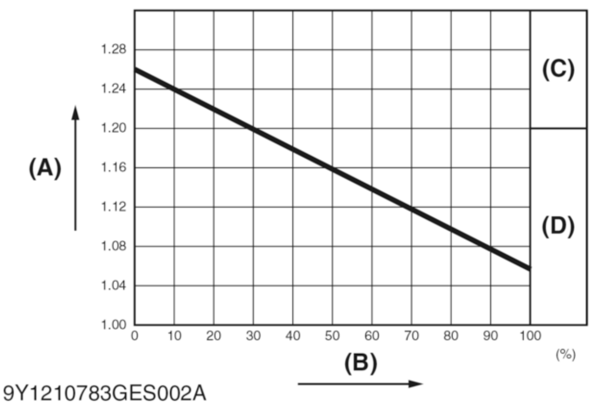
■ **NOTE**
- **Electrolyte specific gravity and amount of discharge.**
  Use the following table as a reference.



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

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

4.11 Checking starter motor

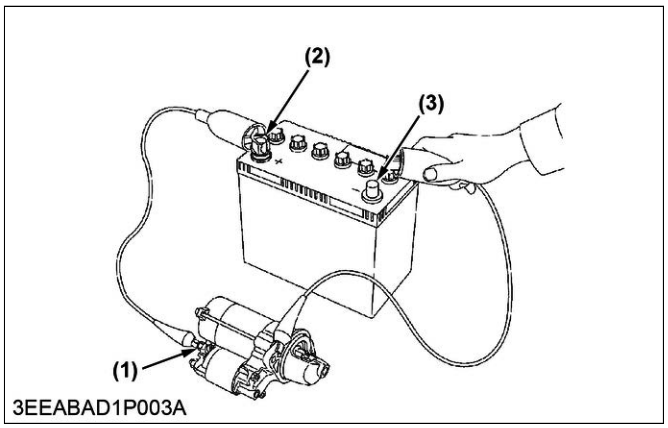
CAUTION
- **To prevent an accidental short circuit, attach the positive cable to the positive terminal before the negative cable is attached to the negative terminal.**
- **Do not remove the battery cap while the engine operates.**
- **Keep electrolyte away from eyes, hands and clothes.**
  If you are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

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

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

Tools required
- Circuit tester
- Jumper lead

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



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

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

4.12 Checking magnetic switch of starter

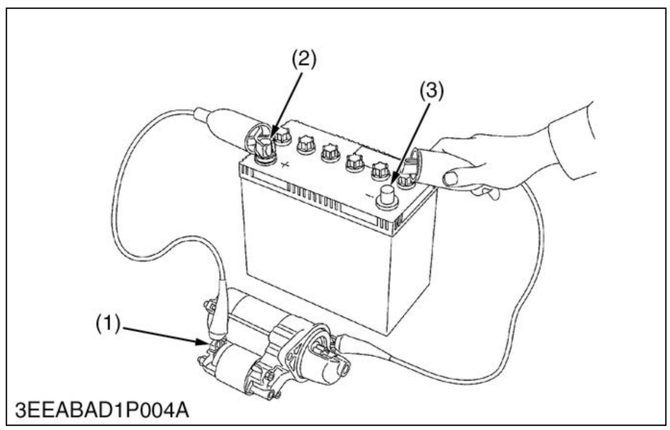
CAUTION
- **To prevent an accidental short circuit, attach the positive cable to the positive terminal before the negative cable is attached to the negative terminal.**
- **Do not remove the battery cap while the engine operates.**
- **Keep electrolyte away from eyes, hands and clothes.**
  If you are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

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

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

Tools required
- Circuit tester
- Jumper lead

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



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

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

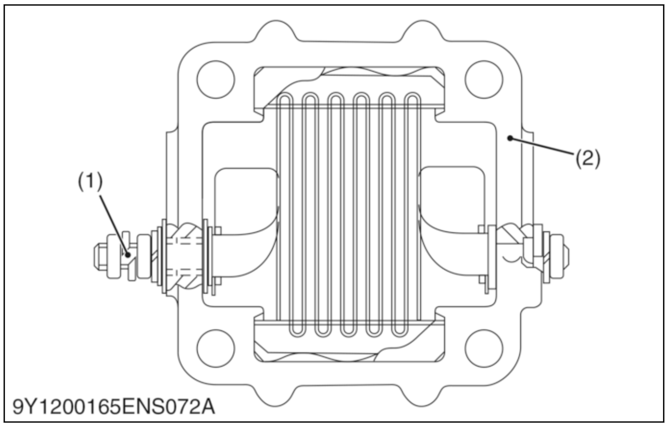
4.13 Checking intake air heater

Tools required
- Circuit tester

1. Disconnect the leads from the intake air heater.

2. Measure the resistance between the positive terminal (1) and the intake air heater body (2).

Resistance of the heater coil	12 V specification	Approx. 0.3 Ω (Approx. 42 A: at 25 ℃ (77 ℉))



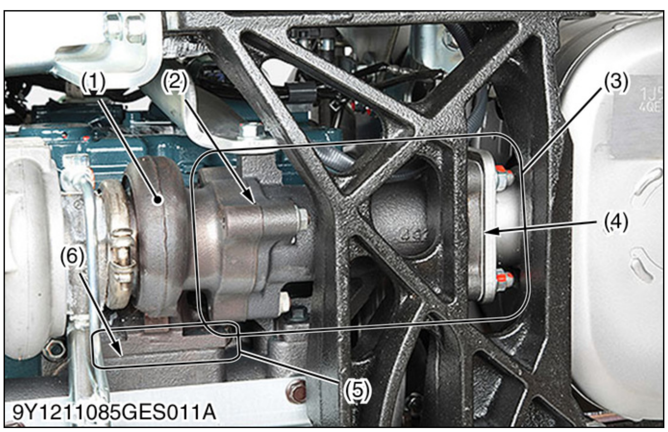
(1) Positive terminal (2) Intake air heater body

■ **NOTE**

- **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.**

4.14 Checking exhaust gas leakage of turbocharger turbine side

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



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

■ **NOTE**

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

4.15 Checking air leakage of turbocharger compressor side

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

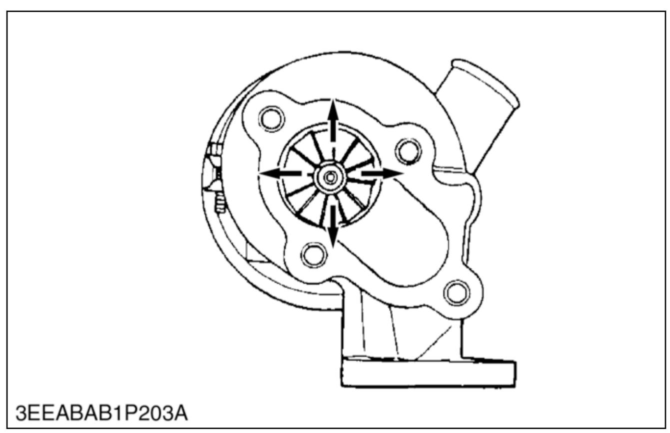
(1) Compressor cover

■ **NOTE**

- **If you find an air leakage, change the clamps and / or the inlet hose.**

4.16 Checking radial clearance of turbocharger

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



■ **NOTE**

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

4.17 Checking injector

Tools required

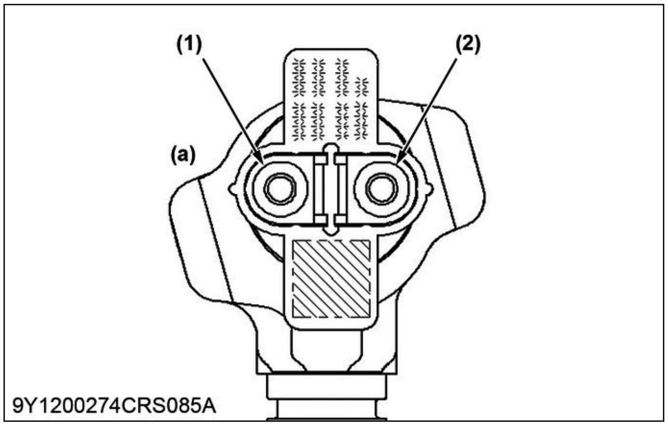
- Circuit tester

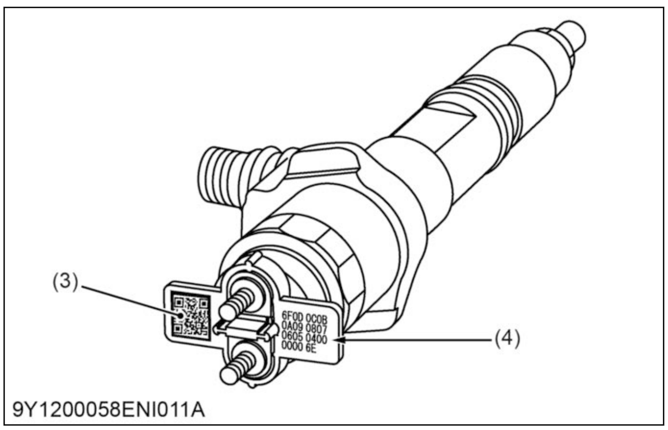
1. Remove the cylinder head cover 2.

2. Disconnect the injector cable.
3. Measure the resistance between injector terminals (1) and (2).

Resistance	Factory specification	0.4 to 0.7 Ω

■ NOTE
- **If the measurement is out of the factory specifications, replace the injector.**
- **When replace the injector, write the ID (4) (QR (3)) code of replaced injector in the ECU with the diagnosis tool.**





(1) Terminal COMMON
(2) Terminal TWV
(3) QR code
(4) ID code
(a) Injector

RELATED PAGE
7.55 Replacing injector on page 3-212

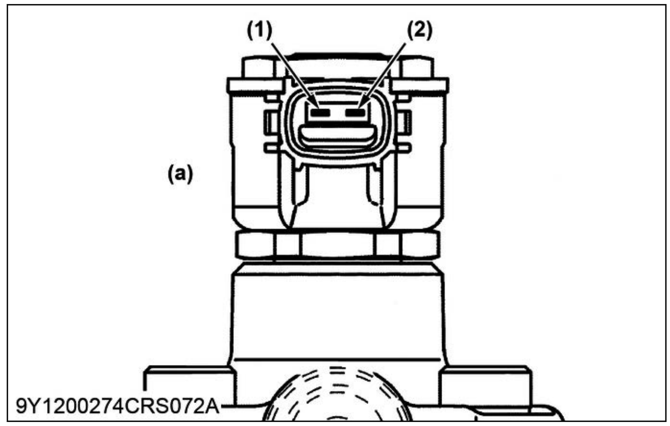
4.18 Checking pre-stroke control valve (PCV)

Tools required
- Circuit tester

1. Place the key switch in the OFF position.
2. Disconnect the PCV wiring harness connector.
3. Measure the resistance between PCV terminals (1) and (2).

Resistance	Factory specification	0.47 Ω at 20 ℃ (68 ℉)

■ NOTE
- **If the measurement is out of the factory specifications, replace the supply pump.**



(1) Terminal PCV−
(2) Terminal PCV+
(a) Pre-stroke control valve (PCV)

RELATED PAGE
7.54 Replacing supply pump on page 3-210

4.19 Checking pressure relief valve (PRV)

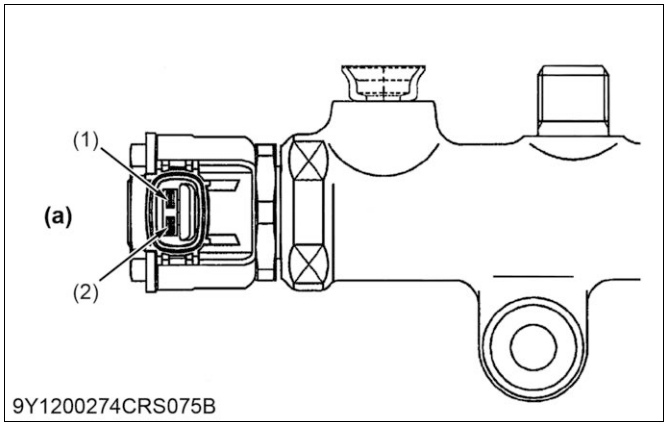
Tools required
- Circuit tester

1. Place the key switch in the OFF position.
2. Disconnect the PRV wiring harness connector.

3. Measure the resistance between PRV terminals (1) and (2).

Resistance	Factory specification	0.47 Ω at 20 ℃ (68 ℉)

■ **NOTE**
- **If the measurement is out of the factory specifications, replace the rail assembly.**



(1) Terminal PRV+
(2) Terminal PRV−
(a) Pressure relief valve (PRV)

— RELATED PAGE —
5.12 Removing common rail on page 3-131
6.35 Installing common rail on page 3-172

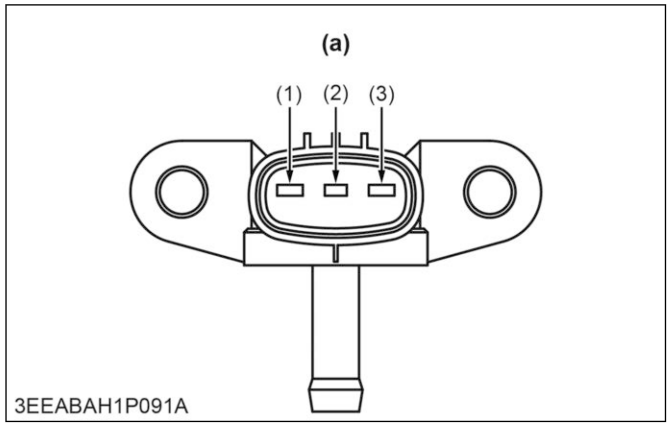
4.20 Checking boost sensor

Tools required
- Circuit tester

1. Place the key switch in the ON position.
2. Measure the voltage between the boost sensor terminal (2) and (3) connector from the wiring harness side.
3. Start the engine, change the depressed amount of the accelerator pedal, and check the same items again.

Engine state	Output voltage	
Key switch ON	Factory specification	Approx. 1.0 V
After engine start-up		Approx. 1.0 to 2.2 V

■ **NOTE**
- **If the measurement is out of the factory specifications, measure the voltage between boost sensor terminal (1) and (3) (from the wiring harness side).**



(1) Terminal A-VCC2
(2) Terminal PIM
(3) Terminal A-GND4
(a) Terminal layout

4. Set the key switch to the OFF position.
5. Disconnect the boost sensor connector from the socket.
6. Place the key switch in the ON position.
7. Measure the voltage between boost sensor terminal (2) and (3) connector (from the wiring harness side).

Terminal PIM (2) and terminal A-GND4 (3)	Factory specification	Approx. 5 V

■ **NOTE**
- **If the measurement is out of the factory specification, replace the boost pressure sensor.**

4.21 Checking intake air temperature sensor

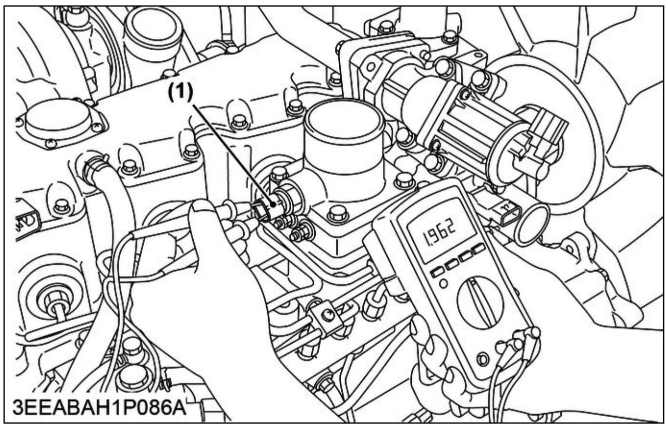
Tools required
- Circuit tester

1. Turn the key switch OFF.
2. Remove the connector from the sensor side.

3. Measure the resistance between the terminals on the sensor side.

Factory specification	
Temperature	**Resistance**
20 ℃ 68 ℉	Approx. 2.4 kΩ
60 ℃ 140 ℉	Approx. 0.58 kΩ
100 ℃ 212 ℉	Approx. 0.18 kΩ

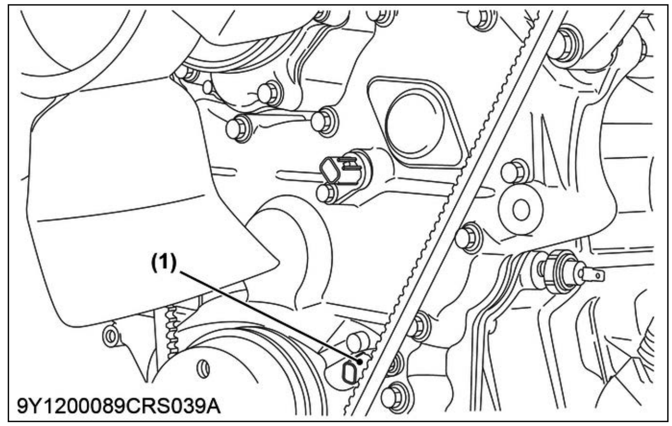
■ NOTE
- **If the measurement is out of the factory specifications, replace the intake air temperature sensor (1).**



(1) Intake air temperature sensor

4.22 Checking crankshaft position sensor

1. Disconnect the sensor and check the following items.
   - Check that there is a large amount of magnetic foreign material adhering to the sensor surface or not.
   - Check that there are interference marks of the pulsar and the sensor or not.
   - Check that there are any pulsar gear abnormalities or not.



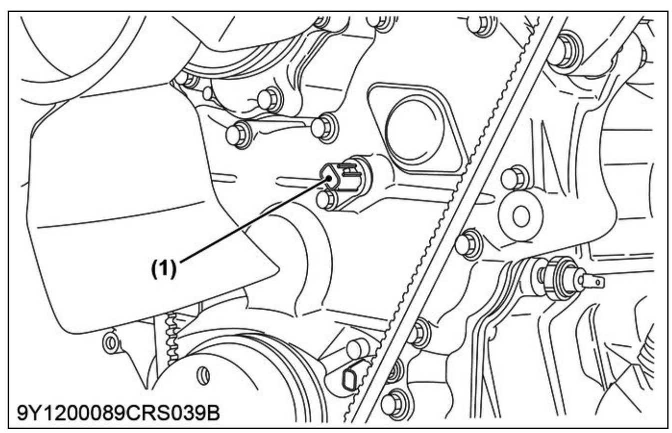
(1) Crankshaft position sensor

■ NOTE
- **If the sensor is faulty, replace the crankshaft position sensor.**

RELATED PAGE
4.34 Adjusting crankshaft position sensor air gap on page 3-118

4.23 Checking camshaft position sensor

1. Disconnect the sensor and check the following items.
   - Check that there is a large amount of magnetic foreign material adhering to the sensor surface or not.
   - Check that there are interference marks of the pulsar and the sensor or not.
   - Check that there are any pulsar gear abnormalities or not.



(1) Camshaft position sensor

■ NOTE
- **If the sensor is faulty, replace the camshaft position sensor.**

4.24 Checking coolant temperature sensor

Tools required

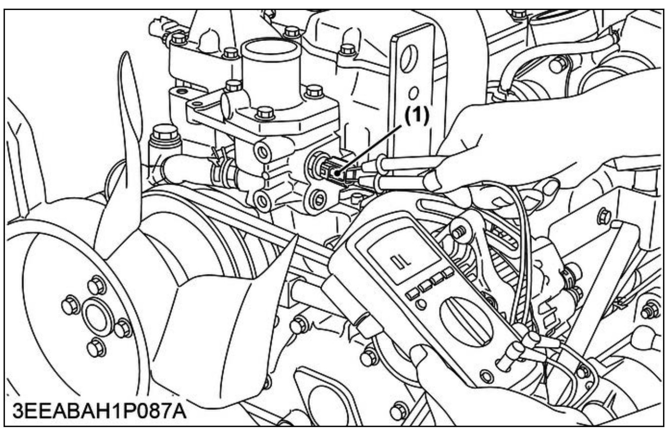
- Circuit tester

1. Turn the key switch OFF.
2. Remove the connector from the sensor side.
3. Measure the resistance between the terminals on the sensor side.

Factory specification	
Temperature	**Resistance**
20 ℃ 68 ℉	Approx. 2.5 kΩ
40 ℃ 104 ℉	Approx. 1.2 kΩ
60 ℃ 140 ℉	Approx. 0.58 kΩ
80 ℃ 176 ℉	Approx. 0.32 kΩ
100 ℃ 212 ℉	Approx. 0.18 kΩ

■ **NOTE**

- **If the measurement is out of the factory specifications, replace the coolant temperature sensor (1).**



(1) Coolant temperature sensor

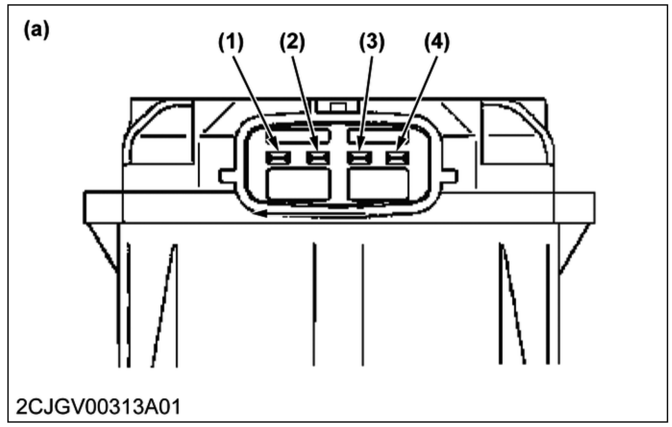
4.25 Checking EGR system

Tools required

- Circuit tester

1. Disconnect the EGR valve connector.
2. Check of battery line of motor in EGR valve.
3. Measure the voltage between terminal power (4) and terminal ground (3) at key ON status.

Terminal power (4) and terminal ground (3)	Factory specification	9 to 16 V



(1) Terminal CAN1-H
(2) Terminal CAN1-L
(3) Terminal ground
(4) Terminal power (+12 V)
(a) Terminal layout

4.26 Checking air flow sensor

Tools required

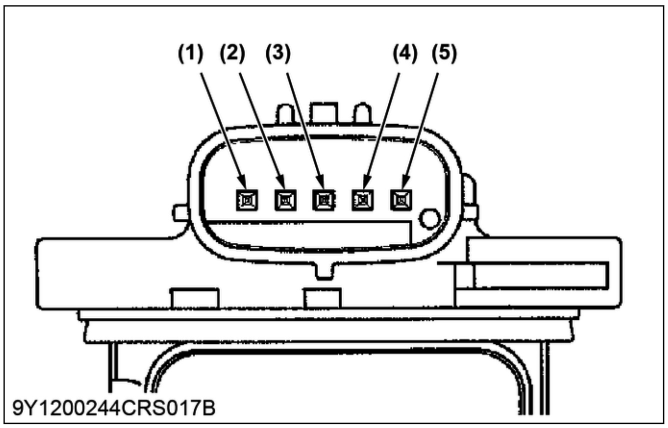
- Circuit tester

1. Turn the key switch OFF.
2. Remove the connector from the sensor side.

3. Measure the resistance between the terminal IATS (2) and the terminal A-GND 10 (1) on the sensor side.

Factory specification	
Temperature	Resistance
20 ℃ 68 ℉	Approx. 2.43 kΩ
40 ℃ 104 ℉	Approx. 1.15 kΩ
60 ℃ 140 ℉	Approx. 0.587 kΩ
80 ℃ 176 ℉	Approx. 0.321 kΩ
100 ℃ 212 ℉	Approx. 18.3 kΩ
150 ℃ 302 ℉	Approx. 7.88 kΩ
200 ℃ 392 ℉	Approx. 4.00 kΩ
250 ℃ 482 ℉	Approx. 2.30 kΩ

NOTE
- **If the measurement is out of the factory specifications, replace the air flow sensor.**

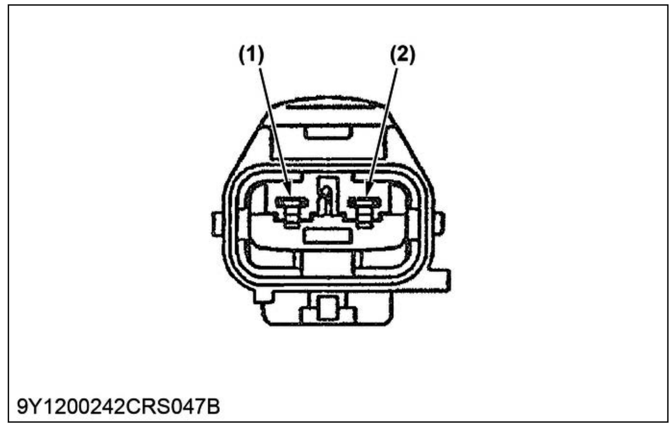


(1) Terminal A-GND 10
(2) Terminal IATS
(3) Terminal AFS
(4) Terminal Ground
(5) Terminal Power (+12 V)

4.27 Checking exhaust gas temperature sensor

Tools required
- Circuit tester

1. Turn the key switch OFF.
2. Remove the connector from the sensor side.
3. Measure the resistance between the terminal (1) and terminal A-GND3 (2) on the sensor side.



(1) Terminal (T_0 : IDOC, T_1 : ODOC, T_2 : ODPF)
(2) Terminal A-GND3

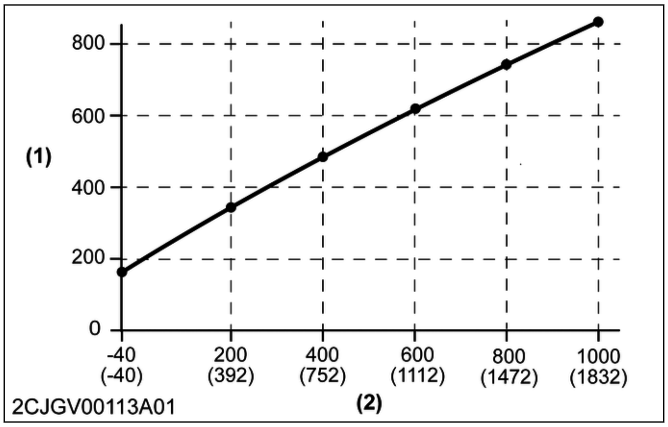
4.28 Checking SCR inlet temperature sensor

Tools required
- Circuit tester

1. Turn the key switch OFF.
2. Remove the connector from the sensor side.

3. Measure the resistance between the terminals on the sensor side.

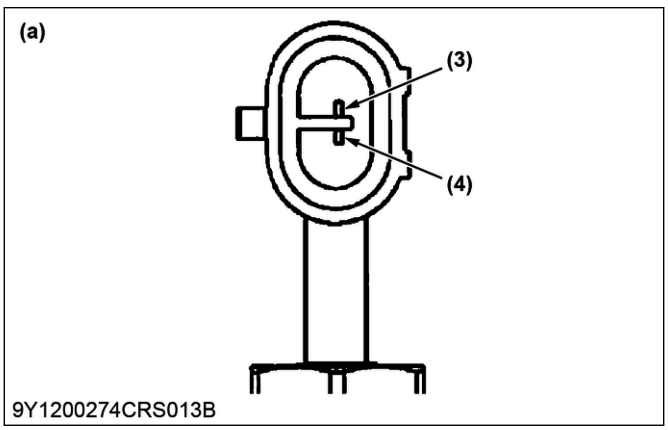
Resistance	Factory specification	220 Ω @25 ℃ (77 ℉)



(1) Sensor resistance (Ω)
(2) SCR temperature (℃ (℉))

■ **NOTE**

- **If the measurement is out of the factory specifications, replace the SCR inlet temperature sensor.**



(3) Terminal EGT 1
(4) Terminal SGND
(a) SCR temperature sensor terminal layout

4.29 Checking DEF pump

Tools required

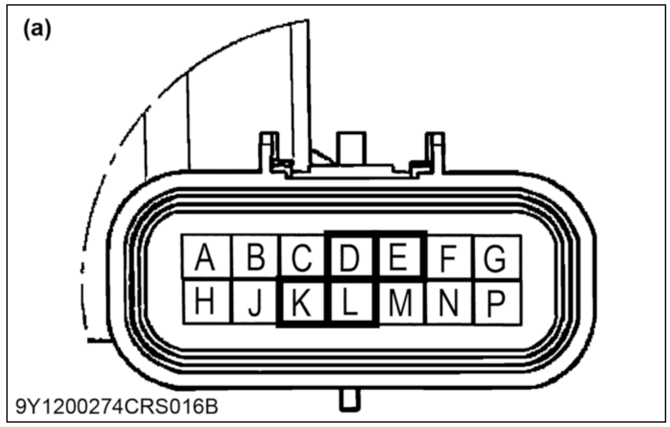
- Circuit tester

1. Disconnect the DEF pump unit connector.
2. Measure the resistance between the K and D / E / L of the DEF pump unit side connector.

Resistance D−K E−K L−K	Factory specification	Approx. 1.5 kΩ or higher

■ **NOTE**

- **If the measurement is out of the factory specifications, replace the DEF pump.**



D Terminal DEF pump (U-phase)
E Terminal DEF pump (V-phase)
L Terminal DEF pump (W-phase)
K Terminal SGND
(a) Terminal layout

4.30 Checking DEF tube

Tools required

- Circuit tester

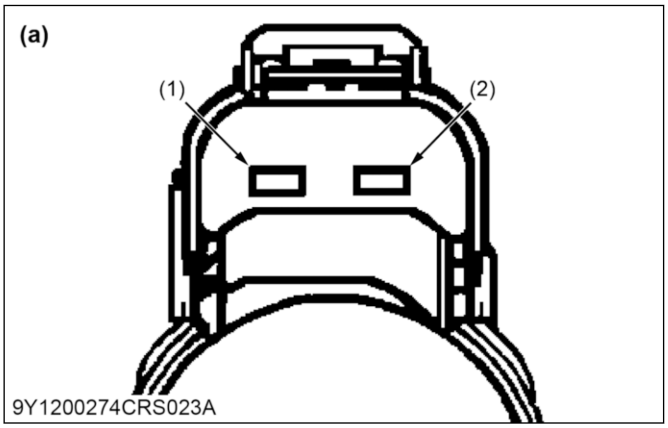
1. Disconnect the tube heater.

2. Measure the resistance between terminal tube heater (1) and terminal power (2).

Resistance	Suction	Factory specification	Approx. 8.6 Ω / m
	Delivery		Approx. 3.2 Ω / 3 m
	Return		Approx. 2.5 Ω / 4 m

■ **NOTE**

- **If the measurement is out of the factory specifications, replace the tube heater.**



(1) Terminal tube heater
(2) Terminal power (+12 V)
(a) Tube heater terminal

4.31 Checking DEF injector

Tools required

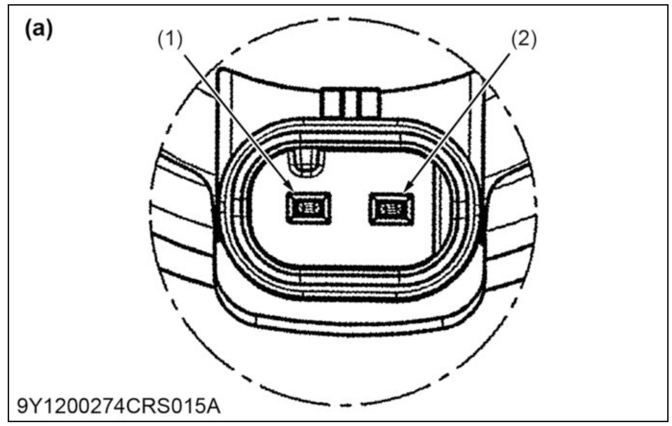
- Circuit tester

1. Disconnect the injector cable connector.
2. Measure the resistance between injector terminal INJ (+) (1) and terminal INJ (-) (2).

Resistance	Factory specification	Approx. 7 Ω

■ **NOTE**

- **If the measurement is out of the factory specifications, replace the DEF injector.**
- **When replace the DEF injector, write the ID (QR) code of replaced DEF injector in the ACU with the diagnosis tool.**



(1) Terminal INJ (+)
(2) Terminal INJ (-)
(a) DEF injector

RELATED PAGE

7.60 Replacing DEF injector on page 3-228

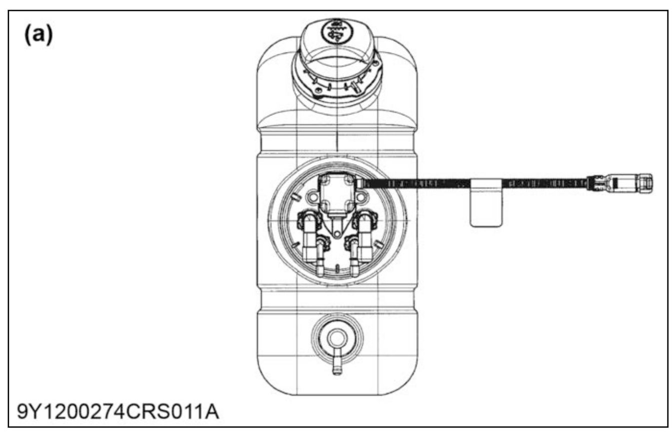
4.32 Checking DEF tank unit

1. Make sure that there is no leakage of DEF (urea aqueous) tank.

Factory specification	No leakage of DEF

■ **NOTE**

- **If the measurement is out of the factory specifications, replace the DEF tank.**



(a) DEF tank unit

4.33 Checking coolant valve

Tools required

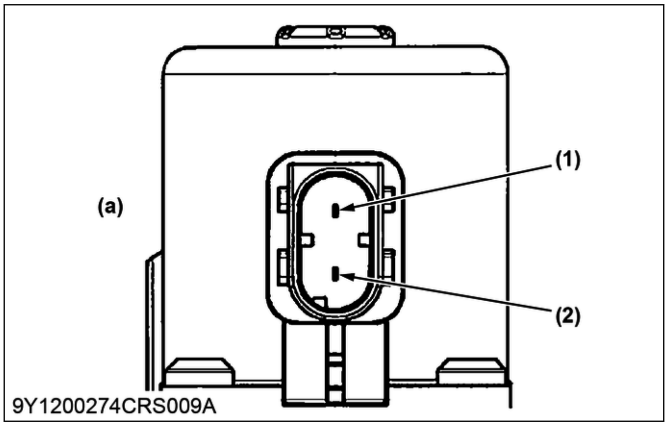
- Circuit tester

1. Disconnect the tank heater coolant valve connector.

2. Measure the resistance between coolant valve (+) terminal (1) and coolant valve (-) terminal (2).

Resistance	Factory specification	Approx. 9 to 13 Ω at room temperature

■ **NOTE**
- **If the measurement is out of the factory specifications, replace the coolant valve.**



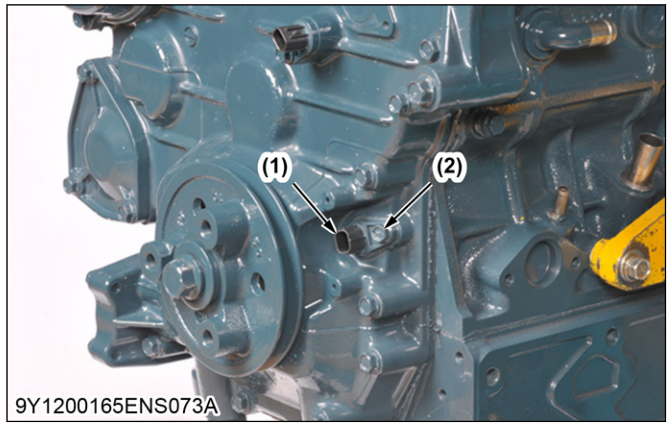
(1) Coolant valve (+)
(2) Coolant valve (-)
(a) Coolant valve terminal layout

4.34 Adjusting crankshaft position sensor air gap

■ **IMPORTANT**
- **If you drop the crankshaft position sensor, do not reuse it.**
- **If the crankshaft position sensor, gear case and/or pulsar gear are replaced, use a combination of shims to adjust the sensor's air gap.**

Tools required
- Measurement jig 1
- Measurement jig 2
- Dial gauge

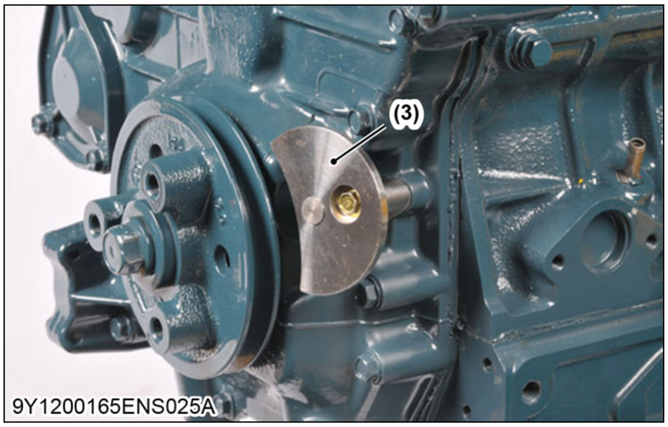
1. Remove the crankshaft position sensor mounting screw (2).
2. Remove the crankshaft position sensor (1).

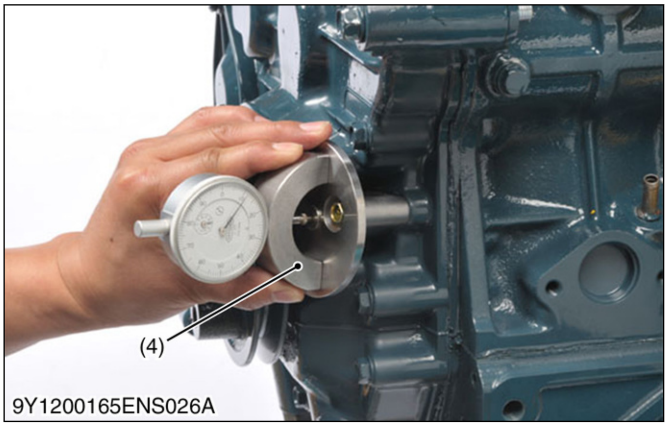


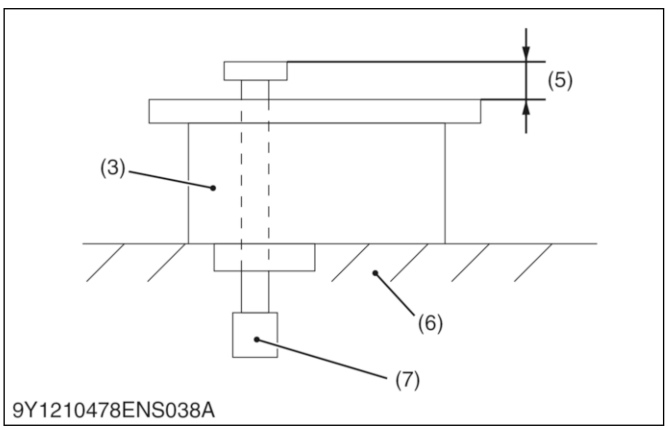
(1) Crankshaft position sensor
(2) Crankshaft position sensor mounting screw

3. Align the TC mark of flywheel with the flywheel housing timing window.
4. Install the measurement jig 1 (3) to the sensor mounting position.

5. Set the dial gauge at the measurement jig 2 (4), then measure the protrusion (5) of the jig 1 (3).







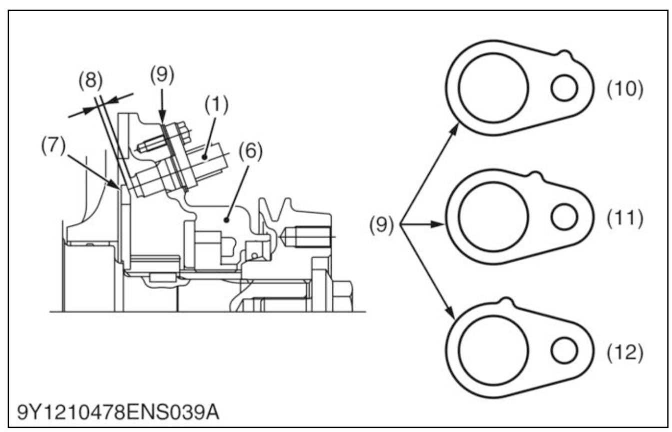
(3) Measurement jig 1
(4) Measurement jig 2
(5) Protrusion
(6) Gear case
(7) Pulsar gear

6. Refer to the protrusion (5) you measured, and select the number of adjusting shims (9) from the table.

Combination of shims

Protrusion (5)	**Thickness & number of shims**		
	Shim (10) 0.25 mm 0.0098 in.	**Shim (11) 0.50 mm 0.020 in.**	**Shim (12) 1.00 mm 0.0394 in.**
	1G381-044 20	**1G381-044 30**	**1G381-044 40**
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.



(1) Crankshaft position sensor
(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.))

7. Install the crankshaft position sensor (1) and tighten to the specified torque.

Tightening torque	Crankshaft position sensor mounting screw (2)	4 to 5 N·m 0.4 to 0.6 kgf·m 3 to 4 lbf·ft

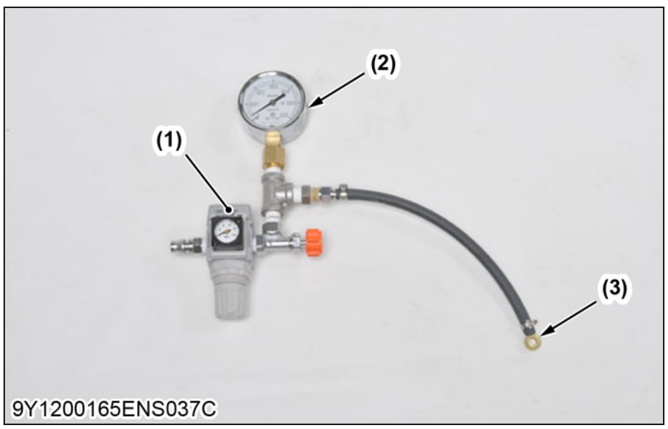
4.35 Checking fuel leakage of the overflow pipe

Tools required

- Air pressure adjustment equipment

Specification of air pressure adjustment equipment

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 (2)	0 to 0.06 MPa 0 to 0.6 kgf/cm^2 0 to 8 psi
Fuel pipe joint (3)	14117-42560



(1) Regulator
(2) Pressure gauge
(3) Fuel pipe joint

1. Connect the fuel pipe joint (3) of air pressure adjustment equipment to the eye joint bolt (5).
2. Tighten the valve (6).
3. Connect the air hose to the air pressure adjustment equipment.
4. Adjust the air pressure of the regulator (1).

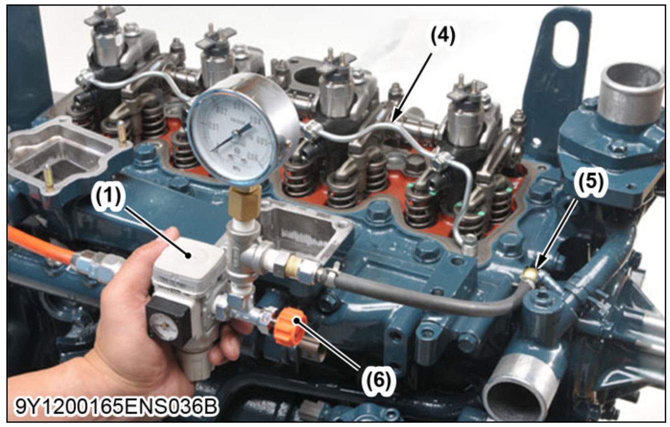
Air pressure of regulator	0.03 to 0.05 MPa 0.3 to 0.5 kgf/cm^2 5 to 7 psi

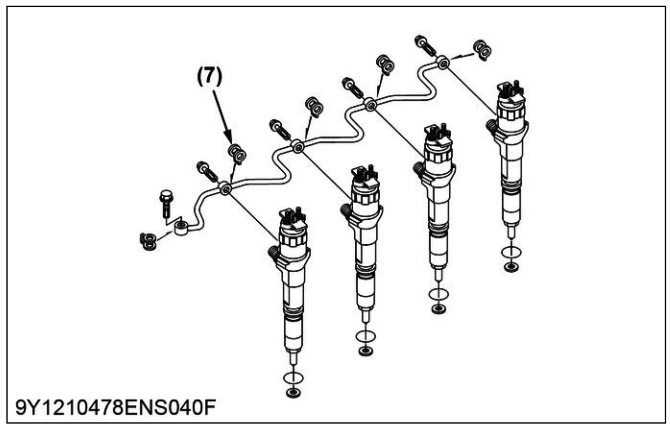
5. Open the valve (6) gradually, then add pressure.

Adding pressure	0.03 MPa 0.3 kgf/cm^2 4 psi

6. Tighten the valve (6).
7. Check the decreased pressure after 4 seconds.

Decreased pressure	After 4 second is lower than 0.001 MPa 0.01 kgf/cm^2 0.1 psi





(1) Regulator
(4) Overflow pipe
(5) Eye joint bolt
(6) Valve
(7) Gasket

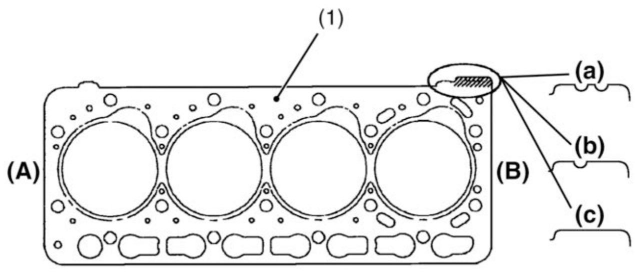
■ **NOTE**

- **If the decreased pressure is higher than standard value, it means that there is fuel leakage.**
  Replace the gasket (7), then check the fuel leakage again.

4.36 Selecting cylinder head gasket

Replacing 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).



3EEABAB1P068A

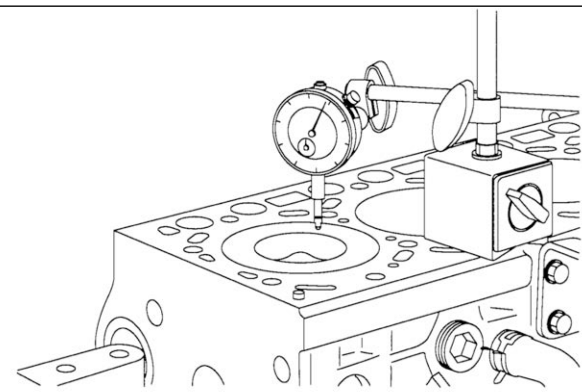
(1) Cylinder head gasket
(A) Gear case side
(B) Flywheel side
(a) 2 notches
(b) 1 notch
(c) Without notch

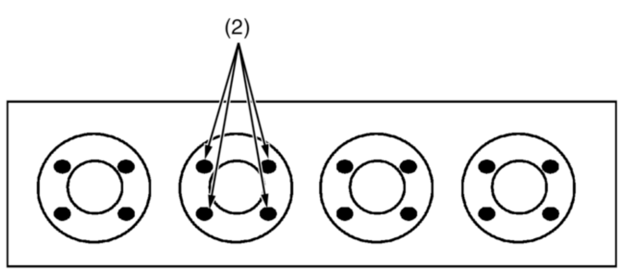
Selecting cylinder head gasket

■ **NOTE**

- **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.**

1. **Measure the piston head's protrusion or recessing between measurement points (2) of the each piston and crankcase surface using the dial gauge as shown in figure.**


3EEABAC1P025A



3EEABAC1P026A

(2) Measurement points

2. **Calculate the average of the measurements.**
3. **Use the table below to select an applicable cylinder head gasket.**

Notch of cylinder head gasket	Model	Code number	Piston head's protrusion or recessing from the level of crankcase cylinder face. (average of 4 pistons)
2 notches (a)	V3800-TIEF4 V3800-TIEF4C	1G514-03310	-0.0700 to +0.0490 mm -0.00275 to +0.00192 in.
	V3800-TIEF4H	1J507-03310	+0.220 to +0.340 mm +0.00867 to +0.0133 in.
1 notch (b)	V3800-TIEF4 V3800-TIEF4C	1G514-03600	+0.0500 to +0.149 mm +0.00197 to +0.00586 in.
	V3800-TIEF4H	1J507-03600	+0.341 to +0.441 mm +0.0135 to +0.0173 in.
Without notch (c)	V3800-TIEF4 V3800-TIEF4C	1G514-03610	+0.150 to +0.200 mm +0.00591 to +0.00787 in.
	V3800-TIEF4H	1J507-03610	+0.442 to +0.492 mm +0.0174 to +0.0193 in.

4.37 Measuring angular deviation between crankshaft T.D.C. and crank position sensor detected T.D.C.

■ **IMPORTANT**

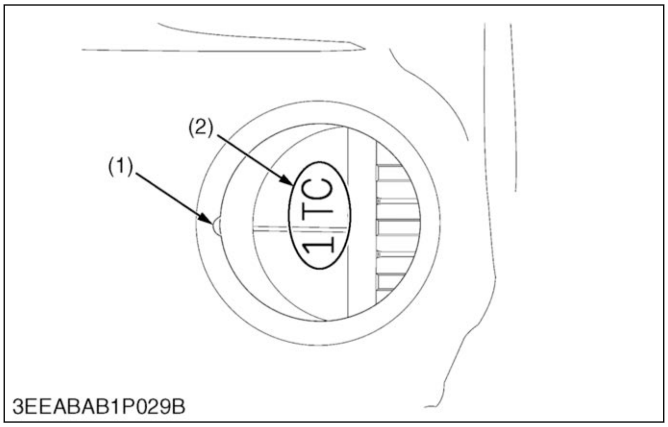
- **If the crankshaft, gear case and/or crank gear are replaced, it is necessary to calibrate the injection timing with the diagnosis tool.**

Tools required

- Dial gauge
- Circuit tester
- Rotation Sensor Signal Interface Unit

1. Remove the cylinder head cover, an injector and rocker arm.

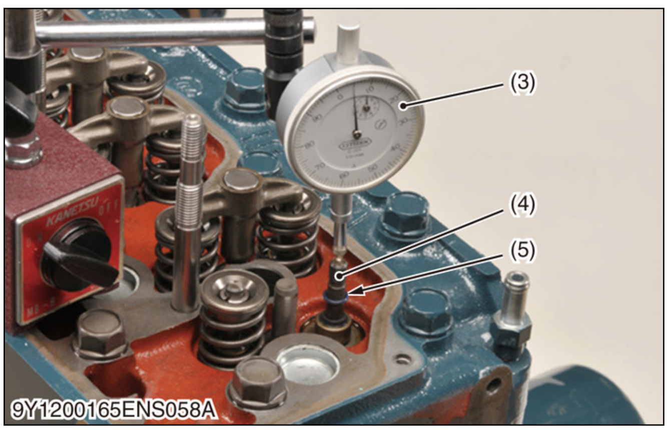
2. Bring the piston of cylinder 4 to T.D.C.



(1) TC mark (flywheel housing) (2) TC mark (flywheel)

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).

IMPORTANT
- **Do not drop the valve (4) into the cylinder.**



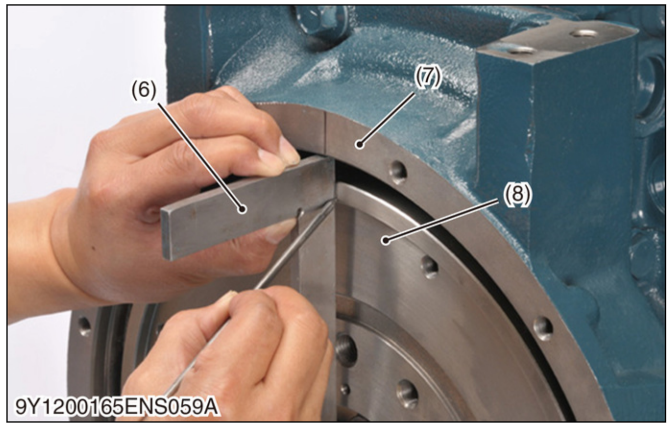
(3) Dial gauge (5) O-ring
(4) Valve

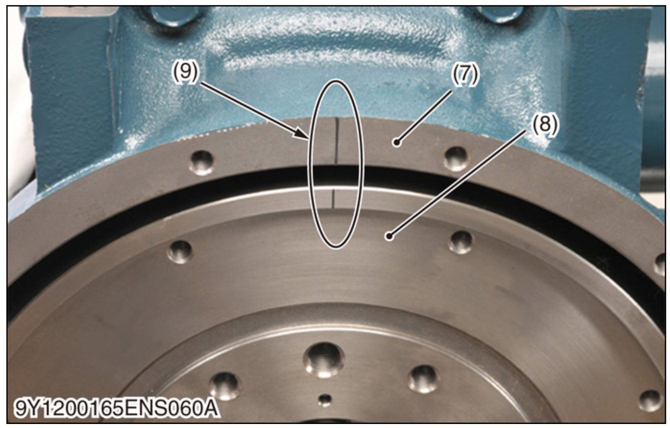
6. Turn the flywheel counterclockwise and measure the position where the tip of the valve (4) is the highest.

IMPORTANT
- **When measuring the highest position of the tip of the valve (4), do not rotate the flywheel clockwise.**
  If you go past the highest point of the valve (4), back the flywheel up slightly and measure the highest point of the valve (4).

7. Stop the flywheel at the position where the tip of the valve (4) is the highest.
8. Put a tri-square (6) on the flywheel housing (7) and flywheel (8) and draw a reference line (9).

IMPORTANT
- **The reference line (9) indicates the T.D.C. of the crankshaft.**

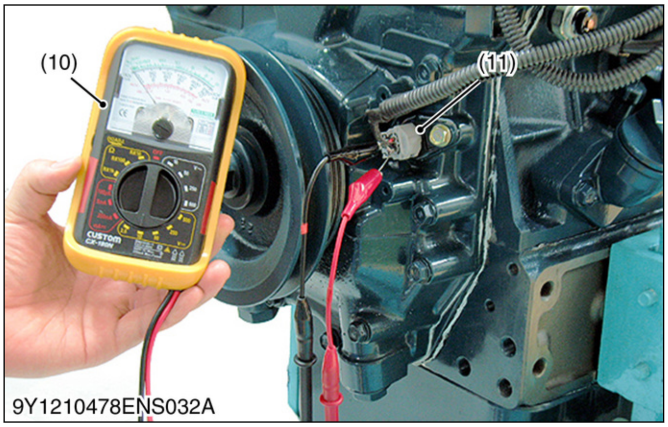


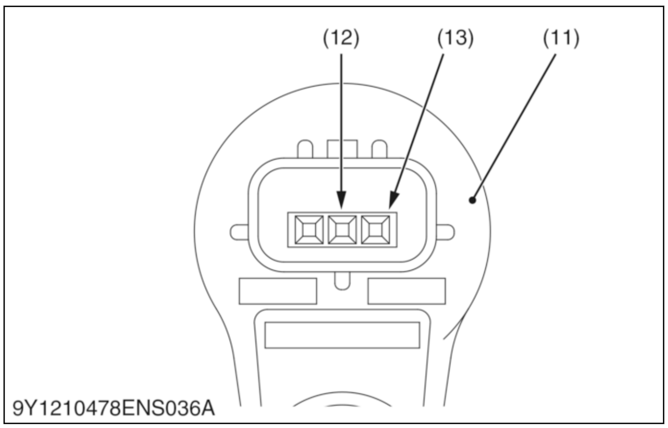


(6) Tri-square (9) Reference line
(7) Flywheel housing
(8) Flywheel

9. Connect the engine harness and the main switch.
10. Connect the battery.

11. Attach a circuit tester (10) to the output terminal (13) and ground terminal (12) of the crankshaft position sensor (11).



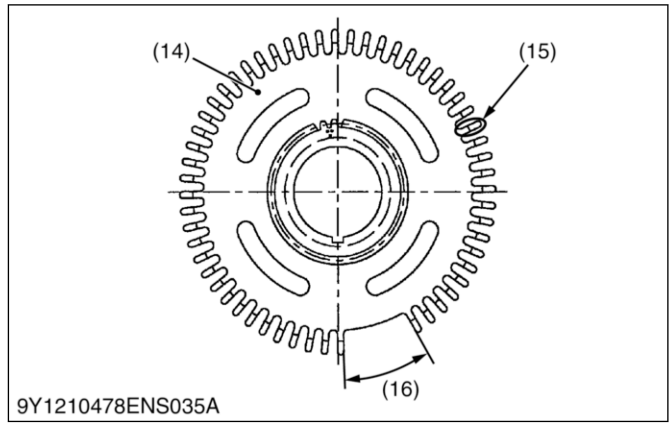


(10) Circuit tester
(11) Crankshaft position sensor
(12) Ground terminal
(13) Output terminal

12. Turn the main switch ON.
13. Turn the flywheel (8) and make sure that the voltage of the crankshaft position sensor (11) goes from 0 → 5 V or 5 → 0 V.

■ **IMPORTANT**
- **When the crankshaft position sensor (11) detects the teeth of the pulsar gear (14), the tester indicates 0 V.**

14. Rotate the flywheel (8) and align the crankshaft position sensor (11) to the part of the pulsar gear (14) that is missing teeth (16).
15. The 14th tooth (15) from the missing teeth (16) 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 (15).

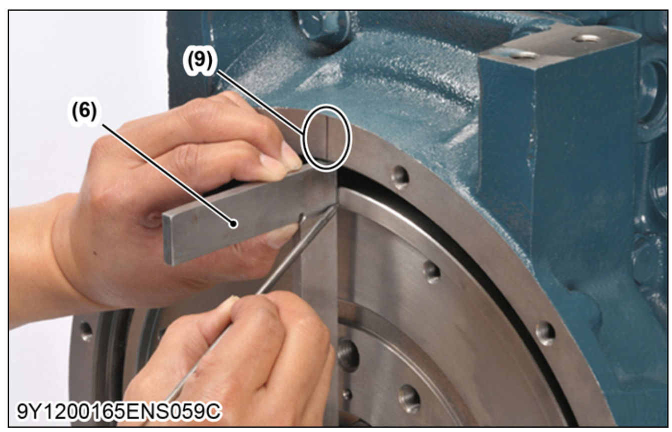


(14) Pulsar gear
(15) 14th tooth
(16) Missing teeth

17. That point is where the crankshaft position sensor detects T.D.C.

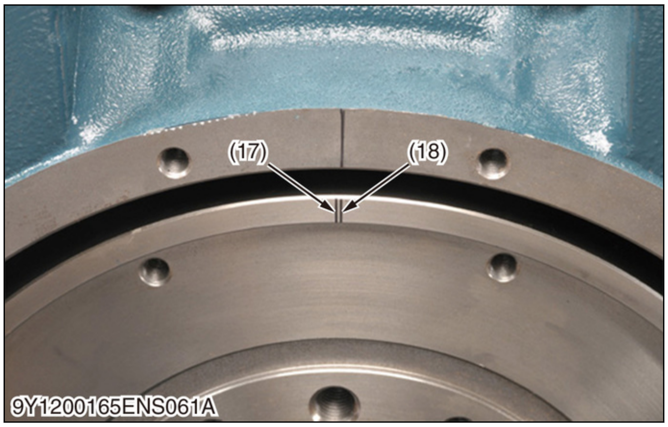
■ **IMPORTANT**
- **The position where the needle of the tester changes momentarily from 0 →5 V is the detection point of crankshaft position sensor T.D.C. (18).**

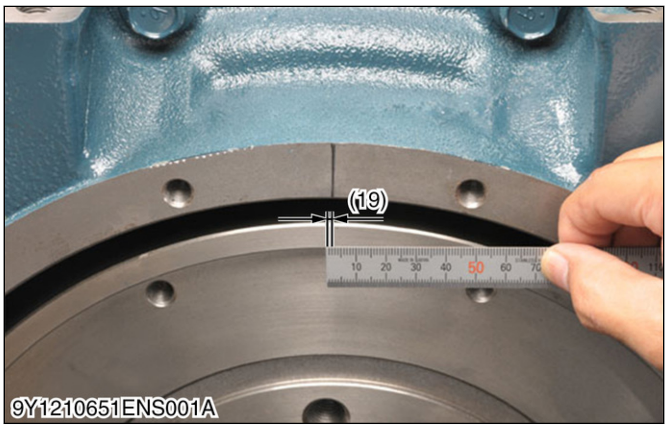
18. Set the tri-square (6) on the reference line (9) on the flywheel housing side and mark the detection point of crankshaft position sensor T.D.C. (18) on the flywheel.



(6) Tri-square
(9) Reference line

19. Measure the actual interval (19) between the crankshaft T.D.C. (17) and the detection point of crankshaft position sensor T.D.C. (18).





(17) Crankshaft T.D.C.
(18) Detection point of crankshaft position sensor T.D.C.
(19) Actual interval

20. Calculation of fuel injection timing correction 1.0 mm (0.039 in.) = 360 / (flywheel diameter × π).

■ **IMPORTANT**

- **The reference line indicates the crankshaft T.D.C. (17) of the crankshaft.**
  If the detected T.D.C. is ahead of the crankshaft T.D.C., it is considered minus.
  If the detected T.D.C. lags behind the crankshaft T.D.C., it is considered plus.

■ **NOTE**

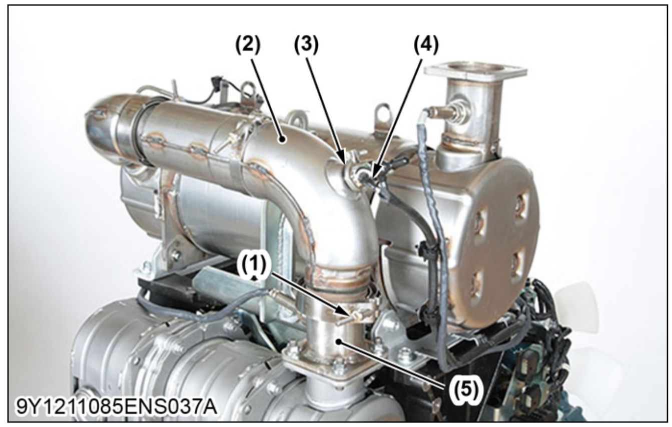
- **Corrected angle = (360 / (flywheel diameter × π)) × actual interval**

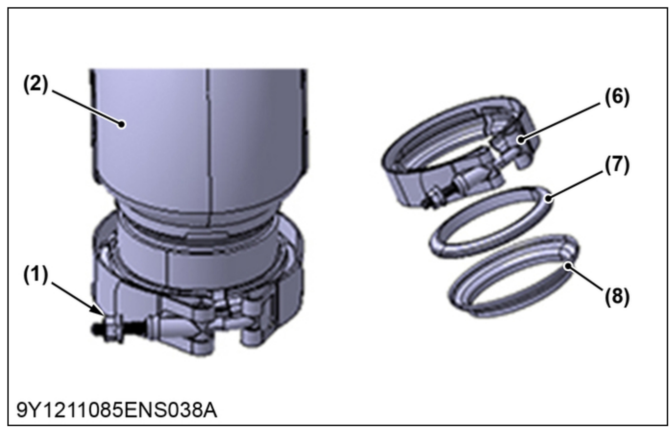
21. Overwrite the injection timing correction value in the engine ECU.

4.38 Replacing the SCR mixing pipe and slip band

Removing SCR mixing pipe and slip band

1. Remove the DEF injector band (3) and gasket.
2. Remove the DEF injector (4) from the SCR mixing pipe (2).
3. Check and write down the position of the SCR mixing pipe slip band nut (1) and what direction it is facing.
4. Loosen the SCR mixing pipe slip band nut (1).
5. Pull out the SCR inlet pipe (5).
6. Open up the joint of SCR mixing pipe slip band (6) and remove it from the SCR mixing pipe (2).
7. Remove the SCR mixing pipe slip band gasket (7).
8. Remove the SCR mixing pipe slip band slip flare (8).

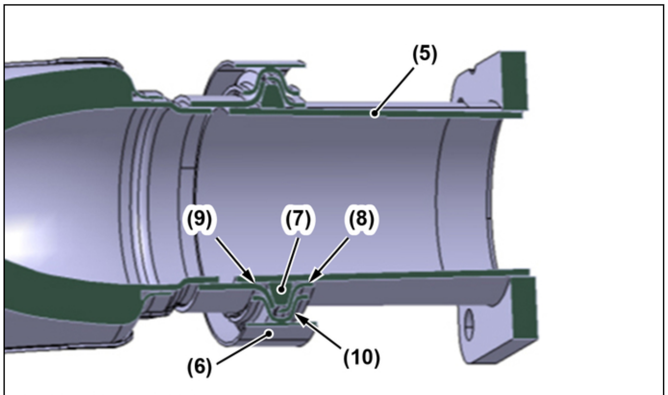




(1) SCR mixing pipe slip band nut
(2) SCR mixing pipe
(3) DEF injector band
(4) DEF injector
(5) SCR inlet pipe
(6) SCR mixing pipe slip band
(7) SCR mixing pipe slip band gasket
(8) SCR mixing pipe slip band slip flare

Installing SCR mixing pipe and slip band

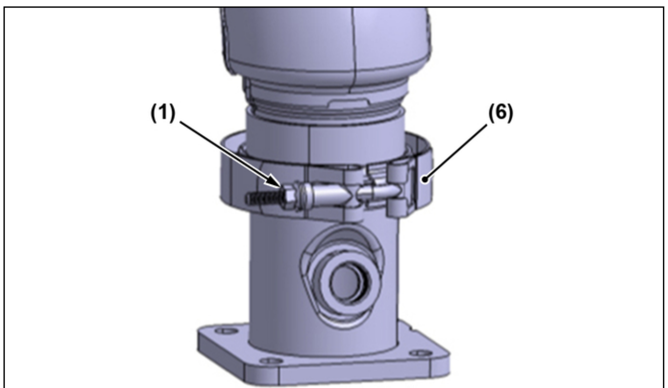
1. Make sure the new SCR mixing pipe slip band gasket (7) and slip flare (8) are fully set in the V shaped part (10) for the band.
2. Assemble the SCR mixing pipe slip band (6) on the SCR mixing pipe flare (9).
3. Make sure the SCR mixing pipe flare (9) is set on the SCR mixing pipe slip band gasket (7) and V shaped part (10).
4. Reconfirm that the SCR mixing pipe slip band gasket (7) and slip flare (8) are fully set in the V shaped part (10) for the band.
5. Install the SCR inlet pipe (5) on the SCR mixing pipe slip band (6) and push it on until it reaches the SCR mixing pipe flare (9).



9Y1211085ENS039A

(5) SCR inlet pipe
(6) SCR mixing pipe slip band
(7) SCR mixing pipe slip band gasket
(8) SCR mixing pipe slip band slip flare
(9) SCR mixing pipe flare
(10) V shaped part

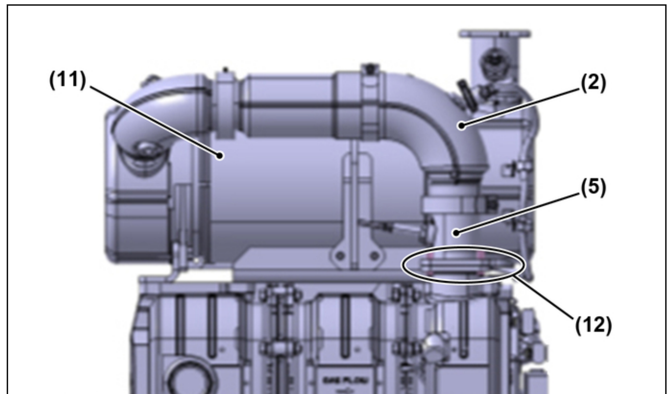
6. Rotate the SCR mixing pipe slip band (6) to make sure it adapts and is set correctly.
7. Set the SCR mixing pipe slip band nut (1) in the position that it was in prior to disassembly and temporarily tighten the nut.



9Y1211085ENS040A

(1) SCR mixing pipe slip band nut
(6) SCR mixing pipe slip band

8. Install the SCR muffler (11) on the engine or machine and make sure the SCR mixing pipe (2) and SCR inlet pipe (5) are set in their correct positions.
9. In the case that the positions of the SCR mixing pipe (2) and SCR inlet pipe (5) are not correct, loosen the temporarily tightened nut (1) and set the SCR mixing pipe (2) and SCR inlet pipe (5) in their correct positions.
10. Correctly set the SCR mixing pipe inlet pipe flange part (12) and muffler full assembly (DPF) flange part (12).
11. Tighten until the resistance increases when tightening the SCR mixing pipe slip band nut (1).
12. Upon increase of resistance while tightening, move the SCR mixing pipe (2) up and down and side to side until the tension is equal all around the circumference adapting the SCR mixing pipe slip band (6).



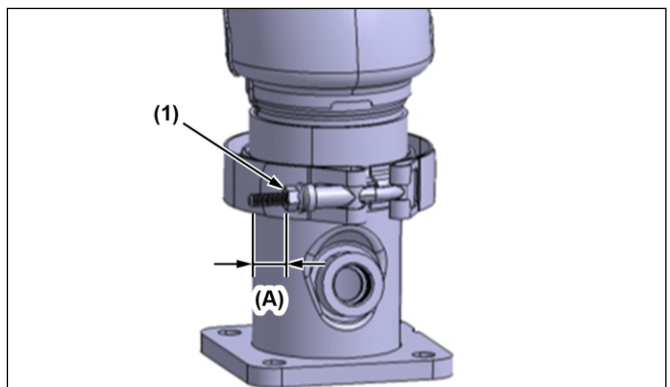
9Y1211085ENS041A

(2) SCR mixing pipe
(5) SCR inlet pipe
(11) SCR muffler
(12) Flange part

13. Tighten the SCR mixing pipe slip band nut (1) to the specified torque.
14. Make sure the SCR mixing pipe slip band nut (1) is screwed to (A) from the tip of the screw.

Tightening torque	SCR mixing pipe slip band nut (1)	15 to 17 N·m 1.6 to 1.7 kgf·m 11 to 12 lbf·ft

(A)	Approx. 20 mm Approx. 0.79 in.



9Y1211085ENS040B

(1) SCR mixing pipe slip band nut

■ **NOTE**

- **If less than 15 mm (0.59 in.), move the SCR mixing pipe (2) up and down and side to side again to further adapt the SCR mixing pipe slip band (6).**
- **Make sure the tightening torque of the SCR mixing pipe slip band nut (1) is 12 N·m (1.2 kgf·m, 8.8 lbf·ft) or higher.**
- **If the tightening torque is not 12 N·m (1.2 kgf·m, 8.8 lbf·ft) or higher, tighten the**

SCR mixing pipe slip band nut (1) to the specified torque.

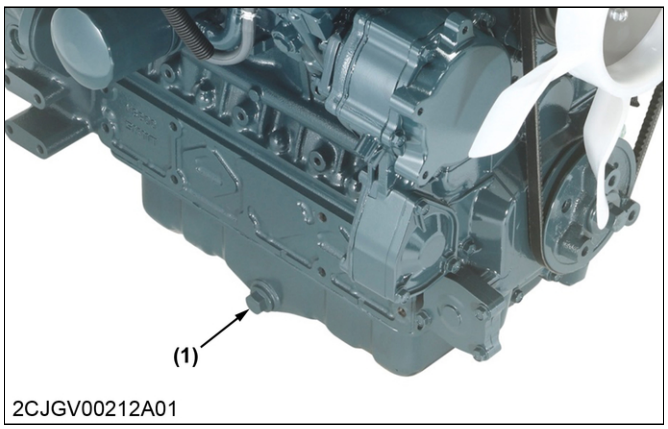
15. Replace the DEF injector band (3) and gasket with new one.
16. Make sure keep clean the contact surface of gasket.
17. Tighten the DEF injector band (3) to their specified torque.

Tightening torque	DEF injector band (3)	3.7 to 4.0 N·m 0.38 to 0.40 kgf·m 2.8 to 2.9 lbf·ft

5. Disassembling

5.1 Draining engine oil

1. Start and increase the temperature of the engine for approximately 5 minutes.
2. Put an oil pan below the engine.
3. Remove the drain plug (1) to drain the engine oil.



(1) Drain plug

4. After you drain, tighten the drain plug (1) to the specified torque.

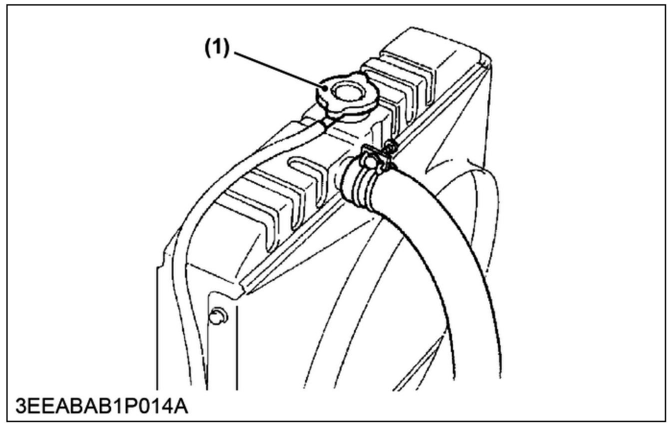
Tightening torque	Drain plug (1)	45 to 53 N·m 4.5 to 5.5 kgf·m 33 to 39 lbf·ft

5.2 Draining coolant

CAUTION

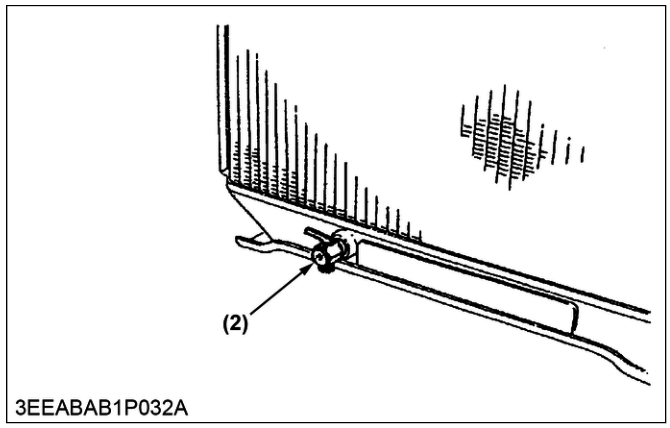
- **Do not remove the radiator cap while you operate or immediately after you stop the engine.**
- **If not, hot water can flow out from the radiator.**
- **Only open the cap after more than 10 minutes for the temperature of the radiator to decrease.**

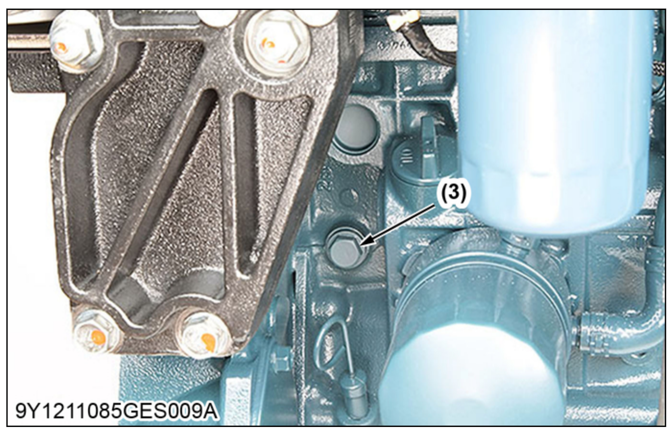
1. Prepare a bucket.
2. Remove the radiator cap (1) to drain the coolant fully.



(1) Radiator cap

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





(2) Drain valve (3) Drain plug

4. After you drain, close the drain valve (2) and drain plug (3).

5.3 Removing selective catalytic reduction (SCR) muffler

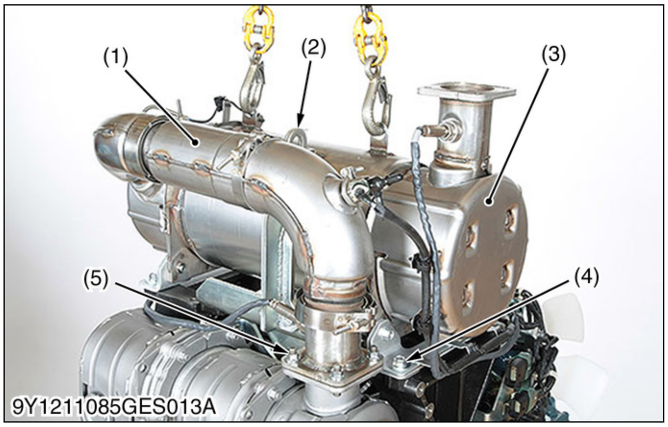
IMPORTANT

- **Be sure to loosen the NOx sensor tightening nut or the SCR inlet temperature sensor 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.**

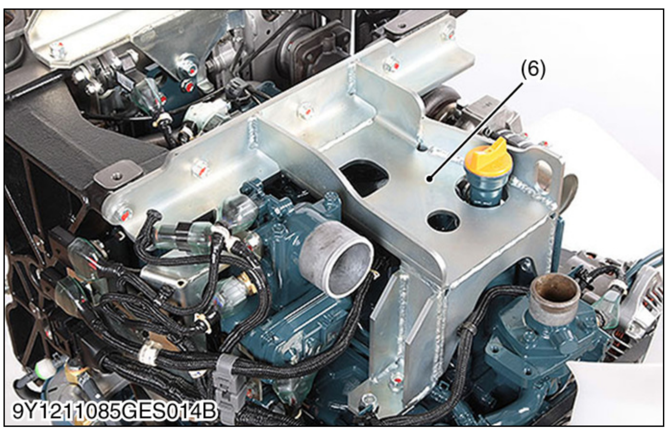
Tools required
- Crowfoot wrench

1. Lift the SCR muffler assembly (3).
2. Loosen the SCR mounting screw (4).
3. Remove the 4 nuts (5) of SCR mixing pipe (1).
4. Loosen the bolt of SCR mixing pipe stay (2).
5. Remove the SCR muffler assembly (3).



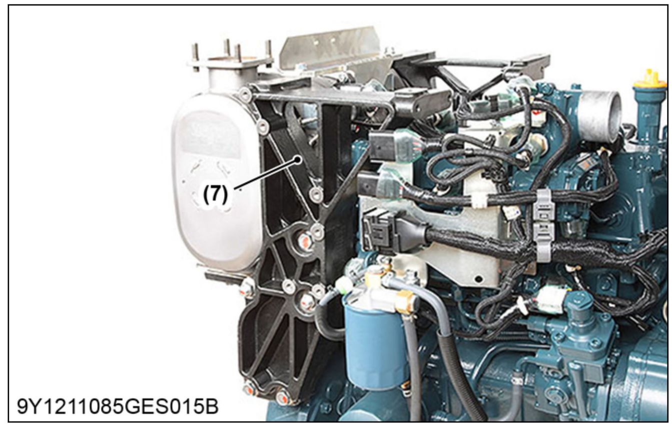
(1) SCR mixing pipe
(2) SCR mixing pipe stay
(3) SCR muffler assembly
(4) SCR mounting screw
(5) Nut

6. Remove the SCR stay (6).



(6) SCR stay

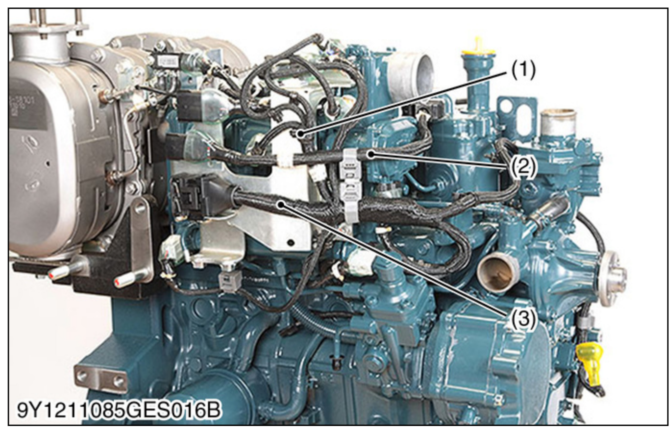
7. Remove the base of SCR (7).



(7) Base of SCR

5.4 Removing CRS intermediate harness

1. Disconnect the engine ECU intermediate harness.
2. Remove the DPF intermediate harness (1) from the bracket.
3. Remove the injector intermediate harness (2) from the bracket.
4. Remove the engine intermediate harness (3) from the bracket.

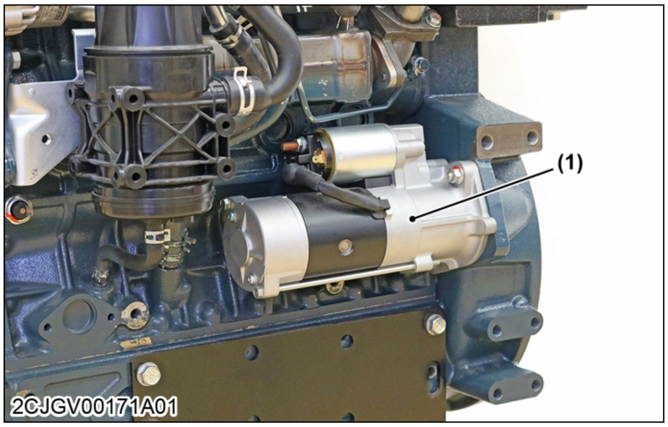


(1) DPF intermediate harness
(2) Injector intermediate harness
(3) Engine intermediate harness

5.5 Removing external components

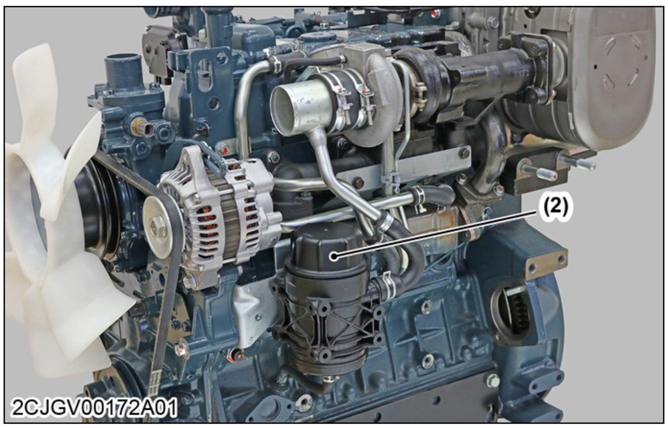
1. Remove the air cleaner.

2. Remove the starter (1).



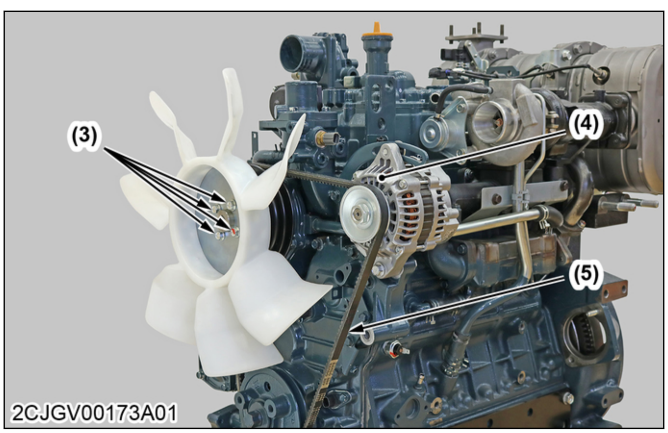
(1) Starter

3. Remove the oil separator (2).



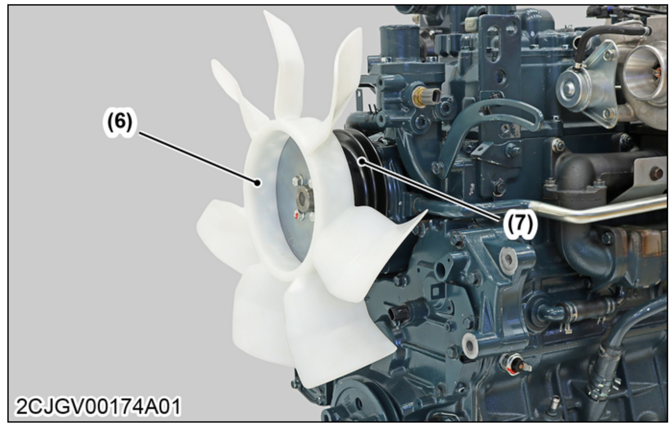
(2) Oil separator

4. Loosen the cooling fan mounting screws (3).
5. Remove the alternator (4).
6. Remove the fan belt (5).



(3) Cooling fan mounting screw (5) Fan belt
(4) Alternator

7. Remove the cooling fan (6) and fan pulley (7).



(6) Cooling fan (7) Fan pulley

5.6 Removing DPF muffler full assembly

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.**

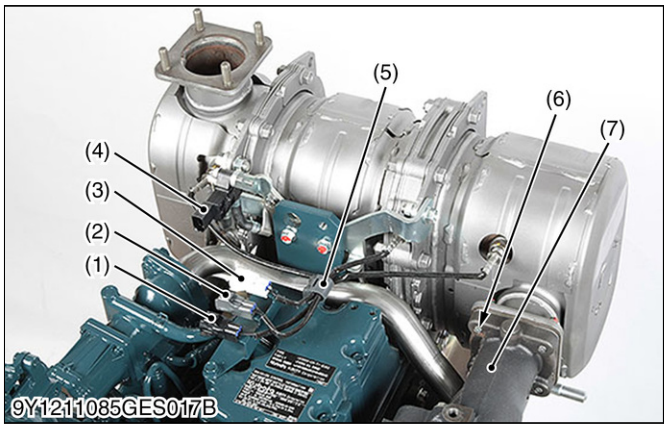
NOTE

- **Always work in the workshop equipped with an electric lift (including mobile lift).**
- **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 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.**

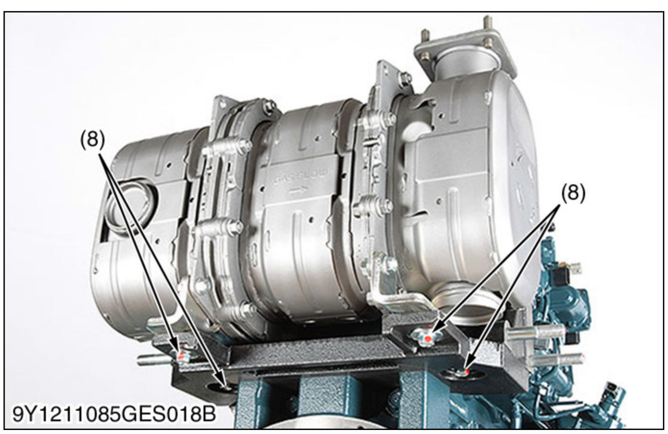
Tools required
- Crowfoot wrench

1. Remove the connectors of temperature sensor (1), (2), (3) from the bracket.
2. Remove the clamp (5).
3. Remove the 4 muffler flange screws (6).



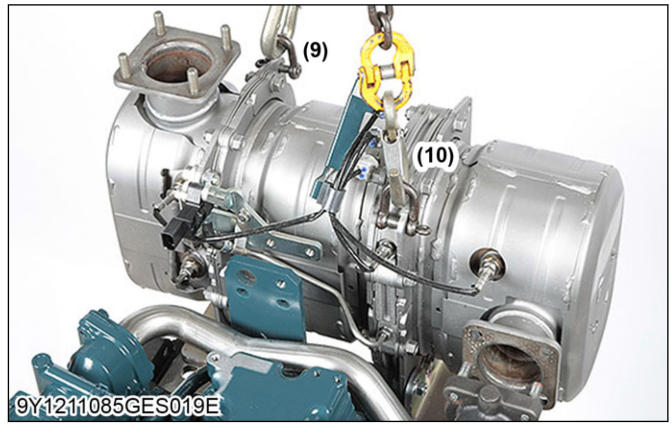
(1) Connector of temperature sensor (T_0)
(2) Connector of temperature sensor (T_1)
(3) Connector of temperature sensor (T_2)
(4) Differential pressure sensor
(5) Clamp
(6) Muffler flange screw
(7) Muffler flange

4. Remove the muffler full assembly (DPF) mounting screws (8).



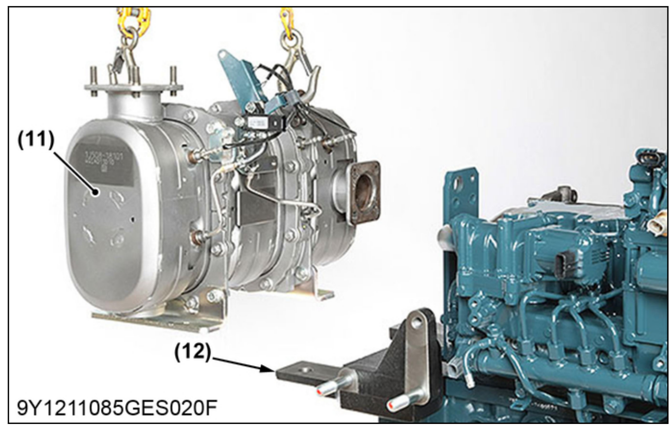
(8) Muffler full assembly (DPF) mounting screw

5. Set the shackle to the position (a) (9) and position (b) (10) of the muffler full assembly (DPF) (11) (Refer to the photo).



(9) Position (a)
(10) Position (b)

6. Lift the muffler full assembly (DPF) (11) and remove the muffler full assembly (DPF) (11).
7. Remove the DPF bracket (12).



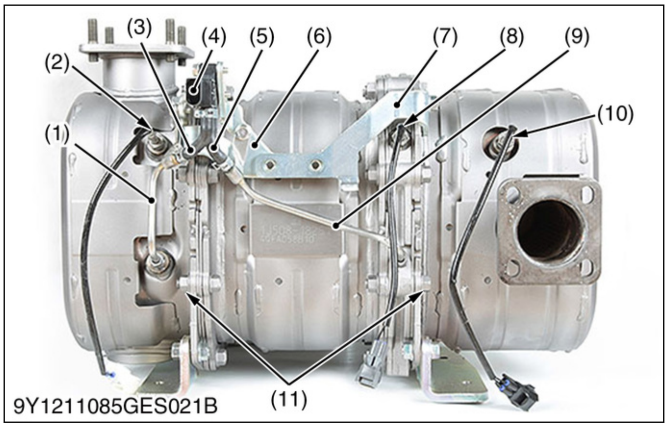
(11) Muffler full assembly (DPF)
(12) DPF bracket

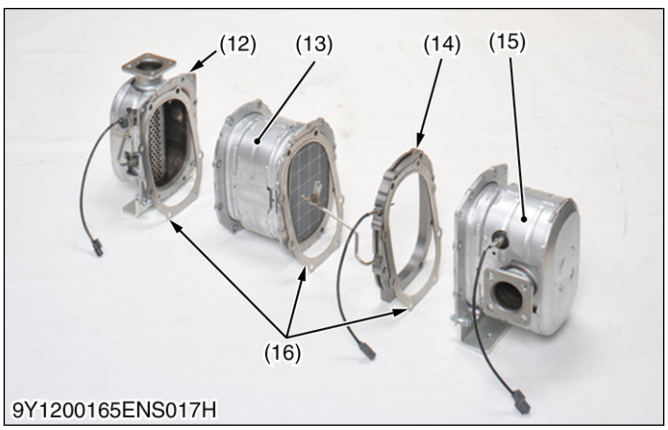
5.7 Disassembling DPF assembly

■ **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 engine ECU, check the operating time by connecting the service tool (Diagmaster).**
- **When 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 (3), (5) from the differential pressure pipe (1), (9).
2. Remove the differential pressure sensor (4).
3. Remove the DPF stay (6), (7).
4. Loosen the filter comp (DPF) mounting screw (11) and remove the filter comp (DPF) (13).

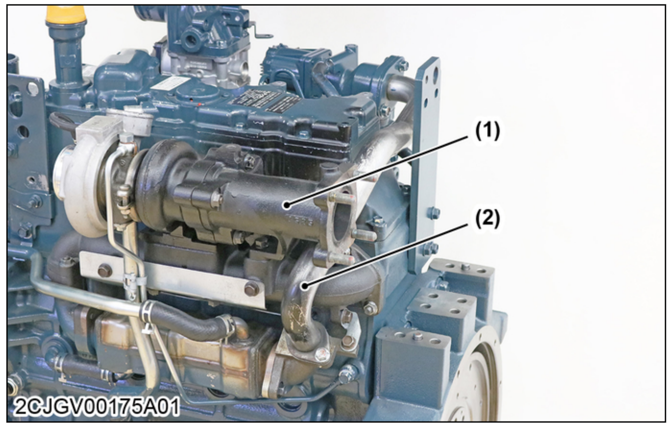




(1) Differential pressure pipe
(2) Temperature sensor (T_2)
(3) Tube
(4) Differential pressure sensor
(5) Tube
(6) DPF stay
(7) DPF stay
(8) Temperature sensor (T_1)
(9) Differential pressure pipe
(10) Temperature sensor (T_0)
(11) Filter comp (DPF) mounting screw
(12) Body (DPF outlet)
(13) Filter comp (DPF)
(14) Collar (DPF)
(15) Catalyst (DOC)
(16) Gasket

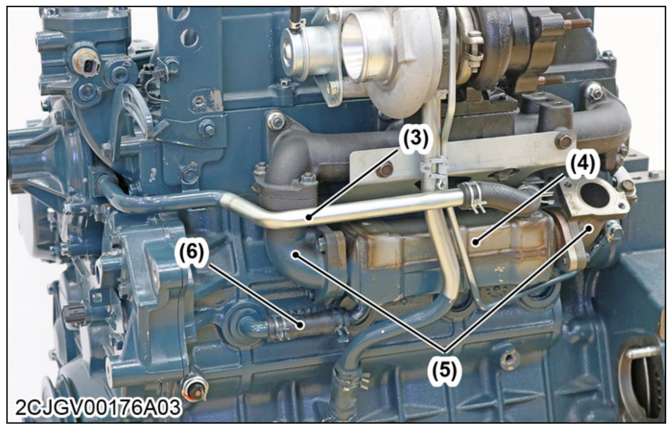
5.8 Removing EGR cooler

1. Remove the muffler flange (1).
2. Remove the EGR pipe (2).



(1) Muffler flange
(2) EGR pipe

3. Remove the EGR cooler pipe (3).
4. Remove the EGR cooler hose (6).
5. Remove the EGR cooler (4).
6. Remove the EGR cooler flange (5).



(3) EGR cooler pipe
(4) EGR cooler
(5) EGR cooler flange
(6) EGR cooler hose

5.9 Removing turbocharger

CAUTION

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

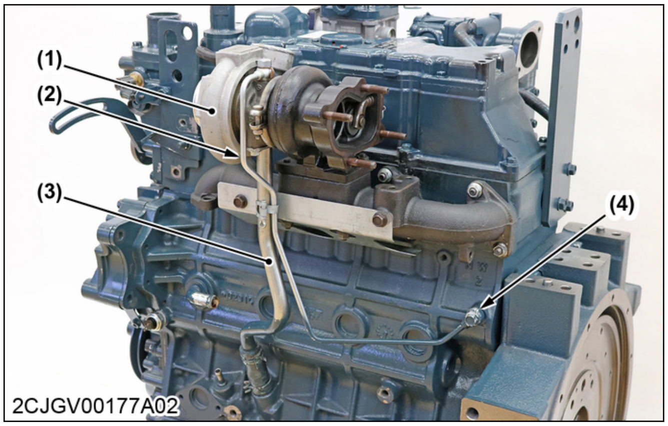
NOTE

- **When you remove the turbocharger assembly, do not let dust, dirt and other unwanted materials in the oil pipes.**

1. Remove the oil pipe joint screw (4).
2. Remove the oil pipe (2).
3. Remove the return pipe (crankcase side) (3).

4. Remove the turbocharger assembly (1).

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

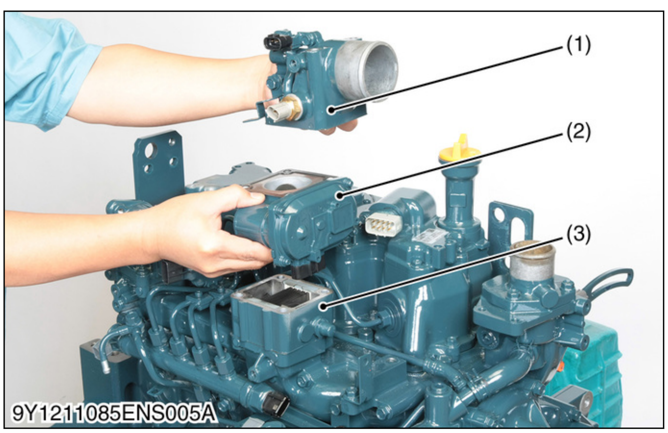


(1) Turbocharger assembly
(2) Oil pipe
(3) Return pipe
(4) Oil pipe joint screw

5.10 Removing 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 (2).**

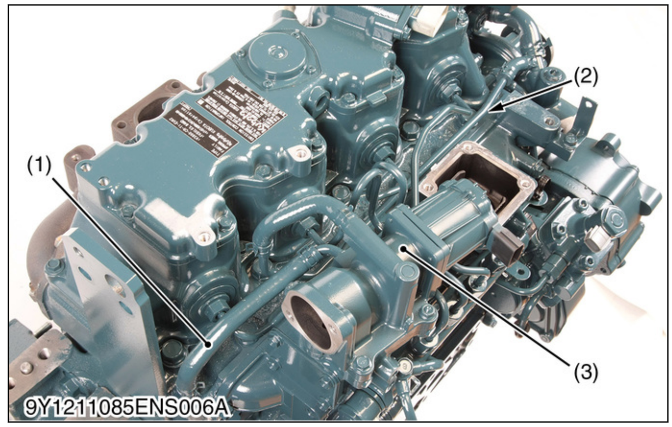


(1) Air cleaner flange
(2) Intake throttle valve
(3) Intake air heater

5.11 Removing EGR valve

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

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



(1) Cooler pipe
(2) Cooler pipe
(3) EGR valve

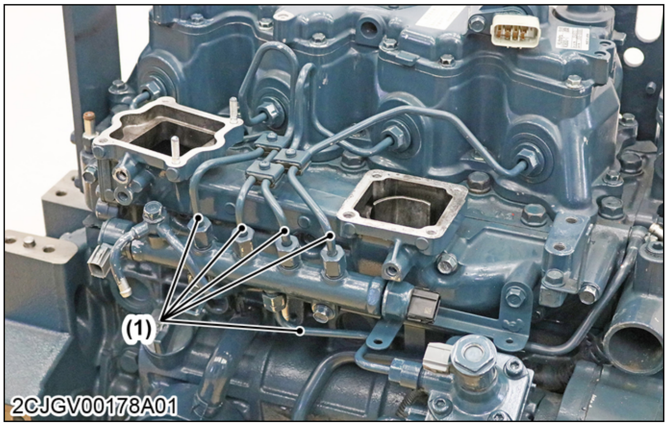
5.12 Removing common rail

CAUTION
- **Do not loosen the injection pipe (1) when the fuel is under high pressure (within five minutes of stopping the engine).**

■ NOTE
- **Replace the rail assembly if the exchange of the pressure relief valve (3) or the rail pressure sensor (5) is necessary.**
- **Do not remove the pressure relief valve (3) and rail pressure sensor (5) from the common rail (4).**
- **When removing the common rail (4), do not hold it by the pressure relief valve (3) and rail pressure sensor (5).**

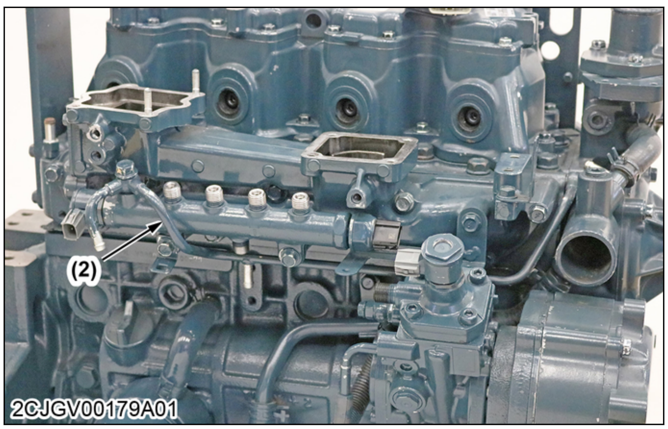
1. Remove the injection pipe (1).

■ **IMPORTANT**
- **Store the injection pipe (1) so it does not get any dust in it.**



(1) Injection pipe

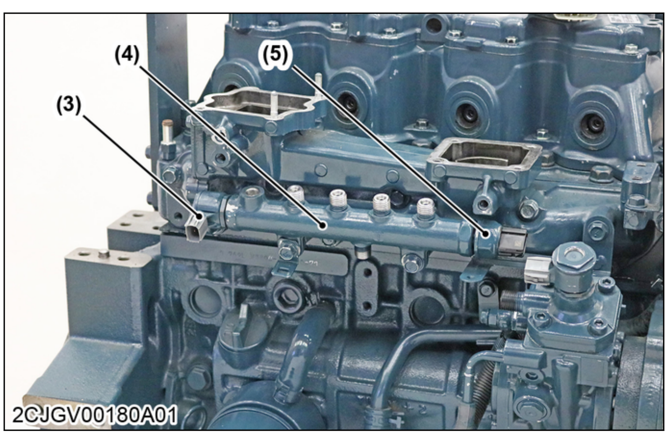
2. Remove the overflow pipe (2).



(2) Overflow pipe

3. Remove the common rail (4).

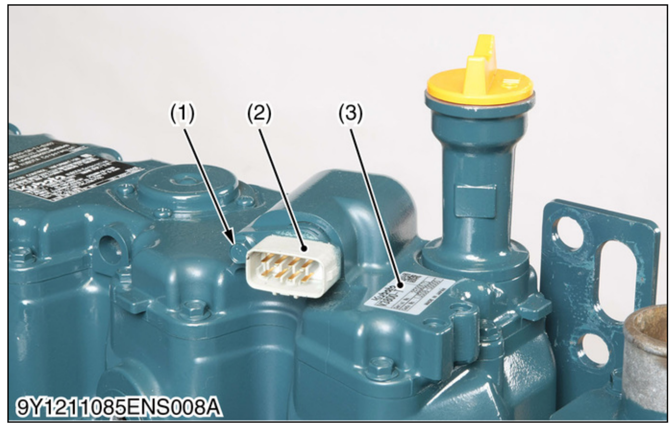
■ **IMPORTANT**
- **Store the common rail (4) so it does not get any dust in it.**



(3) Pressure relief valve
(4) Common rail
(5) Rail pressure sensor

5.13 Removing injector harness connector

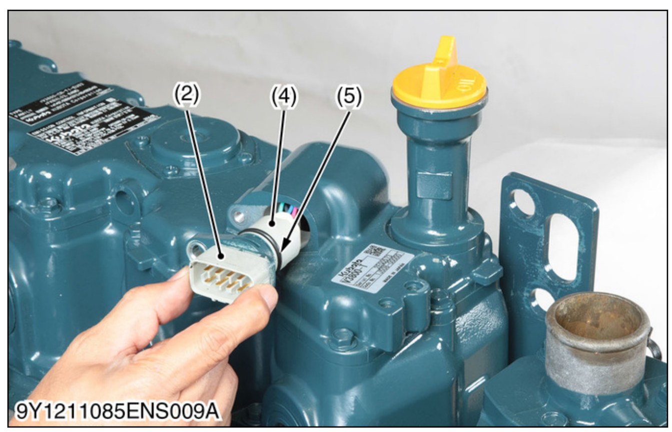
1. Remove the screw (1).
2. Pull the injector harness connector (2) out from cylinder head cover 2 (3).



(1) Screw
(2) Injector harness connector
(3) Cylinder head cover 2

3. Disconnect the injector harness connector (2) from the injector harness (4).

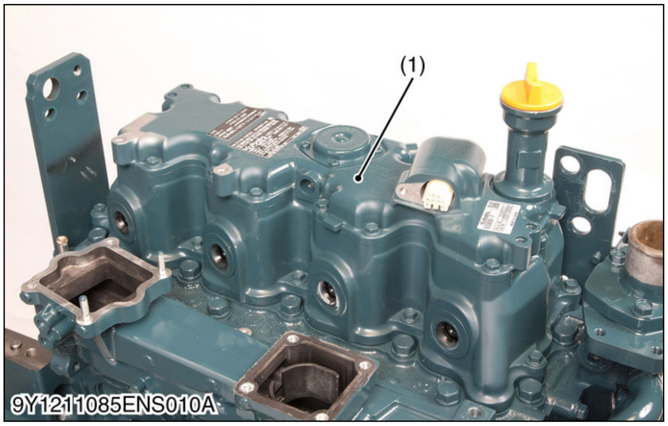
■ **IMPORTANT**
- **Be careful not to damage the injector harness (4) and O-ring (5) when you pull the connector out.**



(2) Injector harness connector
(4) Injector harness
(5) O-ring

5.14 Removing cylinder head cover

1. Remove the cylinder head cover 2 (1).

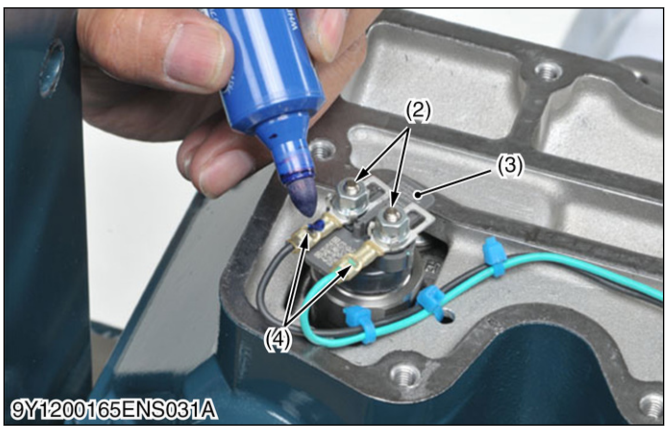


(1) Cylinder head cover 2

2. Mark the injector terminals (2) and the injector leads (4).

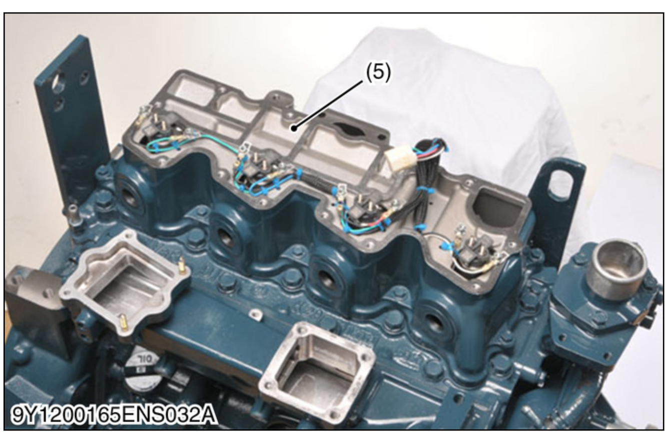
■ **NOTE**

- **Marking is effective to prevent miswiring during reassembly.**



(2) Injector terminal
(3) Injector QR code tag
(4) Injector lead

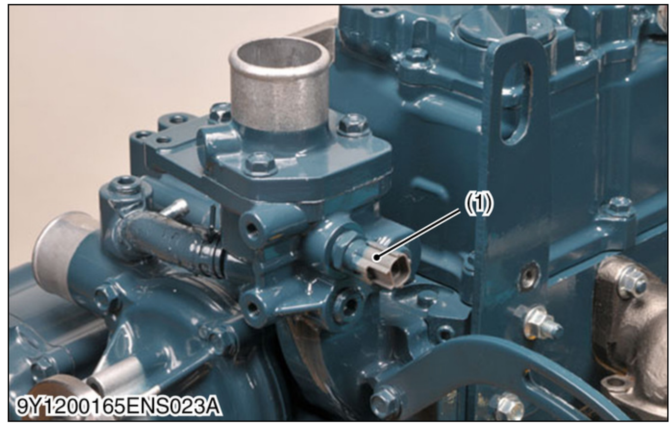
3. Remove the injector lead from the injectors.
4. Remove the cylinder head cover 1 (5).



(5) Cylinder head cover 1

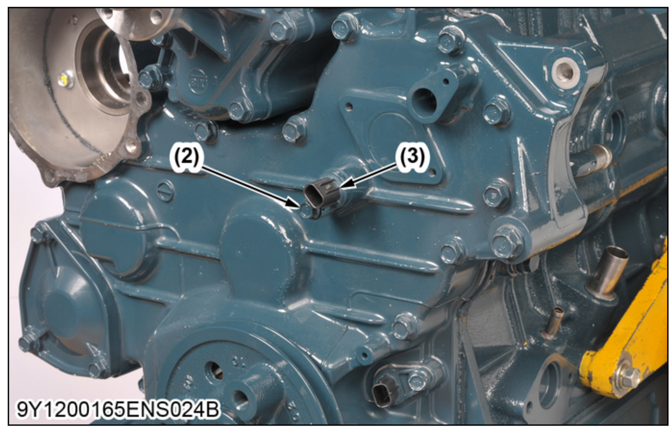
5.15 Removing sensors

1. Remove the coolant temperature sensor (1).



(1) Coolant temperature sensor

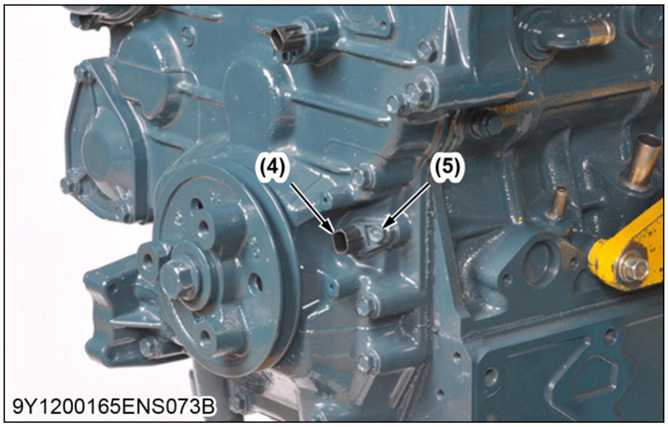
2. Remove the camshaft position sensor mounting screw (2).
3. Remove the camshaft position sensor (3).



(2) Camshaft position sensor mounting screw
(3) Camshaft position sensor

4. Remove the crankshaft position sensor mounting screw (5).

5. Remove the crankshaft position sensor (4).



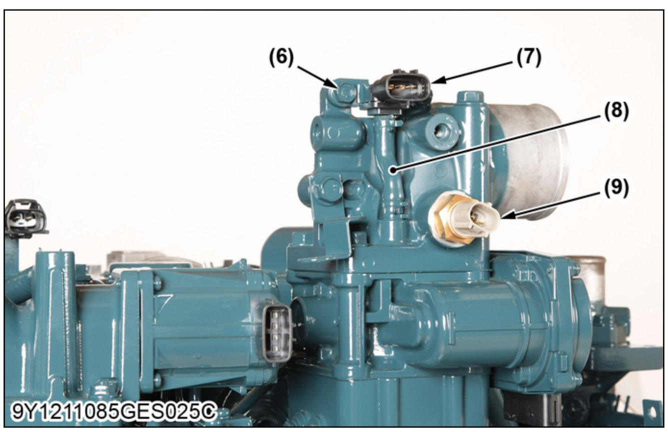
(4) Crankshaft position sensor
(5) Crankshaft position sensor mounting screw

■ **IMPORTANT**
- **If you drop the sensor, do not reuse it.**

6. Remove the intake air temperature sensor (9).
7. Remove the hose (8) from the boost sensor (7).

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

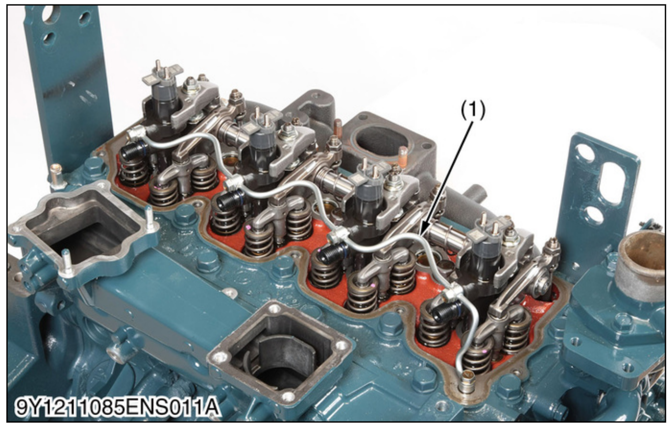
8. Remove the boost sensor mounting screw (6).
9. Remove the boost sensor (7).



(6) Boost sensor mounting screw
(7) Boost sensor
(8) Hose
(9) Intake air temperature sensor

5.16 Removing injector

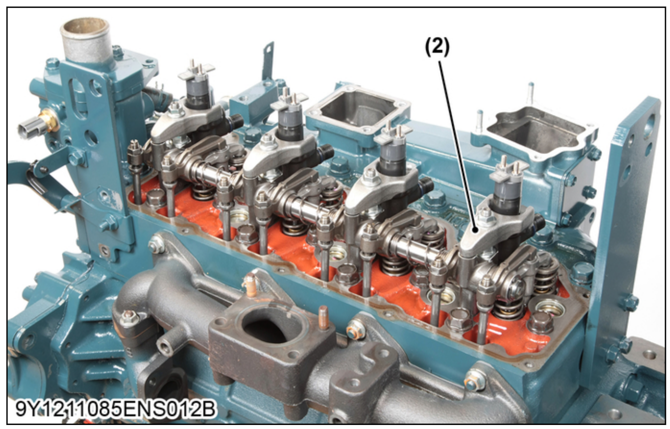
1. Remove the overflow pipe (1).

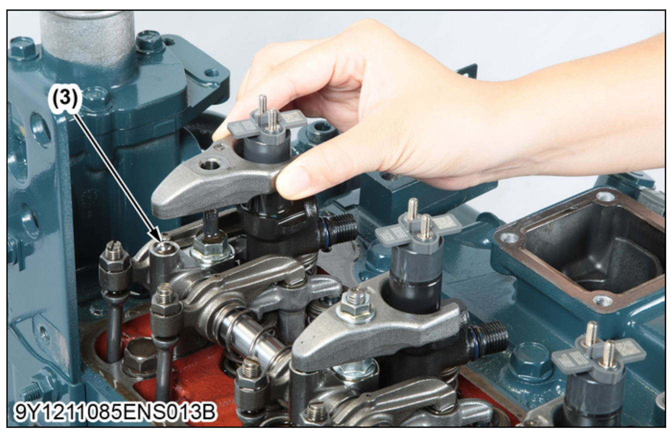


(1) Overflow pipe

2. Remove the injector clamp (2).

■ **IMPORTANT**
- **Do not lose the ball (3) of the rocker arm bracket.**

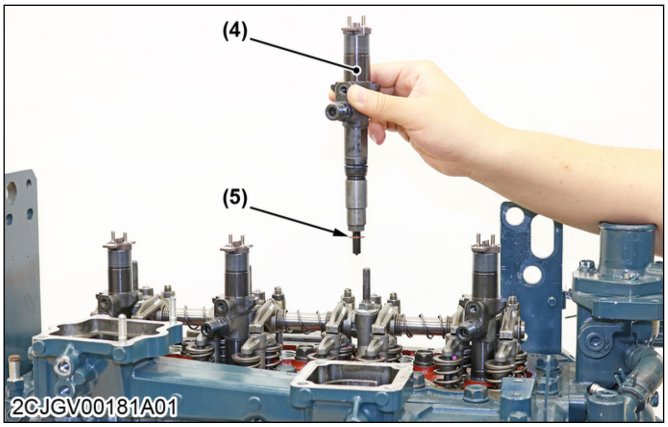


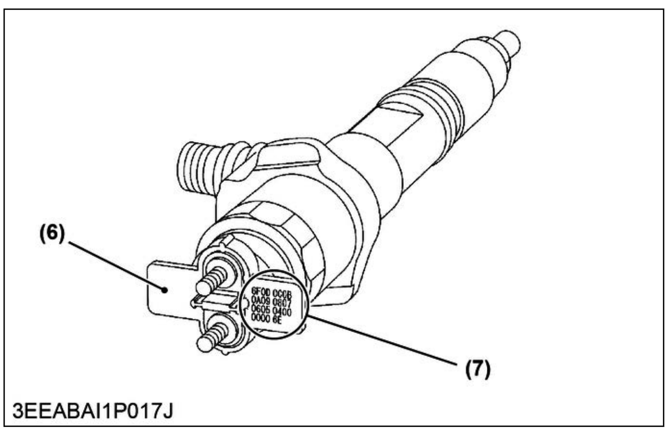


(2) Injector clamp
(3) Ball

3. Remove the injector (4) and its gasket (5).

■ **IMPORTANT**
- **Do not disassemble the injector (4).**
- **Do not remove the injector QR code tag (6).**
- **Do not damage the injector QR code tag (6).**
- **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 (7) to the engine ECU).**
- **Store the injectors so they do not get any dust in them.**



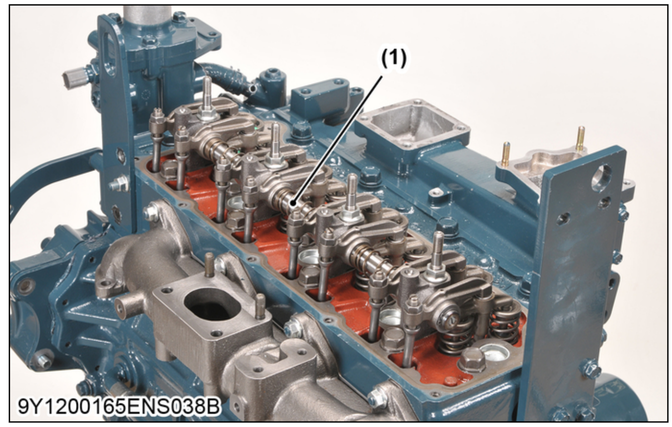


(4) Injector
(5) Gasket
(6) Injector QR code tag
(7) Injector ID code

5.17 Removing rocker arm

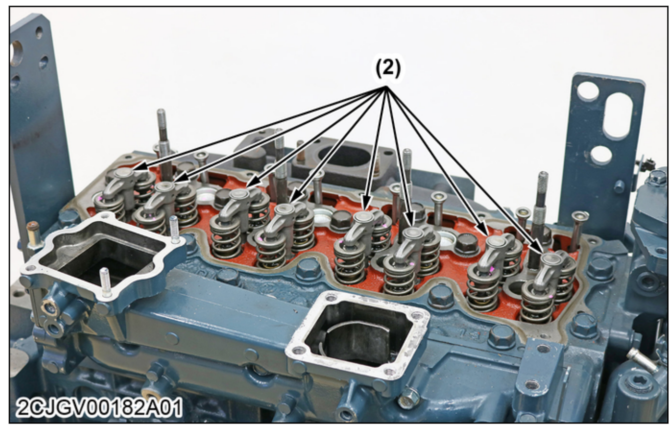
1. Remove the rocker arm (1).

■ **IMPORTANT**
- **Do not lose the ball of the rocker arm bracket.**



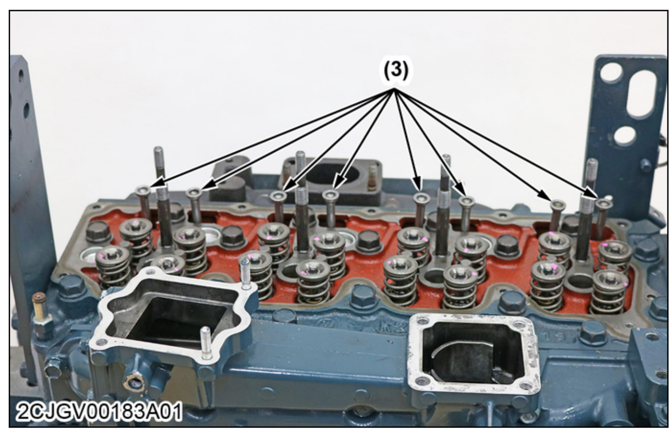
(1) Rocker arm

2. Remove the valve bridge arms (2).



(2) Valve bridge arm

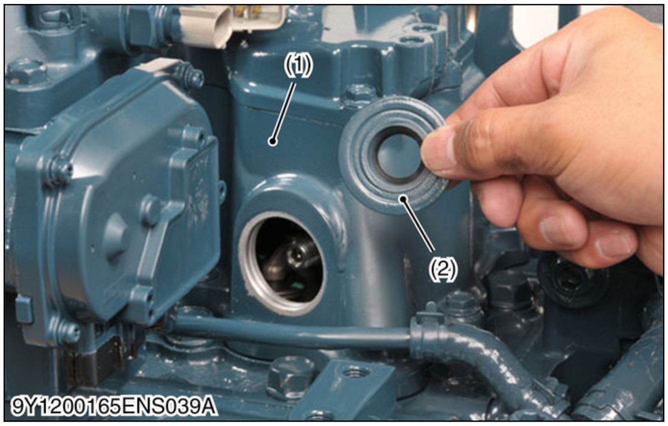
3. Remove the push rods (3).



(3) Push rod

5.18 Removing injector oil seal

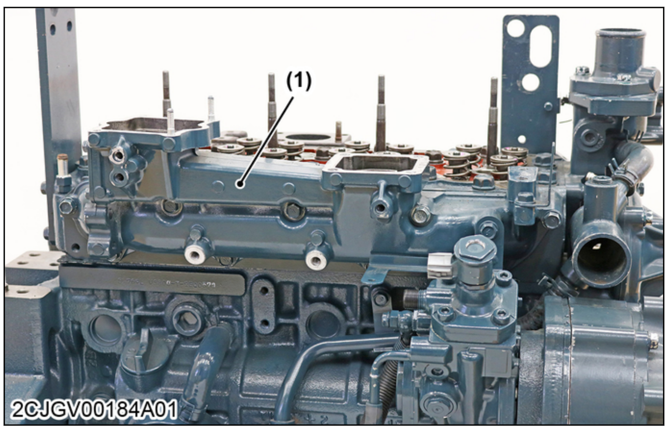
1. Remove the injector oil seal (2) from cylinder head cover1 (1).



(1) Cylinder head cover 1 (2) Injector oil seal

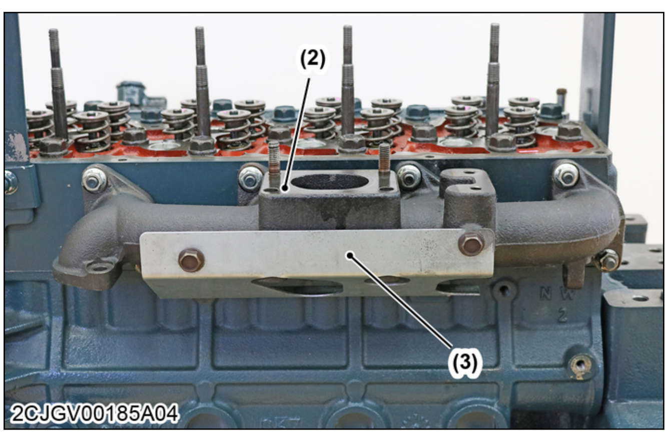
5.19 Removing cylinder head

1. Remove the intake manifold (1).



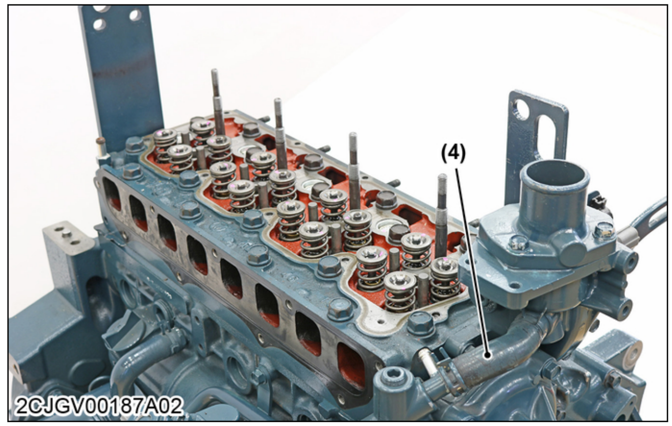
(1) Intake manifold

2. Remove the cover (3) and the exhaust manifold (2).



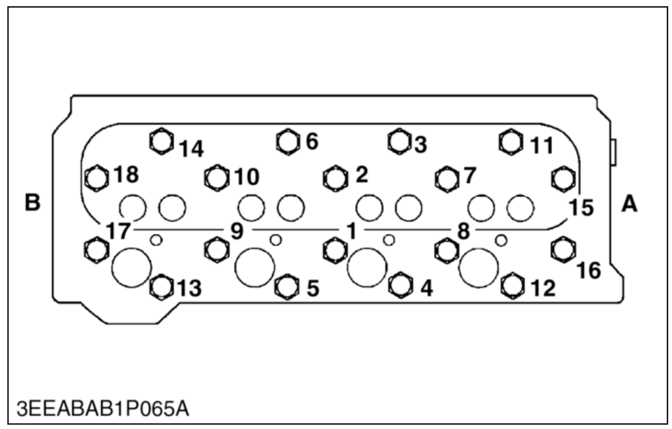
(2) Exhaust manifold (3) Cover

3. Loosen the pipe clamp and remove the water return hose (4).



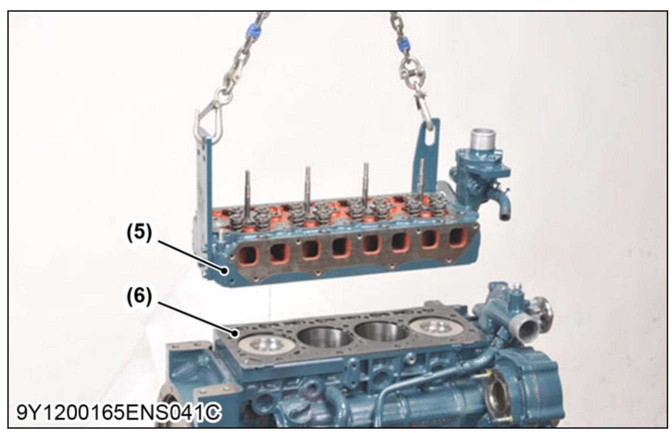
(4) Water return hose

4. Remove the cylinder head mounting screw in the sequence of **18** to **1**.



A Gear case side B Flywheel side

5. Remove the cylinder head (5) and cylinder head gasket (6).



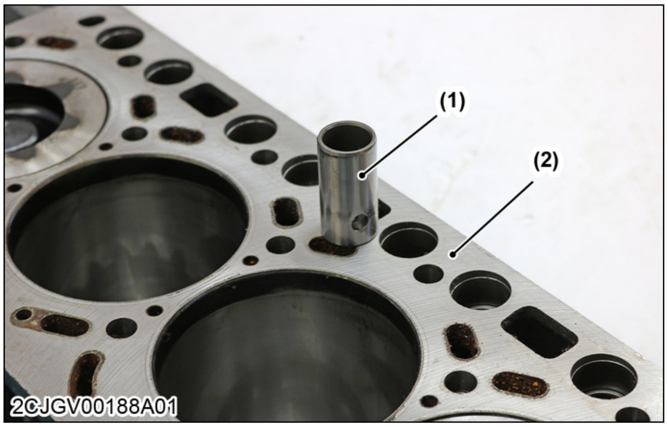
(5) Cylinder head (6) Cylinder head gasket

5.20 Removing tappet

■ **NOTE**

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

1. Remove the tappets (1) from the crankcase (2).



(1) Tappet (2) Crankcase

5.21 Removing valve

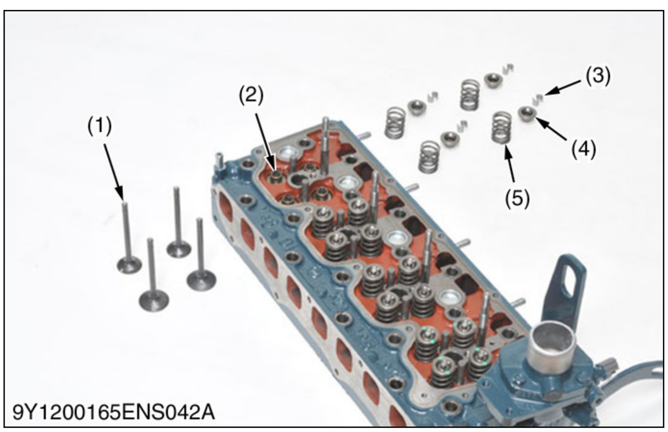
■ **NOTE**

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

Tools required

- Valve spring compressor

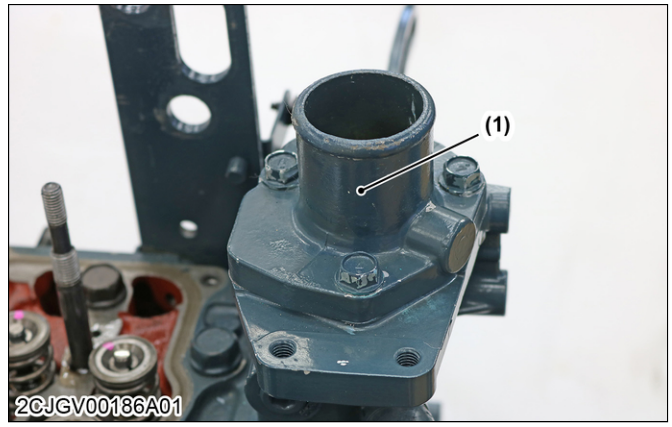
1. Push the valve spring (5) with the valve spring retainer (4) by valve spring compressor and remove the valve spring collets (3).
2. Remove the valve spring (5) and valve (1).
3. Remove the valve stem seal (2).



(1) Valve
(2) Valve stem seal
(3) Valve spring collet
(4) Valve spring retainer
(5) Valve spring

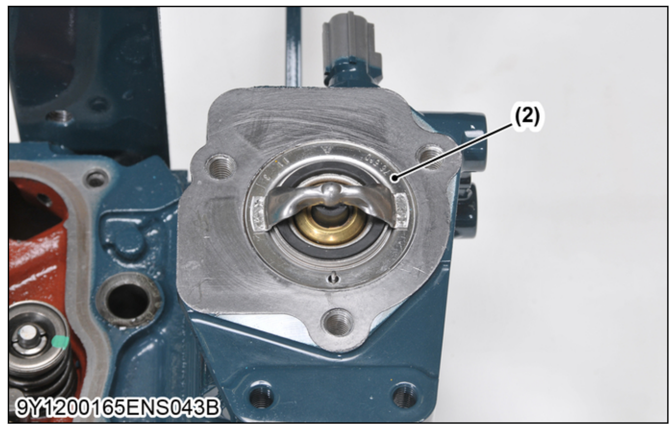
5.22 Removing thermostat assembly

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



(1) Thermostat cover

2. Remove the thermostat assembly (2).



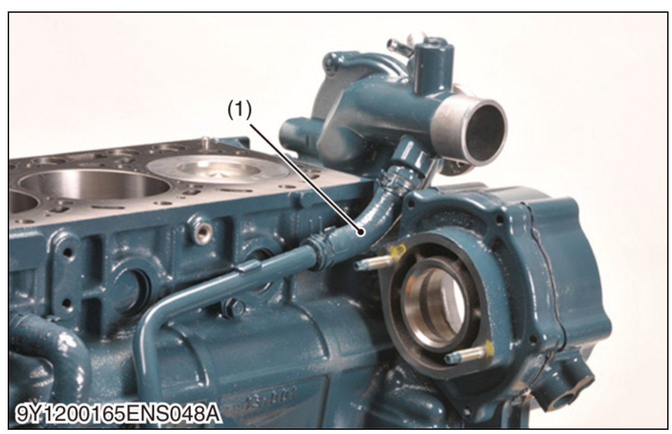
(2) Thermostat assembly

5.23 Removing water pump

■ **NOTE**

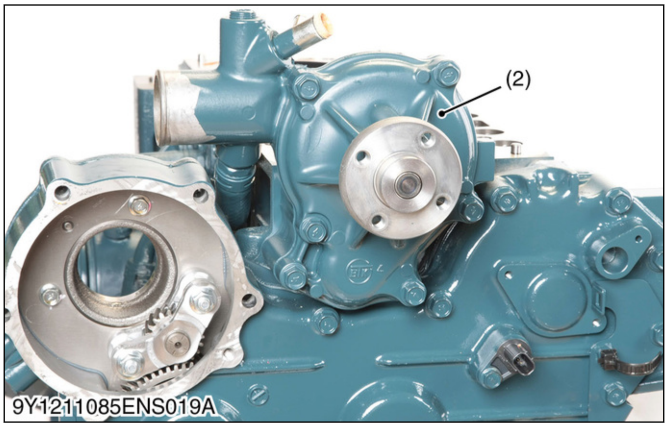
- **This work is only for V3800-TIEF4 model.**

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



(1) Water pipe

2. Remove the water pump (2).



(2) Water pump

5.24 Removing supply pump

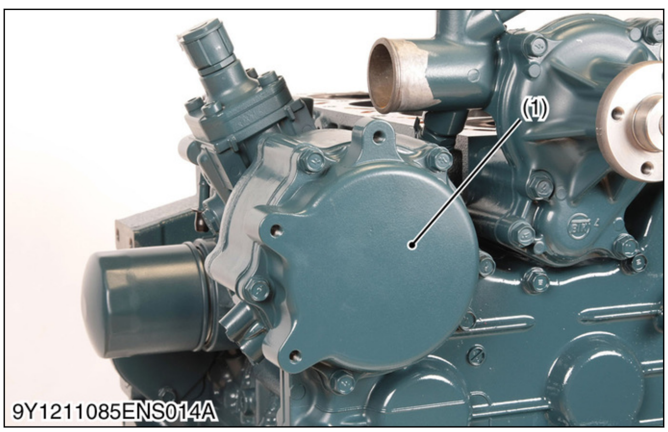
CAUTION

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

Tools required

- Flywheel stopper
- Gear puller

1. Remove the supply pump gear cover (1).

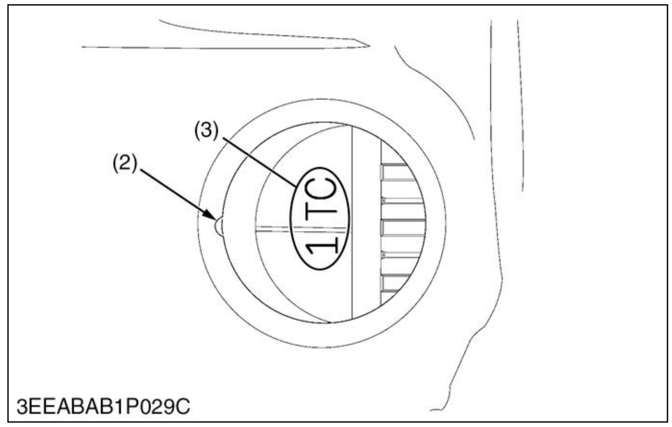


(1) Supply pump gear cover

2. Put the piston of the number 4 cylinder at TDC.

NOTE

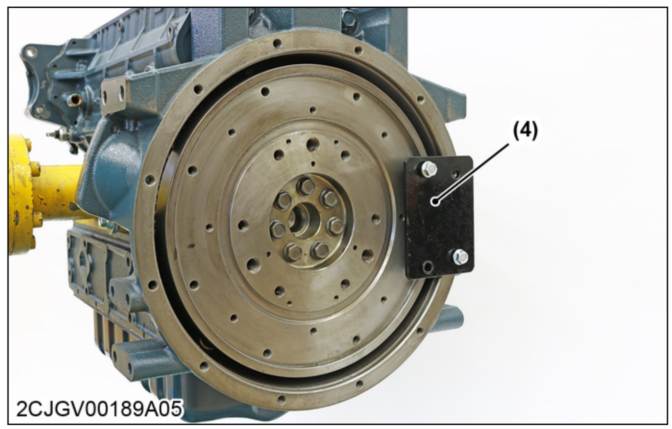
- **When positioning the piston of the 4th cylinder to TDC, rotate the flywheel counterclockwise and align the [TC] mark (3) on the flywheel with the mark (2) on the housing of the flywheel.**



(2) Mark (3) TC mark

- **If the supply pump gear timing mark (7) meshes with idle gear 3 (9), then the piston of the 4th cylinder is TDC.**
- **If they do not mesh, rotate the flywheel counterclockwise one revolution.**

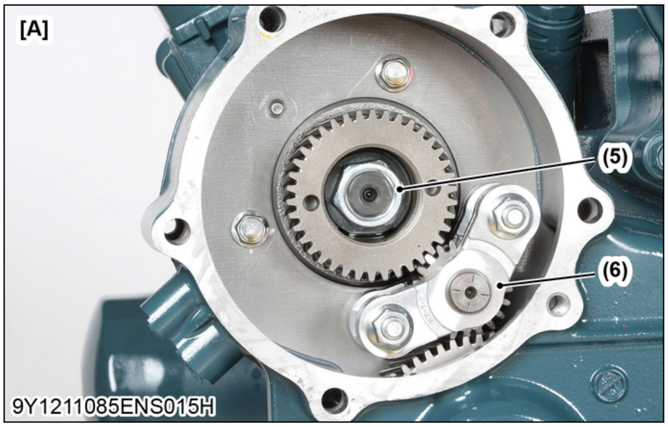
3. Fix the flywheel with flywheel stopper (4).



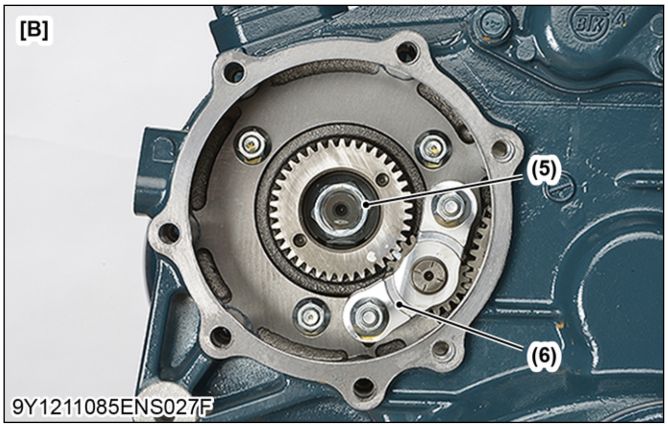
(4) Flywheel stopper

4. Loosen the supply pump gear mounting nut (5).

5. Remove the idle gear 3 upper holder (6).



9Y1211085ENS015H

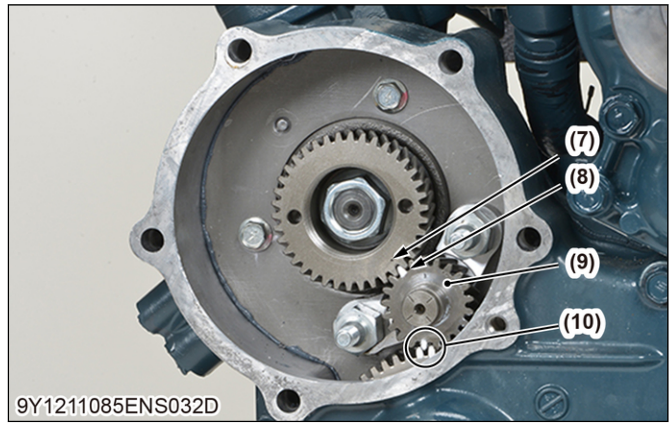


9Y1211085ENS027F

(5) Supply pump gear mounting nut
(6) Idle gear 3 upper holder
[A] V3800-TIEF4
[B] V3800-TIEF4C

6. Make a temporary mark (8) with a white paint marker pen on the tooth of idle gear 3 (9).
7. Make a temporary mark (10) with a white paint marker pen on the tooth of idle gear 3 (9) and idle gear 2 or idle gear 1.

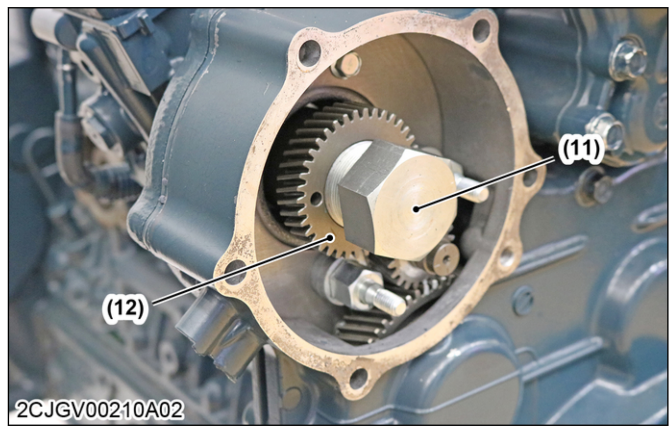
■ **NOTE**
- **This mark is extremely useful during reassembly of the supply pump gear and idle gear 3 (9) to get the timing right.**



9Y1211085ENS032D

(7) Timing mark
(8) Temporary mark
(9) Idle gear 3
(10) Temporary mark

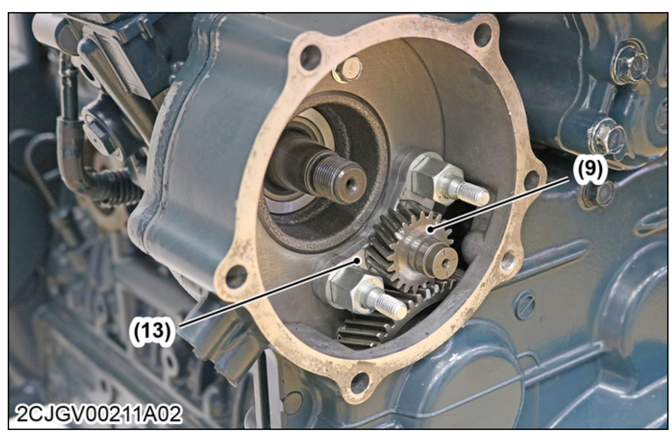
8. Remove the supply pump gear mounting nut (5).
9. Set the gear puller (11).
10. Remove the supply pump gear (12) with a 41 mm (1.6 in.) deep socket wrench.



2CJGV00210A02

(11) Gear puller
(12) Supply pump gear

11. Remove idle gear 3 (9) and idle gear 3 base holder (13).

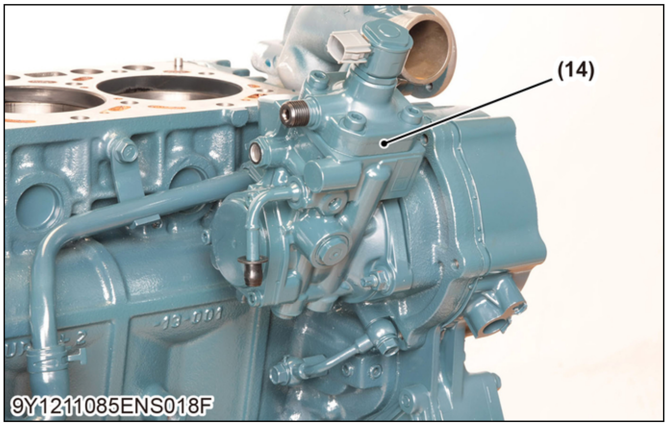


2CJGV00211A02

(9) Idle gear 3
(13) Idle gear 3 base holder

12. Remove the supply pump (14).

■ **NOTE**
- **Do not disassemble the supply pump (14).**
- **Store the supply pump (14) so it does not get any dust in it.**

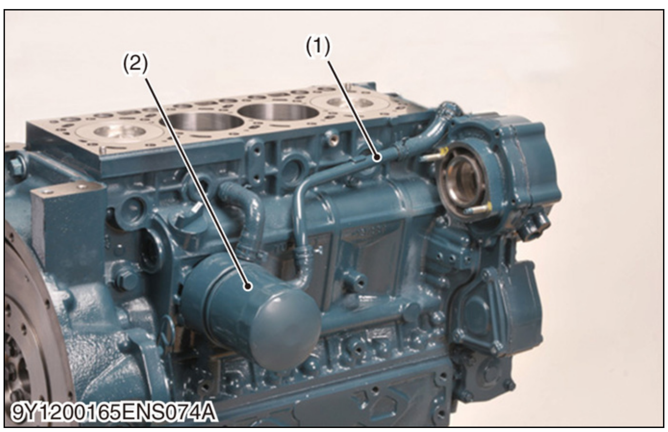


(14) Supply pump

5.25 Removing oil cooler

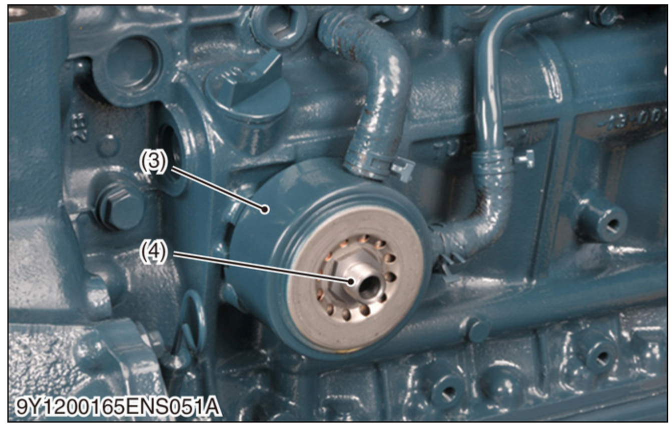
Tools required
- Filter wrench

1. Remove the water pipe (1).
2. Remove the oil filter cartridge (2) with the filter wrench.



(1) Water pipe (2) Oil filter cartridge

3. Remove the oil cooler joint screw (4).
4. Remove the oil cooler (3).

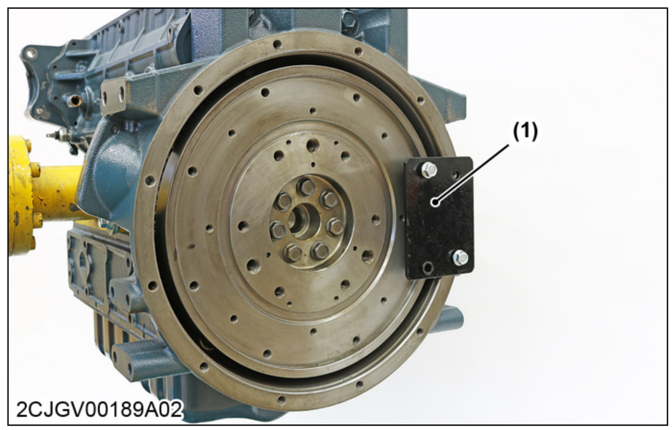


(3) Oil cooler (4) Oil cooler joint screw

5.26 Removing fan drive pulley

Tools required
- Flywheel stopper

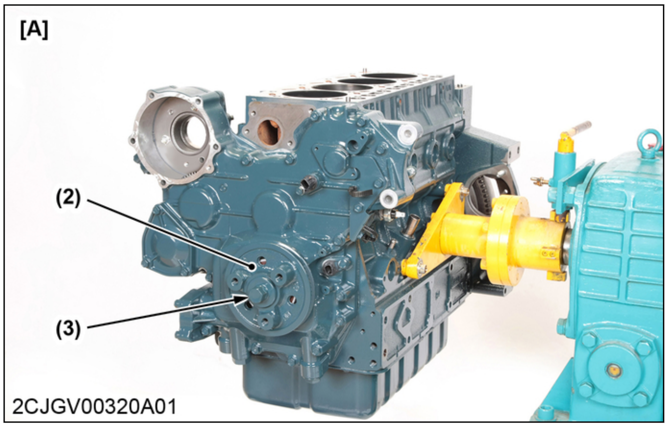
1. Mount a flywheel stopper (1) on the flywheel.

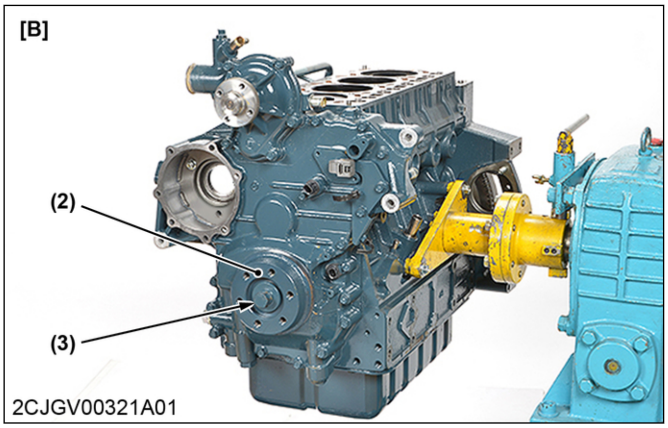


(1) Flywheel stopper

2. Remove the crankshaft screw (3).

3. Remove the fan drive pulley (2).

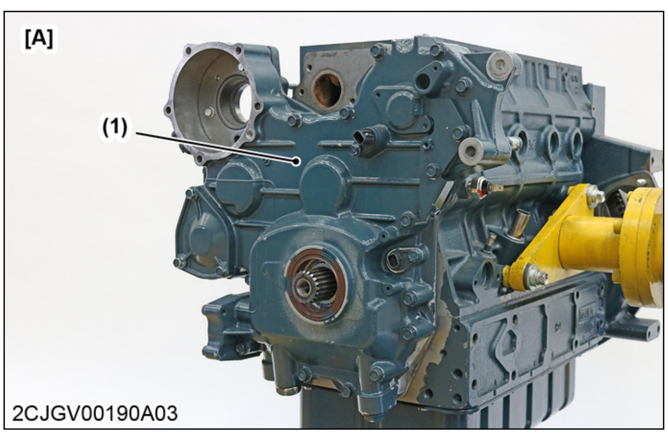


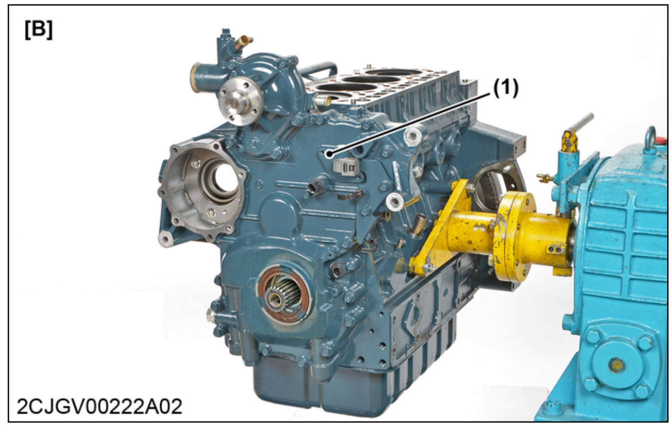


(2) Fan drive pulley
(3) Crankshaft screw
[A] V3800-TIEF4
[B] V3800-TIEF4C

5.27 Removing gear case cover

1. Remove the gear case cover (1).

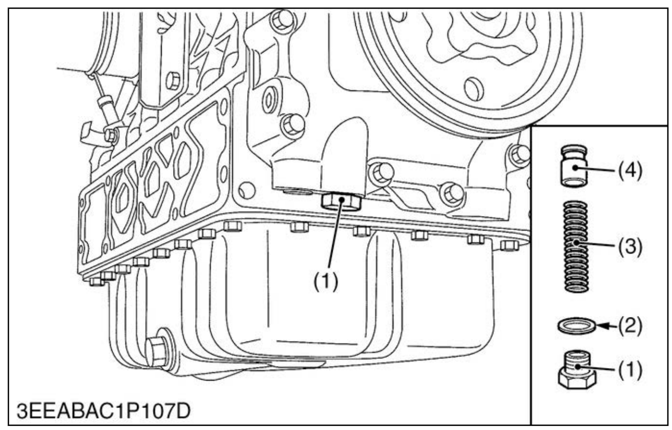




(1) Gear case cover
[A] V3800-TIEF4
[B] V3800-TIEF4C

5.28 Removing relief valve

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

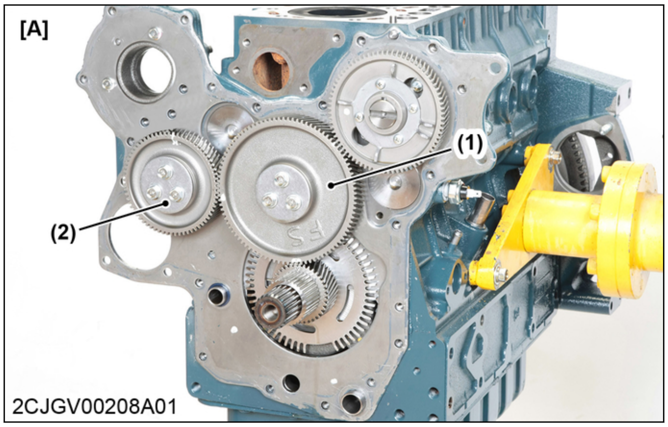


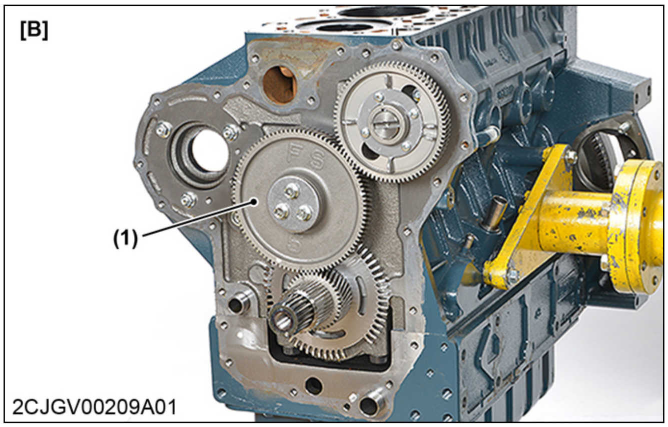
(1) Relief valve retaining plug
(2) Packing
(3) Spring
(4) Relief valve

5.29 Removing idle gear

1. Remove the idle gear 1 (1). [A] and [B]

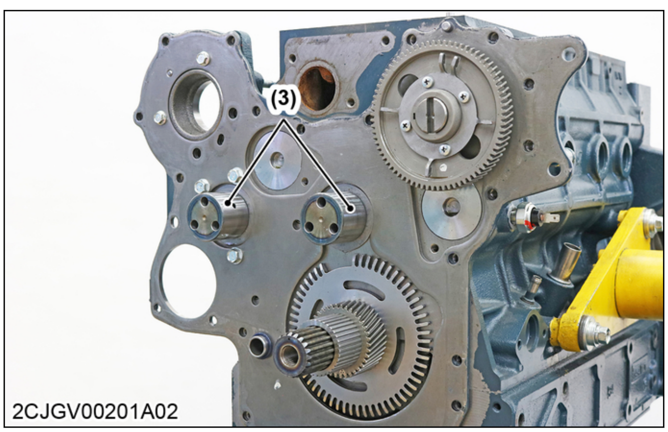
2. Remove the idle gear 2 (2). [A]





(1) Idle gear 1
(2) Idle gear 2
[A] V3800-TIEF4
[B] V3800-TIEF4C

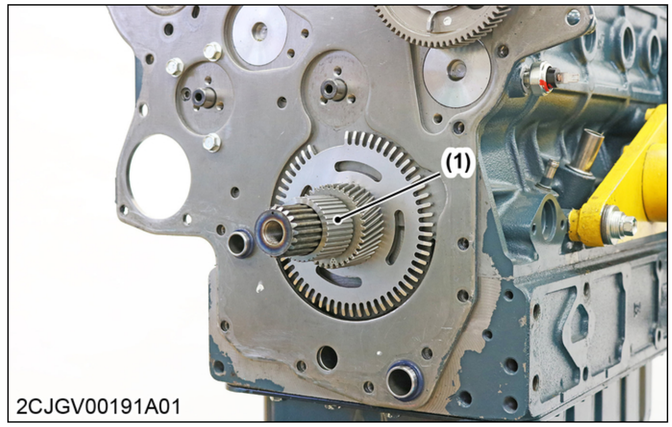
3. Remove the idle gear shafts (3).



(3) Idle gear shaft

5.30 Removing oil pump drive gear

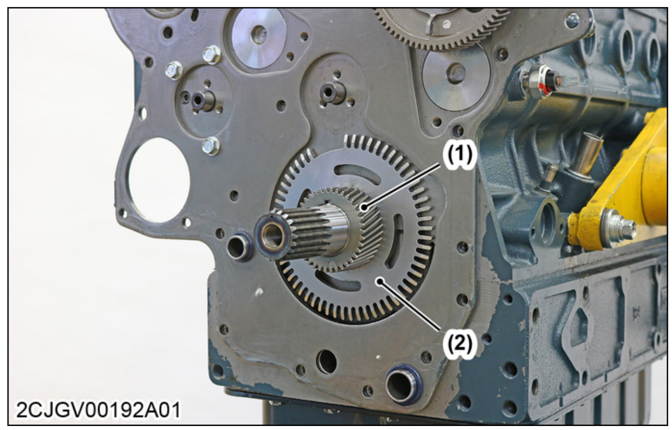
1. Remove the oil pump drive gear (1).



(1) Oil pump drive gear

5.31 Removing crank gear with crank pulsar gear

1. Remove the crank gear (1) with crank pulsar gear (2).



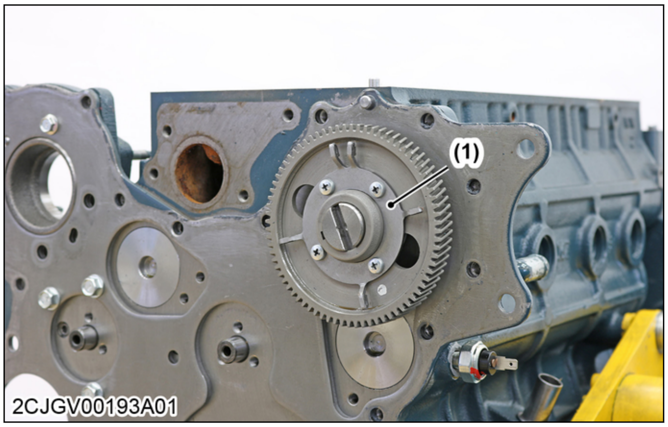
(1) Crank gear
(2) Crank pulsar gear

5.32 Removing camshaft with cam gear

Tools required

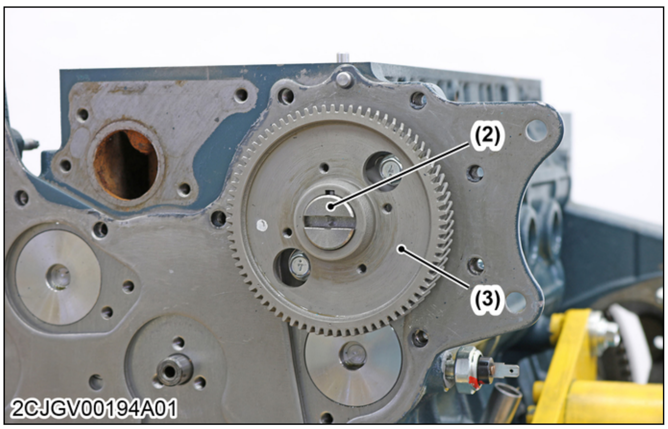
- Impact screwdriver

1. Remove the cam pulsar gear (1).



(1) Cam pulsar gear

2. Remove the camshaft set screws and draw out the camshaft (2) with cam gear (3).



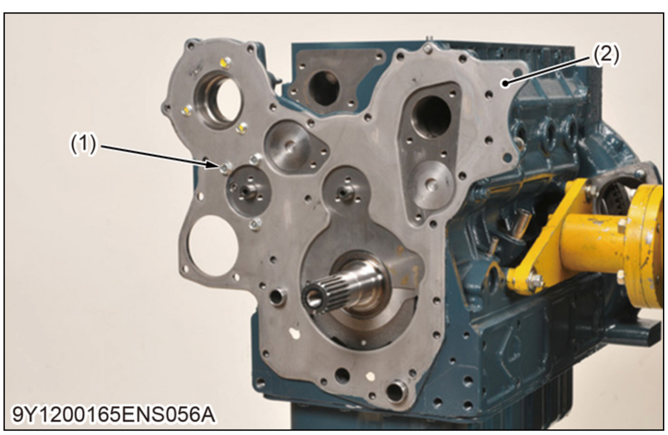
(2) Camshaft (3) Cam gear

5.33 Removing plate

NOTE

- **This work is only for V3800-TIEF4 model.**

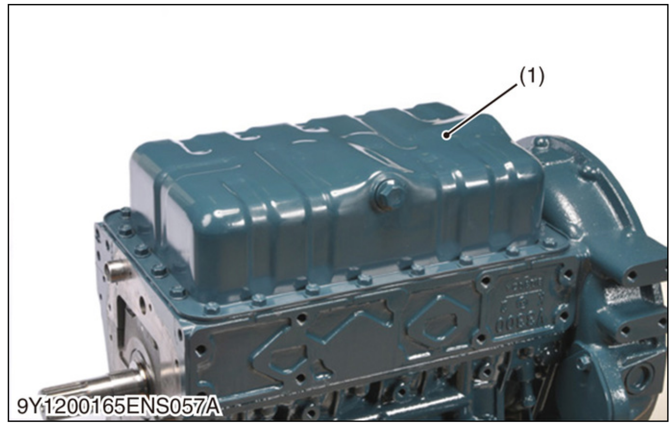
1. Remove the plate mounting screws (1).
2. Remove the plate (2).



(1) Plate mounting screw (2) Plate

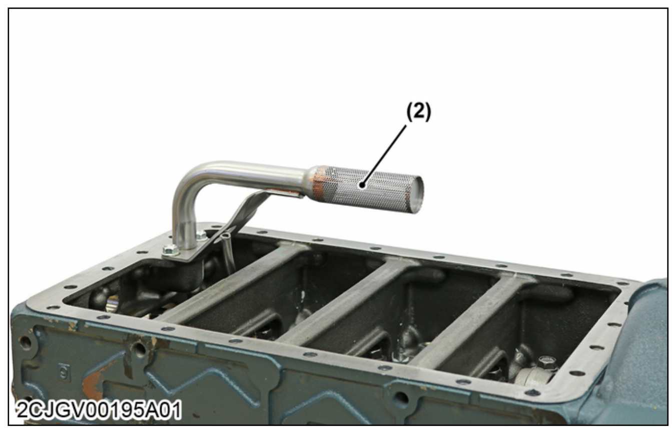
5.34 Removing oil pan and oil strainer

1. Remove the oil pan (1).



(1) Oil pan

2. Remove the oil strainer (2), using care not to damage the O-ring.

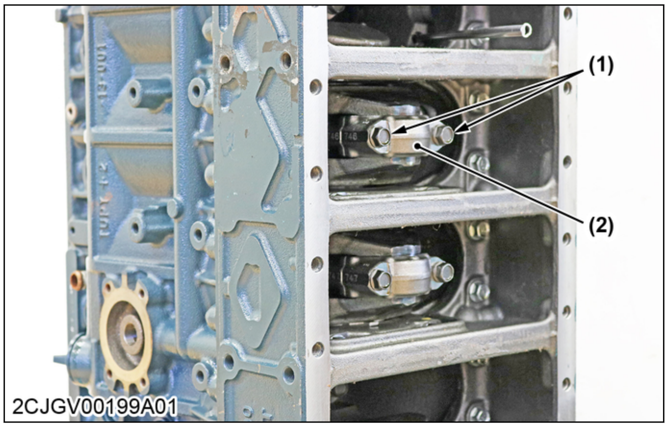


(2) Oil strainer

5.35 Removing piston

1. Turn the flywheel and move the piston to bottom dead center.
2. Remove the connecting rod screws (1).

3. Remove the connecting rod cap (2).

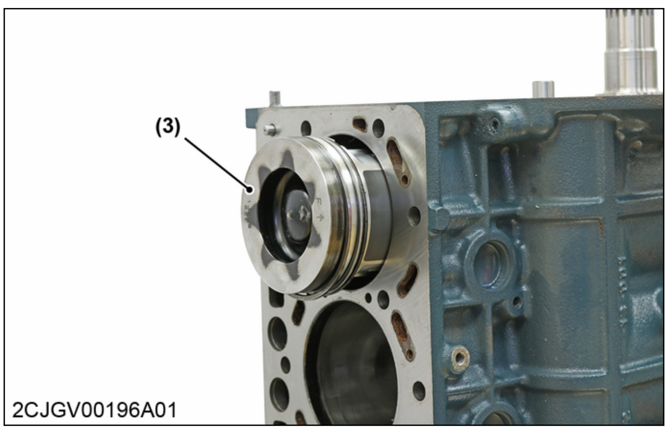


(1) Connecting rod screw (2) Connecting rod cap

4. Fully clean the carbon in the cylinders.
5. Turn the flywheel and move the piston (3) to top dead center.
6. Lightly tap the connecting rod big end bore from the bottom of the crankcase with the grip of a hammer to pull the piston (3) out.

IMPORTANT

- **Do not change the combination of cylinder and piston.**
  Align the position of each piston by the its mark. For example, mark "1" on the No. 1 piston.



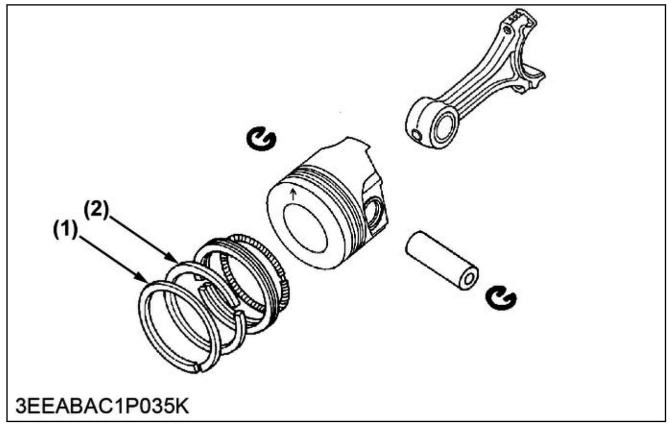
(3) Piston

5.36 Removing piston ring

Tools required

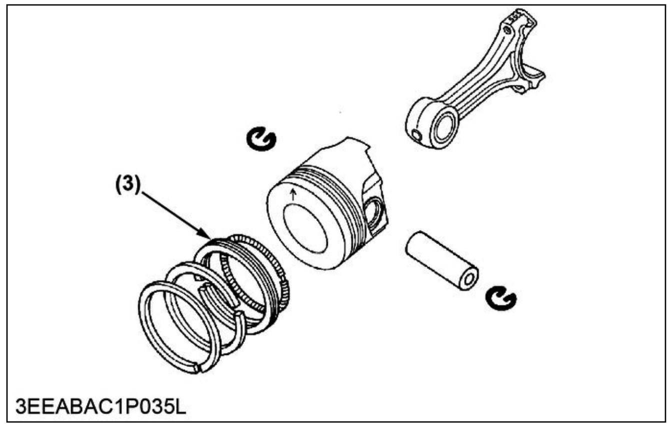
- Piston ring pliers

1. Remove the top ring (1) and second ring (2) with a piston ring pliers.



(1) Top ring (2) Second ring

2. Remove the oil ring (3) with a piston ring pliers.



(3) Oil ring

5.37 Disassembling piston assembly

1. Remove the piston pin snap ring (1) from the piston (2).

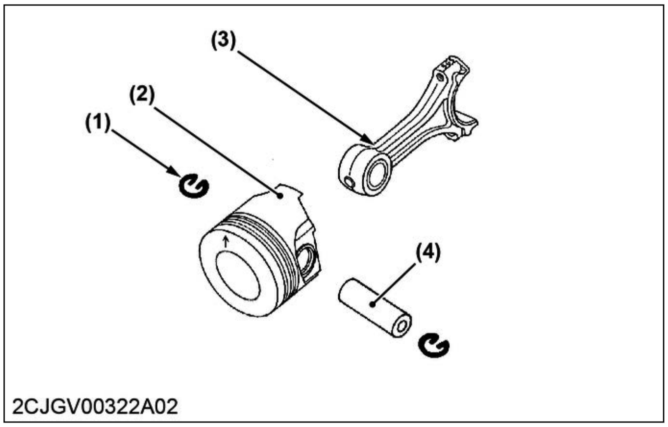
2. Remove the piston pin (4) to disconnect the connecting rod (3) from the piston (2).

IMPORTANT

- **Put a mark on the connecting rod (3) and the piston (2) with the same number to keep the same combination.**

NOTE

- **If do not remove the piston pin (4) easily, put the piston fully in 80 ℃ (176 ℉) oil for 10 to 15 minutes.**



(1) Piston pin snap ring
(2) Piston
(3) Connecting rod
(4) Piston pin

5.38 Removing flywheel

IMPORTANT

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

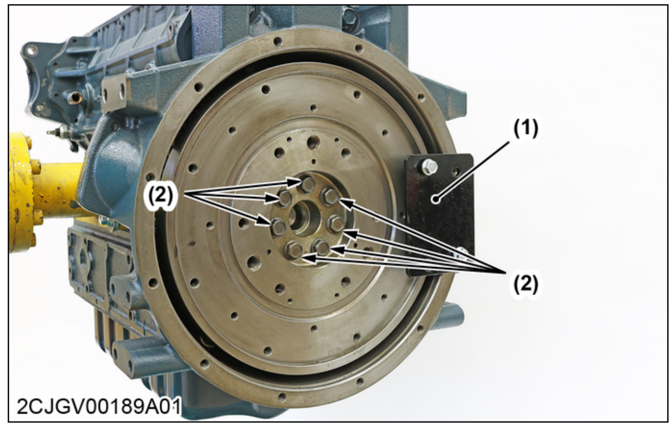
NOTE

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

Tools required

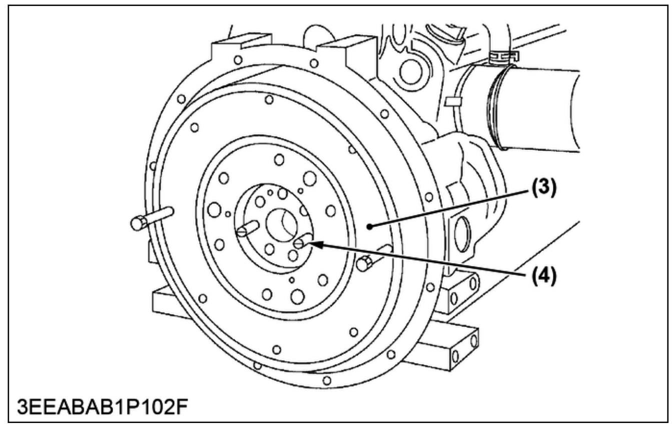
- Flywheel stopper
- Flywheel guide screw

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



(1) Flywheel stopper
(2) Flywheel screw

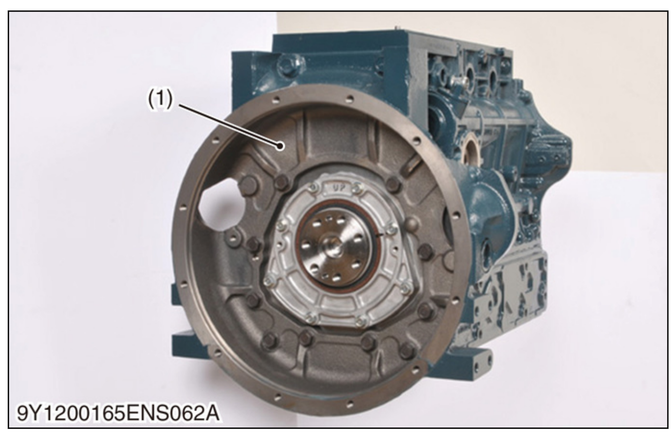
3. Set the flywheel guide screw (4).
4. Remove the flywheel (3).



(3) Flywheel
(4) Flywheel guide screw

5.39 Removing flywheel housing

1. Remove the flywheel housing (1).



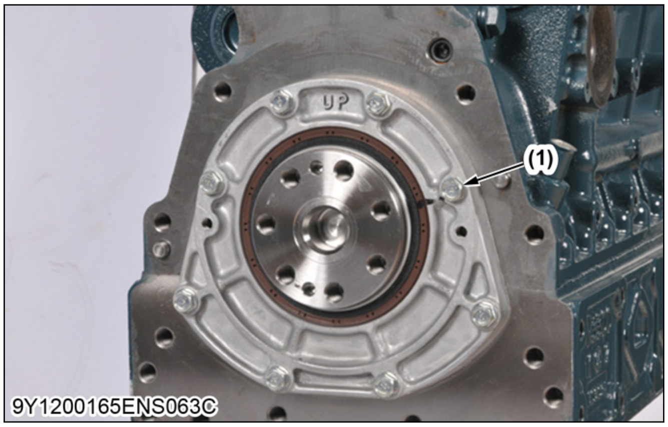
(1) Flywheel housing

5.40 Removing bearing case cover

■ **NOTE**

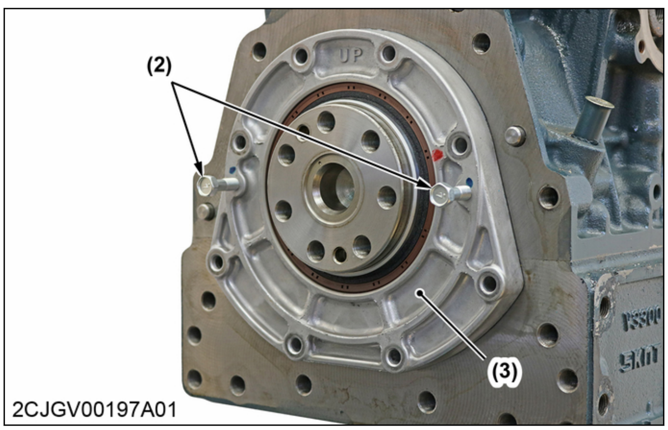
- **Before disassembling, check the side clearance of crankshaft. Also check it after reassembling.**

1. Remove the bearing case cover mounting screws (1).



(1) Bearing case cover mounting screw

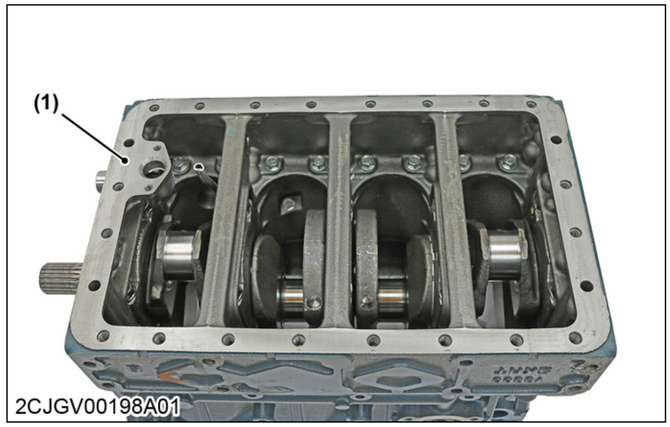
2. Set the screws (2) in the jack-up holes to remove the bearing case cover (3).



(2) Screw (3) Bearing case cover

5.41 Removing crankcase 2

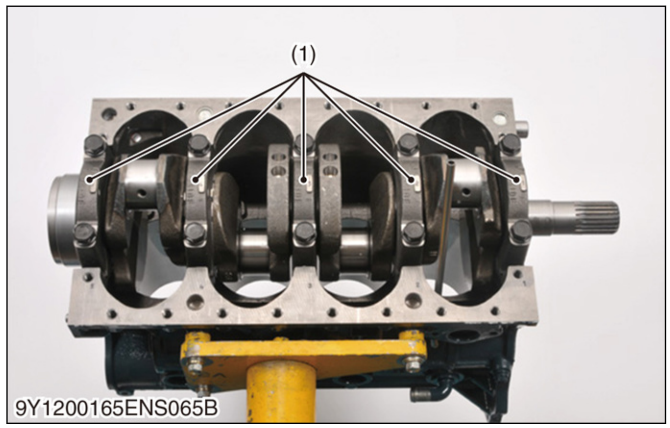
1. Remove the crankcase 2 (1).



(1) Crankcase 2

5.42 Removing main bearing case

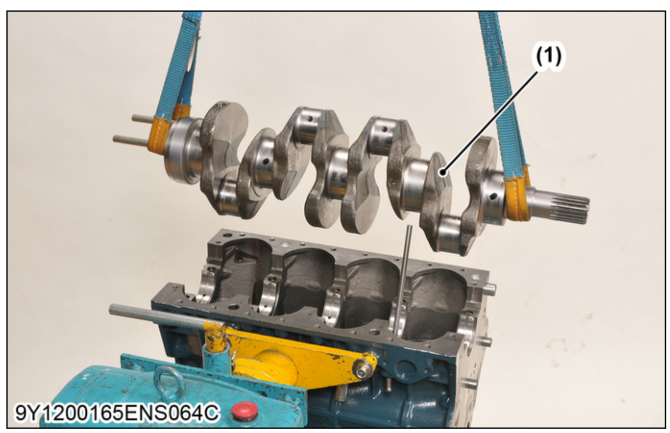
1. Remove the main bearing case (1).



(1) Main bearing case

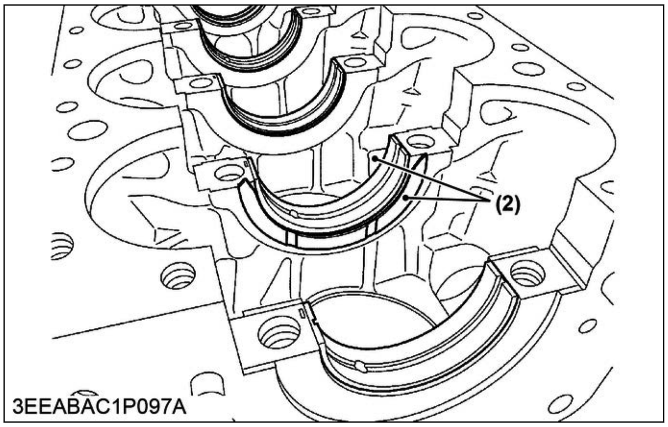
5.43 Removing crankshaft

1. Remove the crankshaft (1).



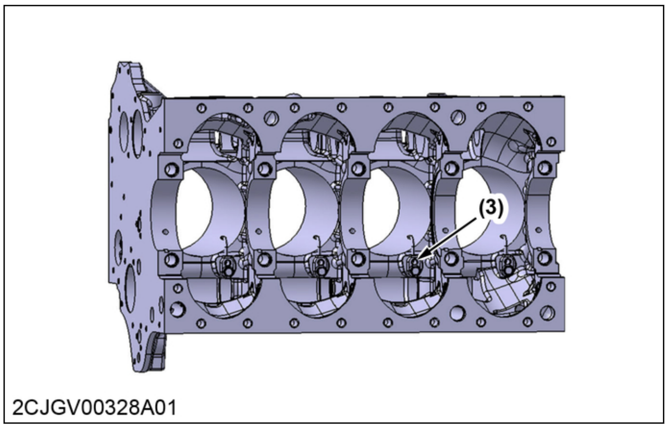
(1) Crankshaft

2. Remove the thrust bearing (2).



(2) Thrust bearing

3. Remove the oil jet (3).



(3) Oil jet

5.44 Disassembling starter

1. Disconnect the solenoid switch (3).
2. Remove the 2 through screws (10) and the 2 brush holder lock screws.
3. Remove the rear end frame (14) and the brush holder (13).

■ **NOTE**

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

4. Disconnect the armature (11) and the yoke (12).

■ **IMPORTANT**

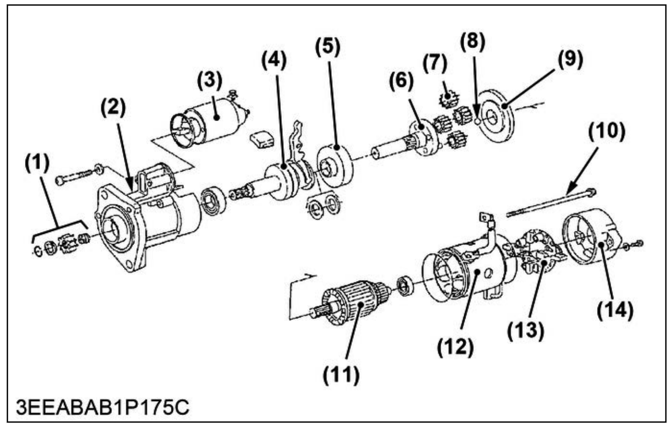
- **Before disconnecting the yoke, put tally marks on the yoke and the front bracket.**

5. Remove also the ball (8) from the tip of the armature.
6. Remove the set of packings (9), the 4 planetary gears and another packing.

■ **IMPORTANT**

- **Take note of the positions of the set of packings and the setup bolt.**

7. Remove the gear (1) and shaft assembly (4), (5), (6). Take note of the position of the lever.



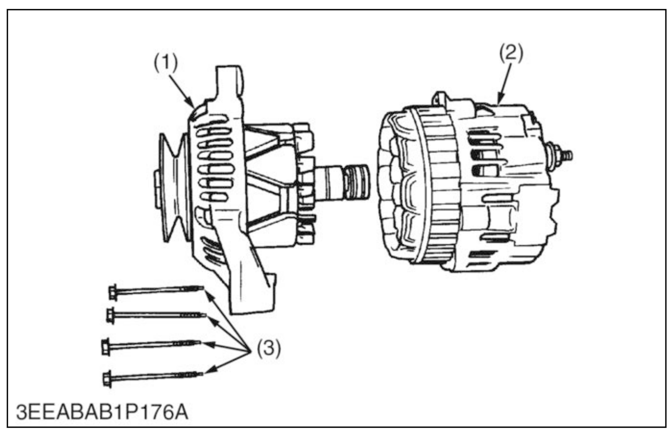
(1) Gear
(2) Front bracket
(3) Solenoid switch
(4) Overrunning clutch
(5) Internal gear
(6) Shaft
(7) Planetary gear
(8) Ball
(9) Set of packings
(10) Through screws
(11) Armature
(12) Yoke
(13) Brush holder
(14) Rear end frame

5.45 Disassembling alternator

1. Remove the 4 screws (3).
2. Separate the front bracket (1) and the rear bracket (2) from each other.

■ **IMPORTANT**

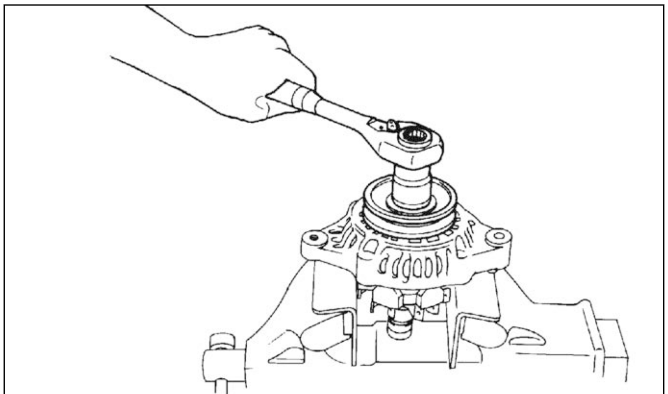
- **Put a tally line on the front bracket (1) and the rear bracket for reassembling them later.**



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

3. Hold the rotor (base of the claw) in a vise.

4. Loosen the lock nut.



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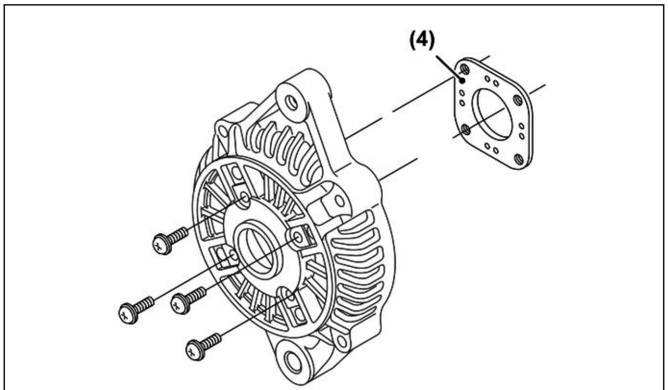
5. Remove the 4 screws to detach the bearing retainer (4).



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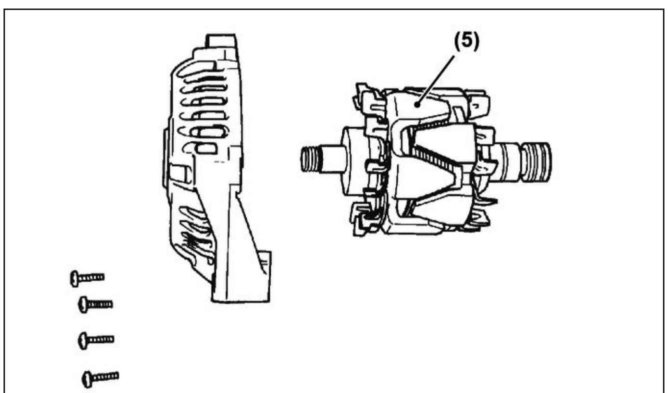
(4) Bearing retainer

6. Temporarily install the nut on the pulley screw.
7. Detach the rotor (5).



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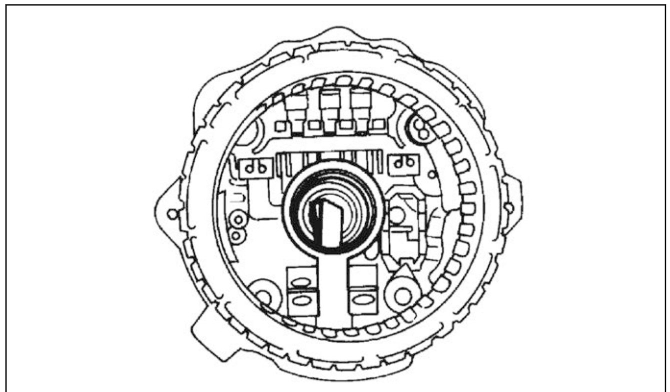
(5) Rotor

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



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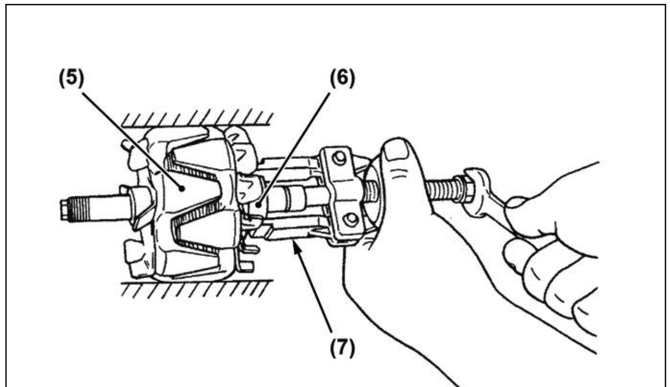
9. Lightly secure the rotor (5) with a vise to prevent damage.
10. Remove the bearing (6) with a puller (7).



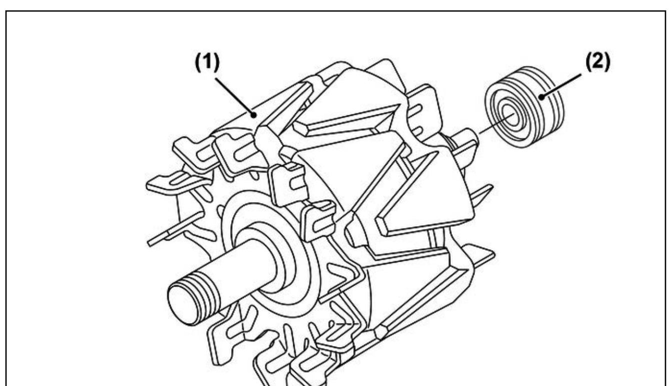
3TMABAB9P028C

(5) Rotor
(6) Bearing
(7) Puller

6. Assembling

6.1 Assembling alternator

1. Lightly secure the rotor with a vise to prevent damage.
2. Install the bearing (2) to the slip ring side of rotor (1).



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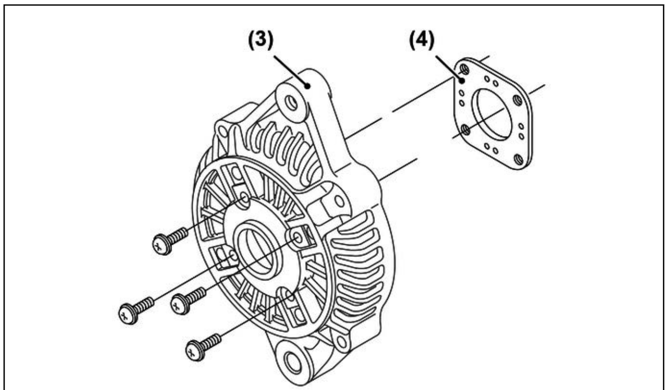
(1) Rotor
(2) Bearing

3. Install the bearing retainer (4) to the front bracket (3).



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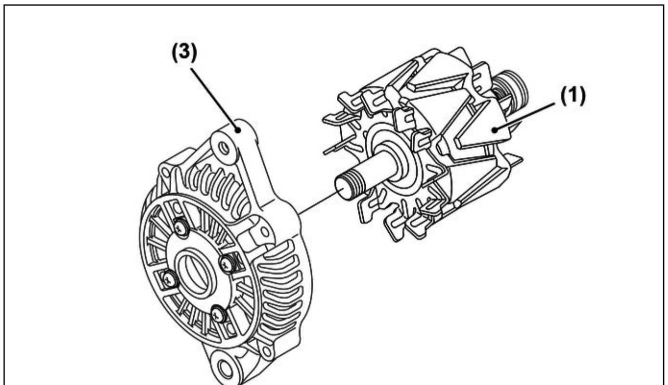
(3) Front bracket (4) Bearing retainer

4. Install the rotor (1) to the front bracket (3).



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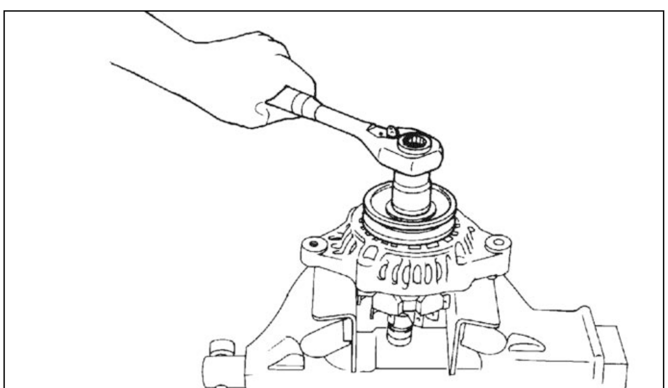
(1) Rotor (3) Front bracket

5. Lightly secure the rotor with a vise to prevent damage.
6. Install the pulley and tighten the pulley nut to the specified torque.

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



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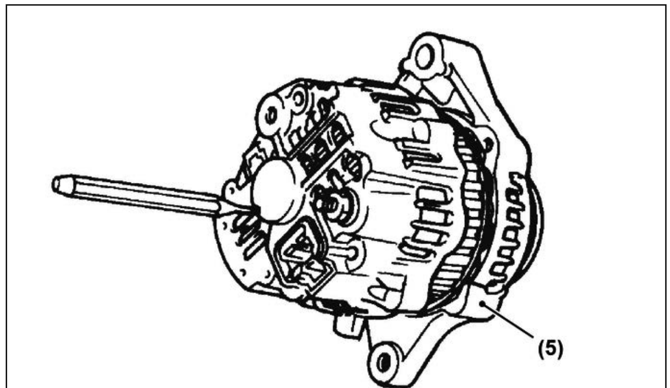
7. Fit the brush with its sliding face in the clockwise direction when viewed from front.

■ **IMPORTANT**

- **Be sure to keep the 2 brushes deep in the brush holder.**
  Otherwise the rotor and the rear section can not be fitted into the position.

8. Push the brushes into place using a 4 mm hex. wrench.
9. Keep the brushes from popping out using a pin-pointed punch.
10. Align the mark line (5) of the front bracket with that of the rear bracket.



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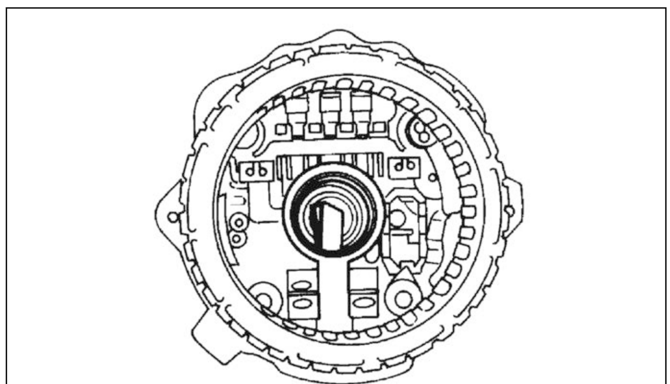
(5) Mark line

11. Tighten the 4 screws.



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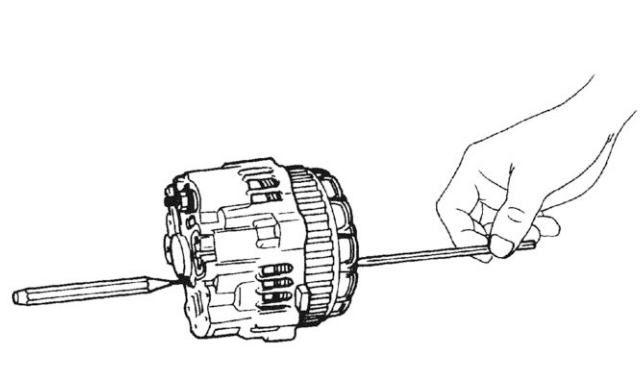
12. Draw out the pin-pointed punch out of the brush holder.



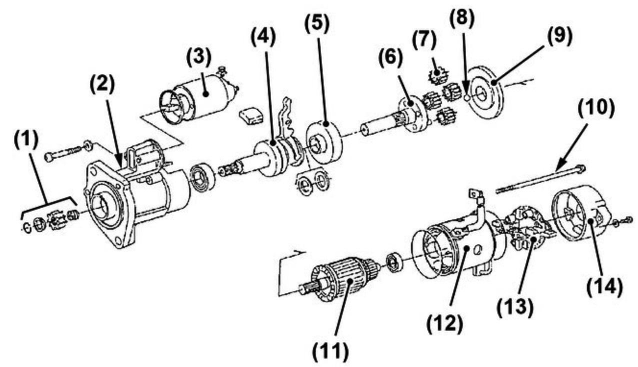
3EEABAB1P180A

6.2 Assembling starter

■ IMPORTANT
- **Apply grease to the gears, bearings, shaft's sliding part and ball.**

■ NOTE
- **Do not damage the brush and commutator.**

1. Install the shaft assembly (4), (5), (6) to the front bracket (2).
2. Install the pinion gear (1).
3. Install the set of packings (9), the 4 planetary gears (7) and another packing.
4. Install the armature (11) to the yoke (12).
5. Install the ball (8) to the tip of the armature (11).
6. Install the brush holder (13) and rear end frame (14).
7. Install the 2 brush holder lock screws.
8. Install the 2 through screws (10).
9. Install the solenoid switch (3).



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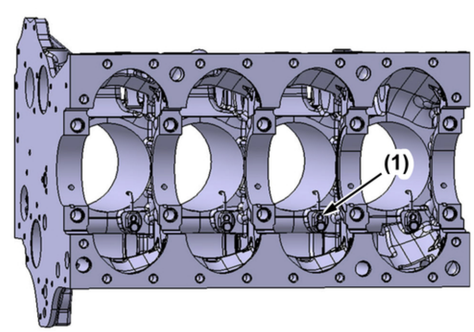
(1) Pinion gear
(2) Front bracket
(3) Solenoid switch
(4) Overrunning clutch
(5) Internal gear
(6) Shaft
(7) Planetary gear
(8) Ball
(9) Set of packings
(10) Through screws
(11) Armature
(12) Yoke
(13) Brush holder
(14) Rear end frame

6.3 Installing crankshaft

1. Install the oil jet (1).



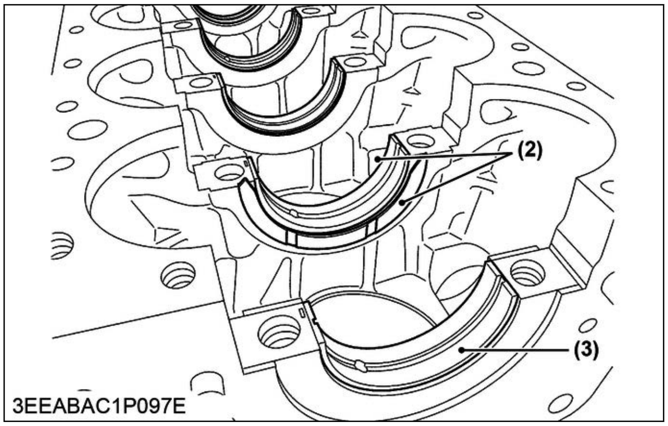
2CJGV00328A02

(1) Oil jet

2. Install the thrust bearing (2) with the oil groove facing outside, into both side of 4th main bearing case.

■ **NOTE**

- **Apply oil to the crankshaft bearing (3) and thrust bearing (2).**

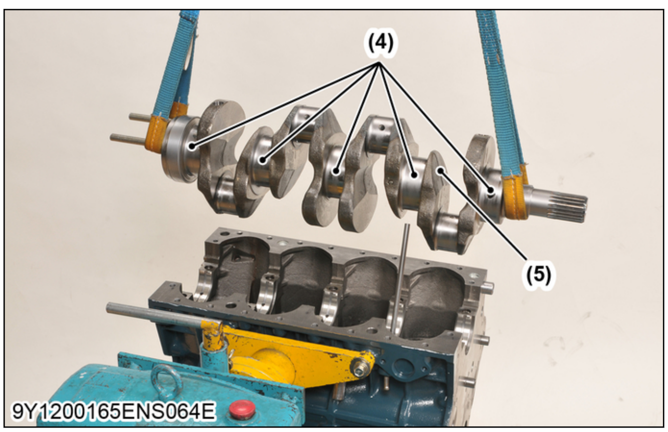


(2) Thrust bearing (3) Crankshaft bearing

3. Install the crankshaft (5).

■ **NOTE**

- **Apply oil to the crankshaft journal (4).**



(4) Crankshaft journal (5) Crankshaft

6.4 Installing main bearing case

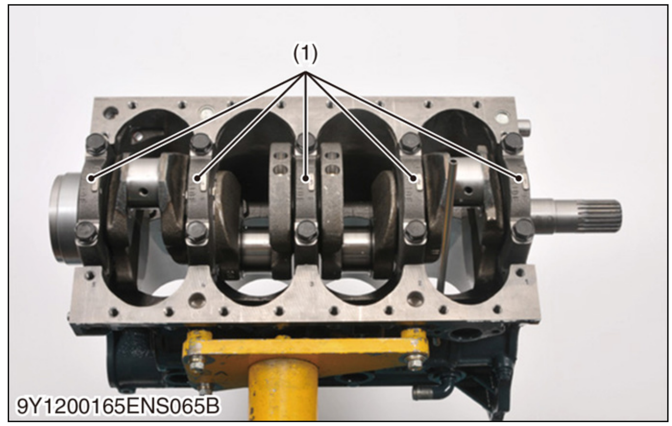
1. Install the main bearing case (1).

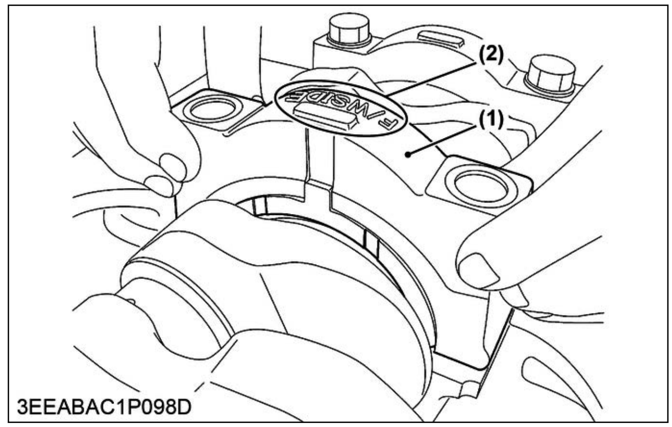
■ **IMPORTANT**

- **The main bearing case has the same number as the one engraved on the crankcase.**
- **Set the casting mark [F / W SIDE] (2) on the main bearing case facing towards the flywheel side.**

■ **NOTE**

- **Apply oil to the crankshaft bearing and thrust bearing.**





(1) Main bearing case (2) F/W SIDE mark

2. Tighten the main bearing case screws to the specified torque.

■ **NOTE**

- **Apply engine oil to the main bearing case screws.**

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

6.5 Installing crankcase 2

■ **IMPORTANT**

- **Make sure the crankcase 1 and 2 are clean.**

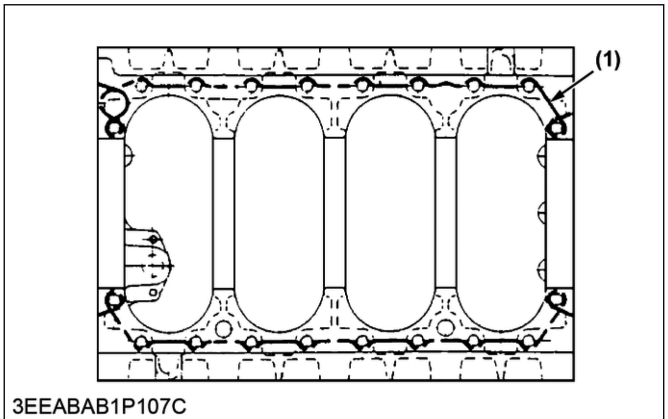
Tools required

- Liquid gasket (Three bond 1217H)

1. Apply liquid gasket (1) to the crankcase 2.

■ **IMPORTANT**

- **Make sure that the liquid gasket coating surface is free of water, dust and oil in order to keep sealing effect.**
- **Carefully apply the liquid gasket evenly.**

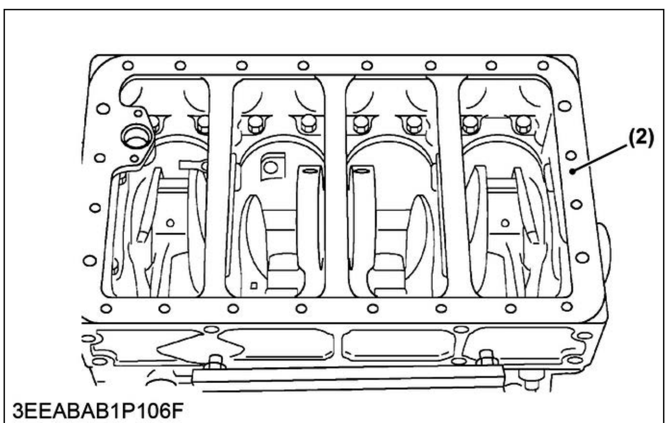


(1) Liquid gasket

2. Install the crankcase 2 (2) and loosely tighten the crankcase 2 mounting screw.

■ **NOTE**

- **Tighten the crankcase 2 mounting screws with even force on the diagonal line.**
- **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.**



(2) Crankcase 2

6.6 Installing flywheel housing

■ **NOTE**

- **Make sure the surface of crankcase 1, 2 are clean and alignment between crankcase 1 and 2 is correct.**

Tools required

- Liquid gasket (Three Bond 1217H)

1. Apply the liquid gasket to flywheel housing.

■ **IMPORTANT**

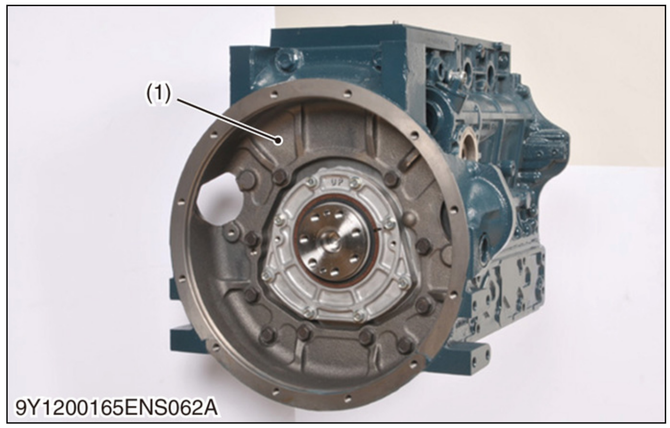
- **Make sure that the liquid gasket coating surface is free of water, dust and oil in order to keep sealing effect.**
- **Make sure the surfaces align when mounting parts with a liquid gasket applied to them.**

2. Install the flywheel housing (1).

■ **NOTE**

- **Tighten the flywheel housing mounting screws with even force on the diagonal line.**
- **Mount parts with a liquid gasket within 10 minutes of application.**

Tightening torque	Flywheel housing mounting screw	103 to 117 N·m 10.5 to 12.0 kgf·m 76.0 to 86.7 lbf·ft



(1) Flywheel housing

— RELATED PAGE —
6.7 Aligning surface of crankcase 1 and crankcase 2 on page 3-152

6.7 Aligning surface of crankcase 1 and crankcase 2

■ **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.**

Tools required

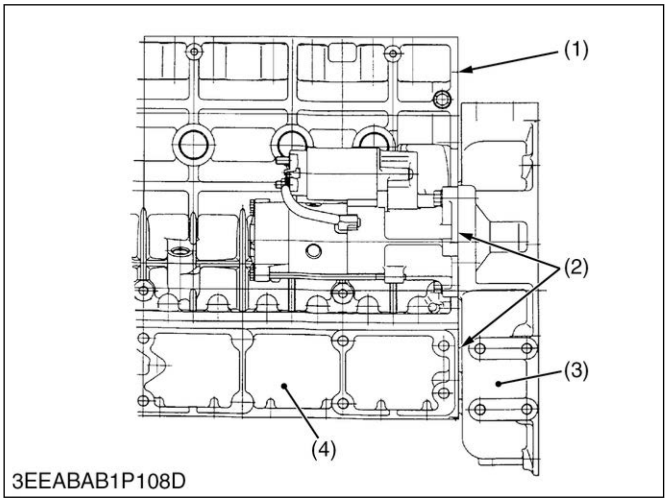
- Jig for alignment crankcase 1 and 2

1. Using the surface that touches jig or the flywheel housing (3) as a reference, line up crankcases 1 and 2.
2. Install crankcase 2 (4) and loosely tighten the screw.

3. Tighten the flywheel housing mounting screw and crankcase 2 mounting screw to the specified torque.

■ **NOTE**
- **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	Flywheel housing mounting screw	103to 117 N·m 10.5 to 12.0 kgf·m 76.0 to 86.7 lbf·ft



(1) Crankcase 1
(2) Gap in alignment
(3) Flywheel housing
(4) Crankcase 2

6.8 Installing bearing case cover

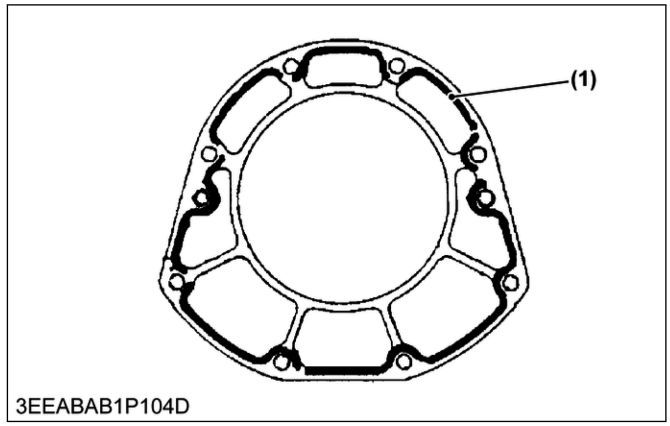
■ **IMPORTANT**
- **In case of replacing the oil seal, insert the oil seal to the bearing case cover not to be tilted. The seal should be flush with the cover.**
- **Before installing the bearing case cover / oil seal assembly, lube the seal and install it not to damage the seal.**

■ **NOTE**
- **Check the side clearance of crankshaft after assembling.**

Tools required
- Liquid gasket (Three Bond 1217H)

1. Apply the liquid gasket (1) to bearing case cover.

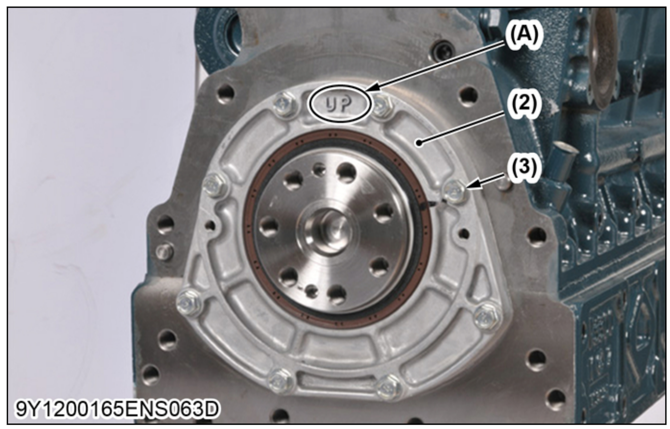
■ **IMPORTANT**
- **Make sure that the liquid gasket coating surface is free of water, dust and oil in order to keep sealing effect.**



(1) Liquid gasket

2. Install the bearing case cover / oil seal assembly to position the casting mark **[UP]** (A) on it upward.

■ **NOTE**
- **When mounting the adhesive-applied parts, be careful to fit them to the mating parts.**
- **Apply oil to the lip of oil seal.**



(2) Bearing case cover
(3) Bearing case cover mounting screw
(A) Casting mark UP

3. Tighten the bearing case cover mounting screws (3) with even force on the diagonal line.

■ **NOTE**
- **Assemble the adhesive-applied parts within 10 minutes.**

6.9 Installing flywheel

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

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

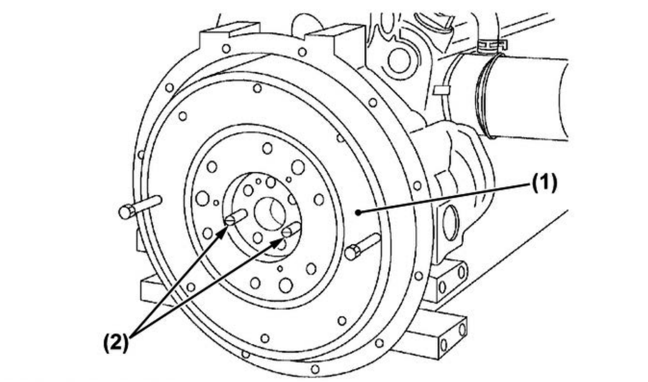
Tools required
- Flywheel stopper

- Flywheel guide screw

1. Set the flywheel guide screw (2).
2. Install the flywheel (1).
3. Attach the flywheel stopper and tighten to the specified torque.

■ **NOTE**
- **Apply engine oil to the flywheel screws.**
- **Check 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



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(1) Flywheel (2) Flywheel guide screw

6.10 Assembling piston assembly

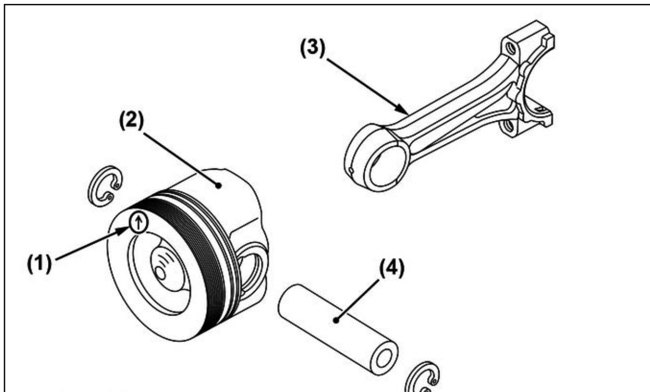
CAUTION
- **The end faces of the oil ring are plated with hard chrome. When you install the piston into the cylinder, do not give a damage to the cylinder by the oil ring. If the ring's planting is scratched, it may get stuck on the cylinder wall, causing serious damage.**

■ **IMPORTANT**
- **Put a mark on the connecting rod and the piston with the same number to keep the same combination.**

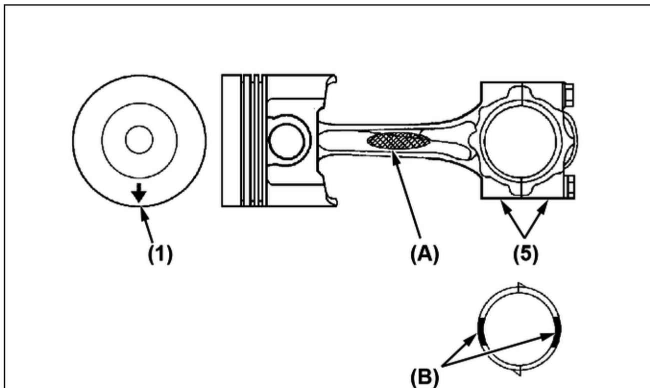
■ **NOTE**
- **Be sure the crank pin bearing and the connecting rod are same ID colors.**

1. Put the piston fully in 80 ℃ (176 ℉) oil for 10 to 15 minutes.
2. Install the piston pin (4) and the connecting rod (3) to the piston (2).

■ **NOTE**
- **Apply engine oil to the piston pin.**
- **Align the mark [↑] (1) on the piston to the connecting rod numbering mark (5).**



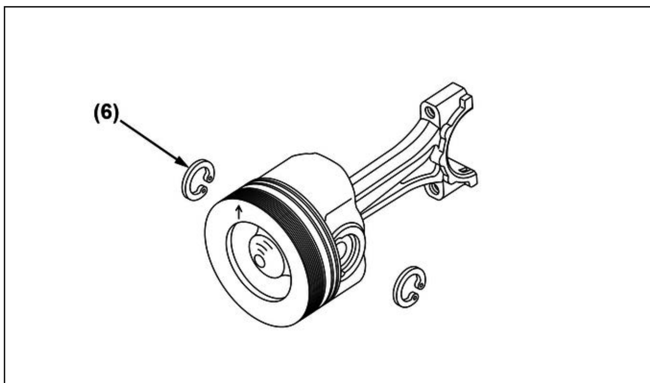
2CJGV00326A01



3EEABAC1P036J

(1) Mark (↑)
(2) Piston
(3) Connecting rod
(4) Piston pin
(5) Numbering mark
(A) Connecting rod ID color: Blue or without color
(B) Crank pin bearing ID color: Blue or without color

3. Install the piston pin snap ring (6).



2CJGV00325A01

(6) Piston pin snap ring

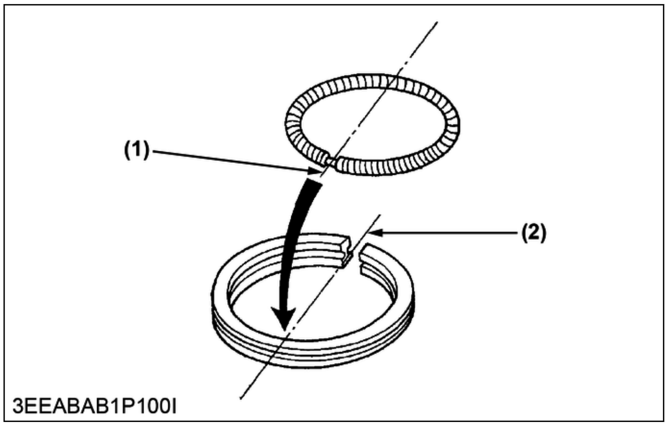
6.11 Installing piston ring

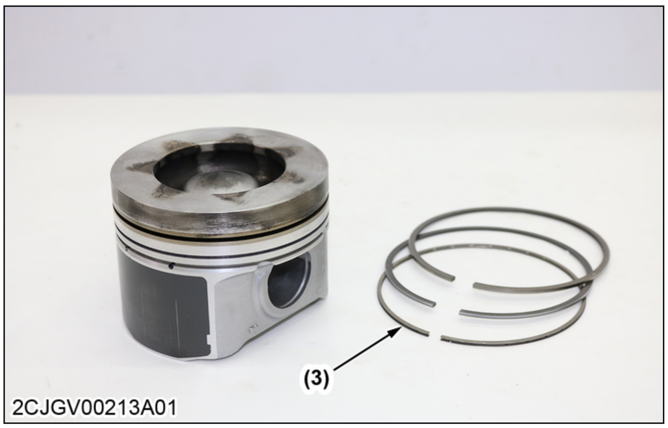
Tools required

- Piston ring pliers

1. Install the oil ring (3) to the piston with a piston ring pliers.

■ **NOTE**
- **Set the expander joint (1) on the opposite side of the oil ring gap (2).**

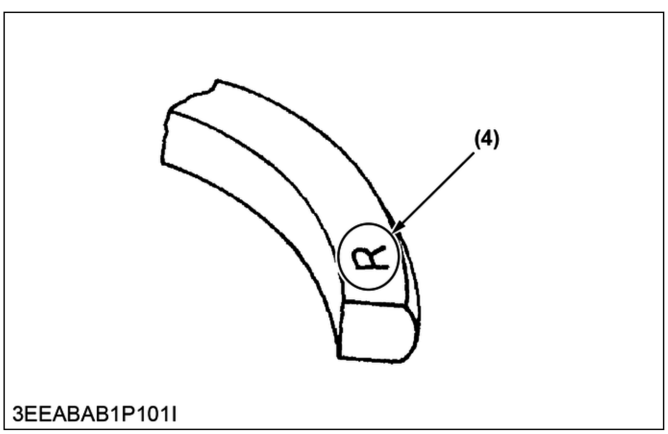




(1) Expander joint
(2) Oil ring gap
(3) Oil ring

2. Install the second ring (6) and top ring (5) to the piston with a piston ring pliers.

■ **NOTE**
- **Set the manufacturer mark (4) upward.**



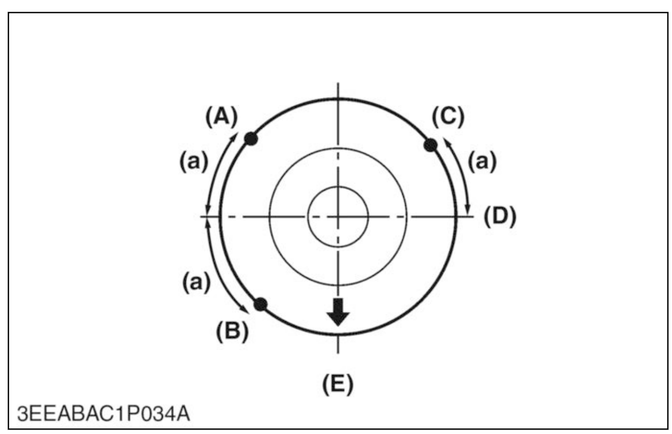
(4) Manufacturer mark
(5) Top ring
(6) Second ring

6.12 Installing piston

■ **IMPORTANT**
- **Do not change the combination of cylinder number and piston.**
  Align the position of each piston by the its mark. For example, mark "1" on the No. 1 piston.
- **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.**

Tools required
- Piston ring compressor

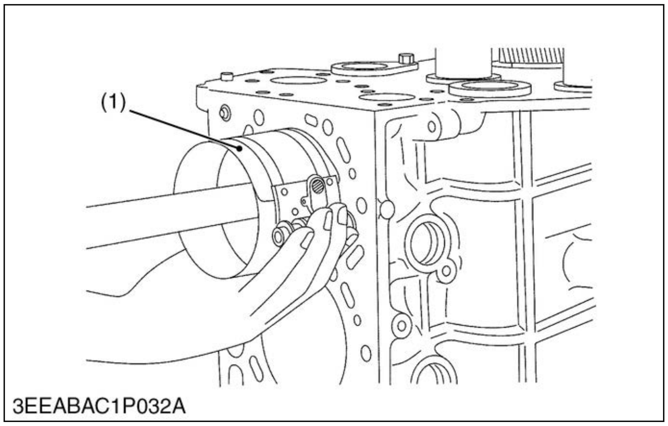
1. Clean the carbon in the cylinders.
2. Turn the flywheel and move the crankshaft to top dead center.
3. Place the gap of each piston ring like the figure.



(A) Top ring gap
(B) Second ring gap
(C) Oil ring gap
(D) Piston pin hole
(E) Supply pump side
(a) 0.79 rad (45°)

4. Set the piston ring compressor (1) to the piston.

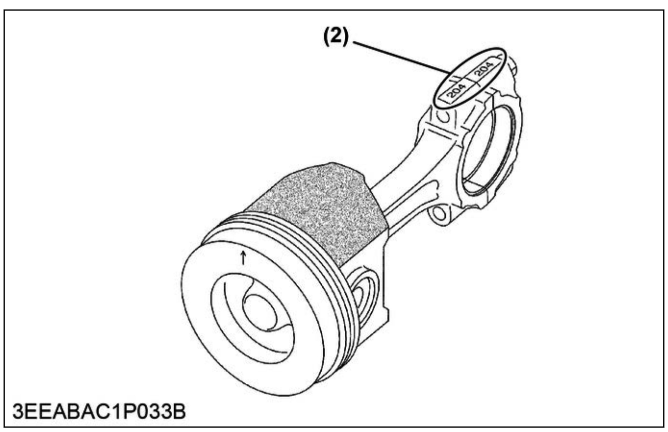
■ **IMPORTANT**
- **Be carefully to set the piston ring compressor. Otherwise, their chrome-plated section of piston rings may be scratched, causing trouble inside the liner.**



(1) Piston ring compressor

5. Install the piston to cylinder.

■ **NOTE**
- **Apply sufficient engine oil to the piston.**
- **Point the numbering mark (2) on the connecting rod to the supply pump.**
- **Align the numbering marks (2) with each other.**



(2) Numbering mark

6. Turn the flywheel and move the piston to bottom dead center.
7. Install the connecting rod cap and loosely tighten the connecting rod screw by hand.

■ **NOTE**
- **Apply engine oil to the connecting rod screws.**
- **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.**

8. Tighten the connecting rod screw to the specified torque.

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

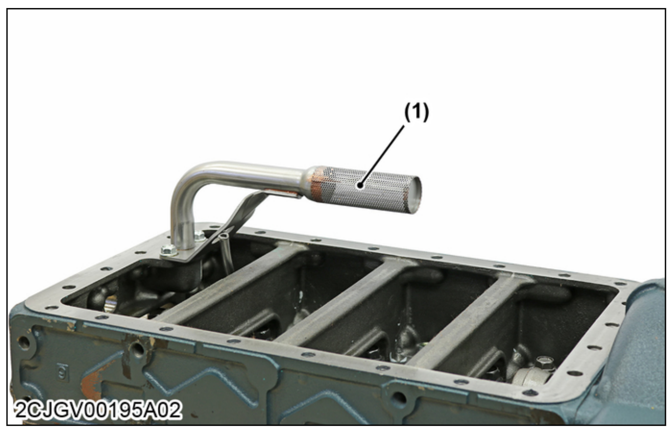
6.13 Installing oil strainer and oil pan

■ **NOTE**
- **Clean the oil pan and crankcase 2 surface that attached each other.**

Tools required
- Liquid gasket (Three Bond 1217H)

1. Install the oil strainer (1), using care not to damage the O-ring.

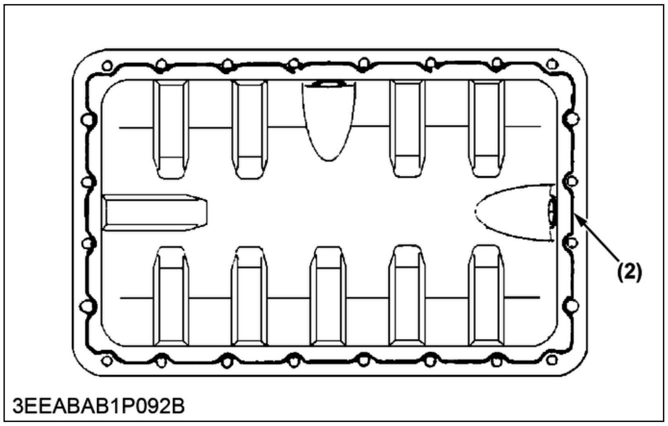
■ **NOTE**
- **After cleaning the oil strainer (1), install it.**



(1) Oil strainer

2. Apply liquid gasket (2) to the oil pan as shown in the figure.

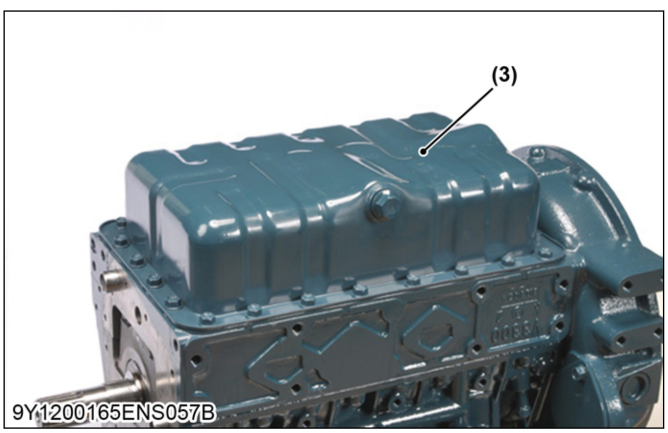
NOTE
- **Confirm that the liquid gasket (2) coating surface is free of water, dust and oil in order to maintain sealing effect.**
- **Make sure the surfaces align when mounting parts with a liquid gasket (2) applied to them.**
- **Carefully apply the liquid gasket (2) evenly.**



(2) Liquid gasket

3. Install the oil pan (3).

NOTE
- **Mount parts with a liquid gasket within 10 minutes of application.**
- **Tighten the mounting screws of the oil pan (3) in diagonal sequence from the center to tighten equally.**
- **Install the oil pan (3) with its central drain plug facing toward the air suction side.**



(3) Oil pan

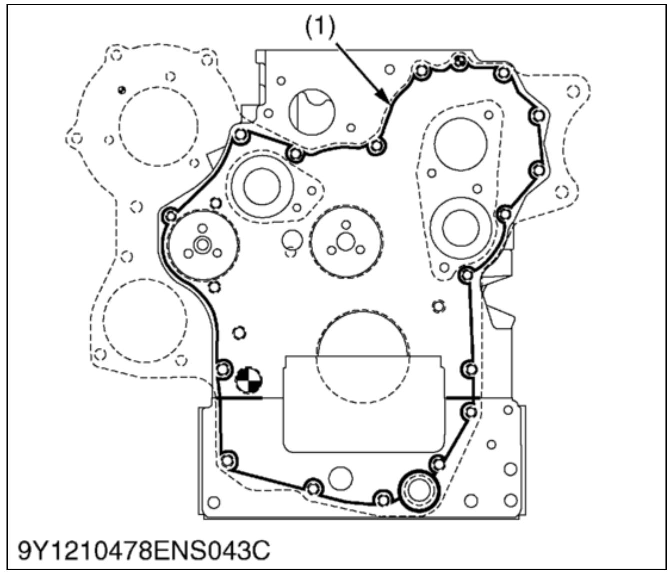
6.14 Installing plate

NOTE
- **Clean the surface of the crankcase side.**
- **This work is only for V3800-TIEF4 model.**

Tools required
- Liquid gasket (Three Bond 1217H)

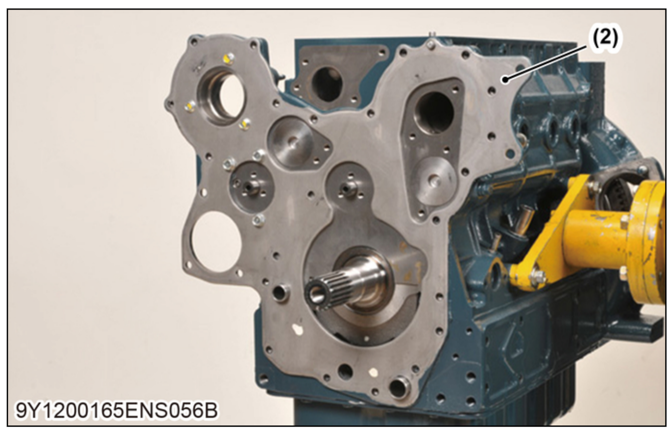
1. Apply liquid gasket (1) on the surface of the crankcase side where the plate will be installed to.

NOTE
- **Carefully apply liquid gasket evenly.**



(1) Liquid gasket

2. Install the plate (2).

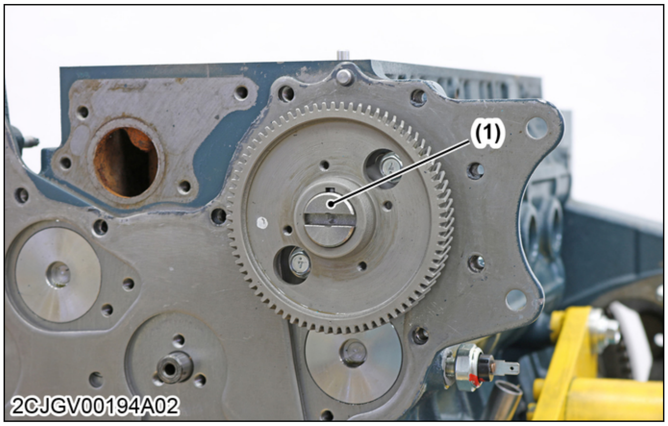


(2) Plate

6.15 Installing camshaft with cam gear

1. Install the camshaft (1) with cam gear.

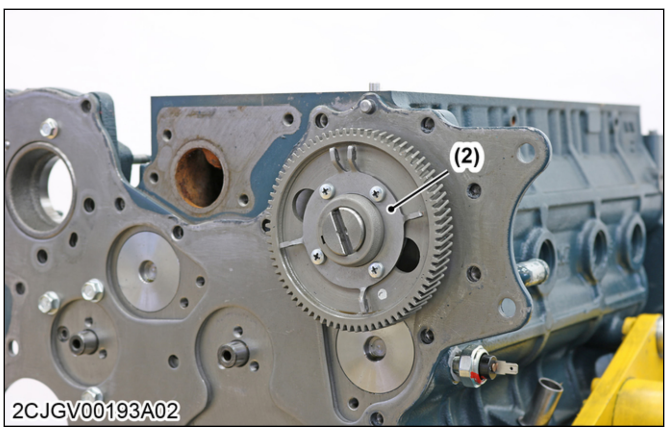
Tightening torque	Camshaft set screw	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft



(1) Camshaft

2. Install the cam pulsar gear (2) and tighten to specified torque.

Tightening torque	Cam pulsar gear retaining screw	4.7 to 5.6 N·m 0.48 to 0.58 kgf·m 3.5 to 4.1 lbf·ft



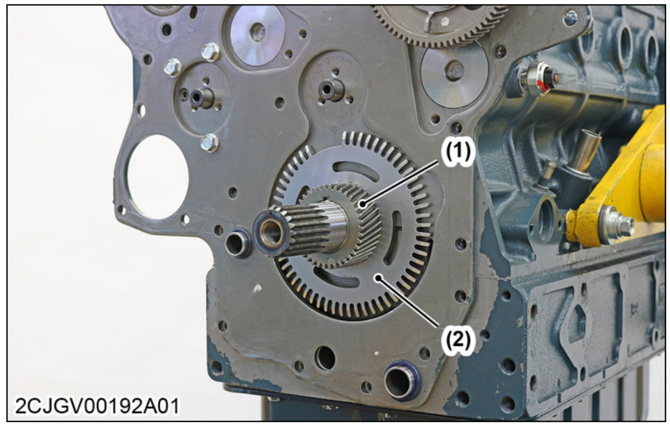
(2) Cam pulsar gear

6.16 Installing crank gear with crank pulsar gear

■ **NOTE**

- **When the crank gear is replaced, check the air gap of the crankshaft position sensor.**
- **When the crank gear is replaced, it is necessary to calibrate the injection timing with the diagnosis tool.**

1. Install the crank gear (1) with crank pulsar gear (2).



(1) Crank gear (2) Crank pulsar gear

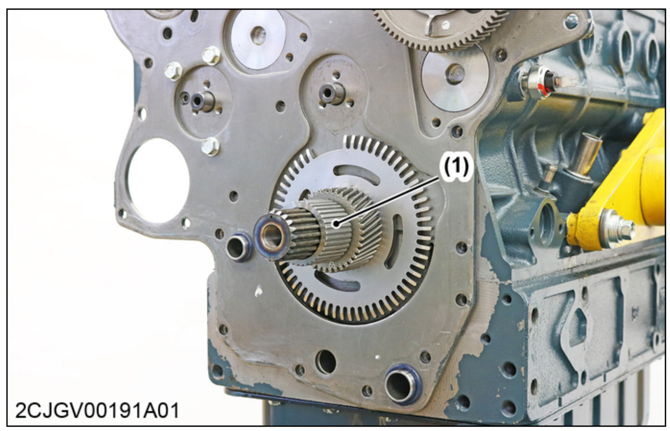
RELATED PAGE

4.34 Adjusting crankshaft position sensor air gap on page 3-118

4.37 Measuring angular deviation between crankshaft T.D.C. and crank position sensor detected T.D.C. on page 3-121

6.17 Installing oil pump drive gear

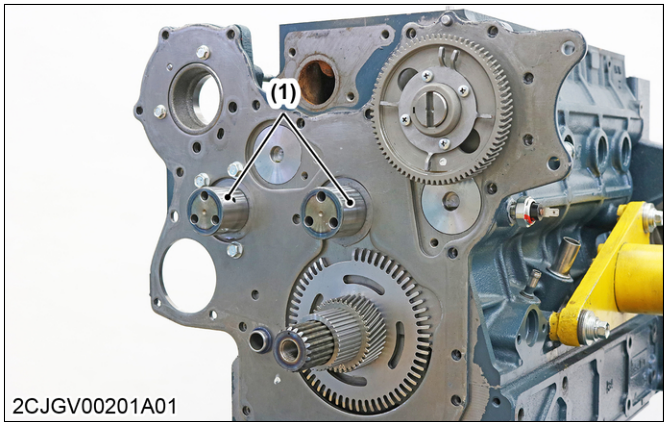
1. Install the oil pump drive gear (1).



(1) Oil pump drive gear

6.18 Installing idle gear

1. Install the idle gear shaft (1).



(1) Idle gear shaft

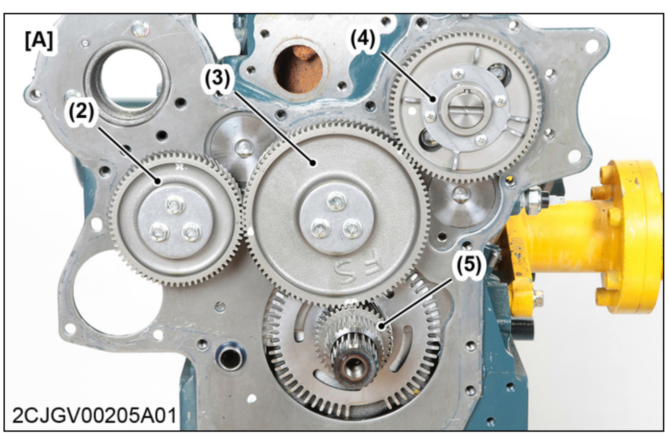
2. Install the idle gear 2 (2).

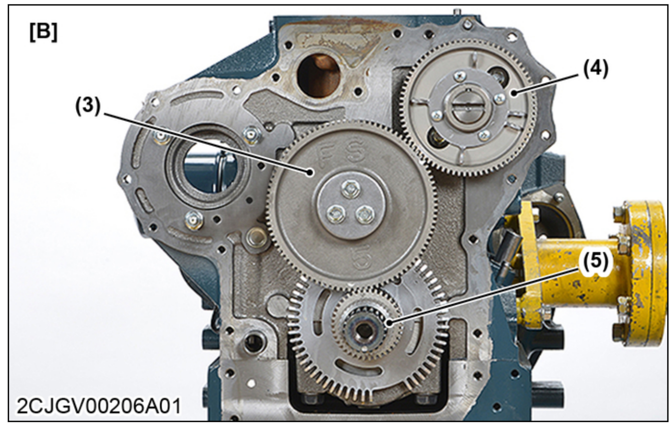
■ NOTE
- **Apply the engine oil inside of idle gear 2 (2).**
- **This work is only for V3800-TIEF4 model.**

3. Install the idle gear 1 (3).

■ IMPORTANT
- **Apply the engine oil inside of idle gear 1 (3).**
- **When mounting idle gear 1 (3), bring the piston of cylinder 4 to T.D.C. and mount the gears with their marks aligned to the respective gears.**
  - **a. Idle gear 1 (3) and cam gear (4) [A], [B]**
  - **b. Idle gear 1 (3) and crank gear (5) [A], [B]**
  - **c. Idle gear 1 (3) and idle gear 2 (2) [A]**
- **If you install idle gear 3, it is also need to align matching mark.**
  - **a. Idle gear 2 (2) and idle gear 3 [A]**
  - **b. Idle gear 1 (3) and idle gear 3 [B]**

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



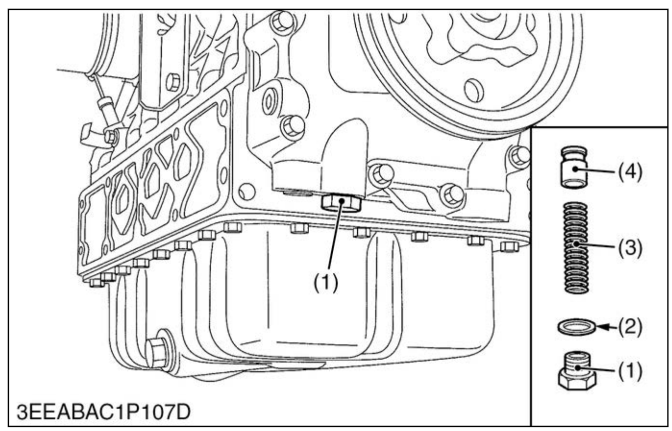


(2) Idle gear 2
(3) Idle gear 1
(4) Cam gear
(5) Crank gear
[A] V3800-TIEF4
[B] V3800-TIEF4C

6.19 Installing relief valve

1. Install the relief valve (4), the spring (3) and packing (2).
2. Install the relief valve retaining plug (1) tighten to specified torque.

Tightening torque	Relief valve retaining plug (1)	95.2 to 108 N·m 9.70 to 11.1 kgf·m 70.2 to 80.2 lbf·ft



(1) Relief valve retaining plug
(2) Packing
(3) Spring
(4) Relief valve

6.20 Installing gear case cover

■ NOTE
- **In order to keep an airtight seal, check and make sure there is no water, debris, or oil on the surface where the liquid gasket will be applied.**
- **When the gear case is replaced, check the air gap of the crankshaft position sensor.**
- **When the gear case is replaced, it is necessary to calibrate the injection timing with the diagnosis tool.**

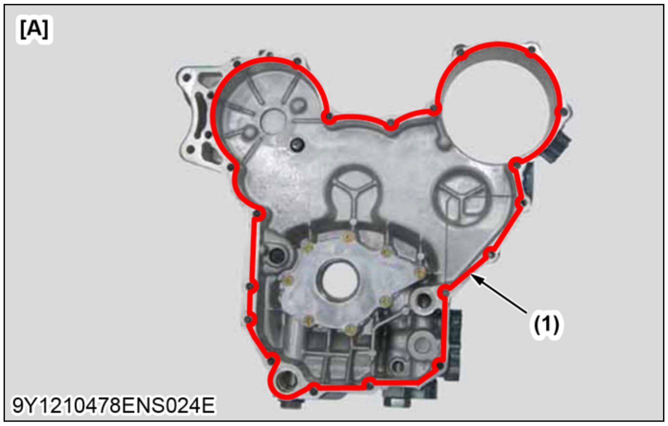
- **If disassemble oil pump cover, tighten the oil pump cover screw to the specified torque.**

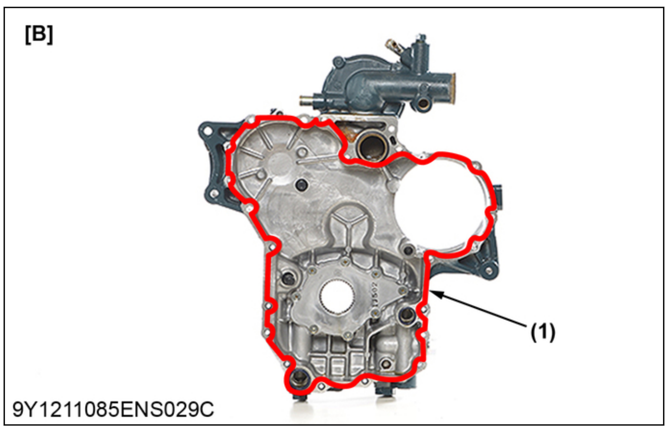
Tightening torque	Oil pump cover screw	7.9 to 9.3 N·m 0.80 to 0.95 kgf·m 5.8to 6.8 lbf·ft

Tools required

- Liquid gasket (Three Bond 1217H)

1. Apply the liquid gasket (1) to the gear case cover (2).
   - Make sure the surfaces align when mounting parts with a liquid gasket applied to them.
   - Be careful to apply the liquid gasket evenly.

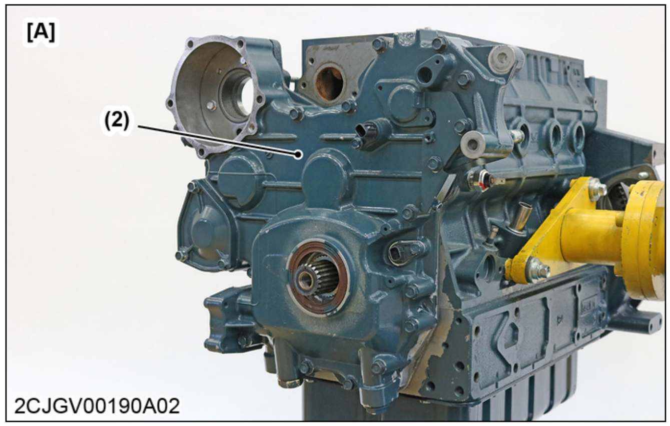


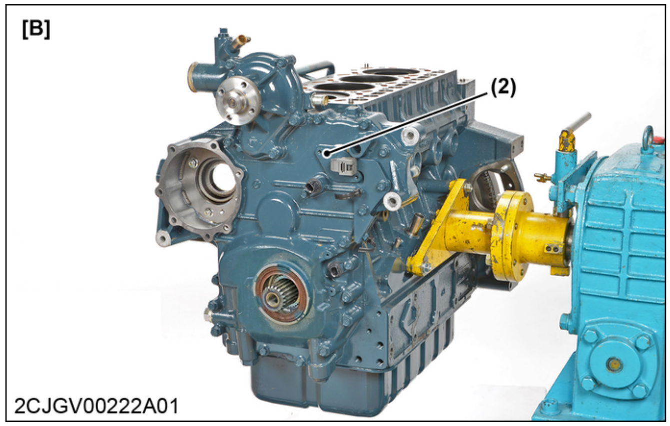


(1) Liquid gasket
[A] V3800-TIEF4
[B] V3800-TIEF4C

2. Install the gear case cover (2) tighten to specified torque.
   - Mount parts with a liquid gasket within 10 minutes of application.
   - Apply oil to the lip of oil seal.

Tightening torque	Gear case cover mounting screw	33 to 36 N·m 3.3 to 3.7 kgf·m 24 to 26 lbf·ft





(2) Gear case cover
[A] V3800-TIEF4
[B] V3800-TIEF4C

RELATED PAGE

4.34 Adjusting crankshaft position sensor air gap on page 3-118

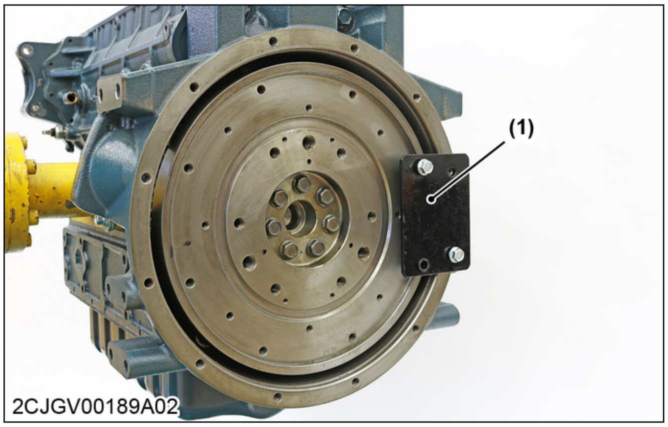
4.37 Measuring angular deviation between crankshaft T.D.C. and crank position sensor detected T.D.C. on page 3-121

6.21 Installing fan drive pulley

Tools required

- Flywheel stopper

1. Mount the flywheel stopper (1) on the flywheel.



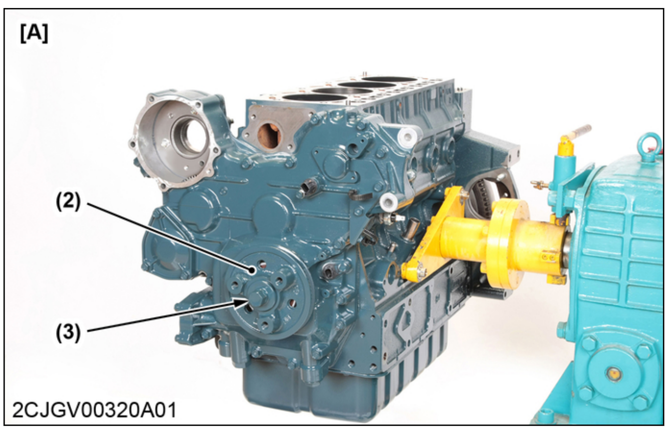
(1) Flywheel stopper

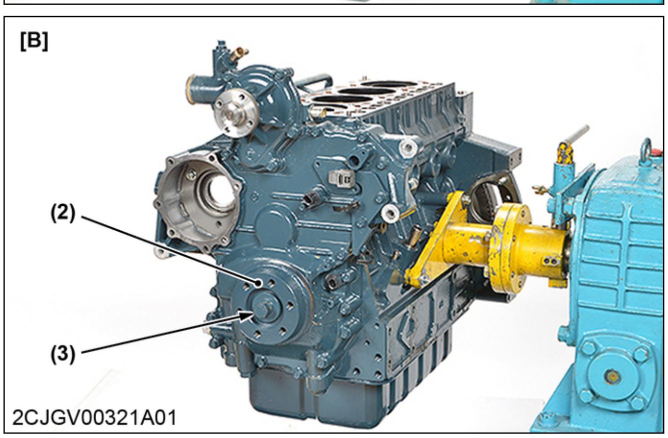
2. Install the fan drive pulley (2).
3. Install the crankshaft screw (3) and tighten to specified torque.

■ **NOTE**

- **Apply the engine oil to the crankshaft screw.**

Tightening torque	Crankshaft screw (3)	255 to 274 N·m 26.0 to 28.0 kgf·m 188 to 202 lbf·ft



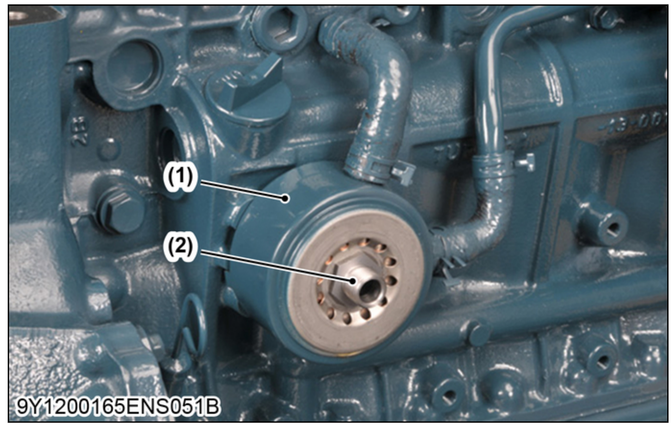


(2) Fan drive pulley
(3) Crankshaft screw
[A] V3800-TIEF4
[B] V3800-TIEF4C

6.22 Installing oil cooler

1. Install the oil cooler (1).
2. Install the oil cooler joint screw (2) and tighten to the specified tightening torque.

Tightening torque	Oil cooler joint screw (2)	40 to 44 N·m 4.0 to 4.5 kgf·m 29 to 32 lbf·ft



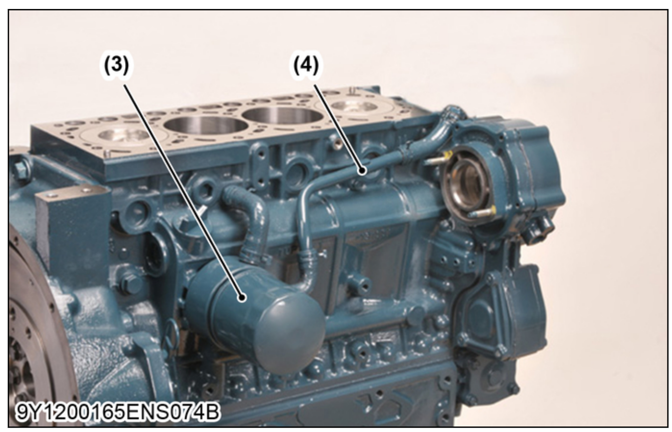
(1) Oil cooler
(2) Oil cooler joint screw

3. Tight the oil filter cartridge (3) by hand.

■ **NOTE**

- **Apply the engine oil to O-ring of oil filter cartridge (3).**

4. Install the water pipe (4).



(3) Oil filter cartridge
(4) Water pipe

6.23 Installing water pump

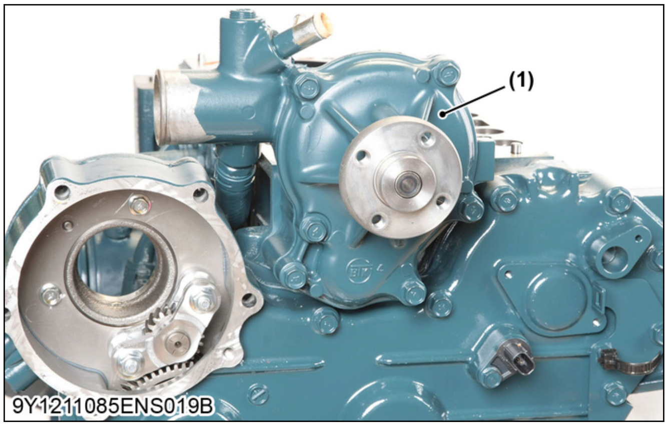
■ **NOTE**

- **This work is only for V3800-TIEF4 model.**

1. Install the water pump (1).

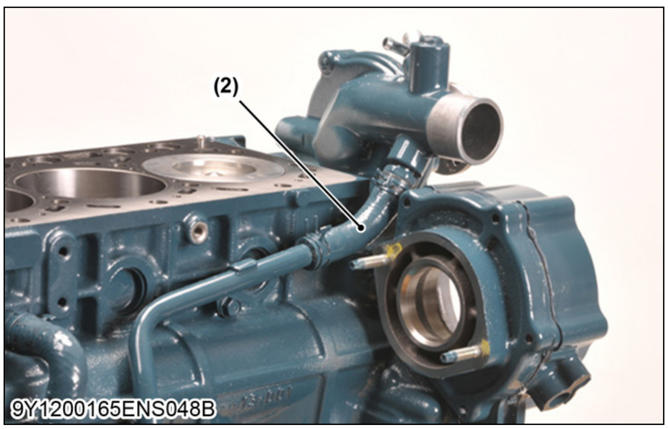
■ **NOTE**

- **Take care not to forget mounting the O-ring and not to let it out of position.**



(1) Water pump

2. Install the water pipe (2).



(2) Water pipe

6.24 Installing supply pump

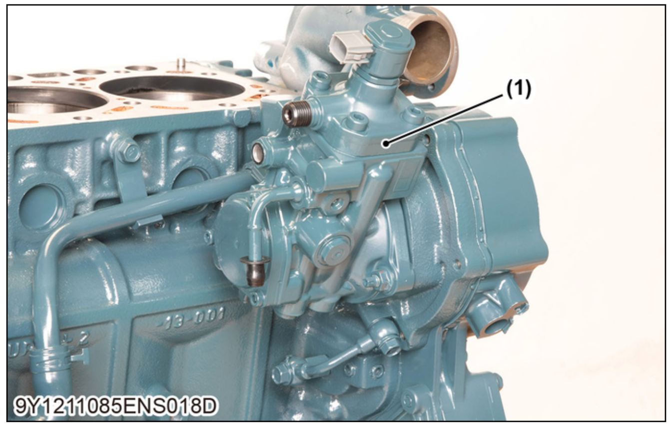
■ **NOTE**

- **Do not disassemble the supply pump.**
- **Replace the O-ring of the supply pump with a new one.**
- **Replace the supply pump gear cover gasket with a new one.**
- **When replacing the supply pump with a new one, use the diagnosis tool to conduct learning of discrepancies in the new supply pump.**

Tools required

- Supply pump gear reinstall jig
- Flywheel stopper

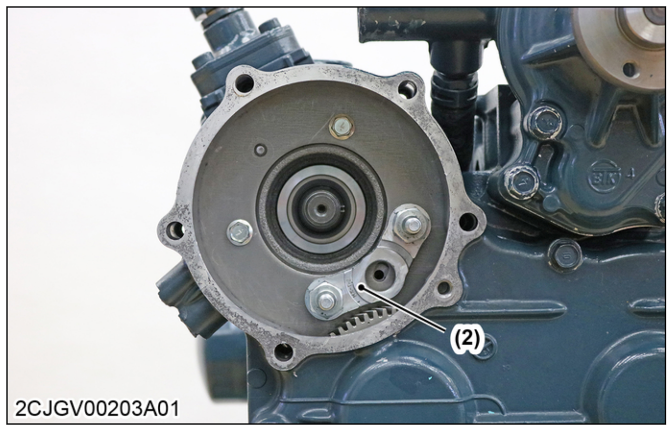
1. Install the supply pump (1).



(1) Supply pump

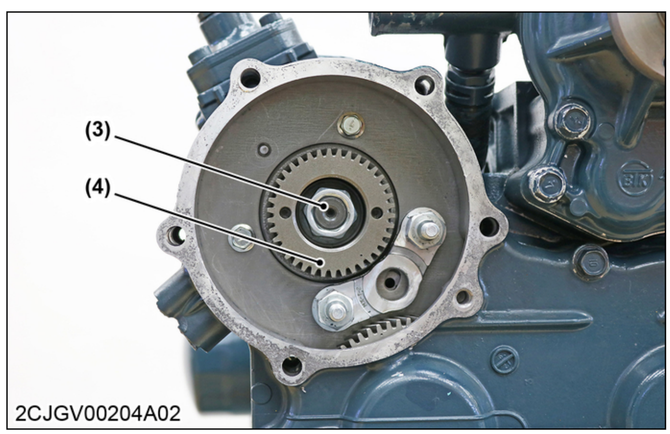
2. Install idle gear 3 base holder (2).

Tightening torque	Idle gear 3 base holder mounting screw	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft



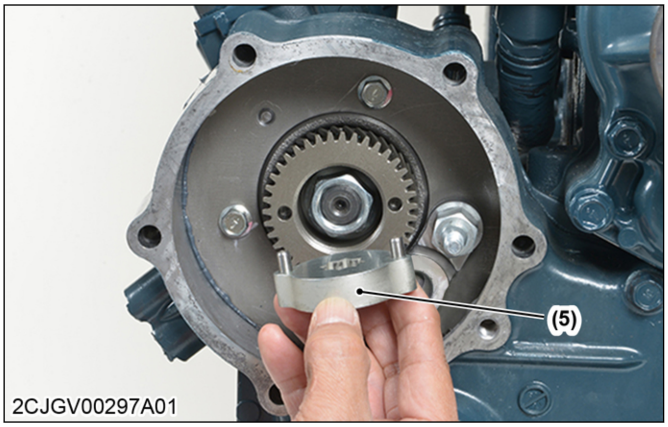
(2) Idle gear 3 base holder

3. Install the supply pump gear (4) and tight the supply pump gear mounting nut (3) loosely.



(3) Supply pump gear mounting nut (4) Supply pump gear

4. Set the supply pump gear reinstalling jig (5).

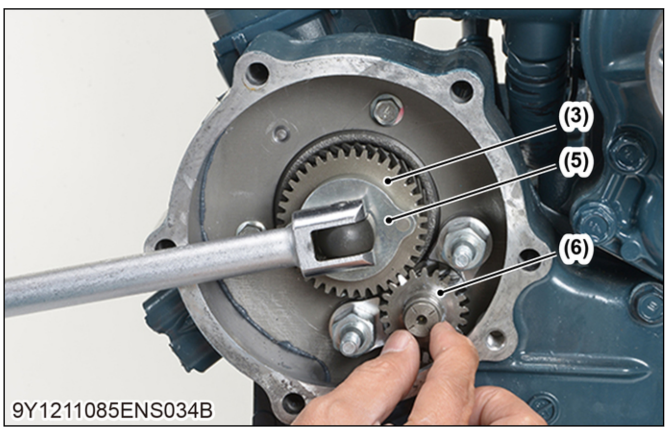


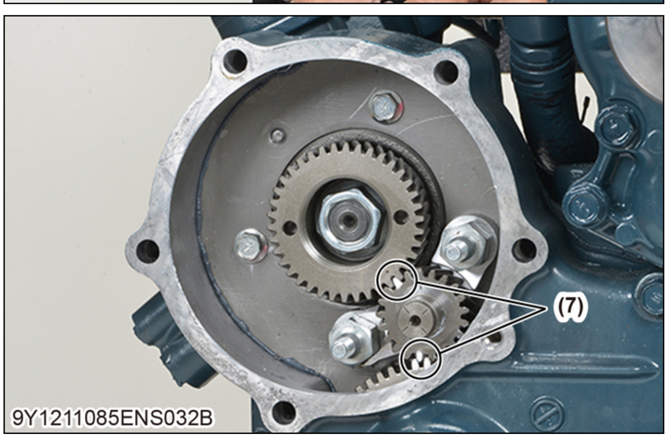
(5) Supply pump gear reinstall jig

5. Turn the supply pump gear (4) clockwise and counterclockwise until being able to install the idle gear 3 (6).

IMPORTANT

- **Align the alignment mark or temporary mark (7) of supply pump gear (4), idle gear3 and idle gear 1 or idle gear 2.**

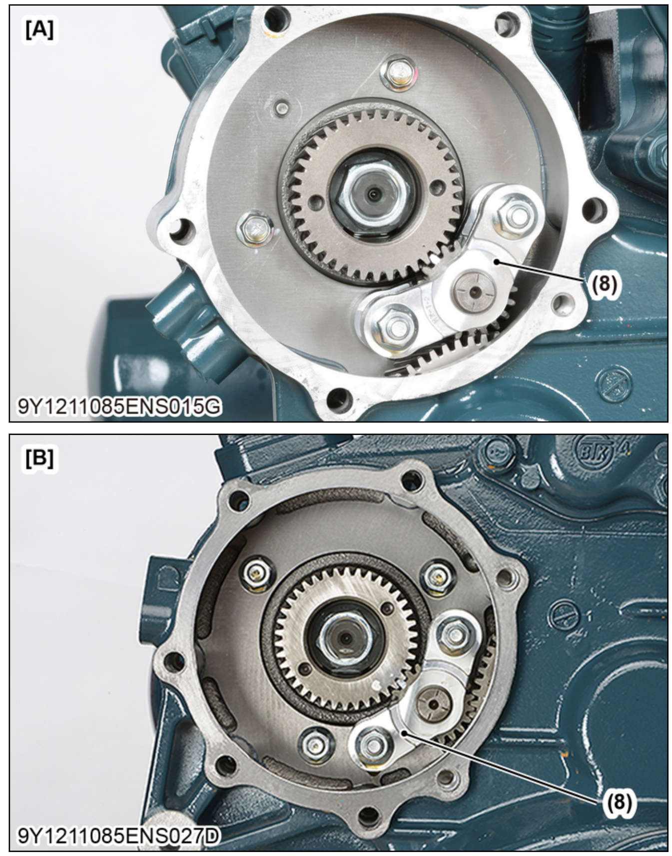




(3) Supply pump gear mounting nut
(5) Supply pump gear reinstall jig
(6) Idle gear 3
(7) Temporary mark

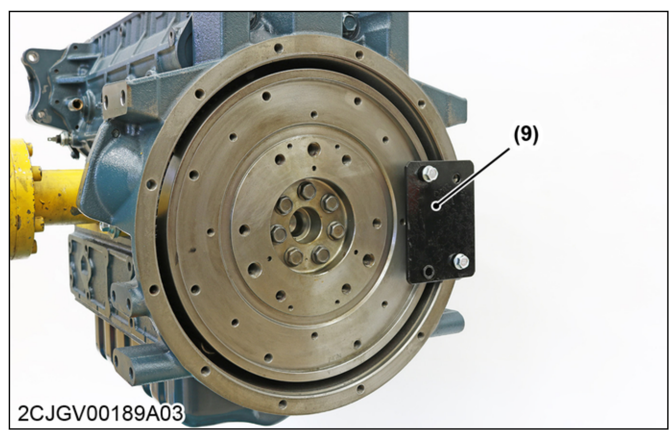
6. Install the idle gear 3 upper holder (8).

Tightening torque	Idle gear 3 upper holder mounting screw	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft



(8) Idle gear 3 upper holder
[A] V3800-TIEF4
[B] V3800-TIEF4C

7. Fix the flywheel with flywheel stopper (9).



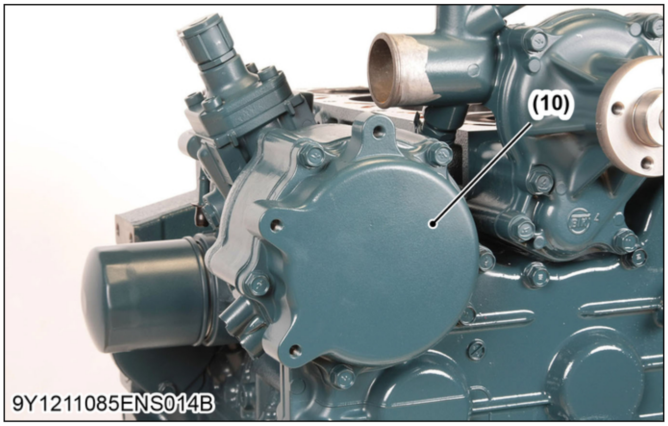
(9) Flywheel stopper

8. Tighten the supply pump gear mounting nut (3) to specified torque.

   ■ NOTE
   - **After tightening the supply pump gear mounting nut (3), remove the flywheel stopper (9).**

Tightening torque	Supply pump gear mounting nut (3)	128 to 147 N·m 13.0 to 15.0 kgf·m 94.1 to 108 lbf·ft

9. Install the supply pump gear cover (10).



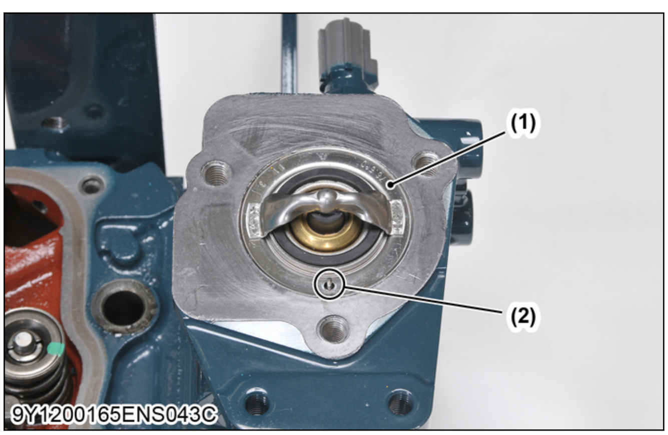
(10) Supply pump gear cover

6.25 Installing thermostat assembly

■ NOTE
- **Replace the gasket with a new one.**

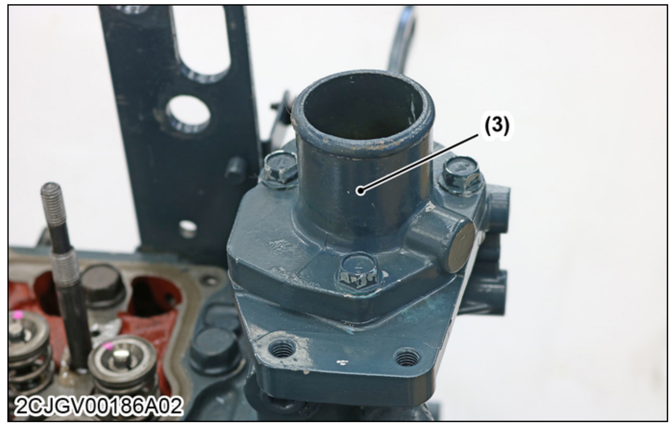
Tools required
- Liquid gasket (Three Bond 1217H)

1. Install the thermostat assembly (1) with jiggle valve (2) facing toward the intake manifold side.



(1) Thermostat assembly (2) Jiggle valve

2. Apply the liquid gasket to only at the thermostat cover side of the gasket.
3. Install the thermostat cover (3).



(3) Thermostat cover

6.26 Installing valve

■ NOTE
- **Clean the valve stem and valve guide hole.**

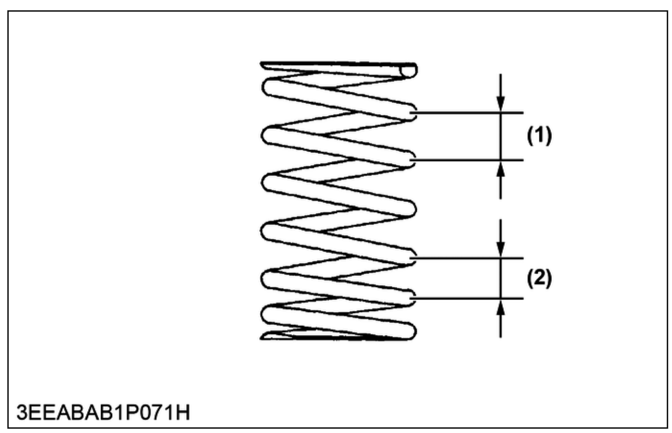
Tools required
- Valve spring compressor

1. Install the valve stem seal (4).

   ■ NOTE
   - **Apply the engine oil sufficiently.**

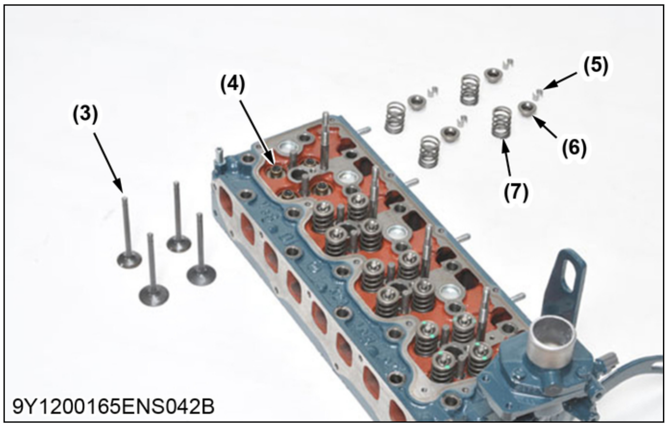
2. Install the valve (3).
3. Set the valve spring (7) and valve spring retainer (6).

   ■ NOTE
   - **Install the valve spring with its small pitch (2) end downward (at the head side).**



(1) Large pitch (2) Small pitch

4. Compress the valve spring with valve spring compressor and install the valve spring collet (5).



(3) Valve
(4) Valve stem seal
(5) Valve spring collet
(6) Valve spring retainer
(7) Valve spring

5. Remove the valve spring compressor.
6. After installing the valve spring collets (5), lightly tap the stem tip to attach it correctly with the plastic hammer.

6.27 Installing tappet

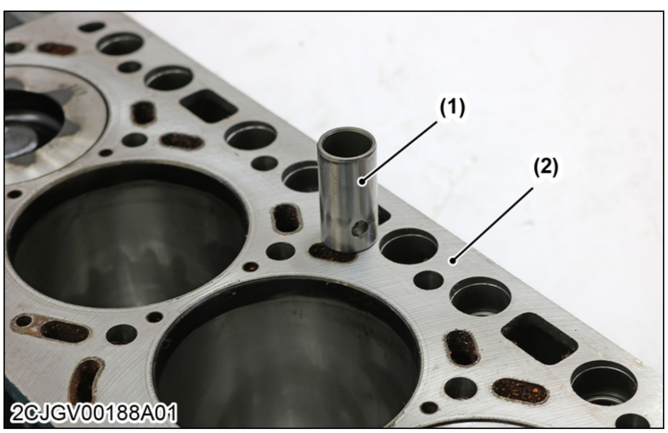
■ **IMPORTANT**

- **Do not change the combination of cylinder number and tappet.**

■ **NOTE**

- **Apply engine oil thinly around tappets.**

1. Install the tappets (1) to the crankcase (2).



(1) Tappet
(2) Crankcase

6.28 Installing cylinder head

■ **IMPORTANT**

- **When replacing the piston, piston pin bushing, connecting rod or crank pin bearing, select the cylinder head gasket (2) thickness to meet with the top clearance refer to the "Selecting cylinder head gasket".**

■ **NOTE**

- **Replace the cylinder head gasket (2) with a new one.**
- **The cylinder head (1) should be free of scratches and dust.**
- **It is not necessary to retighten the cylinder head mounting screw after operating the engine for 30 minutes.**

1. Install the cylinder head gasket (2).

■ **NOTE**

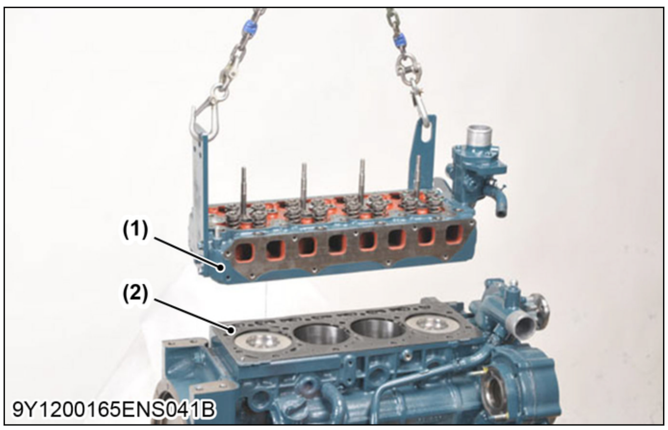
- **When installing the gasket, set it to the knock pin hole. Take care not to mount it reversely.**
- **Take care for handling the gasket not to damage it.**

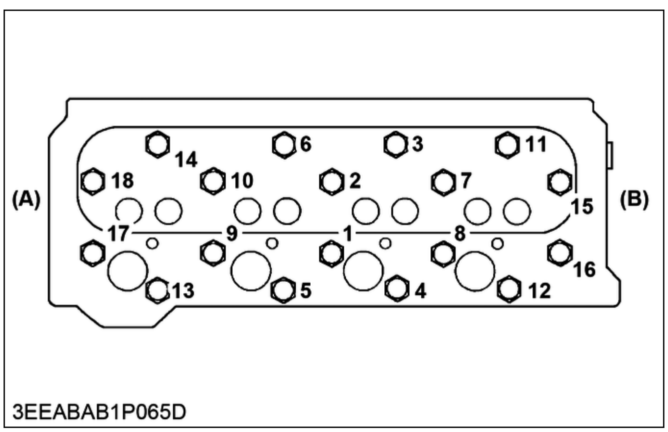
2. Install the cylinder head (1) and tighten to the specified torque.

■ **NOTE**

- **If reuse the cylinder head mounting screw, apply the engine oil.**
  If use new cylinder head mounting screw, do not need to apply the engine oil.
- **Tighten the cylinder head mounting screw gradually in the sequence of 1 to 18.**

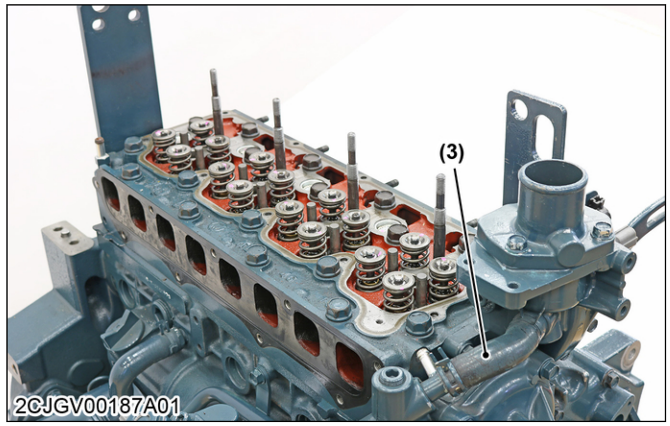
Tightening torque	Cylinder head mounting screw	V3800-TIEF4 V3800-TIEF4C	98.1 to 107 N·m 10.0 to 11.0 kgf·m 72.4 to 79.5 lbf·ft
Tightening torque	Cylinder head mounting screw	V3800-TIEF4H	120 to 130 N·m 12.3 to 13.2 kgf·m 88.5 to 95.8 lbf·ft





(1) Cylinder head
(2) Cylinder head gasket
(A) Flywheel side
(B) Gear case side

3. Connect the water return hose (3).



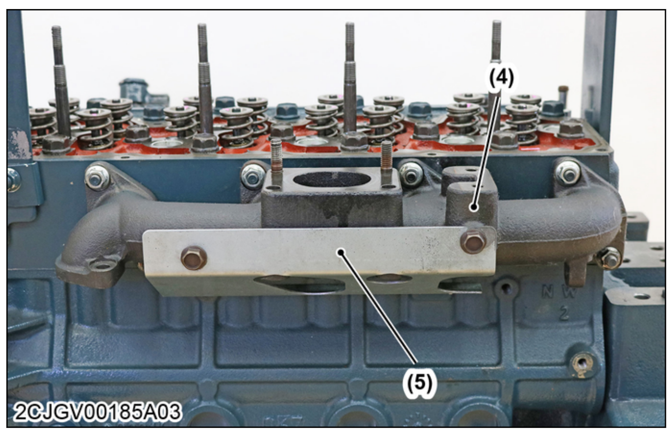
(3) Water return hose

4. Install the exhaust manifold (4) and cover (5) and tight to the specified torque.

■ **NOTE**

- **Replace the exhaust manifold gasket with a new one.**

Tightening torque	Exhaust manifold mounting nut	30 to 34 N·m 3.0 to 3.5 kgf·m 22 to 25 lbf·ft
Tightening torque	Exhaust manifold mounting screw	30 to 34 N·m 3.0 to 3.5 kgf·m 22 to 25 lbf·ft



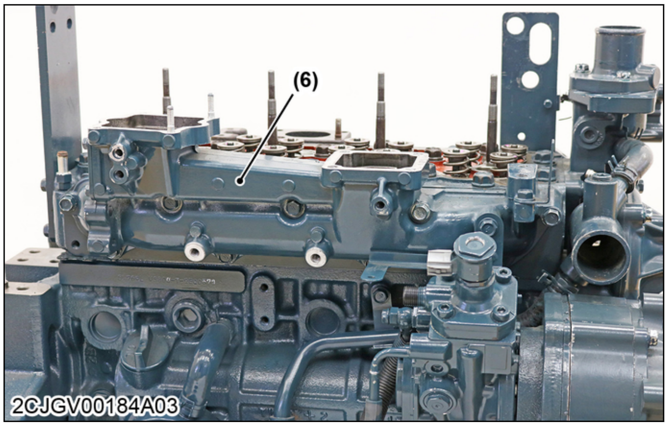
(4) Exhaust manifold
(5) Cover

5. Install the intake manifold (6).

■ **NOTE**

- **Replace the intake manifold gasket with a new one.**

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



(6) Intake manifold

— RELATED PAGE —

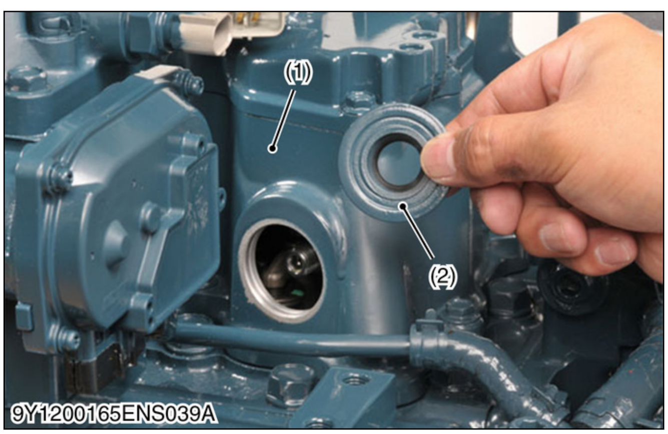
4.36 Selecting cylinder head gasket on page 3-120

6.29 Installing injector oil seal

■ **NOTE**

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

1. Install the injector oil seal (2) to the cylinder head cover 1 (1).



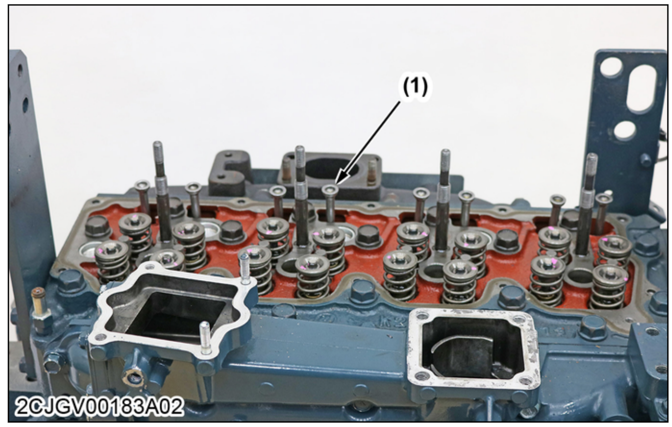
(1) Cylinder head cover 1 (2) Injector oil seal

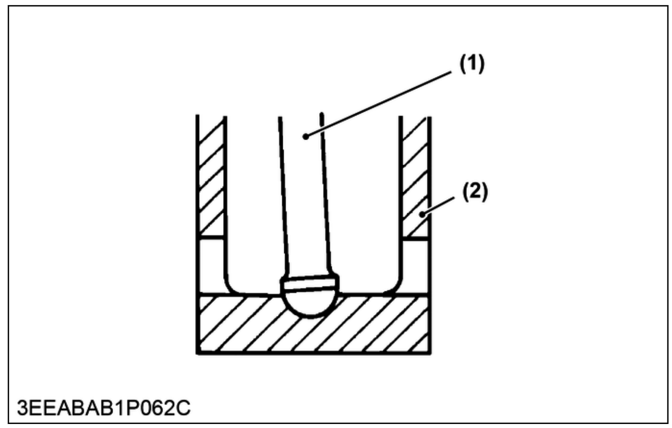
6.30 Installing rocker arm assembly

1. Install the push rod (1).

■ **NOTE**

- **When installing the push rod (1), mount it securely in the groove of the tappet (2).**

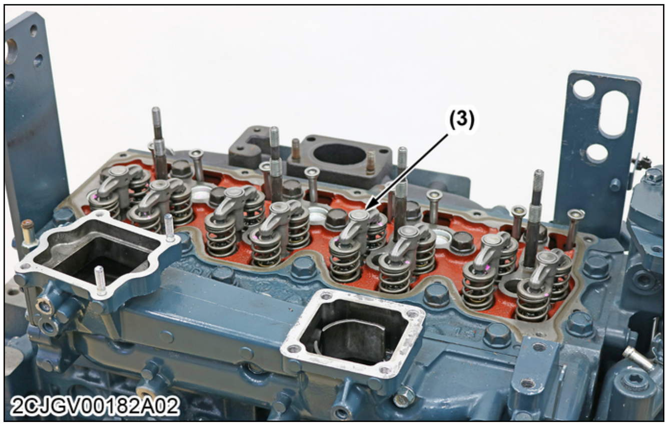


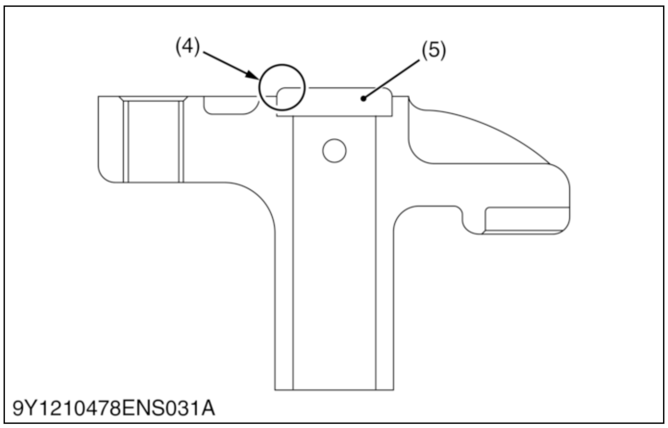


(1) Push rod (2) Tappet

2. Install the valve bridge arm (3).

■ **NOTE**
- **Face the pad (5) R face (4) up and install it on the valve bridge arm (3).**





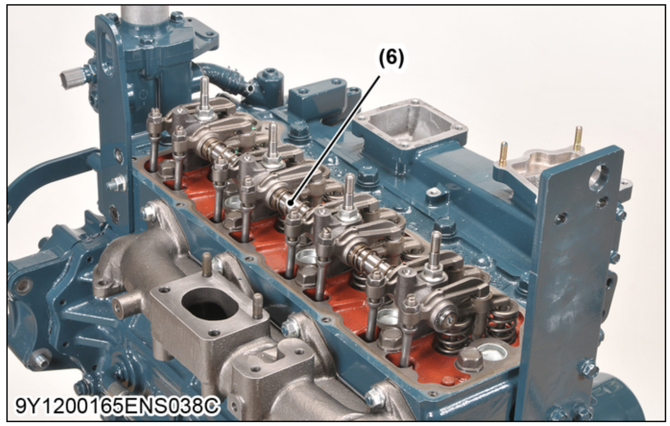
(3) Valve bridge arm
(4) R face
(5) Pad

3. Install the rocker arm assembly (6) and tighten the rocker arm bracket nut to the specified torque.

■ **IMPORTANT**
- **Apply the engine oil to the rocker arm bracket nut.**
- **After installing the rocker arm assembly, 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

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

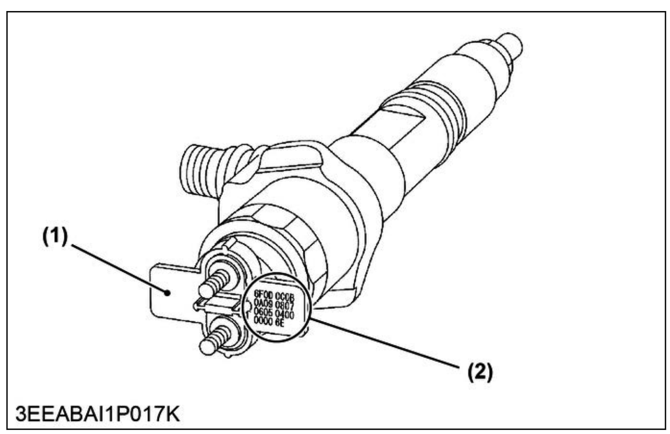


(6) Rocker arm assembly

RELATED PAGE
4.2 Adjusting valve clearance on page 3-102

6.31 Installing injector

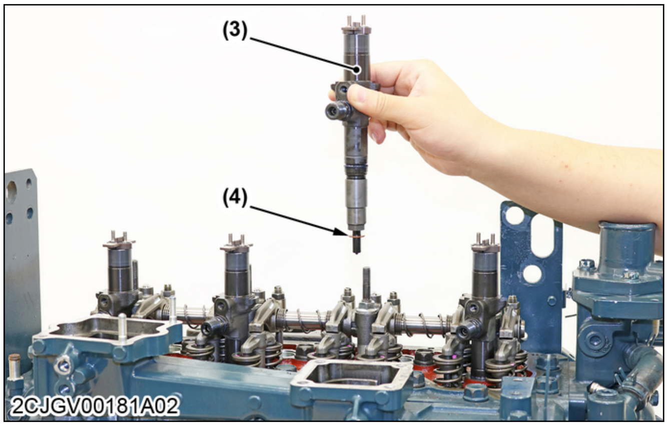
■ **IMPORTANT**
- **Do not disassemble the injector.**
- **Do not remove and damage the injector QR code tag (1).**
- **Do not lose the ball of the rocker arm bracket.**
- **Do not get the injectors out of order.**
  If the injectors get out of order, it is necessary to perform injector correction (writing the injector ID codes (2) to the ECU).
- **Store the injectors so they do not get any dust in them.**
- **If replace the injectors, it is necessary to perform injector correction (writing the injector ID codes (2) to the ECU).**



(1) Injector QR code tag
(2) Injector ID code

1. Install the injector (3) and its gasket (4).

■ **NOTE**
- **Replace the injectors' gaskets (4) with new ones.**

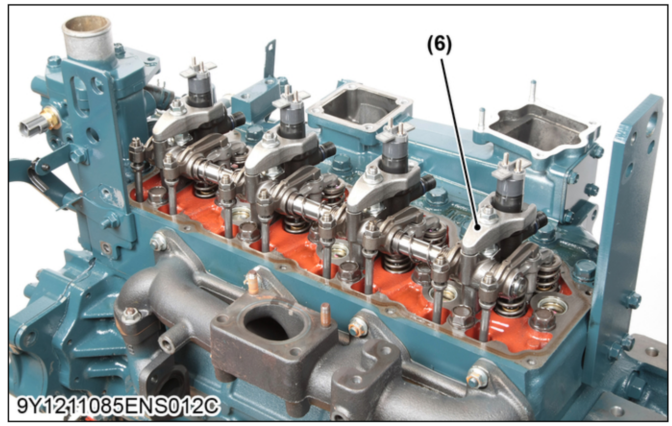


(3) Injector (4) Gasket

2. Install the injector clamp (6) and tighten to the specified torque.

■ **NOTE**
- **When installing injector clamps (6), check and make sure the ball (5) is in the rocker arm bracket.**

Tightening torque	Injector clamp nut	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft

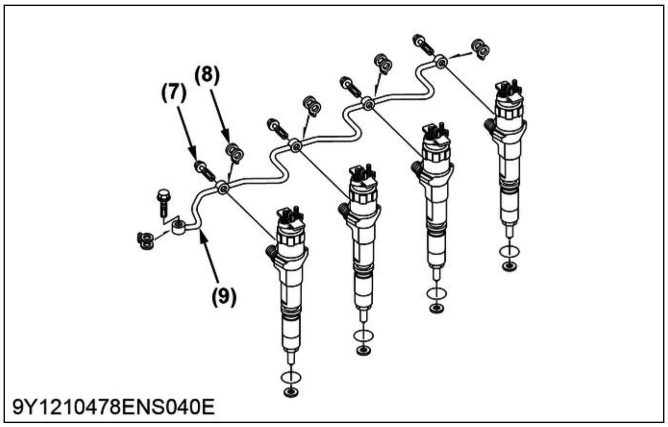


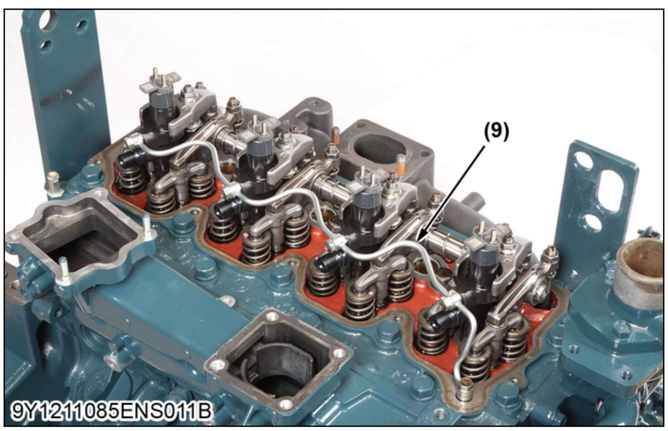
(5) Ball (6) Injector clamp

3. Install the overflow pipe (9) and tighten the overflow pipe joint screw (7) to the specified torque.

■ **NOTE**
- **Replace the injectors' gaskets (8) with new ones.**
- **After installing the overflow pipe (9), in order to check the fuel leakage, add pressure by air from the fuel pipe joint.**
  Check the fuel leakage of overflow pipe (9) and gasket (8).
- **In case there is fuel leakage, replace the gasket (8), then check the fuel leakage again.**

Tightening torque	Overflow pipe joint screw (7)	9.81 to 11.2 N·m 1.00 to 1.15 kgf·m 7.24 to 8.31 lbf·ft





(7) Overflow pipe joint screw
(8) Gasket
(9) Overflow pipe

RELATED PAGE
7.55 Replacing injector on page 3-212
4.35 Checking fuel leakage of the overflow pipe on page 3-120

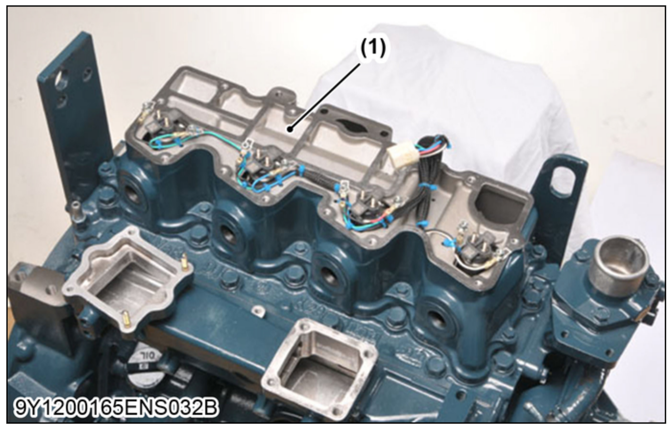
6.32 Installing cylinder head cover

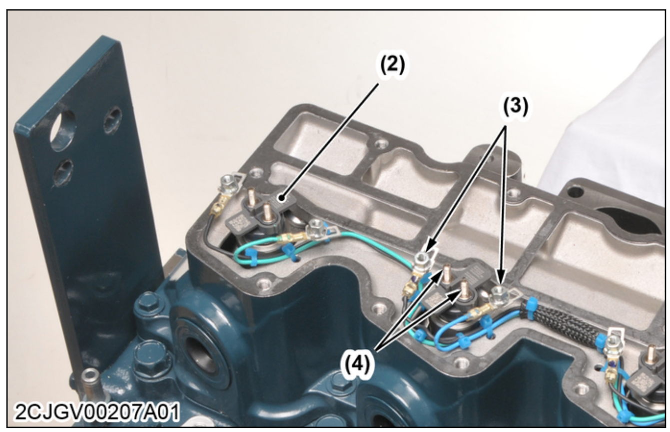
■ **NOTE**
- **Replace the gasket with a new one.**

1. Install the cylinder head cover 1 (1) and tighten to the specified torque.
2. Connect the injector lead (3) to the injector terminal (4) and tighten to the specified torque.

■ **NOTE**
- **Do not damage injector QR code tags (2) when installing cylinder head cover 1 (1).**

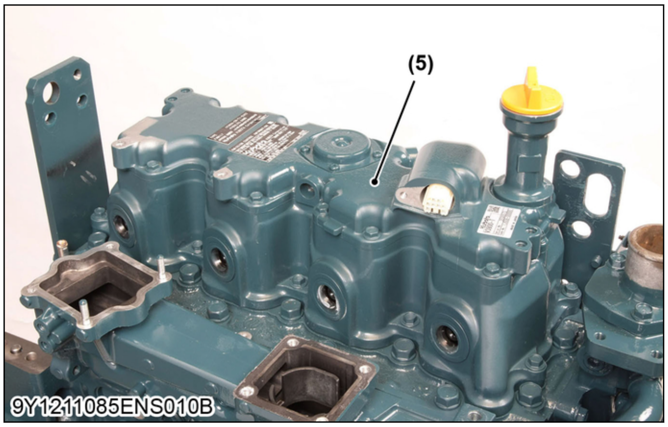
Tightening torque	Cylinder head cover 1 screw	6.87 to 11.2 N·m 0.700 to 1.15 kgf·m 5.07 to 8.31 lbf·ft
	Injector terminal nut	1.6 to 2.2 N·m 0.16 to 0.23 kgf·m 1.2 to 1.6 lbf·ft





(1) Cylinder head cover 1
(2) Injector QR code tag
(3) Injector lead
(4) Injector terminal

3. Install the cylinder head cover 2 (5) and tighten to the specified torque.



(5) Cylinder head cover 2

6.33 Installing sensors

■ **IMPORTANT**

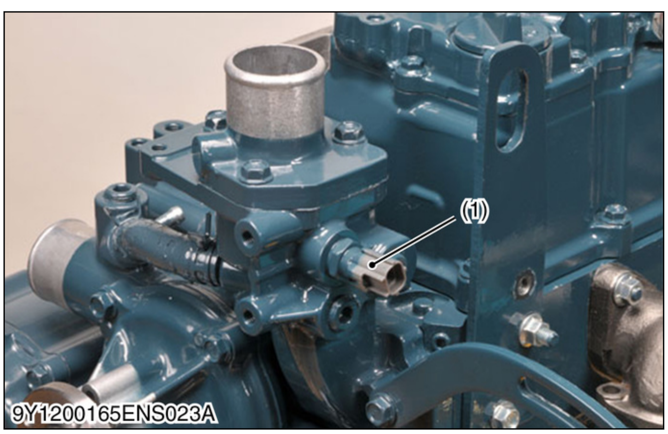
- **If you drop the sensor, do not reuse it.**

■ **NOTE**

- **Replace the gasket with a new one.**
- **Replace the O-ring with a new one.**
- **If the hose is damaged, replace it with a new one.**

1. Install the coolant temperature sensor (1) and tighten to the specified torque.

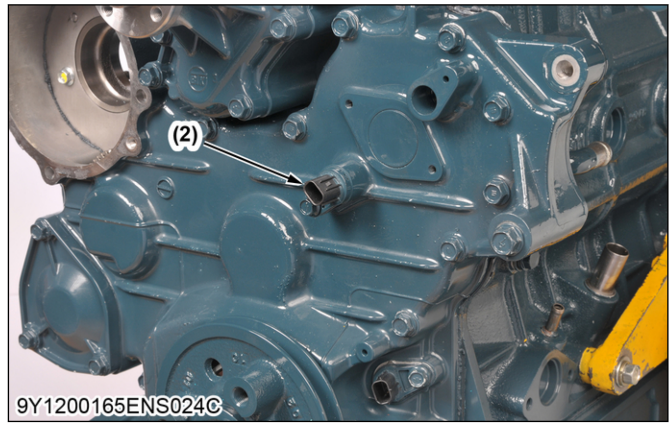
Tightening torque	Coolant temperature sensor (1)	16 to 23 N·m 1.6 to 2.4 kgf·m 12 to 17 lbf·ft



(1) Coolant temperature sensor

2. Install the camshaft position sensor (2).
3. Tighten the camshaft position sensor mounting screw to the specified torque.

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



(2) Camshaft position sensor

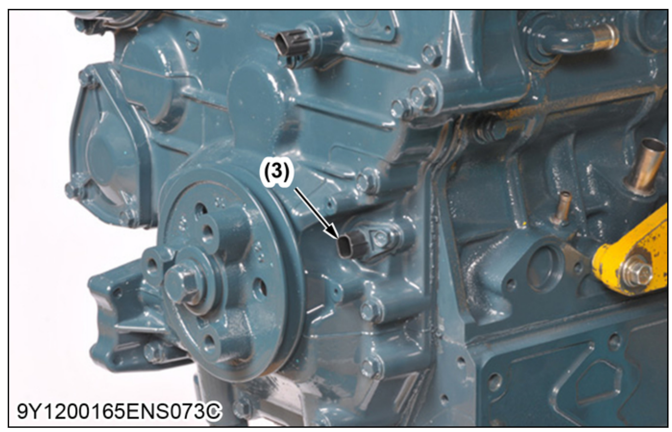
4. Install the crankshaft position sensor (3).

■ **IMPORTANT**

- **If the crankshaft position sensor (3), gear case and/or pulsar gear are replaced, use a combination of shims to adjust the sensor's air gap.**

5. Tighten the crankshaft position sensor mounting screw to the specified torque.

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



(3) Crankshaft position sensor

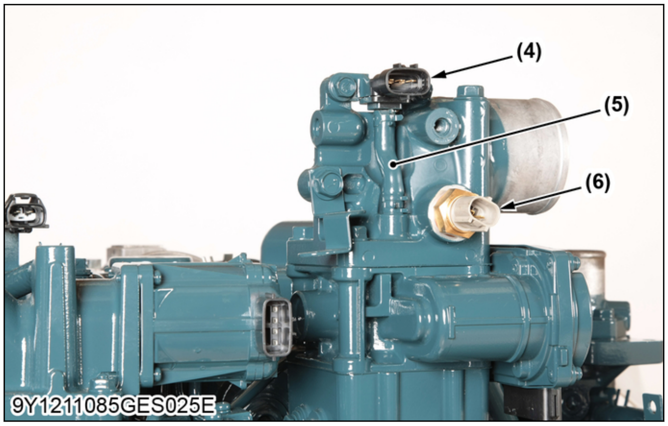
6. Install the intake air temperature sensor (6) and tighten to the specified torque.

Tightening torque	Intake air temperature sensor (6)	30 to 39 N·m 3.0 to 4.0 kgf·m 22 to 28 lbf·ft

7. Install the boost sensor (4) and the hose (5).

8. Tighten the boost sensor mounting screw to the specified torque.

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



(4) Boost sensor
(5) Hose
(6) Intake air temperature sensor

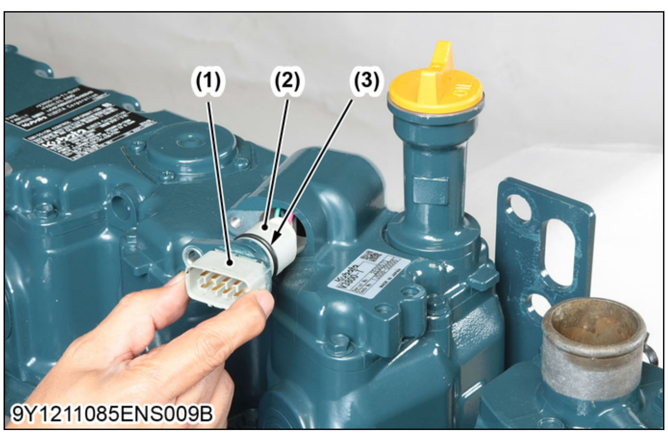
RELATED PAGE
4.34 Adjusting crankshaft position sensor air gap on page 3-118

6.34 Installing injector harness connector

NOTE

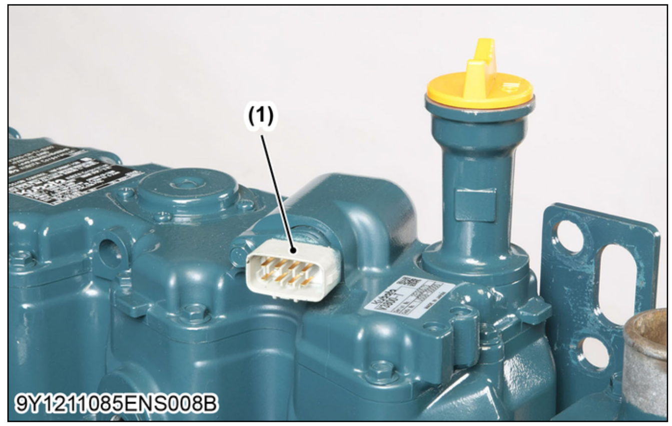
- **If the O-ring (3) is damaged, replace the injector harness connector (1).**

1. Connect the injector harness connector (1) to injector harness (2).



(1) Injector harness connector
(2) Injector harness
(3) O-ring

2. Install the injector harness connector (1).



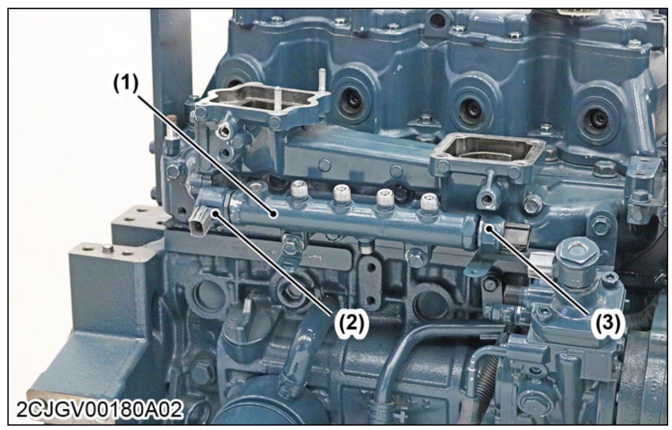
(1) Injector harness connector

6.35 Installing common rail

IMPORTANT

- **Replace the rail assembly, if the exchange of the pressure relief valve (2) or the rail pressure sensor (3) is necessary.**

1. Install the common rail (1).

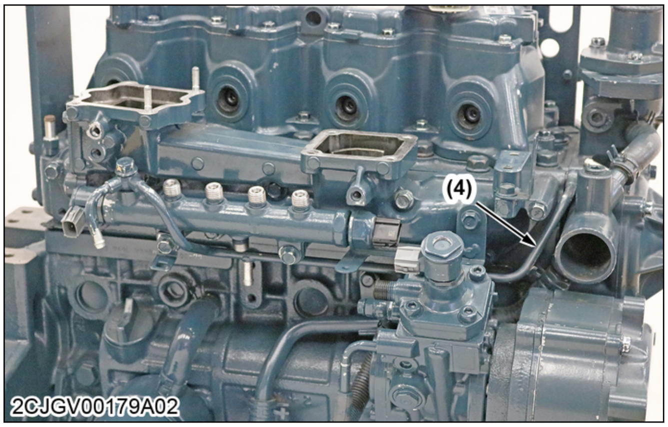


(1) Common rail
(2) Pressure relief valve
(3) Rail pressure sensor

2. Install the overflow pipe (4).

3. Tighten the overflow pipe joint screw to the specified torque.

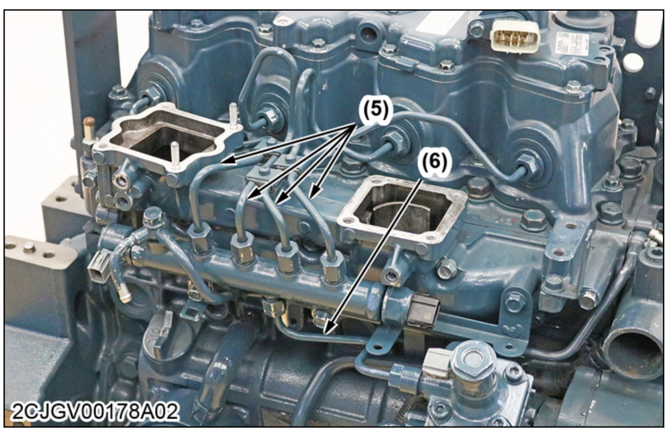
Tightening torque	Overflow pipe joint screw (M8)	16 to 19 N·m 1.6 to 2.0 kgf·m 12 to 14 lbf·ft
	Overflow pipe joint screw (M10)	7.9 to 12 N·m 0.80 to 1.3 kgf·m 5.8 to 9.4 lbf·ft



(4) Overflow pipe

4. Install the injection pipes (5) (6).
5. Tighten the injection pipe retaining nut to the specified torque.

Tightening torque	Injection pipe retaining nut	23 to 36 N·m 2.3 to 3.7 kgf·m 17 to 26 lbf·ft



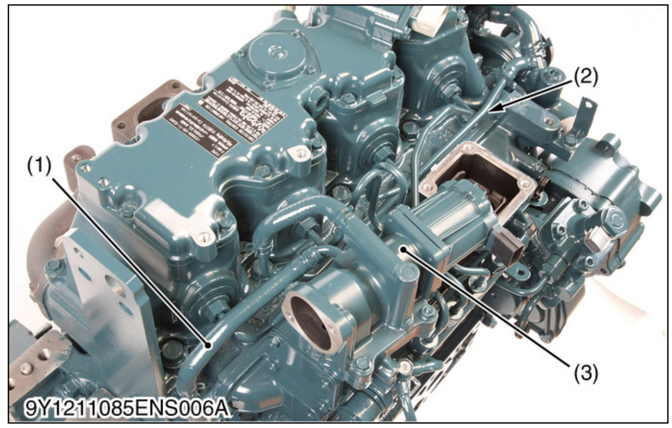
(5) Injection pipe (6) Injection pipe

6.36 Installing EGR valve

NOTE
- **Do not disassemble the EGR valve assembly.**
- **Replace the gaskets with new ones.**

1. Install the EGR valve (3).
2. Connect the cooler pipe (1) (2) of EGR valve (3).

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



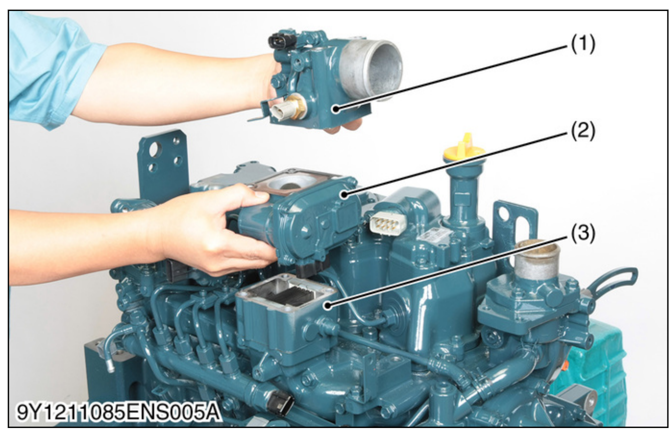
(1) Cooler pipe
(2) Cooler pipe
(3) EGR valve

6.37 Installing intake throttle valve and intake air heater

NOTE
- **Do not disassemble the intake throttle valve (2).**
- **Replace the gaskets with new ones.**

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

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



(1) Air cleaner flange
(2) Intake throttle valve
(3) Intake air heater

6.38 Installing turbocharger assembly

■ **NOTE**

- **After you replace the turbocharger assembly (1), fill clean engine oil through the oil filler port of the turbocharger.**
- **Before you start the engine, make sure that the air cleaner is in the correct position.**
- **Replace the gaskets with new ones.**

1. Install turbocharger assembly (1).

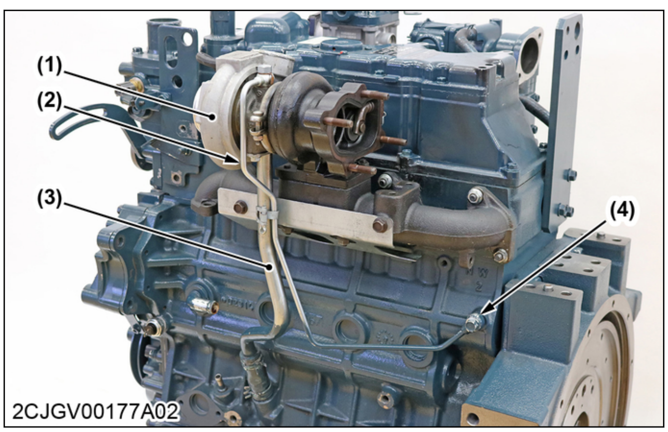
   ■ **NOTE**

   - **Do not let dust, dirt and other unwanted materials in the oil pipes.**
   - **Fill clean engine oil through the oil filler port of the turbocharger.**

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

2. Connect the return pipe (3) and oil pipe (2).
3. Tighten the oil pipe joint screw (4) to the specified torque.

Tightening torque	Oil pipe joint screw (4)	16 to 19 N·m 1.6 to 2.0 kgf·m 12 to 14 lbf·ft



(1) Turbocharger assembly
(2) Oil pipe
(3) Return pipe
(4) Oil pipe joint screw

6.39 Installing EGR cooler

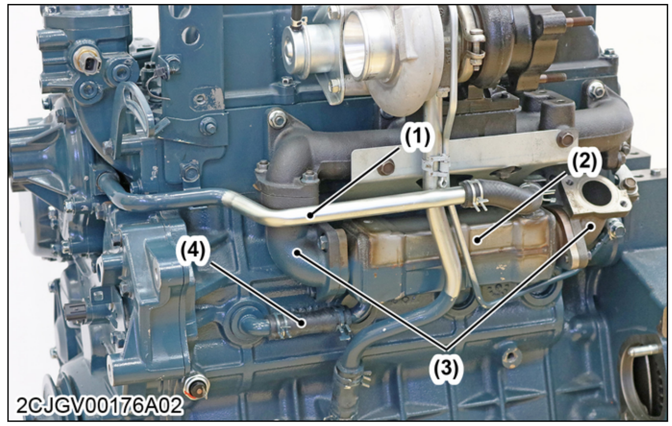
■ **NOTE**

- **Replace the gaskets with new ones.**

1. Install the EGR cooler (2), the EGR cooler flange (3).

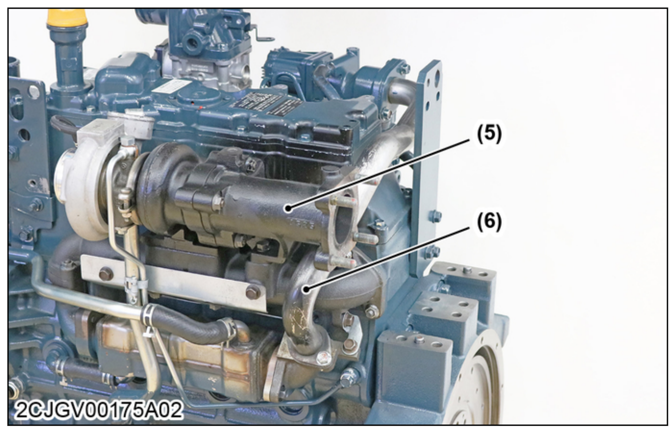
Tightening torque	EGR cooler flange (3)	30 to 34 N·m 3.0 to 3.5 kgf·m 22 to 25 lbf·ft

2. Install the EGR cooler pipe (1).
3. Connect the EGR cooler hose (4).



(1) EGR cooler pipe
(2) EGR cooler
(3) EGR cooler flange
(4) EGR cooler hose

4. Install the EGR pipe (6).
5. Install the muffler flange (5).



(5) Muffler flange
(6) EGR pipe

6.40 Assembling DPF assembly

■ **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.**

■ **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.**
- **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.**
- **When installing 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.**
- **Replace the gasket with a new one.**
- **If the differential pressure tube is damaged or cracked, replace it.**
- **When replacing the differential pressure pipe, 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.**

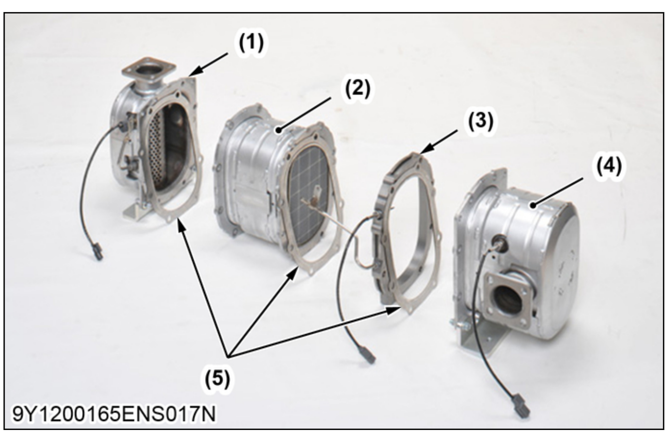
Tools required

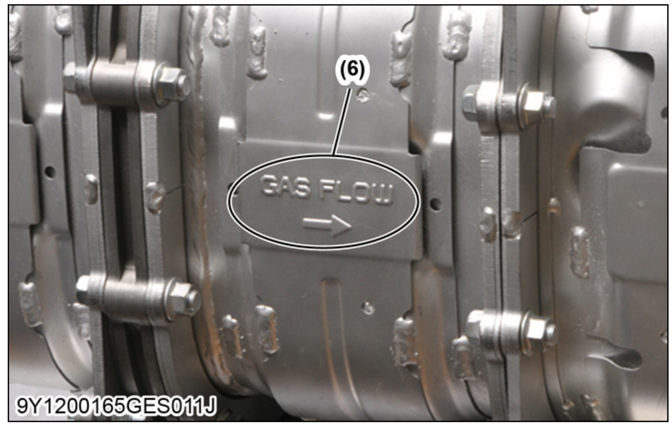
- Crowfoot wrench

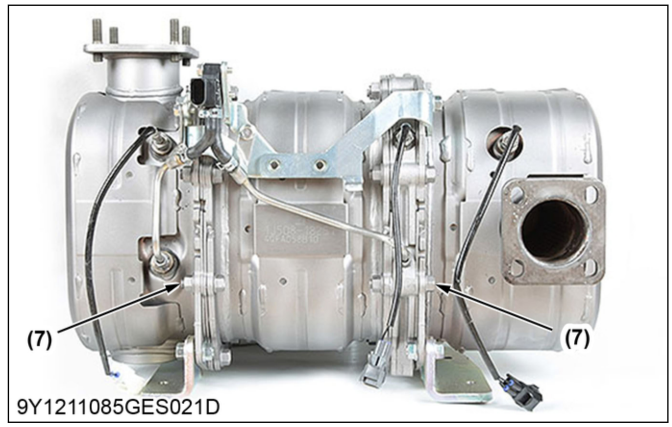
1. Assemble the body (DPF outlet) (1), filter comp (DPF) (2) and catalyst (DOC) (4) and loosely tighten the filter comp (DPF) mounting screw (7).

■ NOTE

- **Assemble the filter comp (DPF) (2) in the correct direction by referring the mark [GAS FLOW→] (6) (Catalyst (DOC) (4) to Body (DPF Outlet) (1)) on the side showing the flow of exhaust gas.**
- **Replace the gasket (5) with a new one.**



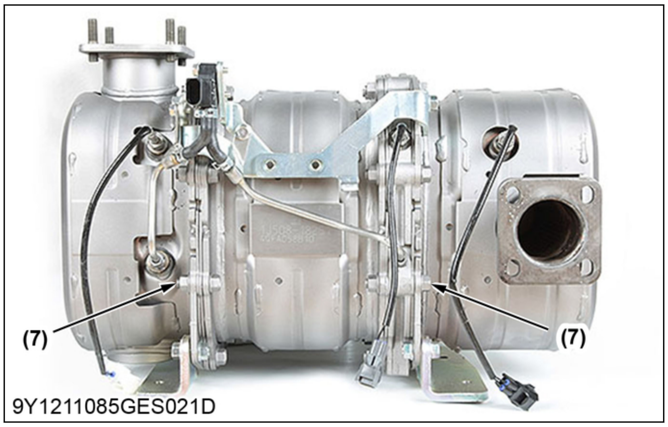




(1) Body (DPF outlet)
(2) Filter comp (DPF)
(3) Collar (DPF)
(4) Catalyst (DOC)
(5) Gasket
(6) GAS FLOW →
(7) Filter comp (DPF) mounting screw

2. Tighten the filter comp (DPF) mounting screw (7) to the specified torque.

Tightening torque	Filter comp (DPF) mounting screw (7)	49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	Exhaust gas 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



(7) Filter comp (DPF) mounting screw

6.41 Installing DPF muffler full assembly

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.**

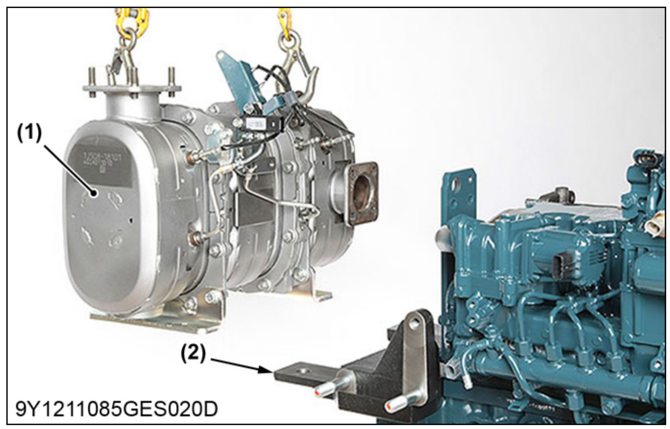
NOTE

- **Always work in the workshop equipped with a electric lift (including mobile lift).**
- **Put a product (engine) on a stable ground, and set the parking brake.**
- **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.**
- **When installing 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.**
- **Replace the gasket with a new one.**
- **If the differential pressure tube is damaged or cracked, replace it.**
- **When replacing the differential pressure pipe, 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.**

Tools required

- Anti-seize & lubricating compound (Bostick, NEVER SEEZ, Pure Nickel Special Grade)
- Crowfoot wrench

1. Install the DPF bracket (2).
2. Lift the muffler full assembly (DPF) (1) and install the muffler full assembly (DPF) (1) on the DPF bracket (2).



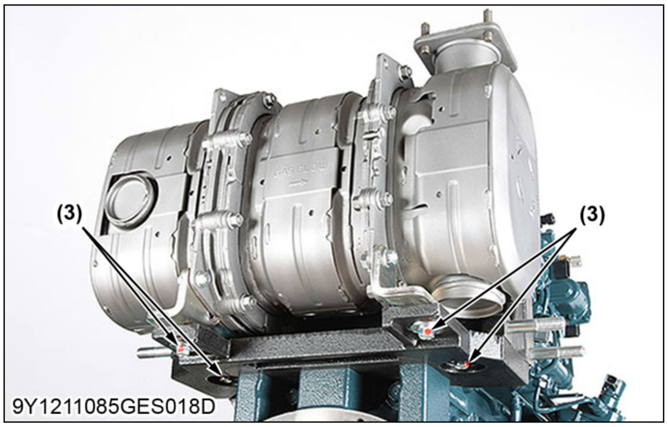
(1) Muffler full assembly (DPF) (2) DPF bracket

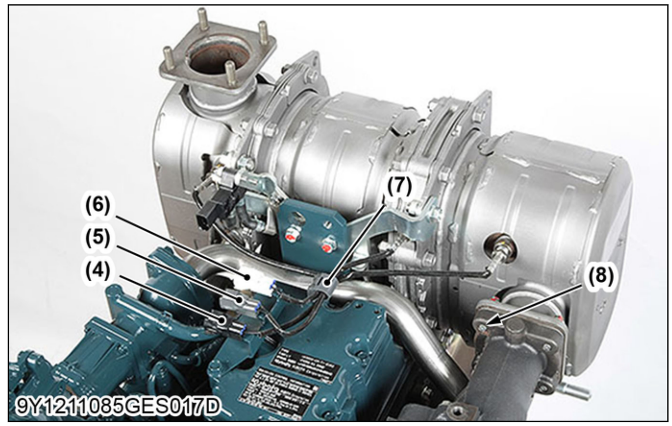
3. Loosely tighten the muffler full assembly (DPF) mounting screws (3).
4. Loosely tighten the muffler flange screw (8).
5. Tighten the muffler full assembly (DPF) mounting screws (3) and muffler flange screw (8) to the specified torque.

Tightening torque	Muffler flange screw (8)	49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft

6. Clamp the cord of temperature sensor with clamp (7).

7. Attach the temperature sensor connector (4), (5), (6) to the bracket.

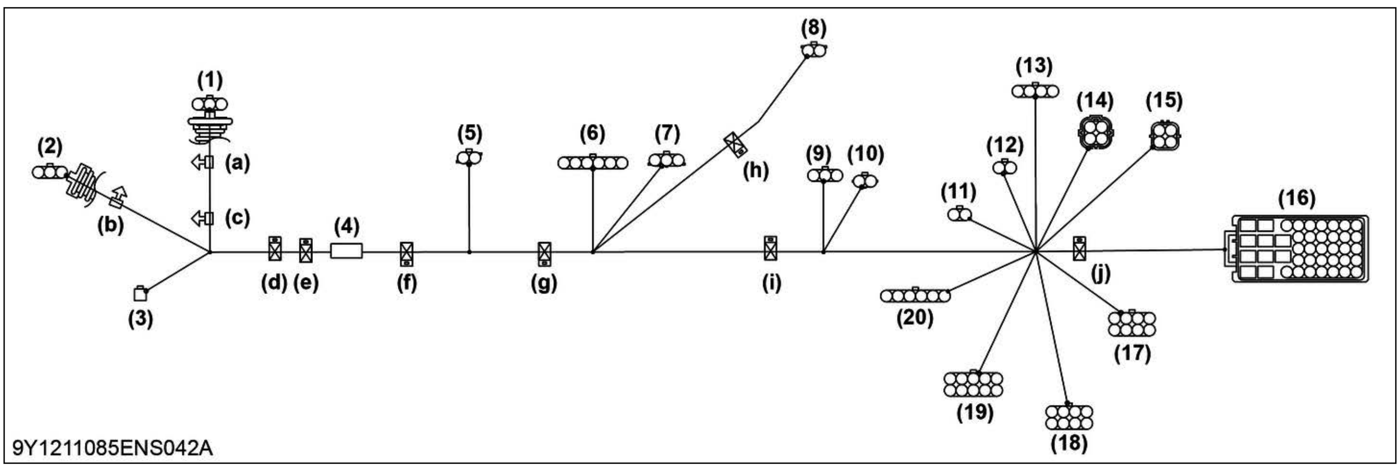




(3) Muffler full assembly (DPF) mounting screw
(4) Temperature sensor connector (T_0)
(5) Temperature sensor connector (T_1)
(6) Temperature sensor connector (T_2)
(7) Clamp
(8) Muffler flange screw

6.42 Installing CRS intermediate harness

1. Connect the engine intermediate harness (engine side).



(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) Intake throttle valve connector (6P)
(7) Rail pressure sensor connector (3P)
(8) PCV (Pre-stroke Control Valve) connector (2P)
(9) Boost pressure sensor connector (3P)
(10) Intake air temperature sensor connector (2P)
(11) Resistor 120 Ω (2P)
(12) Resistor 1.1 kΩ (2P)
(13) EGR valve connector (3P)
(14) CAN connector (4P)
(15) CAN connector (4P)
(16) Engine intermediate connector
(17) Engine joint connector 4 (8P)
(18) Engine joint connector 3 (8P)
(19) Engine joint connector 2 (10P)
(20) Engine joint connector 1 (6P)
(a) Clamp
to (j)

2. Connect the injector intermediate harness (engine side).

9Y1200165ENS002C

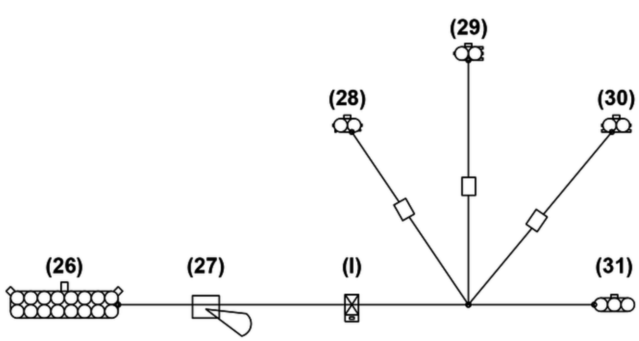
(21) Injector connector (10P)
(22) Name plate
(23) Injector intermediate connector (12P)
(k) Clamp

3. Connect the air flow sensor intermediate harness (engine side).

9Y1200165ENS003A

(24) Air flow sensor intermediate connector (6P)
(25) Air flow sensor connector (5P)

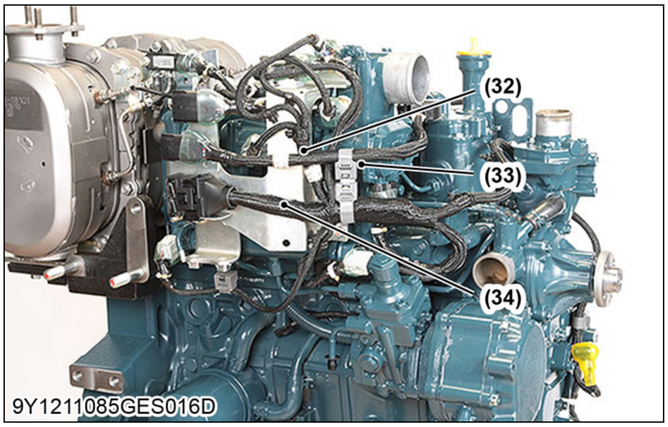
4. Connect the DPF intermediate harness (engine side).



9Y1200165ENS004D

(26) DPF intermediate connector (16P)
(27) Name plate
(28) DPF temperature sensor (T_2) (2P)
(29) DPF temperature sensor (T_1) (2P)
(30) DPF temperature sensor (T_0) (2P)
(31) DPF differential pressure sensor (ΔP) (3P)
(l) Clamp

5. Connect the ECU intermediate harness.



(32) DPF intermediate harness (33) Injector intermediate harness (34) Engine intermediate harness

6. Connect the starter B terminal.

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

7. Connect the air heater terminal.

Tightening torque	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

6.43 Installing external components

NOTE

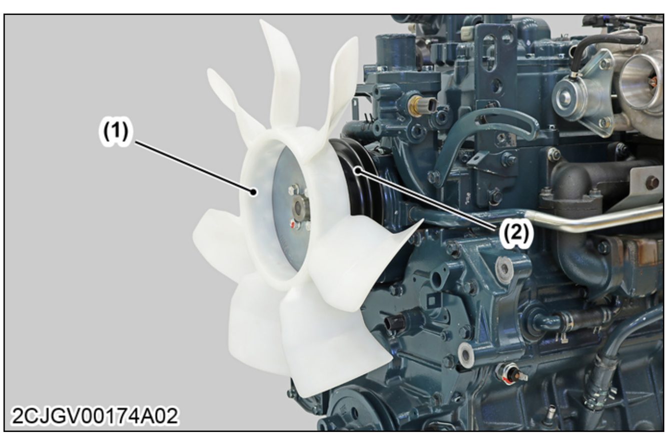
- **Check for cracks on the fan belt surface.**

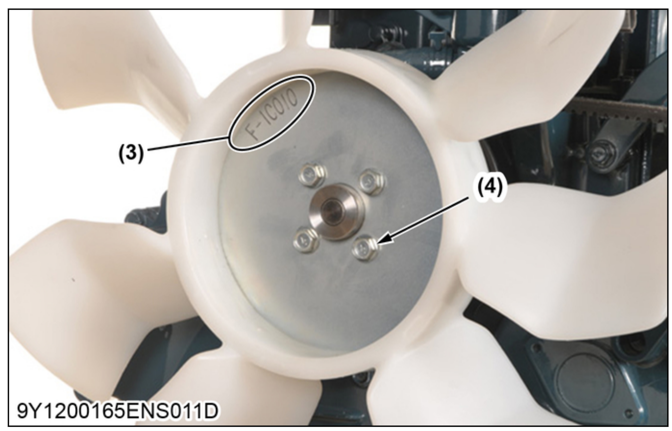
Tools required

- Sonic belt tension meter

1. Install the fan pulley (2) and the cooling fan (1) and loosely tighten the cooling fan mounting screw(4).

   IMPORTANT
   - **Do not put the cooling fan (1) in the incorrect direction.**
   - **Install the fan so that the parts number (3) of the fan is toward the front side (radiator side).**



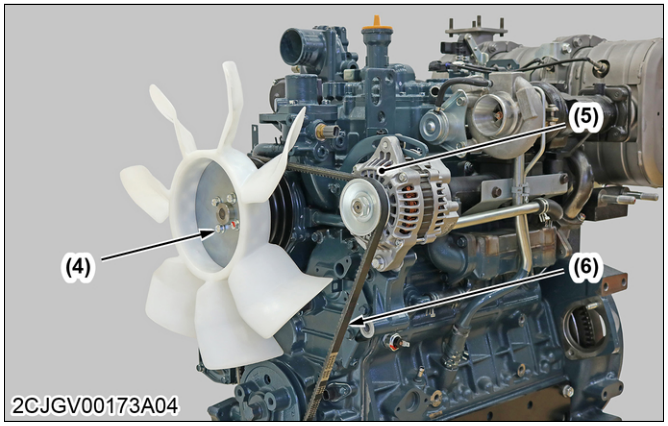


(1) Cooling fan
(2) Fan pulley
(3) Parts number
(4) Cooling fan mounting screw

2. Install the alternator (5).
3. Install the fan belt (6).

4. Tighten the cooling fan mounting screw (4).

Tightening torque	Cooling fan mounting screw (4)	9.81 to 11.2 N·m 1.00 to 1.15 kgf·m 7.24 to 8.31 lbf·ft

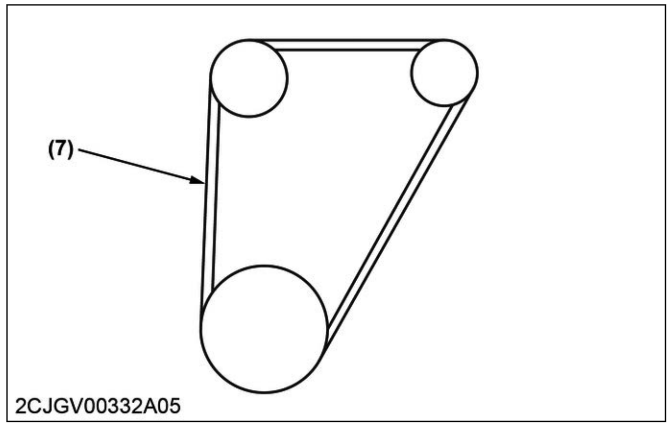


(4) Cooling fan mounting screw
(5) Alternator
(6) Fan belt

5. Adjust the tension of fan belt halfway (7) between the fan drive pulley and fan pulley with sonic belt tension meter.

Sonic belt tension meter setting value	V3800-TIEF4, V3800-TIEF4C	V3800-TIEF4H
Mass (Mass per 1 rib 1 m of belt)	110 g/rib/m	18 g/rib/m
Width (Number of ribs)	1	6
Span (Distance of between the fan drive pulley and alternator pulley)	290 mm 11.4 in.	317 mm 12.5 in.

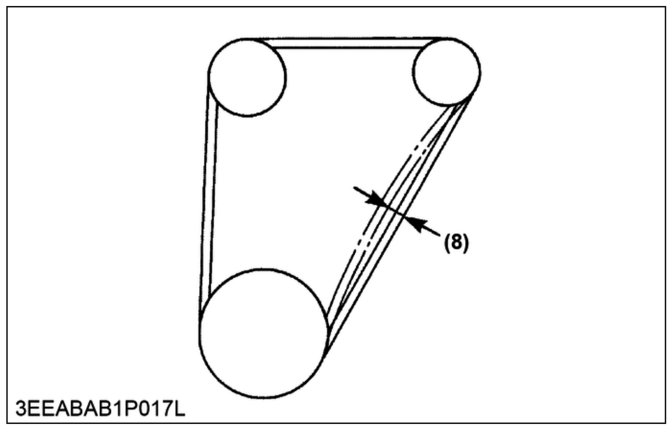
Belt tension (After installing)	Factory specification	V3800-TIEF4 V3800-TIEF4C	441 to 480 N 45.0 to 48.9 kgf 99.2 to 107 lbf
		V3800-TIEF4H	650 to 850 N 66.3 to 86.6 kgf 147 to 191 lbf
Belt tension (After engine operation)	Factory specification	V3800-TIEF4 V3800-TIEF4C	391 to 480 N 39.9 to 48.9 kgf 87.9 to 107 lbf
		V3800-TIEF4H	420 to 550 N 42.9 to 56.0 kgf 94.5 to 123 lbf



(7) Fan belt halfway

(Reference)

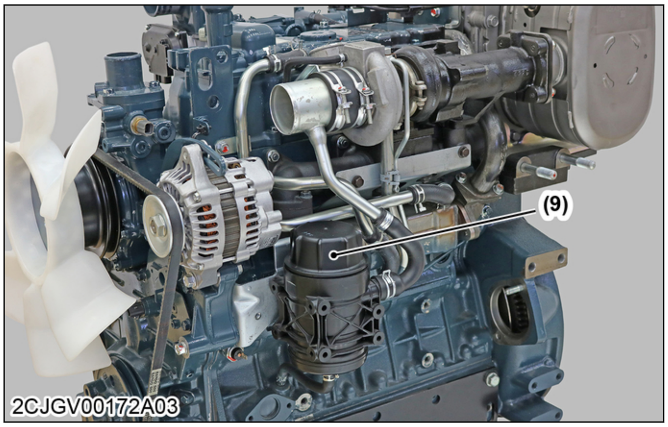
a. Push the belt halfway between the fan drive pulley and alternator pulley at a specified force to measure the deflection (8).



(8) Deflection

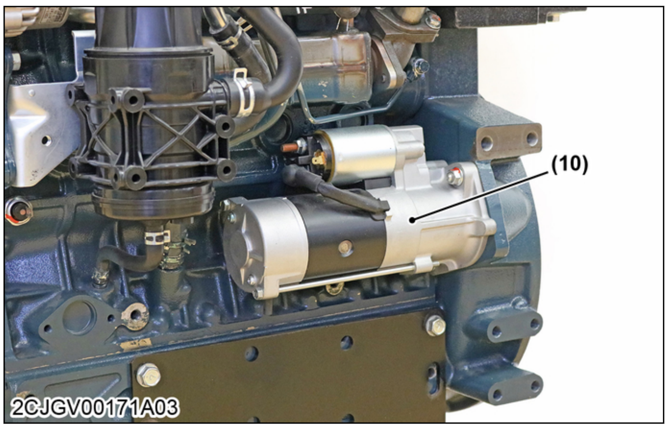
Deflection (8)	Factory specification	V3800-TIEF4 V3800-TIEF4C	10 to 12 mm 0.40 to 0.47 in. (under load of 59 to 68 N (6.0 to 7.0 kg, 14 to 15 lbf))
		V3800-TIEF4H	9.0 to 11 mm 0.36 to 0.43 in. (under load of 59 to 68 N (6.0 to 7.0 kg, 14 to 15 lbf))

6. Install the oil separator (9).



(9) Oil separator

7. Install the starter (10).



(10) Starter

6.44 Installing SCR muffler assembly

■ **NOTE**

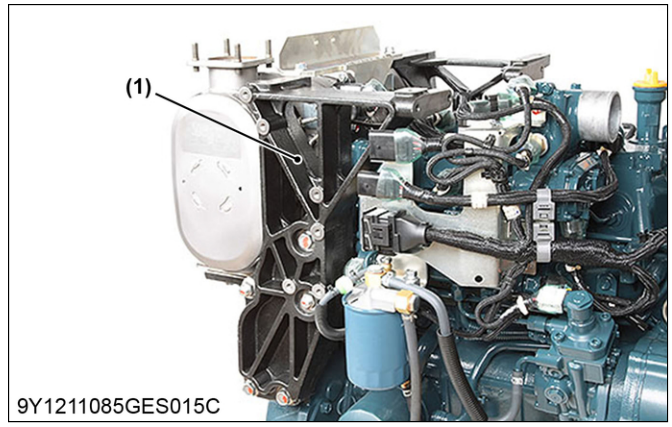
- **Always work in the workshop equipped with a electric lift (including mobile lift).**
- **Tighten the NOx sensor tightening nut or the SCR inlet temperature sensor tightening nut to the specified torque with crowfoot wrench.**
- **When replacing the NOx sensor, check that it is coated with anti-seize & lubricating compound, and then attach it to its correct position.**
- **When the SCR inlet temperature sensor is removed, wipe off the anti-seize & lubricating compound, apply a anti-seize & lubricating compound (Bostick, NEVER SEEZ, Pure Nickel Special Grade), and then attach them to their correct position.**
- **When replacing the SCR inlet temperature sensor, check that it is coated with anti-seize & lubricating compound, and then attach it to its correct position.**

Tools required

- Anti-seize & lubricating compound (Bostick, NEVER SEEZ, Pure Nickel Special Grade)
- Crowfoot wrench

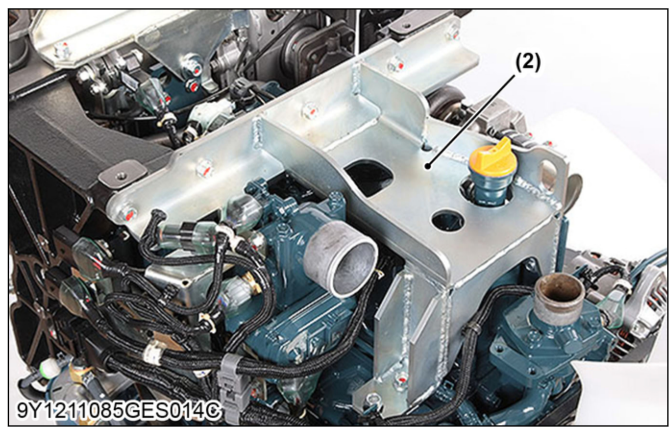
1. Install the base of SCR (1) tighten to specified torque.

Tightening torque	Base of SCR (1)	124 to 147 N·m 12.6 to 15.0 kgf·m 91.2 to 108 lbf·ft



(1) Base of SCR

2. Install the SCR stay (2) tighten to specified torque.



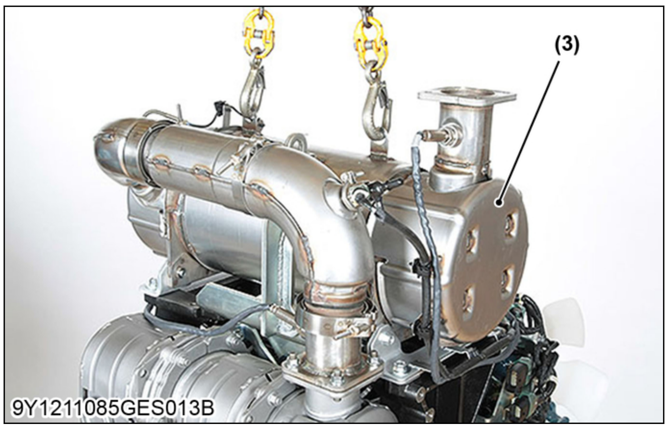
(2) SCR stay

3. Install the SCR muffler assembly (3).

■ **NOTE**

- **When you carry SCR muffler assembly, use lift for safety.**
- **If you replace NOx sensor or SCR inlet temperature sensor, tighten to specified torque.**

Tightening torque	SCR muffler assembly mounting screw	49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	NOx sensor	40 to 60 N·m 4.1 to 6.1 kgf·m 30 to 44 lbf·ft
	SCR inlet temperature sensor	40.5 to 49.5 N·m 4.13 to 5.04 kgf·m 29.9 to 36.5 lbf·ft



(3) SCR muffler assembly

6.45 Filling coolant

■ **IMPORTANT**

- **Do not mix the different type or brand of L.L.C.**
- **Do not use an anti-freeze and scale inhibitor at the same time.**

■ **NOTE**

- **Make sure the drain valve is closed.**

1. Fill the coolant until below the port from filling port.

■ **IMPORTANT**

- **Make sure that you close the radiator cap correctly.**
- **When you add the coolant, release the air from the engine coolant channels.**
- **The engine releases the air when it shakes the radiator upper and lower hoses.**

6.46 Filling engine oil

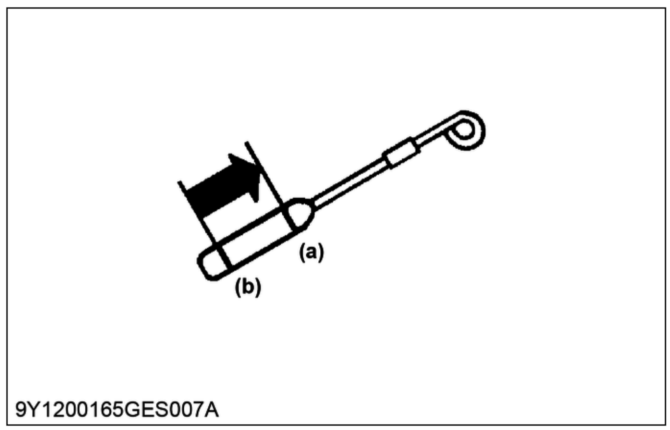
■ **IMPORTANT**

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

■ **NOTE**

- **Make sure the drain plug is tightened.**

1. Fill the engine oil until the upper line (a) on the dipstick from filling port (1).



(1) Filling port
(a) Upper line
(b) Lower line

7. Servicing

7.1 Checking cylinder head top clearance

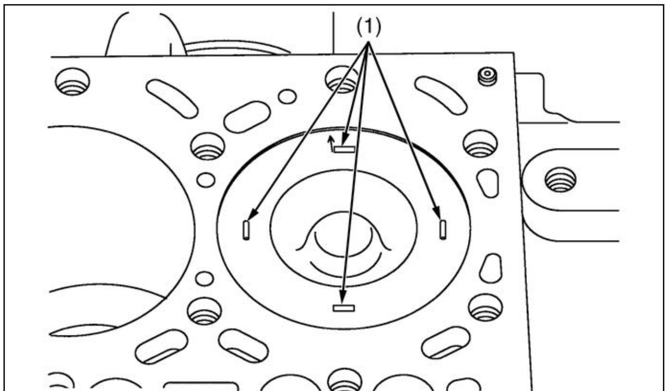
Tools required

- Plastigauge

1. Remove the cylinder head.

2. With the piston at TDC, use grease to affix three or four plastigauges (1) to the crown of the piston; keep the gauges away from the intake valve and combustion chamber fittings.

Plastigauge (1) cut size	Diameter	1.5 mm 0.059 in.
	Length	5.0 to 7.0 mm 0.20 to 0.27 in.



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(1) Plastigauge

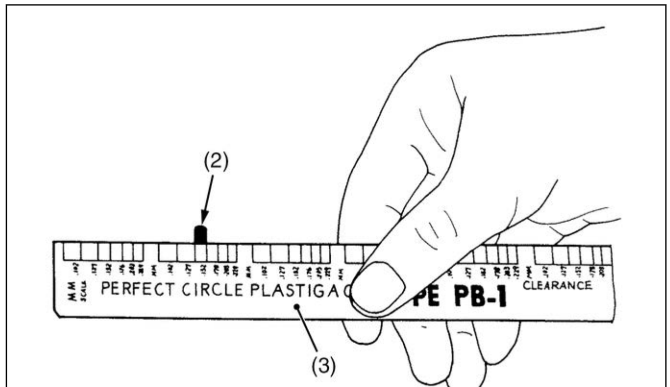
3. Take the piston to an intermediate position, install the cylinder head and tighten the head bolts to the specified torque.

Tightening torque	Cylinder head mounting screw	V3800-TIEF4 V3800-TIEF4C	98.1 to 107 N·m 10.0 to 11.0 kgf·m 72.4 to 79.5 lbf·ft
		V3800-TIEF4H	120 to 130 N·m 12.3 to 13.2 kgf·m 88.5 to 95.8 lbf·ft

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).

■ **NOTE**
- **Top clearance = Width of the crushed plastigauge (2)**
- **If they are out of spec, check the oil clearance of the crank pin, journal and piston pins.**

Top clearance	Factory specification	0.701 to 0.930 mm 0.0276 to 0.0366 in.



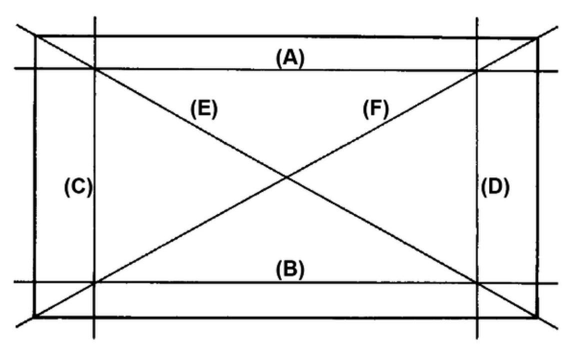
9Y1210783ENS003A

(2) Crushed plastigauge (3) Scale

7.2 Checking cylinder head surface flatness

Tools required
- Straightedge
- Feeler gauge

1. Clean the cylinder head surface.
2. Place a straightedge on the cylinder head's four sides (A), (B), (C) and (D) and two diagonal (E) and (F) as shown in the figure.



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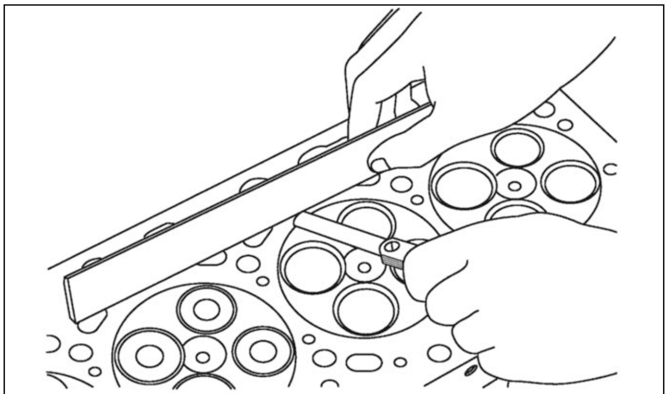
3. Measure the clearance with a feeler gauge.

NOTE
- **If the measurement is more than the allowable limit, make it straight with a surface grinder.**

IMPORTANT
- **Check the valve recessing after you correct.**

Cylinder head surface flatness	Allowable limit	0.05 mm 0.002 in.



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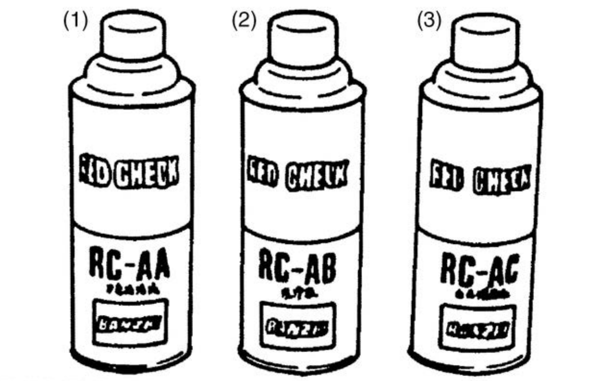
7.3 Checking cylinder head flaw

Tools required
- Red permeative liquid
- Detergent
- White developer

1. Clean the surface of the cylinder head with detergent (2).
2. Apply some red permeative liquid (1) on the cylinder head surface.
3. After you apply, do not touch it for 5 to 10 minutes.
4. Clean away the red permeative liquid on the cylinder head surface with detergent (2).
5. Apply the white developer (3) on the cylinder head surface.

NOTE
- **If you found a red flaw, replace the cylinder head.**



3TMABAB0P059B

(1) Red permeative liquid
(2) Detergent
(3) White developer

7.4 Checking valve recessing

Tools required
- Depth gauge

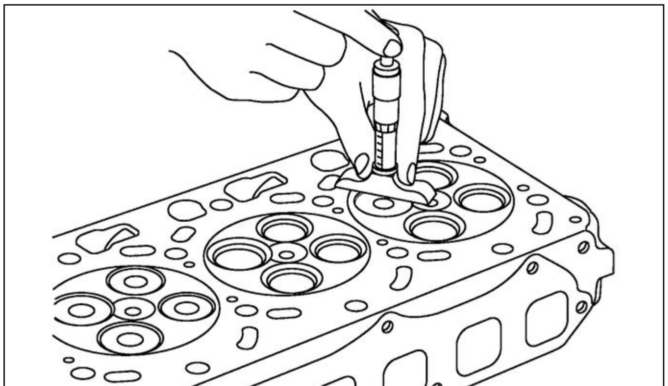
1. Clean the cylinder head surface (1), valve face and valve seat.
2. Set the valve into the valve guide.

3. Measure the valve recessing with a depth gauge.

■ NOTE

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

Valve recess-ing	Factory speci-fication	Intake valve	0.60 to 0.80 mm 0.024 to 0.031 in.
		Exhaust valve	0.850 to 1.05 mm 0.0335 to 0.0413 in.
	Allowable limit	1.2 mm 0.047 in.	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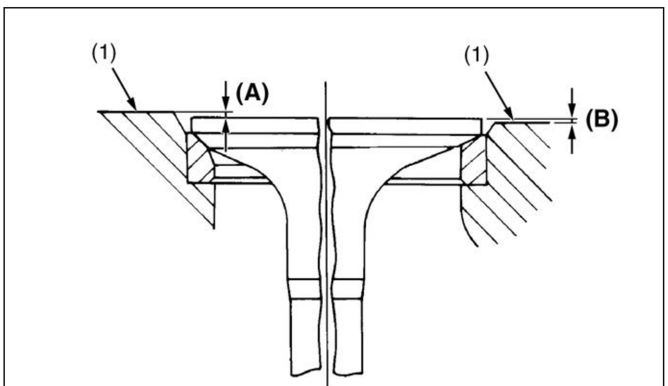


3TMABAB1P058A

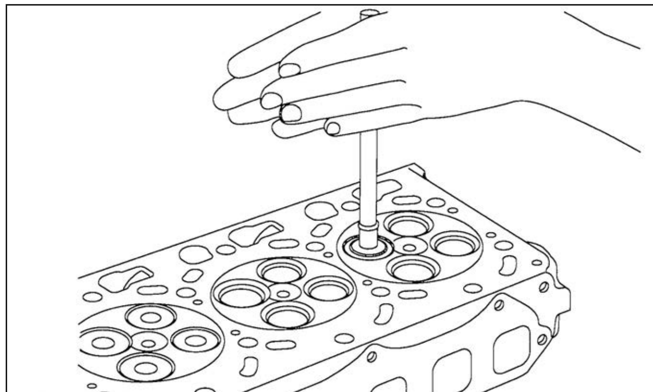
(1) Cylinder head surface
(A) Recessing
(B) Protrusion

7.5 Adjusting valve lapping

Tools required

- Compound
- Valve lapping tool
- Prussian Blue

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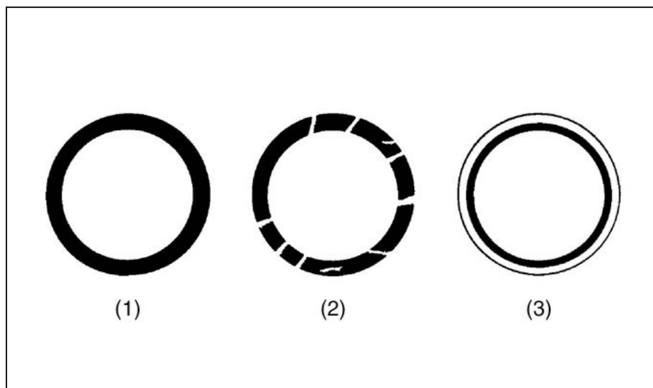
4. Apply Prussian Blue to the contact surface to measure the seated rate.

■ NOTE

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

■ IMPORTANT

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



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

RELATED PAGE

7.4 Checking valve recessing on page 3-184
4.2 Adjusting valve clearance on page 3-102

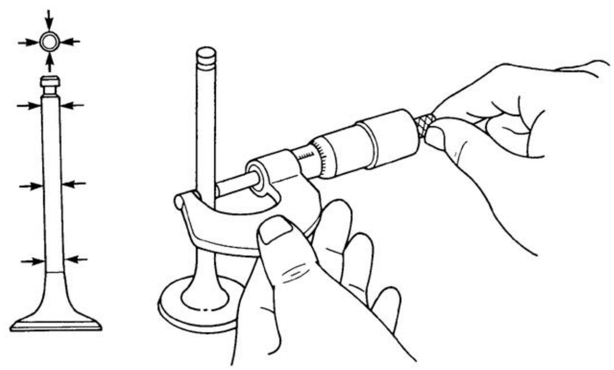
7.6 Checking clearance between valve stem and valve guide

Tools required

- External micrometer
- Small hole gauge

1. Remove carbon from the valve guide section.
2. Measure the valve stem O.D. with an external micrometer.

Valve stem O.D.	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.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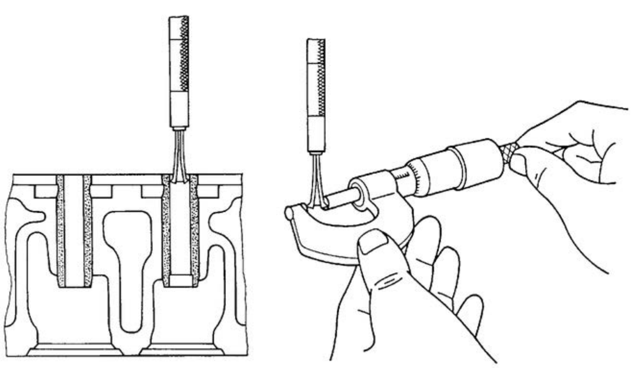
3. Measure the valve guide I.D. with a small hole gauge.

Valve guide I.D.	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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4. Calculate the clearance.

■ **NOTE**
- **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.	

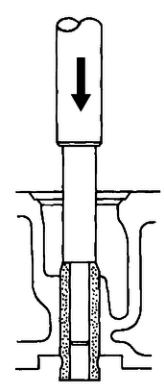
RELATED PAGE
7.7 Replacing valve guide on page 3-186

7.7 Replacing valve guide

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

Tools required
- Press tool
- Valve guide replacing tool

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

(A)

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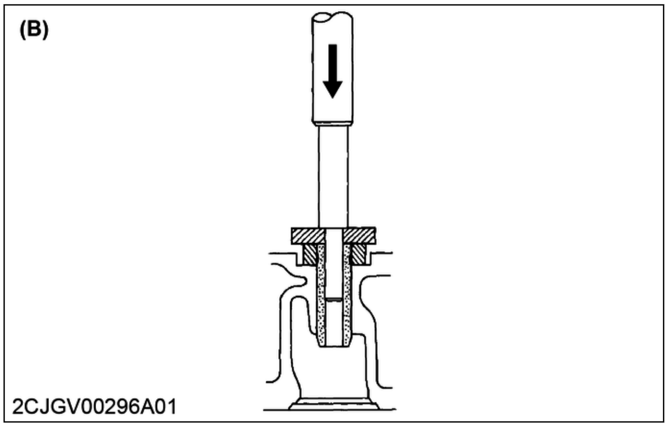
(A) Removing direction

Installing valve guide
1. Clean the new valve guide and valve guide bore, and apply engine oil to them.
2. Press fit the new valve guide with the valve guide replacing tool.



(B) Installing direction

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

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.

7.8 Adjusting valve angle

■ **NOTE**

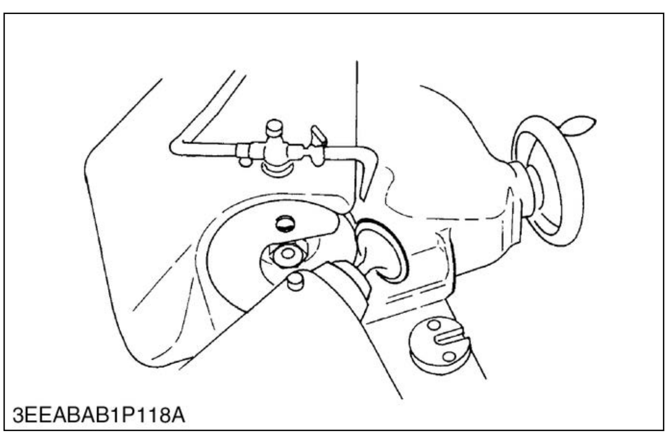
- **Before you adjust the valve, check the valve stem and measure the I.D. of the valve guide section.**
  Repair them if necessary.

Tools required

- Valve refacer

1. Adjust the valve with a valve refacer.

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



7.9 Adjusting valve seat

■ **NOTE**

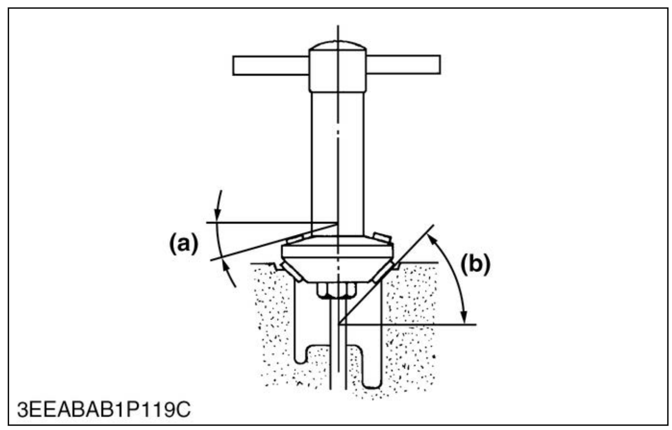
- **Before you adjust the valve seat, check the valve stem and measure the I.D. of the valve guide section.**
  Repair them if necessary.
- **After you adjust the valve seat, be sure to check the valve recessing.**

Tools required

- Valve seat cutter
- Valve lapping tool.
- Prussian Blue

1. Slightly adjust the seat surface with a 1.0 rad (60°) or 0.79 rad (45°) valve seat cutter.

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



(a) 0.26 rad (15°) or 0.52 rad (30°)
(b) 0.79 rad (45°) or 1.0 rad (60°)

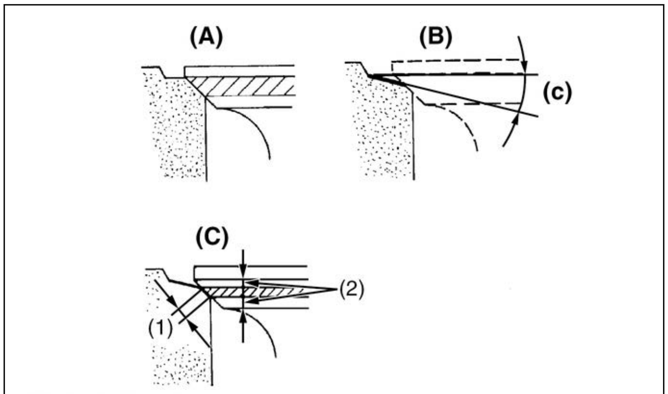
2. Adjust the seat width with a 0.52 rad (30°) or 0.26 rad (15°) valve seat cutter.
3. After you adjust the seat, check that the valve seating is flat.
4. Apply a thin layer of compound between the valve face and valve seat, and lap them with a valve lapping tool.

5. Check the valve seating with Prussian Blue.

■ **NOTE**

- **The valve seating surface must show good contact on all sides.**

Valve seat width (1)	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.



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(1) Valve seat width
(2) Identical dimensions
(A) Check the contact
(B) Correct seat width
(C) Check the contact
(c) 0.52 rad (30°) or 0.26 rad (15°)

RELATED PAGE

7.6 Checking clearance between valve stem and valve guide on page 3-185

7.4 Checking valve recessing on page 3-184

7.10 Checking free length of valve spring

Tools required

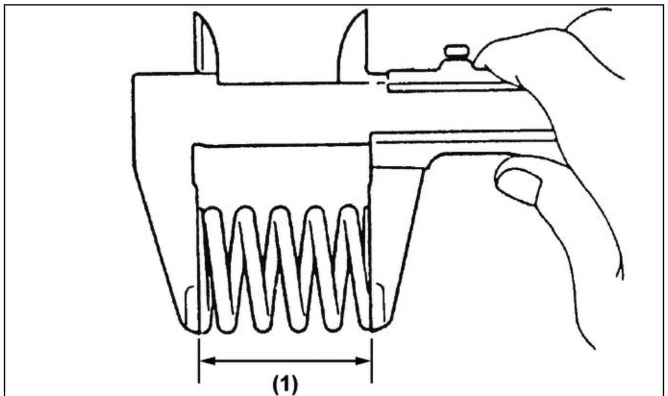
- Vernier caliper

1. Measure the free length (1) of valve spring with a vernier calipers.

■ **NOTE**

- **If the measurement is less than the allowable limit, replace it.**

Free length (1)	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.



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(1) Free length

2. Check the full surface of the valve spring for scratches.

■ **NOTE**

- **If there is a damage, replace it.**

7.11 Checking tilt of valve spring

Tools required

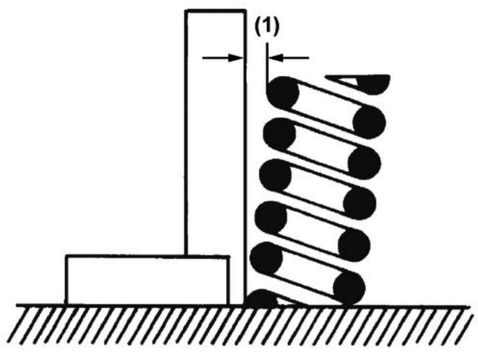
- Surface plate
- Square

1. Put the valve spring on a surface plate, and put a square on the side of the valve spring.

2. Turn the valve spring to measure the maximum tilt (1).

   ■ **NOTE**
   - **If the measurement is more than the allowable limit, replace it.**

Tilt (1)	Allowable limit	1.0 mm 0.039 in.



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(1) Tilt

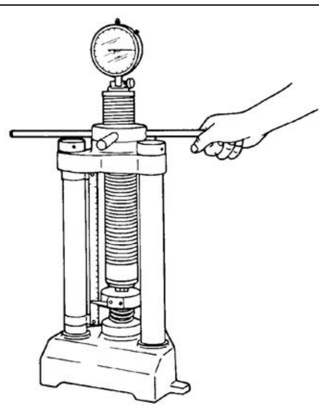
3. Check the full surface of the valve spring for scratches.

   ■ **NOTE**
   - **If there is a damage, replace it.**

7.12 Checking set load of valve spring

Tools required
- Valve spring tester

1. Put the valve spring on a tester and compress the valve spring to the specified setting length.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2. Read the compression load on the gauge.

   ■ **NOTE**
   - **If the measurement is less than the allowable limit, replace the valve spring.**

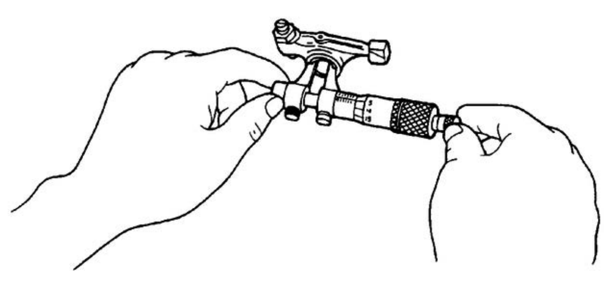
Setting load / Setting length	Factory speci-fication	Intake valve	63.5 N / 31.5 mm 6.48 kgf / 31.5 mm 14.3 lbf / 1.24 in.
		Exhaust valve	63.5 N / 31.5 mm 6.48 kgf / 31.5 mm 14.3 lbf / 1.24 in.
	Allowable limit	Intake valve	45.9 N / 31.5 mm 4.68 kgf / 31.5 mm 10.3 lbf / 1.24 in.
		Exhaust valve	45.9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

7.13 Checking oil clearance between rocker arm and rocker arm shaft

Tools required
- Internal micrometer
- External micrometer.

1. Measure the rocker arm I.D. with an internal micrometer.

Rocker arm I.D.	Factory specifi-cation	16.000 to16.027 mm 0.62993 to 0.63098 in.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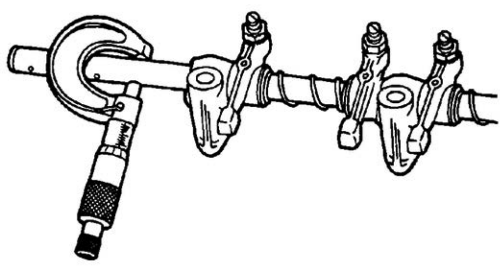
2. Measure the rocker arm shaft O.D. with an external micrometer.

Rocker arm shaft O.D.	Factory specification	15.973 to 15.984 mm 0.62886 to 0.62929 in.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3. Calculate the oil clearance.

■ **NOTE**
- **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 0.054 mm 0.00063 to 0.0021 in.
	Allowable limit	0.15 mm 0.0059 in.

7.14 Checking oil clearance between valve bridge shaft and valve bridge arm

Tools required
- Internal micrometer
- External micrometer.

1. Measure the valve bridge arm I.D. with an internal micrometer.

Valve bridge arm I.D.	Factory specification	9.050 to 9.065 mm 0.3563 to 0.3568 in.


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2. Measure the valve bridge shaft O.D with an external micrometer.

Valve bridge shaft O.D.	Factory specification	9.023 to 9.032 mm 0.3553 to 0.3555 in.


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3. Calculate the oil clearance.

■ **NOTE**
- **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.

7.15 Checking push rod alignment

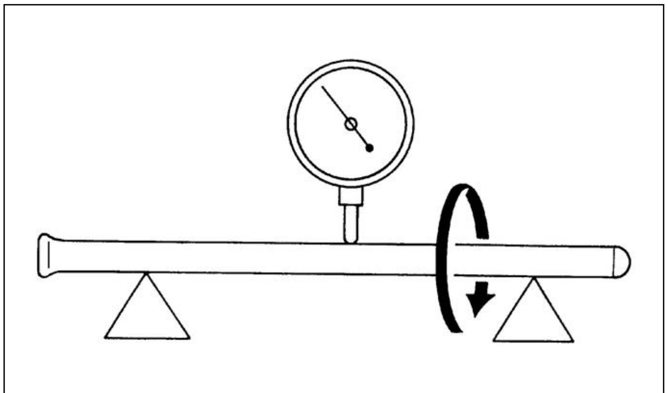
Tools required
- V blocks
- Surface plate
- Dial gauge

1. Put the push rod on V blocks.

2. Measure the push rod alignment.

■ **NOTE**
- **If the measurement is more than the allowable limit, replace the push rod.**

Push rod alignment	Allowable limit	0.25 mm 0.0098 in.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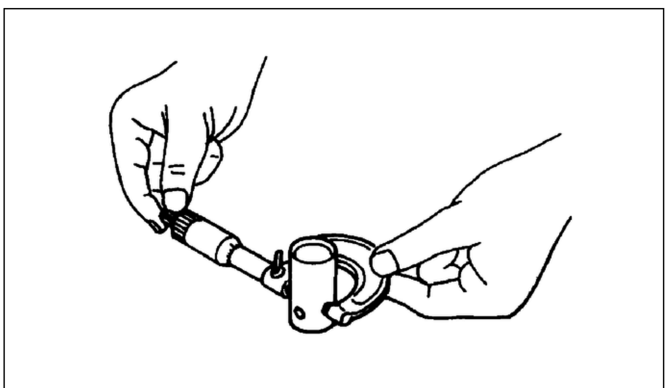
7.16 Checking oil clearance between tappet and tappet guide bore

Tools required
- External micrometer
- Cylinder gauge

1. Measure the tappet O.D. with an external micrometer.

Tappet O.D.	Factory specification	23.959 to 23.980 mm 0.94327 to 0.94409 in.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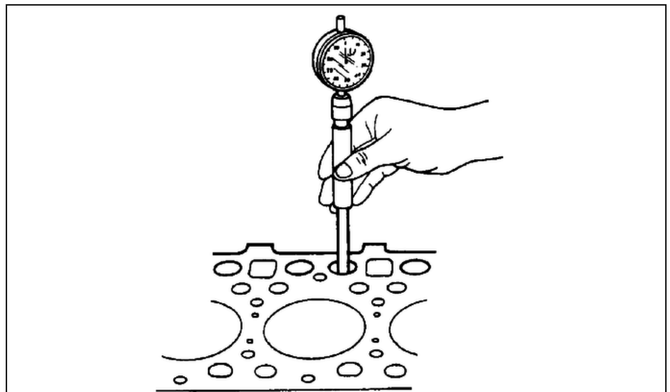
2. Measure the tappet guide bore I.D. with a cylinder gauge.

Tappet guide bore I.D.	Factory specification	24.000 to 24.021 mm 0.94489 to 0.94570 in.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3. Calculate the oil clearance.

■ **NOTE**
- **If the oil clearance is more than the allowable limit or the tappet has a damage, replace the tappet.**

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

7.17 Checking timing gear backlash

Tools required
- Dial gauge (lever type)

1. Set a dial gauge (lever type) with its point on the gear tooth.

2. Hold the mating gear and move the gear to measure the backlash.

■ **NOTE**

- **If the backlash is more than the allowable limit, measure the oil clearance in the journal part of each shaft.**
- **If the oil clearance is correct, replace the gear.**
- **If the crank gear is replaced, it is necessary to calibrate the injection timing with the diagnosis tool.**

[V3800-TIEF4, V3800-TIEF4C]

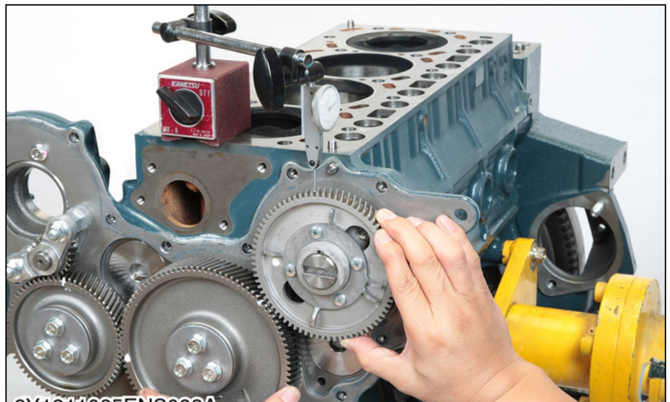
Backlash between crank gear and idle gear 1	Factory specification	0.0490 to 0.193 mm 0.00193 to 0.00759 in.
	Allowable limit	0.22 mm 0.0087 in.
Backlash between idle gear 1 and cam gear	Factory specification	0.0490 to 0.189 mm 0.00193 to 0.00744 in.
	Allowable limit	0.22 mm 0.0087 in.

[V3800-TIEF4]

Backlash between idle gear 3 and supply pump gear	Factory specification	0.0540 to 0.167 mm 0.00213 to 0.00657 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.
Backlash between idle gear 2 and idle gear 3	Factory specification	0.0490 to 0.159 mm 0.00193 to 0.00625 in.
	Allowable limit	0.22 mm 0.0087 in.

[V3800-TIEF4C]

Backlash between idle gear 3 and supply pump gear	Factory specification	0.0540 to 0.167 mm 0.00213 to 0.00657 in.
	Allowable limit	0.22 mm 0.0087 in.
Backlash between idle gear 1 and idle gear 3	Factory specification	0.0490 to 0.162 mm 0.00193 to 0.00637 in.
	Allowable limit	0.22 mm 0.0087 in.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— RELATED PAGE —

4.37 Measuring angular deviation between crankshaft T.D.C. and crank position sensor detected T.D.C. on page 3-121

7.18 Checking side clearance of idle gear 1, 2

Tools required

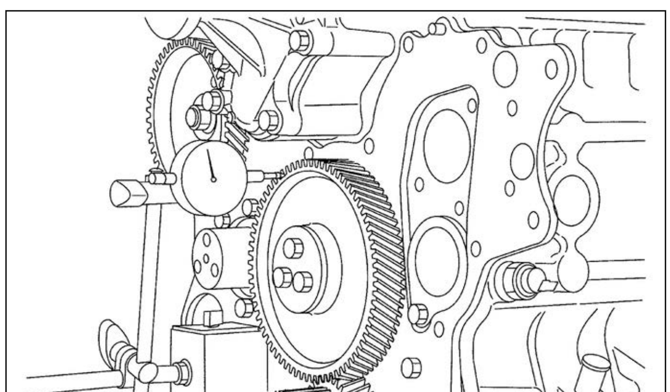
- Dial gauge

1. Set a dial gauge with its point on the idle gear 1, 2.
2. Move the idle gear 1, 2 to the front and rear to measure the side clearance.

■ **NOTE**

- **If the measurement is more than the allowable limit, replace the idle gear 1, 2 collar.**

Side clearance of idle gear 1, 2	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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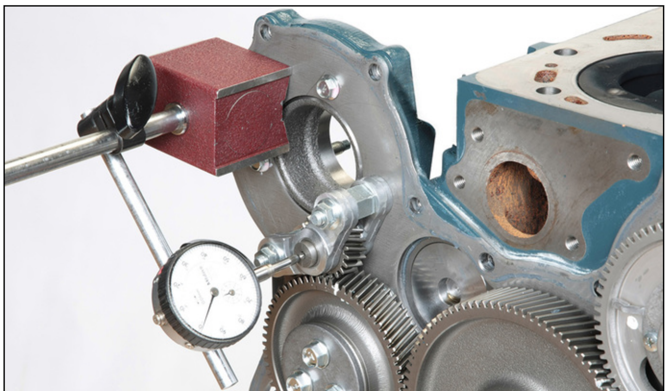
7.19 Checking side clearance of idle gear 3

Tools required
- Dial gauge

1. Set a dial gauge with its point on the idle gear 3.
2. Move the idle gear 3 to the front and rear to measure the side clearance.

■ **NOTE**
- **If the measurement is more than the allowable limit, replace the idle gear 3 holder.**

Side clearance of idle gear 3	Factory specification	0.10 to 0.40 mm 0.0040 to 0.015 in.
	Allowable limit	0.90 mm 0.035 in.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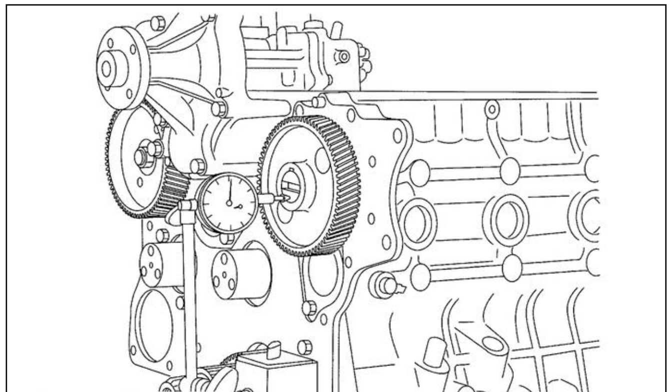
7.20 Checking side clearance of camshaft

Tools required
- Dial gauge

1. Set a dial gauge with its point on the camshaft.
2. Move the cam gear to the front and rear to measure the side clearance.

■ **NOTE**
- **If the measurement is more than the 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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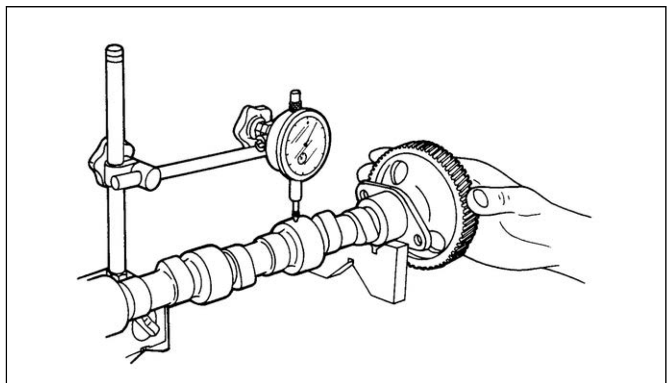
7.21 Checking camshaft alignment

Tools required
- V blocks
- Surface plate
- Dial gauge

1. Hold the two end journals of camshaft with V blocks on the surface plate.
2. Set a dial gauge with its point on the middle journal.
3. Turn the camshaft slowly and read the variation on the indicator (Half of the measurement).

■ **NOTE**
- **If the measurement is more than the allowable limit, replace the camshaft.**

Camshaft alignment	Allowable limit	0.01 mm 0.0004 in.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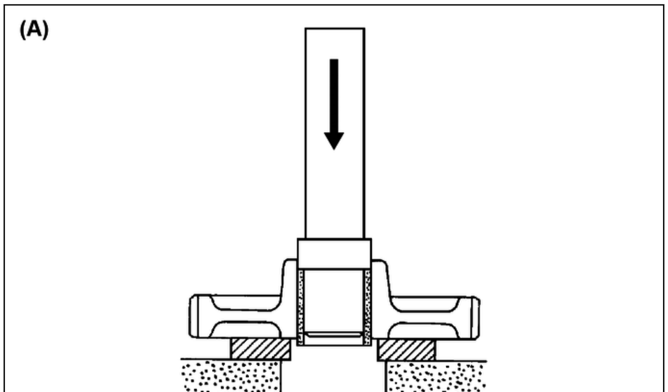
7.22 Replacing idle gear bushing

Tools required
- Press tool
- Idle gear bushing replacing tool

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



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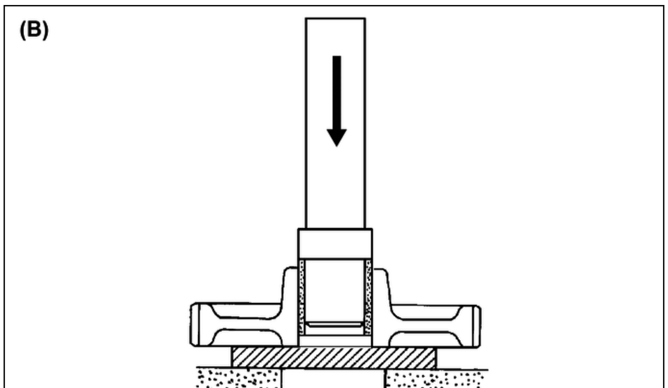
(A) Removing direction

Installing idle gear bushing

1. Clean a new idle gear bushing and idle gear bore, and apply engine oil to them.
2. Press fit the new bushing with the replacing tool.

■ **NOTE**

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



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(B) Installing direction

7.23 Checking cam height

Tools required

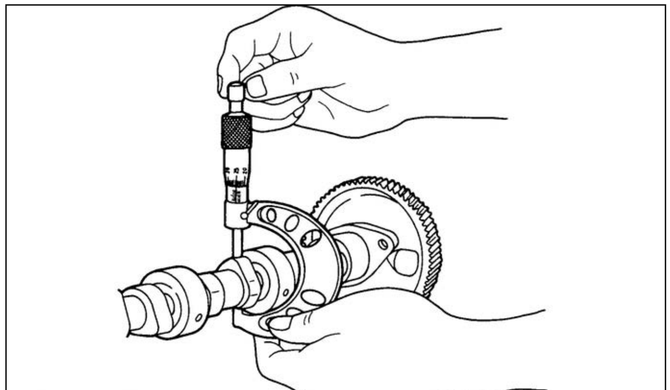
- External micrometer

1. Measure the height of the cam at its highest point with an external micrometer.

■ **NOTE**

- **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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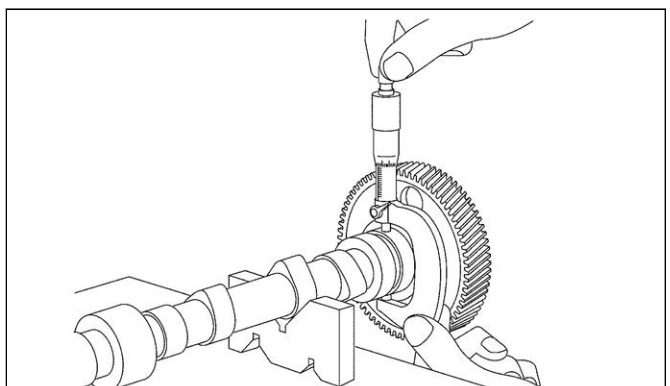
7.24 Checking oil clearance between camshaft journal and cylinder block bore

Tools required

- External micrometer
- Internal micrometer

1. Measure the camshaft journal O.D. with an external micrometer.

Camshaft journal O.D.	Factory specification	45.934 to 45.950 mm 1.8085 to 1.8090 in.



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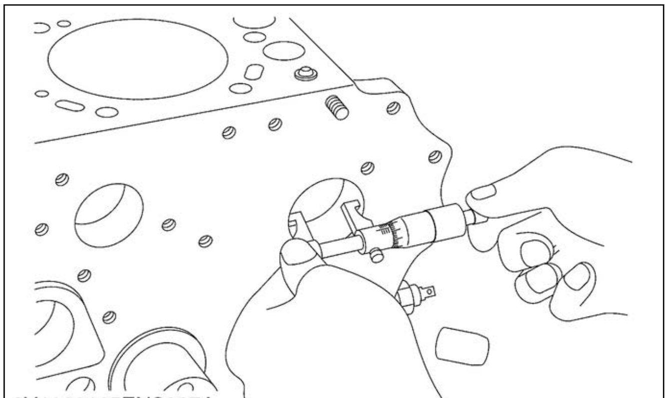
2. Measure the cylinder block bore I.D. for the camshaft with an internal micrometer.

Camshaft bearing I.D.	Factory specification	46.000 to 46.025 mm 1.8111 to 1.8120 in.



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3. Calculate the oil clearance.

■ **NOTE**
- **If the oil clearance is more than the allowable limit, replace the camshaft.**

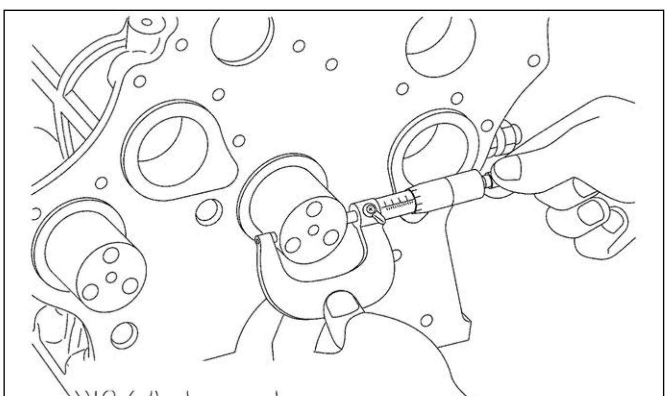
Oil clearance of camshaft journal	Factory specification	0.050 to 0.091 mm 0.0020 to 0.0035 in.
	Allowable limit	0.15 mm 0.0059 in.

7.25 Checking oil clearance between idle gear shaft 1, 2 and idle gear 1, 2 bushing

Tools required
- External micrometer
- Internal micrometer

1. Measure the idle gear shaft O.D. with an external micrometer.

Idle gear shaft 1, 2 O.D.	Factory specification	44.959 to 44.975 mm 1.7701 to 1.7706 in.



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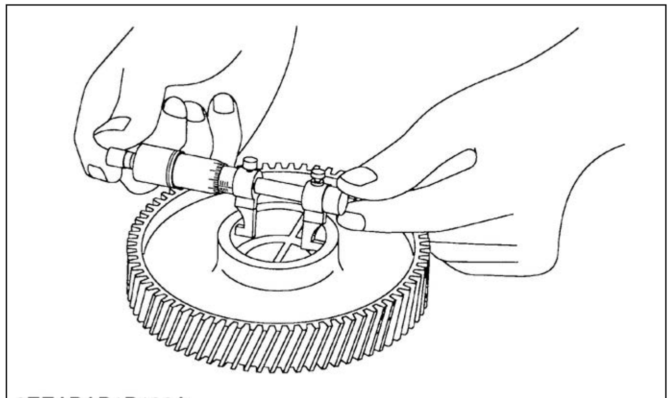
2. Measure the idle gear bushing I.D. with an internal micrometer.

Idle gear 1, 2 bushing I.D.	Factory specification	45.025 to 45.050 mm 1.7727 to 1.7736 in.



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3. Calculate the oil clearance.

■ **NOTE**
- **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.

RELATED PAGE
7.22 Replacing idle gear bushing on page 3-193

7.26 Checking oil clearance between idle gear 3 shaft and idle gear 3 holder

Tools required
- External micrometer
- Internal micrometer

1. Measure the idle gear 3 shaft O.D. with an external micrometer.

Idle gear 3 shaft O.D.	Factory specification	15.957 to 15.984 mm 0.62823 to 0.62929 in.

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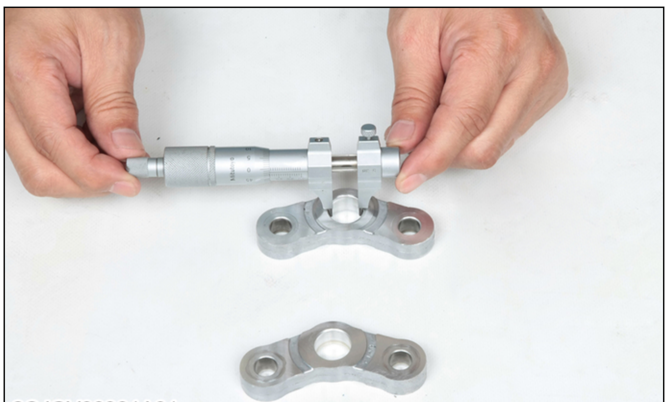
2. Measure the idle gear 3 holder I.D. with an internal micrometer.

Idle gear 3 holder I.D.	Factory specification	16.000 to 16.018 mm 0.62993 to 0.63062 in.



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3. Calculate the oil clearance.

■ **NOTE**
- **If the oil clearance is more than the allowable limit, replace the holder.**

Oil clearance between idle gear 3 shaft and idle gear 3 holder	Factory specification	0.016 to 0.061 mm 0.00063 to 0.0024 in.
	Allowable limit	0.10 mm 0.0039 in.

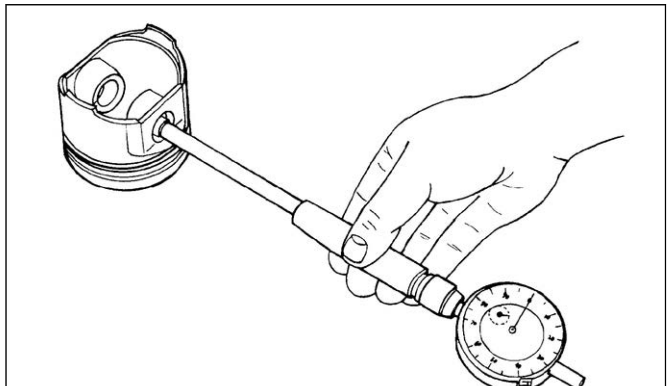
7.27 Checking piston pin bore I.D.

Tools required
- Cylinder gauge

1. Measure the piston pin bore I.D. in the horizontal and vertical directions with a cylinder gauge.

■ **NOTE**
- **If the measurement is more than the allowable limit, replace the piston.**
- **When replacing the piston, select the cylinder head gasket thickness to meet with the top clearance.**

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.



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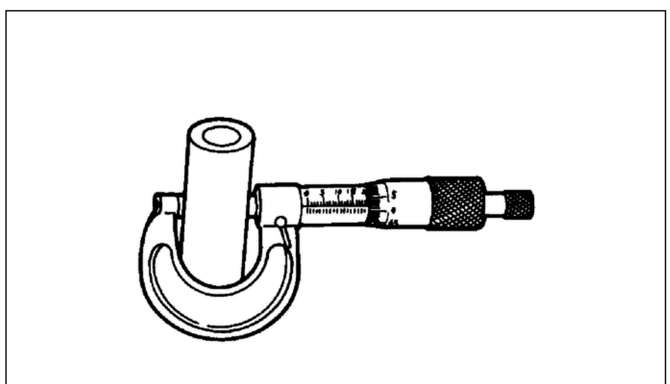
RELATED PAGE
4.36 Selecting cylinder head gasket on page 3-120

7.28 Checking oil clearance between piston pin and small end bushing

Tools required
- External micrometer
- Internal micrometer or cylinder gauge

1. Measure the piston pin O.D. where it contacts the bushing with an external micrometer.

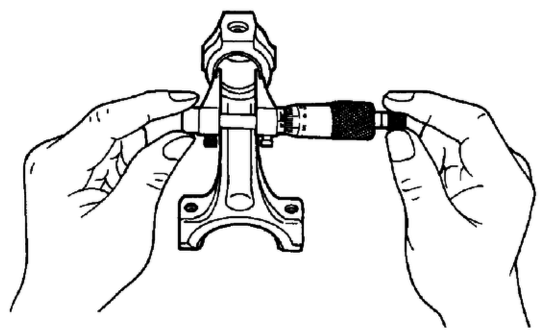
Piston pin O.D.	Factory specification	30.006 to 30.011 mm 1.1814 to 1.1815 in.



2CJGV00302A01

2. Measure the small end bushing I.D. at the connecting rod small end with an internal micrometer or cylinder gauge.

Small end bushing I.D.	Factory specification	30.031 to 30.046 mm 1.1824 to 1.1829 in.



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3. Calculate the oil clearance.

■ **NOTE**
- **If the clearance more than the allowable limit, replace the bushing.**
- **If it still more than the allowable limit, replace the piston pin.**
- **When replacing the small end bushing, select the cylinder head gasket thickness to meet with the top clearance.**

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.

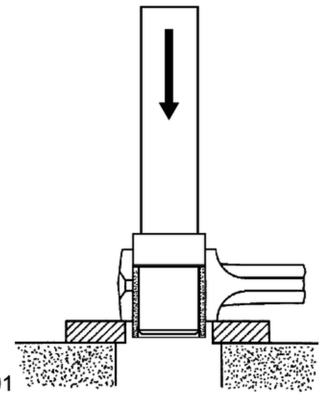
RELATED PAGE
4.36 Selecting cylinder head gasket on page 3-120
7.29 Replacing small end bushing on page 3-197

7.29 Replacing small end bushing

Tools required
- Small end bushing replacing tool

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

(A)



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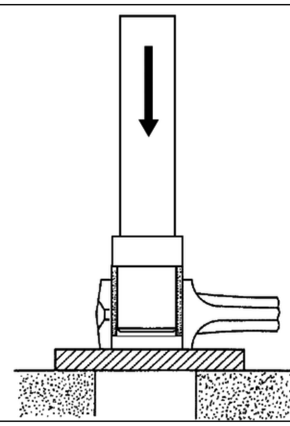
(A) Removing direction

Installing small end bushing
1. Clean a new small end bushing and bore.
2. Insert a new bushing onto the tool.

■ **NOTE**
Apply engine oil to a new small end bushing and bore.

(B)



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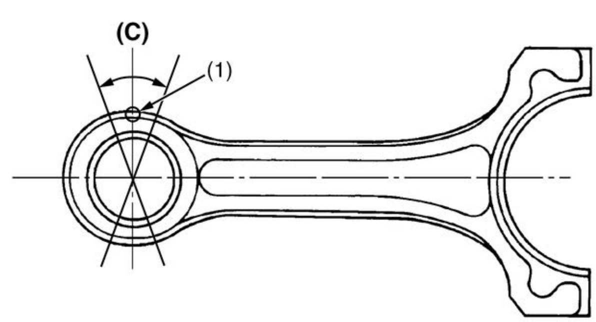
(B) Installing direction

3. 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.



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(1) Seam (C) 0.26 rad (15°)

■ **NOTE**

- **When replacing the small end bushing, select the cylinder head gasket thickness to meet with the top clearance.**

— RELATED PAGE —

4.36 Selecting cylinder head gasket on page 3-120

7.30 Checking connecting rod alignment

■ **NOTE**

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

Tools required

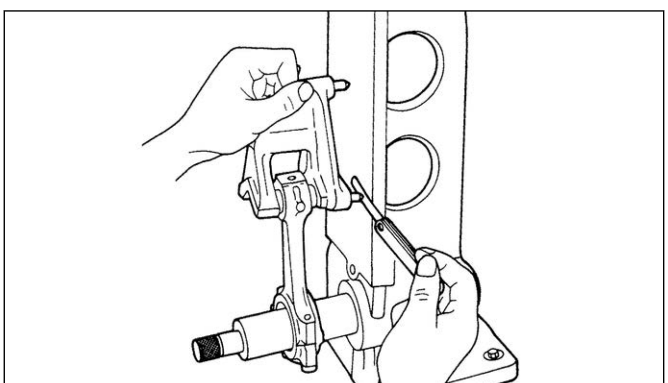
- Connecting rod alignment tool
- Feeler gauge

1. Remove the piston pin from the piston.
2. Install the piston pin into the connecting rod.
3. Install the connecting rod on the alignment tool of the connecting rod.
4. Put a gauge on the piston pin, and move it against the face plate.

■ **NOTE**

- **If the gauge does not touch fully against the face plate, measure the space between the gauge pin and face plate.**
- **If the measurement is more than the allowable limit, replace the connecting rod.**
- **When replacing the connecting rod, select the cylinder head gasket thickness to meet with the top clearance.**

Connecting rod alignment	Allowable limit	0.05 mm 0.002 in.



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— RELATED PAGE —

4.36 Selecting cylinder head gasket on page 3-120

7.28 Checking oil clearance between piston pin and small end bushing on page 3-196

7.31 Checking piston ring gap

Tools required

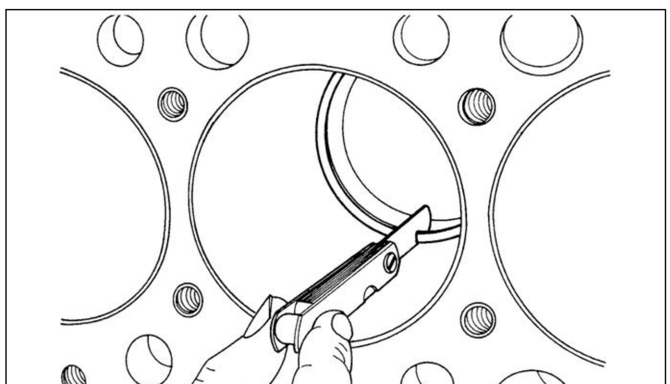
- Feeler gauge

1. Put the piston ring into the lower part of the liner (the least worn out part) with the piston.
2. Measure the ring gap with a feeler gauge.

■ **NOTE**

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

Top ring	Factory specification	0.30 to 0.40 mm 0.012 to 0.015 in.	
	Allowable limit	1.25 mm 0.0492 in.	
Second ring	Factory specification	V3800-TIEF4 V3800-TIEF4C	0.45 to 0.60 mm 0.018 to 0.023 in.
		V3800-TIEF4H	0.30 to 0.40 mm 0.012 to 0.015 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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7.32 Checking clearance between piston ring and ring groove

Tools required

- Feeler gauge

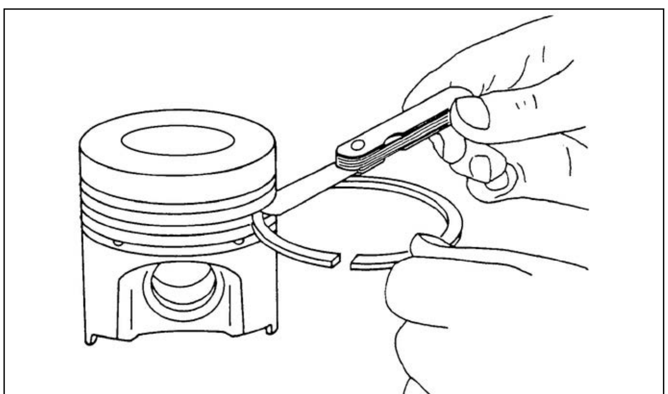
1. Clean the rings and the ring grooves, and install each ring in its groove.

2. Measure the clearance between the ring and the groove with a feeler gauge.

■ **NOTE**

- **If the clearance is more than the allowable limit, replace the piston ring.**
- **If the clearance stays more than the allowable limit with new ring, replace the piston also.**
- **When replacing the piston, select the cylinder head gasket thickness to meet with the top clearance.**

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	V3800-TIEF4 V3800-TIEF4C	0.065 to 0.10 mm 0.0026 to 0.0039 in.
			V3800-TIEF4H	–
		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		0.15 mm 0.0059 in.
		Oil ring		0.15 mm 0.0059 in.



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RELATED PAGE

4.36 Selecting cylinder head gasket on page 3-120

7.33 Checking side clearance of crankshaft

Tools required

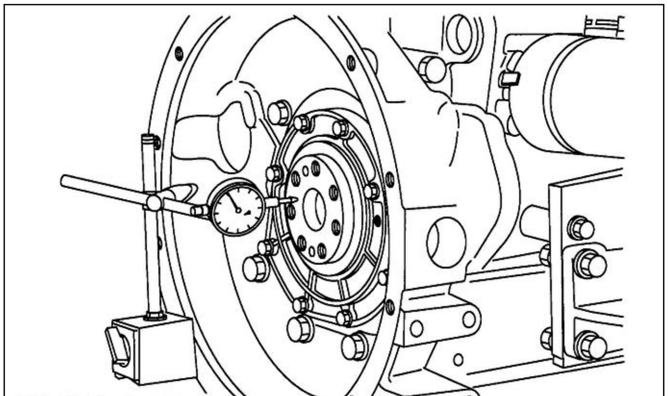
- Dial gauge

1. Set a dial gauge with its point on the end of the crankshaft.

2. Move the crankshaft to the front and rear to measure the side clearance.

■ **NOTE**
- **If the measurement is more than the allowable limit, replace the thrust bearings.**
- **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.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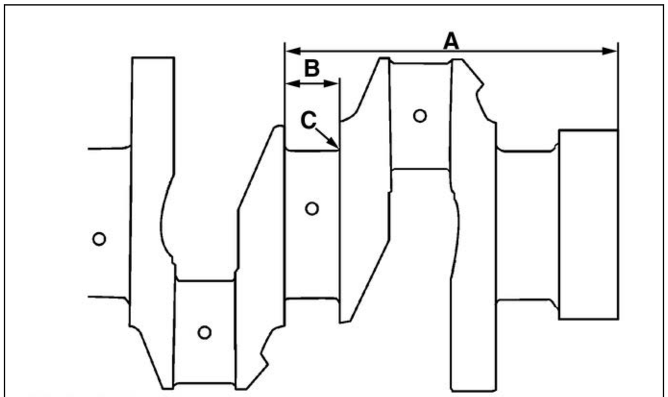
(Reference)
- Oversize dimensions of crankshaft journal

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.	169.20 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 = 0.8 S		



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A Dimension A
B Dimension B
C Dimension C

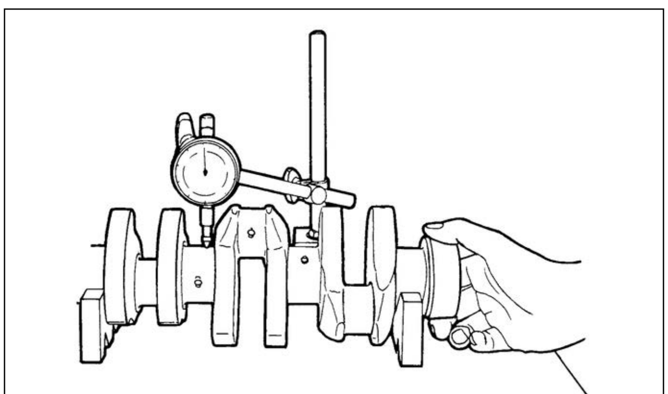
7.34 Checking crankshaft alignment

Tools required
- V blocks
- Surface plate
- Dial gauge

1. Hold the two end journals of crankshaft with V blocks on the surface plate.
2. Set a dial gauge with its point on the middle journal.
3. Turn the crankshaft slowly and read the variation on the indicator (Half of the measurement).

■ **NOTE**
- **If the measurement is more than the allowable limit, replace the crankshaft.**
- **If the crankshaft is replaced, it is necessary to calibrate the injection timing with the diagnosis tool.**

Crankshaft alignment	Allowable limit	0.02 mm 0.0008 in.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— RELATED PAGE —
4.37 Measuring angular deviation between crankshaft T.D.C. and crank position sensor detected T.D.C. on page 3-121

7.35 Checking oil clearance between crankpin and crankpin bearing

Tools required

- Plastigauge

1. Clean the crankpin and crankpin bearing (2).
2. Put a strip of plastigauge on the center of the crankpin.

NOTE
- **Do not put the plastigauge into the crankpin oil hole.**

3. Install the connecting rod cap.
4. Tighten the connecting rod screws to the specified torque.

NOTE
- **When you tighten the connecting rod screws, do not move the crankshaft.**

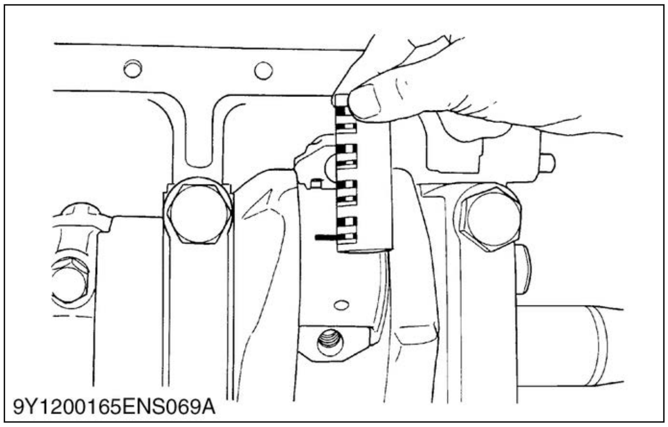
Tightening torque	Connecting rod screw	79 to 83 N·m 8.0 to 8.5 kgf·m 58 to 61 lbf·ft

5. Remove the connecting rod cap again.
6. Measure the width that it becomes flat with the scale to get the oil clearance.

NOTE
- **If the clearance more than the allowable limit, replace the crankpin bearing (2).**
- **If it still more than the allowable limit, replace the piston pin.**
- **When replacing the crankpin bearing (2), select the cylinder head gasket thickness to meet with the top clearance.**

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

Oil clearance between crankpin and crankpin bearing (2)	Factory specification	0.018 to 0.051 mm 0.00071 to 0.0020 in.
	Allowable limit	0.20 mm 0.0079 in.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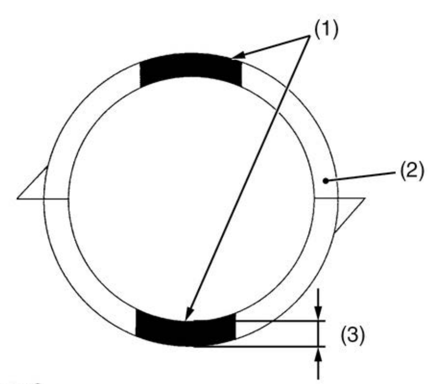
IMPORTANT
- **To replace it with a specific STD service part, make sure the crankpin bearing (2) has the same ID color (1) as the connecting rod.**

ID Color	Connecting rod	Crankpin 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	56.000 to 56.010 mm 2.2048 to 2.2051 in.	S	1C020-22334	1.491 to 1.496 mm 0.05870 to 0.05889 in.



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(1) ID color
(2) Crankpin bearing
(3) Center wall thick

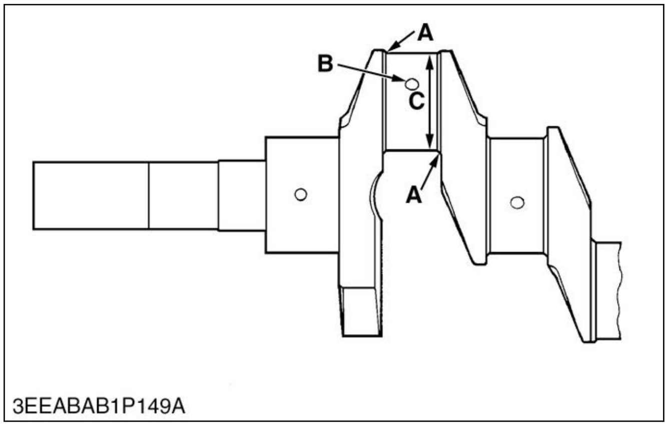
(Reference)
- Undersize dimensions of crank pin

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

(Continued)

Undersize	0.2 mm 0.008 in.	0.4 mm 0.02 in.
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 crankpin must be fine-finished to higher than Rmax = 0.8 S		

* Holes to be de-burred and edges rounded with 1.0 to 1.5 mm (0.040 to 0.059 in.) relief.



A Dimension A
B Dimension B
C Dimension C

7.36 Checking oil clearance between crankshaft journal and crankshaft bearing

Tools required

- Plastigauge

1. Clean the crankshaft journal and crankshaft bearing.
2. Put a strip of plastigauge on the center of the journal.

IMPORTANT

- **Do not put the plastigauge into the oil hole of the journal.**

3. Install the main bearing case.
4. Tighten the screws 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

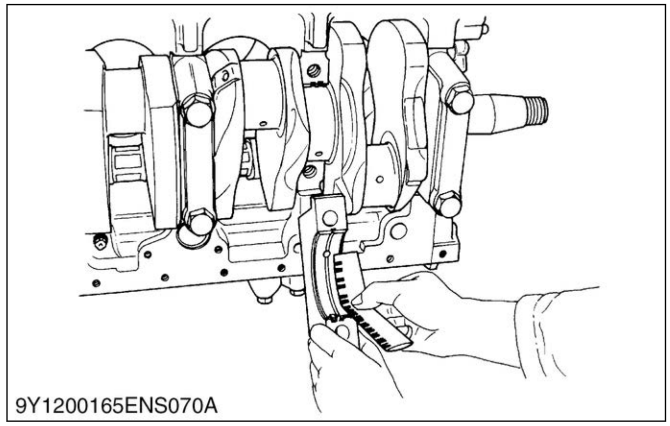
5. Remove the main bearing case again.
6. Measure the width that it becomes flat with the scale to get the oil clearance.

NOTE

- **If the clearance more than the allowable limit, replace the crankshaft bearing.**
- **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.

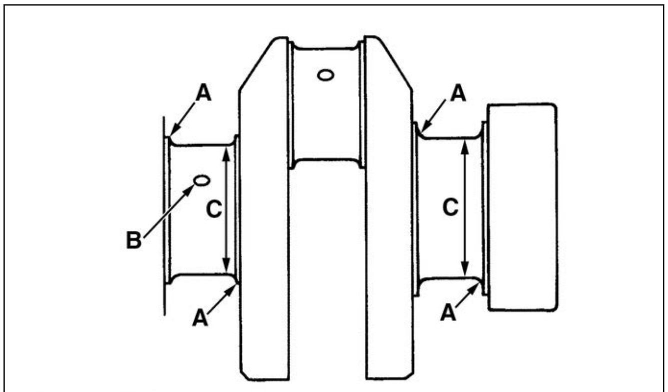


(Reference)

- 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 = 0.8 S		

* Holes to be de-burred and edges rounded with 1.0 to 1.5 mm (0.040 to 0.059 in.) relief.



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A Dimension A
B Dimension B
C Dimension C

7.37 Replacing crankshaft sleeve

Tools required

- Sleeve guide
- Crankshaft sleeve press fit tool

Removing crankshaft sleeve

1. Remove the used crankshaft sleeve.

Installing crankshaft sleeve

1. Set the sleeve guide (3) to the crankshaft (1).
2. Heat a new sleeve to the specified temperature.

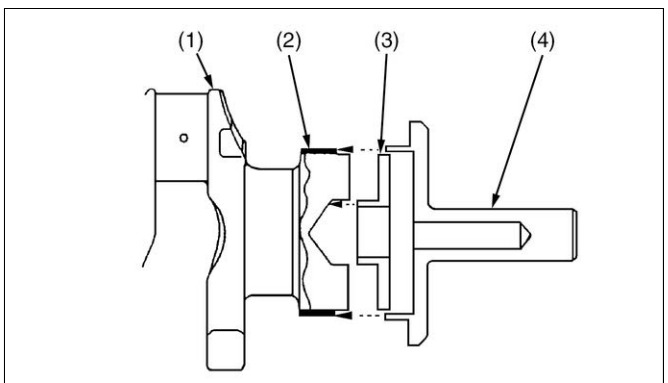
Heating temperature of a new sleeve	150 to 200 °C 302 to 392 °F

3. Set the sleeve to the crankshaft (1) as shown in figure.

■ **NOTE**

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

4. Press fit the sleeve using the crankshaft sleeve press fit tool (4).



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(1) Crankshaft
(2) Crankshaft sleeve
(3) Sleeve guide
(4) Crankshaft sleeve press fit tool

7.38 Checking cylinder wear

Tools required

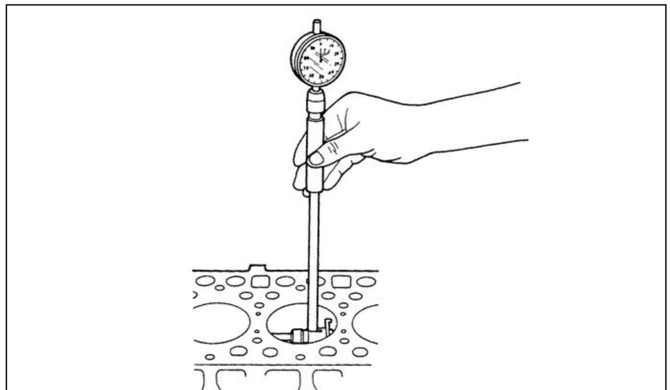
- Cylinder gauge

1. Measure the cylinder bore I.D. at the 6 positions (see figure) with a cylinder gauge and find the maximum and minimum inner diameters.
2. Find the difference between the maximum and the minimum inner diameters.

■ **NOTE**

- **If the maximum I.D. or the difference is more than the allowable limit, bore and hone it to the oversize dimension.**

Cylinder bore I.D.	Factory specification	100.000 to 100.022 mm 3.93701 to 3.93787 in.
	Allowable limit	100.150 mm 3.94291 in.



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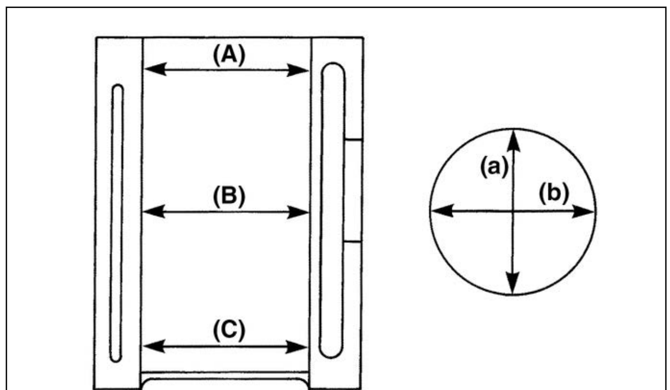

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(A) Top
(B) Middle
(C) Bottom
(a) Right-angled to piston pin
(b) Piston pin direction

3. Check the cylinder wall for scratches.

■ **NOTE**

- **If you find deep scratches, bore the cylinder.**

RELATED PAGE

7.39 Adjusting cylinder correction (over size) on page 3-204

7.39 Adjusting cylinder correction (over size)

Tools required

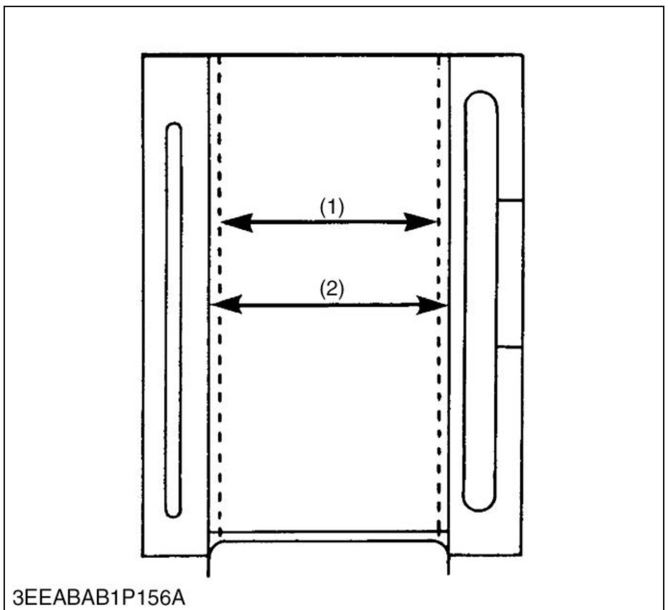
- Cylinder gauge

1. Measure the cylinder bore I.D. at the 6 positions (see figure) with a cylinder gauge and find the maximum and minimum inner diameters.
2. If the cylinder wear is more than the allowable limit, bore and hone it to the specified dimension.

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

   - Oversize cylinder bore I.D.

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



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

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

RELATED PAGE

7.38 Checking cylinder wear on page 3-203

7.40 Checking clearance between inner rotor and outer rotor

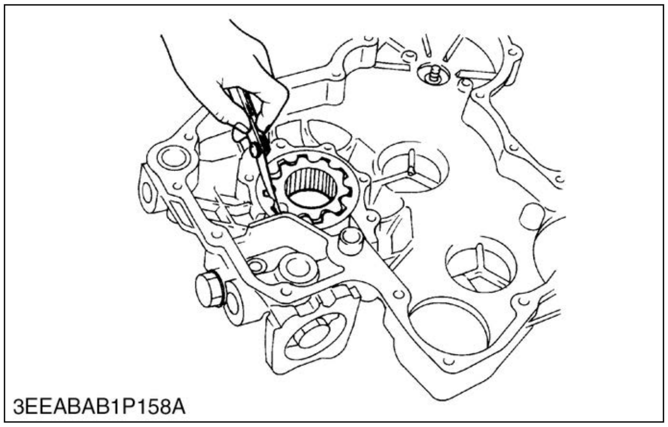
Tools required

- Feeler gauge

1. Measure the clearance between the lobes of the inner rotor and the outer rotor with a feeler gauge.

   ■ NOTE
   - **If the clearance more than the 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.



7.41 Checking clearance between outer rotor and pump body

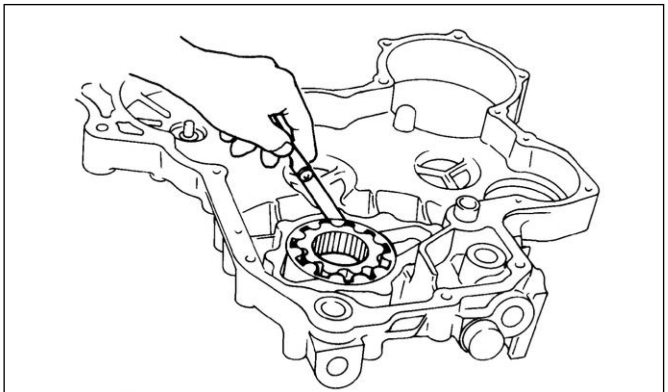
Tools required

- Feeler gauge

1. Measure the clearance between the outer rotor and the pump body with a feeler gauge.

■ **NOTE**
- **If the clearance more than the allowable limit, replace the oil pump rotor assembly.**
- **If the clearance stays more than the allowable limit after replacing the oil pump rotor assembly, replace the gear case.**
- **If the gear case is replaced, it is necessary to calibrate the injection timing with the diagnosis tool.**

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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RELATED PAGE
4.37 Measuring angular deviation between crankshaft T.D.C. and crank position sensor detected T.D.C. on page 3-121

7.42 Checking clearance between rotor and cover

Tools required
- Plastigauge
- Impact screwdriver

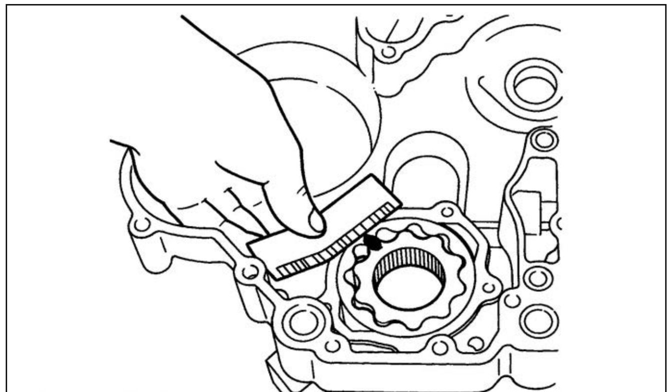
1. Put a strip of plastigauge on the rotor face with grease.
2. Install the cover and tighten the screws with the specified torque.

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

3. Remove the cover carefully.
4. Measure the width that plastigauge becomes flat with the scale to get the oil clearance.

■ **NOTE**
- **If the clearance is more than the 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.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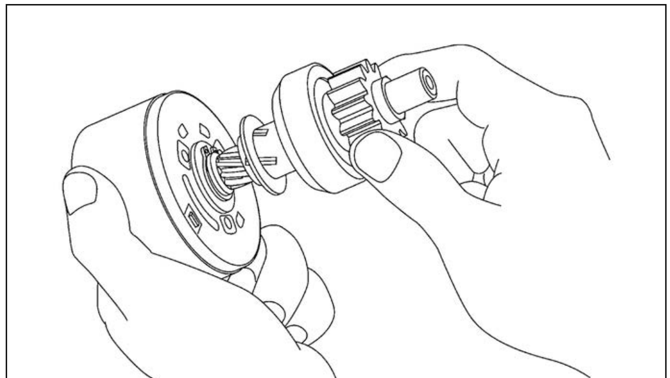
7.43 Checking overrunning clutch of starter

1. Check the pinion for wear or damage.

■ **NOTE**
- **If there is any damage, replace the overrunning clutch assembly.**

2. Check that the pinion turns freely and smoothly in the direction that it overruns (Check the overrunning function.).

■ **NOTE**
- **If there is any damage, replace the overrunning clutch assembly.**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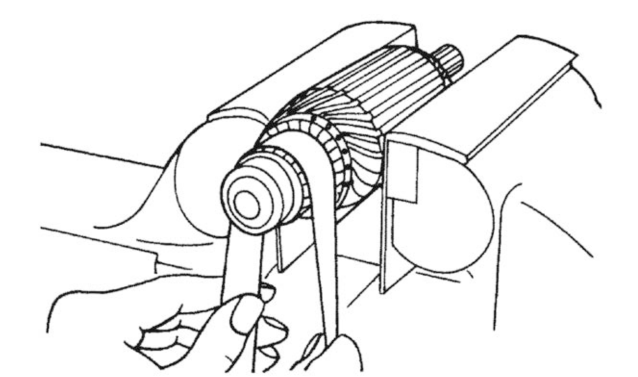
7.44 Checking commutator and mica of starter

Tools required
- Emery paper (#300)
- External micrometer

1. Check the contact of the commutator for wear.
2. Grind the commutator with emery paper (#300) if it is lightly worn.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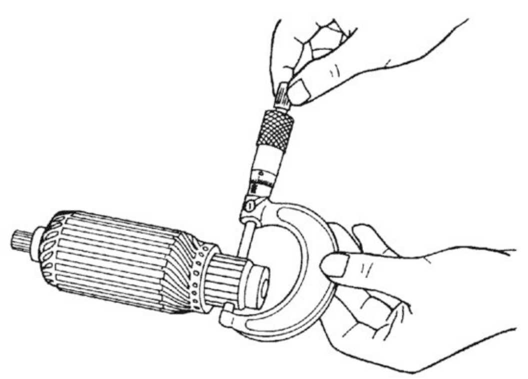
3. Measure the commutator O.D. with an external micrometer at several points.

■ **NOTE**
- **If the minimum O.D. is less than the allowable limit, replace the armature assembly.**
- **If the difference of the O.D.'s more than the allowable limit, correct the commutator on a lathe to the factory specification.**

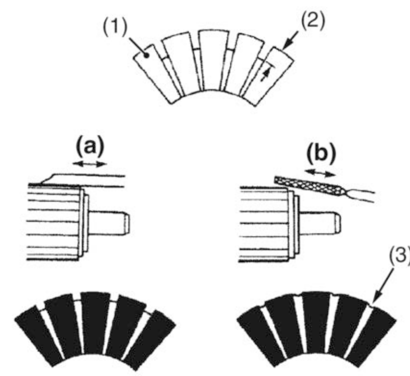
Commutator O.D.	Factory specification	32.0 mm 1.26 in.
	Allowable limit	31.4 mm 1.24 in.


3EEABAB1P183A

4. Measure the mica undercut.

■ **NOTE**
- **If the undercut is less than the allowable limit, correct it with a saw blade. Chamfer the segment edges.**

Mica undercut	Factory specification	0.50 mm 0.020 in.
	Allowable limit	0.20 mm 0.0079 in.



3EEABAB1P184A

(1) Segment
(2) Depth of mica
(3) Mica
(a) Good
(b) Bad

7.45 Checking brush wear of starter

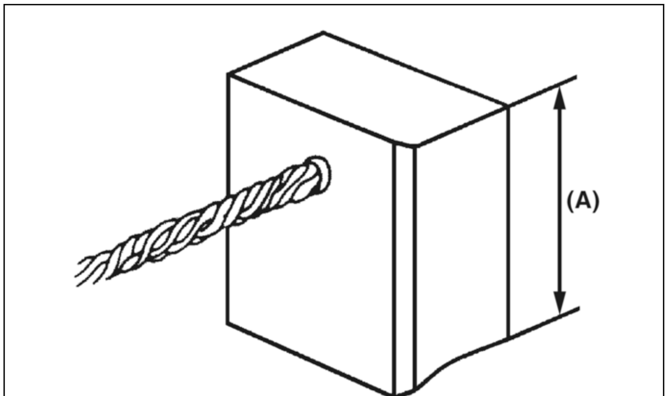
Tools required
- Vernier caliper
- Emery paper (#300 or above)

1. Measure the brush length (A) with a vernier caliper.

■ **NOTE**

- **If the length is less than the allowable limit, replace the yoke assembly and brush holder assembly.**

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



3EEABAB1P185A

(A) Brush length

2. After you replace the brush, put an emery paper (#300 or above) on the commutator and correct the contact position.

7.46 Checking brush holder of starter

Tools required

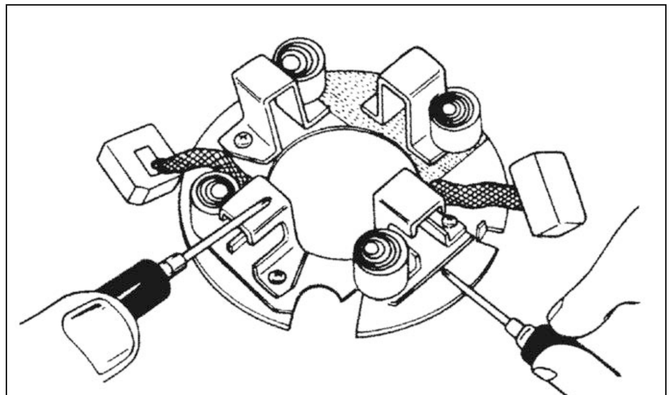
- Circuit tester

1. Check the continuity across the brush holder and the holder support with a circuit tester.

■ **NOTE**

- **If electricity flows, replace the brush holder assembly.**

Resistance between brush holder and holder support	Factory specification	Infinity



3EEABAB1P189A

7.47 Checking armature coil of starter

Tools required

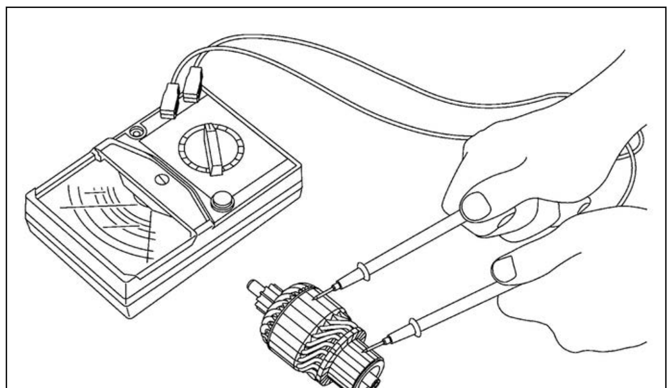
- Circuit tester

1. Check the continuity across the commutator and armature coil core with the resistance range of circuit tester.

■ **NOTE**

- **If electricity is out of factory specification, replace the armature assembly.**

Resistance between commutator and armature coil core	Factory specification	Infinity

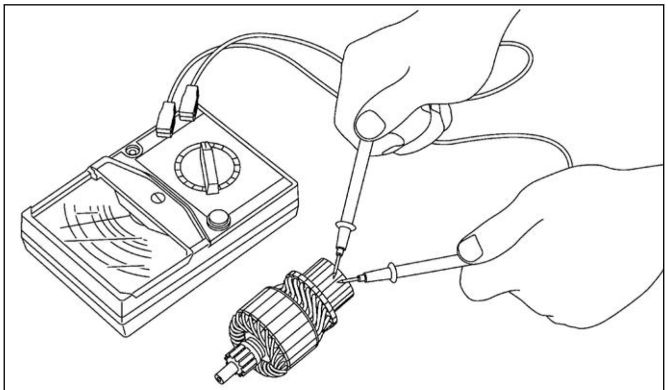


3EEAEAC1P048A

2. Check the continuity across the segments of the commutator with the resistance range of circuit tester.

■ NOTE
- **If electricity is out of factory specification, replace the armature assembly.**

Resistance between commutator and segment	Factory specification	0 Ω



3EEAEAC1P049A

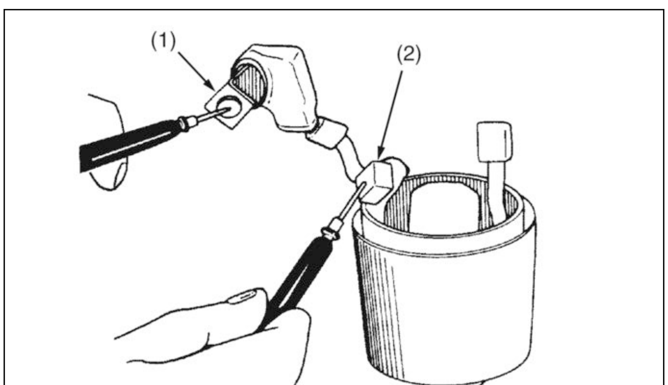
7.48 Checking field coil of starter

Tools required
- Circuit tester

1. Check the continuity across the lead (1) and brush (2) with a resistance range of circuit tester.

■ NOTE
- **If electricity is out of factory specification, replace the yoke assembly.**

Resistance between lead and brush	Factory specification	0 Ω



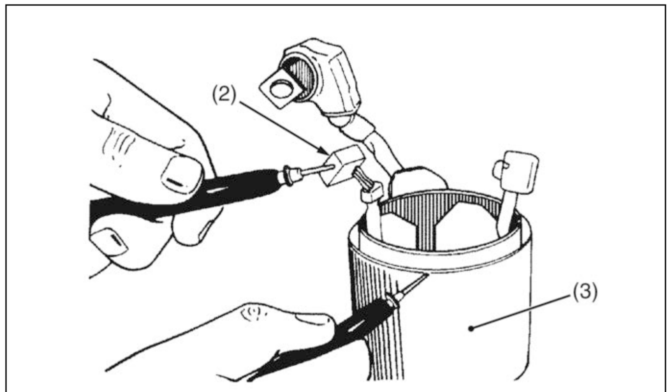
3EEABAB1P190A

(1) Lead (2) Brush

2. Check the continuity across the brush (2) and yoke (3) with a resistance range of circuit tester.

■ NOTE
- **If electricity is out of factory specification, replace the yoke assembly.**

Resistance between brush and yoke	Factory specification	Infinity



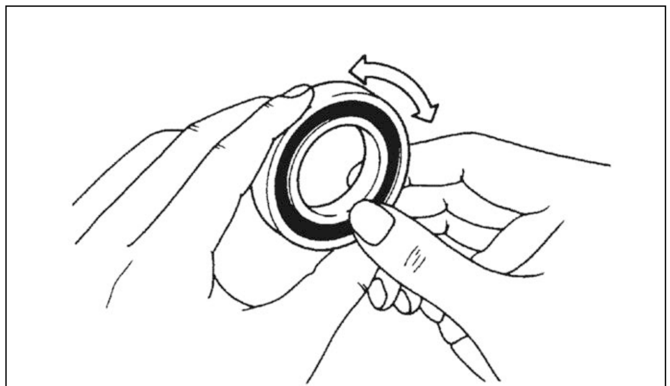
3EEABAB1P191A

(2) Brush (3) Yoke

7.49 Checking bearing of alternator

1. Check that the bearing can turn smoothly.

■ NOTE
- **If not smoothly, replace it.**



3EEABAB1P192A

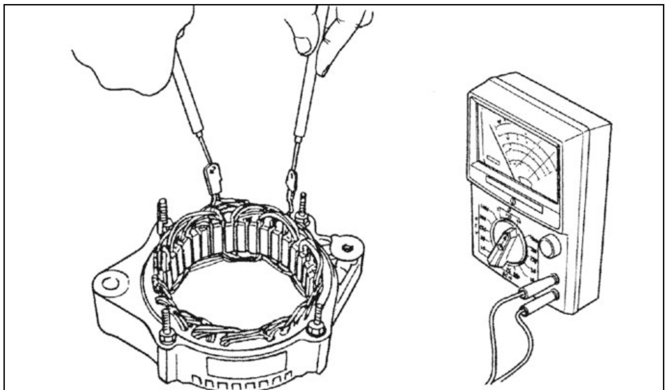
7.50 Checking stator of alternator

Tools required
- Circuit tester

1. Measure the resistance across each lead of the stator coil with the resistance range of circuit tester.

■ **NOTE**
- **If electricity is out of factory specification, replace the stator assembly.**

Resistance	Factory specification	Less than 1.0 Ω



3EEABAB1P193A

2. Check the continuity across each stator coil lead and core with the resistance range of circuit tester.

■ **NOTE**
- **If it does not show infinity, replace the stator assembly.**

Resistance	Factory specification	Infinity

7.51 Checking rotor of alternator

Tools required
- Circuit tester

1. Measure the resistance across the slip rings with the resistance range of circuit tester.

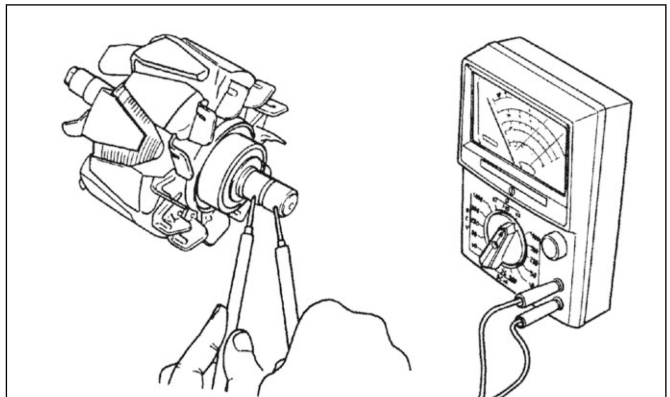
■ **NOTE**
- **If electricity is out of factory specification, replace the rotor.**

Resistance between slip rings	Factory specification	2.8 to 3.3 Ω

2. Check the continuity across the slip ring and core with the resistance range of circuit tester.

■ **NOTE**
- **If electricity is out of factory specification, replace the rotor.**

Resistance between slip ring and rotor core	Factory specification	Infinity



3EEABAB1P194A

7.52 Checking slip ring of alternator

Tools required
- Emery paper (#500 to 600)
- Vernier caliper

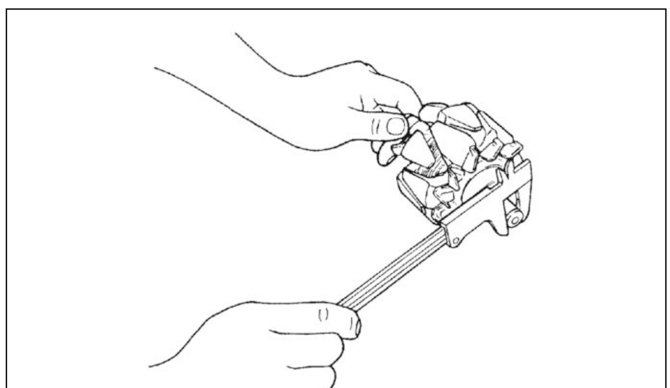
1. Check the slip ring for dirt or scratch.

■ **NOTE**
- **If dirt is detected, clean the slip ring using a cloth soaked in alcohol.**
- **If there is slight score, correct with an emery paper (#500 to 600).**

2. Measure the O.D. of the slip ring with a vernier calipers.

■ **NOTE**
- **If the measurement is less than the 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.



3EEABAB1P195A

7.53 Checking brush wear of alternator

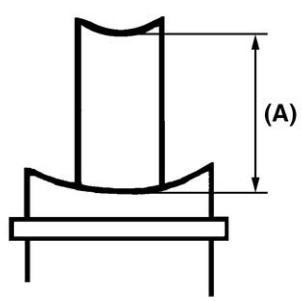
Tools required

- Vernier caliper

1. Measure the brush length (A) with a vernier calipers.

   NOTE
   - **If the measurement is less than the allowable limit, replace it.**

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



3EEABAD1P002A

(A) Brush length

2. Make sure that the brush moves smoothly.

   NOTE
   - **If the brush is damaged and not smoothly, replace it.**

7.54 Replacing supply pump

Tools required

- Laptop computer (Diagmaster (software) installed)
- Interface (DST-i)

Removing supply pump

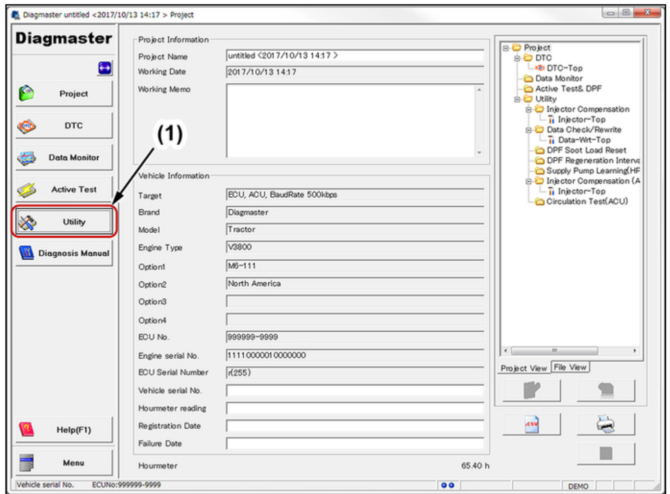
1. Remove the supply pump.

Installing supply pump

1. Install the supply pump.

Initializing supply pump

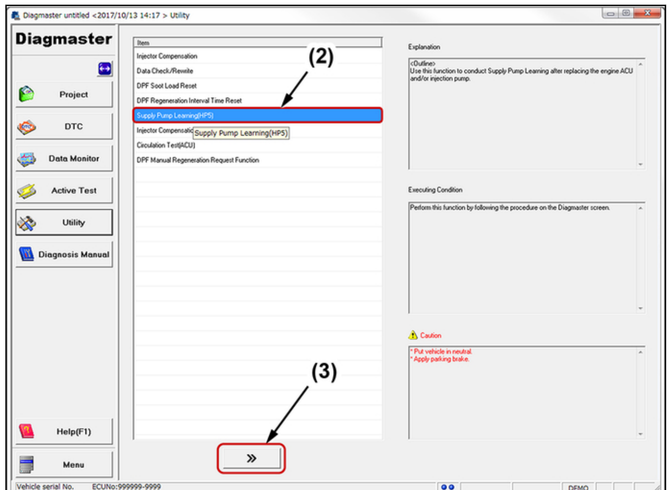
1. Start "Diagmaster", then click the **[Utility]** button (1) from the project window.



2CJGV00226A01

(1) Utility button

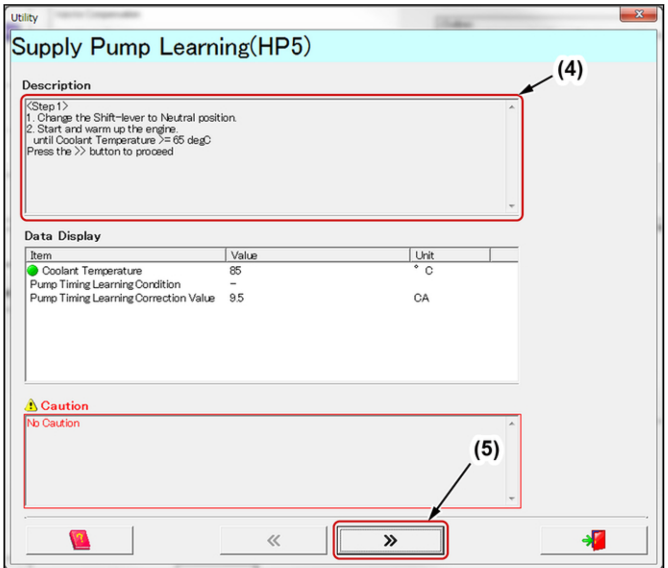
2. Select the "Supply Pump Learning (HP5)" item (2), then click the **[proceed]** button (3).



2CJGV00227A01

(2) Supply Pump Learning (HP5) item
(3) Proceed button

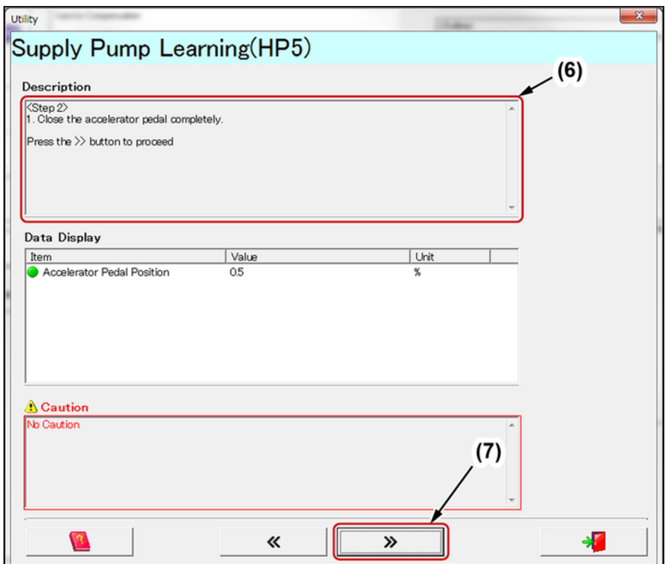
3. Follow the instructions according to steps of "Description" screen (4), then click the **[proceed]** button (5).



2CJGV00228A01

(4) Description screen (5) Proceed button

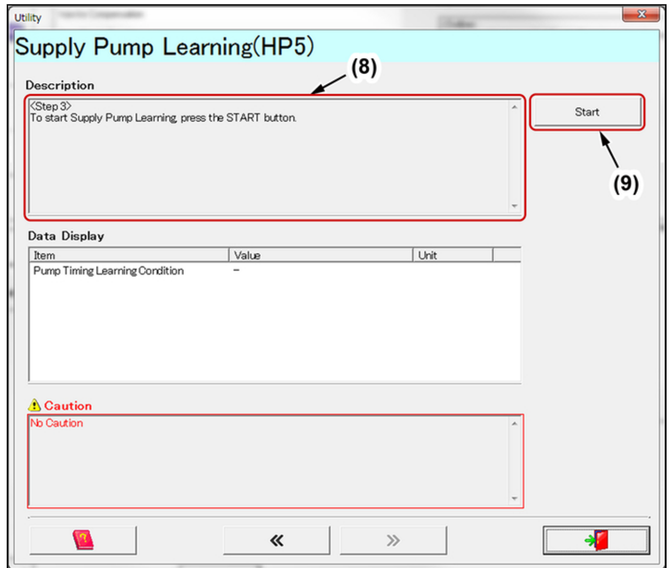
4. Follow the instructions according to steps of "Description" screen (6), then click the **[proceed]** button (7).



2CJGV00229A01

(6) Description screen (7) Proceed button

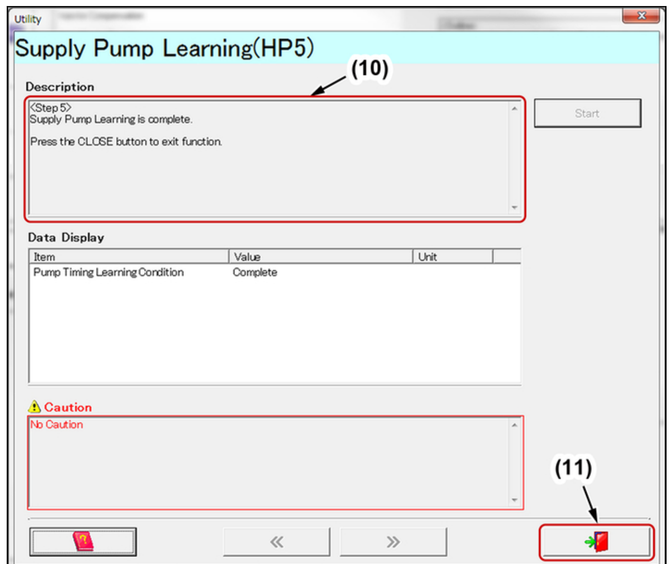
5. Follow the instructions according to steps of "Description" screen (8), then click the **[Start]** button (9).



2CJGV00230A01

(8) Description screen (9) Start button

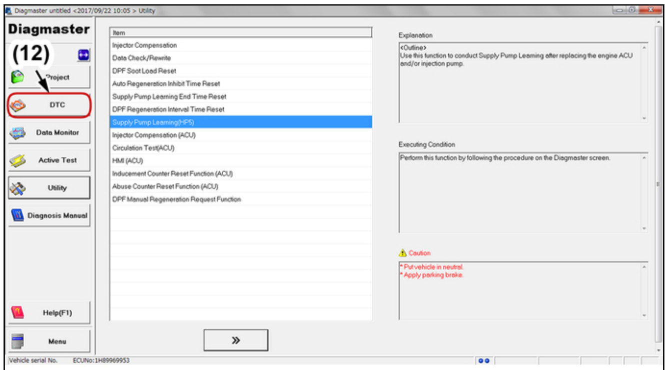
6. Follow the instructions according to steps of "Description" screen (10), then click the **[Close]** button (11).



2CJGV00231A01

(10) Description screen (11) Close button

7. Click the **[DTC]** button (12)



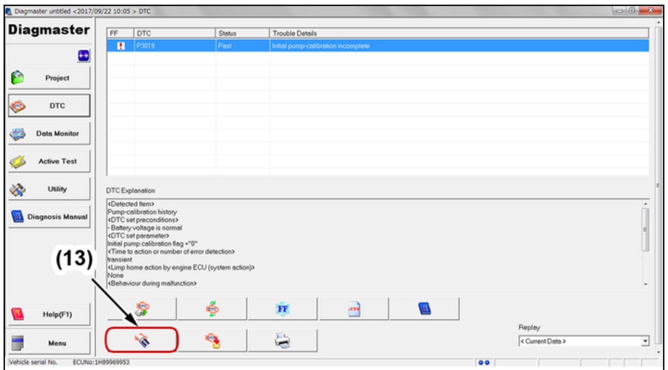
2CJGV00314A01

(12) DTC button

8. Confirm that the status of "P3019" is "Past", then click the **[Clear DTC]** button (13).

NOTE

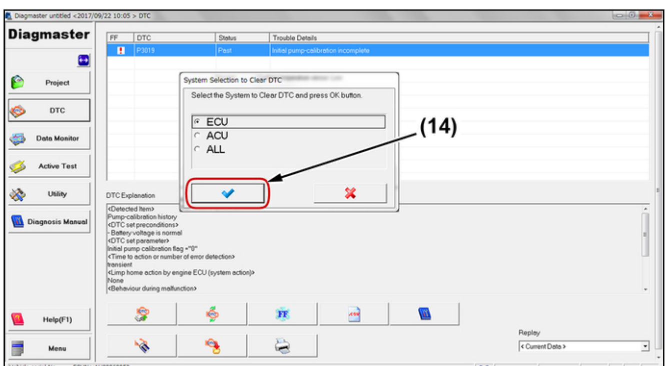
- **This DTC is a DTC that always occurs when "Supply Pump Learning (HP5)" is executed, it is not a malfunction.**



2CJGV00315A01

(13) Clear DTC button

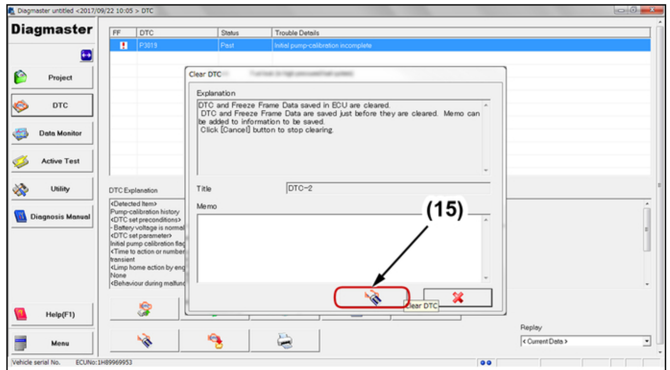
9. Select the "ECU" system, then click the **[OK]** button (14).



2CJGV00316A01

(14) OK button

10. Click the **[Clear DTC]** button (15) to clear DTC and exit function.



2CJGV00317A01

(15) Clear DTC button

RELATED PAGE

5.24 Removing supply pump on page 3-138
6.24 Installing supply pump on page 3-162

7.55 Replacing injector

NOTE

- **When you register the injector ID to ECU, you have to stop the engine, then place the key switch in the ON position.**

Tools required

- Laptop computer (Diagmaster (software) installed)
- Interface (DST-i)

Removing injector

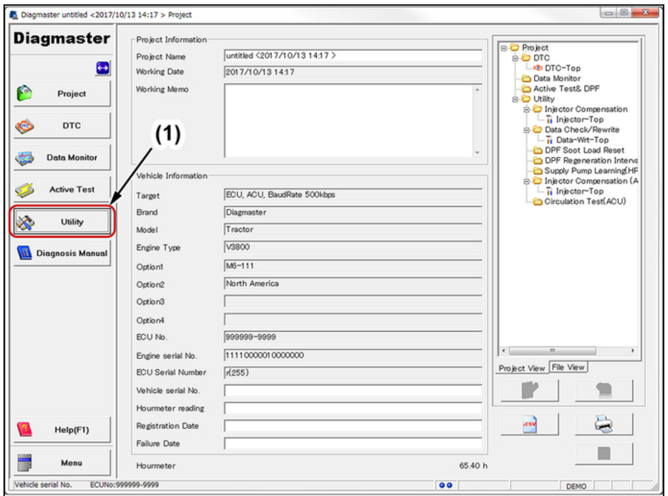
1. Remove the injector.

Installing injector

1. Install the injector.

Injector compensation

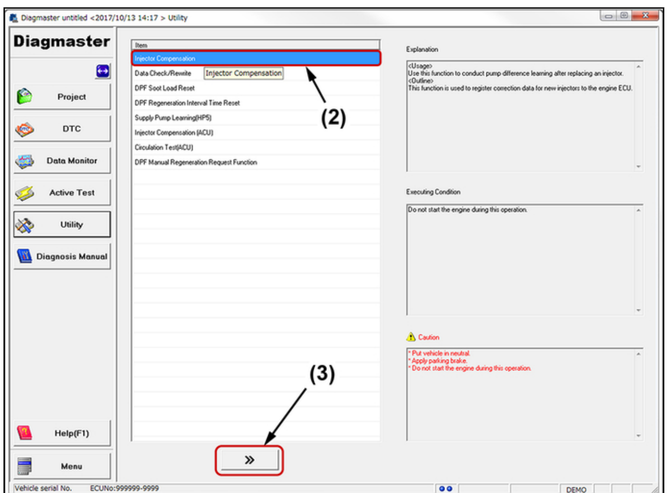
1. Start "Diagmaster", then click the **[Utility]** button (1) from the project window.



2CJGV00226A01

(1) Utility button

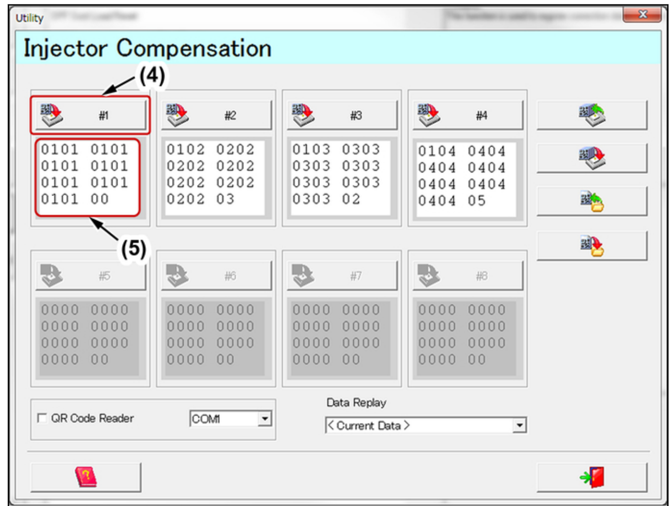
2. Select the "Injector Compensation" item (2), then click the **[proceed]** button (3).



2CJGV00232A01

(2) Injector Compensation item (3) Proceed button

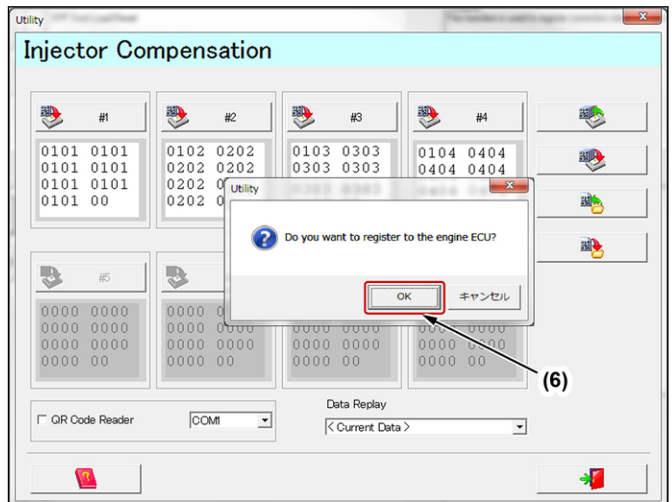
3. Enter the injector compensation value to the initial display (5), then click the **[Register]** button (4).



2CJGV00233A01

(4) Register button (5) Initial display

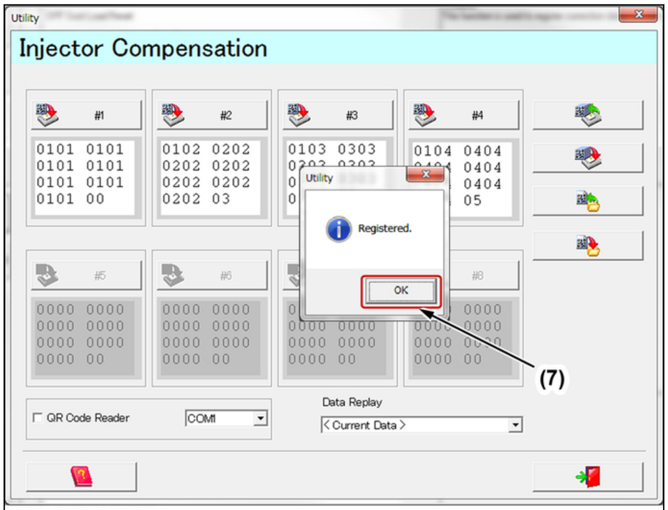
4. Click the **[OK]** button (6) if rewriting is OK.



2CJGV00234A01

(6) OK button

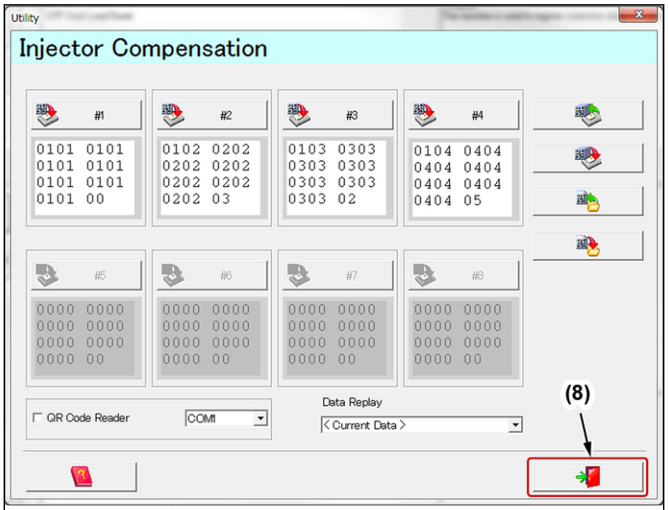
5. Click the **[OK]** button (7) when rewriting is correctly completed.



2CJGV00235A01

(7) OK button

6. Click the **[Close]** button (8) to exit function.

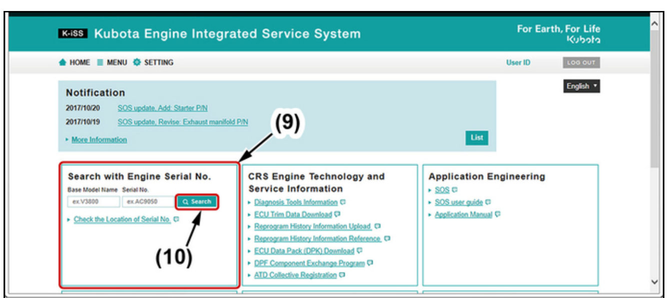


2CJGV00233A02

(8) Close button

K-iSS registration

1. Enter the base model name and serial number to the "Search with Engine Serial No." window (9), then click the **[Search]** button (10).

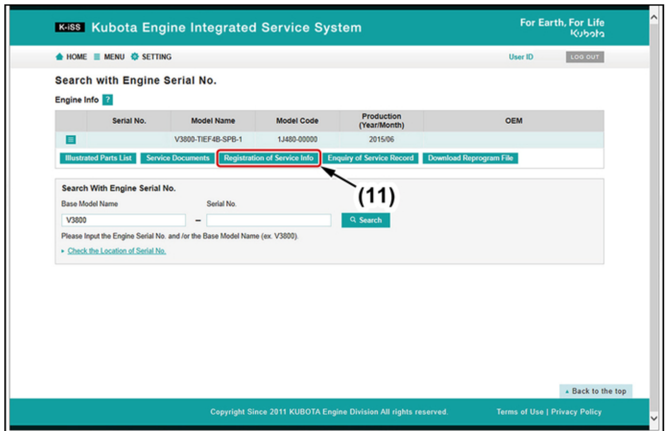


2CJGV00236A05

(9) Search with Engine Serial No. window

(10) Search button

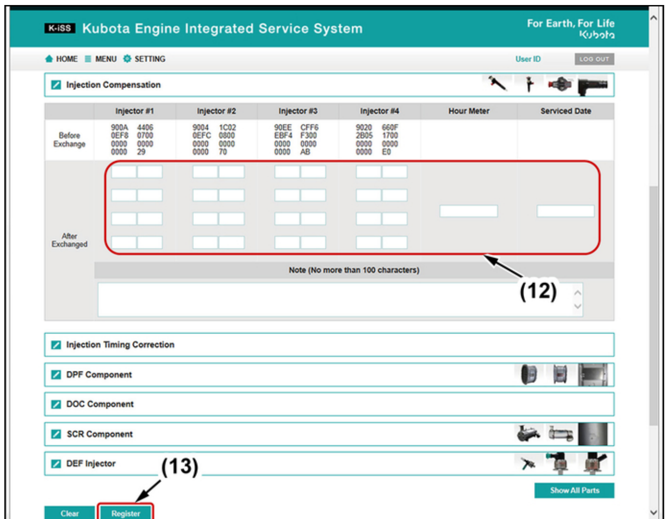
2. Click the **[Registration of Service Info.]** button (11).



2CJGV00237A06

(11) Registration of Service Info. button

3. Select the "Injection Compensation" and enter the new service information to the "After Exchanged" window (12), then click the **[Register]** button (13).



2CJGV00238A03

(12) After Exchanged window

(13) Register button

RELATED PAGE

5.16 Removing injector on page 3-134
6.31 Installing injector on page 3-168

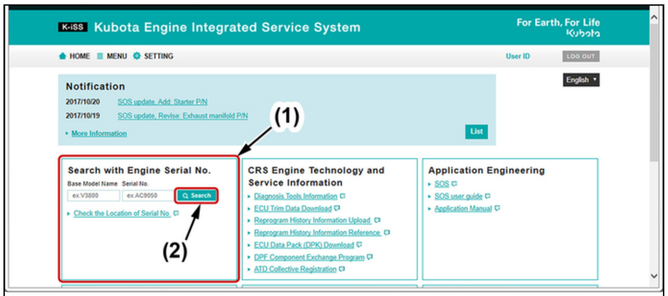
7.56 Replacing ECU

Tools required

- Laptop computer (Diagmaster (software) installed)
- Interface (DST-i)

Download DPK file (from K-iSS)

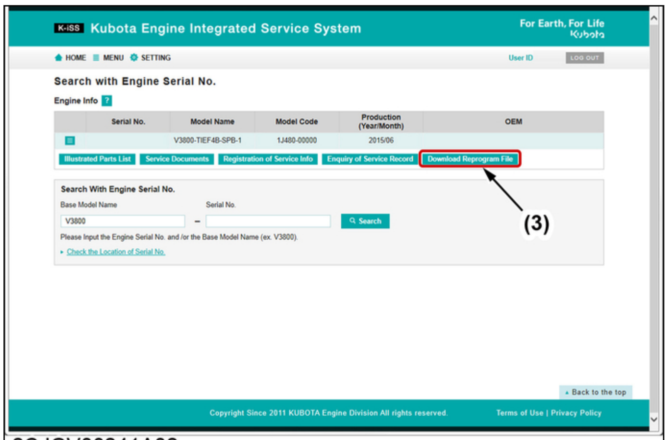
1. Enter the base model name and serial number to the "Search with Engine Serial No." window (1), then click the **[Search]** button (2).



2CJGV00240A02

(1) Search with Engine Serial No. window
(2) Search button

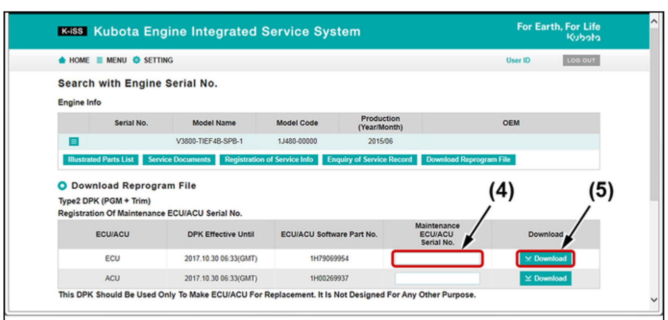
2. Click the **[Download Reprogram File]** button (3).



2CJGV00241A02

(3) Download Reprogram File button

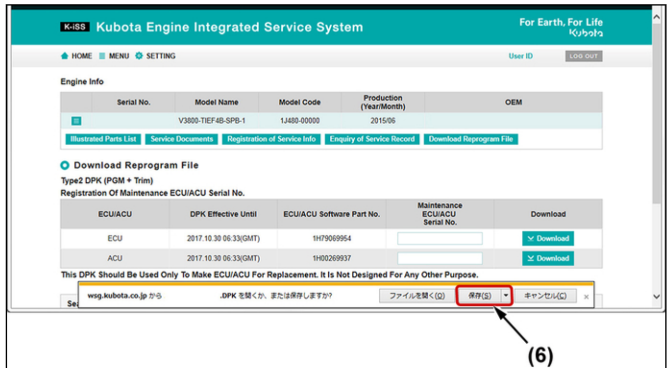
3. Enter the service ECU serial number (4), then click the **[Download]** button (5).



2CJGV00242A03

(4) Service ECU serial number
(5) Download button

4. Click the **[Save]** button (6), then download the DPK file.

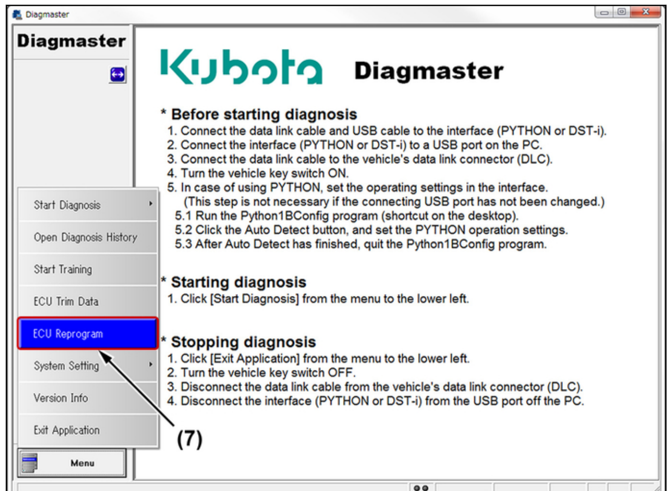


2CJGV00243A02

(6) Save button

ECU reprogram

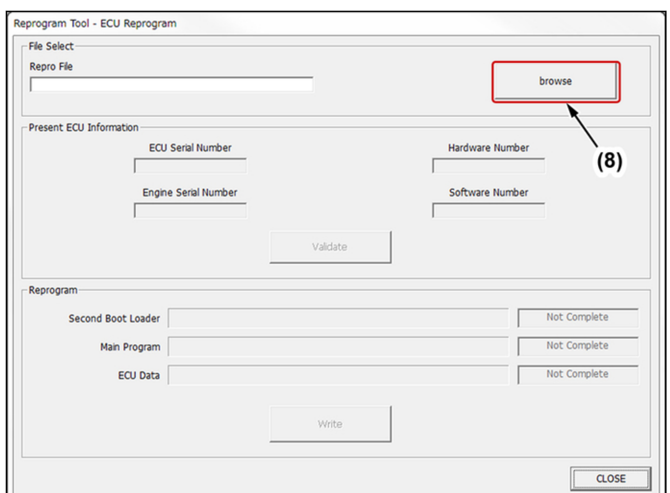
1. Start "Diagmaster" and click the **[ECU Reprogram]** button (7) from the default window.



2CJGV00244A03

(7) ECU Reprogram button

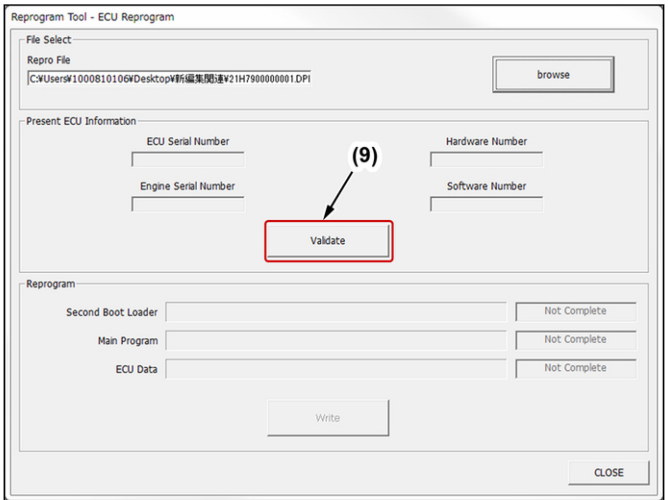
2. Select the download file (DPK file), then click the **[browse]** button (8).



2CJGV00245A03

(8) Browse button

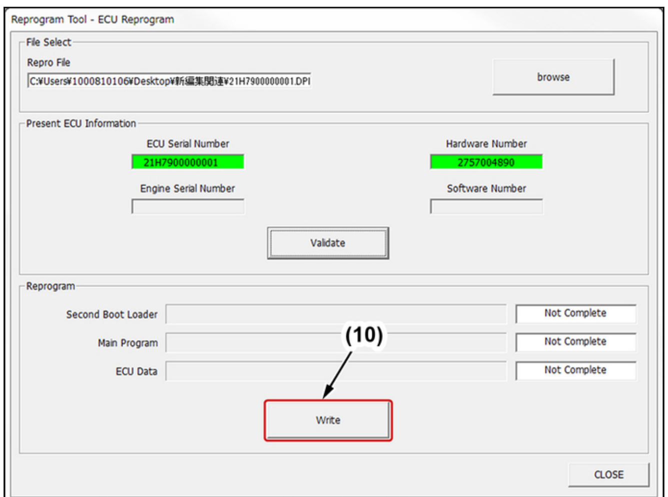
3. Click the **[Validate]** button (9).



2CJGV00246A03

(9) Validate button

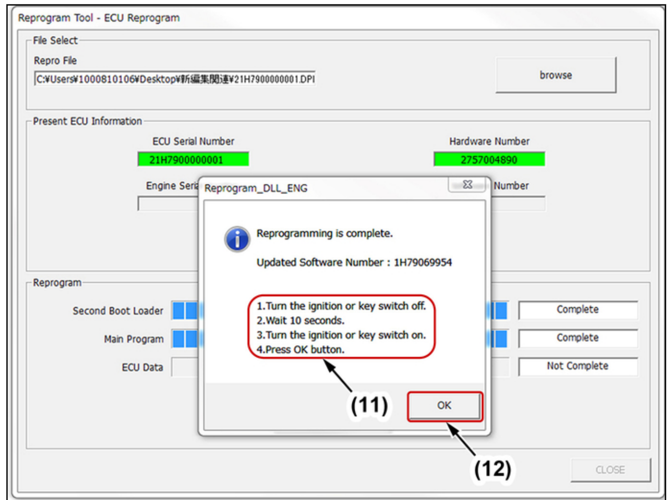
4. If "Present ECU Information" is correct (green color), click the **[Write]** button (10).



2CJGV00247A03

(10) Write button

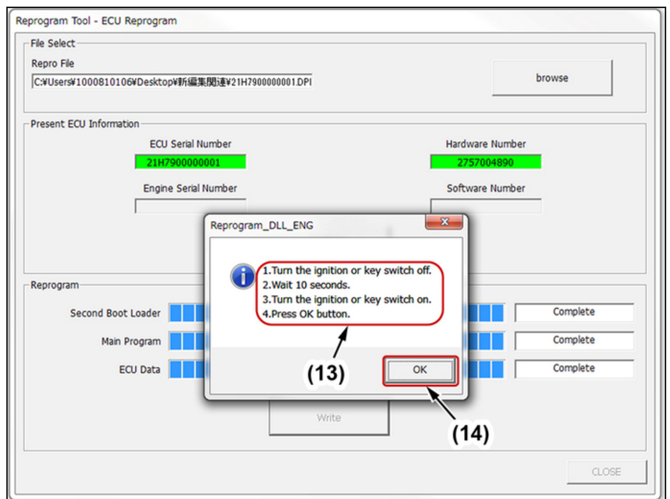
5. After the main program rewriting is complete, follow the "instruction" (11), then click the **[OK]** button (12).



2CJGV00248A03

(11) Instruction (12) OK button

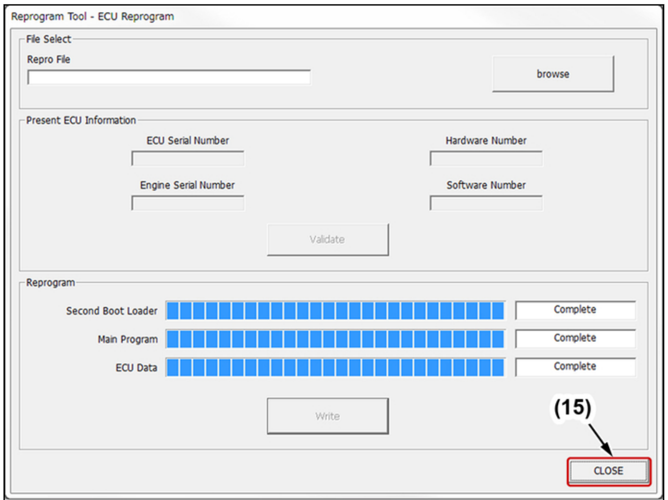
6. After the ECU data rewriting is complete, follow the "instruction" (13), then click the **[OK]** button (14).



2CJGV00249A03

(13) Instruction (14) OK button

7. Click the **[CLOSE]** button (15) to exit function.

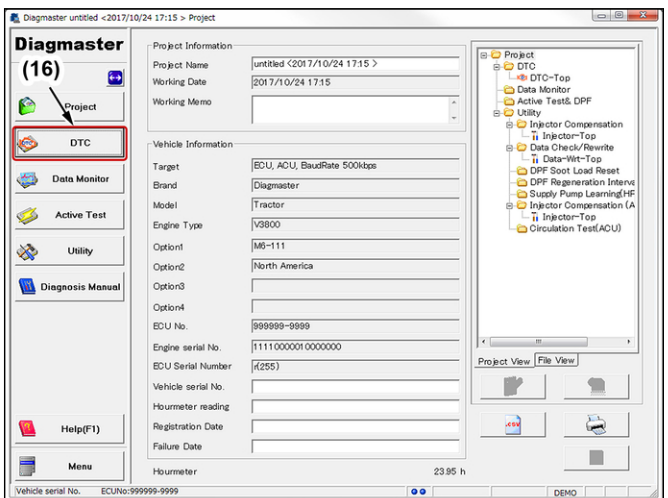


2CJGV00250A03

(15) CLOSE button

Clear DTC

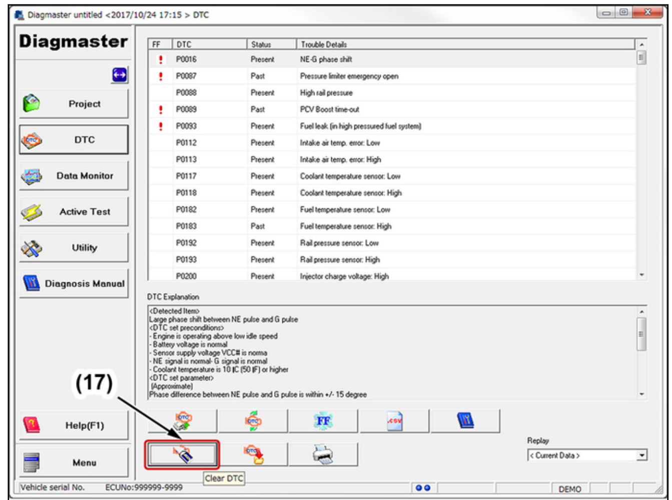
1. Connect the reprogrammed service ECU to the engine, then key switch ON.
2. Start "Diagmaster", then click the **[DTC]** button (16) from the project window.



2CJGV00251A03

(16) DTC button

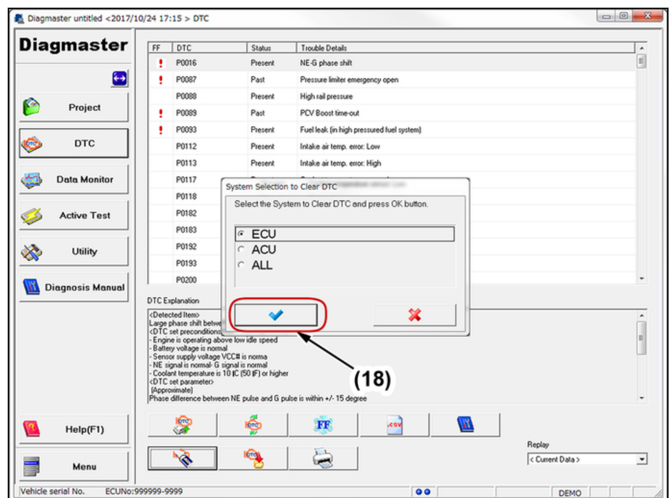
3. Click the **[Clear DTC]** button (17).



2CJGV00252A03

(17) Clear DTC button

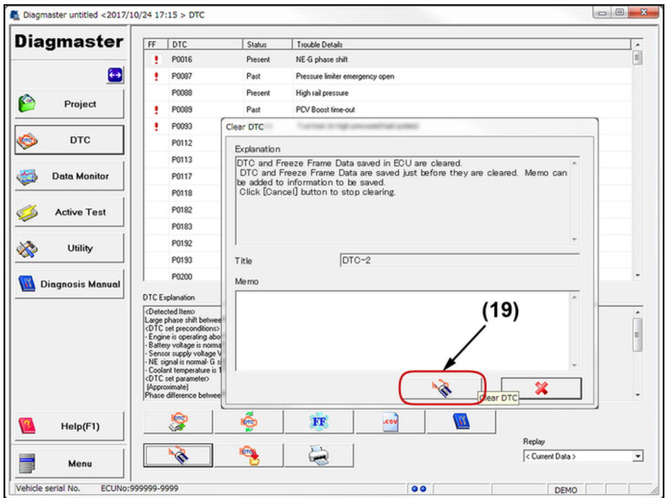
4. Select the "ECU" system, then click the **[OK]** button (18).



2CJGV00253A03

(18) OK button

5. Click the **[Clear DTC]** button (19) to clear DTC and exit function.



2CJGV00254A03

(19) Clear DTC button

Initializing supply pump

1. Initialize the supply pump.

DPF manual regeneration

1. Perform the DPF manual regeneration.

— RELATED PAGE —

7.54 Replacing supply pump on page 3-210
7.57 Replacing DPF on page 3-218

7.57 Replacing DPF

Tools required

- Laptop computer (Diagmaster (software) installed)
- Interface (DST-i)

Removing DPF muffler full assembly

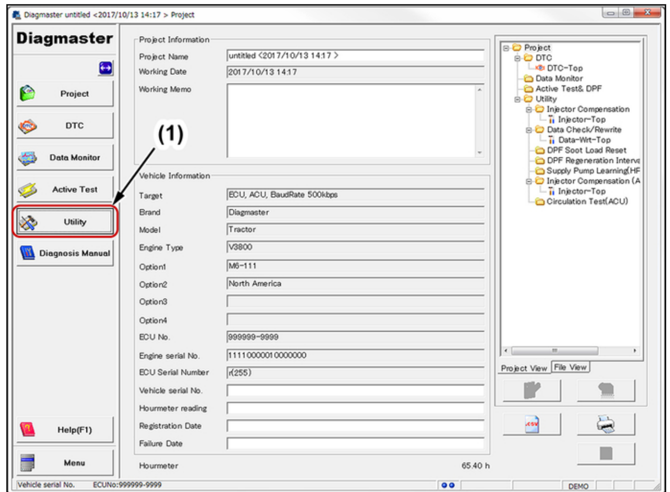
1. Remove the DPF muffler full assembly.
2. Disassemble the DPF assembly.

Installing DPF muffler full assembly

1. Assemble the DPF assembly.
2. Install the DPF muffler full assembly.

DPF regeneration interval time reset

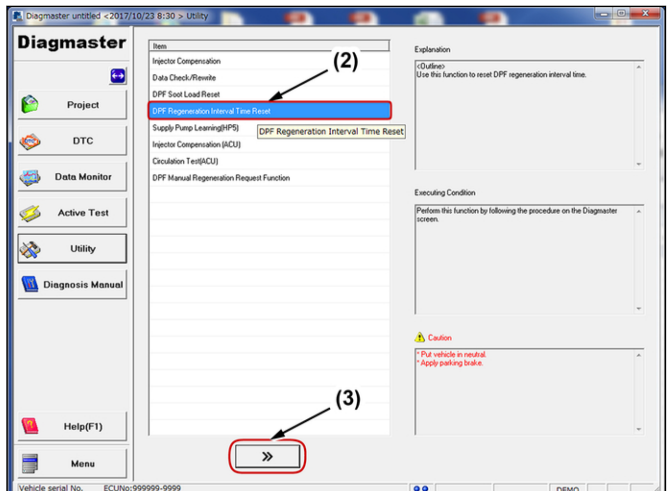
1. Start "Diagmaster", then click the **[Utility]** button (1) from the project window.



2CJGV00226A01

(1) Utility button

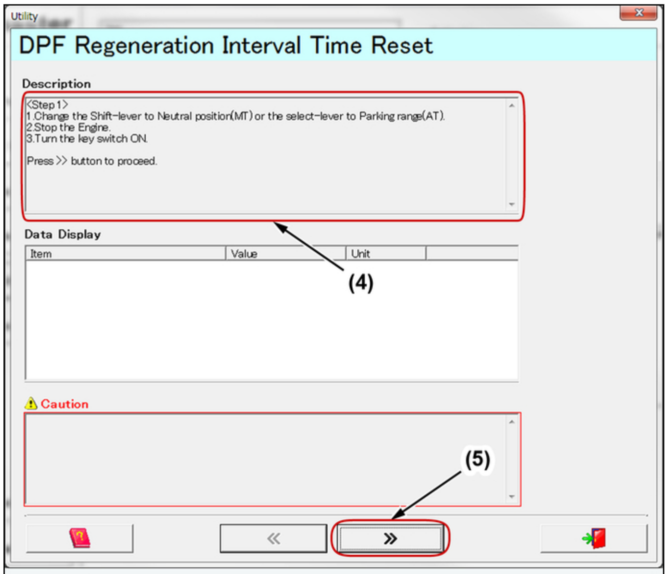
2. Select the "DPF Regeneration Interval Time Reset" item (2), then click the **[proceed]** button (3).



2CJGV00255A01

(2) DPF Regeneration Interval Time Reset item
(3) Proceed button

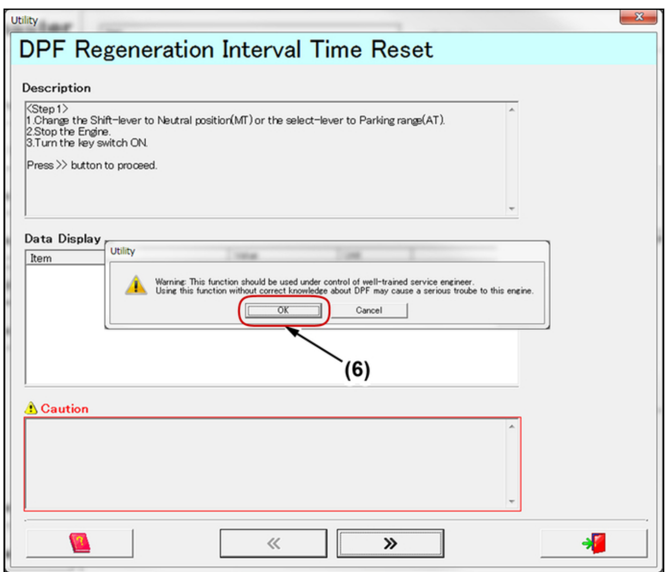
3. Follow the instructions according to steps of "Description" screen (4), then click the **[proceed]** button (5).



2CJGV00256A01

(4) Description screen (5) Proceed button

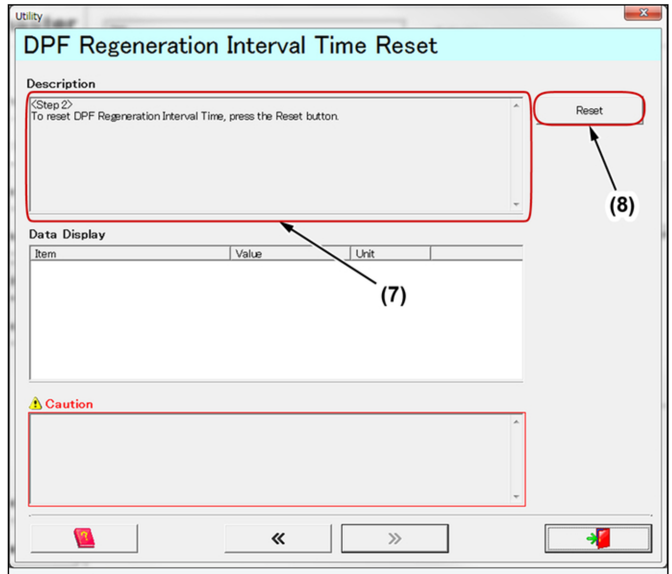
4. Confirm warning description, then click the **[OK]** button (6).



2CJGV00257A01

(6) OK button

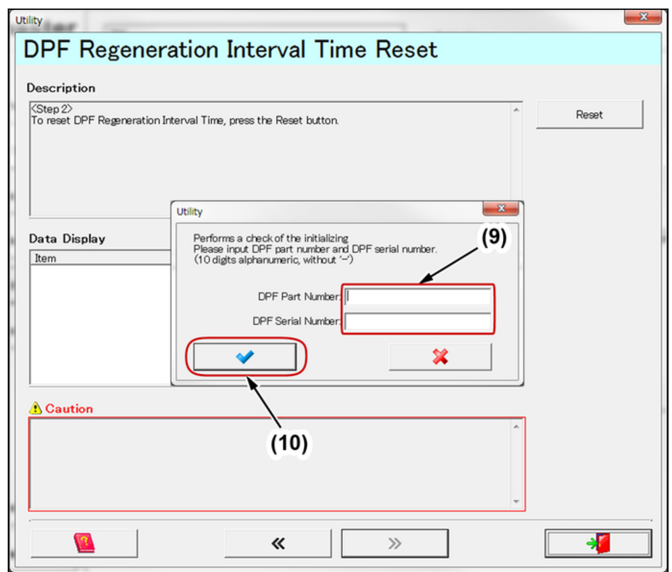
5. Follow the instructions according to steps of "Description" screen (7), then click the **[Reset]** button (8).



2CJGV00258A01

(7) Description screen (8) Reset button

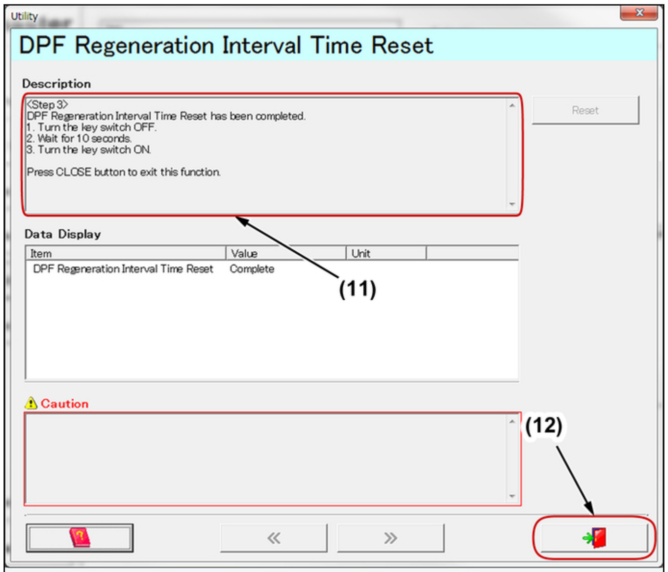
6. Enter the "DPF part number and DPF serial number" (9), then click the **[OK]** button (10).



2CJGV00259A01

(9) DPF part number and DPF serial number (10) OK button

7. Follow the instructions according to steps of "Description" screen (11), then click the **[Close]** button (12) to exit function.

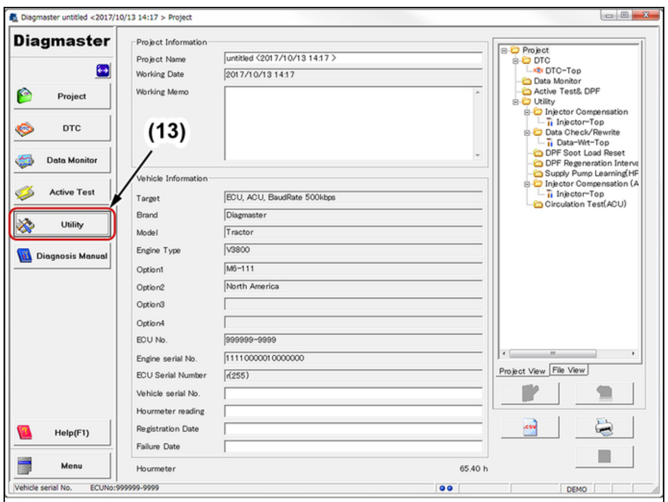


2CJGV00260A01

(11) Description screen (12) Close button

DPF soot load reset

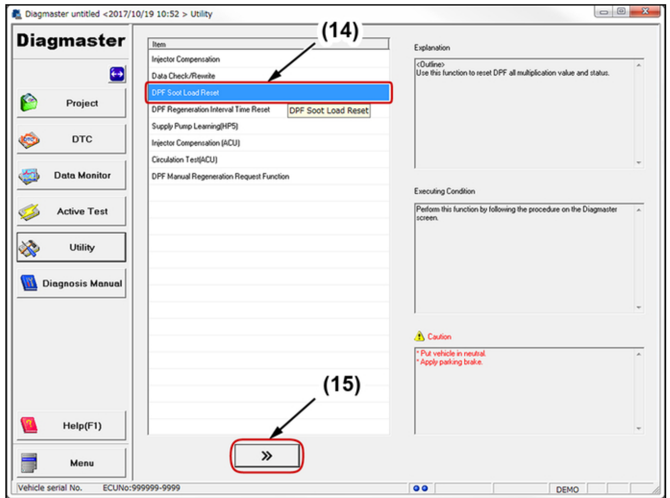
1. Start "Diagmaster", then click the **[Utility]** button (13) from the project window.



2CJGV00226A02

(13) Utility button

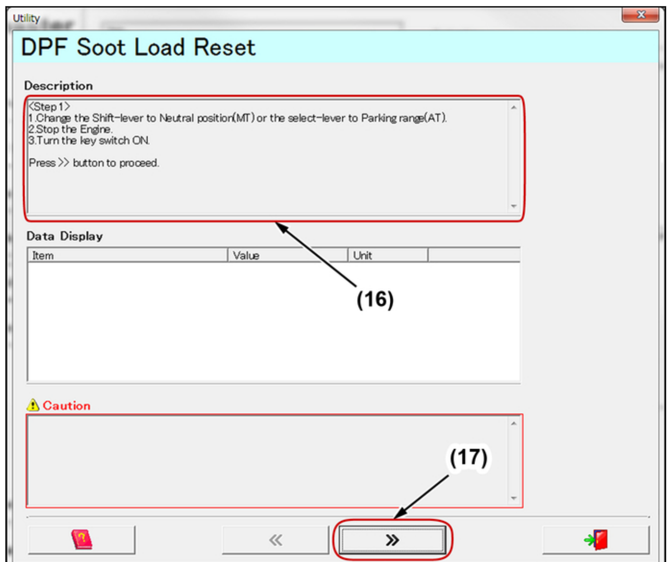
2. Select the "DPF Soot Load Reset" item (14), then click the **[proceed]** button (15).



2CJGV00261A02

(14) DPF Soot Load Reset item (15) Proceed button

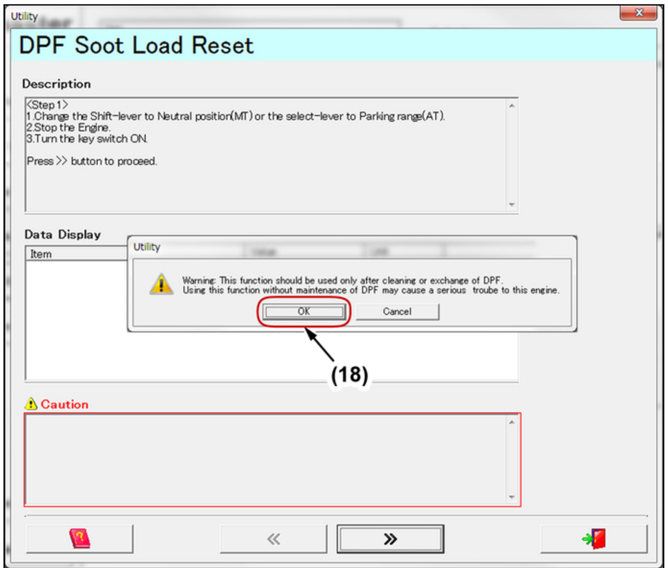
3. Follow the instructions according to steps of "Description" screen (16), then click the **[proceed]** button (17).



2CJGV00262A02

(16) Description screen (17) Proceed button

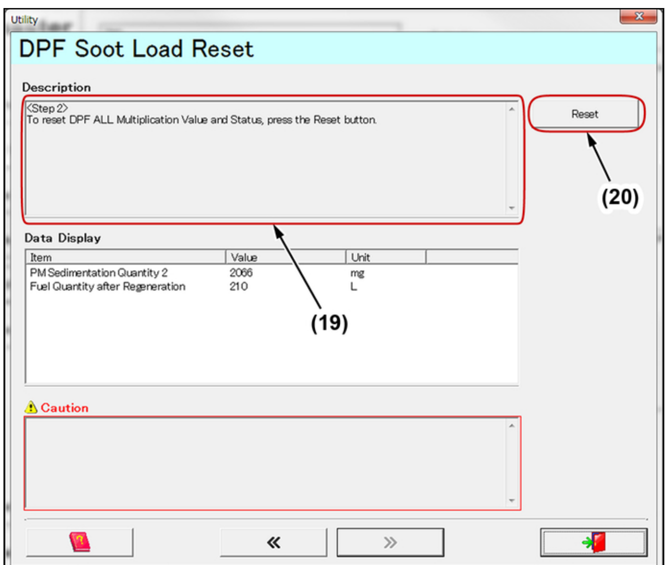
4. Confirm warning description, then click the **[OK]** button (18).



2CJGV00263A02

(18) OK button

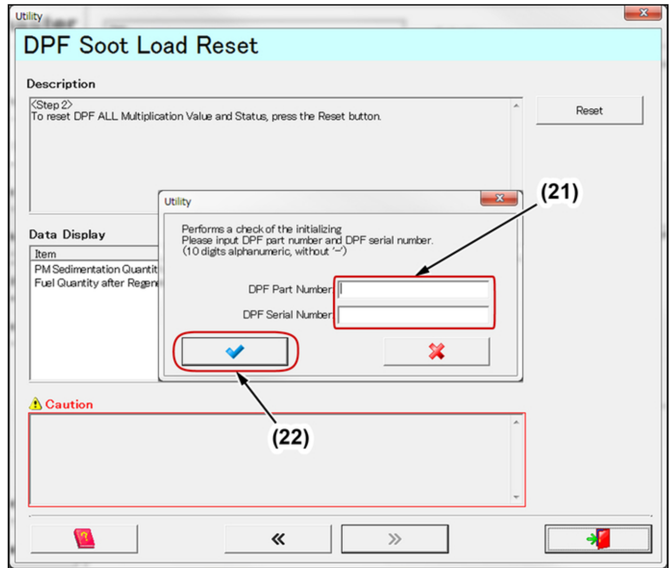
5. Follow the instructions according to steps of "Description" screen (19), then click the **[Reset]** button (20).



2CJGV00264A02

(19) Description screen (20) Reset button

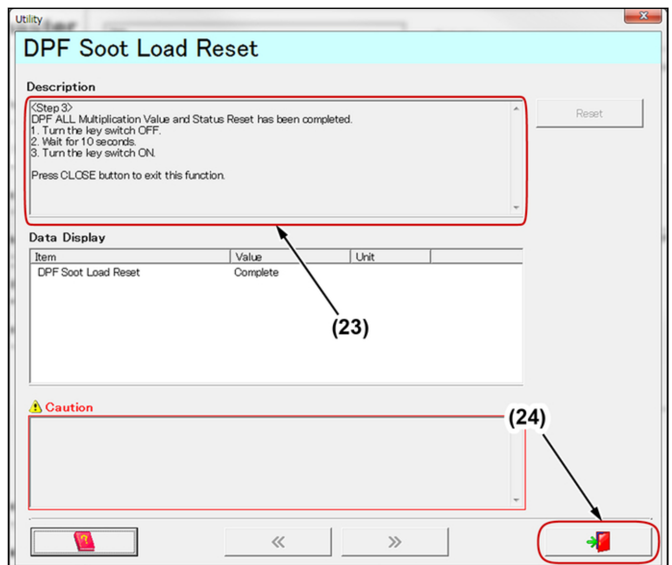
6. Enter the "DPF part number and DPF serial number" (21), then click the **[OK]** button (22).



2CJGV00265A02

(21) DPF part number and DPF serial number (22) OK button

7. Follow the instructions according to steps of "Description" screen (23), then click the **[Close]** button (24) to exit function.

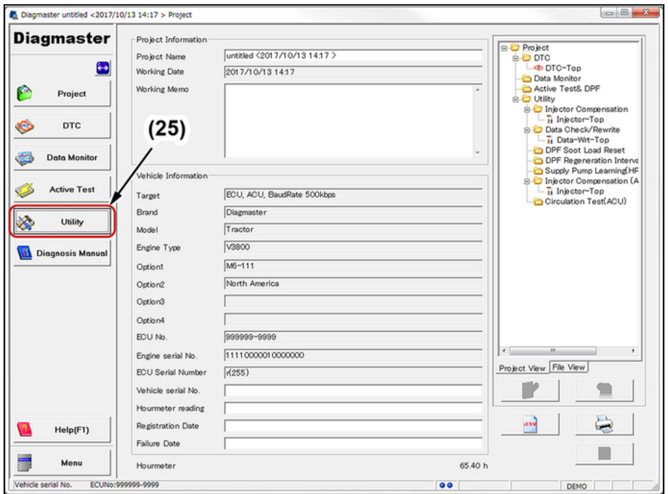


2CJGV00266A02

(23) Description screen (24) Close button

DPF manual regeneration

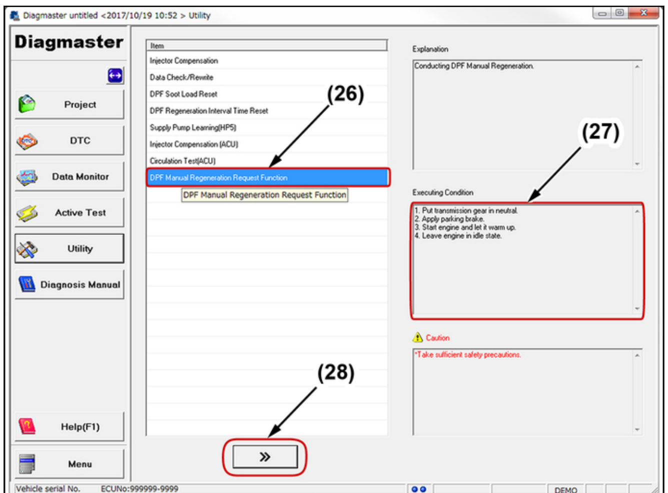
1. Start "Diagmaster", then click the **[Utility]** button (25) from the project window.



2CJGV00226A03

(25) Utility button

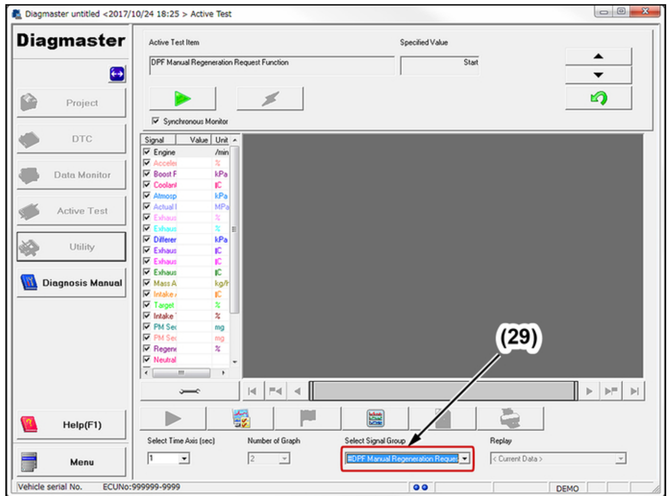
2. Select the "DPF Manual Regeneration Request Function" item (26).
3. Follow the instructions according to steps of "Executing Condition" screen (27), then click the **[proceed]** button (28).



2CJGV00267A02

(26) DPF Manual Regeneration Request Function item
(27) Executing Condition screen
(28) Proceed button

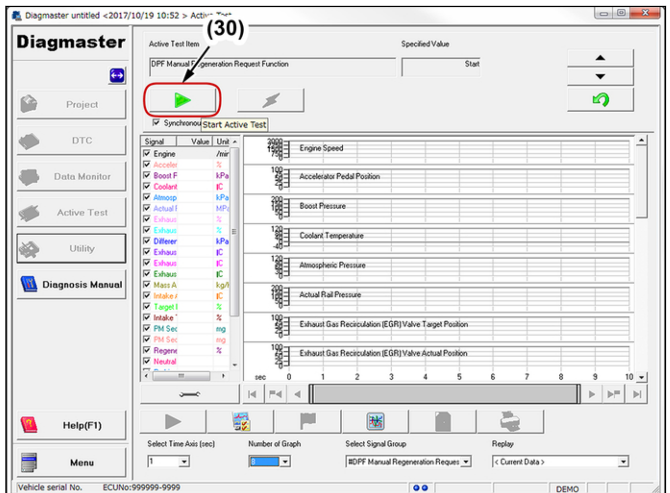
4. Select the "#DPF Manual Regeneration Request Function" (29) from "Select Signal Group".



2CJGV00268A02

(29) #DPF Manual Regeneration Request Function

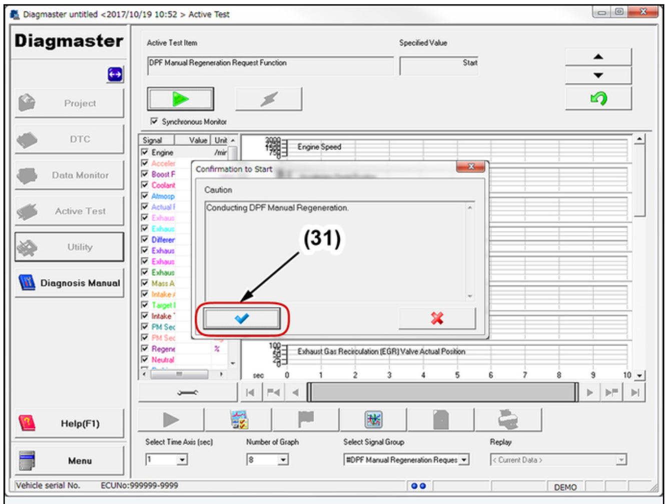
5. Click the **[Start Active Test]** button (30).



2CJGV00269A02

(30) Start Active Test button

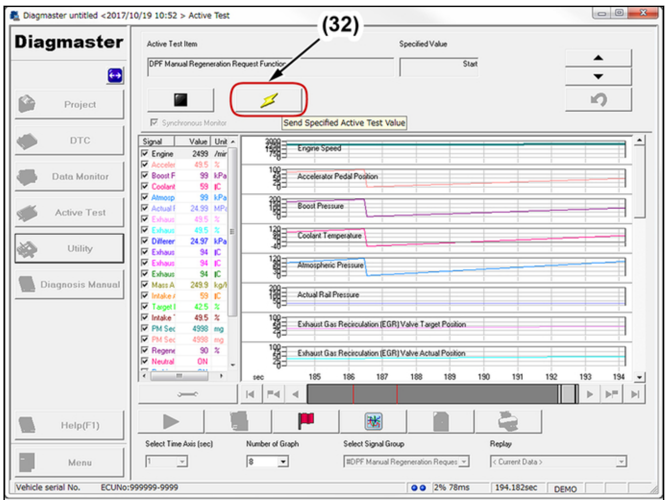
6. Confirm caution description, then click the **[OK]** button (31).



2CJGV00270A02

(31) OK button

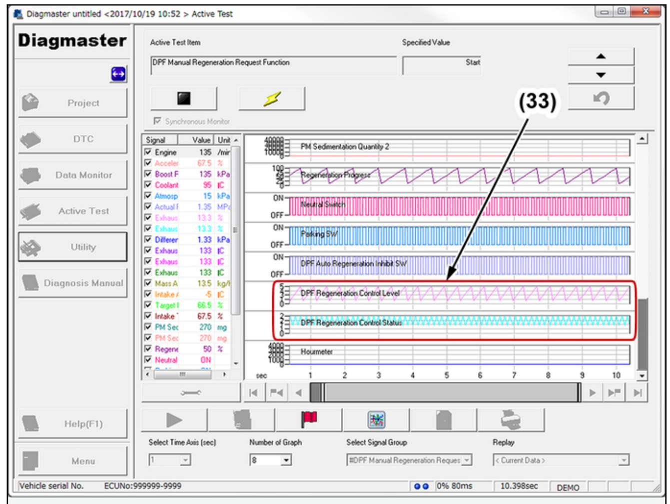
7. Click the **[Send Specified Active Test Value]** button (32).



2CJGV00271A02

(32) Send Specified Active Test Value button

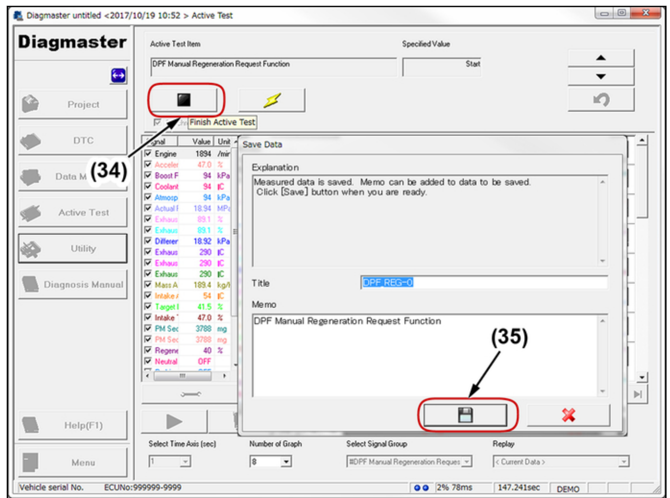
8. To start DPF manual regeneration, click the **[DPF manual regeneration]** button on the machine.
9. Observe the data monitor until the "DPF regeneration control level / status" (33) value becomes "0".



2CJGV00272A02

(33) DPF regeneration control level / status

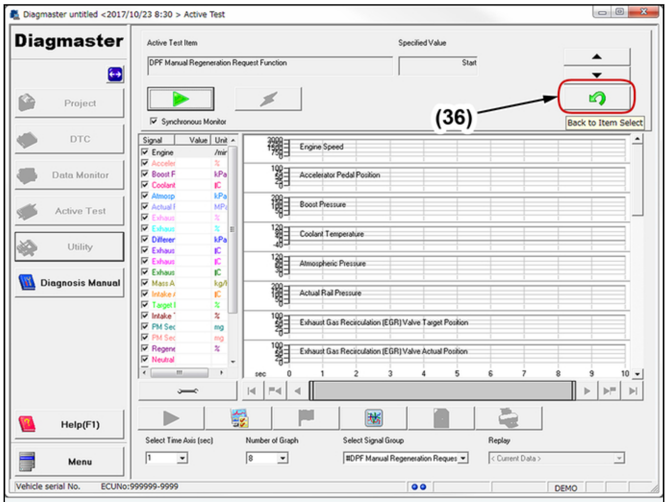
10. Click the **[Finish Active Test]** button (34) to stop the data monitor, then click the **[Save]** button (35) to save monitor data.



2CJGV00273A02

(34) Finish Active Test button (35) Save button

11. Click the **[Back to Item Select]** button (36) to exit from active test.

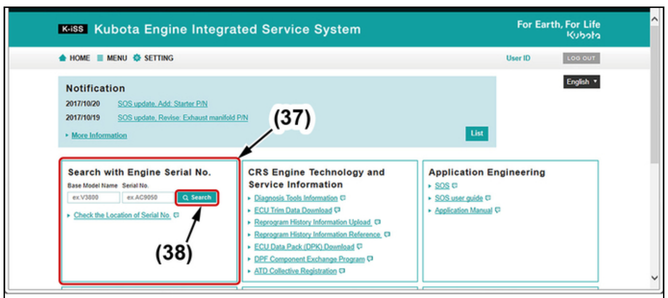


2CJGV00274A02

(36) Back to Item Select button

K-iSS registration

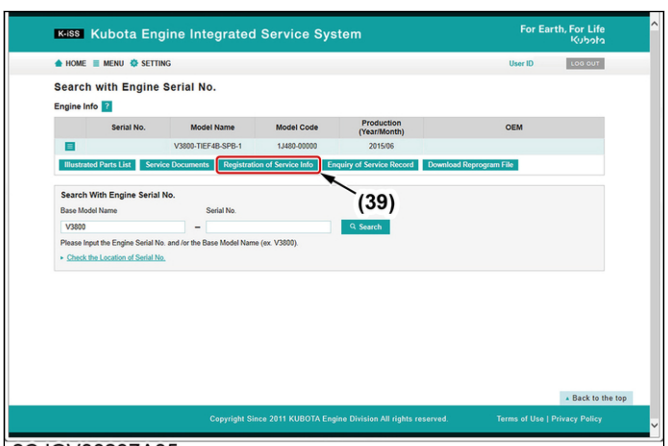
1. Enter the base model name and serial number to the "Search with Engine Serial No." window (37), then click the **[Search]** button (38).



2CJGV00236A04

(37) Search with Engine Serial No. window
(38) Search button

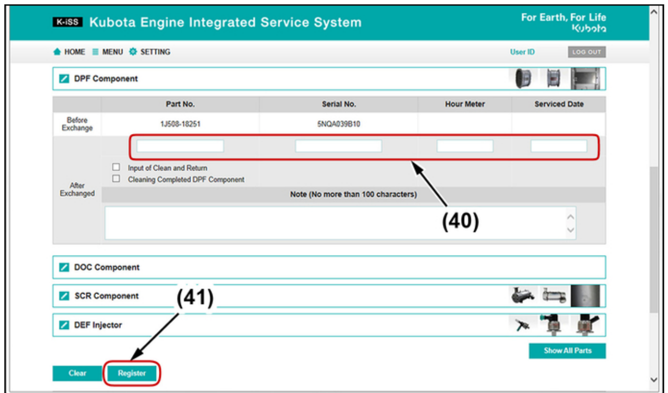
2. Click the **[Registration of Service Info.]** button (39).



2CJGV00237A05

(39) Registration of Service Info. button

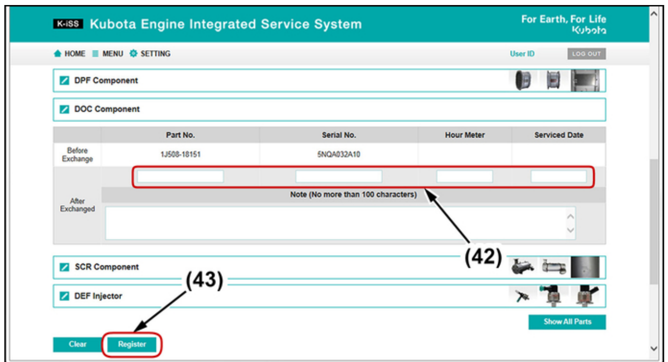
3. Select the "DPF Component" and enter the new service information to the "After Exchanged" window (40), then click the **[Register]** button (41).



2CJGV00275A03

(40) After Exchanged window
(41) Register button

4. If you replace DOC component, select the "DOC Component" and enter the new service information to the "After Exchanged" window (42), then click the **[Register]** button (43).



2CJGV00276A03

(42) After Exchanged window
(43) Register button

RELATED PAGE

5.6 Removing DPF muffler full assembly on page 3-128

5.7 Disassembling DPF assembly on page 3-129

6.40 Assembling DPF assembly on page 3-174

6.41 Installing DPF muffler full assembly on page 3-176

7.58 Replacing SCR

Tools required

- Laptop computer (Diagmaster (software) installed)
- Interface (DST-i)

Removing SCR muffler

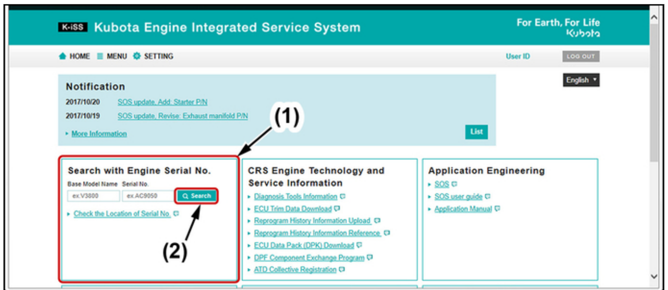
1. Remove the selective catalytic reduction (SCR) muffler.

Installing SCR muffler

1. Install the SCR muffler.

K-iSS registration

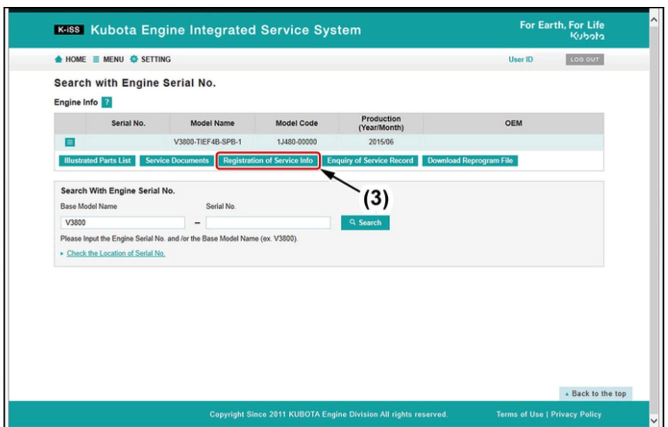
1. Enter the base model name and serial number to the "Search with Engine Serial No." window (1), then click the **[Search]** button (2).



2CJGV00240A02

(1) Search with Engine Serial No. window
(2) Search button

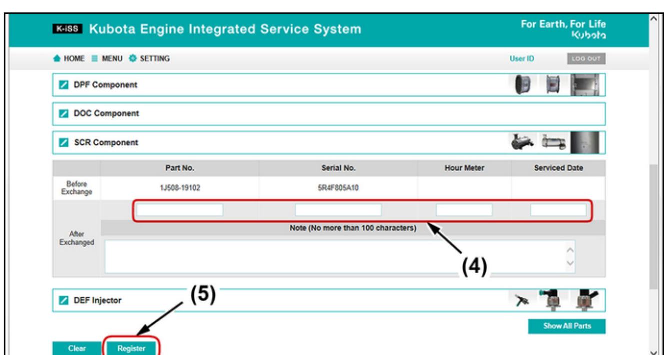
2. Click the **[Registration of Service Info.]** button (3).



2CJGV00237A04

(3) Registration of Service Info. button

3. Select the "SCR Component" and enter the new service information to the "After Exchanged" window (4), then click the **[Register]** button (5).



2CJGV00277A02

(4) After Exchanged window
(5) Register button

RELATED PAGE
5.3 Removing selective catalytic reduction (SCR) muffler on page 3-126
6.44 Installing SCR muffler assembly on page 3-181

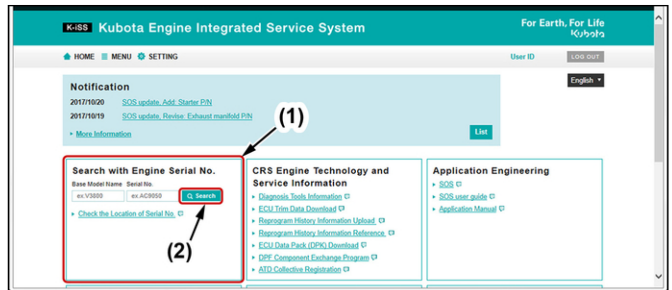
7.59 Replacing ACU

Tools required

- Laptop computer (Diagmaster (software) installed)
- Interface (DST-i)

Download DPK file (from K-iSS)

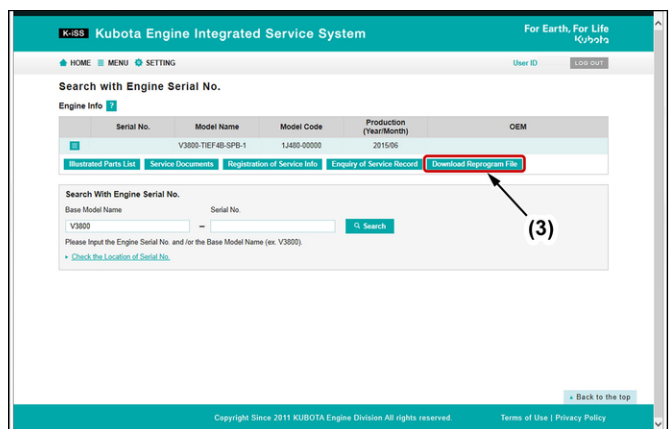
1. Enter the base model name and serial number to the "Search with Engine Serial No." window (1), then click the **[Search]** button (2).



2CJGV00240A02

(1) Search with Engine Serial No. window
(2) Search button

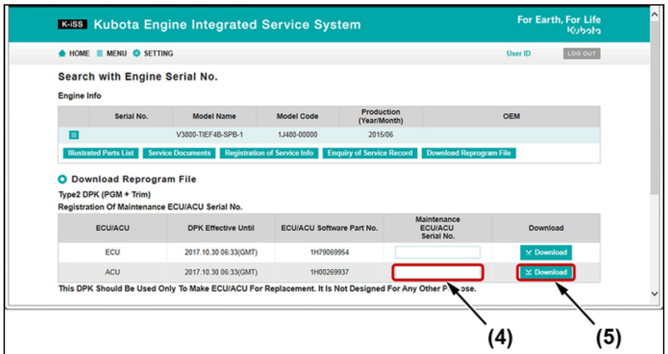
2. Click the **[Download Reprogram File]** button (3).



2CJGV00241A02

(3) Download Reprogram File button

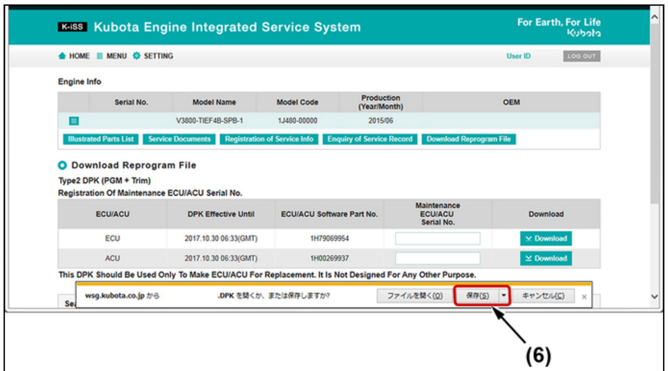
3. Enter the service ACU serial number (4), then click the **[Download]** button (5).



2CJGV00242A04

(4) Service ACU serial number (5) Download button

4. Click the **[Save]** button (6), then download the DPK file.

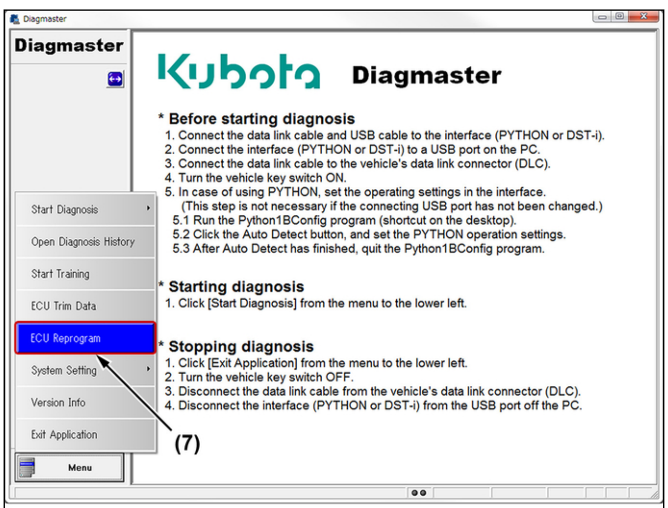


2CJGV00243A02

(6) Save button

ACU reprogram

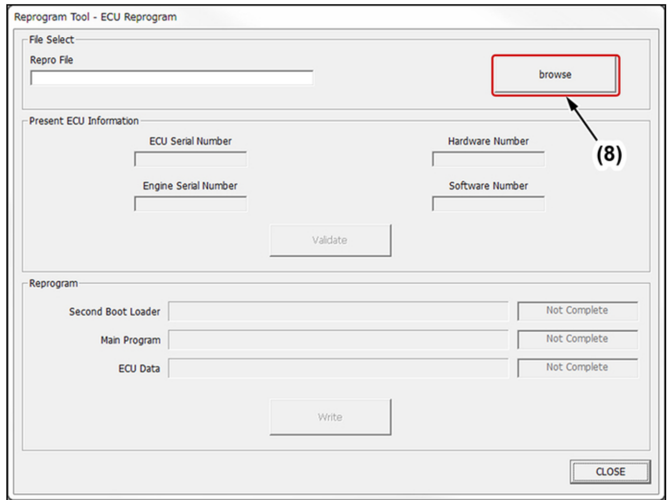
1. Start "Diagmaster", then click the **[ECU Reprogram]** button (7) from the first window.



2CJGV00244A03

(7) ECU Reprogram button

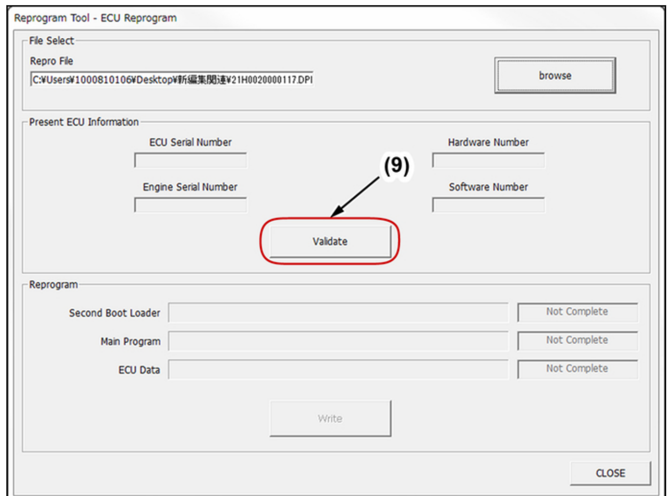
2. Select the download file (DPK file), then click the **[browse]** button (8).



2CJGV00245A03

(8) Browse button

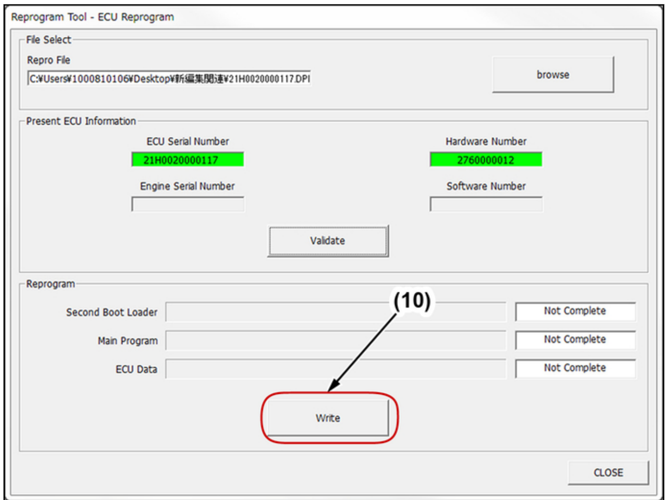
3. Click the **[Validate]** button (9).



2CJGV00278A03

(9) Validate button

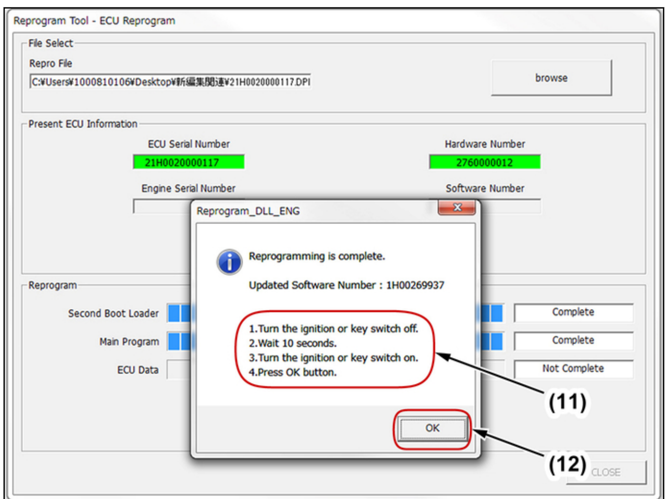
4. If "Present ECU Information" is correct (green color), click the **[Write]** button (10).



2CJGV00279A03

(10) Write button

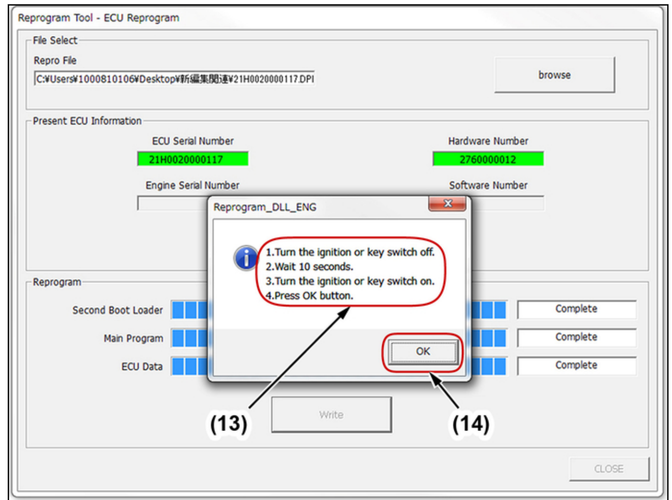
5. After the main program rewriting is complete, follow the "instruction" (11), then click the **[OK]** button (12).



2CJGV00280A03

(11) Instruction (12) OK button

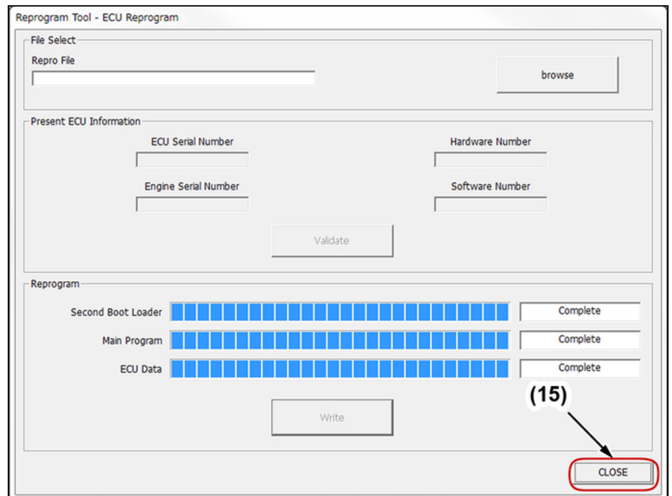
6. After the ACU data rewriting is complete, follow the "instruction" (13), then click the **[OK]** button (14).



2CJGV00281A03

(13) Instruction (14) OK button

7. Click the **[CLOSE]** button (15) to exit function.

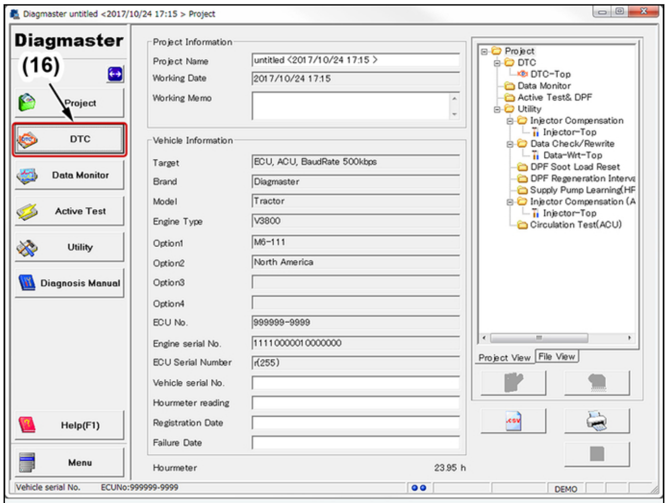


2CJGV00282A03

(15) CLOSE button

Clear DTC

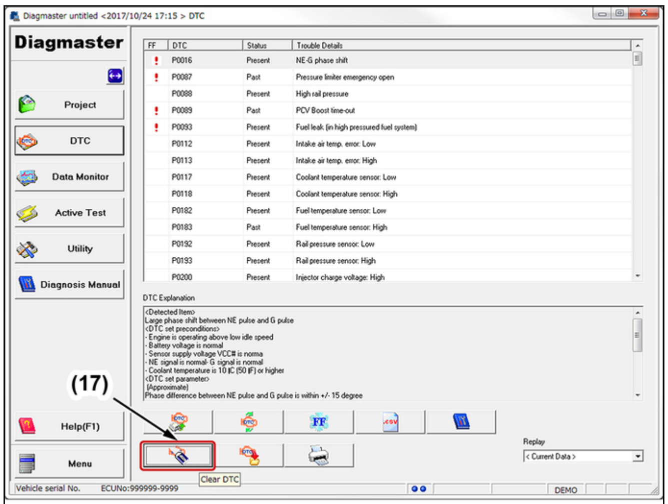
1. Connect the reprogrammed service ACU to the engine, then key switch ON.
2. Start "Diagmaster", then click the **[DTC]** button (16) from the project window.



2CJGV00251A03

(16) DTC button

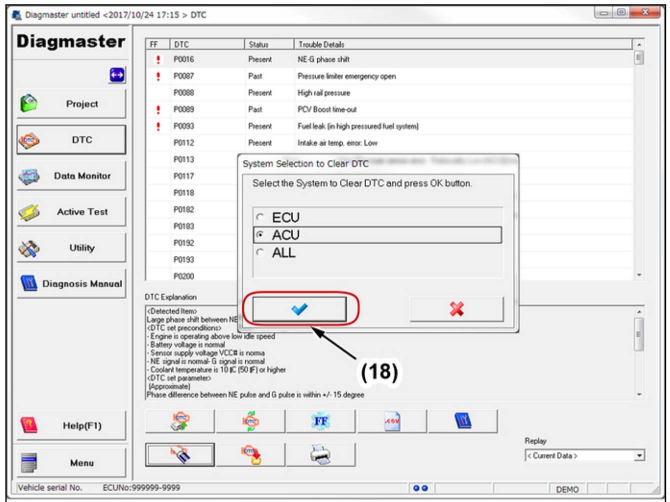
3. Click the **[Clear DTC]** button (17).



2CJGV00252A03

(17) Clear DTC button

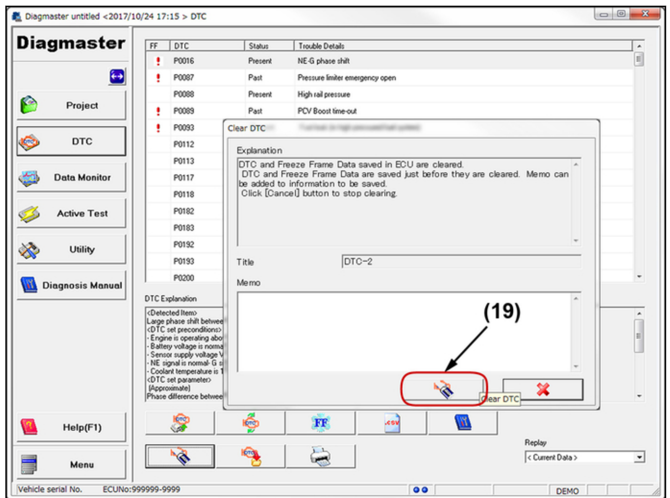
4. Select the "ACU" system, then click the **[OK]** button (18).



2CJGV00283A03

(18) OK button

5. Click the **[Clear DTC]** button (19) to clear DTC and exit function.



2CJGV00254A03

(19) Clear DTC button

7.60 Replacing DEF injector

Tools required

- Laptop computer (Diagmaster (software) installed)
- Interface (DST-i)

Removing DEF injector

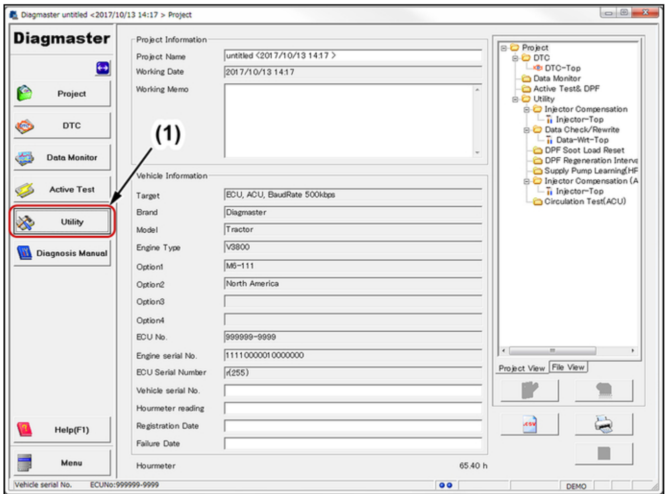
1. Remove the DEF injector.

Installing DEF injector

1. Install the DEF injector.

DEF injector compensation

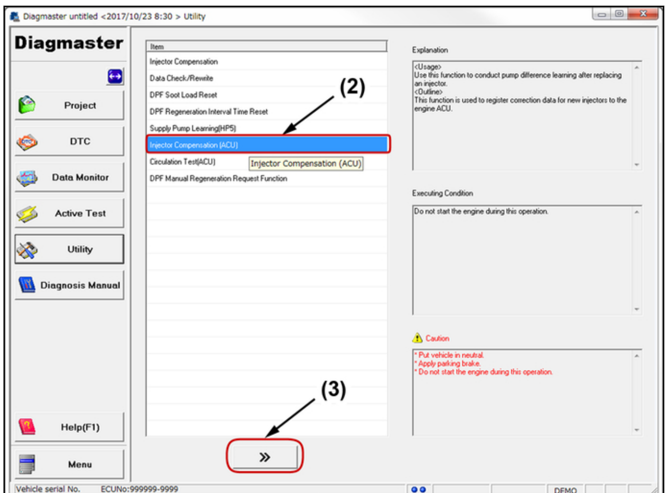
1. Start "Diagmaster", then click the **[Utility]** button (1) from the project window.



2CJGV00226A01

(1) Utility button

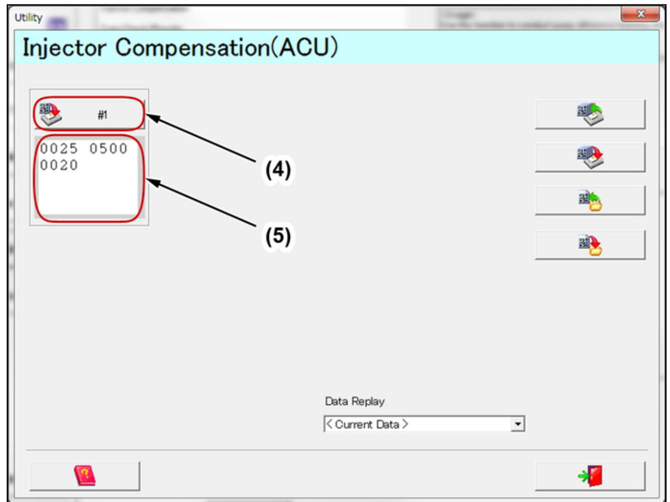
2. Select the "Injector Compensation (ACU)" item (2), then click the **[proceed]** button (3).



2CJGV00284A01

(2) Injector Compensation (ACU) item
(3) Proceed button

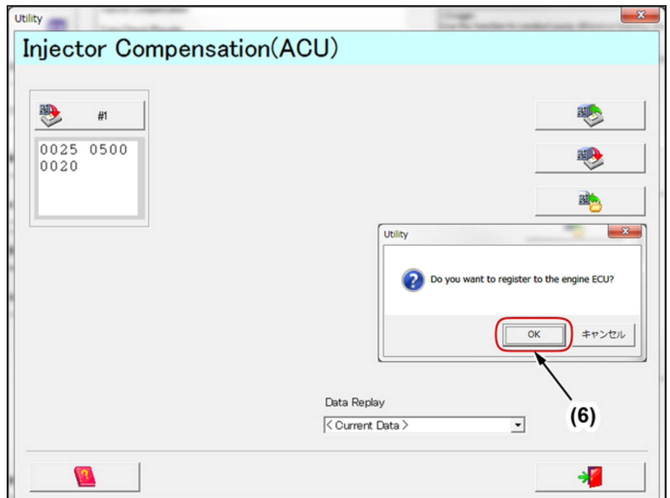
3. Enter the injector compensation value to the initial display (5), then click the **[Register]** button (4).



2CJGV00285A01

(4) Register button
(5) Initial display

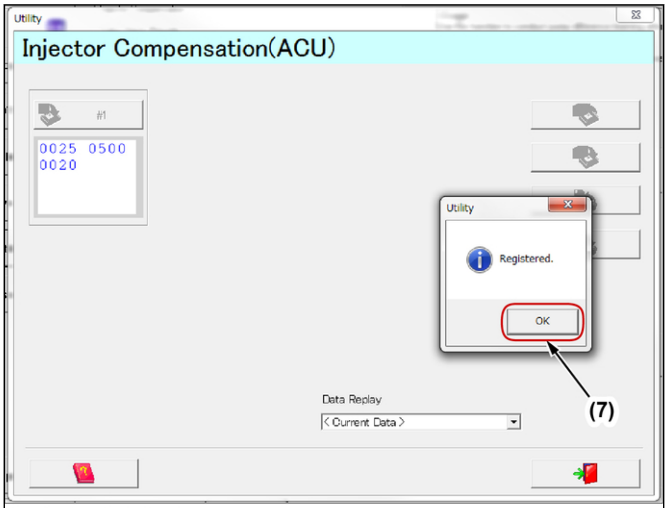
4. Click the **[OK]** button (6) if rewriting is OK.



2CJGV00286A01

(6) OK button

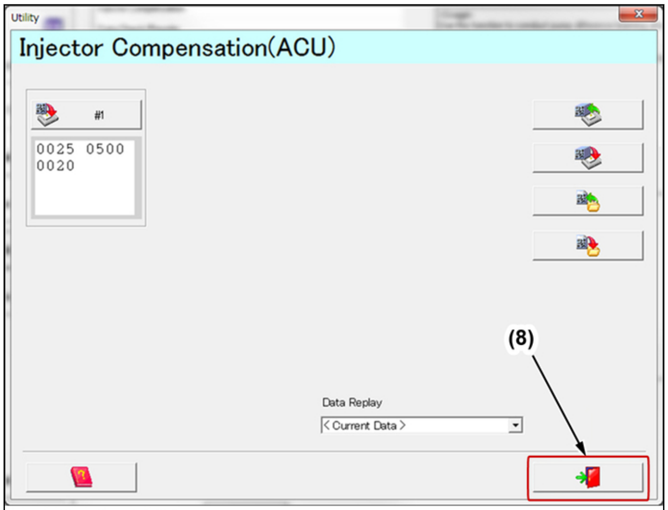
5. Click the **[OK]** button (7) when rewriting is correctly completed.



2CJGV00287A01

(7) OK button

6. Click the **[Close]** button (8) to exit function.

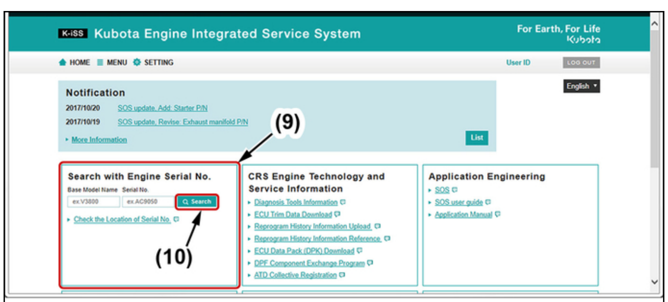


2CJGV00288A01

(8) Close button

K-iSS registration

1. Enter the base model name and serial number to the "Search with Engine Serial No." window (9), then click the **[Search]** button (10).

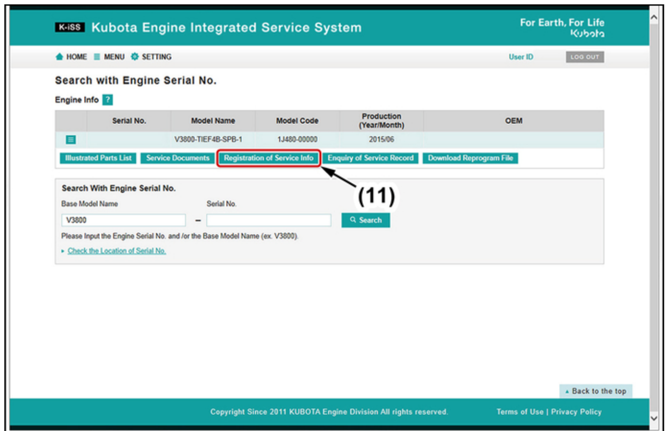


2CJGV00236A05

(9) Search with Engine Serial No. window

(10) Search button

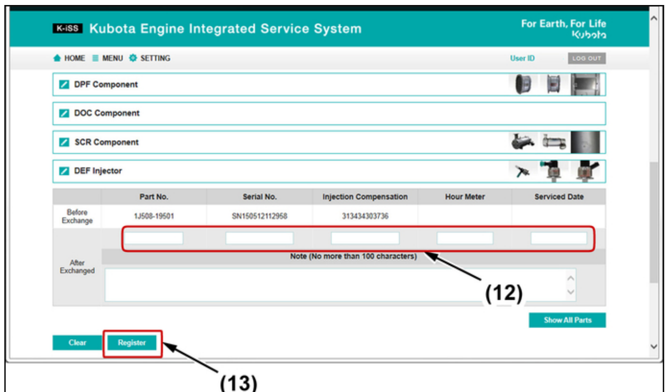
2. Click the **[Registration of Service Info.]** button (11).



2CJGV00237A06

(11) Registration of Service Info. button

3. Select the "DEF Injector" and enter the new service information to the "After Exchanged" window (12), then click the **[Register]** button (13).



2CJGV00289A03

(12) After Exchanged window

(13) Register button

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