WSM

WORKSHOP MANUAL
LPG ENGINE

WG3800-E5C

Kubota

KiSC issued 04, 2020 A

TO THE READER

This Workshop Manual tells the servicing personnel about the mechanism, servicing and maintenance of the WG3800-E5C. It contains 4 parts: **"Information"**, **"General"**, **"Mechanism"** and **"Servicing"**.

■ **Information**

This section contains information below.

- Safety First
- Specification
- Important Items of Exhaust Emission Regulation
- Performance Curve
- Dimension
- Wiring Diagram

■ **General**

This section contains information below.

- Engine Identification
- General Precautions
- Maintenance Check List
- Check and Maintenance
- Special Tools

■ **Mechanism**

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

■ **Servicing**

This section contains information below.

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

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

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

December 2019

KiSC issued 04, 2020 A

Record of Revisions

For pdf, use search function {Search word} to find all revised locations.

Last digit of the Code No.	Month of Revision	Main Revised Point and Corrective Measures {Search word}	Reference Page
1	2020.04	Delete WG3800-L-E5C model	–
		Changes about engine specification due to design change	I-4

I INFORMATION

INFORMATION

CONTENTS

1. SAFETY FIRST

⚠ SAFETY FIRST

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

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

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

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

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

■ NOTE
- **Gives helpful information.**

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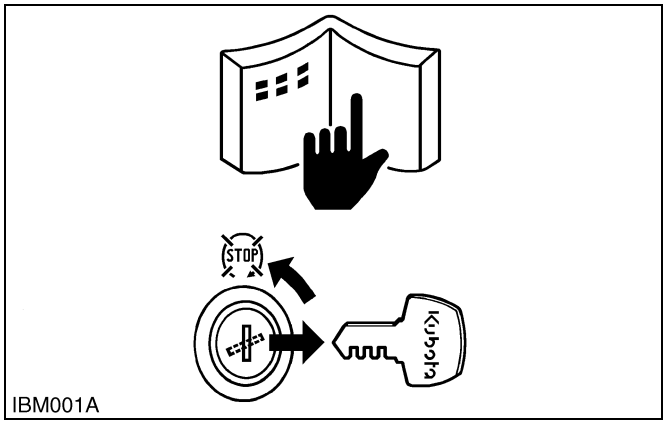

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IBM011A

BEFORE YOU START SERVICE

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

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START SAFELY

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

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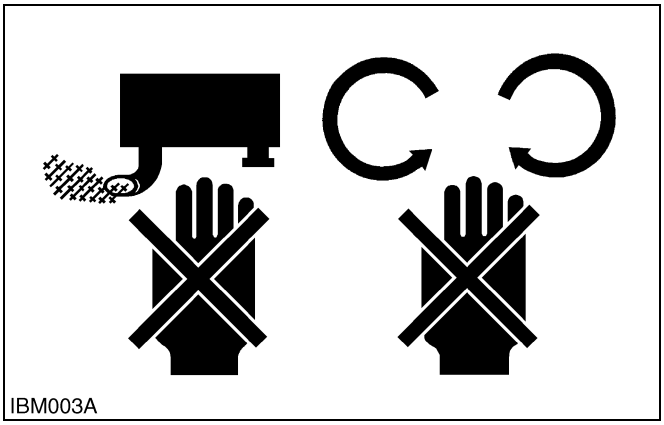
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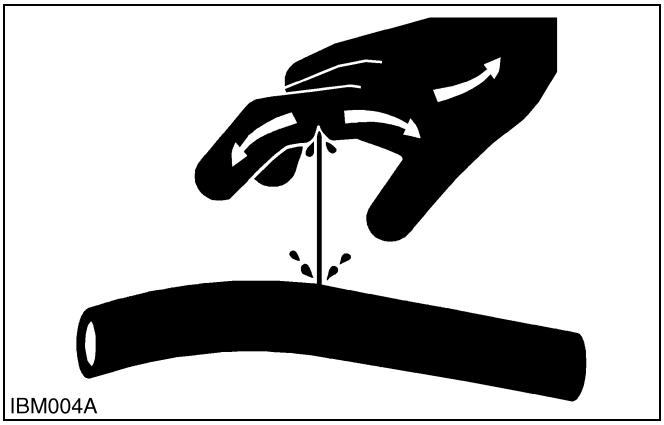
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OPERATE SAFELY

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

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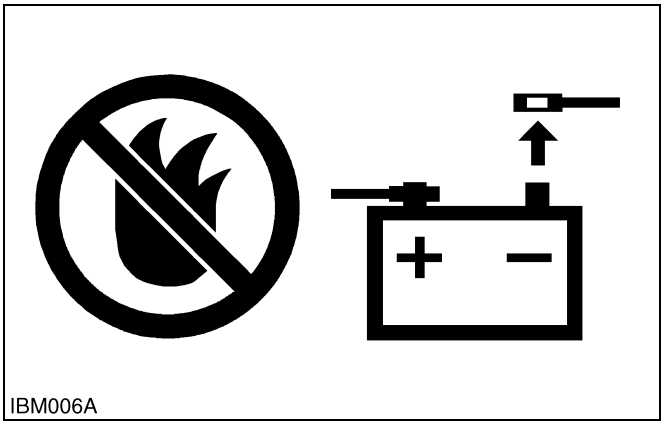
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PREVENT A FIRE

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

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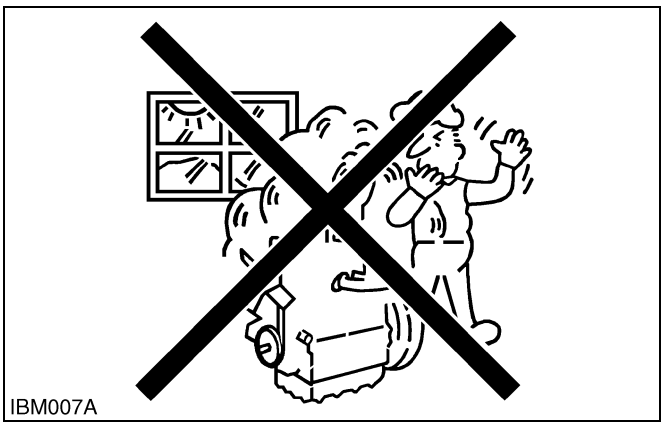
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KEEP A GOOD AIRFLOW IN THE WORK AREA

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

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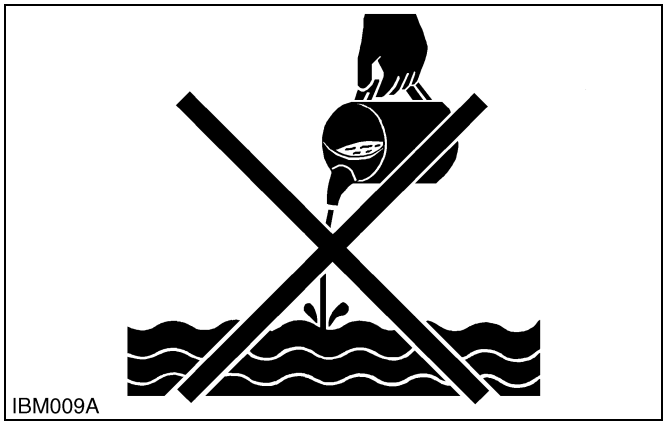
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DISCARD FLUIDS CORRECTLY

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

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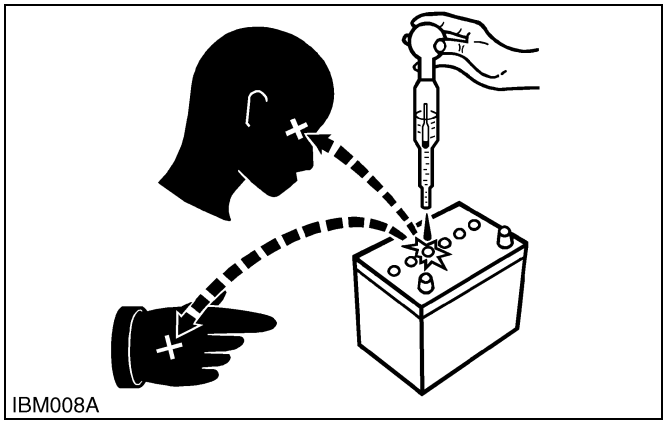
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PREVENT ACID BURNS

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

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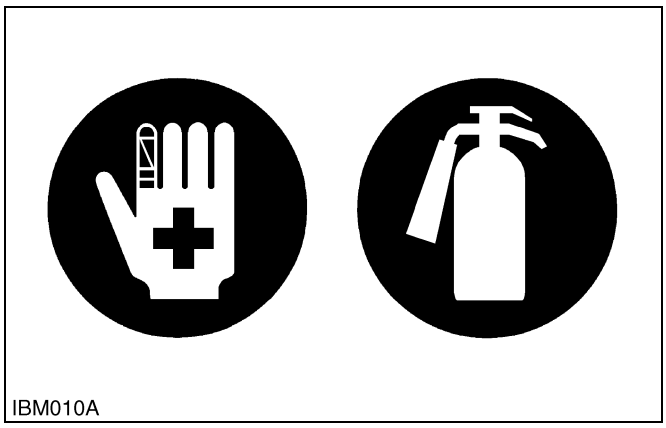
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PREPARE FOR EMERGENCIES

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

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2. SPECIFICATIONS

Model	WG3800-L-E5C
	LPG
Number of Cylinder	4
Type	Vertical, water cooled, 4-cycle LPG engine
Bore × Stroke	100.0 × 120.0 mm (3.937 × 4.724 in.)
Total Displacement	3.769 L (230.0 cu.in.)
SAE Gross Intermittent	69.0 kw (92.5 HP) / 2500 min^{-1} (rpm)
ISO / SAE Net Intermittent	61.8 kW (82.9 HP) / 2500 min^{-1} (rpm)
ISO Net Continuous	52.5 kW (70.4HP) / 2500 min^{-1} (rpm)
Maximum Bare Speed	2500 min^{-1} (rpm)
Minimum Bare Idling Speed	700 min^{-1} (rpm)
Cylinder Head	Overhead-Valve
Ignition System	Full Transistor Battery Ignition Type
Governor	Electronic Governor
Direction of Rotation	Counter-Clockwise (Viewed from Flywheel Side)
Spark Plug Type / Spark Plug Gap	NGK IFR6F8DN / 0.70 to 0.80 mm (0.028 to 0.031 in.)
Ignition Timing	0.72 rad (41°) before T.D.C. / 2500 min^{-1} (rpm) 0.26 rad (15°) before T.D.C. / 700 min^{-1} (rpm)
Firing Order	1-3-4-2
Compression Ratio	10.0 : 1
Lubricating System	Forced Lubrication by Trochoid Pump
Oil Pressure Indication	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
Starting Motor	12 V, 2.5 kW
Battery	12 V, 55 AH or Equivalent
Charging Alternator	12 V, 1200 W
Fuel	LPG
Lubricating Oil	API classification SL or higher SAE 10W-30
Lubricating Oil Capacity	12.2 L (3.22 U.S.gals)
Weight (Dry)	268 kg (591 lbs)
Application	General Power Source

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

*KUBOTA RECOMMENDED LPG FUEL SPECIFICATIONS

- Commercial Propane gas only.
- Equivalent to Propanes H-D-5 of GPA* standards.

(vol %)

C_3H_8	C_3H_6	C_4H_{10}	Others
≥ 90 %	≤ 5 %	≤ 2.5 %	–

*GPA means Gas Processors Association (U.S.A.)

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3. IMPORTANT ITEMS OF EXHAUST EMISSION REGULATION

WG3800 is available and unavailable in those countries.

kW, Disp.	Model	Type	North America	Europe	Japan
19 < P, 1.0 < L	WG3800-E5C	E5	Available	Available	Non-available

Current and future emission regulations.

HC+NO_x/CO (g/kWh)

Countries		kW, disp.	2014	2015	2016	2017	2018	2019	2020	2021
USA	CARB	19 < P < 560 1.0 < L	0.8/20.6*							
	EPA	19 < P ≤ 560 1.0 < L	2.7/4.4* **							
Canada		19 < P	None				2.7/4.4* **			
Japan		19 ≤ P < 560	HC/0.6 g/kWh, NO_x/0.6 g/kWh, CO/20 g/kWh							
EU		19 ≤ P < 56 1.0 < P	None					2.7/4.4* **		

- *: with evaporative emission regulation
- **: See figure below

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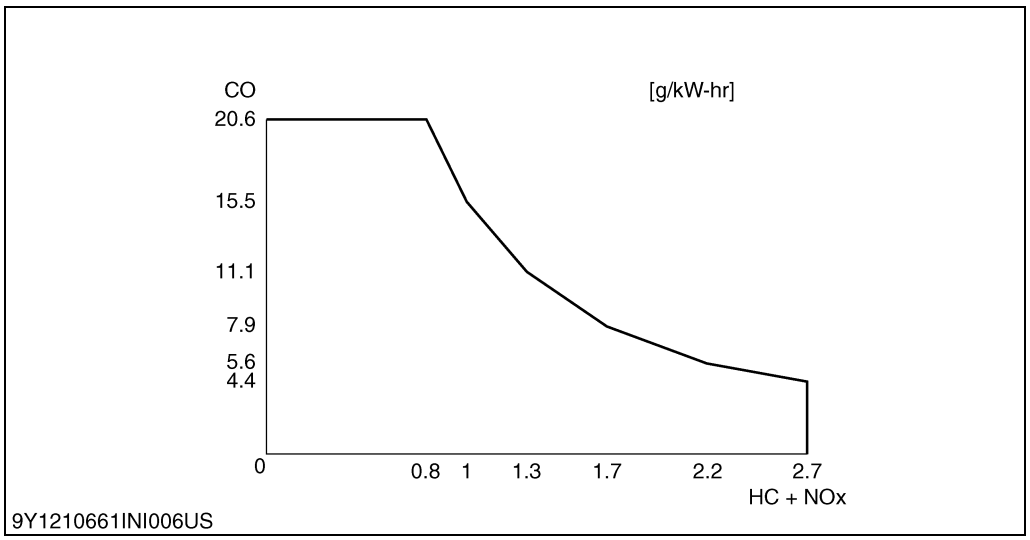

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[1] THREE-WAY CATALYST

A three-way catalyst is a catalyst that oxidizes HC to CO_2 and H_2O and also CO to CO_2 respectively and at the same time reduces NOx to N_2 near the stoichiometric ratio.

The main basic component of an exhaust gas purification system that uses a three-way catalyst is feedback control of air-fuel ratio by means of an O_2 sensor for the purpose of maximizing the emission purification efficiency characteristic with reference to the intake air-fuel ratio of the three-way catalyst.

KUBOTA engines have catalytic converter type catalytic device.

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[2] VAPORIZER AND LOCK OFF VALVE

Vaporizer requires a normally-open electrically controlled fuel lock off valve that is close coupled to the vaporizer and off when ignition switch is off or when the engine is not running normally (supplied from KUBOTA). In operation without a lock off upstream the vaporizer will flow fuel with the engine off. The vaporizer is not a fuel shut-off safety device.

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[3] LENGTH OF THE VAPOR HOSE

Vapor hose length must not exceed 700 mm (27.6 in), shorter is generally considered better. Care should be taken with hose routing and length to minimize the affect on vaporizer vibration isolation. The metal reinforced hose should not be used.

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[4] IMPORTANT NOTICE

These instructions are provided to the Final Engine Assemblers (FEA) who must ensure the engine, exhaust system (catalyst), fuel system etc, are installed correctly in the engine's certified configuration.

Please make sure whether emission-related items are certain on application review.

(for EPA only)

Failing to follow these instructions when installing a certified engine in a piece of nonroad equipment violates federal law (40 CFR 1068.105 (b)), subject to fines or other penalties as described in the Clean Air Act.

The contractual agreement contract is necessary before mass-production.

9Y3210051INI0008US0

[5] EMISSION-RELATED INSTALLATION INSTRUCTIONS

(1) Exhaust System

KUBOTA supplies a certified catalyst. FEA must use a KUBOTA certified catalyst and assemble the exhaust system parts according to the instructions.

No other catalyst is certified for use with WG 3800 Engine. No Other Catalyst can be used.

FEA may only install the exhaust system parts confirmed at application review.

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(2) Intake System

To prevent decreases of engine output performance, intake resistance must be kept below a certain point.

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(3) Crankcase Ventilation Connections

Crankcase emissions may not be discharged directly into the ambient atmosphere throughout its useful life. (40 CFR 1048.115 (a))

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(4) Gaseous Fuel System

FEA must use only the vaporizer and the lock off valve KUBOTA offers and assemble the LPG fuel system parts according to the instructions.

9Y3210051INI0012US0

(5) Engine Control Unit (ECU)

Installation must use all 4 of the vibration mounts.

ECU header pins must be horizontal or point downward.

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(6) Vehicle Interface Connectors

Vehicle interface connectors shall be connected with your wire harness.

9Y3210051INI0014US0

(7) Malfunction Indicator Light (MIL)

When the MIL goes on, it must display "Check Engine", "Service Engine Soon", or a similar message that EPA approve. (40 CFR 1048.110 (b))

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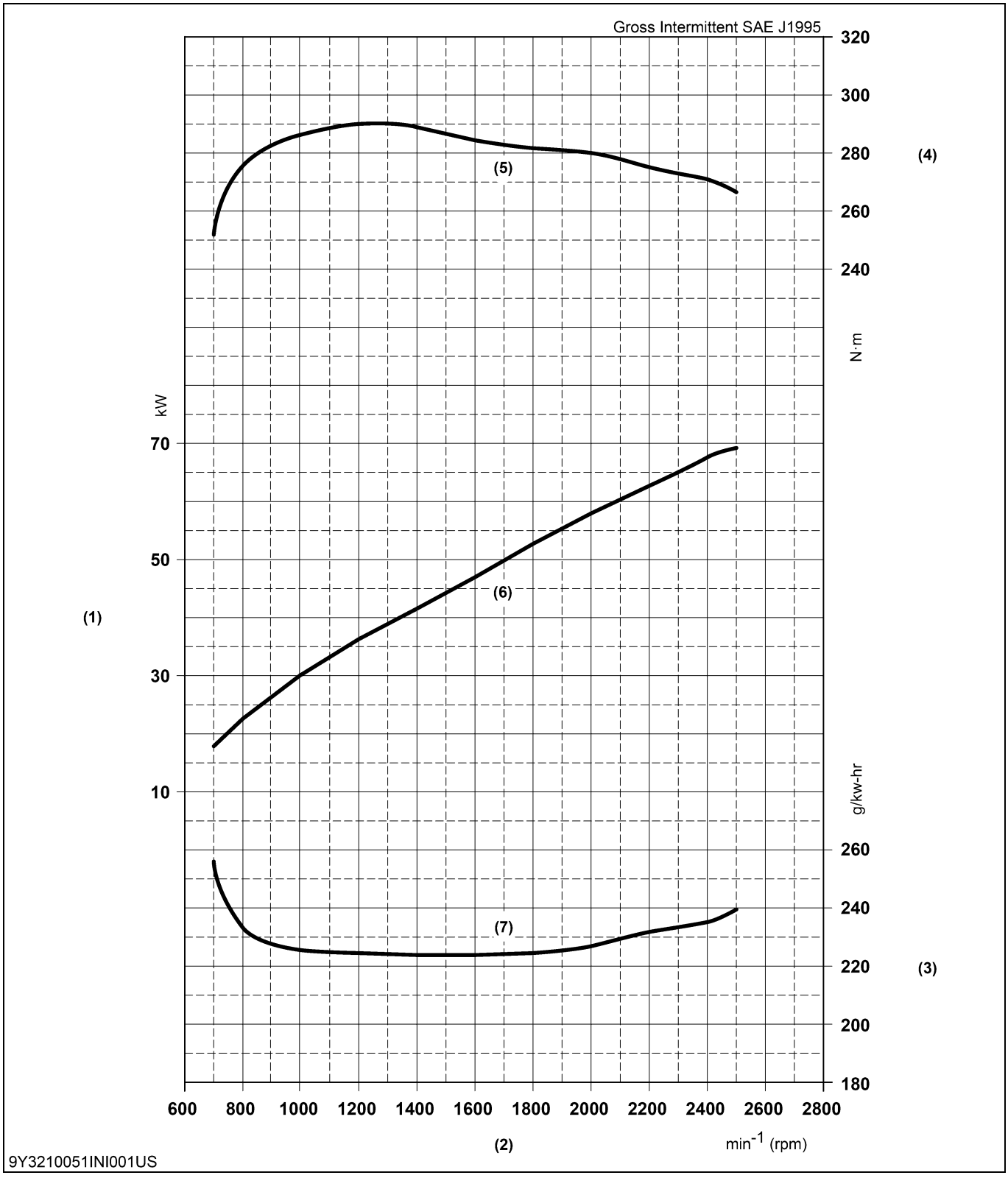
4. PERFORMANCE CURVES

WG3800-L-E5C



(1) Brake Horsepower
(2) Engine Speed
(3) Specific Fuel Consumption
(4) Torque
(5) Gross Intermittent Torque
(6) Gross Intermittent Brake Horsepower
(7) Gross Intermittent Specific Fuel Consumption

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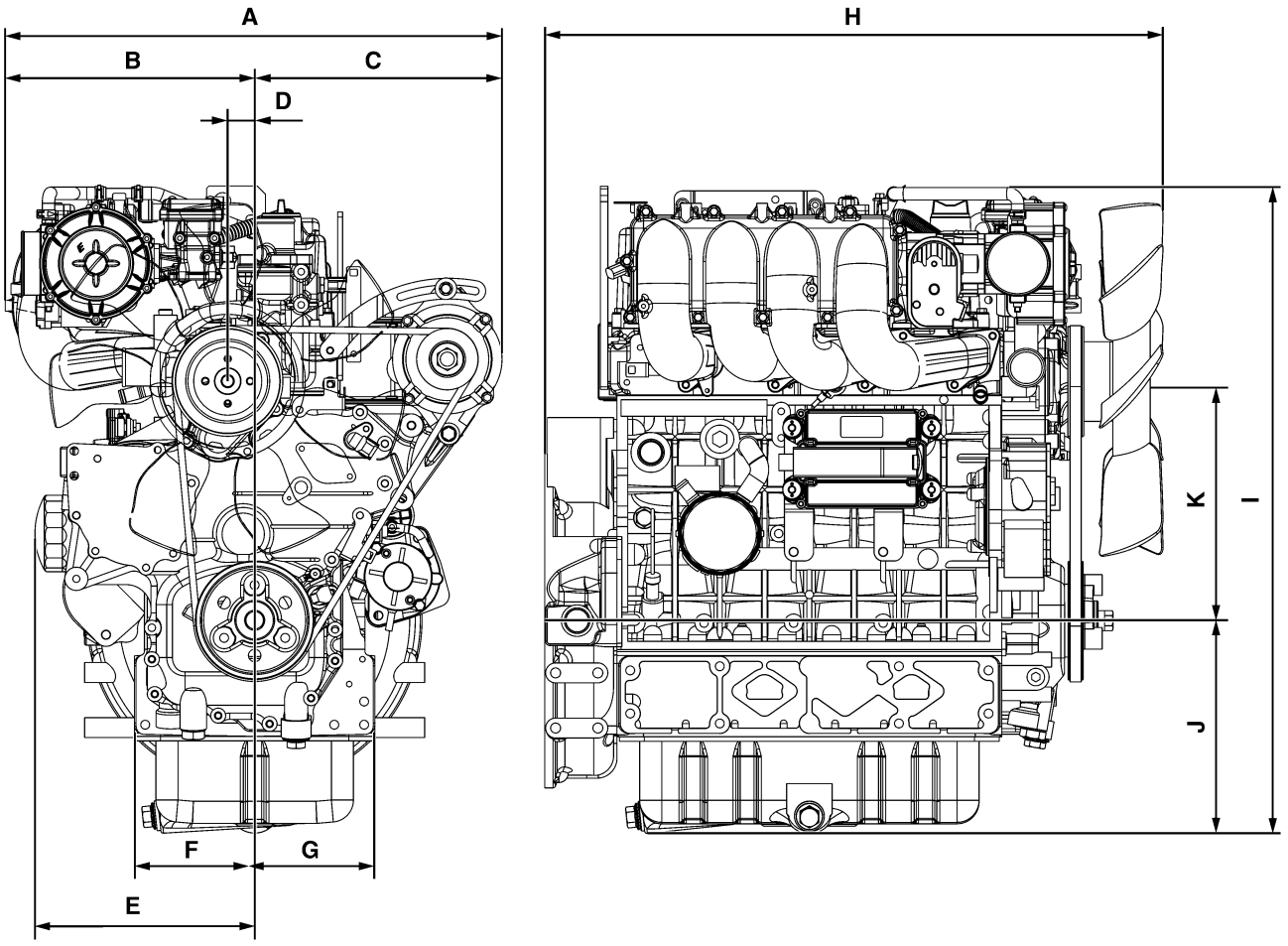
[1] DIMENSIONS

WG3800-L-E5C



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A	599.0 mm (23.58 in.)	**G**	145 mm (5.71 in.)
B	300.8 mm (11.84 in.)	**H**	745.4 mm (29.35 in.)
C	298.2 mm (11.74 in.)	**I**	780.7 mm (30.74 in.)
D	32.5 mm (1.28 in.)	**J**	256.7 mm (10.11 in.)
E	264.9 mm (10.43in.)	**K**	288.5 mm (11.36 in.)
F	145 mm (5.71 in.)		

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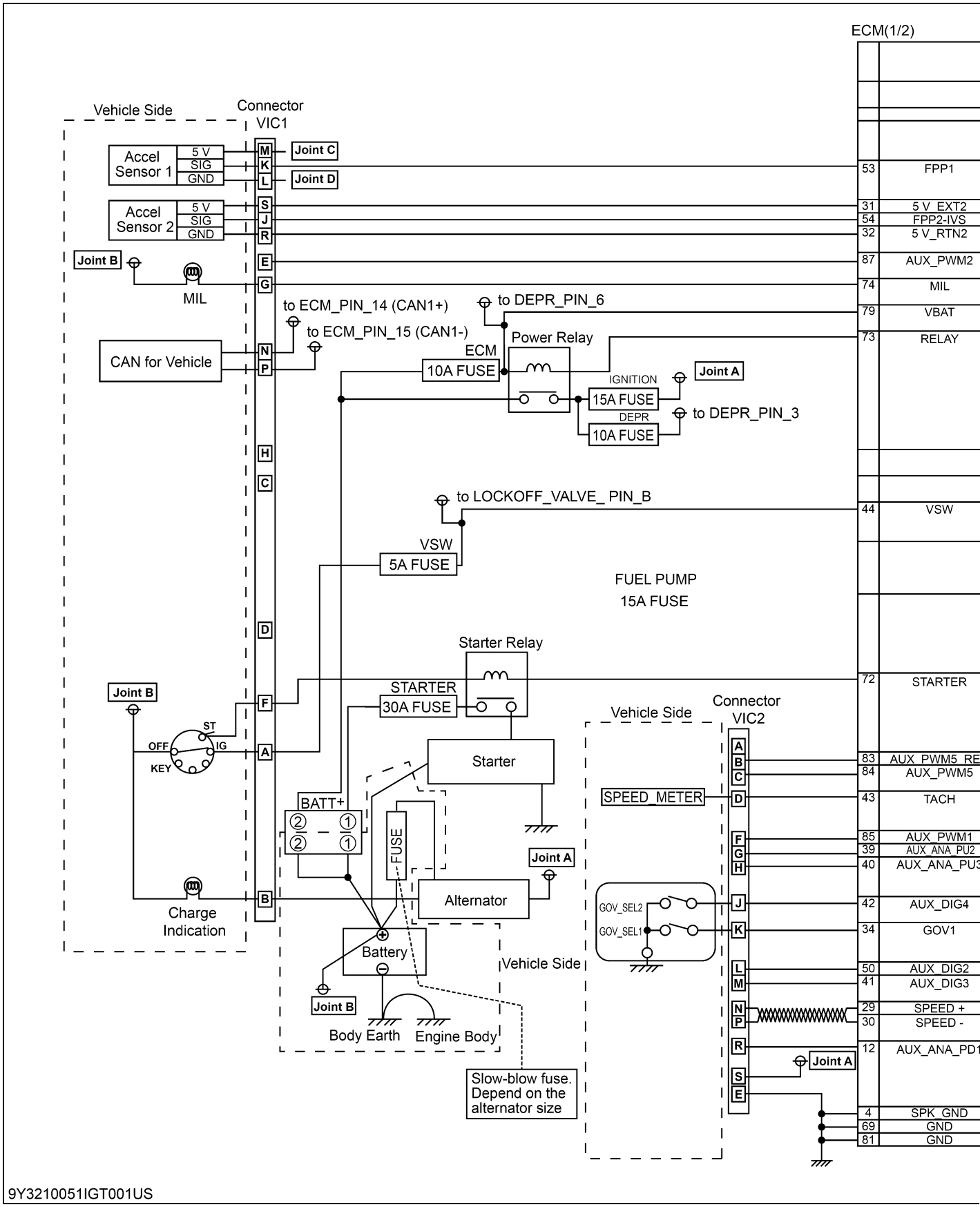
5. WIRING DIAGRAM

WG3800-L



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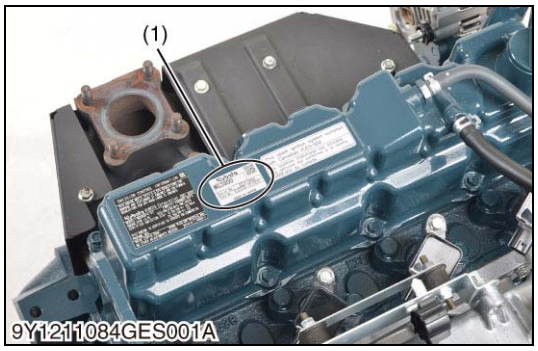
G GENERAL

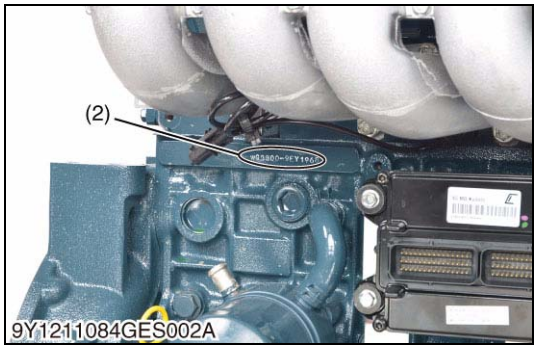
GENERAL

CONTENTS

1. ENGINE IDENTIFICATION

[1] ENGINE MODEL NAME, CODE NUMBER AND ENGINE SERIAL NUMBER





You must identify the engine model name and serial number before you start a job.

When you get in touch with the manufacturer, always tell your engine model name and serial number.

■ **Engine Model Name and Number Label**

The engine model name and engine code number are written in this label.

■ **Engine Serial Number**

The engine serial number is an identified number for the engine. It appears after the engine model name.

It shows the month and year of manufacture as below.

Engine Series

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

Production Year

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

(1) Engine Model Name and Number Label (2) Engine Serial Number

(To be continued)

(Continued)

Production Month and Lot Number

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

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

(a) (b)(c)(d) (e)
e.g. WG3800 - 2 K Y 0001

(a) **WG3800**: Engine Model Name
(b) **2**: Engine Series (WG3800 series)
(c) K: Production Year (2019)
(d) Y: Production Month (December)
(e) **0001**: Lot Number: (**0001 ~ 9999** or **A001 ~ Z999**)

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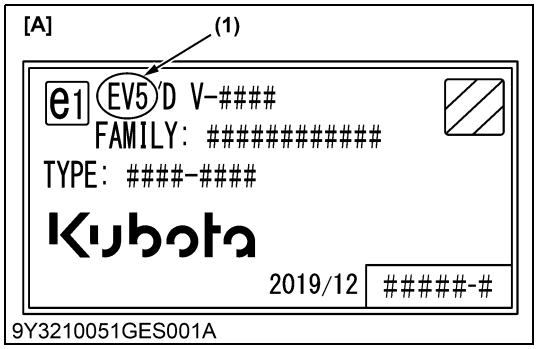
[2] E5 ENGINE



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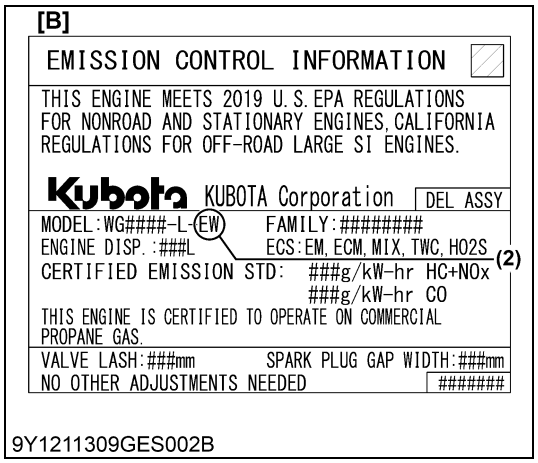

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[Example: Engine Model Name WG3800-L-E5C - XXXX]

The emission controls previously implemented in various countries to prevent air pollution will be stepped up as Non-Road Emission Standards continue to change. The timing or applicable date of the specific Non-Road Emission regulations depends on the engine displacement and output classification.

Over the past several years, KUBOTA has been supplying SI engines that comply with regulations in the respective countries affected by Non-Road Emission regulations. For KUBOTA Engines, E5 will be the designation that identifies engine models affected by the next emission phase (See the table below).

When servicing or repairing ###-E5 series engines, use only replacement parts for that specific E5 engine, designated by the appropriate E5 KUBOTA Parts List and perform all maintenance services listed in the appropriate KUBOTA Operator's Manual or in the appropriate E5 KUBOTA Workshop Manual. Use of incorrect replacement parts or replacement parts from other emission level engines (for example: E3 engines), may result in emission levels out of compliance with the original E5 design and EPA or other applicable regulations. Please refer to the emission label located on the engine head cover to identify Engine Displacement and Output classification and Emission Control Information. E5 engines are identified with "ET" at the end of the Model designation, on the US EPA label. Please note: E5 is not marked on the engine.

Category (1)	Engine output classificaion	EU regulation
EV5	From 56 to 130 kW	STAGE V

Category (2)	Engine output classificaion	EPA regulation
EW	L > 1.0, P > 19	Tier 2 duty cycle

(1) "E5" engines are identified with "EV5" at the first line on the EU regulation label.
(2) "E5" engines are identified with "EW" at the end of the Model designation, on the US EPA label.

[A] EU Label
[B] EPA Label

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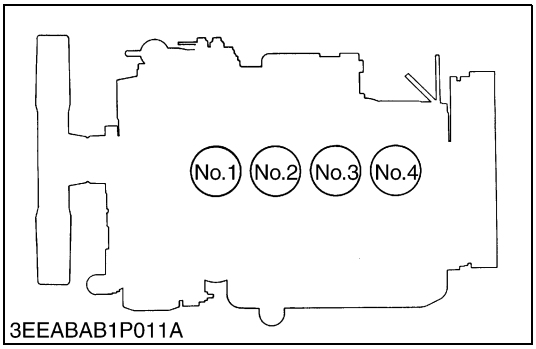
[3] CYLINDER NUMBER



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The cylinder numbers of KUBOTA gasoline, LPG and natural gas engine is designated asshown in the figure.

The sequence of cylinder numbers is given as No.1, No.2, No.3and No.4 starting from the gear case side.

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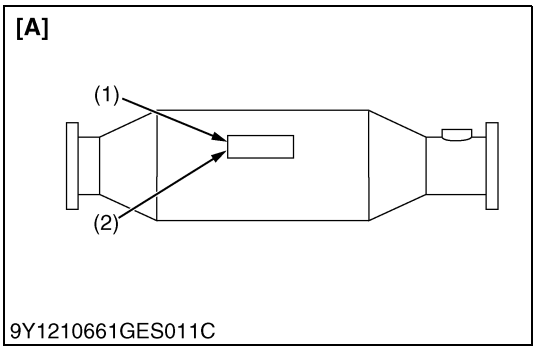
[4] CONVERTER



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KUBOTA provides the converter as the catalyst parts.

The parts number and the manufacturing date are marked on surfaces of the catalyst parts as the catalyst identification.

■ **IMPORTANT**

- **To trace of the converter, put down the catalyst identification and engine identification when new service converter is installed.**

(1) Part Number
(2) Date / Serial Number
[A] CATALYTIC CONVERTER

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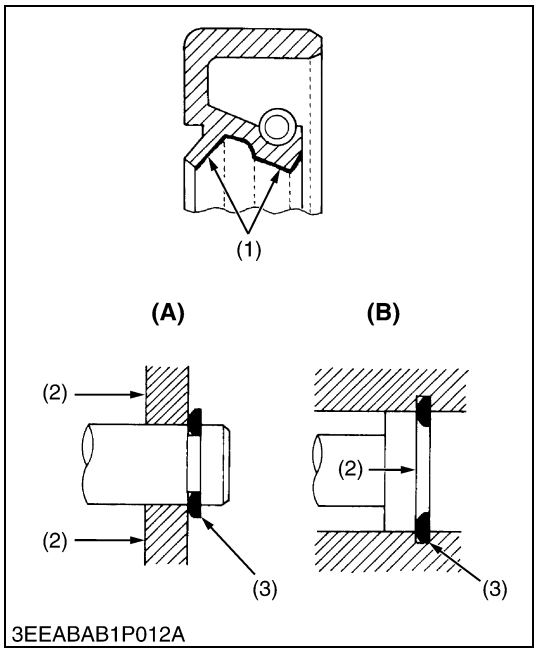
2. GENERAL PRECAUTIONS



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

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

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

9Y3210051GEG0005US0

3. MAINTENANCE CHECK LIST

To make sure that the engine operates safely for a long time, refer to the table below to do regular inspections. (The schedule applies to an engine in use under normal conditions.)

	Item	Service Interval										
		Every 8 hrs (Daily)	Every 50 hrs (Weekly)	Every 100 hrs	Every 200 hrs	Every 400 hrs	Every 500 hrs	Every 1000 hrs	Every 1500 hrs	Every 2000 hrs	Every 1 year	Every 2 years
	Check of engine oil level	☆										
	Check of Coolant Level and Replenishment	☆										
	Check of air cleaner element	if neces-sary										
	Cleaning of air cleaner element	if neces-sary		☆								
	Check of LPG tank setting condition	if neces-sary										
	Check of LPG fuel connector	☆										
	Change of engine oil		★			☆						
	Replacement of oil filter cartridge		★			☆						
	Check of LPG fuel hose and clamp bands		☆									
	Cleaning of spark plug			if neces-sary								
	Check of fan belt tension and damage			☆								
	Replacement of fuel filter			if neces-sary							☆	
	Check of LPG tank setting condition				☆							
	Check of radiator hoses and clamp bands				☆							
	Replacement of fan belt						☆					
	Check of PCV valve							☆				
	Check of coolant hose of LPG vaporizer							☆				
	Check of LPG Lock off valve							☆				
	Check of valve clearance							☆				
	Replacement of oil separator element								☆			
	Replacement of spark plug									☆		
*	Replacement of air cleaner element										☆	
	Replacement of intake pipe clamp bands										☆	
	Cleaning of water jacket and radiator interior										☆	
	Replacement of oil separator rubber hose											☆
	Replacement of intake air line											☆
	Replacement of breather hose											☆
	Replacement of LPG fuel hose and clamp bands											☆
	Replacement of coolant hose of LPG vaporizer											☆
	Check of LPG vaporizer											☆
	Replacement of radiator hoses and clamp bands											☆
	Replacement of lockoff valve filter											☆
	Change of radiator coolant											☆

(To be continued)

(Continued)

★ Change the engine oil and replace the oil filter cartridge after the first 50 hours of operation.

*: Change more often when operating under dusty conditions.

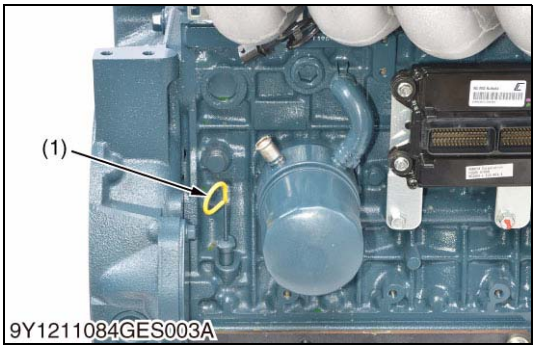
CAUTION

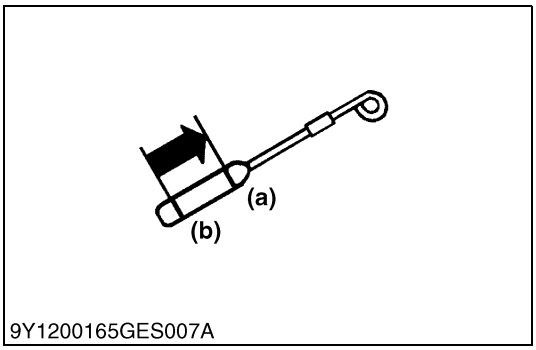
- **When changing or inspecting, be sure to level and stop the engine.**

9Y3210051GEG0006US0

4. CHECK AND MAINTENANCE

[1] DAILY CHECK POINTS





Check of Engine Oil Level

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

■ **IMPORTANT**

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

■ **NOTE**

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

(1) Dipstick

(a) Upper Line
(b) Lower Line

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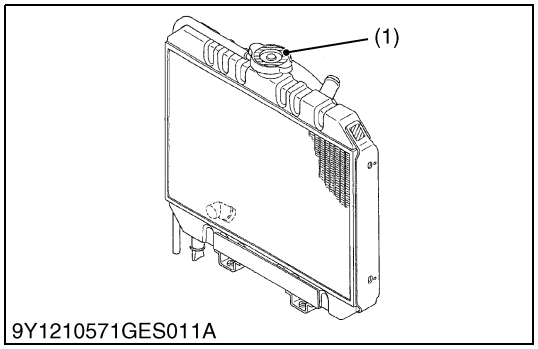

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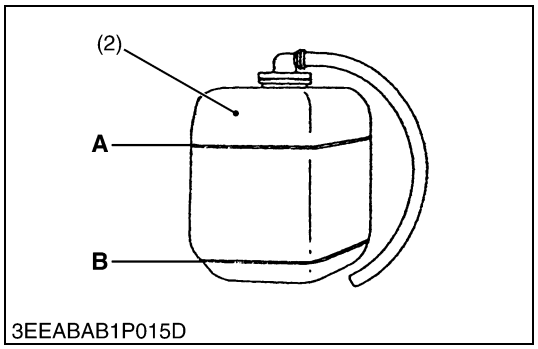

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Check of Coolant Level and Replenishment

CAUTION

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

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

IMPORTANT

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

(1) Radiator Cap
(2) Recovery Tank

A: FULL
B: LOW

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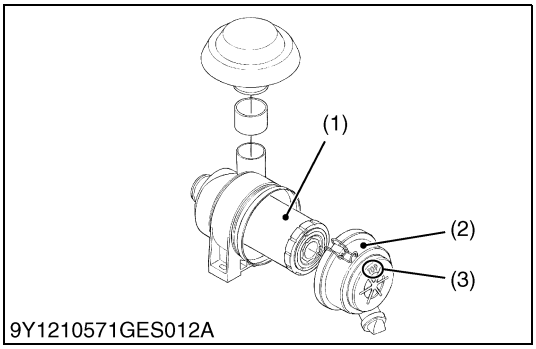

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Check of Air Cleaner Element (If necessary)

1. Remove the dust cup in the air cleaner.
2. Examine the dust in the dust cup and the element.

(When reassembling)

- Install the air cleaner dust cup with **"TOP"** indicated on the rear of the cup.

(1) Element
(2) Dust Cap
(3) **"TOP"** Mark

9Y3210051GEG0009US0

Cleaning of Air Cleaner Element

1. Remove the air cleaner element.
2. The pressure of compressed air must be less than 210 kPa (2.1 kgf/cm^2, 30 psi).
   Keep an appropriate distance between the nozzle and the filter.

■ **NOTE**

- **The air cleaner uses a dry element. Do not apply oil to it.**
- **Do not operate the engine without the filter element.**
- **Replace the element once a year or every sixth cleaning.**

9Y3210051GEG0010US0

Check of LPG Tank Setting Condition (If necessary)

1. Examine the setting condition of LPG fuel tank.

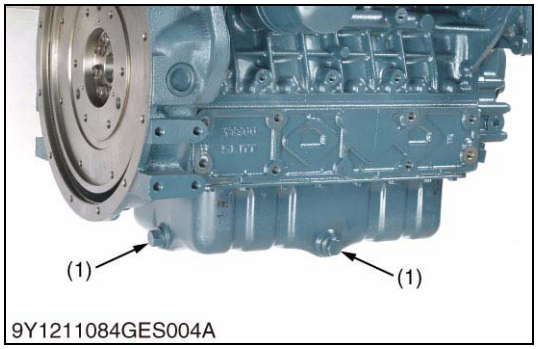
9Y3210051GEG0011US0

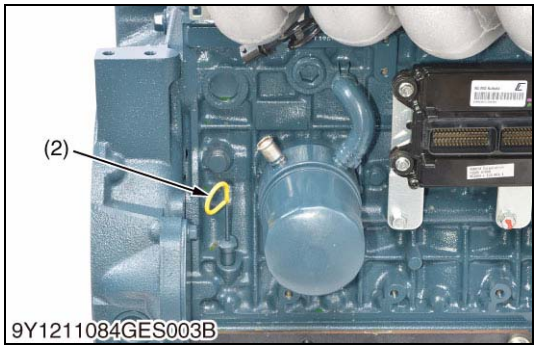
Check of LPG Fuel Connector

1. Examine the connector of LPG line (hoses and clamps).

9Y3210051GEG0012US0

[2] CHECK POINTS OF INITIAL 50 HOURS





Change of Engine Oil

CAUTION

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

1. Start and warm-up the engine for approximately 5 minutes.
2. Put an oil pan below the engine.
3. Remove the drain plug (1) at the bottom of the engine and drain the oil fully.
4. Tighten the drain plug (1).
5. Fill new oil until the upper line on the dipstick (2).

IMPORTANT

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

Above 25 °C (77 °F)	SAE30 or SAE10W-30 or SAE15W-40
0 °C to 25 °C (32 °F to 77 °F)	SAE20 or SAE10W-30
0 °C to −20 °C (32 °F to −4 °F)	SAE10W or SAE10W-30

Engine oil capacity	12.2 L 3.22 U.S.gals

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

(1) Drain Plug (2) Dipstick

9Y3210051GEG0013US0

Replacement of Oil Filter Cartridge

CAUTION

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

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

IMPORTANT

- **To prevent serious damage to the engine, use only KUBOTA genuine filters or its equivalent.**

(1) Oil Filter Cartridge

9Y3210051GEG0014US0

[3] CHECK POINTS OF EVERY 50 HOURS

CAUTION

- **Stop the engine before you do the check and replace below.**
- **Make sure to check the fuel line periodically. The fuel line is subject to wear and aging, fuel may leak out onto the running engine, causing a fire.**

9Y3210051GEG0015US0

Check of LPG Fuel Hose and Clamp Bands

■ **IMPORTANT**

- **Never test for gas leaks with a FLAME.**

■ **NOTE**

- **Examine the fuel leakage with soapy water or gas-detector, if leakage is found, correct leakage or replace the hose.**

9Y3210051GEG0016US0

[4] CHECK POINTS OF EVERY 100 HOURS

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Cleaning of Air Cleaner Element

1. Remove the air cleaner element.
2. Use clean dry compressed air on the inner side of the element. The pressure of compressed air must be less than 210 kPa (2.1 kgf/cm^2, 30 psi).
   Keep an appropriate distance between the nozzle and the filter.

■ **NOTE**

- **The air cleaner uses a dry element. Do not apply oil to it.**
- **Do not operate the engine without the filter element.**
- **Replace the element once a year or every sixth cleaning.**

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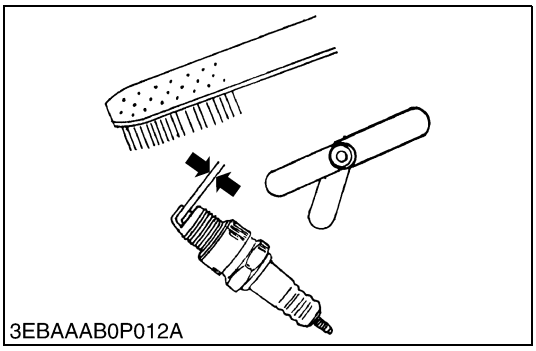

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Cleaning of Spark Plug (If Necessary)

1. Remove the spark plug, and remove carbon from the electrode with a wire brush or other tools.
2. Measure the spark plug gap with a feeler gauge, and adjust or replace the spark plug if the measured gap differs from the service specification.
3. Replace the spark plug if the electrode or the insulator is deformed or cracked.
4. Tighten the spark plug with a plug wrench.

■ **IMPORTANT**

(When reassembling)

- **Put the ignition coil inside the spark plug terminal firmly.**
- **Make sure that the wiring and the ignition coil are correctly connected.**
- **Fix the ignition coil by screw.**

Spark plug gap	Service specification	0.70 to 0.80 mm 0.028 to 0.031 in.

Spark plug	NGK IFR6F8DN

Tightening torque	Spark plug	24.5 to 29.4 N·m 2.50 to 2.99 kgf·m 18.1 to 21.6 lbf·ft
	Ignition coil mounting screw / nut	9.81 to 11.3 N·m 1.00 to 1.15 kgf·m 7.24 to 8.33 lbf·ft

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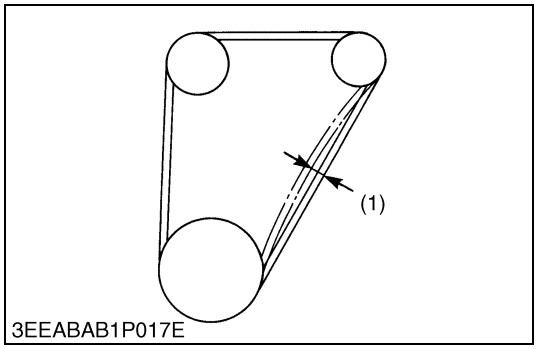

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Fan Belt Tension

1. Examine if the fan belt is worn out and sunk in the pulley groove, and if it is, replace it.
2. Push the belt halfway between the fan drive pulley and alternator pulley at a specified force 59 to 68 N (6.0 to 7.0 kg, 14 to 15 lbf) to measure the deflection (1).
3. If the measurement is out of the service specifications, loosen the alternator mounting screws and adjust its position.

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

(1) Deflection

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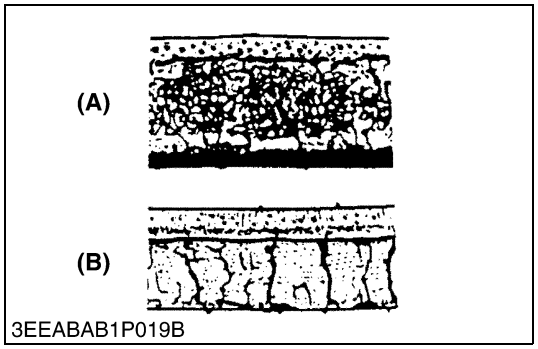

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Fan Belt Damage and Wear

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

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

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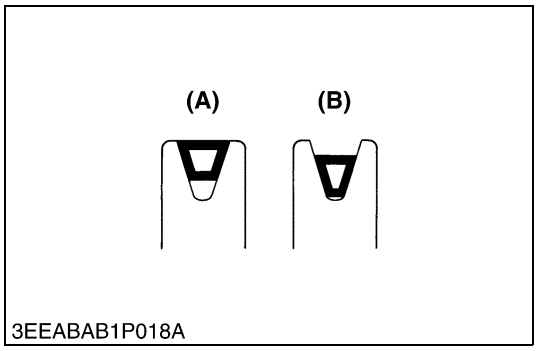

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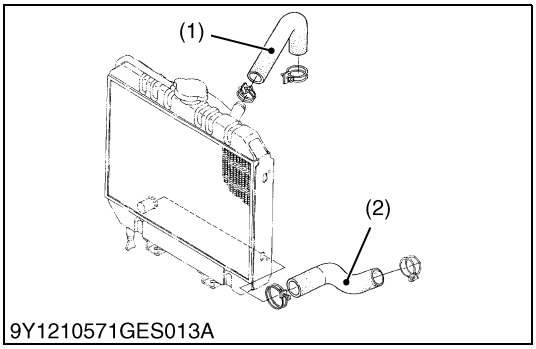
[5] CHECK POINTS OF EVERY 200 HOURS



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Check of LPG Tank Setting Condition

1. Examine the setting condition of LPG fuel tank.

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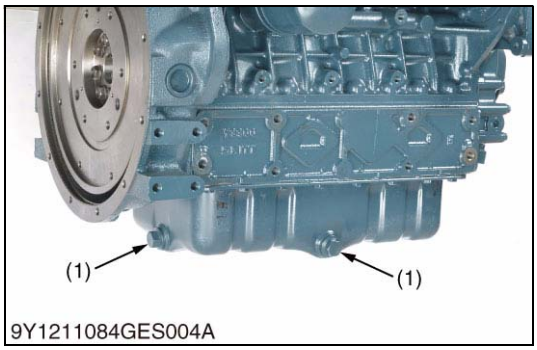
Check of Radiator Hoses and Clamp Bands

1. Make sure that the radiator hoses connections are correct for every 200 hours of operation or every 6 months, whichever comes first.
2. If the clamp is loose, apply oil to the threads and tighten it again correctly.
3. The radiator hose material is rubber and deteriorates naturally. You must replace the radiator hose every 2 years. Also replace the clamp and tighten it correctly.

(1) Upper Hose (2) Lower Hose

9Y3210051GEG0023US0

[6] CHECK POINTS OF EVERY 400 HOURS



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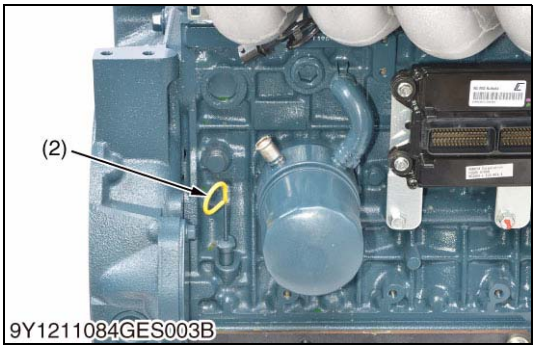


9Y1211084GES003B

Change of Engine Oil

CAUTION

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

1. Start and warm-up the engine for approximately 5 minutes.
2. Put an oil pan below the engine.
3. Remove the drain plug (1) at the bottom of the engine and drain the oil fully.
4. Tighten the drain plug (1).
5. Fill new oil until the upper line on the dipstick (2).

IMPORTANT

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

Above 25 °C (77 °F)	SAE30 or SAE10W-30 or SAE15W-40
0 °C to 25 °C (32 °F to 77 °F)	SAE20 or SAE10W-30
0 °C to −20 °C (32 °F to −4 °F)	SAE10W or SAE10W-30

Engine oil capacity	12.2 L 3.22 U.S.gals

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

(1) Drain Plug (2) Dipstick

9Y3210051GEG0024US0

Replacement of Oil Filter Cartridge

CAUTION

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

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

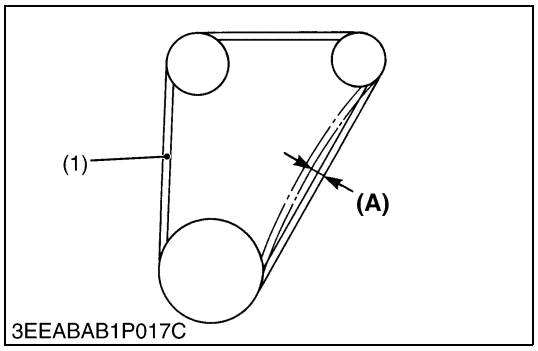
IMPORTANT

- **To prevent serious damage to the engine, use only KUBOTA genuine filters or its equivalent.**

(1) Oil Filter Cartridge

9Y3210051GEG0025US0

[7] CHECK POINTS OF EVERY 500 HOURS



Replacement of Fan Belt

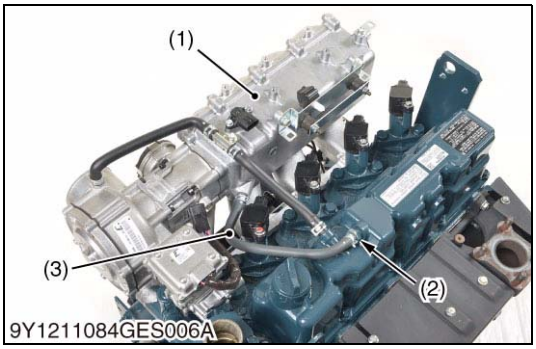
1. Remove the alternator.
2. Remove the fan belt (1).
3. Replace the fan belt with a new one.
4. Install the alternator.
5. Check the deflection **(A)** of fan belt.

Deflection **(A)**	Service specification	10 to 12 mm / 59 to 68 N 0.40 to 0.47 in. / 59 to 68 N (6.0 to 7.0 kgf, 14 to 15 lbf)

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

9Y3210051GEG0026US0

[8] CHECK POINTS OF EVERY 1000 HOURS



Check of PCV Valve

1. Disconnect the breather hose (3) from the intake manifold (1).
2. Blow into the breather hose (3).
3. Stop to blow.
4. Make sure that a slight operation sound is heard from the PCV valve.
5. If there is no operation sound, replace the PCV valve (2).
6. Connect the breather hose (3) to the intake manifold (1)

(1) Intake Manifold
(2) PCV Valve
(3) Breather Hose

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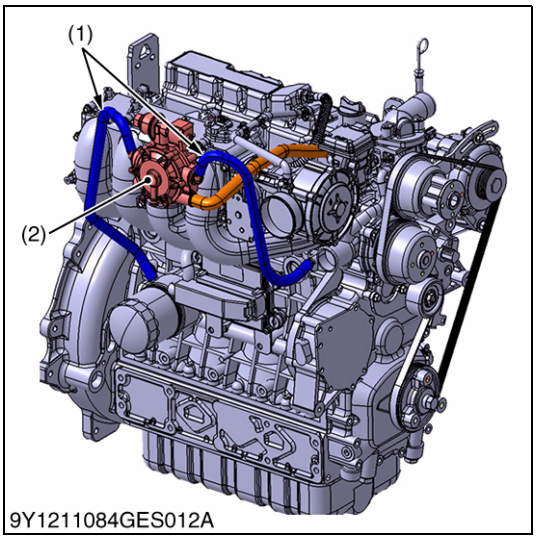

Check of Coolant Hose of LPG Vaporizer

1. Examine the coolant hoses (1) for damage.
2. If the coolant hose is damaged, replace it.

(1) Coolant Hose
(2) Vaporizer

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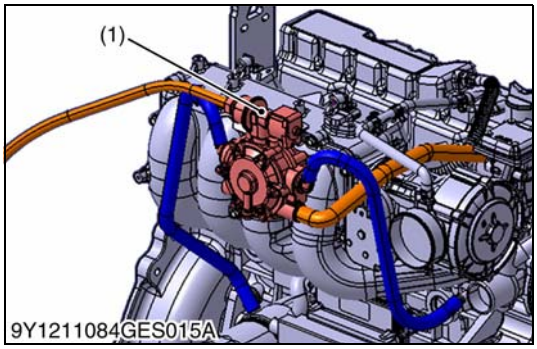

Check of LPG Lock Off Valve

1. Start the engine.
2. Make sure that an operation sound of solenoid is heard from the LPG lock off valve (1).
3. Make sure that there is no fuel leakage from the LPG lock off valve (1).
4. If there is no operation sound or fuel leakage, replace the LPG lock off valve (1).

(1) LPG Lock Off Valve

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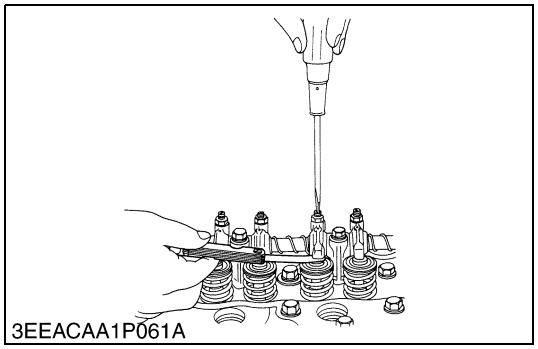
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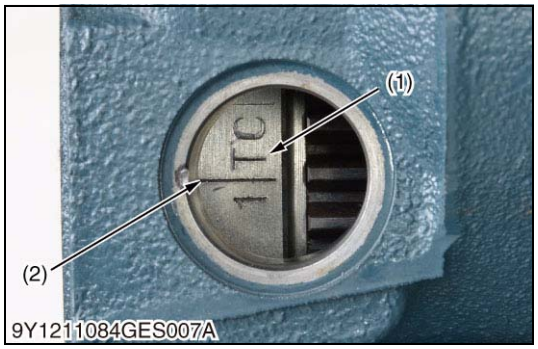

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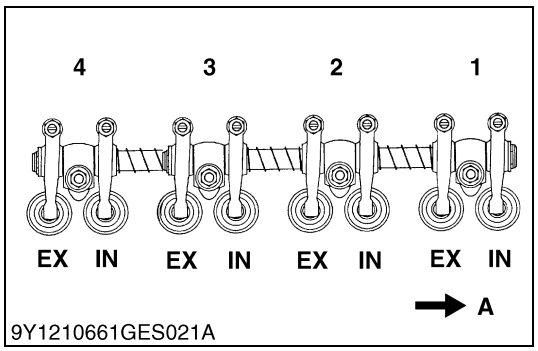

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Valve Clearance

■ **IMPORTANT**

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

1. Remove the head cover.
2. Align the **"1TC"** mark line (1) on the flywheel and alignment mark (2) on the housing. Make sure that the No.1 piston comes to the compression or overlap top dead center.
3. Examine the subsequent valve clearance at the mark "☆" with a feeler gauge.
4. If the clearance is out of the service specifications, adjust with the adjusting screw.

Adjustable Cylinder Location of Piston		Intake valve	Exhaust valve
When No. 1 piston is at compression top dead center	1st	☆	☆
	2nd	☆	
	3rd		☆
	4th		
When No. 1 piston is at overlap position	1st		
	2nd		☆
	3rd	☆	
	4th	☆	☆

Intake and exhaust valve clearance (cold)	Service specification	0.18 to 0.22 mm 0.0071 to 0.0086 in.

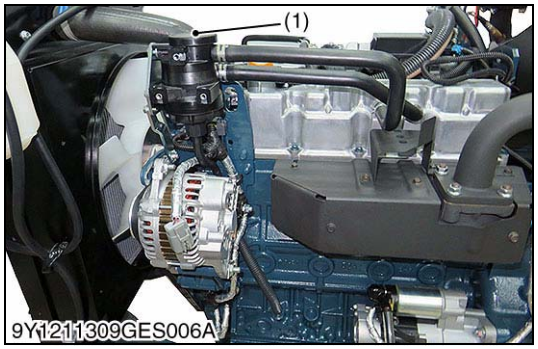
■ **NOTE**

- **The sequence of cylinder numbers is No.1, No.2, No.3 and No.4 and it starts from the gear case side.**
- **After you adjust the valve clearance, tighten the lock nut of the adjusting screw.**

(1) **"1TC"** Mark
(2) Alignment Mark
A: Gear Case Side

9Y3210051GEG0030US0

[9] CHECK POINTS OF EVERY 1500 HOURS



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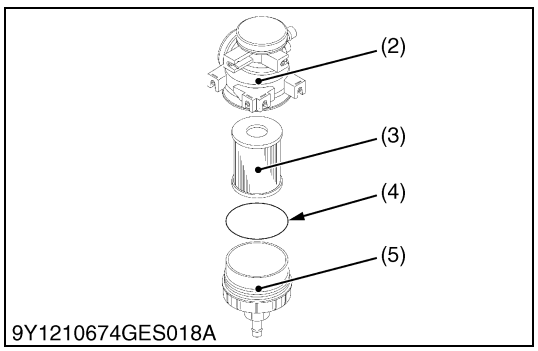

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Replacement of Oil Separator Element

CAUTION

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

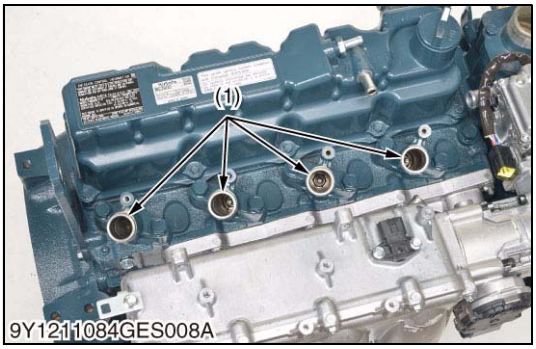
1. Remove the case (5).
2. Remove the oil separator element (3) and O-ring (4).
3. Replace the oil separator element and O-ring with a new one.

Tightening torque	Case of oil separator	9.50 to 10.5 N·m 0.969 to 1.07 kgf·m 7.01 to 7.74 lbf·ft

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

9Y3210051GEG0031US0

[10] CHECK POINTS OF EVERY 2000 HOURS



Replacement of Spark Plug

1. Disconnect the ignition coil.
2. Remove the spark plug.
3. Replace the new spark plug.
4. Tighten the spark plug with a plug wrench.

■ **IMPORTANT**

(When reassembling)

- **Put the ignition coil inside the spark plug terminal firmly.**
- **Make sure that the wiring and the ignition coil are correctly connected.**
- **Fix the ignition coil by screw.**

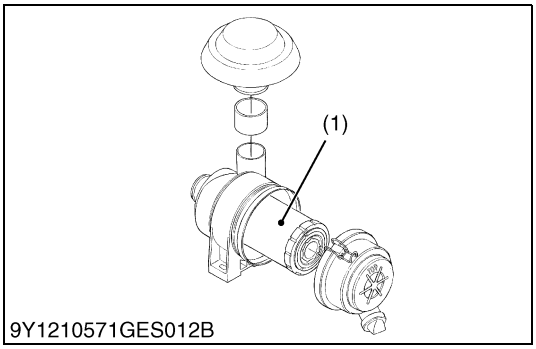
Spark plug	NGK IFR6F8DN

Tightening torque	Spark plug	24.5 to 29.4 N·m 2.50 to 2.99 kgf·m 18.1 to 21.6 lbf·ft
	Ignition coil mounting screw	9.81 to 11.3 N·m 1.00 to 1.15 kgf·m 7.24 to 8.33 lbf·ft

(1) Spark Plug

9Y3210051GEG0032US0

[11] CHECK POINTS OF EVERY 1 YEAR

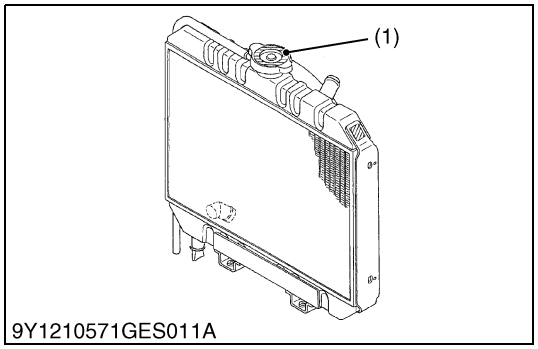


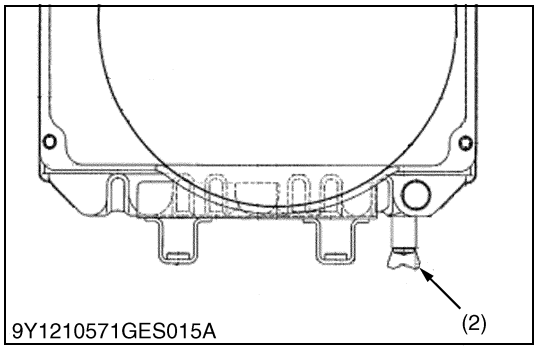
Replacement of Air Cleaner Element

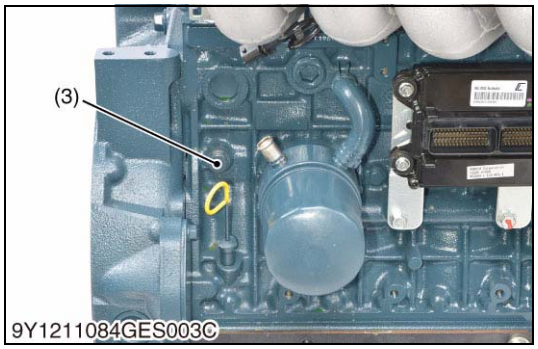
1. Remove the dust cup from the air cleaner.
2. After cleaning the dust cup, remove the air cleaner element.
3. Replace the new air cleaner element.

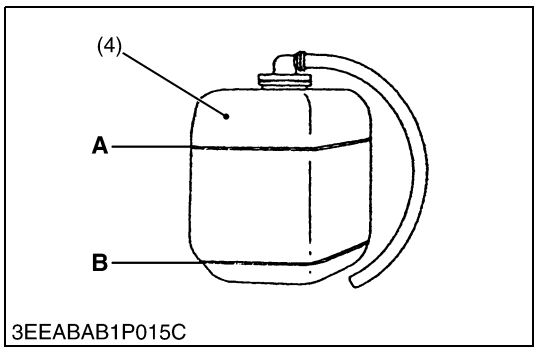
(1) Air Cleaner Element

9Y3210051GEG0033US0









Cleaning of Water Jacket and Radiator Interior

CAUTION

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

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

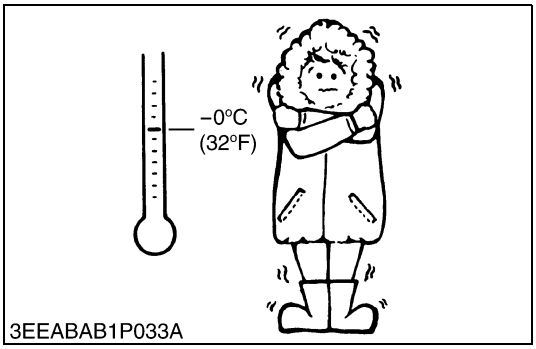
IMPORTANT

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

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

A: FULL
B: LOW

9Y3210051GEG0034US0



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Anti-freeze

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

■ **IMPORTANT**

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

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

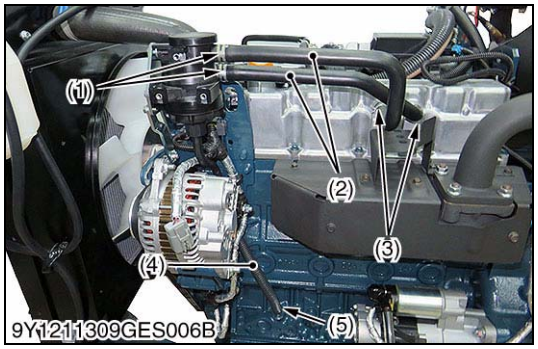
* At 1.01 × 100000 Pa (760 mmHg) pressure (atmospheric). Use a radiator pressure cap that lets the pressure collect in the cooling system to get a higher boiling point.

■ **NOTE**

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

9Y3210051GEG0035US0

[12] CHECK POINTS OF EVERY 2 YEARS



Replacement of Oil Separator Rubber Hose

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

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

9Y3210051GEG0037US0

Replacement of Intake Air Line

1. Replace the intake hose and the clamps between the air cleaner and the electronic throttle body or gas mixer.

9Y3210051GEG0038US0

Replacement of Breather Hose

1. Replace the breather hose and the clamps between the head cover and the intake manifold.

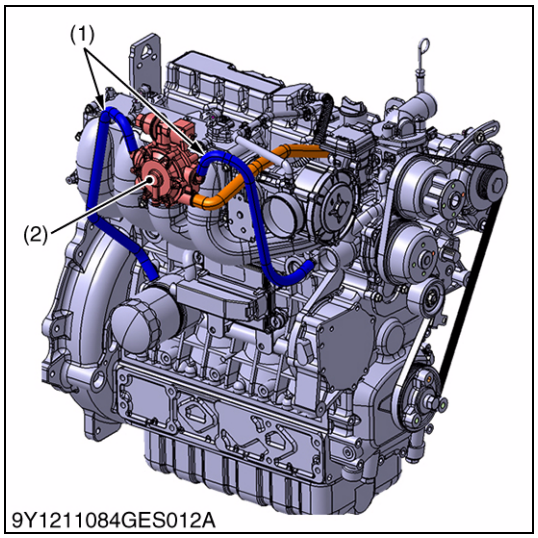
(1) Breather Hose

9Y3210051GEG0039US0

Replacement of LPG Fuel Hose and Clamp Bands

1. Replace the fuel hose and the clamps.

9Y3210051GEG0040US0

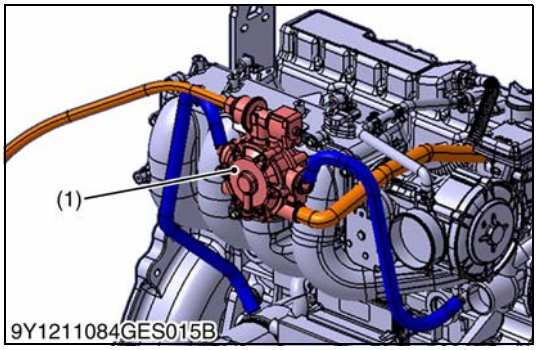


Replacement of Coolant Hose of LPG Vaporizer

1. Connect the new coolant hose (1) to the vaporizer (2).
2. Fill the coolant to radiator, and bleed the air from the vaporizer (2).

(1) Coolant Hose
(2) Vaporizer

9Y3210051GEG0041US0



Check of LPG Vaporizer

1. Connect the diagnostic tool (EDIS), and key on, engine off.
2. Check whether the DTC appear or not.
3. Check that the LPG fuel tank has a minimum 1/4 tank of fuel, and manual valve is open.
4. Connect a pressure gauge to the primary test port of vaporizer.
5. Key on and engine start.
6. Measure the pressure of test port.
   If the measurement value is out of service specification, replace the vaporizer.

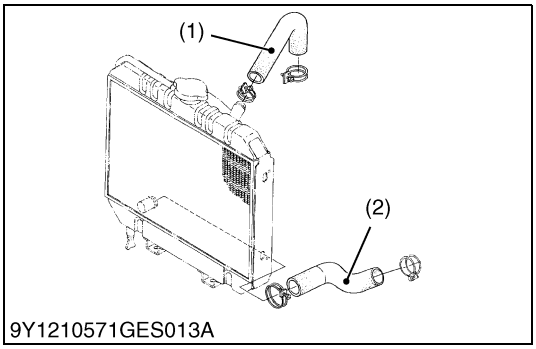
Test port pressure	Service specification	14 to 24 kPa 0.15 to 0.24 kgf/cm^2 2.1 to 3.4 psi

■ **IMPORTANT**

- **After checking, connect the test plug and check the gas leak with bubbles or leak checker or equivalent during engine running.**
- **Recommended pressure gauge range is 0 to 69 kPa (0 to 10 psi).**
- **Use 3/16 hex socket head screw for test port plug.**

(1) Vaporizer

9Y3210051GEG0042US0



Replacement of Radiator Hoses and Clamp Bands

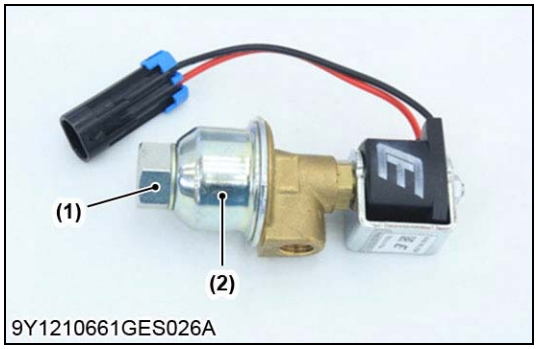
CAUTION

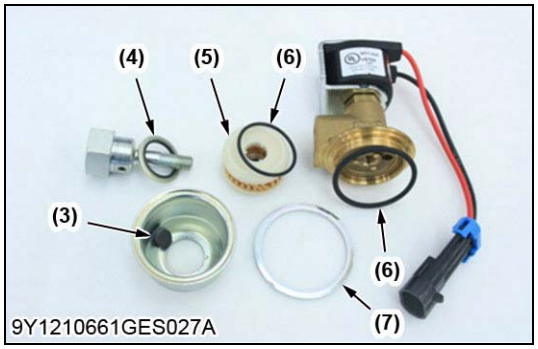
- **Do not remove the radiator cap when the engine is hot. Then loosen the cap to the stop to release unwanted pressure before you remove the cap fully.**

1. Drain the coolant.
2. Loosen the clamp bands.
3. Remove the upper hose (1) and lower hose (2).
4. Replace the upper / lower hose (1), (2) and clamp bands with new ones.
5. Tighten the clamp bands correctly.
6. Fill with clean water and anti-freeze until the coolant level is immediately below the port. Install the radiator cap correctly.

(1) Upper Hose (2) Lower Hose

9Y3210051GEG0043US0





Replacement of Lockoff Valve Filter

1. Remove the fitting union (1) and open the filter chamber (2).
2. Replace lockoff valve filter (5), magnet (3), seal (4) and O-rings (6).
3. Reassemble lockoff valve filter (5), magnet (3) , seal (4), O-rings (6) and the filter chamber (2).
4. Tighten the fitting union (1) at specific torque.

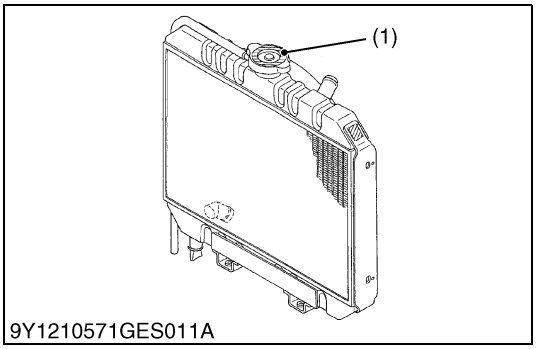
Tightening torque	Fitting union	11.2 to 12.8 N·m 1.15 to 1.30 kgf·m 8.26 to 9.44 lbf·ft

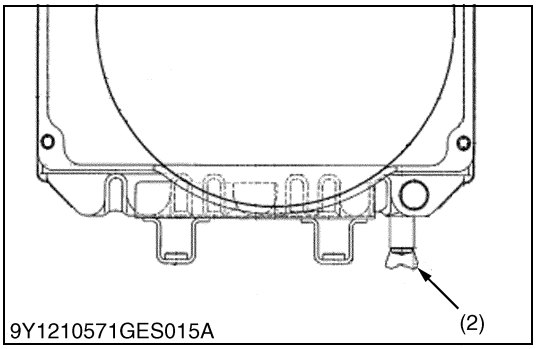
■ **NOTE**

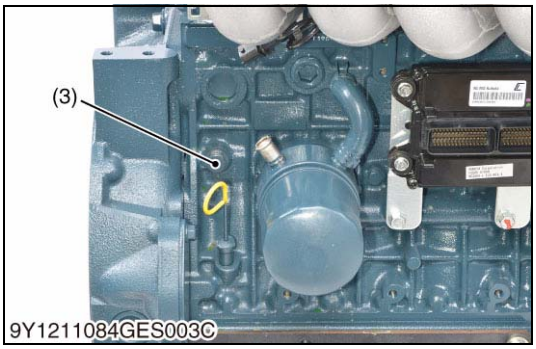
- **When reassemble the spacer ring, be careful of the direction.**

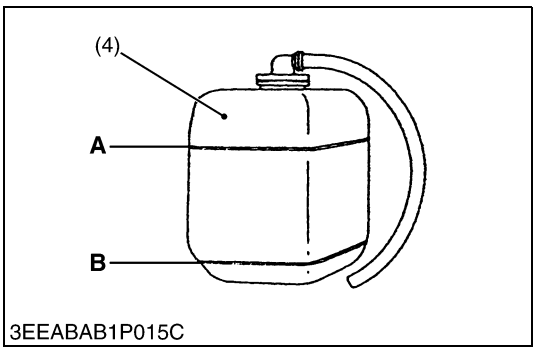
(1) Fitting Union
(2) Filter Chamber
(3) Magnet
(4) Seal
(5) Lockoff Valve Filter
(6) O-ring
(7) Spacer Ring

9Y3210051GEG0044US0









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

CAUTION

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

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

IMPORTANT

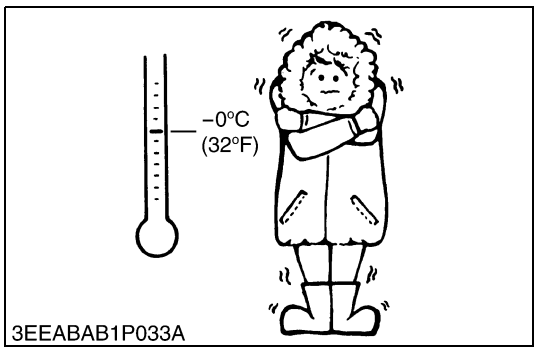
- **Do not start the engine without coolant.**
- **Use clean and soft water with anti-freeze to fill the radiator and recovery tank.**
- **Make sure that when you mix the anti-freeze and water, the ratio of anti-freeze is less than 50 %.**
- **Make sure that you close the radiator cap correctly. If the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

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

A: FULL
B: LOW

(To be continued)

(Continued)



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■ **Anti-freeze**

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

■ **IMPORTANT**

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

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

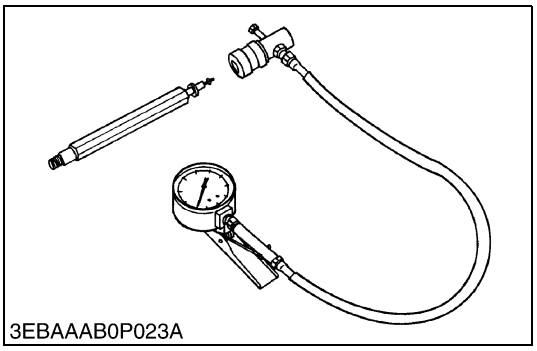
* At 1.01 × 100000 Pa (760 mmHg) pressure (atmospheric). Use a radiator pressure cap that lets the pressure collect in the cooling system to get a higher boiling point.

■ **NOTE**

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

9Y3210051GEG0045US0

5. SPECIAL TOOLS

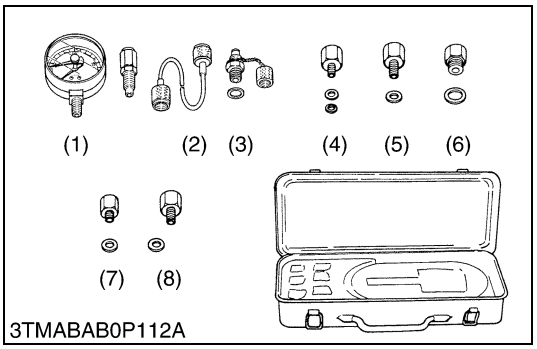

3EBAAAB0P023A

Compression Tester

Code No.
- 07909-30251

Application
- To measure the gasoline, LPG / Natural gas engine compression and to make a decision for a large overhaul if necessary.

9Y3210051GEG0046US0



3TMABAB0P112A

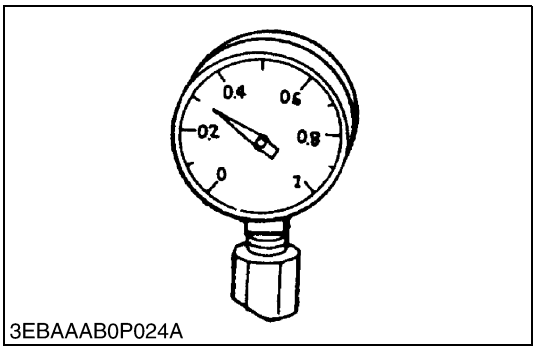
Oil Pressure Tester

Code No.
- 07916-32032

Application
- To measure the engine oil pressure.

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

9Y3210051GEG0047US0



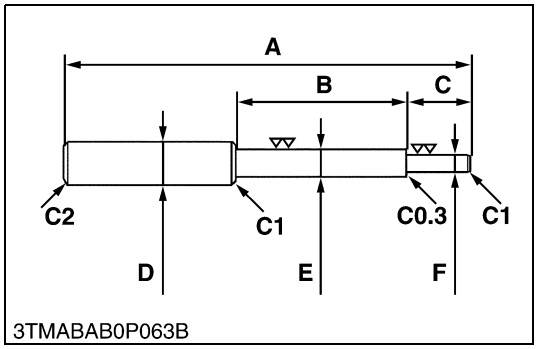
3EBAAAB0P024A

Pressure Gauge

Specification
- 1745 kPa (17.79 kgf/cm^2, 253.1 psi)

Application
- To measure the pressure of vaporizer.

9Y3210051GEG0048US0



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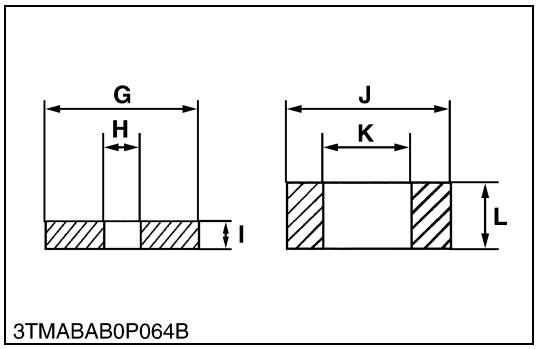


3TMABAB0P064B

Valve Guide Replacing Tool

Application

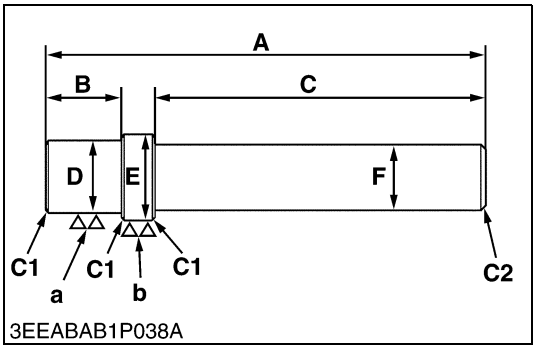
- To press out and press fit the valve guide.

■ **NOTE**

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

A	225 mm (8.86 in.)
B	70 mm (2.8 in.)
C	45 mm (1.8 in.)
D	20 mm dia. (0.79 in dia.)
E	11.7 to 11.9 mm dia. (0.461 to 0.468 in. dia.)
F	6.50 to 6.60 mm dia. (0.256 to 0.259 in. dia.)
G	25 mm dia. (0.98 in. dia.)
H	6.70 to 7.00 mm dia. (0.264 to 0.275 in. dia.)
I	5 mm (0.2 in.)
J	20 mm dia. (0.79 in. dia.)
K	12.5 to 12.8 mm dia. (0.493 to 0.503 in. dia.)
L	7.90 to 8.10 mm (0.311 to 0.318 in.)
C1	Chamfer 1.0 mm (0.039 in.)
C2	Chamfer 2.0 mm (0.079 in.)
C0.3	Chamfer 0.3 mm (0.01 in.)

9Y3210051GEG0049US0



3EEABAB1P038A

Small End Bushing Replacing Tool

Application

- To press out and press fit the bushing.

■ NOTE

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

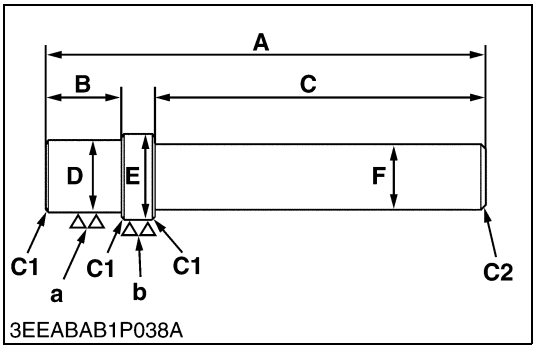
[Press out]

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

[Press fit]

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

9Y3210051GEG0050US0



3EEABAB1P038A

Idle Gear Bushing Replacing Tool

Application

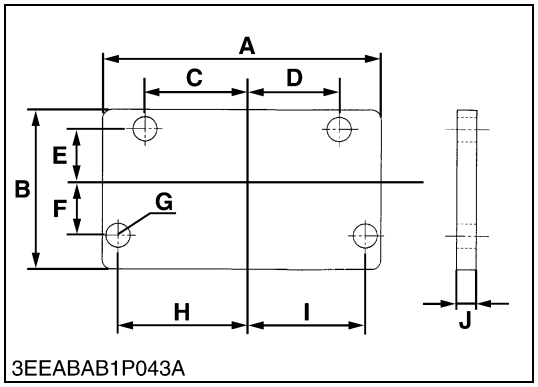
- To press out and press fit the bushing.

■ NOTE

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

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

9Y3210051GEG0051US0



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Flywheel Stopper

Application

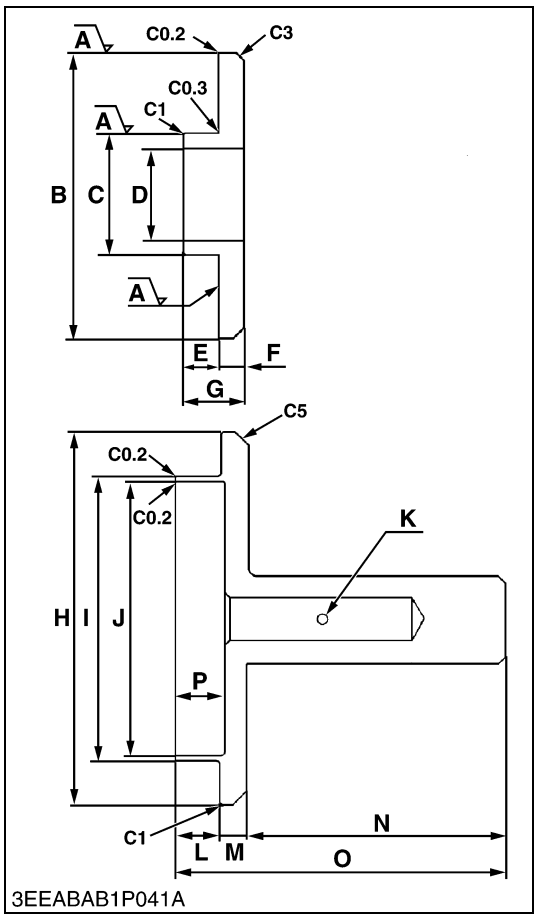
- To loosen and tighten the flywheel screw.

■ NOTE

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

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

9Y3210051GEG0052US0



3EEABAB1P041A

Crankshaft Sleeve Press Fit Tool

Application

- To press fit the crankshaft sleeve.

■ NOTE

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

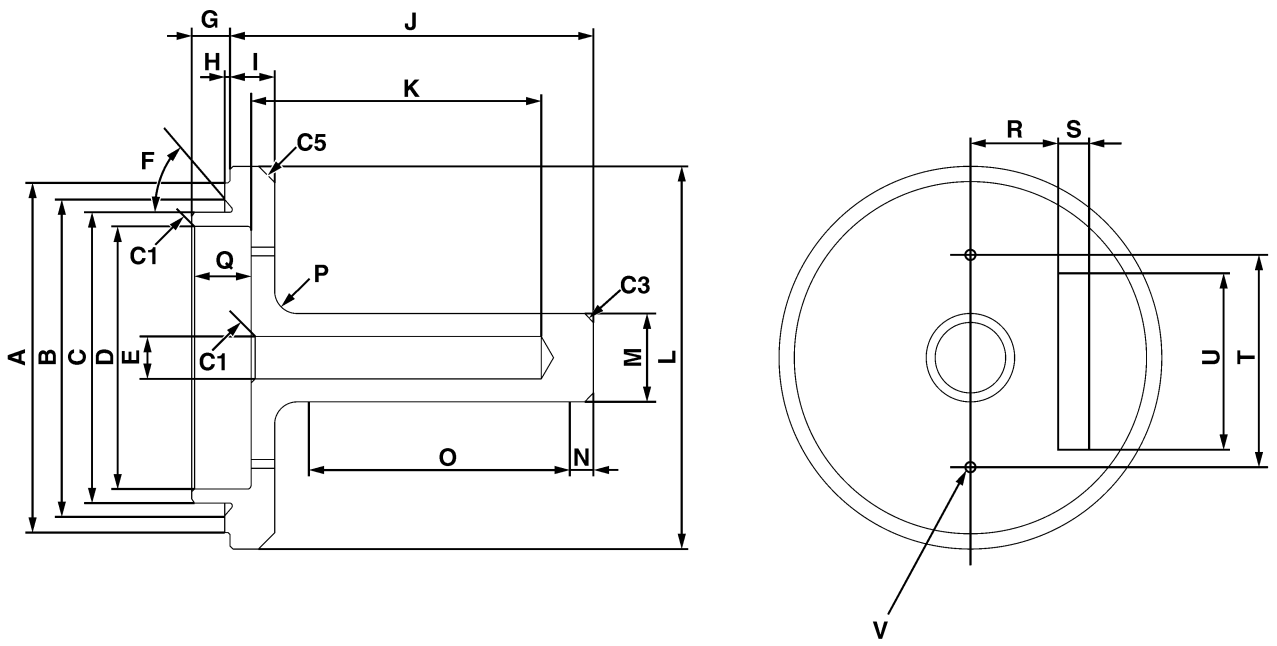
A	Rmax = 12.5 S
B	94.5 to 95.0 mm dia. (3.72 to 3.74 in. dia.)
C	40 mm dia. (1.6 in. dia.)
D	30 mm dia. (1.2 in. dia.)
E	12 mm (0.47 in.)
F	7.90 to 8.10 mm (0.311 to 0.318 in.)
G	20 mm (0.79 in.)
H	130 mm dia. (5.12 in. dia.)
I	99.40 to 99.60 mm dia. (3.914 to 3.921 in. dia.)
J	95.05 to 95.20 mm dia.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

9Y3210051GEG0053US0

Bearing Case Cover Oil Seal Replacing Tool

Application

- To install bearing case cover oil seal.



9Y1211084GES013A

A	118.8 to 119.2 mm dia. (4.678 to 4.692 in. dia.)	**N**	8.0 mm dia. (0.31 in. dia.)
B	108.0 to 108.2 mm dia. (4.252 to 4.259 in. dia.)	**O**	90 mm dia. (3.5 in. dia.)
C	98.70 to 98.90 mm dia. (3.886 to 3.893 in. dia.)	**P**	16 mm dia. (0.63 in. dia.)
D	89.000 to 89.087 mm dia. (3.5040 to 3.5073 in. dia.)	**Q**	20.5 mm (0.807 in.)
E	5.0 mm dia. (0.20 in. dia.)	**R**	30 mm (1.2 in.)
F	0.86 rad (49°)	**S**	10 mm (0.39 in.)
G	13.5 mm (0.531 in.)	T	72 mm (2.8 in.)
H	2.0 mm (0.079 in.)	**U**	60 mm (2.4 in.)
I	15 mm (0.59 in.)	**V**	2.0 mm dia. (0.079 in.)
J	125 mm (4.92 in.)	**C1**	Chamfer 1.0 mm (0.039 in.)
K	100 mm (3.94 in.)	**C3**	Chamfer 3.0 mm (0.12 in.)
L	130 mm dia. (5.12 in. dia.)	**C5**	Chamfer 5.0 mm (0.20 in.)
M	30 mm dia. (1.2 in. dia.)		

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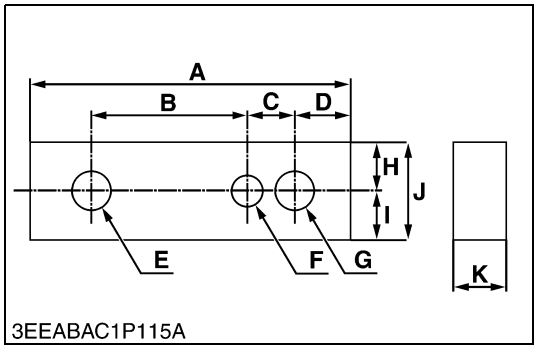


3EEABAC1P115A

Crankcase 1 and 2 Aligning Tool

Application

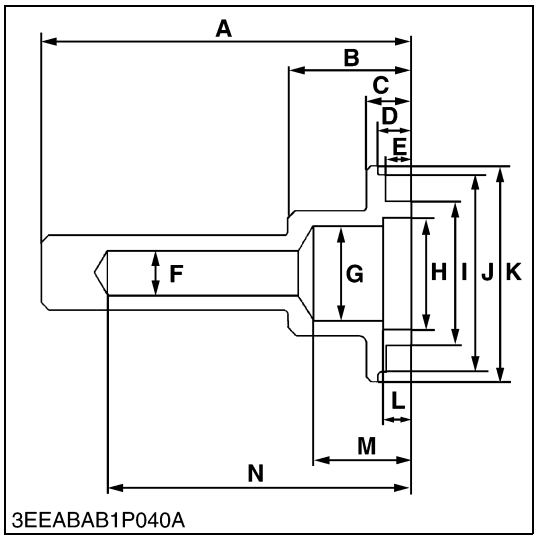
- To aligning the crankcase 1 and 2.

■ **NOTE**

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

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

9Y3210051GEG0055US0



3EEABAB1P040A

Gear Case Oil Seal Press Fit Tool

Application

- To press fit the oil seal.

■ **NOTE**

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

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

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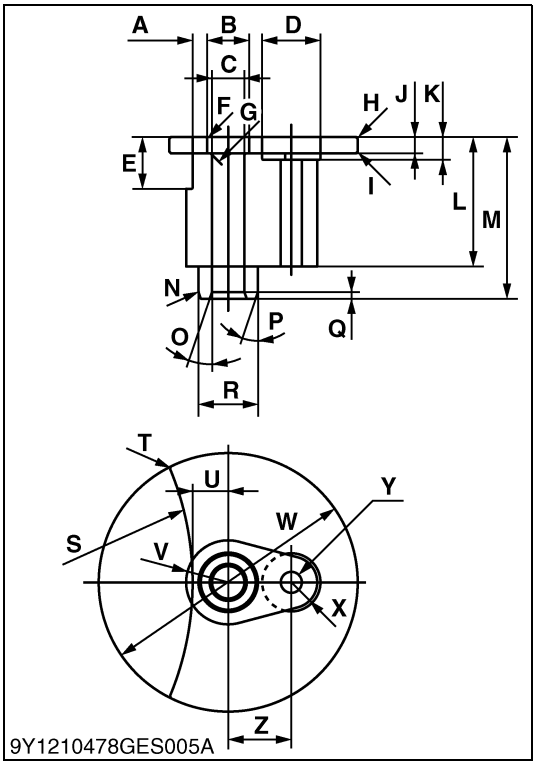

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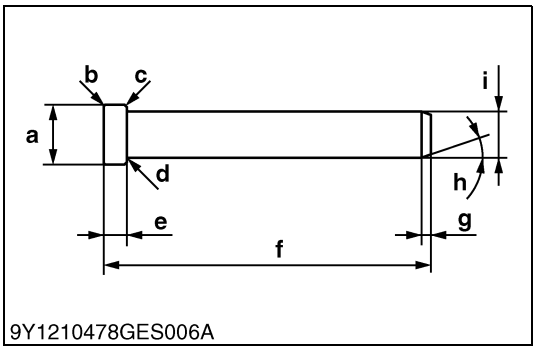

9Y1210478GES006A

Jig 1 for Measuring the Air Gap of the Crankshaft Position Sensor

Application

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

■ **NOTE**

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

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

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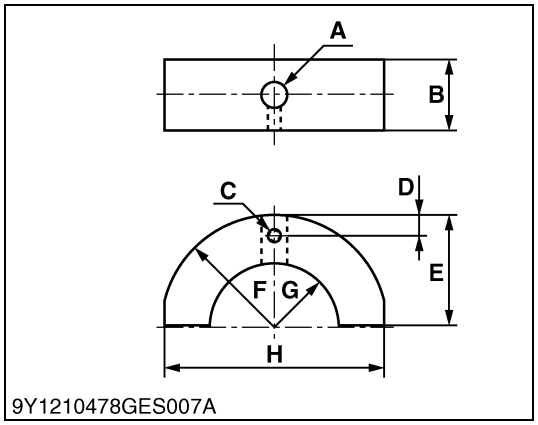


9Y1210478GES007A

Jig 2 for Measuring the Air Gap of the Crankshaft Position Sensor

Application

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

■ **NOTE**

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

A	8.0 mm dia. reamer (0.31 in. dia. reamer)
B	22.0 mm (0.866 in.)
C	M4 × 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.)

9Y3210051GEG0058US0

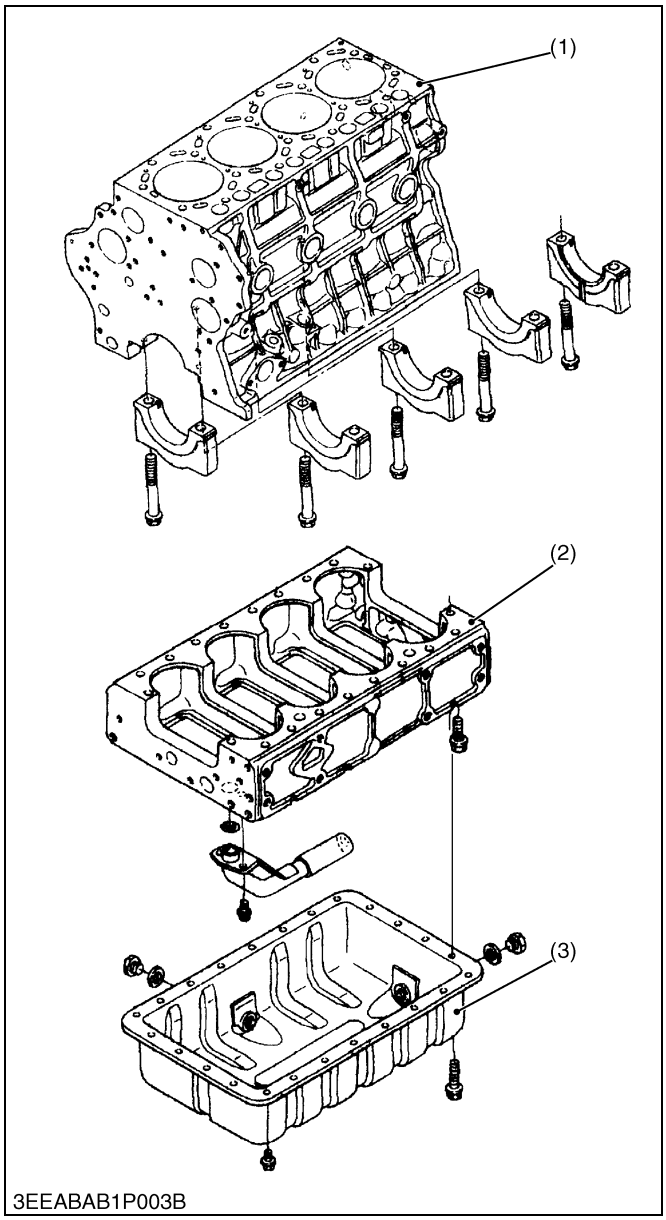
1 ENGINE

MECHANISM

CONTENTS

1. ENGINE BODY

[1] CYLINDER BLOCK



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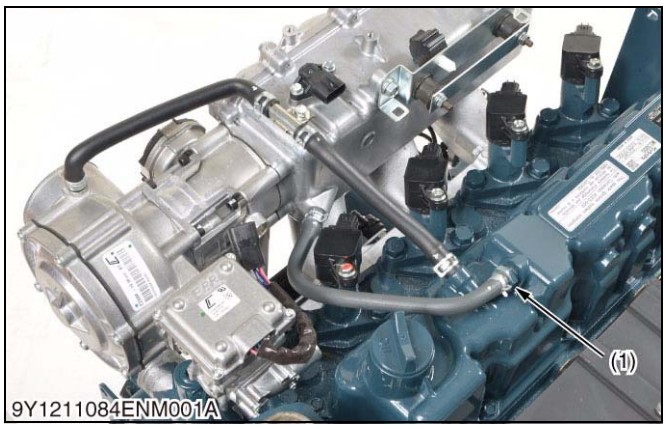
The engine utilizes a split crankcase to produce greater durability and operate more quietly; the crankcase is split into two parts, crankcase 1 (1), which houses the parts for combustion and crankcase 2 (2), which completes crankcase 1 and produces low-noise.

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

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

9Y3210051ENM0001US0

[2] PCV VALVE



9Y1211084ENM001A

The PCV valve consists of a spring and a valve, and it is installed in the head cover.

The PCV valve controls the inhalation volume of blow-by gas and the volume of fresh air according to the engine operation status.

(1) PCV Valve

9Y3210051ENM0002US0

[3] OIL SEPARATOR

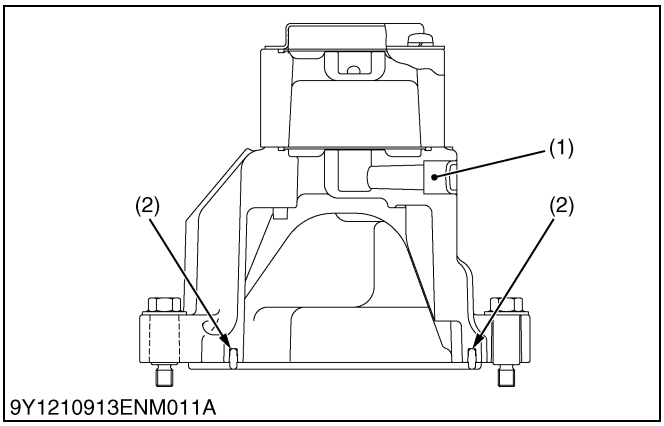
Removes oil in the blow-by gases that pass through the element (1) and the oil is returned to the oil pan.

Blow-by gases that pass through the element (1) are mixed into the mixer downstream through the head cover.

(1) Element

9Y3210051ENM0003US0

[4] HALF-FLOATING HEAD COVER

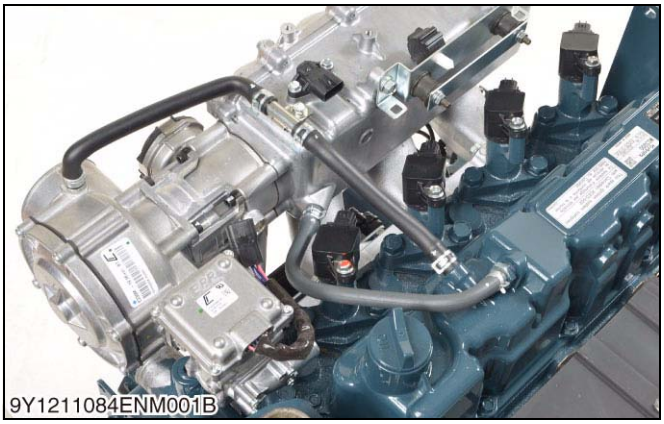


The rubber packing (2) is attached to keep the cylinder head cover (1) approximately 0.5 mm (0.02 in.) off the cylinder head. This decreases the noise from the cylinder head.

(1) Cylinder Head Cover (2) Rubber Packing

9Y3210051ENM0004US0

[5] POSITIVE CRANKCASE VENTILATION (PCV) SYSTEM

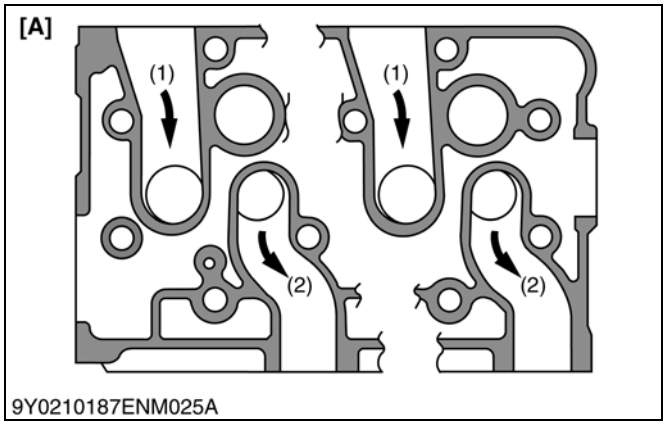


During normal compression stroke, a small amount of gases in the combustion chamber escapes past the piston. Approximately 70 % of these blowby gases are unburned fuel (HC) that can dilute and contaminate the engine oil, cause corrosion to critical parts, and contribute to sludge build up.

The purpose of the Positive Crankcase Ventilation (PCV) system is to remove these harmful gases from the crankcase before damage occurs and combine them with the engine's normal incoming air / fuel charge.

9Y3210051ENM0005US0

[6] CYLINDER HEAD

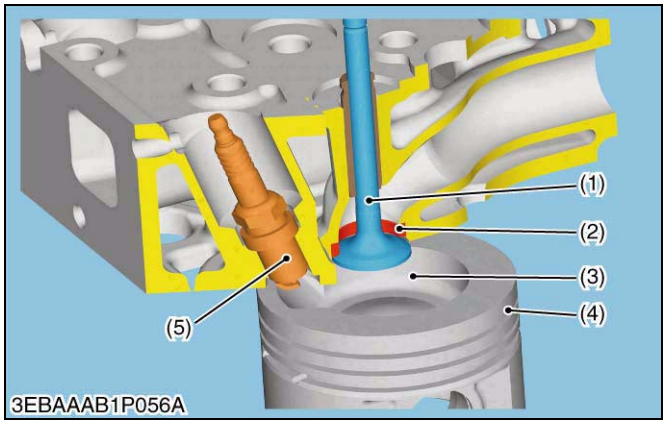


Intake and Exhaust Port

The cross-flow type intake / exhaust ports, which lower the heat conduction from the exhaust port to the intake port. The low heat conduction keeps the intake air from being heated and expanded by the exhaust gas.

(1) Intake Port
(2) Exhaust Port

9Y3210051ENM0006US0



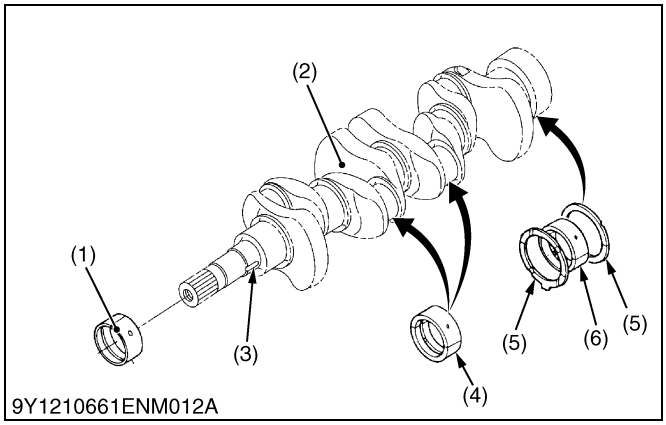
Combustion System

The Spark Ignition type combustion chamber, compactly placed on top of the piston head, successfully reduces emissions. To ensure even more reliable emission life, the intake / exhaust valve seats are fitted with special heat resistant stellite alloys.

(1) Valve
(2) Valve Seat
(3) Main Combustion Chamber
(4) Piston
(5) Spark Plug

9Y3210051ENM0007US0

[7] CRANKSHAFT



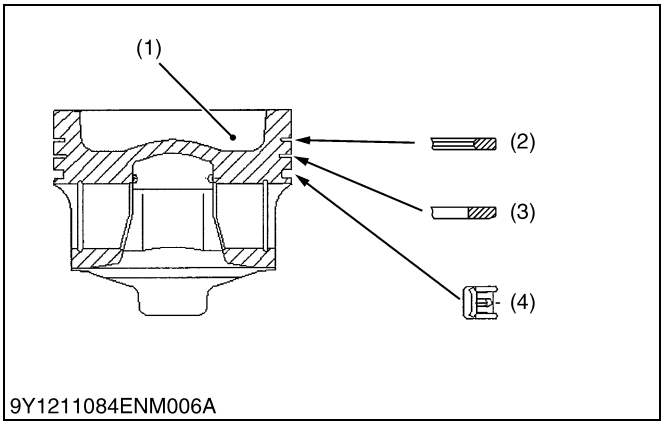
The crankshaft with the connecting rod converts the reciprocating motion of the piston into rotating motion. The crankshaft (2) has oil passages drilled so that oil can flow from the main bearings to the crank pin bearings.

The front journal is supported by a sleeve type bearing (crankshaft bearing 1) (1), the intermediate journal by a split type (crankshaft bearing 3) (4), and the rear by a split type (crankshaft bearing 2) (6) with thrust bearings (5).

(1) Crankshaft Bearing 1
(2) Crankshaft
(3) Feather Key
(4) Crankshaft Bearing 3
(5) Thrust Bearing
(6) Crankshaft Bearing 2

9Y3210051ENM0008US0

[8] PISTON AND PISTON RING



9Y1211084ENM006A

Piston and Piston Ring

The piston has a slightly oval shape when cold (in consideration of thermal expansion) and a concave head.

Top Ring:

The top ring is of inner bevel type. The barrel face type has an arc sliding surface easy to run in and prevents abnormal wears by providing a maintained oil film against the lined wall.

Second Ring:

The second compression ring is an undercut ring to prevent shortage of oil.

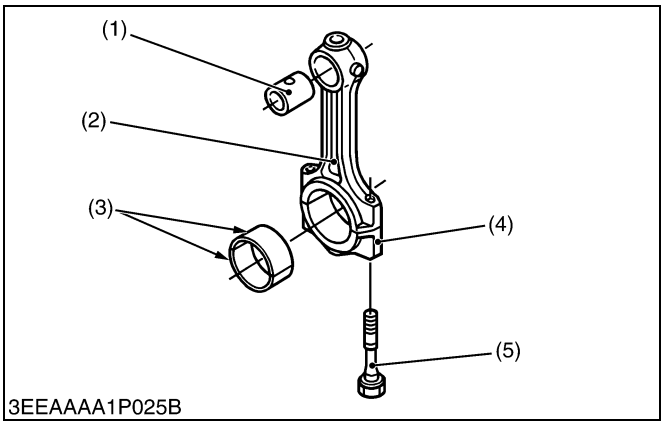
Oil Ring:

Oil ring consists of three steel components, that is upper and lower rails and one spacer being held between two rails. This function is particularly effective in preventing oil-up because of high boost at the time of engine coasting.

(1) Combustion Chamber
(2) Top Ring
(3) Second Ring
(4) Oil Ring

9Y3210051ENM0009US0

[9] CONNECTING ROD



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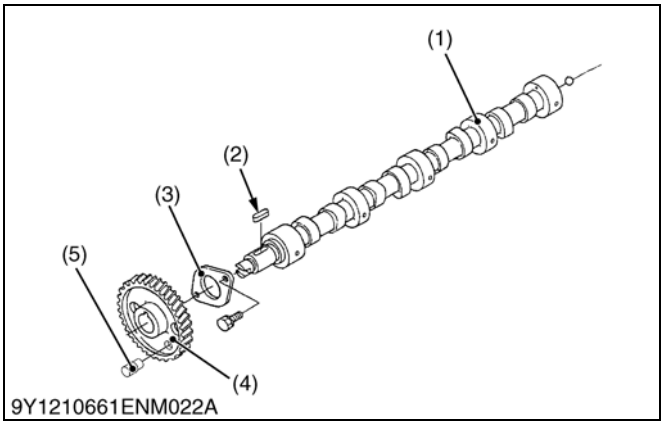
The connecting rod (2) is used to connect the piston with the crankshaft. The big end of the connecting rod has a crankpin bearing (3) (split type) and the small end has a small end bushing (1) (solid type).

(1) Small End Bushing
(2) Connecting Rod
(3) Crankpin Bearing
(4) Connecting Rod Cap
(5) Connecting Rod Screw

9Y3210051ENM0010US0

[10] CAMSHAFT



9Y1210661ENM022A

The camshaft (1) is made of special cast iron, and the journal and cam sections are chilled to resist wear.

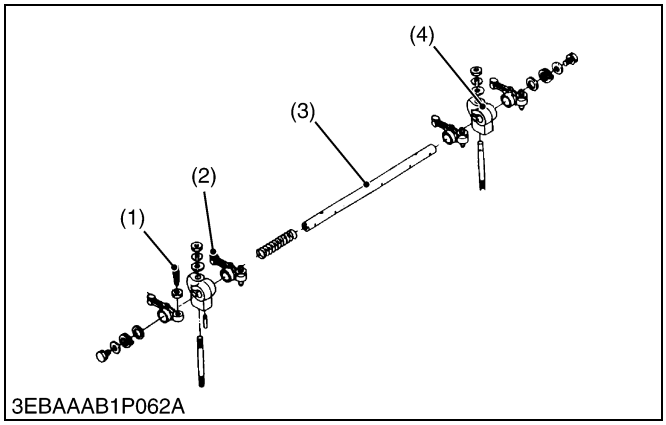
The cams on the camshaft cause the intake and exhaust valves to open as the camshaft rotates. The bearing and journals are force-lubricated.

A rotation detective pin is attached to the cam gear.

(1) Camshaft
(2) Feather Key
(3) Camshaft Stopper
(4) Cam Gear
(5) Pin

9Y3210051ENM0011US0

[11] ROCKER ARM ASSEMBLY



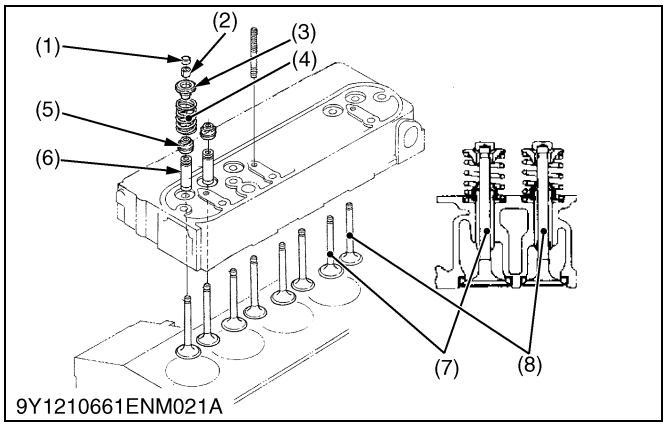
The rocker arm assembly includes the rocker arms (2) and adjusting screws (1), the end of which rests on the push rods, rocker arm brackets (4) and rocker arm shaft (3).

The rocker arms swing and transmits the reciprocating motion of the push rods to the inlet and exhaust valves to open and close them.

(1) Adjusting Screw
(2) Rocker Arm
(3) Rocker Arm Shaft
(4) Rocker Arm Bracket

9Y3210051ENM0012US0

[12] INLET AND EXHAUST VALVES



The valve and its guide for the inlet are different from those for the exhaust.

Other parts, such as the spring (4), spring retainer (3), collet (2), stem seal (5), and cap (1) are the same for both the inlet and exhaust.

(1) Valve Cap
(2) Collet
(3) Spring Retainer
(4) Spring
(5) Stem Seal
(6) Valve Guide
(7) Inlet Valve
(8) Exhaust Valve

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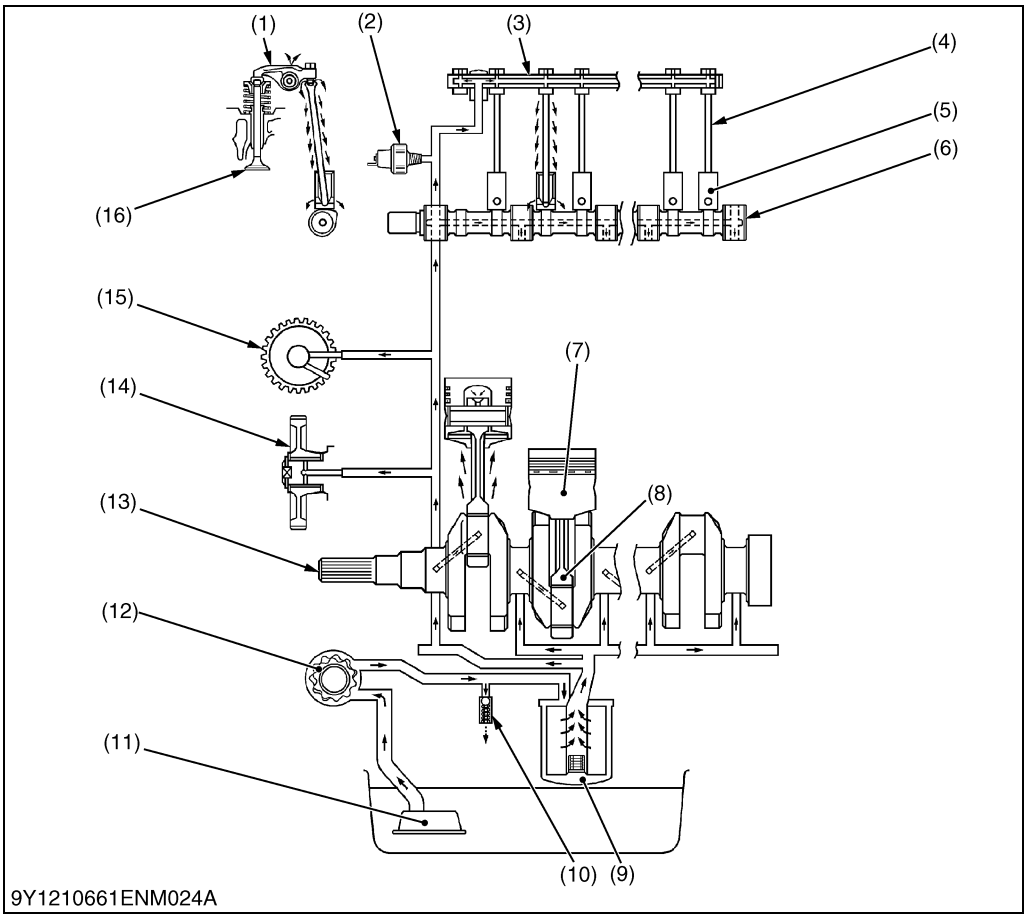
2. LUBRICATING SYSTEM

[1] GENERAL



(1) Rocker Arm
(2) Oil Pressure Switch
(3) Rocker Arm Shaft
(4) Push Rod
(5) Tappet
(6) Camshaft
(7) Piston
(8) Connecting Rod
(9) Oil Filter Cartridge
(10) Relief Valve
(11) Oil Strainer
(12) Oil Pump
(13) Crankshaft
(14) Idle Gear
(15) PTO Shaft
(16) Valve

Engine lubricating system may be classified as:

- Full pressure feed type
- Pressure feed and splash type

KUBOTA engines have lubricating system of full pressure feed type.

This system consists of an oil strainer (11), oil pump (12), relief valve (10), oil filter cartridge (9) and oil pressure switch (2).

The oil pump sucks lubricating oil from the oil pan through the oil strainer and the oil flows down to the oil filter, cartridge where it is further filtered. Then the oil is forced to crankshaft (13), connecting rods (8), idle gear (14), PTO shaft (15), camshaft (6) and rocker arm shaft (3) to lubricate each part through the oil gallery.

Some part of oil, splashed by the crankshaft or leaking and dropping from gaps of each part, lubricates following parts.

- Pistons (7)
- Cylinder walls
- Small ends of connecting rods
- Tappets (5)
- Push rods (4)
- Intake and exhaust valves (16)
- Timing gears

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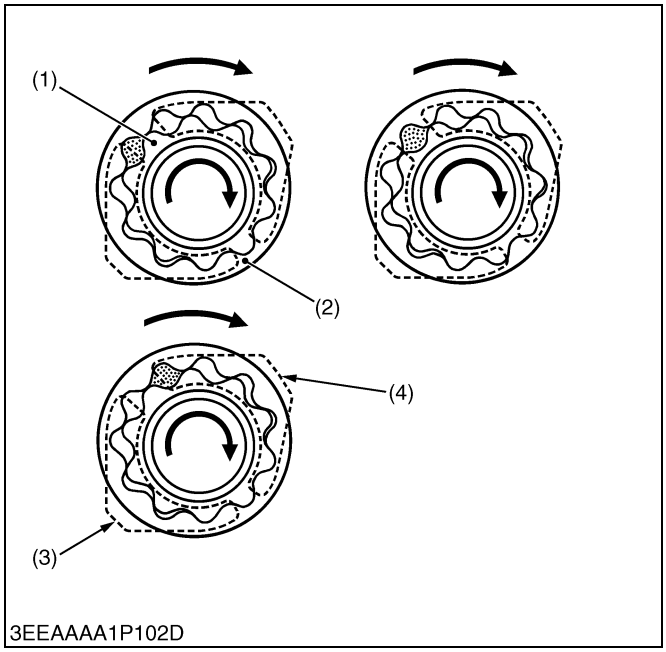
[2] OIL PUMP



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This oil pump has an inner rotor (1) and an outer rotor (2).

The inner rotor (1), which is driven by crankshaft, rotates the outer rotor (2) in the same direction.

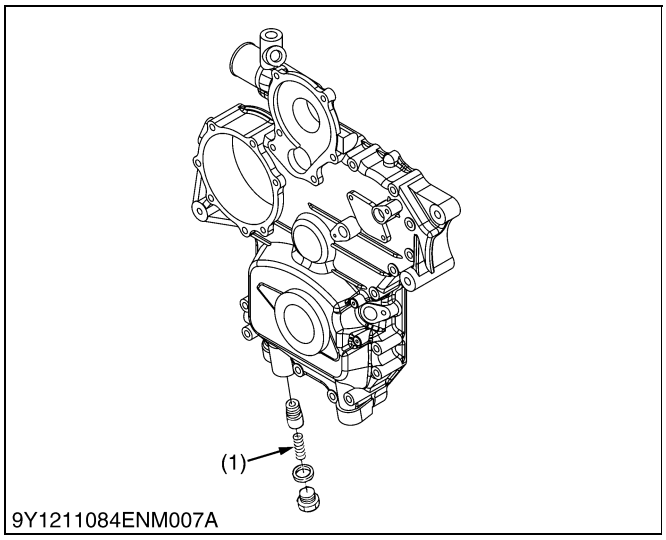
The inner rotor (1) has one less lobe than the outer rotor (2), and they are eccentrically engaged with each other.

This allows the other lobes to slide over the outer lobes, making a seal to prevent back-up of oil. As the lobes slide up and over the lobes on the outer rotor (2), oil is drawn in. As the lobes fall into the outer rotor's cavities, oil is squeezed out.

(1) Inner Rotor
(2) Outer Rotor
(3) Inlet Port
(4) Outlet Port

9Y3210051ENM0015US0

[3] RELIEF VALVE



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

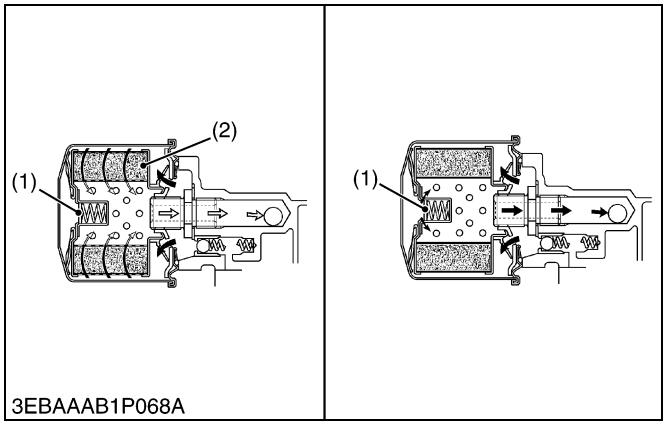
This relief valve is a ball direct acting type, and is best suited for low pressures.

When the pressure of the oil, forced by the pump, exceeds the specified value, the oil pushes back the ball and escapes to the oil pan.

(1) Spring

9Y3210051ENM0016US0

[4] OIL FILTER CARTRIDGE



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After lubricating, the lubricating oil brings back various particles of grit and dirt to the oil pan. Those particles and the impurities in the lubricating oil can cause wear or seizure of the engine parts. It may also impair the physical and chemical properties of the oil itself.

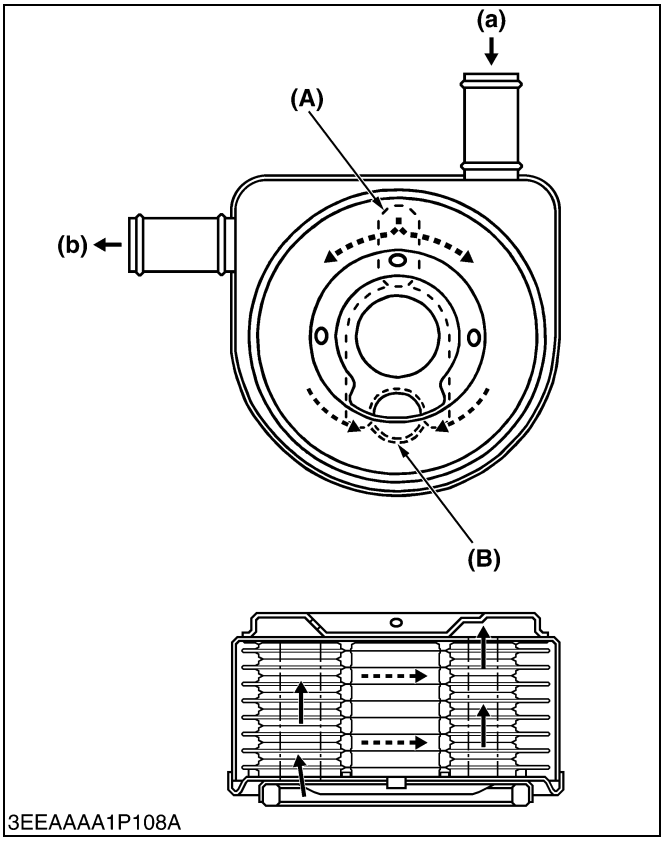
The lubricating oil which is force-fed by the pump, is filtered by the filter cartridge with the filter element (2).

When the filter element accumulates on excessive amount of dirt and the oil pressure in the inlet line builds up by 98 kPa (1.0 kgf/cm^2, 14 psi) more than the outlet line, the bypass valve (1) opens to allow the oil to flow from the inlet into the outlet line, bypassing the filter element.

(1) Bypass Valve
(2) Filter Element

9Y3210051ENM0017US0

[5] OIL COOLER



3EEAAAA1P108A

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

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

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

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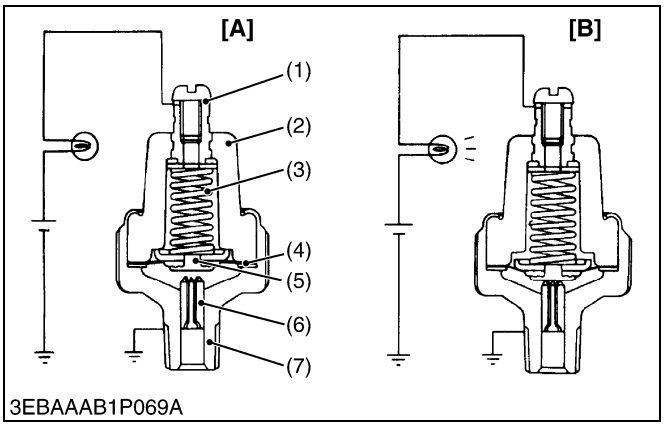
[6] OIL PRESSURE SWITCH



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The oil pressure switch is mounted on the cylinder block and is led to the lubricating oil passage.

When the oil pressure falls below the specified value, the oil pressure warning lamp lights.

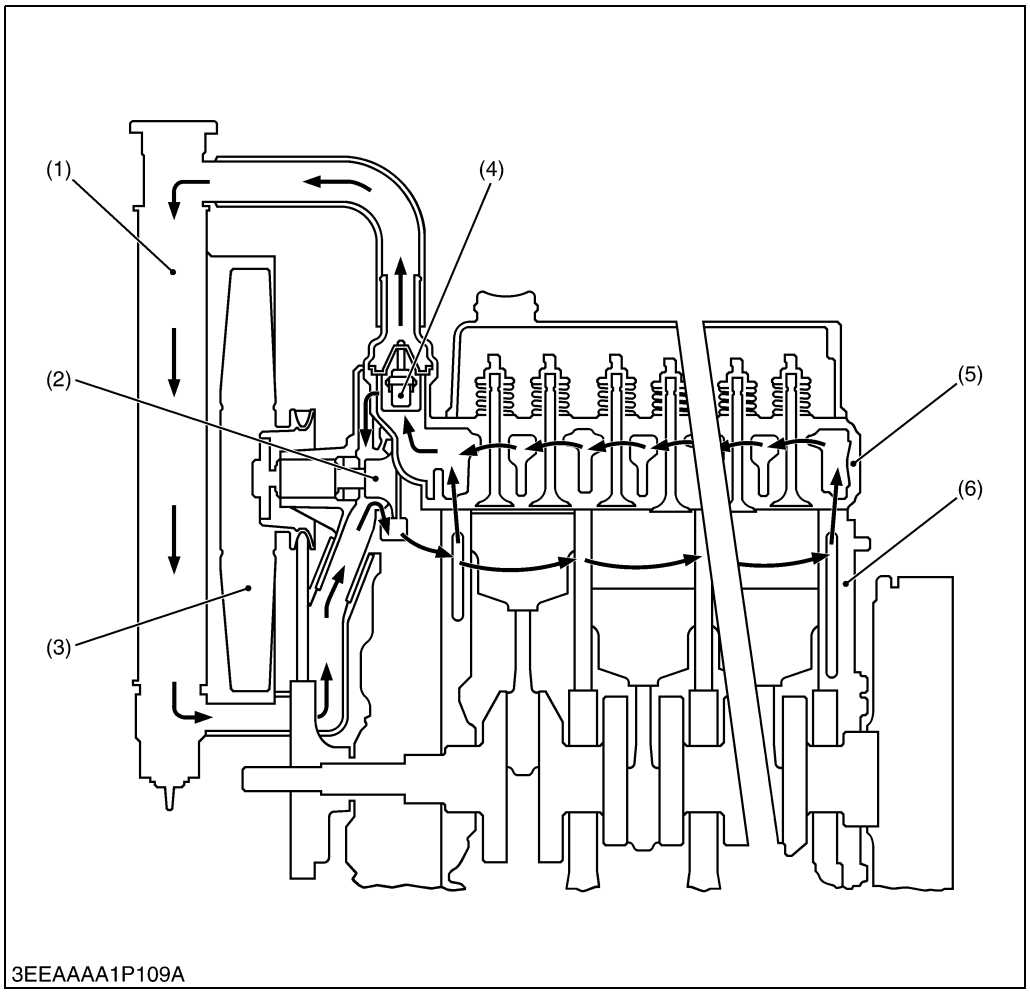
(1) Terminal
(2) Insulator
(3) Spring
(4) Rubber Gasket
(5) Contact Rivet
(6) Contact
(7) Oil Switch Body

[A] At the proper oil pressure
[B] At lower oil pressure, 50 kPa (0.5 kgf/cm^2, 7 psi) or less

9Y3210051ENM0019US0

3. COOLING SYSTEM

[1] GENERAL



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(1) Radiator
(2) Water Pump
(3) Cooling Fan
(4) Thermostat
(5) Cylinder Head
(6) Cylinder Block

The cooling system consists of a radiator (1), a centrifugal water pump (2), a cooling fan (3) and a thermostat (4).

The coolant is cooled through the radiator core, and the fan behind the radiator pulls the cooling air through the core to improve cooling.

The water pump sucks the coolant from the radiator or from the cylinder head and forces it into the cylinder block.

The thermostat opens or closes according to the coolant temperature, to allow the coolant to flow from the cylinder block to the radiator while open, or only to the water pump while closed.

Thermostat's valve opening temperature	Service specification	74.5 to 78.5 °C 166.1 to 173.3 °F

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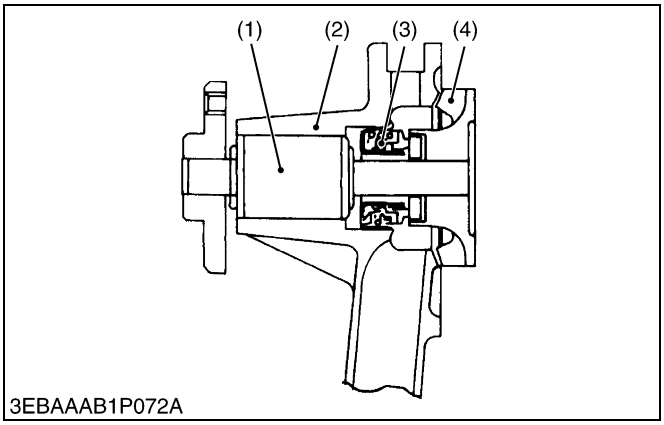
[2] WATER PUMP



The water pump is driven by the crankshaft and a V belt. The rotating impeller (4) in the water pump sucks the coolant from the radiator and sends it into the water jacket in the cylinder block.

The mechanical seal (3) prevents the water from entering the bearing unit (1).

(1) Bearing Unit
(2) Water Pump Body
(3) Mechanical Seal
(4) Impeller

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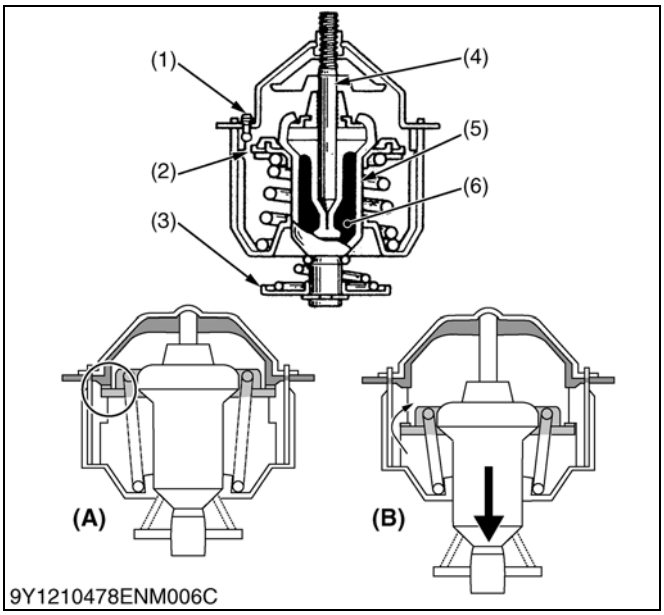
[3] THERMOSTAT



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

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

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

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

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

(1) Jiggle Valve
(2) Valve
(3) Bypass Valve
(4) Piston
(5) Pellet
(6) Wax

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

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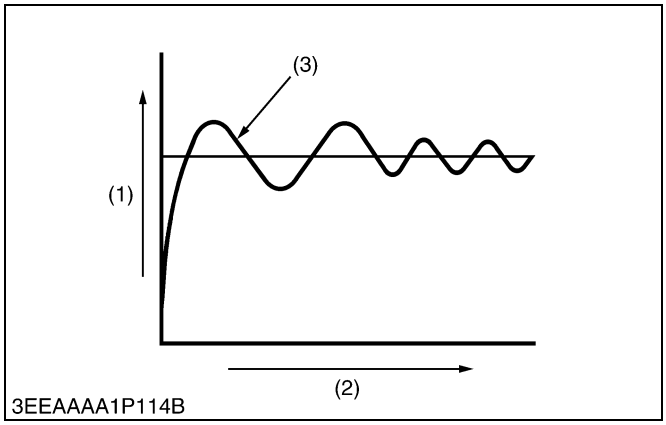
[4] BOTTOM BYPASS SYSTEM



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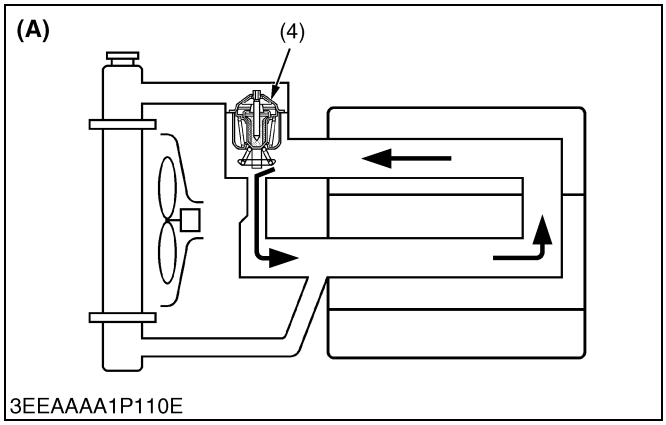

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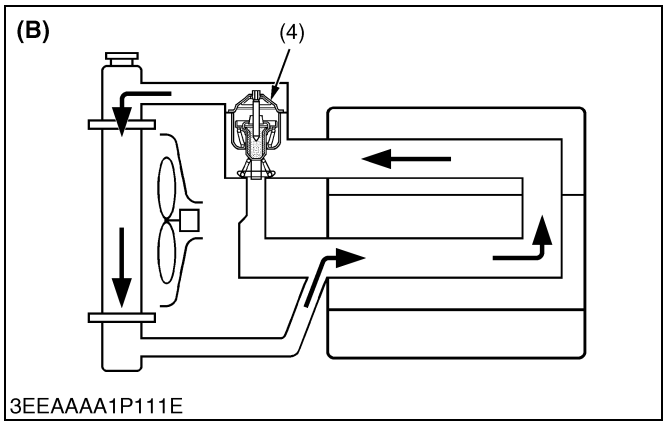

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In addition to improving the cooling performance of the radiator by utilizing a bottom bypass system, the mechanism utilizes a 3-stage thermostat valve that reduces thermal shock considerably compared to previous radiators.

When the coolant inside the engine is cool, the thermostat (4) stays closed and coolant circulates inside the engine via the bypass pipe.

When the temperature of the coolant exceeds the opening temperature of the thermostat (4), the thermostat opens in three stages, sending the now hot coolant to the radiator. Further, when the thermostat is fully open, it is structured so the hot coolant does not flow into the engine via the bypass circuit, thus increasing the cooling performance of the system.

(1) Coolant Temperature
(2) Time
(3) Overshoot
(4) Thermostat

(A) Bypass Opened
(B) Bypass Closed

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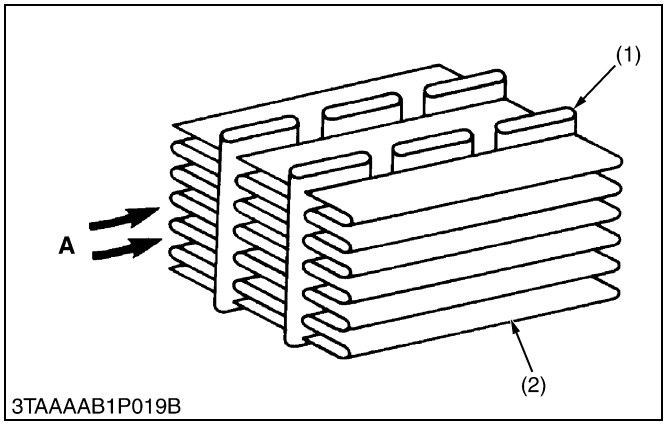
[5] RADIATOR



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The radiator core consists of coolant carrying tubes (1) and fins (2) meeting at a right angle with the tubes. The fin is a louverless, corrugated type which is light in weight, high in heat exchange ratio and less apt to clog.

The coolant in the tubes is cooled by the air flowing through the tube walls and fins.

(1) Tube
(2) Fin

A: Cooling Air

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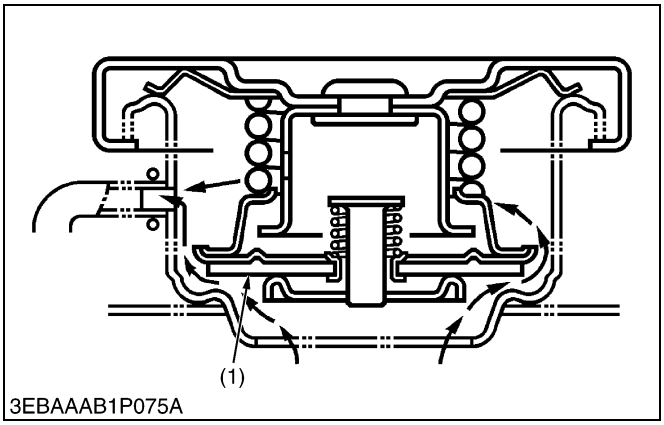
[6] RADIATOR CAP



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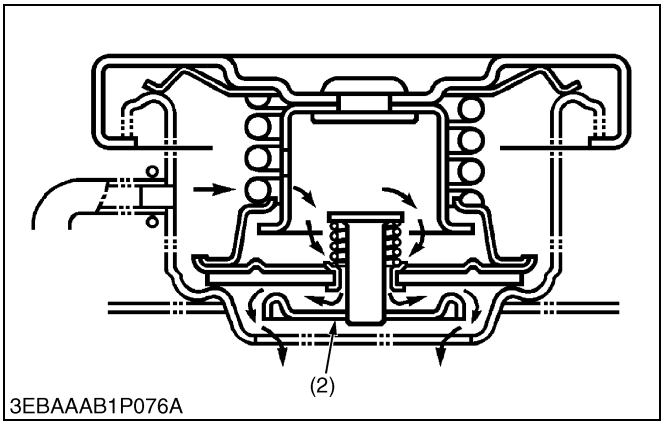

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The pressure type radiator cap prevents differences in pressure between the inside and the outside of the radiator from deforming the radiator.

When the coolant temperature rises and the pressure in the radiator increases above the specified pressure, the pressure valve (1) opens to reduce the internal pressure.

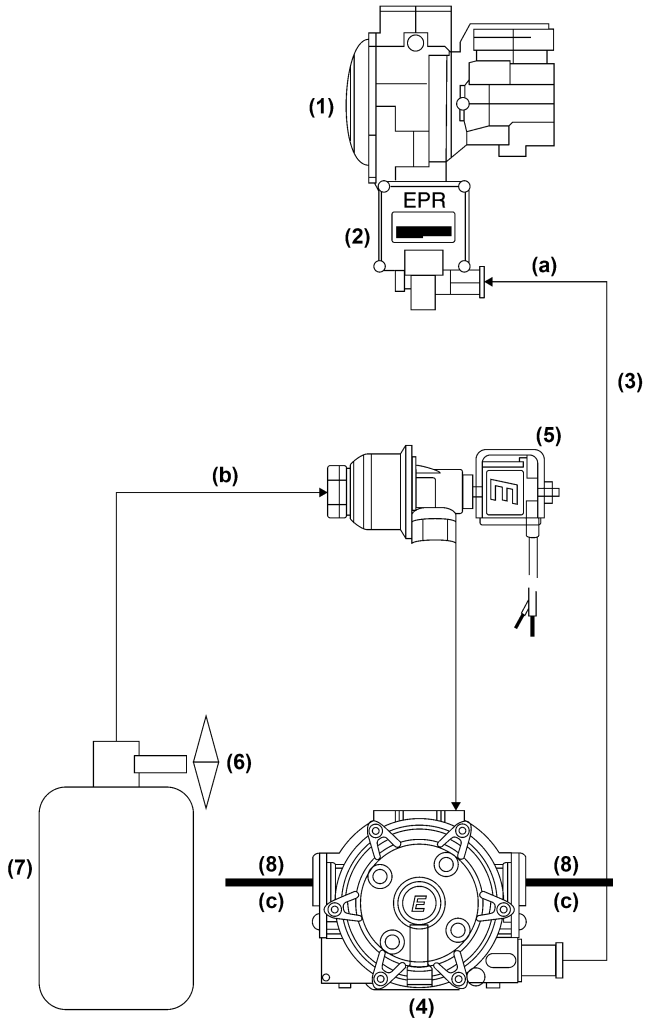
When the coolant temperature falls and a vacuum forms in the radiator, the vacuum valve (2) opens to introduce the air into the radiator.

(1) Pressure Valve (Opening pressure 88 kPa (0.90 kgf/cm^2, 13 psi))
(2) Vacuum Valve

9Y3210051ENM0025US0

4. FUEL SYSTEM

[1] GENERAL



9Y3210051ENM001A

(1) Mixer
(2) Regulator (D-EPR)
(3) Vapor Hose*
(4) Vaporizer (DSR)
(5) Lock Off Valve
(6) LPG Manual Valve*
(7) LPG Tank*
(8) Coolant Hose*

(a) Gaseous Propane Line*
(b) Liquid Propane Line*
(c) Hot Coolant Inlet or Outlet Line*

Component Marked * is Not Provided by KUBOTA

LPG Fuel:

The LPG fuel stored in the LPG tank (7) is sent to vaporizer (4) by pressure in the gaseous phase in the tank through the lock off valve (5).

The LPG fuel is evaporated in vaporizer (4) and is sent to the regulator (2) as a gaseous fuel of gas pressure near the atmospheric pressure.

The regulator mixer (1) mixes the gas and air is supplied in the cylinder.

9Y3210051ENM0026US0

[2] ELECTRONIC THROTTLE BODY (ETB)

The Kubota fuel systems utilize Drive By Wire (DBW), to control engine speed, in this type of application. There is no direct connection between the operator pedal, and the throttle shaft. Speed and load control are determined by the ECU. Defaults programmed into the ECU software, and throttle position sensors, allow the ECU, to maintain safe operating control, over the engine.

In a drive by wire application, the Electronic Throttle Body (ETB) device, or "throttle body assembly", is connected to the intake manifold of the engine. The electronic throttle control device, utilizes an electric motor, connected to the throttle shaft. In addition, a Accelerator Position Sensor (APS) is located in the operator's compartment. When the engine is running, electrical signals are sent from the foot pedal position sensor, to the engine ECU, when the operator depresses or release the foot pedal. The ECU then sends an electrical signal to the motor, on the electronic throttle control, to increase or decrease the angle of the throttle blade, thus increasing or decreasing the air flow to the engine.

The electronic throttle control device also incorporates two internal Throttle Position Sensors (TPS), which provide output signals to the ECU, as to the location of the throttle shaft and blade. The TPS information is used by the ECU, to correct for speed and load control, as well as emission control, and engine protection.

The ETB utilized on USA emission certified engines do not require any periodic adjustment.

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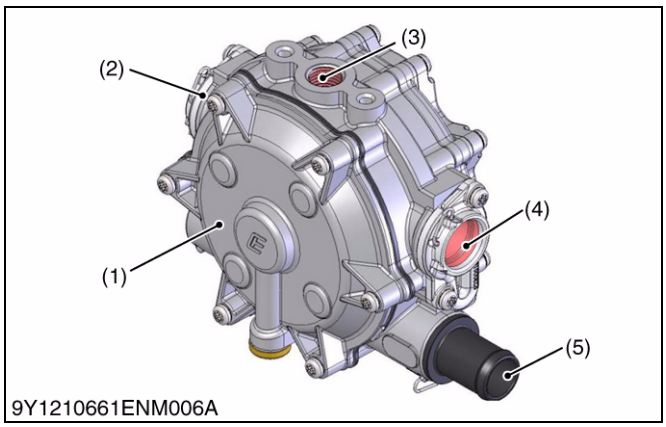
[3] VAPORIZER (DUAL STAGE REGULATOR)



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When evaporating by primary chamber of vaporizer liquid propane needs the evaporation heat.

This vaporizer installs the water jacket, throws the coolant of engine, heats primary chamber, promotes evaporation.

(1) Vaporizer
(2) Hot Coolant In / Out
(3) Fuel In
(4) Hot Coolant Out / In
(5) Fuel Out

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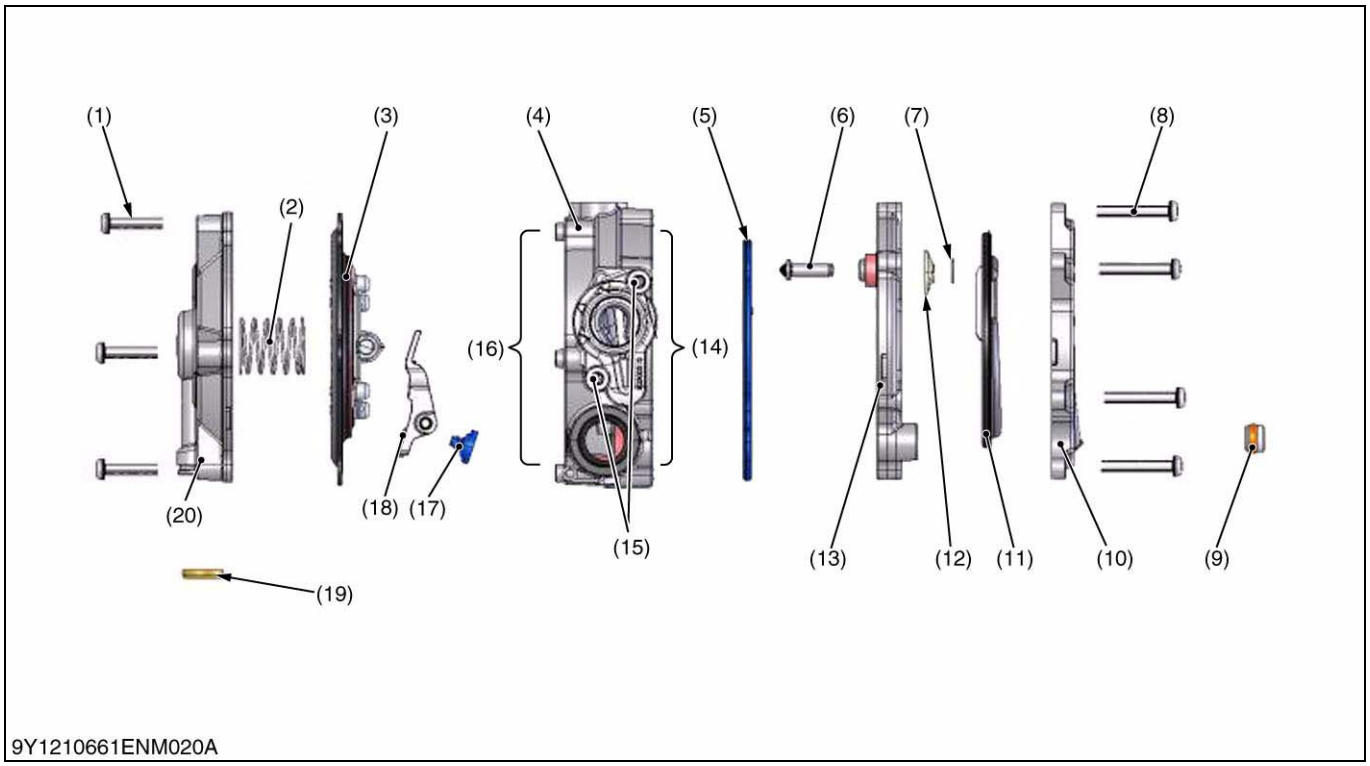

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(1) Secondary Cover Screw
(2) Secondary Spring
(3) Secondary Diaphragm
(4) Heat Exchanger
(5) Coolant Gasket
(6) Primary Pin
(7) Primary Spring Retaining Clip
(8) Primary Cover Screw
(9) Primary Test Port Plug
(10) Primary Cover
(11) Primary Diaphragm
(12) Primary Spring
(13) Primary Plate
(14) Primary Chamber
(15) Coolant Fitting Housing Retaining Screw
(16) Secondary Chamber
(17) Secondary Seat
(18) Secondary Lever
(19) Secondary Cover Vent
(20) Secondary Cover

The DSR is a combination vaporizer, pressure regulating device. The DSR is a two stage regulator that is a positive pressure regulator that is normally open in the secondary chamber, when the engine is cranking or running, pressure from the secondary chamber passes from the regulator to Direct Electronic Pressure Regulator (DEPR), and mixer.

Propane fuel enters the primary port of the DSR, and passes through the primary jet, and into the primary/exchanger chamber. As the propane passes through the heat exchanger, the fuel expands, and creates pressure inside the chamber. The pressure rises as the fuel expands, when the pressure rises above 10.34 kpa (1.5 psi); sufficient pressure is exerted on the primary diaphragm, to cause the diaphragm plate to pivot, and press against the primary valve pin, thus closing off the flow of fuel. This action causes the flow of fuel, into the regulator to be regulated. When the engine is cranking, sufficient vacuum will be introduce into the secondary chamber, from the EPR/mixer, drawing the secondary diaphragm down onto the spring loaded lever, and opening the secondary valve, allowing vaporized fuel, to pass to the mixer. Increased vacuum, in the secondary chamber, increases the downward action on the secondary lever, causing it to open wider, allowing more fuel to flow to the mixer.

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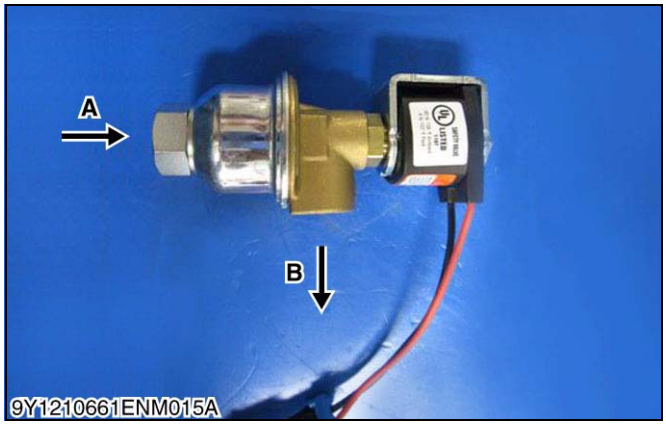
[4] LOCK OFF VALVE



Vaporizer requires a normally-closed electrically controlled fuel lock off valve that is close coupled to the vaporizer and off when ignition switch is off or when the engine is not running normally. In operation without a lock off upstream the vaporizer will flow fuel with the engine off. The vaporizer is not a fuel shut-off safety device

A: From LPG Tank **B: To Vaporizer**

9Y3210051ENM0030US0

[5] MIXER

The air valve mixer is an air-fuel metering device, and is completely self-contained. The mixer is an air valve design, utilizing a relatively constant pressure drop, to draw fuel into the mixer from cranking, to full load. The mixer is mounted in the air stream, ahead of the throttle control device.

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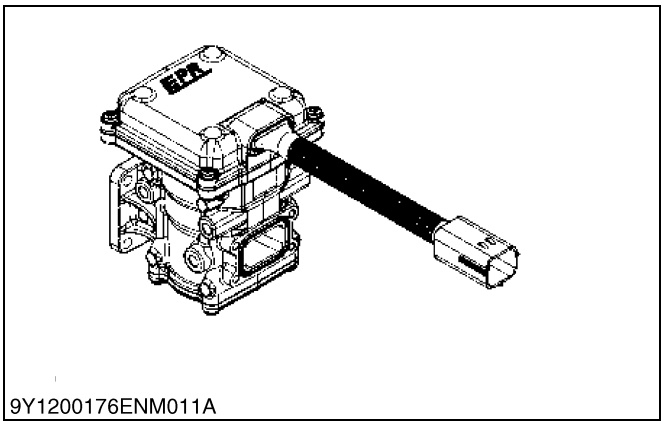
[6] DIRECT ELECTRONIC PRESSURE REGULATOR (DEPR)



The Direct Electronic Pressure Regulator (DEPR) is the primary fuel control device, used to keep both performance and emissions control. The DEPR contains an internal computer, which communicates to the Engine Control Unit (ECU), via a Communications Area Network (CAN), high speed connection.

The DEPR precisely controls the fuel flow required to ensure Stoichiometric (correct air / fuel mixture for complete burn) fuel delivery to the engine combustion chambers. The DEPR also contains internally mounted fuel pressure and temperature sensors, which provide input across the CAN link, to the ECU, for fuel calculation. The ECU will process this information and command changes back across the CAN link, to the DEPR, to adjust fueling.

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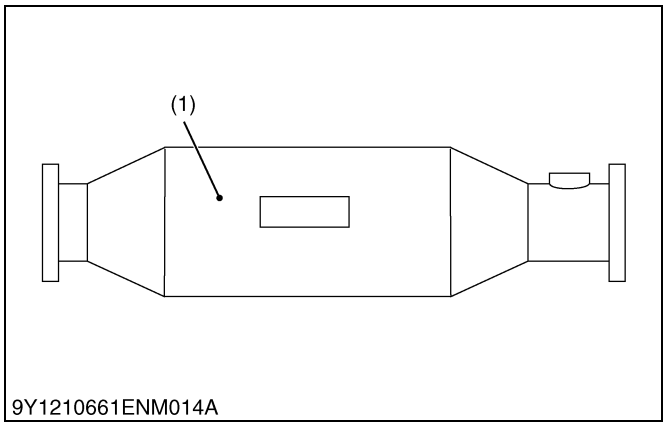
5. EXHAUST SYSTEM

[1] THREE-WAY CATALYST



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A three-way catalyst is a catalyst that oxidizes HC to CO_2 and H_2O and also CO to CO_2 respectively and at the same time reduces NOx to N_2 near the stoichiometric ratio.

The main basic component of an exhaust gas purification system that uses a three-way catalyst is feedback control of air-fuel ratio by means of an oxygen sensor for the purpose of maximizing the emission purification efficiency characteristic with reference to the intake air-fuel ratio of the three-way catalyst.

KUBOTA engines have catalytic converter type.

(1) Catalytic Converter

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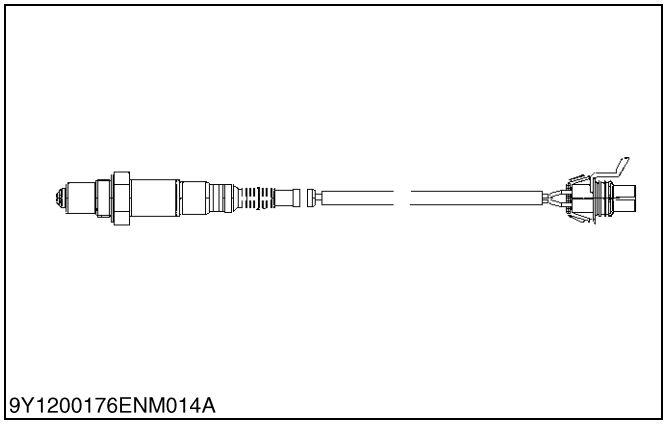
[2] OXYGEN SENSOR



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An Oxygen sensor is an essential element of a feedback control of air-fuel ratio. The sensor has a mechanism in which a zirconia tube, which is a solid electrolyte, is exposed into the exhaust gas and the outside of a zirconia tube to an exhaust gas, the inside to an atmosphere with a known oxygen concentration respectively. Any difference produced between the two sides of the zirconia tube causes electromotive force to be generated. Oxygen sensor should be installed at the catalyst inlet and outlet each.

[Pre-Catalyst Oxygen Sensor]

When the air-fuel ratio is rich, HC, CO, H_2, etc. react with the oxygen (O_2) that remains in the exhaust gas. This causes a significant reduction of the concentration of the remaining oxygen, which considerably increases the ratio of it to the concentration of oxygen contained in the atmosphere inside, increasing the electromotive force. When the air-fuel ratio is lean, the process is the other way around, resulting in a significant drop in the electromotive force near the stoichiometric ratio. That is, the feedback control functions as electronic control that reduces the air-fuel ratio when it is judged to be on the rich side based on the electromotive force and increases the ratio when it is on the lean side.

[Post-Catalyst Oxygen Sensor]

A post-catalyst oxygen sensor provides information that can be used 1) to diagnose how efficiently a catalyst is using the available oxygen to react and 2) to adjust or trim pre-catalyst equivalence ratio (air-fuel ratio) to a desired level to optimize catalyst conversion efficiency.

CAUTION

- **When you have to exchange O2 sensor, please attached it immediately after opening from package.**

9Y3210051ENM0034US0

6. ELECTRICAL SYSTEM

[1] STARTING SYSTEM

(1) General

The starting device consists of the starter, starter switch, fuse, battery etc., and the outline of the basic operation is as the followings;

1. Voltage from battery is added to the **B** terminal of starter switch through the fuse.
2. If the starter switch is turned on, **B** terminal will be connected to **AC**, and the electrical current will flow to each load.
3. If the starter switch is turned to the starting position, **B** terminal will be connected to **AC**, **19**, and **50** will be connected to the **ST** terminal of starter (in case of the type with safety relay, it shall be connected via relay) to start the engine.
4. After the engine is started, if you have let your hand off the starter switch, it automatically returns to **ON** position.

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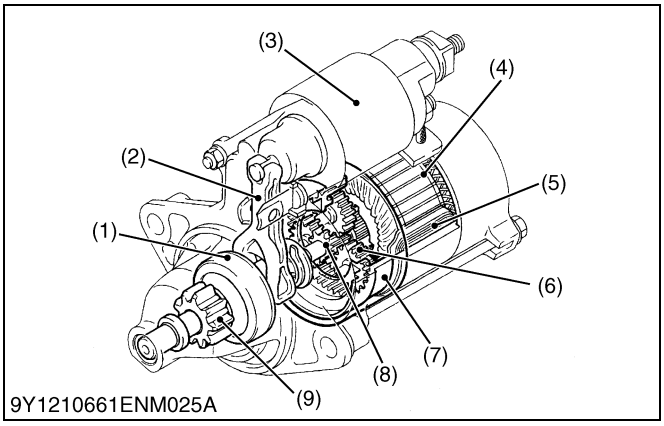
(2) Starter

[A] P Type Starters



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- The P type starters are reduction type starters that uses a planetary gears. The P types use the same type of compact, high-speed motor as the reduction type, and have planetary gears between the clutch and armature.
  As a result, a more compact and lightweight starter design has been achieved.
- To engage with the engine, the magnetic switch moves the clutch forward via the drive lever.
  The clutch slides along a shaft (planetary carrier shaft) connected to the planetary gears.
- The P type starters are equipped with shock absorbers that reduce the shock generated during starter actuation.

(1)	Clutch	(6)	Planetary Gear
(2)	Drive Lever	(7)	Internal Gear
(3)	Magnetic Switch	(8)	Sun Gear
(4)	Armature	(9)	Pinion Gear
(5)	Field Coil		

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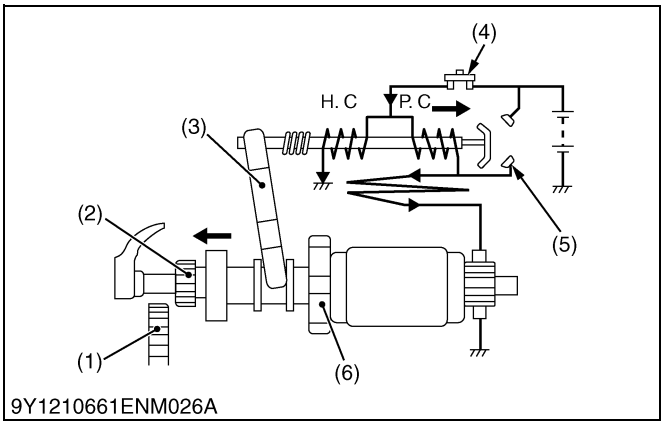

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Starter Switch ON

When the starter switch is on, current flows to both the pull-in coil PC and holding coil HC, and the plunger is pulled in by the electromagnetic force generated in both coils.

The pinion gear is thus pushed out to the left, and engages with the ring gear.

(1)	Ring Gear	(4)	Starter Switch
(2)	Pinion Gear	(5)	Plunger
(3)	Drive Lever	(6)	Planetary Gear

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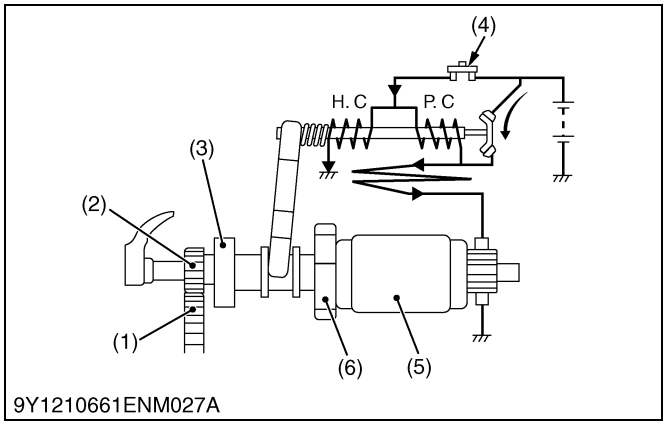

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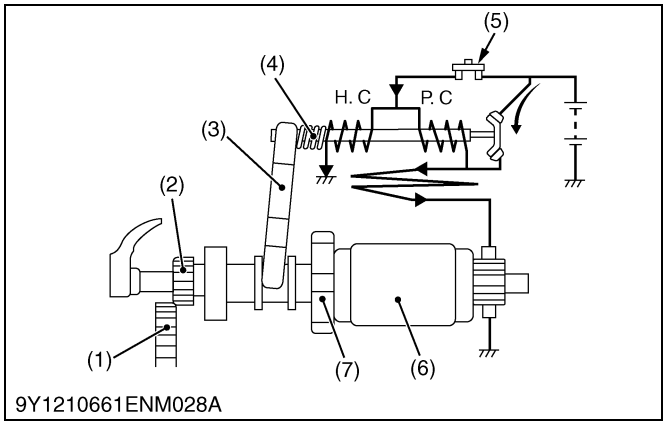

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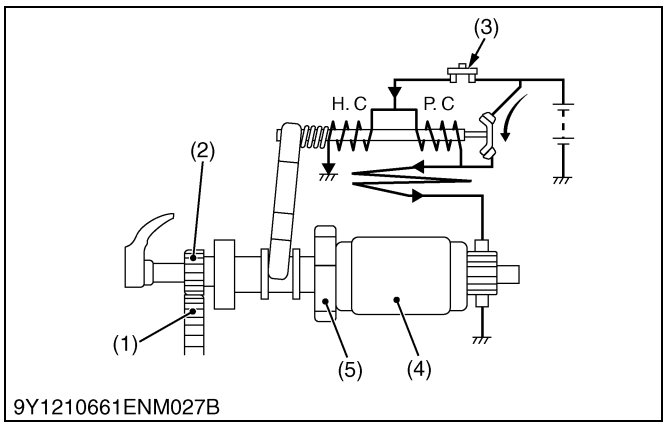

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When the Pinion Gear Engages with the Ring Gear without Collision

When the pinion gear engages with the ring gear at a certain position, the magnetic switch main contact closes, and a large current flows through the main contact to the armature.

The force of the armature spiral spline pushes the pinion gear forward, engaging the pinion gear with the ring gear to start the engine.

(1) Ring Gear
(2) Pinion Gear
(3) Clutch
(4) Starter Switch
(5) Armature

9Y3210051ENM0038US0

When the Pinion Gear and Ring Gear Collide

If the pinion gear and ring gear teeth contact, the pinion gear cannot move any further. If this happens, the magnetic switch drive spring compresses, and the magnetic switch contact closes. As a result, the armature rotates at high torque, and the teeth alignment position slides. The compression force of the drive spring and the force of the armature spiral spline move the pinion gear forward, engaging the pinion gear with the ring gear to start the engine.

(1) Ring Gear
(2) Pinion Gear
(3) Drive Gear
(4) Drive Spring
(5) Starter Switch
(6) Armature
(7) Planetary Gear

9Y3210051ENM0039US0

Starter Switch OFF

When the starter switch is turned **OFF**, the magnetic switch attraction is cancelled and the pinion gear is returned by the magnetic switch return spring.

The main contact then opens, interrupting the flow of current to the armature.

(1) Ring Gear
(2) Pinion Gear
(3) Starter Switch
(4) Armature
(5) Planetary Gear

9Y3210051ENM0040US0

[B] Overrunning Clutch

Function

In case that the pinion gear and ring gear are still inter meshed even when the engine is started, the motor will be forced to run in abnormal rotation, and the armature, brush, etc. will be damaged.In order to prevent such an error, the overrunning clutch will function as the device to let the pinion race against the armature shaft when the engine is started, and to shut off transmission of rotation of the engine to the motor.

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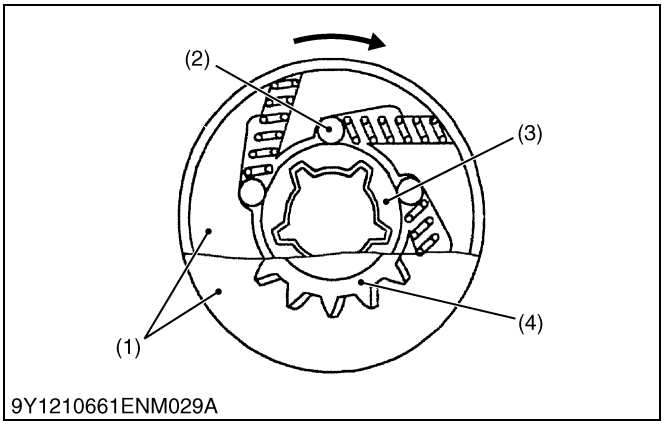

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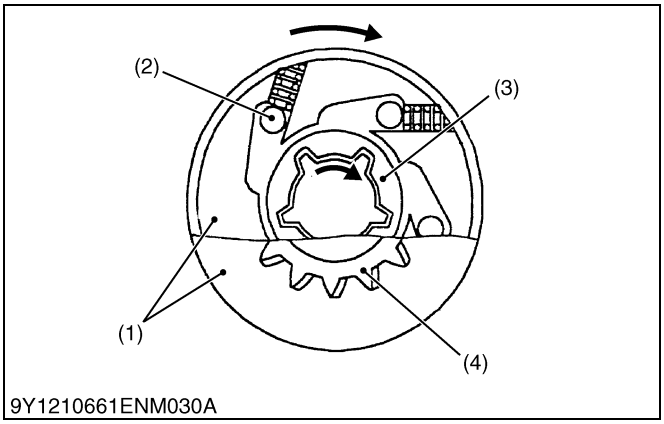

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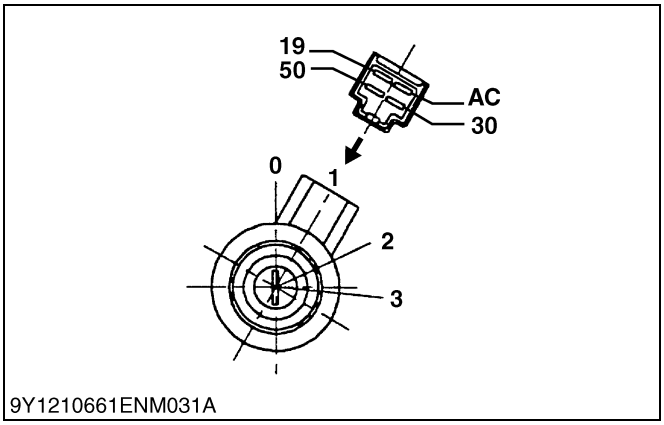
Action

1. When starting:
   If the outer is rotated in the arrow mark direction receiving rotation of the armature, the clutch roller will be pushed toward the narrower side of clearance between the outer concave side and the inner so that the outer and inner will be locked. The roller will function as a wedge between the inner and outer, and will transmit the rotation of the outer to the inner, and both will rotate in the same speed.
2. After the engine is started:
   When the pinion is forced to rotate by the ring gear, rotation of the inner (rotation of engine × gear ratio) will become faster than that of the outer (a number of rotation of armature), and the clutch roller will move toward the direction that compresses the spring.
   Consequently, clearance between the outer concave side and the inner becomes wide to prevent overrunning of the armature.
   (It is required to decrease the contact pressure of the pinion gear and ring gear to realize smooth separation of the pinion gear, and for the sake of this, the pinion gear must be in the state of racing.)

(1)	Outer (Integral Structure with Spline Tube)	(3)	Inner (Integral Structure with Pinion Tube)
(2)	Clutch Roller	(4)	Pinion Gear

9Y3210051ENM0042US0

(3) Starter Switch



9Y1210661ENM031A

Starter Switch

Starter switch is an important part comprising of the starting device of engine. Particularly, as seizing of the starter may be incurred due to failure of the starter switch, careful consideration is required for the installation position, place, and direction, so that rain or cleaning water should not directly splash on the starter switch.

As the standard part of KUBOTA engine, the starter switch in below figure is recommended.

[Connection Diagram]

Position	19	30	50	AC
0				
1		●		●
2	●	●		●
3	●	●	●	●

9Y1210661ENM032US

9Y3210051ENM0043US0

(4) Starter Safety System

The ECU can be configured for either auto cranking (crank until starting) or crank limiting (maximum crank time and disabling of starter if frequency and number of tries is too high).

9Y3210051ENM0044US0

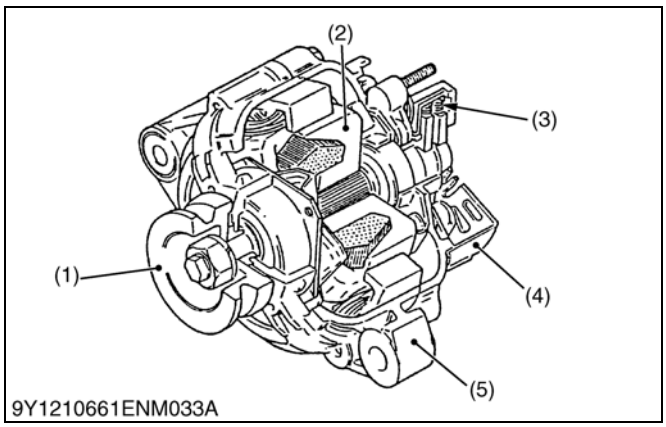
[2] CHARGING SYSTEM

(1) General

The function of the charging device is to charge batteries.

9Y3210051ENM0045US0

(2) IC Regulator Built-in Type Alternator



9Y1210661ENM033A

The alternator is the incorporated with an IC regulator, this has been made small size and light weight by the semiconductor technique of the IC regulator.

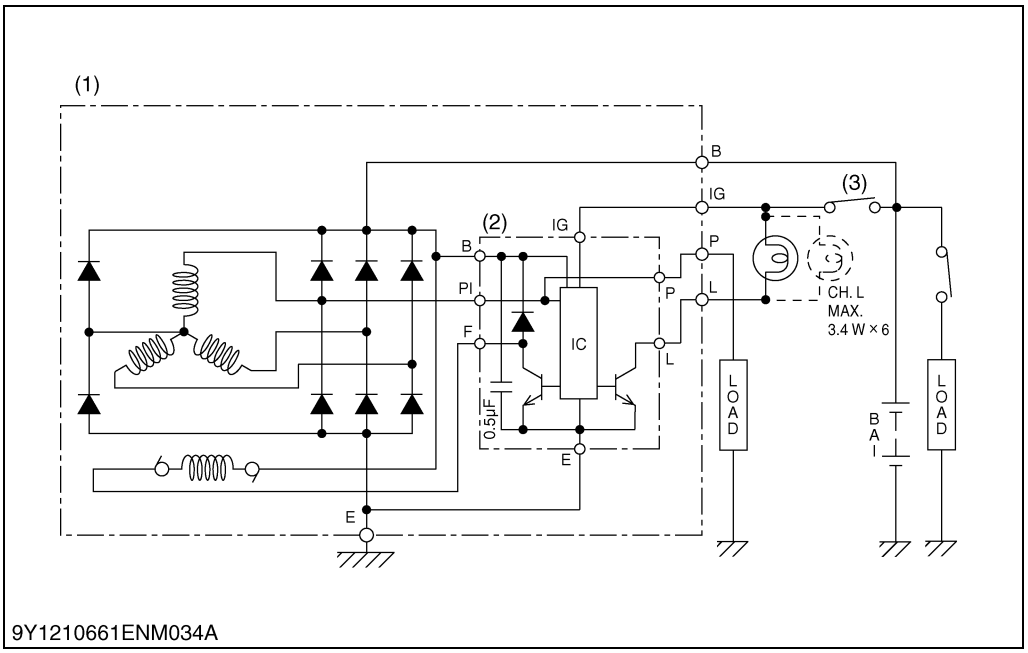
The cooling property and safety is improved by incorporating the cooling fan and roller that is an integral structure.

Further, the serviceability is also improved by facilitating mounting and removal of the rectifier and IC regulator.

(1) Pulley
(2) Rotor
(3) Brush
(4) Cover
(5) Drive and Frame

9Y3210051ENM0046US0

D2 Type Regulator



9Y1210661ENM034A

(1) Alternator Assembly
(2) IC Regulator
(3) Key Switch

IC regulator has a special feature that makes it possible to interrupt field current by using the transistor or IC instead of the contact-point-type regulator.

IC regulator has the special features as follows:

1. Readjustment for this regulator is unnecessary because the control voltage does not change over time. Further, vibration-proof property and durability is excellent because IC regulator has no moving parts.
2. Since IC regulator has over-temperature compensation property, which makes the control voltage low if the temperature is increased, it makes it possible to properly charge the batteries.
   The circuit inside IC regulator is as shown in the following figure.
   It consists of the monolithic IC-incorporated hybrid IC. (Since the inside circuit of the monolithic IC is extremely complex, it is described as **M.IC** circuit.)
   Tr1 has the function as the contact point to control field electrical current, and as the charging lamp relay to light the charging lamp.
   M.IC controls **Tr1** and **Tr2** by detecting decrease of the output voltage of alternator, decrease of the **L** terminal voltage, disconnection of the rotor coil, etc.

9Y3210051ENM0047US0

Charge Light Control

Turns the charge light **ON** and **OFF** in accordance with alternator power generation.

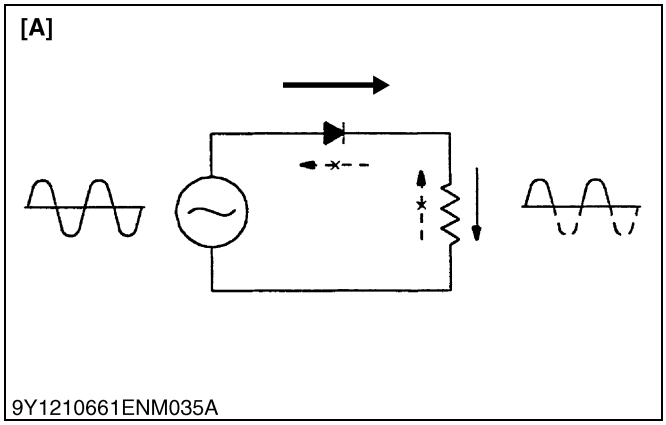
9Y3210051ENM0048US0

Specification of Alternator with IC (Incorporated with) Regulator

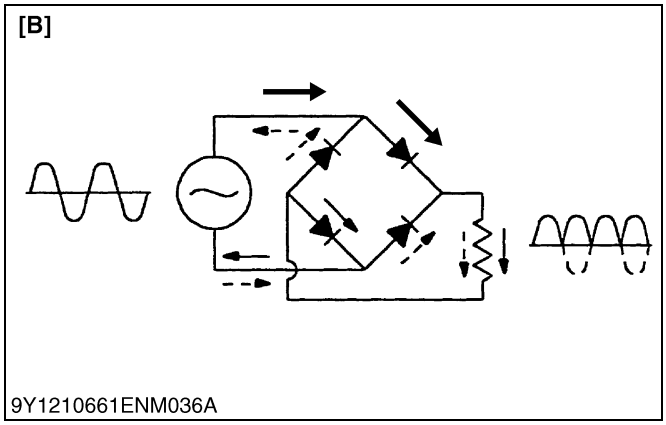
Nominal voltage	12 V
Maximum output	100 A
Rotational direction	Right as seen from pulley side
Armature wiring	3 phase, Y wiring
Rectifying system	Total wave rectification
min^{-1} (rpm) at no load (when cold)	14 V at 0 A 1050 to 1350 min^{-1} (rpm)
min^{-1} (rpm) at max. output (when cold)	14 V at maximum output below 4000 min^{-1} (rpm)

Generating capacity will be determined by rpm of engine and pulley ratio.

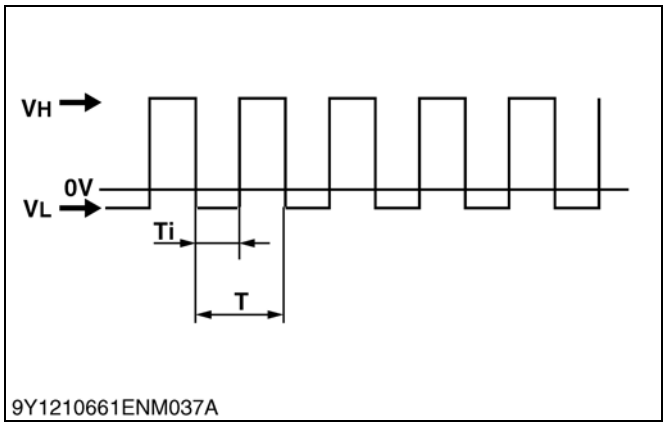
9Y3210051ENM0049US0



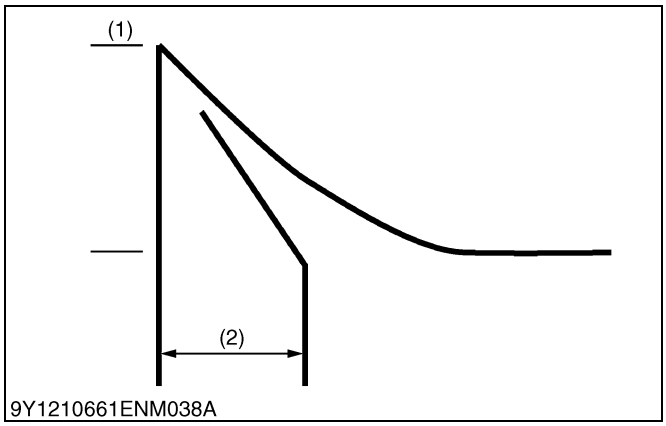
9Y1210661ENM035A



9Y1210661ENM036A



9Y1210661ENM037A



9Y1210661ENM038A

Total Wave Rectification

In case of the generator for mobile equipment of which purpose is to charge the batteries, alternating current cannot be used as it is. Because of this, it is required to conduct the action called rectification so that the alternating current can be changed to direct current. Alternator conducts rectification by means of diode.

If the voltage is applied to diode in the normal direction, enough electrical current can flow even by small voltage, however if applied in the reverse direction, it inhibits the reserve flow of electrical current.

Using this property, alternate current generated in the stator coil is changed to the direct current.

As for the rectification using diode, there are two methods, i.e., "half-wave rectification" that takes out only positive portion of alternate current, and 'total-wave rectification' that rectifies both positive and negative current and change to the direct current.

[A] Half-wave Rectification **[B] Total-wave Rectification**

9Y3210051ENM0050US0

Alternator P Terminal

P terminal waveform: The alternator **P** terminal outputs rotation signals required by a tachometer, etc.

The **P** terminal corresponds with one phase of the alternator stator and the output waveform during power generation is a waveform equivalent to the rectangular wave with a frequency in proportion to the number of revolutions of the alternator.

Frequency (1/T):	**Number of Revolutions of Alternator [rpm] / 10 [Hz]**
Duty (Ti/T):	**Approx. 50 %**
VH (average):	**About +0 to 2 V with Reference to the Alternator B Terminal Voltage (Average)**
VL:	**About −2 to 0 V**

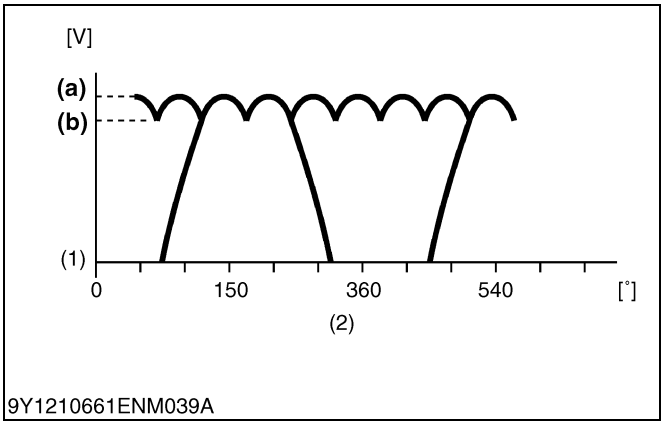
9Y3210051ENM0051US0

■ **NOTE**

- **As with the B terminal waveform, the P terminal waveform includes noise, which varies depending on the number of revolutions, output and wiring (see the waveform in a separate material).**
- **Surge voltage may be generated by any charging cable disconnection (especially with high number of revolutions / high output), etc.**

(1) Approx. 150 V (2) Approx. 180 ms

9Y3210051ENM0052US0



9Y1210661ENM039A

Surge voltage waveform with any charging cable disconnection.

- May be VHmin = 6.5 V in high electric load shedding or unloaded condition with the battery fully charged.

(1) Voltage
(2) Angle of Rotation (°)
(a) VH max
(b) VH min

9Y3210051ENM0053US0

Load Connected To the P Terminal

P terminal output current: 0.5 A max (average current).

■ **NOTE**

- **Ensure that there is no load short circuit or wrong wiring.**
- **Do not connect inductive or capacitive load (connection of such load subject to discussion of the specification).**
- **When detecting a waveform, take the noise and VHmin into consideration.**
- **Take the surge voltage into consideration for the input of the load.**
- **Use the actual equipment for sufficient check of the operation of the load.**

9Y3210051ENM0054US0

[3] ENGINE CONTROL UNIT (ECU)


9Y1211084ENM004A

The ECU will use signal inputs, from the engine sensors, to control the fuel metering and speed control, while the engine is running. As well, the ECU will provide diagnostic control, over the fuel system.

9Y3210051ENM0055US0

[4] ENGINE COOLANT TEMPERATURE SENSOR


9Y1210913ENM006A

Ignition timing, fuel rate, and boost levels can be configured to vary with engine coolant temperature. This is typically done at very cold or very hot conditions. Coolant temperature is also used in the airflow models in the ECU.

9Y3210051ENM0056US0

[5] TEMPERATURE AND MANIFOLD ABSOLUTE PRESSURE SENSOR (TMAP SENSOR)


9Y1210913ENM007A

TMAP sensor is mounted in the intake manifold and measures the absolute pressure as well as the temperature of the air / fuel stream. MAP data is used by the ECU for calculating airflow pressure. The temperature information from the TMAP is used for a density correction in the mass air flow calculation.

9Y3210051ENM0057US0

[6] CRANKSHAFT POSITION SENSOR


9Y1211084ENM005A

To determine the engine RPM and piston position of number one cylinder, the ECU receives this information from the crankshaft position sensor. The crankshaft position sensor is located near the crankshaft at the front of the engine (gear case side) and reads a pick up wheel mounted internally within the engine.

9Y3210051ENM0058US0

[7] CAMSHAFT POSITION SENSOR


9Y1211309ENM001A

The camshaft position sensor is used to determine which stroke of the engine cycle the engine is running on for control of the fuel and spark. The camshaft position sensor is mounted at the front of the engine (gear case side) and reads a pick up wheel mounted internally within the engine.

9Y3210051ENM0059US0

[8] KNOCK SENSOR


9Y1210661ENM017A

The knock sensor is used to detect detonation through mechanical vibration in the engine block and / or cylinder heads and provide feedback for the ignition system to retard spark to reduce knock intensity. In most applications the knock sensor is used to protect the engine from damage that can be caused from detonation or knock based on fixed spark advance.

The Knock Sensor is a 5 volt reference signal sensor, which operates by the resistance change in the sensor, to output a reference voltage for the Engine Control Unit (ECU) to use. The knock sensor sends a base or "no knock" signal to the ECU, when knocking does occur the sensor detects the increased vibration, and increases the voltage output to the ECU. When the ECU receives the voltage change, the ECU will slightly retard the timing, until such time, the knocking no longer exists.

9Y3210051ENM0060US0

[9] IGNITION COIL


9Y1210913ENM010A

Ignition coil is a transformer to generate high electric voltage necessary for the ignition. Around the iron core of multi-layer thin crude steel plates, secondary coil is wound, on whose outside, in the same direction, primary coil is wound. The empty space in the case is filled with resin for electric insulation and good heat radiation.

The ignition timing is controlled by ECU and the high voltage is applied to the spark plugs by the ECU signals.

9Y3210051ENM0061US0

SERVICING

CONTENTS

1. TROUBLESHOOTING

[1] FOR GENERAL

Symptom	Probable Cause	Solution	Reference Page
Engine Will Not Turn Over	Engine jammed	Check engine to find the problem and repair it	–
	Battery discharged	Charge	–
	Starter malfunctioning	Repair or replace	1-S20
	Wires disconnected	Reconnect	–
Engine Turns Over Slowly but Does Not Start	Increased resistance of moving parts	Repair or replace	–
	Excessively high viscosity engine oil at low temperature	Use specified engine oil	I-4, G-8
Engine Turns Over at Normal Speed but Does Not Start	Compression leak	Check the compression pressure and repair	1-S11
	Improper valve clearance	Adjust	1-S12
	Damaged ignition coil	Replace	1-S18
	Damaged spark plug	Adjust spark plug gap or replace	G-12, 1-S17
	Clogged air cleaner	Clean or replace	G-12
Rough Low-Speed Running and Idling	Damaged ignition coil	Replace	1-S18
	Damaged spark plug	Adjust spark plug gap or replace	G-12, 1-S17
	Improper valve clearance	Adjust	1-S12
Rough High-Speed Running	Damaged spark plug	Adjust spark plug gap or replace	G-12, 1-S17
	Damaged ignition coil	Replace	1-S18
Engine Speed Does Not Increase	Clogged air cleaner	Clean or replace	G-12
	Damaged ignition coil	Replace	1-S18
	Damaged throttle body	Replace	1-S15
	Breather tube has separated	Attach correctly	G-16
	Improper input signal to ECU	Check the wire harness	–
Deficient Output	Improper intake or exhaust valve sealing	Replace	1-S43
	Improper valve clearance	Adjust	1-S12
	Piston ring and cylinder worn	Replace	1-S50, 1-S55
	Clogged air cleaner	Clean or replace	G-12
Engine Noise	Improper valve clearance	Adjust	1-S12
	Spark knock due to low-octane fuel or carbon	Use higher-octane fuel and remove carbon	–
	Rattles from loosely mounted external components	Retighten	–

Symptom	Probable Cause	Solution	Reference Page
Exhaust Flames	Damaged ignition coil	Replace	1-S18
	Damaged spark plug	Adjust spark plug or replace	G-12, 1-S17
	Wires disconnected or damaged wire	Reconnect / replace	–
	Bad connection of ignition coil and spark plug	Reconnect	–

9Y3210051ENS0001US0

[2] FOR LPG FUEL

Symptom	Probable Cause	Solution	Reference Page
Engine Will Not Turn Over	Damaged vaporizer	Replace	–
	Damaged LPG lock off valve	Replace	–
Engine Turns Over at Normal Speed but Does Not Start	No LPG fuel	Fill LPG fuel Check LPG tank and valve Check LPG lock off valve	–
Rough Low-Speed Running and Idling	Shortage of gas supply	Fill LPG fuel Check LPG lock off valve	–
Defection Output	LPG density is rich or lean	Repair or replace of fuel system Replace vaporizer	–

9Y3210051ENS0002US0

2. SERVICING SPECIFICATIONS

ENGINE BODY

Item		Service Specification	Service Limit
Valve Clearance (Cold)		0.18 to 0.22 mm 0.0071 to 0.0086 in.	–
Compression Pressure	– Variance Among Cylinder	1.75 MPa 17.8 kgf/cm^2 253 psi –	1.40 MPa 14.3 kgf/cm^2 203 psi 10 % or less
Top Clearance		1.43 to 1.65 mm 0.0563 to 0.0649 in.	–
Cylinder Head Surface	Flatness	–	0.05 mm 0.002 in.
Valve Recessing (Intake and Exhaust)		−0.050 to 0.25 mm −0.0020 to 0.0098 in.	0.40 mm 0.016 in.
Valve Stem to Valve Guide • Valve Stem • Valve Guide	Clearance O.D. I.D.	0.040 to 0.070 mm 0.0016 to 0.0027 in. 7.960 to 7.975 mm 0.3134 to 0.3139 in. 8.015 to 8.030 mm 0.3156 to 0.3161 in.	0.10 mm 0.0039 in. – –
Valve Face	Angle (Intake) Angle (Exhaust)	1.0 rad 60° 1.0 rad 60°	– –
Valve Seat	Angle (Intake) Angle (Exhaust) Width (Intake) Width (Exhaust)	1.0 rad 60° 1.0 rad 60° 2.15 mm 0.0846 in. 2.50 mm 0.0984 in.	– – – –
Valve Timing (Intake Valve)	Open Close	0.24 rad 14° before T.D.C. 0.63 rad 36° after B.D.C.	– –
Valve Timing (Exhaust Valve)	Open Close	0.70 rad 40° before B.D.C. 0.21 rad 12° after T.D.C.	– –

Item		Service Specification	Service Limit
Valve Spring	Free Length	50.7 to 51.2 mm 2.00 to 2.01 in.	50.2 mm 1.98 in.
	Tilt	–	1.0 mm 0.039 in.
	Setting Load / Setting Length	136 N / 41.05 mm 13.9 kgf / 41.05 mm 30.6 lbf / 1.616 in.	130 N / 41.05 mm 13.3 kgf / 41.05 mm 29.2 lbf / 1.616 in.
Rocker Arm Shaft to Rocker Arm	Oil Clearance	0.016 to 0.045 mm 0.00063 to 0.0017 in.	0.15 mm 0.0059 in.
• Rocker Arm Shaft	O.D.	15.973 to 15.984 mm 0.62886 to 0.62929 in.	–
• Rocker Arm	I.D.	16.000 to 16.018 mm 0.62993 to 0.63062 in.	–
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.	–
Timing Gear • Crank Gear to Idle Gear 1	Backlash	0.049 to 0.193 mm 0.00193 to 0.00759 in.	0.23 mm 0.0091 in.
• Idle Gear 1 to Cam Gear	Backlash	0.049 to 0.189 mm 0.00193 to 0.00744 in.	0.23 mm 0.0091 in.
Idle Gear	Side Clearance	0.15 to 0.30 mm 0.0059 to 0.012 in.	0.9 mm 0.04 in.
Camshaft	Side Clearance	0.070 to 0.22 mm 0.0028 to 0.0086 in.	0.30 mm 0.012 in.
	Bend	–	0.01 mm 0.0004 in.
Cam Height	Intake	38.86 mm 1.530 in.	38.36 mm 1.510 in.
	Exhaust	38.56 mm 1.518 in.	38.06 mm 1.498 in.
Camshaft Journal to Cylinder Block Bore	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.	–
• Cylinder Block Bore	I.D.	46.000 to 46.025 mm 1.8111 to 1.8120 in.	–

Item		Service Specification	Service Limit
Idle Gear Shaft to Gear Bushing	Oil Clearance	0.050 to 0.091 mm 0.0020 to 0.0035 in.	0.10 mm 0.0039 in.
• Idle Gear Shaft	O.D.	44.959 to 44.975 mm 1.7701 to 1.7706 in.	–
• Idle Gear Bushing	I.D.	45.025 to 45.050 mm 1.7727 to 1.7736 in.	–
Piston Pin Bore	I.D.	26.006 to 26.013 mm 1.0239 to 1.0241 in.	26.05 mm 1.026 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.	26.006 to 26.011 mm 1.0239 to 1.0240 in.	–
• Small End Bushing	I.D.	26.031 to 26.046 mm 1.0249 to 1.0254 in.	–
Piston Ring Gap	Top Ring	0.30 to 0.45 mm 0.012 to 0.017 in.	1.25 mm 0.0492 in.
	Second Ring	0.30 to 0.45 mm 0.012 to 0.017 in.	1.25 mm 0.0492 in.
	Oil Ring	0.25 to 0.75 mm 0.0099 to 0.029 in.	1.25 mm 0.0492 in.
Piston Ring to Piston Ring Groove	Top Ring (Clearance)	0.05 to 0.09 mm 0.002 to 0.003 in.	0.15 mm 0.0059 in.
	Second Ring (Clearance)	0.093 to 0.120 mm 0.00367 to 0.00472 in.	0.20 mm 0.0079 in.
	Oil Ring (Clearance)	0.060 to 0.15 mm 0.0024 to 0.0059 in	0.2 mm 0.008 in
Connecting Rod	Alignment	–	0.05 mm 0.002 in.
Crankshaft	Side Clearance	0.15 to 0.31 mm 0.0059 to 0.012 in.	0.50 mm 0.020 in.
	Bend	–	0.02 mm 0.0008 in.
Crankpin to Crankpin Bearing	Oil Clearance	0.010 to 0.043 mm 0.00040 to 0.0016 in.	0.20 mm 0.0079 in.
• Crankpin	O.D.	52.977 to 52.990 mm 2.0857 to 2.0862 in.	–
• Crankpin Bearing	I.D.	53.000 to 53.020 mm 2.0867 to 2.0874 in.	–

Item		Service Specification	Service Limit
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	–
• Crankshaft Bearing 1	I.D.	75.008 to 75.039 mm 2.9531 to 2.9542 in.	–
Cylinder Liner [Standard]	I.D.	100.000 to 100.022 mm 3.93701 to 3.91787 in.	100.150 mm 3.9429 in.
Cylinder Liner [Oversize: 0.50 mm (0.020 in.)]	I.D.	100.500 to 100.522 mm 3.95670 to 3.95755 in.	100.650 mm 3.96260 in.

LUBRICATING SYSTEM

Item		Service Specification	Service Limit
Engine Oil Pressure	At Idle Speed	More than 69 kPa 0.7 kgf/cm^2 10 psi	50 kPa 0.5 kgf/cm^2 7 psi
	At Rated Speed	245 to 441 kPa 2.5 to 4.5 kgf/cm^2 36 to 64 psi	250 kPa 2.5 kgf/cm^2 36 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		Service Specification	Service Limit
Fan Belt	Tension	10 to 12 mm / 59 to 68 N 0.40 to 0.47 in. / 59 to 68 N (6.0 to 7.0 kgf, 14 to 15 lbf)	–
Thermostat	Opening-Temperature (When the valve starts to open)	74.5 to 78.5 °C 166.1 to 173.3 °F	–
	Opening-Temperature (When the valve opened completely)	90 °C 194 °F	–
Radiator	Water Tightness	No leak at specified pressure	–
Radiator Cap	Pressure Decreasing Time	More than 10 seconds for pressure decrease from 90 → 60 kPa from 0.9 → 0.6 kgf/cm^2 from 10 → 9 psi	–

IGNITION SYSTEM

Item		Service Specification	Service Limit
Ignition Timing	L (LPG)	0.72 rad (41°) before T.D.C. / 2500 min^{-1} (rpm) 0.26 rad (15°) before T.D.C. / 700 min^{-1} (rpm)	– –
Crankshaft Position Sensor	Resistance	0.95 to 1.25 kΩ at 20 °C (68 °F)	–
Camshaft Position Sensor	Resistance	0.95 to 1.25 kΩ at 20 °C (68 °F)	–
Spark Plug (NGK: IFR6F8DN)	Plug Gap	0.70 to 0.80 mm 0.028 to 0.031 in.	–
Resistance of Ignition Coil	Primary (+) - (−)	0.63 to 0.77 Ω at 25 °C (77 °F)	–
	Secondary Side (Primary (+) - Plug Cap)	7.29 to 8.91 kΩ at 25 °C (77 °F)	–

ELECTRICAL SYSTEM

Item		Service Specification	Service Limit
Starter			
• 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	Length	18.0 mm 0.709 in.	11.0 mm 0.433 in.
Alternator	No-load Voltage	More than 13.5 V	–
• Stator	Resistance	Less than 1.0 Ω	–
• Rotor	Resistance	2.8 to 3.3 Ω	–
• Slip Ring	O.D.	22.7 mm 0.894 in.	22.1 mm 0.870 in.
• Brush	Length	10.5 mm 0.413 in.	8.4 mm 0.33 in.

9Y3210051ENS0003US0

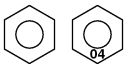
3. TIGHTENING TORQUES

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

9Y3210051ENS0004US0

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

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

Indication on top of bolt	 **No-grade or 4T**			 **7T**		
Indication on top of nut	 **No-grade or 4T**					
Unit	**N·m**	**kgf·m**	**lbf·ft**	**N·m**	**kgf·m**	**lbf·ft**
M6	7.9 to 9.3	0.80 to 0.95	5.8 to 6.8	9.81 to 11.2	1.00 to 1.15	7.24 to 8.31
M8	18 to 20	1.8 to 2.1	13 to 15	24 to 27	2.4 to 2.8	18 to 20
M10	40 to 45	4.0 to 4.6	29 to 33	49 to 55	5.0 to 5.7	37 to 41
M12	63 to 72	6.4 to 7.4	47 to 53	78 to 90	7.9 to 9.2	58 to 66

9Y3210051ENS0005US0

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

■ **NOTE**

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

Item	Dimension × Pitch	N·m	kgf·m	lbf·ft
Cylinder head 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
*Flywheel screw	M12 × 1.25	98.10 to 107.9	10.01 to 11.00	72.36 to 79.58
*Fan drive pulley mounting screw	M16 × 1.5	255 to 274	26.0 to 28.0	188 to 202
*Main bearing case screw 1	M14 × 1.5	138 to 147	14.0 to 15.0	102 to 108
*Cylinder head cover screw	M6 × 1.0	6.86 to 11.3	0.700 to 1.15	5.06 to 8.33
Bearing case cover mounting screw	M8 × 1.0	23.5 to 27.5	2.40 to 2.80	17.4 to 20.2
*Rocker arm bracket screw	M10 × 1.25	49 to 55	5.0 to 5.7	37 to 41
*Idle gear shaft mounting screw	M8 × 1.25	24 to 27	2.4 to 2.8	18 to 20
Drain plug	M22 × 1.5	45 to 53	4.5 to 5.5	33 to 39
Oil cooler joint screw	M20 × 1.5	39 to 45	4.0 to 4.5	29 to 33
Exhaust manifold mounting nut	M8 × 1.25	30 to 34	3.0 to 3.5	22 to 25
Oil pump cover screw	M6	7.9 to 9.3	0.80 to 0.95	5.8 to 6.8
PCV Valve	M16 × 1.5	9.81 to 11.2	1.00 to 1.15	7.24 to 8.33
Spark plug	M14 × 1.25	24.5 to 29.4	2.50 to 3.00	18.1 to 21.6
Ignition coil mounting screw	M6 × 1.0	9.81 to 11.7	1.00 to 1.20	7.24 to 8.67
Coolant temperature sensor	M12 × 1.5	16.7 to 19.6	1.7 to 2.0	12.4 to 14.4
Crankshaft position sensor mounting screw	M6 × 1.0	9.81 to 11.3	1.00 to 1.15	7.24 to 8.33
Camshaft position sensor mounting screw	M6 × 1.0	9.81 to 11.3	1.00 to 1.15	7.24 to 8.33
TMAP sensor mounting screw	M5 × 0.8	2.8 to 4.0	0.29 to 0.40	2.1 to 2.9
Knock sensor mounting screw	M6 × 1.0	15.0 to 25.0	1.53 to 2.54	11.1 to 18.4
Electronic Throttle Body mounting screw	M6 × 1.0	7.0 to 9.0	0.72 to 0.91	5.2 to 6.6
DEPR mounting screw	M5 × 0.8	2.8 to 4.0	0.29 to 0.41	0.63 to 0.89
Mixer assembly mounting screw	M6 × 1.0	7.0 to 9.0	0.72 to 0.91	5.2 to 6.6
ECU component mounting screw	M6 × 1.0	9.81 to 11.7	1.00 to 1.20	7.24 to 8.67
Starter **B** terminal nut	M8 × 1.25	9.8 to 12	1.0 to 1.2	7.2 to 8.8
Alternator's pulley nut	–	58.4 to 78.9	5.96 to 8.04	43.1 to 58.1
ECU stay	M10 × 1.25	49 to 55	5.0 to 5.7	37 to 41
Exhaust manifold cover mounting screw	M6 × 1.0	13.8 to 15.3	1.41 to 1.56	10.2 to 11.2
Flywheel housing mounting screw	M12 × 1.25	103 to 117	10.5 to 12.0	76.0 to 86.7
Crankcase 2 mounting screw	M10 × 1.25	49 to 55	5.0 to 5.7	37 to 41
Relief valve retaining screw	M22 × 1.5	69 to 78	7.1 to 7.9	51 to 57

Item	Dimension × Pitch	N·m	kgf·m	lbf·ft
Cam pulser gear mounting screw	M5	4.7 to 5.7	0.48 to 0.58	3.5 to 4.2
Fuse box mounting nut	M6 × 1.0	2.7 to 3.3	0.28 to 0.34	2.0 to 2.4
Case of oil separator	–	9.50 to 10.5	0.969 to 1.07	7.01 to 7.74
Lockoff valve fitting union	PT 1/4	11.2 to 12.8	1.15 to 1.30	8.26 to 9.44

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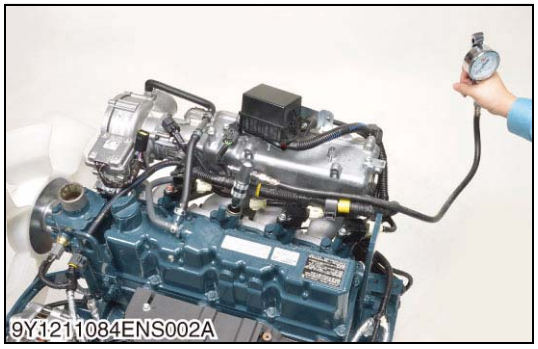
4. CHECKING, DISASSEMBLING AND SERVICING

[1] CHECKING AND ADJUSTING

(1) Engine Body



Compression Pressure

1. Operate the engine for warming-up.
2. Stop the engine.
3. Disconnect DEPR connector, fuse box and all ignition coil connectors.
4. Remove the air cleaner, the muffler and all spark plugs.
5. Set a compression tester with the adaptor to the spark plug hole.
6. Crank the engine with the starter for 5 to 10 seconds and measure the maximum compression pressure.
7. Do the steps 5 through 6 again for each cylinder.
8. If the measurement is below the service limit, examine the cylinder wall and piston rings.

■ **NOTE**

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

Compression pressure	Service specification	1.75 MPa 17.8 kgf/cm^2 253 psi
	Service limit	1.40 MPa 14.3 kgf/cm^2 203 psi

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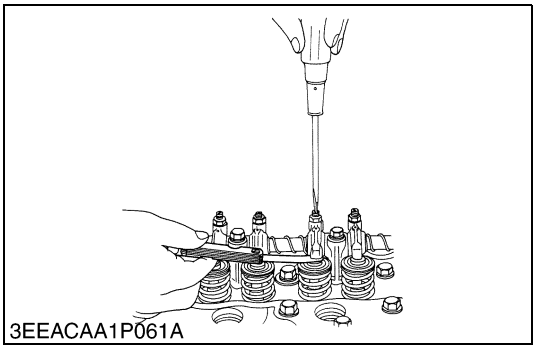
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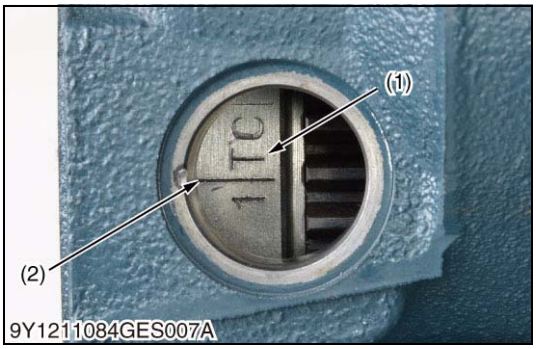

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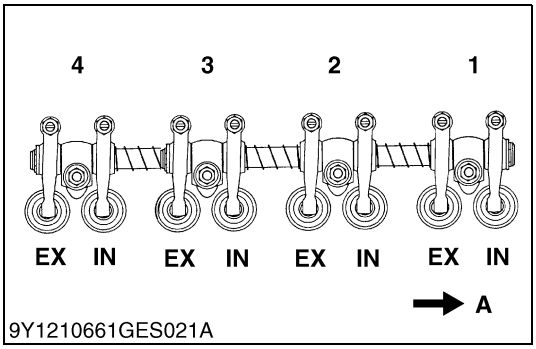

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Adjusting Valve Clearance

■ **IMPORTANT**

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

1. Remove the head cover.
2. Align the **"1TC"** mark line (1) on the flywheel and alignment mark (2) on the housing. Make sure that the No.1 piston comes to the compression or overlap top dead center.
3. Examine the subsequent valve clearance at the mark "☆" with a feeler gauge.
4. If the clearance is out of the service specifications, adjust with the adjusting screw.

Adjustable Cylinder Location of Piston		Intake valve	Exhaust valve
When No. 1 piston is at compression top dead center	1st	☆	☆
	2nd	☆	
	3rd		☆
	4th		
When No. 1 piston is at overlap position	1st		
	2nd		☆
	3rd	☆	
	4th	☆	☆

Intake and exhaust valve clearance (cold)	Service specification	0.18 to 0.22 mm 0.0071 to 0.0086 in.

■ **NOTE**

- **The sequence of cylinder numbers is No.1, No.2, No.3 and No.4 and it starts from the gear case side.**
- **After you adjust the valve clearance, tighten the lock nut of the adjusting screw.**

(1) **"1TC"** Mark
(2) Alignment Mark

A: Gear Case Side

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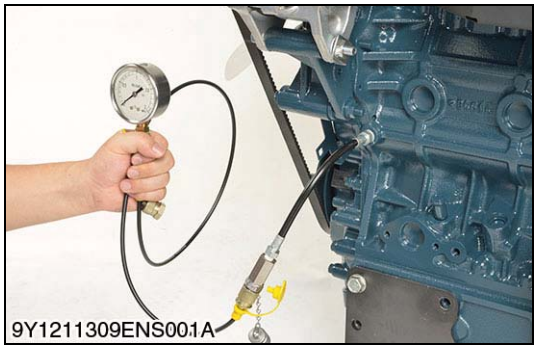
(2) Lubricating System



Engine Oil Pressure

1. Remove the engine oil switch, and set the oil pressure tester.
2. Operate the engine for warming-up.
3. Measure the oil pressure at the idle speed and rated speed.
4. If the oil pressure is less than the service limit, do a check below.
   - Engine oil level
   - Oil pump
   - Oil strainer
   - Oil filter cartridge
   - Oil passage
   - Oil clearance
   - Relief valve

Engine oil pressure	At idle speed	Service specification	More than 69 kPa 0.7 kgf/cm^2 10 psi
		Service limit	50 kPa 0.5 kgf/cm^2 7 psi
	At rated speed	Service specification	245 to 441 kPa 2.5 to 4.5 kgf/cm^2 36 to 64 psi
		Service limit	250 kPa 2.5 kgf/cm^2 36 psi

(When reassembling)

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

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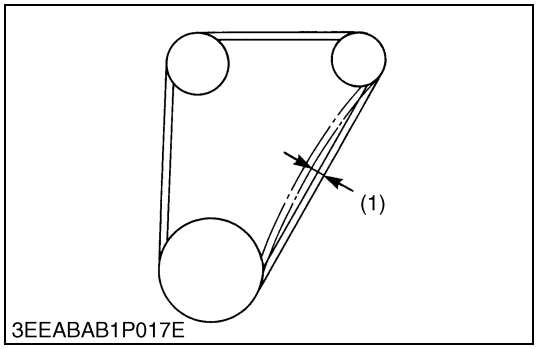
(3) Cooling System



Fan Belt Tension

1. Examine if the fan belt is worn out and sunk in the pulley groove, and if it is, replace it.
2. Push the belt halfway between the fan drive pulley and alternator pulley at a specified force 59 to 68 N (6.0 to 7.0 kg, 14 to 15 lbf) to measure the deflection (1).
3. If the measurement is out of the service specifications, loosen the alternator mounting screws and adjust its position.

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

(1) Deflection

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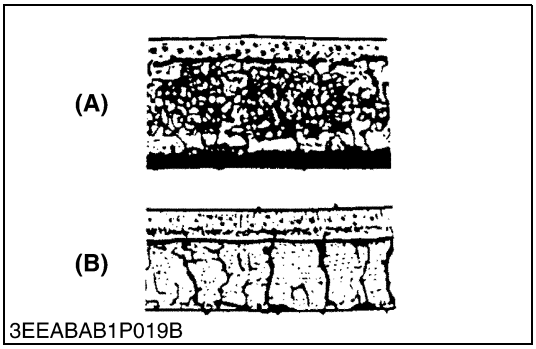

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Fan Belt Damage and Wear

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

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

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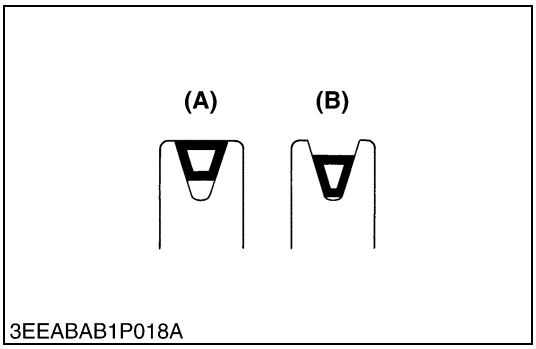

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Radiator Cap Air Leakage

CAUTION

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

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

Pressure decreasing time	Service specification	More than 10 seconds for pressure decrease from 90 to 60 kPa (from 0.9 to 0.6 kgf/cm^2, from 10 to 9 psi)

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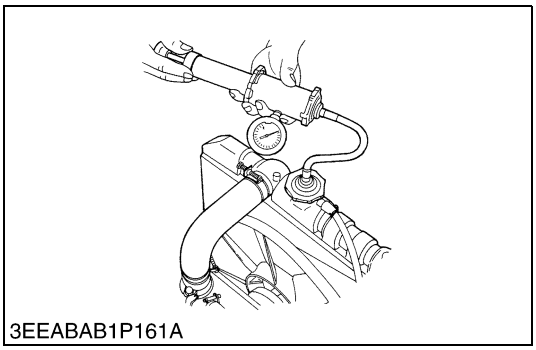
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Radiator Water Leakage

1. Fill a specified quantity of water into the radiator.
2. Set a radiator tester and an adaptor on the radiator. Increase the water pressure to the specified pressure with the radiator tester and adaptor.
3. Examine the radiator for water leakage.
4. For water leakages from the pinhole, replace the radiator or repair with the radiator cement. When water leak is too much, replace the radiator.

Radiator water leakage test	Service specification	No leak at specified pressure

■ **NOTE**

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

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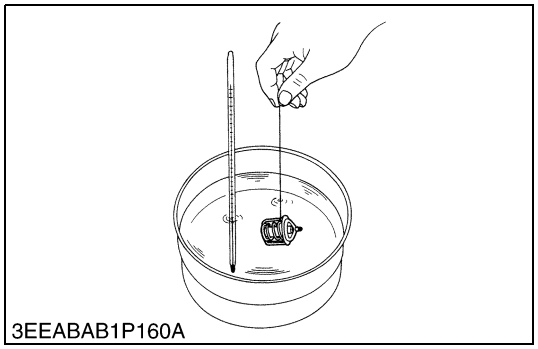
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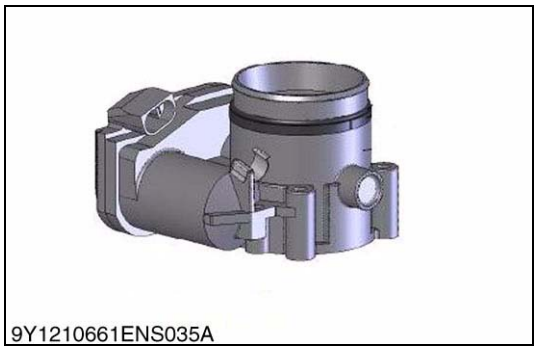
Opening-temperature of Thermostat Valve

1. Hang the thermostat in the water by a string with its end put between the valve and the seat.
2. Increase the temperature of the water gradually, read the temperature when the valve opens and disconnects the string.
3. Continue to increase the temperature and read the temperature when the valve opens approximately 8 mm (0.3 in.).
4. If the measurement is out of the service specifications, replace the thermostat.

Opening- temperature (When the valve starts to open)	Service specification	74.5 to 78.5 °C 166.1 to 173.3 °F
Opening- temperature (When the valve opened completely)	Service specification	90 °C 194 °F

9Y3210051ENS0014US0

(4) Fuel System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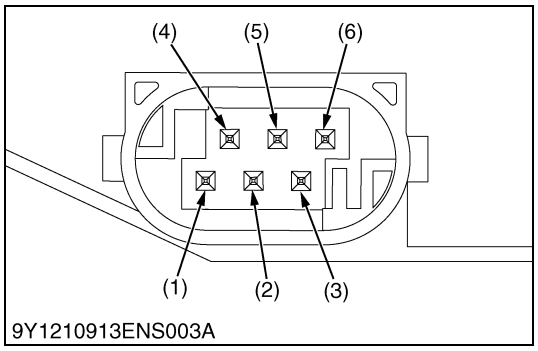

9Y1210913ENS003A

Resistance of Throttle Body

1. Disconnect the connector.
2. Measure the resistance between terminal **1** and terminal **4** with an ohmmeter.
3. If the resistance is 0 ohm or infinity, replace it.
4. Measure the resistance between terminal **2** and terminal **3** with an ohmmeter.
5. If the resistance is not with in the service specifications, replace it.

Resistance	Service specifica-tion	Terminal **1** – Terminal **4**	Continuity
		Terminal **2** – Terminal **3**	0.625 to 3.000 kΩ at 20 °C (68 °F)

(1) Terminal **1**
(2) Terminal **2**
(3) Terminal **3**
(4) Terminal **4**
(5) Terminal **5**
(6) Terminal **6**

(A) Electronic Throttle Body (ETB)

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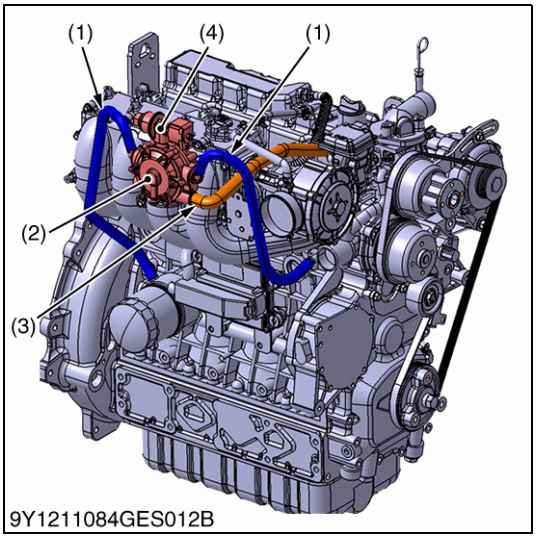

9Y1211084GES012B

Vaporizer Hose

1. Connect the coolant hose (1) and (2) through the vaporizer.
2. Connect the vapor hose (4).

CAUTION

- **All fuel connections added to this engine must be installed by qualified personnel and utilizing recognized procedures and standards.**
- **These non-KUBOTA installed parts, such as hoses, fittings, piping, should be approved for LPG use and conform to UL, CSA, NFPA, and all other recognized standards.**
- **An approved, LPG lock off valve must be directly connected to the KUBOTA vaporizer**

NOTE

- **The LPG liquid in joint (fitting) to the vaporizer / regulator is not provided in the KIT by KUBOTA, due to the many different connection requirements by the OEM.**
- **Vapor hose length must not exceed 700 mm (27.6 in), shorter is generally considered better.**
- **Each hose must be tightened with a hose clamp.**

(1) Coolant Hose (ϕ16 mm (5/8 in.) Hose Fitting)
(2) Vaporizer
(3) Vapor Hose
(4) LPG Lock Off Valve

9Y3210051ENS0016US0

(5) Ignition System


9Y1211084ENS003A

Resistance of Crankshaft Position Sensor / Camshaft Position Sensor

1. Disconnect the connector.
2. Measure the resistance with an ohmmeter.
3. If the resistance is not with in the service specifications, replace it.

Resistance	Service specification	0.95 to 1.25 kΩ at 20 °C (68 °F)

NOTE

- **This table shows the results of the test conducted by using the "Sanwa-made testers SP-10/SP-150" (analog meter).**
- **Use of other testers than those above may show different measured results.**

(When reassembling)

- **Make sure to be connected firmly.**

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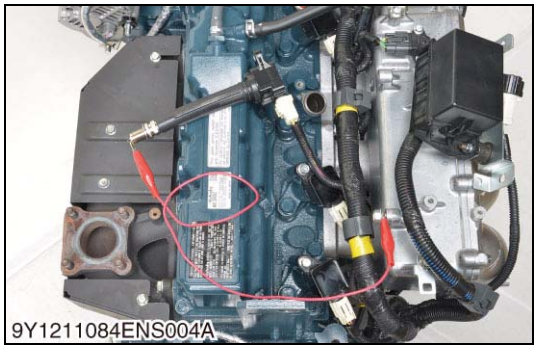

Spark Test

1. Close the LPG tank valve.
2. Disconnect the LPG lock off valve connector.
3. Remove the spark plug, put it inside the ignition coil firmly, and then ground the threaded section to the engine body (not to painted or resin parts).
4. Disconnect other ignition coil connector.
5. Rotate the starter with the key switch and check that the plug sparks.
6. If test is **OK**, tighten the spark plug with a plug wrench.

■ IMPORTANT

(When reassembling)

- **Put the ignition coil inside the spark plug terminal firmly.**
- **Make sure that the wiring and the ignition coil are correctly connected.**
- **Make sure that the removed connectors are correctly connected.**
- **Open the LPG tank valve and connect LPG lock off valve connector.**

⚠ CAUTION

- **This test is hazardous of electric shocks. Never use hand or screwdriver to press the plug to ground it to the engine body.**
- **Keep inflammable away from the engine.**

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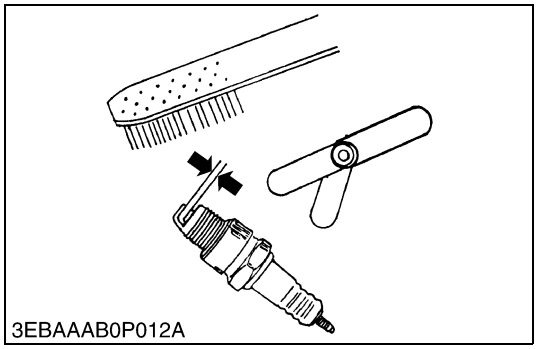

Spark Plug Gap

1. Remove the spark plug, and remove carbon from the electrode with a wire brush or other tools.
2. Measure the spark plug gap with a feeler gauge, and repair or replace the plug if the measured gap differs from the service specification.
3. Replace the plug if the electrode or the insulator is deformed or cracked.
4. Tighten the plug with a plug wrench.

■ IMPORTANT

(When reassembling)

- **Put the ignition coil inside the spark plug terminal firmly.**
- **Make sure that the wiring and the ignition coil are correctly connected.**
- **Fix the ignition coil by screw.**

Spark plug gap	Service specification	0.70 to 0.80 mm 0.028 to 0.031 in

Spark plug	NGK: IFR6F8DN

Tightening torque	Spark plug	24.5 to 29.4 N·m 2.50 to 2.99 kgf·m 18.1 to 21.6 lbf·ft
	Ignition coil mounting screw / nut	9.81 to 11.3 N·m 1.00 to 1.15 kgf·m 7.24 to 8.33 lbf·ft

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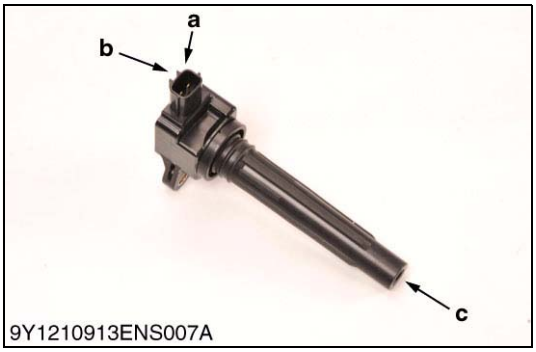

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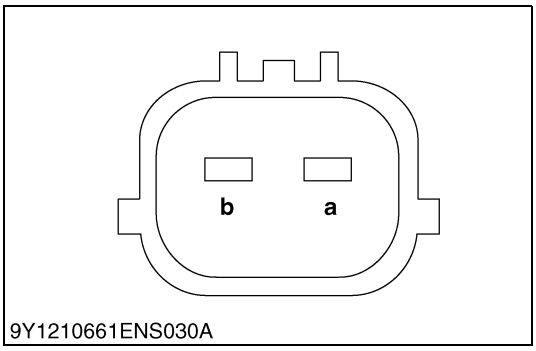

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Resistance of Ignition Coil

1. Disconnect the ignition coil.
2. Measure the resistance with an ohmmeter.
3. If the resistance is not with in the service specifications, replace it.

Resistance	Service specification	**a – b**	0.63 to 0.77 Ω at 25 °C (77 °F)

9Y3210051ENS0020US0

(6) Electrical System

CAUTION

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

IMPORTANT

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

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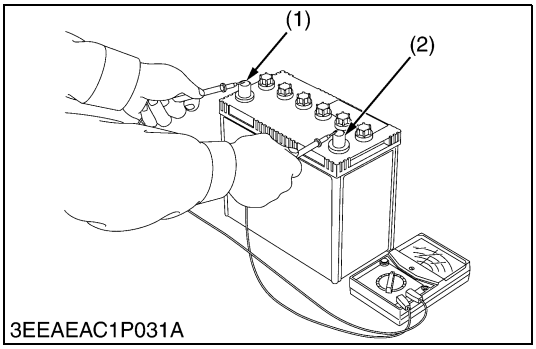

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Battery Voltage

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

Battery voltage	Service specification	More than 12 V

(1) Positive Terminal (2) Negative Terminal

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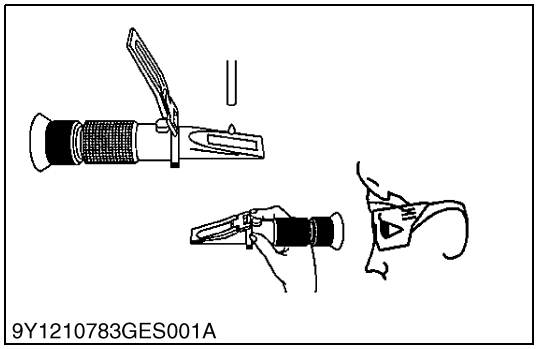
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Battery Specific Gravity

CAUTION

- **If battery acid (dilute sulfuric acid) gets on you it could cause blindness or burns, or could cause corrosion of machinery and tools so please be careful when handling.**
- **Wear safety glasses and rubber gloves when performing battery maintenance and inspection (measuring specific gravity, replenishing water, or charging).**
- **If the gas that is generated is ignited by an ignition source, it may explode so be very careful with sparks and fire.**
- **Keep your body and face as far away from the battery as you can when performing maintenance and inspection.**
- **Do not allow people who do not know how to handle a battery or who do not sufficiently understand the danger perform inspection or maintenance.**

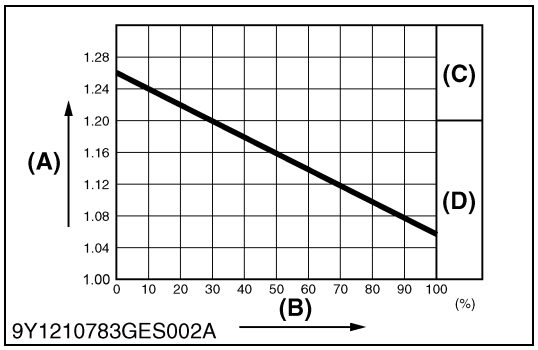
(Measurement items)

■ **Zero adjustment**

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

■ **Measurement of test fluid**

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



9Y1210783GES002A

(Reference)

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

(A) Electrolyte Specific Gravity
(B) Discharge
(C) Good
(D) Charging is necessary.

■ **NOTE**

Temperature conversion of electrolyte specific gravity

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

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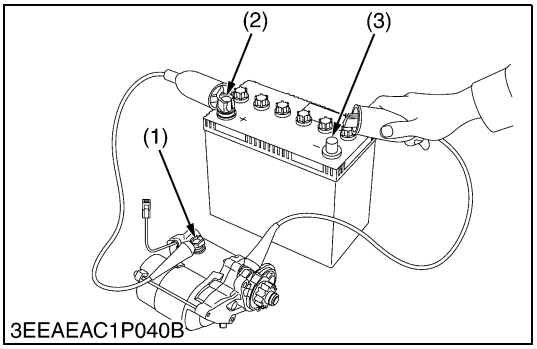

Motor Test

CAUTION

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

1. Disconnect the negative cable from the battery.
2. Disconnect the positive cable from the battery.
3. Disconnect the leads from the starter **B** terminal.
4. Remove the starter from the engine.
5. Connect a jumper lead from the starter **C** terminal (1) to the battery positive terminal (2).
6. Connect a jumper lead momentarily between the starter body and the battery negative terminal (3).
7. If the motor does not operate, starter is defective. Repair or replace the starter.

■ **NOTE**

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

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

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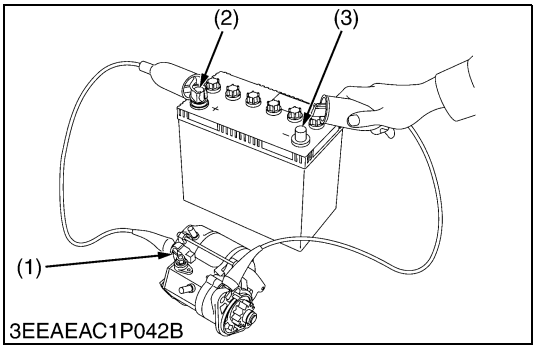

Magnetic Switch Test

1. Disconnect the negative cable from the battery.
2. Disconnect the positive cable from the battery.
3. Disconnect the leads from the starter **B** terminal.
4. Remove the starter from the engine.
5. Connect a jumper lead from the starter **S** terminal (1) to the battery positive terminal (2).
6. Connect a jumper lead momentarily between the starter body and the battery negative terminal (3).
7. If the pinion gear does not come out, the magnetic switch is defective. Repair or replace the starter.

■ **NOTE**

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

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

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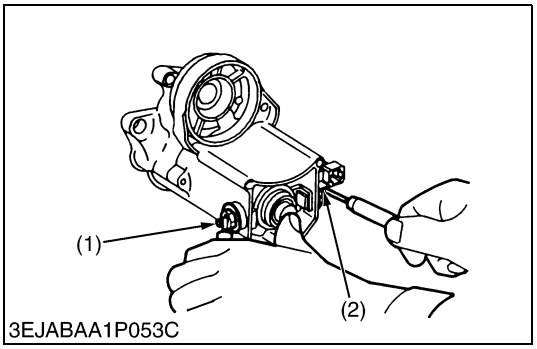

Magnetic Switch Continuity Test

1. Push in the plunger. Then examine the continuity across the **C** terminal (1) and the **B** terminal (2) with a circuit tester.
2. If it is not continuous or it shows a value, replace the magnetic switch.

(1) **C** Terminal
(2) **B** Terminal

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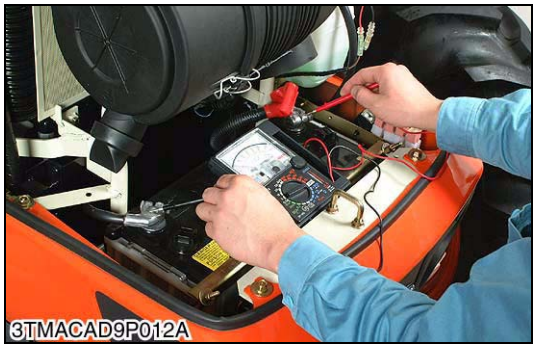


Alternator-on Unit Test

Before testing

- Before the alternator-on unit test, do a check of the list below:
  - Battery terminal connections
  - Circuit connection
  - Fan belt tension
  - Charge indicator lamp
  - Fuses on the circuit
  - Abnormal noise from the alternator
- Prepare full charged battery for the test.

■ **NOTE**

- **Do not touch the engine parts that turns while the engine operates.**
  Keep a safety distance from the engine parts that turn.

1. Start the engine.
2. When the engine operates, measure the voltage between battery terminals. If the voltage is between 13.8 V and 14.8 V, the alternator operates correctly.
3. If the results of alternator-on unit test are not in the service specifications, disassemble the alternator. Examine each component part to find out the problem. Refer to "DISASSEMBLING AND ASSEMBLING" and "SERVICING" for the alternator.

Regulating voltage at no load	Service specification	13.8 to 14.8 V at 25 °C (77 °F)

9Y3210051ENS0027US0

Resistance of Coolant Temperature Sensor

1. Disconnect the connector.
2. Measure the resistance with an ohmmeter.
3. If the resistance is not with in the service specifications, replace it.

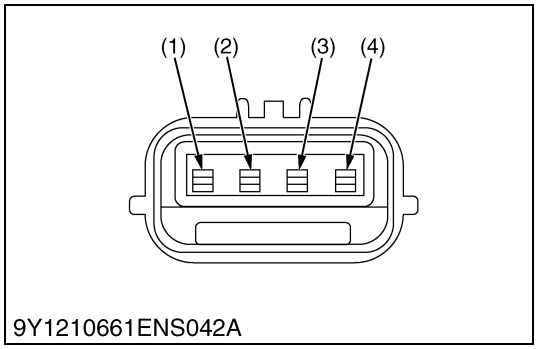
Resistance	Service specification	2.32 to 2.59 kΩ at 20 °C (68 °F)

9Y3210051ENS0028US0

Resistance of Temperature and Manifold Absolute Pressure (TMAP) Sensor

1. Measure the resistance between the terminal **1** and terminal **3** of the sensor.
2. If the measurement is not in the service specification, the sensor is damaged. Then replace it with a new one.
3. If the measurement is in the service specification, the sensor is correct electrically.

Resistance of TMAP sensor	Service specification	Terminal **1** – Terminal **3**	2.174 to 2.942 kΩ at 20 °C (68 °F)



(1) Terminal **1**
(2) Terminal **2**
(3) Terminal **3**
(4) Terminal **4**

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[2] DISASSEMBLING AND ASSEMBLING

■ **IMPORTANT**
- **When reassembling, replace all of the O-rings and gaskets by new ones.**
- **When disassembling the LPG engine after completely consuming the fuel in piping.**

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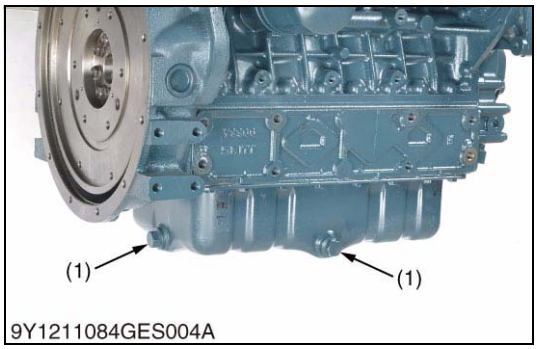
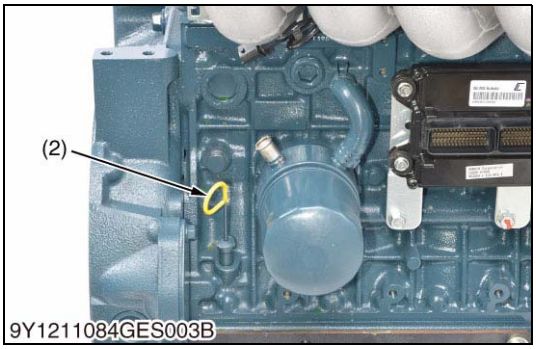
(1) Draining Engine Oil and Coolant





Draining Engine Oil

1. Start and increase the temperature of the engine for approximately 5 minutes.
2. Put an oil pan below the engine.
3. Remove the drain plug (1) to drain the oil.
4. After you drain, tighten the drain plug.

(When refilling)
- Fill the engine oil until the upper line on the dipstick (2).

■ **IMPORTANT**
- **When using an oil of different maker or viscosity from the previous one, remove all of the old oil.**
- **Do not mix different types of oil.**
- **Engine oil should have properties of API classification SL or higher.**
- **Use the correct SAE Engine Oil by reference to the ambient temperature.**

Above 25 °C (77 °F)	SAE30 or SAE10W-30 or SAE15W-40
0 °C to 25 °C (32 °F to 77 °F)	SAE20 or SAE10W-30
0 °C to −20 °C (32 °F to −4 °F)	SAE10W or SAE10W-30

Engine oil capacity	12.2 L 3.22 U.S. gals

Tightening torque	Drain plug	32.4 to 37.2 N·m 3.31 to 3.79 kgf·m 23.9 to 27.4 lbf·ft

(1) Drain Plug (2) Dipstick

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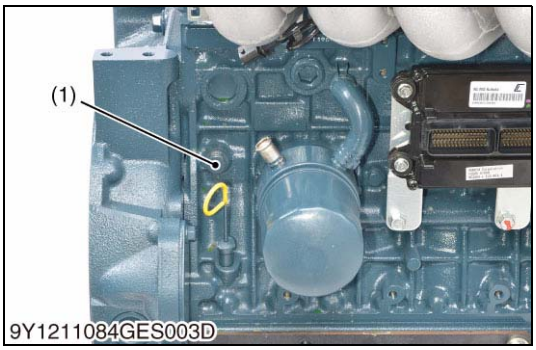

Draining Coolant

CAUTION
- **Do not remove the radiator cap while you operate or immediately after you stop the engine. If not, hot water can flow out from the radiator. Only open the cap after more than 10 minutes for the temperature of the radiator to decrease.**

1. Prepare a bucket.
2. Open the coolant drain plug (1) to drain the coolant.
3. After you drain, close the coolant drain plug (1).

(1) Coolant Drain Plug

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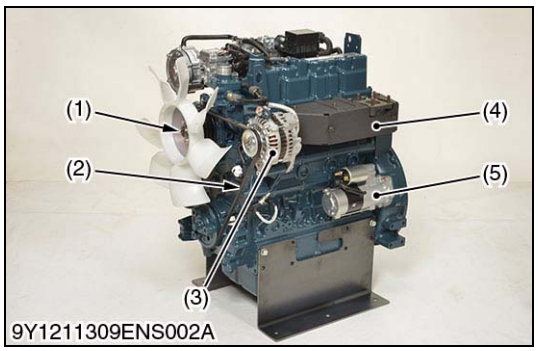
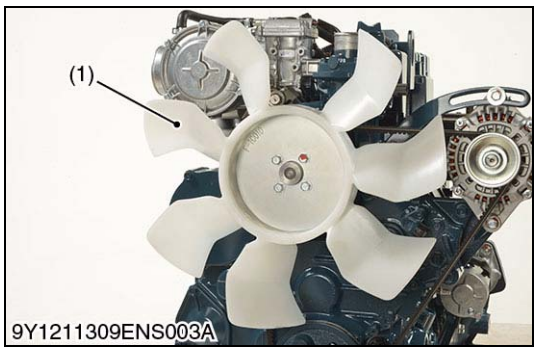
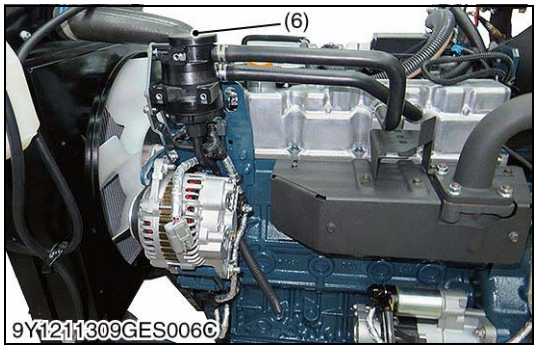
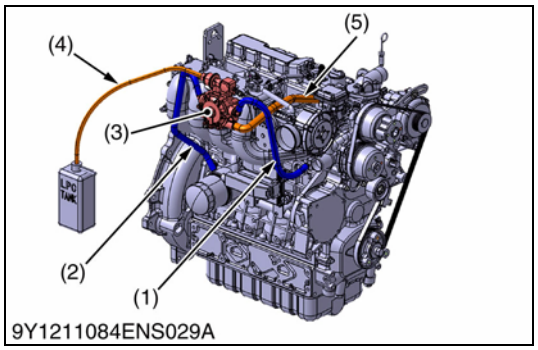
(2) External Components









Alternator, Starter and Others

1. Remove the air cleaner and muffler and exhaust manifold (4).
2. Remove the cooling fan (1), fan belt (2), oil separator (6), alternator (3) and starter (5).

(When reassembling)

- Examine for cracks on the belt surface.

■ IMPORTANT

- **After you assemble the fan belt, adjust the fan belt tension.**
- **Do not put the fan in the incorrect direction.**

Tightening torque	Exhaust manifold mounting nut	29.4 to 34.3 N·m 3.00 to 3.49 kgf·m 21.7 to 25.2 lbf·ft
	ECU mounting screw	5.0 to 7.8 N·m 0.51 to 0.79 kgf·m 3.7 to 5.7 lbf·ft

(1) Cooling Fan
(2) Fan Belt
(3) Alternator
(4) Exhaust Manifold
(5) Starter
(6) Oil Separator

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Vapor Hose and Coolant Hose

CAUTION

- **Close the LPG tank valve.**
- **In order to reduce the fuel pressure, do not remove the fuel hose at least 3 minutes after stopping the engine.**
- **Vent the air of the water passage of vaporizer (3) after removing the coolant hose (1), (2).**

1. Disconnect the vapor hose (4).
2. After drain the coolant, disconnect the coolant hose (1), (2).
3. Remove the vaporizer (3) (if necessary).

■ IMPORTANT

- **When disassembling the fuel system, make sure that the LPG tank valve is closed.**

(When reassembling)

- Bleed the vaporizer after supplying coolant.

(1) Coolant Hose
(2) Coolant Hose
(3) Vaporizer
(4) Vapor Hose
(5) LPG Lock Off Valve

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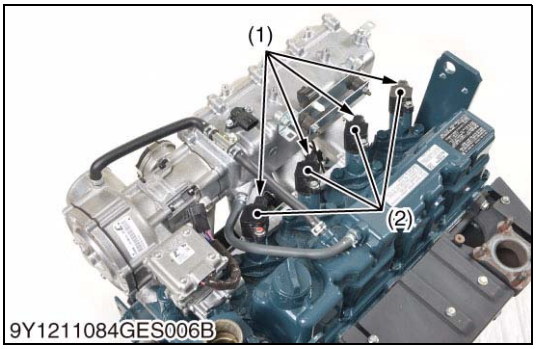

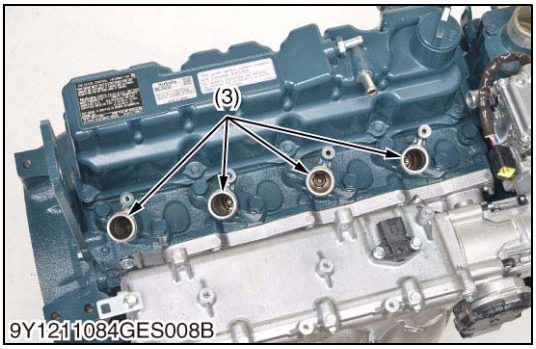

Ignition Coil and Spark Plug

1. Disconnect the ignition coil connector (1).
2. Remove the ignition coil (2).
3. Remove the spark plug (3).

(When reassembling)

- Tighten the spark plug with a plug wrench.

■ **NOTE**

(When reassembling)

- **Put the ignition coil inside the spark plug terminal firmly.**
- **Make sure that the wiring and the ignition coil are correctly connected.**
- **Make sure that the removed connectors are correctly connected.**
- **Fix the ignition coil by screw.**

Tightening torque	Spark plug	24.5 to 29.4 N·m 2.50 to 2.99 kgf·m 18.1 to 21.5 lbf·ft
	Ignition coil mounting screw	9.81 to 11.3 N·m 1.00 to 1.15 kgf·m 7.24 to 8.33 lbf·ft

(1) Ignition Coil Connector
(2) Ignition Coil
(3) Spark Plug

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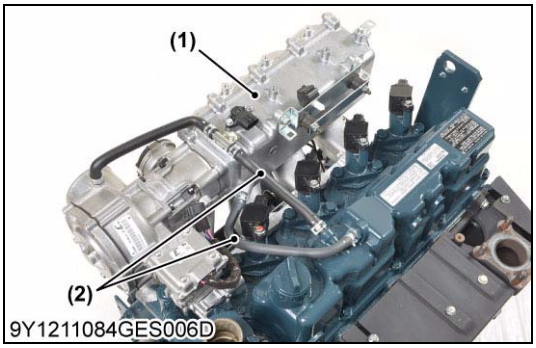
(3) Cylinder Head and Valves



Intake Manifold

1. Remove the breather hose (2).
2. Remove the intake manifold (1).

(When reassembling)

- Check the breather hose to not touch other parts.

(1) Intake Manifold
(2) Breather Hose

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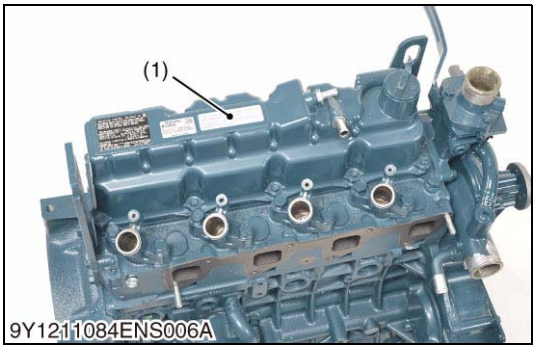

Cylinder Head Cover

1. Remove the cylinder head cover (1).

(When reassembling)

- Make sure that the cylinder head cover gasket is not defective.
- Tighten the head cover mounting screws to specified torque.
- Replace the cylinder head cover gasket with a new one.

Tightening torque	Cylinder head cover screw	9.81 to 11.3 N·m 1.00 to 1.15 kgf·m 7.24 to 8.33 lbf·ft

(1) Cylinder Head Cover

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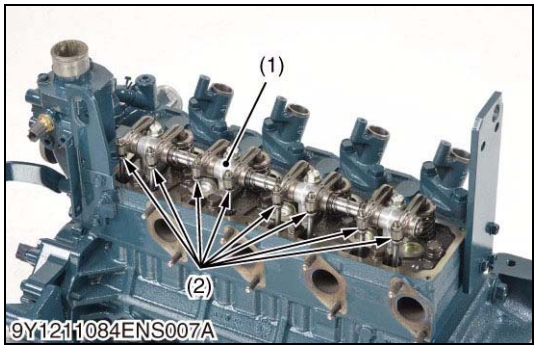

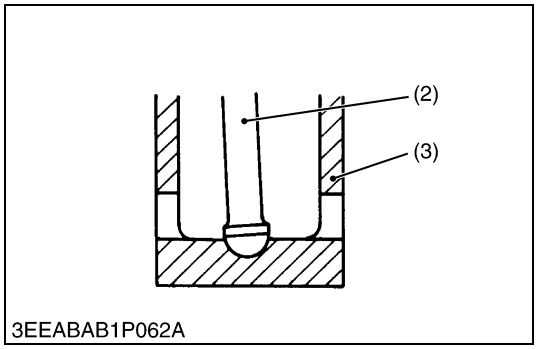

Rocker Arm and Push Rods

1. Remove the screws of the rocker arm bracket.
2. Remove the rocker arm assembly (1).
3. Remove the push rods (2).

(When reassembling)

- When you put the push rods (2) on the tappets (3), make sure that their ends are correctly engaged with the grooves.

■ **IMPORTANT**

- **After you install the rocker arm, adjust the valve clearance.**

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

(1) Rocker Arm Assembly
(2) Push Rod
(3) Tappet

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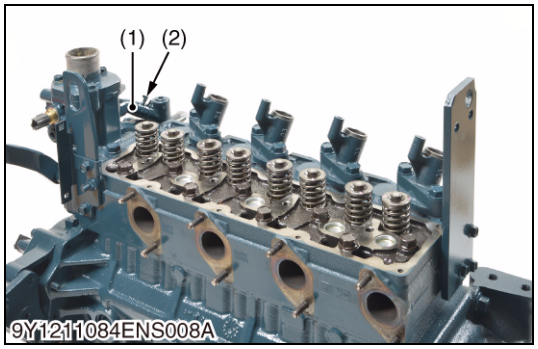
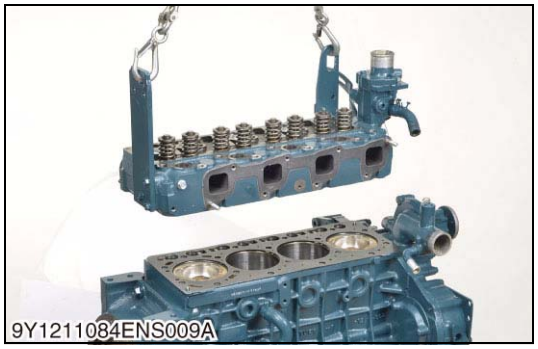




Cylinder Head

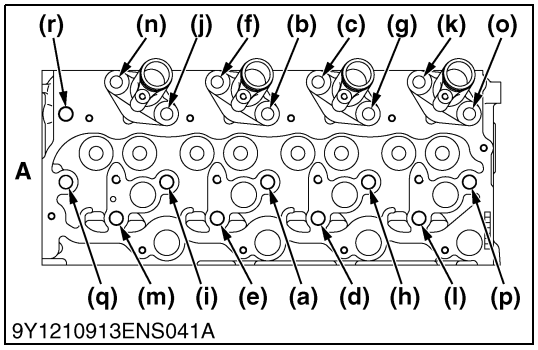
1. Loosen the pipe clamps (2), and remove the water return hose (1).
2. Remove the spark plug.
3. Remove the cylinder head screw in the sequence of **(r)** to **(a)**.
4. Remove the ignition coil flange and flange gasket.
5. Lift up the cylinder head to remove.
6. Remove the cylinder head gasket.

(When reassembling)

- Replace the cylinder head gasket with a new one.
- Tighten the cylinder head screws in a diagonal sequence. Start from the center in the sequence of **(a)** to **(r)**.
- Tighten them equally, or the shape of the head changes after some time.

■ **NOTE**

- **Ignition coil flange mounting screw: length = 115 mm (4.53 in.)**
- **others: 90.5 mm (3.56 in.)**



Tightening torque	Cylinder head screw	98.1 to 107 N·m 10.0 to 11.0 kgf·m 72.4 to 79.5 lbf·ft
	Spark plug	24.5 to 29.4 N·m 2.50 to 3.00 kgf·m 18.1 to 21.5 lbf·ft

(1) Water Return Hose
(2) Hose Clamp

A: Gear Case Side
(r) to (a): To Loosen
(a) to (r): To Tighten

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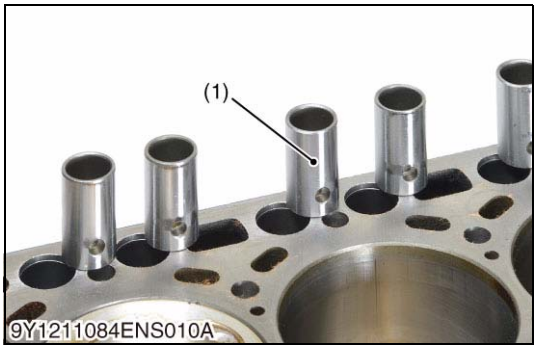

Tappets

1. Remove the tappets (1) from the crankcase.

(When reassembling)

- Before you install the tappets, apply a thin layer of engine oil around them.
- Examine the contact between tappets and cams that it turns correctly. If it is defective, replace the tappets.

■ IMPORTANT

- **Do not change the combination of tappet and tappet guide.**

(1) Tappet

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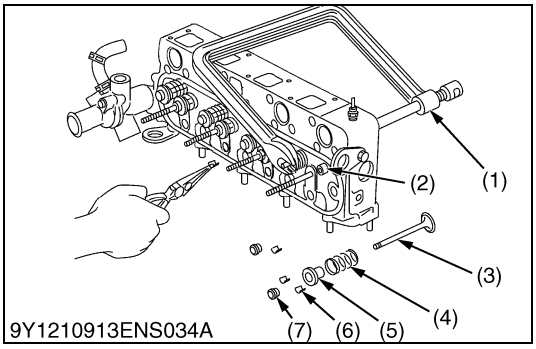

Valves

1. Remove the valve caps (7).
2. Push the valve spring retainer with the valve spring replacer (1) and remove the valve spring collets (6).
3. Remove the valve spring retainer (5), valve spring (4) and valve (3).
4. Remove the valve stem seal (2).

(When reassembling)

- Clean the valve stem and the valve guide hole, and apply engine oil sufficiently.
- After you install the valve spring collets (6), lightly tap the stem tip to attach it correctly with the plastic hammer.

■ IMPORTANT

- **Do not change the combination of valve and valve guide.**

(1) Valve Spring Replacer
(2) Valve Stem Seal
(3) Valve
(4) Valve Spring
(5) Valve Spring Retainer
(6) Valve Spring Collet
(7) Valve Cap

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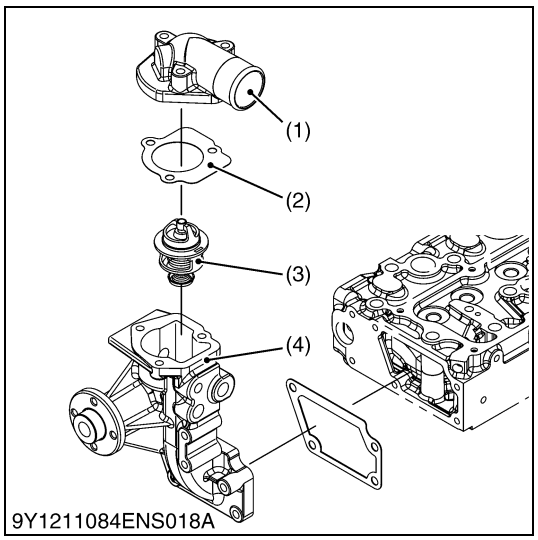
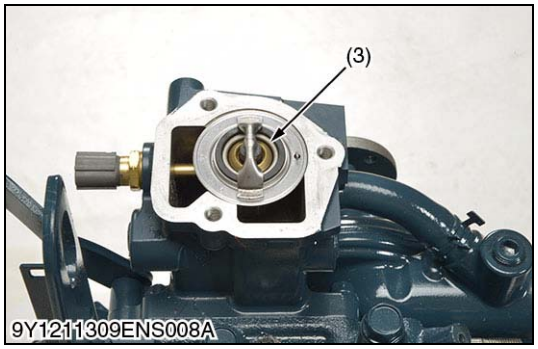
(4) Thermostat





Thermostat Assembly

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

(When reassembling)

- Replace the thermostat cover gasket (2) with a new one.
- Apply a liquid gasket (Three Bond 1215 or equivalent) to the water flange (4).

(1) Thermostat Cover
(2) Thermostat Cover Gasket
(3) Thermostat Assembly
(4) Water Flange 1

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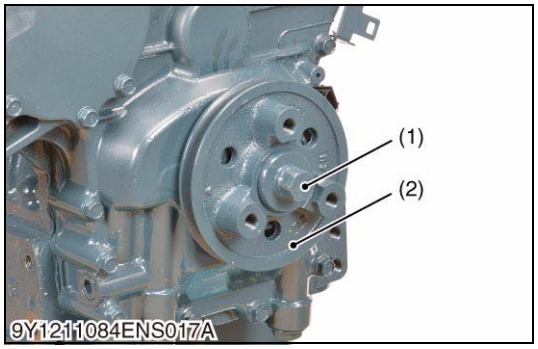
(5) Gear Case and Timing Gears



Fan Drive Pulley

1. Lock the flywheel with the flywheel stopper.
2. Remove the mounting screw (1) of the fan drive pulley.
3. Remove the fan drive pulley (2).

Tightening torque	Fan drive pulley mounting nut	255 to 274 N·m 26.0 to 28.0 kgf·m 188 to 202 lbf·ft

(1) Fan Drive Pulley Mounting Screw
(2) Fan Drive Pulley

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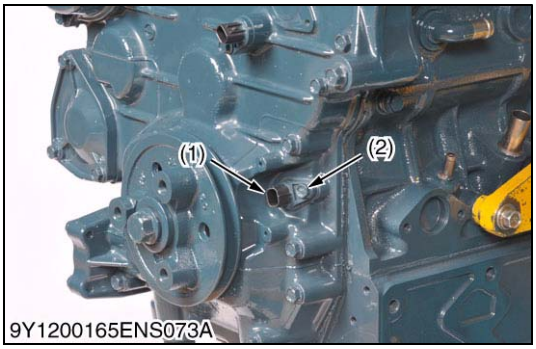

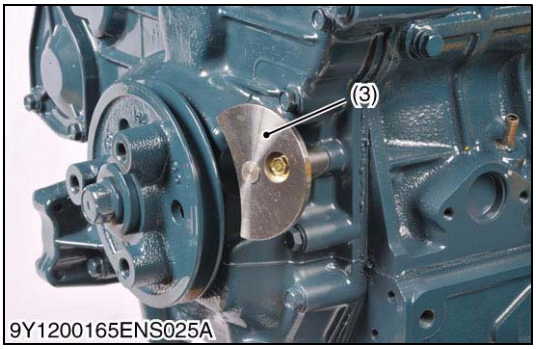

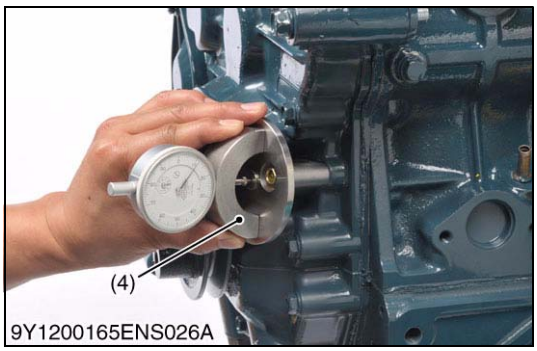

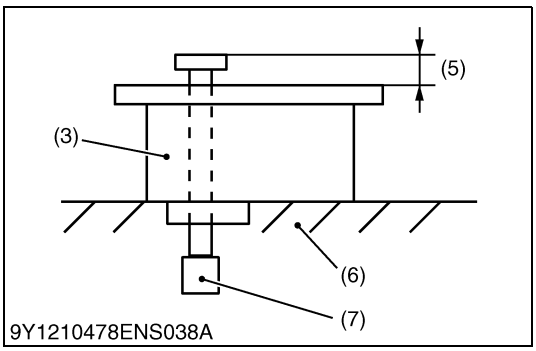

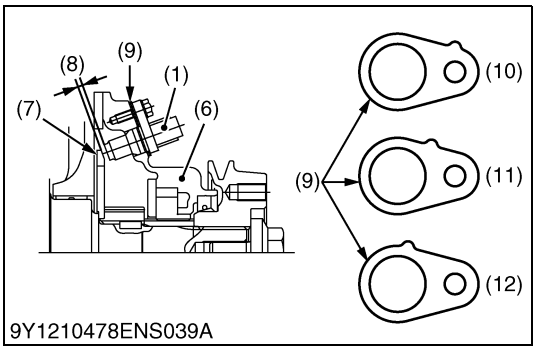

Crankshaft Position Sensor

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

(When reassembling)

- Replace the O-ring with a new one.

■ **IMPORTANT**

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

Selecting adjustment shims

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

Combination of Shims

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

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

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

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

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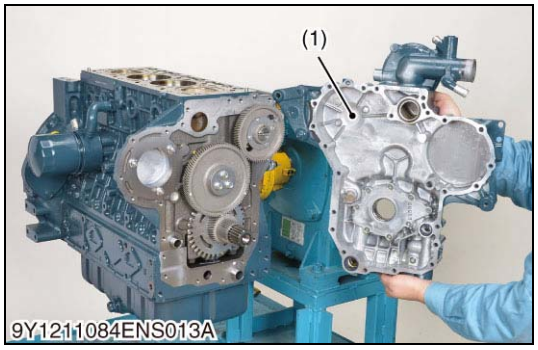

Gear Case

1. Remove the gear case (1).

(When reassembling)

- In order to maintain an airtight seal, check and make sure there is no water, debris, or oil on the surface where the liquid gasket will be applied.
- Be careful to apply the liquid gasket (2) evenly. (Refer to the photo.)

(1) Gear Case (2) Liquid Gasket

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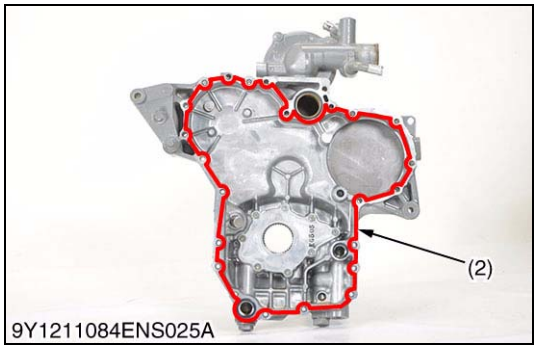

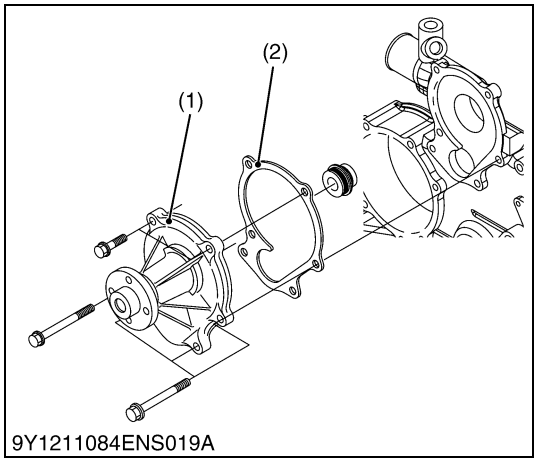

Water Pump Assembly

1. Remove the water pump assembly.

(When reassembling)

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

(1) Water Pump

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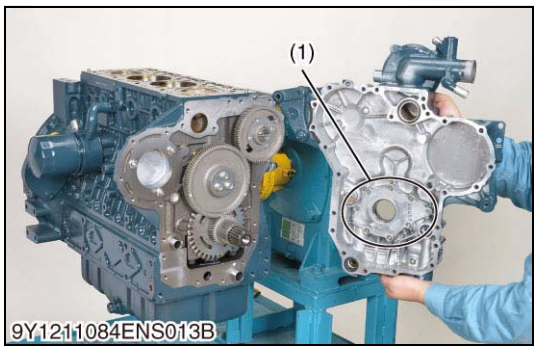

Oil Pump (If Necessary)

1. Remove the oil pump cover screw.

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

(1) Oil Pump Gear

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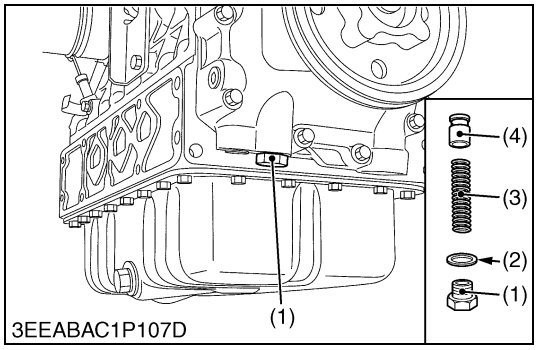

Relief Valve

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

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

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

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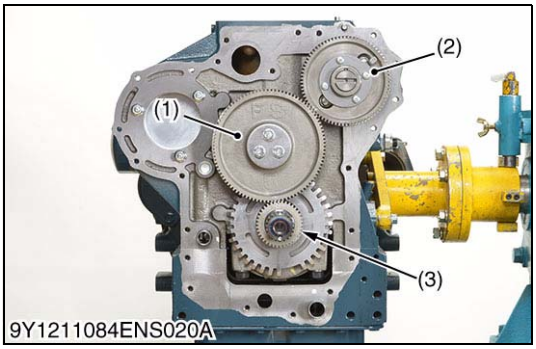

Idle Gear

1. Remove the idle gear mounting screw.
2. Remove the idle gear (1).

(When reassembling)

- Align each gear with its mark.
- Idle gear (1) and crank gear (3).
- Idle gear (1) and cam gear (2).

(1) Idle Gear
(2) Cam Gear
(3) Crank Gear

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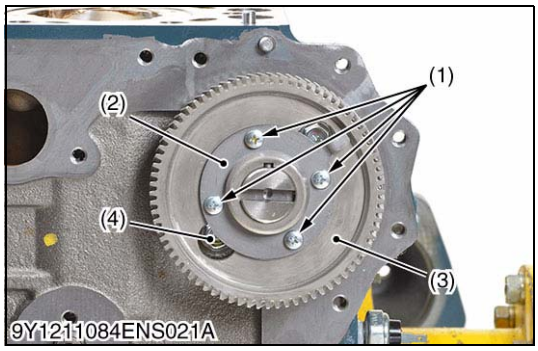

Camshaft

1. Remove the cam pulser gear mounting screws (1).
2. Remove the cam pulser gear (2).
3. Remove the camshaft set screws (4) and pull out the camshaft (3).

(When reassembling)

- When you install the idle gear, align the marks on the gears.

Tightening torque	Camshaft set screw	24 to 27 N·m 2.4 to 2.8 kgf·m 18 to 20 lbf·ft
	Cam pulser gear mounting screw	4.7 to 5.7 N·m 0.48 to 0.58 kgf·m 3.5 to 4.2 lbf·ft

(1) Cam Pulser Gear Mounting Screw
(2) Cam Pulser Gear
(3) Camshaft
(4) Camshaft Set Screw

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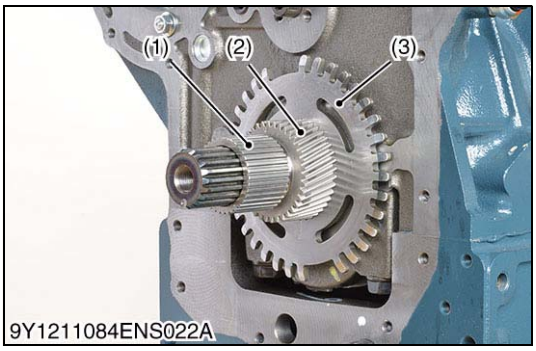

Crank Gear

1. Remove the oil pump drive gear (1).
2. Pull out the crank gear (2) with crank pulser gear (3).

(1) Oil Pump Drive Gear
(2) Crank Gear
(3) Crank Pulser Gear

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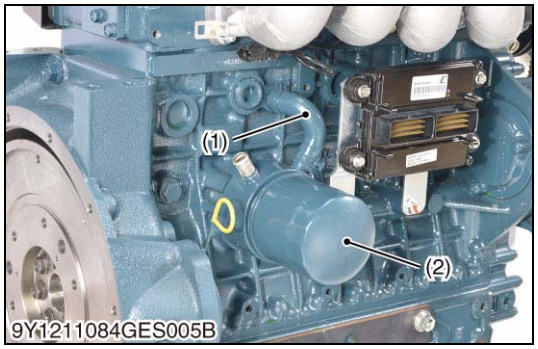
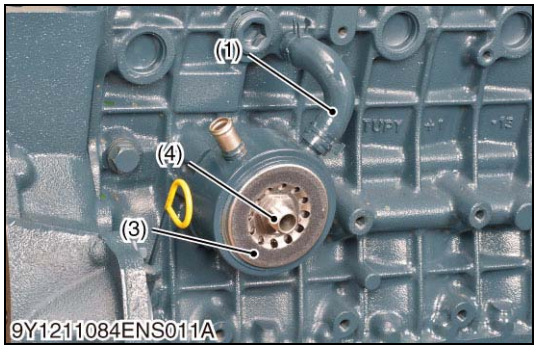
(6) Piston and Connecting Rod





Oil Cooler (If Necessary)

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

(When reassembling)

- When mounting the oil cooler (3), take care not to forget mounting the O-ring and not to let it out of position.

Tightening torque	Oil cooler joint screw	39.2 to 49.0 N·m 4.00 to 4.99 kgf·m 29.0 to 36.1 lbf·ft

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

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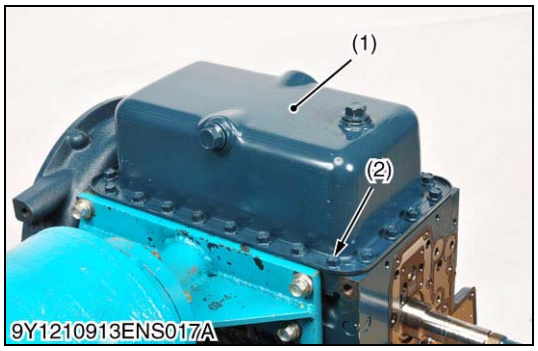

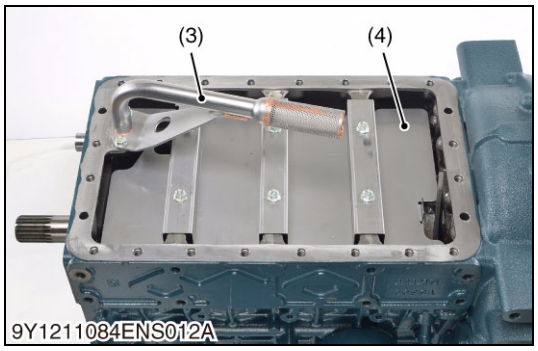

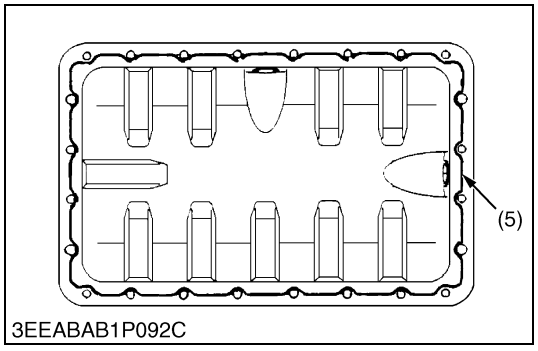

Oil Pan and Oil Strainer

1. Remove the oil pan mounting screws (2) and oil pan (1).
2. Remove the oil strainer (3) and baffle plate (4).

(When reassembling)

- After you clean the oil strainer (3), make sure that the filter mesh is clean and install it.
- Visually examine the O-ring, apply engine oil and install it.
- Install the O-ring to the oil strainer (3) certainly.
- Apply liquid gasket (5) (Three Bond 1217H) to the oil pan as shown in the figure.
- Confirm that the liquid gasket coating surface is free of water, dust and oil in order to maintain sealing effect.
- Carefully apply the adhesive evenly.
- Tighten the mounting screws of the oil pan in diagonal sequence from the center to tighten equally.

■ **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.**

(1) Oil Pan
(2) Oil Pan Mounting Screw
(3) Oil Strainer
(4) Baffle Plate
(5) Liquid Gasket

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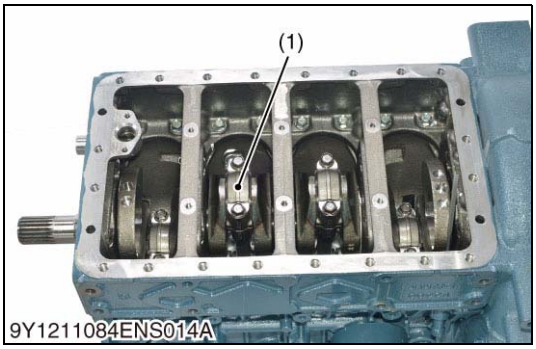

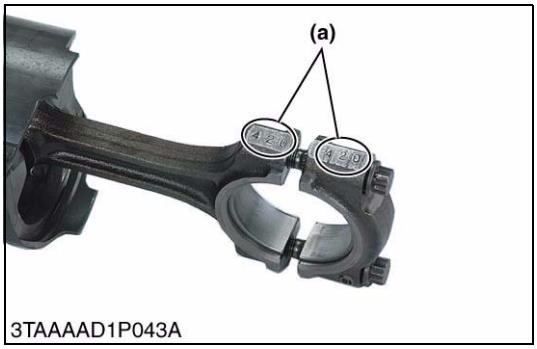

Connecting Rod Cap

1. Remove the connecting rod cap (1).

(When reassembling)

- Align the marks **(a)** with each other. (Face the marks toward the intake manifold.)
- Apply engine oil to the connecting rod screws and lightly screw it in by hand, then tighten it to the specified torque.
  If the connecting rod screw won't be screwed in smoothly, clean the threads.
  If the connecting rod screw is still hard to screw in, replace it.

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

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

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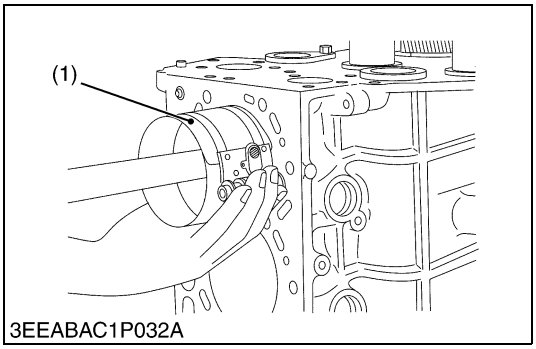
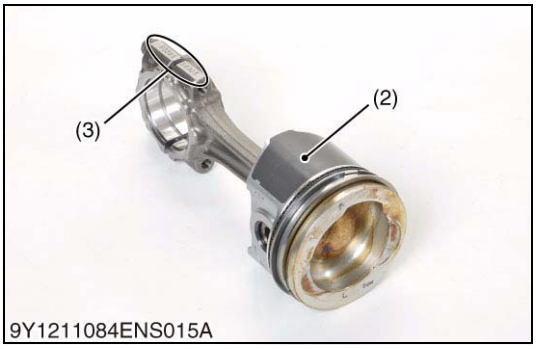


Piston

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

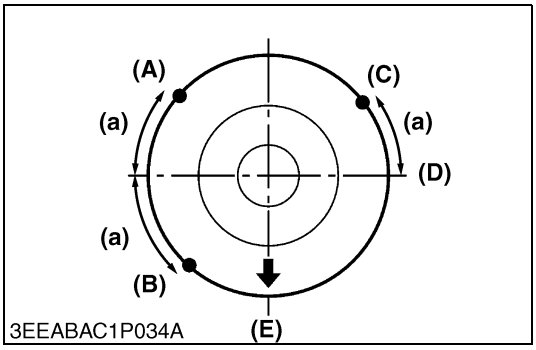
(When reassembling)

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



■ **IMPORTANT**

- **Do not change the combination of cylinder and piston. Align the position of each piston by the its mark. For example, mark "1" on the No. 1 piston.**
- **When inserting the piston into the cylinder, place the gap of each piston ring like the figure.**
- **Install the pistons with a piston ring compressor (1) carefully. Otherwise, their chrome-plated section of piston rings may be scratched, causing trouble inside the liner.**
- **When you install the piston in position, do not give a damage to the layer of molybdenum disulfide on the piston skirt. This layer can decrease the clearance with the cylinder liner. Immediately after you press-fit the piston pin, the piston is hot and the layer comes off easily. Only put in the piston after its temperature decreases.**



(1) Piston Ring Compressor
(2) Layer of Molybdenum Disulfide in Piston Skirt
(3) Mark

(A) Top Ring Gap
(B) Second Ring Gap
(C) Oil Ring Gap
(D) Piston Pin Hole
(E) Supply Pump Side

(a) 0.79 rad (45°)

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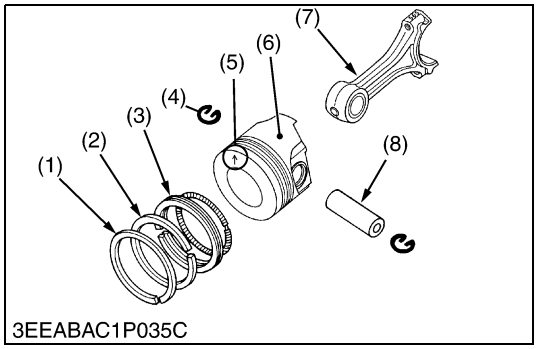

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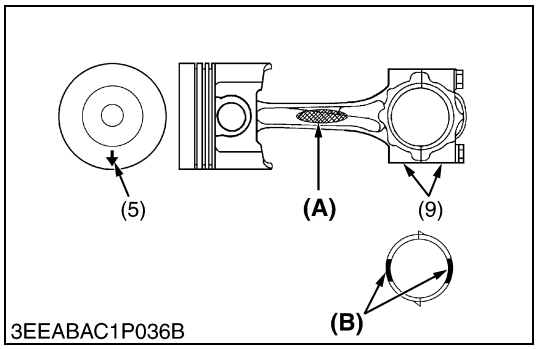

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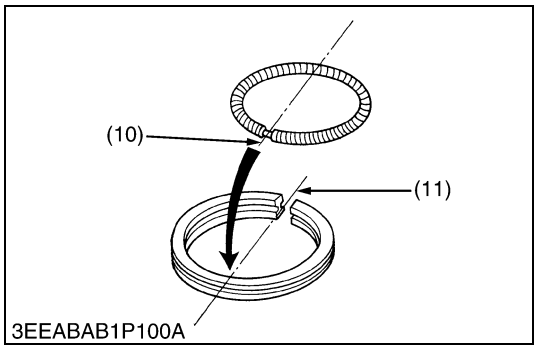

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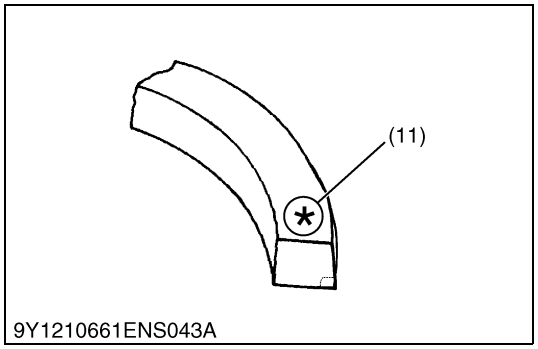

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Piston Ring and Connecting Rod

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

(When reassembling)

- Be sure the crank pin bearing and the connecting rod are same I.D. colors.
- When you install the rings to the piston, set the manufacturer mark (12) upward.
- When you install the oil ring on the piston, set the expander joint (10) on the opposite side of the oil ring gap (11).
- Apply engine oil to the piston pin.
- When you install the piston pin, put the piston fully in 80 °C (176 °F) oil for 10 to 15 minutes.
- When you install the piston to the connecting rod, align the mark (↑) (5) on the piston to the connecting rod numbering mark (9).
- The end faces of the oil ring are plated with hard chrome. When you install the piston into the cylinder, do not give a damage to the cylinder by the oil ring. If the ring's planting is scratched, it may get stuck on the cylinder wall, causing serious damage.

■ **IMPORTANT**

- **Put a mark on the connecting rod and the piston with the same number to keep the same combination.**

(1) Top Ring
(2) Second Ring
(3) Oil Ring
(4) Piston Pin Snap Ring
(5) Mark (↑)
(6) Piston
(7) Connecting Rod
(8) Piston Pin
(9) Numbering Mark
(10) Expander Joint
(11) Oil Ring Gap
(12) Manufacturer Mark

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

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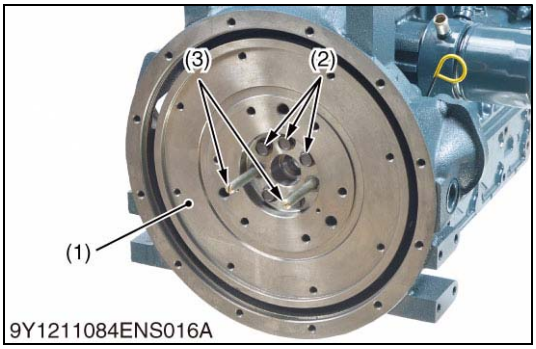
(7) Crankshaft



Flywheel

1. Attach the stopper to the flywheel (1).
2. Remove 2 flywheel screws (2).
3. Put the 2 flywheel guide screws (3) in the holes.
4. Remove all the flywheel screws (2).
5. Remove the flywheel (1) slowly along the flywheel guide screws (3).

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

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

(When reassembling)
- Put in 2 flywheel guide screws (3).
- Examine that there are no metal particles that remain on the flywheel mounting surfaces.
- Apply engine oil to the threads and the flange seat face of the flywheel screw. Then attach the screw.

Tightening torque	Flywheel screw	98.10 to 107.9 N·m 10.01 to 11.00 kgf·m 72.36 to 79.58 lbf·ft

(1) Flywheel
(2) Flywheel Screw
(3) Flywheel guide screw

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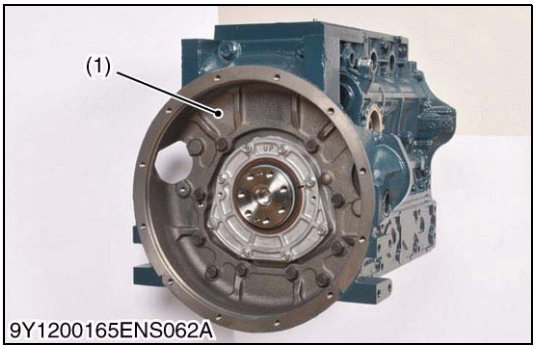

Flywheel Housing

1. Remove the flywheel housing (1).

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

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

Tightening torque	Flywheel housing mounting screw	103 to 117 N·m 10.5 to 12.0 kgf·m 76.0 to 86.7 lbf·ft

(1) Flywheel Housing

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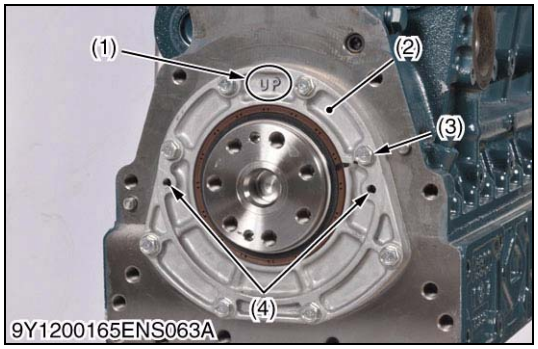

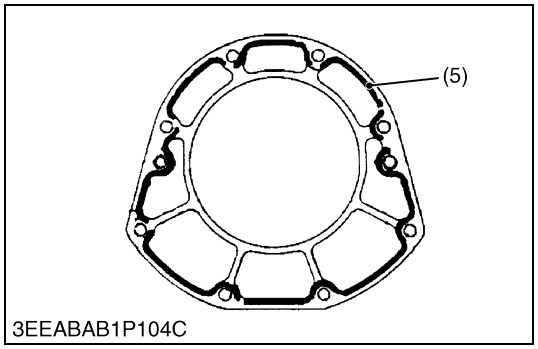

Bearing Case Cover

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

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

(When reassembling)

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

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

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

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

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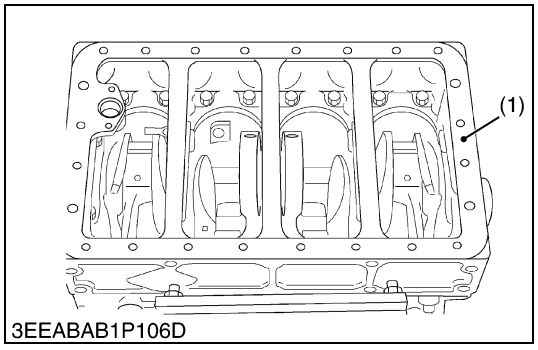

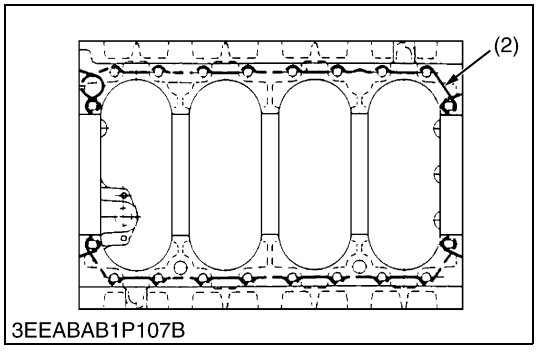

Crankcase 2

1. Remove the crankcase 2 (1).

(When reassembling)

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

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

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

(1) Crankcase 2
(2) Liquid Gasket

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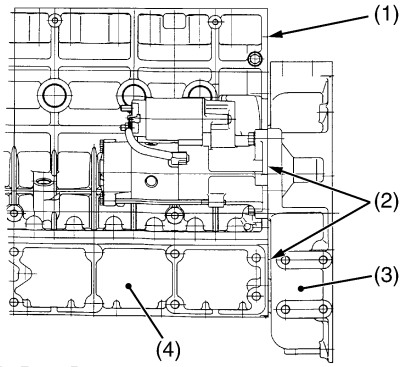

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Crankcase 1 and Crankcase 2

(When reassembling)

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

■ **NOTE**

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

Tightening torque	Crankcase 2 mounting screw	49 to 55 N·m 5.0 to 5.7 kgf·m 37 to 41 lbf·ft
	Flywheel housing mounting screw	103 to 117 N·m 10.5 to 12.0 kgf·m 76.0 to 86.7 lbf·ft

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

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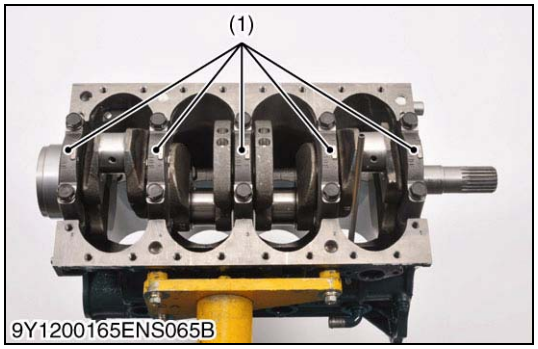

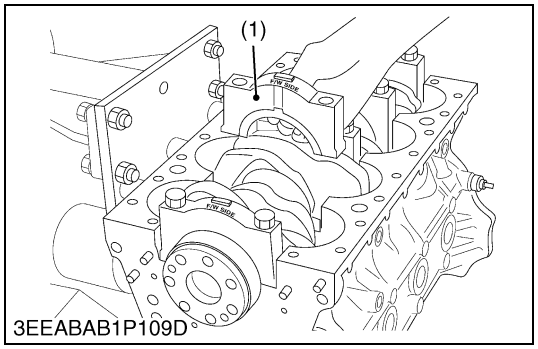

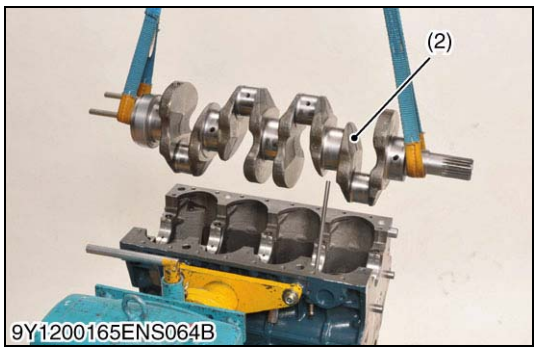

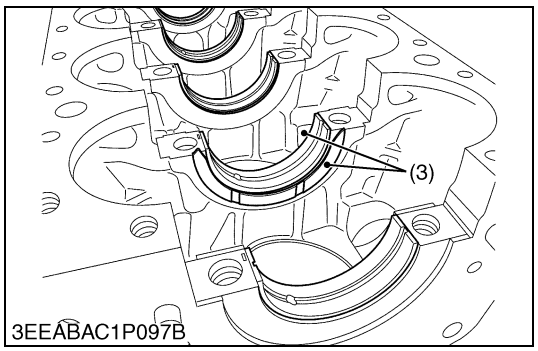

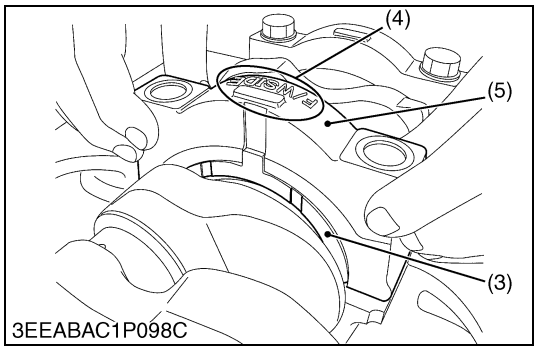

Crankshaft

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

(When reassembling)

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

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

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

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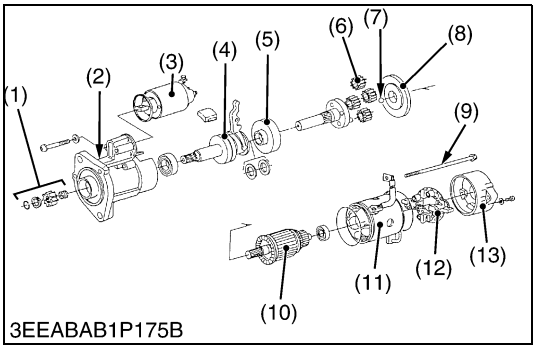
(8) Starter



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Disassembling Motor

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

■ **IMPORTANT**

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

■ **NOTE**

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

(When reassembling)

- Apply grease to the gears and overrunning clutch part.

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

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

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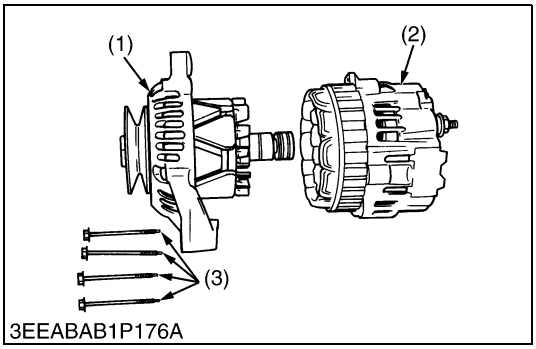
(9) Alternator



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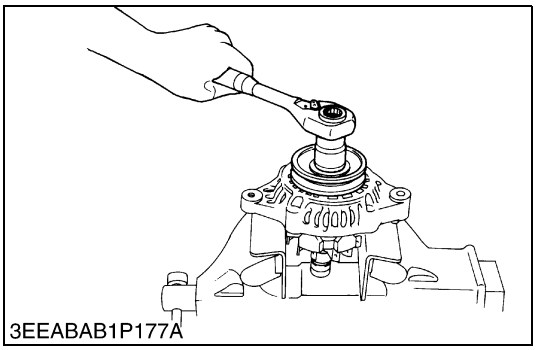
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Front Bracket

1. Remove the 4 screws (3).
2. Separate the front bracket (1) and the rear bracket (2) from each other.

■ **IMPORTANT**

- **Put a tally line on the front bracket and the rear bracket for reassembling them later.**

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

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Pulley

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

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

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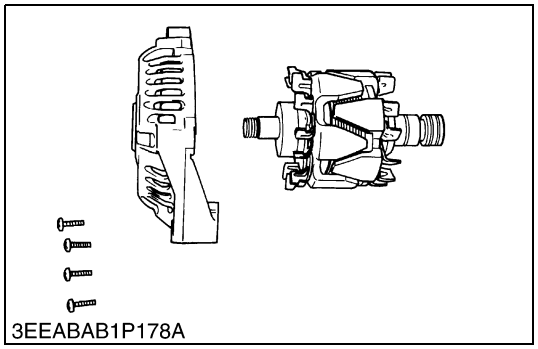
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Rotor

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

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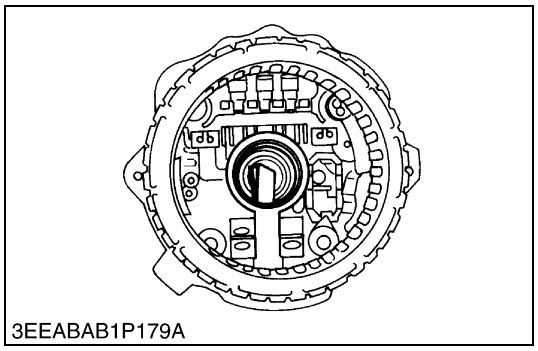
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Brush

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

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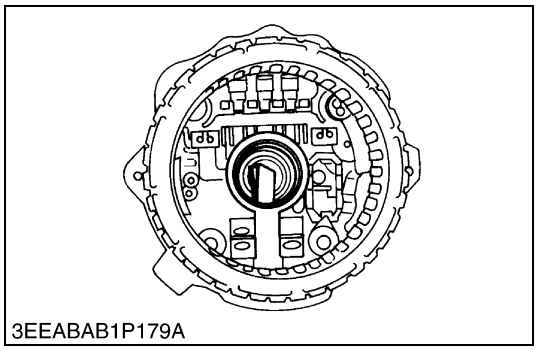
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Reassembling the Brush

1. Fit the brush with its sliding face in the clockwise direction when viewed from front.

■ **IMPORTANT**

- **Be sure to keep the 2 brushes deep in the brush holder. Otherwise the rotor and the rear section can not be fitted into the position.**
- **Use a 4 mm hex. wrench to push the brushes into place.**
- **Using a pin-pointed (2 mm (0.08 in.)) punch, keep the brushes from popping out.**

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

(1) Marking

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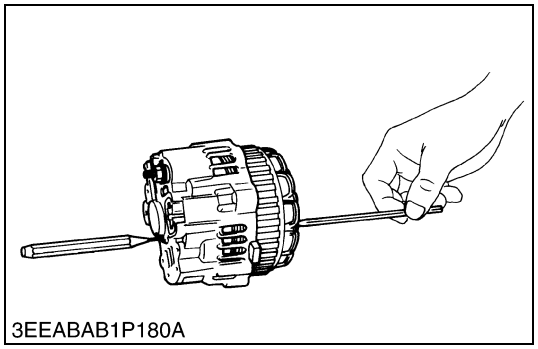
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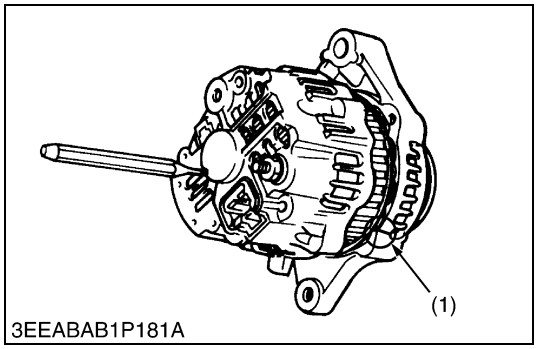

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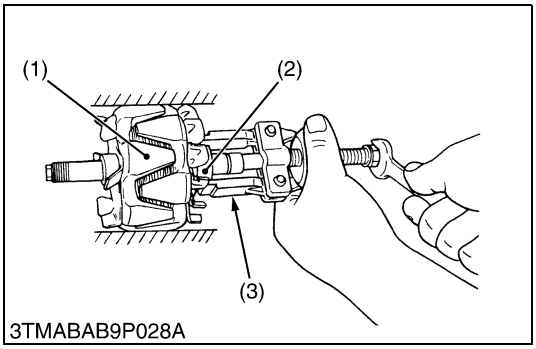

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Bearing at Slip Ring Side

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

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

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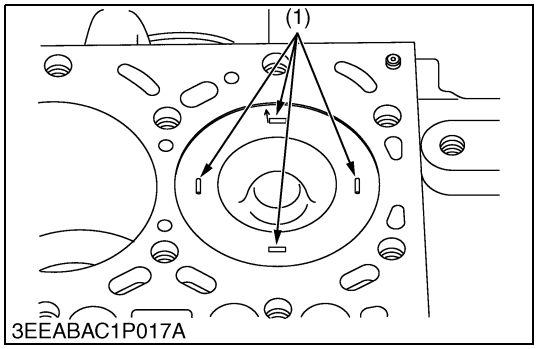
[3] SERVICING
(1) Cylinder Head and Valves



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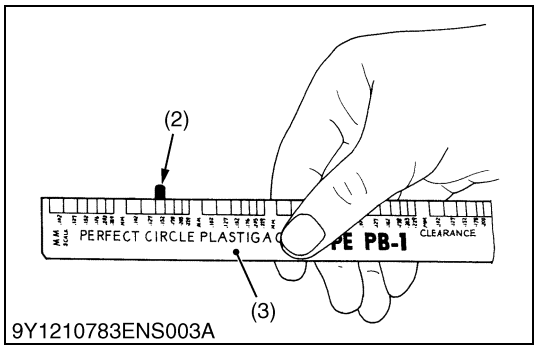

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Top Clearance

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

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

Top clearance	Service specification	1.43 to 1.65 mm 0.0563 to 0.0649 in

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

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

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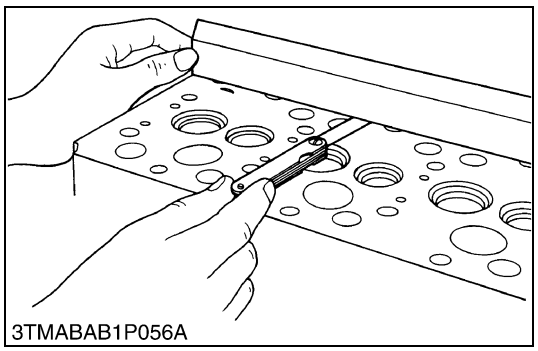
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Cylinder Head Surface Flatness

1. Clean the cylinder head surface.
2. Put a straightedge on the cylinder head.
3. Measure the clearance with a feeler gauge at the 6 places (see the figure).
4. If the measurement is more than the service limit, make it straight with a surface grinder.

■ **IMPORTANT**
- **Do not put a straightedge on the combustion chamber.**
- **Examine the valve recessing after you correct.**

Cylinder head surface flatness	Service limit	0.05 mm 0.002 in.

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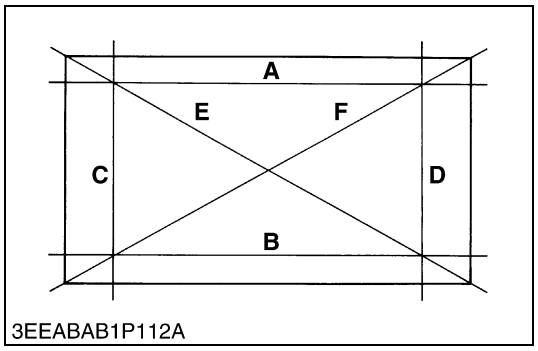

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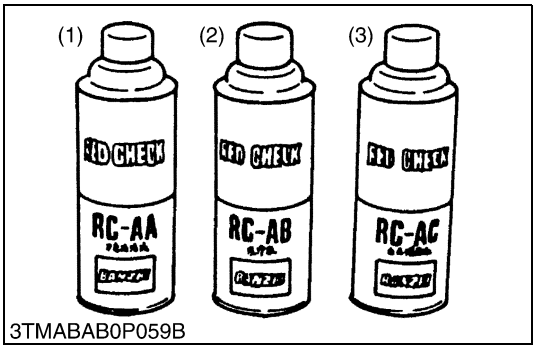

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Cylinder Head Flaw

1. Prepare an air spray red check.
2. Clean the surface of the cylinder head with detergent (2).
3. Apply some red permeative liquid (1) on the cylinder head surface. After you apply, do not touch it for 5 to 10 minutes.
4. Clean away the red permeative liquid on the cylinder head surface with detergent (2).
5. Apply the white developer (3) on the cylinder head surface.
6. If you found a red flaw, replace the cylinder head.

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

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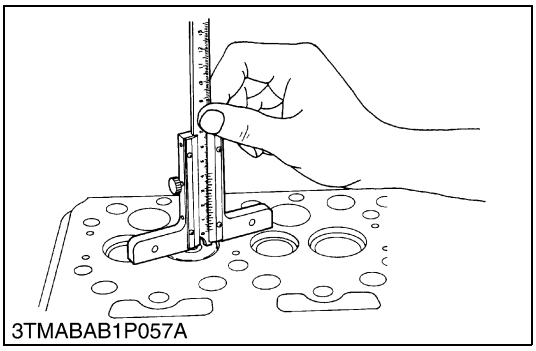
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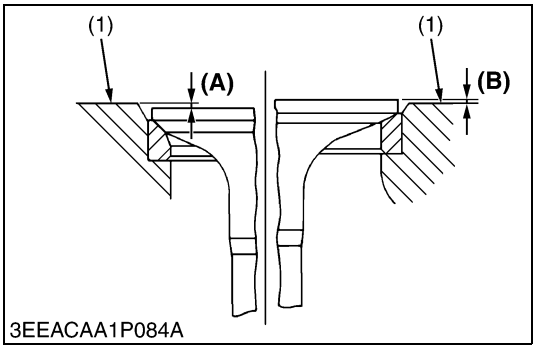
Valve Recessing

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

Valve recessing (Intake and Exhaust)	Service specification	0.050 (protrusion) to 0.25 (recessing) mm 0.0020 (protrusion) to 0.0098 (recessing) in.
	Service limit	0.40 (recessing) mm 0.016 (recessing) in.



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(1) Cylinder Head Surface
(A) Recessing
(B) Protrusion

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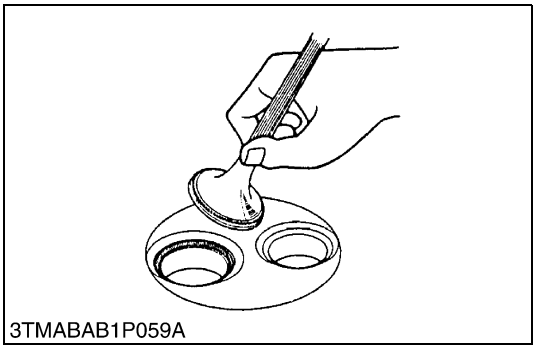
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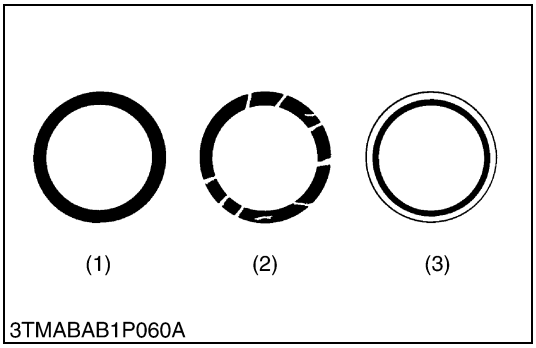
Valve Seating

1. Apply a thin layer of Prussian Blue on the valve face. Then put the valve on its seat to examine the contact.
2. If the valve is not fully around the seat or the contact is less than 70 % of the service specification, correct the valve seat. See the next section.
3. If the valve contact width cannot get the service specification, replace the valve or correct the contact of the valve seat.

Valve contact width (intake)	Service specification	2.15 mm 0.0846 in.
Valve contact width (exhaust)		2.50 mm 0.0984 in.



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(1) Correct
(2) Incorrect
(3) Incorrect

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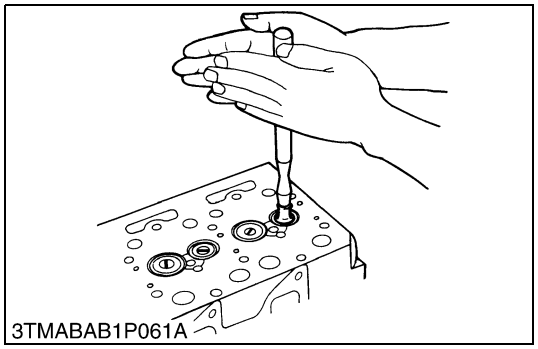
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Valve Lapping

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

■ **IMPORTANT**

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

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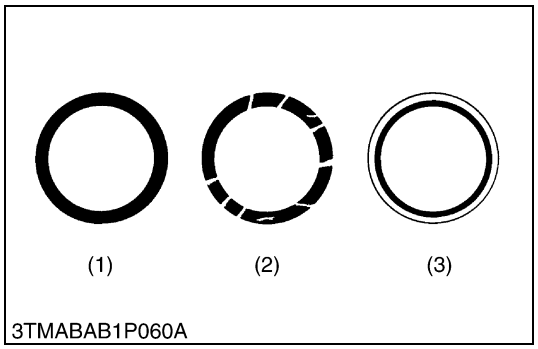

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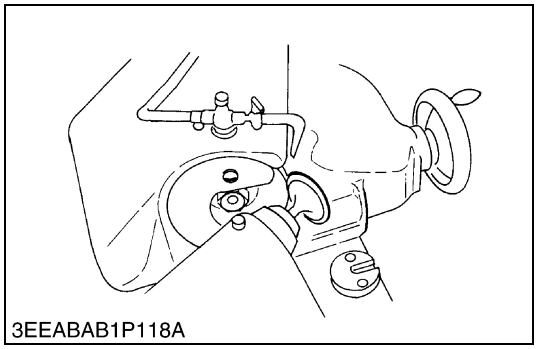
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Correction of Valve and Valve Seat

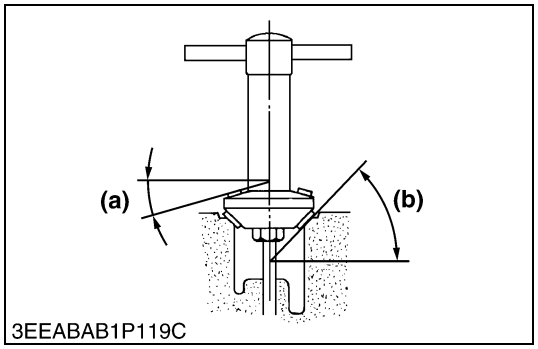
■ **NOTE**

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

1) Correction of valve

1. Correct the valve with a valve refacer.

Valve face angle	Service specification	Intake	1.0 rad 60°
		Exhaust	1.0 rad 60°



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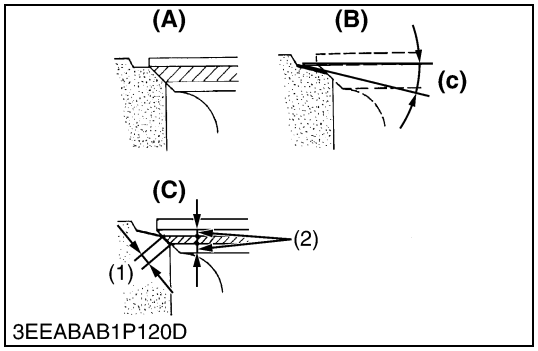
2) Correction of valve seat

1. Slightly correct the seat surface with a 1.0 rad (60°) or 0.79 rad (45°) valve seat cutter.
2. Correct the seat surface with a 0.52 rad (30°) or 0.26 rad (15°) valve seat cutter. The width must be near the specified valve seat width (2.12 mm, 0.0835 in.).
3. After you correct the seat, examine that the valve seating is flat. Apply a thin layer of compound between the valve face and valve seat, and lap them with a valve lapping tool.
4. Examine the valve seating with Prussian Blue. The valve seating surface must show good contact on all sides.

Valve seat angle	Service specification	Intake	1.0 rad 60°
		Exhaust	1.0 rad 60°



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(1) Valve Seat Width
(2) Identical Dimensions

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

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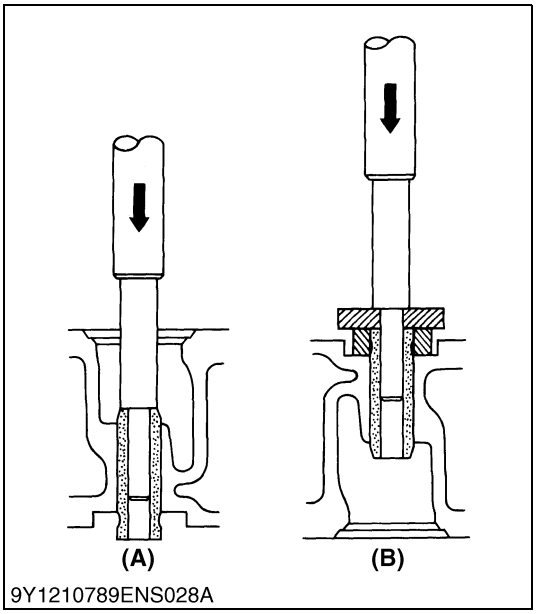

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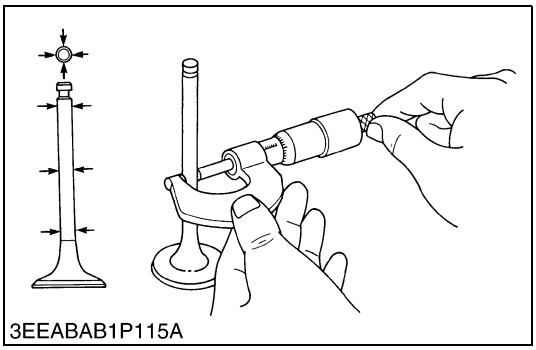
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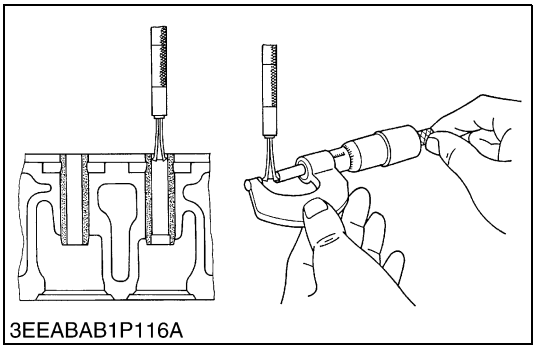
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Replacement of Valve Guide

(When removing)

1. Press out the used valve guide with the valve guide replacing tool. (See page **"SPECIAL TOOLS"**.)

(When installing)

1. Clean the new valve guide and valve guide bore, and apply engine oil to them.
2. Press fit the new valve guide with the valve guide replacing tool.
3. Ream accurately the I.D. of the valve guide to the specified dimension.

Valve guide I.D. (Intake and exhaust)	Service specification	8.015 to 8.030 mm 0.3156 to 0.3161 in.

■ **IMPORTANT**

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

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

9Y3210051ENS0077US0

Clearance between Valve Stem and Valve Guide

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

Clearance between valve stem and valve guide	Service specification	0.040 to 0.070 mm 0.0016 to 0.0027 in.
	Service limit	0.10 mm 0.0039 in.

Valve stem O.D.	Service specification	7.960 to 7.975 mm 0.3134 to 0.3139 in.
Valve guide I.D.	Service specification	8.015 to 8.030 mm 0.3156 to 0.3161 in.

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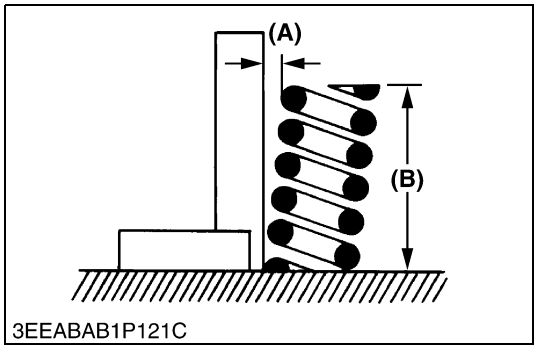

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Free Length and Tilt of Valve Spring

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

Tilt **(A)**	Service limit	1.0 mm 0.039 in.

Free length **(B)**	Service specification	50.7 to 51.2 mm 2.00 to 2.01 in.
	Service limit	50.2 mm 1.98 in.

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

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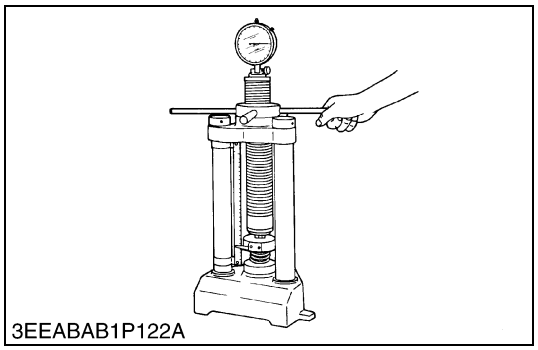
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Setting Load of Valve Spring

1. Put the valve spring on a tester.
2. Compress the valve spring to the specified setting length.
3. Read the compression load on the gauge.
4. If the measurement is less than the service limit, replace the valve spring.

Setting load / Setting length	Service specification	136 N / 41.05 mm 13.9 kgf / 41.05 mm 30.6 lbf / 1.616 in.
	Service limit	130 N / 41.05 mm 13.3 kgf / 41.05 mm 29.2 lbf / 1.616 in.

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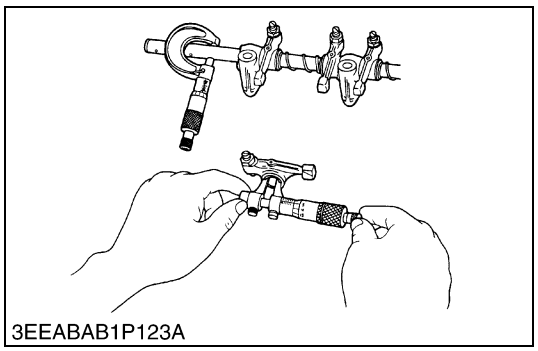
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Oil Clearance between Rocker Arm and Rocker Arm Shaft

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

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

Rocker arm shaft O.D.	Service specification	15.973 to 15.984 mm 0.62886 to 0.62929 in.
Rocker arm I.D.	Service specification	16.000 to 16.018 mm 0.62993 to 0.63062 in.

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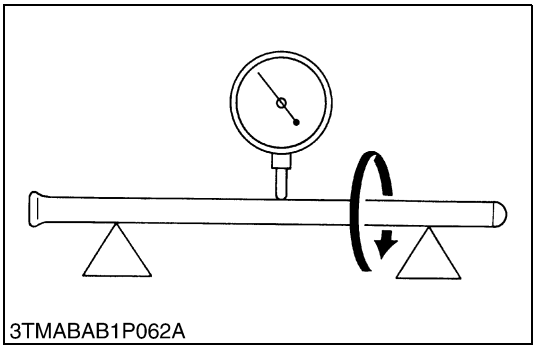
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Push Rod Alignment

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

Push rod alignment	Service limit	0.25 mm 0.0098 in.

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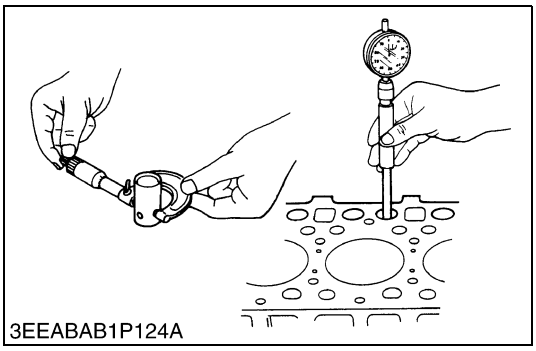
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Oil Clearance between Tappet and Tappet Guide Bore

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

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

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

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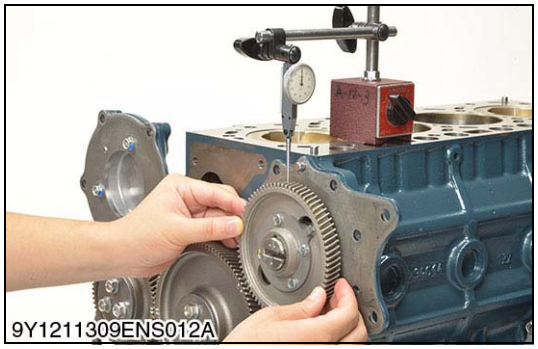
(2) Timing Gear and Camshaft



Timing Gear Backlash

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

Backlash between idle gear and crank gear	Service specification	0.049 to 0.193 mm 0.00193 to 0.00759 in.
	Service limit	0.23 mm 0.0091 in.

Backlash between idle gear and cam gear	Service specification	0.049 to 0.189 mm 0.00193 to 0.00744 in.
	Service limit	0.23 mm 0.0091 in.

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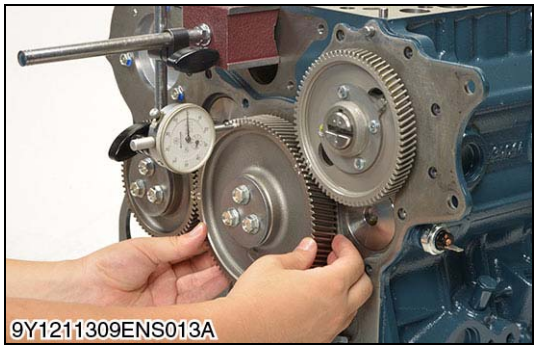

Side Clearance of Idle Gear

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

Side clearance of idle gear	Service specification	0.15 to 0.30 mm 0.0059 to 0.012 in.
	Service limit	0.9 mm 0.04 in.

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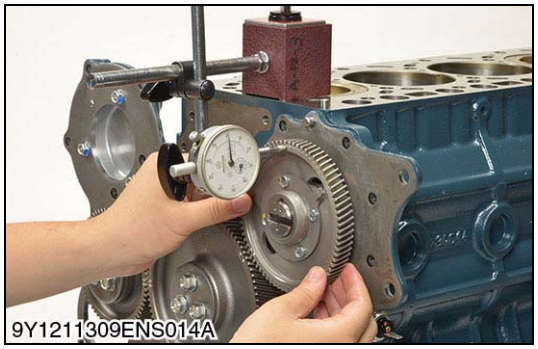

Side Clearance of Camshaft

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

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

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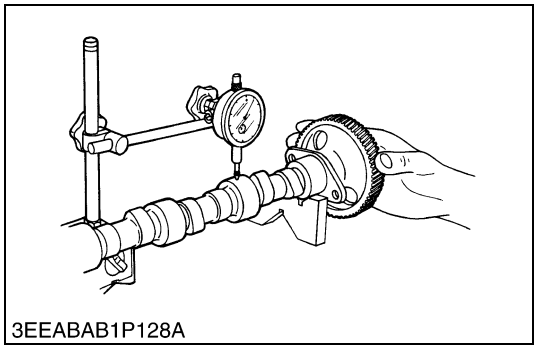

Camshaft Alignment

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

Camshaft bend	Service limit	0.01 mm 0.0004 in.

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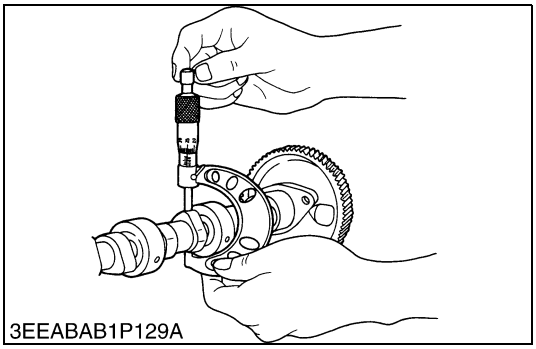
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Cam Height

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

Cam height	Service specification	Intake valve	38.86 mm 1.530 in.
		Exhaust Valve	38.56 mm 1.518 in.
	Service limit	Intake valve	38.36 mm 1.510 in.
		Exhaust valve	38.06 mm 1.498 in.

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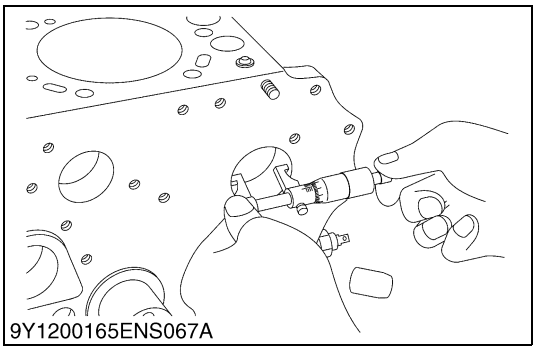
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Oil Clearance between Camshaft Journal and Cylinder Block Bore

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

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

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

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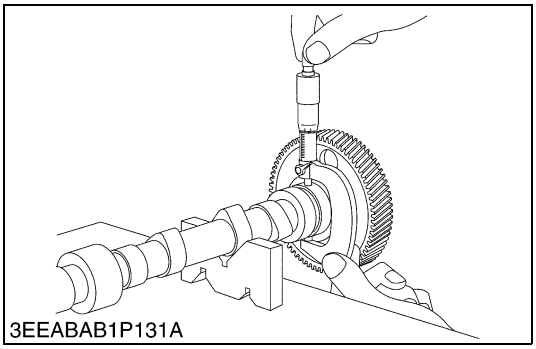
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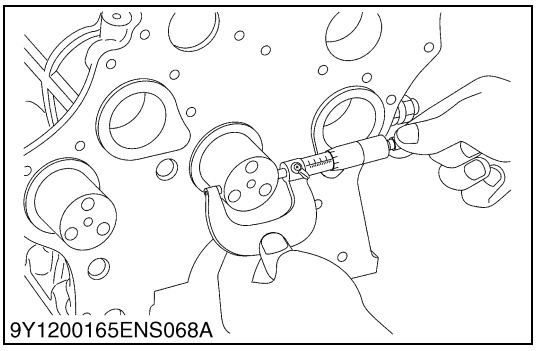
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Oil Clearance between Idle Gear Shaft and Idle Gear Bushing

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

Oil clearance between idle gear shaft and idle gear bushing	Service specification	0.050 to 0.091 mm 0.0020 to 0.0035 in.
	Service limit	0.10 mm 0.0039 in.

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

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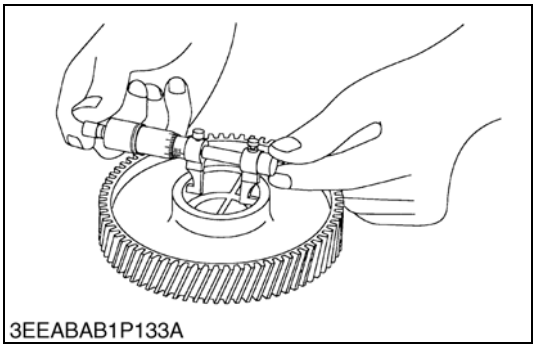
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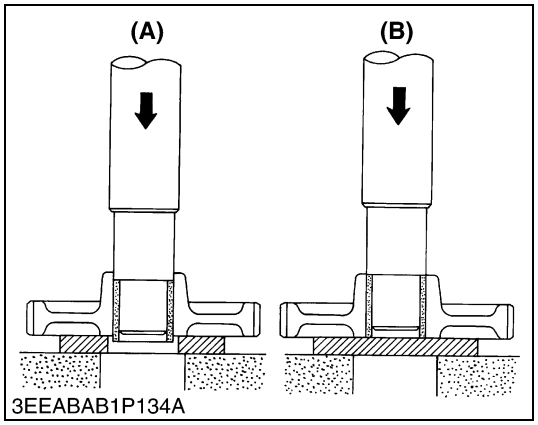

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Replacement of Idle Gear Bushing

(When removing)

1. Press out the used idle gear bushing with the replacing tool. (See page **"SPECIAL TOOLS"**.)

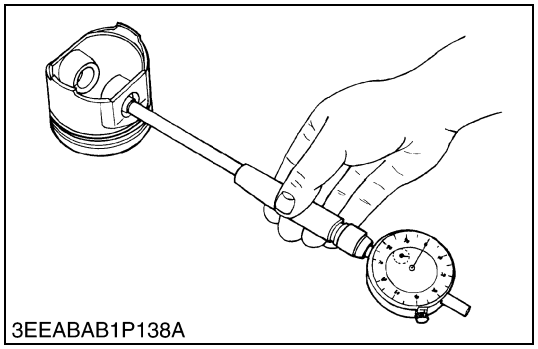
(When installing)

1. Clean a new idle gear bushing and idle gear bore, and apply engine oil to them.
2. Press fit the new bushing with the replacing tool.
   Make sure that the bushing end aligns the end of the idle gear.

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

9Y3210051ENS0091US0

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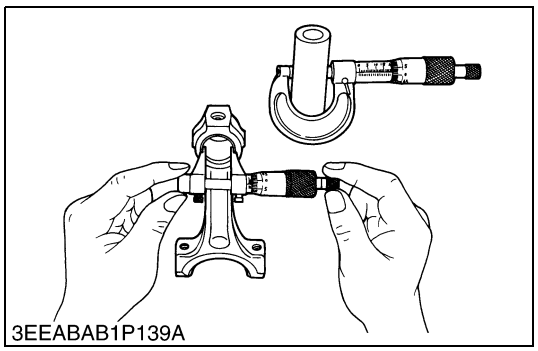
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Piston Pin Bore I.D.

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

Piston pin bore I.D.	Service specification	26.006 to 26.013 mm 1.0239 to 1.0241 in.
	Service limit	26.05 mm 1.026 in.

9Y3210051ENS0092US0

Oil Clearance between Piston Pin and Small End Bushing

1. Measure the piston pin O.D. where it touches the bushing with an external micrometer.
2. Measure the small end bushing I.D. with an internal micrometer.
3. Calculate the oil clearance.
4. If the oil clearance is more than the service limit, replace the bushing.
5. If the oil clearance stays more than the service limit, replace the piston pin also.

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

Piston pin O.D.	Service specification	26.006 to 26.011 mm 1.0239 to 1.0240 in.
Small end bushing I.D.	Service specification	26.031 to 26.046 mm 1.0249 to 1.0254 in.

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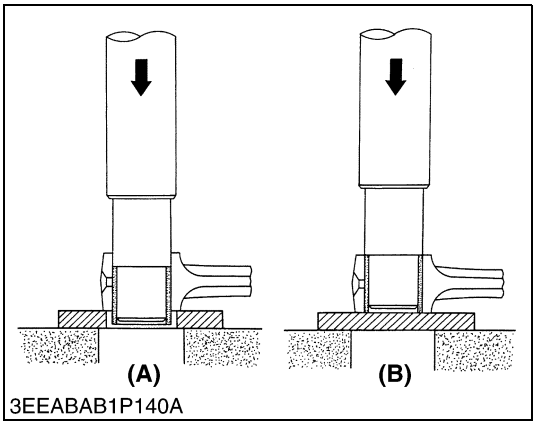

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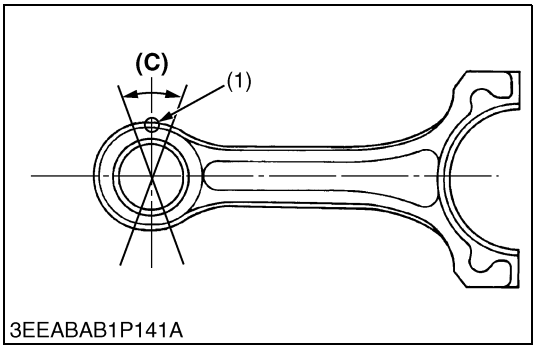

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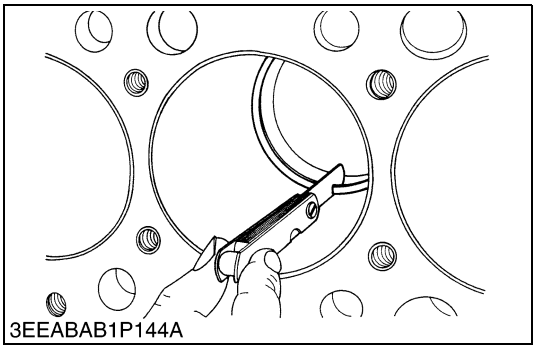
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Replacement of Small End Bushing

(When removing)

1. Press out the used small end bushing with the replacing tool. (See page **"SPECIAL TOOLS"**.)

(When installing)

1. Clean a new small end bushing and bore, and apply engine oil to them.
2. Make sure that the oil hole of the connecting rod aligns the bushing hole. Then press fit the new bushing with the replacing tool.

(1) Seam

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

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Piston Ring Gap

1. Put the piston ring into the lower part of the liner (the least worn out part) with the piston.
2. Measure the ring gap with a feeler gauge.
3. If the ring gap is more than the service limit, replace the ring.

Piston ring gap	Top ring	Service specification	0.30 to 0.45 mm 0.012 to 0.017 in
		Service limit	1.25 mm 0.0492 in.
	Second ring	Service specification	0.30 to 0.45 mm 0.012 to 0.017 in.
		Service limit	1.25 mm 0.0492 in.
	Oil ring	Service specification	0.25 to 0.75 mm 0.0099 to 0.029 in.
		Service limit	1.25 mm 0.0492 in.

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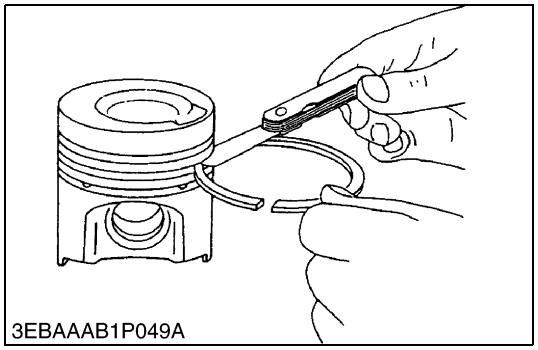
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Clearance between Piston Ring and Piston Ring Groove

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

Clearance between piston ring and piston ring groove	Top ring	Service specification	0.05 to 0.09 mm 0.002 to 0.003 in
		Service limit	0.15 mm 0.0059 in.
	Second ring	Service specification	0.093 to 0.120 mm 0.00367 to 0.00472 in
		Service limit	0.20 mm 0.0079 in.
	Oil ring	Service specification	0.060 to 0.15 mm 0.0024 to 0.0059 in.
		Service limit	0.2 mm 0.008 in.

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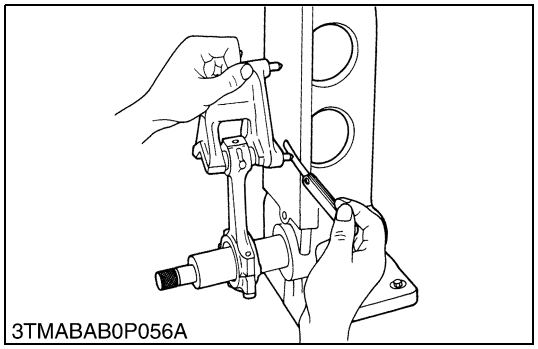
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Connecting Rod Alignment

■ **NOTE**

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

1. Install the piston pin into the connecting rod.
2. Install the connecting rod on the alignment tool of the connecting rod.
3. Put a gauge on the piston pin, and move it against the face plate.
4. If the gauge does not touch fully against the face plate, measure the space between the gauge pin and face plate.
5. If the measurement is more than the service limit, replace the connecting rod.

Connecting rod alignment	Service limit	0.05 mm 0.002 in.

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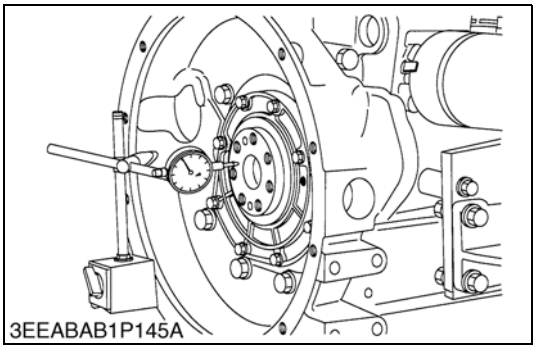
(4) Crankshaft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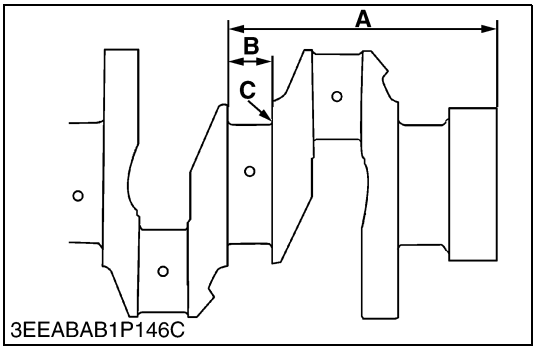

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Side Clearance of Crankshaft

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

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

(Reference)

- Oversize dimensions of crankshaft journal

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

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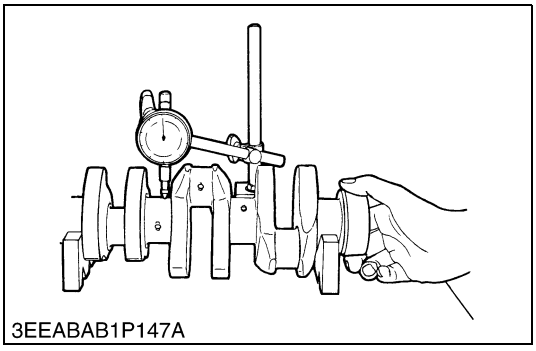
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Crankshaft Alignment

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

Crankshaft alignment	Service limit	0.02 mm 0.0008 in.

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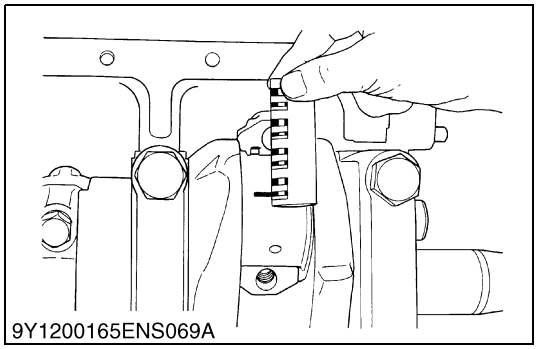
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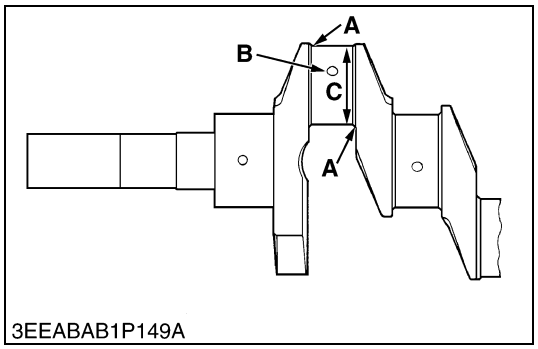

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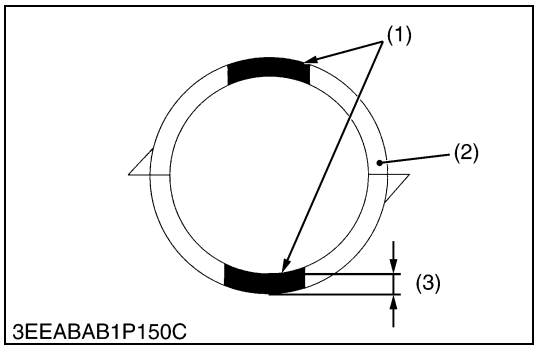

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Oil Clearance between Crank Pin and Crank Pin Bearing

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

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

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

Oil clearance between crank pin and crank pin bearing	Service specification	0.010 to 0.043 mm 0.00040 to 0.0016 in.
	Service limit	0.20 mm 0.0079 in.

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

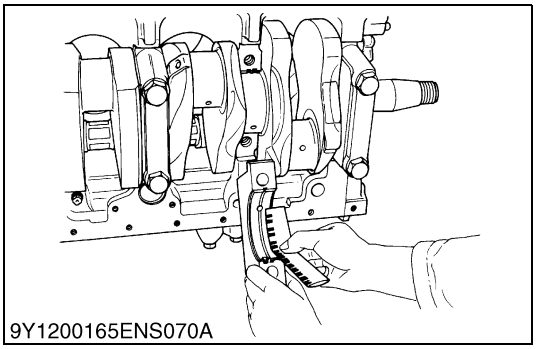
ID Color	Connecting rod	Crank pin bearing		
	Large-end in. dia.	Class	Part code	Center wall thick
Blue	56.010 to 56.020 mm 2.2052 to 2.2055 in.	L	1C020-22313	1.496 to 1.501 mm 0.05890 to 0.05909 in.
Without color	56.00 to 56.01 mm 2.2048 to 2.2051 in.	S	1C020-22334	1.491 to 1.496 mm 0.05870 to 0.05889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

(Reference)
- Undersize dimensions of crank pin

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

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

9Y3210051ENS0100US0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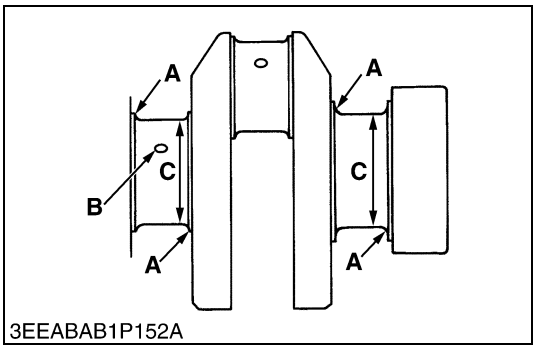

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Oil Clearance between Crankshaft Journal and Crankshaft Bearing

1. Clean the crankshaft journal and crankshaft bearing.
2. Put a strip of plastigauge on the center of the journal.

■ **IMPORTANT**

- **Do not put the Plastigauge into the oil hole of the journal.**

3. Install the main bearing case.
4. Tighten the screws to the specified torque.
5. Remove the main bearing case again.
6. Measure the width that it becomes flat with the scale to get the oil clearance.
7. If the clearance more than the service limit, replace the crankshaft bearing.
8. If the same dimension bearing is not applicable because of the crankshaft journal wear, replace it with an undersize one. Refer to the table and figure.

Crankshaft journal O.D.	Service specification	74.977 to 74.990 mm 2.9519 to 2.9523 in.

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

(Reference)

- Undersize dimensions of crankshaft journal

Undersize	0.2 mm 0.008 in.	0.4 mm 0.02 in.
Dimension **A**	2.8 to 3.2 mm radius 0.11 to 0.12 in. radius	2.8 to 3.2 mm radius 0.11 to 0.12 in. radius
*Dimension **B**	1.0 to 1.5 mm relief 0.040 to 0.059 in. relief	1.0 to 1.5 mm relief 0.040 to 0.059 in. relief
Dimension **C**	74.777 to 74.790 mm dia. 2.9440 to 2.9444 in. dia.	74.577 to 74.590 mm dia. 2.9361 to 2.9366 in. dia.
The crankshaft journal must be fine-finished to higher than Rmax = 0.8S *Holes to be de-burred and edges rounded with 1.0 to 1.5 mm (0.040 to 0.059 in.) relief.		

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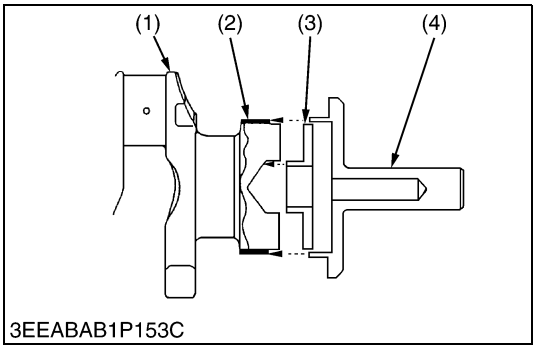

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Replacement of Crankshaft Sleeve

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

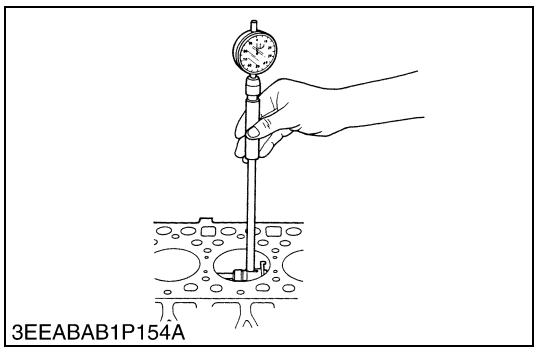
■ **NOTE**

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

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

9Y3210051ENS0102US0

(5) Cylinder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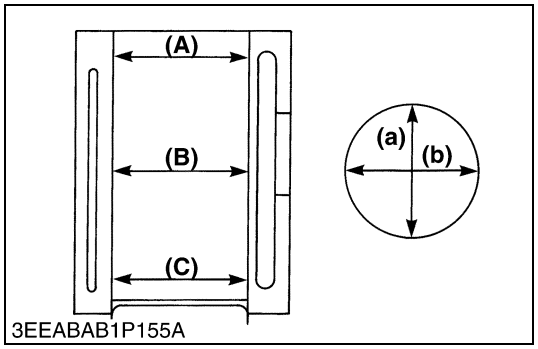

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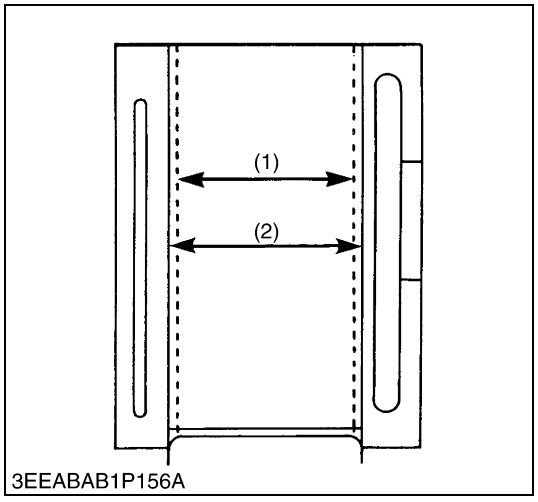

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Cylinder Wear

1. Measure the I.D. of the cylinder at the 6 positions (see figure) with a cylinder gauge and find the maximum and minimum inner diameters.
2. Find the difference between the maximum and the minimum inner diameters.
3. If the maximum I.D. or the difference is more than the service limit, bore and hone it to the oversize dimension. (Refer to "Cylinder Correction (Oversize)".)
4. Check the cylinder wall for scratches. If you find deep scratches, bore the cylinder. (Refer to "Cylinder Correction (Oversize)".)

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

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

9Y3210051ENS0103US0

Cylinder Correction (Oversize)

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

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

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

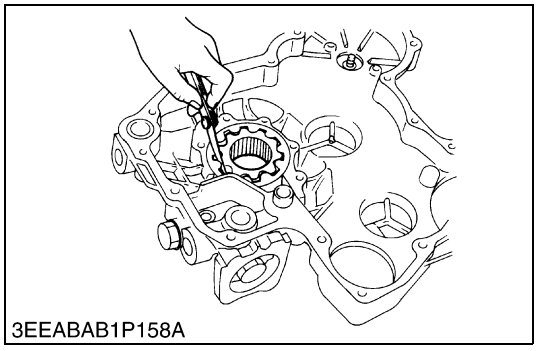
■ **NOTE**

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

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

9Y3210051ENS0104US0

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

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

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

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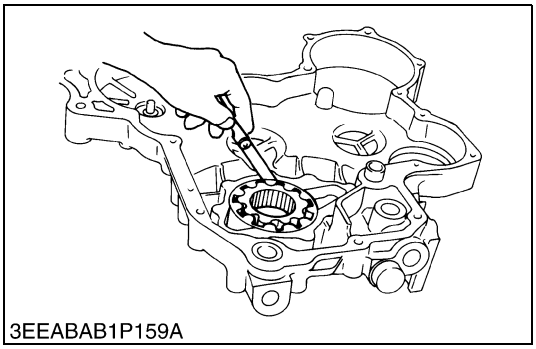
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Clearance between Outer Rotor and Pump Body

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

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

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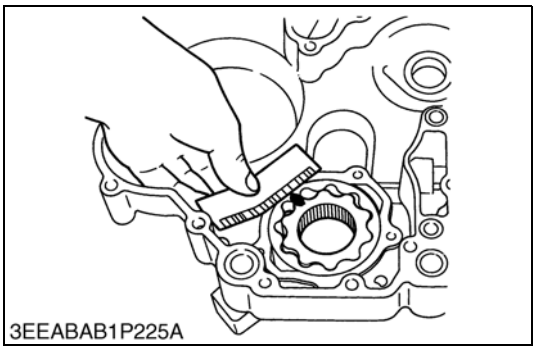
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Clearance between Rotor and Cover

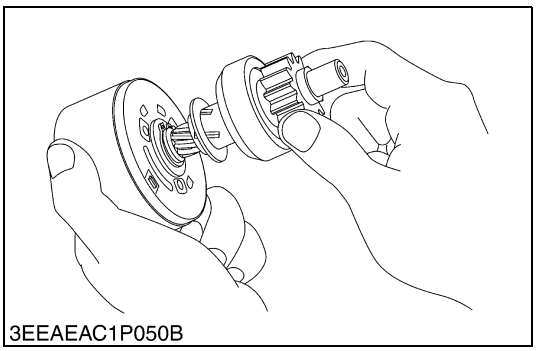
1. Put a strip of Plastigauge on the rotor face with grease.
2. Install the cover and tighten the screws with the specified torque.
3. Remove the cover carefully.
4. Measure the width that Plastigauge becomes flat with the scale to get the oil clearance.
5. If the clearance is more than the service limit,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

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

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

9Y3210051ENS0107US0

(7) Starter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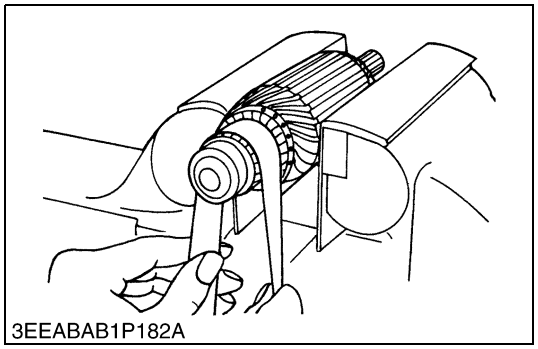
Overrunning Clutch

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

9Y3210051ENS0108US0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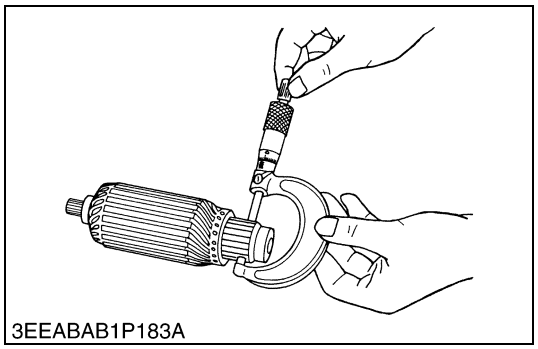
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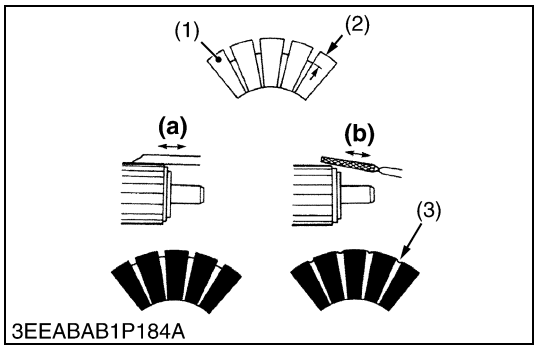

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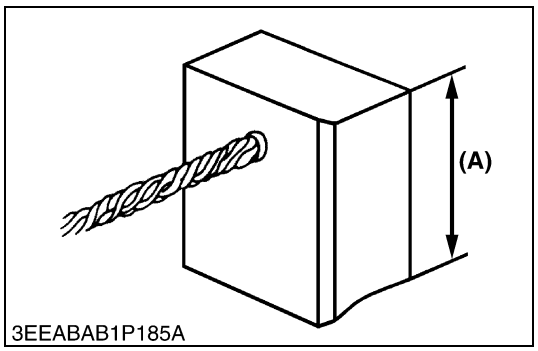

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Commutator and Mica

1. Check the contact of the commutator for wear.
2. Grind the commutator with emery paper (#300) if it is lightly worn.
3. Measure the commutator O.D. with an outside micrometer at several points.
4. If the minimum O.D. is less than the service limit, replace the armature assembly.
5. If the difference of the O.D.'s more than the service limit, correct the commutator on a lathe to the service specification.
6. Measure the mica undercut.
7. If the undercut is less than the service limit, correct it with a saw blade. Chamfer the segment edges.

Commutator O.D.	Service specification	32.0 mm 1.26 in.
	Service limit	31.4 mm 1.24 in.
Mica under cut	Service specification	0.50 mm 0.020 in.
	Service limit	0.20 mm 0.0079 in.

(1) Segment
(2) Depth of Mica
(3) Mica
(a) Good
(b) Bad

9Y3210051ENS0109US0

Brush Wear

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

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

(A) Brush Length

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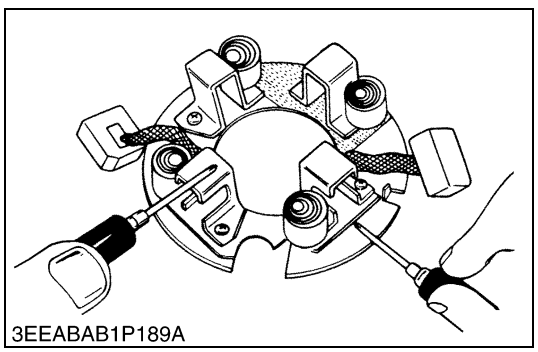
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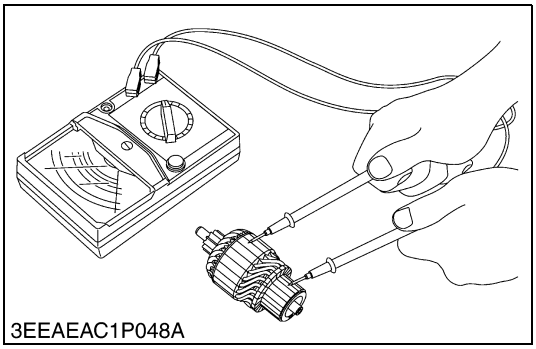
Brush Holder

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

Resistance between brush holder and holder support	Service specification	Infinity

9Y3210051ENS0111US0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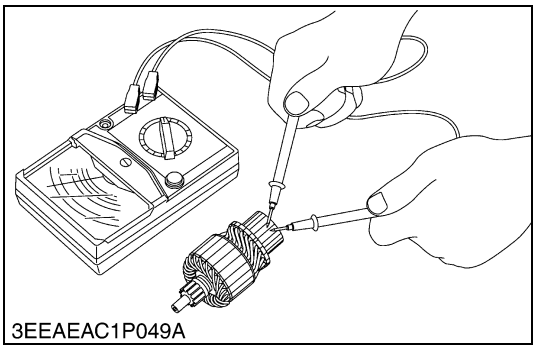
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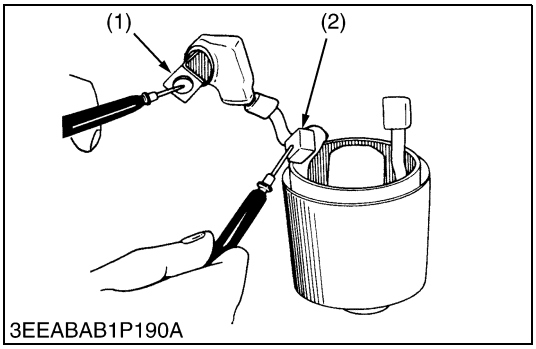
Armature Coil

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

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

9Y3210051ENS0112US0



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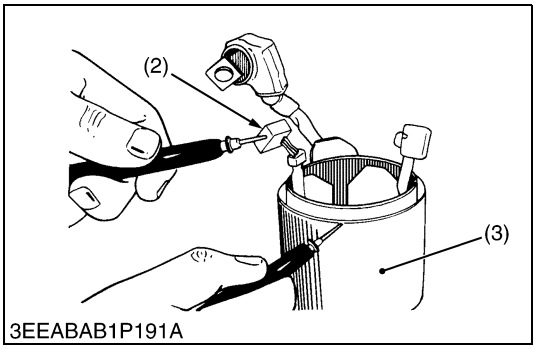
Field Coil

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

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

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

9Y3210051ENS0113US0



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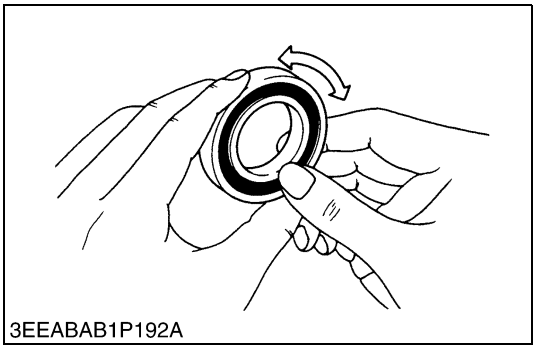
(8) Alternator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Bearing

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

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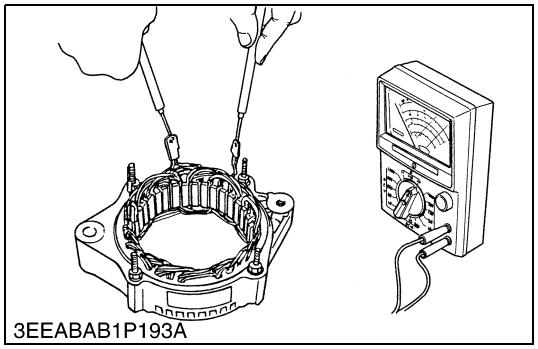
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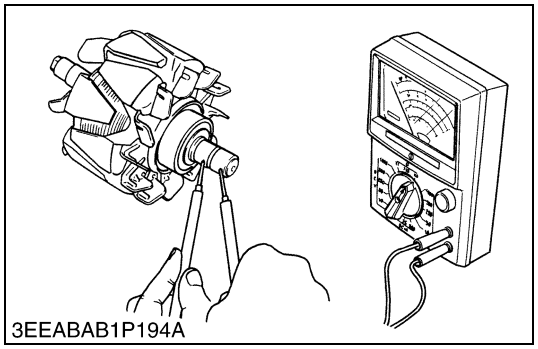
Stator

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

Resistance	Service specification	Less than 1.0 Ω

9Y3210051ENS0115US0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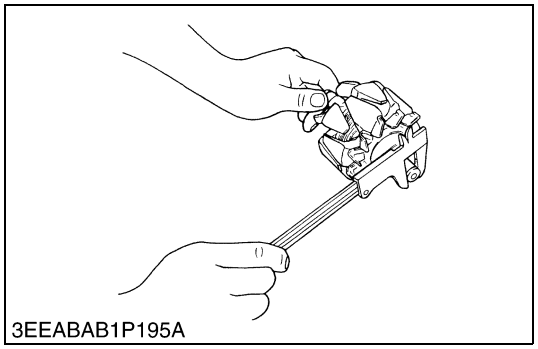
Rotor

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

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

9Y3210051ENS0116US0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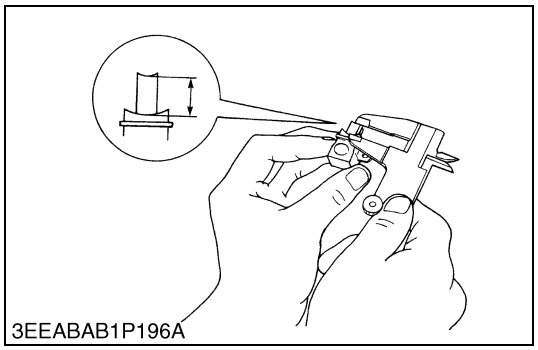
Slip Ring

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

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

9Y3210051ENS0117US0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Brush Wear

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

Brush length	Service specification	10.5 mm 0.413 in.
	Service limit	8.4 mm 0.33 in.

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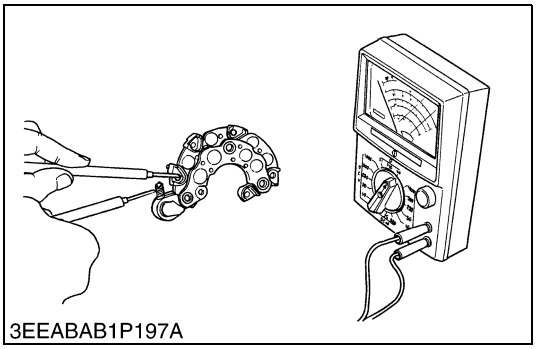
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Rectifier

1. Examine the continuity across each diode of rectifier with the resistance range of circuit tester.
2. The rectifier is correct if the diode in the rectifier conducts electricity only in one direction.

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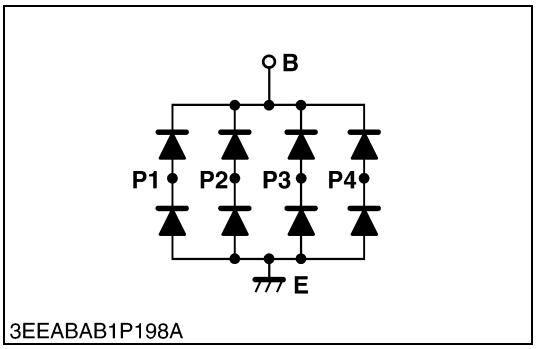

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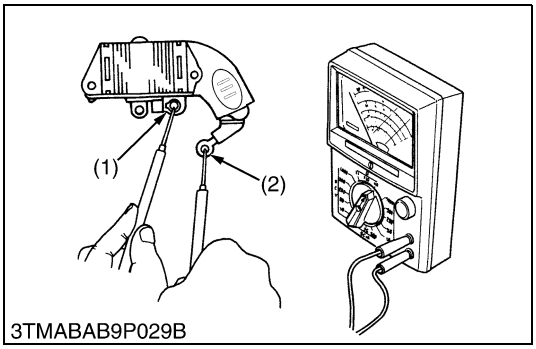

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IC Regulator

1. Examine the continuity across the **B** terminal (2) and the **F** terminal (1) of IC regulator with the resistance range of circuit tester.
2. The IC regulator is correct if it conducts electricity only in one direction.

(1) **F** Terminal (2) **B** Terminal

9Y3210051ENS0120US0

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KUBOTA Corporation

Printed in Japan 2020. 04, S, EI, EI, engusa Code No.9Y311-00511
2019. 12, S, EI, EI, engusa

WG3800L

<Note>The picture shows the pin arrangement of the connector housing viewed from the harness connector mating side.