WSM

WORKSHOP MANUAL
GASOLINE,LPG, NATURAL GAS ENGINE
WG972-E4 (EFI)

Kubota

KiSC issued 07, 2015 A

TO THE READER

This Workshop Manual tells the servicing personnel about the mechanism, servicing and maintenance of the WG972-E4. It contains 4 parts: **"Information"**, **"General"**, **"Mechanism"** and **"Servicing"**.

■ **Information**

This section contains information below.

- Safety First
- Specification
- Performance Curve
- Important Items of Exhaust Emission Regulation
- 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.

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

March, 2015

KiSC issued 07, 2015 A

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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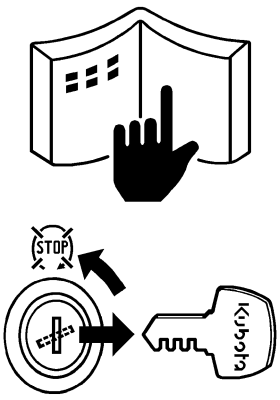

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BEFORE YOU START SERVICE

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

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START SAFELY

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

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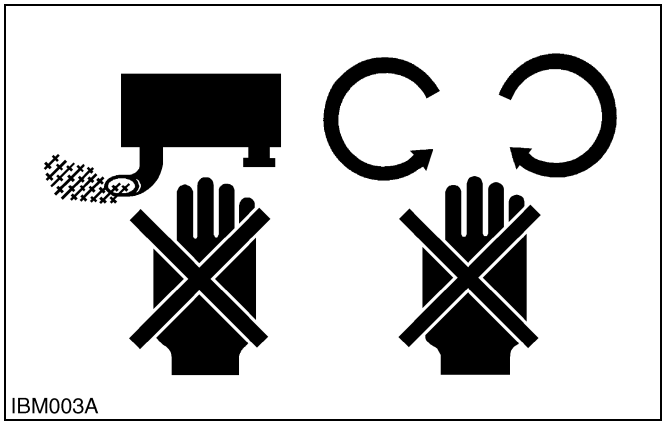
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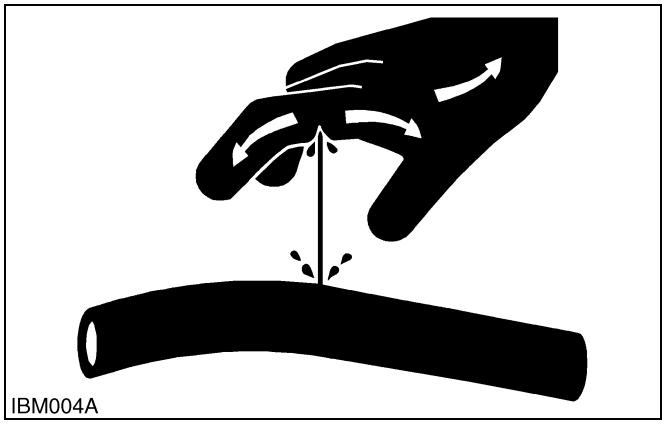
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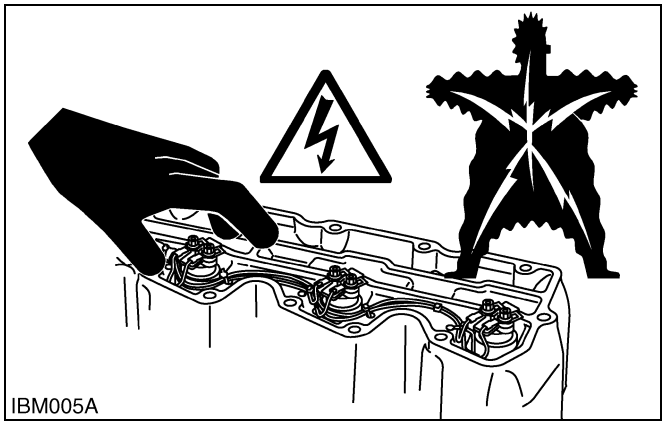
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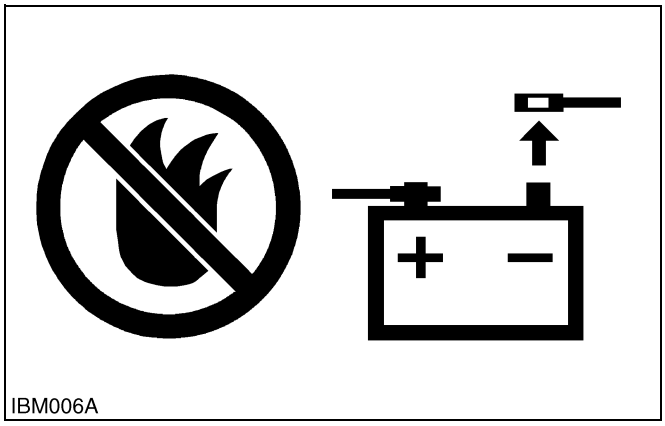
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OPERATE SAFELY

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

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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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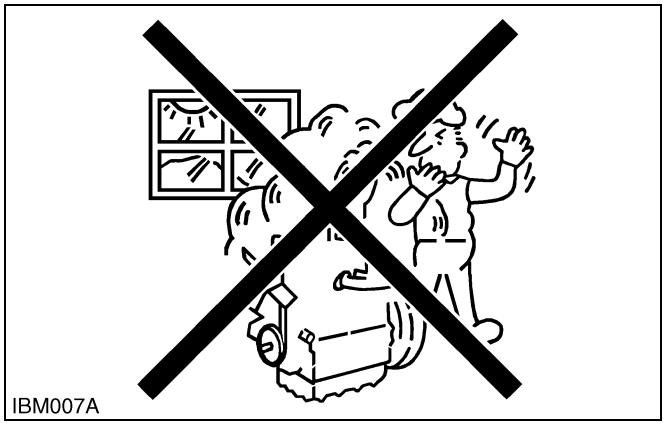
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KEEP A GOOD AIRFLOW IN THE WORK AREA

- 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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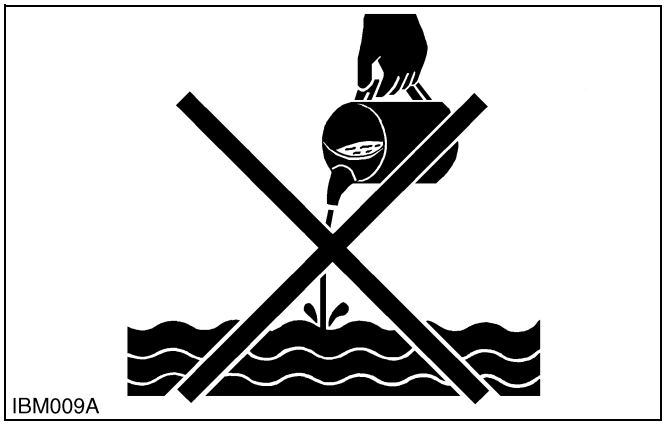
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DISCARD FLUIDS CORRECTLY

- 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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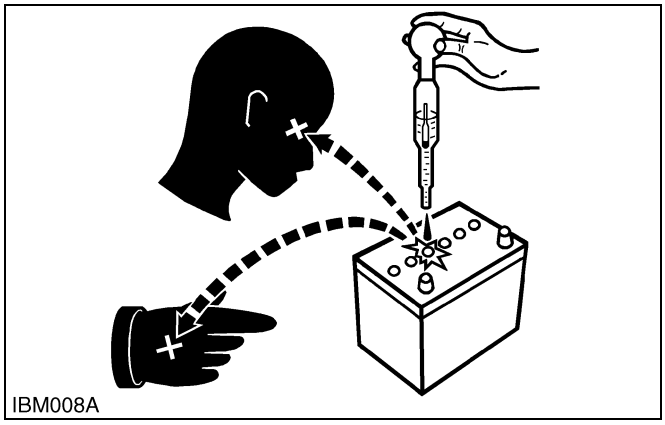
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PREVENT ACID BURNS

- 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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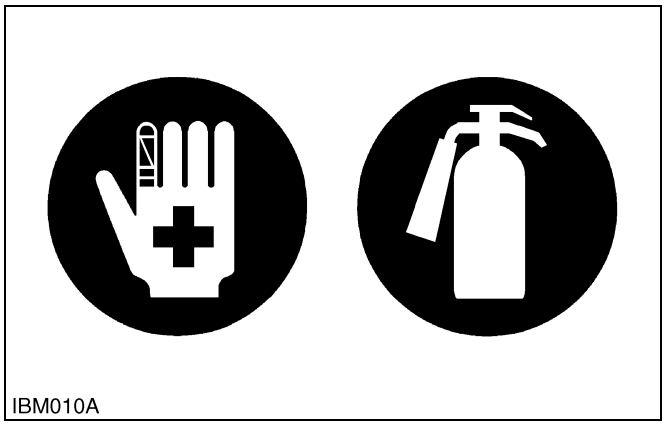
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PREPARE FOR EMERGENCIES

- 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	WG972-GL-E4	
	Gasoline	LPG
Number of Cylinder	3	
Type	Vertical, Water cooled, 4-cycle Dual Fuel (Gasoline/LPG) engine	
Bore × Stroke	74.5 × 73.6 mm (2.93 × 2.90 in.)	
Total Displacement	0.962 L (58.7 cu.in.)	
SAE Net Continuous	17.6 kW / 3600 min^{-1} (rpm) 23.6 HP / 3600 min^{-1} (rpm)	16.3 kW / 3600 min^{-1} (rpm) 21.9 HP / 3600 min^{-1} (rpm)
SAE Net Intermittent	22.0 kW / 3600 min^{-1} (rpm) 29.5 HP / 3600 min^{-1} (rpm)	20.3 kW / 3600 min^{-1} (rpm) 27.2 HP / 3600 min^{-1} (rpm)
SAE Gross Intermittent	23.2 kW / 3600 min^{-1} (rpm) 31.1 HP / 3600 min^{-1} (rpm)	22.0 kW / 3600 min^{-1} (rpm) 29.5 HP / 3600 min^{-1} (rpm)
Maximum Bare Speed	3570 to 3630 min^{-1} (rpm)	
Minimum Bare Idling Speed	970 to 1030 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	NGK BKR6E	
Ignition Timing (no-load condition)	0.70 rad (40 °) before T.D.C. / 3600 min^{-1} (rpm)	0.37 rad (21 °) before T.D.C. / 3600 min^{-1} (rpm)
Firing Order	1-2-3	
Compression Ratio	9.2 : 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 (not included in the basic model), Forced Circulation with Water Pump	
Starting System	Electric Starting with Starter (12 V, 1.0 kW)	
Starting Motor	12 V, 1.0 kW	
Battery	12 V, 52 AH or equivalent	
Charging Alternator	12 V, 480 W	
Fuel	Unleaded gasoline	Commercial LPG*
Lubricating Oil	Better than SL Class (API)	
Lubricating Oil Capacity	3.4 L (0.90 U.S.gals)	
Catalytic Muffler / Converter	Three Way Catalyst	
Weight (Dry)	74.0 kg (163 lbs)	77.7 kg (171 lbs)

■ **NOTE**

- **Specifications are subject to change without notice.**
  ***: LPG regulator with vaporizer operates on a liquid withdrawal type system.**

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Model	WG972-G-E4
	Gasoline
Number of Cylinder	3
Type	Vertical, Water cooled, 4-cycle Gasoline engine
Bore × Stroke	74.5 × 73.6 mm (2.93 × 2.90 in.)
Total Displacement	0.962 L (58.7 cu.in.)
SAE Net Continuous	18.7 kW / 3600 min^{-1} (rpm) 25.1 HP / 3600 min^{-1} (rpm)
SAE Net Intermittent	23.1 kW / 3600 min^{-1} (rpm) 31.0 HP / 3600 min^{-1} (rpm)
SAE Gross Intermittent	24.2 kW / 3600 min^{-1} (rpm) 32.5 HP / 3600 min^{-1} (rpm)
Maximum Bare Speed	3570 to 3630 min^{-1} (rpm)
Minimum Bare Idling Speed	970 to 1030 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	NGK BKR6E
Ignition Timing (no-load condition)	0.70 rad (40 °) before T.D.C. / 3600 min^{-1} (rpm)
Firing Order	1-2-3
Compression Ratio	9.2 : 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 (not included in the basic model), Forced Circulation with Water Pump
Starting System	Electric Starting with Starter (12 V, 1.0 kW)
Starting Motor	12 V, 1.0 kW
Battery	12 V, 52 AH or equivalent
Charging Alternator	12 V, 480 W
Fuel	Unleaded gasoline
Lubricating Oil	Better than SL Class (API)
Lubricating Oil Capacity	3.4 L (0.90 U.S.gals)
Catalytic Muffler / Converter	Three Way Catalyst
Weight (Dry)	74.0 kg (163 lbs)

9Y1211108INI0002US0

Model	WG972-L-E4	WG972-N-E4
	LPG	CNG
Number of Cylinder	3	
Type	Vertical, water cooled, 4-cycle LPG engine	Vertical, water cooled, 4-cycle CNG engine
Bore × Stroke	74.5 × 73.6 mm (2.93 × 2.90 in.)	
Total Displacement	0.962 L (58.7 cu.in.)	
SAE Net Continuous	16.3 kW / 3600 min^{-1} (rpm) 21.9 HP / 3600 min^{-1} (rpm)	15.0 kW / 3600 min^{-1} (rpm) 20.1 HP / 3600 min^{-1} (rpm)
SAE Net Intermittent	20.3 kW / 3600 min^{-1} (rpm) 27.2 HP / 3600 min^{-1} (rpm)	18.8 kW / 3600 min^{-1} (rpm) 25.2 HP / 3600 min^{-1} (rpm)
SAE Gross Intermittent	22.0 kW / 3600 min^{-1} (rpm) 29.5 HP / 3600 min^{-1} (rpm)	20.4 kW / 3600 min^{-1} (rpm) 27.4 HP / 3600 min^{-1} (rpm)
Maximum Bare Speed	3570 to 3630 min^{-1} (rpm)	
Minimum Bare Idling Speed	970 to 1030 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	NGK BKR6E	
Ignition Timing (no-load condition)	0.37 rad (21 °) before T.D.C. / 3600 min^{-1} (rpm)	0.49 rad (28 °) before T.D.C. / 3600 min^{-1} (rpm)
Firing Order	1-2-3	
Compression Ratio	9.2 : 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 (not included in the basic model), Forced Circulation with Water Pump	
Starting System	Electric Starting with Starter (12 V, 1.0 kW)	
Starting Motor	12 V, 1.0 kW	
Battery	12 V, 52 AH or equivalent	
Charging Alternator	12 V, 480 W	
Fuel	Commercial LPG*	CNG
Lubricating Oil	Better than SL Class (API)	
Lubricating Oil Capacity	3.4 L (0.90 U.S.gals)	
Catalytic Muffler / Converter	Three Way Catalyst	
Weight (Dry)	77.4 kg (171 lbs)	

■ **NOTE**

- **Specifications are subject to change without notice.**

  ***: LPG regulator with vaporizer operates on a liquid withdrawal type system.**

9Y1211108INI0003US0

3. EMISSION REGULATION

[1] GENERAL

Along with E4 models, are yet available to be used in the following countries per output category.

kW, Disp.	Model	Type	North America	Europe	Japan
19 < P ≤ 30, 0.825 < L ≤ 1.0	WG972-E4	E4	Available	Available	None Available

Current and future emission regulations.

$HC+NO_x/CO$ (g/kW·h)

Countries		Power [kW], Disp. [L]	2014	2015	2016	2017	2018	2019	2020	2021
USA	CARB	P ≤ 19, 0.225 ≤ L	8.0/549*							
		19 < P, L ≤ 0.825	8.0/549*							
		19 < P, 0.825 < L ≤ 1.0	6.5/375*	0.8/20.6*						
	EPA	P ≤ 19, 0.225 ≤ L	8.0/610*							
		19 < P ≤ 30, L ≤ 1.0	8.0/610*							
Canada		P ≤ 19, 0.225 ≤ L	8.0/610							
		19 < P	None							
EU		P ≤ 19, 0.225 ≤ L Gas Engine is not covered	12.1/610					8/610		
		19 < P < 56	None					Σ2.7 to Σ0.8 / 4.4 to 20.6		
Japan		P < 19, 0.225 ≤ L	12.1/610	8/610						

- *: with evaporative emission regulation

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[2] IMPORTANT ITEMS OF EXHAUST EMISSION REGULATION

(1) Important Notice

There are necessary emission-related items for compliance with emission regulations.

For mass-production Kubota prepares the installation instructions.

These instructions are provided for the final engine assemblers who must ensure the engine, exhaust system (catalyst), intake system, gasoline fuel system and etc, are installed correctly in the engine's certified configuration.

(for EPA only)

Failing to these instructions when installing a certified engine in a piece of non-load equipment violates federal law (40CFR 1068. 105(b)), subject to fines or other penalties as described in) the Clean Air Act.

9Y1211108INI0005US0

(2) Emission-Related Installation Instructions

1) Air Intake System

You must use the original air cleaner and inlet pipe to observe the applicable emissions laws.

2) Exhaust System

Kubota offers certified catalytic converter, catalytic muffler and O_2 sensor.

Catalyst parts and O_2 sensor other than Kubota must not be used because other catalyst and O_2 sensor are not certified our engine.

3) Gasoline Fuel System

If your equipment uses a volatile liquid fuel (such as gasoline), it must use the original fuel system components to observe the applicable emissions laws.

4) Gaseous Fuel System

You must use only the regulator with vaporizer Kubota offers and assemble the LPG fuel and CNG fuel system parts according to the instructions.

5) Electrical System

You should wire correctly for securing the performance and safety.

6) Engine Labels

EPA/CARB label must be visible at any time. Be careful not to damage the label.

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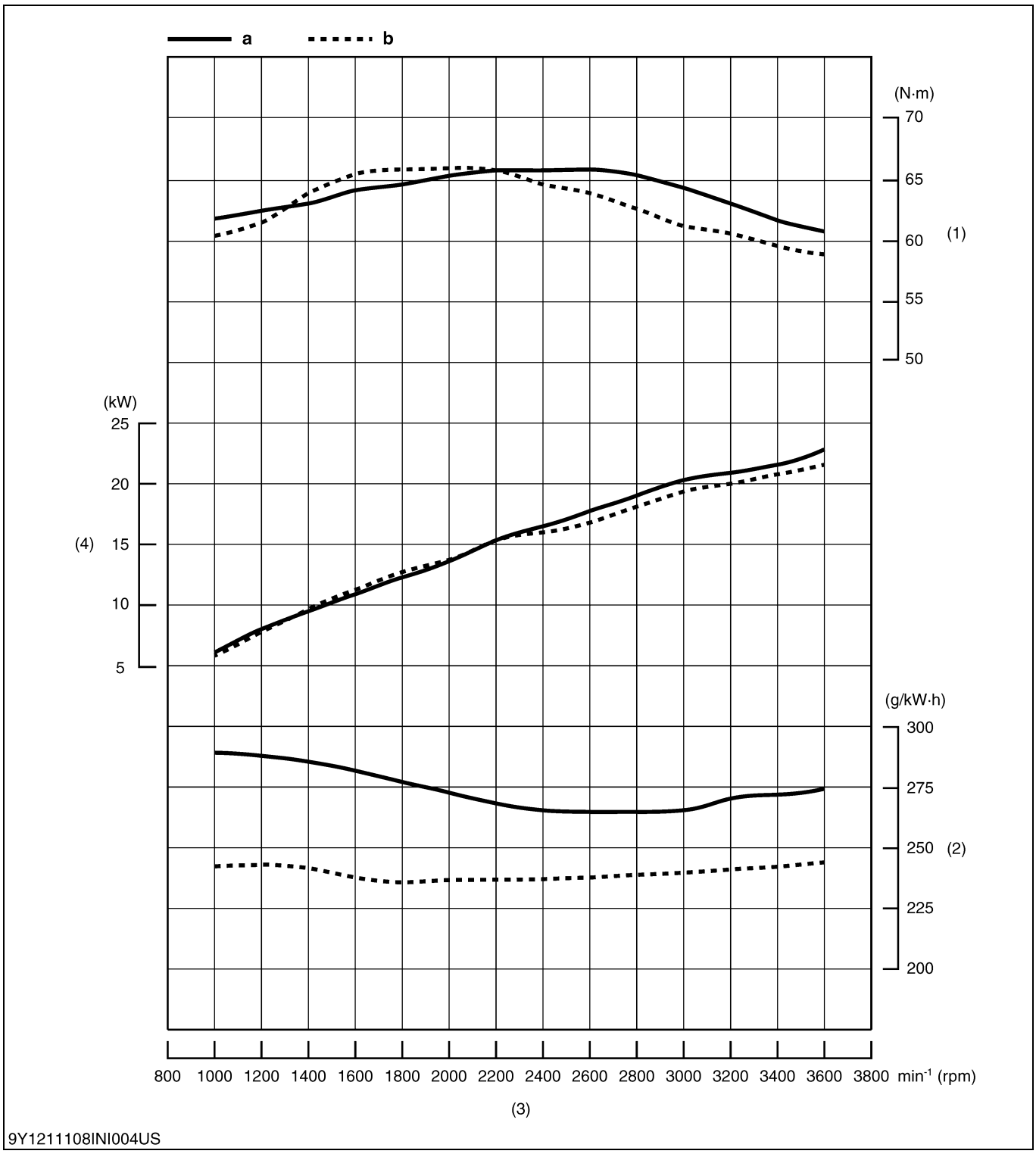
4. PERFORMANCE CURVES

WG972-GL-E4



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(1) Torque
(2) B.S.F.C. (Brake Specific Fuel Consumption)
(3) Engine Speed
(4) Brake Horsepower

a: Gasoline Use

b: LPG Use

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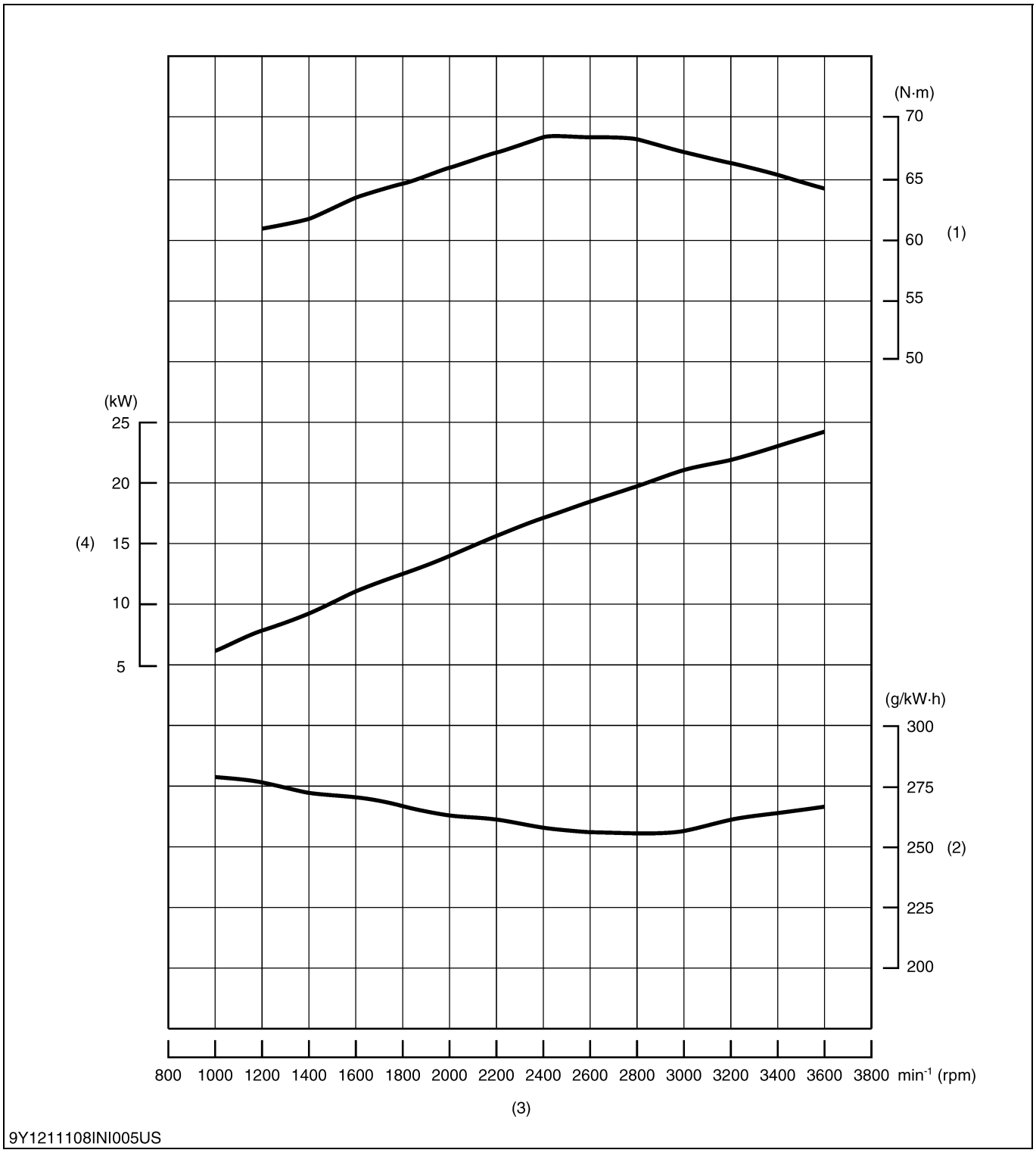
WG972-G-E4



(1) Torque
(2) B.S.F.C. (Brake Specific Fuel Consumption)
(3) Engine Speed
(4) Brake Horsepower

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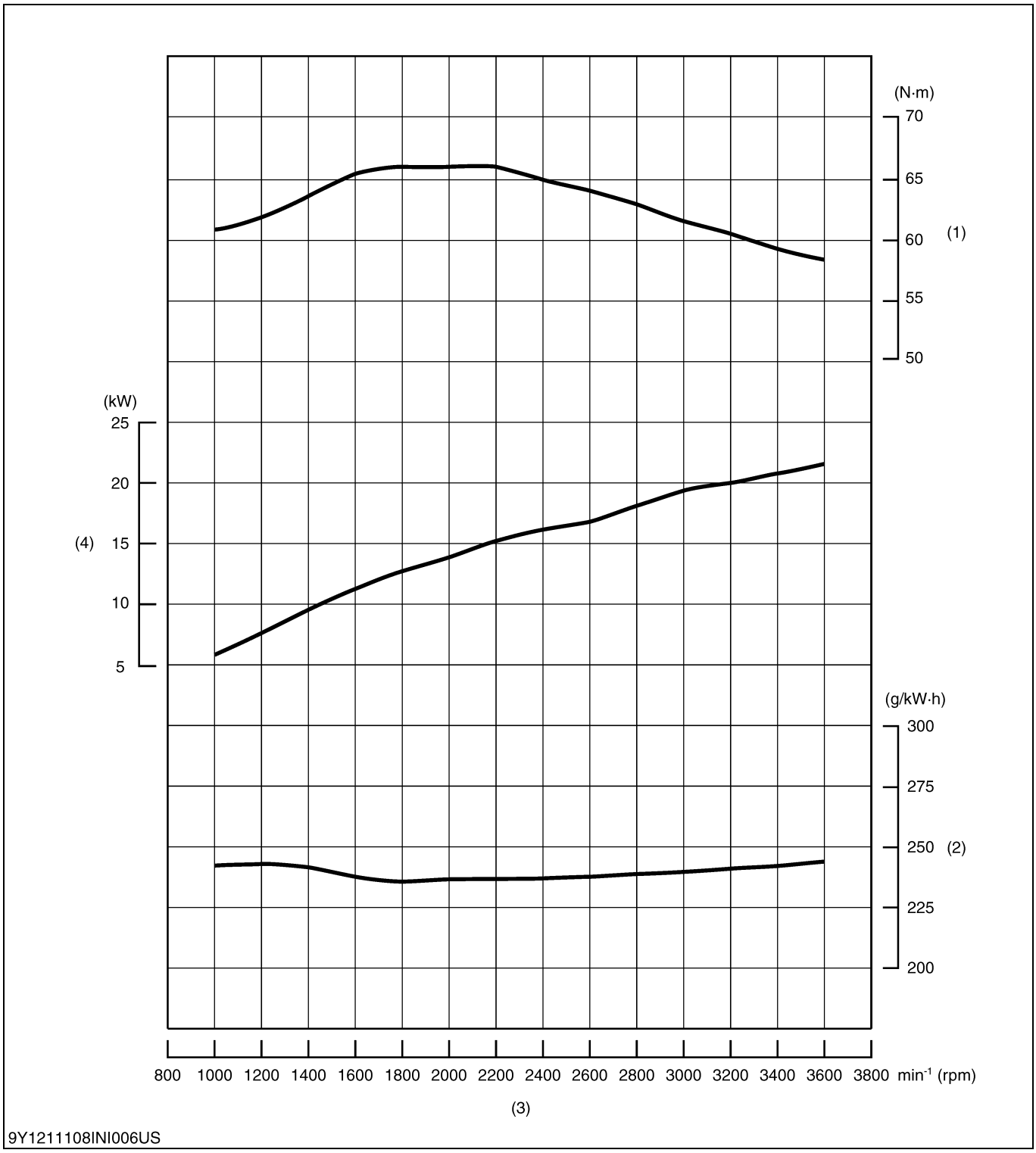
WG972-L-E4



(1) Torque
(2) B.S.F.C. (Brake Specific Fuel Consumption)
(3) Engine Speed
(4) Brake Horsepower

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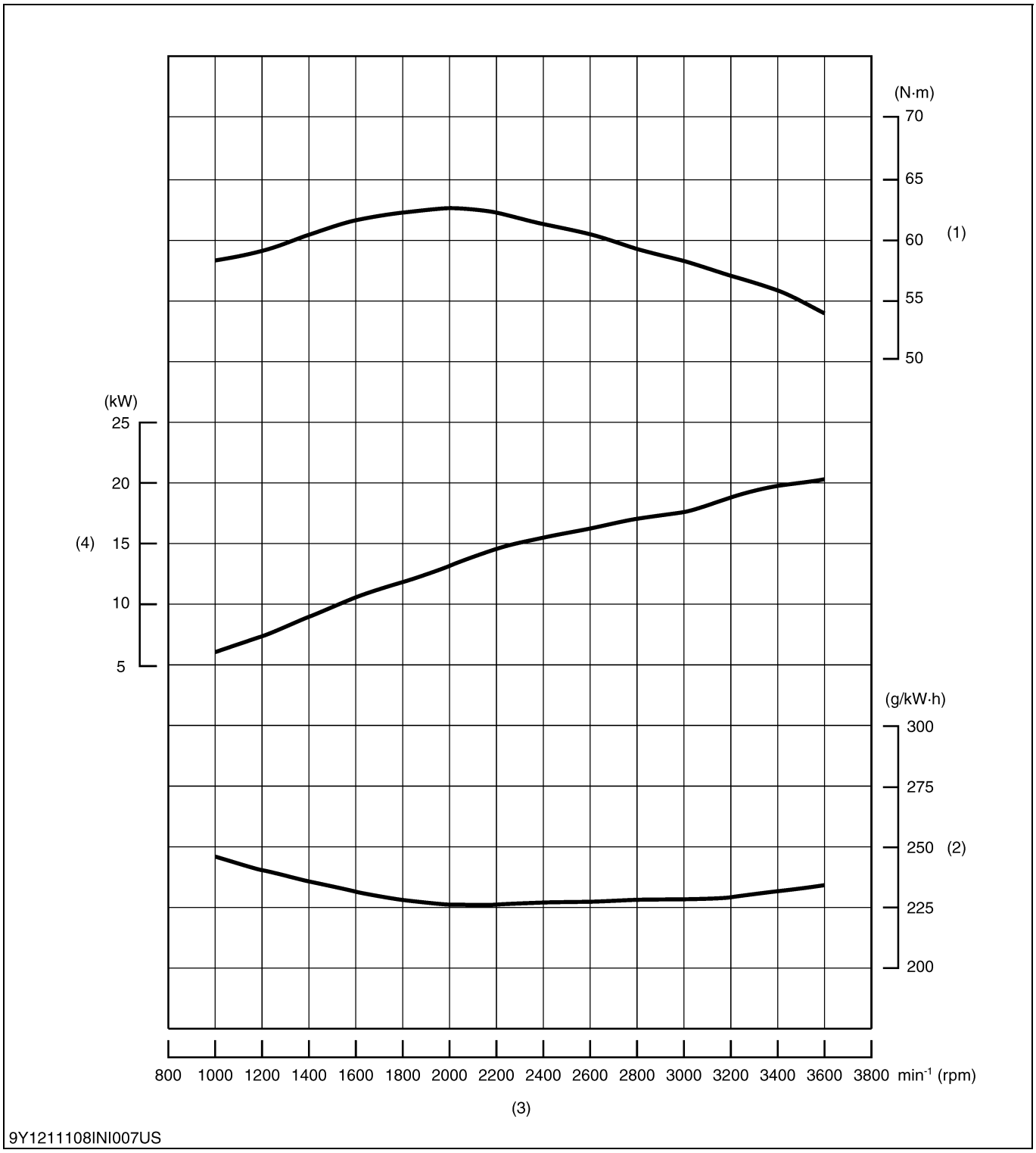
WG972-N-E4



(1) Torque
(2) B.S.F.C. (Brake Specific Fuel Consumption)
(3) Engine Speed
(4) Brake Horsepower

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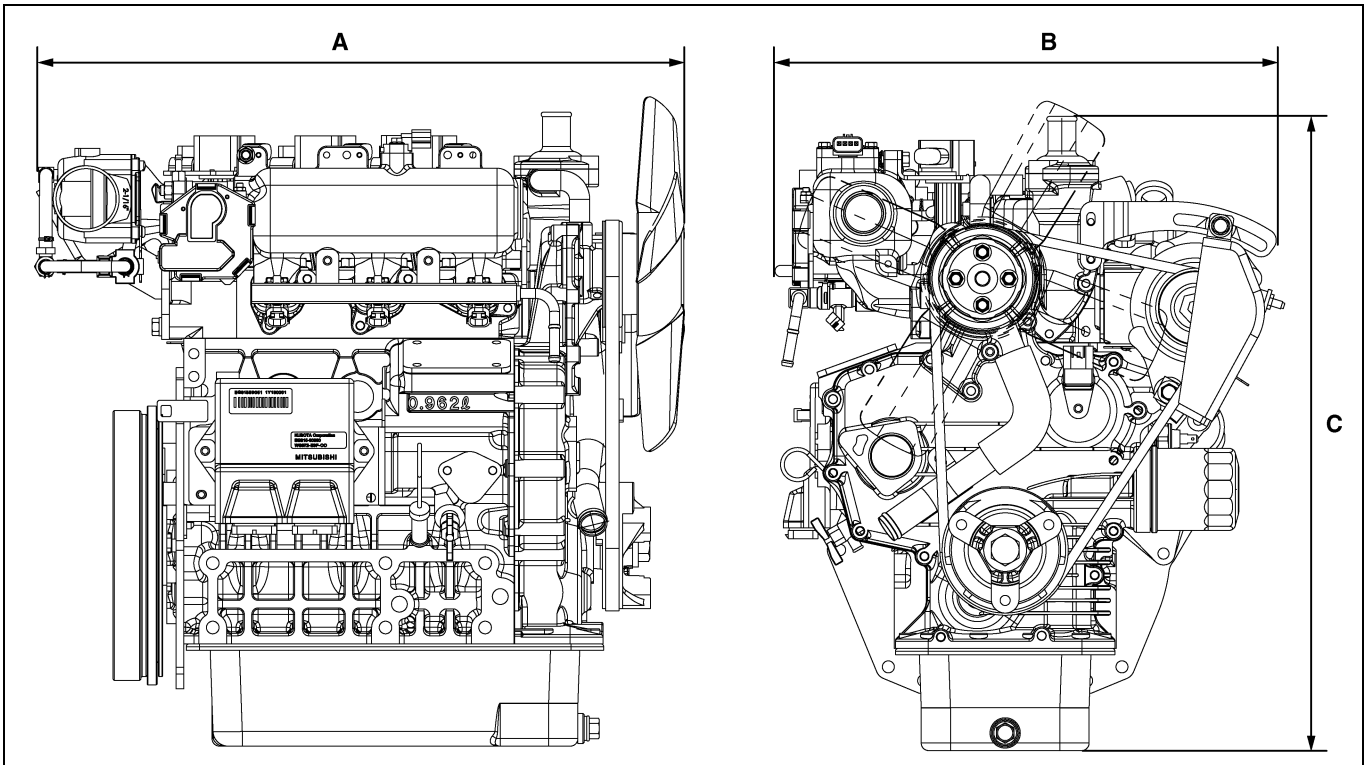
5. DIMENSIONS

WG972-GL-E4



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	WG972-GL-E4
A	516 mm (20.3 in.)
B	393 mm (15.5 in.)
C	503 mm (19.8 in.)

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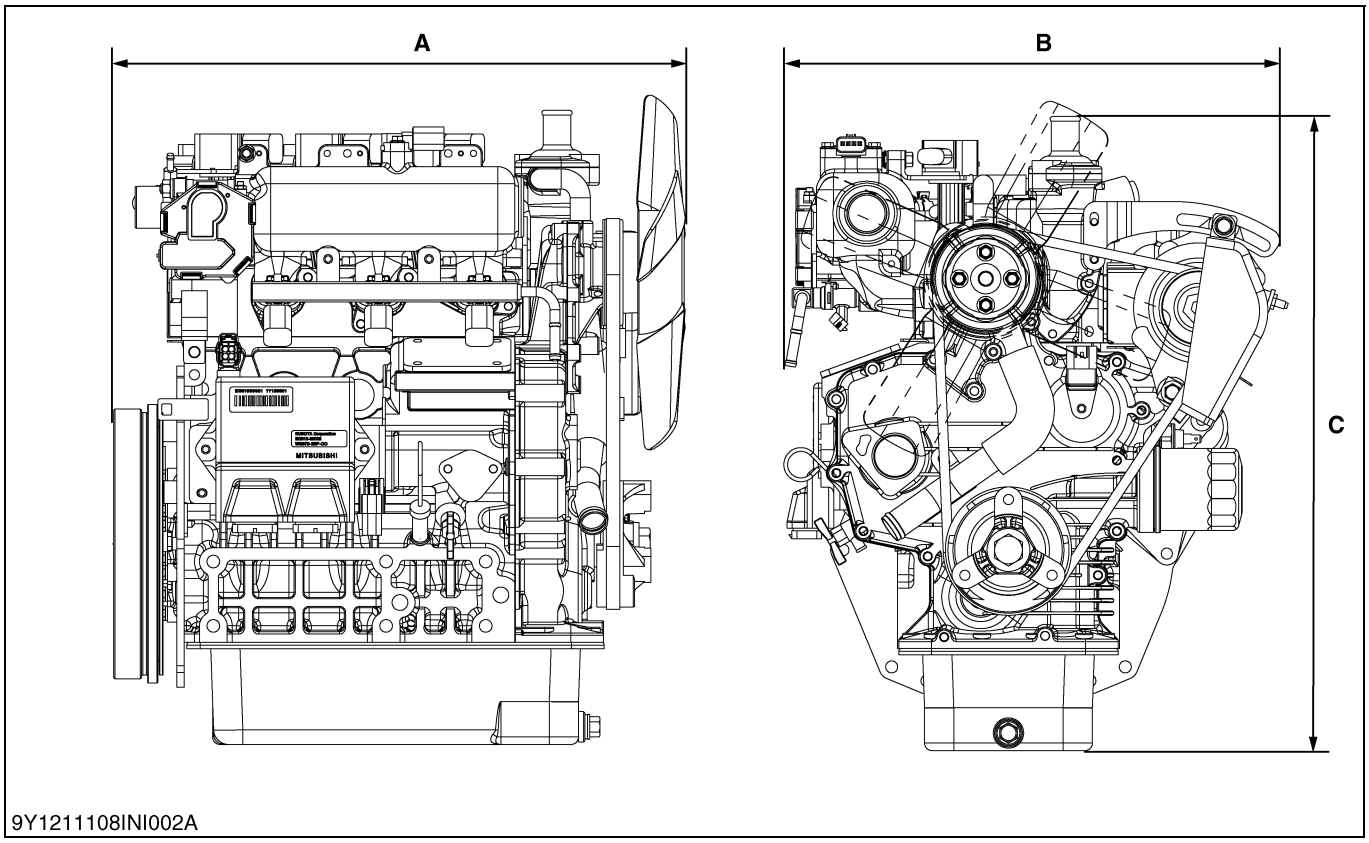
WG972-G-E4



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	WG972-G-E4
A	453 mm (17.8 in.)
B	393 mm (15.5 in.)
C	503 mm (19.8 in.)

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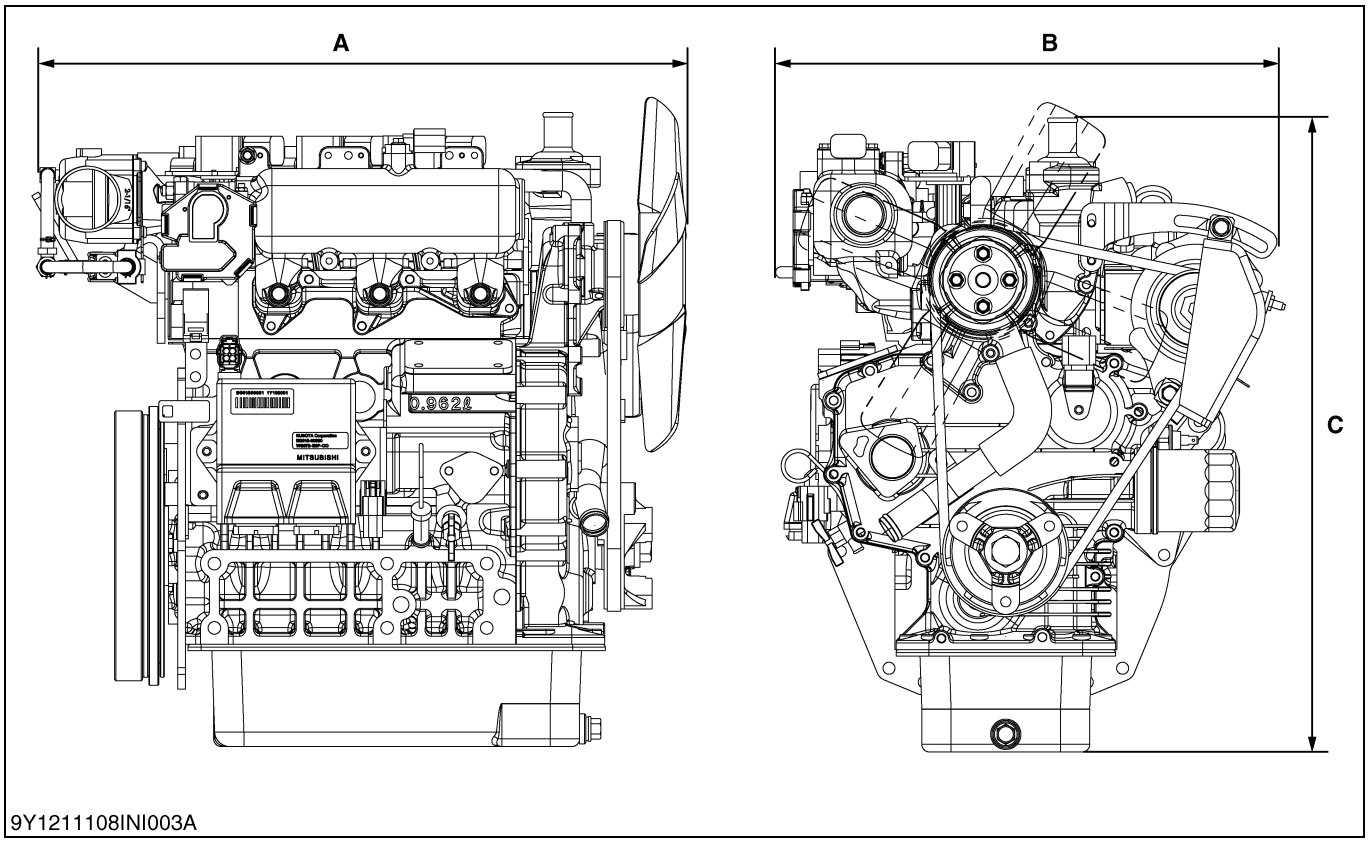
WG972-L-E4, WG972-N-E4



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	WG972-L-E4, WG972-N-E4
A	516 mm (20.3 in.)
B	393 mm (15.5 in.)
C	503 mm (19.8 in.)

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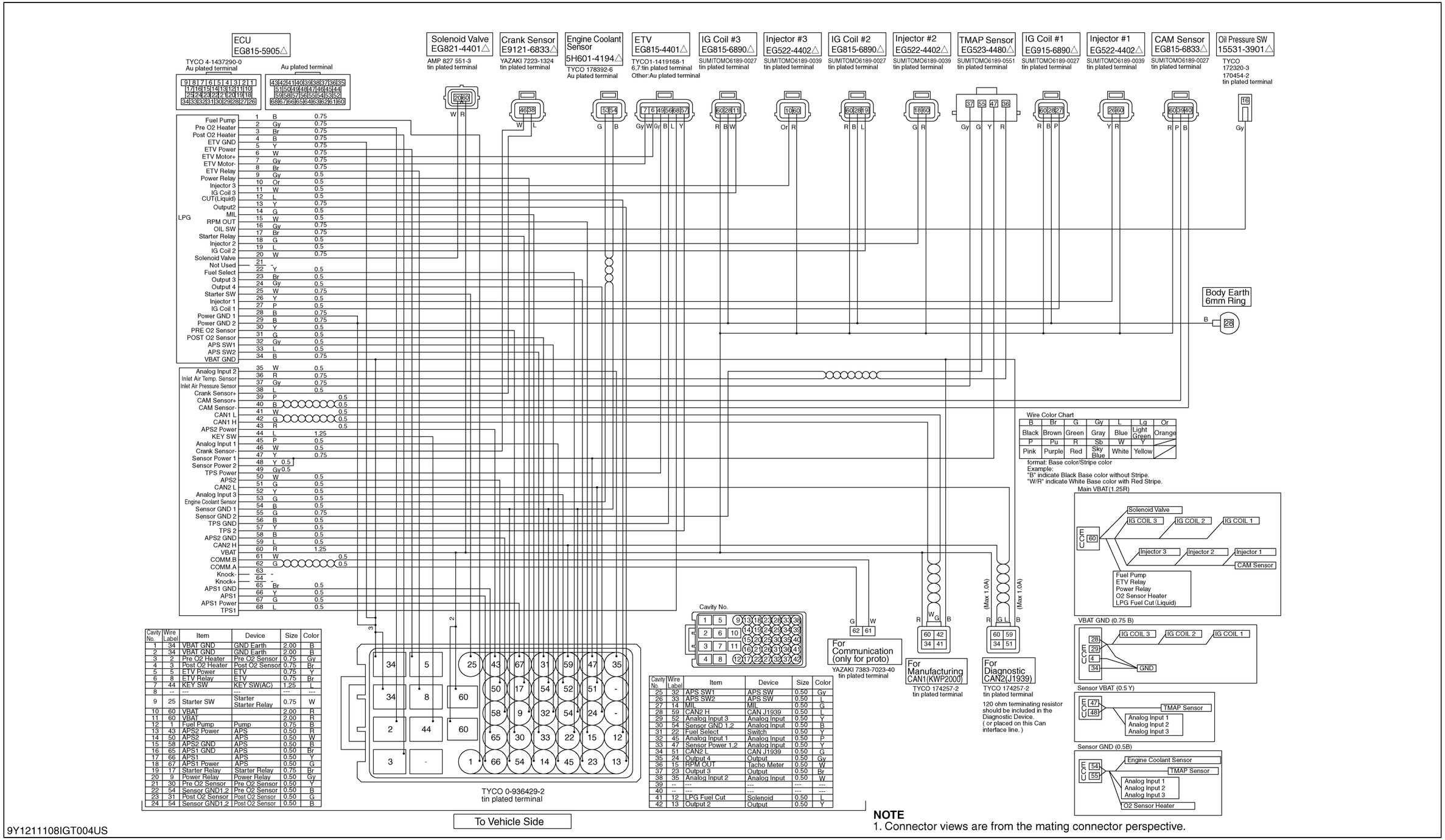
6. WIRING DIAGRAM

WG972-GL-E4

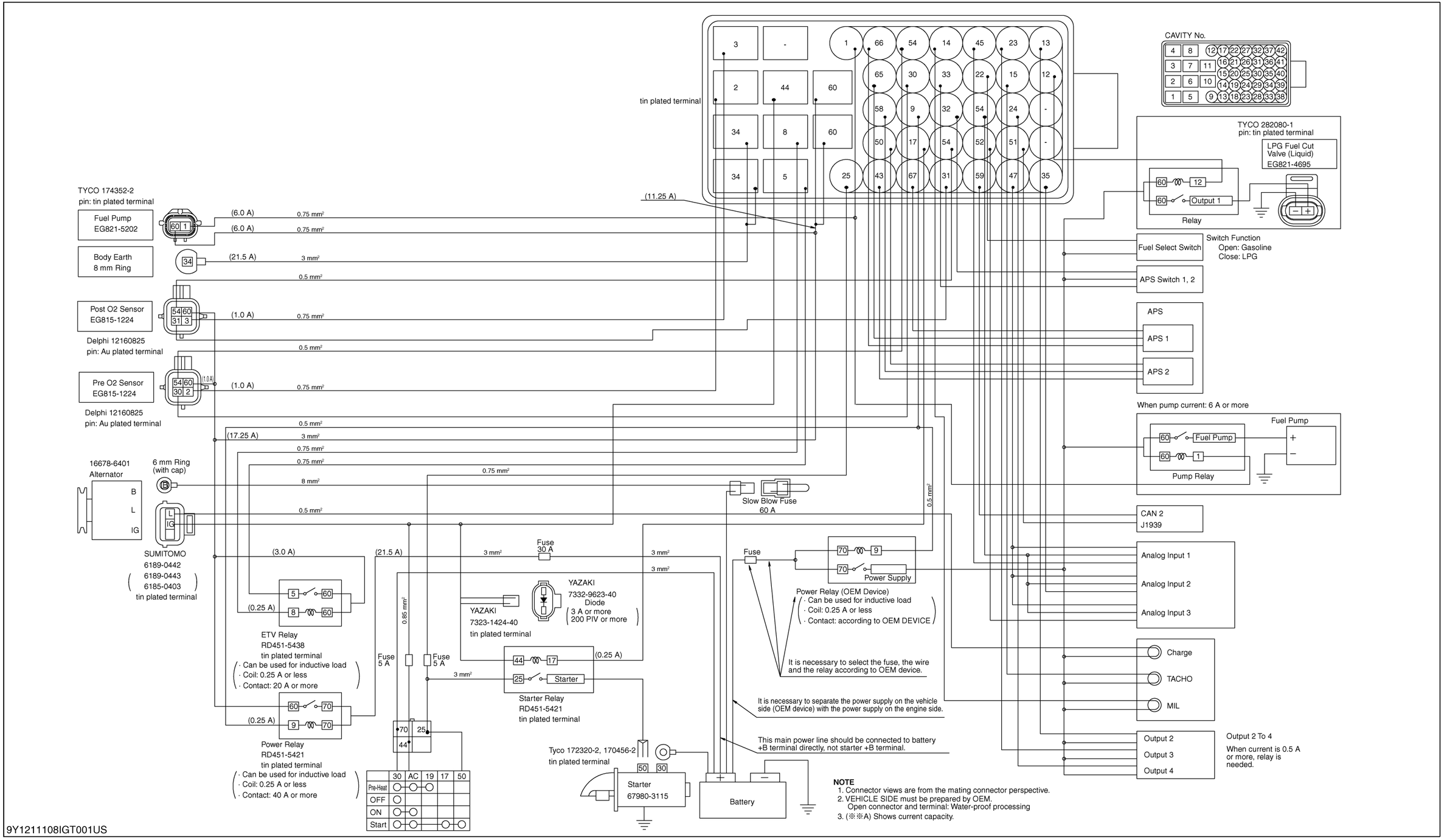


Cavity No.	Wire Label	Item	Device	Size	Color
1	34	VBAT GND	GND Earth	2.00	B
2	34	VBAT GND	GND Earth	2.00	B
3	2	Pre O2 Heater	Pre O2 Sensor	0.75	Gy
4	3	Post O2 Heater	Post O2 Sensor	0.75	Br
5	5	ETV Power	ETV	0.75	Y
6	8	ETV Relay	ETV	0.75	Br
7	44	KEY SW	KEY SW(AC)	1.25	L
8	--	---	---	---	---
9	25	Starter SW	Starter Starter Relay	0.75	W
10	60	VBAT		2.00	R
11	60	VBAT		2.00	R
12	1	Fuel Pump	Pump	0.75	B
13	43	APS2 Power	APS	0.50	R
14	50	APS2	APS	0.50	W
15	58	APS2 GND	APS	0.50	B
16	65	APS1 GND	APS	0.50	Br
17	66	APS1	APS	0.50	Y
18	67	APS1 Power	APS	0.50	G
19	17	Starter Relay	Starter Relay	0.75	Br
20	9	Power Relay	Power Relay	0.50	Gy
21	30	Pre O2 Sensor	Pre O2 Sensor	0.50	Y
22	54	Sensor GND1,2	Pre O2 Sensor	0.50	B
23	31	Post O2 Sensor	Post O2 Sensor	0.50	G
24	54	Sensor GND1,2	Post O2 Sensor	0.50	B

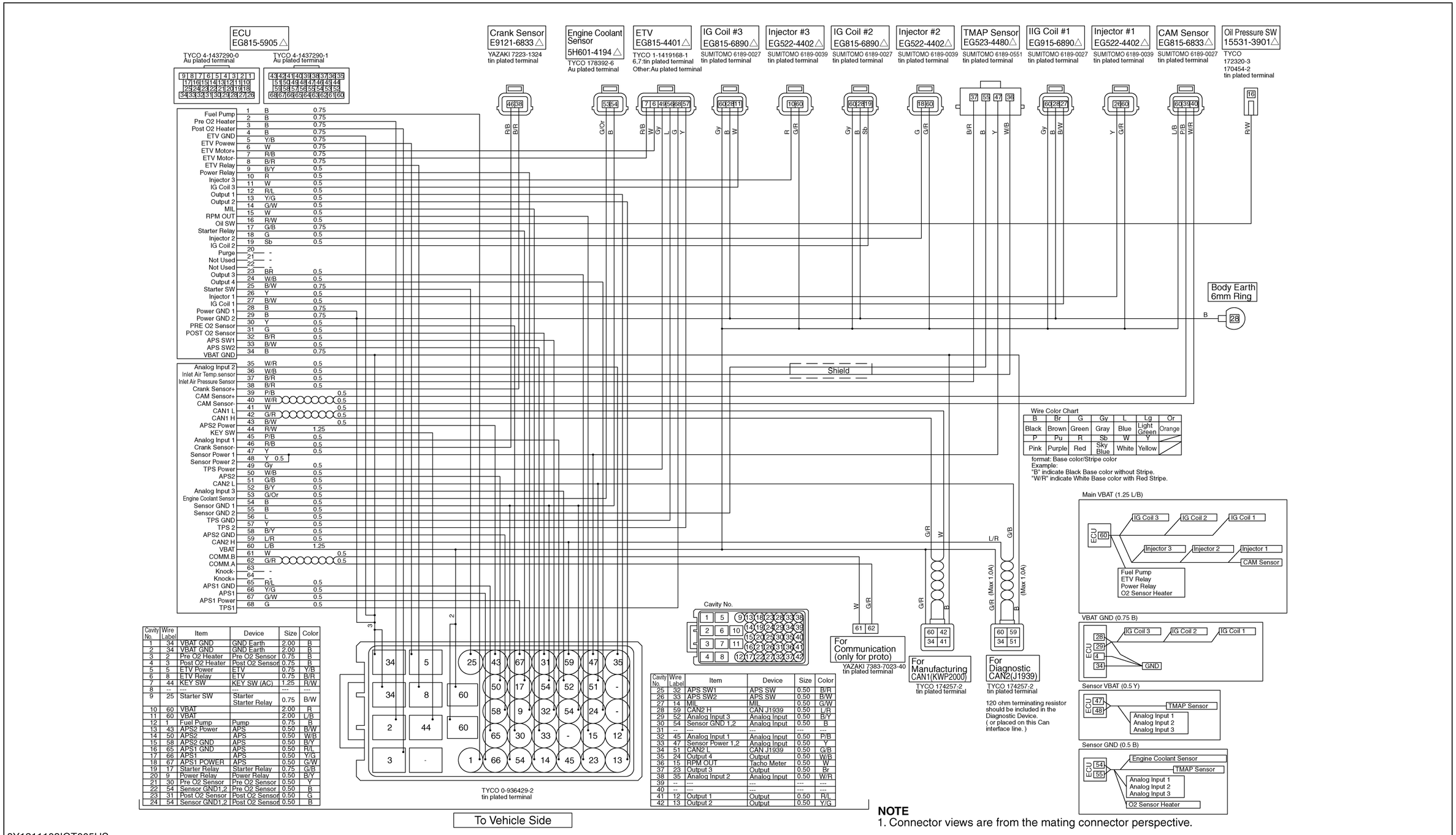
Cavity No.	Wire Label	Item	Device	Size	Color
25	32	APS SW1	APS SW	0.50	Gy
26	33	APS SW2	APS SW	0.50	L
27	14	MIL	MIL	0.50	G
28	59	CAN2 H	CAN J1939	0.50	L
29	52	Analog Input 3	Analog Input	0.50	Y
30	54	Sensor GND 1,2	Analog Input	0.50	B
31	22	Fuel Select	Switch	0.50	Y
32	45	Analog Input 1	Analog Input	0.50	P
33	47	Sensor Power 1,2	Analog Input	0.50	Y
34	51	CAN2 L	CAN J1939	0.50	G
35	24	Output 4	Output	0.50	Gy
36	15	RPM OUT	Tacho Meter	0.50	W
37	23	Output 3	Output	0.50	Br
38	35	Analog Input 2	Analog Input	0.50	W
39	--	---	---	---	---
40	--	---	---	---	---
41	12	LPG Fuel Cut	Solenoid	0.50	L
42	13	Output 2	Output	0.50	Y

NOTE
1. Connector views are from the mating connector perspective.

9Y1211108IGT004US


tin plated terminal
CAVITY No.
TYCO 282080-1
pin: tin plated terminal
LPG Fuel Cut Valve (Liquid)
EG821-4695
Relay
Output 1
TYCO 174352-2
pin: tin plated terminal
Fuel Pump
EG821-5202
(6.0 A)
0.75 mm²
Body Earth
8 mm Ring
(21.5 A)
3 mm²
0.5 mm²
Post O2 Sensor
EG815-1224
(1.0 A)
Delphi 12160825
pin: Au plated terminal
Pre O2 Sensor
EG815-1224
(11.25 A)
Fuel Select Switch
Switch Function
Open: Gasoline
Close: LPG
APS Switch 1, 2
APS
APS 1
APS 2
When pump current: 6 A or more
Fuel Pump
Pump Relay
(17.25 A)
16678-6401
Alternator
6 mm Ring
(with cap)
8 mm²
SUMITOMO
6189-0442
6189-0443
6185-0403
tin plated terminal
Slow Blow Fuse
60 A
CAN 2
J1939
Analog Input 1
Analog Input 2
Analog Input 3
(3.0 A)
(21.5 A)
Fuse
30 A
Fuse
(0.25 A)
Power Supply
Power Relay (OEM Device)
· Can be used for inductive load
· Coil: 0.25 A or less
· Contact: according to OEM DEVICE
ETV Relay
RD451-5438
tin plated terminal
· Can be used for inductive load
· Coil: 0.25 A or less
· Contact: 20 A or more
0.85 mm²
Fuse
5 A
YAZAKI
7323-1424-40
tin plated terminal
YAZAKI
7332-9623-40
Diode
3 A or more
200 PIV or more
Starter
Starter Relay
RD451-5421
tin plated terminal
It is necessary to select the fuse, the wire and the relay according to OEM device.
It is necessary to separate the power supply on the vehicle side (OEM device) with the power supply on the engine side.
This main power line should be connected to battery +B terminal directly, not starter +B terminal.
Charge
TACHO
MIL
Output 2
Output 3
Output 4
Output 2 To 4
When current is 0.5 A or more, relay is needed.
Power Relay
RD451-5421
tin plated terminal
· Can be used for inductive load
· Coil: 0.25 A or less
· Contact: 40 A or more
Pre-Heat
OFF
ON
Start
Tyco 172320-2, 170456-2
tin plated terminal
Starter
67980-3115
Battery
NOTE
1. Connector views are from the mating connector perspective.
2. VEHICLE SIDE must be prepared by OEM.
Open connector and terminal: Water-proof processing
3. (※※A) Shows current capacity.
9Y1211108IGT001US

WG972-G-E4

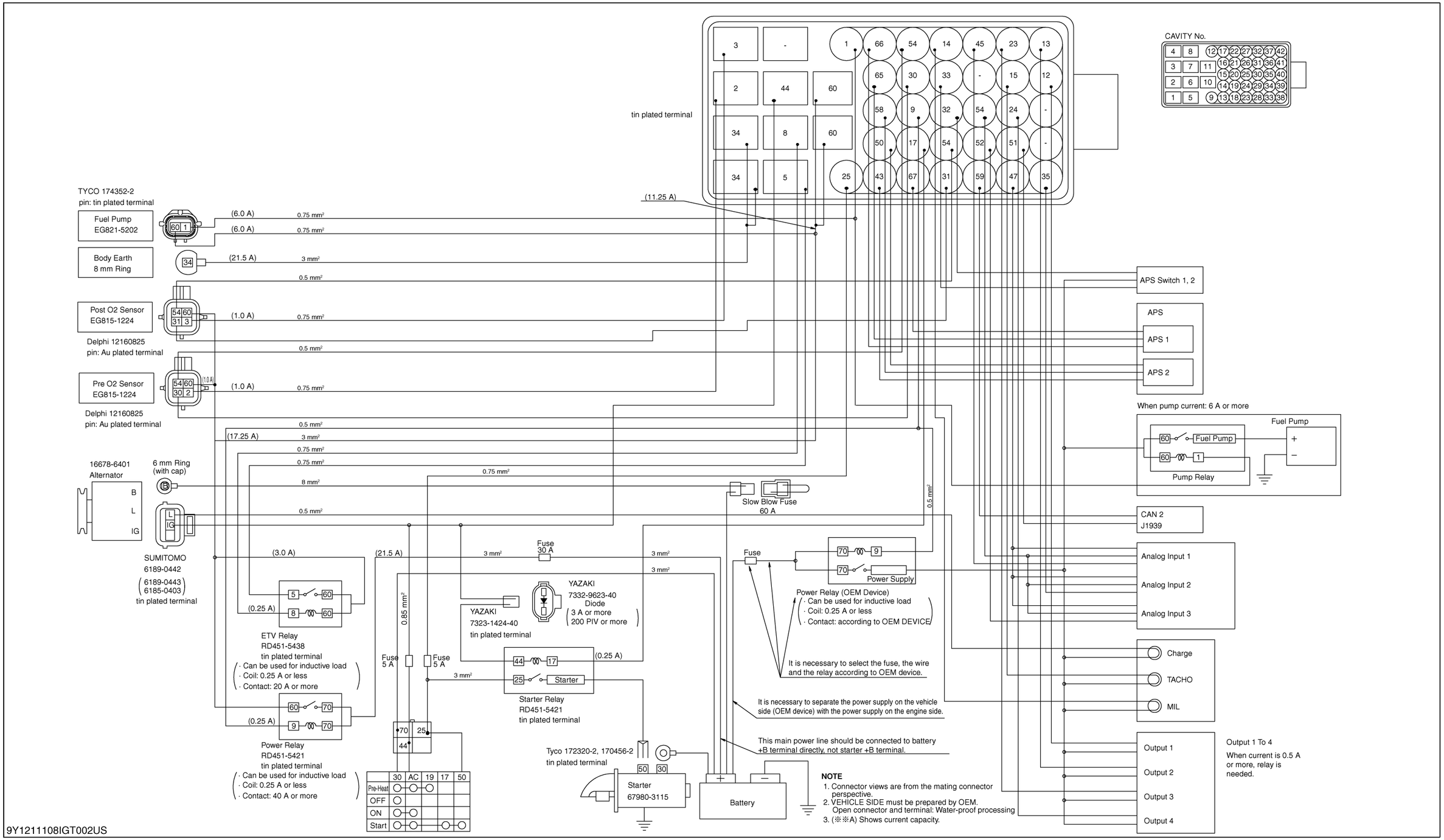


Cavity No.	Wire Label	Item	Device	Size	Color
1	34	VBAT GND	GND Earth	2.00	B
2	34	VBAT GND	GND Earth	2.00	B
3	2	Pre O2 Heater	Pre O2 Sensor	0.75	B
4	3	Post O2 Heater	Post O2 Sensor	0.75	B
5	5	ETV Power	ETV	0.75	Y/B
6	8	ETV Relay	ETV	0.75	B/R
7	44	KEY SW	KEY SW (AC)	1.25	R/W
8	--	---	---	---	---
9	25	Starter SW	Starter Starter Relay	0.75	B/W
10	60	VBAT		2.00	R
11	60	VBAT		2.00	L/B
12	1	Fuel Pump	Pump	0.75	B
13	43	APS2 Power	APS	0.50	B/W
14	50	APS2	APS	0.50	W/B
15	58	APS2 GND	APS	0.50	B/Y
16	65	APS1 GND	APS	0.50	R/L
17	66	APS1	APS	0.50	Y/G
18	67	APS1 POWER	APS	0.50	G/W
19	17	Starter Relay	Starter Relay	0.75	G/B
20	9	Power Relay	Power Relay	0.50	B/Y
21	30	Pre O2 Sensor	Pre O2 Sensor	0.50	Y
22	54	Sensor GND1,2	Pre O2 Sensor	0.50	B
23	31	Post O2 Sensor	Post O2 Sensor	0.50	G
24	54	Sensor GND1,2	Post O2 Sensor	0.50	B

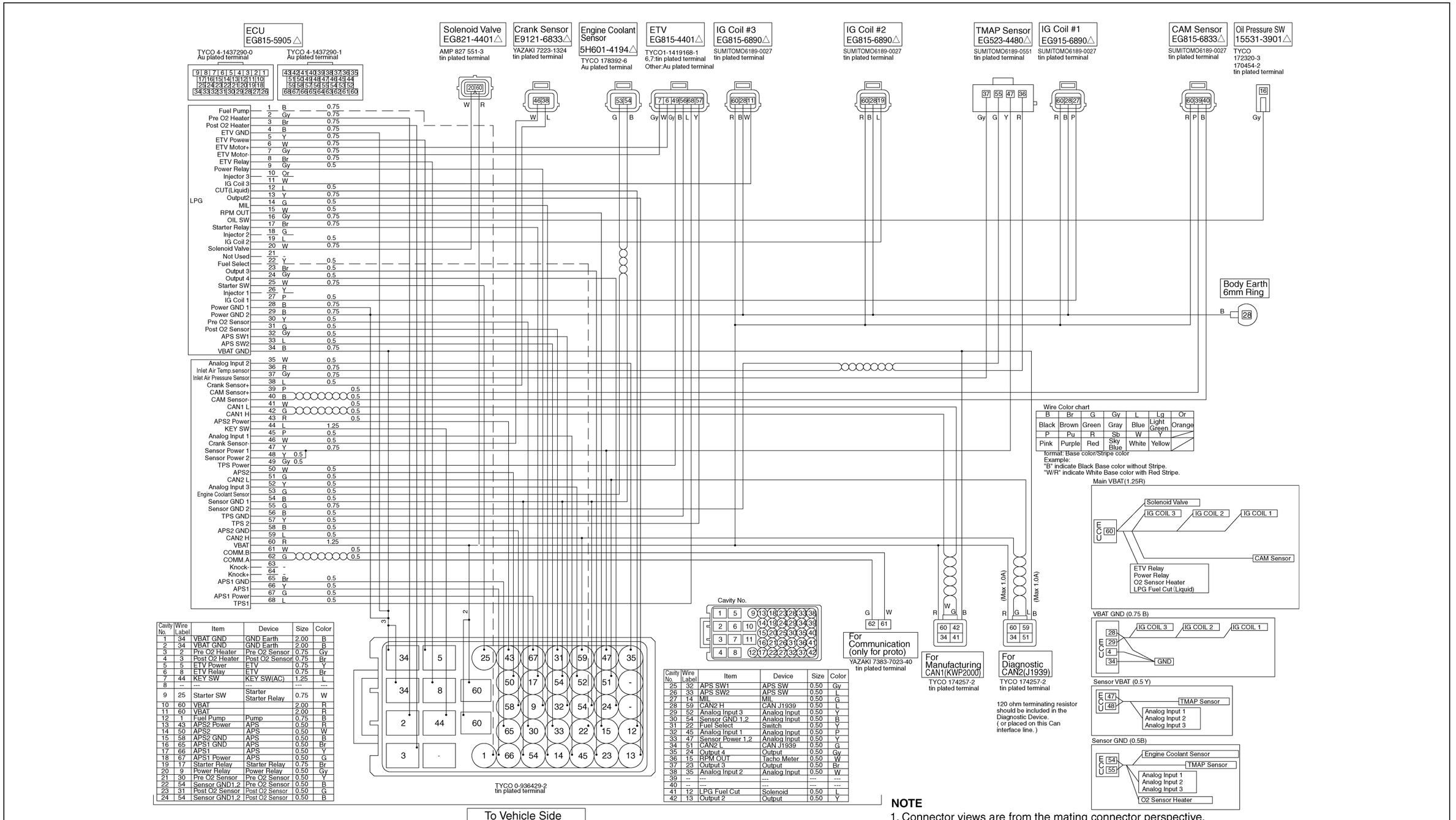
Cavity No.	Wire Label	Item	Device	Size	Color
25	32	APS SW1	APS SW	0.50	B/R
26	33	APS SW2	APS SW	0.50	B/W
27	14	MIL	MIL	0.50	G/W
28	59	CAN2 H	CAN J1939	0.50	L/R
29	52	Analog Input 3	Analog Input	0.50	B/Y
30	54	Sensor GND 1,2	Analog Input	0.50	B
31	--	---	---	---	---
32	45	Analog Input 1	Analog Input	0.50	P/B
33	47	Sensor Power 1,2	Analog Input	0.50	Y
34	51	CAN2 L	CAN J1939	0.50	G/B
35	24	Output 4	Output	0.50	W/B
36	15	RPM OUT	Tacho Meter	0.50	W
37	23	Output 3	Output	0.50	Br
38	35	Analog Input 2	Analog Input	0.50	W/R
39	--	---	---	---	---
40	--	---	---	---	---
41	12	Output 1	Output	0.50	R/L
42	13	Output 2	Output	0.50	Y/G

NOTE
1. Connector views are from the mating connector perspective.

9Y1211108IGT005US


tin plated terminal
CAVITY No.
TYCO 174352-2
pin: tin plated terminal
Fuel Pump
EG821-5202
Body Earth
8 mm Ring
Post O2 Sensor
EG815-1224
Delphi 12160825
pin: Au plated terminal
Pre O2 Sensor
EG815-1224
Delphi 12160825
pin: Au plated terminal
16678-6401
Alternator
6 mm Ring
(with cap)
SUMITOMO
6189-0442
(6189-0443
6185-0403)
tin plated terminal
(11.25 A)
(6.0 A)
(6.0 A)
(21.5 A)
(1.0 A)
(1.0 A)
(17.25 A)
(3.0 A)
(21.5 A)
(0.25 A)
(0.25 A)
(0.25 A)
0.75 mm²
3 mm²
0.5 mm²
8 mm²
0.85 mm²
Fuse 30 A
Fuse 5 A
Fuse 5 A
Slow Blow Fuse 60 A
YAZAKI
7323-1424-40
tin plated terminal
YAZAKI
7332-9623-40
Diode
(3 A or more
200 PIV or more)
ETV Relay
RD451-5438
tin plated terminal
(· Can be used for inductive load
· Coil: 0.25 A or less
· Contact: 20 A or more)
Power Relay
RD451-5421
tin plated terminal
(· Can be used for inductive load
· Coil: 0.25 A or less
· Contact: 40 A or more)
Starter Relay
RD451-5421
tin plated terminal
Tyco 172320-2, 170456-2
tin plated terminal
Starter
67980-3115
Battery
Pre-Heat
OFF
ON
Start
30 AC 19 17 50
Fuse
Power Supply
Power Relay (OEM Device)
(· Can be used for inductive load
· Coil: 0.25 A or less
· Contact: according to OEM DEVICE)
It is necessary to select the fuse, the wire and the relay according to OEM device.
It is necessary to separate the power supply on the vehicle side (OEM device) with the power supply on the engine side.
This main power line should be connected to battery +B terminal directly, not starter +B terminal.
APS Switch 1, 2
APS
APS 1
APS 2
When pump current: 6 A or more
Fuel Pump
Pump Relay
CAN 2
J1939
Analog Input 1
Analog Input 2
Analog Input 3
Charge
TACHO
MIL
Output 1
Output 2
Output 3
Output 4
Output 1 To 4
When current is 0.5 A or more, relay is needed.
NOTE
1. Connector views are from the mating connector perspective.
2. VEHICLE SIDE must be prepared by OEM.
Open connector and terminal: Water-proof processing
3. (※※A) Shows current capacity.
9Y1211108IGT002US

WG972-L-E4, WG972-N-E4



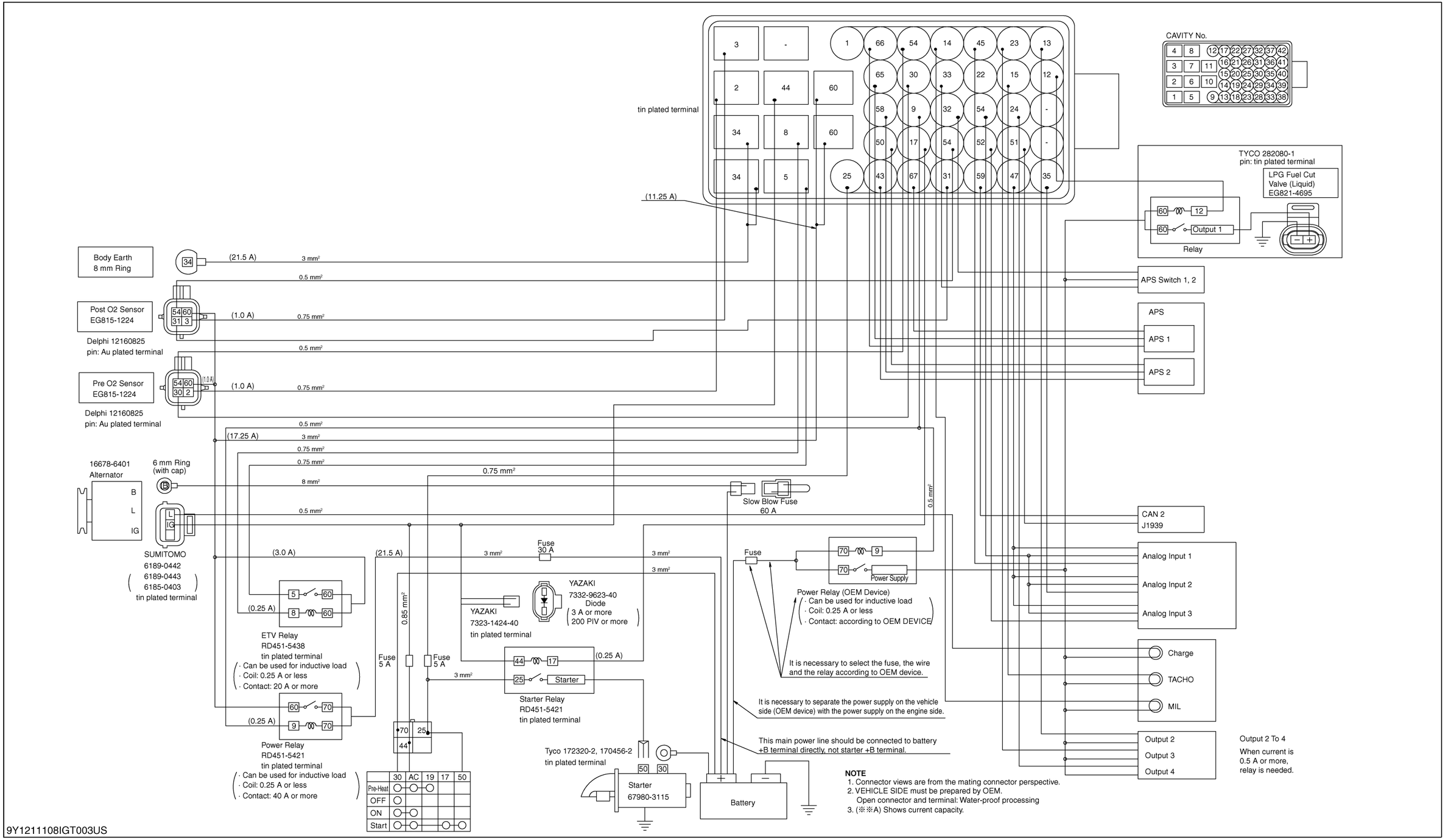
Cavity No.	Wire Label	Item	Device	Size	Color
1	34	VBAT GND	GND Earth	2.00	B
2	34	VBAT GND	GND Earth	2.00	B
3	2	Pre O2 Heater	Pre O2 Sensor	0.75	Gy
4	3	Post O2 Heater	Post O2 Sensor	0.75	Br
5	5	ETV Power	ETV	0.75	Y
6	8	ETV Relay	ETV	0.75	Br
7	44	KEY SW	KEY SW(AC)	1.25	L
8	--	---	---	---	---
9	25	Starter SW	Starter Starter Relay	0.75	W
10	60	VBAT		2.00	R
11	60	VBAT		2.00	R
12	1	Fuel Pump	Pump	0.75	B
13	43	APS2 Power	APS	0.50	R
14	50	APS2	APS	0.50	W
15	58	APS2 GND	APS	0.50	B
16	65	APS1 GND	APS	0.50	Br
17	66	APS1	APS	0.50	Y
18	67	APS1 Power	APS	0.50	G
19	17	Starter Relay	Starter Relay	0.75	Br
20	9	Power Relay	Power Relay	0.50	Gy
21	30	Pre O2 Sensor	Pre O2 Sensor	0.50	Y
22	54	Sensor GND1,2	Pre O2 Sensor	0.50	B
23	31	Post O2 Sensor	Post O2 Sensor	0.50	G
24	54	Sensor GND1,2	Post O2 Sensor	0.50	B

Cavity No.	Wire Label	Item	Device	Size	Color
25	32	APS SW1	APS SW	0.50	Gy
26	33	APS SW2	APS SW	0.50	L
27	14	MIL	MIL	0.50	G
28	59	CAN2 H	CAN J1939	0.50	L
29	52	Analog Input 3	Analog Input	0.50	Y
30	54	Sensor GND 1,2	Analog Input	0.50	B
31	22	Fuel Select	Switch	0.50	Y
32	45	Analog Input 1	Analog Input	0.50	P
33	47	Sensor Power 1,2	Analog Input	0.50	Y
34	51	CAN2 L	CAN J1939	0.50	G
35	24	Output 4	Output	0.50	Gy
36	15	RPM OUT	Tacho Meter	0.50	W
37	23	Output 3	Output	0.50	Br
38	35	Analog Input 2	Analog Input	0.50	W
39	--	---	---	---	---
40	--	---	---	---	---
41	12	LPG Fuel Cut	Solenoid	0.50	L
42	13	Output 2	Output	0.50	Y

NOTE

1. Connector views are from the mating connector perspective.

9Y1211108IGT006US



9Y1211108IGT003US

G GENERAL

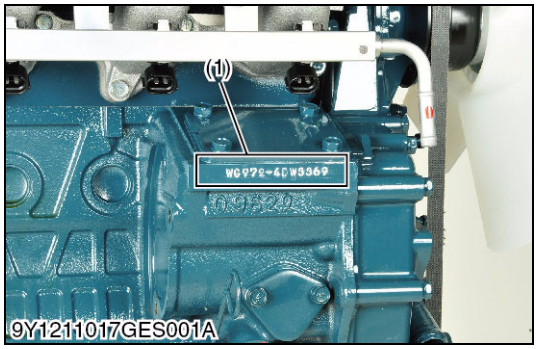
GENERAL

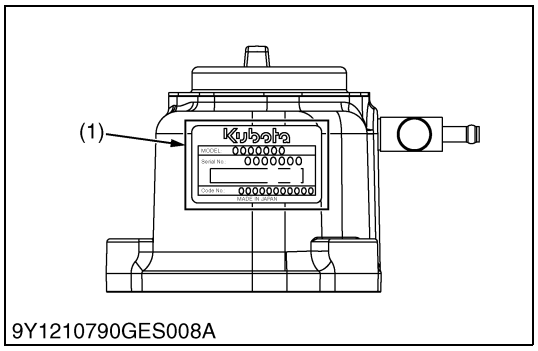
CONTENTS

1. ENGINE IDENTIFICATION

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

When contacting the manufacture, always specify your engine model name, code number and serial number. They are necessary to be identified before the engine can be serviced or parts replaced.





■ **Engine Model Name and Number Label**

The engine model number, the engine serial number and engine code number are written in label.

■ **Engine Serial Number**

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

It indicates month and year of manufacture as follows.

Engine Series

Number	Series	Number	Series
1	05 Series (Include: WG)	5	Air Cooled Gasoline
2	V3 Series	6	GZ, OC, AC, EA and E Series
3	–	7	03 Series
4	SM Series (Include: WG)	8	07 Series

Year of manufacture

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

(1) Engine Serial Number

(To be continued)

(Continued)

Month of manufacture

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

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

(a) (b)(c)(d) (e)
e.g. WG972 - 4 F S 0001

(a) Engine Model Name: **WG972**
(b) Engine Series: 4 indicates WG series
(c) Year: F indicates 2015
(d) Month: S or T indicates September
(e) Lot Number: (**0001 ~ 9999** or **A001 ~ Z999**)

9Y1211108GEG0001US0

[2] TAMPER RESISTANCE

Any modifications to the tamper resistance parts on this engine will cause this engine to be in noncompliance with emission regulations.

9Y1211108GEG0056US0

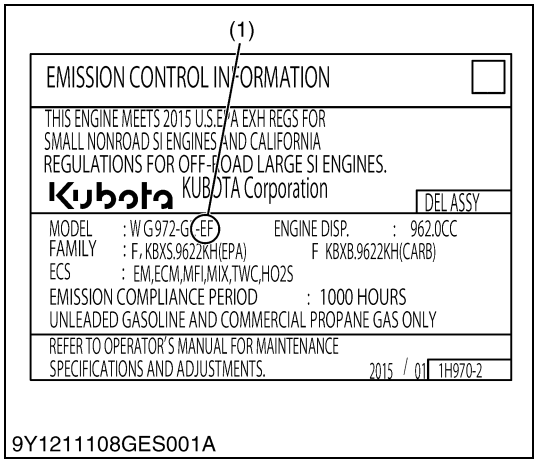
[3] E4 ENGINE

[Example: Engine Model Name WG972-GL-**E4**-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, E4 will be the designation that identifies engine models affected by the next emission phase (See the table below).

When servicing or repairing ###-E4 series engines, use only replacement parts for that specific E4 engine, designated by the appropriate E4 KUBOTA Parts List and perform all maintenance services listed in the appropriate KUBOTA Operator's Manual or in the appropriate E4 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 E4 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. E4 engines are identified with "EF" at the end of the Model designation, on the US EPA label. Please note: E4 is not marked on the engine.



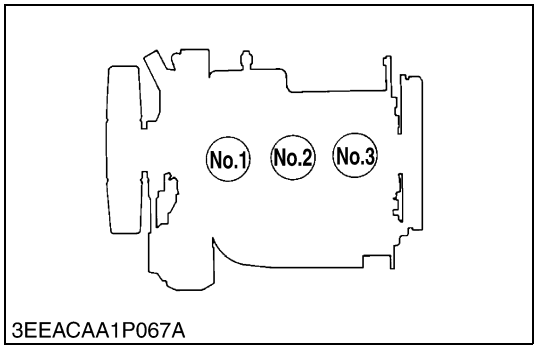
9Y1211108GES001A

Category (1)	Displacement and Output classification	EPA Regulation	CARB Regulation
EF	LSI **/ Family Name: #KBXS#######(EPA) #KBXB#######(CARB)**	Tier 3	Tier 4

(1) "E4" engines are identified with "EF" at the end of the Model designation, on the US EPA label.
"E4" designates EPA Tier 3 / CARB Tier 4 models, depending on engine displacement and output classification.

9Y1211108GEG0002US0

[4] CYLINDER NUMBER



3EEACAA1P067A

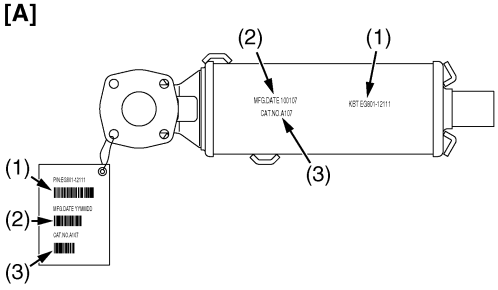
The cylinder numbers of KUBOTA gasoline, gasoline / LPG and natural gas engine are designated as shown in the figure.

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

9Y1211108GEG0003US0

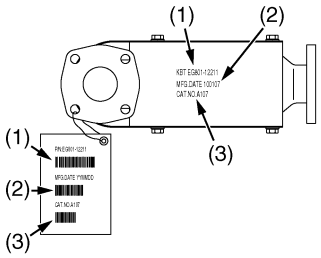
[5] CATALYTIC MUFFLER / CONVERTER

[A]



9Y1210571GES006A

[B]



9Y1210571GES007A

KUBOTA provides the catalytic muffler and converter as the catalyst parts.

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

■ **IMPORTANT**

- **To trace of the catalytic muffler/converter, put down the catalyst identification and engine identification when new service catalytic muffler/converter is installed.**
- **The WG972-E4 engine must use the below catalytic parts.**

Genuin Part	Part No.
CATALYTIC MUFFLER	EG821-1211-##
CATALYTIC CONVERTER	EG821-1221-##

- **Any modifications to the fuel system or any adjustments made on this engine will cause this engine to be in noncompliance with emission regulations.**

■ **NOTE**

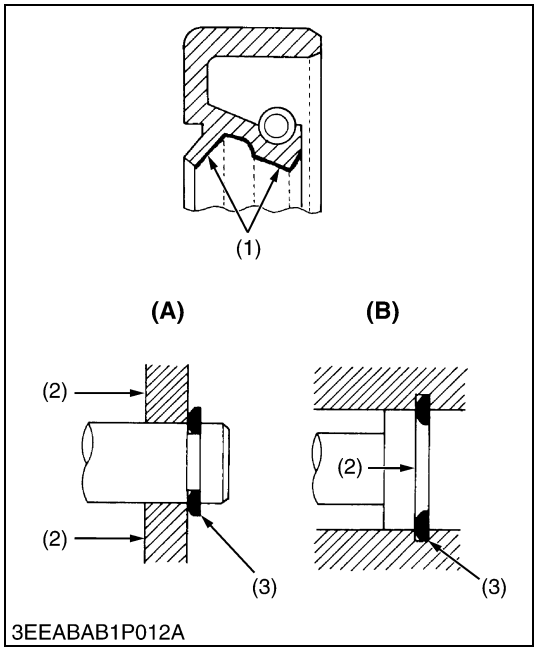
- **New service catalytic muffler/converter has the bar code tag of the catalyst identification as the figure.**
- **Catalyst identification are catalyst lot number, parts number and manufacturing date.**
- **Engine identification are engine model name, code number and serial number.**

(1) Part Number
(2) Manufacturing Date 6 digits
(3) Catalyst Lot Number 4 or 5 digits

[A] CATALYTIC MUFFLER
[B] CATALYTIC CONVERTER

9Y1211108GEG0004US0

2. GENERAL PRECAUTIONS



3EEABAB1P012A

- 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. Do not try to give a heavy load immediately, if not, you can cause serious damage to the engine.

(1) Grease
(2) Force
(3) Sharp Edge
(A) External Snap Ring
(B) Internal Snap Ring

WSM000001GEG0091US0

3. MAINTENANCE CHECK LIST

In order to keep your engine in good working conditions, be sure to follow the maintenance / checking schedule given in the table below. (The schedule applies to an engine in use under normal conditions.)

[WG972-GL-E4]

	Item	Service Interval							
		Every 8 hrs (Daily)	Every 50 hrs (Weekly)	Every 100 hrs	Every 200 hrs	Every 1000 hrs	Every after 1000 hrs	Every 1 year	Every 2 years
	Checking and Cleaning each part	☆							
	Checking and filling engine oil	☆							
	Checking and filling radiator coolant	☆							
	Checking air cleaner element	if necessary							
	Checking the connector of fuel hoses and clamps between gas tank and gas mixer (Gas line)	☆							
	Cleaning air cleaner primary element	if necessary	☆						
	Checking fuel hoses and clamps (Gasoline line)		☆						
	Checking fuel leakage of fuel hoses and clamps between gas tank and gas mixer (Gas line)		☆						
	Checking battery electrolyte level		☆						
	Cleaning spark plug			if necessary					
	Adjusting spark plug			if necessary					
	Checking fuel filter (Gasoline line)			☆					
	Checking fan belt tension and damage			☆					
	Adjusting fan belt tension			if necessary					
	Replacing engine oil		★		☆				
	Replacing oil filter cartridge		★		☆				
	Checking fuel tank setting condition (Gas line)	if necessary			☆				
	Checking battery specific gravity				☆				
	Checking radiator hoses and clamp bands				☆				
*1	Replacing spark plug					☆			
	Checking hot water line of gas regulator (Gas line)					☆			
	Adjusting valve clearance					☆			
	Cleaning combustion chamber						if necessary		
	Replacing fuel filter (Gasoline line)			if necessary				☆	
*1 *2 *3	Replacing air cleaner primary element							☆	
*1 *2 *3	Replacing air cleaner secondary element							☆	
	Cleaning fuel tank (Gasoline line)							☆	
*1	Replacing fuel hoses and clamps (Gasoline line)							☆	
	Replacing radiator coolant							☆	
	Cleaning radiator and water jacket							☆	

(To be continued)

(Continued)
[WG972-GL-E4]

Item		Service Interval							
		Every 8 hrs (Daily)	Every 50 hrs (Weekly)	Every 100 hrs	Every 200 hrs	Every 1000 hrs	Every after 1000 hrs	Every 1 year	Every 2 years
*1	Replacing intake hoses and clamp bands (Intake air line)								☆
*1	Replacing fuel hoses and clamps between gas tank and gas mixer (Gas line)								☆
	Replacing hot water line of gas regulator (Gas line)								☆
	Checking inner parts of gas regulator (Gas line)								☆
	Replacing breather tube								☆
	Replacing Battery								☆
	Replacing radiator hoses and clamp bands								☆

★ Change engine oil and replace oil filter cartridge after the first 50 hours of operation.
*1 This is not necessary to keep the emission related warranty valid.
To ensure the best quality and reliability, use new KUBOTA Genuine parts or their equivalents for repair and replacement, whenever you have maintenance done.
*2 Change more often when operating under dusty conditions.
*3 Replace the element after 6 times cleaning.

9Y1211108GEG0005US0

In order to keep your engine in good working conditions, be sure to follow the maintenance / checking schedule given in the table below. (The schedule applies to an engine in use under normal conditions.)

[WG972-G-E4]

	Item	Service Interval							
		Every 8 hrs (Daily)	Every 50 hrs (Weekly)	Every 100 hrs	Every 200 hrs	Every 1000 hrs	Every after 1000 hrs	Every 1 year	Every 2 years
	Checking and Cleaning each part	☆							
	Checking and filling engine oil	☆							
	Checking and filling radiator coolant	☆							
	Checking air cleaner element	if necessary							
	Cleaning air cleaner primary element	if necessary	☆						
	Checking fuel hoses and clamps		☆						
	Checking battery electrolyte level		☆						
	Cleaning spark plug			if necessary					
	Adjusting spark plug			if necessary					
	Checking fuel filter			☆					
	Checking fan belt tension and damage			☆					
	Adjusting fan belt tension			if necessary					
	Replacing engine oil		★		☆				
	Replacing oil filter cartridge		★		☆				
	Checking battery specific gravity				☆				
	Checking radiator hoses and clamp bands				☆				
*1	Replacing spark plug					☆			
	Adjusting valve clearance					☆			
	Cleaning combustion chamber						if necessary		
	Replacing fuel filter			if necessary				☆	
*1 *2 *3	Replacing air cleaner primary element							☆	
*1 *2 *3	Replacing air cleaner secondary element							☆	
	Cleaning fuel tank							☆	
*1	Replacing fuel hoses and clamps							☆	
	Replacing radiator coolant							☆	
	Cleaning radiator and water jacket							☆	
*1	Replacing intake hoses and clamp bands								☆
	Replacing breather tube								☆
	Replacing Battery								☆
	Replacing radiator hoses and clamp bands								☆

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

*1 This is not necessary to keep the emission related warranty valid.

To ensure the best quality and reliability, use new KUBOTA Genuine parts or their equivalents for repair and replacement, whenever you have maintenance done.

*2 Change more often when operating under dusty conditions.

*3 Replace the element after 6 times cleaning.

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In order to keep your engine in good working conditions, be sure to follow the maintenance / checking schedule given in the table below. (The schedule applies to an engine in use under normal conditions.)

[WG972-L-E4, WG972-N-E4]

	Item	Service Interval							
		Every 8 hrs (Daily)	Every 50 hrs (Weekly)	Every 100 hrs	Every 200 hrs	Every 1000 hrs	Every after 1000 hrs	Every 1 year	Every 2 years
	Checking and Cleaning each part	☆							
	Checking and filling engine oil	☆							
	Checking and filling radiator coolant	☆							
	Checking air cleaner element	if necessary							
	Checking the connector of fuel pipe and clamps between gas tank and gas mixer	☆							
	Cleaning air cleaner primary element	if necessary	☆						
	Checking fuel leakage of fuel pipe and clamps between gas tank and gas mixer		☆						
	Checking battery electrolyte level		☆						
	Cleaning spark plug			if necessary					
	Adjusting spark plug			if necessary					
	Checking fan belt tension and damage			☆					
	Adjusting fan belt tension			if necessary					
	Replacing engine oil		★		☆				
	Replacing oil filter cartridge		★		☆				
	Checking fuel tank setting condition (Gas line)	if necessary			☆				
	Checking battery specific gravity				☆				
	Checking radiator hoses and clamp bands				☆				
*1	Replacing spark plug					☆			
	Checking hot water line of gas regulator					☆			
	Adjusting valve clearance					☆			
	Cleaning combustion chamber						if necessary		
*1 *2 *3	Replacing air cleaner primary element							☆	
*1 *2 *3	Replacing air cleaner secondary element							☆	
	Replacing radiator coolant							☆	
	Cleaning radiator and water jacket							☆	
*1	Replacing intake hoses and clamp bands (Intake air line)								☆
*1	Replacing fuel hoses and clamps between gas tank and gas mixer								☆
	Replacing hot water line of gas regulator								☆
	Checking inner parts of gas regulator								☆
	Replacing breather tube								☆
	Replacing Battery								☆
	Replacing radiator hoses and clamp bands								☆

(To be continued)

(Continued)

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

*1 This is not necessary to keep the emission related warranty valid.

To ensure the best quality and reliability, use new KUBOTA Genuine parts or their equivalents for repair and replacement, whenever you have maintenance done.

*2 Change more often when operating under dusty conditions.

*3 Replace the element after 6 times cleaning.

9Y1211108GEG0007US0

CAUTION

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

■ NOTE

Engine oil

- Engine oil should have properties of API classification SL or higher.
- Oil used in the engine should have API classification and Proper SAE Engine Oil Viscosity according to the ambient temperatures where the engine is operated.

Above 25 °C (77 °F)	SAE30 or SAE10W-30, 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

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

Fuel

- Fuel is flammable and can be dangerous. You should handle fuel carefully.

■ Gasoline [WG972-GL-E4, WG972-G-E4]

- Use unleaded gasoline and E10 only.
- DO NOT USE gasoline blended with methyl alcohol.

■ Gaseous Fuel

- Be sure that the fill up valve and the liquid withdrawal valve are closed.
- Be sure that LPG hose or CNG hose is connected with the liquid withdrawal valve.
- Be sure that LPG tank or CNG tank is set firmly not to move by machine vibration.
- Never use LPG fuel on the WG972-G, N engine. Otherwise severe damage will occur.
- Never use CNG fuel on the WG972-G, L, GL engine. Otherwise severe damage will occur.

LPG [WG972-GL-E4, WG972-L-E4]

- Use commercial Propane Gas only.
- Equivalent to Propane HD-5 of GPA* standards.
- Fuel tank is liquid withdrawal type.

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

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

CNG [WG972-N-E4]

- Use commercial Compressed Natural Gas only.
- Consult KUBOTA for further info of fuel used.

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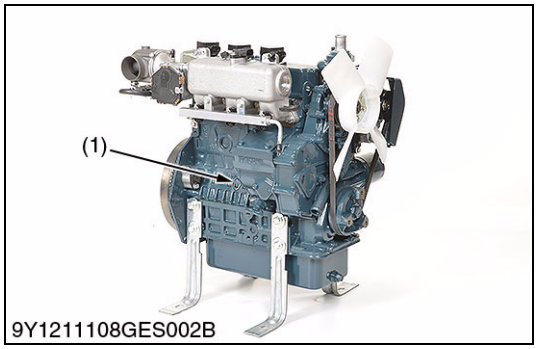
4. CHECK AND MAINTENANCE

[1] DAILY CHECK POINTS



Checking Engine Oil Level

1. Check the engine oil level before starting or more than 5 minutes after stopping the engine.
2. To check the oil level, draw out the dipstick (1), wipe it clean, reinsert it, and draw it out again.
   Check to see that the oil level lies between the two notches.
3. If the level is too low, add new oil to the specified level.
4. After adding oil, wait more than 5 minutes and check the oil level again. It takes some time for the oil to drain down to the oil pan.

■ **IMPORTANT**

- **When using oil of different brands from the previous one, be sure to drain all the previous oil before adding the new engine oil. Never mix two different types of oil.**
- **Engine oil should have properties of API classification SL or higher.**
- **Change the type of engine oil according to the ambient temperature.**

Above 25 °C (77 °F)	SAE30 or SAE10W-30, 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

■ **NOTE**

- **Be sure to inspect the engine, locating it on a horizontal place. If set on gradients, accurately, oil quantity may not be measured.**
- **Be sure to keep the oil level between upper and lower limits of the dipstick. Too much oil may cause a drop in output or excessive blow-by gas. On the closed breather type engine in which mist is sucked through port, too much oil may caused oil hammer. While too little oil, may seize the engine's rotating and sliding parts.**

(1) Dipstick

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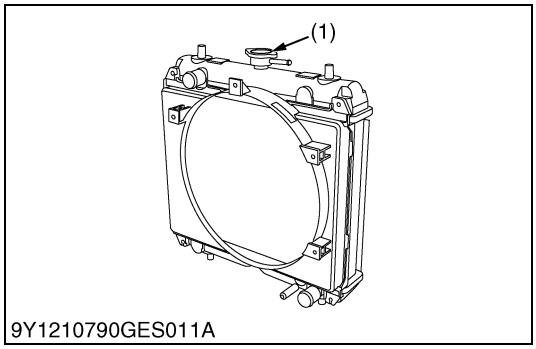

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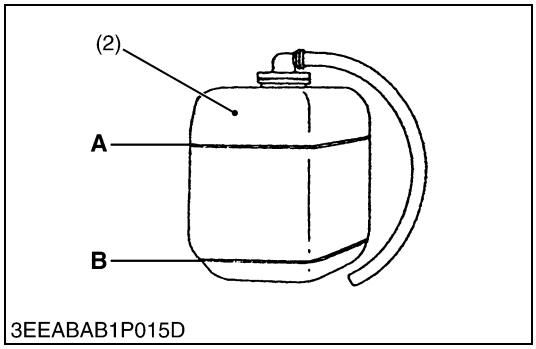

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Checking and Filling Radiator Coolant

1. Without recovery tank:
   Remove the radiator cap (1) and check to see that the coolant level is just below the port.
   With recovery tank (2):
   Check to see that the coolant level lies between **FULL "A"** and **LOW "B"**.
2. If coolant level is too low, check the reason for decreasing coolant.
   (Case 1)
   If coolant is decreasing by evaporation, fill only fresh, soft water.
   (Case 2)
   If coolant is decreasing by leak, fill coolant of the same manufacture and type in the specified mixture ratio (fresh, soft water and L.L.C.). If the coolant brand cannot be identified, drain out all of the remaining coolant and refill with a totally new brand of coolant mix.

CAUTION

- **Do not remove the radiator cap until coolant temperature is below its boiling point. Then loosen the cap slightly to relieve any excess pressure before removing the cap completely.**

IMPORTANT

- **During filling the coolant, air must be vented from the engine coolant passages. The air vents by jiggling the radiator upper and lower hoses.**
- **Be sure to close the radiator cap securely. If the cap is loose or improperly closed, coolant may leak out and the engine could overheat.**
- **Do not use an antifreeze and scale inhibitor at the same time.**
- **Never mix the different type or brand of L.L.C..**

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

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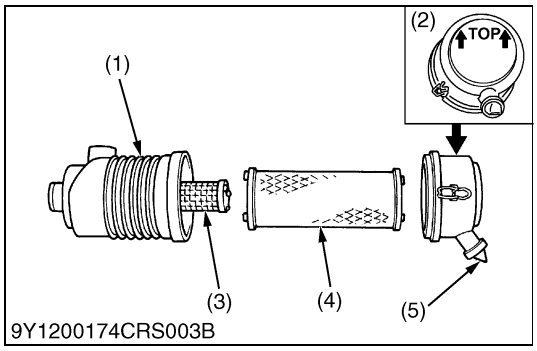

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Checking Air Cleaner Element (If Necessary)

1. Remove the cover (2) and the primary element (4) in the air cleaner.
2. Check the dust in the cover (2), the primary (4) and secondary (3) element.
3. If the primary element (4) is stained, clean it.

(When reassembling)

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

NOTE

- **Avoid touching the element except when cleaning.**
- **The air cleaner uses a dry element, never apply oil.**
- **Do not operate the engine with filter element removed.**
- **Do not touch the secondary element (3) except in cases replacing is required.**

(1) Air cleaner body
(2) Cover
(3) Secondary element
(4) Primary element
(5) Evacuator valve

9Y1211108GEG0017US0

Checking Fuel Tank Setting Condition (Gas Line) (If Necessary) [WG972-GL, WG972-L, WG972-N]

1. Check that LPG or CNG fuel tank is installed firmly.
2. Be sure that the fill up valve and liquid withdrawal valve of the LPG or CNG fuel tank can be opened and closed easily.

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Checking the Connector of Fuel Pipe and Clamps (Gas Line) [WG972-GL, WG972-L, WG972-N]

1. Check the all connectors of fuel pipe and clamps between gas tank and gas mixer for leaks.

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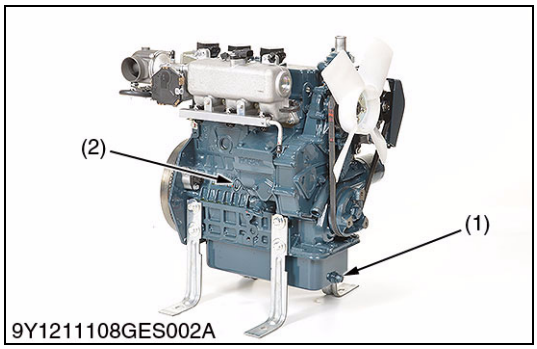
[2] CHECK POINTS OF INITIAL 50 HOURS



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Replacing Engine Oil

CAUTION

- **Be sure to stop engine before replacing engine oil.**

1. Start and warm up the engine for approx. 5 minutes.
2. Place an oil pan underneath the engine.
3. To drain the used oil, remove the drain plug (1) at the bottom of the engine and drain the oil completely.
4. Screw the drain plug (1).
5. Fill new oil up to upper line on the dipstick (2).

■ **IMPORTANT**

- **When using an oil of different brands or viscosity from the previous one, remove all of the old oil.**
- **Never mix two different types of oil.**
- **Engine oil should have properties of API classification SL or higher.**
- **Use the proper SAE Engine Oil according to ambient temperature.**

Above 25 °C (77 °F)	SAE30 or SAE10W-30, 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	3.4 L 0.90 U.S.gals

Tightening torque	Drain plug	33 to 37 N·m 3.3 to 3.8 kgf·m 24 to 27 lbf·ft

(1) Drain Plug (2) Dipstick

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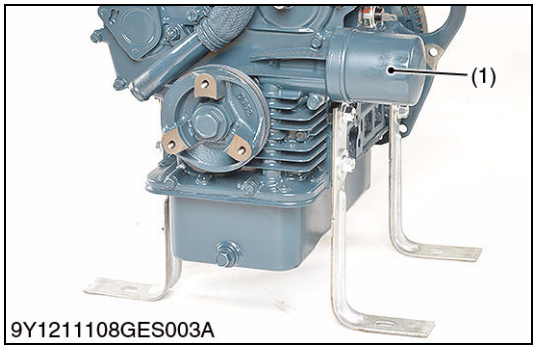


Replacing Oil Filter Cartridge

CAUTION
- **Be sure to stop the engine before replacing oil filter cartridge.**
- **Allow engine to cool down sufficiently, oil can be hot and cause burns.**

1. Remove the oil filter cartridge (1) with the filter wrench.
2. Apply a slight coat of oil onto the new cartridge gasket.
3. To install the new cartridge, screw it in by hand. Over tightening may cause deformation of rubber gasket.
4. After the new cartridge has been replaced, the engine oil level normally decreases a little. Thus, operate the engine for a while and check for oil leaks through the seal before checking the engine oil level. Add oil if necessary.

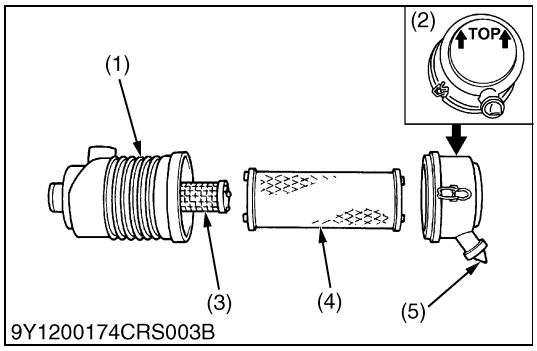
IMPORTANT
- **To prevent serious damage to the engine, replacement element must be highly efficient. Use only a KUBOTA genuine filter or its equivalent.**

NOTE
- **Wipe off any oil sticking to the machine completely.**

(1) Engine Oil Filter Cartridge

9Y1211108GEG0021US0

[3] CHECK POINTS OF EVERY 50 HOURS



Cleaning Primary Air Cleaner Element

1. Open the evacuator valve once a week under ordinary conditions - or daily when used in a dusty place. This will get rid of large particles of dust and dirt.
2. Wipe the inside air cleaner clean with cloth if it is dirty or wet.
3. To clean the element, use clean dry compressed air on the inside of the element.
   Air pressure at the nozzle must be under 205 kPa (2.09 kgf/cm^2, 30.5 psi).
   Keep reasonable distance between the nozzle and the filter.
4. If the primary element (4) is stained heavily, replace it soon.
   At this time, replace the secondary element (3) too.

IMPORTANT
- **Make sure the wing bolt for the element is tight enough. If it is loose, dust and dirt may be sucked, wearing down the cylinder liner and piston ring earlier and thereby resulting in poor power output.**
- **Do not overservice the air cleaner element.**
  Overservicing may cause dirt to enter the engine causing premature wear. Use the dust indicator as a guide on when to service.

NOTE
- **Avoid touching the element except when cleaning.**
- **Replace the element once a year or every 6th cleaning.**
- **The secondary element (3) should be removed only if it is to be replaced.**
- **To protect the engine, do not remove the secondary element (3) in servicing the primary element (4).**

(1) Air cleaner body
(2) Cover
(3) Secondary element
(4) Primary element
(5) Evacuator valve

9Y1211108GEG0022US0

CAUTION
- **Stop the engine before checking or replacing the fuel pipes. Broken fuel pipes can cause fires.**
- **Make sure to check the fuel line periodically. The fuel line is subject to wear and aging, fuel may leak out onto the operating engine, causing a fire.**

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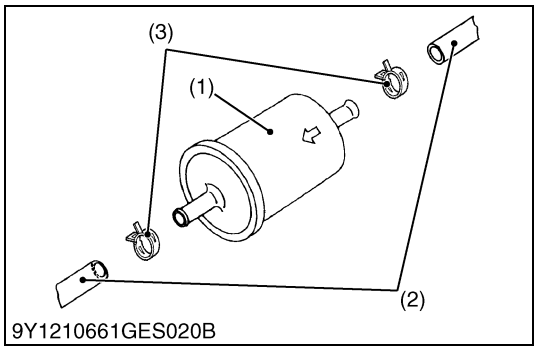

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Checking Fuel Pipes and Clamps (Gasoline Line) [WG972-GL, WG972-G]

1. Check whether the clamps are loose. If the clamps are loose, apply oil to the screw of the clamp, and tighten the clamp securely.
2. Check whether the fuel pipes are worn out or damaged. If any worn or damaged are found, replace them and clamps at once.

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

■ **NOTE**
- **Replace the fuel hose together with the clamp every year. However, since fuel pipes are made of rubber, if the fuel hose and clamp are found to be damaged or deteriorate before one year passes, replace or repair them at once.**

(1) Gasoline Fuel Filter (3) Clamp
(2) Fuel Hose

9Y1211108GEG0024US0

Checking Fuel Leakage of Fuel Pipes and Clamps (Gas Line) [WG972-GL, WG972-L, WG972-N]

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

1. To check all connections for leaks between the fuel tank and gas mixer, use a soap solution or equivalent.
2. Turn on the gas at low idling rpm. Bubbles will indicate a loose connection.
3. If any leakages are found, correct leakage or replace the hose.

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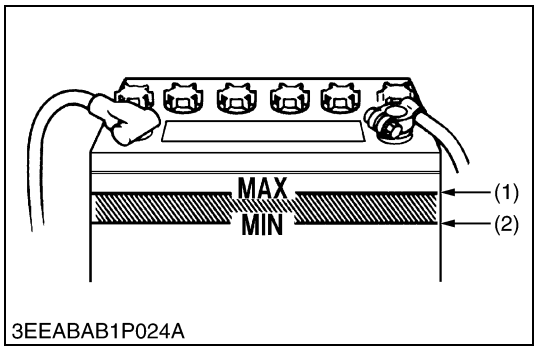

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Checking Battery Electrolyte Level

1. Check the battery electrolyte level.
2. If the level is below than lower level line, add the distilled water to pour level of each cell.

CAUTION
- **Never remove the vent plugs while the engine is operating.**
- **Keep electrolyte away from eyes, hands and clothes. If you are spattered with it, wash it away completely with water immediately and get medical attention.**
- **Wear eye protection and rubber gloves when working around battery.**

(1) Maximum (2) Minimum

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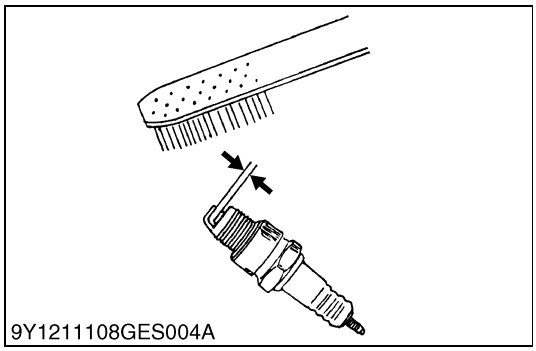
[4] CHECK POINTS OF EVERY 100 HOURS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Cleaning Spark Plug (If Necessary)

1. Remove the spark plug, and remove carbon from the electrode with a wire brush or other tools.
2. After cleaning, be sure to adjust for proper clearance.

■ **IMPORTANT**

- **If the spark plug electrode or its insulator is soiled or is covered with deposited carbon, it may cause engine trouble.**

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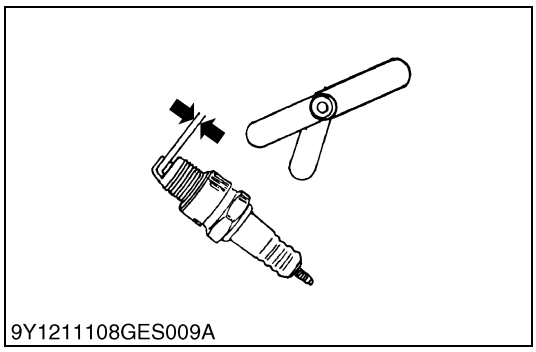
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Adjusting Spark Plug (If Necessary)

1. Measure the spark plug gap with a feeler gauge, and repair or replace the spark plug if the measured gap differs from the factory specification.
2. Replace the spark plug if the electrode or the insulator is deformed or cracked.
3. Tighten the spark plug with a plug wrench.

■ **IMPORTANT**

- **If the spark plug electrode or its insulator is soiled or is covered with deposited carbon, it may cause engine trouble.**

(When reassembling)

- Put the high tension cord cap inside the spark plug terminal firmly.
- Make sure that the cylinder number is corresponding to the high tension cord number.
- Wrong connection causes high temperature on catalytic muffler/converter.

Spark plug gap	Factory specification	0.70 to 0.80 mm 0.029 to 0.032 in.

Spark plug	NGK BKR6E

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

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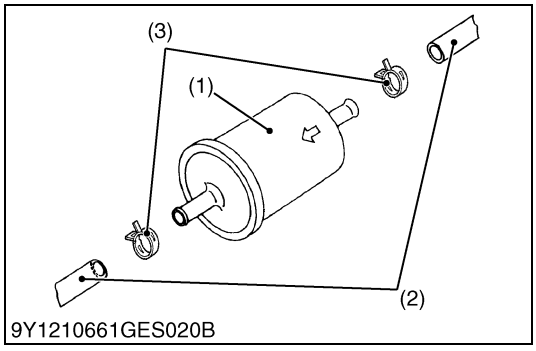

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Checking Fuel Filter (Gasoline Line) [WG972-GL, WG972-G]

1. Check the fuel filter with visual check.
2. If the fuel filter is dirty, replace it.

CAUTION

- **Stop the engine when trying to check and clean the fuel filter.**
- **Gasoline fuel is extremely flammable, so avoid fires.**

(1) Gasoline Fuel Filter
(2) Fuel Hose
(3) Clamp

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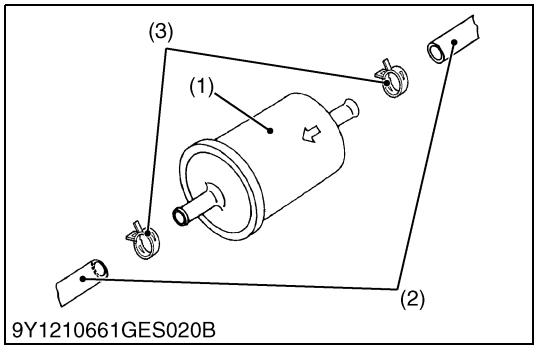

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Replacing Fuel Filter (Gasoline Line) (If Necessary) [WG972-GL, WG972-G]

1. Loosen clamps and remove the fuel hoses.
2. Replace the fuel filter with the new one.

CAUTION

- **Stop the engine when trying to check and clean the fuel filter.**
- **Gasoline fuel is extremely flammable, so avoid fires.**

(1) Gasoline Fuel Filter
(2) Fuel Hose
(3) Clamp

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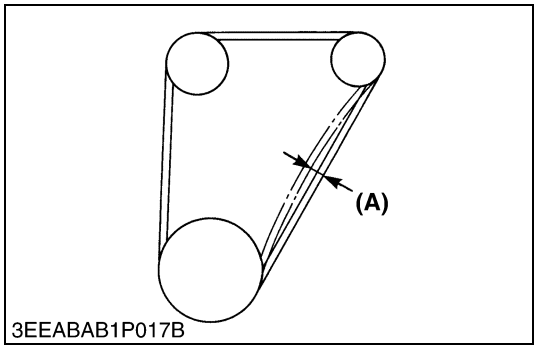

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Checking Fan Belt Tension

1. Measure the deflection **(A)**, depressing the belt halfway between the fan drive pulley and alternator pulley at specified force 98 N (10 kgf, 22 lbf).
2. If the measurement is not within the factory specifications, adjust the fan belt tension.

Deflection **(A)**	Factory specification	7.0 to 9.0 mm 0.28 to 0.35 in.

(A) Deflection

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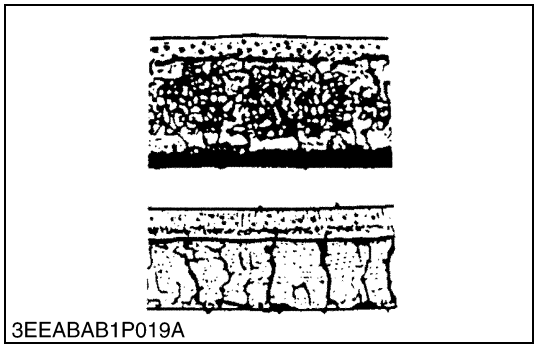
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Checking Fan Belt Damage and Wear

1. Check the fan belt for damage.
2. If the fan belt is damaged, replace it.
3. Check if the fan belt is worn and sunk in the pulley groove.
4. If the fan belt is nearly worn out and deeply sunk in the pulley groove, replace it.

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

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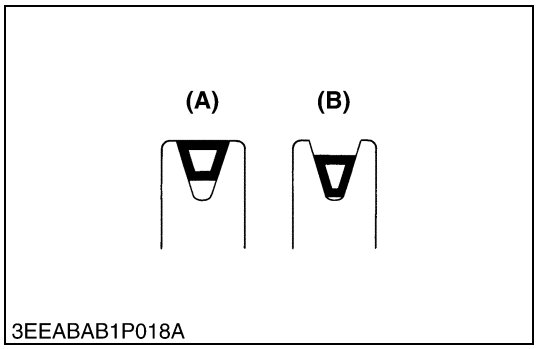

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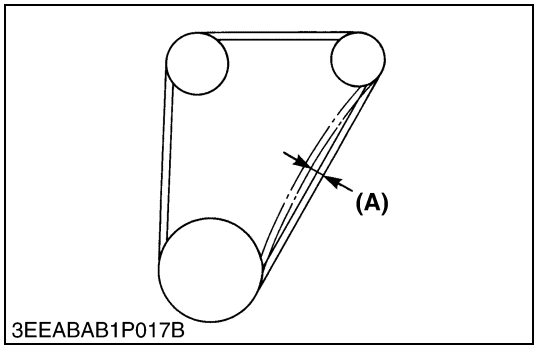

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Adjusting Fan Belt Tension (If Necessary)

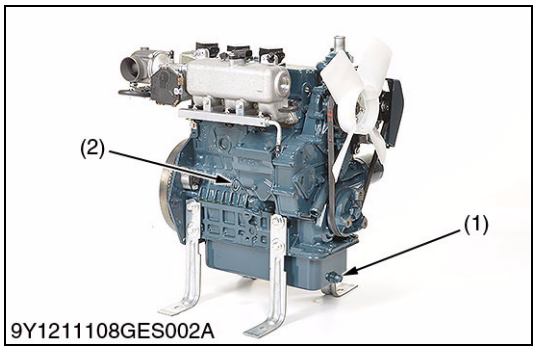
1. Loosen the alternator mounting screws.
2. Relocate the alternator to adjust fan belt tension with the specified deflection.

Deflection **(A)**	Factory specification	7.0 to 9.0 mm 0.28 to 0.35 in.

(A) Deflection

9Y1211108GEG0032US0

[5] CHECK POINTS OF EVERY 200 HOURS



Replacing Engine Oil

CAUTION

- **Be sure to stop engine before replacing engine oil.**

1. Start and warm up the engine for approx. 5 minutes.
2. Place an oil pan underneath the engine.
3. To drain the used oil, remove the drain plug (1) at the bottom of the engine and drain the oil completely.
4. Screw the drain plug (1).
5. Fill new oil up to upper line on the dipstick (2).

IMPORTANT

- **When using an oil of different brands or viscosity from the previous one, remove all of the old oil.**
- **Never mix two different types of oil.**
- **Engine oil should have properties of API classification SL or higher.**
- **Use the proper SAE Engine Oil according to ambient temperature.**

Above 25 °C (77 °F)	SAE30 or SAE10W-30, 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	3.4 L 0.90 U.S.gals

Tightening torque	Drain plug	33 to 37 N·m 3.3 to 3.8 kgf·m 24 to 27 lbf·ft

(1) Drain Plug (2) Dipstick

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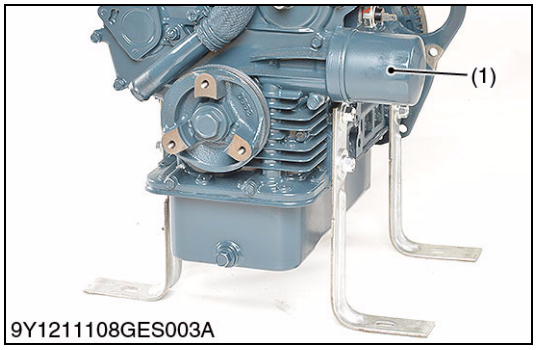

Replacing Oil Filter Cartridge

CAUTION

- **Be sure to stop the engine before replacing oil filter cartridge.**
- **Allow engine to cool down sufficiently, oil can be hot and cause burns.**

1. Remove the oil filter cartridge (1) with the filter wrench.
2. Apply a slight coat of oil onto the new cartridge gasket.
3. To install the new cartridge, screw it in by hand. Over tightening may cause deformation of rubber gasket.
4. After the new cartridge has been replaced, the engine oil level normally decreases a little. Thus, operate the engine for a while and check for oil leaks through the seal before checking the engine oil level. Add oil if necessary.

IMPORTANT

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

NOTE

- **Wipe off any oil sticking to the machine completely.**

(1) Engine Oil Filter Cartridge

9Y1211108GEG0021US0

Checking Fuel Tank Setting Condition (Gas Line) [WG972-GL, WG972-L, WG972-N]

1. Check that LPG or CNG fuel tank is installed firmly.
2. Be sure that the fill up valve and liquid withdrawal valve of the LPG or CNG fuel tank can be opened and closed easily.

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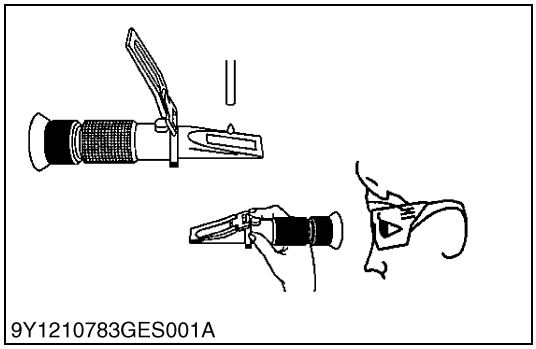

9Y1210783GES001A

Checking 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, filling water, or charging).**
- **If the gas that is generated is ignited by an ignition source, it may explode so be very careful with sparks and fire.**
- **Keep your body and face as far away from the battery as you can when performing maintenance and inspection.**
- **Do not allow people who do not know how to handle a battery or who do not sufficiently understand the danger perform inspection or maintenance.**

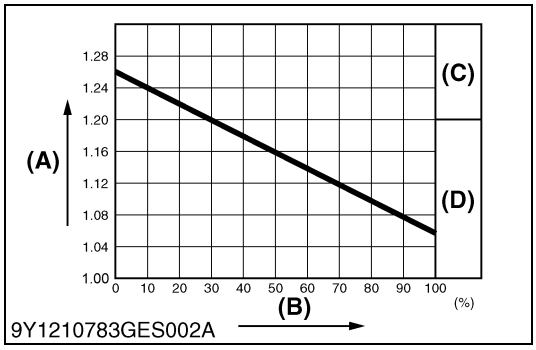
(Measurement items)

■ **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	**(C) Good**
(B) Discharge	**(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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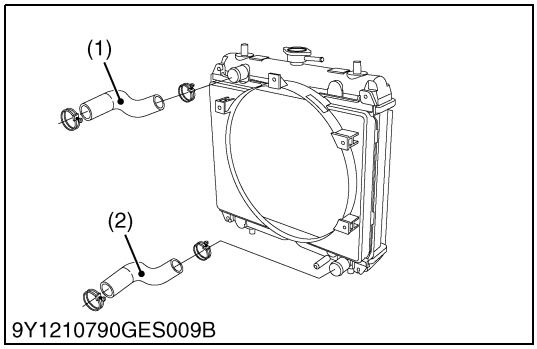


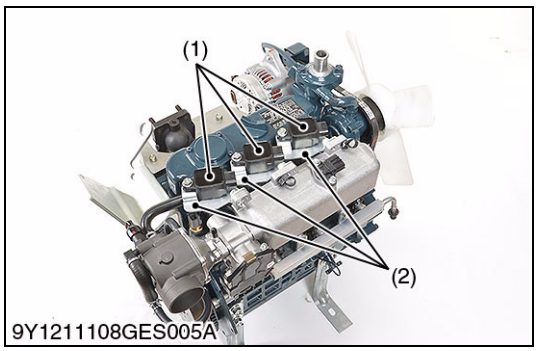
Checking Radiator Hoses and Clamp Bands

1. Check to see if the radiator hoses are properly fixed every 200 hours of operation or every six months, whichever comes first.
2. If the clamp is loose, apply oil to the threads and retighten it securely.
3. The coolant hose is made of rubber and tends to age. It must be replaced every two years. Also replace the clamp and tighten it securely.

(1) Upper Hose (2) Lower Hose

9Y1211108GEG0034US0

[6] CHECK POINTS OF EVERY 1000 HOURS



Replacing Spark Plug

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

■ **IMPORTANT**

(When reassembling)

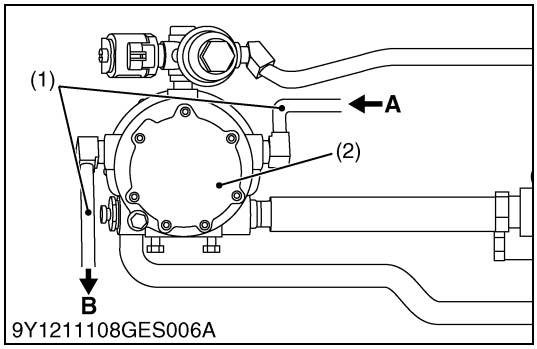
- **Put the high tension cord cap inside the spark plug terminal firmly.**
- **Make sure that the cylinder number is corresponding to the high tension cord number.**
- **Wrong connection causes high temperature on catalytic muffler/converter.**

Spark plug	NGK BKR6E

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

(1) Ignition Coil (2) Ignition Coil Stay

9Y1211108GEG0035US0

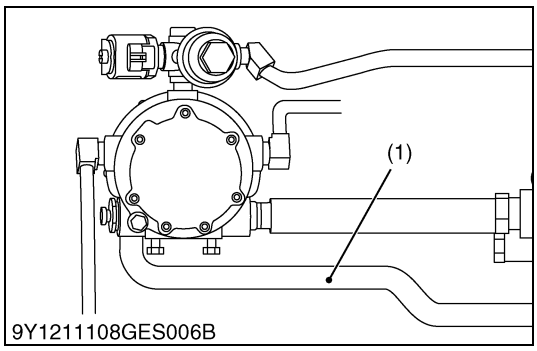


Checking Hot Water Line of Gas Regulator (Gas Line) [WG972-GL, WG972-L, WG972-N]

1. Check the coolant hoses (1) are not damaged.
2. If the coolant hoses (1) are damaged, replace it.
3. Check the hot water lines are not leaking.

(1) Coolant Hose **A: Hot water IN**
(2) Regulator with Vaporizer **B: Hot water OUT**

9Y1211108GEG0036US0

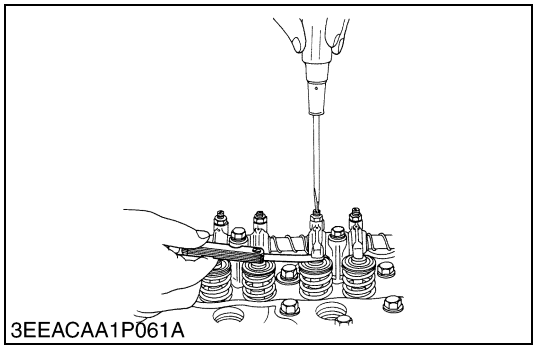


Checking Balance Hose of Gas Regulator (Gas Line) [WG972-GL, WG972-L, WG972-N]

1. Check the balance hose (1) is not damaged.
2. If the balance hose (1) is damaged, replace it.

(1) Balance Hose

9Y1211108GEG0037US0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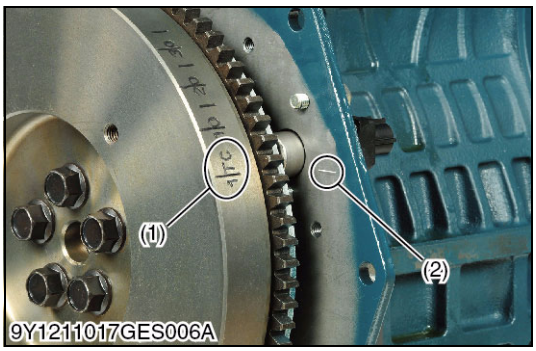

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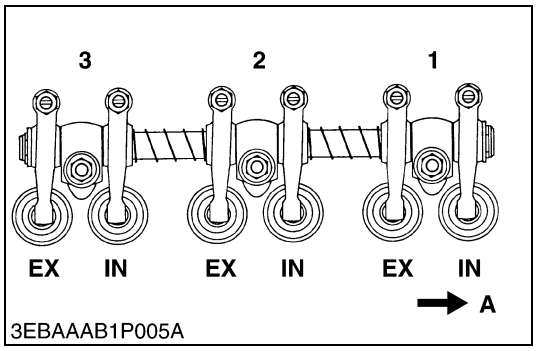

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Checking Valve Clearance

■ **IMPORTANT**

- **The valve clearance must be checked and adjusted when engine is cold.**

1. Remove the cylinder head cover and the spark plugs.
2. Align the **"1TC"** mark (1) on the flywheel and alignment mark (2) on the rear end plate so that the No. 1 piston comes to the compression top dead center.
3. Check the following valve clearance marked with "★" using a feeler gauge.
4. If the clearance is not within the factory specifications, adjust with the adjusting screw.
5. Then turn the flywheel 6.28 rad (360 °), and align the **"1TC"** mark (1) on the flywheel and alignment mark (2) on the rear end plate so that the No. 1 piston comes to the overlap position.
6. Check the following valve clearance marked with "☆" using a feeler gauge.
7. If the clearance is not within the factory specifications, adjust with the adjusting screw.

Adjustable Cylinder Location of Piston	Valve Arrangement	
	Intake valve	Exhaust valve
No. 1	★	★
No. 2	☆	★
No. 3	★	☆

★: When No. 1 piston is at the compression top dead center position.
☆: When No. 1 piston is at the overlap position.

Intake and exhaust valve clearance (cold)	Factory specification	0.145 to 0.185 mm 0.00571 to 0.00728 in.

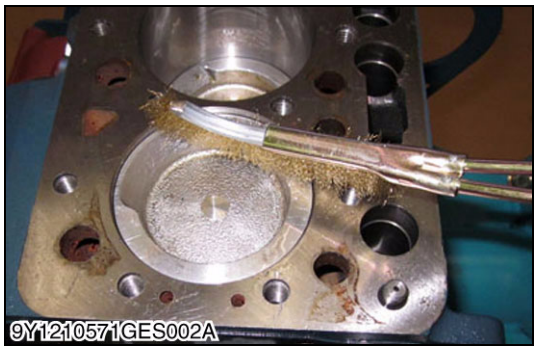
■ **NOTE**

- **The sequence of cylinder numbers is given as No. 1, No. 2 and No. 3 starting from the gear case side.**
- **After adjusting the valve clearance, secure the adjusting screw with the lock nut.**

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

9Y1211108GEG0038US0

[7] CHECK POINTS OF EVERY AFTER 1000 HOURS



Cleaning Combustion Chamber (If Necessary)

1. Remove the breather hose.
2. Remove the head cover screws.
3. Remove the cylinder head cover.
4. Remove the screws of the rocker arm bracket.
5. Remove the rocker arm assembly.
6. Remove the push rods.
7. Remove the cylinder head screw.
8. Lift up the cylinder head to remove.
9. Remove the cylinder head gasket.
10. Clean the carbon of the combustion chamber (piston head and piston side of cylinder head) with wire brush.

(When reassembling)

- When you put the push rods on the tappets, make sure that their ends are correctly engaged with the grooves.
- Make sure that the cylinder head cover gasket is not damaged.
- Replace the cylinder head gasket with a new one.
- Replace the exhaust manifold gasket with a new one.
- Replace the muffler gasket with a new one.

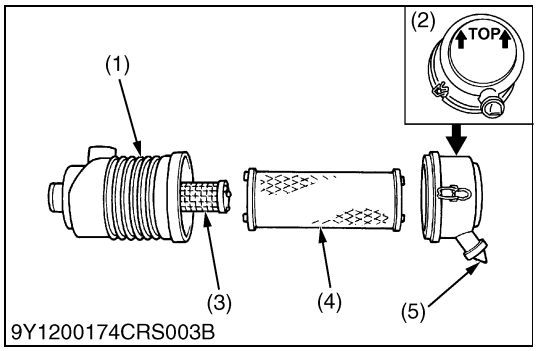
■ **IMPORTANT**

- **After you install the rocker arm, adjust the valve clearance.**
- **Put the high tension cord cap inside the spark plug terminal firmly.**
- **Make sure that the cylinder number is corresponding to the high tension cord number.**
- **Wrong connection causes high temperature on catalytic muffler/converter.**

Tightening torque	Cylinder head screw	38 to 42 N·m 3.8 to 4.3 kgf·m 28 to 31 lbf·ft
	Rocker arm bracket screw	9.81 to 11.3 N·m 1.0 to 1.15 kgf·m 7.24 to 8.31 lbf·ft
	Cylinder head cover screw	6.86 to 11.3 N·m 0.70 to 1.15 kgf·m 5.10 to 8.32 lbf·ft

9Y1211108GEG0039US0

[8] CHECK POINTS OF EVERY 1 YEAR



9Y1200174CRS003B

Replacing Air Cleaner Primary and Secondary Element

1. Remove the cover (2) from the air cleaner.
2. After cleaning the cover (2), remove the used air cleaner primary (4) and secondary (3) element.
3. Replace the new air cleaner primary (4) and secondary (3) element.

(When reassembling)

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

■ **IMPORTANT**

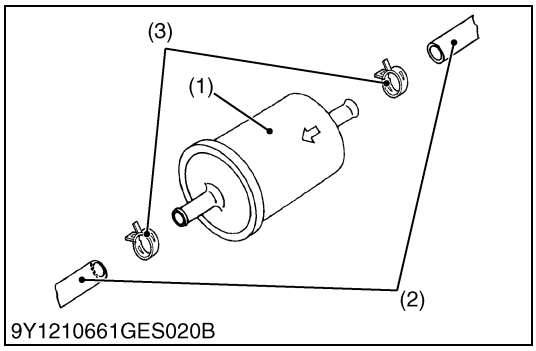
- **Make sure the hooking clip for cover for the element is tight enough. If it is loose, dust and dirt may be sucked in, wearing down the cylinder liner and piston ring earlier and thereby resulting in poor power output**

■ **NOTE**

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

(1) Air cleaner body
(2) Cover
(3) Secondary element
(4) Primary element
(5) Evacuator valve

9Y1211108GEG0040US0



9Y1210661GES020B

Replacing Gasoline Fuel Hose, Clamps and Fuel Filter (Gasoline Line) [WG972-GL, WG972-G]

1. Replace the fuel filter (1) with a new one.
2. Replace the hose (2) and clamp (3) with new ones.

⚠ CAUTION

- **In order to reduce the fuel pressure, do not remove the fuel hose at least 3 minutes after stopping the engine.**
- **Remove the hose after covering the hose with a waste to prevent scatter of fuel.**

■ **IMPORTANT**

- **When the fuel pipes are not installed, plug them at both ends with clean cloth or paper to prevent dirt from entering. Dirt in the pipes can cause fuel injector malfunction.**

(1) Fuel Filter
(2) Fuel Hose
(3) Clamp

9Y1211108GEG0041US0

Cleaning Fuel Tank Inside (Gasoline Line) [WG972-GL, WG972-G]

1. Following the unit / machine's operators manual, drain the gasoline fuel in the fuel tank.
2. Clean the fuel tank inside.

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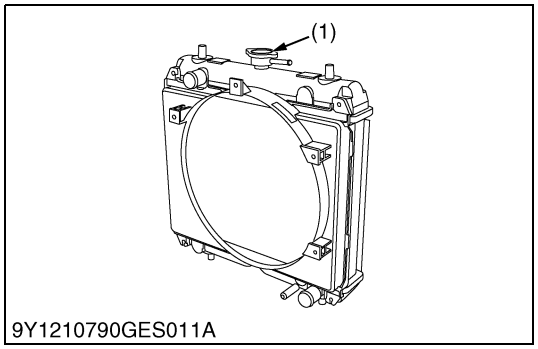

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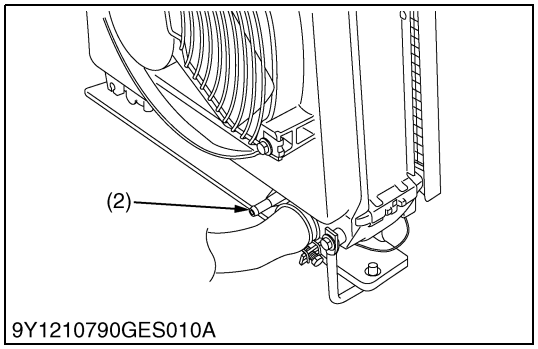

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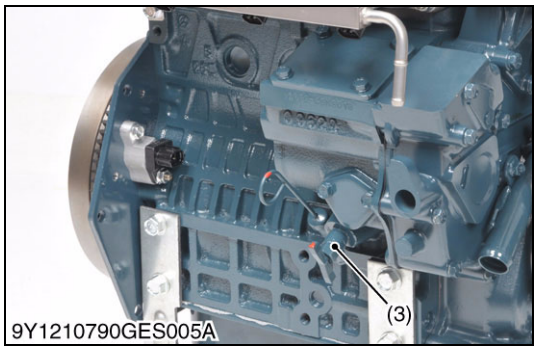

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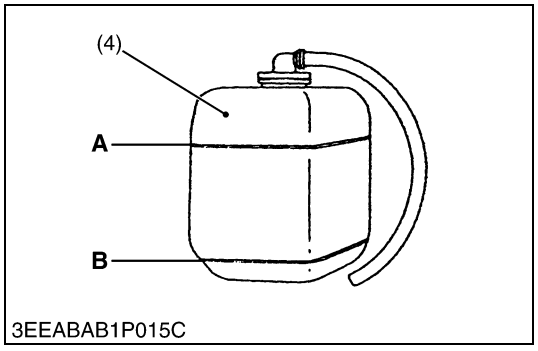

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Cleaning Radiator and Water Jacket

CAUTION

- **Do not stop the engine suddenly, stop it after about 5 minutes ofunloaded idling.**
- **Work only after letting the engine and radiator cool off completely (more than 30 minutes after it has been stopped).**
- **Do not remove the radiator cap while coolant is hot. When cool to the touch, rotate cap to the first stop to allow excess pressure to escape. Then remove cap completely.**
  If overheats should occur, steam may gush out from the radiator or recovery tank; Severe burns could result.

1. Stop the engine and let cool down.
2. To drain the coolant, open the radiator drain plug (2) and remove the radiator cap (1). Then radiator cap (1) must be removed to drain the coolant completely. And open the drain valve (3) of engine body.
3. After all coolant is drained, close the drain plug.
4. Fill with clean water and cooling system cleaner.
5. Follow directions of the cleaner instruction.
6. After flushing, fill with clean water and anti-freeze until the coolant level is just below the port. Install the radiator cap (1) securely.
7. Fill with coolant up to **FULL "A"** mark on the recovery tank (4).
8. Start and operate the engine for few minutes.
9. Stop the engine and let cool. Check coolant level of recovery tank (4) and add coolant if necessary.

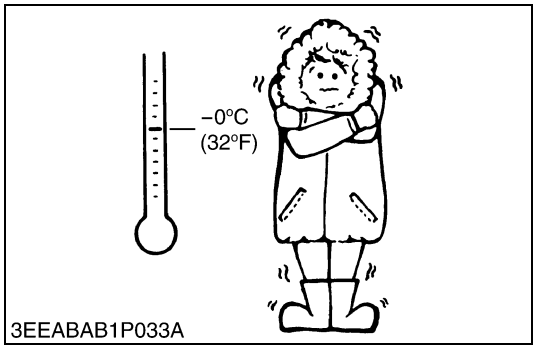
IMPORTANT

- **Do not start engine without coolant.**
- **Use clean, fresh, soft water and anti-freeze to fill the radiator and recovery tank.**
- **When the anti-freeze is mixed with fresh, soft water, the anti-freeze mixing ratio must be less than 50 %.**
- **Securely tighten radiator cap. If the cap is loose or improperly fitted, water may leak out and the engine could overheat.**

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

A: FULL
B: LOW

9Y1211108GEG0043US0



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Anti-Freeze

- There are two types of anti-freeze available: use the permanent type (PT) for this engine.
- Before adding anti-freeze for the first time, clean the radiator interior by pouring fresh, soft water and draining it a few times.
- The procedure for mixing water and anti-freeze differs according to the make of the anti-freeze and the ambient temperature. Basically, it should be referred to SAE J1034 standard, more specifically also to SAE J814c.
- Mix the anti-freeze with fresh, soft water, and then fill into the radiator.

■ **IMPORTANT**

- **When the anti-freeze is mixed with fresh, soft water, the anti-freeze mixing ratio must be less than 50 %.**

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

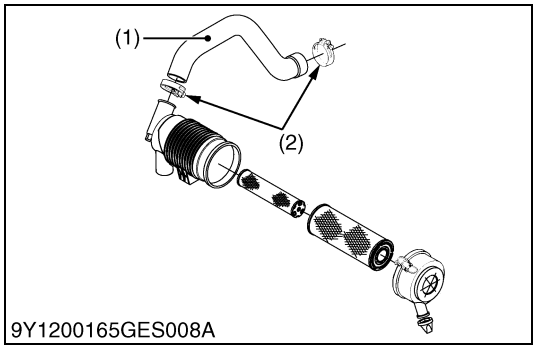
* At 1.01 × 100000 Pa (760 mmHg) pressure (atmospheric). A higher boiling point is obtained by using a radiator pressure cap which permits the development of pressure within the cooling system.

■ **NOTE**

- **The above data represents industrial standards that necessitate a minimum glycol content in the concentrated anti-freeze.**
- **When the coolant level drops due to evaporation, add fresh, soft water only to keep the anti-freeze mixing ratio less than 50 %. In case of leakage, add anti-freeze and fresh, soft water in the specified mixing ratio.**
- **Anti-freeze absorbs moisture. Keep unused anti-freeze in a tightly sealed container.**
- **Do not use radiator cleaning agents when anti-freeze has been added to the coolant.**
  (Anti-freeze contains an anti-corrosive agent, which will react with the radiator cleaning agent forming sludge which will affect the engine parts.)

9Y1211108GEG0044US0

[9] CHECK POINTS OF EVERY 2 YEARS



9Y1200165GES008A

Replacing Intake Air Line

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

■ **NOTE**

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

(1) Intake Air Hose (2) Clamp

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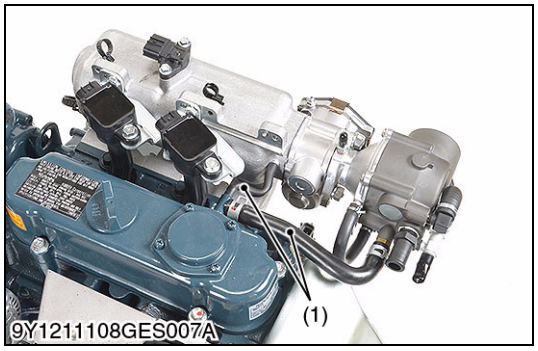

Replacing Breather Hose [WG972-GL, WG972-L, WG972-N]

1. Replace the breather hoses (1) and the clamps between the head cover and the gas mixer, and between the head cover and intake manifold.

(1) Breather Hose

9Y1211108GEG0046US0

Replacing Breather Hose [WG972-G]

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

9Y1211108GEG0060US0

Replacing Fuel Hose and Clamps (Gas Line) [WG972-GL, WG972-L, WG972-N]

1. Replace the fuel hose and the clamps between gas tank and gas mixer.

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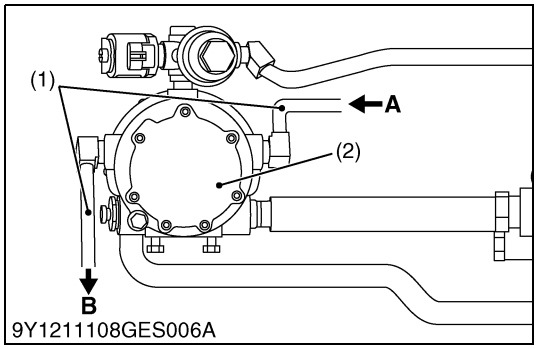
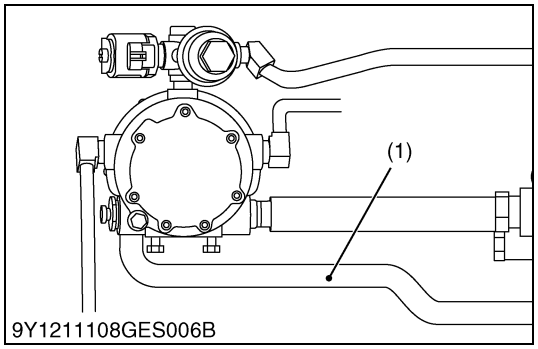


Replacing Hot Water Line of Gas Regulator (Gas Line) [WG972-GL, WG972-L, WG972-N]

1. Remove the hot water hoses (1) and replace with the new ones.
2. Connect the new hot water hoses (1) to the gas regulator (2).
3. The coolant filled to radiator, and bleed the air from the gas regulator (2).

(1) Hot Water Hose
(2) Gas Regulator
A: Hot water IN
B: Hot water OUT

9Y1211108GEG0048US0

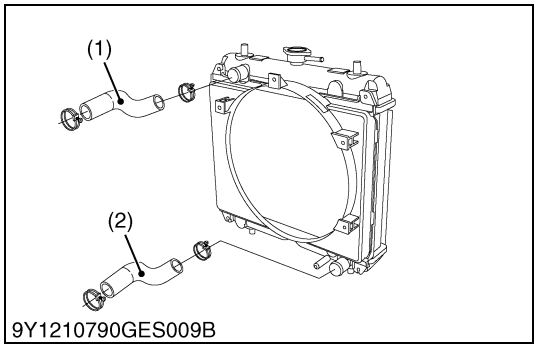


Replacing Balance Hose of Gas Regulator (Gas Line) [WG972-GL, WG972-L, WG972-N]

1. Remove the used balance hose and replace it with the new one.
2. Connect the new balance hose to the gas regulator.

(1) Balance Hose

9Y1211108GEG0059US0



Replacing Radiator Hoses and Clamp Bands

CAUTION

- **Do not remove the radiator cap when the engine is hot. Then loosen cap slightly to the stop to relieve any excess pressure before removing cap completely.**

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

(1) Upper Hose
(2) Lower Hose

9Y1211108GEG0053US0

Replacing Battery

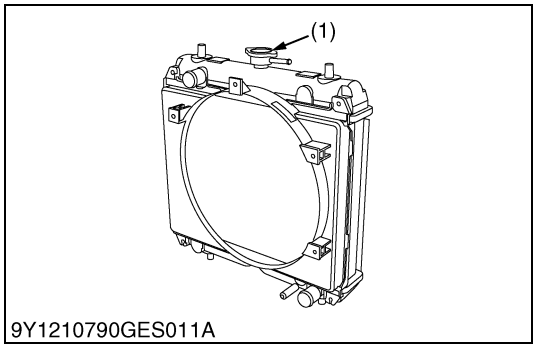
CAUTION

- **When the battery is being activated, hydrogen and oxygen gases in the battery are extremely explosive. Keep open sparks and flames away from the battery at all times, especially when charging the battery.**
- **When charging battery, remove battery vent plugs.**
- **When disconnecting the cable from the battery, start with the negative terminal first. When connecting the cable to the battery, start with the positive terminal first.**
- **Never check battery charge by placing a metal object across the posts.**

1. Disconnect the negative terminal and positive terminal.
2. Remove the battery holder.
3. Remove the used battery.
4. Replace the new battery.
5. Tighten the battery holder.
6. Connect the positive terminal.
7. Connect the negative terminal.

9Y1211108GEG0054US0

Changing Radiator Coolant (L.L.C.)



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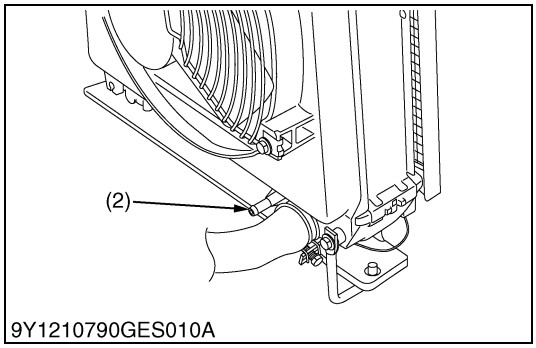

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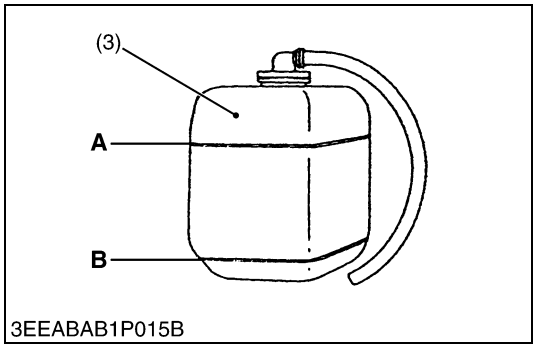


3EEABAB1P015B

CAUTION

- **Do not remove the radiator cap when the engine is hot. Then loosen cap slightly to the stop to relieve any excess pressure before removing cap completely.**

1. Stop the engine and let cool down.
2. To drain the coolant, open the radiator drain plug (2) and remove the radiator cap (1). Then radiator (1) must be removed to completely drain the coolant. And open the drain valve of engine body.
3. After all coolant is drained, close the drain plug (2).
4. Fill with clean water and cooling system cleaner.
5. Follow directions of the cleaner instruction.
6. After flushing, fill with clean water and anti-freeze until the coolant level is just below the port. Install the radiator cap (1) securely.
7. Fill with coolant up to **FULL "A"** mark on the recovery tank (3).
8. Start and operate the engine for few minutes.
9. Stop the engine and let cool. Check coolant level of radiator and recovery tank (3) and add coolant if necessary.

■ **IMPORTANT**

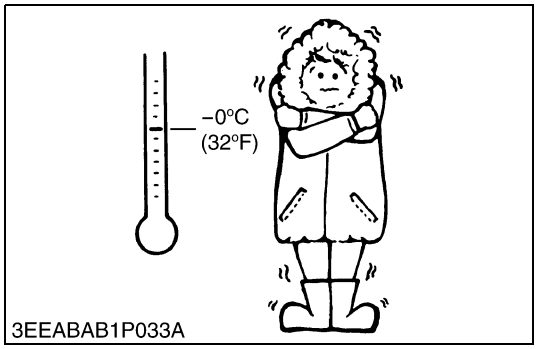
- **Do not start engine without coolant.**
- **Use clean, fresh, soft water and anti-freeze to fill the radiator and recovery tank.**
- **When the anti-freeze is mixed with fresh, soft water, the anti-freeze mixing ratio must be less than 50 %.**
- **Securely tighten radiator cap. If the cap is loose or improperly fitted, water may leak out and the engine could overheat.**

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

A: Full
B: Low

(To be continued)

(Continued)



3EEABAB1P033A

(Anti-freeze)

- There are two types of anti-freeze available; use the permanent type (PT) for this engine.
- Before adding anti-freeze for the first time, clean the radiator interior by pouring fresh, soft water and drain it a few times.
- The procedure for mixing water and anti-freeze differs according to the make of the anti-freeze and the ambient temperature. Basically, it should be referred to SAE J1034 standard, more specifically also to SAE J814c.
- Mix the anti-freeze with fresh, soft water, and then fill into the radiator.

■ **IMPORTANT**

- **When the anti-freeze is mixed with fresh, soft water, and anti-freeze mixing ratio must be 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). A higher boiling point is obtained by using a radiator pressure cap which permits the development of pressure within the cooling system.

■ **NOTE**

- **The above data represents industrial standards that necessitate a minimum glycol content in the concentrated anti-freeze.**
- **When the coolant level drops due to evaporation, add fresh, soft water only to keep the anti-freeze mixing ratio less than 50 %. In case of leakage, add anti-freeze and fresh, soft water in the specified mixing ratio.**
- **Anti-freeze absorbs moisture. Keep unused anti-freeze in a tightly sealed container.**
- **Do not use radiator cleaning agents when anti-freeze has been added to the coolant.**
  (Anti-freeze contains an anti-corrosive agent, which will react with the radiator cleaning agent forming sludge which will affect the engine parts.)

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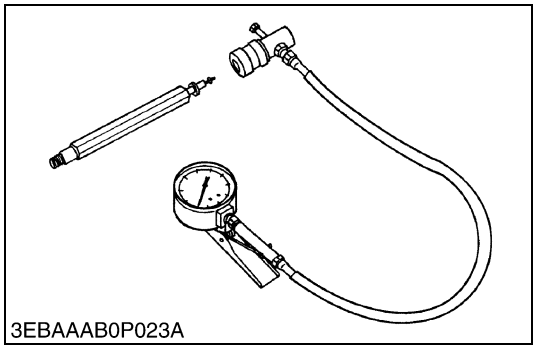
5. SPECIAL TOOLS

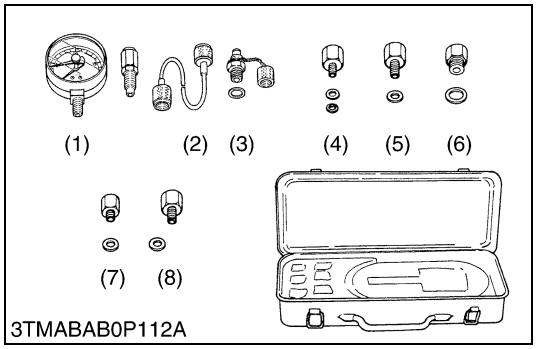

3EBAAAB0P023A

Compression Tester

Code No.
- 07909-30251

Application
- Use to measure gasoline engine compression and diagnose the engine for a major overhaul.

9Y1211108GEG0008US0



3TMABAB0P112A

Oil Pressure Tester

Code No.
- 07916-32032

Application
- Use to measure lubricating oil pressure.

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

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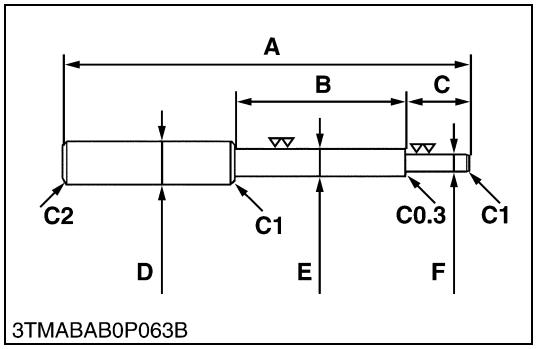
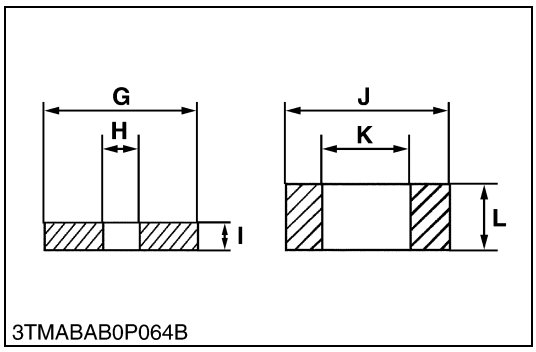


3TMABAB0P063B

Valve Guide Replacing Tool

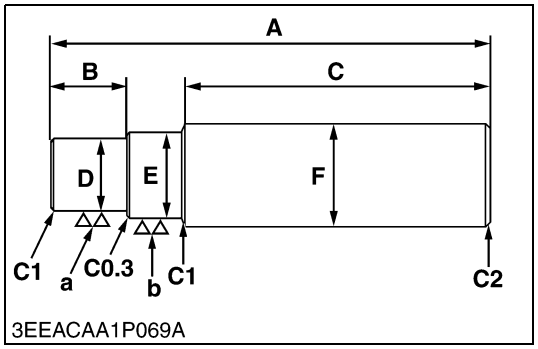
Application
- Use to press out and press fit the valve guide.



3TMABAB0P064B

A	200 mm (7.87 in.)
B	80 mm (3.1 in.)
C	40 mm (1.6 in.)
D	20 mm dia. (0.79 in. dia.)
E	9.960 to 9.980 mm dia. (0.3922 to 0.3929 in. dia.)
F	5.50 to 5.70 mm dia. (0.217 to 0.224 in. dia.)
G	15 mm (0.59 in.)
H	6.00 to 6.10 mm dia. (0.237 to 0.240 in. dia.)
I	5 mm (0.2 in.)
J	18 mm dia. (0.71 in. dia.)
K	10.6 to 10.7 mm dia. (0.418 to 0.421 in. dia.)
L	7 mm (0.3 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.)

9Y1211108GEG0009US0



3EEACAA1P069A

Bushing Replacing Tool

Application

- Use to press out and to press fit the bushing.

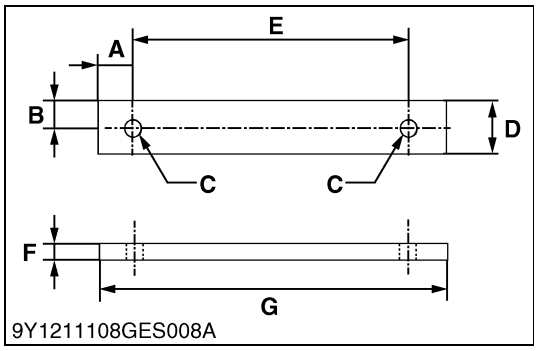
[For small end bushing]

A	145 mm (5.71 in.)
B	20 mm (0.79 in.)
C	100 mm (3.94 in.)
D	19.90 to 19.95 mm dia. (0.7835 to 0.7854 in. dia.)
E	21.90 to 21.95 mm dia. (0.8622 to 0.8641 in. dia.)
F	25 mm dia. (0.98 in. dia.)
a	6.3 µm (250 µin.)
b	6.3 µm (250 µin.)

[For idle gear bushing]

A	150 mm (5.91 in.)
B	20 mm (0.79 in.)
C	100 mm (3.94 in.)
D	19.90 to 19.95 mm dia. (0.7835 to 0.7854 in. dia.)
E	21.90 to 21.95 mm dia. (0.8622 to 0.8641 in. dia.)
F	25 mm dia. (0.98 in. dia.)
a	6.3 µm (250 µin.)
b	6.3 µm (250 µin.)

9Y1211108GEG0010US0



9Y1211108GES008A

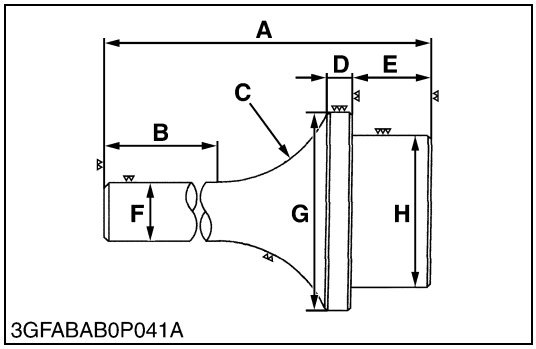
Flywheel Stopper

Application

- Use to loosen and tighten the flywheel screw.

A	20 mm (0.79 in.)
B	15 mm (0.59 in.)
C	10 mm dia. (0.39 in. dia.)
D	30 mm (1.2 in.)
E	80 mm (3.1 in.)
F	8 mm (0.3 in.)
G	120 mm (4.72 in.)

9Y1211108GEG0011US0



3GFABAB0P041A

Crankshaft Bearing 1 Replacing Tool

Application

- Use to press out and press fit the crankshaft bearing 1.

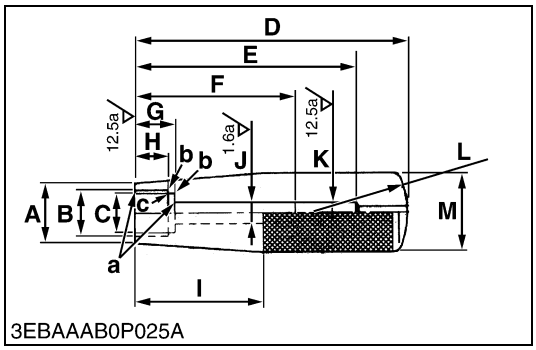
[Press Out]

A	135 mm (5.31 in.)
B	72 mm (2.8 in.)
C	40 mm radius (1.6 in. radius)
D	10 mm (0.39 in.)
E	22 mm (0.87 in.)
F	20 mm dia. (0.79 in. dia.)
G	47.90 to 47.95 mm dia. (1.886 to 1.887 in. dia.)
H	43.90 to 43.95 mm dia. (1.729 to 1.730 in. dia.)

[Press Fit]

A	130 mm (5.12 in.)
B	72 mm (2.8 in.)
C	40 mm radius (1.6 in. radius)
D	9 mm (0.4 in.)
E	24 mm (0.94 in.)
F	20 mm (0.79 in.)
G	68 mm dia. (2.7 in. dia.)
H	43.90 to 43.95 mm dia. (1.729 to 1.730 in. dia.)

9Y1211108GEG0012US0



3EBAAAB0P025A

Valve Stem Seal Replacing Tool

Application

- Use to press fit the valve stem seal.

A	17.5 mm dia. (0.689 in. dia.)
B	13.7 to 13.9 mm dia. (0.540 to 0.547 in. dia.)
C	11.0 to 11.2 mm dia. (0.433 to 0.440 in. dia.)
D	75 mm (3.0 in.)
E	60 mm (2.4 in.)
F	45 mm (1.8 in.)
G	11.5 to 11.6 mm (0.453 to 0.456 in.)
H	8.5 mm (0.33 in.)
I	37.5 mm (1.48 in.)
J	6 mm dia. (0.2 in. dia.)
K	6 mm dia. (0.2 in. dia.)
L	R 30
M	26 mm dia. (1.0 in. dia.)
a	Chamfer 0.3 mm (0.01 in.)
b	Chamfer 0.4 mm (0.02 in.)
c	Chamfer 0.2 mm (0.008 in.)

9Y1211108GEG0013US0

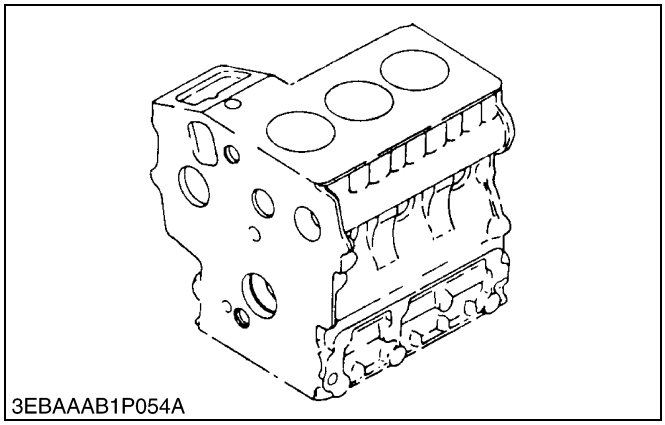
1 ENGINE

MECHANISM

CONTENTS

1. ENGINE BODY

[1] CYLINDER BLOCK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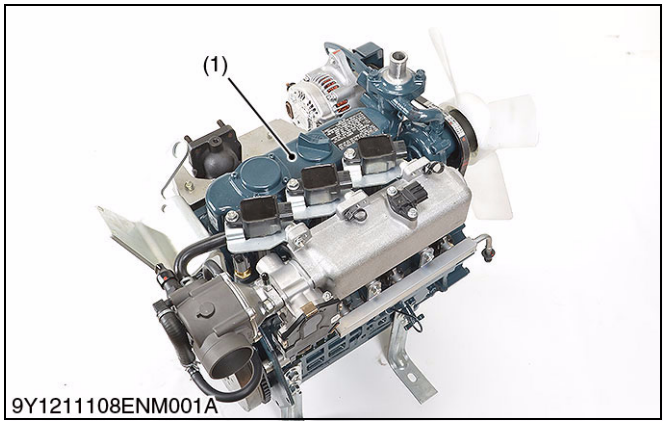
The engine has a high durability tunnel-type cylinder block in which the crank bearing component is a constructed body. Furthermore, liner less type, allow effective cooling, less distortion, and greater wear resistance. The noise level is reduced to a minimum because each cylinder has its own chamber.

To increase the rigidity of the cylinder block, parts of engine block which support main bearing case has thicker rib for additional rigidness to improve noise and vibration.

9Y1211108ENM0001US0

[2] HALF-FLOATING HEAD COVER



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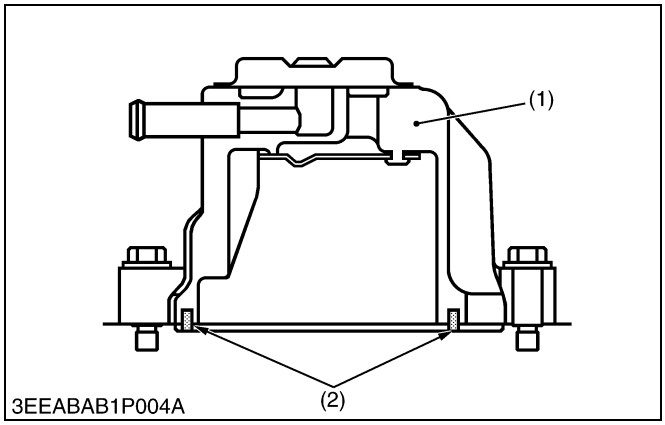


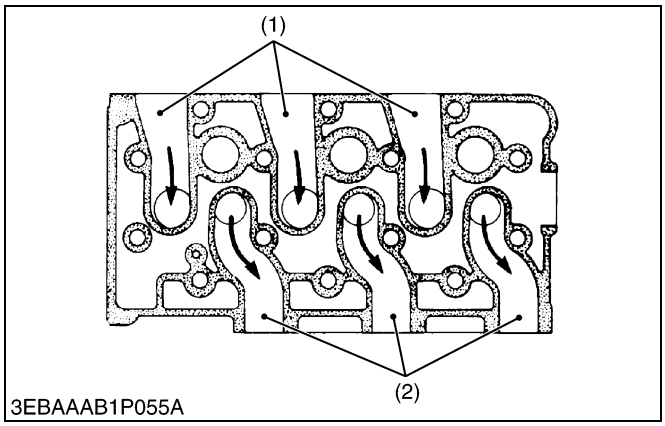
3EEABAB1P004A

The rubber packing is fitting in to keeping the head cover 0.5 mm (0.02 in.) or so off the cylinder head. This arrangement helps reduce noise coming from the cylinder head.

(1) Cylinder Head Cover (2) Rubber Packing

9Y1211108ENM0002US0

[3] CYLINDER HEAD

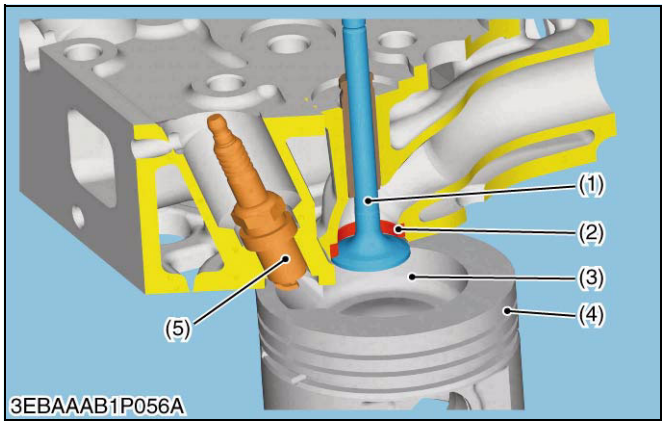


Intake and Exhaust Port

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

9Y1211108ENM0003US0



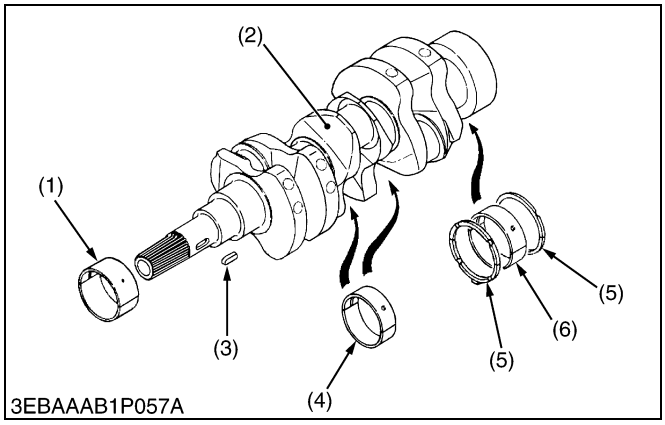
Combustion System

The Spark Ignition type combustion chamber, compactly set 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

9Y1211108ENM0004US0

[4] CRANKSHAFT



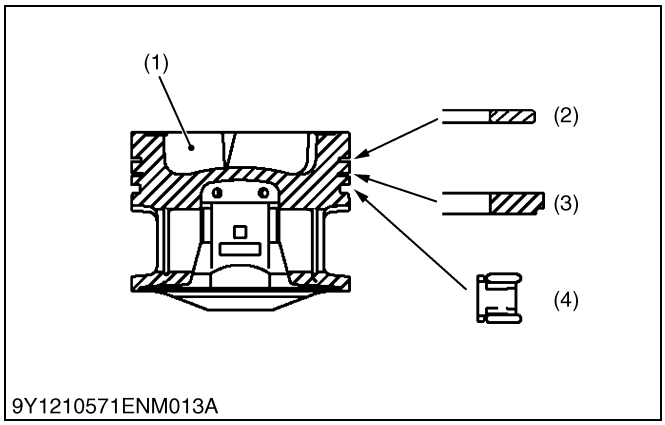
The crankshaft with the connecting rod converts the reciprocating motion of the piston into rotating motion. The crankshaft (2) has oil passages drilled so that oil can flow from the main bearings to the crank pin bearings.

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

9Y1211108ENM0005US0

[5] PISTON AND PISTON RING



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Piston and Piston Ring

The piston head has the combustion chamber (1) with the concave of bathtub shaped type.

Top Ring:

Barrel-faced type has an ideal shape in terms of lubrication theory in order to prevent abnormal wear due to edge loading at the time of initial running-in, and it is very effective in prevention of blow-by.

Second Ring:

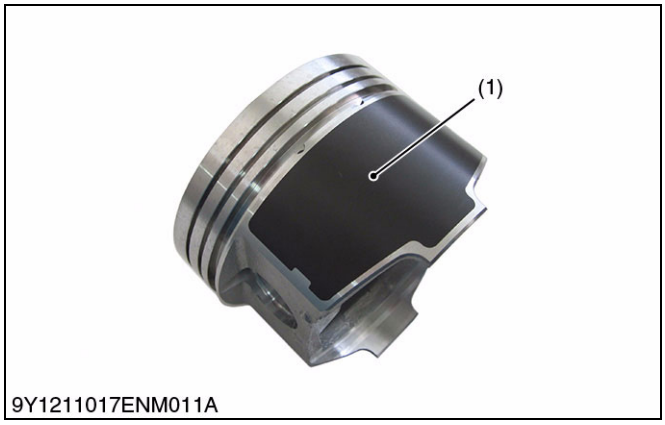
In this type, undercut machining is interrupted at both ends of the joint. It has an oil scraping property which is inherent to the scraper type as well as control action against blow-by which is caused by undercutting.

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

9Y1211108ENM0006US0



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Piston Skirt

Piston's skirt is coated with **molybdenum disulfide★**, which reduces the piston slap noise and thus the entire operating noise.

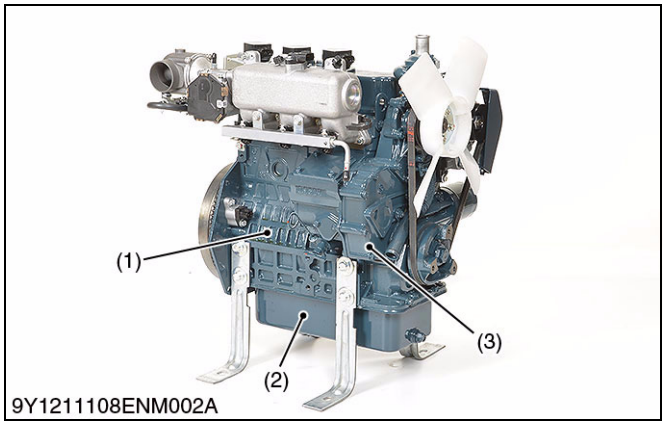
★ Molybdenum disulfide (MoS_2)

The molybdenum disulfide serves as a solid lubricant, like a Graphite or Teflon. This material helps resist metal wears even with little lube oil.

(1) Molybdenum Disulfide

9Y1211108ENM0007US0

[6] OIL PAN



9Y1211108ENM002A

The oil pan is expanded under the gear case. Therefore, the height of the engine can be lowered more than so far while securing a necessary amount of oil.

(1) Crank Case
(2) Oil Pan
(3) Gear Case

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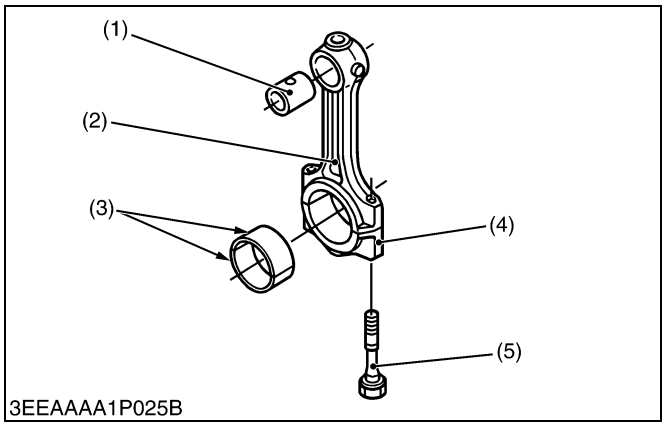
[7] CONNECTING ROD



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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

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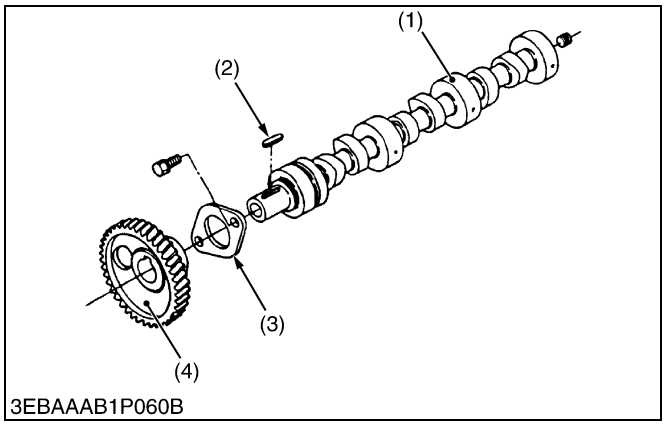
[8] CAMSHAFT



3EBAAAB1P060B

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.

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

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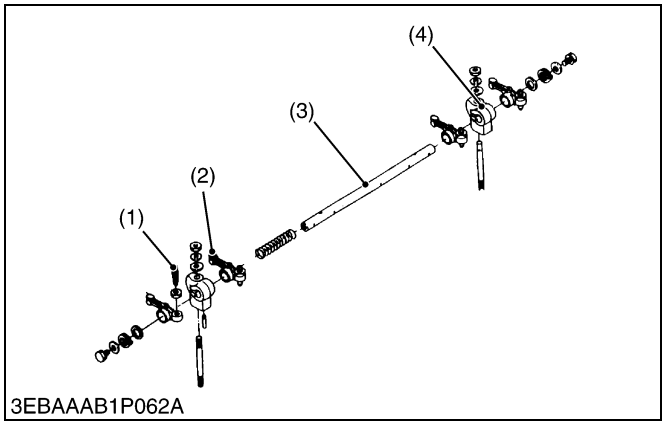
[9] ROCKER ARM ASSEMBLY



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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

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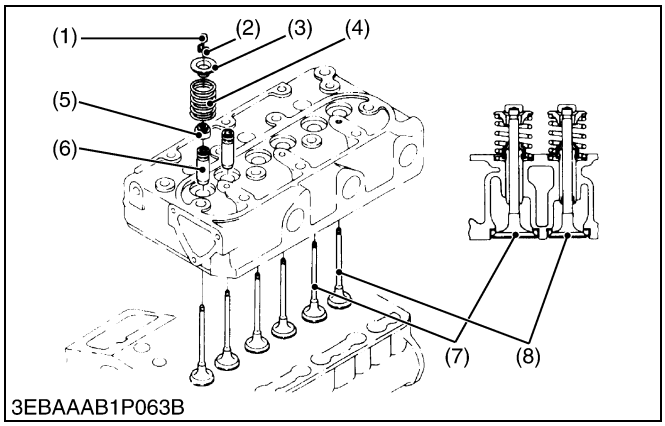
[10] INLET AND EXHAUST VALVES



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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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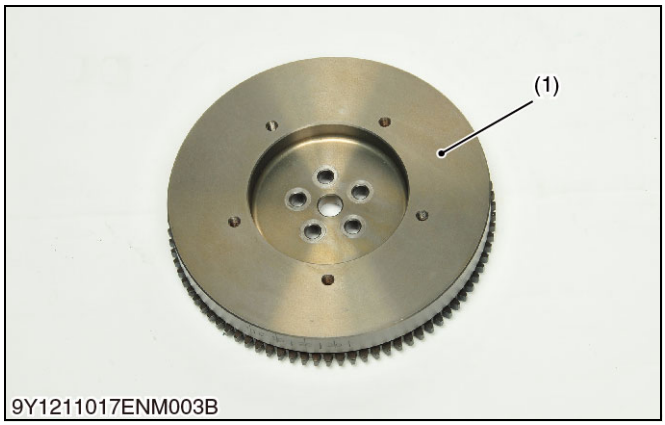
[11] FLYWHEEL



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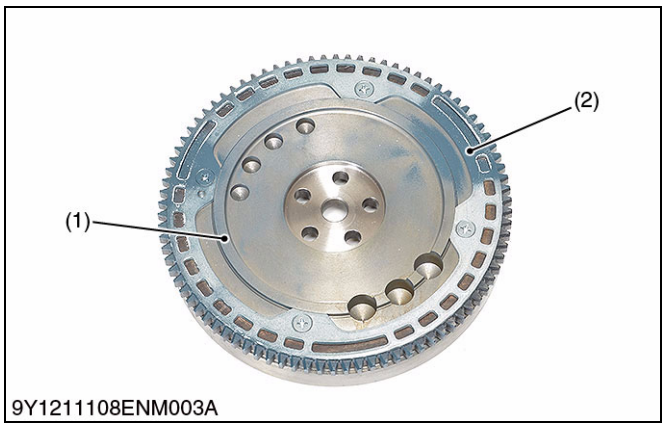

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The flywheel (1) is connected with the crankshaft, it stores the rotating force in the combustion stroke as inertial energy to rotate the crankshaft smoothly.

The flywheel periphery is provided with marks showing fuel injection timing and top dead center.

The flywheel has ring gear teeth around its outer rim, which mesh with the drive pinion of the starter.

Also, a rotor is attached to the flywheel and the rotor (2) has some holes. Some of these holes are different form from the other ones.

Crank position sensor is sensing piston position and engine speed by different form holes of rotor and determines the injection timing.

(1) Flywheel
(2) Rotor

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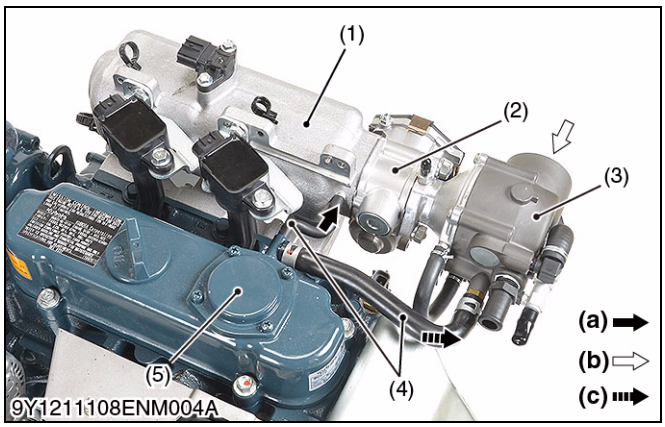
[12] CLOSED BREATHER



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Blow-by gas **(a)** and **(c)** from crankcase is removed oil in the breather assembly (3) and sent to forward and backward of the electronic throttle body (2) where the blow-by gas **(a)** and **(c)** is mixed with the intake air **(b)**.

(1) Inlet manifold
(2) Electronic Throttle Body
(3) Gas Mixer
(4) Breather Tube
(5) Breather Assembly

(a) Blow-by Gas at Throttle close
(b) Intake Air
(c) Blow-by Gas at Throttle open

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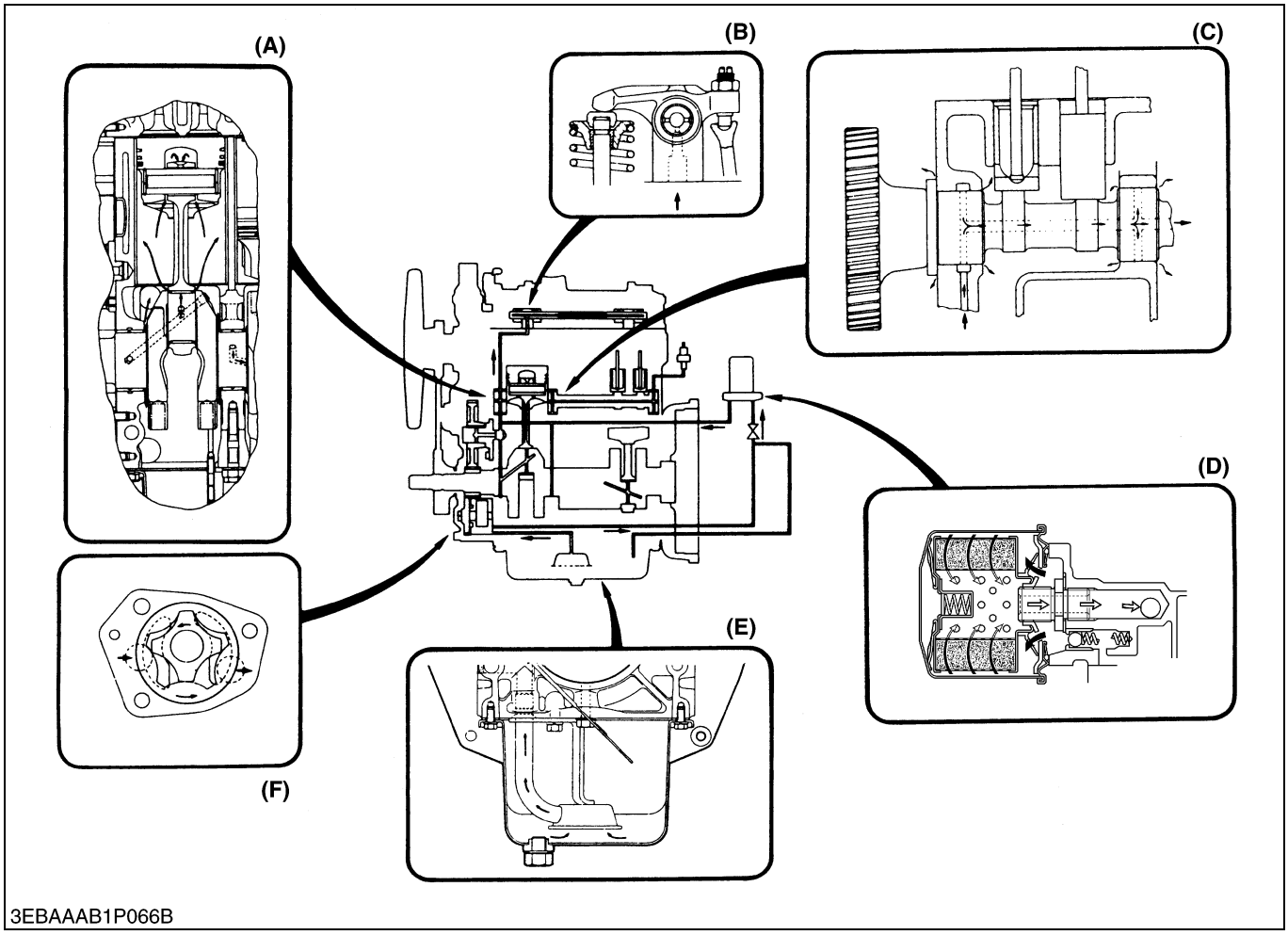
2. LUBRICATING SYSTEM

[1] GENERAL



(A) Piston
(B) Rocker Arm and Rocker Arm Shaft
(C) Camshaft
(D) Oil Filter Cartridge and Relief Valve
(E) Oil Strainer
(F) Oil Pump

The lubricating system consists of an oil strainer, an oil pump, a relief valve, an oil filter cartridge and an oil pressure switch. The oil pump sucks the lubricating oil in the oil pan through the strainer and sends it to the oil filter cartridge, where the oil is further filtered.

The filtered oil is forced to the crankshaft, the connecting rods, the idle gear, the camshaft and the rocker arm shaft through the oil passage in the cylinder block and the shafts to lubricate the bearings.

Some oil, splashed by the crankshaft or thrown off from the bearings, lubricates other engine parts: the pistons, the cylinder walls, the piston pins, the tappets, the push rods, the timing gears, and the inlet and exhaust valves.

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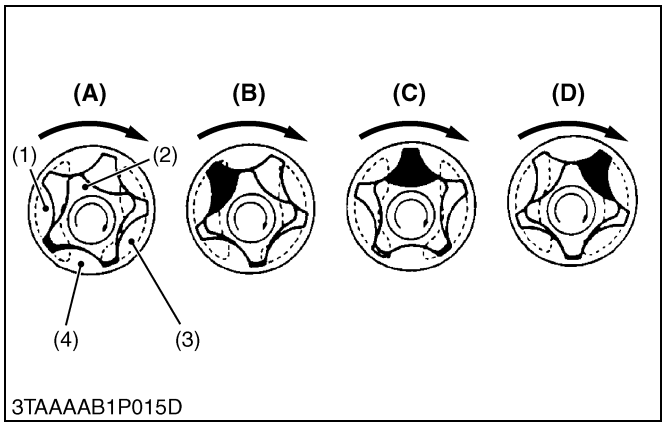
[2] OIL PUMP



3TAAAAB1P015D

The oil pump is a trochoid pump, whose rotors have trochoid lobes. The inner rotor (2) has 4 lobes and the outer rotor (4) has 5 lobes, and they are eccentrically engaged with each other. The inner rotor, which is driven by the crankshaft through the gears, rotates the outer rotor in the same direction, varying the space between the lobes.

While the rotors rotate from **(A)** to **(B)**, the space leading to the inlet port increases, which causes the vacuum to suck in the oil from the inlet port.

When the rotors rotate to **(C)**, the space between both rotors switches from the inlet port to the outlet port. At **(D)**, the space decreases and the sucked oil is discharged from the outlet port.

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

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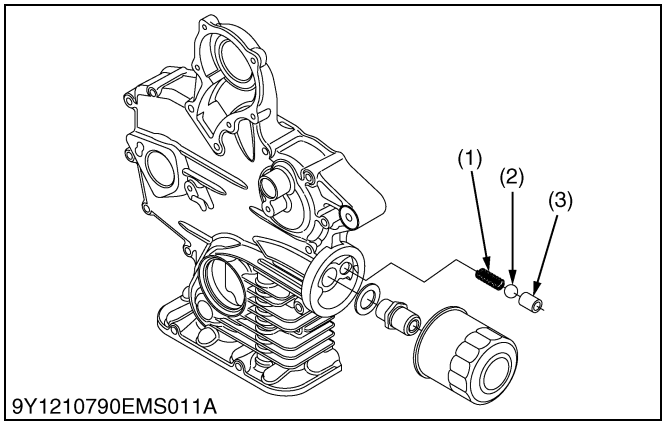
[3] RELIEF VALVE



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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 (2) and escapes to the oil pan.

(1) Spring
(2) Ball
(3) Valve Seat

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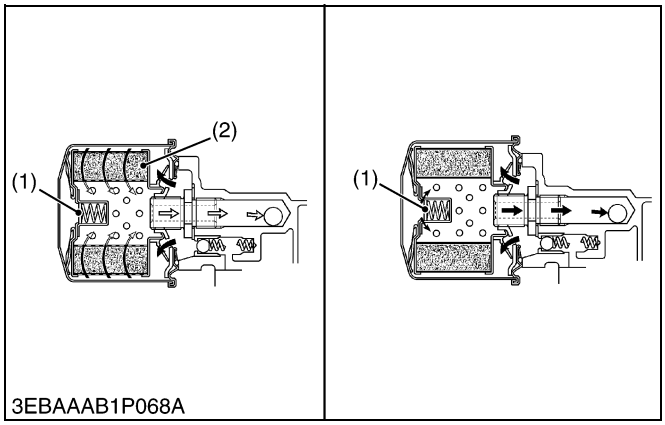
[4] OIL FILTER CARTRIDGE



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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

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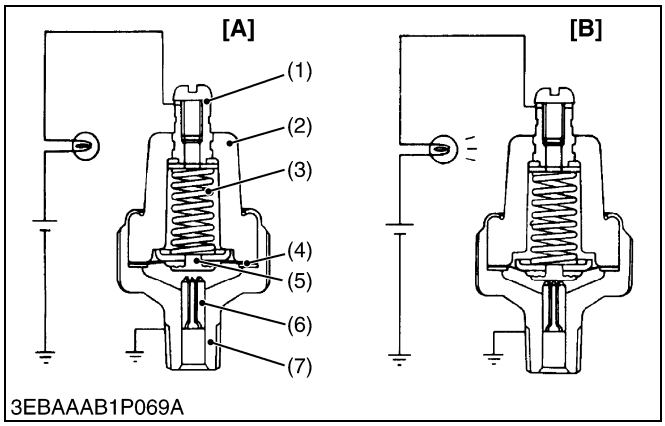
[5] OIL PRESSURE SWITCH



3EBAAAB1P069A

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

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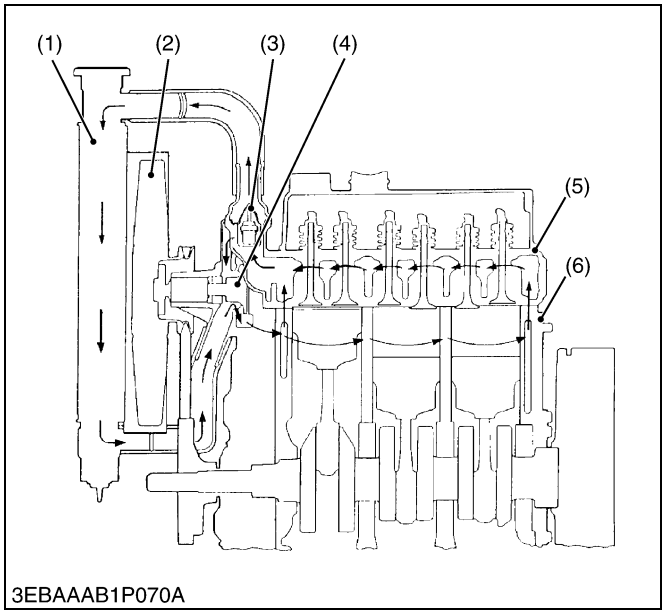
3. COOLING SYSTEM

[1] GENERAL



3EBAAAB1P070A

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

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	Factory specification	69.5 to 72.5 °C 157.1 to 162.5 °F

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

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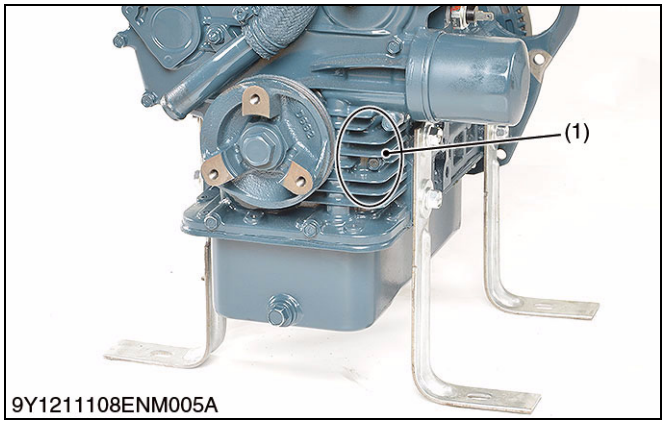
[2] COOLING FIN



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The cooling fin is set up around the oil passage in the gear case.

Therefore, the temperature of oil is decreased by the wind generated by the cooling fan.

(1) Cooling Fin

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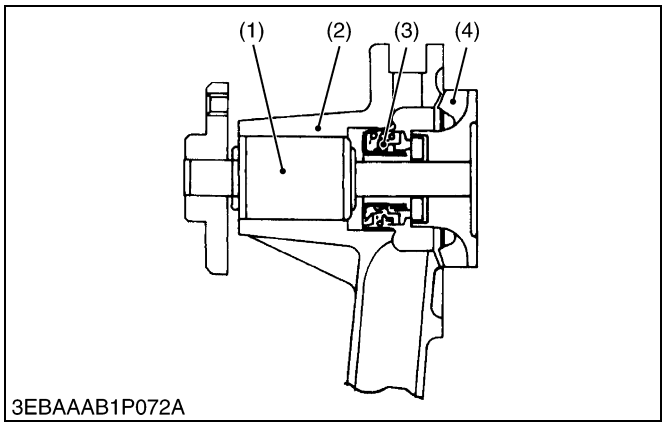
[3] WATER PUMP



3EBAAAB1P072A

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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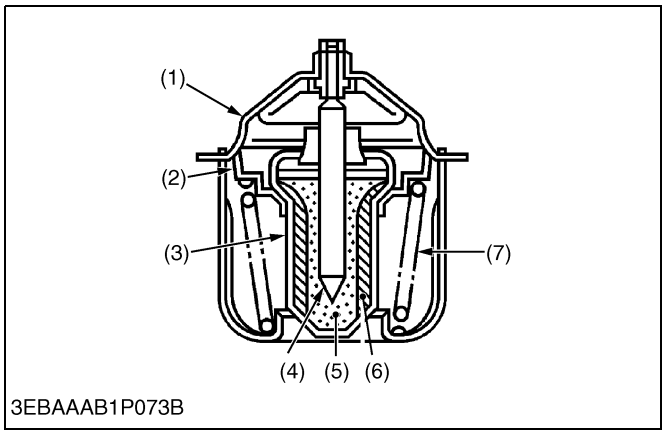
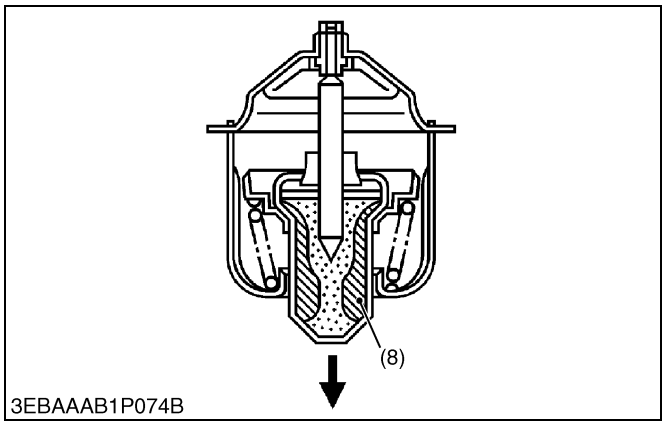
[4] THERMOSTAT



3EBAAAB1P073B



3EBAAAB1P074B

The thermostat is of the wax pellet type.

The thermostat controls the flow of the coolant to the radiator to keep the proper temperature.

The case, which serves as a valve seat, has a spindle inserted in the pellet (3) which is installed to the valve (2). The spindle is covered with the synthetic rubber (5) in the pellet.

The wax is charged between the pellet and the rubber.

■ **At low temperature (lower than valve opening temperature (at beginning))**

The valve (2) is seated by the spring (7) and the coolant circulates in the engine through the water return hose without operating into the radiator. Only the air in the water jacket escapes to the radiator through the leak hole of the thermostat.

■ **At high temperature (higher than valve opening temperature (opened completely))**

As the coolant temperature rises, the wax in the pellet (3) turns liquid and expands, repelling the spindle, which causes the pellet to lower. The valve (2) opens to send the coolant to the radiator.

(1)	Seat	(5)	Synthetic Rubber
(2)	Valve	(6)	Wax (Solid)
(3)	Pellet	(7)	Spring
(4)	Spindle	(8)	Wax (liquid)

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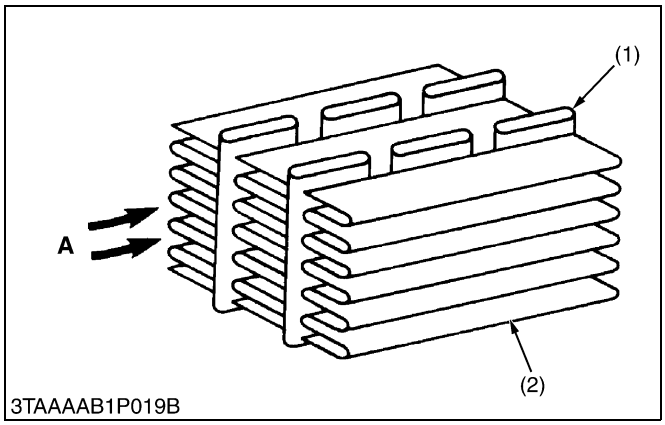
[5] RADIATOR



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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	**A:**	**Cooling Air**
(2)	Fin		

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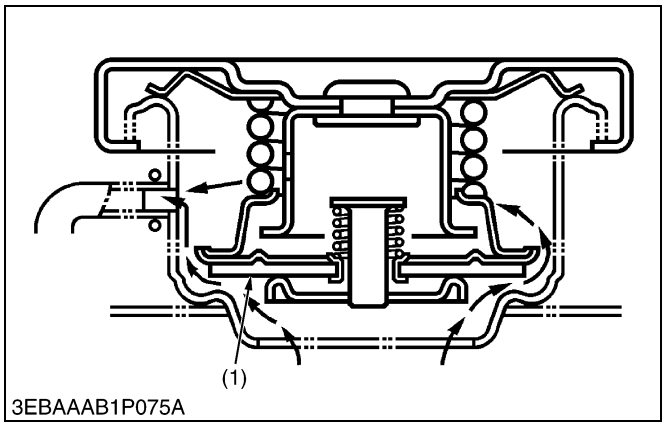
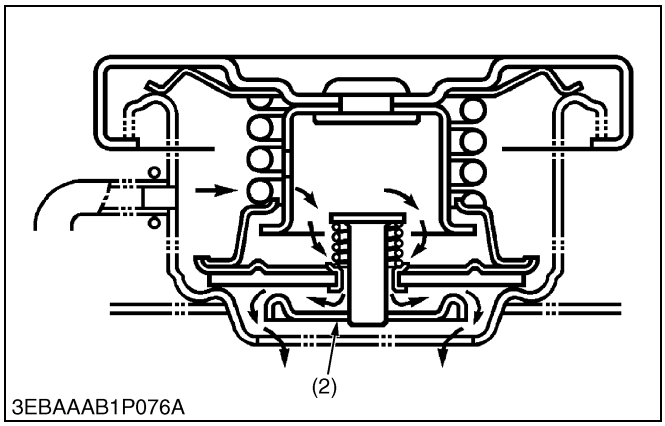
[6] RADIATOR CAP



3EBAAAB1P075A



3EBAAAB1P076A

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

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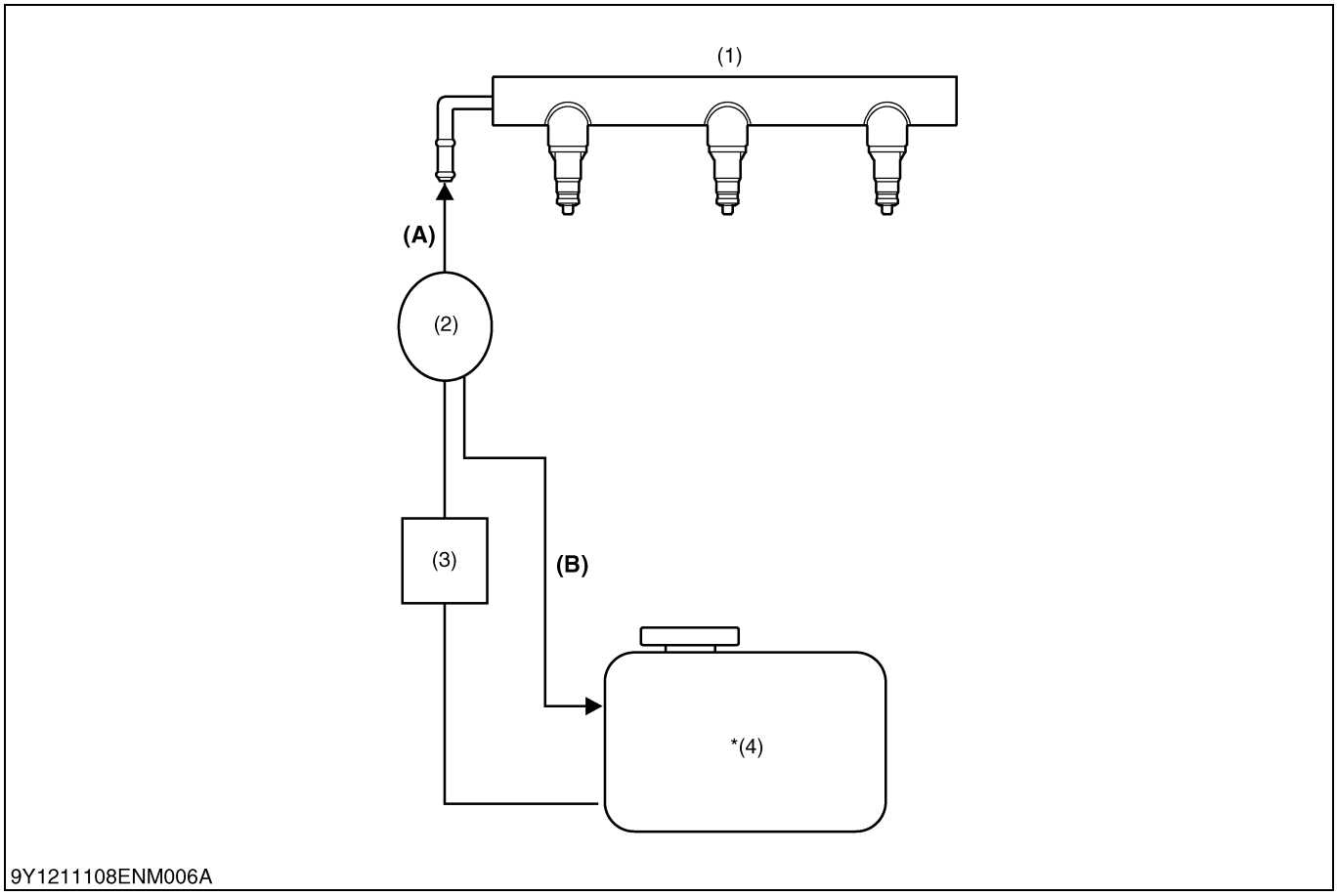
4. FUEL SYSTEM

[1] GENERAL

Gasoline Fuel System [WG972-GL, WG972-G]



9Y1211108ENM006A

(1) Fuel Rail
(2) Fuel Pump Assembly*
(3) Fuel Filter*
(4) Gasoline Tank*
(A) Gasoline line
(B) Bleed / Return circuit (If necessary)

■ **NOTE**
- **The *-marked component parts are Not Provided by KUBOTA.**
- **All fuel connections added to this engine must be installed by qualified personnel and utilizing recognized procedures and standards.**

WG972-GL-E4:

This fuel system has 2 ways.

For gasoline, the fuel is fed from the gasoline tank (4) through the fuel filter (3) to the fuel rail (1) by the fuel pump assembly (2).

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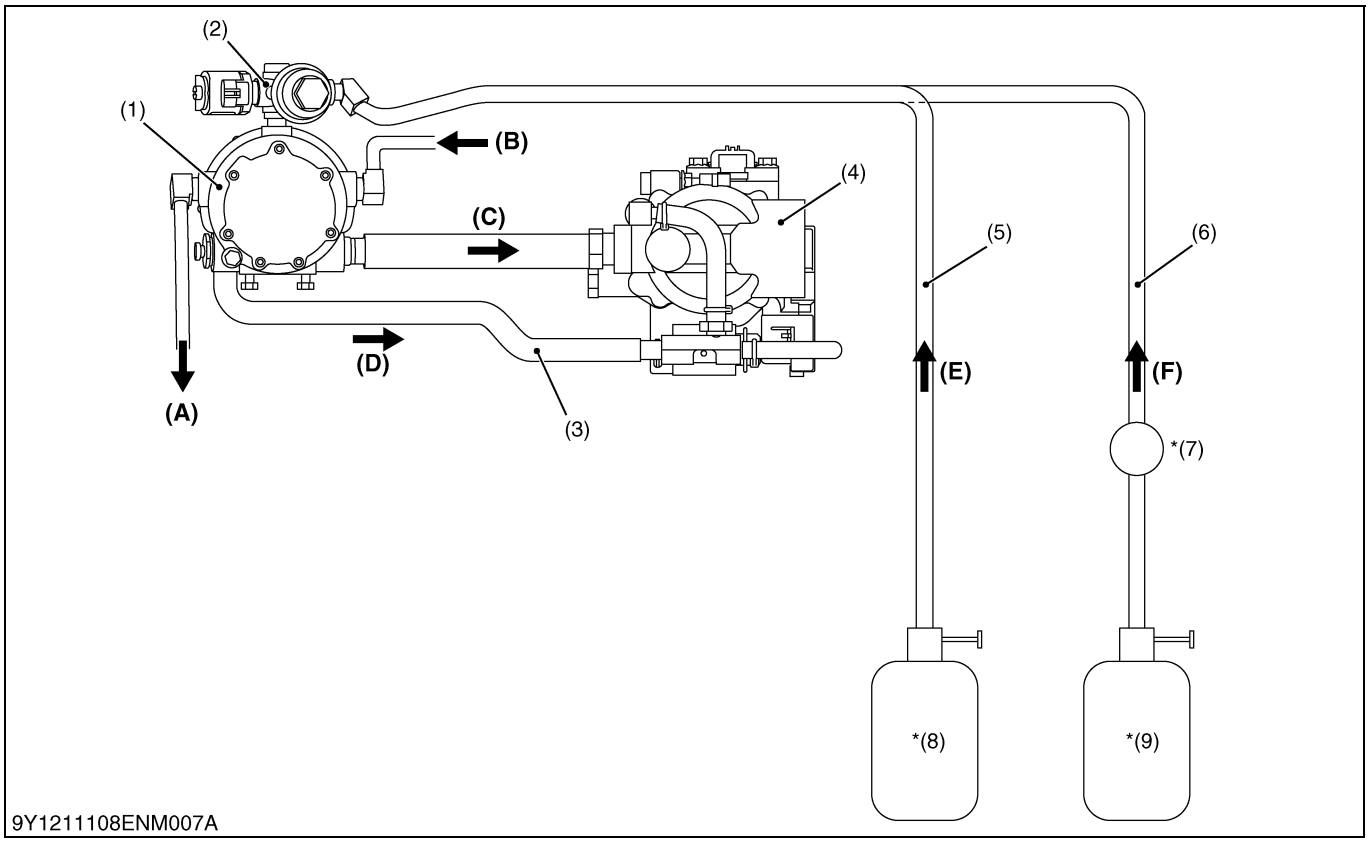
Gaseous Fuel System [WG972-GL, WG972-L, WG972-N]



(1) Gas Regulator with Vaporizer*
(2) Lock Off Valve*
(3) Balance Line*
(4) Gas Mixer
(5) LPG Line [WG972-GL, WG972-L]
(6) CNG Line [WG972-N]
(7) High Pressure Regulator*
(8) LPG Tank (with Manual Valve)*
(9) CNG Tank (with Manual Valve)*

(A) Hot Water OUT
(B) Hot Water IN
(C) LPG Line / CNG Line (Gaseous)
(D) To Gas Mixer
(E) LPG Line (Liquid)
(F) CNG Line (Gaseous)

■ **NOTE**
- **The *-marked component parts are Not Provided by KUBOTA.**
- **These non-KUBOTA installed parts, such as hoses, fittings, piping and shut off solenoid valve should be approved for LPG or CNG use and conform to UL, CSA, NFPA, MSHA and all other applicable standards.**
- **All fuel connections added to this engine must be installed by qualified personnel and utilizing recognized procedures and standards.**
- **Never use LPG fuel on the WG972-G, N engine. Otherwise severe damage will occur.**
- **Never use CNG fuel on the WG972-G, L, GL engine. Otherwise severe damage will occur.**

WG972-GL-E4:

This fuel system has 2 ways.

For LPG fuel, the liquid fuel stored in the LPG tank (8) is sent to Gas regulator with vaporizer (1) by pressure in the gaseous phase in the tank through the lock off valve (2) (including fuel filter).

The liquid fuel is evaporated in vaporizer (1) and is sent to the LPG mixer (4) as a gaseous fuel. The LPG mixer (4) mixes the gaseous fuel and air, and the mixture gas is supplied to the cylinder.

WG972-N-E4:
- Lock off valve and pressure sensor should be installed between the CNG tank and high pressure regulator.
- The related parts and the method of installation should be approved for CNG use and conform to local regulations and all other standards.

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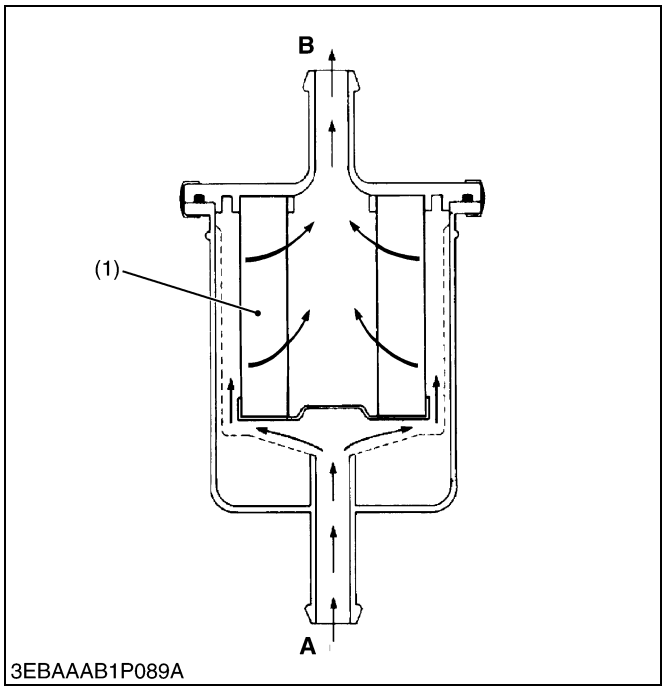
[2] FUEL FILTER (GASOLINE LINE) [WG972-GL, WG972-G]



The fuel filter is installed in the fuel line between the fuel tank and the feed pump.

As the fuel flows from the inlet **"A"** through the filter element (1), the dirt and impurities in the fuel are filtered, allowing only clean fuel to penetrate the inside of the filter element. The cleaned fuel flows out from the outlet **"B"**.

Type of filter element	Accordion-pleated paper type
Material of filter element	Cotton fiber
Filter mesh	15 µm (0.00059 in.)

(1) Filter Element

A: Inlet
B: Outlet

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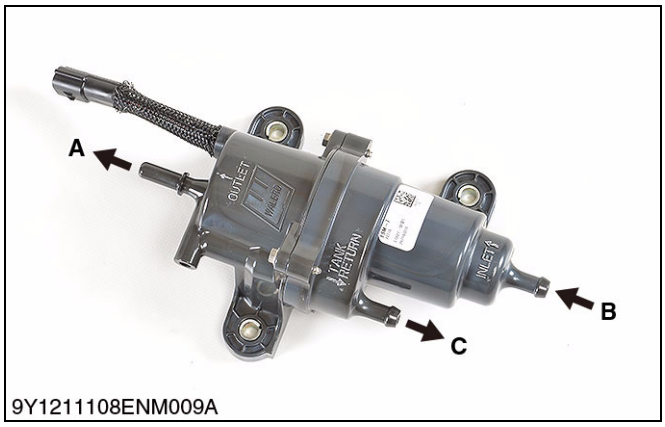
[3] FUEL PUMP (GASOLINE LINE) [WG972-GL, WG972-G]



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The gasoline system will use an external electric gasoline fuel pump.

The pump will be mounted in the chassis of the vehicle, or equipment near the fuel tank.

Gasoline rated fuel hose and securing devices supplied by the OEM, will be used to transfer the pumped fuel to the fuel rail.

The OEM may have installed a fuel filtration device ahead of the electric pump, which may be located in the tank or an external filter.

Most industrial equipment will be exposed to dusty and dirty environments, therefore use caution when opening the gasoline tank, to prevent dirt and debris from falling in the tank.

For the filter maintenance, refer to "3. MAINTENANCE CHECK LIST".

The electric gasoline fuel pump, used on USA emission certified engines are a critical part of the certified emissions system, and do not require any periodic adjustment.

A: Fuel OUT **C: Fuel Return to Tank**
B: Fuel In

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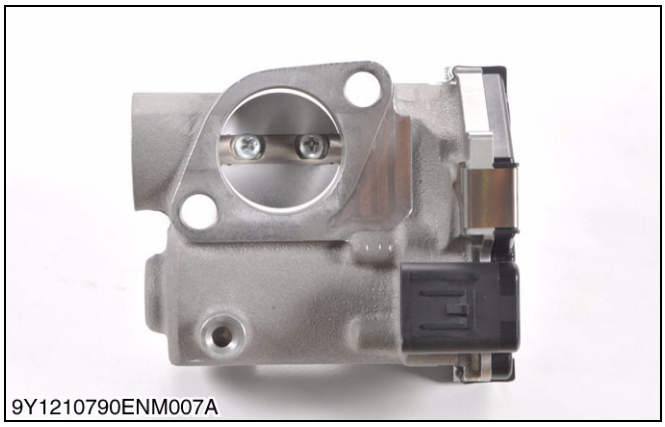
[4] ELECTRONIC THROTTLE BODY (ETB)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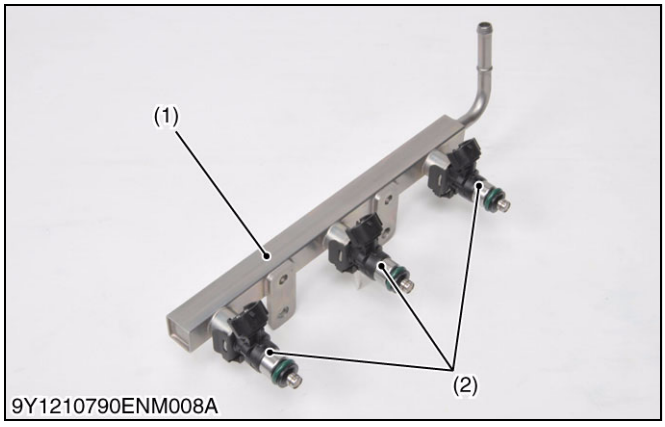
The ETB is connected to the intake manifold of the engine. The ETB uses an electric motor connected to the throttle shaft. In addition, an accelerator position sensor (a foot pedal position sensor) is located in the operator's compartment. When the engine is operating, electrical signals are sent from the accelerator position sensor (the foot pedal position sensor) to the Engine Control Unit (ECU) when the operator depresses or releases the accelerator. The ECU then sends an electrical signal to the motor on the ETB to increase or decrease the angle of the throttle blade, thus increasing or decreasing the air flow to the engine.

9Y1211108ENM0030US0

[5] INJECTORS AND FUEL INJECTION RAIL (GASOLINE LINE) [WG972-GL, WG972-G]



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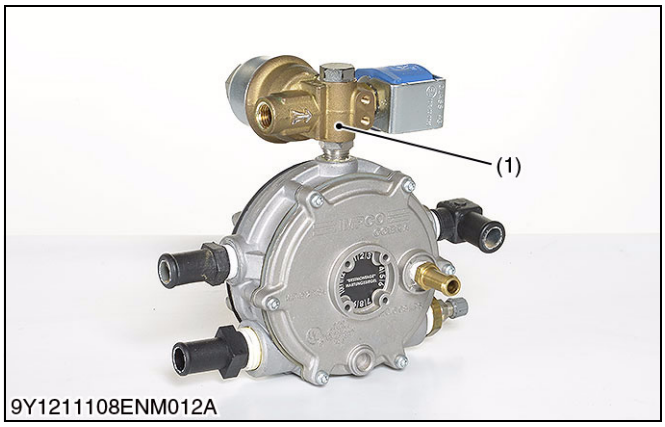
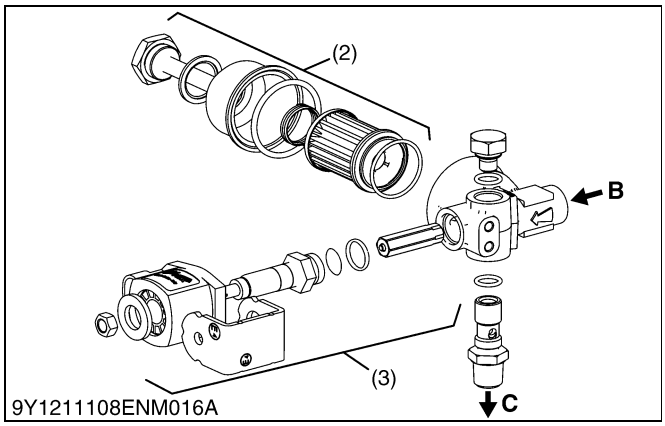
The gasoline fuel delivery system, uses a fuel injection rail (1) mounted with injectors (2), for each cylinder. The Engine Control Unit (ECU) will use the gasoline fuel delivery calibrations, to pulse width modulate each injector (2), to deliver the correct amount of gasoline, for optimized performance and emission control. The injector pulsing or "firing" is accomplished by supplying a 12 volt supply, to the positive side of the injector coil, and switching the ground circuit side, using the injector drivers, internal to the ECU. Injectors (2) are an emissions control device, and do not require periodic adjustment.

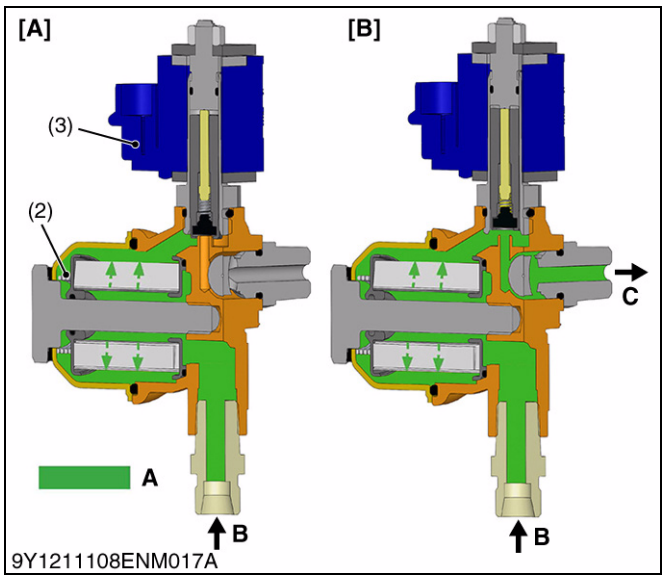
(1) Fuel Injection Rail (2) Injector

9Y1211108ENM0031US0

[6] LOCK OFF VALVE (GAS LINE) [WG972-GL, WG972-L, WG972-N]







The lock off valve blocks off liquid fuel flow to regulator by solenoid. Lock off valve has fuel filter and liquid fuel comes to lock off valve after passing through the filter. When applying current, the lock off valve closes the fuel passage.

Lock off valve is assembled to regulator.

(1) Lock Off Valve
(2) Filter Part
(3) Valve Part

[A] Lock Off Valve "Close"
[B] Lock Off Valve "Open"
A: Fuel
B: Fuel In (From Fuel Tank)
C: Fuel Out (To Regulator)

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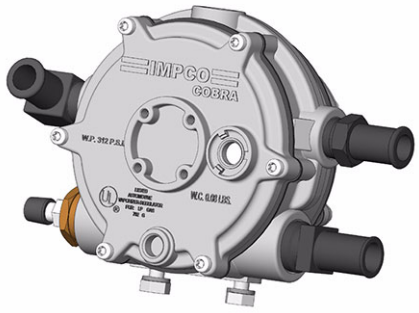
[7] REGULATOR WITH VAPORIZER (GAS LINE) [WG972-GL, WG972-L, WG972-N]



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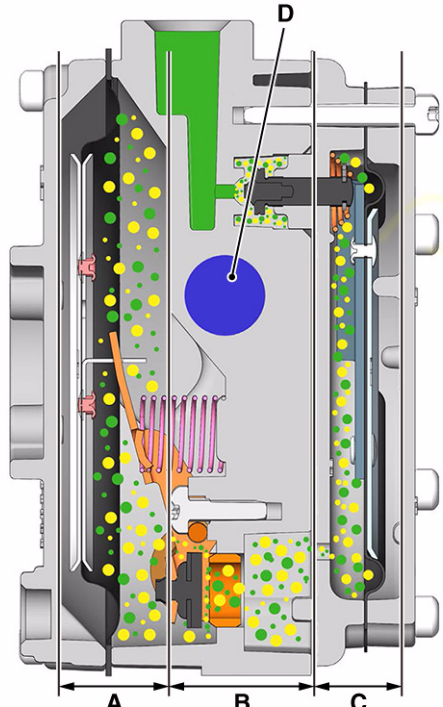

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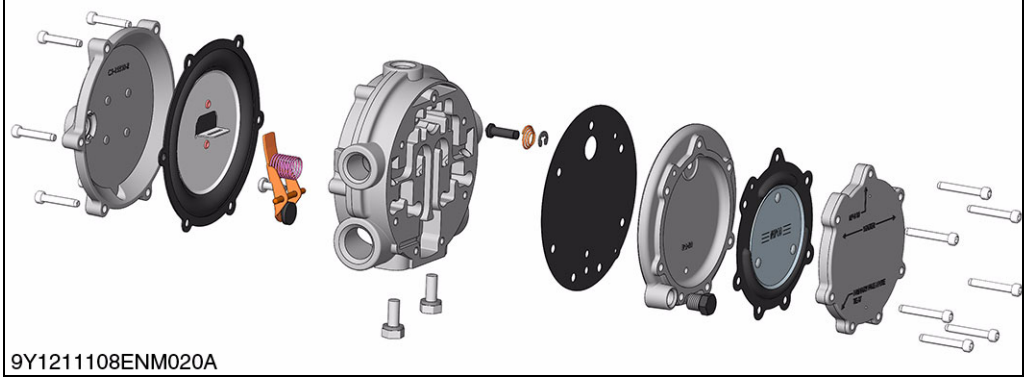

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Regulator with vaporizer evaporates the liquid fuel (LPG / CNG) into the gaseous fuel and then sends to the mixer. Regulator with vaporizer has the following structures and functions.

■ **Evaporator**

Evaporator has a long fuel passage to evaporate liquid fuel to gaseous fuel.

■ **Hot Water Line**

The coolant water of the engine is made to circulate as a heat source to prevent freezing of vaporizer by latent heat of vaporization.

■ **Primary Stage**

There is a primary valve which is safety device for abnormal pressure.

■ **Secondary Stage**

Secondary stage has a secondary valve and controls the quantity of gaseous fuel flowing to the mixer.

A: Secondary Stage
B: Evaporator
C: Primary Stage
D: Hot Water Line

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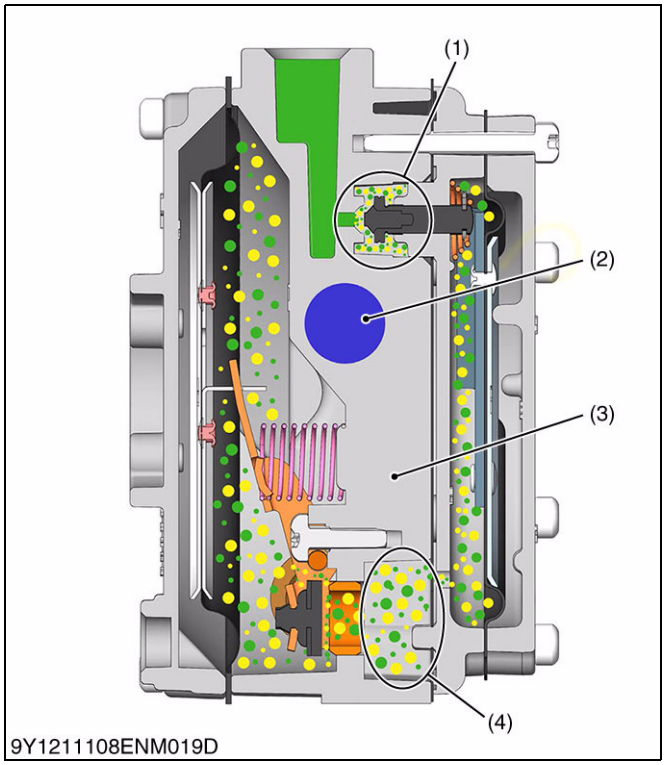

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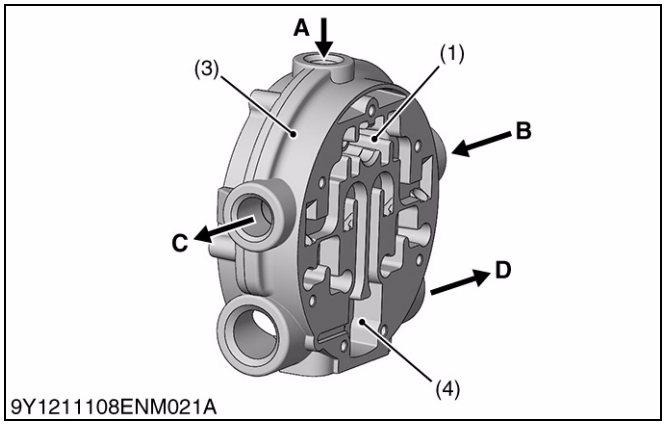

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Evaporator

Liquid fuel comes to regulator from lock off valve, and then comes into evaporator (1) through primary valve. Evaporator (1) has a long fuel passage and liquid fuel evaporates to gaseous fuel while passing through this long passage.

Also, evaporator has hot water passage. The latent heat of vaporization of fuel is generated when liquid changes to gas. The coolant water of the engine is made to circulate in evaporator as a heat source to prevent freezing of vaporizer by latent heat of vaporization.

Outlet of evaporator is connecting with primary chamber and secondary chamber, and also gaseous fuel flows to primary chamber and secondary chamber.

(1)	Inlet of Evaporator	**A:**	**Liquid Fuel In (To Regulator)**
(2)	Hot Water Passage	**B:**	**Hot Water In**
(3)	Evaporator	**C:**	**Hot Water Out**
(4)	Outlet of Evaporator	**D:**	**Gaseous Fuel Out (From Regulator)**

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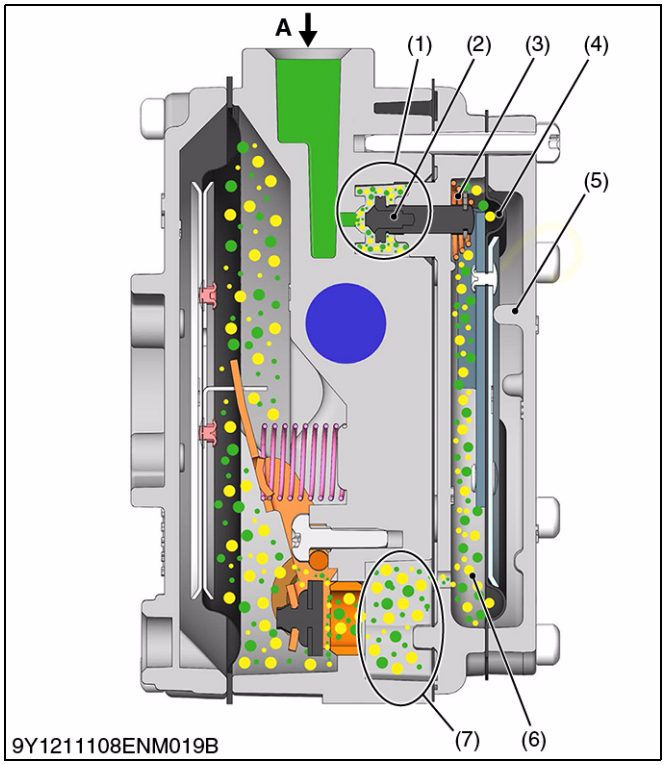

Primary Stage

Primary valve is pulled by primary valve spring at normal condition and primary valve opens inlet of liquid fuel.

Gaseous fuel fills in primary chamber and gas pressure does not push down primary valve spring in normal condition.

When the gaseous fuel pressure in primary chamber got to be abnormal, the diaphragm swells by pressure in primary chamber and push down the primary valve spring through fulcrum point. Therefore primary valve is closed and stop the inlet of liquid fuel.

Primary stage is safety device for abnormal gaseous pressure.

(1) Inlet of Evaporator
(2) Primary Valve
(3) Primary Valve Spring
(4) Membrane Primary Stage
(5) Fulcrum Point of Membrane Primary Stage
(6) Primary Chamber
(7) Outlet of Evaporator

A: Liquid Fuel In

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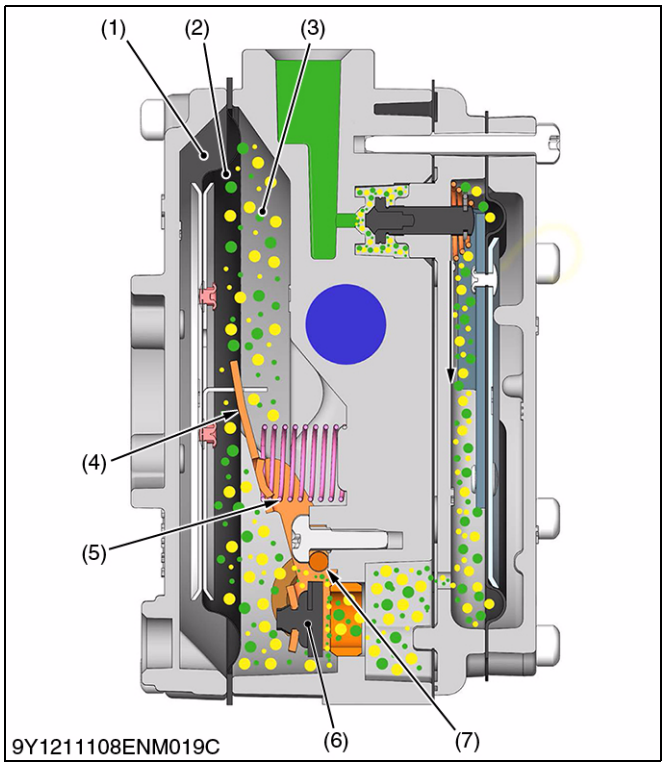

Secondary Stage

Gaseous fuel fills in primary chamber, and then gaseous fuel pushes up secondary valve and flows in secondary chamber. Gaseous fuel flows out to mixer from regulator after gaseous fuel was filled in secondary chamber.

There is balance connection chamber on the opposite side of secondary chamber through the membrane secondary stage. This balance connection chamber is connecting with mixer. Balance connection chamber gets negative pressure by negative pressure from mixer, and then membrane is pulled to the direction of balance connection chamber. Then lever is pulled by membrane, and also secondary valve moves to close direction. Thus secondary stage is adjusting gaseous fuel quantity flowing to the mixer.

(1) Balance Connection Chamber
(2) Membrane Secondary Stage
(3) Secondary Chamber
(4) Lever
(5) Secondary Valve Spring
(6) Secondary Valve
(7) Fulcrum Point of Secondary Valve

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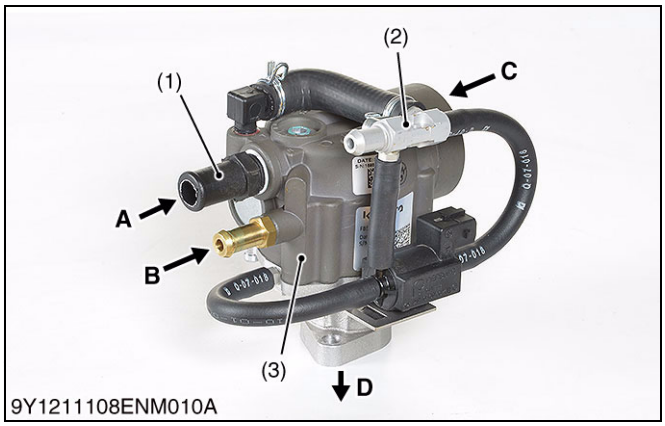
[8] MIXER (GAS LINE) [WG972-GL, WG972-L, WG972-N]



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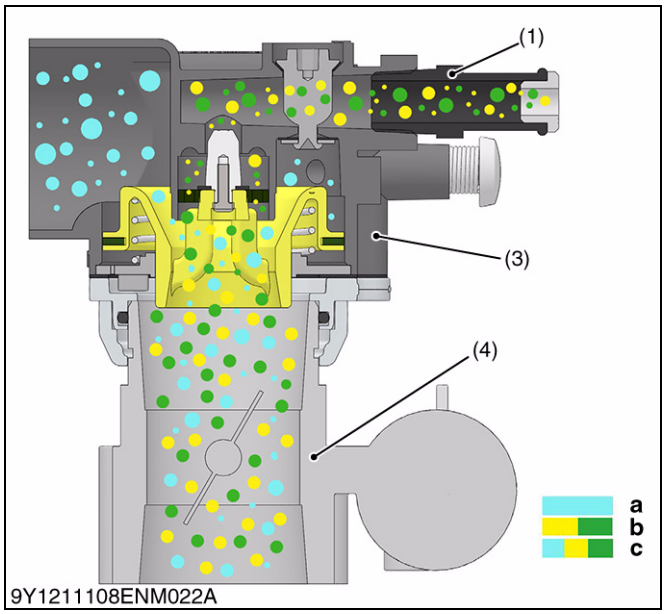

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Mixer (3) is a device to mix air and gaseous fuel with proper ratio required by the engine. The gaseous LPG or CNG fuel flows to the mixer through main jet (1) from the Regulator with vaporizer.

When the engine starts, the LPG fuel flows out from main jet (1) to venturi a constant amount and is mixed with air quantity corresponding to the opening of the throttle valve and is supplied to the cylinder.

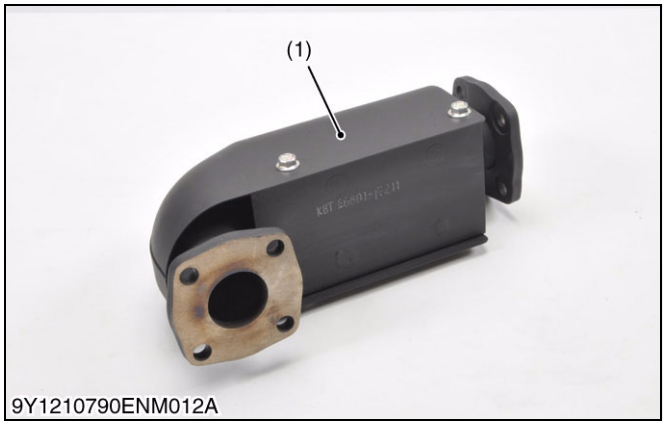
(1) Main Jet (LPG / CNG)
(2) Regulator Reference Port (Connecting with Secondary Stage in Regulator)
(3) Mixer
(4) Electronic Throttle Body

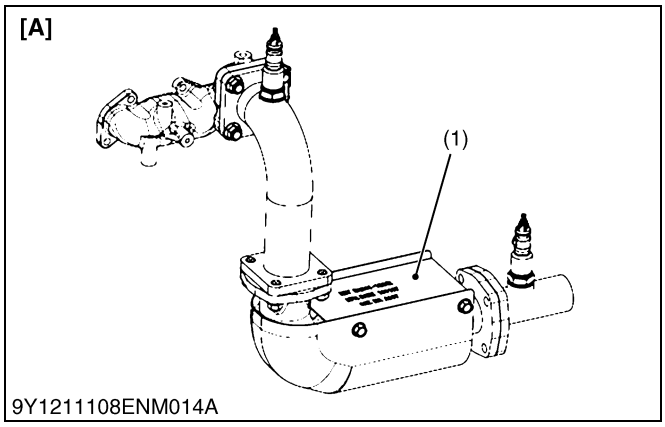
A: Gaseous Fuel (LPG / CNG)
B: Blow-by Gas (From Head Cover)
C: Air
D: Mixture (Air and Fuel)
a: Air
b: Vapor Fuel
c: Mixture

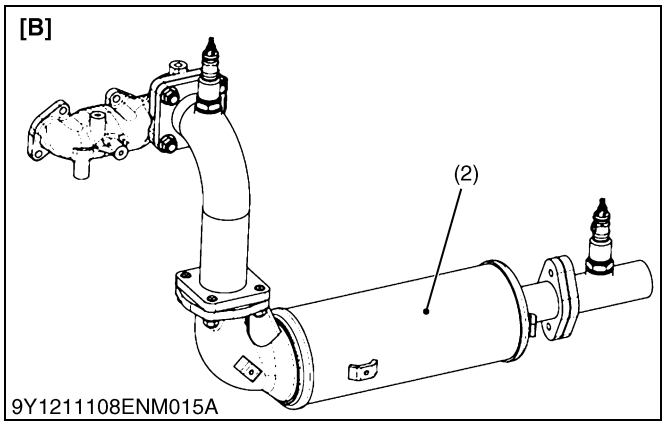
9Y1211108ENM0032US0

5. EXHAUST SYSTEM

[1] THREE-WAY CATALYST







A three-way catalyst is a catalyst that removes CO, HC and NOx at the same time by oxidation-reduction reaction.

A three-way catalyst 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 is a three-way catalyst and it is feedback control of air-fuel ratio by means of an oxygen sensor.

The purpose is to make maximizing the emission purification efficiency characteristic with reference to the intake air-fuel ratio.

Because the good balance of carbon, hydrogen and oxygen in exhaust gas is necessary to operate three-way catalyst and oxidation-reduction reaction successfully. Also the balanced condition is theoretical air fuel ratio.

KUBOTA engines have two kinds of catalytic devices which are catalytic muffler and catalytic converter. Both of catalytic devices are attached after exhaust manifold.

If catalytic converter is adopted, additional muffler should be assembled after catalytic converter.

(1) Catalytic Converter
(2) Catalytic Muffler

[A] CATALYTIC CONVERTER
[B] CATALYTIC MUFFLER

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[2] OXYGEN SENSOR


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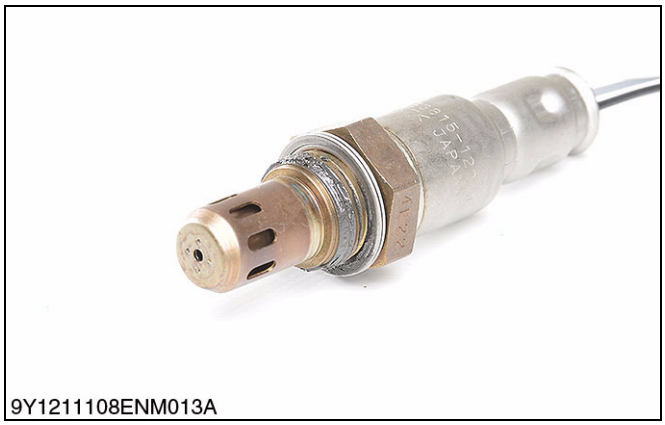
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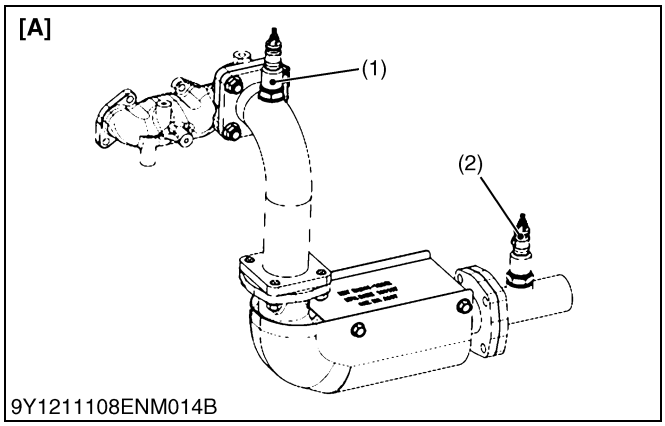

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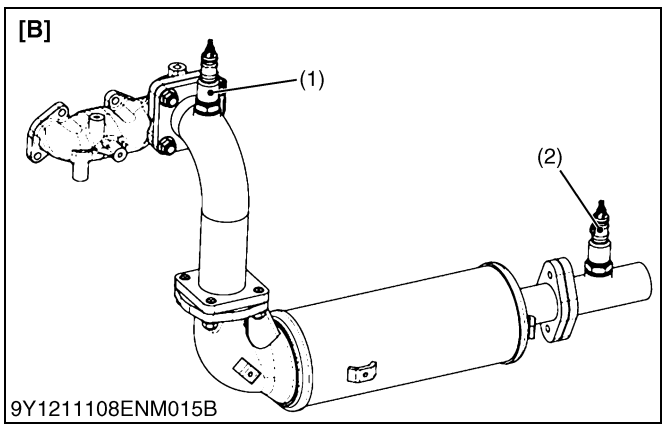

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An Oxygen sensor is an essential element of a feedback control of air-fuel ratio.

The sensor has a zirconia tube which is a solid electrolyte.

The outside of zirconia tube contacts with the exhaust gas and the inside of zirconia tube contacts with the atmosphere to know each oxygen concentration.

The difference of oxygen concentration produced between the outside and inside of the zirconia tube causes electromotive force to be generated.

Oxygen sensor should be installed at the both of inlet and outlet of catalyst.

[Pre-Catalyst Oxygen Sensor]

When the air-fuel ratio is rich, HC, CO, and 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.

Thus, pre-catalyst oxygen sensor is sensing the density of oxygen in exhaust gas before passing of catalyst, and adjusts the appropriate fuel injection quantity.

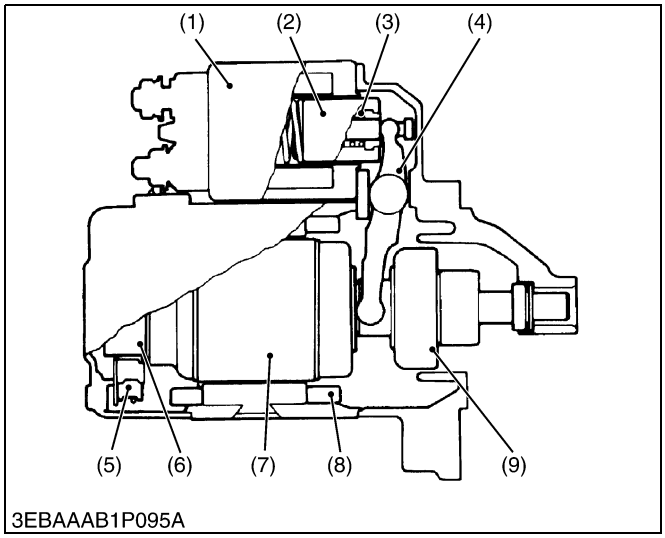
[Post-Catalyst Oxygen Sensor]

A post-catalyst oxygen sensor is sensing the density of oxygen in exhaust gas after passing of three-way catalyst. Also the post-catalyst oxygen sensor senses deterioration of catalyst, and also keeps and improves the purification performance.

(1)	Pre-Catalyst Oxygen Sensor	**[A]**	**CATALYTIC CONVERTER**
(2)	Post-Catalyst Oxygen Sensor	**[B]**	**CATALYTIC MUFFLER**

9Y1211108ENM0039US0

6. ELECTRICAL SYSTEM
[1] STARTING SYSTEM



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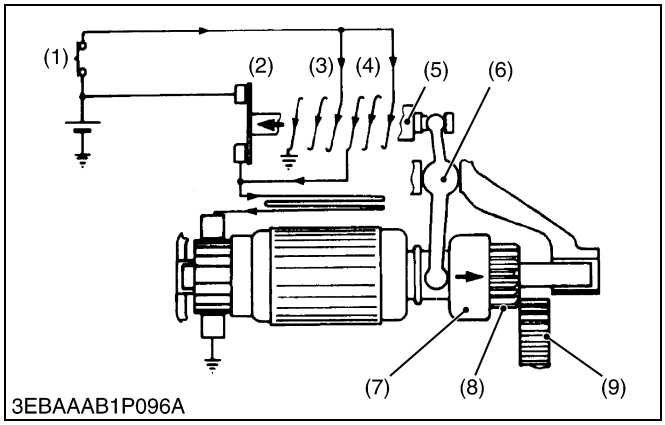

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Starter

The starter is the electromagnetic drive type.

Type of motor	DC, Series-wound, Electromagnetic drive
Nominal output	12 V
Nominal output	1.0 kW
Nominal output	30 seconds (Do not rotate continuously for longer periods.)
Direction of rotation	Clockwise as viewed from pinion side

(1) Solenoid Switch
(2) Plunger
(3) Spring
(4) Shift Lever
(5) Brush
(6) Commutator
(7) Armature
(8) Field Coil
(9) Overrunning Clutch

9Y1211108ENM0040US0

Operation of Starter

[When key switch is turned to "START" position]

The contacts of key switch (1) close and the holding coil (3) is connected to the battery to pull the plunger (5).

The pull-in coil (4) and the starting motor are also connected to the battery.

The pinion (8) is pushed against the ring gear (9) with the overrunning clutch (7) by the shift lever (6) and the magnetic switch is closed.

[When the solenoid switch is closed]

The current from the battery flows through the solenoid switch (2) to the starting motor.

The pinion (8), which is pushed against the ring gear (9) and rotated along the spline, meshes with the ring gear to crank the engine.

The engine starts and increases its speed.

While the pinion spins faster than the armature, the overrunning clutch (7) allows the pinion to spin independently from the armature.

The pull-in coil (4) is short-circuited through the solenoid switch (2) and the key switch (1).

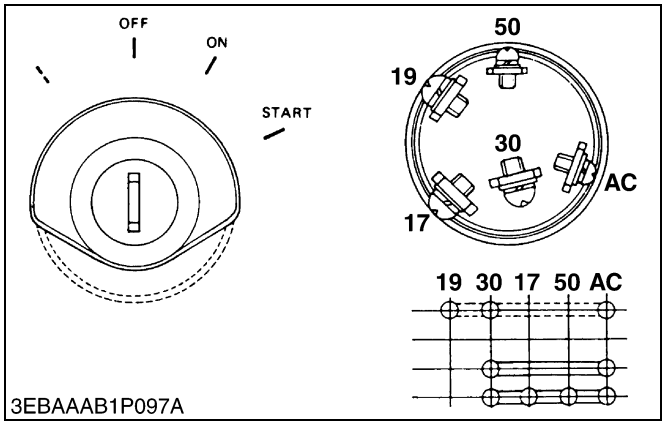
[When the key switch is released]

The current from the battery flows to the holding coil (3) through the pull-in coil (4) to diminish the magnetism between them.

The plunger (5) is pushed by the spring to pull in the pinion.

(1) Key Switch
(2) Solenoid Switch
(3) Holding Coil
(4) Pull-in Coil
(5) Plunger
(6) Shift Lever
(7) Overrunning Clutch
(8) Pinion
(9) Ring Gear

9Y1211108ENM0041US0



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Key Switch

The key switch has 4 positions. The terminal **"30"** is connected to the battery.

It is released at the **"START"** position and returns to the **"ON"** position.

[START]

When the key is turned to the **"START"** position, through the **"ON"** position the current supplied to the starter to regulator, oil lamp and accessory.

50 to starter

30 from battery

AC to regulator, oil lamp and accessory

[ON]

Only the terminal **"AC"** is connected to the battery. At any position of the key except the **"OFF"** position, the terminal **"AC"** is connected to the **"30"** terminal.

30 from battery

AC to regulator, oil lamp and accessory

9Y1211108ENM0042US0

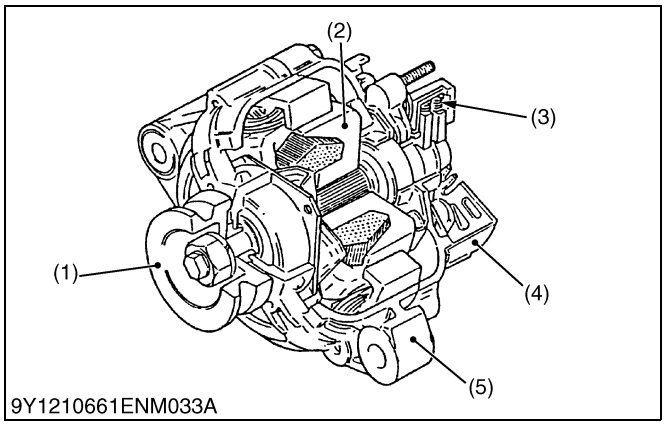
[2] CHARGING SYSTEM

(1) General

The function of the charging device is to charge batteries.

9Y1211108ENM0043US0

(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.

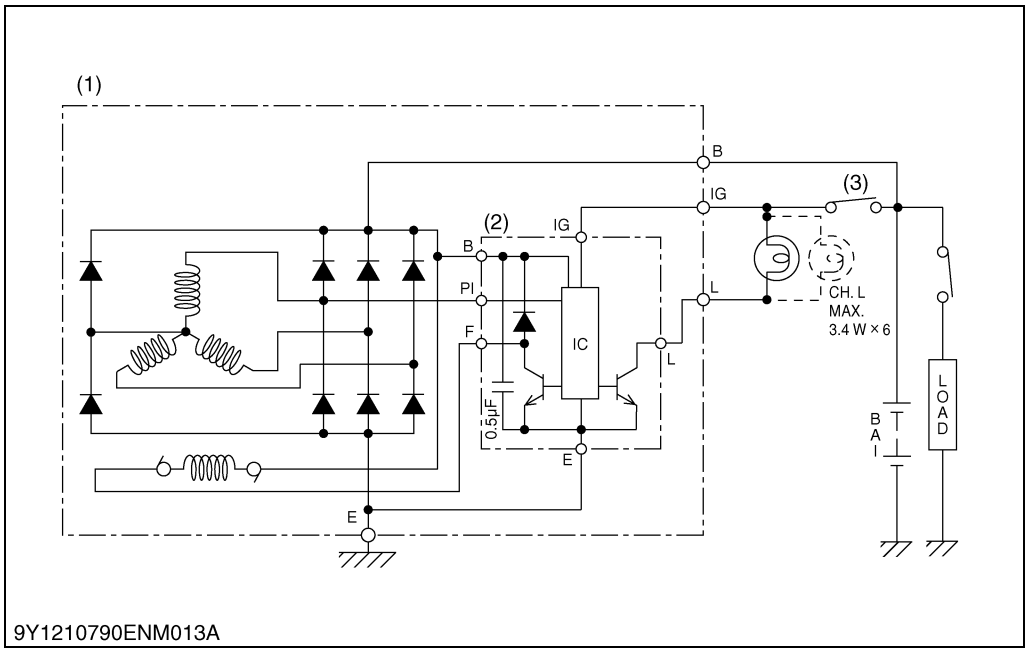
The cooling property and safety is improved by incorporating the cooling fan and roller that is an integral structure.

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

9Y1211108ENM0044US0

D2 Type Regulator



9Y1210790ENM013A

(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.

9Y1211108ENM0045US0

Charge Light Control

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

9Y1211108ENM0046US0

Specification of Alternator with IC (Incorporated with) Regulator

Nominal voltage	12 V
Maximum output	40 A, 60 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)	13.5 V at 0 A 1050 to 1350 min^{-1} (rpm)
min^{-1} (rpm) at max. output (when cold)	13.5 V at maximum output below 4000 min^{-1} (rpm)

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

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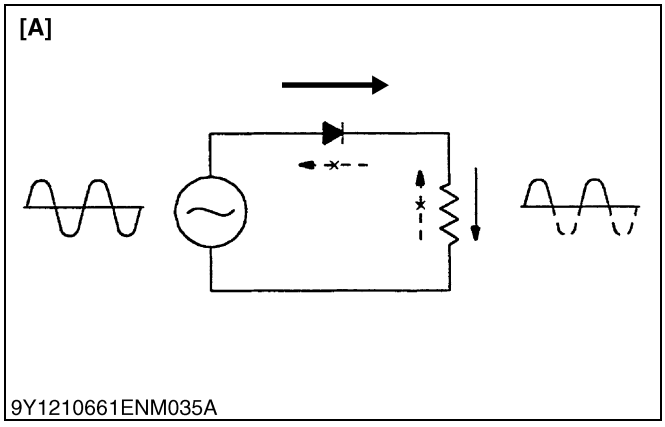

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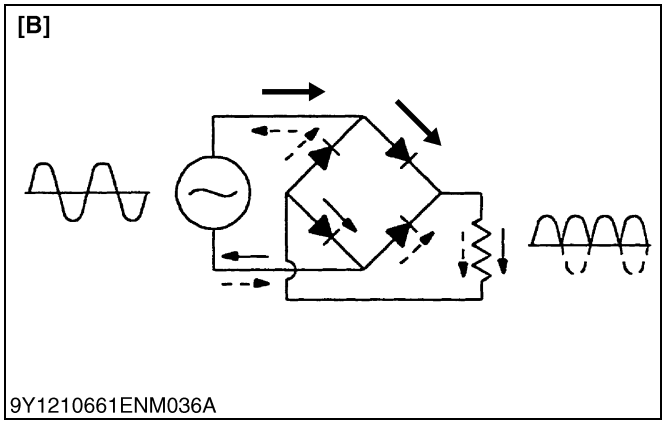

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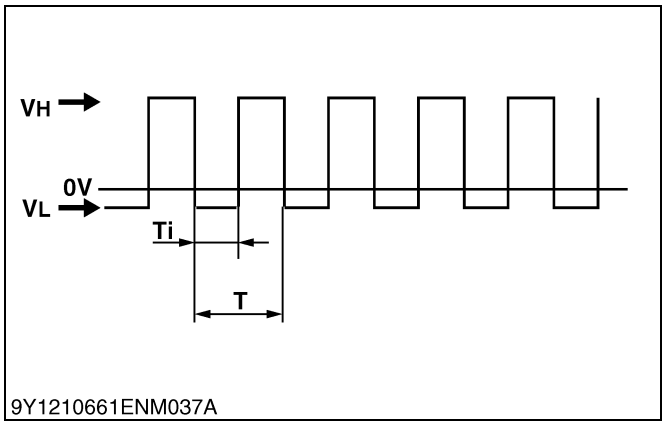

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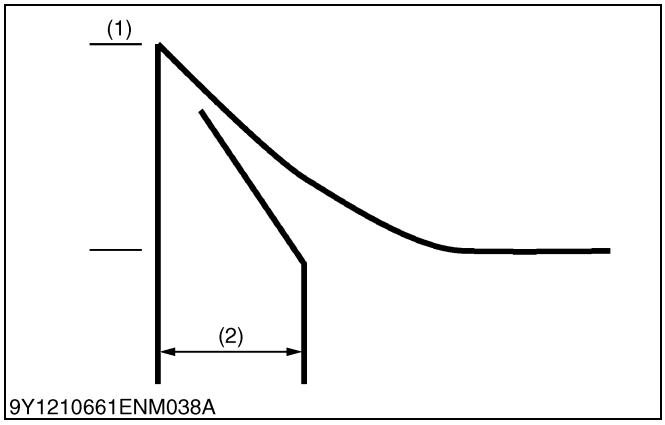

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Total Wave Rectification

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 removes 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**

9Y1211108ENM0048US0

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**

9Y1211108ENM0049US0

■ **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

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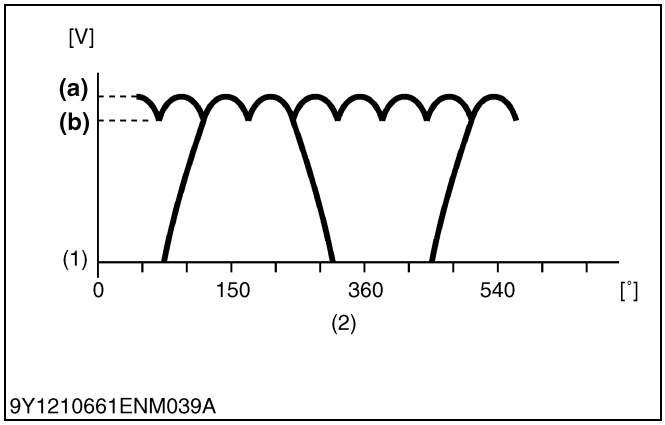

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Surge voltage waveform with any charging cable disconnection.

- 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

9Y1211108ENM0051US0

[3] ENGINE CONTROL UNIT (ECU)


9Y1211017ENM006A

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

9Y1211108ENM0052US0

[4] WATER TEMPERATURE SENSOR


9Y1210790ENM015A

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.

9Y1211108ENM0053US0

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


9Y1210790ENM016A

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.

9Y1211108ENM0054US0

[6] CRANKSHAFT POSITION SENSOR


9Y1211017ENM012A

The Crankshaft Position Sensor provides engine speed information.

9Y1211108ENM0055US0

[7] CAMSHAFT POSITION SENSOR


9Y1210790ENM018A

The Camshaft Position sensor informs the ECU which cylinders are in compression to signal spark timing.

9Y1211108ENM0056US0

[8] IGNITION COIL


9Y1210790ENM019A

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.

9Y1211108ENM0057US0

SERVICING

CONTENTS

1. TROUBLESHOOTING

[1] FOR GENERAL

Symptom	Probable Cause and Checking Procedure	Solution	Reference Page
Engine Does Not Turn Over	1. Seizure of crankshaft, piston, etc.	Check if crankshaft rotates	–
		Repair or replace	1-S33, 1-S36
	2. Battery discharged	Charge	–
	3. Wire disconnection or damaged	Check the wire harness	–
		Reconnect or replace	–
	4. Starter malfunctioning	Repair or replace	1-S22, 1-S23, 1-S58
Engine Turns Over Slowly But Does Not Start	1. Increased resistance of moving parts	Repair or replace	–
	2. Excessively high viscosity engine oil at low temperature	Use specified engine oil	G-15
Engine Turns Over At Normal Speed But Does Not Start	1. Fuel does not flow	Check the fuel tank, fuel filter, fuel hoses and fuel pump	–
		Repair or replace	G-15
	2. Fuel filter clogged	Check and replace	G-16, G-17
	3. Damaged spark plug	Check and adjust or replace	1-S20, 1-S21
	4. Damaged ignition coil	Check and replace	1-S21
	5. Wires disconnection or damaged	Check the wire harness	–
		Reconnect or replace	–
	6. Bad connection of ignition coil and spark plug	Reconnect	–
	7. Clogged air cleaner	Clean or replace	G-14, G-24
	8. Improper valve clearance	Check the compression pressure	1-S14
		Adjust	1-S15
	9. Improper intake and exhaust valve sealing	Check the compression pressure	1-S14
		Check and replace	1-S42
	10. Excessive wear of rings and liners	Check the compression pressure	1-S14
		Check and replace	1-S50, 1-S56

Symptom	Probable Cause and Checking Procedure	Solution	Reference Page
Deficient Output	1. Fuel is insufficient	Check the fuel system	–
	2. Damaged spark plug	Check and adjust or replace	1-S20, 1-S21
	3. Damaged ignition coil	Check and replace	1-S21
	4. Wires disconnection or damaged	Check the wire harness	–
		Reconnect or replace	–
	5. Bad connection of ignition coil and spark plug	Reconnect	–
	6. Clogged air cleaner	Clean or replace	G-14, G-24
	7. Insufficient oil in lubricating system	Check oil pressure and lubricating	1-S16
		Repair	1-S57
	8. Oil filter clogged	Check and replace	G-18
	9. Improper valve clearance	Check the compression pressure	1-S14
		Adjust	1-S15
	10. Improper intake and exhaust valve sealing	Check the compression pressure	1-S14
		Check and replace	1-S42
	11. Excessive wear of rings and liners	Check the compression pressure	1-S14
		Check and replace	1-S50, 1-S56
	12. Excessive carbon in engine	Remove carbon	1-S40
	13. Improper clearance of bearing	Check and adjust	1-S52, 1-S54, 1-S55
Rough Low-speed Operating And Idling	1. Damaged spark plug	Check and adjust or replace	1-S20, 1-S21
	2. Damaged ignition coil	Check and replace	1-S21
	3. Wires disconnection or damaged	Check the wire harness	–
		Reconnect or replace	–
	4. Bad connection of ignition coil and spark plug	Reconnect	–
	5. Improper valve clearance	Check the compression pressure	1-S14
		Adjust	1-S15
	6. Improper intake and exhaust valve sealing	Check the compression pressure	1-S14
		Check and replace	1-S42
	7. Excessive wear of rings and liners	Check the compression pressure	1-S14
		Check and replace	1-S50, 1-S56

Symptom	Probable Cause and Checking Procedure	Solution	Reference Page
Rough High-speed Operating	1. Damaged spark plug	Check and adjust or replace	1-S20, 1-S21
	2. Damaged ignition coil	Check and replace	1-S21
	3. Wires disconnection or damaged	Check the wire harness	–
		Reconnect or replace	–
	4. Bad connection of ignition coil and spark plug	Reconnect	–
	5. Improper valve clearance	Check the compression pressure	1-S14
		Adjust	1-S15
	6. Improper intake and exhaust valve sealing	Check the compression pressure	1-S14
		Check and replace	1-S42
	7. Excessive wear of rings and liners	Check the compression pressure	1-S14
		Check and replace	1-S50, 1-S56
Engine Speed Does Not Increase	1. Damaged spark plug	Check and adjust or replace	1-S20, 1-S21
	2. Damaged ignition coil	Check and replace	1-S21
	3. Wires disconnection or damaged	Check the wire harness	–
		Reconnect or replace	–
	4. Bad connection of ignition coil and spark plug	Reconnect	–
	5. Improper input signal to ECU	Check the wire harness	★
	6. Clogged air cleaner	Clean or replace	G-14, G-24
	7. Breather tube has separated	Attach correctly	1-M5
	8. Damaged throttle body	Replace	★
Engine Suddenly Stop	1. Insufficient fuel	Check the fuel tank and refill the fuel	G-10
		Check the fuel system for air or leaks	G-15
	2. Wire disconnection or damaged	Check the wire harness	–
		Reconnect or replace	–
	3. Clogged air cleaner	Clean or replace	G-14, G-24
	4. Overheating of moving parts	Check amount of engine oil	G-11
		Check lubricating system	–
		Replace oil filter cartridge	G-18
	5. Improper valve clearance	Adjust	–
Excessive Black Exhaust Gas Is Observed	1. Fuel system is bad	Check the fuel system	–
	2. Fuel is extremely poor quality	Replace fuel	G-10
Excessive White Exhaust Gas Is Observed	1. Excessive engine oil	Reduce oil to specified level	1-S25
	2. Damaged valve stem seal	Replace	1-S29
	3. Piston ring and liner worn or stuck	Check and replace	1-S50, 1-S56

Symptom	Probable Cause and Checking Procedure	Solution	Reference Page
Lubricant Oil Consumption Is Excessive	1. Oil leakage from oil seal, gasket, etc.	Replace	–
	2. Damaged valve stem seal	Replace	1-S29
	3. Piston ring and liner worn or stuck	Replace	1-S50, 1-S56
Engine Overheats	1. Insufficient engine oil	Check engine oil level	G-11
		Refill oil as required	G-10
	2. Fan belt broken or elongated	Check and adjust fan belt or replace	1-S17
	3. Coolant insufficient	Refill coolant	G-25, G-26
	4. Excessive concentration of antifreeze	Add water only or change to coolant with the specified mixing ratio	G-26
	5. Radiator net or radiator fin clogged with dust	Clean net or fin carefully	–
	6. Inside of radiator or coolant flows route corroded	Clean or replace radiator and parts	G-25
	7. Damaged fan or radiator or radiator cap	Replace damaged parts	–
	8. Damaged thermostat	Check thermostat and replace	1-S17
	9. Damaged temperature sensor	Check temperature with thermometer and replace	1-S23
	10. Overload running	Reduce load	–
	11. Head gasket damaged or water leakage	Replace	–
Engine Noise	1. Improper valve clearance	Adjust	1-S15
	2. Spark knock due to low octane fuel or carbon	Use higher-octane fuel and remove carbon	1-S20, 1-S21, 1-S40
	3. Rattles from loosely mounted external components	Retighten	–
Exhaust Flames	1. Damaged spark plug	Check and adjust or replace	1-S20, 1-S21
	2. Damaged ignition coil	Check and replace	1-S21
	3. Wires disconnection or damaged	Check the wire harness	–
		Reconnect or replace	–
	4. Bad connection of ignition coil and spark plug	Reconnect	–

★: Refer to Diagnosis Manual

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[2] FOR GASOLINE FUEL [WG972-GL, WG972-G]

Symptom	Probable Cause and Checking Procedure	Solution	Reference Page
Engine Turns Over At Normal Speed But Does Not Start	1. Spark plug electrodes are wet with gasoline	Dry electrode and restart	–

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[3] FOR GAS FUEL [WG972-GL, WG972-L, WG972-N]

Symptom	Probable Cause and Checking Procedure	Solution	Reference Page
Engine Turns Over At Normal Speed But Does Not Start	1. Insufficient gas fuel	Fill gas fuel	G-10
	2. Damaged gas fuel tank valve	Check and replace	–
	3. Damaged lock off valve	Check and replace	1-S19
	4. Damaged gas regulator	Check and replace	–
Rough Low-speed Operating And Idling	1. Shortage of gas supply	Fill gas fuel	G-10
		Check lock off valve	1-S19
Deficient Output	1. Gas fuel density is rich	Check and replace gas regulator	–
	2. Shortage of gas supply	Repair or replace of fuel system	G-15
		Replace gas regulator	–

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2. SERVICING SPECIFICATIONS

ENGINE BODY

Item		Factory Specification	Allowable Limit
Valve Clearance (Cold)		0.145 to 0.185 mm 0.00571 to 0.00728 in.	–
Compression Pressure	– Variance Among Cylinder	1.27 MPa 13.0 kgf/cm^2 185 psi –	0.88 MPa 9.0 kgf/cm^2 130 psi 10 % or less
Top Clearance		1.15 to 1.35 mm 0.0453 to 0.0532 in.	–
Cylinder Head Surface	Flatness	–	0.05 mm 0.002 in.
Valve Recessing (Intake and Exhaust)		0.10 (protrusion) to 0.10 (recessing) mm 0.0039 (protrusion) to 0.0039 (recessing) in.	0.30(recessing) mm 0.012(recessing) in.
Valve Stem to Valve Guide (Inlet)	Clearance	0.030 to 0.060 mm 0.0012 to 0.0024 in.	0.10 mm 0.0039 in.
• Valve Stem	O.D.	5.965 to 5.980 mm 0.2348 to 0.2354 in.	–
• Valve Guide	I.D.	6.010 to 6.025 mm 0.2367 to 0.2372 in.	–
Valve Stem to Valve Guide (Exhaust)	Clearance	0.030 to 0.057 mm 0.0012 to 0.0022 in.	0.10 mm 0.0039 in.
• Valve Stem	O.D.	5.968 to 5.980 mm 0.2350 to 0.2354 in.	–
• Valve Guide	I.D.	6.010 to 6.025 mm 0.2367 to 0.2372 in.	–
Valve Face	Angle	0.79 rad 45 °	–
Valve Seat	Angle	0.79 rad 45 °	–
Valve Timing (Intake Valve)	Open Close	0.35 rad 20 ° before T.D.C. 0.79 rad 45 ° after B.D.C.	– –
Valve Timing (Exhaust Valve)	Open Close	0.87 rad 50 ° before B.D.C. 0.26 rad 15 ° after T.D.C.	– –

Item		Factory Specification	Allowable Limit
Valve Spring	Free Length	31.3 to 31.8 mm 1.24 to 1.25 in.	28.4 mm 1.12 in.
	Tilt	–	1.2 mm 0.047 in.
	Setting Load / Setting Length	65 N / 27.0 mm 6.6 kgf / 27.0 mm 15 lbf / 1.06 in.	55 N / 27.0 mm 5.6 kgf / 27.0 mm 12 lbf / 1.06 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.	10.473 to 10.484 mm 0.41233 to 0.41275 in.	–
• Rocker Arm	I.D.	10.500 to 10.518 mm 0.41339 to 0.41409 in.	–
Push Rod	Alignment	–	0.25 mm 0.0098 in.
Tappet to Tappet Guide Bore	Oil Clearance	0.016 to 0.052 mm 0.00063 to 0.0020 in.	0.10 mm 0.0039 in.
• Tappet	O.D.	17.966 to 17.984 mm 0.70733 to 0.70803 in.	–
• Tappet Guide Bore	I.D.	18.000 to 18.018 mm 0.70867 to 0.70937 in.	–
Timing Gear			
• Crank Gear to Idle Gear	Backlash	0.0430 to 0.124 mm 0.00170 to 0.00488 in.	0.15 mm 0.0059 in.
• Idle Gear to Cam Gear	Backlash	0.0470 to 0.123 mm 0.00185 to 0.00484 in.	0.15 mm 0.0059 in.
• Crank Gear to Oil Pump Drive Gear	Backlash	0.0410 to 0.123 mm 0.00162 to 0.00484 in.	0.15 mm 0.0059 in.
Idle Gear	Side Clearance	0.20 to 0.51 mm 0.0079 to 0.020 in.	0.80 mm 0.031 in.
Camshaft	Side Clearance	0.15 to 0.31 mm 0.0059 to 0.012 in.	0.50 mm 0.020 in.
	Alignment	–	0.01 mm 0.0004 in.
	Cam Height (Intake and Exhaust)	26.88 mm 1.058 in.	26.83 mm 1.056 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.	32.934 to 32.950 mm 1.2967 to 1.2972 in.	–
• Cylinder Block Bore	I.D.	33.000 to 33.025 mm 1.2993 to 1.3001 in.	–

Item		Factory Specification	Allowable Limit
Idle Gear Shaft to Idle Gear Bushing	Oil Clearance	0.020 to 0.088 mm 0.00079 to 0.0035 in.	0.10 mm 0.0039 in.
• Idle Gear Shaft	O.D.	19.967 to 19.980 mm 0.78611 to 0.78661 in.	–
• Idle Gear Bushing	I.D.	20.000 to 20.051 mm 0.78741 to 0.78940 in.	–
Piston Pin Bore	I.D.	20.000 to 20.013 mm 0.78741 to 0.78791 in.	20.05 mm 0.7894 in.
Piston Pin to Small End Bushing	Oil Clearance	0.012 to 0.038 mm 0.00048 to 0.0014 in.	0.10 mm 0.0039 in.
• Piston Pin	O.D.	20.002 to 20.013 mm 0.78748 to 0.78791 in.	–
• Small End Bushing	I.D.	20.025 to 20.040 mm 0.78839 to 0.78897 in.	–
Piston Pin to Small End Bushing (Spare Parts)	Oil Clearance	0.013 to 0.075 mm 0.00052 to 0.0029 in.	0.15 mm 0.0059 in.
• Small End Bushing	I.D.	20.026 to 20.077 mm 0.78843 to 0.79043 in.	–
Piston Ring			
• Top Ring	Gap	0.15 to 0.35 mm 0.0059 to 0.013 in.	1.25 mm 0.0492 in.
• Second Ring	Gap	0.30 to 0.45 mm 0.012 to 0.017 in.	1.25 mm 0.0492 in.
• Oil Ring (Upper and lower rail)	Gap	0.20 to 0.70 mm 0.0079 to 0.027 in.	1.25 mm 0.0492 in.
Piston Ring to Piston Ring Groove			
• Top Ring	Clearance	0.080 to 0.12 mm 0.0032 to 0.0047 in.	0.15 mm 0.0059 in.
• Second Ring	Clearance	0.065 to 0.10 mm 0.0026 to 0.0039 in.	0.15 mm 0.0059 in.
• Oil Ring	Clearance	0.060 to 0.15 mm 0.0024 to 0.0059 in.	0.20 mm 0.0079 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.
	Alignment	–	0.02 mm 0.0008 in.

Item		Factory Specification	Allowable Limit
Crankpin to Crankpin Bearing	Oil Clearance	0.020 to 0.051 mm 0.00079 to 0.0020 in.	0.15 mm 0.0059 in.
• Crankpin	O.D.	33.959 to 33.975 mm 1.3370 to 1.3375 in.	–
• Crankpin Bearing	I.D.	33.995 to 34.010 mm 1.3384 to 1.3389 in.	–
Crankshaft Journal to Crankshaft Bearing 1	Oil Clearance	0.0340 to 0.106 mm 0.00134 to 0.00417 in.	0.20 mm 0.0079 in.
• Crankshaft Journal	O.D.	43.934 to 43.950 mm 1.7297 to 1.7303 in.	–
• Crankshaft Bearing 1	I.D.	43.984 to 44.040 mm 1.7317 to 1.7338 in.	–
Crankshaft Journal to Crankshaft Bearing 2 (Flywheel Side)	Oil Clearance	0.028 to 0.059 mm 0.0011 to 0.0023 in.	0.20 mm 0.0079 in.
• Crankshaft Journal	O.D.	43.934 to 43.950 mm 1.7297 to 1.7303 in.	–
• Crankshaft Bearing 2	I.D.	43.978 to 43.993 mm 1.7315 to 1.7320 in.	–
Crankshaft Journal to Crankshaft Bearing 3 (Intermediate)	Oil Clearance	0.028 to 0.059 mm 0.0011 to 0.0023 in.	0.20 mm 0.0079 in.
• Crankshaft Journal	O.D.	43.934 to 43.950 mm 1.7297 to 1.7303 in.	–
• Crankshaft Bearing 3	I.D.	43.978 to 43.993 mm 1.7315 to 1.7320 in.	–
Cylinder Liner [Standard]	I.D.	74.500 to 74.519 mm 2.9331 to 2.9338 in.	74.669 mm 2.9397 in.
Cylinder Liner [Oversize: 0.5 mm (0.02 in.)]	I.D.	75.000 to 75.019 mm 2.9528 to 2.9535 in.	75.150 mm 2.9587 in.

LUBRICATING SYSTEM

Item		Factory Specification	Allowable Limit
Engine Oil Pressure	At Idle Speed	More than 50 kPa 0.5 kgf/cm^2 7 psi	–
	At Rated Speed	200 to 440 kPa 2.0 to 4.5 kgf/cm^2 29 to 64 psi	150 kPa 1.5 kgf/cm^2 21 psi
Inner Rotor to Outer Rotor	Clearance	0.030 to 0.14 mm 0.0012 to 0.0055 in.	–
Outer Rotor to Pump Body	Clearance	0.070 to 0.15 mm 0.0028 to 0.0059 in.	–
Inner Rotor to Cover	Clearance	0.0750 to 0.135 mm 0.00296 to 0.00531 in.	–

COOLING SYSTEM

Item		Factory Specification	Allowable Limit
Fan Belt	Tension	7.0 to 9.0 mm / 98 N 0.28 to 0.35 in. / 98 N (10 kgf, 22 lbf)	–
Thermostat	Valve Opening Temperature (At Beginning)	69.5 to 72.5 °C 157.1 to 162.5 °F	–
	Valve Opening Temperature (Opened Completely)	85 °C 185 °F	–
Radiator Cap	Pressure Falling Time	More than 10 seconds for pressure fall from 90 → 60 kPa 0.9 → 0.6 kgf/cm^2 10 → 9 psi	–
Radiator	Weak Leakage Test Pressure	No leak at specified pressure	–

IGNITION SYSTEM

Item		Factory Specification	Allowable Limit
Ignition Timing (no-load condition)			
[WG972-G]		0.70 rad (40 °) B.T.D.C. 3600 min^{-1} (rpm)	–
[WG972-GL]	Gasoline	0.70 rad (40 °) B.T.D.C. 3600 min^{-1} (rpm)	–
	LPG	0.37 rad (21 °) B.T.D.C. 3600 min^{-1} (rpm)	–
[WG972-L]		0.37 rad (21 °) B.T.D.C. 3600 min^{-1} (rpm)	–
[WG972-N]		0.49 rad (28 °) B.T.D.C. 3600 min^{-1} (rpm)	–

Item		Factory Specification	Allowable Limit
Crankshaft Position Sensor	Resistance	1.85 to 2.45 kΩ at 20 °C (68 °F)	–
Camshaft Position Sensor	Conduction of each pins	Not conduction (Check with communication ECU)	
Spark Plug (NGK: BKR6E)	Plug Gap	0.70 to 0.80 mm 0.029 to 0.032 in.	–
Resistance of Ignition Coil	Conduction of each pins	Check ignition coil as ignition unit (Spark test).	–

ELECTRICAL SYSTEM

Item		Factory Specification	Allowable Limit
Starter			
• Commutator	O.D.	30.0 mm 1.18 in.	29.0 mm 1.14 in.
• Difference	O.D.	Less than 0.02 mm 0.0008 in.	0.05 mm 0.002 in.
• Mica	Undercut	0.50 to 0.80 mm 0.020 to 0.031 in.	0.2 mm 0.0079 in.
• Brush	Length	14.0 mm 0.551 in.	9.0 mm 0.35 in.
Alternator	No-load Voltage	14.2 V to 14.8 V at 5000 min^{-1} (rpm), 25 °C (77 °F)	–
• Stator	Resistance	Less than 1.0 Ω	–
• Rotor	Resistance	2.9 Ω	–
• Slip Ring	O.D.	14.4 mm 0.567 in.	14.0 mm 0.551 in.
• Brush	(Length)	10.5 mm 0.413 in.	8.4 mm 0.33 in.
Lock Off Valve (Gas Line)	Resistance	12.65 Ω at 20 °C (68 °F)	–

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3. TIGHTENING TORQUES

Screws, bolts and nuts must be tightened to the specified torque using a torque wrench, several screws, bolts and nuts such as those used on the cylinder head must be tightened in proper sequence and the proper torque.

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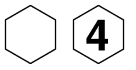
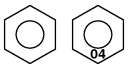
[1] TIGHTENING TORQUES FOR GENERAL USE SCREWS, BOLTS AND NUTS

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

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

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

■ **NOTE**

- **For "*" marked screws, bolts and nuts on the table, apply engine oil to their threads and seats before tightening.**
- **The letter "M" in Size means that the screw, bolt or nut dimension stands for metric. The size is the nominal outside diameter in mm of the threads.**

Item	Dimension × Pitch	N·m	kgf·m	lbf·ft
*Cylinder head cover screw	M6 × 1.0	6.87 to 11.2	0.700 to 1.15	5.07 to 8.31
*Rocker arm bracket screw	M6 × 1.0	9.81 to 11.2	1.00 to 1.15	7.24 to 8.31
*Cylinder head screw	M8 × 1.25	38 to 42	3.8 to 4.3	28 to 31
*Fan drive pulley screw	M12 × 1.5	98.1 to 107	10.0 to 11.0	72.4 to 79.5
*Idle gear shaft mounting screw	M6 × 1.0	9.81 to 11.2	1.00 to 1.15	7.24 to 8.31
Oil pump gear mounting nut	M10 × 1.25	39.2 to 45.1	4.00 to 4.59	29.0 to 33.2
*Connecting rod screw	M7 × 0.75	27 to 30	2.7 to 3.1	20 to 22
*Flywheel screw	M10 × 1.25	54 to 58	5.5 to 6.0	40 to 43
Bearing case cover mounting screw	M6 × 1.0	9.81 to 11.2	1.00 to 1.15	7.24 to 8.31
*Main bearing case screw 2	M7 × 1.0	27 to 30	2.7 to 3.1	20 to 22
*Main bearing case screw 1	M6 × 1.0	13 to 15	1.3 to 1.6	9.4 to 11
Oil pressure switch	PT 1/8	15 to 19	1.5 to 2.0	11 to 14
Spark plug	M14 × 1.25	24.5 to 29.4	2.50 to 2.99	18.1 to 21.6
Drain plug	M12 × 1.25	33 to 37	3.3 to 3.8	24 to 27
Joint for Gas IN (Liquid) of regulator with vaporizer	PT - 1/4	20 to 39	2.0 to 4.0	15 to 28
Regulator with Vaporizer mounting screw	1/4-20 UNC	5.4 to 6.6	0.55 to 0.67	4.0 to 4.8
Starter **B** terminal nut	–	9.81 to 11.7	1.00 to 1.20	7.24 to 8.67
Alternator's pulley nut	–	58.4 to 78.9	5.95 to 8.05	43.1 to 58.2
Exhaust manifold mounting screw/nut	M6 × 1.0	9.81 to 11.3	1.00 to 1.15	7.24 to 8.31
Catalytic converter mounting nut	M8 × 1.25	30 to 34	3.0 to 3.5	22 to 25
Catalytic muffler mounting nut	M8 × 1.25	30 to 34	3.0 to 3.5	22 to 25
Water temperature sensor	M12 × 1.25	less than 19.6	less than 2.00	less than 14.5
TMAP sensor screw	M5 × 0.8	2.0 to 7.0	0.20 to 0.71	1.5 to 5.0
Oxygen sensor	M18 × 1.5	39.2 to 48.9	3.99 to 4.99	28.9 to 36.0
Ignition coil screw	M6 × 1.0	9.81 to 11.3	1.00 to 1.15	7.24 to 8.31
Camshaft position sensor screw	M6 × 1.0	9.81 to 11.3	1.00 to 1.15	7.24 to 8.31
Crankshaft position sensor screw	M6 × 1.0	9.81 to 11.3	1.00 to 1.15	7.24 to 8.31

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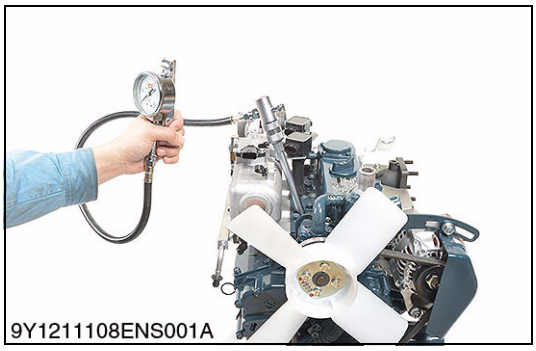
4. CHECKING, DISASSEMBLING AND SERVICING

[1] CHECKING AND ADJUSTING

(1) Engine Body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Compression Pressure

1. Operate the engine until it is warmed up.
2. Stop the engine.
3. Remove the air cleaner, the muffler/converter and all spark plugs.
4. Set a compression tester with the adaptor to the spark plug hole.
5. Operate the engine with the starter for 5 to 10 seconds keeping throttle valve fully open and read the maximum compression pressure.
6. Repeat steps 4 and 5 for each cylinder.
7. If the measurement is below the allowable limit, apply a small amount of oil to the cylinder wall through the spark plug hole and measure the compression pressure again.
8. If the compression pressure is still less than the allowable limit, check the top clearance, valve clearance and cylinder head.
9. If the compression pressure increases after applying oil, check the cylinder wall and piston rings.

■ **NOTE**

- **Check the compression pressure with the specified valve clearance.**
- **Always use a fully charged battery for performing this test.**
- **Variances in cylinder compression values should be under 10 %.**
- **Replace the muffler/converter gasket with a new one.**

Compression pressure	Factory specification	1.27 MPa 13.0 kgf/cm^2 185 psi
	Allowable limit	0.88 MPa 9.0 kgf/cm^2 130 psi

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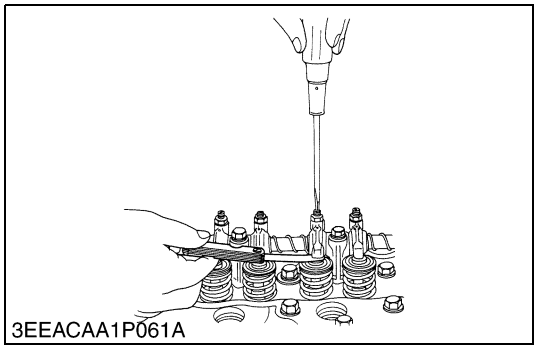
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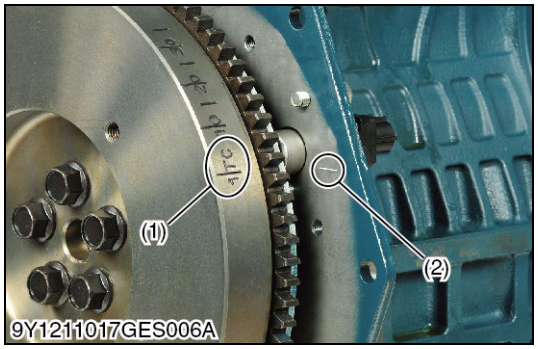

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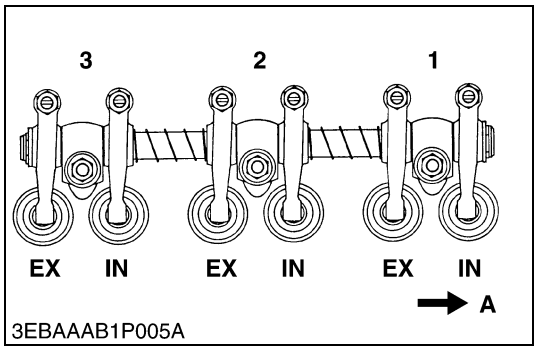

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Adjusting the Valve Clearance

■ **IMPORTANT**

- **The valve clearance must be checked and adjusted when engine is cold.**

1. Remove the cylinder head cover and the spark plugs.
2. Align the **"1TC"** mark (1) on the flywheel and alignment mark (2) on the rear end plate so that the No. 1 piston comes to the compression top dead center.
3. Check the following valve clearance marked with "★" using a feeler gauge.
4. If the clearance is not within the factory specifications, adjust with the adjusting screw.
5. Then turn the flywheel 6.28 rad (360 °), and align the **"1TC"** mark (1) on the flywheel and alignment mark (2) on the rear end plate so that the No. 1 piston comes to the overlap position.
6. Check the following valve clearance marked with "☆" using a feeler gauge.
7. If the clearance is not within the factory specifications, adjust with the adjusting screw.

Adjustable Cylinder Location of Piston	Valve Arrangement	
	Intake valve	Exhaust valve
No. 1	★	★
No. 2	☆	★
No. 3	★	☆

★: When No. 1 piston is at the compression top dead center position.
☆: When No. 1 piston is at the overlap position.

Intake and exhaust valve clearance (cold)	Factory specification	0.145 to 0.185 mm 0.00571 to 0.00728 in.

■ **NOTE**

- **The sequence of cylinder numbers is given as No. 1, No. 2 and No. 3 starting from the gear case side.**
- **After adjusting the valve clearance, secure the adjusting screw with the lock nut.**

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

A: Gear Case Side

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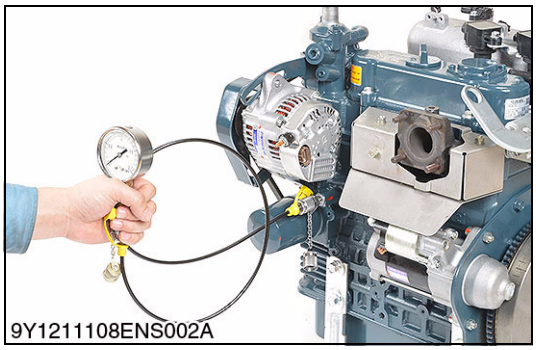
(2) Lubricating System



Engine Oil Pressure

1. Remove the engine oil pressure switch, and set an oil pressure tester.
2. Start the engine. After warming up, measure the oil pressure of both idling and rated speeds.
3. If the oil pressure is less than the allowable limit, check the following.
   - Engine oil insufficient
   - Oil pump damaged
   - Oil strainer clogged
   - Oil filter cartridge clogged
   - Oil gallery clogged
   - Excessive oil clearance
   - Foreign matter in the relief valve

(When reassembling)

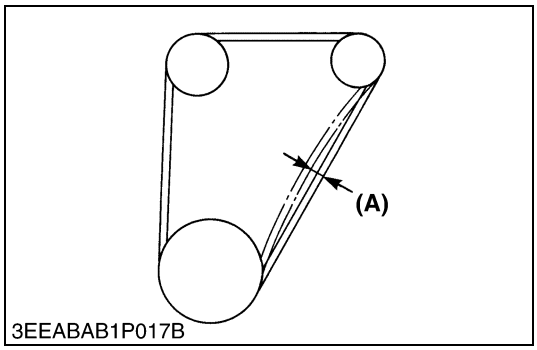
- After checking the engine oil pressure, tighten the engine oil pressure switch to the specified torque.

Engine oil pressure	At idle speed	Factory specification	More than 50 kPa 0.5 kgf/cm^2 7 psi
	At rated speed	Factory specification	200 to 440 kPa 2.0 to 4.5 kgf/cm^2 29 to 64 psi
		Allowable limit	150 kPa 1.5 kgf/cm^2 21 psi

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

9Y1211108ENS0009US0

(3) Cooling System



3EEABAB1P017B

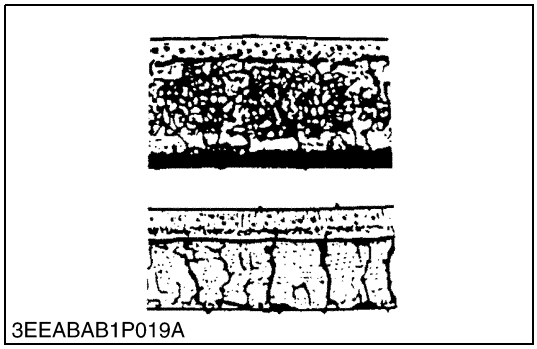
Fan Belt Tension

1. Measure the deflection **(A)**, depressing the belt halfway between the fan drive pulley and alternator pulley at specified force 98 N (10 kgf, 22 lbf).
2. If the measurement is not within the factory specifications, loosen the alternator mounting screws and relocate the alternator to adjust.

Deflection **(A)**	Factory specification	7.0 to 9.0 mm 0.28 to 0.35 in.

(A) Deflection

9Y1211108ENS0010US0

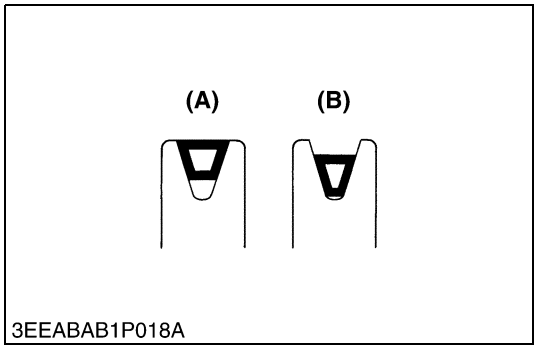

3EEABAB1P019A

Fan Belt Damage and Wear

1. Check the fan belt for damage.
2. If the fan belt is damaged, replace it.
3. Check if the fan belt is worn and sunk in the pulley groove.
4. If the fan belt is nearly worn out and deeply sunk in the pulley groove, replace it.

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

9Y1211108ENS0011US0



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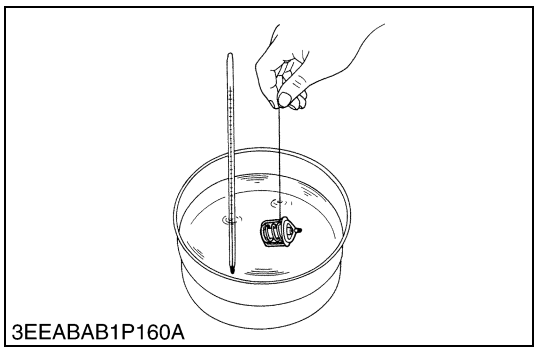

3EEABAB1P160A

Thermostat Valve Opening Temperature

1. Suspend the thermostat in the water by a string with its end inserted between the valve and seat.
2. Heating the water gradually, read the temperature when the valve opens and leaves the string.
3. Continue heating and read the temperature when the valve opens approx. 8 mm (0.3 in.).
4. If the measurement is not within the factory specifications, replace the thermostat.

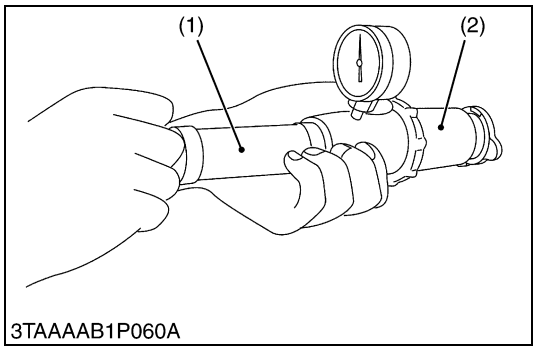
Thermostat's valve opening temperature	Factory specification	69.5 to 72.5 °C 157.1 to 162.5 °F
Temperature at which thermostat completely opens	Factory specification	85 °C 185 °F

9Y1211108ENS0012US0

CAUTION

- **When removing the radiator cap, wait at least ten minutes after the engine has stopped and cooled down. Otherwise, hot water may gush out, scalding nearby people.**

9Y1211108ENS0013US0



3TAAAAB1P060A

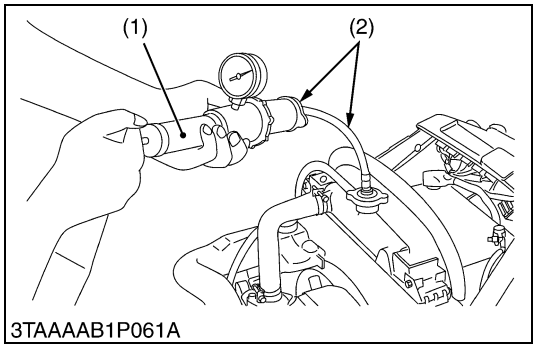
Radiator Cap Air Leakage

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

Pressure falling time	Factory specification	More than 10 seconds for pressure fall from 90 to 60 kPa from 0.9 to 0.6 kgf/cm^2 from 10 to 9 psi

(1) Radiator Tester (2) Adaptor

9Y1211108ENS0014US0



3TAAAAB1P061A

Radiator Water Leakage

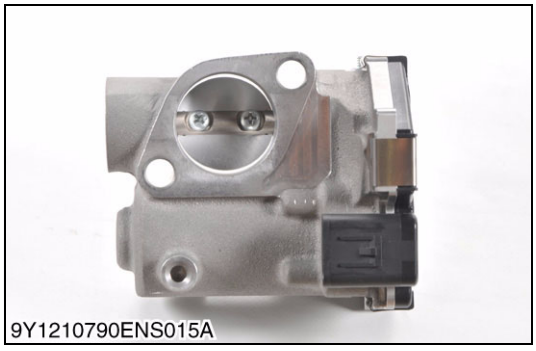
1. Pour a specified amount of water into the radiator.
2. Set a radiator tester (1) and an adaptor (2) and raise the water pressure to the specified pressure.
3. Check the radiator for water leaks.
4. For water leak from the pinhole, repair with the radiator cement. When water leak is excessive, replace the radiator.

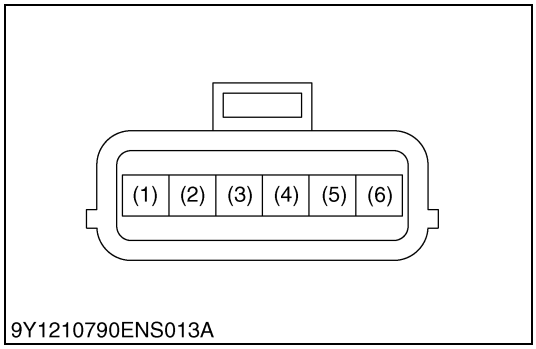
Radiator water leakage test pressure	Factory specification	No leak at specified pressure

(1) Radiator Tester (2) Adaptor

9Y1211108ENS0015US0

(4) Fuel System


9Y1210790ENS015A



9Y1210790ENS013A

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 factory specifications, replace it.

Resistance	Factory specifica-tion	Terminal **1** – Terminal **2**	Continuity
		Terminal **3** – Terminal **4**	Continuity

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

9Y1211108ENS0016US0

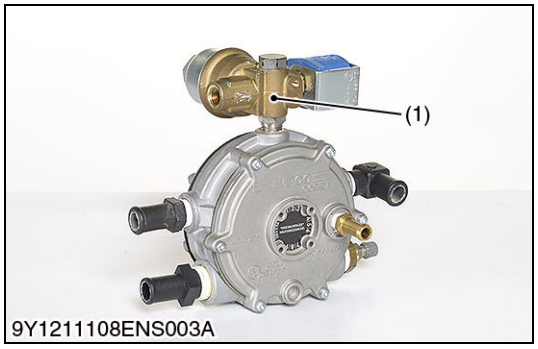

9Y1210790ENS017A

Resistance of Injector (Gasoline line) [WG972-GL, WG972-G]

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

Resistance	Factory specification	11.7 to 12.3 Ω at 20 °C (68 °F)

9Y1211108ENS0019US0



9Y1211108ENS003A

Resistance of Lock Off Valve (Gas line) [WG972-GL, WG972-L, WG972-N]

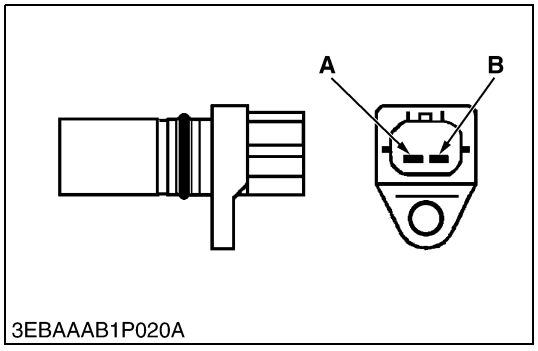
1. Disconnect the connector.
2. Measure the resistance with an ohmmeter between the connector terminals.
3. If the factory specification is not indicated the solenoid is damaged.

LPG cut off solenoid	Factory specification	Approx. 12.65 Ω at 20 °C (68 °F)

(1) LPG Lock Off Valve

9Y1211108ENS0033US0

(5) Ignition System



3EBAAAB1P020A

Resistance of Crankshaft Position Sensor

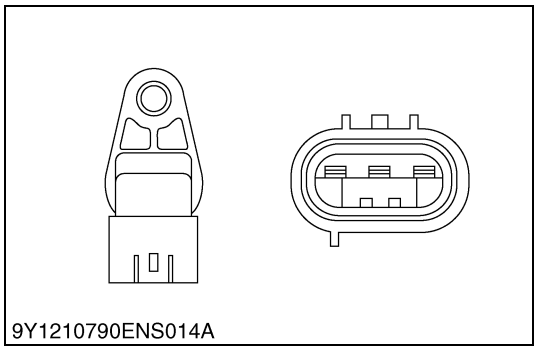
1. Disconnect the connector.
2. Measure the resistance with an ohmmeter.
3. If the resistance is not with in the factory specifications, replace it.

Resistance	Factory specifica-tion	**A** - **B**	1.85 to 2.45 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.**

9Y1211108ENS0020US0


9Y1210790ENS014A

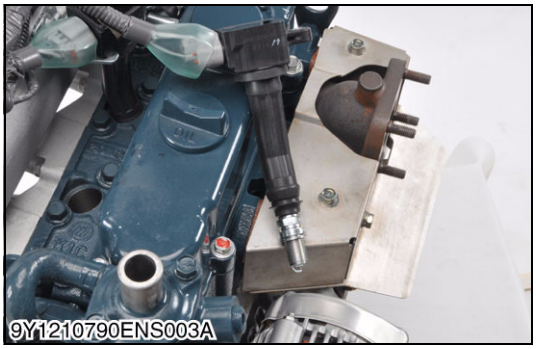
Conduction of Camshaft Position Sensor

1. Disconnect the connector.
2. Check the conduction of each pins.

Conduction	Factory specification	Not conduction

■ **NOTE**
- **It is a simple check way, so if you need in detail, check the signal of camshaft position sensor with diagnostic tool.**

9Y1211108ENS0021US0



Spark Test

1. Disconnect all injector connector.
2. 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).
3. Rotate the starter with the key switch and check that the plug sparks.
4. 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.**

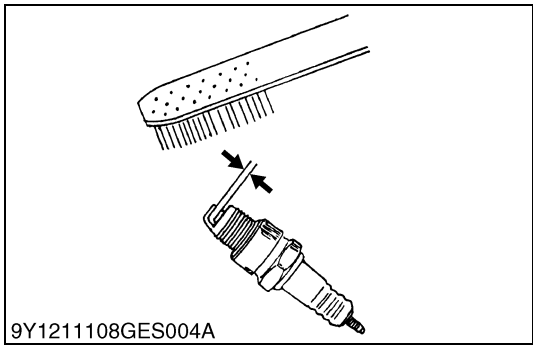
CAUTION

- **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.**

■ **NOTE**

- **Spark test can be done using the diagnostic tool. Refer to Diagnosis Manual for more information.**

9Y1211108ENS0022US0



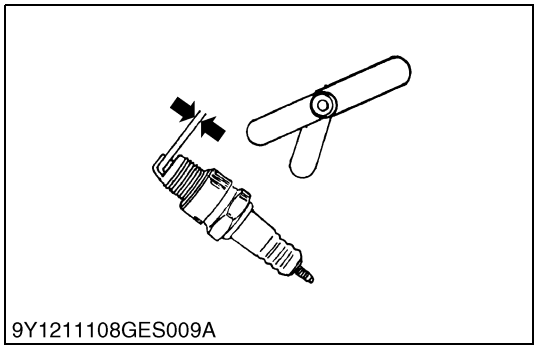
Spark Plug Cleaning

1. Remove the spark plug, and remove carbon from the electrode with a wire brush or other tools.
2. After cleaning, be sure to adjust for proper clearance.

■ **IMPORTANT**

- **If the spark plug electrode or its insulator is soiled or is covered with deposited carbon, it may cause engine trouble.**

9Y1211108ENS0115US0


9Y1211108GES009A

Spark Plug Gap

1. Measure the spark plug gap with a feeler gauge, and repair or replace the spark plug if the measured gap differs from the factory specification.
2. Replace the spark plug if the electrode or the insulator is deformed or cracked.
3. Tighten the spark plug with a plug wrench.

■ **IMPORTANT**

- **If the spark plug electrode or its insulator is soiled or is covered with deposited carbon, it may cause engine trouble.**

(When reassembling)

- Put the high tension cord cap inside the spark plug terminal firmly.
- Make sure that the cylinder number is corresponding to the high tension cord number.
- Wrong connection causes high temperature on catalytic muffler/converter.

Spark plug gap	Factory specification	0.70 to 0.80 mm 0.029 to 0.032 in.

Spark plug	NGK BKR6E

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

9Y1211108ENS0116US0


9Y1210790ENS004A

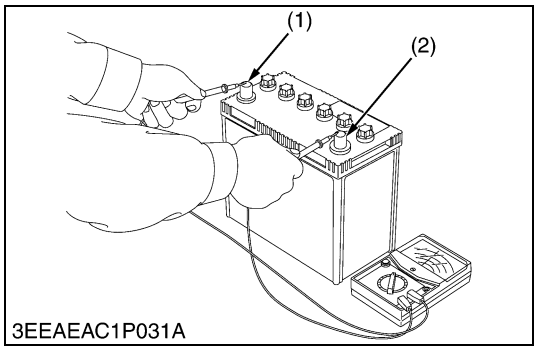
Check Ignition Coil

Ignition coil has three pins at connector, so you cannot check this type of ignition coil by itself.

Check for ignition system as sparking test.

9Y1211108ENS0024US0

(6) Electrical System



3EEAEAC1P031A

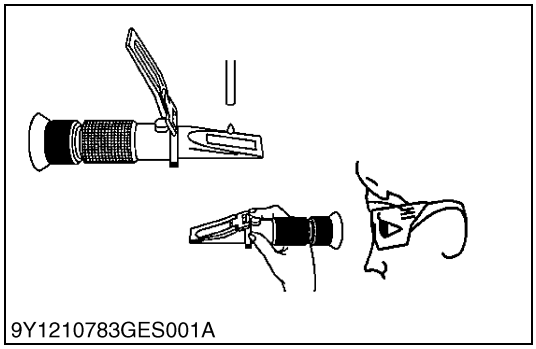
Battery Voltage

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

Battery voltage	Factory specification	More than 12 V

(1) Positive Terminal (2) Negative Terminal

9Y1211108ENS0025US0


9Y1210783GES001A

Battery Specific Gravity

1. Measure the specific gravity of the electrolyte in each cell with a battery and coolant tester.
2. If the electrolyte temperature is different from the one that the battery and coolant tester calibrated, correct the specific gravity measurement. Use the formula below in **(Reference)**.
3. If the specific gravity is less than 1.215 (after it is corrected for temperature), charge or replace the battery.
4. If the specific gravity is different between 2 cells by more than 0.05, replace the battery.

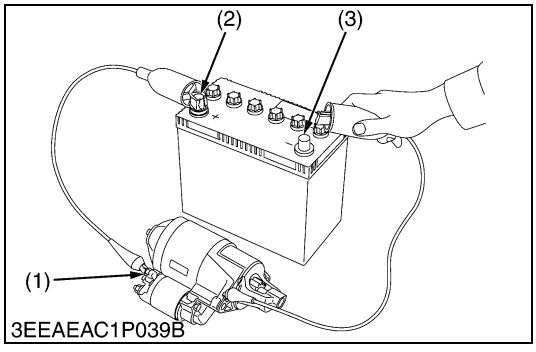
(Reference)

- The specific gravity changes with temperature.
  To be accurate, the specific gravity
  decreases by 0.0007 when temperature increases by 1 °C (decreases by 0.0004 when temperature increases by 1 °F),
  increases by 0.0007 when temperature decreases by 1 °C (increases by 0.0004 when temperature decreases by 1 °F).
  Thus, if you refer to 20 °C (68 °F), correct the specific gravity reading by the formula below:
  – Specific gravity at 20 °C = Measured value + 0.0007 × (electrolyte temperature −20 °C)
  – Specific gravity at 68 °F = Measured value + 0.0004 × (electrolyte temperature −68 °F)

Specific Gravity	State of Charge
1.260 Sp. Gr.	100 % Charged
1.230 Sp. Gr.	75 % Charged
1.200 Sp. Gr.	50 % Charged
1.170 Sp. Gr.	25 % Charged
1.140 Sp. Gr.	Very Little Useful Capacity
1.110 Sp. Gr.	Discharged

At an electrolyte temperature of 20 °C (68 °F)

9Y1211108ENS0026US0



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Motor Test

CAUTION

- **Secure the starter to prevent it from jumping up and down while testing the motor.**

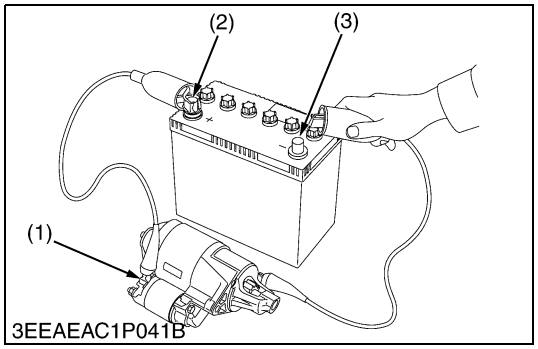
1. Disconnect the battery negative cable from the battery.
2. Disconnect the battery positive cable from the battery.
3. Disconnect the leads from the starter **B** terminal.
4. Remove the starter from the engine.
5. Connect a jumper lead from the starter **C** terminal (1) to the battery positive terminal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

NOTE

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

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

9Y1211108ENS0027US0



Magnetic Switch Test

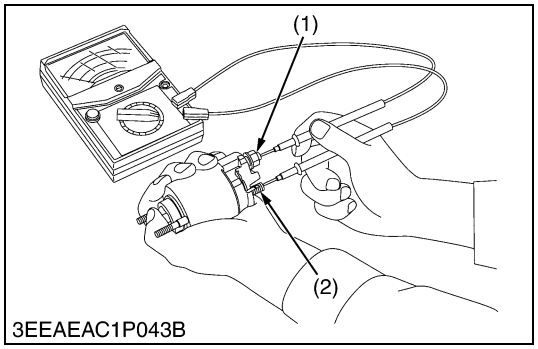
1. Disconnect the battery negative cable from the battery.
2. Disconnect the battery positive cable from the battery.
3. Disconnect the leads from the starter **B** terminal.
4. Remove the starter from the engine.
5. Connect a jumper lead from the starter **S** terminal (1) to the battery positive terminal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

■ **NOTE**

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

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

9Y1211108ENS0028US0



Magnet Switch Continuity Test

1. Check the continuity across the **C** terminal (1) and the **B** terminal (2) with a circuit tester, pushing in the plunger.
2. If not continuous or if a certain value is indicated, replace the magnet switch.

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

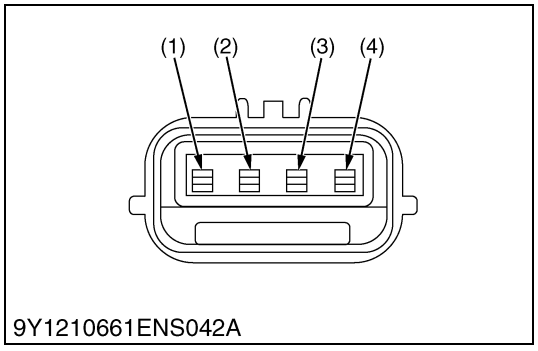
9Y1211108ENS0029US0

Resistance of Water Temperature Sensor

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

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

9Y1211108ENS0030US0



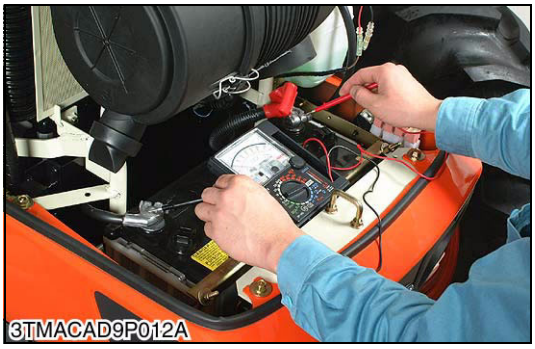
Resistance of Temperature and Manifold Absolute Pressure (TMAP) Sensor

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

Resistance of pressure sensor	Factory specifica-tion	Terminal **1** – Terminal **3**	5.4 to 6.6 kΩ at 0 °C (32 °F)

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

9Y1211108ENS0031US0



Alternator on Unit Test

(Before testing)

- Before alternator on unit test, check the battery terminal connections, circuit connection, fan belt tension, charging indicator lamp, fuses on the circuit, and abnormal noise from the alternator.
- Prepare full charged battery for the test.

■ **NOTE**

- **Be careful not to touch the rotating engine parts while engine is operating.**
  Keep safety distance from the engine rotating parts.

1. Start the engine.
2. When the engine is operating measure the voltage between two battery terminals. If the voltage is between 14.2 V and 14.8 V, the alternator is operating normally.
3. If the results of alternator on unit test are not within the specifications, disassemble the alternator and check the each component part for finding out the failure. See the "DISASSEMBLING AND ASSEMBLING" and "SERVICING" for alternator.

Regulating voltage at no load	Factory specification	14.2 to 14.8 V at 5000 min^{-1} (rpm), 25 °C (77 °F)

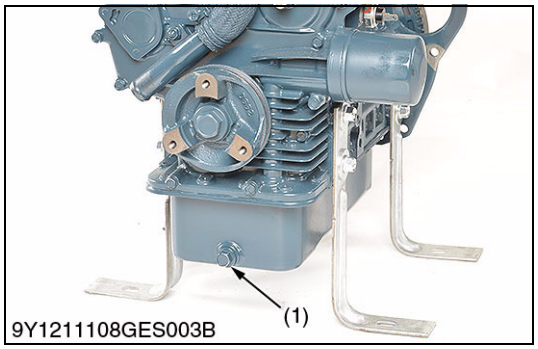
9Y1211108ENS0032US0

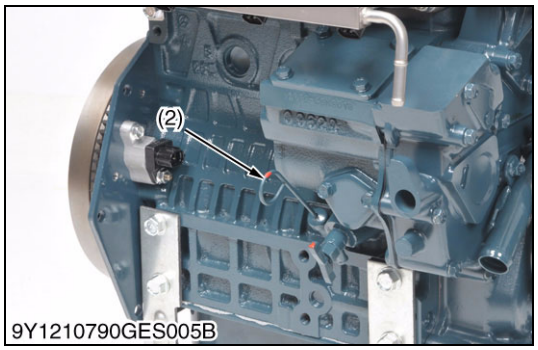
[2] DISASSEMBLING AND ASSEMBLING

■ **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.**

9Y1211108ENS0034US0

(1) Draining Coolant and Engine Oil





Draining Engine Oil

1. Start and warm up the engine for approx. 5 minutes.
2. Place an oil pan underneath the engine.
3. Remove the drain plug (1) to drain oil.
4. After draining, screw in the drain plug (1).

(When refilling)
- Fill the engine oil up to 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.**
- **Never mix two different types of oil.**
- **Engine oil should have properties of API classification SH.**
- **Use the proper SAE Engine Oil according to ambient temperature.**

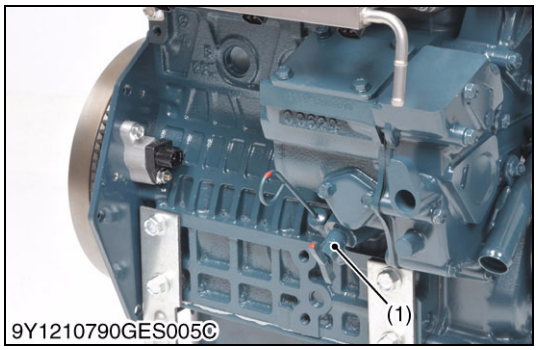
Above 25 °C (77 °F)	SAE30 or SAE10W-30, SAE15W-40
0 °C to 25 °C (32 °F to 77 °F)	SAE20 or SAE10W-30
Below 0 °C (32 °F)	SAE10W or SAE10W-30

Engine oil capacity	3.4 L 0.90 U.S.gals

Tightening torque	Drain plug	33 to 37 N·m 3.3 to 3.8 kgf·m 24 to 27 lbf·ft

(1) Drain Plug (2) Dipstick

9Y1211108ENS0035US0



Draining Coolant

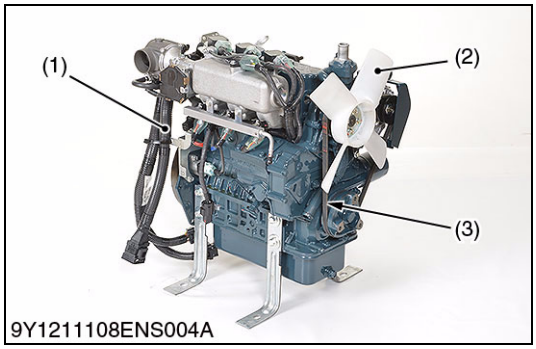
CAUTION
- **Never remove radiator cap while operating or immediately after stopping. Otherwise, hot water will spout out from the radiator. Wait for more than ten minutes to cool the radiator, before opening the cap.**

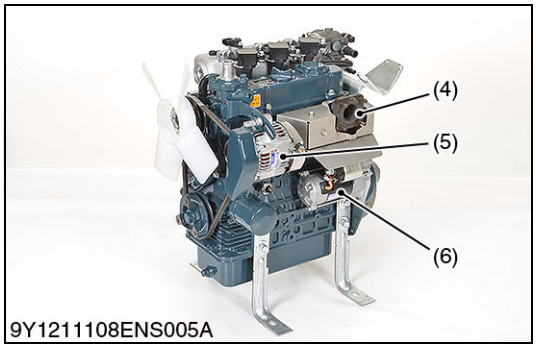
1. Prepare a bucket. Open the coolant drain valve.

(1) Coolant Drain Valve

9Y1211108ENS0036US0

(2) External Components





Alternator, Starter and Others

1. Remove the wiring harness (1).
2. Remove the air cleaner, catalytic muffler/converter and exhaust manifold (4).
3. Remove the cooling fan (2), fan pulley and fan belt (3).
4. Remove the alternator (5).
5. Remove the starter (6).

(When reassembling)

- Check to see that there are no cracks on the belt surface.
- Replace the exhaust manifold gasket with a new one.
- Replace the muffler/converter gasket with a new one.

■ **IMPORTANT**

- **After reassembling the fan belt (3), be sure to adjust the fan belt tension.**
- **Do not confuse the direction of the cooling fan (2).**
- **To trace of the catalytic muffler/converter, put down the catalyst identification and engine identification when new service catalytic muffler/converter is installed.**

Tightening torque	Exhaust manifold mounting screw/nut	9.81 to 11.2 N·m 1.00 to 1.15 kgf·m 7.24 to 8.31 lbf·ft
	Catalytic converter mounting nut	29.4 to 34.3 N·m 3.00 to 3.50 kgf·m 21.7 to 25.2 lbf·ft

(1) Wiring Harness
(2) Cooling Fan
(3) Fan Belt
(4) Exhaust Manifold
(5) Alternator
(6) Starter

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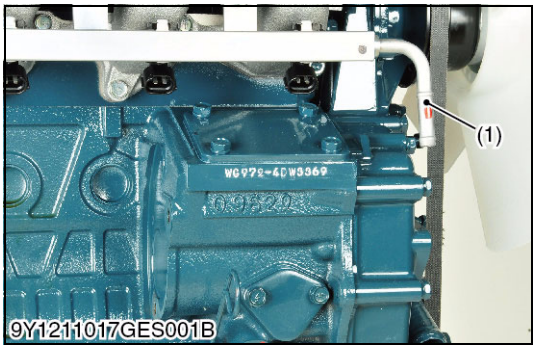

Gasoline Line [WG972-GL, WG972-G]

1. Disconnect the gasoline hose from the connector (1).

(1) Gasoline Hose Connector

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Gas Line [WG972-GL, WG972-L, WG972-N]

1. Remove the coolant hoses and fuel hoses of regulator with vaporizer.
2. Remove the regulator with vaporizer and the stay.

(When reassembling)

- Be sure to attach the coolant hoses and fuel hoses firmly.
- Install regulator with vaporizer with finger tight only. And then tighten with specified torque in final installation.

Tightening torque	Regulator with vaporizer mounting screw	5.4 to 6.6 N·m 0.55 to 0.67 kgf·m 4.0 to 4.8 lbf·ft

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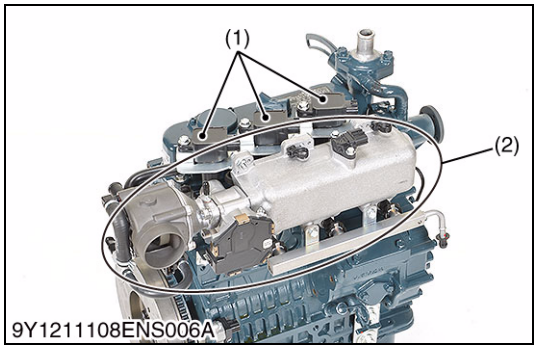

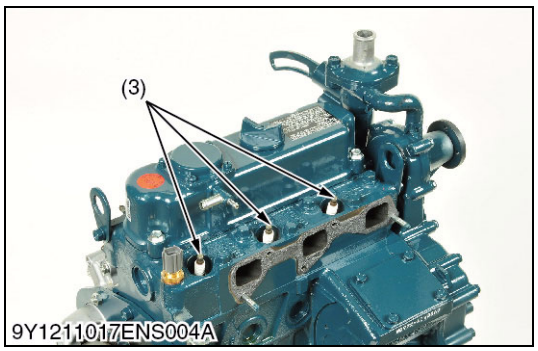

Ignition Coil and Spark Plug

1. Remove the ignition coil (1).
2. Remove the intake manifold assembly (2).
3. Remove the spark plug (3).

(When reassembling)

- Tighten the spark plug with a plug wrench.

■ **IMPORTANT**

- **Put the ignition coil inside the spark plug terminal firmly.**
- **Wrong connection causes high temperature on catalytic muffler/converter.**

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

(1) Ignition Coil
(2) Intake Manifold Assembly
(3) Spark Plug

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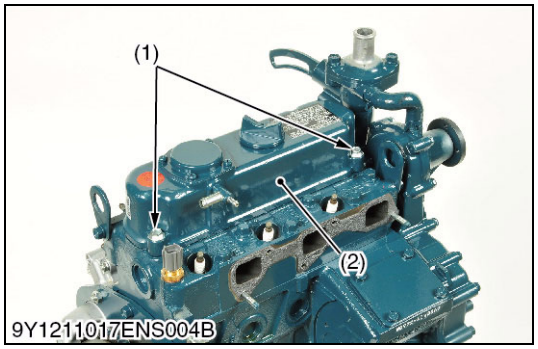
(3) Cylinder Head, Valves and Oil Pan



Cylinder Head Cover

1. Remove the head cover screws/nuts (1).
2. Remove the cylinder head cover (2).

(When reassembling)

- Check to see if the cylinder head cover gasket is not damaged.

Tightening torque	Cylinder head cover screw	6.87 to 11.2 N·m 0.700 to 1.15 kgf·m 5.07 to 8.31 lbf·ft

(1) Head Cover Screws/Nuts
(2) Cylinder Head Cover

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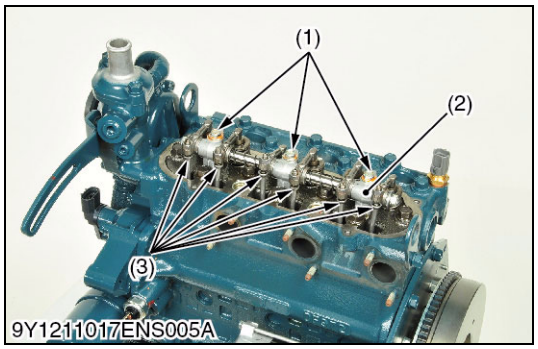

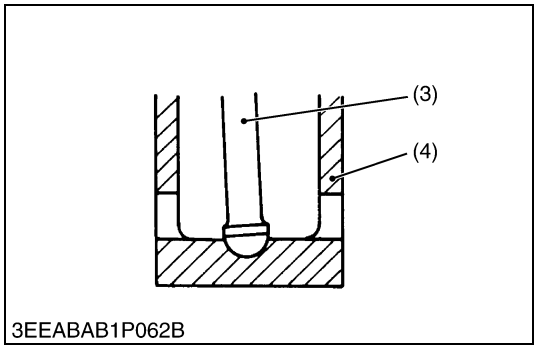

Rocker Arm and Push Rod

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

(When reassembling)

- When putting the push rods (3) onto the tappets (4), check to see if their ends are properly engaged with the dimples.

■ **IMPORTANT**

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

Tightening torque	Rocker arm bracket screw	9.81 to 11.2 N·m 1.00 to 1.15 kgf·m 7.24 to 8.31 lbf·ft

(1) Rocker Arm Bracket Screws/Nuts
(2) Rocker Arm Assembly
(3) Push Rod
(4) Tappet

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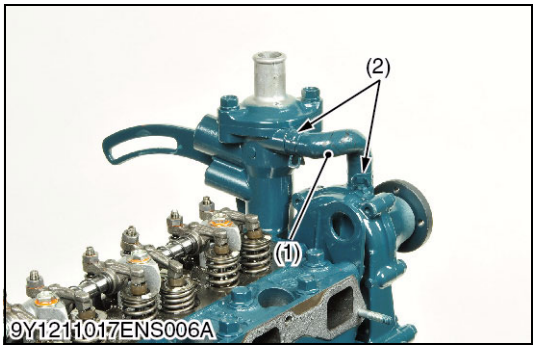

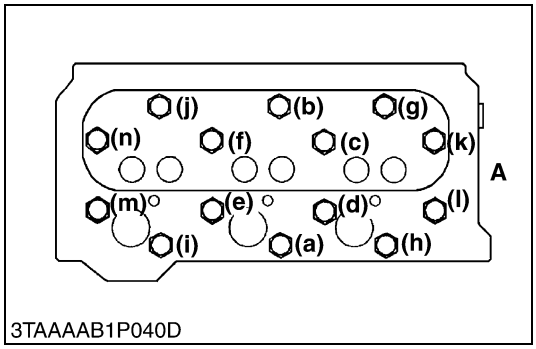

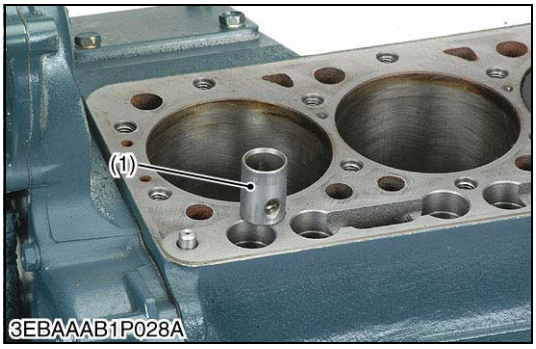

Cylinder Head

1. Loosen the pipe clamps (2), and remove the water return hose (1).
2. Remove the cylinder head screw in the order of **(n)** to **(a)**.
3. Lift up the cylinder head to remove.
4. Remove the cylinder head gasket.

(When reassembling)

- Replace the cylinder head gasket with a new one.
- Tighten the cylinder head screws after applying sufficient oil.
- Tighten the cylinder head screws in order of **(a)** to **(n)**.
- Tighten them uniformly, or the head may deform in the long run.

Tightening torque	Cylinder head screw	38 to 42 N·m 3.8 to 4.3 kgf·m 28 to 31 lbf·ft

(1) Water Return Hose
(2) Hose Clamp

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

9Y1211108ENS0042US0

Tappets

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

(When reassembling)

- Visually check the contact between tappets and cams for proper rotation. If problem is found, replace tappets.
- Before installing the tappets, apply engine oil thinly around them.

■ **IMPORTANT**

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

(1) Tappet

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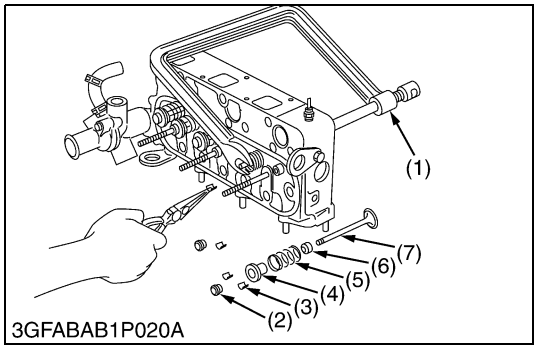

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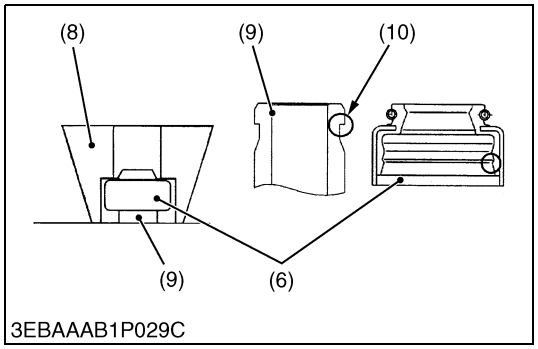

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Valves

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

(When reassembling)

- Wash the valve stem and valve guide hole, and apply engine oil sufficiently.
- After installing the valve spring collets, lightly tap the stem to assure proper fit with a plastic hammer.
- Install a new stem seal on the valve guide (9) vertically with a jig (8) when insert the stem seal (6). (See page G-32: "Valve Stem Seal Replacing Tool".)

■ **IMPORTANT**

- **Be sure stem seal (6) seats firmly against groove of valve guide (10).**
- **Use care to prevent damage to lip of stem seal and valve stem when remove the valve spring collet by compressing the valve spring.**
- **Do not change the combination of valve and valve guide.**

(1) Valve Spring Replacer
(2) Valve Cap
(3) Valve Spring Collet
(4) Valve Spring Retainer
(5) Valve Spring
(6) Valve Stem Seal
(7) Valve
(8) Jig
(9) Valve Guide
(10) Groove of Valve Guide

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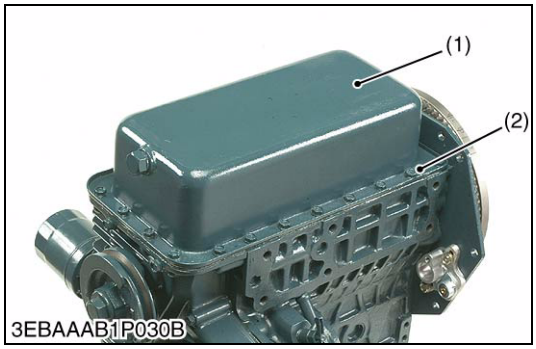

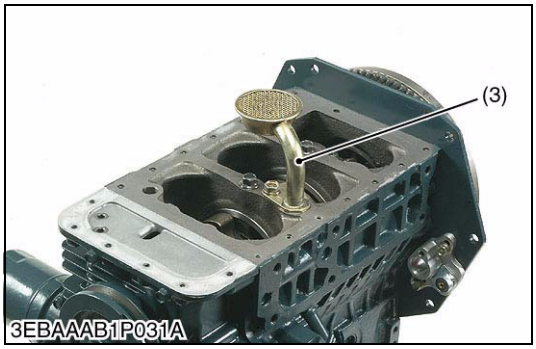

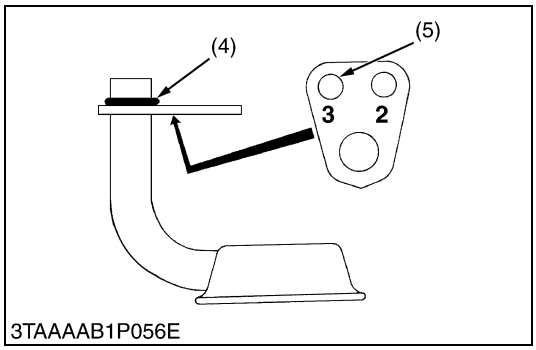

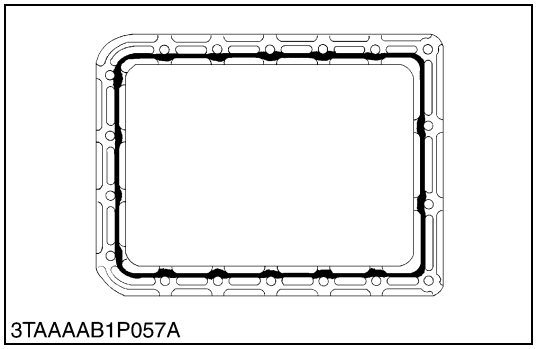

Oil Pan and Oil Strainer

1. Remove the oil pan mounting screws (2).
2. Remove the oil pan (1) by lightly tapping the rim of the pan with a wooden hammer.
3. Remove the oil strainer (3).

(When reassembling)

- After cleaning the oil strainer, check to see that the filter mesh in clean, and install it.
- Visually check the O-ring (4), apply engine oil, and install it.
- Securely fit the O-ring to the oil strainer.
- To avoid uneven tightening, tighten oil pan mounting screws in diagonal order form the center.
- Using the hole numbered **"3"** (5), install the oil strainer by mounting screw.

■ **IMPORTANT**

- **Scrape off the old adhesive completely. Wipe the sealing surface clean. Now apply new adhesive 3.0 to 5.0 mm (0.12 to 0.19 in.) thick all over the contact surface. Apply the adhesive also on the center of the flange as well as on the inner wall of each bolt hole.**
- **Cut the nozzle of the "liquid gasket" (Three Bond 1207D or equivalent) container at its second notch. Apply "liquid gasket" about 5.0 mm (0.19 in.) thick.**
  Within 20 minutes after the application of fluid sealant, reassemble the components. Wait then for about 30 minutes, and pour oil in the crankcase.

(1) Oil Pan
(2) Oil Pan Mounting Screw
(3) Oil Strainer
(4) O-ring
(5) Hole Numbered **"3"**

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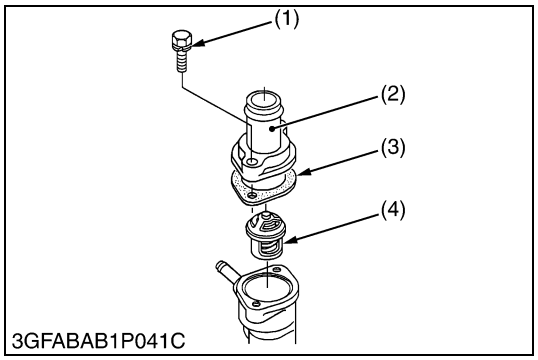
(4) Thermostat



Thermostat Assembly

1. Remove the thermostat cover mounting screws (1), and remove the thermostat cover (2).
2. Remove the thermostat assembly (4).

(When reassembling)

- Apply a liquid gasket (Three Bond 1215 or equivalent) only at the thermostat cover side of the gasket (3).

(1) Thermostat Cover Mounting Screw
(2) Thermostat Cover
(3) Thermostat Cover Gasket
(4) Thermostat Assembly

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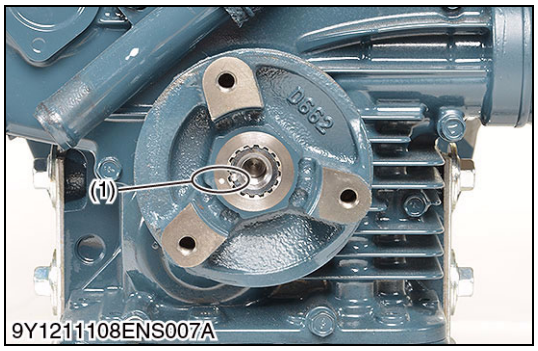
(5) Timing Gear, Camshaft



Fan Drive Pulley

1. Secure the flywheel with flywheel stopper.
2. Remove the fan drive pulley screw.
3. Draw out the fan drive pulley with a puller.

(When reassembling)

- Install the pulley to the crankshaft, aligning the mark (1) on them.
- Apply engine oil to the fan drive pulley retaining screws. And tighten them.

Tightening torque	Fan drive pulley screw	98 to 107 N·m 10 to 11 kgf·m 72.4 to 79.5 lbf·ft

(1) Alignment Mark

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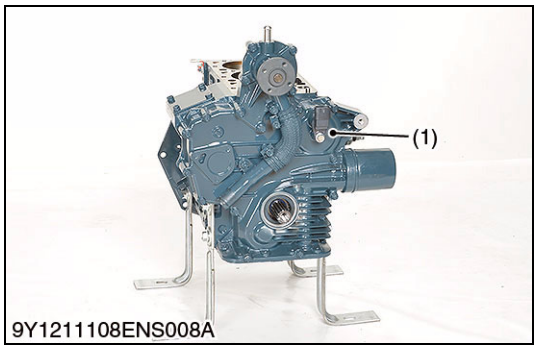

Gear Case

1. Remove the screw.
2. Remove the gear case (1).

(When reassembling)

- Apply a liquid gasket (Three Bond 1215 or equivalent) to both sides of the gear case gasket.
- Be sure to set three O-rings inside the gear case.

(1) Gear Case

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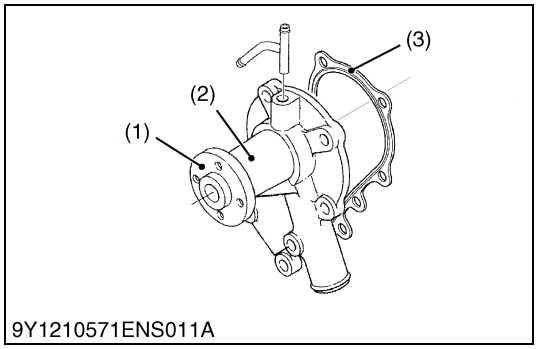

Water Pump Assembly

1. Remove the water pump assembly (2) from the gear case cover.

(When reassembling)

- Apply a liquid gasket (Three Bond 1215 or equivalent) to both sides of water pump gasket (3).

(1) Water Pump Flange
(2) Water Pump Assembly
(3) Water Pump Gasket

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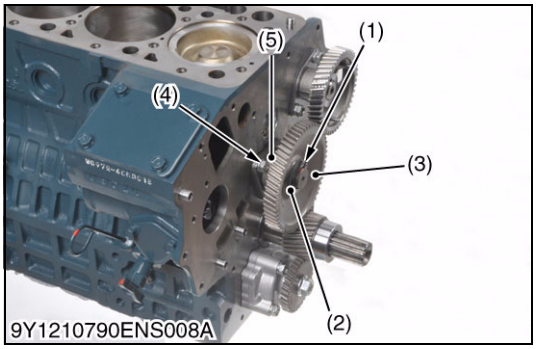

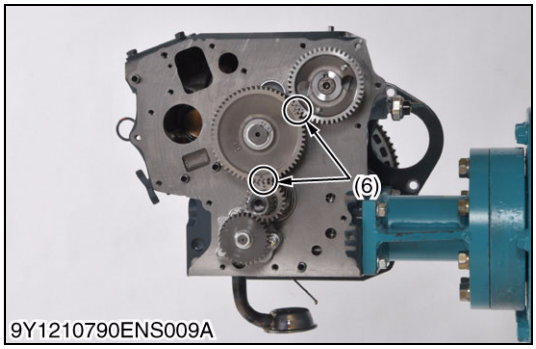

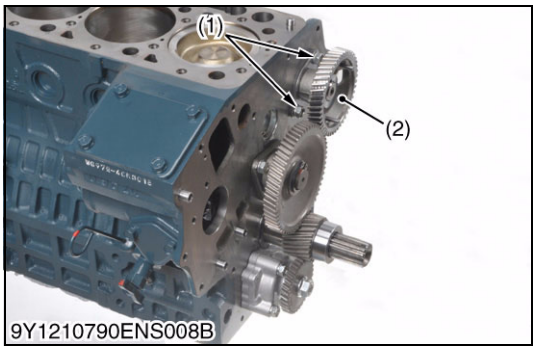

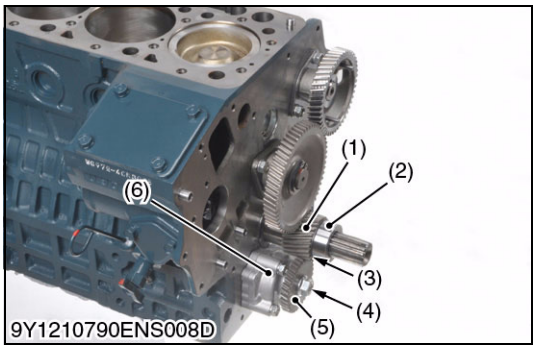

Idle Gear

1. Remove the external snap ring (1), the collar (3) and the idle gear (2).
2. Remove the idle gear shaft mounting screws (4).
3. Remove the idle gear shaft (5).

(When reassembling)

- Apply engine oil to the idle gear shaft mounting screw (4). And tighten them.
- Install the idle gear, aligning the mark (6) on the gears referring to the photo.

Tightening torque	Idle gear shaft mounting screw	9.81 to 11.2 N·m 1.00 to 1.15 kgf·m 7.24 to 8.31 lbf·ft

(1) External Snap Ring
(2) Idle Gear
(3) Idle Gear Collar
(4) Idle Gear Shaft Mounting Screw
(5) Idle Gear Shaft
(6) Alignment Mark

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Camshaft

1. Remove the camshaft mounting screws (1) and draw out the camshaft with gear (2) on it.

(When reassembling)

- When install the camshaft, apply engine oil to the camshaft journals.
- Apply engine oil to the camshaft mounting screws. And tighten them.

(1) Camshaft Mounting Screw
(2) Camshaft Gear

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Oil Pump and Crankshaft Gear

1. Remove the oil pump gear (5).
2. Remove the oil pump (6).
3. Remove the collar (2), O-ring and crankshaft oil slinger (3).

(When reassembling)

- Install the collar (2) after aligning the marks on the gear.

Tightening torque	Oil Pump Gear Mounting Nut	39.2 to 45.1 N·m 4.00 to 4.59 kgf·m 29.0 to 33.2 lbf·ft

(1) Crankshaft Gear
(2) Crankshaft Collar
(3) Crankshaft Oil Slinger
(4) Oil Pump Gear Mounting Nut
(5) Oil Pump Gear
(6) Oil Pump

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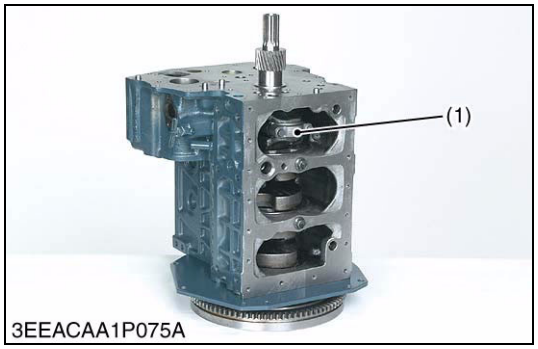
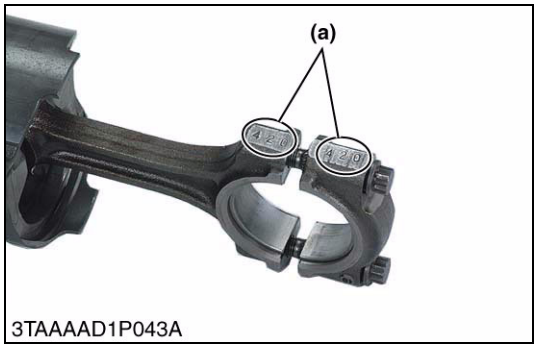
(6) Piston and Connecting Rod





Connecting Rod Cap

1. Remove the connecting rod caps (1) using a hexagonal 7 mm socket.

(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	27 to 30 N·m 2.7 to 3.1 kgf·m 20 to 22 lbf·ft

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

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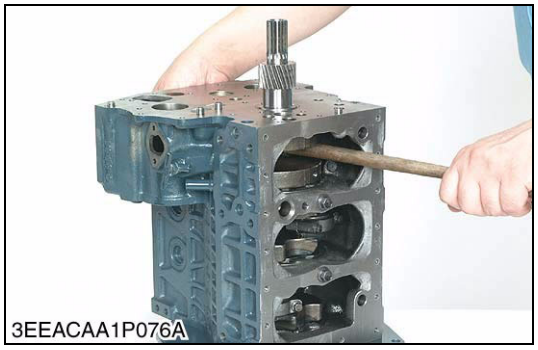

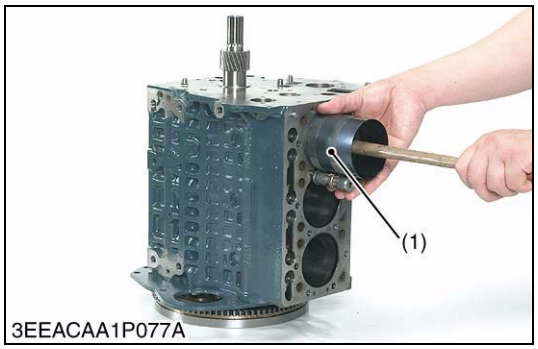

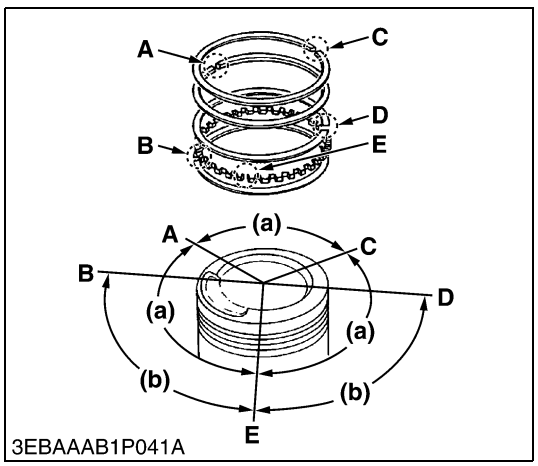

Piston

1. Turn the flywheel and bring the piston to top dead center.
2. Draw out the piston upward by lightly tapping it from the bottom of the crankcase with the grip of a hammer.
3. Draw out the other pistons after the same method as above.

(When reassembling)

- Before inserting the piston into the cylinder, apply enough engine oil to the piston.
- When inserting the piston into the cylinder, face the mark on the connecting rod to the fuel camshaft.
- When inserting the piston into the cylinder, place the gap **"C"** of the top compression ring on the opposite side of the slant portion, and stagger the gaps **"A"**, **"E"** of the second compression ring and spacer making 2.09 rad (120 °) from the gap of the top compression ring. Further, stagger the gaps **"D"**, **"B"** of the upper and lower side rail making 1.6 rad (90 °) from the gap of the spacer.

■ **IMPORTANT**

- **Do not change the combination of cylinder and piston. Make sure of the position of each piston by marking. For example, mark "1" on the No. 1 piston.**
- **When installing the piston into the cylinder, place the gaps of all of the piston rings as shown in the figure.**
- **Carefully insert the piston using a piston ring compressor (1). Otherwise, their chrome-plated section may be scratched, causing trouble inside the cylinder.**

(1) Piston Ring Compressor
A: Second Compression Ring Gap
B: Side Rail Gap
C: Top Compression Ring Gap
D: Side Rail Gap
E: Spacer Gap
(a) 2.09 rad (120 °)
(b) 1.6 rad (90 °)

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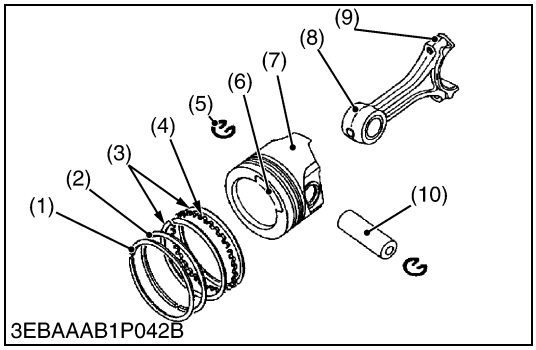

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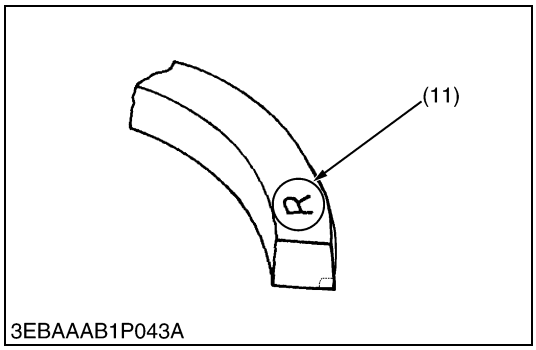

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Piston Ring and Connecting Rod

1. Remove the piston rings using a piston ring tool.
2. Remove the piston pin (10), and separate the connecting rod (8) from the piston (7).

(When reassembling)

- When installing the second compression ring (2), assemble the rings so that the manufacturer's mark (11) near the gap faces the top of the piston.
- Apply engine oil to the piston pin.
- When installing the connecting rod to the piston, immerse the piston in 80 °C (176 °F) oil for 10 to 15 minutes and insert the piston pin to the piston.
- When installing the connecting rod to the piston, align the mark (9) on the connecting rod to the plug recess (6).

■ **IMPORTANT**

- **Mark the same number on the connecting rod and the piston so as not to change the combination.**

(1) Top Ring
(2) Second Ring
(3) Side Rail
(4) Spacer
(5) Piston Pin Snap Ring
(6) Plug Recess
(7) Piston
(8) Connecting Rod
(9) Mark
(10) Piston Pin
(11) Manufacturer's Mark

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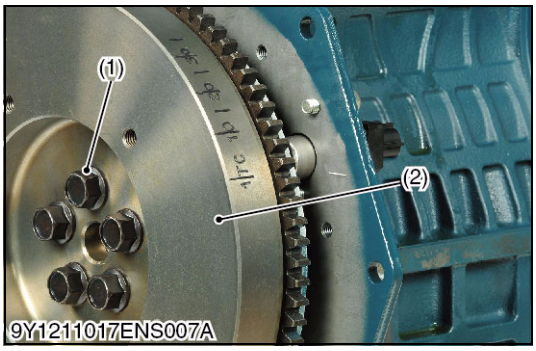
(7) Crankshaft



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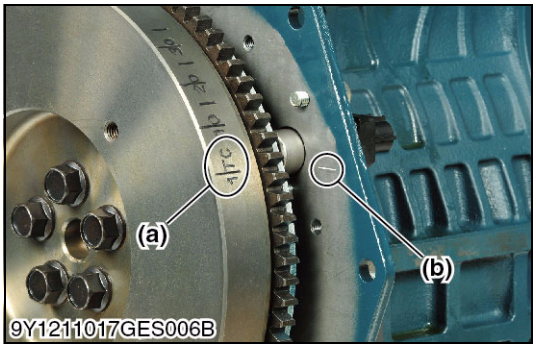

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Flywheel

1. Secure the flywheel to keep it from turning using a flywheel stopper.
2. Remove all flywheel screws (1) and then remove the flywheel (2).

(When reassembling)

- Move crankpin of No.1 cylinder to top dead center position.
- Align the **"1TC"** mark **(a)** on the outer surface of the flywheel horizontally with the alignment mark **(b)** on the rear end plate. Now fit the flywheel in position.
- Apply engine oil to the threads and the undercut surface of the flywheel screw and fit the screw.

Tightening torque	Flywheel screw	54 to 58 N·m 5.5 to 6.0 kgf·m 40 to 43 lbf·ft

(1) Flywheel Screw
(2) Flywheel
(a) 1TC Mark
(b) Alignment Mark

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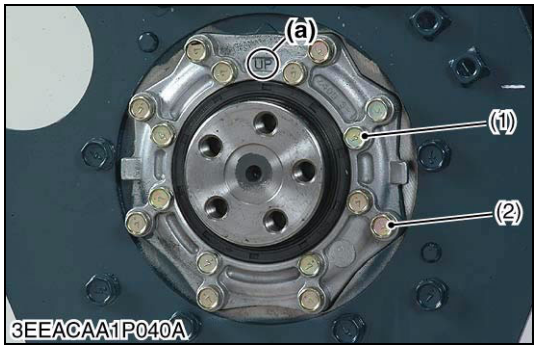

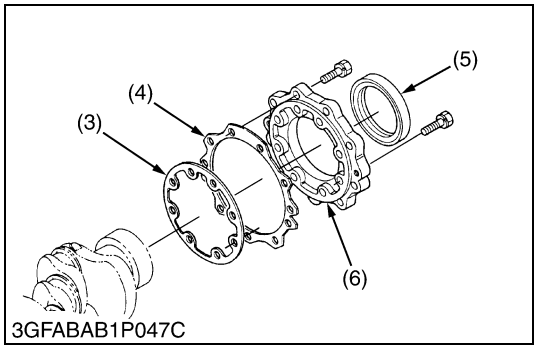

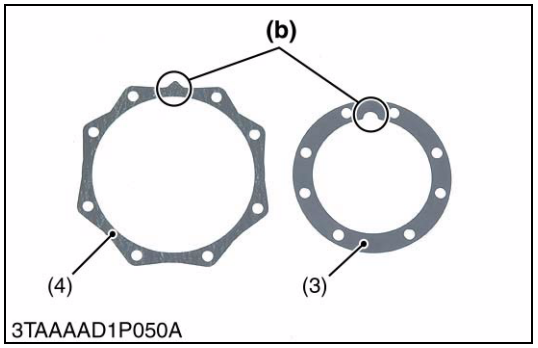

Bearing Case Cover

1. Remove the bearing case cover mounting screws. First, remove inside screws (1) and then outside screws (2).
2. Remove the bearing case cover (6).

(When reassembling)

- Fit the bearing case gasket (3) and the bearing case cover gasket (4) with correct directions.
- Install the bearing case cover (6) to position the casting mark "UP" **(a)** on it upward.
- Apply engine oil to the oil seal (5) lip and be careful that it is not rolled when installing.
- Tighten the bearing case cover mounting screws with even force on the diagonal line.

Tightening torque	Bearing case cover mounting screw	9.81 to 11.3 N·m 1.00 to 1.15 kgf·m 7.24 to 8.31 lbf·ft

(1) Bearing Case Cover Mounting Screw (Inside)
(2) Bearing Case Cover Mounting Screw (Outside)
(3) Bearing Case Gasket
(4) Bearing Case Cover Gasket
(5) Oil Seal
(6) Bearing Case Cover
(a) Top Mark "UP"
(b) Upside

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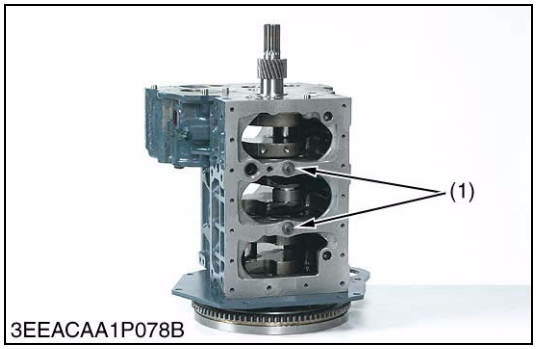

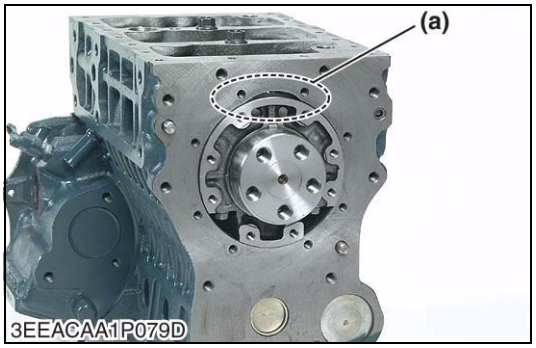

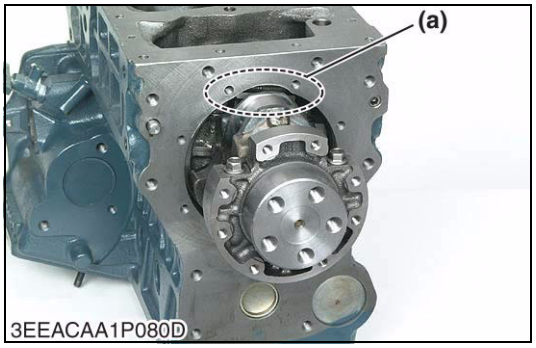

Crankshaft Assembly

1. Remove the main bearing case screw 2 (1).
2. Turn the crankshaft to set the crankpin of the third cylinder to the bottom dead center. Then draw out the crankshaft until the crankpin of the second cylinder comes to the center of the third cylinder.
3. Turn the crankshaft by 2.09 rad (120 °) counterclockwise to set the crankpin of the second cylinder to the bottom dead center. Draw out the crankshaft until the crankpin of the first cylinder comes to the center of the third cylinder.
4. Repeat the above steps to draw out all the crankshaft.

(When reassembling)

- Clean the oil passage of the crankshaft with compressed air.
- Install the crankshaft assembly, aligning the screw hole of main bearing case screw 2 with the screw hole of crankcase.
- When tightening the main bearing case screw 2, apply oil to the main bearing case screw 2 (1) and screw by hand before tightening the specific torque. If not smooth to screw by hand, align the screw holes between the crankcase and the main bearing case.

Tightening torque	Main bearing case screw 2	27 to 30 N·m 2.7 to 3.1 kgf·m 20 to 22 lbf·ft

(1) Main Bearing Case Screw 2

(a) Cut Place for Removing and Installing the Crankshaft

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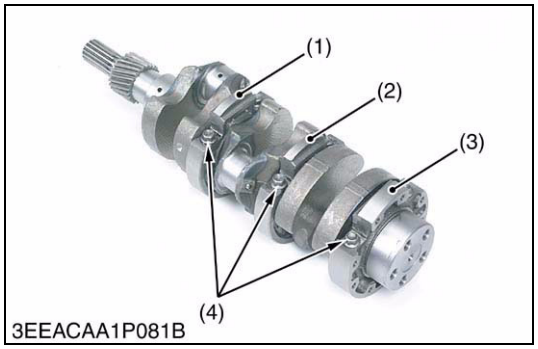

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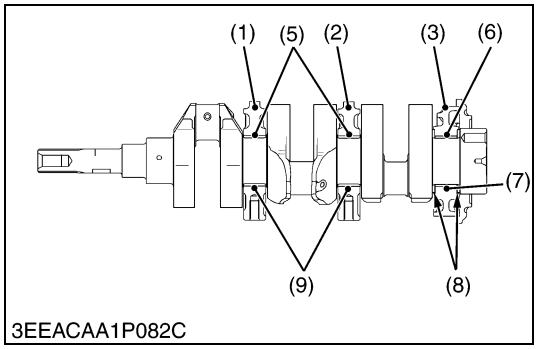

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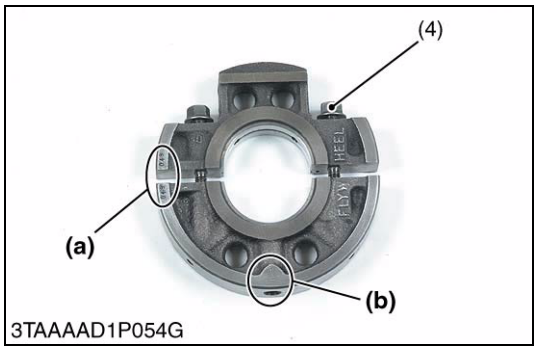

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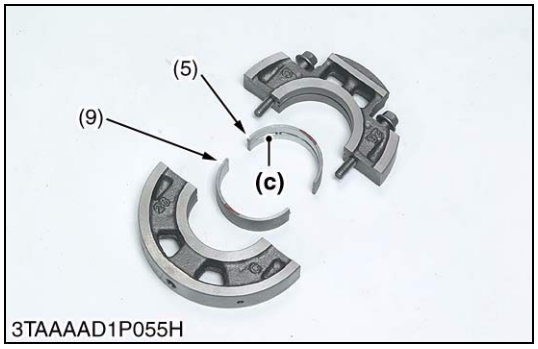

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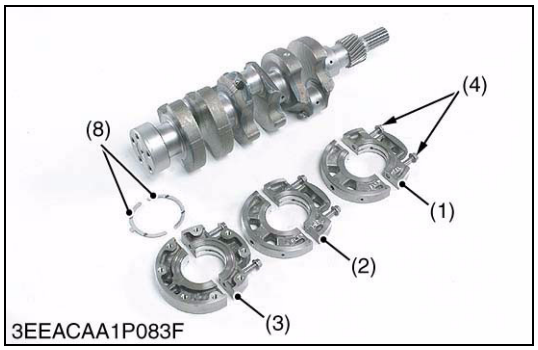

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Main Bearing Case Assembly

1. Remove the two main bearing case screws 1 (4), and remove the main bearing case assembly 1 (1), being careful with crankshaft bearing 3 (5), (9).
2. Remove the main bearing case assembly 2 (2) and the main bearing case assembly (3) as above. Keep in mind, however, that the thrust bearing (8) is installed in the main bearing case assembly (3).

(When reassembling)

- Clean the oil passage in the main bearing cases.
- Apply clean engine oil to the bearings.
- Install the main bearing case assemblies in original positions. Since diameters of main bearing cases vary, install them in order of marking **(b)** from the gear case side. (Refer to the figure.)
- Be careful not to confuse the top and bottom of the crankshaft bearing 3 (5), (9). (Install the bearing with the oil groove **(c)** up.)
- Match the alignment numbers **(a)** on the main bearing case assembly 1.
- Do the same for the main bearing case assembly 2 (2) and the main bearing case assembly (3) too.
- When installing the main bearing case 1 and 2, face the mark **"FLYWHEEL"** to the flywheel.
- Install the thrust bearing (8) with its oil groove facing outward.
- Make sure that the main bearing case moves smoothly after tightening the main bearing case screw 1 to the specified torque.

Tightening torque	Main bearing case screw 1	13 to 15 N·m 1.3 to 1.6 kgf·m 9.4 to 11 lbf·ft

(1) Main Bearing Case Assembly 1
(2) Main Bearing Case Assembly 2
(3) Main Bearing Case Assembly
(4) Main Bearing Case Screw 1
(5) Crankshaft Bearing 3 (Upper, with Oil Groove)
(6) Crankshaft Bearing 2 (Upper, with Oil Groove)
(7) Crankshaft Bearing 2 (Lower)
(8) Thrust Bearing
(9) Crankshaft Bearing 3 (Lower)

(a) Alignment Number
(b) Marking (1 or 2)
(c) Oil Groove

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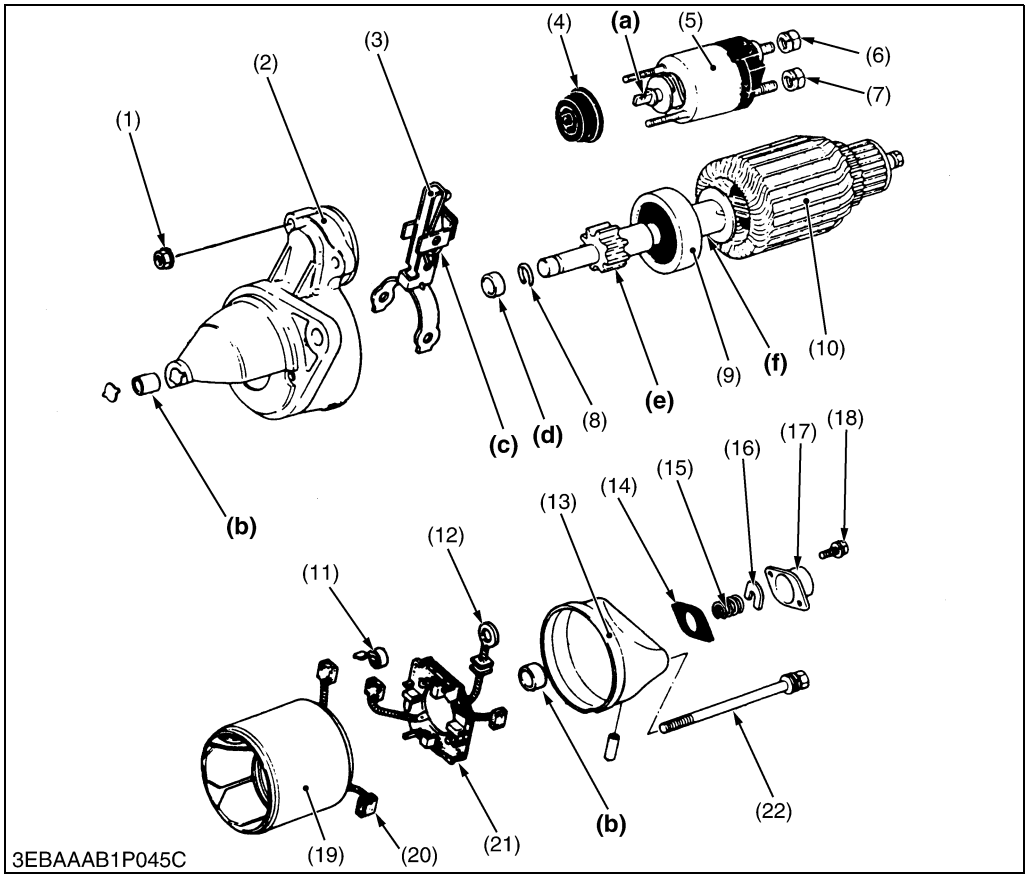
(8) Starter



(1) Solenoid Switch Mounting Nut
(2) Starter Drive Housing
(3) Drive Lever
(4) Gasket
(5) Solenoid Switch
(6) **B** Terminal Nut
(7) **C** Terminal Nut
(8) Snap Ring
(9) Overrunning Clutch
(10) Armature
(11) Brush Spring
(12) Connecting Lead
(13) Rear End Frame
(14) Gasket
(15) Brake Spring
(16) Brake Shoe
(17) End Frame Cap
(18) Screw
(19) Yoke
(20) Brush
(21) Brush Holder
(22) Through Bolt

1. Remove the **C** terminal nut (7), and disconnect the connecting lead (12).
2. Remove the solenoid switch mounting nuts (1), and remove the solenoid switch (5).
3. Remove the end frame cap (17).
4. Remove the brake shoe (16), brake spring (15) and gasket (14).
5. Remove the through bolts (22), and remove the rear end frame (13).
6. Remove the brush from the brush holder while holding the spring up.
7. Remove the brush holder (21).
8. Draw out the yoke (19) from the starter drive housing (2).
9. Draw out the armature (10) with the drive lever (3).

■ **NOTE**

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

(When reassembling)

- Apply grease (DENSO.CO.LTD. No. 50 or equivalent) to the parts indicated in the figure.
  - Joint of solenoid switch **(a)**
  - Bushing **(b)**
  - Drive lever **(c)**
  - Collar **(d)**
  - Teeth of pinion gear **(e)**
  - Armature shaft **(f)**

Tightening torque	Starter's terminal **B** mounting nut	9.81 to 11.7 N·m 1.00 to 1.20 kgf·m 7.24 to 8.67 lbf·ft

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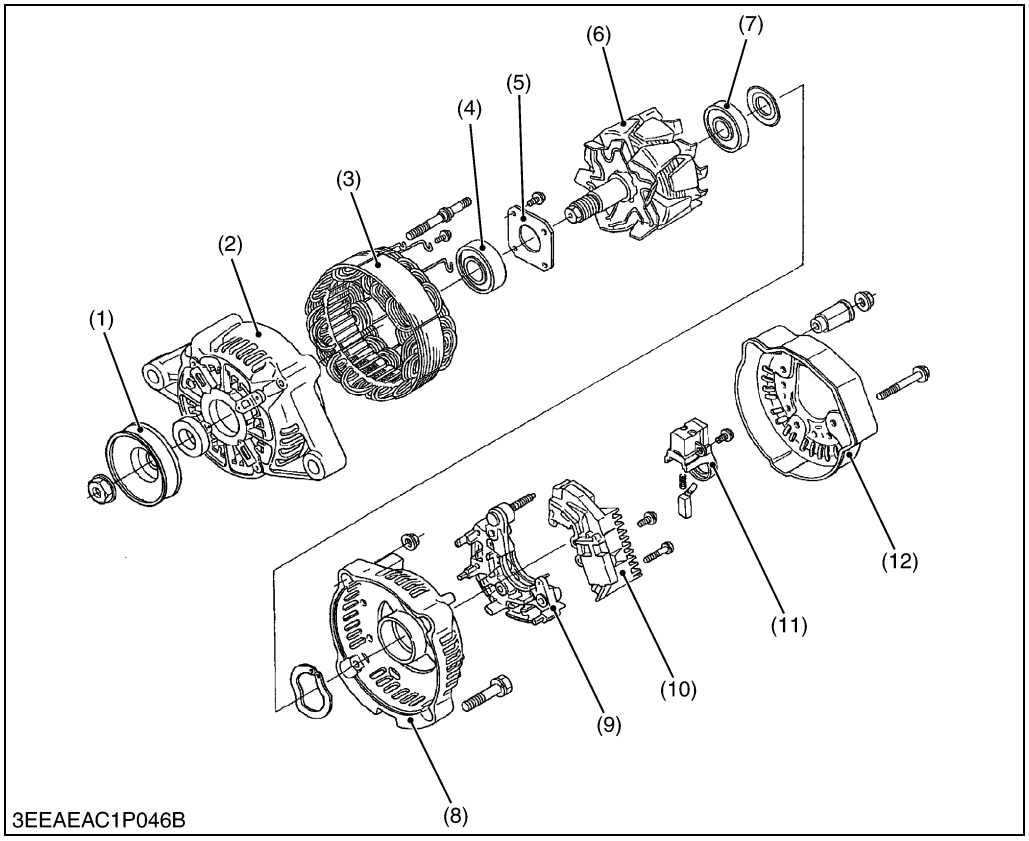
(9) Alternator



(1) Pulley
(2) Drive End Frame
(3) Stator
(4) Bearing
(5) Retainer Plate
(6) Rotor
(7) Bearing
(8) Rear End Frame
(9) Rectifier
(10) IC Regulator
(11) Brush Holder
(12) Rear End Cover

1. Remove the pulley (1).
2. Remove the rear end cover (12).
3. Remove the brush holder (11).
4. Remove the IC regulator (10).
5. Remove the four screws holding the stator lead wires.
6. Remove the rectifier (9).
7. Remove the rear end frame (8).
8. Press out the rotor (6) from drive end frame (2).
9. Remove the retainer plate (5).
10. Press out the bearing (4) from drive end frame (2) with a press and jig.
11. Lightly secure the rotor with a vise to prevent damage, and remove the bearing (7) with a puller.

(When reassembling)

Tightening torque	Alternator's 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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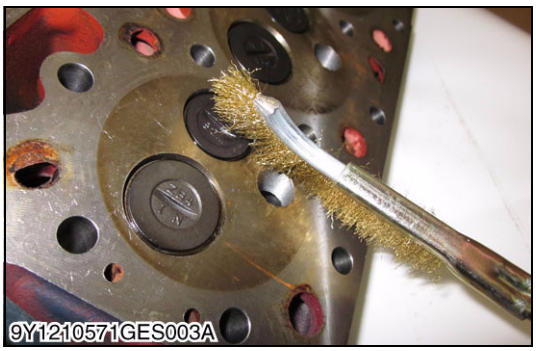
[3] SERVICING
(1) Combustion Chamber



Cleaning Combustion Chamber

Clean any carbon deposits from the combustion chamber walls including the cylinder head surface, surroundings of valve tops, and piston top surfaces. Check valve seating according to following section, and do valve seat grinding if necessary.

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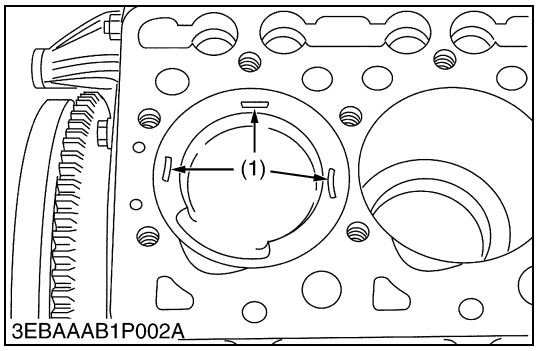
(2) Cylinder Head and Valves



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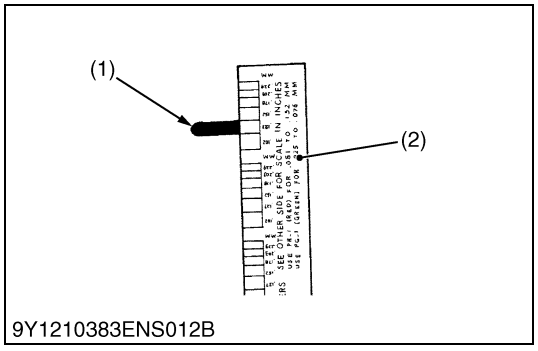

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Top Clearance

1. Remove the cylinder head.
2. With the piston at TDC, use grease to affix three or four plastigauges 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 measure the thickness of the plastigauges.
6. If they are out of spec, check the oil clearance of the crank pin journal and piston pins.

Top clearance	Factory specification	1.15 to 1.35 mm 0.0453 to 0.0532 in.

Tightening torque	Cylinder head screws	38 to 42 N·m 3.8 to 4.3 kgf·m 28 to 31 lbf·ft

(1) Plastigauge (2) Scale

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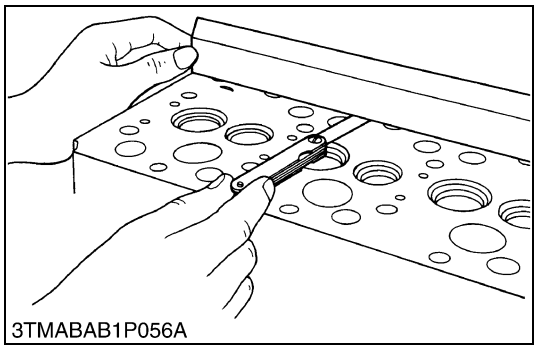
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Cylinder Head Surface Flatness

1. Clean the cylinder head surface.
2. Place a straightedge on the cylinder head's four sides and two diagonal as shown in the figure.
3. Measure the clearance with a feeler gauge.
4. If the measurement exceeds the allowable limit, correct it with a surface grinder.

■ **IMPORTANT**

- **Be sure to check the valve recessing after correcting.**

Cylinder head surface flatness	Allowable limit	0.05 mm 0.002 in.

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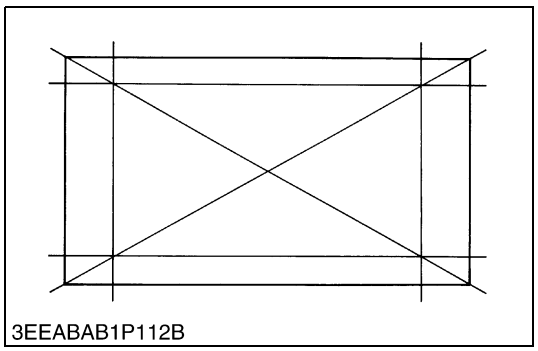
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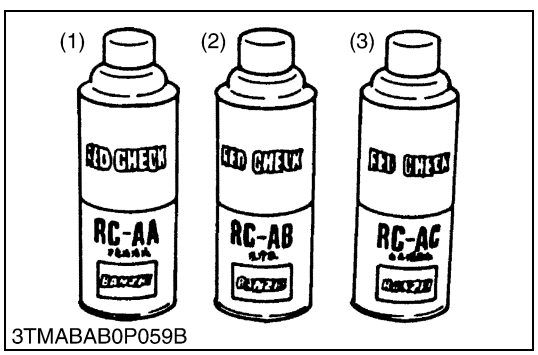
Cylinder Head Flaw

1. Prepare an air spray red check.
2. Clean the surface of the cylinder head with the detergent (2).
3. Spray the cylinder head surface with the red permeative liquid (1). Leave it five to ten minutes after spraying.
4. Wash away the red permeative liquid on the cylinder head surface with the detergent (2).
5. Spray the cylinder head surface with the white developer (3).
6. If flawed, it can be identified as red marks.



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

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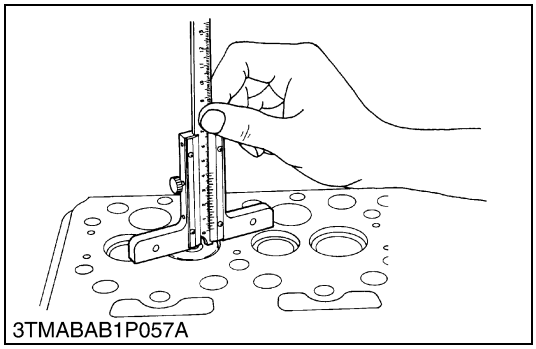
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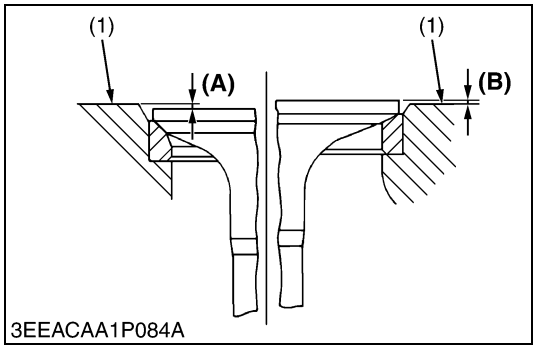
Valve Recessing

1. Clean the cylinder head, the valve face and seat.
2. Insert the valve into the valve guide.
3. Measure the valve recessing with a depth gauge.
4. If the measurement exceeds the allowable limit, replace the valve.
5. If it still exceeds the allowable limit after replacing the valve, replace the cylinder head.

Valve recessing (Intake and Exhaust)	Factory specification	0.10 (protrusion) to 0.10 (recessing) mm 0.0039 (protrusion) to 0.0039 (recessing) in.
	Allowable limit	0.30 (recessing) mm 0.012 (recessing) in.



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

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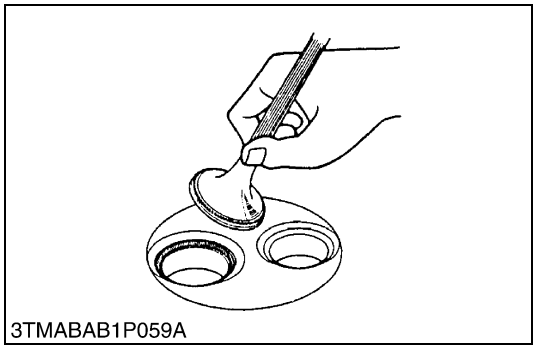
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Valve Seating

1. Coat the valve face lightly with prussian blue and put the valve on its seat to check the contact.
2. If the valve seats all the way around the valve seat, the valve seat is correct.
3. If the valve does not seat all the way around the valve seat, lapping the valve as follows.
4. If the valve contact is incorrect after lapping the valve, replace or correct the valve or correct the contact of valve seating.

(1) Correct
(2) Incorrect

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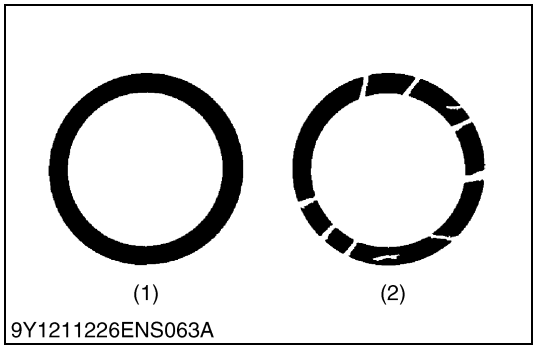

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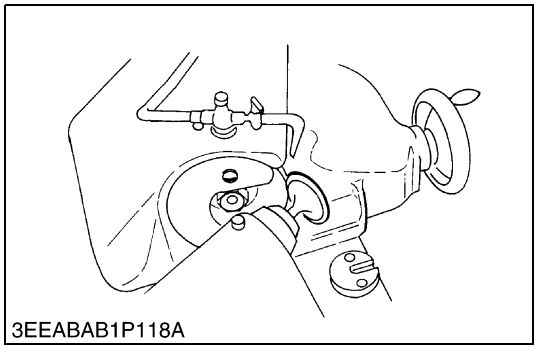
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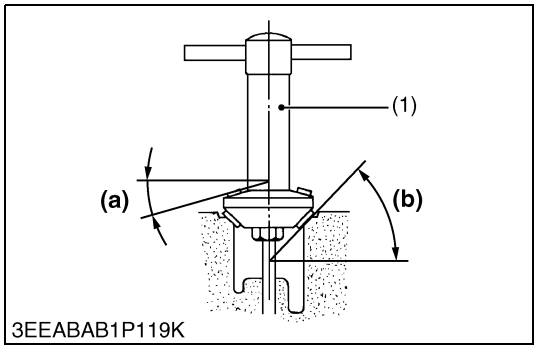

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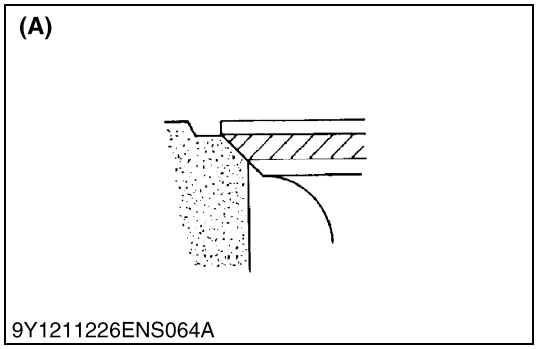

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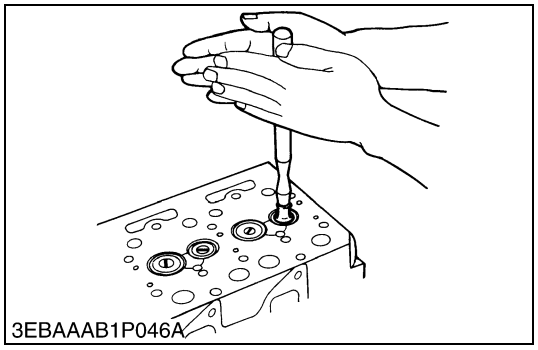
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Correcting Valve and Valve Seat

■ **NOTE**
- **Before correcting the valve and seat, check the valve stem and the I.D. of valve guide section, and repair them if necessary.**
- **After correcting the valve seat, be sure to check the valve recessing.**

1) Correcting Valve

1. Correct the valve with a valve refacer.

Valve face angle	Factory specification	IN.	0.785 rad 45 °
		EX.	0.785 rad 45 °

2) Correcting Valve Seat

1. Slightly correct the seat surface with a 0.785 rad (45 °) valve seat cutter.
2. Resurface the seat surface with a 0.262 rad (15 °) valve seat cutter.
3. After resurfacing the seat, lap the valve as follows.

Valve seat angle	Factory specification	IN.	0.785 rad 45 °
		EX.	0.785 rad 45 °

(1) Valve Seat Cutter
(a) 0.262 rad (15 °)
(b) 0.785 rad (45 °)
(A) Check Contact

9Y1211108ENS0068US0

Valve Lapping

1. Apply compound evenly to the valve lapping surface.
2. Insert the valve into the valve guide. Lap the valve onto its seat with a valve flapper.
3. After lapping the valve, wash the compound away and apply prussian blue to the contact surface to check the seated rate.
4. If the valve seats all the way around the valve seat, apply oil and repeat valve lapping with oil.
5. If the valve contact is incorrect, replace or correct the valve or correct the contact of valve seating.

■ **IMPORTANT**
- **When valve lapping is performed, be sure to check the valve recessing and adjust the valve clearance after assembling the valve.**

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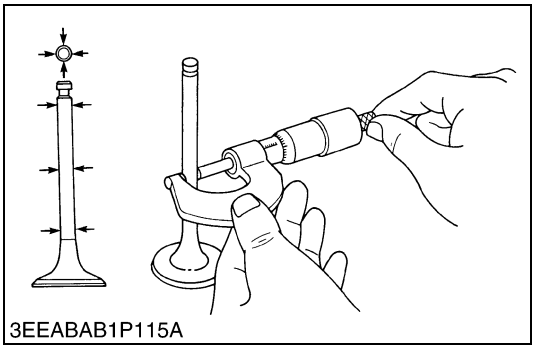
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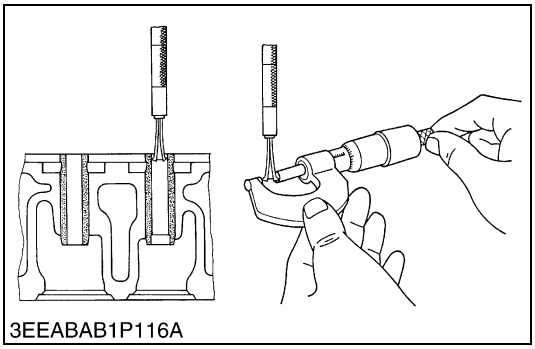
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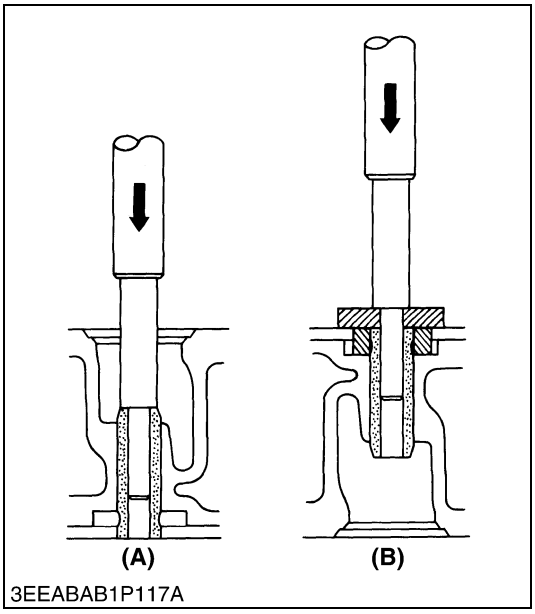

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Clearance between Valve Stem and Valve Guide

1. Remove carbon from the valve guide section.
2. Measure the valve stem O.D. with an outside micrometer.
3. Measure the valve guide I.D. with a small hole gauge, and calculate the clearance.
4. If the clearance exceeds the allowable limit, replace the valves. If it still exceeds the allowable limit, replace the valve guide.

Clearance between valve stem and valve guide (Inlet)	Factory specification	0.030 to 0.057 mm 0.0012 to 0.0022 in.
	Allowable limit	0.10 mm 0.0039 in.

Valve stem O.D. (Inlet)	Factory specification	5.965 to 5.980 mm 0.2348 to 0.2354 in.
Valve guide I.D. (Inlet)	Factory specification	6.010 to 6.025 mm 0.2367 to 0.2372 in.

Clearance between valve stem and valve guide (Exhaust)	Factory specification	0.030 to 0.057 mm 0.0012 to 0.0022 in.
	Allowable limit	0.10 mm 0.0039 in.

Valve stem O.D. (Exhaust)	Factory specification	5.968 to 5.980 mm 0.2350 to 0.2354 in.
Valve guide I.D. (Exhaust)	Factory specification	6.010 to 6.025 mm 0.2367 to 0.2372 in.

9Y1211108ENS0070US0

Replacing Valve Guide

(When removing)

1. Press out the used valve guide using a valve guide replacing tool.

(When installing)

1. Clean a new valve guide and valve guide bore, and apply engine oil to them.
2. Press in a new valve guide using a valve guide replacing tool.
3. Ream precisely the I.D. of the valve guide to the specified dimension.

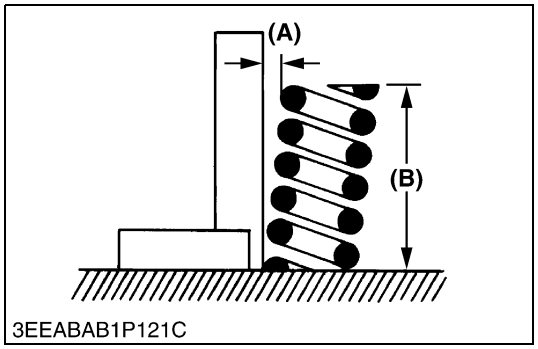
Valve guide I.D.(Intake and exhaust)	Factory specification	6.010 to 6.025 mm 0.2367 to 0.2372 in.

■ **IMPORTANT**

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

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

9Y1211108ENS0071US0



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Free Length and Tilt of Valve Spring

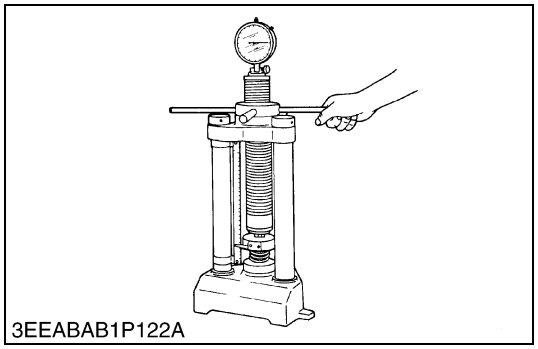
1. Measure the free length **(B)** of valve spring with vernier calipers. If the measurement is less than the allowable limit, replace it.
2. Put the spring on a surface plate, place a square on the side of the spring.
3. Check to see if the entire side is in contact with the square. Rotate the valve spring and measure the maximum tilt **(A)**. If the measurement exceeds the allowable limit, replace it.
4. Check the entire surface of the valve spring for scratches. If there is any problem, replace it.

Tilt **(A)**	Allowable limit	1.2 mm 0.047 in.

Free length **(B)**	Factory specification	31.3 to 31.8 mm 1.24 to 1.25 in.
	Allowable limit	28.4 mm 1.12 in.

(A) Tilt **(B) Free length**

9Y1211108ENS0072US0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Valve Spring Setting Load

1. Place the valve spring on a tester and compress it to the same length it is actually compressed in the engine.
2. Read the compression load on the gauge.
3. If the measurement is less than the allowable limit, replace it.

Setting load / setting length	Factory specification	65 N / 27.0 mm 6.6 kgf / 27.0 mm 15 lbf / 1.06 in.
	Allowable limit	55 N / 27.0 mm 5.6 kgf / 27.0 mm 12 lbf / 1.06 in.

9Y1211108ENS0073US0


3TAAAAD1P060A

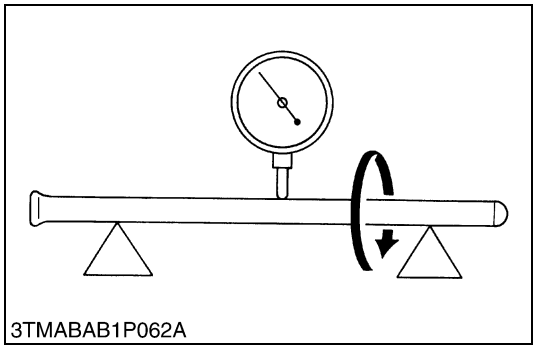
Oil Clearance between Rocker Arm and Rocker Arm Shaft

1. Measure the rocker arm shaft O.D. with an outside micrometer.
2. Measure the rocker arm I.D. with an inside micrometer, and then calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit, replace the rocker arm and measure the oil clearance again. If it still exceeds the allowable limit, replace also the rocker arm shaft.

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

Rocker arm shaft O.D.	Factory specification	10.473 to 10.484 mm 0.41233 to 0.41275 in.
Rocker arm I.D.	Factory specification	10.500 to 10.518 mm 0.41339 to 0.41409 in.

9Y1211108ENS0074US0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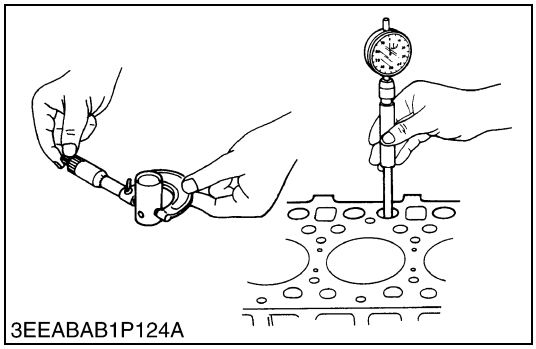
Push Rod Alignment

1. Place the push rod on V blocks.
2. Measure the push rod alignment.
3. If the measurement exceeds the allowable limit, replace the push rod.

Push rod alignment	Allowable limit	0.25 mm 0.0098 in.

9Y1211108ENS0075US0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Oil Clearance between Tappet and Tappet Guide Bore

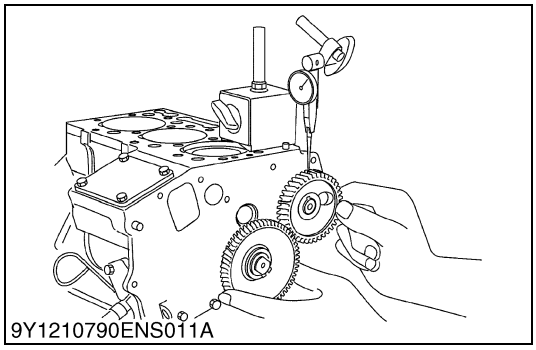
1. Measure the tappet O.D. with an outside micrometer.
2. Measure the I.D. of the tappet guide bore with a cylinder gauge, and calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit or the tappet is damaged, replace the tappet.

Oil clearance between tappet and tappet guide bore	Factory specification	0.016 to 0.052 mm 0.00063 to 0.0020 in.
	Allowable limit	0.10 mm 0.0039 in.

Tappet O.D.	Factory specification	17.966 to 17.984 mm 0.70733 to 0.70803 in.
Tappet guide bore I.D.	Factory specification	18.000 to 18.018 mm 0.70867 to 0.70937 in.

9Y1211108ENS0076US0

(3) Timing Gear and Camshaft


9Y1210790ENS011A

Timing Gear Backlash

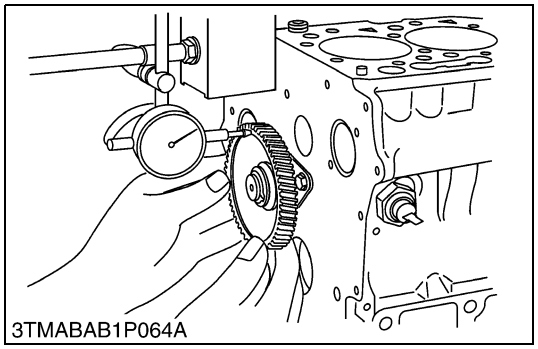
1. Set a dial indicator (lever type) with its tip on the gear tooth.
2. Move the gear to measure the backlash, holding its mating gear.
3. If the backlash exceeds the allowable limit, check the oil clearance of the shafts and the gear.
4. If the oil clearance is proper, replace the gear.

Backlash between idle gear and crank gear	Factory specification	0.0430 to 0.124 mm 0.00170 to 0.00488 in.
	Allowable limit	0.15 mm 0.0059 in.

Backlash between idle gear and cam gear	Factory specification	0.0470 to 0.123 mm 0.00185 to 0.00484 in.
	Allowable limit	0.15 mm 0.0059 in.

Backlash between oil pump drive gear and crank gear	Factory specification	0.0410 to 0.123 mm 0.00162 to 0.00484 in.
	Allowable limit	0.15 mm 0.0059 in.

9Y1211108ENS0077US0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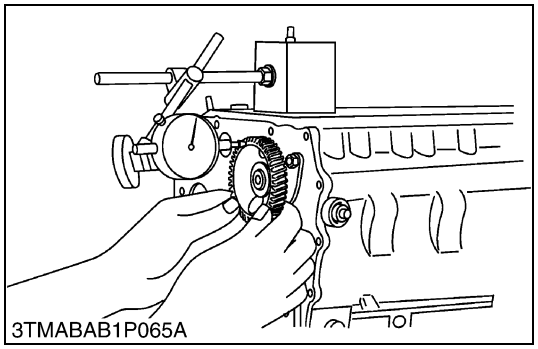
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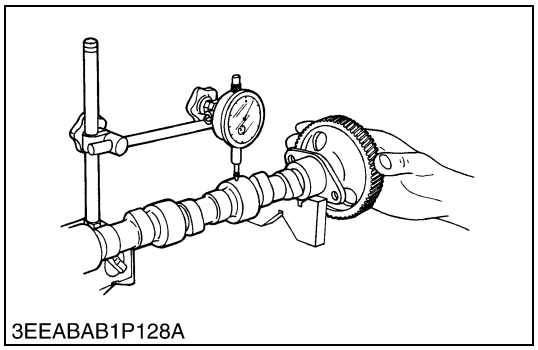
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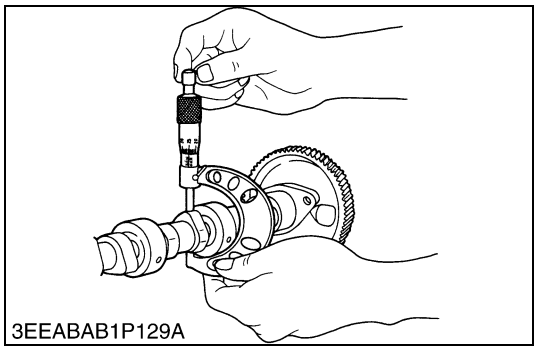
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Idle Gear Side Clearance

1. Set a dial indicator with its tip on the idle gear.
2. Measure the side clearance by moving the idle gear to the front and rear.
3. If the measurement exceeds the allowable limit, replace the idle gear collar.

Idle gear side clearance	Factory specification	0.20 to 0.51 mm 0.0079 to 0.020 in.
	Allowable limit	0.80 mm 0.031 in.

9Y1211108ENS0078US0

Camshaft Side Clearance

1. Set a dial indicator with its tip on the camshaft.
2. Measure the side clearance by moving the cam gear to the front and rear.
3. If the measurement exceeds the allowable limit, replace the camshaft stopper.

Camshaft side clearance	Factory specification	0.15 to 0.31 mm 0.0059 to 0.012 in.
	Allowable limit	0.50 mm 0.020 in.

9Y1211108ENS0079US0

Camshaft Alignment

1. Support the camshaft with V blocks on the surface plate at both end journals.
2. Set a dial indicator with its tip on the intermediate journal.
3. Measure the camshaft alignment.
4. If the measurement exceeds the allowable limit, replace the camshaft.

Camshaft alignment	Allowable limit	0.01 mm 0.0004 in.

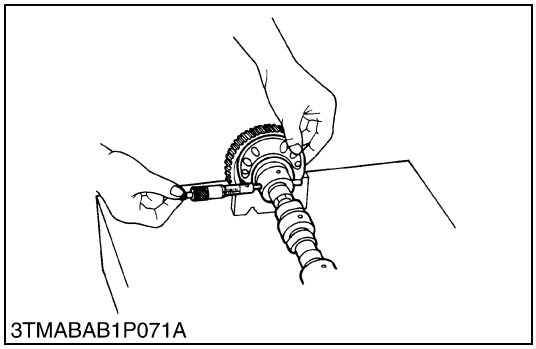
9Y1211108ENS0080US0

Cam Height

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

Cam height of intake and exhaust	Factory specification	26.88 mm 1.058 in.
	Allowable limit	26.83 mm 1.056 in.

9Y1211108ENS0081US0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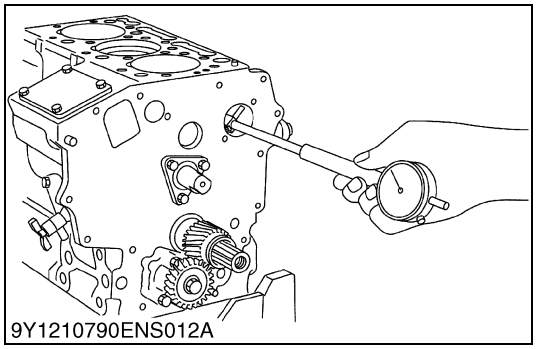
Oil Clearance of Camshaft Journal

1. Measure the camshaft journal O.D. with an outside micrometer.
2. Measure the cylinder block bore I.D. for camshaft with a inside micrometer, and calculate the oil clearance.
3. If the clearance exceeds the allowable limit, replace the camshaft.

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

Camshaft journal O.D.	Factory specification	32.934 to 32.950 mm 1.2967 to 1.2972 in.
Camshaft bearing I.D. (Cylinder block bore I.D.)	Factory specification	33.000 to 33.025 mm 1.2993 to 1.3001 in.

9Y1211108ENS0082US0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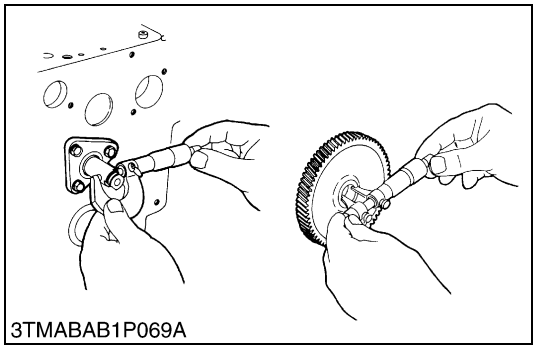
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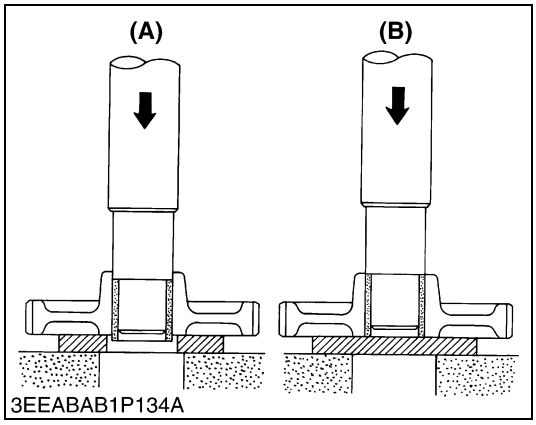
Oil Clearance between Idle Gear Shaft and Idle Gear Bushing

1. Measure the idle gear shaft O.D. with an outside micrometer.
2. Measure the idle gear bushings I.D. with an inside micrometer, and calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit, replace the bushing.
4. If it still exceeds the allowable limit, replace the idle gear shaft.

Oil clearance between idle gear shaft and idle gear bushing	Factory specification	0.020 to 0.084 mm 0.00079 to 0.0033 in.
	Allowable limit	0.10 mm 0.0039 in.

Idle gear shaft O.D.	Factory specification	19.967 to 19.980 mm 0.78611 to 0.78661 in.
Idle gear bushing I.D.	Factory specification	20.000 to 20.051 mm 0.78741 to 0.78940 in.

9Y1211108ENS0083US0



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Replacing Idle Gear Bushing

(When removing)

1. Press out the used idle gear bushing using an idle gear bushing replacing tool.

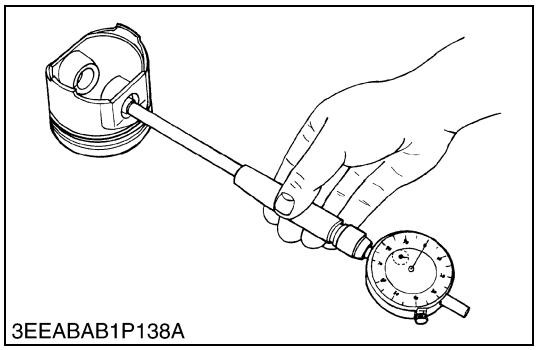
(When installing)

1. Clean a new idle gear bushing and idle gear bore, and apply engine oil to them.
2. Press in a new bushing using an idle gear bushing replacing tool, until it is flush with the end of the idle gear.

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

9Y1211108ENS0084US0

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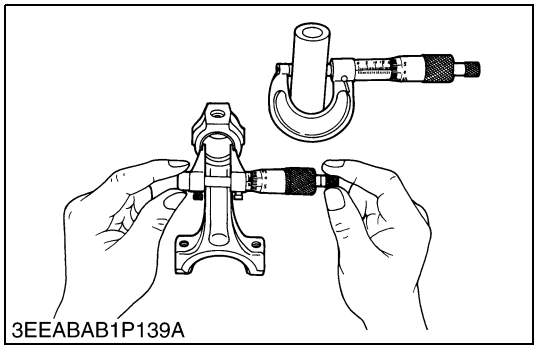
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Piston Pin Bore I.D.

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

Piston pin bore I.D.	Factory specification	20.000 to 20.013 mm 0.78741 to 0.78791 in.
	Allowable limit	20.05 mm 0.7894 in.

9Y1211108ENS0085US0

Oil Clearance between Piston Pin and Small End Bushing

1. Measure the O.D. of the piston pin where it contacts the bushing with an outside micrometer.
2. Measure the small end bushing I.D. with an inside micrometer, and calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit, replace the bushing. If it still exceeds the allowable limit, replace the piston pin.

Oil clearance between piston pin and small end bushing	Factory specification	0.012 to 0.038 mm 0.00048 to 0.0014 in.
	Allowable limit	0.10 mm 0.0039 in.

Piston pin O.D.	Factory specification	20.002 to 20.013 mm 0.78748 to 0.78791 in.
Small end bushing I.D.	Factory specification	20.025 to 20.040 mm 0.78839 to 0.78897 in.

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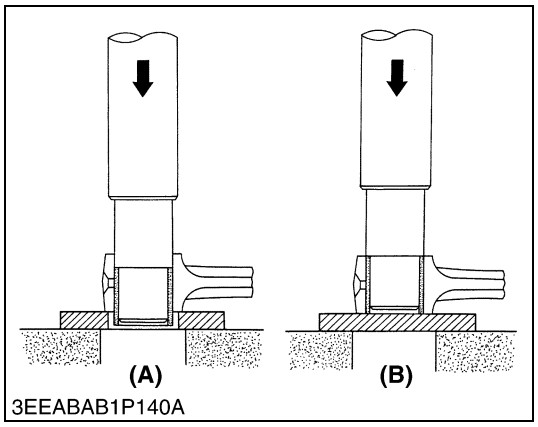

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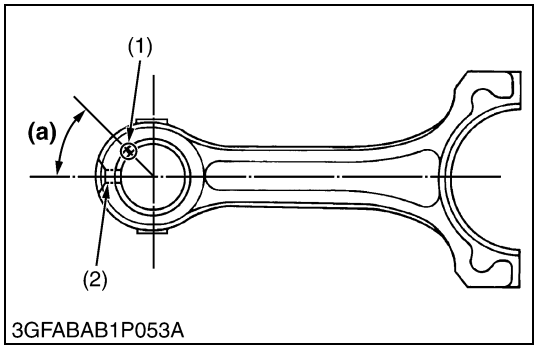

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Replacing Small End Bushing

(When removing)

1. Press out the used bushing using a small end bushing replacing tool. (Refer to G-31.)

(When installing)

1. Clean a new small end bushing and bore, and apply engine oil to them.
2. Using a small end bushing replacing tool, press in a new bushing (service parts) taking due care to see that the connecting rod hole matches the bushing hole.

[Servicing parts dimension]

Oil clearance between piston pin and small end bushing (Spare parts)	Factory specification	0.013 to 0.075 mm 0.00052 to 0.0029 in.
	Allowable limit	0.15 mm 0.0059 in.

Small end bushing I.D. (Spare parts)	Factory specification	20.026 to 20.077 mm 0.78843 to 0.79043 in.

(1) Seam
(2) Oil Hole

(A) When Removing
(B) When Installing
(a) 0.79 rad (45 °)

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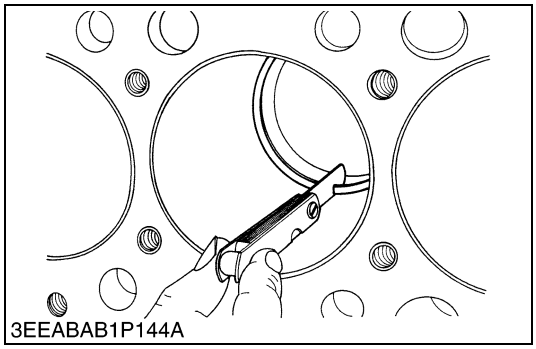
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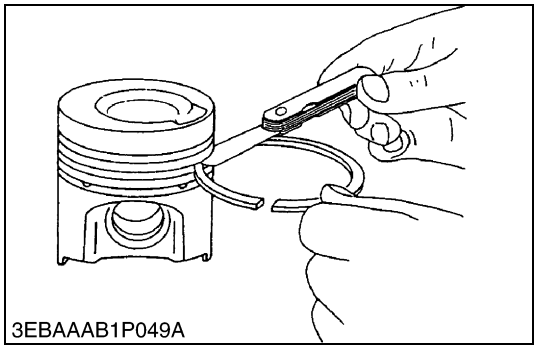
Piston Ring Gap

1. Insert the piston ring into the lower part of the cylinder (the least worn out part) with a piston ring compressor and piston.
2. Measure the ring gap with a feeler gauge.
3. If the measurement exceeds the allowable limit, replace the piston ring.

Piston ring gap	Top ring	Factory specification	0.15 to 0.35 mm 0.0059 to 0.013 in.
		Allowable limit	1.25 mm 0.0492 in.
	Second ring	Factory specification	0.30 to 0.45 mm 0.012 to 0.017 in.
		Allowable limit	1.25 mm 0.0492 in.
	Oil ring	Factory specification	0.20 to 0.70 mm 0.0079 to 0.027 in.
		Allowable limit	1.25 mm 0.0492 in.

9Y1211108ENS0088US0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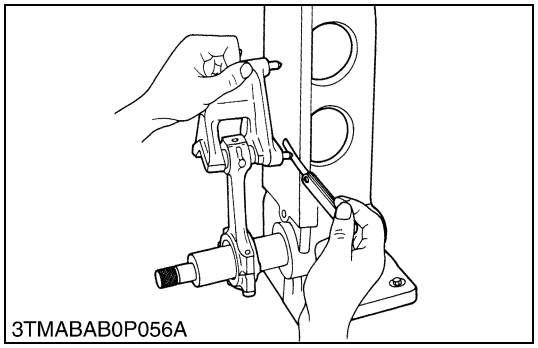
Clearance between Piston Ring and Piston Ring Groove

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 thickness gauge.
3. If the clearance exceeds the allowable limit, replace the piston ring.
4. If the clearance still exceeds the allowable limit with new ring, replace the piston.

Clearance between piston ring and piston ring groove	Top ring	Factory specification	0.080 to 0.12 mm 0.0032 to 0.0047 in.
		Allowable limit	0.15 mm 0.0059 in.
	Second ring	Factory specification	0.065 to 0.10 mm 0.0026 to 0.0039 in.
		Allowable limit	0.15 mm 0.0059 in.
	Oil ring	Factory specification	0.060 to 0.15 mm 0.0024 to 0.0059 in.
		Allowable limit	0.20 mm 0.0079 in.

9Y1211108ENS0089US0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Connecting Rod Alignment

1. Remove the crankpin bearing, and install the connecting rod cap.
2. Install the piston pin in the connecting rod.
3. Install the connecting rod on the connecting rod alignment tool.
4. Put a gauge over the piston pin, and move it against the face plate.
5. If the gauge does not fit squarely against the face plate, measure the space between the pin of the gauge and the face plate.
6. If the measurement exceeds the allowable limit, replace the connecting rod.

Space between gauge pin face plate	Allowable limit	0.05 mm 0.002 in.

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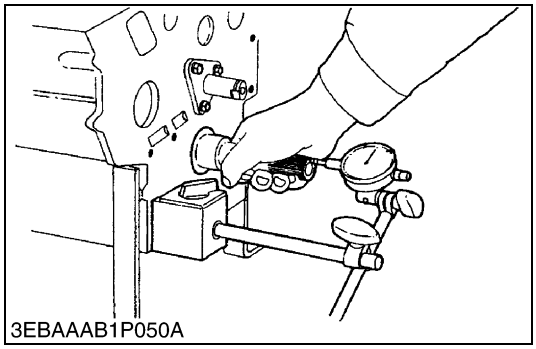
(5) Crankshaft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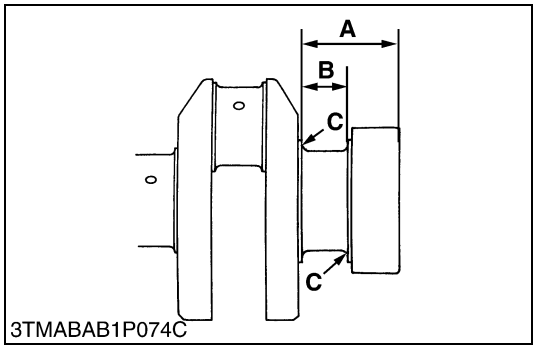

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Crankshaft Side Clearance

1. Set a dial indicator with its tip on the end of the crankshaft.
2. Measure the side clearance by moving the crankshaft to the front and rear.
3. If the measurement exceeds the allowable limit, replace the thrust bearings.
4. If the same size bearing is useless because of the crankshaft journal wear, replace it with an oversize one referring to the table and figure.

Crankshaft side clearance	Factory specification	0.15 to 0.31 mm 0.0059 to 0.012 in.
	Allowable limit	0.50 mm 0.020 in.

(Reference)

- Oversize thrust bearing

Oversize	Bearing	Code Number	Marking
0.2 mm 0.008 in.	Thrust bearing 1 02	15261-23950	020 OS
	Thrust bearing 2 02	15261-23970	020 OS
0.4 mm 0.02 in.	Thrust bearing 1 04	15261-23960	040 OS
	Thrust bearing 2 04	15261-23980	040 OS

- Oversize dimensions of crankshaft journal

Oversize	0.2 mm 0.008 in.	0.4 mm 0.02 in.
Dimension **A**	46.00 to 46.20 mm 1.811 to 1.818 in.	46.10 to 46.30 mm 1.815 to 1.822 in.
Dimension **B**	23.20 to 23.25 mm 0.9134 to 0.9153 in.	23.40 to 23.45 mm 0.9213 to 0.9232 in.
Dimension **C**	1.8 to 2.2 mm radius 0.071 to 0.086 in. radius	1.8 to 2.2 mm radius 0.071 to 0.086 in. radius
The crankshaft journal must be fine-finished to higher than Rmax = 0.8S		

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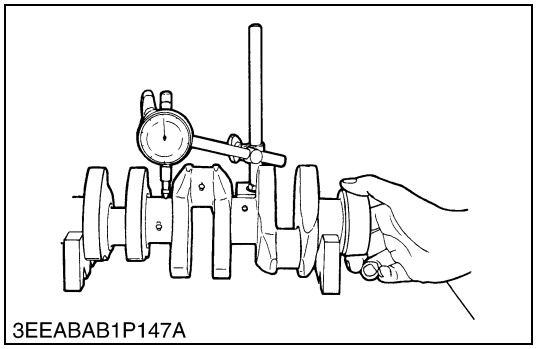
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Crankshaft Alignment

1. Support the crankshaft with V blocks on the surface plate at both end journals.
2. Set a dial indicator with its tip on the intermediate journal.
3. Measure the crankshaft alignment.
4. If the measurement exceeds the allowable limit, replace the crankshaft.

Crankshaft alignment	Allowable limit	0.02 mm 0.0008 in.

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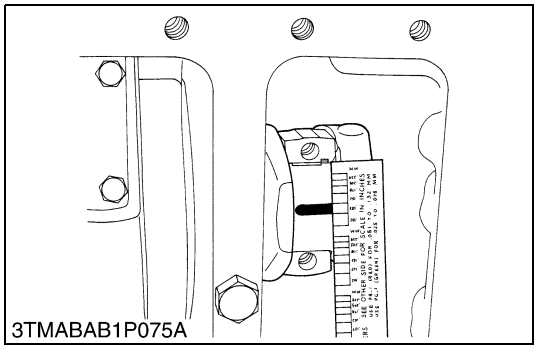
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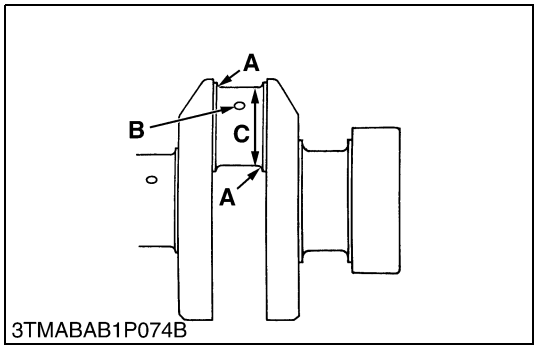

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Oil Clearance between Crankpin and Crankpin Bearing

1. Clean the crankpin and crankpin bearing.
2. Put a strip of plastigage on the center of the crankpin.
3. Install the connecting rod cap and tighten the connecting rod screws to the specified torque, and remove the cap again.
4. Measure the amount of the flattening with the scale, and get the oil clearance.
5. If the oil clearance exceeds the allowable limit, replace the crankpin bearing.
6. If the same size bearing is useless because of the crankpin wear, replace it with an undersize one referring to the table and figure.

■ **NOTE**
- **Never insert the plastigage into the crankpin oil hole.**
- **Be sure not to move the crankshaft while the connecting rod screws are tightened.**

Oil clearance between crankpin and crankpin bearing	Factory specification	0.020 to 0.051 mm 0.00079 to 0.0020 in.
	Allowable limit	0.15 mm 0.0059 in.

Crankpin O.D.	Factory specification	33.959 to 33.975 mm 1.3370 to 1.3375 in.
Crankpin bearing I.D.	Factory specification	33.995 to 34.010 mm 1.3384 to 1.3389 in.

(Reference)
- Undersize crankpin bearing

Undersize	Bearing	Code Number	Marking
0.2 mm 0.008 in.	Crankpin bearing 02	15861-22970	020 US
0.4 mm 0.02 in.	Crankpin bearing 04	15861-20980	040 US

- Undersize dimensions of crankpin

Undersize	0.2 mm 0.008 in.	0.4 mm 0.02 in.
Dimension **A**	2.3 to 2.7 mm radius 0.091 to 0.10 in. radius	2.3 to 2.7 mm radius 0.091 to 0.10 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**	33.759 to 33.775 mm dia. 1.3291 to 1.3297 in. dia.	33.559 to 33.575 mm dia. 1.3213 to 1.3218 in. dia.
The crankpin 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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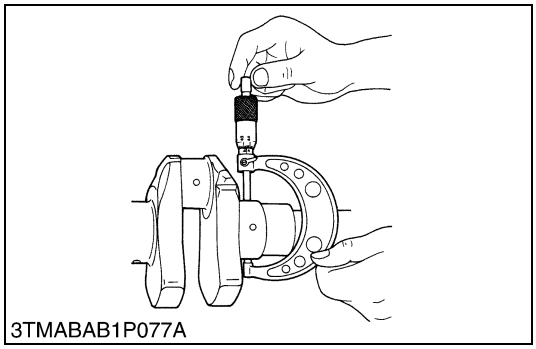
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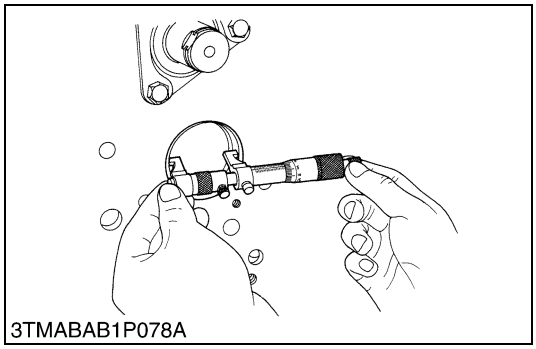
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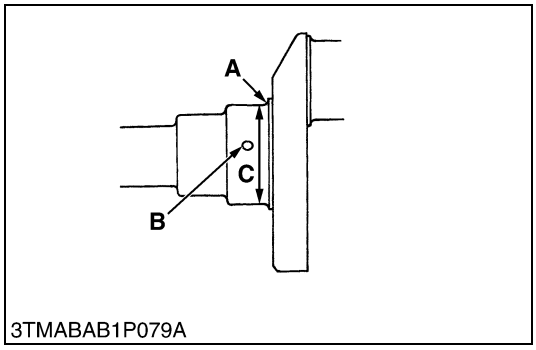

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Oil Clearance between Crankshaft Journal and Crankshaft Bearing 1

1. Measure the O.D. of the crankshaft front journal with an outside micrometer.
2. Measure the I.D. of the crankshaft bearing 1 with an inside micrometer, and calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit, replace the crankshaft bearing 1.
4. If the same size bearing is useless because of the crankshaft journal wear, replace it with an undersize one referring to the table and the figure.

Oil Clearance between crankshaft journal and crankshaft bearing 1	Factory specification	0.0340 to 0.106 mm 0.00134 to 0.00417 in.
	Allowable limit	0.20 mm 0.0079 in.

Crankshaft journal O.D.	Factory specification	43.934 to 43.950 mm 1.7297 to 1.7303 in.
Crankshaft bearing 1 I.D.	Factory specification	43.984 to 44.040 mm 1.7317 to 1.7338 in.

(Reference)

- Undersize crankshaft bearing 1

Undersize	Bearing	Code Number	Marking
0.2 mm 0.008 in.	Crankshaft bearing 1 02	1G460-23910	020 US
0.4 mm 0.02 in.	Crankshaft bearing 1 04	1G460-23920	040 US

- Undersize dimensions of crankshaft journal

Undersize	0.2 mm 0.008 in.	0.4 mm 0.02 in.
Dimension **A**	1.8 to 2.2 mm radius 0.071 to 0.086 in. radius	1.8 to 2.2 mm radius 0.071 to 0.086 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**	43.734 to 43.750 mm dia. 1.7219 to 1.7224 in. dia.	43.534 to 43.550 mm dia. 1.7140 to 1.7145 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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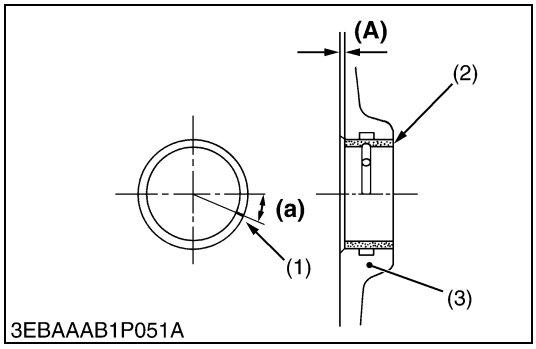

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Replacing Crankshaft Bearing 1

(When removing)

1. Press out the used crankshaft bearing 1 using a crankshaft bearing 1 replacing tool.

(When installing)

1. Clean a new crankshaft bearing 1 and crankshaft journal bore, and apply engine oil to them.
2. Using a crankshaft bearing 1 replacing tool, press in a new bearing 1 (2) so that its seam (1) directs toward the exhaust manifold side. (See figure.)

Dimension **(A)**	Factory specification	0 to 0.3 mm 0 to 0.01 in.

(1) Seam
(2) Crankshaft Bearing 1
(3) Cylinder Block
(A) Dimension
(a) 0.37 rad (21 °)

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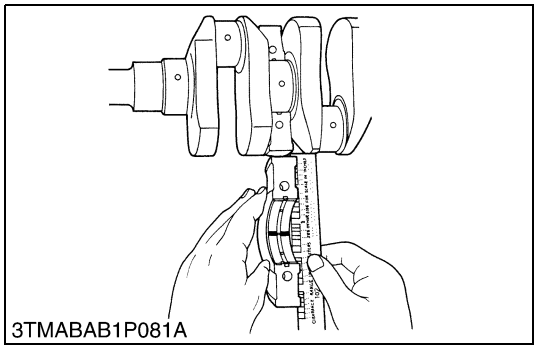
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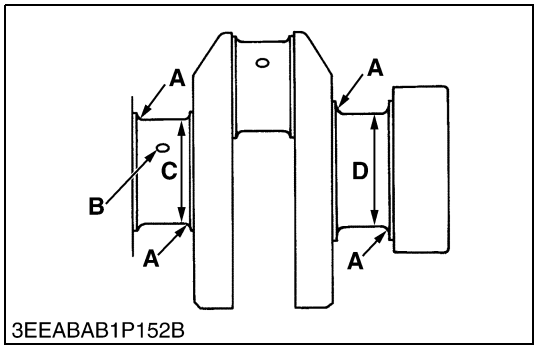

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Oil Clearance between Crankshaft Journal and Crankshaft Bearing 2 (Crankshaft Bearing 3)

1. Put a strip of plastigage on the center of the journal.
2. Install the bearing case and tighten the bearing case screws 1 to the specified torque, and remove the bearing case again.
3. Measure the amount of the flattening with the scale, and get the oil clearance.
4. If the oil clearance exceeds the allowable limit, replace the crankshaft bearing 2 (crankshaft bearing 3).
5. If the same size bearing is useless because of the crankshaft journal wear, replace it with an undersize one referring to the table and figure.

■ **NOTE**

- **Be sure not to move the crankshaft while the bearing case screws are tightened.**

Oil clearance between crankshaft journal and crankshaft bearing 2	Factory specification	0.028 to 0.059 mm 0.0011 to 0.0023 in.
	Allowable limit	0.20 mm 0.0079 in.

Crankshaft journal O.D. (Flywheel side)	Factory specification	43.934 to 43.950 mm 1.7297 to 1.7303 in.
Crankshaft bearing 2 I.D.	Factory specification	43.978 to 43.993 mm 1.7315 to 1.7320 in.

Oil clearance between crankshaft journal and crankshaft bearing 3	Factory specification	0.028 to 0.059 mm 0.0011 to 0.0023 in.
	Allowable limit	0.20 mm 0.0079 in.

Crankshaft journal O.D. (Intermediate)	Factory specification	43.934 to 43.950 mm 1.7297 to 1.7303 in.
Crankshaft bearing 3 I.D.	Factory specification	43.978 to 43.993 mm 1.7315 to 1.7320 in.

(To be continued)

(Continued)

(Reference)

- Undersize crankshaft bearing 2 and 3

Undersize	Bearing	Code Number	Marking
0.2 mm 0.008 in.	Crankshaft bearing 2 02	15694-23930	020 US
	Crankshaft bearing 2F 02	1G460-07530	
	Crankshaft bearing 3 02	1G460-07580	020 US
	Crankshaft bearing 3F 02	1G460-07630	
0.4 mm 0.02 in.	Crankshaft bearing 2 04	15694-23940	040 US
	Crankshaft bearing 2F 04	1G460-07540	
	Crankshaft bearing 3 04	1G460-07590	040 US
	Crankshaft bearing 3F 04	1G460-07640	

- Undersize dimensions of crankshaft journal

Undersize	0.2 mm 0.008 in.	0.4 mm 0.02 in.
Dimension **A**	1.8 to 2.2 mm radius 0.071 to 0.086 in. radius	1.8 to 2.2 mm radius 0.071 to 0.086 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, D**	43.734 to 43.750 mm dia. 1.7219 to 1.7224 in. dia.	43.534 to 43.550 mm dia. 1.7140 to 1.7145 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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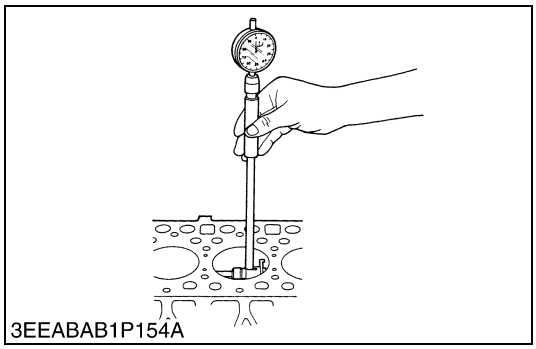
(6) Cylinder



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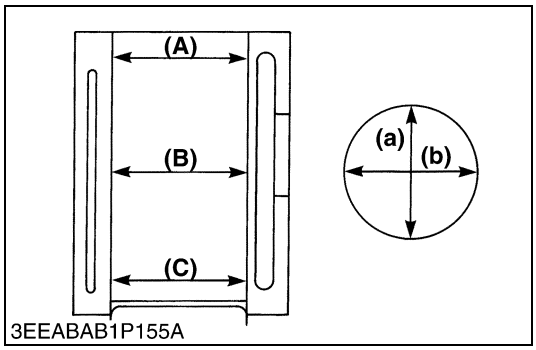

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Cylinder Wear

1. Measure the I.D. of the cylinder at the six positions (see figure) with a cylinder gauge to find the maximum and minimum I.D.'s.
2. Get the difference (Maximum wear) between the maximum and the minimum I.D.'s.

Cylinder I.D.	Factory specification	74.500 to 74.519 mm 2.9331 to 2.9338 in.
	Allowable limit	74.669 mm 2.9397 in.

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

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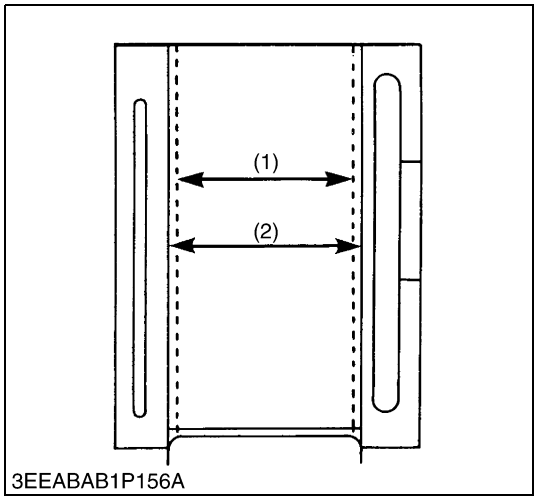

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Correcting Cylinder (Oversize)

1. When the cylinder is worn beyond the allowable limit, bore and hone it to the specified dimension.

Cylinder liner I.D.	Factory specification	75.000 to 75.019 mm 2.9528 to 2.9535 in.
	Allowable limit	75.150 mm 2.9587 in.
Finishing	Hone to 2.2 to 3.0 µmRz (87 to 110 µin.Rz)	

2. Replace the piston and piston rings with oversize ones.
   Oversize: 0.5 mm (0.02 in.)
   Marking: 05

■ **NOTE**

- **When the oversize cylinder is worn beyond the allowable limit, replace the cylinder block with a new one.**

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

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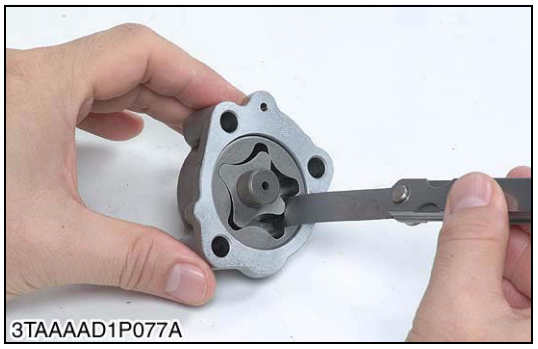
(7) Oil Pump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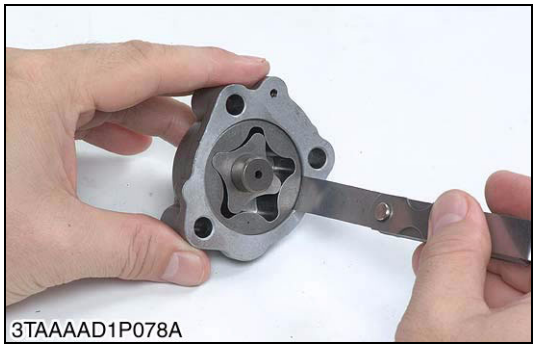
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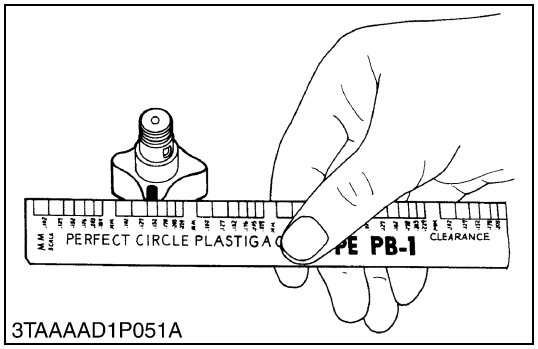

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Rotor Lobe Clearance

1. Measure the clearance between lobes of the inner rotor and the outer rotor with a thickness gauge.
2. If the clearance exceeds the factory specifications, replace the oil pump rotor assembly.

Rotor lobe clearance	Factory specification	0.030 to 0.14 mm 0.0012 to 0.0055 in.

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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 thickness gauge.
2. If the clearance exceeds the factory specifications, replace the oil pump rotor assembly.

Clearance between outer rotor and pump body	Factory specification	0.070 to 0.15 mm 0.0028 to 0.0059 in.

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Clearance between Rotor and Cover

1. Put a strip of plastigage onto the rotor face with grease.
2. Install the cover and tighten the screws.
3. Remove the cover carefully, and measure the amount of the flattening with the scale and get the clearance.
4. If the clearance exceeds the factory specifications, replace oil pump rotor assembly.

Clearance between rotor and cover	Factory specification	0.0750 to 0.135 mm 0.00296 to 0.00531 in.

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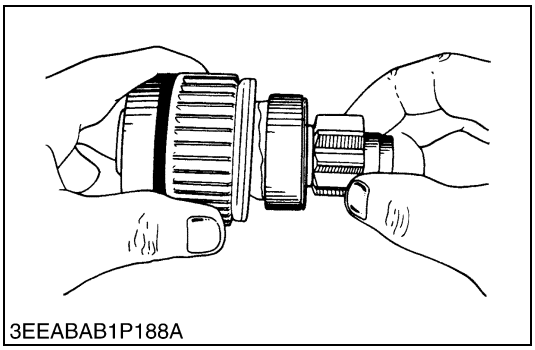
(8) Starter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Overrunning Clutch

1. Inspect the pinion for wear or damage.
2. If there is any problem, replace the overrunning clutch assembly.
3. Check that the pinion turns freely and smoothly in the overrunning direction and does not slip in the cranking direction.
4. If the pinion slips or does not rotate in the both directions, replace the overrunning clutch assembly.

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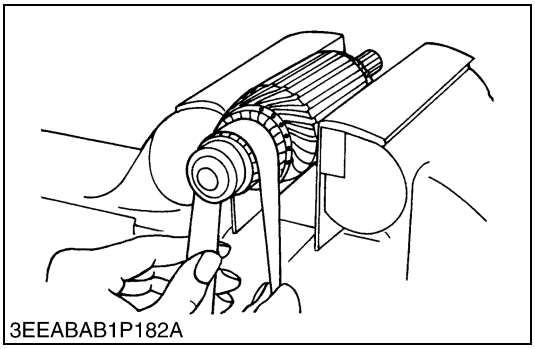
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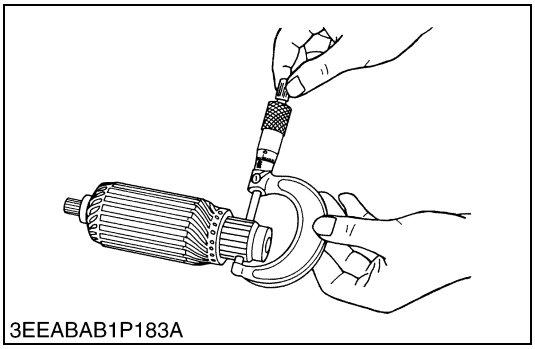
Commutator and Mica

1. Check the contact face of the commutator for wear, and grind the commutator with emery paper if it is slightly worn.
2. Measure the commutator O.D. with an outside micrometer at several points.
3. If the minimum O.D. is less than the allowable limit, replace the armature.
4. If the difference of the O.D.'s exceeds the allowable limit, correct the commutator on a lathe to the factory specification.
5. Measure the mica undercut.
6. If the undercut is less than the allowable limit, correct if with a saw blade and chamfer the segment edges.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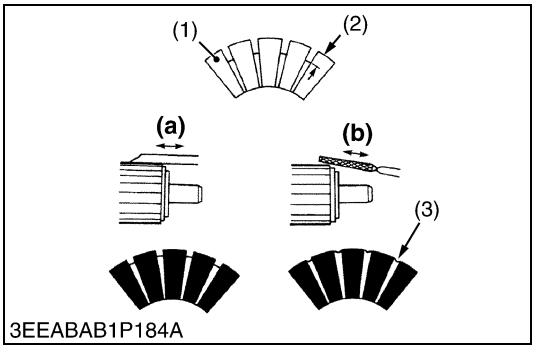
Commutator O.D.	Factory specification	30.0 mm 1.18 in.
	Allowable limit	29.0 mm 1.14 in.

Difference of O.D.'s	Factory specification	Less than 0.02 mm 0.0008 in.
	Allowable limit	0.05 mm 0.002 in.

Mica under cut	Factory specification	0.50 to 0.80 mm 0.020 to 0.031 in.
	Allowable limit	0.20 mm 0.0079 in.



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(1) Segment
(2) Undercut
(3) Mica

(a) Good
(b) Bad

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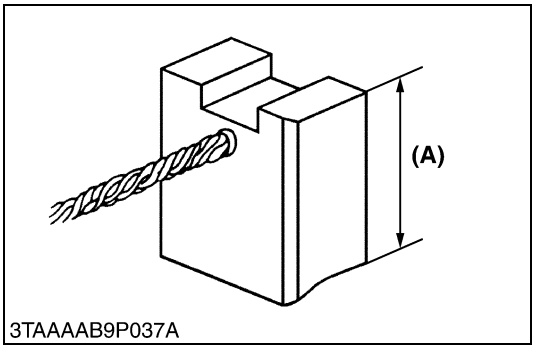

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Brush Wear

1. If the contact face of the brush is dirty or dusty, clean it with emery paper.
2. Measure the brush length **(A)** with vernier calipers.
3. If the length is less than the allowable limit, replace the yoke assembly and brush holder.

Brush length **(A)**	Factory specification	14.0 mm 0.551 in.
	Allowable limit	9.0 mm 0.35 in.

(A) Brush Length

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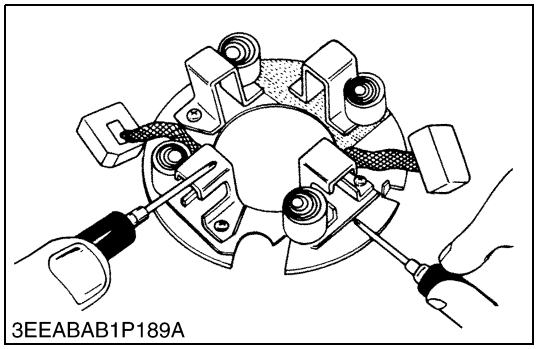
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Brush Holder

1. Check the continuity across the brush holder and the holder support with an ohmmeter.
2. If it conducts, replace the brush holder.

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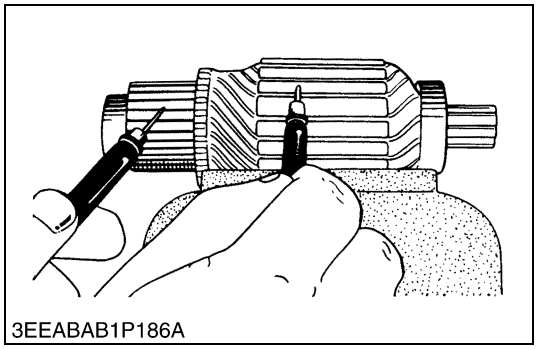
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Armature Coil

1. Check the continuity across the commutator and armature coil core with an ohmmeter.
2. If it conducts, replace the armature.
3. Check the continuity across the segments of the commutator with an ohmmeter.
4. If it does not conduct, replace the armature.

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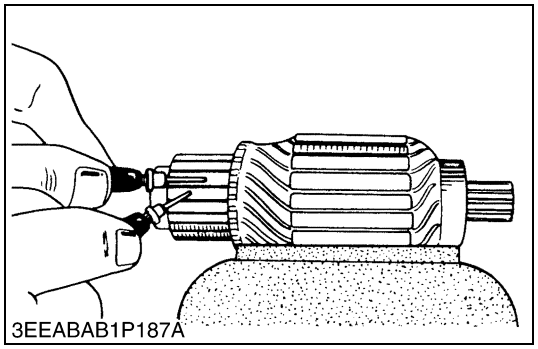
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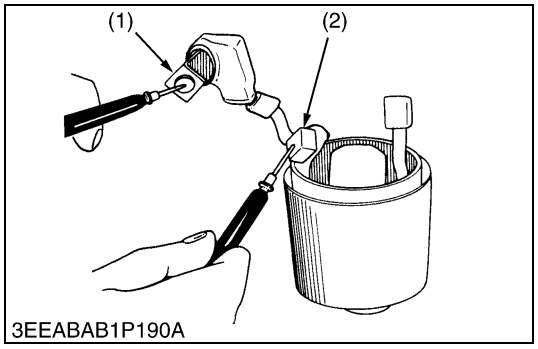

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Field Coil

1. Check the continuity across the lead (1) and brush (2) with an ohmmeter.
2. If it does not conduct, replace the yoke assembly.
3. Check the continuity across the brush (2) and yoke (3) with an ohmmeter.
4. If it conducts, replace the yoke assembly.

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

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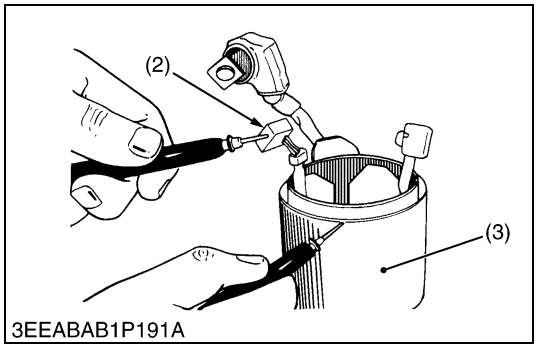

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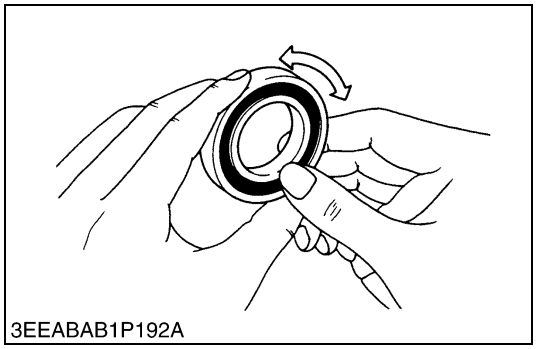
(9) Alternator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Bearing

1. Check the bearing for smooth rotation.
2. If it does not rotate smoothly, replace it.

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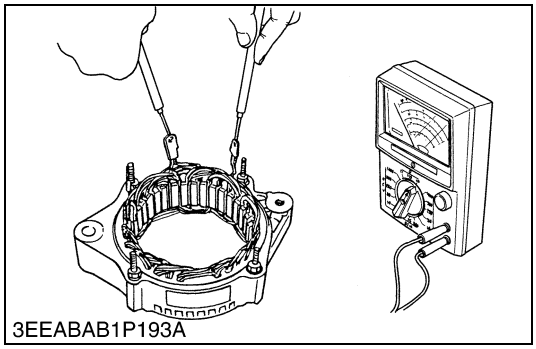
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Stator

1. Measure the resistance across each lead of the stator coil with resistance range of circuit tester.
2. If the measurement is not within factory specification, replace it.
3. Check the continuity across each stator coil lead and core with resistance range of circuit tester.
4. If infinity is not indicated, replace it.

Resistance	Factory specification	Less than 1.0 Ω

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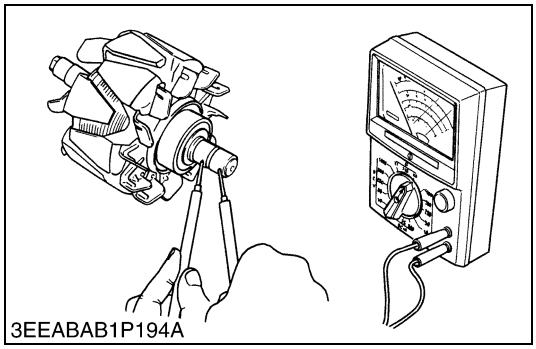
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Rotor

1. Measure the resistance across the slip rings.
2. If the resistance is not the factory specification, replace it.
3. Check the continuity across the slip ring and core with resistance range of circuit tester.
4. If infinity is not indicated, replace it.

Resistance	Factory specification	2.9 Ω

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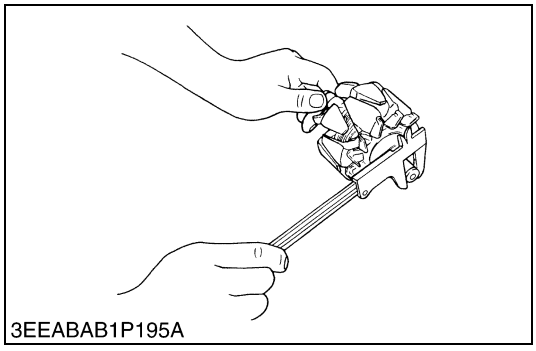
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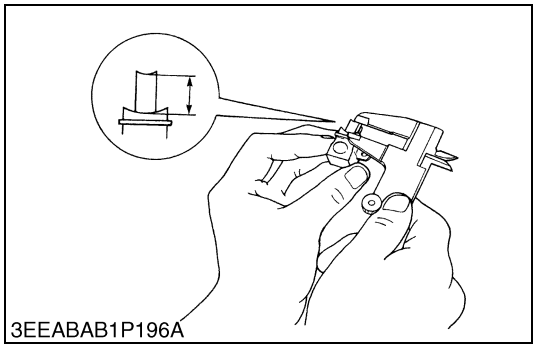
Slip Ring

1. Check the slip ring for score.
2. If scored, correct with an emery paper or on a lathe.
3. Measure the O.D. of slip ring with vernier calipers.
4. If the measurement is less than the allowable limit, replace it.

Slip ring O.D.	Factory specification	14.4 mm 0.567 in.
	Allowable limit	14.0 mm 0.551 in.

9Y1211108ENS0111US0

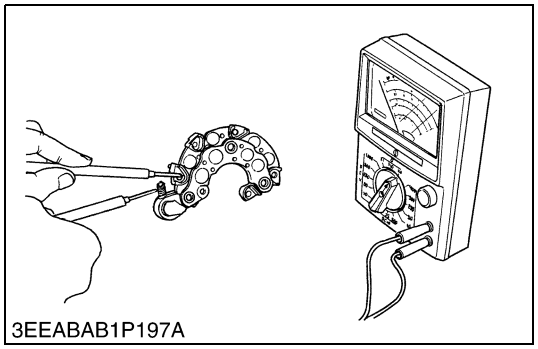

3EEABAB1P196A

Brush Wear

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

Brush length	Factory specification	10.5 mm 0.413 in.
	Allowable limit	8.4 mm 0.33 in.

9Y1211108ENS0112US0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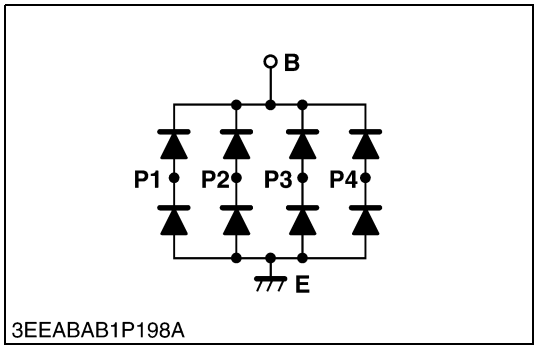
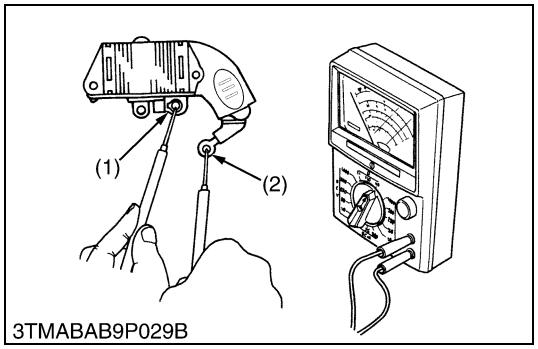
Rectifier

1. Check the continuity across each diode of rectifier with resistance range of circuit tester.
2. The rectifier is normal if the diode in the rectifier conducts in one direction and does not conduct in the reverse direction.

9Y1211108ENS0113US0



3EEABAB1P198A



3TMABAB9P029B

IC Regulator

1. Check the continuity across the **B** terminal (2) and the **F** terminal (1) of IC regulator with resistance range of circuit tester.
2. The IC regulator is normal if the conducts in one direction and does not conduct in the reverse direction.

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

9Y1211108ENS0114US0

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