

SHOP MANUAL

KOMATSU

67E-1 SERIES

DIESEL ENGINE

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TO THE READER

This Shop Manual has been prepared to provide servicing personnel with information on the mechanism, service and maintenance of 3D67E Series. It is divided into three parts, "General", "Mechanism" and "Servicing".

■ General

Information on the engine identification, the general precautions, maintenance check list, check and maintenance and special tools are described.

■ Mechanism

Information on the structure and function are included. This part should be understood before proceeding with troubleshooting, disassembling and servicing.

■ Servicing

Information on the troubleshooting, servicing specification lists, tightening torque, checking and adjusting, disassembling and assembling, and servicing which cover procedures, precautions, factory specifications and allowable limits.

All information illustrations and specifications contained in this manual are based on the latest product information available at the time of publication.

The right is reserved to make changes in all information at any time without notice.

SAFETY FIRST

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

DANGER

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

WARNING

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

CAUTION

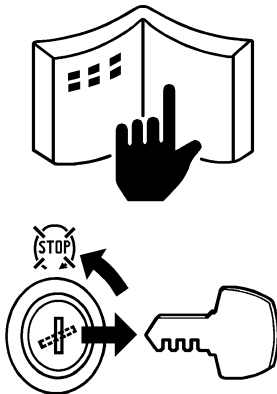
- Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

■ IMPORTANT

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

■ NOTE

- Gives helpful information.



BEFORE SERVICING AND REPAIRING

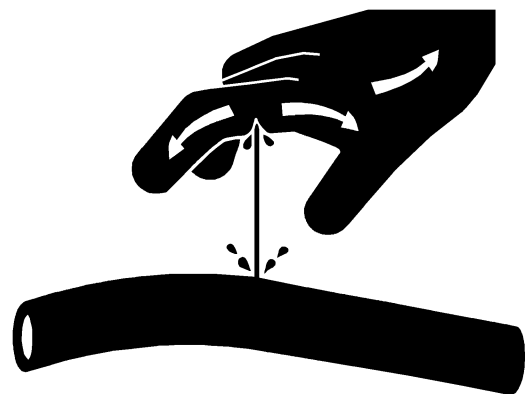
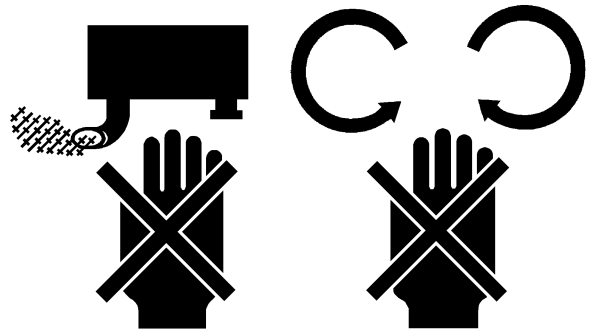
- Read all instructions and safety instructions in this manual and on your engine safety decals.
- Clean the work area and engine.
- Park the machine on a firm and level ground.
- Allow the engine to cool before proceeding.
- Stop the engine, and remove the key
- Disconnect the battery negative cable

SAFETY STARTING

- Do not start the engine by shorting across starter terminals or bypassing the safety start switch.
- Unauthorized modifications to the engine may impair the function and / or safety and affect engine life.

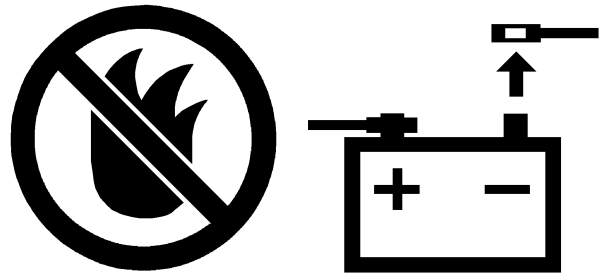
SAFETY WORKING

- Do not work on the machine while under the influence of alcohol, medication, or other substances or while fatigued.
- Wear close fitting clothing and safety equipment appropriate to the job.
- Use tools appropriate to the work. Makeshift tools, parts, and procedures are not recommended.
- When servicing is performed together by two or more persons, take care to perform all work safely.
- Do not touch the rotating or hot parts while the engine is running.
- Never remove the radiator cap while the engine is running, or immediately after stopping. Otherwise, hot water will spout out from radiator. Only remove radiator cap when cool enough to touch with bare hands. Slowly loosen the cap to first stop to relieve pressure before removing completely.
- Escaping fluid (fuel or hydraulic oil) under pressure can penetrate the skin causing serious injury. Relieve pressure before disconnecting hydraulic or fuel lines. Tighten all connections before applying pressure.
- Wear a suitable hearing protective device such as earmuffs or earplugs to protect against objectionable or uncomfortable loud noises.

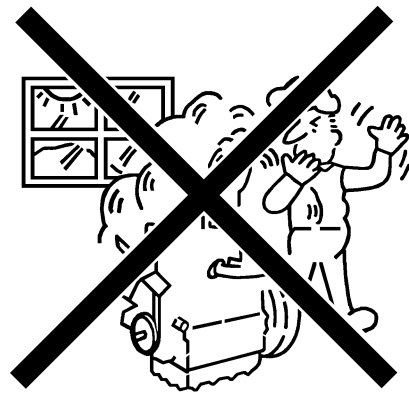


AVOID FIRES

- Fuel is extremely flammable and explosive under certain conditions. Do not smoke or allow flames or sparks in your working area.
- To avoid sparks from an accidental short circuit, always disconnect the battery negative cable first and connect it last.
- Battery gas can explode. Keep sparks and open flame away from the top of battery, especially when charging the battery.
- Make sure that no fuel has been spilled on the engine.

VENTILATE WORK AREA

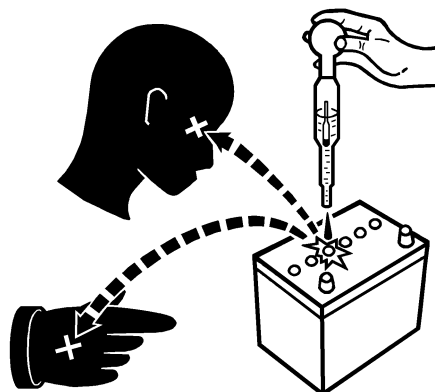
- If the engine must be running to do some work, make sure the area is well ventilated. Never run the engine in a closed area. The exhaust gas contains poisonous carbon monoxide.

DISPOSE OF FLUIDS PROPERLY

- Do not pour fluids into the ground, down a drain, or into a stream, pond, or lake. Observe relevant environmental protection regulations when disposing of oil, fuel, coolant, electrolyte and other harmful waste.

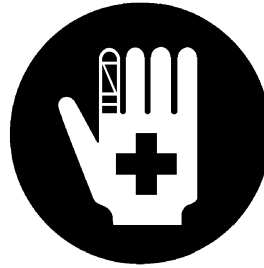
PREVENT ACID BURNS

- Sulfuric acid in battery electrolyte is poisonous. It is strong enough to burn skin, clothing and cause blindness if splashed into eyes. Keep electrolyte away from eyes, hands and clothing. If you spill electrolyte on yourself, flush with water, and get medical attention immediately.

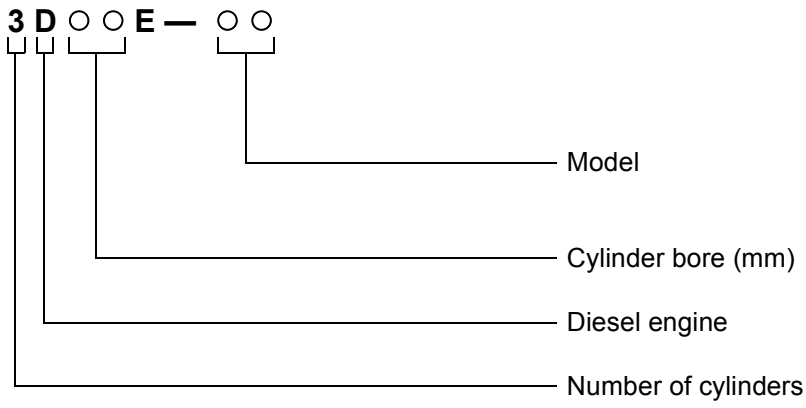


PREPARE FOR EMERGENCIES

- Keep a first aid kit and fire extinguisher handy at all times.
- Keep emergency numbers for doctors, ambulance service, hospital and fire department near your telephone.



ENGINE NOMENCLATURE



APPLICABLE MACHINE, SERIAL NUMBER

Engine	Machine model	Machine Serial No.	Remarks
3D67E-1A	PC18MR-2	12001 and up	

1. GENERAL

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SPECIFICATIONS

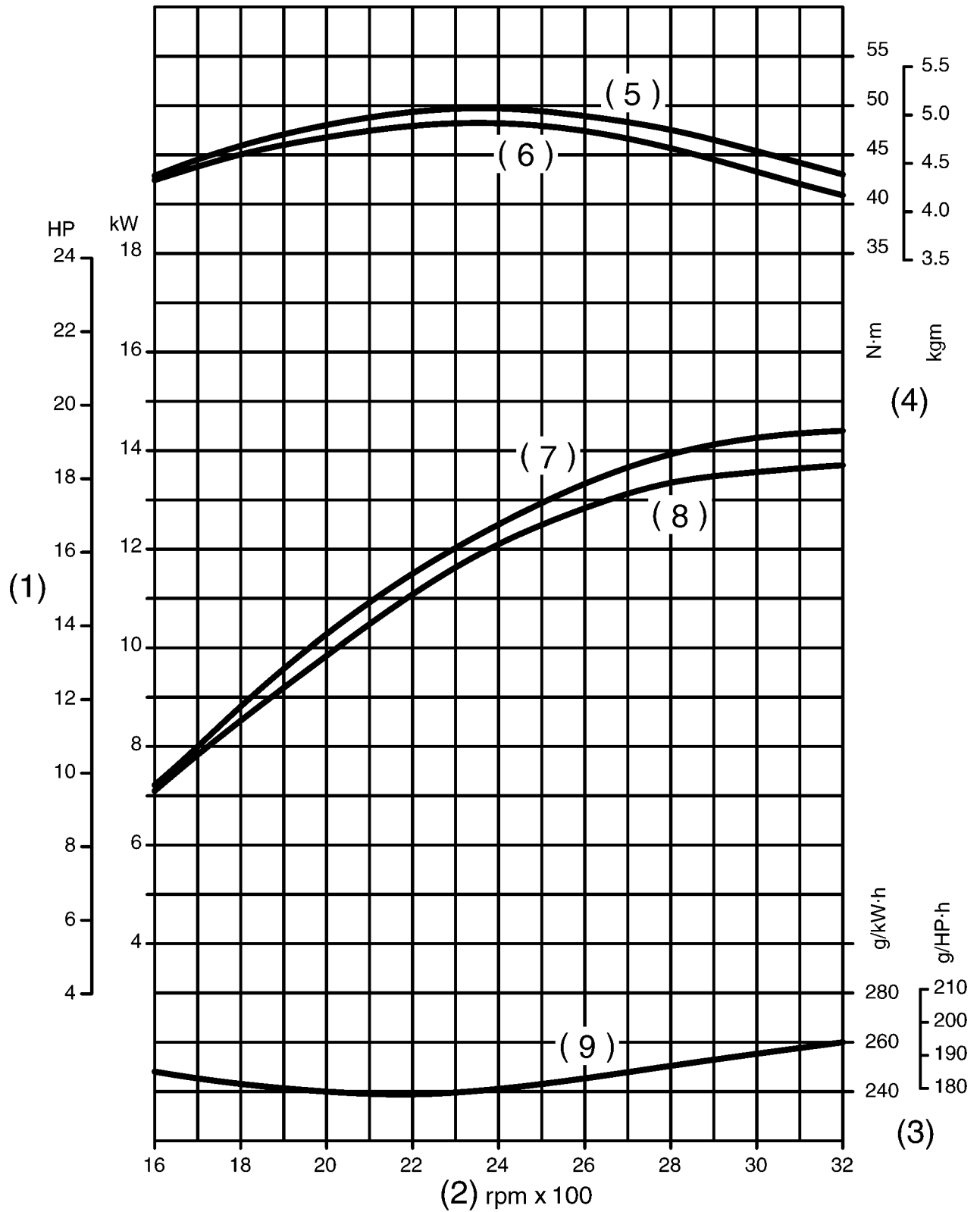
Model		3D67E-1A
Number of Cylinders		3
Type		Vertical, water-cooled, 4-cycle diesel engine
Bore x Stroke	mm	67 x 73.6
Total Displacement		cc
SAE Net Continuous		kW/(rpm) {HP/rpm}
SAE Net Intermittent		kW/(rpm) {HP/rpm}
SAE Gross Intermittent		kW/(rpm) {HP/rpm}
Maximum Bare Speed		(rpm)
Minimum Bare Idling Speed		(rpm)
Combustion Chamber		Spherical Type (E-TVCS)
Fuel Injection Pump		Bosch MD Type mini pump
Governor		Centrifugal ball mechanical governor
Direction of Rotation		Counter-clockwise (viewed from flywheel)
Injection Nozzle		Bosch throttle type
Injection Timing (before T.D.C.)		16 to 18°
Firing Order		1 - 2 - 3
Injection Pressure		13.73 MPa {140 kg/cm ² }
Compression Ratio		24 : 1
Lubricating System		Forced lubrication by pump
Cooling System		Pressurized radiator, forced circulation with water pump
Starting System		Cell starter (with glow plug)
Starting Motor		12 V, 1.0 kW
Recommended Battery Capacity (5 Hr capacity)		12 V, 36AH, equivalent
Charging Generator		12 V, 150 W
Fuel		Diesel Fuel No.2-D
Lubricating Oil		Class CF lubricating oil as per API classification is recommended. If this class of lubricating oil is not available, preferably use Class CD or CE lubricating oil. For details on recommended lubricating oils, see page G-7, 11.
Lubricating Oil Capacity	Depth 101 mm	—
	Depth 121 mm	3.1 ℓ
Weight (Dry) BB spec.		kg

■ NOTE

- Specifications are subject to change without notice.
- The battery capacity is indicated in 5-hour ratio.

PERFORMANCE CURVES

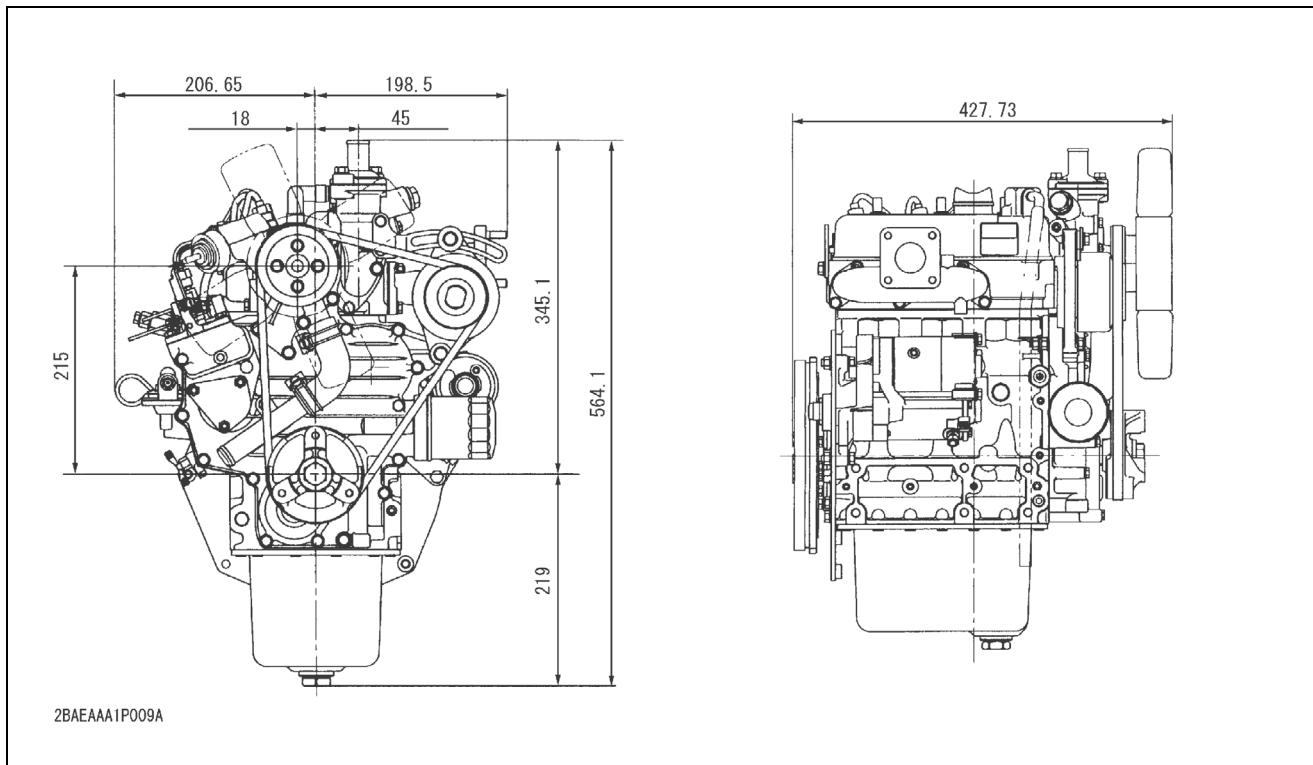
■ 3D67E-1A



- | | | |
|------------------|---------------------|-----------------------|
| (1) Horsepower | (4) Torque | (7) Gross B.H.P. |
| (2) Engine Speed | (5) Gross Torque | (8) Overload B.H.P. |
| (3) B.S.F.C. | (6) Overload Torque | (9) Overload B.S.F.C. |

DIMENSIONS

3D67E-1A

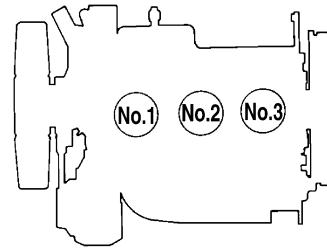


ENGINE IDENTIFICATION

1. CYLINDER NUMBER

The cylinder numbers of diesel engine are designated as shown in the figure.

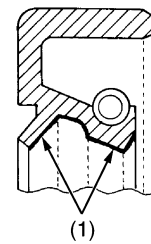
The sequence of cylinder numbers is given as No.1, No.2 and No.3 starting from the gear case side.



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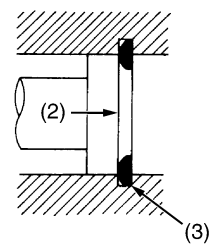
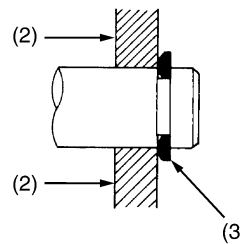
GENERAL PRECAUTION

- During disassembly, carefully arrange removed parts in a clean area to prevent confusion later. Screws, bolts and nuts should be replaced in their original position to prevent reassembly errors.
- When special tools are required, use genuine special tools. Special tools which are not frequently used should be made according to the drawings provided.
- Before disassembling or servicing live wires, make sure to always disconnect the grounding cable from the battery first.
- Remove oil and dirt from parts before measuring.
- Use only genuine parts for parts replacement to maintain engine performance and to ensure safety.
- Gaskets and O-rings must be replaced during reassembly. Apply grease to new O-rings or oil seals before assembling.
- When reassembling external or internal snap rings, position them so that the sharp edge faces against the direction from which force is applied.
- Be sure to perform run-in the serviced or reassembled engine. Do not attempt to give heavy load at once, or serious damage may result to the engine.



(A)

(B)



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- | | |
|---|-------------------------------|
| (1) Grease | (A) External Snap Ring |
| (2) Force | (B) Internal Snap Ring |
| (3) Place the Sharp Edge against the Direction of Force | |

MAINTENANCE CHECK LIST

To maintain long-lasting and safe engine performance, make it a rule to carry out regular inspections by following the table below.

The lubricating oil change intervals listed in the table below are for Classes CF, CE and CD lubricating oils of API classification with a low-sulfur fuel in use. If the CF-4 or CG-4 lubricating oil is used with a high-sulfur fuel, change the lubricating oil at shorter intervals than recommended in the table below depending on the operating condition.

Item		Service Interval											
		Every 50 hours	Every 75 hours	Every 100 hours	Every 150 hours	Every 200 hours	Every 400 hours	Every 500 hours	Every 1 year	Every 800 hours	Every 1500 hours	Every 3000 hours	Every 2 years
Checking fuel hose and clamp bands		☆											
*Changing engine oil	Oil pan depth (121 mm)			☆									
Check fan belt tension and damage				☆									
Cleaning air cleaner element				☆									
Cleaning fuel filter				☆									
*Replacing oil filter cartridge	Oil pan depth (121 mm)					☆							
Checking radiator hoses and clamp bands						☆							
Checking intake air line						☆							
Replacing fuel filter							☆						
Cleaning fuel tank inside								☆					
Cleaning water jacket and radiator interior								☆					
Replacing fan belt								☆					

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

Item	Service Interval											
	Every 50 hours	Every 75 hours	Every 100 hours	Every 150 hours	Every 200 hours	Every 400 hours	Every 500 hours	Every 1 year	Every 800 hours	Every 1500 hours	Every 3000 hours	Every 2 years
**Replacing air cleaner element								☆				
Checking valve clearance									☆			
***Checking injection nozzle condition										☆		
Checking injection pump											☆	
Replacing intake air line												☆
Replacing radiator hoses and clamp bands												☆
Replacing fuel pipes and clamp bands												☆
Changing radiator coolant (L.L.C.)												☆

** Or, every sixth cleanings of air cleaner element.

*** Maintenance interval as per EPA instructions.



CAUTION

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

NOTE

• **Lubricating Oil**

With the emission control now in effect, the CF-4 and CG-4 lubricating oils have been developed for use of a low-sulfur fuel on-road vehicle engines. When an off-road vehicle engine runs on a high-sulfur fuel, it is advisable to employ the CF, CD or CE lubricating oil with a high total base number. If the CF-4 or CG-4 lubricating oil is used with a high-sulfur fuel, change the lubricating oil at shorter intervals.

- **Lubricating oil recommended when a low-sulfur or high-sulfur fuel is employed.**

Lubricating oil class	Fuel	Low sulfur (0.5 % ≥)	High sulfur	Remarks
	CF		○	○
CF-4		○	×	
CG-4		○	×	

○: Recommendable ×: Not recommendable

CHECK AND MAINTENANCE

1. DAILY CHECK POINTS

Checking Engine Oil Level

1. Level the engine.
2. To check the oil level, draw out the oil level gauge (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.

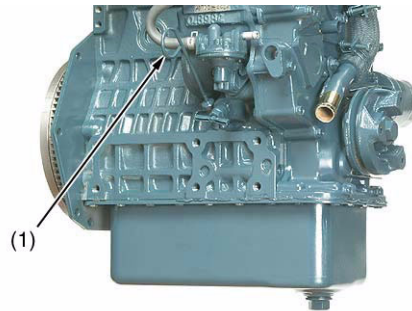
■ IMPORTANT

- When using an oil of different maker or viscosity from the previous, drain old oil. Never mix two different types of oil.

■ NOTE

- Be sure to inspect the engine, locating it on a horizontal place. If placed on gradients, accurately, oil quantity may not be measured.
- Be sure to keep the oil level between upper and lower limits of the oil level gauge. 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 cause oil hammer. While too little oil, may seize the engine's rotating and sliding parts.

(1) Oil level gauge



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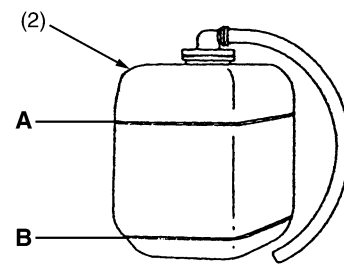
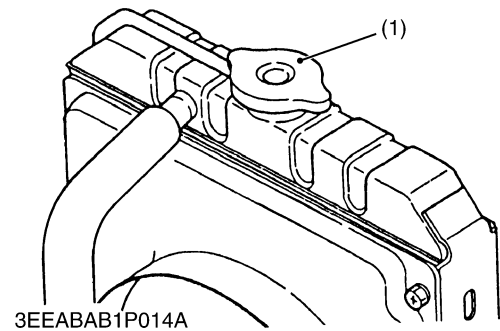
Checking and Replenish Coolant

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)**.
If coolant level is too low, check the reason for decreasing coolant.
(Case 1)
If coolant is decreasing by evaporation, replenish only fresh, soft water.
(Case 2)
If coolant is decreasing by leak, replenish 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 | (A) FULL |
| (2) Recovery Tank | (B) LOW |



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2. CHECK POINTS OF EVERY 50 HOURS

Checking Fuel Hose and Clamp Bands

1. If the clamp (1) is loose, apply oil to the threads and securely retighten it.
2. The fuel hose (2) is made of rubber and ages regardless of the period service. Change the fuel hose together with the clamp every two years.
3. However, if the fuel hose and clamp are found to be damaged or deteriorate earlier than two years, then change or remedy.
4. After the fuel hose and the clamp have been changed, bleed the fuel system.

⚠ CAUTION

- **Stop the engine when attempting the check and change prescribed above.**

(When bleeding fuel system)

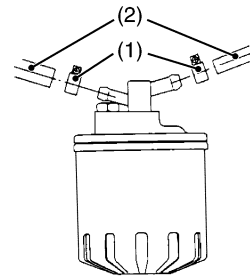
1. Fill the tank with fuel and open the cock (4).
2. Loosen the air vent plug (3) of the fuel filter a few turns.
3. Screw back the plug when bubbles do not come up any more.
4. Open the air vent cock (5) on top of the fuel injection pump.
5. If equipped electrical fuel feed pump, turn the key to AC position and pump the fuel up for 10 to 15 seconds.
If equipped mechanical fuel feed pump, set the stop lever on stop position and crank the engine for 10 to 15 seconds.
6. Close securely the air vent cock after air bleeding.

■ NOTE

- **Always keep the air vent cock on the fuel injection pump closed except when air is vented, or it may cause the engine to stop.**

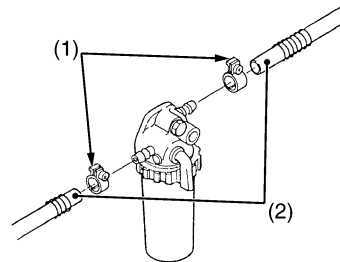
- | | |
|-------------------|---------------------------|
| (1) Clamp | [A] Cartridge Type |
| (2) Fuel Hose | [B] Element Type |
| (3) Air Vent Plug | |
| (4) Fuel Cock | |
| (5) Air Vent Cock | |

[A]



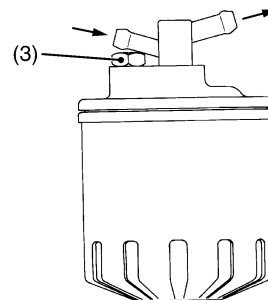
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[B]



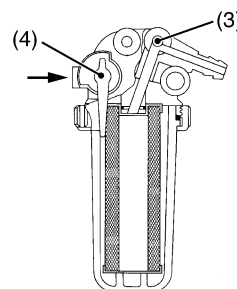
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[A]

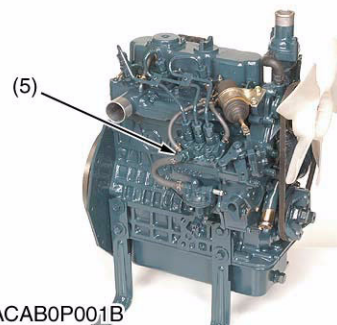


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[B]



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3. CHECK POINTS OF EVERY 100 HOURS

Changing Engine Oil

⚠ CAUTION

- **Be sure to stop engine before changing 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 oil level gauge (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 CD/CE/CF/CF-4/CG-4.**
- **Use the proper SAE Engine Oil according to ambient temperature.**

Above 25°C	SAE30 or SAE10W-30 SAE10W-40
0 to 25°C	SAE20 or SAE10W-30 SAE10W-40
Below 0°C	SAE10W or SAE10W-30 SAE10W-40

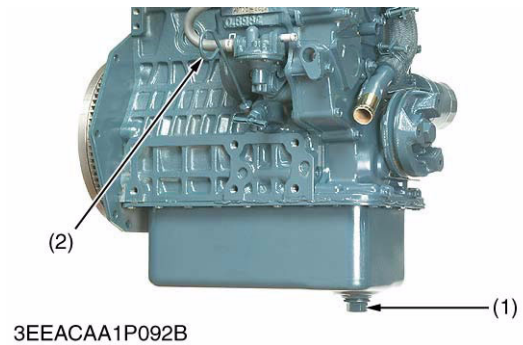
Engine Oil Capacity

(Oil capacities shown are for standard oil pans)

Models	Oil pan depth
	121 mm
3D67E-1A	3.6 ℓ

(1) Drain Plug

(2) Oil level gauge



Checking Fan Belt Tension and Damage

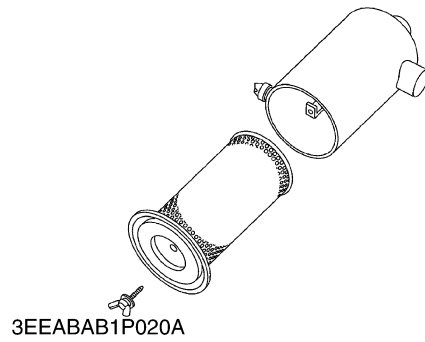
See page S-16.

Cleaning Air Cleaner Element

1. Remove the air cleaner element.
2. Use clean dry compressed air on the inside of the element.
Pressure of compressed air must be under 205 kPa {2.1 kg/cm²}.
Maintain reasonable distance between the nozzle and the filter.

■ **NOTE**

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

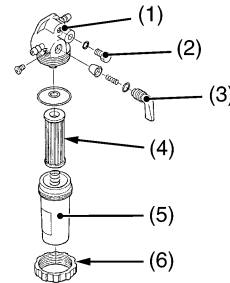


Cleaning Fuel Filter (Element Type only)

1. Close the fuel cock (3).
2. Unscrew the retaining ring (6) and remove the cup (5), and rinse the inside with kerosene.
3. Take out the element (4) and dip it in the kerosene to rinse.
4. After cleaning, reassemble the fuel filter, keeping out dust and dirt.
5. Bleed the fuel system.

■ **IMPORTANT**

- **If dust and dirt enter the fuel, the fuel injection pump and injection nozzle will wear quickly. To prevent this, be sure to clean the fuel filter cup periodically.**



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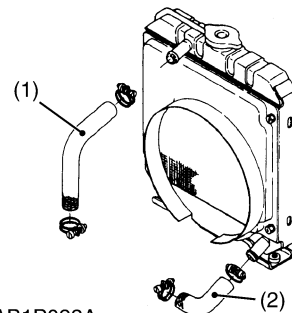
- | | |
|-------------------|--------------------|
| (1) Cock Body | (4) Filter Element |
| (2) Air Vent Plug | (5) Filter Cup |
| (3) Fuel Cock | (6) Retaining Ring |

4. CHECK POINTS OF EVERY 200 HOURS

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 water 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 |
|----------------|----------------|



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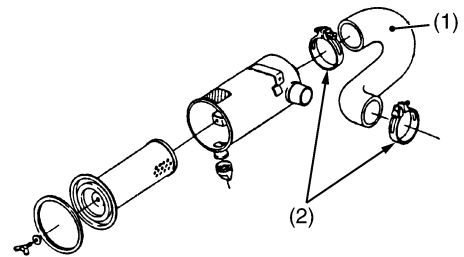
Checking Intake Air Line

1. Check to see if the intake air hose(s) and the breather tube (3) are properly fixed every 200 hours of operation.
2. If the clamp is loose, apply oil to the threads and retighten it securely.
3. The intake air hose(s) and the breather tube are made of rubber and tends to age. It must be changed every two years. Also change the clamp and tighten it securely.

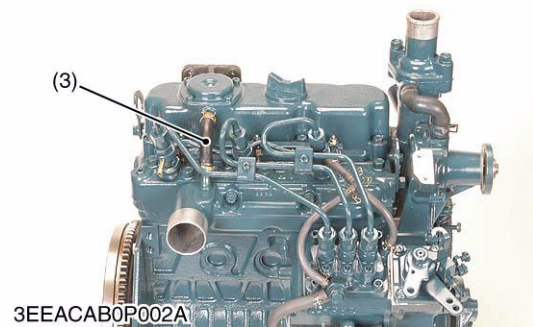
■ **IMPORTANT**

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

- (1) Intake Air Hose (3) Breather Tube
 (2) Clamp



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3EEACAB0P002A

Replacing Oil Filter Cartridge

CAUTION

- **Be sure to stop the engine before replacing filter cartridge.**
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 normally decreases a little. Thus see that the engine oil does not leak through the seal and be sure to read the oil level on the oil level gauge. Then, replenish the engine oil up to the specified level.

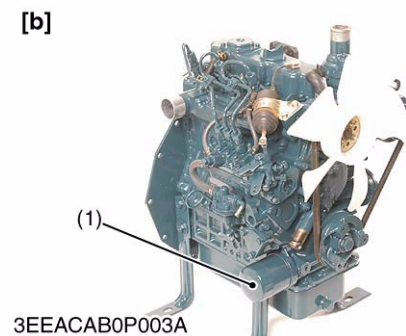
■ **IMPORTANT**

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

- (1) Engine Oil Filter Cartridge
[a] Standard Type [b] One-side Maintenance Type



3EEACAA1P056B



3EEACAB0P003A

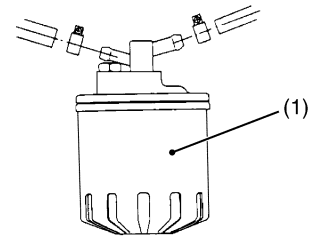
5. CHECK POINTS OF EVERY 400 HOURS

Replacing Fuel Filter Cartridge (Cartridge Type)

Water and dust in fuel are collected in the filter cartridge. So, change the filter cartridge every 400 hours service.

1. Remove the used filter cartridge with filter wrench.
2. Apply a thin film of fuel to the surface of new filter cartridge gasket before screwing on.
3. Then tighten enough by hand.
4. Loosen the air vent plug to let the air out.
5. Start engine and check for fuel leakage.

(1) Fuel Filter Cartridge



3EEACAA1P057B

Replacing Fuel Filter Element (Element Type)

1. Close the fuel cock (3).
2. Unscrew the retaining ring (6) and remove the cup (5), and rinse the inside with kerosene.
3. Replace the filter element (4).
4. Reassemble the fuel filter, keeping out dust and dirt.
5. Bleed the fuel system.

(1) Cock Body

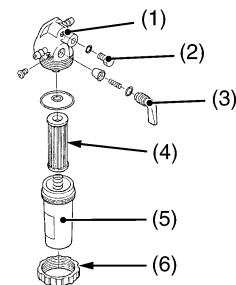
(4) Filter Element

(2) Air Vent Plug

(5) Filter Cup

(3) Fuel Cock

(6) Retaining Ring



3EEABAB1P023A

6. CHECK POINTS OF EVERY 500 HOURS

Cleaning Fuel Tank Inside

Cleaning Water Jacket and Radiator Interior

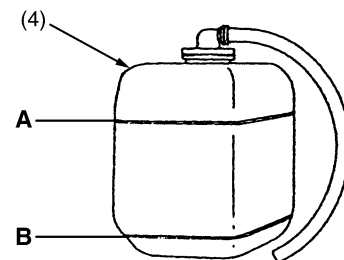
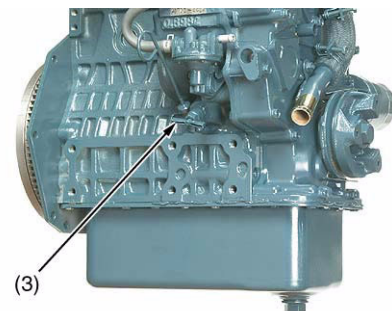
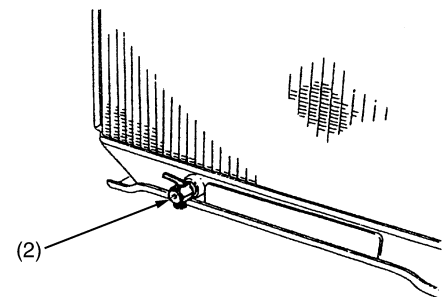
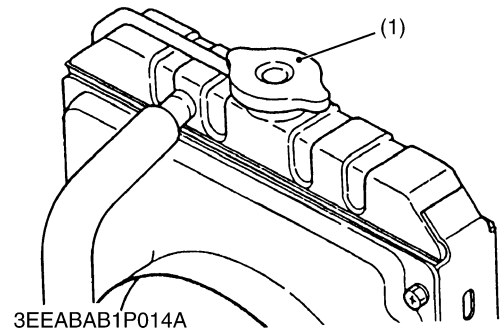
⚠ CAUTION

- **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 cap (1) must be removed to completely drain the coolant. And open the drain cock (3).
 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 radiator and recovery tank (4) and add coolant if necessary.

■ INPORTANT

- **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 | A : Full |
| (2) Drain Plug | B : Low |
| (3) Drain Cock | |
| (4) Recovery Tank | |



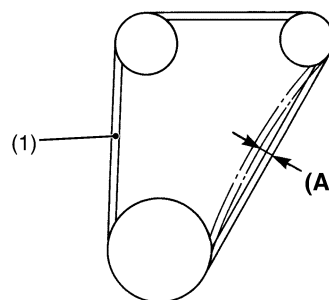
Replacing Fan Belt

1. Remove the alternator.
2. Remove the fan belt (1).
3. Replace new fan belt.
4. Install the alternator.
5. Check the fan belt tension.

Deflection (A)	Factory spec.	7.0 to 9.0 mm / 98 N {10 kg}
-----------------------	---------------	---------------------------------

(1) Fan Belt

(A) Deflection



3EEABAB1P017C

7. CHECK POINTS OF EVERY YEAR OR EVERY SIXTH CLEANINGS OF AIR CLEANER ELEMENT

Replacing Air Cleaner Element

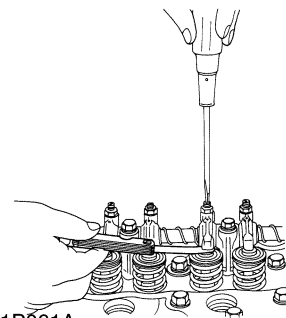
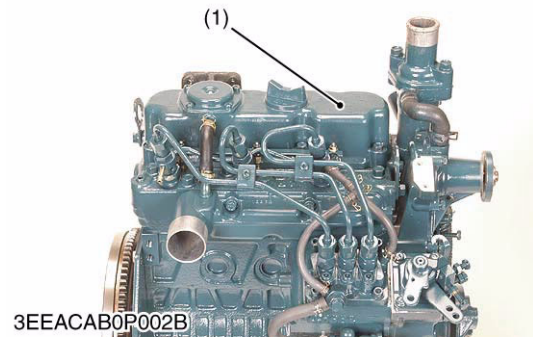
See page G-12.

8. CHECK POINTS OF EVERY 800 HOURS

Checking Valve Clearance

■ IMPORTANT

- **The valve clearance must be checked and adjusted when engine is cold.**
1. Remove the cylinder head cover (1) and the glow plugs.
 2. Align the "1TC" mark (2) on the flywheel and alignment mark (3) 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 thickness gauge.
 4. If the clearance is not within the factory specifications, adjust with the adjusting screw.
 5. Then turn the flywheel 360°, and align the "1TC" mark (2) on the flywheel and alignment mark (3) 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 thickness gauge

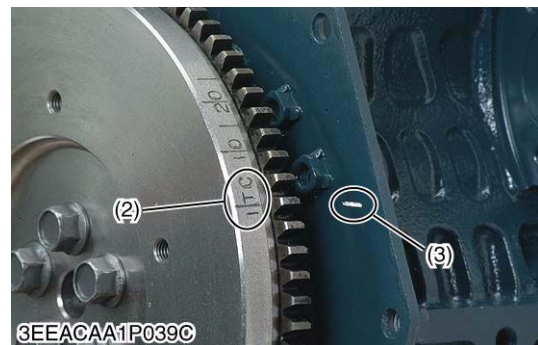


Engine model valve arrangement Adjustable cylinder location of piston	3D67E-1A	
	Intake valve	Exhaust valve
No.1	★	★
No.2	☆	★
No.3	★	☆

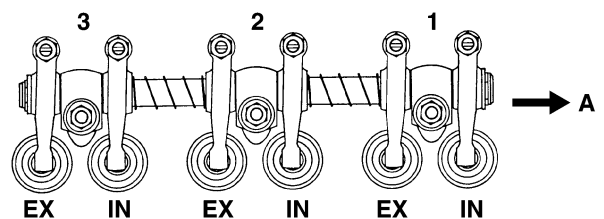
★: When No.1 piston is at the compression top dead center position.

☆: When No.1 piston is at the overlap position.

7. If the clearance is not within the factory specifications, adjust with the adjusting screw.



Intake and exhaust valve clearance (Cold)	Factory spec.	0.145 to 0.185 mm



3EEACAA1P068A

■ 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) Cylinder Head Cover **A: Gear Case Side**
- (2) "1TC" Mark
- (3) Alignment Mark

9. CHECK POINTS OF EVERY 1500 HOURS

Checking Fuel Injection Nozzle Condition

See page S-22, 23.

10. CHECK POINTS OF EVERY 3000 HOURS

Checking Injection Pump

See page S-18, 19, 20, 21.

11. CHECK POINTS OF EVERY 2 YEARS

Replacing Intake Air Line

See page G-13.

Replacing Radiator Hoses and Clamp Bands

See page G-12.

Replacing Fuel Hoses and Clamp Bands

See page G-10.

Changing Radiator Coolant (L.L.C.)

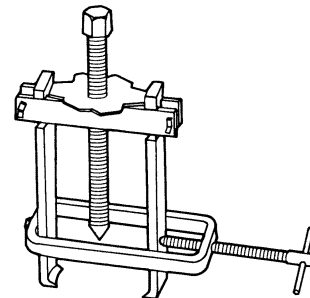
See page G-9, 15.

SPECIAL TOOLS

Special Use Puller Set

Code No: KT07916-09032

Application: Use exclusively for pulling out bearing, gears and other parts with ease.

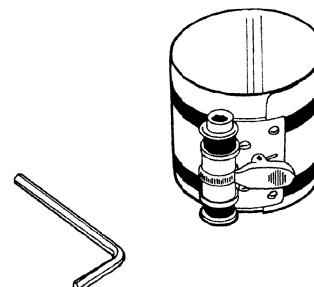


3TMABAB0P049A

Piston Ring Compressor

Code No: KT07909-32111

Application: Use exclusively for pushing in the piston with piston rings into the cylinder.

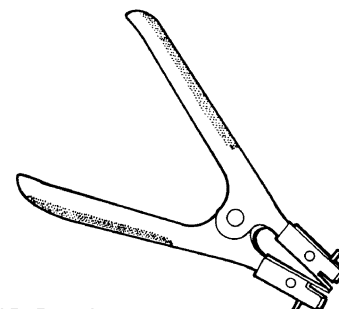


3TMABAB0P050A

Piston Ring Tool

Code No: KT07909-32121

Application: Use exclusively for removing or installing the piston ring with ease.



3TMABAB0P051A

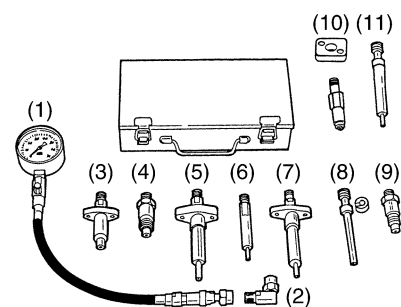
Diesel Engine Compression Tester

KT07909-30208 (Assembly)

KT07909-31251 (G)

Code No: KT07909-30934 (A to F) KT07909-31271 (I)
KT07909-31211 (E and F) KT07909-31281 (J)
KT07909-31231 (H)

Application: Use to measure diesel engine compression and diagnostics of need for major overhaul.



3TMABAB0P052A

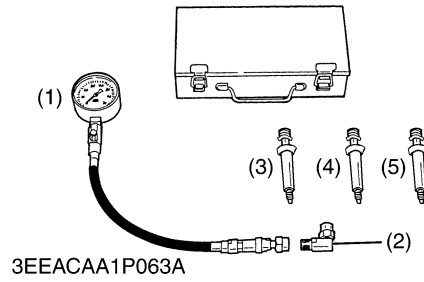
- | | |
|----------------------|-----------------------|
| (1) Gauge | (7) Adaptor F |
| (2) L Joint | (8) Adaptor G |
| (3) Adaptor A | (9) Adaptor H |
| (4) Adaptor B | (10) Adaptor I |
| (5) Adaptor C | (11) Adaptor J |
| (6) Adaptor E | |

Diesel Engine Compression Tester (for Glow Plug)

Code No: KT07909-39081 (Assembly)
 KT07909-31301 (L) KT07909-31291 (K)
 KT07909-31311 (M)

Application: Use to measure diesel engine compression and diagnostics of need for major overhaul.

- (1) Gauge
- (2) L Joint
- (3) Adaptor K
- (4) Adaptor L
- (5) Adaptor M

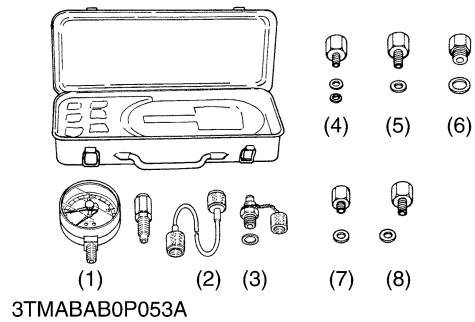


Oil Pressure Tester

Code No: KT07916-32032

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



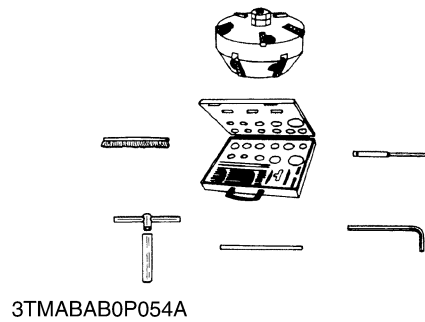
Valve Seat Cutter

Code No: KT07909-33102

Application: Use to reseal valves.

Angle: 45°
 15°

Diameter: 28.6 mm 38.0 mm
 31.6 mm 41.3 mm
 35.0 mm 50.8 mm

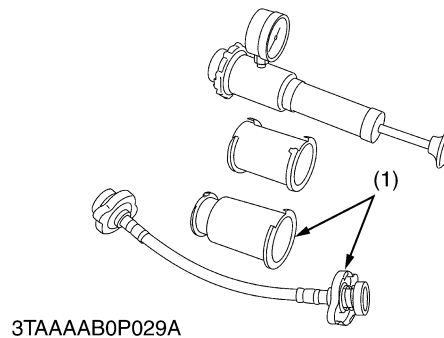


Radiator Tester

Code No: KT07909-31551

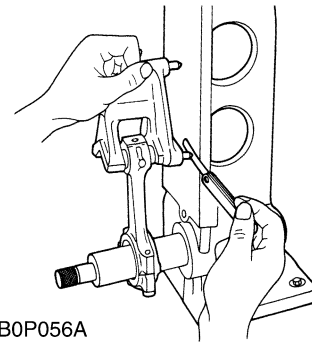
Application: Use to check of radiator cap pressure, and leaks from cooling system.

Remarks: Adaptor (1) BANZAI Code No. RCT-2A-30S.



Connecting Rod Alignment Tool

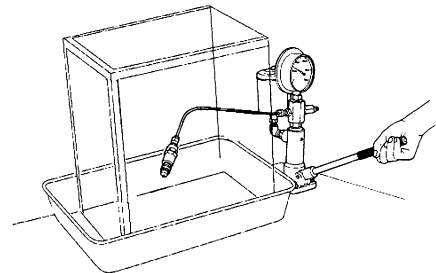
Code No: KT07909-31661
 Application: Use to check the connecting rod alignment.
 Connecting rod big end I.D.
 Applicable range: 30 to 75 mm dia.
 Connecting rod length
 65 to 300 mm



3TMABAB0P056A

Nozzle Tester

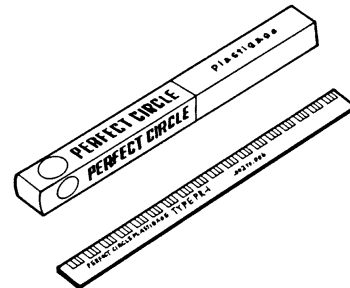
Code No: KT07909-31361
 Application: Use to check the fuel injection pressure and spray pattern of nozzle.
 Measuring range: 0 to 50 MPa {0 to 500 kg/cm²}



3TLABAB1P041A

Plastigage

Code No: KT07909-30241
 Application: Use to check the oil clearance between crankshaft and bearing, etc..
 Measuring range
 Green 0.025 to 0.076 mm
 Red..... 0.051 to 0.152 mm
 Blue 0.102 to 0.229 mm



3TMABAB0P058A

Red Check

Code No: KT07909-31371
 Application: Use to check cracks on cylinder head, cylinder block, etc..

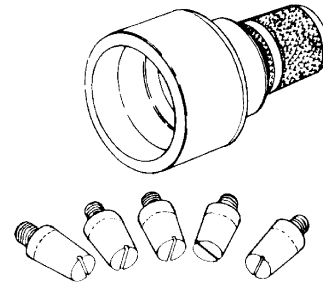


3TMABAB0P059A

Crank Sleeve Setter (for Z482/D662/D722/D782-E2B)

Code No: KT07916-34041

Application: Use to fix the crankshaft sleeve.

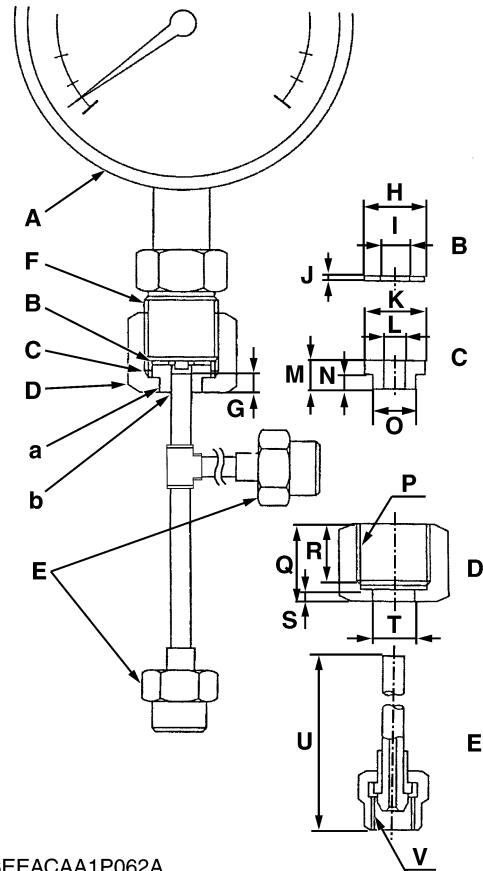


3EEACAB0P004A

Injection Pump Pressure Tester

Application: Use to check fuel tightness of injection pumps.

A	Pressure gauge full scale: More than 29.4 MPa {300 kg/cm ² }
B	Copper gasket
C	Flange (Material : Steel)
D	Hex. nut 27 mm across the plat
E	Retaining nut
F	PF 1/2
G	5 mm
H	17 mm dia.
I	8 mm dia.
J	1.0 mm
K	17 mm dia.
L	6.10 to 6.20 mm dia.
M	8 mm
N	4 mm
O	11.97 to 11.99 mm dia.
P	PF 1/2
Q	23 mm
R	17 mm
S	4 mm
T	12.00 to 12.02 mm dia.
U	100 mm
V	M12 x P1.5
a	Adhesive application
b	Fillet welding on the enter circumference

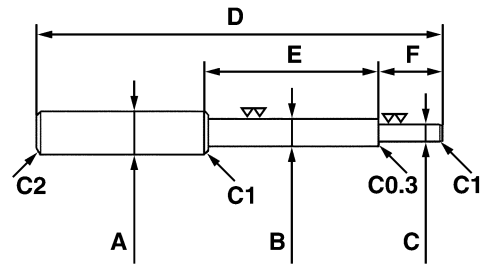


3EEACAA1P062A

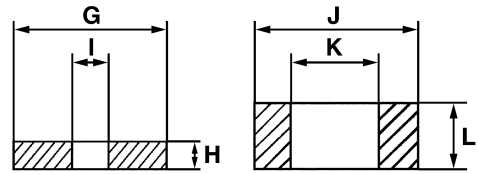
Valve Guide Replacing Tool

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

A	20 mm dia.
B	9.96 to 9.98 mm dia.
C	5.5 to 5.7 mm dia.
D	200 mm
E	80 mm
F	40 mm
G	15 mm
H	5 mm
I	6.0 to 6.1 mm dia.
J	18 mm dia.
K	10.6 to 10.7 mm dia.
L	7 mm
C1	Chamfer 1.0 mm
C2	Chamfer 2.0 mm
C0.3	Chamfer 0.3 mm



3TMABAB0P063A



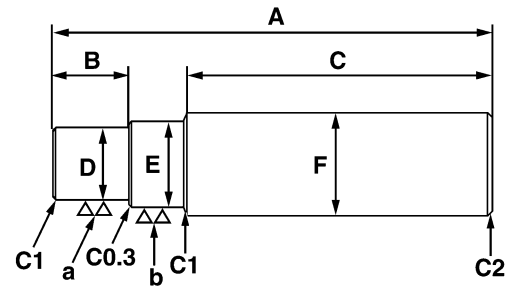
3TMABAB0P064A

Bushing Replacing Tools

Application: Use to press out and to press fit the bushing.

1. For small end bushing

A	145 mm
B	20 mm
C	100 mm
D	19.90 to 19.95 mm
E	21.90 to 21.95 mm dia.
F	25 mm
a	6.3 μm
b	6.3 μm



3EEACAA1P069A

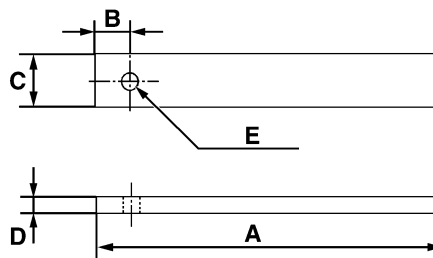
2. For idle gear bushing

A	150 mm
B	20 mm
C	100 mm
D	19.90 to 19.95 mm
E	21.90 to 21.95 mm dia.
F	25 mm
a	6.3 μm
b	6.3 μm

Flywheel Stopper

Application: Use to loosen and tighten the flywheel screw.

A	200 mm
B	20 mm
C	30 mm
D	8 mm
E	10 mm dia.



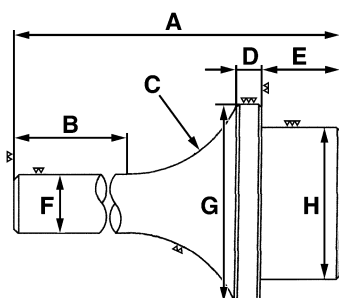
3TMABAB0P067B

Crankshaft Bearing 1 Replacing Tool

Application: Use to press out and press fit the crankshaft bearing 1.

[Press Out]

A	135 mm
B	72 mm
C	40 mm radius
D	10 mm
E	22 mm
F	20 mm dia.
G	47.90 to 47.95 mm dia.
H	43.90 to 43.95 mm dia.



3GFABAB0P041A

[Press Fit]

A	130 mm
B	72 mm
C	40 mm radius
D	9 mm
E	24 mm
F	20 mm dia.
G	68 mm dia.
H	39.90 to 39.95 mm dia.

2. MECHANISM

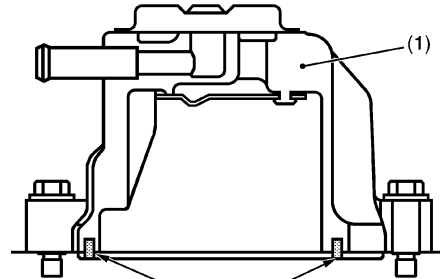
ENGINE BODY	M- 2
1. HALF-FLOATING HEAD COVER	M- 2
2. CLOSED BREATHER	M- 2
3. PISTON	M- 3
4. OIL PAN	M- 3

ENGINE BODY

1. HALF-FLOATING HEAD COVER

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

- (1) Cylinder Head Cover
- (2) Rubber Packing

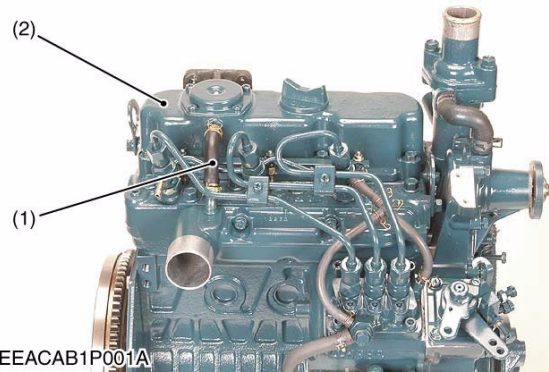


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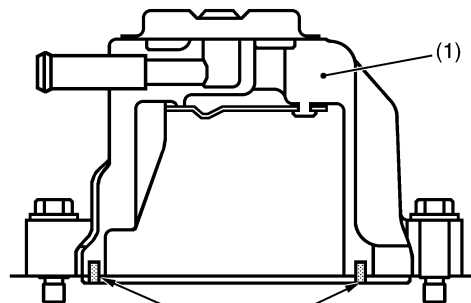
2. CLOSED BREATHER

Closed breather system has been adopted to prevent the release of blowby gas into the atmosphere. After its oil content is filtered by oil shield (4), the blowby gas is fed back to the intake manifold through breather valve (3) to be used for re-combustion.

- (1) Breather Tube
- (2) Cylinder Head Cover
- (3) Breather Valve (PCV)
- (4) Oil Shield
- (5) Rubber Packing



3EEACAB1P001A



EEABAB1P004A

3. PISTON

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

★Molybdenum disulfide (MoS₂)

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



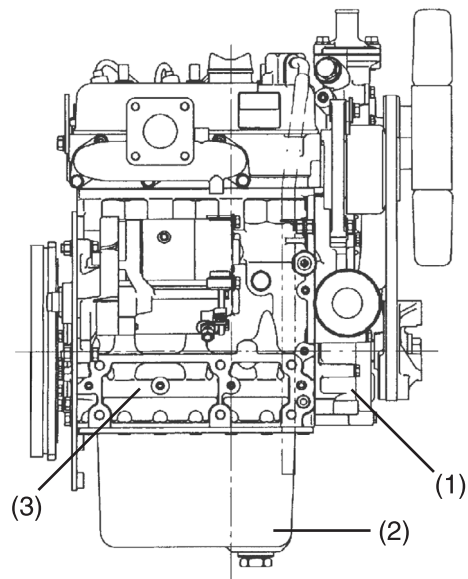
4. OIL PAN

The oil pan is extended 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) Gear Case

(3) Cylinder Block

(2) Oil Pan



3. SERVICING

TROUBLESHOOTING	S- 2
SERVICING SPECIFICATION	S- 6
TIGHTENING TORQUES	S- 11
1. TIGHTENING TORQUES FOR SPECIAL USE SCREWS, BOLTS AND NUTS	S- 11
2. TIGHTENING TORQUES FOR GENERAL USE SCREWS, BOLTS AND NUTS	S- 12
CHECKING, DISASSEMBLING AND SERVICING	S- 13
1. CHECKING AND ADJUSTING	S- 13
2. DISASSEMBLING AND ASSEMBLING	S- 29
3. SERVICING	S- 53

TROUBLESHOOTING

Trouble	Cause	Remedy
Engine does not start	Engine unit	
	• Air leakage to outside (Insufficient compression pressure)	• Replace head gasket • Tighten head bolts, injection nozzles, and glow plugs
	• Internal air leakage (Insufficient compression pressure)	• Check cylinders and piston rings for wear and replace them
	• Defective valve timing (Insufficient compression pressure)	• Check timing gear
	• Defective contact of valve (Insufficient compression pressure)	• Replace valve spring and repair valve seat contact
	• Seized crankshaft, camshaft, piston, or bearing metal	• Repair or replace
	• Increased volume of combustion chamber (Insufficient compression pressure)	• Correct sinking distance of valves
	Fuel system	
	• Fuel tank is empty	• Add fuel
	• Use of viscous fuel	• Use specified fuel
	• Use of fuel of low cetane number	• Use specified fuel
	• Water in fuel	• Use specified fuel
	• Gasoline in fuel	• Use specified fuel
	• Clogged fuel filter	• Replace fuel filter element
	• Fuel leakage through injection pipe nut	• Tighten nut
	• Clogged fuel pipe	• Clean and repair
	• Defective injection pump	• Repair or replace
	• Defective fuel feed pump	• Replace
	• Defective fuel injection timing	• Adjust
	• Defective injection pump	• Repair or replace
	• Removed or broken start spring or governor spring	• Repair or replace
	Electrical system	
	• Insufficient battery capacity or dead battery	• Use battery of specified capacity
	• Over-discharged battery	• Charge or replace
	• Defective starting motor	• Repair or replace
	• Wrong or defective wiring	• Check and repair
	• Defective starting switch	• Check and repair
	• Broken fuse	• Remove cause and replace
	• Malfunctioning or defective engine stop solenoid	• Check and repair or replace

Trouble	Cause	Remedy
Engine does not stop	Fuel system	
	• Removed control rack and fork lever	• Repair
	• Sticking control rack of injection pump	• Repair or replace injection pump
	Electrical system	
	• Wrong or defective wiring	• Check and repair
Engine hunts	Air intake and exhaust systems	
	• Clogged air cleaner	• Clean or replace air cleaner element
	Fuel system	
	• Clogged fuel filter	• Replace filter element
	• Fuel leakage through injection pipe nut	• Tighten nut
	• Defective injection nozzle	• Repair or replace
	• Clogged fuel overflow pipe	• Repair bent part or clean
	• Defective governor spring, start spring, or idle limit spring	• Replace spring
	• Malfunction of governor weight	• Repair
• Defective injection pump	• Repair or replace	
Exhaust gas is white or blue	Engine unit	
	• Worn piston ring, piston, and cylinder	• Replace piston ring and piston and repair cylinder
	• Increased volume of combustion chamber (Insufficient compression pressure)	• Correct sinking distance of valves
	Lubrication system	
	• Too much oil	• Reduce oil level to specified level
	Fuel system	
• Defective fuel injection timing	• Adjust	
Exhaust gas is black or dark gray and output is insufficient	Engine unit	
	• Overload	• Reduce load
	• Air leakage to outside of cylinder	• Tighten head bolts, injection nozzles, and glow plugs
	• Slight seizure of moving parts of engine	• Repair or replace
	Fuel system	
	• Use of low-grade fuel	• Use specified fuel
	• Clogged fuel filter	• Replace filter element
	• Defective fuel injection timing	• Adjust
	• Defective spraying of fuel	• Repair or replace injection nozzle
	• Uneven fuel injection rate	• Repair or replace injection pump
Air intake and exhaust systems		
• Clogged air cleaner	• Clean or replace element	

Trouble	Cause	Remedy
Much oil is consumed	Engine unit	
	• Leakage through tightened parts and plugs	• Tighten to specified torque
	• Defective crankshaft oil seals, O-rings, gaskets, etc.	• Replace
	• Defective valve stem seals	• Replace seals
	• Abutment joints of piston rings are in same direction	• Set abutment joints in opposite directions
	• Worn or sticking O-rings	• Replace
	• Worn piston ring grooves	• Replace pistons and piston rings
Fuel is in oil	Fuel system	
	• Defective injection pump	• Replace pump element or pump assembly
	• Defective fuel feed pump	• Replace
Water is in oil	Engine unit	
	• Broken head gasket	• Replace
	• Cracked crankcase or cylinder head	• Replace
• Broken O-ring or packing in water passage between gear case and crankcase	• Replace	
Oil pressure is low	Lubrication system	
	• Low oil level	• Add oil to specified level
	• Low quality of oil	• Use specified oil
	• Defective relief valve	• Repair or replace
	• Too large oil clearance of each bearing metals	• Check and replace bearing metals, bushings, shaft, etc.
	• Clogged oil passage	• Check and clean
	• Defective oil pump	• Check and replace
• Defective oil hole or plug or omission of fitting of plug	• Check and repair	
Oil pressure is high	Lubrication system	
	• Low oil temperature	• Run engine until oil temperature rises
	• Use of low-quality oil	• Use specified oil
	• Defective relief valve	• Repair or replace

Trouble	Cause	Remedy
Engine overheats	Cooling system	
	• Loosened or broken fan belt	• Adjust or replace
	• Low coolant level	• Add coolant to specified level
	• Clogged radiator net or radiator fins	• Clean
	• Dirty coolant	• Replace coolant
	• Defective radiator or radiator cap	• Check and replace
	• Clogged coolant passage	• Clean
	• Defective route of cooling air	• Secure route of cooling air
	• Defective thermostat	• Replace
	• Defective water pump seal	• Replace
	Engine unit	
	• Continuous overload operation	• Reduce load
	• Broken head gasket (Reduced coolant)	• Replace
	• Insufficient tightening of head bolts	• Tighten to specified torque
	Lubrication system	
• Low oil level	• Add oil to specified level	
Fuel system		
• Use of low-grade fuel	• Use specified fuel	
• Defective fuel injection timing	• Adjust	
Battery is discharged abnormally (Battery is dead)	Electrical system	
	• Loosened fan belt	• Adjust or replace
	• Deteriorated battery	• Replace
	• Low electrolyte level	• Add distilled water and charge
	• Wrong or defective wiring	• Check and repair
• Defective alternator, AC dynamo, or regulator	• Repair or replace	
Glow lamp does not light up	Electrical system	
	• Broken glow lamp	• Replace
	• Wrong or defective wiring	• Check and repair
	• Defective switch	• Replace
• Defective glow lamp timer	• Replace	
Charge lamp does not light up	Electrical system	
	• Wrong or defective wiring	• Check and repair
	• Defective alternator or regulator	• Repair or replace
	• Broken bulb	• Replace
• Broken fuse	• Replace	
Charge lamp does not go off	Electrical system	
	• Loosened or broken fan belt	• Adjust or replace
	• Wrong or defective wiring	• Check and repair
• Defective alternator, AC dynamo, or regulator	• Repair or replace	

SERVICING SPECIFICATION

Item		Factory Specification	Allowable Limit
Valve Clearance (Cold)		0.145 to 0.185 mm	—
Compression Pressure	3D67E-1A	2.84 to 3.24 MPa {29.0 to 33.0 kg/cm ² }	2.26 MPa {23.0kg/cm ² }
	Variance Among Cylinder	—	10 % or less
Top Clearance		0.50 to 0.70 mm	—
Cylinder Head Surface	Flatness	—	0.05 mm
Valve Recessing (Intake and Exhaust)		-0.10 to 0.10 mm	0.30 mm
Valve Stem to Valve Guide	Clearance	0.030 to 0.057 mm	0.10 mm
	Valve Stem (O.D.)	5.968 to 5.980 mm	—
	Valve Guide (I.D.)	6.010 to 6.025 mm	—
Valve Face	Angle	45°	—
Valve Seat	Angle	45°	—
	Width	2.12 mm	—
Valve Spring	Free Length	31.3 to 31.8 mm	28.4 mm
	Tilt	—	1.2 mm
	Setting Load / Setting Length	64.7 N / 27.0 mm {6.6 kg / 27.0 mm}	54.9 N / 27.0 mm {5.6 kg / 27.0 mm}
Rocker Arm Shaft to Rocker Arm	Oil Clearance	0.016 to 0.045 mm	0.15 mm
	Rocker Arm Shaft (O.D.)	10.473 to 10.484 mm	—
	Rocker Arm (I.D.)	10.500 to 10.518 mm	—
Push Rod	Alignment	—	0.25 mm
Tappet to Tappet Guide Bore	Oil Clearance	0.016 to 0.052 mm	0.10 mm
	Tappet (O.D.)	17.966 to 17.984 mm	—
	Tappet Guide Bore (I.D.)	18.000 to 18.018 mm	—
Timing Gear	Crank Gear to Idle Gear (Backlash)	0.043 to 0.124 mm	0.15 mm
	Idle Gear to Cam Gear (Backlash)	0.047 to 0.123 mm	0.15 mm
	Idle Gear to Injection Pump Gear (Backlash)	0.046 to 0.124 mm	0.15 mm
	Crank Gear to Oil Pump Drive Gear (Backlash)	0.041 to 0.123 mm	0.15 mm
Idle Gear	Side Clearance	0.20 to 0.51 mm	0.80 mm
Camshaft	Side Clearance	0.15 to 0.31 mm	0.5 mm
	Alignment	—	0.01 mm
	Cam Height (Intake and Exhaust)	26.88 mm	26.83 mm

Item		Factory Specification	Allowable Limit
Camshaft Journal to Cylinder Block Bore	Oil Clearance	0.050 to 0.091 mm	0.15 mm
	Camshaft Journal (O.D.)	32.934 to 32.950 mm	—
	Cylinder Block Bore (I.D.)	33.000 to 33.025 mm	—
Idle Gear Shaft to Idle Gear Bushing	Oil Clearance	0.020 to 0.084 mm	0.10 mm
	Idle Gear Shaft (O.D.)	19.967 to 19.980 mm	—
	Idle Gear Bushing (I.D.)	20.000 to 20.051 mm	—
Piston Pin Bore	I.D.	20.000 to 20.013 mm	20.05 mm
Piston Pin to Small End Bushing	Oil Clearance	0.014 to 0.038 mm	0.10 mm
	Piston Pin (O.D.)	20.002 to 20.011 mm	—
	Small End Bushing (I.D.)	20.025 to 20.040 mm	—
Piston Pin to Small End Bushing (Spare Parts)	Oil Clearance	0.015 to 0.075 mm	0.15 mm
	Small End Bushing (I.D.)	20.026 to 20.077 mm	—
Piston Ring Gap	Top Ring	0.25 to 0.40 mm	1.25 mm
	Second Ring	0.25 to 0.40 mm	1.25 mm
	Oil Ring	0.15 to 0.30 mm	1.25 mm
Piston Ring to Piston Ring Groove	Clearance	0.090 to 0.120 mm	0.15 mm
	Oil Ring Clearance	0.04 to 0.08 mm	0.15 mm
Connecting Rod	Alignment	—	0.05 mm
Crankshaft	Side Clearance	0.15 to 0.31 mm	0.50 mm
	Alignment	—	0.02 mm
Crankpin to Crankpin Bearing	Oil Clearance	0.020 to 0.051 mm	0.15 mm
	Crankpin (O.D.)	33.959 to 33.975 mm	—
	Crankpin Bearing (I.D.)	33.995 to 34.010 mm	—
Crankshaft Journal to Crankshaft Bearing 1	Oil Clearance	0.034 to 0.106 mm	0.20 mm
	Crankshaft Journal (O.D.)	39.934 to 39.950 mm	—
	Crankshaft Bearing 1 (I.D.)	39.984 to 40.040 mm	—
Crankshaft Journal to Crankshaft Bearing 2 (Flywheel Side)	Oil Clearance	0.028 to 0.059 mm	0.20 mm
	Crankshaft Journal (O.D.)	43.984 to 43.950 mm	—
	Crankshaft Bearing 2 (I.D.)	43.978 to 43.993 mm	—

Item		Factory Specification	Allowable Limit
Crankshaft Journal to Crankshaft Bearing 3 (Intermediate)	Oil Clearance	0.028 to 0.059 mm	0.20 mm
	Crankshaft Journal (O.D.)	39.934 to 39.950 mm	—
	Crankshaft Bearing 3 (I.D.)	39.978 to 39.993 mm	
Cylinder Liner [Standard]	I.D.	67.000 to 67.019 mm	67.169 mm
Cylinder Liner Oversize : 0.25 mm	I.D.	67.250 to 67.269 mm	67.419 mm

LUBRICATING SYSTEM

Item		Factory Specification	Allowable Limit
Engine Oil Pressure	At Idle Speed	Min. 49 kPa {0.5 kg/cm ² }	—
	At Rated Speed	196 to 441 kPa {2.0 to 4.5 kg/cm ² }	147 kPa {1.5 kg/cm ² }
Inner Rotor to Outer Rotor	Clearance	0.03 to 0.14 mm	
Outer Rotor to Pump Body	Clearance	0.07 to 0.15 mm	
Inner Rotor to Cover	Clearance	0.075 to 0.135 mm	

COOLING SYSTEM

Item		Factory Specification	Allowable Limit
Fan Belt	Tension	7.0 to 9.0 mm / 98 N {10 kg}	—
Thermostat	Valve Opening Temperature (At Beginning)	69.5 to 72.5°C	—
	Valve Opening Temperature (Opened Completely)	85°C	—
Radiator Cap	Pressure Falling Time	10 seconds or more 88 → 59 kPa {0.9 → 0.6 kg/cm ² }	—
Radiator	Weak Leakage Test Pressure	No leak at specified pressure 157 kPa {1.6 kg/cm ² }	—

FUEL SYSTEM

Item		Factory Specification	Allowable Limit
Injection Pump	3D67E-1A (3200 rpm) (Injection Timing)	16 to 18° before T.D.C.	
Pump Element	Fuel Tightness	—	13.73 MPa {140 kg/cm ² }
Delivery Valve	Fuel Tightness	10 seconds 13.73 → 12.75 MPa {140 → 130 kg/cm ² }	5 seconds 13.73 → 12.75 MPa {140 → 130 kg/cm ² }
Fuel Injection Nozzle	Injection Pressure	13.73 to 14.71 MPa {140 to 150 kg/cm ² }	—
	Valve Seat Tightness	No leak at specified pressure 12.75 MPa {130 kg/cm ² }	—

ELECTRICAL SYSTEM

Item		Factory Specification	Allowable Limit
Glow Plug	Resistance	Approx. 0.9 Ω	—
Starting motor	Electromagnetic Drive Type (Commutator) (O.D.)	28.0 mm	27.0 mm
	Planetary Gear Reduction Type (Commutator) (O.D.)	30.0 mm	29.0 mm
	Electromagnetic Drive Type (Difference of O.D.'s)	Max. 0.05 mm	0.4 mm
	Planetary Gear Reduction Type (Difference of O.D.'s)	Max. 0.02 mm	0.05 mm
	Mica Undercut	0.50 to 0.80 mm	0.20 mm
	Electromagnetic Drive Type (Brush Length)	16.0 mm	10.5 mm
	Planetary Gear Reduction Type (Brush Length)	14.0 mm	9.0 mm
Dynamo	No-load Output	AC20V or more at 5200 rpm	—
	Regulating Voltage	14 to 15 V at 5200 rpm	—
Alternator	Stator Resistance	Max. 1.0 Ω	—
	Rotor Resistance	2.9 Ω	—
	Slip Ring O.D.	14.4 mm	14.0 mm
	Brush Length	10.0 mm	1.5 mm

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.

1. 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 x Pitch means that the screw, bolt or nut dimension stands for metric. The size is the nominal outside diameter in mm of the threads. The pitch is the nominal distance in mm between two threads.

Item	Size x Pitch	Nm	kgm
*Cylinder head cover screw	M6 x 1	6.86 to 11.3	0.7 to 1.15
Injection pipe retaining nut	M12 x 1.5	24.5 to 34.3	2.5 to 3.5
Overflow pipe retaining nut	M12 x 1.5	19.6 to 24.5	2.0 to 2.5
Nozzle holder assembly	M20 x 1.5	49.0 to 68.6	5.0 to 7.0
Glow plug	M8 x 1	7.85 to 14.7	0.8 to 1.5
*Rocker arm bracket screw	M6 x 1	9.8 to 11.3	1.00 to 1.15
*Cylinder head screw	M8 x 1.25	37.3 to 42.2	3.8 to 4.3
*Fan drive pulley screw	M12 x 1.5	98.1 to 107.9	10.0 to 11.0
*Idle gear shaft mounting screw	M6 x 1	9.8 to 11.3	1.00 to 1.15
*Connecting rod screw	M7 x 0.75	26.5 to 30.4	2.7 to 3.1
*Flywheel screw	M10 x 1.25	53.9 to 58.8	5.5 to 6.0
Bearing case cover mounting screw	M6 x 1	9.8 to 11.3	1.00 to 1.15
*Main bearing case screw 2	M7 x 1	26.5 to 30.4	2.7 to 3.1
*Main bearing case screw 1	M6 x 1	12.7 to 15.7	1.3 to 1.6
Nozzle holder	—	34.3 to 39.2	3.5 to 4.0
Oil pressure switch	PT 1/8	14.7 to 19.6	1.5 to 2.0
Starting motor (C terminal nut)	—	5.9 to 11.8	0.6 to 1.2

2. TIGHTENING TORQUES FOR GENERAL USE SCREWS, BOLTS AND NUTS

When the tightening torques are not specified, tighten the screws, bolts and nuts according to the table below.

Nominal Diameter	Grade Unit	Standard Screw and Bolt 4		Special Screw and Bolt 7	
		Nm	kgm	Nm	kgm
M6		7.9 to 9.3	0.80 to 0.95	9.8 to 11.3	1.00 to 1.15
M8		17.7 to 20.6	1.8 to 2.1	23.5 to 27.5	2.4 to 2.8
M10		39.2 to 45.1	4.0 to 4.6	48.1 to 55.9	4.9 to 5.7
M12		62.8 to 72.6	6.4 to 7.4	77.5 to 90.2	7.9 to 9.2

Screw and bolt material grades are shown by numbers punched on the screw and bolt heads. Prior to tightening, be sure to check out the numbers as shown below.

Punched number	Screw and bolt material grade
None or 4	Standard screw and bolt SS41, S20C
7	Special screw and bolt S43C, S48C (Refined)

CHECKING, DISASSEMBLING AND SERVICING

1. CHECKING AND ADJUSTING

1) Engine Body

Compression Pressure

1. Run the engine until it is warmed up.
2. Stop the engine.
3. **[a] Nozzle Hole Adaptor Setting:**
Remove the air cleaner, the muffler and all injection nozzles.
[b] Glow Plug Hole Adaptor Setting :
Remove the air cleaner, the muffler, the breather tube, the head cover and all glow plugs.
4. **[a] Nozzle Hole Adaptor Setting:**
Set a compression tester (Code No. KT07909-30208) with the adaptor (Adaptor H, code No. KT07909-31231) to the nozzle hole.
[b] Glow Plug Hole Adaptor Setting:
Set a compression tester (Code No. KT07909-30208) with the adaptor (Adaptor L, code No. KT07909-31301) to the glow plug hole.
5. After making sure that the stop lever is set at the stop position (non-injection), run the engine with the starting motor and measure the 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 nozzle hole or the glow 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 %.

Compression pressure	Factory spec.	2.84 to 3.24 MPa {29 to 33 kg/cm ² }
	Allowable limit	2.26 MPa {23 kg/cm ² }

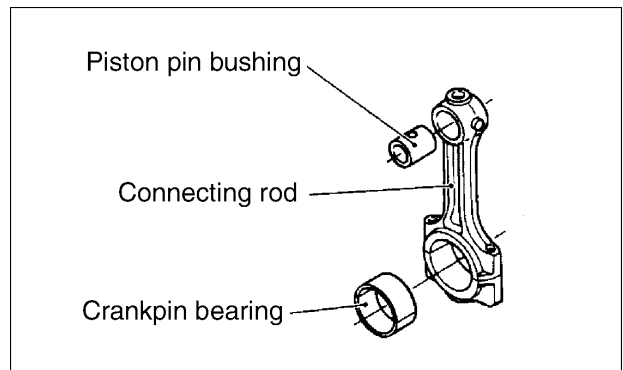
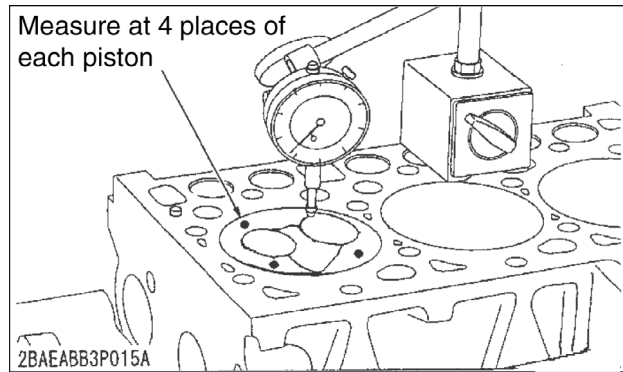
[a] Nozzle Hole Adaptor Setting

[b] Glow Plug Hole Adaptor Setting

Top clearance

- Measure the top clearance by measuring the projection of the piston to check that the specified compression ratio is maintained.
1. Remove the cylinder head and head gasket.
 2. Clean the crankcase surface and install a dial gauge.
 3. Set the measured piston to the top dead center and lightly hit its top with a plastic hammer to lower it by the oil clearance, and then measure its projection.
 4. Measure at 4 places of each piston and obtain the average.
 5. If the projection of the piston is out of the standard range, check the oil clearance of the crank pin and piston pin, and then replace the crank pin bearing metal and piston pin bushing if necessary.

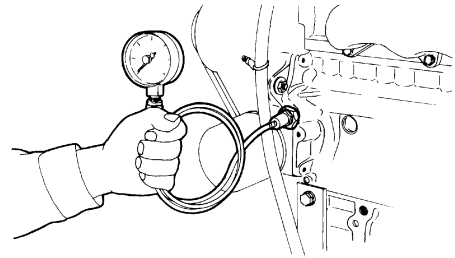
Top clearance	Standard value	0.50 to 0.70 mm
Projection of piston	Standard value	0.40 to 0.60 mm
Thickness of gasket	Standard value	1.10 mm



2) Lubricating System

Engine Oil Pressure

1. Remove the engine oil pressure switch, and set an oil pressure tester (Code No.: KT07916-32032).
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 defective
 - Oil strainer clogged
 - Oil filter cartridge clogged
 - Oil gallery clogged
 - Excessive oil clearance
 - Foreign matter in the relief valve



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Engine oil pressure	At idle speed	Factory spec.	Min. 49 kPa {0.5 kg/cm ² }
	At rated speed	Factory spec.	196 to 441 kPa {2.0 to 4.5 kg/cm ² }
		Allowable limit	147 kPa {1.5 kg/cm ² }

(When reassembling)

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

Tightening torque	Oil pressure switch	14.7 to 19.6 Nm {1.5 to 2.0 kgm}
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Relief Valve

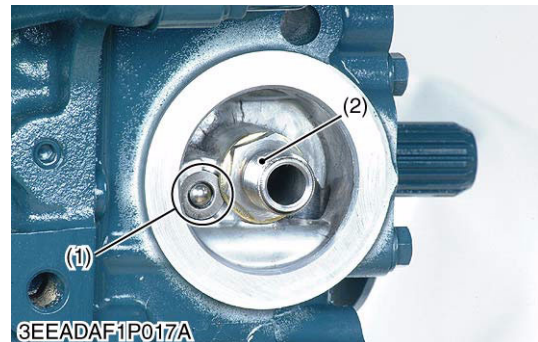
1. Remove the oil filter base.
2. Check the relief valve for dirt, and the seat and ball for damage.
3. If damaged, replace.
4. Check the free length of spring.
5. If less than the allowable limit, replace.

Spring free length	Factory spec.	32 mm
	Allowable limit	28 mm

Tightening torque	Joint	39.2 to 49.0 Nm {4.0 to 5.0 kgm}
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(1) Relief Valve

(2) Joint



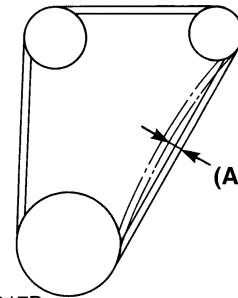
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3) Cooling System

Fan Belt Tension

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

Deflection (A)	Factory spec.	7.0 to 9.0 mm
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Fan Belt Damage and Wear

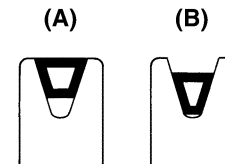
1. Check the fan belt for damage.
2. If the fan belt is damaged, replace it.
3. Check if the fan belt is worn and sunk in the pulley groove.
4. If the fan belt is nearly worn out and deeply sunk in the pulley groove, replace it.

(A) Good

(B) Bad



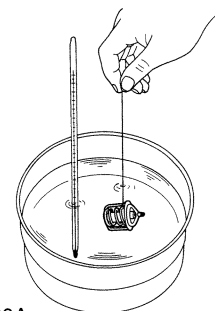
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Thermostat Valve Opening Temperature

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.
4. If the measurement is not within the factory specifications, replace the thermostat.



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Thermostat's valve opening temperature	Factory spec.	69.5 to 72.5°C
Temperature at which thermostat completely opens	Factory spec.	85°C

CAUTION

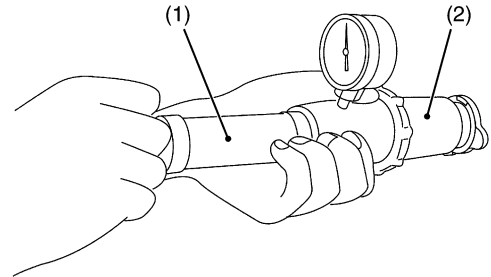
- When removing the radiator cap, wait at least ten minutes after the engine has stopped and cooled down. Otherwise, hot water may gush out, scalding nearby people.

Radiator Cap Air Leakage

1. Set a radiator tester (1) and adaptor (2) (BANZAI Code No.: RCT-2A-30S) on the radiator cap.
2. Apply the specified pressure (88 kPa {0.9 kg/cm²}), and measure the time for the pressure to fall to 59 kPa {0.6 kg/cm²}.
3. If the measurement is less than the factory specification, replace the radiator cap.

Pressure falling time	Factory spec.	More than 10 seconds for pressure fall from 88 to 59 kPa {from 0.9 to 0.6 kg/cm ² }
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(1) Radiator Tester (2) Adaptor



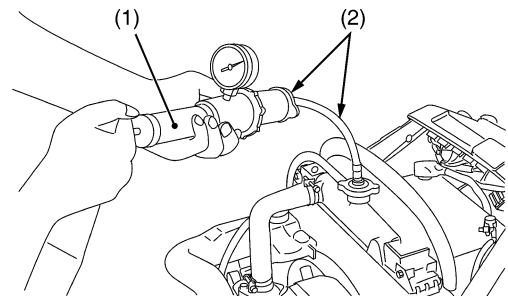
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Radiator Water Leakage

1. Pour a specified amount of water into the radiator.
2. Set a radiator tester (1) (Code No. KT07909-31551) and an adaptor (2) (BANZAI Code No.: RCT-2A-30S) 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 spec.	157 kPa {1.6 kg/cm ² }
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(1) Radiator Tester (2) Adaptor

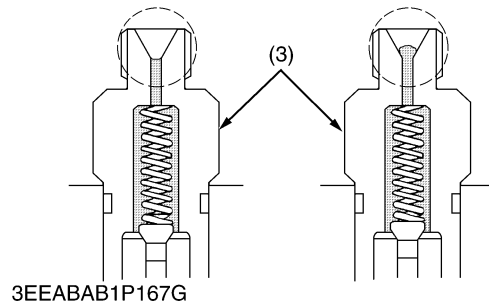
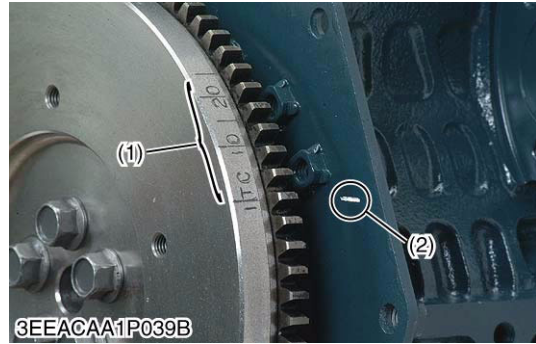


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4) Fuel System

Injection Timing

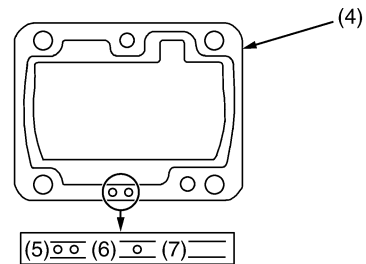
1. Remove the injection pipes.
2. Remove the engine stop solenoid.
3. Turn the flywheel counterclockwise (viewed from flywheel side) until the fuel fills up to the hole of the delivery valve holder (3) for No.1 cylinder.
4. After the fuel fills up to the hole of the delivery valve holder for No.1 cylinder, turn back (clockwise) the flywheel around 90°.
5. Turn the flywheel counterclockwise to set at around 25° before T.D.C..
6. Slowly turn the flywheel counterclockwise and stop turning when the fuel begins to come up, to get the present injection timing.
7. Check to see the degree on flywheel. The flywheel has mark "1TC", "10", and "20" for the crank angle before the top dead center of No.1 cylinder.
8. Check to see if the timing angle lines on the flywheel is aligned with the alignment mark (2).
9. If the injection timing is out of adjustment, readjust the timing with shims.



3D67E-1A (3200 rpm spec.)

Injection timing	Factory spec.	16 to 18° before T.D.C.
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- | | |
|----------------------------------|---------------------------|
| (1) Timing Line | (5) Two-holes: 0.20 mm |
| (2) Alignment Mark | |
| (3) Delivery Valve Holder | (6) One-hole: 0.25 mm |
| (4) Shim(Soft Metal Gasket Shim) | (7) Without hole: 0.30 mm |



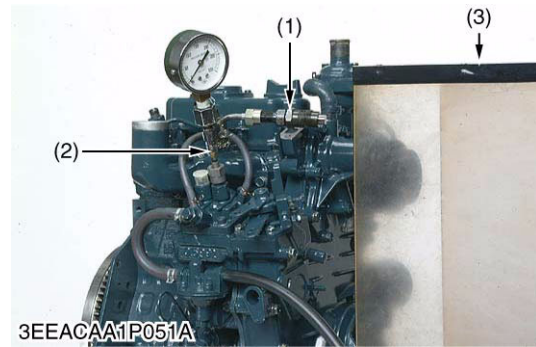
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Injection Timing (Continue)■ **NOTE**

- The sealant is applied to both sides of the shim (soft metal gasket shim). The liquid gasket is not required for assembling.
- Shims are available in thickness of 0.20 mm , 0.25 mm and 0.30 mm. Combine these shims for adjustments.
- Addition or reduction of shim (0.05 mm) delays or advances the injection timing by approx.0.5°.
- In disassembling and replacing the injection pump, be sure to use the same number of new shims with the same thickness.
- Refer to figure below to check the thickness of the shims.
- The injection timing might be changed by the application.

Fuel Tightness of Pump Element

1. Remove the engine stop solenoid.
2. Remove the injection pipes and glow plugs.
3. Install the injection pump pressure tester to the injection pump.
4. Install the injection nozzle (1) jetted with the proper injection pressure to the injection pump pressure tester (2). (Refer to the photo.)
5. Set the speed control lever to the maximum speed position.
6. Run the starting motor to increase the pressure.
7. If the pressure can not reach the allowable limit, replace the pump with new one.



Fuel tightness of pump element	Allowable limit	13.73 MPa {140 kg/cm ² }
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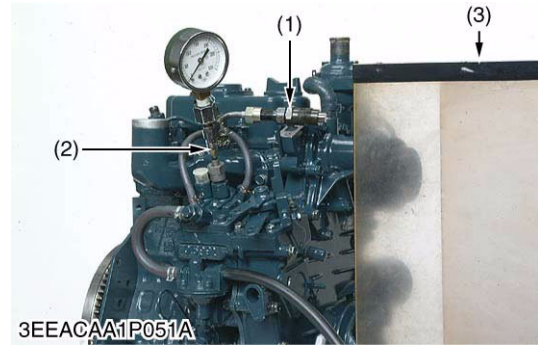
■ NOTE

- **Never try to disassemble the injection pump assembly. For repairs, please contact your Komatsu distributor.**

- | | |
|------------------------------------|----------------------|
| (1) Injection Nozzle | (3) Protection Cover |
| (2) Injection Pump Pressure Tester | for Jetted Fuel |

Fuel Tightness of Delivery Valve

1. Remove the engine stop solenoid.
2. Remove the injection pipes and glow plugs.
3. Set a pressure tester to the fuel injection pump.
4. Install the injection nozzle (1) jetted with the proper injection pressure to the injection pump pressure tester (2).
5. Run the starting motor to increase the pressure.
6. Stop the starting motor when the fuel jets from the injection nozzle.
After that, turn the flywheel by the hand and raise the pressure to approx. 13.73 MPa {140 kg/cm²}.
7. Now turn the flywheel back about half a turn (to keep the plunger free). Maintain the flywheel at this position and clock the time taken for the pressure to drop from 13.73 to 12.75 MPa {from 140 to 130 kg/cm²}.
8. Measure the time needed to decrease the pressure from 13.73 to 12.75 MPa {from 140 to 130 kg/cm²}.
9. If the measurement is less than allowable limit, replace the pump with new one.



Fuel tightness of delivery valve	Factory spec.	10 seconds 13.73 → 12.75 MPa {140 → 130 kg/cm ² }
	Allowable limit	5 seconds 13.73 → 12.75 MPa {140 → 130 kg/cm ² }

■ NOTE

- **Never try to disassemble the injection pump assembly. For repairs, please contact your Komatsu distributor.**

- | | |
|------------------------------------|--------------------------------------|
| (1) Injection Nozzle | (3) Protection Cover for Jetted Fuel |
| (2) Injection Pump Pressure Tester | |

⚠ CAUTION

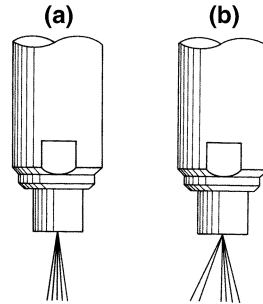
- Check the injection pressure and condition after confirming that there is nobody standing in the direction the fume goes.
- If the fume from the nozzle directly contacts the human body, cells may be destroyed and blood poisoning may be caused.

Nozzle Spraying Condition

1. Set the injection nozzle to a nozzle tester (Code No. KT07909-31361), and check the nozzle spraying condition.
2. If the spraying condition is defective, replace the nozzle piece.

(a) Good

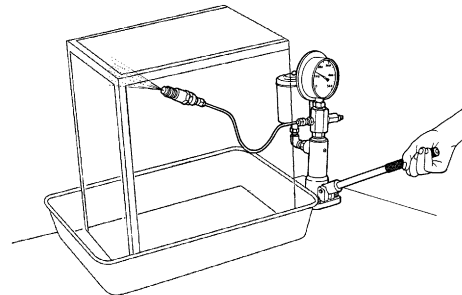
(b) Bad



3EEABAB1P037A

Fuel Injection Pressure

1. Set the injection nozzle to a nozzle tester (Code No. KT07909-31361).
2. Slowly move the tester handle to measure the pressure at which fuel begins jetting out from the nozzle.
3. If the measurement is not within the factory specifications, replace the adjusting washer (1) in the nozzle holder to adjust it.

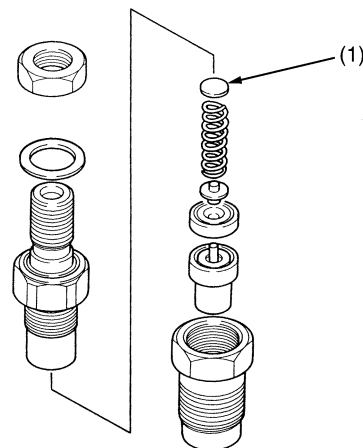


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Fuel injection pressure	Factory spec.	13.73 to 14.71 MPa {140 to 150 kg/cm ² }
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(Reference)

- Pressure variation with 0.01 mm difference of adjusting washer thickness.
Approx. 235 kPa {2.4 kg/cm²}
- (1) Adjusting Washer

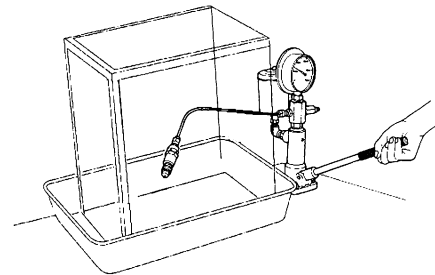


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Valve Seat Tightness

1. Set the injection nozzle to a nozzle tester (Code No. KT07909-31361).
2. Raise the fuel pressure, and keep at 12.75 MPa {130 kg/cm²} for 10 seconds.
3. If any fuel leak is found, replace the nozzle piece.

Valve seat tightness	Factory spec.	No fuel leak at 12.75 MPa {130 kg/cm ² }
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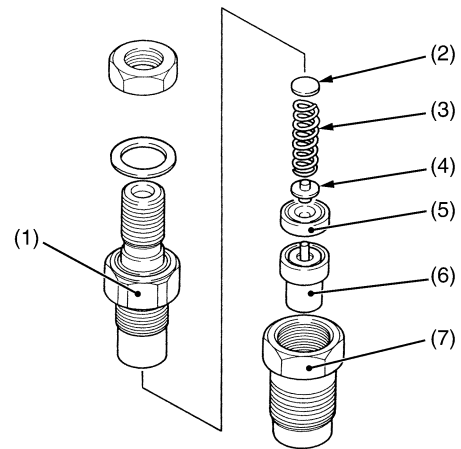
Nozzle Holder

1. Secure the nozzle retaining nut (7) with a vise.
2. Remove the nozzle holder (1), and take out parts inside.

(When reassembling)

- Assemble the nozzle in clean fuel oil.
- Install the push rod (4), noting its direction.
- After assembling the nozzle, be sure to adjust the fuel injection pressure.

Tightening torque	Nozzle holder	34.3 to 39.2 Nm {3.5 to 4.0 kgm}
	Overflow pipe nut	19.6 to 24.5 Nm {2.0 to 2.5 kgm}
	Nozzle holder assembly	49.0 to 68.6 Nm {5.0 to 7.0 kgm}



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- | | |
|----------------------|--------------------------|
| (1) Nozzle Holder | (5) Distance Piece |
| (2) Adjusting Washer | (6) Nozzle Piece |
| (3) Nozzle Spring | (7) Nozzle Retaining Nut |
| (4) Push Rod | |

5) Electrical System

⚠ CAUTION

- To avoid accidental short circuit, be sure to attach the positive cable to the positive terminal before the negative cable is attached to the negative terminal.
- Never remove the battery cap while the engine is running.
- Keep electrolyte away from eyes, hands and clothes. If you are splattered with it, wash it away completely with water immediately.
- Keep open sparks and flames away from the battery at all times. Hydrogen gas mixed with oxygen becomes very explosive.

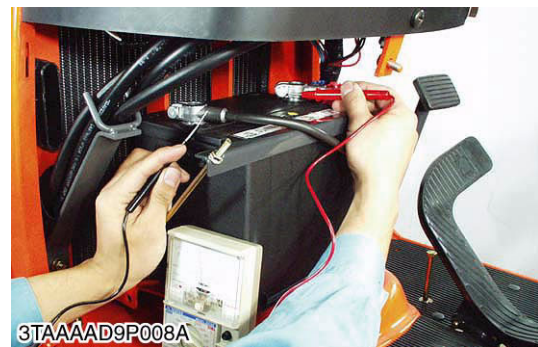
■ IMPORTANT

- If the machine is to be operated for a short time without battery (using a slave battery for starting), use additional current (lights) while engine is running and insulate terminal of battery. If this advice is disregarded, damage to alternator and regulator may result.
- Insulate terminal of battery. If this advice is disregarded, damage to alternator and regulator may result.

Battery Voltage

1. Stop the engine and turn the main switch off.
2. Connect the COM (-) lead of the voltmeter to the battery's negative terminal post and the (+) lead to the positive terminal post, and measure the battery voltage.
3. If the battery voltage is less than the factory specification, check the battery specific gravity and recharge the battery.

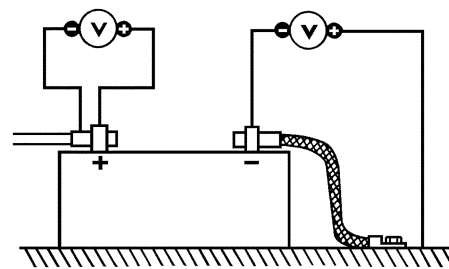
Battery voltage	Factory spec.	Min. 12 V
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Battery Terminal Connection

1. Turn the main switch on, and turn on the head light or all accessories.
2. Measure the voltage with a voltmeter across the battery's positive terminal post and the cable terminal, and the voltage across the battery's negative terminal post and the chassis.
3. If the measurement exceeds the factory specification, clean the battery terminal posts and cable clamps, and tighten them firmly.

Potential difference	Factory spec.	Max. 0.1 V
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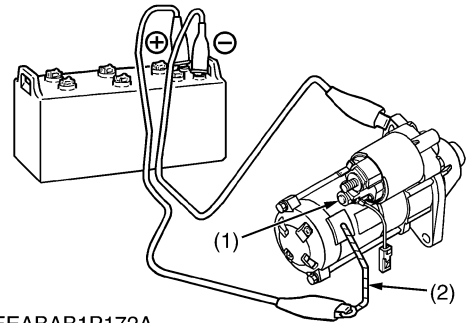


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Starting Motor Test**⚠ CAUTION**

- **Secure the starting motor 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 and the leads from the starting motor.
 3. Remove the starting motor from the engine.
 4. Disconnect the connecting lead (2) from the starting motor C terminal (1).
 5. Connect a jumper lead from the connecting lead (2) to the battery positive terminal post.
 6. Connect a jumper lead momentarily between the starting motor housing and the battery negative terminal post.
 7. If the motor does not run, check the motor.

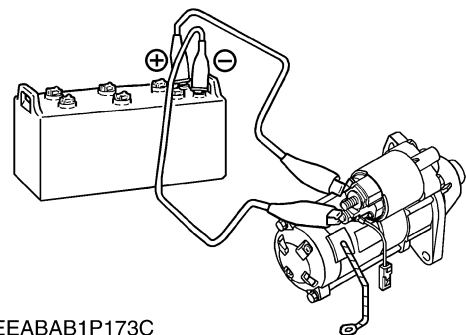
(1) C Terminal (2) Connecting Lead



3EEABAB1P172A

Starter Magnet Switch Test (Pull-in, Holding Coils)**■ NOTE**

- **Prepare a 6 V battery for the test, and each test should be carried out for 3 to 5 seconds.**
- 1) Checking Pull-in Coil**
 1. Connect jumper lead from the battery's negative terminal post to the C terminal.
 2. The plunger should be attracted strongly when a jumper lead is connected from the battery positive terminal to the S terminal.
 - 2) Checking Holding Coil**
 1. Connect jumper leads from the battery's negative terminal post to the body and the battery's positive terminal post to the S terminal.
 2. Push the plunger in by hand and release it. Then, the plunger should remain being attracted.

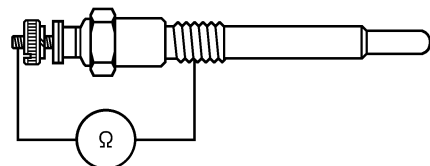


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Glow Plug Continuity

1. Disconnect the lead from the glow plugs.
2. Measure the resistance with an ohmmeter between the glow plug terminal and the chassis.
3. If 0 Ω is indicated, the screw at the tip of the glow plug and the housing are short-circuited.
4. If the factory specification is not indicated, the glow plug is faulty.

Glow plug resistance	Factory spec.	Approx. 0.9 Ω
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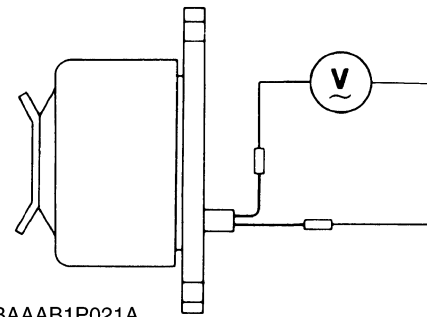


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No-load Dynamo Output

1. Disconnect the lead wires from the dynamo.
2. Start the engine and operate the dynamo at the specified speed.
3. Measure the output voltage with a volt meter.
If the measurement is not within the specified values, replace the dynamo.

No-load output	Factory spec.	AC 20 V or more at 5200 rpm
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Continuity across Regulator's Terminals

1. Measure with a circuit tester according to the list below.

■ NOTE

- For this test, use only Analog Meter and do not use a high voltage tester such as a M Ω meter.
- This check sheet shows the results of the test conducted by using Analog Meter.
- Use of other testers than those above may show different measured results. Ω shall be used as the unit for the measuring range.
- The judgement should be as below table.
- "ON" if the indicator moves, otherwise "OFF".

■ Check Table (★: ON, ☆: OFF)

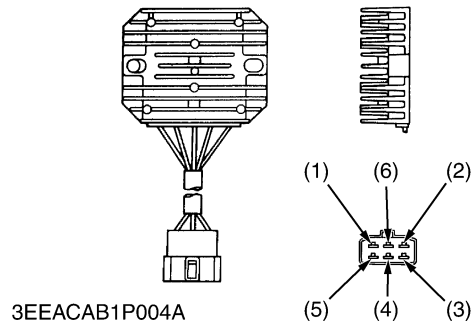
Tester + terminal	Tester - terminal	Code colors					
		Blue	Blue	Red	Yellow	Green	Black
Cord colors	Blue		☆	★	☆	☆	☆
	Blue	☆		★	☆	☆	☆
	Red	☆	☆		☆	☆	☆
	Yellow	★	★	★		☆	★
	Green	☆	☆	☆	☆		☆
	Black	☆	☆	☆	☆	☆	

- | | |
|----------|------------|
| (1) Blue | (4) Yellow |
| (2) Blue | (5) Green |
| (3) Red | (6) Black |

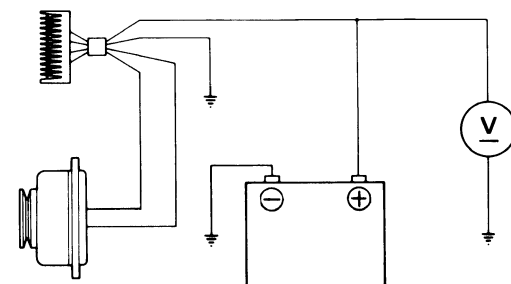
Regulating Voltage

1. Complete the charging circuit with a fully charged battery and operate the dynamo at the specified speed.
2. Measure the battery voltage with a volt meter.
3. If the measurement is not within the specified values, replace the regulator.

Regulating voltage	Factory spec.	14 to 15 V at 5200 rpm
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3EBAAAB1P022A

Alternator on Unit Test

- 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.

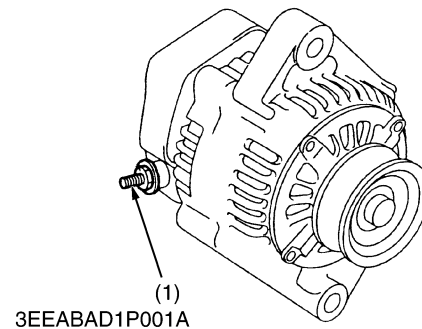
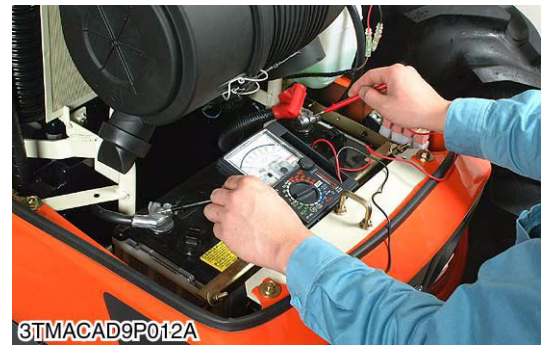
■ **NOTE**

- **Be careful not to touch the rotating engine parts while engine is running. Keep safety distance from the engine rotating parts.**
 1. Start the engine.
 2. Increase the engine speed to the rated speed and check the battery terminal voltage between + and – at no load.
 3. Turn on the all accessories (lights, heater, and so on) if without any accessory, temporally put an electrical load, and check the output current at the cable connected with alternator terminal **B**.
 4. 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 spec.	13.8 to 14.8 V at 25°C
Output current	Factory spec.	Approx. 30 A at 25°C

*The output of alternator might be different depending on OEM engine model.

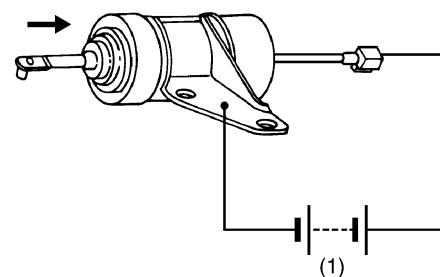
(1) Alternator Terminal **B**



Engine Stop Solenoid Test (Energize to Stop Type)

1. Disconnect the **1P** connector from the engine stop solenoid.
2. Remove the engine stop solenoid from the engine.
3. Connect the jumper leads from the battery positive terminal to the **1P** connector, and from the battery negative terminal to the engine stop solenoid body.
4. If the solenoid plunger is not attracted, the engine stop solenoid is faulty.

(1) Battery (12 V)



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Engine Stop Solenoid Test (Energize to Run Type)

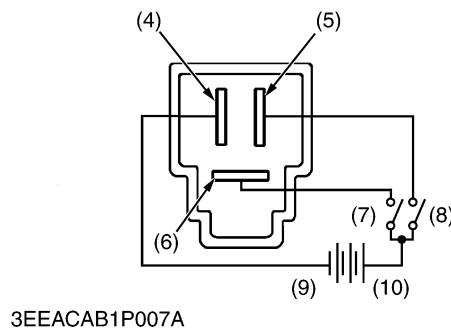
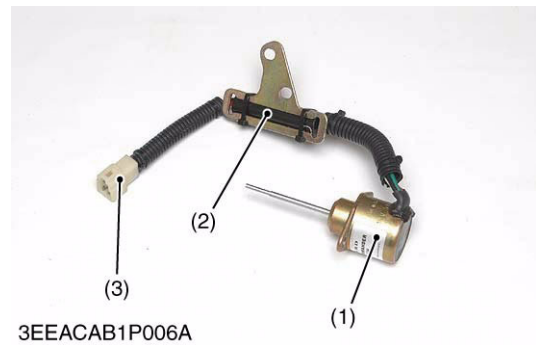
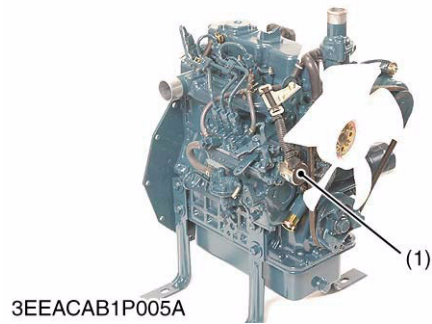
1. Disconnect the **3P** connector (3) from the engine stop solenoid (1) wiring harness.
2. Remove the engine stop solenoid (1) from the engine.
3. Connect the jumper leads from the pulling coil terminal (6) to the switch (7), and from switch (7) to the battery positive terminal (10).
4. Connect the jumper leads from the holding terminal (5) to the switch (8), and from switch (8) to the battery positive terminal (10).
5. Connect the jumper leads from the ground terminal (4) to the battery negative terminal (9).
6. When switch (7) is turned on, the plunger pull into the solenoid body and then the plunger comes out within approximately 1.2 seconds.
7. Turn on the switch (8) then turn on the switch (7), the plunger pull into the solenoid body and it keeps in holding position after turn off the switch (7).
8. If the plunger is not attracted, the engine stop solenoid is faulty.

Pull coil energized time	Factory spec.	0.52 to 1.20 seconds
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■ **NOTE**

- **This solenoid assembly includes reverse polarity protected pulling coil timer module (2) to prevent solenoid burnout due to engine over crank or misadjustment of linkage by limiting the pull coil ON time.**

- | | |
|-------------------------------|--------------------------------|
| (1) Engine Stop Solenoid | (6) Pulling Coil Terminal |
| (2) Pulling Coil Timer Module | (7) Switch for Pulling Coil |
| (3) 3P Connector | (8) Switch for Holding Coil |
| (4) Ground Terminal | (9) Battery Negative Terminal |
| (5) Holding Coil Terminal | (10) Battery Positive Terminal |



3EEACAB1P007A

2. DISASSEMBLING AND ASSEMBLING

1) Draining Coolant and Engine Oil

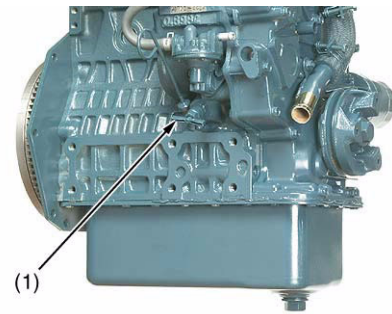
Draining Coolant

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 cock.

(1) Coolant Drain Cock



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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. **(When refilling)**
 - Fill the engine oil up to the upper line on the oil level gauge (2).

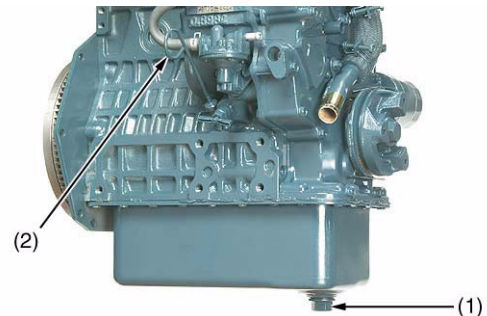
■ IMPORTANT

- **Never mix two different type of oil.**
- **Use the proper SAE Engine Oil according to ambient temperature.**

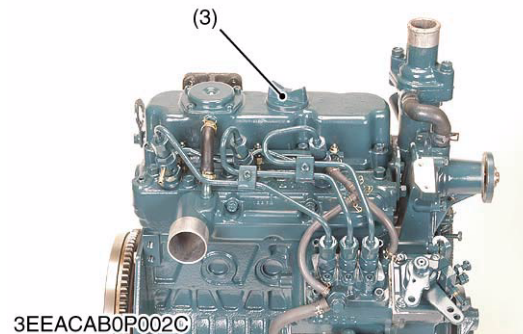
(1) Drain Plug

(3) Oil Inlet Plug

(2) Oil Level Gauge



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2) External Components

Alternator, Starting motor and Others

1. Remove the air cleaner and muffler.
2. Remove the engine stop solenoid (1).
3. Remove the cooling fan (2), fan pulley and fan belt (3).
4. Remove the alternator.
5. Remove the starting motor.

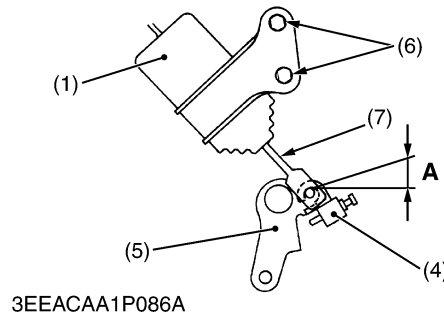
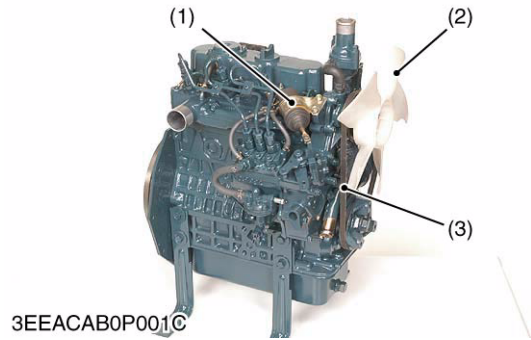
(When reassembling)

- Check to see that there are no cracks on the belt surface.

■ IMPORTANT

- Keep the engine stop lever (5) to touch the stopper (4). Tighten the engine stop solenoid mounting screw (6) so that there be no gap between the engine stop lever and the engine stop solenoid plunger (7).
- After reassembling the fan belt, be sure to adjust the fan belt tension.
- Do not confuse the direction of the fan.

- | | |
|--------------------------|---|
| (1) Engine Stop Solenoid | (6) Engine Stop Solenoid Mounting Screw |
| (2) Cooling Fan | (7) Plunger |
| (3) Fan Belt | |
| (4) Stopper | A: 0 mm |
| (5) Engine Stop Lever | |



3) Cylinder Head, Valves and Oil Pan

Cylinder Head Cover

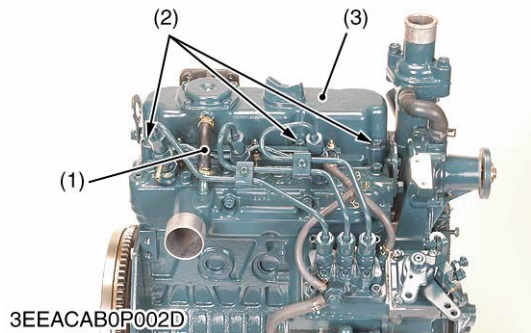
1. Remove the breather tube (1).
2. Remove the head cover screws (2).
3. Remove the cylinder head cover (3).

(When reassembling)

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

Tightening torque	Cylinder head cover screw	6.86 to 11.3 Nm {0.7 to 1.15 kgm}
-------------------	---------------------------	--------------------------------------

- | | |
|-----------------------|-------------------------|
| (1) Breather Tube | (3) Cylinder Head Cover |
| (2) Head Cover Screws | |



Injection Pipes

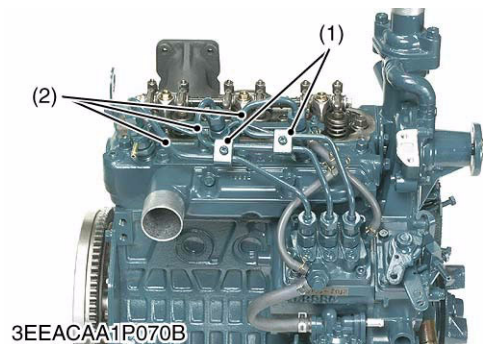
1. Loosen the screws on the pipe clamp (1).
2. Detach the injection pipes (2).

(When reassembling)

- Send compressed air into the pipes to blow out dust. Then, reassemble the pipes in the reverse order.

Tightening torque	Injection pipe retaining nut	24.5 to 34.3 Nm {2.5 to 3.5 kgm}
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- | | |
|----------------|--------------------|
| (1) Pipe Clamp | (2) Injection Pipe |
|----------------|--------------------|



Nozzle Holder Assembly and Glow Plug

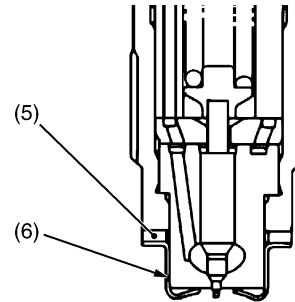
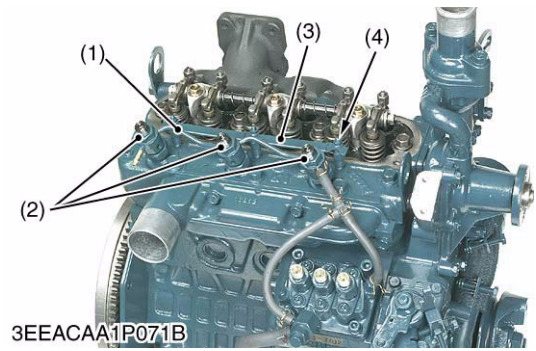
1. Remove the overflow pipe (1).
2. Remove the nozzle holder assemblies (2).
3. Remove the copper gasket (5) and the heat seal (6).
4. Remove the lead (3) from the glow plugs (4).
5. Remove the glow plugs (4).

(When reassembling)

- Replace the copper gasket and heat seal with new one.

Tightening torque	Overflow pipe retaining nut	19.6 to 24.5 Nm {2.0 to 2.5 kgm}
	Nozzle holder assembly	49.0 to 68.6 Nm {5.0 to 7.0 kgm}
	Glow plug	7.85 to 14.7 Nm {0.8 to 1.5 kgm}

- | | |
|----------------------------|-------------------|
| (1) Overflow Pipe | (4) Glow Plug |
| (2) Nozzle Holder Assembly | (5) Copper Gasket |
| (3) Lead | (6) Heat Seal |



Rocker Arm and Push Rod

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

(When reassembling)

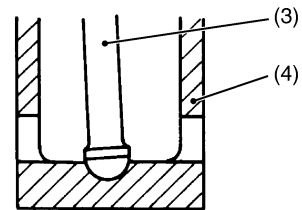
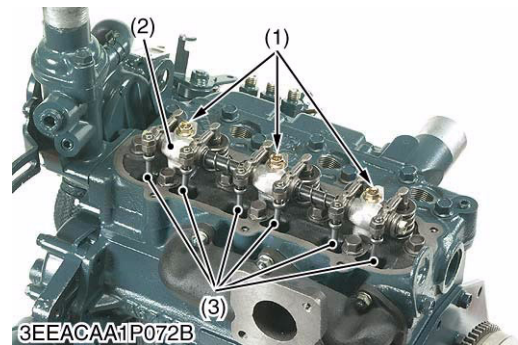
- When putting the push rods (3) onto the tappets (4), check to see if their ends are properly engaged with the dimples.

■ **IMPORTANT**

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

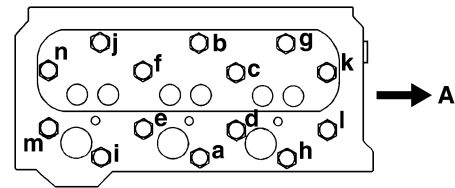
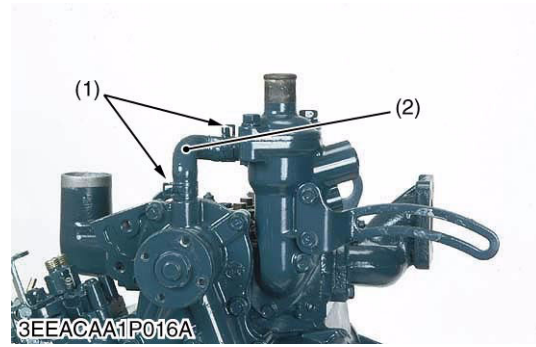
Tightening torque	Rocker arm bracket screw	9.8 to 11.3 Nm {1.00 to 1.15 kgm}
-------------------	--------------------------	--------------------------------------

- | | |
|-------------------------------|--------------|
| (1) Rocker Arm Bracket screws | (3) Push Rod |
| (2) Rocker Arm Assembly | (4) Tappet |



Cylinder Head

1. Loosen the pipe clamps (1), and remove the water return pipe (2).
2. Remove the cylinder head screw in the order of (n or j) to (a).
3. Lift up the cylinder head to detach.
4. Remove the cylinder head gasket and O-ring (3).
(When reassembling)
 - Replace the cylinder head gasket with a new one.
 - Securely fit the O-ring (3) to the pipe pin.
 - Tighten the cylinder head screws after applying sufficient oil.
 - Tighten the cylinder head screws in order of (a) to (n or j).
 - Tighten them uniformly, or the head may deform in the long run.
 - Retighten the cylinder head screws after running the engine for 30 minutes.



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Tightening torque	Cylinder head screw	37.3 to 42.2 Nm {3.8 to 4.3 kgm}
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- | | | |
|-----------------------|--|------------------------------------|
| (1) Pipe Clamp | | A: Gear Case Side |
| (2) Water Return Pipe | | (n or j) to (a): To Loosen |
| (3) O-ring | | (a) to (n or j): To Tighten |

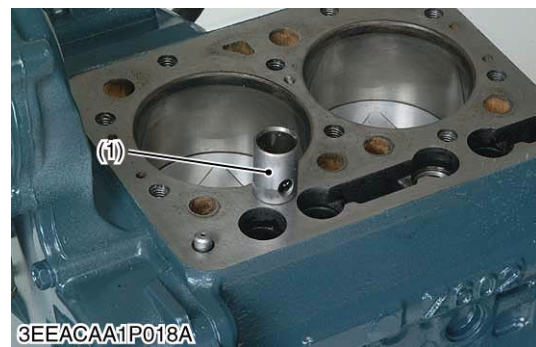


Tappets

1. Remove the tappets (1) from the crankcase.
(When reassembling)
 - Visually check the contact between tappets and cams for proper rotation. If defect is found, replace tappets.
 - Before installing the tappets, apply engine oil thinly around them.

■ **NOTE**

- **Do not change the combination of tappet and tappet guide.**
- (1) Tappet



Valves

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

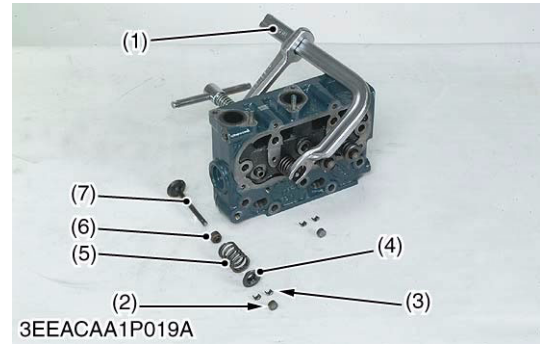
(When reassembling)

- Wash the valve stem seal 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.

■ IMPORTANT

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

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



Oil Pan and Oil Strainer

1. Remove the oil pan mounting screws (1).
2. Remove the oil pan (2) 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 is 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 from the center.
- Using the hole (5) numbered "3", install the oil strainer by mounting screw.

■ **IMPORTANT**

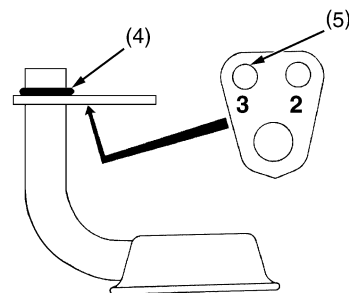
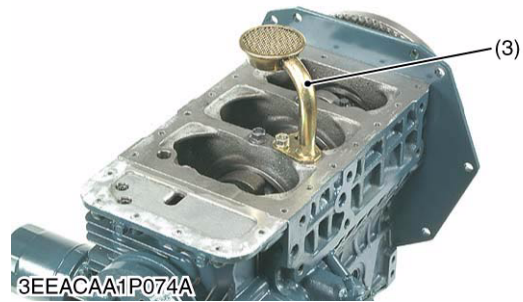
- **Scrape off the old adhesive completely. Wipe the sealing surface clean. Now apply new adhesive 3 to 5 mm thick all over the contact surface. Apply the adhesive also on the center of the flange as well as on the inner wall of each screw hole.**
- **Cut the nozzle of the "liquid gasket" (Three Bond 1207D or equivalent) container at its second notch. Apply "liquid gasket" about 3 to 5 mm 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.

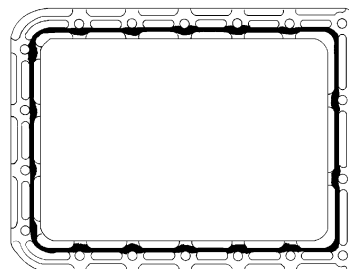
- | | |
|----------------------------|-----------------------|
| (1) Oil Pan Mounting Screw | (4) O-ring |
| (2) Oil Pan | (5) Hole Numbered "3" |
| (3) Oil Strainer | |



[b]



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4) Thermostat

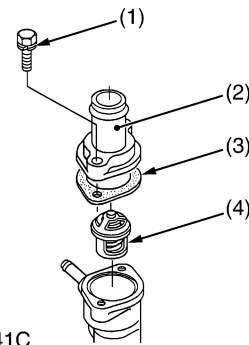
Thermostat Assembly

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 | (3) Thermostat Cover
Gasket |
| (2) Thermostat Cover | (4) Thermostat Assembly |



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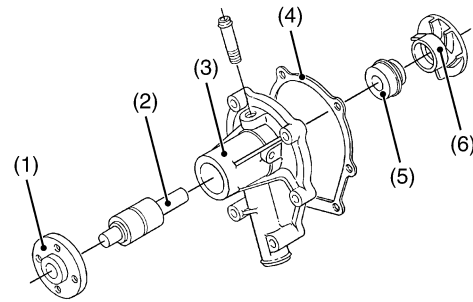
Water Pump Assembly

1. Loosen the alternator mounting screws, and remove the fan belt.
2. Remove the fan and fan pulley.
3. Remove the water pump assembly from the gear case cover.
4. Remove the water pump flange (1).
5. Press out the water pump shaft (2) with the impeller (6) on it.
6. Remove the impeller from the water pump shaft.
7. Remove the mechanical seal (5).

(When reassembling)

- Apply a liquid gasket (Three Bond 1215 or equivalent) to the both sides of gasket (4).
- Replace the mechanical seal with new one.

- | | |
|-----------------------|--------------------------|
| (1) Water Pump Flange | (4) Water Pump
Gasket |
| (2) Water Pump Shaft | |
| (3) Water Pump Body | (5) Mechanical Seal |
| | (6) Impeller |



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5) Timing Gear, Camshaft and Fuel Camshaft

Injection Pump, Fuel Feed Pump and Speed Control Plate
(for Energize to Stop Type Engine Stop Solenoid)

1. Remove the socket head screws and nuts, and remove the injection pump (1).
2. Remove the screws and separate the speed control plate (2), taking care not to damage the governor spring (4).
3. Disconnect the governor spring (4) and remove the speed control plate (2).
4. Remove the fuel feed pump (3).

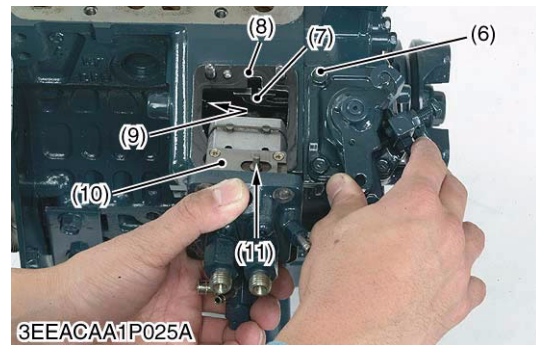
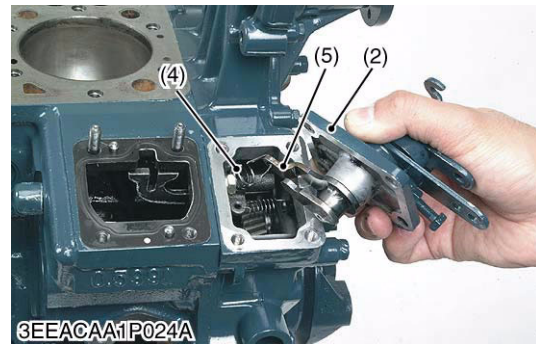
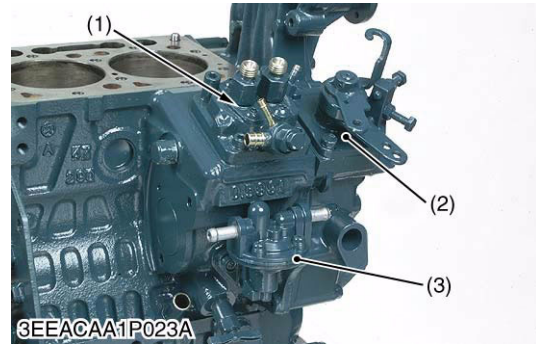
(When reassembling)

- Hook the governor spring (4) to the governor lever (5) first and install the speed control plate (2).
- Be sure to place the copper washers underneath two screws (6). (Two screws (6) in the upper of the speed control plate (2).)
- Position the slot (7) on the fork lever just under the slot (8) on the crankcase.
- Insert the injection pump (1) so that the control rod (10) should be pushed by the idling adjusting spring (9) at its end and the pin (11) on the rod engages with the slot (7) on the fork lever (as shown in the photo).

■ NOTE

- The sealant is applied to both sides of the soft metal gasket shim. The liquid gasket is not required for assembling.
- Addition or reduction of shim (0.05 mm) delays or advances the injection timing by approx. 0.5°
- In disassembling and replacing, be sure to use the same number of new gasket shims with the same thickness.

- | | |
|-----------------------------|-----------------------------|
| (1) Injection Pump | (7) Slot (Fork Lever Side) |
| (2) Speed Control Plate | (8) Slot (Crankcase Side) |
| (3) Fuel Feed Pump | (9) Idling Adjusting Spring |
| (4) Governor Spring | (10) Control Rod |
| (5) Governor Lever | (11) Pin |
| (6) Screw and Copper Washer | |



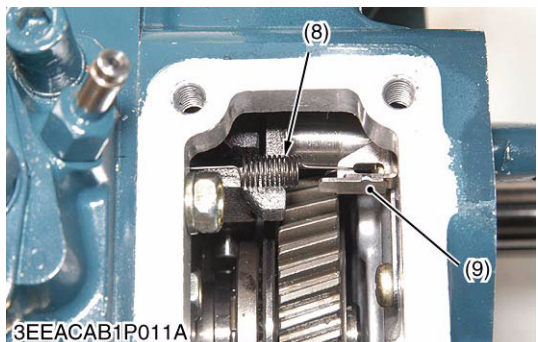
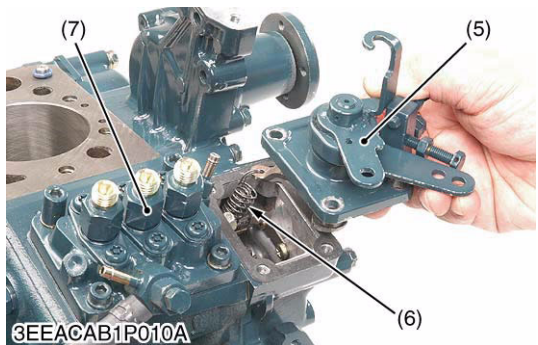
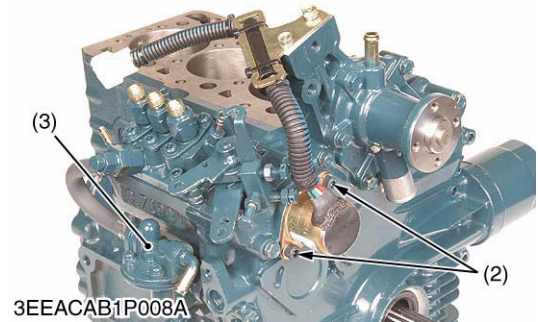
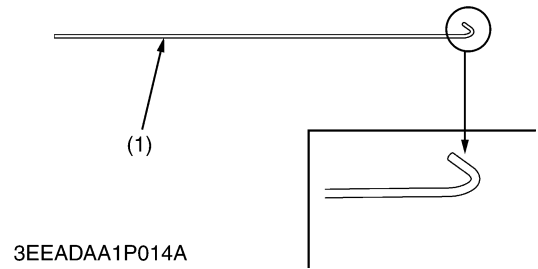
Injection Pump, Fuel Feed Pump and Speed Control Plate
(for Energize to Run Type Engine Stop Solenoid)

■ NOTE

- **Specific tool (1) :**
1.2 mm diameter hard wire with its end hooked, overall length 200 mm.
The tip of wire is bent like the hook to hang governor springs.

1. Remove the socket head screws (2), and remove the stop solenoid (4).
2. Remove the screws and separate the speed control plate (5), taking care not to damage the governor spring (6).
3. Disconnect the governor spring (6) and remove the speed control plate (5) using the specific tool (1).
4. Remove the fuel feed pump (3).
5. Disconnect the start spring (8) from the bracket (9) using the specific tool (1).
6. Remove the socket head screws and nuts, and remove the injection pump (7).

- | | |
|-------------------------|---------------------|
| (1) Specific Tool | (6) Governor Spring |
| (2) Socket Head Screw | (7) Injection Pump |
| (3) Fuel Feed Pump | (8) Start Spring |
| (4) Stop Solenoid | (9) Bracket |
| (5) Speed Control Plate | |



Injection Pump, Fuel Feed Pump and Speed Control Plate
(for Energize to Run Type Engine Stop Solenoid) (Continue)

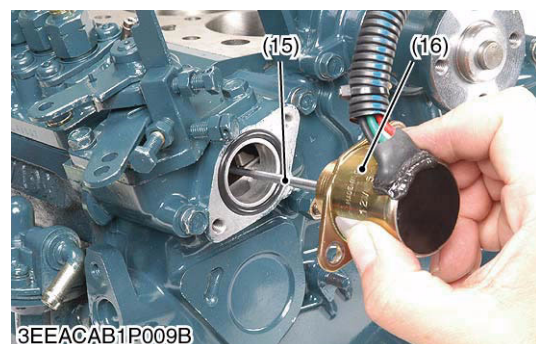
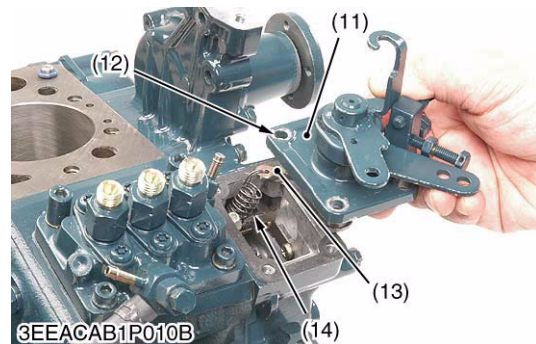
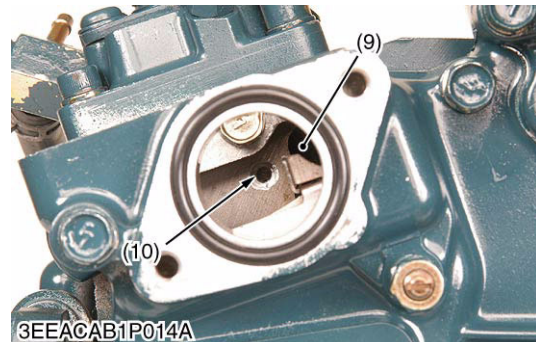
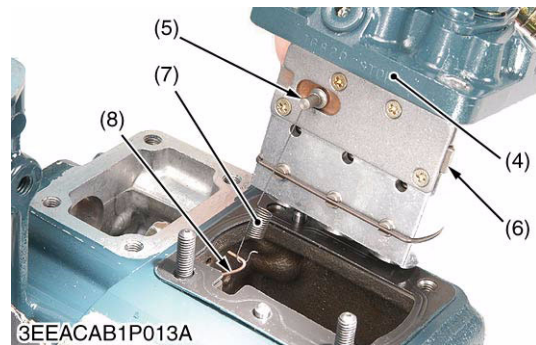
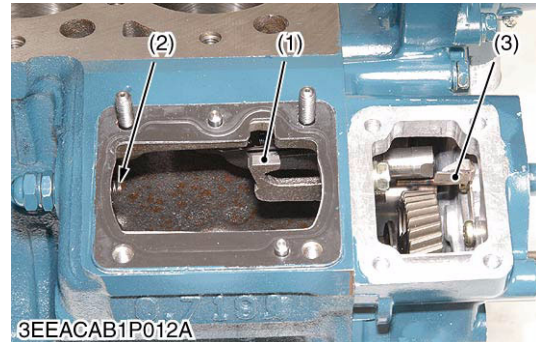
(When reassembling)

1. Move the fork lever (1) to the gear case side.
2. Hook the start spring (7) to the injection pump control rack pin (5).
3. Put the specific tool (8) through the fork lever hole of cylinder block (9) and hook the start spring (7).
4. Keep this spring slightly extended and install the injection pump (4). Make sure the control rod (6) should be pushed by the idling adjusting spring (2) and the pin (5) on the rod engages with the fork lever (1).
5. Hook the start spring (7) to the bracket (3) using the specific tool (8).
6. Hook the governor springs (small and large) (14) to the governor lever (13) using the specific tool (8) and install the speed control plate (11). Be sure to place the copper washers underneath two screws (12) in the upper of the speed control plate.
7. Install the stop solenoid rod (15) to the guide hole of cylinder block (10) and fix the stop solenoid (16) with socket head screws.

■ **NOTE**

- **Be careful not to stretch the start spring (7) too long. Otherwise it may get deformed permanently.**
- **Make sure the start spring (7) is tight on the bracket (3).**
- **The sealant is applied to both sides of the soft metal gasket shim. The liquid gasket is not required for assembling.**
- **Addition or reduction of shim (0.05 mm) delays or advances the injection timing by approx. 0.5°.**
- **In disassembling and replacing, be sure to use the same number of new gasket shims with the same thickness.**

- | | |
|-------------------------------------|---------------------------------------|
| (1) Fork Lever | (9) Fork Lever Hole of Cylinder Block |
| (2) Idling Adjusting Spring | (10) Guide Hole of Cylinder Block |
| (3) Bracket | (11) Speed Control Plate |
| (4) Injection Pump | (12) Screw and Copper Washer |
| (5) Injection Pump Control Rack Pin | (13) Governor Lever |
| (6) Injection Pump Control Rod | (14) Governor Spring |
| (7) Start Spring | (15) Stop Solenoid Rod |
| (8) Specific Tool | (16) Stop Solenoid |

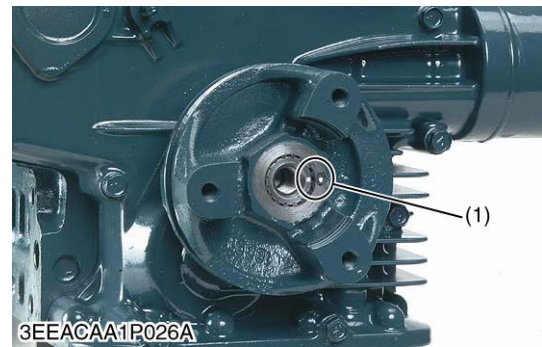


Fan Drive Pulley

1. Secure the flywheel to keep it from turning.
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	98.1 to 107.9 Nm {10.0 to 11.0 kgm}
-------------------	------------------------	--

(1) Alignment Mark



Gear Case

1. Disconnect the start spring (2) from the fork lever 1 (3).
2. Remove the screw (1) of inside the gear case and outside screws.
3. Remove the gear case (4).

(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.

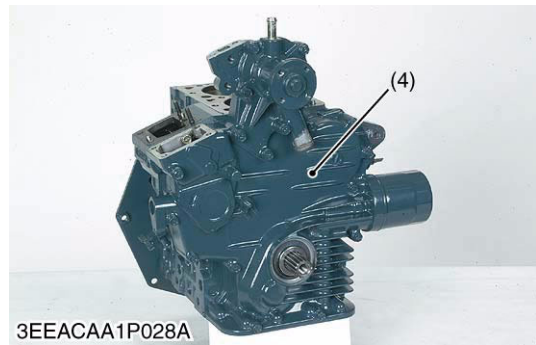
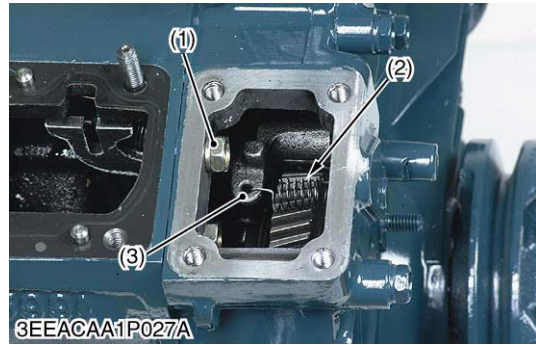
■ **NOTE**

- **The gear case for energize to run type stop solenoid and the gear case for one-side maintenance are available to meet customer's requirements. (Option)**

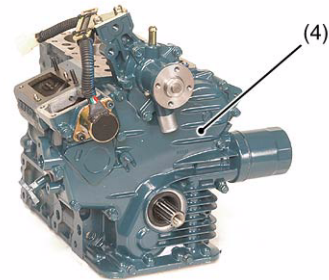
- (1) Screw (Inside)
- (2) Start Spring
- (3) Fork Lever 1
- (4) Gear Case

[a] Gear Case for Energize to Run Type Stop Solenoid (Option)

[b] Gear Case for One-side Maintenance (Option)

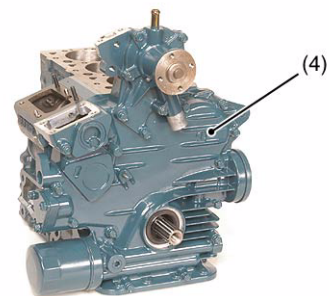


[a]



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[b]



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Idle Gear

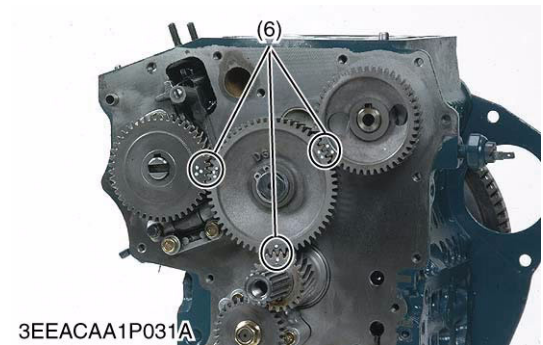
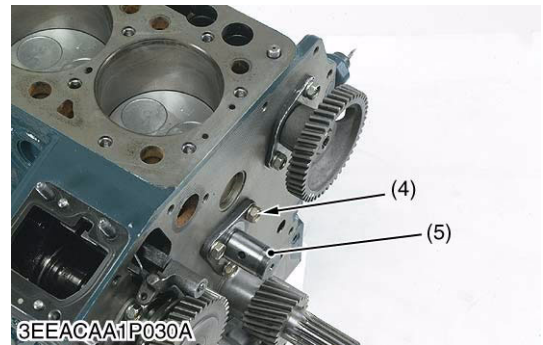
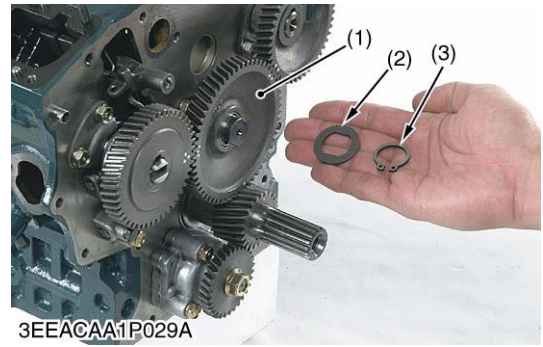
1. Remove the external snap ring (3), the collar (2) and the idle gear (1).
2. Remove the idle gear shaft mounting screws (4).
3. Remove the idle gear shaft (5).

(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	9.8 to 11.3 Nm {1.00 to 1.15 kgm}
-------------------	--------------------------------	--------------------------------------

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



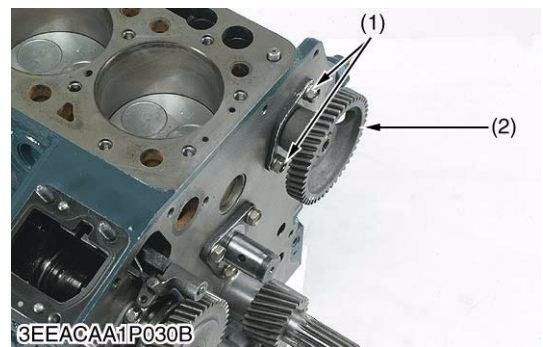
Camshaft

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 |
|-----------------------------|-------------------|



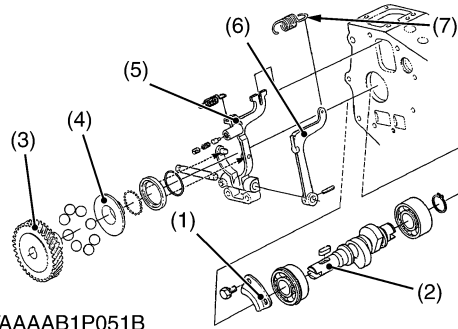
Fuel Camshaft

1. Remove the retaining plate (1).
2. Remove the fork lever holder mounting screws (8), then draw out the injection pump gear (3) and fuel camshaft (2) with the governor fork assembly.

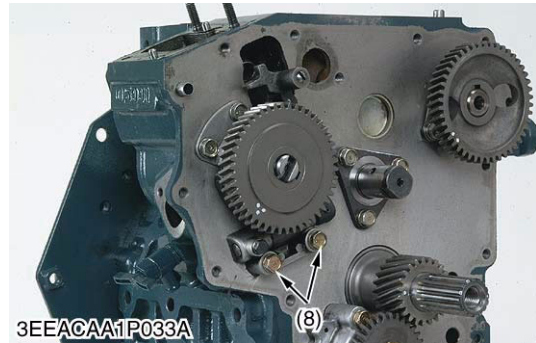
(When reassembling)

- Hook the governor spring (7) to the fork lever 2 (6) as shown in the figure before installing the fork lever assembly to the crankcase.

- | | |
|-------------------------|--------------------------------------|
| (1) Retaining Plate | (5) Fork Lever 1 |
| (2) Fuel Camshaft | (6) Fork Lever 2 |
| (3) Injection Pump Gear | (7) Governor Spring |
| (4) Governor Sleeve | (8) Fork Lever Holder Mounting Screw |



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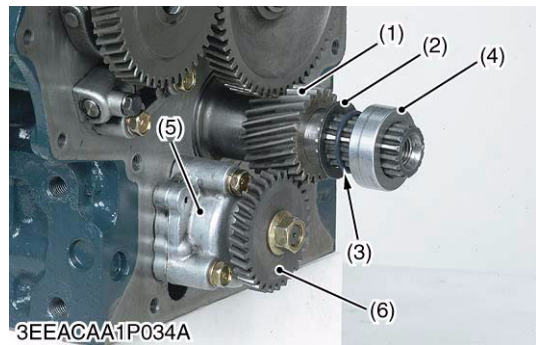
Oil Pump and Crankshaft Gear

1. Remove the oil pump gear (6).
2. Remove the oil pump (5).
3. Remove the collar (4), O-ring (3) and crankshaft oil slinger (2).
4. Remove the crankshaft gear (1) with a puller.

(When reassembling)

- Install the collar (4) after aligning the marks on the gear. (See the photo at "Idle Gear".).

- | | |
|----------------------------|-----------------------|
| (1) Crankshaft Gear | (4) Crankshaft Collar |
| (2) Crankshaft Oil Slinger | (5) Oil Pump |
| (3) O-ring | (6) Oil Pump Gear |



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Oil Pump and Crankshaft Gear

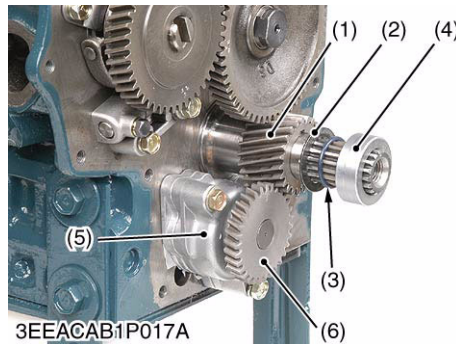
(One-side Maintenance Type)

1. Remove the oil pump (5).
2. Remove the collar (4), O-ring (3) and crankshaft oil slinger (2).
3. Remove the crankshaft gear (1) with a puller.

(When reassembling)

- Install the collar (4) after aligning the marks on the gear. (See the photo at "Idle Gear".).

- | | |
|----------------------------|-----------------------|
| (1) Crankshaft Gear | (4) Crankshaft Collar |
| (2) Crankshaft Oil Slinger | (5) Oil Pump |
| (3) O-ring | (6) Oil Pump Gear |



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6) Piston and Connecting Rod

Connecting Rod

1. Remove the connecting rod caps (1) using a bihexagonal 8 mm socket.

(When reassembling)

- Align the marks (a) with each other. (Face the marks toward the injection pump.)
- Apply engine oil to the connecting rod screws and lightly screw it in by hand, then tighten it to the specified torque.

If the connecting rod screw won't be screwed in smoothly, clean the threads.

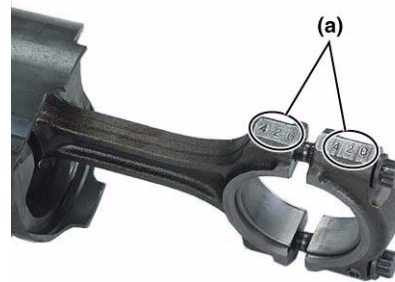
If the connecting rod screw is still hard to screw in, replace it.

Tightening torque	Connecting rod screw	26.5 to 30.4 Nm {2.7 to 3.1 kgm}
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(1) Connecting Rod Cap (a) Mark



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Piston

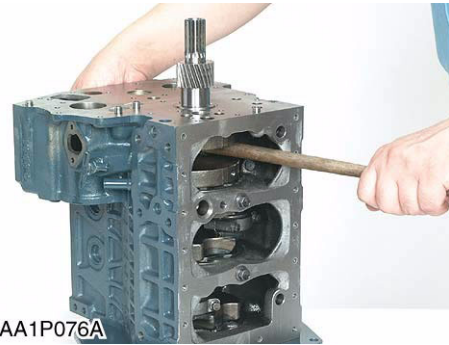
1. Turn the flywheel and bring the piston to top dead center.
2. Draw out the piston upward by lightly tapping it from the bottom of the crankcase with the grip of a hammer.
3. Draw out the other piston in the same method as above.

(When reassembling)

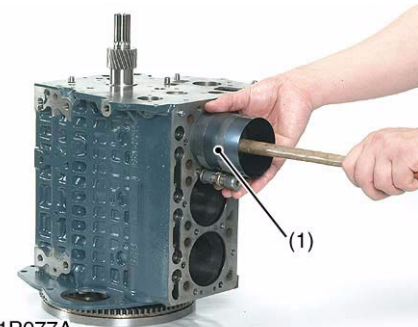
- Before inserting the piston into the cylinder, apply enough engine oil to the piston.
- When inserting the piston into the cylinder, face the mark on the connecting rod to the injection pump.

■ **IMPORTANT**

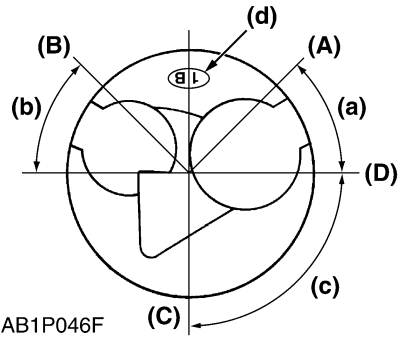
- Do not change the combination of cylinder and piston. Make sure of the position of each piston by marking. For example, mark "1" on the No.1 piston.
- When installing the piston into the cylinder, place the gaps of all the piston rings as shown in the figure.
- Carefully insert the piston using a piston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



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3TMABAB1P046F

Models	Mark
3D67E-1A	A

- | | |
|----------------------------|----------|
| (1) Piston Ring Compressor | (a) 45° |
| (A) Top Ring Gap | (b) 45° |
| (B) Second Ring Gap | (c) 90° |
| (C) Oil Ring Gap | (d) Mark |
| (D) Piston Pin Hole | |

Piston Ring and Connecting Rod

1. Remove the piston rings using a piston ring tool (Code No. KT07909-32121).
2. Remove the piston pin (7), and separate the connecting rod (6) from the piston (5).

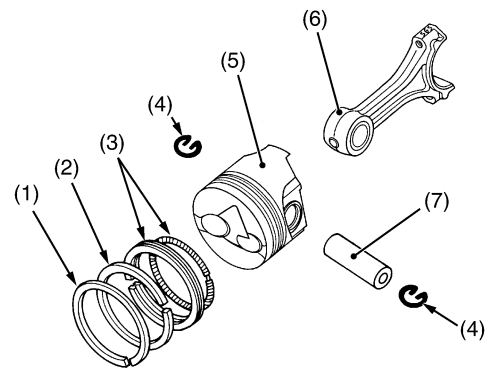
(When reassembling)

- When installing the ring, assemble the rings so that the manufacturer's mark (12) near the gap faces the top of the piston.
- When installing the oil ring onto the piston, place the expander joint (10) on the opposite side of the oil ring gap (11).
- Apply engine oil to the piston pin.
- When installing the connecting rod to the piston, immerse the piston in 80°C 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 (8) on the connecting rod to the fan-shaped concave (9).

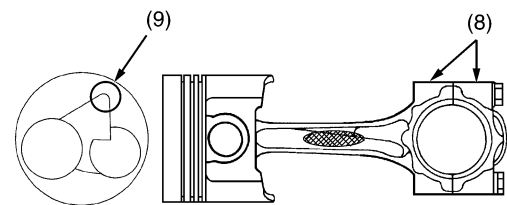
■ **NOTE**

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

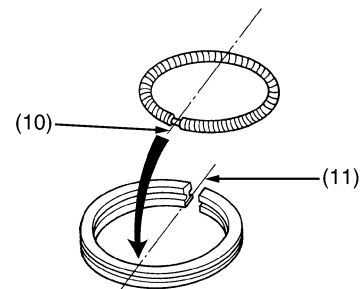
- | | |
|--------------------------|--------------------------|
| (1) Top Ring | (7) Piston Pin |
| (2) Second Ring | (8) Mark |
| (3) Oil Ring | (9) Fan-Shaped Concave |
| (4) Piston Pin Snap Ring | (10) Expander Joint |
| (5) Piston | (11) Oil Ring Gap |
| (6) Connecting Rod | (12) Manufacturer's Mark |



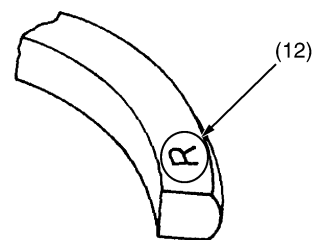
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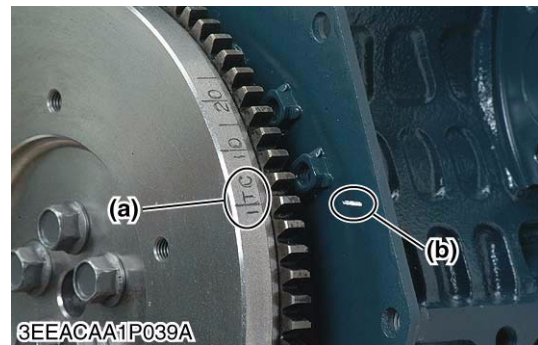


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7) Crankshaft

Flywheel

1. Secure the flywheel to keep it from turning using a flywheel stopper. (Refer to "SPECIAL TOOLS".)
2. Remove all flywheel screws (1) and then remove the flywheel (2).
(When reassembling)
 - 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.

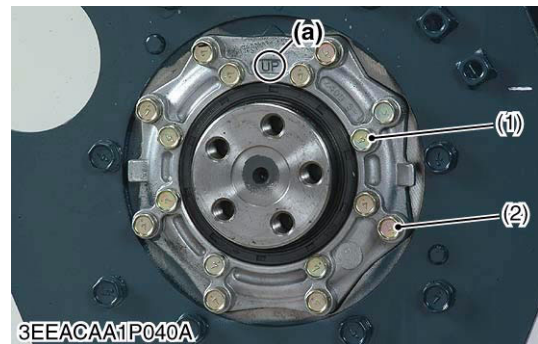


Tightening torque	Flywheel screw	53.9 to 58.8 Nm {5.5 to 6.0 kgm}
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- (1) Flywheel Screw (a) 1TC Mark
- (2) Flywheel (b) Alignment Mark

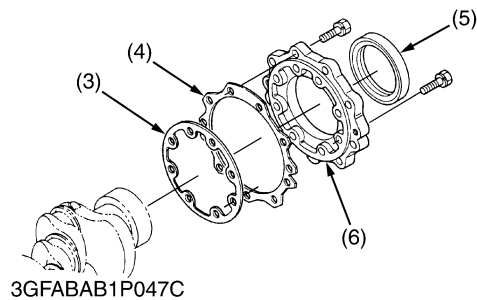
Bearing Case Cover

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 take care that it is not rolled when installing.
 - Tighten the bearing case cover mounting screws with even force on the diagonal line.

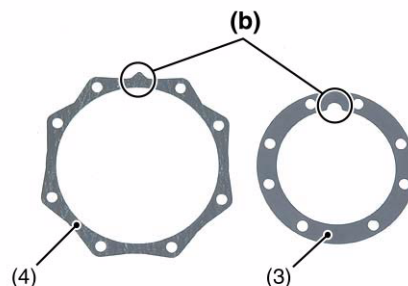


Tightening torque	Bearing case cover mounting screw	9.8 to 11.3 Nm {1.00 to 1.15 kgm}
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- (1) Bearing Case Cover Mounting Screw (Inside)
- (2) Bearing Case Cover Mounting Screw (Outside)
- (3) Bearing Case Gasket
- (4) Bearing Case Cover Gasket
- (5) 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 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.

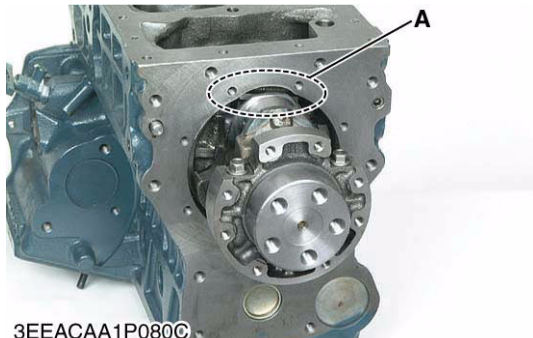
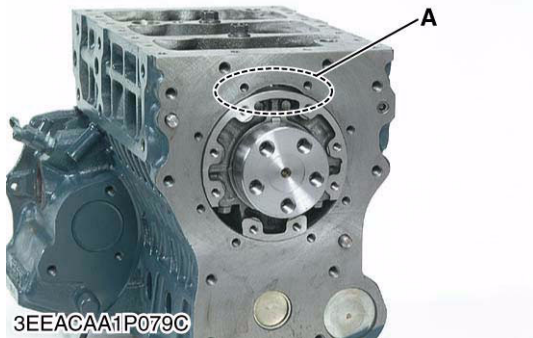
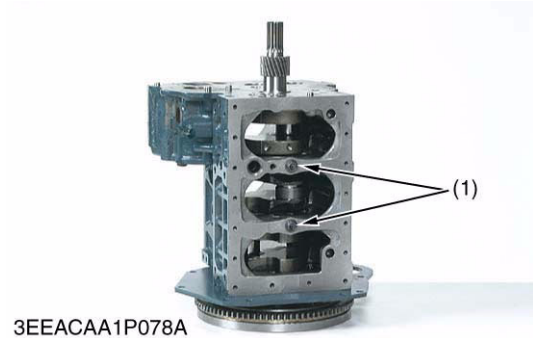
(When reassembling)

- 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	26.5 to 30.4 Nm {2.7 to 3.1 kgm}
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(1) Main Bearing Case Screw 2

A: Cut place for removing and installing the crankshaft



Main Bearing Case Assembly

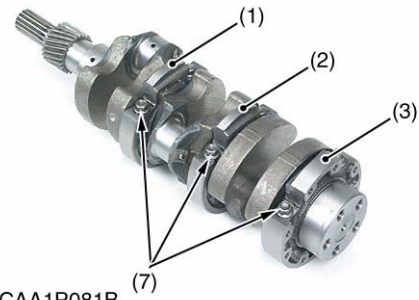
1. Remove the two main bearing case screws 1 (7), and remove the main bearing case assembly 1 (1), being careful with crankshaft bearing 3 (4).
2. Remove the main bearing case assembly 2 (2) and the main bearing case assembly (3) as above. Keep in mind, however, that the thrust bearing (6) is installed in the main bearing case assembly (3).

(When reassembling)

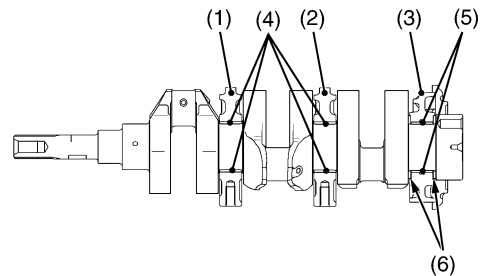
- Clean the oil passage in the main bearing cases.
- Apply clean engine oil on the bearings.
- Install the main bearing case assemblies in original positions. Since diameters of main bearing cases vary, install them in order to marking (b) (1, 2) from the gear case side. (Refer to the figure.)
- Match 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 (6) with its oil groove facing outward.
- Confirm 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	12.7 to 15.7 Nm {1.3 to 1.6 kgm}
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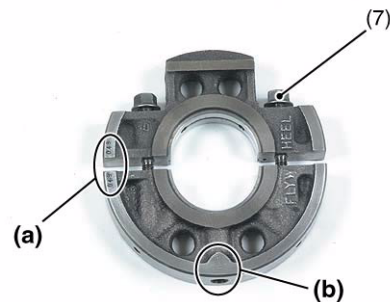
- | | |
|---|--|
| <ul style="list-style-type: none"> (1) Main Bearing Case Assembly 1 (2) Main Bearing Case Assembly 2 (3) Main Bearing Case Assembly (4) Crankshaft Bearing 3 (5) Crankshaft Bearing 2 (6) Thrust Bearing (7) Main Bearing Case Screw 1 | <ul style="list-style-type: none"> (a) Alignment Number (b) Marking (1, 2) |
|---|--|



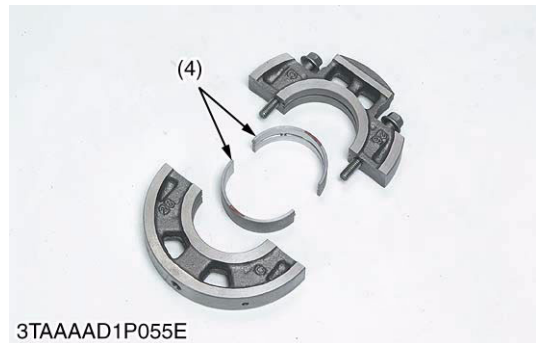
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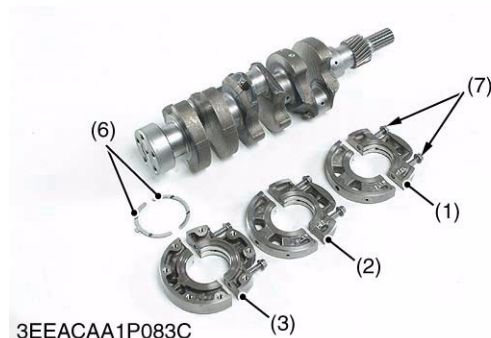
3EEACAA1P082B



3TAAAAD1P054E



3TAAAAD1P055E



3EEACAA1P083C

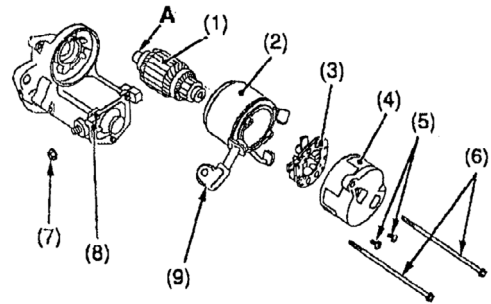
8) Starting Motor (Reduction Type)

Disassembling Motor

1. Disconnect the connecting lead (9) from the magnet switch (8).
2. Remove the screws (6), and then separate the end frame (4), yoke (2) and armature (1).
3. Remove the two screws (5), and then take out the brush holder (3) from the end frame (4).

(When reassembling)

- Apply grease to the spline teeth (A) of the armature (1).



T12630EL01601

Tightening torque	Nut (7)	5.9 to 11.8 Nm {0.6 to 1.2 kgm}
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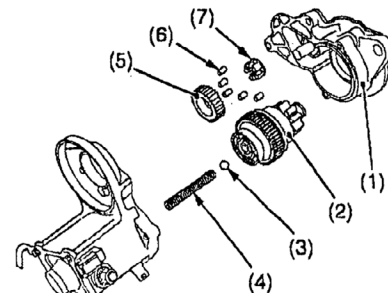
- | | |
|------------------|------------------------|
| (1) Armature | (7) Nut |
| (2) Yoke | (8) Magnet Switch |
| (3) Brush Holder | (9) Connecting Lead |
| (4) End Frame | |
| (5) Screw | A: Spline Teeth |
| (6) Screw | |

Disassembling Magnet Switch

1. Remove the drive end frame (1) mounting screws.
2. Take out the overrunning clutch (2), ball (3), spring (4), gear (5), rollers (6) and retainer (7).

(When reassembling)

- Apply grease to the gear teeth of the gear (5) and overrunning clutch (2), and ball (3).



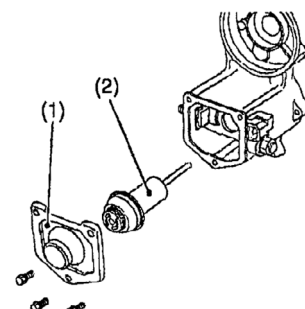
T12630EL01701

- | | |
|------------------------|--------------|
| (1) Drive End Frame | (5) Gear |
| (2) Overrunning Clutch | (6) Roller |
| (3) Ball | (7) Retainer |
| (4) Spring | |

Plunger

1. Remove the end cover (1).
2. Take out the plunger (2).

- | | |
|---------------|-------------|
| (1) End Cover | (2) Plunger |
|---------------|-------------|



T12630EL01801

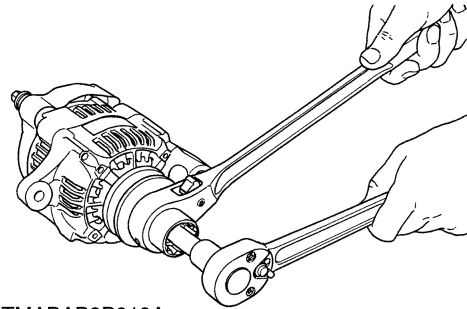
9) Alternator

Pulley

1. Secure the hexagonal end of the pulley shaft with a double-ended ratchet wrench as shown in the figure, loosen the pulley nut with a socket wrench and remove it.

(When reassembling)

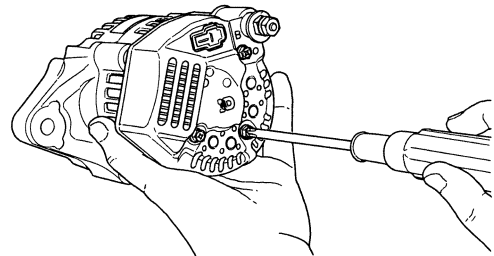
Tightening torque	Pulley nut	58.3 to 78.9 Nm {5.95 to 8.05 kgm}
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3TMABAB9P019A

Rear End Cover

1. Unscrew the three rear end cover screws and the B terminal nut, and remove the rear end cover.

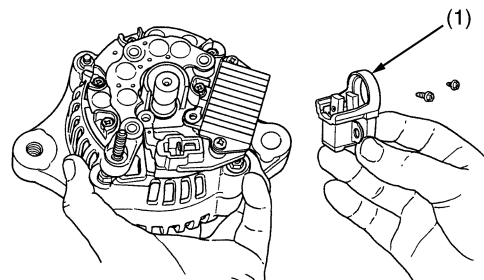


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Brush Holder

1. Unscrew the two screws holding the brush holder, and remove the brush holder (1).

(1) Brush Holder

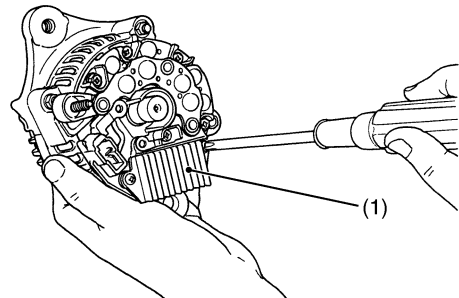


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IC Regulator

1. Unscrew the three screws holding the IC regulator, and remove IC regulator (1).

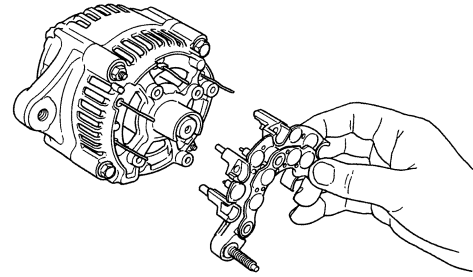
(1) IC Regulator



3EEACAA1P054A

Rectifier

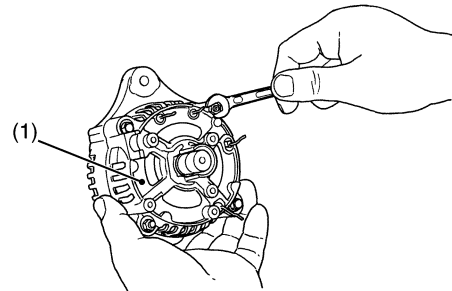
- Remove the four screws holding the rectifier and the stator lead wires.
- Remove the rectifier (1).
 - Rectifier



3EEACAA1P055A

Rear End Frame

- Unscrew the two nuts and two screws holding the drive end frame and the rear end frame.
- Remove the rear end frame (1).
 - Rear End Frame



3TMABAB9P024A

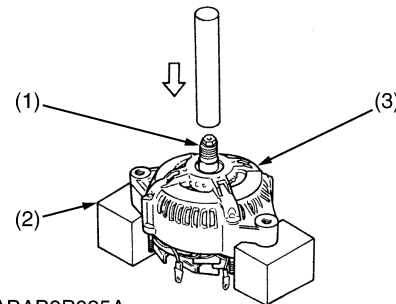
Rotor

- Press out the rotor (1) from drive end frame (3).

■ **IMPORTANT**

- Take special care not to drop the rotor and not to damage the slip ring or fan, etc.**

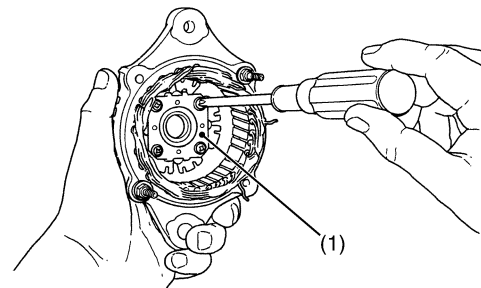
- | | |
|-----------|---------------------|
| (1) Rotor | (3) Drive End Frame |
| (2) Block | |



3TMABAB9P025A

Retainer Plate

- Unscrew the four screws holding the retainer plate, and remove the retainer plate (1).
 - Retainer Plate

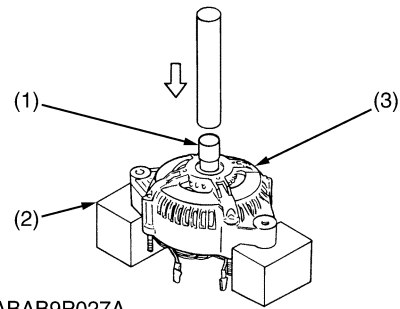


3TMABAB9P026A

Bearing on Drive End Side

1. Press out the bearing from drive end frame (3) with a press and jig (1).

- (1) Jig
- (2) Block
- (3) Drive End Frame

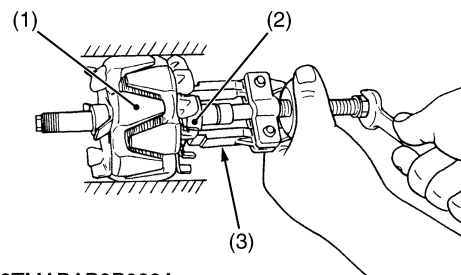


3TMABAB9P027A

Bearing at Slip Ring Side

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

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



3TMABAB9P028A

3. SERVICING

1) Cylinder Head and Valves

Cylinder Head Surface Flatness

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

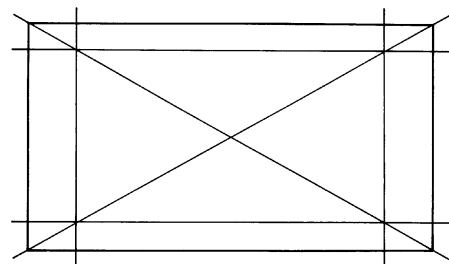
■ **IMPORTANT**

- **Do not place the straightedge on the combustion chamber.**
- **Be sure to check the valve recessing after correcting.**

Cylinder head surface flatness	Allowable limit	0.05 mm
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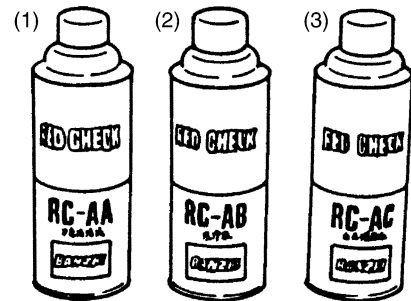


3EEABAB1P112B

Cylinder Head Flaw

1. Prepare an air spray red check (Code No. KT07909-31371).
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.

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



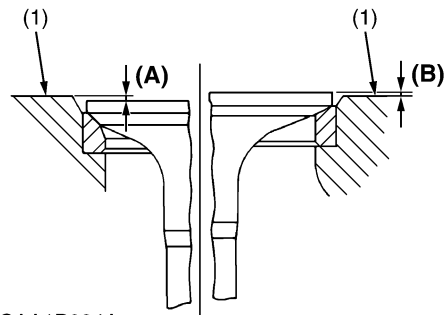
3TMABAB0P059B

Valve Recessing

1. Clean the cylinder head surface, valve face and valve 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 spec.	0.10 (protrusion) to 0.10 (recessing) mm
	Allowable limit	0.30 (recessing) mm

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



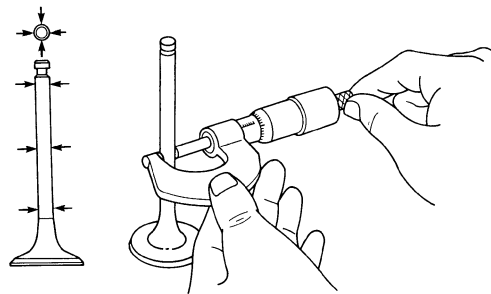
3EEACAA1P084A

Clearance between Valve Stem and Valve Guide

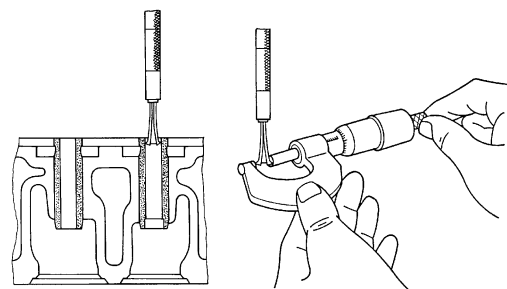
1. Remove carbon from the valve guide section.
2. Measure the valve stem O.D. with an outside micrometer.
3. Measure the valve guide I.D. with a small hole gauge, and calculate the clearance.
4. If the clearance exceeds the allowable limit, replace the valves. If it still exceeds the allowable limit,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

Clearance between valve stem and valve guide	Factory spec.	0.030 to 0.057 mm
	Allowable limit	0.10 mm

Valve stem O.D.	Factory spec.	5.968 to 5.980 mm
Valve guide I.D.	Factory spec.	6.010 to 6.025 mm



3EEABAB1P115A



3EEABAB1P116A

Replacing Valve Guide

(When removing)

1. Press out the used valve guide using a valve guide replacing tool. (Refer to "SPECIAL TOOLS".)

(When installing)

1. Clean a new 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.

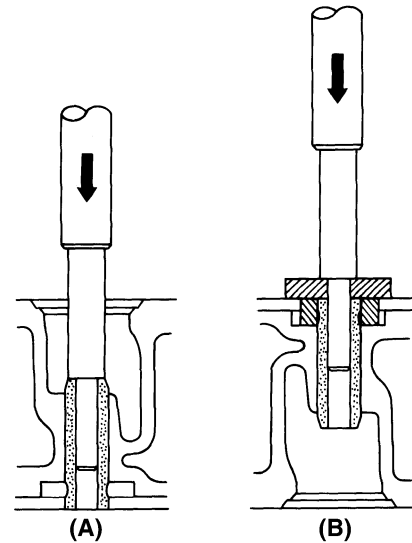
Valve guide I.D. (Intake and Exhaust)	Factory spec.	6.010 to 6.025 mm
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■ **IMPORTANT**

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

(A) When removing

(B) When installing



3EEABAB1P117A

Valve Seating

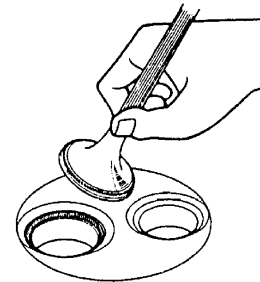
1. Coat the valve face lightly with prussian blue and put the valve on its seat to check the contact.
2. If the valve does not seat all the way around the valve seat or the valve contact is less than 70 %, correct the valve seating as follows.
3. If the valve contact does not comply with the reference value, replace the valve or correct the contact of valve seating.

Valve seat width	Factory spec.	2.12 mm
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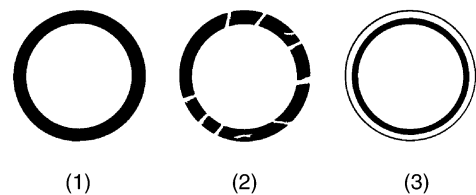
(1) Correct

(3) Incorrect

(2) Incorrect



3TMABAB1P059A



(1)

(2)

(3)

3TMABAB1P060A

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.

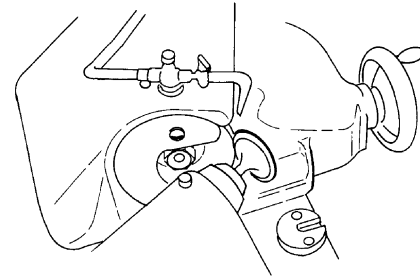
Valve face angle	Factory spec.	45°
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2) Correcting Valve Seat

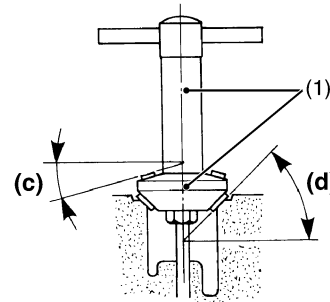
2. Slightly correct the seat surface with a 45° valve seat cutter (Code No. KT07909-33102).
3. Fitting the valve, check the contact position of the valve face and seat surface with prussian blue. (Visual check) [If the valve has been used for a long period, the seat tends to come in contact with the upper side of the valve face.]
4. Grind the upper surface of the seat with a 15° valve seat cutter until the valve seat touches to the center of the valve face (so that (a) equals (b) as shown in the figure)
5. Grind the seat with a 45° valve seat cutter again, and visually recheck the contact between the valve and seat.
6. Repeat steps 3 and 4 until the correct contact is achieved.
7. Continue lapping until the seated rate becomes more than 70 % of the total contact area.

Valve seat angle	Factory spec.	45°
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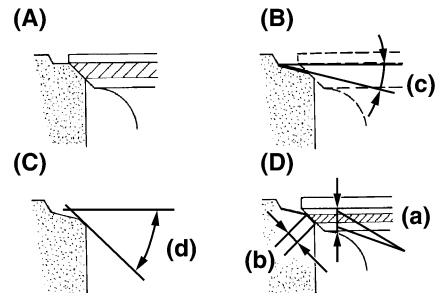
- (1) Valve Seat Cutter (a) Identical Dimensions
- (A) Check Contact (b) Valve Seat Width
- (B) Correct Seat Width (c) 15°
- (C) Correct Seat Surface (d) 45°
- (D) Check Contact



3EEABAB1P118A



3EEABAB1P119B



3EEACAA1P088A

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 or screwdriver.
3. After lapping the valve, wash the compound away and apply oil, then repeat valve lapping with oil.
4. Apply prussian blue to the contact surface to check the seated rate. If it is less than 70 %, repeat valve lapping again.

■ **IMPORTANT**

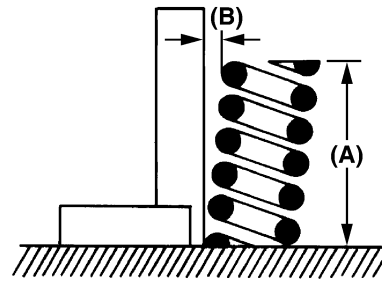
- When valve lapping is performed, be sure to check the valve recessing and adjust the valve clearance after assembling the valve.



3EEACAA1P044A

Free Length and Tilt of Valve Spring

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



3EEABAB1P121B

Free length (A)	Factory spec.	31.3 to 31.8 mm
	Allowable limit	28.4 mm

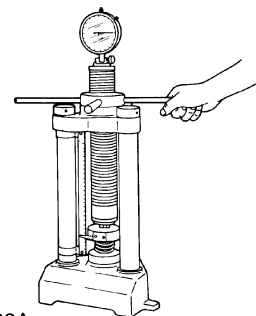
Tilt (B)	Allowable limit	1.2 mm
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(A) Free Length

(B) Tilt

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.



3EEABAB1P122A

Setting load / Setting length	Factory spec.	64.7 N/27.0 mm {6.6 kg/27.0 mm}
	Allowable limit	54.9 N / 27.0 mm {5.6 kg/27.0 mm}

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.



3TAAAD1P060A

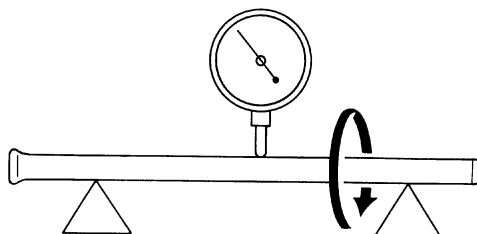
Oil clearance between rocker arm and rocker arm shaft	Factory spec.	0.016 to 0.045 mm
	Allowable limit	0.15 mm

Rocker arm shaft O.D.	Factory spec.	10.473 to 10.484 mm
Rocker arm I.D.	Factory spec.	10.500 to 10.518 mm

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
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3TMABAB1P062A

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 spec.	0.016 to 0.052 mm
	Allowable limit	0.10 mm

Tappet O.D.	Factory spec.	17.966 to 17.984 mm
Tappet guide bore I.D.	Factory spec.	18.000 to 18.018 mm



3TAAAAD1P061A



3EEACAA1P045A

2) Timing Gear, Camshaft

Timing Gear Backlash

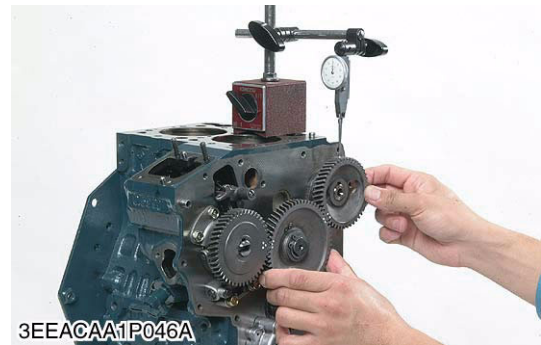
1. Set a dial indicator (lever type) with its tip on the gear tooth.
2. Move the gear to measure the backlash, holding its mating gear.
3. If the backlash exceeds the allowable limit, check the oil clearance of the shafts and the gear.
4. If the oil clearance isn't proper, replace the gear.

Backlash between idle gear and crank gear	Factory spec.	0.043 to 0.124 mm
	Allowable limit	0.15 mm

Backlash between idle gear and cam gear	Factory spec.	0.047 to 0.123 mm
	Allowable limit	0.15 mm

Backlash between idle gear and injection pump gear	Factory spec.	0.046 to 0.124 mm
	Allowable limit	0.15 mm

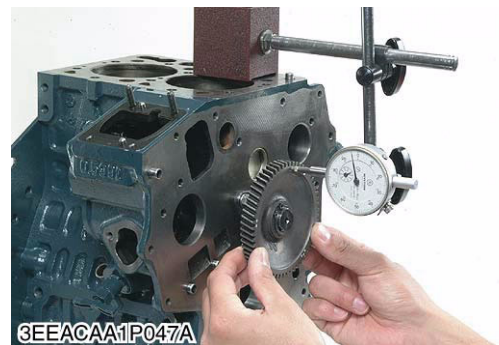
Backlash between oil pump drive gear and crank gear	Factory spec.	0.041 to 0.123 mm
	Allowable limit	0.15 mm



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 spec.	0.20 to 0.51 mm
	Allowable limit	0.80 mm



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 spec.	0.15 to 0.31 mm
	Allowable limit	0.50 mm



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
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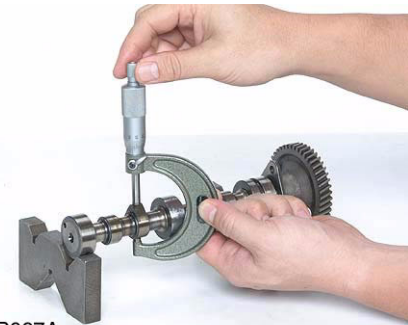


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Cam Height

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 spec.	26.88 mm
	Allowable limit	26.83 mm



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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 oil clearance exceeds the allowable limit, replace the camshaft.

Oil clearance of camshaft journal	Factory spec.	0.050 to 0.091 mm
	Allowable limit	0.15 mm



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Camshaft journal O.D.	Factory spec.	32.934 to 32.950 mm
Camshaft bearing I.D. (Cylinder block bore I.D.)	Factory spec.	33.000 to 33.025 mm



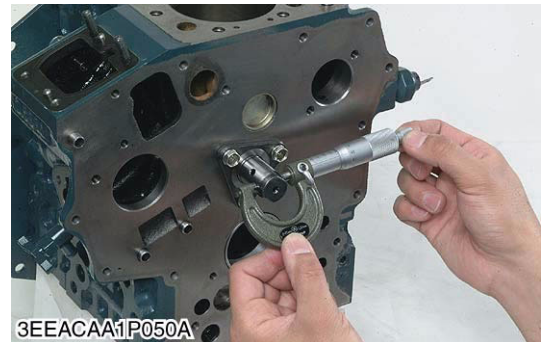
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Oil Clearance between Idle Gear Shaft and Idle Gear Bushing

1. Measure the idle gear shaft O.D. with an outside micrometer.
2. Measure the idle gear bushing 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 spec.	0.020 to 0.084 mm
	Allowable limit	0.10 mm

Idle gear shaft O.D.	Factory spec.	19.967 to 19.980 mm
Idle gear bushing I.D.	Factory spec.	20.000 to 20.051 mm



Replacing Idle Gear Bushing

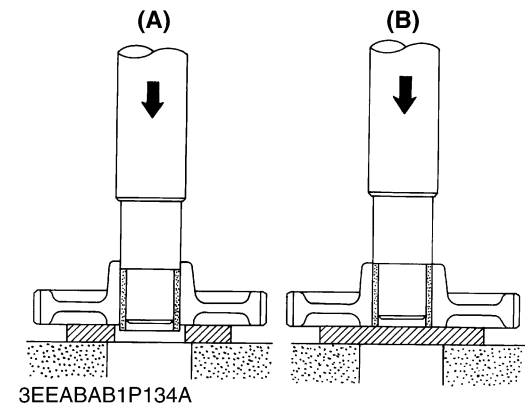
(When removing)

1. Press out the used idle gear bushing using an idle gear bushing replacing tool. (Refer to "SPECIAL TOOLS".)

(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

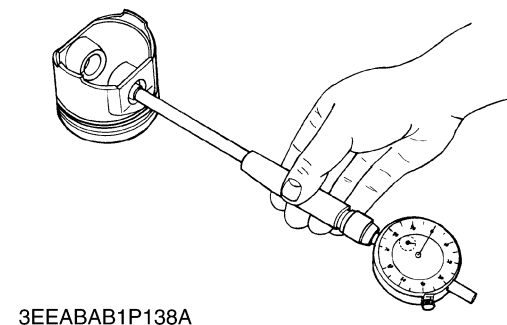


3) Piston and Connecting Rod

Piston Pin Bore I.D.

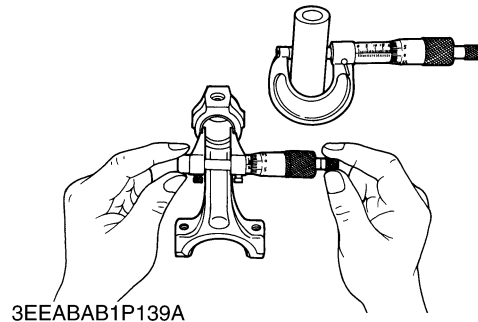
1. Measure the piston pin bore I.D. in both the horizontal and vertical directions with a cylinder gauge.
2. If the measurement exceeds the allowable limit, replace the piston.

Piston pin bore I.D.	Factory spec.	20.000 to 20.013 mm
	Allowable limit	20.05 mm



Oil Clearance between Piston Pin and Small End Bushing

1. Measure the piston pin O.D. 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.



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Oil clearance between piston pin and small end bushing	Factory spec.	0.014 to 0.038 mm
	Allowable limit	0.10 mm

Piston pin O.D.	Factory spec.	20.002 to 20.011 mm
Small end bushing I.D.	Factory spec.	20.025 to 20.040 mm

Replacing Small End Bushing

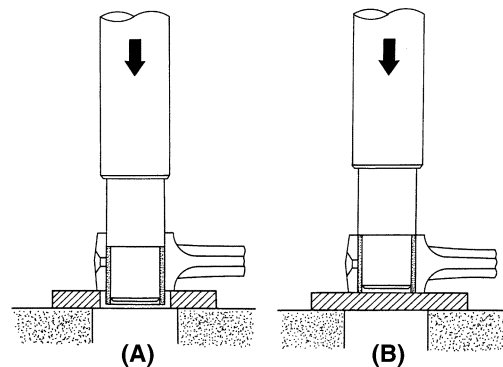
(When removing)

1. Press out the used bushing using a small end bushing replacing tool. (Refer to "SPECIAL TOOLS".)

(When installing)

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

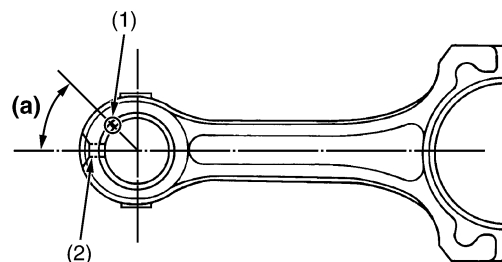
[Servicing parts dimension]



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Oil clearance between piston pin and small end bushing (Spare parts)	Factory spec.	0.015 to 0.075 mm
	Allowable limit	0.15 mm

Small end bushing I.D. (Spare parts)	Factory spec.	20.026 to 20.077 mm
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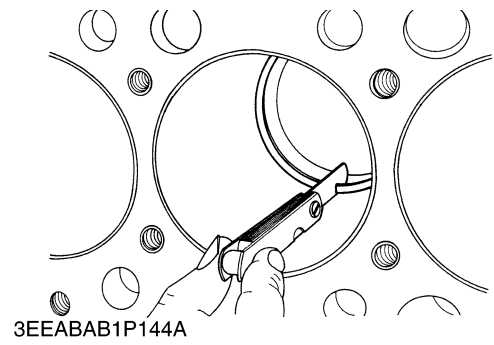
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- (1) Seam
- (2) Oil Hole
- (A) When removing
- (B) When installing
- (a) 45°

Piston Ring Gap

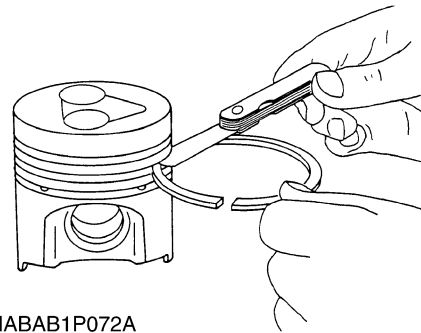
1. Insert the piston ring into the lower part of the cylinder (the least worn out part) with piston.
2. Measure the ring gap with a thickness gauge.
3. If the measurement exceeds the allowable limit, replace the piston ring.

Piston ring gap	Top ring	Factory spec.	0.25 to 0.40 mm
		Allowable limit	1.25 mm
	Second ring	Factory spec.	0.25 to 0.40 mm
		Allowable limit	1.25 mm
	Oil ring	Factory spec.	0.15 to 0.30 mm
		Allowable limit	1.25 mm



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.

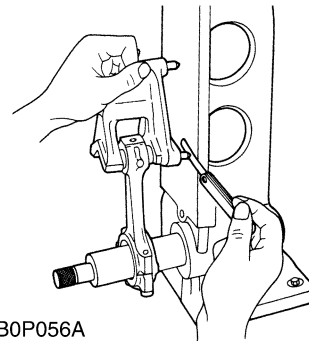


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Clearance between piston ring and piston ring groove	Second ring	Factory spec.	0.090 to 0.120 mm
		Allowable limit	0.15 mm
	Oil ring	Factory spec.	0.04 to 0.08 mm
		Allowable limit	0.15 mm

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 (Code No. KT07909-31661).
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.



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Space between gauge pin face plate	Allowable limit	0.05 mm
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4) Crankshaft

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 spec.	0.15 to 0.31 mm
	Allowable limit	0.50 mm

(Reference)

- Oversize thrust bearing

Oversize	Bearing	Code Number	Marking
0.2 mm	Thrust bearing 1 02	KT15261-23950	020 OS
	Thrust bearing 2 02	KT15261-23970	020 OS
0.4 mm	Thrust bearing 1 04	KT15261-23960	040 OS
	Thrust bearing 2 04	KT15261-23980	040 OS

- Oversize dimensions of crankshaft journal

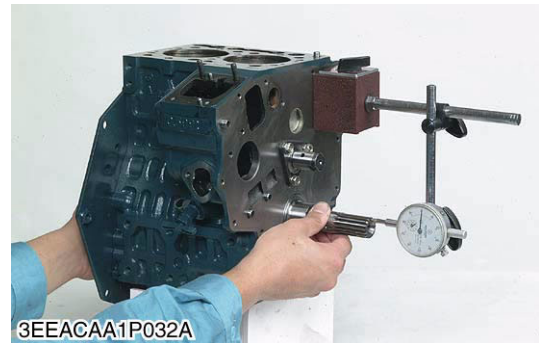
Oversize	0.2 mm	0.4 mm
Dimension A	23.40 to 23.45 mm	23.80 to 23.85 mm
Dimension B	46.1 to 46.3 mm	46.3 to 46.5 mm
Dimension C	1.8 to 2.2 mm radius	1.8 to 2.2 mm radius

(0.8-S)
The crankshaft journal must be fine-finished to higher than ▽▽▽▽

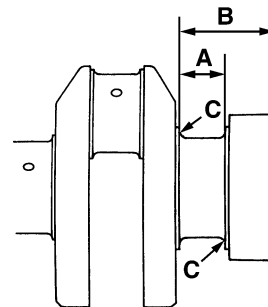
Crankshaft Alignment

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.

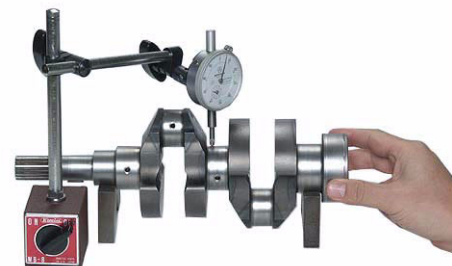
Crankshaft alignment	Allowable limit	0.02 mm
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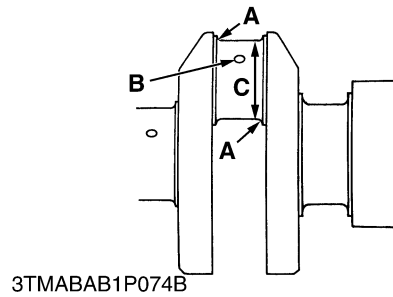
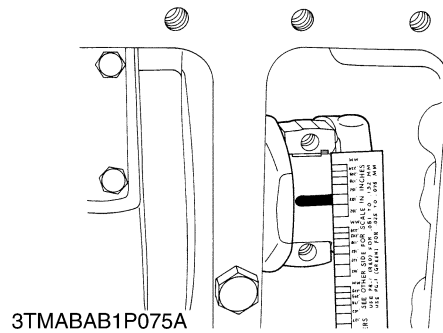
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Oil Clearance between Crankpin and Crankpin Bearing

1. Clean the crankpin and crankpin bearing.
2. Put a strip of plastigage (Code No.: KT07909-30241) 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 spec.	0.020 to 0.051 mm
	Allowable limit	0.15 mm

Crankpin O.D.	Factory spec.	33.959 to 33.975 mm
Crankpin bearing I.D.	Factory spec.	33.995 to 34.010 mm

(Reference)

- Undersize crankpin bearing

Undersize	Bearing	Code Number	Marking
0.2 mm	Crankpin bearing 02	KT15861-22970	020 US
0.4 mm	Crankpin bearing 04	KT15861-22980	040 US

- Undersize dimensions of crankpin

Undersize	0.2 mm	0.4 mm
Dimension A	2.3 to 2.7 mm radius	2.3 to 2.7 mm radius
Dimension B	4 mm dia.	4 mm dia.
Dimension C	33.759 to 33.775 mm dia.	33.559 to 33.575 mm dia.

(0.8-S)

The crankshaft journal must be fine-finished to higher than ▽▽▽▽

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 figure.

Oil clearance between crankshaft journal and crankshaft bearing 1	Factory spec.	0.034 to 0.106 mm
	Allowable limit	0.20 mm

Crankshaft journal O.D.	Factory spec.	39.934 to 39.950 mm
Crankshaft bearing 1 I.D.	Factory spec.	39.984 to 40.040 mm



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(Reference)

- Undersize crankshaft bearing 1

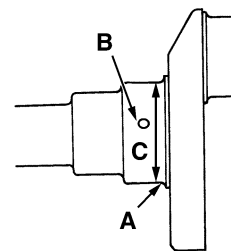
Undersize	Bearing	Code Number	Marking
0.2 mm	Crankshaft bearing 1 02	KT15861-23910	020 US
0.4 mm	Crankshaft bearing 1 04	KT15861-23920	040 US

- Undersize dimensions of crankshaft journal

Undersize	0.2 mm	0.4 mm
Dimension A	1.8 to 2.2 mm radius	1.8 to 2.2 mm radius
Dimension B	5 mm dia.	5 mm dia.
Dimension C	39.734 to 39.750 mm dia.	39.534 to 39.550 mm dia.

(0.8-S)

The crankshaft journal must be fine-finished to higher than ▽▽▽▽



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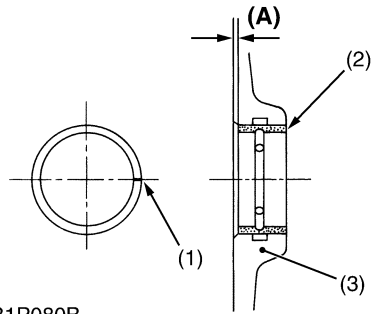
Replacing Crankshaft Bearing 1

(When removing)

1. Press out the used crankshaft bearing 1 using a crankshaft bearing 1 replacing tool. (Refer to "SPECIAL TOOLS".)

(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.)



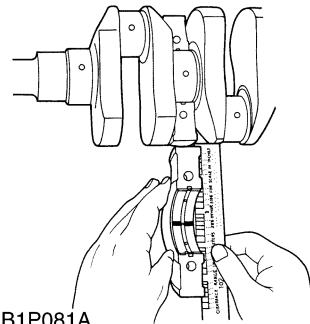
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Dimension (A)	Factory spec.	0.0 to 0.3 mm
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- (1) Seam
 - (2) Crankshaft Bearing 1
 - (3) Cylinder Block
- (A) Dimension**

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

1. Put a strip of plastigage (Code No. KT07909-30241) 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.



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■ **NOTE**

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

Oil clearance between crankshaft journal and crankshaft bearing 2 (Crankshaft bearing 3)	Factory spec.	0.028 to 0.059 mm
	Allowable limit	0.20 mm

Crankshaft journal O.D. (Flywheel side)	Factory spec.	43.934 to 43.950 mm
Crankshaft bearing 2 I.D.	Factory spec.	43.978 to 43.993 mm

Crankshaft journal O.D. (Intermediate)	Factory spec.	39.934 to 39.950 mm
Crankshaft bearing 3 I.D.	Factory spec.	39.978 to 39.993 mm

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

(Reference)

- Undersize crankshaft bearing 2 and 3 (0.2 mm)

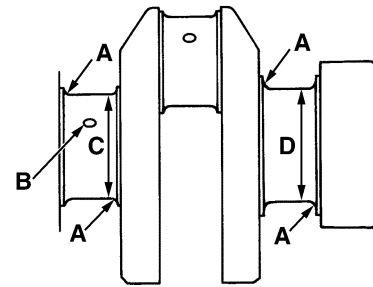
Bearing	Code Number	Marking
Crankshaft bearing 2 02	KT15694-23930	020 US
Crankshaft bearing 3 02	KT15861-23860	

- Undersize crankshaft bearing 2 and 3 (0.4 mm)

Bearing	Code Number	Marking
Crankshaft bearing 2 04	KT15694-23940	040 US
Crankshaft bearing 3 04	KT15861-23871	

- Undersize dimensions of crankshaft journal

Undersize	0.2 mm	0.4 mm
Dimension A	1.8 to 2.2 mm radius	1.8 to 2.2 mm radius
Dimension B	3 mm dia.	3 mm dia.
Dimension C	39.734 to 39.750 mm dia.	39.534 to 39.550 mm dia.
Dimension D	43.734 to 43.750 mm dia.	43.534 to 43.550 mm dia.
(0.8-S)		
The crankshaft journal must be fine-finished to higher than ▽▽▽▽		

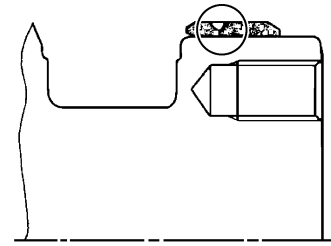


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Crankshaft Sleeve Wear

1. Check the wear on the crankshaft sleeve.
2. If the wear exceeds the allowable limit or when the engine oil leaks, replace the crankshaft sleeve.

Wear of sleeve	Allowable limit	0.1 mm
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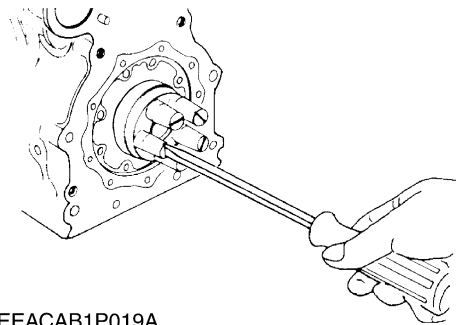
Replacing Crankshaft Sleeve

1. Remove the used crankshaft sleeve.
2. Set the sleeve guide (4) to the crankshaft.
3. Heat a new sleeve to a temperature between 150 and 200°C and fix the sleeve to the crankshaft as shown in figure.
4. Press fit the sleeve using the auxiliary socket for pushing (3) (Code No. KT07916-34041).

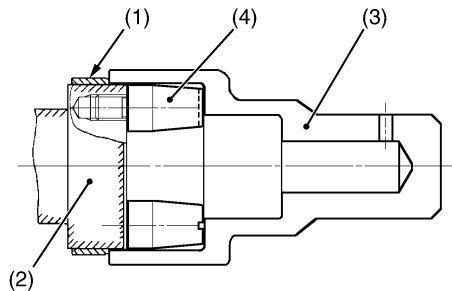
■ **NOTE**

- **Mount the sleeve with its largely chamfered surface facing outward.**
- **Should heating is not enough, a sleeve might stop halfway, so careful.**

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



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5) Cylinder

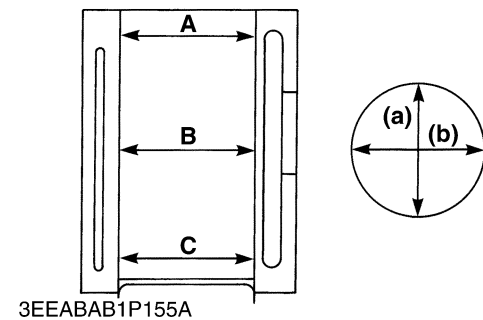
Cylinder Wear

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.
3. If the wear exceeds the allowable limit, bore and hone to the oversize dimension. (Refer to "Correcting Cylinder".)
4. Visually check the cylinder wall for scratches. If deep scratches are found, the cylinder should be bored. (Refer to "Correcting Cylinder".)



Cylinder I.D.	Factory spec.	67.000 to 67.019 mm
	Allowable limit	67.169 mm

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



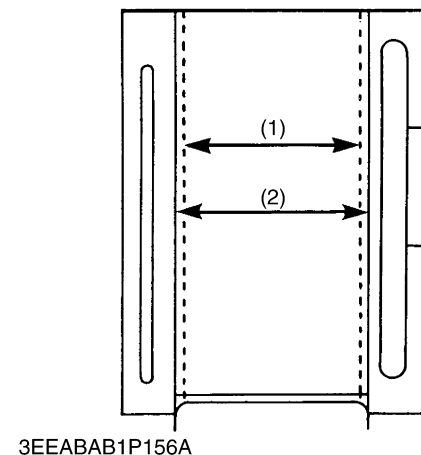
Correcting Cylinder

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

Cylinder I.D. [Oversize]	Factory spec.	67.250 to 67.269 mm
	Allowable limit	67.419 mm
Finishing	Horn to 1.2 to 2.0 μm Rmax. ▽▽▽▽	

2. Replace the piston and piston rings with oversize ones.
 Oversize : 0.25 mm

Part Name	Code Number	Marking
Piston	KT1E051-21900	025
Piston ring assembly	KT16853-21090	



NOTE

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

- (1) Cylinder I.D. (2) Cylinder I.D.
 [Before Correction] [Oversize]

6) Oil Pump

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.

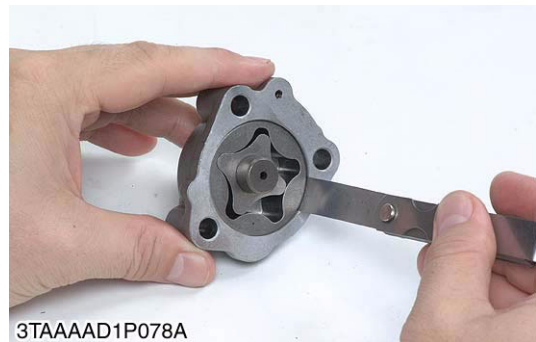
Rotor lobe clearance	Factory spec.	0.03 to 0.14 mm
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Clearance between Outer Rotor and Pump Body

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.

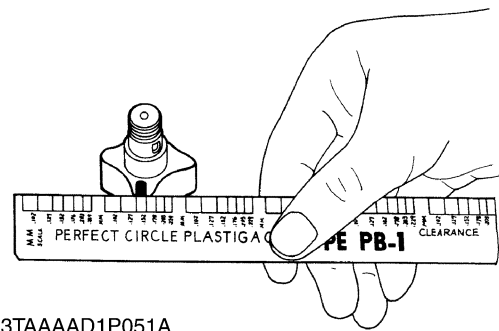
Clearance between outer rotor and pump body	Factory spec.	0.07 to 0.15 mm
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Clearance between Rotor and Cover

1. Put a strip of plastigage (Code No. KT07909-30241) 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 the oil pump rotor assembly.

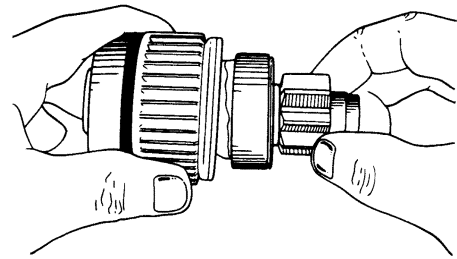
Clearance between rotor and cover	Factory spec.	0.075 to 0.135 mm
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7) Starting motor

Overrunning Clutch

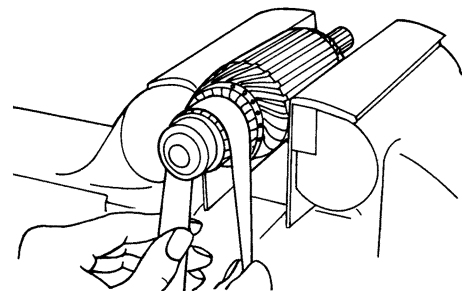
1. Inspect the pinion for wear or damage.
2. If there is any defect, replace the overrunning clutch assembly.
3. Check that the pinion turns freely and smoothly in the overrunning direction and does not slip in the cranking direction.
4. If the pinion slips or does not rotate in the both directions,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



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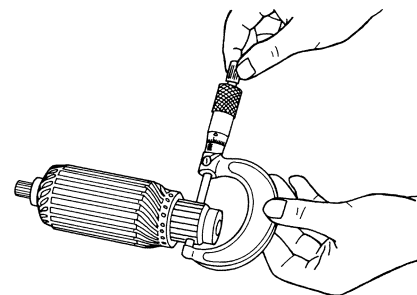
Commutator and Mica

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 it with a saw blade and chamfer the segment edges.



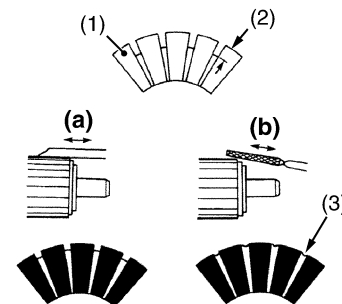
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Commutator O.D.	Factory spec.	Electromagnetic drive type	28.0 mm
		Planetary gear reduction type	30.0 mm
	Allowable limit	Electromagnetic drive type	27.0 mm
		Planetary gear reduction type	29.0 mm



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Difference of O.D.'s	Factory spec.	Electromagnetic drive type	Max. 0.05 mm
		Planetary gear reduction type	Max. 0.02 mm
	Allowable limit	Electromagnetic drive type	0.4 mm
		Planetary gear reduction type	0.05 mm



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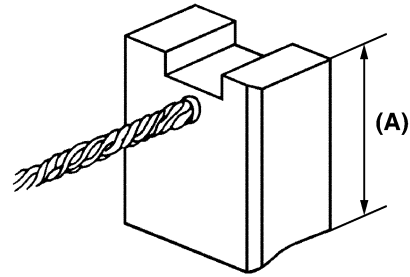
Mica undercut	Factory spec.	0.50 to 0.80 mm
	Allowable limit	0.20 mm

- (1) Segment (a) **Correct**
- (2) Undercut (b) **Incorrect**
- (3) Mica

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.

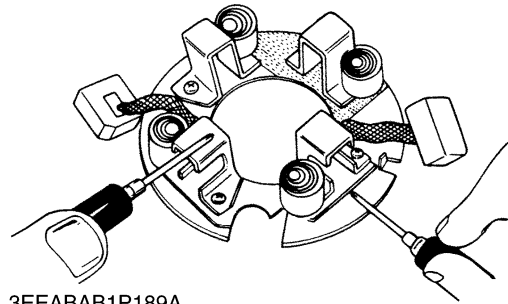
Brush length (A)	Factory spec.	Electromagnetic drive type	16.0 mm
		Planetary gear reduction type	14.0 mm
	Allowable limit	Electromagnetic drive type	10.5 mm
		Planetary gear reduction type	9.0 mm



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Brush Holder

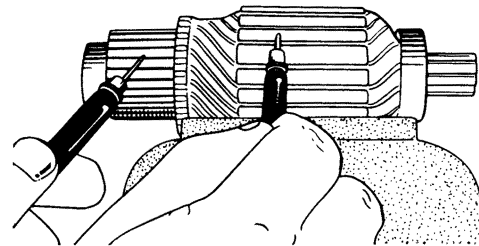
1. Check the continuity across the brush holder and the holder support with an ohmmeter.
2. If it conducts, replace the brush holder.



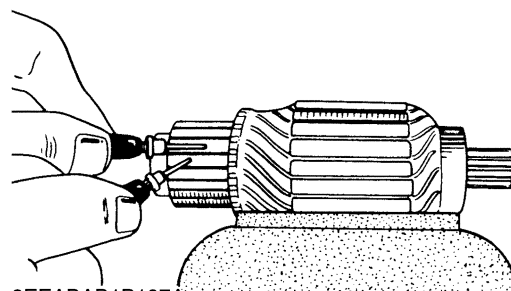
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Armature Coil

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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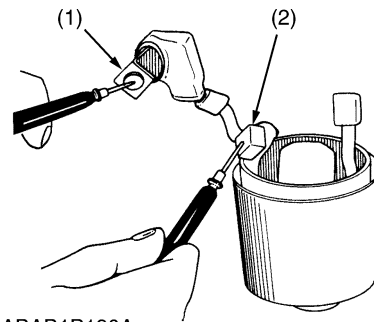


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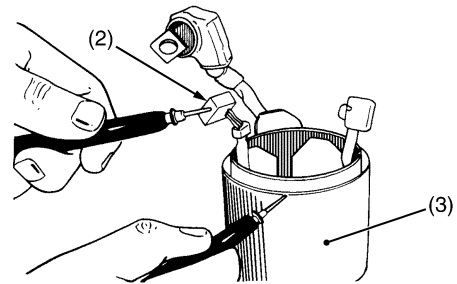
Field Coil

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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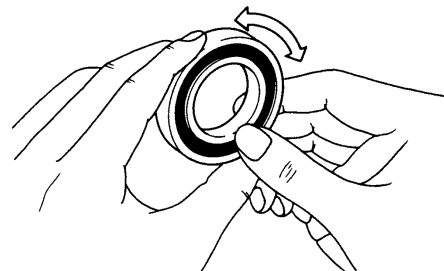


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8) Alternator

Bearing

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

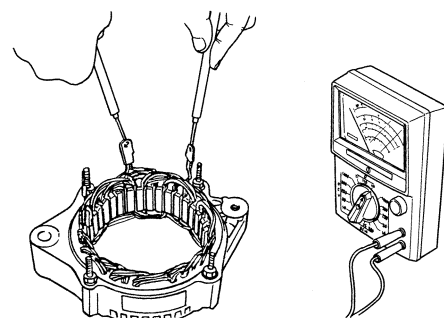


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Stator

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

Stator resistance	Factory spec.	Max. 1.0 Ω
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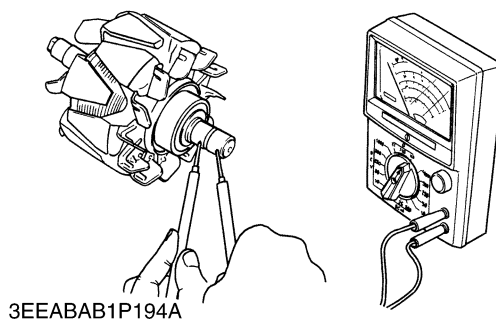


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Rotor

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 an ohmmeter.
4. If continuous, replace it.

Rotor resistance	Factory spec.	2.9 Ω
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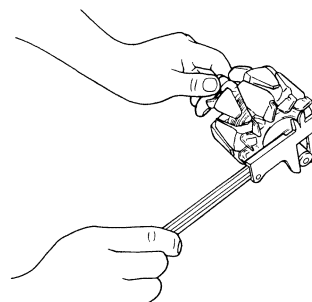


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Slip Ring

1. Check the slip ring for score.
2. If scored, correct with an sand paper or on a lathe.

Slip ring O.D.	Factory spec.	14.4 mm
	Allowable limit	14.0 mm

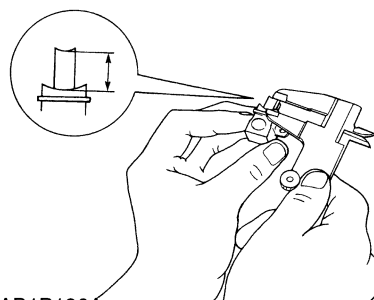


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Brush Wear

1. Check the length of the brush, if the length is shorter than the allowable limit, replace it.
2. Make sure that the brush moves smoothly.
3. If the brush is defective, replace it

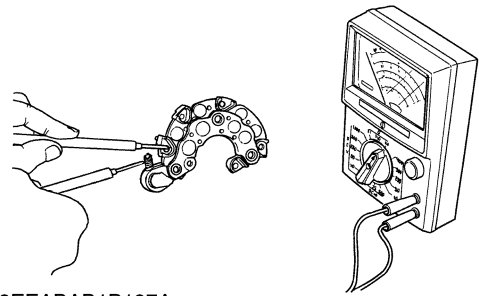
Brush length	Factory spec.	10.0 mm
	Allowable limit	1.5 mm



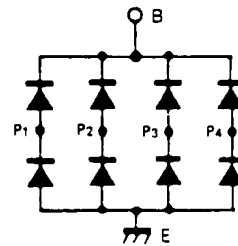
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Rectifier

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



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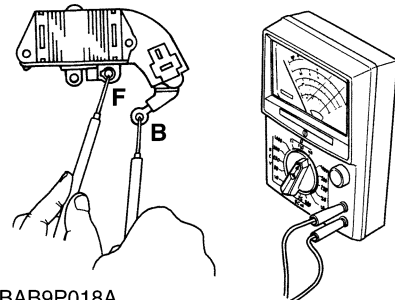
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IC Regulator

1. Check the continuity across the "B" terminal and the "F" terminal of IC regulator with an ohmmeter.
2. The IC regulator is normal if the conducts in one direction and does not conduct in the reverse direction.

B: "B" Terminal

F: "F" Terminal

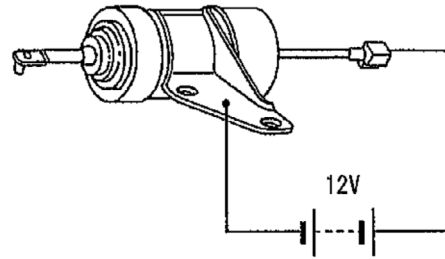


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9) Stop solenoid

Check of operation

1. Remove the stop solenoid from the engine.
2. Apply DC 12 V between the IP connector and body of the stop solenoid and check that the plunger is pulled in.
3. If the check result is abnormal, replace the stop solenoid.



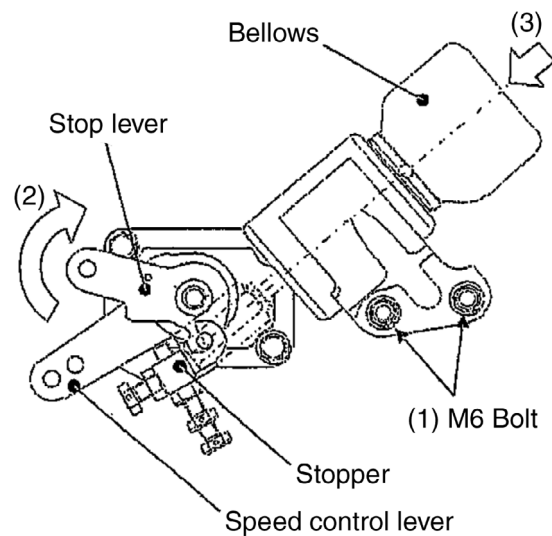
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Installation procedure

1. Insert the stop solenoid hook in the U-groove of the stop lever and tighten the 2 M6 bolts lightly.
2. Move the stop lever with the hand in the direction of the arrow and pull the stop solenoid rod. While the stop lever is in contact with the stopper, tighten the 2 M6 bolts to fix the stop solenoid.
3. After installing, push the end of the plunger at the stop solenoid bellows to check that the plunger moves smoothly.
4. After installing the stop solenoid, check the safety and then start and stop the engine to check the operation of the stop solenoid.

NOTE

- While the stop lever is set as shown in the figure, the engine is running.



NOTE

- While the power is applied, if the stop solenoid hook presses the stop lever strongly, the stop solenoid may not be installed normally. In this case, check the installing condition. If the moving stroke of the stop solenoid is insufficient, the holding force of the holding coil lowers and the rod may return to the stop position after the pulling coil is turned OFF.

