WSM

WORKSHOP MANUAL
DIESEL ENGINES

68mm STROKE SERIES
(SM SERIES)

Kubota

KiSC issued 04, 2006 A

TO THE READER

This Workshop Manual has been prepared to provide servicing personnel with information on the mechanism, service and maintenance of KUBOTA Diesel Engine 68 mm STROKE SERIES. It is divided into two parts, "Mechanism" and "Disassembling and Servicing".

■ **Mechanism**

Information on construction and functions are included for each engine section. This part should be understood before proceeding with trouble-shooting, disassembling and servicing.

■ **Disassembling and Servicing**

Under the heading "General" come general precautions, troubleshooting, lists of servicing specifications and periodic inspection items. For each engine section, there are "Checking and Adjustment", "Disassembling and Assembling", and "Servicing" which cover procedures, precautions, factory specification and allowable limits.

All the engines that have been menufactured since January of 1994 are clean exhaust engines.

The mark [E] in the WSM refers to the said clean engine.

All information, illustrations and specifications contained in this manual are based on the latest production information available at the time of publication. The right is reserved to make changes in all information at any time without notice.

July 1990

CONTENTS

M. MECHANISM

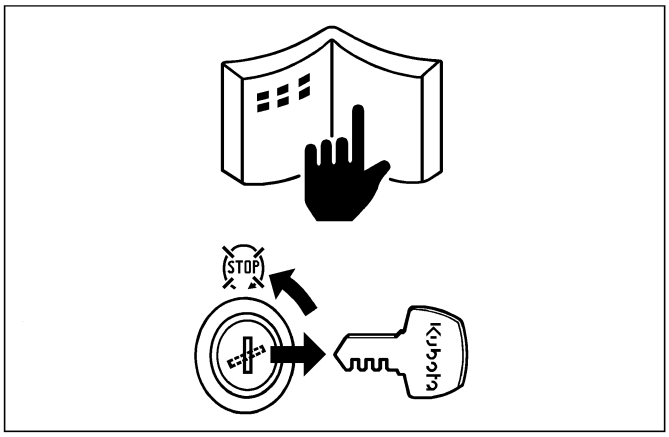
S. DISASSEMBLING AND SERVICING

⚠ 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.

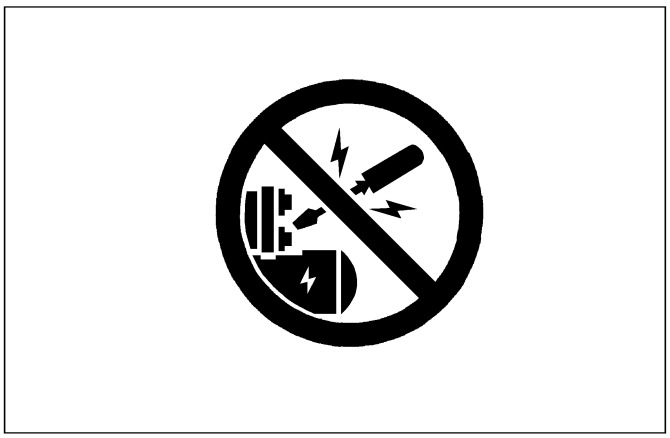
It is essential that you read the instructions and safety regulations before you attempt to repair or use this unit.

⚠ **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.**



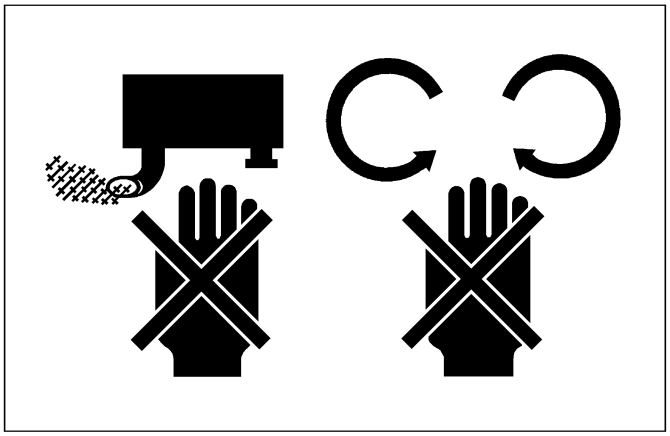
BEFORE SERVICING AND REPAIRING

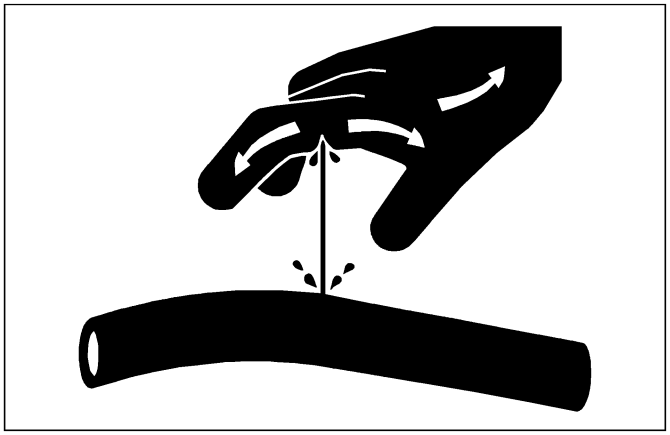
- Read all instructions and safety instructions in this manual and on your engine safety decals.
- Clean the work area and engine.
- Park the machine on a firm and level ground.
- Allow the engine to cool before proceeding.
- Stop the engine, and remove the key.
- Disconnect the battery negative cable.



SAFETY STARTING

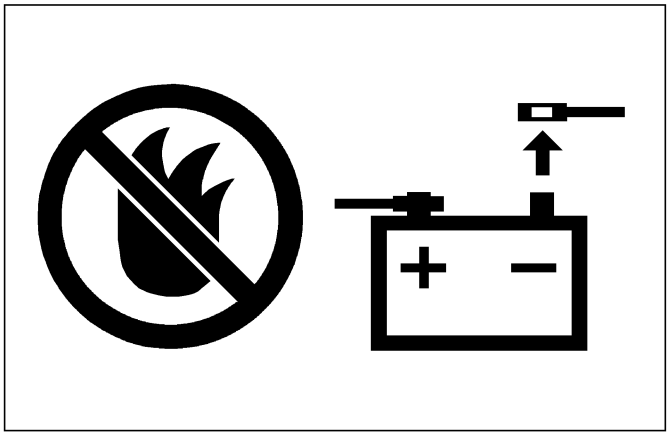
- Do not start the engine by shorting across starter terminals or bypassing the safety start switch.
- Unauthorized modifications to the engine may impair the function and / or safety and affect engine life.





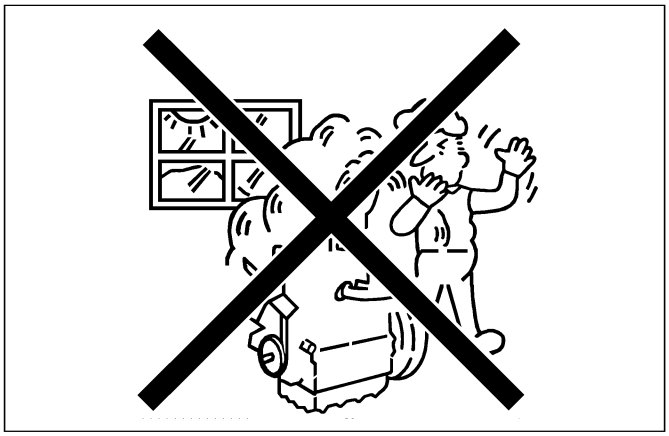
SAFETY WORKING

- 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.



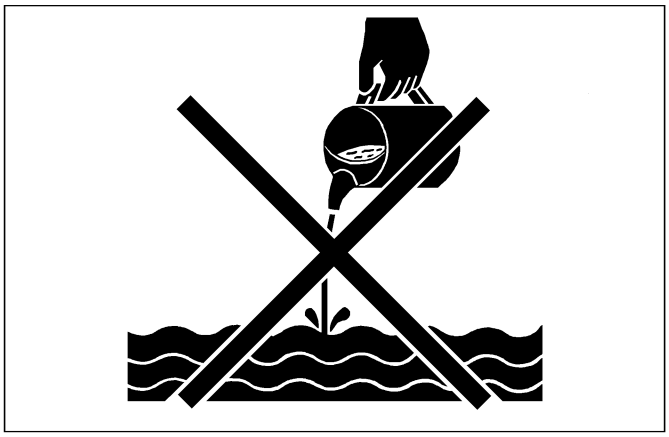
AVOID FIRES

- 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.



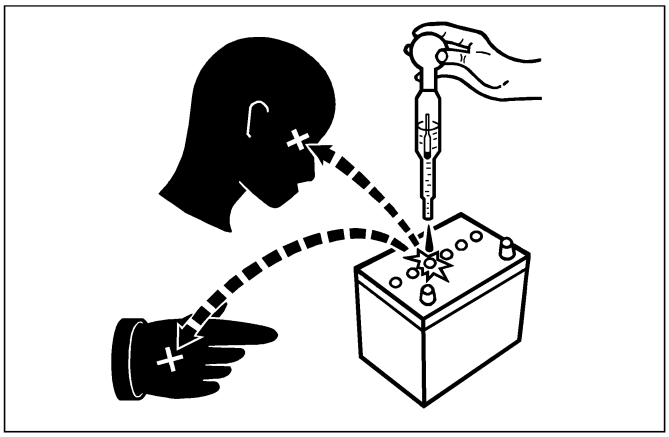
VENTILATE WORK AREA

- 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.



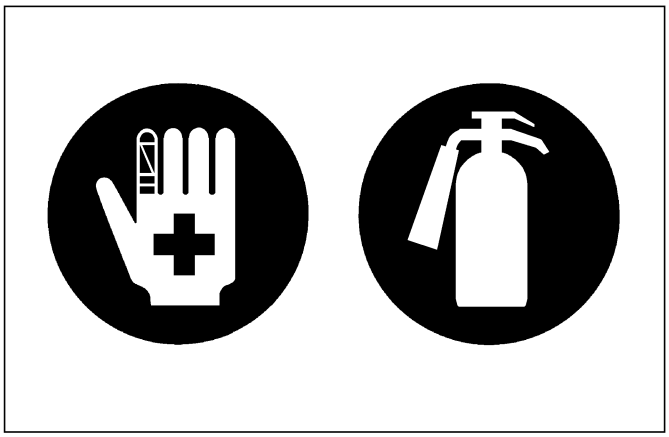
DISPOSE OF FLUIDS PROPERLY

- 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.

SPECIFICATIONS

Model		Z442-B (E)	Z482-B (E)	D662-B (E)	D722-B (E)
Type		Vertical, liquid cooled, 4-cycle diesel engine			
Number of Cylinders		2	2	3	3
Bore x Stroke mm (in.)		64 x 68 (2.52 x 2.68)	67 x 68 (2.64 x 2.68)	64 x 68 (2.52 x 2.68)	67 x 68 (2.64 x 2.68)
Total Displacement CC (cu. in.)		437 (26.70)	479 (29.23)	656 (40.05)	719 (43.89)
Brake Horse Power	SAE Net Cont. H.P. kW/ min^{-1} (rpm) (HP/ min^{-1} (rpm))	7.5 / 3600 (10.0 / 3600)	8.1 / 3600 (10.8 / 3600)	11.2 / 3600 (15.0 / 3600)	12.2 / 3600 (16.3 / 3600)
	SAE Net Intermittent H.P. kW/ min^{-1} (rpm) (HP/ min^{-1} (rpm))	8.6 / 3600 (11.5 / 3600)	9.3 / 3600 (12.5 / 3600)	12.9 / 3600 (17.3 / 3600)	14.0 / 3600 (18.8 / 3600)
	SAE Gross Intermittent H.P. kW/ min^{-1} (rpm) (HP/ min^{-1} (rpm))	9.5 / 3600 (12.7 / 3600)	10.4 / 3600 (13.9 / 3600)	14.3 / 3600 (19.2 / 3600)	15.6 / 3600 (20.9 / 3600)
	DIN 6271-NA kW/ min^{-1} (rpm) (ps/ min^{-1} (rpm))	7.4 / 3600 (10.0 / 3600)	7.9 / 3600 (10.8 / 3600)	11.0 / 3600 (15.0 / 3600)	12.1 / 3600 (16.4 / 3600)
	DIN 6271-NB kW/ min^{-1} (rpm) (ps/ min^{-1} (rpm))	8.2 / 3600 (11.1 / 3600)	8.9 / 3600 (12.1 / 3600)	12.3 / 3600 (16.7 / 3600)	13.3 / 3600 (18.1 / 3600)
	DIN 70020 kW/ min^{-1} (rpm) (ps/ min^{-1} (rpm))	8.9 / 3600 (12.1 / 3600)	9.7 / 3600 (13.2 / 3600)	13.5 / 3600 (18.3 / 3600)	14.6 / 3600 (19.9 / 3600)
Maximum Bare Speed		3800 min^{-1} (rpm)			
Minimum Bare Idling Speed		900 to 1000 min^{-1} (rpm)			
Combustion Chamber		Spherical type			
Fuel Injection Pump		Bosch MD mini Pump			
Governor		Centrifugal Ball Mechanical Governor			
Direction of Rotation		Counter-clockwise (viewed from flywheel)			
Injection Nozzle		Bosch Throttle Type			
Injection Timing		0.35 to 0.38 rad (20° to 22°) before T.D.C.			
Injection Order		1 - 2	1 - 2	1 - 2 - 3	1 - 2 - 3
Injection Pressure		13.73 MPa (140 kgf/cm^2, 1991 psi)			
Compression Ratio		23 : 1			
Lubricating System		Forced Lubrication by Pump			
Oil Pressure Indication		Electrical Type Switch			
Lubricating Filter		Fuel Flow Paper Filter (Cartridge Type)			
Cooling System		Pressurized Radiator (not included in the basic model), Forced Circulation with Water Pump			
Starting System		Electric starting with Cell Starter			
		12 V, 0.8 kW			
Starting Support Device		by Glow Plug in Combustion Chamber			
Battery		12 V, 35 AH, equivalent			
Generator for Charging		12 V, 150 W			
Fuel		Diesel Fuel No. 2-D (ASTM D975)			
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 S-12, 15.			
Lubricating Oil Capacity		2.1 L (2.2 U.S.qts., Oil pan depth 101 mm)		3.2 L (3.4 U.S.qts., Oil pan depth 101 mm)	
		2.5 L (2.6 U.S.qts., Oil pan depth 121 mm)		3.8 L (4.0 U.S.qts., Oil pan depth 121 mm)	
Weight (Dry)		53.1 kg (117.1 lbs)	53.1 kg (117.1 lbs)	63.7 kg (140.4 lbs)	63.1 kg(139.1 lbs)
Application		General Power Source			

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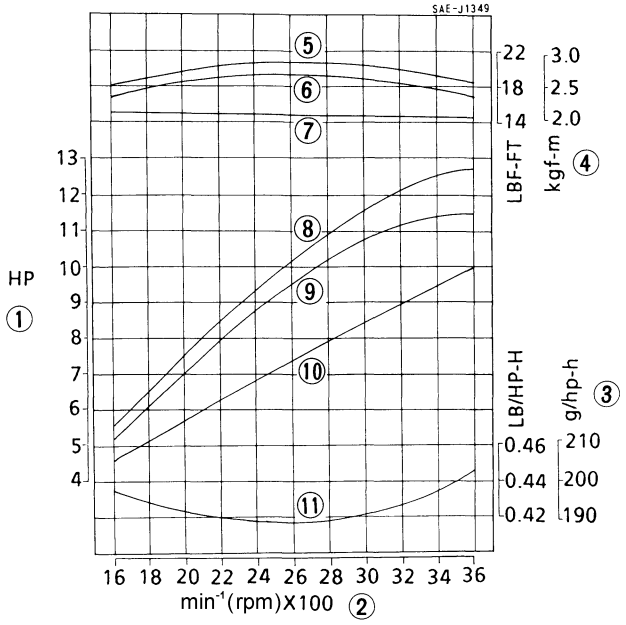
PERFORMANCE CURVES

■ Z442-B (E)

(SAE)



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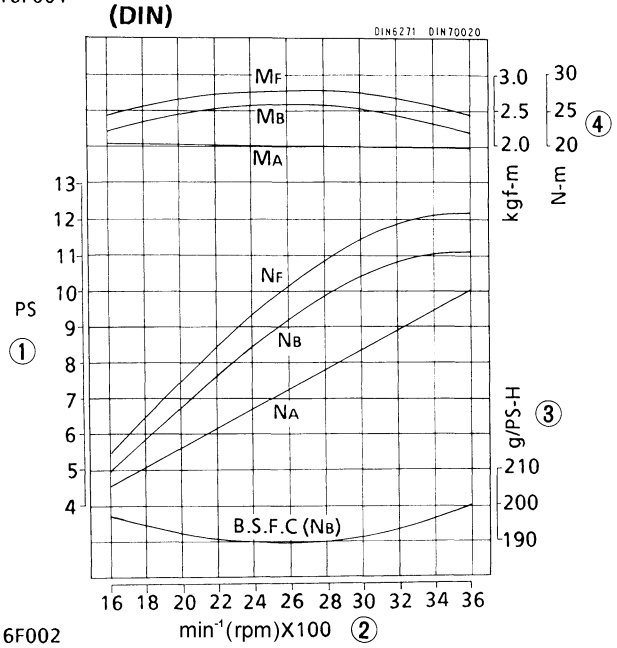
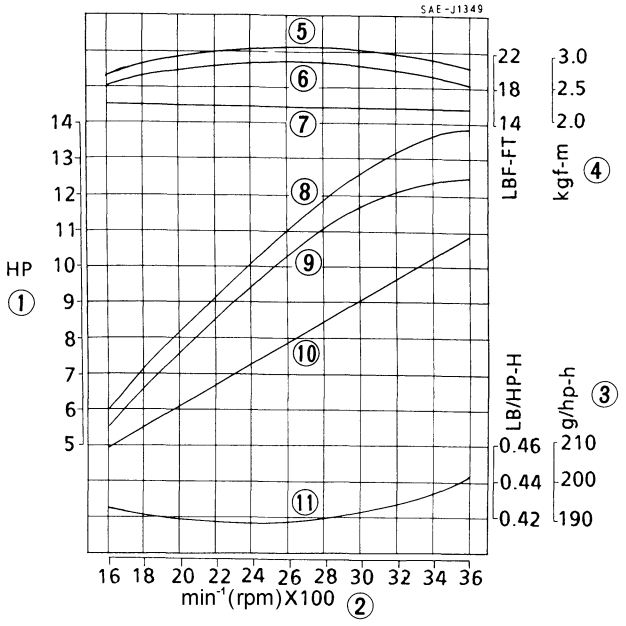


■ Z482-B (E)

(SAE)



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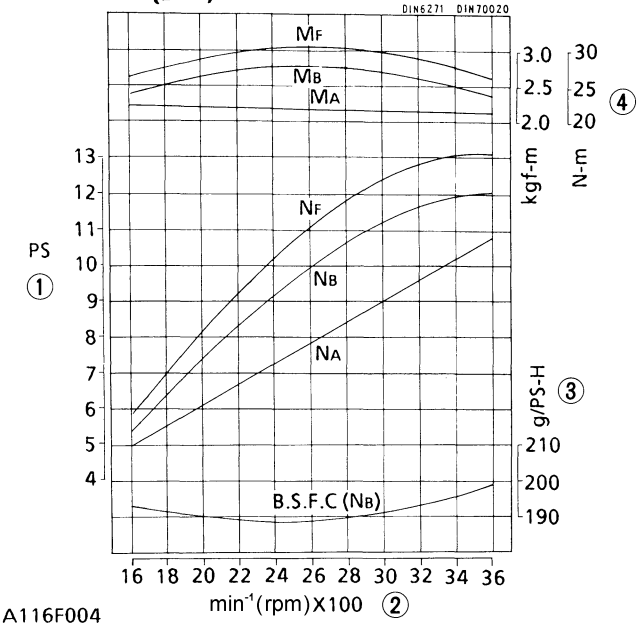

(1) Brake Horsepower
(2) Engine Speed
(3) B.S.F.C.
(4) Torque
(5) Gross Intermittent Torque
(6) Net Intermittent Torque
(7) Net Cont. Torque
(8) Gross Intermittent B.H.P.
(9) Net Intermittent B.H.P.
(10) Net Cont. B.H.P.
(11) B.S.F.C. (Net Intermittent)

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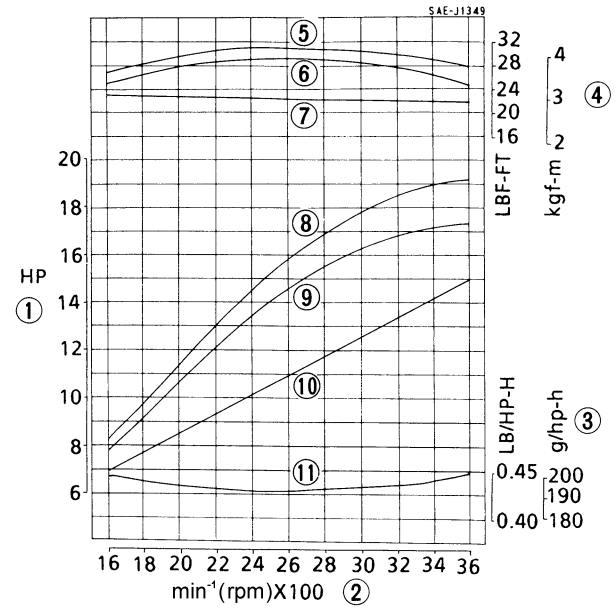
■ D662-B (E)

(SAE)



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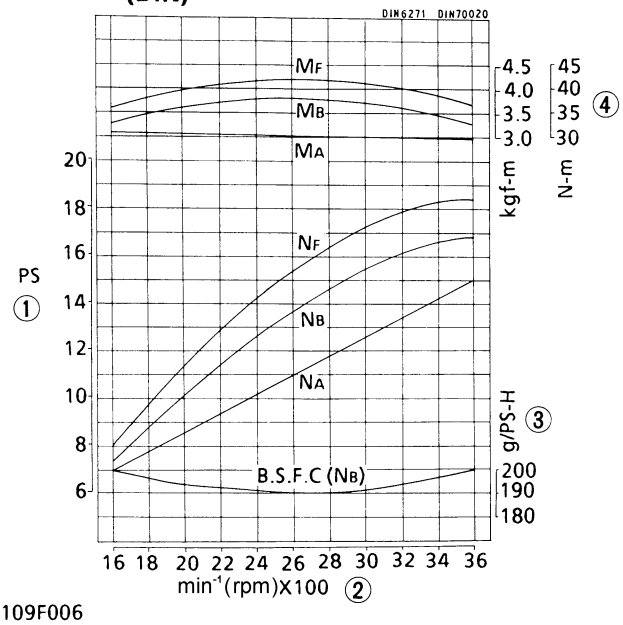

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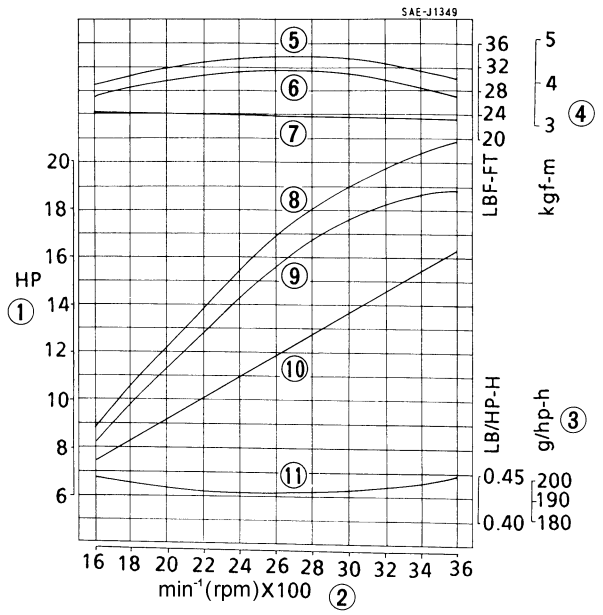
■ D722-B (E)

(SAE)



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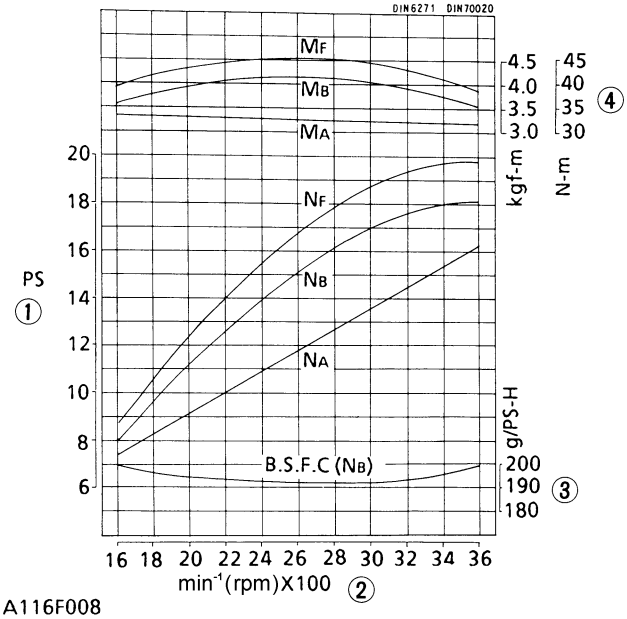

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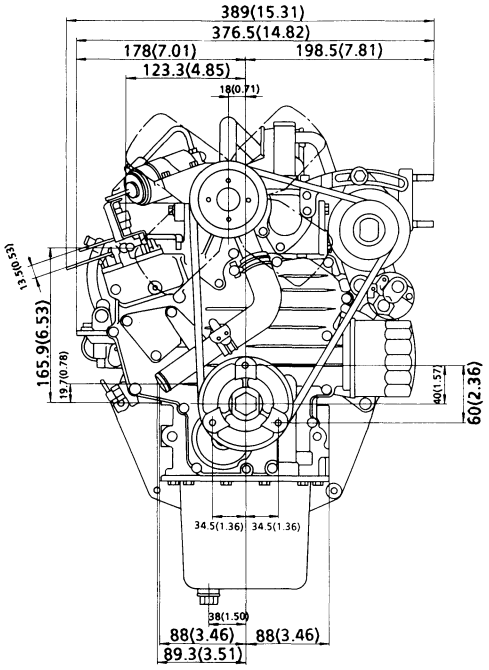
(1) Brake Horsepower
(2) Engine Speed
(3) B.S.F.C.
(4) Torque
(5) Gross Intermittent Torque
(6) Net Intermittent Torque
(7) Net Cont. Torque
(8) Gross Intermittent B.H.P.
(9) Net Intermittent B.H.P.
(10) Net Cont. B.H.P.
(11) B.S.F.C. (Net Intermittent)

DIMENSIONS

■ Z442-B (E), Z482-B (E)

Unit: mm (in.)



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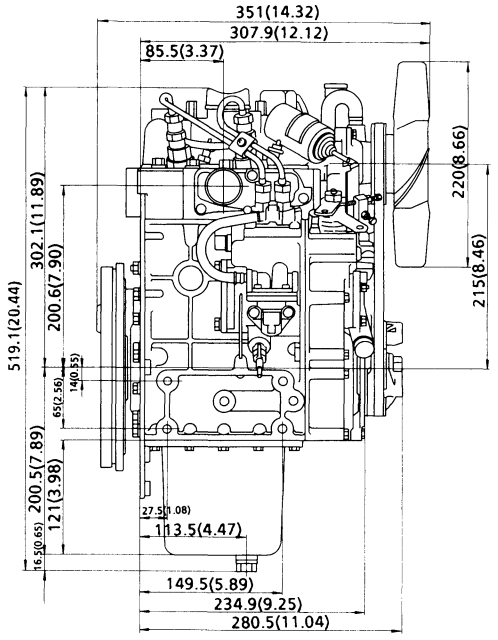

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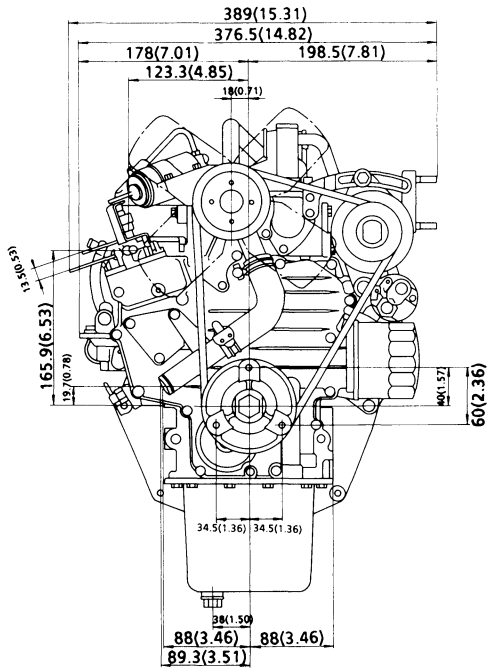
■ D662-B (E), D722-B (E)



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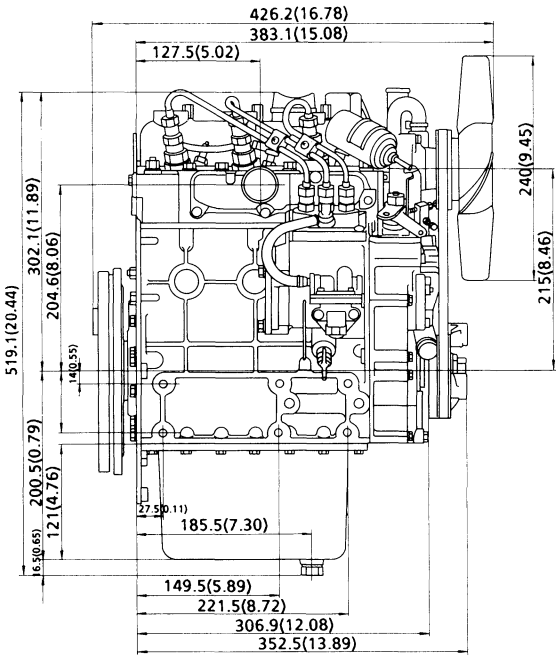

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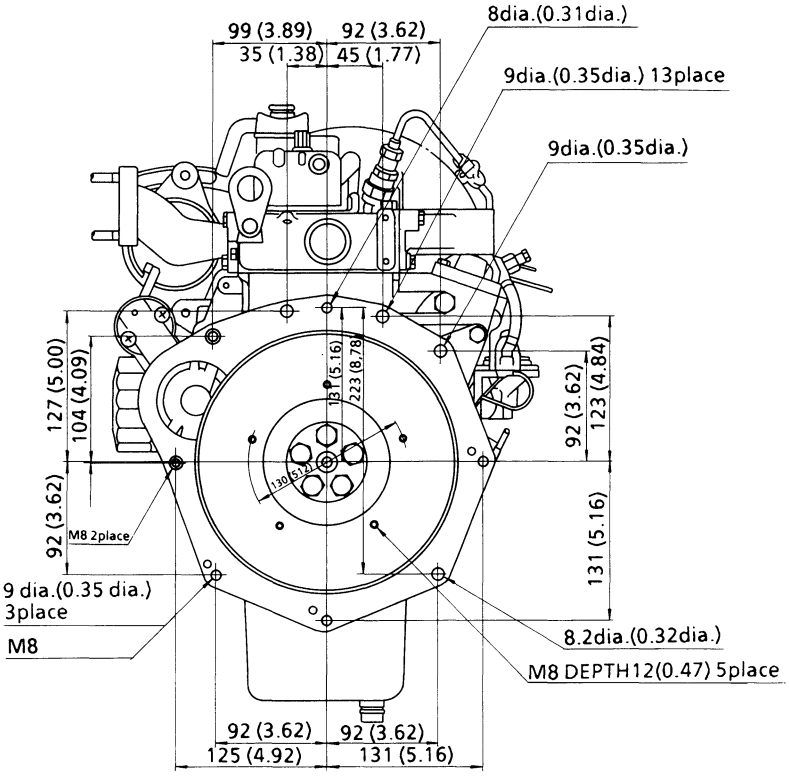
■ Z442-B (E), Z482-B (E)
D662-B (E), D722-B (E)

Unit: mm (in.)

A: 16 dia. (0.63 dia.)
B: 25.4 dia. (1.00 dia.)
C: 12 (0.47)
D: 8 (0.31)



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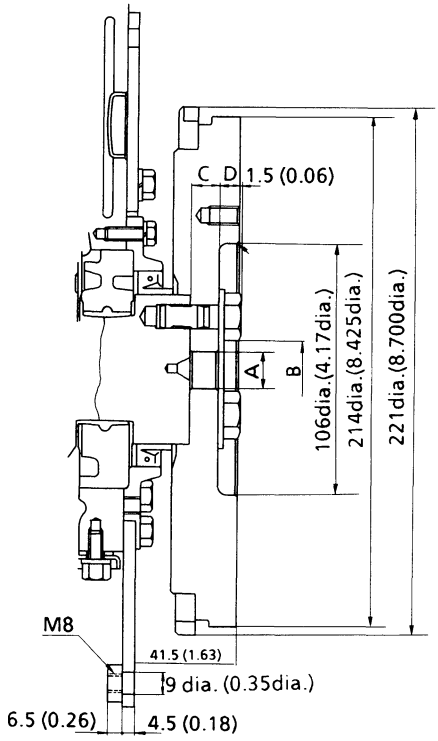

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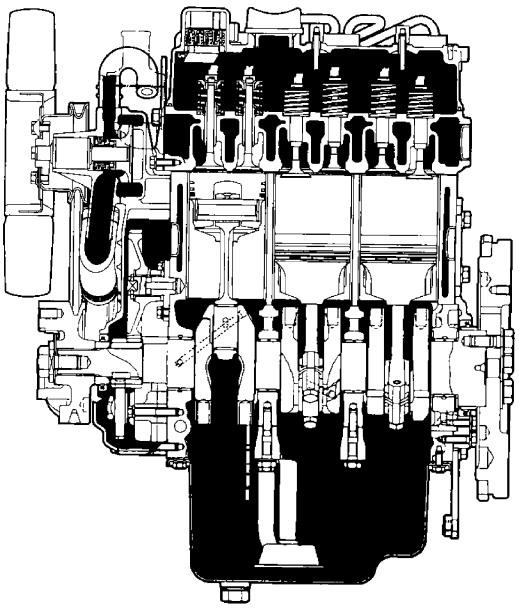
F FEATURE



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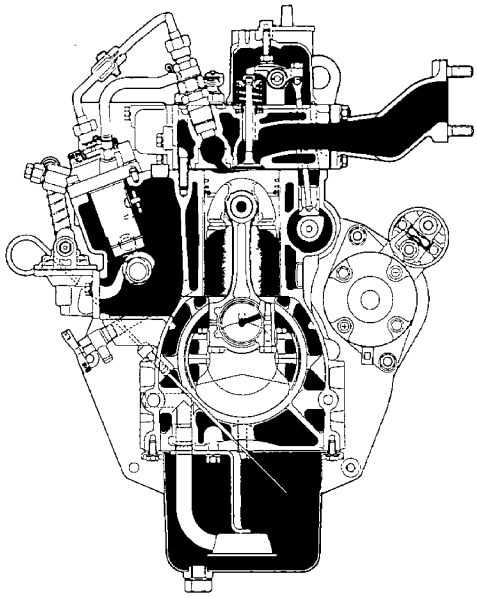

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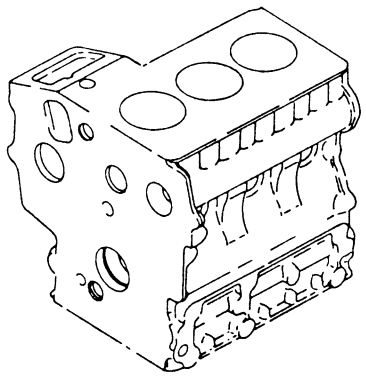
The Z442-B, Z482-B, D662-B, D722-B are vertical, liquid-cooled, 4-cycle diesel engines.
They incorporate KUBOTA's foremost technologies. With KUBOTA's the "NTVCS" (New Three Vortex Combustion System), well-known Bosch MD mini type injection pump and the well-balanced design, they give greater power, low fuel consumption, little vibration and quiet operation.

■ **NOTE**

- **Since January 1994, E-TVCS has been used for the combustion chamber of our products instead of traditional N-TVCS.**
  E-TVCS was developed with an eye toward clean exhaust gas which is more environmentally friendly.
  The combustion chamber models mentioned hereinafter refers to E-TVCS.
  Model of combustion chamber :
  N-TVCS (Engine Serial Number ; 489290 or lower)
  E-TVCS (Engine Serial Number ; 489291 or higher)

1 ENGINE BODY

[1] CYLINDER BLOCK



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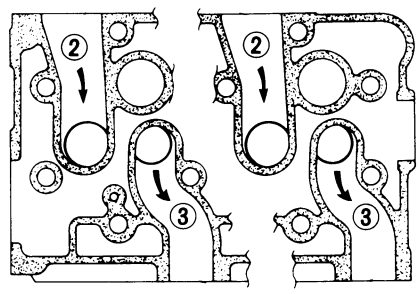
The engine has a high durability tunnel-type cylinder block in which the crank bearing component is a constructed body. Furthermore, liner less type, allow effective cooling, less distortion, and greater wear-resistance. The noise level is reduced to a minimum because each cylinder has its own chamber.

[2] CYLINDER HEAD



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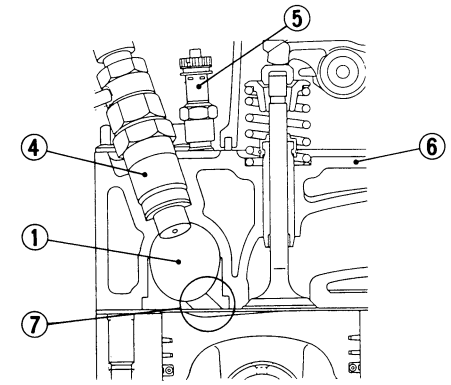

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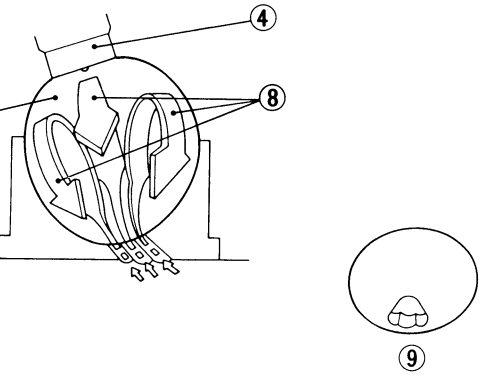

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The cross-flow type intake/exhaust ports in this engine have their openings at both sides of the cylinder head. Because overlaps of intake/exhaust ports are smaller than in ports of other types which have openings on one side, the suction air can be protected from being heated and expanded by heated exhaust air. The cool, high density suction air has high volume efficiency and raises the power of the engine. Furthermore, distortion of the cylinder head by heated exhaust gas is reduced because intake ports are arranged alternately. The combustion chamber is of KUBOTA's exclusive New TVCS combustion chamber type. Suction air is whirled to be mixed effectively with fuel, prompting combustion and reducing fuel consumption.

In the combustion chamber are installed throttle type injection nozzle and rapid heating sheathed type glow plug. This glow plug assures easier than ever engine starts even at −15°C (5°F).

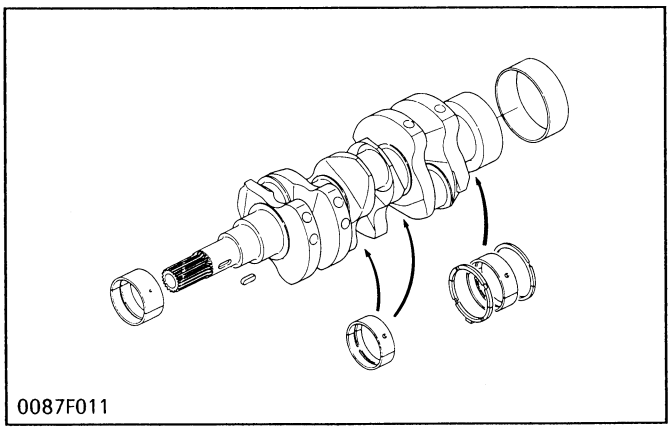
(1) Combustion Chamber
(2) Intake Port
(3) Exhaust Port
(4) Nozzle Assembly
(5) Glow Plug
(6) Cylinder Head
(7) Fan-shaped Concave
(8) Stream
(9) Air Inlet

■ Combustion System

These engine use the "NTVCS" (New Three Vortex Combustion System) to achieve perfect combustion for maximum power. The NTVCS combustion system provides unique shape of throat in the air inlet (9) for combustion chamber, to produce three streams (8) of air in the chamber (1) when compressing, giving an ideal mixture of air and fuel.

In addition, a fan-shaped concave (7) is provided on top of the piston to allow a smooth ejection of the exhaust gas, offering highly efficient combustion.

[3] CRANKSHAFT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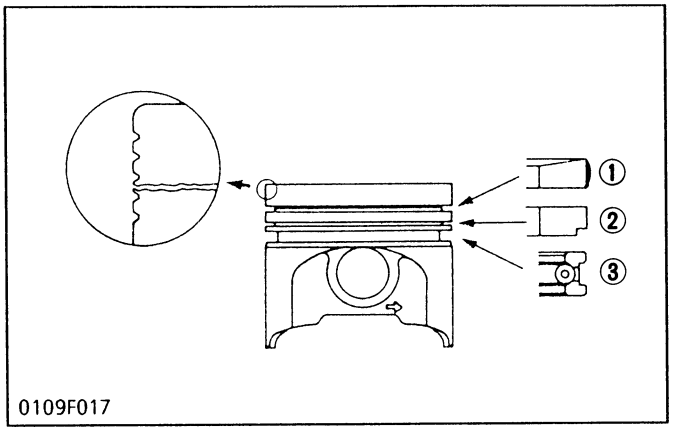
The crankshaft with the connecting rod converts the reciprocating motion of the piston into the rotating motion.

The crankshaft is made of tough special alloy steel, and the journals, pins and oil seal sliding portions are induction hardened to increase the hardness for higher wear resistance.

The front journal is supported by a solid type bearing, the intermediate journal by a split type, and the rear journal by a split type with thrust bearings.

The crankshaft is provided with an oil gallery, through which engine oil is fed to the crank pin portion, and lubricate it.

[4] PISTON AND PISTON RINGS



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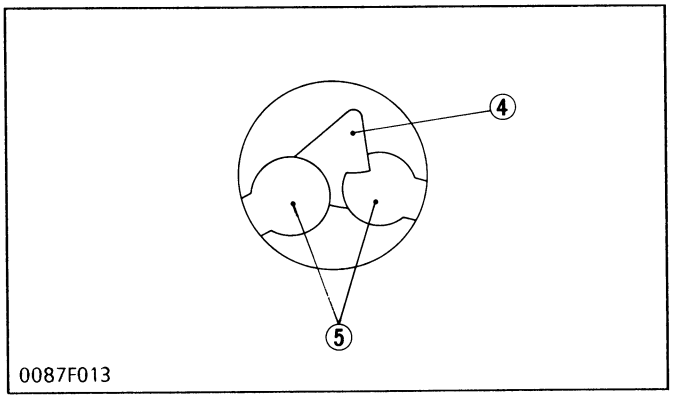


0087F013

The piston is made of aluminum alloy.

Two recesses for the valves are provided on top of the piston. A fan-shaped depression is also given atop the piston in order to allow combustion gas to jet smoothly. The piston pin is slightly out of the center of the piston. In this design, the run-out of the piston at the top and bottom dead points can be reduced, thereby resulting in lower operating noise.

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

Three rings are installed in grooves in the piston.

The top ring (1) is a keystone type, which can stand against heavy loads, and the barrel face on the ring fits well to the cylinder wall.

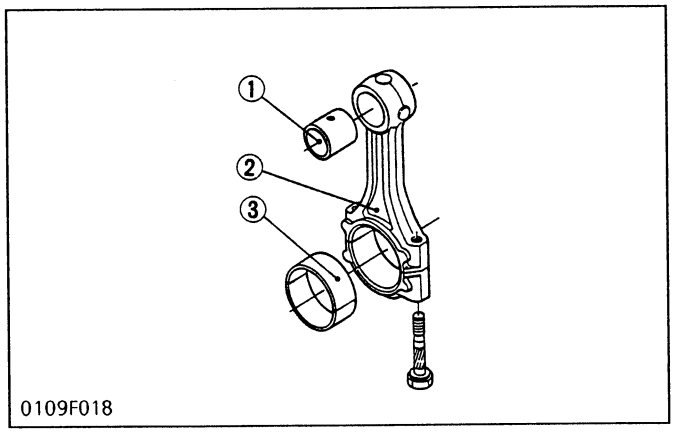
The second ring (2) is an undercut type, which effectively prevents the oil from being carried up.

The oil ring (3) has chamfered contact faces and an expander ring, which increase the pressure of the oil ring against the cylinder wall.

Several grooves are cut on the topland to help heat dissipate and to prevent scuffing.

(1) Top Ring
(2) Second Ring
(3) Oil Ring
(4) Fan-Shaped Concave
(5) Valve Recess

[5] CONNECTING ROD

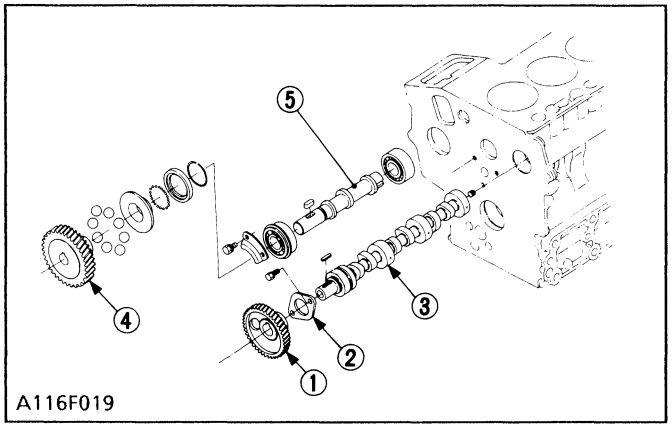


0109F018

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

(1) Small End Bushing
(2) Connecting Rod
(3) Crank pin Bearing

[6] CAMSHAFT

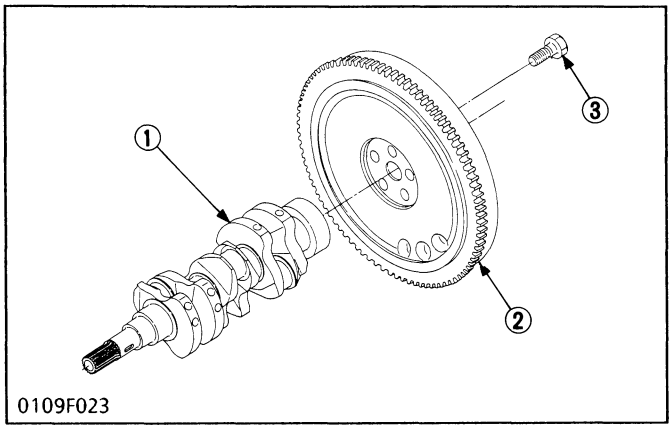


A116F019

The camshaft (3) is made of special cast iron and the journal and cam sections are chilled to resist wear. The journal sections are force-lubricated. The fuel camshaft (5) controls the reciprocating movement of the injection pump. The fuel camshaft is made of carbon steel and the cam sections are quenched and tempered to provide greater wear resistance.

(1) Cam Gear
(2) Camshaft Stopper
(3) Camshaft
(4) Injection Pump Gear
(5) Fuel Camshaft

[7] FLYWHEEL



0109F023

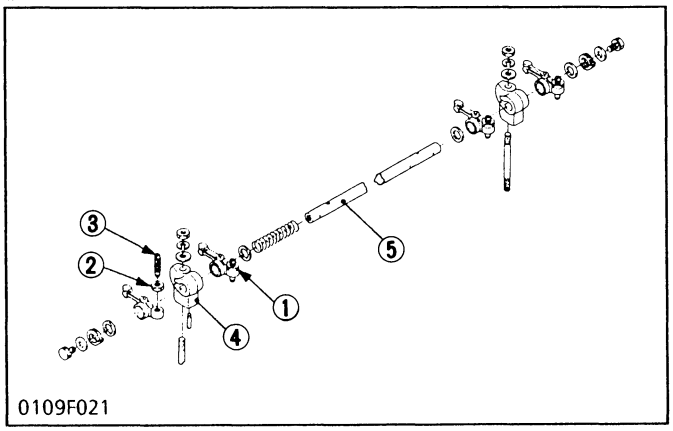
The flywheel stores the rotating force in the combustion stroke as inertial energy, reduces crankshaft rotating speed fluctuation and maintains the smooth rotating conditions.

The flywheel periphery is inscribed with the marks showing top dead center mark **TC**.

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

(1) Crankshaft
(2) Flywheel
(3) Flywheel Screw

[8] ROCKER ARM



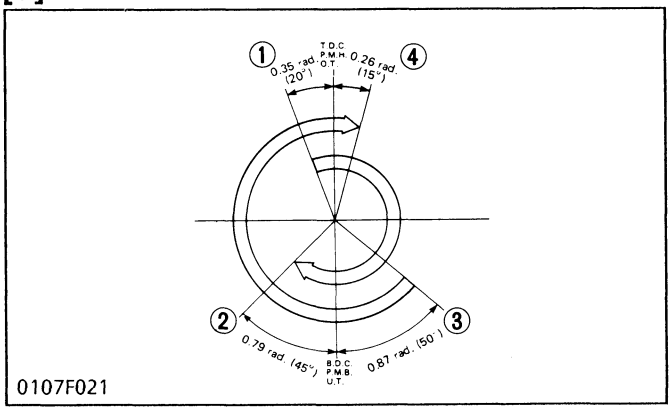
0109F021

The rocker arm assembly includes the rocker arms (1), rocker arm brackets (4) and rocker arm shaft (5) and converts the reciprocating movement of the push rods to an open/close movement of the inlet and exhaust valves.

Lubricating oil is pressurized through the bracket to the rocker arm shaft, which serves as a fulcrum so that the rocker arm and the entire system are lubricated sufficiently.

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

[9] VALVE TIMING



0107F021

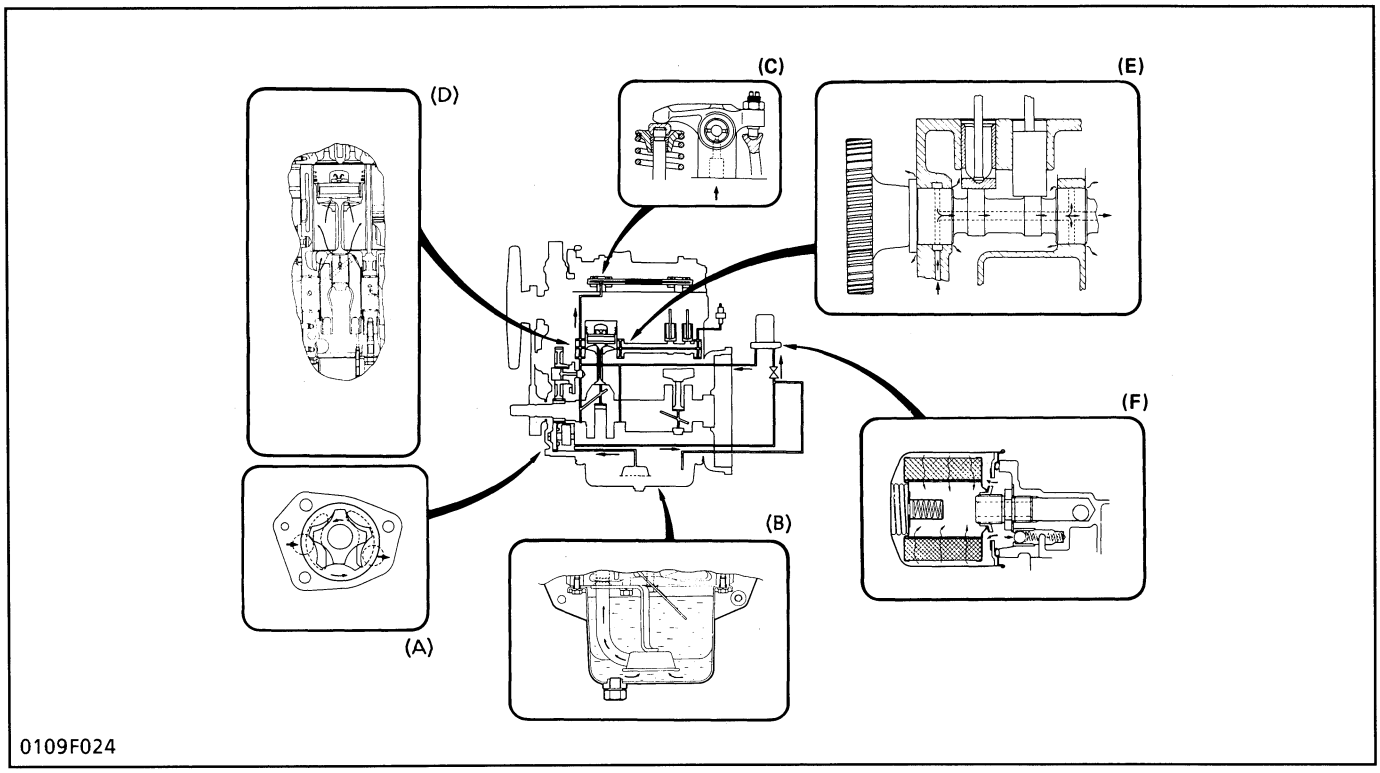
The timing for opening and closing the valve is extremely important to achieve effective air intake and sufficient gas exhaust.

The appropriate timing can be obtained by aligning the marks on the crank gear and the cam gear when assembling.

Inlet valve open ①	0.35 rad (20°) before T.D.C.
Inlet valve close ②	0.79 rad (45°) after B.D.C.
Exhaust valve open ③	0.87 rad (50°) before B.D.C.
Exhaust valve close ④	0.26 rad (15°) after T.D.C.

2 LUBRICATING SYSTEM

[1] GENERAL



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

This engine's lubricating system consists of oil strainer, oil pump, relief valve, oil filter cartridge and oil switch. The oil pump sucks lubricating oil from the oil pan through the oil strainer and the oil flows down to the filter cartridge, where it is further filtered. Then the oil is forced to crankshaft, connecting rods, idle gear, camshaft and rocker arm shaft to lubricate each part. Some part of oil, splashed by the crankshaft or leaking and dropping from gaps of each part, lubricates these parts: pistons, cylinders, small ends of connecting rods, tappets, pushrods, inlet and exhaust valves and timing gears.

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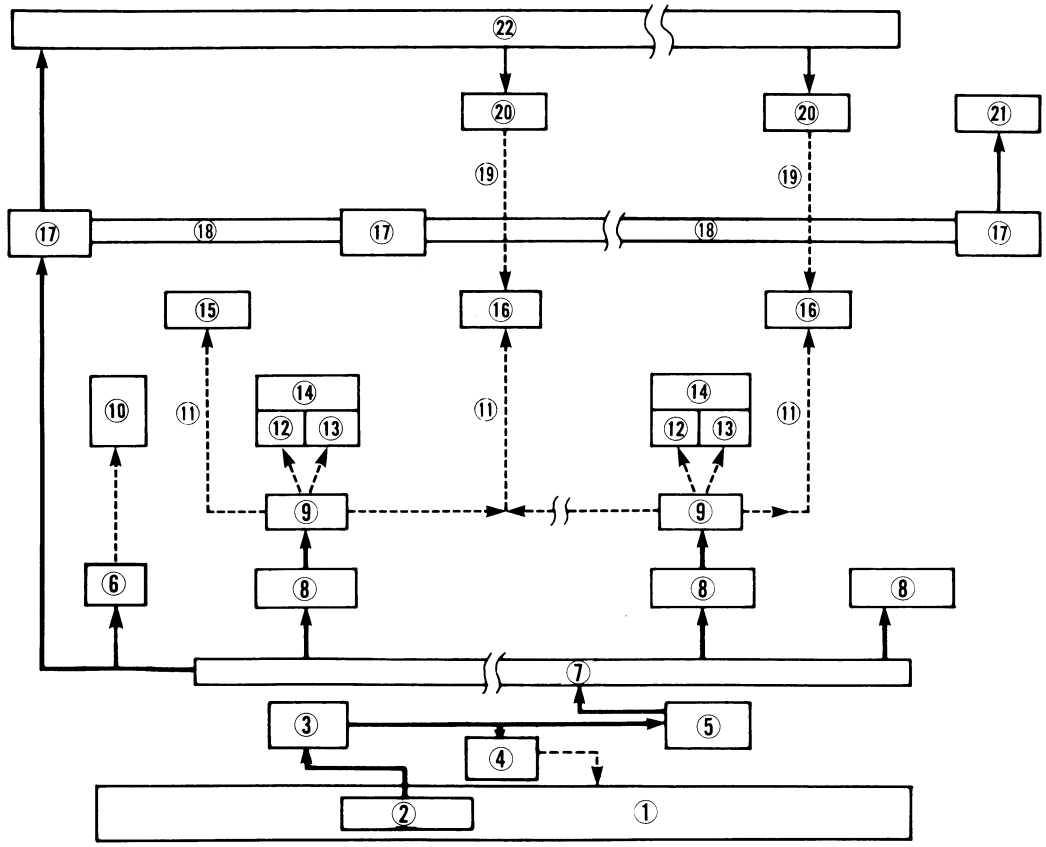
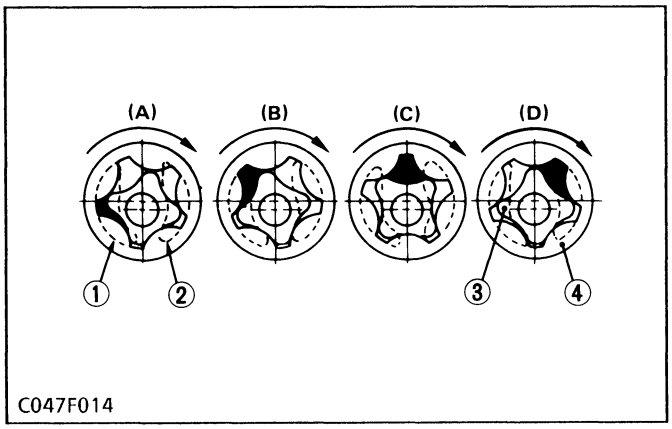


0107F025

Engine Oil Flow

(1) Oil Pan
(2) Oil Strainer
(3) Oil Pump
(4) Relief Valve
(5) Oil Filter Cartridge
(6) Idle Gear
(7) Main Oil Gallery
(8) Main Bearing
(9) Big End
(10) Timing Gear
(11) Splash
(12) Bore
(13) Small End
(14) Piston
(15) Fuel Camshaft
(16) Tappets
(17) Camshaft Bearing
(18) Camshaft
(19) Drain
(20) Rocker Arm
(21) Oil Switch
(22) Rocker Arm Shaft

[2] OIL PUMP



C047F014

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

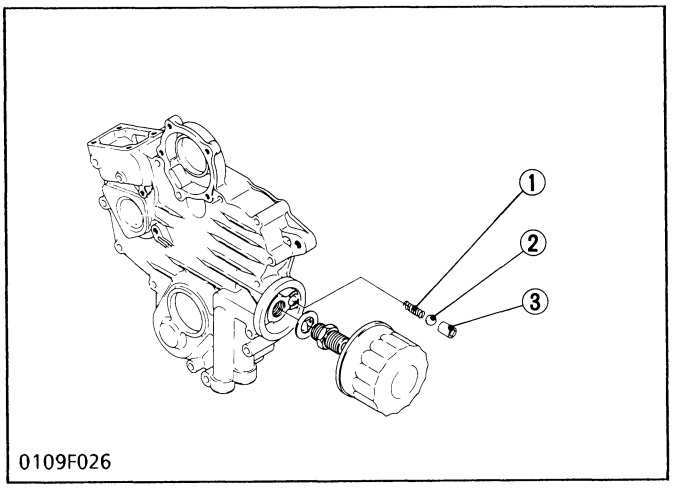
The oil pump is a trochoid pump, whose rotors have trochoid lobes. The inner rotor (3) has 4 lobes and the outer rotor (4) has 5 lobes, and they are eccentrically engaged with each other. The inner rotor, which is driven by the crankshaft through the gears, rotates the outer rotor in the same direction, varying the space between the lobes.

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

When the rotors rotate to (C), the space between both rotors switches from the inlet port to the outlet port.

At (D), the space decreases and the sucked oil is discharged from the outlet port.

[3] RELIEF VALVE



0109F026

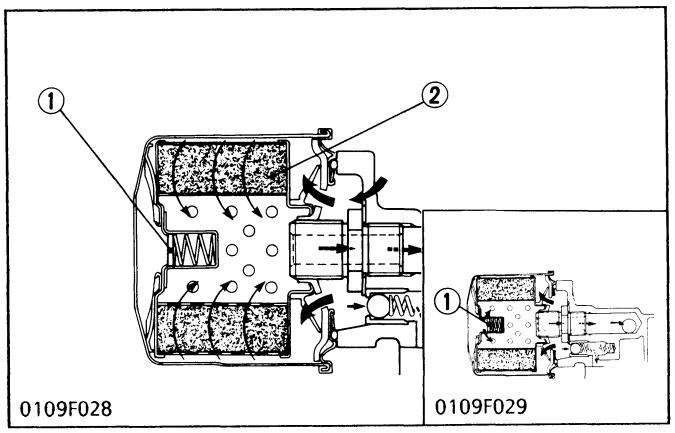
The relief valve prevents the damage to the lubricating system due to the high pressure of the oil.

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

When the pressure of the oil, forced by the pump, exceeds the specified value, the oil pushes back the ball (2) and escapes to the oil pan.

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

[4] OIL FILTER CARTRIDGE



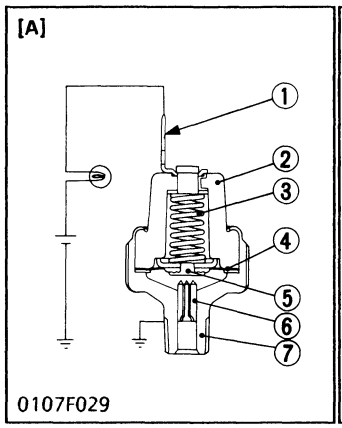
0109F028 0109F029

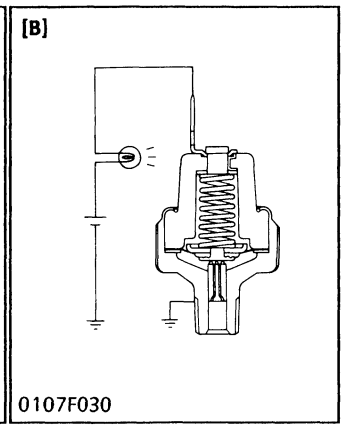
After lubricating, the lubricating oil brings back various particles of grit and dirt to the oil pan. Those particles and the impurities in the lubricating oil can cause wear or seizure of the engine parts. It may also impair the physical and chemical properties of the oil itself.

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

(1) Bypass Valve
(2) Filter Element

[5] OIL PRESSURE SWITCH





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

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

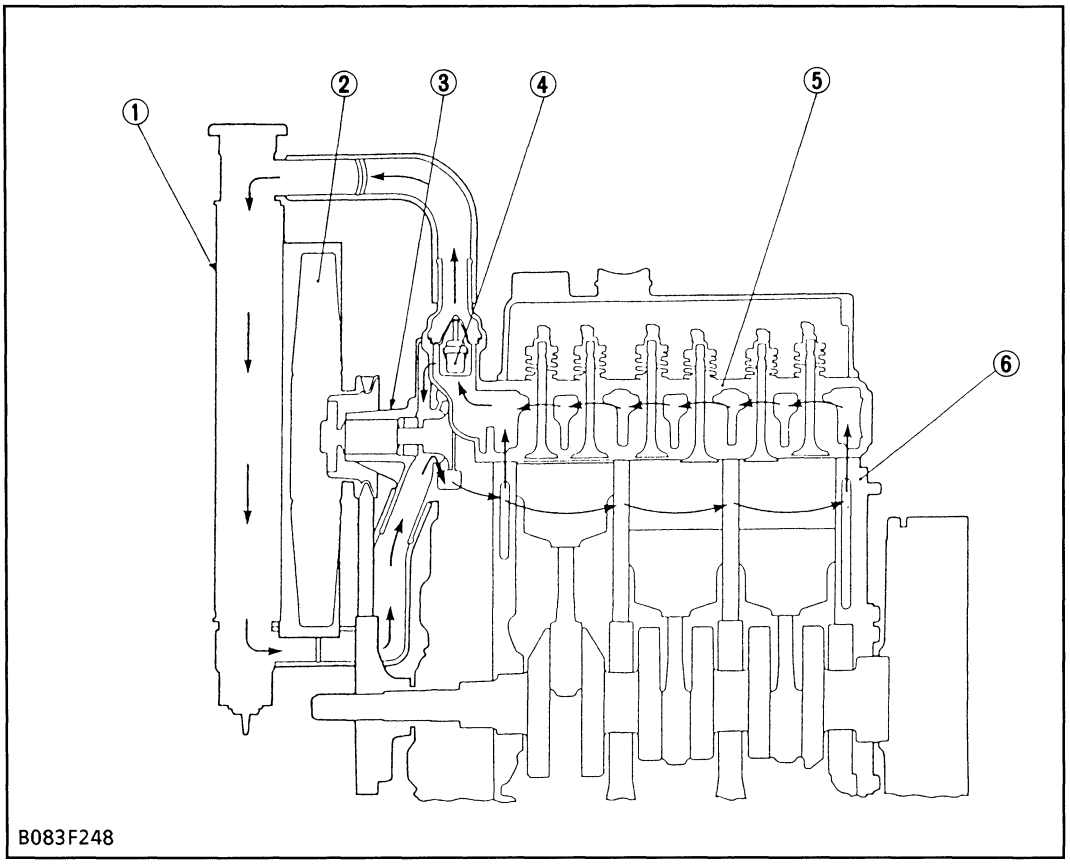
[A] At the proper oil pressure

[B] At lower oil pressure, 49 kPa (0.5 kgf/cm², 7 psi) or less

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

3 COOLING SYSTEM

[1] GENERAL



B083F248

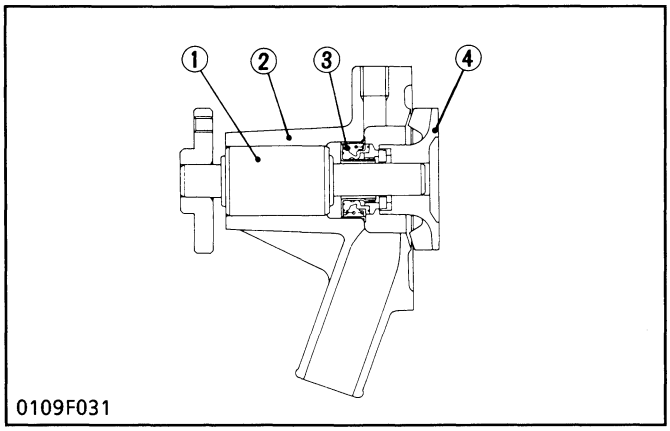
(1) Radiator
(2) Suction Fan
(3) Thermostat
(4) Water Pump
(5) Cylinder Head
(6) Cylinder Block

The cooling system consists of a radiator (1) (not included in the basic engine), centrifugal water pump (4), suction fan (2) and thermostat (3).

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

The water pump sucks the cooled water, forces it into the cylinder block and draws out the hot water. Then the cooling is repeated. Furthermore, to control temperature of water, a thermostat is provided in the system. When the thermostat opens, the water moves directly to radiator, but when it closes, the water moves toward the water pump through the bypass between thermostat and water pump. The opening temperature of thermostat is approx. 71°C (160°F).

[2] WATER PUMP

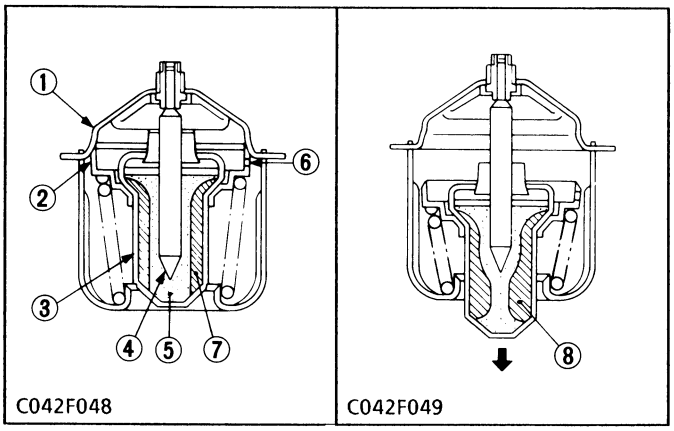


0109F031

The water pump is driven by the crankshaft via a V-belt. Water cooled in the radiator is sucked into the water pump from its lower portion and is sent from the center of the water pump impeller (4) radially outward into the water jacket in the crankcase.

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

[3] THERMOSTAT



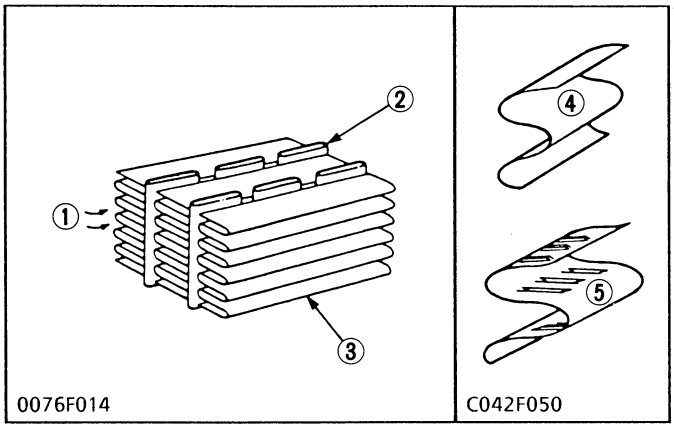
(1) Seat
(2) Valve
(3) Pellet
(4) Spindle
(5) Synthetic Rubber
(6) Leak Hole
(7) Wax (solid)
(8) Wax (liquid)

The thermostat maintains the cooling water at correct temperature. KUBOTA's engine uses a wax pellet type thermostat. Wax is enclosed in the pellet. The wax is solid at low temperatures, but turns liquid at high temperatures, expands and opens the valve.

(A) At low temperatures (lower than 71°C (160°F)).
As the thermostat is closed, cooling water circulates in the engine through the water return pipe without running to the radiator. Air in the water jacket escapes to the radiator side through leak hole (6) of the thermostat.

(B) At high temperatures (higher than 71°C (160°F)).
When the temperature of cooling water exceeds 71°C (160°F), wax in the pellet turns liquid and expands. Because the spindle (4) is fixed, the pellet (3) is lowered, the valve (2) is separated from the seat (1), and then cooling water is sent to the radiator.

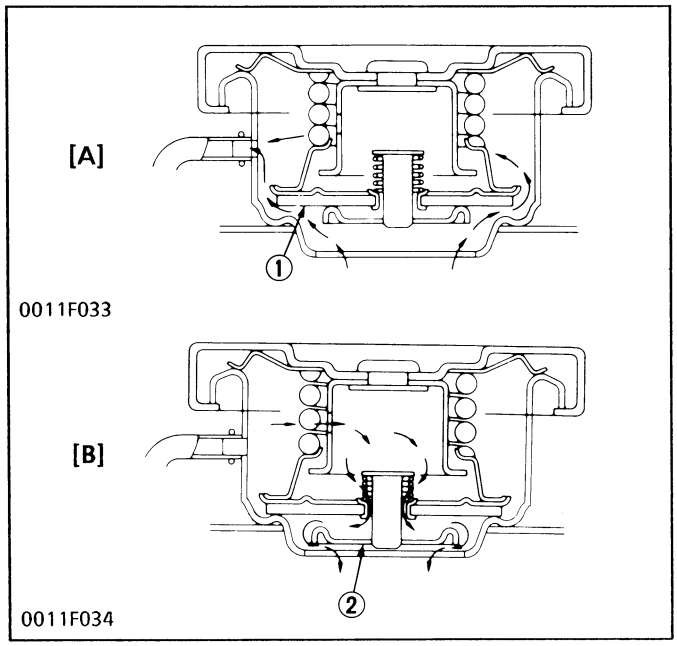
[4] RADIATOR (not included in the basic engine)



The radiator core consists of water carrying tubes and fins (3) at a right angle to the tubes (2). Heat of hot water in the tubes is radiated from the tube walls and fins. KUBOTA's engine uses corrugated fin type core which has a light weight and high heat transfer rate. Clogging is minimized by the louverless corrugated fins.

(1) Cooling Air
(2) Tube
(3) Fin
(4) Louverless Corrugated Fin
(5) Louvered Corrugated Fin

[5] RADIATOR CAP



The radiator cap is for sustaining the internal pressure of the cooling system at the specified level 88 kPa (0.9 kgf/cm^2, 13 psi) when the engine is in operation. The cap consists of a pressure valve (1) a vacuum valve (2), valve springs, gasket, etc.

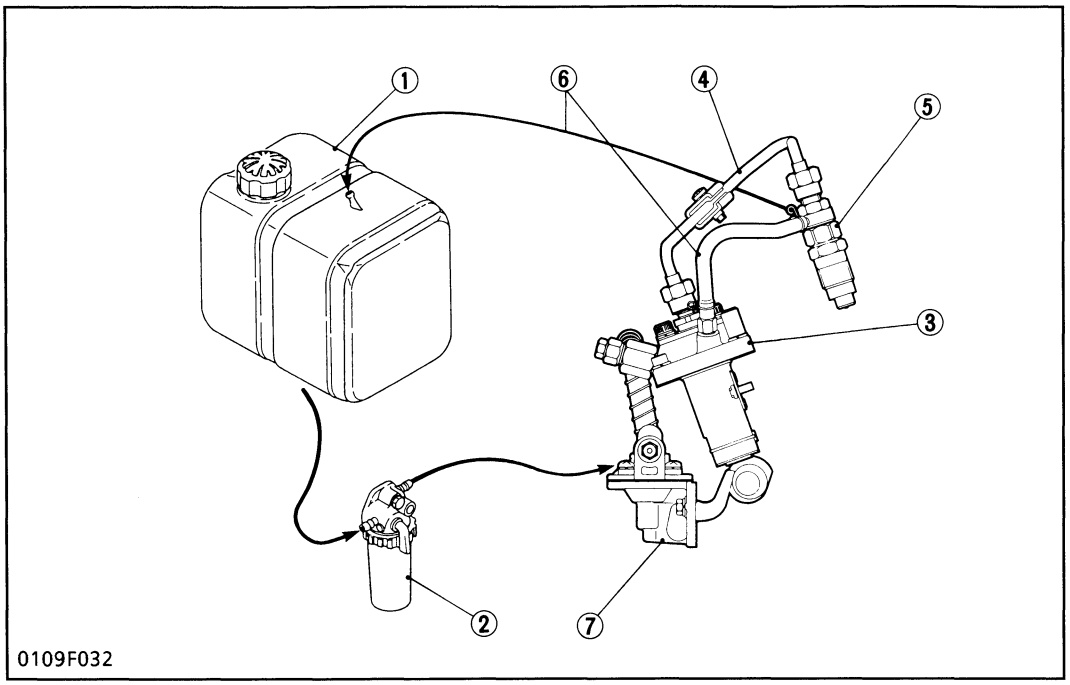
Cooling water is pressurized by thermal expansion of steam, and as its boiling temperature rises, generation of air bubbles will be suppressed. (Air bubbles in cooling water lowers the cooling effect.)

[A] When radiator internal pressure is high
[B] When radiator internal pressure is negative

(1) Pressure Valve
(2) Vacuum Valve

4 FUEL SYSTEM

[1] GENERAL



0109F032

*(1) Fuel Tank
(2) Fuel Filter
(3) Injection Pump
(4) Injection Pipe
(5) Injection Nozzle
(6) Fuel Overflow Pipe
**(7) Fuel Feed Pump

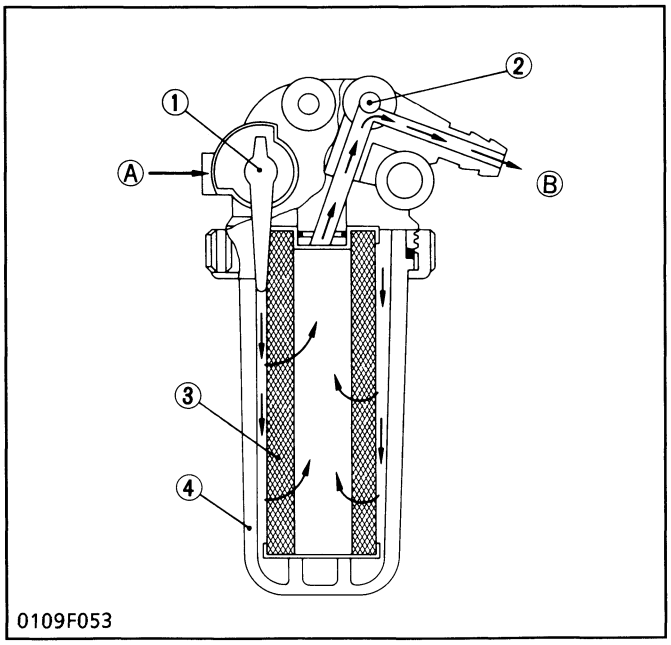
Fuel from the fuel tank (1) passes through the fuel filter (2), and then enters the injection pump (3) after impurities such as dirt, water, etc. are removed.

The fuel pressurized by the injection pump to the opening pressure (13.73 to 14.71 MPa, 140 to 150 kgf/cm^2, 1991 to 2134 psi), of the injection nozzle (5) is injected into the combustion chamber.

Part of the fuel fed to the injection nozzle (5) lubricates the moving parts of the plunger inside the nozzle, then returns to the fuel tank through the fuel overflow pipe (6) from the upper part of the nozzle holder.

■ **NOTE**
- **Component marked * is not included in the basic model.**
- **Component marked ** is included only in the basic model.**

[2] FUEL FILTER (not included in the basic model)



0109F053

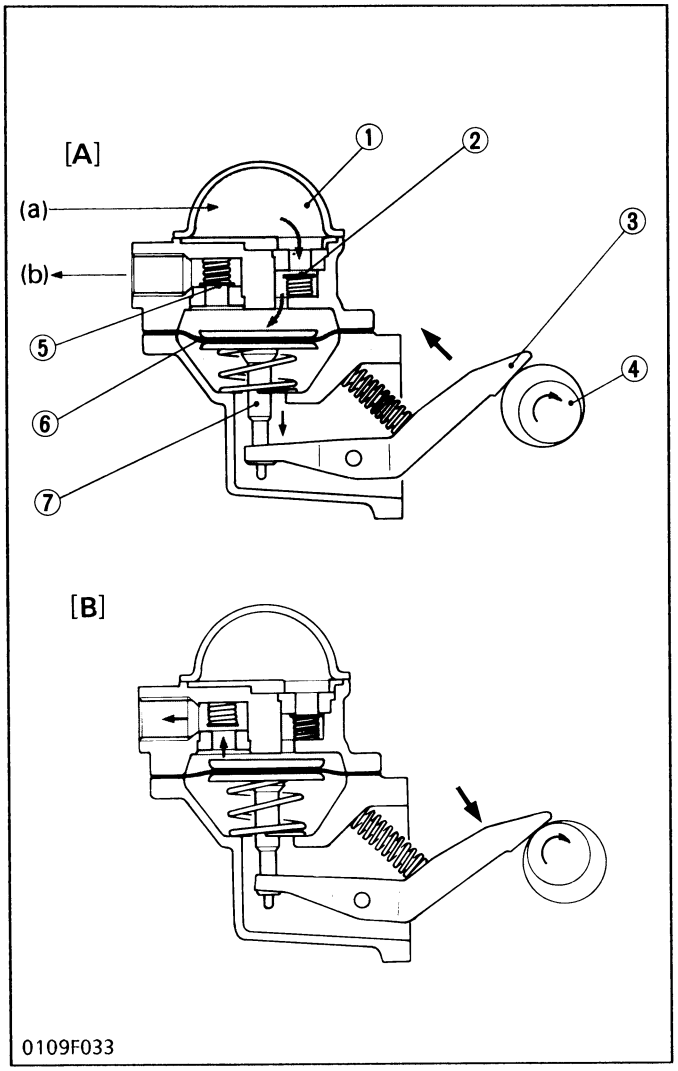
Each moving part of the injection pump and nozzle is extremely precision machined, and clearances of their sliding parts are extremely small. Fuel itself serves as lubricating oil. For this reason, it is extremely important to completely remove water and dirt contained in fuel.

This fuel filter, which uses very fine filter paper, serves to separate and filter dirt in fuel and water accumulated in the tank.

Air vent plug is fitted to the cock body. Before starting or after disassembling and reassembling, loosen this plug and bleed the air in the fuel system.

(A) Inlet
(B) Outlet
(1) Fuel Cock
(2) Air Vent Plug
(3) Filter Element
(4) Filter Cup

[3] FUEL FEED PUMP



The filtered fuel is fed to the injection pump by the fuel fed pump.

The chamber (1) is enclosed with the inlet valve (2), the outlet valve (5) and the diaphragm (6), which is linked to the rocker arm with the pull rod (7). The rocker arm is swinged by the eccentric cam on the fuel camshaft (4).

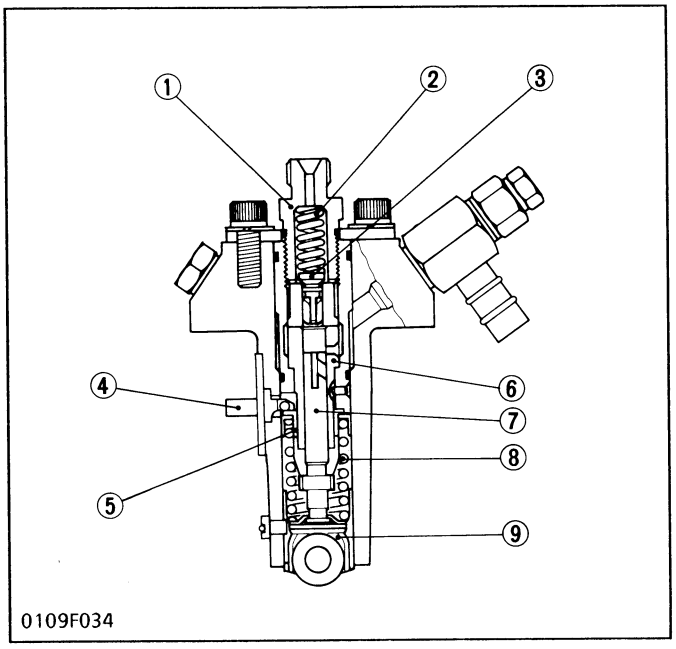
When the diaphgram is pulled down, vaccum in the chamber (1) causes the outlet valve (5) to close and the atomospheric pressure in the fuel tank to force the fuel into the chamber, opening the inlet valve (2).

When the diaphragm is pushed up by the cam, the pressure in the chamber causes the inlet valve to close and forces out the fuel, opening the outlet valve.

(A) Inlet Stroke
(a) from fuel filter
(1) Chamber
(2) Inlet Valve
(3) Rocker Arm
(4) Fuel Camshaft

(B) Discharge Stroke
(b) to injection pump
(5) Outlet Valve
(6) Diaphragm
(7) Pull Rod

[4] INJECTION PUMP

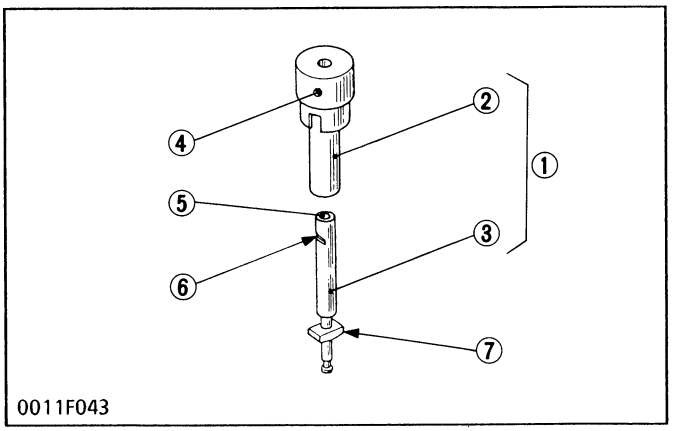


A Bosch MD type mini pump is used for the injection pump. It is small, lightweight and easy to handle.

The plunger (7) with a right-hand lead reciprocates via the tappet roller (9) by means of the camshaft fuel cam, causing the fuel to be delivered into the injection nozzle.

(1) Delivery Valve Holder
(2) Delivery Valve Spring
(3) Delivery Valve
(4) Control Rod
(5) Control Sleeve
(6) Cylinder
(7) Plunger
(8) Plunger Spring
(9) Tappet

(1) Pump Element



0011F043

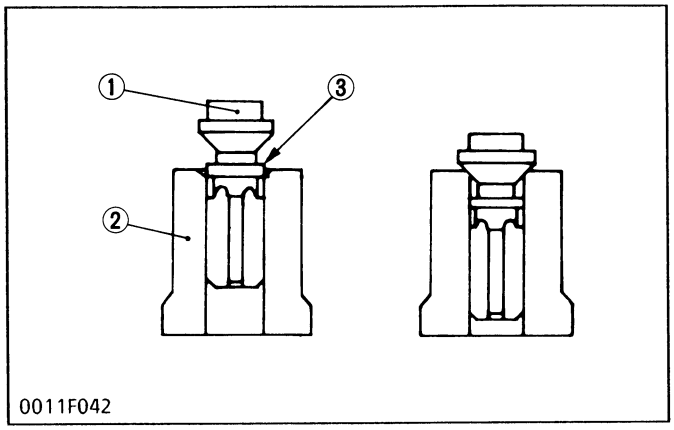
The pump element (1) is consist of the plunger (3) and cylinder (2).

The sliding surfaces are super-precision machined to maintain injection pressure at engine low speeds. Since the driving face (7) fits in the control sleeve, the plunger (3) is rotated by the movement of the control rack to increase or decrease of fuel delivery.

As described above, the plunger (3) is machined to have the slot (5) and the control groove (6).

(1) Pump Element
(2) Cylinder
(3) Plunger
(4) Feed Hole
(5) Slot
(6) Control Groove
(7) Driving Face

(2) Delivery Valve



0011F042

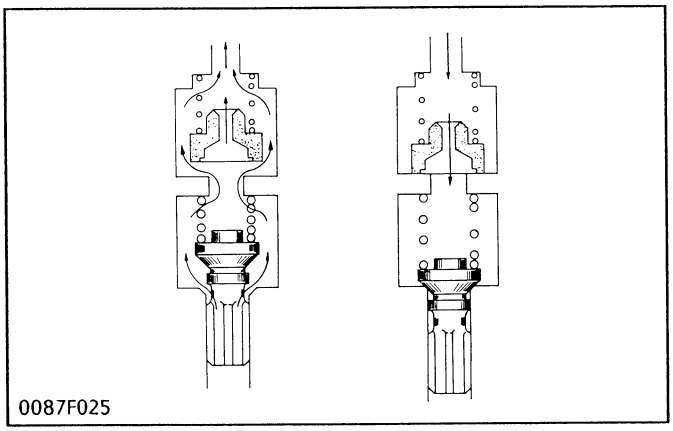
The delivery valve consists of the valve (1) and the Valve seat (2).

The delivery valve prevents the fuel from flowing back into the delivery chamber through the injection pipe. It also prevents the fuel from dribbling at the injection nozzle.

When the delivery stroke ends the relief plunger moves into the bore of the valve seat and seals the delivery line from the delivery chamber. The relief plunger lowers further until the valve seats suck back the fuel to prevent dribbling at the injection nozzle.

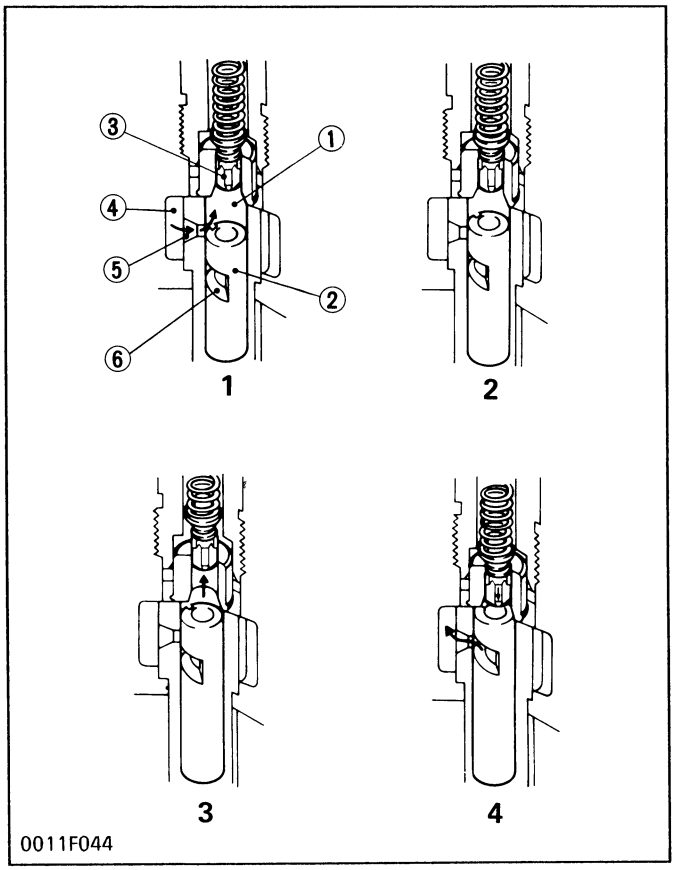
(1) Valve
(2) Valve Seat
(3) Relief Plunger

(3) Dumping Valve


0087F025

1. **At fuel injection**
   Since dumping valve is pushed up to press the spring, fuel is pressure-fed to injection nozzle the same as without dumping valve.
2. **At suck-back**
   At suck-back by delivery valve after fuel injection fuel returns through dumping valve orifice Generally second injection is apt to occur by reflex pressure due to reaction of sudden pressure drop when changing into suck-back by delivery valve from high injection pressure. As a result of preventing this second injection perfectly by dumping valve and dissolving nozzle clogging, durability of injection nozzle is improved.

(4) Operation of Pump Element



1. Before delivery
As the tappet lowers, the plunger (2) also lowers and fuel is drawn into the delivery chamber (1) through the feed hole (5) from the fuel chamber (4).

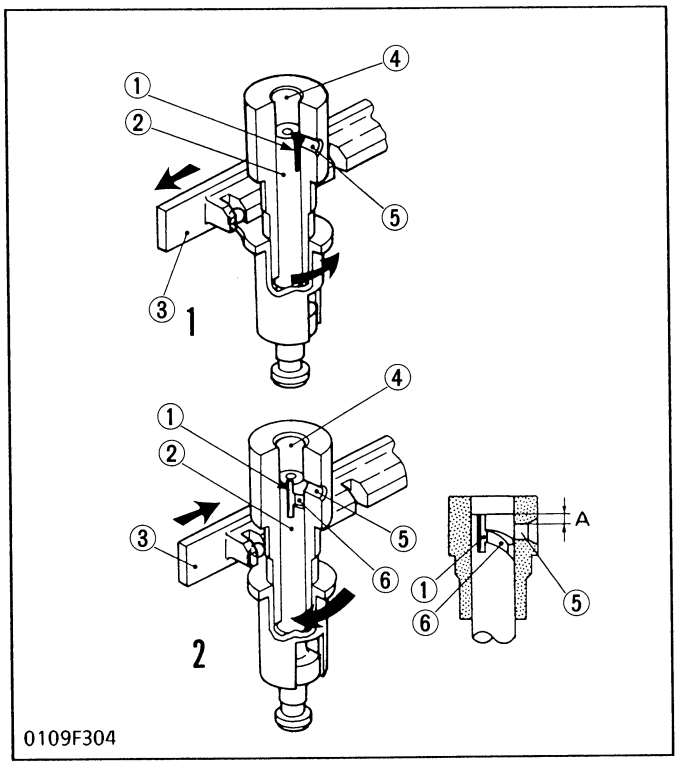
2. Beginning of delivery
When the plunger is pushed up by the cam and the head of the plunger closes the feed hole, the pressure in the delivery chamber rises to push the relief plunger (3) open.
Fuel is then force-fed into the injection pipe.

3. Delivery
While the plunger is rising, the delivery of fuel continues.

4. End of delivery
When the plunger rises further and the control groove (6) on its periphery meets the feed hole,the fuel returns to the fuel chamber from the delivery chamber through the control groove and the feed hole.

(1) Delivery Chamber
(2) Plunger
(3) Relief Plunger
(4) Fuel Chamber
(5) Feed Hole
(6) Control Groove

(5) Injection Control

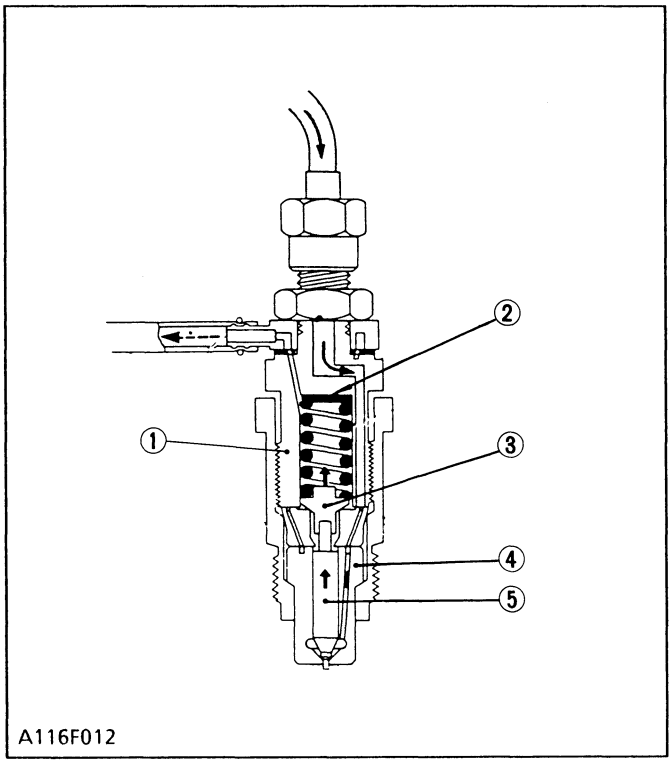


1. No fuel delivery
At the engine stop position of the control rod (3), the lengthwise slot (1) on the plunger (2) aligns with the feed hole (5). And the delivery chamber (4) is led to the feed hole during the entire stroke of the plunger.
The pressure in the delivery chamber does not build up and no fuel can be forced to the injection nozzle.

2. Fuel delivery
The plunger (2) is rotated (See figure) by the control rod (3). When the plunger is pushed up, the hole (5) is closed. The pressure in the delivery chamber (4) builds up and forcefeeds the fuel to the injection nozzle until the control groove (6) meets the feed hole (5).
The amount of the fuel corresponds to the distance "**A**".

(1) Slot
(2) Plunger
(3) Control Rod
(4) Delivery Chamber
(5) Feed Hole
(6) Control Groove

[5] INJECTION NOZZLE



A116F012

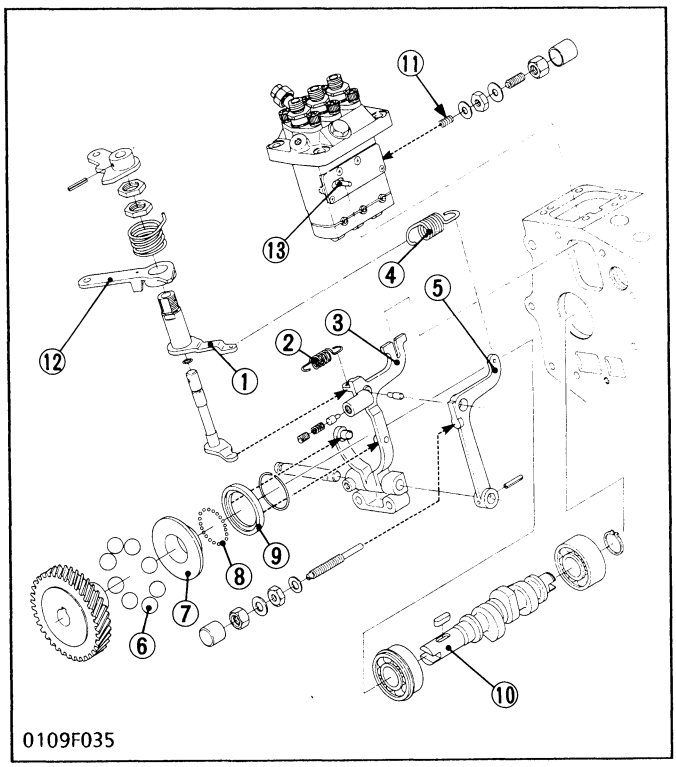
This nozzle is throttle-type. The needle valve (5) is pushed against the nozzle body (4) by the nozzle spring via the push rod (3). Fuel pressurized by the injection pump pushes the needle valve up and then is injected into the sub-combustion chamber.

Excessive flow passes from nozzle holder center through the eye joint and the fuel overflow pipe to the fuel tank.

The injection pressure is 13.73 to 14.71 MPa (140 to 150 kgf/cm^2, 1991 to 2134 psi), and is adjusted with adjusting washers (2).

(1) Nozzle Holder Body
(2) Adjusting Washer
(3) Push Rod
(4) Nozzle Body
(5) Needle Valve

[6] GOVERNOR



0109F035

(1) Governor Lever
(2) Start Spring
(3) Fork Lever 1
(4) Governor Spring
(5) Fork Lever 2
(6) Steel Ball
(7) Governor Sleeve
(8) Steel Ball
(9) Governor Ball Case
(10) Fuel Camshaft
(11) Idling Ajust Spring
(12) Speed Control Lever
(13) Control Rod

The governor controls the amount of the fuel to be fed in the entire speed range to prevent the engine from changing its speed according to the load.

The fork lever 1 (3) is held where two forces on it are balanced. One is the force that fork lever 2 pushes, which is caused by the tension of the governor spring (4) between the governor lever (1) and fork lever 2 (5). Another is the component of the centrifugal force produced by the steel balls (6) which are rotated by the fuel camshaft (10).

■ At start

The steel ball (6) has no centrifugal force.

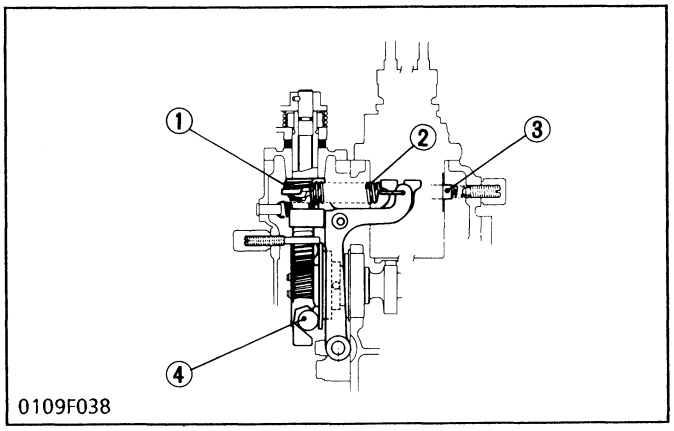
Fork lever 1 (3) is pulled by the start spring (2) and the control rod (13) moves to the maximum injection position for easy starting.

■ At idling

When the speed control lever (12) is set at the idling position, the governor spring (4) is pulled slightly.

As the camshaft rotates, the steel ball (6) increase their centrifugal force and push the governor sleeve (7). Fork lever 1 (3) pushed by the governor sleeve, pushes the control rod (13) and the control rod compresses the idling adjust spring (11).

The control rod is kept at a position where the centrifugal force is balanced with the spring tensions on the control rod, providing stable idling.



0109F038

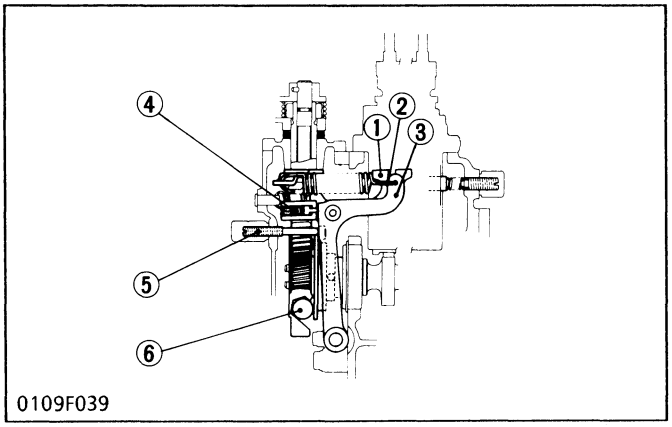
■ At medium or high speed running

When the speed control lever (1) is turned further, the governor spring (2) increases the tension and the control rod (3) is pulled to increase the engine speed.

The steel ball (4) increase their centrifugal force and the control rod is pushed, decreasing the engine speed, until the centrifugal force and the spring tension are balanced.

When the engine speed is dropped with the increase of the load , the centrifugal force of the steel ball decreases and the control rod is pulled. The amount of the fuel to the injection nozzle is increased to produce a higher engine torque required for the load.

(1) Speed Control Lever
(2) Governor Spring
(3) Control rod
(4) Steel Ball



0109F039

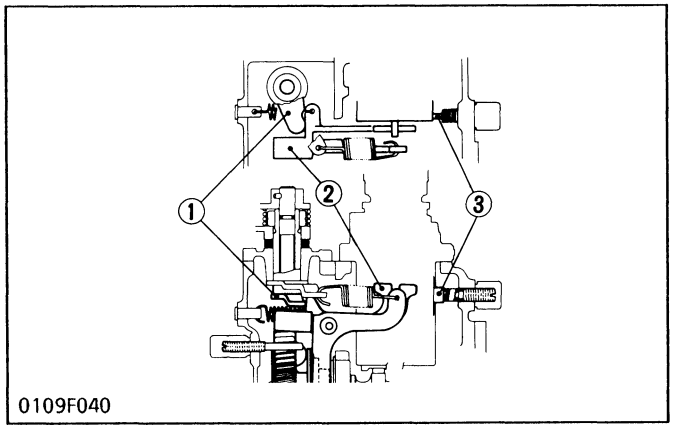
■ At maximum speed running with an overload

When the engine is overloaded at the high speeds and the engine speed drops, the centrifugal force of the steel ball (6) decreases and the governor spring (2) pulls fork lever 1 (1) and 2 (3).

When fork lever 2 contacts the adjusting screw (5), the spring (4) which is built in fork lever 1 begins to push the fork lever 1 to pull the control rod.

The fuel to the injection nozzle is increased to run the engine at high speed and torque.

(1) Fork Lever 1
(2) Governor Spring
(3) Fork Lever 2
(4) Spring
(5) Adjusting Screw
(6) Steel Ball



0109F040

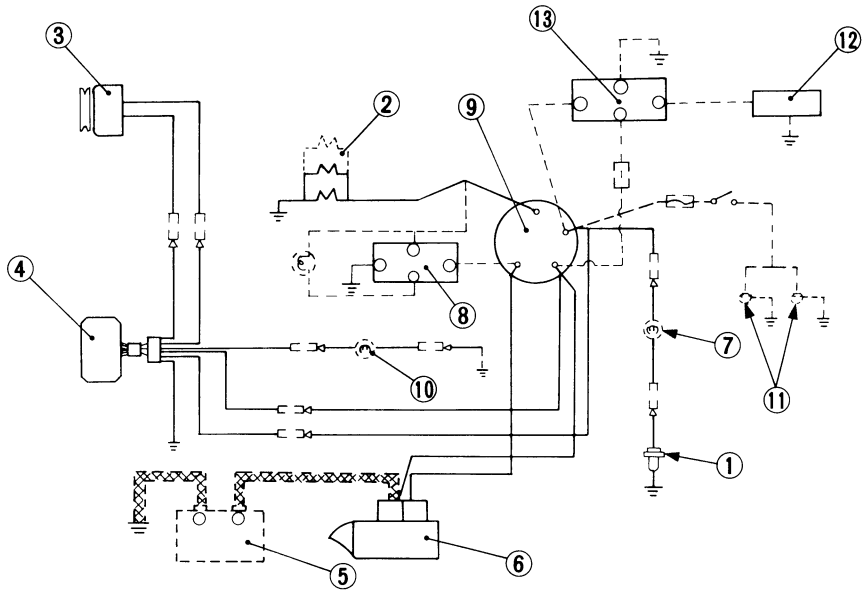
■ To stop the engine

When the stop lever (1) is moved to the stop position, fork lever 1 (2) is pushed and the control rod (3) is moved to stop the fuel injection.

(1) Stop Lever
(2) Fork Lever 1
(3) Control Rod

5 ELECTRICAL SYSTEM

Z442-B·Z482-B·D662-B·D722-B



A116P013

The electrical system of the engine consists of a starting system (including a starter, glow plugs and others), a charging system (including an AC dynamo, a regulator and others), a battery and an oil switch.

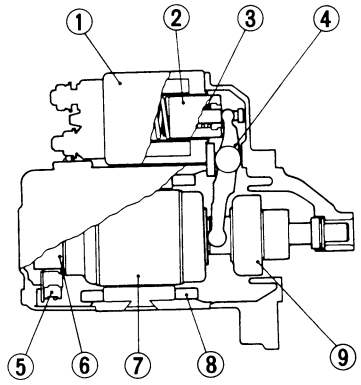
■ **NOTE**

- **Components marked * are not included in the basic model.**

(1) Oil Pressure Switch
(2) Glow Plug
(3) AC Dynamo
(4) Regulator
*(5) Battery
(6) Starter
*(7) Oil Lamp
*(8) Lamp Timer
*(9) Key Switch
*(10) Charge Lamp
*(11) Light
*(12) Solenoid
*(13) Timer

[1] STARTING SYSTEM

(1) Starter

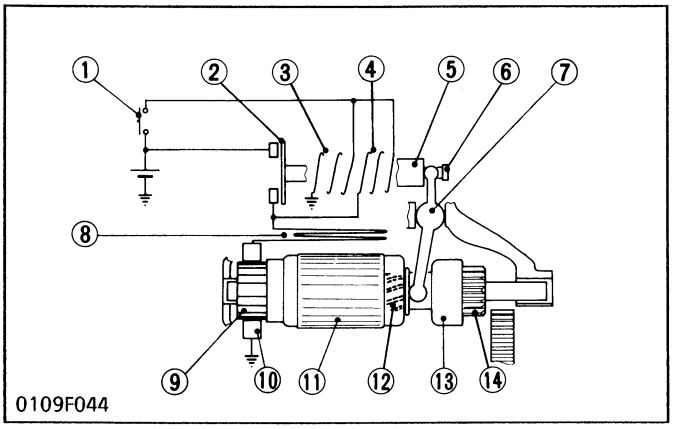


0109F043

The starter is of the electromagnetic drive type.
It is composed of a starting motor and a solenoid switch.

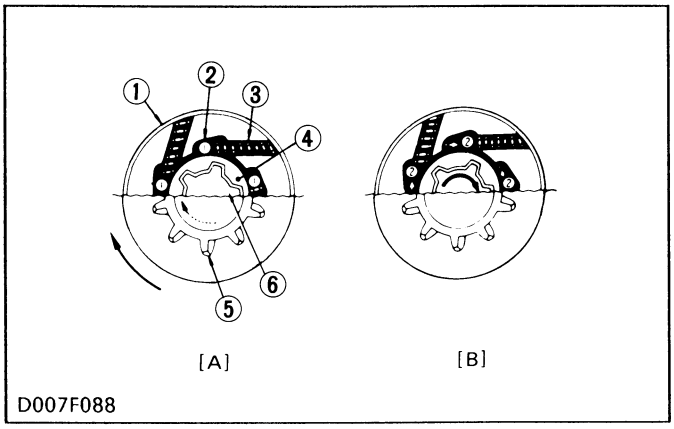
(1) Solenoid Switch
(2) Plunger
(3) Spring
(4) Shift Lever
(5) Brush
(6) Commutator
(7) Armature
(8) Field Coil
(9) Overrunning Clutch

KiSC issued 04, 2006 A



1. Schematic Circuit

(1) Key Switch
(2) Solenoid Switch
(3) Holding Coil
(4) Pull-in Coil
(5) Plunger
(6) Rod
(7) Shift Lever
(8) Field Coil
(9) Commutator
(10) Brush
(11) Armature
(12) Spiral Spline
(13) Overrunning Clutch
(14) Pinion



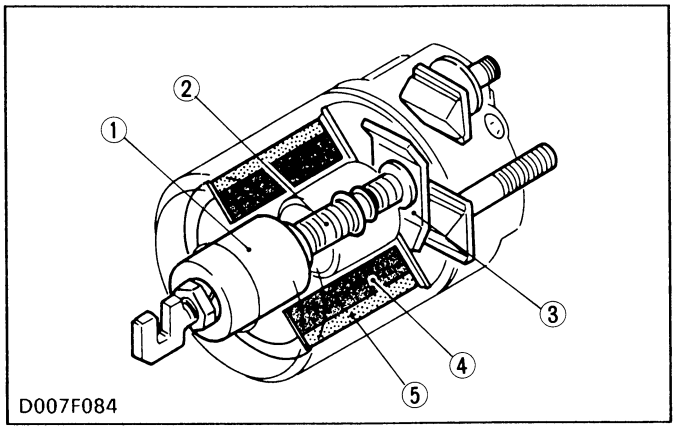
2. Overrunning Clutch

The overrunning clutch is so constructed that the power transmission relationship is automatically severed when the clutch pinion shaft (6) speed exceeds the clutch gear outer (1) speed at increased engine speeds. Therefore, the armature drives the ring gear and is never driven by the engine.

[A] When power is transmitted

[B] Idling rotation with clutch pinion shaft speed exceed that of clutch gear outer

(1) Clutch Gear outer
(2) Roller
(3) Roller Spring
(4) Spline Tube Inner
(5) Pinion Gear
(6) Clutch Pinion Shaft

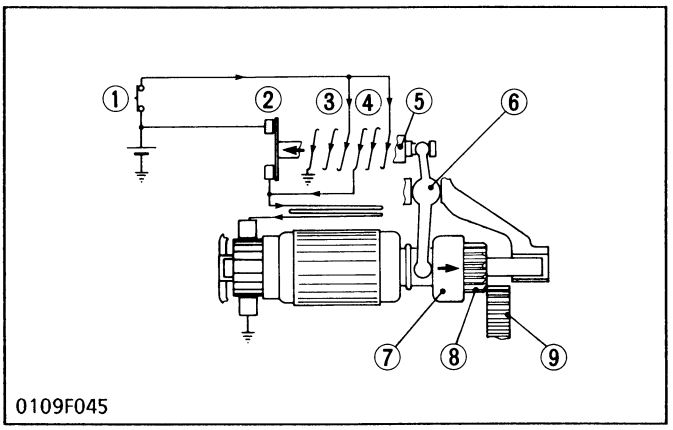


3. Solenoid Switch

The solenoid switch forces out the pinion for engaging with the ring gear, and operates as a relay to drive the armature.

It consists of a pull-in coil, a holding coil and a plunger.

(1) Plunger
(2) Spring
(3) Contact Plate
(4) Pull-in Coil
(5) Holding Coil



0109F045

4. Operating of Starter

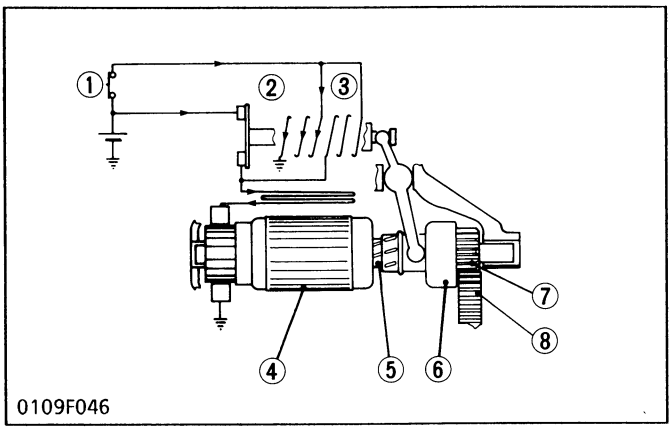
■ When Main Switch Is Turned to "START" Position

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

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

The pinion (8) is pushed against the ring gear (9) with the overrunning clutch (7) by the drive lever (6) and the solenoid switch (2) is closed.

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



0109F046

■ When Solenoid Switch Is Closed

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

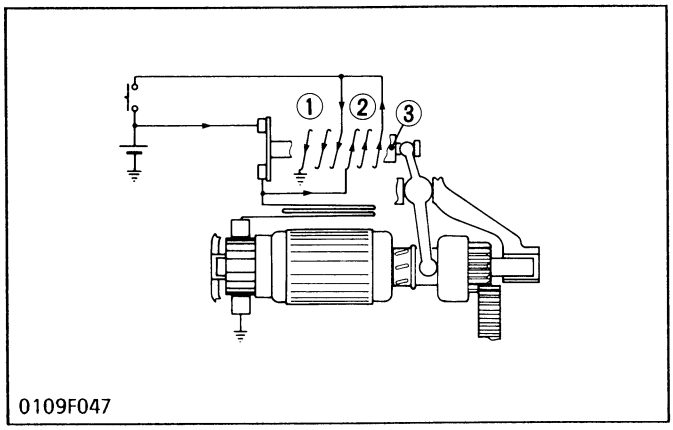
The pinion (7), which is pushed against the ring gear (8) and rotated along the spline (5), meshes with the ring gear to crank the engine.

The engine starts and increases its speed.

While the pinion spins faster than the armature, the overrunning clutch (6) allows the pinion to spin independently from the armature.

The pull-in coil (3) is short-circuited through the solenoid switch (2) and the main switch (1).

(1) Main Switch
(2) Solenoid Switch
(3) Pull-in Coil
(4) Armature
(5) Spiral Spline
(6) Overrunning Clutch
(7) Pinion
(8) Ring Gear



0109F047

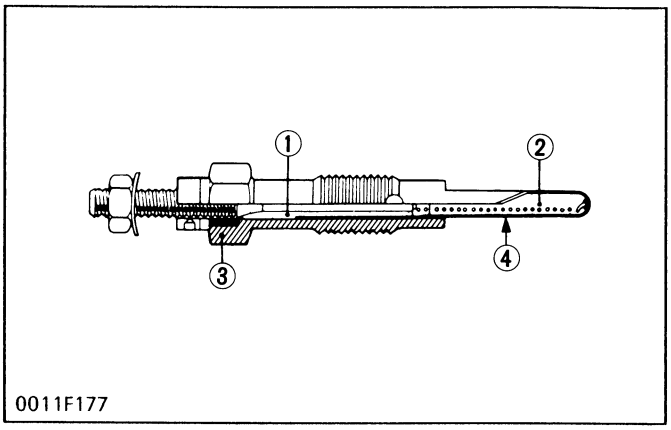
■ When Main Switch Is Released

The current from the battery flows to the holding coil (1) through the pull-in coil (2) to diminish the magnetism between them.

The plunger (3) is pushed by the spring to pull in the pinion.

(1) Holding Coil
(2) Pull-in Coil
(3) Plunger

(2) Glow Plug

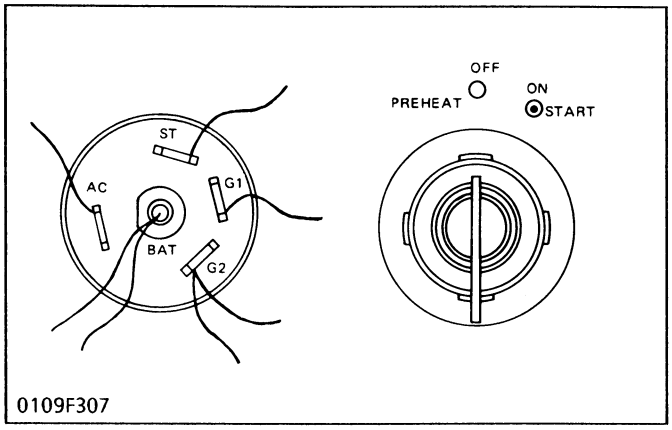


0011F177

Each sub-combustion chamber has a glow plug for easy starting. The glow plug is of the quick-heating type.

(1) Insulating Powder
(2) Metal Tube
(3) Housing
(4) Heat Coil

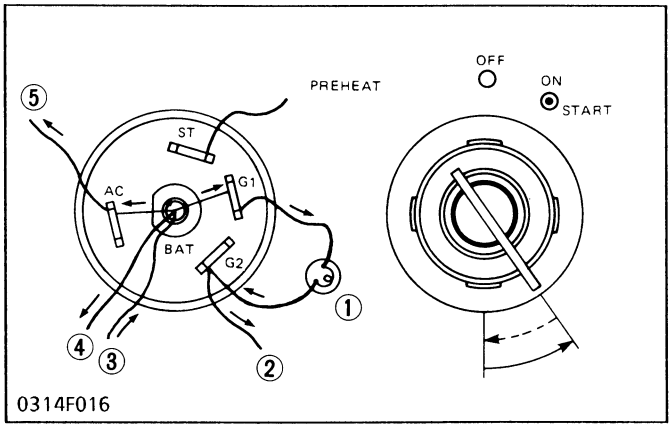
(3) Key Switch (not included in the basic model)



0109F307

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

The key released at the "PREHEAT" position returns to the "OFF" position. And it released at the "START" position returns to the "ON" position.

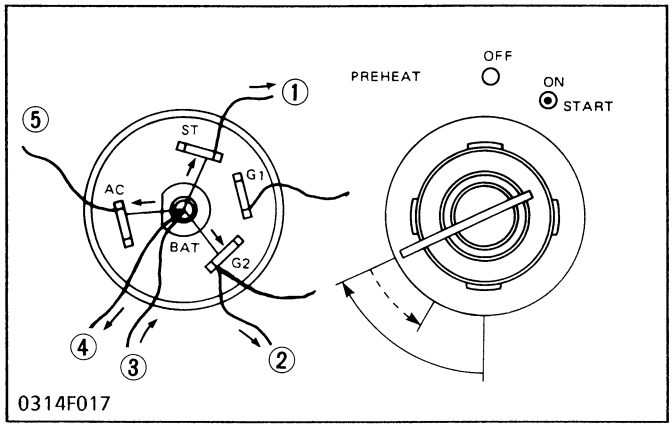


0314F016

■ PREHEAT

While the key switch is turned and held at the "PREHEAT" position, the current is supplied to the glow plugs through the lamp timer.

(1) Lamp Timer
(2) To Glow Plugs
(3) From Battery
(4) To Regulator
(5) To Oil Pressure Lamp and Accessory

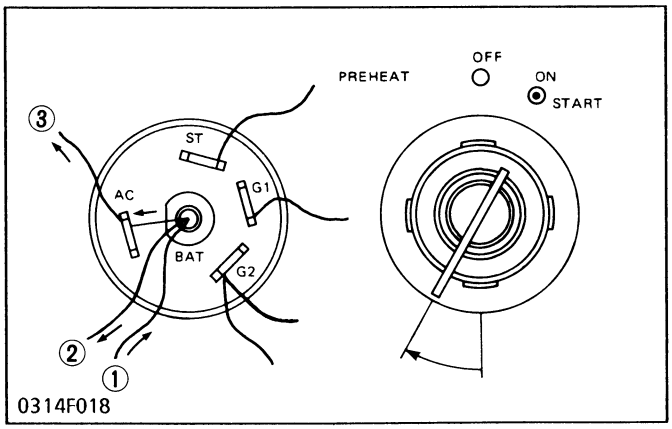


0314F017

■ START

When the key is turned to the "START" position, through the "ON" position the current is supplied to the starter.

(1) To Starter
(2) To Glow Plug
(3) From Battery
(4) To Regulator
(5) To Oil Pressure Lamp and Accessory



■ **ON**

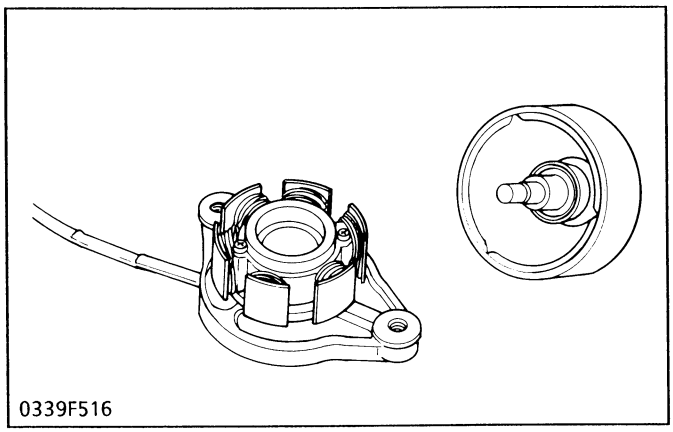
Only the terminal "AC" is connected to the battery.

At any position of the key except the "OFF" position, the terminal "AC" is connected to the "BAT" terminal.

(1) From Battery
(2) To Regulator
(3) To Oil Pressure Lamp and accessory

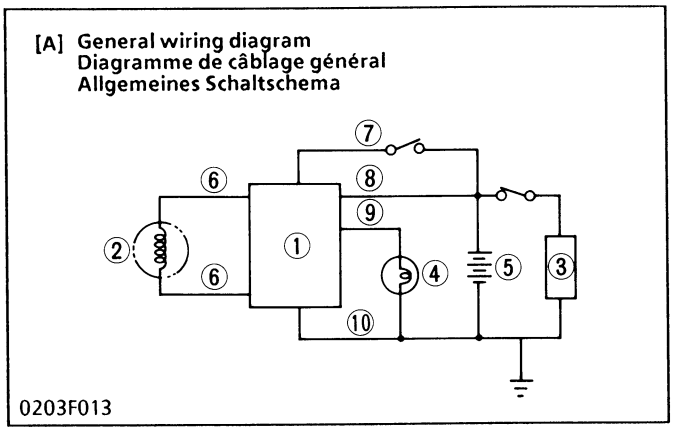
[2] CHARGING SYSTEM

(1) Dynamo



This dynamo is an 8-8 pole rotating magnet type generator. It is simple in construction, consisting of a stator and rotor. The rotor is made up of eight permanent magnet pole pieces assembled on a shaft and rotates on the center of the stator around which eight electromagnetic coils are provided for. This dynamo produces higher voltage in slow speed rotation, and charges electric current to the battery during engine idling.

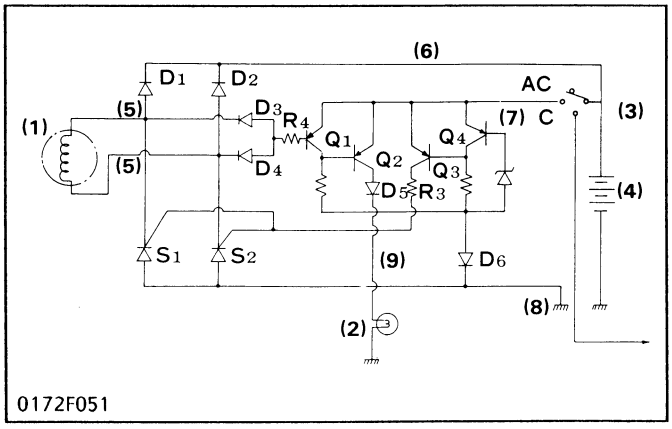
(2) Regulator



The regulator performs rectification and voltage regulation. The regulator converts AC into DC which flows through the power consuming circuits and the battery, and also charges the battery. If however, the battery voltage exceeds a certain level. The DC current is cut off from the charging circuit to prevent overcharging.

(1) Regulator
(2) Dynamo
(3) Load
(4) Charge Lamp
(5) Battery
(6) Blue Lead Wire
(7) Yellow Lead Wire
(8) Red Lead Wire
(9) Green Lead Wire
(10) Black Lead Wire

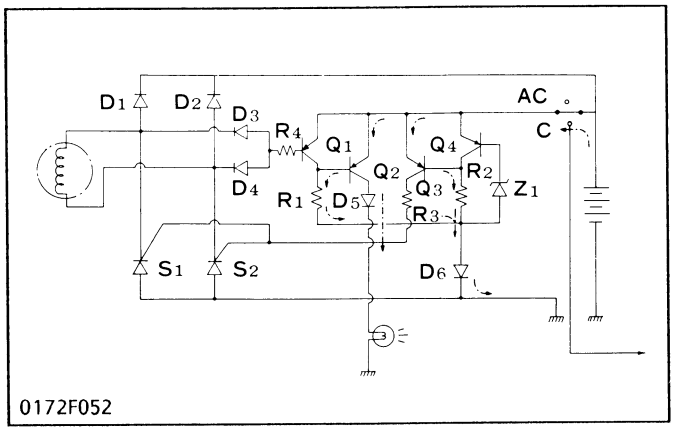
(3) Charging Mechanism



The charging mechanism is described in four sections:

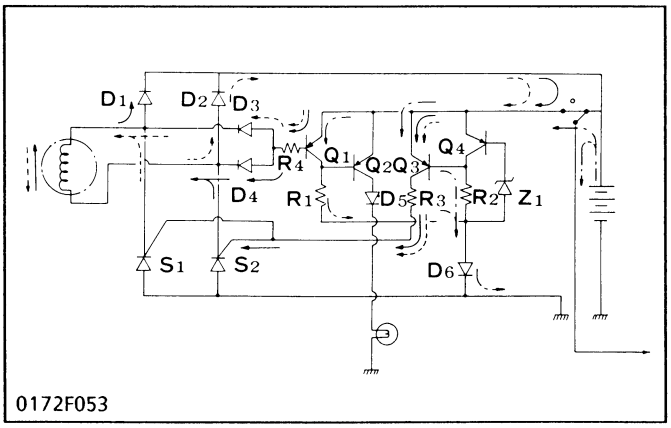
1) When key switch is ON
2) At starting
3) In charging
4) Over-charge protection

(1) GEN: Magnet type AC generator
(2) LAMP: Charge indication lamp (not included in the basic engine)
(3) KEY SW: Key switch (not included in the basic engine)
(4) BATT: Battery (not included in the basic engine)
(5) Blue: GEN connecting terminal
(6) Red: BATT + connecting terminal
(7) Yellow: BATT voltage test terminal
(8) Black: BAT – connecting terminal
(9) Green: LAMP connecting terminal
S_1, S_2: Output control/rectification thyristor (SCR)
D_1, D_2: Output rectifying diode
D_3, D_4: GEN generation detecting diode
D_5, D_6: Protection diode for wrong connecting of BATT
Z_1: BATT terminal voltage setting diode
Q_1: GEN generation detecting transistor
Q_2: LAMP on/off transistor
Q_3: Gate current control transistor
Q_4: BATT voltage detecting transistor



1) When Key Switch is "ON"

When the engine is at standstill with key switch set at position 1, the circuit functions to light LAMP, as shown in Fig. 1. With key switch at position 1, current flows to base of Q_2 through the route of BATT --→ emitter/base of Q_2 --→ R_1 --→ D_6 --→ BATT and collector of Q_2 is then turned on. As a result, current also flows to LAMP though the route of BATT --→ emitter/collector of Q_2 --→ D_5 --→ LAMP --→ BATT lighting LAMP to indicate that charging is not carried out. At this time, though current flows to base of Q_3 through the route of BATT --→ emitter/base of Q_3 --→ R_2 --→ D_6 --→ BATT, collector of Q_3 has no current because GEN is stationary.

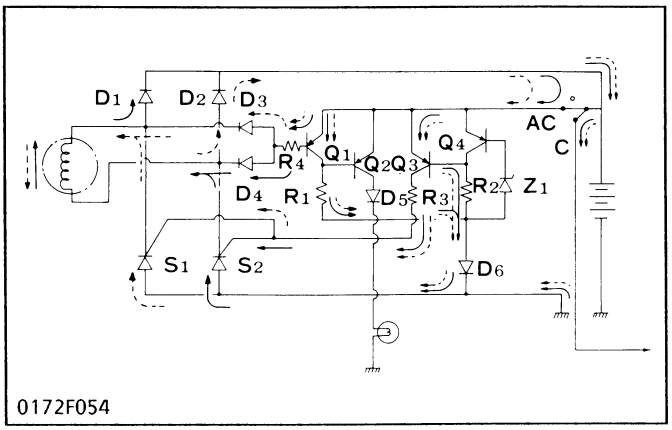


0172F053

2) At Starting

When key switch is turned to position 2, coil of starter relay is energized and starter starts engine. GEN also starts generation for charging and LAMP is turned off.

In detail, with GEN starting, current flows to base of Q_1 through the route of GEN → D_1 → emitter/base of Q_1 → R_4 → D_4 → GEN, or GEN --→ D_2 --→ emitter/base of Q_1 --→ R_4 --→ D_3 --→ GEN, and therefore current also flows through Q_1, short-circuiting emitter and base of Q_2. As a result, base current of Q_2 is interrupted, Q_2 is turned off and accordingly current to LAMP is also interrupted.



0172F054

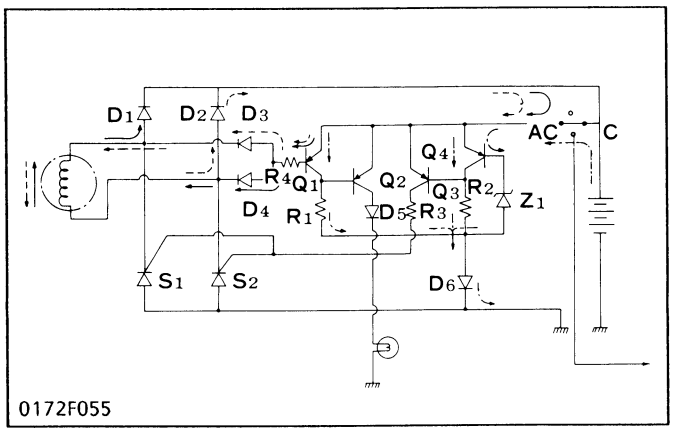
3) In Charging

Because BATT terminal voltage just after engine start is lower than setting value (14 to 15V), or lower than zener lever of Z_1, current is not supplied to base of Q_4 and Q_4 is off, as shown in Fig. 2. Q_3 is on with base current which flows through the route of BATT - --→ emitter/base of Q_3 --→ R_2 --→ D_6 --→ BATT, and gate current is supplied to S_1 or S_2 through the route of GEN → D_1 → emitter/collector of Q_3 → R_3 → gate/cathode of S_2 → GEN, or GEN --→ D_2 --→ emitter/collector of Q_3 --→ R_3 --→ gate/cathode of S_1 --→ GEN.

When engine speed is increased so that GEN generation voltage becomes higher than BATT terminal voltage S_1 or S_2 is turned on and, as shown in Fig. 3, charge current is supplied to BATT through the route of GEN → D_1 → BATT → anode/cathode of S_2 → GEN, or GEN --→ D_2 --→ BATT --→ anode/cathode of S_1 --→ GEN.

After S_1 or S_2 is turned on, collector current of Q_1 and base current of Q_3 are supplied by GEN, not BATT.

When key switch is returned to position 1 after engine is started, BATT is charged, if BATT terminal voltage is lower than the setting value, or zener level of Z_1.



0172F055

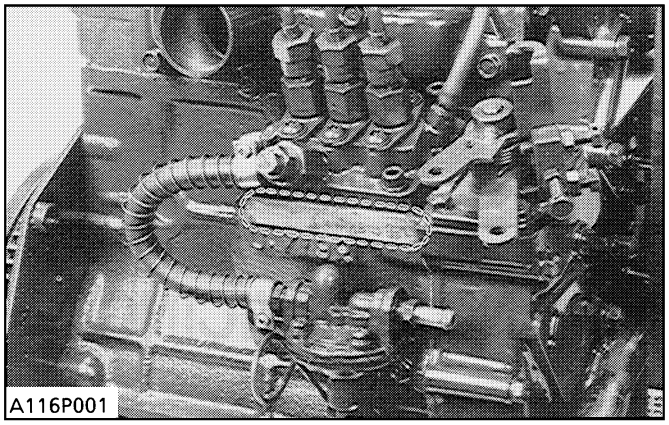
4) Over-Charge Protection

When BATT terminal voltage is higher than the setting value or zener level of Z_1, BATT is not charged by the function of circuit as shown in Fig. 4. That is, Q_4 is on with base current which flows through the route of BATT --→ emitter/base of Q_4 --→ Z_1 --→ D_6 --→ BATT, shortcircuiting emitter and base of Q_3. Therefore, Q_3 is off with no base current and gate current is not supplied to S_1 and S_2. Consequently S_1 and S_2 are off and BATT is not charged.

G GENERAL

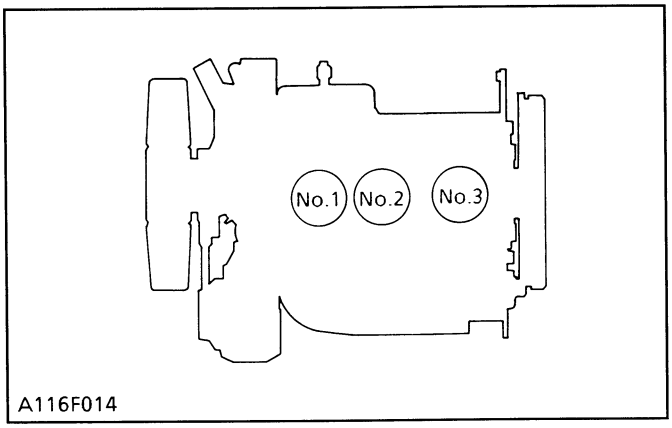
[1] ENGINE IDENTIFICATION

Model Name and Engine Serial Number



When contacting the manufacturer, always specify your engine model name and serial number.

Cylinder Number



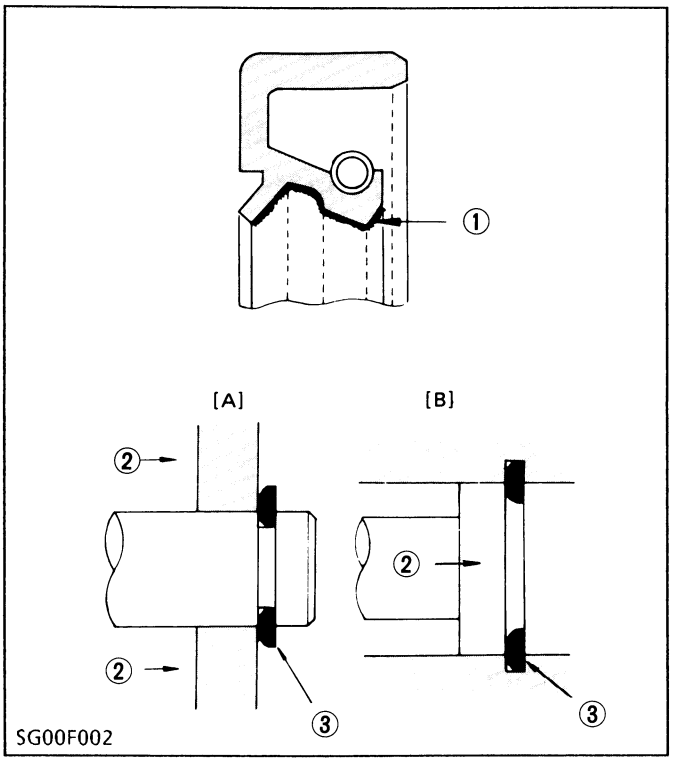
The cylinder numbers of 68 mm STROKE SERIES diesel engine are designated as shown in the figure.
The sequence of cylinder numbers is given as No.1, No.2, No.3 starting from the gear case side.

[2] GENERAL PRECAUTIONS

■ **Precation at overheating**

Take the following actions in the event the coolant temperature be nearly or more than the boiling point, what is called "Overheating".

(1) Stop the machine operation in a safe place and keep the engine unloaded idling.
(2) Don't stop the engine suddenly, but stop it after about 5 minutes of unloaded idling.
(3) Keep yourself well away from the machine for further 10 minutes or while the steam spout out.
(4) Checking that there gets no danger such as burn, get rid of the causes of overheating according to the manual.
And then, start again the engine.



- 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 Kubota's 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 Kubota 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.

⚠ CAUTION

- **All current Kubota production engines are asbestos-free.**
  However, some engines, which were produced before the introduction of applying asbestos-free regulations, are still being used in the market.
  In servicing such as overhauling for the engine which contain asbestos, follow the specified safety rules and regulations and handle them with due care.

(1) Grease
(2) Force
(3) Place the Sharp Edge against the Direction of Force

[A] External Snap Ring
[B] Internal Snap Ring

[3] TIGHTENING TORQUES

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

(1) Tightening torques for special use screws, bolts and nuts

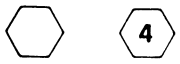
■ NOTE

- **In removing and applying the bolts and nuts marked with "*", pneumatic wrench or similar pneumatic tool, if employed, must be used with enough care not to get them seized.**
- **For "*" marked screws, bolts and nuts on the table, apply engine oil to their threads and seats before tightening.**

Item	Size x Pitch	N·m	kgf·m	ft-lbs
* Cylinder head cover cap nut	M6 x 1.0	3.9 to 5.9	0.4 to 0.6	2.9 to 4.3
* Cylinder head screw	M8 x 1.25	37.3 to 42.2	3.8 to 4.3	27.5 to 31.1
* Bearing case screw 1	M6 x 1.0	12.7 to 15.7	1.3 to 1.6	9.4 to 11.6
* Bearing case screw 2	M7 x 1.0	26.5 to 30.4	2.7 to 3.1	19.5 to 22.4
* Flywheel screw	M10 x 1.25	53.9 to 58.8	5.5 to 6.0	39.8 to 43.4
* Connecting rod screw	M7 x 0.75	26.5 to 30.4	2.7 to 3.1	19.5 to 22.4
* Rocker arm bracket nut	M6 x 1.0	9.81 to 11.28	1.00 to 1.15	7.23 to 8.32
* Idle gear shaft screw	M6 x 1.0	9.81 to 11.28	1.00 to 1.15	7.23 to 8.32
Glow plug	M8x 1.0	7.8 to 14.7	0.8 to 1.5	5.8 to 10.8
Nozzle holder assembly	M20 x 1.5	49.0 to 68.6	5.0 to 7.0	36.2 to 50.6
Oil switch taper screw	PT 1/8	14.7 to 19.6	1.5 to 2.0	10.8 to 14.5
Injection pipe retaining nut	M12 x 1.5	24.5 to 34.3	2.5 to 3.5	18.1 to 25.3
Starter's terminal B mounting nut	M8	8.8 to 11.8	0.9 to 1.2	6.5 to 8.7

(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.

Grade / Nominal Diameter / Unit	Standard Screw and Bolt  SG00F004			Special Screw and Bolt 		
	N·m	kgf·m	ft-lbs	N·m	kgf·m	ft-lbs
M 6	7.9 to 9.3	0.80 to 0.95	5.8 to 6.9	9.8 to 11.3	1.00 to 1.15	7.23 to 8.32
M 8	17.7 to 20.6	1.8 to 2.1	13.0 to 15.2	23.5 to 27.5	2.4 to 2.8	17.4 to 20.3
M10	39.2 to 45.1	4.0 to 4.6	28.9 to 33.3	48.1 to 55.9	4.9 to 5.7	35.4 to 41.2
M12	62.8 to 72.6	6.4 to 7.4	46.3 to 53.5	77.5 to 90.2	7.9 to 9.2	57.1 to 66.5

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)

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[4] TROUBLESHOOTING

Symptom	Probable Cause	Solution	Reference Page
Engine Does Not Start	• No fuel	Replenish fuel	–
	• Air in the fuel system	Bleed air	S-14
	• Water in the fuel system	Replace fuel and repair or replace fuel system	–
	• Fuel pipe clogged	Clean	–
	• Fuel filter clogged	Replace	S-16
	• Excessively high viscosity of fuel or engine oil at low temperature	Use the specified fuel or engine oil	S-15
	• Fuel with low cetane number	Use the specified fuel	–
	• Fuel leak due to loose injection pipe retaining nut	Tighten nut	S-27
	• Incorrect injection timing	Adjust	S-57
	• Fuel cam shaft worn	Replace	–
	• Injection nozzle clogged	Clean	S-56
	• Injection pump defective	Repair or replace	S-57
	• Fuel pump defective	Repair or replace	–
	• Seizure of crankshaft, camshaft, piston or bearing	Repair or replace	–
	• Compression leak from cylinder	Replace head gasket, tighten cylinder head bolt, glow plug and nozzle holder	S-24
	• Improper valve seat alignment, valve spring broken, valve seized	Repair or replace	S-39
	• Improper valve timing	Adjust	S-57
	• Piston ring worn	Replace	S-34
	• Excessive valve clearance	Adjust	S-19
[Starter Does Not Work]	• Battery discharged	Charge	–
	• Starter defective	Repair or replace	S-61
	• Main switch defective	Repair or replace	–
	• Wiring disconnected	Connect	–
Engine Revolution Is Not Smooth	• Fuel filter clogged or dirty	Replace	S-16
	• Air cleaner clogged	Clean or replace	S-15
	• Fuel leak due to loose injection pipe retaining nut	Tighten nut	S-14
	• Injection pump defective	Repair or replace	S-57
	• Incorrect nozzle opening pressure	Adjust	S-56
	• Injection nozzle suck or clogged	Repair or replace	S-56
	• Fuel over flow pipe clogged	Clean	–
	• Governor defective	Repair	–
Either White Or Blue Exhaust Gas Is Observed	• Excessive engine oil	Reduce to the specified level	–
	• Piston ring worn or stuck	Replace	S-34
	• Incorrect injection timing	Adjust	S-57
	• Deficient compression	Check the compression pressure	S-24
Either Black Or Dark Gray Exhaust Gas Is Observed	• Overload	Lessen the load	–
	• Low grade fuel used	Use the specified fuel	–
	• Fuel filter clogged	Replace	S-16
	• Air cleaner clogged	Clean or replace	S-15
Deficient Output	• Incorrect injection timing	Adjust	S-57
	• Engine's moving parts seem to be seizing	Repair or replace	–
	• Uneven fuel injection	Repair or replace the injection pump	–
	• Deficient nozzle injection	Repair or replace the nozzle	S-56
	• Compression leak	Replace head gasket, tighten cylinder head bolt, glow plug and nozzle holder	S-24

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Symptom	Probable Cause	Solution	Reference Page
Excessive Lubricant Oil Consumption	• Oil ring worn or stuck • Piston ring groove worn • Valve stem and guide worn • Crankshaft bearing, and crank pin bearing worn	Replace Replace the piston Replace Replace	S-34 S-43 S-38 S-48, 49, 50
Fuel Mixed Into Lubricant Oil	• Injection pump's plunger worn	Replace pump element or pump	–
Water Mixed Into Lubricant Oil	• Head gasket defective • Crank case or cylinder head flawed	Replace Replace	S-28 S-37
Low Oil Pressure	• Engine oil insufficient • Oil strainer clogged • Oil filter cartridge clogged • Relief valve stuck with dirt • Relief valve spring weaken or broken • Excessive oil clearance of crankshaft bearing • Excessive oil clearance of rocker arm boss. • Oil passage clogged • Different type of oil • Oil pump defective	Replenish Clean Replace Clean Replace Replace Replace Clean Use the specified type of oil Repair or replace	– S-32 S-16 – – S-48, 49, 50 S-41 – S-15 S-52, 53
High Oil Pressure	• Different type of oil • Relief valve defective	Use the specified type of oil Replace	S-15 –
Engine Overheated	• Engine oil insufficient • Fan belt broken or tensioned improperly • Coolant insufficient • Radiator net and radiator fin clogged with dust • Inside of radiator corroded • Coolant flow route corroded • Radiator cap defective • Radiator hose damaged • Thermostat defective • Water pump defective • Overload running	Replenish Replace or adjust Replenish Clean Clean or replace Clean or replace Replace Replace Replace Replace Loosen the load	– S-15 – – S-17 S-17 S-54 S-16 S-55 S-55 –
Battery Quickly Discharge	• Battery electrolyte insufficient • Fan belt slips • Wiring disconnected • Regulator defective • AC dynamo defective • Battery defective	Replenish distilled water and charge Adjust belt tension or replace Connect Replace Replace Replace	– S-54 – – S-60 –

[5] SERVICING SPECIFICATIONS

(1) ENGINE BODY

Cylinder Head

Item		Factory Specification	Allowable Limit
Cylinder Head Surface Flatness		–	0.05 mm 0.0020 in.
Top Clearance		0.50 to 0.70 mm 0.0197 to 0.0276 in.	–
Cylinder Head Gasket Thickness (Grommet Section)	Free	1.15 to 1.30 mm 0.04153 to 0.0512 in.	–
	Tightened	1.05 to 1.15 mm 0.0413 to 0.0453 in.	–
Compression Pressure		2.84 to 3.24 MPa 29 to 33 kgf/cm^2 412 to 469 psi	2.26 MPa 23 kgf/cm^2 327 psi

Valves

Valve Clearance (Cold)	0.145 to 0.185 mm 0.00571 to 0.00728 in.	–
Valve Seat Width	2.12 mm 0.0835 in.	–
Valve Seat Angle	0.785 rad 45°	–
Valve Face Angle	0.785 rad 45°	–
Valve Recessing	-0.10 to 0.10 mm -0.0039 to 0.0039 in.	0.30 mm 0.0118 in.
Clearance between Valve Stem and Valve Guide	0.030 to 0.057 mm 0.00118 to 0.00224 in.	0.10 mm 0.0039 in.
Valve Stem O.D.	5.968 to 5.980 mm 0.23496 to 0.23543 in.	–
Valve Guide I.D.	6.010 to 6.025 mm 0.23661 to 0.23720 in.	–

Valve Timing

Inlet Valve	Open	0.35 rad (20°) before T.D.C.	–
	Close	0.79 rad (45°) after B.D.C.	–
Exhaust Valve	Open	0.87 rad (50°) before B.D.C.	–
	Close	0.26 rad (15°) after T.D.C.	–

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Valve Spring

Item	Factory Specification	Allowable Limit
Free Length	31.3 to 31.8 mm 1.232 to 1.252 in.	28.4 mm 1.118 in.
Setting Load/Setting Length	64.7 N/27 mm 6.6 kgf/27 mm 14.6 lbs/1.063 in.	54.9 N/27 mm 5.6 kgf/27 mm 12.3 lbs/1.063 in.
Tilt	–	1.2 mm 0.047 in.

Rocker Arm

Clearance between Rocker Arm Shaft and shaft Hole	0.016 to 0.045 mm 0.00063 to 0.00177 in.	0.15 mm 0.0059 in.
Rocker Arm Shaft O.D.	10.473 to 10.484 mm 0.41232 to 0.41276 in.	–
Rocker Arm Shaft Hole I.D.	10.500 to 10.518 mm 0.41339 to 0.41410 in.	–

Tappet

Clearance between Tappet and Guide	0.016 to 0.052 mm 0.00063 to 0.00205 in.	0.10 mm 0.0039 in.
Tappet O.D.	17.966 to 17.984 mm 0.70732 to 0.70803 in.	–
Tappet Guide I.D.	18.000 to 18.018 mm 0.70866 to 0.70937 in.	–

Camshaft

Camshaft Side Clearance	0.15 to 0.31 mm 0.0059 to 0.01220 in.	0.5 mm 0.020 in.
Camshaft alignment	–	0.01 mm 0.0004 in.
Cam height (IN., EX.)	26.88 mm 1.0583 in.	26.83 mm 1.0563 in.
Oil clearance of camshaft	0.050 to 0.091 mm 0.0020 to 0.0036 in.	0.15 mm 0.0059 in.
Camshaft journal O.D.	32.934 to 32.950 mm 1.2966 to 1.2972 in.	–
Camshaft bearing I.D.	33.000 to 33.025 mm 1.2992 to 1.3002 in.	–

Timing Gear

Item	Factory Specification	Allowable Limit
Timing gear backlash		
Crank gear – Oil Pump Drive Gear	0.041 to 0.123 mm 0.00161 to 0.00484 in.	0.15 mm 0.0059 in.
Idle gear – Cam gear	0.047 to 0.123 mm 0.00185 to 0.00484 in.	0.15 mm 0.0059 in.
Idle gear – Injection pump gear	0.046 to 0.124 mm 0.00181 to 0.00488 in.	0.15 mm 0.0059 in.
Idel gear – Crank gear	0.043 to 0.124 mm 0.00169 to 0.00488 in.	0.15 mm 0.0059 in.
Idle gear Side clearance	0.20 to 0.51 mm 0.0079 to 0.0201 in.	0.80 mm 0.0315 in.
Clearance between idle gear shaft and idle gear bushing	0.020 to 0.084 mm 0.00079 to 0.00331 in.	0.10 mm 0.0039 in.
Idle Gear shaft O.D.	19.967 to 19.980 mm 0.78610 to 0.78661 in.	–
Idle Gear Bushing I.D.	20.000 to 20.051 mm 0.78740 to 0.78941 in.	–

Cylinder Liner

Cylinder liner I.D.	Z442-B (E) D662-B (E)	64.000 to 64.019 mm 2.51968 to 2.52043 in.	64.169 mm 2.52634 in.
	Z482-B (E) D722-B (E)	67.000 to 67.019 mm 2.63779 to 2.63854 in.	67.169 mm 2.64445 in.
Oversized cylinder liner I.D.	Z442-B (E) D662-B (E)	64.250 to 64.269 mm 2.52953 to 2.53027 in.	64.419 mm 2.53618 in.
	Z482-B (E) D722-B (E)	67.250 to 67.269 mm 2.64764 to 2.64839 in.	67.419 mm 2.65429 in.

Crankshaft

Crankshaft alignment	–	0.02 mm 0.0008 in.
Oil clearance between crankshaft and crankshaft bearing 1	0.034 to 0.106 mm 0.00134 to 0.00417 in.	0.20 mm 0.0079 in.
Crankshaft O.D.	39.934 to 39.950 mm 1.57221 to 1.57284 in.	–
Crankshaft bearing 1 I.D.	39.984 to 40.040 mm 1.57417 to 1.57638 in.	–
Oil clearance between crankshaft and crankshaft bearing 2	0.028 to 0.059 mm 0.00110 to 0.00232 in.	0.20 mm 0.0079 in.
Crankshaft O.D.	43.934 to 43.950 mm 1.72968 to 1.73031 in.	–
Crankshaft bearing 2 I.D.	43.978 to 43.993 mm 1.73142 to 1.73201 in.	–

Crankshaft

Item	Factory Specification	Allowable Limit
Oil clearance between crankshaft and crankshaft bearing 3	0.028 to 0.059 mm 0.00110 to 0.00232 in.	0.20 mm 0.0079 in.
Crankshaft O.D.	39.934 to 39.950 mm 1.57221 to 1.57284 in.	–
Crankshaft bearing 3 I.D.	39.978 to 39.993 mm 1.57394 to 1.57453 in.	–
Oil clearance between crank pin and crank pin bearing	0.020 to 0.051 mm 0.00079 to 0.00201 in.	0.15 mm 0.0059 in.
Crankshaft O.D.	33.959 to 33.975 mm 1.33697 to 1.33760 in.	–
Crank pin bearing I.D.	33.995 to 34.010 mm 1.33840 to 1.33898 in.	–
Crankshaft side clearance	0.15 to 0.31 mm 0.0059 to 0.0122 in.	0.5 mm 0.0197 in.

Connecting Rod

Connecting rod alignment	–	0.05 mm 0.0020 in.
Clearance between piston pin and small end bushing	0.014 to 0.038 mm 0.00055 to 0.00150 in.	0.10 mm 0.0039 in.
Piston pin O.D.	20.002 to 20.011 mm 0.78748 to 0.78783 in.	–
Small end bushing I.D.	20.025 to 20.040 mm 0.78839 to 0.78897 in.	–

Piston/Piston Ring

Piston pin hole I.D.		20.000 to 20.013 mm 0.78740 to 0.78791 in.	20.05 mm 0.7894 in.
Piston ring clearance	Second compression ring 2	0.085 to 0.115 mm 0.0033 to 0.0045 in.	0.15 mm 0.0059 in.
	Oil ring	0.02 to 0.06 mm 0.0008 to 0.0024 in.	0.15 mm 0.0059 in.
Ring gap	Top compression ring and oil ring	0.15 to 0.30 mm 0.0059 to 0.0118 in.	1.2 mm 0.0472 in.
	Second compression ring	0.30 to 0.45 mm 0.0118 to 0.0177 in.	1.2 mm 0.0472 in.
Oversize of piston rings		+ 0.25 mm + 0.0098 in.	–

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(2) LUBRICATING SYSTEM

Oil Pump

Item		Factory Specification	Allowable Limit
Engine oil pressure	At idle speed	49 kPa 0.5 kgf/cm^2, 7 psi	–
	At rated speed	196 to 441 kPa 2.0 to 4.5 kgf/cm^2 28 to 64 psi	147 kPa 1.5 kgf/cm^2 21 psi
Clearance between inner rotor and outer rotor		0.03 to 0.14 mm 0.012 to 0.0055 in.	–
Clearance between outer rotor and pump body		0.07 to 0.15 mm 0.0028 to 0.0059 in.	–
End clearance between inner rotor and cover		0.075 to 0.135 mm 0.00295 to 0.00531in.	–

(3) COOLING SYSTEM

Thermostat

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

Radiator

Radiator water tightness	Water tightness at specified pressure 157 kPa 1.6 kgf/cm^2, 23 psi	–
Radiator cap air leakage	10 seconds or more 88 → 59 kPa 0.9 → 0.6 kgf/cm^2 13→9 psi	–
Fan belt tension	7.0 to 9.0 mm/98 N 0.28 to 0.35 in./98 N (10 kgf, 22 lbs.)	–

(4) FUEL SYSTEM

Injection Pump

Injection timing	0.35 to 0.38 rad before T.D.C. (20° to 22°)	–
Fuel tightness of pumpe element	–	14.71 MPa 150 kgf/cm^2, 2134 psi
Fuel tightness of delivery valve	–	5 seconds 14.71 → 13.73 MPa 150 → 140 kgf/cm^2 2134 → 1991 psi

Injection Nozzle

Item	Factory Specification	Allowable Limit
Fuel Injection pressure	13.73 to 14.71 MPa 140 to 150 kgf/cm^2 1991 to 2134 psi	–
Fuel tightness of nozzle valve seat	When the pressure is 12.75 MPa (130 kgf/cm^2, 1849 psi), the valve seat must be fuel tightness.	–

(5) ELECTRICAL SYSTEM

Starter

Commutator O.D.	28.0 mm 1.102 in.	27.0 mm 1.063 in.
Mica undercut	0.5 to 0.8 mm 0.020 to 0.031 in.	0.2 mm 0.008 in.
Brush length	16.0 mm 0.630 in.	10.5 mm 0.413 in.

Dynamo

No-load voltage	AC20V or more at 5200 min^{-1} (rpm)	–

Glow Plug

Glow plug resistance	Approx. 0.9 Ω	–

[6] 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.

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 800 hours	Every 1500 hours	Every one year	Every two years
Checking fuel pipes and clamps		☆										
* Changing engine oil	(1) Oil pan depth (101 mm) (3.98 in.)		☆									
	(2) Oil pan depth (121 mm) (4.76 in.)			☆								
Cleaning air filter element				☆								
Cleaning fuel filter				☆								
Checking fan belt tension and damage				☆								
Checking water pipes and clamps						☆						
* Changing oil filter cartridge	(1) Oil pan depth (101 mm) (3.98 in.)				☆							
	(2) Oil pan depth (121 mm) (4.76 in.)					☆						
Changing fuel filter cartridge							☆					
Cleaning radiator interior								☆				
Changing radiator cleaner and coolant												☆
Changing air filter element											☆	
Checking valve clearance									☆			
** Checking injection nozzle pressure										☆		
Changing water pipes and clamps												☆
Changing fuel pipes and clamps												☆

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

Fuel / Lubricating oil class	Low sulfur	High sulfur	Remarks
CF	❍	❍	TBN ≥ 10
CF-4	❍	X	
CG-4	❍	X	

❍ : Recommendable X : Not recommendable

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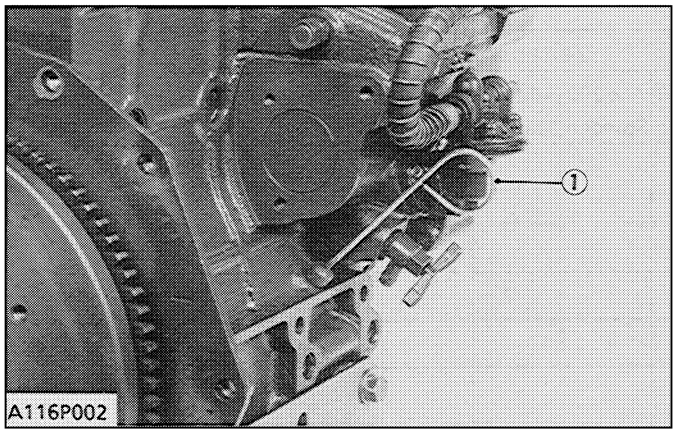
[7] CHECK AND MAINTENANCE

(1) Daily Check Points



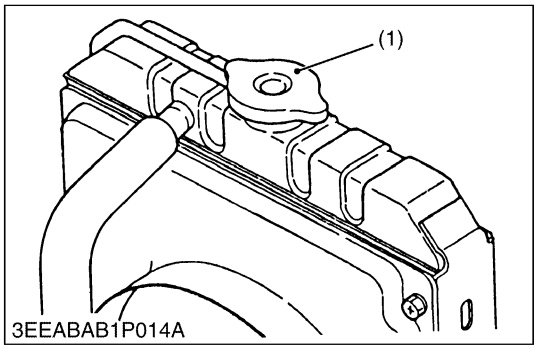
Checking Engine Oil Level

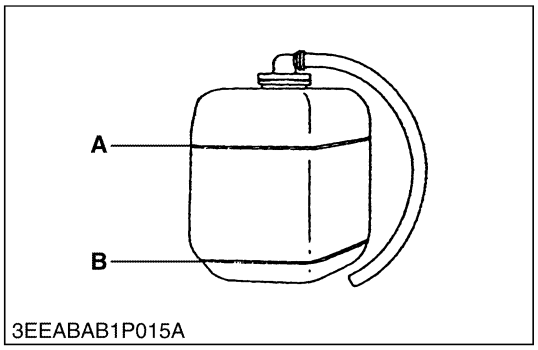
1. Level the engine.
2. To check the oil level, draw out the dipstick, (1) wipe it clean, reinsert it, and draw it out again. Check to see that the oil level lies between the two notches.
3. If the level is too low, add new oil to the specified level.

■ IMPORTANT

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

(1) Dipstick





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 :
   Check to see that the coolant level lies between **FULL** (**A**) and **LOW** (**B**).
2. If coolant level is too low, check the reason for decreasing coolant.
   Case 1) If coolant is decreasing by evaporation, 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** **(B) LOW**

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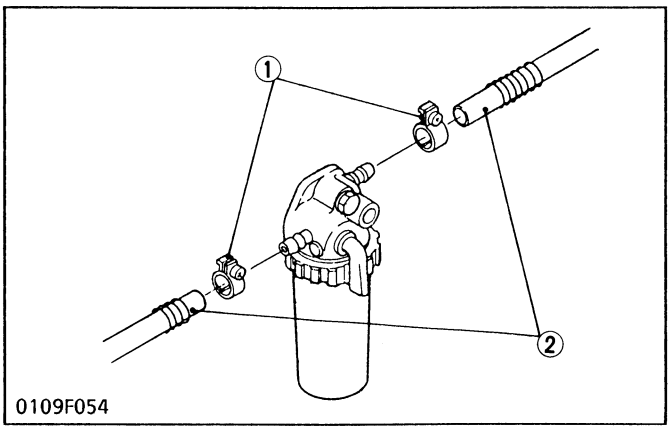
(2) Check Point of Every 50 hours



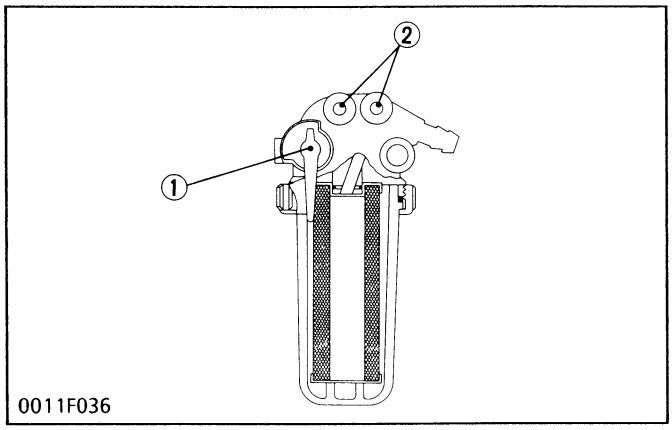
Checking Fuel Pipe

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

⚠ CAUTION

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

(1) Clamp
(2) Fuel Pipe



(When bleeding fuel system)

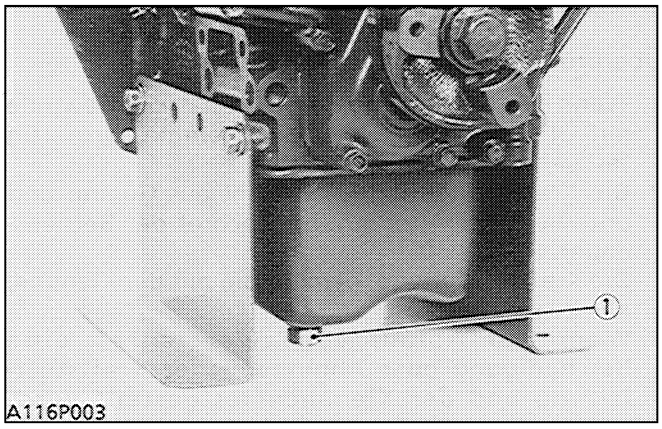
1 Fill the fuel tank with fuel, and open the fuel cock (1).
2. Loosen the air vent plug (2) of the fuel filter a few turns.
3. Screw back the plug when bubbles do not come up any more.
4. Open the air vent cock on top of the fuel injection pump.
5. Retighten the plug when bubbles do not come up any more.

■ NOTE

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

(1) Fuel Cock
(2) Air Vent Plug

(3) Check Point of Every 100 hours



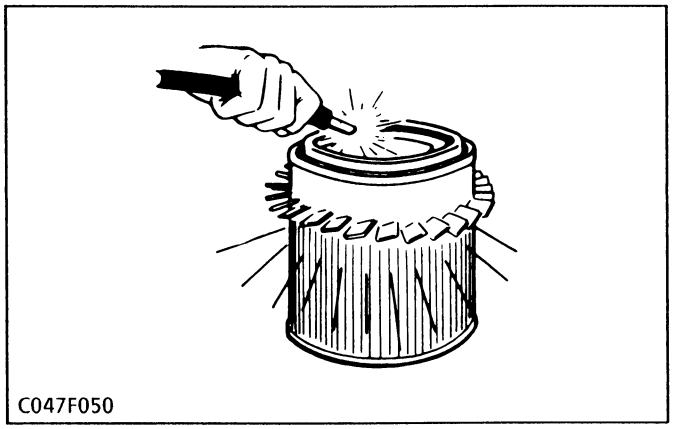
Changing Engine Oil

1. After warming up, stop the engine.
2. To change the used oil, remove the drain plug at the bottom of the engine and drain off the oil completely.
3. Reinstall the drain plug.
4. Fill the new oil up to the upper notch on the dipstick.

■ IMPORTANT

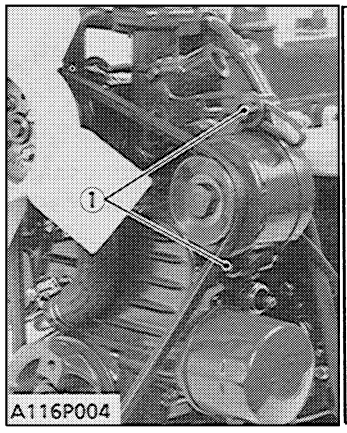
- **Change the type of engine oil according to the ambient temperature.**
  Above 25°C (77°F)---------- SAE 30 or 10W-30
  0°C to 25°C (32°F to 77°F)------ SAE 20 or 10W-30
  Below 0°C (32°F)---------- SAE 10 W or 10W-30

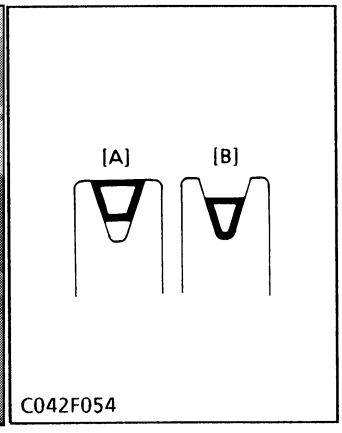
(1) Drain Plug



Cleaning Air Filter Element

- **When dry dust adheres**
  Use clean dry compressed air on the inside of the element.
  Pressure of compressed air must be under 205kPa (2.1 kgf/cm², 30psi).
  Maintain reasonable distance between the nozzle and the filter.



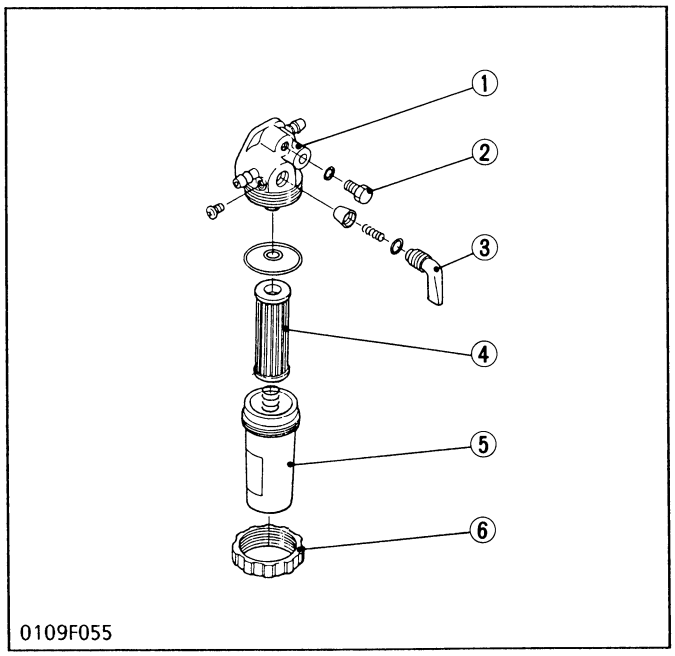


Checking Fan Belt Tension

1. Measure the deflection, depressing the belt halfway between the fan drive pulley and the AC dynamo pulley at 98 N (10kgf, 22 lbs) of force.
2. If the measurement is not the specified value, loosen the bolts and the nuts, and relocate the AC dynamo to adjust.

Fan belt tension	Factory spec.	7.0 to 9.0 mm / 98N 0.28 to 0.35 in. / 98N (10kgf,22lbs)

[A] Good
[B] Bad
(1) Tension Pulley Adjusting Bolts



0109F055

Cleaning Fuel Filter

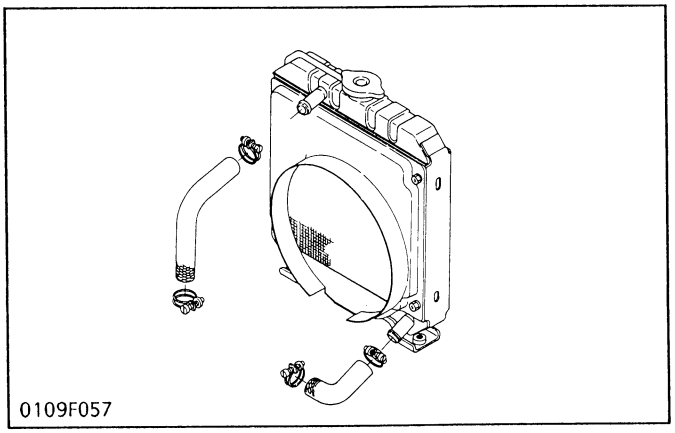
1. Close the fuel filter cock (3).
2. Unscrew the screw ring (6) and remove the cup (5), and rinse the inside with kerosene.
3. Take out the element (4) and dip it in the kerosene to rinse.
4. After cleaning, reassemble the fuel filter, keeping out dust and dirt.
5. Bleed the fuel system.

■ 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.**

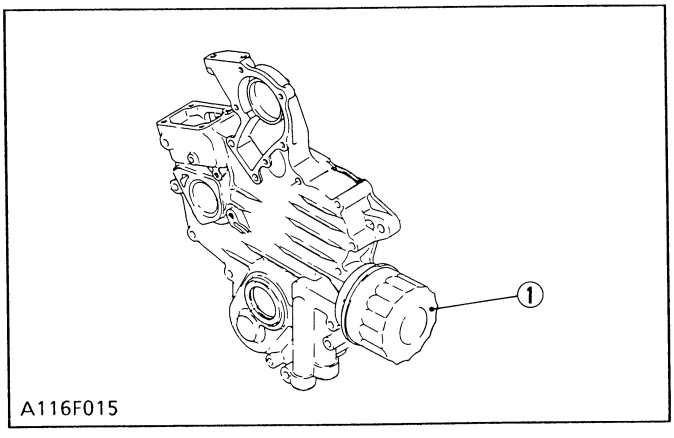
(1) Cock Body
(2) Air Vent Plug
(3) Filter Cock
(4) Filter Element
(5) Filter Cup
(6) Screw Ring

(4) Changing of Every 200 hours


0109F057

Checking radiator hoses (water pipes)

1. Check to see if the water pipes are properly fixed every 200 hours of operation or every six months, whichever comes first.
2. If clamp bands are loose or water leaks, tighten bands securely. Replace hoses and tighten clamp bands securely, if radiator hoses are swollen, hardened or cracked.
3. Replace hoses and clamp bands every 2 years or ealier if checked and found that hoses are swollen, hardened or cracked.



A116F015

Changing Engine Oil Filter Cartridge

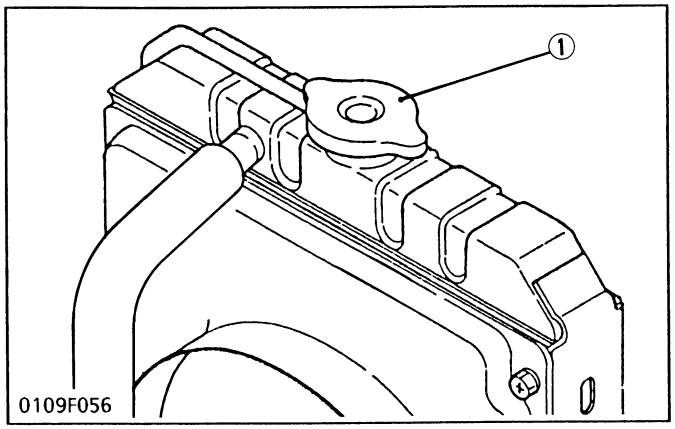
1. Remove the oil filter cartridge with a filter wrench.
2. Apply engine oil to the rubber gasket on the new cartridge.
3. Screw the new cartridge in by hand.

■ NOTE

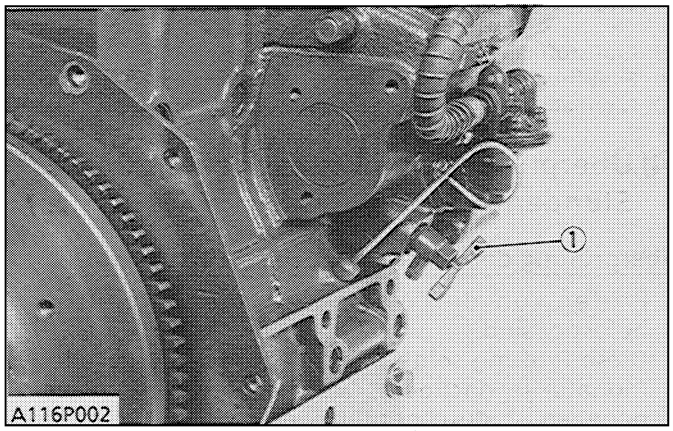
- **Over-tightening may cause deformation of rubber gasket.**
- **After cartridge has been replaced, engine oil normally decreases a little.**
  Check the oil level and add new oil to the specified level.

(1) Filter Cartridge

(5) Check Point of Every 500 hours



(1) Radiator Cap



(2) Drain Cock

Cleaning of water jacket (radiator interior)

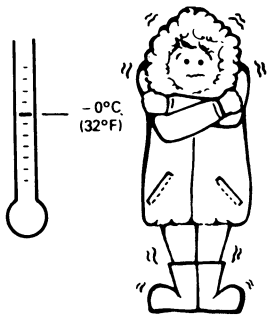
1. The cooling system should be cleaned on the following occasions:
   - Every 500service hours.
   - When adding antifreeze.
   - When changing from water containing antifreeze to pure water.
2. When cleaning the cooling system, Kubota Detergent No. 20 is recommended to effectively wash away the rust build-up.

⚠ CAUTION

- **Do not remove the radiator cap until cooling water temperature is enoughly cooled. Then loosen the cap sightly to relieve any excess pressure before removing the cap completely.**

■ IMPORTANT

- **Use clean, fresh water to fill the radiator.**
- **To drain the used coolant completely, open the radiator drain cocks and remove the radiator cap.**
- **Do not use the antifreeze during hot weather to maintain engine performance since the boiling point of coolant rises.**
- **The radiator should be filled with part antifreeze and part water at all times as recommended by the antifreeze manufacturer.**
- **Do not use an antifreeze and scale inhibitor at the same time.**



0203F015

Antifreeze

If the cooling water freezes, the engine cylinder block, cylinder head and radiator may crack. In cold weather, before the temperature drops below 0°C (32°F), drain out the water after operating or add a proper amount of antifreeze.

- There are two types of antifreeze solutions: permanent type (PT) and semi-permanent type (SPT). For the KUBOTA engines, be sure to use the permanent type.
- When antifreeze is used for the first time, fill and drain clean water twice or three times so as to completely clean the inside of the radiator.
- The procedure for mixing water and antifreeze differs according to the make of the antifreeze and the ambient temperature. Basically, it should be refered to SAE J1034 standard, more specifically also to SAE J814c.
- Mix the antifreeze and water, then pour the mixture into the radiator.

Vol % antifreeze	Freezing point		Boiling point	
	°C	°F	°C	°F
40	–24	–12	106	222
50	–37	–34	108	226
60	–52	–62	111	232
70	–64	–84	114	238

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

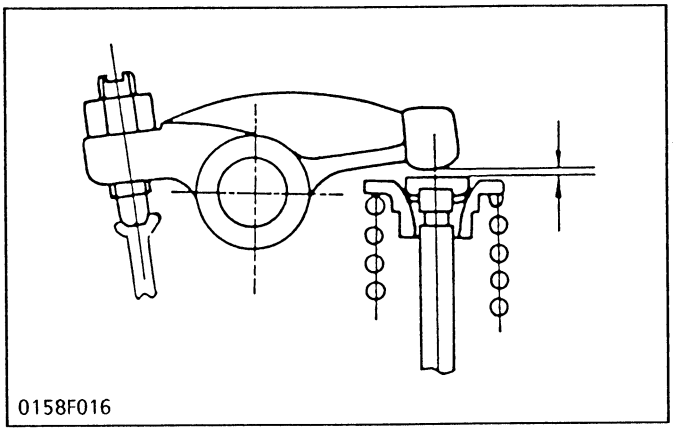
■ IMPORTANT

- **When the anti-freeze is mixed with water, the anti-freeze mixing ratio must be less than 50%.**
- **Do not use antifreeze during hot weather to keep the engine performance since the cooling water boiling point rises.**

■ NOTE

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

(6) Check Point of Every 800 hours



Valve Clearance

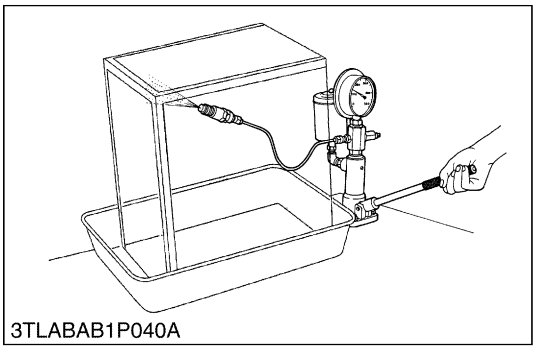
See page S-25.

Valve clearance	Factory spec.	0.145 to 0.185 mm 0.00571 to 0.00728 in.

(7) Check Points of 1500 hours

⚠ 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.

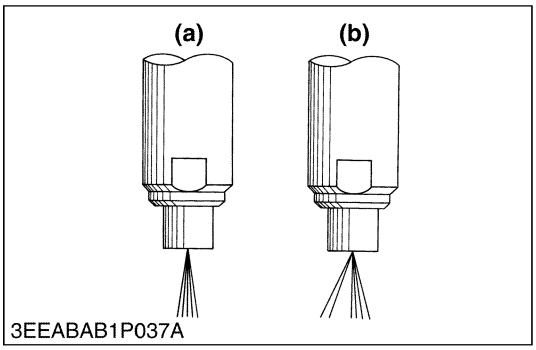


Fuel Injection Pressure

1. Set the injection nozzle to a nozzle tester (Code No. 07909-31361).
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 injection nozzle assembly.

Fuel injection pressure	Factory spec.	13.73 to 14.71 MPa 140 to 150 kgf/cm^2 1991 to 2134 psi

W10408820

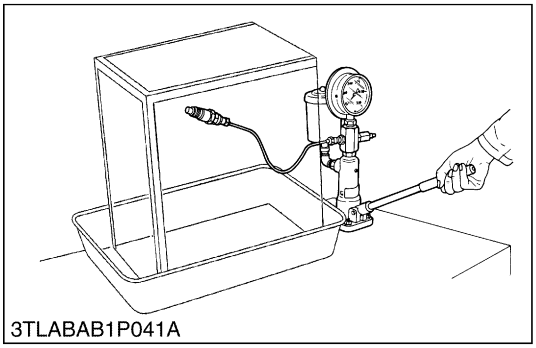


Nozzle Spraying Condition

1. Set the injection nozzle to a nozzle tester (Code No. 07909-31361), and check the nozzle spraying condition.
2. If the spraying condition is defective, replace the injection nozzle assembly.

(a) Good **(b) Bad**

W10411400



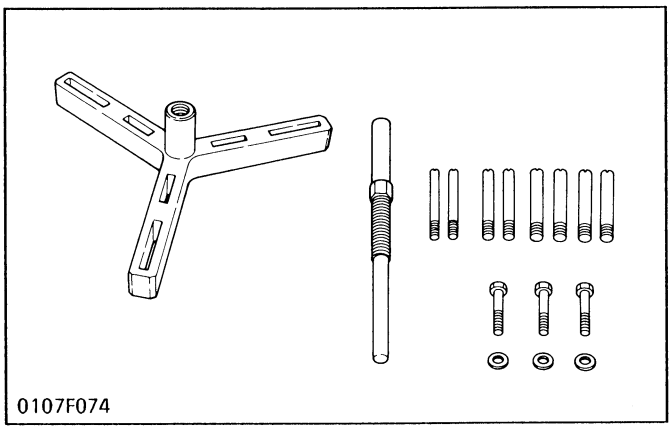
Valve Seat Tightness

1. Set the injection nozzle to a nozzle tester (Code No. 07909-31361).
2. Raise the fuel pressure, and keep at 12.75 MPa (130 kgf/cm^2, 1849 psi) for 10 seconds.
3. If any fuel leak is found, replace the injection nozzle assembly.

Valve seat tightness	Factory spec.	No fuel leak at 12.75 MPa 130 kgf/cm^2 1849 psi

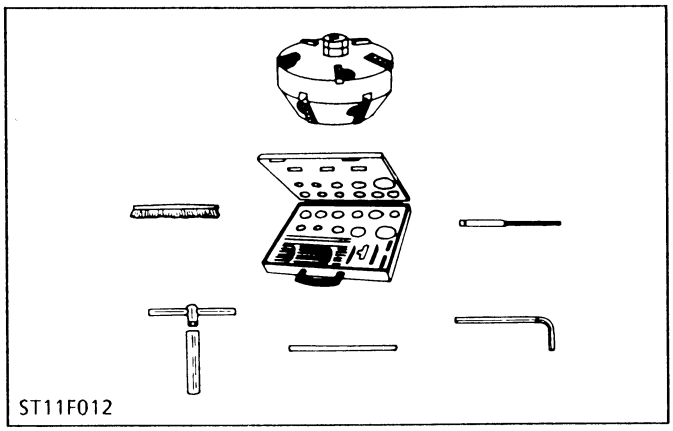
W10412730

[8] SPECIAL TOOLS


0107F074

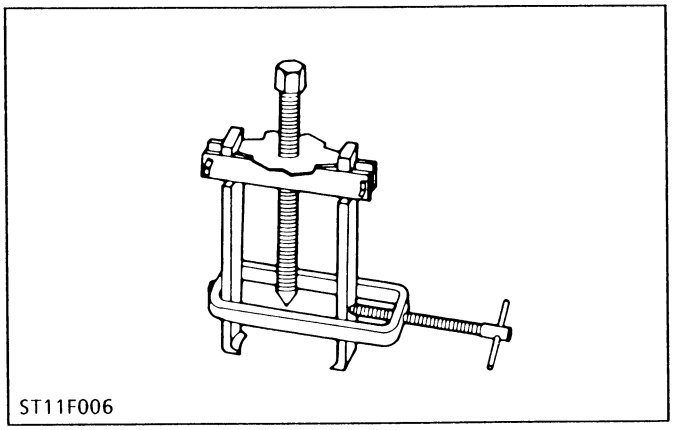
Flywheel Puller (For vertical type diesel engines)

Code No: 07916-32011
Application: Use exclusively to take off the flywheel of all vertical type diesel engines safely and easily.


ST11F012

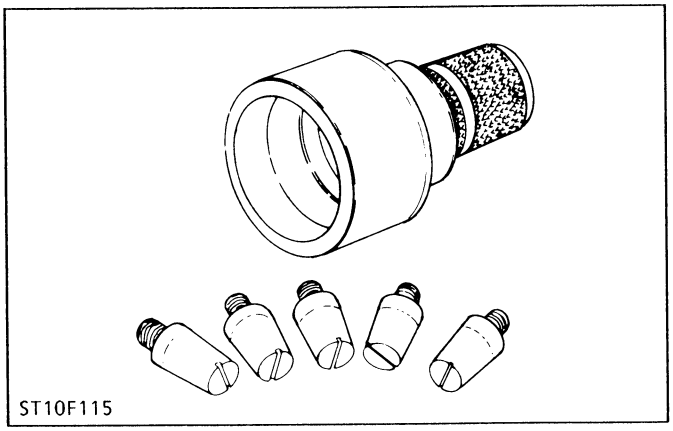
Valve Seat Cutter Set

Code No: 07909-33102
Application: Use for correcting valve seats.


ST11F006

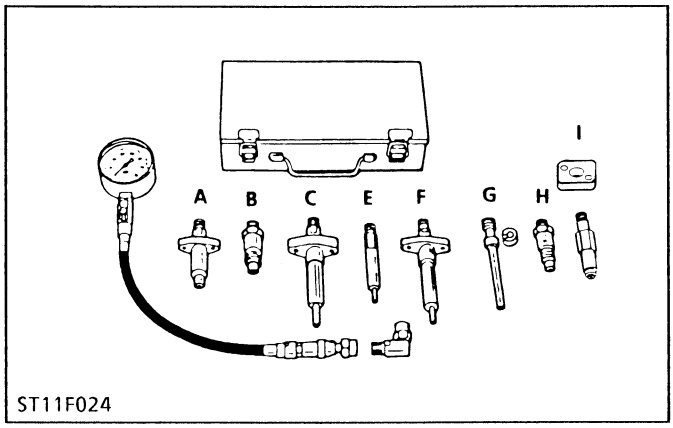
Special-use Puller Set

Code No: 07916-09032
Application: Use for pulling out bearings, gears and other parts.


ST10F115

Crank Sleeve Setter

Code No: 07916-34041
Application: Use to fix the crankshaft sleeve of the engine models Z442-B (E), Z482-B (E), D662-B (E), D722-B (E).

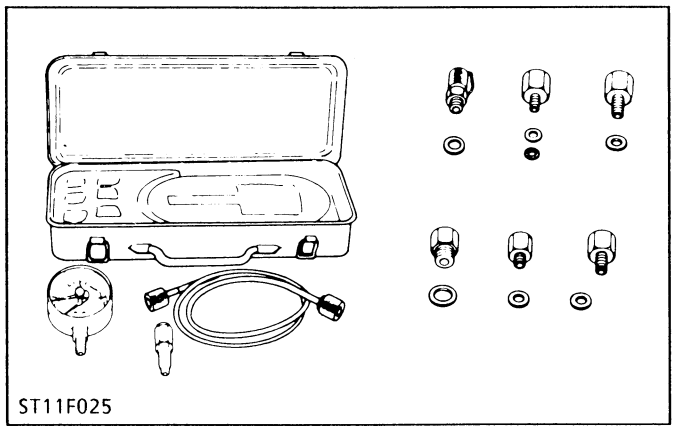


ST11F024

Diesel Engine Compression Tester

Code No: 07909-30208 (Assembly)
07909-30934 (A to F)
07909-31211 (E and F)
07909-31251 (G)
07909-31231 (H)
07909-31271 (I)

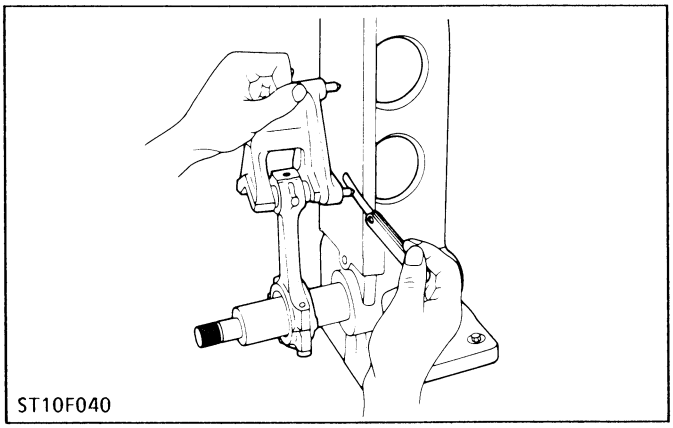
Application: Use for measuring diesel engine compression pressure.


ST11F025

Oil Pressure Tester

Code No: 07916-32032

Application: Use for measuring lubricating oil pressure.

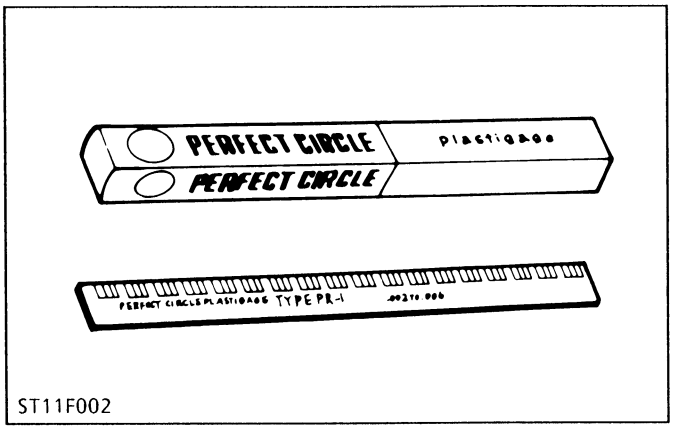

ST10F040

Connecting Rod Alignment Tool

Code No: 07909-31661

Application: Use for checking the connecting rod alignment.

Applicable: range: Connecting rod big end I.D. 30 to 75 mm (1.18 to 2.95 in. dia.) Connecting rod length 65 to 330 mm (2.56 to 12.99 in.)



ST11F002

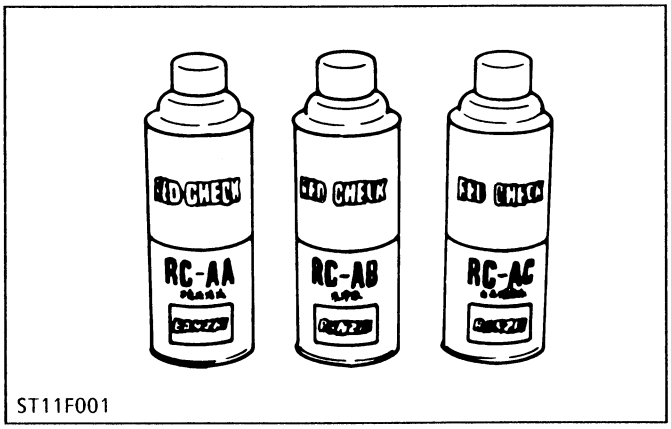
Plastigage

Code No: 07909-30241

Application: Use for checking the oil clearance between crankshaft and bearing, etc.

Measuring: range:
Green —— 0.025 to 0.076 mm (0.001 to 0.003 in.)
Red —— 0.051 to 0.152 mm (0.002 to 0.006 in.)
Blue —— 0.102 to 0.229 mm (0.004 to 0.009 in.)

KiSC issued 04, 2006 A



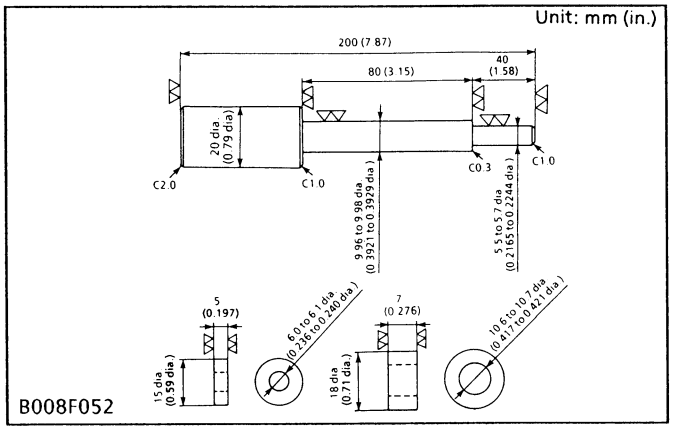
ST11F001

Red Check (Crack check liquid)

Code No: 07909-31371
Application: Use for checking cracks on cylinder head, cylinder block, etc.

■ **NOTE**

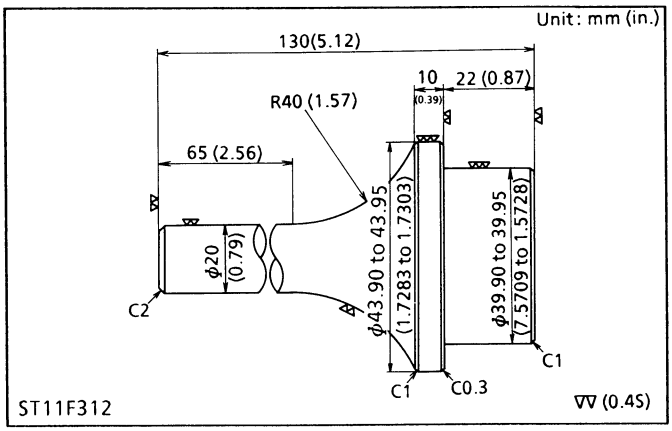
- **The following special tools are not provided, so make them referring to the figures.**



B008F052

Valve Guide Replacing Tool

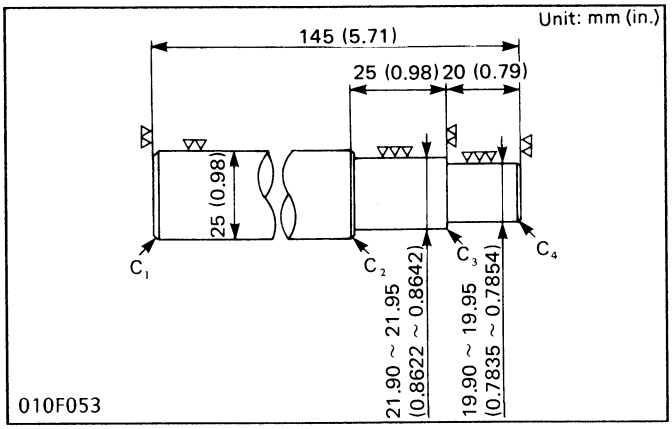
Application: Use to press out and press fit the valve guide.



ST11F312

Crankshaft Bearing 1 Replacing Tool

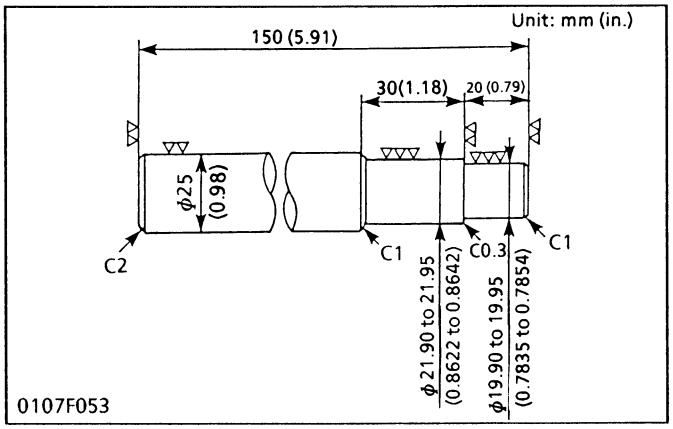
Application: Use to press out and press fit the crankshaft bearing 1.



010F053

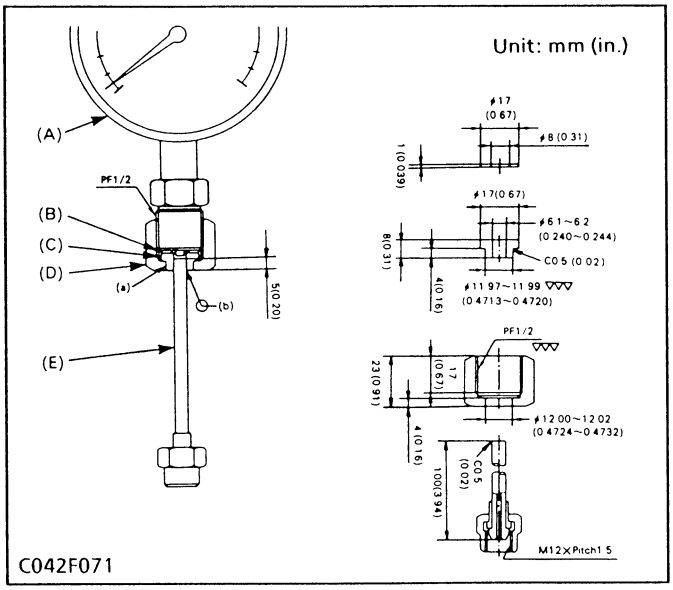
Connecting Rod Small End Bushing Tool

Application: Use to press out and press fit the connecting rod small end bushing.



Idle Gear Bushing Replacing Tool

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



Injection Pump Pressure Tester

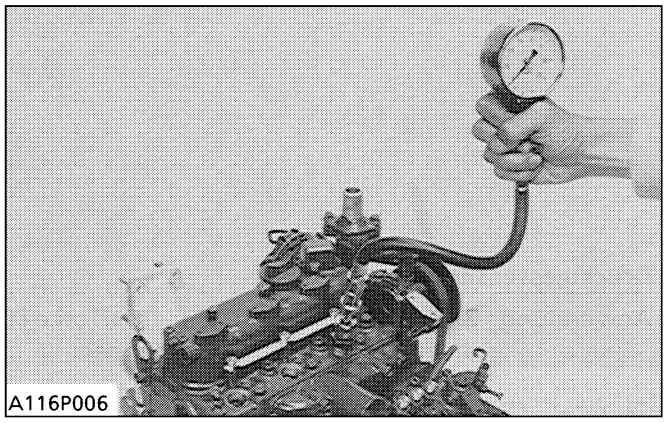
Application: Use to check the fuel tightness.

[A] Pressure Gauge, Full scale: more than 29.4 MPa (300 kgf/cm², 4267 psi)
[B] Copper Gasket
[C] Flange (Material: Steel)
[D] Hex. Nut, 27 mm (1.06 in.) across the flat (Material: Steel)
[E] Injection Pipe

(a) Adhesive application
(b) Fillet welding on the enter circumference

1 ENGINE BODY

CHECKING AND ADJUSTING


A116P006

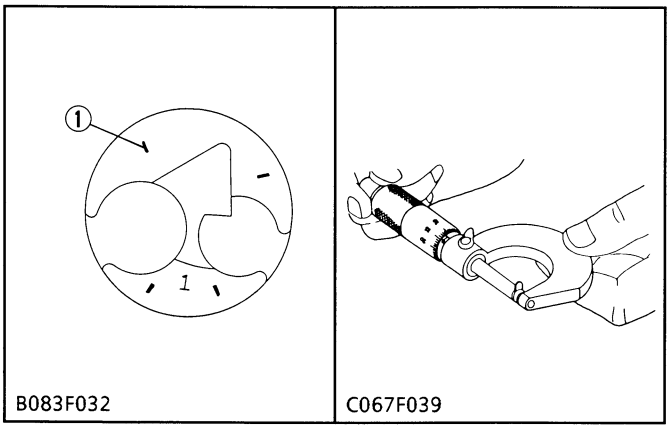
Compression Pressure

1. After warming up the engine, stop it and remove the air cleaner, the muffler and all nozzle holders.
2. Install a compression tester (Code No: 07909-30208) for diesel engines to nozzle holder hole.
3. After making sure that the speed control lever is set at the stop position (Non-injection), run the engine at 200 to 300 min^{-1} (rpm) with the starter.
4. Read the maximum pressure. Measure the pressure more than twice.
5. If the measurement is below the allowable limit, check the cylinder, piston ring, top clearance, valve and cylinder head.

■ **NOTE**

- **Variances in cylinder compression values should be under 10%.**

Compression pressure	Factory spec.	2.84 to 3.24 MPa 29 to 33 kgf/cm^2 412 to 469 psi
	Allowable limit	2.26 MPa 23 kgf/cm^2 327 psi



B083F032

C067F039

(1) Fuse

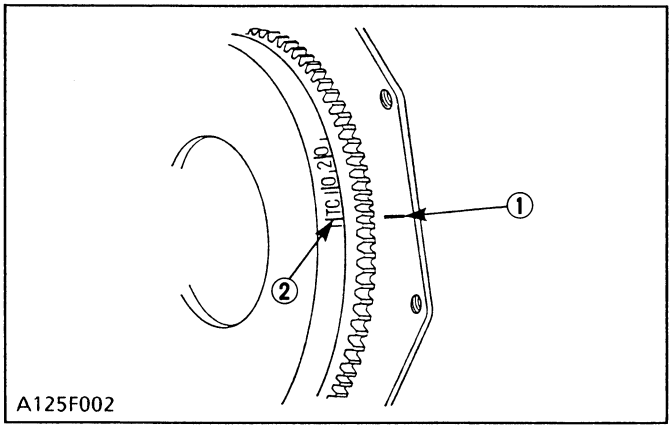
Top Clearance

1. Remove the cylinder head (then don't attmpt to remove the cylinder head gasket).
2. Bring the piston to its top dead center fasten 1.5 mm dia. 5 to 7 mm long fuse wires to 3 to 4 spots on the piston top with grease so as to avoid the intake and exhaust valves and the combustion chamber ports.
3. Bring the piston to its bottom dead center, install the cylinder head, and tighten the cylinder head screws to specification.
4. Turn the crank shaft until the piston exceeds its top dead center.
5. Remove the cylinder head, and measure squeezed fuse wires for thickness.
6. If the measurement is not within the specified value, check the oil clearance of the crankpin journal and the piston pin.

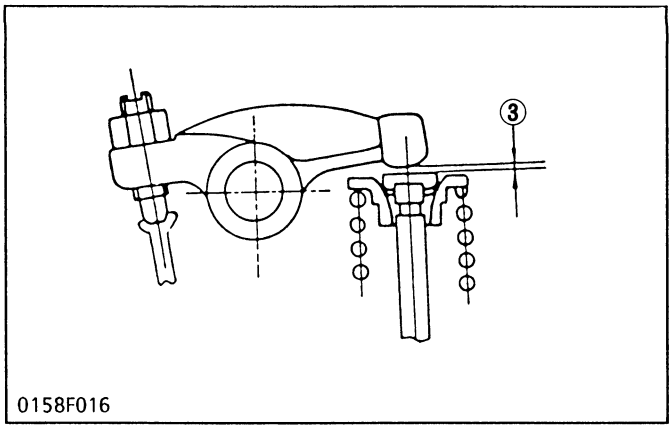
Top clearance	Factory spec.	0.50 to 0.70 mm 0.0197 to 0.0276 in.
Tightening torque	Cylinder head screw	37.3 to 42.2 N·m 3.8 to 4.3 kgf·m 27.5 to 31.1 ft-lbs

■ **NOTE**

- **Head gasket must be changed to new one.**



A125F002



0158F016

(1) Punch Mark
(2) TC Mark Line
(3) Valve Clearance

Checking Valve Clearance

■ IMPORTANT

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

1. Remove the head cover.
2. Align the "1TC" mark on the flywheel and punch mark (1) on the plate so that the No. 1 piston comes to the compression or overlap top ded dead center.
3. Check the following valve clearance marked with "o" using a feeler gauge.
4. If the clearance is not within the factory specifications, adjust with the adjusting screw.

Valve clearance	Factory spec.	0.145 to 0.185 mm 0.00571 to 0.00728 in.

■ NOTE

- **The "TC" making on the flywheel is just for No. 1 cylinder. There is no "TC" marking for the other cylinders.**
- **No. 1 piston comes to the T.D.C. position when the "TC" marking is aligned with the punch mark of the rear end plate. Turn the flywheel 0.26 rad (15°) clockwise and counter-clockwise to see if the piston is at the compression top dead center or the overlap position. Now referring to the table below, readjust the valve clearance. (The piston is at the top dead center when both the In. and EX valves do not move; it is at the overlap position when both the valves move.**
- **Finally turn the flywheel 6.28 rad (360°) to make sure the "TC" marking and the punch mark are perfectly aligned. Adjust all the other valve clearances as required.**
- **After turning the flywheel counterclockwise twice or three times, recheck the valve clearance.**
- **After adjusting the valve clearance, firmly tighten the lock nut of the adjusting screw.**

Engine Model Valve arrengement Adjustable cylinder Location of piston		Z442-B (E), Z482-B (E)		D662-B (E), D722-B (E)	
		IN.	EX.	IN.	EX.
When No. 1 piston is compression top dead center	1st	o	o	o	o
	2nd		o		o
	3rd			o	
When No. 1 piston is overlap position	1st				
	2nd	o		o	
	3rd				o

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DISASSEMBLING AND ASSEMBLING

■ **NOTE**

- **The cylinder heads with serial numbers 489291 and on are partially modified in configuration because of the introduction of the nozzle heat seal.**
  For replacing the cylinder head, see the Parts List and choose the right one in reference to its serial number.

[1] DRAINING WATER AND OIL

Draining Cooling Water and Engine Oil

⚠ **CAUTION**

- **Never remove radiator cap until cooling water temperature is below its boiling point. Then loosen cap slightly to the stop to relieve any excess pressure before removing cap completely.**

1. Prepare a bucket. Open the drain cock to drain cooling water.
2. Prepare an oil pan. Remove the drain plug to drain engine oil in the pan.

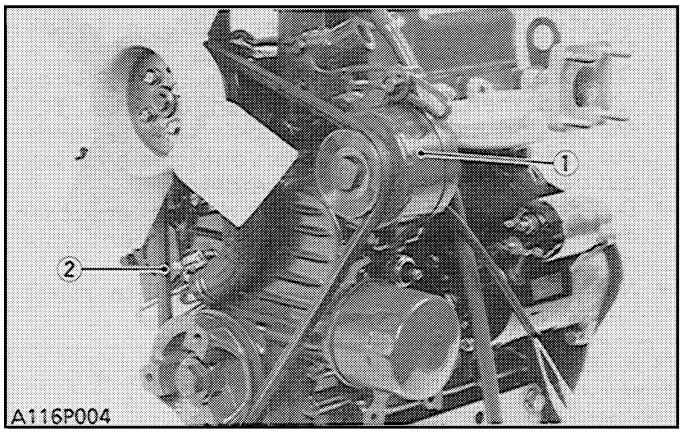
[2] EXTERNAL COMPONENTS

Air Cleaner and Muffler

1. Remove the air cleaner.
2. Remove muffler retaining nuts to remove the muffler.

(When reassembling)

- Install the muffler gasket so that its steel side face the muffler.



Dynamo and Fan Belt

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

(When reassembling)

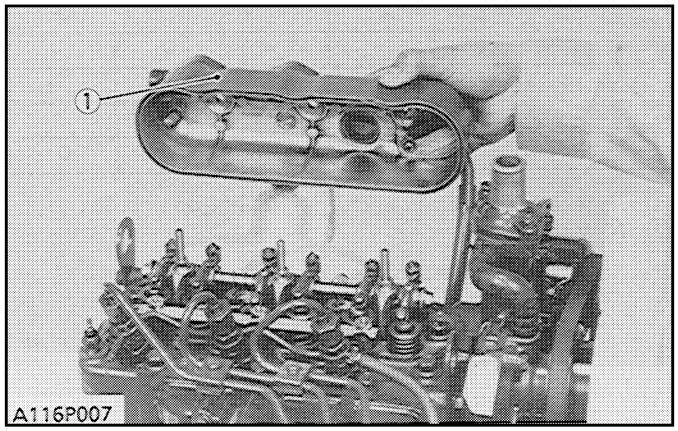
- Check to see that there are no cracks on the belt surface.

■ **IMPORTANT**

- **After reassembling the fan belt, be sure to adjust the fan belt tension.**

(1) Dynamo (2) Fan Belt

[3] CYLINDER HEAD AND VALVES



Cylinder Head Cover

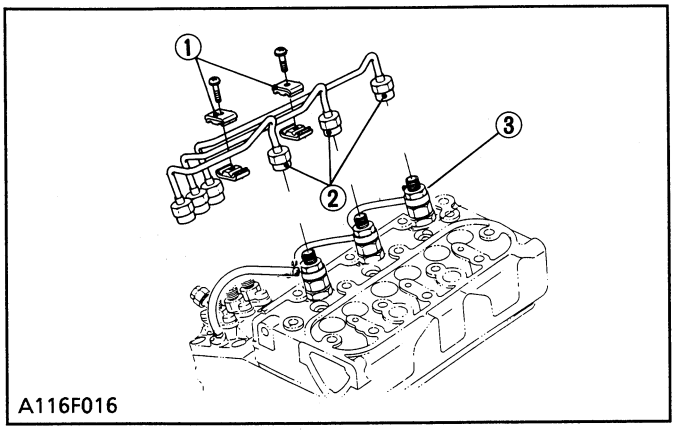
1. Remove the cylinder head cover cap nuts.
2. Remove the cylinder head cover (1).

(When reassembling)

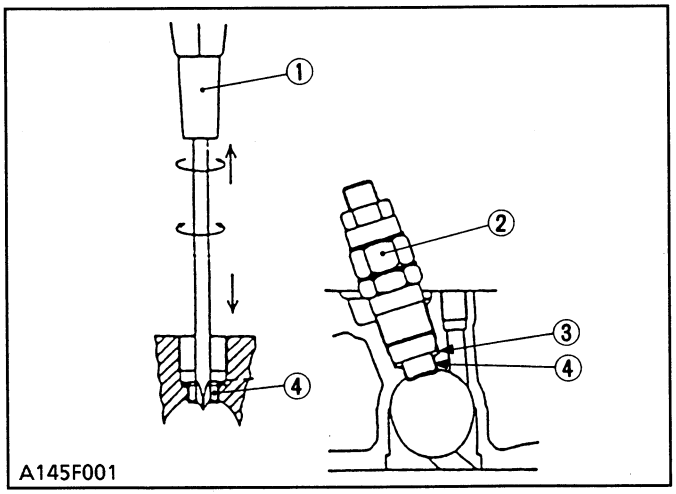
- Check to see that the cylinder head cover gasket is not defective.

Tightening torque	Cylinder head cover nut	3.9 to 5.9 N·m 0.4 to 0.6 kgf·m 2.9 to 4.3 ft-lbs

(1) Head Cover



(1) Pipe Clamps
(2) Injection Pipes
(3) Nozzle Holder Assembly



(1) Plus Screw Driver
(2) Injection Nozzle
(3) Injection Nozzle Packing
(4) Heat Seal

Injection Pipe and Nozzle Holder Assembly

1. Loosen the pipe clamps (1).
2. Remove the injection pipes (2).
3. Remove the fuel overflow pipe.
4. Loosen the lock nuts, and remove the nozzle holder assemblies (3).
5. Remove the copper gaskets on the seats.
6. Remove the nozzle heat seal. (Serial No.: 489291~)

Tightening torque	Injection pipe retaining nuts	24.5 to 34.3 N·m 2.5 to 3.5 kgf·m 18.1 to 25.3 ft-lbs
	Nozzle holder assembly	49.0 to 68.6 N·m 5.0 to 7.0 kgf·m 36.2 to 50.6 ft-lbs

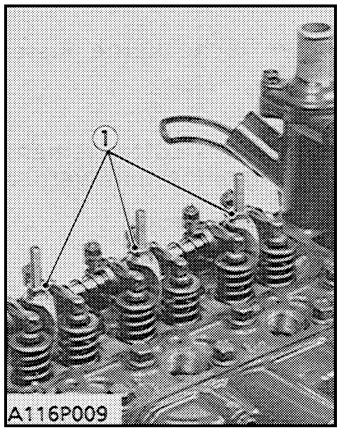
Nozzle Heat Seal Service Removal Procedure (Engine Serial Number : 489291 and beyond)

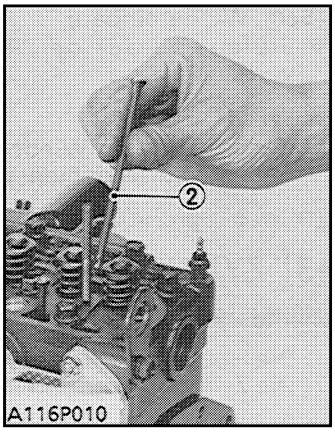
■ IMPORTANT

- **Use a plus (phillips head) screw driver that has a Dia. which is bigger than the heat seal hole. (Approx. 6 mm) 1/4 in.**

1. Drive screw driver lightly into the heat seal hole.
2. Turn screw driver three or four times each way.
3. While turning the screw driver, slowly pull the heat seal out together with the injection nozzle gasket.

   If the heat seal drops, repeat the above procedure. Heat seal and injection nozzle gasket must be changed when the injection nozzle is removed for cleaning or for service.





Rocker Arm and Push Rod

1. Remove the rocker arm bracket mounting nuts (1).
2. Remove the rocker arm as a unit.
3. Remove the push rods (2).

■ IMPORTANT

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

Tightening torque	Rocker arm brakcet nut	9.81 to 11.28 N·m 1.00 to 1.15 kgf·m 7.23 to 8.32 ft-lbs
Valve clearance	Factory spec.	0.145 to 0.185 mm 0.0057 to 0.0073 in.

■ NOTE

- **When putting the push rods (2) onto the tappets, check to see if their ends are properly engaged with the grooves.**

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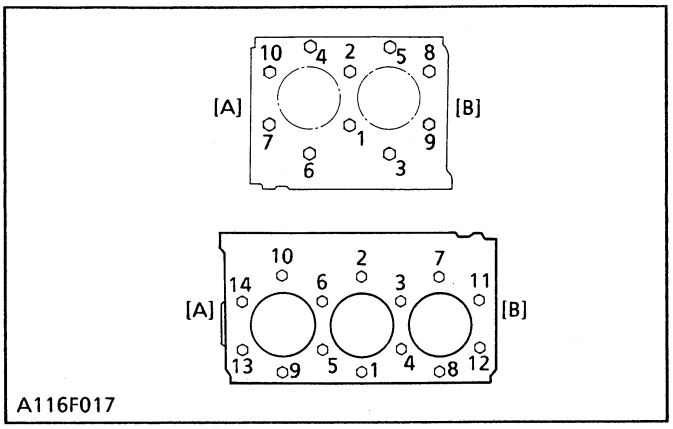

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Cylinder Head

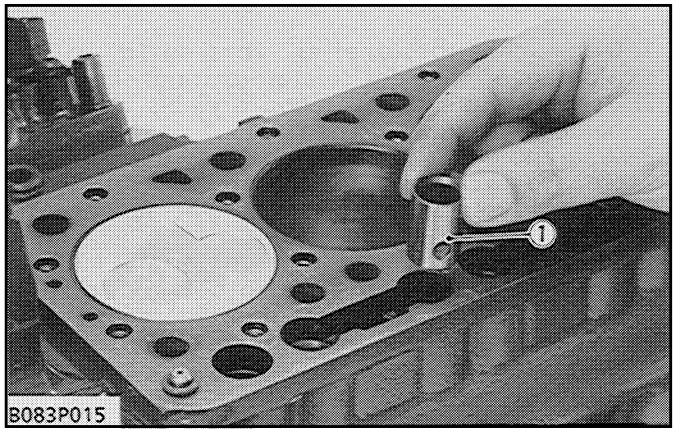
1. Loosen the pipe band, and remove the water return pipe.
2. Remove the cylinder head screws in the order of (⑩, ⑭) to (①), and remove the cylinder head.

(When reassembling)

- Replace the head gasket with a new one.
- Install the cylinder head, using care not to damage the O-ring.
- Tighten the cylinder head screws gradually in the order of (①) to (⑩, ⑭) after applying engine oil.
- Retighten the cylinder head screws and nuts after running the engine for 30 minutes.

Tightening torque	Glow plug	7.8 to 14.7 N·m 0.8 to 1.5 kgf·m 5.8 to 10.8 ft-lbs
	Cylinder head screw	37.3 to 42.2 N·m 3.8 to 4.3 kgf·m 27.5 to 31.1 ft-lbs

[A] Gear case side
[B] Flywheel side



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Tappets

1. Remove the cylinder head gasket and O-ring.
2. Remove the tappets from the crankcase.

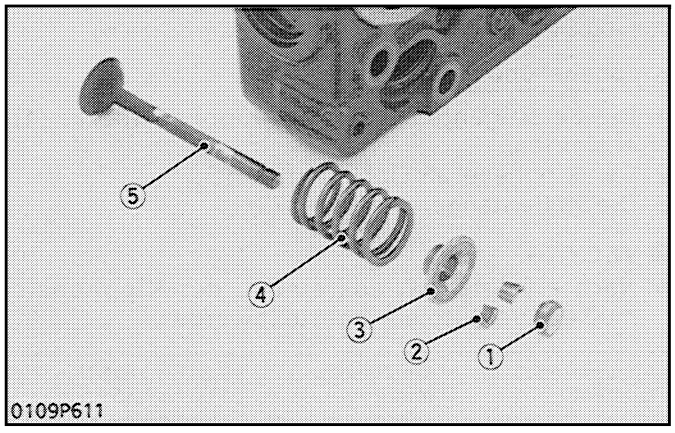
(When reassembling)

- Before installing the tappets, apply engine oil thinly around them.

■ NOTE

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

(1) Tappet



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Valves

1. Remove the valve cap (1).
2. Remove the valve spring collet (2) with a valve lifter.
3. Remove the valve spring retainers (3), valve spring (4) and valve (5).

■ IMPORTANT

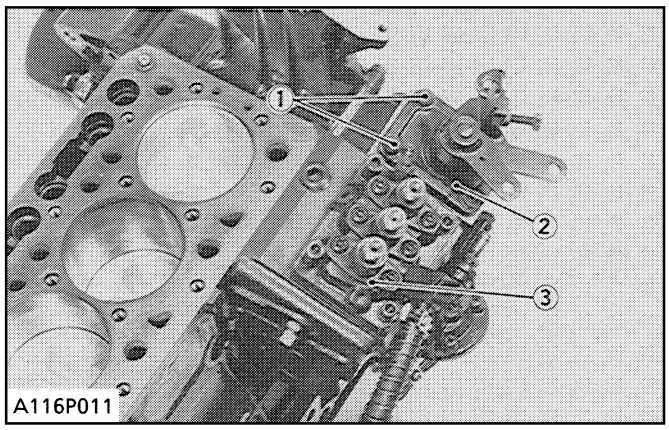
- **Don't change the combination of the valve and valve guide.**

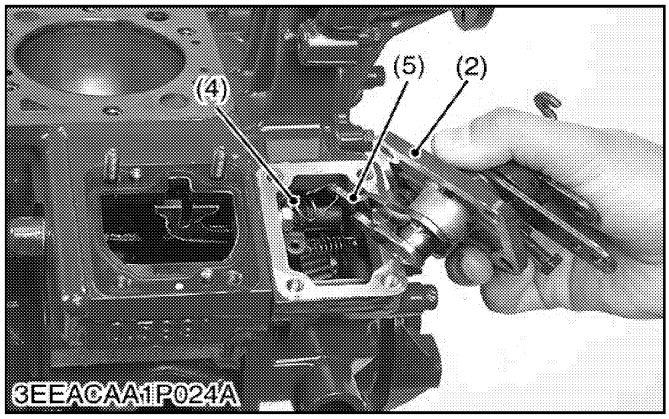
(When reassembling)

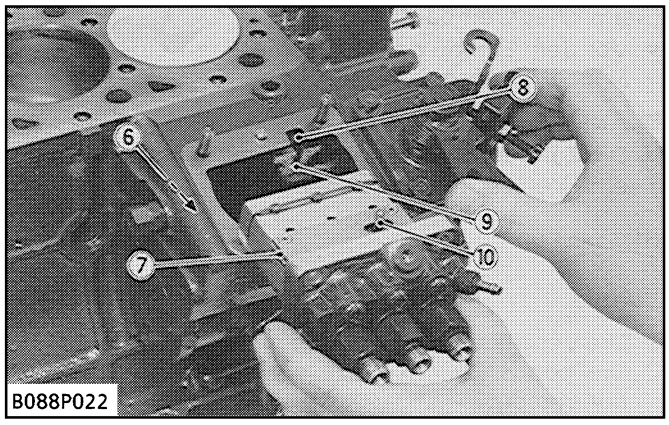
- Wash the valve stem and valve guide hole, and apply engine oil sufficiently.
- After installing the valve spring collets, lightly tap the stem to assure proper fit with a plastic hammer.

(1) Valve Cap
(2) Valve Spring Collet
(3) Valve Spring Retainer
(4) Valve Spring
(5) Valve

[4] TIMING GEAR AND CAMSHAFT







Injection Pump and Speed Control Plate

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

(When reassembling)

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

■ NOTE

(Engine serial number : ~489290)

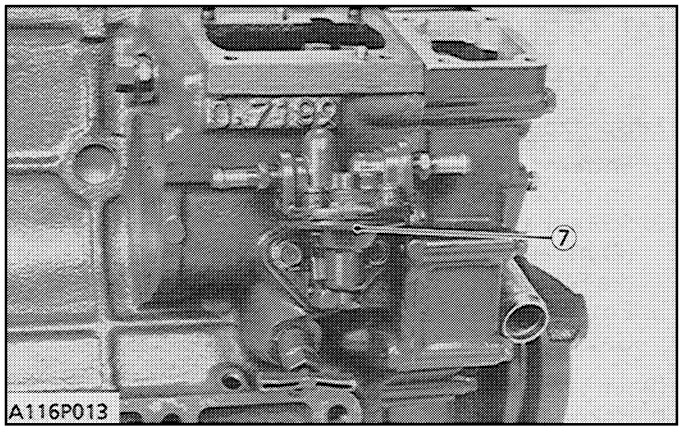
- **Insert the same number of shims as used before between crank case and pump.**
- **Addition or reduction of shim (0.15 mm, 0.0059 in.) delays or advances the injection timing by approx. 0.026 rad (1.5°).**
- **Apply liquid-type gasket (Three Bond 1215 or its equivalent) to both sides of the injection pump shim before reassembling.**

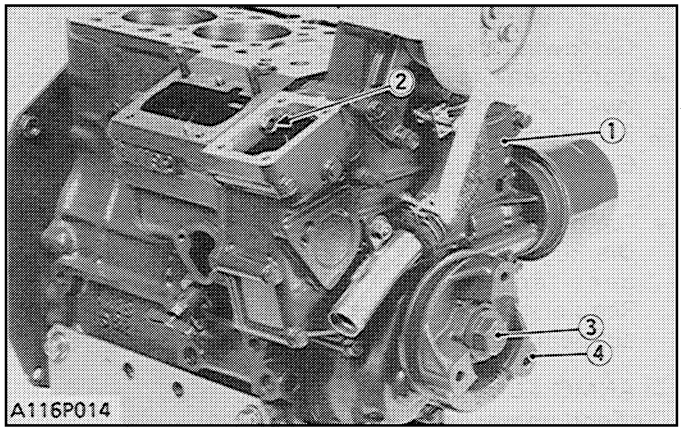
(Engine serial number : 489291~)

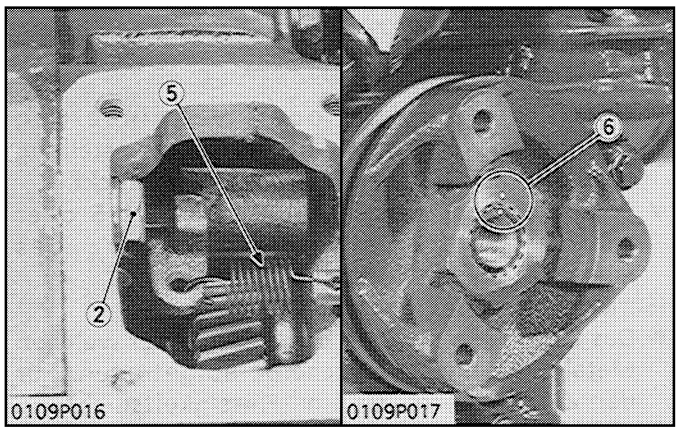
- **The sealant is applied to both sides of the soft metal gasket shim. The liquid gasket is not required for assembling.**
- **Addition or reduction of shim (0.05 mm, 0.0020 in.) delays or advances the injection timing by approx. 0.0087 rad (0.5°).**
- **In disassembling and replacing, be sure to use the same number of new gasket shims with the same thickness.**

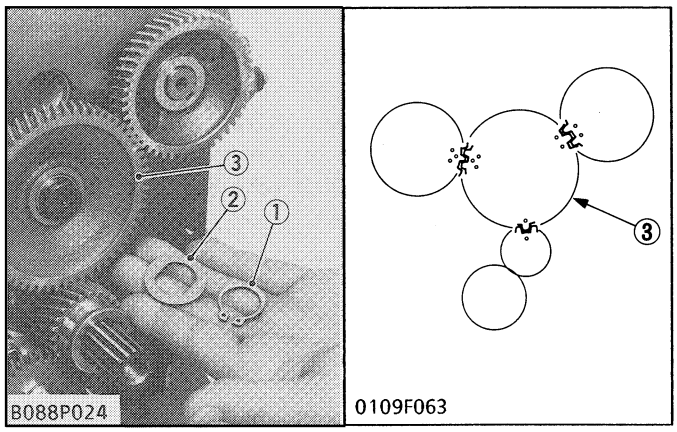
Tightening torque	Injection pump retaining screw and nut	9.81 to 11.28 N·m 1.00 to 1.15 kgf·m 7.23 to 8.32 ft-lbs

(1) Screws and Copper Washers
(2) Speed Control Plate
(3) Injection Pump
(4) Spring
(5) Lever
(6) Spring
(7) Control Rod
(8) Slot (Crankcase Side)
(9) Slot (Fork Lever Side)
(10) Pin









Pulley and Gear Case

(1) Remove the fuel feed pump (7).
(2) Unscrew the fan drive pulley mounting screw (3) and remove the fan drive pulley (4).
(3) Unscrew the screw (2) and disconnect the start spring (5) in the speed control plate mounting hole.
(4) Unscrew the retaining screws and remove the gear case (1).

(When reassembling)

- Apply liquid-type gasket (Three Bond 1215 or its equivalent) to both sides of the gear case packing.
- Be sure to set three O-rings inside the gear case.
- Install the pulley to the crankshaft, aligning the marks (6) on them. (See photo)

Tightening torque	Fan drive pulley retaining screw	117.7 to 127.5 N·m 12.0 to 13.0 kgf·m 86.80 to 94.03 ft-lbs
	Gear case screw	9.81 to 11.28 N·m 1.0 to 1.15 kgf·m 7.23 to 8.32 ft-lbs

(1) Gear Case
(2) Screw
(3) Fan Drive Pulley Retaining Screw
(4) Fan Drive Pulley
(5) Start Spring
(6) Aligning Mark
(7) Fuel Feed Pump

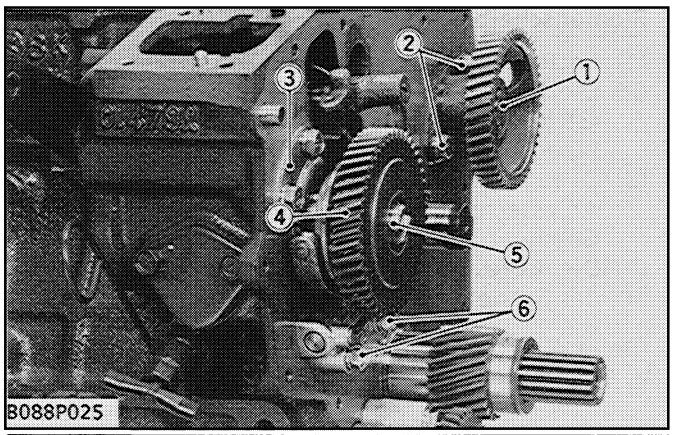
Idle Gear

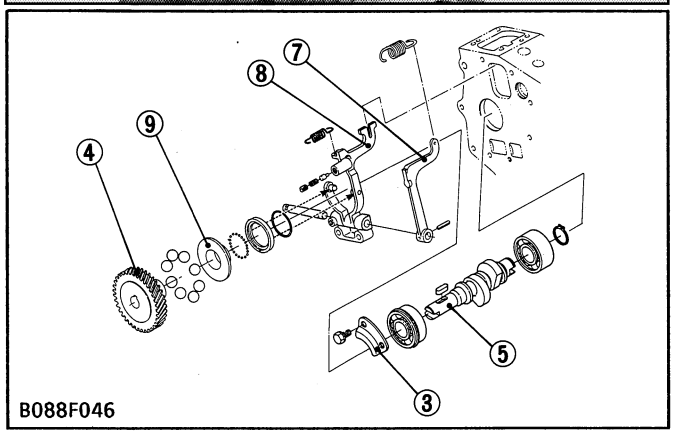
1. Remove the external snap ring (1), the collar (2) and the idle gear (3).

(When reassembling)

- Install the idle gear, aligning the marks on the gears referring to the figure.

(1) External Snap Ring
(2) Idle Gear Collar
(3) Idle Gear





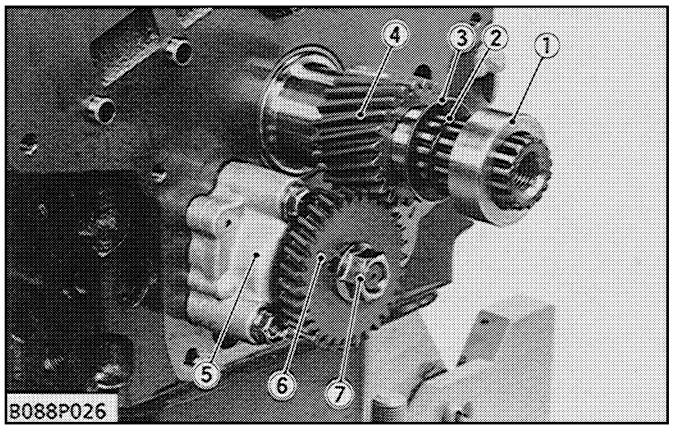
Fuel Camshaft

1. Remove the screws (2) and draw out the camshaft (1) with the gear on it.
2. Remove the retaining plate (3).
3. Remove the screws (6), then draw out the injection pump gear (4) and fuel camshaft (5) with the governor fork assembly.

(When reassembling)

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

(1) Camshaft
(2) Screw
(3) Retaining Plate
(4) Injection Pump Gear
(5) Fuel Camshaft
(6) Screw
(7) Fork Lever 2
(8) Fork Lever 1
(9) Governor Sleeve



Oil Pump and Crankshaft Gear

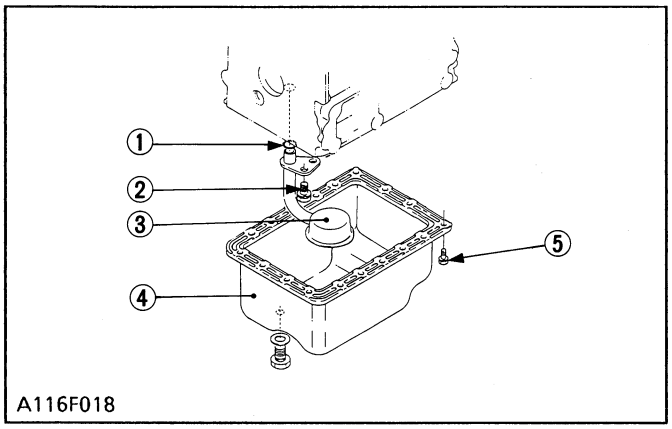
1. Unscrew the flange nut (7) and remove the oil pump gear (6).
2. Unscrew the retaining screws and remove the oil pump (5).
3. Remove the collar (1), O-ring (2) and oil slinger (3).
4. Remove the crankshaft gear (4) with a puller.

(When reassembling)

- Install the collar after aligning the marks on the gears. (See the figure at "Idle Gear")

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

[5] PISTON AND CONNECTING ROD



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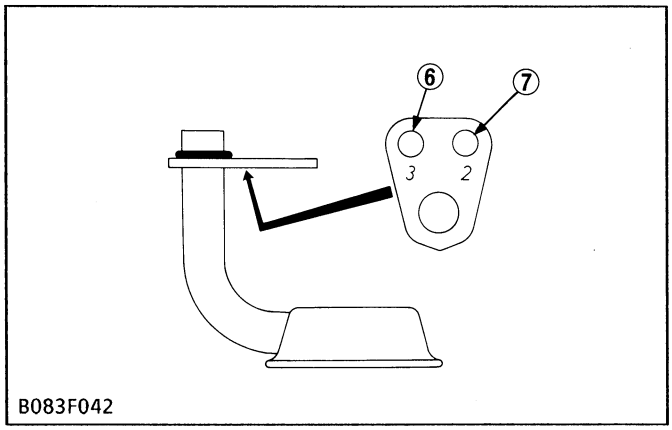

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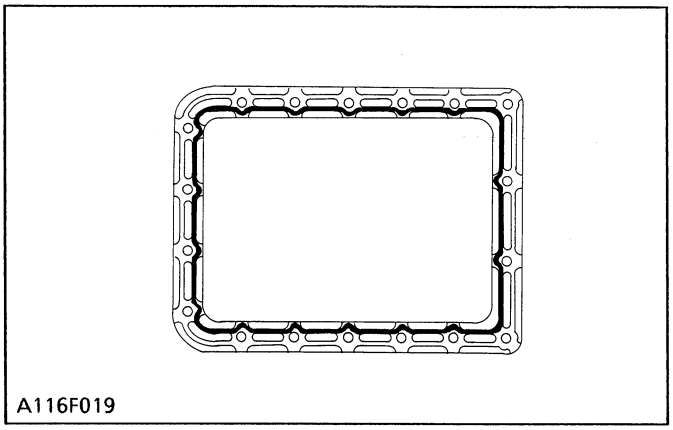
Oil Pan and Oil Strainer

1. Unscrew the oil pan mounting screws (5), and remove the oil pan (4).
2. Unscrew the oil strainer mounting screw (2), and remove the oil strainer (3).

(When reassembling)

- Install the oil strainer, using care not to damage the O-ring (1).
- Using the hole (6) numbered **"3"**, install the oil strainer by mounting screw (D662-B, D722-B).
- Using the hole (7) numbered "2", install the oil strainer by mounting screw (Z442-B, Z482-B).
- Apply liquid gasket (Three Bond 1207D or equivalent) to the oil pan as shown in the figure.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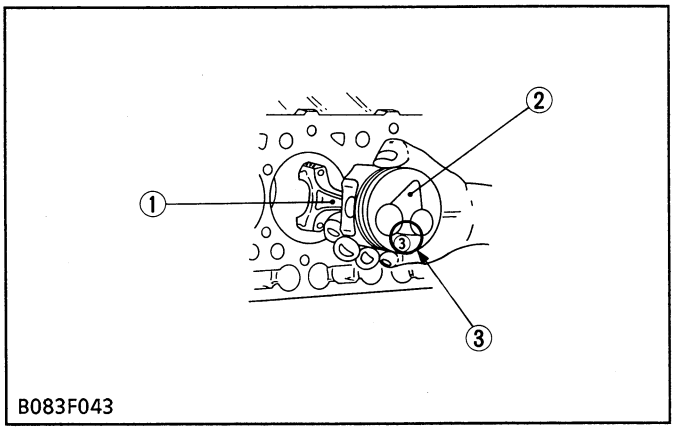
■ IMPORTANT

- **Scape off the old adhesive completely. Wipe the sealing surface clean using waste cloth soaked with gasoline. Now apply new adhesive 3~5 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 bolt hole.**
- **Cut the nozzle of the "fluid sealant" container at its second notch. Apply "fluid sealant" about 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) O ring
(2) Screw
(3) Oil Strainer
(4) Oil Pan
(5) Oil Pan Mounting Screws
(6) Hole
(7) Hole



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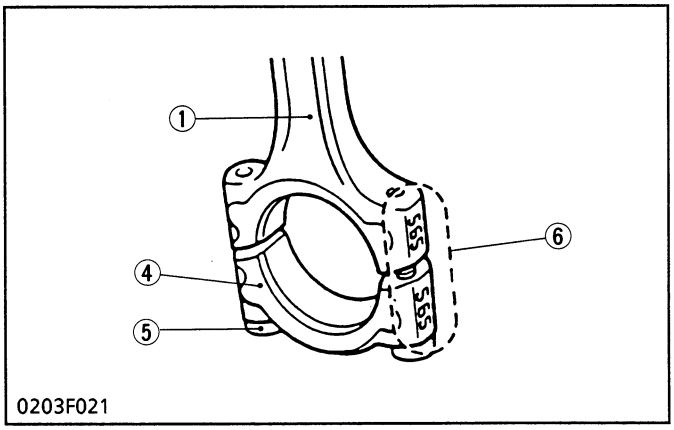

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Piston and Connecting Rod

1. Unscrew the connecting rod screws (6), and remove the connecting rod cap (5).
2. Turn the crankshaft to bring the piston to top dead center.
3. Push the connecting rod from the bottom of the cylinder block with a hummer grip, and pull out the piston (2) and connecting rod (1).

■ IMPORTANT

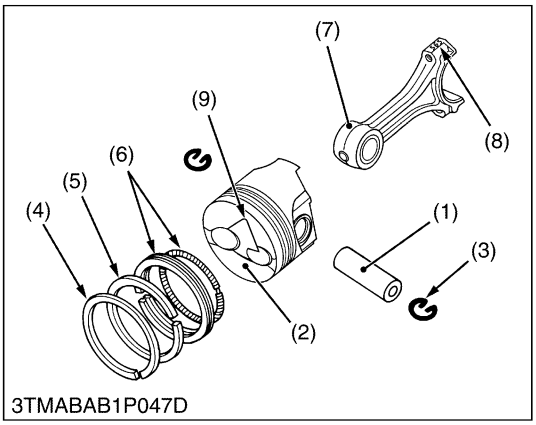
- **Do not change the combination of cylinder and piston.**

(When reassembling)

- Before inserting the piston into the cylinder, apply enough engine oil to the inside surface of the cylinder.
- Apply engine oil to the crank pin bearings and connecting rod screws.
- Be sure to install the piston and connecting rod into the cylinder so that the number (3) on the piston head opposite side of the injection pump.
- Align the alignment marks (7) on the connecting rod (1) and connecting rod cap (5).
- When inserting the piston into the cylinder, face the mark on the connecting rod to the injection pump.

Tightening torque	Connecting rod screw	26.5 to 30.4 N·m 2.7 to 3.1 kgf·m 19.5 to 22.4 ft-lbs

(1) Connecting Rod
(2) Piston
(3) Number
(4) Connecting Rod Cap
(5) Connecting Rod Screw
(6) Alignment Mark



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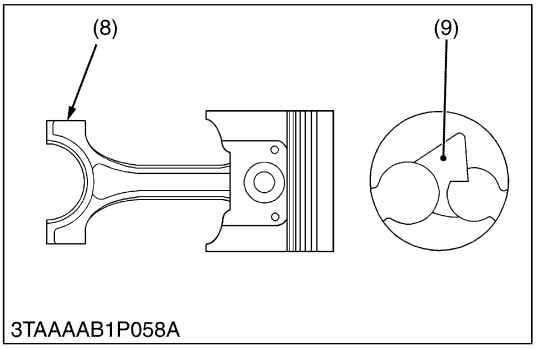

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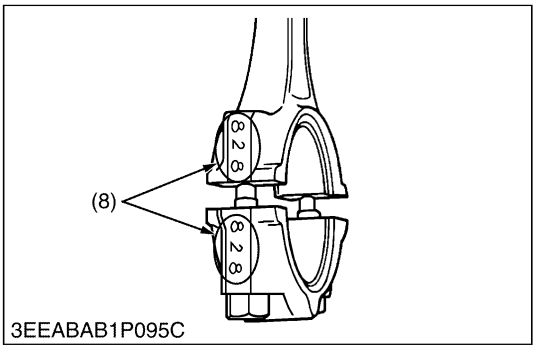

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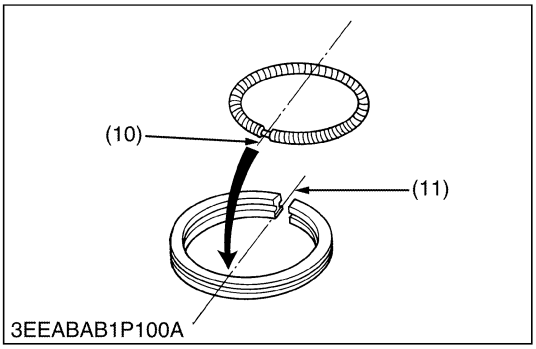

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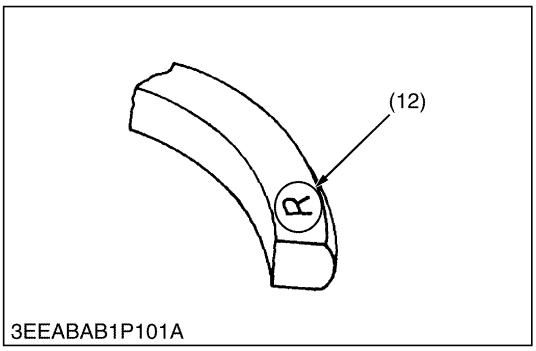

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Piston Ring and Connecting Rod

1. Remove the piston rings using a piston ring tool (Code No. 07909-32121).
2. Remove the piston pin (1), and separate the connecting rod (7) from the piston (2).

(When reassembling)

- When installing the rings, 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 piston pin, immerse the piston in 80 °C (176 °F) oil for 10 to 15 minutes and insert the piston pin to the piston.
- When installing the connecting rod to the piston, align the mark (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) Piston Pin
(2) Piston
(3) Piston Pin Snap Ring
(4) Top Ring
(5) Second Ring
(6) Oil Ring
(7) Connecting Rod
(8) Mark
(9) Fan-Shaped Concave
(10) Expander Joint
(11) Oil Ring Gap
(12) Manufacturer's Mark

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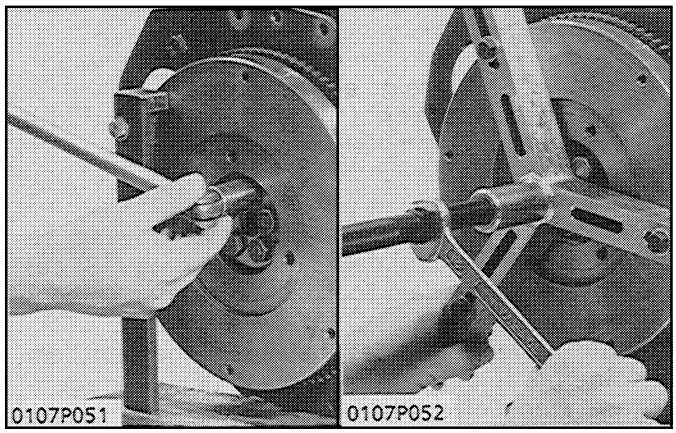
[6] FLYWHEEL AND CRANKSHAFT



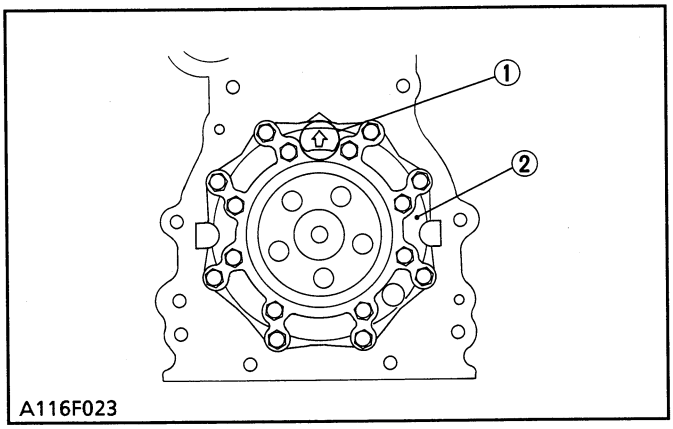
Flywheel

1. Lock the flywheel not to turn using the flywheel stopper.
2. Remove the flywheel bolts, except for two which must be loosened and left as they are.
3. Set a flywheel puller (Code No: 07916-32011), and remove the flywheel.

(When reassembling)

- Apply engine oil to the flywheel screws.

Tightening torque	Flywheel screw	53.9 to 58.8 N·m 5.5 to 6.0 kgf·m 39.8 to 43.4 ft-lbs



Bearing Case Cover

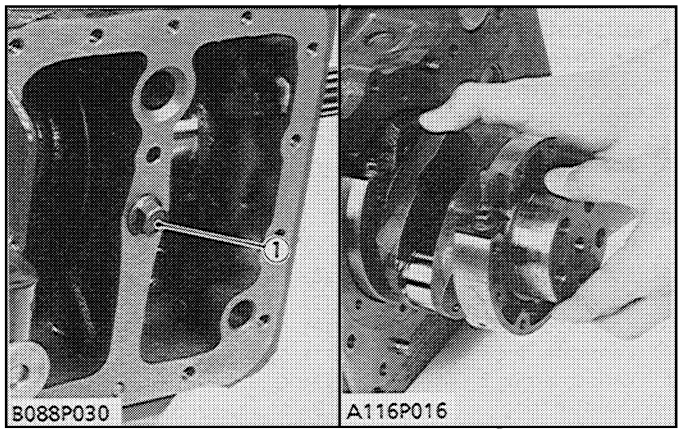
1. Unscrew the bearing case cover mounting screws.
2. Remove the bearing case cover (2).

(When reassembling)

- Apply liquid-type gasket (Three Bond 1215 or its equivalent) to both sides of a new bearing case cover gasket.
- Install the bearing case cover to position the casting mark " ↑ " (1) on it upward.
- Tighten the bearing case cover mounting screws with even force on the diagonal line.

Tightening torque	Bearing case cover mounting screw	9.81 to 11.28 N·m 1.00 to 1.15 kgf·m 7.23 to 8.32 ft-lbs

(1) Mark
(2) Bearing Case Cover



Crankshaft

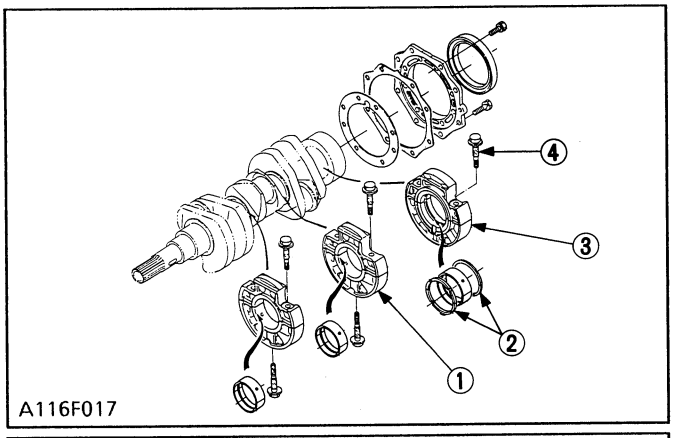
1. Unscrew the bearing case screws 2 (1), and draw out the crankshaft.

(When reassembling)

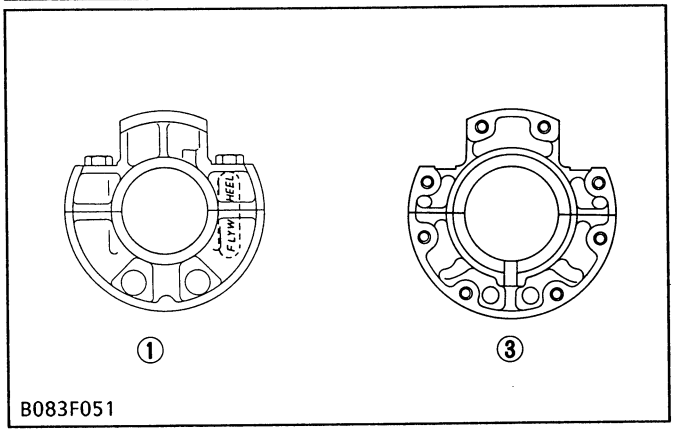
- Install the crankshaft sub assembly, aligning the screw hole of main bearing case 2 with the screw hole of cylinder block.
- Apply engine oi to the seat and thread of bearing case screw 2. After tightening it.

Tightening torque	Bearing case screw 2	26.5 to 30.4 N·m 2.7 to 3.1 kgf·m 19.5 to 22.4 ft-lbs

(1) Bearing Case Screw 2



A116F017



B083F051

Main Bearing Case Assembly

1. Remove the two bearing case screws 1 (4), and remove the main bearing case assembly 1 (3), being careful with the thrust bearing (2) and crankshaft bearing 2.
2. Remove the main bearing case assemblies 2, 3.

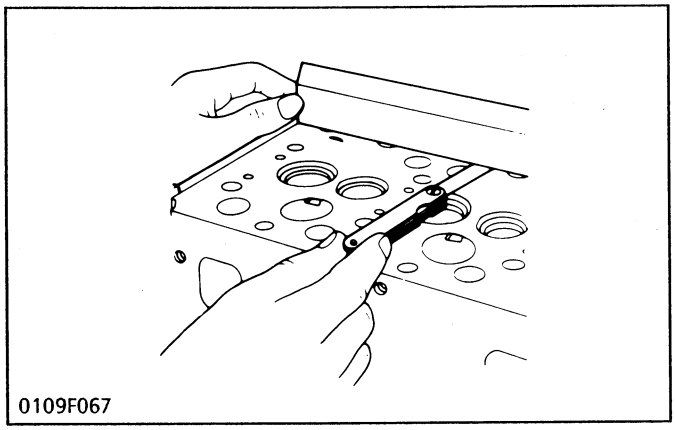
(When reassembling)

- Clean the oil passage in the main bearing case.
- Apply clean engine oil on the crankshaft bearing 2 and thrust bearings.
- Install the main bearing case assemblies in the original positions. Since diameters of main bearing cases vary, install them in order of makings (1, 2) from the gear case side.
- When installing the main bearing case assemblies 2, 3, face the mark "FLYWHEEL" to the flywheel.
- Be sure to install the thrust bearing with its oil groove facing outward.

(1) Main Bearing Case Assembly 2
(2) Thrust Bearing
(3) Main Bearing Case Assembly 1
(4) Bearing Case Screw 1

SERVICING

[1] CYLINDER HEAD AND VALVES


0109F067

Cylinder Head Surface Flatness

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

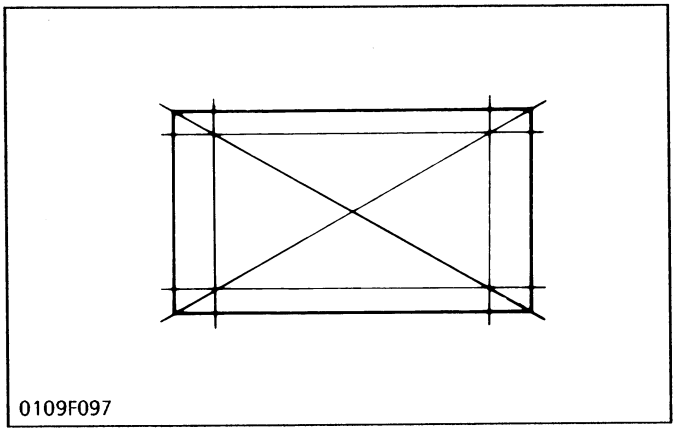
■ NOTE

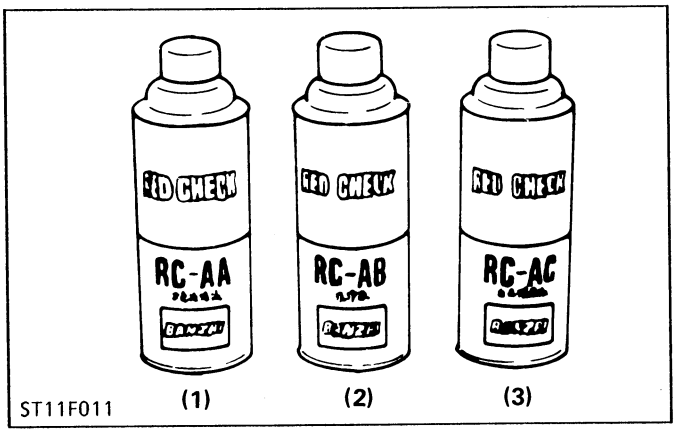
- **Do not place the straightedge on the combustion chamber.**

■ IMPORTANT

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

Cylinder head surface flatness	Allowable limit	0.05 mm 0.0020 in.
Finishing	8 μR max (8 (320)) ▽▽	unit: μm (μin.)


0109F097

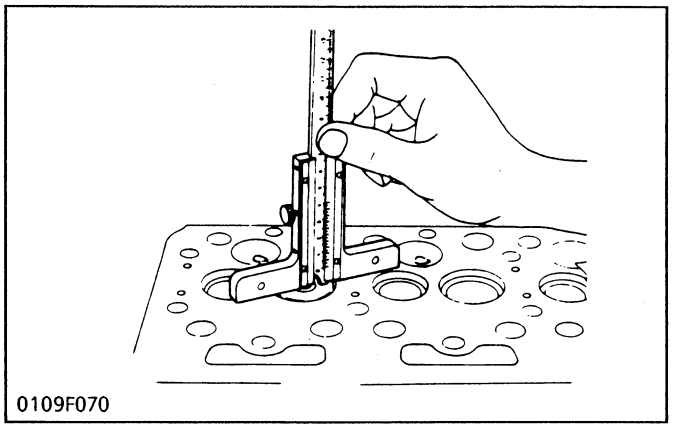


ST11F011

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

Cylinder Head Flaw

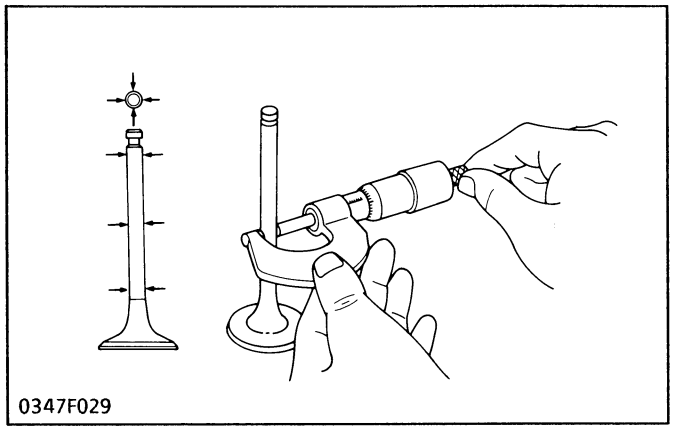
1. Prepare an air spray red check (Code No. 07909-31371).
2. Clean the surface of the cylinder head with detergent (1).
3. Spray the cylinder head surface with the red permeative liquid (2).
   Leave it five to ten minutes after spraying.
4. Wash away the red permeative liquid on the cylinder head surface with the detergent (2).
5. Spray the cylinder head surface with white developer (3).
   If flawed, it can be identified as red marks.


0109F070

Valve Recessing

1. Clean the cylinder head, the 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 to 0.10 mm −0.0039 to 0.0039 in.
	Allowable limit	0.30 mm 0.0118 in.

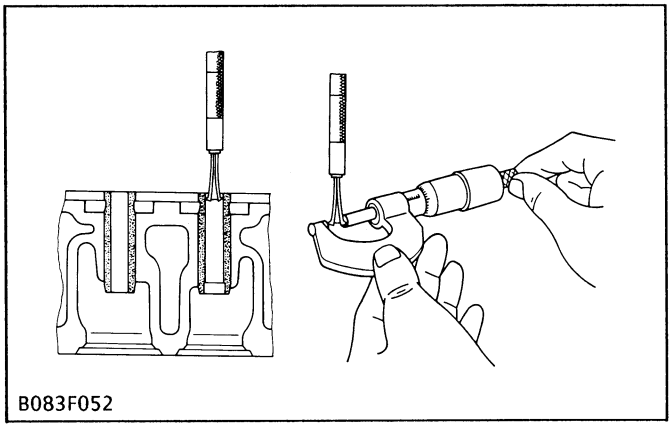

0347F029

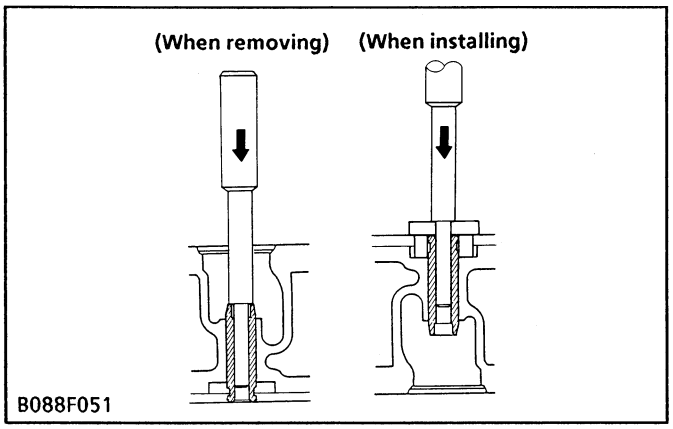
Clearance between Valve Stem and Valve Guide

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 valve guide or valve.

Clearance between valve stem and valve guide	Factory spec.	0.030 to 0.057 mm 0.00118 to 0.00224 in.
	Allowable limit	0.10 mm 0.0039 in.

Valve stem O.D.	Factory spec.	5.968 to 5.980 mm 0.23496 to 0.23543 in.
Valve guide I.D.	Factory spec.	6.010 to 6.025 mm 0.23661 to 0.23720 in.


B083F052



B088F051

Replacing Valve Guide

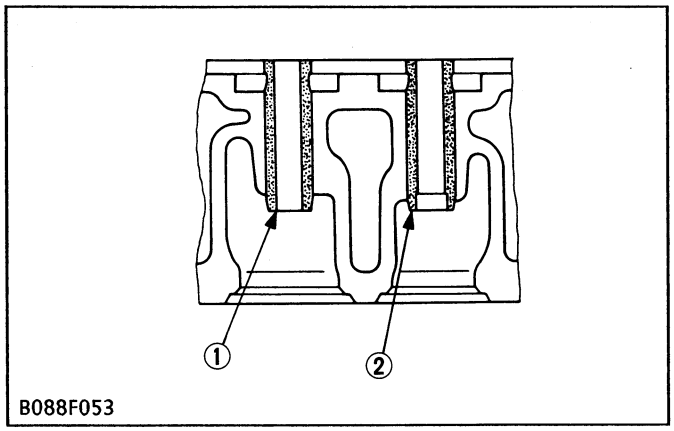
(When removing)

1. Using a valve guide replacing tool (see page S-22), press out the used valve guide.

(When installing)

1. Clean a new valve guide, and apply engine oil to it.
2. Using a valve guide replacing tool, press in a new valve guide until it is flush with the cylinder head as shown in the figure.
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 0.23661 to 0.23720 in.



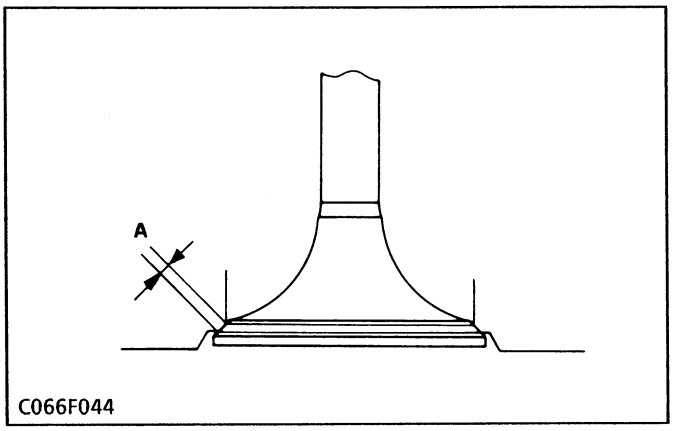
B088F053

■ **IMPORTANT**

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

(1) Intake Valve Guide (2) Exhaust Valve Guide

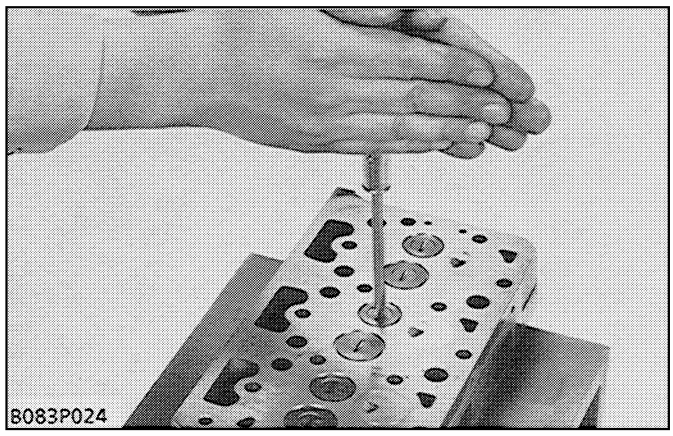
Width of Contact between Valve and Valve Seat



C066F044

1. Check the contact between the valve face and valve seat.
2. If the contact is uneven or the width of contact (A) is excessively large, correct the valve and valve seat referring to **"Correcting Valve and Valve Seat"**.

Valve seat width	Factory spec.	2.12 mm 0.0835 in.

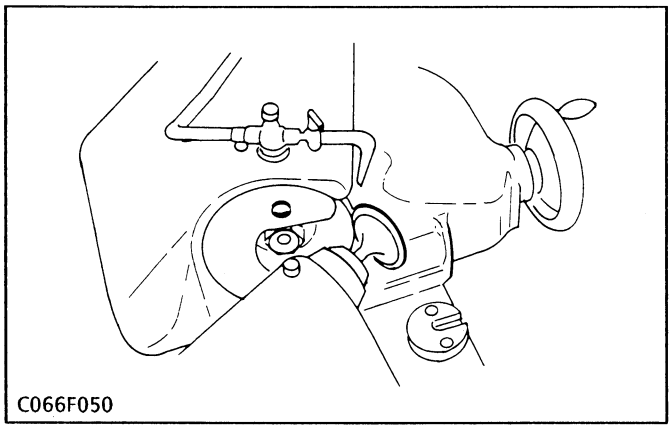

B083P024

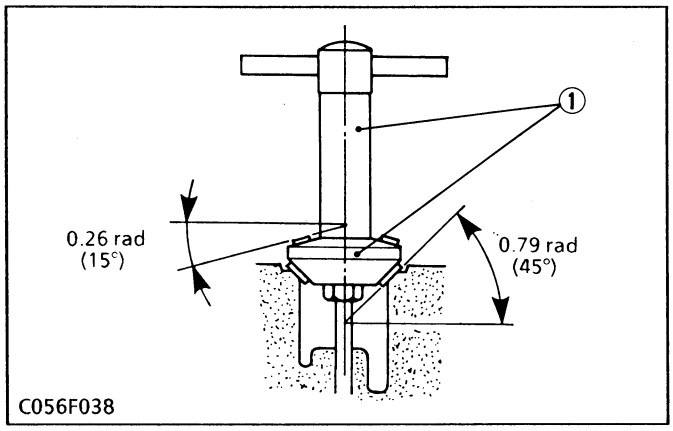
Valve Lapping

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 red lead or prussian blue to the contact surface to check the seated rate. If it is less than 70%, repeat valve lapping again.

■ **IMPORTANT**

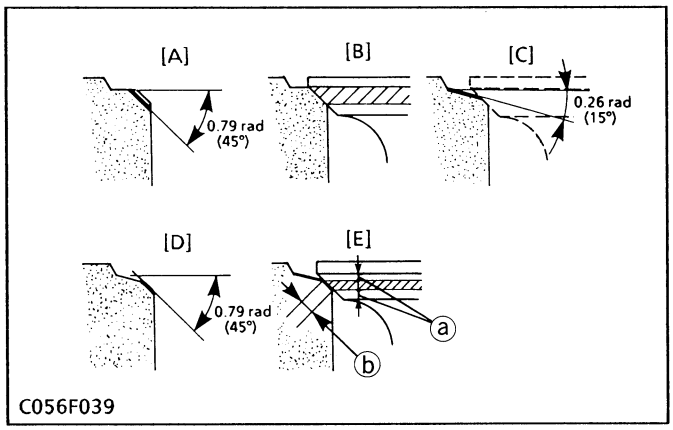
- **When valve lapping is performed, be sure to check the valve recessing and adjust the valve clearance after assembling the valve. (See page S-19)**


C066F050



C056F038

(1) Valve Seat Cutter



C056F039

(A) Slightly Correct
(B) Check Contact
(C) Correct Seat Width
(D) Correct Seat Surface
(E) Check Contact

(a) Identical Dimensions
(b) Valve Seat Width

Correcting Valve and Valve Seat

■ NOTE

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

1) Correcting Valve

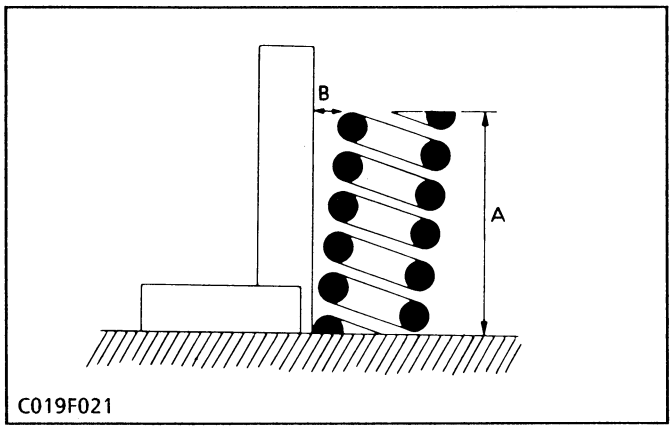
1. Correct the valve with a valve refacer.

Valve face angle	Factory spec.	0.785 rad 45.0°

2) Correcting Valve Seat

1. Slightly correct the seat surface with a 0.79 rad (45°) valve seat cutter (1) (Code No. 07909-33102).
2. Fitting the valve, check the contact position of the valve face and seat surface with red lead. (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.]
3. Grind the upper surface of the valve seat with a 0.26 rad (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).
4. Grind the seat with a 0.79 rad (45°) valve seat cutter again, and visually recheck the contact between the valve and seat.
5. Repeat steps 3 and 4 until the correct contact is achieved.
6. Continue lapping until the seated rate becomes more than 70% of the total contact area.

Valve seat angle	Factory spec.	0.785 rad 45.0°

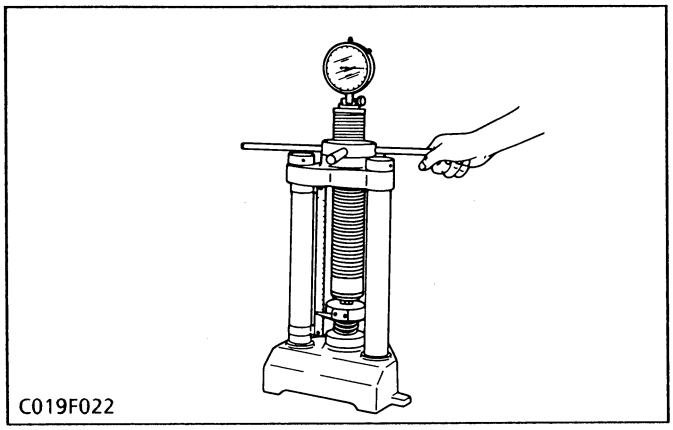


C019F021

Free Length and Tilt of Valve Spring

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

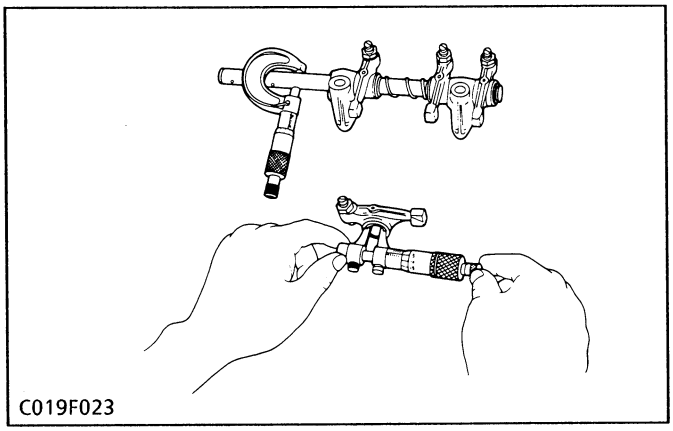
Free length **A**	Factory spec.	31.3 to 31.8 mm 1.232 to 1.252 in.
	Allowable limit	28.4 mm 1.118 in.
Tilt **B**	Allowable limit	1.2 mm 0.047 in.


C019F022

Valve Spring Setting Load

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

Setting load	Factory spec.	64.7 N / 27 mm 6.6 kgf / 27 mm 14.6 lbs / 1.063 in.
Setting length	Allowable limit	54.9 N / 27 mm 5.6 kgf / 27 mm 12.3 lbs / 1.063 in.

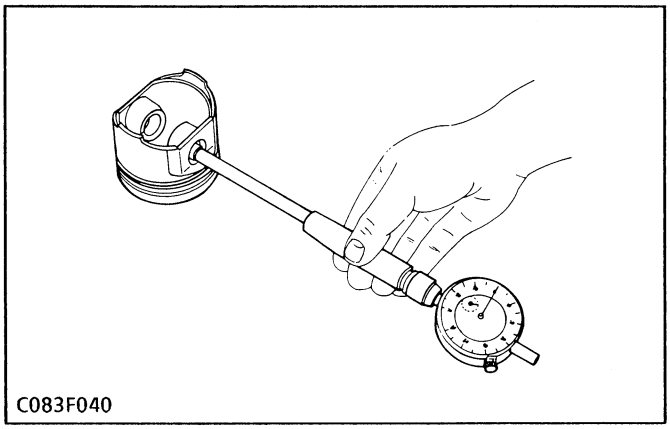

C019F023

Oil Clearance between Rocker Arm and Rocker Arm Shaft

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

Oil clearance between rocker arm and rocker arm shaft	Factory spec.	0.016 to 0.045 mm 0.00063 to 0.00177 in.
	Allowable limit	0.15 mm 0.0059 in.
Rocker arm shaft O.D.	Factory spec.	10.473 to 10.484 mm 0.41232 to 0.41276 in.
Rocker arm I.D.	Factory spec.	10.500 to 10.518 mm 0.41339 to 0.41410 in.

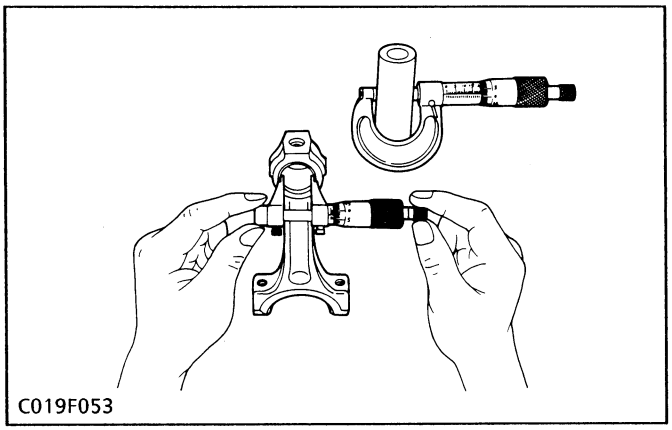
[2] PISTON AND CONNECTING ROD


C083F040

Piston Pin-Bore I.D.

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

Piston pin-hole I.D.	Factory spec.	20.000 to 20.013 mm 0.78740 to 0.78791 in.
	Allowable limit	20.05 mm 0.7894 in.

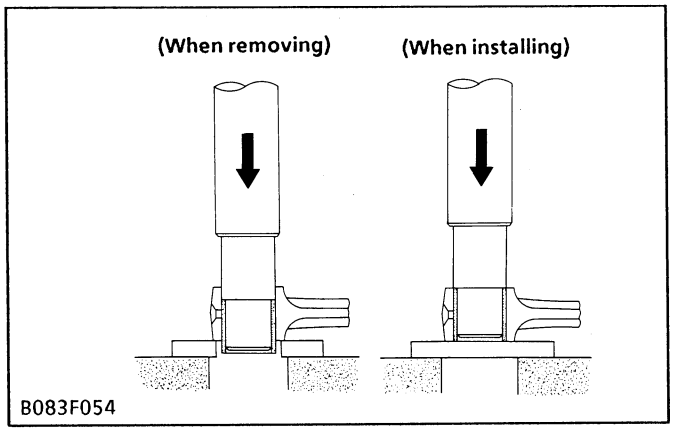

C019F053

Oil Clearance between Piston Pin and Small End Bushing

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

Oil clearance between piston pin and small end bushing	Factory spec.	0.014 to 0.038 mm 0.00055 to 0.00150 in.
	Allowable limit	0.10 mm 0.0039 in.

Piston pin O.D.	Factory spec.	20.002 to 20.011 mm 0.78748 to 0.78783 in.
Small end bushing I.D.	Factory spec.	20.025 to 20.040 mm 0.78839 to 0.78897 in.



B083F054

Replacing Small End Bushing

(When removing)

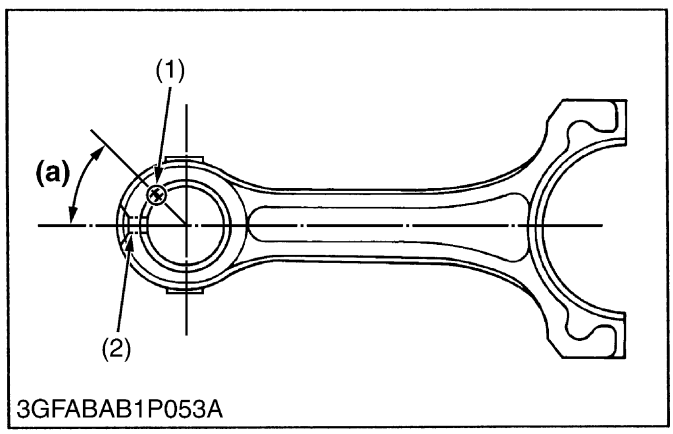
1. Using a small end bushing replacing tool (see page S-22), press out the used bushing.

(When installing)

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

[Service parts dimension]

Oil clearance between piston pin and small end bushing	Factory spec.	0.015 to 0.075 mm 0.00059 to 0.00295 in.
	Allowable limit	0.15 mm 0.0059 in.



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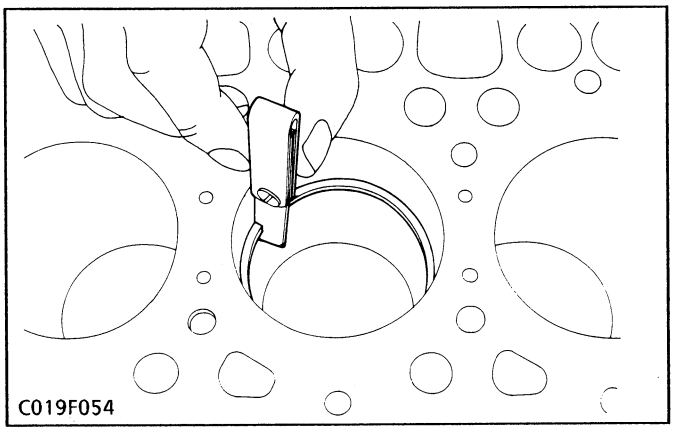
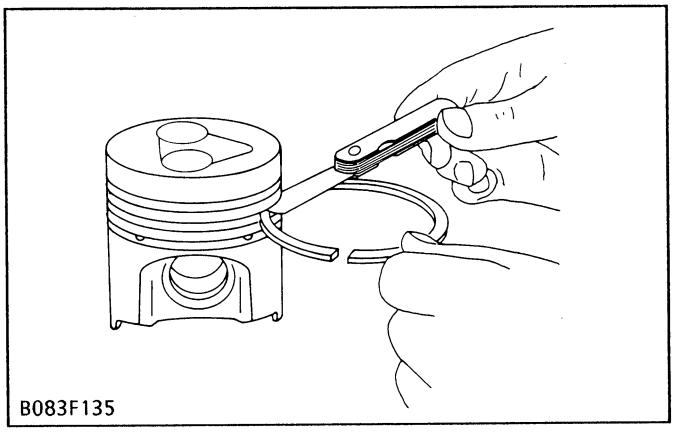
(1) Seam
(2) Oil Hole
(a) 0.785 rad(45°)


C019F054

Piston Ring Gap

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

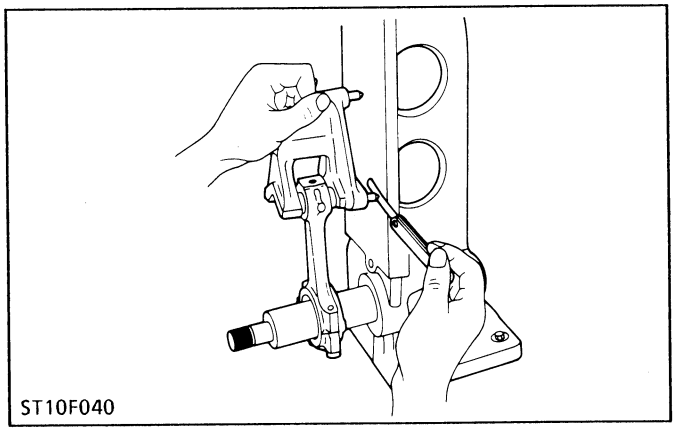
Piston ring gap	Top compression ring and oil ring	Factory spec.	0.15 to 0.30 mm 0.0059 to 0.0118 in.
		Allowable limit	1.2 mm 0.0472 in.
	Second compression ring	Factory spec.	0.30 to 0.45 mm 0.0118 to 0.0177 in.
		Allowable limit	1.2 mm 0.0472 in.


B083F135

Clearance between Piston Ring and Groove

1. Remove carbon from the ring grooves.
2. Place the ring into each ring groove, and measure the clearance at several points around the ring groove with a feeler gauge.
3. If the clearance exceeds allowable limit, replace the piston ring since compression leak and oil shortage result.
4. If the clearance still exceeds the allowable limit after replacing the piston ring, replace the piston.

Clearance between piston ring and groove	Second compression ring	Factory spec.	0.085 to 0.115 mm 0.0033 to 0.0045 in.
		Allowable limit	0.15 mm 0.0059 in.
	Oil ring	Factory spec.	0.02 to 0.06 mm 0.0008 to 0.0024 in.
		Allowable limit	0.15 mm 0.0059 in.

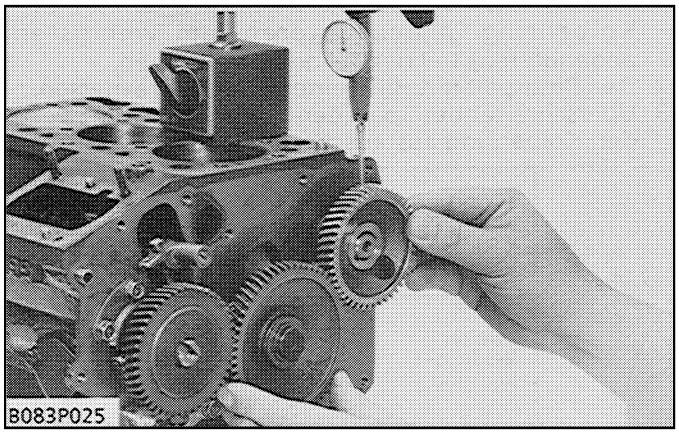

ST10F040

Connecting Rod Alignment

1. Remove the connecting rod crank pin bearing, and install the connecting rod cap.
2. Set the connecting rod to the connecting rod alignment tool (Code No. 07909-31661).
3. Install the piston pin into the connecting rod. Set the gauge on the piston pin.
4. Measure three point's gaps between the pins of the gauge and flat surface of the alignment tool. If the measurement exceeds the allowable limit, replace it.

Bend of connecting rod	Allowable limit	0.05 mm 0.0020 in. (gauge pin span at 100 mm, 3.94 in.)

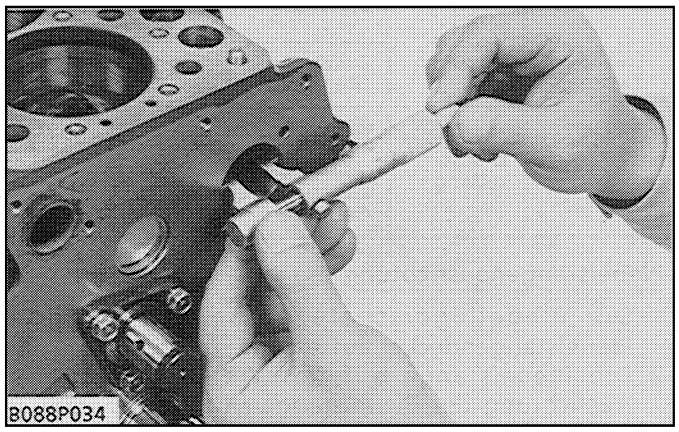
[3] TIMING GEAR AND CAMSHAFT

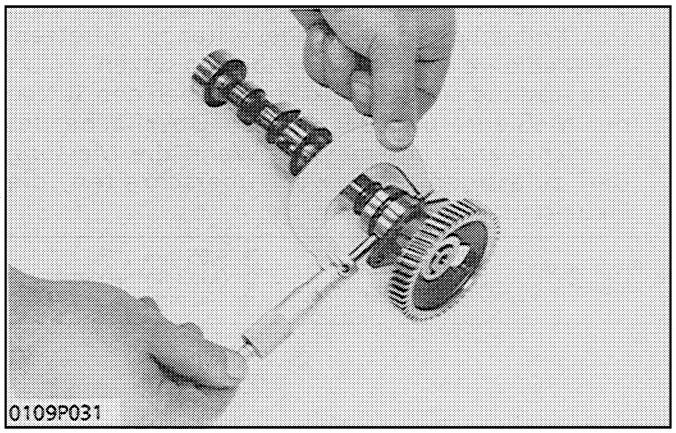

B083P025

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 shaft and gear.
4. If the oil clearance is proper, replace the gears.

Backlash between idle gear and crank gear	Factory spec.	0.043 to 0.124 mm 0.00169 to 0.00488 in.
	Allowable limit	0.15 mm 0.0059 in.
Backlash between idle gear and cam gear	Factory spec.	0.047 to 0.123 mm 0.00185 to 0.00484 in.
	Allowable limit	0.15 mm 0.0059 in.
Backlash between idle gear and injection pump gear	Factory spec.	0.046 to 0.124 mm 0.00181 to 0.00488 in.
	Allowable limit	0.15 mm 0.0059 in.
Backlash between oil pump gear and crank gear	Factory spec.	0.041 to 0.123 mm 0.00161 to 0.00484 in.
	Allowable limit	0.15 mm 0.0059 in.

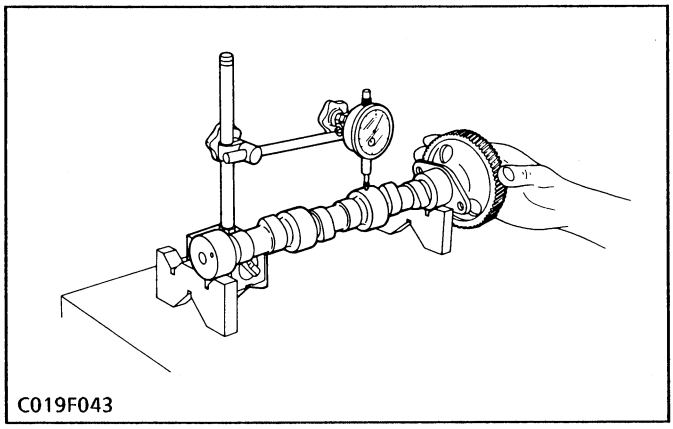

B088P034


0109P031

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 an inside micrometer, and calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit, replace the camshaft.

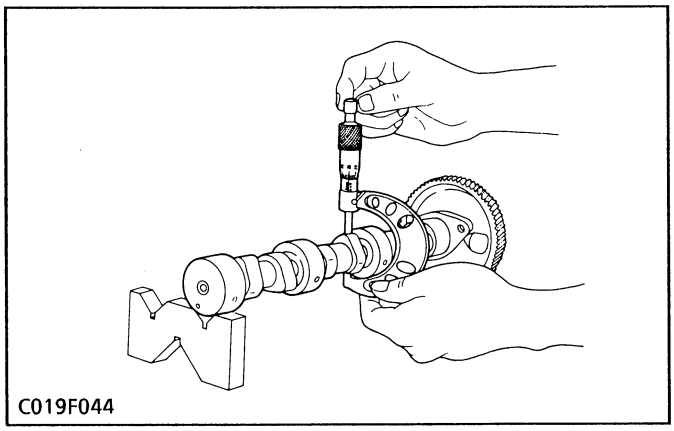
Oil clearance of camshaft journal	Factory spec.	0.050 to 0.091 mm 0.0020 to 0.0036 in.
	Allowable limit	0.15 mm 0.0059 in.
Camshaft journal O.D.	Factory spec.	32.934 to 32.950 mm 1.2966 to 1.2972 in.
Cylinder block bore I.D. (Bearing portion)	Factory spec.	33.000 to 33.025 mm 1.2992 to 1.3002 in.


C019F043

Camshaft Alignment

1. Support the camshaft with V-blocks on the surface plate and set a dial indicator with its tip on the intermediate journal at right angle.
2. Rotate the camshaft on the V-blocks and get the misalignment (half of the measurement).
3. If the misalignment exceeds the allowable limit, replace the camshaft.

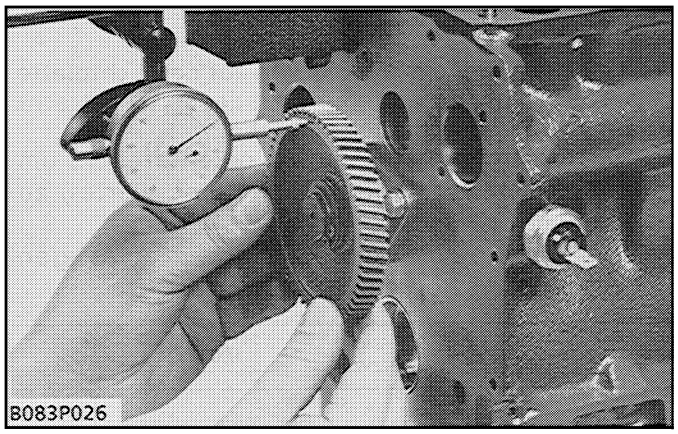
Misalignment	Allowable limit	0.01 mm 0.0004 in.


C019F044

Intake and Exhaust Cam Heights

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.

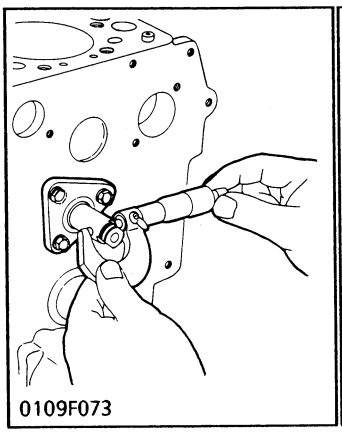
Intake and exhaust cam heights	Factory spec.	26.88 mm 1.0583 in.
	Allowable limit	26.83 mm 1.0563 in.


B083P026

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 or idle gear shaft.

Idle gear side clearance	Factory spec.	0.20 to 0.51 mm 0.0079 to 0.0201 in.
	Allowable limit	0.80 mm 0.0315 in.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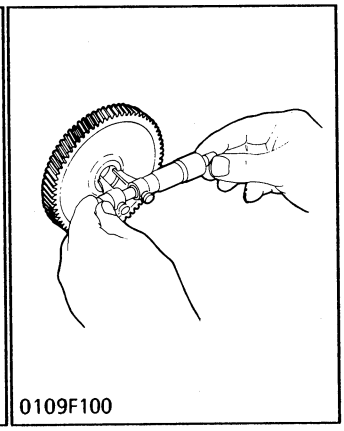
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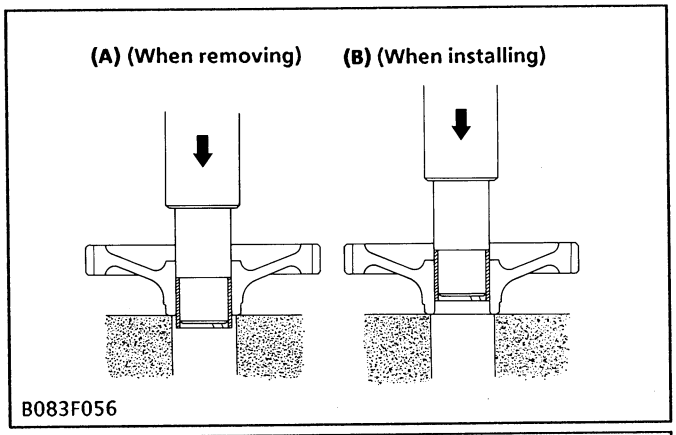
Oil Clearance between Idle Gear Shaft and Idle Gear Bushing

1. Measure the I.D. of the idle gear bushing with an inside micrometer.
2. Measure the O.D. of the idle gear shaft with an outside micrometer, and calculate the oil clearance.
3. If the clearance exceeds the allowable limit, replace the bushing. 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 0.00079 to 0.00331 in.
	Allowable limit	0.10 mm 0.0039 in.
Idle gear shaft O.D.	Factory spec.	19.967 to 19.980 mm 0.78610 to 0.78661 in.
Idle gear bushing I.D.	Factory spec.	20.000 to 20.051 mm 0.78740 to 0.78941 in.



B083F056

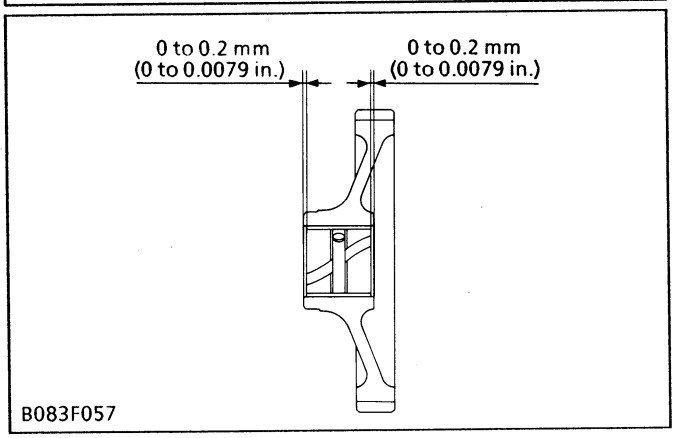
Replacing Idle Gear Bushing

(A) (When removing)

1. Using an idle gear bushing replacing tool (see page S-23), press out the used bushing.

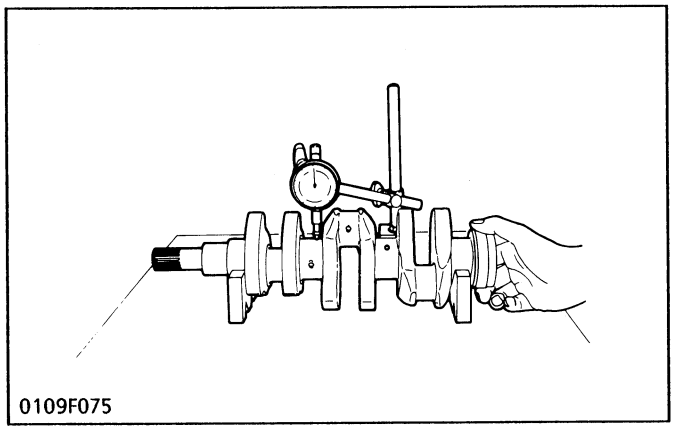
(B) (When installing)

1. Clean a new idle gear bushing and idle gear bore, and apply engine oil to them.
2. Using an idle gear bushing replacing tool, press in a new bushing (service parts) to the specified dimension. (See figure)



B083F057

[4] CRANKSHAFT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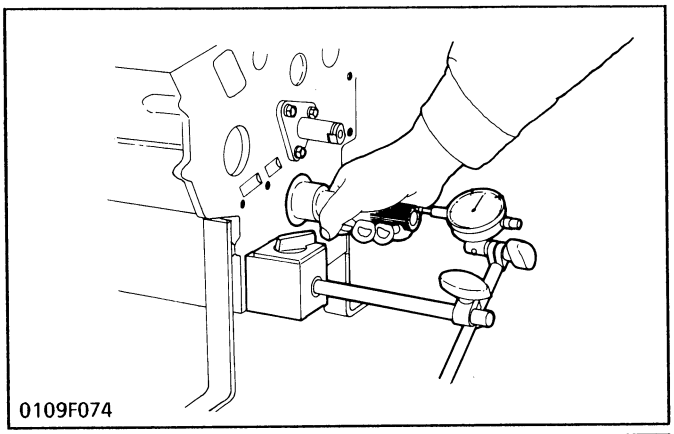
Crankshaft Alignment

1. Support the crankshaft with V-blocks on the surface plate and set a dial indicator with its tip on the intermediate journal at right angle.
2. Rotate the crankshaft on the V-blocks and get the misalignment (half of the measurement).
3. If the misalignment exceeds the allowable limit, replace the crankshaft.

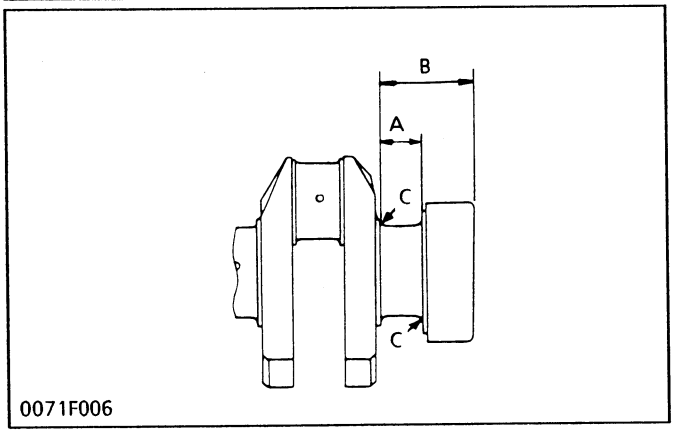
Misalignment	Allowable limit	0.02 mm 0.0008 in.


0109F074

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 0.0059 to 0.0122 in.
	Allowable limit	0.5 mm 0.0197 in.



0071F006

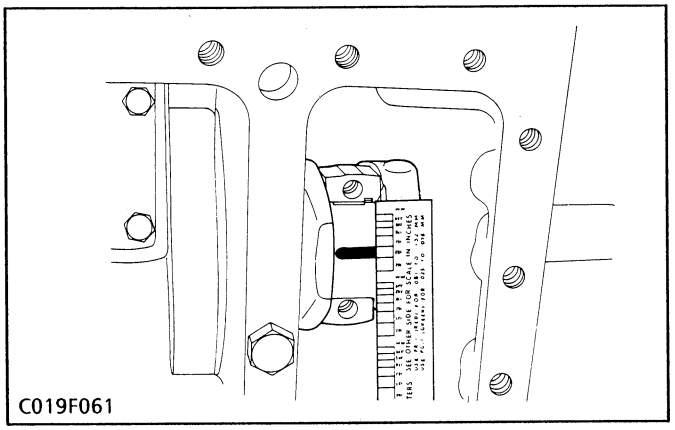
(Reference)

- Oversize thrust bearing

Oversize	Bearing	Code Number	Marking
0.2 mm 0.008 in.	Thrust bearing 1 02	15261-23951	020 OS
	Thrust bearing 2 02	15261-23971	020 OS
0.4 mm 0.016 in.	Thrust bearing 1 04	15261-23961	040 OS
	Thrust bearing 2 04	15261-23981	040 OS

- Oversize dimensions of crankshaft journal

Oversize / Dimension	0.2 mm 0.008 in.	0.4 mm 0.016 in.
A	23.40 to 23.45 mm 0.9213 to 0.9232 in.	23.80 to 23.85 mm 0.9370 to 0.9390 in.
B	46.1 to 46.3 mm 1.815 to 1.823 in.	46.3 to 46.5 mm 1.823 to 1.831 in.
C	1.8 to 2.2 mm radius 0.071 to 0.087 in. radius	1.8 to 2.2 mm radius 0.071 to 0.087 in. radius
The crankshaft journal must be fine-finished to higher than ▽▽▽▽ (0.4S).		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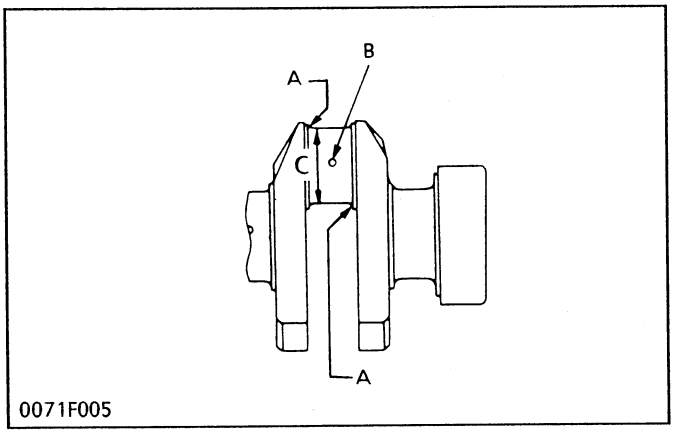


0071F005

Oil Clearance between Crank Pin and Crank Pin Bearing

1. Clean the crank pin and crank pin bearing.
2. Put a strip of plastigage (Code No. 07909-30241) on the center of the crank pin.

■ IMPORTANT

- **Never insert the press gauge into the crank pin oil hole.**

3. Install the connecting rod cap and tighten the connecting rod screws to the specified torque (26.5 to 30.4 N·m, 2.7 to 3.1 kgf·m, 19.5 to 22.4 ft-lbs), and remove the cap again.

■ NOTE

- **Be sure not to move the crankshaft while the connecting rod screws are tightened.**

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 crank pin bearing.
6. If the same size bearing is useless because of the crank pin wear, replace it with an undersize one referring to the table and figure.

Oil clearance between crank pin and crank pin bearing	Factory spec.	0.020 to 0.051 mm 0.00079 to 0.00201 in.
	Allowable limit	0.15 mm 0.0059 in.
Crank pin O.D.	Factory spec.	33.959 to 33.975 mm 1.33697 to 1.33760 in.
Crank pin bearing I.D.	Factory spec.	33.995 to 34.010 mm 1.33840 to 1.33898 in.

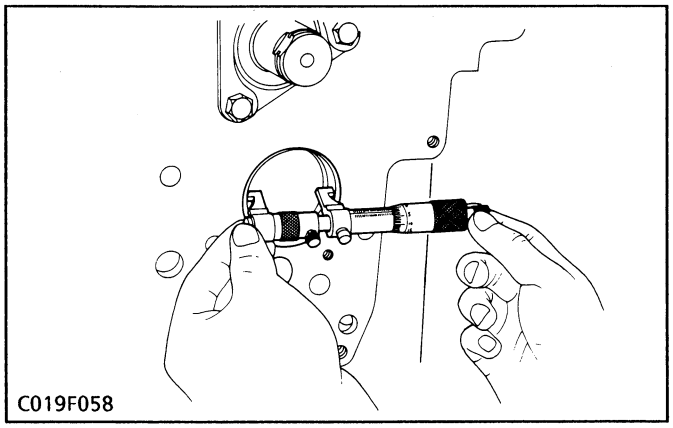
(Reference)

- Undersize crank pin bearing

Undersize	Bearing	Code Number	Marking
0.2 mm 0.008 in.	Crank pin bearing 02	15861-22971	020 US
0.4 mm 0.016 in.	Crank pin bearing 04	15861-22981	040 US

- Undersize dimensions of crank pin

Undersize / Dimension	0.2 mm 0.008 in.	0.4 mm 0.016 in.
A	2.3 to 2.7 mm radius 0.091 to 0.106 in. radius	2.3 to 2.7 mm radius 0.091 to 0.106 in. radius
B	4 mm dia. 0.16 in. dia.	4 mm dia. 0.16 in. dia.
C	33.759 to 33.775 mm 1.32910 to 1.32973 in.	33.559 to 33.575 mm 1.32122 to 1.32185 in.
The crank pin must be fine-finished to higher than ▽▽▽▽ (0.4S).		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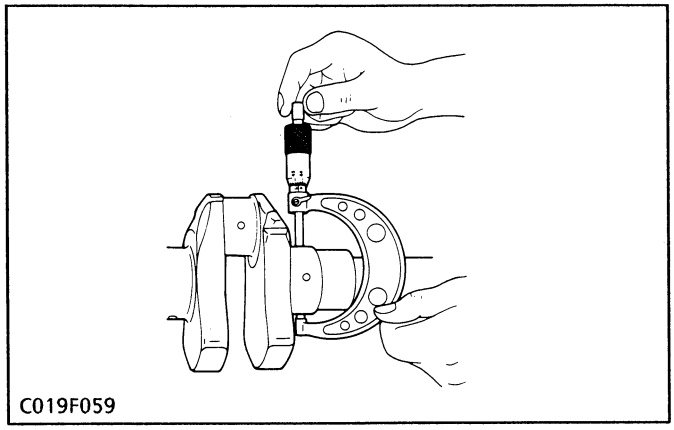
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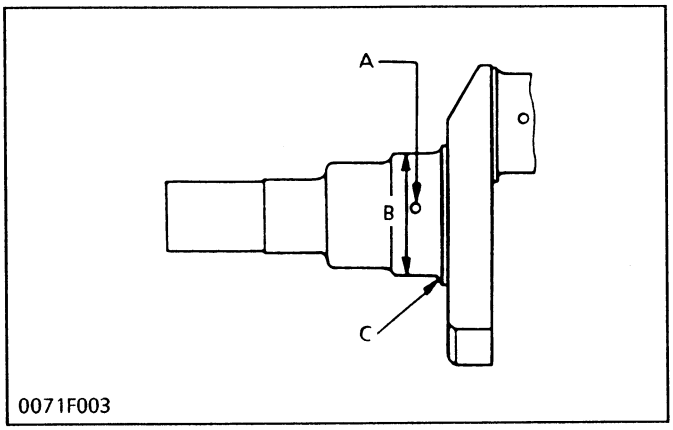

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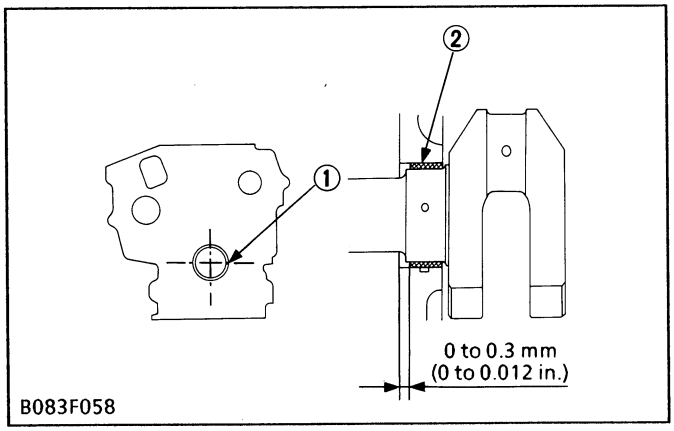

B083F058

(1) Seam (2) Crankshaft Bearing 1

Oil Clearance between Crankshaft Journal and Crankshaft Bearing 1

1. Measure the I.D. of the crankshaft bearing 1 with an inside micrometer.
2. Measure the O.D. of the crankshaft front journal with an outside 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 .

Oil clearance between crank shaft journal and crankshaft	Factory spec.	0.034 to 0.106 mm 0.00134 to 0.00417 in.
	Allowable limit	0.20 mm 0.0079 in.
Crankshaft journal O.D.	Factory spec.	39.934 to 39.950 mm 1.57221 to 1.57284 in.
Crankshaft bearing 1 I.D.	Factory spec.	39.984 to 40.040 mm 1.57417 to 1.57638 in.

(Reference)

- Undersize crank shaft bearing 1

Undersize	Bearing	Code Number	Marking
0.2 mm 0.008 in.	Crankshaft bearing 1 02	15861-23911	020 US
0.4 mm 0.016 in.	Crankshaft bearing 1 04	15861-23921	040 US

- Undersize dimensions of crank shaft journal

Undersize / Dimension	0.2 mm 0.008 in.	0.4 mm 0.016 in.
A	5 mm dia. 0.20 in. dia.	5 mm dia. 0.20 in. dia.
B	39.734 to 39.750 mm 1.56433 to 1.56496 in.	39.534 to 39.550 mm 1.55646 to 1.55709 in.
C	1.8 to 2.2 mm radius 0.071 to 0.087 in. radius	1.8 to 2.2 mm radius 0.071 to 0.087 in. radius

- The crankshaft journal must be fine-finished to higher than ∇∇∇∇ (0.4S).
- Chamfer the oil hole with an oilstone.

Replacing Crankshaft Bearing 1

(When removing)

1. Using a crankshaft bearing 1 replacing tool (see page S-22), press out the used crankshaft bearing.

(When installing)

1. Clean a new crankshaft bearing 1 and crankshaft journal, 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 side in the cylinder block. (See figure)

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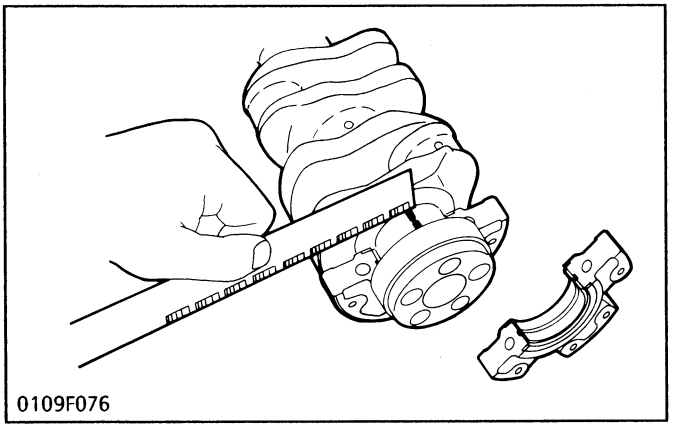
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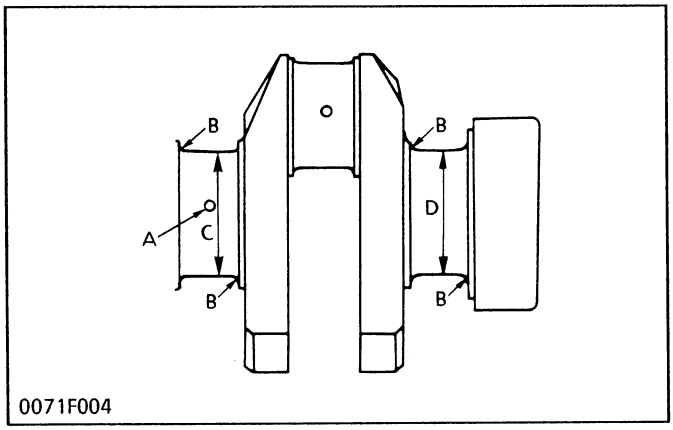

0071F004

Oil Clearance between Crankshaft Journal and Crankshaft Bearing 2 and 3

1. Put a strip of plastigage (Code No. 07909-30241) on the center of the journal.
2. Install the bearing case and tighten the bearing case screws 1 to the specified torque (12.7 to 15.7 N·m, 1.3 to 1.6 kgf·m, 9.4 to 11.6 ft-lbs), and remove the bearing case again.

■ NOTE

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

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 or 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.

Oil clearance between crankshaft journal and crankshaft bearing 2 and 3	Factory spec.	0.028 to 0.059 mm 0.00110 to 0.00232 in.
	Allowable limit	0.20 mm 0.0079 in.

Crankshaft journal O.D. (Flywheel side)	Factory spec.	43.934 to 43.950 mm 1.72968 to 1.73031 in.
Crankshaft bearing 2 I.D.	Factory spec.	43.978 to 43.993 mm 1.73142 to 1.73201 in.
Crankshaft journal O.D. (Intermediate)	Factory spec.	39.934 to 39.950 mm 1.57221 to 1.57284 in.
Crankshaft bearing 3 I.D.	Factory spec.	39.978 to 39.993 mm 1.57394 to 1.57453 in.

(Reference)

- Undersize crankshaft bearing 2 and 3

Undersize	Bearing	Code Number	Marking
0.2 mm 0.008 in.	Crankshaft bearing 2 02	15694-23931	020 US
	Crankshaft bearing 3 02	15861-23861	020 US
0.4 mm 0.016 in.	Crankshaft bearing 2 04	15694-23941	040 US
	Crankshaft bearing 3 04	15861-23871	040 US

- Undersize dimensions of crankshaft journal

Undersize / Dimension	0.2 mm 0.008 in.	0.4 mm 0.016 in.
A	3 mm dia. 0.12 in. dia.	3 mm dia. 0.12 in. dia.
B	1.8 to 2.2 mm radius 0.071 to 0.087 in. radius	1.8 to 2.2 mm radius 0.071 to 0.087 in. radius
C	39.734 to 39.750 mm 1.56433 to 1.56496 in.	39.534 to 39.550 mm 1.55646 to 1.55709 in.
D	43.734 to 43.750 mm 1.72181 to 1.72244 in.	43.534 to 43.550 mm 1.71394 to 1.71457 in.
The crank pin jounrnal must be fine-finished to higher than ▽▽▽▽ (0.4S).		

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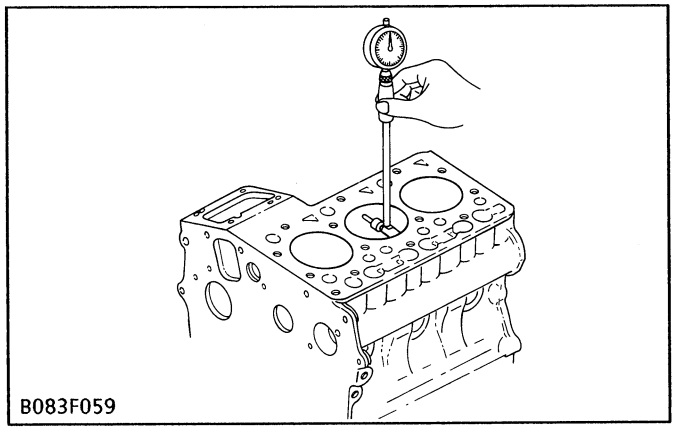
[5] CYLINDER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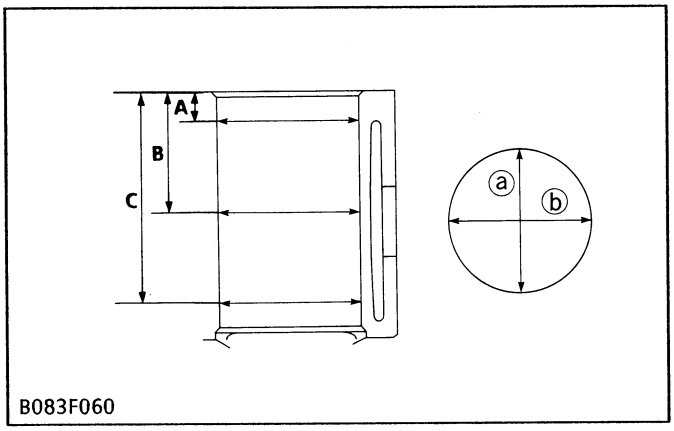

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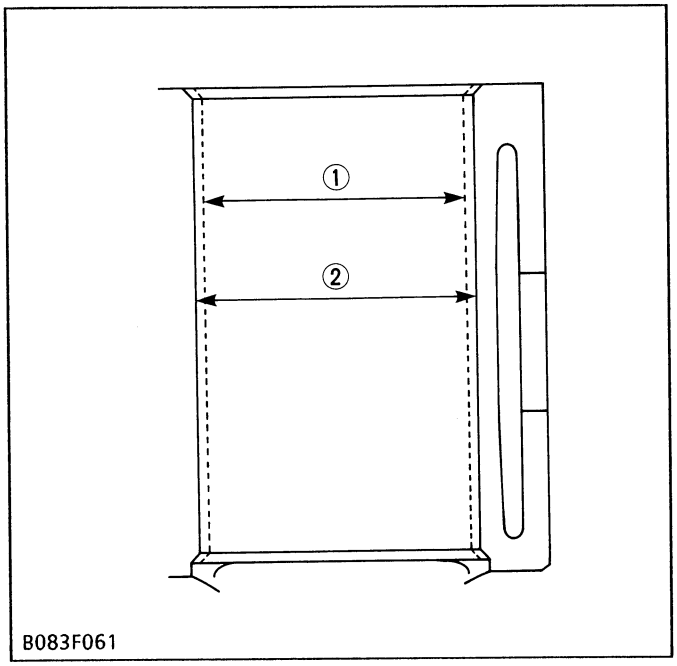


B083F061

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

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.	Z442-B D662-B	64.000 to 64.019 mm 2.51968 to 2.52043 in.
		Z482-B D722-B	67.000 to 67.019 mm 2.63779 to 2.63854 in.
Maximum wear	Allowable limit		0.15 mm 0.0059 in.

A : Approx. 10 mm (0.394 in.)
B : Approx. 45 mm (1.771 in.)
C : Approx. 95 mm (3.740 in.)
a : Right-angled to Piston Pin
b : Piston Pin Direction

Correcting Cylinder

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

Oversize cylinder I.D.	Factory spec.	Z442-B D662-B	64.250 to 64.269 mm 2.52953 to 2.53027 in.
		Z482-B D722-B	67.250 to 67.269 mm 2.64764 to 2.64839 in.
Maximum wear	Allowable limit		0.15 mm 0.0059 in.

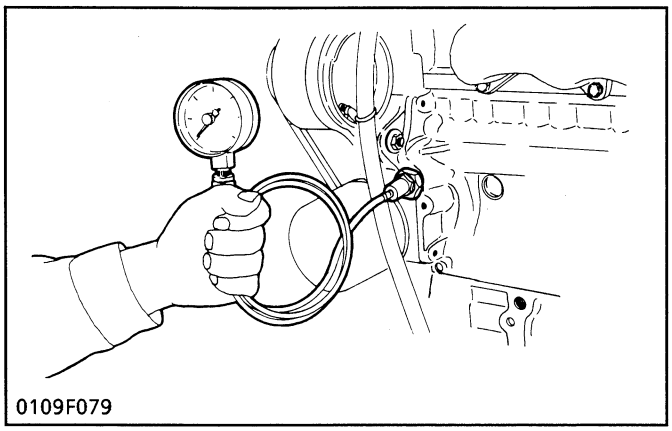
2. Replace the piston and piston rings with oversize ones.

Oversize	Model	Part Name	Code Number	Marking
0.25 mm 0.0098 in.	Z442-B D662-B	Piston	16861-21900	0.25 OS
		Piston ring assembly	16861-21090	0.25 OS
	Z482-B D722-B	Piston	16851-21900	0.25 OS
		Piston ring assembly	16851-21090	0.25 OS

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

2 LUBRICATING SYSTEM

CHECKING


0109F079

Engine Oil Pressure

1. Remove the oil pressure switch, and install the engine oil pressure tester (Code No. 07916-32032). (Adaptor screw size: PT1/8).
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

Engine oil pressure	At idle speed	Factory spec.	49 kPa 0.5 kgf/cm^2 7 psi
	At rated speed	Factory spec.	196 to 441 kPa 2.0 to 4.5 kgf/cm^2 28 to 64 psi
		Allowable limit	147 kPa 1.5 kgf/cm^2 21 psi

(When reassembling)

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

Tightening torque	Oil pressure switch	14.7 to 19.6 N·m 1.5 to 2.0 kgf·m 10.8 to 14.5 ft-lbs

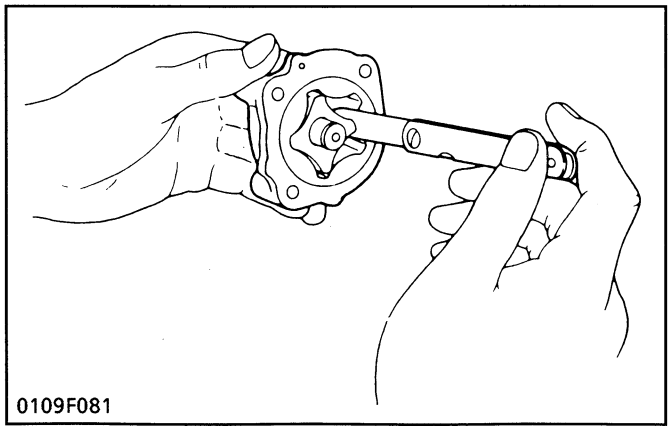
DISASSEMBLING AND ASSEMBLING

Oil Pump

1. See page S-31.

SERVICING

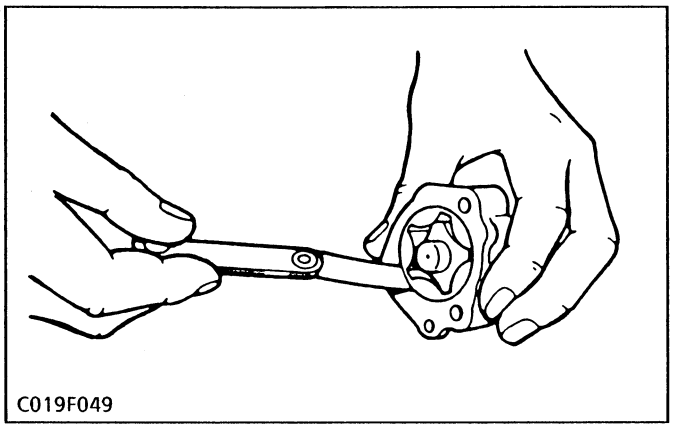
[1] OIP PUMP


0109F081

Rotor Lobe Clearance

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

Rotor lobe clearance	Factory spec.	0.03 to 0.14 mm 0.012 to 0.0055 in.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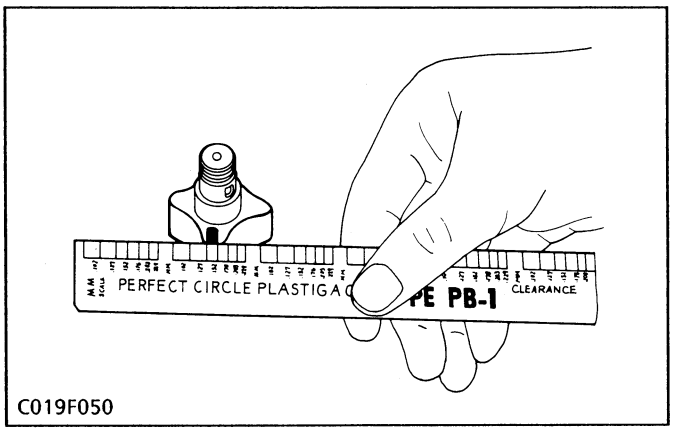
Clearance between Outer Rotor and Pump Body

1. Measure the clearance between the outer rotor and the pump body with a feeler gauge.
2. If the clearance exceeds the allowable limit, replace the oil pump rotor assembly.

Clearance between outer rotor and pump body	Factory spec.	0.07 to 0.15 mm 0.0028 to 0.0059 in.



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Clearance between Rotor and Cover

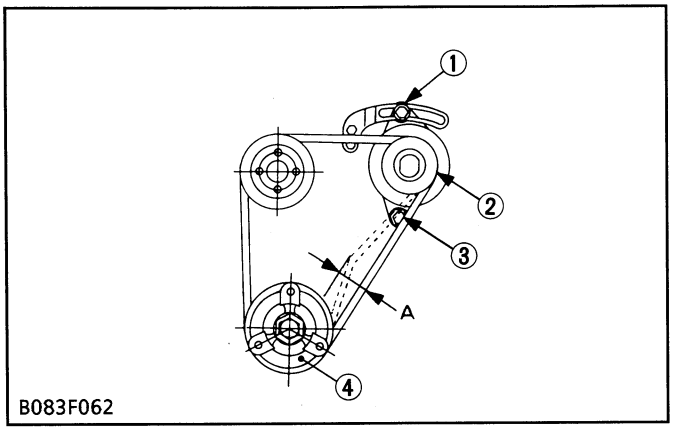
1. Put a strip of press gauge (Code No. 07909-30241) onto the rotor face with grease.
2. Install the cover and tighten the screws.
3. Remove the cover carefully, and measure the width of the press gauge with a sheet of gauge.
4. If the clearance exceeds the allowable limit, replace oil pump rotor assembly.

Clearance between rotor and cover	Factory spec.	0.075 to 0.135 mm 0.00295 to 0.00531 in.

3 COOLING SYSTEM

CHECKING AND ADJUSTING

[1] FAN BELT



Fan Belt Tension

1. Measure the deflection (A), depressing the belt halfway between the fan drive pulley (4) and dynamo pulley (2) at specified force (98 N, 10 kgf, 22 lbs).
2. If the measurement is not the factory specification, loosen the dynamo mounting screws (1), (3) and relocate the dynamo to adjust.

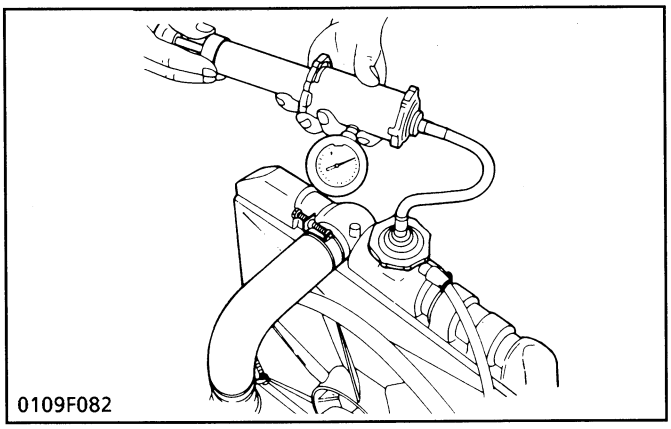
Fan belt tension (Deflection **A**)	Factory spec.	7.0 to 9.0mm/98N 0.28 to 0.35 in./98 N (10kgf,22lbs)

(1) Dynamo Mounting Screw
(2) Dynamo Pulley
(3) Dynamo Mounting Screw
(4) Fan Drive Pulley

[2] RADIATOR

⚠ CAUTION

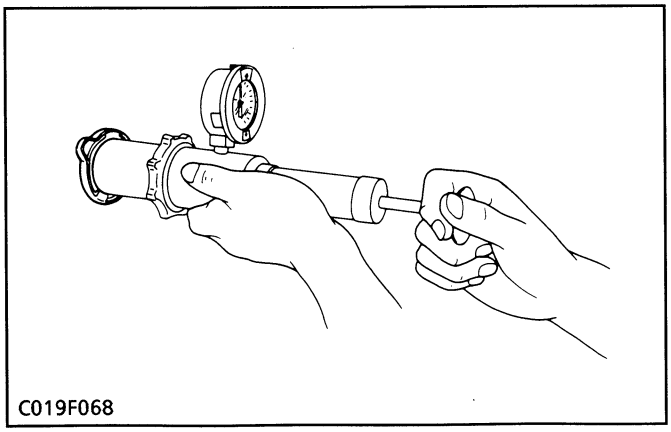
- **Never remove the radiator cap while operating or immediately after stopping. Otherwise, hot water will spout out from the radiator. Wait for more than ten minutes to cool the radiator, before opening the cap.**



Radiator Water Tightness

1. Pour a specified amount of water into the radiator.
2. Warm up the engine and stop it.
3. Set a radiator tester (Code No. 07909-31551) and raise the water pressure to the specified pressure.
4. Check the radiator for water leaks.
5. For water leak from the pinhole, repair with the radiator cement. When water leak is excessive, replace the radiator.

Radiator leakage test pressure	Factory spec.	157 kPa 1.6 kgf/cm^2 23 psi

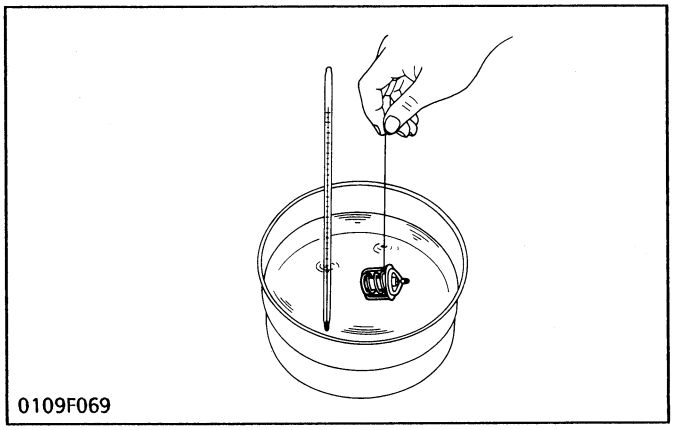


Radiator Cap Tightness

1. Set a radiator tester on the radiator cap.
2. Apply the pressure of 88 kPa (0.9 kgf/cm^2, 13 psi) and measure the time for the pressure to fall to 59 kPa (0.6 kgf/cm^2, 9 psi).
3. If the measurement is less than the factory specification, replace the radiator cap.

Radiator cap tightness (Pressure falling time)	Factory spec.	More than 10 seconds for pressure fall from 88 to 59 kPa (from 0.9 to 0.6 kgf/cm^2, from 13 to 9 psi)

[3] THERMOSTAT



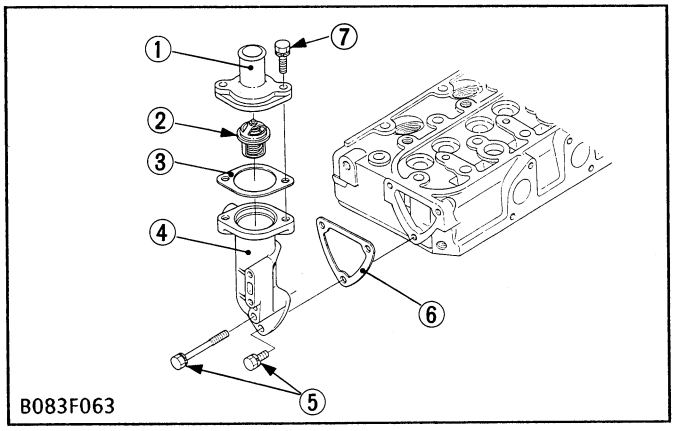
Thermostat Valve Opening Temperature

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. 6 mm (0.236 in.).
4. If the measurement is not within the factory specifications, replace the thermostat.

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

DISASSEMBLING AND ASSEMBLING

[1] THERMOSTAT



Thermostat and Water Flange

1. Unscrew the thermostat cover mounting screws (7), and remove the thermostat cover (1).
2. Remove the thermostat (2).
3. Unscrew the water flange mounting screws (5), and remove the water flange (4).

(When reassembling)

- Apply liquid-type gasket (Three Bond 1215 or its equivalent) to both sides of a new thermostat cover gasket (3).
- Apply liquid-type gasket (Three Bond 1215 or its equivalent) to both sides of a new water flange gasket (6).

(1) Thermostat Cover
(2) Thermostat
(3) Thermostat Cover Gasket
(4) Water Flange
(5) Water Flange Mounting Screw
(6) Water Flange Gasket
(7) Thermostat Cover Mounting Screw

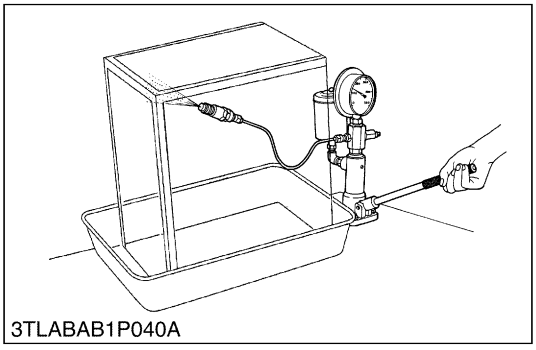
4 FUEL SYSTEM

CHECKING AND ADJUSTING

[1] INJECTION NOZZLE

⚠ CAUTION

- **Check the nozzle 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.**



3TLABAB1P040A

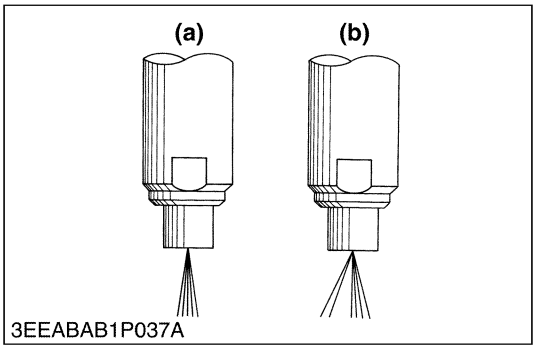
Nozzle Injection Pressure

1. Set the injection nozzle to the nozzle tester.
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 injection nozzle assembly.

Fuel injection pressure	Factory spec.	13.73 to 14.71 MPa 140 to 150 kgf/cm^2 1991 to 2134 psi

(1) Adjusting Washer

W1037197



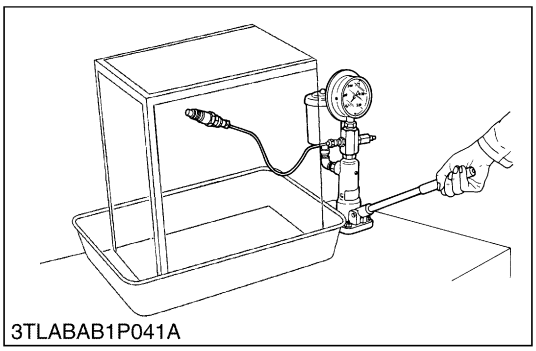
3EEABAB1P037A

Nozzle Spraying Condition

1. Set the injection nozzle to a nozzle tester (Code No. 07909-31361), and check the nozzle spraying condition.
2. If the spraying condition is defective, replace the injection nozzle assembly.

(a) Good **(b) Bad**

W1037394



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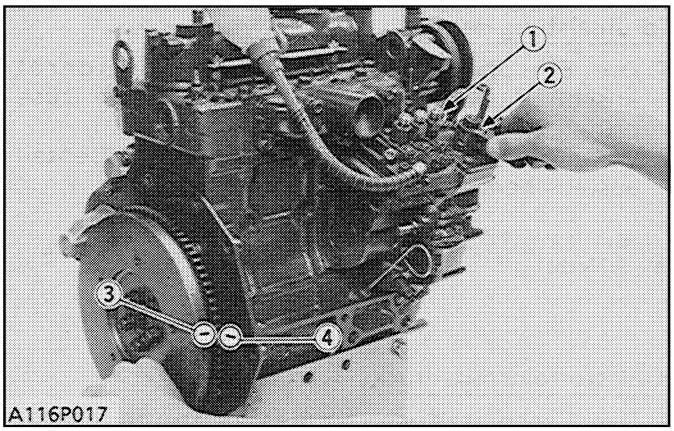
Valve Seat Tightness

1. Set the injection nozzle to a nozzle tester (Code No. 07909-31361).
2. Raise the fuel pressure, and keep at 12.75 MPa (130 kgf/cm^2, 1849 psi) for 10 seconds.
3. If any fuel leak is found, replace the injection nozzle assembly.

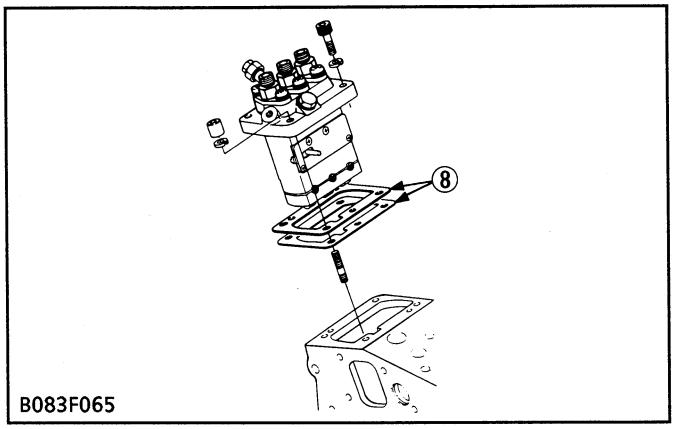
Valve seat tightness	Factory spec.	No fuel leak at 12.75 MPa 130 kgf/cm^2 1849 psi

W1088949

[2] INJECTION PUMP



A116P017



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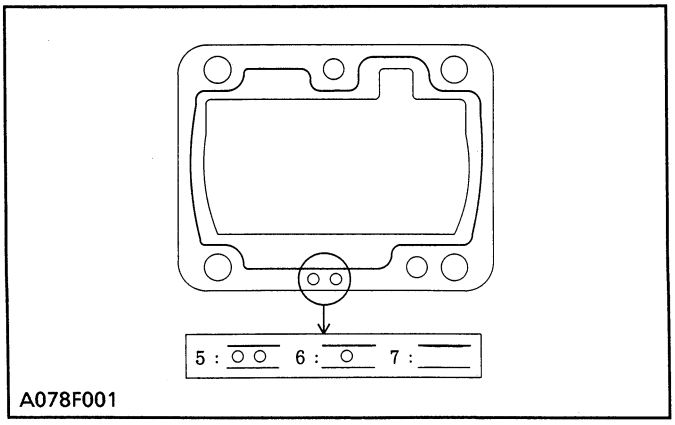
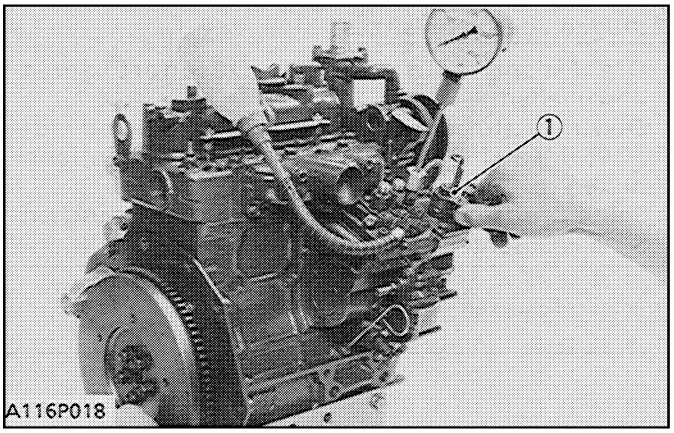


A078F001



A116P018

Injection Timing

1. Remove the injection pipes.
2. Set the speed control lever (2) to the maximum fuel discharge position.

3. Turn the flywheel until the fuel fills up to the hole of the delivery valve holder (1).
4. Turn the flywheel further to check the injection timing, and stop turning when the fuel begins to flow over again.
5. Check to see if the mark or timing angle lines (3) on the flywheel is aligned with the punch mark (4).
6. If the timing is out of adjustment, readjust the timing with shims (8).

(Injection Timing)

0.35 to 0.38 rad (20° to 22°) B.T.D.C

■ NOTE

(Engine serial number : ~489290)

- **Shims are available in thickness of 0.15 mm, 0.30 mm. Combine these shims for adjustments.**
- **Addition or reduction of shim (0.15 mm, 0.0059 in.) delays or advances the injection timing by approx. 0.026 rad (1.5°).**
- **After adjusting the injection timing, apply liquid-type gasket (Three Bond 1215 or its equivalent) to both sides of the injection pump shim before reassembling.**

(Engine serial number : 489291~)

- **The sealant is applied to both sides of the 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, 0.0020 in.) delays or advances the injection timing by approx. 0.0087 rad (0.5°).**
- **In disassembling and replacing, be sure to use the same number of new gasket shims with the same thickness.**

(1) Delivery Valve Holder
(2) Speed Control Lever
(3) Mark
(4) Mark
(5) 2-holes : 0.20 mm
(6) 1-hole : 0.25 mm
(7) Without hole : 0.30 mm
(8) Shim

Pump Element Fuel Tightness

1. Remove the injection pipes and injection nozzles.
2. Install the pressure tester (see page S-23) to the injection pump.
3. Set the speed control lever (1) to the maximum fuel discharge position.
4. Turn the flywheel counterclockwise to raise the fuel pressure.
5. If the fuel pressure can not reach the allowable limit, replace the pump element or injection pump assembly.

Pump element fuel tightness (Fuel pressure)	Allowable limit	14.71 MPa 150 kgf/cm² 2134 psi

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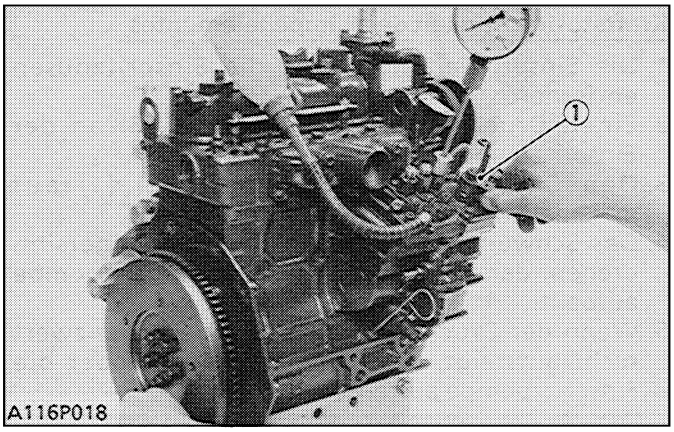


(1) Speed Control Lever

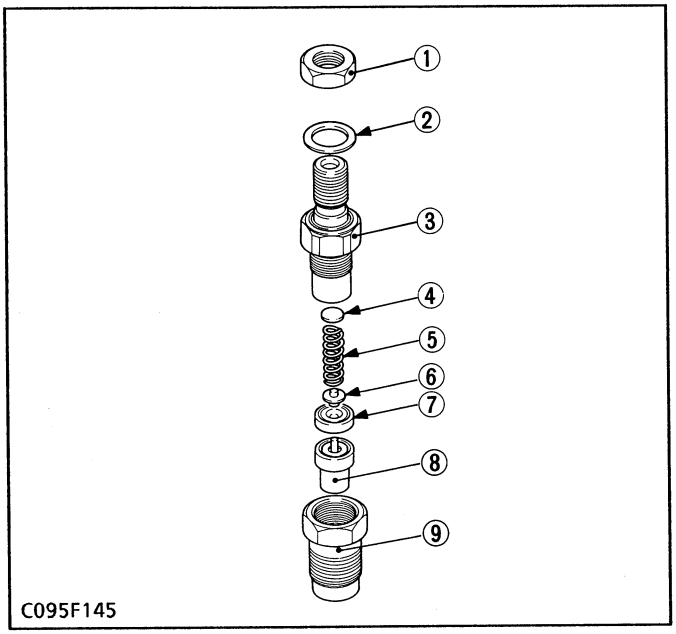
Delivery Valve Fuel Tightness

1. Remove the injection pipes and injection nozzles.
2. Install the pressure tester (see page S-23) to the injection pump.
3. Set the speed control lever (1) to the maximum fuel discharge position.
4. Turn the flywheel counterclockwise to raise the fuel pressure to 14.71 MPa (150 kgf/cm^2, 2134 psi).
5. Set the plunger of the injection pump at the bottom dead center to reduce the delivery chamber pressure to zero.
6. Measure the falling time of the fuel pressure from 14.71 to 13.73 MPa (from 150 to 140 kgf/cm^2, from 2134 to 1991 psi).
7. If the measurement is less than the allowable limit, replace the delivery valve or injection pump assembly.

Pressure falling time	Allowable limit	5 seconds

DISASSEMBLING AND ASSEMBLING

[1] INJECTION NOZZLE



(1) Fuel Overflow Pipe Nut
(2) Plain Washer
(3) Nozzle Holder
(4) Adjusting Washer
(5) Nozzle Spring
(6) Push Rod
(7) Distance Piece
(8) Nozzle Piece
(9) Nozzle Retaining Nut

Injection Nozzle

1. Remove the injection nozzle from the cylinder head.
2. Secure the nozzle retaining nut (9) in a vise.
3. Remove the nozzle holder (3), and take out the adjusting washer (4), nozzle spring (5), push rod (6), distance piece (7) and nozzle piece (8).

(When reassembling)

- Assemble the injection nozzle in clean fuel.
- Install the push rod (6), noting its direction.

Tightening torque	Fuel overflow pipe nut	19.6 to 24.5 N·m 2.0 to 2.5 kgf·m 14.5 to 18.1 ft-lbs
	Nozzle holder (3) to nozzle retaining nut (9)	34.3 to 39.2 N·m 3.5 to 4.0 kgf·m 25.3 to 28.9 ft-lbs
	Injection nozzle to cylinder head	49.0 to 68.6 N·m 5.0 to 7.0 kgf·m 36.2 to 50.6 ft-lbs

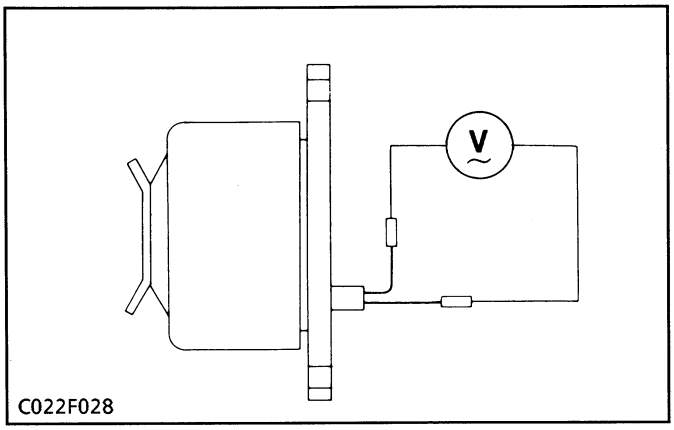
■ IMPORTANT

- **The nozzle piece is precisely finished. Do not use a piece of metal but a piece of wood to remove the carbon deposits.**
- **After assembling the nozzle, be sure to adjust the injection pressure. (See "Fuel Injection Pressure")**

5 ELECTRICAL SYSTEM

CHECKING

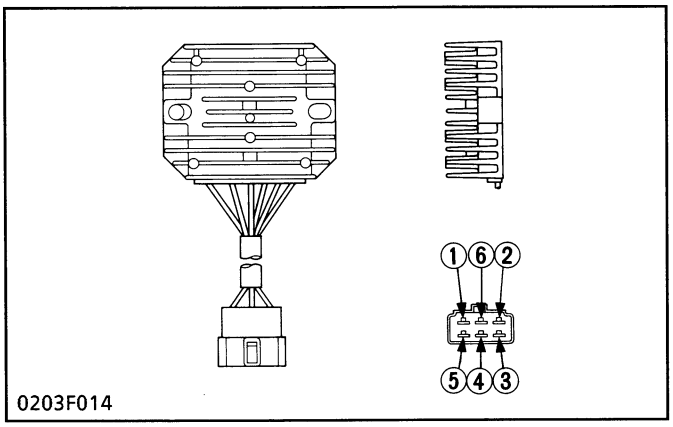
[1] DYNAMO AND REGULATOR



Dynamo No-load Voltage

1. Disconnect the lead wire from the Dynamo.
2. Start the engine and measure the voltage generated by the Dynamo
3. Measure the output voltage with a voltmeter.
   If the measurement is not within the factory specifications, replace the dynamo.

No load dynamo voltage	Factory spec.	AC20V or more at 5200 min-1(rpm)



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

Continuity across Regulator's Terminals

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

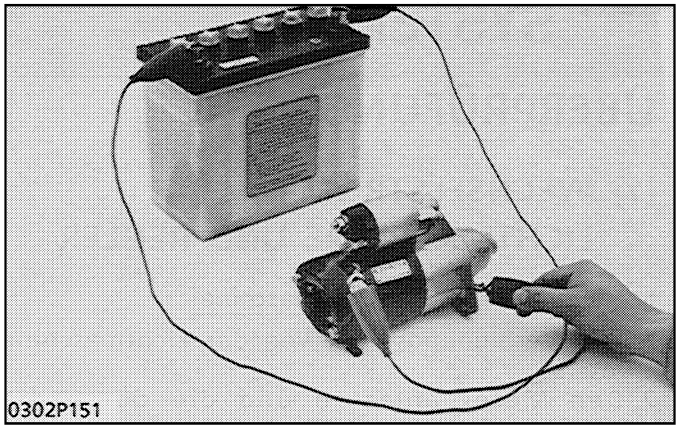
■ **NOTE**

- **For this test, use only Analog Meter and do not use a high voltage tester such as a MΩ meter.**
- **This check sheet shows the results of the test conducted by using the "Sanwa-made testers SP-10 and SP-15D" (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 judgment shold be as below table. "ON" if the indicator moves, otherwise "OFF".**

■ **Check Table**

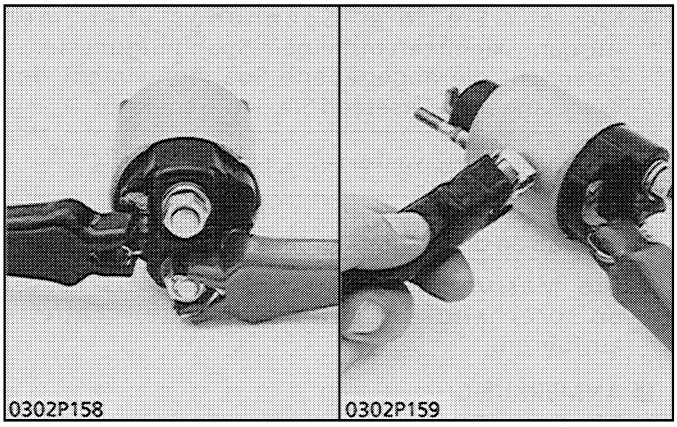
− terminal Tester \ + terminal Tester		Cord colors					
		blue	blue	red	yellow	green	black
Cord colors	blue		OFF	**ON**	OFF	OFF	OFF
	blue	OFF		**ON**	OFF	OFF	OFF
	red	OFF	OFF		OFF	OFF	OFF
	yellow	**ON**	**ON**	**ON**		OFF	**ON**
	green	OFF	OFF	OFF	OFF		OFF
	black	OFF	OFF	OFF	OFF	OFF	

[2] STARTER


0302P151

Motor Test

1. Disconnect the connecting lead from the "C" terminal of the starter and connect a jumper lead from the connecting lead to the positive battery terminal.
2. Connect a jumper lead momentarily between the starter body and the negative battery terminal.
3. If the motor does not run, check the motor.


0302P158

0302P159

Magnet Switch

■ **NOTE**

- **Each test should be carried out for a start time (3 to 5 seconds), and at half of the rated voltage (6V).**

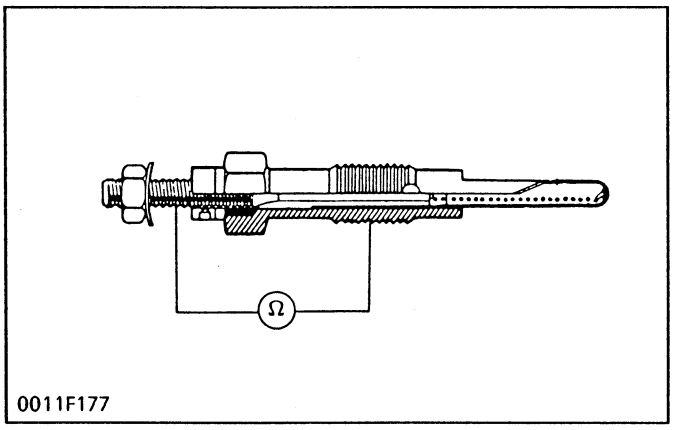
1) Checking Pull-in Coil

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.

[3] GLOW PLUG



0011F177

Glow Plug

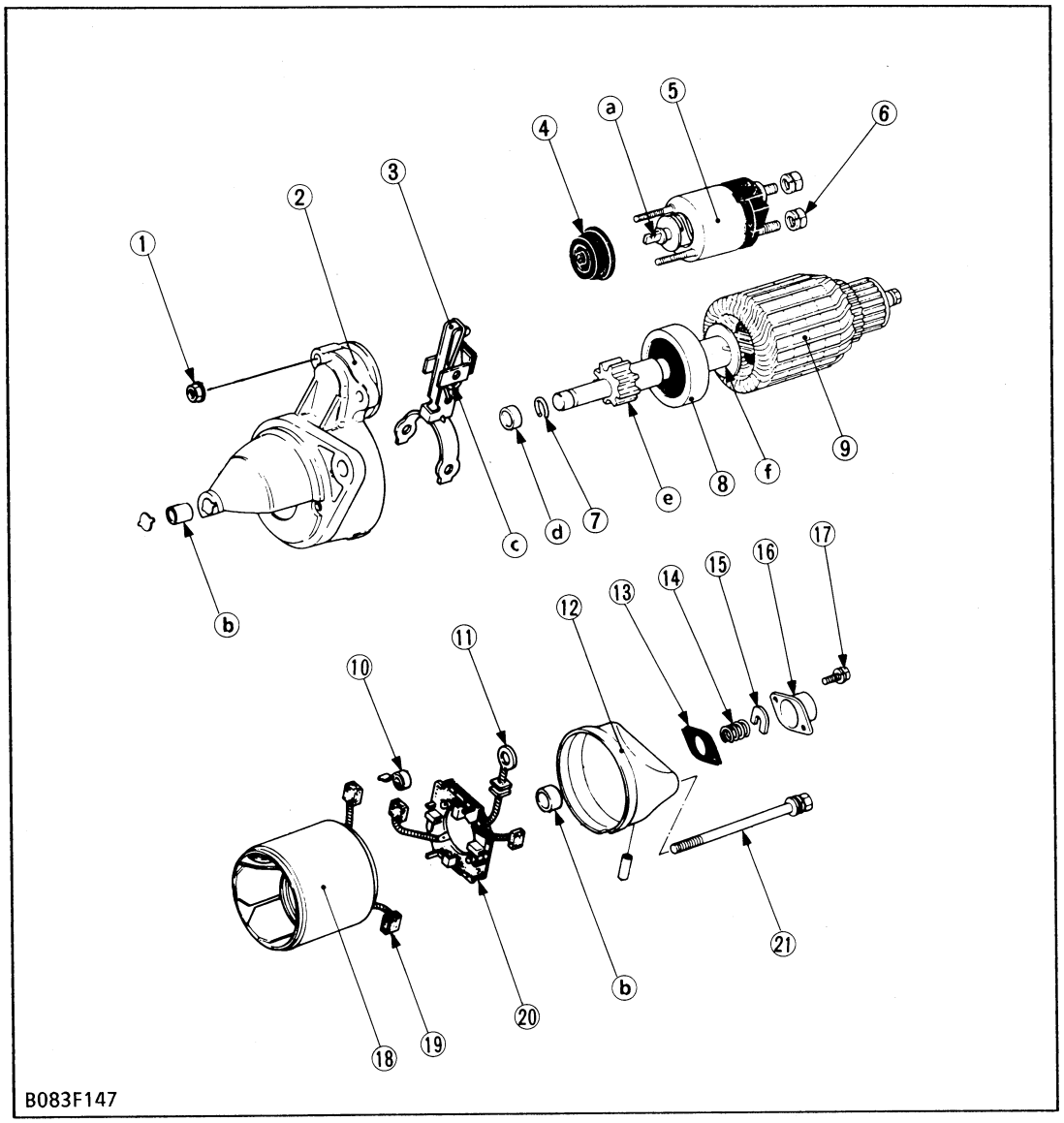
1. Disconnect the leads from the glow plugs.
2. Measure the resistance with circuit tester across the glow plug terminal and the housing.
3. If 0 ohm is indicated, the screw at the tip of the glow plug and the housing are short-circuited.
   If the reference value is not indiacated, the glow plug is faulty, replace the glow plug.

Glow plug resistance	Factory spec.	Approx. 0.9 Ω

DISASSEMBLING AND ASSEMBLING

[1] STARTER

Disassembling Starter



B083F147

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

1. Unscrew the mounting nut (6), and disconnect the connecting lead (11).
2. Unscrew the solenoid switch mounting nuts (1), and remove the solenoid switch (5).
3. Remove the end frame cap (16).
4. Remove the brake shoe (15), brake spring (14) and gasket (13).
5. Unscrew the through bolts (21), and remove the rear end frame (12).
6. Remove the brush from the brush holder while holding the spring up.
7. Remove the brush holder (20).
8. Draw out the yoke (18) from the starter drive housing (2).
9. Draw out the armature (9) with the drive lever (3).

■ **NOTE**

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

(When reassembling)

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

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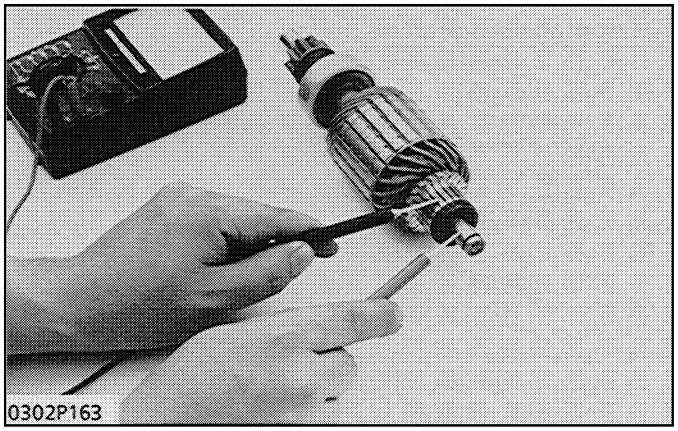
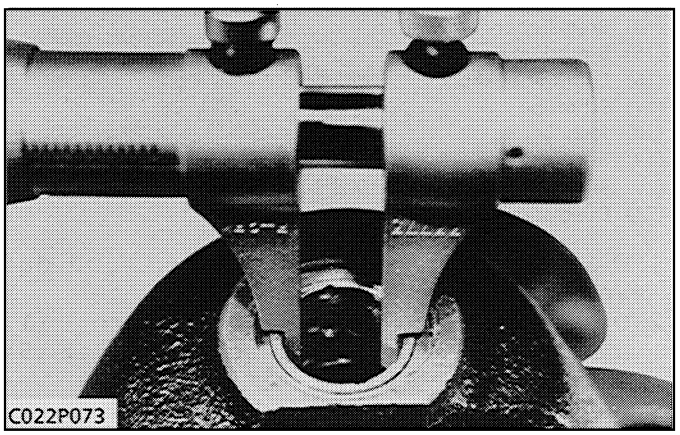
SERVICING

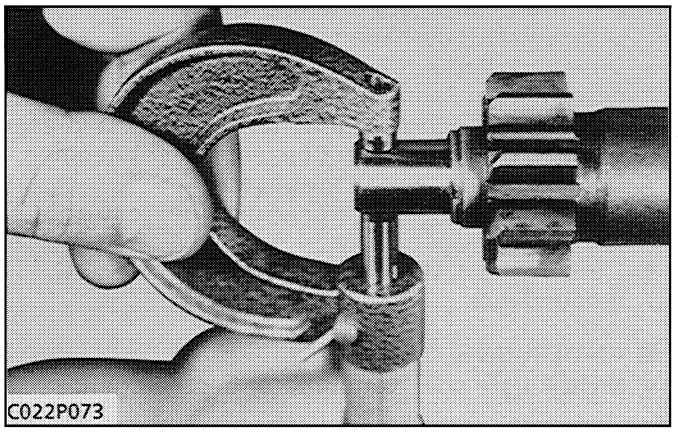
[1] STARTER



Armature Coil

1. Check the continuity across the commutator and armature shaft with an ohmmeter.
2. If it conducts, replace the armature.



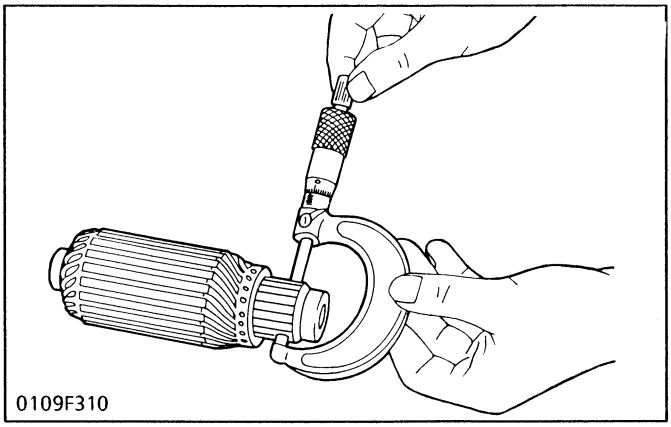


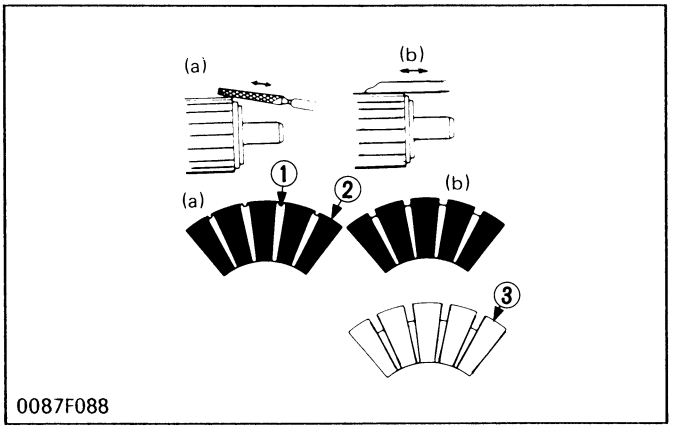
Clearance between Armature Shaft and Bushing

1. Measure the bushing I.D. of the drive side and commutator side.
2. Measure the armature shaft O.D. of the drive side and commutator side, and calculate the clearance.
3. If the clearance exceeds the allowable limit, replace the bushing.

Clearance between armature shaft and bushing	Factory spec.	Commutator side	0.03 to 0.10 mm 0.0012 to 0.0039 in.
		Drive side	0.05 to 0.10 mm 0.0020 to 0.0039 in.
	Allowable limit		0.20 mm 0.0079 in.

Armature shaft O.D.	Factory spec.	12.50 mm 0.4921 in.
Bushing I.D. (Commutator side)	Factory spec.	12.53 to 12.60 mm 0.4933 to 0.4961 in.
Bushing I.D. (Drive side)	Factory spec.	12.55 to 12.60 mm 0.4941 to 0.4961 in.


0109F310



0087F088

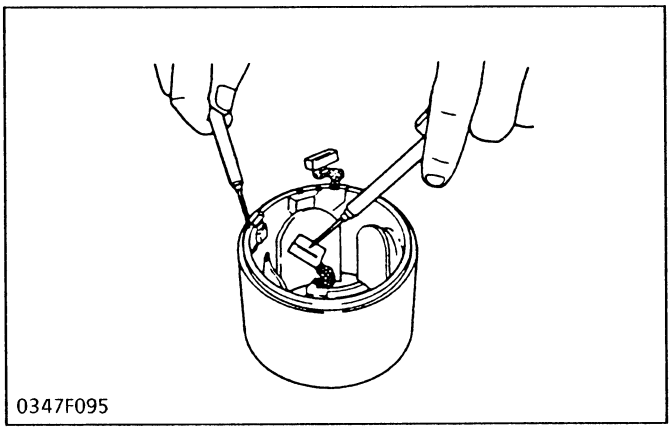
(a) Bad **(b) Good**

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

Commutator and Mica

1. If the commutator surface is dirty or dusty, clean it with a sandpaper.
2. Measure the commutator O.D. with vernier calipers at several points.
3. If the difference of the O.D.'s exceeds the allowable limit, correct the commutator on a lathe to the factory specification.
4. If the minimum O.D. is less than the allowable limit, replace the armature.
5. Measure the mica undercut depth.
6. If the undercut is less than the allowable limit, correct with a saw blade and chamfer the segment edges.

Commutator O.D.	Factory spec.	28.0 mm 1.102 in.
	Allowable limit	27.0 mm 1.063 in.
Difference of O.D.'s	Factory spec.	Less than 0.05 mm 0.002 in.
	Allowable limit	0.4 mm 0.016 in.
Mica undercut	Factory spec.	0.5 to 0.8 mm 0.020 to 0.031 in.
	Allowable limit	0.2 mm 0.008 in.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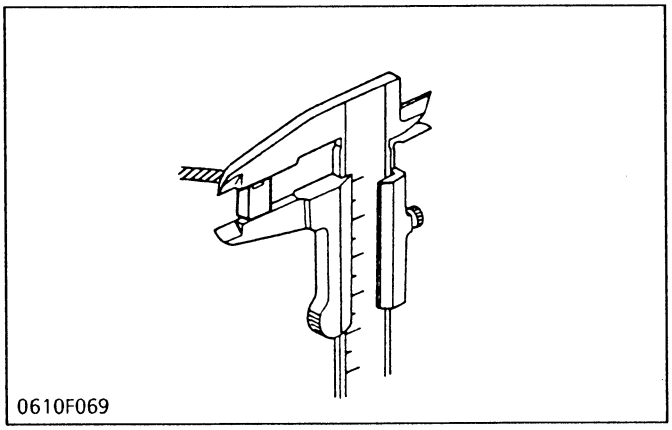
Field Coil

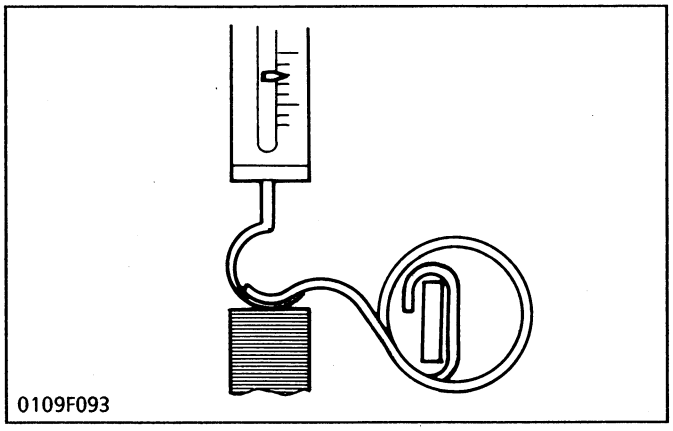
1. Check the continuity across the yoke and brush with an ohmmeter.
2. If either are not conducting, replace the yoke assembly.


0610F069

Brush Wear

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

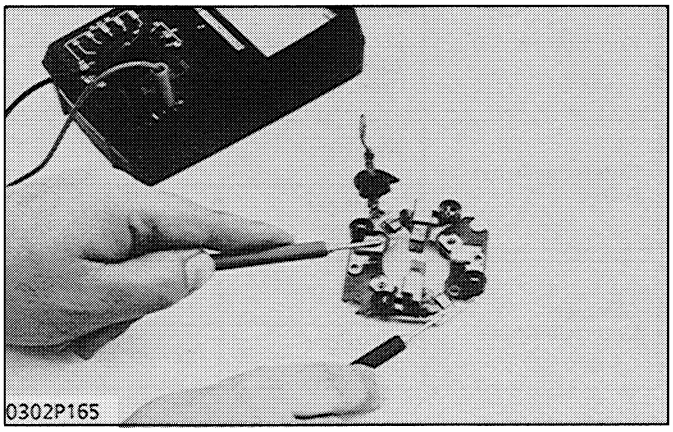
Brush length	Factory spec.	16.0 mm 0.630 in.
	Allowable limit	10.5 mm 0.413 in.


0109F093

Brush Spring

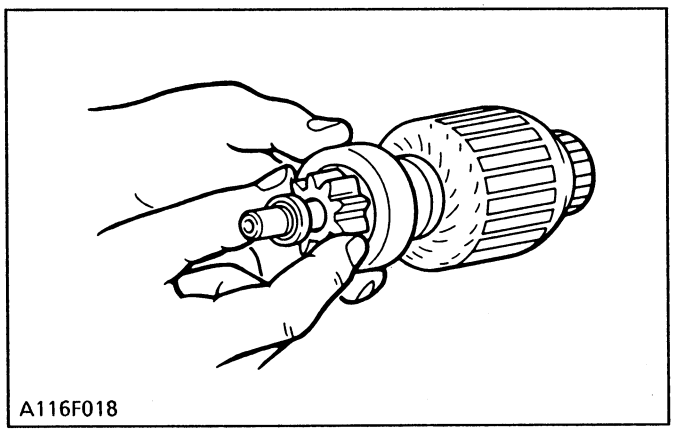
1. Pull the brush in the brush holder with a spring scale.
2. Measure the brush spring tension required to raise the spring from contact position with the commutator.
3. If the tension is less than the allowable limit, replace the spring.

Spring tension	Factory spec.	13.7 to 25.5 N 1.4 to 2.6 kgf 3.1 to 5.7 lbs
	Allowable limit	8.8 N 0.9 kgf 2.0 lbs


0302P165

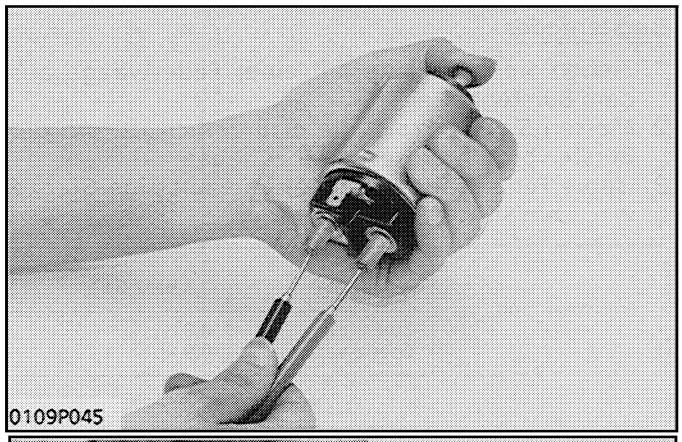
Brush Holder

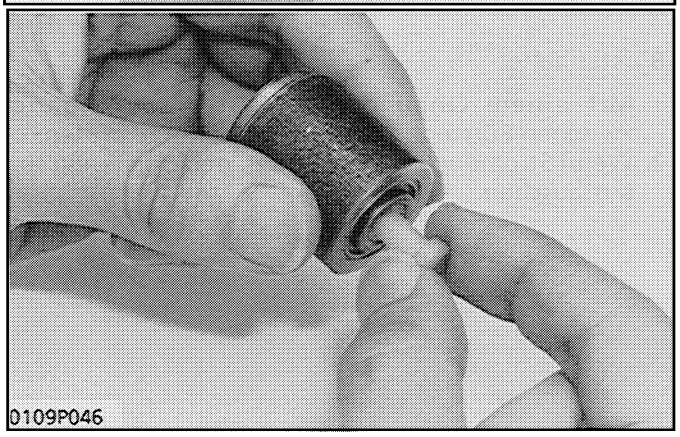
1. Check the continuity across the brush holder and holder support with an ohmmeter.
2. If it conducts, replace the brush holder.


A116F018

Overrunning Clutch

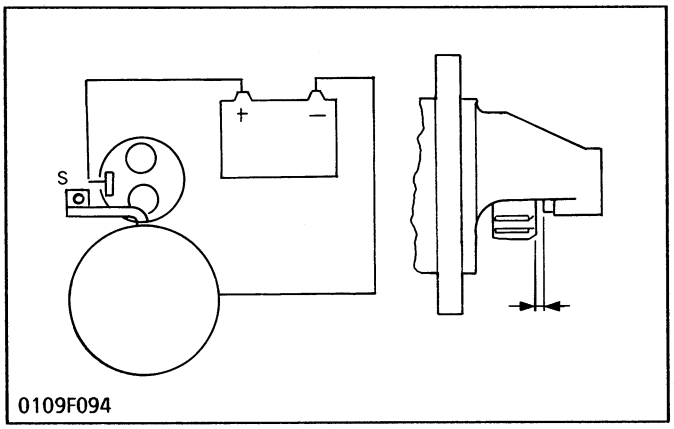
1. Inspect the pinion for wear or damage.
2. If there is any defect, replace it.
3. Check that the pinion turns freely and smoothly in the overrunning direction and does not slip in the cranking direction.
4. If the pinion slips or does not turn in both directions, replace the overrunning clutch assembly.


0109P045


0109P046

Solenoid Switch

1. Check the continuity across **"B"** and **"M"** terminals with an ohmmeter, pushing in the plunger.
2. If not continuous or if a certain value is indicated, replace the solenoid switch.
3. Pull the pull-rod to check the spring built in the plunger



0109F094

Pinion Clearance

1. Reassemble the starter with connecting leads unconnected.
2. Connect a cable from the negative terminal of the battery to the starter body and a cable from **"S"** terminal of the starter to the positive terminal of the battery to force out the pinion.
3. Push back the pinion slightly to kill the play, and measure the pinion clearance.
4. If the clearance is not within the specified values, add or remove the washer between the solenoid switch and front end frame.

Pinion clearance	Factory spec.	0.5 to 2.0 mm 0.020 to 0.079 in.

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