

KUBOTA

Workshop Manual

03 Series

Diesel Engine

Reprinted from KUBOTA Workshop Manual, 92.4 mm Stroke Diesel Engine (English language only)
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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 92.4 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 troubleshooting, 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 manufactured 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.

Due to covering many models of this manual, illustration or picture being used have not been specified as one model.

August '91

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SAFETY FIRST

This symbol, the industry's "Safety Alert Symbol", is used throughout this manual and decals on the engine 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**

: Immediate hazards which **WILL** result in severe personal injury or death.



WARNING : Hazards or unsafe practices which **COULD** result in severe personal injury or death.



CAUTION : Hazards or unsafe practices which **COULD** result in minor personal injury.



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



NOTE : Gives helpful information.

SAFETY SERVICING AND REPAIRING

- (1) Before working on the engine :
 - Stop the engine, and remove the key.
 - Allow the engine to cool before proceeding.
 - Place the engine on a firm and level surface.
 - Disconnect the battery's ground cable.
 - Clean the work area and engine.
- (2) Do not work on the engine while under the influence of alcohol, medication, or other substances or while fatigued.
- (3) Do not wear a necktie, scarf, necklace, loose or bulky clothing when you work near machine tools or moving parts.
- (4) Wear a suitable hearing protective device such as earmuffs or earplugs to protect against objectionable or uncomfortable loud noises.
- (5) Use tools appropriate to the work. Makeshift tools, parts, and procedures will not make good repairs.
- (6) When servicing is performed together by two or more persons, take care to perform all work safely.
- (7) 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.
- (8) Do not touch the rotating or hot parts while the engine is running.
- (9) Fuel is extremely flammable and explosive under certain conditions. Do not smoke or allow flames or sparks in your working area.
- (10) To avoid sparks from an accidental short circuit, always disconnect the battery's ground cable first and connect it last.
- (11) 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.
- (12) Battery gas can explode. Keep sparks and open flame away from the top of battery, especially when charging the battery.
- (13) Never remove the radiator cap while the engine is running, or immediately after stopping. Otherwise, hot water will spout out from radiator. Wait for more than ten minutes to cool the radiator, before removing the cap.
- (14) Escaping fuel fluid under pressure can penetrate the skin causing serious injury. Relieve pressure before disconnecting fuel lines. Tighten all connections before applying pressure.
- (15) Do not start the engine by shorting across starter terminals.
- (16) Unauthorized modifications to the engine may impair the function and / or safety and affect engine life.

SPECIFICATIONS

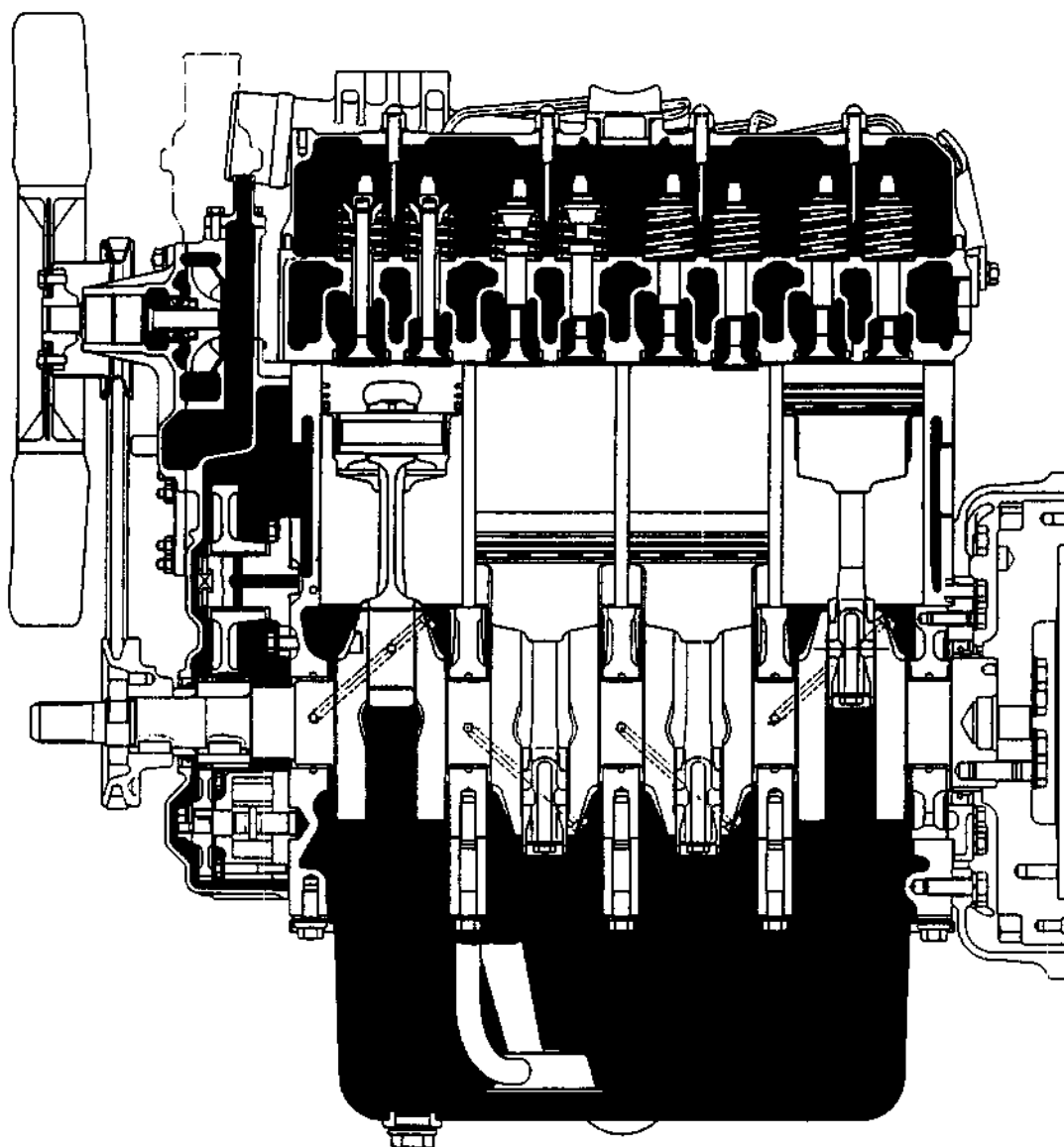
Model		D1403-B (E)	D1703-B (E)
Number of Cylinders		3	
Type		Vertical, water-cooled, 4-cycle diesel engine	
Bore x Stroke	mm (in.)	80 x 92.4 (3.15 x 3.64)	87 x 92.4 (3.43 x 3.64)
Total Displacement	cm ³ (cu. in.)	1393 (85.01)	1647 (100.55)
E n g i n e	SAE Net Cont.	kW/rpm (HP/rpm)	18.6/2800 (25.0/2800)
	SAE Net Intermittent	kW/rpm (HP/rpm)	21.6/2800 (29.0/2800)
	SAE Gross Intermittent	kW/rpm (HP/rpm)	23.1/2800 (31.0/2800)
	DIN6271-NA	kW/rpm (PS/rpm)	18.4/2800 (25.0/2800)
	DIN6271-NB	kW/rpm (PS/rpm)	20.6/2800 (28.0/2800)
	DIN70020	kW/rpm (PS/rpm)	22.1/2800 (30.0/2800)
Maximum Bare Speed		3000 rpm	
Minimum Idling Speed		700 to 750 rpm	
Combustion Chamber		Spherical Type	
Fuel Injection Pump		Bosch Type Mini Pump (PFR 3M)	
Governor		Centrifugal Ball Mechanical Governor	
Direction of Rotation		Counter-clockwise (Viewed from flywheel side)	
Injection Nozzle		BOSCH Throttle-Type	
Injection Timing		0.314 rad. (18°) Before T.D.C	
Firing Order		1-2-3	
Injection Pressure		13.73 MPa (140 kgf/cm ² , 1991 psi)	
Compression Ratio		23 : 1	
Lubricating System		Forced Lubrication by trochoid Pump	
Oil Pressure Indicating		Electrical Type Switch	
Lubricating Filter		Full Flow Paper Filter (Cartridge Type)	
Cooling System		Pressurized radiation, forced Circulation with Water Pump	
Starting System		Electric Starting with Starter	
		12 V 1.2 kw	
Starting Support Device		By Glow Plug in Combustion Chamber	
Battery		12V 70 to 80 AH	
Dynamo for Charing		12V, 360W	
Fuel		Diesel Fuel No.2-D (ASTM D975)	
Lubricating Oil		Better than CD class (API)	
* Lubricating Oil Capacity	Oil pan depth 90 mm (3.54 in.)	5.6 ℓ (1.48 US gals, 1.23 Imp gals)	
	Oil pan depth 124 mm (4.88 in.)	7.0 ℓ (1.85 US gals, 1.54 Imp gals)	
Weight (Dry)		148 (326) kg (lbs)	

*90 mm (3.54 in.) Oil pan depth is optional

V1903-B (E)	V2203-B (E)	F2803-B (E)
4		5
Vertical, water-cooled, 4-cycle diesel engine		
80 x 92.4 (3.15 x 3.64)	87 x 92.4 (3.43 x 3.63)	87 x 92.4 (3.43 x 3.64)
1857 (113.37)	2197 (134.08)	2746 (167.59)
25.4/2800 (34.0/2800)	29.8/2800 (40.0/2800)	37.3/2800 (50.0/2800)
29.1/2800 (39.0/2800)	34.3/2800 (46.0/2800)	42.9/2800 (57.5/2800)
31.3/2800 (42.0/2800)	36.9/2800 (51.0/2800)	46.2/2800 (62.0/2800)
25.0/2800 (34.0/2800)	29.4/2800 (40.0/2800)	36.8/2800 (50.0/2800)
27.6/2800 (37.5/2800)	32.7/2800 (44.5/2800)	40.8/2800 (55.5/2800)
29.8/2800 (40.5/2800)	35.3/2800 (48.5/2800)	44.1/2800 (60.0/2800)
3000		
700 to 750		
Spherical Type		
Bosch type Mini Pump (PFR 4M)		Bosch type Mini Pump (PFR 5M)
Centrifugal Ball Mechanical Governor		
Counter-clockwise (Viewed from flywheel side)		
BOSCH Throttle-Type		
0.314 rad. (18°) Before T.D.C		0.332 rad. (19°) Before T.D.C.
1-3-4-2		1-3-5-4-2
13.73 MPa (140 kgf/cm ² , 1991 psi)		
23 : 1		
Forced Lubrication by trochoid Pump		
Electrical Type Switch		
Full Flow Paper Filter (Cartridge type)		
Pressurized radiation, Forced Circulation with water Pump		
Electric Starting with Starter		
12V, 1.4 kW		
By Glow Plug in Combustion Chamber		
12V, 110 to 120AH		
12V, 360W	12V, 420W	
Diesel Fuel No.2-D (ASTM D975)		
Better than CD Class (API)		
7.6 ℓ (2.01 US gals, 1.672 Imp gals)		-
9.5 ℓ (2.51 US gals, 2.09 Imp gals)		12.0 ℓ (3.17 US gals, 2.64 Imp gals)
180 (397)		223 (492)

M. MECHANISM MECANISME MECHANISMUS

F FEATURE



A109F003

The 92.4 mm STROKE SERIES ENGINE are vertical, water-cooled, 4-cycle diesel engine.

It is incorporated KUBOTA's foremost technologies. With KUBOTA's New TVCS (Three Vortex Combustion System), well-known Bosch type injection pump and the well-balanced designs, 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.

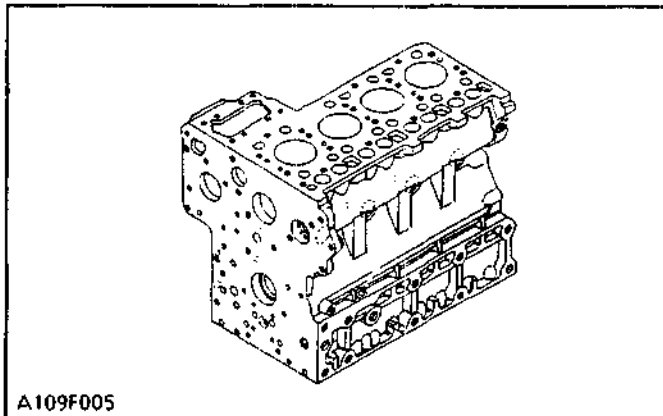
The combustion chamber models mentioned hereinafter refers to E-TVCS.

Model of combustion chamber :

E-TVCS Serial Number : D1403 ; 12212 & above
 D1703 ; 4254 & above
 V1903 ; 1563 & above
 V2203 ; 60897 & above
 F2803 ; 105568 & above

1 ENGINE BODY

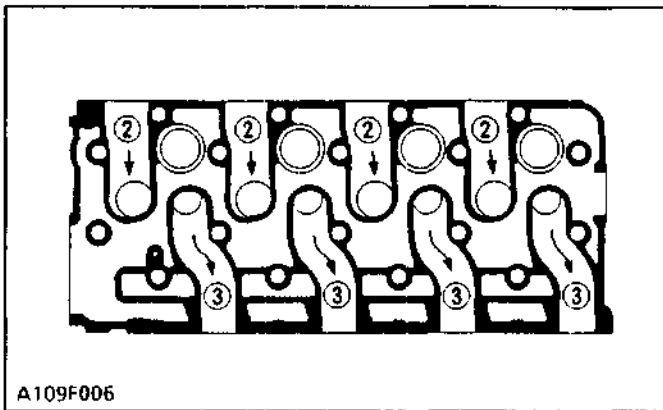
[1] CYLINDER BLOCK



A109F005

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.

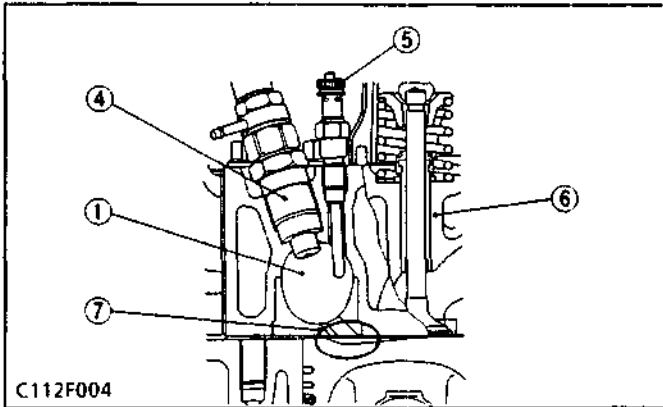
[2] CYLINDER HEAD



A109F006

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.

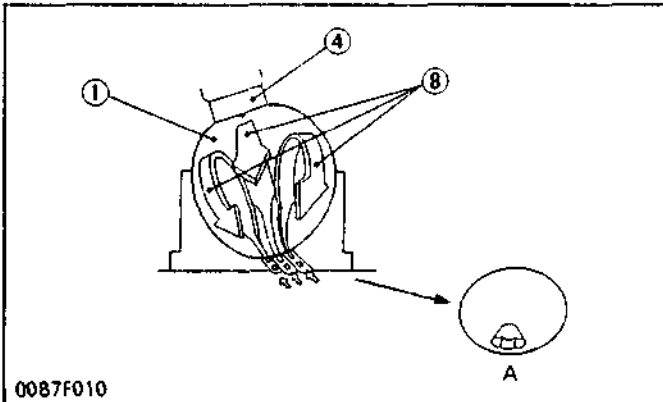
In the combustion chamber are installed throttle type injection nozzle and rapid heating sheathed type glow plug. This glow plug assures easier than ever engine starts even at -15°C (5°F).



C112F004

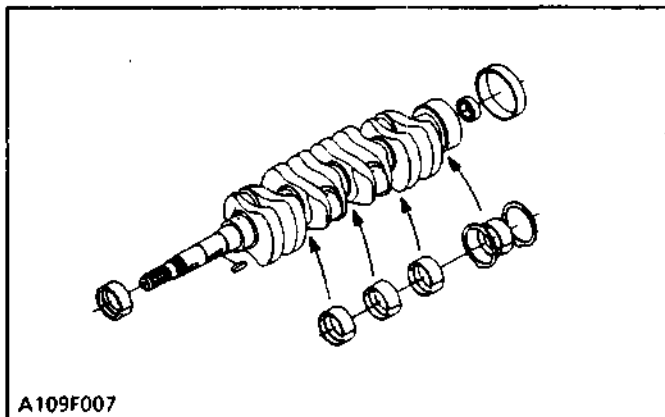
- (1) Combustion Chamber
- (2) Intake Port
- (3) Exhaust Port
- (4) Nozzle Assembly
- (5) Glow Plug
- (6) Cylinder Head
- (7) Depression
- (8) Compressed Air

[A] Connect to Combustion Chamber



0087F010

[3] CRANKSHAFT



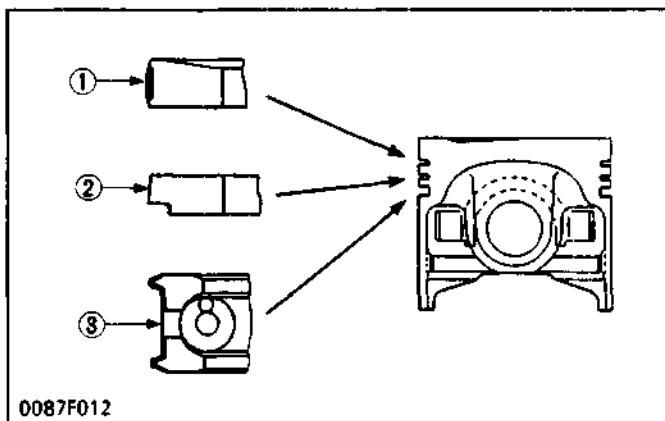
The crankshaft with the connecting rod converts the reciprocating motion of the piston into the rotating motion.

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



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

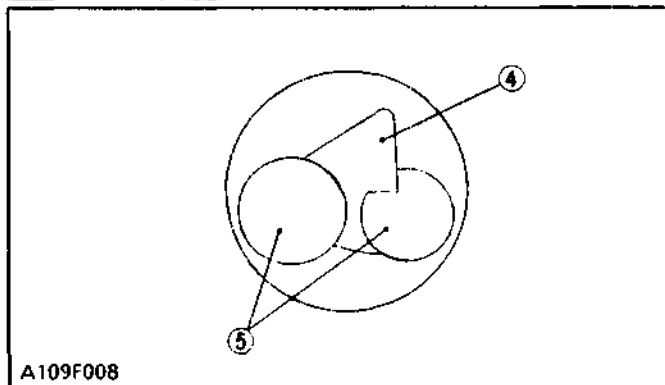
Three rings are installed in grooves in the piston.

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.

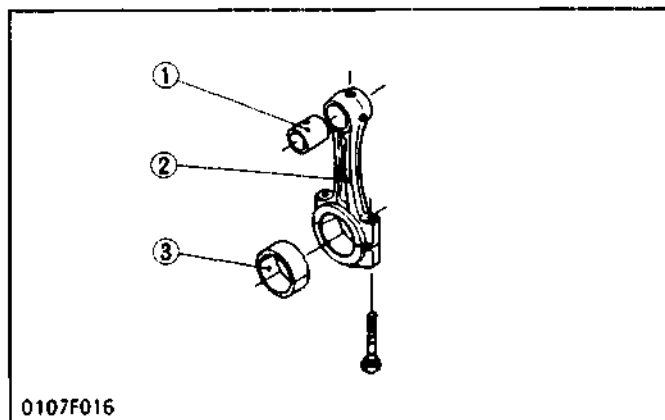
The oil ring (3) has chamfered contact faces and an expander ring, which increase the pressure of the oil ring against the cylinder wall.

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



- (1) Top Ring
- (2) Second Ring
- (3) Oil Ring
- (4) Depression
- (5) Valve Recess

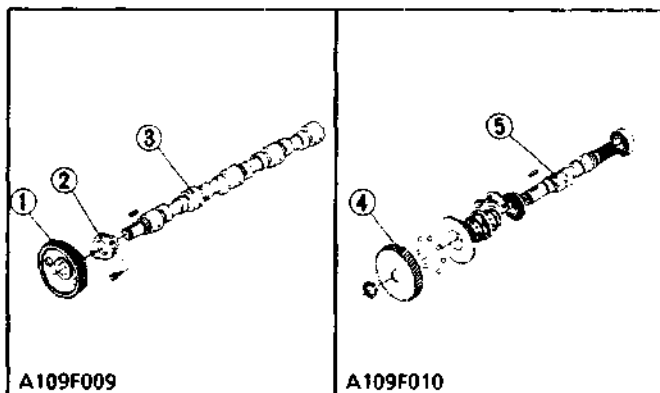
[5] CONNECTING ROD



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

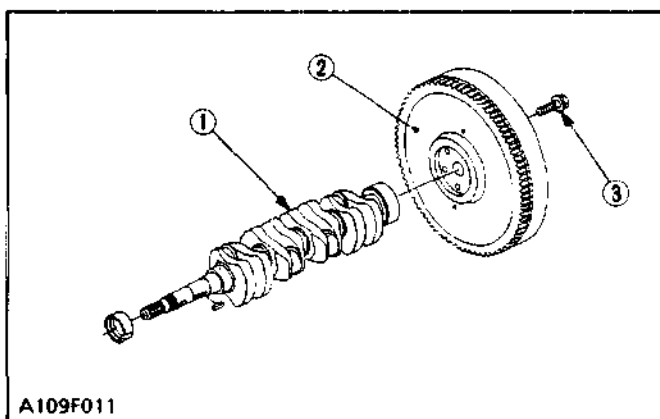
[6] CAMSHAFT



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



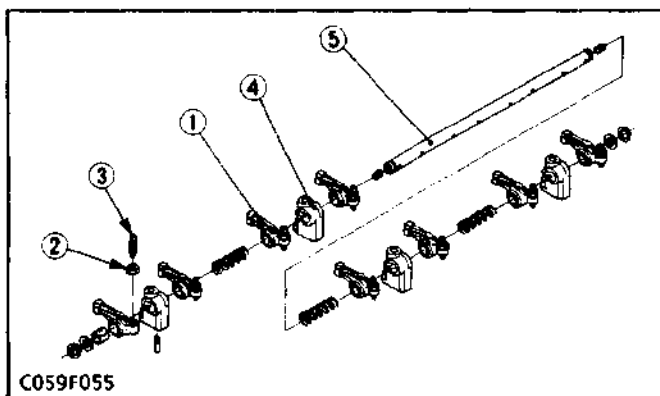
The flywheel stores the rotating force in the combustion stroke as inertial energy, reduces crankshaft rotating speed fluctuation and maintains the smooth rotating conditions.

The flywheel periphery is inscribed with the marks showing fuel injection timing angle lines and 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



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

Lubricating oil 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

2 LUBRICATING SYSTEM

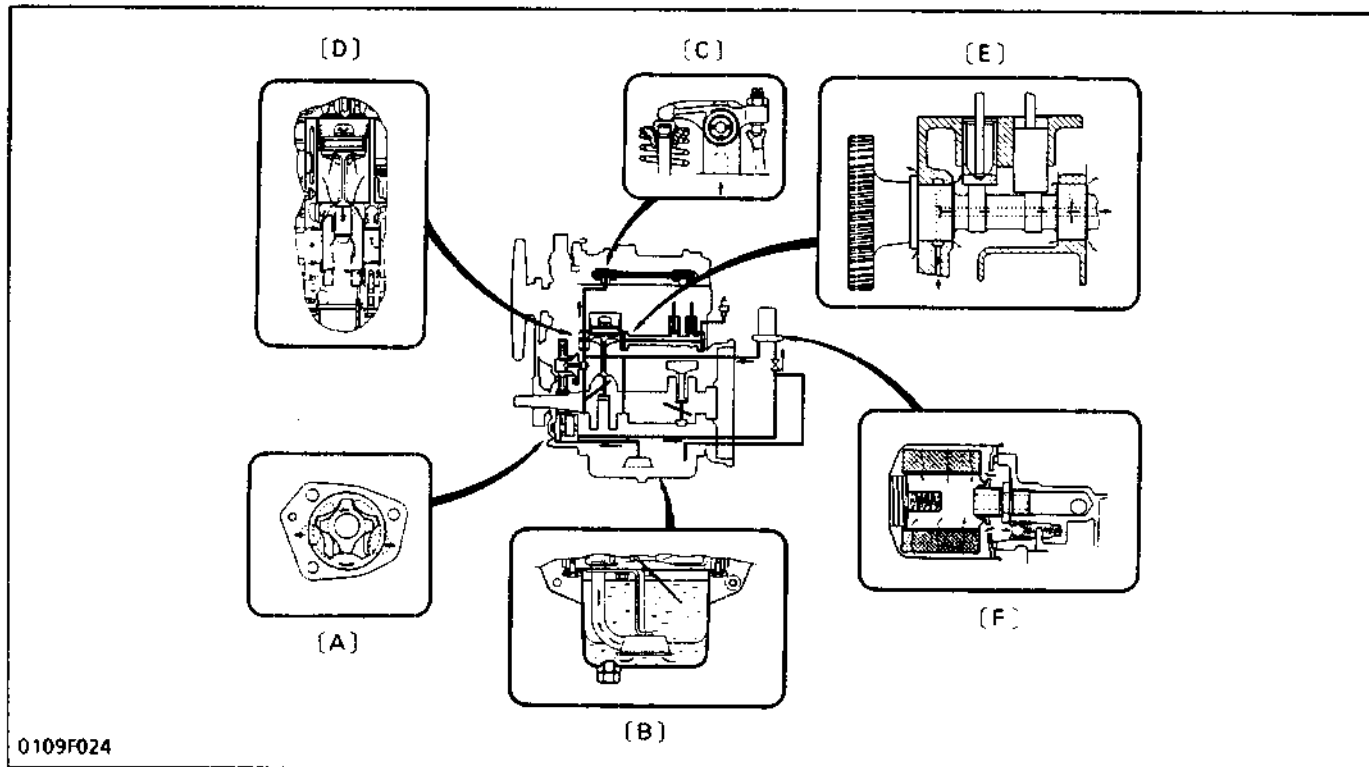
2 SYSTEME DE LUBRIFICATION

2 SCHMIERUNGS-SYSTEM

[1] GENERAL

[1] GENERALITES

[1] ALLGEMEINES



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.

Le système de lubrification du moteur se compose d'une crépine, d'une pompe à huile, d'une soupape de décharge, d'un filtre à huile à cartouche et d'un manoccontact de pression d'huile. La pompe à huile aspire l'huile du carter par l'intermédiaire de la crépine et la force au travers de la cartouche filtre, qui en assure une filtration plus parfaite. Ensuite, l'huile est forcée vers le vilebrequin, les bielles, le pignon de renvoi, l'arbre à cames et l'axe de culbuteurs, afin de lubrifier toutes ces pièces.

L'huile éclaboussée par le vilebrequin ou dégouttant des orifices des différentes pièces lubrifie les pièces suivantes: pistons, cylindres, pied de bielle et bielle, poussoirs, tiges de poussoirs, soupapes d'admission et d'échappement et pignons de distribution.

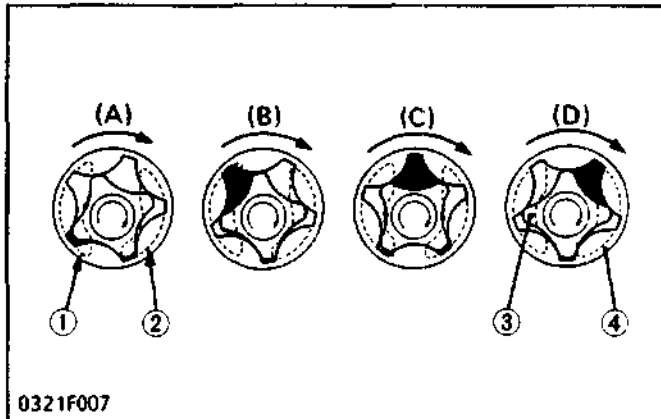
Dieses Motorschmierungs-system umfaßt den Ölfilter, die Ölpumpe, das Überdruckventil, die Ölfilterpatrone und den Ölschalter. Die Ölpumpe saugt das Schmieröls aus der Ölwanne durch den Ölfilter an. Das Öl fließt sodann in die Filterpatrone, wo es weiter gefiltert wird. Anschließend wird das Öl zur Kurbelwelle sowie zu den Pleuelstangen, dem Leerlaufgetriebe, der Nockenwelle und der Kipphebelachse gepreßt und sorgt für die Schmierung eines jeden dieser Teile. Ein Teil des Öls, der von der Kurbelwelle abgeschleudert wird oder an den Zwischenräumen der Teile austritt und heruntertropft, übernimmt die Schmierung dieser Teile: Kolben, Zylinder, Pleuelstangenkopf, Stößel, Stößelstangen, Ein- und Auslaßventile und Steuerungen.

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

- [A] Pompe à huile
- [B] Crépine
- [C] Culbuteur et axe de culbuteur
- [D] Piston
- [E] Arbre à cames
- [F] Cartouche de filtre à huile et soupape de décharge

- [A] Ölpumpe
- [B] Ölfilter
- [C] Kipphebel und Kipphebelachse
- [D] Kolben
- [E] Nockenwelle
- [F] Ölfilterpatrone und Überdruckventil

[2] OIL PUMP



The oil pump in this engine is a trochoid pump.

Inside the pump body, the 4 lobe inner rotor (3) is eccentrically engaged with the 5 lobe outer rotor (4). The inner rotor is driven by the crankshaft via gears, which in turn rotate the outer rotor.

When the inner rotor rotates, the outer rotor also rotates in the same direction.

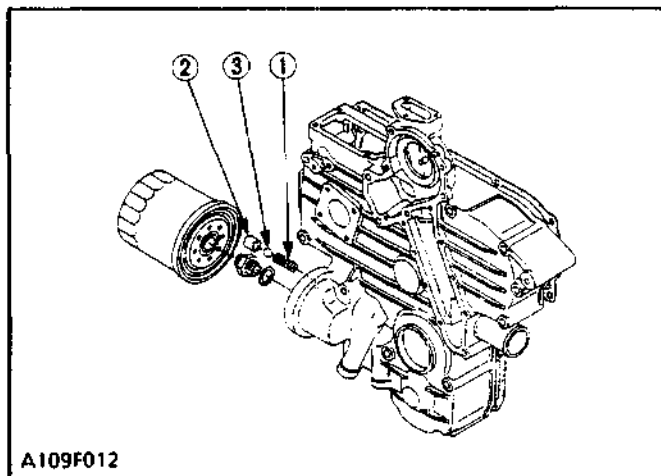
The two rotors have differences in lobe number and center, which generates space between lobes as shown in the figure.

At position (A), there is little space between lobes in the inlet port. As the rotor rotates towards position (B), the space between the lobes becomes larger, creating a negative pressure which sucks in oil.

Outside the inlet port, as shown in position (C), the space between the lobes becomes gradually smaller, and oil pressure increases. At position (D), oil is discharged from the outlet port.

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

[3] RELIEF VALVE

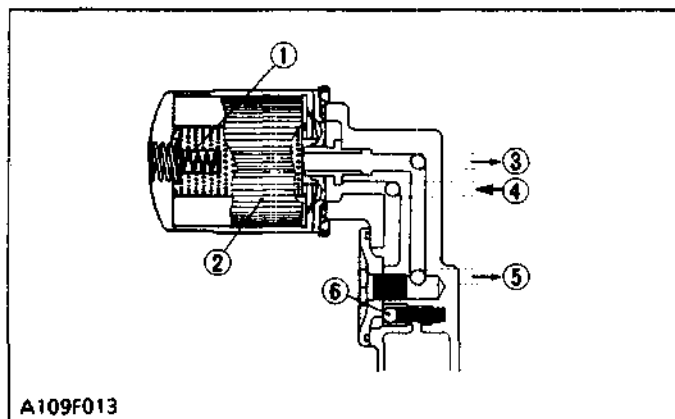


The relief valve prevents the damage of the lubricating system due to high oil pressure. This relief valve is a ball type direct acting relief valve, and is best suited for low pressures.

When oil pressure exceeds the upper limit, the ball (3) is pushed back by the pressure oil and the oil escapes.

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

[4] OIL FILTER CARTRIDGE



Oil filter, relief valve

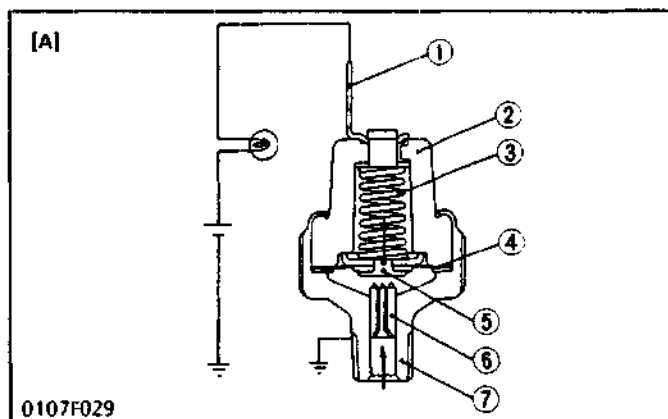
Engine oil being fed from the oil pump is filtered through the filter element and then supplied to the related parts. A relief valve is provided just before the oil filter in order to maintain the oil at a constant pressure and to let excessive oil flow into the oil pan.

The oil comes into the filter element through its outer surface and out of its inner surface.

A bypass valve is provided inside the filter. When the element gets dirty and the oil starts flowing against a resistance of 1 kgf / cm² or higher, the oil does not flow through the element, but through this bypass valve.

- | | |
|--|--|
| (1) Bypass Valve | (4) From oil pump |
| (2) Filter Element | (5) To crank shaft journal and crank pin |
| (3) To idle gear, cam shaft and rocker arm shaft | (6) Relief valve |

[5] OIL PRESSURE SWITCH



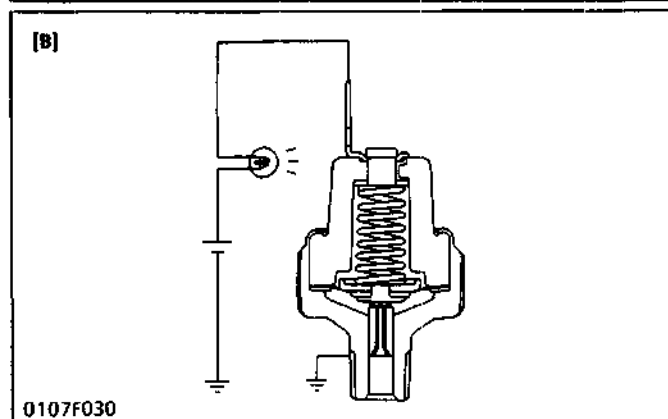
The oil pressure switch is mounted on the cylinder-block, to warn the operator that the lubricating oil pressure is poor.

If the oil pressure falls below 49 kPa (0.5 kgf/cm², 7 psi), the oil warning lamp will light up, warning the operator. In this case, stop the engine immediately and check the cause of pressure drop.

[A] At Proper Oil Pressure

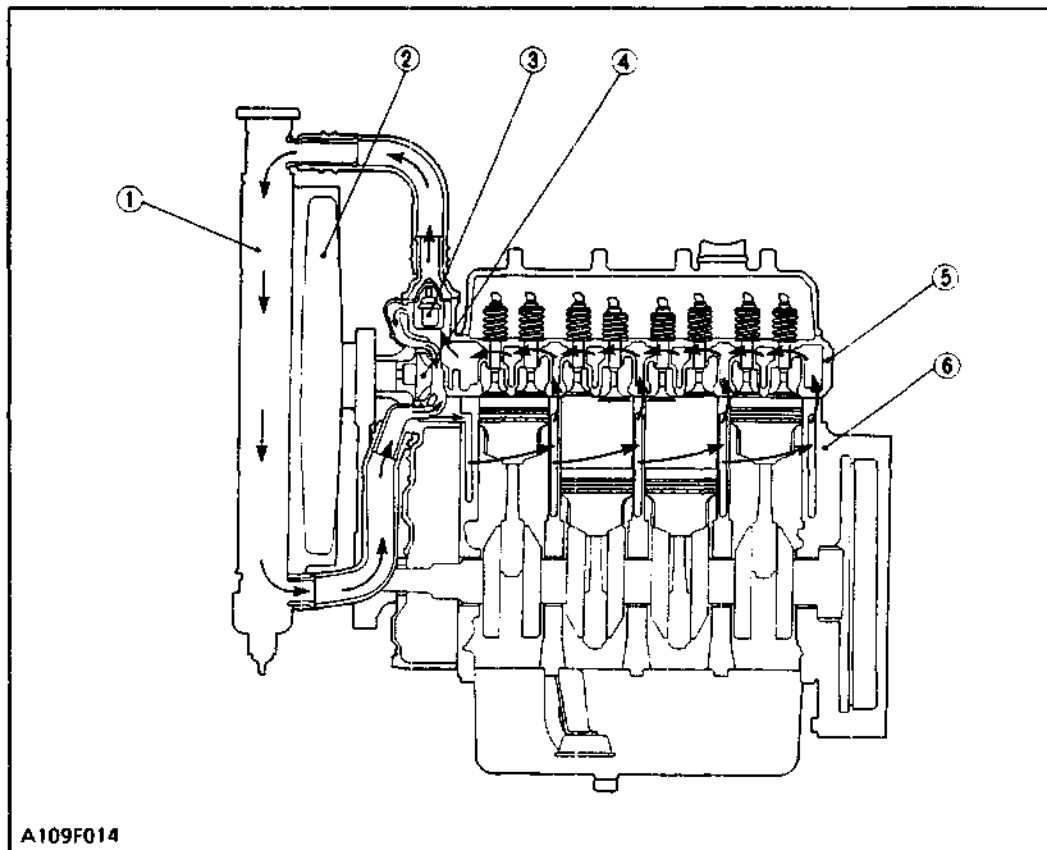
[B] At Oil Pressures of 49 kPa (0.5 kgf/cm², 7 psi) or Less

- | |
|---------------------|
| (1) Terminal |
| (2) Insulator |
| (3) Spring |
| (4) Diaphragm |
| (5) Contact Rivet |
| (6) Contact |
| (7) Oil Switch Body |



3 COOLING SYSTEM

[1] GENERAL



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

A109F014

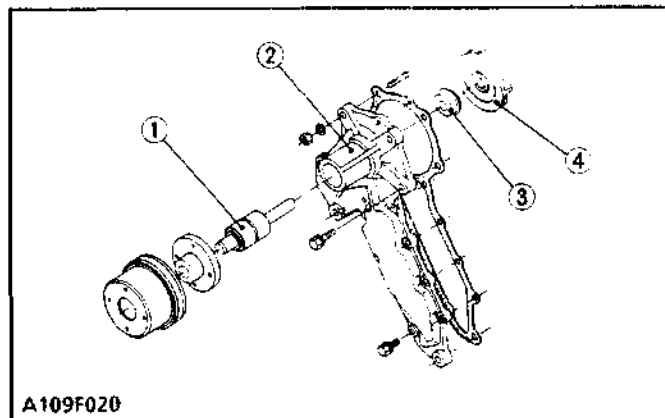
The cooling system consists of a radiator (1) (not included in the basic engine), centrifugal water pump (4), suction fan (2) and thermostat (3).

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 (159.8°F).

[2] WATER PUMP

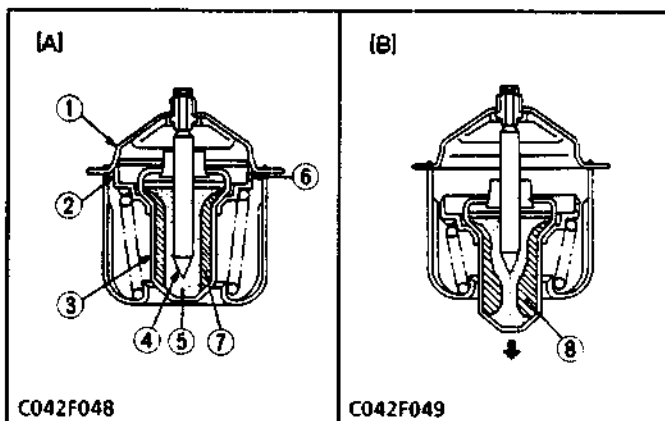


A109F020

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.

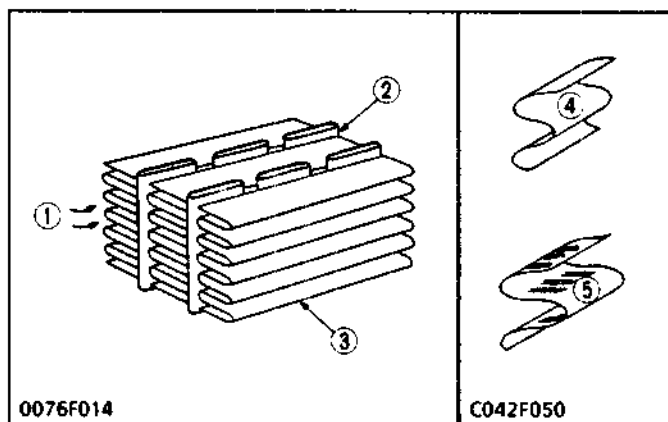
(A) At low temperatures (lower than 71°C (159.8°F)).

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 (159.8°F)).

When the temperature of cooling water exceeds 71°C (159.8°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.

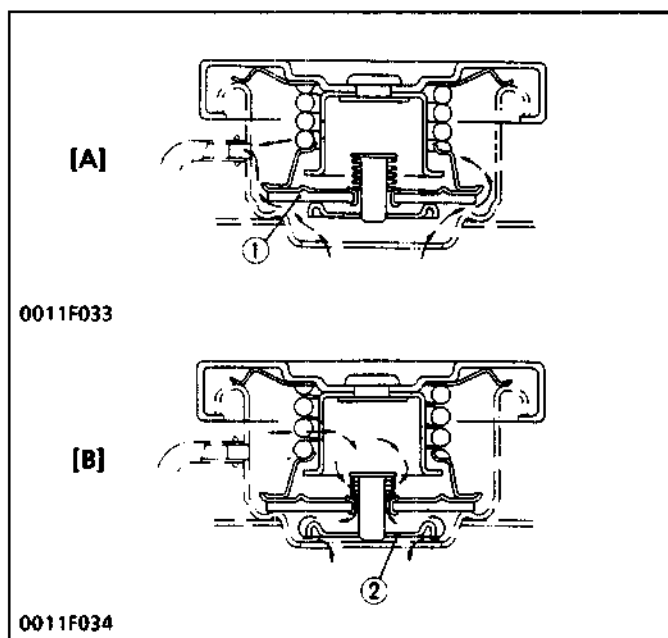
[4] RADIATOR (not included in the basic engine)



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/cm², 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.)

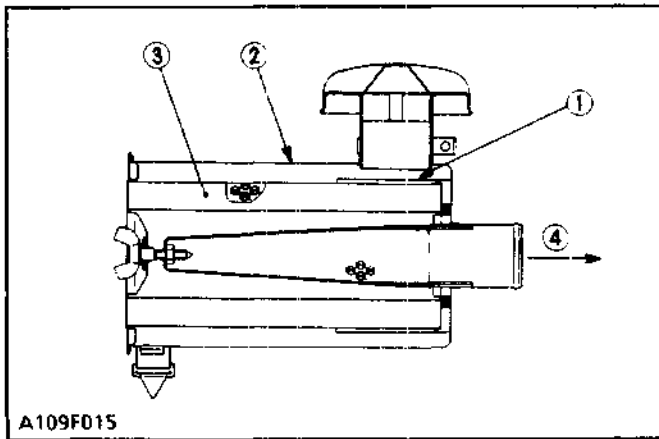
(A) When radiator internal pressure is high

(B) When radiator internal pressure is negative

- (1) Pressure Valve
- (2) Vacuum Valve

4 INTAKE AND EXHAUST SYSTEM

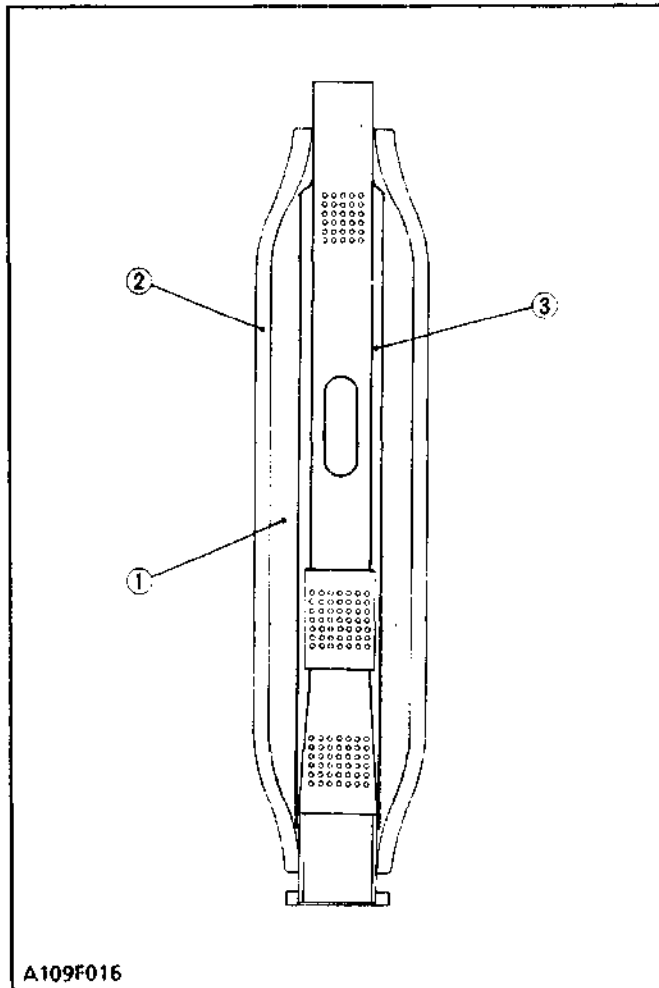
[1] AIR CLEANER (not included in the basic engine)



The air cleaner is a dry-cyclone type for easy maintenance. Sucked air is caused to flow in a whirling way with air guide (1). The dust, while circulating in the air flow, is absorbed by the element (3) and thus prevented from entering the engine.

- (1) Air Guide
- (2) Air Cleaner Body
- (3) Air Filter Element
- (4) To Cylinder

[2] MUFFLER (not included in the basic engine)



High temperature and high pressure exhaust gas is intermittently discharged by fuel combustion generating pressure waves inside the exhaust pipe which will result in noise.

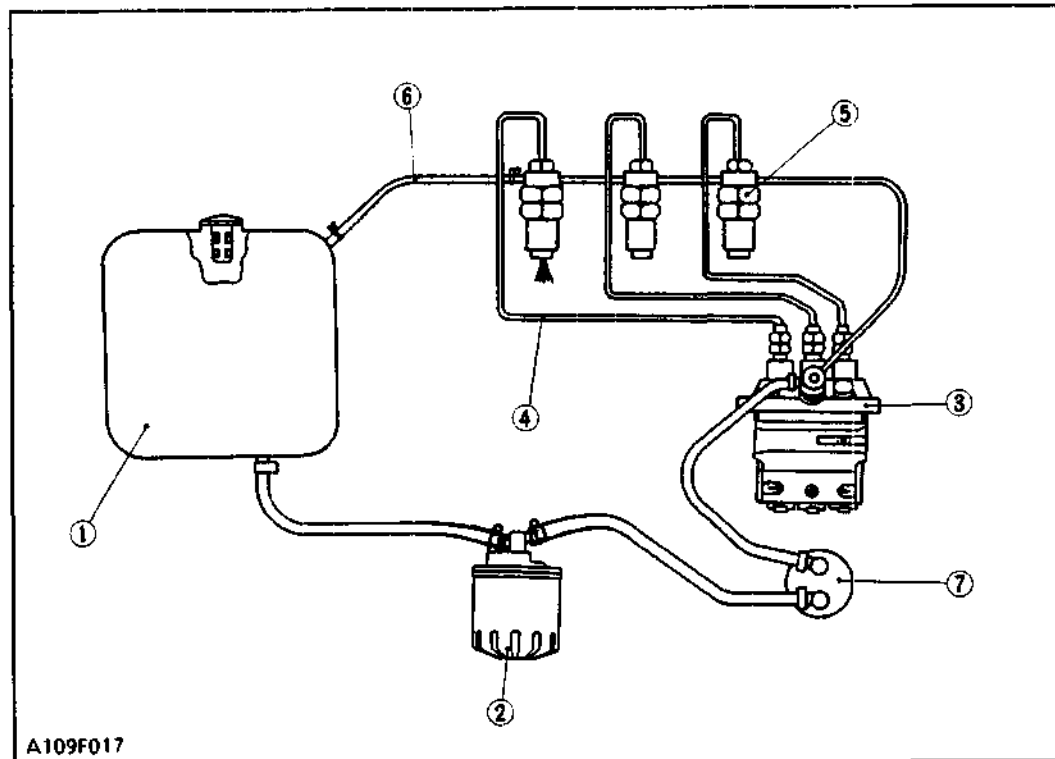
The muffler is used to reduce this noise.

This muffler consists of a perforated inner tube (3) and outer tube (2), glass wool (1), etc. The glass wool placed between the outer tube and main body, absorbs the exhaust noise of higher frequency.

- (1) Glass Wool
- (2) Outer Tube
- (3) Inner Tube

5 FUEL SYSTEM

[1] GENERAL



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

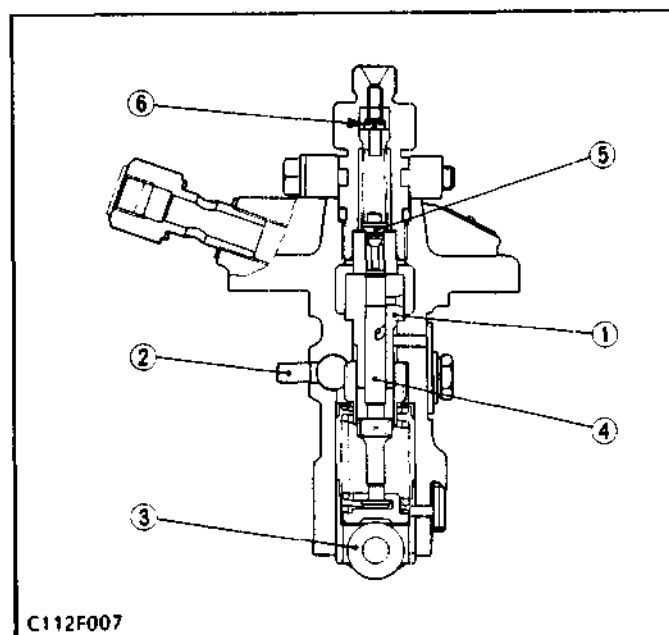
A109F017

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/cm², 1991 to 2062 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.

[2] INJECTION PUMP

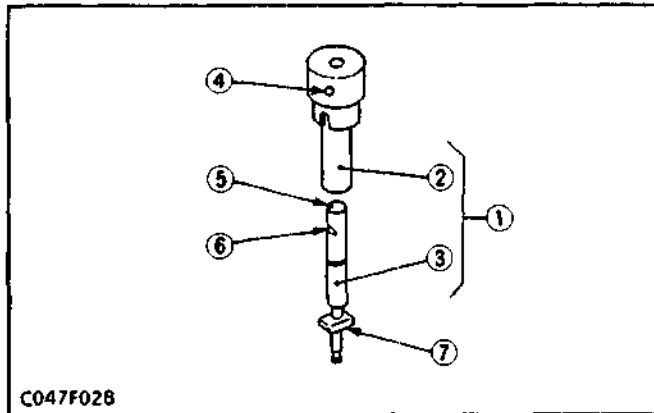


C112F007

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

The plunger (4) with a right-hand lead reciprocates via the tappet roller (3) by means of the camshaft fuel cam, causing the fuel to be delivered into the injection nozzle.

- (1) Cylinder
- (2) Control Rack
- (3) Tappet Roller
- (4) Plunger
- (5) Delivery Valve
- (6) Dumping Valve

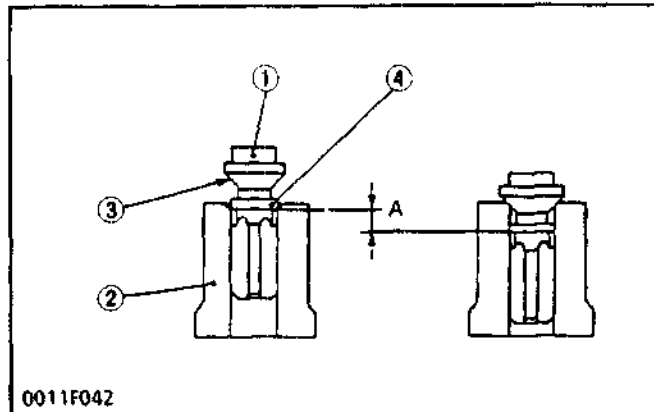
(1) Pump Element

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

(2) Delivery Valve

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

The delivery valve performs the following functions.

1. Reverse flow preventing function

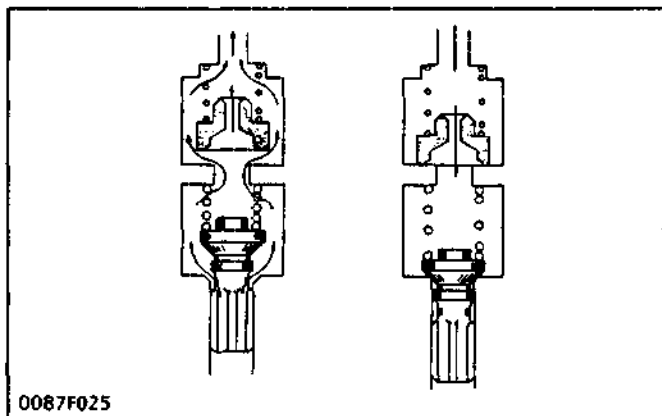
If the fuel flow reverse from the injection nozzle side when the plunger lowers, the time lag between the next delivery start and the nozzle injection start increases. To avoid this, the delivery chamber to injection pipe interruption by delivery valve (1) prevents this reverse flow, thus keeping fuel always filled in the nozzle and pipe.

2. Suck-back function

After completing the fuel delivery, the delivery valve lowers, and the relief plunger (4) end contacts the delivery valve seat (2). The valve further lowers until its seat surface (3) seats firmly the delivery valve seat. During this time, the amount of fuel corresponding to (A) is sucked back from inside the injection pipe, the pressure inside the pipe is reduced, thus leading to an improved injection shut off and preventing after leakage dribbling.

- | | |
|-------------------------|--------------------|
| (1) Delivery Valve | (3) Seat Surface |
| (2) Delivery Valve Seat | (4) Relief Plunger |

(3) Dumping Valve



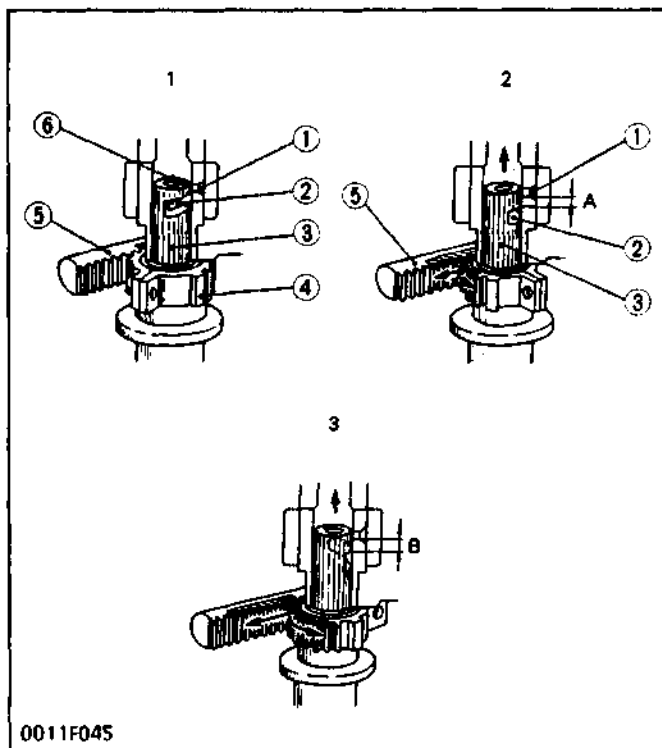
1. At fuel injection

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) Injection Control



1. No fuel delivery Engine stop

When the control rack (5) is set at the engine stop position, the plunger does not force fuel and no fuel is delivered since the feed hole (1) aligns with the slot (6) in the plunger (3).

2. Partial fuel delivery

When the plunger (3) is rotated by the control rack (5) in the direction of arrow, the fuel is delivered to the injection nozzle.

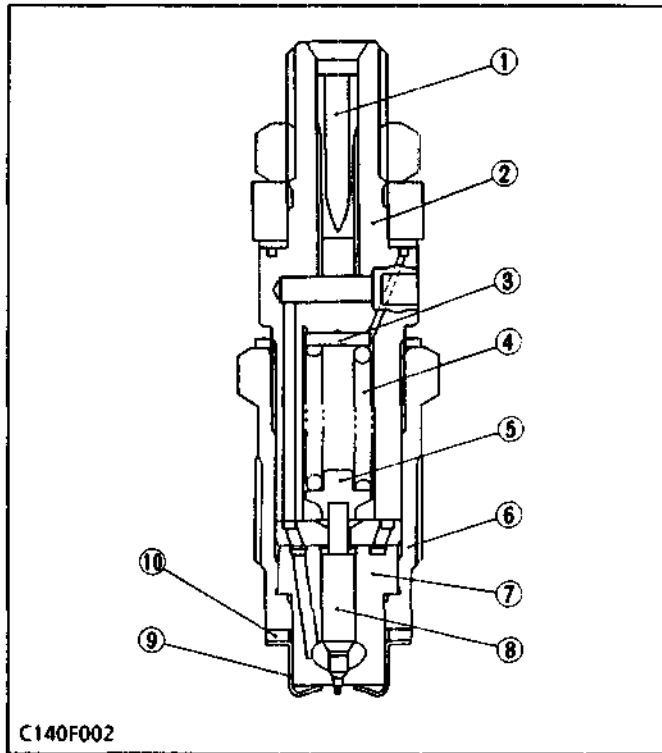
The amount of fuel corresponds to the effective stroke (A) from closing the feed hole (1) by the plunger head to contact of the control groove (2) with the feed hole.

3. Maximum fuel delivery

When the control rack is moved to the extreme end in the direction of the arrow, the effective stroke (B) of the plunger is at its maximum, thus the maximum fuel delivery occurs.

- (1) Feed Hole
- (2) Control Groove
- (3) Plunger
- (4) Control Sleeve
- (5) Control Rack
- (6) Slot

[3] INJECTION NOZZLE



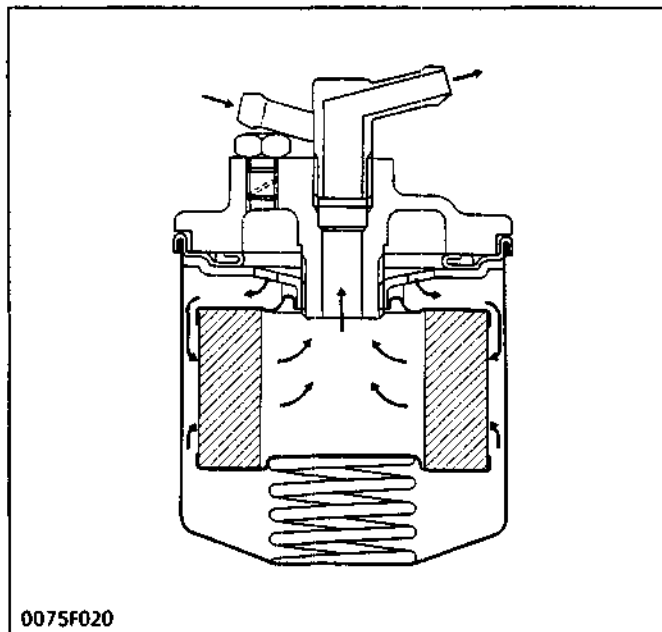
Used as the injection nozzle, the small-sized NIPPONDENSO-made OPD mini nozzle is of a flat-cut-provided double throttle type. This type of nozzle is designed to control the injection quantity when the lift rate is low at start of the injection, and to cut down on the knocking sound caused by excessive fuel injection by giving the needle valve section more taper than before to prevent the rapid increase in the injection quantity when the initial injection turns into the full-force injection.

Also, employed to prevent the injection quantity loss in the throttle section caused by carbon, the flat cut provided at the needle valve section helps the throttle withstand long use and reduce as much knocking sound as when it was new.

The heat seal is employed to improve the durability and reliability of the nozzle.

- | | |
|------------------------|-------------------|
| (1) Bar Filter | (6) Retaining Nut |
| (2) Nozzle Holder Body | (7) Nozzle Body |
| (3) Adjusting Washer | (8) Needle Valve |
| (4) Nozzle Spring | (9) Heat Seal |
| (5) Push Rod | (10) Packing |

[4] FUEL FILTER

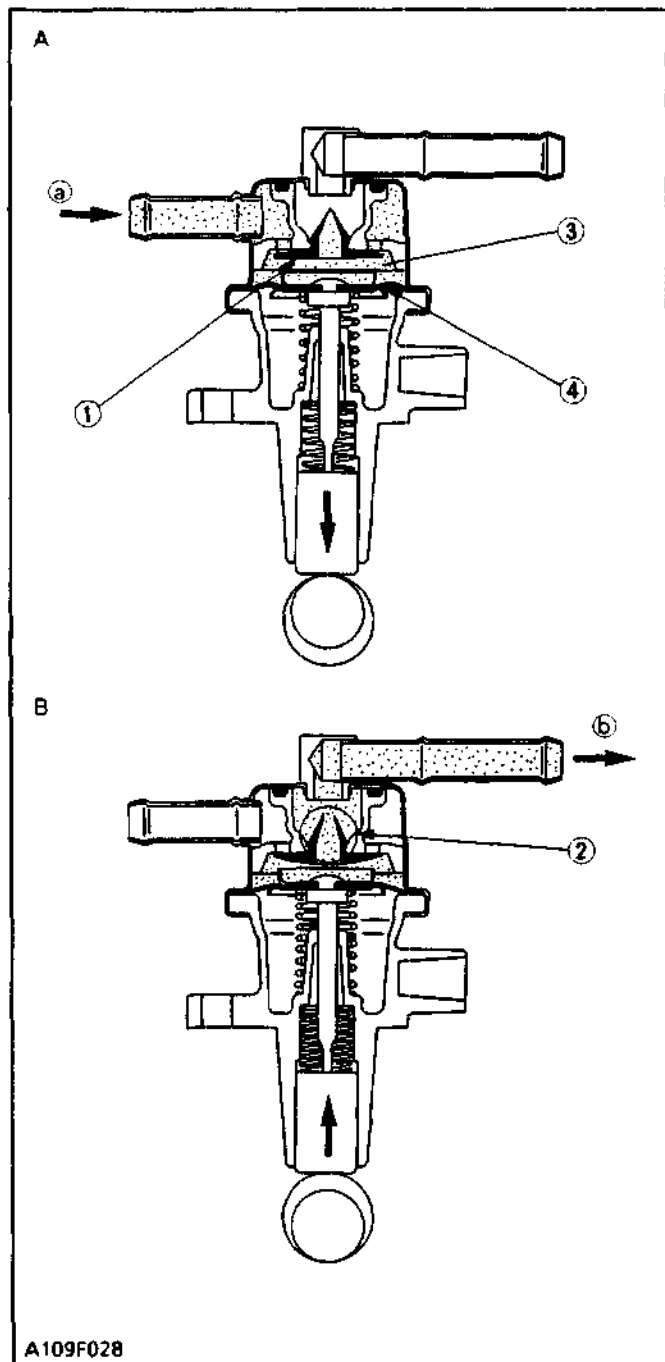


A fuel filter is used to prevent dirty fuel from reaching the injection pump and injection nozzles.

The filter cartridge will require occasional replacement to maintain an adequate flow of fuel to the injection pump. The frequency of this service will vary according to the cleanliness of available fuel and the care used in storage.

The fuel filter eliminates the foreign matter which is fed from the fuel tank and protects injection pump and injection nozzles. When fuel enters the filter, it passes from the filter element's circumference forward the center for filtering.

- | |
|---------------------------|
| (1) Cover |
| (2) Fuel filter cartridge |
| (3) Air vent plug |

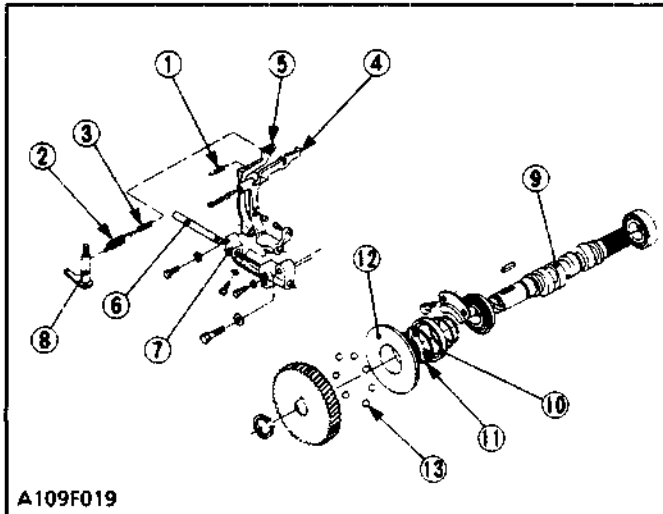
[5] FUEL LIFT PUMP

Filtered fuel is fed to the injection pump by the fuel lift pump. The fuel lift pump operates as shown in the figure. Power is applied to the tappet by an eccentric movement on the fuel camshaft. As the fuel camshaft rotates, the eccentric movement causes the tappet to move up and down. The tappet is linked to a flexible diaphragm (4) via the pull rod.

When the diaphragm is pulled down, a low vacuum or low pressure area is created above the diaphragm. This causes atmospheric pressure in the fuel tank to force fuel into the fuel lift pump. The inlet valve (1) opens to admit fuel into the chamber (3).

When the diaphragm is pushed up, pressure is created in the area above the diaphragm. This pressure closes the inlet valve and opens the outlet valve (2), forcing fuel from the pump through the fuel pipe to the injection pump.

[6] GOVERNOR

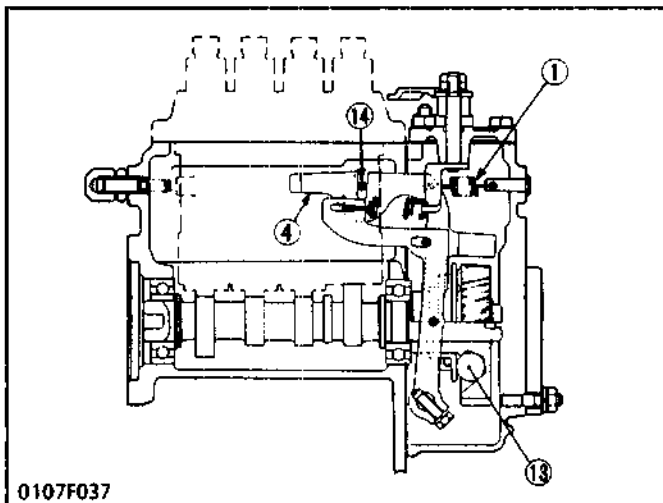


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The governor serves to keep engine speed constant by automatically adjusting the amount of fuel supplied to the engine according to changes in the load. This engine employs an all-speed governor which controls the centrifugal force of the steel ball (13) weight, produced by rotation of the fuel camshaft (9), and the tension of the governor spring 1 (2) and 2 (3) are balanced.

- | | |
|-----------------------|-------------------------|
| (1) Start Spring | (8) Governor Lever |
| (2) Governor Spring 1 | (9) Fuel Camshaft |
| (3) Governor Spring 2 | (10) Governor Ball Case |
| (4) Fork Lever 1 | (11) Steel Ball |
| (5) Fork Lever 2 | (12) Governor Sleeve |
| (6) Fork Lever Shaft | (13) Steel Ball |
| (7) Fork Lever Holder | |

■ At start

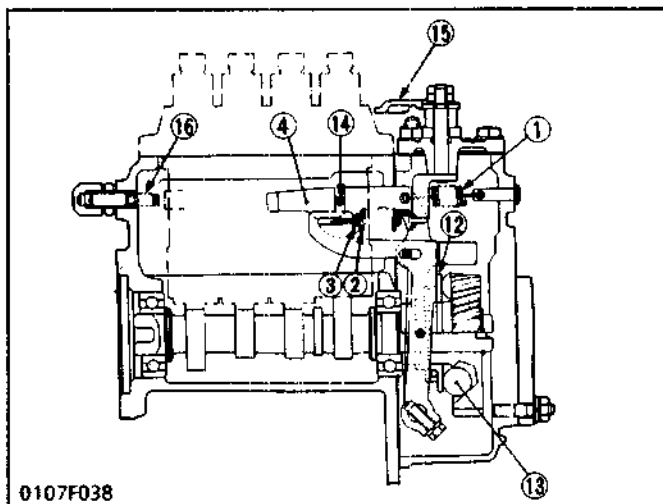


0107F037

Since the steel ball (13) have no centrifugal force, a fork lever 1 (4) is pulled to the right by the starter spring (1). Accordingly, the control rack (14) moves to the maximum injection position to assure easy starting.

- (14) Control Rack

■ At idling



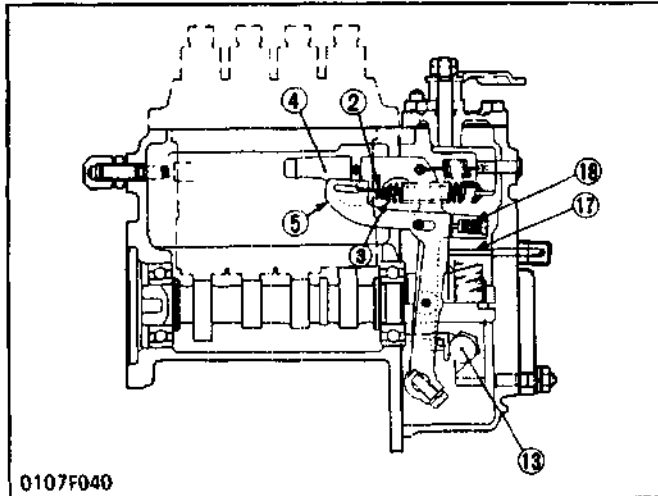
0107F038

When the speed control lever (15) is set at the idling position after the engine starts, the governor spring 1 (2) does not work at all and the governor spring 2 (3) does only act slightly. The governor sleeve (12) is pushed leftward by a centrifugal force of steel ball (13).

Therefore, the fork lever 1 (4) and control rack (14) are moved to the left by the governor sleeve and then the idling limit spring (16) is compressed by the control rack. As a result, the control rack is kept at a position where a centrifugal force of steel ball and forces start spring (1), governor spring 2 and idling limit spring are balanced, providing stable idling.

- (15) Speed Control Lever
(16) Idling Limit Spring

■ At high speed running with overload

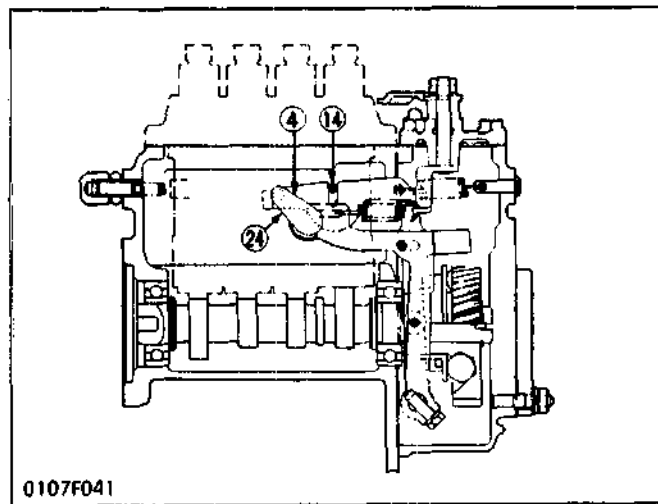


When an overload is applied to the engine running at a high speed, the centrifugal force of steel ball (13) becomes small as the engine speed is dropped, and fork lever 2 (5) is pulled to the right by the governor springs 1 (2) and 2 (3), increasing fuel injection. Though, fork lever 2 becomes ineffective in increasing fuel injection when it is stopped by the adjusting bolt (17).

After that, when the force of torque spring (18) becomes greater than the centrifugal force of the steel ball, fork lever 1 (4) moves rightward to increase fuel injection, causing the engine to run continuously at a high torque.

- (17) Adjusting Bolt
- (18) Torque Spring

■ To stop engine



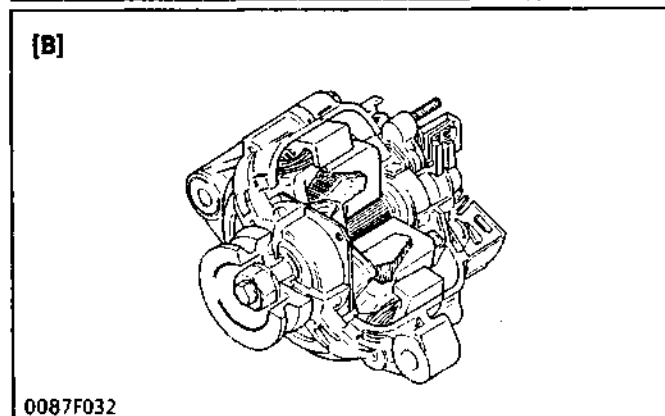
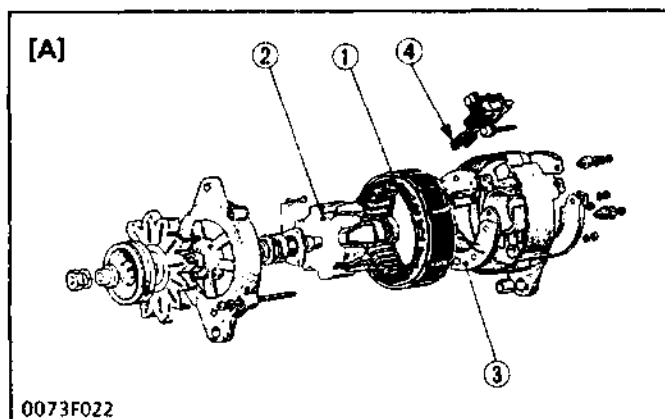
When the stop lever (19) is moved to STOP position, fork lever 1 (4) is moved leftward and the control rack (14) is moved to the non-injection position, stopping the engine.

- (19) Stop Lever

6 ELECTRICAL SYSTEM

[1] CHARGING SYSTEM

(1) Alternator



The alternator generates 3-phase current at a fixed coil by the rotation of a rotor which is then emitted as full-wave rectified current by a diode. The alternator can generate power at all speeds from low to high.

(D1403-B, D1703-B, V1903-B, F2803-B)

A compact alternator with an IC regulator is used, having the following characteristics:

- Approximately 26% lighter and 17% smaller than a standard alternator.
- Cooling performance and safety have been improved by combining the cooling fan with the rotor and incorporating the fan / rotor unit inside the alternator.
- IC regulator is fitted inside the alternator.
- The rectifier, IC regulator and similar components are easy to remove, making it easier to service the alternator.

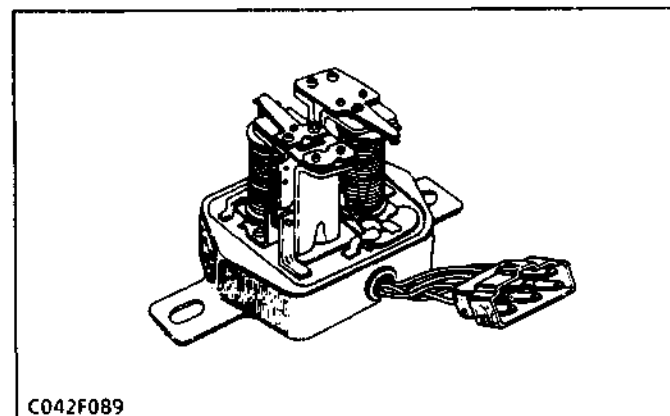
(1) Armature
(2) York

(3) Rectifier
(4) Brush

[A] Standard

[B] Compact type (equipped with IC regulator)

(2) Regulator (Contact type)



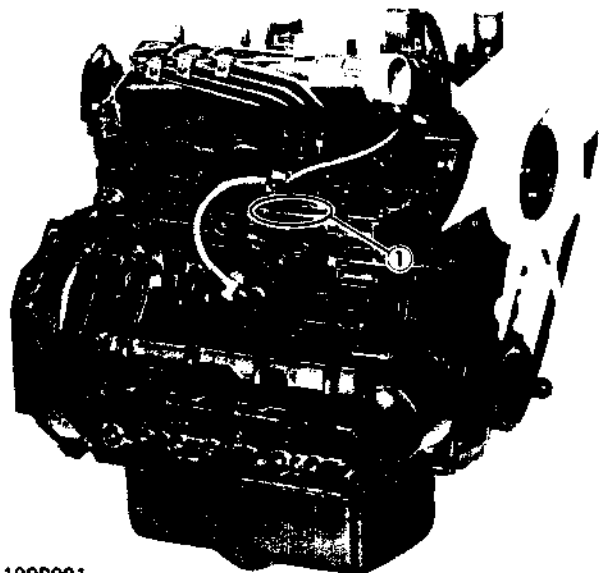
The regulator regulates the charging voltage. Since the alternator speed is varied by engine speed variation, the output voltage from alternator varies. However, constant voltage (12 V) must be supplied to the battery. That is the regulator which works to keep the charging voltage at 12 V.

S. **DISASSEMBLING AND SERVICING**
DEMONTAGE ET ENTRETIEN
AUSBAU UND WARTUNG



[1] ENGINE IDENTIFICATION

Model Name and Engine Serial Number

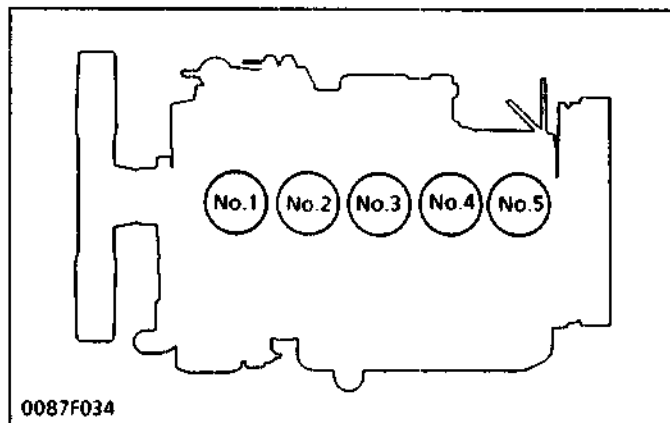


A109P001

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

(1) Engine Model and Serial Number

Cylinder Number

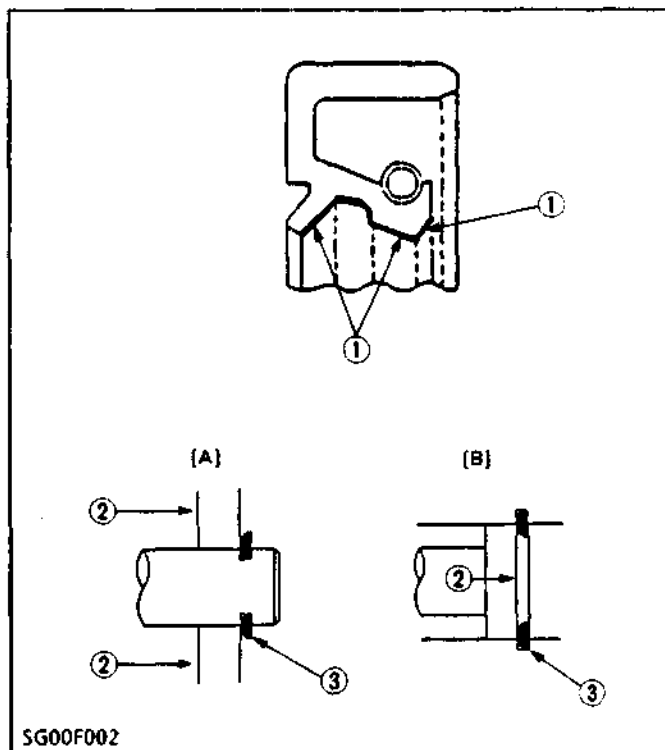


0087F034

The cylinder numbers of 92.4 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, No.4 and No.5 starting from the gear case side.

[2] GENERAL PRECAUTION



- During disassembly, carefully arrange removed parts in a clean area to prevent confusion later. Screws, bolts and nuts should be replaced in their original position to prevent reassembly errors.
- When special tools are required, use 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

- Certain components used in this engine (cylinder head-gasket, exhaust gasket, etc.) contain asbestos. Handle with care according to safety regulation.

- (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

- For "*" marked screws, bolts and nuts on the table, apply engine oil to their threads and seats before tightening.
- After well cleaning its thread and bearing surface, fit a new head bolt (rust-preventive oil applied) without applying engine oil to it.
- When reusing the head bolt, apply engine oil to its thread and bearing surface before fitting it. After installing the engine, let it run for 30 minutes, and retighten the head bolt. (Before retightening it, loosen it by 30 to 90°.)

Item	Size x Pitch	N·m	kgf·m	ft-lbs
Head cover cap nut	M8 x 1.25	6.9 to 8.8	0.7 to 0.9	5.1 to 6.5
* Head bolt	M11 x 1.25	93.1 to 98.0	9.5 to 10.0	68.7 to 72.3
* Bearing case bolt 1	M9 x 1.25	46.1 to 50.9	4.7 to 5.2	34.0 to 37.6
* Bearing case bolt 2	M10 x 1.25	68.6 to 73.5	7.0 to 7.5	50.6 to 54.2
* Flywheel bolt	M12 x 1.25	98.0 to 107.8	10.0 to 11.0	72.3 to 79.5
* Connecting rod bolt (Non-flange bolt)	M8 x 1.0	36.3 to 41.2	3.7 to 4.2	26.6 to 30.4
(flange bolt)	M8 x 1.0	44.1 to 49.0	4.5 to 5.0	32.5 to 36.2
* Rocker arm bracket nut	M8 x 1.25	22.5 to 27.5	2.4 to 2.8	17.4 to 20.3
* Idle gear shaft bolt	M8 x 1.25	22.5 to 27.5	2.4 to 2.8	17.4 to 20.3
* Crankshaft end nut	M30 x 1.5	137.3 to 156.9	14.0 to 16.0	101.2 to 115.7
Crankshaft end bolt (F2803-B(E))	M16 x 1.5	313.8 to 333.4	32.0 to 34.0	231.4 to 245.9
Glow plug	M10 x 1.25	19.6 to 24.5	2.0 to 2.5	14.5 to 18.1
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

(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 S431, S20C
7	Special Screw and Bolt S43C, S48C (Refined)

[4] TROUBLESHOOTING

Symptom	Probable Cause	Solution	Reference Page
Engine does not start	<ul style="list-style-type: none"> No fuel Air in the fuel system Water in the fuel system Fuel pipe clogged Fuel filter clogged Excessively high viscosity of fuel or engine oil at low temperature Fuel with low cetane number Fuel leak due to loose injection pipe retaining nut Incorrect injection timing Fuel cam shaft worn Injection nozzle clogged Injection pump malfunctioning Seizure of crankshaft, camshaft, piston, cylinder liner or bearing Compression leak from cylinder Improper valve timing Piston ring and liner worn Excessive valve clearance 	Replenish fuel Vent air Change fuel and repair or replace fuel system Clean Clean or change Use the specified fuel or engine oil Use the specified fuel Tighten nut Adjust Replace Clean Repair or replace Repair or replace Replace head gasket, tighten cylinder head bolt, glow plug and nozzle holder Correct or replace timing gear Replace Adjust	S-41 S-39 S-105 S-53 S-87, 19 S-43
Starter does not run	<ul style="list-style-type: none"> Battery discharged Starter malfunctioning Key switch malfunctioning Wiring disconnected 	Charge Repair or replace Repair or replace Connect	
Engine revolution is not smooth	<ul style="list-style-type: none"> Fuel filter clogged or dirty Air cleaner clogged Fuel leak due to loose injection pipe retaining nut Injection pump malfunctioning Incorrect nozzle opening pressure Injection nozzle stuck or clogged Fuel over flow pipe clogged Governor malfunctioning 	Clean or change Clean or change Tighten nut Repair or replace Adjust Repair or replace Clean Repair	S-41 S-41 S-107
Either white or blue exhaust gas is observed	<ul style="list-style-type: none"> Excessive engine oil Piston ring and liner worn or stuck Incorrect injection timing Deficient compression 	Reduce to the specified level Repair or replace Adjust Adjust top clearance	S-87, 19 S-105 S-53
Either black or dark gray exhaust gas is observed	<ul style="list-style-type: none"> Overload Low grade fuel used Fuel filter clogged Air cleaner clogged Deficient nozzle injection 	Lessen the load Use the specified fuel Clean or change Clean or change Repair or replace the nozzle	
Deficient output	<ul style="list-style-type: none"> Incorrect injection timing Engine's moving parts seem to be seizing Uneven fuel injection Deficient nozzle injection Compression leak 	Adjust Repair or replace Repair or replace the injection pump Repair or replace the nozzle Replace head gasket, tighten cylinder head bolt, glow plug and nozzle holder	S-105 S-107

Symptom	Probable Cause	Solution	Reference Page
Excessive lubricant oil consumption	<ul style="list-style-type: none"> Piston ring's gap facing the same direction Oil ring worn or stuck Piston ring groove worn Valve stem and guide worn Oil leaking due to defective seals or packing 	Shift ring gap direction	S-67
		Replace Replace the piston Replace Replace	S-87
Fuel mixed into lubricant oil	<ul style="list-style-type: none"> Injection pump's plunger worn Deficient nozzle injection Injection pump broken 	Replace pump element or pump Repair or replace the nozzle Replace	S-107
Water mixed into lubricant oil	<ul style="list-style-type: none"> Head gasket defective Cylinder block or cylinder head flawed 	Replace Replace	
Low oil pressure	<ul style="list-style-type: none"> Engine oil insufficient Oil strainer clogged Relief valve stuck with dirt Relief valve spring weaken or broken Excessive oil clearance of crankshaft bearing Excessive oil clearance of crank pin bearing Excessive oil clearance of rocker arm bearing Oil passage clogged Different type of oil Oil pump defective 	Replenish Clean Clean Replace Replace Replace Replace Clean Use the specified type of oil Repair or replace	S-67
			S-39
High oil pressure	<ul style="list-style-type: none"> Different type of oil 	Use the specified type of oil	S-39
	<ul style="list-style-type: none"> Relief valve defective 	Replace	
Engine overheated	<ul style="list-style-type: none"> Engine oil insufficient Fan belt broken or elongated Cooling water insufficient Radiator net and radiator fin clogged with dust Inside of radiator corroded Cooling water flow route corroded Radiator cap defective Overload running Head gasket defective Incorrect injection timing Unsuitable fuel used 	Replenish Change or adjust Replenish Clean Clean or replace Clean or replace Replace Loosen the load Replace Adjust Use the specified fuel	S-39
Battery quickly discharge	<ul style="list-style-type: none"> Battery electrolyte insufficient Fan belt slips Wiring disconnected Rectifier defective Alternator defective Battery defective 	Replenish distilled water and charge Adjust belt tension or change Connect Replace Replace Change	

[5] SERVICING SPECIFICATIONS

(1) ENGINE BODY

Cylinder Head

Item	Factory Specification	Allowable Limit
Cylinder head surface flatness	—	0.05 mm/500 mm 0.0019 in./19.69 in.
Top clearance	0.55 to 0.70 mm 0.0217 to 0.0276 in.	—
Thickness of gasket	Free	—
	Tightened	—
Compression pressure	36 to 38 kgf/cm ² /250 rpm 35.3 to 37.2 MPa/250 rpm 512 to 540 psi/250 rpm	26 kgf/cm ² /250 rpm 25.5 MPa/250 rpm 370 psi/250 rpm
Variance among cylinders		10% or less

Valve

Valve clearance (Cold)		0.18 to 0.22 mm 0.0071 to 0.0087 in.	—
Valve seat width	IN.	2.12 mm 0.0835 in.	—
	EX.	2.12 mm 0.0835 in.	—
Valve seat angle	IN.	60° 1.047 rad.	—
	EX.	45° 0.785 rad.	—
Valve face angle	IN.	60° 1.047 rad.	—
	EX.	45° 0.785 rad.	—
Valve recessing	Protrusion	0.05 mm (0.0020 in.) to	0.4 mm (0.0157 in.)
	Recess	0.15 mm (0.0059 in.)	
Clearance between valve stem and valve guide		0.040 to 0.070 mm 0.0016 to 0.0028 in.	0.1 mm 0.0039 in.
Valve stem O.D.		7.960 to 7.975 mm 0.3134 to 0.3140 in.	—
Valve guide I.D.		8.015 to 8.030 mm 0.3156 to 0.3161 in.	—

Valve Timing

Item			Factory Specification	Allowable Limit			
Intake valve	D1403-B(E)	Open	0.14 rad. (8°) before T.D.C.	-			
		Close	0.35 rad. (20°) after B.D.C.	-			
	D1703-B(E) V1903-B(E) V2203-B(E) F2803-B(E)	Open	0.21 rad. (12°) before T.D.C.	-			
		Close	0.63 rad. (36°) after B.D.C.	-			
			Exhaust valve		Open	1.05 rad. (60°) before B.D.C.	-
					Close	0.21 rad. (12°) after T.D.C.	-

Valve Spring

Free length	41.7 to 42.2 mm 1.6417 to 1.6614 in.	41.2 mm 1.6220 in.
Setting load / setting length	117.6 N/35.0 mm 12.0 kgf/35.0 mm 26.4 lbs/1.3780 in.	100.0 N/35.0 mm 10.2 kgf/35.0 mm 22.5 lbs/1.3780 in.
Tilt	—	1.0 mm 0.039 in.

Rocker Arm

(V2203-B), serial number: ~3422 Clearance between rocker arm shaft and rocker arm	0.018 to 0.070 mm 0.0007 to 0.0026 in.	0.15 mm 0.0059 in.
Rocker arm shaft O.D.	13.973 to 13.984 mm 0.5501 to 0.5506 in.	—
Rocker arm bush I.D.	14.002 to 14.043 mm 0.5513 to 0.5529 in.	—
(V2203-B(E), serial number: 3423~ and D1403-B(E), D1703-B(E), V1903-B(E), F2803(E), all) Clearance between rocker arm shaft and rocker arm	0.016 to 0.045 mm 0.0006 to 0.0018 in.	0.15 mm 0.0059 in.
Rocker arm shaft O.D.	13.973 to 13.984 mm 0.5501 to 0.5506 in.	—
Rocker arm I.D. for shaft	14.000 to 14.018 mm 0.5512 to 0.5519 in.	—

Tappet

Clearance between tappet and guide	0.020 to 0.062 mm 0.0008 to 0.0024 in.	0.07 mm 0.0028 in.
Tappet O.D.	23.959 to 23.980 mm 0.9433 to 0.9441 in.	—
Tappet guide I.D.	24.000 to 24.021 mm 0.9449 to 0.9457 in.	—

Camshaft

Item		Factory Specification	Allowable Limit
Camshaft side clearance		0.07 to 0.22 mm 0.0028 to 0.0087 in.	0.3 mm 0.0118 in.
Camshaft alignment		—	0.01 mm 0.00039 in.
Cam height	IN, EX.	33.47 mm 1.3177 in.	33.42 mm 1.3157 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.		39.934 to 39.950 mm 1.5722 to 1.5728 in.	
Camshaft bearing I.D.		40.000 to 40.025 mm 1.5748 to 1.5758 in.	

Timing Gear

Timing gear backlash			
Crank gear – Idle gear		0.0415 to 0.1122 mm 0.0016 to 0.0044 in.	0.15 mm 0.0059 in.
Idle gear – Cam gear		0.0415 to 0.1154 mm 0.0016 to 0.0045 in.	0.15 mm 0.0059 in.
Idle gear – Injection pump gear		0.0415 to 0.1154 mm 0.0016 to 0.0045 in.	0.15 mm 0.0059 in.
Crank gear – Oil pump gear		0.0415 to 0.1090 mm 0.0016 to 0.0043 in.	0.15 mm 0.0059 in.
Clearance between idle gear shaft and idle gear bushing		0.025 to 0.066 mm 0.0010 to 0.0026 in.	0.10 mm 0.0039 in.
V2203-B(E)	Idle gear bushing I.D.	32.000 to 32.025 mm 1.2598 to 1.2608 in.	—
	Idle gear shaft O.D.	31.959 to 31.975 mm 1.2582 to 1.2589 in.	—
D1403-B(E) D1703-B(E) V1903-B(E) F2803-B(E)	Idle gear bushing I.D.	38.000 to 38.025 mm 1.4961 to 1.4970 in.	—
	Idle gear shaft O.D.	37.959 to 37.975 mm 1.4944 to 1.4951 in.	—
Idle gear side clearance Idle gear		0.20 to 0.51 mm 0.0079 to 0.0200 in.	0.9 mm 0.0354 in.

Piston/Piston Ring

Item	Factory Specification	Allowable Limit
Piston Pin Bore	25.000 to 25.013 mm 0.9843 to 0.9848 in.	25.05 mm 0.9862 in.
Clearance between compression ring 2 and ring groove	0.093 to 0.120 mm 0.0037 to 0.0047 in.	0.20 mm 0.0079 in.
Clearance between oil ring and ring groove	0.020 to 0.052 mm 0.0008 to 0.0020 in.	0.15 mm 0.0059 in.
Ring gap		
Compression ring 1	0.30 to 0.45 mm 0.0118 to 0.0177 in.	1.25 mm 0.0492 in.
Compression ring 2	0.30 to 0.45 mm 0.0118 to 0.0177 in.	1.25 mm 0.0492 in.
Oil ring	0.25 to 0.45 mm 0.0098 to 0.0177 in.	1.25 mm 0.0492 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 0.0006 to 0.0015 in.	0.15 mm 0.0059 in.
Piston pin O.D.	25.002 to 25.011 mm 0.9843 to 0.9847 in.	-
Small end bushing I.D.	25.025 to 25.040 mm 0.9852 to 0.9858 in.	-

Crankshaft

Crankshaft alignment	-	0.02 mm 0.00079 in.
Oil clearance between crankshaft journal and crankshaft bearing 1	0.04 to 0.118 mm 0.0016 to 0.0046 in.	0.2 mm 0.0079 in.
Crankshaft journal O.D.	51.921 to 51.940 mm 2.0441 to 2.0449 in.	-
Crankshaft bearing 1 I.D.	51.980 to 52.039 mm 2.0465 to 2.0488 in.	-
Oil clearance between crankshaft journal and crankshaft bearing 2	0.04 to 0.104 mm 0.0016 to 0.0041 in.	0.2 mm 0.0079 in.
Crankshaft O.D.	51.921 to 51.940 mm 2.0441 to 2.0449 in.	-
Crankshaft bearing 2 I.D.	51.980 to 52.025 mm 2.0465 to 2.0482 in.	-
Oil clearance between crank pin and crank pin bearing	0.025 to 0.087 mm 0.0009 to 0.0034 in.	0.2 mm 0.0079 in.
Crank pin O.D.	46.959 to 46.975 mm 1.8488 to 1.8494 in.	-
Crank pin bearing I.D.	47.000 to 47.046 mm 1.8504 to 1.8522 in.	-
Crankshaft side clearance	0.15 to 0.31 mm 0.0059 to 0.0122 in.	0.5 mm 0.0197 in.

Cylinder Bore

Cylinder bore I.D.	D1703-B(E), V2203-B(E), F2803-B(E)	87.000 to 87.022 mm 3.4252 to 3.4261 in.	+ 0.15 mm 0.0059 in.
	D1403-B(E) V1903-B(E)	80.000 to 80.019 mm 3.1496 to 3.1504 in.	

(2) LUBRICATING SYSTEM**Oil Pump**

Item		Factory Specification	Allowable Limit
Engine oil pressure	At idle speed	1.0 kgf/cm ² 98 kPa, 14 psi or more	0.5 kgf/cm ² 49 kPa, 7 psi
	At rated speed	3.0 to 4.5 kgf/cm ² 294.2 to 441 kPa 42.7 to 64 psi	2.5 kgf/cm ² 245 kPa 36 psi
Engine oil pressure switch working pressure		0.5 kgf/cm ² , 49 kPa, 7 psi	
Clearance between inner rotor and outer rotor		0.10 to 0.16 mm 0.0039 to 0.0063 in.	—
Clearance between outer rotor and pump body		0.11 to 0.19 mm 0.0043 to 0.0075 in.	—
End clearance between inner rotor and cover		0.105 to 0.150 mm 0.0041 to 0.0059 in.	—

(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 1.4 kgf/cm ² 137 kPa, 20 psi	—
Radiator cap air leakage	10 seconds or more 0.9 → 0.6 kgf/cm ² 88 → 59 kPa, 13 → 9 psi	—
Fan belt tension	10 to 12 mm/10 kgf 0.394 to 0.472 in./22.1 lbs.	—

(4) FUEL SYSTEM**Injection Pump**

Item		Factory Specification	Allowable Limit
Injection timing	D1403-B(E), D1703-B(E), V1903-B(E), V2203-B(E)	0.30 to 0.33 rad. T.D.C. (17° to 19° before)	—
	F2803-B(E)	0.31 to 0.35 rad. T.D.C. (18° to 20° before)	
Fuel tightness of pump element		—	14.7 MPa 150 kgf/cm ² , 2133 psi
Fuel tightness of delivery valve		More 10 seconds 14.7 → 13.7 MPa 150 → 140 kgf/cm ² 2133 → 1990 psi	5 seconds 14.7 → 13.7 MPa 150 → 140 kgf/cm ² 2133 → 1990 psi

Injection Nozzle

Fuel injection pressure	13.73 to 14.71 MPa 140 to 150 kgf/cm ² 1991 to 2133 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.	30.0 mm 1.1811 in.	29.0 mm 1.1417 in.
Mica undercut	0.5 to 0.8 mm 0.0197 to 0.0315 in.	0.2 mm 0.0079 in.
Brush length	15.0 mm 0.591 in.	10.0 mm 0.394 in.

Alternator

Output current		14 V, 35 A/4000 rpm	—
Rotor coil resistance (F – E)	V2203-B(E)	4 Ω	—
	D1403-B(E), D1703-B(E), V1903-B(E), F2803-B(E)	2.9 Ω	
Slip Ring O.D.	V2203-B(E)	32.5 mm 1.2795 in.	32.1 mm 1.2638 in.
	D1403-B(E), D1703-B(E), V1903-B(E), F2803-B(E)	14.4 mm 0.567 in.	14.0 mm 0.551 in.
Brush length	V2203-B(E)	12.5 mm 0.4921 in.	5.5 mm 0.2165 in.
	D1403-B(E), D1703-B(E), V1903-B(E), F2803-B(E)	10.5 mm 0.413 in.	4.5 mm 0.177 in.

Glow Plug

Glow plug resistance	0.8 Ω	—
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[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 hrs	Every 75 hrs	Every 100 hrs	Every 150 hrs	Every 200 hrs	Every 300 hrs	Every 400 hrs	Every 500 hrs	Every 800 hrs	Every one year	Every two years
Checking fuel pipes and clamps		○										
* Changing engine oil	(1) Oil pan depth (90 mm)		○									
	(2) Oil pan depth (124 mm)			○								
	(3) Oil pan depth (90 mm)				○							
	(4) Oil pan depth (124 mm)					○						
Cleaning air filter element				○								
Cleaning fuel filter element				○								
Checking fan belt tension and damage				○								
Checking water pipes and clamps						○						
* Changing oil filter cartridge	(5) Oil pan depth (90 mm)				○							
	(6) Oil pan depth (124 mm)					○						
	(7) Oil pan depth (90 mm)						○					
	(8) Oil pan depth (124 mm)							○				
Changing fuel filter cartridge								○				
Cleaning radiator interior									○			
Changing radiator cleaner and coolant												○
Changing air filter element											○	
Checking valve clearance										○		
Changing water pipes and clamps												○
Changing fuel pipes and clamps												○

(1), (2) For generators (3000 / 3600 rpm)

(3), (4) For generators (1800 / 1500 rpm) and general construction / industrial machinery and farm equipment

(5), (6) For generators (3000 / 3600 rpm) and general construction / industrial machinery and farm equipment

(7), (8) For generators (1800 / 1500 rpm)

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

CAUTION

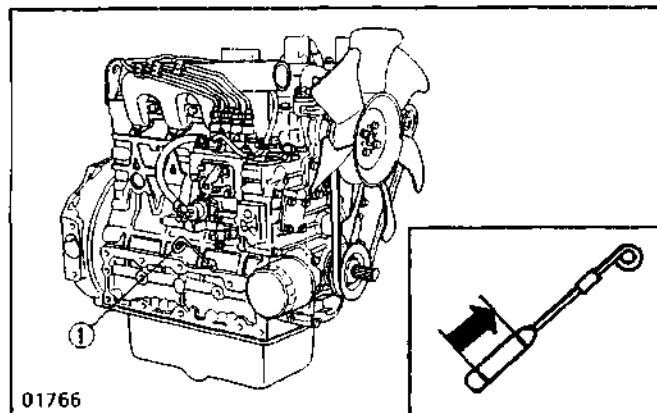
- When changing or inspecting, be sure to level and stop the engine.

[7] CHECK AND MAINTENANCE

■ NOTE

- Some types of gearcases are provided with an oil filler port. When the cylinder head has been reassembled or when the valve clearance has been readjusted, apply an enough amount of oil to the intake and exhaust valves, push rod and rocker arm just before fitting the head cover in position.

(1) Daily Check Points

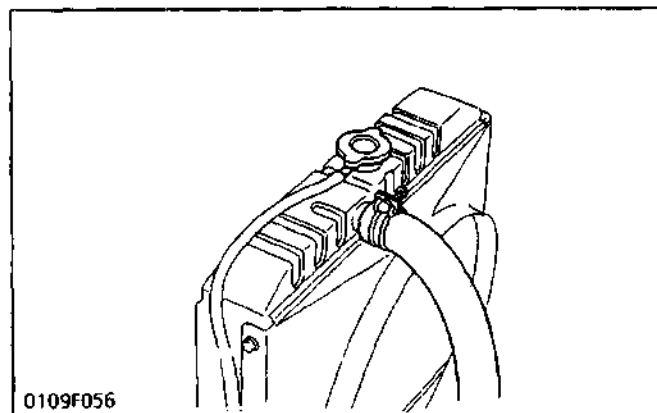


Checking Engine Oil Level

- Level the engine.
- To check the oil level, draw out the dipstick, wipe it clean, reinsert it, and draw it out again. Check to see that the oil level lies between the two notches.
- 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.



Checking and Replenish Cooling Water

- Remove the radiator cap and check to see that the cooling water level is just below the port.
- If low, add clean water and antifreeze.

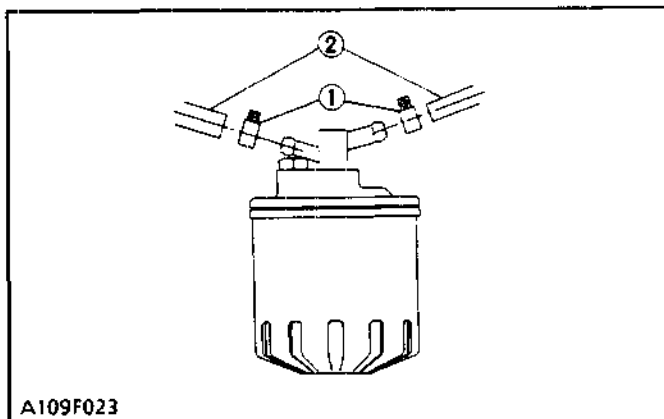


CAUTION

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

■ IMPORTANT

- Be sure to close the radiator cap securely. If the cap is loose or improperly closed, water may leak out and the engine could overheat.
- Do not use an antifreeze and scale inhibitor at the same time.

(2) Check Point of Every 50 hours

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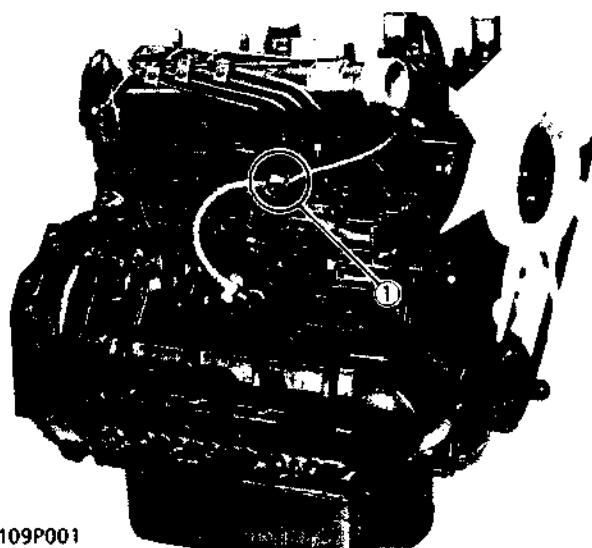
Checking Fuel Pipe

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



A109P001

(When bleeding fuel system)

1. Fill the fuel tank with fuel, and open the fuel cock.
2. Open the air vent plug on the fuel injection pump.
3. Pull the engine stop knob back completely to prevent the engine from starting while turning the key to rotate the engine for about 10 seconds.
4. Close the air vent plug.

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) Air Vent Plug

(3) Check Point of Every 75, 100, 150, 200 hours (For details, refer to page S-32)

Models	Oil pan depth	
	124 mm (4.88 in.)	* 90 mm (3.54 in.)
D1403-B(E) D1703-B(E)	7.0 ℓ (1.85 U.S.gal.) (1.54 Imp.gal.)	5.6 ℓ (1.48 U.S.gal.) (1.23 Imp.gal.)
V1903-B(E) V2203-B(E)	9.5 ℓ (2.51 U.S.gal.) (2.09 Imp.gal.)	7.6 ℓ (2.01 U.S.gal.) (1.672 Imp.gal.)
F2803-B(E)	12.0 ℓ (3.17 U.S.gal.) (0.64 Imp.gal.)	—

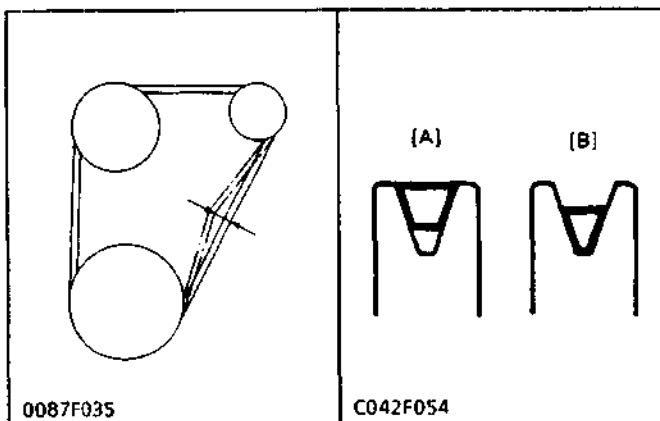
* 90 mm (3.54 in.) oil pan depth is optional.

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

- Engine oil should be MIL-L-2104C or have properties of API classification CD/CE grades.
- 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

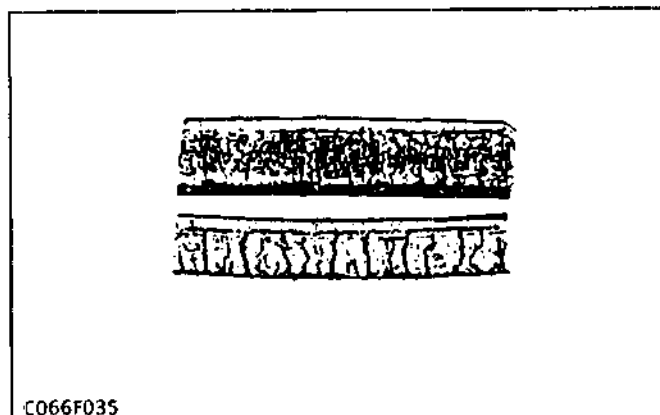
(4) Check Point of Every 100 hours**Checking Fan Belt Tension**

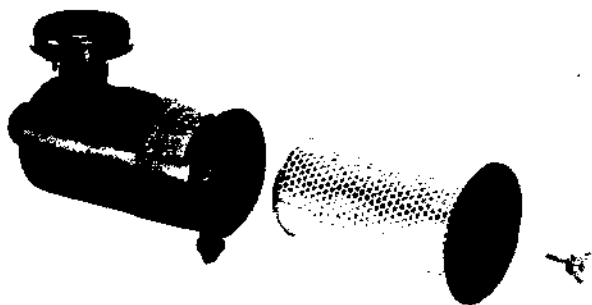
1. Press the fan belt between fan pulley and pulley at force of 98 N (10 kgf, 22 lbs). Check if the fan belt deflection is 10 to 12 mm (0.394 to 0.472 in.)
2. If the deflection is not within the factory specifications, loosen the bolt and nuts, and relocate the alternator to adjust,

[A] Good
[B] Bad

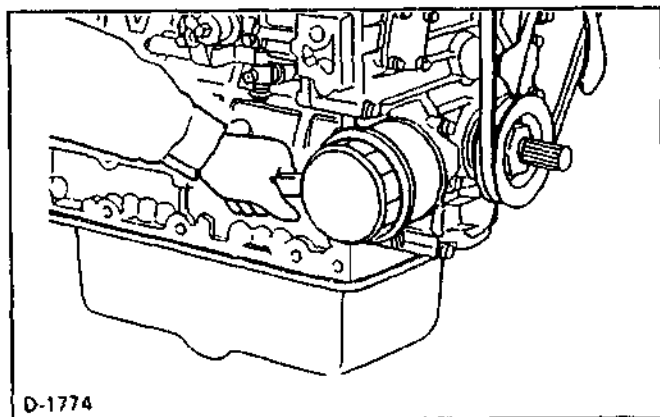
Checking Fan Belt Damage

1. Check the fan belt for damage.
2. Check if the fan belt is worn and sunk in the pulley groove.
3. Replace the fan belt if the belt is damaged or nearly worn out and deeply sunk in the pulley groove.





A109P002

(4) Check Point of Every 200 hours

D-1774

Cleaning Air Cleaner

1. Remove the air cleaner element.
2. Use clean dry compressed air on the inside of the element.
Air pressure at the nozzle must not exceed 690 kPa (7 kgf/cm², 100 psi).
Maintain reasonable distance between the nozzle and the filter.

■ NOTE

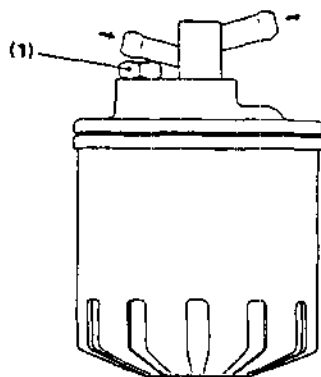
- Change the element once a year or every 6th cleaning.
- The air cleaner uses a dry element. Never apply oil to it.

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.

(5) Check Point of Every 150, 200, 300, 400 hours (For details, refer to page S-32)**[A] Changing fuel filter cartridge**

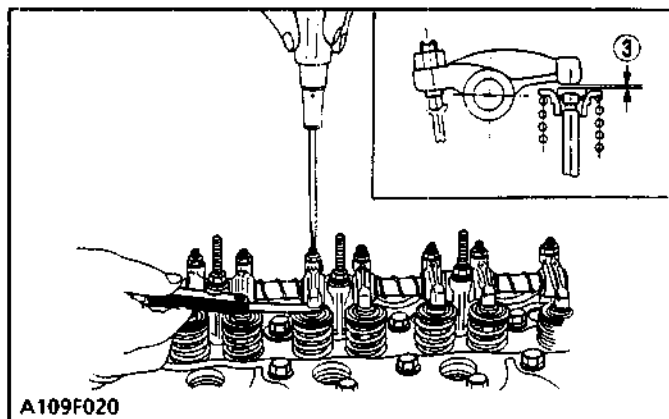
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Changing Fuel Filter Cartridge

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

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

(1) Air Vent Plug

(5) Check Point of Every 800 hours

A109F020



A109P003

- (1) Projection
(2) TC Mark Line
(3) Valve Clearance

Checking Valve Clearance**■ IMPORTANT**

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

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

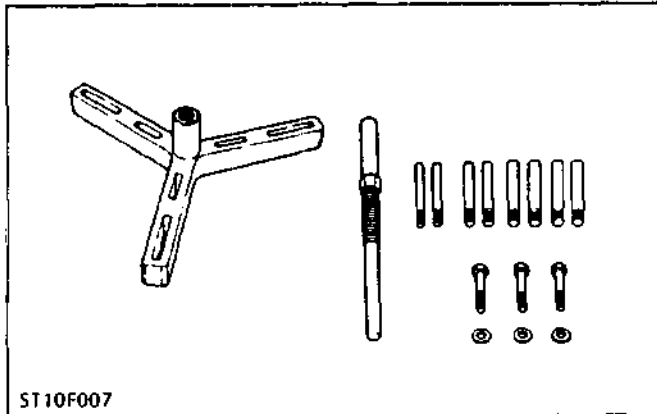
Valve clearance	Factory spec.	0.18 to 0.22 mm 0.0071 to 0.0087 in.
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■ NOTE

- The "TC" marking 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 projection in the window on flywheel-housing. 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°) and align the "TC" marking and the projection perfectly. Adjust all the other valve clearance 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 arrangement Adjustable cylinder Loca- tion of piston		D1403-B(E) D1703-B(E)		V1903-B(E) V2203-B(E)		F2803-B(E)	
		IN.	EX.	IN.	EX.	IN.	EX.
When No.1 piston is compress- ion top dead center	1 st	o	o	o	o	o	o
	2 nd		o	o		o	
	3 rd	o			o		o
	4 th						
When No.1 piston is overlap position	1 st						
	2 nd	o			o		o
	3 rd		o	o		o	
	4 th			o	o	o	o
	5 th					o	o

[8] SPECIAL TOOLS

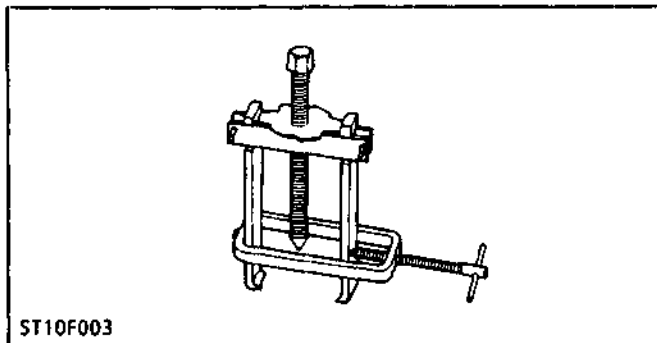


ST10F007

Flywheel Puller

Code No: 07916-32011

Application: Use to remove the flywheel.

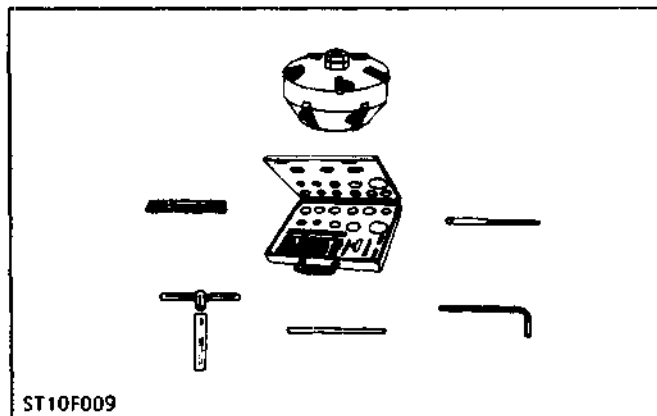


ST10F003

Special-use Puller Set

Code No: 07916-09032

Application: Use for pulling out bearings, gears and other parts.

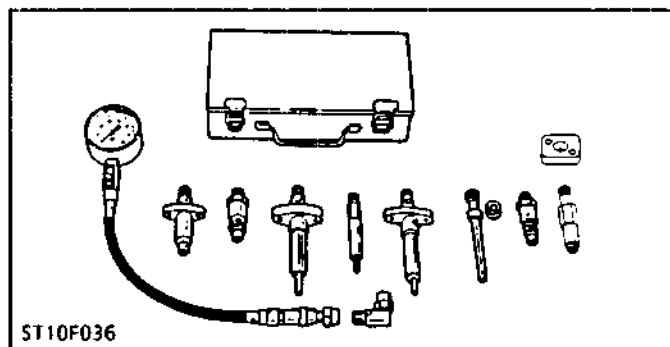


ST10F009

Valve Seat Cutter Set

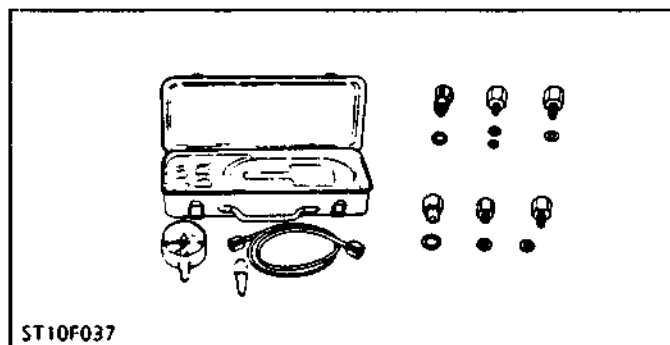
Code No: 07909-33102

Application: Use for correcting valve seats.

**Diesel Engine Compression Tester**

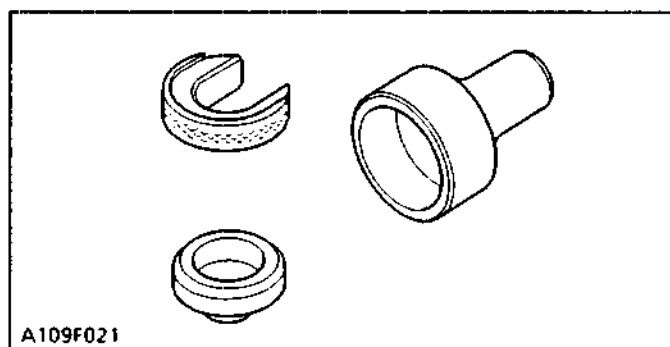
Code No: 07909-30207

Application: Use for measuring diesel engine compression pressure.

**Oil Pressure Tester**

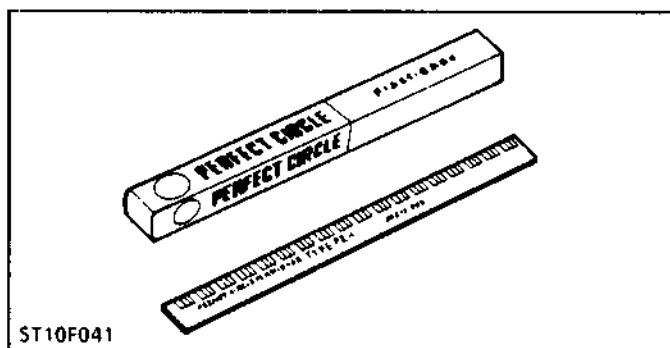
Code No: 07916-32031

Application: Use for measuring lubricating oil pressure.

**Auxiliary Socket For Fixing Crankshaft Sleeve**

Code No: 07916-32091

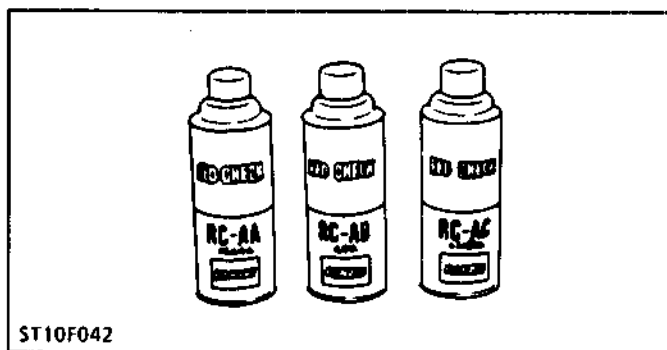
Application: Use to fix the crankshaft sleeve of the diesel engine.

**Plastigage**

Code No: 07909-30241

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

Measuring: 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.)

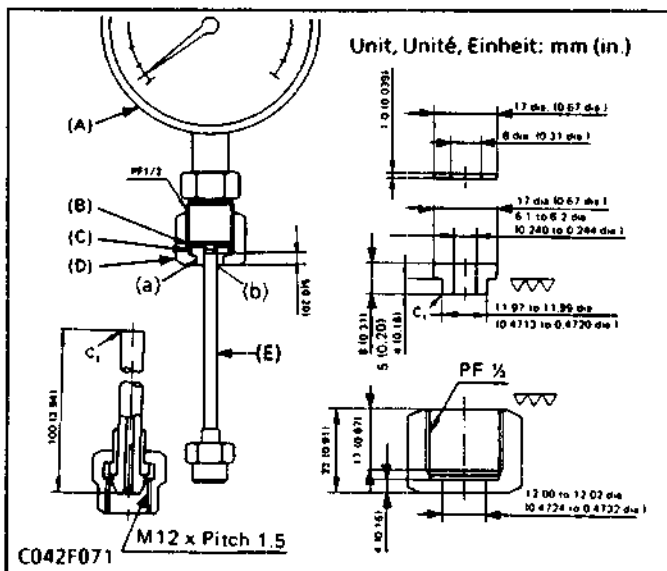
**Red Check (Crack check liquid)**

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.

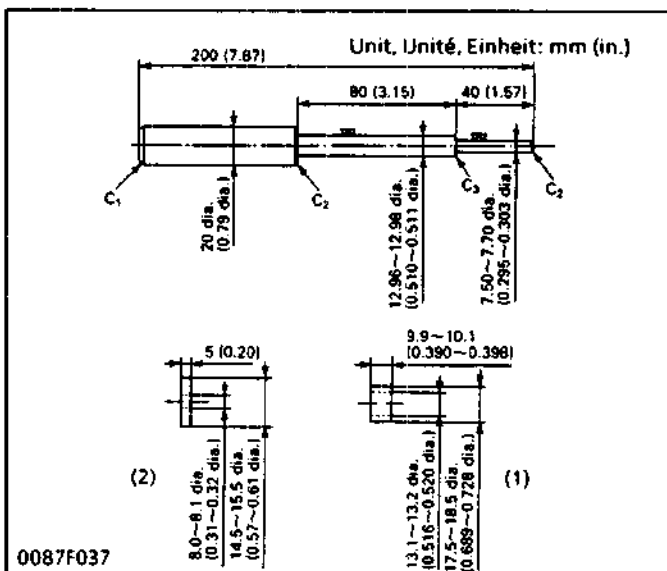
**Injection Pump Pressure Tester**

Application: Use for checking fuel tightness of the injection pump.

A	Pressure gauge Full scale: More than 29.4 MPa (300 kgf/cm ² , 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

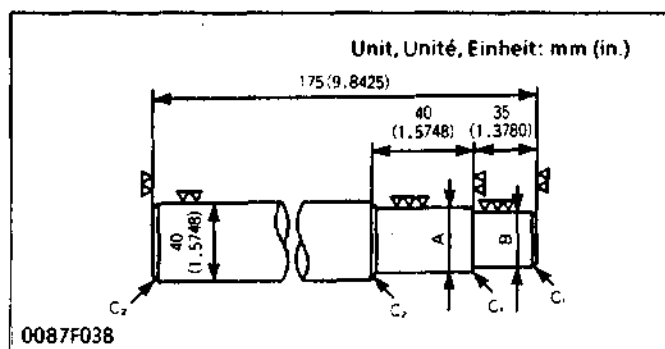
**Valve Guide Replacing Tool**

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

- Spacer
- Stopper

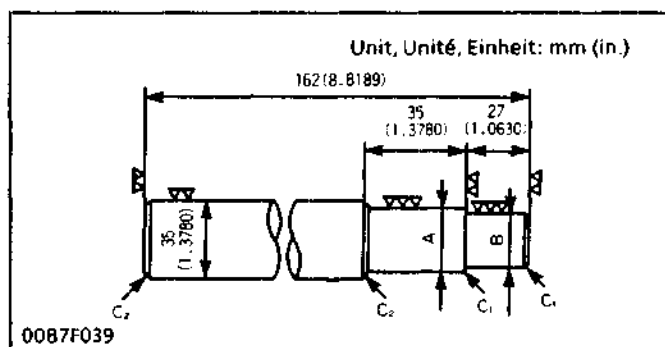
*Chamfer	mm	in.
C ₁	2.0	0.079
C ₂	1.0	0.039
C ₃	0.3	0.012

**Unit : mm (in.)

**Idle gear Bushing Replacing Tool**

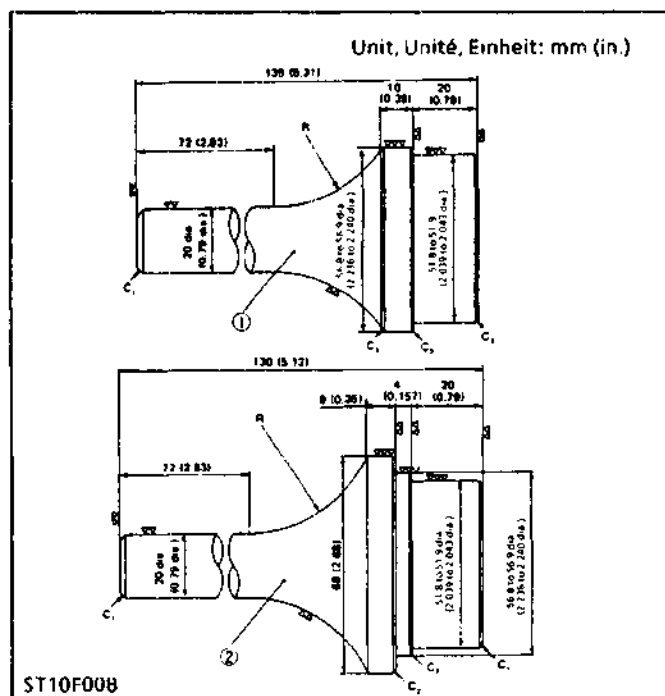
Application: Use to press out and to press fit the idle gear bushing.

V2203-B(E)	A	35.90 to 35.95 mm 1.4134 to 1.4154 in.
	B	31.959 to 31.975 mm 1.2582 to 1.2589 in.
D1403-B(E) D1703-B(E) V1903-B(E) F2803-B(E)	A	41.90 to 41.95 mm 1.6496 to 1.6516 in.
	B	37.959 to 37.975 mm 1.4950 to 1.4951 in.

**Small End Bushing Replacing Tool**

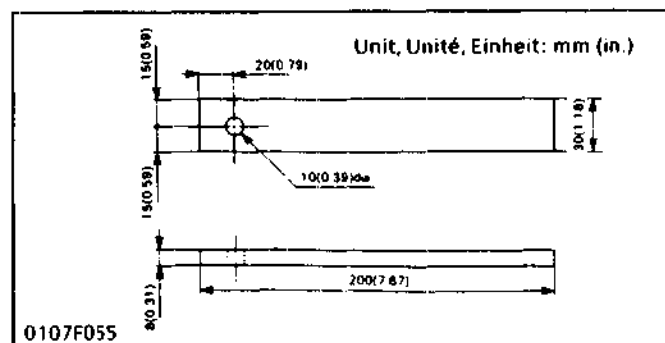
Application: Use to press out and to press fit the small end bushing.

A	27.90 to 27.95 mm 1.0984 to 1.1004 in.
B	25.002 to 25.011 mm 0.9843 to 0.9847 in.

**Crankshaft Bearing 1 Replacing Tool**

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

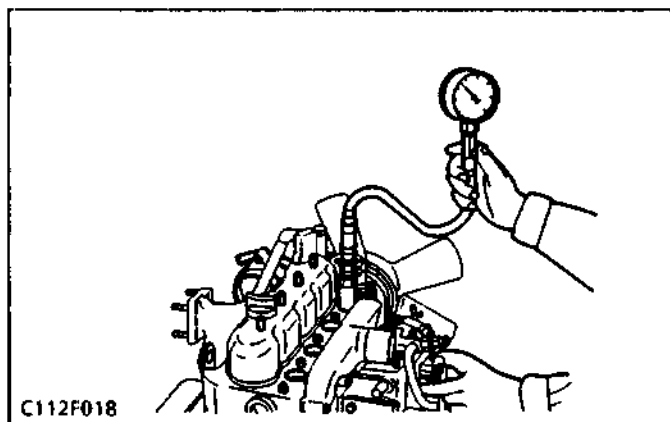
*Chamfer	mm	in.
C ₁	2.0	0.079
C ₂	1.0	0.039
C ₃	0.3	0.012
**Radius	mm	in.
R	240	1.57

**Flywheel Stopper**

Application: Use to loosen and tighten the flywheel screw.

1 ENGINE BODY

CHECKING AND ADJUSTING

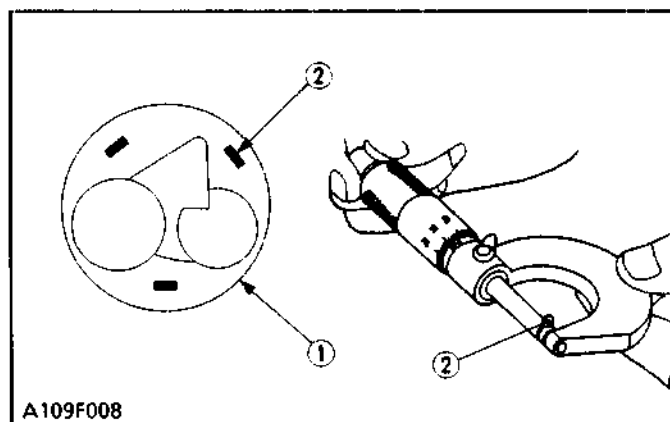


Compression Pressure

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: 07909-30207) 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 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 among cylinders compression values should be under 10 %.



(1) Piston

(2) Fuse (1.5 mm dia.)

Top Clearance

1. Remove the cylinder head (then don't attempt 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 recess for 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 bolts to specified torque.
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.	0.55 to 0.70 mm 0.0217 to 0.0276 in.
Tightening torque	Cylinder head bolts	93.1 to 98.0 N·m 9.5 to 10.0 kgf·m 68.7 to 72.3 ft·lbs

DISASSEMBLING AND ASSEMBLING

[1] DRAINING WATER AND OIL

■ NOTE

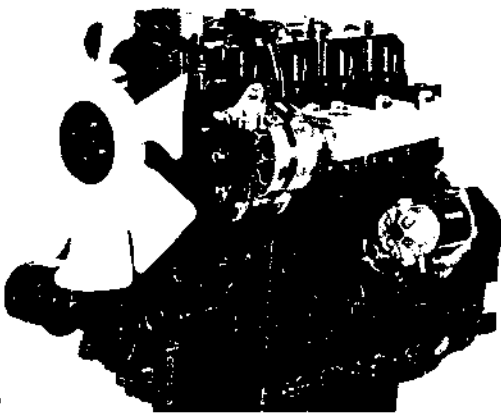
- Some types of gearcases are provided with an oil filter port. When the cylinder head has been reassembled or when the valve clearance has been readjusted, apply an enough amount of oil to the intake and exhaust valves, push rod and rocker arm just before fitting the head cover in position.

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



A109P004

Air Cleaner, Muffler and others

1. Remove the air cleaner and muffler.
2. Remove the fan, fan belt, alternator and starter.

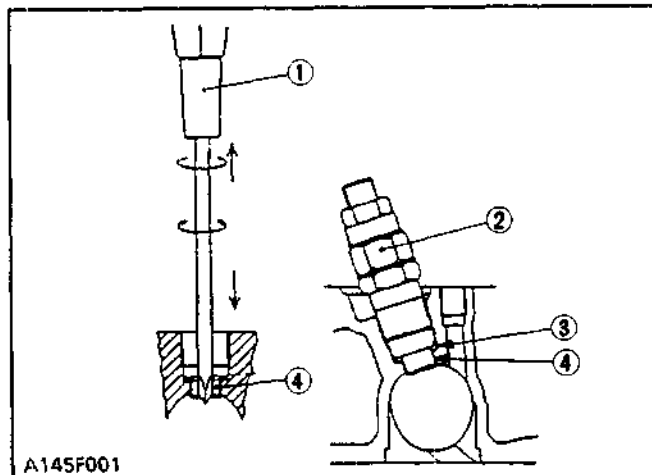
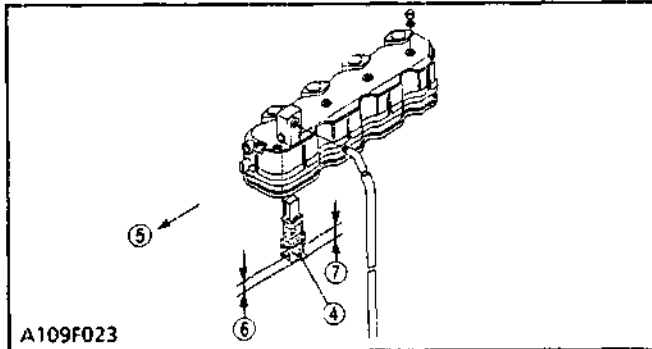
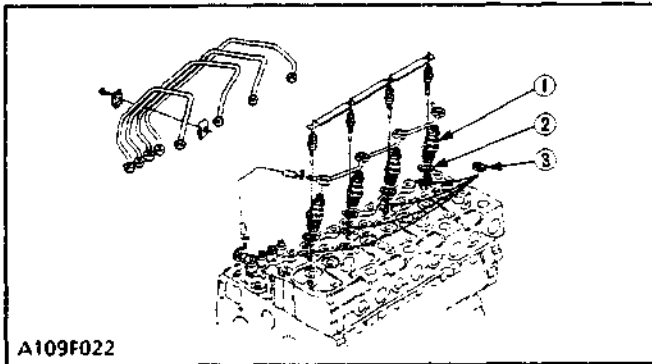
(When reassembling)

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

[3] CYLINDER HEAD AND VALVES



Cylinder Head Cover and Nozzle Holder

1. Remove the injection pipes and overflow pipes.
2. Remove the glow plugs.
3. Remove the nozzle holder and copper gaskets.
4. Remove the heat seal.
5. Remove the head cover.

(When reassembling)

- Check to see that the cylinder head cover gasket is not defective.
- Be sure to place the heat seal (3) and breather oil shield (4) (See Fig).

- | | |
|-------------------------|--------------------|
| (1) Nozzle Holder | (5) Gear Case Side |
| (2) Copper Gasket | (6) Short Plate |
| (3) Heat Seal | (7) Long Plate |
| (4) Breather Oil Shield | |

Nozzle Heat Seal Service Removal Procedure

■ 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.

- | | |
|-----------------------|-----------------------------|
| (1) Plus Screw Driver | (3) Injection Nozzle Packin |
| (2) Injection Nozzle | (4) Heat Seal |

Rocker Arm, Push Rod and In./Ex. Manifold

1. Remove the rocker arm as a unit.
2. Remove the push rods.
3. Remove the In./Ex. manifold.

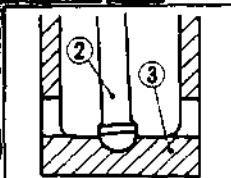
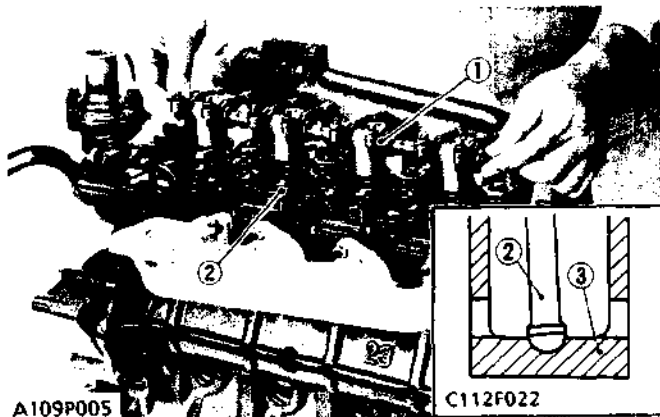
(When reassembling)

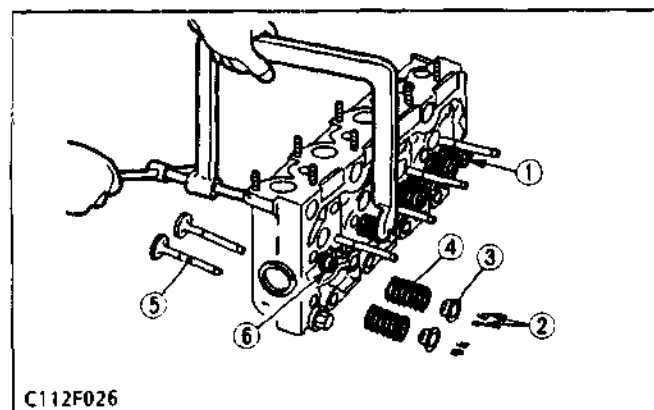
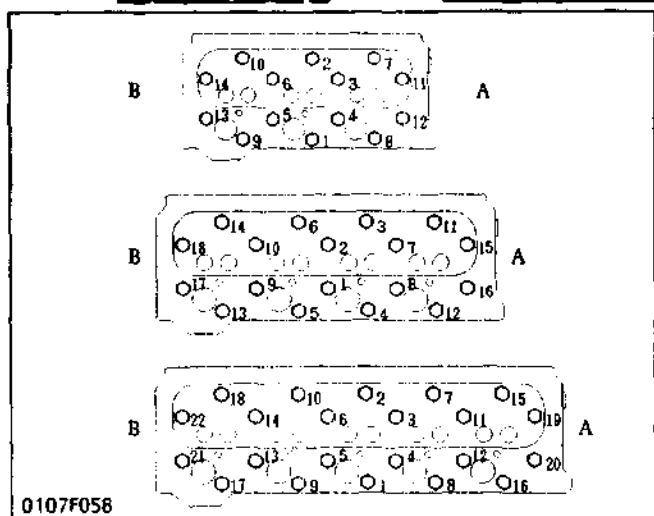
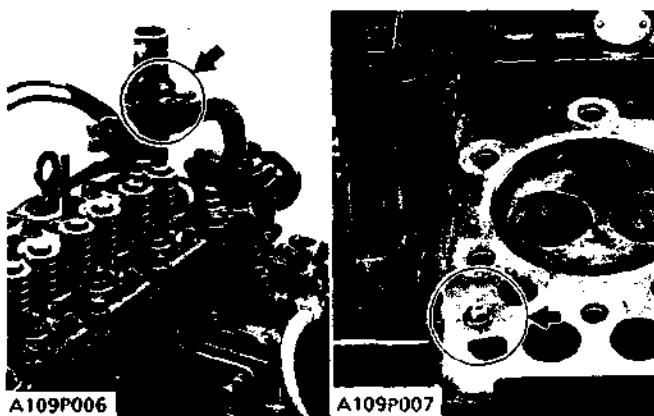
- When putting the push rods onto the tappets, check to see if their ends are properly engaged with the grooves.

■ IMPORTANT

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

- | | |
|----------------|------------|
| (1) Rocker Arm | (3) Tappet |
| (2) Push Rod | |





Cylinder Head and Tappet

1. Loosen the pipe band, and remove the water return pipe.
2. Remove the cylinder head bolts in the order of (22) to (1), and remove the cylinder head.
3. Remove the cylinder head gasket and O-ring.
4. Remove the tappets from the crank case.

(When reassembling)

- Replace the head gasket with a new one.
- Before installing the tappets, apply engine oil thinly around them.
- Install the cylinder head, using care not to damage the O-ring.
- Tighten the cylinder head bolt gradually in the order of (1) to (14-18-22) after applying engine oil.
- Retighten the cylinder head bolt after running the engine for 30 minutes.

NOTE

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

[A] Gear case side

[B] Flywheel side

Tightening torque	Cylinder head bolts	93.1 to 98.0 N·m 9.5 to 10.0 kgf·m 68.7 to 72.3 ft·lbs
-------------------	---------------------	--

Valve

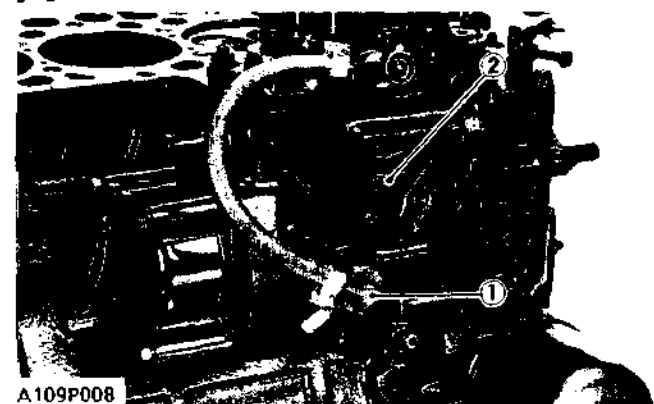
1. Remove the valve cap (1).
2. Remove the valve spring collet (2) with a valve lifter.
3. Remove the valve spring retainers (3), valve spring (4) and valve (5).

(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 | (4) Valve Spring |
| (2) Valve Spring Collet | (5) Valve |
| (3) Valve Spring Retainer | (6) Valve Stem Seal |

[4] GEAR CASE



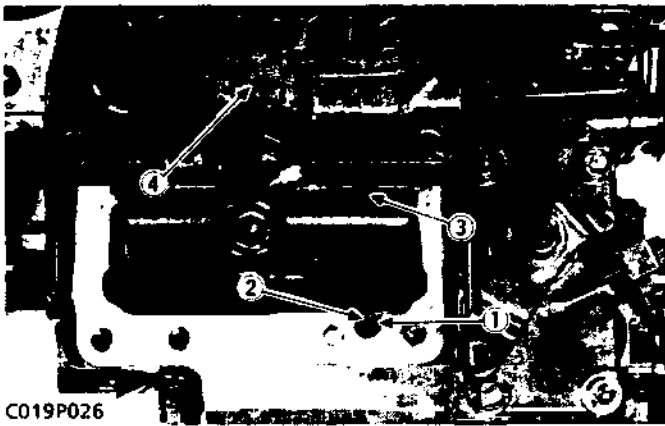
Fuel Feed Pump and Pump Cover

1. Loosen the pipe clamp and remove the fuel pipe from the injection pump side.
2. Remove the fuel feed pump (1).
3. Remove the injection pump cover (2).

(When reassembling)

- Apply a liquid gasket (Three Bond 1215 or equivalent) to the both sides of fuel feed pump gasket.

- | |
|--------------------------|
| (1) Fuel Feed Pump |
| (2) Injection Pump Cover |



C019P026

- (1) Notch
- (2) Groove
- (3) Control Rack Pin
- (4) Injection Pump

Injection Pump

1. Align the control rack pin (3) with the notch (1) on the crankcase, and remove the injection pump (4).
2. Remove the injection pump shims.
3. In principle, the injection pump should not be disassembled.

(When reassembling)

- When installing the injection pump, insert the control rack pin (3) firmly into the groove (2) of the fork lever and thrust lever.

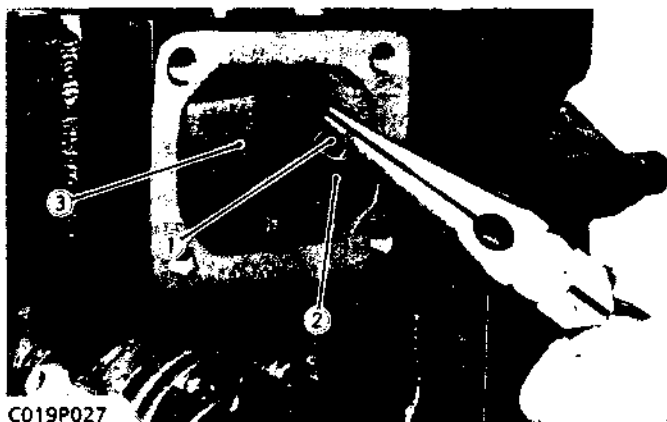
■ NOTE

Engine serial number :D1403;~12211/D1703;~4253
/V1903;~1562/V2203;~60896
/F2803;~105567

- 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 :D1403;12212~/D1703; 4254~
/V1903;1563~/V2203;60897~
/F2803;105568~

- 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.



C019P027

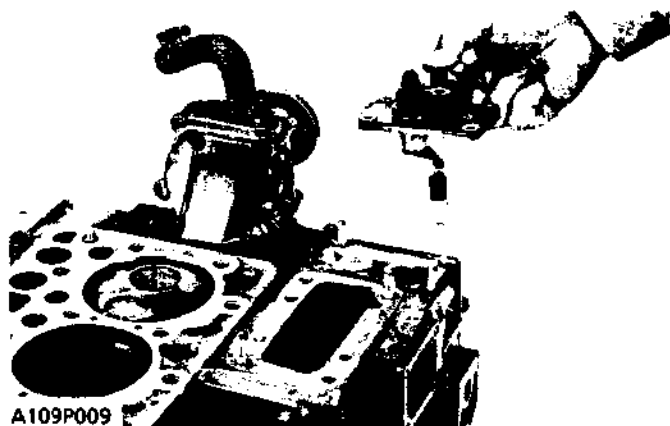
Governor Spring

1. Remove the governor springs 1 (2) and 2 (1) from the fork lever 2 (3).

(When reassembling)

- Fix the governor springs 1 and 2 to the governor lever, and pull the springs through the window of the injection pump, and springs will be able to be hooked on to the governor fork lever 2 with ease.

- (1) Governor Spring 2
- (2) Governor Spring 1
- (3) Fork Lever 2



Speed Control Plate

1. Remove the speed control plate with the governor springs 1 and 2.

(When reassembling)

- Be careful not to drop the governor springs 1 and 2 into the gear case.
- Apply a liquid gasket (Three Bond 1215 or equivalent) to both sides of the speed control plate gasket.



Start Spring

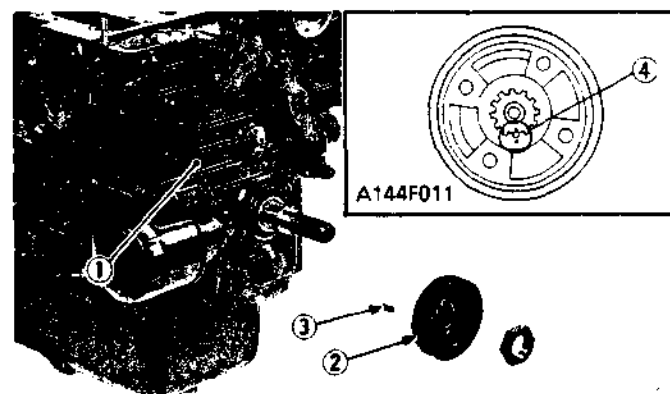
1. Remove the start spring (1) from the fork lever 1 (2).

(When reassembling)

- Be careful not to drop the start spring into the gear case.
- Hook the start spring so that the longer hook is on the fork lever side.

(1) Start Spring

(2) Fork Lever 1

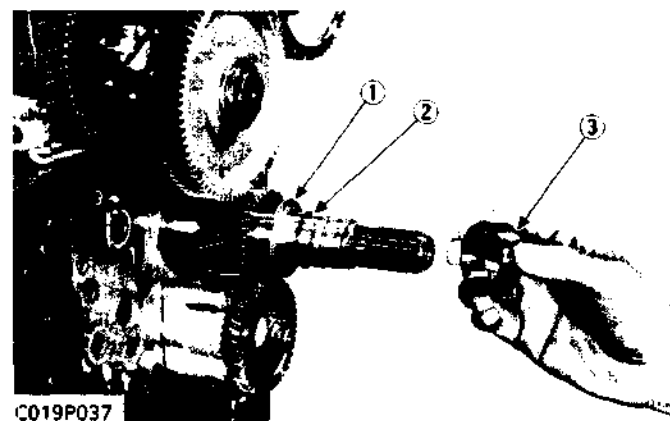


Gear Case

1. Pull out the fan drive pulley (2) with a puller.
2. Remove the feather key (3).
3. Remove the gear case (1).

(When reassembling)

- Apply a liquid gasket (Three Bond 1215 or equivalent) to both sides of the gear case gasket.
- Grease thinly to the oil seal, and install it, ensuring the lip does not come off.
- Install the pulley (F2803) to the crankshaft, aligning the marks (4) on them.



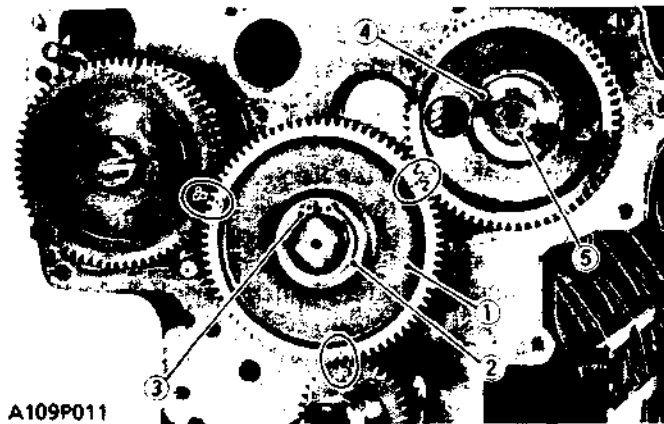
Crankshaft Oil Slinger

1. Remove the crankshaft collar (3).
2. Remove the O-ring (2).
3. Remove the crankshaft oil slinger (1).

(1) Crankshaft Oil Slinger

(2) O-ring

(3) Crankshaft Collar



A109P011

Idle Gear and Camshaft

1. Remove the idle gear (1).
2. Align the round hole on the cam gear with the camshaft stopper mounting screw position and remove the bolts.
3. Remove the cam gear (4) with camshaft (5).

(When reassembling)

- Apply engine oil thinly to the camshaft and idle gear bushing before installation.

■ IMPORTANT

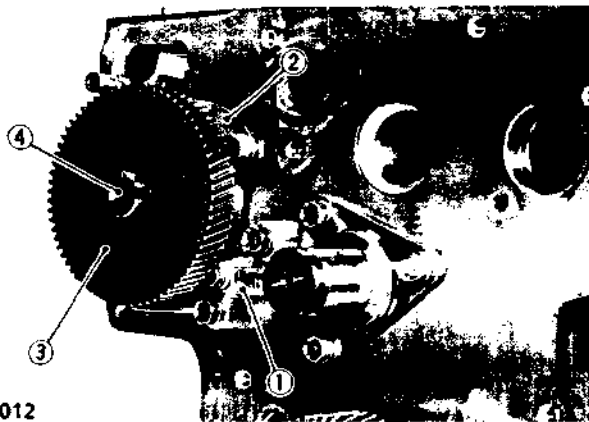
- When installing the idle gear, be sure to align the alignment marks on gears.

- | | |
|------------------------|--------------|
| (1) Idle Gear | (4) Cam Gear |
| (2) Idle Collar 2 | (5) Camshaft |
| (3) External Snap Ring | |

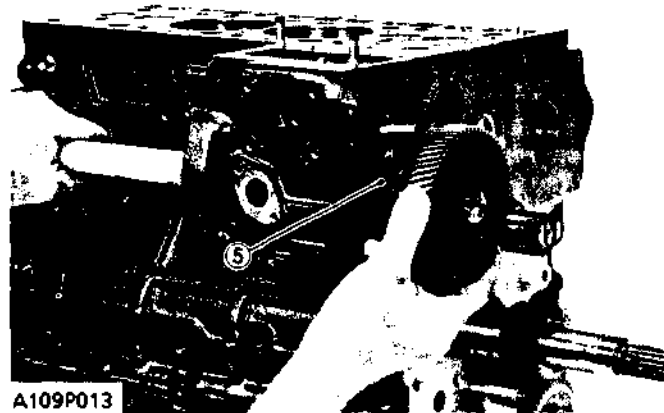
Fuel Camshaft and Fork Lever Assembly

1. Remove the fuel camshaft cover.
2. Remove the fork lever holder mounting bolt.
3. Remove the fuel camshaft stopper.
4. Remove the fuel camshaft and fork lever shaft at the same time.

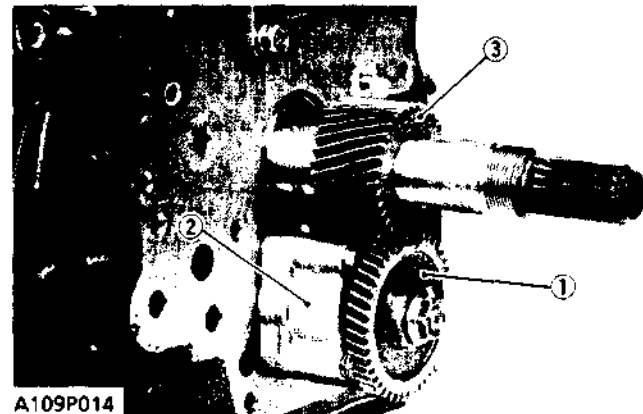
- | | |
|---------------------------|-------------------------|
| (1) Fork Lever Holder | (4) Fuel Camshaft |
| (2) Fuel Camshaft Stopper | (5) Fork Lever Assembly |
| (3) Injection Pump Gear | |



A109P012



A109P013



A109P014

Oil Pump and Crank Gear

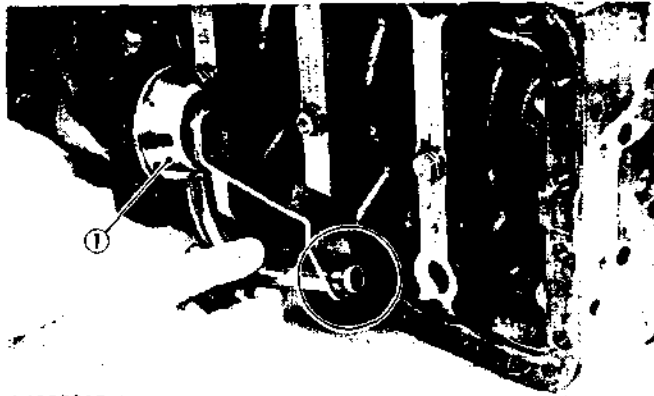
1. Pull out the oil pump drive gear (1) with a puller.
2. Remove the oil pump mounting bolts.
3. Remove the oil pump (2).
4. Remove the crank gear with a special-use puller set (Code No: 07916-09032).
5. Remove the feather key on the crankshaft.

(When reassembling)

- Check to see that the feather key is on the crankshaft.
Heat the crank gear to approx. 80 °C (176 °F), and fit on the crankshaft.

- | | |
|-------------------------|----------------|
| (1) Oil Pump Drive Gear | (3) Crank Gear |
| (2) Oil Pump | |

[5] PISTON AND CONNECTING ROD



A109P015

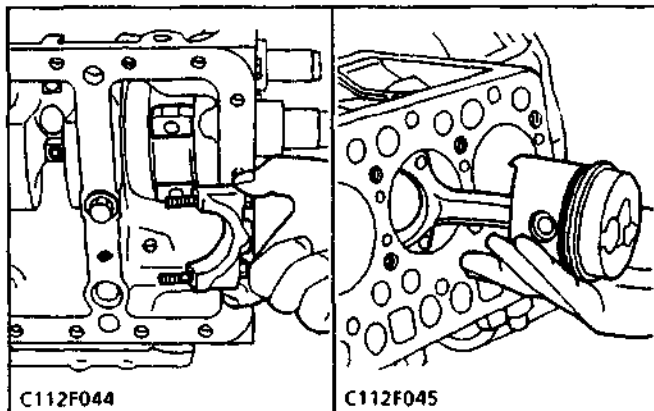
Oil Pan and Oil Strainer

1. Remove the oil pan and strainer (1).

(When reassembling)

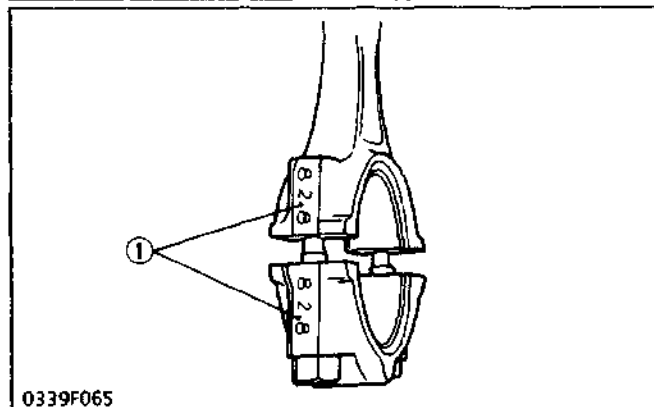
- After cleaning the oil strainer, install it.
- Install the oil strainer (1), being careful not to damage the O-ring.
- Apply a liquid gasket (Three Bond 1215 or equivalent) to both sides of the oil pan gasket.
- To avoid uneven tightening, tighten mounting bolts in diagonal order from the center.

(1) Oil Strainer

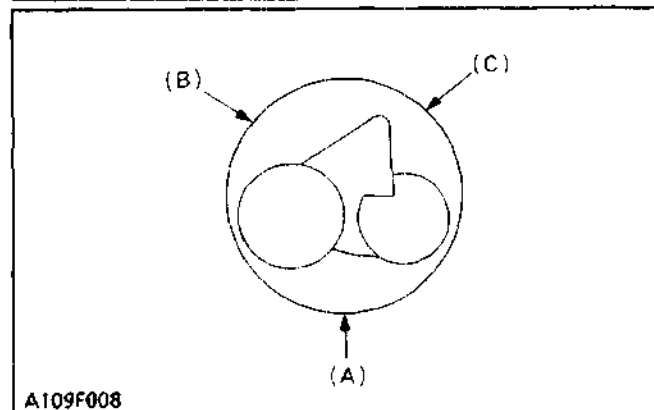


C112F044

C112F045



0339F065



A109F008

Piston

1. Turn the flywheel, and bring the piston to the bottom dead center.
2. Remove the connecting rod bolt and take off the connecting rod cap.
3. Turn the flywheel, and bring the piston to the top dead center.
4. Pull out the piston upward by lightly tapping it from the bottom of the crankcase with the grip of a hammer.

(When reassembling)

- Apply engine oil to the piston, piston ring and cylinder bore.
- When inserting the piston into the cylinder, face the number (1) on the connecting rod to the injection pump.
- Align the number (1) on the connecting rod and connecting rod cap.
- Apply engine oil to the crank pin bearings and bolts.

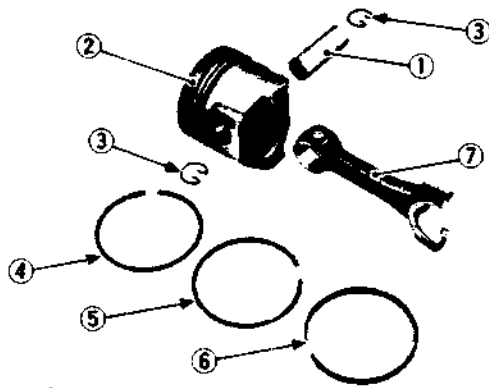
Tightening torque	Connecting rod bolt	Non-Flange bolt	36.3 to 41.2 N·m 3.7 to 4.2 kgf·m 26.6 to 30.4 ft·lbs
		Flange bolt	44.1 to 49.0 N·m 4.5 to 5.0 kgf·m 32.5 to 36.2 ft·lbs

■ IMPORTANT

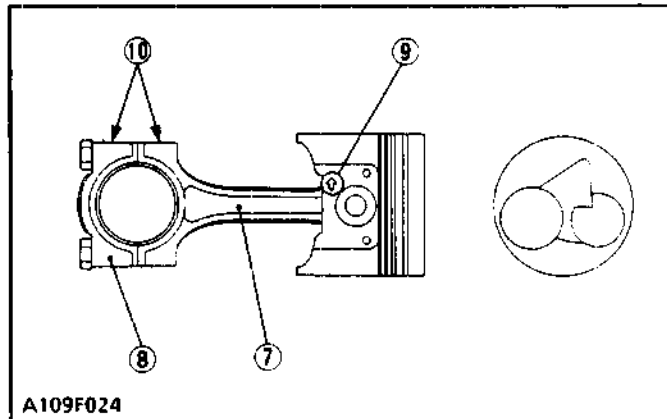
- Do not change the combination of cylinder and piston. Make sure of the position of each piston by marking.
- The oil ring's edge is hard-chromium plated; and when inserting the piston into the cylinder, make certain the piston ring compressor is tight so that the oil ring is not caught by the cylinder, peeling off the plating.
- Place the piston rings so that there are gaps every 120° (2.09 rad.) with no gap facing the piston pin in the cylinder. (See Fig.)

(1) Align the mark

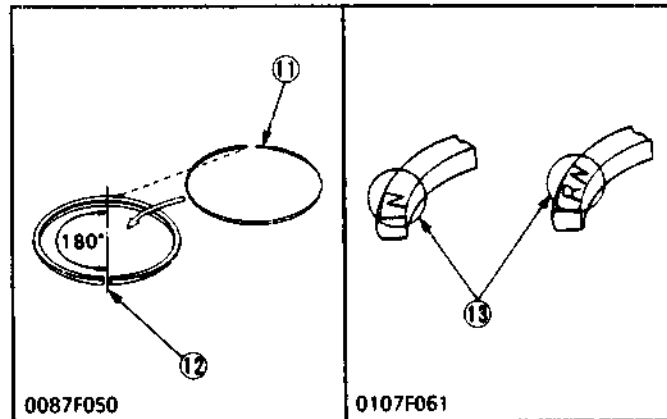
- (A) Top Ring Gap
(B) Second Ring Gap
(C) Oil Ring Gap



0107P046



A109F024



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0107F061

Piston Ring and Connecting Rod

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

(When reassembling)

- When installing the ring, assemble the rings so that the manufacturer's mark (13) near the gap faces the top of the piston.
- When installing the oil ring onto the piston, place the expander joint (11) on the opposite side of the oil ring gap (12).
- Apply engine oil to the piston pin.
- When installing the connecting rod to the piston, immerse the piston in 80°C (176°F) oil for 10 to 15 minutes and insert the piston pin to the piston.

■ NOTE

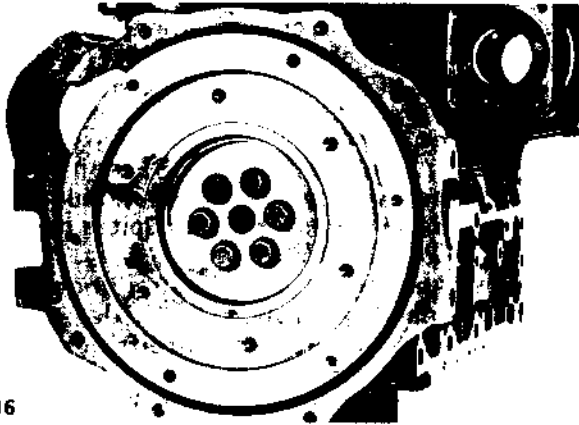
- When installing the connecting rod to the piston, align the mark (10) on the connecting rod to the arrow's direction of casting mark on the piston.

■ IMPORTANT

- 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) Compression Ring 1
- (5) Compression Ring 2
- (6) Oil Ring
- (7) Connecting Rod
- (8) Connecting Rod Cap
- (9) Casting Mark
- (10) Mark
- (11) Expander Joint
- (12) Oil Ring Gap
- (13) Manufacturer's Mark

[6] FLYWHEEL AND CRANKSHAFT



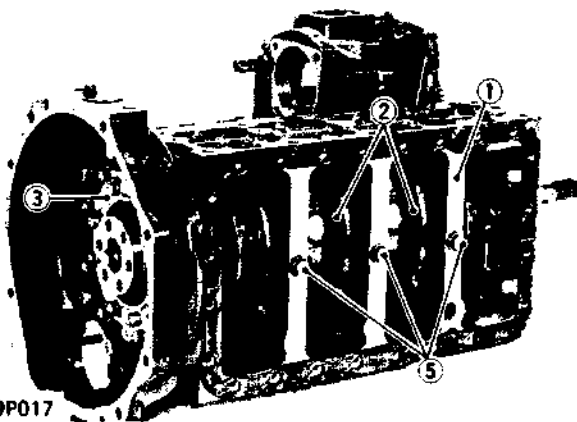
A109P016

Flywheel

1. Lock the flywheel not to turn using the flywheel stopper.
2. Remove the flywheel screws, 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 bolt.



A109P017

Bearing Case Cover and Crankshaft

■ NOTE

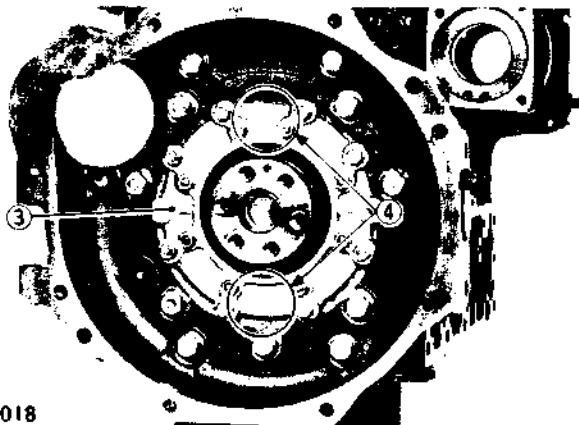
- Before disassembling, check the side clearance of crankshaft. Also check it during reassembly.

1. Remove the bearing case cover (3).
2. Remove the bearing case screw 2 (5).
3. Pull out the crankshaft.

(When reassembling)

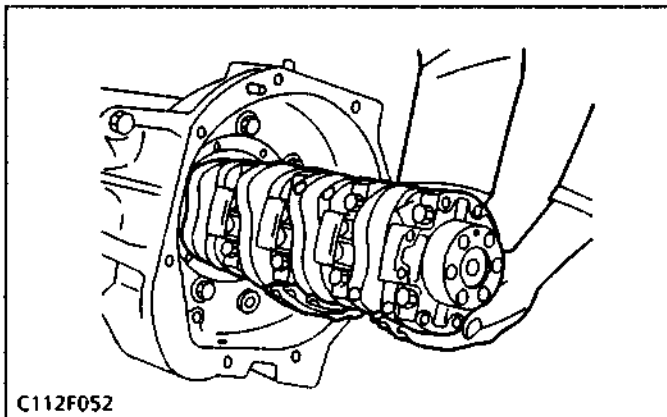
■ IMPORTANT

- Install the crankshaft sub assembly, aligning the screw hole of main bearing case 2 (2) with the screw hole of cylinder block (1).
- Apply engine oil to the seat and thread of bearing case screw 2 (5) and tightening it.
- Install the bearing case cover (3) to position the casting mark "下" (4) on it downward or the casting mark "up" (4) on it upward.
- Tighten the bearing case cover mounting screws with even force on the diagonal line.

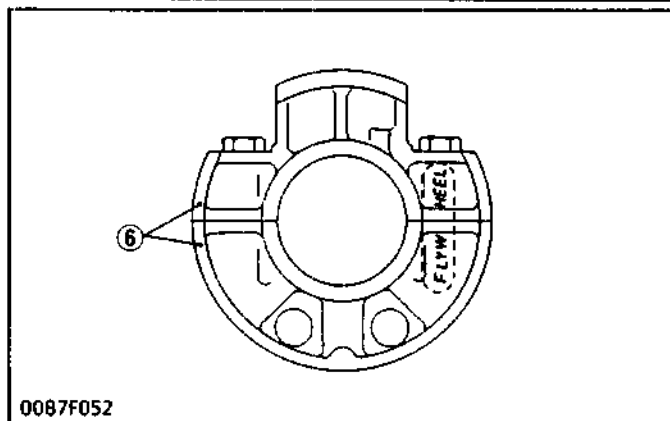
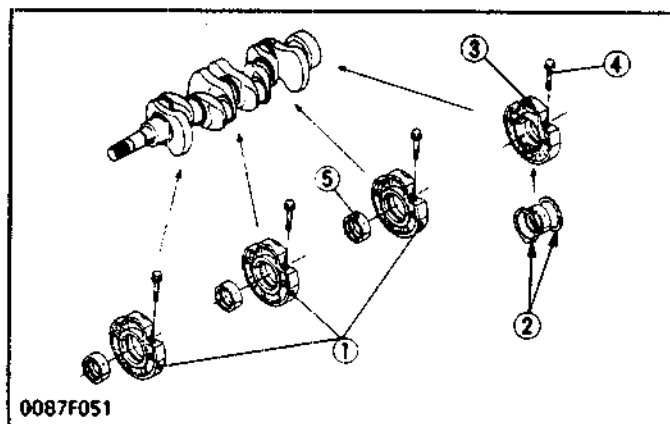


A109P018

- (1) Cylinder Block
- (2) Main Bearing Case 2
- (3) Bearing Case Cover
- (4) Casting Mark "下" or "up"
- (5) Bearing Case Screw 2



C112F052



Main Bearing Case Assembly

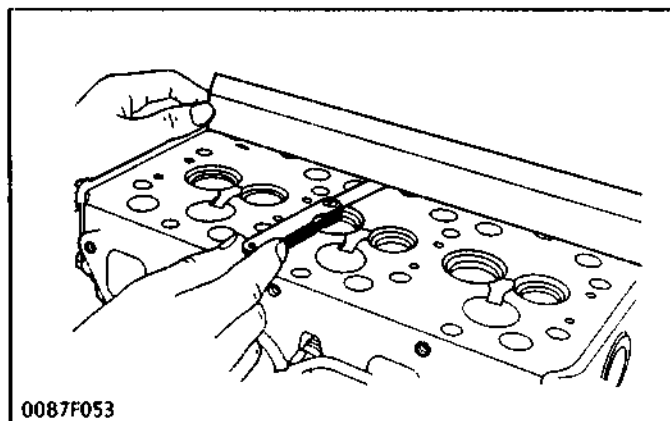
1. Remove the two bearing case screws 1 (4), and remove the main bearing case assembly 1 (3), being careful with the thrust bearing (2) and crankshaft bearing (5).
2. Remove the main bearing case 1, 2 and 3 (1) as above.

(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 markings (A, B, C) from the gear case side.
- Match the alignment numbers (6) on the main bearing case.
- When installing the main bearing case 1, 2 and 3, face the mark "FLYWHEEL" to the flywheel.
- Be sure to install the thrust bearing with its oil groove facing outward.
- Confirm that the main bearing case moves smoothly and horizontally after tightening the bearing case screw 1 to the specified torque.

SERVICING

[1] CYLINDER HEAD

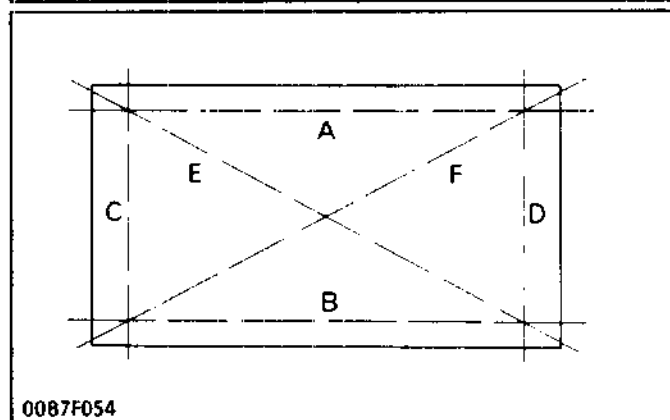


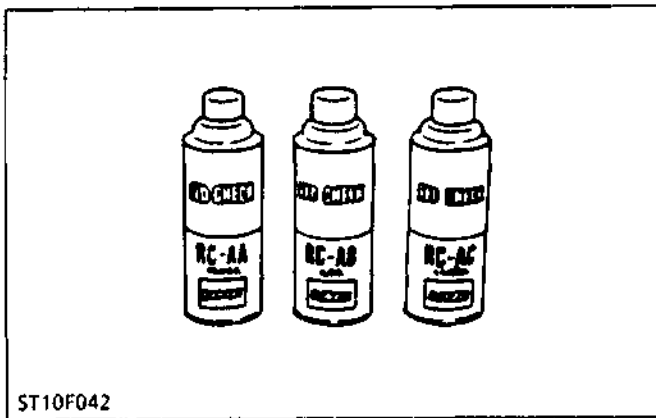
Cylinder Head Surface Flatness

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. Measure the clearance with a feeler gauge.
3. If the measurement exceeds the allowable limit, replace the cylinder head.

NOTE

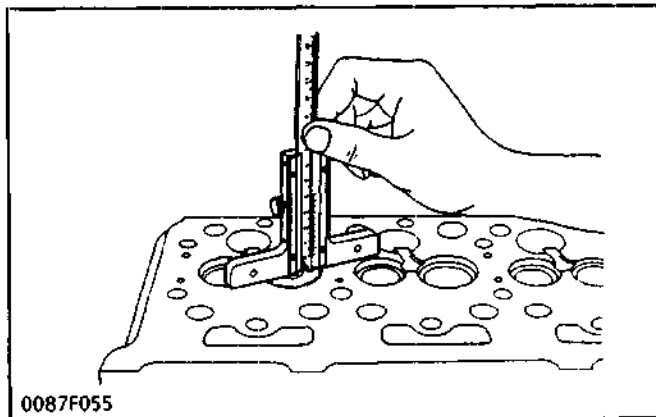
- Do not place the straight edge on the combustion chamber.





Cylinder Head Flaw

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

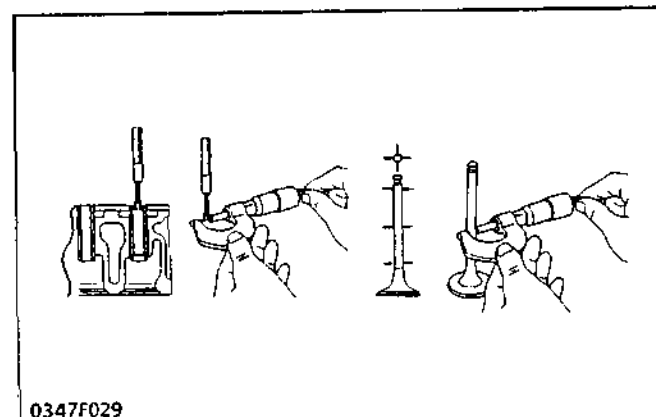
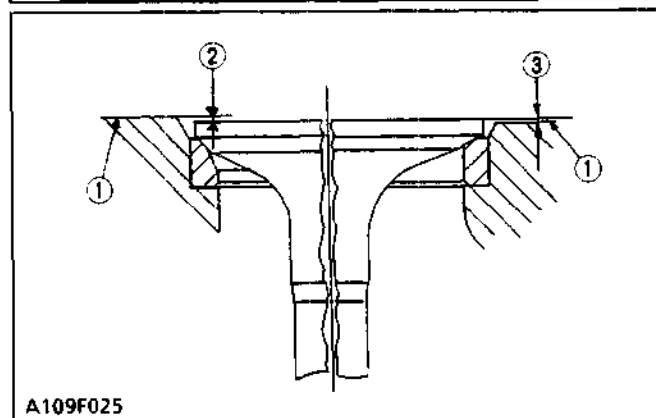


Valve Recessing

1. Clean the cylinder head, the valve face and seat.
2. Insert the valve into guide.
3. Measure the valve recessing or protrusion with a depth gauge or dial gauge.
4. If the measurement exceeds the allowable limit, replace the valve or cylinder head.

Valve recessing	Factory spec.	(Protrusion) 0.05 mm (0.0020 in.) to (recessing) 0.15 mm (0.0059 in.)
	Allowable limit	(recessing) 0.4 mm (0.0157 in.)

- (1) Cylinder Head Surface
(2) Recessing
(3) Protrusion



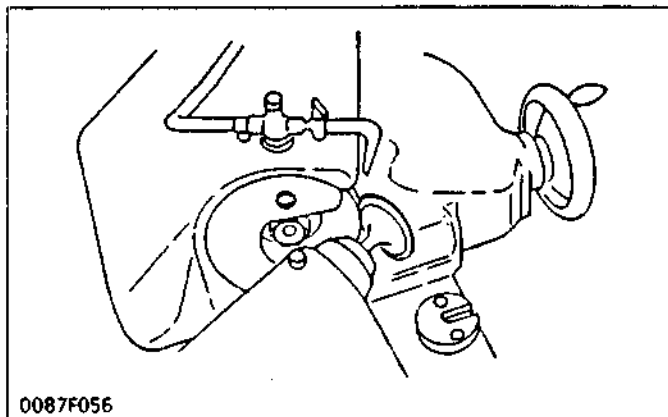
Clearance between Valve Stem and guide

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. of the cylinder head at the most wear part as shown in the figure below with a small hole gauge. And calculate the clearance.
4. If the clearance exceeds the allowable limit, replace the valves. If it still exceeds the allowable limit, replace the valve guide.

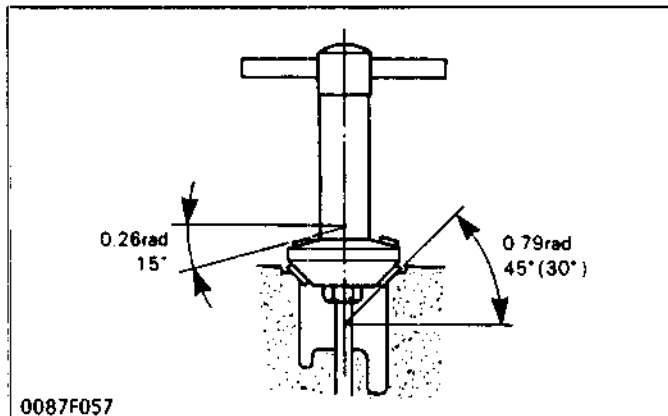
Clearance between valve stem and guide	Factory spec.	0.040 to 0.070 mm 0.0016 to 0.0028 in.
	Allowable limit	0.1 mm 0.0039 in.

Valve guide I.D.	Factory spec.	8.015 to 8.030 mm 0.3156 to 0.3161 in.
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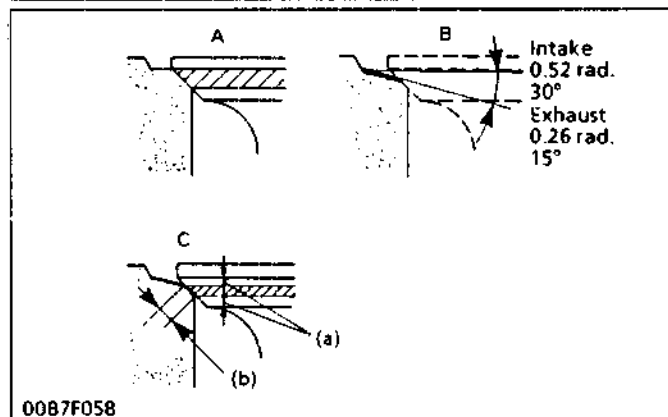
Valve stem O.D.	Factory spec.	7.960 to 7.975 mm 0.3134 to 0.3140 in.
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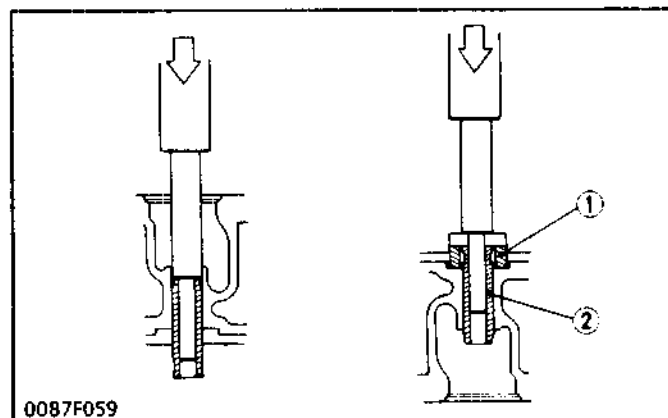
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0087F057



0087F058



0087F059

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.

2) Correcting Valve Seat

1. Slightly correct the seat surface with a 60° (Intake valve) or 45° (Exhaust valve) seat cutter (1) (Code No: 07909-33102).
2. Resurface the seat surface with 30° valve seat cutter to intake valve seat and with 15° valve seat cutter to exhaust valve seat so that the width is close to specified valve seat width. (2.12 mm 0.0835 in.)
3. After resurfacing the seat, inspect for even valve seating, apply a thin film of compound between the valve face and the valve seat, and fit them with valve lapping tool.
4. Check valve sealing with prussian blue, the valve seating surface should show good contact all the way around.

[A] Check Contact

[B] Correct Seat Width

[C] Check Contact

(a) Identical Dimensions

(b) Valve Seat Width

(When removing)

1. Using a valve guide replacing tool, press out the used valve guide.

(When installing)

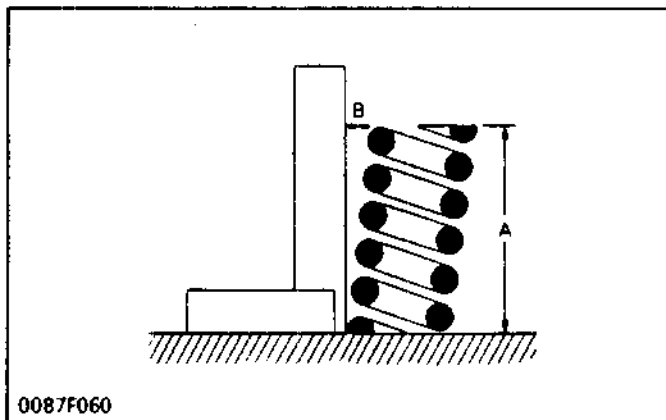
1. Clean a new valve guide, and apply engine oil to it.
2. Using a valve guide replacing tool, press in a new valve guide until it is flush with the cylinder head as shown in the figure.
3. Ream precisely the I.D. of the valve guide to the specified dimension. (See page S-16)

NOTE

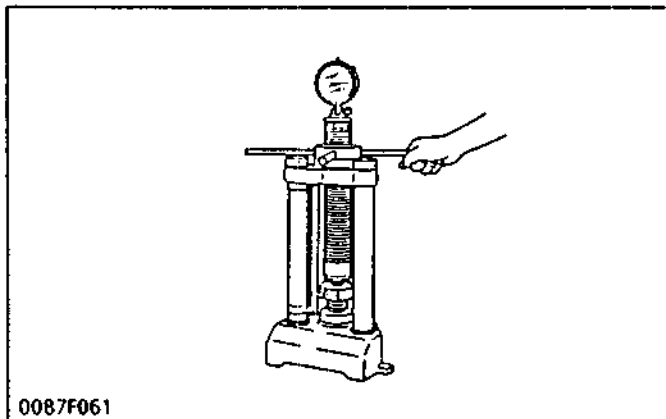
- Be careful not to strike valve guide with a hammer, etc. during replacement.

(1) Spacer

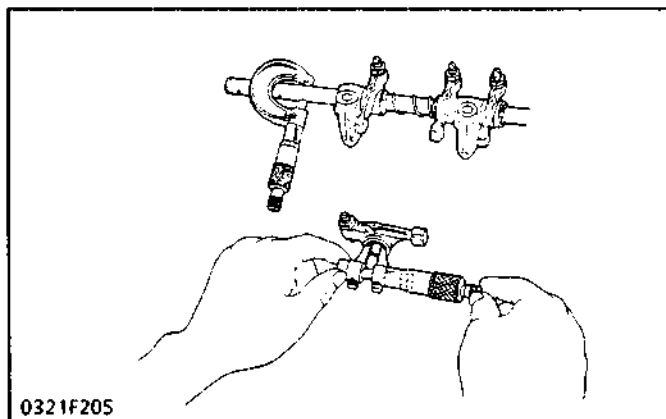
(2) Valve Guide



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0321F205

Valve Spring

1. Measure the length A with vernier calipers. If the measurement is less than the allowable limit, replace.
2. Put the spring on a surface plate, place a square on the side of the spring, and 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.
3. Check the entire surface of the spring for scratches. Replace it, if any.
4. Place the spring on a tester and compress it to the same length it is actually compressed in the engine. Read the compression load on the gauge. If the measurement exceeds the allowable limit, replace it.

Free length	Factory spec.	41.7 to 42.2 mm 1.6417 to 1.6614 in.
	Allowable limit	41.2 mm 1.6220 in.

Tilt	Factory spec.	1.0 mm 0.039 in.
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Setting load / Setting length	Factory spec.	12.0 kgf / 35.0 mm 117.6 N / 35.0 mm 26.4 lbs. / 1.3780 in.
	Allowable limit	10.2 kgf / 35.0 mm 100.0 N / 35.0 mm 22.5 lbs. / 1.3780 in.

Oil Clearance of Rocker Arm Shaft and Bearing

1. Measure the rocker arm bearing I.D. with an inside micrometer.
2. Measure the rocker arm shaft O.D. with an outside micrometer.
3. If the clearance exceeds the allowable limit, replace the bushing.
4. If the clearance still exceeds the allowable limit after replacing the bushing, replace the rocker arm shaft.

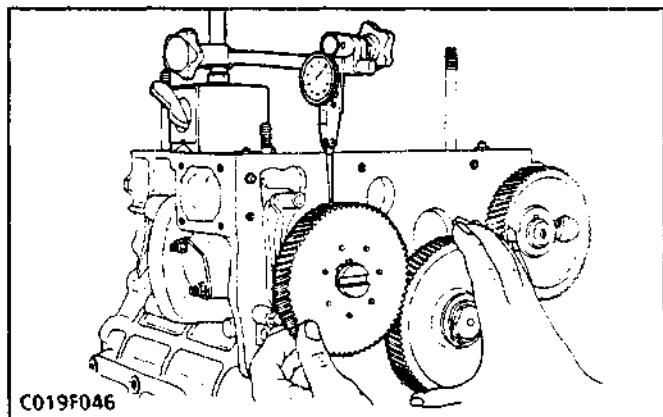
[With bushing]

Oil clearance of rocker arm shaft and bush	Factory spec.	0.018 to 0.070 mm 0.0007 to 0.0026 in.
	Allowable limit	0.15 mm 0.0059 in.
Rocker arm shaft O.D.	Factory spec.	13.973 to 13.984 mm 0.5501 to 0.5506 in.
Rocker arm bush I.D.	Factory spec.	14.002 to 14.043 mm 0.5513 to 0.5529 in.

[Bushless type]

Oil clearance of rocker arm shaft and bearing	Factory spec.	0.016 to 0.045 mm 0.0006 to 0.0015 in.
	Allowable limit	0.15 mm 0.0059 in.
Rocker arm shaft O.D.	Factory spec.	13.973 to 13.984 mm 0.5501 to 0.5506 in.
Rocker arm bush I.D.	Factory spec.	14.000 to 14.018 mm 0.5512 to 0.5517 in.

[2] TIMING GEAR AND CAMSHAFT

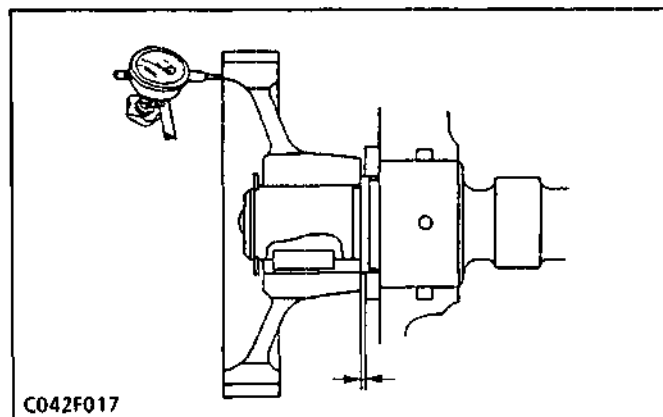


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Timing Gear Backlash

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

Crank gear Idle gear	Factory spec.	0.0415 to 0.1122 mm 0.0016 to 0.0044 in.
	Allowable limit	0.15 mm 0.0059 in.
Idle gear Cam gear	Factory spec.	0.0415 to 0.1154 mm 0.0016 to 0.0045 in.
	Allowable limit	0.15 mm 0.0059 in.
Idle gear Injection pump gear	Factory spec.	0.0415 to 0.1154 mm 0.0016 to 0.0045 in.
	Allowable limit	0.15 mm 0.0059 in.
Crank gear Oil pump gear	Factory spec.	0.0415 to 0.1090 mm 0.0016 to 0.0043 in.
	Allowable limit	0.15 mm 0.0059 in.

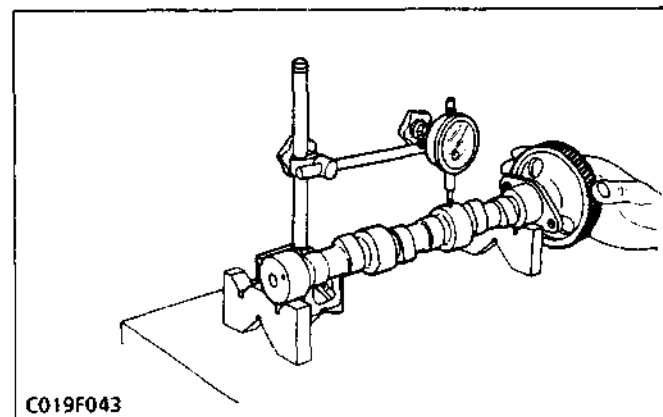


C042F017

End Play of Camshaft

1. Move the camshaft to the flywheel side.
2. Set a dial indicator to the cam gear face.
3. Pull the cam gear with the camshaft to its end.
4. Measure the clearance between the cam gear and camshaft stopper.
5. If the clearance exceeds the allowable limit, replace the camshaft stopper.

End play of camshaft	Factory spec.	0.07 to 0.22 mm 0.0027 to 0.0087 in.
	Allowable limit	0.3 mm 0.0118 in.

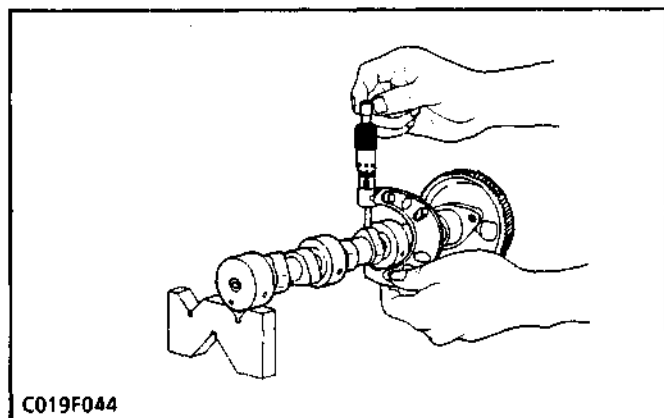


C019F043

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.

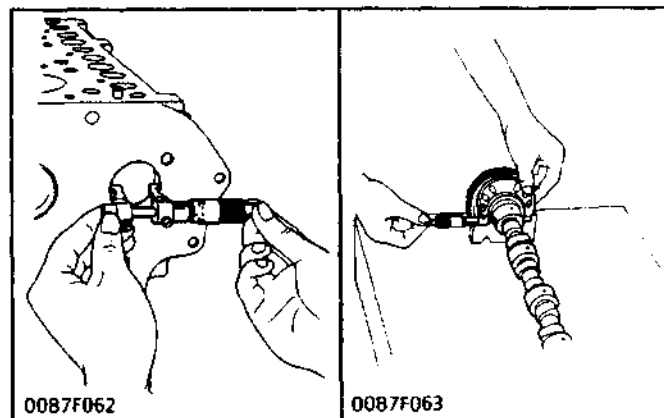
Camshaft alignment	Allowable limit	0.01 mm 0.00039 in.
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Intake and Exhaust Cam Height

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

Intake and exhaust cam height	Factory spec.	33.47 mm 1.3177 in.
	Allowable limit	33.42 mm 1.3157 in.



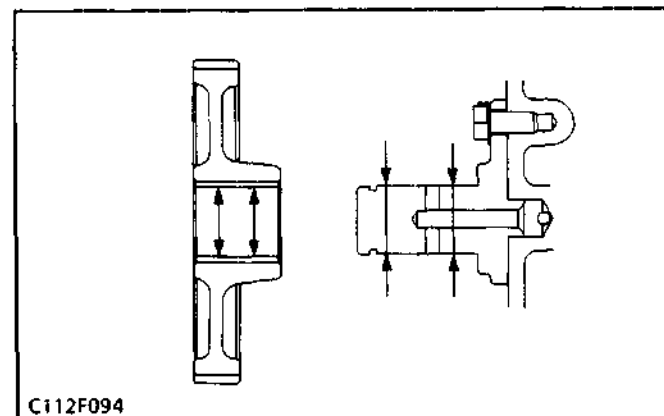
Oil Clearance of Camshaft Journal

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. Calculate the oil clearance.
3. If the 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.	39.934 to 39.950 mm 1.5722 to 1.5728 in.
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Camshaft bearing I.D.	Factory spec.	40.000 to 40.025 mm 1.5748 to 1.5758 in.
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Clearance between Idle Gear Shaft and Idle Gear

Bushing

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

Clearance between idle gear shaft and idle gear bushing	Factory spec.	0.025 to 0.066 mm 0.0010 to 0.0026 in.
	Allowable limit	0.1 mm 0.0039 in.

[V2203-B(E)]

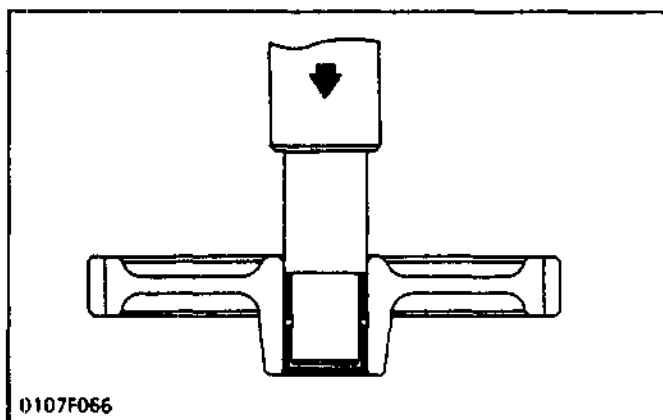
Idle gear bushing I.D.	Factory spec.	32.000 to 32.025 mm 1.2598 to 1.2608 in.
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Idle gear shaft O.D.	Factory spec.	31.959 to 31.975 mm 1.2582 to 1.2589 in.
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[D1403-B(E), D1703-B(E), V1903-B(E), F2803-B(E)]

Idle gear bushing I.D.	Factory spec.	38.000 to 38.025 mm 1.4961 to 1.4970 in.
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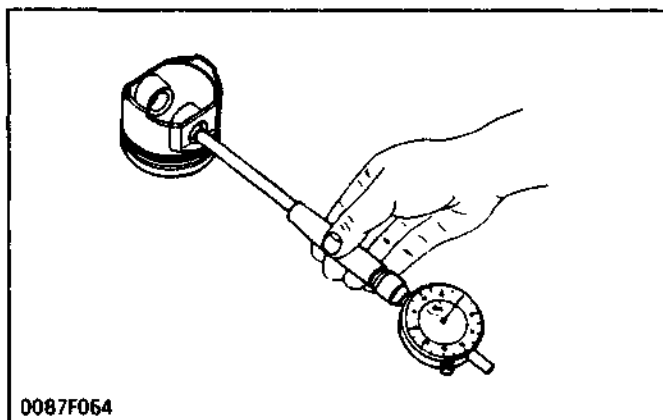
Idle gear shaft O.D.	Factory spec.	37.959 to 37.975 mm 1.4944 to 1.4951 in.
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Replacing Idle Gear Bushing

1. Press the used bushing out using a idle gear bushing replacing tool.
2. Press fit new bushing.

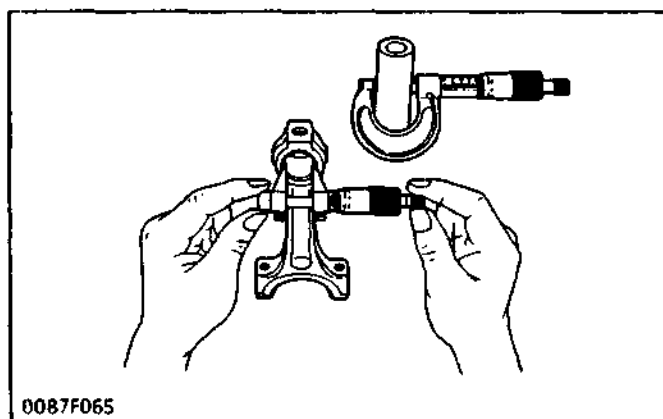
[3] PISTON AND CONNECTING ROD



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 bore I.D.	Factory spec.	25.000 to 25.013 mm 0.9843 to 0.9848 in.
	Allowable limit	25.05 mm 0.9862 in.



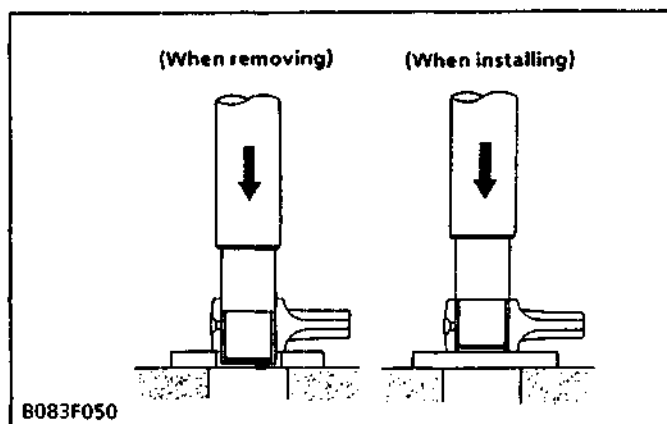
Oil Clearance between Piston Pin and Small End Bushing

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 piston pin bushing at the connecting rod small end with a cylinder gauge. 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 0.0006 to 0.0015 in.
	Allowable limit	0.15 mm 0.0059 in.

Piston pin O.D.	Factory spec.	25.002 to 25.011 mm 0.9843 to 0.9847 in.
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Small end bushing I.D.	Factory spec.	25.025 to 25.040 mm 0.9852 to 0.9858 in.
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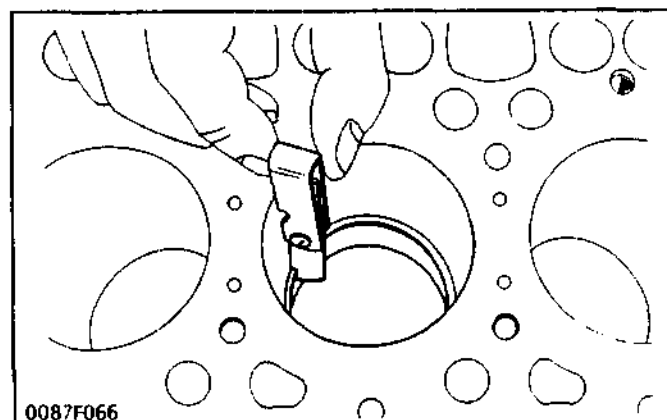
Replacing Connecting Rod Small End Bushing

(When removing)

1. Press out the small end bushing with a connecting rod small end bushing replacing tool.

(When installing)

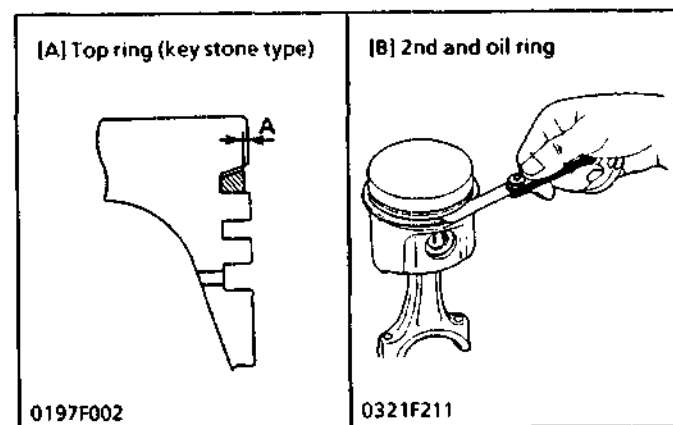
1. Clean a new small end bushing and bore, and apply engine oil to them.
2. Press fit a new bushing, taking due care to see that the connecting rod hole matches the bushing hole.



Piston Ring Gap

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

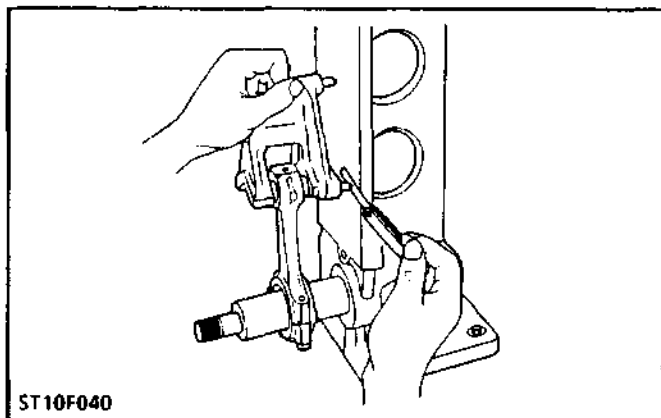
Compression ring 1, 2	Factory spec.	0.30 to 0.45 mm 0.0118 to 0.0177 in.
	Allowable limit	1.25 mm 0.0492 in.
Oil ring	Factory spec.	0.25 to 0.45 mm 0.0098 to 0.0177 in.
	Allowable limit	1.25 mm 0.0492 in.



Clearance between Piston Ring and Groove

1. Remove carbon from the ring grooves.
2. Measure the clearance between the ring and the groove with a feeler gauge or depth gauge.
3. If the clearance exceeds allowable limit, replace the ring since compression leak and oil shortage result.
4. If the clearance still exceeds the allowable limit after replacing the ring, replace the piston.

Factory spec.	2nd ring	0.093 to 0.12 mm 0.0037 to 0.0047 in.
	Oil ring	0.020 to 0.052 mm 0.00079 to 0.0020 in.
Allowable limit [B]	2nd ring	0.2 mm 0.0079 in.
	Oil ring	0.15 mm 0.0059 in.
Factory specification: A		More than 0.2 mm 0.0079 in.



Connecting Rod Alignment

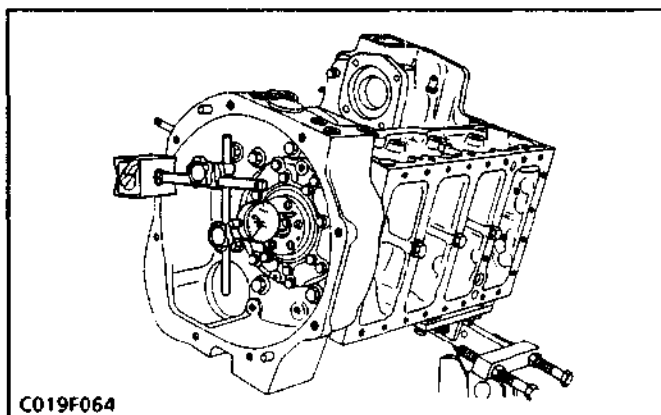
NOTE

- Since the I.D. of the connecting rod small end bushing is the basis of this check, check the bushing for wear beforehand.

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

Connecting rod alignment	Allowable limit	0.05 mm 0.0020 in.
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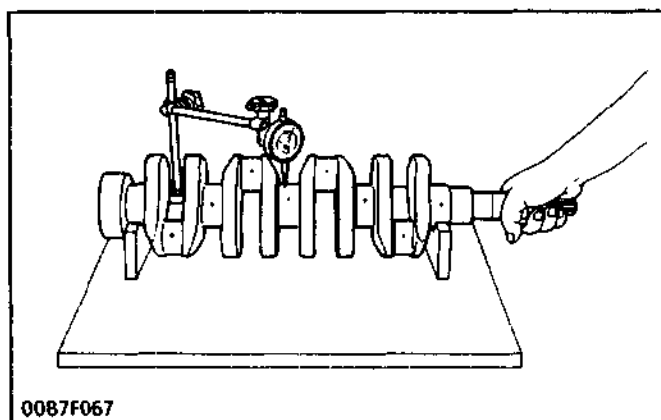
[4] CRANKSHAFT



Side Clearance of Crankshaft

1. Move the crankshaft to the flywheel side.
2. Set a dial indicator to the crankshaft.
3. Measure the end play by pulling the crankshaft toward the crank gear.
4. If the measurement exceeds the allowable limit, replace the thrust bearing 1 and 2.

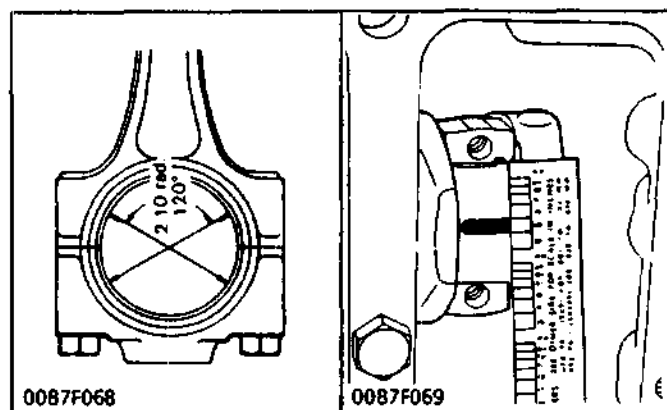
Crankshaft side clearance	Factory spec.	0.15 to 0.31 mm 0.0059 to 0.0122 in.
	Allowable limit	0.5 mm 0.0197 in.



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.

Crankshaft Alignment	Allowable limit	0.02 mm 0.00079 in.
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Oil Clearance between Crank Pin and Crank Pin Bearing

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 in each direction as shown in the figure.

IMPORTANT

- Never insert the press gauge into the crank pin oil hole.
3. Install the connecting rod cap and tighten the screws to the specified torque, and remove the cap again.

NOTE

- Fasten the crankshaft so that it does not turn.
4. Measure the amount of the flattening with the scale and get the oil clearance.
 5. If the clearance exceeds the allowable limit, replace the bearing.

(Reference)

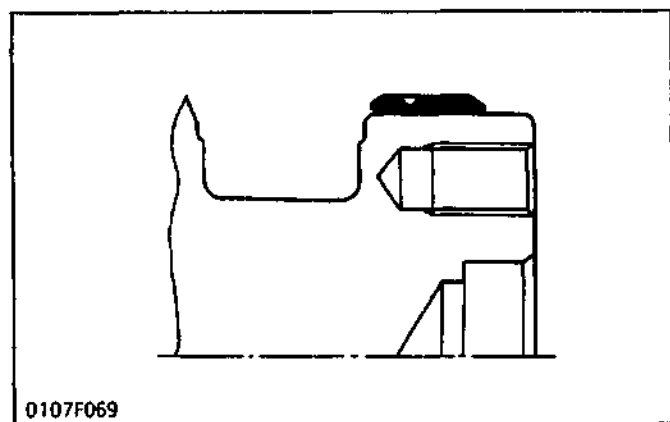
- When the oil clearance is to be measured by removing the crankshaft, tighten the connecting rod cap with the specified torque, then measure the crank pin bearing I.D. with a cylinder gauge or an inside micrometer. And measure the crank pin O.D. with an outside micrometer. Calculate the oil clearance.

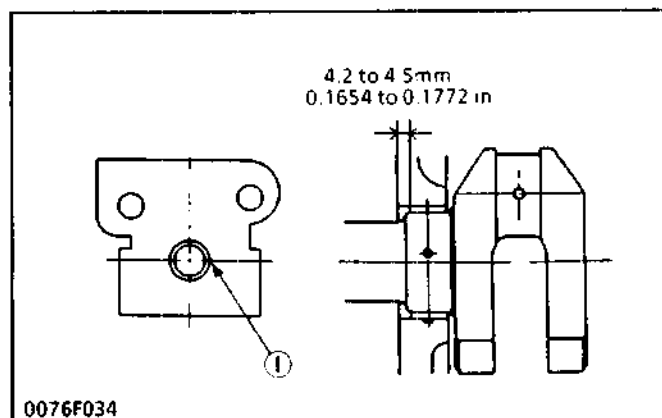
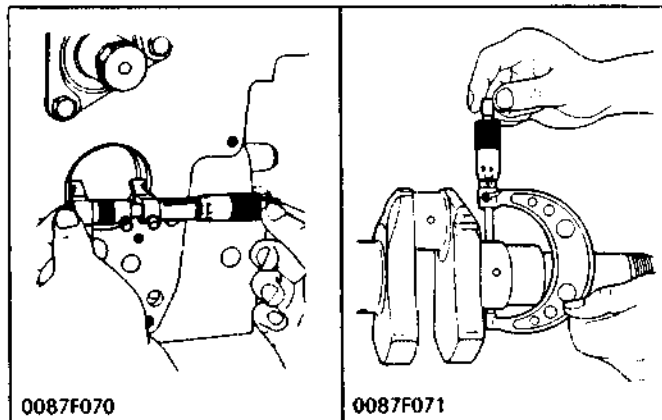
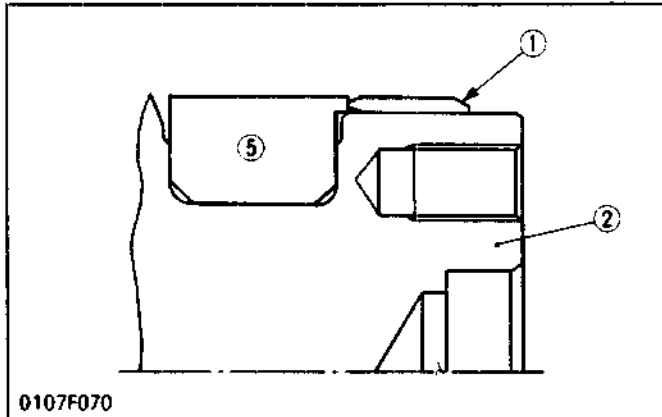
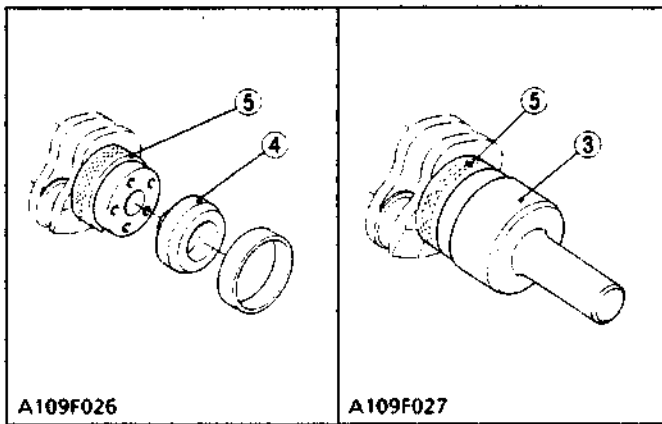
Oil clearance between crank pin and crank pin bearing	Factory spec.	0.025 to 0.087 mm 0.0009 to 0.0034 in.
	Allowable limit	0.2 mm 0.0079 in.
Crank pin O.D.	Factory spec.	46.959 to 46.975 mm 1.8488 to 1.8494 in.
Crank pin bearing I.D.	Factory spec.	47.000 to 47.046 mm 1.8504 to 1.8522 in.

Crankshaft Sleeve Wear

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

Wear of sleeve	Allowable limit	0.1 mm 0.004 in.
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Replacing Crankshaft Sleeve

1. Remove the used crankshaft sleeve using a special-use puller set (Code No:07916-32091).
2. Set the sleeve guide (4) to the crankshaft.
3. Set the stopper (5) to the crankshaft as shown in figure.
4. Heat a new sleeve to a temperature between 150 and 200°C (302 and 392°F), and fix the sleeve to the crankshaft as shown in figure.
5. Press fit the sleeve using the auxiliary socket for pushing (3).

NOTE

- Mount the sleeve with its largely chamfered surface facing outward.

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

Oil Clearance between Crankshaft Journal and Crankshaft Bearing 1

1. Measure the O.D. of the crankshaft journal with an outside micrometer.
2. Measure the I.D. of the crankshaft bearing 1 with an inside micrometer. Calculate the oil clearance.
3. If the clearance exceeds the allowable limit, replace the crankshaft bearing 1.

Oil clearance between crankshaft journal and crankshaft bearing 1	Factory spec.	0.04 to 0.118 mm 0.0016 to 0.0046 in.
	Allowable limit	0.2 mm 0.0079 in.

Crankshaft journal 1 O.D.	Factory spec.	51.921 to 51.940 mm 2.0441 to 2.0449 in.
Crankshaft bearing 1 I.D.	Factory spec.	51.980 to 52.039 mm 2.0466 to 2.0488 in.

Replacing Crankshaft Bearing 1

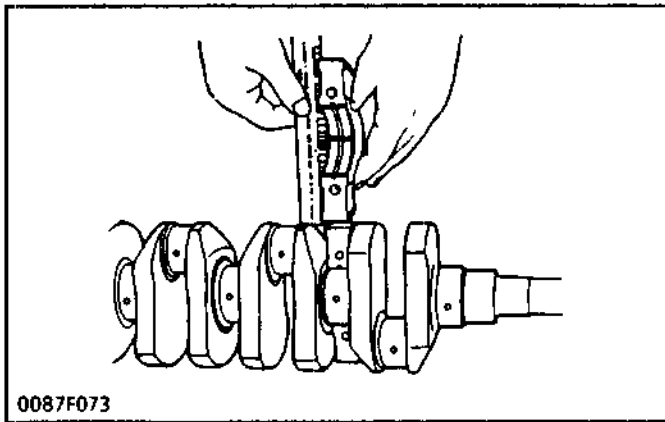
(When removing)

1. Press out the bearing 1 with crankshaft bearing 1 replacing tool.

(When installing)

1. Clean a new bearing 1 and bore, and apply engine oil to them.
2. Press fit a new bearing 1 using an inserting tool, taking due care to see that the seam of bearing 1 faces the exhaust manifold side.

- (1) Seam



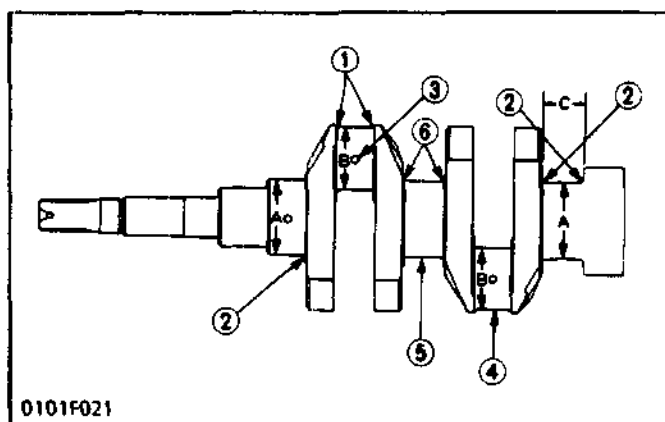
Oil Clearance between Crankshaft Journal and Crankshaft Bearing 2

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

■ IMPORTANT

- Never insert the plastigage into the oil hole of the journal.
3. Install the main bearing case and tighten the screws to the specified torque, and remove the cases again.
 4. Measure the amount of the flattening with the scale and get the oil clearance.
 5. If the clearance exceeds the allowable limit, replace the crankshaft bearing.

Oil clearance between crankshaft and crankshaft bearing 2	Factory spec.	0.04 to 0.104 mm 0.0016 to 0.0041 in.
	Allowable limit	0.2 mm 0.0079 in.
Crankshaft O.D.	Factory spec.	51.921 to 51.940 mm 2.0441 to 2.0449 in.
Crankshaft bearing 2 I.D.	Factory spec.	51.980 to 52.025 mm 2.0466 to 2.0482 in.



Undersized and Oversized Bearing

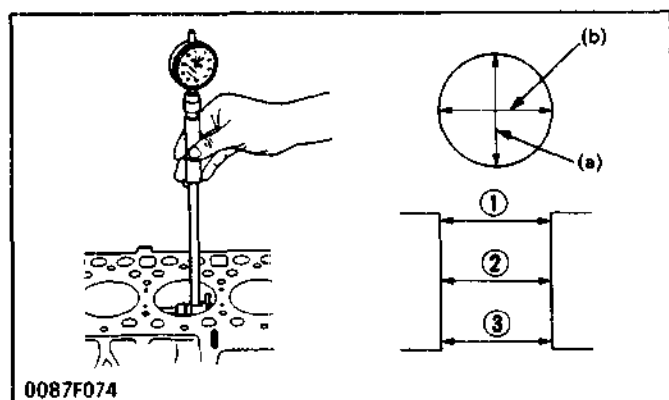
If the standard-size bearing cannot be employed due to excessive wear of the crank pin and crank journal, employ under-size or over-size bearings.

For under size or oversize bearing use, take the precautions noted below.

1. The crank pin (4), crank journal (5) and crank journal side surface (6) must be fine-finished to higher than $\frac{0.4-5}{\text{VVVV}}$ (0.000016 in.-5)
2. Grind the crankpin (4) and journal (5) with a wheel which has specified round corner and width without shoulder.
3. Be sure to chamfer the oil hole circumference (3) with an oil stone.
 - (1) 3.3 to 3.7 mm radius (0.1299 to 0.1457 in. radius)
 - (2) 2.8 to 3.2 mm radius (0.1102 to 0.1260 in. Radius)
 - (3) Oil hole must be 1.0 to 1.5 mm Radius (0.0394 to 0.0591 in. Radius)

Size	Code No.	Name of bearing	Bearing mark	Crankshaft processing dimension	
-0.2 mm -0.008 in.	17331-2391-1	Crankshaft bearing 1 (0.2 minus)	020 US	A	51.721 to 51.740 mm 2.0363 to 2.0370 in.
-0.2 mm -0.008 in.	17331-2393-1	Crankshaft bearing 2 (0.2 minus)	020 US		
-0.4 mm -0.016 in.	17331-2392-1	Crankshaft bearing 1 (0.4 minus)	040 US		51.521 to 51.540 mm 2.0284 to 2.0291 in.
-0.4 mm -0.016 in.	17331-2394-1	Crankshaft bearing 2 (0.4 minus)	040 US		
-0.2 mm -0.008 in.	17331-2297-1	Crank pin bearing (0.2 minus)	020 US	B	46.759 to 46.775 mm 1.8409 to 1.8415 in.
-0.4 mm -0.016 in.	17331-2298-1	Crank pin bearing (0.4 minus)	040 US		46.559 to 46.575 mm 1.8330 to 1.8337 in.
+ 0.2 mm + 0.008 in.	15221-2395-1	Thrust bearing 1 (0.2 plus)	020 OS	C	26.20 to 26.25 mm 1.0315 to 1.0335 in.
	19202-2397-1	Thrust bearing 2 (0.2 plus)			
+ 0.4 mm + 0.016 in.	15221-2396-1	Thrust bearing 1 (0.4 plus)	040 OS		26.40 to 26.45 mm 1.0394 to 1.0413 in.
	19202-2398-1	Thrust bearing 2 (0.4 plus)			

[5] CYLINDER BORE

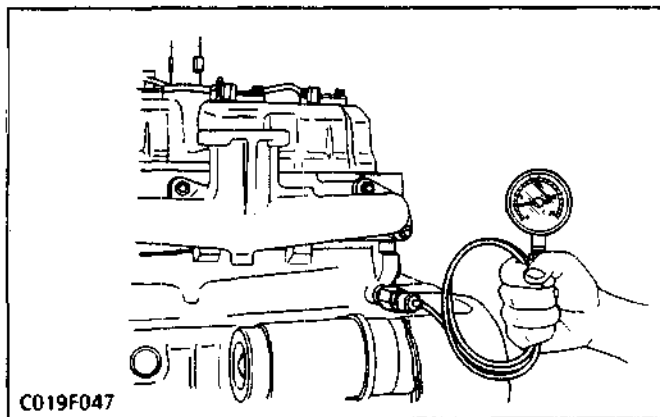


Cylinder Bore I.D.

1. Measure the six points shown in the figure with a cylinder gauge to find out the maximum wear. Generally, position (1) in the (a, b) direction (at about 20 mm (0.79 in.) from the top) shows the maximum wear. Since position (3) at the lower part of the bore will show the minimum wear, find these difference. (See page 5-19)

2 LUBRICATING SYSTEM

CHECKING



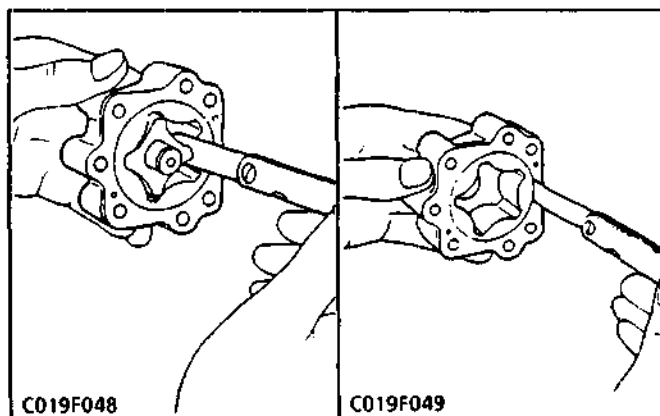
Engine Oil Pressure

1. Remove the oil switch and set a pressure tester (Code No: 07916-32031).
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 gallery clogged
 - Excessive oil clearance of bearing
 - Foreign matter in the relief valve

At idle speed	Allowable limit	0.5 kgf/cm ² 49 kPa, 7 psi
At rated speed	Factory spec.	3.0 to 4.5 kgf/cm ² 294.2 to 441 kPa 42.7 to 64 psi
	Allowable limit	2.5 kgf/cm ² 245 kPa 36 psi

SERVICING

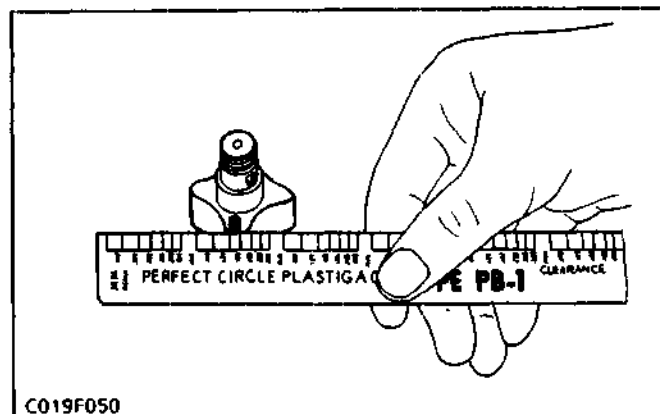
[1] OIL PUMP



Rotor and Lobe Clearance

1. Measure the clearance between lobes of the inner rotor and the outer rotor with a feeler gauge.
2. Measure the clearance between the outer rotor and the pump body with a feeler gauge.
3. If the clearance exceeds the factory spec. replace the oil pump rotor assembly.

Clearance between inner rotor and outer rotor	Factory spec.	0.03 to 0.14 mm 0.0012 to 0.0055 in.
Clearance between outer rotor and pump body	Factory spec.	0.11 to 0.19 mm 0.0043 to 0.0075 in.



Clearance between Rotor and Cover

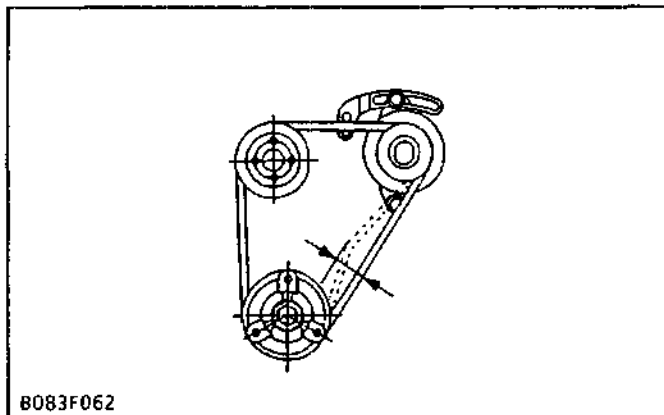
1. Put a strip of plastigage (Code No: 07909-30241) onto the rotor face with grease.
2. Install the cover and tighten the screws.
3. Remove the cover carefully, and measure the width of the press gauge with a sheet of gauge.
4. If the clearance exceeds the factory spec. replace oil pump rotor assembly.

End clearance between inner rotor and cover	Factory spec.	0.105 to 0.150 mm 0.0041 to 0.0059 in.
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3 COOLING SYSTEM

CHECKING

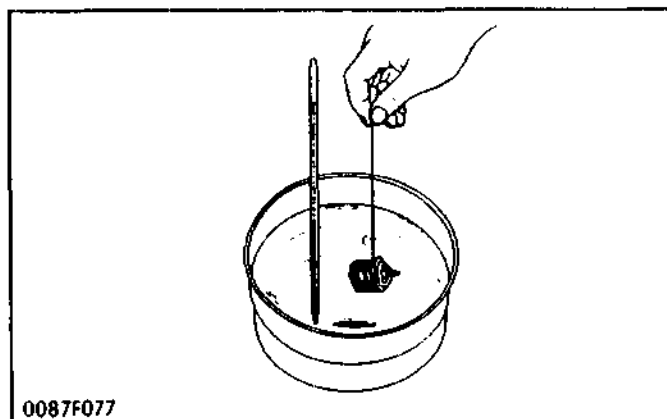
[1] FAN BELT



Fan Belt Tension

1. Press the fan belt between fan pulley and pulley at force of 10 kgf (98N, 22 lbs). Check if the fan belt deflection is 10 to 12 mm (0.394 to 0.472 in.)
2. If the deflection is not within the factory specifications, loosen the bolt and nuts, and relocate the alternator to adjust.

[2] RADIATOR



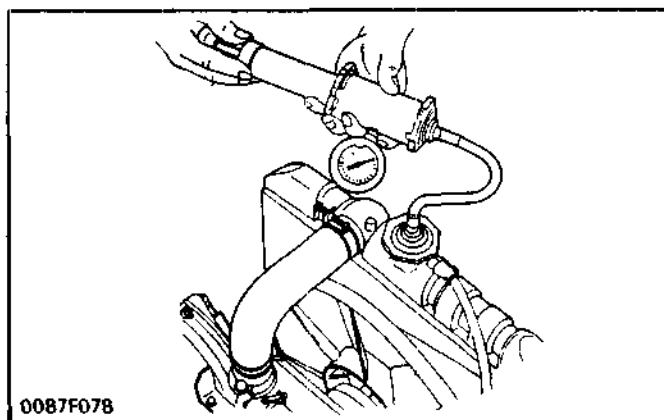
CAUTION

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

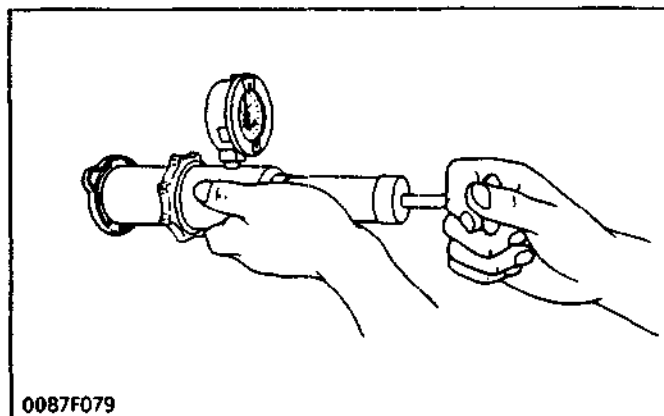
Thermostat's Valve Opening Temperature

1. Push down the thermostat valve and insert a string between the valve and the valve seat.
2. Place the thermostat and a thermometer in a container with water and gradually heat the water.
3. Hold the string to suspend the thermostat in the water. When the water temperature rises, the thermostat valve will open, allowing it to fall down from the string. Read the temperature at this moment on the thermometer.
4. Continue heating the water and read the temperature when the valve has risen by about 8 mm (0.315 in.).
5. If the measurement is not acceptable, replace the thermostat.

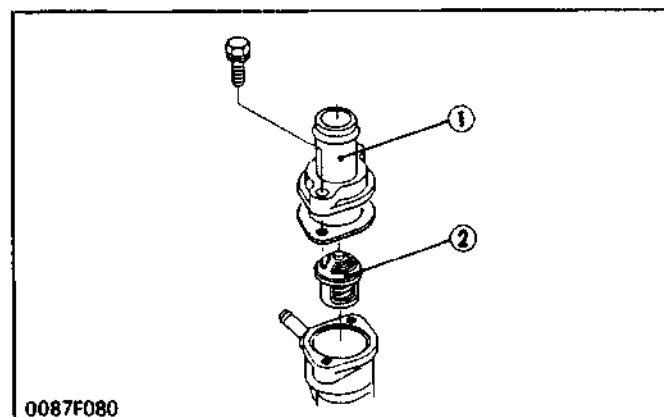
Thermostat's valve opening temperature	Factory spec.	69.5 to 72.5°C 157.1 to 162.5°F
Temperature at which thermostat completely opens	Factory spec.	85°C 185.5°F

**Radiator Water Leakage**

1. Pour a specified amount of water into the radiator.
2. Set a radiator tester (Code No: 07909-31551). Increase water pressure to the specified pressure of 1.4 kgf/cm² (137 kPa, 20 psi).
3. Check each section for water leakage.
4. When water leakage is excessive, replace the radiator. If water leakage is caused by a small pinhole, correct the radiator with radiator cement.

**Radiator Cap Air Leakage**

1. Set a radiator tester (Code No: 07909-31551) to the radiator cap.
2. Apply the specified pressure of 0.9 kgf/cm² (98.1 kPa, 12.8 psi).
3. Check if the pressure drop to less than 0.6 kgf/cm² (59 kPa, 9 psi) in 10 seconds.
4. If the pressure is less than the factory specification, replace it.

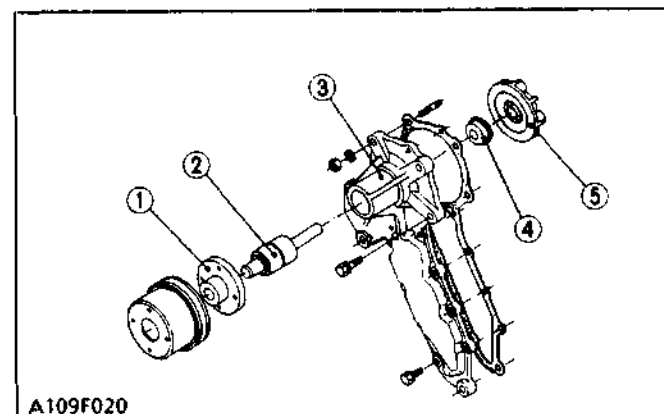
DISASSEMBLING AND ASSEMBLING**Thermostat**

1. Remove the thermostat cover (1).
2. Remove the thermostat (2).

(When reassembling)

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

- (1) Thermostat Cover
(2) Thermostat

**Water Pump**

1. Remove the fan and fan pulley.
2. Remove the water pump from gear case cover.
3. Remove the water pump flange (1).
4. Press out the water pump shaft (2) with the impeller (5) on it.
5. Remove the impeller from the water pump shaft.
6. Remove the mechanical seal (4).

(When reassembling)

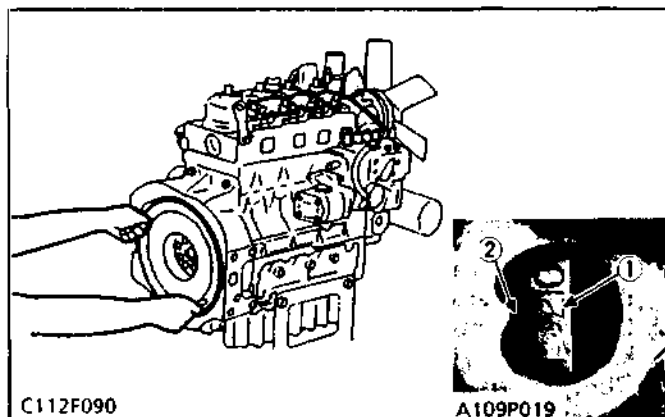
- Replace the mechanical seal with new one.

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

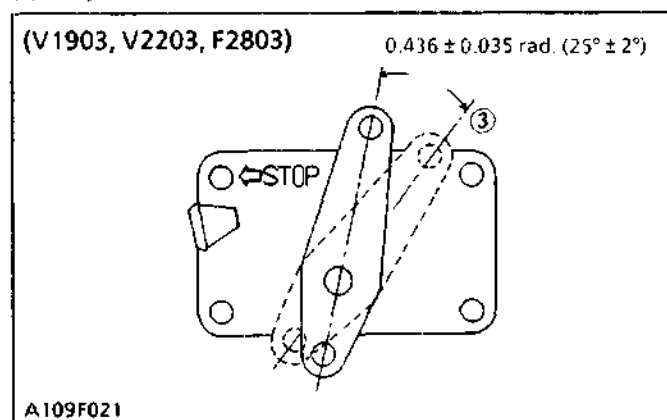
4 FUEL SYSTEM

CHECKING AND ADJUSTING

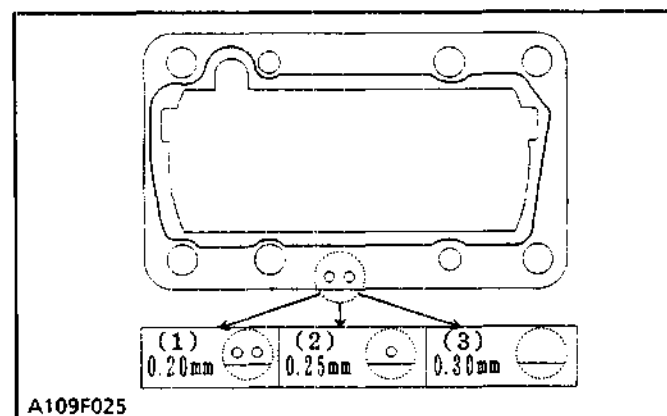
[1] INJECTION PUMP



- (1) Timing Mark
(2) Projection



- (3) Stop Lever in Free Position



- (5) 2-holes : 0.20 mm
(6) 1-hole : 0.25 mm
(7) Without hole : 0.30 mm

Injection Timing

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

NOTE

- The F2803, V2203 and V1903 pumps have a displacement angle. In adjusting the injection timing, pull the stop lever from its free position by $0.436 \pm 0.035 \text{ rad. } (25^\circ \pm 2^\circ)$ toward the stop position.
- 3. Turn the flywheel counterclockwise (facing the flywheel) until the fuel fills up to the hole of the delivery valve holder for 1st cylinder.
- 4. Turn the flywheel further and stop turning when the fuel begins to flow over, to get the present injection timing.
- 5. (The flywheel has mark 1TC and four lines indicating every $0.087 \text{ rad. } (5^\circ)$ of crank angle from $0.175 \text{ rad. } (10^\circ)$ to $0.436 \text{ rad. } (25^\circ)$ before mark 1TC) Calculate the angle which the projection of the window points out. If the calculation differs from specified injection timing, add or remove the shim to adjust.

(Injection Timing)

- D1403 / D1703 : $0.14 \text{ to } 0.27 \text{ rad.}$
 V1903 / V2203 : $(17^\circ \text{ to } 19^\circ) \text{ B.T.D.C.}$
 F2803 : $0.314 \text{ to } 0.349 \text{ rad. } (18^\circ \text{ to } 20^\circ) \text{ B.T.D.C.}$

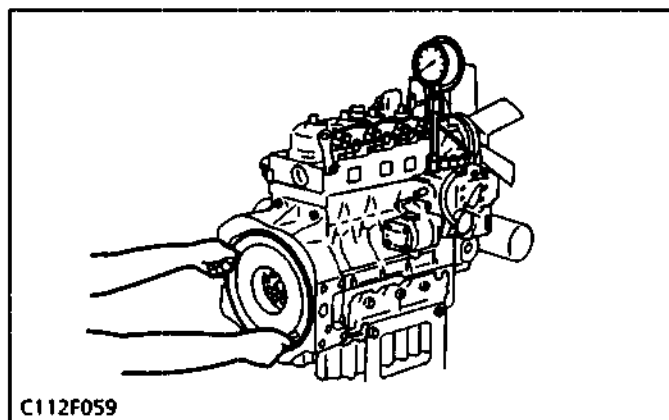
NOTE

(Engine serial number : D1403-12211, D1703-4253, V1903-1562, V2203-60896, F2803-105567 or lower)

- 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. $0.026 \text{ rad } (1.5^\circ)$.
- 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 : D1403-12212, D1703-4254, V1903-1563, V2203-60897, F2803-105568 or higher)

- 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. $0.0087 \text{ rad } (0.5^\circ)$.
- In disassembling and replacing, be sure to use the same number of new gasket shims with the same thickness.



Fuel Tightness of Pump Element

1. Remove the injection pipe.
2. Install the injection pump pressure tester (1) to the injection pump.
3. Set the speed control lever to the maximum speed position.
4. Turn the flywheel ten times or more to increase the pressure.
5. If the pressure can not reach the allowable limit, replace the pump element or injection pump assembly.

Fuel tightness of pump element	Allowable limit	150 kgf/cm ² 14.7 MPa, 2133 psi
--------------------------------	-----------------	---

(1) Injection Pump Pressure Tester

Fuel Tightness of Delivery Valve

1. Set a pressure tester to the fuel injection pump.
2. Rotate the flywheel and raise the pressure to 155-160 kg/cm².
3. Now turn the flywheel back about half a turn (to keep the plunger free). Maintain the flywheel at this position and clock the time taken for the pressure to drop from the 150 kg/cm² down to 140 kg/cm².
4. Measure the time needed to decrease the pressure from 150 to 140 kg/cm² (14.7 to 13.7 MPa, 2133 to 1990 psi).
5. If the measurement is less than allowable limit, replace the delivery valve.

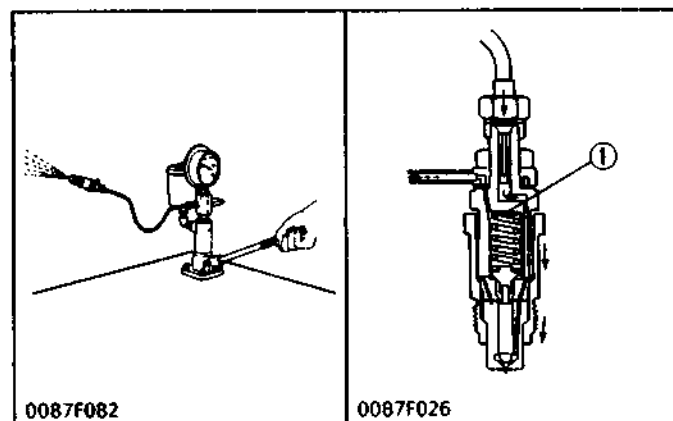
Fuel tightness of delivery valve	Allowable limit	5 seconds 150 → 140 kgf/cm ² 14.7 → 13.7 MPa 2133 → 1990 psi
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[2] INJECTION NOZZLE



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.



(1) Adjusting Washer

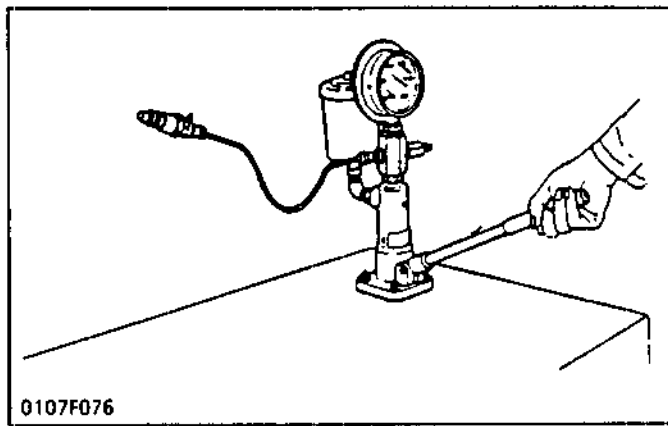
Nozzle Injection Pressure

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, disassemble the injection nozzle, and change adjusting washer (1) until the proper injection pressure is obtained.

(Reference)

- Pressure variation with 0.025 mm (0.00098 in.) difference of adjusting washer thickness.
Approx. 6 kgf/cm² (588.6 kPa, 85.32 psi)

Fuel injection pressure	Factory spec.	140 to 150 kgf/cm ² 13.73 to 14.71 MPa 1991 to 2133 psi
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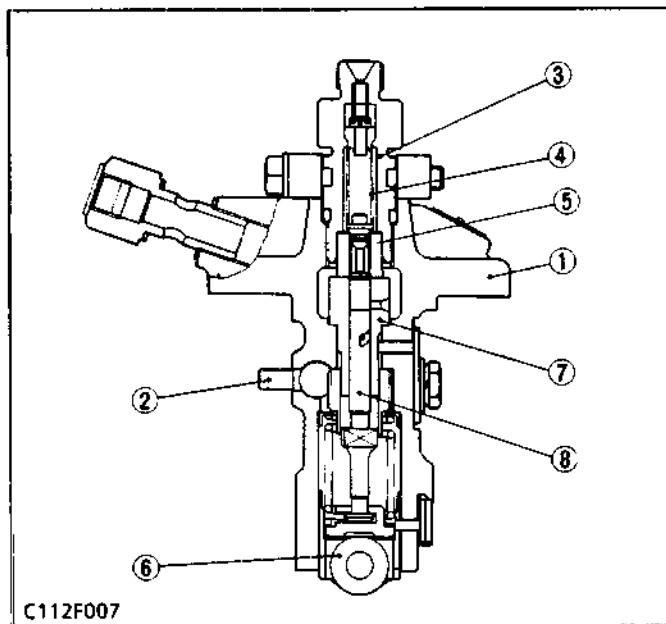


Fuel Tightness of Needle Valve Seat

1. Set the injection nozzle to a nozzle tester. Apply a pressure 130kgf/cm² (12.75 MPa, 1849 psi).
2. After keeping the nozzle under this pressure for 10 seconds, check to see if fuel leaks from the nozzle.
3. If fuel should leak, replace the nozzle piece.

DISASSEMBLING AND ASSEMBLING

[1] INJECTION PUMP

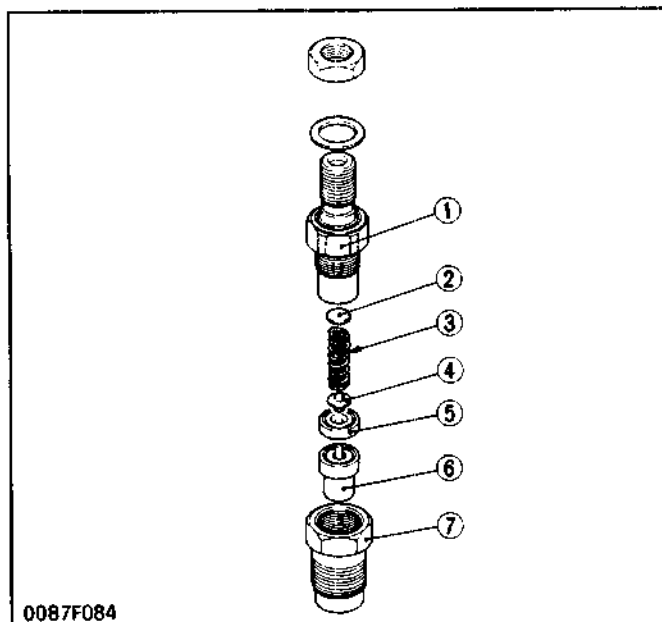


■ IMPORTANT

- If replacing the pump element, the amount of fuel injection should be adjusted on a specified bench.

- (1) Pump Body
- (2) Control Rack
- (3) Delivery Valve Holder
- (4) Delivery Valve Spring
- (5) Delivery Valve
- (6) Tappet Roller
- (7) Cylinder
- (8) Plunger

[2] INJECTION NOZZLE



Nozzle Holder

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

(When reassembling)

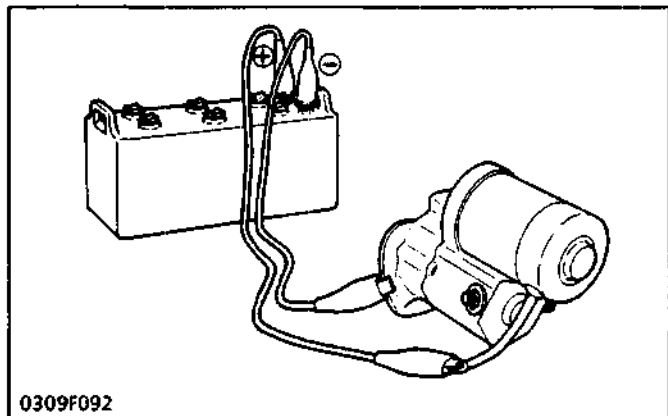
- Assemble the nozzle in clean fuel oil.
- Install the push rod (4), noting its direction.
- After assembling the nozzle, be sure to adjust the fuel injection pressure.

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

5 ELECTRICAL SYSTEM

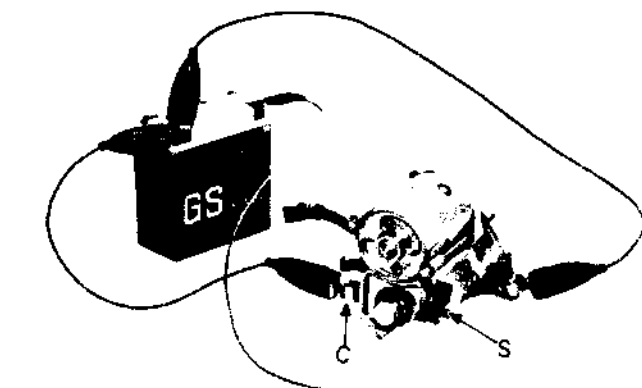
CHECKING

[1] STARTER



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.



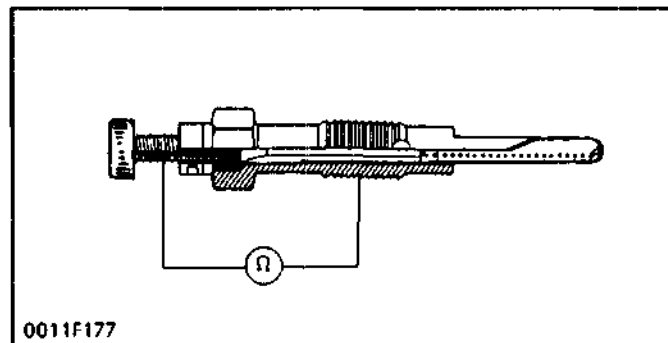
Magnet Switch

1. Disconnect the connecting lead from the "C" terminal of the starter.
2. Connect jumper leads from the negative terminal of 6 V battery to the body and "C" terminal of the magnet switch.
3. The pinion gear should pop out, when a jumper lead is connected between the positive terminal of the battery to the "S" terminal of the magnet switch.
4. The pinion gear should stay out without the jumper from the negative terminal to the "C" terminal.

NOTE

- Each test should be carried out for a short time, about 3 to 5 seconds.

[2] GLOW PLUG

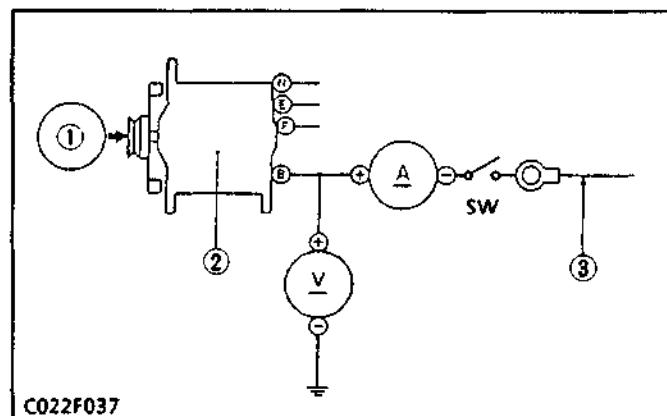


Glow Plug

1. Disconnect the leads from the glow plugs.
2. Measure the resistance with an 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 indicated, the glow plug is faulty, replace the glow plug.

Glow plug resistance	Factory spec.	0.8 Ω
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[3] STANDARD-ALTERNATOR AND REGULATOR



C022F037

(1) Revolution Counter
(2) Alternator

(3) B terminal Lead

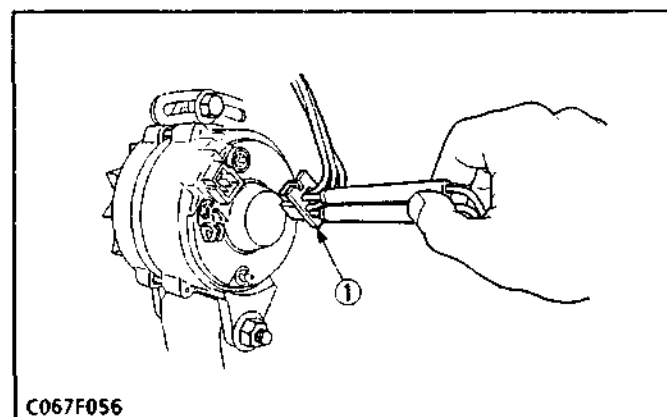
Output Current

1. Disconnect the cable from the alternator's B terminal and connect an ammeter and voltmeter to B terminal. Then switch on all electrical loads (such as lights and battery) and read the meters.

Output current	35 A
Voltage	14 V
Rotational speed	4000 rpm

NOTE

- Be sure to disconnect the battery's negative cable before setting the ammeter and voltmeter.
- When the electrical load is considerably low or the battery is fully charged, the specified reading cannot be obtained.



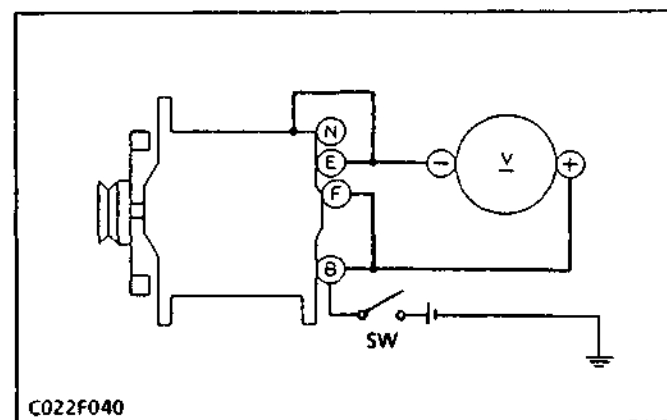
C067F056

Connector Voltage

1. Disconnect the connector from the alternator.
2. Turn the main switch on and then measure the voltage across the alternator connector's F and E terminals.

Connector voltage (F-E)	Factory spec.	12 V
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(1) Coupler

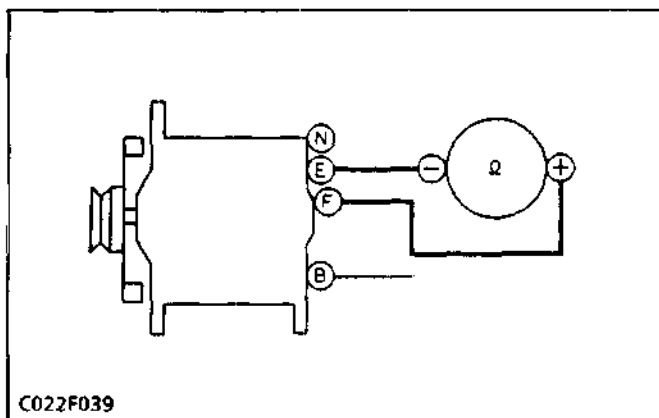


C022F040

No-Load Testing

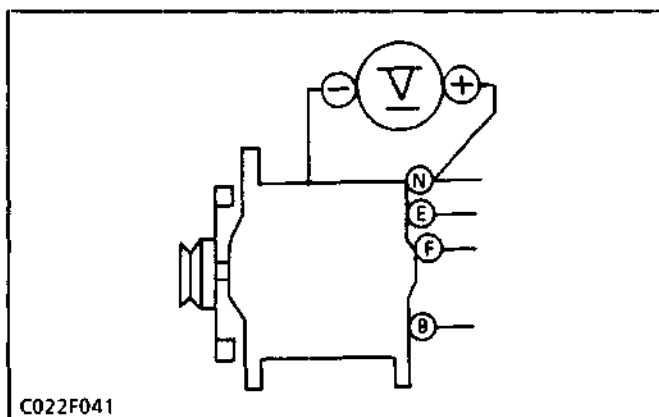
1. Disconnect the alternator's connector, connect the alternator's F terminal to B terminal, and ground E terminal to the body. (Do not remove the B terminal lead to battery.)
2. Start the engine and speed up the alternator to the specified rpm. (1050 to 1350). Next, turn the key-switch off of battery circuit or disconnect the battery's negative cable.
3. Connect a voltmeter across B terminal and E terminal and measure the voltage.

Voltage	14 V
Rotational speed	1050 to 1350 rpm

**Rotor Coil Resistance**

1. Disconnect the alternator connector and then measure the resistance across the alternator's F and E terminals.

Terminal resistance (F - E)	Factory spec.	4 ohms
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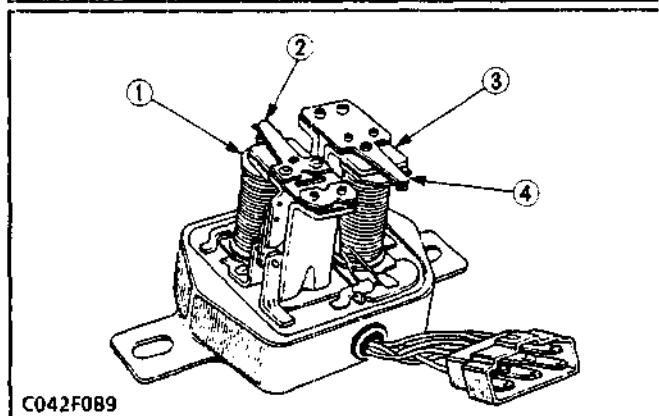
**Cut-In Voltage**

1. Connect a voltmeter across the alternator's N terminal and the body.
2. Remove the fuse shown in below and connect a bulb (30W) in its place.
3. Speed up the alternator until the charge warning lamp goes off or dims, then read the voltmeter.

Cut-in voltage	Factory spec.	4.5 to 5.8 V
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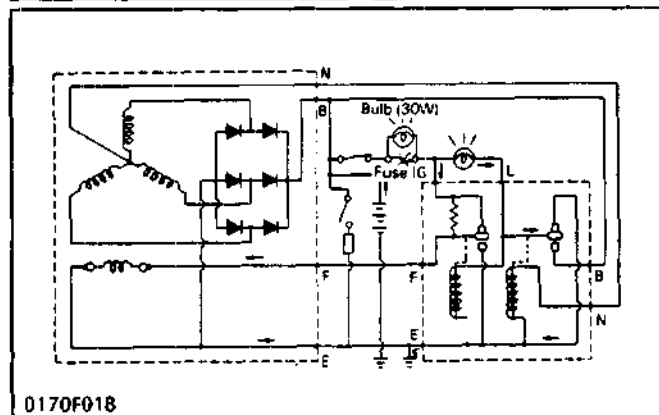
NOTE

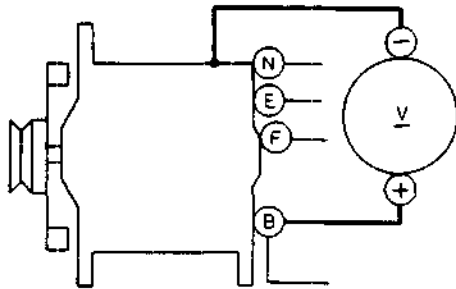
- When the cut-in voltage is high, bend the adjusting arm (4) of voltage relay close to the pressure coil, and when low, bend it away from.



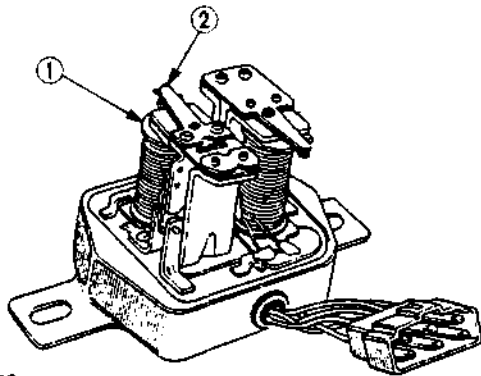
- (1) Voltage Regulator
(2) Adjusting Arm

- (3) Voltage Relay
(4) Adjusting Arm





C022F042



C042F089

No-Load Regulating Voltage

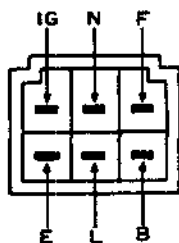
1. Connect a voltmeter across the alternator's B terminal and the ground.
2. Start the engine, speed up to a rate (approx. 1300 rpm) where the alternator is self-excited, and disconnect the battery's negative cable.
3. Read the voltmeter while gradually accelerating the engine.

Regulating voltage	Factory spec.	13.8 to 14.8 V
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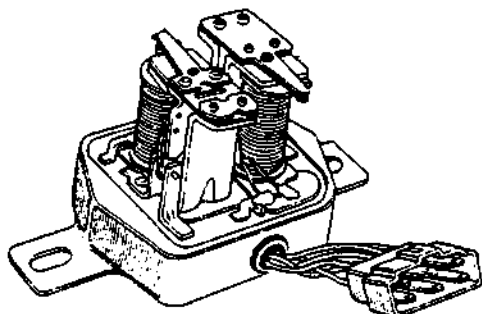
NOTE

- Be sure to gradually accelerate the engine while reading the voltmeter. Never obtain the specified engine speed by decelerating the engine from maximum speed.
- When the regulating voltage is high, bend the adjusting arm (2) of voltage regulator (1) close to the voltage coil, and when low, bend it away from.

- (1) Voltage Regulator
(2) Adjusting Arm



C022F046



C042F089

Regulator Relay

Test terminals IG-F, F-E, N-E, L-E, B-E and B-L.

1. Check the continuity across the each terminals.
(The nominal resistances between terminals are given below for reference.)
2. Press the adjusting arm (2) of the voltage regulator (1) or press the adjusting arm (4) of voltage relay (3) and check the continuity.
(The nominal resistances between terminals are given below for reference.)

NOTE

- "Pull" means the condition where the armature point is contacting the high-speed side point with finger pressure only.
- "Stationary" means the condition where the armature point is in contact the low-speed side point.

(1) Voltage Regulator
(2) Adjusting Arm

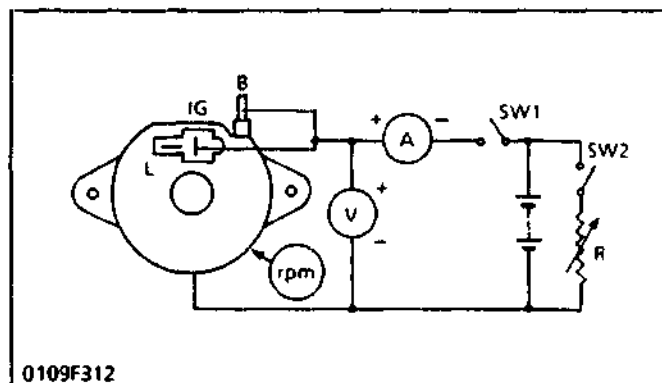
(3) Voltage Relay
(4) Adjusting Arm

Terminals	Voltage relay	Voltage regulator	Normal resistance Ω	Failure and Probable Causes
IG — F (Black/white) (White/green)	—	Stationary	0	If the reading is over 0, bad contact on low-speed side point of voltage regulator.
	—	Pull	Approx. 11	If the reading is not normal res., the control resistor is faulty.
F — E (White/Green) (Black)	—	Stationary	∞	If the reading is not ∞ , bad contact on low-speed side point of voltage regulator.
	—	Pull	0	If the reading is not 0, bad contact on high-speed side point of voltage regulator.
I — E (White/Red) (Black)	Stationary state	—	0	If reading is over 0, bad contact on voltage relay point P1.
	Pull	—	Approx. 100	If reading is 0, deposition occurs on voltage relay point P1. If reading is ∞ , voltage coil is cut.
N — E (White/Black) (Black)	—	—	Approx. 23	If reading is 0, relay coil is shorted. If reading is ∞ , pressure coil is cut
B — E (White) (Black)	Stationary	—	∞	If reading is ∞ , voltage relay point 2 is melted and burned.
B — L (White) (White/Red)	Pull	—	0	If reading is over 0, bad contact on voltage relay point P2.

[4] COMPACT TYPE (EQUIPPED WITH IC REGULATOR)

(precaution when checking)

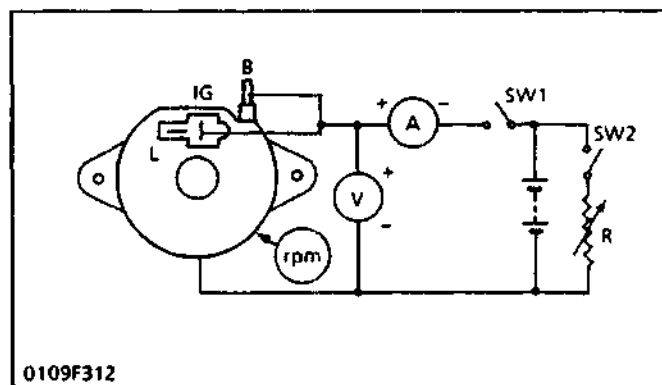
- Do not directly connect the terminal "L" with the terminal "B". Otherwise, the three exciting diodes may be damaged. When connecting the terminal "L", insert a 3.4 W lamp between the terminals "L" and "B".
- Always use a fully charged battery.
- Be careful to observe the proper polarity of the battery. Never install the battery in the wrong direction.
- Never disconnect the battery while the alternator is operating.



Regulating Voltage

1. Make the connections as shown in the figure, and turn on switch "SW1".
2. Increase the alternator speed to 5000 rpm.
3. Turn on switch "SW2". Adjust load resistance "R" so that the ammeter shows 10A.
4. Check that the voltage reading on the voltmeter is within the factory specifications.

Regulating voltage	Factory spec.	14.2 to 14.8 V
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No-Load Characteristics

1. Make the connections as shown in the figure, and turn on switch "SW1".
2. Increase the alternator speed so that the pointer of the ammeter swings to the plus side.
3. Turn off switch "SW1" to decrease the speed, and read the speed at which the voltage is equal to the factory specification.
4. The speed must be below the factory specification.

No-load characteristics	Factory spec.	1400 rpm or less* at 13.5 V
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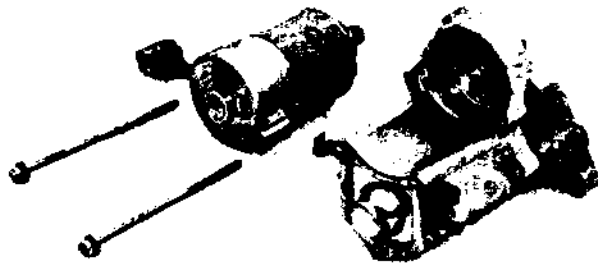
Output Characteristics

1. Make the connections as shown in the figure above, and turn on switch "SW1" and "SW2".
2. Increase the alternator speed while adjusting the load resistance so that the voltage complies with the factory specification.
3. Read the speed at which the current is equal to the factory specification.
4. The speed must be below the factory specification.
5. Decrease the speed so that the current approaches zero, the turn off switches "SW1" and "SW2".

Output characteristics	Factory spec.	43 A or more at 13.5 V, 5000 rpm
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DISASSEMBLING AND ASSEMBLING

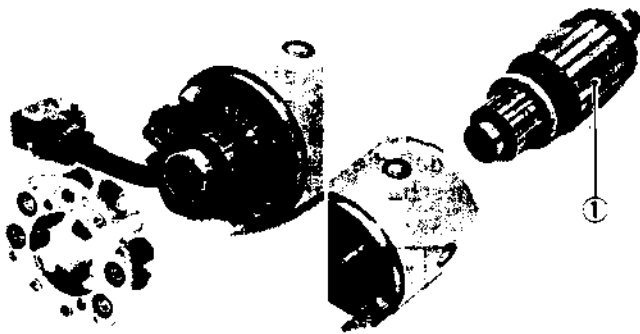
[1] STARTER



0107P085

Starter Motor

1. Disconnect the connecting lead.
2. Remove the mounting nuts.
3. Remove the magnet switch by sliding it up so that it is disconnected from the drive lever.



0107P086

0107P087

Brush Holder

1. Draw out the brush from the holder while holding the spring up.
2. Remove the brush holder.

(When reassembling)

- Do not damage the brush, commutator and bearing.

Armature

1. Draw out the armature (1).

(1) Armature

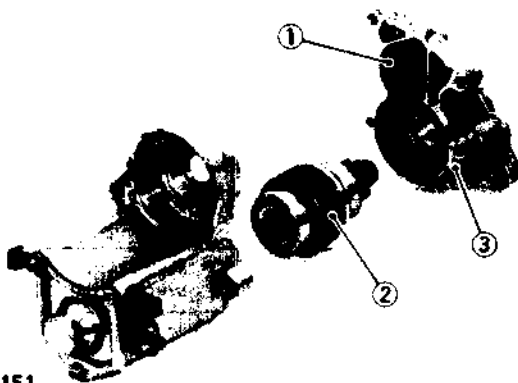
Housing, Idle Gear and Overrunning Clutch

1. Remove the housing (3).
2. Remove the idle gear (1) and the overrunning clutch (2).

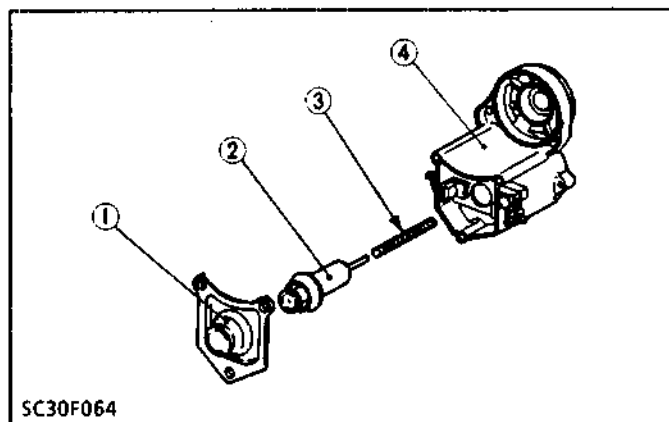
■ NOTE

- Do not damage the clutch bearing and do not let the dust adhere to it.
- Do not lose the steel ball in the overrunning clutch.

- (1) Idle Gear
(2) Overrunning Clutch
(3) Housing

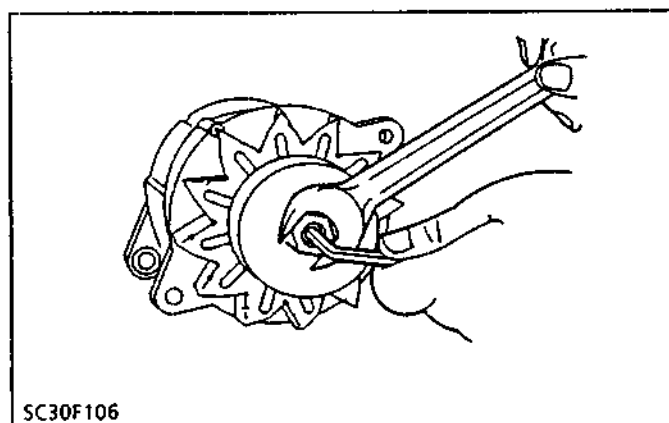


C095P151

**Plunger**

1. Remove the end cover (1) of solenoid switch (4).
2. Remove the plunger (2) and spring (3).

- (1) End Cover
- (2) Plunger
- (3) Spring
- (4) Solenoid Switch

[2] ALTERNATOR**Pulley**

1. Hold the shaft with an Allen wrench and remove the nut.
2. Remove the pulley.
3. Remove the fan.

Drive Side End Frame and Rotor

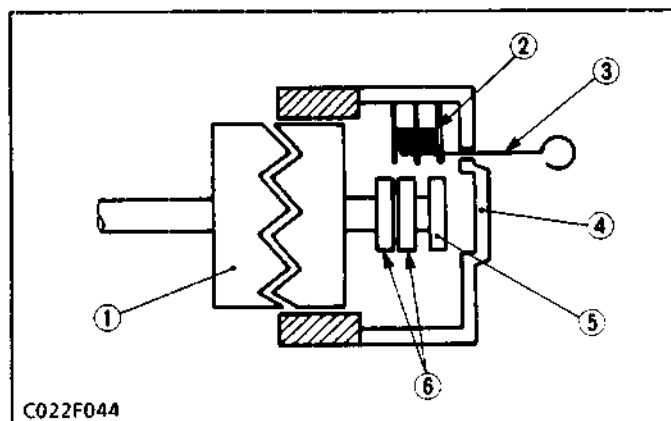
1. Remove the through bolts.
2. Remove the drive end frame.
3. Draw out the rotor.

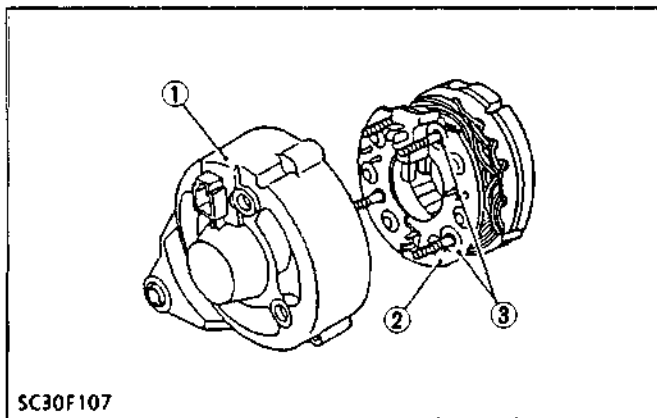
(When reassembling)

- Install the rotor, lifting up the brushes with a wire through the access hole.

- (1) Rotor
- (2) Brush
- (3) Wire
- (4) End Frame
- (5) Bearing
- (6) Slip Ring

C022P019

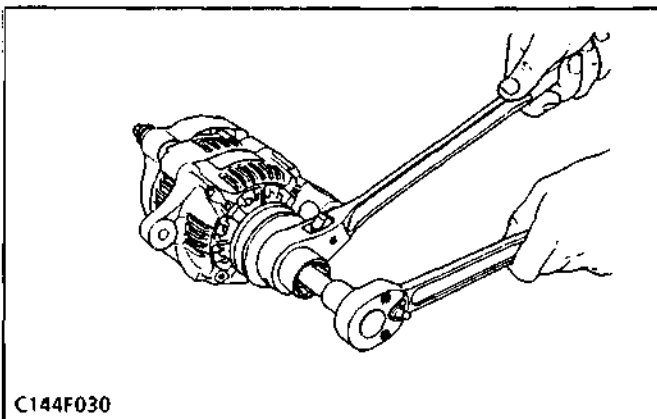


**Rectifier**

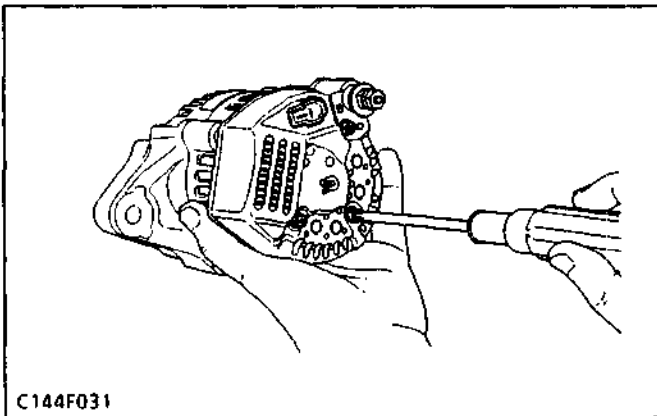
1. Remove the nuts.
2. Remove the end cover (1).
3. Remove the rectifier (2).

(When reassembling)

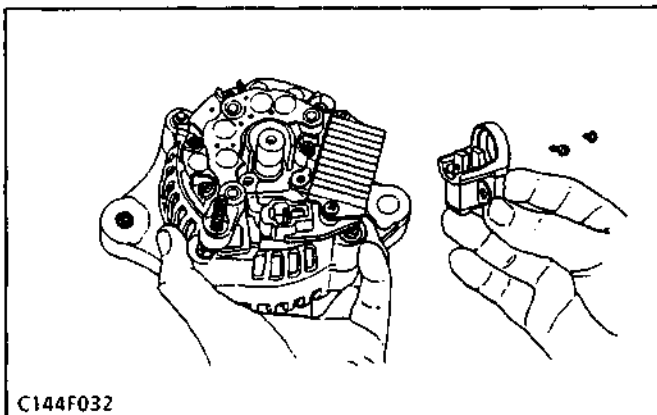
- Be sure to install the insulation washer (3) on the bolt at the positive diode side.

[2] ALTERNATOR (D1403-B, D1703-B, V1903-B, F2803-B)**Pulley**

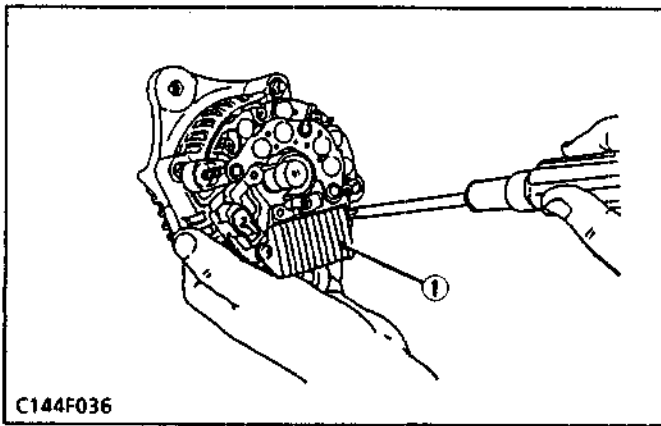
1. With the hexagonal end of the pulley shaft secured with a double-ended ratchet wrench as shown in the photo, loosen the pulley nut with a socket wrench and remove it.

**Rear End Cover**

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

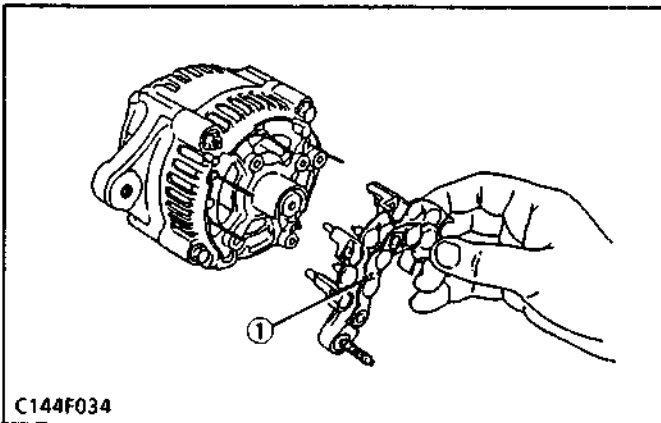
**Brush Holder**

1. Unscrew the two screws holding the brush holder and remove the brush holder.

**IC Regulator**

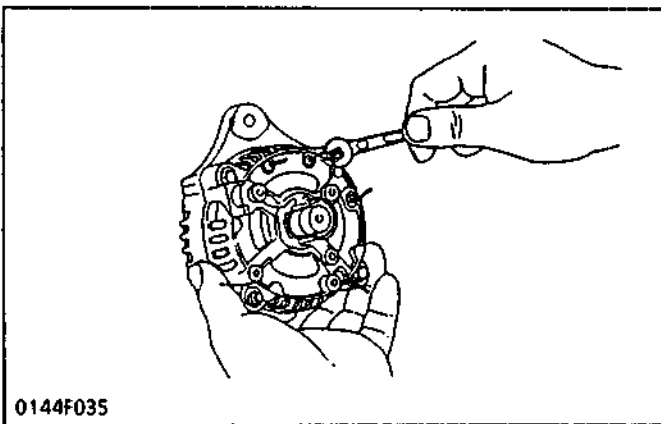
1. Unscrew the three screws holding the IC regulator (1) and remove the regulator.

(1) IC Regulator

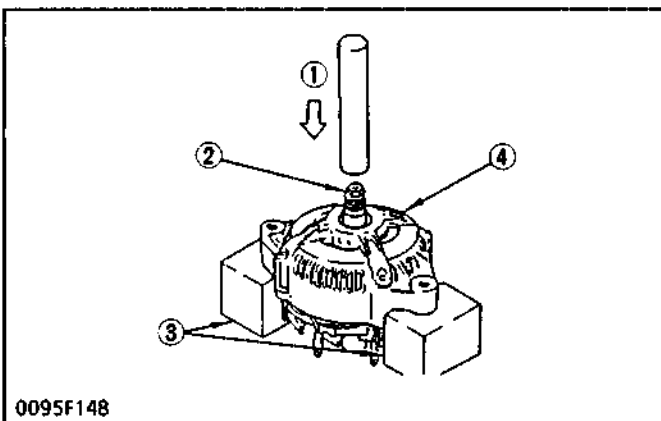
**Rectifier**

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

(1) Rectifier

**Rear End Frame**

1. Remove the two nuts and two screws holding the drive end frame and the rear end frame.
2. Remove the rear end frame.

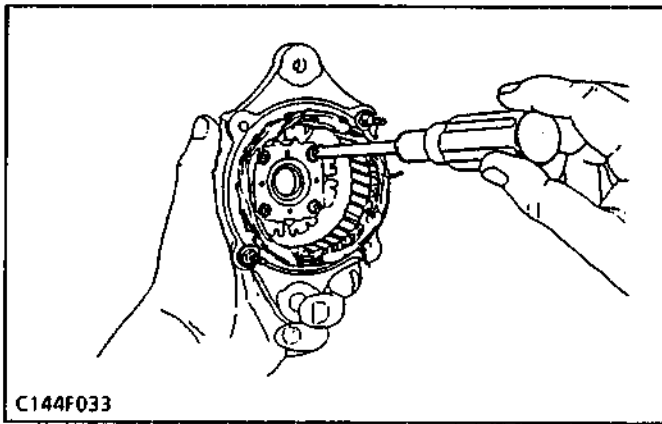
**Rotor**

1. With the drive end frame held level on the blocks as illustrated, press out the rotor.

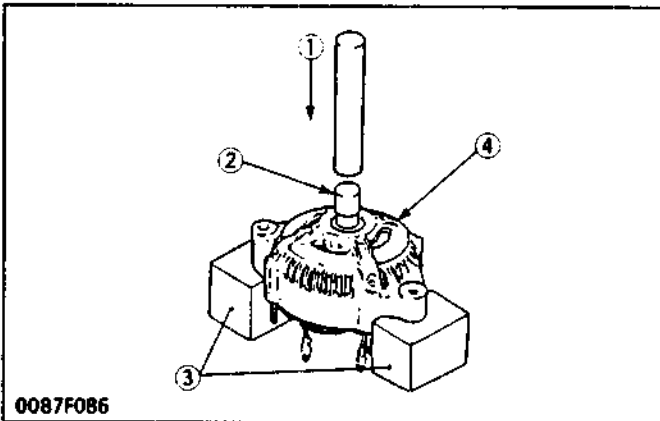
■ IMPORTANT

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

- (1) Press
(2) Rotor
(3) Block
(4) Drive End Frame

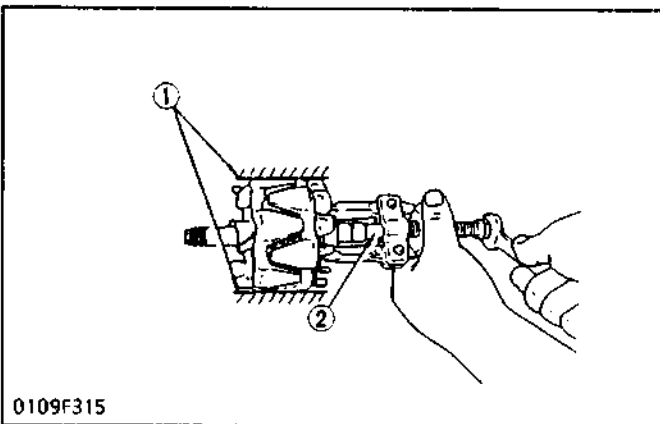
**Retainer Plate**

1. Remove the screws holding the retainer plate and remove the retainer plate.

**Bearing on the Drive End Side**

1. With the drive end frame held level on blocks as illustrated extract the bearing with a press and jig.

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

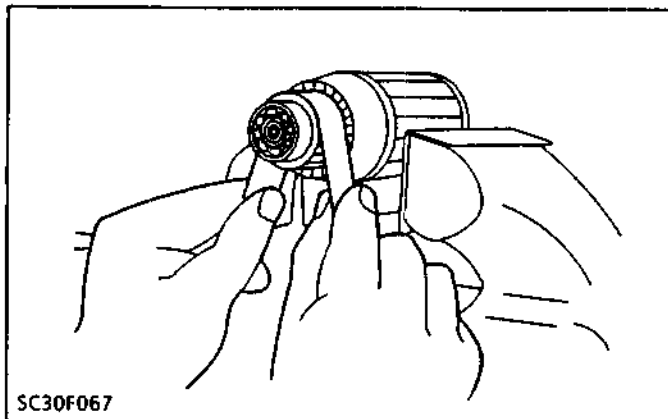
**Bearing at the Slip Ring Side**

1. Using a puller, extract the bearing in the manner shown in the figure.

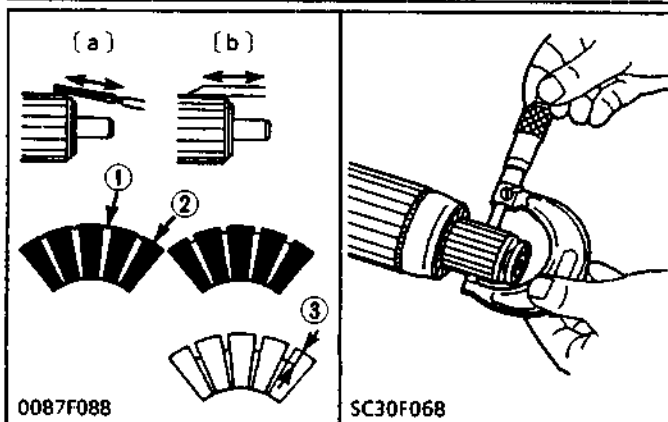
- (1) Lightly secure with a vise to prevent damage
- (2) Press at the center

SERVICING

[1] STARTER

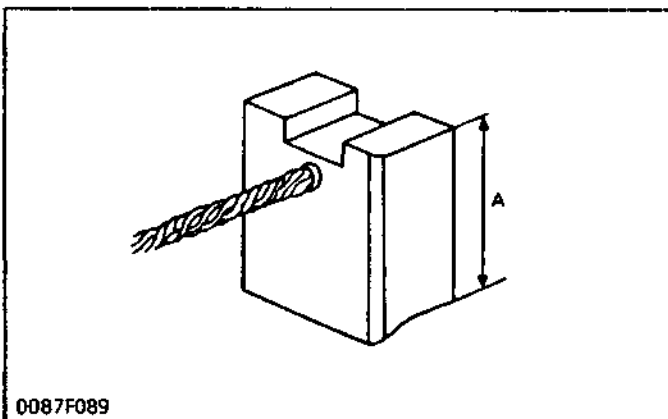


SC30F067

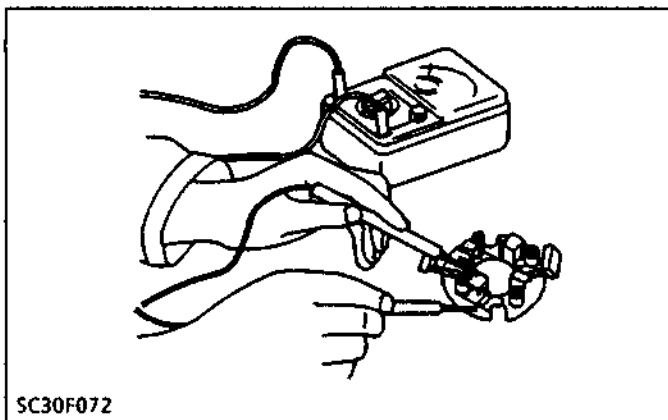


0087F088

SC30F068



0087F089



SC30F072

Commutator and Mica

1. Check the contact face of the commutator for wear, and grind the commutator with sand paper if it is slightly worn.
2. Measure the commutator O.D. 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.
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.	30 mm 1.1811 in.
	Allowable limit	29 mm 1.1417 in.
Mica under cut	Factory spec.	0.5 to 0.8 mm 0.0197 to 0.0315 in.
	Allowable limit	0.2 mm 0.0079 in.

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

- [a] Bad
[b] Good

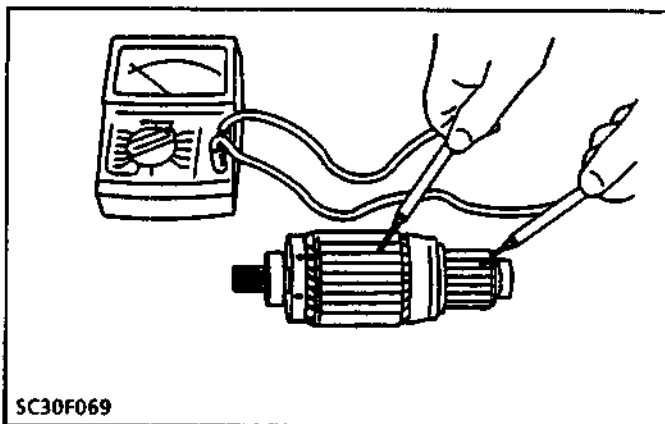
Brush Wear

1. Measure the brush length A.
2. If the length is less than the allowable limit, replace the brush.

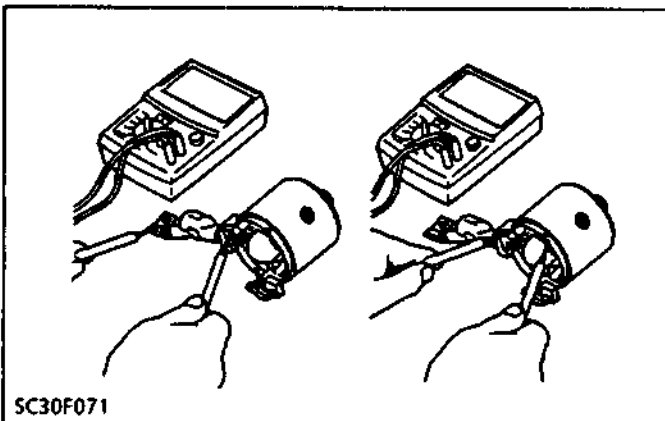
Brush length	Factory spec.	15 mm 0.59 in.
	Allowable limit	10.0 mm 0.394 in.

Brush Holder

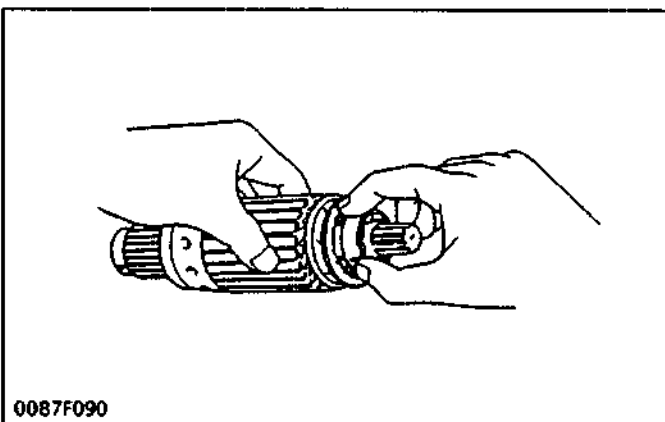
1. Check the continuity across the brush holder and holder support with an ohmmeter.
2. If it conducts, replace it.

**Armature Coil**

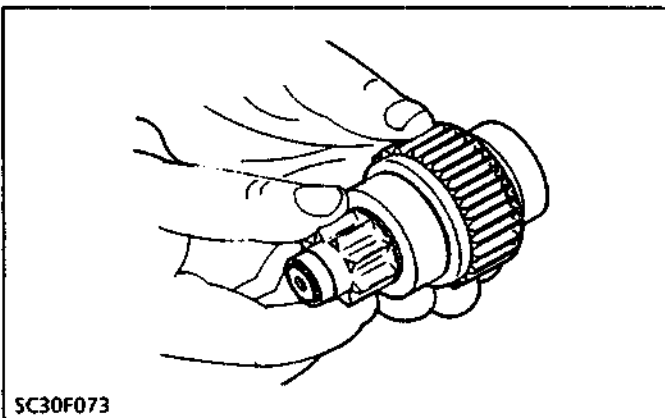
1. Check the continuity across the commutator and armature core with an ohmmeter.
2. If it conducts, replace it.

**Yoke**

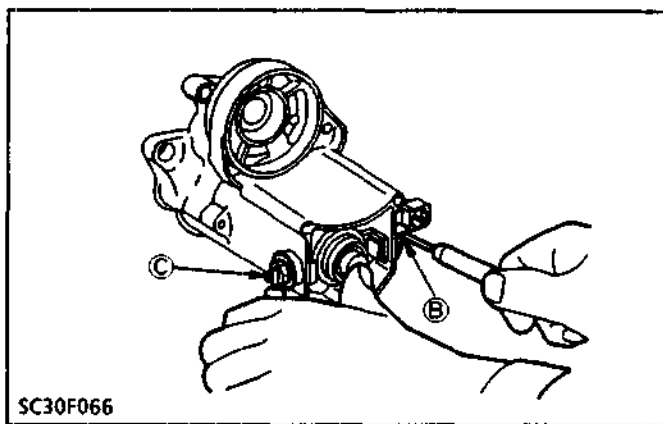
1. Check the continuity across the lead and brush with an ohmmeter.
2. If it does not conduct, replace the yoke.
3. Check the continuity across the brush and yoke with an ohmmeter.
4. If it conducts, replace the yoke.

**Armature Bearing**

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

**Overrunning Clutch**

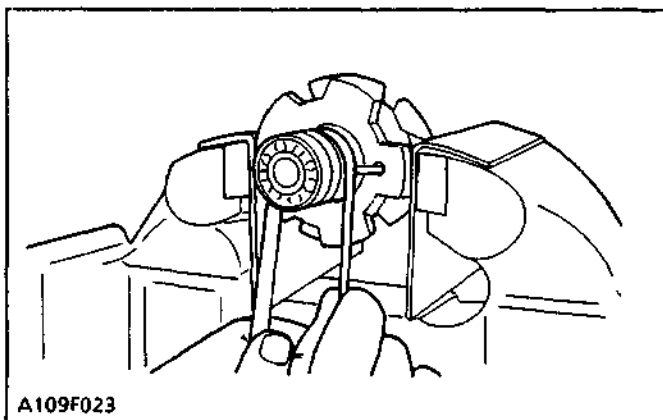
1. Check the clutch for smooth rotation.
2. The overrunning clutch should engage and rotate with the pinion shaft in driving direction and disengage in reverse.



Magnet Switch

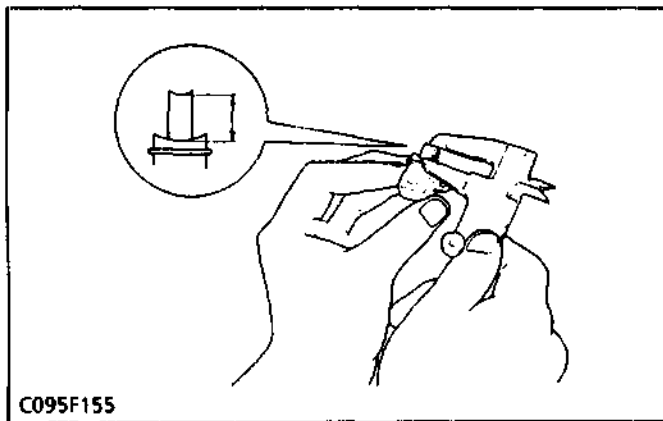
1. Check the continuity across the "C" terminal and the "B" terminal with an ohmmeter pushing the plunger.
2. If it does not conduct, check the contacts.

[2] ALTERNATOR



Slip Ring

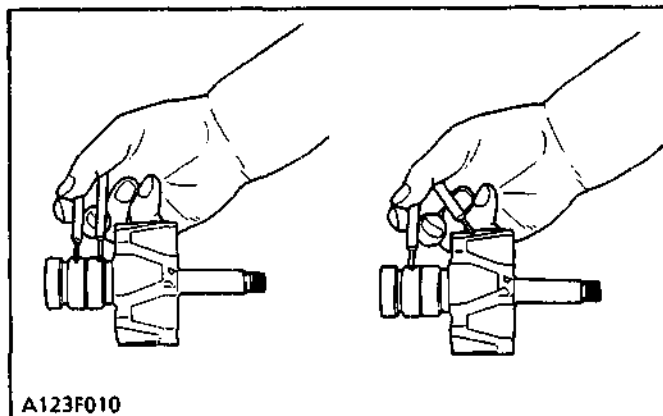
1. Check the slip ring for score.
2. If scored, correct with a sand paper or on a lathe.
(Slip Ring O.D. See page S-21)



Brush Wear

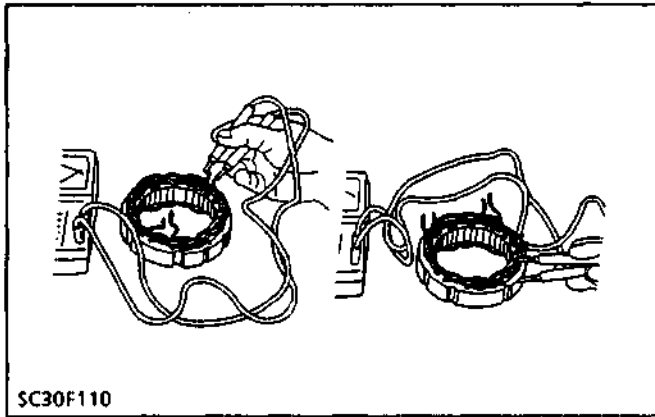
1. Check the length of the brush, if the length is shorter than the allowable limit, replace.
2. Make sure that the brush moves smoothly.
3. If the brush is defective, replace.

Brush length	Factory spec.	V2203-B	12.5 mm 0.4921 in.
		D1403-B, V1703-B, V1903-B, F2803-B	10.5 mm 0.413 in.
	Allowable limit	V2203-B	5.5 mm 0.2165 in.
		D1403-B, V1703-B, V1903-B, F2803-B	4.5 mm 0.177 in.



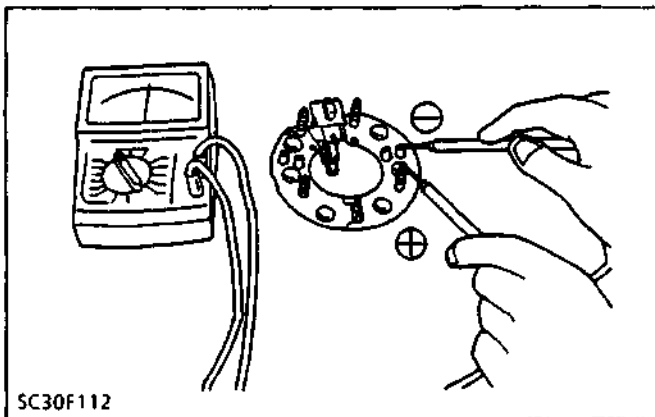
Rotor Coil

1. Check the continuity across the slip ring and core with an ohmmeter.
2. If conduct, replace.
3. Measure the resistance across the slip rings.
4. If the resistance is 0Ω, replace.
(Rotor coil resistance See Page S-21)



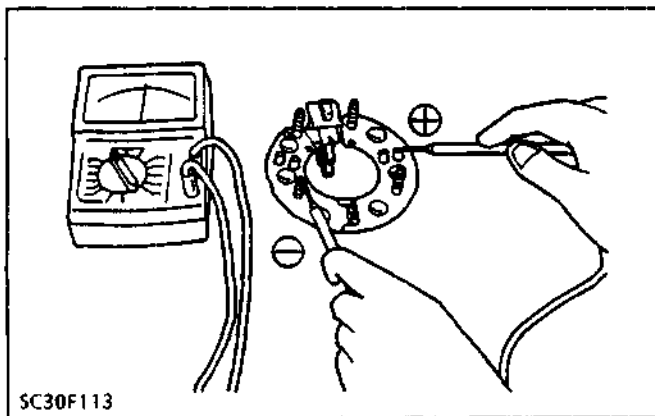
Stator Coil

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



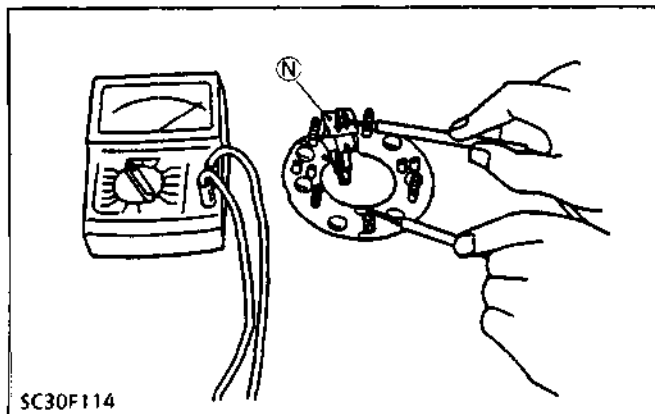
Positive Diodes

1. Connect the positive lead of the ohmmeter to the M6 screw and the negative lead to each coil connecting terminal, and check the continuity.
2. If a certain value is not indicated, replace the diode assembly.
3. Interchange the connection of the leads and check the continuity.
4. If any value is indicated, replace the diode assembly.



Negative Diodes

1. Connect the positive lead of the ohmmeter to each coil connecting terminal and the negative lead to the M5 screw, and check the continuity.
2. If a certain value is not indicated, replace the diode assembly.
3. Interchange the connection of the leads and check the continuity.
4. If any value is indicated, replace the diode assembly.



"N" Terminal and Coil Connection

1. Check the continuity across "N" terminal and coil connecting terminals (inside) with an ohmmeter.
2. If it does not conduct, replace.